7. Effects of the Environment on the Project

The CEAA requires an assessment of the potential effects that the environment (i.e., natural events such as weather conditions) may have on the Project and the resulting environmental effects that could occur as a result. The following sections provide a description of the natural events that could affect the Project, the design aspects of the Project to prevent such effects from occurring (including the risk of occurrence) and a description of the potential impacts on the Project in the event the effect does occur, and the resulting potential environmental effects.

7.1 Construction Period

The natural environmental conditions that could occur during construction and impact the Project include inclement weather conditions such as excessive precipitation and associated flooding in the Kabinakagami River, extremely cold winter weather, extreme icing conditions and extremely hot summer weather. Other events that could potentially occur include seismic events, fires and the presence of wildlife (e.g., bears).

7.1.1 Precipitation and Flooding

7.1.1.1 Potential Effects on the Project

Flooding in the Kabinakagami River from heavy precipitation and/or snow melt during construction could potentially result in overtopping of cofferdams and subsequent inundation of working areas. The Phase 1 and 2 cofferdams at each site are anticipated to remain in the river through the duration of the spring freshet, thereby exposing them to higher risk of flooding. Extremely high floods could also result in cofferdam failure.

7.1.1.2 Potential Effects on the Environment

If any cofferdam were to fail due to overtopping or very high floods in exceedance of the design criteria, it would likely cause the work area to be flooded. Failure of the cofferdam or flooding of the work area would likely result in the downstream transport of fine impervious fill material from the cofferdam structure or result in mobilization of fine sediments and other debris from the area within the cofferdam, which would have an adverse effect on water quality, due to turbidity and suspended solids and on aquatic habitat due to sedimentation and infilling of the rocky channel bed with fine materials. In addition, cofferdam failure or overtopping could have the potential for water coming into contact with potentially hazardous materials in the work area (e.g., fuels, oils, solvents, uncured concrete) and being transported downstream. This could also have an adverse effect on surface water quality, aquatic biota and habitat. Cofferdam failure or overtopping could also jeopardize the safety of the workforce.

Adverse effects of cofferdam failure and associated flooding of the work area will vary depending on the severity of the failure (i.e., the amount of cofferdam material eroded and the amount of flow released into the area behind the cofferdam and subsequently back to the river) and the nature of the construction activities occurring within the cofferdam area at the time of failure.

7.1.1.3 *Mitigation Measures*

Cofferdams will be designed to be stable and not be overtopped at the 1 in 25-yr flow rate and an Emergency Preparedness Plan will be prepared to detail how to respond in the event that flows are anticipated to be higher than the design flow during construction. It is anticipated that floods potentially exceeding the design flow will be well-forecasted to allow time to prepare accordingly. The Emergency Preparedness Plan will document the measures that will be undertaken in the event that such floods are forecast or predicted to occur. This will include mitigation such as

- removing all machinery and equipment from the area behind the cofferdam
- removing all hazardous materials, if present (although potentially hazardous materials (e.g., fuels and other hydrocarbons, will not be stored behind cofferdams)
- removing any source of erodible material (e.g. sediment stockpiles).

7.1.1.4 *Net Effects and Significance of Net Negative Effects*

Implementation of these mitigation measures will minimize the amount of material (either hazardous or erodible) that could potentially be transported into the river in the event of a flood exceeding the design criteria for the cofferdams and causing cofferdam failure or overtopping, with subsequent inundation of the work area. The net effects of a cofferdam failure or overtopping, should they occur would be dependent on the magnitude of the failure/overtopping event. However, it is anticipated that failure would result in negative effects on surface water quality (due to turbidity or contaminants such as hydrocarbons if present in the flooded work area), aquatic habitat and aquatic biota. The following identifies the significance of these net negative effects.

Value of Resource

Surface water quality, aquatic biota and aquatic habitat have a ***High*** value in the local area since fish are harvested by CLFN and members of the general public.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of failure or overtopping event and the nature of materials behind the cofferdam at the time. Assuming the worst case scenario of a complete failure, the magnitude of effect on surface water quality, aquatic biota and habitat would be ***Moderate***. It is assumed that cofferdam failure would occur during high flow periods, so the release of fine sediments from the cofferdam would be somewhat diluted at these high flow rates, thereby decreasing the overall magnitude.

Geographic Extent of Effect

The geographic extent would likely occur >500 m from the Project Area, due to downstream transport of materials in the Kabinakagami River, therefore the geographic extent is ***High***.

Duration and Frequency of Effect

The effect would occur once immediately upon cofferdam failure, so the duration and frequency are considered to be ***Low***.

Reversibility of Effect

The effects on surface water quality are ***Reversible*** since they will eventually diminish to restore existing conditions.

Ecological or Social Context

The area is determined to have ***Moderate*** fragility with respect to effects on surface water quality, aquatic habitat and biota due to cofferdam failure.

Probability of Effect

The probability of a cofferdam failure/overtopping event due to high flows is ***Low*** since cofferdams will be designed to not fail or be overtopped at the 1:25-yr flood, which has a 4% probability of occurrence in any given year.

Overall Assessment

Given the low probability of effect, this is considered to be ***Not Significant***.

7.1.2 Extreme Winter Conditions

7.1.2.1 Potential Effects on the Project

Working through the winter period is planned at times and the Project Area typically experiences very cold conditions (see Section 4.1.1). Mean minimum daily temperatures reach their lowest levels in January (-24.9ºC), with -45.3ºC being recorded as the lowest daily temperature. Wind chill, which is not included in the temperature noted, would increase the effect of the cold weather significantly. Extreme cold conditions could result in health and safety risks to the labour force (i.e., frost bite, hypothermia, etc.) and could cause equipment inefficiencies or breakdowns. Subcontractors and workers to be employed for this Project will be predominantly from the regional area and therefore, are accustomed to working under these conditions. The Contractor will be required to provide and implement health and safety measures that will protect the workers from extreme weather conditions including providing recommendations for appropriate clothing.

The Contractor’s scheduling of the construction process has taken into account cold winter conditions, when determining what activities can be conducted during winter. Earth dam and concrete constructions will not be undertaken under such cold conditions, although it is possible to pour concrete with special measures if necessary to meet overall scheduling requirements.

7.1.2.2 Potential Effects on the Environment

Although extremely cold weather conditions can have a number of negative effects on the Project, including the construction process, the labour force and equipment, none of the negative effects on the Project would have corresponding negative effects on the environment. Therefore no net negative effects are anticipated due to extremely cold weather conditions.

7.1.3 Icing Conditions

7.1.3.1 Potential Effects on the Project

Ice storms, such as the one that occurred in eastern Ontario and Quebec in 1998, could affect on-site construction activities and workers. Impacts could include loss of power, unsafe working conditions and damaged/inoperable equipment) and ice damming which could lead to flooding/inundation of the work area. Ice storms of the severity of those experienced in 1998 are a relatively rare event, but storms of less severity may still have the potential to impact working conditions. The Contractor will be required to develop and implement health and safety measures to be employed during icing conditions.

7.1.3.2 *Potential Effects on the Environment*

The majority of the potential effects on the Project as a result of icing conditions would not result in corresponding negative effects on the environment. However, ice damming, causing backwater effects and inundation of the work areas behind cofferdams, could potentially result in similar negative effects as discussed in Section 7.1.1.

7.1.3.3 *Mitigation Measures*

Monitoring will be conducted when icing is occurrence to assess the potential for significant ice damming downstream from any construction work area. If it is determined that ice damming may cause backwater effects and cofferdam inundation, the following mitigation will occur:

- removing all machinery and equipment from the area behind the cofferdam
- removing all hazardous materials, if present (although potentially hazardous materials (e.g., fuels and other hydrocarbons, will not be stored behind cofferdams)
- removing any source of erodible material (e.g. sediment stockpiles).

7.1.3.4 *Net Effects and Significance of Net Negative Effects*

Implementation of these mitigation measures will minimize the amount of material (either hazardous or erodible) that could potentially be transported into the river in the event of a flood due to ice damming, with subsequent inundation of the work area. The net effects of cofferdam overtopping event would be dependent on the magnitude of the overtopping event. However, it is anticipated that overtopping would result in negative effects on surface water quality (due to turbidity or contaminants such as hydrocarbons if present in the flooded work area), aquatic habitat and aquatic biota. The following identifies the significance of these net negative effects.

Value of Resource

Surface water quality, aquatic biota and aquatic habitat have a ***High*** value in the local area since fish are harvested by CLFN and members of the general public.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of overtopping event and the nature of materials behind the cofferdam at the time. Assuming the worst case scenario of a complete overtopping and hydraulic connection with the river, the magnitude of effect on surface water quality, aquatic biota and habitat would be ***Moderate***.

Geographic Extent of Effect

The geographic extent would likely occur >500 m from the Project Area, due to downstream transport of materials in the Kabinakagami River, therefore the geographic extent is ***High***.

Duration and Frequency of Effect

The effect would occur once immediately upon cofferdam overtopping, so the duration and frequency are considered to be ***Low***.

Reversibility of Effect

The effects on surface water quality are ***Reversible*** since they will eventually diminish to restore existing conditions.

Ecological or Social Context

The area is determined to have ***Moderate*** fragility with respect to effects on surface water quality, aquatic habitat and biota due to cofferdam overtopping due to an ice dam.

Probability of Effect

The probability of a cofferdam overtopping event due to a downstream ice dam is ***Low***.

Overall Assessment

Given the low probability of effect, this is considered to be ***Not Significant***.

7.1.4 Extreme Summer Conditions

7.1.4.1 Potential Effects on the Project

Extremely hot summer conditions may also pose health and safety risks to the labour force (e.g., sunburns, sun stroke, heat exhaustion and dehydration). Drought or extremely low water levels would not have a negative impact on construction. To mitigate the negative effects of hot conditions on the workers, the Contractor will be required to develop and implement health and safety measures that will protect the workers during these extreme summer conditions.

7.1.4.2 Potential Effects on the Environment

Although extremely hot weather conditions can have a number of negative effects on the Project, including the construction process and the labour force, none of the negative effects on the Project would have corresponding negative effects on the environment. Therefore, no net negative effects are anticipated due to extremely hot weather conditions.

7.1.5 Seismic Events

7.1.5.1 Potential Effects on the Project

A seismic event (i.e., earthquake) could potentially result in damage to structures such as cofferdams or the facility components being constructed at the time. Such damage could also endanger workforce safety during the seismic event. As discussed in Section 4.1.4, the Study Area has a very low potential for seismic events.

7.1.5.2 Potential Effects on the Environment

A seismic event could potentially result in damage and associated failure of cofferdams or hazardous material containment devices.

Cofferdam failure could result in a number of negative effects on the environment, as discussed in Section 7.1.1. Failure of hazardous material containment devices could potentially have negative effects on a number of VECs including surface water, soil and groundwater quality, and aquatic and terrestrial biota, as discussed in Section 6.1.3.

7.1.5.3 *Mitigation Measures*

Dam safety assessments will be completed using current seismic loading parameters based on current MNR standards and the incremental hazard classification for the dams. This will include temporary cofferdams used during construction. All new structures will be designed in accordance with the Ontario Building Code, CSA standards and/or MNR requirements as appropriate.

Mitigation in the event of a cofferdam failure due to a seismic event would involve removing all equipment/material from the cofferdam area (to the extent that it is safely possible to do so immediately following the failure). Sediment containment or material clean-up would be initiated immediately.

Mitigation in the event of a containment failure would be per the spill response measures discussed in Section 6.1.3.2.

7.1.5.4 *Net Effects and Significance of Net Negative Effects*

The net effects of a cofferdam failure due to a seismic event would be dependent on the magnitude of the failure event. However, it is anticipated that failure would result in negative effects on surface water quality (due to turbidity or contaminants such as hydrocarbons if present in the flooded work area), aquatic habitat and aquatic biota.

The net effects of a failure of a hazardous material containment structure would be dependent on the location of the structure, and the nature of the material and volume released to the environment.

The following identifies the significance of these net negative effects.

Value of Resource

Surface water quality, aquatic biota and aquatic habitat have a ***High*** value in the local area since fish are harvested by CLFN and members of the general public. Terrestrial habitat and biota have a ***Moderate to High*** value.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of failure and the nature of materials behind the cofferdam or within the failure containment structure at the time. Assuming the worst case scenario of a complete failure, the magnitude of effect on surface water quality, aquatic biota and habitat would be ***Moderate***.

Geographic Extent of Effect

The geographic extent would likely occur >500 m from the Project Area if the failure were to occur in or adjacent to water, due to downstream transport of materials in the Kabinakagami River, therefore the geographic extent is ***High***. Failure of an on-land material containment structure may have a ***Low to Moderate*** geographic extent depending on the volume of material released.

Duration and Frequency of Effect

The effect would occur once immediately upon failure due to the seismic event, so the duration and frequency are considered to be ***Low***.

Reversibility of Effect
The effects are ***Reversible*** since they will eventually diminish to restore existing conditions.

Ecological or Social Context
The area is determined to have ***Moderate*** fragility with respect to effects on VECs due to containment and cofferdam failure.

Probability of Effect
The probability of a structure failure due to a seismic event is ***Low*** given the low probability of seismic events in the Project Area.

Overall Assessment
Given the low probability of effect, this is considered to be ***Not Significant***.

7.1.6 Forest Fires

7.1.6.1 Potential Effects on the Project

Forest fires occurring in the Project Area during construction could potentially result in

- requirement to evacuate the work area
- preventing access to or from the work area
- damage to structures and/or equipment.

Should this occur, effects to the Project could include risks to worker safety, delays in construction scheduling (if workers have to evacuate or structures/equipment are damaged) and financial costs.

7.1.6.2 Potential Effects on the Environment

Forest fires occurring as a result of natural causes may have adverse effects on Project construction, including delays, damage to equipment and structures and worker safety risks. Burning of construction equipment and materials during a fire, should the work area become engulfed, could potentially have adverse effects on air quality and surface water quality with corresponding effects on VECs and potentially VSCs due to harmful contaminants in the air or deposited in water.

7.1.6.3 Mitigation Measures

Throughout the duration of the construction period, Northland and/or the Contractor will stay in communication with MNR regarding fires in the area. The Contractor will have an emergency response plan in place should forest fires approach the Project Area. The plan would involve the evacuation of workers and equipment away from the Project Area to minimize the equipment and materials that could be burned by a fire.

7.1.6.4 Net Effects and Significance of Net Negative Effects

The effects could vary depending on the severity of the fire but, assuming the mitigation noted above is sufficient to minimize the amount of equipment/material caught in the fire, effects would tend to be local in extent, minor in magnitude and short-term in duration. Some adverse effect on air quality would be anticipated to occur if equipment and material were to be burned during a fire. Deposition of ash within watercourses could have negative effects on surface water quality and biota.

Value of Resource
Since a number of VECs and VSCs could be negatively affected by a fire that burns Project equipment and materials, the value is considered to be ***High***.

Magnitude of Effect
The magnitude of effect is dependent on the magnitude of the fire and the amount and nature of Project equipment/materials burned in the fire. Assuming the worst case scenario of a large forest fire burning equipment/material at each Project work area, including hazardous materials (e.g., hydrocarbons), the magnitude of effect on the environment would be ***High***.

Geographic Extent of Effect
The geographic extent is dependant on the magnitude of the fire and the nature and amount of equipment/material burned in the fire. Large fires could cause effects >500 m from the Project Area, therefore the geographic extent would be ***High***, while small fires or fires that do not burn much Project equipment/material could cause effects that would be contained to the Project Area.

Duration and Frequency of Effect
The effects of a large magnitude fire occurring during construction could potentially be present well into the operations period, so the duration and frequency of such a fire would be ***High***, although the duration of frequency of a small controllable fire would be ***Low***.

Reversibility of Effect
The effects on VECs and VSCs after a fire are generally ***Reversible*** since they will eventually diminish to restore existing conditions.

Ecological or Social Context
The area is determined to have ***High*** fragility with respect to effects of a forest fire.

Probability of Effect
The probability of a fire is ***Low*** given the mitigation proposed.

Overall Assessment
Given the low probability of effect, this is considered to be ***Not Significant***.

7.1.7 Wildlife

7.1.7.1 Potential Effects on the Project

Wildlife, particularly bears, could potentially represent a hazard to worker safety throughout the construction period. Bears could potentially be drawn to the site due to the presence of garbage or food waste, which could result in interactions between bears and the workforce. All workers on site will undergo bear safety training prior to working on the site, including protocols regarding proper disposal of waste and how to react if confronted by a bear.

7.1.7.2 Potential Effects on the Environment

Nuisance wildlife may have to be captured and transported off-site. This would be in accordance with MNR protocols for wildlife handling, removal and transport, and would be done by qualified individuals, likely from the MNR. Given this, no negative effects on the environment are anticipated to occur.

7.2 Operations Period

The natural environmental conditions that could occur during operations and could impact the Project include: seismic events, climate change, weather related effects, flooding and forest fires. These are evaluated in the following sections.

7.2.1 Flooding and Dam Failure

7.2.1.1 Effects on the Project

Extreme flooding due to heavy precipitation and/or snowmelt in the Kabinakagami River during operations will result in an increase in head pond water level. Should flows become higher than the IDF for the Project (a 1:100-yr flood), dam failure could result. However, the earth dam sections will be designed with adequate freeboard and the top of the earth dams will be 1.0 m higher than the IDF corresponding flood level. The risk of a dam failure is very low and generally accepted in dam engineering practice. The dam spillway's design has been established to accommodate the 1:1000-yr storm event, adding additional design safety/conservatism.

In addition, Northland will be developing an emergency response plan to deal with floods greater than 1:100 should they occur during operations. Dam failure caused by accidents and malfunctions is discussed in Section 6.2.1.

7.2.1.2 Effects on the Environment

Given the relatively small volume of the incremental amount of water retained in the head pond, the magnitude and duration of the dam break flood would be expected to be relatively minor. Effects could include mobilization of channel bed and bank sediments within the head pond and within the downstream area due to higher flow velocities associated with the increased flow being released from the head pond during failure. Such mobilization could result in temporarily impaired water quality and negative effects on aquatic habitat due to erosion as well as deposition within downstream reaches. Dam failure could also result in displacement of aquatic biota (e.g., fish and benthic invertebrates) which would result in temporary disturbance of these communities. Human safety risks would also be present in the event of a dam failure, if humans were present in the downstream reach. During a flood of the nature that would have the potential to cause a dam failure, human use of the river system would not likely be occurring.

7.2.1.3 Mitigation Measures

The mitigation to prevent or minimize the potential for a dam failure is to design the dams to appropriate safety standards in accordance with industry standard design practices.

7.2.1.4 Net Effects and Significance of Net Negative Effects

The net effects of a dam failure could vary depending on the magnitude of the failure. A dam failure could have negative effects on a number of VECs and VSCs.

Value of Resource

Since a number of VECs and VSCs could be negatively affected by a dam failure, the value of the resource potentially affected is considered to be ***High***.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of the dam failure. Assuming the worst case scenario of a large failure of all four facilities, the magnitude of effect on the environment would be ***High***.

Geographic Extent of Effect

The geographic extent of a dam failure is dependant on the magnitude of the failure. However, a failure would likely have negative effects > 500 m from the Project Area, therefore the geographic extent would be ***High***.

Duration and Frequency of Effect

The effects of a large magnitude dam failure could potentially persist for a long duration period so the duration and frequency of such a failure would be ***High***.

Reversibility of Effect

The effects on VECs and VSCs after a dam may be ***Reversible*** over time since they will eventually diminish to restore existing conditions.

Ecological or Social Context

The area is determined to have ***Moderate*** fragility with respect to effects of a dam failure.

Probability of Effect

The probability of a dam failure is ***Low*** given the proposed engineering design standards.

Overall Assessment

Given the low probability of a dam failure, this is considered to be ***Not Significant***.

7.2.2 Seismic Events

Section 7.1.5 above provides information and discussion on the effects of seismic events during construction. This discussion and effects are the same for events during operations. The facilities will be designed to meet building code and dam safety requirements for seismic activity.

7.2.3 Climate Change

The Government of Canada's report, *2006 Canada's Fourth National Report on Climate Change*, states that climate change in Canada will result in warmer temperatures that will affect variables such as evaporation and snow cover. Predictions of climate change effects on regional precipitation patterns are less understood and the Report acknowledges that these uncertainties limit the ability to predict hydrological changes at the watershed scale. Nevertheless, in terms of potential hydrologic effects, Government of Canada (2006) predictions indicate that for many regions of Canada, warmer winter temperatures would likely increase the frequency of mid-winter thaws and rain-or-snow events, thereby increasing the potential for increased winter flows. Conversely, reduced winter snow cover would likely result in fewer and less severe spring flooding events. Warmer summer temperatures would likely result in lower seasonal flows and warmer water temperatures.

The average annual global temperature is projected to warm 1.1 to 6.4°C during the next century, with land areas warming more than the oceans and higher latitudes warming more than lower latitudes (IPCC 2007a:13). As more heat is trapped in the lower atmosphere by additional greenhouse gases, the frequency and size of extreme weather events such as ice storms, heavy rains, droughts, and wind storms are expected to increase (IPCC 2007a:15; in MNR, 2011).

Globally averaged mean water vapour, evaporation, and precipitation are projected to increase (Meehl and Stocker, 2007:750; in MNR, 2011). Precipitation levels are projected to decline in tropical areas and increase at high latitudes (IPCC 2007a:74; in MNR, 2011)).

During the 20th century, total annual precipitation increased 13% in Canada south of 55° latitude (Groisman et al. 2001). During the latter part of the century between 1950 and 1998, total annual precipitation increased by about 5% across Canada (Kharin and Zwiers 2000; in MNR, 2011).

In Ontario, temperatures have increased approximately 1.4°C since the mid-1950s, which is greater than the Canadian average increase (1.3°C) (Environment Canada, 2007). According to MNR (2009b), in northern Ontario, the mean annual temperature for the 1961 to 1990 period was 0 to 3°C and the predicted[1] global annual mean for 2025 is 2.25 to 2.5°C while the predictions for 2055 and 2085 are respectively 4 to 4.5°C and 6 to 6.5°C. These data are supported by other projections[2] of average summer and winter air temperature increases for the northern Ontario (MNR, 2011); maximum increases for 2025 compared to the 1971 to 2000 reference period are + 3°C during the summer and + 4°C during the winter. The summer increases for 2055 and 2085 are respectively + 4°C and + 6°C while the winter increase for these years are + 7°C and + 10 C. Across the province, warming will be greater in winter than in summer and greater in the north than in the south (Colombo *et al*., 2007 cited in MNR, 2011).

Average annual precipitation is expected to increase in most regions of Canada, and changes in precipitation patterns are also likely, including more frequent, heavy-precipitation events and larger year-to-year variability. Furthermore, most models indicate that there will be reduced precipitation during summer months and increased precipitation during winter months (MOE, 2006). Climate change will alter Ontario's precipitation patterns. Using greenhouse gas concentrations developed for the A2 scenario, the CGCM2 projects decreased precipitation by 2070 to 2100 in northwestern Ontario, and increased precipitation for northeastern Ontario during the warm season (April to September) (MNR, 2011)[3]. During the cold season (October to March) areas around Lake Superior, Lake Nipigon, Lake of the Woods, and James Bay are

[1] Predictions generated by the Canadian Global Climate Model v. 2 (CGCM2; Flato et al. 2000, Flato and Boer 2001 in MNR, 2009) under the International Panel on Climate Change (IPCC) A2 emissions scenario (Nakicenovic et al. 2000 in MNR, 2009). The A2 emissions scenario assumes relatively high and increasing greenhouse gas emission rates over the entire period from the present to 2100.
[2] From the CGCM2 Model – A2 emission scenario.
[3] MNR Region compared to the 1971 to 2000 reference period from the CGCM1 model – A2 emission scenario.

projected to receive more precipitation, while the far north is projected to receive less (MNR, 2011).

The Climate Change Mapping Tool (MNR, 2007b) suggests that the average annual precipitation in the majority of the Kabinakagami River basin should increase slightly (0 to 10%) over the period 2011 to 2040 for both warm and cold weather periods. It should be noted that the uncertainties associated with any type of climate change prediction tools are quite large.

7.2.3.1 *Potential Effects of Climate Change on the Project*

A warmer, wetter climate scenario that results in higher runoff and streamflow on average could result in higher river flows. This would have a positive economic impact on the Project since higher river flows would result in increased power generation. This would result in longer duration of operation at higher flows, up to the maximum flow for each facility, with potentially more volume and higher duration spillage.

In terms of economic risk to the Project, a warmer-drier climate scenario that results in less runoff and streamflow on average could result in lower river flows, which may be more pronounced during typical summer low flow months. This in turn, could result in a decrease in the amount of energy generation from the Project, which could affect the economics of the Project, but not to a degree that the Project would be rendered uneconomic. The Project remains economically feasible taking into account potential future climate change projections. Lower flows may result in reduced duration of spillage over the overflow weir and longer duration and/or higher frequency of operation at the lower end of the operational capacity of the turbines (e.g., between 8 and 20 m^3/s). This in turn may increase the frequency of operation of the head ponds within the Low Water Zone.

Increased variability, frequency and intensity of precipitation events could impact the frequency and magnitude of future flood events. However, the structural integrity of the Project would not be affected, since the facility will be designed for certain head pond levels that can be managed and maintained within the limits of the specified IDF for the Project (1:100-yr flood), as determined using current MNR Dam Safety Guidelines. A gradual increase in magnitude or frequency of flooding events will not affect the Project within its regulatory requirement for passing the IDF (as determined using MNR Guidelines).

7.2.3.2 *Potential Environmental Effects*

The following sections identify the general potential effects of climate change on the environment based on the results of a literature review, and then extrapolate these potential effects to identify the potential effects on the environment of the Project under future potential climate change scenarios.

7.2.3.2.1 General Potential Effects on the Environment in Northern Ontario due to Climate Change – Literature Review

The following sections identify the potential effects of climate change on the environment, based on a review of the available literature on the topic. These effects could potentially vary across environments and may not all be applicable to the Kabinakagami River, but do provide a general indication of the effects on aquatic environments that may occur throughout Canada should climate change predictions be borne out.

Effects on Riverine Environments

Hydrological Cycle – Stream/River Water Levels

The water balance of streams and rivers is determined by the rate of inflow less the rate of loss. Potential effects of a warmer climate on inflow and outflow of stream/river water levels include:

- **Precipitation**: The volume, timing, and intensity of precipitation affects the amount of flow in streams and rivers. For example, whether precipitation falls as snow or rain in winter can influence water levels in late summer (Kundzewicz and Mata, 2007; in MNR, 2011).
- **Inflow and outflow from other streams and rivers**: Climate change will affect the volume and timing of stream and river water flow. Therefore, a reduction in stream flow caused by increased temperatures, decreased precipitation, and increased evaporation will reduce availability of water to the stream or river.
- **Inflow from run-off**: A reduction in direct run-off caused by increased temperatures, decreased precipitation, and increased evaporation can reduce the volume of water available to a stream or river.
- **Groundwater inflow and outflow**: Groundwater is an important source of water for streams and rivers in Ontario. Changes in the timing of snow and rainfall events, increased risk of drought and reduced soil moisture, and higher evaporation rates work to reduce recharge rates and groundwater levels (Mortsch et al., 2003; in MNR, 2011). Extreme rainfall events do not necessarily contribute to aquifer recharge rates because much of the water is lost as overland flow and run-off (Mortsch et al. 2003; in MNR, 2011). Therefore, even if some streams and rivers experience increased rainfall due to climate change, the characteristics (e.g., extreme rainfalls) and the timing (e.g., early snow melts) of precipitation may reduce groundwater recharge rates.
- **Evaporation**: Unless offset by equal or greater amounts of precipitation, increased evaporation resulting from higher temperatures, a longer growing season, and extended ice-free periods, will reduce the volume of water available for streams and rivers. Changes in incoming solar radiation, humidity, and wind speed will also affect evaporation (Kundzewicz and Mata, 2007; in MNR, 2011).
- **Increased effects of flooding:** Flooding can scour aquatic vegetation from the stream bed and increase the volumes of silt and organic debris deposited downstream, which can destroy eggs, displace young fish and suppress benthic production. This may affect fish production through changes in food web dynamics. The vulnerability of a particular fish species to flooding increases if the spawning season coincides with periodic floods (Ryder and Pesendorfer, 1988:9; in MNR, 2011).
- **Changes to the freshet:** Historically, significant volumes of water have been stored over winter in the snow pack and released in spring. An earlier (and possibly reduced) freshet

may occur in response to warming. This may affect the seasonality of river flows in areas where much winter precipitation currently falls as snow (Kundzewicz and Mata, 2007; in MNR, 2011).

- **Run-off patterns:** The timing and magnitude of run-off is a critical factor influencing biota and ecosystem processes (Allan et al., 2005; in MNR, 2011). Most climate change projections suggest that for areas with less water in the system, run-off will decline; more run-off will occur in winter and less run-off in summer (Kundzewicz and Mata, 2007; in MNR, 2011).

Temperature – Stream/River

Stream temperatures are spatially heterogeneous, with temperatures in the summer generally following a gradient of cooler waters upstream and warmer waters downstream. Channel morphometry, influxes of groundwater, inflows from tributaries, and surface runoff in areas affected by different land use practices increases the thermal heterogeneity in streams (Webb et al., 2008; in MNR, 2011).

Streams and rivers respond rapidly to changes in air temperature because they are relatively shallow, with flowing, mixing water (Allan et al. 2005; in MNR, 2011). Water temperature in streams and rivers can change at a rate as high as 3°C per hour (Ryder and Pesendorfer, 1988; in MNR, 2011).

Small streams have large thermal fluxes while larger rivers have greater thermal stability (Ryder and Pesendorfer, 1988; in MNR, 2011). Streams and rivers do not normally thermally stratify because the current is usually strong enough to keep the shallow waters mixed (Welcomme, 1979; in MNR, 2011).

Water temperature affects the composition of stream and river biological communities (Ryder and Pesendorfer, 1988; in MNR, 2011). Annual fluctuation in stream temperature is very important to stream organisms because critical life history variables (e.g., reproduction and growth) of lotic plants and animals are regulated by temperature (Hauer and Hill, 1996).

Global warming is expected to increase water temperatures of most running water ecosystems (Allan et al., 2005; in MNR, 2011). However, the response of stream temperature to climate change is complex and dependent on topography and geography of the drainage basin in which it is located (Meisner et al., 1988; in MNR, 2011) and surrounding vegetation (Hauer and Hill, 1996; in MNR, 2011). Typically, the greatest source of heat in freshwater is solar radiation, which is particularly true for rivers or streams that are exposed to direct sunlight over most of their surface (Hauer and Hill, 1996; in MNR, 2011). Many small streams, however, are located under tree canopy cover that shades the water from direct sunlight. In such cases, transfer of heat from the air and flows from groundwater are more important than direct solar radiation in governing stream temperatures (Hauer and Hill, 1996; in MNR, 2011). Groundwater discharge is important for maintaining cooler temperatures in streams and provides coldwater refuge during summer (Meisner et al., 1988; Mortsch et al., 2003; in MNR, 2011) and warmwater refugia in winter (Meisner et al. 1988; in MNR, 2011). This cooling influence could be reduced as groundwater temperatures increase in response to increases in air temperature (Meisner et al. 1988; in MNR, 2011).

Turbidity

Turbidity is likely to be more critical in streams and rivers than in lakes because water levels can change rapidly. In a warmer climate, streams and rivers may be subjected to:

- **Increased erosion**: Increased erosion from increased flow associated with extreme weather events. Flooding results in large inputs of fine particulate organic matter and dissolved organic matter when water enters the stream (Hynes, 1975; in MNR, 2011).
- **Enhanced permafrost thawing**: This thawing may increase sediment and organic matter loads in Far North streams and rivers, which may reduce light penetration and productivity (Wrona et al., 2006; in MNR, 2011).

Ice Dynamics

River beds are susceptible to ice scouring (Ryder and Pesendorfer, 1988; in MNR, 2011). A warmer climate may increase the size of winter habitat through:

- **Increased flow**: An increase in winter flows and reduced ice cover will potentially increase the availability of habitat. Streams and rivers that traditionally freeze to the bottom during winter will experience increased flow in response to increasing precipitation and higher winter temperatures. Reduced ice thickness may provide year-round flowing water, which will increase habitat availability and improve survival of species traditionally susceptible to winter kill (Wrona et al., 2006; in MNR, 2011).
- **Increased oxygen**: A climate-induced decrease in the duration of the river-ice season, or an increase in the size and frequency of open water sections where re-aeration can occur, may decrease the potential risk of oxygen depletion (Prowse and Beltaos, 2002; in MNR, 2011).

Chemical Characteristics

Overall, the concentrations and types of chemicals in streams and rivers vary greatly according to location, climate, physiography, geology, surrounding land use patterns, and biota (Hynes, 1970; in MNR, 2011).

Dissolved oxygen concentrations are not uniform within streams and rivers, and are a function of water temperature, groundwater flow, and stream flow (Hauer and Hill, 1996; in MNR, 2011). Seasonal variation in dissolved oxygen content of rivers can result from leaf inputs in the fall, which reduces oxygen levels; seasonal photosynthesis peaks and declines; winter ice cover on rivers, which serves to decrease oxygen levels; high discharge situations, which tend to reduce oxygen content (Hynes, 1970; in MNR, 2011). A warmer climate will:

- **Change oxygen levels**: As stream and groundwater temperatures increase, the oxygen saturation of the water will decrease and the rates of decomposition and respiration will increase (Kling et al., 2003; in MNR, 2011).

- **Increase the significance of cumulative effects**: Some types of land use change will exacerbate the effects of climate change, including the expansion of urban and industrial areas and agricultural practices.

Biological Diversity

The variety of species living in a stream or river can vary from the headwaters to the outlet, and can be influenced by the flow, temperature, substrate, and nutrients available along the stream continuum (Vannote et al., 1980; in MNR, 2011). A warmer climate will:

- **Reduce available habitat**: The coldwater stream habitat for some fish species decreases with warmer air temperatures and warming of surface waters and ground water inputs (Mortsch et al., 2003; in MNR, 2011).
- **Increase stress on biota**: Warming could increase thermal stress on stream and river biota. Rivers with low oxygen at low flows will severely limit biota survival and activity (Reiger et al., 1996; in MNR, 2011).
- **Increase productivity**: Primary and secondary productivity will increase when nutrients such as phosphorus and nitrogen are not limiting (Kling et al., 2003; in MNR, 2011), but productivity could decline in drought conditions if stream and river habitat shrinks (Kling et al., 2003; in MNR, 2011).

Effects of Climate Change on Mercury in Aquatic Environments

Plants and animals concentrate or bio-accumulate mercury. Mercury accumulation can affect many biological functions, as well as human use of plants or animals. In a warmer climate:

- **Mercury release and uptake will increase:** Mercury release and uptake by biota will likely increase in anoxic conditions because heavy metals such as mercury become more soluble in the absence of oxygen. Oxygen binds with these elements to form insoluble compounds that sink to the bottom and remain trapped in the sediments. As more detritus is added to bottom layers, which in turn requires more oxygen, mercury and other metals are released back into the water for uptake by aquatic organisms (Kling et al., 2003; in MNR, 2011).
- **Mercury toxicity will increase:** Mercury-induced toxicity is a function of species body size, the chemical form of the mercury, and other factors, such as water temperature (Sorensen 1991:295; in MNR, 2011). Metabolism increases at higher temperatures, which increase both the level of mercury accumulation and the susceptibility of fish to it (Macleod and Pessah, 1973; in MNR, 2011).

Effects on Lake Environments

Hydrological Cycle – Lake Levels

Climate change will affect the volume and timing of stream and river flow supplying lakes. For example, a reduction in streamflow caused by increased temperatures, decreased precipitation, and increased evaporation will reduce lake water inflows.

A reduction in direct run-off caused by increased temperatures, decreased precipitation, and increased evaporation can reduce water volume in a lake. A change in the timing of run-off (e.g., increased winter rain events) can affect late summer water levels. In areas that do experience increased rainfall due to climate change, the form of precipitation (e.g., extreme rainfall events) and the timing (e.g., early snow melts) may in fact reduce groundwater recharge rates.

Unless offset by equal or greater amounts of precipitation, increased evaporation resulting from higher temperatures, a longer growing season, and extended ice-free periods, will reduce the volume of water available for streams, rivers, and lakes (Allan et al. 2005, Kundzewicz and Mata 2007; in MNR, 2011).

Lower water levels in Ontario due to climate change could potentially have the following effects on aquatic ecosystems:

- Changes to the physical and chemical processes such as stratification, nutrient cycling, and oxygen dynamics (Wrona et al. 2006; in MNR, 2011).
- Lower water levels could increase levels of contaminants and amplify the effects of contamination (Mortsch et al. 2003, Wrona et al. 2006; in MNR, 2011).
- Fish movement, access to spawning and nursery habitat, and migration may be impaired (Koonce et al. 1996 in Mortsch et al. 2003:94, Wrona et al. 2006; in MNR, 2011).
- Reduced streamflow into lakes will increase lake water renewal time (Schindler et al. 1990, 1996; Schindler 1998; Mortsch et al. 2003:13; in MNR, 2011), which could increase the risk of exposure to anoxic conditions.

Water Temperature – Lakes

Warmer waters will result in reductions of summer habitats for coldwater fish species such as Lake Trout (Schindler 1998; in MNR, 2011) and may favour warm-water fish species (e.g., Walleye and Northern Pike) and lead to changes in the fish communities of many lakes across Ontario. Overall, fish productivity may increase in some lakes due to an increase in growth rates and food supply.

In a warming climate, the nature and magnitude of contaminant transfer in the food webs will likely change. Contaminants in bottom sediments may dissociate from the solid phase with a rise in the rate of organic carbon metabolism and, along with other contaminants originating from low temperature concentration, may increase in lake bottom waters (Wrona et al. 2006; in MNR, 2011).

Projected temperature increases and changes in the timing and magnitude of precipitation will affect the deposition of contaminants. This may enhance contaminant influxes into aquatic ecosystems and increase the exposure of aquatic organisms resulting in higher contaminant loads, including biomagnification (Wrona et al. 2006; in MNR, 2011).

Warmer water enhances productivity, which could increase the number and growth of undesirable species (e.g., algal blooms) (Mortsch et al. 2003:91; in MNR, 2011). Oxygen levels in the hypolimnion (i.e., the bottom area of the lake water column, beneath the thermocline) can be reduced by the decomposition of organic matter that drifts down from the surface (Allan et al. 2005; in MNR, 2011).

Transparency and Ultraviolet Radiation

Potential effects of increased UV radiation on aquatic organisms include but are not limited to:

- decreased nitrogen uptake rates by plankton
- reduced populations of consumers that feed on primary producers
- damage to DNA
- damage to photosynthetic function
- effects on the competitive ability of different periphyton species
- changes in phytoplankton species composition
- exacerbation of the biotic effects of acid precipitation in lakes
- immune system suppression in fish (Greifenhagen and Noland 2003; in MNR, 2011).

Ice Dynamics

Warmer temperatures will change the ice regime of waterbodies in northern regions, including Ontario (Assel et al. 1995, 2003; Assel and Robertson 1995; Fang and Stefan 1998; Quinn et al. 1999; Magnuson et al. 2000; Lofgren et al. 2002; Kundzewicz and Mata 2007; in MNR, 2011).

In response to warmer temperatures between 1864 and 1995 (an increase in air temperature of 1.2°C over 100 years), ice break-up dates were, on average, 6.5 days earlier and freeze-up dates were 5.8 days later in the Northern Hemisphere (Magnuson et al. 2000; in MNR, 2011).

Climate-induced shortening of the ice-in season will affect evaporation rates (Allan et al. 2005). In the Great Lakes, the greatest losses due to evaporation occur in late autumn and winter when cold, dry air passes over the warmer lakes (Mortsch et al. 2003:49; in MNR, 2011). Ice protects the shoreline and prevents erosion during winter storms. Therefore, a reduction in the ice-in periods will render shorelines more susceptible to extreme storm events (Mortsch et al. 2003:49; in MNR, 2011). This may lead to increased oxygen consumption in the deeper waters as algae decompose, which may limit the amount of oxygen available for species inhabiting deeper waters.

A shorter ice-in season means a reduced risk of low dissolved oxygen conditions, which will increase the chances of over-winter survival of fish eggs (Mortsch et al. 2003:49; in MNR, 2011) and fish, particularly in some of the more shallow mesotrophic and eutrophic lakes (Stefan et al. 2001; in MNR, 2011). Loss of winter ice cover and associated warming may be beneficial to fish populations where productivity and growth are currently limited by the duration of open water periods (Hostetler and Small 1999 in Mortsch et al. 2003:87, Stefan et al. 2001; in MNR, 2011). A shorter ice-in season means that fewer atmospheric airborne particulates are stored in the snow and ice pack.

Dissolved Oxygen

In a warmer climate, dissolved oxygen availability in the water is reduced because the amount that can be dissolved in water is lower and because the metabolic rates of organisms are higher (Lehman 2002 in Mortsch et al. 2003:52; in MNR, 2011). Warmer water temperatures may reduce the length of the ice season and therefore reduce the risk of winterkill caused by oxygen depletion. A warmer climate could extend the period of thermal stratification, which prevents re-oxygenation of the deep, hypolimnetic waters below the thermocline. Therefore, warmer lake temperatures could lead to anoxia by increasing the metabolic rate of sediment bacteria as well as biological productivity and respiration in the water column, and by decreasing dissolved oxygen saturation values (Blumberg and DiToro 1990 in Mortsch et al. 2003:91; in MNR, 2011).

Mercury release and uptake by biota will likely increase in anoxic conditions because heavy metals such as mercury become more soluble in the absence of oxygen. Metabolism increases at higher temperatures, which increase both the level of mercury accumulation and the susceptibility of fish to it (Macleod and Pessah 1973; in MNR, 2011).

Biological Diversity

In some of the deep stratified lakes, if dissolved oxygen concentrations do not become limiting cold-and cool water fishes are also expected to benefit because this level of warming will not exceed thermal tolerance and will promote metabolic activity (Magnuson et al. 1997; in MNR, 2011). In contrast, smaller and shallower lakes may experience a significant loss of cold hypolimnetic volume and consequently coldwater fish may lose habitat (Allan et al. 2005, Magnuson et al. 1997; in MNR, 2011). Lake trout will likely disappear from a number of the shallower lakes in Ontario as temperatures rise. Therefore, lakes with maximum depths of less than 20 m were assessed as having high risk of losing lake trout populations due to hypolimnetic habitat loss associated with a warming climate. Lakes with maximum depths of less than 25 m were considered at moderate risk of losing lake trout populations (Jackson 2007; in MNR, 2011).

7.2.3.2.2 Potential Site-Specific Effects on the Project Study Area due to Climate Change

As noted in the previous section, climate change may result in a number of effects on the Kabinakagami River, even in the absence of the proposed Project facilities. Such changes may include:

- lower summer flow rates
- earlier onset of spring freshet conditions and earlier ice-out
- increased flood levels during more extreme precipitation events
- increase water temperature and loss/decrease of cold water habitat
- decreased dissolved oxygen levels
- increased generation and toxicity of mercury.

The literature on climate changes predicts that these effects may occur on aquatic environments throughout Canada, potentially including the Kabinakagami River, in the absence of the proposed facility. The following sections assess the potential incremental effects that the proposed facility may have on these variables.

Flow Rates

Environmentally, lower river flows would not be aggravated (i.e., reduced further) by operation of the Project, since the run-of-river mode of operation will continue, with all flows being passed through the generating stations and not stored at any time. Therefore, while there may be less water in the Kabinakagami River as a whole due to the potential long-term effects of climate change, operation of the facilities will not result in any change in the amount of flow in the river. Decreased overall flows in the river may result in lesser durations of the time that water is passing over the spillway (if the flow peaks are shorter duration and lesser magnitude), but this is not anticipated to have any negative effects on VSCs or VECs. Potential lower flows in the river overall due to climate change may have a number of adverse effects on VSCs and VECs in the river upstream and downstream from the facilities (e.g., decreases in aquatic habitat and corresponding effects on biota, impaired river navigation), but the operation of the facilities is not anticipated to worsen any of these potential effects of climate change.

Maintaining the head ponds within the Target Operating Zone will prevent significant decreases in water level due to very low flows, although if the frequency of flows between 8 and 20 m^3/s increases, there would be a corresponding increase in the frequency of operation within the Low Water Zone (in operation due to turbine limitations when flows are less than 20 m^3/s), which could result in an increase in the frequency of very minor water level fluctuations in the head ponds and downstream reach. However, the minor magnitude of these fluctuations when the facility is operating within the low water zone is not anticipated to have any measurable negative effect on the aquatic environment within the head ponds or downstream from Site 6 – Wapoose.

Decreased summer flow rates could potentially result in an increase in the frequency of flow being below the minimum operational level of the proposed facilities (i.e., 8 m^3/s). Under current hydrological conditions (based on the hydrological record), flows below this level occur approximately 3% of the time, but do not occur in all years. Increasing the frequency and/or duration of such low flows would result in the proposed facilities being shut down more often. When this occurs, as noted in Section 5.9.2.1, the facilities will shut off and pass 3 m^3/s through the turbines to maintain downstream flow, while 5 m^3/s is retained to fill the head pond to above the spillway such that spilling commences. Once this occurs, all flow through the turbine will be shut down and all flow in the river will be flowing over the spillway. Under a worst-case scenario (i.e., all head ponds at the bottom of the Low Water Level zone), the amount of time required to fill all head ponds and commence spilling would be 9.6 hours. During this time period, flow, water level and wetted perimeter in the Kabinakagami River downstream from the facilities will continue to decrease until all reaches of the river downstream are at 3 m^3/s and then it will remain stable until spilling commences and flow increases to the natural level throughout the river. Negative effects on aquatic biota due to dewatering along the shorelines could potentially occur during this situation. In order to mitigate this potential effect, as noted in Section 5.9.2.1, when flows in the river reach 12 m^3/s and are continuing to decrease, Northland will operate the head ponds as close to the spillway crest level as possible, so that in the event the facilities have to be shut down due to low water levels, the amount of time required to commence spilling is minimized.

Evaporation rates may increase in rivers and lakes due to warmer air temperatures as a result of climate change. Earlier ice-out and later ice-in during the spring and early winter respectively, may increase the susceptibility of the river to higher evaporation rates and therefore, decrease in flow due to water loss. However, this effect would be occurring throughout the Kabinakagami watershed and the incremental effect caused by the increased surface area of the head pond is negligible compared to the overall surface area of the river that will be subject to increased evaporation.

Earlier Onset of Spring Freshet Conditions and earlier Ice-Out

Climate change could potentially result in earlier onset of ice-out and spring freshet conditions in the Kabinakagami River due to earlier snow melt and more precipitation earlier in the late winter/early spring than it currently occurs. However, due to the run-of-river nature of the proposed facilities, all flow that enters the head ponds will be passed downstream, with no effects on downstream flow rate. All flow in excess of the capacity of each of the facilities will be passed over the spillway. Therefore, regardless of when the spring freshet occurs, there will be no effect on downstream flow rates, since there is no storage occurring within the head ponds and all flow is passed downstream. Therefore, the presence of the facility is not anticipated to have any negative effect on the river and its biota due to the earlier onset of spring freshet conditions as a result of climate change.

Increased Flood Levels During More Extreme Precipitation Events

Increased flood levels during extreme precipitation events will cause natural increases in water level in each of the head ponds, as would occur in the absence of the facilities. Since the facilities have no ability to control water levels when flows exceed the powerhouse capacity, water levels in the head pond will rise and fall based on the natural amount of inflow coming into the head ponds, in a similar manner as would be occurring in all other areas of the Kabinakagami River. An increase in the rate at which flows rise and fall may result in increased levels of shoreline erosion, but again, this effect would likely be occurring in all areas of the river and is not isolated to the proposed head ponds. Earlier ice-out may subject the shorelines of the head ponds to increased susceptibility to erosion during late winter storms and precipitation events if ice cover is not present to protect shorelines. No additional mitigation is possible to prevent the potential for increased erosion due to ice out and extreme precipitation events, since flows cannot be controlled at that level. However, shoreline erosion monitoring is proposed over the life of the facilities, so any increase in erosion due to such occurrences would be noted and remediated as necessary, through consultation with CLFN and regulatory authorities.

The facilities have been designed in accordance with provincial dam safety standards and industry standard practices.

Increased Water Temperature

Decreases in summer flow rates in the river, particularly when coupled with hotter summer months as a result of climate change, could result in an increase in water temperature within the head ponds, due to less flow and corresponding increase in residence time. The increase in residence time would result in an increase in the amount of time that the surface is exposed to sunlight in the head ponds, and therefore, particularly if climate change results in greater intensity of sunlight, the increase in head pond surface water temperature as water flow travels through the Project reach may be greater than that occurring under conditions where the facilities were not present. The potential increase in water temperature would be anticipated to occur primarily around the shallow shorelines where sunlight may be able to penetrate throughout the shallower water column and these areas may be subject to less flow circulation than within the centre of the channel. However, the deeper portions of the head ponds in the main channel will not be as exposed to the warming effects of increased air temperature and sunlight intensity and would be anticipated to maintain similar temperature as inflowing waters into the head pond. During operational periods water will be drawn into the powerhouses from the full depth of the water column, therefore a portion of the discharge from each powerhouse will be from the deeper cooler waters to maintain water temperature downstream. During extremely low flow periods when flows decrease below the operational threshold of the facilities and all flow is spilled, water will discharged from the surface of the head ponds and therefore, has the potential to be slightly warmer due to increased exposure to higher air temperatures and increased sunlight intensity due to global warming. Therefore, the proposed Project may result in increases in water temperature within the head ponds and in the downstream flow, particularly during very low flow periods, than what would be occurring if the facilities were not in place.

Increased water temperature is not anticipated to have any negative effects on any of the species that are predicted to flourish within the head pond environments such as Walleye, Northern Pike, White Sucker and Yellow Perch, since these species are tolerant of warmer water environments.

However, this could potentially result in a decrease in suitability of habitat downstream from Site 6 – Wapoose for cold-water species such as Brook Trout. Such species may not be able to utilize the main river channel or portions of it, having instead to seek out thermal refuges in groundwater fed tributaries or in groundwater upwellings in the main channel. However, climate change may result in a long-term temperature increase in the Kabinakagami River, even if the Project were not in operation. As noted throughout the literature review in 7.2.3.2.1, climate change may have negative effects on coldwater species such as Brook Trout in many river systems due to low flows and temperature increases. The potential incremental effects due to the presence of the Project are considered to have minor potential to affect local Brook Trout populations in the river downstream from the facilities, but generally, if climate change predictions are borne out, the incremental effect due to the proposed facilities will be very minor compared to the effects that will be occurring throughout Canada.

Decreased Dissolved Oxygen

Climate change has the potential to result in decreased dissolved oxygen throughout river and lake systems due to higher water temperatures, lower flows and less circulation. Higher temperatures within the shallower portions of the head ponds could also potentially result in slightly lower dissolved oxygen levels in the future. However, based on the timeline for potential climate change predictions to occur to a level that would have substantial effects on dissolved oxygen, it is anticipated that the facility head ponds will be into a natural state of organic decomposition and association biological oxygen demand (i.e., the increased decomposition predicted to occur in the years immediately following head pond inundation will have been restored to naturally occurring levels), such that no incremental impact on dissolved oxygen is anticipated to occur in these shallow areas. Dissolved oxygen within the main river channel in the head ponds is not anticipated to decrease to levels that would have any negative effects on biota, since water temperatures will remain more stable in the deeper areas, no thermocline is anticipate to develop in head ponds and flow circulation will continue to occur within these areas.

Increased Mercury Generation and Toxicity

Methyl mercury production due to initial head pond inundation is anticipated to be returned to natural baseline levels over a period of up to 30 years. The 2001 IPCC report predicts a 1.4 to 5.8°C global average temperature increase over the period 1990 to 2100. While this data does not provide any indication of actual increases within the Study Area, assuming that these average predictions do occur in a linear rate between 1990 and 2100, the projected temperature change between the years 2015 and 2040 (the expected duration of elevated mercury concentrations due to the Project) would range from 0.356 to 1.476°C. The anticipated water temperature increase associated with such an increase in air temperature, particularly at the channel bed of the head ponds where methyl mercury generation occurs will be lower. Such a water temperature increase is not anticipated to have any effect on mercury generation, particularly near the end of the period where elevated methyl mercury generation levels will be much reduced compared to peak levels. Therefore, higher mercury generation rates and increased mercury toxicity could occur throughout the Kabinakagami River watershed, but it is not anticipated that the specific effects of the Project will act cumulatively with the overall effects of climate change to result in higher mercury levels in surface water and aquatic biota and fish.

7.2.3.3 *Mitigation Measures*

No specific mitigation measures are proposed to prevent/minimize negative effects on the environment due to the effects of climate change acting on the Project. The run-of-river mode of operation will substantially mitigate potential changes in the environment due to the effects of climate change acting on the Project, to the extent possible.

7.2.3.4 *Net Effects and Significance of Net Negative Effects*

No net negative effects would be associated with a higher flow, wetter weather climate change scenario.

A lower flow, hotter weather scenario may result in a number of potential low-magnitude effects associated with the changes due to climate change acting with the Project including higher frequency of operations within the Low Water Zone, increase in the frequency of plant shut downs due to low flows (and associated decreases in flow downstream during the period until spilling commences) and increases in water temperature in the head pond due to lower flows and hotter temperatures throughout the summer period. This may affect cold-water fish species within and immediately downstream from the Project Area.

Value of Resource

Fish, including cold-water fish species such as Brook Trout, are highly valued by CLFN and members of the general public, so the value of the resource is ***High***.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of climate change. However, the incremental effects of climate change interacting with the Project are anticipated to be ***Low*** with respect to incremental changes in water temperature, water level fluctuations associated with increased frequency of operations within the Low Water Zone and potential increase in the frequency of flow decreases immediately following cessation of operations of the facilities during extremely low flow periods.

Geographic Extent of Effect

The geographic extent of effects is dependent on the magnitude of climate change. Effects, particularly those related to water temperature may have the potential to extend >500 m from the Project Area, therefore the geographic extent would be ***High***.

Duration and Frequency of Effect

The effects of climate change would be occurring throughout the duration of the Project upon their onset, so the duration would be ***High***.

Reversibility of Effect

The effects of climate change interacting with the Project may be ***Reversible*** if climate change started reversing.

Ecological or Social Context

The area is determined to have ***Moderate to High*** fragility with respect to effects of climate change due to the presence of cold water fish species, which could be affected by changes in water temperature in the Kabinakagami River.

Probability of Effect

The probability of climate change occurring within the lifetime of the Project to the degree where effects on environmental may occur due to operations of the Project is ***Unknown***.

Overall Assessment

Given the low magnitude of incremental effect on water temperature and flow/water level during low water periods, and the uncertain probability, the potential incremental effects of the Project due to climate change are considered to be ***Not Significant***. However, climate change itself could potentially result in significant effects on aquatic habitat and biota throughout Ontario and Canada.

7.2.4 Lightning Strikes

7.2.4.1 *Effects on the Project*

Lightning strikes to electrical equipment could damage or make the equipment inoperable. Depending on the severity of the event, it could affect the ability of the station to transmit power to the provincial grid. During such a scenario, the stations would shut down, but continue to pass all flow in the river through the turbines, as discussed in Section 6.2.2.

Lighting strikes would not be anticipated to cause fire in any Project equipment, although they could cause natural forest fires.

7.2.4.2 *Effects on the Environment*

If flow in the river is less than 12 m^3/s at the time of outage, there could be a short-term decrease in flow rate and water level downstream from the facilities, since a portion of the flow will be retained in the head ponds to fill them above the overflow weir to commence spilling. Given the small size of the head ponds, it is anticipated that the water level in the head pond would increase and spilling would commence in a relatively short duration of time, after which, natural water levels and flows would be restored. During this time period, there could be some decrease in water levels downstream from the facilities, which could result in mortality of benthic invertebrates and small fish if they are not able to mobilize out of the dewatered area, and alterations in habitat use. During such low flow periods, water levels in the Kabinakagami River will already be very low and fish will likely be using the deeper portions of the channel already. Therefore, effects are anticipated to be relatively low.

If flows are >12 m^3/s, no change in river flow would occur due to the outage with all flow being passed through the turbines, therefore, no negative effects are anticipated to occur.

7.2.4.3 *Mitigation Measures*

Mitigation in the event of an outage is to continue passing all flow in the river through the turbines if flow is >12 m^3/s in the river. If flow is <12 m^3/s the facility cannot indefinitely pass this low amount, then at least 3 m^3/s will be released downstream at all times, while the remainder is retained to fill the head pond to the level at which spilling commences, at which time, natural downstream river flows will be maintained.

7.2.4.4 *Net Effects and Significance of Net Negative Effects*

The net effects of a power outage due to a lightning strike during low flow periods (<12 m^3/s) would be a short term reduction in flow rates downstream from the facility until the head pond is filled and spilling commences. There would be no net negative effects if a power outage were to occur at higher flow rates, since all flow in the river will continue to be passed through the non-operating turbine.

Value of Resource

Surface water flows and levels and aquatic habitat and biota are highly valued by members of the CLFN and the general public since they support a valued fishery and other socio-economic uses of the Kabinakagami River (e.g., navigation),therefore, the value of the resource potentially affected is considered to be ***High***.

Magnitude of Effect
The magnitude of effect is considered to be ***Moderate***.

Geographic Extent of Effect
The geographic extent of reduced flows in the river would likely extend >500 m from the Project Area, therefore the geographic extent would be ***High***.

Duration and Frequency of Effect
The effects of a power outage due to lightning strike would be a short term occurrence until the head pond fills to commence spilling so the duration and frequency of such an occurrence would be ***Low***.

Reversibility of Effect
The effects on water levels and flows would be ***Reversible*** since natural flow conditions would be restored once spilling commences or the power is restored to the plant.

Ecological or Social Context
The area is determined to have ***Moderate*** fragility with respect to decreased flow rates at low flow periods.

Probability of Effect
The probability of a lightning strike causing a power outage at some point in the life of the Project is ***Moderate to High*** although the probability of an outage at flow rates less than 12 m^3/s is low.

Overall Assessment
Given the low probability of a lightning strike causing an outage at low flow periods, and the short duration time that the effect of reduced flows would occur, this is considered to be ***Not Significant***.

7.2.5 Ice Jams

7.2.5.1 *Effects on the Project*

Significant ice jams in the river upstream from a facility could temporarily limit flow to the facilities as water is backed up behind the ice jam and not available for streamflow.

7.2.5.2 *Effects on the Environment*

Ice cover forms on the Kabinakagami River during winter under existing conditions. With completion of the Project, it is anticipated that solid ice cover will form on the head ponds. The volume of ice on the head ponds may be higher than that formed on the river during existing conditions, as the surface area of the head ponds will be larger than the surface area of the river proper. However, it is possible that the ice thickness will be less than existing ice cover because it will be thermal cover only, formed without juxtaposition. During annual spring flood conditions above the rated flow of the generating units, the level of the head ponds will increase as excess flow is discharged over the spillways, resulting in break-up of the ice cover, which will then be discharged over the spillways. Some melting of ice may also occur along the periphery of the head ponds.

The elevation of the headpond at Site 3 - Neeskah under spring flood conditions is some 10 m lower than the river banks at the upstream end of the head pond, and some 25 m lower than the level of Constance Lake. Flooding conditions caused by ice jamming, should it occur, are therefore not anticipated at the Project Area or at Constance Lake.

Ice jamming and flooding conditions near the mouth of the Albany River, over 400 river km downstream of the Kabinakagami River project sites, are well known. The Albany River generates very large volumes of ice which accumulate at flat or narrow sections of the river and which introduce the reported flooding problems. Hatch has been conducting ice studies on behalf of Kashechewan First Nation over the past 3 years and it has been found that flooding is caused by a combination of rapid increases in flow rates and large volumes of sound river ice. Particularly, it has been found that without exception, winter conditions generate a massive volume of ice on the Albany River and that jamming and flooding can be predicted by, local spring flows and melt sequences only. Even if there were an increase in the amount of ice available to cause jams (which is thought to be unlikely), the risk of ice jam flooding would be unchanged.

It is therefore not anticipated that the Kabinakagami River Project will contribute in any way to the flooding problems at Fort Albany or Kashechewan. It is noted that river flows and associated ice generation at the Project site accounts for only about 3% of the Albany River flows at the location of Fort Albany. Most importantly: a) the Project is operated as a run-of-river facility without any change to downstream flow conditions, b) generation of ice volumes by the Albany River itself far exceed that required for initiation of ice jamming, c) spring flood melt sequences are dictated by climatic conditions, not the volume of ice on the river.

7.2.6 Severe Weather Conditions

7.2.6.1 Effects on the Project

Severe weather events (e.g., ice storms, tornadoes, etc.) could also potentially result in prolonged losses of access to the facilities or loss of communications.

Ice storms, such as the one that occurred in eastern Ontario and Quebec in 1998, could affect operational activities. Impacts could include loss of power to the site, unsafe working conditions and damaged/inoperable equipment and structural failure (e.g., transmission lines). Ice storms of the severity of those experienced in 1998 are a relatively rare event, but storms of less severity may still have the potential to impact operations.

Procedures will be developed and implemented by Northland specifying what safety measures will be employed during severe weather conditions. Northland will be able to operate structures manually if required. Northland will develop an occupational safety and communications plan to address potential safety issues.

7.2.6.2 *Effects on the Environment*

If severe weather were to cause a power outage, effects on the environment would the same as those discussed in Section 7.2.4 (power outage due to lightning strikes).

7.2.7 ***Sustained Drought***

7.2.7.1 *Effects on the Project*

Sustained drought would result in reduced river flow. This in turn could result in decreased quantity of water available for power generation which could adversely affect the economics of the Project.

7.2.7.2 *Effects on the Environment*

The run-of-river nature of facility operations would continue during a sustained drought, with all flow being passed over the overflow weirs when flow in the river is less than 8 m^3/s. Therefore, there would not be any negative effects on flow or water levels in the Kabinakagami River due to drought forcing the Project to temporarily cease operations. A drought of this nature occurring during a hot period would result in longer residence times and potentially increases in surface water temperature in the head ponds during the drought period. This could potentially result in a decrease in suitability of habitat downstream from Site 6 – Wapoose for species such as Brook Trout. Such species may not be able to utilize the main river channel or portions of it, having instead to seek out thermal refuges in groundwater fed tributaries or in groundwater upwellings in the main channel. However, sustained drought would likely have other negative effects on the aquatic biota in the Kabinakagami River unrelated to the Project, so the effect of slightly higher temperatures in the head ponds and immediate downstream area may be relatively low.

7.2.7.3 *Mitigation Measures*

No specific mitigation measures are proposed to prevent/minimize negative effects on the environment due to the effects of sustained drought acting on the Project. The run-of-river mode of operation will substantially mitigate potential changes in the environment due to the effects of drought acting on the Project, to the extent possible.

7.2.7.4 *Net Effects and Significance of Net Negative Effects*

A sustained drought during a hot weather period may result in low-magnitude effects associated with the changes due to drought acting with the Project, including increases in water temperature in the head pond due to longer residence time. This may affect cold-water fish species within and immediately downstream from the Project Area.

Value of Resource

Fish are highly valued by CLFN and members of the general public, so the value of the resource is ***High***.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude and duration of the drought and the weather at the time of the drought. However, the effects of drought interacting with the Project are anticipated to be ***Low***.

Geographic Extent of Effect

The geographic extent of effects is dependent on the magnitude of the drought and the weather at the time. Effects, particularly those related to water temperature may have the potential to extend >500 m from the Project Area, therefore the geographic extent would be ***High***.

Duration and Frequency of Effect

The effects of drought would be infrequent, but since the overall effects could extend through the operational period, the duration is ***High***.

Reversibility of Effect

The effects of drought interacting with the Project may be ***Reversible*** once the drought conditions ceased.

Ecological or Social Context

The area is determined to have ***Moderate to High*** fragility with respect to effects of drought due to the presence of cold water fish species.

Probability of Effect

The probability of a sustained drought occurring within the lifetime of the Project to the degree where effects on environmental may occur due to operations of the Project is ***Unknown***.

Overall Assessment

Given the low magnitude of effect and the uncertain probability, this is considered to be ***Not Significant***.

7.2.8 Forest Fires

7.2.8.1 Potential Effects on the Project

Forest fires occurring in the Project Area during operations could potentially result in

- requirement to evacuate the facilities
- preventing access to or from the facilities
- damage to structures and/or equipment, including the transmission line.

Should this occur, effects to the facilities could include risks to worker safety and financial costs associated with fire damage or shutdown requirements.

7.2.8.2 Potential Effects on the Environment

Forest fires occurring as a result of natural causes may have adverse effects on Project operations, including required shutdowns, damage to equipment and structures and worker safety risks. Burning of facility equipment and materials during a fire, should the facility area become engulfed, could potentially have adverse effects on air quality and surface water quality with corresponding effects on VECs and potentially VSCs due to harmful contaminants in the air or deposited in water.

7.2.8.3 Mitigation Measures

Throughout the life of the Project, Northland will stay in communication with MNR regarding fires in the area. An emergency response plan will be in place should forest fires approach the

Project Area. The plan would involve the evacuation of operators/maintenance staff and equipment away from the Project Area to minimize the equipment and materials that could be burned by a fire.

7.2.8.4 *Net Effects and Significance of Net Negative Effects*

The effects could vary depending on the severity of the fire but, assuming the mitigation noted above is sufficient to minimize the amount of equipment/material caught in the fire, effects would tend to be local in extent, minor in magnitude and short-term in duration. Some adverse effect on air quality would be anticipated to occur if equipment and material were to be burned during a fire. Deposition of ash within watercourses could have negative effects on surface water quality and biota.

Value of Resource

Since a number of VECs and VSCs could be negatively affected by a fire that burns Project equipment and materials, the value is considered to be ***High***.

Magnitude of Effect

The magnitude of effect is dependent on the magnitude of the fire and the amount and nature of Project equipment/materials burned in the fire. Assuming the worst case scenario of a large forest fire burning equipment/material at each Project work area, including hazardous materials (e.g., hydrocarbons), the magnitude of effect on the environment would be ***High***.

Geographic Extent of Effect

The geographic extent is dependent on the magnitude of the fire and the nature and amount of equipment/material burned in the fire. Large fires could cause effects >500 m from the Project Area, therefore the geographic extent would be ***High***, while small fires or fires that do not burn much Project equipment/material could cause effects that would be contained to the Project Area.

Duration and Frequency of Effect

The effects of a large magnitude fire occurring during operations could potentially be present for a longer period of time, so the duration and frequency of such a fire would be ***High***, although the duration of frequency of effects of a small controllable fire would be ***Low***.

Reversibility of Effect

The effects on VECs and VSCs after a fire are generally ***Reversible*** since they will eventually diminish to restore existing conditions.

Ecological or Social Context

The area is determined to have ***High*** fragility with respect to effects of a forest fire.

Probability of Effect

The probability of a fire is ***Low*** given the mitigation proposed.

Overall Assessment

Given the low probability of effect, this is considered to be ***Not Significant***.

7.2.9 Wildlife

7.2.9.1 Potential Effects on the Project

Wildlife, particularly bears, could potentially represent a hazard to worker safety throughout the operations period. Bears could potentially be drawn to the site due to the presence of garbage or food waste, which could result in interactions between bears and the workforce. All workers on site will undergo bear safety training prior to working on the site, including protocols regarding proper disposal of waste and how to react if confronted by a bear.

7.2.9.2 Potential Effects on the Environment

Nuisance wildlife may have to be captured and transported off-site if it presents a safety to operations and maintenance staff. This would be in accordance with MNR protocols for wildlife handling, removal and transport, and would be done by qualified individuals, likely from the MNR. Given this, no negative effects on the environment are anticipated to occur.