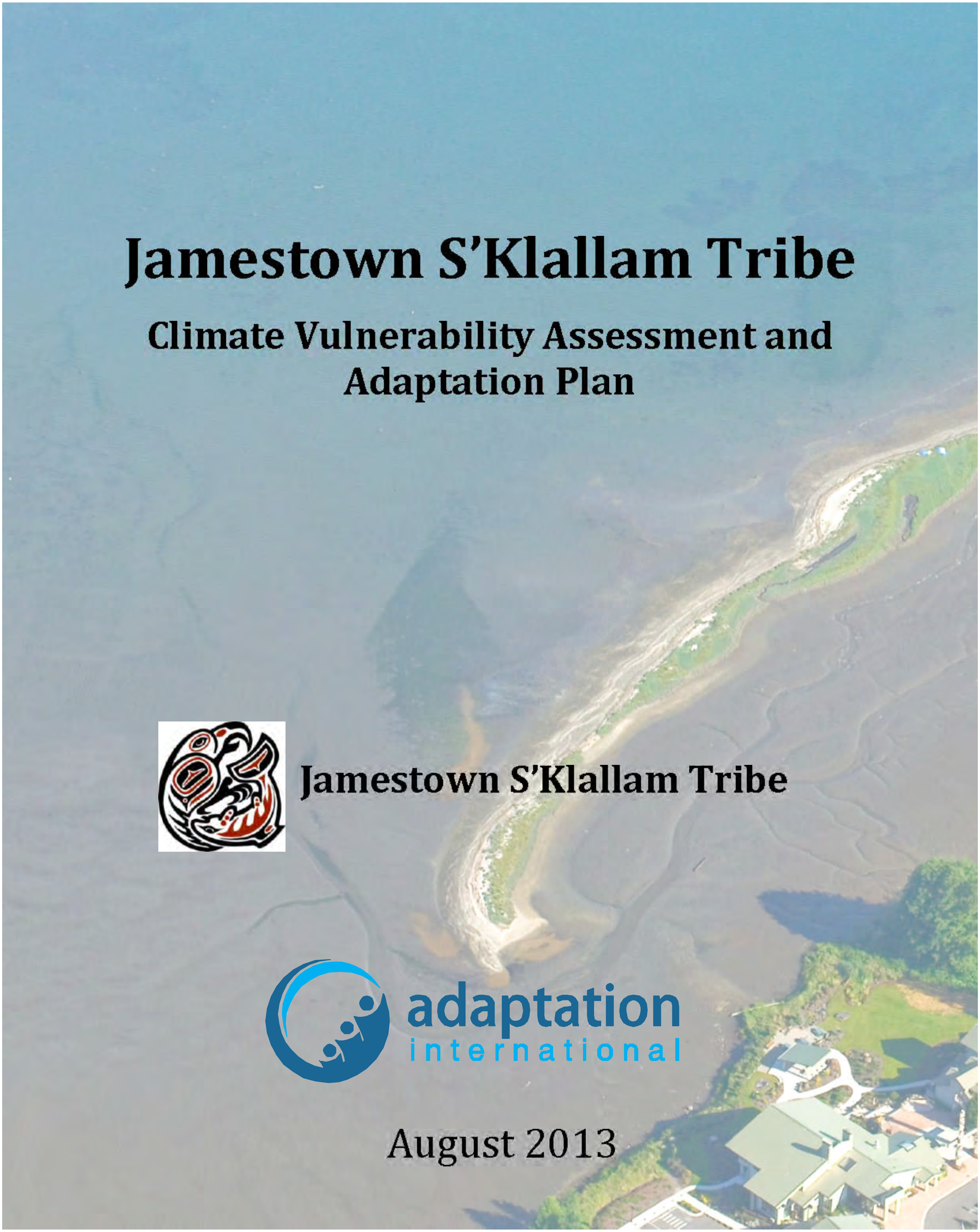

Jamestown S'Klallam Tribe

Climate Vulnerability Assessment and Adaptation Plan

Jamestown S'Klallam Tribe

adaptation international

August 2013

Acknowledgements

Thank You

This project would not have been successful with out the combined efforts of all the individuals listed below. The collaborative approach taken by the Jamestown S'Klallam Tribe, Adaptation International, and Washington Sea Grant proved invaluable in identifying the key areas of concern, evaluating potential climate impacts, and developing a suite of adaptation strategies to help the Tribe begin preparing for climate change. With this project, the Jamestown S'Klallam Tribe has created a foundation for on-going climate action and made a crucial step towards becoming climate resilient.

Climate Change Working Group

Liz Mueller	Tribal Vice Chair, Family Support Services Director
Marlin Holden	Tribal Elder, Chair Fish and Game Subcommittee
Elaine Grinnell	Tribal Elder
Robin Allen	Tribal Elder
Kathy Duncan	Tribal Elder
Annette Nesse	Chief Operations Officer
Diane Gange	Chief Financial Officer
Leanne Jenkins	Planning Director
Scott Chitwood	Natural Resources Director
Doug Sellon	Executive Director - Economic Development Authority
Cindy Lowe	Health Administrator and Dental Clinic Manager
Byron Rot	Natural Resources Manager, Adaptation Project Manager
Hansi Hals	Environmental Planning Manager, Adaptation Project Manager
Bill Laubner	Tribal Facilities Manager
Ben Neff	Economic Development Authority
Pam Edens	Tribal GIS Specialist
Sascha Petersen	Adaptation International
Jacob Bell	Adaptation International
Melissa Stults	Adaptation International
Jamie Parks	Adaptation International
Ian Miller	Washington Sea Grant

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Recommended Citation Format

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I. JAMESTOWN S'KLALLAM TRIBE AND RESILIENCE

Jamestown S'Klallam Tribal Citizens and their descendants reside in a landscape that has sustained them for thousands of years, the Olympic Peninsula of Washington State. Particularly over the last two centuries, the Jamestown S'Klallam people have successfully navigated a variety of societal changes, all while maintaining a connection to the resource-rich ecosystems of the region. The Jamestown people are now experiencing yet another broad-scale transformation to their homelands, the impacts of global climate change.

Changing climate and its associated impacts are not entirely new to the Tribe, which has successfully adapted to past climate variations. Yet the large magnitude and rapid rate of current and projected climate change require unique responses. To protect and preserve culturally important resources and assets; ensure continued economic growth; and promote long-term community vitality; it is important to incorporate climate change into the Tribe's planning efforts and operations.

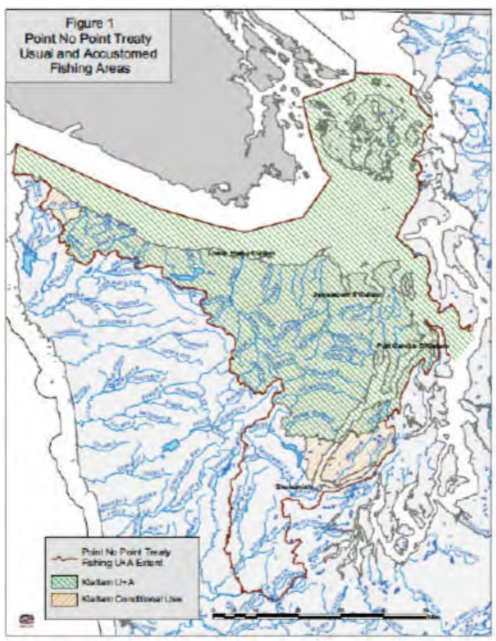


Figure 1: Jamestown S'Klallam Usual and Accustomed Area from Point No Point Treaty

The broad landscape of the Tribe's Usual and Accustomed area on the North and East sides of the Olympic Peninsula (Figure 1) remains the cohesive cultural and natural resource foundation of the Jamestown S'Klallam people. This persisting idea of an ecosystem-wide homeland is culturally essential, as Jamestown Tribal Citizens are themselves spread across the large geography of the Usual and Accustomed area, and provides an empowering perspective when facing climate change impacts that cut across sectors and landscapes.

Taking action now to evaluate the impacts of climate change will help the Jamestown S'Klallam Tribe prepare for and increase their resilience to climate and weather related events. Planning for the future will allow the tribe to benefit from emerging opportunities, protect against undesired impacts, and ensure that they continue to achieve their mission.

> *The Jamestown S'Klallam Tribe seeks to be self-sufficient and to provide quality governmental programs and services to address the unique social, cultural, natural resource and economic needs of our people. These programs and services must be managed while preserving, restoring and sustaining our Indian heritage and community continuity.*

Image Credit: Dale Faulstich,
Jamestown S'Klallam Tribe, 1989

II. CHANGING CLIMATE CONDITIONS

A. Increasing Temperatures

- **Average annual air and ocean temperatures have increased over the last century and are projected to continue to increase (potentially more than 9° Fahrenheit by the 2080s).**
- **Higher average temperatures will generate more extreme heat events and increased heat stress for plants, animals, infrastructure, and humans.**

1. Observed Changes

Last year (2012) was the hottest year on record for the contiguous 48 States, based on temperature records going back to 1895[1]. Although temperatures in Washington State during 2012 didn't set many new records, they were above average. These higher temperatures are part of a long-term global trend, with the top 10 warmest years globally all occurring since 1998. Over the last century, average annual air temperature in the Pacific Northwest has increased by 1.5°F[2,3]. There is a clear correlation between rising atmospheric concentrations of carbon dioxide (CO_2), and rising global average temperatures (Figure 2)[4].

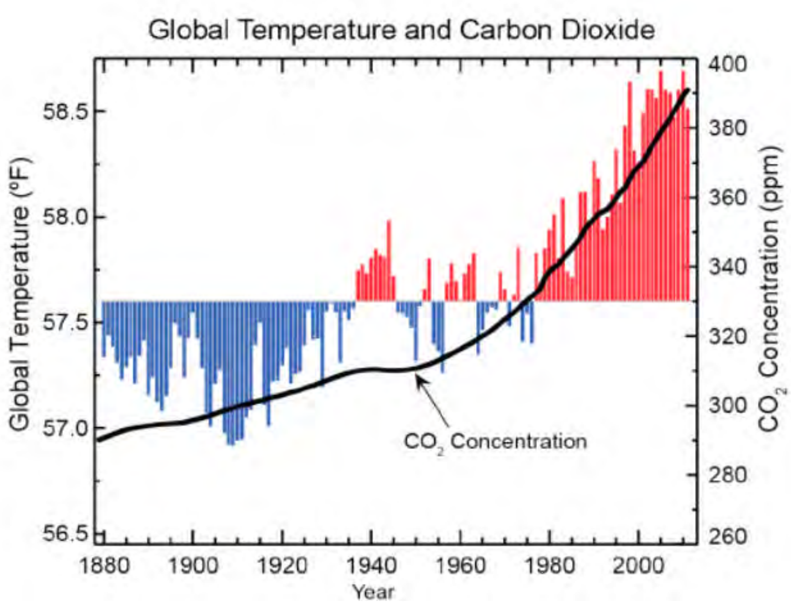


Figure 2: Global Average Temperature and Carbon Dioxide Levels. The year is shown along the horizontal axis (x-axis) increasing from 1880 on the left to 2010 on the right. Global average temperature is shown on the left vertical axis (y-axis) and represented by the blue and red bars on the graph. Blue bars represent years with lower than average temperature and red bars represent years with higher than average temperature. Global average annual temperature has increased more than 1.4°F since 1880. Atmospheric concentrations of carbon dioxide for each year are shown by the dark black line and the vertical scale on the far right (y-axis). As concentrations of carbon dioxide have increased, so have global temperatures[5].

Higher average temperatures are associated with warmer summers and more extreme heat events. Extremely high temperatures and low temperatures occurred almost equally across the United States during the 1940s and 1950s. Now, extreme high temperatures are occurring almost twice as frequently as extremely low temperatures[6].

2. Projections of future changes and climate exposure

The increases in temperature that have been observed are part of a global pattern of change that is driven primarily by human activity[7]. Research into the increasing atmospheric concentrations of greenhouse gases since the industrial revolution (mid 1800s) has convinced scientists and others that human produced greenhouse gas emissions are the main driver of current and future climate change. This is in contrast to slower, smaller scale, climate changes in the Earth's history that have been driven by complex non-human events such as solar output, distance of the Earth from the sun, ocean circulation, and composition of the atmosphere. The burning of fossil fuels releases greenhouse gasses (primarily carbon dioxide, CO_2) into the atmosphere. These gasses act like a blanket around the earth trapping in heat and warming the planet. The more greenhouse gasses present in the atmosphere, the thicker the "blanket" and higher the overall temperature.

Scientists use computers to model, or project, the potential impacts of these greenhouse gas emissions. This report considers the potential impacts of both a low emissions scenario (where global greenhouse gas emissions in the future decrease rapidly) and a high emissions scenario (where global greenhouse gas emissions continue to increase throughout the century). Scientists label the low emission scenario "B1" and the higher emissions scenarios "A1B". Both of these scenarios are based on equally plausible storylines incorporating future projections of population, economic productivity, technology development, and other factors[8].

All climate change projection scenarios show temperatures continuing to increase throughout the coming decades, with higher emission correlated to higher temperatures. In the Pacific Northwest, average annual temperatures are expected to increase between 3.3°F and 9.7°F by the 2080s, depending on the emissions scenario[9]. Both air and ocean temperatures are increasing (Figure 3 - atmospheric temperature, Figure 4 - sea surface temperatures). Temperature increases have already produced very noticeable impacts (Figure 5). Even the lower projected temperature increase of 3.3°F is likely to influence extreme events and weather, considering that the changes observed so far have occurred with a 1.4°F global average temperature increase.

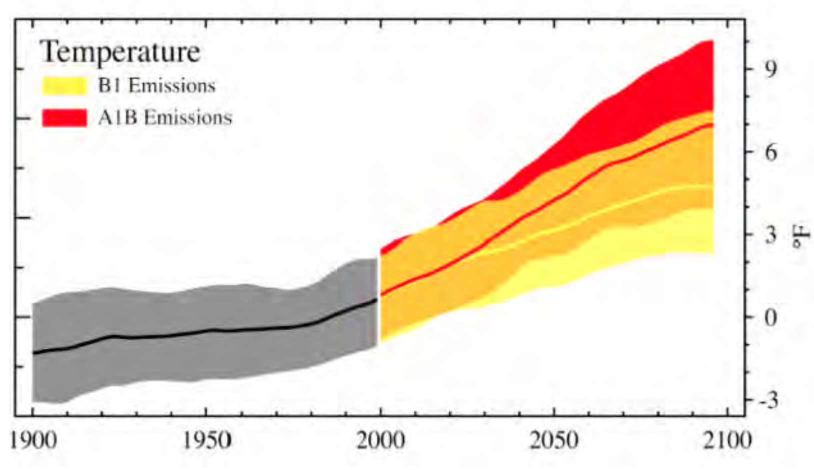


Figure 3: Measured and projected temperatures for Washington State. The year 1900 to 2100 is shown along the horizontal axis (x-axis) and temperature (degrees Fahrenheit) is show along the far right vertical axis (y-axis). The measured average annual temperature from 1900-2000 is shown by the black line (the gray area represents uncertainty). The projected future temperatures 2000-2100 for two global emissions scenarios (B1 – Lower (Yellow) and A1B – Higher (Red)) for the Pacific Northwest are shown with the yellow and red lines (with the yellow and red shading representing uncertainty in those projections)[10].

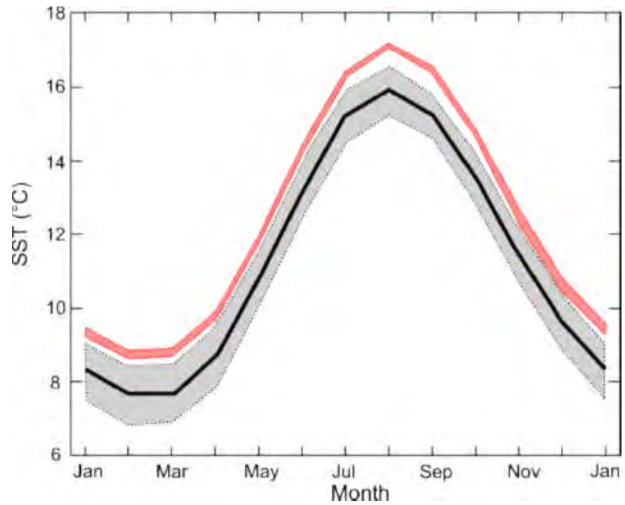


Figure 4: Current and projected sea surface temperature. This figure depicts the annual cycle of sea surface temperature for the coastal waters of the Pacific Northwest for 1970-1999 (black line is the average and gray shading is the range). The months are shown along the horizontal axis (x-axis) and the average sea surface temperature is shown along the vertical axis (y-axis in °C). The projected 2.2°F (1.2°C) increase in sea surface temperature by the middle of the century (2030-2059) is shown by the red line. Adapted from Mote and Salathé, 2010[11].

Anderson Glacier **Lillian Glacier**

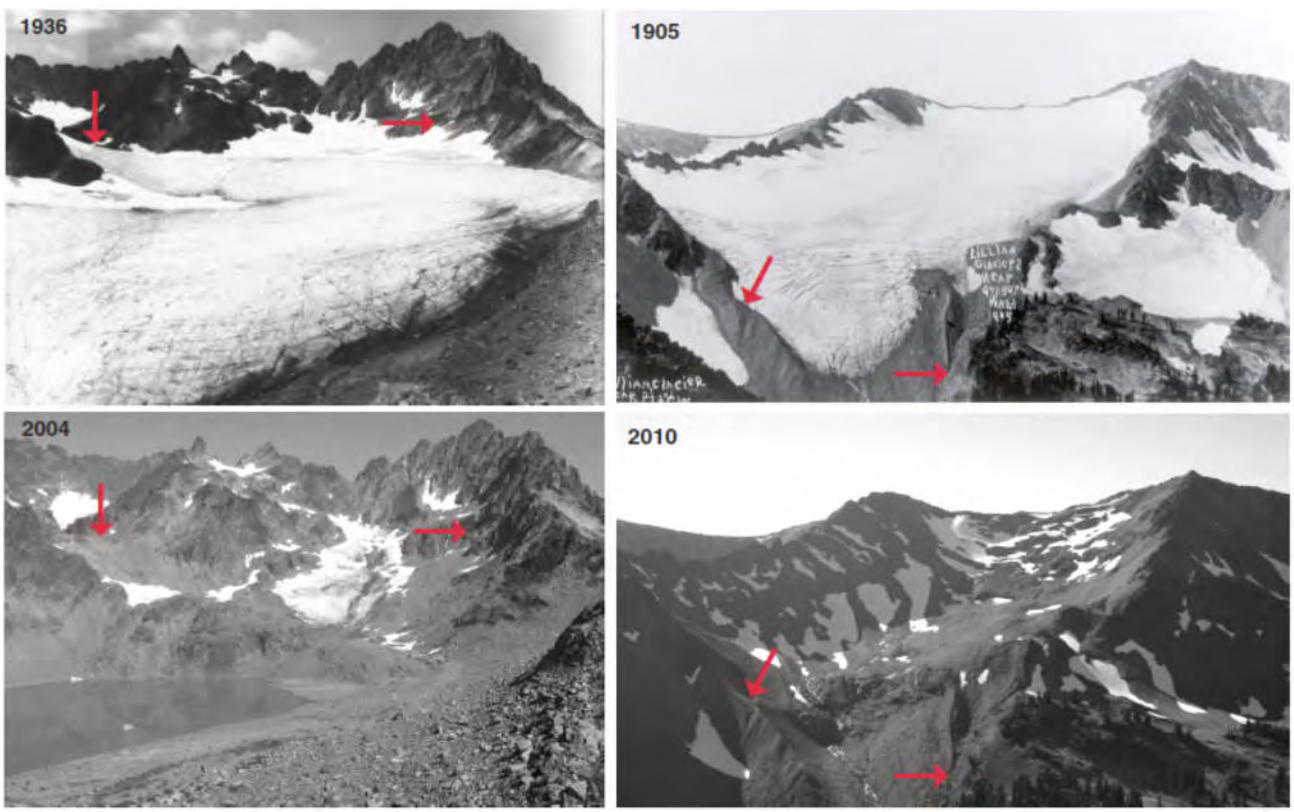


Figure 5: Anderson and Lillian Glacier Retreats. Increasing temperatures have very real impacts in a variety of areas. These changes can be seen by the observed retreat of the Anderson Glacier (left panels 1936 Asahel Curtis, 2004 Matt Hoffman) on the southern slope of Mount Anderson and Lillian Glacier (right panels, 1906 Olympic National Park, 2010 Josh McLean) in the Olympic Mountains[12]. Red arrows identify identical locations.

The approximately 2.2°F (1.2°C) increase in sea surface temperatures in Pacific Northwest coastal waters projected by mid-century is expected to directly impact the growth and survival of many marine species that are important for the Tribe, as well as the prevalence of conditions leading to shellfish biotoxin events. See the sections on "key areas of concern" for a more complete discussion of increasing water temperature impact on valued marine species.

B. Changing Precipitation Patterns

- **Shifting seasonal precipitation will lead to wetter winters and drier summers.**
- **Winter snowpack has decreased and spring snowmelt occurs earlier, increasing spring stream flows and decreasing summer and fall flows.**
- **Water usage from the Dungeness River is already considered critical due to multiple competing uses; especially during low flow conditions in the late summer and early fall.**

1. Observed Changes

Across Washington State, snowpack has decreased by up to 30% and spring snowmelt is occurring up to 30 days earlier, with the result of increasing winter stream flow and up to a 15% decrease in summer stream flow. For the Dungeness River, March stream flow has increased 1-2% and June stream flow has decreased 2-5% from the period 1948-2008 as snow melt has occurred 10 to 20 days earlier over the same period[13].

The Dungeness River already experiences competition for a limited water supply. A large number of agricultural users in the Sequim Valley region depend on irrigation from the Dungeness during the late summer and fall. These withdrawals are in direct competition with residential and instream water uses. The limited overall water quantity during the summer prompted the Washington Department of Ecology to enact a new water rule on January 2, 2013. The Dungeness is considered "water-critical" due to competing water uses and the four fish species using the river are protected under the Endangered Species Act. The new water rule is designed to ensure no net loss of water from the river.

2. Projections of future changes and climate exposure

Due to high annual and inter-annual variability, there is no real trend in climate projections of average annual precipitation changes for Washington State[14]. However, there is some suggestion that seasonal patterns of precipitation may change over time with projected increases in fall and winter precipitation and significant decreases in summertime precipitation[15,16]. Winter snowpack will continue to decrease and snowmelt will continue to occur earlier in the Northern Olympic Peninsula.

These changes in snowpack and seasonal precipitation will change stream flow patterns in the Dungeness River with higher winter flows (more winter rains) and lower summer flows (less winter snowpack melt) (Figure 6 & Figure 7). The frequency of extreme precipitation events will also change; 20-year flood events may occur as much as 44% more frequently in transition river basins such as the Elwha and Dungeness by the middle of the century[17].

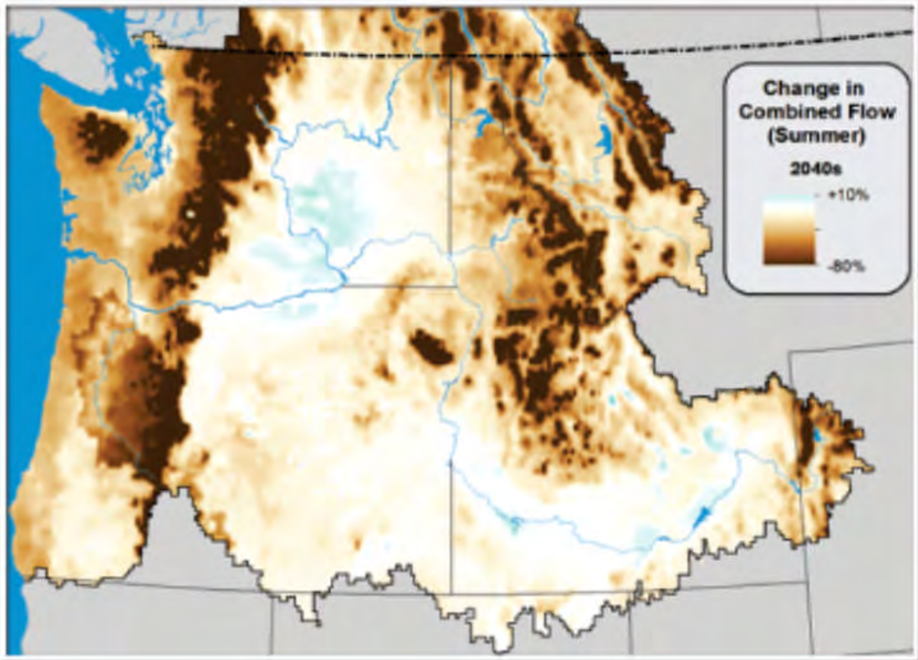


Figure 6: Projected change in summer stream flows across the Pacific Northwest[18]. Summer (June, July, August) low-flows in the Dungeness are projected to decrease about 20% by the 2040s (A1B emissions scenario)[19]

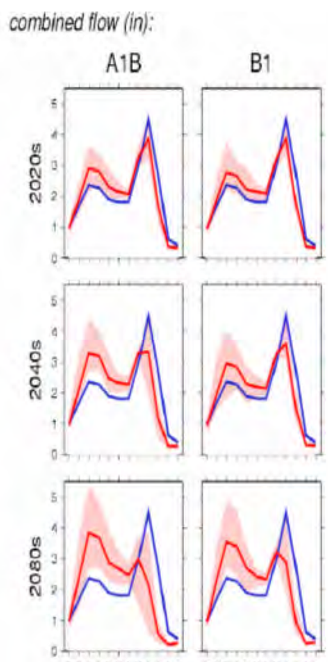


Figure 7: Projected shifts in Dungeness River stream flow patterns. The figure shows the projected shifts for the 2020s, 2040s, and 2080s (rows) for two global emissions scenarios; the first column is the higher emissions (A1B) scenario and the second column is the lower emissions (B1) scenario. Dark blue line represents current average seasonal stream flow with months listed from October through September on the bottom. Red line represents projected stream flow with shaded area showing uncertainty in projections. Even by the 2040s (second row), there is a substantial shift in stream flow from early summer to winter as higher temperatures melt snowpack earlier and summers become drier[20].

In the Dungeness River, lower summertime flows combined with higher water temperatures will likely increase stress to rearing salmon fry and adult salmon species returning to the river, and increase existing human-use withdrawals from the river. The Dungeness does enjoy some adaptive advantages to temperature stressors, including a steep grade and high altitude snow pack that are projected to keep water temperatures cooler than surrounding air temperatures. The increasing severity and frequency of riverine flooding events also has the potential to impact human infrastructure along the Dungeness. The 20-year flood events (5% annual chance of flooding) and 50-year flood events (2% annual chance of flooding) are projected to become about 50% stronger by the 2040s (A1B scenario)[21]. The railroad trestle bridge and the Audubon center will be at increasing risk from this future flood regime. The trestle pilings and the dike that protect the Audubon Center are of particular concern.

C. Sea Level Rise and Coastal Flooding

- **Sea levels have been rising over the last century and will continue to rise in the future.**
- **Relative sea level in Sequim Bay and Jamestown Beach may increase 1-2 feet by the middle of the century and 2-5 feet by the end of the century.**
- **Rising sea levels will increase coastal flood risk.**

1. Observed Changes to Sea Level

Rising sea levels have a variety of impacts on the coastal built environment including: increasing intermittent coastal flooding (Figure 8); accelerating erosion; redistribution of sediment and alteration of coastal habitat; promoting coastal bluff failure; and directly damaging homes and roads. Climate change, primarily through increasing ocean temperature and the melting of land-based ice, is increasing the volume of water in the ocean basins, raising the average level of the surface of the ocean.

Figure 8: Storm surge and coastal flooding in Anacortes. Increasingly frequent flooding of near-coastal areas, like the storm surge and flooding in Anacortes, WA February 4th, 2006, is one of the impacts expected as a result of sea level rise[22].

Specifically of concern to coastal communities is "relative" sea level, or the level of the sea relative to the level of the land, which is a function of both global sea level, as well as the vertical motion of the land itself:

Relative Sea Level Change = Mean Sea Level Change – Vertical Land Movement

In the Pacific Northwest, the elevation of the land is not stable. Instead, the land's surface is being forced upwards or downwards by a combination, primarily, of tectonic forcing and adjustment to the loss of continental glaciers at the end of the last ice age (Figure 9).

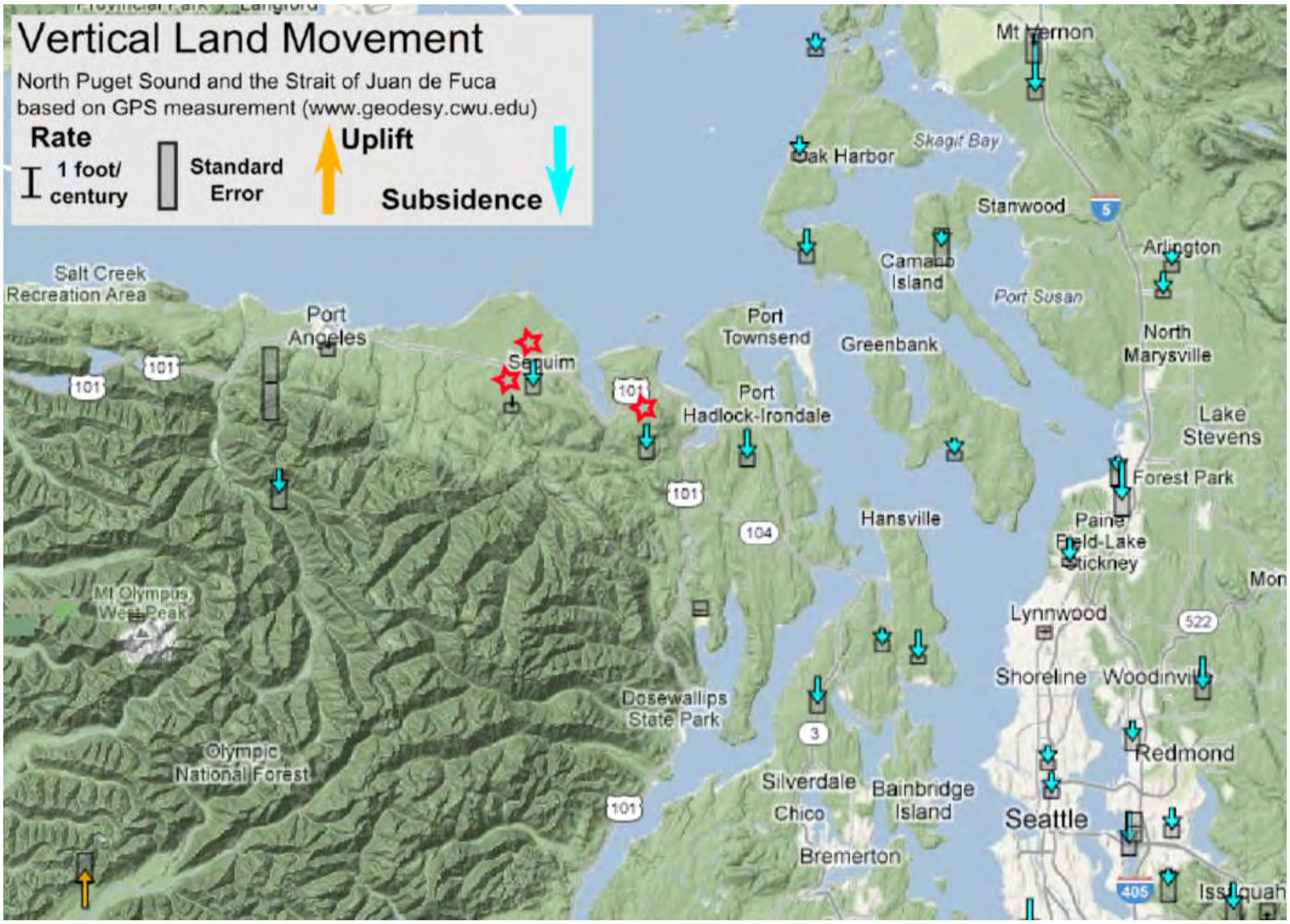


Figure 9: **Rates of vertical land movement for sites adjacent to Sequim Bay.** Continuous GPS sites in the Pacific Northwest monitor rates of vertical land movement. Orange arrows represent land that is uplifting (rising). Blue arrows represent land that is subsiding (sinking). Red star mark the three sites used to estimate average subsidence in this assessment (Table A-1).
Figure adapted from http://www.panga.cwu.edu/demo_vms/velo_map.html.

Relative sea level rise is observed in water level records collected near Sequim Bay, with noted month-to-month variability driven in part by periodic climate anomalies like the El Nino-Southern Oscillation, and the Pacific Decadal Oscillation. The longest water level record in Washington State, collected since 1892 in Seattle, shows a relative sea level rise of 0.68 feet/century (2.06 mm/year, see Appendix A).

2. Projections of future changes and climate exposure

In general, recent sea level rise research strongly suggests that earlier projections of the rate of sea level rise were too conservative (i.e. underestimates). The most recent projections include improved measurements and models describing the contribution of water from melting land-based ice (the Greenland Ice Cap, for example) to the global oceans[23].

For this assessment, a local relative sea level curve was created for the study area by combining recent projections of global sea level[24] with estimates of vertical land movement for the Sequim Bay region. The global sea level rise projections for the West Coast of the United States estimate a rise of 0.6 to 1.6 feet by 2050, and 1.6 to 4.6 feet by 2100, with the ranges primarily reflecting uncertainty in future greenhouse gas emissions. Estimates of vertical land movement were taken from three GPS stations located around Sequim Bay (Figure 9). These three stations suggest average vertical land movement in Sequim Bay of -0.7 feet/century (-2.11 mm/yr). These data sources were combined to produce the final relative sea level curve for the Sequim Bay region (Figure 10). More detail on these projections is included in Appendix A.

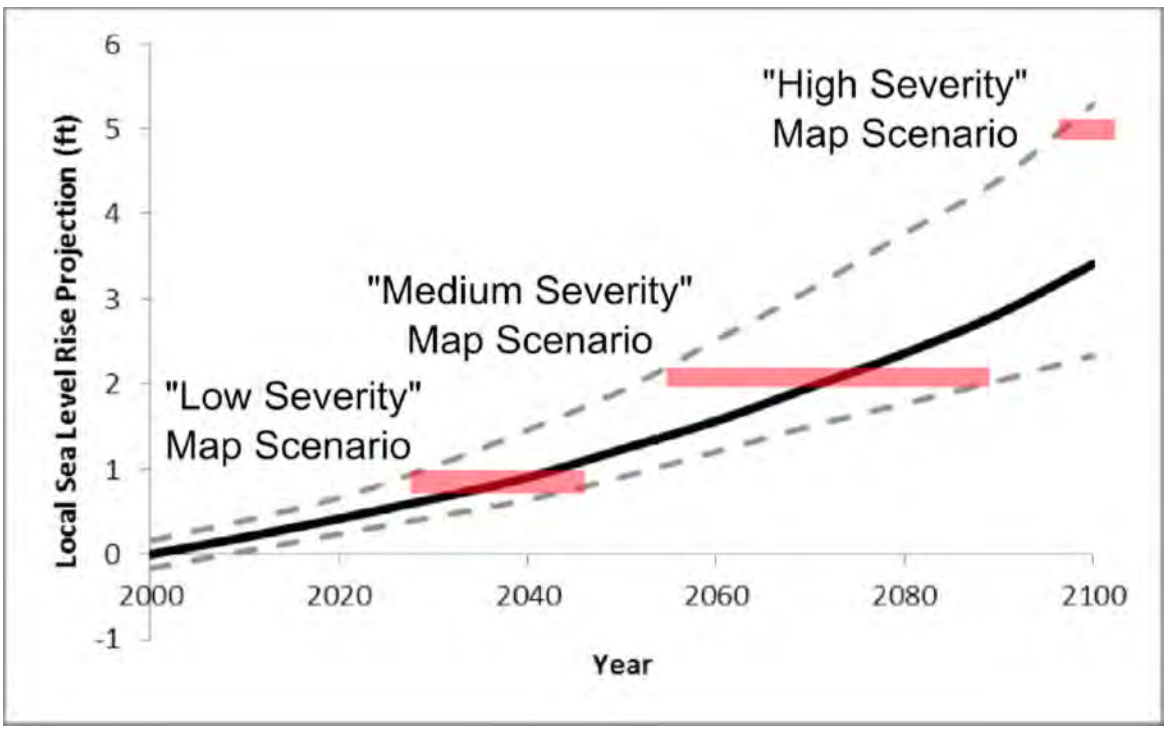


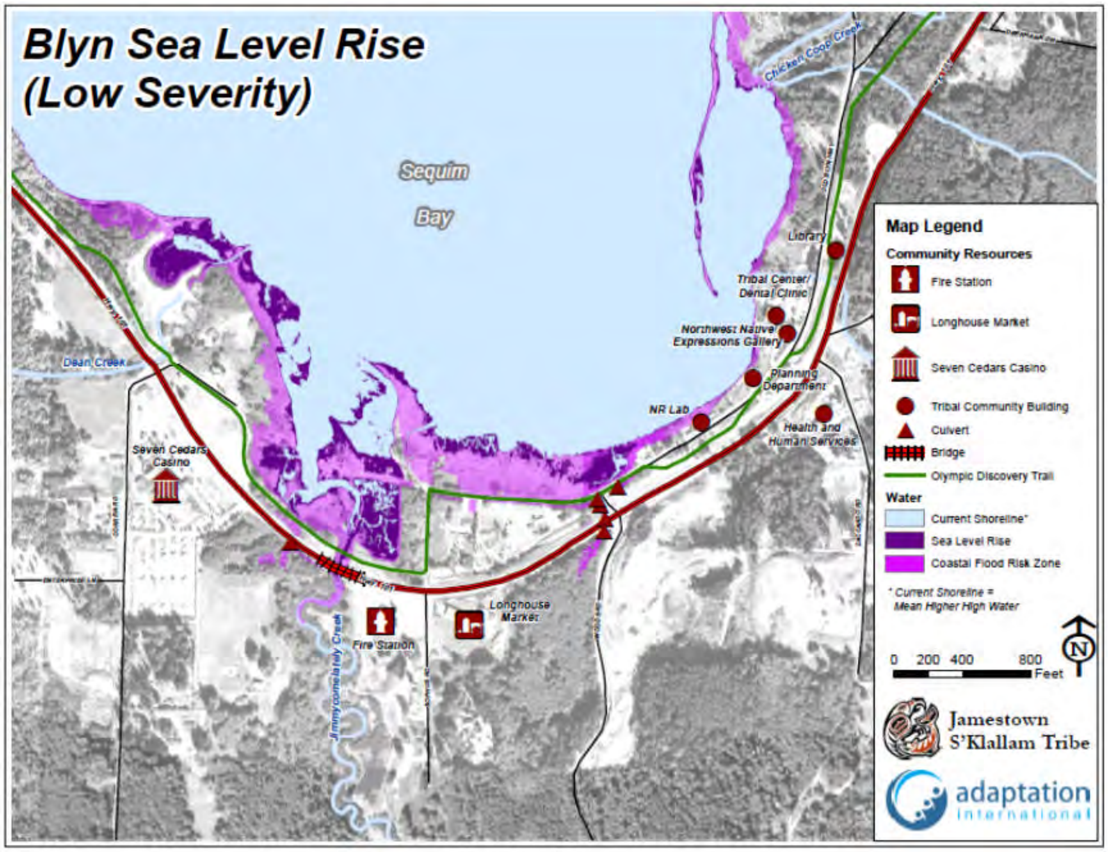
Figure 10: Relative sea level rise projections for the Sequim Bay region to 2100. Average trend line is shown (dark black line) along with range (high and low dashed lines). These customized projections are based off the linear vertical land movement trend combined with the projected rates of sea level rise for the West Coast. Red boxes correlate to sea level rise scenarios presented in this assessment. "Low Severity" = 0.8 feet, "Medium Severity" = 2.0 feet, and "High Severity" = 5.1 feet above the current sea level.

In order to visualize the potential impacts of rising seas in the Sequim Bay region, three representative scenarios were selected for mapping (Figure 10), a "Low Severity" scenario with a mean water level of 0.8 feet above the current sea level[1] (projected to occur between 2025 and 2045), a "Medium Severity" scenario with a mean water level of 2.0 feet above current sea level (projected to occur between 2055 and 2090), and a "High Severity" scenario with a mean water level of 5.1 feet above the current sea level, which may occur by the end of the century. For visualization purposes these water levels were mapped onto the existing landscape as measured by a 2012 high-resolution topographic survey conducted by FEMA[25] and available through the Puget Sound LiDAR Consortium.

When interpreting the mapped scenarios it is important to be aware that for most of the soft shorelines of Sequim Bay and Jamestown Beach, rising sea levels and storm surge will not simply cover new areas of land, they will influence erosion and patterns of change too complex to project in a mapping exercise. The scenarios created for this project are meant to assist in adaptation planning and should be combined with local knowledge, such as patterns of flooding and existing storm impacts, in order to identify areas or infrastructure at most risk from sea level rise. Synthesis of scientific projections with local knowledge is a central approach of this assessment; specifically work with Jamestown S'Klallam Tribal Citizens during site visits and through the climate working group workshop. Section VI describes this process.

Twelve different sea level rise maps were created for this project using the process described above. The dark purple colored areas represent areas currently above most tides that will be frequently inundated at high tide in these future scenarios. The light purple Coastal Flood Risk Zone is based on the 50-year storm surge event and was added to reflect the probable reach of water under winter storm conditions. Details on the development of this storm impact layer can be found in Appendix A. Five of the maps are provided below (Figure 11). The complete set of maps has been provided alongside this report.

[1] Current shoreline represented by the Mean Higher High Water (MHHW).


Blyn Sea Level Rise
(Low Severity)
Sequim
Bay
Chicken Coop Creek
Library
Tribal Center/
Dental Clinic
Northwest Native
Expressions Gallery
Planning
Department
NR Lab
Health and
Human Services
Dean Creek
Seven Cedars
Casino
Longhouse
Market
Fire Station
Jimmycomelately Creek
Map Legend
Community Resources
Fire Station
Longhouse Market
Seven Cedars Casino
Tribal Community Building
Culvert
Bridge
Olympic Discovery Trail
Water
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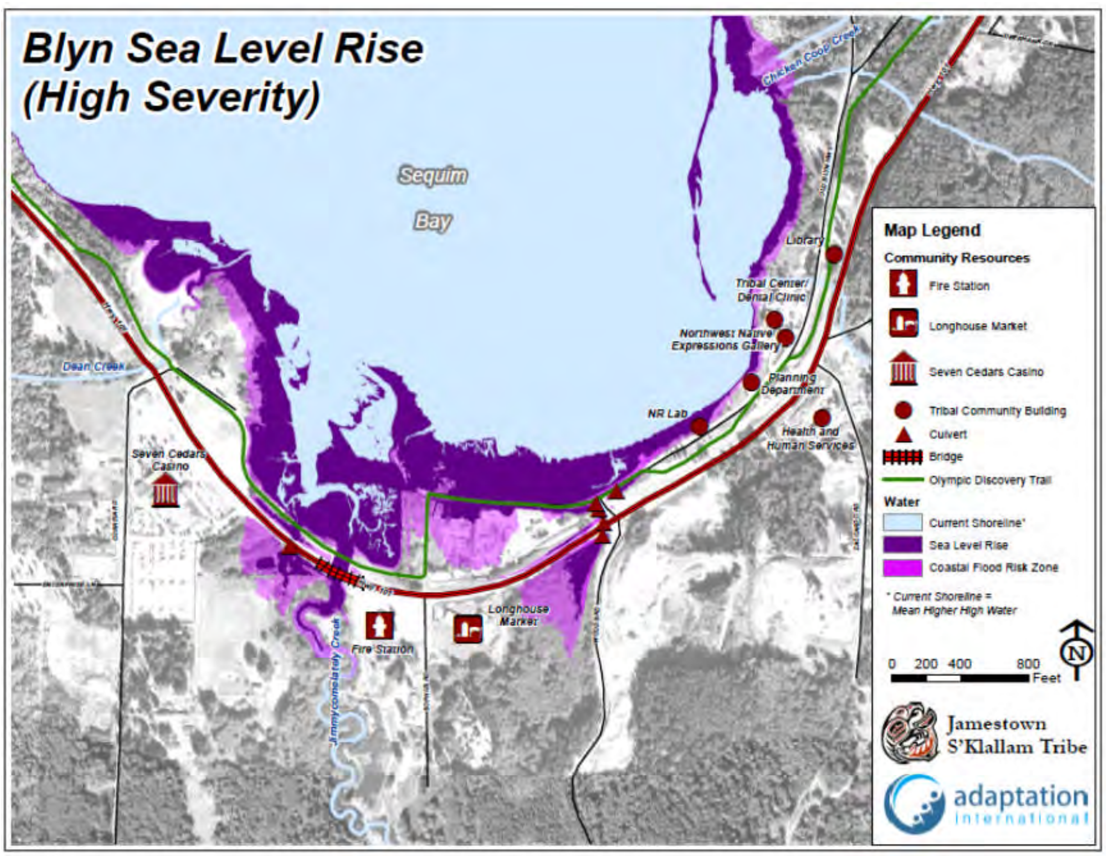
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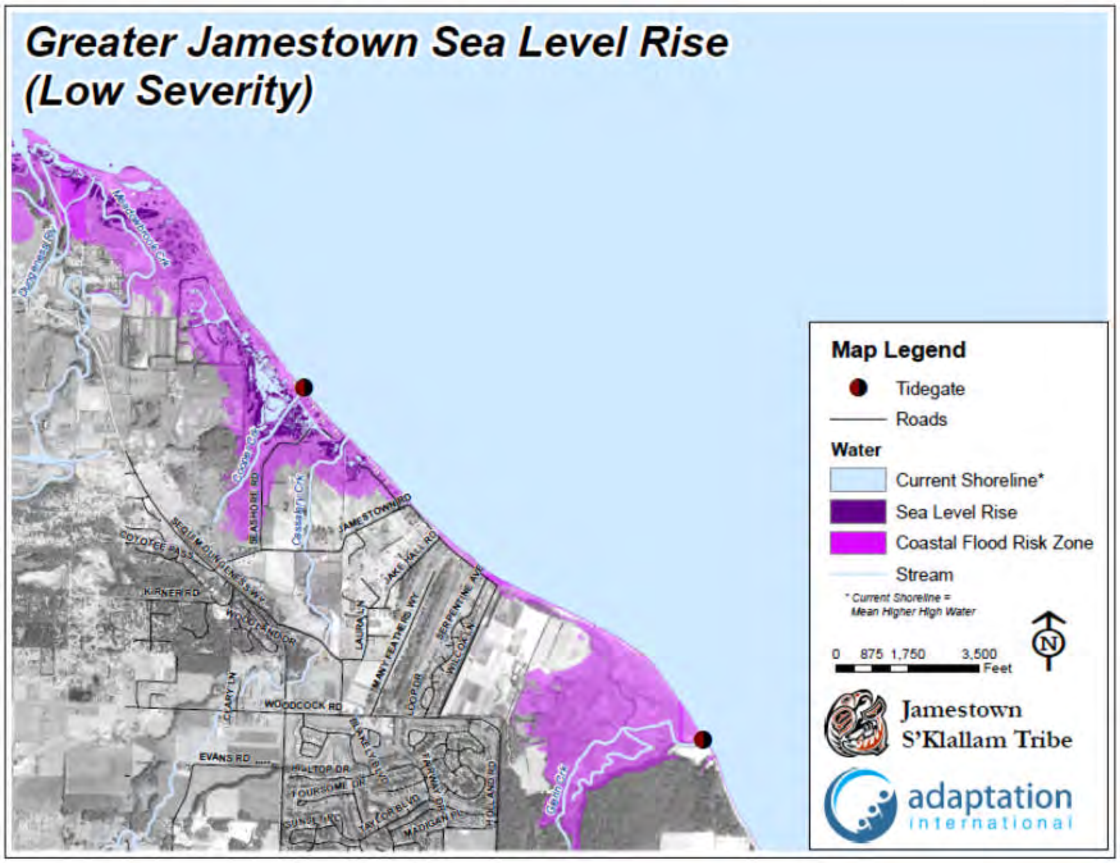
Greater Jamestown Sea Level Rise
(Low Severity)
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Tidegate
Roads
Water
Current Shoreline*
Sea Level Rise
Coastal Flood Risk Zone
Stream
* Current Shoreline = Mean Higher High Water
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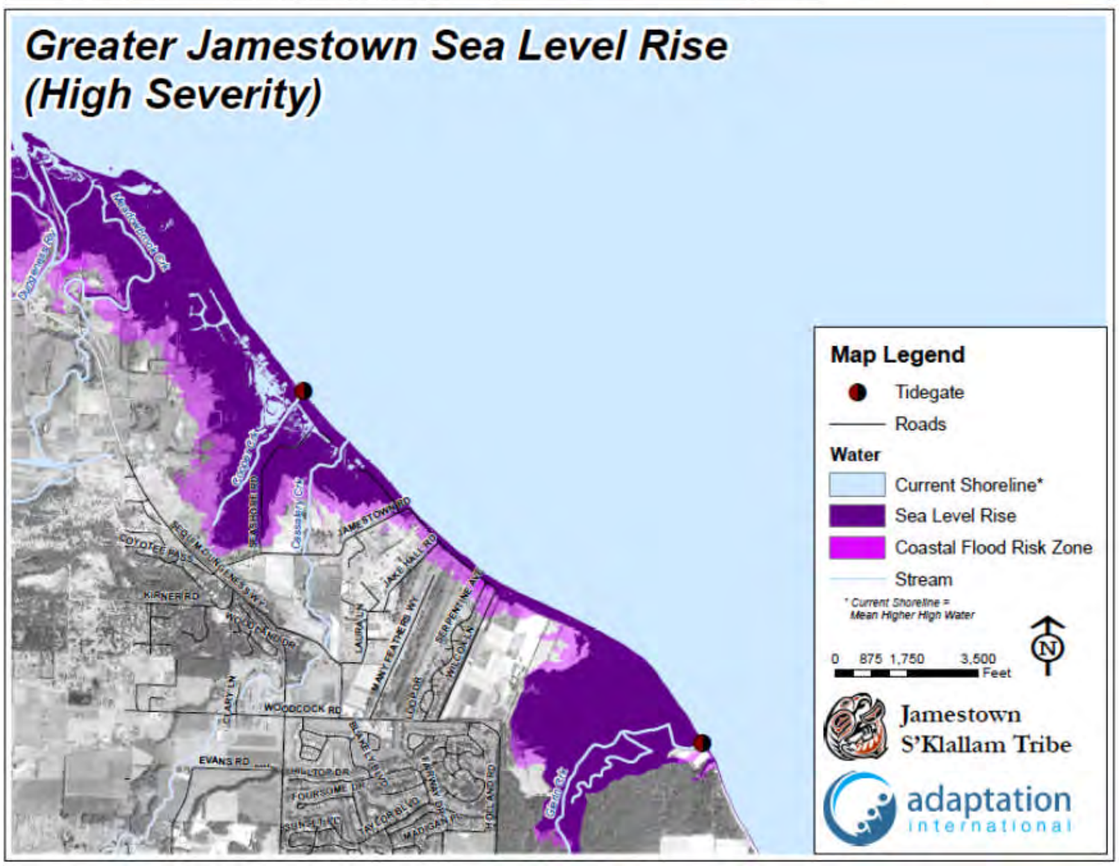
Jamestown S'Klallam Tribe
adaptation international


Greater Jamestown Sea Level Rise
(High Severity)
Map Legend
Tidegate
Roads
Water
Current Shoreline*
Sea Level Rise
Coastal Flood Risk Zone
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* Current Shoreline = Mean Higher High Water
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Jamestown S'Klallam Tribe
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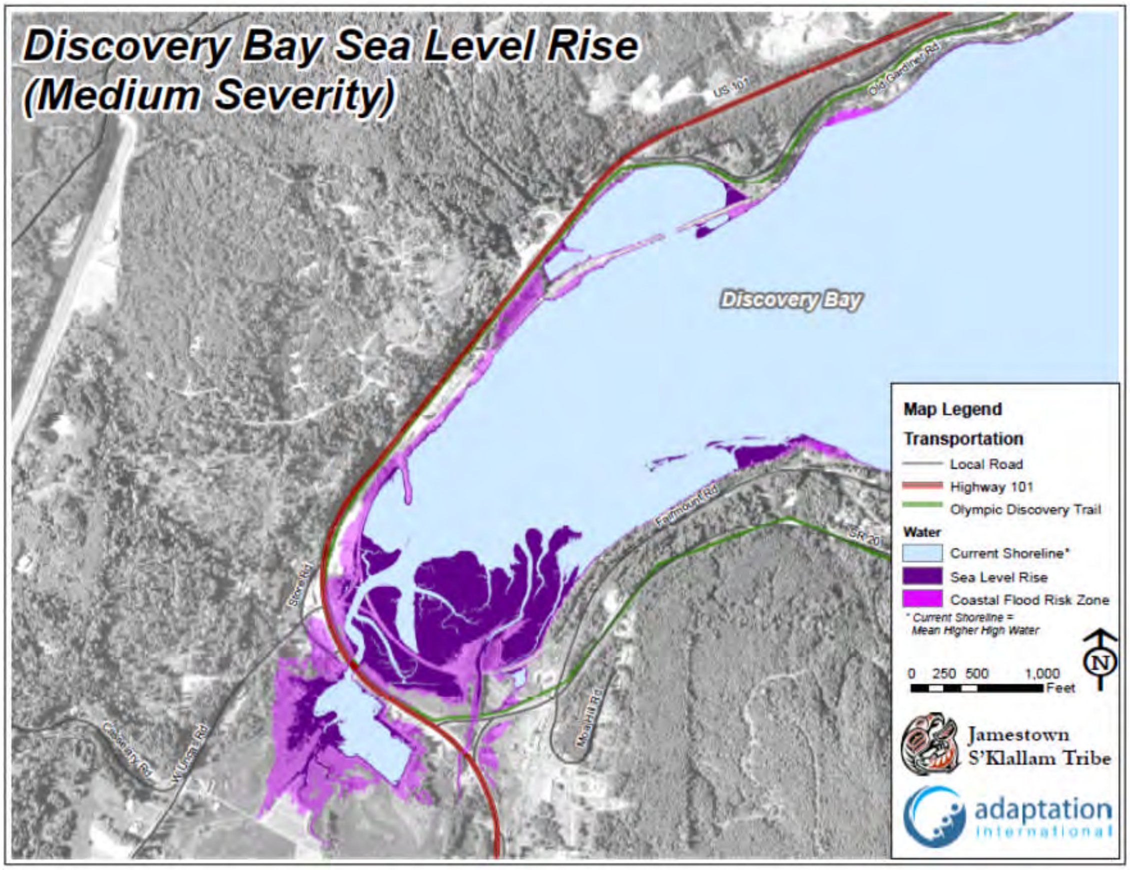

Figure 11: Sample sea level rise inundation and coastal flood maps. The five maps shown represent a sample of the 12 maps created for the project. The other maps and more detail on the mapping process can be found in Appendices E and F.

D. Ocean Acidification and Temperature Increases

- **Higher acidity, corrosive ocean waters will make it more difficult for some organisms to build their shells, potentially affecting their survivability and the abundance of predator species, such as Salmon.**
- **Higher acidity, corrosive waters have already been observed in the Strait of Juan de Fuca.**

1. Observed Changes

Oceans have absorbed about one quarter of human produced CO_2 emissions in the last two centuries[26], a process that drives ocean acidification. This acidification has a variety of chemical consequences that lead ultimately to a reduced availability of carbonate ions (CO_3^-) in seawater, one of the structural building blocks for organisms that utilize calcium carbonate ($CaCO_3$) to build and maintain their shells (Figure 12). Examples of organisms that utilize $CaCO_3$ in the marine waters of the Strait of Juan de Fuca include oysters, clams, mussels, geoducks, and small marine organisms such as phytoplankton and zooplankton that form the foundation of the marine food chain.

Ocean water off the Washington coast is particularly vulnerable to acidification due to seasonal upwelling, which draws water from intermediate depths (250 – 500 feet) to the surface. Deeper ocean water naturally has higher concentrations of CO_2 than surface waters. This mixing of deep water with the surface water decreases the pH (increases acidity) and increases the corrosive nature of the water. This type of upwelling event is already affecting shellfish in Puget Sound. During upwelling events starting in the mid-2000s, commercial oyster hatchery operations experienced production failure levels of larval death[27]. How corrosive ocean water becomes is dependent on its aragonite saturation, a process discussed in detail in Appendix B. Levels of ocean pH and aragonite saturation have been recorded through the Strait of Juan de Fuca to Puget Sound (Figure 13).

Figure 12: Dissolution of pteropod shell in higher acidity water. Dissolution occurred over 45 days in waters with pH and carbonate levels expected at the end of the century[28].

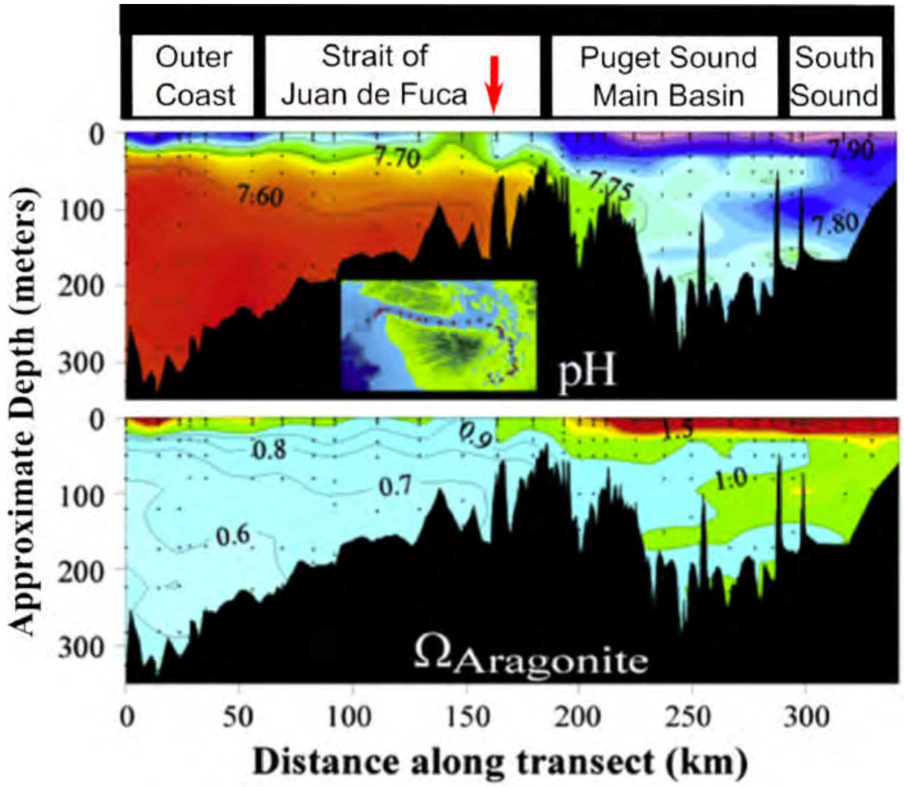

Figure 13: Measurements of pH and aragonite saturation along the coast of Washington. A scientific cruise measured pH and Ω aragonite of seawater from the outer coast to south Puget Sound. The route of the cruise is shown in the inset box (upper panel). The red arrow marks the location of the sampling site nearest to the Sequim Bay area. Red areas in the upper panel represent low pH and higher acidity waters. Ω aragonite (lower panel) is a measure of the availability of calcium carbonate to many marine organisms. In general, levels below 1 (light blue) are corrosive and may make it difficult for some marine organisms to build shells[29].

2. Projections of future changes and climate exposure

Increased concentration of CO_2 in the atmosphere will continue to increase acidification of the ocean. Future ocean acidification is an emerging area of scientific research in which few studies have made detailed projections of ocean chemistry under climate change scenarios.

For the coastal zones of Northern California, current models suggest that as the century progresses, parts of the coastal ocean will be almost continuously bathed in more corrosive waters. Surface waters will experience increasingly frequent periods of corrosiveness, while deeper areas will be almost entirely corrosive by the later half of the 21st century (See Appendix B for more detail). These projections are broadly relevant to conditions on Washington's outer coast, as the Northern California and Washington coast waters are both dominated by upwelling events, and are part of the California Current System. As outer coastal waters are transported into the Strait of Juan de Fuca it is likely that the Strait will see an increasing occurrence of corrosive conditions.

More than 30% of the marine species in Puget Sound are potentially susceptible to more corrosive waters, including many that are of critical importance for the Jamestown S'Klallam Tribe such as oyster, clams, and geoducks[30]. Also susceptible are small marine organisms that form the basis of the marine food chain that supports salmon and other tribally important species. Impact events such as the oyster spat failures that affected oyster hatcheries over the last decade will likely increase as oceans become more acidic and corrosive.

E. Forest Habitat Changes

- **Forest habitat on the Olympic Peninsula has been dynamic over time, relating to changes in temperature and precipitation.**
- **The Northeastern portion of the Olympic Peninsula is projected to become drier, shifting tree species away from primarily western hemlock to primarily Douglas-fir and causing coincident declines in western redcedar.**

1. Observed Changes

Lower elevations in the Northeast portion of the Olympic Peninsula are dominated by western hemlock and Douglas-fir species. Both the Tribal Campus in Blyn and Jamestown Beach are located in the "Western Hemlock" forest zone of the Olympic Peninsula according to work done by the Olympic National Park and Olympic National Forest (Figure 14).

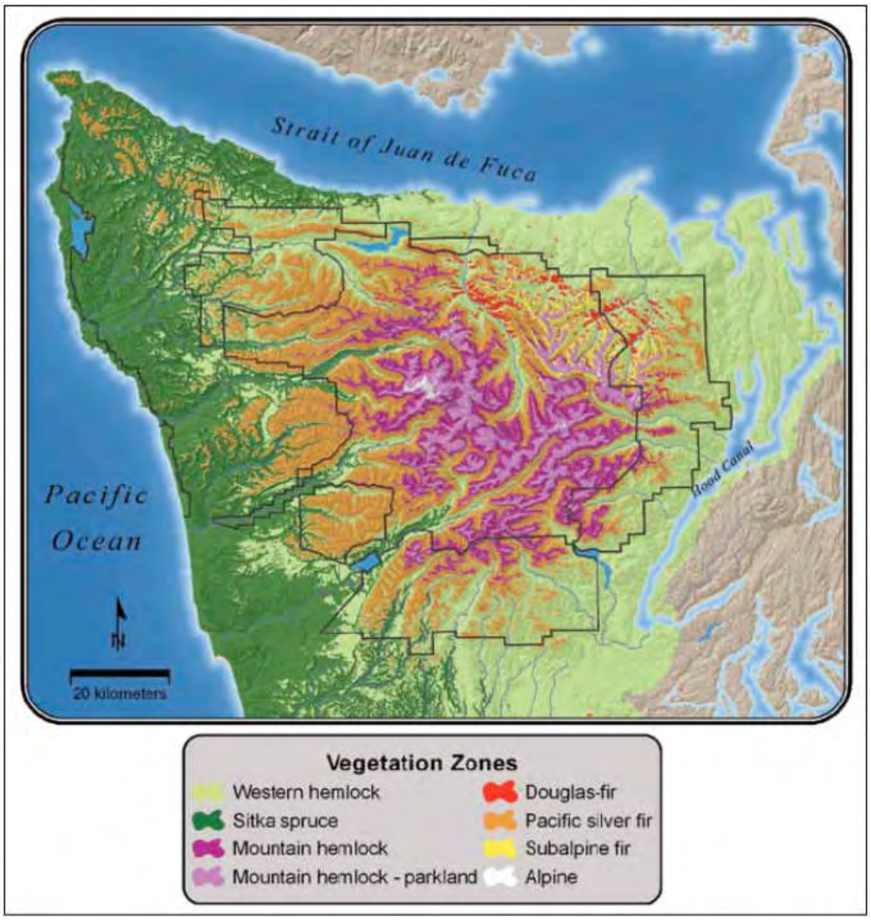

Figure 14: Vegetation zones on the Olympic Peninsula[31].

Wildfire has been, and will continue to be, a natural part of the forest ecosystem. Warmer temperatures and drier conditions have already led to an increase in the number and extent of wildfires since the 1970s[32]. Fire on the Olympic Peninsula, though infrequent, plays an important role in maintaining biological diversity. Fires have been most frequent on the northeastern side of the Peninsula, with major wildfire return periods of 234 years in the areas surrounding the majority of the Tribe's resources[33]. Increased forest mortality from fire and disease is evident throughout Washington, though it has not yet been seen in large extent on the Olympic Peninsula.

2. Projections of future changes and climate exposure

Increasing temperatures and decreased summer precipitation will likely contribute to the northeast portion of the Olympic Peninsula becoming drier at lower elevations. This drying would promote growth of Douglas-fir and lodgepole pine and decrease abundance of western hemlock and western redcedar in this area[34]. Western redcedar is a key cultural resource for the Tribe and will be discussed in greater detail in the "Key Areas of Concern" section.

Increased drought stress will likely decrease forest growth and lower productivity, as well as increase fire risk. By mid century, the annual likelihood of a very large fire in the Pacific Northwest will increase from a 1 in 20 chance of occurrence to a 1 in 2 chance[35] of occurrence. Changing climate conditions driven by increasing temperatures and shifting precipitation patterns will affect forest composition as tree species shift from their current locations to areas more suitable to their survival. Current conditions allow for mountain pine beetle outbreaks and suitable conditions are projected to increase as temperatures rise[36]. Broadly, increased drought conditions will likely leave forests more susceptible to insect attack[37].

F. Human Health

- **Tribal community health is experiencing ongoing changes related to an ageing population, influx of retirement age non-tribal citizens, and shifting natural resources. These trends are projected to continue.**
- **Climate change impacts human health directly (e.g. storm events) and indirectly through intermediate environmental factors (e.g. air pollution).**
- **Population-wide changes to tribally valued plants and animals have the potential to disrupt cultural, spiritual, socioeconomic, and nutritional health.**

1. Observed Changes

Consultation with Tribal Citizens and tribal health department staff suggests that observed changes to community environmental health revolve around two central issues:

1) Changes to the overall vitality of natural resources; and
2) On-going demographic changes in the Sequim/Blyn area.

Natural resources are an integral part of the cultural health and wellness of the tribal population. Traditional foods provide a nutrient-rich and culturally important component of the modern diet, along with their harvesting and processing activities being associated with a less sedentary lifestyle[38]. Such diets and lifestyles provide food packed with essential fatty acids, antioxidants, and protein, and are associated with prevention and mitigation of chronic diseases such as diabetes, heart disease, and cancer[39]. Thus, a change to the vitality or availability of natural resources has the potential to directly affect the health of Tribal Citizens.

There are a number of health and wellness programs organized by the Tribe's Social and Community Services Department with the common aim of "Preserving, Restoring and Sustaining our Indian Heritage and Community Continuity." These social programs include elder gatherings, youth after school programs, summer culture camps, youth empowerment, and tribal artistry workshops. In their varied activities, these programs continue to rely on natural resources harvested from the Usual & Accustomed Area[40].

The demographics of locally residing Jamestown S'Klallam Tribal Citizens reflect a population composed primarily of adults and elders (those persons older than 55 years of age)[41]. The tribal health clinic reports that for Tribal Citizens in the local service area (Clallam/ Jefferson Counties), the top five reasons for clinic visits include; chronic pain, hypertension, diabetes, anxiety, and depression[42], health outcomes often related to the complex processes of ageing. Smoking and lack of physical activity were also cited as prevalent behaviors contributing to this range of health issues.

Each Tribal Citizen is provided access to a managed care program, which provides individual health insurance coverage and other medical services. Tribal health infrastructure includes a Family Health Clinic (primary care) in Sequim, and a Family Dental Clinic in Blyn. Tribal health department leadership does not foresee any major changes to future access or provision of health services, and is moving forward under the assumption that they will be serving an aging, largely retired population.

2. Projections of future changes and climate exposure

The broad "Changing Climate Conditions" described for temperatures, precipitation, oceans, and forest, constitute *regional climate exposure*, an exposure that can directly and indirectly impact human health. Direct climate health impacts include extreme storm events or wildfires, while indirect health impacts are experienced through intermediate environmental factors, such as air pollution. Understanding the potential magnitude of future health impacts requires the application of the regional climate exposures to the projected health vulnerabilities of the population under consideration, their existing environmental determinants of health, and the resilience of the public health system they access[43]. Using these considerations, Table 1 identifies the relevant events of regional climate exposure and general health impacts. The climate exposures and health effects with the greatest potential impact are explored individually in the "Key Area of Concern."

Table 1: Climate health impacts for Tribal Citizens

Regional Climate Exposure		Health Impact for Tribal Citizens
Extreme storm events	⇨	Accident and injury; mental and socioeconomic distress
Plant and animal population health	⇨	Disruption to cultural, spiritual, and socioeconomic health; nutritional impact
Zoonotic diseases, including vector-borne diseases	⇨	Increasing exposure risk to shellfish biotoxins, emerging exposure to insect (vector) related illnesses
Air pollution concentration and distribution, including wildfire	⇨	Respiratory distress and illness; increased exposure to air pollutants
Increased pollen production	⇨	Acute and sustained allergic response
Precipitation events	⇨	Emerging sources of environmental contamination

III. DESCRIPTION OF THE PROCESS

A. Climate Change Working Group

A climate change working group was convened to provide strategic guidance and input for this project. The working group included 15 individuals who are Tribal Citizens, representatives of the Tribal Government, or both. This diverse group of individuals included the Tribal Vice Chair, Tribal Elders, Chief Operations Officer, Chief Financial Officer, Economic Development Authority Executive Director, Planning Director, Health Administrator, Facilities Manager, Natural Resource Director, and Natural Resource Managers. The group stayed actively engaged throughout the project and provided extremely valuable insight, information, and guidance on identifying, analyzing, and prioritizing the key areas of concern for the community.

B. Interviews/Meetings

Early on in the project, Adaptation International conducted interviews with four sub-groups of the climate change working group. The sub-groups were separated topically and focused on: infrastructure, natural resources, economics & finance, and health and social services. These groupings allowed the working group members direct communication with the project team, facilitated discussion of impacts by sector, and directed initial identification of key areas of concern.

C. Workshop

The second level of working group engagement occurred during the middle of the project with a workshop conducted over two mornings. Detailed results of the workshop are shown in Appendix C. Day one of the workshop started with the findings from a rapid climate assessment and a discussion of climate change exposures for the community. A combination of meetings followed including large group sessions and smaller breakout groups to facilitate a detailed analysis of the sensitivity, adaptive capacity, and vulnerability of the key areas of concern for the Tribe. Day two of the workshop focused on verifying the results from day one and creating a more detailed prioritization of the key climate related vulnerabilities for the Tribe. A detailed description of these exercises and the prioritization scoring can be seen in Appendix C.

Although not every member of the working group was able to attend both days of the workshop, it was extremely productive. The working group members' combined expertise from a variety of departments and diverse sets of experiences and backgrounds allowed for a detailed, multi-sectoral, and multi-disciplinary analysis of climate change issues. A high level summary of the key areas of concern is provided below and each of the key areas of concern is covered in more detail later in the report.

D. Vulnerability Rankings

Climate vulnerability depends on exposure, sensitivity, and adaptive capacity (as shown in Figure 15). ***Climate exposure*** is the extent and magnitude of a climate or weather event. ***Sensitivity*** is the degree to which that area of concern is susceptible to a climate impact. ***Adaptive capacity*** it the ability of the area of concern to adjust to or respond to the changing conditions. Thus, it is critical not only to consider climate impacts themselves, but also how the areas of concern are likely to respond to those impacts. Through the consideration of both climate impact variables and related environmental stressors, working group members identified the sensitivity and adaptive capacity of each of the key areas of concern.

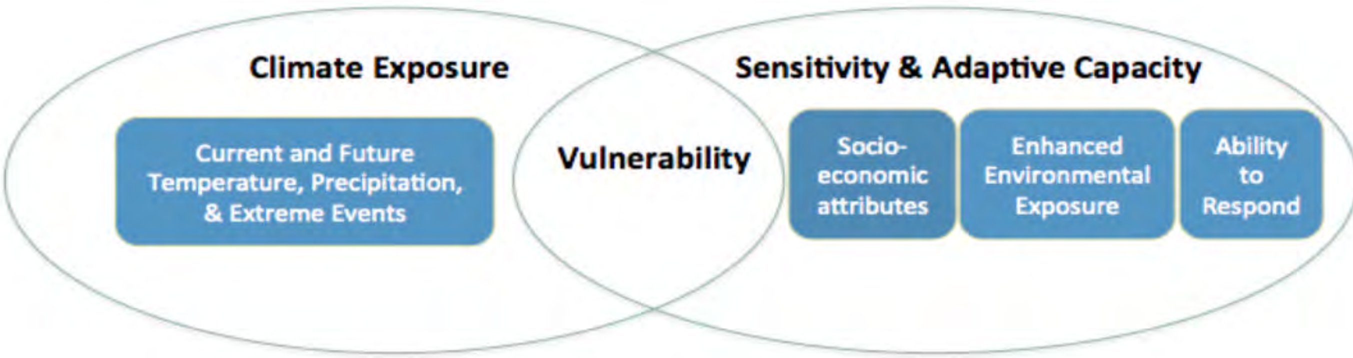

Figure 15: Climate Vulnerability. Climate vulnerability depends on climate exposure, sensitivity, and adaptive capacity.

During workshop breakout sessions, each key area of concern was assigned a sensitivity ranking and an adaptive capacity ranking (Table 2, additional detail available in Appendix C). The **sensitivity rankings** ranged from **S0**– *System will not be affected by the climate impact* to **S4** - *System will be greatly affected by the climate impact.* The **adaptive capacity** rankings were also assigned on a five-point scale from **AC0** – *System is not able to accommodate or adjust to the climate impact* to **AC4** – *System is able to accommodate or adjust to the climate impact in a beneficial way.*

Table 2: Sensitivity and adaptive capacity levels and descriptions.

Sensitivity Levels	
S0	System will not be affected by the climate impact
S1	System will be minimally affected by the climate impact
S2	System will be somewhat affected by the climate impact
S3	System will be largely affected by the climate impact
S4	System will be greatly affected by the climate impact

Adaptive Capacity Levels	
AC0	System is not able to accommodate or adjust to the impact
AC1	System is minimally able to accommodate or adjust to the impact
AC2	System is somewhat able to accommodate or adjust to the impact
AC3	System is mostly able to accommodate or adjust to impact
AC4	System is able to accommodate or adjust to impact in beneficial way

The key areas of concern were then placed in a vulnerability matrix to determine the relative vulnerability rankings between areas of concern. Those that are the most vulnerable have the highest sensitivity and the lowest adaptive capacity (e.g salmon (long-term)). Those that were the least vulnerable have lower sensitivity and higher adaptive capacity (e.g. Natural Resources Lab and Planning Department buildings). All key areas of concern are shown in Figure16.

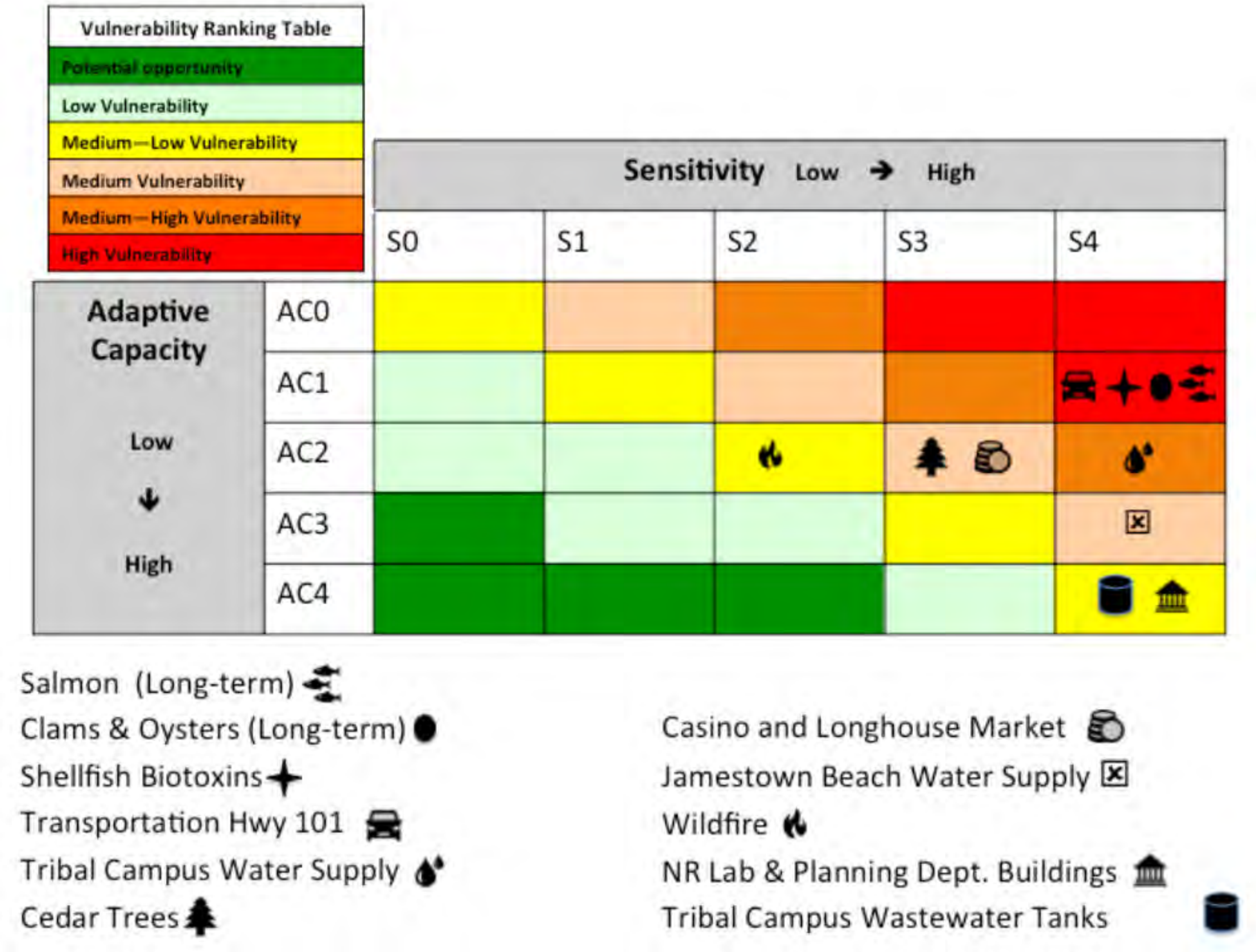

Figure 16: Climate Vulnerability Rankings for Key Areas of Concern. Rankings are based on sensitivity and adaptive capacity as determined by the climate change working group[44].

E. Prioritizing Key Areas of Concern

During day two of the workshop, the working group members focused on prioritizing the vulnerabilities in order to determine where to focus limited tribal resources. Prioritization moved beyond vulnerability rankings and allowed the working group members to differentiate between key areas of concern ranked at the same or similar vulnerability levels. The prioritization criteria are shown below. The scores for each criterion ranged from low (1) to high (5), except for the "Potential for Adaptation' for which scoring is reversed. Additional Details in Appendix C.

Magnitude of Impacts: Reflection of the scale and intensity of a climate impact

Timing of Impacts: Reflection of when the climate impact is likely to occur

Persistence and Reversibility: How persistent or irreversible the impacts are

Likelihood of Impacts: How likely it is for the impact to occur

Distributional Nature of Impacts: Indication of how widely the community may be impacted

Importance of System at Risk: Measure of the cultural, economic, social value of the system affected

Potential for Adaptation: Availability of actions to prepare for or respond to the climate impacts.

The following prioritization represents the collective understanding of the working group and highlights some key differences between the key areas of concern. Vulnerability rankings do not always lead directly to priority rankings, for example the Casino and Longhouse Market received a "Medium Vulnerability" ranking but they are in the "High Priority" category due to the revenue they generate for the Tribe. Grouped areas of prioritization have emerged as the most important measure for tribal planning:

Very High Priority Areas of Concern[2]

- *Salmon*
- *Clams & Oysters*
- *Shellfish Biotoxins*
- *Wildfire*
- *Cedar Harvests*

High Priority Areas of Concern

- *Casino and Longhouse Market*
- *Transportation Hwy 101*
- *Blyn Tribal Campus Water Supply*

Medium Priority Areas of Concern

- Jamestown Beach Water Supply
- NR Lab & Planning Dept. Buildings,
- Blyn Tribal Campus Wastewater Tanks

Very high priority areas of concern are those areas sharing high community value, with a large magnitude of expected impacts, persistence, hazardous timing, and limited potential for adaptation. Most of these areas of concern ranked particularly high in cultural importance. Salmon and shellfish lead this category due to their cultural, social, and economic value and the limited tribal control over of their adaptive capacity.

High priority areas of concern include the important economic resources of the Casino and the Longhouse Market, as well as Highway 101, the critical transportation link between the community and surrounding area. However, the timing of severe climate impacts to these areas of concern is likely many decades in the future, so the need for immediate preparation is limited.

Medium priority areas of concern include very specific impacts with a generally high potential for adaptation. For example, although the Jamestown Beach water supply is critical for the tribal residences and other families living at the beach, overall impacts are limited to that geographic area and there are many adaptation response options.

[2] Despite prioritization rankings, it should be kept in mind that all of these categories include *key areas of concern*, and therefore each area remains an important climate change issue for the Tribe, specifically selected from a broader range of community concerns.

IV. KEY AREAS OF CONCERN

Group 1: Very High Priority Areas of Concern

A. Salmon

High Vulnerability	Very High Priority

1. Why Salmon are Important

Salmon species are an iconic cultural resource for many coastal tribes of the Pacific Northwest. Traditionally, salmon provided the foundation for almost all aspects of cultural life for the Jamestown S'Klallam Tribe and was an important trade good with more interior tribes[45] of the Pacific Northwest. Salmon continue to represent an important tribal cultural connection to the waters of the Usual & Accustomed area and also provide a valuable economic and nutritional resource for the tribe.

Traditional foods, such as Salmon, provide a nutrient-rich and culturally important component of the modern diet, along with their harvesting and processing activities being associated with a more active lifestyle[46]. Such diets and lifestyles provide food packed with essential fatty acids, antioxidants, and protein and are associated with prevention and mitigation of chronic diseases such as diabetes, heart disease, and cancer[47]. Local fishing is considered a top contributor to physical activities among Tribal Citizens[48].

Tribal Citizens' commercial and subsistence harvest varies depending on the year and salmon-type, though Coho and Chum are the predominate harvest species. Generally, about 10% of *all* tribal finfish harvests are dedicated to subsistence, with the exception of the small numbers of Steelhead, the majority (70-90%) of which are used for subsistence[49]. Chinook salmon are present in the Dungeness River but haven't been commercially harvested since the 1980s due to low populations. Another salmon resource available to Tribal Citizens is fish surpluses from hatcheries. Every year, once the Quilcene hatchery has enough fish for reproduction, the surplus Coho are given to tribes in the region. This represents a significant contribution to the dietary health of the families that participate in this program. There are some financial barriers to becoming directly involved in commercial and subsistence harvest, as most of the fishing is done out of privately owned boats, so shared distribution of salmon is often the central opportunity for Tribal Citizens' access to this resource[50].

The Dungeness River has many competing uses for its water and chronic low flows in late summer and early fall when use demand is the highest[51]. The river is therefore considered "water-critical" and is home to Chinook, summer chum, bull trout, and steelhead, all of which are afforded protection under the Endangered Species Act. A new rule by the Washington Department of Ecology went into effect January 2, 2013 and is designed to ensure no net loss of water from the river. These competing water uses and low summer/fall flows are an environmental stressor to salmon populations using the river.

2. Potential Impacts of Climate Change

Especially when focusing on salmonid species, it can be difficult to unravel the multiple stressors affecting riverine, coastal, and ocean survival rates and ultimately harvest. Some environmental conditions are due to changing climate conditions while others are due to increases in population, land use changes, pollution, and other stressors. There are, however, some key climate related concerns.

Important stream systems in the Usual & Accustomed Area are trending towards more transient (mixed rain/snow) and less winter snowpack dominated watersheds. Increased winter rain and smaller snowpack could lead to more intense winter flooding events and streambed scouring, along with altered timing of river flow, all salmon-sensitive aspects of the hydrological cycle[52,53].

Figure 17 highlights additional stress to salmon stocks as temperatures increase. Heat tolerance in salmon depends on the species. Temperatures above 70°F in rivers can be particularly stressful, increasing disease and creating excess mortality. The steep gradient of the Dungeness watershed and the snowmelt that provides river water inputs over the summer will likely help to mitigate the higher air temperatures (as seen by the dark blue dot on the Dungeness River near the head of Sequim Bay within the yellow territory, upper right quadrant of right panel). By mid-century, expected increases in weekly average temperature for the Dungeness River are less than 1.8°F (1°C)[54].

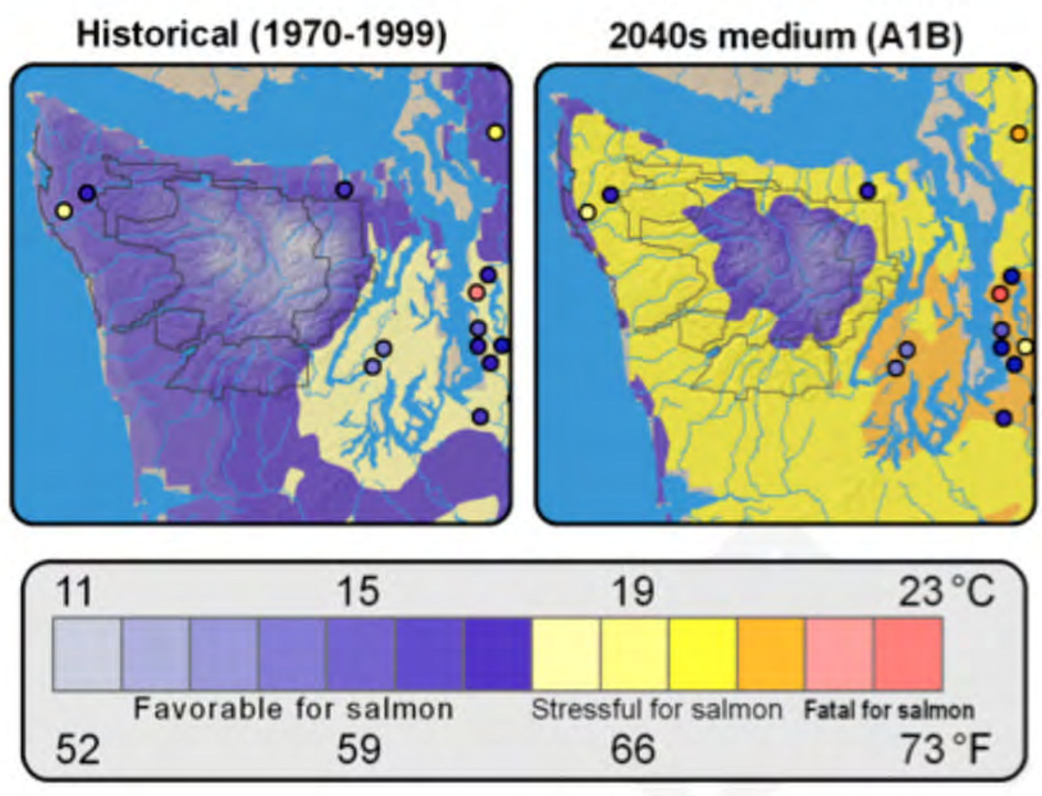

Figure 17: Current and projected air and river water temperatures on the Olympic Peninsula. Average weekly August air temp (shading) and river water temperatures (dots) for historic conditions, 1970-1999 (left panel) and future projections, 2040s (high emissions scenario – right panel)[55]. The Dungeness River (upper right quadrant) will likely remain cool (see blue dot in right panel), even as land temperatures increase, owing to steep gradient and snowmelt that supplies water to the river over the summer.

In Southeast Alaska, decades of data from salmon returns to a single stream have shown a trend towards earlier return migration of most populations and a shorter overall run, along with noted warming in the river itself. These shifting patterns raise questions about increased air and river temperatures decreasing overall genetic diversity in the salmon population and lower overall resilience to change[56].

Any large-scale change to the quality and quantity of a traditional food such as salmon will have impacts that affect the people who depend on them. Depending on magnitude of change to salmon populations, Tribal Citizens could experience impacts to commercial fishing, diet, active lifestyles, and cultural wellness. The complex threats facing salmon in the north Pacific are an immediate risk to tribal community health and wellness.

3. Actions to Increase Resilience

The environmental changes described above do not happen in isolation. Climate change impacts are complicated by competing uses for water from salmon spawning habitat, which is especially true for the Dungeness River watershed. Dungeness River water itself is used for salmon habitat, as irrigation for agriculture, and drinking water is taken from the associated shallow water table aquifer[57]. As summer flows decrease, there will be less water available for both salmon returning to spawn and agriculture uses. Warmer temperatures will increase evapotranspiration (i.e. water use of crops and vegetation), dry out soils, and increase agricultural demand for water resources. Lower flow rates will mean that the water stays in the river longer and has higher water temperatures that will add stress to salmon returning to the river. To address these threats, the Jamestown S'Klallam Tribe should pursue, to the extent appropriate, the following:

Table 3: Resilience Strategies for Salmon. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Salmon (focus on addressing other stressors)[3]	**Cost**	**Ease of Implementation**	**Political/ Community Support**	**Timing of Action**	**Partnerships Required**
Reduce other stressors to salmon stream habitats, including: urbanization, sedimentation and pollution of streams, changes in streamside vegetation, erosion due to land-use practices such as road building and clear cutting, and the draining of wetlands[58, 59].	Medium	Moderate	Low	Immediate -to-Medium-Term	Yes (surrounding communities, Counties, State, private land owners)
Restore connections to flood plains by setting back dikes or other barriers.	High	Low	Medium	Immediate –to-Medium-Term	Yes on Non-Tribal Land.

[3] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

Restore stream and streamside habitats[60](including planting native trees and removing invasive vegetation) and enhance instream survivability[61], likely in partnership.	High	Moderate (Tribal Land) Hard (Non-tribal Land)	Medium	Medium- to Long-Term	Yes (Forest Service, National Park Service, private land owners)
Ensure sustainable harvesting of salmon. This includes ensuring that a diversity of species are caught via monitoring programs (to the extent possible given current population levels) as opposed to unevenly catching one species[62].	Low	Moderate	Medium	Immediate	Yes (surrounding communities, Tribes, State, private industry)
Managing hatchery programs to minimize harm done to wild stocks[63]	Low	Easy	High	Immediate	Yes

While the Tribe undertakes many natural resource programs that strive to protect salmon, it is highly likely that climate change will make existing management practices less effective. To address the new and enhanced stressors salmon are likely to face due to climate change, it is recommended that the Tribe continue to work in collaboration with the diverse group of stakeholders relevant to salmon habitat to continue to reduce as many of the existing stressors to salmon (i.e., habitat fragmentation, changes in streamside vegetation, sedimentation and pollution of streams), to best enhance their capacity to adapt to climate impacts. This includes working to restore stream habitats, ensure sustainable harvesting of existing stocks, and enhancing the ability of the salmon to reach their spawning grounds. Should it become necessary to reduce the salmon harvest due to threatened salmon populations, the Tribe may wish to convene a working group to investigate the potential risk to community health and wellness from this diminished cultural, dietary, and economic resource.

B. Clams & Oysters

High Vulnerability	Very High Priority

1. Why Clams and Oysters are Important

Clams and oysters have been an integral part of tribal life for the Jamestown S'Klallam people throughout their history. Tribal Citizens continue to participate in subsistence and commercial harvest of littleneck and manila clams, oysters, shrimp, crab, mussels, and geoducks. Of these, geoducks and crab provide the largest annual harvest[64]. Harvesting of geoducks is economically important for the Tribe, generating revenue that is used to support Tribal Government operations and local employment. Although less economically valuable, intertidal shellfish, particularly clams and oysters, are culturally and nutritionally important for the Tribe. They provide high quality sources of protein and nutrients, are readily available, and intimately connect Tribal Citizens to their cultural heritage. Additionally, local fishing is considered a top contributor to physical activity among Tribal Citizens[65]. There are few financial barriers to personal harvest of clams and oysters, making them the most easily accessed and well-distributed subsistence resource among Tribal Citizens[66].

There are shellfish harvest beaches throughout the Usual & Accustomed area, although some beaches see more consistent use for subsistence harvest. Traditional foods, such as shellfish, provide a nutrient-rich and culturally important component of the modern diet, along with their harvesting and processing activities being associated with a less sedentary lifestyle[67]. Such diets and lifestyles provide food packed with essential fatty acids, antioxidants, and protein and are associated with prevention and mitigation of chronic diseases such as diabetes, heart disease, and cancer[68].

2. Potential Impacts of Climate Change

Clams and oysters face serious threats from changing climate conditions. The concerns come primarily from changing habitat conditions due to warming water temperatures and increasing ocean acidity. Rising temperatures will favor more heat tolerant shellfish species, increase overall suffering from thermal stress, and decreased reburrowing activity[69]. As studied under laboratory conditions, shellfish generally exhibit negative responses to conditions of elevated CO_2 and reduced pH, in effect being forced to exert more energy to build their shells and prosper[70,71]. Higher air temperatures during low-tide events have the potential to add additional stress to these species.

Commercial Pacific oyster larvae operations in Washington and Oregon have recently suffered from increases in corrosive seawater, particularly during major upwelling events. Upwelled water is naturally higher in elevated CO_2 and lower pH, providing a glimpse into a future ocean under acidification conditions. During upwelling events starting in the mid-2000s, commercial oyster hatchery operations experienced "production failure" levels of larval death[72]. Upon further research, it was observed that increasing acidification of the water negatively impacts both larval production and midstage growth of the oysters[73].

3. Actions to Increase Resilience

Efforts to help clams and oysters be more resilient to climate change primarily focus on reducing or eliminating existing stressors, thereby increasing overall adaptive capacity and resilience. To help achieve this goal, the Jamestown S'Klallam Tribe should, to the extent appropriate, undertake the following:

Table 4: Resilience Strategies for clams and Oysters. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

***Clams & Oysters (focus on limiting other stressors)*[4]**	**Cost**	**Ease of Implementation**	**Political/ Community Support**	**Timing of Action**	**Partnerships Required**
Monitor and continue to improve local water-quality since a significant amount of bivalve species decline is associated with water-quality degradation [74]. Consider expanding monitoring to include continuous water temperature and pH.	Medium	Hard	High	Medium-Term	Yes (surrounding communities, State, private land owners)
Ensure sustainable harvesting of clams and oysters[75].	Low	Moderate	High	Immediate	Yes (with State, industry, other Tribes)
Rebuild stocks (i.e., restoration)[76].	Medium	Moderate	Medium	Medium-Term	Yes (with State DNR)
Hatchery propagation and restocking of populations in areas where natural reproduction of native bivalves is limited. If this is pursued, ensure replaced stocks are indigenous to the area[77].	Medium	Easy	Medium	Immediate	Yes (with State DNR)
Transplanting adult clams and oysters (assisted migration) from remnant populations into areas that are more suitable for reproductive success[78].	Medium	Moderate	Medium	Immediate	Yes (with State DNR)
Develop cultural center and traditional Longhouse around Harvest Beach in Blyn to enhance understanding of shellfish heritage and engage more Trial Citizens in the harvest of clams and oysters[79].	Medium	Easy	Medium	Immediate	No

C. Shellfish Biotoxins

High Vulnerability	Very High Priority

1. Why Shellfish Biotoxins are Important

Harmful Algal Blooms (HABs) have been increasing in frequency, intensity, and duration around the world[80] and this has the potential to affect human health. Under the right conditions, some algae produce potent natural toxins that can bioaccumulate in filter feeding shellfish. These toxins rarely harm the shellfish, but in high concentrations can harm humans and other animals that consume

[4] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

the shellfish. In the Pacific Northwest, the dinoflagelate, *Alexandrium Catenella*, is of particular concern as a cause of paralytic shellfish poisoning (PSP)[81]. HABs develop due to a complex "…combination of physical, chemical, and biological mechanisms and their interactions that are, for the most part, poorly understood."[82] These factors include climate conditions, eutrophication from human inputs and agricultural run-off, and fishing pressure[83]

Seasonal increases in PSP closed the Juan de Fuca geoduck fishery in 2011 long enough that harvest quotas rolled over into a new management period in April. This type of occurrence highlights the changing biotoxin event impact to natural resource management and commercial harvesting opportunities. Alterations to commercial fishing opportunities can limit treaty rights and have a direct impact on the livelihoods of Tribal Citizens. In an instance of biotoxin emergence in the local harvesting area, a family was diagnosed with Diarrhetic Shellfish Poisoning (DSP) in 2011 contracted through the consumption of mussels in Sequim Bay State Park. This was the first U.S. case of confirmed DSP, and therefore led to the first DSP commercial fishing closure in Washington State. Although the plankton that causes DSP has been in Puget Sound for decades, it had previously never produced a known toxic event[84].

As discussed earlier, shellfish harvesting is important for the Tribe from a nutritional and cultural standpoint. The Natural Resources department tests year round for shellfish biotoxins and works closely with the County and State health departments to post beach closure information when appropriate. Yet with Tribal Citizens and others harvesting shellfish annually, the potential risk of poisoning from shellfish is significant.

2. Potential Impacts

There are many environmental and human factors that affect the occurrence of HABs, making it difficult to determine the exact climate related contribution to their increasing frequency[85]. Sea surface temperatures greater than 55.4°F (13°C) have been found to promote HABs and make PSP more likely. In Puget Sound, shellfish toxicity tends to occur in the late summer and early fall, correlating with higher water temperatures[86]. As the climate warms and air temperatures increase, water temperatures will also rise. A sea surface temperature increase of 3.6°F (2°C) is projected to double the number of days annually (from 68 days currently to 137 days) that water temperatures in Puget Sound are above the threshold. The expansion of the seasonality and potentially the range of HABs will increase the likelihood of human exposure to toxic shellfish in new or unaccustomed months and locations (Figure 21). It is also possible that the area will see the emergence of new or different types of algal blooms of biotoxins.

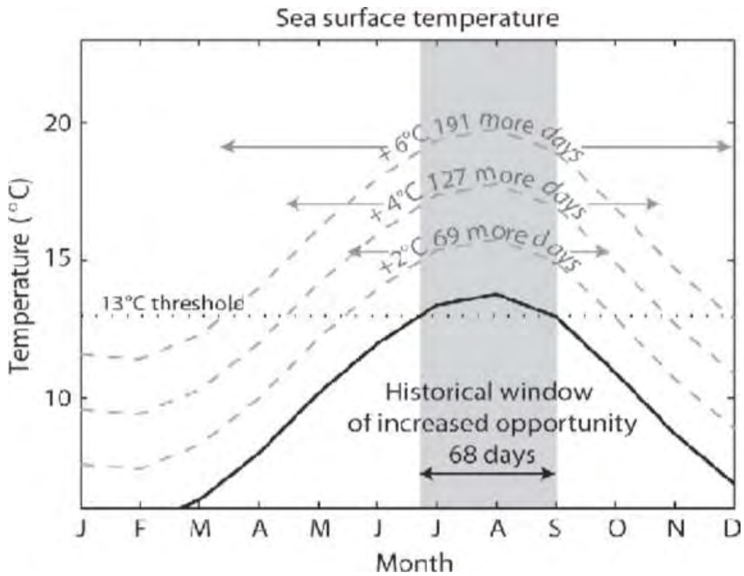

Figure 18: How sea surface temperature affects the annual window for HABs. Potential increase in the number of days above the 55.4°F (13°C) threshold where Harmful Algal Blooms (HABs) that produce Paralytic Shellfish Poisoning (PSP) occur more frequently. A 3.6°F (2°C) increase in sea surface temperature has the potential to double the number of days annually when the waters of Puget Sound are above this threshold. The dark black line and shaded region indicate current conditions. Dashed curves represent 2°C, 4°C, and 6°C increases in the sea surface temperature and the associated increase in the number of days above the threshold[87].

3. Actions to Increase Resilience

Although it is difficult to make exact projections of how HABs events will be altered by a changing climate and other environmental conditions, the potential concerns for human health and the cultural heritage associated with shellfish harvest make planning a necessity. The following strategies could be used to decrease risk of exposure to shellfish biotoxins in the tribal community:

Table 5: Resilience strategies for Harmful Algal Blooms. This table provides a select list of key actions to increase resilience of the Tribe to shellfish biotoxins and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Shellfish Biotoxins[5]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Continuation and extension of monitoring program. This includes working with academic community to identify or develop environmental predictors of harmful algal blooms.	Low	Easy	High	Immediate	Yes (with State)
Decrease other potential stressors that increase the likelihood of a HAB occurring, such as large nitrogen or phosphorous loading (eutrophication) from agricultural run-off.	Medium	Hard	Medium	Immediate	Yes (private land owners)

[5] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

Enhance beach alert system, including the posting of signs in Blyn, in the newspaper, and on the Tribe website.	Medium	Moderate	Medium	Immediate to Medium-Term	No
Revisit public health response to beach closure or biotoxin events through coordination County and State Public Health Officers.	Low	Easy	Medium	Immediate	Yes (with County & State)

Many harvesters contact the Tribe for updates on the current monitoring results before they undertake harvesting activities. Unfortunately, the 2011 family contraction of DSP in Sequim Bay State Park suggests a knowledge and communication gap in the location and timing of biotoxin exposure that extends beyond the Tribe. The Jamestown S'Klallam Tribe does not have jurisdiction over all shellfish beds in the Sequim area, but it could consider a leadership role in strategies for public alerts to ensure that shifts in timing and location of HAB risk are better understood and communicated. It may also be worth investing in furthering partnerships to enhance monitoring and testing for current and future potential shellfish biotoxins.

Although a case of biotoxin poisoning has never been diagnosed at the Jamestown Health Clinic, the clinic should ensure adequate preparation for such an event. The Health Clinic could revisit its protocol for: awareness of warnings or beach closures during a biotoxin event; tools for diagnosis at the clinic; and notification pathways with the County Public Health Officer and other stakeholders.

D. Wildfire

Medium - Low Vulnerability	Very High Priority

1. Why Wildfire is Important

Forests have always been an integral part of tribal life on the Olympic Peninsula, providing a multitude of resources from cedar trees, berries, and medicinal plants to large animal resources such as deer and bear.

Wildfire can have very direct impacts on local Tribal Citizens and their properties. Fighting wildfires nationally costs $1.8 billion annually, with home protection activities contributing substantially to this amount[88]. Many of the Jamestown S'Klallam tribal lands are located in the rain shadow of the Olympic Mountains, Clallam County, one of the driest counties (and highest wildfire risk) in Washington State west of the Cascades. Homes along the urban wildland interface are especially vulnerable to wildfire damage. In Clallam County, there are 14,686 homes in the 24% developed portion of the urban-wildland interface. In Jefferson County there are 10,475 homes in the 24% developed portion of the urban-wildland interface[89]. A number of tribal homes are located within this developed interface. With growing populations in the area, the future development of the urban-wildland interface will determine vulnerability and costs of fighting wildfire. The potential loss of tribal residences, rental property, and other tribal infrastructure is a key concern for the Tribe. This is particularly true for the upper Tribal Campus area south of Highway 101 and the Casino and Longhouse Market areas[90].

Wildfire also has other indirect impacts. Large wildfires have the potential to create substantial shifts in the ecological structure of the forested area, altering the success of plants and animals essential to tribal cultural health and wellness. Wildfire can leave large areas of sediment unprotected by vegetation and therefore more susceptible to erosion during heavy precipitation events. Increased sediment run-off can clog rivers and make salmon passage more difficult. One study of a large fire followed by a flood event in Oregon found that the associated landslides and high debris flows drastically reduced fish populations, although the stocks were back to pre-event abundance within four years[91].

Wildfire impacts on air quality can occur both locally and regionally, with instances of impaired air quality/visibility occurring hundreds of miles downwind from a wildfire source. Wildfire smoke contains various air pollutants and Particulate Matter less than 2.5 microns in diameter ($PM_{2.5}$) is often its most hazardous constituent, its small size means that it is breathed more deeply into the lungs and through more protective membranes[92]. Wildfire smoke exposure causes respiratory and cardiovascular distress and infection, and inflammation to existing conditions, such as asthma, bronchitis, chest pain, and chronic obstructive pulmonary disease. Through these pathways, wildfire events are related to increases in medical visits, hospitalizations, and emergency room visits[93].

Currently, the Jamestown Health Clinic does not identify respiratory illness as a top five "reason for visit" of Tribal Citizens to the health clinic, but does mention that there are some cases of existing chronic respiratory illnesses among the tribal population. The clinic staff highlights the main determinants of these illnesses as; smoking, genetic predisposition, pharmaceutical side effects, allergies, and indoor off-gassing from the preponderance of new work buildings and residences, along with stagnant wood smoke air pollution events in the fall season[94].

2. Potential Impacts

Warmer and drier summers are expected to increase drought stress in the forests around the tribal lands. Higher drought stress is correlated with increase susceptibility to insect attack, more tree mortality, and increased wildfire risk. Increased wildfires on the northeastern portion of the Olympic Peninsula hold immediate potential for impacts to air quality, but less obvious may be large scale wildfires in the region that synchronize with wind patterns to push wildfire smoke over Clallam/Jefferson counties. Major wildfire events in the Pacific Northwest are currently at the mercy of a predominantly westward wind, which pushes wildfire smoke inland[95], however it is unclear how current prevailing wind regimes will be altered under climate change[96]. Two members of the tribal climate change working group expressed concern for the potential of a wildfire starting at Bell Hill, moving southeast and quickly reaching the Tribal Campus area. The existence of current respiratory illness among the tribal population, and known sensitivity to some environmental determinants, suggests that a wildfire event that worsens air quality has high likelihood for respiratory health impacts.

3. Actions to Increase Resilience

Wildfire abatement focuses on both prevention and rapid response. The following strategies highlight actions the Tribe could, to the extent appropriate, use for wildfire preparedness.

Table 6: Resilience strategies for wildfire. This table provides a select list of key actions to increase resilience for wildfire and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Wildfire[6]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Expand or adjust the region's protected areas to incorporate greater landscape diversity. This facilitates range-shifts in terrestrial communities and enhances ecosystem resilience to change[97].	High	Moderate	Medium	Medium- to Long-Term	Yes (with private, State, and Federal land owners)
Manage forest density for reduced susceptibility to drought stress[98,99]. This includes developing a strategy to reduce biomass fuel in the wildfire-urban interface.	Moderate	Moderate	Medium	Immediate	Yes, State, Federal Agencies
Monitoring trends in forest condition and climate to proactively identify areas with high susceptibility to wildfire[100,101].	Low	Easy	High	Immediate	Yes, State and Federal Agencies
Start a public communication effort concerning strategies to reduce personal harm from fire. Highlight activities such as the use of fire resistant building materials, keeping vegetation and trees a minimum distance from houses[102].	Low	Easy	Medium	Immediate	No
Update Building Codes to require or provide incentives for FireSmart building standards for new builds and renovations[103].	Medium	Moderate	High	Immediate to Medium-Term	No
Establish a community evacuation plan and ensure the community knows about the plan (i.e., integrate into all tribal emergency management plans)[104].	Low	Easy	High	Immediate	No
For critical facilities, establish a back-up power supply in the event that electric water pumps are unavailable[105].	High	Moderate	Medium	Medium-Term	No
Create defensible space around essential infrastructure, communication towers, power lines, wastewater treatment, water, emergency response facilities, key transportation corridors (per Hazard Mitigation Plan).	Medium to High	Moderate	Medium	Immediate to Medium - Term	No
Update Tribal Public Health and Safety Code to include Wildfire and Air Pollution response[106].	Low	Easy	High	Immediate to Long - Term	No

[6] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

E. Cedar Harvest

Medium Vulnerability	Very High Priority

1. Why Cedar is Important

The Jamestown S'Klallam people have used western redcedar for a variety of purposes including building houses, making canoes, fishing, making baskets, and carving totems[107]. The act of cedar harvesting, and the long heritage of the resources it provides, is an important component of self-identity and artistic expertise of the Jamestown S'Klallam people.

Tribal Citizens who harvest cedar bark to make traditional baskets have already noticed changes in the optimal timing of these harvests[108]. Ideal harvest times are in the spring when temperature and precipitation conditions allow for the removal of large strips of bark with minimal effort, and help avoid permanent harm to the tree. Increasing temperatures and declines in spring and summer precipitation have shifted this optimal harvest window earlier in the year.

2. Potential Impacts

Work by the Olympic National Park and the Olympic National Forest suggests that increasing temperatures and declining summer precipitation will increase drought stress in the northeastern portion of the Olympic Peninsula[109]. Western redcedar populations in these areas are expected to decline, making the trees less accessible and resulting in more obstructions to successful tribal harvest.

3. Actions to Increase Resilience

The Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following:

Table 7: Resiience strategies for Cedar. This table provides a select list of key actions to increase resilience of local cedar populations and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Cedar Harvest[7]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Make sure that future plantings happen in areas that are protected and have high soil moisture content.	Low	Medium	High	Immediate to Long-Term	Yes with State & Federal
Consider assisted migration, or helping cedar trees grow in regions where they have not historically been located, but where they are likely to survive given changing climate conditions[110].	Medium	Moderate	Medium	Immediate to Long-Term	Not required but could be helpful

[7] A complete list including additional potential strategies is available in Appendix C. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium -Term, Long -Term); Required Partnerships (Yes, No).

Create a monitoring and reporting system to track how red cedar abundance and yields are changing. Partner with traditional harvesters to gather on-the-ground observations.	Low	Easy	High	Immediate	No

Group 2: High Priority Areas of Concern

F. Casino and Longhouse Market

Medium Vulnerability	High Priority

1. Why the Casino and Longhouse Marker are Important

The 7 Cedars Casino and the Longhouse Market are large revenue sources for the Tribe[111]. Employment statistics for recent years suggest that the Resort (which includes the Casino, Longhouse Market, and Dungeness Golf Course) is a major employer for local Tribal Citizens[112]. Although Jamestown S'Klallam Tribe provides its citizens health care coverage irrespective of employment, employment is still an important indicator of improved health for the access it provides to other health-supportive goods and services, and its role in preventing financial stress. Adverse effects of working in a casino environment may include exposure to second-hand smoke and addictive behaviors[113].

2. Potential Impacts

Major impacts to the operation of these businesses would impair employee work schedules in the short-term and in the longer-term may discourage tourist groups from visiting the area. Any long-term decline in tourist revenue could be a threat to staff numbers, benefits received, and overall job satisfaction. The Resort businesses also provide direct funding for the Tribal Government and associated tribal programs. The revenue generated through these businesses (along with the Economic Development Authority and geoduck fishery) provides a key financial resource for all of the Tribe's efforts, including health care and natural resource protection.

Even the high severity sea level rise and storm surge scenario is not projected to directly inundate the Casino and Longhouse Market. However, concern over flooding of transportation corridors and adjacent land could deter visitation and use of the facilities. The scenario maps also do not estimate flooding due to a heavy precipitation event coinciding with an extreme high tide. In this case, flooding may be greater as stormwater outflow would be impeded by the high tide. These types of "worst case" complex storm impacts should be considered in current and future construction at these facilities. Higher sea levels could raise the local water table and may decrease the feasibility and effectiveness of a septic field for the Casino, an important concern when planning additional facilities as part of the Casino Resort complex.

3. Actions to Increase Resilience

To help adapt to climate impacts and maintain the economic viability of the Casino and Longhouse Market, the Tribe should consider, to the extent appropriate, the following.

Table 8: Resilience strategies for the Casino and Longhouse Market. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Casino and Longhouse Market[8]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Flood proof the buildings by increasing ground floor elevation or building protective barriers.	Medium to High	Moderate	Low	Medium-Term	No
Providing multiple points of entry & egress to the facilities, including a route that is less vulnerable to flooding and wildfire.	High	Moderate to Hard	Low	Medium to Long-Term	Yes, likely with DOT
Move critical systems to higher levels (off the ground floor or out of the basement)[114].	Medium to High	Moderate	Low	Immediate	No
Consider protective green infrastructure in front of the facilities to create a natural buffer to storm surge and flooding.	Low to Medium	Easy to Moderate	Medium	Immediate	Yes, likely with State
Ensure that any future buildings associated with the Casino and/or Longhouse Market (i.e., parking lots, hotels) are built at higher elevation and outside the flood zone[115].	Medium	Easy	Medium	Long-term	No
Use permeable paving to manage water[116,117]	Medium	Easy	Low	Medium	No

G. Transportation - Highway 101

High Vulnerability | **High Priority**

1. Why Highway 101 is Important

Highway 101 serves a critical function as the primary access route for goods and services from the Tribe to other counties. There is no overland alternative route for Highway 101 as water features and the rugged topography of the area have historically prevented development of a redundant transportation network. This makes continuous access to and along Highway 101 of great importance. To the extent that climate change threatens Highway 101, it also threatens the economic health of the region.

2. Potential Impacts

In the event of an extreme storm event under the medium severity and high severity sea level rise scenarios there is the potential for flooding of Highway 101 near the head of Discovery Bay (Figure 22). There is also a lower likelihood of flooding near the tribal campus under the high severity scenario. The potential for these events to occur in the near-term is low, but could result in the inability to use Highway 101 for 12-24 hours during and immediately following extreme storms.

[8] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

There is a stronger potential for flooding along the Olympic Discovery Trail during extreme storm events, even under the low severity sea level rise scenario. Some portions of the trail in the Tribal Campus area and in Discovery Bay would be permanently submerged under the high severity sea level rise scenario. While trail flooding holds less transportation impact than flooding of Highway 101, the trail is an important personal use resource to maintain.

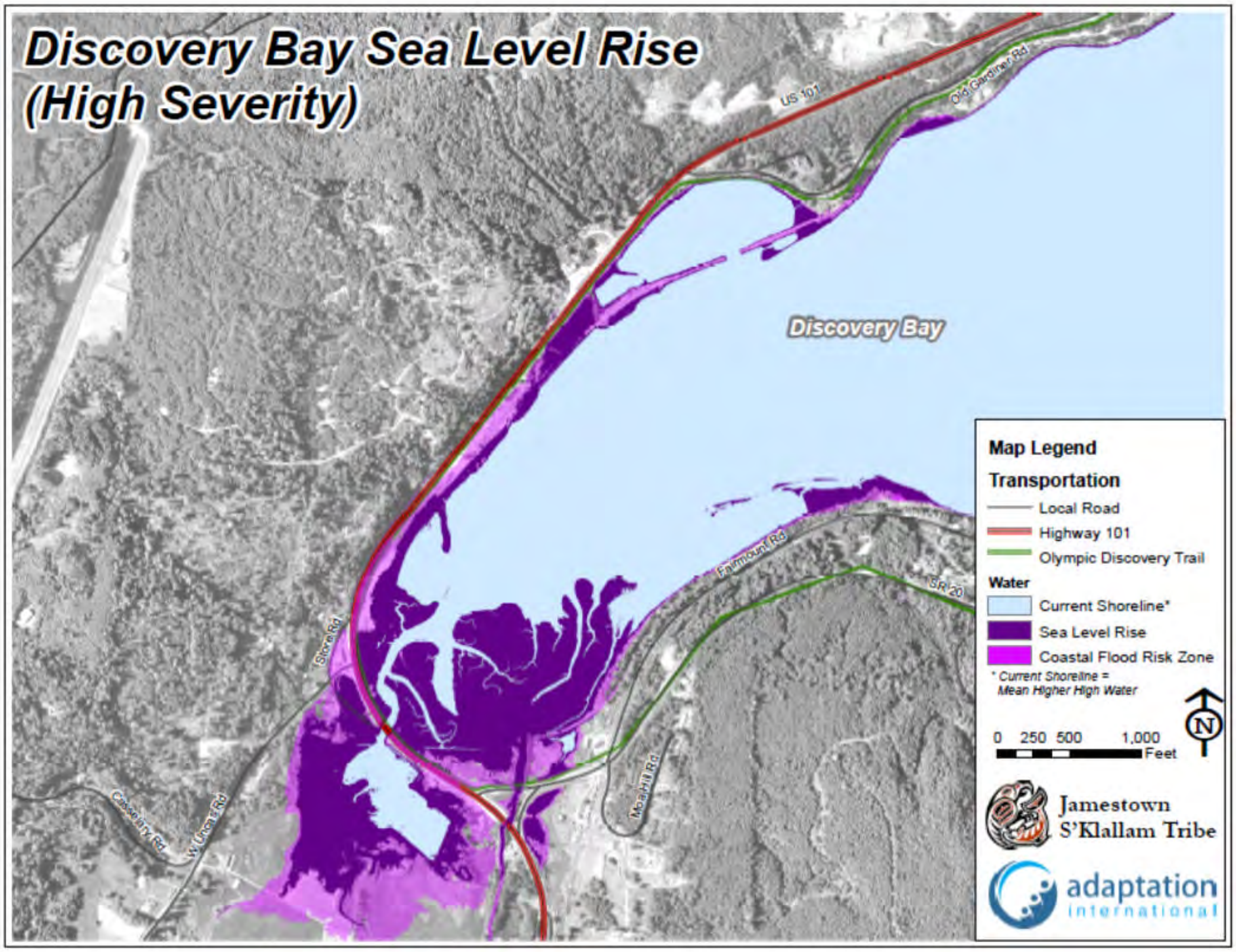

Figure 19: High severity sea level rise scenario for Discovery Bay. This map shows a potential inundation of Highway 101 at the head of Discovery Bay under the high severity sea level rise scenario. Dark purple areas would be covered under high tides and light pink areas would be inundated during 50-year storm events.

Extreme storm events raise concerns for accident and injury around homes and along transportation corridors, as well as the potential inability of rescue responders to reach victims or victims to reach shelters and emergency care centers. Elders are a particularly vulnerable segment of the population during storm events and may have health issues that become increasingly urgent when combined with a degraded transportation system. These include decreased access to medications, advanced medical equipment and services, and family members.

3. Actions to Increase Resilience

To help adapt to the climate impacts and potential disruption of travel due to flooding of Highway 101, the Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following.

Table 9: Resilience strategies for Highway 101. This table provides a select list of key actions to increase resilience for transportation and number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Transportation Hwy 101[9]	**Cost**	**Ease of Implementation**	**Political/ Community Support**	**Timing of Action**	**Partnerships Required**
Identify roads/bridges susceptible to flooding and work with Washington Department of Transportation to identify funding to raise these vulnerable pieces of infrastructure [118], especially in conjunction with future repairs.	High	Moderate	Medium	Immediate to Long-Term	Yes (DOT)
Work with residents to create a home emergency kit that ensures that all residents have the resources they need to survive in the event of a temporary closure of Hwy 101. A particular focus should be paid to Elders and other more vulnerable segments of the population. This kit should include back-up medications, rations of food, and secondary communication technologies.	Low	Easy	High	Immediate	No
Clearly identify evacuation routes (including through the use of signage) and make sure all residents are aware of these routes[119].	Low	Easy	High	Immediate	No
Create bioswales to store water and help with natural drainage alongside roads[120] particularly in Blyn and along Discovery Bay.	Medium	Moderate	Medium	Immediate to Medium - Term	Yes (DOT)
Re-naturalize floodplains[121].	Medium	Moderate to Hard	Medium	Medium to Long-Term	Yes (private land owners and business owners)

[9] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

H. Tribal Campus Water Supplies

Medium-High Vulnerability	High Priority

1. Why Tribal Campus Water Supplies are Important

Access to clean and abundant drinking water and sanitation services is a direct determinant of human health. A local well and storage tanks currently provide the primary water resource for the tribal campus area. The water is used indoors for drinking and sanitation, and outdoors for watering the landscaping around the buildings. A large portion of the tribal government services are coordinated and run from the Tribal Campus area. Without sufficient water resources for the Tribal Campus it would be difficult for staff to complete their jobs and maintain operations.

The buildings in this area also provide meeting places for Tribal Citizens for a variety of formal and informal events. It is the economic center of tribal operations and a showcase for tourists and other visitors. The facilities also house the dental clinic that provides dental services to Tribal Citizens.

2. Potential Impacts

Changing precipitation patterns and smaller snowpack has the potential to decrease local water supplies or create shifts in groundwater availability. In the event of water loss for the staff at the Tribal Campus, immediate outside water provision would be necessary to maintain a safe and comfortable work environment. Secondarily, water resources are needed in order to maintain landscaping. Existing water storage tanks are sufficient to maintain critical water service for a few days (not including landscaping). The exact number of days has not been determined since the Tribe has not had the tanks in operation for a full summer, but the Tribe is monitoring water use and working to ensure that sufficient water resources are available.

3. Actions to Increase Resilience

There is an ongoing effort to expand and diversify the water supply resources for the Tribal campus area. Completion of new wells in conjunction with a Utility Master Plan is designed to ensure sufficient water resources for the Tribal Campus area as it continues to develop. The water infrastructure itself is all relatively new and is therefore not a current cause for concern. An immediate and low cost method to extend the limited water supplies for the region and increase capacity for new uses is to increase water use efficiency through changes to behaviors and appliances. To help adapt to the climate impacts on water supply and quality, the Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following strategies.

Table 10: Resilience strategies for Tribal Campus water supplies. This table provides a select list of key actions to increase resilience and number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Tribal Campus Water Supplies[10]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Initiate rainwater capture and reuse programs.	Low	Easy	Medium	Immediate	No
Ensure that new wells are sited outside of coastal and riverine flood zones and that a hydraulic assessment is completed to assess and limit impact of potentially elevated water table due to sea level rise.	Medium	Medium	Medium	Immediate to Medium - Term	No
Enhance water efficiency/conservation programs.	Low	Easy	Medium	Immediate	No
Design planting and landscaping to use native and drought tolerant vegetation and provide summer shade for buildings where appropriate.	Medium	Easy	High	Immediate	No
Install water efficient fixtures, fittings, and appliances throughout the Tribal Campus.	Low to Medium	Easy	Medium	Immediate	No

Group 3: Medium Priority Areas of Concern

I. Water Supply – Jamestown Beach

Medium Vulnerability	Medium Priority

1. Why the Jamestown Beach Water Supply is Important

The homes located along Jamestown Beach Road, including tribal residences, all receive their water from a local well. The Tribe is responsible for well operation and also owns a number of properties in the area. This is the single potable water source for the homes along the beach as well as many of the homes inland.

2. Potential Impacts

Any inundation of the lands immediately above or surrounding the well has the potential for introduction of contaminants into the water source (Figure 20). Major inundation events should be treated as a challenge to well water quality and should be followed up with appropriate testing to ensure water standards are being met. These scenarios highlight the potential climate and weather related exposure for the well but do not take into account the potential for salt water intrusion into either the well itself or the well housing, which could occur during sea level rise independent of an extreme flood event.

[10] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

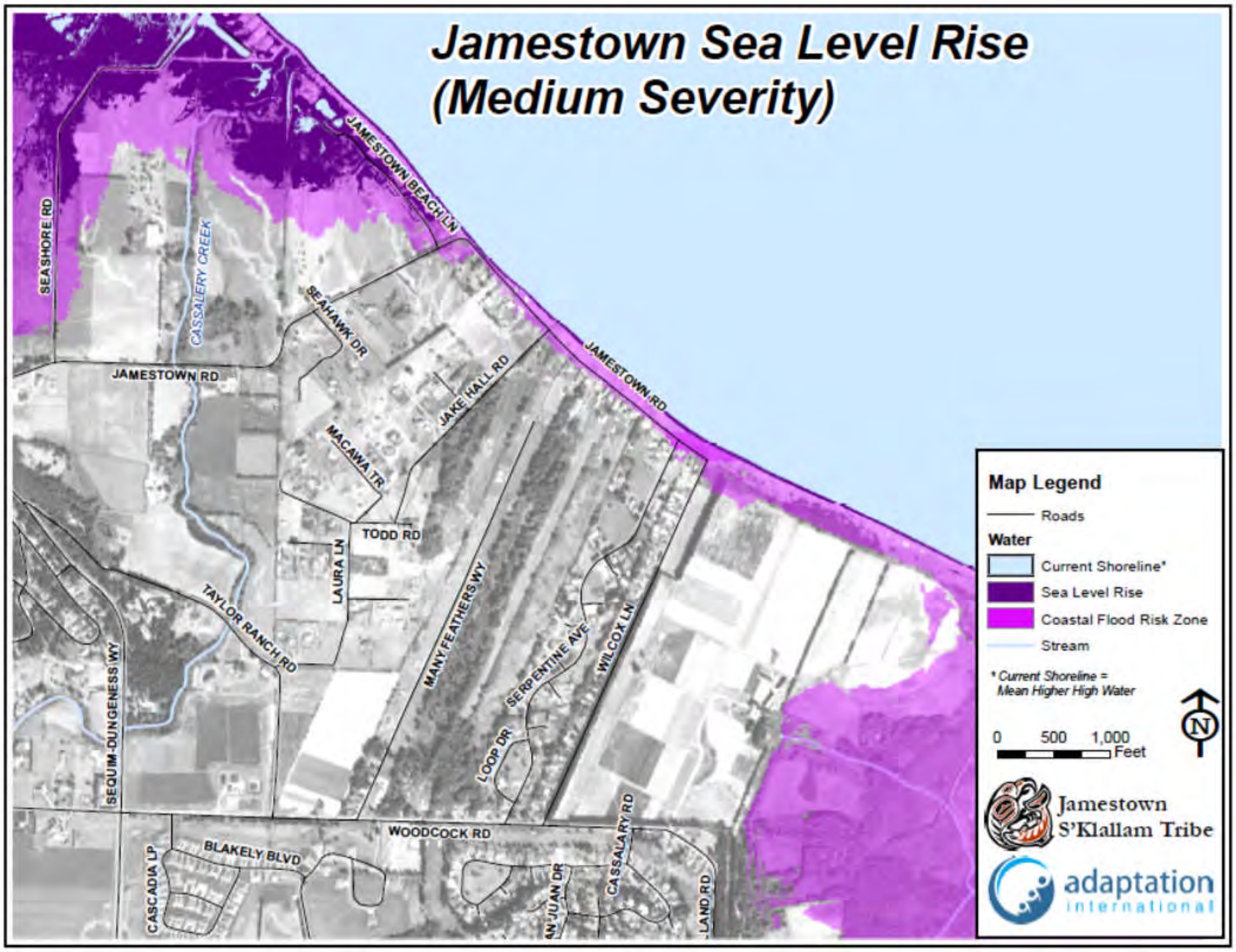

Figure 20: Jamestown Beach medium-severity sea level rise map. Potential inundation and storm surge zones for the Jamestown Beach Area under the Medium Severity sea level rise scenario (about 2 feet) projected to occur between 2055-2090. An artesian well is the sole drinking water source for the majority of the houses located near the beach, including tribal residences.

It will take time for sea level rise to happen and the medium severity scenario is not projected to occur for a number of decades (2055-2090). However, these maps do not incorporate dynamic shoreline processes like the potential for increased erosion, or the potential for disruption of groundwater inputs to the well. Nor do they include projections of changes in wave dynamics or storm orientations that could create wave pileup on the Jamestown Beach. These unmapped processes hold potential for increasing the extent and magnitude of coastal flooding and potentially damaging the well in advance of what the sea level rise maps project.

The well is ranked medium vulnerability due to the medium-term nature of the climate exposure. The well was ranked at medium priority since a well or pump failure would be a significant impact to the Tribal Citizens who receive water from the well, but they represent a small sub-set of the full tribal community and would continue to have access to other water sources in the greater Sequim region.

3. Actions to Increase Resilience

The Indian Health Service installed the Jamestown beach well in the 1960s, and although it is still working, it is in need of replacement. The most cost effective time to decrease the vulnerability of the well to coastal flooding is to conduct a retrofit in conjunction with other repairs or replacement. The Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following strategies.

Table 11: Resilience strategies for Jamestown Beach well. This table provides a select list of key actions to increase resilience of the Jamestown Beach water supply and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Jamestown Beach Water Supplies[11]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Conduct a hydrological connectivity groundwater assessment to evaluate the potential for saltwater intrusion with an elevated water table as sea levels rise.	Medium	Medium	Medium	Immediate	No
Evaluate the potential for connecting the residences in the area to a secondary water supply.	Low	Medium	High	Immediate to Medium - Term	No
Ensure that any new well(s) are sited outside of coastal flood zones. Include this concern when requesting funding from the Indian Health Service or others for replacement and relocation of the well.	Low	Medium	High	Medium - Term	No on Tribal Land
Following any major flood event, conduct well water sampling to ensure water safety standards are being met.	Low	Easy	High	Immediate	No

J. Natural Resources Lab & Planning Department Buildings

Medium-Low Vulnerability	Medium Priority

1. Why these Tribal Campus Buildings are Important

The Tribal Campus remains a connective link between modern tribal services and the traditional tribal use areas. The campus's centralization of services facilitates open access from the public and Tribal Citizens, communication across tribal departments, cultural connection to the surrounding landscape, and a celebration of cultural wealth through well-maintained and decorated facilities. The Natural Resource and Planning Department contribute greatly to the ongoing successes of tribal activities and in turn, benefit from their location on the Tribal Campus.

[11] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

2. Potential Impacts

On the Tribal Campus, the Natural Resources lab and Planning Department buildings are the most vulnerable to near-term sea-level rise. The foundation of the Natural Resources Lab in particular may be subject to flooding during storm events under the low severity sea level rise scenario. Offices and staff would likely need to be relocated during temporary inundation scenarios. It is ranked as a medium priority because the organization and location of tribal departments is part of a longer term planning operation, reliant on opportunities for purchasing, renovating, or constructing other properties, and subject to the options for project funding.

3. Actions to Increase Resilience

Both the Natural Resources Lab and the Planning Department buildings are ageing and will likely need replacement or substantial upgrade within the next 10 years. It will be cost effective to incorporate planning for sea level rise at that time, Particularly, by making sure that any new construction is located out of or above the sea level rise inundation areas and storm surge zones. The Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following strategies,

Table 12: Resilience strategies for Tribal Campus buildings. This table provides a select list of key actions to increase resilience of buildings on the Tribal Campus and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Tribal Campus Buildings[12]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
Develop a relocation and business continuity plan in the event that the buildings are temporarily unable to be used due to near term flooding.	Low	Easy	High	Immediate	No
Consider a tribal policy of "managed retreat" from higher risk coastal flood zones so that over time, as buildings are renovated or replaced, they are moved out of the future flood risk zones.	Medium	Medium	Medium	Medium-Term to Long-Term	No
Ensure that any new buildings are sited outside of coastal flood zones.	Medium	Medium	High	Medium-Term	No

These adaptation strategies highlight the possibility of developing a new tribal policy of "managed retreat" from sensitive or high-risk coastal flood zone areas. This proactive policy would ensure that as tribal property and tribal buildings are renovated or replaced they are moved back from the shoreline and out of future flood risk zones. Incorporating consideration of future sea levels during any major construction, retrofit, or rebuilding effort will allow design changes to be incorporated at minimum cost. Also, moving the built environment back from the shoreline will allow for natural ecosystems to respond to the higher sea levels, improve ecosystem resiliency to those changes, and enhance the long-term survival of species important to the Tribe.

[12] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

K. Tribal Campus Wastewater Tanks

Medium-Low Vulnerability	Medium Priority

1. Why the Tribal Campus Wastewater Tanks are Important

The wastewater collection tanks are a critical link in the safe treatment of wastewater for the Tribal Campus facilities and without their proper operation, effluent and sewage cannot be transferred to the processing facilities. Treatment of wastewater is important for protecting community health and disruption of the collection network will limit the ability to safely use Tribal Campus buildings.

2. Potential Impacts

The wastewater collection tanks for the Tribal Campus are located near the coastal flood zone for the medium severity sea level rise scenario and well within the storm surge zone for the high severity sea level rise scenario. Near-term impacts from coastal flooding are likely to be limited to temporary inundation of the facility. Medium-term impacts are likely longer periods of inundation and potential erosion and destabilization of the area around the wastewater tanks. The tanks are a key link in wastewater collection and processing infrastructure for the Tribe and required for the safe and effective treatment of waste.

3. Actions to Increase Resilience

It will be cost effective to incorporate planning for sea level rise when the wastewater tanks need to be replaced. Particularly by making sure that any new construction is located out of or above the sea level rise inundation and storm surge zones. The Jamestown S'Klallam Tribe should consider, to the extent appropriate, the following strategies.

Table 13: Resilience strategies for the Tribal Campus wastewater collection tanks. This table provides a select list of key actions to increase resilience and a number of criteria to be used in the evaluation, prioritization, and selection of strategies.

Tribal Campus Wastewater Tanks[13]	Cost	Ease of Implementation	Political/ Community Support	Timing of Action	Partnerships Required
As the wastewater collection tanks near the end of their useful life, plan to relocate new tanks out of the future storm surge risk zones.	Low	Medium	High	Medium-Term	No
Consider a tribal policy of "managed retreat" from higher risk coastal flood zones so that over time as buildings are renovated or replaced they are moved out of the future flood risk zones.	Medium	Medium	Medium	Medium - Term to Long - Term	No
Incorporate consideration of current and future coastal flood risk zones into any utility or wastewater mater plan.	Low	Easy	High	Immediate	No

[13] A complete list including additional potential strategies is available in Appendix D. Qualitative metrics are as follows: Cost (Low, Medium, High); Ease of Implementation (Easy, Moderate, Hard); Political/Community Support (Low, Medium, High); Timing of Action (Immediate, Medium-Term, Long-Term); Required Partnerships (Yes, No).

L. NEXT STEPS

The Jamestown S'Klallam Tribal Government and Tribal Citizens are well poised to successfully prepare for changing climate conditions on the Olympic Peninsula. The ongoing efforts by the Tribal Natural Resource Department, Health Department, and others have created a foundation that can be used to move from planning to action. The Tribe has been responding and adapting to a changing climate for thousands of years. Preparing for continued and accelerated change is not something new, but a continuation of the holistic natural resource and culturally driven approach that has kept the Jamestown S'Klallam Tribe a vibrant and growing community.

A portion of the climate change working group reconvened April 22nd, 2013 to discuss the detailed findings of the project, review the actions to increase resilience, and discuss next steps. In collaboration with the working group and other stakeholders, a total of four next steps are identified to help the Tribe move forward with building preparedness for climate change. They are: 1) prioritizing adaptation strategies for implementation and identify individuals or departments responsible for implementation; 2) building community support for climate preparedness; 3) incorporating climate preparedness into the Tribal Government operations and policies and 4) collaborating with surrounding communities, the county, and other key stakeholders to monitor key changes to local and regional climate that are likely to affect the Tribe. A proposed progression through these four activities is presented below, along with more detail on each of the four recommended next steps.

Step One: Prioritizing adaptation strategies for implementation and identifying individuals or departments responsible for implementation

To maintain the momentum established through this process, the Tribe should start by prioritizing the adaptation actions identified in Appendix D, identifying at least two or three for immediate implementation. In prioritizing actions, the Tribe should consider which actions will provide immediate value, which actions are likely to secure public support, which actions can be financed (either through existing budgets or with external support), and which actions are likely to provide the greatest social, cultural, economic, and environmental value to the Tribe. As part of this process, the Tribe should identify the individuals or departments that are responsible for implementing each action and assign a timeline by which each action will be completed. Actions can be grouped into three categories: actions for immediate implementation within the next year; actions to implement in the medium term (2-5 years); and actions for implementation in the future (i.e., 6+ years).

It is also worth noting that a number of additional funding sources are available to help the Tribe implement prioritized adaptation actions. The Tribe is encouraged to leverage the work they have done and the information summarized in this report to secure additional funding such as grants through federal agencies and private foundations. Moreover, having a vulnerability assessment and a list of prioritized adaptation actions will likely enhance the Tribe's chances of securing additional funding as it demonstrates the Tribe's foresight and readiness to act.

Step Two: Building community support for climate preparedness

Building community support, particularly with Tribal Citizens, is a key component of the long-term engagement necessary to support tribal actions to enhance climate resilience. Building community support is listed as the second step in the process but, in reality, this will be an ongoing effort that requires continual emphasis. Utilizing the results from Step One (prioritizing adaptation actions) can be an effective way to begin engaging citizens, departments, and surrounding communities in climate preparedness. Moreover, some of the discrete actions listed in this report will likely require additional funding and allocating that funding requires political support. This support starts with understanding how climate change will affect the resources and assets that the Tribe values and why taking these actions will help protect those assets.

There are many ways to engage the tribal community as a whole. The overviews of selected key areas of concern provided alongside this report provide a starting point for that engagement. These short, graphically rich, documents are designed to help broaden the conversation throughout the tribal community and provide a non-technical summary of the issue and the potential actions to increase resilience. Additionally, the Tribe should consider integrating climate change discussions into existing outreach efforts and working to ensure that supporting material are provided at appropriate community events.

Step Three: Incorporating climate preparedness into Tribal Government operations & policy

For many communities there is a gap between the identification of actions to increase climate resilience and the implementation or operationalization of those actions. The tribal climate change working group acknowledges the potential for this gap to appear and has identified the need to develop direct guidance on how to incorporate consideration of climate change into the ongoing tribal policies, rules, and actions.

Simply asking project sponsors or project managers to consider and prepare for climate change is not sufficient. The Tribal Government, and in particular the climate working group, should work to develop specific guidance for how to integrate a set of key climate variables into the project approval process. For example, depending on the project lifespan, the Tribe could require that new buildings be built outside the coastal flood risk zone or with a certain amount of freeboard.

Step Four: Collaborate with surrounding communities, counties, and other key stakeholders to monitor key changes in climate likely to affect the Tribe

Because the magnitude of effects from climate change will vary locally, the Tribe should partner with state, federal, academic, private, and nonprofit entities that currently monitor how social, economic, and natural systems are shifting. For example, specific hazards associated with erosion of the shoreline are identified in this report, and monitoring the shoreline may help identify the scale of change in advance of significant consequences. Washington Sea Grant has funding to establish a shoreline monitoring program on the Olympic Peninsula, and placement of monitoring sites in areas identified as important by the Tribe may be used to gather the information needed to reduce community vulnerability. This type of monitoring will help the Tribe ensure that it is integrating the most up-to-date information into its planning processes. This step may require little, if any, additional financial resources from the Tribe but will provide critical information that will help the Tribe more effectively prepare for existing and projected futures changes in climate.

Preparing for, or adapting to, the impacts of climate change is not an outcome, but a process. While this report incorporates the best available science to date, there will likely be highly applicable scientific findings and discoveries over the next few years and decades. In order to be responsive to that new information, it is important to set-up a dynamic process that can incorporate relevant data as it becomes available.

V. Glossary

Adaptive Capacity – The ability of a system to adjust to climate variability or change, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.

Corrosive - Corrosive ocean water has low pH levels relative to contemporary values and reduced availability of carbonate ions. Corrosive waters make it more difficult for some organisms that use carbonate ions to build and repair their shells.

Resilience – The capacity to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

Sensitivity – The degree to which a system is directly or indirectly affected, either adversely or beneficially, by climate variability or change.

Vulnerability – The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate variability and change.

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