8.16 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

Effects of the Environment on the Project are associated with risks of natural hazards and influences of nature on the Project. Typically, potential effects of the environment on any project are a function of project or infrastructure design in the context of its receiving environment, and ultimately how the project is affected by nature. These effects may arise from physical conditions, land forms, and site characteristics or other attributes of the environment which may act on the project such that the project components, schedule, and/or costs could be substantively and adversely changed.

In general, environmental conditions that can affect Construction of the Project, infrastructure, or operational performance will be communicated to the Design Team and addressed through engineering design and industry standards. Good engineering design involves the consideration of environmental effects and loadings or stresses (from the environment) on a project. The planning and engineering design for this Project are no exception.

As a matter of generally accepted engineering practice, responsible and viable engineering designs tend to consistently overestimate and account for possible forces of the environment, and thus inherently incorporate several factors of safety to ensure that a project is designed to be safe and reliable throughout its lifetime. For the Project, long-term environmental management and Project longevity are inherent considerations in the best management practices of the design and associated Project risk management. Equipment and materials that are able to withstand severe weather and other influences will be used. Environmental stressors, such as those that could arise as a result of climate change, severe weather, or other factors (*e.g.,* seismic events, fires), would more than adequately be addressed by good engineering design, materials selection, best practices, and engineering foresight. As will be demonstrated, while there is potential for natural forces to affect the Project, it is not likely to have a substantive effect on Construction or Operation due to planned mitigation and design.

Mitigation strategies for minimizing the likelihood of a significant adverse effect of the environment on the Project are inherent in: the planning process being conducted, the application of engineering design codes and standards, construction practices, and monitoring. As such, and in consideration of the responsible design and best management practices that will be applied throughout the design, Construction, Operation, and Decommissioning, Reclamation and Closure phases of the Project, as will be demonstrated in the following sub-sections, the Effects of the Environment on the Project during all phases of the Project have been rated not significant.

8.16.1 Environmental Attributes

The environmental attributes that are considered to have a potential effect on the Project are based on the Final Guidelines (NBENV 2009), the Terms of Reference (Stantec 2012a), regulatory consultation, public and stakeholder input, a review of the known past and existing conditions, and knowledge gained through projections of potential future conditions (*e.g.,* potential effects of climate change).

Based on the issues and concerns identified, the environmental attributes selected for consideration include:

- severe weather, including:
  - wind;
  - precipitation;
  - floods;
  - hail;
  - electrical storms; and
  - tornadoes;
- climate change;
- seismic activity; and
- forest fires resulting from causes other than the Project.

Effects of the environment are largely addressed through design and compliance with codes and standards that provide sufficient margins of safety to prevent damage from environmental forces based on known information (*e.g.,* design standards for protecting structures from earthquakes, severe wind, snow loads, and other severe weather), or through existing practices and mechanisms aimed at preventing the occurrence of or responding to these types of effects (*e.g.,* prevention and response procedures for forest fires). Climate conditions and climate change are presently the focus of much concern globally, however. *"With global attention now focused on climate change, government agencies, non-profit organizations, the private sector, and individual citizens are gearing up to face climate-related challenges"* (NOAA 2010). As a result, a more thorough investigation of the effects of climate and climate change on the Project was undertaken as compared to that undertaken for the other environmental attributes listed above, to assess the potential effects of the environment on the Project from this emerging global environmental threat.

8.16.2 Selection of Effects

The environmental attributes listed in Section 8.16.1 have the potential to affect the Project in several ways. For example, effects on the Project may include:

- reduced visibility and inability to manoeuver construction and operation equipment;
- delays in receipt of materials and/or supplies (*e.g.,* construction materials, reagents) and/or in delivering products;
- changes to the ability of workers to access the site (*e.g.,* if a road were to wash out);

- damage to infrastructure;
- increased structural loading; and/or
- loss of electrical power resulting in potential loss of production.

These and other changes to the Project by the environment are generally characterized as delays or damage to the Project processes, equipment, and vehicles. As a result, the effects analysis for Effects of the Environment on the Project is focused on the following effects:

- delays in Construction and/or Operation; and
- damage to infrastructure.

Some effects, such as damage to infrastructure, can also result in consequential effects on the environment; these environmental effects are addressed as Accidents, Malfunctions and Unplanned Events in Section 8.17.

8.16.3 Environmental Assessment Boundaries

8.16.3.1 Spatial Boundaries

The spatial boundaries for the assessment of the Effects of the Environment on the Project include all areas where Project-related activities are expected to occur. For the purpose of this EIA Report, the spatial boundaries for Effects of the Environment on the Project are limited to the Project Development Area (PDA) as defined in Chapter 3. Where consequential environmental effects are identified, they are considered within the boundaries of the specific zone of influence of those consequences. Accidental events that could arise as a result of effects of the environment (*e.g.*, severe weather) are addressed in Section 8.17.

8.16.3.2 Temporal Boundaries

The temporal boundaries for the assessment of Effects of the Environment on the Project include the three phases of Construction, Operation, and Decommissioning, Reclamation and Closure (including Post-Closure activities such as ongoing monitoring and maintenance activities) of the Project as defined in Chapter 3.

8.16.3.3 Administrative and Technical Boundaries

8.16.3.3.1 Climate and Climate Change

Climate is defined as the statistical average (mean and variability) of weather conditions over a substantial period of time (typically 30 years), accounting for the variability of weather during that period (Catto 2006). The relevant parameters used to characterize climate are most often surface variables such as temperature, precipitation, and wind, among others.

Climate change is an acknowledged change in climate that has been documented over two or more periods, each with a minimum of 30 years (Catto 2006). The Intergovernmental Panel on Climate Change (IPCC) defines climate change as a change in the state of the climate that can be identified (*e.g.,* by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC 2012). The United Nations Framework Convention on Climate Change (UNFCCC) makes a distinction between climate change attributed to human activities and climate variability attributable to natural causes, by defining climate change as a change of climate directly or indirectly attributed to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods (IPCC 2007a).

The definition of climate change dictates the context in which the effects of those changes are discussed. While it is appropriate to examine the effects of projected climate change on the Project over the next 50 to 100 years through the Operation and subsequently into Post-Closure of the Project, it is not fitting to consider the effects of climate change projections on Construction which will take place over a relatively short period of time in the near future. Construction will occur over the first two years of the Project, and thus rather than considering the effects of long-term climate change on Construction, it is more appropriate to consider the effects of recent climatological conditions, especially the potential adverse effects of weather variability and weather extremes (*e.g.,* change in precipitation) during Construction.

The technical boundaries for the establishment of climate conditions include the spatial coverage of weather stations across the province, the number of parameters monitored at each station, and the temporal coverage of data collection at each station. While there is relatively good spatial coverage of meteorological stations throughout New Brunswick, a number of these stations have existed for a limited period of time (or are no longer operational), and many monitor and record only a very few number of key weather parameters. Environment Canada maintains overall responsibility for meteorological monitoring in Canada, but fiscal restraint and rationalization in recent decades has limited the comprehensive monitoring and reporting of weather information (*e.g.,* some weather stations are no longer operational, or are now monitoring a limited number of parameters).

Technical boundaries for the prediction of effects of climate change relate to the inherent uncertainty of global climate models in predicting future changes in climate parameters, and specifically their application of global-scale prediction algorithms to a relatively localized scale through "downscaling" techniques. Global climate models can provide relatively useful information for predicting and preparing for global and macro-level changes in climate, but their ability to pinpoint location-specific changes to climate on a localized level is limited.

8.16.3.3.2 Seismic Activity

Seismic activity is dictated by the local geology of an area and the movement of tectonic plates comprising the Earth's crust. Natural Resources Canada monitors seismic activity throughout Canada and identifies areas of known seismic activity in order to document, record, and prepare for seismic events that may occur.

There are no known technical boundaries for the establishment of existing conditions for seismic activity. However, the ability of experts and of existing monitoring and modelling tools to predict a seismic event into the future tends to be very limited, except for very substantive events a short period of time before they occur. This technical boundary is overcome by the use of conservative building codes and standards which inherently incorporate several factors of safety to account for possible effects of environmental forces such as seismic events. A probabilistic seismic hazard assessment has been carried out to assist in developing seismic design criteria for the Project.

8.16.3.3.3 Forest Fires

The management, monitoring and control of forest fires in New Brunswick are the responsibility of the New Brunswick Department of Natural Resources (NBDNR) under the *Forest Fires Act*. Day-to-day management of these issues is carried out by the Forest Fire Management Section of NBDNR, with on-the-ground assistance by NBDNR's conservation offices throughout the province. Monitoring and response to major fire events is coordinated by the province's Emergency Measures Organization, with assistance as necessary from private contractors (*e.g.,* Forest Protection Limited).

There are no known technical boundaries for the establishment of existing conditions for forest fires. Prediction of forest fire activity is linked to the operation of a Fire Weather Index operated during dry seasons to establish burning restrictions in specific geographic areas when dry conditions prevail, though the index is more of a management tool to prevent forest fires than a predictive tool to predict if, when and where a fire may occur.

8.16.4 Residual Effects Rating Criteria

A significant adverse residual effect of the environment on the Project is one that would result in:

- a substantial change of the Project schedule (*e.g.,* a delay resulting in the construction period being extended by one season);
- a long-term interruption in service (*e.g.,* an interruption in mining activities such that production targets cannot be met);
- damage to Project infrastructure resulting in a significant environmental effect;
- damage to the Project infrastructure resulting in a substantial increase in risks to the health and/or safety of the public, or substantial risks of a business interruption; and/or
- damage to the Project infrastructure resulting in repairs that could not be technically or economically implemented.

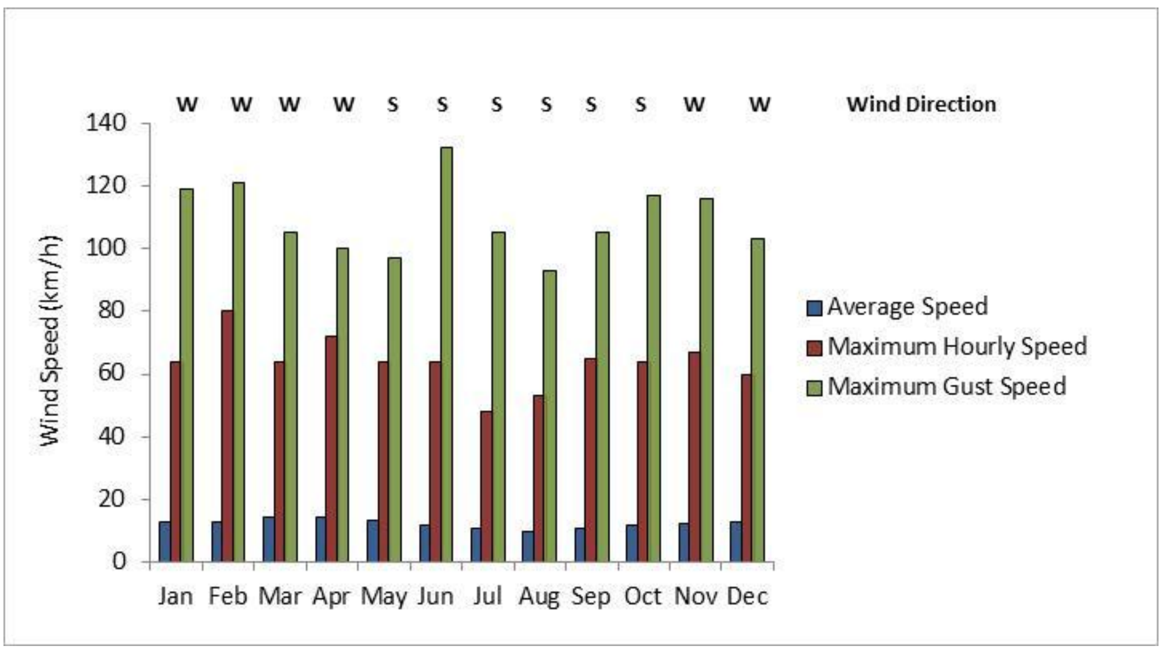
8.16.5 Existing Conditions

8.16.5.1 Climatological Background (1971 to 2000)

The current climate conditions are generally described by the most recent 30 year period for which Environment Canada has developed statistical summaries—generally referred to as "climate normals". The closest weather station to the Project with available historical data is the Juniper weather station, located approximately 25 km from the Project. No historical climate data for wind speed and wind direction are available for the Juniper station, therefore, wind data from the Fredericton Airport weather station, located approximately 70 km from the Project, are also briefly discussed to provide some indication of the magnitude of winds experienced in the region. The most recent 30-year period for which climate normals data are available from the Juniper and Fredericton Airport weather stations is for the period of 1971 to 2000; this period has been chosen as the applicable period for summarizing current climate conditions for the Project (Environment Canada 2012h; 2012k). It is also important to note that the climate normals data presented herein for precipitation at Juniper and Fredericton (Environment Canada 2012h; 2012k) are statistically similar with data collected and estimated for the Project at the Sisson site (Section 8.4.2; Knight Piésold 2012d).

8.16.5.1.1 Wind

Monthly average wind speeds measured at the Fredericton Airport range from 10.0 to 14.6 km/h, with an annual average wind speed of 12.4 km/h (Figure 8.16.1). From May to October, the dominant wind direction is from the south, with winds predominantly blowing from the west from November to April (Environment Canada 2012h). Maximum hourly wind speeds, averaged from 1971 to 2000 for each month, range from 48 km/h to 80 km/h; while maximum gusts for the same period range from 93 km/h to 132 km/h. Occurrences of extreme winds are uncommon at Fredericton—over the last three decades there has been an average of 2.2 days per year with winds greater than or equal to 52 km/h and 0.3 days per year with winds greater than or equal to 63 km/h (Environment Canada 2012h).



Source: Environment Canada (2012h).

Figure 8.16.1 Predominant Monthly Wind Direction, Monthly Mean, Maximum Hourly and Maximum Gust Wind Speeds (1971 to 2000) at Fredericton, New Brunswick

8.16.5.1.2 Precipitation

Precipitation in Juniper has been, on average, well distributed throughout the year (Section 8.2.2.1). From 1971 to 2000, Juniper received an average of 1,190.7 mm of precipitation each year, of which 885.1 mm (73% of the total) was rain and 305.6 mm (27% of the total) was snowfall (as water equivalent). Extreme daily precipitation at Juniper ranged from 50.6 mm (June 1993) to 91.2 mm (April 1973). On average in Juniper, there have been 7.1 days a year with rainfall greater 25 mm, while snowfalls greater than 25 cm occur on average 1.4 days per year (Environment Canada 2012k).

Precipitation at the Fredericton Airport has also been, on average, well distributed throughout the year (Section 8.2.2.1). From 1971 to 2000, Fredericton received an average of 1,143.3 mm of precipitation a year, of which 885.5 mm was rain and 276.5 mm was snowfall (as water equivalent). Extreme daily precipitation at the Fredericton Airport ranged from 45.4 mm (March 1998) to 148.6 mm (August 1989). On average, there have been 6.6 days each year with rainfall greater than 25 mm, and snowfalls greater than 25 cm occur on average 1.1 days each year (Environment Canada 2012h).

In a recent Hydrometeorology study conducted in support of the Project (Knight Piésold 2012d), it was concluded, based on an analysis of the site and long-term regional data, that the PDA is estimated to be wetter and receive approximately 27% more precipitation than Juniper (1,136 mm between the years 1969-2012). Furthermore, based on the results from the watershed modelling conducted by Knight Piésold, the mean annual precipitation (MAP) was estimated to be approximately 1,350 mm/year (which is the MAP estimate adopted for the Project), with 1,013 mm falling as rain and 337 mm falling as snow. The estimated mean annual lake evaporation is 500 mm at the TSF. Snow can generally be expected from November to March, with accumulations remaining on the ground from December to February. The annual wet and dry year precipitation values, which provide a measure of variability from one year to the next, were calculated to be 1,634 mm and 1,066 mm, respectively (Knight Piésold 2012d).

8.16.5.1.3 Severe Weather Events

Extreme precipitation and storms can occur in New Brunswick throughout the year but tend to be more common and severe during the winter. Winter storms generally bring high winds and a combination of snow and rain. Freezing rain has been observed on approximately 12 days a year in New Brunswick, ranging from an average of 34 hours to 59 hours a year at Fredericton and Moncton, respectively. One of the most noteworthy storms in recent history struck eastern New Brunswick on January 4, 1989, where Moncton experienced 110 km/h winds and 67 cm of snow over a 24 hour period. The Groundhog Day storm in February 1976 was an intense winter storm that caused a great deal of damage in southern New Brunswick (Environment Canada 2004). More recently, extreme storm events in December 2010 affected much of New Brunswick, where some areas received as much as 200 mm of rain; these events threatened public safety and transportation systems, and damages were estimated to be approximately $50 million (Government of New Brunswick 2012).

In the summer and fall, southern New Brunswick is expected to experience at least one heavy rainstorm every one to two years (Environment Canada 2004). Although the frequency of heavy rainstorms is not available for western New Brunswick, based on climate normals compiled by Environment Canada (2012h; 2012k) and the fact that southern New Brunswick experiences heavier rainfall than western New Brunswick, the frequency of heavy rainstorms for the Project is expected to be less than one every one to two years. In a study conducted in support of the Project (Knight Piésold 2012d), the mean extreme 24-hour rainfall was estimated, based on annual maximum daily precipitation from Juniper (1969-2004), to be 72.2 mm, with a standard deviation of 17.3 mm.

In New Brunswick, river valleys and flood plains can pose a risk because of ice jams, harsh weather and the floods of annual spring thaw (Government of Canada 2012). Flooding in New Brunswick is rather common, especially along the St. John River (Environment Canada 2004). Therefore, flooding is listed as one of the regional hazards in New Brunswick through the federal governments "Get Prepared" campaign (Government of Canada 2012), and the New Brunswick Emergency Measures Organization monitors flooding as a natural risk and hazard through its “River Watch” program (http://www2.gnb.ca/content/gnb/en/news/public_alerts/river_watch.html).

Electrical storms, or thunderstorms, which are more frequent in New Brunswick than the rest of Atlantic Canada, occur on average 10 to 20 times a year (Environment Canada 2004). Generally, only one of these storms (per year) is extreme enough to produce hail. Thunderstorms can produce extremes of rain, wind, hail and lightning; however, most of these storms are relatively short-lived (Environment Canada 2004).

Tornadoes are rare, but do occur in New Brunswick. According to Environment Canada (2012l), western New Brunswick is considered part of Canada’s tornado zone. In fact, 423 confirmed and probable F2 Tornadoes[1] have occurred in western New Brunswick between 1729 and 2009 (Environment Canada (2012m)). Of Canada’s ten worst tornadoes on record, one F3 tornado occurred in eastern New Brunswick at Bouctouche on August 6, 1879 (Natural Resources Canada 2009), which killed 5 people, injured 10, and left 25 families homeless—this is considered to be the easternmost major tornado in North America (Public Safety Canada 2007).

8.16.5.2 Seismic Activity

As discussed in Section 6.3.1.3.1, the Project lies within the Northern Appalachians seismic zone, one of five seismic zones in southeastern Canada, where the level of historical seismic activity is low. Historical seismic data recorded throughout eastern Canada has identified clusters of earthquake activity. Earthquakes in New Brunswick generally cluster in three regions: the Passamaquoddy Bay region, the Central Highlands (Miramichi) region, and the Moncton region (Burke 2011).

The largest earthquake instrumentally recorded in New Brunswick was a magnitude 5.7 event (on the Richter scale) on January 9, 1982, located in the north-central Miramichi Highlands. This earthquake was followed by strong aftershocks of magnitude 5.1 and 5.4. Prior to 1982, other moderate earthquakes with estimated magnitude in the range of approximately 4.5 to 6.0 occurred in 1855, 1869, 1904, 1922, and 1937 (Basham and Adams 1984). The 1869 and 1904 earthquakes were both located within the Passamaquoddy Bay region, with estimated magnitudes of 5.7 and 5.9, respectively (Fader 2005). The maximum credible earthquake magnitude for the Northern Appalachians region is estimated to be magnitude 7.0, based on historical earthquake data and the regional tectonics (Adams and Halchuk 2003). There is potential for large earthquakes of up to about magnitude 7.5 along the

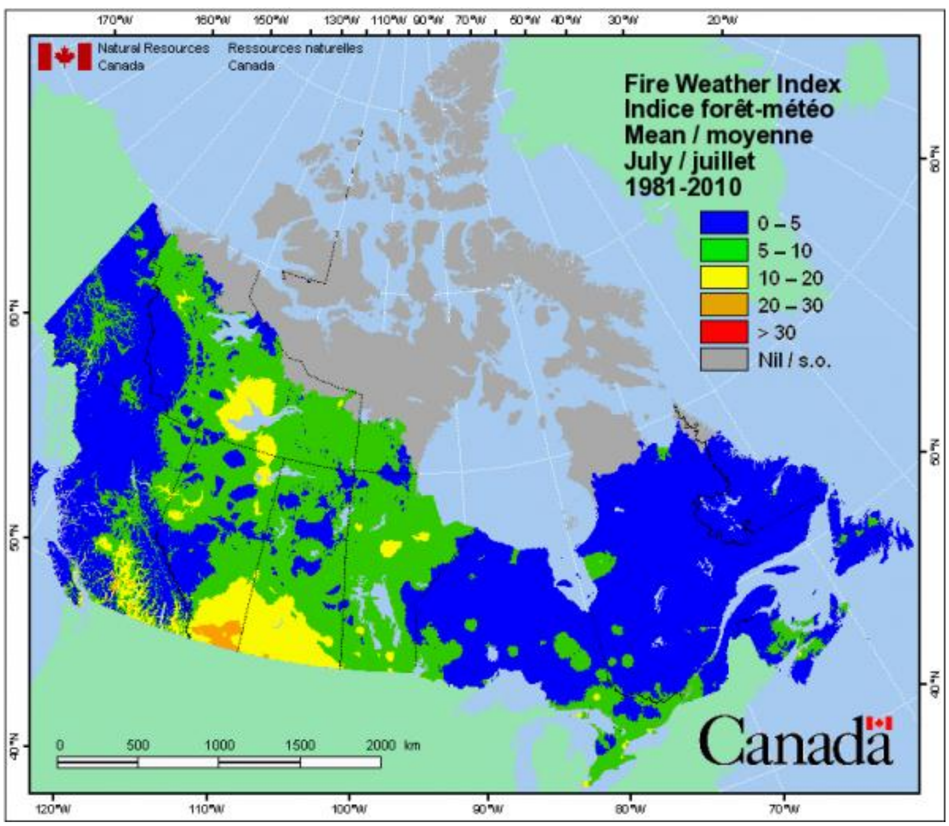
[1] Tornadoes are classified on a scale known as the Fujita scale. F2 Tornadoes (“significant tornado”) have winds ranging between 181–252 km/h, where: roofs are torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; and light object missiles generated. F3 Tornadoes (“severe tornado”) have winds ranging between 253-330 km/h and result in roofs and walls torn off well-constructed houses, trains overturned, and most trees in forests uprooted.

fault zones associated with the St. Lawrence River. However, these events would be located over 200 km from the Project site, and therefore the amplitude of ground motions experienced at the Project site would be low due to attenuation over a large distance. Review of historical earthquake records and regional tectonics indicates that the Project site is situated in a region of low seismicity. A probabilistic seismic hazard analysis has been carried out using historical earthquake data and the regional tectonics to identify potential seismic sources and to estimate the maximum earthquake magnitude for each seismic source. The corresponding median maximum acceleration is 0.07g for a return period of 500 years (Samuel Engineering 2013).

8.16.5.3 Forest Fires

The Fire Weather Index is a component of the Canadian Forest Fire Weather Index System. It is a numeric rating of fire intensity. It combines the Initial Spread Index and the Buildup Index, and is a general index of fire danger throughout the forested areas of Canada (Natural Resources Canada 2012).

The mean Fire Weather Index in Napadogan for July (*i.e.,* normally the driest month of the year), when risk of forest fire is typically the greatest, is rated from 5-10 (for years 1981-2010) (Figure 8.16.2); this is in the lower range of possible risk which, at the highest range, can exceed 30 on the Fire Weather Index (Natural Resources Canada 2012).



Source: Natural Resources Canada (2012).

Figure 8.16.2 Average Fire Weather Index for the Month of July (1981-2010)

8.16.6 Effects Assessment

As discussed in Chapter 3, the Project will be designed, constructed, and operated in compliance with various codes, standards, best practices, acts and regulations that govern the required structural integrity, safety, reliability, and environmental and operating performance of the various Project components to minimize the potential for significant adverse effects of the environment on the Project. Adherence to these codes, standards, acts and regulations will help ensure that the Project is carried out in a manner that minimizes the potential effects of the environment on the Project, including damage to infrastructure that could result from their occurrence.

As outlined in the introduction to this section, the Project will be designed in accordance with several best management and engineering design practices. As a factor of safety, and a matter of responsible engineering practice, the design and materials to be chosen for construction of the Project will be selected so that the Project will withstand environmental stressors that could occur from various natural and environmental phenomena (*e.g.,* extreme storms, increased precipitation and other factors arising from climate change, and others). The EIA has been carried out in parallel to Project design, and the results of the EIA have informed the design of the Project such that any potential concerns are addressed and the potential for significant adverse effects of the environment on the Project is minimized.

The Project will be constructed to meet all applicable building, safety and industry codes and standards. The engineering design of the Project will consider and incorporate potential future changes in the forces of nature that could affect its operation or integrity (*e.g.,* climate change), and Project components and infrastructure will be designed and built to adapt to or withstand these effects. The Project components will be designed to meet the National Building Code of Canada, the Canadian Dam Association Guidelines, and other design codes and standards for wind, snowfall, extreme precipitation, seismicity, and other weather variables. These standards and codes provide factors of safety regarding environmental loading (*e.g.,* snow load, high winds, seismic events), and Project specific activities and events. Design requirements address issues associated with environmental extremes including:

- wind loads;
- storm water drainage from rain storms and floods;
- weight of snow and ice, and associated water;
- earthquake loads; and
- erosion protection of slopes, embankments, ditches and open drains.

To account for potential weather extremes, engineering specifications of the National Building Code of Canada contains design specific provisions, such as:

- critical structures, piping, tanks and steel selection to prevent brittle fracture at low ambient conditions;
- electrical grounding structures for lightning protection;

- maximum motor ambient temperature; and
- ice and freeze protection.

Compliance with this and other Codes will minimize the likelihood of adverse effects of the environment on the Project, including those that may be significant and as a consequence of extreme events. Building codes are established in Canada to manage normal effects of the environment on structures (*e.g.,* weatherproofing) but also for extreme events that can possibly be anticipated. Other mitigation measures implemented as part of the planning process, including adherence to engineering design codes and standards, use of good engineering judgment and careful construction practices, care in selection of appropriate construction materials and equipment, careful planning of operation activities (*e.g.,* TSF embankment raises; receipt of materials and/or supplies, product deliveries), and the implementation of a proactive monitoring, maintenance and safety management program, will minimize the potential for adverse effects of the environment on the Project to such an extent that they are not significant.

Codes and standards are set in legislation as minimum requirements. They are continuously reviewed as new information becomes available. In addition to complying with codes and standards, the Basic Engineering Team for the Project will adopt a proactive approach to incorporate climate change considerations and adaptation measures into the Project. Several publications are available to guide design engineers in this regard, including, for example, the PIEVC (Public Infrastructure Engineering Vulnerability Committee) “Engineering Protocol for Infrastructure Vulnerability Assessment and Adaptation to a Changing Climate” (PIEVC 2011). This protocol outlines a process to assess the infrastructure component responses to changing climate to assist engineers and proponents in effectively incorporating climate change into design, development and management of their existing and planned infrastructure. This and other guidance will be considered, as applicable, in advancing the design and construction of the Project.

8.16.6.1 Effects of Climate on the Project

To assess the environmental effects of climate on the Project, current climate and climate change must both be considered. Current climate conditions are established by compiling relevant historical data and establishing a climatological background for the Napadogan area. Climate change effects projected over the life of the Project are determined through reviewing the climate modelling research to establish the current state of understanding of trends likely in the Napadogan area over the next 50 to 100 years. Projections vary among these global and downscaled model results, mainly as a result of varying levels of precision in data used to run climate models and because of variations in the projections of future greenhouse gas (GHG) emission scenarios. A consensus has evolved regarding the climate change-related effects most likely to affect Atlantic Canada and New Brunswick (Vasseur and Catto 2008).

Numerous climate-related conditions, linked primarily to global warming, have been observed across Atlantic Canada, the entire country and globally. Many believe that these changes to the climate regime will accelerate over the next century, as has been the case with global temperatures over the past two decades (IPCC 2007a; 2007b). For example, increased temperatures, changing precipitation patterns and intensity, and increasing drought and associated lowering water levels are all conditions that are being studied and measured. Of these, several have been projected to affect infrastructure in

Atlantic Canada, including changing precipitation patterns, higher temperatures, more storm events, increasing storm intensity, rising sea levels, storm surges, and coastal erosion and flooding (Vasseur and Catto 2008). Those most relevant to the Project over the next 50 to 100 years are changing precipitation patterns, increased number and intensity of storms, and flooding.

8.16.6.1.1 Climate Change Predictions for New Brunswick and Atlantic Canada

Predicting the future environmental effects of climate change for a specific area using global data sets is problematic due to generic data and larger scale model outputs which do not take into account local climate. Accurate regional and local projections require the development of specific regional and local climate variables and climate change scenarios (Lines *et al.* 2005). As a result, downscaling techniques have emerged over the last decade as an important advancement in climate modelling. Downscaling is used to introduce micro-scale interactions by including local climate variables. Downscaling techniques are particularly important for Atlantic Canada due to the inherent variability associated with this predominantly coastal climate. Statistical downscaling uses global climate model (GCM) projections as well as historical data from weather stations across the region, and studies the relationship between these sets of data. Downscaling produces more detailed predictions for each of these weather stations (Lines *et al.* 2005) and has allowed for a better understanding of future climate scenarios based on precise and accurate historic data sets.

Results tend to differ between a Statistical Downscaling Model (SDSM) and Canadian Global Climate Model (CGCM). The overall mean annual maximum temperature increase projected for Atlantic Canada between years 2020 and 2080 ranged from 1.6C° to 4.7C° for the SDSM model results, and 1.1C° to 3.6C° for the CGCM1 model results (Lines *et al.* 2005). This is consistent with predicted mean annual maximum temperature for the same time period at Fredericton (the nearest location to the Project), predicted to range from 1.8C° to 5.0C° for the SDSM model results and 1.1C° to 3.9C° for the CGCM1 model results (Lines *et al.* 2005) (Table 8.16.1).

Table 8.16.1 Projected Mean Annual Maximum and Minimum Temperature Change, and Precipitation Percent Change for both SDSM and CGCMI Model Results

Period	T_{max}		T_{min}		% Precipitation	
	SDSM	CGCM1	SDSM	CGCM1	SDSM	CGCM1
2020s	1.8	1.1	1.8	1.8	20	2
2050s	3.1	2.1	2.8	2.9	21	-2
2080s	5.0	3.9	4.2	4.2	21	3

Notes:
1) A positive value denotes an increase, a negative value denotes a decrease.
SDSM = Statistical Downscaling Model.
CGCM = Canadian Global Climate Model.
T_{max} = Mean annual maximum temperature change.
T_{min} = Mean annual minimum temperature change.

Source: Lines *et al.* (2005).

The SDSM projections for maximum temperature for 2050 at Fredericton are for summer, fall and winter increases (2.7C° to 5.5C°), while for the spring, slight cooling is anticipated (-0.5C°) (Lines *et al.* 2005). By the year 2080, temperatures are projected to increase in all seasons, with greater warming in the summer, fall and winter (4.3C° to 7.0C°) than the spring (1.3C°) (Lines *et al.* 2005). This average temperature change is expected to be gradual over the period and is likely to affect precipitation types and patterns. The warmer fall and winter temperatures could mean later freeze up; wetter, heavier snow; more liquid precipitation occurring later into the fall; and possibly more freezing precipitation during both seasons. With little change in spring temperatures, differences in fresh water ice formation and breakup patterns will likely be slight over the next century. Changes to precipitation patterns due to warmer weather over the fall and winter months, on the other hand, could lead to stronger spring run-off (Natural Resources Canada 2001).

There is less agreement among the global circulation and regional downscaling models regarding changes in precipitation. Annual precipitation increases projected for Atlantic Canada between the years 2020 and 2080 range from 18% to 21% for the SDSM model results, and -2% to 2% for the CGCM1 model results (Lines *et al.* 2005). Precipitation trends are of more interest when taken together with the temperature increases and the seasonality of the predicted changes. Statistical Downscaling Model trends for the years 2020 to 2080 indicate a temperature increase of 8% to 12% for the winter months and 21% to 35% for the summer months (Lines *et al.* 2005). It is generally considered that the increased precipitation being projected for portions of western Atlantic Canada may be the result of continued landfall of dying hurricanes and tropical storms reaching into this area in the summer and fall months (Lines, G., Personal communication, March 5, 2006). While SDSM results highlight an increase in summer and fall precipitation, the CGCM1 results range from no change in the 2020s to a reduction in precipitation over the summer season for the years 2050 to 2080 (Lines *et al.* 2005). This is consistent with trends projected by Environment Canada (2008), where global model results highlight a reduction in summer precipitation for the 2080s.

The inconsistencies between SDSM and CGCM1 predicted seasonal precipitation changes highlight the inherent variability and uncertainty in climate modelling, which is considered as a technical boundary in this assessment. Due to the increased precision of localized data used in SDSM relative to global modelling, confidence is considered to be greater in the SDSM results relative to global model results. Nonetheless, SDSM methods still embody the uncertainties inherent in all climate models, and as such, their results must be interpreted with some caution.

Regardless of the differences in the temperature and precipitation changes between global climate and SDSM projections, there is a general consensus in the climatological community concerning the overall anticipated environmental effects of climate change. For example, over the next 100 years, Atlantic Canada will likely experience warmer temperatures, more storm events, increasing storm intensity, and flooding (Vasseur and Catto 2008). In a recent study (Knight Piésold 2012d), the 24-hour extreme precipitation values for return periods of 10, 50, and 200 years at the PDA have been estimated to be 95 mm, 117 mm, and 136 mm, respectively. The 24-hour Probable Maximum Precipitation (PMP) value, considered in the design of the Project, was estimated to be 352 mm. .

As described above, severe weather is predicted to be more frequent and more intense over the next 100 years. Many reports indicate the likelihood of growing insurance claims and other measures of these changes. For instance, in Canada, the insured catastrophe losses totalled approximately $1.6 billion in 2011 and nearly $1 billion in each of the previous two years (IBC 2012). These losses have been attributed to extreme weather events, an increase in claims resulting from smaller weather events that result in significant property damage, and aging sewer infrastructure which is often incapable of handling higher levels of precipitation. As a result, water claims have now surpassed fire as the number one cause of home insurance losses in many parts of the country (IBC 2012).

While advances in modelling science over the last decade have improved confidence in long-term, projections, like all modelling projections, the results and guidance they provide are not meant as absolutes, but rather are intended to allow for preparations, for design considerations, and to facilitate adaptation.

8.16.6.1.2 Characterization of Effects of Climate on the Project

The environmental attributes of climate, as earlier defined, are important considerations in Construction and Operation. While current climate conditions and weather variability may affect Construction, projected longer term climate change scenarios may affect Operation and into Closure and especially Post-Closure. The potential effects that these climate conditions may have on the Project are described and predicted where possible. To address these environmental effects, proactive design, planning, and maintenance are required in consideration of the potential normal and extreme conditions that might be encountered throughout the life of the Project.

As previously described, by building to current building codes and standards, selecting appropriate construction materials, designs and practices, environmental stressors on the Project such as those that could arise as a result of climate change, severe weather, and other factors would be expected to be adequately addressed. This is central to Northcliff's commitment to responsible development of the Project and to managing risks to the Project and subsequently the environment.

8.16.6.1.2.1 Construction Phase

The relatively short period of construction of even a large project is generally not considered as a period over which the effects of future climate change can or should be considered. Rather, for Construction, it is more important to consider recent climate trends (1971-2000 averages and extremes) and assess the likelihood and effect of severe and extreme weather events on the Project so that they may be accounted for in the design and construction processes and timelines. The historical and projected extremes in temperature, intense precipitation, or other storm events, are important considerations that must be accounted for in the design of the Project and in all other aspects of Construction.

Extreme low temperatures have the potential to reduce the ductility of construction materials used in Project components (*e.g.*, buildings, ancillary facilities), and increase susceptibility to brittle fracture. The materials specified for the Project will be in compliance with the applicable standards and codes and will maintain structural integrity at the anticipated minimum and ambient temperatures near the PDA to prevent damage to Project infrastructure that could pose a substantial health and safety risk, could delay the Construction schedule, or could not be technically or economically repaired.

Reduced visibility due to storm events could make manoeuvring of equipment difficult. However, these short delays are anticipated and can often be predicted, and allowance for them will be included in the Construction schedule. Disruption of Construction activities and delays to the Construction schedule will be avoided by scheduling tasks that require precise movements (*e.g.,* positioning steel I-beams in place with cranes) for periods when the weather conditions are favourable.

Wind storm events and severe precipitation events could potentially cause:

- reduced visibility and inability to manoeuver construction equipment;
- delays in receipt of construction materials;
- inability of construction personnel to access the site (*e.g.,* if a road were to wash out);
- damage to infrastructure; and/or
- increased structural loading.

Wind, snow and ice, for instance, have the potential to increase loadings on buildings, but building codes and standards (*e.g.,* National Building Code of Canada) include factors of safety in order to account for possible extreme conditions that could otherwise affect the structural integrity of buildings and structures. Extreme snowfall can also affect winter construction by causing a delay in construction or a delay in delivery of materials, and resulting in additional effort for snow clearing and removal. This additional effort, however, would not substantially change the Project schedule. Extreme snowfall contributing to unusual flooding during snowmelt and extreme rainfall events could potentially lead to flooding and erosion. Extreme precipitation events, however, are an expected work condition and the construction schedule allows for weather conditions typical for the region. The TSF is being designed with storm allowances for containment of largest design storm event (see Section 3.2.4.3.3). These allowances are sufficiently conservative to account for extreme weather events and to take into account any increase in the frequency and/or severity of significant storm events that might arise from climate change over the life of the Project. As such, site water management features and the early development of starter embankments for the TSF to contain water for use in Project start-up will be in place early in the Construction phase to manage any potential increased site run-off from precipitation events that could occur.

Erosion as a result of extreme precipitation and potential flooding is not anticipated to have a substantive adverse effect on Construction due to standard mitigation measures that will be implemented (*e.g.,* collection and management of site water, use of erosion and sedimentation control structures, construction methods that stabilize erodible soils as early as possible after ground has been disturbed).

The potential effects of climate on Construction will be considered in the planning and design of the Project and in the scheduling of Construction activities to limit delays, prevent damage to infrastructure and the environment, and to maximize the safety of construction staff. Compliance with design and building codes and standards are expected to account for weather extremes through built-in factors of safety to prevent undue damage to infrastructure from such events. Although it is possible for the PDA to experience extreme weather conditions during Construction, a substantive delay (*e.g.,* a delay for more than one season) is not anticipated. Further, no substantial damages to Project infrastructure are anticipated as a result of climate due to design and working standards during Construction, and the limited duration of Construction. Therefore, the effects of climate are not expected to adversely affect Construction of the Project in a manner that cannot be planned for or accommodated through design and other mitigation and adaptive management strategies. As a result, the effects of the environment on Project Construction are expected to be not significant.

8.16.6.1.2.2 Operation Phase, and Decommissioning, Reclamation and Closure Phase

A wide range of climate effects during Operation, and eventual Decommissioning, Reclamation and Closure phase, must be considered in the design and execution of the Project. For simplicity, the Decommissioning, Reclamation and Closure phase is considered along with the Operation phase as it will occur in the relatively distant future, and will be susceptible to future predicted changes in local, regional and global climate, should these occur. Forecasted changes in climate may affect Operation and Decommissioning, Reclamation and Closure in both positive and negative ways, and may vary from nominal to extreme effects. Climate changes that could potentially have residual effects on the Project include:

- increased frequency and magnitude of heavy precipitation events;
- increased frequency of extreme storms accompanied by heavy and/or freezing precipitation, thunderstorms, and strong winds; and
- increased incidence of flooding and erosion.

Each of these effects must be considered in terms of how they may adversely affect the Project if they are not planned, engineered, and designed to account for such effects. Such effects could cause:

- reduced visibility and inability to manoeuver operation equipment;
- delays in shipment of materials, supplies and/or products;
- changes to the ability of workers to access the site (*e.g.,* if a road were to wash out);
- damage to infrastructure;
- increased structural loading; and/or
- loss of electrical power resulting in potential loss of production.

As such, it is important that the predicted effects of climate change on the Project be carefully taken into account in the planning, design, and construction activities; the selection of materials to be used; and the operating plans for the Project to ensure the long-term viability and sustainability of the Project.

The PDA could experience heavy rain, snowfall and/or freezing rain events that are capable of, for example, delaying the shipment of materials, causing an interruption of services such as electrical power, or water supply for extended periods of time, or increasing structural loading on the Project components. As described above, environmental stressors potentially associated with climate change and severe weather would be more than adequately addressed by engineering design to comply with building codes and standards that incorporate factors of safety to account for these changes, and careful materials selection for Project-related infrastructure. The National Building Code of Canada (2010, Volume 2, Appendix C, Division B) provides for factors of safety to account for possible extreme weather (including allowances for future increased frequency and/or severity of these storms that could arise from climate change), and will form the basis of the design and construction of the Project-related buildings and structures. The TSF will be constructed to meet the Dam Safety Guidelines (Canadian

Dam Association 2007) of the Canadian Dam Association and with sufficient capacity and freeboard to store the probable maximum precipitation at all times during Operation and into Post-Closure (see Section 3.4.2.3.3). Many of the major structures, such as the TSF, will be constructed in stages throughout the Project life; the design criteria will be re-assessed prior to construction of each new stage, and this will provide an opportunity to ensure that any observed or predicted changes in the environmental are accounted for in the design. As a result, structures will be designed such that they will be able to withstand extremes of temperature, wind, rain, snow, and ice events through the life of the Project and into Post-Closure (as applicable). The structures and foundations will be designed to withstand these weather-related factors and loads, in consideration of future climate changes, and to be in compliance with applicable codes and standards. Should any observed future effects of climate change threaten to cause an undesirable effect on the Project itself or on Operation carried out as part of it, Northcliff will actively manage and adapt to these situations to prevent undue damage to infrastructure or the carrying out of normal operations.

Erosion as a result of extreme precipitation and potential flooding will occur but is not anticipated to have a significant adverse effect on the Project during the Operation or Decommissioning, Reclamation and Closure phases due to planned mitigation (*e.g.,* robust site water management structures). Following construction, exposed soils will be stabilized, roadways will use suitable gravel bases and sub-bases to prevent erosion, and exposed areas will be vegetated where possible to prevent surface erosion. The planned implementation of the EPP as part of the ESMS mitigates the risk of erosion, and thus an adverse effect of erosion is not expected.

During electrical storms, fault currents (defined as a current that is several times larger in magnitude than the current that normally flows) may result from a lightning strike and could result in danger to personnel and damage to infrastructure, such as pipelines and coatings. These types of adverse effects can occur where a pipeline or other infrastructure is close to the grounding facilities of electrical transmission line structures, sub-stations, generating stations, and other facilities that have high fault current-carrying grounding networks. Project infrastructure, including pipelines and electrical transmission lines for the Project, will be built to construction standards in order to minimize effects of the environment on the Project, including fault currents, and suitably distant from transmission infrastructure to minimize these types of effects. The potential for adverse effects of the environment on the Project will be determined by the Design Team and subsequently mitigated by design and adherence to codes and standards. Similarly, lightning strikes can also result in power outages that may cause temporary delays in production within the processing facilities and other infrastructure. Contingency plans, including emergency back-up power for necessary operations, will be in place to manage temporary power outages. A lightning strike could ignite a fire—forest fires are discussed below and as an accidental event in Section 8.17.

In summary, potential effects of climate and climate change on the Project during the Operation and Decommissioning, Reclamation and Closure phases will be considered and incorporated in the planning and design of Project infrastructure to minimize the potential for long-term damage to infrastructure, taking into account the existing climate conditions and the reasonably foreseeable future climate conditions. Inspection and maintenance programs will prevent the deterioration of the infrastructure and will help to maintain it in compliance with applicable building codes. As the Project advances through its stages of Operation and ultimate Decommissioning, Reclamation and Closure, any observed effects of climate change that may occur will be incorporated in the active management and operation of the Project, and modifications to infrastructure or operations through an adaptive management approach to prevent an undue effect of the environment on the Project that could adversely affect operations, damage infrastructure, cause Project delays, or otherwise adversely affect the normal course of Operation at the facilities. Although it is likely that western New Brunswick will experience extreme weather conditions during the life of the Project into Closure and Post-Closure, the likely adverse effects on the Project during these activities will have been taken into consideration in the planning and design of the Project (or managed adaptively as appropriate as information regarding climate change evolves) such that substantive damage to the Project or interruption to the Project schedule are not anticipated.

8.16.6.2 Effects of Seismic Activity on the Project

Though the Project lies within one of five seismic zones in southeastern Canada, the level of historical seismic activity near the PDA is low. Other areas of the province (the Passamaquoddy Bay region, the Miramichi region, and the Moncton region) have historically experienced relatively higher levels of seismic activity, but these are sufficiently distant to the Project that the risk that a major seismic event in these areas could adversely affect the Project in a significant way is low. Though past occurrence of seismic activity in an area is not necessarily an indicator that a significant seismic event could not occur in the future, the likelihood of a major seismic event in the immediate vicinity of the Project that could cause major Project damage or interrupt operations during any phase is low.

The Project and related facilities and infrastructure will be designed to the applicable standard in consideration of the maximum credible earthquake magnitude for the region. The National Building Code of Canada provides for sufficient factors of safety to account for seismic activity in active seismic zones in Canada, and will form the basis of the design and construction of the Project-related buildings and structures. As such, the Project and related facilities and infrastructure will be designed to account for a one-in-2,500-year seismic event. Furthermore, the TSF will be constructed to meet the guidelines of the Canadian Dam Association for a one-in-5,000-year seismic event, which are also developed to withstand reasonably probable seismic activity (see Section 3.2.4.3.3). The intent of these and other design standards is to maintain the integrity of the facilities based on the level of risk for an earthquake in the area of a magnitude up to the maximum credible earthquake. Therefore, seismicity is not considered to have the potential to substantively damage project infrastructure or components during all phases of the Project, due to planned design mitigation and the application of the National Building Code of Canada and other applicable guidelines.

8.16.6.3 Effects of Forest Fires on the Project

New Brunswick has a forest fire control program in place to identify and control fires, minimizing the potential magnitude and extent of any forest fire, and their potential consequent effects on the Project during any phase. The proposed safety and security programs for the Project are capable of rapid detection and response to any forest fire threat. A cleared buffer will be maintained around Project infrastructure, where feasible, that would reduce the potential for a fire to affect the structures (which given the nature of the materials they contain are inherently fire resistant). Firefighting capabilities (including appropriate equipment) on-site will be at a high level of training and readiness. The safety and security programs will be in place in conjunction with facility, community, and provincial emergency response crews to provide for rapid detection and response to any fire threat. This includes fires that could start within the facility perimeter as well as fires approaching from outside the facility (*i.e.,* forest fires).

In the event that a forest fire did occur in close proximity of the Project, while Project-related infrastructure would not likely to be substantively affected by the fire, there is potential risk of contact with fuel storage tanks and the explosives storage facility, thereby potentially creating a risk of fire or explosion with these products which are by their nature highly flammable and/or explosive. As detailed in Chapter 3 and in the ESMS, however, emergency response capability, emergency response plans, and fire trained individuals and response equipment is planned in readiness for, and in response to, such accidental events. The potential environmental effects of Project-caused fires are assessed in Section 8.17.

With respect to the effects of forest fires on the Project, the facility structures will be constructed primarily of concrete and steel, which are not typically affected by fire, and the majority of materials handled (*e.g.*, ore, waste rock, tailings, concentrate, APT) are not flammable. If a forest fire were to occur in direct proximity to the Project, emergency measures would be in place to quickly control and extinguish the flames prior to contact with Project components. In addition, the cleared safety buffer zone established around Project components further decreases the likelihood of a forest or brush fire causing substantive damage to the Project.

8.16.7 Determination of Significance

The Project has been designed and will be carried out to withstand environmental conditions by applying good engineering principles and practices, and by following various codes and standards from the National Building Code of Canada and other sources. There are no environmental components that, at any time during the Project, are anticipated to have the potential to result in a substantial change to the Project schedule, a long-term interruption in service, damage to Project infrastructure causing a significant environmental effect or an increased safety risk, or damage to Project infrastructure requiring repairs that cannot be technically or economically implemented. Northcliff will keep apprised of changing information regarding climate change and design and operations will be managed adaptively to ensure that the effects of the environment on the Project will be mitigated.

Northcliff will adopt an adaptive management approach to its operations throughout the life of the Project to monitor any observed effects of climate change, and adapt the Project infrastructure or operations as necessary, so as to prevent a significant environmental effect of the Project. Accordingly, the effects of the environment on the Project, including severe weather, climate change, seismicity, fires, and other environmental forces during all phases of the Project are rated not significant.

8.16.8 Follow-up or Monitoring

No follow-up or monitoring is recommended for Effects of the Environment on the Project.