



# Resilient infrastructure. Resilient economy. Resilient future.

*Exploring Ontario's climate vulnerability and the case for resilience*

*January 2022*

# About this document

In 2021, the Ontario Environment Industry Association (ONEIA) struck a special working group, under the oversight of its Climate Change Committee, to examine the issue of climate resilient infrastructure. This group was made up of a cross-section of leading experts drawn from the fields of consulting engineering, technology and related fields and included those with decades of experience in areas as diverse as building science, manufacturing, law and public policy, water/wastewater/stormwater, energy systems, mining , transportation, and climate science (for a list of contributing experts, please see Appendix One).

The working group addressed five (5) broad areas:

1. What are the climate challenges facing Ontario in the coming decades?
2. What benefits can we derive from proactively addressing them?
3. How do we define climate resilient infrastructure?
4. Which areas of critical infrastructure are particularly vulnerable to climate shifts and what should we do to protect them?
5. What opportunities for investment and growth does resiliency present and how can we take advantage of them?

The group paid particular attention to generating specific, practical recommendations about what Ontario should do to mitigate the threats posed by climate change AND to maximize the economic opportunity that such mitigation presents.

This document is a summary of their approach, work, and recommendations.

# The climate challenges facing Ontario

A range of climate models are in universal agreement: Ontario's climate will change rapidly in the coming decades. While some of these changes may be beneficial in some areas (e.g. longer growing seasons, increased productivity of northern farmland, etc.) the changing climate is expected to result in significant negative impacts in a range of areas, including:



The impacts of various manifestations of a changing climate will be interrelated. Weather events such as wind storms, extreme rainfall and flooding events, extreme heat, and other extreme weather events driven by a changing climate can result not just in threats to personal and public health, but in surface and overland flooding, wind damage, droughts, and other damage to personal property and key infrastructure. An increased number of extreme heat days will be more likely, as some models predict average temperatures will increase by 2.5°-3°C by 2050. These heat events, in turn, are likely to increase the risk of forest fires, increase energy costs for cooling of buildings, and pose threats to the personal health of vulnerable populations – particularly if they are accompanied by power outages.

# How Ontario will benefit from improved climate resiliency

Proactively addressing the challenge posed by a changing climate by making our infrastructure more resilient is not just an issue of our personal duty to safeguard our fellow citizens. It can also deliver definite additional benefits to Ontario's society and economy, including the following:

**Preventing economic disruption and higher future costs:** Investing in resilient infrastructure will reduce disruptions to the activities that power Ontario's economy. Resilient infrastructure creates more secure supply chains, as essential elements such as energy grids, roads and bridges that can withstand or quickly recover from extreme weather events will take on increasing significance as the frequency of climate disruptions increases. Delaying action also comes at a cost, as a \$1 investment now saves between \$3 and \$10 in recovery costs, if and when the infrastructure fails.

**Boosting investor confidence and competitiveness:** A growing consideration for international investors will be whether the jurisdiction that receives their investment has taken measures to protect infrastructure from climate change – and this will be of particular importance to capital-heavy investment. Resilient infrastructure will be another factor in making Ontario an attractive international investment destination – and a lack of such a resiliency strategy may place us at a competitive disadvantage to those jurisdictions that have made their infrastructure more resilient.

**Economic growth and export-ready innovation:** Making investments in climate resilient infrastructure will grow Ontario companies, expand the provincial economy and position those companies to export their resilience solutions to other global jurisdictions. The Province can also use its existing procurement budgets to invest in Ontario innovations that support climate resilient infrastructure, giving innovative companies their first “market-making” customer. The Province can also reform its regulatory regime to set standards that will drive investments in climate resilient infrastructure and give Ontario innovations and technological solutions a foothold in the marketplace.

**Positioning Ontario as a global leader:** Climate resiliency can fundamentally change the “brand” and orientation of Ontario. Imagine an Ontario with new innovative roads that allow for drainage and manage heat, decentralized energy sources and resilient transmission to maintain power, homes and business retrofitted with back-up power sources, or municipalities that have conducted vulnerability assessments and updated their infrastructure to withstand increased stormwater flooding. The path to resiliency leads to economic benefits for individuals, businesses, investors and a reputation to support future generations of economic growth and prosperity.



# Defining climate resilient infrastructure

Climate resilient infrastructure is built, maintained or retrofitted to successfully withstand stresses from extreme climate events. These stresses can be direct, from rainfall, heat and wind, or indirect, from flooding, weather-related loss of electricity or water supply. It can respond to and recover rapidly from disruptions caused by these climate conditions.

Climate resilient infrastructure is built infrastructure (vertical, linear and other engineered systems that provide critical services) which has the ability to resist the effects of a changing climate and to mitigate performance deviations. Put another way, climate resilient infrastructure is designed, operated, maintained and restored to absorb or avoid damage as a result of climate change and continue to provide critical services to the asset user.

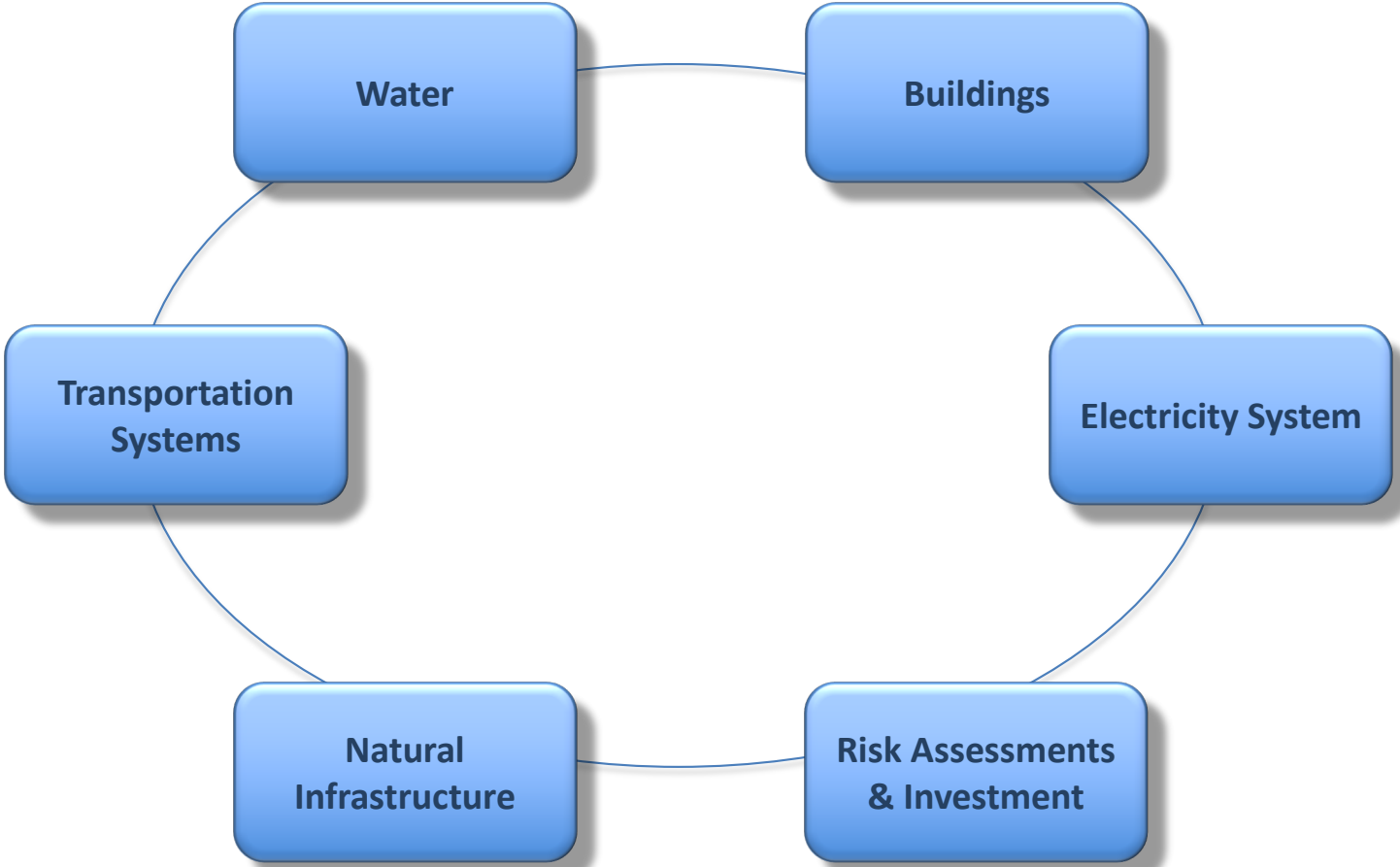
The definition of “infrastructure” includes any engineered and built systems and structures that provide critical services to a population of people. This includes buildings, but also includes structures and systems relied on for transportation of people such as roads, rail, bridges, paths, transmission of power and other utilities, protection of property, the storage, treatment and transmission of water and wastewater, communication, ports, and more. This infrastructure provides critical services to Ontarians, supports sustained economic growth, enjoyment of property and long-term community health and wellbeing.

Exciting examples include new innovative roads that allow for drainage and manage heat, decentralized energy sources and resilient transmission to maintain power, homes and business retrofitted with back-up power sources, vulnerability assessments and updated watermains by municipalities to withstand increased stormwater flooding.



# Exploring the opportunities of climate resilient infrastructure

The ONEIA Working Group on Climate Resilient Infrastructure examined six (6) key areas in which climate change will present both challenges and opportunities for Ontario’s society, communities and industry. It outlined the types of impacts these factors are likely to produce and made specific recommendations for consideration as we mitigate them.



# Climate Challenges: The vulnerability of our buildings

According to the Insurance Bureau of Canada (IBC), property and casualty insurance payouts from extreme weather averaged \$405 million annually from 1983 to 2008 and rose to more than \$1.8 billion annually from 2009 to 2018 . Approximately 1.7 million Canadian households, or 19% of Canada’s population, are at risk of riverine and/or overland flooding. It is worthy of note that this data does not include condominium or apartment buildings, in which an increasing percentage of Ontario residents reside. In addition, there is no reliable data outlining the potential buildings at risk of damage or failure due to extreme wind, storm or heat events.

For every dollar in insurance claims for homes and businesses in Canada, the IBC estimates governments pay three dollars to repair damage to public infrastructure as a result of extreme weather. In 2008, the annual cost attributed to climate change was \$5 Billion, in 2020 that estimate is expected to be \$21 Billion, and by the year 2050, \$43 Billion.

*“Modernize the Building Code to better equip homes and buildings to be better able to withstand extreme weather events.”*

*– Made in Ontario Environment Plan 2018*





# Climate Challenges: The vulnerability of our buildings

Climate change will have specific and multi-layered impacts on the buildings in which we live and work, including:

- **Increased wildfires** can cause damages from flame as well as smoke particulate;
- **Melting permafrost** can undermine substructures and foundation systems in northern parts of Ontario;
- **Severe wind events** can damage roofing, cladding and glazing systems, as well as disrupt the electrical transmission (grid);
- Overland flooding and sewage back-up from **extreme rainfall events** lead to flooded basements, washed out roads, damage to structures and resultant effects from mold;
- **Extreme heat and cold** can threaten individuals and also impact the electricity supply, which is more susceptible to failure under extreme heat conditions and/or extreme storm events. Extended heat waves increase the load on building Heating, Ventilation and Air Conditioning (HVAC) systems, while higher temperatures and rainfall exacerbate wear on exterior building elements; and
- **Drought events** can negatively impact building foundation systems.

**The costs of climate disruption - a practical example:** Following the 2013 floods in Alberta, between 150,000 to 180,000 people could not access downtown Calgary office buildings for approximately two weeks. This resulted in 5.1 million lost work hours, equivalent to a \$500-million loss in GDP for the province from one extreme weather event.

# RECOMMENDATIONS: More resilient buildings

RECOMMENDATION	SUPPORTING DETAILS
<p>The National Building Code and provincial codes should be aligned towards the realities of climate change and its impact on building infrastructure to ensure that municipal jurisdictions are provided with the best information around this topic, so they in turn can develop policy for the community of investors, builders and owners, and other key stakeholders.</p>	<p>It is significantly cheaper to properly design new builds for the changing climate than retrofitting. It costs 0-5% more in up-front costs to design climate resilient buildings than those not built to meet the future challenges. This minimal additional cost will also be offset by reduced insurance and recovery costs. In this area regulation is necessary to create a fair playing field as the economic drivers dominate the industry. Builders do not live in the homes they build so their investment is not focused upon the longer-term climate resilience of the building. Property developers and managers are increasingly aware of the future costs, however updating the code makes sure that even those less aware are still planning and designing in preparation for the future climate.</p>

# RECOMMENDATIONS: More resilient buildings

RECOMMENDATION	SUPPORTING DETAILS
<p>Ontario should support the development and adoption of tools and approaches for conducting Building Vulnerability Assessments, and incorporate these methods into applicable professional Codes and Practices in collaboration with the various stakeholders (e.g. PEO, ESSCO, ONEIA, BOMA, etc.).</p>	<p>Ontario’s approach to promoting climate resilient infrastructure must consider the full life cycle of the building infrastructure, including design, operations and maintenance. Much of the focus of the engineering community has been on the design and construction of new infrastructure. Mitigating the impacts of climate change, reducing vulnerability and improving resiliency for new buildings is supported by a number of tools and approaches. Ontario needs to support the engineering community in integrating the use of more robust and inclusive tools and approaches for the assessment of climate vulnerability of existing infrastructure – enabling the adaptation of infrastructure to accommodate the potential impacts of a changing climate. Other stakeholders in infrastructure will benefit from increased certainty and confidence in the resiliency and reliability of the asset – owners and operators, tenants, lenders, insurers, investors, users, neighbours, and more. Infrastructure resiliency to climate change should be a mandatory disclosure. Transactional due diligence is evolving to include such mandatory disclosures. Engineers, consultants and other advisors need consistent direction (i.e. policy, guidelines, standards) on which all infrastructure stakeholders can consistently and reliably depend.</p> <p>In order to provide building owners with the ability to meet the challenge of climate change, it is recommended that they consider undertaking Resiliency Vulnerability Assessments on their building infrastructure. These studies include an estimate of the climate impacts on the ability of the building to continue to provide critical services, and on the components of the infrastructure, such as deterioration, damage and destruction. “Critical services” for buildings include but are not limited to power, telecommunications, transportation, fresh clean air, heating and cooling, water, clean and safe working conditions, structural integrity, etc.</p>

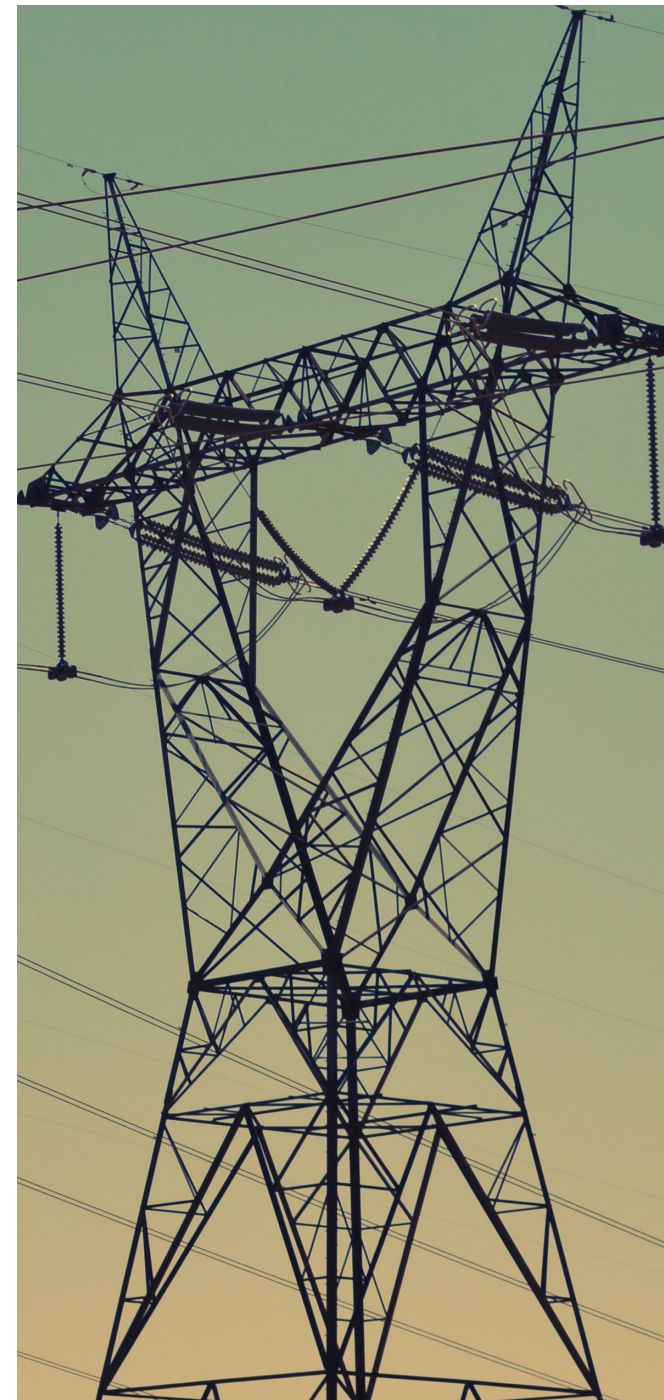
# Climate Challenges: Energy

Climate change is already impacting both the demand and supply of energy in Ontario. The Ontario Energy Board forecasts and monitors for increases in energy demand and, due to climate change, we can expect increased demands due to higher air conditioning use in the summer and potentially increased heating needs in the winter. The ongoing electrification of vehicles will also put more demand on our system in coming years. In a “just-in-time” economy, a momentary outage can cost manufacturers millions of dollars and companies will only grow more dependent upon reliable energy supplies in the future.

Utility and energy distributors in Ontario have currently adopted a range of models to assess their vulnerability to the impacts of climate change. This unstructured approach, with parties using different metrics and systems, does not lend itself to a comprehensive understanding of system-wide vulnerability nor to being able to compare different areas of the province.

As a result of the collective efforts of Ontario businesses and residents (and shifts in the province’s economy), electricity use has declined over the last 10 years. Due in part to the province’s extensive efforts that encourage people to use energy more efficiently, including programs such as Save on Energy and other energy-efficiency measures, Ontarians have contributed to 15.4 terawatt-hours (TWh) of energy savings since 2006, an amount of electricity equivalent to that needed to power 1.7 million homes for one year.

The Independent Electricity Systems Operator (IESO) recognizes that there is still much that can be done to capitalize on the opportunities created by energy efficiency and build on the progress made so far. Their measures to date demonstrate unquestioningly that energy efficiency is the most cost-effective model for addressing energy capacity issues.





# Climate Challenges The vulnerability of our electricity system

Ontario's electricity system is vulnerable to climate change in a number of areas, including:

- **Energy capacity:** The rise in average outdoor temperatures and the increase in severity of weather-related events in Ontario has affected energy production and transmission capacity, as well as reliability.
- **Extreme heat:** Extreme heat events cause electricity demand surges and high daily peaks over the summer months. This places additional strain on the existing generation and transmission systems which are already close to their capacity over these months. According to forecasts from the IESO, Ontario electricity generation in the summer months will be at a capacity deficit by as early as 2023 due to the planned refurbishment and retirement of nuclear power plants.
- **Hydroelectric power:** Rising temperatures, changing precipitation patterns and shifts in water flows and levels in lakes and rivers directly influence the production of hydroelectric power, which currently supplies 25% of Ontario's electricity.
- **Efficiency loss:** When temperatures are higher, the generation of electricity is less efficient (specifically in nuclear and thermal (gas) power plants) and the transmission loss of electricity increases.
- **Extreme weather events:** Increases in the number of extreme weather events (including forest fires, floods, ice storms, tornadoes), can increase the risk of significant damage to essential energy infrastructure, resulting in supply disruptions. This can cost businesses considerable time and money in lost productivity and business stability.

**An example of vulnerability:** The majority of Hydro One's transmission system was built in the 1950s. Replacement, repair and equipment upgrades are required across the system. One out of four transformers has reached the end of its expected service life and more than 10,000 steel towers across the province are more than 80 years old.





# RECOMMENDATIONS: A more resilient electricity system

RECOMMENDATIONS	SUPPORTING DETAILS
<p>Develop programs to support whole building energy consumption and peak demand improvements, including existing building energy audits and the recommissioning of building control systems. Customized programs should be developed to incentivize industrial energy efficiency projects which focus on continual improvement.</p> <p>Standards setting bodies should improve equipment standards to require higher efficiency designs and technologies.</p> <p>The National Building Code and Provincial codes should be reviewed and adjusted to increase energy efficiency requirements in the design of new buildings.</p>	<p>The Province should strengthen the ability of the energy industry to anticipate the effects of climate change and integrate its impacts into its operational and infrastructure planning</p> <p>The creation of climate resilient energy infrastructure is critical to facilitating a stable environment from which businesses and industry can thrive. In order to improve the reliability of energy supply across the province, the reduction of energy consumption and peak demand from businesses and industry through increased energy efficiency of buildings, equipment and processes should be implemented. Further energy infrastructure improvements can safeguard power plants, energy storage and distribution systems, to reduce the impact of extreme weather events.</p> <p>Reducing businesses’ dependency on energy increases their resiliency during energy shortages, but importantly, also reduces their cost of doing business, helping improve competitiveness. This would both reduce the strain on the current electricity grid during peak periods, and protect businesses in the face of rising energy costs. The IESO indicated that the cost of energy saved through efficiency programs in 2017, resulting in 1.8 TWh of saved energy, was approximately 2¢ / kWh.</p>

# Climate Challenges: Water

Adequately operating water infrastructure and systems are essential to maintaining human health and wellbeing. Ontario cities and workplaces would become rapidly dysfunctional without proper potable water, sanitary sewage services, and proper stormwater drainage. Failures of these systems cause harm to individual health and cause stress and mental distress for those faced with flooded homes and communities.

Water infrastructure failures – particularly where stormwater systems are overwhelmed by extreme precipitation events – are largely the cause of rising insurance claims, increasing replacement and repair costs, and rising insurance premiums for homes and businesses. For example, the Greater Toronto and Hamilton Area has seen a 20% rise in insurance premiums in recent years.

Reports have noted that 20% of Ontario's water, wastewater and stormwater infrastructure is in poor to very poor condition. Ontario needs to fill the short-term municipal gaps (impacted by operating losses with short term stimulus) and develop innovative models to continue making long-term investments in drinking water and wastewater/sewage management/infrastructures to ensure public health and safety and create healthy and resilient communities.

In addition to their role in supporting individual and community health, water infrastructure investments provide abundant economic opportunities and drive business growth. Ontario is already a leading hub for water technologies with more than 900 companies and 22,000 employees in the industry. Local procurement and implementation of made-in-Ontario water innovations would improve health and safety, grows business and provide opportunities for global export.

## Impacts of climate change on water infrastructure

**Increased flooding:** Increased flooding in Ontario is pushing Ontario's water infrastructure beyond its limits. Aging drinking water, monitoring, sewage and stormwater systems are less able to withstand extreme weather events and provide adequate levels of service, posing a great health risk to the public.

**Sewage overflows:** Overflows pose additional health risks by their potential to contaminate water bodies and drinking water. In 2017-18 there were a total of 1,327 bypasses and overflows from all municipal wastewater sources.

**Stormwater Infrastructure:** Increased flooding has overwhelmed stormwater infrastructure in several communities including Toronto, Peterborough, London, Peel Region and Halton Region

## RECOMMENDATIONS: More resilient water infrastructure

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province should create a digitization policy for water infrastructure that supports municipal procurement and de-risks investment in new technologies.</p>	<p>A digitization policy for water infrastructure provides a myriad of current and future benefits as systems face increasing stresses from climate change. These include efficient data collection for monitoring, forecasting and planning, better management of water systems (including in times of flooding), addressing sewage overflows, addressing and eradicating emerging contaminants using sensor and monitoring systems, and the integration of intelligent systems that can use machine learning to identify abnormalities in operational water processes. All of these benefits will improve water management operations by integrating real-time data for impactful, evidence-based decision-making.</p> <p>In addition to creating more effective, resilient systems, digitization can increase economic activity, by driving government investment and procurement in innovative made-in-Ontario solutions. By providing support and programs for more education and demonstration of the digital products and what they can do for the operational inefficiency in a utility or industrial facility. Ontario could establish itself as a leader by creating incentives through new short-term stimulus programs for decision makers and users to embrace digital infrastructure investment, regardless of any trepidation towards the use of technology.</p> <p>A digitization policy should include the development of new provincial guidelines for evidence-based decisions in real-time; which allows the government to spur innovation and technology uptake through regulation without picking winners. The government should also develop new policies for data security to de-risk these investments and help clarify how to implement this digital infrastructure.</p>

# RECOMMENDATIONS: More resilient water infrastructure

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province should create a decentralization policy for small, rural, and northern communities to improve these communities' ability to select and invest in updated climate-resilient water systems.</p>	<p>Creating a decentralized water system in smaller centers addresses a number of weaknesses in the current water infrastructure that will be further highlighted as the water infrastructure faces additional strain as a result of climate change. The benefits include the provision of cost-efficient wastewater management options with reduced capital investment and lower operation and maintenance costs, flexible modular designs that meet each community's specific needs and enables connections to sewerage where centralization is not economical, shorter construction timelines and rapid deployment, the protection of groundwater and water bodies from untreated wastewater contamination, and decentralized monitoring that builds resilience by being less dependent on transportation links and centralized labs.</p> <p>A decentralization policy could outline new design standards and codes to adapt to disruptive events and revise where necessary existing legal provisions and standards that ensure safe reuse and economic feasibility of new wastewater infrastructure. That combined with modernizing wastewater regulation to meet new possible stringent guidelines would drive municipal infrastructure investments towards climate resilient solutions.</p> <p>Lastly, adjusting the monitoring regulation to remove the prohibition on remote or small-scale monitoring innovations will reduce costs and improve the speed and effectiveness of water monitoring in smaller, more remote communities.</p>

# Climate Challenges: Transportation systems

Ontario's transportation infrastructure is the backbone of much of the province's economy. Whether it is the highways and railways that connect thousands of Ontario factories and warehouses into North American supply chains that rely on "just in time" delivery or the transit and commuting roads that make our major urban centers productive and functional, transport drives Ontario.

As our population and economy grows, this system has to balance the twin imperatives of sustainability and resiliency. Ontario's Infrastructure Plan (*Building Ontario*) focuses on accelerating the delivery of transit and transportation projects and extending the life and performance of existing infrastructure. A foundation of the strategy is improving how we plan, procure, and manage infrastructure to maximize the life, performance, resilience, and value of our infrastructure including roads, bridges and transit systems. With this in mind, we must consider the potentially significant impacts of a changing climate.

Work by Natural Resources Canada in 2016 has highlighted a number of transportation infrastructure policy and investment gaps in Ontario. For example, NRCAN highlights that the cumulative impacts of climate change on transportation infrastructure, referring to two or more simultaneous impacts, are understudied and difficult to predict. In addition, communities and practitioners in Ontario have not yet integrated adaptation goals into much of their transportation planning and decision-making.

**Extreme weather events - Two practical transportation examples:** In 2005, a high magnitude localized storm event washed away a large part of Finch Ave. in Toronto, damaging culverts, severing utility lines and creating one of the country's largest insurance claim events for that year related to residential flooding. In 2013, flooding in Northern Ontario prompted six towns to declare a state of emergency when roads were washed out, cutting off for many their only links to the outside world for a sustained period.





# Climate Challenges: Transportation systems

Climate change poses a number of challenges to our transportation systems, including the following:

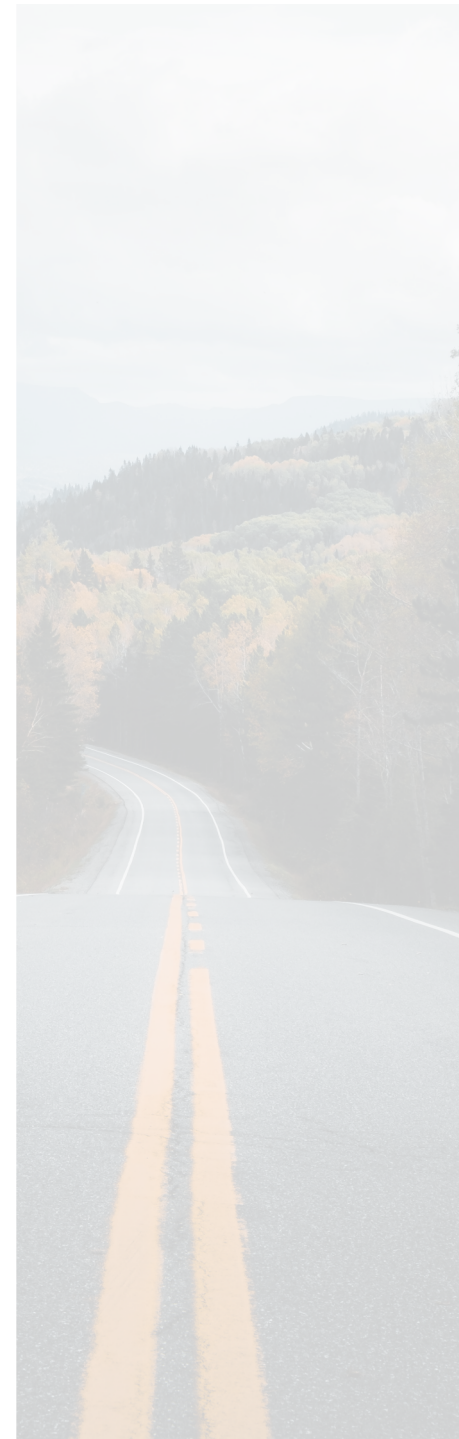
**Roadway damage:** Sustained high temperatures can cause changes in asphalt composition, damaging roadways. Higher temperatures can create rutting and potholes, particularly in high-traffic areas and can place stress on bridge joints. High temperatures can also cause rail tracks to expand and buckle, and airport pavement to deteriorate. More frequent and severe heat waves may require track repairs or speed restrictions to avoid derailments, and closures or delays at airstrips.

**Extreme precipitation:** Heavy precipitation can result in flooding, weaken or wash out the soil and culverts that support roads, tunnels, and bridges. Heavy precipitation can also flood or leave debris on railways, disrupting rail transit. Premature pavement deterioration is a common result of road flooding.

**Freeze-thaw cycles:** These cycles have been a source of annual damage to Ontario roads and bridges, and this is predicted to be exacerbated in most areas of the Province under a changing climate.

**Water level rise:** Roads, railways, ports, tunnels, and airports that are adjacent to waterways and the Great Lakes are vulnerable to water level rise, which could lead to accelerated deteriorations, delays as well as temporary and permanent closures. Underground transit infrastructure like the TTC could be significantly impacted by more frequent, and extreme flooding events.

**Reduced ice roads:** Warming temperatures would reduce the number of days when ice roads or winter routes are open or reduce the capacity of the ice roads during operation, limiting transportation access to these areas. These routes are used to connect northern communities, as well as the oil, gas, and mining industries.



# RECOMMENDATIONS: More resilient transportation infrastructure

RECOMMENDATIONS	SUPPORTING DETAILS
<p>Working with Natural Resources Canada’s Climate Change Adaptation Program or other agencies, the Province should continue to study climate change adaptation interdependencies, invest in developing more robust historical records and climate modeling processes, and help train engineers in dealing effectively with climate uncertainty.</p>	<p>To ensure transportation infrastructure is resilient and adapted to the effects of climate change including extreme weather events, we must look beyond historical information to future trends and what they might mean for Ontario. Further investment is required to study the potential impacts of a changing climate on Ontario transportation infrastructure, recognizing that there is much inter-dependency between infrastructure and different regions, and different assets will be impacted in different ways. Work is also required to further develop and establish the tools, methods and guidance required to consistently incorporate climate change considerations in transportation infrastructure engineering design, operations and maintenance work.</p>

# RECOMMENDATIONS: More resilient transportation infrastructure

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province, through its Ministry of Transportation and Ministry of Infrastructure, should continue to develop directives and guidance for incorporating climate resilience into engineering designs provided for transportation infrastructure projects.</p> <p>The Province should support and encourage the development and adoption of tools and approaches that promote climate-resilient transport infrastructure, and then incorporate these methods into applicable professional Codes and Practices in partnership with PEO, OSPE, ESSCO, ONEIA, APGO and other stakeholders.</p>	<p>A lack of defined engineering standard of care complicates the use of climate change data when planning and designing climate resilient transportation infrastructure. The absence of practice standards and methodologies for the use of localized climate projection data makes it harder for decision-makers to justify investment in adaptive infrastructure. In addition to defining the engineering standard of care for using climate data, remedies include maintaining and developing more robust historical records and climate modeling processes, and training engineers in dealing effectively with climate uncertainty.</p> <p>In Europe, a report titled Impacts of climate change on transport: A focus on road and rail transport infrastructures, prepared by the Joint Research Centre of the European Commission, studied the vulnerability of the continent’s road systems to a changing climate and concluded that if the problem is not faced in new strategies of design and maintenance, the changes in climate could “... accelerate their deterioration, and increase severe damages risks, traffic interruption and accidents that could, in turn, affect economic activities”.</p> <p>Metrolinx’s Climate Adaptation Strategy outlines an integrated approach to how this regional transit body is embedding climate resiliency into how it plans, builds, and operates regional transportation in the face of a changing climate. Comparable strategies, including enabling towns and cities to more consistently integrate climate resiliency within transportation infrastructure technical standards, manuals and project agreements, requires investment.</p> <p>By way of example, the Province of British Columbia has published a technical circular which requires engineering design work to evaluate risk and include adaptation measures to the impacts of future climate change, weather extremes and climate-related events, as well as changes in average climate conditions. This policy applies to all new projects, as well as rehabilitation and maintenance projects.</p>



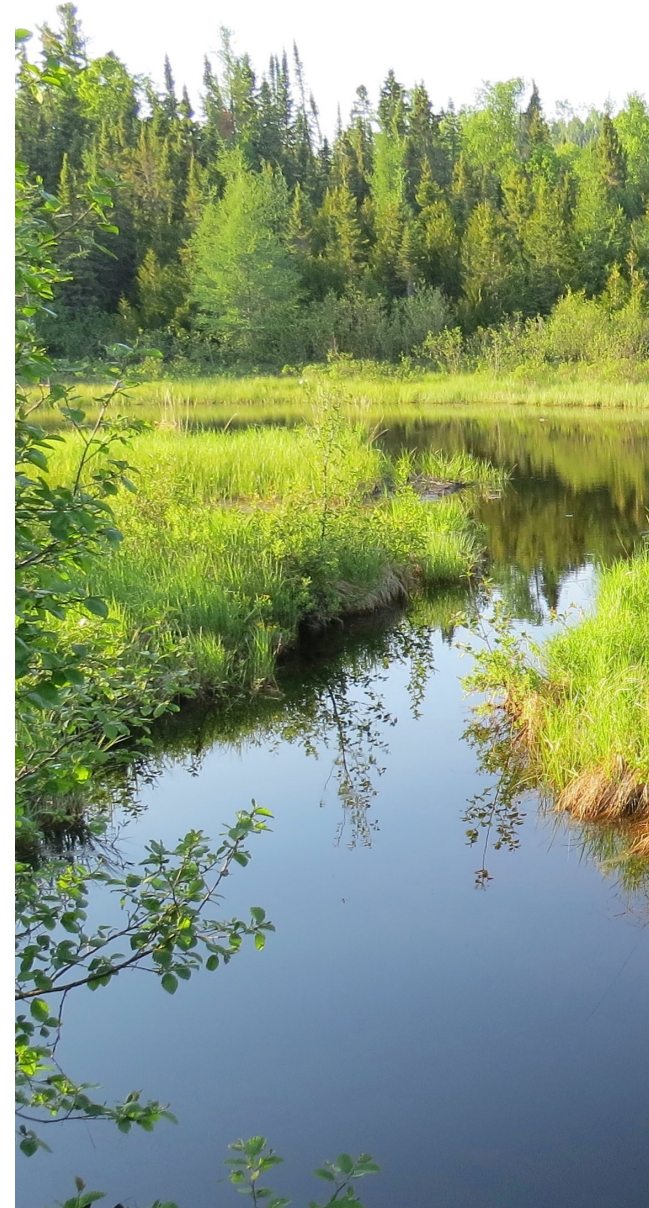
# Climate Challenges: Natural infrastructure

Natural infrastructure refers to natural features and areas which deliver many ecosystem services and benefits, and which can be strategically managed to increase resilience. Natural infrastructure resilience can range from conserving naturally occurring features like coastal wetlands to implementing permeable pavements to allow water to soak into the ground and planting more trees.

Improving natural infrastructure resilience to the threats of climate change must be implemented with the simultaneous intentions of developing new infrastructure which allow these naturally-buffering processes to continue despite the pressures of climate change, while also minimizing costs and maximizing a diversity of benefits including social, economic and ecological.

Investments in natural infrastructure provide economic benefits and demonstrate a good return on investment. Natural infrastructure innovations and hybrid infrastructure solutions tend to be more cost-effective than purely grey infrastructure resilience projects. Natural infrastructure can reduce flood damage costs, mitigate heat impacts and provide increased health and wellbeing by offering environmental and social benefits.

Despite these challenges natural infrastructure can mitigate concerns caused by climate change by increasing water absorption and reducing runoff, improving water quality, reducing the risks of flood, reducing soil erosion, reducing air temperatures and improving water system efficiency thus reducing energy use.



# Climate Challenges: Natural infrastructure

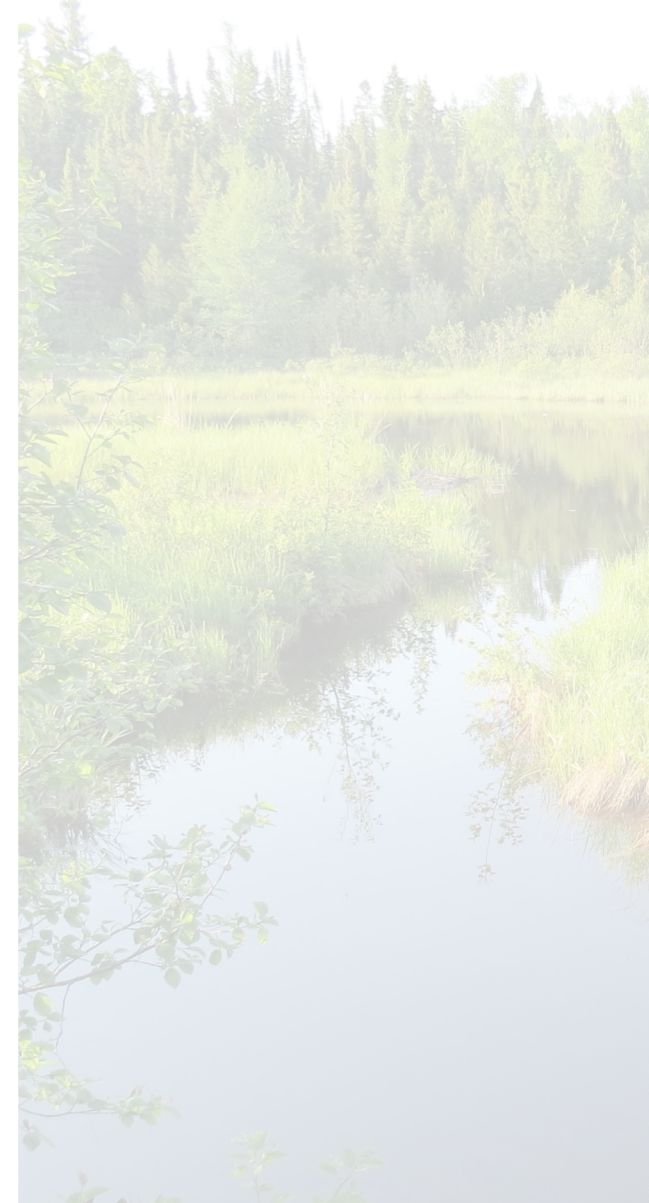
Climate change poses a number of challenges to Ontario's natural infrastructure, including the following:

**Extreme precipitation:** Heavy precipitation can result in flooding that can wash away natural flood plains, overwhelm and weaken natural swales and damage marshlands that play an important role in mitigating flooding.

**Freeze-thaw cycles:** While native Ontario species are accustomed to the extremes between winter and summer, the rapid changes, often several times within a season, can weaken native species and make them more vulnerable to pests and shorten their life cycles.

**Soil erosion and soil health:** Healthy agricultural and forest soils are natural carbon sinks that play a key role in moderating atmospheric carbon and providing rooting beds for vegetation that mitigates flooding. As environmental extremes become more pronounced the soil microbes that play a necessary role in maintaining soil health will come under increasing stress.

**Invasive species:** Climate change has resulted in certain species of flora and fauna thriving and posing a threat to natural species that play an important role in regulating our natural ecosystems. For example, invasive insect species that would normally be killed off by sustained colder winters can devastate tree populations. This combined with extreme heat then provides fuel for forest fires and deforests urban tree canopies that mitigate urban heat islands.



## RECOMMENDATIONS: More resilient natural infrastructure

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province should amend existing legislation, including the <i>Planning Act</i> and <i>Infrastructure for Jobs and Prosperity Act</i> to require the design and expansion of natural infrastructure on private and public lands to mitigate climate risks and the potential costs of natural hazards and climatic threats to water and existing infrastructure.</p>	<p>Investment opportunities today should aim to mitigate the issues of tomorrow, optimise benefits and efficiencies of the natural processes in question, and balance short-term needs with long-term goals.</p> <p>Natural infrastructure strategies should improve community resilience to hazards and risks and build linkages between multiple benefits. Some examples might include soil stabilisation and wave attenuation [force dampening] and urban trees.</p>

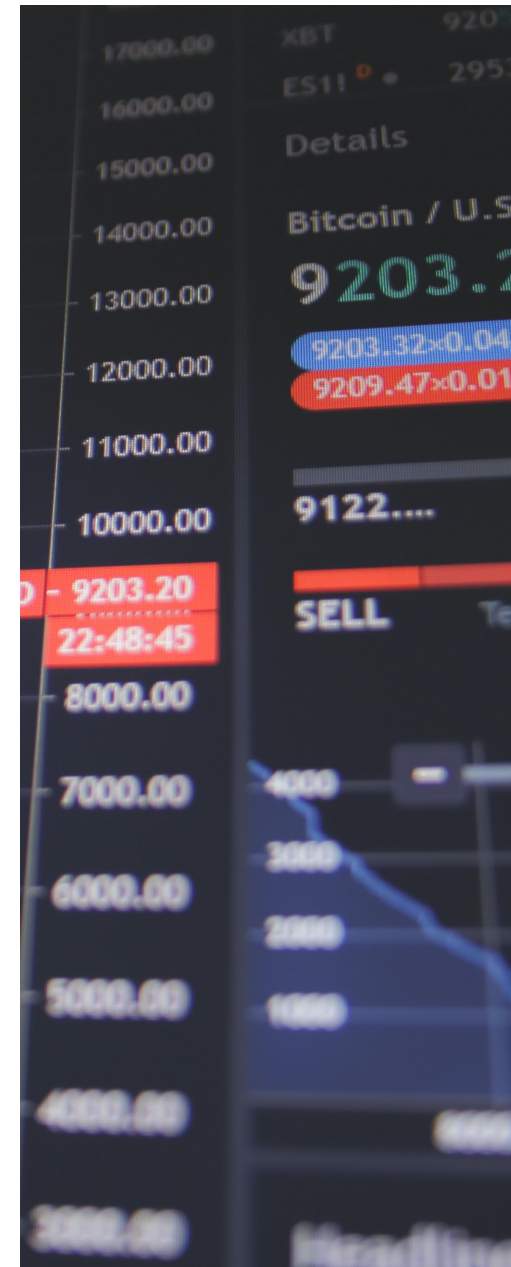


# Understanding risks to better leverage innovation and investment

Risks to infrastructure from a changing climate pose a challenge to industry, to our cities and dwellings, and to individual Ontario citizens. Yet the challenge posed by climate change offers an opportunity to develop new, resilient design and asset management practices. It also offers an opportunity to develop new ways of funding infrastructure that leverages traditional government spending against private contributions and investment markets.

To help us meet the climate change challenge, we need to unlock innovation and new investments in tools that allow for better understanding, mitigation, and management of climate change risks. Better risk assessments will allow for a systematic and replicable approach that highlights key interactions between key assets and climate. These tools can also be used to inform adaptation and mitigation strategies that provide opportunities for investment by both the government and industry to reduce future costs associated with extreme events and ensure strong supply chains.

While Ontario has taken steps to develop a Climate Risk Assessment for the province, it also needs to find ways to effectively utilize capital that will drive immediate economic growth, provide investment into Ontario business innovators and lay the groundwork for future prosperity. Investing in climate resilient infrastructure will have to be based on the proper data that aligns with pre-existing standards. Developing regulations that are not prescriptive but that guide procurement, while allowing businesses to prove their technologies and products, will be a key factor in this regard.



# RECOMMENDATIONS: Risk assessments and investment

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province should incorporate international guidance into the Climate Risk Assessment for Ontario to better support climate risk assessment across different industry sectors.</p>	<p>The Institute for Catastrophic Loss Reduction (ICLR), along with the Climate Risk Institute (CRI) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) took ownership of Engineers Canada’s Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol in early 2020. The PIEVC Protocol follows ISO 31000:2018 Risk Management standards to address climate risk to infrastructure and can be applied to any type of infrastructure or asset. New ownership of the Protocol will allow for extended training opportunities for engineers and designers in Ontario to learn how to best handle climate risks in their work.</p> <p>This international guidance helps to shape and develop climate risk assessment frameworks that are scalable to the various to financial, spatial, and temporal scales required by different sectors of industry.</p>
<p>The Province should establish an Ontario-wide community and appropriate regulations to drive inter-industry collaboration to support the shift to more climate resilient infrastructure.</p>	<p>The drive towards improved infrastructure resiliency will be most effective and efficient through inter-industry and intra-industry initiatives, rather than through initiatives of individual firms. Such multi-organizational innovation and integrated value chain management can result in selective competitive advantage and improve the overall efficiency of the industry. The implication is that one of the more significant challenges for sustainable infrastructure development will be the management of relationships and effective communication across value and supply chains of all involved organizations and industries. The power of collaboration is great and not often is it effectively utilized on both internal and external fronts. Internal collaboration brings together research, design, engineering and marketing functions. Researchers and designers need to be attuned to changing attitudes towards engineering products and services, and must feel the pulse of the economy, the regulatory environment and the competitive marketplace. This industry collaboration requires policy shift and the support of the Ontario government.</p>

# RECOMMENDATIONS: Risk assessments and investment

RECOMMENDATIONS	SUPPORTING DETAILS
<p>The Province should promote the use of performance-based asset management planning that prioritizes optimizations and efficiency of infrastructure systems.</p>	<p>Ontario should support municipalities and utilities in asset mapping to support long-term investments to increase resiliency, sustainability and innovation. Asset mapping should include measuring asset performance including structural performance, capacity and functionality and relates to the mandated levels of service, community objectives and regulatory requirements including applicable codes and standards.</p>
<p>The Province should unlock funds from Green Bonds or the Ontario Carbon Trust (when the Ontario emissions reduction fund becomes available) where short term investments are required to remedy any deficiencies for which short term risk is not acceptable and risk is assessed with respect to health, safety, economic and environmental impacts.</p>	<p>We have seen some recent investments in municipal infrastructure through new federal and provincial stimulus packages. Further investments could be made by unlocking these funds and aligning them with the goals of climate resiliency. These investments should be based upon proper climate asset mapping and projects need to mitigate the effects of the changing climate in Ontario.</p> <p>Short-term investments should prioritize efficiency updates for all systems including water, energy and buildings, the protection of drinking water and infiltration systems, improving stormwater and sewage systems to minimize sewage by-pass events.</p>
<p>The Province should enact measures that unlock funds from Green Bonds and the Ontario Carbon Trust to invest in long-term plans to address future demands including service demand management, alternative innovative services and partnerships based on community growth and vision</p>	<p>Make capital investments with the goal of robust, sustainable infrastructure for the next 30 years today that will allow us to meet the future challenges of climate change by taking full advantage of technological advancement in Ontario cleantech, environment and business sector innovations.</p>

# About ONEIA

Established in 1991, The Ontario Environment Industry Association (ONEIA) is the business association representing the interests of the environment industry in Ontario. Our network of thousands of contacts includes key people at environmental technology, product and service companies, law, investment and insurance firms, institutes, universities and governments. Through their innovation and experience in Ontario and around the world, Ontario's environment industry provides market-driven solutions for society's most pressing environmental problems.

While our industry is diverse, ONEIA provides a place where a variety of companies, entrepreneurs and other organizations in the environment field can come together to work on common concerns, share information and explore business opportunities. Through ONEIA, they can work towards a society that understands and values the contribution that market-based solutions make to our environmental problems.

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# References

- [Adapting to Climate Change State of Play and Recommendations for the Electricity Sector in Canada](#) (2016), Canadian Electricity Association.
- [Advancing the Climate Resilience of Canadian Infrastructure](#) (2021), International Institute for Sustainable Development.
- [Best Practices and Resources on Climate Resilient Natural Infrastructure](#) (2018), Canadian Council of Ministers of the Environment.
- [Canada's Changing Climate Report](#) (2019), Environment and Climate Change Canada.
- [Climate Change Adaptation: A priorities plan for Canada](#) (2012), Climate Change Adaptation Project.
- [Climate Change Impacts & Adaptation in Ontario: The Energy Sector](#) (2015), Ontario Centre for Climate Impacts and Adaptation Resources.
- [Climate Change Impacts & Adaptation in Ontario: Water and Transportation Infrastructure](#) (2015), Ontario Centre for Climate Impacts and Adaptation Resources.
- [Climate Change Overview](#), Green Infrastructure Ontario Coalition, accessed on March 22, 2021.
- [Climate Change Toolkit for Health Professionals: Module 3 – Climate Change Health Impacts across Canada](#) (2019), Canadian Association of Physicians for the Environment (CAPE).
- [Climate Resilient Buildings and Core Public Infrastructure Initiative](#), Infrastructure Canada, modified March 22, 2019. [Climate Resilience Resources](#), BOMA Canada.
- [Combating Canada's Rising Flood Costs: Natural infrastructure is an underutilized option](#) (2018), Moudrak, N., Feltmate, B., Venema, H., Osman, H. Prepared for Insurance Bureau of Canada. Intact Centre on Climate Adaptation, University of Waterloo.
- [Costing Climate Change Impacts to Public Infrastructure \(CIPI\): Buildings](#) (2021), Financial Accountability Office of Ontario.
- [Developing Climate Change Economic Case Analysis: A Guide to Using the Climate Change Cost-Benefit Analysis Tool](#) (2015), Golder Associates & Ontario Centre for Climate Impacts and Adaptation Resources.
- [Energy Efficiency Research](#), Independent Electricity System Operator, accessed October 9, 2020.
- [ESG-Related Investment Fund Disclosure- CSA Staff Notice 81-334](#) (2022), Ontario Securities Commission.
- [2011-2012 Evaluation of the Disaster Financial Assistance Arrangements Program](#) (2011), Public Safety Canada.



# References

[Green Infrastructure and Climate Change Collaborating to Improve Community Resiliency](#) (2016), United States Environmental Protection Agency.

HARTSHORN, J., Maher, M., Stahl, R., Crooks, J and Z. Bond (2005). Creative Destruction: Building Toward Sustainability. Canadian Journal of Civil Engineering, 32(1): pp. 170-180.

[The Impacts of Climate Change on the Great Lakes](#) (2019), Environmental Law & Policy Centre.

[Investing in Canada's Future: The cost of climate change adaptation](#) (2019), Insurance Bureau of Canada & Federation of Canadian Municipalities.

[Investing in the Future: The Economic Case for Natural Infrastructure in Ontario](#) (2019), Greenbelt Foundation.

[Made-in-Ontario Environment Plan](#), Ontario Ministry of Environment, Conservation and Parks, accessed October 9, 2021.

[Megatrends: The Impact of Infrastructure on Ontario's and Canada's Future](#) (2016), Residential and Civil Construction Alliance of Ontario.

[Monitoring the State of Canada's Core Public Infrastructure: Canadian Infrastructure Report Card](#) (2019).

New International Standards for climate change adaptation include: ISO 14090:2019 – Adaptation to climate change – Principles, requirements and guidelines, ISO 14091:2020 – Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment, and ISO 14092:2020 – Adaptation to climate change – Requirements and guidance on adaptation planning for local governments and communities

[Ontario Climate Data Portal](#), LAMPS, York University.

[Rebuilding Ontario: an infrastructure plan for the people](#) (2019), Ministry of Infrastructure.

[Retrofitting](#), Natural Resources Canada, modified September 5, 2019.

[System Investments](#), Hydro One, accessed October 9, 2021.

[Toward Net-Zero Water: Best management practices for decentralized sourcing and treatment](#) (2011), Cascadia Green Building Council.

[The State of Ontario's Water and Wastewater Infrastructure](#) (2018), Ontario Sewer & Waterman Construction Association.

[Climate Risks and Adaptation Practice for the Canadian Transportation Sector 2016 \(2017\)](#), WOULD SMA, C., Towns, W.

# Appendix One: Contributing professionals

The *Resilient infrastructure. Resilient economy. Resilient future.* report was produced by a Working Group formed under the supervision of the Association's Climate Change Committee. This working group contained a number of professionals who volunteered their time to co-write this report.

## **ONEIA Climate Change Committee Co-Chairs**

- Janet Bobeckko, Certified Specialist in Environmental Law, Partner, WeirFoulds LLP
- Janya Kelly, Climate Change Specialist, Golder, a member of WSP

## **Contributing professionals**

- Melissa Annett, Strategic Director, Manufacturing, RWDI
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- Irene Hassas, Vice President, Corporate Development and Partnerships, Aslan Technologies
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- Brent Langille, Strategic Director/Principal, RWDI
- Gord Rajewski, National Building Science Leader, Pinchin
- Norman Shippee, Climatologist, Stantec
- Marc Trudell, Vice President of Corporate Development, Englobe

## Appendix Two: Case studies in practical resilience

### **Developing culturally-informed climate risk assessment models through First Nations collaboration**

The First Nations Infrastructure Resilience Toolkit (FN-IRT) was developed by OFNTSC (The Ontario First Nations Technical Service Corporation) and consulting engineering firm Stantec to help First Nations consider climate risks in the lifecycle of their assets and enhance their asset management planning. The climate risk assessment module of the Toolkit is based on Engineers Canada's PIEVC Protocol and integrates Traditional Indigenous Knowledge with climate and engineering information to identify and qualify climate risks to community infrastructure. The Toolkit also supports risk and asset management planning; providing guidance on how to better plan maintenance, repair and replacement of assets.

The FN PIEVC was used in three Ontario FN communities: Mohawk Council of Akwesasne (water and wastewater infrastructure); the Oneida Nation of the Thames (housing and education infrastructure) and the Moose Cree FN – Moose Factory (water and wastewater infrastructure). Infrastructure data is extracted from the First Nation Asset Condition Reporting System (ACRS), a report required by INAC every 3 years for all department-funded assets, and Integrated Capital Management System (ICMS) databases. Leveraging existing data sources, the Toolkit allows First Nations communities to cost-effectively develop a risk profile and identify adaptation measures for their infrastructure. The process also allows the user to identify data gaps that may need to be addressed in the future.

The FN PIEVC process can also be used by smaller municipalities (as it is effectively a “light” version of the full PIEVC), making it an excellent example of cross-cultural collaboration to blend traditional knowledge with other approaches. The FN-IRT was given the 2019 Award of Merit – Research and Studies by Consulting Engineers Ontario.

## Appendix Two: Case studies in practical resilience

### **Decentralized monitoring for remote areas creates more resilient, healthy communities**

Proper testing of potable water becomes even more important as water bodies and the systems used to protect public health in remote communities are subjected to the climate-induced stress. Kingston firm Tecta-PDS partnered with SEPAQ (The Société des établissements de plein air du Québec's), the body responsible for testing potable water across multiple remote sites in Quebec. The Société integrated TECTA-PDS' "lab in a box" solution, which provides automated, laboratory grade testing at the site of the testing, eliminating the need for a highly skilled lab technicians and allowing for automated email reporting and alerts. This lowered the risk of testing being interrupted by extreme weather (e.g. melting ice roads or washouts affecting transportation routes) and ensured higher sample quality and shorter timelines. Lastly, the project creates jobs in the local community and reduced costs by saving on shipping costs. The impact on homes, businesses and public health was reduced as faster results reduced the number of days that back-up sources of potable water were required.

### **Cost-effectiveness of natural infrastructure investment**

The Gibraltar Point Erosion Control project at the Toronto Islands is an example of resilience thinking in infrastructure design. The point at the southwesterly tip of the Toronto Islands has been experiencing erosion since 1879 and, in recent years, severe storm events and erosion has led to exposure of and damage to existing infrastructure.

The initial proposal was to create a large costly offshore break wall to control waves, that would have appeared above the water level and would have interfered with water activities in the area. In 2016, the TRCA, in collaboration with coastal engineers, came up with an alternative, natural infrastructure solution: an innovative nearshore reef, designed to halt shoreline erosion while also providing habitat for fish foraging and spawning. The project plan also includes beach restoration at Gibraltar Point and has gained public support. This natural infrastructure costs nearly half of what the break wall was estimated to cost.

## Appendix Two: Case studies in practical resilience

### **Measuring the resiliency of transportation infrastructure**

Several member companies of ONEIA are also members of the Institute for Sustainable Infrastructure, a not-for-profit organization that developed the Envision™ rating system, a powerful and proven tool for the screening of infrastructure sustainability and resiliency. Envision™ is a rating system for sustainable infrastructure which provides guidance and a way of measuring the performance of infrastructure in a number of areas including climate resiliency. The system is a comprehensive framework of 60 sustainability criteria that evaluate the environmental, social, and economic costs and benefits of infrastructure throughout the entire asset life cycle including operations. The system can be used both as a self-assessment tool or as a certification tool through external accreditation. Many public agencies in the US (including most notably the City of Los Angeles) use Envision™ as the de facto standard for sustainable infrastructure design and resiliency evaluation. The Los Angeles example is aspirational. The Mayor of the City of Los Angeles published an Executive Directive in 2018 ordering that all City departments, including transportation, integrate resilience and sustainability principles into City capital planning, and made specific reference to the use of the Envision™ tool.

### **Decentralized sewage systems reduce contamination risks, create local benefits**

Burlington-based Aslan Technologies worked with the community of Shakespeare, Ontario to upgrade their local septic/sewage systems to make them more climate resilient and reduce chance of groundwater contamination from extreme weather events. With support from the municipal, provincial and federal governments, the company partnered to create a decentralized sewage system. Not only was this system more climate-resilient, it reduced costs to the municipality as it did not have to pay to extend the centralized sewage system, leading to lower project costs and a reduced tax burden for residents.