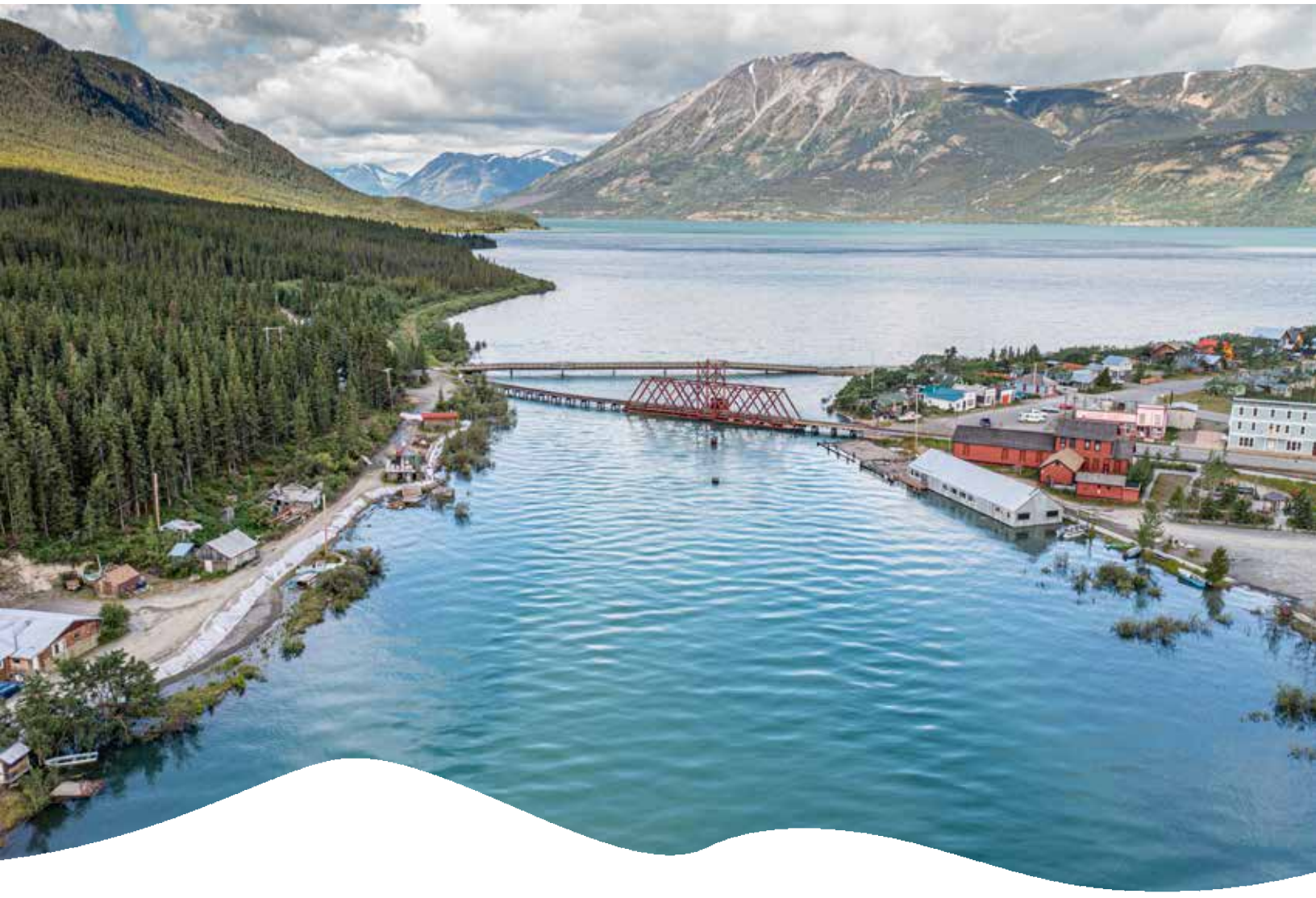
ASSESSING CLIMATE CHANGE

RISK AND RESILIENCE IN THE YUKON

MAIN REPORT



Yukon

Yukon University

CLIMATE RISK INSTITUTE

RESILIENT NORTH CONSULTING

Crown-Indigenous Relations and Northern Affairs Canada | Relations Couronne-Autochtones et Affaires du Nord Canada

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Contents

Message from the project team

Thank you to everyone who participated in this project. Your contributions helped to highlight the fact that while climate change continues to challenge us in unprecedented ways, Yukoners are resilient. We have a rich history of responding to changes on the land, and a wealth of knowledge to guide our understanding of risks and resilience.

We heard from people who have seen the changes on the land firsthand, and those who are working with communities to anticipate, prepare for, and respond to changes. Participants in this project include Indigenous knowledge holders and Elders, youth, and subject-matter experts working for federal, territorial, Indigenous and municipal governments, as well as academic and private-sector organizations.

Your guidance helped frame an understanding of how climate changes affect the things we value. By centring this risk assessment around a common set of resilience values, we are able to show that climate change impacts are interrelated and affect all aspects of Yukoners' lives. By adapting to climate change, we can protect and uphold the things that Yukoners value, which will make us more resilient in the long run.

We appreciated the opportunities to learn from one another. One of the most important lessons from this project was that bringing together diverse ways of knowing helps build resilience. Often, scientific ways of knowing focus on logic, research, data and numerical information. Indigenous worldviews offer teachings and stories about relying on relationships and values to increase resilience, learning how to live with uncertainty, and preparing for the unknown. Bringing in both these approaches can lead to creative and effective solutions for working together, sharing limited resources, and maintaining culture and ways of life.

Everyone can help build resilience to climate change impacts: individuals, municipalities, communities, First Nation and Inuvialuit governments, territorial and federal governments, academics, non-governmental organizations and the private sector. We hope this report helps us continue to work together so we can take the path to a highly resilient Yukon.

Sincerely,

The project team:
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YukonU - Climate Change and Indigenous Knowledge Research
Resilient North Consulting
Climate Risk Institute

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Definitions

Adaptation	Adapting to climate change involves making informed, forward-looking decisions to avoid or minimize the negative impacts that climate change may have on human health, well-being, ways of life, infrastructure, the natural and built environment, and livelihoods.
Climate risk assessments	These provide the information that governments, communities and organizations can use to prepare for, mitigate or adapt to climate change.
Exposure	The extent to which people, locations or assets are subjected to a climate hazard.
Flood mapping	A flood map estimates the risk of flooding in a community or area. See Box 10.
Geohazard mapping	Geohazards are geological and environmental conditions that have the potential to affect public safety, the environment and infrastructure.
Groundwater flooding	This occurs when the water table rises above the level of a basement, crawl space, or, potentially, the ground surface. See Box 8.
Hazard	A climate hazard is a process or event that can have an impact on people, infrastructure, the natural and built environment, the delivery of services, and livelihoods. See Box 1.
Impact	The effect of a hazard on people, infrastructure, the natural and built environment, the delivery of services, and livelihoods.
Indicator	Indicators of climate change include degree of temperature, amount of rainfall, and date of ice break-up.
Permafrost	Permafrost is soil or rock that remains frozen from one year to the next.
Resilience	Resilience is the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance. Different people and places have different levels of resilience. See Figure 1: The framework for resilience.
Risk	Risk is the potential for adverse consequences for human or ecological systems. See Box 2.
Thresholds	These are the tipping points (for indicators such as amount of rainfall) that are likely to trigger climate impacts if they are exceeded,
Transboundary Indigenous groups	Some Indigenous peoples in the Northwest Territories and British Columbia have traditional territory in the Yukon.
Vulnerability	This is sensitivity or susceptibility to harm and a lack of capacity to cope and adapt.

KEY MESSAGES

Note: For an Executive Summary of this report please visit Yukon.ca/climate-risk-assessment.

The Yukon's resilience stems from strong relationships, self-sufficiency, communities working together, ongoing connection to the land, and making the most of limited resources. Climate change continues to affect the Yukon at a disproportionate rate when compared to southern Canada, and its impacts pose cross-cutting and interconnected risks to Yukoners' way of life. Everyone can help build resilience to climate change impacts: individuals, municipalities, communities, Indigenous peoples, territorial and federal governments, academics, non-governmental organizations and the private sector.

Urgent and continuous action is needed to keep up with the many climate changes already underway. This includes timely completion of and continued work to build on actions in *Our Clean Future.* The Government of Yukon, in partnership with participating Yukon First Nations, trans-boundary Indigenous groups and Yukon municipalities, is already taking action on the highest risks — floods, wildfires, permafrost thaw, and ecosystem changes — through actions in *Our Clean Future.* Adaptation actions often build on one another (in other words, from assessing risks to implementing strategies to reduce those risks), and the Government of Yukon will need to take an adaptive management approach, continuing to evaluate and adjust actions to reduce risks and build capacity over time. In the long term, increased and sustained resources for adaptation to match observed and projected changes will be required in order for the Yukon to be able to prepare and respond to increasing climate change risks.

Climate change impacts are interrelated and affect all aspects of Yukoners' lives. Each of the seven climate change priorities identified during the assessment process affects the values that matter to Yukoners. For example, Priority 1 (impacts to transportation infrastructure) came up in almost every discussion with project participants. Resilience values such as food security and health and well-being, including mental health, are affected by every priority identified in the assessment. This means that intergovernmental collaboration, whole-of-government response, and partnerships are important.

Climate change impacts are not equally distributed across the Yukon, and equity must be considered in climate change adaptation. The Yukon's communities are remote, and therefore face additional challenges due to their relative isolation and limited financial resources. Socio-economic standing, gender, Indigeneity and other factors may affect the severity with which people experience climate change and may influence their ability to adapt.

Some of the most important actions that build resilience are not just about climate change — they also support people who face greater risks. This includes, for example, ensuring adequate housing, access to food, employment, education and health. Values such as health and well-being, food security, and safe access to the land are threatened by multiple and interconnected climate change impacts. Implementing strategies such as the Government of Yukon's *Putting People First* strategy (Government of Yukon 2020c) and the 2020 Agriculture Policy (Government of Yukon 2020a) will help build climate resilience. Communities across the Yukon are also leading the way in addressing some of these challenges.

Climate action should support reconciliation. Understanding the vulnerabilities, exposure and risks that communities face means confronting the historical events that shaped the Yukon — including the 19th and 20th century whaling industry at Herschel Island-Qikiqtaruk, the Klondike Gold Rush, the 1918 flu epidemic, the construction of the Alaska Highway, and residential schools. While First Nations and the Inuvialuit continue to be resilient, the lived reality of Indigenous people needs to be understood and incorporated into analyses of the distribution and experience of climate-related impacts. In this regard, building climate resilience cannot be separated from First Nations and Inuvialuit self-determination and reconciliation.

Bringing together diverse ways of knowing builds resilience. Indigenous knowledge offers teachings about living with uncertainty, building relationships to cope with changes, and broadening the understanding of resilience to maintain a way of life and culture. Indigenous peoples and First Nations are often leading adaptation across the Yukon. The Umbrella Final Agreement, First Nation Final Agreements, Inuvialuit Final Agreement and Gwich'inComprehensive Land Claim Agreement (GCLCA-YTA)[1] are important mechanisms to support this work. They provide resources and avenues for co-management and working together by various government bodies.

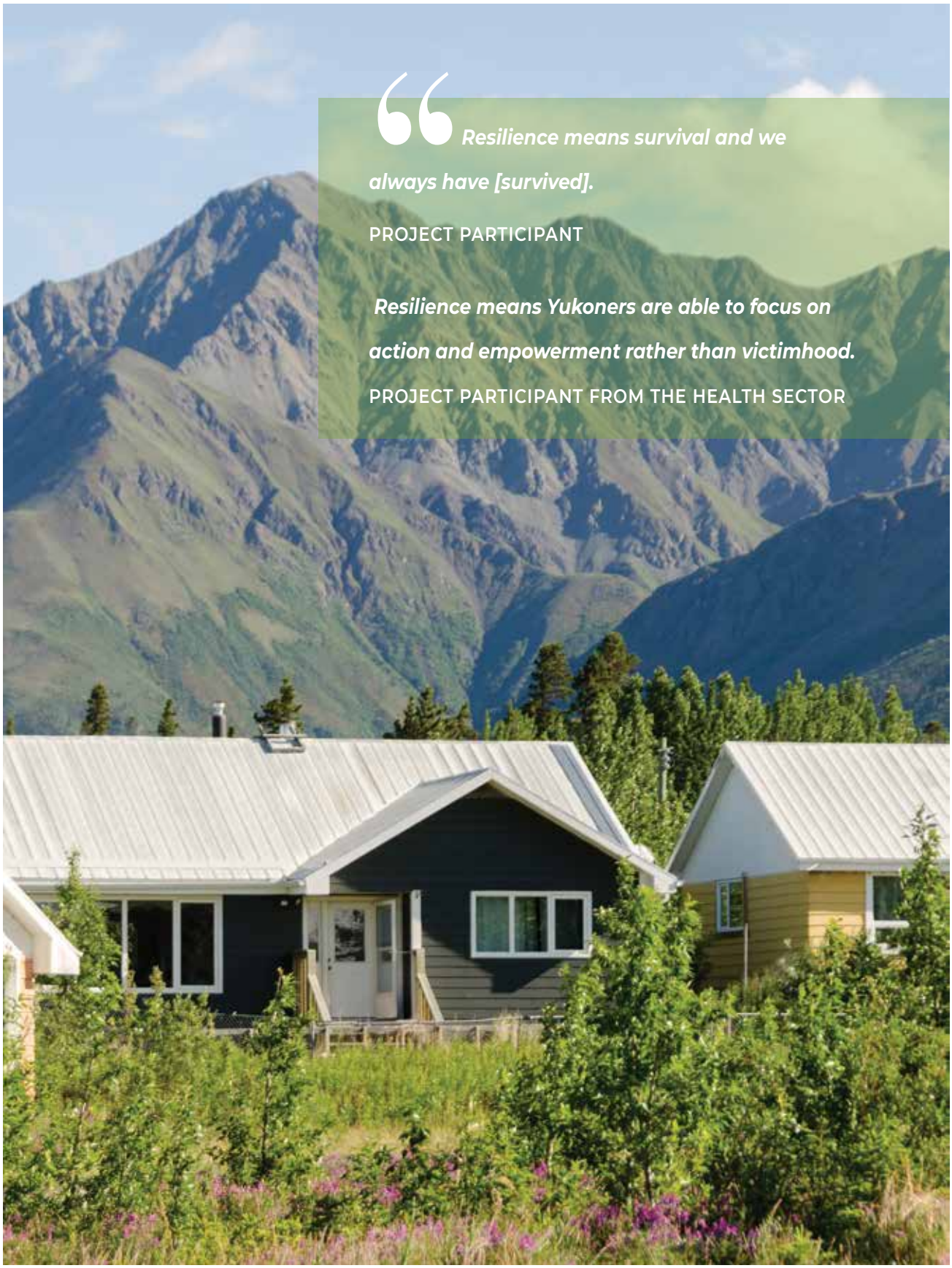
Supporting communities' capacity to undertake climate change adaptation initiatives is essential. Continued collaboration and partnerships across the Yukon are vital for building resilience to climate impacts. Yukon communities witness climate change impacts and are aware of the risks, but often lack the resources and capacity to work together and implement solutions. Better coordination, clarity around government roles and responsibilities and resources to inform adaptation are needed. Adaptation actions should include opportunities for two-way information sharing, listening to local knowledge, and building capacity. In the Yukon, local knowledge is especially important for adaptation actions due to data limitations and gaps in monitoring, climate change records, and community-level data. Intergovernmental collaboration, whole-of-government response, and partnerships can also help buffer some of the capacity limitations at the community level. Supporting the capacity of communities and governments to meaningfully consider climate change in regional land-use plans is also important.

Government collaboration on and ownership of climate risks is an essential part of adaptation. While community response and adaptation planning are important parts of building resilience to climate change impacts, it is also recommended that governments continue to take a leadership role in developing and implementing adaptation strategies. This includes actions by federal, territorial, Indigenous and municipal governments. Climate change risks are distributed across government mandates, so it is important to implement risk management and reduction strategies

1. The Yukon Transboundary Agreement (YTA) is a core part of the Gwich'in Comprehensive Land Claim Agreement (GCLCA) and it is known as Appendix C of the GCLCA.

using a whole-of-government approach. Additionally, governments must continue to take action on areas such as social supports, housing, economic development and food security, and supporting people and communities who face greater risks.

Training, capacity building, and support for staff to interpret climate projections and related information is crucial. There are substantive gaps in training and skills with respect to using climate projections to inform decision-making – including the skills needed to understand data availability and gaps, incorporate climate projections, and interpret and use regional climate data. Areas where training is especially needed include infrastructure development, land-use planning, emergency preparedness, agriculture, mining and tourism. Participants who work for territorial, First Nations or municipal governments explained that their organizations or teams are often aware of the climate hazards involved, but are unsure how to interpret climate projections, apply emerging climate-related codes and standards (if they are aware of them), or assess the level of risk.



> *Resilience means survival and we always have [survived].*
>
> PROJECT PARTICIPANT

> *Resilience means Yukoners are able to focus on action and empowerment rather than victimhood.*
>
> PROJECT PARTICIPANT FROM THE HEALTH SECTOR

1 INTRODUCTION

This project supports the implementation of *Our Clean Future*, the Government of Yukon's climate change, energy and green economy strategy (Government of Yukon 2020b). In *Our Clean Future,* the government commits to assessing climate hazards (Box 1) and vulnerabilities to those hazards across the territory every three to four years between 2020 and 2030 to prioritize climate change adaptation actions.[2] *Our Clean Future* sets out an adaptation target: "by 2030, [the] Yukon will be highly resilient to the impacts of climate change."

BOX 1 WHAT IS A CLIMATE HAZARD?

A climate hazard is an environmental process or event that can have an impact on people, infrastructure, the natural and built environment, the delivery of services, and livelihoods. Some of the main hazards facing the Yukon include permafrost thaw, flooding, wildfire, landslides and extreme precipitation. A hazard may have different impacts in different parts of the territory. It may occur in the near future or the distant future or may already be occurring.

In 2019 the Government of Yukon declared a climate emergency.[3] In 2020, it released *Our Clean Future: a Yukon strategy for climate change, energy and a green economy* in partnership with Yukon First Nations, transboundary Indigenous governments[4] and Yukon municipalities, and with input from the private sector and members of the public. The strategy includes more than 50 actions that will help build resilience in infrastructure, communities, services and business practices.

Governments and communities across the Yukon are also leading adaptation actions. In 2020 Yukon First Nations declared a climate emergency;[5] they are developing a youth-centred climate plan that integrates the worldviews and value systems of the Yukon's Indigenous peoples, such as their profound relationships with land, water and animals. Municipalities are developing emergency preparedness plans and working with communities on responses to climate risks.

While Yukoners are working hard to adapt to climate change impacts, these impacts are projected to increase, and the remoteness of the Yukon's communities, along with the disproportionate extent of changes in the North, increase the risk that these impacts will occur.

2. This also stems from the 2017 December Report of the Auditor General of Canada to the Yukon Legislative Assembly's *Climate Change in the Yukon* Report, which stated that the Government of Yukon should complete a comprehensive, territory-wide risk assessment to prioritize commitments to manage the impacts of climate change.
3. See https://nationalpost.com/pmn/news-pmn/canada-news-pmn/politicians-in-yukon-vote-unanimously-to-declare-climate-emergency.
4. Some Indigenous peoples in the Northwest Territories and British Columbia have traditional territory in the Yukon. Representatives from transboundary Indigenous governments contributed to the development of *Our Clean Future* and to this assessment.
5. http://afnyukon.ca/wp-content/uploads/2020/02/Yukon-First-Nations-Climate-Change-Emergency-Declaration.pdf.

BOX 2 | RISK AND RISK ASSESSMENT

According to the Intergovernmental Panel on Climate Change, in the context of climate change impacts, risks result from dynamic interactions between climate-related hazards and the exposure and vulnerability of the affected human or ecological system (IPCC 2022: 7). The International Standards Organization (ISO) defines a climate risk assessment as including the consideration of vulnerabilities, exposure and climate change hazards, or the consideration of likelihoods and consequences (ISO 2019).

How do we know when we're doing enough to build resilience to the impacts of climate change? Where do governments, communities, and others have a role to play? How can we build on the strengths that already exist here? These are the questions that the Yukon climate risk assessment aimed to answer.

The risk assessment had three main objectives:

- build an understanding of climate resilience across the Yukon;
- determine the priorities for reducing risks; and
- identify the factors that contribute to resilience.

The information gained from the risk assessment will support climate change planning and adaptation across the Yukon. Climate change adaptation involves making informed and forward-looking decisions in order to minimize negative climate impacts on health, well-being, livelihoods and infrastructure. Effective risk reduction measures will save lives, support healthy ecosystems and communities, minimize damage to buildings and infrastructure, and protect ways of life, including Indigenous cultures.

BUILDING A SHARED UNDERSTANDING OF RESILIENCE

Yukoners are resilient. This is a clear message from the discussions held as part of the assessment. These conversations highlighted many examples of resilience: young people in Ross River making sure Elders' homes are safe when the ground shifts from permafrost thaw; people in Burwash Landing sharing harvested meat with their neighbours during power outages; land guardians across the Yukon, with the guidance of Elders, monitoring how animals and plants are changing; and communities throughout the Yukon growing their own food to reduce the dependency on southern imports. The Yukon has no shortage of examples of self-sufficiency, working together, and persevering through ongoing change.

> "**You're always** ensuring everyone's got food, if one house is low on food, there's sharing. Teaching resilience through sharing and caring... that is our [community] value; ensuring everyone is taken care of.
>
> PROJECT PARTICIPANT FROM BURWASH LANDING

The Intergovernmental Panel on Climate Change (IPCC) defines resilience as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance..." (IPCC 2022: 9, note 12) and the World Health Organization makes the important point that

resilience "is much more than just the absence of vulnerability; it is about whole system capacity" (WHO 2015: 7). Resilience is relative to specific people and places (Office of the CMOH 2020). The ability of people and places to bounce back from climate-related stresses depends on a range of factors that affect individual and community health and well-being (BCMOECC n.d.).

In developing the framework, team members built on IPCC's definition of resilience, reviewed studies and adaptation policies from other jurisdictions and feedback from the public engagement carried out during the development of *Our Clean Future,* as well as discussions, feedback and review with project participants. See Box 3.

BOX 3 | PROJECT TEAM AND PROJECT PARTICIPANTS

Project team members — throughout this report, the term "project team" refers to the Government of Yukon's Climate Change Secretariat; Brian Horton, Manager of the Yukon University Climate Research Division; Jocelyn Joe-Strack, Indigenous Knowledge Research Chair at Yukon University; Steve Roddick from Resilience North; and the Climate Risk Institute.

Project participants were central to informing the approach throughout the assessment. They included people from a variety of backgrounds — representatives from the Government of Yukon, Yukon First Nations and transboundary Indigenous groups, municipalities, academia, non-profit organizations, and sectors such as health, food, tourism, mining and local business development.[6]

RESILIENCE FRAMEWORK

In *Our Clean Future*, the Government of Yukon recognizes the importance of reducing the climate risks that all Yukoners face while also improving the conditions that can make people vulnerable. These efforts include improving human health, food security and housing to enhance the resilience of Yukoners and Yukon communities. The resilience framework considers the issues that contribute to vulnerability in the first place, along with the specific circumstances of Yukon communities, such as food insecurity and strong dependence on land-based activities.

This approach is consistent with community-led planning initiatives in the Yukon,[7] with the Yukon Chief Medical Officer's report on the health effects of climate-related events (Office of the CMOH 2020), and with other Canadian jurisdictions that consider the underlying social conditions that affect resilience.[8] The following additional reasons help explain why the assessment is based on a resilience framework.

6. The project team did not complete a public engagement, although some community members participated in the assessment in their capacity as employees of Yukon First Nations, municipalities and transboundary Indigenous groups. The risk assessment followed an extensive two-year public engagement process to develop *Our Clean Future,* the Yukon's clean growth and climate change strategy. The input received as part of that process informed this assessment.
7. For example, Carcross/Tagish First Nation, Kwanlin Dün First Nation and Ta'an Kwäch'än Council are working together on the Indigenous land relationship plan, "How We Walk with the Land and Water." It is centred on a values-based framework.
8. This assessment drew on the health determinants identified by British Columbia, the Expert Panel on Climate Change Adaptation and Resilience Results report to the Government of Canada; and, discussions with the Government of Nova Scotia on assessing health and well-being as part of the risk assessment. The Government of Saskatchewan also recently released a Climate Resilience report, which adopts a systems perspective for climate risk and resilience.

UNIQUE CIRCUMSTANCES OF NORTHERN AND REMOTE COMMUNITIES

It is widely recognized that climate change impacts are more pronounced in northern communities. In the Yukon, these changes combine with circumstances that affect the territory's ability to adapt; for example, many Yukon communities are remote, and depend heavily on land-based activities and food sources. Local governments are already grappling with insufficient capacity and the challenges of isolation.

In addition, Indigenous peoples continue to heal from the historical and ongoing burdens of colonialism. These circumstances affect food security, access to housing, transportation, and mental and physical health, all of which in turn affect vulnerability to climate change (AFN 2020; Streicker 2016). The Yukon also faces climate-related impacts to its infrastructure from floods, wildfire, thawing permafrost and extreme precipitation (ibid.). These circumstances mean that risk assessment must consider both the impacts of climate change and the social, economic and cultural factors that are linked to vulnerability to these impacts.

INCLUDING LOCAL GOVERNMENT PERSPECTIVES

Yukon communities are taking leadership on adaptation to climate change, so it was important to include their perspectives in the assessment. For example, since 2008, a total of more than $14 million in federal project funding has been provided by the Climate Change Preparedness in the North Program and the Climate Change and Health Adaptation Program.[9] More than two-thirds of these projects were partnerships between two or more organizations. Most were implemented by First Nations or territorial government agencies — often in partnership with non-profit, Indigenous or academic organizations. It was important for this assessment to include the perspectives of these various organizations, as well as local governments.

DATA LIMITATIONS IN THE NORTH

The Yukon faces limitations in data. Historical climate records, landscape- and community-level climate monitoring, and biodiversity-related information are rarely available. Hydrological monitoring data for precipitation, river flow and lake level monitoring is sparse, which means that flood forecasters must often rely on local observations to fill gaps. Data are also limited due to privacy concerns related to publishing information about small populations.

Because of these data limitations, it was important to supplement the assessment's review of existing studies and data with local perspectives. This also helped provide local information about issues identified in past research and about the consequences of risks and the sources of resilience.

BUILDING CAPACITY

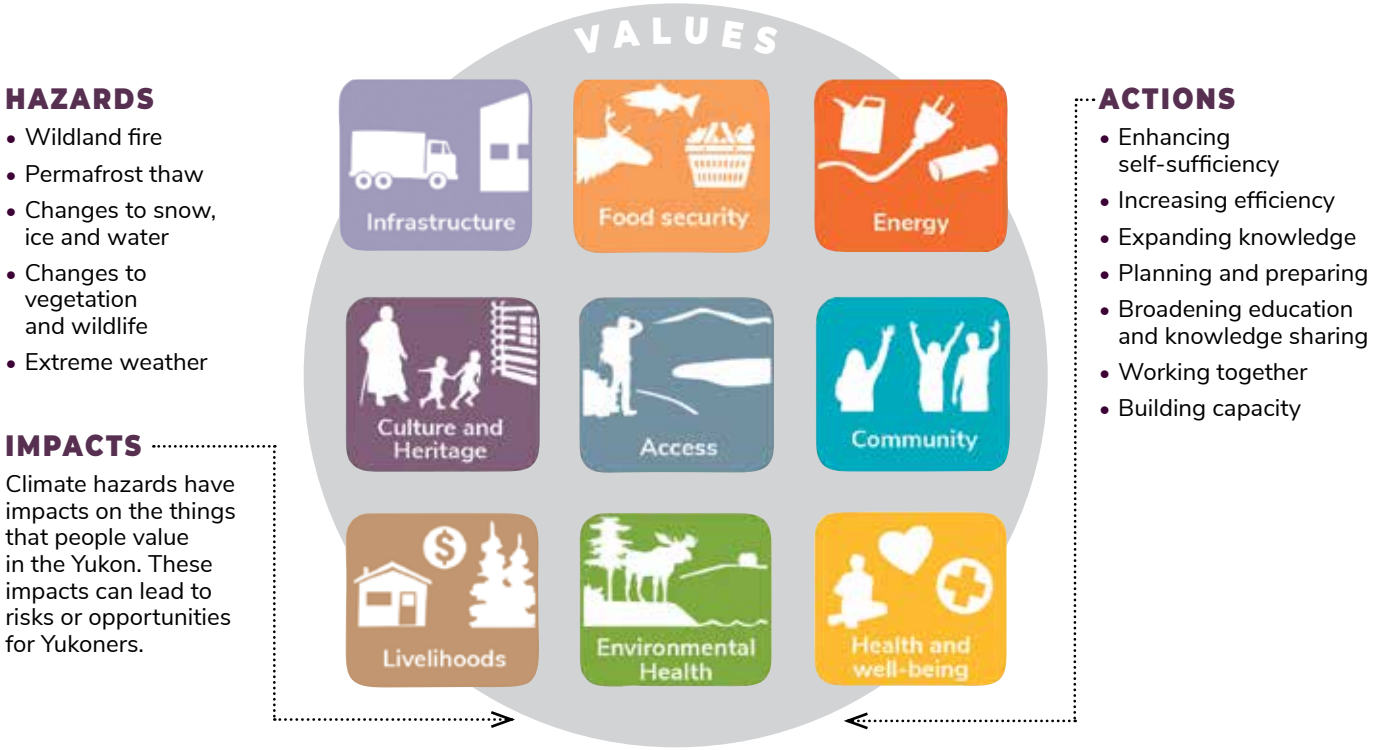
The assessment also developed an understanding of resilience and capacity and of the steps that people, governments and organizations should take to plan and implement adaptation actions. In addition, a shared understanding of climate resilience and adaptation helps inform how the Government of Yukon's *Our Clean Future* strategy can evolve so that it continues to address the social, economic and cultural impacts of climate change and to reflect the diverse realities and capacities of Yukon governments, communities, partners and stakeholders.

9. Information from Crown-Indigenous Relations and Northern Affairs Canada.

RESILIENCE FRAMEWORK

The framework for resilience that the project participants developed (Figure 1) focuses on the connections between the **impacts** of a changing climate, the **values** that are important to Yukoners; and the types of **actions** that build resilience to those impacts to uphold the values (see Table 3 for more details on these actions).

Figure 1 The Yukon framework for resilience



CLIMATE IMPACTS

The Yukon is already experiencing significant climate changes. Since 1948, temperatures in northern Canada have increased by 2.3°C. Northern Canada has warmed and will continue to warm at more than double the global rate (Bush and Lemmen 2019). Over the same period, rain and snowfall have increased in the Yukon and become more variable (Streicker 2016).

Climate impacts are the result of climate hazards. These are some of the most important types of impacts, as outlined in *Our Clean Future* and confirmed with project participants:

- increased wildfire risk, which affect people, communities, wildlife and ecosystems;
- the effects of permafrost thaw, which are damaging roads and infrastructure, changing landscapes and affecting ecosystems;
- changes to snow, water and ice, which are affecting river flow, water temperatures and aquatic health, and biodiversity;
- changes to weather, vegetation and wildlife, which are reducing access to country foods, lessening food security, and affecting physical, mental and spiritual health and well-being; and
- more frequent extreme weather events, such as floods, that can harm health, threaten safety, and destroy homes and ecosystems.

Team members reviewed the literature to develop a list of 41 climate impacts based on these impact types, as outlined in Table 1. The impacts are organized according to the five types of climate hazards identified in the resilience framework, not in order of importance. As noted in Table 1, not all changes will be negative; see Impact 27 (increased agricultural opportunities).

Team members facilitated group discussions and one-on-one interviews with participants to understand how Yukoners experience these impacts. All discussions happened online due to COVID-19 restrictions. Participants were asked to describe how these impacts affect the nine values in the resilience framework. This informed an understanding of the types of actions Yukoners can take to build resilience and the opportunities to build on existing adaptation efforts.

Table 1 Climate impacts included in the assessment

Climate hazard	Impact no.	Impact
Wildfire	1	Wildfire smoke is transported long distances, affecting local and regional air quality.
	2	Wildfires threaten communities, heritage values, and infrastructure.
	3	The frequency, intensity and scale of wildfire changes affect wildlife and ecosystems.
Permafrost thaw	4	Permafrost thaw and ground subsidence damage buildings and infrastructure.
	5	Hydrological cycles are affected by permafrost thaw and melting glaciers.
	6	Permafrost thaw impacts surface runoff, river turbidity and water quality.
	7 *	Permafrost thaw destabilizes soil conditions.
	8	Permafrost thaw alters landforms and ecology.
	9	Permafrost thaw causes critical infrastructure failures.

Climate hazard	Impact no.	Impact
Snow, ice and water	10	Storm surges, shoreline erosion and decreasing near-shore ice alter the Yukon North Slope.
	11	Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure.
	12	Warming winter conditions reduce the availability of winter roads and ice bridges.
	13	A changing climate and landscape affect Yukon heritage sites.
	14	Changes in winter precipitation and weather affect infrastructure.
	15	Changing winter conditions affect ecosystems and wildlife.
	16	Changes to snow and ice cover create unsafe or unreliable conditions that reduce access.
	17	The timing of ice break-up on waterways changes, including earlier spring break-up.
	18*	Groundwater levels are raised in some regions or areas, posing risks to community infrastructure.
	19	Ice-jam floods occur along the Yukon River and in other important watersheds.
	20	Water temperatures rise in some rivers and lakes, disrupting ecosystems.
	21 *	The combination of reduced sea ice and changing economic trends results in more traffic in the Northwest Passage.
Changes to vegetation and wildlife	22 *	Longer growing seasons increase the productivity of forests.
	23 *	Changing climate affects the composition, distribution and movement of plants and wildlife.
	24	Changing climate conditions affect the health and availability of plants, wildlife and fish.
	25 *	The presence and spread of invasive species increase, disrupting local/native ecosystems.
	26 *	A warming climate worsens the spread of illness and parasites in plant and animals.
	27	Longer growing seasons and warmer temperatures increase agricultural opportunities.
Extreme weather	28	The health and safety of people on the land are at risk from variable, uncertain and extreme weather.
	29	Flooding in communities is more frequent and severe.
	30	Extreme winter precipitation leads to transportation interruptions or failures.
	31	Washouts and landslides lead to transportation service interruptions or failures.
	32	Extreme precipitation increases the erosion of and damage to riverbanks.
	33	Extreme precipitation events cause damage.
	34	Rain-on-snow events affect transportation safety and increase the demand for emergency services.
	35*	Extreme precipitation and flash flooding cause physical and chemical instability at mine sites.
	36	High-wind extreme weather events reduce visibility, creating health and safety risks.
	37*	The number of extremely cold days decreases, reducing the risk of illness/injury.
	38	Mental health concerns associated with climate change increase.
	39	A range of climate-related factors disrupt critical supply chains.
	40	The decreasing reliability of supply chains affects access to and affordability of resources.
	41*	The Yukon experiences high population growth, with increased climate-related migration.

Note: An asterisk (*) indicates an impact that did not receive enough responses for conclusive results. It may be worth assessing these impacts in future assessments.

VALUES

The framework includes nine values that Yukoners identified as important to their resilience (Table 2). These values were developed by reviewing climate change adaptation frameworks that consider health and well-being, such as those developed by BCMOE (n.d.) and the Shift Collaborative (2019), as well as themes emerging from public engagement completed for *Our Clean Future,* and by learning from project participants. The assessment considered how climate change impacts are affecting each of these values, based on participant input and risk scores.

Table 2 The nine resilience values

Value #	Value	Description
1	Infrastructure	Public and private built infrastructure, including critical and transportation infrastructure, are resilient.
2	Food security	The production, distribution, availability, accessibility and affordability of (culturally appropriate, nutritional) food, including commercial and traditional food sources, ensure that Yukoners have the food they need.
3	Energy	Reliable, affordable and sustainable energy is available to Yukoners.
4	Culture and heritage	Yukoners uphold their cultural heritage, as well as a broad range of cultural values and ways of life.
5	Access	Yukoners have safe access to important places.
6	Community	Yukoners maintain strong community connection, capacity and belonging in order to withstand, respond to and recover from adversity.
7	Livelihoods	Yukoners have opportunities to pursue reliable, sustainable livelihoods and have good levels of household financial security.
8	Environmental health	Yukon's ecosystems support all living things, including the biodiversity of plants, animals and fungi.
9	Health and well-being	Yukoners' mental and physical health and well-being are strong and improving.

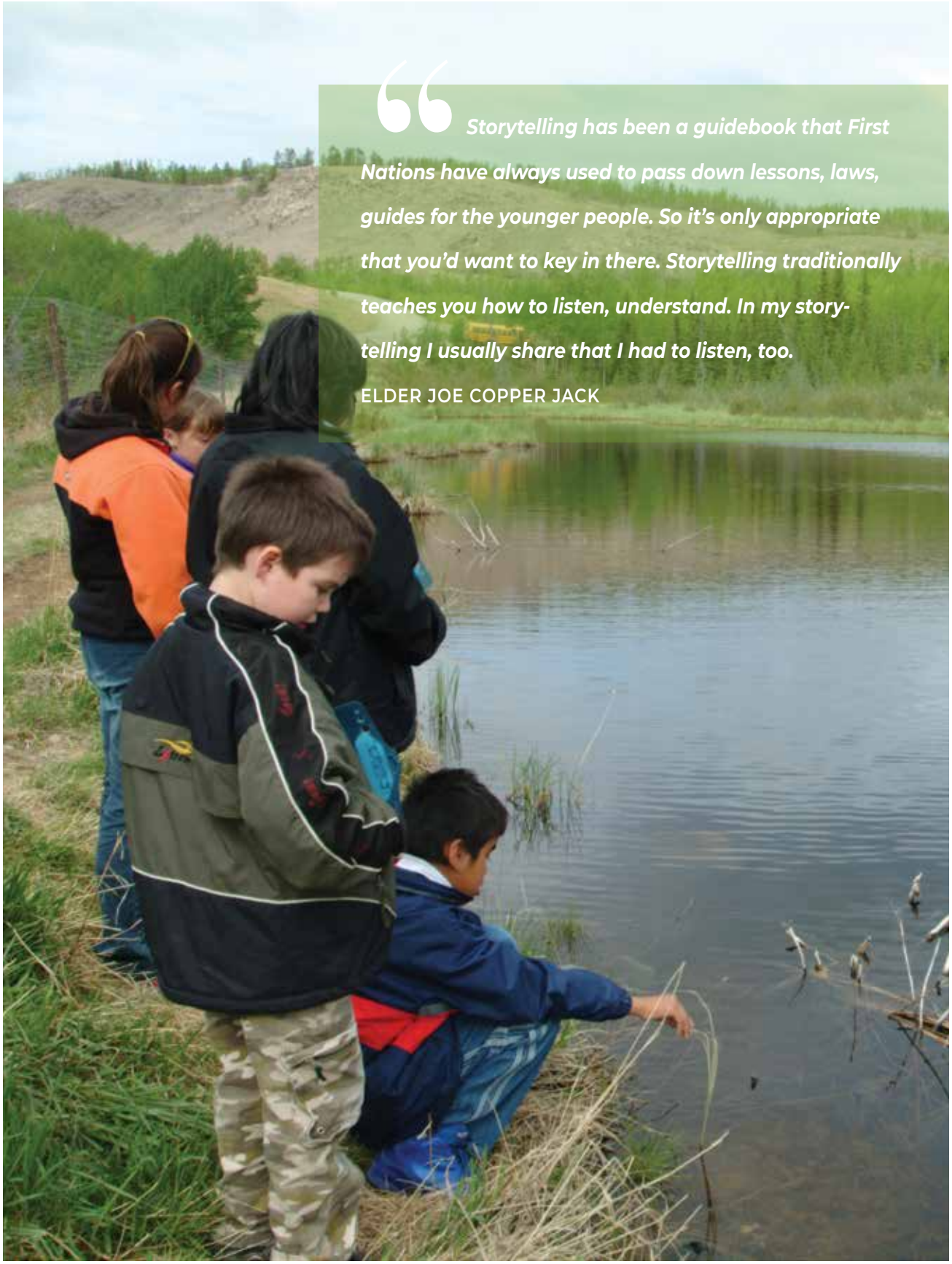
ACTIONS

Actions reduce the risks that climate change impacts pose to the nine resilience values. The actions can focus on adaptation: making informed, forward-looking decisions to minimize negative impacts while also taking advantage of new opportunities that may arise. Actions can also focus on broader social issues, such as housing, poverty reduction, health and wellness. See Table 3. These actions support resilience by reducing the conditions that make people more likely to experience negative consequences from climate impacts.

The project team used this list of actions as a starting point in discussions with participants, asking about Yukoners' ability to respond to climate change impacts, and exploring how individuals, communities, governments, the private sector and academic institutions can play a part. Participants also scored their perceived level of ability to carry out actions to increase resilience for each impact. See Table A2 in Appendix 3.

Table 3 Types of actions to increase resilience

Actions	Description
Enhancing self-sufficiency	Yukoners provide for their community, their neighbours and themselves by enhancing local resources to reduce dependence on external supply chains.
Increasing efficiency	Yukoners use resources — financial, energy, material — efficiently, effectively and fairly.
Expanding knowledge	Yukoners include a range of perspectives to understand climate change impacts, inform adaptation planning and build resilience.
Planning and preparing	Yukoners develop and implement plans and policies to prepare for and manage climate change impacts.
Broadening education and knowledge sharing	Yukoners have access to education and training that builds resilience. Knowledge is shared within and across communities and organizations.
Working together	Yukoners collaborate to build strong relationships, networks and communication. Federal, territorial, municipal and Indigenous governments work together to support shared priorities and Indigenous sovereignty.
Building capacity	People and communities develop and maintain the financial and human resources and the skills needed to respond to climate change.



> *Storytelling has been a guidebook that First Nations have always used to pass down lessons, laws, guides for the younger people. So it's only appropriate that you'd want to key in there. Storytelling traditionally teaches you how to listen, understand. In my story-telling I usually share that I had to listen, too.*
>
> ELDER JOE COPPER JACK

2 HOW THE ASSESSMENT WAS CARRIED OUT

PARTICIPANTS

People from a variety of backgrounds participated in the assessment. They included representatives from the Government of Yukon, Yukon First Nations, Inuvialuit and transboundary Indigenous governments, municipalities, academia, non-profit organizations, and sectors such as health, food, tourism, mining, and local business development. Youth from the Yukon Climate Change Panel and the Yukon First Nation Climate Action Fellowship also took part.

Participants engaged in facilitated group discussions and one-on-one interviews, completed a scoring of climate risks, and confirmed the findings. All discussions happened online due to COVID-19 restrictions. Participants shared local observations and experience from their work, anecdotes about their communities, and visions for resilience. Conversations focused on Yukon climate change hazards, values and community actions; how resilience is understood and practised; and how climate-related hazards affect various aspects of health and well-being.

Approximately 70 participants took part; 33 participants scored the risks according to likelihood and consequence. Respondents were invited to rank select climate impacts based on their area of subject-matter expertise. Not all respondents ranked each risk.

BRINGING TOGETHER INDIGENOUS, LOCAL AND SCIENTIFIC WAYS OF KNOWING

The assessment included Indigenous, local and scientific perspectives; the first perspective involved employees of Yukon First Nations and transboundary Indigenous governments, youth, Elders and knowledge holders.[10] Jocelyn Joe-Strack, a member of Champagne and Aishihik First Nations, scientist, philosopher and Yukon University Research Chair in Indigenous Knowledge, has long-standing relationships with Yukon First Nations. Ms. Joe-Strack developed the plan for working with project participants.

The assessment process focused on breaking down barriers and building relationships through a series of conversations. The conversations included people working for territorial and Indigenous governments and municipalities, and in the private and public sectors. Keeping group sizes small allowed for meaningful discussion, reflection and relationship building.

The structure of some sessions allowed for Indigenous knowledge to be included, and knowledge keepers were invited to share their perspectives. See Box 4.

10. The project team members will continue explore how to work meaningfully with Yukon First Nations and transboundary Indigenous governments to share the findings from the assessment and respond to its findings.

BOX 4 | THE ROLE OF INDIGENOUS KNOWLEDGE

A session titled "Part of the Land, Part of the Water" (taking its name from the book by McClellan et al. 1987) provided an opportunity to explore the role of Indigenous knowledge in understanding and building resilience to climate change in the Yukon. Three knowledge holders, along with Directors from Government of Yukon, took part. The session included a review of the teachings in a message from Teslin Tlingit Council Elder Virginia Smarch.

Including Indigenous teachings allowed for various forms of knowledge sharing. These teachings contain important information about the ways that Indigenous peoples are connected to the land and respond to changes on the land. This approach helped participants consider how different worldviews can be brought together to better understand resilience.

Discussions highlighted the importance of concepts prominent in Indigenous worldviews, such as connection, reciprocity, unpredictability, relationships, storytelling and stewardship. These concepts can help guide actions to strengthen resilience.

Discussions were held in an inclusive manner, to support meaningful contributions to discussions on resilience. See Box 5.

BOX 5 | BEING INCLUSIVE

The risk assessment process incorporated Indigenous, local and scientific ways of knowing in order to support meaningful and broad-based contributions to the understanding of resilience. Team members followed these guidelines when they engaged with project participants throughout the assessment:

- honour the background, worldview and priorities of all participants;
- create a safe and respectful context to allow for a range of information and contributions;
- encourage different organizations, sectors and people from various areas of expertise to work together;
- bring together voices and experiences related to cross-sector climate impacts;
- engage with participants in a way that accommodates their understanding and experience of climate change impacts;
- take extra care when discussing issues related to current and ongoing hardships in communities;
- encourage youth to participate; and
- be flexible in order to adjust to the challenges that participants face due to the COVID-19 pandemic.

PROJECT ACTIVITIES

Climate risk assessments provide the building blocks that governments, communities, and organizations can use to adapt to climate changes that create or increase risk (ISO 2019). In developing the method for this risk assessment, the project team reviewed various risk assessment methods and learned from work in other jurisdictions across Canada.

In 2020, the Yukon Climate Change Secretariat worked with the Canadian Council of Ministers of the Environment and with provinces and territories across Canada to develop guidance on good practices in climate change risk assessments (CCME 2021: 3–4). This guidance informed the method for assessing risk in the Yukon:

- assessing climate change risks should be an iterative process that assists participants in understanding how climate change is impacting, and projected to impact, their jurisdiction, as well as the effects of adaptation actions;
- people carrying out risk assessments can pick from a range of activities, such as identifying hazards, assessing vulnerability and adaptive capacity, determining the likelihood and consequences of events arising from climate change impacts, and engagement with partners and stakeholders; and
- activities should be chosen based on their relevance to local needs, capabilities and context.

The project team reviewed a range of frameworks and steps for completing climate change risk assessments. The team drew on the International Standards Organization's 31000 risk management steps (ISO 2018) and adapted those steps to be appropriate to the Yukon context (Table 4).

Table 4 Steps in the Yukon Climate Risk Assessment

Risk management step	Timeline	Activities completed	How the activities informed the risk assessment
Establish context Identify risk	Fall 2020	**Conversations Round 1: Introduction, framework development** Four sessions: (1) Government of Yukon representatives, (2) Yukon First Nations, (3) municipalities, and (4) transboundary Indigenous governments and people working in food security, poverty reduction, and business development.	Team members presented a draft resilience framework and asked participants to discuss their local adaptation priorities and their understanding of resilience, in theory and in practice. Team members then adapted the framework based on what they heard. Team members drafted a list of 41 impacts from a literature review and input from the first round of conversations. These impacts were entered into a database and used to inform subsequent steps.
Analyze risk	Winter 2020	**Conversations Round 2: How climate change impacts could play out in the Yukon, and Yukoners' capacity to reduce risks** Six sessions were facilitated to explore possible scenarios arising from climate impacts (see Appendix 4). The conversations included participants from different backgrounds, communities, and work settings in order to broaden perspectives and include lived experience.	The scenarios included: a highway washout; a winter flood; community housing and infrastructure damage from permafrost thaw; supply chain interruptions affecting food security; and, safety concerns on the land. There was also a scenario dedicated to Teslin Tlingit teachings from the "Part of the Land, Part of the Water" session. Team members used scenarios to explore the likelihood and consequences of climate change impacts. This is a useful approach that allows lived experience to be included in the understanding of risks, and to provide information when there is not a lot of data. Team members supplemented the risk database with examples from participants' experience and observations.
	Winter 2021	**Risk scoring:** Participants scored the likelihood and consequence of each of the 41 impacts	Participants scored risks and their organizations' ability to respond or to reduce risks. The team reviewed the risk scores alongside the feedback from the first and second rounds of discussions to identify high-risk areas and priorities for building resilience.
Information sharing and project update	Spring 2021	**Yukon Climate Change Adaptation Forum: Shared emerging findings and lessons learned with Yukoners who did not participate in the project** The forum was a collaboration between the Government of Yukon, the Council of Yukon First Nations, Yukon University, and the Assembly of First Nations-Yukon Region.	The forum provided an opportunity to engage with people who work on issues related to climate change but who did not participate in the assessment. Participants provided reflections on Yukon resilience. The forum also included a session that brought together the Yukon Youth Panel on Climate Change and the Yukon First Nations Fellowship to share perspectives on the Yukon's resilience and how the Yukon can be resilient by 2030.

Risk management step	Timeline	Activities completed	How the activities informed the risk assessment
Evaluate risks	Spring 2021	**Conversations Round 3: Sharing results and validating scores** Nine validation sessions were held, one for each value in the resilience framework. Subject-matter experts and government representatives from territorial, municipal and First Nations governments attended.	Team members shared the results of the risk scoring process, discussing how the risks affect each of the nine values of the resilience framework, and the capacity of Yukoners to respond to risks. Staff from across the Government of Yukon reviewed and validated the results.

Activities included developing a resilience framework for Yukon; hosting a series of conversations with project participants; scoring risks and compiling a risk database (Box 6), and reviewing the results (see Table 4). Participants also developed recommendations for building resilience.

BOX 6 | RISK DATABASE

Risk assessments provide a snapshot of risk at a given time. In order to be meaningful in the long term, risk assessments need to be repeated periodically. This is because climate change is not a linear process and what was (or was not) identified at a given point in time may not be valid at a later date. *Our Clean Future* commits to completing climate change risk assessments on an ongoing basis.

The risk database that results from these assessments will be used by the Government of Yukon to monitor and assess climate change risks over the years ahead. The database contains a list of climate impacts, risk scores, and information such as trends or projections that can help assess the likelihood and consequences of impacts. The list of climate impacts (see Table 1) is based on the types of impacts identified when developing *Our Clean Future*, reviewing literature, and speaking with project participants.

As shown in Table 4, three rounds of facilitated group conversations informed the assessment: (1) the meaning of Yukon resilience, in theory and in practice, and the presentation of the proposed risk assessment framework; (2) discussing how climate change impacts could play out in the Yukon and Yukoners' ability to reduce risks; and (3) sharing the risk-scoring results to confirm priorities and findings.

Participants explored three main questions throughout the assessment:

- What climate change impacts are the most significant?
- In what ways are Yukoners undertaking actions, or ready to take actions, to manage climate risk?
- What additional support or work is required to make sure that Yukoners are resilient?

SCORING

Team members developed a list of climate change impacts that face Yukon people and communities (see Table 1). They chose these impacts based on climate projections, a review of existing data and reports, and input from project participants. These impacts have been compiled into a risk database (Box 6).

Participants scored each impact by considering two factors:

- the likelihood that climate-related impacts will occur by 2030; and
- the consequence if those impacts do occur.

The higher the score the more serious the impact. Participants scored the likelihood and consequence of each impact on each of the resilience values. This helped to highlight which climate impacts affect which value. Appendix 1 provides risk maps that visualize the most significant impacts for each of the resilience values.

RISK SCORE

The risk score for each impact was determined by multiplying the score for likelihood by the score for consequence. Risk scores range from 1 to 25. The higher the risk score, the more serious the impact is. Impacts with high risk scores can be prioritized so that measures to manage or reduce them can be developed and implemented. See Figure 2.

Figure 2 Determining a climate risk score

RISK SCORE: LIKELIHOOD

Assessing the likelihood of climate impacts in the Yukon is challenging and is complicated by gaps in information and data, and modeling limitations. Furthermore, participants varied in their level of experience and confidence level in projecting future impacts. By providing participants with an initial assessment of likelihood, the project team hoped to reduce some of the uncertainty and variability in responses.

The team members provided participants with an initial assessment of the likelihood of each of 41 impacts for the year 2030.[11] This initial assessment of likelihood was on a scale of 1 to 5 (see Table 5), and was derived using climate projections, a literature review, information from subject-matter experts, and Round 2 of discussions (Table 4), which explored possible scenarios arising from climate impacts in the Yukon (scenarios are described in Appendix 4).

11. The assessment initially looked at likelihood for two future time periods: 2030 and 2050. However, the results show scores only for 2030. This is because participants were much more confident ranking risks for the near term. In validation sessions, participants noted that they were more confident in their scores for 2030 and that further analysis and information to support ranking would need to be provided in order for them to be able to rank 2050 likelihoods.

Table 5 How likelihood was scored: initial assessment of likelihood provided to participants

Score	Likelihood	Description
1	Very low	Not likely to occur in planning period
2	Low	May occur once per decade
3	Moderate	More likely than not to occur once per decade, may occur multiple times per decade
4	High	More likely than not to occur multiple times per decade, may occur annually
5	Very high	Likely annual, ongoing occurrences

Participants then evaluated their agreement with this likelihood score, selecting whether the initial assessment by the team members was too low, about right, or too high. See Table 6. The project team then reviewed the pool of responses for each impact to determine whether the initial assessment should be adjusted to correspond with the participants' input.

Table 6 Participants' agreement with likelihood score levels, initial assessment

Level of agreement	Description
Too low	The impact is more likely to occur than estimated
About right	The impact is likely to occur as estimated
Too high	The impact is not likely to occur that frequently

RISK SCORE: CONSEQUENCE

Consequence refers to the severity of outcomes for each value in the resilience framework if the impact occurs. Participants were asked to provide a consequence score for each impact based on the status quo; in other words, assuming that no additional efforts, actions or policies are used to manage the impact. Participants scored the potential consequence of each of the 41 impacts on a scale of 1 to 5. See Table 7. Team members provided participants with templates to guide their scoring. See Appendix 2, Table A1, for more information about consequence.

Table 7 How consequence was scored

Score	Description
1	Very low
2	Low
3	Moderate
4	High
5	Very high

Participants scored the consequence of the impacts on each of the nine values (see Table 2 for the values; see Table A1 for consequence scores). In many instances, a climate hazard can have consequences for multiple values. For example, permafrost thaw will have impacts on physical infrastructure (Value 1), which could then cause impacts to community (Value 6), since buildings are no longer available for community events. Permafrost thaw could also have impacts on landforms and ecology, which could in turn affect livelihoods (Value 7) and environmental health (Value 8). This scoring process demonstrated how interconnected climate change impacts are in all aspects of Yukoners' lives.

Participants were provided with scoring guides for each value to help them come up with consequence scores.[12] See Table 8 for an example and Appendix 2 for the complete scoring results.

Table 8 Sample scoring guide to assess the consequence of impacts (Value 6: Community)

Risk level	Score	Description
Very low	1	Communities are not affected.
Low	2	Communities in the Yukon respond well. While a small number of people within a community may be affected, recovery is complete.
Moderate	3	Some communities and larger groups of people (for example, several families) face challenges responding and recovering, vulnerable populations in particular. Connections to community and capacity are strained, but recover.
High	4	An entire community, and/or a significant number of people in a several communities have difficulty responding and recovering. Many people and/or community services are affected. Community connections and capacity are strained; recovery is slow and often incomplete.
Very high	5	Multiple communities and/or large proportions of the population are unable to respond. Connections and cohesion within the community break down. Capacity to respond becomes very limited; some communities, individuals do not recover.

ACTION SCORE

Action scores measure the level of ability that participants perceive they have to build capacity and increase resilience. As detailed in Figure 1 and Table 3, there are seven types of actions in the resilience framework: Enhancing self-sufficiency; Increasing efficiency; Expanding knowledge; Planning and preparing; Broadening education and knowledge sharing; Working together; and Building capacity.

Participants were asked to indicate, based on their personal experience and knowledge, their level of agreement with whether their organization or community was taking specific action, scoring this level of agreement on a scale of 1 to 5. See Table 9. Their responses were then reflected in scores, ranging from very low, low, moderate to high (see Table A2).

12. The assessment recognizes that industry standards apply to consequence rankings set for certain sectors, such as mining and electricity generation. The consequence rankings in the assessment scoring were not meant to replace or replicate those existing industry standards.

Table 9 Participants' level of agreement that their organization or community is taking action to build resilience

Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1	2	3	4	5

The climate risk assessment is not a comprehensive review of the Yukon's adaptive capacity, but these action scores provide insight into those topics for which participants feel there are existing strengths, or where specific actions are needed to build individual or community resilience.

Including resilience in the assessment process allowed participants to explore how various stakeholders — governments, communities and organizations — can reduce their vulnerability to climate impacts. For policy-makers and community leaders, this part of the process helped identify areas where Yukoners are ready to manage or already managing climate risks, and those where additional support and effort is needed.

The project team developed a risk map for each value in the Resilience Framework, which is a graphic representation of the likelihood and consequence of the most significant risks. See Appendix 1.

For more detailed information on how the risks were scored, refer to Appendix 2.

A NOTE ON METHODOLOGY

This assessment contributed to a shared understanding of climate change risks and resilience. This required the broadening of perspectives beyond what is typically considered in risk assessments. The assessment considered lived experience, stories, anecdotal evidence and local observations, and Indigenous knowledge, as well as numerical scores for risk likelihood and consequence. It adapted the principles and frameworks outlined in two reports by the International Standards Organization (ISO): *ISO 31000: Risk Management – Principles and Guidelines* (ISO 2018) and *ISO 14091: Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment* (ISO 2021).

ISO 31000 outlines the standards and guidelines for risk assessments. It explains that risk assessments aim to manage risk through careful and systematic identification, analysis and treatment. It recommends that risk management frameworks be continually improved and strengthened as they are integrated in planning and decision-making. ISO 14091, which discusses risk assessments in the context of climate change, recognizes that climate change risks differ from other risks, given the difficulty in predicting their probabilities. This means that climate change risk assessments might need to incorporate methods that build on conventional methods. Assessments that primarily rely on statistical probabilities can be ineffective when looking at climate change impacts (ISO 2021). This is especially true in the Yukon, where there are significant gaps in data and information for climate projections, as well as capacity limitations across governments and communities to interpret and use the probabilities of climate risks in decision-making.

The approach taken for this Yukon assessment — a holistic look at societal resilience, values and challenges as they intersect with a rapidly changing climate — emphasizes the qualitative expertise and knowledge of Yukoners. Where risk analyses often focus on quantifiable information, such as

economic losses or damage, the Yukon assessment created a resilience framework to understand and represent a diverse set of values and potential consequences to those values as a result of climate change impacts.

Most of those consequences are not readily quantifiable. However, similar to conventional risk assessment, a detailed and reproducible framework for ranking likelihood and consequence was established, and participant expertise and input supported the scoring of risks. While the analysis does not provide quantitative or statistical modeling of risk, the framework nevertheless captures the primary elements of risk management: documentation and communication with its key audiences, systematic identification of risk scenarios, and risk analysis. Furthermore, the focus on resilience and areas of action strengthens the link to and supports integration with risk treatment (or adaptation planning and decision-making), and the framework is tailored to the Yukon context.

Future versions of the risk assessment can expand and refine the list of risks identified and can continue to increase the depth of risk analysis. Qualitative and semi-quantitative risk assessments similar to that undertaken in the Yukon, which rely on the expertise and local knowledge of Yukoners, would benefit from additional opportunities to workshop and share knowledge, something that has necessarily been limited during the COVID-19 pandemic. Further refinements, including but not limited to increasing the regional or community-level scale of analysis, expanding the list of risks identified and analyzed, and incorporating climate and systems modeling, may also be possible.

DEVELOPING RECOMMENDATIONS

After the participants scored the climate risks, the results were reviewed with experts. This included reviewing the impacts with high risk scores, considering the levels of actions taken, and noting the gaps — identified by participants and others — where more research and information is needed.

The project team led nine validation sessions to discuss the results for each of the nine values in the resilience framework; see Table 4. Subject-matter experts and government representatives from territorial, municipal and Indigenous governments attended. Team members shared the results of the risk-scoring process, discussing how the risks affect each value in the resilience framework and the capacity of Yukoners to respond to risks. These validation sessions also explored recommendations for actions that can build resilience in the Yukon.

The recommendations were identified based on scoring, participant input, and lessons learned from existing work; for example, through *Our Clean Future.* In determining the recommended actions, the project team also considered the difference between the level of risk and the actions to uphold the nine values.

YOUTH

The team members held a series of conversations on what Yukoners, communities, organizations and governments can do to remain resilient in the face of climate change impacts. These discussions were part of the Yukon Adaptation Forum, which was hosted in collaboration with the Government of Yukon, Yukon University, the Council of Yukon First Nations and the Assembly of First Nations-Yukon Region.

One of the sessions brought together the Yukon Youth Panel on Climate Change, which includes 12 young climate leaders from across the territory, and the Yukon First Nations Climate Action Fellows. The Climate Action Fellowship was co-created by the Assembly of First Nations-Yukon Region, the Council of Yukon First Nations, Yukon University, Youth Climate Lab and Revitalizing Indigenous Values for Earth's Regeneration (RIVER). The fellowship includes 13 young people from Yukon and transboundary B.C. First Nations.

Youth were invited to share their ideas with other participants at the forum, and were asked, "What does a resilient Yukon look like in 2030?" Youth emphasized urgency, transformational thinking, and the need to work together. They talked about the importance of five themes: knowledge and experience; self-sufficiency; connection; responsibility; and leadership.
See Figure 3a and 3b.

Overall, youth participation in the assessment reaffirmed that supporting youth leadership and engagement in climate action is an important part of building resilience to climate change impacts. Project discussions brought forward ideas about how young people can meaningfully contribute to adaptation. This ranges from taking part in local projects to informing climate policies and plans.

Figure 3a **Graphic representation of the youth-led discussions on resilience at the Adaptation Forum**

> **We help each other...** The [Yukon Youth Climate] panel and [Yukon First Nations] fellowship have different names but we are working towards similar goals.
>
> PARTICIPANT, YOUTH SESSION – CLIMATE CHANGE ADAPTATION FORUM

Yukon youth leadership on climate action

In the Yukon, young people across the territory are already leaders in addressing climate change. In recent years, young climate activists have held high-profile climate marches, called on governments to take stronger actions, led projects in their communities and schools, and worked with their peers to come up with ideas to mitigate and adapt to climate change impacts.

Throughout the assessment, participants shared examples of how communities and organizations can involve young people in local adaptation work:

- including youth in projects related to land-based activities, such as ranger patrols, search and rescue, and monitoring;
- mentoring and training youth in assessing risks to community buildings located on permafrost or in areas prone to flooding, and teaching skills for monitoring and construction upgrades. This can help communities be more prepared, and help strengthen a sense of working together, particular in small, remote communities; and
- providing opportunities for youth to work on local farms and in food production to support food security.

Yukon youth are also shaping climate change policies and actions. The Yukon Youth panelists are providing advice to government on the Yukon's climate change actions, including *Our Clean Future*. The Yukon First Nations Fellows are developing a Yukon First Nations Reconnection Plan. Their vision and plan will help guide future climate action and priorities for First Nations.

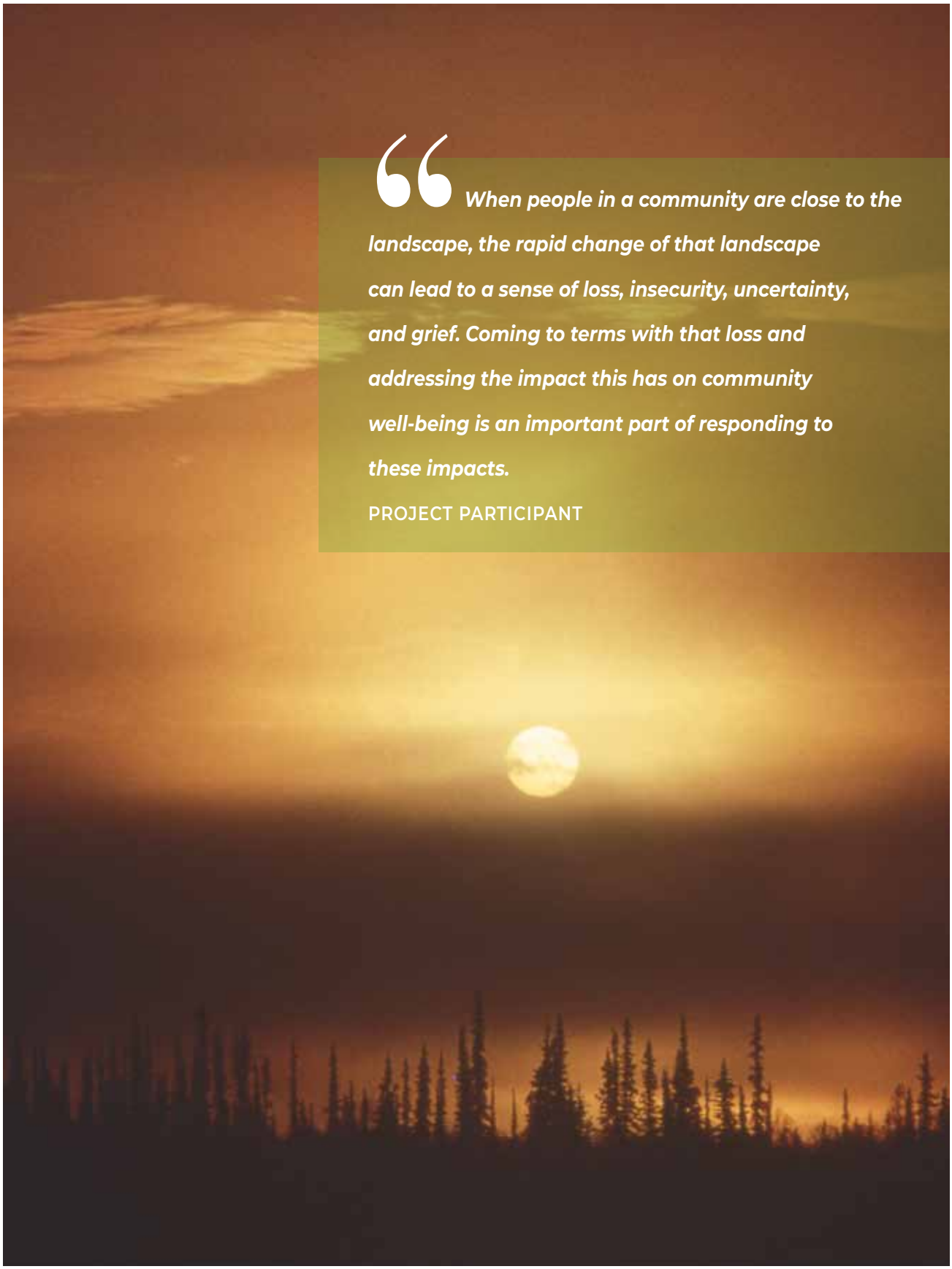
> **I think of the Tr'ondëk Hwëch'in...** They are very resilient. They have been put through an untold amount of pain and hurt. They have been told to lose their traditions and culture... when you go to Moosehide, you feel it. I feel [our resilience] the second I'm there and I see the smiling faces of the community members. It feels like home.
>
> YFN CLIMATE CHANGE FELLOW

The themes shown in Figure 3a and 3b present a broad vision for resilience in the Yukon: a persevering, self-sufficient, prepared and respectful community. Yukon youth discussed working together in respect to achieve shared values, to celebrate Yukon culture, to be food secure and energy secure, to live in energy-efficient homes and to implement modern policies. They envision people connected to and responsible for the land and water, following youth leadership, learning from experience, and ensuring that vulnerable people have wellness and equality.

The core values that youth raised also aligned with the values and actions in the resilience framework.

Recommendations related to youth are included in the Recommendations chapter.

Figure 3b Graphic representation of the youth-led discussions on resilience at the Adaptation Forum



> ***When people in a community are close to the landscape, the rapid change of that landscape can lead to a sense of loss, insecurity, uncertainty, and grief. Coming to terms with that loss and addressing the impact this has on community well-being is an important part of responding to these impacts.***
>
> PROJECT PARTICIPANT

3 PRIORITIES AND ACTIONS TO BUILD RESILIENCE

HOW THE PRIORITIES WERE IDENTIFIED

The project team identified the priorities in the following ways: by reviewing the impacts that scored high for multiple values (see Table 1), by highlighting recurring themes from discussions with participants, and by focusing on areas that participants identified as significant for building resilience.

Seven priorities emerged from the assessment:

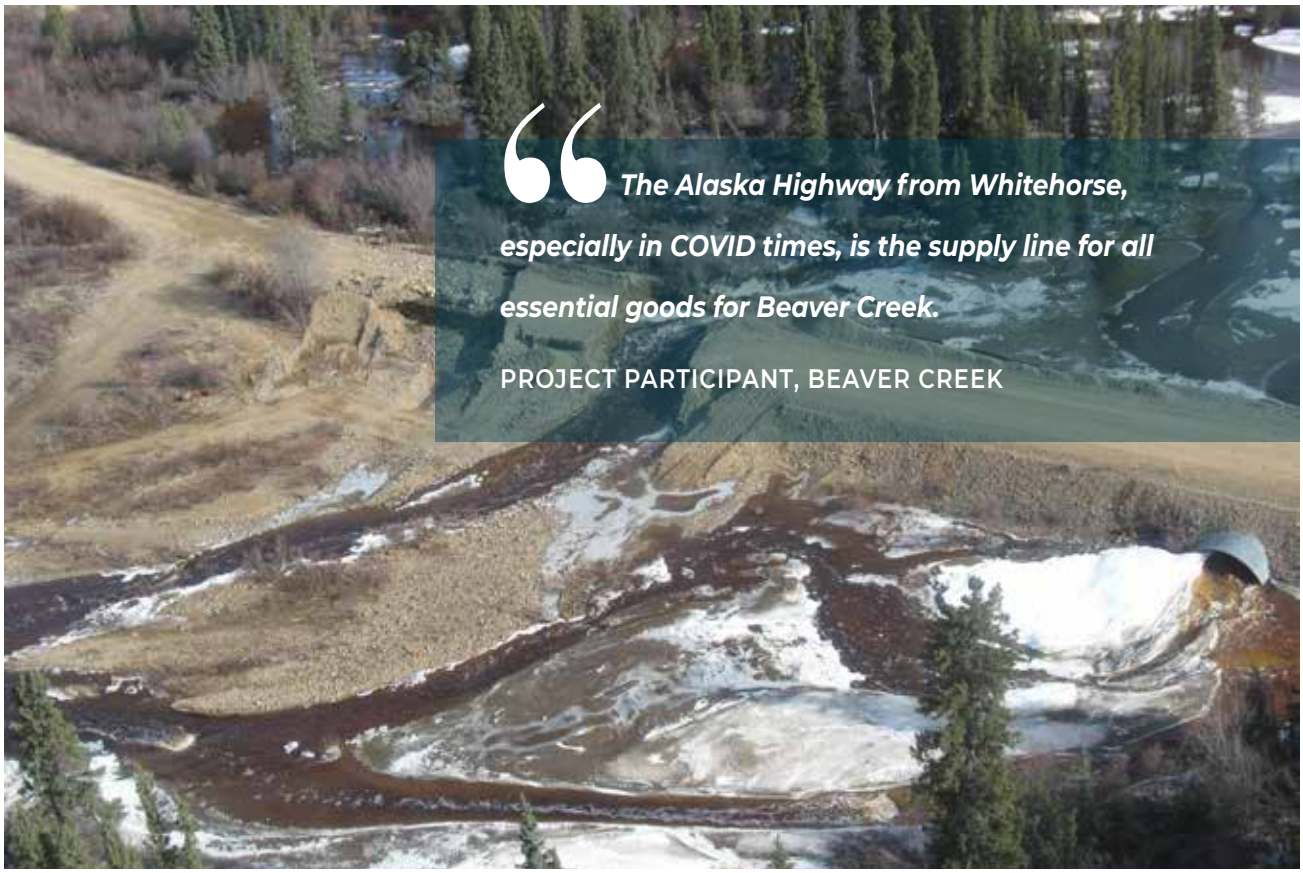
- Priority 1: Extreme weather and precipitation events that threaten transportation infrastructure;
- Priority 2: Floods and fires that affect communities and livelihoods;
- Priority 3: Permafrost thaw that affects communities, infrastructure and access;
- Priority 4: Changing climate conditions that affect land, water, animals and plants;
- Priority 5: Changing conditions on the land that pose risks to safety, access, culture and heritage, and livelihoods;
- Priority 6: Multiple climate change impacts that affect health and well-being; and
- Priority 7: Risks to the Yukon's economy.

All seven priorities are equally important, and all are linked to several climate change impacts. Each description of the priorities begins with a risk and action analysis. The text then describes how these impacts affect the nine values in the resilience framework:

See Table 2 for more information on the nine resilience values.

This discussion of values is followed by recommended actions to help the Yukon build resilience for the priority. The actions were identified based on risk scores, participant input, and lessons learned from existing work; for example, through *Our Clean Future.* Table A2 in Appendix 3 summarizes the risk scores and action scores for each impact.

Priority 1 Extreme weather and precipitation events that threaten transportation infrastructure



RISK AND ACTION ANALYSIS: PRIORITY 1

The Yukon is remote, and its transportation network is critical. Impacts to transportation infrastructure affect supply chains, and can affect the flow of essential goods and services and disrupt connections between communities (Pendakur 2017). For example, flooding in 2012 led to a washout on the Alaska Highway, making the highway impassable between Teslin and Watson Lake for several days. This resulted in the sudden reduction in the availability of fresh foods, fuel and other goods.

Transportation infrastructure came up in almost every discussion of risks related to extreme weather events, wildfires, floods and permafrost thaw.

How these impacts affect the resilience values

Participants gave high risk scores to impacts relating to these values.

Value 1: Infrastructure — Critical transportation infrastructure, both public and private, are affected by extreme weather and precipitation events. In the assessment, the highest rated risks for this value related to supply chain interruptions from hazards like erosion, landslides, extreme precipitation, fires, and floods.

Value 2: Food security — Supply chain disruptions and price increases can affect food security. Extreme weather events such as flooding and freezing rain – as well as wildfires — can also disrupt the delivery of services and the flow of goods from the south (Pendakur 2017).[13] Local food production cannot currently make up for any major disruptions to the food supply; only a small percentage of the Yukon's commercial food is locally produced.

Value 3: Energy — Extreme precipitation events can cause highway washouts and landslides, which can in turn limit access to fuel supplies. In addition, restricted access to communities can hinder the repair and maintenance of power lines and other sources of power (Boyle et al. 2013; Streicker 2016).

Value 6: Community — The reduced number and availability of winter roads and ice bridges can disrupt the delivery of food, fuel and essential services to communities such as Old Crow, Dawson and Inuvik.

Value 7: Livelihoods — Interruptions to transportation infrastructure from extreme weather events can affect local businesses and sectors such as tourism that rely on access to remote areas.

Value 9: Health and well-being — Interruptions to transportation infrastructure can affect communities' access to healthcare services and lead to mental health impacts from isolation.

Table 10 summarizes the risk scores for the most significant impacts related to Priority 1.

13. This was confirmed in discussions with project participants.

Table 10 Summary of risk scores for impacts related to Priority 1: Extreme weather and precipitation events that threaten transportation infrastructure

No.	Impact		Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from very low to very high	Consequences to values
2		Wildfires threaten communities, heritage values, and infrastructure	INF 17	FS 11	EN 15	**High:** more likely than not to occur multiple times per decade; may occur annually	• Supply chain interruptions • Interruptions in access to essential services such as health care and social services • Interruptions of essential supplies such as fresh food and fuel • Mental health impacts from isolation • Higher food prices due to supply chain interruptions • Disruptions to local business and tourism • Hindered repair and maintenance of power supply
			CH 16	AC 14	CM 15		
			LH 12	EH 16	HW 16		
12		Warming winter conditions reduce the availability of winter roads and ice bridges	INF 13	FS 15	EN 13	**High:** more likely than not to occur multiple times per decade; may occur annually	
			CH 12	AC 16	CM 14		
			LH 13	EH 12	HW 14		
31		Washouts and landslides lead to transportation service interruptions or failures	INF 13	FS 13	EN 12	**Moderate:** more likely than not to occur once per decade; may occur multiple times per decade	
			CH 11	AC 13	CM 12		
			LH 11	EH 10	HW 12		
33		Extreme precipitation events cause damage	INF 17	FS 16	EN 15	**High:** more likely than not to occur multiple times per decade; may occur annually	
			CH 15	AC 16	CM 16		
			LH 16	EH 15	HW 16		
39	Range of hazards	A range of climate-related factors disrupt critical supply chains	INF 14	FS 17	EN 15	**High:** more likely than not to occur multiple times per decade; may occur annually	
			CH 9	AC 18	CM 16		
			LH 16	EH 12	HW 17		

Legend:
The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods
Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high

Risk score
Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 1

The action scores (which measure the level of ability that participants perceive they have to build capacity and increase resilience; see Table A2 in Appendix 3) suggest that communities have only a low to moderate level of resilience for addressing Priority 1. Transportation experts noted that there are capacity gaps related to planning and preparedness. In some cases, trade-offs between building new infrastructure and upgrading and maintaining existing infrastructure can make it challenging to proactively reduce risk. These are the most important actions to take to build resilience for Priority 1.

Carry out vulnerability assessments and geohazard mapping for the Yukon's transportation infrastructure

The Government of Yukon is in the process of completing several actions outlined in *Our Clean Future* that will build capacity to address risks to transportation infrastructure. They include mapping flood and geohazard risks along transportation corridors, and considering climate change information in upcoming road infrastructure developments. It is important to complete these actions as quickly as possible in order to be proactive and to limit any costs and effects associated with impacts. Increasing the resilience of the Yukon's transportation infrastructure will also safe-guard the economic activities that rely on it for transporting goods and providing services.

Make resources available for responding to recommendations from road vulnerability assessments and hazard mapping

Once vulnerability assessments and hazard mapping are completed, government resources will be needed to address their findings. Resources include equipment, staff capacity, and funding for maintenance and upgrades; additional resources will be required to address projected winter conditions.

Support food security for store-bought and locally produced foods

Participants, including those who work on food security, explained that promoting local food security can help build resilience by reducing reliance on southern imports and buffering the effects of interruptions to supply chains. They discussed actions in the Yukon 2020 Agriculture Policy (Government of Yukon 2020a), the City of Whitehorse 2020 Local Food and Urban Agriculture Study (City of Whitehorse n.d.), and community-based plans such as Kluane First Nation's Food Security Strategy (KFN 2014). In 2019, the Arctic Institute of Community-Based Research completed an extensive review of food security projects across the Yukon (AICBR 2019) and recommended resources for further local projects. This review can be used to inform future community-based projects on food security.

Explore opportunities to support household and business preparedness for power outages

Project participants noted that households often have back-up heat and energy sources — wood stoves, generators, solar panels — that lessen their vulnerability to power outages or highway washouts. These risks vary depending on the season. In the winter, power interruptions are most significant during periods of extreme cold. In the summer, risks relate more to food storage. Although communities may be able to withstand short-term disruptions, it is important to increase preparedness in case risks persist beyond current capacity. This can include ensuring that homes have a 72-hour emergency preparedness kit and that Yukoners have plans in place for back-up heat and power in case there are service interruptions.

Table 11 summarizes the recommended actions to increase resilience for Priority 1.

Table 11 Summary of recommended actions, Priority 1: Extreme weather and precipitation events that threaten transportation infrastructure

Impact no.	Significant impacts, Priority 1	Recommended actions to increase resilience
2	Wildfires threaten communities, heritage values, and infrastructure	• Carry out vulnerability assessments and hazard mapping for Yukon's transportation infrastructure • Make resources available for responding to recommendations from road vulnerability assessments and hazard mapping • Support food security for store-bought and locally produced foods • Explore opportunities to support household preparedness to power outages
12	Warming winter conditions reduce the availability of winter roads and ice bridges	
31	Washouts and landslides lead to transportation service interruptions or failures	
33	Extreme precipitation events cause damage	
39	A range of climate-related factors disrupt critical supply chains	

Priority 2 Floods and fires that affect communities and livelihoods

RISK AND ACTION ANALYSIS: PRIORITY 2

Most Yukon communities are located along rivers or lakes and in or near forested areas. This makes flooding and wildfire critical hazards. Rain and storm events are projected to increase; late season freeze-thaw cycles on rivers are creating ice which is more prone to ice-jam damming; and, heavy snowpack with warmer springs is leading to freshet flooding (Streicker 2016). Flood risk is increasing; in addition, insect outbreaks, variability in precipitation, warming temperatures, longer shoulder seasons, and increased winds increase the risk of forest fire, both frequency and severity (ibid.). Climate change is increasing the risk of both floods and wildfires. Regional considerations also affect floods and wildfires; see Box 7.

Photo: Jason Wolsky

BOX 7 | REGIONAL CONSIDERATIONS: FLOODS AND WILDFIRES

Floods

Spring break-up events that pose a flooding risk to Yukon communities have generally been restricted to the Yukon and Klondike rivers near Dawson City, and the Porcupine River at Old Crow. Other communities that could be affected by floods during break-up include Carmacks (Yukon and Nordenskiold rivers), Ross River and Pelly Crossing (Pelly River), Mayo (Stewart River), and Upper Liard (Liard River).

Spring freshet (high flow driven by spring snowmelt) has resulted in flooding in Carmacks, Teslin, Upper Liard, Rock Creek, Ross River and Mayo. Communities that could also be affected by spring freshet flooding include Dawson, Old Crow, and Pelly Crossing.

Bennett Lake, Tagish Lake and Marsh Lake in the Southern Lakes region, and Lake Laberge, experienced historic flooding in 2007 and again in 2021. These flood events, less than 15 years apart, both eclipsed water levels associated with the 100-year return period event (the 100-year return period event is expected to be exceeded once every 100 years on average, but has a 1 per cent chance of being equalled or exceeded in any year). The peak summer water level in the Southern Lakes and Lake Laberge is driven by a combination of snowmelt, precipitation, and summer temperatures influencing glacial melt.

Smaller creek and river systems may have spring freshets that affect transportation infrastructure such as roads, bridges and culverts. The area around the Liard River basin and Watson Lake is regularly affected, as is the North Alaska Highway northwest of Haines Junction.

With climate change, stream crossings are increasingly affected by summer rains, especially along the Dempster Highway.

River freeze-up can result in high water in places such as Carmacks and the Marwell area of Whitehorse.

Wildfires

The majority of wildfires in the Yukon are caused by lightning strikes. Most of these fires start and remain in wilderness areas far away from human activity, where they can fulfill their natural ecological role in the boreal forest.

On the other hand, areas immediately around communities and critical infrastructure are the top priority for both wildfire suppression and preventative hazard reduction work. Reducing hazards around communities prevents flammable vegetation from growing dense and creating a greater risk of dangerous wildfire conditions.

HOW THESE IMPACTS AFFECT THE RESILIENCE VALUES

Participants gave high risk scores to impacts associated with flooding and fires across multiple resilience values.

Value 2: Food Security and **Value 5: Access** — Wildfire smoke and subsequent impacts to air quality can prevent people from going on the land or water to gather or harvest traditional foods. Fire-related highway closures affect critical infrastructure, which affects road-based food and fuel delivery.

Value 3: Energy — Wildfires can damage transmission lines, which can lead to power outages. Although this impact had moderate scores, participants noted that it is likely to increase over time. Participants from YEC in the scoring process noted that wooden transmission poles and high fuel loads around communities contribute to risk, and that households without back-up heat or power, or with a single highway access point, face the highest risk.

Value 6: Community — Wildland fires and floods can damage homes and community buildings, such as recreation centres, fire halls, wastewater treatment plants, public works buildings, etc. Buildings whose structures and surrounding properties have not been constructed or maintained to resist ignition from wildfire embers face greater wildfire risks.

Value 7: Livelihoods — Damage to private property from wildfires and floods can be costly and can affect household financial security. Damage to private property can also affect home businesses, which make up a significant portion of the economy in the Yukon (in 2019, 58.6 per cent of all businesses in the Yukon were home-based).[14]

Value 9: Health and well-being — Exposure to wildfire smoke can worsen respiratory conditions. Flooding can be harmful or fatal, and damage to buildings can lead to long-term indoor air quality problems; extreme weather and emergencies can affect mental health.

Building capacity for addressing flood risks

Discussions with experts in emergency management and response revealed that most efforts to date have focused on managing fire risk. Although fires continue to pose high risks in the Yukon, there is more established capacity to prevent and respond to fire than there is for flooding. For example, there are established firefighting crews in place to respond to wildland fires in communities through hired staff, First Nations crews and contractors. Participants in the assessment explained that roles and responsibilities for responding to floods are less clear.

At the same time, climate change hazards are increasing the flood risk across the territory. As noted in Box 7, severe flood levels occurred in the Southern Lakes in 2007 and then again in 2021. Participants said that both flood and fire hazards need further attention, but that it is important to continue to build capacity for flood forecasting and mapping, preparedness and response. This finding was reflected in the risk scores; participants gave a higher risk score to floods than they did to wildfires.

14. The Professional, Scientific and Technical Services sector and the Construction sector had the largest number of home-based businesses: 384 and 372, respectively. Combined, these sectors represented 39.8 per cent of all home-based businesses. https://yukon.ca/sites/yukon.ca/files/ybs/2019_business_survey_report.pdf.

Flooding at Marsh Lake, 2021. Photo: Jason Wolsky

The risk scores suggest that building resilience to floods is critical. Damage from extreme precipitation events (Impact 33) scored high for six of the nine values, and flood-related risks received low action scores (indicating a low level of resilience). Floods from both surface water and groundwater pose risks, and building resilience to both is important. See Box 8. Project participants noted that more can be done to build capacity to plan for, prepare and respond to flood risks, and to work together to reduce flood-related risks. Gaps include a lack of flood forecasting data and limited local capacity to respond to flood risks.

BOX 8 | WHAT IS GROUNDWATER FLOODING?

Groundwater flooding occurs when the water table rises above the level of a basement, crawl space, or, potentially, the ground surface. This is distinct from what most people likely think of as simply "flooding," which typically refers to the overflow of surface water, usually from a lake or river. Groundwater also plays a role in that type of flooding. For example, above-average groundwater levels can increase groundwater discharge to streams and rivers and can limit groundwater recharge from rain and snowmelt. According to the Water Resources Branch, this can lead to or worsen flooding because rain and snowmelt that cannot infiltrate the ground will flow on the surface — this was thought to be the case in spring 2021 in many regions of southern and central Yukon because of wet conditions in the summer and fall of 2020.

BUILDING CAPACITY FOR INCIDENT RESPONSE

In 2021, the Yukon's response capacity was stretched due to a combination of floods, fires and the COVID-19 pandemic. See Box 9. The combination of these issues presented serious challenges to a system that was already operating at full capacity. For example, many flood response plans involve setting up emergency shelters for people who have been displaced. These shelters often have high density — which is complicated by social distancing requirements.

BOX 9 | LESSONS FROM 2021 – FLOODS, FIRES AND A PANDEMIC

The year 2021 highlighted important lessons for emergency response. Throughout the winter of 2020–21, the southern Yukon experienced unusually high precipitation. This was followed by a cooler-than-average spring that delayed snowmelt, then by above-average temperatures in June, culminating in a heat wave at the end of June and into early July. The heat resulted in a rapid melt of the record-breaking snowpack in the alpine regions of the Southern Lakes basin. At the same time, the heat led to favourable conditions for forest fires. As a result, the Yukon experienced wildfires and flooding at the same time, all while emergency response agencies were grappling with the COVID-19 outbreak. While emergency response efforts were considerable, the combination of floods, fires, and the pandemic stretched the Yukon's capacity to deal with multiple stressors at once to its limit.

The 2021 events present an opportunity to build resilience, as the Yukon can learn from its response to these stressors. Opportunities exist to bring together those responsible for forecasting, planning and responding to emergencies to share lessons learned, resource requirements, and roles and responsibilities should a similar situation occur in the coming years. Opportunities also exist to learn from past flooding events, such as the 2007 flood in the Southern Lakes region.

The Government of Yukon is working to identify and seek resources to support a flood program, which will bring together different government departments working on forecasting, preparing for and responding to floods.

Table 12 summarizes the risk scores for the most significant impacts related to Priority 2.

Table 12 Summary of risk scores for impacts related to Priority 2: Floods and fires that threaten communities and livelihoods

No.	Impact		Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
2		Wildfires threaten communities, heritage values, and infrastructure	INF 17	FS 11	EN 15	**High:** More likely than not to occur multiple times per decade; may occur annually	• Impacts to air quality (wildfire smoke) • Damage to homes, buildings and community infrastructure • Physical health and safety risks • Safety risks for getting out on the land and impacts to harvested foods, cultural practices, and well-being • Damage to community spaces can affect ability to gather • Damage to transportation infrastructure and interruptions to supply chains • Reduced access to seasonal and ice roads • Mental health impacts • Costly damage affecting household financial security • Damage to energy infrastructure
			CH 16	AC 14	CM 15		
			LH 12	EH 16	HW 16		
11		Changing water levels, conditions, and flow in rivers and lakes affect community infrastructure	INF 20	FS 15	EN 17	**Very high:** Likely annual, ongoing occurrences	
			CH 18	AC 16	CM 16		
			LH 14	EH 16	HW 14		
17		Changes to the timing of ice freeze-up and break-up on waterways	INF 14	FS 14	EN 11	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 14	AC 17	CM 14		
			LH 13	EH 11	HW 13		
18		Groundwater levels are raised in some regions or areas, posing risks to community infrastructure	Impact 18 did not receive enough responses for conclusive results. It may be worth assessing in a future climate risk assessment.				
19		Ice-jam floods occur along the Yukon River and in other important watersheds	INF 15	FS 11	EN 10	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 11	AC 13	CM 12		
			LH 9	EH 11	HW 11		
29		Flooding in communities is more frequent and severe	INF 16	FS 14	EN 14	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 14	AC 15	CM 14		
			LH 12	EH 12	HW 13		
33		Damage from extreme precipitation events	INF 17	FS 16	EN 15	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 15	AC 16	CM 16		
			LH 16	EH 15	HW 16		

Legend:
The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods
Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high
Risk score
Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 2

Build capacity for flood forecasting

Increased snowfall, longer shoulder seasons, extreme precipitation events, warming temperatures, and changing weather patterns are increasing the complexity of water systems and present a challenge for forecasts and for infrastructure planning and development. In addition, the Yukon has few climate and water monitoring stations (maintained by federal and territorial governments), and many of them lack long-term data. Long-term resources to operate, maintain and expand the network of hydrometric and meteorological stations, build and improve forecasting models for stream flow, lake level and break-up, and increase human resources to support forecasting efforts can help build resilience in flood forecasting. Local observations can also provide critical information to support flood forecasting and response efforts. Building on existing capacity and working with communities (for example, through community-led monitoring and citizen science)[15] can further support forecasting.

Build capacity to predict areas vulnerable to groundwater flooding and mitigate the potential adverse impacts of groundwater floods in those areas

Enhanced groundwater monitoring would help identify where groundwater flooding could occur and damage infrastructure, and would support the design of systems to mitigate potential damage. Monitoring groundwater levels in strategically located and designed groundwater monitoring wells would also strengthen understanding of groundwater recharge and discharge conditions and contribute to assessments of flood probability. It was inferred that high groundwater levels in spring 2021 were based on meteorological conditions in 2020, but direct measurements were not available to support this inference.

Support community preparedness for floods

The Government of Yukon is working on flood maps and emergency response plans for all communities across the territory. Flood maps are important for adapting to increased flood risk (see Box 10). Some communities already have physical structures in place to reduce floods, such as the Dawson City Dike. Until flood maps are completed, some communities will lack information about how to reduce their flood risk. Communities that already have flood maps can build resilience by increasing their capacity to identify and develop projects to reduce flood risk.

15. Citizen science is when the public voluntarily helps conduct scientific research. Citizen scientists may design experiments, collect data, analyze results, and solve problems. https://www.nps.gov/subjects/citizenscience/citizen-science.htm.

BOX 10 | FLOOD MAPS

A flood map estimates the risk of flooding in a community or area. Flood mapping has increasingly been highlighted as a key tool, not just to support emergency response, but also for development planning and reducing community vulnerability to flooding in the face of the Yukon's changing climate. In the Yukon, flood modelling and flood mapping are complicated by ice-jam potential in several locations, and therefore may require tools beyond what is needed in other jurisdictions. There are different kinds of flood maps that serve different purposes, including flood inundation maps, flood hazard maps, flood risk maps, and flood awareness maps. The most basic are flood inundation maps, which are used for emergency responses. These show the extent of historic floods, often the flood of record for a location, or for flood events of different magnitudes (for example, the 100-year flood). They are the first step in creating flood hazard and flood risk maps that are used more broadly for development planning and decision-making.

Support preparedness for floods and fires on private and commercial properties

It is important that territorial, municipal and Indigenous governments make sure that people are taking actions to reduce the risk of wildfires and floods for private properties, including homes and home-based businesses. This could include providing financial incentives for retrofits to private properties to make them fire-resistant and reduce fire risk, mandating fire-resistant materials in building codes, and ensuring that people have a 72-hour preparedness kit and are aware of the importance of back-up heat and power. Supports for businesses can include providing financial incentives for completing building upgrades to reduce fire and flood risk for commercial properties.

Increase capacity for incident response

In addition to increased investment in risk reduction, preparedness and recovery, increased capacity for incident response will create a more resilient territory. Increased capacity would enable the necessary response during extended and more severe wildland fire seasons, which is currently provided primarily by seasonal employees; would allow simultaneous response to multiple emergency events, including different kinds of emergencies (such as floods, fires and earthquakes); and would make sure that robust programs are in place for incident response not related to wildland fires. Although flooding is identified as a leading hazard in this report, there is currently no coordinated flood management program within the Yukon.

Capacity increase would see more trained and experienced personnel available when critically required. While increased capacity for wildland fire response could involve a relatively straightforward increase in staffing levels, other climate-related emergency response will require significantly more consideration. In the absence of dedicated programs for specific non-wildfire emergencies, or a general all-hazard response program, increasing capacity requires developing and maintaining the programs that enable safe and effective response. Elements of these programs include appropriate policy and safe operating procedures, preparedness and decision-support systems, and training.

Support preparedness for fires on publicly owned properties

This can include ensuring that properties and critical infrastructure owned by territorial, municipal and Indigenous governments are built or retrofitted to be fire resistant; ensuring that landscaping follows FireSmart principles; ensuring that new developments follow Canadian Standards Association (CSA) standards for wildfire resilient development in the north; and ensuring that future planning projects zone land appropriately to avoid hazardous areas.

Incorporate information on flood risks into community infrastructure development

A range of parties are involved in developing community infrastructure: municipal and Indigenous governments, private contractors, and Government of Yukon departments. Providing guidance, policies, tools and standards on considering flood risk in community infrastructure procurement and management can help build resilience.

Make sure that Yukoners work together on flood-related emergency response

Smaller and more remote communities have limited access to the equipment needed to prevent or mitigate flood damage. Throughout the assessment, emergency response experts said that it is critical for communities to incorporate flood prevention into emergency management plans, and to understand their roles and responsibilities in responding to flood risk. Sharing information about emergency management planning and carrying out regular drills on emergency response can help build resilience. Establishing regular reviews of emergency preparedness plans to make sure they are adequate and up to date is another possible action. Some groups are already collaborating to make the most of limited resources. For example, the Village of Teslin and Teslin Tlingit Council have developed a joint emergency management plan, which helps them work more efficiently with each other and with the Government of Yukon. Throughout the 2021 flood season, the Carmacks Incident Management Team included representatives from Little Salmon Carmacks First Nation, the Village of Carmacks and the Government of Yukon.

Explore how collaboration can support emergency planning and response

Areas where overlapping jurisdictions may create confusion or misunderstanding around roles and responsibilities for emergency management planning need to be reviewed. This may include reviewing the *Civil Emergency Measures Act* to make sure that it acknowledges the authorities that exist under the First Nations Final Agreements and the capacity and expertise that Indigenous governments can bring to emergency management. Raising awareness of the importance of emergency management and of the role that municipalities, Indigenous governments and communities, the territorial government, and the private sector can play in emergency planning can also help build resilience. Exploring opportunities to increase collaboration with neighbouring jurisdictions can also help build resilience.

Assess financial recovery from emergencies related to floods and wildfires

The Government of Yukon is assessing the ways that Yukoners can obtain adequate insurance for fires, floods and permafrost damage. Completing this assessment quickly will help support financial recovery.

Table 13 summarizes the recommended actions to increase resilience for Priority 2.

Table 13 Summary of recommended actions, Priority 2: Floods and fires that threaten communities and livelihoods

Impact no.	Significant impacts, Priority 2	Recommended actions to increase resilience
2	Wildfires threaten communities, heritage values, and infrastructure	• Build capacity for flood forecasting and flood mapping • Expand monitoring and modelling to support flood forecasting • Build capacity to predict areas vulnerable to groundwater flooding and to mitigate the potential adverse impacts of groundwater floods in those areas • Support community preparedness for floods • Support preparedness for floods and fires on private and commercial properties • Increase capacity for incident response • Support preparedness for fires on publicly owned properties • Incorporate information on flood risks into community infrastructure development • Ensure that Yukoners work together on flood-related emergency response • Explore how collaboration can support emergency planning and response • Ensure adequate financial recovery is available for emergencies related to floods and wildfires
11	Changing water levels, conditions and flow in rivers and lakes affect community infrastructure	
17	The timing of ice break-up on waterways changes, including earlier spring break-up	
18	Groundwater levels are raised in some regions or areas, posing risks to community infrastructure	
19	Ice-jam floods occur along the Yukon River and in other important watersheds	
29	Flooding in communities is more frequent and severe	
33	Extreme precipitation events cause damage	

Priority 3 Permafrost thaw that affects communities and infrastructure

> ***Everybody in the community is impacted. If one person can't access a building, everyone feels the grief of that person losing access. If there is one house that's in a spot that is not stable because it is in the zone of a landslide or permafrost, the entire community feels anxiety and feels grief over the change of that landscape. When you have a community feeling anxious, isolated, at risk — that impacts all of the relationships between the community and governments who work with them.***
>
> PERMAFROST SCIENTIST WHO PARTICIPATED IN THE CLIMATE RISK ASSESSMENT

RISK AND ACTION ANALYSIS: PRIORITY 3

Permafrost is soil or rock that remains frozen for longer than two consecutive years. It is stable while frozen, but can cause damage when it thaws. Risk assessments that consider permafrost thaw often score the likelihood and consequence of impacts on infrastructure, roads or physical assets. It is well-documented that permafrost thaw can pose significant risks to roads and highways, community infrastructure, and mines (Streicker 2016). This assessment included these impacts, and demonstrated that they also affect health and well-being, Yukoners' culture and heritage, and sense of community and belonging.

Participants shared examples of this throughout the discussions and the risk-scoring exercise. In some communities, costly and recurring damage to roads and buildings is leading to difficult conversations about whether to move Elders' homes, or whether to shut down a community building. Several project participants noted that the thought of relocation has come up in the past. While addressing these concerns relies on technical expertise, it should also consider the values that are important to community members. Isolated communities with limited resources and in areas with high risk of permafrost thaw will see more significant impacts. See Box 11 regarding regional considerations for permafrost thaw.

Although impacts related to permafrost thaw received moderate risk scores, team members identified this hazard as a priority after considering the scores and having discussions with project participants and subject-matter experts. Experts noted that permafrost thaw may be a slow process, which can reduce the sense of urgency in responding to it. However, permafrost is also vulnerable to other climate hazards, such as wildfires, river erosion and changing hydrology, and it can thaw rapidly once it is disturbed. Responding quickly can be hard, partly because of the time and expertise required to hire engineering firms, obtain land-use permits, and complete Yukon Environmental and Socio-economic Assessment Board reviews. In addition, addressing permafrost damage is costly: stabilizing the Ross River school cost more than $1.5 million, with ongoing costs for the foreseeable future.

BOX 11 | REGIONAL CONSIDERATIONS: PERMAFROST THAW

Increasing air temperatures and disturbances such as forest fires and river erosion can trigger or worsen the impacts of permafrost thaw. Permafrost thaw affects most communities across the Yukon, and those with limited resources and ice-rich permafrost that is more likely to thaw will see more significant impacts.

Many factors influence where permafrost occurs and its corresponding temperature and ice content, including latitude, altitude, slope, ground type, soil moisture, snowpack, etc. The high variability in the nature and spatial distribution of permafrost makes it difficult to categorize the Yukon's geographic regions according to risks related to the climate hazard of permafrost thaw. The level of risk in any location depends on site-specific permafrost characteristics, such as its ice content, depth, thickness, and temperature, and on ground type. Permafrost that contains no ice is stable if it thaws. Permafrost that contains a significant amount of ice will settle and cause ground instability when it thaws.

North of Dawson, permafrost is continuous, with 90–100 per cent of the ground underlain by permafrost. Permafrost in this area is generally thick and cold. Old Crow and Ross River are underlain by ice-rich permafrost that is vulnerable to thawing.

Farther south, permafrost becomes progressively thinner (in other words, the bottom of the permafrost doesn't extend as deep) and more discontinuous. It also becomes "warmer," meaning that it is warmer than –2°C. The permafrost present in most of the southern Yukon is considered "warm." Whitehorse is in an area of sporadic discontinuous permafrost, with 10–50 per cent of the ground underlain by permafrost. This permafrost is often very thin and warm, making it particularly vulnerable to thawing.

Many participants noted that the North Alaska Highway was particularly vulnerable to permafrost thaw. A study published in 2015 (Calmels et al. 2015) found that, of the 200-km section between Burwash Landing and the Yukon-Alaska border, 42.7 per cent — almost half — is highly vulnerable to permafrost thaw.

HOW THESE IMPACTS AFFECT THE RESILIENCE VALUES

Value 1: Infrastructure — Impacts to infrastructure related to permafrost thaw received high scores. Permafrost-related risks to infrastructure are widespread, and can affect community infrastructure, transportation corridors and mining infrastructure.

Value 2: Food Security — Throughout the assessment participants noted that communities are concerned about downstream impacts from mining sites that may be affected by climate hazards. Communities and Indigenous governments often express concerns over permafrost degradation during environmental assessments related to mining. For example, some participants noted that this is top of mind for the White River First Nation, whose moose harvest camp on the Yukon River is downstream from the Minto Mine. The First Nation has expressed concerns over contamination of water supplies if a failure were to occur. Concerns focus on the long-term risks from waste rock facilities and tailing ponds, and the implications for the fish and wildlife that people depend on. People are also concerned about health and safety risks, and about their access to important places on the land and water.

Value 3: Energy — Permafrost thaw could lead to maintenance problems along transmission lines. Participants noted that more information is needed to assess which regions are particularly vulnerable.

Value 4: Culture and Heritage and **Value 5: Access** — Historic buildings and community buildings that serve as meeting and gathering spaces are being destabilized due to ground slumping from permafrost thaw. Changes to the landscape that people rely on can also lead to a loss of identity and cultural connection and can reduce self-sufficiency (Middleton et al. 2020). The Vuntut Gwitchin First Nation has already witnessed sudden and dramatic changes, such as the lake drainage in Old Crow Flats/Van Tat.

Value 6: Community — Significant risks relate to community infrastructure and the safety and health of residents. Participants in the assessment shared that in Ross River, people have expressed concerns regarding permafrost damage to Elders' homes, how this might affect their health and safety, and the community's ability to repair the homes. According to a Ross River participant in the validation sessions, and Streicker (2016), when the Ross River School closed in 2019 for repairs to permafrost damage, the community had to adjust to the disruption of the school year, increased child care costs, and the loss of an important community gathering space.

Value 8: Environmental Health — Permafrost thaw can pose risks to water quality (Schaefer et al. 2020) and lead to significant changes in vegetation, lakes and wetlands (ACIA 2004).

Table 14 summarizes the risk scores for the most significant impacts related to Priority 3.

Table 14 Summary of risk scores for impacts related to Priority 3: Permafrost thaw that affects communities, infrastructure and access

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high	Consequences to values
4		Permafrost thaw and ground subsidence damage buildings and infrastructure	INF 17	FS 12	EN 12	**High:** More likely than not to occur multiple times per decade; may occur annually	• Damage to homes and community gathering spaces • Damage to critical infrastructure • Health and safety concerns for community members living in or accessing buildings with permafrost damage • Difficulty accessing the land • Changes to the landscape and impacts to wildlife • Exposure of traditionally harvested ecosystems to contamination • Damage to mining infra-structure and downstream impacts to communities • Mental health impacts associated with changing landscapes • Impacts to cultural and community values from reduced access to the land • Impacts to culture, community gathering, ability to share know-ledge, bring together Elders and youth
			CH 14	AC 15	CM 14		
			LH 11	EH 12	HW 11		
8		Permafrost thaw alters landforms and ecology	INF 11	FS 10	EN 9	**Moderate:** More likely than not to occur once per decade; may occur multiple times per decade	
			CH 13	AC 11	CM 11		
			LH 11	EH 11	HW 10		
9		Permafrost thaw causes critical infrastructure failures	INF 16	FS 9	EN 13	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 12	AC 11	CM 11		
			LH 11	EH 11	HW 10		

Legend:
The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods
Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high
Risk score
Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 3

Participants gave low to moderate action scores to permafrost thaw. This suggests that although people are aware of the issue and have some knowledge of it, more could be done to increase awareness, work together, build capacity, and strengthen planning and implementation of risk reduction measures.

Make sure that permafrost data are available to those responsible for planning, developing and upgrading infrastructure and continue to support research efforts that characterize permafrost

The Government of Yukon's Yukon Permafrost Database was publicly released in December of 2021 and will include information from sources external to the Government of Yukon to contribute to and bolster the database's effectiveness and applicability. The Government of Yukon is also developing protocols to require contractors to submit any permafrost data collected during new geotechnical investigations. Building collaboration within the Government of Yukon and between the government and the private-sector entities responsible for development will help make sure that relevant information is available to teams that plan, design and manage infrastructure.

Raise awareness and build capacity for adopting northern infrastructure standards

During a validation session (Table 4) participants noted that more can be done to raise awareness of standards such as the Northern Infrastructure Standardization Initiative (NISI), and that more can be done to build capacity to implement these standards. Understanding the capacity and resources needed to implement northern infrastructure standards can help build resilience.

Build the capacity of key sectors to consider climate projections and impacts

In *Our Clean Future,* the Government of Yukon has committed to including new provisions in quartz mining licences by 2022 that will require critical mine infrastructure to be planned, designed and built to withstand the current and projected impacts of climate change. Guidance already exists, such as the Mining Association of Canada's *Guide on Climate Change Adaptation for the Mining Sector* (MAC 2021) and the NISI standards, and the Government of Yukon is working on climate change guidance that requires proponents to evaluate mining projects for climate-related risks. At the same time, work is needed to create standards and guidance to make sure that mine infrastructure is resilient to climate change, and to include appropriate provisions in regulatory instruments.

Conduct studies to understand how permafrost thaw will affect water quality

Permafrost contains substantial reservoirs of mercury and as it thaws it will likely increase the level of methylmercury in river basins (Schaefer et al. 2020). In addition, the release of previously frozen organic carbon leads to various water quality issues. Impacts to groundwater can affect drinking water quality and supply, and the health and availability of fish. Both these impacts can affect people, Community (Value 6), Culture and heritage (Value 4) and Food security (Value 2). Advancing the understanding of water quality throughout the territory, notably in regions with permafrost, is essential to understanding how water is affected and will continue to be affected by climate change. Currently, long-term water quality monitoring takes place at 13 locations in the territory. Such monitoring is recommended in additional locations to bolster regional understanding. Additionally, further region-specific studies are required to understand how permafrost thaw will affect drinking water supply, human health, fish populations and ecosystem health.

Table 15 summarizes the recommended actions to increase resilience for Priority 3.

Table 15 Summary of recommended actions, Priority 3: Permafrost thaw that affects communities, infrastructure and access

Impact no.	Significant impacts, Priority 3	Recommended actions to increase resilience
4	Permafrost thaw and ground subsidence damage buildings and infrastructure	• Ensure that permafrost data are available to those responsible for planning, developing and upgrading infrastructure; continue to support research efforts that characterize permafrost • Raise awareness and build capacity for adopting northern infrastructure standards • Build the capacity of key sectors to consider climate projections and impacts • Ensure that the mining sector is planning for and reducing risks to its infrastructure stemming from permafrost thaw
8	Permafrost thaw alters landforms and ecology	
9	Permafrost thaw causes critical infrastructure failures	

Priority 4 Changing climate conditions that affect land, water, animals and plants

RISK AND ACTION ANALYSIS: PRIORITY 4

Yukoners have a close relationship to the land, water, plants and animals. For Yukon First Nations people and transboundary Indigenous peoples in particular, cultural identity is inseparable from the land. Throughout the assessment, participants emphasized that environmental health is closely linked to human health and well-being, and that climate change is affecting places and species that are important for Yukon communities, cultures, health and well-being, and food security.
See Box 12.

BOX 12 | CLIMATE CHANGE IMPACTS ON ECOSYSTEMS AND PEOPLE

A comprehensive review of the impacts of climate change on plants, fish, wildlife and biodiversity in the Yukon is beyond the scope of this report. However, past research, as well as participant input throughout the assessment provided many examples of climate change impacts to ecologically and culturally significant plants and animals. Examples of impacts include changes to river flows, water temperature, and water quality from warming air temperatures, as well as glacial melt and permafrost thaw that can affect fish habitat (Streicker 2016: 18). Yukon community members and scientists have already observed changes in salmon migration and populations, and in conditions around fishing sites (Streicker 2016). Although no predictions of the cumulative impacts of these changes are available, it is widely recognized that climate change impacts will put stress on fish (Streicker 2016).

A warming climate affects the spread of illness and parasites, such as biting flies, ticks and mosquitoes (Office of the CMOH 2020). Local and scientific observations document changes in the health and wellness of culturally significant species. For example, White River First Nation citizens have noticed white spots appearing on beavers and hair loss in moose (Guyot et al. 2006). Researchers have also found winter ticks, which can cause illness and death in animals such as elk, deer and moose (Environment Yukon 2013).

Scientific and local evidence show that impacts related to climate change — such as earlier spring thaws, changes in water, and warmer winters — have already affected animal and plant habitat, range and diversity (Streicker 2016). Changes in caribou migration patterns and populations have been observed (ibid.). Woodland and barren-ground caribou are expected to be affected by altered food sources, breeding grounds and migration routes (Furgal et al. 2008; Streicker 2016). People have noted a change in bird migratory patterns, an increase in eagles and beavers, and a decline of rabbits and caribou (Guyot et al. 2006).

On the North Slope, shoreline erosion has the potential to alter near-shore marine food sources. Access to the North Slope is critical for Inuvialuit and Gwich'in, who rely on the area for traditional food sources. Wildlife populations have altered their ranges due to shifts in habitat and Inuvialuit harvesters have had to adjust their harvest patterns. Travel is more uncertain and carries greater risk, particularly on the open ocean (Government of Yukon 2019). Researchers and communities are working to understand the magnitude of shoreline erosion and the resulting impacts on plants and animals, and the people who depend on them.

HOW THESE IMPACTS AFFECT THE RESILIENCE VALUES

Participants gave high scores to impacts related to environmental health across many resilience values:

Value 2: Food Security; Value 4: Culture and Heritage; and **Value 6: Community —** The health and availability of key plants and wildlife affects food security. Participants were concerned about the health and availability of key plants and wildlife, and about their ability to safely and consistently reach harvesting areas. Harvested food is especially important in more remote areas of the Yukon, where there is limited access into communities (one participant spoke of "one road in, one road out"), a higher dependence on local food sources or traditional foods, and/or fewer

grocery stores. Risks to hunting and trapping were noted by multiple participants, particularly for remote areas and for people who rely on subsistence hunting and depend on access to the land and river travel for livelihood and food security.

Climate impacts related to harvested foods are inherently tied to Value 4 (Culture and heritage) and Value 6 (Community). The traditional and cultural aspects of harvested foods are important for building a sense of community and maintaining cultural identity. Sharing harvested food is important for maintaining a sense of community through reciprocity, stewardship and preparedness.

Value 8: Environmental health — Recent and significant disturbances to Yukon ecosystems, some of which are related to climate change, include invasive species, insect infestations, disease and loss of biodiversity (Streicker 2016). Participants were very concerned about impacts such as the spread of illness from insects and parasites in plants and animals, such as spruce bark beetle and winter ticks. These impacts can have cascading impacts; for example, a spruce bark beetle infestation can increase the fire hazard (Furgal and Prowse 2008).

Value 9: Health and well-being — The spread of illness and parasites in plants and animals could lead to the transmission of disease and other negative human health outcomes. Participants noted this as an important area for future research.

Table 16 summarizes the risk scores for the most significant impacts related to Priority 4.

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 4

Resilience is difficult to quantify for Priority 4, due to the complexity of the relationships between humans, plants and animals, the localized nature of some impacts, and the diversity of ecosystems and communities throughout the territory. Participants gave low to moderate action scores for impacts to environmental health, due to gaps in capacity with respect to monitoring changes to animals and plants, particularly during winter. Participants mentioned the vastness and diversity of Yukon ecosystems, which make monitoring and research challenging.

Participants noted the urgency of action — climate change is one of the biggest threats facing species in the Yukon, given the range of impacts already experienced. At the same time, gathering and analyzing the information needed to adapt (through data collection, monitoring and modeling) cannot always be done quickly enough to keep pace with the changes. In addition, the speed of change and the Yukon's mountainous terrain make it difficult to develop models. Participants emphasized the importance of identifying priority ecosystems and species in order to develop the most important adaptation measures first.

At the same time, examples of existing adaptation actions can be found in planning, monitoring programs, stewardship initiatives, land guardian programs, and traditional land-use mapping. These efforts are building capacity and increasing the ability to monitor changes and respond to them. Joint management initiatives among federal, territorial and Indigenous governments — and the implementation of Yukon First Nation, Inuvialuit, and Gwich'in Final Agreements — are identifying priorities for conservation, management and stewardship. The implementation of co-management and joint management agreements over lands and waters can build meaningful relationships, advance reconciliation, and build capacity to adapt to climate change impacts.

Table 16 Summary of risk scores for impacts related to Priority 4: Changing climate conditions that affect land, water, animals and plants

No.	Impact		Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
15		Changing winter conditions affect ecosystems and wildlife	INF 12	FS 15	EN 13	**High:** More likely than not to occur multiple times per decade; may occur annually	• Threats to wildlife and plant health and abundance • Changes to migration patterns • Stress to wildlife habitats (terrestrial and aquatic) • Threats to biodiversity • Food security concerns • Health and well-being impacts from reduced food security • Impacts to cultural and community values from reduced access to country food
			CH 13	AC 14	CM 14		
			LH 15	EH 17	HW 12		
20		Water temperatures rise in some rivers and lakes, disrupting ecosystems	INF 7	FS 13	EN 7	**Moderate:** More likely than not to occur once per decade; may occur multiple times per decade	
			CH 10	AC 7	CM 9		
			LH 12	EH 13	HW 10		
23		Changing climate affects composition, distribution and movement of plants and wildlife	Impact 23 did not receive enough responses for conclusive results. It may be worth assessing in a future climate risk assessment				
24		Changing climate conditions affect the health and availability of plants, wildlife and fish	INF 8	FS 19	EN 9	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 18	AC 10	CM 15		
			LH 17	EH 20	HW 14		
26		A warming climate worsens the spread of illness and parasites in plants and animals	INF 6	FS 14	EN 6	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 12	AC 6	CM 14		
			LH 12	EH 16	HW 16		

Legend:

The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods

Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high

Risk score

Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

The following actions provide a starting point for building resilience.

Identify the ecosystems and species at most risk from climate change impacts

Although many efforts have been made to understand and adapt to climate change impacts on specific ecosystems and species, the Government of Yukon has not yet identified a strategy to identify the ecosystems and species that face the highest risk from a changing climate. Models that predict the impacts of climate change on species, particularly species at risk, are still being developed.

Throughout the assessment, participants said that the Yukon ecosystems that likely face the greatest risks of climate change include those in coastal areas, low-elevation meadows, alpine areas, and rivers. They pointed to areas such as the eastern North Slope, which are culturally and ecologically significant and lack monitoring capacity, as warranting special attention.

Further work to identify next steps should be informed by Indigenous, local and scientific knowledge, and should build on past efforts by governments, communities, the private sector, and research and academic institutions. A range of resources can support this work, including tools such as Nature Serve's climate change vulnerability index (Nature Serve n.d.), community plans, past research, policy priorities and joint management and co-management plans. Another useful source is the 2018–19 review of information regarding food and climate change in the Yukon to inform climate change adaptation efforts, which highlights key species of plants, animals and fish (AICBR 2019).[16] Participants also noted that there are opportunities to learn from initiatives throughout the rest of Canada's north and in Alaska.

Increase monitoring capacity in order to forecast, assess and respond to changes

Monitoring changes to animals, plants, fungi and ecosystems can support planning for adaptation measures by providing information about the changes that are happening and how they will affect environmental health in the future. Although monitoring is carried out throughout the Yukon, it needs to increase given the pace of climate change impacts, and given the persisting gaps in information.

A sustained capacity to maintain and monitor changes, and to compile long-term datasets is needed. Additionally, given the vastness of the territory, more monitoring stations (such as weather stations and wildlife cameras) in remote areas can help fill gaps and increase understanding of variability from region to region and animals' responses to change. Currently, stations are located near communities, which means that changes in more remote areas have to estimated.

Scale up existing monitoring

These examples of monitoring, from across the territory, can be scaled up to fill information gaps on environmental health impacts from a changing climate.

Community-based monitoring: Indigenous-led projects to monitor climate and the environmental effects of climate change on communities and lands can support local adaptation planning. For example, Carcross/Tagish First Nation has partnered with Tsay Keh Dene Nation and a private company in British Columbia to build a community-led monitoring project that examines

16. This was produced by the Arctic Institute of Community-Based Research (AICBR) in collaboration with the Government of Yukon and other participants.

environmental data and Indigenous knowledge to create a holistic picture of how the climate is changing across their Traditional Territory. The project combines tracking of current and historical climate trends with knowledge shared by Elders while also providing opportunities for youth mentorship and climate change awareness.

Participants noted that given the data gaps in the Yukon, local knowledge and observations that go back generations provide an invaluable opportunity to understand climate change impacts to animals, plants and ecosystems.

> "**There is knowledge** about the effects on species and communities that have been observed for generations... If we know what questions to ask we may have a way of answering them unlike anywhere else because our traditions are still intact and we maintain a connection to the land.
>
> PROJECT PARTICIPANT

Land guardian programs: These programs can support and/or facilitate community-based monitoring and can help fill gaps in information and build capacity to adapt to changes to plants and animals. There are opportunities to learn from the work of groups such as the Kaska Dena Land Guardians. They work with the guidance of Elders to document invasive species, animal migration patterns, and conditions related to weather, water and snowpack. They are also working on a program to track the health of moose, sheep and caribou. They use this information to improve decision-making and collaboration with the Province of British Columbia to inform climate change adaptation.

Monitoring in parks and protected areas: Collaborative relationships are the basis for effective long-term monitoring to inform on climate change in parks and broader landscapes. For example, climate-focused monitoring at Herschel Island-Qikiqtaruk Territorial Park is based on collaborations between Yukon Parks, the Inuvialuit, regional co-management bodies, and national and international researchers. The Herschel Island-Qikiqtaruk ecological monitoring program, led by Yukon Parks, has tracked changes in wildlife, vegetation and landforms for more than 30 years, which has helped managers to look ahead and adapt when making management decisions for the park.

Build capacity for responding to invasive species

Participants noted that there are gaps in knowledge about invasive species.[17] Experts who work on environmental health noted that there are significant gaps in managing invasive species and their impacts on biodiversity.[18] This makes the Yukon vulnerable to invasive species, which can transmit disease and compete with native species. Additionally, due to the remoteness of much of the Yukon it is not easy to access many areas, and it may be difficult to know when invasive species arrive. Building capacity for prevention, early detection, rapid response and management is needed.

17. According to an assessment participant from Environment Yukon, "There remains very little expertise in this area. No one has been able to ascertain the cause [of] the loss of alder along the Yukon River in Whitehorse, as an example. There is little monitoring except for species known to impact harvested vertebrates."
18. Participants explained that in the Yukon, there is no single government department that has a mandate to manage or respond to impacts of biodiversity outside specific sectors or areas (such as parks). Plants, fungi and invertebrates are examples. The Department of Environment manages wildlife (vertebrate animals) and their habitat, which is harvest focused. Fungi and plants fall under the responsibility of the Department of Energy, Mines, and Resources, but they are considered in the context of forestry and agriculture. This leads to a gap in managing many invasive species and their effects on biodiversity more broadly.

Continue to expand the network of protected areas

Parks and protected area networks are recognized as one of the best tools to conserve wildlife and the ecosystems they rely on in the face of climate change. These areas can help buffer the impacts of extreme climate events, maintain provision of ecosystem goods and services, facilitate the adaptation of people and nature to new climate conditions, and contribute to climate change mitigation by storing carbon. They facilitate adaptation to climate change risks by maintaining or increasing ecosystem health, integrity and connectivity, and they can help facilitate the movement of species across the landscape as climate conditions shift. This can increase the climate change resilience of entire ecosystems, both inside and outside of protected areas. The Yukon's protected area network is not yet complete. For example, the *Parks and Land Certainty Act* commits the Government of Yukon to have one core protected park within each ecoregion. This has not yet been achieved.

In *Our Clean Future,* and the Yukon Parks Strategy (Government of Yukon 2020d), the Government of Yukon commits to continuing to incorporate climate change into the design of protected and managed areas using landscape conservation science, in order to allow native species to move, adapt and survive in the face of climate change. This includes working with well-established international standards for aspects such as protected area design, ecological buffers, climate change resilience and landscape connectivity. The Government of Yukon commits to continuing to expand the protected area network through regional land-use planning and other collaborative planning processes, and to draw on Indigenous, local and scientific ways of knowing.

Continue to build capacity to consider climate change impacts in parks, protected areas and managed areas

The impacts of climate change in parks, protected areas and other managed areas are important to consider during the management planning phase and during the implementation of these plans. However, capacity to incorporate climate projections in planning and conservation is still low. Participants who work for territorial, Indigenous or municipal governments said that their organizations or teams are often aware of the climate hazards involved, but are unsure how to interpret climate projections or assess the level of risk. Often, this expertise is held by private consulting companies. Training and support to interpret climate change projections, monitor site-specific changes, and adapt management and planning accordingly can help build adaptability and resilience.

Continue to manage parks and protected areas collaboratively with First Nations and Inuvialuit, as well as explore how the idea of Indigenous Protected and Conserved Areas may apply in the Yukon

Working together to identify and designated new protected areas and territorial parks is an important part of reconciliation. In addition to establishing new collaboratively managed protected areas under existing designations, such as territorial parks or habitat protection areas, the Government of Yukon should continue to explore how to implement Indigenous Protected and Conserved Areas (IPCAs). The Yukon Parks Strategy commits the Government of Yukon to engage in discussions with Indigenous partners to explore how the idea of IPCAs may apply in the Yukon.

Participants also noted that, in addition to continued implementation of established plans for parks and protected areas, collaborative management arrangements can help build resilience, as they

incorporate shared values, a range of knowledge systems and oversight among federal, territorial and Indigenous governments.

Explore how nature-based solutions may apply in the Yukon

According to the International Union for Conservation of Nature (IUCN), nature-based solutions are "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."[19]

Nature-based solutions range in size from small, localized approaches to buildings or infrastructure developments to regional approaches involving ecosystems. They include using ecological processes of vegetation, land and water as infrastructure, such as to prevent and mitigate floods, mitigate the effects of extreme heat or purify groundwater (CCME 2018).

Most of the Yukon's communities are small and are surrounded by wilderness areas that have experienced limited development and built infrastructure. Here, nature-based solutions are more likely to involve protecting, restoring and maintaining existing ecosystems and natural infrastructure that provide benefits to communities and ecosystems. Regional land-use planning is one of the methods that can be used to expand the protected area network and advance nature-based solutions for climate change adaptation, mitigation and resilience building.

Nature-based solutions, from the project-specific to the regional scale, will be important to consider as the Government of Yukon explores solutions to address the risks and priority areas identified through this risk assessment.

Table 17 summarizes the recommended actions to increase resilience for Priority 4.

Table 17 Summary of recommended actions, Priority 4: Changing climate conditions that affect land, water, animals and plants

Impact no.	Significant impacts, Priority 4	Recommended actions to increase resilience
15	Changing winter conditions affect ecosystems and wildlife	• Identify the ecosystems and species at most risk from climate change impacts • Increase monitoring capacity in order to forecast, assess and respond to changes • Build capacity for responding to invasive species • Continue to expand the network of protected areas • Continue to build capacity to consider climate change impacts in parks, protected areas and managed areas • Continue to manage parks and protected areas collaboratively with First Nations and Inuvialuit, and explore how the idea of Indigenous Protected and Conserved Areas may apply in the Yukon • Explore how nature-based solutions may apply in the Yukon
20	Water temperatures rise in some rivers and lakes, disrupting ecosystems	
23	Changing climate affects composition, distribution and movement of plants and wildlife	
24	Changing climate conditions affect the health and availability of plants, wildlife and fish	
26	A warming climate worsens the spread of illness and parasites in plants and animals	

19. https://www.iucn.org/theme/nature-based-solutions/about

Priority 5 Changing conditions on the land that pose risks to safety, access, culture and heritage, and livelihoods

RISK AND ACTION ANALYSIS: PRIORITY 5

Climate change impacts pose risks for Yukoners, Yukon First Nations and transboundary Indigenous peoples who use important places on the land and water for food security, livelihoods, cultural and traditional activities, and recreation.

Participants gave some of the highest scores to changing snow and ice cover (Impact 16), which create unsafe or unreliable conditions for access to the land, and for traveling on rivers and lakes. This scored among the top impacts for almost every one of the nine resilience values. Throughout the assessment process, many participants noted that changing conditions on rivers and lakes create safety risks for winter travel. In discussions with project participants, they also noted that in some cases, rivers and lakes are no longer freezing over, which prevents travel on the ice. Hunting and fishing seasons are reduced when there is a shorter period for travel on ice and permafrost, and when access to the land may be hazardous. Changes to snow and ice cover can also affect the ability of animals such as moose and elk to travel and avoid predators (Sheedy 2018).

Risks to safety also stem from the increasing variability in the timing of freeze-up and break-up. Later freeze-up or earlier break-up make it difficult to plan for river and creek crossings. Changes to freeze-up and break-up timing can also have implications for the formation of ice jams, as a variety

of complex processes influence their formation, duration and severity. In locations where ice jams result in high water levels and associated flooding, changes to the hydro-climatic drivers of ice break-up will reduce the ability of models to forecast the timing and severity of break-up. In addition, freeze-thaw cycles in winter months are projected to become more frequent.[20] This can lead to an increase in midwinter break-up events (Newton et al. 2017). Participants scored Impact 17 (the timing of ice freeze-up and break-up) as one of the most significant for the Access value.

Community-based research across the Yukon highlights cases where these effects are especially pronounced. In Beaver Creek, community members have noted that the river no longer freezes over, leaving them with no ice to travel on (Guyot et al. 2006). In the Kluane area, community research noted that many fishing spots are no longer safely accessible due to the changing environment and thin ice (KFN and AICBR 2016). Citizens of White River First Nation have noted that changes in creeks and rivers affect their access to cabins and to hunting and fishing sites.

> “**We've had people** in the river and we've had to mobilize. I've lived this scenario. When somebody is lost, somebody is in the river, somebody is in trouble — the town stops. It's people with boats. It's other search people in town. You'd think that would be the people with the boats, in the Ski-doos and the people who can go out on the land, but... it's also the sandwiches that need to be made. The beds that need to be made. The hospitality that has to take place for the people that are coming into town to help you.
>
> PROJECT PARTICIPANT FROM MAYO

Experts in search and rescue, backcountry safety and Indigenous knowledge holders explained that even people who have experience traveling in the backcountry will find conditions difficult due to their increasing unpredictability. Established routes through remote areas, known to be safe for decades, may be hazardous due to changing climate conditions. Wildland fires also create challenges for access to backcountry areas; they can reduce air quality, pose health and safety risks, and prevent access to the land.

In addition, search-and-rescue operators are seeing new types of backcountry users, with visitors and tourists eager to experience the land for harvesting or recreational use. Participants in the scenario discussion on challenges on the land (Appendix 4) said that in some cases, backcountry users may not be experienced on the land, or may not have the time or equipment needed to appropriately deal with the increasing unpredictability and extreme weather events. For example, in Kluane National Park and Reserve, the past few years have seen a record number of accidents related to creek crossings and high water levels. This has affected both experienced and inexperienced travelers.

HOW THESE IMPACTS RELATE TO THE RESILIENCE VALUES

Value 2: Food security — Participants, including subject-matter experts, highlighted that safe access to the land and water is a critical part of food security. They gave high scores to the impacts related to safe and reliable access to harvesting areas. Vulnerability to these impacts increases in the northern part of the territory. Participants noted that, generally, going north there is increasing

20. As outlined in Appendix 5, ensemble projections were produced using data provided by IPCC, PCMDI, WRCP and CMIP Phase 5 AR5 (accessed from CRI 2019).

distance from regional hubs (including Whitehorse) and increasing dependence on the land for food. In more remote areas of the Yukon, there is limited access, greater dependence on local food sources or traditional foods, and/or fewer grocery stores. Risks to hunting and trapping were noted by multiple participants, particularly for remote areas and people who rely on subsistence hunting and depend on access to the land and river travel for livelihood and food security.

Lack of access amplifies other issues related to food insecurity, particularly for people who are already food insecure. Participants said that access to foods harvested from the land and water is at risk from changes to land conditions, and to changes in wildlife health and migration patterns (Sheedy 2018). Especially in remote areas, store-bought food can be expensive, with poor quality and selection (AICBR n.d.). Participants in the validation session on food security (Table 4) said that access to the land can also be restricted because of the costs of the equipment and fuel needed to reach remote areas. Getting out on the land may also require taking time off wage work, which may not be possible for some families. Participants indicated that the changing affordability of foods could have significant potential consequences for food security, particularly for people who earn a low wage.

Value 4: Culture and Heritage — Participants gave some of the highest scores to Impact 16 (changes to snow and ice cover) for this value. Participants in the validation sessions (Table 4) said that heritage sites, including historical buildings and structures, natural heritage sites, and traditional and cultural sites, are affected by a wide range of climate and landscape changes, including changing snow patterns and higher snow loads, increasing freeze-thaw cycles, thawing permafrost, coastal erosion, damage from floods and wildfires, and the cumulative impacts of tourism activities and ecosystem-level changes (see Osipova et al. 2020; Streicker 2016; WMAC 2021). For example, in some cases the roofs of smokehouses, fishing and hunting camp structures and family cabins are caving in from increased snow loads. Traditional camps along riverbanks and lakeshores and on the North Slope are at risk from flooding, storm surges and erosion. The loss of cultural heritage sites can affect peoples' sense of belonging, and their ability to carry out traditional, ceremonial and spiritual practices.

Value 5: Access — This value, along with Infrastructure, had the most number of impacts with high scores. Participants felt that the most significant impacts affected access to important places on the land and access to goods and services through the Yukon's transportation infrastructure.

Value 7: Livelihoods — The variability of conditions on the land, as well as extreme weather conditions, limit the ability of tourism operators to safely conduct land- and water-based activities such as boat trips, guided hikes and hunts, fishing and canoe trips, especially in backcountry areas where access to emergency services is limited. Access to traplines and hunting sites may also be affected.

Table 18 summarizes the risk scores for the most significant impacts related to Priority 5.

Table 18 Summary of risk scores for impacts related to Priority 5: Changing conditions on the land that pose risks to safety, access, culture and heritage, and livelihoods

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
1		Wildfire smoke is transported long distances, affecting local and regional air quality	INF 15	FS 16	EN 15	**High:** More likely than not to occur multiple times per decade; may occur annually	• Health and safety risks when traveling on the land • Difficulty accessing cultural and heritage sites • Damage to historic buildings and structures, natural heritage sites, and traditional and cultural sites; for example, traditional camps along river-banks and lakeshores at risk from flooding or erosion • Damage to community gathering places, such as fishing and hunting camps, cultural sites and harvest sites, for example, roofs of smokehouses, fishing and hunting camp structures, and family cabins caving in from high snow loads • Food insecurity, particularly in remote communities • Reduced access for businesses operating in remote areas • Increased pressure on communities for search and rescue • Negative impacts to cultural values, health and well-being, and community values
			CH 16	AC 16	CM 15		
			LH 16	EH 17	HW 17		
7		Permafrost thaw destabilizes soil conditions	INF 18	FS 12	EN 10	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 10	AC 16	CM 12		
			LH 10	EH 10	HW 8		
10		Storm surges, shoreline erosion and decreasing near-shore ice alter the Yukon North Slope	INF 12	FS 10	EN 7	**Moderate:** More likely than not to occur once per decade; may occur multiple times per decade	
			CH 13	AC 12	CM 12		
			LH 10	EH 12	HW 10		
16		Changes to snow and ice cover create unsafe or unreliable conditions that reduce access to the land	INF 21	FS 21	EN 16	**Very high:** Likely annual, ongoing occurrences	
			CH 19	AC 23	CM 19		
			LH 20	EH 21	HW 20		
17		The timing of ice break-up on waterways changes, including earlier spring break-up	INF 14	FS 14	EN 11	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 14	AC 17	CM 14		
			LH 13	EH 11	HW 13		
28		The health and safety of people on the land are at risk from variable, uncertain and extreme weather	INF 12	FS 14	EN 12	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 15	AC 12	CM 15		
			LH 16	EH 13	HW 14		

Legend:

The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods

Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high

Risk score

Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 5

The level of resilience to risks related to safety on the land is uncertain, and likely varies across the Yukon. While some people have adapted to changing climate and weather by changing when, where and what they hunt, fish or gather, others are finding it harder to adapt (Sheedy 2018). The ability to predict and adapt to these conditions is vital in order to increase resilience. The irregularity of weather patterns due to climate change may compromise the capacity of Elders and knowledge holders to predict conditions (ibid.).

Furthermore, participants noted that most of the people involved in search-and-rescue operations are older, and that there is a shortage of new rangers to fill these positions. Including youth in training and activities for rangers, search-and-rescue, monitoring, and land-based activities is a way to build local resilience to changing conditions on the land.

> “ **The rangers themselves** got stuck out there. In really deep snow. And then when the rangers are stuck — who goes out and gets them?
>
> PROJECT PARTICIPANT

Action scores for capacity related to Priority 5 varied, partly due to participants' uncertainty about what they can do to reduce risk. Participants gave low scores to actions related to planning and preparedness, working together, and capacity. At the scenario session on safety on the land search-and-rescue experts noted that the increasingly variable conditions make it less easy to predict where and when people will go missing or need help out on the land. See Appendix 4 for more information about scenarios. At the same time, some communities are starting to monitor changing conditions on the land, and to share information with local hunters and trappers and community members.

> “ **We are working on** training our staff in ice travel so that we can do it safely, especially in the context of climate change. We also work with the local trappers to share information on ice changes.
>
> PROJECT PARTICIPANT, WHITE RIVER FIRST NATION

Clarify roles and capacity to address risks related to access

Current efforts to address risks related to safe access to the land are fragmented. The Government of Yukon and Government of Canada provide search-and-rescue services for parks and protected areas. Communities provide assistance in local areas, and the RCMP responds to incidents on Crown land. Furthermore, some communities have started to develop projects that monitor and share information about changing conditions. Participants explained that capacity varies across communities, and that efforts can be strengthened by support for predicting and responding to safety concerns. This is an area where collaboration between neighbouring jurisdictions can build resilience as well. Clarifying the roles and capacity to manage risks related to access can start with discussions between federal, territorial and Indigenous governments, the RCMP, parks agencies and rangers and first responders. These discussions should bring together diverse ways of knowing.

These are some actions that governments and others can take:

- provide support to monitor and communicate information on snowpack, weather, and river flows and levels;
- provide the equipment required to travel safely in the backcountry;
- provide supports (such as funding, equipment) for people who are unable to afford safe access to backcountry areas; and
- explore options for formal agreements between governments, especially First Nations, trans-boundary Indigenous groups, and municipal governments, to provide back-up, training and planning for emergency response and search and rescue.

Explore ways to support food security for harvested foods

Options should consider various peoples' access to harvested foods. Examples of ways to support food security include food preservation and storage (such as root cellars and community freezers), hunter support programs and subsidies, culture camps, and camps for training and knowledge transmission for small and big game. Some groups and communities are developing food security strategies to increase access to harvested foods. For example, Teslin Tlingit Council is working on a comprehensive food security strategy, which considers wildlife management as part of the plan.

Continue to build resilience to climate change impacts on the North Slope

Participants gave the lowest action scores to risks that affect the Yukon North Slope. A participant from the Wildlife Management Advisory Council (North Slope) noted during the scoring process that areas such as this, which have co-management arrangements, provide an opportunity for regional collaboration between territorial governments and others on both sides of the Yukon/NWT border, and also noted that if the Indigenous Protected and Conserved Area is implemented for Aullaviat/Aunguniarvik in Inuvialuktun (eastern Yukon North Slope), it will support adaptation to the increased risks related to changes in climate.

Document and protect heritage sites to adapt to a changing climate

Many heritage sites are located within parks and protected areas that are affected by changing conditions on the land. The Kluane/Wrangell-St. Elias/Glacier Bay/Tatshenshini-Alsek system of parks is a UNESCO World Heritage Site. Ivvavik National Park, Vuntut National Park, Herschel Island-Qikiqtaruk Territorial Park, Tr'ondëk-Klondike, and the Yukon Ice Patches are on UNESCO's tentative list of World Heritage sites. All sites are at risk of climate change impacts. Other Yukon parks and protected areas also contain important heritage sites.

In *Our Clean Future,* the Government of Yukon commits to documenting information from historic sites and culturally important places on the North Slope that are at risk due to climate change. Participants stated that projects to record such heritage sites are necessary in order to preserve the memory of these places if the physical sites are lost.

Members of the heritage community who participated in the assessment were aware of climate change impacts to heritage sites, but had insufficient planning capacity and funding to take substantive action. In general, participants gave capacity the lowest action scores for impacts to heritage sites, which suggests that more skills and resources (financial and human) are needed. Participants noted that methods such as remote sensing can allow for safe monitoring in areas that will be adversely affected by changing environmental conditions. Participants gave the highest action score to knowledge — creating knowledge and bringing together different ways of knowing to understand and respond to risks.

Continue to develop community-based monitoring and safety programming

Partnerships between communities and governments can support local harvest and monitoring initiatives. For example, Ta'an Kwäch'än Council is supporting access and knowledge by bringing in Canadian-origin Chinook salmon fry to Fox Creek, and partnering with Fisheries and Oceans Canada to build fishing nets for families.

Partnerships with businesses can also support local harvest and monitoring initiatives. SmartICE, a private company based in Labrador and Newfoundland, recently began a four-year project with Kluane First Nation to initiate and evaluate both community-based ice monitoring and Indigenous knowledge-based travel safety communication to reduce travel risk on Lù'àn Män (Kluane Lake).

Table 19 summarizes the recommended actions to increase resilience for Priority 5.

Table 19 Summary of recommended actions, Priority 5: Changing conditions on the land that pose risks to safety, access, culture and heritage, and livelihoods

Impact no.	Significant impacts, Priority 5	Recommended actions to increase resilience
1	Wildfire smoke is transported long distances, affecting local and regional air quality	• Clarify roles and capacity to address risks related to safe access to the land • Support food security for harvested foods. Examples include food preservation and storage (e.g., root cellars, community freezers), hunter support programs and subsidies, culture camps, and camps for training and knowledge transmission for small and big game for family members, youth, and middle generations • Continue to build resilience to climate change impacts on the North Slope • Document and protect heritage sites to adapt to a changing climate • Continue to develop community-based monitoring and safety programming
7	Permafrost thaw destabilizes soil conditions	
10	Storm surges, shoreline erosion and decreasing near-shore ice alter the Yukon North Slope	
16	Changes to snow and ice cover create unsafe or unreliable conditions that reduce access to the land	
17	The timing of ice break-up on waterways changes, including earlier spring break-up	
28	The health and safety of people on the land are at risk from variable, uncertain and extreme weather	

Priority 6 Multiple climate change impacts that affect health and well-being

> ***It's important to think of mental health as a cultural practice rather than [only] something offered through a clinical setting. This can help reduce the stigma around mental health... from mental health equating to 'I'm going to get counselling,' to partaking in community and normalizing our anxiety around environmental change.***
>
> PROJECT PARTICIPANT, CANADIAN MENTAL HEALTH ASSOCIATION — YUKON DIVISION

RISK AND ACTION ANALYSIS: PRIORITY 6

Human health and well-being are linked to environmental health, and climate change is affecting places and species that are important for Yukon communities, cultures, health and well-being, and food security. Health risks stem from increased risk of fires, floods and other extreme weather events.

Special attention needs to be paid to mental health risks. Mental health effects are associated with a range of climate impacts, and include an increasing sense of uncertainty, fear and anxiety (Office of the CMOH 2020; Middleton et al. 2020). Changes to the landscape that people rely on can also lead to a loss of identity and cultural connection and to reduced self-sufficiency (Middleton et al. 2020). Participants said that increasing mental health concerns associated with climate change were among the most significant impacts for Value 4 (Culture and heritage) and Value 6 (Community). In addition, stress is often worsened by a sense of isolation. Participants noted that when physical access to places, goods and services is affected, phone and online communications become especially important.

Remote First Nations such as Vuntut Gwitchin First Nation and Kluane First Nation have already witnessed sudden and dramatic changes, such as the catastrophic lake drainage in Old Crow Flats/Van Tat, and the "river piracy" that diverted flow from the Slims River (Shugar et al. 2017). These changes are expected to increase.

Mental health concerns can also arise from impacts to community infrastructure, food security, environmental health, and access. For example, when the Ross River School closed because of unsafe conditions due to permafrost thaw, it affected the community's ability to gather, carry out ceremonies, stay active, and bring together Elders and youth. Participants explained that communities such as Mayo, Old Crow and Lower Post are seeing that damage related to flooding, permafrost thaw or wildfires is also affecting local buildings that people rely on for gatherings and ceremonies.

Project participants often spoke about the past and present-day burdens of colonialism. This includes the legacy of forced relocation, the 1918 flu epidemic, Klondike Gold Rush, World War II, construction of the Alaska Highway, the removal of children from their family and culture to attend residential school, and the impacts on traditional languages and practices. Families have experienced loss of childhood, culture and family as well as loss of skills, experience and comfort accessing the land. This history cannot be separated from the consideration of climate change impacts felt in communities today.

HOW THESE IMPACTS AFFECT THE RESILIENCE VALUES

Participants scored Impact 38 (mental health concerns) highest for Value 6 (Community), Value 9 (Health and well-being), and Value 4 (Culture and Heritage), indicating that mental health risks are most significant for those values.

Value 8: Environmental health — Extreme weather events, permafrost thaw, and changes to the health and availability of key species that Yukoners depend on affect environmental health. Communities' health and well-being are affected when people are unable to harvest animals that are important to their diet and culture. For example, Yukon First Nations have been issuing voluntary fishing closures and have noted the impacts on their citizens' well-being.[21]

Value 9: Health and well-being — Participants gave the highest scores for this value to increasing mental health concerns associated with climate change, especially with changes to snow and ice cover that lead to unreliable access to the land.

> "I liken it to homesickness for the home you used to know; it's not quite the way it used to be.
>
> PROJECT PARTICIPANT

Although the action scores for this priority indicate that Yukoners have some confidence in their ability to manage these risks, the scores also reveal a lack of capacity and ability to work together to address the challenge.

Table 20 summarizes the risk scores for the most significant impacts related to Priority 6.

21. See, for example, https://www.yukon-news.com/news/trondk-hwchin-issues-voluntary-closure-on-fall-chum-fishing/.

Table 20 Summary of risk scores for impacts related to Priority 6: Multiple climate change impacts that affect health and well-being

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
16		Changes to snow and ice cover create unsafe or unreliable conditions that reduce access to the land	INF 21	FS 21	EN 16	**Very high:** Likely annual, ongoing occurrences	• Decline in mental health and well-being • Climate-change-related grief and loss • Health impacts from changes to environmental health • Community isolation • Impacts to culture, community gatherings, ability to share knowledge, bring together Elders and youth
			CH 19	AC 23	CM 19		
			LH 20	EH 21	HW 20		
24		Changing climate conditions affect the health and availability of plants, wildlife and fish	INF 8	FS 19	EN 9	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH 18	AC 10	CM 15		
			LH 17	EH 20	HW 14		
38		Mental health concerns associated with climate change increase	INF 11	FS 15	EN 11	**Very high:** Likely annual, ongoing occurrences	
			CH 19	AC 14	CM 20		
			LH 19	EH 13	HW 22		

Legend:

The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods

Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high

Risk score

Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 6

Support for health and social programs and services, with a focus on land-based activities

Throughout discussions with health experts and community representatives, participants noted that building capacity for culturally appropriate mental health measures is a priority. This includes, for example, ensuring that alternatives exist for community members in remote communities who may not benefit from phone counselling sessions.

Participants gave examples of how Indigenous values and knowledge can provide guidance in addressing mental health challenges. For example, as noted by a participant from the Canadian Mental Health Association, forming relationships and reciprocity between mental health service providers and community members can contribute to ongoing support. This can include inviting counselors to community discussions, sharing circles and events that help develop ongoing relationships. Participants suggested that thinking of mental health services alongside cultural practices can help normalize mental health challenges and support solutions.

> “ **We need more support** for mental health and organizations that support, protect and empower Indigenous women and people who are vulnerable. People who are struggling. The LGBQ community. My mom and my grandma are residential school survivors. It’s so hard, trying to walk in a path of light... It would help if there could be places for people to go to feel safe if they need it. Resilience is community and people. And holding each other up and supporting them. That means holding them up through their addictions and their personal problems. The mental health crisis is not a joke. I’d like to see more action about that.
>
> YUKON FIRST NATIONS CLIMATE ACTION FELLOW

Implement recommendations from related efforts to address mental health and wellness

Participants pointed out that implementing the recommendations of strategies such as the Government of Yukon’s *Putting People First,* a comprehensive review of the Yukon’s health and social programs and services, (Government of Yukon 2020c) could also address some of the underlying health challenges that put people at higher risk. Relevant recommendations include on-the-land mental health and substance treatment supports and providing land-based healing in communities.

Address environmental anxiety through arts and culture

Art and cultural expression can help people address anxiety and/or grief related to environmental change. Talking about Yukoners’ lived experience with environmental change and reduced access to the land can help reduce the stigma associated with mental health issues. Participants gave examples from the Yukon’s cultural community, including the Available Light Film Festival, which showcases movies that explore themes such as environmental change. Holistic, culturally informed mental health support can also be offered on the land and in the form of eco-art or traditional healing practices, to provide direct connection with natural environments.

Table 21 summarizes the recommended actions to increase resilience for Priority 6.

Table 21 Summary of recommended actions, Priority 6: Multiple climate change impacts that affect health and well-being

Impact no.	Significant impacts, Priority 6	Recommended actions to increase resilience
16	Changes to snow and ice cover create unsafe or unreliable conditions that reduce access to the land	• Support health and social programs and services, with a focus on land-based activities • Provide culturally appropriate mental health measures; for example, those that promote forming relationships and reciprocity between healthcare providers and community members • Implement recommendations from strategies focused on health and well-being, such as Putting People First. • Create opportunities for people to cope with environmental anxiety through arts and culture
24	Changing climate conditions affect the health and availability of plants, wildlife and fish	
38	Mental health concerns associated with climate change increase	

Priority 7 Risks to the Yukon's economy

RISK AND ACTION ANALYSIS: PRIORITY 7

The assessment did not complete a comprehensive analysis of climate change impacts on the Yukon's economy. However, this section summarizes scores and input received when reviewing risks that affect Value 7 (Livelihoods) and Value 3 (Energy). This section presents a starting point for further consideration of the breadth of economic impacts that may arise due to climate change. It presents the impacts linked to the following key sectors, as well as options for building resilience, as identified through risk scoring and discussions with project participants:

- agriculture;
- energy;
- mining; and
- tourism.

There is a need to enhance understanding of how climate change will affect Yukon businesses, and to a greater extent, how it will affect the Yukon's economy as a whole. This includes identifying potential risks and emerging economic opportunities. These topics need further consideration, especially in the context of COVID-19 economic hardships and recovery.

AGRICULTURE SECTOR

Climate projections show that in the Yukon, average annual yields for agriculture are expected to increase due to warmer temperatures and longer growing seasons (Streicker 2016). Although this

may increase food security by reducing the Yukon's reliance on southern imports, experts on food security told the project team that local food production would need to be scaled up extensively to take advantage of climate-related opportunities. This would include securing a labour force, land, storage facilities and economic support.

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 7: AGRICULTURE SECTOR

Potential actions are outlined in the 2020 Yukon Agriculture Policy, the City of Whitehorse 2020 Local Food and Urban Agriculture Study (City of Whitehorse n.d.), and First Nation-led projects such as Kluane First Nation's food security strategy (KFN 2014).

In *Our Clean Future,* the Government of Yukon commits to providing access to funding for agricultural producers to adapt to the impacts of climate change, adopt low-carbon practices and use surface water and groundwater efficiently. This will help local farmers take advantage of the opportunities associated with a changing climate, and will support local employment and food production. The Government of Yukon is also continuing to fund research on how climate change could affect local agriculture and how agricultural producers can adapt to climate change, and to fund community gardens and greenhouses, especially in rural communities. Understanding priority areas for directing investments to improve the local food sector can also help build resilience.

ENERGY SECTOR

Close to 93 percent of the Yukon's electricity comes from hydroelectric generation and one wind turbine (Energy Branch 2018). The Yukon Energy Corporation (YEC) is the main generator and transmitter of electricity for the territory. In the Yukon, climate change impacts pose risks for hydroelectricity transmission and storage. In 2012, YEC worked with the Northern Climate ExChange to project the impacts of climate change on hydroelectricity generation. This research found that the Yukon's generation of hydropower was not expected to be negatively impacted by climate change (NCE 2012). This is because anticipated increases in temperatures and precipitation will generally lead to increased water flow from early spring to late fall, which will enable YEC to generate more electricity for a longer period (NCE 2012).

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 7: ENERGY SECTOR

YEC is currently evaluating the potential for climate change impacts to pose risks to the transmission of energy, such as damage to power lines from forest fires or permafrost thaw. YEC is considering this information as part of ongoing operations and maintenance.

YEC has formally incorporated climate change predictions into its hydrological modelling for short-, medium- and long-term planning. This includes evaluating how changing water flow timing and water levels and increased river flows could affect hydro generation at the Whitehorse, Aishihik and Mayo dams. This information will be used in dam classification (per the Canadian Dam Association) and will inform adaptation planning. YEC is working on a climate change adaptation plan that identifies risks and appropriate responses to make sure that the territory's main electrical grid is resilient to the impacts of climate change. Completing these actions in a timely manner will help build resilience.

Impacts related to heating

Climate change also poses a risk to heating in the Yukon. The territory relies heavily on imported fossil fuels for residential and commercial heating needs and is dependent on its road network for a reliable supply. Changes in extreme weather events, flooding or wildfires can have a negative effect on fuel availability and prices. Heat during Yukon's subarctic winters is a necessity for all Yukoners. There is an opportunity to develop a local renewable heat energy market that can reduce the Yukon's reliance on fossil fuels, lower greenhouse gas emissions, and improve the territory's energy security.

MINING SECTOR

The mining sector employs a significant number of Yukoners,[22] and often requires access to remote areas, where snow and ice cover and other climate impacts can affect the ability to travel to and from work sites, store equipment, excavate and extract materials. Impacts such as changing conditions on rivers and lakes, extreme weather, and fires pose risks for safe access to and from work sites. According to the Water Resources Branch, changes in precipitation regimes can also cause erroneous predictions of water quantity and water quality during the planning and operation of mines, and result in inadequate management of contaminated water. Additionally, permafrost thaw and extreme precipitation can pose hazards for critical mining infrastructure. This can lead to environmental impacts in surrounding ecosystems and can affect communities.

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 7: MINING SECTOR

The assessment found that more can be done to build the resilience of the mining sector. The Government of Yukon is working on including climate change impacts in licensing requirements for new quartz mines by 2022. Ensuring that the companies operating in the Yukon have the capacity to consider climate change impacts and to adjust operations can help build resilience. This can include cataloguing existing infrastructure at risk due to permafrost thaw, estimating costs associated with potential climate impacts, and assessing risks for mines located on permafrost.

Guidance already exists, such as the Mining Association of Canada's *Guide on Climate Change Adaptation for the Mining Sector* (MAC 2021) and the Northern Infrastructure Standardization Initiative (NISI) standards, but it is not clear to what extent mines operating in the Yukon have been able to implement this information. Currently, there are no requirements for the mining sector to adopt building standards that take into account permafrost thaw.

TOURISM SECTOR

> "**Even in Haines Junction** in the past twenty years, we're seeing a different demographic. A newer demographic of folks who are eager to get out on the land to experience it either for harvesting purposes or for recreational enjoyment. The skiers, the paddlers, the hikers and the climbers, the mountaineers.
>
> PROJECT PARTICIPANT, KLUANE NATIONAL PARK AND RESERVE

22. The sector employed the highest proportion of casual/temporary employees (21.1%) in 2019. https://yukon.ca/sites/yukon.ca/files/ybs/2019_business_survey_report.pdf.

Tourism is a significant driver of the Yukon's economy[23] and all regions rely on it. Tourism also provides important employment opportunities for a diversity of people. These are some of the climate change impacts that are relevant for the tourism sector:

- Changes to snow and ice cover that create unsafe or unreliable conditions. These changes may have significant implications for tourism operators and their clients as well as unguided visitors and residents who rely on stable snow and ice conditions for activities such as dog mushing, snowmobiling, ice fishing, skiing and snowshoeing.
- Changes to water conditions on lakes and rivers may affect the ability of tourism operators, their clients, and unguided visitors and residents to safely engage in boating, hiking, hunting, fishing and other activities.
- Sudden changes to the weather can also pose a risk to visitors, and weather conditions are becoming increasingly difficult to predict.

> "**We're seeing those** extreme weather events where temperatures are not just changing by a few degrees in winter — you have these wild swings... Most of the impact that I'm seeing is based around water and temperatures that alter water from freezing to melting... That's tough to predict for someone on the land.
>
> PROJECT PARTICIPANT, KLUANE NATIONAL PARK AND RESERVE

RECOMMENDED ACTIONS TO INCREASE RESILIENCE, PRIORITY 7: TOURISM SECTOR

These impacts are important to consider in the context of a growing tourism sector. The Yukon Tourism Development Strategy (Government of Yukon n.d.) aims to double tourism revenue from 2016 levels by 2028, as part of its recovery efforts from the COVID-19 crisis. Additionally, Parks Yukon expects backcountry use to be a significant growth area for the territory's parks system over the next decade. This includes the use of parks outside of the traditional summer season, which has been a growing trend. Campground use is growing steadily at about 12 per cent annually (Government of Yukon 2020d).

To address changing snow, ice, water and weather conditions, participants recommended the following actions:

- support tourism operators, their clients, and unguided visitors and residents with better access to key information on snowpack, weather conditions, and flows and water levels in rivers and lakes;
- develop decision-making tools for tourism operators, their clients, and unguided visitors and residents to help them make good decisions with respect to safety in the backcountry;
- make sure that emergency response planning for situations such as fires and floods accounts for visitors;
- support tourism operators by gathering more information on the implications of climate change on insurance policies; and
- help offset the cost of safety equipment required by tourism operators to safely take clients into the backcountry.

23. https://yukon.ca/en/find-tourism-and-visitor-statistics-and-reports#economic-impact-of-tourism-in-yukon.

Table 22 summarizes the risk scores for the most significant impacts related to Priority 7 (all sectors).

Table 22 Summary risk scores for impacts related to Priority 7: Risks to the Yukon's economy

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
Agriculture							
27		Longer growing seasons and warmer temperatures increase agricultural opportunities	INF 3	FS 3	EN 3	**Very low:** Not likely to occur in planning period	• Increased food security • Increased business opportunities *The assessment found that risks to local food production likely outweigh the possible opportunities associated with warmer temperatures*
			CH 3	AC 3	CM 4		
			LH 4	EH 4	HW 4		
Energy							
11		Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure	INF 20	FS 15	EN 17	**Very high:** Likely annual, ongoing occurrences	• Increased capacity for hydroelectricity generation • Possible damage to energy infrastructure
			CH 18	AC 16	CM 16		
			LH 14	EH 16	HW 14		

TABLE 22 (continued)

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
Mining							
7		Permafrost thaw destabilizes soil conditions	INF **18**	FS **12**	EN **10**	**High:** More likely than not to occur multiple times per decade; may occur annually	• Reduced access to work sites • Possible infrastructure failure and risks to surrounding ecosystems and communities
			CH **10**	AC **16**	CM **12**		
			LH **10**	EH **10**	HW **8**		
8		Permafrost thaw alters landforms and ecology	INF **11**	FS **10**	EN **9**	**Moderate:** More likely than not to occur once per decade; may occur multiple times	
			CH **13**	AC **11**	CM **11**		
			LH **11**	EH **11**	HW **10**		
9		Permafrost thaw causes critical infrastructure failures	INF **16**	FS **9**	EN **13**	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH **12**	AC **11**	CM **11**		
			LH **11**	EH **11**	HW **10**		
11		Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure	INF **20**	FS **15**	EN **17**	**Very high:** Likely annual, ongoing occurrences	
			CH **18**	AC **16**	CM **16**		
			LH **14**	EH **16**	HW **14**		
16		Changes to snow and ice cover create unsafe or unreliable conditions that reduce access	INF **21**	FS **21**	EN **16**	**Very high:** Likely annual, ongoing occurrences	
			CH **19**	AC **23**	CM **19**		
			LH **20**	EH **21**	HW **20**		
35		Extreme precipitation and flash flooding cause physical and chemical instability in mine sites	Impact 35 did not receive enough responses for conclusive results. It may be worth assessing in a future climate risk assessment				

TABLE 22 (continued)

Impact			Risk score (1–25) = Likelihood x Consequence			Likelihood based on a score from 1 (very low) to 5 (very high)	Consequences to values
Tourism							
1		Wildfire smoke is transported long distances, affecting local and regional air quality	INF **15**	FS **16**	EN **15**	**High:** More likely than not to occur multiple times per decade; may occur annually	• Safety risk and reduced access for tourism activities such as dog mushing, snowmobiling, hunting and fishing, boating, skiing and snowshoeing, and backcountry access
			CH **16**	AC **16**	CM **15**		
			LH **16**	EH **17**	HW **17**		
16		Changes to snow and ice cover create unsafe or unreliable conditions that reduce access	INF **21**	FS **21**	EN **16**	**Very high:** Likely annual, ongoing occurrences	
			CH **19**	AC **23**	CM **19**		
			LH **20**	EH **21**	HW **20**		
28		The health and safety of people on the land are at risk from variable, uncertain and extreme weather	INF **12**	FS **14**	EN **12**	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH **15**	AC **12**	CM **15**		
			LH **16**	EH **13**	HW **14**		
29		Flooding in communities is more frequent and severe	INF **16**	FS **14**	EN **14**	**High:** More likely than not to occur multiple times per decade; may occur annually	
			CH **14**	AC **15**	CM **14**		
			LH **12**	EH **12**	HW **13**		

Legend:

The nine values: AC = Access CH = Culture and heritage CM = Community EH = Environmental Health EN = Energy FS = Food security HW = Health and well-being INF = Infrastructure LH = livelihoods

Likelihood score: 1 = very low 2 = low 3 = moderate 4 = high 5 = very high

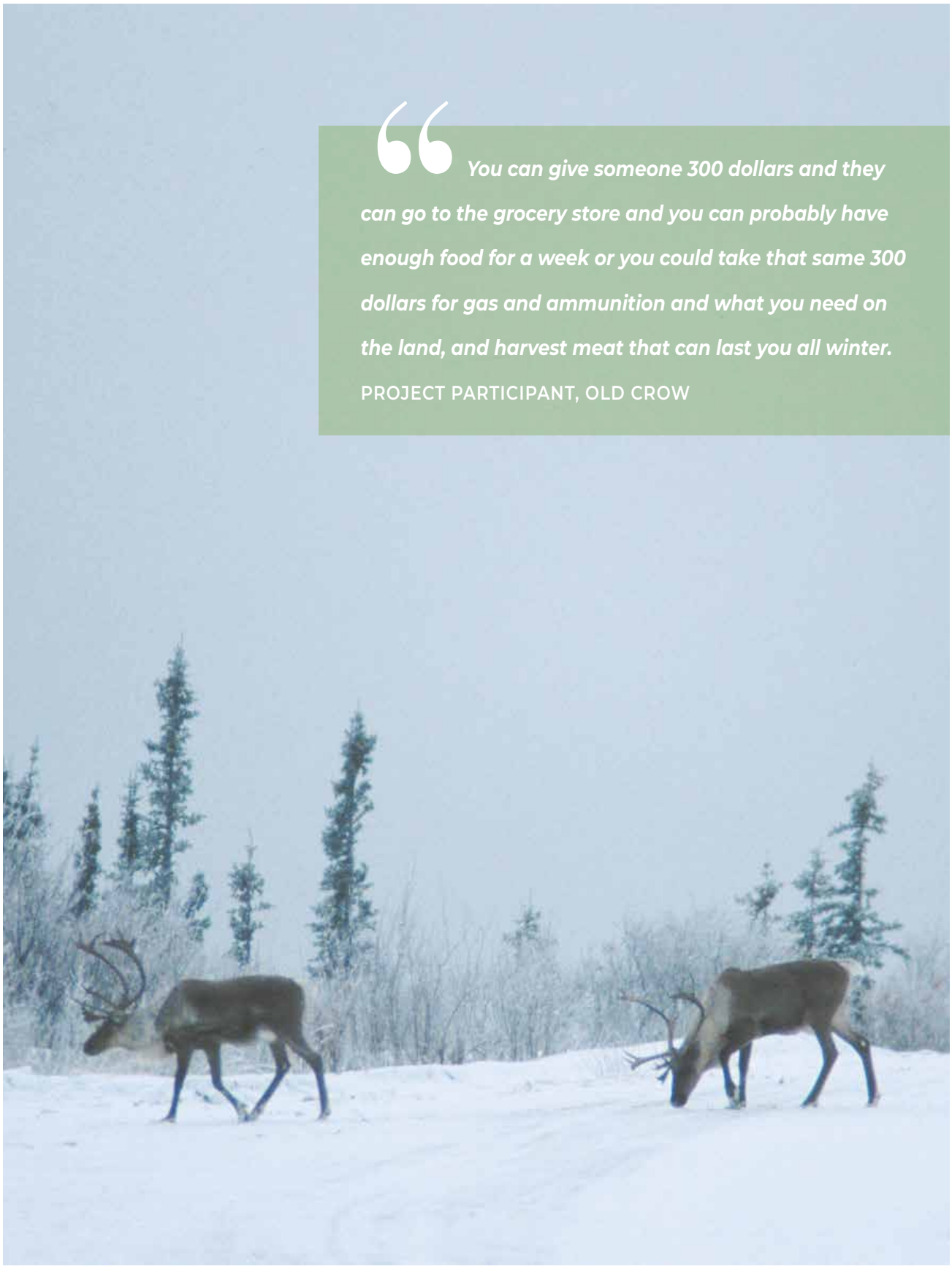
Risk score

Low 0–4 Low 5–8 Moderate 9–12 Moderate 13–15 High 16–20 High 21–25

Table 23 summarizes the recommended actions to increase resilience for Priority 7.

Table 23 Summary of recommended actions, Priority 7: : Risks to the Yukon's economy

Impact no.	Significant impacts, Priority 7	Recommended actions to increase resilience
Agriculture		
27	Longer growing seasons and warmertempera-tures increase agricultural opportunities	• Implement food strategies developed by Yukon governments, First Nations and municipalities
Energy		
11	Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure	• Continue to use climate projections into hydrological modeling and incorporate climate-related risks into adaptation planning
Mining		
7	Permafrost thaw destabilizes soil conditions	• Ensure that mining companies operating in the Yukon are considering climate change impacts and adjusting operations to reduce risks • Ensure that mining companies are adopting building standards and guidelines that take into account climate change hazards such as permafrost thaw, hydrological changes and extreme weather events.
8	Permafrost thaw alters landforms and ecology	
9	Permafrost thaw causes critical infrastructure failures	
11	Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure	
16	Changes to snow and ice cover create unsafe or unreliable conditions that reduce access	
35	Extreme precipitation and flash flooding cause physical and chemical instability in mine sites	
Tourism		
1	Wildfire smoke is transported long distances, affecting local and regional air quality	• Support tourism operators, their clients, and unguided visitors and residents with better access to key information on snowpack, weather conditions and flows and water levels in rivers and lakes • Develop decision-making tools for tourism operators, their clients, and unguided visitors and residents to help them make quality decisions with respect to safety in the back-country • Ensure that emergency response planning for situations such as fires and floods accounts for visitors • Support tourism operators by gathering more information on the implications of climate change on insurance policies • Help offset the cost of safety equipment required by tourism operators to safely take clients into the backcountry
16	Changes to snow and ice cover create unsafe or unreliable conditions that reduce access	
28	The health and safety of people on the land are at risk from variable, uncertain and extreme weather	
29	Flooding in communities is more frequent and severe	



> *You can give someone 300 dollars and they can go to the grocery store and you can probably have enough food for a week or you could take that same 300 dollars for gas and ammunition and what you need on the land, and harvest meat that can last you all winter.*
>
> PROJECT PARTICIPANT, OLD CROW

4 RECOMMENDATIONS

As outlined in Chapter 3, the assessment identified seven priorities for Yukon and a range of recommended actions that governments and communities can take to build resilience. In addition, the assessment identified the following overarching themes and goals for moving forward. These themes and goals provide the basis for how to implement the recommended actions outlined in Chapter 3. The Government of Yukon should consider how to incorporate these actions into its implementation of *Our Clean Future*.

Overarching themes:

- the interconnections of impacts and values — it is hard to separate impacts on one value from impacts on other values;
- the resilience that already exists in remote communities;
- the importance of remote communities working together; and
- the importance of including diverse ways of knowing.

Goals for building resilience:

- build long-term capacity to understand and plan for future climate conditions and work together;
- make sure that adaptation contributes to reconciliation;
- continue to consider community values in building climate resilience;
- create equal opportunities for people to adapt; and
- recognize and continue to support youth leadership in climate action.

Acting on these goals can help build resilience in many different risk areas. The assessment confirmed that climate change impacts are cross-cutting; it is hard to separate impacts on one value from impacts on other values. When the team members discussed risk scores related to fire, floods or permafrost thaw with participants, the discussions often covered multiple values. Impacts to infrastructure came up in almost every discussion, and impacts related to access, infrastructure, community, health and well-being and culture and heritage were also frequently discussed. The scores reinforced this: several impacts were cited for four or more values. This affirms the importance of breaking down barriers and increasing communication between the organizations that manage risk, and that building resilience in one area is likely to benefit many values.

BUILDING CAPACITY

CAPACITY TO ADAPT TO CLIMATE CHANGE IMPACTS AND WORK TOGETHER

Throughout the assessment, participants said that generally they were aware of and had knowledge about climate change impacts, but often lacked the financial resources, human capacity, or training to take action. This was confirmed in the scoring process, which showed higher action scores related to Expanding knowledge, and to Broadening education and knowledge sharing, and lower action scores for Planning and preparing, and for Building capacity. Throughout the assessment, participants said that it was much more challenging to build long-term capacity for monitoring, planning and implementation than it was to secure funding for initial assessments or information gathering.

Similarly, participants from the Government of Yukon, municipalities and Indigenous governments said that it was more difficult to secure flexible long-term funding for human resources than it was for projects. As a result, the teams who anticipate, plan for and respond to risks are often stretched for staff and time, and face challenges implementing the plans and priorities that they have identified. Additionally, funding programs often target "shovel-ready" projects, and have strict spending guidelines. This can make it challenging for small teams with limited capacity to plan for, develop, and implement adaptation projects. These findings suggest that Yukon resilience can be enhanced by increasing available resources and capacity and by improving planning and preparedness, while building on existing knowledge and relationships.

CAPACITY TO INTERPRET CLIMATE PROJECTIONS AND RELATED INFORMATION TO INFORM DECISION-MAKING

There are still substantive gaps in training and skills with respect to using climate projections to inform decision-making. This came up in discussions on land-use planning, emergency preparedness plans, and infrastructure development. In *Our Clean Future,* the Government of Yukon commits to working with First Nations and municipalities to complete emergency management plans for all Yukon communities. In these plans, the Government of Yukon provides technical assistance and guidance to communities and First Nations, but the communities themselves are responsible for determining future climate conditions. Participants who work for territorial, First Nations or municipal governments also said that their organizations or teams are often aware of the climate hazards involved, but are unsure how to interpret climate projections, apply codes and standards (if they are even aware of them), or assess the level of risk.

Often, this expertise is held by private consulting companies. Training and support for incorporating climate projections in areas such as planning, emergency preparedness and infrastructure development can help build resilience. Training in the skills needed to incorporate climate projections, interpret and use regional climate data, and raise awareness and capacity for implementing northern infrastructure standards is an important first step.

SHARING INFORMATION

Throughout the assessment participants said that people can do better at sharing information about future climate conditions, climate risks and resources in order to support climate resilience. In particular, it is important to prioritize information sharing for floods, fires and permafrost thaw. Efforts could be made by those who own and maintain data to increase access to this information, and to interpret and act on this data. In some cases, providing resources to establish databases and to disseminate data is needed. This can assist government and community planners, the private sector and academics. For example, the Government of Yukon maintains the Yukon Permafrost Database; however, communities may not be aware of the database or how it can inform adaptation. Better communication between government departments, from government to government, and across communities and private companies who can use this information can build resilience. Participants also pointed to the importance of making sure that technical information is made available in an accessible and easily understood manner.

It is also recommended to explore ways to bring together the relevant data, maps and other information from different departments, sectors and parties in order to better understand vulnerability and adaptive capacity. For example, the Government of Yukon has completed an assessment of all government buildings located on permafrost. This information could be used alongside data on adaptation measures that have been designed for existing buildings. Another example would be to develop maps that show key community buildings and their vulnerability to floods, permafrost thaw and fire. This can lead to a more comprehensive understanding of climate-related vulnerability and adaptive capacity.

THE IMPORTANCE OF APPLIED RESEARCH PARTNERSHIPS

As team members explored options to address the risks and priorities identified in this report, they identified that working collaboratively with academic institutions will be an important way to increase northern capacity and build local expertise. Throughout the assessment, participants pointed to many examples where partnerships between communities, researchers and governments helped fill capacity gaps and address resource constraints. In particular, the NSERC Permafrost Partnership Network for Canada (NSERC PermafrostNet) brings together researchers from 11 universities, with partners in government agencies, industry and Indigenous communities, who work together on monitoring, predicting and adapting to large-scale permafrost thaw and its consequences.[24] The Yukon Geological Survey's (YGS's) participation in the network has led to projects that would not have otherwise been possible for the Government of Yukon to tackle on its own. Through participation in the network, YGS has helped to train new permafrost scientists, gained access to specialized equipment, and received access to funding sources for research in the Yukon. Participation in the network has also built capacity within the Yukon through various learning opportunities for staff, students, community members and youth.

YGS and the Department of Highways and Public Works have also worked together with YukonU researchers to develop geohazard maps for Yukon communities, and to document permafrost occurrences along highway corridors. Working with YukonU allowed YGS to expand the scope of the work and to gain capacity, including for climate projections in mapping and in biophysical and socioeconomic characterizations that have been historically outside of the government's mapping projects. Working together allowed the organizations to access funding sources that enabled them to map more communities more quickly than would have been possible with core funding.

THE IMPORTANCE OF WORKING TOGETHER

Discussions with project participants often highlighted the fact that given the limited resources in remote communities, it is important to work together to address climate risks. Communities often help each other during emergencies, such as providing housing and services to first responders, and sharing volunteer resources and supplies. Working together should also include the authorities across the territory, such as those outlined in the First Nation Final Agreements, and should recognize the roles of Indigenous governments and communities in local planning. For example, the Village of Teslin and Teslin Tlingit Council have a joint emergency response plan, which they developed outside the *Civil Emergency Measures Act*. It is important to work together across all levels of government, and for communities to understand their role in climate change adaptation. This includes collaborations between jurisdictions, since some remote communities in British

24. https://www.permafrostnet.ca/.

Columbia (Atlin), Northwest Territories, and Alaska (Skagway) also rely on the Yukon highway network for essential supplies, food and livelihoods. Ensuring that communities and governments have adequate capacity for meaningful engagement and collaboration is important.

BUILDING RESILIENCE THROUGH RECONCILIATION AND SELF-DETERMINATION

> **The land has always** changed. With the changing land, we've changed. And we've thrived and survived through that.
>
> PROJECT PARTICIPANT

The assessment reaffirmed that in order to be meaningful, climate change action should be aligned with reconciliation and Indigenous peoples' self-determination. This includes building resilience through governance and policy coherence, and respectfully including Indigenous ways of knowing, doing and being in climate change actions.

GOVERNANCE AND POLICY COHERENCE

Aligning climate change adaptation with reconciliation and with Yukon First Nations and trans-boundary Indigenous people's self-governance can strengthen resilience.[25] Project participants often brought up the Umbrella Final Agreement (UFA), the Gwich'in Comprehensive Land Claim Agreement (GCLCA) and the Inuvialuit Final Agreement (IFA) as mechanisms to support resilience. These agreements provide guiding principles and authorities, and outline the roles that Yukon and transboundary First Nations and Inuvialuit can play in adapting to challenges such as climate change. Considering the spirit and intent of *Together Today for Our Children Tomorrow*[26] can offer guidance and direction for working together.

It is recommended that when taking actions to adapt to climate change, governments consider the Umbrella Final Agreement, First Nation Final Agreements and Self-government Agreements, *Together Today for Our Children Tomorrow*, the Gwich'in Comprehensive Land Claim Agreement and the Inuvialuit Final Agreement for clauses or guidance that are relevant to climate change and resilience.

The National Inuit Climate Change Strategy (NICCS), an Inuit-led response to the global climate crisis, was released in June 2019 in Inuvik, Northwest Territories. The NICCS calls for coordinated climate policy and decision-making that improves Inuit quality of life rather than adding to the socio-economic inequities that Inuit already face, and is inclusive of Inuit as rights holders and knowledge holders. The strategy asserts that for climate actions to be effective, appropriate, equitable and sustainable for Inuit Nunangat, they must be in line with the collective Inuit vision for building the sustainability, prosperity and well-being of Inuit Nunangat.

Both the Yukon First Nations' Climate Change Emergency Declaration and the NICCS provide direction for shared efforts to build resilience among Yukon First Nations and Inuvialuit

25. This is consistent with the Yukon First Nations Climate Emergency Declaration: http://afnyukon.ca/wp-content/uploads/2020/02/Yukon-First-Nations-Climate-Change-Emergency-Declaration.pdf.
26. *Together Today for Our Children Tomorrow* is foundational for the government-to-government relationships between the Yukon First Nations and territorial and federal governments in the Yukon. More information: https://cyfn.ca/agreements/together-today-for-our-children-tomorrow/.

governments and their federal, territorial and municipal partners. Likewise, when governments commit to reviewing relevant legislation, such as the *Civil Emergency Measures Act*, this is an opportunity to identify possible roles and responsibilities, and opportunities for working together.

BRING TOGETHER DIVERSE WAYS OF KNOWING

Resilience and adaptability are embedded in Indigenous cultures and ways of knowing (Jack et al. 2020). Bringing together diverse worldviews may lead to innovative approaches for working together to adapt to climate change impacts, share limited resources, and maintain Indigenous cultures and ways of life.

Indigenous knowledge reflects experience that comes from thousands of years of adapting to changing land conditions. Elements of Indigenous worldviews and values include sharing, caring, respect, humbleness, leadership, determination, diligence, preparedness and inherent resiliency. Throughout the assessment, knowledge keepers and Elders shared stories of how to live with uncertainty, prepare for the unknown, and rely on relationships and values. They spoke of adaptability, responsibility for and stewardship of the land.

> “**Old people always say** this land is not our land, this land belongs to our grandchildren and great-grandchildren. So we have to take care of it, so they have a good homeland when their turn comes along.
>
> ELDER JOE COPPER JACK

Traditional stories are a reminder that Indigenous peoples have constantly moved with and adapted to change. Today, Yukon First Nations, Inuvialuit and transboundary Indigenous peoples are demonstrating resilience by reclaiming cultural practices, languages and connections to the land. First Nations and Inuvialuit have continued to build on their knowledge of the land, and remain connected to the land and the water.

Participants emphasized that bringing together Indigenous, local and scientific approaches to climate change adaptation can help build resilience.

- Indigenous governance can provide a model for generations-long planning timelines, stewardship and relationship building.
- Lessons of resilience are embedded in Indigenous teachings and stories. Indigenous-led storytelling can broaden perspectives and knowledge of climate change impacts, and can foster innovation, shared values and relationships to support working together. Storytelling, language and ceremony can be incorporated in any facet of work related to resilience.
- Indigenous community-based adaptation projects can demonstrate how Indigenous, local and scientific worldviews can be combined to monitor climate change impacts and develop adaptation plans.
- Incorporating art and ceremony in climate change adaptation can reduce the stigma related to mental health impacts associated with climate change, and can support healing and reconnection through culture, language and identity.

- Lessons and guidance from the Yukon First Nations Climate Fellowship and the Yukon First Nations Climate Vision and Action Plan could provide direction on how the Government of Yukon should address these risks.

Participants noted the importance of upholding protocols around accessing, sharing and ownership of knowledge as well as ensuring that the true meaning behind the knowledge is brought forward.

ENSURING THAT LOCAL VALUES GUIDE CLIMATE CHANGE ADAPTATION AT THE COMMUNITY LEVEL

The resilience framework in this assessment emphasizes the values that matter to Yukoners so that adaptation actions can help safeguard those values from climate change impacts. Throughout the assessment, participants presented many examples of localized climate change impacts that must be addressed with input from those most affected by them. For example, discussions around relocating community buildings or private property, supporting access to country food, and assisting community members in safely accessing the backcountry must be informed by local values and priorities. Starting the conversation with what is important to Yukoners can broaden adaptation solutions beyond technical fixes, to consider how communities work together, grow and respond to change. This is especially important for the Yukon, where people in small, remote communities are deeply connected to the land, depend on one another and share limited resources.

Community-led planning initiatives across the Yukon offer examples for adaptation that is grounded in local values. For example, How We Walk With the Land and Water is a joint planning effort by Carcross/Tagish First Nation, Kwanlin Dün First Nation and Ta'an Kwäch'än Council to develop an Indigenous land relationship plan.[27] The plan creates a unified vision for the Southern Lakes area that is rooted in Indigenous story, law and knowledge, and brings together Indigenous knowledge and Western science to adapt to climate change impacts.

CLIMATE CHANGE AND EQUITY

Climate change impacts are not equally distributed across the Yukon, and equity must be considered in climate actions. This assessment shows that health and well-being, food security, and safe access to the land are threatened by multiple and interconnected climate change risks. Most of the Yukon's communities are remote, and therefore face additional challenges due to their relative isolation and limited financial resources. Socioeconomic standing, gender, Indigeneity and other factors may affect the severity with which people experience climate change and may influence their ability to act on resilience recommendations.

For example, people who access the land for food and subsistence, who live in remote areas, and who already face food insecurity face especially high risks related to climate change impacts. In remote areas, store-bought food can be expensive, with poor quality and selection. Access to the land can also be restricted because of the costs of the equipment and fuel needed to reach remote areas. Additionally, getting out on the land may also require taking time off wage work, which may not be possible for some families.

27. https://www.howwewalk.org/.

Because of the intersection of multiple social barriers, some of the most important actions that build resilience are not just about climate change — they support populations that face greater risks. This includes, for example, ensuring adequate social protections, housing, food security, employment, education and health care. Additional analysis is needed to determine the most effective way to address existing gaps. Implementing strategies such as the Government of Yukon's Putting People First strategy and 2020 Agriculture Policy will help build climate resilience.

CONTINUING TO RECOGNIZE YOUTH LEADERSHIP

HEALING AND RECONNECTION WITH CULTURE

Yukon First Nations youth emphasized healing from intergenerational trauma and reconnecting with the land as central to building resilience. They pointed to many examples of resilience held in the reconnection to language, culture, and ceremony. This is consistent with the approach called for by Indigenous governments and leaders.

> **The lived reality of** First Nations needs to be understood and incorporated into analyses of the distribution and experience of climate-related impacts. In this regard, addressing the climate crisis cannot be separated from the broader project of First Nations self-determination and reconciliation.
>
> NATIONAL CLIMATE GATHERING REPORT (AFN 2020: 6)

KNOWLEDGE AND EXPERIENCE

The Yukon is a place of hardship and perseverance. Youth spoke of how the Yukon's past and current experience and struggles are the foundation of the territory's culture. They spoke about continuing to build on past experience, revitalizing their knowledge, languages and ways of life.

SELF-SUFFICIENCY

Self-sufficiency was a common topic in discussions with youth. Youth expressed interest in growing food and being energy secure. This interest included strong communities, skilled families and individuals, and robust support for local businesses.

CONNECTION

Many youth spoke of balance, equity, collaboration and joy. They explained that a community offers belonging, identity, well-being and purpose. Youth feel that a resilient Yukon includes healthy relationships with each other, and with family, community and government, and seeking connections to land and water.

RESPONSIBILITY

Yukon First Nations youth talked about an inherent responsibility to the future that should be considered in planning for climate change adaptation. This includes taking responsibility for all Yukon people, especially those most vulnerable and those who face the highest risk of climate impacts. Youth spoke of the need to listen to the people, to the stories and to the land. Both youth and participants in general spoke of urgency, saying that meaningful action must be taken now. Taking on this great task and acknowledging and living this responsibility is core to the Yukon's resilience.

> **The ability to** keep going, to keep going on. I wasn't connected with my culture until after high school. Then I started facilitating blanket exercises — beginning of my journey into my culture, and knowing who I am. To be able to do what my grandparents or great-grandparents couldn't do. This is my resilience. Helping other youth speak up.
>
> PARTICIPANT, YOUTH SESSION – CLIMATE CHANGE ADAPTATION FORUM

5 CONCLUSION

The Yukon risk and resilience assessment demonstrates that climate change impacts affect every facet of Yukoners' lives. By centring this risk assessment on nine resilience values — Infrastructure, Food security, Energy, Culture and Heritage, Access, Community, Livelihood, Environmental health, and Health and well-being — its recommendations can lead the way to protecting and upholding these values for the Yukon.

This assessment is a starting point. It provides a foundation for taking a strategic approach to climate change adaptation in the Yukon. Adaptation actions often build on one another (in other words, from assessing risks to implementing strategies to reduce those risks), and the Government of Yukon will need to take an adaptive management approach, continuing to evaluate and adjust actions to reduce risks and build capacity. This is because climate change is not a linear process and what was (or was not) identified at a given point in time may not be valid at a later date.

To build on this assessment, complementary work on climate risks and resilience could include these tasks:

- implementing the recommendations focused on monitoring, capacity building, and collaboration on risk management;
- identifying the ecosystems and species most at risk from climate change impacts;
- conducting research and/or monitoring to address the topics that need further attention (Chapter 4);
- completing a comprehensive analysis of risks and climate resilience across identity factors including geographical location, socio-economic status, gender, Indigeneity and other factors;
- completing a more in-depth analysis of climate change risks and opportunities for the top economic sectors in the Yukon;
- continuing to find opportunities to meaningfully bring together Indigenous, local and scientific perspectives on risk and resilience in climate change adaptation;
- continuing to build a shared understanding of climate risks, thresholds, and adaptation actions among those responsible for predicting, planning for, and responding to climate change impacts; and
- incorporate participants' confidence levels in the assessment of the likelihood and consequence of risks.

NEXT STEPS

The risk assessment will be repeated on an ongoing basis to inform future versions of *Our Clean Future.* In *Our Clean Future,* the Government of Yukon commits to assess climate hazards and vulnerabilities to those hazards across the Yukon every three to four years between 2020 and 2030 to prioritize climate change adaptation actions. This assessment also provides a starting point for informing how the Yukon can achieve its adaptation target, as set out in *Our Clean Future*: "by 2030, [the] Yukon will be highly resilient to the impacts of climate change."

Throughout the next year, the Government of Yukon will work to respond to these recommendations and engage with partners and stakeholders on issues where they may be best placed to take action. The Government of Yukon will also assess the recommendations to determine which actions should be taken right away to reduce the highest risks.

APPENDICES

APPENDIX 1 RISK MAPS

During the assessment process, the project team produced risk maps (also known as heat maps) for each of the nine resilience values. The risk maps are based on participants' scores for likelihood from 1 to 5 (the x axis, along the bottom) and scores for consequence, also from 1 to 5 (the y axis, along the left side) for each of the 41 impacts.

How each impact scored is shown by where its number appears on the risk map. For example, in the risk map for Value 1, Impacts 11 and 16 received high scores for both likelihood and consequence and therefore appear in the red area of the risk map. Impacts with lower scores appear in the green or yellow areas.

Legend

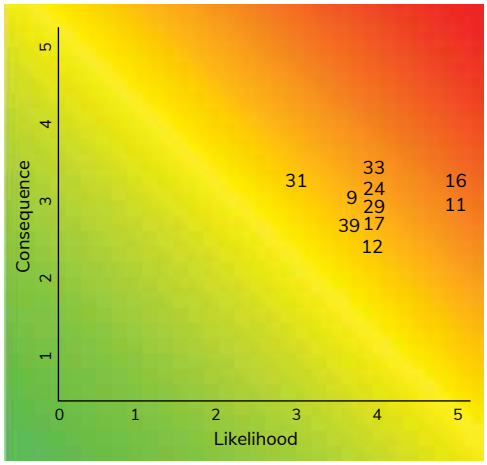
The numbers shown on the risk maps correspond with the numbered impacts listed in Table 1 (page 10) and Table A2. Participants scored every impact statement for its risk to the nine resilience values. Each risk map shows the most significant impacts for these nine values, illustrating how climate risks affect various aspects of Yukoners' lives.

Score	Low	Moderate	High
Score range	0–8	9–15	16–25

Value 1: Infrastructure

Public and private built infrastructure includes critical transportation infrastructure. Community infrastructure includes homes, schools and recreation centres. These are some of the important impacts for this value:

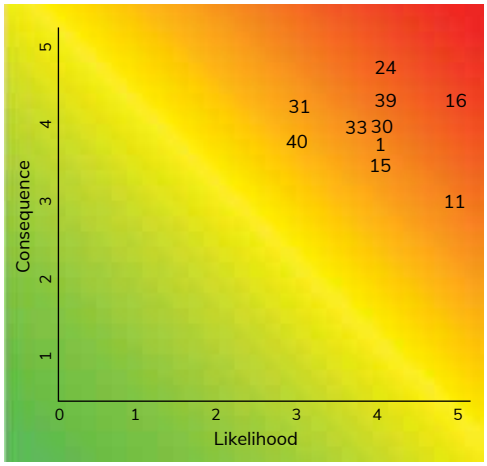
- damage to local, public and critical infrastructure from extreme weather events, thawing permafrost, changing water levels, flooding, and fires



Value 2: Food Security

The production, distribution, availability, accessibility and affordability of culturally appropriate food, including commercial and traditional food sources, makes sure that Yukoners have the food they need. These are some of the important impacts for this value:

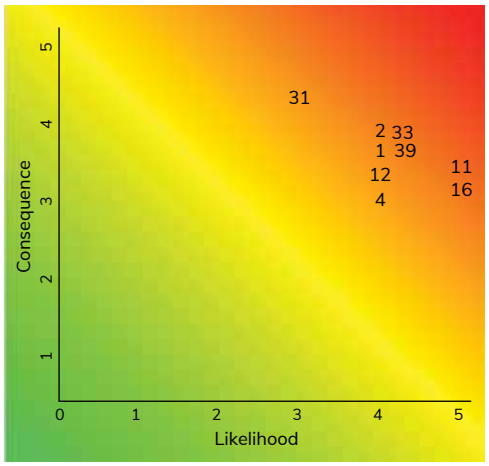
- impacts to access to harvested foods (health and availability of key plants, wildlife, and fish, and the ability to safety and reliably access harvesting areas)
- impacts to supply chains and commercial foods (wildfires, flooding, and freezing rain that can disrupt services and the flow of goods from the south)



Value 3: Energy

Reliable, affordable and sustainable energy is available for Yukoners. This includes electricity infrastructure and fuel imports. These are some of the important impacts for this value:

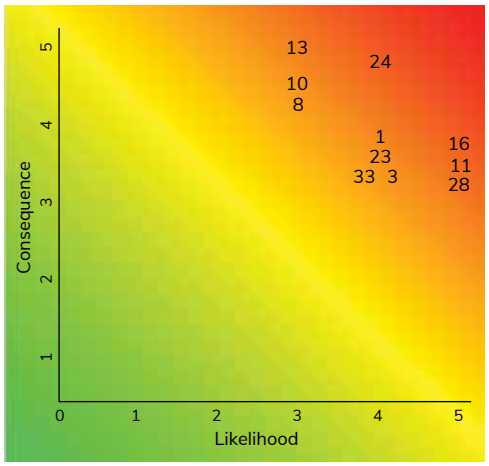
- interruptions to fuel transport to the Yukon (supply chain interruptions due to extreme weather, permafrost thaw)
- damage to hydroelectric power infrastructure (from damage to power lines due to fires, floods, and permafrost thaw)



Value 4: Culture and heritage

Yukoners and Yukon First Nations, Inuvialuit and transboundary Indigenous peoples uphold their cultural heritage, as well as a broad range of cultural values and ways of life. These are some of the important impacts for this value:

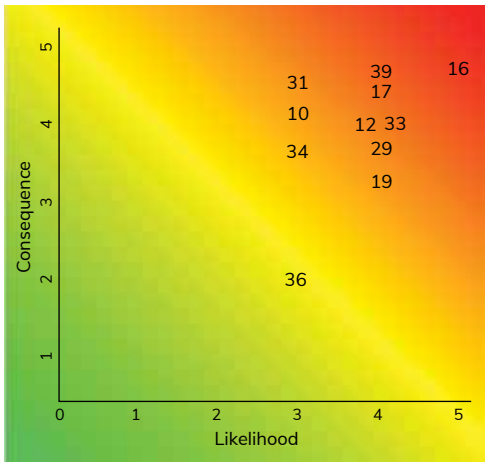
- impacts to cultural and heritage sites from changing snow patterns and higher snow loads, freeze-thaw cycles, thawing permafrost, coastal erosion, damage from floods and wildfires, and cumulative impacts from tourism and ecosystem-level change
- impacts to mental health and cultural values from changes in the plants, wildlife and fish that people depend on
- safety concerns when accessing important places on the land



Value 5: Access

Yukoners are able to safely access important places and services. These are some of the important impacts for this value:

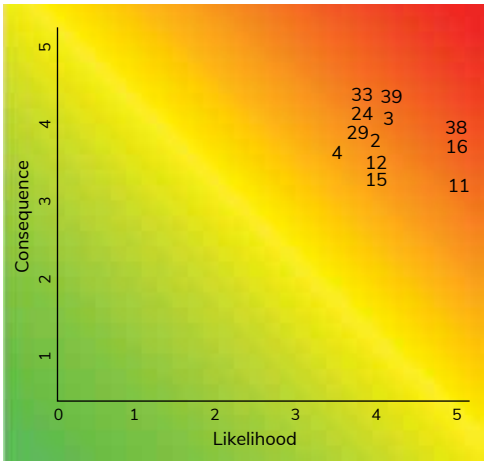
- increasingly variable and unpredictable conditions (extreme weather, changes to snow and ice cover) affect safe access to important places for livelihoods and subsistence, cultural and traditional activities, and recreation



Value 6: Community

Yukoners maintain strong community connection, capacity and belonging in order to withstand, respond to and recover from adversity. These are some of the important impacts for this value:

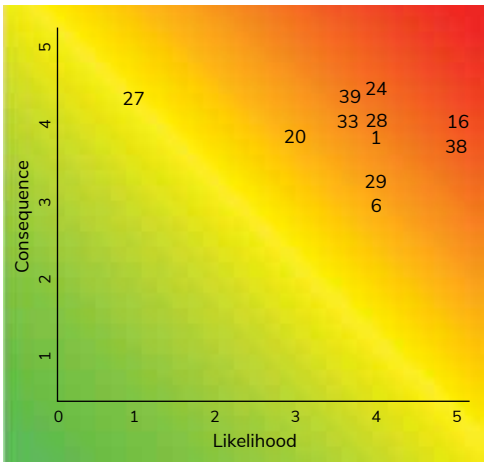
- flood risks from extreme precipitation events and changing water conditions and water levels
- supply chain interruptions from extreme weather events, washouts and landslides, and permafrost thaw
- increased fire risk threatening community infrastructure
- permafrost thaw posing risks for community buildings and community health and safety
- impacts to health and well-being from impacts to plants, wildlife, and fish, and safety concerns from accessing the land



Value 7: Livelihoods

Yukoners have opportunities to pursue reliable, sustainable livelihoods and are financially secure. (This includes key sectors, but not trapping, which is covered in Value 4: Culture and heritage). These are some of the important impacts for this value:

- impacts to sectors such as mining and tourism, that rely on access to remote areas; risks stem from increasingly variable and unpredictable conditions, and extreme weather
- impacts to businesses stemming from supply chain interruptions related to extreme weather events, washouts and permafrost thaw
- impacts to households and private property from wildfires and floods

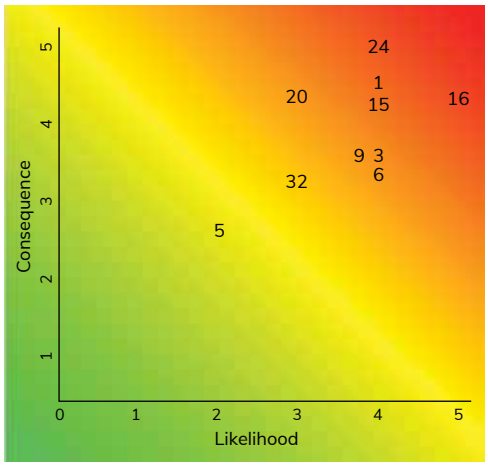


Value 8: Environmental health

The Yukon's ecosystems support all living things, including the biodiversity of plants, animals and fungi. These are some of the important impacts for this value:

- changes in environmental health related to the spread of illness and parasites in plants and animals, invasive species, changes to habitat, and animal migrations
- possible downstream impacts on ecosystems from impacts to critical infrastructure from permafrost thaw and changing water levels

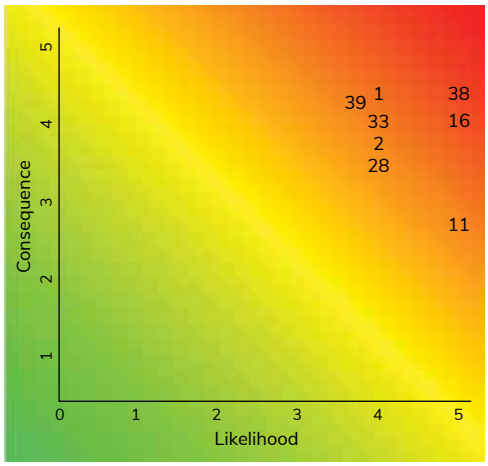
Note: Impacts 9, 23, 25 and 26 did not receive enough responses for conclusive results. It may be worth assessing these impacts in future assessments.



Value 9: Health and well-being

Yukoners' mental and physical health and well-being are strong and improving. These are some of the important impacts for this value:

- increasing mental health concerns associated with a changing climate
- impacts to health and safety during emergencies
- impacts to physical health and injury from wildfire smoke and reduced air quality
- possible health impacts from changes to environmental health



APPENDIX 2 SCORING GUIDES

Participants were provided with supporting information for each of the impacts listed in Table 1. This included related climate data and projections, as well as information from literature review and engagement sessions. Each participant was provided with detailed instructions and a scoring guide before completing the risk evaluation. This supported a shared understanding of the scoring scales to improve consistency across participants. Scoring was completed individually via an electronic survey.

Risks were derived from scores for likelihood (see Table 5) and scores for consequence (see Table 7). While the ranking process produces numerical outputs, likelihood and consequence scores are derived from local experience and knowledge.

This type of scoring approach is known as semi-quantitative. Qualitative approaches ask users to rank risk (very low-low-moderate-high-very high); quantitative approaches are based on statistical modeling. Semi-quantitative approaches rely on expert judgment, as qualitative approaches do, but also provide a scoring methodology to quantify and rank risks. See Table A1.

Table A1 Guide to consequence scores for values

Note: < less than > more than

Value 1. Infrastructure: Public and private built infrastructure, including critical and transportation infrastructure, are resilient

Risk level	Score	Description
Very low	1	No or limited damage; no change in maintenance or repair costs, or lifespan of infrastructure. No noticeable impact on services.
Low	2	Limited damage occurs or accumulates. Costs associated with repairs or replacements are manageable. Disruptions are very short duration (<1 day), and few (1–10) people or businesses are affected.
Moderate	3	Damage occurs or accumulates. Additional funding is required for repairs or replacements, affecting other budgets. Disruptions can be short duration (<72 hours), affecting a moderate number of people (10–20), or be longer disruptions affecting a smaller number (1–10) of people or businesses.
High	4	Considerable damage occurs or accumulates. Repair and replacements costs are significant ($1 million or more), and require reallocation of funding or new external funding. Short- and long-term planning is modified. Service disruptions affect more people and businesses (an entire community, or hundreds of people) and may be prolonged (3–14 days).
Very high	5	Infrastructure or assets are destroyed. Significant reallocation of funding or new funding required. Funding for repairs not always available. Changes to longer-term plans are required to cope with loss. Financial impacts on businesses, residents, government is significant ($10 million or more), resulting in business closures or extended loss of services. Service disruptions are widespread (multiple communities, thousands of people or customers) and prolonged (more than 2 weeks).

Value 2. Food security: The production, distribution, availability, accessibility and affordability of (culturally appropriate) food, including commercial and traditional food sources, makes sure that Yukoners have the food they need

Risk level	Score	Description
Very low	1	No impact to food security. Production and distribution are unaffected. Access to country foods is unaffected..
Low	2	Limited, short-term (<1 week) impact to food security for some Yukoners. Production and distribution are affected only temporarily (<1 week). Some challenges to harvesting and/or accessing country foods (faced by few people in a community). Challenges include prohibitive costs and unsafe access.
Moderate	3	Food security in some communities is affected for extended periods (seasonal). Prices of or access to several staples increase. Production and distribution effects are tangible, with some producers seeing significant financial losses. Distribution chains are disrupted (1 week to 1 season), affecting some communities. The number of food-insecure households across the Yukon increases by approximately 5%. Moderate challenges to harvesting and/or accessing country foods (challenges faced by a growing proportion of people in a community, and/or affects several communities).
High	4	Food security challenges are widespread and prolonged — from seasons to years. Access and price restrict choices for Yukoners. Some producers see repeated, significant losses, and some businesses or producers close. Distribution chains are disrupted regularly (multiple times per year) or for extended periods (seasonal to annual), affecting multiple communities. The number of food-insecure households across the Yukon increases by 10–20%; in some cases large proportions of the population (>50%) of smaller communities are affected. Significant challenges to harvesting and/or accessing country foods (affecting multiple communities and/or a significant number of people in a community).
Very high	5	Significant declines in food security throughout the Yukon. Access and price restrict choices. Multiple staples are limited, and many culturally appropriate foods are no longer accessible. Production and distribution effects are catastrophic, with many producers going out of business. Distribution chains are disrupted, affecting all Yukoners. The number of food-insecure households across the Yukon increases by more than 25%; large proportions of the population (>50%) of several smaller communities are affected. Extensive, long-lasting challenges with access and/or harvest of country foods (affecting multiple communities, and/or an entire community and/or the majority of people in the Yukon).

Value 3. Energy: Reliable, affordable and sustainable energy is available to Yukoners

Risk level	Score	Description
Very low	1	No significant change in energy costs or reliability.
Low	2	Measurable changes in reliability and access are small and manageable. Cost increases for utilities and consumers are limited.
Moderate	3	Outages or supply restrictions are more frequent but short in duration (<1 day) and limited in the number of people or businesses affected (10–11 customers). Price increases, investment and planning are needed to maintain the reliability and availability of energy.
High	4	Noticeable decline in reliability; interruptions in service are more frequent, longer duration (>1 day), and occasionally widespread (affecting hundreds of people or businesses, or entire communities). Outages in winter result in loss of heat, lighting and critical services. Maintaining reliability standards is difficult, despite ongoing investment. The cost of energy increases, with a noticeable impact on individuals, businesses and governments.
Very high	5	Reliability of energy services decreases. Service disruptions are frequent, repeated, widespread (hundreds to thousands of people and/or multiple communities) and often prolonged (>1 week). The cost of energy increases, with considerable impact on individuals, businesses and governments. Outages in winter are prolonged, result in loss of heat, lighting and critical services, and extensive impacts on business.

Value 4. Culture and heritage: Yukoners uphold their cultural heritage, as well as a broad range of cultural values and ways of life

Risk level	Score	Description
Very low	1	Culture, heritage and ways of life in the Yukon are not affected.
Low	2	Culture, heritage and ways of life are affected, but Yukoners are able to carry on important practices.
Moderate	3	The ability to maintain culture and heritage is challenged, and some aspects are lost. Some ways of life shift perceptibly.
High	4	Many aspects of heritage and culture change significantly, while others can't be maintained. While some ways of life are lost, other are maintained.
Very high	5	Many important elements of culture and heritage are lost. Ways of life change significantly, or are lost.

Value 5: Access: Yukoners have safe access to important places

Risk level	Score	Description
Very low	1	Access to places remains unchanged.
Low	2	Safety is increasingly a concern, and ability to access places is sometimes delayed.
Moderate	3	Safety concerns increase, but are manageable. Access to places is often delayed or restricted due to conditions, safety concerns.
High	4	Access to places is challenging; safety concerns limit ability to travel. Access is frequently delayed, or altogether impossible.
Very high	5	Access to important places is restricted, severely limited or lost. Many important places are no longer accessible. Increasing number of Yukoners lose their lives.

Value 6. Community: Yukoners maintain strong community connection, capacity, and belonging in order to withstand, respond to and recover from adversity

Risk level	Score	Description
Very low	1	Communities are not affected.
Low	2	Communities in the Yukon respond well. While a small number of people within a community may be affected, recovery is complete.
Moderate	3	Some communities and larger groups of people (for example, several families) face challenges responding and recovering, vulnerable populations in particular. Connections to community and capacity are strained, but recover.
High	4	An entire community and/or a significant number of people in several communities have difficulty responding and recovering. Many people and/or community services are affected. Community connections and capacity are strained, and recovery is slow and often incomplete.
Very high	5	Multiple communities and/or large proportions of the population are unable to respond. Connections and cohesion within the community break down. Capacity to respond becomes very limited, and some communities and individuals do not recover.

Value 7. Livelihoods: Yukoners have opportunities to pursue reliable, sustainable livelihoods and have good levels of household financial security

Risk level	Score	Description
Very low	1	Livelihoods are not affected.
Low	2	The livelihoods of some Yukoners are temporarily disrupted, but impacts are short-term and manageable.
Moderate	3	Livelihoods are strained for some people, causing difficulties for businesses and individuals. Cumulative or short-term disruptions pose prolonged challenges for some businesses and individuals.
High	4	Many Yukon people and businesses are affected. The financial security of individuals and the financial viability of businesses are reduced. For some businesses and individuals, the long-term viability of livelihoods is in question.
Very high	5	Many Yukon people and businesses are affected. The financial security of many individuals is compromised. The sustainability and financial viability of businesses or economic sectors are in question.

Value 8. Environmental health: The Yukon's ecosystems support all living things, including the biodiversity of plants, animals and fungi

Risk level	Score	Description
Very low	1	The Yukon's ecosystems are not affected.
Low	2	The overall health of ecosystems remains strong, although environmental health in some regions is temporarily degraded.
Moderate	3	Ecosystem health is strained; for some regions or species, changes are likely irreversible. The health and populations of key species (such as moose, caribou, salmon) and plants are threatened.
High	4	Ecosystem health is reduced for most regions or species. Recovery from impacts is slow, or changes are largely irreversible. Populations of key species (such as moose, caribou, salmon) and plants decline, and recovery prospects are low.
Very high	5	Ecosystem and environmental health is degraded irreversibly. Key species and plants decline significantly or are lost.

Value 9. Health and well-being: Yukoners' mental and physical health and well-being are strong and improving

Risk level	Score	Description
Very low	1	The mental and physical health and well-being of Yukoners are not affected.
Low	2	For some people, mental or physical health impacts are tangible but temporary and short-lived. Injuries or accidents lead to a small number (tens of people) of hospitalizations. Yukoners recover well.
Moderate	3	For some people, mental or physical health impacts are tangible and significant, and impacts can be long-lasting. Injuries or accidents lead to an increase in emergency services or number of hospitalizations (tens to hundreds).
High	4	Mental and physical health impacts affect whole communities, or larger proportions of the Yukon population. Many impacts are long-lasting. There are increases in injuries and hospitalizations, and a small number of fatalities.
Very high	5	Mental and physical health impacts affect whole communities and significant proportions of the population. There are increases in injuries (hundreds require hospitalization or treatment), and multiple fatalities.

APPENDIX 3 SUMMARIES OF RISK SCORES AND ACTION SCORES

Table A2 summarizes the risk scores and action scores for each impact. Risk scores were determined by multiplying the score for likelihood (see Table 5) by the score for consequence (see Table 7). Risk scores are presented for each of the nine values in the framework for resilience (Figure 1), averaged across all respondents. Action scores measure the level of ability that participants perceive they have to build capacity and increase resilience. They are shown for each of the seven types of actions in the framework for resilience: enhancing self-sufficiency; increasing efficiency; expanding knowledge; planning and preparing; broadening education and knowledge sharing; working together; and building capacity.

This table highlights several findings:

- which values have the highest risk scores;
- generally, what kinds of actions may be taken to strengthen resilience — for example, if scoring indicates high resilience in areas of expanding knowledge and working together, but low scores for building capacity, this suggests that policies and programs need to focus on mobilizing resources and people and on building relationships to increase capacity and therefore better manage risk; and
- areas where more action can be taken, as indicated by high risk scores but low action scores.

When compiling the risk assessment results, the project team reviewed these scores alongside the semi-quantitative input provided by participants through discussions. Three rounds of facilitated group discussions informed the assessment (see Table 4 in Chapter 2). Participants explored three main questions throughout the assessment:

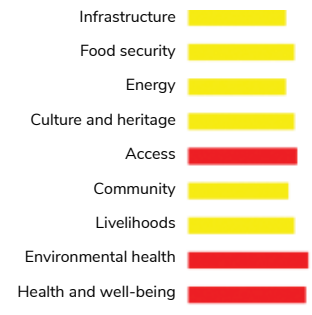
- What climate change impacts are the most significant?
- In what ways are Yukoners undertaking actions, or ready to take actions, to manage climate risk?
- What additional support or work is required to make sure that Yukoners are resilient?

Table A2 Risk scores and action scores for all impacts

Risk scores range from 1 to 25. Action scores range from 1–5.

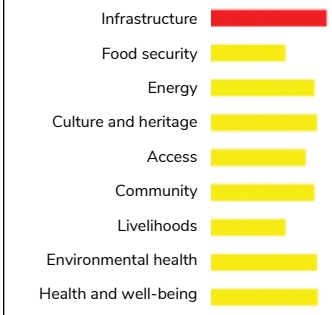
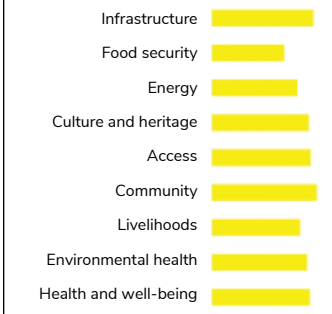
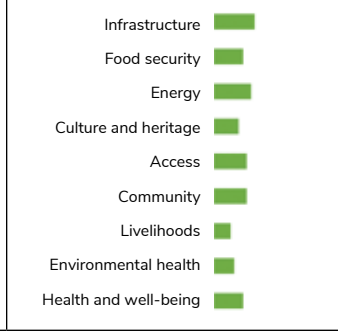
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 1: Wildfire smoke is transported long distances, affecting local and regional air quality.		

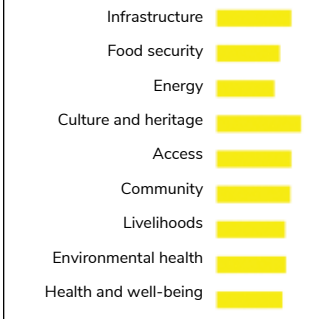
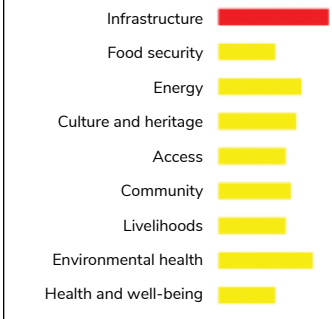
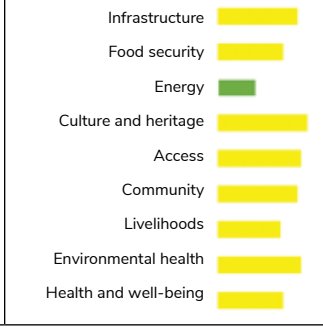
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 2: Wildfires threaten communities, heritage values, and infrastructure		
Impact 3: The frequency, intensity and scale of wildfire changes affect wildlife and ecosystems.		
Impact 4. Permafrost thaw and ground subsidence damage buildings and infrastructure.		
Impact 5: Hydrological cycles are affected by permafrost thaw and melting glaciers.		

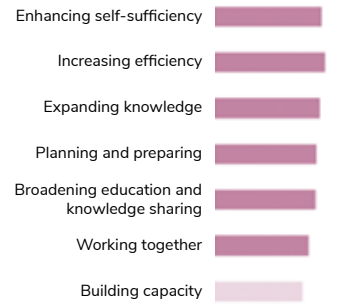
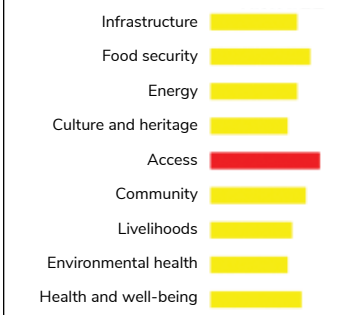
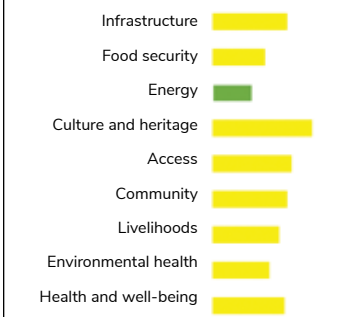
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 6: Permafrost thaw impacts surface runoff, river turbidity and water quality.		
Impact 7: Permafrost thaw destabilizes soil conditions.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	
Impact 8: Permafrost thaw alters landforms and ecology.		
Impact 9: Permafrost thaw causes critical infrastructure failures.		
Impact 10: Storm surges, shoreline erosion and decreasing near-shore ice alter the Yukon North Slope.		

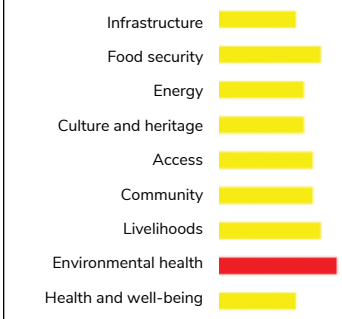
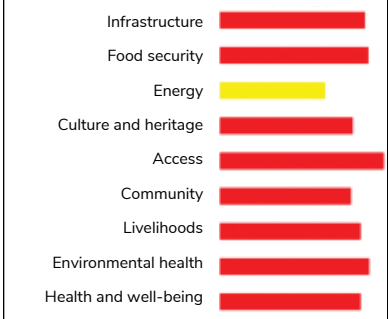
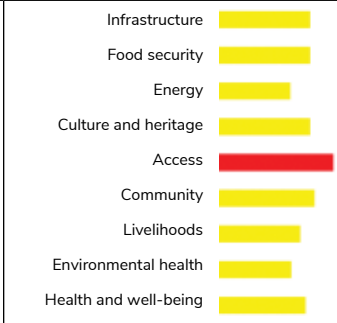
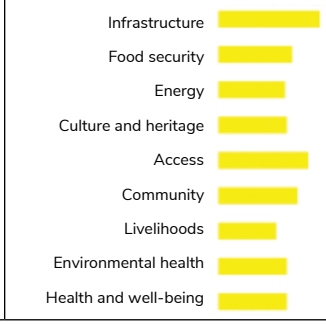
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 11: Changing water levels, conditions and flow in rivers and lakes affect communities and infrastructure.		
Impact 12: Warming winter conditions reduce the availability of winter roads and ice bridges.		
Impact 13: A changing climate and landscape affect Yukon heritage sites.		
Impact 14: Changes in winter precipitation and weather affect infrastructure.		

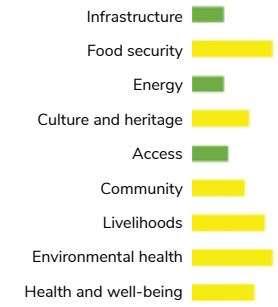
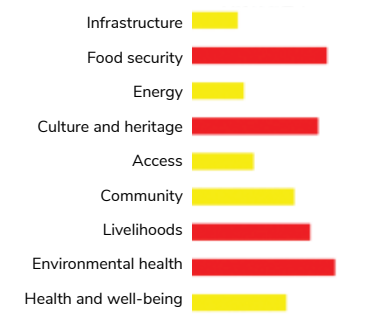
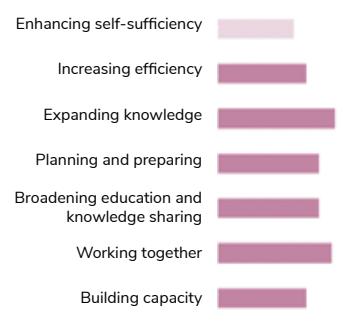
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 15: Changing winter conditions affect ecosystems and wildlife.		
Impact 16: Changes to snow and ice cover create unsafe or unreliable conditions that reduce access.		
Impact 17: The timing of ice break-up on waterways changes, including earlier spring break-up.		
Impact 18: Groundwater levels are raised in some regions or areas, posing risks to community infrastructure.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	
Impact 19: Ice-jam floods occur along the Yukon river and in other important watersheds.		

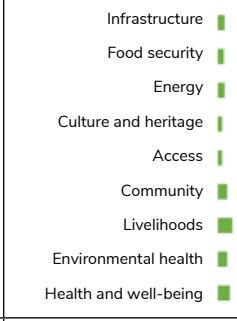
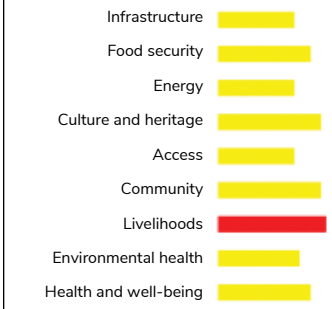
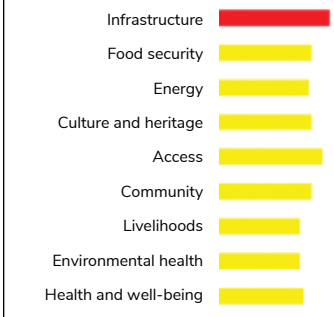
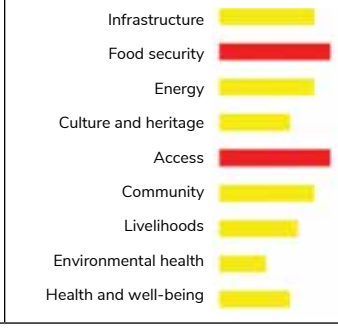
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 20: Water temperatures rise in some rivers and lakes, disrupting ecosystems.		
Impact 21: The combination of reduced sea ice and changing economic trends results in more traffic in the Northwest Passage.	This impact did not receive enough responses for conclusive results. It maybe worth assessing this impact in future assessments.	
Impact 22: Longer growing seasons increase the productivity of forests.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments, particularly in how it relates to environmental health.	
Impact 23: Changing climate affects the composition, distribution and movement of plants and wildlife.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	
Impact 24: Changing climate conditions affect the health and availability of plants, wildlife and fish.		
Impact 25: The presence and spread of invasive species increase, disrupting local/native ecosystems.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	
Impact 26: A warming climate worsens the spread of illness and parasites in plants and animals.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	

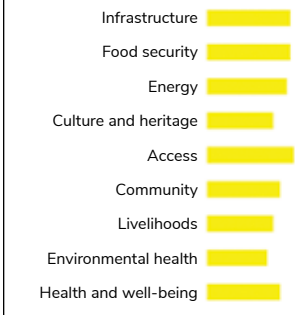
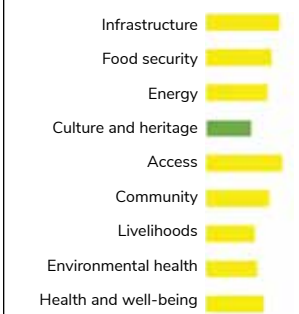
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 27: Longer growing seasons and warmer temperatures increase agricultural opportunities.		
Impact 28: The health and safety of people on the land are at risk from variable, uncertain and extreme weather.		
Impact 29: Flooding in communities is more frequent and severe.		
Impact 30: Extreme winter precipitation leads to transportation interruptions or failures.		

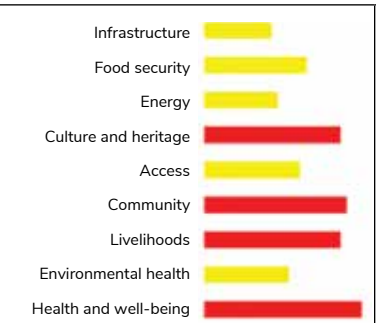
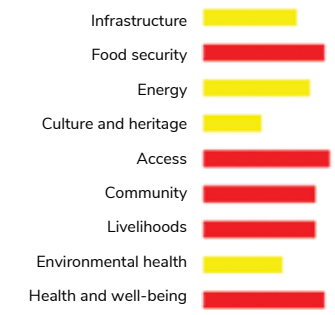
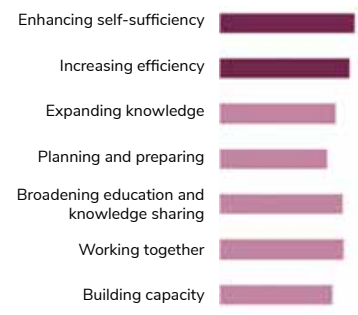
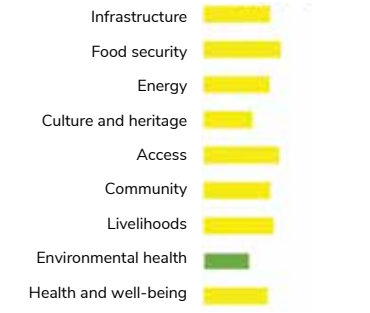
Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 31: Washouts and landslides lead to transportation service interruptions or failures.		
Impact 32: Extreme precipitation increases the erosion of and damage to riverbanks.		
Impact 33: Extreme precipitation events cause damage.		
Impact 34: Rain-on-snow events affect transportation safety and increase the demand for emergency services.		
Impact 35: Extreme precipitation and flash flooding cause physical and chemical instability at mine sites.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	

Legend

Risk scores			Action scores			
Low	Moderate	High	Very low	Low	Moderate	High
0–8	9–15	16–25	1–2	2–3	3–4	4–5

Impact	Risk scores	Action scores
Impact 36: High-wind extreme weather events reduce visibility, creating health and safety risks.		
Impact 37: The number of extremely cold days decreases, reducing the risk of illness/injury.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	
Impact 38: Mental health concerns associated with climate change increase.		
Impact 39: A range of climate-related factors disrupt critical supply chains.		
Impact 40: The decreasing reliability of supply chains affects access and affordability of resources.		
Impact 41: The Yukon experiences high population growth, with increased climate-related migration.	This impact did not receive enough responses for conclusive results. It may be worth assessing this impact in future assessments.	

APPENDIX 4 CLIMATE SCENARIOS: OVERVIEW

Purpose and format of scenario-based discussions

A scenario is a projected series of possible events. Using a scenario to guide discussions is a useful approach that allows lived experience to be included in the understanding of risks, and to provide information when there is not a lot of data. The team members developed six scenarios that enabled them to fill data gaps and to explore adaptation to climate change impacts from a range of perspectives (Table A3). The team used scenarios as a tool to explore the following questions:

- Who feels the impact and why? What protections do they have?
- Who are the key actors in this scenario, and what roles do they play?
- How do people respond in the short term to deal with this situation? How can people prepare for this scenario before it happens (in addition to what they are already doing)?

The team mixed and matched participation to allow for cross-sector discussions. Team members purposely kept the groups small to allow for deeper consideration of the scenarios through two-hour Zoom sessions.

Overall, participants expressed appreciation for the scenario format, acknowledging that it helped to do the following:

- created a shared understanding around climate impacts, resilience actions and roles;
- supported open, free-flowing discussion, which raised issues that might not have come up with a more directed approach;
- welcomed multiple ways of knowing and participant input that drew on professional, personal and cultural experiences living and working in the Yukon; and
- allowed participants to share knowledge and understanding of resilience, and understand how different perspectives can inform solutions.

Table A3 Scenario descriptions

	Scenario
1	**Highway washout** A series of forest fires, river washouts and rain-induced landslides force frequent closures of the Alaska Highway between Watson Lake and Teslin. As a result, tourism and delivery of goods are interrupted. Highway closures have not lasted more than a week, but are happening multiple times per year where they used to happen less frequently. Historically, transportation companies and Yukon retailers have been able to independently manage the impact of infrequent short-term closures, but the increased frequency of these disruptions has led to calls from industry associations for increased supports to businesses. At the same time, the closures are affecting households' access to supplies.
2	**What if it floods… in winter?** In late November, a large rain event occurs after ice has started forming on rivers and lakes. Because there is a combination of strong thick ice and weak thin ice, the weak ice breaks up, then jams, causing flooding in an upstream community. The ice jam eventually breaks from natural causes, but by that time high water has frozen within the community. Recovery efforts that are normally deployed for summer flooding are slowed by cold weather and snowfall that is typical for the time of year.

	Scenario
3	**Permafrost impacts on local infrastructure** A community has experienced many years of impacts due to permafrost thaw. Damage to multiple buildings has included breaking pipes, cracked walls, and doors that won't open or close. While the buildings remain useable for most people, there are fears that Elders and others with limited mobility are not able to safely access and move around in them. Grants have been used to fix the most severe damage, and are still available, but the funder requires that the money be used on existing infrastructure and that the repairs bring the entire building into compliance with national standards for infrastructure on permafrost. In order to meet these standards, the available grant money may only cover the expense of upgrading one or two buildings. Nobody has been able to tell the community how long the repairs may last if they are completed.
4	**When food doesn't come from a truck...** While weather conditions in the Yukon are within normal ranges, a multi-year drought has affected Western Canada and the United States. Crop yields for wheat, fruit, and vegetables have been below the demand for three consecutive years. During this time, prices have increased, and the quality and quantity of food have decreased. Long-term forecasts indicate that the drought could continue for at least another year. Governments are investigating whether there will be enough food to meet national demand, and are also aware that producers are having difficulty meeting quality thresholds for their produce to be exported. Against this backdrop, local food, including agriculture, community gardens and traditional foods has steadily increased.
5	**Part of the land, part of the water** The Part of the Land, Part of the Water session explored the role of Indigenous knowledge in the development of the Yukon climate risk assessment. Participants reviewed the teachings held in a message from Teslin Tlingit Elder Virginia Smarch. They discussed the role of Indigenous knowledge in understanding and realizing resilience to climate change in the Yukon.
6	**Challenges on the land** People are increasingly requiring assistance while on the land, despite having good-quality equipment and experience. Travellers are often getting "trapped" by unexpected conditions. Water is open when it would normally be frozen; snow conditions are too deep; and the timing of high and low river flows has changed — unexpectedly slowing travel or making it impossible. There have been several deaths, and the personal equipment of those travelling has been lost.

APPENDIX 5 SUPPORTING INFORMATION ON CLIMATE CHANGE TRENDS AND PROJECTIONS

This is a summary of climate trends and projections that were generated to inform the risk scoring and the understanding of risks for this assessment (CRI 2019). It is summarized as supporting information and for reference purposes. Ensemble projections were produced using data provided by IPCC, PCMDI, WRCP and CMIP Phase 5 AR5.

Historical climate trends and current changes

In the last 50 years, average temperatures in northern Canada have increased by 2.3°C, with more significant warming in winter and spring than in summer and fall. Warming has been most prominent in the northern Yukon and parts of the central Yukon near Dawson and Mayo. There, annual temperatures have increased by an average of 3.7°C (1.7°C in summer and 7.0°C in winter), relative to the 1961–1990 baseline (CRI 2019). Southern parts of the territory have warmed on average 5.5°C in winter, 1.2°C in summer, and 2.5°C annually, relative to the 1961–1990 baseline. From 1946 to 2016, the average temperature in winter increased across the Yukon, northern British Columbia and Alberta, Northwest Territories and Nunavut by 4°C to 6°C (Bush and Lemmen 2019).

Increases in both average maximum and minimum daily temperatures observed across the territory are linked to corresponding changes in extreme weather events. The number of hot weather extremes (days when the maximum temperature reaches +30°C) has increased by up to three days in most locations, particularly in central and southern parts of the territory. Decreases in cold weather extremes have been more pronounced, with the number of days falling below –30°C decreasing by as much as 30 days per year.

Over the same baseline (1961–1990), average annual precipitation has increased by 6 per cent; however, there are significant regional and seasonal differences. The greatest increase in total precipitation has occurred in the northern and western parts of the territory during winter months, increasing by up to 73 per cent. Conversely, in the south and southeast parts of the Yukon, winter precipitation has decreased by up to 30 per cent, relative to the 1961–1990 baseline. Summer precipitation has increased across the territory, by 20 per cent in the south and 30 per cent in the north. On average, increases in annual precipitation of 4 per cent in the south and 38 per cent in the north of the territory have been observed. Maximum 24-hour precipitation has increased slightly across the territory. Days of heavy snowfall (daily snowfall ≥ 10 cm) have increased at several locations in the Yukon (Bush and Lemmen 2019), while days of heavy rainfall (daily rainfall ≥ 10 mm) have shown no significant positive or negative trends over the past decades.

Projected climate trends

Projections from an ensemble of global climate models under representative concentration pathway (RCP) 8.5, consistent with the current greenhouse gas pathway, show that increasing temperature and precipitation trends in the Yukon are expected to continue into the future. RCP8.5 is one of several representative concentration pathways (RCPs) adopted by IPCC. An RCP indicates a projected trajectory for greenhouse gas concentrations. See Climate Information (n.d.).

By the 2050s, mean annual temperatures are projected to rise by 2–6°C in different parts of the Yukon. Summer increases of 2°C and winter increases ranging from 3°C in the south to 7°C in the north are expected. By the 2080s, mean annual temperature increases will range from 5° to 9°C, moving from south to north. Summer mean temperatures will increase by 5°C, while winter mean temperatures will rise from 6° to 13°C. Daily minimum temperatures are projected to rise more quickly than daily maximum temperatures, primarily

driving mean temperature increase. Extreme heat events are projected to increase by up to 7 and 14 days in the northern and central parts of the territory, respectively.

The overall number of freeze-thaw cycles (days when the maximum temperature is ≥0°C and the minimum temperature is <0°C) is projected to decrease, largely due to warmer temperatures in fall and spring. However, the number of freeze-thaw cycles in winter is projected to increase across the territory.

According to projections from a number of global climate models under RCP8.5, increases in total precipitation are expected to occur in all seasons and in all parts of the territory. The most pronounced changes are projected for the northern part of the territory during winter, with overall increases of up to 25–40 mm in the 2050s and 2080s, respectively. Heavy precipitation events are projected to increase slightly, relative to the 1981–2010 baseline (CRI 2019).

Availability and limitations of climate data

In the Yukon, there are gaps in climate and weather data, and capacity is limited for using and interpreting climate projections and data. Table A4 outlines the relevant climate and weather datasets available for the Yukon.

Weather station data with continuous long-term records are limited in the Yukon. Challenges related to working with station data include sparse station density, data quality and reliability. For example, the AHCCD dataset (see Table A4) provides monthly, seasonal and annual records for up to nine variables for 17 stations in the Yukon, but the stations are largely located in the southern part of the territory. Station records began in 1901 and continue to the present day, but there are few precipitation records for the 2000s, a trend common across the country (Mekis and Vincent 2011).

Interpreting historic and projected trends and using climate and weather data in adaptation planning requires technical knowledge; for example, understanding how to choose climate projection models such as RCP8.5, working with limited datasets, and understanding how to apply existing data to the Yukon. This knowledge is not consistently applied or shared across the territory. The Government of Yukon is working with federal, territorial, and academic partners to develop this capacity.

Table A4 Characteristics of relevant climate and weather datasets available for the Yukon

Dataset name	Data provider	Spatial resolution	Temporal resolution	Time period covered
Adjusted and Homogenized Canadian Climate Data (AHCCD)	Environment and Climate Change Canada	Point locations across the Yukon	Monthly, seasonal, annual	Varies by station, ranging between 1901 and 2020
Canadian Climate Normals	Environment and Climate Change Canada	Point locations across Canada	Hourly, daily, monthly	1981–2010 *
Gridded Historical Climate Data (CANGRD)	Natural Resources Canada	50 km across Canada	Monthly, seasonal, annual	1948–2018 for temperature 1948–2012 for precipitation
NRCANMET	Natural Resources Canada	10 km across Canada	Daily	1950–2012

Dataset name	Data provider	Spatial resolution	Temporal resolution	Time period covered
PNWNAMET	Pacific Climate Impacts Consortium (PCIC)	6 km over northwest North America	Daily	1945–2012
Gridded Mean Monthly Temperature and Precipitation Data for Alaska, British Columbia and Yukon	US National Oceanic and Atmospheric Administration	2 km in Alaska, British Columbia and Yukon	Monthly	1961–2009
Coupled Model Intercomparison Project Phase 5 (CMIP5)	Environment and Climate Change Canada	1x1°C across Canada	Monthly, seasonal, annual	1901–2100, 20-year averages for four future time periods (2021–2040, 2041–2060, 2061–2080, 2081–2100)
Statistically Downscaled Climate Scenarios	Pacific Climate Impacts Consortium (PCIC)	10 km across Canada	Monthly, seasonal, annual	1951–2100, 20-year averages for four future time periods (2021–2040, 2041–2060, 2061–2080, 2081–2100)

*Note: The 1981–2010 period is the latest full set of "normals" — in other words, the full 30-year period — available.

Data sources

Raw climatological data for Canada is provided by Environment and Climate Change Canada (ECCC) (www.ec.gc.ca), or gridded historical data (CANGRD) from Natural Resources Canada/ECCC.

National Building Code of Canada data is provided from the National Research Council (www.nrc-cnrc.gc.ca). Additional content is provided courtesy of the Standards Council of Canada (www.scc.ca).

Projection data is provided from the IPCC (Intergovernmental Panel on Climate Change), the PCMDI (Program for Climate Model Diagnosis and Intercomparison), World Climate Research Program (WCRP), and CMIP (Coupled Model Intercomparison Project - phase 5 - (AR5)), has provided access to the international global climate model (GCM) data which is used in the production of ensemble projections within this tool. Use of the GCM data presented should acknowledge the provision of this raw data: GCM data is provided by international modelling groups to the CMIP5 database (with support of the U.S. Department of Energy), with further analysis by Risk Sciences International (RSI) through the CCHIP.CA web tool (CRI 2019).

REFERENCES

ACIA (Arctic Climate Impact Assessment). 2004. *Impacts of a Warming Climate – Arctic Climate Impact Assessment.* Overview Report. New York: Cambridge University Press. https://www.amap.no/documents/doc/impacts-of-a-warming-arctic-2004/786.

AFN (Assembly of First Nations). 2020. *National Climate Gathering Report: Driving Change, Leading Solutions.* https://www.afn.ca/wp-content/uploads/2021/04/Climate_Gathering_Report_ENG.pdf.

AICBR (Arctic Institute of Community-Based Research). n.d. *Food Security.* https://www.aicbr.ca/food-security.

AICBR (Arctic Institute of Community-Based Research). 2019. Developing local food systems as a way to adapt to climate change. https://www.aicbr.ca/food-systems-resources.

BCMOECC (B.C. Ministry of Environment and Climate Change Strategy). n.d. *Climate Change Health Risks: Overview.* https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/health/final_climate_change_and_health_backgrounder_overview.pdf.

Bourque, J., P. Olmsted, S. Patel, R. Samson, R. Smith, D. Beugin and B. Shaffer. 2021. *Green is the new grey.* Canadian Institute for Climate Choices blog. https://climatechoices.ca/green-is-the-new-grey/.

Boyle J., M. Cunningham and J. Dekens. 2013. *Climate Change Adaptation and Canadian Infrastructure: A review of the literature.* Winnipeg: IISD. https://www.iisd.org/publications/climate-change-adaptation-and-canadian-infrastructure-review-literature.

Bush, E. and D.S. Lemmen. (eds.) 2019. *Canada's Changing Climate Report.* Ottawa: Government of Canada. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_FULLREPORT-EN-FINAL.pdf.

Calmels, F., L.-P. Roy, C. Laurent, M. Pelletier, L. Kinnear, B. Benkert, B. Horton and J. Pumple. 2015. *Vulnerability of the North Alaska Highway to Permafrost Thaw: A Field Guide and Data Synthesis.* Whitehorse: Northern Climate ExChange, Yukon Research Centre.

CCME (Canadian Council of Ministers of the Environment). 2021. *Guidance on Good Practices in Climate Change Risk Assessment.* https://ccme.ca/en/res/riskassessmentguidancesecured.pdf.

CCME (Canadian Council of Ministers of the Environment). 2018. *Best Practices and Resources on Climate Resilient Natural Infrastructure.* https://ccme.ca/en/res/natural_infrastructure_report_en.pdf.

City of Whitehorse. n.d. *2020 Local Food and Urban Agriculture Study.* https://www.whitehorse.ca/departments/planning-building-services-/plans-and-implementation/local-food-and-urban-agriculture.

Climate Information. n.d. *What do different RCPs mean?* https://climateinformation.org/data-variables/what-do-different-rcps-mean/.

CRI (Climate Risk Institute). 2019. *Climate Change Hazards Information Portal.* https://climateriskinstitute.ca/2019/09/13/climate-change-hazards-information-portal-cchip/.

Dudley, N., S. Stolton, A. Belokurov, L. Krueger, N. Lopoukhine, K. MacKinnon, T. Sandwith and N. Sekhran. (eds.) 2010. *Natural Solutions: Protected areas helping people cope with climate change.* Gland, Switzerland; Washington, D.C. and New York: IUCN-WCPA, TNC, UNDP, WCS, The World Bank and WWF. https://wwf.panda.org/wwf_news/?183021/Natural-Solutions-protected-areas-helping-people-cope-with-climate-change.

Energy Branch. 2018. *Yukon's Energy Context.* Whitehorse: Government of Yukon, Department of Energy, Mines and Resources. https://yukon.ca/sites/yukon.ca/files/emr/emr-yukon-energy-context.pdf.

Environment Yukon. 2013. *Winter Ticks* (Dermacentor Albipictus). Whitehorse: Environment Yukon, Animal Health Unit. https://yukon.ca/sites/yukon.ca/files/env/env-winter-ticks-yukon.pdf.

Furgal, C. and T.D. Prowse. 2008. Northern Canada. In Lemmen D.S., F.J. Warren, J. Lacroix and E. Bush (eds.). *From Impacts to Adaptation: Canada in a Changing Climate 2007.* Ottawa: Natural Resources Canada, 57–118. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2007/pdf/full-complet_e.pdf.

Furgal, C., M. Buell, L. Chan, D. Martin and N. Ogden. 2008. Health Impacts of Climate Change in Canada's North. In Séguin J. (ed.) *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*, 305–66. Ottawa: Health Canada. https://publications.gc.ca/site/eng/9.691579/publication.html.

Government of Yukon. n.d. *Yukon Tourism Development Strategy: Sustainable Tourism. Our Path. Our Future. 2018–2028.* https://yukon.ca/sites/yukon.ca/files/tc/tc-yukon-tourism-development-strategy.pdf.

Government of Yukon. 2020a. *Cultivating our Future: 2020 Yukon Agriculture Policy.* Whitehorse: Government of Yukon. https://yukon.ca/en/cultivating-our-future-2020-yukon-agriculture-policy.

Government of Yukon. 2020b. *Our Clean Future: A Yukon strategy for climate change, energy and a green economy.* Whitehorse: Government of Yukon. https://yukon.ca/en/our-clean-future-yukon-strategy-climate-change-energy-and-green-economy.

Government of Yukon. 2020c. *Putting People First.* Whitehorse: Government of Yukon. https://yukon.ca/en/putting-people-first.

Government of Yukon. 2020d. *Yukon Parks Strategy.* https://yukon.ca/en/yukon-parks-strategy.

Government of Yukon. 2019. *Herschel Island-Qikiqtaruk Territorial Park Management Plan.* Whitehorse: Government of Yukon. https://yukon.ca/sites/yukon.ca/files/env/env-herschel-island-qikiqtaruk-territorial-park-management_plan.pdf.

Government of Yukon. 2017. *Yukon "state of play": Analysis of climate change impacts and adaptation.* Whitehorse: Government of Yukon. https://yukon.ca/en/yukon-state-play-analysis-climate-change-impacts-and-adaptation.

Guyot, M., C. Dickson, C. Paci, C. Furgal and H.M. Chan. 2006. "Local observations of climate change and impacts on traditional food security in two northern Aboriginal communities." *International Journal of Circumpolar Health* 65(5):403–415. https://doi.org/10.3402/ijch.v65i5.18135.

IPCC (Intergovernmental Panel on Climate Change). 2022. *Summary for Policymakers.* Cambridge, UK and New York: Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf.

ISO (International Standards Organization). 2021. *ISO 14091: Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment.* Geneva: International Standards Organization. https://www.iso.org/standard/68508.html.

ISO (International Standards Organization). 2019. *ISO 14090: Adaptation to climate change — Principles, requirements and guidelines.* Geneva: International Standards Organization. https://www.iso.org/standard/68507.html.

ISO (International Standards Organization). 2018. *ISO 31000: Risk Management — Guidelines.* Geneva: International Standards Organization. https://www.iso.org/obp/ui/#iso:std:iso:31000:ed-2:v1:en.

Jack, J.C., J. Gonet, A. Mease and K. Nowak. 2020. "Traditional Knowledge underlies One Health." *Science* 369(6511):1576–1576. https://www.science.org/doi/10.1126/science.abe2401.

KFN (Kluane First Nation). 2014. *Nourishing Our Future: An adaptive food security strategy to ensure the cultural and physical well-being of the Kluane First Nation against the impacts of climate change in the Yukon.* https://emrlibrary.gov.yk.ca/ebooks/arctic-institute-of-community-based-research/Nourishing-Our-Future-an-adaptive-food-security-strategy-2014.pdf.

KFN (Kluane First Nation) and AICBR (Arctic Institute of Community-Based Research). 2016. *Nourishing Our Future: Building on Kluane First Nation's Community Food Security Strategy and Youth Engagement in Traditions Related to Fisheries and Fish Health in Kluane Lake.* Whitehorse: KFN and AICBR. https://static1.squarespace.com/static/56afc7218259b53bd8383cb8/t/581bca0eebbd1a9e3ab911c3/1 478216258678/FINALKFNNourishingOurFutureReportPhase2_Aug2016_FINAL%255b2%255d.compress ed.pdf.

Kokelj, S.V., D. Lacelle, T.C. Lantz, J. Tunnicliffe, L. Malone, I.D. Clark and K. Chin. 2013. "Thawing of massive ground ice in mega slumps drives increases in stream sediment and solute flux across a range of watershed scales." *Journal of Geophysical Research: Earth Surface* 118:681–692. https://doi.org/10.1002/jgrf.20063.

MAC (Mining Association of Canada). 2021. *Guide on Climate Change Adaptation for the Mining Sector.* https://mining.ca/wp-content/uploads/2021/10/MAC-Climate-Change-Guide-June-2021.pdf.

McClellan, C. with L. Birckel, R. Bringhurst, J.A. Fall, C. McCarthy and J.R. Sheppard. 1987. *Part of the Land, Part of the Water.* Vancouver, B.C: Douglas and McIntyre.

Mekis, É. and L.A. Vincent. 2011. "An overview of the second generation adjusted daily precipitation dataset for trend analysis in Canada." *Atmosphere - Ocean* 49(2):163–177. https://doi.org/10.1080/07055900.2011.583910.

Middleton, J., A. Cunsolo, A. Jones-Bitton, C. Wright and S. Harper. 2020. "Indigenous mental health in a changing climate: A systematic scoping review of the global literature." *Environmental Research Letters* 15:053001. https://doi.org/10.1088/1748-9326/ab68a9.

Nature Serve. n.d. *Climate Change Vulnerability Index: Species.* https://www.natureserve.org/ccvi-species.

NCE (Northern Climate ExChange). 2014. *Projected Future Changes in Glaciers and their Contribution to Discharge of the Yukon River at Whitehorse. Whitehorse:* Northern Climate ExChange, Yukon Research Centre, Yukon College. https://www.yukonu.ca/sites/default/files/inline-files/glacier_report.pdf.

Newton, B.W., T.D. Prowse and L.P. de Rham. 2017. "Hydro-climatic drivers of mid-winter break-up of river ice in western Canada and Alaska." *Hydrology Research* 48(4):945–956. https://doi.org/10.2166/nh.2016.358.

Office of the CMOH (Chief Medical Officer of Health). 2020. *Health Effects of Extreme Weather Events and Wildland Fires: A Yukon Perspective.* https://yukon.ca/sites/yukon.ca/files/hss/climate_change_report_web_feb.2020_0.pdf.

Osipova, E., M. Emslie-Smith, M. Osti, M. Murai, U. Åberg and P. Shadie. 2020. *IUCN World Heritage Outlook 3*: *A conservation assessment of all natural World Heritage sites.* Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.16.en.

Pendakur, K. 2017. Climate Risks and Adaptation Practices for the Canadian Transportation Sector: Northern Territories. In Palko, K. and Lemmen, D.S. (eds.). *Climate risks and adaptation practices for the Canadian transportation sector 2016.* Ottawa: Government of Canada. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2016/ClimatRisk-E-ACCESSIBLE.pdf.

Schaefer, K., Y. Elshorbany, E. Jafarov, P. Schuster, R. Striegl, K. Wickland and E. Sunderland. 2020. "Potential impacts of mercury released from thawing permafrost." *Nature Communications* 11(1): 1–6. https://doi.org/10.1038/s41467-020-18398-5.

Sheedy, A. 2018. *The Impacts of Climate Change on Traditional and Local Food Consumption in the Yukon.* Arctic Institute of Community-Based Research. https://static1.squarespace.com/static/56afc7218259b53bd8383cb8/t/5b8c2dffcd8366d4a017b372/1535913475657/Literature+Review-CC+impacts+on+traditional+and+local+food+in+Yukon%5BRevised30Aug2018FINAL%5D.pdf.

Shift Collaborative. 2019. *Framework for Collaborative Action on Health & Climate Change User Guide.* Version 1. https://shiftcollaborative.ca/wp-content/uploads/2019/03/SHIFT-Framework-User-Guide-v04.pdf.

Shugar, D.H., J.J. Clague, J.L. Best, C. Schoof, M.J. Willis, L. Copland and G.H. Roe. "River piracy and drainage basin reorganization led by climate-driven glacier retreat." *Nature Geoscience* 10:370–375. https://www.nature.com/articles/ngeo2932.

Skierszkan, E.K., J.W. Dockrey, K. Ulrich Mayer and R.D. Beckie. 2020. "Release of geogenic uranium and varsenic results in water-quality impacts in a subarctic permafrost region of granitic and metamorphic geology." *Journal of Geochemical Exploration* 217:106607. https://doi.org/10.1016/j.gexplo.2020.106607.

Streicker, J. 2016. *Yukon Climate Change Indicators and Key Findings 2015.* Whitehorse: Northern Climate ExChange, Yukon Research Centre, Yukon College. https://www.yukonu.ca/sites/default/files/inline-files/Indicator_Report_Final_web.pdf.

WHO (World Health Organization). 2015. Operational framework for building climate resilient health systems. https://www.who.int/publications/i/item/operational-framework-for-building-climate-resilient-health-systems.

WMACNS (Wildlife Management Advisory Council North Slope). 2021. *The Significance of Aullaviat/Aunguniarvik.* https://wmacns.ca/yukon-north-slope/land/aullaviat/.