Chapter 21.0: Effects of the Environment on the Project

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21.0 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. These effects may arise due to forces of nature associated mainly with weather, climate, climate change, seismic activity or forest fires. Potential effects of the environment on a project are a function of project or infrastructure design in the context of its receiving environment. These effects may arise from physical conditions, land forms, and site characteristics or other attributes of the environment that 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 addressed through engineering design and industry standards. Typical engineering design involves the consideration of environmental effects and loadings or stresses (from the environment) on a project. 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 a considerable margin of safety so that a project is designed to be safe and reliable throughout its lifetime. Further to this, Greenstone Gold Mines GP Inc. (GGM) is committed to an adaptive management approach throughout the life of the Project to monitor for observed effects of the environment, and adapt the Project infrastructure, operation and maintenance activities, and closure as necessary.

For the Project, long-term environmental management and Project longevity are inherent considerations in the standard management practices of the design and associated Project risk management. Furthermore, mitigation strategies for reducing the likelihood of effects on the Project are inherent in the planning process being conducted, the application of engineering design codes and standards, construction practices, and monitoring.

21.1 INFLUENCE OF CONSULTATION AND CONSIDERATION OF ABORIGINAL INFORMATION

Consultation has been ongoing prior to and throughout the environmental assessment (EA) process, and will continue with government agencies, local Aboriginal communities, and stakeholders through the life of the Project. Chapter 3.0 provides more detail on the consultation process covering open houses, site visits, targeted meetings, newsletters, questionnaires, presentations, and capacity funding for technical reviews and community-based studies among other areas. The Record of Consultation (Appendix C) includes detailed comments received during the development of the Final Environmental Impact Statement / Environmental Assessment (Final EIS/EA).
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Effects of Flooding from Kenogamisis Lake on the Project

The Ministry of Natural Resources and Forestry (MNRF) requested the inclusion of detailed flood elevations for Kenogamisis Lake and the consideration of effects to the Project as a result of flooding from Kenogamisis Lake.

In response, the effects of the environment on the Project assessment was updated to include a discussion specific to water levels of Kenogamisis Lake (Section 21.3.1.4). The flood elevation of Kenogamisis Lake is an elevation where inundation would only be expected every 1:100 years. Since the Kenogamisis Lake Dam controls water levels in Kenogamisis Lake and the dam has an Inflow Design Flood of the 1:100 year storm at water level 330.35 m amsl, it is assumed that the appropriate flood elevation for Kenogamisis Lake would be 330.35 m amsl. The flood elevation differs from the Normal High Water Mark, defined as the line delineating a change in shoreline vegetation resulting from routine inundation. A Normal High Water Mark of 330.00 m amsl was conservatively selected based on water level monitoring on Kenogamisis Lake during the 2006-2016 period.

As described in Section 21.3.3 and in the “Hardrock Project - Water Management and Monitoring Plan” (WMMP; Appendix M1), Project water management features have been designed to convey, store and withstand flooding events using two sets of criteria: runoff inflow conveyance and storage containment and flood control and passage.

Considering the potential for flood events from Kenogamisis Lake have been incorporated into the planning and design of Project components, substantive effects of the environment on the Project arising from flooding are not anticipated.

Effects of Climate Change on the Project

Aboriginal communities requested additional information regarding the interaction between climate change and several aspects of the Project, including:

- the air quality effects assessment
- water balance, assimilative capacity, contact water collection system, watercourse crossings and realignment designs and closure activities associated with the tailings management facility (TMF) and waste rock storage areas (WRSAs).

Long Lake #58 First Nation requested additional information to explain why climate change was not included as an indicator in the Goldfield Creek diversion alternatives assessment.

The Ministry of the Environment and Climate Change (MOECC) requested an assessment of the effects of climate change on the Project be conducted and adaptation planning strategies be developed.
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The climate change indicator under atmospheric environment is focused on greenhouse gas emissions and is discussed in Chapter 7.0 (atmospheric environment VC). Considerations related to changes in surface water quantity and flow were assessed in Chapter 10.0 (surface water VC).

Specifically regarding the design of the Goldfield Creek diversion channel, the potential change in the recurrence interval for bankfull or dominant flow is critical in channel design, whereas the Regulatory flood will be used to design the floodway channel/floodplain where appropriate. The significance criteria for change in surface water quantity considers high flow changes such that the existing floodlines are maintained or the floodline is maintained on third party riparian properties. As the diversion creates a new channel and connects with the existing channel of the Southwest Arm Tributary it is expected to create new flood limits; however, GGM will acquire surface rights to these areas and third party riparian properties are not expected to be affected.

The effects of climate change on the Project are assessed in Section 21.4 and includes consideration of:

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

The potential effects of climate change on the Project during the construction, operation, and closure phases have been considered and incorporated in the planning and design of Project infrastructure. Mitigation measures will include applying standard management and design practices to account for weather extremes, including considering changes to shorter recurrence interval storms to account for climate change. Substantive effects of the environment on the Project arising from climate change are not anticipated.

GGM did not receive specific additional information on effects of the environment on the Project through receipt of Project-specific traditional knowledge and traditional land and resource use information.
21.2 SCOPE OF ASSESSMENT

The environmental attributes that are considered to have a potential effect on the Project are based on the Environmental Impact Statement (EIS) Guidelines (Appendix A1), the approved Terms of Reference (ToR) (Appendix A2), and consultation with agencies, Aboriginal communities, and stakeholders, a review of known past and existing conditions, and knowledge gained through projections of potential future conditions (e.g., potential effects of climate change). Based on these sources, the environmental attributes selected for consideration are:

- climate
- weather and weather variables such as:
  - air temperature and precipitation
  - fog and visibility
  - winds
  - extreme weather events
- climate change
- seismic events and landslides
- forest fires from causes other than the Project.

The environmental attributes listed above have the potential to interact with Project components and activities in several ways, including:

- reduced visibility and inability to manoeuvre construction and operation equipment
- delays in receipt of materials and supplies (e.g., construction materials, reagents) and in delivering products
- changes to the ability of workers to access the site (e.g., if a road were to wash out)
- increased structural loading
- loss of electrical power resulting in potential loss of production
- delays to Project schedule
- damage to infrastructure.

Damaged infrastructure can increase the risk of subsequent effects on the environment when the damage compromises the structural integrity and/or intended function of Project components. Pathways for these subsequent environmental effects may include hazardous material release and/or loss of containment, uncontrolled explosion, and Project-related fire. The assessment of environmental effects related to these pathways is addressed as potential accidents or malfunctions in Chapter 22.0.
The spatial boundaries for the assessment of effects of the environment on the Project are confined to the Project development area (PDA), as the focus of this chapter is with potential effects of the environment solely on Project infrastructure.

The temporal boundaries for the assessment of effects of the environment on the Project are defined as the phases of construction, operation, and closure of the Project.

A significant adverse residual effect of the environment on the Project includes:

- a substantial change to the Project construction schedule (e.g., a delay resulting in the construction period being extended by one season)
- a substantial change to the Project operation schedule (e.g., an interruption in servicing such that production targets cannot be met)
- damage to the Project infrastructure resulting in increased safety risk
- damage to the Project infrastructure resulting in repairs that could not be technically or economically implemented.

21.3 CLIMATE

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.

The current climate conditions are generally described by the most recent 30-year period (1981 to 2010; EC 2015a) for which Environment and Climate Change Canada has developed statistical summaries, referred to as climate normals. The closest weather station to the Project with available historical data is the Greenstone Regional Airport station (also referred to as the Geraldton airport), located approximately 14 kilometres (km) north of the Project. Data from this station forms the basis of the assessment of climate for this Final EIS/EA. For the purpose of this assessment, Ontario has been divided into three subregions (NRCan 2014): northern, central, and southern Ontario, with the Project located in the central subregion (Figure 21-1).
Client/Project
Greenstone Gold Mines GP Inc (GGM)
Hardrock Project

Figure No.
21-1

Title
Climate Subregions of Ontario

Notes
1. Natural Resources Canada (2014)
21.3.1 Existing Conditions

21.3.1.1 Air Temperature and Precipitation

The average monthly temperature in Geraldton has ranged between -18.6°C (January) and 17.2°C (July) (Table 21-1). Extreme maximum temperature was 37°C (June 1995) and the extreme minimum temperature was -50.2°C (January 1996). On average, there have been four days per year with temperature greater than 30°C, while days lower than -30°C occur on average 25.1 days per year (EC 2015a).

Geraldton typically gets twice the precipitation in the summer months (June, July and August) than in the winter months (December, January and February). Geraldton averaged 764.6 mm of precipitation per year, of which, approximately 556.1 mm fell as rain and 242.6 cm as snow. Extreme daily precipitation at Geraldton ranged from 18.8 mm (February 2001) to 124.6 mm (September 1985). On average, there have been 3.8 days each year with rainfall greater than 25 mm, and snowfalls greater than 25 cm occur on average 0.13 days (approximately 3.12 hours) per year (EC 2015a).

21.3.1.2 Fog and Visibility

Fog is defined as a ground-level cloud and consists of tiny water droplets suspended in the air and reduced visibility to less than one km (EC 2014a). Summer fog is more common across northern Ontario than in the south, where the foggiest season is the fall and winter. Fog tends to form during the early morning hours with light winds and nighttime cooling of the land. Later in the season, steam fog forms over lakes blanketed by cold dry air (Nav Canada 2002). This is consistent with the measured increase in the hours of reduced visibility (less than one km) in fall and winter relative to the summer months (EC 2015a) (Table 21-1). The Greenstone Regional Airport has experienced, on average, 99.6 hours (4.15 days) per year when visibility is less than 1 km.

21.3.1.3 Winds

Monthly average wind speeds measured at the Greenstone Regional Airport range from 10.3 to 12.2 km/hr, with an annual average wind speed of 11.2 km/hr (Figure 21-2)\(^1\). From May to October, the dominant wind direction is from the south, with the exception of July and August when the dominant wind direction is from the west. This is similar to the wind direction predominantly blowing from the west from November to April. Maximum hourly wind speeds, range from 44 km/hr to 59 km/hr. Maximum gusts for the same period range from 70 km/hr to 107 km/hr (EC 2015a).

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\(^1\) Wind directions shown in Figure 21-2 indicate the direction from which the wind is blowing.
Predominant Monthly Wind Data (1981 to 2010) at Greenstone Regional Airport, Ontario

Environment Canada (2015a)

Notes
1. Environment Canada (2015a)
### Table 21-1: Air Temperature and Precipitation Climate Normals, Greenstone Regional Airport (1981-2010)

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature (°C)</th>
<th>Precipitation (mm)</th>
<th>Mean No. of Days With</th>
<th>Snow (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
<td>Avg</td>
<td>Max (Year)</td>
</tr>
<tr>
<td>JAN</td>
<td>-12.1</td>
<td>-25.1</td>
<td>-18.6</td>
<td>5.9 (1999)</td>
</tr>
<tr>
<td>FEB</td>
<td>-8.4</td>
<td>-23.1</td>
<td>-15.8</td>
<td>9.5 (1991)</td>
</tr>
<tr>
<td>MAR</td>
<td>-1.4</td>
<td>-16.4</td>
<td>-8.9</td>
<td>17.4 (2010)</td>
</tr>
<tr>
<td>APR</td>
<td>7.4</td>
<td>-6.2</td>
<td>0.6</td>
<td>25.8 (1999)</td>
</tr>
<tr>
<td>MAY</td>
<td>15.4</td>
<td>1.5</td>
<td>8.5</td>
<td>32.8 (2010)</td>
</tr>
<tr>
<td>JUN</td>
<td>21.0</td>
<td>7.6</td>
<td>14.3</td>
<td>37.0 (1995)</td>
</tr>
<tr>
<td>JUL</td>
<td>23.5</td>
<td>10.7</td>
<td>17.2</td>
<td>35.0 (2006)</td>
</tr>
<tr>
<td>AUG</td>
<td>22.3</td>
<td>9.7</td>
<td>16.0</td>
<td>33.7 (2005)</td>
</tr>
<tr>
<td>SEP</td>
<td>16.0</td>
<td>4.9</td>
<td>10.5</td>
<td>32.7 (2002)</td>
</tr>
<tr>
<td>OCT</td>
<td>7.6</td>
<td>-1.1</td>
<td>3.3</td>
<td>24.8 (2000)</td>
</tr>
<tr>
<td>NOV</td>
<td>-1.0</td>
<td>-9.7</td>
<td>-5.4</td>
<td>17.7 (2008)</td>
</tr>
<tr>
<td>DEC</td>
<td>-8.9</td>
<td>-19.5</td>
<td>-14.2</td>
<td>10.8 (1982)</td>
</tr>
<tr>
<td>Annual</td>
<td>-1.0</td>
<td>-9.7</td>
<td>-5.4</td>
<td>17.7 (2008)</td>
</tr>
</tbody>
</table>

SOURCE: EC (2015a)

NOTE:
The Greenstone Regional Airport is referred to as the Geraldton Airport in EC 2015a.

### Table 21-2: Hours with Visibility Climate Normals, Greenstone Regional Airport (1981-2010)

<table>
<thead>
<tr>
<th>Visibility (hours with)</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 km</td>
<td>8.6</td>
<td>6.6</td>
<td>10.3</td>
<td>8.1</td>
<td>3.6</td>
<td>3.3</td>
<td>4.2</td>
<td>5.0</td>
<td>7.5</td>
<td>14.6</td>
<td>16.7</td>
<td>11.1</td>
<td>99.6</td>
</tr>
<tr>
<td>1 to 9 km</td>
<td>115.4</td>
<td>83.3</td>
<td>89.3</td>
<td>70.5</td>
<td>64.9</td>
<td>47.3</td>
<td>46.1</td>
<td>57.0</td>
<td>80.1</td>
<td>102.3</td>
<td>135.8</td>
<td>150.5</td>
<td>1,042.3</td>
</tr>
<tr>
<td>&gt; 9 km</td>
<td>620.0</td>
<td>587.6</td>
<td>644.4</td>
<td>641.5</td>
<td>675.5</td>
<td>669.5</td>
<td>693.7</td>
<td>682.1</td>
<td>632.4</td>
<td>627.1</td>
<td>567.5</td>
<td>582.5</td>
<td>7,623.6</td>
</tr>
</tbody>
</table>

SOURCE: EC (2015a)

NOTE:
The Greenstone Regional Airport is referred to as the Geraldton Airport in EC 2015a.
21.3.1.4 Kenogamisis Lake Water Levels

The water level in Kenogamisis Lake is controlled by the operation of the Kenogamisis Lake Dam at the lake outlet. The dam is owned and operated by MNRF. The operating strategy for the dam is outlined in the Aguasabon River System Water Management Plan (OPG 2013). The dam’s normal operating water level ranges between 329.32 m amsl and 329.70 m amsl and is controlled manually at a stop-log weir by the dam operator, the MNRF. During winter drawdown (February 1 to May 31), the water levels may be allowed to drop to 329.20 m amsl without being out of compliance. During spring freshet (April 15 to June 30), the water may be allowed to reach 329.85 m amsl without being out of compliance. During these winter and spring cautionary conditions, further dam management actions are required by the dam operator to avoid out of compliance conditions.

The Water Survey of Canada operates a water level monitoring station on Kenogamisis Lake at the Highway 11 bridge, immediately east of MacLeod Provincial Park. The monitoring station (Station ID 04JD006) has been in operation since 2006, with water levels ranging from 329.23 m amsl to 330.00 m amsl with a mean of 329.52 m amsl. The upper setback zone for the high water level was exceeded twice during the 10 year record (2006-2016), on July 7, 2008 when water levels reached 329.90 m amsl, just above the upper setback compliance level of 329.85 m amsl and on June 7, 2014 when water levels reached 330.00 m amsl. The Project conservatively defined the Normal High Water Mark at 330.00 m amsl. The Normal High Water Mark is defined in the Natural Heritage Reference Manual (MNR 2010) as the line delineating where fish habitat is found within large lakes and rivers and in turn the line from which development setbacks are considered. For inland lakes, the Normal High Water Mark refers to those parts of the waterbody bed and banks that are frequently flooded by water so as to leave a mark on the land and where the natural vegetation changes from predominately aquatic vegetation to terrestrial vegetation (excepting water-tolerant species). Thus, the Normal High Water Mark is expected to observe water levels relatively frequently such that routine inundation to that level results in a change in shoreline vegetation.

MNRF has provided background information regarding flood elevations for Kenogamisis Lake. A Dam Safety Review (DSR) was completed for the Kenogamisis Lake Dam by Marshall Macklin Monaghan in 2014. The MNRF indicated that the DSR confirmed the original work of Acres International that established the 1:100 year flood as the Inflow Design Flood for the dam and determined an associated high water level of 330.35 m amsl. Since the Kenogamisis Lake Dam controls water levels in Kenogamisis Lake and the dam has an Inflow Design Flood of the 1:100 year storm at water level 330.35 m amsl, it is assumed that the appropriate flood elevation for Kenogamisis Lake would be 330.35 m amsl. The flood elevation of Kenogamisis Lake is an elevation where inundation would only be expected every 1:100 years and should not be confused with the Normal High Water Mark, which is a lower elevation selected at 330.00 m amsl which would experience more frequent inundation.
21.3.1.5 Extreme Weather Events

An extreme weather event is defined as “an event that is rare within its statistical reference distribution at a particular place. Definitions of ‘rare’ vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called ‘extreme weather’ may vary from place to place” (IPCC 2007b). Extreme weather events considered here include:

- extreme precipitation and storms
- floods
- hurricanes and tornados
- heat waves and droughts.

Most common extreme weather events in Ontario are major storms that can affect most parts of Ontario at least once or twice a year, which tend to bring high winds, rain, freezing rain or snow. Also common are rapid spring snowmelt and ice jams, which can lead to flooding, especially in northern Ontario (Chiotti and Lavender 2008). Extreme precipitation and storms can occur in Ontario throughout the year but tend to be more common and severe during the winter. Winter storms can bring high winds and a combination of snow and rain. Occasionally, periods of snow coincide with strong winds, bringing about blizzards or whiteout conditions (Nav Canada 2002).

In the spring and summer, triggered by the passage of cold fronts, thunderstorms accompanied by extreme precipitation and lightning can occur across Ontario. Thunderstorms, however, are more prevalent in the south and southwest, relative to other parts of the province. The number of days with lightning varies greatly across the province with the highest frequency (34 days per year) in southwestern Ontario and 15 days to 20 days per year in northern Ontario (Phillips 1991). Some of the worst thunderstorms, mainly those in the southwest, may be accompanied by tornados (Nav Canada 2002). In June 2008, Thunder Bay and the surrounding area received a series of thunderstorms that led to between 70 mm and 80 mm of rain. June’s total rainfall in Thunder Bay amounted to a record 194.4 mm; normal is 85.7 mm. Geraldton also had a new June record of 148 mm in 2008 compared to a normal of 86 mm (EC 2013a).

Ontario also experiences hurricanes, which are tropical cyclones with maximum sustained surface winds of at least 118 km/hr (EC 2014a). According to Emergency Management Ontario (EMO 2012), hurricanes are accompanied by high winds, extreme rainfall, storm surges, thunderstorms and tornados. Due to its location, southern Ontario has a higher risk of hurricanes and post-tropical storms, relative to other regions in Ontario. A hurricane is a large storm system that could affect all of southern Ontario and extend into the lower part of northern Ontario (EMO 2012). However, due to Ontario’s geographic position, hurricanes typically have decreased to tropical storm strength or lower by the time they reach Ontario and are often downgraded into either a tropical storm or a post-tropical storm status. However, post-tropical
storms can bring very heavy rainfall. The only recorded tropical storm that brought sustained hurricane strength winds to Ontario, occurred in 1954 with Hurricane Hazel; it resulted in southern Ontario experiencing extreme precipitation, storm surges, flooding and strong winds (EMO 2012).

Another storm, listed along with Hurricane Hazel as one of the key flooding events in Ontario’s history, is the Timmins Storm. During this event in August 1961, the town of Timmins experienced extremely heavy rainfall which lead to high levels of runoff from torrential rain plus runoff from streets and storm sewers that lead to the town creek rapidly reaching flood stage. Although the rain (193 mm) occurred over a period of approximately 12 hours, with a downpour that lasted about two hours, it damaged roads, houses, foundations, personal property, and five lives were lost (EC 2010).

Ontario experiences an average of 12 tornadoes a year, usually between May and September (GO 2014a). As with other extreme weather events, these also tend to be most frequent in the southern portion of the province. Ontario tornadoes listed on the top weather events of the 20th century, include one in Windsor (April 1974) that touched down in several locations and killed eight people, as well as a series of tornadoes that struck several Ontario communities (Barrie, Grand Valley, Orangeville and Tottenham (May 1985)) that injured hundreds of people and caused damage to over 1,000 buildings and killed 12 people (EC 2013b). Most recently, in June 2014, a tornado moved through the community of Laurel Station to the northwest of Orangeville, with peak winds between 135 and 175 km/hr, which were sufficiently strong to move a vehicle by 3 m, un-roof homes and down trees (EC 2015b).

Heat waves and drought have also been an issue in the south sub-region of Ontario, but have not been a major issue in the north and central subregions historically. This is typically due to the south subregion experiencing warmer temperatures and higher humidity, relative to other regions. This is due to several factors, including the urban heat-island effects associated with more densely populated cities in the south, relative to the rural areas in central and northern Ontario (Chiotti and Lavender 2008).

Ontario has experienced other severe weather events, including the 1998 ice storm, which remains the costliest natural disaster in Canadian history. In that storm, eastern Ontario received approximately 80 mm of freezing rain, double the amount received in any previous ice storm and left 250,000 people in Ontario without power, some for up to 24 days (Chiotti and Lavender 2008).
21.3.2 Effects on the Project

The environmental attributes of climate, as earlier defined, are important considerations in the construction, operation, and closure phases. Extreme temperatures and severe precipitation, fog and visibility, winds and extreme weather events could potentially cause:

- reduced visibility and inability to manoeuver equipment
- delays in construction/operation activities and delays in delivery of material
- inability of personnel to access the site (e.g., if a road were to wash out)
- damage to infrastructure
- increased structural loading.

During 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.

Snow and ice have the potential to increase loadings on buildings, but building codes and standards (e.g., National Building Code of Canada, Ontario Building Code) include factors of safety to account for possible extreme conditions that could 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, is anticipated and would not substantially change the Project schedule.

The development and persistence of ice in creeks and lakes during the winter months could also result in the reduction of process water availability. During winter, ice will form over the free water surface of the TMF and temporarily sequester the frozen water volume from use as mill reclaim water. The water balance accounts for temporary loss of available reclaim water during winter due to ice effects and incorporates the use of water from the dewatering of the historical underground workings and open pit which is less susceptible to freezing conditions.

Extreme precipitation from snowmelt and rainfall events could potentially lead to flooding and erosion. Flooding and erosion could in turn lead to the release of sediment and contact water in runoff and related environmental effects or a possible failure of Project infrastructure. These activities and associated ensuing events are considered accidental releases, and are discussed in Chapter 22.0 (potential accidents or malfunctions).

During operation or closure phases, the PDA could experience heavy rain, snowfall and freezing rain events that are capable of, for example, delaying the transport of materials, causing an interruption of services such as electrical power, or mill reclaim water supply for extended periods of time, or increasing structural loading on the Project components.
Reduced visibility due to fog could make maneuvering of equipment difficult and result in possible delays in the receipt of materials or the inability of personnel to access the Project in the early part of the day. However, these short delays are anticipated and can be reasonably accommodated. Disruption of Project activities can be avoided by scheduling tasks that require precise movements (e.g., positioning equipment/supplies in place with cranes), or delaying the transport of materials to arrive, for periods when the fog has lifted.

Wind storm events could potentially cause reduced visibility (due to blowing snow or dust) and interfere with maneuvering of equipment or transporting materials or staff movements. Wind also has the potential to increase loadings on buildings and cause possible damage to building cladding and the infrastructure. During electrical storms, for example, fault currents (defined as an electric current that flows from one conductor to ground or to another conductor owing to an abnormal connection (including an arc) between the two conductors (IESO 2010)) may arise in electrical systems during a lightning strike. This could result in danger to personnel and damage to infrastructure, such as pipelines and coatings. These types of effects can occur where a pipeline or other infrastructure is close to the grounding facilities of electrical transmission line structures, substations, generating stations, and other facilities that have high fault current-carrying grounding networks. A lightning strike could also ignite a fire (see Chapter 22.0 [potential accidents or malfunctions] for a discussion of fire as an accidental event, and Section 21.5 for a discussion of forest fire).

Heat waves and drought could reduce water levels throughout the surrounding watershed (Chiotti and Lavender 2008) and reduce the amount of water requiring management for the Project. Specifically, extended drought conditions could reduce the amount of water available to meet mill reclaim demand from the TMF and freshwater availability from Kenogamisis Lake. This reduction in water availability in the TMF can be offset by increased dewatering of the historical underground workings and open pit and will offset the amount of effluent requiring treatment and discharge to Kenogamisis Lake. The water balance accounts for the potential for such extended drought conditions by providing flexibility in the sources of water available to meet Project requirements.

**21.3.3 Mitigation and Residual Effects**

To address the potential effects of climate (air temperature, precipitation, fog and visibility, winds and extreme weather events) on the Project, pro-active design, materials selection, planning, and maintenance are required in consideration of the potential normal and extreme conditions that might be encountered throughout the life of the Project.
The potential effects of climate on the Project are addressed as a point of safety, and a matter of standard engineering practice, through the design and materials to be chosen for construction of the Project 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). Engineering standards will be applied to Project design such that potential concerns are addressed up front and the potential for significant adverse effects of the environment on the Project is reduced.

Engineering standards include meeting 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 National Fire Code of Canada, the Canadian Dam Association Guidelines, and other design codes and standards for wind, snowfall, extreme precipitation, and other weather variables associated with climate change. These standards and codes provide factors of safety regarding environmental loading (e.g., snow load, high winds), and Project specific activities and events. Design requirements address issues associated with environmental extremes, such as:

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

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

- critical structures, piping, tanks and steel selection to prevent brittle fracture at low ambient temperatures
- electrical grounding structures for lightning protection
- maximum motor ambient temperature
- ice and freeze protection.
Compliance with these and other codes will reduce the likelihood of adverse effects of the environment on the Project 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 be anticipated. Other mitigation measures implemented as part of the planning process will reduce the potential for adverse effects of the environment on the Project to such an extent that they are not significant. The following are some of those measures:

- Adherence to engineering design codes and standards (e.g., pipelines and distribution/transmission lines will be built to codes and standards that reduce the likelihood and effects of fault currents during lightning strikes).
- Use of good engineering judgment and careful construction practices.
- Care in selection of appropriate construction materials and equipment.
- Careful planning of operation activities such as TMF embankment raises, receipt of materials and supplies, and product deliveries.
- Implementation of proactive monitoring and inspections (e.g., TMF dam inspections).
- Implementation of a maintenance and safety management program.
- Contingency plans, including emergency back-up power for necessary operations, will be in place to manage delays such as possible temporary power outages.

Although it is possible for the PDA to experience extreme weather conditions during the life of the Project, a substantive delay (e.g., a construction delay for more than one season, or a long-term interruption in mining activities such that production targets cannot be met) is not anticipated. Further, no substantial damages to Project infrastructure are anticipated as a result of climate due to design and working standards. For example, short delays are anticipated and can often be predicted, and allowance for them will be included in the construction schedule. As a result, 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 favorable. 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.

Reduced process water availability due to drought in the summer, and the development and persistence of ice in the winter, was taken into consideration during Project design and water management planning. As described in the WMMP (Appendix M1), with the exception of freshwater requirements, process water for the Project will be supplied using reclaim water from the TMF, WRSA runoff and seepage and dewatering water from historical underground workings and open pit. The TMF is capable of meeting the mill water demands during the spring and fall of each year and most of the summer and winter demands. During these periods, the deficit in reclaim supply can be provided by surface runoff in contact water collection ponds and supplemented with dewatering water from the historical underground workings, a source that is less affected by climatic conditions.
Erosion as a result of extreme precipitation and potential flooding is not anticipated to have a significant adverse effect on the Project due to the relatively flat topography of the site and standard mitigation measures that will be implemented (e.g., collection and management of contact water, use of erosion and sedimentation control structures, construction methods that stabilize erodible soils as early as possible after ground has been disturbed). Where road, pond or dam embankments may be subject to potential flooding and wave action, embankments will be hardened to resist erosion and sloped to resist instability under saturating conditions. Following construction, exposed soils will be stabilized, roadways will use appropriate gravel bases and sub-bases to prevent erosion, and exposed areas will be vegetated where possible to prevent surface erosion. The implementation of the Erosion and Sediment Control Management Plan will reduce the risk of erosion and, thus, an adverse effect of erosion is not expected. A Conceptual Erosion and Sediment Control Management Plan is provided in Appendix M5.

The regulatory storm event for projects in Northern Ontario is defined as the most critical of the 1:100 year storm event, the Timmins Storm, or a historical storm observed in the area. For the Project, the Timmins Storm event, a 12-hour storm event with 193 mm of total precipitation, is the most severe of the three and thereby controls the regulatory storm design criteria. The regulatory storm design criteria is used to define the regulatory flood event and associated flood line.

As described in the WMMP (Appendix M1), water management features have been designed to convey, store and withstand flooding events using two sets of criteria as described below and summarized in Table 21-3.

- **Runoff Inflow conveyance and storage containment:**
  - Inflow conveyance structures, including the perimeter contact water collection ditches (WRSAs, overburden storage area, ore stockpile and process plant) and TMF seepage collection ditches will be sized to convey to 1:100 year 24-hour runoff event.
  - Collection ponds associated with the conveyance structures will be designed to contain and store without release the 1:100 year 24-hour runoff event.
  - Road drainage is to be designed according to the Ministry of Transportation standards depending on road usage and bridge/culvert span.
  - The TMF reclaim pond will have the extended capacity to contain and store without release the 1:100 year 24-hour runoff event in addition to normal storage volumes. In the case of the TMF reclaim pond only, the 1:100 year 24-hour runoff event is also referred to as the Environmental Design Flood.

- **Flood Control and Passage:**
  - Contact water collection ponds associated with the process plant, WRSAs, the TMF and open pit post-closure channel/floodplain connecting the pit lake to Kenogamiss Lake will be designed to safely attenuate and pass, by way of emergency spillways, the Timmins regulatory flood event.
The TMF design is guided by requirements of the Lakes and Rivers Improvement Act and the Canadian Dam Association. The TMF will be designed to safely attenuate and pass the Probable Maximum Flood. The Probable Maximum Flood is based on a precipitation event with nearly twice the rainfall depth (360.7 mm) of the Timmins Storm (193 mm), known as the 24-hour Probable Maximum Precipitation storm event. Thus, the TMF will have an emergency spillway throughout dam development to safely pass flood waters between the 1:100 year, 24-hour runoff event and the Probable Maximum Flood.

The Goldfield Creek diversion channel/floodplain will receive emergency spillway flows from the TMF up to the Probable Maximum Flood event. As a result, the diversion channel/floodplain will be designed to convey the Probable Maximum Flood event.

<table>
<thead>
<tr>
<th>Water Management Features</th>
<th>Design Criteria</th>
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</thead>
<tbody>
<tr>
<td><strong>INFLOW CONVEYANCE AND STORAGE CONTAINMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Inflow conveyance structures (Perimeter ditches and collection ditches)</td>
<td>1:100 year, 24-hour storm</td>
</tr>
<tr>
<td>Collection ponds</td>
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<td>Roadside drainage</td>
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<td>TMF reclaim pond</td>
<td>1:100 year, 24-hour storm</td>
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<tr>
<td><strong>FLOOD CONTROL AND PASSAGE</strong></td>
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<td>Collection ponds, post-closure channel from pit lake to Kenogamisis Lake</td>
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<tr>
<td>TMF reclaim pond and emergency spillways and Goldfield Creek diversion</td>
<td>Probable Maximum Flood</td>
</tr>
</tbody>
</table>

In summary, potential effects of climate on the Project during the construction, operation, and closure phases will be considered and incorporated in the planning and design of Project components to reduce the potential for long-term damage to infrastructure, taking into account the existing 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 closure, observed effects of climate that may occur will be incorporated in the active management and operation of the Project. Appropriate modifications to infrastructure or operation will be conducted through an adaptive management approach to prevent an undue effect of the environment on the Project that could adversely affect operation, damage infrastructure, cause Project delays, or otherwise adversely affect the normal course of operation at the Project. Although it is likely that central Ontario will experience extreme weather conditions during the life of the Project, the likely adverse effects on the Project during these activities have been taken into consideration in the planning and design of the Project. Therefore, substantive effects of the environment on the Project arising from climate are not anticipated.
21.4 CLIMATE CHANGE

While climate refers to average weather conditions over a 30-year period, climate change is an acknowledged change in climate that has been documented over two or more periods, each with a minimum duration 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, external forces, or persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC 2012). The United Nations Framework Convention on Climate Change makes a distinction between climate change attributed to human activities and climate variability attributable to natural causes. It defines climate change as a change of climate directly or indirectly attributed to human activity that alters the composition of the global atmosphere, 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. It is reasonable to assess the potential effects of projected climate change on the Project over the longer term and well into post-closure of the Project. It is not fitting to consider the effects of climate change projections on construction, because it takes place over a relatively short period of time and in the immediate future. Construction activities will occur over the first three years of the Project; 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 (see Section 21.3.2). The incremental change in climate during the 15-year operation phase and 5-year active closure phase is considered in the assessment and in design of Project components, as previously described in Section 21.3.3. The potential effects on the Project during operation and into the post-closure phase will be assessed as measurable changes that may occur over this longer time period.

Technical boundaries for the prediction of effects of climate change relate to the inherent uncertainty of climate models in predicting future changes in climate parameters. Global and regional climate models can provide useful information for predicting and preparing for global and macro-level changes in climate; however, the ability of models to pinpoint location-specific changes to climate on a localized level is still relatively limited.
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21.4.1 Climate Change Predictions for Central Ontario

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 that do not take into account local climate. The Canadian Climate Change Scenarios Network (CCCSN) combined data from 24 international climate models to calculate new projections for Ontario (EPCCA 2009). This ensemble approach (multi-model means/medians) has been demonstrated to provide the best projections for climate change as the approach uses mean or median estimates from many models, thereby reducing the uncertainty associated with any individual model (CCCSN 2009; EC 2014b).

The mean monthly temperature and precipitation values were predicted for three levels of projected climate change for the period 2041-2070 in relation to the baseline period of 1961-1990. These three levels are 'low', 'moderate' and 'high', ranging from the least to most aggressive greenhouse gas emission assumptions (EC 2014b). For the purpose of this assessment, the maximum projections under the high scenario are presented, for conservatism.

Climate change predictions for Ontario include increased temperature and precipitation, changes in seasonal precipitation patterns, along with the possible increase in magnitude and frequency of extreme weather events. According to the Government of Ontario (GO 2014b), many Ontarians have already been affected by increased temperatures and extreme weather events, and the province will continue to be affected in the future if today's trends continue.

The overall mean annual maximum temperature increase projected for Ontario between years 2041 and 2070 range from 2.8°C to 4.0°C. This is consistent with the projected increase in mean annual temperature of 3.2°C for the same time period in the area of the Project. The projected increases in average summer and winter temperatures for the area of the Project are 2.9°C and 4.2°C, respectively (EC 2014b).

The overall mean change in annual average precipitation (%) projected for Ontario between years 2041 and 2070 range from 3.8% to 18% increase. This is consistent with the projected increase in annual precipitation of 8.2% for the same time period in the area of the Project. The projected increases in average winter and summer precipitation for the area of the Project are 1.7% and 16.5%, respectively (EC 2014b).

Projected changes in average temperature and precipitation certainly imply more frequent and possibly more intense extreme weather events. In fact, increased moisture in a warmer atmosphere is expected to cause an increasing frequency and severity of extreme weather events, such as severe rain, snow, drought, heat waves, wind, and ice storms (EPCCA 2009). Increased frequency of extreme weather events can, for instance, lead to flash flooding events (GO 2014b).
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 natural catastrophe losses totaled approximately $3.2 billion in 2013. By comparison, total insured losses averaged $400 million a year over a 25-year period from 1983 to 2008. Recent losses have been attributed to extreme weather events and catastrophic losses (e.g., floods in Alberta and Toronto), an increase in claims resulting from smaller weather events that result in property damage, and aging sewer infrastructure that 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 2014).

While advances in modelling science over the last decade have improved confidence in long-term projections, like modelling projections in general, 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.

21.4.2 Effects on the Project

As discussed in Section 21.3.1, 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 (1981-2010 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 (Section 21.3.3).

Further to the potential effects discussed in Section 21.3.2, forecasted changes in climate may affect operation and closure. Changes in climate that could potentially have an effect on the Project are:

- increased frequency and magnitude of severe precipitation events
- increased frequency of extreme storms accompanied by heavy and/or freezing precipitation, thunderstorms, and strong winds
- increased incidence of flooding and erosion
- increased temperatures which could lead to an increase the incidence of forest fire; this is discussed in Section 21.6.
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Each of these potential 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 (see Section 21.3.3). Similar to the effects of climate on the Project, climate change effects could cause:

- reduced visibility and inability to maneuver operation equipment
- delays in the transport 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
- 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 enhance the long-term viability and sustainability of the Project.

21.4.3 Mitigation, Adaptation, and Residual Effects

As discussed in Section 21.3.3, the Project will be designed in accordance with several standard management and engineering design practices. 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. Furthermore, 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. The same standards applied to structural loading will prevent damage to Project infrastructure that could pose a substantial health and safety risk, could delay the Project schedule, or could not be technically or economically repaired.

The MOECC has requested that design for permanent and long-term water management features consider the 1:500 return period storm to account for climate change. As described in Section 21.3.3, the high flow design criteria for permanent and long-term water management features is the regulatory storm event (the Timmins Storm) or where required by other regulatory criteria, the Probable Maximum Flood. Using the Geraldton A climate station Intensity Duration Frequency curve and extrapolating to the 1:500 year return period, 12-hour and 24-hour storms would result in a total of 100 mm and 131 mm of precipitation, respectively. As these precipitation volumes are less than that of the Timmins Storm (193 mm), designing for the Timmins Storm exceeds the 1:500 year storm design criteria recommended by MOECC to address climate change. High flow design features will include emergency spillways and downstream conveyance channels/floodplains.
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It is expected that the 1:100 year flood estimates will change as a result of climate change. If in the future the 1:100 year flood were to be more severe than the Timmins Storm, it would then define the regulatory storm design criteria. To check which criteria is likely to control the regulatory storm event in the future, an estimate was developed of the 1:100 year storm event occurring in the year 2080. The 1:100 year storm event was developed using the Computerized Intensity, Duration and Frequency Curve Climate Change tool developed by Western University and the Canada Water Network (http://www.idf-cc-uwoc.ca/). The predictive tool was set up using a climate change timeline shift from year 2015 to year 2080, climate data from the Greenstone Regional Airport climate station, the CanESM2 (Canadian Center for Climate Modelling and Analysis) model and a conservative climate change case (i.e., RCP 8.5 scenario where radiative forcing continues to, and past, the year 2100). The climate change predictive tool estimated the 12- and 24-hour, 1:100 year storm events of 97 mm and 127 mm based on a future time of 2080 and a conservative case ongoing climate change scenario. These future 1:100 year predictive climate change estimates are approximately 19% and 20% larger than the current 12- and 24-hour storm events, but are less than the Timmins Storm. Therefore, as of the year 2080, the Timmins Storm is expected to continue to control the regulatory storm design criteria and is considered a locally acceptable, long term and permanent flood control design criteria.

It is important to note that 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 Project will adopt a proactive approach to incorporate climate considerations and adaptation measures into the Project. Several publications are available to guide design engineers in this regard, including, for example, the Public Infrastructure Engineering Vulnerability Committee (PIEVC) 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, which assists 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 detailed design and construction of the Project.

In summary, potential effects of climate change on the Project during the construction, operation, and closure phases have been considered and incorporated in the planning and design of Project infrastructure. This is expected to reduce 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 infrastructure and will help to maintain it in compliance with applicable building codes. As the Project advances through its stages of operation and closure, observed effects of climate change that may occur will be incorporated in the active management and operation of the Project, and modifications will be made to the infrastructure or operation through an adaptive management approach. This approach is undertaken to prevent an undue effect of
the environment on the Project that could adversely affect operation, damage infrastructure, cause Project delays, or otherwise adversely affect the normal course of operation at the Project. It is likely that central Ontario will experience extreme weather conditions arising from climate change during the life of the Project. However, the likely adverse effects on the Project during these activities is 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. Therefore, substantive effects of the environment on the Project arising from climate change are not anticipated.

21.5 SEISMIC EVENTS AND LANDSLIDES

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 (NRCan) 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 (NRCan 2013a). In addition, landslides may potentially cause environmental damage and damage to infrastructure, and pose risks to human safety (NRCan 2013b).

21.5.1 Existing Conditions

Northern Ontario has a very low level of seismic activity (Figure 21-3). As noted by NRCan, “From 1970 to 1999 on average only one or two magnitude 2.5 or greater earthquakes have been recorded in this large area. Two magnitude 5 earthquakes have occurred in this region; one in northern Michigan in 1905, located approximately 300 km southwest of the Project; and another in northwest of Kapuskasing in 1928, located approximately 450 km west of the Project” (NRCan 2013a).

Landslides happen in all parts of Canada, even in areas without mountains. Generally, there are four areas in Canada that are susceptible to landslides:

- steep slopes in mountainous terrain of western Canada (green shading) (Figure 21-4)
- areas of fine-grained soil in regions once covered by glacial lakes (orange shading) and glacial seas (purple shading)
- valley sides in the Prairies where rivers have cut down into the Cretaceous bedrock (yellow shading)
- ice-rich, fine-grained soils in permanently frozen ground (permafrost) in Canada’s northern regions (north of dashed black line) (NRCan 2008).

For NRCan (Geological Survey of Canada), one objective of the Public Safety Geoscience Program is the provision of broad, high level information that summarizes the likelihood of threat from a variety of natural hazards, including landslides (Bobrowsky and Dominguez 2012).
Notes
1. Natural Resources Canada (2013a)
Map of Ten Major Landslides

1. Natural Resources Canada (2008)
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21.5.2 Effects on the Project

Though the Project area has not experienced a major landslide, there may be areas of fine-grained soil, once covered by glacial lakes that are susceptible to landslides (Figure 21-4). According to the Geological Survey of Canada’s Landslide Susceptibility Map of Canada, the PDA lies in a region generally rated with the lowest susceptibility, with some localized areas surrounding existing lakes, where the susceptibility rating is low to medium (Bobrowsky and Dominguez 2012). Landslide threat ranges from areas of low susceptibility (1), to highly susceptibility (6). Susceptibility ranking is based on slope, aspect, permafrost, surficial geology, vegetation/land use, distance from water bodies and the coast. For example, the most susceptibility terrains that are ranked from five to six are located in high relief, mountainous areas. Whereas the areas with low to medium susceptibility are typically more flat areas with small slopes that represent more stable landscapes.

Other areas of the region have historically experienced relatively higher levels of seismic activity, but these are a large enough distance from the Project that the risk that a major seismic event in these areas could adversely affect the Project in a substantive 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 vicinity of the Project that could cause major Project damage or interrupt operations during any phase is low.

No major landslides have occurred in central Ontario (NRCan 2008), and the likelihood of a landslide occurring at the Project is low (Bobrowsky and Dominguez 2012). Though a lack of landslide activity in an area is not always an indicator that a landslide event could not occur, the likelihood of a major landslide event in the immediate vicinity of the Project that could cause major Project damage or interrupt operation during any phase is low.

21.5.3 Mitigation and Residual Effects

The Project, related components 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 components. Furthermore, the TMF will be constructed to meet the Technical Bulletin – Geotechnical Considerations for Dam Safety (CDA 2007) and the Lakes and Rivers Improvement Act Administrative Guide requirements (MNR 2011), which were developed as design standards so that relevant infrastructure could withstand reasonably probable seismic activity. Amec Foster Wheeler undertook a hazard potential classification of the historical MacLeod tailings, and given proximity to the realigned Highway 11, a classification of “Very High” was assigned and addressed through design. Mitigation measures, including berms and buttresses, have been incorporated into the Project design for the historical MacLeod tailings.
The intent of these and other design standards is to maintain the integrity of the components based on the level of risk for an earthquake in the area of a magnitude up to the maximum credible earthquake.

The TMF perimeter dams will be designed to accommodate a one-in-10,000-year seismic event and proposed mitigation measures for the historical MacLeod tailings adhere to a design earthquake of 1:6,250 year annual exceedance probability, assumed to be a magnitude 6.0. Therefore, seismicity is considered not to have the potential to substantively damage Project infrastructure or components during any phase of the Project, due to planned design mitigation and the application of the National Building Code of Canada and other applicable guidelines. Therefore, given design and mitigation, substantive effects of the environment on the Project arising from seismic events are not anticipated.

### 21.6 Forest Fire

Prediction of forest fire activity is linked to the operation of a Fire Weather Index 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. Project-caused fire is discussed as a potential accident or malfunction in Chapter 22.0.

#### 21.6.1 Existing Conditions

The mean Fire Weather Index in Geraldton for July (normally the hottest month of the year), when risk of forest fire is typically the greatest, is rated from five to ten (for years 1981-2010) (Figure 21-5); this is in the lower range of possible risk which, at the highest range, can exceed 30 on the Fire Weather Index (NRCan n.d.).

#### 21.6.2 Effects on the Project

The effects of a forest fire on the Project may include:

- **reduced visibility and inability to manoeuvre construction and operation equipment due to smoke**
- **delays in receipt of materials and supplies (e.g., construction materials, reagents) and in delivering products**
- **changes to the ability of workers to access the site (e.g., if fire blocks access to transportation routes)**
- **fire damage to infrastructure**
- **loss of electrical power resulting in potential loss of production.**
Notes
1. Natural Resources Canada (n.d.)

Figure No.
21-5

Title
Average Fire Weather Index for the Month of July (1981 - 2010)
Mitigation and Residual Effects

Ontario has a forest fire control program in place to identify and control fires, reducing their potential magnitude and extent, and their potential consequent effects on the Project during any phase.

The management, monitoring and control of forest fires in Ontario are the responsibility of the MNRF under the Forest Fires Prevention Act.

Day-to-day management of these issues is carried out by the MNRF’s Aviation, Forest Fire and Emergency Services program. That program coordinates forest fire detection, monitoring, suppression and public information and education services for Ontario (GO 2014c). On-the-ground assistance and response to major fire events is coordinated by the MNRF’s Fire Management Headquarters, in Geraldton, with assistance (as necessary) from private contractors (e.g., Geraldton Community Forest).

The proposed safety and security programs for the Project are capable of rapid detection and response to a forest fire threat. A minimum of 30 metres surrounding Project components within the boundary of the PDA will be cleared of flammable debris, which will reduce the potential for a fire to affect the structures, even though the structures will be inherently fire resistant. The Project’s Emergency Response Plan (ERP) will address training employees in fire prevention and control. A Conceptual ERP is provided in Appendix M3. Communication with local emergency providers will be established so that roles and responsibilities are understood, and that the necessary resources required to respond are in place. This Plan will be in place in conjunction with community, and provincial emergency response crews to provide for rapid detection and response to fire. This includes fires that could start within the PDA (see Chapter 22.0 [potential accidents or malfunctions] for a discussion of fire as an accidental event) as well as fires approaching from outside the PDA (e.g., forest fires).

In the event that a forest fire did occur close to the Project, while Project components would not likely to be substantively affected by the fire, there is potential risk of contact with fuel storage tanks and the explosives facility, thereby potentially creating a risk of fire or explosion. As described in Chapter 22.0 (potential accidents or malfunctions), emergency response capability, emergency response plans, and fire trained individuals and response equipment for such accidental events will be in place. A Conceptual ERP is provided in Appendix M3. Maintaining regulated setbacks between the explosives facility and other Project components, as well as clearing the land upon which the structures will be built, will help reduce the susceptibility of these structures to be affected by a forest fire.
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With respect to the effects of a forest fire on the Project, the structures will be constructed primarily of concrete and steel, which are not as susceptible to fire, and the majority of materials handled (e.g., ore, waste rock, tailings) are not flammable. If a forest fire were to occur close 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 setback zone established around Project components will further decrease the likelihood of a forest or brush fire causing substantive damage to the Project. Therefore, substantive effects of the environment on the Project arising from a forest fire are not anticipated.

21.7 SUMMARY OF MITIGATION AND RESIDUAL EFFECTS

Environmental stressors potentially associated with climate conditions, climate change, seismic events, landslides and forest fire would be more than adequately addressed by:

- Engineering design that complies with building codes and standards that incorporate factors of safety to protect Project infrastructure from these stressors
- Using adaptive strategies (e.g., modified Project scheduling to account for weather events)
- Environmental protection and emergency response planning (a Conceptual ERP is provided in Appendix M3).

The potential effects of the environment on construction has been 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 provide a safe environment for construction staff. 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 components are anticipated as a result of environmental forces; Project design and working standards during construction and the limited duration of construction contribute to this conclusion. Therefore, the effects of the environment 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.

The potential effects of the environment on the Project during the operation and closure phases were considered and incorporated in the planning and design of Project infrastructure to reduce the potential for long-term damage to components, taking into account environmental forces. 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 closure, observed effects of the environment that may occur will be incorporated in the active management and operation of the Project. Modifications to infrastructure or operation will be applied through an adaptive management approach to prevent an undue effect of the environment on the Project that could adversely affect operation, damage infrastructure, cause Project delays, or otherwise.
adversely affect the normal course of operation at the Project. Although it is likely that central Ontario will experience extreme weather conditions during the life of the Project, the likely adverse effects on the Project during these activities were taken into consideration in the planning and design of the Project (or managed adaptively as appropriate as information regarding climate change evolves). Therefore, substantive damage to the Project, or interruption to the Project schedule, is not anticipated.

21.8 DETERMINATION OF SIGNIFICANCE

The Project has been designed and will be carried out to withstand environmental conditions by applying standard 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 attributes that, during the Project, are anticipated to have the potential to result in:

- a substantial change to the Project construction schedule (e.g., a delay resulting in the construction period being extended by one season)
- a substantial change to the Project operation schedule (e.g., an interruption in servicing such that production targets cannot be met)
- damage to Project infrastructure resulting in increased safety risk
- damage to Project infrastructure requiring repairs that cannot be technically or economically implemented.

Accordingly, the effects of the environment on the Project during all phases are rated not significant.
21.9 References


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HARDROCK PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT/ ENVIRONMENTAL ASSESSMENT

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