Transport Canada's

CLIMATE CHANGE ADAPTATION PLAN

2021/22 to 2025/26

Transport Canada Transports Canada

Canada

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Executive Summary

Canada's climate is warming at twice the global rate and the Canadian Arctic three times as fast (Flato et al., 2019, p.84). All transportation systems are climate-sensitive and these sensitivities can translate into infrastructure damage and deterioration, disruptions to transport operations, and unsafe conditions for users and operators. The changing climate is affecting, and will continue to affect, all modes of transportation in every Canadian region.

Transport Canada, as a federal department, a transportation asset owner and operator, and through our broader mission of promoting a transportation system in Canada that is safe, secure, efficient and environmentally responsible, has a responsibility to be climate resilient.

This five-year Adaptation Plan, informed by a comprehensive departmental climate risk assessment, presents a series of actions that Transport Canada will undertake to build its climate resilience. It will support Transport Canada in meeting our federal adaptation commitments, including under the Greening Government Strategy, and also help spur adaptation action across the transportation sector within our sphere of influence.

This Plan will be 'evergreen' over its five years, allowing for new or evolving climate risks and opportunities to be considered, and for new actions to be woven into the Plan as they are developed. It will contribute to the department's integrated risk management efforts and demonstrate Transport Canada's continued federal leadership in climate change adaptation.

Welcome to the Plan

Transport Canada's (TC) second Climate Change Adaptation Plan (the Plan) has been developed to position the department to better meet the challenges of a changing climate. More specifically, this five-year Plan will: support TC in meeting our federal adaptation commitments; position the department as a more effective steward of its assets; demonstrate federal leadership in adaptation; and build TC's climate resilience. The Plan will also help spur adaptation action across the transportation sector within our sphere of influence.

The Government of Canada's Greening Government Strategy, released in December 2017 and updated in late 2020, is a key driver for the development and content of this Plan. Under the GGS climate-resilient services and operations theme, departments aim to minimize disruptions and damage to their assets, services and operations related to the impacts of climate change (Treasury Board of Canada, 2020). Hence, a primary focus of this Plan's actions is internal, responsive to the results of our departmental climate risk assessment, and centred on our own assets and operations.

The Plan also contains existing and new actions relating to the regulatory, program and policy functions within TC's mandate that we can leverage to directly or indirectly address climate change impacts and support strengthened climate resilience of the transportation system - recognizing that in many cases, transportation adaptation decisions are ultimately taken by others. In this way, the Plan also supports TC's mission to promote a safe and secure, efficient and environmentally responsible transportation system in Canada.

The development of our Plan leveraged the knowledge and experiences gained from the implementation of our first Adaptation Plan, existing efforts such as TC-led adaptation programs, and the completion of a departmental climate risk assessment. This was a horizontal effort, with engagement from across the department's Directorates and Regions. This new Plan has four strategic goals, each with a set of actions. It is intended

to be 'evergreen', to allow for emerging climate risks and opportunities to be considered and for new actions to be woven into the Plan as they are developed. A first year priority will be the creation of a robust and ongoing performance measurement and reporting process for the Plan's actions and their implementation. The diagram in Figure 1 outlines how elements of the risk assessment and the Plan fit together.

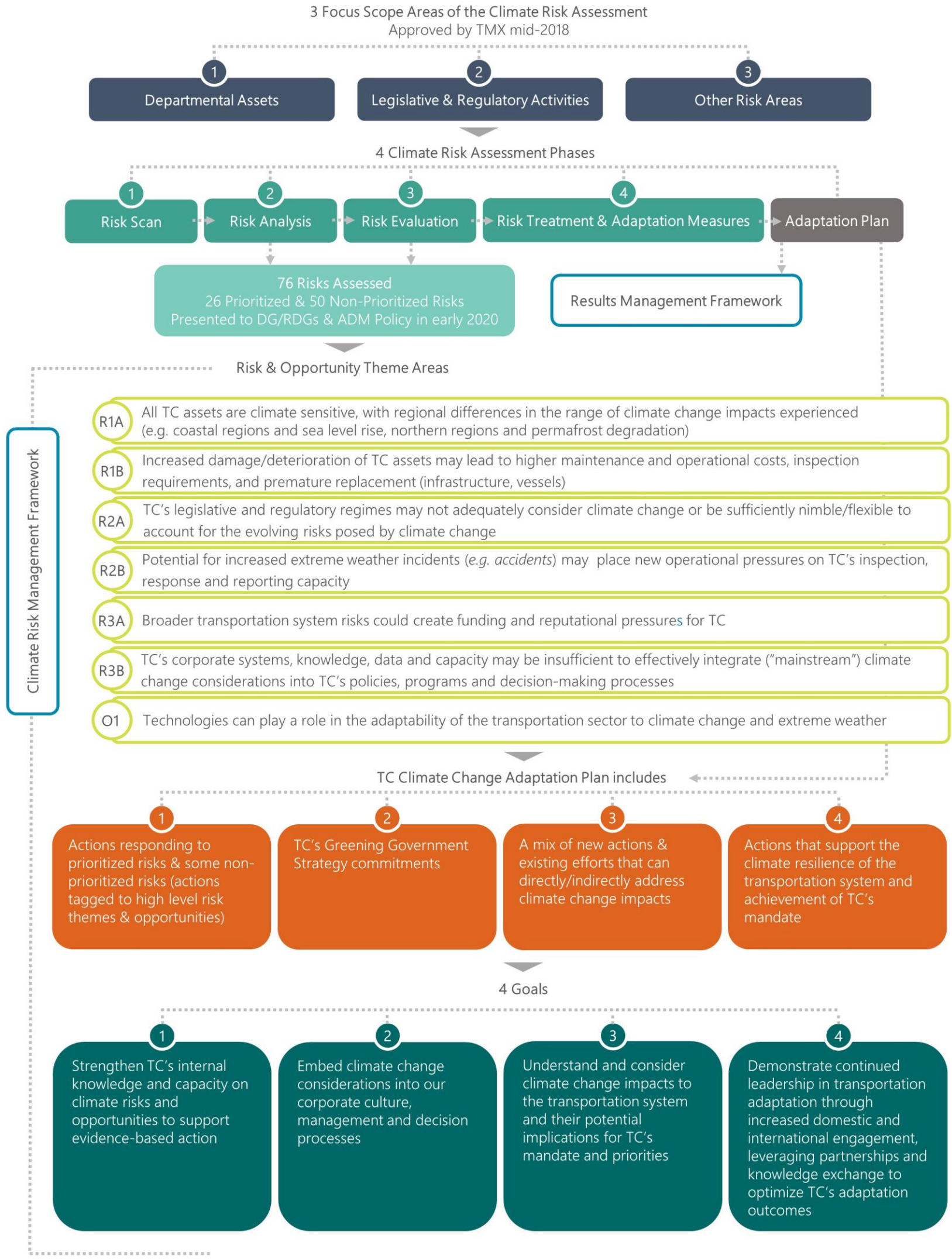

Figure 1. Visual narrative of the key components of, and linkages between, TC's climate risk assessment and the Adaptation Plan

The Plan's development also takes into account climate change projections and our current knowledge of the impacts of the changing climate on Canada's transportation system – a system in which TC not only plays a regulatory and oversight role, but is also an owner and operator of important transportation assets and infrastructure. Our context has also changed significantly since the launch of the departmental climate risk assessment, notably due to the COVID-19 pandemic, which has transformed the way we work. COVID-19's impact on transportation is being felt across the industry (Deloitte, 2020). Building the resilience of our systems and supply chains to stressors and shocks, including to climate, has become increasingly imperative, and there is a need more than ever to 'build back better' (OECD, 2020).

What Adaptation Means

An early definition of two terms often used when describing climate change will help to set the context for what appears later in the Plan – mitigation and adaptation.

Climate change mitigation aims to reduce greenhouse gas emissions contributing to climate change. Mitigation is necessary to reduce the rate and magnitude of climate change. In the context of transportation, mitigation addresses the *impact of transportation activity on the environment*.

Climate change adaptation involves taking action to reduce the vulnerability of natural and human systems to actual or expected changes to the climate (e.g., impacts of the environment on transportation). Adaptation is a form of risk management which can include adjusting activities, decisions and thinking in response to anticipated changes in climate, in order to moderate harm and take advantage of new opportunities. In other words, adaptation is a form of weather and climate risk management. In the context of transportation, adaptation addresses *the impact of the environment on transportation*.

The Changing Climate and Canada

"The Earth's climate is changing, and Canada is warming at a faster rate than most regions in the world." – Climate Risks & Adaptation Practices for the Transportation Sector 2016 (Andrey & Palko, 2017, p.3)

Scientific literature provides overwhelming evidence that the earth's climate is changing. According to a special report by the Intergovernmental Panel on Climate Change (Allen et al., 2018, p.59), human-induced warming reached approximately 1°C (Celsius) above pre-industrial levels by 2017 and continues to increase at a rate of 0.2°C per decade. Changes in climate have been observed through: an increase in global mean surface temperature, a warmer global climate average, warmer ocean surface temperatures, an increase in atmospheric humidity, global mean sea level rise and the loss of Arctic ice (Hoegh-Guldberg et al., 2018, p.186-206). The consequences of this 1°C warming can already be observed in the earth's atmospheric and natural systems (Hoegh-Guldberg et al., 2018, p.212-235).

DID YOU
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*"Global mean sea level has risen an estimated 0.19 metres (m) over the period 1901–2010 (90% uncertainty range between 0.17 m and 0.21 m) as a consequence of the expansion of ocean waters due to warming (warmer water takes up more volume) and the addition of new meltwater from shrinking glaciers and ice sheets worldwide." – **Canada's Changing Climate Report*** (Bush et al., 2019, p.29)

As per *Canada's Changing Climate Report*, which was released in 2019, Canada's climate is warming at twice the global rate and the Canadian Arctic three times as fast (Flato et al., 2019, p.84). From 1950 to 2010, the average annual temperature in Canada increased by close to 1.5°C. This same report also mentions that oceans surrounding Canada have

warmed, become more acidic, and less oxygenated, which is consistent with observed global oceanic changes over the past century (Bush & Lemmen, 2019, p.5).

In many parts of Canada, the effects of widespread warming can already be observed. According to scientific models and projections (e.g. Climate Model Intercomparison Project, CMIP5) these effects are projected to intensify in the future (Flato et al., 2019, p74-111) resulting in, for example, more extreme heat, less extreme cold, longer growing seasons, shorter snow and ice cover seasons, earlier spring peak stream flow, thinning glaciers, thawing permafrost, and fluctuating sea levels (Bush & Lemmen, 2019). In Canada, for example:

- Precipitation is projected to increase for most of Canada, while summer rainfall may decrease in some areas (Zhang et al., 2019, p.173).
- Seasonal availability of freshwater will fluctuate and the risk of water supply shortages in summer will increase (Bonsal et al., 2019, p.267-268).
- Extreme hot temperatures will become more frequent and more intense, increasing the severity of heat waves, and contribute to increased drought and wildfire risks (Zhang et al., 2019, p.154).
- Longer and more widespread sea-ice-free conditions are already observed in the Canadian areas of the Arctic and Atlantic Oceans. By mid-century, Canadian Arctic marine areas, including the Beaufort Sea and Baffin Bay, are projected to have extensive ice-free periods during summer (Derksen et al., 2019, p.200-201).
- Due to local sea level rise, coastal flooding is expected to increase in many areas of Canada such as the Atlantic and Pacific coasts of Canada and the Beaufort coast in the Arctic, where the land is subsiding or slowly uplifting (Greenan et al., 2019, p.387-388).
- The loss of sea ice will increase the risk of damage to coastal infrastructure and ecosystems as a result of larger storm surges and waves (Greenan et al., 2019, p.391-392).

The World Economic Forum's (2021, p.12) *Global Risks Report* identifies "climate action failure" as the second most impactful risk after infectious diseases, and "extreme weather" as the most probable risk to occur in the next two years. The economic costs of climate change and extreme weather in Canada are high and are expected to grow and many of these are costs incurred by the federal government. For example, the National Round Table on the Environment and the Economy (2011, p.40) suggest that the annual costs of inaction in Canada could rise from ~$5 billion on average in 2020 to $21-$43 billion by the 2050s. The Insurance Bureau of Canada (2019) estimates that for every dollar paid out in insurance claims for homes and businesses, the Canadian government pays out $3 to recover public infrastructure damaged by severe weather. According to the Parliamentary Budget Officer (2016, p.1), since 2010, liabilities accruing to the Disaster Financial Assistance Arrangements (DFAA) program have regularly exceeded $1 billion on a yearly basis.

Climate Change and Transportation

A well-functioning transportation system is a key economic enabler and critical for the competitiveness of our economy and ensuring Canadians' quality of life. Our economy relies on an efficient and competitive national transportation system that can export and import goods, including access to domestic and international markets through our trade corridors for natural resources, agricultural products and manufactured goods. In addition to movements of freight traffic, a well-functioning system is also important for the movement of people. The recent COVID-19 pandemic has shown us how external stressors can affect our supply chains and put our transportation system to the test, and how important it is to keep our supply chains moving during these times of crisis. Climate change and related stressors also have the potential to stress our supply chains and transportation systems.

All transportation systems are climate-sensitive and these sensitivities can translate into infrastructure damage and deterioration, disruptions to transport operations, and unsafe

conditions. Extreme weather events (e.g., hurricanes, extreme temperatures), as well as slower onset climate changes (such as permafrost thaw) and combination events (e.g., storms and floods), are already putting pressure on transportation supply chains and affecting efficiency, whether through direct impacts or the exacerbation of existing challenges, including bottlenecks within trade corridors.

Some of the most vulnerable components of Canada's transportation system are integral to remote and resource-based communities in the North. However, the changing climate is, and will continue to, affect all modes of transportation in every Canadian region.

A Council of Canadian Academies (2019, p.ix) report on *Canada's Top Climate Change Risks* found that climate risks to Canada are most acute in six areas, three of which relate directly to transportation – physical infrastructure, coastal and northern communities. Transportation's sensitivities to climate and extreme weather are illustrated by the impacts of events in recent years, such as an increased number of closures of the Confederation Bridge due to high winds, preventing the movement of buses and trucks (Rapaport et al., 2017, p.230), and the June 2013 floods in Alberta which resulted in an estimated $6 billion in damages and recovery costs, and saw 1,000 km of roads destroyed and hundreds of bridges and culverts washed out (Casello & Towns, 2017, p.275).

In 2017/2018, the Hudson Bay Rail Line closed for 18 months, due to cumulative effects of flooding damage and degrading muskeg/permafrost. Without a viable second mode of transportation to bring goods in and out of the community, living

What We Heard

In early 2021, TC engaged with Federal, Provincial and Territorial (FPT) stakeholders as part of a "State of Play" exercise on transportation adaptation. Highlights of 'what we heard' include:

- disruptions due to extreme weather and a changing climate are increasingly impacting transportation corridors which has led to greater interest in understanding system interdependencies and socioeconomic risks;
- PTs have been transitioning from conducting climate risk assessments to applying climate knowledge in their decision-making tools; there has been an increase in the use of innovative technologies to monitor climate conditions and climate risks to transportation assets; and,
- PT transportation stakeholders want to engage more with other PTs, asset operators and users, climate experts and data providers, Indigenous practitioners, and communities.

expenses escalated and some First Nation communities had difficulty accessing medical services in the South (CTV, 2018). And during the winter of 2013/2014, the average rail-freight train speed in the Prairies was reduced by approximately 13 percent, due in part to extreme cold, which resulted in a 30 percent decrease in car-order fulfillment rate (Phillips & Town, 2017, p.126).

Transportation adaptation action is needed to strengthen the transportation system's resilience to both current and future climate conditions in Canada. Responsibility for transportation adaptation lies with sector owners and operators, including TC and other federal partners, as well as other jurisdictions and industry. There are significant complexities involved in advancing adaptation across the sector given the range of cross-sectoral implications, diverse needs of stakeholders, domestic and international dimensions, and the interdependencies and interconnectedness between modes.

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What does adaptation look like in the transportation sector?

For owners and operators in the transportation sector, including TC, adaptation can cover a range of approaches, such as:

Integrating climate considerations into organizational planning, policies and designs - known as 'mainstreaming', this refers to the practice of systematically considering climate risks in broader organizational plans and requirements.

Undertaking risk and vulnerability assessments - processes that assess the vulnerability of transportation infrastructure and operations to climate change and associated risks. Results can inform investments and operational decisions.

Implementing structural and physical (engineering) adaptations - solutions that enhance the physical resiliency of transportation networks or infrastructure components. In some cases, structural adaptations are part of broader climate adaptation strategies and programs.

Integrating smart technologies - monitoring and communications technologies and tools, these can provide climate and weather data to support adaptation decision-making, and allow real-time monitoring of asset conditions.

Changing operations and maintenance practices - such as enhanced site monitoring and accelerated inspection processes/increased maintenance to quickly respond to changing conditions

Adaptation is a Federal Priority

The need to adapt to a changing climate has continued to evolve as an increasingly important issue, both internationally and domestically. Federal departments are expected to be aware of climate risks to their respective mandates, and to adapt their policies, programs and practices accordingly. Several of these key policy drivers are outlined below.

The Federal Adaptation Policy Framework guides domestic action by the Government of Canada to address adaptation. It sets out a vision for adaptation in Canada, defines objectives and roles of the federal government, and provides criteria for setting priorities for action (Government of Canada, 2011). It defines the unique federal role as:

- Generating and sharing knowledge;
- Building adaptive capacity to respond and helping Canadians take action; and,
- Integrating adaptation into federal policy and planning (mainstreaming)

In December 2016, the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) was released, which included numerous actions to meet Canada's emissions reduction targets, grow the economy, and build resilience to a changing climate (Environment and Climate Change Canada, 2016). One of the four pillars of the PCF is "Measures to adapt to the impacts of climate change and build resilience".

TC supports two priority areas under this pillar 'building climate resilience through infrastructure'; and 'supporting particularly vulnerable regions'. Since this time, under the 'Strengthened Climate Plan', the federal government also proposes to develop Canada's first-ever National Adaptation Strategy.

In addition, under the Government of Canada's GGS, federal departments, including TC, are required to:

- Understand and reduce climate change risks to federal assets, services and operations across the country;
- Incorporate the consideration of climate change in business continuity planning, departmental risk planning, and program design and delivery considerations; and
- Integrate climate change adaptation into the design, construction and operation aspects of all major real property projects.

DID YOU
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The 2017 Commissioner of the Environment and Sustainable Development's audit praised Transport Canada as the "gold star" of how federal departments should be preparing for climate related risks. The audit also found TC to be the only department with an adaptation plan in place.

In addition to these policy drivers, the Commissioner of the Environment and Sustainable Development in the fall 2017 audit report stated that: "federal departments and agencies must be proactive to integrate climate change adaptation into their programs and services. Departments and agencies are expected to be aware of the risks to their mandates and adapt their policies and practices based on their vulnerability assessments" (Office of the Auditor General of Canada, 2017, para.2.50)

Adaptation Action at TC

Recognizing the range of potential risks posed by climate change to Canada and its transportation sector, TC developed and implemented its first three-year Climate Change Adaptation Plan. This first Plan was an important first step in better understanding and addressing climate risks to the department, and building TC's own capacity, which were essential foundational elements in strengthening TC's climate change resilience. The process was informed by a literature review and a climate risk scan, through which

climate risks to the department were identified in three areas: TC assets, regulatory activities, and other areas (such as programs, partnerships and initiatives).

TC currently has two adaptation programs, which focus on building knowledge and capacity and convening transportation adaptation stakeholders. These include:

- The Northern Transportation Adaptation Initiative (NTAI), which has been in place since 2011 and received $6.9 million over three years in Budget 2017, was established to support the efficiency, safety, and environmental sustainability of northern transportation systems in light of the effects of a changing climate. The NTAI supports research, knowledge dissemination and the development and testing of innovative technologies, with a focus on increasing the capacity of Northerners to adapt their transportation systems to a changing climate.

DID YOU
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As of February 2021, the TARA initiative has funded climate risk assessments of 45 transportation assets, covering all modes of transportation and across each of TC's five regions. For example, the TARA initiative has supported climate risk assessments of six of TC Atlantic Region's ferry terminals, to better understand the impact of rising sea levels, increased storm surges and high winds to vessels and ports, in order to identify potential adaptation solutions.

In October 2017, Transport Canada's Transportation Assets Risk Assessment (TARA) initiative was announced, receiving up to $16.35 million over five years. The TARA initiative provides funding to federally-owned and/or federally-managed transportation assets (e.g. federal highways, bridges, ports and airports) for climate risk assessments and related activities. The objective is to provide information to owners and operators, including Transport Canada, to make better climate-informed decisions in their asset management and business practices.

Other important adaptation efforts at Transport Canada include:

- Co-leading *The Climate Risks & Adaptation Practices for the Canadian Transportation Sector 2016* report with Natural Resources Canada. Available online, this comprehensive report provided the current state of knowledge on climate risks and adaptation practices for the Canadian transportation sector across all modes.
- Applying a climate change resilience assessment lens to project proposals submitted under the National Trade Corridors Fund (NTCF). One of the program's four primary objectives[1] is to increase the resilience of the Canadian transportation system in a changing climate and ensure it adapts to new technologies and future innovation.
- Hosting a Transportation Adaptation Webinar Series in order to build capacity, and share knowledge and information within our department and the broader Canadian transportation sector on the impacts of a changing climate and adaptation solutions. Since 2015, these have collectively attracted approximately 1,390 participants from all levels of government, industry, associations, academia, and non-governmental organizations.
- Actively engaging in various domestic and international fora, leveraging opportunities to both contribute the department's expertise and experiences to advance the state of knowledge on climate risk assessment and transportation adaptation, and also to learn from our peers. TC is increasingly playing a leadership role, for example, by participating as a Board Member for the Natural Sciences and Engineering Research Council (NSERC)-funded PermafrostNet, and as a vice-chair of the United Nations Economic Commission for Europe Group of Experts on the Assessment of Climate Change Impacts and Adaptation for Inland Transport.

Finally, Transport Canada (TC) has developed an Arctic Transportation Policy Framework (ATPF) to reflect the unique multi-modal transportation challenges in the territorial North. The Framework also includes several elements related to climate change (e.g.

[1] The three other objectives of the NTCF program are – to support the fluidity of Canadian trade, address the transportation needs of Arctic and Northern communities, and leverage investments from multiple partners.

protecting the fragile arctic environment, and adapting infrastructure & transportation operations to climate change). The ATPF obtained approval under Canada's Arctic and Northern Policy Framework (ANPF), to guide TC in enhancing the overall safety, reliability, efficiency, sustainability, and accessibility of Canada's territorial Northern transportation system.

Through our NTAI, TC promotes the knowledge exchange among governments, practitioners and researchers to enhance understanding of knowledge gaps; provides funding support to leverage academic expertise to address gaps; and undertakes related activities aimed at disseminating the considerable advances being generated by research partners. TC is increasingly playing a leadership role, for example, by participating as a Board Member for the Natural Sciences and Engineering Research Council (NSERC)-funded PermafrostNet, and as a vice-chair of the United Nations Economic Commission for Europe Group of Experts on the Assessment of Climate Change Impacts and Adaptation for Inland Transport.

First Plan Achievements

The first Plan provided a solid foundation for the department on adaptation action. It centered on two overarching goals and 28 actions. Of these, 24 actions were completed.[2] Examples of key outcomes in the following three areas include:

1 Improved knowledge & capacity

- Conducted engineering vulnerability assessments for three northern airports (Churchill, Inuvik (Mike Zubko), Cambridge Bay)
- Hosted a Transportation Adaptation Webinar Series – six webinars held, attended by over 500 participants (TC, other levels of government, industry, academia),

[2] Four commitments were not feasible or were delayed (superseded by other priorities, legislative amendments, and/or responsibilities transferred to other departments).

- Released the *Climate Risks & Adaptation Practices for the Canadian Transportation Sector 2016* report. It was downloaded in full or by individual chapter 1290 times [as of October 2017]

2 Strengthened networks

- Engaged in fora such as the Natural Resources Canada Adaptation Plenary and Platform Working Groups and various technical committees of the Transportation Association of Canada
- Supported the development of a Transportation Association of Canada climate change risk assessment tool

3 Increased integration

- Climate risk considerations increasingly incorporated into the department's environmental scan and corporate risk profile, for example: into the corporate risk profile and environmental scan since 2011/2012 and 2012/2013, respectively, and in the Departmental Plans and Departmental Results Reports since 2011/2012;
- TC's Sustainable Transportation Assessment Tool, which is an enhanced Strategic Environmental Assessment preliminary scan, includes a question on 'adaptive capacity'.

Through the implementation of the first Plan and our further transportation adaptation policy and program work, TC has advanced action to better understand and address climate risks to the department and the transportation sector. While notable progress has been made in many areas such as mainstreaming climate considerations into departmental processes and in building capacity, many of the key themes from the first Plan remain relevant and require continued or deeper action moving forward. The range of measures in TC's adaptation plan has been broadened to account for newly identified risks, opportunities and gaps.

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NTAI funding support helped to assess the effectiveness of adaptation work completed at Iqaluit Airport to better deal with permafrost degradation underneath the runway, taxiways and aprons. Work also focused on transferring this knowledge to the airport managers to strengthen their capacity to monitor permafrost conditions and be positioned to adapt as required.

Advancing Ambitious Action

This second Adaptation Plan continues TC's efforts to be an effective steward of federal assets and operations, carries forward TC's leadership in climate change adaptation, and builds on the knowledge gathered and results achieved through the implementation of the first Plan. It also strives towards an increasing level of ambition, through the pursuit of an 'evergreen' plan and the inclusion of an additional list of proposed 'future potential' actions that are ready to be implemented (see Section B), but are currently pending future available resources.

This Plan meets our federal role under the Federal Adaptation Policy Framework and includes our initiatives in support of the Pan-Canadian Framework on Clean Growth and Climate Change. The Plan also directly contributes to the Federal Sustainable

Development Strategy, TC's Departmental Sustainable Development Strategy, the Greening Government Strategy, and several of the UN Sustainable Development Goals, as highlighted in Figure 2 below.

Figure 2. Our Adaptation Plan contributes to meeting key United Nations Sustainable Development Goals and Federal Sustainable Development Goals

The Scope and Methodology

In developing this second Adaptation Plan, TC considered risks and opportunities across the three areas below. The approach did not preclude the consideration of other risks to the broader transportation system that could affect the department, for example, impacts to TC's mandate or new funding pressures. The scope of issues considered under each of these three areas reflects both a more comprehensive process and a greater maturity in our corporate climate risk knowledge compared to the first Plan.

1 Departmental assets, including but not limited to, airports and ports, that are both owned and operated by TC;
2 Legislative and regulatory activities, including legislation, regulations, and standards, led by TC; and

3 Other risk areas, such as: TC's policies, corporate risks, policies, programs, federal assets operated by others.

This Plan is also based on the results of a more robust climate change risk assessment. This included aligning the work with the ISO 31000: Risk Management Guidelines (see Figure 3), and engaging officials across TC to not only identify but also analyze and evaluate risks, a step not taken under the first Adaptation Plan. The climate risk assessment was also grounded in a much stronger evidence base (i.e. transportation sector report; regional/downscaled climate data which covered a wider range of climate change variables across all regions of Canada).

To determine consequence and likelihood ratings, TC defined common rating scales, based upon the department's corporate risk documents. Risk likelihood was based on the probability of the occurrence of the climate variable, with five pre-defined levels. The likelihood of each risk was based on climate information examined by subject matter experts (consultants with climate data expertise).

Figure 3. The steps TC's climate risk assessment followed

Consequences were assessed using the following criteria: 1) Magnitude (e.g., scale and intensity), 2) Persistence and reversibility (e.g., are the effects reversible) and 3) Distribution (e.g., local or distributed effects). Consequences ranged from negligible to extreme across three groups: 1) Assets; 2) People; and 3) TC's mandate and responsibilities.

The Results

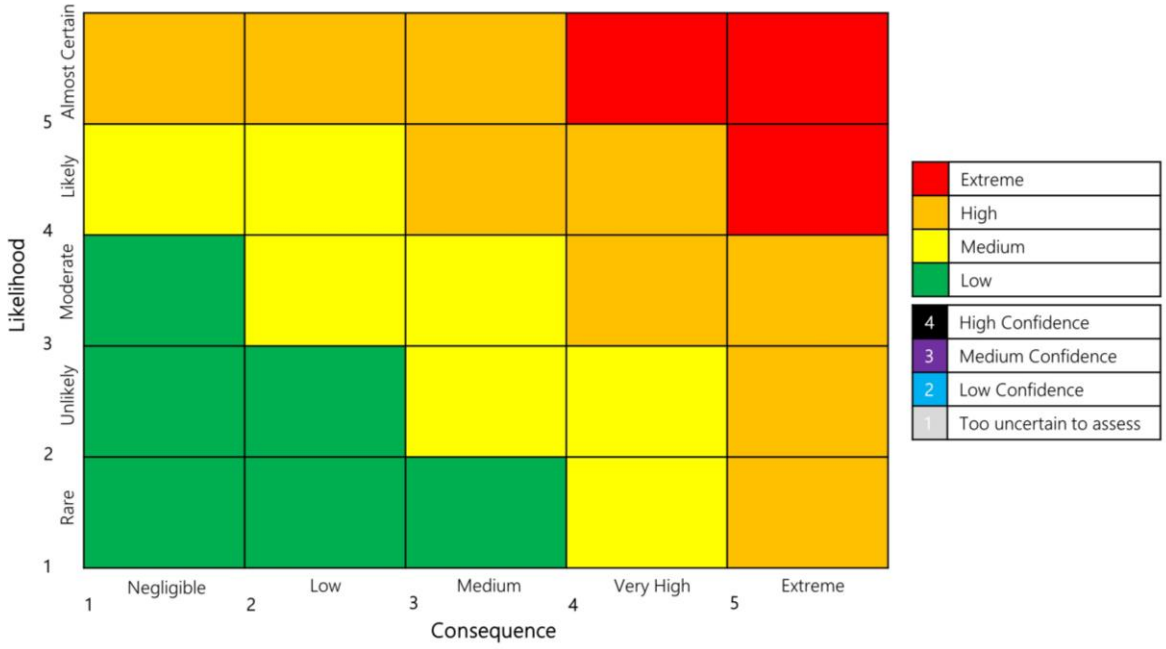
The risk evaluation phase resulted in 26 prioritized and 50 non-prioritized climate risks, organized for ease of reference across six broad groupings: Aviation, Marine, Surface, Multimodal, Corporate, and Transportation of Dangerous Goods, Emergency Preparedness, Management and Response. Opportunities for risk mitigation were also identified. This full set of risks was then analyzed and evaluated in sessions held with TC

staff to determine overall risk ratings for each residual risk, after accounting for existing mitigation (control) measures. Consistent with other risk processes in TC, we decided that:

- Prioritized risks were those that fell within the high (orange) category either in the current or future period (2050s[3]), and risk treatment measures should be developed. No risks were identified in the extreme (red) category.
- Risks that fell in the medium (yellow) or low (green) categories either in the current or future period were deemed to be within tolerable risk levels, with the understanding that existing control measures were in place.

Several high-level risk themes and one high-level opportunity emerged from the analysis. Overall, it was found that extreme weather events (e.g. storms, floods, etc.) and slower-onset climate impacts (e.g. permafrost degradation, sea level rise, etc.) currently pose risks to TC, and may increase in the future. While no 'extreme' (red) risks to TC were identified, some risks move from 'medium' (yellow) in current period to 'high' (orange) in future period. TC has many existing controls in place, such as operational procedures at airports and ports, however, new adaptation measures are needed to further reduce the level of some risks. TC needs to plan for, and be better prepared for, climate change.

[3] Future conditions for the period of 2031-2060 (referred to as 2050s)



Figured 4. An example of a risk matrix used in the climate risk assessment evaluation step

The Adaptation Plan actions were developed to address risks identified and evaluated during the risk assessment. We grouped these risks into high-level risk themes (see below) as a means to summarize the results of the risk assessment at a high-level. The risk themes below also align with the scope of the departmental risk assessment:

R1 | Departmental assets (e.g. TC-owned and operated airports & ports)

- Risk Theme R1A. All TC assets are climate sensitive, with regional differences in the range of climate change impacts experienced (e.g. coastal regions and sea level rise, northern regions and permafrost degradation)
- Risk Theme R1B. Increased damage/deterioration of TC assets may lead to higher maintenance and operational costs, inspection requirements, and premature replacement (infrastructure, vessels)

R2 | Legislative and regulatory activities

- Risk Theme R2A. TC's legislative and regulatory regimes may not adequately consider climate change or be sufficiently nimble/flexible to account for the evolving risks posed by climate change

- Risk Theme R2B. Potential for increased extreme weather incidents (e.g. accidents) may place new operational pressures on TC's inspection, response and reporting capacity

R3 | Other risk areas (e.g., programs and policies, corporate risks, transportation system)

- Risk Theme R3A. Broader transportation system risks could create funding and reputational pressures for TC
- Risk Theme R3B. TC's corporate systems, knowledge, data and capacity may be insufficient to effectively integrate ('mainstream') climate change considerations into TC's policies, programs and decision-making processes

While the primary focus and key outcomes of the climate risk assessment focused on risks, there was one overarching opportunity which emerged:

O1 | Opportunity: Technologies can play a role in the adaptability of the transportation sector to climate change and extreme weather.

Following the risk evaluation phase, Directorates and Regions were asked to develop risk treatment measures for each prioritized residual risk, and provide information on existing adaptation efforts underway in response to the non-prioritized risks. These risk treatment measures were analyzed, and draft adaptation plan actions were developed. Concurrently, the results of the climate risk assessment were considered alongside corporate and public risks within TC's integrated risk process. The achievement of our Adaptation Plan actions will help the department address several of these integrated risks.

TC is taking an adaptive planning approach within this Plan, which will be 'evergreen' to allow for the consideration of new climate risks as they emerge, and new Adaptation Plan actions as they are developed – increasing our flexibility and opportunities for ambition over the life of the Plan.

The actions presented in this first year of the Plan in Section A include those which are currently underway or new, and for which their costs are already captured in existing

DID YOU
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NTAI funding is supporting the Northern Climate ExChange at Yukon University to design and implement systems to alert transportation infrastructure managers about climate change-related hazards, such landslides and ground subsidence caused by permafrost thaw. This pan-northern project involves sites in Yukon, in Nunavut and in Nunavik, northern Québec. Collaborators include Université Laval, Université de Montréal, Transports Québec, and Yukon Highways and Public Works.

budgets or can be absorbed within current departmental resources. As part of this Plan's development, a series of additional 'future potential' actions, which are ready for implementation but do not currently have a funding source, can be found in Section B for consideration in future year updates. Environmental Policy will work with Directorates and Regions to explore opportunities for funding and work with Corporate Planning and Reporting to leverage the department's integrated risk management efforts and Integrated Business Planning process to support adaptation action.

A second important characteristic of this Plan is an intentional shift from risk identification towards the management of climate risks. As such, a key first year action will be the finalization and implementation of a departmental climate risk management framework. Moreover, during the first year of the Plan, TC will develop a results based management approach in order to track progress and measure the effectiveness of our actions undertaken under the Plan. Building from the goals and actions identified herein, TC will further identify associated targets and indicators, as well as monitoring and reporting processes. A feedback loop will be developed, ensuring TC is learning from its actions and adapting its approach as needed.

Our 5-Year Plan of Action

Section A presents TC's Adaptation Plan actions, according to the following four goal areas:

Goal 1 | Strengthen TC's internal knowledge and capacity on climate risks and opportunities to support evidence-based action

Under this goal, TC teams and employees would gain the ability to take adaptation action in their work; this goal would include learning activities, identifying and addressing information gaps, and knowledge dissemination

Goal 2 | Embed climate change considerations into our corporate culture, management and decision processes

Activities under this goal will target the mainstreaming of climate considerations into TC's corporate planning and decision-making tools, relevant regulatory processes, programs, plans, and strategies

Goal 3 | Understand and consider climate change impacts to the transportation system and their potential implications for TC's mandate and priorities

Activities under this goal will support TC's need to continue to effectively deliver its mandate of a safe and secure, efficient and environmentally responsible transportation system within a context of evolving climate change impacts, ranging from adaptation cost-benefit analysis to research on potential climate mitigation and adaptation co-benefits in the transportation sector

Goal 4 | Demonstrate continued leadership in transportation adaptation through increased domestic and international engagement, leveraging partnerships and knowledge exchange to optimize TC's adaptation outcomes

Activities under this goal will ensure that TC continues to engage with domestic and international fora, leverages opportunities to both contribute the department's

expertise and experiences to advance the state of knowledge on transportation adaptation, and is able to learn from its peers

While several goals represent a continuation and extension of key priorities areas from our first Plan (e.g. capacity building), further consideration was given as part of their development to additional areas where we can demonstrate an increasing level of ambition and leadership moving forward. Each goal contains a collection of actions and each of these:

- identifies the lead and supporting Directorates/Regions in the department responsible for undertaking it;
- shows a cross-walk with the high-level risk themes presented on pages 31 and 32 that the action helps address; and
- where applicable, is tagged with the Federal Greening Government Strategy icon, if the action supports the department's Greening Government Strategy commitments.

Roles, Responsibilities and Reporting

Directorates and Regions are primarily responsible for delivering their actions, and reporting on progress. TC's Environmental Policy Directorate is the overall lead on adaptation policy for the department and is responsible for the coordination of the Climate Change Adaptation Plan and is a point of contact for the department. Given the 'evergreen' nature of the Plan, TC's Environmental Policy Directorate will also continue to engage across the department on potential new adaptation actions which could be incorporated in annual updates.

Early on within the first year of implementation (2021/2022), the Environmental Policy Directorate will engage those Directorates and Regions with Adaptation Plan actions in the development of a results management framework for the Plan, which will include targets and indicators and an annual progress reporting process.

To conclude, over our past eleven years of dedicated adaptation efforts, TC has learned that strengthening our climate resilience is indeed a journey, as we continue to build on our initiatives, leverage our experience and engagement, and apply advancements in knowledge, capacity and information in climate science, assessing risk and adaptation. This Plan represents our next step on this path towards reducing climate risks and making more informed climate decisions, and within the sphere of TC's influence, better positioning the transportation sector to take adaptation action.

Section A

TC Climate Change Adaptation Actions

LEGEND	
	Lead OPIs
	Supporting OPIs
	Risk theme to which the action corresponds
	TC DSDS/Greening Government Strategy actions
●	Ongoing actions of the year in which the action is anticipated to begin
★	NEW commitment

GOAL 1 | Strengthen TC's internal knowledge and capacity on climate risks and opportunities to support evidence-based action

Under this goal, TC teams and employees would gain the ability to take adaptation action in their work; this goal would include learning activities, identifying and addressing information gaps, knowledge dissemination

ID	ACTION	ONGOING	STARTING YEAR				
			1	2	3	4	5
1.1	★ NEW COMMITMENT | Develop a strategic communications plan, with internal and external components, to help raise awareness of adaptation initiatives already in place at TC and progress being made towards achieving new adaptation efforts Lead OPI | Environmental Policy · Supporting OPI | Communications · R3B		●				

GOAL 1 | Strengthen TC's internal knowledge and capacity on climate risks and opportunities to support evidence-based action *Under this goal, TC teams and employees would gain the ability to take adaptation action in their work; this goal would include learning activities, identifying and addressing information gaps, knowledge dissemination*							
1.2	★ NEW COMMITMENT | Identify data gaps and share information on migratory changes and the impacts of climate change on wildlife at airports Lead OPI | Civil Aviation · R1A · R3A		●				
1.3	★ NEW COMMITMENT | Engage with TC's Young Professionals Network on adaptation issues Lead OPI | Environmental Policy · R1A · R1B · R3B			●			
1.4	EXISTING COMMITMENT | Implement the Transportation Assets Risk Assessment initiative to: Support risk assessments of federally-owned and/or managed transportation infrastructure; Support research and analysis on risk assessments and climate change adaptation solutions that are of benefit to federal infrastructure; and Share information and analysis with the broader transportation sector to aid in spurring action and increasing the understanding of risks and potential solutions that can be employed Lead OPI | Environmental Policy · Supporting OPI | Transportation Infrastructure Programs · R1A · R1B · R3A · R3B	●					
1.5	EXISTING COMMITMENT | Ensure that scans of emerging transportation technologies and engagement with stakeholders (e.g. Commodity Supply Chain Table, Intelligent Transportation Systems Canada, port authorities, carriers, other federal departments, provinces etc.), which are undertaken to advance TC's knowledge of disruptive and innovative technologies, can be leveraged to also advance technologies that can help improve the climate resilience of Canada's transportation system. Lead OPI | Strategic & Innovation Policy · Supporting OPI | Environmental Policy · R3A · R3B	●					
1.6	EXISTING COMMITMENT | Facilitate departmental adaptive capacity building activities that help strengthen TC's climate change adaptation knowledge and capacity *Capacity-building activities will include, but are not limited to, webinars, training, infographics, presentations etc.* Lead OPI | Environmental Policy · R3B	●					
1.7	EXISTING COMMITMENT | Project to monitor the permafrost under the runways at TC-owned Kuujjuaq airport Lead OPI | Quebec Region · Supporting OPI | Environmental Policy		●				

Goal 2 | Embed climate change considerations into our corporate culture, management and decision processes

Activities under this goal will target the mainstreaming of climate considerations into TC's corporate planning and decision-making tools, relevant regulatory processes, programs, plans, and strategies

ID	Action	ONGOING	STARTING YEAR				
			1	2	3	4	5
2.1	★ NEW COMMITMENT | Strengthen collaboration around transportation adaptation, emergency management and disaster risk reduction within TC and with other relevant government departments as opportunities are identified. Lead OPIs | Environmental Policy · Emergency Preparedness & Management · R3A · R3B			●			
2.2	★ NEW COMMITMENT | Develop and implement TC's climate risk management framework, with initial focus on determining an efficient adaptation plan update process Lead OPI | Environmental Policy · All		●				
2.3	★ NEW COMMITMENT | Develop and implement a results management framework for TC's adaptation plan actions Lead OPI | Environmental Policy · All		●				
2.4	★ NEW COMMITMENT | Enhance the scope of TC's Airport Capital Assistance Program (ACAP) to fund adaptation projects and build climate change considerations into the ACAP's overall scoring matrix Lead OPI | Air, Marine & Environmental Programs · R3B		●				
2.5	★ NEW COMMITMENT | Meet and review with Ottawa Airport Authority to ensure the annual contract between the Airport Authority and TC's Aircraft Services Directorate (ASD) ramp is a priority for snowfall removal to minimize impact on priority Flight Operations Lead OPI | Aircraft Services · R1A · R3B		●				
2.6	★ NEW COMMITMENT | Include climate change considerations, where applicable, within departmental policy reviews to spur strengthened climate resilience across TC's sphere of influence. Lead OPI | Strategic & Innovation Policy · Supporting OPI | Environmental Policy · R3B		●				

Goal 2 | Embed climate change considerations into our corporate culture, management and decision processes *Activities under this goal will target the mainstreaming of climate considerations into TC's corporate planning and decision-making tools, relevant regulatory processes, programs, plans, and strategies*							
2.7	EXISTING COMMITMENT | Apply the Arctic and Northern Lens Assessment to all proposed policies, programs, and regulations to ensure that climate considerations unique to Canada's territorial North are assessed and factored into proposals being advanced by the department Lead OPI | Strategic & Innovation Policy; Supporting OPI | Environmental Policy; Supporting OPI | Multi-modal & Road Safety Programs; R3B		●				
2.8	EXISTING COMMITMENT | Integrate climate change impacts and adaptation into departmental program design and delivery criteria Lead OPI | Environmental Policy; Supporting OPI | Air, Marine & Environmental Programs; R3B		●				
2.9	EXISTING COMMITMENT | Continue to apply the Climate Change Adaptation and Resilience Assessment application requirements of the National Trade Corridors Fund (NTCF) Climate Lens to account for climate change-related risks Lead OPI | Environmental Policy; Supporting OPIs | International Relations and Trade Policy; Transportation Infrastructure Programs; R3A; R3B	●					
2.10	EXISTING COMMITMENT | Account for current and future potential climate risks within departmental business continuity and risk planning in order to adjust TC's risk response and processes, thus strengthening departmental resilience Lead OPI | Corporate Planning & Reporting; Financial Operations, Admin Services & Chief Procurement Officer; Supporting OPI | Environmental Policy; R3B	●					
2.11	EXISTING COMMITMENT | Inform TC's investment planning process through the incorporation of climate change impacts and adaptation considerations within capital and operating approval documents Lead OPI | Finances & Deputy Chief Financial Officer; Supporting OPIs | Environmental Policy; Air, Marine & Environmental Programs; R3B		●				
2.12	EXISTING COMMITMENT | Establish mechanisms that facilitate the consideration of climate risks within the design, construction and operations / maintenance aspects of TC's assets and real property projects Lead OPI | Environmental Policy; Supporting OPI | Air, Marine & Environmental Programs; R1A; R1B		●				

Goal 2 | Embed climate change considerations into our corporate culture, management and decision processes

Activities under this goal will target the mainstreaming of climate considerations into TC's corporate planning and decision-making tools, relevant regulatory processes, programs, plans, and strategies

2.13	EXISTING COMMITMENT | Include climate resilience as an element of TC's research and development (R&D) and innovation initiatives, where appropriate Lead OPI | Innovation Centre · R1A · R1B · R3A · R3B	●					

Goal 3 | Understand and consider climate change impacts to the transportation system and their potential implications for TC's mandate and priorities

Activities under this goal will support TC's need to continue to effectively deliver its mandate of a safe and secure, efficient and environmentally responsible transportation system within a context of evolving climate change impacts, ranging from adaptation cost-benefit analysis to research on potential climate mitigation and adaptation co-benefits in the transportation sector

ID	Action	ONGOING	STARTING YEAR				
			1	2	3	4	5
3.1	★ NEW COMMITMENT | Undertake efforts to better understand the costs of climate change impacts and the benefits of adaptation in the transportation sector Lead OPI | Environmental Policy · R3A			●			
3.2	★ NEW COMMITMENT | Collaborate with Environment and Climate Change Canada's Canadian Centre for Climate Services to better understand and address TC's and the broader transportation sector's climate data needs, and advance efforts to share decision-relevant weather and climate information Lead OPI | Environmental Policy · R1A · R3A · R3B		●				
3.3	★ NEW COMMITMENT | Undertake action to better understand the benefits of nature-based adaptation solutions in the transportation sector Lead OPI | Environmental Policy · R1A · R3A · R3B			●			
3.4	★ NEW COMMITMENT | Conduct a study on co-benefits of adaptation/mitigation in the transportation sector Lead OPI | Environmental Policy · R3A · R3B				●		

Goal 3 | Understand and consider climate change impacts to the transportation system and their potential implications for TC's mandate and priorities *Activities under this goal will support TC's need to continue to effectively deliver its mandate of a safe and secure, efficient and environmentally responsible transportation system within a context of evolving climate change impacts, ranging from adaptation cost-benefit analysis to research on potential climate mitigation and adaptation co-benefits in the transportation sector*							
3.5	★ NEW COMMITMENT | Undertake efforts (e.g. a study/research) to better understand the economic and transportation impacts of disruptions due to climate change on the transportation system for specific modes and supply chains Lead OPI | Economic Analysis; Supporting OPI | International Relations & Trade Policy; R3A; R3B		●				
3.6	★ NEW COMMITMENT | Update Standard 322 to include requirements for airport personnel to be trained on wildlife management, migratory changes and patterns due to a changing climate Lead OPI | Civil Aviation; R2A; R3A		●				
3.7	EXISTING COMMITMENT | Continue to monitor climate and extreme weather-related disruptions at ports and their potential impact on Canadian port sector to inform potential future policy development Lead OPI | Marine Policy; Supporting OPI | Economic Analysis; R2B; R3A	●					
3.8	EXISTING COMMITMENT Identify and map transportation infrastructure and networks that are vulnerable and could be impacted by climate change or extreme weather events such as hurricanes, floods, wildfires, droughts etc. Lead OPI | Economic Analysis; Supporting OPI | Environmental Policy; R3A; R3B	●					

Goal 4 | Demonstrate continued leadership in transportation adaptation through increased domestic and international engagement, leveraging partnerships and knowledge exchange to optimize TC's adaptation outcomes

Activities under this goal will ensure that TC continues to engage with domestic and international fora, leverages opportunities to both contribute the department's expertise and experiences to advance the state of knowledge on transportation adaptation, and is able to learn from its peers

ID	Action	ONGOING	STARTING YEAR				
			1	2	3	4	5
4.1	★ NEW COMMITMENT | Engage in fora, such as the Commodity Supply Chain Table and WESTAC, to advance discussions related to disruptions due to a changing climate and extreme weather events from a supply chain perspective Lead OPI | Surface Policy; Strategic and Innovation Policy; Supporting OPIs | Economic Analysis; Environmental Policy; R3A		●				
4.2	EXISTING COMMITMENT | Continue to actively participate in federal interdepartmental committees and initiatives to advance climate change adaptation, including supporting ECCC efforts to develop a National Adaptation Strategy, work to advance climate resilient codes and standards, and supporting the advancement of Indigenous climate leadership and engagement Lead OPI | Environmental Policy; Supporting OPI | Indigenous Relations and Navigation Protection; R3A; R3B	●					
4.3	EXISTING COMMITMENT | Continue to support, facilitate and/or participate in domestic transportation fora addressing climate change impacts and adaptation issues, including but not limited to Natural Resources Canada's multi-stakeholder Adaptation Platform and Plenary, and the Transportation Association of Canada's Climate Change Integrated Committee Lead OPI | Environmental Policy; All	●					
4.4	EXISTING COMMITMENT | Engage in international transportation adaptation fora to demonstrate Canadian leadership, share experiences and lessons learned, and collaborate to advance the state of knowledge. Fora may include but are not limited to: International Civil Aviation Organization; United Nations Economic Commission for Europe; and Arctic Council Lead OPI | Environmental Policy; Supporting OPI| Marine Safety & Security; All	●					
4.5	EXISTING COMMITMENT | Continue to Vice-Chair the United Nations Economic Commission for Europe Group of Experts on Assessment of Climate Change Impacts and Adaptation for Inland Transport Lead OPI | Environmental Policy; All	●					

Goal 4 | Demonstrate continued leadership in transportation adaptation through increased domestic and international engagement, leveraging partnerships and knowledge exchange to optimize TC's adaptation outcomes *Activities under this goal will ensure that TC continues to engage with domestic and international fora, leverages opportunities to both contribute the department's expertise and experiences to advance the state of knowledge on transportation adaptation, and is able to learn from its peers*								
4.6	EXISTING COMMITMENT | Continue to lead regional engagement sessions annually with northern partners to identify issues and gaps in the northern transportation system, including the impacts of a changing climate Lead OPI | Strategic & Innovation Policy; Supporting OPI | Environmental Policy; R3A		●					
4.7	EXISTING COMMITMENT | Work to enhance partnerships with Indigenous communities and Arctic stakeholders to support Northern Low Impact Shipping Corridors to minimize the impacts of shipping along key routes in Canada's Arctic Lead OPI | Marine Policy; Supporting OPI | Marine Safety & Security; R3A	●						
4.8	EXISTING COMMITMENT | Continue supporting Global Affairs Canada in engagement with the International Joint Commission and the Lake Ontario-Saint Lawrence River Board, and encourage that the orders for managing water levels on the Great Lakes consider marine transportation, are evidence-based, and do not cause economic consequences by unnecessarily impacting shipping and the Seaway Lead OPI | Marine Policy; R3A	●						

Section B

Future Potential Actions

The following is a list of actions that are fully developed with identified action owner(s) and supporting OPI(s), and that could proceed should additional resources become available.

Action	Action Owner(s)	Supporting OPI(s)
Goal 1: Strengthen TC's internal knowledge and capacity on climate risks and opportunities to support evidence-based action *Under this goal, TC teams and employees would gain the ability to take adaptation action in their work; this goal would include learning activities, identifying and addressing information gaps, knowledge dissemination*		
Conduct climate risk assessments of TC owned hangars at their three owned bases (Ottawa, Moncton, and Hamilton)	Aircraft Services	Environmental Policy
Climate change risk analysis at the following airport infrastructures in Quebec: Chevery, Natashquan,Sept-Îles, and Kuujjuaq	Quebec Region	Environmental Policy
Climate change risk analysis at the following port infrastructures in Quebec: Blanc-Sablon, Harrington Harbour, and La Romaine	Quebec Region	Environmental Policy
Goal 2: Embed climate change considerations into our corporate culture, management and decision processes *Activities under this goal will target the mainstreaming of climate considerations into TC's corporate planning and decision-making tools, relevant regulatory processes, programs, plans, and strategies*		
As part of efforts to review and update web-based platform TC Operations Management System (TCOMS), and subject to available funding, ensure that the system is able to capture and share information related to climate change/extreme weather events to appropriate groups, with a Transportation nexus.	Intermodal Surface Security & Emergency Preparedness	Regional Emergency Management

Goal 3: Understand and consider climate change impacts to the transportation system and their potential implications for TC's mandate and priorities *Activities under this goal will support TC's need to continue to effectively deliver its mandate of a safe and secure, efficient and environmentally responsible transportation system within a context of evolving climate change impacts, ranging from adaptation cost-benefit analysis to research on potential climate mitigation and adaptation co-benefits in the transportation sector*		
Work with northern partners to update or develop technical guidance documents that help to mainstream adaptation into design and management of northern transportation infrastructure.	Environmental Policy	
Undertake adaptation outreach and engagement activities tailored to northern transportation stakeholders, with the goal of increasing capacity to adapt existing and future northern transportation infrastructure and operations to climate change	Environmental Policy	Transportation Infrastructure Programs
Update pilot training program to include the identification of and aircraft handling techniques for severe weather conditions not normally encountered e.g. severe wind shear, microbursts, severe icing, lightning, but which may become more prevalent with climate change	Civil Aviation	
Initiate work to implement solutions that will address aircraft de/anti-icing fluids, their use, and management at high-risk aerodromes/airports, and leverage the work initiated with existing aviation safety fora, such as Transport Canada's *De-Icing And Anti-Icing At Remote Locations Working Group*, which is addressing safety aspects related to the use of aircraft de/anti-icing fluids.	Civil Aviation	
Enhanced monitoring activities of vessel traffic in the North, with particular focus on Prairie and Northern Region, and both Flag State and Port State groups, by expanding the current inspection and compliance monitoring program to address the risk associated with increased shipping traffic in Canada's North, as *some these risks associated with increased shipping traffic may exacerbate due to climate change*	Marine Safety and Security - PNR	Marine Safety and Security, Flag State and Port State groups Marine Safety and Security National Capital Region and other regions

Develop tailored operational guidelines or recommendatory measures (e.g. issuance of ship safety bulletins, safety management system guidance, edits to Sailing Directions) for vessels operating within Canadian waters that take into consideration certain maritime hazards exacerbated due to the changing climate, including wind gusts and more unpredictable ice conditions	Marine Safety and Security (various branches)	
Goal 4: Demonstrate continued leadership in transportation adaptation through increased domestic and international engagement, leveraging partnerships and knowledge exchange to optimize TC's adaptation outcomes *Activities under this goal will ensure that TC continues to engage with domestic and international fora, leverages opportunities to both contribute the department's expertise and experiences to advance the state of knowledge on transportation adaptation, and is able to learn from its peers*		
Initiate steps to establish a multi-modal transportation sector network to support transportation adaptation collaboration, address common challenges, and foster peer-to-peer knowledge exchange	Environmental Policy	

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References

Allen, M.R., O.P. Dube, W. Solecki, F. Aragon-Durand, W. Cramer, S. Humphreys, M. Kainuma, J. Kala, N. Mahowald, Y. Mulugetta, R. Perez, M. Wairiu, and K. Zickfeld. (2018). Framing and Context. In Masson Delmotte, V., P. Zhai, H.-O. Portner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (pp.49-91). In Press.

Andrey, J., and Palko, K. (2017). Introduction. In K. Palko and D.S. Lemmen (Eds.), *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 2-10). Government of Canada.

Bonsal, B.R., Peters, D.L., Seglenieks, F., Rivera, A., and Berg, A. (2019). Changes in Freshwater Availability Across Canada. In E.Bush and D.S Lemmen (Eds.), *Canada's Changing Climate Report* (pp.261-342). Government of Canada.

Bush, E. and Lemmen, D.S., (Eds.) (2019). *Canada's Changing Climate Report*. Government of Canada.

Bush, E., Gillett, N., Watson, E., Fyfe, J., Vogel, F. and Swart, N. (2019). Understanding Observed Global Climate Change. In E.Bush and D.S Lemmen (Eds.), *Canada's Changing Climate Report* (pp.24-72). Government of Canada.

Casello, J., and Towns, W. (2017). Urban. In K. Palko and D.S. Lemmen (Eds.), *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 264-309).Government of Canada.

Council of Canadian Academies. (2019). *Canada's Top Climate Change Risks*: *The Expert Panel on Climate Change Risks and Adaptation Potential*. Council of Canadian Academies.

Macdonell, B. (2018, December 2). All aboard: First passenger train in 18 months

departs for Churchill, Man. *CTV News.* https://www.ctvnews.ca/canada/all-aboard-first-passenger-train-in-18-months-departs-for-churchill-man-1.4201440

Deloitte. (2020). *Understanding COVID-19's impact on the transportation sector*. https://www2.deloitte.com/us/en/pages/about-deloitte/articles/covid-19/covid-19-impact-on-transportation-sector.html

Derksen, C., Burgess, D., Duguay, C., Howell, S., Mudryk, L., Smith, S., Thackeray, C. and Kirchmeier-Young, M. (2019). Changes in Snow, Ice, and Permafrost Across Canada.In E.Bush and D.S Lemmen (Eds.), *Canada's Changing Climate Report* (pp. 194-260).Government of Canada. DOI

Environment and Climate Change Canada. (2016*). Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy*. Environment and Climate Change Canada.

Flato, G., Gillett, N., Arora, V., Cannon, A. and Anstey, J. (2019). Modelling Future Climate Change. In E.Bush and D.S Lemmen (Eds.), *Canada's Changing Climate Report* (pp.74-111).Government of Canada.

Greenan, B.J.W., James, T.S., Loder, J.W., Pepin, P., Azetsu-Scott, K., Ianson, D., Hamme, R.C., Gilbert, D., Tremblay, J-E., Wang, X.L. and Perrie, W. (2019). Changes in Oceans Surrounding Canada. In E.Bush and D.S Lemmen (Eds.), *Canada's Changing Climate Report* (pp.343-423). Government of Canada.

Government of Canada. (2011), *Federal Adaptation Policy Framework*. Environment Canada.

Hoegh-Guldberg, O., D. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K.L. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou. (2018) Impacts of 1.5°C Global Warming on Natural and Human Systems. In Masson-Delmotte, V., P. Zhai, H.-O. Portner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Pean, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (Eds.), *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening*

the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (pp.x-x).In Press.

Insurance Bureau of Canada. (2019, January 16). *Severe Weather Causes $1.9 Billion in Insured Damage in 2018.* http://www.ibc.ca/on/resources/media-centre/media-releases/severe-weather-causes-190-million-in-insured-damage-in-2018

National Round Table on the Environment and the Economy. (2011). *Paying the Price: The Economic Impacts of Climate Change for Canada.* National Round Table on the Environment and the Economy

Office of the Auditor General of Canada. (2017). *2017 Fall Reports of the Commissioner of the Environment and Sustainable Development Report 2—Adapting to the Impacts of Climate Change*. https://www.oag-bvg.gc.ca/internet/English/parl_cesd_201710_02_e_42490.html

Organisation for Economic Cooperation and Development. (2020, June 5). *OECD Policy Responses to Coronavirus (COVID-19) Building back better: A sustainable, resilient recovery after COVID-19*. https://www.oecd.org/coronavirus/policy-responses/building-back-better-a-sustainable-resilient-recovery-after-covid-19-52b869f5/#section-d1e883

Parliamentary Budget Officer. (2016). Estimate of the Average Annual Cost for Disaster Financial Assistance Arrangements due to Weather Events. Government of Canada.

Phillips, A., and Towns, W. (2017). The Prairies. In K. Palko and D.S. Lemmen (Eds.), *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 105-137). Government of Canada.

Rapaport, E., Starkman, S., and Towns, W. (2017). Atlantic Canada. In K. Palko and D.S. Lemmen (Eds.), *Climate risks and adaptation practices for the Canadian transportation sector 2016* (pp. 218-262).Government of Canada.

Treasury Board of Canada. (2020). *Greening Government Strategy: A Government of Canada Directive*. https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html

World Economic Forum. (2021). *The Global Risks Report 2020* (16th Edition). World

Economic Forum.

Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., Kharin, V.V. (2019). Chapter 4: Changes in Temperature and Precipitation Across Canada. InBush, E. and Lemmen, D.S. (Eds.), *Canada's Changing Climate Report* (pp.112-193). Government of Canada.