



WORKBOOK AND CASE STUDIES

VOLUME 2

Managing the Risks of Climate Change

A GUIDE FOR ARCTIC AND NORTHERN COMMUNITIES

Written By: Robert A. Black, James P. Bruce, I.D. Mark Egener
Edited By: Creative Communications

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CENTRE FOR INDIGENOUS
ENVIRONMENTAL RESOURCES

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Please contact Shaunna Morgan at smorgan@cier.ca for any questions or comments on this Guide.

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Introduction



INTRODUCTION

The Centre for Indigenous Environmental Resources (CIER) convened a workshop for representatives of a number of Arctic communities and the territorial governments to consider the projected climate change impacts over the next 20 to 30 years. The objective of the workshop was to understand which impacts will create the greatest risks to the Arctic communities and what adaptation strategies should be considered to reduce the risks to acceptable levels.

The meeting participants decided to consider the impacts in three general geographic areas:

- THE EASTERN ARCTIC,
- THE WESTERN ARCTIC, AND
- THE YUKON/MACKENZIE REGION

The following examples illustrate the use of the risk management process to develop adaptation strategies in these three geographic areas.

Case Studies: Arctic and Northern Communities

EASTERN ARCTIC

Members of the CIER workshop breakout group for the Eastern Arctic discussed the climate projections for their region and listed the following as the ones of principal concern:

- Permafrost thaw particularly from the perspective of community planning,
- Species migration,
- Shoreline erosion,
- Food security and potable water availability,
- Food security from the perspective of access to harvesting areas,
- Longer dry seasons including dust and health issues,
- Unpredictable weather changes and seasonal changes,
- Impact on traditional knowledge being passed on, and
- Natural resources exploration

The group decided to consider permafrost thaw as a detailed example because it is one of the most important impacts facing many of their communities over the next 20 to 40 years.

EASTERN ARCTIC *continued*

STEP 1: GETTING STARTED

The group, in defining the risk problem considered the following management implications of permafrost thaw:

- Community planning – areas for new development,
- Erosion,
- Water flow,
- Municipal infrastructure (i.e. roads, reservoirs and sewage lagoons),
- Building instability (i.e. residential, commercial, institutional),
- Water delivery and other municipal services,
- Raising awareness of consequences,
- Developing best practices in communities (i.e. Snow removal),
- Maximizing green spaces and recreation, and
- Possible relocation of buildings and population, among other factors.

They considered that the following would be the principal stakeholders who should be involved or informed about the analysis of the problems. The ones marked with an asterisk (*) would be on the project team:

- Territorial government,
- Elders,*
- Hunters & Trappers Organizations (HTOs),
- Municipality (Council, SAO*, engineering staff, Planning*),
- Church officials,
- Permafrost scientists/research institutions,
- Canadian Standards Organization,
- Private Sector (ie: Contractors, NTI),
- Health officials,
- INAC,
- Engineering institute,
- Home owners,
- Water board.

As part of their initial considerations the group had the following thoughts about communicating with stakeholders:

- Meet with community leaders (municipal council, elders, HTOs),
- Use radio stations for announcing and consulting, -try to get leaders to participate in radio and community outreach initiatives, and
- Ensure that information is translated in appropriate languages (includes posters and communication tools).

The group decided that it had enough information to move on to the next step.

EASTERN ARCTIC *continued***STEP 2: PRELIMINARY ANALYSIS**

The risk scenario for permafrost thaw was developed:

A. Land for development (shortage of land)

- Monitoring and assessment
 - soil analysis
 - site inspection
 - identify hot spots
 - geotechnical sampling
- Full analysis too costly for many communities

B. Infrastructure

- Roads
- Water
- Sewage
- Airstrips
- Water reservoir
- Dump sites
- Bridges
- Culverts

C. Cemeteries, historical/cultural sites

- Historical structure or cultural sites
- Moving of cemetery due diligence

D. Water

- River patterns –ponds disappearing
- Drainage patterns

E. Land slides (erosion)

- Could cause moving of parts of community

F. Building instability

- Housing
- Buildings

G. Mine development /tailings

- Containment of contaminants

EASTERN ARCTIC *continued***TABLE 2:** Preliminary Hazard and Risk Scenario Assessment (Step 2)

| HAZARD: | | | | |
|-----------------|---|-----------|-------------|-----------------------------|
| RISK | EVENT OR RESULT | FREQUENCY | CONSEQUENCE | COMMENTS |
| Permafrost Thaw | Land for Development | 1 2 3 | 1 2 3 | Greater Analysis/Inspection |
| | Infrastructure | 1 2 3 | 1 2 3 | Same as above |
| | Historical and Cultural sites and cemeteries | 1 2 3 | 1 2 3 | Geotechnical/Accessibility |
| | Drainage Patterns | 1 2 3 | 1 2 3 | More Culverts |
| | River Patterns | 1 2 3 | 1 2 3 | Geotechnical |
| | Land Slumps | 1 2 3 | 1 2 3 | Community Planning |
| | Building Instability | 1 2 3 | 1 2 3 | New Practices |
| | Mining Development: Containment of Contaminants | 1 2 3 | 1 2 3 | |

FREQUENCY

1. Unlikely To Occur
2. Moderately Frequent Occurrence
3. Almost Certain To Occur

CONSEQUENCES

1. Low
2. Moderate
3. High

After doing the preliminary analysis the team found that they needed further data for Step 3 particularly in the following areas:

- Updated information on construction techniques
- Installation of monitoring equipment to monitor temperature of the ground, conditions of permafrost
- Feasibility of creating relationships with various research institutes working on the subject.

After recording all their information in the risk library, the group decided to move to Step 3.

EASTERN ARCTIC *continued*

STEP 3: RISK ESTIMATION

In this step the group considered both:

- Gradual thawing of the permafrost
- Episodic/extreme occurrence of a rapid permafrost thaw.

TABLE 3-1: Estimates of Frequency or Probability of Risks

| PROBABILITY OR FREQUENCY | | | | | |
|--|-------------------------|-----------------------|---------------------|--------------|----------------------------|
| Event | Very Unlikely to Happen | Occasional Occurrence | Moderately Frequent | Occurs Often | Virtually Certain to Occur |
| Land for development | | | | | X |
| Infrastructure | | | | X | |
| Historical and cultural sites and cemeteries | | X | | | |
| Drainage patterns | | | | X | |
| River patterns | | | X | | |
| Land slumps | | | X | | |
| Building instability | | | | | X |
| Mining development containment of contaminants | | X | | | |

EASTERN ARCTIC *continued***TABLE 3-2:** Estimates of Consequences of Risks (Permafrost thaw overview)

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | |
| Very Low | | | X | | | | X | | | | |
| Low | | | | | | | | | | | |
| Moderate | | X | | | | | | | | | |
| Major | X | | | | | X | | | | X | X |
| Very Severe | | | | X | X | | | X | X | | |

EASTERN ARCTIC *continued***TABLE 3-3:** Suggested Display for Stakeholders and Risk Perception

| Climate Factors (Hazards) | Risk Scenarios - Aspects of Hazards and Risks to Community | Stakeholders and Perception of Risk |
|---------------------------|--|--|
| Permafrost Thaw | Impacts on Infrastructure | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Very Low Private Sector - Very Severe +- |
| | Cultural and Historical Sites and Cemeteries | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Moderate Private Sector - Low Nti - Moderate |
| | Rivers Changing Courses | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Very Severe Private Sector - Very Severe |
| | Drainage Patterns | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Major Hto-Major Private Sector - Moderate |
| | Land Slumps | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Major Private Sector - Moderate +- |
| | Building Instability | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Moderate Private Sector - Very Severe +- |
| | Containment of Contaminants | Municipal Council-Very Severe Territorial Government-Very Severe Residents - Very Severe Hto-Very Severe Private Sector - Very Severe +- |

After thoroughly discussing their estimates of probability and consequences, the group agreed that there was a consensus among the members for the first round of the risk management process.

EASTERN ARCTIC *continued*

STEP 4: RISK EVALUATION

The group considered the overall consequences and probability of the various risks associated with permafrost thaw and produced the overview chart below:

TABLE 4: Risk Evaluation Matrix (Step 4)

| | | | | | | |
|--|----------|-------------------------|--|-------------------------------|-------------------|---|
| OVERALL CONSEQUENCE OR IMPACT SEVERITY | EXTREME | | Mining Development Conatinent of Contaminants | River Patterns Land Slumps | Infrastructure | Land for Development (Shortage) Building Instability |
| | MAJOR | | | | Drainage Patterns | |
| | MODERATE | | Cultural Shortage Historic Sites and Cemeteries | | | |
| | LOW | | | | | |
| | VERY LOW | | | | | |
| | | VERY UNLIKELY TO HAPPEN | OCCASIONAL OCCURRENCE | MODERATELY FREQUENT | OCCURS OFTEN | VIRTUALLY CERTAIN TO OCCUR |
| FREQUENCY / PROBABILITY | | | | | | |

The evaluation chart clearly indicated to the group the urgent need to consider adaptation measures or risk controls for the highest priority risks from permafrost thaw: creation of shortages of land for development, building instability, infrastructure damages, changes to river flow patterns, land slumps and changes to land drainage patterns.

The group was comfortable that a consensus existed among its members and it was decided to advance to Step 5.

Before doing so the group discussed the need for a dialogue with the key stakeholders, particularly the Council, HTOs and their prime contact in the Territorial government.

All documents used or copies of them including meeting and discussion notes were stored in the risk library.

EASTERN ARCTIC *continued***STEP 5: RISK CONTROLS AND ADAPTATION DECISIONS**

The group now considered the risk controls or adaptation measures needed to lower the higher risks due to permafrost thaw from Step 4 to acceptable or manageable levels.

After discussions with the readily available technical representatives the chart below was developed (only the two highest risks were used in this section of the example):

TABLE 5: Risk Controls and Adaptation Measures

| Risk | Control or Adaptation Measure | Time Frame | Cost | Effectiveness | Acceptability | Comment / Evaluation |
|----------------------------------|---|------------|------|---------------|---------------|---|
| Shortage of Land for Development | Produce Geotechnical Reports | 5-10 years | High | High | High | Geotechnical analysis is necessary for land use planning and it must be included in community planning and zoning by-laws |
| | Community Hazard Maps | 5-10 years | High | High | High | |
| | Amend Development Plans and By-Laws | 5-10 years | High | High | High | Effective but slow |
| | Require New Development Permits | 5-10 years | High | High | High | |
| Building Instability | New Development Standards and Building Practices Monitoring | 5-10 years | High | High | High | Examine new technologies in circumpolar regions Effective but slow |
| | Retrofitting Technologies | Immediate | Med | High | High | |
| | Monitoring of Soil | Immediate | Med | High | High | |

The group agreed that all factors considered would bring risks to manageable and acceptable levels.

There would be a requirement for considerable discussion with and provision of information to all key stakeholder groups, and particularly the territorial and federal governments recognizing that funding assistance would be needed for the technical studies and experts assistance would be required.

The group completed the storing of information in the risk library and decided to move onto Step 6.

STEP 6: IMPLEMENTATION AND MONITORING

For the purposes of this example, the group was tasked to prepare a report for consideration by Council. The findings of the study were documented and recommendations drafted for Council to consider including the urgent needs to begin geotechnical studies and produce hazard maps.

WESTERN ARCTIC

Members of the CIER workshop breakout group for the Western Arctic discussed the climate projections for their region.

The group decided to consider permafrost thaw because it is one of the most serious concerns in the Western Arctic and especially in the community of Tuktoyaktuk.

WESTERN ARCTIC *continued*

STEP 1: GETTING STARTED

The group selected the Project team to include:

- Community Planner (Team Leader),
- Elder,
- Youth,
- Land Administration/Regional Government, and
- Readily available resource person/people.

- Stakeholders:
 - Hamlet Council and Senior Administrative Officer,
 - Inuvialuit Land Administration
 - Tuktoyaktuk Community Corporation,
 - Hunters and Trappers Council
 - Local businesses,
 - Homeowners,
 - Federal government – Indian and Northern Affairs Canada, Environment Canada, Natural Resources Canada, and
 - GNWT – Industry, Tourism and Investment, Municipal and Community Affairs, Dept of Transportation.

The time-frame for completing an overview study, including briefings to Council and key stakeholders was two weeks.

The group decided to keep careful records of all information they received, all documents that they created including meeting notes in a special file set up for the risk management study.

The group decided that it had enough information to move to the next step.

WESTERN ARCTIC *continued*

STEP 2: PRELIMINARY ANALYSIS

A risk scenario for permafrost thaw was developed:

TABLE 2: Preliminary Hazard and Risk Scenario Assessment (Step 2)

| HAZARD: PERMAFROST THAW | | | | |
|------------------------------|-----------------------------|-----------|-------------|--|
| RISK | EVENT OR RESULT | FREQUENCY | CONSEQUENCE | COMMENTS |
| Slumping | Loss of cultural assets | 1 2 3 | 1 2 3 | Includes: historical items, archaeological finds, culturally significant items, etc. |
| | Loss of fresh water habitat | 1 2 3 | 1 2 3 | |
| | Foundation Failure | 1 2 3 | 1 2 3 | |
| | Land Travel | 1 2 3 | 1 2 3 | |
| | Loss of Vegetation | 1 2 3 | 1 2 3 | |
| Surface Water | Change in quality | 1 2 3 | 1 2 3 | |
| | Change in quantity | 1 2 3 | 1 2 3 | |
| | Change in location | 1 2 3 | 1 2 3 | (More info is needed to determine the consequences of location changes) |
| Seabed and Shoreline Erosion | Loss of land | 1 2 3 | 1 2 3 | Shoreline erosion could be considered a separate hazard under the broader |
| Pingos | Deterioration | 1 2 3 | 1 2 3 | |
| | Cultural/economic | 1 2 3 | 1 2 3 | |
| Land Availability | Loss of land for future use | 1 2 3 | 1 2 3 | |
| Contaminants | Sumps | 1 2 3 | 1 2 3 | There are already remediation processes in place. |
| | Soil | 1 2 3 | 1 2 3 | |

WESTERN ARCTIC continued

The group narrowed the risk scenario to two risks (shown above in red type) and considered them over the next 20 years:

- Slumping and the impact on foundations, and
- Changes, especially reduction, to surface water.

The group included several images to illustrate slumps and pingos



The group was satisfied with their preliminary analysis, stored their data in the risk information library and decided to proceed to the next step.

WESTERN ARCTIC *continued***STEP 3: RISK ESTIMATION**

The group made more considered estimates of the frequency and consequences of their selected risks and how stakeholders may perceive them as shown in the tables below

TABLE 3-1: Estimates of Frequency or Probability of Risks

| PROBABILITY OR FREQUENCY | | | | | |
|---|-------------------------|-----------------------|---------------------|--------------|----------------------------|
| Event | Very Unlikely to Happen | Occasional Occurrence | Moderately Frequent | Occurs Often | Virtually Certain to Occur |
| Slumping - foundation failure | | | | | X |
| Surface water change (Loss of quantity) | | | X | | |

WESTERN ARCTIC *continued*

TABLE 3-2: Estimates of Consequences of Risks: Surface Water Quantity Loss

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | |
|-------------|----------------|-----------------|--------------|--------------------|-----------------|------------------|-----------------------|-----|-------|------|------------------|-------------|
| | Degree | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | | Eco-systems |
| Very Low | | X | | X | X | X | X | | X | | | |
| Low | | | X | | | | | | | | | X |
| Moderate | | | | | | | | | | X | X | |
| Major | | | | | | | | X | | | | |
| Very Severe | | | | | | | | | | | | |

TABLE 3-2: Estimates of Consequences of Risks: Infrastructure Failure (Slumping)

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | |
|-------------|----------------|-----------------|--------------|--------------------|-----------------|------------------|-----------------------|-----|-------|------|------------------|-------------|
| | Degree | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | | Eco-systems |
| Very Low | | X | | | | | | | X | X | | |
| Low | | | X | X | | X | | | | | X | X |
| Moderate | | | | | X | | | | | | | |
| Major | | | | | | | X | X | | | | |
| Very Severe | | | | | | | | | | | | |

WESTERN ARCTIC *continued***TABLE 3-3:** Suggested Display for Stakeholders and Risk Perception

| Climate Factors (Hazards) | Risk Scenarios - Aspects of Hazards and Risks to Community | Stakeholders and Perception of Risk |
|------------------------------------|--|--|
| Permafrost melt - slumping | Foundation failure | GNWT - very serious Business owners - serious Public housing occupants - very serious Private home owners - very serious Hamlet - very serious ILA - serious TCC - serious Government of Canada - serious |
| Permafrost melt - surface water | Quantity change | Hamlet - very serious GNWT - very serious HTC - serious Private businesses - low Government of Canada - moderate Community members - very serious ILA - very serious |

The group discussed their estimates of probability and consequences, and agreed that there was a consensus among the members for the first round of the risk management process.

WESTERN ARCTIC *continued*

STEP 4: RISK EVALUATION

The group considered the overall consequences and probability of the various risks associated with permafrost thaw and produced the overview chart below:

TABLE 4: Risk Evaluation

| | | | | | |
|--|----------|-------------------------|-----------------------|-------------------------------|---------------------|
| OVERALL CONSEQUENCE OR IMPACT SEVERITY | EXTREME | | | | |
| | MAJOR | | | | Foundation Failures |
| | MODERATE | | | Loss of Surface Water Quality | |
| | LOW | | | | |
| | VERY LOW | | | | |
| | | VERY UNLIKELY TO HAPPEN | OCCASIONAL OCCURRENCE | MODERATELY FREQUENT | OCCURS OFTEN |
| FREQUENCY / PROBABILITY | | | | | |

The evaluation chart indicated to the group the need to consider adaptation measures or risk controls for the highest priority risk from permafrost melt, foundation failures.

The group was comfortable that a consensus existed among its members and it was decided to advance to Step 5.

Before doing so the group discussed the need for a dialogue with the key stakeholders, particularly the Hamlet Council, Inuvialuit Land Administration, the Tuktoyaktuk Community Corporation and contacts in the Territorial government.

All documents used or copies of them including meeting and discussion notes were stored in the risk library.

WESTERN ARCTIC *continued*

STEP 5: RISK CONTROLS AND ADAPTATION DECISIONS

The group now considered the risk controls or adaptation measures needed to lower the risks due to permafrost melt from Step 4 to acceptable or manageable levels.

After discussions with the readily available technical representatives the chart below was developed:

TABLE 5: Risk Controls and Adaptation Measures

| Risk | Control or Adaptation Measure | Time Frame | Cost | Effectiveness | Acceptability | Comment / Evaluation |
|----------------------------------|--|----------------------------|----------|---------------|---------------|--|
| Foundation Failure (slumping) | Ensure infrastructure inspections occur regularly | Ongoing | Low | High | High | Check report completed by DPW |
| | Review and update (if necessary) building codes | Ongoing | n/a | High | High | Ensure that climate change is being considered; reaffirm needs with senior government |
| | Soil Classification/permafrost mapping | One-time; within two years | High | High | Moderate | Would determine where ice is located under surface |
| | Research and communicate information about new and adaptive infrastructure technologies and best practices | Ongoing | Low | Moderate | High | |
| | Create new and/or more access to gravel source | Ongoing | High | High | Variable | Remedial treatments for domestic foundations |
| | Increase operation, maintenance and repair of foundations | Ongoing | Moderate | High | High | Increase Operations and Maintenance funding |
| | Implementing appropriate new technologies and/or building codes | As possible | TBD | High | Moderate | Would depend on the technology being implemented |
| Loss of Quantity (surface water) | Select future water source(s) that consider climate change effects | As needed | Low | High | High | Observations from community members are to be considered |
| | Research possibility of retaining existing water source | Immediate | Moderate | High | High | |
| | Monitor effect of changing quantity on ecosystems | Ongoing | Moderate | TBD | TBD | Focus on flow and connectivity; consider local observations. Must include a presentation of scientific knowledge |
| | Review and rehearse existing emergency preparedness plan for water supply | Ongoing | Low | High | High | |

*WESTERN ARCTIC continued***STEP 5: RISK CONTROLS AND ADAPTATION DECISIONS**

The group agreed that all factors considered could bring risks to manageable and acceptable levels.

There would be a requirement for considerable discussion with and provision of information to all key stakeholder groups, and particularly the territorial and federal governments recognizing that funding assistance would be needed for the technical studies and experts assistance would be required.

The group completed the storing of information in the risk library and decided to move onto Step 6.

STEP 6: IMPLEMENTATION AND MONITORING

For the purposes of this example, the group was tasked to prepare a report for consideration by the Senior Administrative Officer and Council.

- Prioritization of risk control measures would be included in the report
- Inclusion of monitoring and results reporting
- Provision for a review every 5 years

The findings of the study were documented and recommendations drafted for the Hamlet Council to consider.

Stakeholder information sessions were included in the recommendations.

YUKON AND MACKENZIE REGION

Members of the CIER workshop breakout group for the Yukon/Mackenzie region discussed the climate projections for their region.

YUKON AND MACKENZIE REGION *continued*

STEP 1: GETTING STARTED

The group discussed the risks presented by climate change in their region over the next 25 to 40 years and selected increased precipitation for examination because it was one of the most serious hazards for this area of the Arctic..

The Project team included:

- Community Planner (Team Leader),
- Elder,
- Land Administration/Regional Government representative, and
- A readily available technical resource person from the community.

The group considered that the following would be the principal stakeholders who should be involved or informed about the analysis of the problems. The ones marked with an asterisk would be on the project team:

- Territorial government,
- Elders,
- Hunters & Trappers Organizations (HTOs),
- Municipal Council, SAO, engineering staff,
- Permafrost scientists/research institutions,
- Standing Offer Contractors
- Health officials,
- INAC,
- Homeowners,

As part of their initial considerations the group considered communicating with stakeholders:

- Meet with community leaders,
- Develop a community outreach plan, and
- Ensure that information is translated in appropriate languages (includes posters and communication tools).

The group decided that it had enough information to move on to the next step

YUKON AND MACKENZIE REGION *continued*

STEP 2: PRELIMINARY ANALYSIS

The risk scenario for increased precipitation was developed:

TABLE 2: Preliminary Hazard and Risk Scenario Assessment

| HAZARD : INCREASED PRECIPITATION | | | | |
|-----------------------------------|--|--------------|--------------|----------|
| RISK | EVENT OR RESULT | FREQUENCY | CONSEQUENCE | COMMENTS |
| More Snow Accumulation | <ul style="list-style-type: none"> • Human Mobility • Animal Mobility & Health • Building Loads • Cost of Snow Removal | 1 2 3 | 1 2 3 | |
| Waterway Flooding | <ul style="list-style-type: none"> • Roads Washed Out • Community Flooding • Bank Erosion • Degradation of Fish Habitat • Water Potability Reduction | 1 2 3 | 1 2 3 | |
| Reduction of Ice Thickness | <ul style="list-style-type: none"> • Reduced Human Mobility • Safety • Reliance on other transportation modes | 1 2 3 | 1 2 3 | |
| Reduction in Tourism | <ul style="list-style-type: none"> • Less Income • More reliance on traditional income sources | 1 2 3 | 1 2 3 | |
| Increase in pests | <ul style="list-style-type: none"> • Mosquitoes & Black flies (West Nile, Ticks) • Tree pests | 1 2 3 | 1 2 3 | |
| Increased cost for Infrastructure | <ul style="list-style-type: none"> • Building costs • Road costs • Water treatment systems | 1 2 3 | 1 2 3 | |
| Socio-Economic Implications | <ul style="list-style-type: none"> • Change in Traditional Practices • Increased Health Issues • Availability of Traditional Foods • Reduction in reliability of Traditional Knowledge | 1 2 3 | 1 2 3 | |

Because the group did not have sufficient time in the workshop to consider all of the risks in this scenario, they decided to consider the one that they assessed as the highest risk (shown in red type) for further study:

After recording all their information in the risk library, the group decided to move to Step 3.

YUKON AND MACKENZIE REGION *continued*

STEP 3: RISK ESTIMATION

In this step the group considered in more detail the likelihood and consequences of the risks they had selected from table 2.

TABLE 3-1: Estimates of Frequency of Risks Associated with Increased Precipitation

| PROBABILITY OR FREQUENCY | | | | | |
|----------------------------|-------------------------|-----------------------|---------------------|--------------|----------------------------|
| Event | Very Unlikely to Happen | Occasional Occurrence | Moderately Frequent | Occurs Often | Virtually Certain to Occur |
| More Snow Accumulation | | | | | X |
| Waterway Flooding | | | | X | |
| Reduction of Ice Thickness | | | X | | |
| Reduction in Tourism | | X | | | |
| Increase in pests | | | | X | |

TABLE 3-2: Estimates of Consequences of Risks
Risk Scenario #1: More Snow Accumulation

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Very Low | X | | | | | | X | X | X | | | | |
| Low | | | | | | | | | | | | | |
| Moderate | | X | | | | | | | | X | | | |
| Major | | | X | X | | X | | | | | | | |
| Very Severe | | | | | X | | | | | | X | X | X |

YUKON AND MACKENZIE REGION *continued*

TABLE 3-2: Estimates of Consequences of Risks
Risk Scenario #2: Waterway Flooding

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Degree | | | | | | | | | | | | | |
| Very Low | | | | | | | X | | | | | | |
| Low | | | | | | | | | | | | | |
| Moderate | | | | | | | | | X | X | | | |
| Major | X | | X | | X | X | | X | | | | | |
| Very Severe | | X | | X | | | | | | | X | X | X |

TABLE 3-2: Estimates of Consequences of Risks
Risk Scenario #3: Reduction of Ice Thickness

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Degree | | | | | | | | | | | | | |
| Very Low | X | | | | | | X | X | X | X | | | |
| Low | | | | X | | | | | | | | | |
| Moderate | X | | | | X | | | | | | | | |
| Major | | X | | | | X | | | | | | | |
| Very Severe | | | X | | | | | | | | X | X | X |

YUKON AND MACKENZIE REGION *continued***TABLE 3-2:** Estimates of Consequences of Risks - Risk Scenario #4: Reduction in Tourism

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Very Low | X | X | | X | | | X | X | X | X | | | |
| Low | | | | | | X | | | | | X | X | X |
| Moderate | | | X | | | | | | | | | | |
| Major | | | | | X | | | | | | | | |
| Very Severe | | | | | | | | | | | | | |

TABLE 3-2: Estimates of Consequences of Risks - Risk Scenario #5: Increase in Pests*

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Very Low | | | | | | | | | | | | | |
| Low | X | | | | | | | X | X | | | | |
| Moderate | | X | | X | X | | X | | | | | | |
| Major | | | X | | | X | | | | X | X | X | X |
| Very Severe | | | X | | | | | | | | | | |

*The impact of pests on forests and consequent implications for increased forest fires were considered by the group.

The group discussed their estimates of probability and consequences, and agreed that there was a consensus among the members for the first round of the risk management process.

They did not have time to consider the stakeholders' perception of the risks and decided to do that at the end of the next step.

The group ensured that the documents, notes and other records were saved in the risk library.

YUKON AND MACKENZIE REGION *continued*

STEP 4: RISK EVALUATION

The group considered the overall consequences and probability of the various risks associated with increased precipitation and produced the overview chart below:

TABLE 4: Risk Evaluation Matrix (Step 4)

| | | | | | | |
|--|----------|-------------------------|-----------------------|----------------------------|-------------------|----------------------------|
| OVERALL CONSEQUENCE OR IMPACT SEVERITY | EXTREME | | | | | |
| | MAJOR | | | | Waterway Flooding | More Snow Accumulation |
| | MODERATE | | | Reduction of Ice Thickness | Increase in pests | |
| | LOW | | Reduction of Tourism | | | |
| | VERY LOW | | | | | |
| | | VERY UNLIKELY TO HAPPEN | OCCASIONAL OCCURRENCE | MODERATELY FREQUENT | OCCURS OFTEN | VIRTUALLY CERTAIN TO OCCUR |
| FREQUENCY / PROBABILITY | | | | | | |

The evaluation chart indicated to the group the need to consider adaptation measures or risk controls for the highest priority risks from increased precipitation: snow accumulation.

The group was comfortable that a consensus existed among its members and it was decided to advance to Step 5.

Before doing so the group discussed the need for a dialogue with the key stakeholders, particularly the Council, and contacts in the Territorial government.

All documents used or copies of them including meeting and discussion notes were stored in the risk library.

YUKON AND MACKENZIE REGION *continued*

STEP 5: RISK CONTROLS AND ADAPTATION DECISIONS

The group now considered the risk controls or adaptation measures needed to lower the risks due to high snow accumulation to acceptable or manageable levels (note: time shortages precluded them from considering adaptation measures or risk controls for other risks from Step 4).

TABLE 5: Risk Controls and Adaptation Measures for More Snow Accumulation

| Risk | Control or Adaptation Measure | Time Frame | Cost | Effectiveness | Acceptability | Comment / Evaluation |
|------------------------|--|------------|------|---------------|---------------|--|
| More snow accumulation | Enhanced Snow Removable Capability | Long | High | High | Marginal | |
| | Prioritize Roads to be Cleared | Short | Low | High | Good/Better | |
| | Review Building Codes | Short | Low | High | Very Good | |
| | Prioritize Buildings for Upgrading | Med | Med | High | Good | |
| | Structural Upgrading | Long | High | High | Marginal | |
| | Clearing Important Wildlife Routes | Short | Med | High | High | |
| | Monitoring Wildlife Health & Harvest Control | Short | High | Medium | Medium | <ul style="list-style-type: none"> • Higher acceptability if joint process • Politically sensitive |
| | Food Drops to Wildlife | Short | High | Medium | Medium | |
| | Resource Sharing | Short | Low | High | High | |

The group agreed that all factors considered could bring this particular risk to a manageable and acceptable level.

There would be a requirement for considerable discussion with and provision of information to all key stakeholder groups, and particularly the territorial and federal governments recognizing that funding assistance would be needed for the technical studies and experts assistance would be required.

The group completed the storing of information in the risk library and decided to move onto Step 6.

YUKON AND MACKENZIE REGION *continued*

STEP 6: IMPLEMENTATION AND MONITORING

For the purposes of this example, the group was tasked to prepare a report for consideration by the Council.

- Prioritization of risk control measures would be included in the report
- Inclusion of monitoring and results reporting
- Provision for a review every 5 years

The findings of the study were documented and recommendations drafted for the Hamlet Council to consider.

Stakeholder information sessions were included in the recommendations.

3

Workbook

This Annex contains the templates suggested in Chapter 4 of Volume 1:

- The risk scenarios (*Step 2*)
- Estimates of Frequency or Probability of risks (*Step 3*)
- Estimates of Consequence of risks (*Step 3*)
- Stakeholder Risk Perceptions (*Step 3*)
- Evaluation of Risks (*Step 4*)
- Adaptation Measures and Risk Controls (*Step 5*)

The templates can be photocopied for use by risk project teams. The headings of these templates are suggestions only. The project team can change them to suit their needs.

TABLE 2: Preliminary Hazard and Risk Scenario Assessment (Step 2)

| HAZARD: INCREASED PRECIPITATION | | | | | | | | |
|---------------------------------|-----------------|-----------|---|---|-------------|---|---|----------|
| RISK | EVENT OR RESULT | FREQUENCY | | | CONSEQUENCE | | | COMMENTS |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |
| | | 1 | 2 | 3 | 1 | 2 | 3 | |

Notes: Make rough estimates of
(these will be expanded in Step 3)

- FREQUENCY**
1. Unlikely To Occur
 2. Moderately Frequent Occurrence
 3. Almost Certain To Occur

- CONSEQUENCES**
1. Low
 2. Moderate
 3. High

TABLE 3-2: Estimates of Consequences of Risks - Risk Scenario #5: Increase in Pests*

| IMPACT | Social Factors | | | Economic Factors | | | Environmental Factors | | | | Cultural Aspects | | |
|-------------|-----------------|--------------|--------------------|------------------|------------------|---------------------|-----------------------|-------|------|-------------|-------------------|----------------------|-----------------------|
| | Health & Safety | Displacement | Loss of Livelihood | Property Damage | Financial Impact | Impact on community | Air | Water | Land | Eco-systems | Traditional Foods | Traditional Medicine | Traditional Lifestyle |
| Very Low | | | | | | | | | | | | | |
| Low | | | | | | | | | | | | | |
| Moderate | | | | | | | | | | | | | |
| Major | | | | | | | | | | | | | |
| Very Severe | | | | | | | | | | | | | |

TABLE 4: Risk Evaluation Matrix (Step 4)

| | | | | | | |
|---|-----------------|--------------------------------|------------------------------|----------------------------|---------------------|-----------------------------------|
| OVERALL CONSEQUENCE OR IMPACT SEVERITY | EXTREME | | | | | |
| | MAJOR | | | | | |
| | MODERATE | | | | | |
| | LOW | | | | | |
| | VERY LOW | | | | | |
| | | VERY UNLIKELY TO HAPPEN | OCCASIONAL OCCURRENCE | MODERATELY FREQUENT | OCCURS OFTEN | VIRTUALLY CERTAIN TO OCCUR |
| FREQUENCY / PROBABILITY | | | | | | |

- EXTREME RISK:** Immediate controls required
- HIGH RISK:** High priority control measures required
- MODERATE RISK:** Some controls required to reduce risks to lower levels
- LOW RISK:** Controls not likely required
- NEGLECTIBLE RISK:** Scenarios do not require further consideration

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