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CLIMATE CHANGE CONSIDERATIONS FOR THE PORT HOPE AREA INITIATIVE

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ABSTRACT

The Port Hope Area Initiative (PHAI) is a community-based program intended to develop a safe and long-term (approximately 500 years) solution for the management of historic low-level radioactive waste (LLRW) that has been present in the Port Hope area for many years. The PHAI undertakings involve the construction and management of two Long-Term Low-Level Radioactive Waste Management Facilities (referred to as the LTWMFs) in Port Hope and in Port Granby. These undertakings are currently undergoing detailed examination through the Environmental Screening process under the *Canadian Environmental Assessment Act*. The purpose of the study described in this paper was to provide information necessary to satisfy the requirements of the Scope of Environmental Assessment for the Port Hope and Port Granby Projects. In particular, the purpose of the study was to satisfy the requirements to evaluate greenhouse gas (GHG) emissions from the proposed PHAI initiatives and to evaluate the potential effect of climate change parameters on the two Projects.

The Port Hope and Port Granby Projects will contribute to Ontario's GHG emission inventory due to vehicle exhaust from excavation equipment and haul trucks during the construction phase of the LTWMFs. The construction phase of the Projects is of relatively short duration, and the contribution of GHGs from each Project was determined to be insignificant compared to Ontario's GHG emissions from the Construction and Transportations sectors.

The proposed project elements associated with the Port Hope and Port Granby Projects were each evaluated with respect to potential sensitivities to future change in climate parameters. Considering the potential changes to climate, a screening analysis of each element of the LTWMFs was undertaken. Because it is considered likely that the current design level storms will be exceeded within the next 500 years, it was determined that the stormwater management system was potentially sensitive to changes in climate. Regardless, the potential sensitivity is not considered to pose a potential risk to the public or environment.

1. INTRODUCTION

The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment prepared a General Guidance Document entitled *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners* (FPTCCCEA 2003) that outlines a procedure for assessing whether GHG emissions associated with a project are sufficient to be addressed in greater detail within the environmental assessment (EA) and whether greenhouse gas (GHG) management plans would be required. Based on the Guidance Document and preliminary comments from Environment Canada, this study:

- provides the necessary information to fulfill the climate change requirements of the scopes of the EAs for the Port Hope and Port Granby Projects;
- describes potential changes to the existing biophysical environment over the long term that could occur as a result of climate change and that are relevant to the Port Hope and Port Granby Projects; and
- addresses potential effects on the Port Hope and Port Granby Projects as a result of climate change.

Incorporating climate change considerations in EAs can help to determine whether project designs, works and activities are consistent with jurisdictional actions and initiatives to manage GHG emissions, such as under the Climate Change Action Plan for Canada. It can also assist proponents in using best practices that adapt to possible climate change impacts, such as changes in the frequency or intensity of extreme weather events, increases in mean temperatures or altered precipitation patterns and amounts.

The Guidance Document provides two practical approaches for incorporating climate change considerations in EAs:

1. GHG considerations: where a proposed project may contribute to GHG emissions.
2. Impacts considerations: where climate change parameters may affect a proposed project.

The 2003 FPTCCCEA Guidance Document (FPTCCCEA 2003) provides rationale for how these two types of climate change considerations could fit within a typical EA process (Table 1).

Table 1: Incorporating Climate Change Considerations into Environmental Assessments: Recommended Procedures (FPTCCCEA 2003)

EA Process	**GHG Considerations:** where a project may contribute to GHG emissions	**Impacts Considerations:** where climate change parameters may affect a project
1. Scoping	Preliminary scoping for GHG considerations	Preliminary scoping for climate change impact considerations
2. Data and Information Collection	If needed, identify GHG considerations: • industry profile • project specifics	If needed, identify impacts consideration on the project: • regional climate and related environmental considerations • project sensitivity
3. Analysis of Environmental Effects	Assess GHG considerations: • direct and indirect emissions • effects on carbon sinks	Assess impact considerations: • impact on project • risks to public and the environment
4. Identify Mitigation Measures	If needed, prepare GHG management plan: • jurisdictional considerations • project specifics, if appropriate	If needed, prepare impact management plan: • project specifics • ongoing data clarification
5. Monitoring and Follow up	Monitoring, follow-up and adaptive management measures	Monitoring, follow-up and adaptive management measures

2. GREENHOUSE GAS CONSIDERATIONS

For both the Port Hope and Port Granby Projects, the expected physical works or activities of the Construction and Development Phase are essentially large-scale earth-moving activities, using conventional earth-moving equipment, such as backhoes, front loaders, bulldozers, compactors, dump trucks, graders and cranes. GHG emissions associated with this project phase are from the combustion of fuel used to operate this equipment. Landfill gas from the Highland Drive Landfill in Port Hope, is also currently being released.

Emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) were calculated using diesel fuel combustion emission factors for off-road equipment, published by Environment Canada (2003). Fuel usage was estimated based on information from Chapter 7 of the Port Hope Project Environmental Assessment Study Report (MMM 2005) and Chapter 7 of the Environmental Assessment Study Report for the Port Granby Project (Golder 2005). These emissions were then converted into CO_2-equivalent emissions, using the global warming potential (GWP) value for each gas. GWPs are used to compare the abilities of different greenhouse gases to trap heat in the atmosphere. GWPs are based on the radiative efficiency (heat-absorbing ability) of each gas relative to that of carbon dioxide (CO_2), as well as the decay rate of each gas (the amount removed from the atmosphere over a given number of years) relative to that of CO_2. The GWP provides a method for converting emissions of various gases into a common measure, which allows climate analysts to aggregate the radiative effects of various greenhouse gases into a uniform measure denominated in carbon dioxide equivalents.

3. CLIMATE CHANGE CONSIDERATIONS

3.1 Introduction to Climate Change

The meaning of the term "climate change" within this study is consistent with its definition by the United Nations Framework Convention on Climate Change:

> *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."*

Within the context of this definition, climate change refers to any human-induced changes that are superimposed onto a background of natural climate variability that results from either internal instabilities in the ocean-atmosphere system, or triggering influences such as the El Niño -Southern Oscillation phenomenon, major volcanic eruptions or solar variability. Human-induced changes in climate are assumed to occur over time scales ranging from several decades to centuries.

3.2 Preliminary Scoping For Impact Identification

The first step in determining whether or not observed climate and climate change information needs to be evaluated in more detail in an EA is to determine whether a particular project has any sensitivity to potential changes in climate. Because construction activities occur within a relatively short timeframe, from 2007 to 2013, climate change impacts related to construction are not an issue and have not been considered. The LTWMFs; however, are being designed to provide effective containment for approximately 500 years, therefore, impacts from climate change could be possible.

Determination of project sensitivity to climate can be considered in a number of steps (Barrow and Lee 2000):

Step 1. Which components of the project are important to its success? These components will be project dependent and they should be readily identifiable by the proponent.

Step 2. Which key weather/climate parameters will either directly or indirectly affect the critical project components? A direct effect occurs in response to the elements of weather/climate themselves (e.g., heavy rainfall, flooding, extreme heat, cold, wind stress, etc.), while an indirect effect of weather/climate operates through an intermediate body and not on the project component itself (e.g., temperature influences permafrost which can have effects on the viability of the construction of a project in a particular area, although temperature may not affect the project directly).

Step 3. How sensitive is a project to changes in the key weather/climate parameters? Sensitivity can be categorized as low, medium or high, with high sensitivity implying that a project may fail as a result of its response to a change in the weather/climate parameter, while low sensitivity implies that a weather/climate parameter change will have little effect on the success of a project.

Step 4. Is the sensitivity of a project to weather/climate parameters dependent on a particular threshold value? As long as a particular weather/climate parameter is below a certain value, it may be that a project is not sensitive to this parameter. However, sensitivity may result if this particular threshold value is exceeded. This may occur either as a result of climate change, or simply due to natural climate variability. In the latter case, it is important to use as long a climate record as possible in order to determine the 'true' probability of a particular weather/climate event occurring.

Step 5. Are the key weather/climate parameters likely to be affected by climate change? Information regarding which weather/climate parameters are most likely to change in the future can be found in the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports and the Canada Country Study. One can also examine climate change scenarios available from the Canadian Institute for Climate Studies (CCIS) and from Environment Canada.

The key physical works and activities of both the Port Hope and Port Granby LTWMFs are:

1. Engineered Cover – multi-layer engineered cover approximately 2-m thick, consisting of a polyethylene geomembrane, sands, stones and soils and a vegetated cover. The Port Hope LTWMF will also have a geosynthetic clay liner (GCL);

2. Base Liner – composite liner system including a compacted clay layer and a high density polyethylene (HDPE) geomembrane. The Port Hope LTWMF has a double composite liner system;
3. LTWMF Leachate Collection System – consisting of a granular drainage layer and perforated high density polyethylene (HDPE) pipes to collect leachate. This system will be designed and installed to capture leachate during the construction and development phase when the site has no cover. Once the engineered cover system is in place, the quantity of leachate captured by this system would be substantively reduced;
4. Leachate Treatment System – leachate would be pumped from the LTWMF on a regular basis as required, and treated by the treatment system. This system is not hydraulically connected to surface and groundwater systems;
5. Stormwater Management System – consisting of a series of ditches and ponds. The ponds will be designed for an appropriate capacity (i.e., prevailing regional-scale storm event (RSE) or greater) and period of retention for settlement of suspended particulate. The system will discharge at a controlled rate; and
6. Environmental Monitoring Systems – as necessary: consisting of monitoring wells, grab samples, flow monitoring and monitoring for radioactivity. As required, equipment will be enclosed in a concrete block (or equivalent) structure, designed to applicable building codes.

For the life of the Port Hope and Port Granby Projects, there will be a monitoring/inspection and maintenance/repair program that will ensure that any repairs that may be required due to possible severe weather events will be conducted as required.

The climate change parameters that are considered to have a potential interaction with the LTWMF physical works and activities for both the Port Hope and Port Granby Projects are:

- temperature;
- precipitation;
- soil moisture and groundwater;
- evaporation rate; and
- wind velocity and extreme weather events (other than temperature and precipitation).

To further assess the potential interaction of climate change parameters with the Port Hope and Port Granby Project physical works and activities, a screening exercise was undertaken, to evaluate and rank each potential interaction. The *CEAA* Document (FPTCCCEA 2003) provides a methodology to assist in identifying project sensitivity to changes climate parameters. This screening exercise was conducted based on discussions with, and on the professional judgement of the Engineering Support Consultants who are designing the LTWMFs.

Each of the Port Hope and Port Granby Project physical works and activities have been evaluated against each climate change parameter, and assessed for potential sensitivity. A "Nil" rank was assigned if it was determined that the project physical work or activity was not sensitive to a change in the climate parameter. For example, a change to the mean annual temperature would have no effect on electrical components housed within buildings at the LTWMFs. A "Low" rank was assigned if it was determined that the project physical work or activity was unlikely to be sensitive to a change in the climate parameter. For example, changes to annual rainfall could affect the vegetation on the engineered cover; however, because of the robust design of the final cover system, rainfall would not affect the overall integrity of the cover. A "Medium" rank was assigned if it was possible that the project physical work or activity would be sensitive to a change in the climate parameter. Finally, a "High" rank was assigned if it was likely that the project physical work or activity would be sensitive to a change in the climate parameter.

The *CEAA* Guidance Document (FPTCCCEA 2003) specifies that the interactions (between climate change parameters and project physical works or activities) evaluated as being "Medium" or "High" risk should be assessed in more detail. The only project physical works or activities with a "Medium" rank in the screening exercise was the stormwater management system and its interaction with extreme precipitation events.

3.3 Methodology to Assess Risks Related to Climate Change

Each of the interactions between the climate change parameter and project physical work or activity were further assessed to determine:

1. the sensitivity of the project physical works or activities to the climate change parameter; and
2. the risk level of any impact to the public or the environment.

This was done following the outline in the Guidance Document that specifies:

> *"the analysis should consider the range of possible outcomes under which the climate parameter may adversely affect the project or one of its components. The practitioner should then determine if there are potential risks to the public or the environment if one or more project components is affected by identified changes to climate parameters."*

The Guidance Document methodology also describes four possible cases to be considered (as illustrated in Table 2). The methodology in the Guidance Document then relates the relationship between risk and the confidence level of that finding according to the four cases described in Table 2.

Table 2: Possible Cases for Assessing Risks to the Public or Environment

	High Risk of impacts to the public or the environment	**Low Risk** of impacts to the public or the environment
High Confidence Level of the project's sensitivity to a climate change parameter	**Case One** • Proceed with risk assessment outlined in Guidance Document • Implement appropriate monitoring, follow-up and adaptive management measures	**Case Two** • Practitioner should provide all relevant climate change information • Report in EA • No further action required
Low Confidence Level of the project's sensitivity to a climate change parameter	**Case Three** • Proceed with risk assessment outlined in Guidance Document • Emphasize the uncertainty inherent in the climate change data • Implement appropriate monitoring, follow-up and adaptive management measures	**Case Four** • No further action required • Report in EA

Table 3 provides the results of this assessment on the stormwater management system for the Port Hope Project. The same results were found for the Port Granby Project.

Table 3: Assessment of Interactions Related to Climate Change – Port Hope Project

Project Physical Work or Activity	Climate Parameter	Project's Sensitivity to Climate Change Parameter	Risk Level of Impacts to the Public or Environment	Case	Action
Stormwater management system	Extreme Precipitation	Stormwater system will, at a minimum, be sized for the 100-year design storm or the prevailing Regional Storm Event (RSE). It is possible that an extreme precipitation event greater than the design level event could occur. **High**	In the event of rainfall greater than that used for the engineering design, there may be some localized erosion of ditches and possibly soil cover layer, but the cover geomembrane and GCL liners and consequently the integrity of the LTWMF would not be affected, avoiding risk to the public and the environment. **Low**	Two	No further action

The results showed that, in spite of possible changes to the climate in the future, there were no climate change parameters that would have an effect on the project physical work or activity resulting in a risk to either the public or the environment.

Stormwater management systems are typically sized for the 100-year design storm or the prevailing Regional Storm Event (RSE). The General Circulation Model (GCMs) estimate (within the next 100 years) that storm intensity (not necessarily for hurricane level storms) may increase intensity by 40-50%, and the frequency of extreme weather events in the next 100 years may double. Results from the GCMs also suggest an increase in flooding events, though at this time the theoretical maximum rainfall intensity is yet to be defined. However, Environment Canada (2004) reported a rainfall event in 1989 in Essex County, Ontario (along Lake Erie) of 264-450 mm over a two-day period. Thus, a one-day rainfall event of up to 300-400 mm over the next 500 years is plausible.

The analysis documented in the interactions tables showed that the effect of exceeding the design capacity of the stormwater system may include overflow f the system and some localized soil erosion. There will be neither adverse effects to the LTWMFs nor any risk to the public or the environment as a result of the stormwater system capacity being exceeded. Stormwater would not be contaminated and any localized soil erosion from the stormwater system is easily repairable. Also, any damage due to localized erosion would be identified as part of the ongoing maintenance program. As a result, it is judged that, at this stage of the design effort, the additional cost to construct stormwater management systems using design parameters based on (very) theoretical maximum weather event estimates from the GCMs is not warranted.

Although this analysis has indicated that there is no risk to the public or environment, as part of the Port Hope and Port Granby Projects' adaptive management plans, periodic updating and adjusting of the operations and maintenance of the LTWMFs will be undertaken. During such ongoing maintenance activities, the need to re-assess the design of the stormwater management systems or other components of the LTWMF may be identified and modifications implemented, as required.

3.4 Assessment of Climate Change Impacts

The first step in incorporating consideration of future climate change (e.g., in the EAs for the Port Hope and Port Granby Projects) should be a thorough analysis of current climate conditions, including climate variability. Such analyses are valuable for determining how climate changes might affect such waste management systems and, ultimately, for providing a reference with which to compare the results of any climate change studies.

'Current' climate, also commonly referred to as the *reference* or *baseline* climate, generally corresponds to the climate of the current 30-year *normal* period, as defined by the World Meteorological Organization (WMO) (1983). Usually, the climate of the 30-year period comprising the current normal period ("climate normal") is summarized in terms of its averages, variability and minimum and maximum values

The GCMs, and in particular, coupled Atmosphere-Ocean GCMs are the primary tools used to generate global-scale scenarios of climate change at broad spatial and temporal scales. Although there has been much progress in the refinement of GCM projections in recent years, the accuracy of GCM predictions is still uncertain, even with respect to representations of current climate conditions. Moreover, GCMs differ in their internal parameterizations so that, for any given scenario, there exist a range of possible outcomes depending on which model is used. Nevertheless, data from currently available GCMs project increasing global average temperatures in response to increases in GHG concentrations. To date, climate change scenarios for the Great Lakes Basin have generally been derived from GCM projections. Scenarios have been calculated estimating potential changes in mean seasonal temperature and precipitation in the Basin in response to a doubling of the atmospheric carbon dioxide concentrations above the current level (i.e., $2 \times CO_2$).

GCM-based transformations of climate changes are best suited for projections of large-scale temporal and spatial changes: annual, seasonal or monthly mean temperature and precipitation at global, hemispheric and continental spatial scales. One of the primary advantages in using GCMs is that the internal consistency and physical basis of the models provide plausible estimates of changes in climate variables at these scales, although the plausibility of projected changes is greater for temperature than for precipitation (Beersma *et al*. 1997). In addition, such models are relatively easy to implement and the internal consistency set of the large-scale changes makes comparisons between different scenarios relatively easy.

For many climate change studies, including those for EAs, scenarios of climate change derived directly from GCM output may not be of sufficient spatial or temporal resolution. The spatial resolution of GCMs, in particular, means that the representation of, for example, orography and land surface characteristics, is much simplified. Also, at the present time, the GCMs do not include some of the characteristics that may have important influences on regional climate (e.g., the Great Lakes system in North America) (Barrow and Lee 2000).

Therefore, when assessing climate change at the regional level, it is necessary to employ some other method to derive regional estimates that may be evaluated in conjunctions with the GCM predictions. This is referred to as downscaling. There are several methods that can be employed for this purpose:

- process-based techniques;
- empirically-based techniques;
- historical or spatial analogues; and
- synthetic climate generators.

Process-based techniques may consist of simplified 1-dimensional or 2-dimensional climate models. Alternatively, they may employ detailed mesoscale, high resolution 3-dimensional models either separately or nested within large-scale GCMs. Empirically-based techniques may include statistical weather generators or local area atmosphere-surface transfer functions with links to synoptic scale circulation features derived from GCM projections. Historical analogues may include using surrogate variables to estimate paleo-climates or using actual measured data on climate variability if suitable data are available from historical instrumental records. Spatial analogues may use climate information from another location where the climate may be warmer/colder, wetter/drier than the current climate in the region of interest. Synthetic climate generators may employ arbitrary adjustments to one or more climate variables individually.

In attempting to define potential changes in climate in the Great Lakes region over the next 500 years, it is necessary to consider variability that stems from both natural causes and potential anthropogenic-induced climate forcing. In general, climate change modelling that is related to the effects of increased GHG emissions from fossil fuel combustion has focused on predicting climatic changes over the next century (i.e., to 2100) often assuming doubling of the CO_2 concentrations in the atmosphere. Since the atmospheric lifetime for most of the major GHG may range from 50 to 200 years, any shifts in climate parameters due to a $2\times CO_2$ climate scenario would only be applicable to the state of the climate 500 years from present if it is assumed that there will be no additional changes in socio-economic conditions and/or technological advances in either energy generation or associated energy-related GHG emissions. However, given the rapid advances in technological sophistication that have arisen over the past century as well as the increasing pace of technological change over the same period, it is unreasonable to assume that energy policy will continue to rely on fossil fuel combustion over the next 500 years as well. It is simply not possible at present to predict how energy will be generated 100 years from today, let alone 500 years into the future.

In fact, it is conceivable that, with a switch to alternative energy generation over the next 100 years, atmospheric CO_2 levels 500 years from now could return to current concentration levels. If that were to occur, the main drivers for climate change would be the same natural climate forcing mechanisms that have influenced climate in this region in the past. It is entirely possible that the climate in the Great Lakes region 500 years from present could be cooler and wetter than today, rather than warmer and drier as predicted by some GCMs that focus on CO_2 forcing over the next 100 years. As such, the evaluation of potential climatic influences on the long-term management of low-level radioactive waste cannot rely only on projected climate scenarios that are based solely on GHG forcing. The approach to this study was to include alternative scenarios that also reflect the natural variability of long-term climate change.

In general terms, GCM simulations for the Ontario-Great Lakes Basin, suggest:

- A 3 ^{o}C to 9 ^{o}C increase in average temperature, being more pronounced in winter than in summer;
- A northward translation of the 0^{o} C isotherm;
- An increase in total precipitation from +10 % to +40 %. However, other simulations show a decrease in precipitation, by about -20 %;
- Seasonally, the winter and spring will become wetter, and the summer and autumn, drier;
- A decrease in the duration of the snowfall season;
- Greater evaporation and evapo-transpiration (from bare soil, vegetation) will occur, beginning earlier and continuing longer throughout the hydrological year;
- Greater lake evaporation will occur, resulting in large reductions in lake levels, by 1 m or more;
- Decreases in soil moisture in southern areas and increases in the north;
- Decreases in surface runoff; and
- Earlier occurrence of snowmelt and spring runoff.

More precise values and ranges cannot be provided to all of the above listed projected climate conditions due to the inherent limitations of GCMs. GCMs perform reasonably well at representing large-scale features of the climate at global, hemispherical and continental levels. Relative confidence in GCM results decreases more so at regional and "local" spatial scales, particularly with respect to the geographical distribution of change within a specific study area. This, therefore, has implications for the present study.

Overall, GCMs are excellent tools for investigating climatic change within the next 100 years. However, at present these models have limited capability to adequately represent plausible future changes at regional scales.

3.4.1 Analogue Climate Scenarios

Analogue scenarios are constructed by identifying a recorded climate regime that may resemble the future climate anticipated for a particular site or region. These recorded climates may be identified in the long observational record at a site (*temporal analogues*) or be from other geographical locations (*spatial analogues*). The observations from an earlier part of the instrumental record or from another site are then used to represent the climate scenario. Such records can be employed to evaluate the impact of a changed climate on a project and they have the advantage of representing conditions that have actually been observed and experienced.

Spatial analogues use regional data which today have a climate analogous to that anticipated for the study region in the future. In essence, the climate record from one location is assumed to represent the future climate at a different location. The main disadvantage of using spatial analogues as scenarios of future climate relates to the lack of correspondence between such features as day-length, vegetation cover, soil type, proximity to large water bodies such as the

Great Lakes or other geographic features. This means that it is unlikely that the spatial analogue scenario would represent physically-plausible conditions for a project site in the future (Barrow and Lee 2000).

An alternative to the generation of future climate scenarios from GCMs, and the one that is used in this study, is to employ temporal analogues (also called "historical analogues"). Namely, temporal analogues use historical climate data from the distant or recent past to:

1. Identify and quantify the climate of markedly "warm", "cold", "wet" and/or "dry" climatic periods.
2. Extrapolate these regimes "forward in time" (relative to the present), assuming that they are a plausible representation of some future climate.

In essence, the climate of the past is used as an analogue for a plausible future climate.

4. RESULTS

As the length of these two Projects is approximately 500 years, thus extending 400 years beyond the current GCMs' predictive capability, a second approach for evaluating climate change is also provided. This approach, known as a climate analogue, is based on the historic data record for a relatively defined geographic area (i.e., the analogue data applies to the two Projects' area along the north shore of Lake Ontario), and estimates (using statistical techniques) values to bound the range of key climate parameters: for a wet scenario; dry scenario; cold scenario and warm scenario. This is not a predictive modelling technique, but provides an extrapolation based on the range of existing data in the Port Hope area.

The results from the combination of the GCM, climate analogue, and temporal analogue analyses, with a focus on Southern Ontario, are provided below:

	GCMs for Southern Ontario	**Analogue**
Total Annual Precipitation (total of snow and rainfall)	Min – 665 mm Max – 915 to 1165 mm	• Dry Scenario – 675 mm • Wet Scenario – 1050 mm
Total Annual Rainfall		• Dry Scenario – 600 mm • Wet Scenario – 940 mm
Total Annual Snowfall		• Dry Scenario – 70 cm • Wet Scenario – 250 cm
Frequency and/or Severity of Precipitation Extremes	In the next 100 years the frequency of extreme events will increase and possibly double, therefore the 1-in-100 year storm may become a 1-in-50 year storm. (Kharin and Zwiers 2003)	• Rainfall – return period of maximum daily event (144.8 mm) is six years • Snowfall – return period of maximum daily snow event (61 cm) is 14 years • It may be possible for a maximum daily rainfall event of 300 to 400 mm within the next 500 years
Frequency and/or Severity of Extreme Daily Temperature	McGuffie et al. 1999 • Warm Scenario – some GCMs indicate maximum temperatures could exceed 40°C • Cold Scenario – minimum temperatures < -20° C are predicted.	• Warm Scenario – maximum temperature 39° C • Cold Scenario – minimum temperature -39° C

5. CONCLUSION

GHG emissions were calculated with available data, for several points in time during the Construction and Development Phase of the Port Hope and Port Granby Projects. Where possible, years with high emission rates were assessed to determine the maximum potential GHG emissions. The calculated emissions were only a very small portion (much less than 0.1%) of the provincial GHG emissions in the construction and transportation sectors. Therefore, no management or mitigation measures are required with respect to the generation of GHGs.

A climate change assessment was conducted following the methodology outlined by the *CEAA* Guidance Document (FPTCCCEA 2003). Considering possible changes to climate parameters in the future, it was determined that there were no climate parameters that would have an effect on either the Port Hope or Port Granby Project physical works or activities resulting in a risk to either the public or the environment. Therefore no management or mitigation measures are required with respect to climate change impacts.

The analysis addressed potential effects of various climate parameters on the works and activities for the Port Hope and Port Granby Projects. Only the stormwater management system was identified as possibly being sensitive to the effects of climate change, namely extreme precipitation events. Given the low sensitivity of each of the Project's works and activities to each of the climate parameters identified in the previous analysis, any potential effects of changes to multiple climate parameters (e.g., increased temperatures accompanied by less precipitation) seem highly unlikely. Nonetheless, ongoing inspection and maintenance will facilitate the early identification of system elements that may require future modification.

This analysis was undertaken to assess the potential effects of climate change on the Port Hope and Port Granby Projects for its current planned life to approximately year 2500.

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