Environment

Guide to Considering Climate Change in Project Development in Nova Scotia

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GLOSSARY

Adaptation

Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

Adaptation benefits

The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

Adaptation costs

Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

Adaptive capacity

The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with the consequences. It is a function of the project resources, access to information on climate variability and change, and skills to make use of the information. (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

Aerosol

A suspension of fine solid or liquid particles in gas e.g. smoke, fog, mist.

Afforestation

The act or process of establishing forest on lands that are not forested.

Carbon Dioxide Equivalent (CO_2e)

The concentration of CO_2 that would cause the same level of radiative forcing as a given type and concentration of greenhouse gas.

Carbon footprint

The total amount of greenhouse gas emissions caused directly and indirectly by a project expressed by the amount of tonnes of carbon dioxide (equivalent of greenhouse gases) emitted.

Carbon sequestration
The removal and storage of carbon from the atmosphere in carbon sinks (such as oceans, forests, or soils) through physical or biological processes, such as photosynthesis.

Carbon 'sink'
A natural or man-made reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.

Climate change
A change of climate 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 (UNFCCC 2010).

Climate scenario
A projection of future climatic conditions.

Climate variability
Fluctuations in climate over a shorter term - the departures from long-term averages or trends, over seasons or a few years, such as those caused by the El Niño Southern Oscillation phenomenon.

Deforestation
The act or process of clearing forests.

Disaster
A serious disruption of the functioning of a community or a society causing widespread human, material, economic, or environmental losses that exceed the ability of the affected community/society to cope using its own resources. It results from the combination of hazards, conditions of vulnerability, and insufficient capacity or measures to reduce the potential negative consequences of risk.

El Niño-Southern Oscillation (ENSO)
An irregularly occurring pattern of abnormal warming of the surface coastal waters off Ecuador, Peru, and Chile. This coupled atmosphere-ocean phenomenon is associated with the fluctuation of inter-tropical surface pressure pattern and circulation in the Indian and Pacific oceans, called the Southern Oscillation. This phenomenon triggers a shift in seasonal patterns of weather systems over many subtropical and mid-latitude parts of the globe. La Niña is the opposite of an El Niño event, during which waters in the west Pacific are warmer than normal and trade winds are stronger.

Greenhouse Gas
Gases listed in the Kyoto Protocol including: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6) (UNFCCC 2010a).

Hazard
A source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these.

Mitigation
Measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards. In the context of climate change, mitigation means a human intervention to reduce the sources or enhance the sinks of greenhouse gases (Climate Change 2001: The Scientific Basis. IPCC TAR, 2001).

Resilience / resilient
The capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the system is capable or organizing itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Risk
The chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value.

Risk management
The systematic application of management policies, procedures, and practices to the tasks of analysing, evaluating, controlling, and communicating about risk issues.

Sensitivity
Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

Vulnerability
The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is the function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. (Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC TAR, 2001).

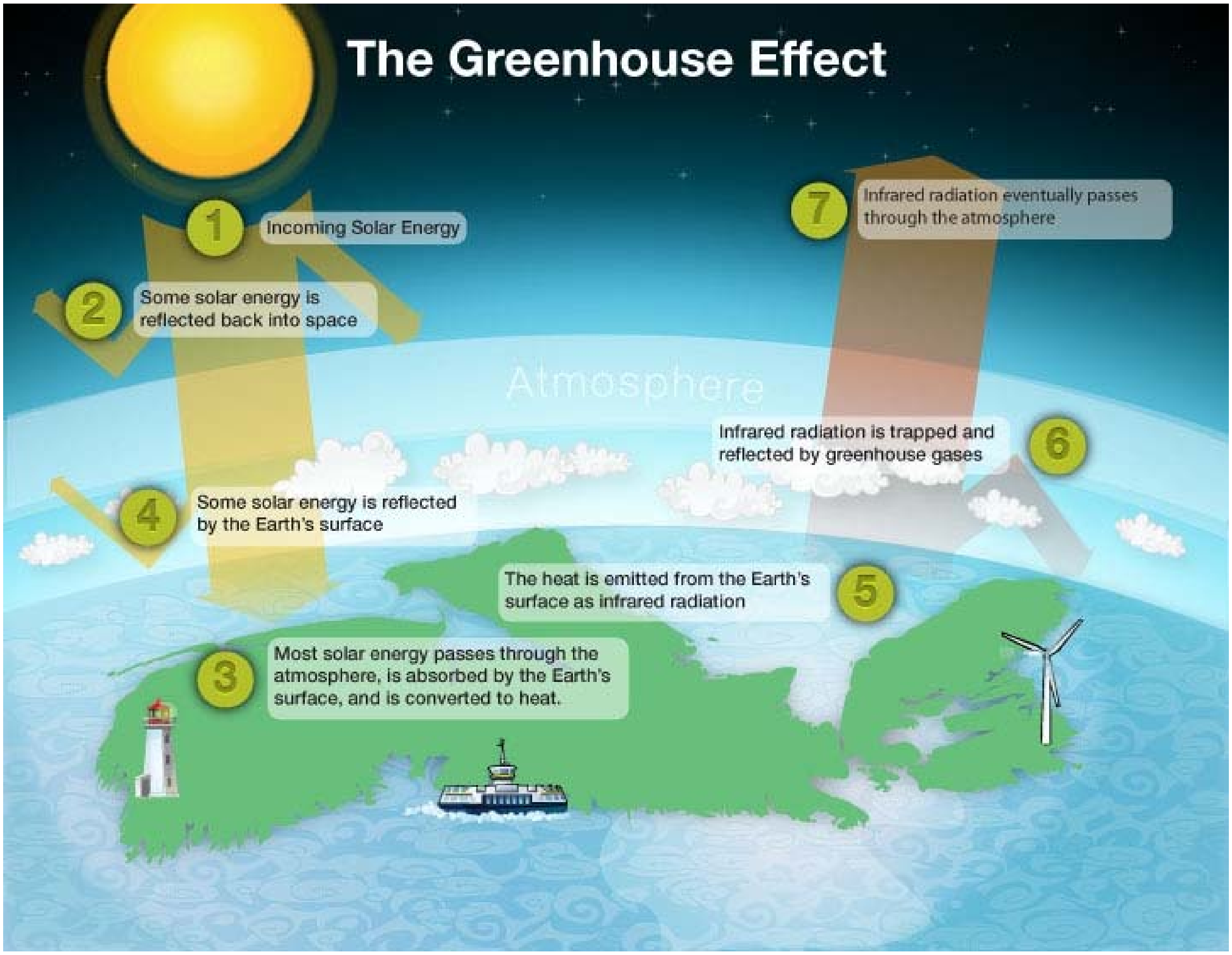
ABBREVIATIONS AND ACRONYMS

AOGCM	Atmospheric-Ocean General Climate Model
AR4	Fourth Assessment Report (of the Intergovernmental Panel on Climate Change)
CCS	Carbon Capture and Storage
CO_2e	Carbon Dioxide Equivalent
ENSO	El Niño-Southern Oscillation
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organization
NSE	Nova Scotia Environment
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
WBCSD	World Business Council for Sustainable Development

1.0 INTRODUCTION

1.1 Climate Change Mitigation and Adaptation

Since the start of the industrial revolution, human activities have been causing greenhouse gas (GHG) levels in the atmosphere to rapidly increase. These gases help control the earth's temperature to make it habitable. However, as the graphic below explains, increased levels of GHGs have caused an imbalance that results in climate change, having a dramatic effect on the climate system and people's lives, especially in vulnerable coastal regions like Nova Scotia.



According to the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), warming of the climate system is now evident from increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global mean sea levels. Previous IPCC projections of a temperature rise of between 0.15 to 0.3 degrees centigrade per decade are now supported by an observed global value of 0.2 degrees centigrade per decade. For the next two decades, a warming trend of about 0.2 degrees centigrade is projected for a range of greenhouse gas (GHG) emission scenarios. Even if the concentration of all greenhouse gases and aerosols is kept constant at year 2000 levels, a further warming of about 0.1 degrees centigrade per decade is expected.

As a consequence it is anticipated that sea-levels and global sea water temperature will increase; weather patterns will change resulting in an increase in the frequency and intensity of extreme events (droughts, floods, etc.) and possibly hurricanes. All these features combine to pose a serious threat to Nova Scotia's sustainable development objectives.

There are two types of responses to climate change: mitigation and adaptation.

Mitigation aims to avoid, reduce or at least limit climate change by reducing greenhouse gas (GHG) emissions through: energy efficiency, the use of renewable energy such as solar and wind power, reducing or capturing/storing GHG emissions, restoring, enhancing, and preserving forest and wetlands that act as carbon 'sinks'. ***Adaptation*** consists of action(s) to reduce the consequences or avoid impacts of climate change on a project, thereby reducing potential for costly modifications to projects in areas prone to climate change impacts. ***Both*** mitigation and adaptation help to reduce risks to projects associated with climate change from both regulatory risks, such as cap-and-trade or carbon tax legislation, and the risks associated with climate change impacts, *e.g.* increased storm surge elevations. By addressing climate change at an early stage in a project's development, proponents can potentially reduce operational costs associated with emissions and the maintenance of vulnerable infrastructure. Responses to both can be readily incorporated into EA.

While mitigation is crucial to limit medium and long-term impacts from climate change, climate change is already happening, and will continue and is expected to accelerate until the levels of GHGs that are currently in the earth's atmosphere are reduced. Many GHGs take approximately 100 years to naturally dissipate. Adaptation measures are needed because some climate change is already occurring and will be unavoidable regardless of efforts taken to reduce future emissions in the short term.

1.2 Nova Scotia Climate Change Legislation and Strategy

The *Environmental Goals and Sustainable Prosperity Act, 2007* established the long-term environmental and economic objective for Nova Scotia to fully integrate environmental sustainability with economic prosperity and to demonstrate international leadership by having one of the cleanest and most sustainable environments in the world by the year 2020. The *Act* lays out key targets relevant to climate change and projects requiring EA in Nova Scotia including:

- 10% reduction of GHG emissions (below 1990 levels);
- 18.5% of total electricity needs to come from renewable energy sources by the year 2013;
- development of a comprehensive water-resource management strategy by 2010;
- a policy of preventing the net loss of wetlands to be established in 2009; and
- by 2010, Nova Scotia will adopt strategies to ensure the sustainability of the Province's natural capital in forestry, mining, parks, and biodiversity.

Nova Scotia's Climate Change Action Plan (2009) succinctly identifies the 'triple threat' of challenges to Nova Scotia when it comes to addressing climate change, these challenges also represent the reasons why addressing climate change is so important:

- "*Because most of the energy we use comes from fossil fuels, we have an unusually long way to go in curbing emissions that cause climate change.*
- *We're at the northern end of the Atlantic hurricane track, where most storms similar to Hurricane Juan could hit us as the planet warms.*
- *With 7600 km of coastline, we are exceptionally vulnerable to rising sea levels caused by climate change*."

Many large scale projects are required to go through the environmental assessment (EA) process. Through the EA, the environmental effects of the proposed project are predicted and evaluated, and a conclusion is made on the acceptability of the project from an environmental perspective. The Climate Change Action Plan identifies a number of actions that are relevant to projects requiring EA in the province including:

- Increasing overall energy efficiency in the province by 20% over 2008 levels by 2020;
- Applying of a "green filter" to projects requiring government approval;
- Developing of a strategy to ensure the sustainability of the province's natural capital;
- Setting as a key priority of the water resource management strategy the consideration of climate change impacts on water quality and quantity by 2010;
- Launching a web site of information and tools to support adaptation to climate change; and
- Establishing criteria for the consideration of climate change during Nova Scotia Environment's environmental assessment process and developing guidance for project proponents.

1.3 Why is Climate Change Important to a Project?

To reduce project risks associated with compliance with existing and future GHG reduction targets and legislation both in Canada and elsewhere related to GHGs, such as carbon cap-and-trade or carbon tax systems, certain projects will need to consider their 'carbon footprint'. This includes accounting for GHG emissions through all phases of the project lifecycle including: design, construction, operation, and eventual abandonment of the project. In addition, existing carbon sinks such as forests may be lost if these are not considering in the design of a project.

One of the most compelling reasons for considering climate change is that climate data play a key role in the planning and design of infrastructure. Under climate change, the use of historic data alone may no longer be appropriate. Conventional uses of historic data such as the exclusive use of climatic normals could render infrastructure vulnerable by leading to designs with insufficient load and adaptive capacity, or by leading to planning decisions that situate projects in environments that become unsafe or difficult to maintain over time. While current climate-related assumptions may, as the result of climate change, *already* be somewhat out of date, they could, depending in part upon the design methods used, result in longer-lived projects becoming more vulnerable. In addition, there is a potential that design professionals, infrastructure owners and operators may be held civilly liable for property damage or injury for not taking climate change effects into account (Gherbaz, 2008).

Many projects in Nova Scotia can have relatively long life spans ranging from twenty to over one hundred years. Highway infrastructure, mine tailings facilities, and energy infrastructure are just a few such examples. It is important to consider how changing climate will influence the project over its expected lifetime, and how this will affect the environment and the on-going physical (direct impacts such as sea-level rise) and financial (costs such as insurance premiums and maintenance) viability of the project. Considering climate change early in the decision making process may avoid future costs to the project and related impacts on the environment.

1.4 Is this Guide Applicable to Your Project?

This Guide can be used for many types of projects in Nova Scotia. The extent of analysis required will depend on project-specific factors including project type, size, location, and duration. In general, all projects should assess their carbon footprint, review possible options to reduce greenhouse gas emissions, and assess any impacts the project may have on carbon sinks (Section 2). GHG mitigation plans may not be required for all projects, especially those with limited operational emission sources. Similarly, all projects should, as a minimum, identify whether or not there are potential hazards from climate change that could affect the project (Section 3). If potential hazards are identified then the proponent should follow the steps outlined in Sections 3 to 5 to assess the risk and identify possible adaptation options. For further information or assistance the proponent/practitioner should contact the Environmental Assessment Branch (http://www.gov.ns.ca/nse/ea/) and/or the Climate Change Directorate (http://climatechange.gov.ns.ca/).

1.5 Organization of the Guide

This Guide has been developed to assist project proponents in determining the extent to which climate change considerations need to be addressed in project design and operation in Nova Scotia. The Guide outlines a step-by-step process through a series of questions for proponents to follow when evaluating projects in relation to GHG emissions and climate change impacts.

While proponents should consider climate change mitigation and adaptation concurrently when planning a project, for ease of use, mitigation and adaptation guidance are presented in separate sections (Sections 2 and 3 respectively). Each step of the guide provides succinct instruction and references to resources pertaining to that step.

This guidance document is based on the following principles for identifying appropriate mitigation and adaptation measures[1]:

- Keep options open and flexible – so that further measures or strategies can be put in place to meet needs identified in the future;
- Avoid decisions that will make it more difficult to manage climate risks in the future (*e.g.* inappropriate development in a flood risk area); and
- Find 'win–win' options that contribute to climate change mitigation and adaptation, and to wider project objectives (*e.g.* business opportunities from energy efficiency measures).

[1] Strategic Environmental Assessment and Climate Change: Guidance for Practitioners . June 2007. United Kingdom Environment Agency (http://www.environment-agency.gov.uk/research/policy/40121.aspx)

2.0 GREENHOUSE GAS EMISSIONS AND MITIGATION

2.1 Introduction

Mitigating the effects of climate change is the principle behind setting GHG emission reduction targets and supporting initiatives to reduce GHG emissions from individuals, governments, and industry. The Government of Nova Scotia has set an ambitious climate change mitigation target. Nova Scotia Environment aims to reduce GHG emissions in the province by at least ten per cent from 1990 levels by 2020 and is acting on a plan to meet that target through the *Environmental Goals and Sustainable Prosperity Act*, and the Nova Scotia Climate Change Action Plan.

Measuring and managing GHG emissions and preserving carbon sinks have become increasingly important operational issues with sustainability, profitability, and regulatory compliance implications. As a result, organizations are preparing and reporting their GHG inventory, also known as their carbon footprint, to determine GHG emissions from specific operations, projects, or for their entire entity. Once organizations determine their carbon footprint, targets can be set for reducing or eliminating GHG emissions and for conserving carbon sinks. Everything from simple efficiency measures to using innovative new technologies can help organizations reduce GHG emissions and even save money. The key is to integrate these strategies at the early stages of project planning. Considering the GHG emission implications of a new project during the design phase promotes improved GHG management throughout the project lifecycle by highlighting the opportunities for improvement before project decisions have been made. The following steps should be followed to assess a project's GHG inventory or carbon footprint, and resulting actions to be taken to reduce a project's carbon footprint. Guidance for each step is provided in Section 2.2.

Step 1 - Scoping

A. Identify GHG emission sources
B. Calculate impacts on carbon sinks e.g. forests.
C. Confirm regulatory requirements

Step 2 – Develop GHG Inventory

A. Determine operational boundaries
B. Describe operations that contribute GHGs
C. Estimate annual GHG emissions

Step 3 – Identify GHG Emission Reductions

A. Identify feasible reduction measures
B. Identify opportunities to enhance carbon storage/sequestration into sorts, biota, and geotechnical solutions

Step 4 – GHG Mitigation Plan

A. Describe actions to be taken to reduce GHG emissions

2.2 Guidance

Step 1 - Scoping

The first step in the process of determining a project's potential carbon footprint is to undertake a high level scoping of the project based on existing information. This is done to identify the potential sources of GHG emissions and the potential impact on carbon sinks *e.g.* clearing of forest areas. The footprint assessment should cover all activities associated with the construction, operations, and decommissioning phases of the project.

The scoping should address three distinct GHG categories: **direct** emissions, **indirect** emissions, and **sinks**.

A. Using available project information on process, equipment, and energy sources, identify the potential GHG emission sources associated with the project.

Direct emissions are those GHG emissions that are generated by the project such as process emissions and emissions from self-generated power. Indirect emissions are GHG emissions from sources outside the project boundary but used as an input to the project such as electricity generated from an offsite fossil fuel power plant. Further information on typical GHG sources can be found on Environment Canada's website.[2]

B. Calculate area of forest loss associated with the project.

Sinks include features of the environment that have the ability to remove GHGs from the atmosphere such as forests. GHG sinks can also include man-made technology such as carbon capture and storage (CCS), however, the technical feasibility of carbon capture and storage in Nova Scotia to offset project GHGs would have to be demonstrated by the proponent if proposed.

C. Is the project subject to federal or provincial legislation and regulations, or municipal by-laws or ordinances? If so, these should be described. If there are specific monitoring and reporting requirements, the proponent should ensure that the required methodologies or protocols are taken into account in the estimation of GHG emissions (Step 2C below).

At this stage the proponent should also review relevant regulatory requirements regarding GHG emission reductions, including validation/verification and reporting requirements that may affect the project. For Nova Scotia regulatory requirements see: http://www.gov.ns.ca/legislature/legc/ and http://www.gov.ns.ca/just/regulations/consregs.htm. For federal regulatory requirements see: http://www.ec.gc.ca/cc/default.asp?Lang=En. In addition, the municipality in which a project is located may also have requirements or objectives with respect to GHGs and proponents are encouraged to consult with municipal representatives when conducting the scoping.

Step 2 – Develop a GHG Inventory

Once a proponent has identified the potential sources of GHG emissions, the next step is to quantify or develop an inventory of the GHG emissions. Both the International Organization for Standardization (ISO)[3]

[2] http://www.ec.gc.ca/pdb/ghg/about/faq_e.cfm

[3] CAN/CSA-ISO 14064-1-06, Greenhouse Gases - Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals and CAN/CSA-ISO 14064-2-06, Greenhouse Gases - Part 2: Specification with Guidance at the Project Level for Quantification, Monitoring and Reporting of Greenhouse Gas Emission Reductions or Removal Enhancements

and the World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD)[4] have developed standard practices for quantifying GHG emissions. In general these protocols address the following key questions.

A. What are the operational boundaries of the project? Identify the physical and process boundaries of the project.

The first step in preparing a GHG Inventory is the setting of the operational boundaries. This defines what activities and GHG emission sources will be included in the GHG inventory. The project GHG Inventory should include all GHG emissions resulting from all project operations including planning, development, construction, operation, and decommissioning. The operational boundary will include GHG emissions categorized as direct emissions, indirect emissions. and impacts on GHG sinks as described in 'Scoping' above.

B. Identify and describe the operations within the project boundary that will contribute GHG emissions.

Once the project boundary has been defined, this is used to identify and describe all of the operations within the project boundary. This can be done in the form of a list including the name and description for each operation and unit of equipment (mobile or stationary), as well as details about any fuel or electricity consumption, transportation requirements, and industrial processes.

C. Estimate GHG emissions in CO_2e/year from the project based on projected construction, operations, and, if feasible, decommissioning activities using available data and references. NSE recognizes that depending on the level of design available early in the project, there may be uncertainty or unknowns with respect to emission rates, and in some cases, emission sources.

The list of operations can be used to identify the direct GHG emissions, indirect GHG emissions, and impacts on GHG sinks associated with the project that are within the project boundary. The list of GHG emission sources is used to estimate the expected project GHG emissions in terms of tonnes of CO_2e per year. Specific calculations and emission factors for various processes and equipment are available from a number of resources. Commonly used resources for estimating GHGs for a variety of activities are provided in Appendix G-1. Proponents should confirm the appropriate methodology with NSE during this stage of the assessment.

[4] http://www.ghgprotocol.org/standards/publications

Step 3 – Identify GHG Emission Reduction Opportunities

A. Review major sources of emissions and determine if there are feasible reduction strategies available for the project.

Once the project GHG Inventory has been developed, the inventory can be used to identify the major sources of GHG emissions where reductions may be possible. GHG emission reduction actions can include: energy efficiency; fuel switching; adoption of industry best practices; conservation and enhancement of carbon storage/sequestration into soils, biota, as well as geological solutions; and potentially investments in GHG emission offset projects. A list of possible GHG emission reduction strategies is provided in Appendix G-2.

Step 4 – Develop a GHG Mitigation Plan

A. Prepare a GHG Mitigation Plan that summarizes the findings of the previous steps and identifies the actions the proponent proposes to take to reduce GHG emissions over the life time of the project. The plan should also include the proposed monitoring and continual improvement procedures to be implemented as well as a commitment to update the plan as regulatory requirements evolve.

The GHG Mitigation Plan should outline how GHG emission reduction opportunities are incorporated into the project design and subsequent operations of the project. The plan should also describe the how the GHG emissions will be monitored and reductions tracked. The GHG Mitigation Plan should be based on a continual improvement model incorporating monitoring emissions and commitment to introducing new GHG emission reduction and removal practices over time. The GHG Mitigation Plan can also link to other air and water pollution reduction opportunities, as these may reinforce each other, and should happen concurrently.

3.0 ADAPTATION

3.1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "an adjustment in natural or human systems in response to actual or expected climatic stimuli (variability, extremes, and changes) or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2001)[5]. Adapting to environmental risk is an integral part of natural and human history, and is a key element in the survival of all living organisms. The history of human and natural systems contains many examples of successes and failures in adapting to a variety of risks, some climatic (*e.g.* hurricanes, floods), some geologic (*e.g.* landslides, volcanoes), others anthropogenic (*e.g.* war, pollution). Societies throughout history have had to adapt to variations or changes in their climate through a variety of strategies and by using knowledge accumulated

[5] http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=0

through experience of past climatic events. In addition, societies have also had to cope with and respond to extreme weather events, such as droughts, floods and hurricanes.

3.2 What Does Climate Change Adaptation Involve?

Adaptation reduces the impacts of climate change on human and natural systems. It consists of a variety of behavioural, structural and technological adjustments. Adaptation measures can vary in their timing (anticipatory or planned versus reactive), scope (short-term versus long-term; localised versus regional); approach (passive versus active), and agent (private sector versus public sector; societies versus natural systems). A broad range of adaptation measures can be implemented in response to both observed and anticipated climate change. Such measures include enhancing water use efficiency, reducing pollution that can preserve resilience of natural systems, acquiring insurance to cover potential climate change loses, changing building codes, investing in air-conditioning, constructing sea walls, burial of overhead utilities, and location of project infrastructure away from high risk coastal zones.

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Furthermore, it is possible that projects that do not take account of climate change may lead to maladaptation inadvertently increasing exposure and/or vulnerability of a project to climate change. Maladaptation also includes actions undertaken to adapt to climate impacts that do not succeed in reducing vulnerability but instead increase exposure to damage. For example, new infrastructure may not be designed to cope with changed weather extremes and thus may either provide inadequate protection from extreme events or may have a shorter useful lifetime than intended.

Successfully adapting to risks associated with climate change requires, during project development, an understanding of the nature and scope of such risks, and the identification, evaluation, and implementation of viable, cost-effective risk-management options.

3.3 Uncertainty in Climate Change Projections

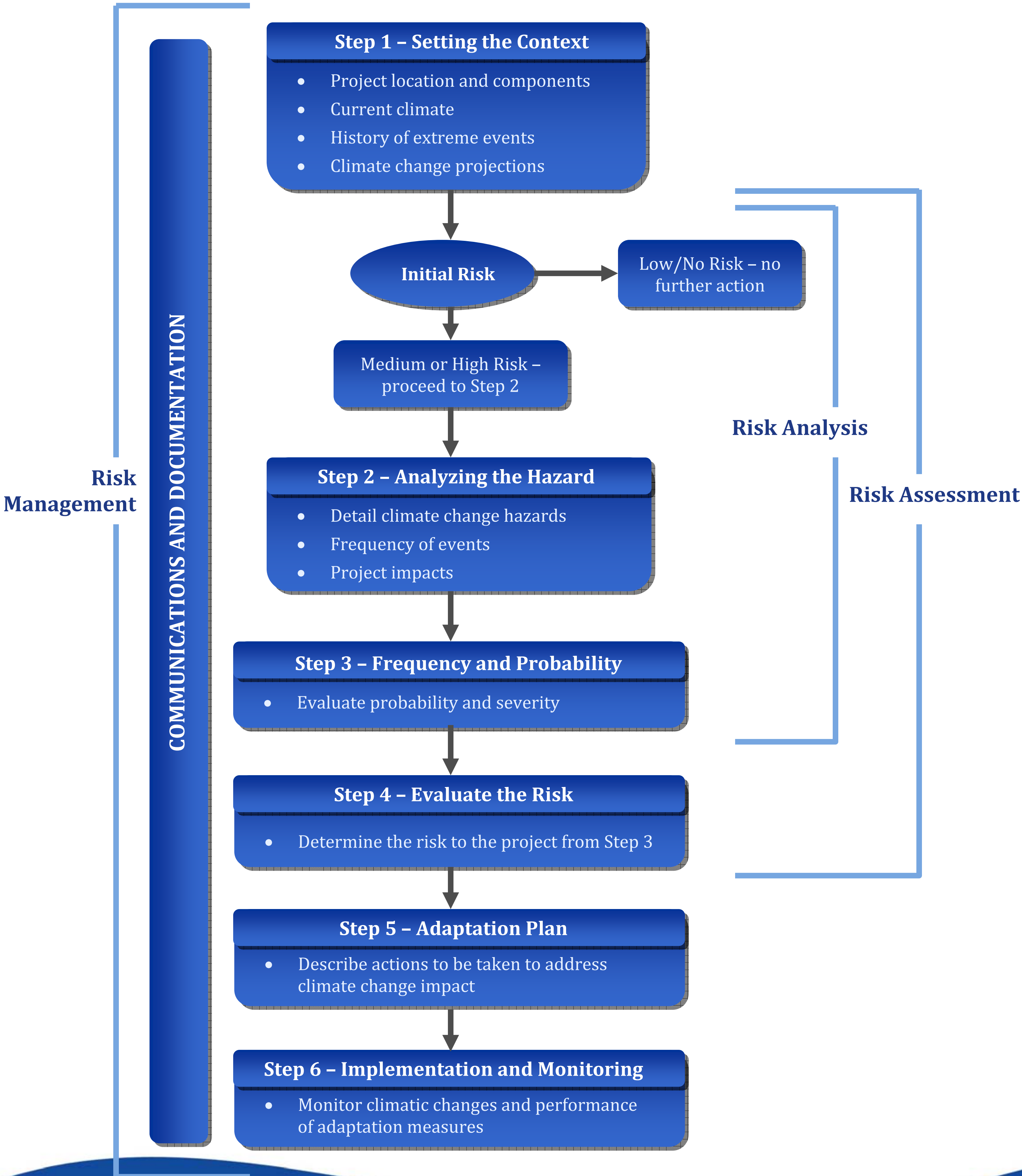
Scenarios of future climate are based mainly on the output of atmospheric-ocean General Climate Models (or Global Circulation Models) (AOGCMs). These use mathematical descriptions of atmospheric and oceanic motions, energy fluxes, and water fluxes to simulate past, present, and future climates. Past and present climates are used to validate the models. Future climate is driven primarily by forcing due to greenhouse gases and aerosol particles (which tend to partly counteract the greenhouse effect).

Greenhouse gas and aerosol forcing is estimated by means of developing scenarios of future emissions. These can have a very wide range in outcomes depending on the future growth of world populations, economies, energy use, the sources of energy used, and extent of deforestation or afforestation. Our present atmosphere has about 30% more CO_2 (the most abundant of the greenhouse gases) than in pre-industrial times. IPCC's range of emission estimates suggest that CO_2 concentrations could be as much as triple pre-industrial by 2100 or could be less than double pre-industrial concentrations by 2100. The outcome depends primarily on the rate of growth of economies and of fossil fuel use and the extent of measures taken to reduce the latter. This creates the greatest uncertainty in projections of future climate. Further discussion of the primary scenarios used in climate modeling is provided in Appendix A-1.

Because of the uncertainty that is evident with the magnitude, timing, and character of many potential climate change-related impacts, adaptation should be pursued as much as possible in accordance with a vulnerability-based approach. Instead of looking mostly forward (to the climatic conditions that may arise and the effects they might eventually have), vulnerability-based approaches focus more on the experience of climate variability and extremes in the recent past. In other words, what has been the demonstrated vulnerability of a project type to climate extremes in the recent past, and what sorts of adaptations might be required in order to reduce this vulnerability?

Uncertainty, however, does not mean project proponents should not be pro-active. Rather, climate change-related uncertainty needs to be understood by decision makers; and the steps taken to address this uncertainty must be demonstrated. Potential climate change impacts, addressing uncertainty, and adaptation planning at a project level can be determined by taking the following steps. Detailed guidance is provided in Section 3.4.

Figure 3-1 - Steps in the Climate Change Risk Management Process



The following sections provide step by step guidance to assist project proponents in addressing uncertainty and developing project specific adaptation plans.

3.4 Guidance

3.4.1 Risk Management Approach

While there is broad agreement on the general trends and global effects of climate change, a significant amount of uncertainty remains in relation to the projection of specific future climate parameters for given locations. As such, *risk management* techniques have been developed with climate change applications specifically in mind *e.g.*, Bruce et al. (2006). These techniques provide order to the process of considering the vulnerability of a location or project to changing climate, and assessing adaptation options in light of a range of climate outcomes and their probability of occurrence within a given time period. A risk management-based approach can be used to guide the identification of project responses to climate projections including an initial assessment of the extent to which climate change factors may or may not be of concern.

There are many risk assessment frameworks available to proponents and it should be noted that this guide does not provide the user with details on how to conduct a risk assessment but adopts a methodology based on the *Canadian Standards Association's Risk Management: Guidelines for Decision-Makers (CAN/CSA-Q850-97)*, *Caribbean Risk Management Guidelines for Climate Change Adaptation Decision Making*, and Bruce et al. (2006). This approach consists of a number of sequential but interrelated actions as shown in Figure 3-1. The follow sections focus on climate change hazard identification and assessment as an example of the application of risk management in project decision making related to climate change.

Step 1 – Setting the Context

A. The context for the risk management framework will come from a description of the project and the existing environment where the project will be located. Based on a general review of the above information, proponents should identify whether their projects are considered high, medium, or low/no risk. No further assessment is required for low/no risk projects.

The risk management approach begins by 'setting the context' or determining the exposures, if any, that a particular project may have to the effects of climate change. By documenting the context, including the project components, location, duration, and key unknowns, the proponent can develop a rationale for the level of detail required in the assessment. For example, a facility in an industrial park well above sea-level is less likely to be impacted by climate change than a large industrial facility located on the coast. In this step projects can be assigned to one of three categories: high risk, moderate risk, or low/no risk, on the basis of the nature, magnitude, and sensitivity to climate risks. The high-risk category will include projects that are reliant on resources affected by climate (water resources), are located in hazard zones (coastal zones, floodplains), or have long-term infrastructure. Moderate risk projects include projects that have some specific climate vulnerabilities related to an aspect or aspects of the project or that could increase vulnerabilities external to the project. Low/No risk projects include those projects that will not be affected in any significant way by climate.

Step 2 - Analysing the Hazard

A. Detail known climate change hazards, frequency, and how the hazards may impact the project.

In this step, the proponent should document details on climate change hazards relevant to the project from available sources. Project-specific modeling is generally not required to identify climate hazards to which a project may be vulnerable. It is acceptable to assess these hazards from current climate extremes. A review of climate change hazards during project design provides the opportunities to: avoid high risk project locations; design appropriate climate risk management measures to reduce vulnerability; and/or determine financing or insurance options for vulnerable projects.

When assessing the vulnerability of a project to climate hazards, the timing and certainty of climate change impacts are two important considerations that need to be taken into account:

Timing: What is the life span of the project? Some projects may be sensitive to climate changes projected for the short to medium term *e.g.* changes in precipitation intensity. Others may have low or no sensitivity to climate change in the short to medium term but will be sensitive to impacts in the long term *e.g.* sea-level rise.

Certainty of climate change impacts: Impacts that are the result of increased temperature or higher sea level are considered to be virtually certain to occur whereas impacts that are the result of more frequent drought or flood may be less certain.

This analysis of the vulnerability of a project should include the following elements:

- What are the climate change impacts applicable to the project location (Appendix A-1)?
- What components of the project are likely to be affected by climate change (*e.g.* use of water, access roads, coastal infrastructure)?
- Is the proposed project located in an area or region that could be vulnerable to climate change (*e.g.* flood-prone areas, low-lying coastal area, or areas susceptible to forest fires)?
- Is there a local or community climate change strategy in place that the proposed project would need to be aligned, or at least consistent, with?
- External climate risks affected by the project, *i.e.* the extent to which the project may have consequences for the vulnerability of external natural and human systems, and the adaptive capacity of the natural and human systems.

In assessing past vulnerability, it is important to assess whether the climate factors that posed the threat up to now are likely to persist more or less as is, or whether their character, frequency, or intensity could change (for better or worse) with time. Climate models, as discussed above, are one means for doing this assessment and consensus is still evolving with respect to means for integrating the changing climate into climatic design values (Mailhot et al., 2007; Livezey et al 2007). It is important to note, however, that especially for the short-to-medium term (1-20 years into the future, depending on the variable of interest) examining current climatic extremes or trend analysis may be equally useful tools.

Use of Current Climatic Extremes

The United Nations Environment Programme (UNEP) proposes that in light of the uncertainty associated with projections, and the absence of sufficient long-term (30 year +) data in many areas needed for accurate trend analysis, that the first option should be to address vulnerability to current climate extremes (hurricanes, storms, floods, droughts), and thereafter, for those projects (such as transportation) that may be sensitive to changes in precipitation and temperature, that downscaled climate scenarios should be used to determine vulnerability and appropriate adaptation measures. Global scenarios can be used for sea-level rise, but proponents will need to add storm surge to determine the extent of coastal areas that could be inundated.

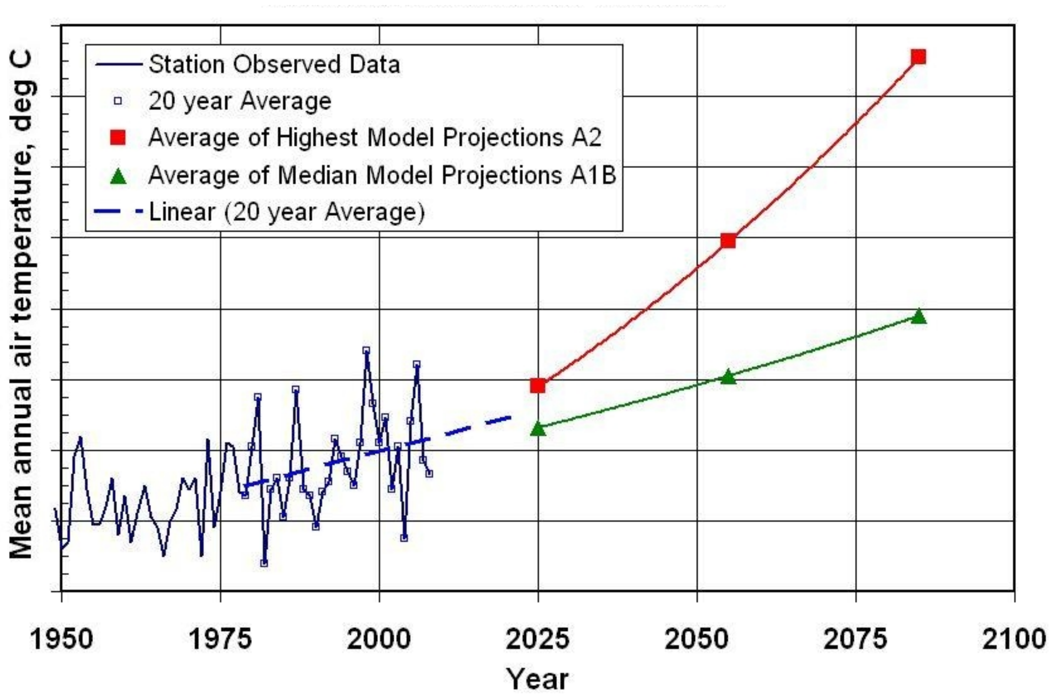
For trend analysis, proponents would review what have been the trends in key climatic parameters over recent history for the location being considered for the project. Are there strong linear components present in the trends that might be reasonable to extrapolate into the future?

A reasonable approach, which is being increasingly advocated by Environment Canada and others, is as follows:

i. Analyze the most recent 20 or 30 years of data from a nearby and climatologically representative climatic station(s)[6] to identify climate variability and recent climate warming trends (or interpolate from gridded climatic analysis). If using climate trends, consider the changes that began after a significant temperature change point.

ii. Consider the design temperature over the longer term service life of the infrastructure or project. Climate considerations should be used from a variety of sources including trend information, for example, the most recent IPCC climate model results and downscaling, published climate change impacts assessment results, or other climatologically representative climate change study results (available at www.climatechange.gov.ns.ca). Ideally, the range of future values should include results from several climate models as well as estimates of future median and high projections. The point selected from this range of future values should reflect an acceptable risk and be applicable at the end of the project life (e.g. an estimate for 2060 would be required for a project life of 50 years). Figure 3-2 provides an example of this method.

Figure 3-2 Example Trend Analysis for Temperature



[6] Stations with suitable continuous records in Nova Scotia include: Nappan, Kentville, Greenwood, Shearwater, and Sydney.

Tools available to assist proponents in analyzing the hazard to projects from climate are provided in Appendix A-2.

Step 3 – Estimating the Probability and Severity of Climate Change Hazards

A. Evaluate the probability and severity of the climate change hazards identified in Step 2.

Once the potential climate change impacts that could affect a project have been identified, the next step is to estimate the frequency or probability of the climate change event. This is carried out by taking the available historical data and trends analyses, and combining them with available climate change projections to assign a probability to the event occurring as shown in the example below (after Bruce et al., 2006). For convenience, a blank table is provided in Appendix A-3

Hazard	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
List climate change hazards identified in Step 2.	*Not likely to occur during the planning period*	*May occur sometime but not often during the planning period*	*Likely to occur at least once during the planning period*	*Likely to occur several times during the planning period*	*Happens often and will happen again during the planning period*
Extreme storm surge event			√		

Once the hazard and the probability of its occurrence have been identified, the severity of the impacts can be qualitatively or, if data allow, quantitatively assessed across a range of socio-economic and biophysical categories. This assessment is based on available research, historical data, and professional judgement. An example of a severity matrix is provided below.

Impact Degree	Social Factors				Economic Factors			Environmental Factors			
	Displacement	Health	Loss of Livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air Quality	Water Quantity and Quality	Land Degradation	Eco-system Impairment
Very low				√			√	√			
Low		√									
Moderate	√		√			√			√	√	√
Major					√						
Extreme											

References to assist in the assessment of the probability and severity of climate change impacts or events are provided in Appendix A-2. For convenience a blank table has been provided in Appendix A-3.

Step 4 – Evaluating the Risk

A. Using the probability and severity of climate change impacts or hazards, determine the risk of the impacts to the project to identify which impacts present the highest risks to the project and to assist in the determination of priorities for implementing adaptation measures where required.

Risk is defined in CSA Q850/97 Risk Management: Guidelines for Decisions Makers as: a measure of the probability and severity of an adverse effect to human health, property, or the environment. Risk can be expressed mathematically as the product of the probability of an event multiplied by the consequence or severity of the event. This approach can also be used qualitatively in risk assessments where numerical probabilities have not been established as in the case of most events resulting from climate change.

The determination of risk associated with the projected climate change impacts is based on the setting and components of the project; the probability of the impact occurring (based on the estimated frequency or likelihood of the impact occurring) and the resulting consequence (based on the estimated severity of the impact) using professional judgement, available assessments of similar projects, and literature. Proponents can describe risks based on a descriptive categories such as Low, Moderate, or High or numerical categories., where:

Low = Risks that require no or minimal actions. Minimal actions could include public education/awareness.

Moderate = Some actions or controls will be required to reduce risks to low or negligible levels.

High = These risk areas will require high-priority actions to reduce risks to low or negligible levels.

Since climate change impacts can have both environmental and socio-economic considerations, the categories can be further subdivided as below:

For socio-economic considerations: L_S, M_S, or H_S

For environmental considerations: L_E, M_E, or H_E.

This approach allows the user to then integrate the probability and severity for both environmental and socio-economic considerations in order to develop an overall risk for the potential impacts on a project. These integrated risks can also be assigned L, M and H and Figure 3-3 provides a suggested matrix for determining the integrated risk.

The findings can then be used to prioritize the development of adaptation options and priorities in Step 5. An example of the output of this step is provided in Figure 3-4.

Figure 3-3 Determining the Integrated Risk

		PROBABILITY		
		LOW	**MEDIUM**	**HIGH**
IMPACT SEVERITY	**HIGH**	**M**	**H**	**H**
	MEDIUM	**L**	**M**	**H**
	LOW	**L**	**L**	**M**

Using climate change impacts on coastal settings, some example questions to ask in this step could include:

- What are the likely climate change projections for coastal flooding?
- Is the project in an area that is susceptible to coastal flooding?
- Is any project infrastructure to be significantly impacted by sea-level rise, increased storm events, or flooding?
- What are the social, human health, ecological, and economic impacts associated with damage to a project's coastal infrastructure?
- Is any pollution prevention program likely to be significantly impacted by reductions in ecosystem resilience brought about by climate change?

- Can components of the project be re-designed or relocated to minimize the hazards associated with the impacts?

Additional resources on evaluating risks due to climate change are provided in Appendices A-1 and A-2. A blank table is provided for convenience in Appendix A-3.

Figure 3-4 Example Risk Evaluation Tabulation – Project in Coastal Area (DeRomilly and DeRomilly et al., 2005)

Item	Probability (Frequency of event)	Consequence (Impact severity)	Segregated risk	Integ-rated risk	Risk to Project
1. COASTAL ZONES					
Impacts on coastal wetlands/ecosystems					
• Sea level rise/storm surge	**H**	$H_S H_E$	$H_S H_E$	**H**	**H**
Impacts from erosion					
• Sea level rise/storm surge	**H**	$H_S H_E$	$H_S H_E$	**H**	**H**
Impacts from flooding					
• Sea level rise/storm surge	**H**	$H_S H_E$	$H_S H_E$	**H**	**H**
2. COMMUNITIES/INFRASTRUCTURE/TRANSPORTATION					
Impacts on settlements & related coastal infrastructure					
• Sea level rise/storm surge	**H**	$H_S H_E$	$H_S H_E$	**H**	**H**
• Storm and combined sewer surcharging and failure	**M**	$M_S H_E$	$M_S H_E$	**H**	**H**
• Ice damage	**L**	$L_S L_E$	$L_S L_E$	**L**	**L**
• Disruption to critical utilities	**M**	$H_S L_E$	$H_S L_E$	**H**	**H**
• Increased insurance cost	**H**	$H_S L_E$	$H_S L_E$	**H**	**H**
• Increased economic costs associated with adaptation	**H**	$H_S L_E$	$H_S L_E$	**H**	**H**
Impacts on settlement patterns & land-use					
• Extreme events, sea level rise & storm surge	**H**	$H_S H_E$	$H_S H_E$	**H**	**H**
• Increase in areas of flooding and severity	**H**	$H_S M_E$	$H_S M_E$	**H**	**H**
• Increased risk of forest fire in urban/rural fringe	**M**	$H_S H_E$	$H_S H_E$	**H**	**H**
Impacts on transportation infrastructure					
• infrastructures & patterns	**M**	$H_S L_E$	$H_S L_E$	**M**	**M**
• frequency and cost of maintenance	**M**	$M_S L_E$	$M_S L_E$	**M**	**M**
3. WATER RESOURCES					
Impacts on the variability of quality & quantity of surface water resources					
• Potable water	**L**	$M_S M_E$	$L_S L_E$	**L**	**L**
• Agriculture	**H**	$M_S M_E$	$M_S M_E$	**H**	**n/a**
• Water chemistry	**M**	$M_S M_E$	$M_S M_E$	**M**	**M**
• Management of dams	**M**	$H_S H_E$	$H_S H_E$	**H**	**H**
Impacts on groundwater supplies					
• Groundwater contamination	**M**	$H_S H_E$	$H_S H_E$	**H**	**H**
• Quantity of groundwater	**M**	$M_S M_E$	$M_S M_E$	**M**	**M**
• Salt water intrusion	**H**	$M_S M_E$	$M_S M_E$	**H**	**H**
• Agriculture	**H**	$M_S M_E$	$M_S M_E$	**H**	**n/a**

Step 5 - Adaptation Planning

A. Where a project has been identified with medium to high integrated risks from climate change impacts, a proponent should develop an Adaptation Plan.

Many projects include environmental management or impact mitigation measures to demonstrate the actions that will be taken to minimize impacts on the environment from the project. Likewise, climate change adaptation plans are as essential to those projects that may be impacted by their environmental settings.

Adaptation planning and management approaches have been broken down into four principal strategies:

Strategy 1 - Prevention Of Loss, Tolerating Loss (Enhancing the Resilience of Natural Systems), And Spreading/Sharing Loss. Prevention of loss involves proactive actions to reduce the susceptibility of a project to the impacts of climate. Tolerating loss (includes enhancing the resilience of natural systems and infrastructure) involves situations where adverse impacts are accepted in the short term because they can be absorbed by natural systems and infrastructure without long term damage. Spreading or sharing loss involves actions which distribute the financial impact over a larger third party entity. For example, certain adaptation actions may be undertaken directly by the federal, provincial, or municipal governments. Insurance mechanisms also fall into this strategy.

Strategy 2 - Changing Use or Activity. Changing use or activity involves a modifying the activity to adjust to the adverse as well as the positive consequences of climate change.

Strategy 3 – Relocation. Relocation involves situations where the implementation of a project is considered more important than its location, and the project or affected portion is reconfigured or moved to an area that to make it less susceptible to climate change.

Strategy 4 – Restoration or Adaptive Management. Restoration aims to restore a project to its original condition following damage or modification due to climate.

The text box below explains the broad approaches to adaptation planning and management.

Adaptation Planning and Management

Rather than viewed as an impediment or cost issue, adaptation measures should be viewed as actions that will result in benefits independent of climate change. What does adaptation look like in practice?

- Adaptation proceeds in a rational fashion;
- Adaptation is not a response, but instead is a portfolio of responses;
- Adaptation is a shared responsibility between project developers and government; and
- Adaptation links the needs of today with the expected challenges of tomorrow.

There are various ways to classify adaptation strategies. First, depending on the timing, goal, and motive of its implementation, adaptation can be either *reactive* or *planned.* Reactive adaptation occurs after the initial impacts of climate change are apparent, while planned adaptation takes place before impacts are apparent. Second, adaptation may be considered to be *incremental* or *deliberate.* Incremental adaptation occurs generally in response to changing conditions, *e.g.* increasing the use of air conditioning due to gradually increasing summer temperatures. Deliberate adaptation arises from strategic actions taken by the proponent in response to climate change data.

The suitability of a particular adaptation strategy or plan depends on local conditions and a proponent's priorities. Adaptation involves developing organizational knowledge and capacity, developing or retaining expertise, implementing appropriate management mechanisms, and building knowledge. These processes can take time to implement so affected proponents should not delay in their initiation.

Planning for climate change greatly reduces the potential cost of reactive adaptation responses at a later date when resources and other constraints may limit the range of adaptation options available. Although due to data gaps at specific project locations and scale, reactive adaptation may be the most effective measure in the short to medium term. The long lead time associated with climate change response requires planned adaptive strategies to explicitly address the large uncertainties relating to the nature, scope and intensity of climate change impacts.

The Adaptation Plan should cover 'planned adaptation' management mechanisms (principally changes to the design or building standards) and identify, where possible, natural responses to climate change occurring in the ecosystem associated with the development. Examples of adaptation to climate change are provided in Tables 3-1 and 3-2.

Table 3-1 Types of Adaptation to Climate Change

Anticipatory or Planned	Reactive
• Purchase of insurance • Construction above storm surge levels • Early-warning systems • Relocation of vulnerable components during project design • Adaptive design that allows for changes to the project during operations	• Relocation or reinforcement of vulnerable components following storm events • Changes in insurance premiums • Compensation

Table 3-2 Example Adaptation Measures

Example Sectors	Type of Adaptation	Options
Coastal Zones	Prevent the loss	• Coastal protection • Storm surge barriers • Upgrade drainage systems • Erosion and sediment controls • Habitat protection and enhancement *e.g.* wetlands, salt marsh
	Relocation	• Relocate project or components of project • Set back project from the coast
Water	Prevent the loss	• Leakage control; water conservation measures • Locate water supply away from areas susceptible to groundwater intrusion • Increase capacity of on-site storage • Design surface water drainage systems to accommodate projected flows
Health	Prevent the loss	• Air conditioning • Resilient building design • Minimize areas of ponding except those necessary for stormwater control and treatment

Having identified adaptation options, the next step is to evaluate and select measures for implementation, where required. The following is a list of criteria that could be used to evaluate appropriate adaptation options.

- Effectiveness – The extent to which the adaptation option reduces vulnerability and potentially provides other benefits. It compares vulnerability without adaptation to vulnerability with adaptation. This difference in vulnerability is the primary benefit of the adaptation option. Ancillary or co-benefits can be considered if the adaptation option provides benefits to other sectors or for other project objectives. This criterion can indicate relative differences in effectiveness between multiple project alternatives. Effectiveness also includes the concept of flexibility. In other words, flexible adaptation measures can be adjusted in response to changing conditions or will be effective under different (plausible) climate scenarios.

- Cost – This criterion typically includes the initial costs of implementing an adaptation option. However, costs over time, such as operation and maintenance, administration and staffing, expected frequency of reconstruction and so forth, should also be considered. An accounting of costs should include non-economic and non-quantifiable costs as well as economic and/or quantifiable costs. For example, costs such as a reduction in viable habitat for significant species or an increased impact on human health should be considered alongside more traditional costs. General guidance on cost-benefit analysis is provided in Appendix A-3.

- Feasibility – Do the necessary legal, administrative, financial, technical, and other resources exist, and are they available for use on this adaptation option? This typically means that adaptation measures that can be implemented under the current project operational framework will be favoured over adaptation options that require new technology or other significant changes in the operational context.

Step 6 – Implementation and Monitoring

A. If an Adaptation Plan is identified in Step 5, then a monitoring program should be carried out to assess the performance of the adaptation measures over the lifetime of the project as well as keeping current on climate change projections relevant to the project.

The proponent should identify how it will monitor the performance of the adaptation measures implemented during the project. To monitor climate change projections during the life of the project, the proponent should consult the Nova Scotia Environment's climate change web site (www.climatechange.gov.ns.ca) for updates on climatic trends and climate change projections. The monitoring plan should be considered a 'living document' that can be updated as the project proceeds and effects are better understood.

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Appendix A-1
Climate Change Projections

Global Climate Change Projections

Greenhouse gas emissions are expected to lead to climatic changes in the 21st century and beyond. These changes will potentially have wide-ranging effects on the natural environment as well as on human societies and economies. While estimates have been made of the potential direct impacts on various socio-economic sectors on a global scale, the full consequences are more complicated to assess, since impacts to one sector will likely affect other sectors as well, both directly and indirectly.

To assess the potential impacts of climate change on a project, it is necessary to estimate the extent and magnitude of climate change at a number of scales. Although much progress has been made in understanding the climate system and climate change, projections of climate change and its impacts still contain many uncertainties, particularly at the regional and local levels.

Scenarios of future climate are based mainly on the output of atmospheric-ocean General Climate Models (or Global Circulation Models) (AOGCMs). These use mathematical descriptions of atmospheric and oceanic motions, energy fluxes, and water fluxes to simulate past, present, and future climates. Past and present climates are used to validate the models. Future climate projections are driven primarily by factoring in greenhouse gases as well as aerosol particles (which tend to partly counteract the greenhouse effect) based upon future economic scenarios (see text box below). The model results can have a very wide range depending on the assumptions of future world populations, economic performance, energy use, energy sources, and extent of deforestation or reforestation. Currently, our atmosphere has about 30% more CO_2 (the most abundant of the greenhouse gases) than in pre-industrial times. IPCC's range of emission estimates suggest that CO_2 concentrations could range between less than double to triple pre-industrial concentrations by 2100. The model outcomes (Figure 3-1) depend primarily on the rate of growth of economies and growth or reduction in fossil fuel use.

It is important to note that because of the inertia in the climate system, most of the warming and other associated changes in climate over the next couple of decades will result largely from GHG's which have already been emitted into the atmosphere. As such, the uncertainty associated with predictions that look 20-30 years out may be significantly less than the uncertainty associated with much longer-term projections.

However, most climate model analyses have used simply a projection of greenhouse gas and aerosol forcing that increases at approximately the same rate as during the past decade. This also results in a range of outcomes because of the differences between models used and their underlying assumptions. Most of the available literature is based on such climate model analyses, and the following range of outcomes generally reflects these model differences. In cases where recent trends are consistent with projections, more confidence can be placed in the model outputs so some recent trends are cited. However where results are available using a broader range of future emission scenarios (the IPCC-SRES scenarios) these have been used *e.g.*, for sea level rise, and so reflect uncertainties in both future emissions and in the models.

IPCC Economic Scenarios

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1F1), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumptions that similar improvement rates apply to all energy supply and end-use technologies).

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

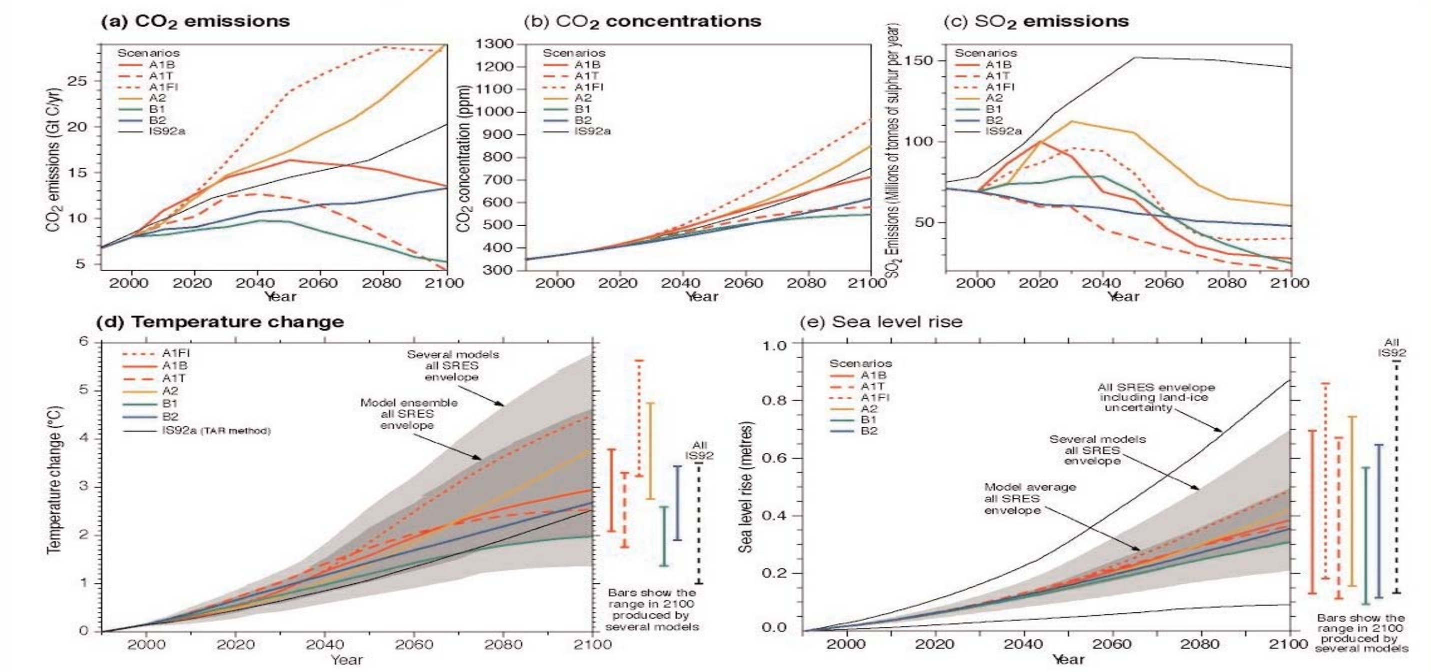
The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A2 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

Source: Box 5 IPCC 2001, The Scientific Basis, Technical Summary

Estimates of the potential direct impacts on various socio-economic sectors have been made, but in reality the full consequences would be more complicated because impacts on one sector can also affect other sectors indirectly. To assess potential impacts, it is necessary to estimate the extent and magnitude of climate change, especially at the regional and local levels. Although much progress has been made in understanding the climate system and climate change, projections of climate change and its impacts still contain many uncertainties at these levels. Techniques have been developed to take the global climate model outcomes for a given future date and 'downscale' these to a specific area to provide a range of estimates of future climatic factors. These techniques fall into two categories: statistical methods and dynamical approaches. The latter attempts to build regional models 'nested' in the global models to better take into account topographic, water-land, and other factors that affect local and regional climate. However, the science to do this well is still evolving and currently statistical techniques are generally more useful.

Projections of the Global Climate of the 21st Century



Climate change projections have widely differing degrees of uncertainty associated with them. Large-scale (*e.g.* large regional or global) climate projections typically have lower uncertainty than those for a specific location such as a project site. The timeframe of the projections is an important consideration also. Medium term projections (for between 2040 and 2060) tend to have less uncertainty associated with them than either shorter or longer-term predictions (Shiermeier, 2007). This results from two factors (Cox et al., 2007). First, for predictions or more than fifty years, uncertainty levels in the models increase since the level of carbon dioxide emissions resulting from human activity cannot be accurately forecasted over that time period. Second, shorter-term predications may be less accurate due to uncertainty related to initial conditions and the potential that human-induced change in the short term may in some cases be obscured or outweighed by natural variability.

Project adaptation decisions, however, need to be taken at a local geographic scale, such as a watershed, where credible climate change projections are currently lacking, and within an appropriate time scale *e.g.* 10 to 25 years for an oil and gas project to > 100 years for a transportation project. In addition, certain climate variables are more predictable than others. Projections of temperature, for example, tend to be more sound than those for rainfall. Likewise, average conditions are easier to project than changes in extremes.

Techniques have been developed to take the global climate model outcomes for a given future date and 'downscale' these to a specific area to provide a range of estimates of future climatic factors. Such techniques fall into two categories: statistical methods and dynamical approaches. Because the science involved with dynamic approaches (building regional models 'nested' in the global models to better take into account topographic, water-land, and other factors that affect local and regional climate) is still evolving, statistical techniques are generally more common and useful. Statistically downscaled temperature and precipitation data for selected sites in Nova Scotia has been developed by Environment Canada.

Climate Change Projections for Nova Scotia

Canada's national assessment of climate change impacts *From Impacts to Adaptation: Canada in a Changing Climate 2007* details a number of key climate change considerations facing projects in the region:

- More storm events, with increasing intensity and increased storm surges;
- Sea-level rise;
- Increased coastal erosion and flooding; and
- Increasing pressure on water resources.

Further discussion on projected changes in Atlantic Canada can be found at:
http://adaptation.nrcan.gc.ca/assess/2007/index_e.php.

As noted in Section 3.3, climate modelling in general is based on large regional areas that provide limited applicability to a project level assessment of impacts. To provide more Nova Scotia specific impacts, Lines et al, 2008 (see References) used statistical downscaling of two global climate models combined with historical climate records to derive temperature precipitation projections for selected sites in Nova Scotia. These data clearly indicate how sub-regional and local micro-climate factors influence climate change impacts across the province.

A significant concern for projects in Nova Scotia is vulnerability to extreme events. Two elements are important when determining that vulnerability: are extreme events increasing in frequency and intensity and is a project vulnerable due to its location or nature? Extreme events such as heat waves, droughts, flash floods, and storm surge damages are increasing world-wide. Climate models are projecting that those events will continue to increase.

A summary of projected climate change impacts for Nova Scotia for Tri-decadal Periods 2020, 2050, and 2080 is provided in Table A-1. Associated impacts on Nova Scotia's socio-economic sectors are provided in Table A-2.

Table A-1 Summary of Projected Climate Change Impacts for Nova Scotia for Tri-decadal Periods 2020, 2050 and 2080 (Lines, pers. Comm., 2009)

Climate Variable	Mean Change	Variability / Frequency	Extreme Value	Knowledge Gap
Periods	**2020s/2050s/2080s**	**2020s/2050s/2080s**	**2020s/2050s/2080s**	
Maximum Temperature	+1.6/+2.4/+3.9 (increase from 61-90 normals)	Hot days per year. (days above 30C) 23/34/48	Number of heat waves (days above 35C). 2.4/6/16.9	
Minimum Temperature	+1.8/+2.5/+3.7 (increase from 61-90 normals)	Cold days per year. (days below -10C) 11/8/5	Not Available.	
Season Length	Growing Season Length (days per year) 204/213/221	Surprises possible. (Late hard frost in spring, early hard frost in fall)	Longest projected season 237 days in Annapolis Valley by 2080	
Precipitation Amount	% change amount +9.4/+9.5/+9.0	Max number consecutive dry days 10.7/10.6/10.8	Max 120-hr (5 day) precipitation (mm) 109.7/110.5/108.3	
Period	**By 2080s**	**By 2080s**	**By 2080s**	
Sea Level	.5 to 1.1m plus .2m from crustal subsidence	Plus or minus .2m	1.3m	Regional variations on mean and extreme amount unknown.
Synoptic Storms	Not Applicable	Increase in intense storms. Decrease in weak storms. (North of 30N)	Not Applicable.	Specific number and intensity of future storms over NS unknown.
Tropical Cyclones	Increase in peak wind speed	Unknown	Not Applicable.	Increase in frequency unknown.
Ozone (Smog)	Unknown	Increase in production of smog with increase in maximum temperature.	Not Available.	Projections of ozone production increase unavailable.
Fog	Not Available.	Frequency of occurrence may increase with increased storm activity.	Not Available.	Specifics of frequency change over NS unknown.
Winds	See Tropical Cyclone above			
Waves	Increase in mean Significant Wave amount over North Atlantic (0.5-1.0M by 2080s).	Increase in Significant Wave occurrence (return period of 20year wave height reducing to 8-16yrs).	Not Available.	Need more specifics regionally.
Ice Storms (ZR)	Decrease in Freezing Rain episodes in Fall. Increase in Freezing Rain episodes in Winter	Not Applicable	Not Applicable	

Table A-2 Impacts of climate change on the socio-economic sectors in the Province of Nova Scotia (De Romilly and De Romilly Limited et al, 2005).

Sector	Example Impacts
Communities, Infrastructure and Transportation	
a) Impact on Infrastructure	• Possible intensified damage and disruption to coastal infrastructure, essential services and communications from extreme events, sea level rise and storm surge flooding. • Possible increased overflow incidents from storm sewers and combined sanitary systems unable to deal with more frequent, high-intensity rainfall and storms. • Changes in distribution and range of river and coastal ice, compounded by break-up and extreme events, will likely increase damage to river and coastal infrastructure. • Buried municipal infrastructure in coastal areas at risk of being inundated or damaged by sea-level rise. • Possible increased damage and disruption to vulnerable critical services, utilities and other infrastructure, including power outages and disruption of communications, due to extreme events.
b) Impacts on Built Infrastructure	• Possible increased incidents of structural failures. • Projected increased insurance costs associated with damage to vulnerable infrastructure and buildings or loss of insurance in future.
c) Impact on Land Use Planning	• Increased uncertainty in human settlement patterns and urban planning due to climate variability, sea-level rise and impacts from extreme events. Much of the coastline in HRM is sensitive to the effects of sea-level rise combined with extreme events. • Indications are that some low-lying communities in HRM will be flooded more frequently and the floods will become more severe. • Anticipated increased economic and social costs associated with adaptation by vulnerable coastal communities.
d) Impact on Transportation Infrastructure, Operations and Maintenance	• Projected increase in the frequency and unpredictability of break up of ice on rivers, and flooding with associated change in patterns of damage to property, highways, and bridges. • Anticipated increased costs for road maintenance related to pavement softening and traffic-related rutting. • Potential for increased cracking and deterioration of pavements related to frost action and increase in number of freeze-thaw cycles. • Anticipated increased costs for road construction and maintenance.
e) Change in Recreational Activities	• Projected sea level rise highly likely to reduce, or modify, or eliminate existing recreational beaches. • Potential direct and indirect effects on tourism through beach loss, impacted infrastructure, and ecosystem degradation.
Coastal Zones	
a) Change in Natural Erosion, Migration, and Deposition Patterns (incl. Beach Dunes)	• Rising sea level likely to expose coastlines to increase damage from wave action, and intensify rates of erosion. • Potential for increased variability in shore-line dynamics with potential changes in shoreline advance or erosion, and resultant impact on distribution of beaches.
b) Changes in Current Flooding Patterns	• Sea level will rise in Atlantic Canada over the next century with the result that storm surges in HRM are likely to inundate areas never before flooded. • Sea-level rise and storm surge likely to result in the inundation of low-lying coastal lands. • Potential increases in the extent and location of marine pollution associated

Sector	Example Impacts
	with stormwater run-off.
Human Health	
a) Change in Use and Capacity of Public Health System	• Persistence of foreign diseases will likely increase; • Stress and over-loading of the capacity of public health system, from the cumulative effects of extreme events, introduction of foreign diseases, and break-down in essential services such as electrical power and communications during or following extreme events.
b) Change in Incidence, Distribution and Severity of Vector (animal, bird, insect) and Flood Borne Disease	• Incidents and distribution of vector-borne diseases (*e.g.,* Lyme disease, West Nile virus) and flood borne diseases will likely increase as a result of changes in temperature, precipitation, and extreme events.
c) Change in Respiratory Disorders	• Possible increased incidents and distribution of respiratory disorders associated with increases in temperature and air pollution (strong connection between higher daily temperatures and the potential for smog).
d) Change in Illness, Stress, Injury and Casualty Rates	• Health impact of thermal extremes (death and illness in vulnerable sectors of the community including the elderly, frail and ill); • Incidents of health impacts associated with extreme weather events and other natural hazards (deaths, injuries, infectious diseases, stress-related disorders, adverse health effects associated with social disruption, environmentally-forced migration). Extreme events such as heat waves are projected to be more numerous in HRM.
e) Change in Eye and Skin Disorders	• Increased incidents of disruption to the immune system and increased incidents of skin cancer and cataracts in the eyes due to changes in levels of ultra-violet radiation.
f) Change in General Public Health by Food-Borne Diseases	• Possible increased incidence of food-poisoning and intestinal tract ailments associated with spoiled food in summer temperatures. • Seafood affected by increased levels of pollution associated with run-off events of increased severity. • Anticipated increased incidence in toxic algae blooms from change in sea level, temperature, and sediment in precipitation runoff.
Water Resources	
a) Change in Surface Water Supply and Quality	• Potential for increased variability in the quality and quantity of water resources. • Possible increased variability in water supply, affecting energy production (hydropower), domestic and industrial water supplies, agriculture production and pollution events and extent. • Anticipated increases in both intense rain events and sea level rise places HRM at risk for reductions in surface water quality from run-off, flooding, pollution, evaporation, decreased flow. • Potential for cumulative effect of increased consumptive use of water linked to regions with significant growth in population.
b) Change in Ground Water Supply and Quality	• Potential for increased incidents and distribution of environmental and water contamination primarily related to agricultural run-off (*i.e.*, manure) and water management (*e.g.*, well-head and water quality management). • Changes in temperature and precipitation likely to alter recharge to groundwater aquifers, causing shifts in water table levels in unconfined aquifers. • Possible increased incidents of salt-water intrusion in coastal aquifers affecting potable and agricultural groundwater supplies. • Potential for increased incidents of aquatic pollution associated with runoff and flooding. •

Sector	Example Impacts
c) Affect on Aquatic Life from Precipitation	• Potential increase in surface water temperatures affecting trout and salmon habitat. • Potential decrease in groundwater flows resulting in higher water temperature and poorer water quality of surface waters.
Forests	
a) Change in Soil Erosion Potential	• Increased soil erosion and run-off as a result of changes in temperature, precipitation and wind likely to impact habitat, wildlife, and sediment in storm run-off.
b) Change in Forest Fire Potential	• Anticipated increase incidents and range of forest fires due to changes in temperature and precipitation bringing about extended hot dry conditions.
c) Change in Sustainable Forest and Wildlife Habitat	• Potential for increased variability in forest structure, composition, productivity, and regeneration as a result of changes in temperature, precipitation and wind. Warmer and more humid climate could increase the numbers of local and exotic forest pests.
d) Change in Pest Populations	• Potential for increased variability in incidents and locations of pests, and on the pest cycle, and rate of infestation. For example, the Gypsy Moth has rarely caused more than trace defoliation in Atlantic Canada. However, it likes hardwood foliage and is potentially a risk to these species. Winter temperature increase is a critical limitation to development and survival of this moth, as eggs are killed on prolonged exposure to temperatures at or below -9ºC, (exposure at -23ºC for even short periods is lethal). • Possible increased risk of invasive species, especially as winter temperatures rise. Potential changes in range and distribution of invasive species. Changes in precipitation and temperature significantly affect the impacts from invasive species.
Environment	
a) Change in Abundance and Distribution of Wildlife Populations	• Possible changes in the distribution, range and number of birds and other wildlife depend on habitat affected by climate change. Up to a certain point, living organisms can adapt to natural stresses such as new climatic conditions. More resistant species may survive, others will have to migrate if they can, whereas still others will disappear and be replaced by different species that are better adapted to the new conditions. Wildlife is sensitive to climate variations. Mild winters will enhance the reproductive capacities of some species, leading to a gradual northward expansion of their populations. • Anticipated changes in biodiversity. • Projected increased stress on native species due to invasion/migration of alien species without natural controls.
b) Change in Abundance and Distribution of Isolated Populations and Ecosystems	• Projected increased stress on isolated wildlife populations and ecosystems, such as protected areas that are ecosystem “islands”, which will likely threaten the sustainability of the species or ecosystem.

c) Change in the Migration of Species (*i.e.*, Coastal Water-Fowl)	• Anticipated changes in river flow - earlier break-up, stronger spring flows, and reduced summer flow could:
	  • alter the migration patterns of species, particularly waterfowl due to changes in coastal wetlands from temperature, precipitation, season, and sea level.
	  • further threaten certain endangered species (for example ducks and aquatic species).

Appendix A-2
Adaptation References

Analyzing Climate Hazards

The Canadian Engineering Vulnerability Assessment Protocol
http://www.pievc.ca/e/abo_overview_.cfm

Engineers Canada and its partners have established the Public Infrastructure Engineering Vulnerability Committee (PIEVC). Through the study of four categories of public infrastructure – buildings; roads and associated structures; storm water and wastewater systems; and water resources – PIEVC has produced an engineering vulnerability assessment protocol. The five-step protocol provides a procedure for shifting through data for developing relevant information on specific elements of the climate and characteristics of a given infrastructure. The Protocol then considers how this information might interact and result in the infrastructure being vulnerable or adaptive to climate change.

The Engineering Vulnerability Assessment Protocol provides a procedure or template for sifting through data to develop relevant information on:

a) specific elements of the climate;
b) characteristics of a given infrastructure; and
c) how a) and b) might interact to make that infrastructure vulnerable (or resilient) to climate change.

The five-step Protocol supplies a guide for practitioners to follow while conducting a climate change infrastructure engineering vulnerability assessment on specific infrastructure. It is most specifically geared towards assessments of existing assets but could be used fro new projects as well. It can assist practitioners to effectively incorporate climate change adaptation into design development and
management decision-making.

The Protocol utilizes the following five steps.

Step 1: Project Definition

Step 1 in using the Protocol centres on defining the boundary conditions of the vulnerability assessment by describing the infrastructure being assessed, its location, load, age and other relevant factors, plus the historic climate of the region where the infrastructure is located. Step 1 also involves identifying major documents and information likely to be relevant to the assessment.

Step 2: Data Gathering and Sufficiency

Step 2 calls upon interdisciplinary judgment in the form of engineering, climatology, operations, maintenance and management expertise to be applied to the following two key activities.

1) Specifying components of the infrastructure to be considered in the assessment
This involves identifying the infrastructure's physical components (and how many); location; technical considerations (*e.g.*, construction material, age, regional importance and physical condition); operation and maintenance practices; and performance measures to operate and manage the infrastructures (*e.g.*, policies, guidelines, regulations, as well as insurance and legal considerations).

2) Identifying sources of climate information
Sources include historical climate data from Environment Canada as well as local or regional climate data collected by the province or at the municipal level. Other useful sources include the National Building Code of Canada, Appendix C, Climate Information; flood-plan mapping; regionally specific climate modelling; heat units (*e.g.*, for energy use, HVAC, agriculture and degree-day) plus other appropriate resources such as regional or local studies completed for the area of interest. Together, such information sources contribute toward understanding of how climate variables – including increases or decreases in temperature, more or less precipitation, or the timing and intensity of weather events – may impact infrastructure.

Step 3: Vulnerability Assessment

In this step, information gathered during the earlier steps is used to identify relationships between the infrastructure components, the climate and other factors that could lead to infrastructure vulnerability. This requires identifying components of the infrastructure susceptible to climate changes and then relating these vulnerable components to other aspects of the infrastructure. Depending on the number of relationships involved, Step 3 anticipates that the practitioner conducting the assessment will prioritize these relationships.

Using this information, the practitioner applies professional judgement and works with the facility's owner and operational personnel to assess the infrastructure's vulnerability and to identify areas in need of further evaluation or immediate action.

Step 3 also places an onus on the practitioner to identify and make recommendations on infrastructure or components of it not rendered vulnerable by climate changes.

Step 4: Indicator Analysis

Building on the previous step, Step 4 anticipates that the practitioner will conduct vulnerability indicator analysis. This analysis would consider the current load on the infrastructures, climate change and other effects on the infrastructure. It would also take into account the infrastructure's capacity as it ages and as changes in capacity occur. This will allow the practitioner to determine whether:

- a vulnerability exists – meaning total load exceeds total capacity; or
- an adaptive capacity exists – meaning total load is less than total capacity.

Under Step 4, if the results of the indicator analysis are brought into question by the quality of the data or by statistical error, the practitioner must reconsider the information gathered during Steps 1 and 2, and call for additional work outside the scope of the vulnerability assessment.

Step 5 – Recommendations

Based on Steps 1 through 4, recommendations in Step 5 generally will fall into the following categories:

- remedial action is required to upgrade the infrastructure;
- management action is required to account for changes in the infrastructure capacity;
- continued monitoring of performance of infrastructure and re-evaluation at a later time;
- no further action is required; and/or
- identification of gaps in data availability or data quality that require further work.

WikiAdpat web based database of adaptation references
http://wikiadapt.org/index.php?title=Main_Page

CRiSTAL (Community-based Risk Screening Tool - Adaptation and Livelihoods)
http://www.iisd.org/pdf/2007/brochure_cristal.pdf

CRiSTAL is a tool designed to assist project planner and managers with integrating risk reduction and climate change adaptation into community-level projects. Developed by IISD in partnership with the World Conservation Union (IUCN) and the Stockholm Environment Institute, the tool (a) helps users to systematically understand the links between local livelihoods; (b) enables users to assess a project's impact on community level adaptive capacity; and (c) assists users in making adjustments to improve a project's impact on adaptive capacity. CRiSTAL aims to provide a logical, user-friendly process to help users better understand the links between climate-related risks, people’s livelihoods, and project activities. CRiSTAL is divided into two modules: the first is designed to help collect and organize information on the climate and livelihood context of the project area. The second module then uses this information to help analyze how a project affects local vulnerability and adaptive capacity, providing a basis for devising project adjustments that foster adaptation to climate change.

Compendium on Methods and Tools to Evaluate Impacts of Vulnerability and Adaptation to Climate Change
http://unfccc.int/adaptation/nairobi_workprogramme/compendium_on_methods_tools/items/2674.php

United Kingdom Climate Impacts Programme (UKCIP) Adaptation Wizard
http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=147&Itemid=273

Intergovernmental Panel on Climate Change (IPCC) summaries for regions and ecological zones
http://www.ipcc.ch/ipccreports/ar4-wg2.htm

Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies
http://www.ivm.vu.nl/en/Images/UNEPhandbookEBA2ED27-994E-4538-B0F0C424C6F619FE_tcm53-102683.pdf

Strategic Environmental Assessment and Adaptation to Climate Change
http://www.oecd.org/dataoecd/0/43/42025733.pdf

Adapting to Coastal Climate Change: A Guidebook for Development Planners
http://www.usaid.gov/our_work/cross-cutting_programs/water/docs/coastal_adaptation/adapting_to_coastal_climate_change.pdf

CEF Consultants Limited and CBCL Limited, 2005. A Guide to Incorporating Adaptation to Climate Change into Land Use Planning.

Probability, Severity and Risk Assessment

Bell, A.V., N. Collins, and R.Young, 2003. Practitioner's Guide to Incorporating Climate Change into the Environmental Assessment Process.

Black, R.A., J.P. Bruce, and I. D. Mark Egener, 2009. Adapting to Climate Change. A Risk-based Guide for Alberta Municipalities

http://adaptation.nrcan.gc.ca/projdb/pdf/176b_e.pdf

Cameron Consulting Incorporated, 2002 – present. A Practitioner's Guide to Incorporating Climate Change Adaptation into Design, Development and Management Decision Making.

Climate Change Impacts & Risk Management: A Guide for Business and Government
http://www.preventionweb.net/files/7786_riskmanagement1.pdf

Climate adaptation: Risk, uncertainty and decision-making UKCIP Technical Report May 2003
http://www.ukcip.org.uk/images/stories/Pub_pdfs/Risk.pdf

Climate Change Impacts on Permafrost Engineering and Design. Panel on Energy Research and Development (PERD). 1998.

Caribbean Risk Management Guidelines for Climate Change Adaptation Decision Making. Caricom Adapting to Climate Change in the Caribbean (ACCC) Project. 2003.

Guide to the Integration of Climate Change Adaptation into the Environmental Impact Assessment (EIA) Process. South Pacific Regional Environment Programme; Caricom Adapting to Climate Change in the Caribbean (ACCC) Project; Canadian International Development Agency.

Wilby, R.L., J. Troni, Y. Biot, L. Tedd, B. C. Hewitson, D. M. Smith, and R. T. Sutton, 2009. A review of climate risk information for adaptation and development planning**.** *Int. J. Climatol.* **29**: 1193–1215.

Appendix A-3
Blank Risk Assessment Forms

Probability

Hazard	Very Unlikely to Happen	Occasional Occurrence	Moderately Frequent	Occurs Often	Virtually Certain to Occur
List climate change hazards identified in Step 2.	*Not likely to occur during the planning period*	*May occur sometime but not often during the planning period*	*Likely to occur at least once during the planning period*	*Likely to occur several times during the planning period*	*Happens often and will happen again during the planning period*

Severity (completed for each hazard in Probability table)

Impact Degree	Social Factors				Economic Factors			Environmental Factors			
	Displacement	Health	Loss of Livelihood	Cultural Aspects	Property Loss	Financial Loss	GDP Impact	Air Quality	Water Quantity and Quality	Land Degradation	Eco-system Impairment
Very low											
Low											
Moderate											
Major											
Extreme											

Risk Evaluation Tabulation

Item	Probability (from Probability table above)	Consequence (from Severity table above)	Segregated Risk (based on social and environmental risk)	Integ-rated risk	Risk to Project
1. *USER TO INSERT SECTOR (S) OF CONCERN. ADD SECTORS AS REQUIRED.					
List impacts/hazards relevant to sector of concern. Add rows as required.	**H, M, L**	**H_S, M_S, L_S, H_E, M_E, L_E**	**H_S, M_S, L_S, H_E, M_E, L_E**	**H, M, L**	**H, M, L**
2.					
3.					

Appendix A-4
Guidance on Cost-Benefit Analysis

When identifying viable adaptation options to be included in an Adaptation Plan (Step 5), a cost-benefit analysis can be undertaken to determine the economic feasibility of proposed adaptation measures. A cost-benefit analysis is a conceptual framework that is increasingly used for the evaluation of adaptation projects. It differs from a straightforward financial appraisal in that it considers all gains (benefits) and losses (costs) regardless of to whom they accrue. A benefit is then any gain in "utility"; a cost is any loss of utility as measured by the "opportunity cost" of the proposed project and in practice, many benefits or damages are not readily determined in monetary terms.

Step by step process for undertaking cost benefit analysis for adaptation measures is outlined in *Costing the Impacts of Climate Change in the UK*, published in 2004 by the United Kingdom Climate Impacts Programme (UKCIP) (http:// www.ukcip.org.uk/ images/stories/ Pub_pdfs/ Costings%20overview.pdf; http://www.ukcip.org.uk/images/stories/Pub_pdfs/CostingsImplementationGuidelines.pdf). As well, *The Cost of Adaptation to Climate Change in Canada: A Stratified Estimate by Sectors and Regions – Social Infrastructure* (Dore, M & I. Burton. 2001. AIRG Environment Canada) summarizes micro-level data in order to estimate the costs of adaptation to climate change at both sectoral and regional levels (http://www.adaptation.rncan.gc.ca/projdb/pdf/crosscutting4a_e.pdf)

In summary, the process for identifying costs consists of the following four steps:

Step 1: Identify and measure climate impacts in physical units *e.g.* metres of shoreline lost and associated indirect effects.

Step 2: Converting these physical impacts into monetary values.

Step 3: Calculating the costs of the proposed adaptation options.

Step 4: Assign weighting to the costs and benefits of the adaptation options, and choosing the preferred option(s) taking account of the risks and uncertainties.

Cost-Benefit Assessment can be used in the context of other decision support tools, such as multi-criteria analysis, in cases where criteria other than economic efficiency are important. In identifying the costs and benefits of climate change impacts and adaptation, the costing method incorporates assumptions about socio-economic changes. This allows the user to identify potential costs with and without climate change. Techniques like sensitivity analysis, simulation and interval analysis are suggested to help understand the sensitivity of the costing assessment to input data and models used, and to key assumptions made.

Recently, the Global Environment Facility (GEF) presented the results of a study on "Shaping Climate-Resilient Development," which provides a set of tools for decision makers to adopt a tailored approach for estimating adaptation costs based on local climate conditions, and for building more resilient economies. The report by the Economics of Climate Adaptation Working Group evaluates current and potential costs of climate change and how to prevent them by determining a location's total climate risk – calculated by combining existing climate risks, climate change and the value of future economic development – and using a cost-benefit analysis to create a list of location specific measures to adapt to the identified risk. The methodology was tested in localities within eight different countries (China, United States, Guyana, Mali, United Kingdom, Samoa, India and Tanzania), which together represent a wide range of climate hazards, economic impacts, and development stages. The findings are documented in *Report of the Economics of Climate Adaptation Working Group - Shaping Climate-Resilient Development: A Framework for Decision-making.*
http://www.gefweb.org/uploadedFiles/Publications/ECA_Shaping_Climate%20Resilent_Development.pdf

Appendix G-1

Emission Factors and Quantification References

Environment Canada National GHG Inventory
http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm

Environment Canada, Sector Specific Protocols and Guidance Manuals
http://www.ec.gc.ca/pdb/ghg/guidance/calcu_pro_e.cfm

US EPA, 40 CFR Part 98, Mandatory Greenhouse Gas Reporting, Subparts A to Subpart PP
http://www.epa.gov/climatechange/emissions/downloads09/FinalMandatoryGHGReportingRule.pdf

2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 3 – Industrial Processes and Product Use
http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html

American Petroleum Institute (API) Compendium of GHG Emissions Methodology for the Oil and Gas Industry, August 2009
http://www.api.org/ehs/climate/new/upload/2009_GHG_COMPENDIUM.pdf

Appendix G-2

GHG Emission Reduction Strategies

- Design of energy efficient buildings according to LEED standards (*e.g*., improved thermal envelope, higher efficiency HVAC systems, water conservation).
- Use of low carbon footprint or green construction materials.
- Use of heat pumps.
- Purchase green energy.
- On-site green power systems *e.g.* solar water heating; embedded renewable generation.
- Install LED lighting for outdoor work areas and parking lots.
- Select project location to reduce transportation requirements.
- Modal shift *i.e*., switching to less GHG intensive mode of transportation - switching from trucks to rail.
- Investigate combined heat and power or district energy arrangements with neighbouring facilities.
- Install energy efficient lighting.
- Construct project buildings with green roofs.
- Switch to lower carbon fuels *e.g.* replace oil or electricity with natural gas.
- Activity switching *i.e.*, replacing GHG generating activity with less emission intensive activity.
- Minimize clearing to maintain forest carbon sink.
- Reforest cleared areas to offset loss of carbon sink associated with the project.
- Implementation of industry specific best management practices and best available control technologies *e.g.*, cogeneration, flare reduction, gas recovery, gas re-injection, N_2O BACT in adipic and nitric acid production, improved maintenance, upset condition mitigation, fugitives mitigation.
- Implement leak detection and repair program.
- Undertake or invest in carbon/GHG offset projects to offset emissions associated with the Project.

- Directory of Nova Scotia and federal funding programs - http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm?attr=0