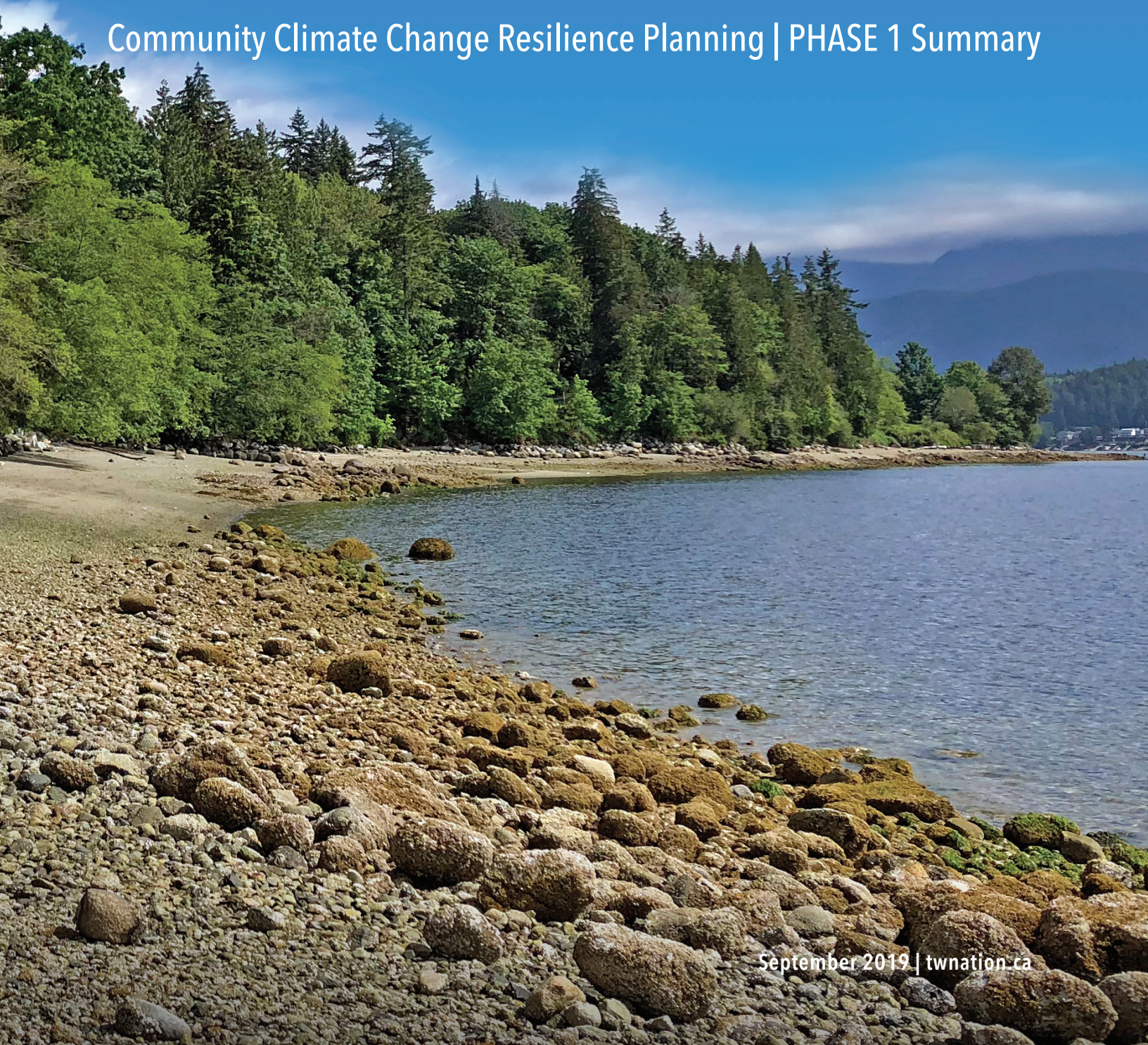
TSLEIL-WAUTUTH
THE PEOPLE OF THE INLET

Understanding Our Community's Climate Change Vulnerabilities

Community Climate Change Resilience Planning | PHASE 1 Summary



September 2019 | twnation.ca

The Tsleil-Waututh Nation Community Climate Change Resilience Planning project is led by the Nation's Treaty, Lands & Resources Department, in coordination with Public Works and other departments.

TSLEIL-WAUTUTH
THE PEOPLE OF THE INLET

Technical work to complete the assessment was led by consultant Kerr Wood Leidal Associates Ltd. (KWL) with Inlailawatash Limited Partnership (ILP) leading the archaeological assessment.

KERR WOOD LEIDAL
consulting engineers

Inlailawatash

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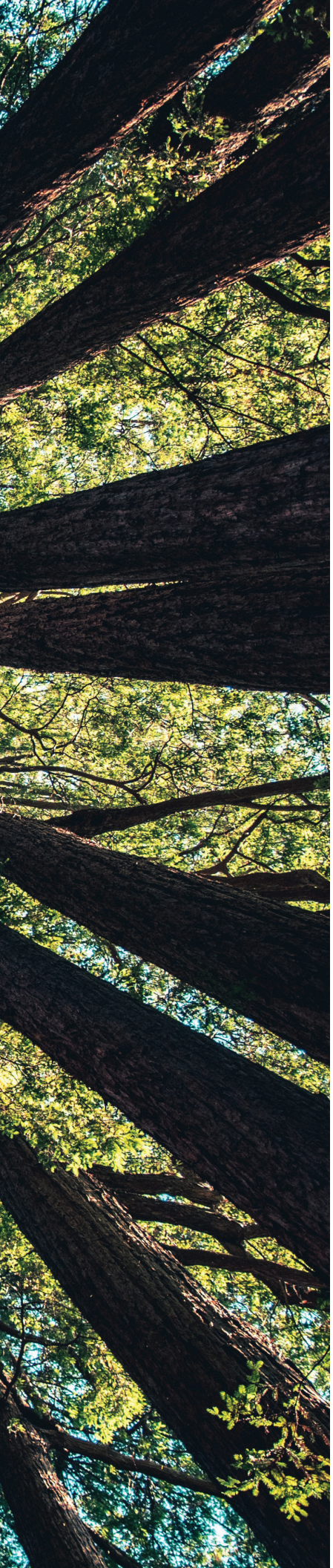
PHOTO CREDIT: Casey Horner/Unsplash



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PREPARING FOR CLIMATE CHANGE

Climate change has the potential to profoundly impact the Tsleil-Waututh Nation (TWN) and many key aspects of community life. It influences the ability of our community to harvest some wild foods and medicinal plants, how we access the shoreline and marine waters, and how we connect with Nature. It poses community health risks, influence our ability to practice spiritual and cultural ceremonies, and share cultural teachings.

Impacts from climate change are already being experienced. Stronger storms are causing more severe flooding in urban areas and increasing erosion which is damaging property, cultural areas, and natural habitats. More frequent extreme summer heat and poor air quality from forest fires expose vulnerable people to increased health risks. Drier summers are threatening western red cedar and current forest ecosystems. Ocean changes are impacting the survival of clams and other marine food sources that are essential to the health of TWN people. Many of these impacts are expected to become more severe as climate change continues in the future.

A Tradition of Stewardship

TWN culture and heritage is built on a strong connection with, and a deep obligation to be the caretakers and protectors of, our traditional lands and waters. Natural resources continue to be vitally important, not only for staple foods (e.g., salmon, clams, and crab), but also for cultural and spiritual practices, artistic representation, recreation, and technological and economic development. The ability to access and sustainably manage these resources is directly linked to our community health and provides important opportunities to pass on cultural teachings and the *hən̓q̓əmin̓əm* language to the next generation.

TWN is committed to addressing climate change because taking care of the environment and the community lies at the heart of who we are as a people. Our health and survival are closely tied to the health of our waters, lands, and the air that we breathe. Guided by our sacred obligation to protect and be good stewards of the environment, our deep connection to Burrard Inlet and the surrounding lands, and our ancestral knowledge that has been passed on from generation-to-generation, we have governed and survived in this place for thousands of years.

Living in Harmony

Prior to contact, our ancestors thrived for thousands of years by living in harmony with Nature, and governing the waters and lands in our traditional territory in a sustainable manner. The family histories, legends, traditions, and knowledge that are passed on from generation to generation provide valuable information as to how our ancestors survived and adapted to adverse conditions, changing seasons, historic floods, and more.

Moving forward, there are important steps the Nation can take to reduce the impacts of climate change on our community to ensure that we can continue to thrive into the future. Our Community Climate Change Resilience Planning (CCCRP) project is leading our response. This has started with work to understand how climate change will impact our community, determining where we are most vulnerable, and beginning to use this information to chart an effective plan for action. Community input, ancestral knowledge, and western science all have an important role to play in informing and guiding this work.

This report serves to build an understanding of community vulnerability to climate change and begins to explore potential climate adaptation actions.

About this Summary Report

This report provides a summary of Phase 1 of the CCCRP, which includes climate change hazard and vulnerability assessments. The full technical report, the "**Climate Change Vulnerability Assessment Report**" is available at www.twnation.ca.

PHOTO CREDIT: Haley Crozier

Gabriel George presenting at the TWN-hosted Climate Change Summit on July 18, 2018.

INTRODUCTION TO THE COMMUNITY CLIMATE CHANGE RESILIENCE PLANNING PROJECT

TWN has embarked on a proactive, integrated, and community-based planning process to prepare the community for climate change. The multi-year Community Climate Change Resilience Planning (CCCRP) project will build an understanding of the level of impact climate change hazards may have on the community, as well as develop and guide implementation of adaptation measures. Climate change adaptation measures are intended to protect the community from, or build its resilience to climate change impacts, such that future generations of Tsleil-Waututh people can continue to thrive in a changing climate.

The project focuses on climate change impacts to Sleil-Waututh, also known as Burrard Inlet IR#3, which is the current village site for the Nation. In the future, TWN hopes to expand the assessment to consider the vulnerability of other areas within its traditional territory.

TWN youth and elder shoreline tour and discussion of climate change impacts on April 3, 2019.

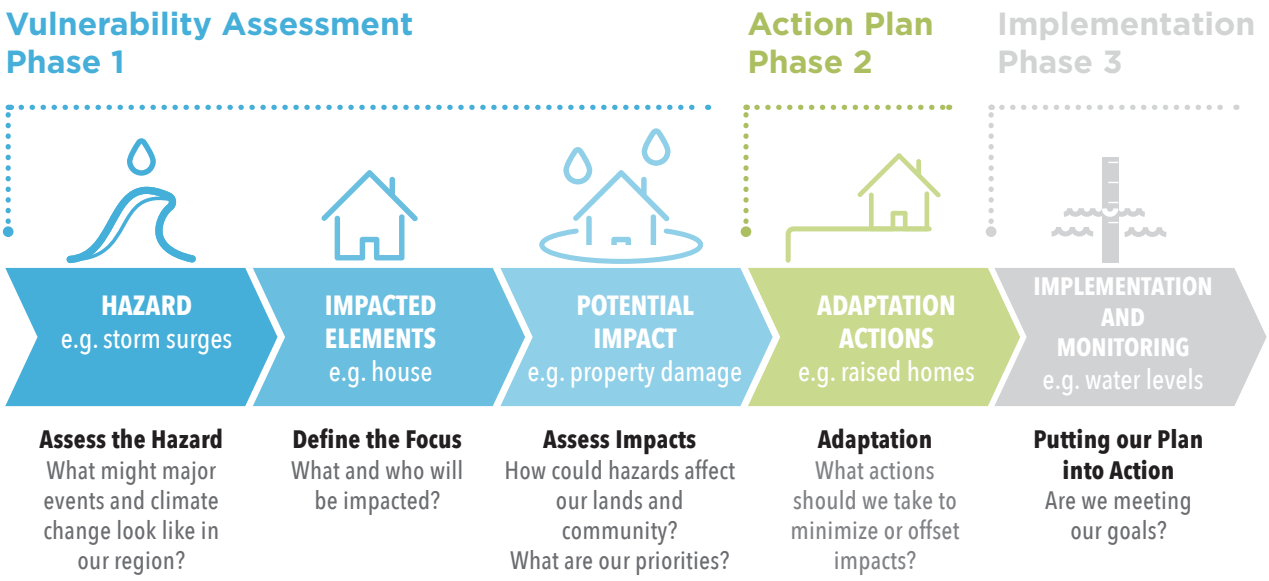
A Multi-Phase Project

The CCCRP project involves three phases:

Vulnerability Assessment (Phase 1) – involves completing hazard, vulnerability, and archaeological assessments to understand how climate change might impact the community.

Action Plan (Phase 2) – includes developing a detailed road map of prioritized and cost-effective actions to guide allocation of community resources and efforts to promote climate change adaptation.

Implementation and Monitoring (Phase 3) – this is the operational phase in which climate change adaptation measures from the Action Plan are implemented and tracked to monitor their effectiveness. Adjustments may be needed as new information and opportunities become available.



Aligned with Existing TWN Initiatives

The importance of addressing climate change is deeply rooted in a number of existing TWN policies, plans, and environmental stewardship initiatives. These include the TWN Stewardship Policy (2009), Comprehensive Community Plan (2010), Burrard Inlet Action Plan (2015), Cumulative Effects Monitoring initiative, and Land Use Plan (2019). The CCCRP project builds on the foundations set by these policies and plans, advances knowledge and understanding of climate change impacts and vulnerabilities, and integrates community input, values, and traditional knowledge.

PHASE 1 APPROACH

An integrated planning approach was used to consider impacts to a wide range of core community values and assets to understand how climate change might impact not only buildings, roads, and other infrastructure; but also species, habitats, and ecosystems, cultural and community health, sites of archaeological and cultural significance, community services, and current and future economic activities.

The assessments drew on a combination of traditional and local knowledge and scientific approaches. Key features, or building blocks, of the project approach are described below:

Focused on Community Sectors

Climate change impacts were considered for **specific elements** of the community identified as priorities by TWN staff and community members. These elements served as the foundation for the hazard assessment, vulnerability assessment, and developing preliminary adaptation measures. Thirty-four (34) elements were identified across six (6) broad sectors, including:

Ecological Systems
(e.g., impacts to shellfish and beaches)

Land Use & Real Estate
(e.g., community housing and buildings)

Infrastructure & Community Services
(e.g., water infrastructure and emergency services)

Archaeological & Cultural Heritage Sites
(e.g., archaeological sites and community cemetery)

Community & Cultural Health
(e.g., physical health and well-being)

Economy
(e.g., employment and business assets)

TWN's holistic approach promotes a deeper understanding of climate change impacts on the community and opens the door for considering dynamic climate change adaptation strategies such as cultural and nature-based solutions that extend beyond conventional structural approaches.

Consultation with the TWN Land Use Planning Committee on February 28, 2019.

Multi-Hazard and Values-Based Approach

A **multi-hazard approach** (investigation of multiple climate change hazards) helped to build a more complete understanding of the hazards and their inter-connectedness (some hazards cause multiple impacts).

Informed by community engagement, a **values-based approach** (investigation informed by community values) was used to focus analyses on elements of greatest importance to the TWN community.

Building on Best Practices

Methodologies for Phase 1 were based on models used in other communities, and established best practices including:

- Swinomish Climate Change Initiative Vulnerability Assessment Framework [1]
- Source-Pathway-Receptor-Consequence model [2]
- ICLEI Canada's Building Adaptive & Resilient Communities (BARC) Program[3]

[1] Swinomish Indian Tribal Community Office of Planning and Community Development, 2009. Swinomish Climate Change Initiative Impact Assessment Technical Report. Retrieved from: www.swinomish-nsn.gov/climate_change/Docs/SITC_CC_ImpactAssessment TechnicalReport_complete.pdf.

[2] HR Wallingford. 2005. RASP – A Hierarchy of Risk-based Methods and Their Application. HRPP 333. Reproduced from a paper presented at the 40th Defra Flood and Coastal Management Conference, University of York, July 2005. Available at: http://eprints.hrwallingford.co.uk/76/1/HRPP333_RASP_-_A_hierarchy_of_risk-based_methods_and_their_application.pdf Integrated Ocean Observing System. 2016. Climate. Retrieved from http://www.nanoos.org/education/themes/climate.php. Accessed Oct 6, 2016.

[3] ICLEI – Local Governments for Sustainability, Canada. 2010. Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Action. Retrieved from: http://www.icleicanada.org/images/icleicanada/pdfs/GuideWorkbookInfoAnnexes_WebsiteCombo.pdf.

Guided by Community Input and Values

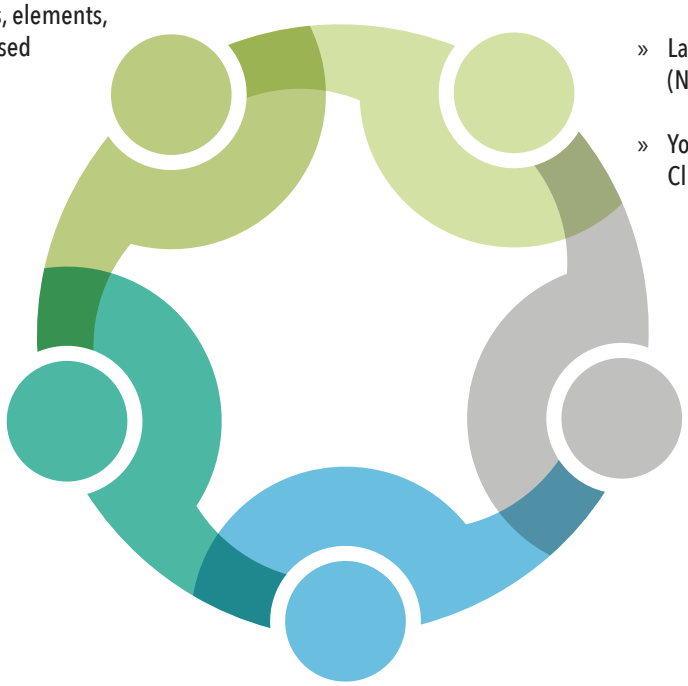
Community engagement is an integral part of the CCCRP process. The knowledge and input shared by community members and staff throughout Phase 1 provided valuable insights and observations of environmental changes and impacts on TWN lands, and informed identification of community priorities for assessment and preliminary adaptation measures.

TWN Land Use Plan Working Group

- Provided input and direction on hazard & vulnerability assessment and adaptation measures during 3 workshops
- Informed the project methodology, including changes to sectors, elements, and hazards assessed

TWN Community Members

- Shared information, learned about and provided input at the following engagement events:
  - TWN Climate Summit (July 2018)
  - Community Art Project (Sept 2018)
  - Land Use Plan Film Screening (Nov 2018)
  - Youth & Elders Shoreline Tour and Climate Change Forum (Apr 2019)



TWN Departmental Staff

- Shared technical knowledge and data during 6 workshops
- Directly informed hazard and vulnerability assessment results and maps

TWN Steering Committee & Project Manager

- Guided project objectives, scope, and overall direction
- Reviewed and informed project deliverables

Inlailawatash Limited Partnership

- Completed an assessment of archaeological sites that may be impacted by climate change
- Shared technical knowledge and informed the vulnerability assessment of cultural and archaeological sites

Sample of community comments from climate change engagement

“Our once plentiful clams... eelgrass and kelp beds... have been lost.”

“The climate changes we are seeing... is Mother Nature trying to correct herself... We need to take care of Mother Nature and she will take care us.”

“Climate change is happening incrementally... slow, small changes. But altogether it adds up to a big impact.”

“We are losing land ... and archaeological sites... to big waves and erosion along the shoreline... In some areas up to 36 ft of land has been lost.”

“TWN Youth have an opportunity to be inspired... to build knowledge and careers... around climate change action.”

COMMUNITY CONTEXT

The ***səl̓ilwətaʔɬ***, or Tsleil-Waututh Nation, are the "People of the Inlet" and have used, occupied, and governed the lands and waters of ***səl ilw̓ət*** (Burrard Inlet) and the surrounding areas since time out of mind. TWN is a small, but growing Coast Salish community of more than 500 people, many of whom now reside on Sleil-Waututh (Burrard Inlet IR#3) located on the north shore of Burrard Inlet.

Information on the current status and condition of TWN lands and waters was gathered, providing a baseline of current conditions to project future impacts from climate change. Observations were collected on:

- locations of community assets and infrastructure;
- the composition of sediment (e.g., gravel, sand) along shorelines and creeks;
- vegetation present in marine, intertidal, and riparian areas;
- habitat types present in intertidal areas; and
- the presence of archaeological sites that might be impacted by climate change forces.

This data collection involves a combination of on-site investigations, background report reviews and conversations with staff and knowledge holders. Baseline investigations as part of the project involves:

BASELINE CONDITIONS

A creeks are comprised of steep ravines, with near-vertical banks (cobble and gravel in fine-grained sediment). Creek beds are a mix of boulders, cobbles, and gravel sitting on top of till.

B second and third growth forest including Pacific crab apple, western hemlock, bigleaf maple, western redcedar, black cottonwood, red alder, Douglas-fir

C abundant native plants including salmonberry, red huckleberry, bracken fern, sword fern, and vine maple

D steep scarp with fine-grained sediments (sand-gravel base with a gravel-cobble-boulder surface).

E shoreline vegetation is generally tolerant to ocean salt spray, temporary flooding, and unstable slopes

F rockweed and sea lettuce are the most common forms of intertidal vegetation. Eelgrass covers less than 1% of intertidal lands but can extend below the low tide line (not mapped).

G steep scarp with fine-grained sediments (sand-gravel base with a gravel-cobble-boulder surface)

H shallow slope shoreline with fine grained soils (mud, clay, sand)

I intertidal areas with fine-grained soils (gravel, sand, mud) provide habitat for shellfish, salmon, forage fish, and waterfowl

TWN Traditional Territory covers a vast area of 190,000 hectares reaching from Burrard Inlet and the Fraser River to the south to Mamquam Lake to the north. Burrard Inlet IR#3 is approximately 111 hectares (276 acres) in size and includes 2 km of shoreline lined with deciduous and mixed forest that extends towards the steep slopes of Mount Seymour.

This map shows the baseline conditions in IR#3, gathered through site investigations completed during Phase 1 of the CCCRP.

There are three designated archaeological sites on reserve, which are all experiencing undercut soil erosion. Oral histories record up to 6m of shoreline erosion since the mid-20th century in some designated archaeological sites. Previously unrecorded archaeological and cultural site material was found as part of the archaeological assessment and there are likely other sites not yet recorded.

1. Maplewood Flats
2. Existing Community Housing
3. Administrative Building
4. Community Centre
5. Takaya Golf Centre
6. Leasehold Housing

Burrard Inlet IR#3 Boundary

CLIMATE CHANGE PROJECTIONS FOR THE REGION

Scientific studies and modelling from regional, national, and international sources have projected what climate change might look like in communities and landscapes across Metro Vancouver and the Salish Sea. Some of these impacts are already being experienced. Others are predicted to occur over the next 50 to 100 years.

Sea Level Rise

Sea level rise represents the long-term increase in water levels compared to the local land level. Sea level rise is occurring to varying degrees along the coast of BC, in part as the result of climate change (thermal expansion and glacier melt) and due to shifting tectonic plates causing land along the shore to rise ("uplift") or fall ("subsidence"). Sea level rise leads to overall higher water levels for tides and storm surges. *According to the Province of BC's Sea Level Rise Policy (2011), communities should plan for 1 m of global sea level rise by the year 2100 and 2 m by the year 2200*[4].

For this project, hazards associated with sea level rise include coastal flooding, coastal erosion, and intertidal area change.

Ocean Condition Changes

Climate change is causing multiple effects on the world's oceans, which absorb carbon dioxide and solar heat and receive the freshwater that flows from the land. Resulting oceanic changes include an increase in ocean acidity, changing salinity, increasing water temperatures, and shifting ocean circulation patterns. *Ocean changes have been observed by TWN first-hand, especially the effects on traditional harvest areas in the waters and beaches surrounding Burrard Inlet including Port Moody Arm and Indian Arm*[5].

For this project, hazards associated with ocean condition changes include ocean acidification and harmful algal blooms, as well as changing water temperatures, salinity, and oxygen levels.

[4] Ausenco Sandwell, 2011. Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use. Prepared for BC Ministry of Environment.

[5] Hyland, S. 2018. Ocean Acidification Research Paper.

Climate Change Forces and Hazards

Climate change refers to changes in long-term weather normals and patterns, which causes significant changes to global environmental conditions such as air temperature, precipitation patterns, ocean conditions, and sea levels. These broad changes, or **climate change forces**, are expected to affect communities and ecosystems through a range of specific **hazards** felt on a regional or local scale. For example, changing precipitation patterns across Metro Vancouver (force) could lead to an increase in the frequency and magnitude of surface flooding across the North Shore (hazard), including on TWN lands.

Precipitation Changes

Rising temperatures are expected to lead to increased moisture in the atmosphere, which will result in changes in the seasonality, intensity, and overall amounts of precipitation. For TWN, climate change is expected to cause more frequent and severe rainfall events and a decrease in total precipitation volumes in summer months. *Recent projections for Metro Vancouver estimate the intensity of rainfall events will increase by 17% by 2050s and 32% by 2080. The same report projects total summer precipitation will decline by 18% and 29% over the same period*[6].

For this project, hazards associated with precipitation changes include creek flooding, creek erosion, and urban flooding.

Air Temperature Changes

Global air temperatures are rising due to increased concentrations of greenhouse gases in the atmosphere, which trap heat and cause a warming of the earth[7]. *Current trends show that air temperatures on the west coast are rising, measuring an increase of 1.3 ^{0}C over the past century, with more rapid warming during summer months*[3]. *Warming of about 1.7 ^{0}C is projected by 2050 and 2.7 ^{0}C by 2080*[8].

For this project, hazards associated with air temperature changes include extreme heat, wildfire, vector-borne disease, and invasive species.

[6]Metro Vancouver. 2016. Climate Projections for Metro Vancouver. Accessed: October 25, 2018. Retrieved from: http://www.metrovancouver.org/services/air-quality/Air Quality Publications/ClimateProjectionsForMetroVancouver.pdf,

[7]Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013, The physical science basis In Stocker T., editor; Qin D., editor; Plattner G., editor; Tignor M., editor; Allen S., editor; Boschung J., editor; Nauels A., editor; Xia Y., editor; Bex V., editor; and Midgley P., editor. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 1–1535. Cambridge University Press, New York,

[8] Intergovernmental Panel on Climate Change (IPCC). 2013. Summary for policymakers; in Climate Change 2013: The Physical Science Basis (Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change). Accessed: December 12. Retrieved from: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_SPM_FINAL.pdf

HAZARD ASSESSMENT

Thirteen (13) climate change-related hazards were identified as having the potential to impact Burrard Inlet IR#3. These hazards were selected through literature review and conversations with TWN staff and community members on community values, assets, and climate change concerns. Over time, additional climate change hazards for TWN may emerge and create a need for further assessment in the future.

In Phase 1 of the CCCRP, numerical modelling informed assessment of sea level rise and precipitation changes on reserve lands. A review of available scientific information informed analysis of temperature and ocean changes. Details on the methodologies and references used may be found in the Community Climate Change Vulnerability Assessment Report.

Hazard results are summarized in the following pages, grouped into hazards associated with the ocean and shorelines, and hazards in creek and upland areas.

These icons used in this document to present the sector groups expected to be impacted by each hazard:

Ecological Systems

Land Use & Real Estate

Infrastructure & Community Services

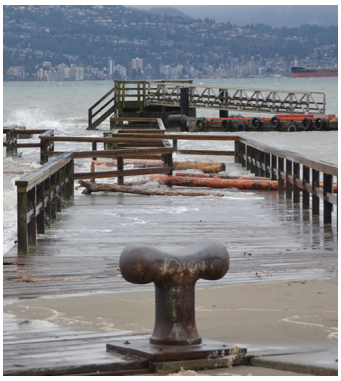
Archaeological & Cultural Heritage Sites

Community & Cultural Health

Economy

PHOTO CREDIT: Sarah Dal Santo, March 2019

Ocean and Shoreline Associated Hazards



COASTAL FLOODING

Coastal flooding occurs when a combination of tides, wind, and waves cause ocean water levels to rise and flood shoreline areas. Flooding will be even more severe when added to longer-term sea level rise (SLR). **Coastal flood hazard modelling results showed that most waterfront properties may experience flooding during an extreme flood under a 2 m sea level rise scenario. The most impacted structures are located near the mouths of George Creek and include a sewer main, the community canoe shed, and other cultural sites along the shore.**

COASTAL EROSION

Coastal erosion refers to the carving away of land by water, primarily due to wave action. TWN traditional knowledge and community member experiences highlight significant changes to the Burrard Inlet shoreline. Boat wakes and wind-generated waves have contributed to the shoreline erosion that has been experienced to date. In the future, higher sea levels combined with more severe storm events and winds may further exacerbate shoreline erosion. Site investigations and analysis show that important community areas and features including Maplewood Flats, the Cemetery Headland, and the Whey-ah-wichen (Cates Park) Headland are highly sensitive to erosion by waves at higher sea levels. **Erosion in these areas may affect waterfront properties and natural habitats, and threaten buildings, archaeological, and other cultural sites**.

PHOTO CREDIT: Sara Hyland

OCEAN ACIDIFICATION

Oceans around the world are expected to become more acidic due to increasing carbon dioxide from the atmosphere mixing with ocean water. There is evidence that the waters of Burrard Inlet have become more acidic since the 1950s, due in part to increasing carbon emissions but also due to industrial discharges around the Inlet[9]. Because the waters around TWN are naturally more acidic than other marine areas of coastal BC, **ocean acidification from climate change poses an acute threat to species (particularly shellfish) along the mudflats and beaches of Burrard Inlet IR#3.**

[9]Hyland, S. 2018, Ocean Acidification Research Paper

INTERTIDAL AREA CHANGE

The intertidal zone is the area of the beach located between the high and low tide lines. As the sea level rises, the intertidal area will shift landward. When the intertidal zone is not able to move inland due to development or natural features and intertidal area is lost, this is known as "coastal squeeze". Hazard assessment findings suggest that the IR#3 foreshore will face a high degree of coastal squeeze, with the intertidal area decreasing by up to approximately 20% under a 1 m SLR scenario. **This will have significant impacts on species that live in the intertidal zone (e.g., shellfish) or that forage for food in these areas (e.g., marine birds and salmon). Many of these species are critically important as sources of food for TWN community and cultural health, and serve as important opportunities to share traditional teachings**.

HARMFUL ALGAL BLOOMS

While many forms of algae are good for the environment, high accumulations of phytoplankton species that produce toxins are referred to as harmful algal blooms (HABs). **HABs can severely reduce dissolved oxygen levels and lead to accumulation of toxins, affecting the health of ocean plants and animals.** The waters of Burrard Inlet will be increasingly vulnerable to HABs as water temperatures rise and summer precipitation decreases. While no HABs have been recorded in Burrard Inlet so far, non-harmful blooms were reported in 2014.

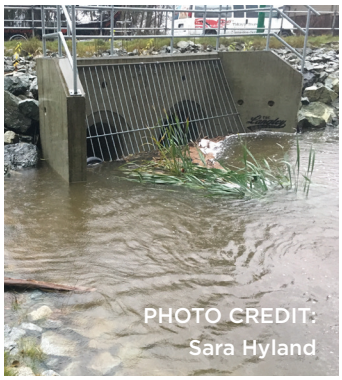
OTHER OCEAN-RELATED CONDITIONS

Climate change is expected to affect the physical water properties of Burrard Inlet in many different ways, including increasing ocean temperatures, changing ocean salinity, and reducing the amount of oxygen dissolved in ocean water ("hypoxia"). **These changes are expected to have significant and broad-reaching impacts on marine life health (particularly shellfish, salmon, and other fish) and lead to further impacts on terrestrial species that rely on the ocean as a food source**.

MARINE INVASIVE NON-NATIVE SPECIES

Climate change has the potential to make local waters more habitable for invasive non-native species, particularly those from warmer waters. Over time, native shellfish have been replaced by invasive shellfish species such as purple varnish clam and soft-shell clams. While not yet found in B.C., ocean temperatures and other ocean changes could facilitate the invasion of invasive European green crab into the region.

Creek and Upland Associated Hazards



CREEK FLOODING

Creek flooding along the three main creeks in Burrard Inlet IR#3 (George, Thomas, and Big John) can occur due to high flows from intense rainfall and/or blocked culverts. Creek flooding can cause damage to adjacent properties and road washouts at creek crossings. In Burrard Inlet IR#3, the creek flood hazard is considered low in upland areas due to the confined ravine topography, but along **Dollarton Highway overtopping and flooding at crossings could cause road washouts or significant damage to adjacent properties or infrastructure**.

CREEK EROSION

Creek erosion is the continuous wearing away of the bed and banks of a stream by the water, which can cause creek channel instability, threaten nearby structures or cultural sites, and lead to the accumulation of sediment in downstream habitats. Creek erosion is a natural process, but can be exacerbated by more frequent, more intense rainfall expected under climate change. **While the majority of community buildings are located away from creek banks, creek erosion in Burrard Inlet IR#3 has some potential to damage creekside or downstream archaeological sites in localized areas**.

URBAN FLOODING

Urban flooding can occur when major rainfall events overwhelm the capacity of the stormwater system, causing rainfall to pool and flow overland with potential damage to buildings and infrastructure. Community members noted a number of areas where repeated flooding of this type has occurred on residential properties. Assessment results suggest that overland flooding from infrequent large storm events (i.e., 10% likelihood of occurring in a given year) could cause **significant flooding along Sleil-Waututh Road, Ghum Lye Drive, and Alder Court, and minor flooding at the east and west ends of Takaya Drive**.

[13]BC Ministry of Healthy Living and Sport. 2010. Evidence Review: Communicable Disease (Vector-borne Disease Management). Retrieved from: https://www2.gov.bc.ca/assets/gov/health/about-bc-s-health-care-system/public-health/communicable-disease-prevention/communicable_disease_vector-borne_disease_management-evidence_review.pdf.

EXTREME HEAT

Extreme heat events can be measured in different ways but ultimately refer to days when air temperatures are significantly hotter than normal. **This has the potential to affect less drought-tolerant trees, increase creek water temperatures, reduce creek flows, and increase the risk of wildfires. Extended periods of extreme heat can cause heat exhaustion or heat stroke, particularly among vulnerable groups**.

WILDFIRE

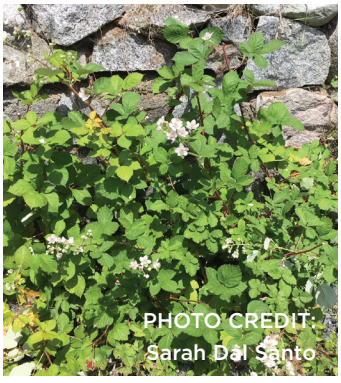
The risk of wildfire is expected to rise with climate change due to hotter and drier summers (drought) and more storms (lightning strikes)[12]. In dry conditions, the forested areas on Burrard Inlet IR#3 are at risk of a wildfire that **could impact wildlife habitats, as well as development and infrastructure along the forest/urban area interface. Community member health and the opportunity for recreation, cultural practices, and job productivity is also impacted by poor air quality and smoke from wildfires across BC**.

VECTOR-BORNE DISEASES

Vector-borne diseases are caused by parasites, viruses, and bacteria transmitted by living organisms ("vectors"), such as insects. As air temperatures warm and precipitation patterns change, disease-carrying species have the potential to migrate to areas that where they couldn't previously have survived. In Metro Vancouver, the two main vectors that transmit disease are mosquitoes and ticks[13]. These species prefer moist vegetated areas (e.g., forests, parks, and riparian areas) which are all present within Burrard Inlet IR#3. **Vector-borne diseases could affect the health of TWN community members, with potential impacts to cultural activities and job productivity.**

INVASIVE NON-NATIVE SPECIES

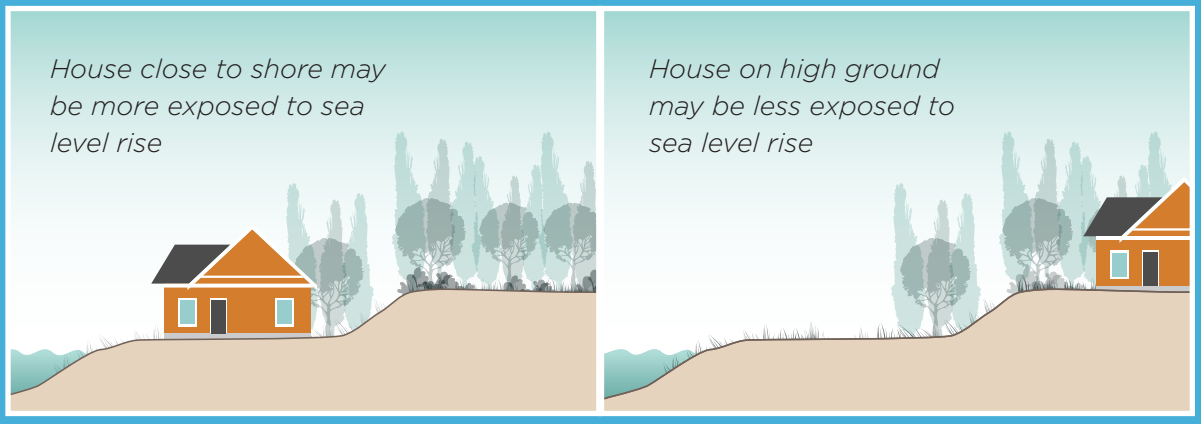
Similar to those in the marine environment, native species along creeks and in upland areas are also experiencing competition from invasive non-native species of plants and animals. Ongoing changes to air temperatures and precipitation patterns from climate change could increase the success and abundance of some invasive species. **TWN is already managing invasive species of plants (e.g., Japanese knotweed, English ivy, Himalayan blackberry, giant hogweed) and animals (e.g., American bullfrog)**.



VULNERABILITY ASSESSMENT

A detailed vulnerability assessment was completed for all significant hazards with the potential to affect values and assets important to the TWN community. Vulnerability is a measure of how susceptible an element might be to a particular hazard, and it is useful to identify particular areas of weakness that may need attention. Vulnerability is influenced by the level of **exposure**, **sensitivity** and **adaptive capacity** of the element.

EXAMPLE:
Over time, a house located close to the shoreline may be exposed to hazards such as sea level rise and coastal erosion. If the house is located in an area with finer soils that are easily eroded, the home may be very sensitive to the impacts of sea level rise. There are a number of ways that can be used to improve the adaptive capacity of of the home and its occupants, e.g., moving the home to higher ground (illustrated below), elevating the home, shoreline hardening, or other nature-based solutions.



Climate change will affect each of the community elements in different ways, some that can be anticipated and others that are yet unknown.

Impacts to elements were assessed using a combination of expert judgment, community input, and spatial analysis to predict potential impacts on elements of the community. Results of the vulnerability assessment highlighted community elements considered to be most vulnerable to climate change hazards, and which hazards are expected to pose the greatest risk to TWN.

Details of the results from the vulnerability assessment can be found on pages 26 to 27.

Whey-ah-Wichen (Cates Park) trees felled by severe wind storm, December 2006.

Vulnerability Assessment Summary

A list of 34 priority "elements", grouped under six "sectors", were defined through a series of workshops with TWN staff and community members. Each of these elements was assessed to determine how vulnerable they might be to the identified climate change hazards.

The following matrix summarizes the results from the vulnerability assessment for each element. Elements were categorized as having either a high, moderate, or low vulnerability to each relevant hazard. The scores for each element were added together to determine which elements are most vulnerable across all relevant hazards. Through this process, twelve community elements have been identified as **our most vulnerable elements** (shown on page 28). This approach made it possible to combine traditional knowledge and technical analysis under one rating system.

In many cases, the **level of uncertainty of the results is high**, particularly for elements that are intangible (e.g., social, cultural, and spiritual well-being) or for hazards without region or location-specific data (e.g., ocean acidification).

These results are intended as a **starting point** for TWN to begin developing adaptation measures that address areas where the Nation appears to be particularly vulnerable. These measures may need refinement over time as more information about climate change impacts in the region becomes available.

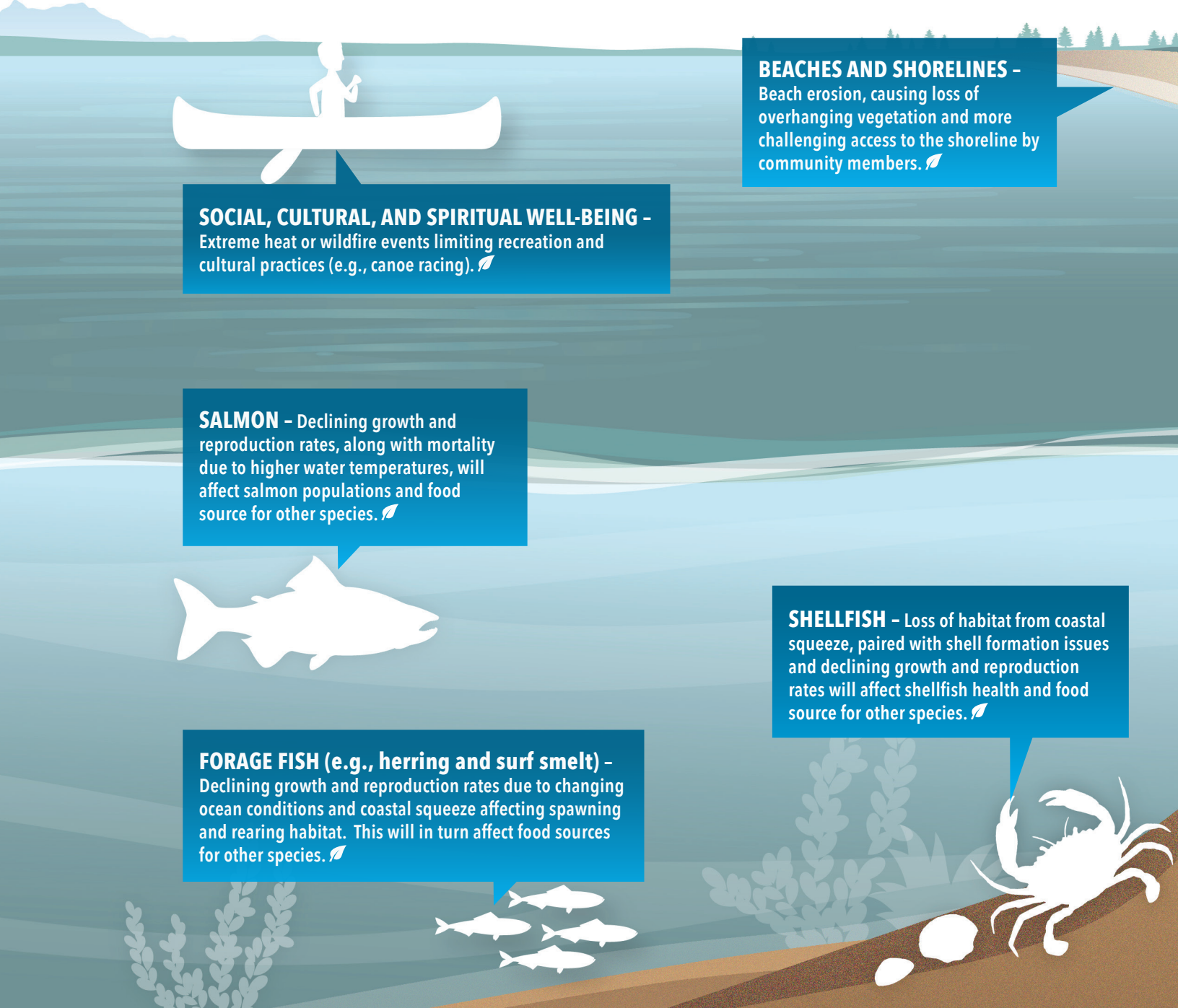
SECTOR	ELEMENT
Ecological Systems	Shellfish
	Salmon
	Forage fish
	Other finfish
	Marine birds and waterfowl
	Marine and semi-aquatic mammals
	Beaches and shoreline
	Tidelands and marine habitats
	Marine water quality
	Upland wildlife
	Forested areas and medicinal plants
	Freshwater creeks, streams, wetlands, and groundwater
	Air quality
Land Use and Real Estate	Near-shore lands
	TWN community housing
	Market (leasehold) housing
	Community buildings
	Hazardous sites
	Future land use opportunities
Infrastructure and Community Services	Water supply and distribution system
	Sewer/Wastewater collection system
	Stormwater system
	Roads and emergency access
	Energy and telecommunication systems
Archaeological and Cultural Heritage Sites	Archaeological sites
	Cemetery
	Other cultural and traditional use sites
Community and Cultural Health	Physical health (general population)
	Mental health
	Vulnerable populations
	Social, cultural, and spiritual well-being
Economy	Employment and productivity
	Commercial assets
	Future economic development opportunities

Coastal Flooding	Coastal Erosion	Intertidal Area Change	Ocean Acidification	Harmful Algal Blooms	Other Ocean Conditions	Creek Flooding	Creek Erosion	Urban Flooding	Extreme Heat Events	Wildfire	Vector-Borne Diseases	Invasive Species	OUR MOST VULNERABLE ELEMENTS
SEA LEVEL RISE			OCEAN CHANGES			PRECIPITATION CHANGE			TEMPERATURE CHANGE				
	Med	High	High	Med	High		Low					Med	
		High	Med	Med	High	Med	Low					Med	
	Med	High	Med	Med	High							Med	
		Med	Med	Med	High							Med	
	Low	High	Med	Low	High								
	Low	Med	Med	Low	Med				Low				
Med	High	High	Med				Med		Low	Med		Med	
Med	Low		Med		High				Low			Med	
Low	Low			Med	High	Med	Low	Med	Low				
Low	Low	Low	Low	Low	Low	Low	Low		Med	High			
Med	Med					Low	Low		High	High		Med	
Med	Low					Med	Low	Med	High	Low			
									High	High			
Low	Low					Low	Low	Med		Med		Med	
Low	Med					High	Low	High		High		Med	
						Low		Low		High		Low	
Med	Low					Low	Low	Med		High		Med	
Med													
Low	Med					Low		Low		Med		Med	
Low	Med					Med	Med		Med	Low			
Med	High					High	Med			Low			
Med	Med					High	Med	Low		Low			
Med	High					High	Med	Med	Med	Med			
Low	Med					Low	Med	Low	Med	Med			
High	High	Med	High			High	Low	Low	High	High		Med	
Low	Med							Low		Low			
High	Med	High				High	Med		Med	Med	Low	Med	
Low	Low			Med		Low	Low	Low	Med	Med	Low	Med	
Med	Low	Low				Low	Low	Low	Low	Med	Low		
Low						Low	Low	Low	High	Med	Med	Med	
Med	Low	High	Med	Med	High	Med	Med		High	Med	Low	Med	
Med	Med					Med	Med	Med	Low	Med	Low		
Low	Low	Med						Low		Low			
Low	Med			Med		Low	Low			Med			

Our Most Vulnerable Elements

Climate change is expected to impact TWN community, lands, and culture in many ways – some we can anticipate today and others that are not yet known. The list of elements that community members most cared about formed the basis for the vulnerability assessment.

Results from the vulnerability assessment found the following community elements to be particularly vulnerable to impacts from climate change hazards.



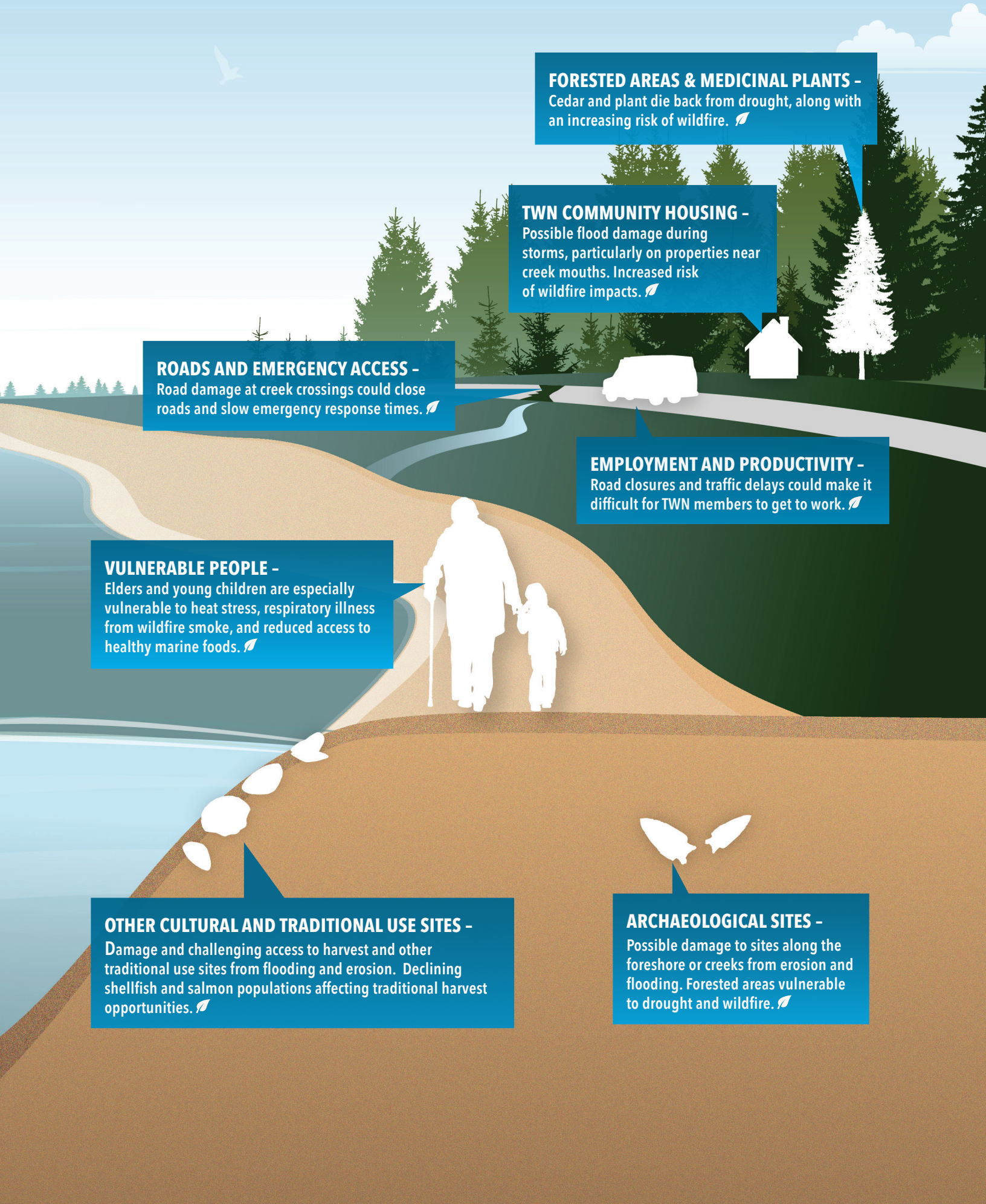
BEACHES AND SHORELINES – Beach erosion, causing loss of overhanging vegetation and more challenging access to the shoreline by community members.

SOCIAL, CULTURAL, AND SPIRITUAL WELL-BEING – Extreme heat or wildfire events limiting recreation and cultural practices (e.g., canoe racing).

SALMON – Declining growth and reproduction rates, along with mortality due to higher water temperatures, will affect salmon populations and food source for other species.

SHELLFISH – Loss of habitat from coastal squeeze, paired with shell formation issues and declining growth and reproduction rates will affect shellfish health and food source for other species.

FORAGE FISH (e.g., herring and surf smelt) – Declining growth and reproduction rates due to changing ocean conditions and coastal squeeze affecting spawning and rearing habitat. This will in turn affect food sources for other species.


FORESTED AREAS & MEDICINAL PLANTS –
Cedar and plant die back from drought, along with an increasing risk of wildfire.
TWN COMMUNITY HOUSING –
Possible flood damage during storms, particularly on properties near creek mouths. Increased risk of wildfire impacts.
ROADS AND EMERGENCY ACCESS –
Road damage at creek crossings could close roads and slow emergency response times.
EMPLOYMENT AND PRODUCTIVITY –
Road closures and traffic delays could make it difficult for TWN members to get to work.
VULNERABLE PEOPLE –
Elders and young children are especially vulnerable to heat stress, respiratory illness from wildfire smoke, and reduced access to healthy marine foods.
OTHER CULTURAL AND TRADITIONAL USE SITES –
Damage and challenging access to harvest and other traditional use sites from flooding and erosion. Declining shellfish and salmon populations affecting traditional harvest opportunities.
ARCHAEOLOGICAL SITES –
Possible damage to sites along the foreshore or creeks from erosion and flooding. Forested areas vulnerable to drought and wildfire.

PRELIMINARY ADAPTATION TOOLKIT

Results from the vulnerability assessment informed the identification of 49 preliminary adaptation measures that will serve as a starting point to develop TWN's Action Plan for climate change adaptation in Phase 2 of the CCCRP.

The measures in this adaptation "toolkit" were identified through best practice research, professional expertise, and community input. Identified preliminary adaptation measures represent:

» specific actions that can be implemented in the short term;

» longer-term actions that call for further scientific research and analysis;

» measures that TWN is already developing and implementing (e.g., land use planning); and/or

» ongoing actions that can be credited as contributing to adaptation.

The preliminary adaptation toolkit is organized into six themes shown below:

» Policy, Planning, and Partnerships

» Structural Works

» Resilient Infrastructure & Nature-based Concepts

» Community Preparedness

» Scientific and Traditional Knowledge

» Education and Communications

SCREENING CRITERIA

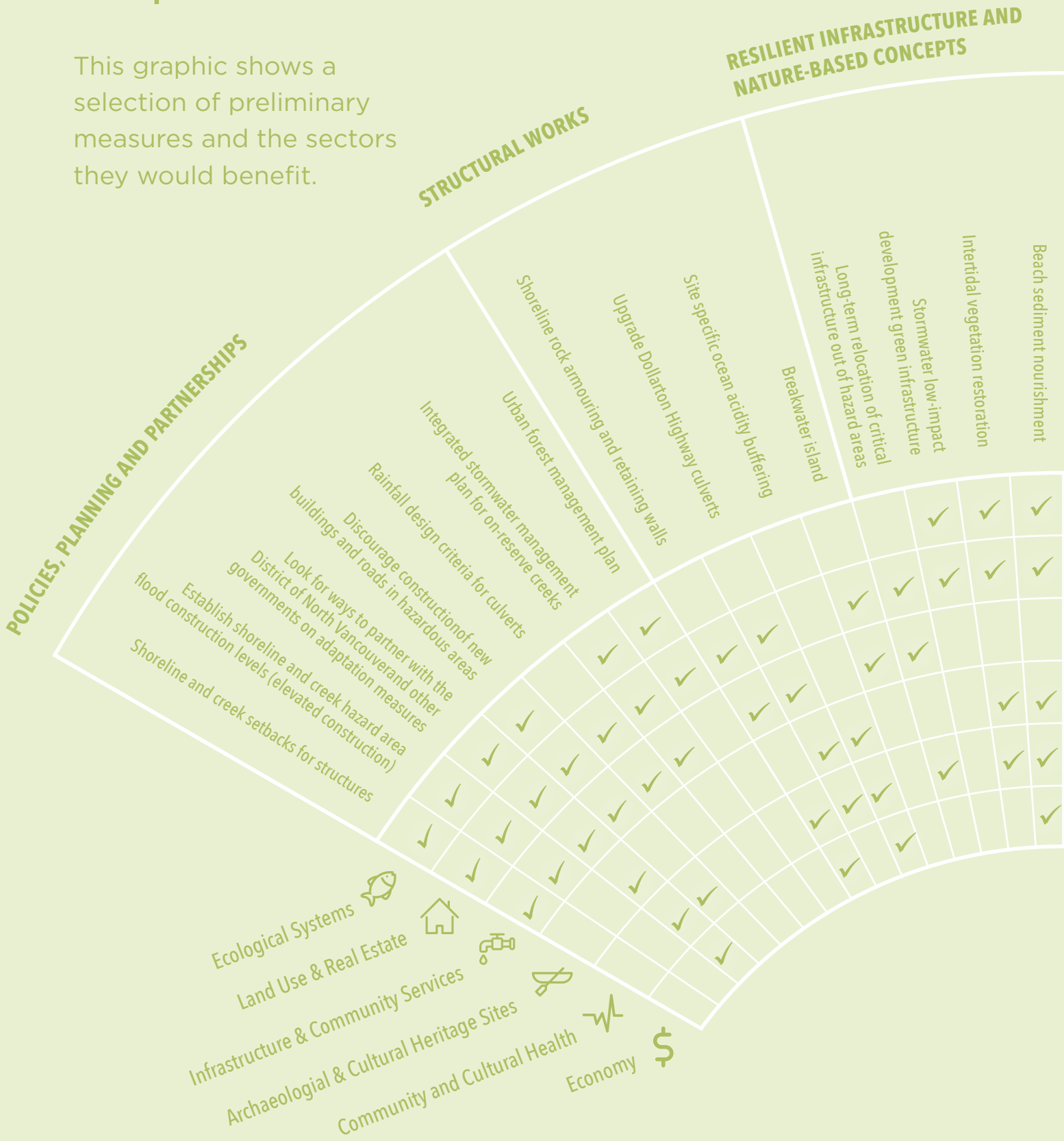
The following six criteria were established based on TWN community goals and tailored with input from community members and TWN staff to be used in evaluating adaptation measures in Phase 2.

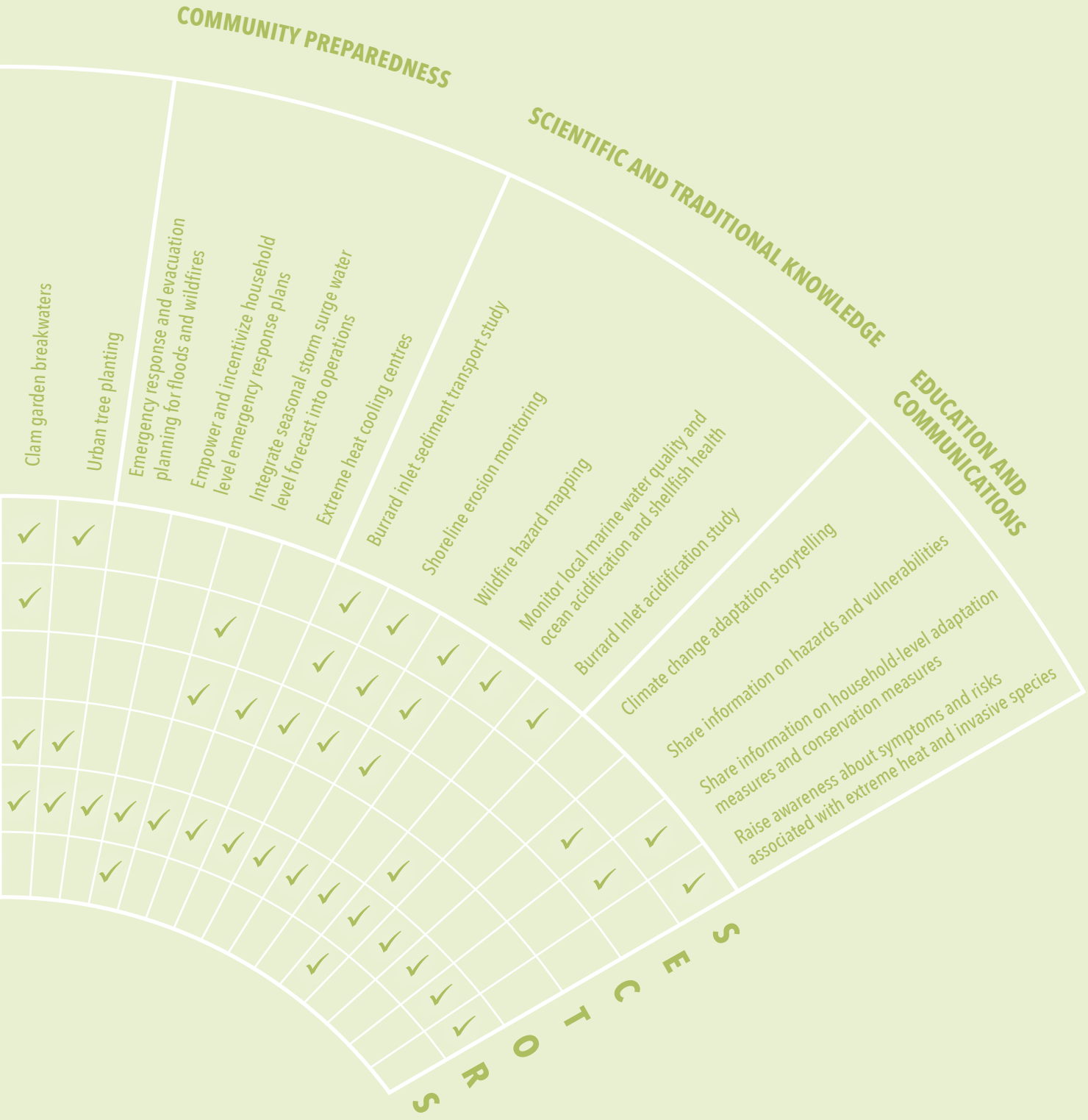
Uncertainty Tolerance	Ecosystem Impact	Implementation and Cost	Collaborative	Social and Traditional Teachings	Capacity Building and Co-benefits
How flexible is the adaptation measure to changes in climate projections?	How much will the adaptation measure negativity impact existing and/or future habitat?	What resources are required to implement the measure? How much influence does TWN have over implementation?	Does the adaptation measure present an opportunity for TWN to continue to build relationships with its neighbours?	How well is the adaptation measure aligned with social and traditional teachings?	How much does the adaptation measure enable capacity building for the TWN community? What co-benefits does the adaptation measure enable?

PHOTO CREDIT: Sarah Dal Santo, Community Garden

Preliminary Climate Change Adaptation Toolkit

This graphic shows a selection of preliminary measures and the sectors they would benefit.




COMMUNITY PREPAREDNESS
SCIENTIFIC AND TRADITIONAL KNOWLEDGE
EDUCATION AND COMMUNICATIONS
Clam garden breakwaters
Urban tree planting
Emergency response and evacuation planning for floods and wildfires
Empower and incentivize household level emergency response plans
Integrate seasonal storm surge water level forecast into operations
Extreme heat cooling centres
Burrard inlet sediment transport study
Shoreline erosion monitoring
Wildfire hazard mapping
Monitor local marine water quality and ocean acidification and shellfish health
Burrard Inlet acidification study
Climate change adaptation storytelling
Share information on hazards and vulnerabilities
Share information on household-level adaptation measures and conservation measures
Raise awareness about symptoms and risks associated with extreme heat and invasive species
SECTORS

KEY FINDINGS AND NEXT STEPS

TWN is committed to strengthening community resilience to climate change. The Community Climate Change Resilience Planning (CCCRP) project will guide the development and implementation of community-based climate adaptation measures to prepare and protect current and future generations from the impacts of climate change.

The Climate Change Vulnerability Assessment (Phase 1) of the CCCRP incorporates the rich history and traditional knowledge of the Tsleil-Waututh people. It uses an integrated, multi-hazard, values-based approach to build an understanding of potential climate change impacts and develops preliminary strategies to build community capacity and resilience.

Key findings from Phase 1 of the CCCRP project include:

- Key climate change forces of concern for TWN are: sea level rise, changing oceanic condition, precipitation, and temperature changes. These may result in a range of hazards including foreshore and upland flooding and erosion, increasing incidence of extreme storms, longer periods of drought, extreme heat, and more.

- Climate change hazards are already and will continue to impact the TWN across a variety of identified community sectors including: community lands, infrastructure, and housing, ecological systems, traditional and cultural sites, community and cultural health, and economy.

- Results of the vulnerability assessment reveal that TWN is particularly vulnerable to impacts of shoreline erosion, declining shellfish and salmon populations, flood damage, extreme heat and risk of wildfire, loss of archaeological sites, and drought. Vulnerabilities may change over time, and may require further analysis as more information becomes available.

- The CCCRP Phase 1 toolkit of preliminary adaptation measures provides a starting point for consideration and prioritization of climate change adaptation actions.

- Drawing on Tsleil-Waututh's depth of experience with community resilience and environmental stewardship, and collaborating with other key partners will be important strategies needed to prepare the community for the impacts of climate change.

These findings will inform the next phase of the CCCRP project which includes development of a detailed adaptation action plan and identification of metrics for ongoing monitoring of adaptation implementation.

Carving inside TWN Community Centre

TERMINOLOGY

» **Adaptation** - Process of undertaking procedures, actions, and/or developing structures to moderate potential negative impacts of climate change, while taking advantage of potential new opportunities.

» **Adaptive Capacity** - The degree to which an element (person, place, object, condition) is able to adapt to an impact from a hazard, either due to inherent qualities or the community's capacity to make changes.

» **Climate Change** - Climate change refers to changes in long-term local and regional weather patterns such as changes in precipitation patterns and warming of average air temperatures.

» **Climate Resilience** - The ability of a system, community, business, or natural environment to anticipate, prevent, withstand, respond to, and recover from a climate-related hazard in a timely an efficient manner.

» **Climate Scenario** - A scenario that models the difference between one climate setting and another (e.g., current and future sea level rise conditions). Modelling is based on best available data and a simplified representation of the future climate conditions in response to changing greenhouse gas emissions.

» **Community Sectors -** A grouping of aspects of the community, otherwise known as elements, that are related and work together to provide a similar service to members or the natural environment.

» **Elements** - Specific aspects of the community that may be affected by hazards. Elements are grouped under high-level sectors for the purpose of the vulnerability assessment. For example, shellfish represent an element within the Ecological Systems sector in this project.

» **Exposure** - The degree to which an element is exposed to or interacts with a hazard (e.g., spatial proximity or population affected).

» **Hazard** - A potentially damaging physical event that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. In the context of this report, hazards can result from a variety of climate change forces (such as sea level rise and changing precipitation, temperatures and oceanic conditions).

» **Impacts** - Impacts generally refer to effects of hazards on lives and livelihoods; community and ecosystem health and well-being; economic, social and cultural assets; and/or community services and infrastructure within a specific time period. Impacts can also be referred to as consequences and outcomes.

» **Sensitivity** - The degree to which the function or health of an element (which may be a person, place, object or condition) responds to and is inherently susceptible to impacts from a hazard.

» **Vulnerability** - A measure of how responsive an element or community is to impacts from hazards. Vulnerability is influenced by the level of exposure and sensitivity to a hazard, as well as adaptive capacity.

Source: Adapted from Climate Lens – General Guidance published by Infrastructure Canada, June 2018

Climate change community art project

PHOTO CREDIT: Matthew Smith/Unsplash

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Tsleil-Waututh Nation
PEOPLE OF THE INLET