# South Kachemak Watershed Collaborative Restoration Plan

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## INTRODUCTION

The Chugach Regional Resource Commission (CRRC) serves the greater Chugach region of Southcentral Alaska including Lower Cook Inlet, Resurrection Bay and Prince William Sound. Within Lower Cook Inlet, CRRC serves the Port Graham Village Council, Nanwalek IRA Council, and Seldovia Village Tribe[1]. Therefore, CRRC established the South Kachemak Bay Watershed Collaborative (Collaborative or SKBWC) to protect salmon streams located within the south Kachemak Bay Watershed (watershed; Figure 1). The Lower Cook Inlet tribes experince a lack on inclusion in land and water management planning regarding in the watershed even though they have substantial traditional and experiential knowledge regarding climate change resilience and mitigation, especially regarding impacts to fish and wildlife resources in the Watershed.

For thousands of years, the Dena'ina, Alutiiq and Sugpiaq people have inhabited the Cook Inlet region located on the Southern tip of southcentral Alaska as "Tikahtnu." As a result, as stewards of the watershed are the main dependent on its subsistence resources since time immemorial. All the Tribes have a substantial interest in the impacts of climate change and land and water management actions impacting salmon rivers and streams within the watershed.

Many changes related to warming fresh and marine water temperatures impact the subsistence resources that the above communities rely upon. These changes are happening at a rate thought impossible a decade ago. Land management activity within the watershed can exacerbate such impacts. Increasingly common drought conditions and spruce beetle outbreaks in the region threaten the health of the watershed and the plants and animals upon which rural communities rely upon for subsistence. The goal of this plan was to work with Federal, state, tribal, local, research, conservation and other stakeholders to be more inclusive of tribal and other local communities and other stakeholders in monitoring, planning and decision-making that impacts the watershed. Preserving connectivity and non-climate stressor mitigation actions will ensure better protection and management of salmon habitat in the Watershed.

Broadly, the SKBWC is a consortium of stakeholders across the watershed working in tandem toward the common goal to protect natural resources in the watershed. The SKBWC is supported by a library of reports and other documents providing CRRC with current conditions, data, and reports on a variety of topics in the watershed (Appendix A). This initiative focuses on the South Kachemak Bay Planning Region[2] is comprised of three 10-digit hydrologic units: English Bay (HUC10 #1902030112; 1,001.6 sq km), Port Dick (HUC10 #1902020213; 332.6 sq km), and Rocky River (HUC10 #1902020214; 908.1 sq km) (Table1). There are three tribal villages within this planning region Seldovia (population: 242), Paluwik (Port Graham; population 142) and Nanwalek (population 172).

| Kachemak Bay Watershed Collaborative | | | |
|---|---|---|---|
| South Kachemak Bay Planning Region | | | |
| HUC Name | HUC 10 Code | Area (sq km) | Area (acre) |
| English Bay-Frontal Cook Inlet | 1902030112 | 1001.55 | 247,487.51 |
| Port Dick | 1902030113 | 332.59 | 82,185.61 |
| Rocky River- Frontal Rocky Bay | 1902030114 | 908.12 | 224,402.11 |

Table 1. South Kachemak Bay Watershed Planning Region Hydrologic Unit Codes.

[1] Seldovia is also included in this report due to its proximity to the CRRC communities and the organization's close working relationship with the Seldovia Village Tribe.

[2] Planning units were derived from the National Hydrography Dataset and Watershed Boundary Dataset.

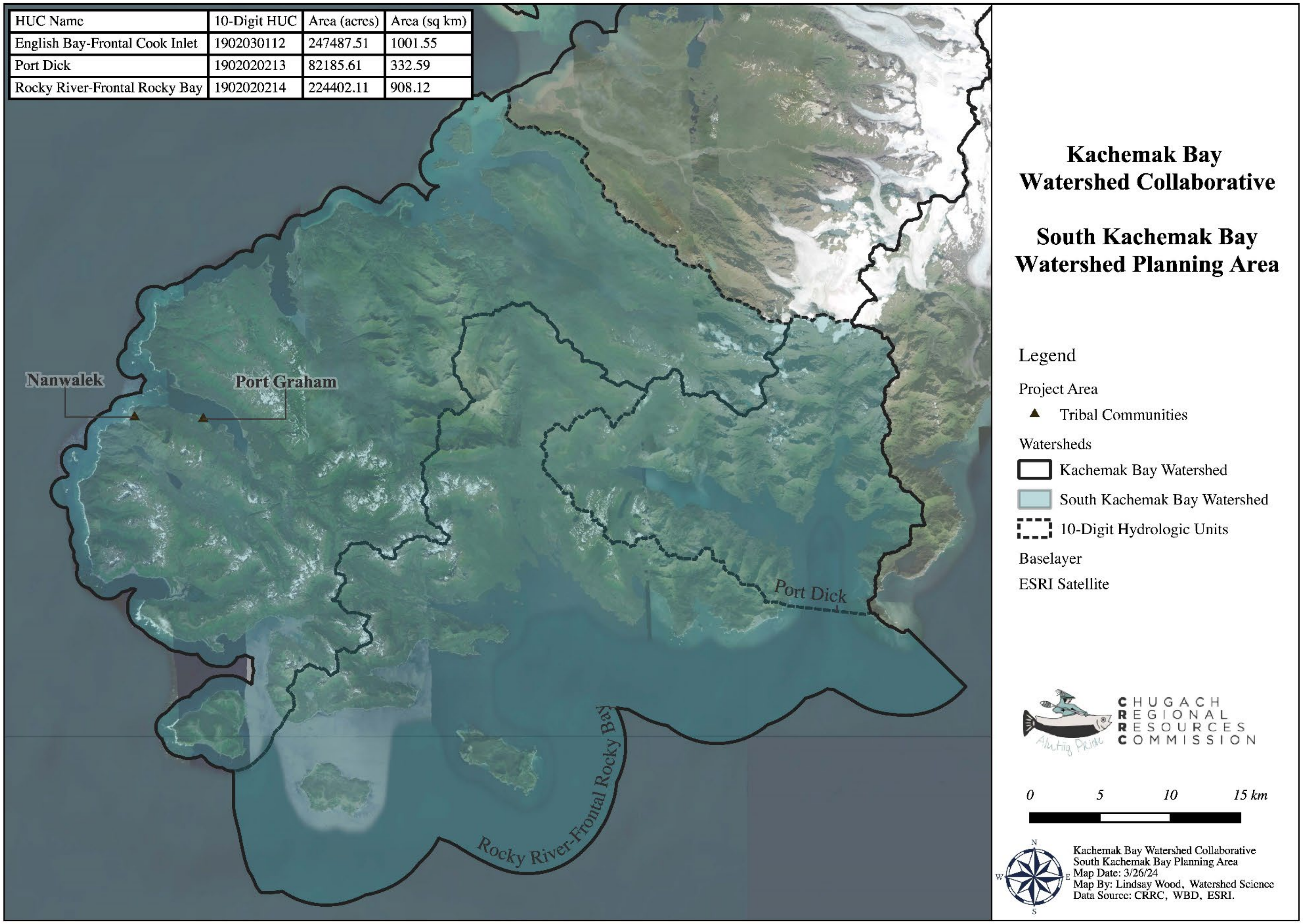



Figure 1. South Kachemak Bay Watershed Planning Area.

## SOUTH KACHEMAK BAY WATERSHED COLLABORATIVE MISSION AND VISION

The South Kachemak Bay Watershed Collaborative is a collaboration of the Chugach Regional Resources Commission and Lower Cook Inlet Alaska Native communities focused on the protection and sustainable management of environment and community adaptation priorities.

### MISSION

Utilize available environmental data, identify and fill new environmental data to protect the South Kachemak Bay Watershed while ensuring Alaska Native tribal sovereignty.

### VISION

Climate adapted peoples and ecosystems in the South Kachemak Bay Watershed Area.

### PRIORITIES

Create a Conservation Stewardship Legacy

- Utilize ecosystem-based science to identify best practices to manage land and water resources and adapt to environmental changes.
- Examine local land use planning processes and designations that govern public use and access.
- Foster relationships with regional organizations advocating for balanced stewardship and use of public lands.

Stakeholder Involvement

- Improve dialogue and relationships with persons and entities invested in the Watershed through public and stakeholder outreach of research findings and traditional Alaska Native Knowledge.
- Expand the lines of communication with tribes and local communities, state and federal agencies and branches of government, water authorities, and city and borough representatives.
- Ensure that land management decisions are based on sound science and through analysis, with consideration for past mistakes so they are not repeated.
- Pursue collective measures that increase water storage, stream flows, and habitat protection to benefit local communities, agriculture, area businesses, and diverse, sustainable biotic communities, including fish and wildlife.
- Return decision-making to tribal entities and local communities.

Stakeholder Priorities

- Wetland protection prioritization to maintain anadromous stream connectivity.
- Protection of habitat corridors.
- Remediate South Kachemak Contaminated Sites.
- Increase forest health.
- Reduce forest loss due to insect damage and disease.
- Reduce forest loss due to fire.
- Support enhanced environmental monitoring.
- Initiate a Community Catalyst Program.
- Develop climate ready infrastructure.
- Increase water supply reliability.

## SOUTH KACHEMAK EXISTING CONDITIONS

### CLIMATE CHANGE

Climate change is impacting the subsistence resources that such communities rely upon due to warming fresh and marine water temperatures at a rate no one thought possible a decade ago, and there is an urgent need for a broader range of stakeholder inclusion in planning for sustainable management of the watershed going forward.

#### Stream Temperature

Increasing stream temperatures also pose a major risk to rural and Tribal communities in the watershed. Salmon are an incredibly important resource in the region, providing food and jobs for local residents and playing a vital ecological role as well. In early July 2019, for the first time ever, stream temperatures in salmon spawning areas of the Kenai Peninsula exceeded eighty degrees. Similarly, other rivers on the Kenai Peninsula set temperature records in July of 2019. For spawning adult salmon or growing juveniles, temperatures above eighty degrees can be lethal, primarily due to the loss of oxygen in the water. Additionally, the warm water makes fish lethargic and therefore more susceptible to predation.

#### Air Temperature

Unusually hot and dry weather in the summer of 2019 resulted in Jakolof Creek, which flows through the traditional territory of the Seldovia Village Tribe, running completely dry starting in mid-July from the mouth of the bay all the way up to the switchbacks and, at the time of our visit to the area, was still receding. Portions of nearby Kingfisher Creek were also dry. This was the second time in 4 years that Jakolof Creek has dried up resulting in a mass die-off of all of the fish in the system at the time. Figure 2 shows the average daily temperature on the Kenai Peninsula.

Daily Average Temperature Patterns on the Kenai Peninsula

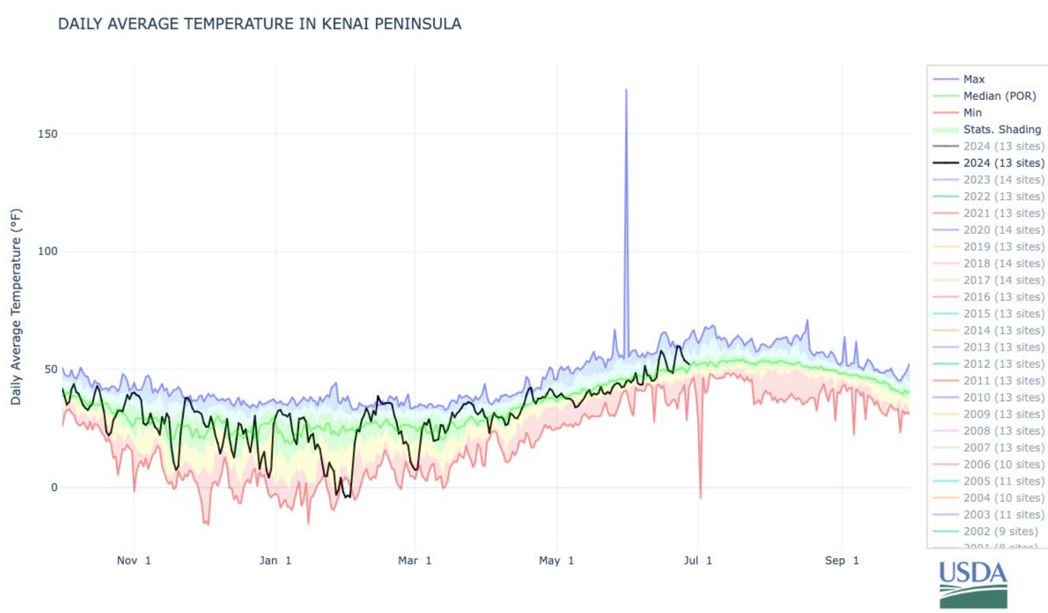


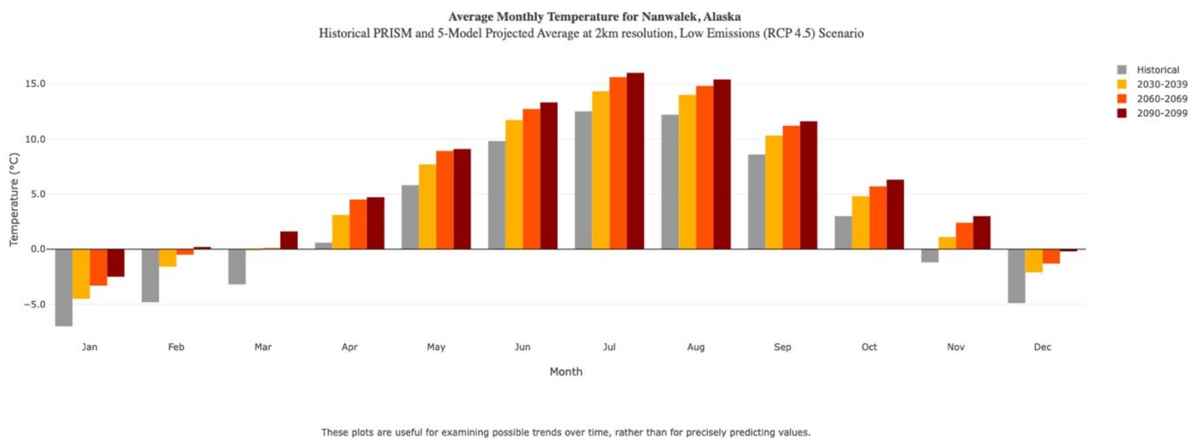

Figure 2. NRCS AWS Plot for Daily Average Temperature on the Kenai Peninsula.

### *Future Temperature Projections*

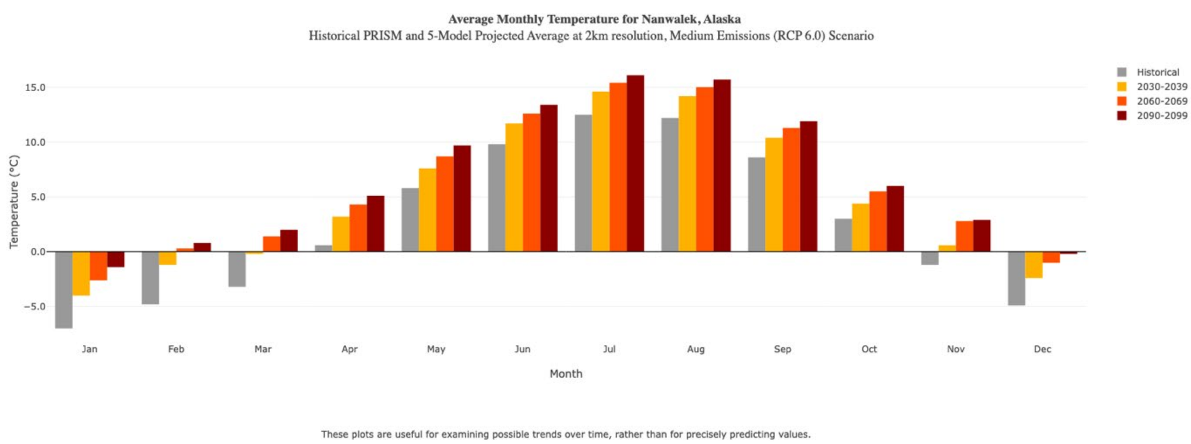
Future temperature projections for each community are found on the following pages.

## Average Monthly Temperature Projection: Nanwalek, Alaska

### Low Emission Scenario




### Medium Emission Scenario




### High Emission Scenario

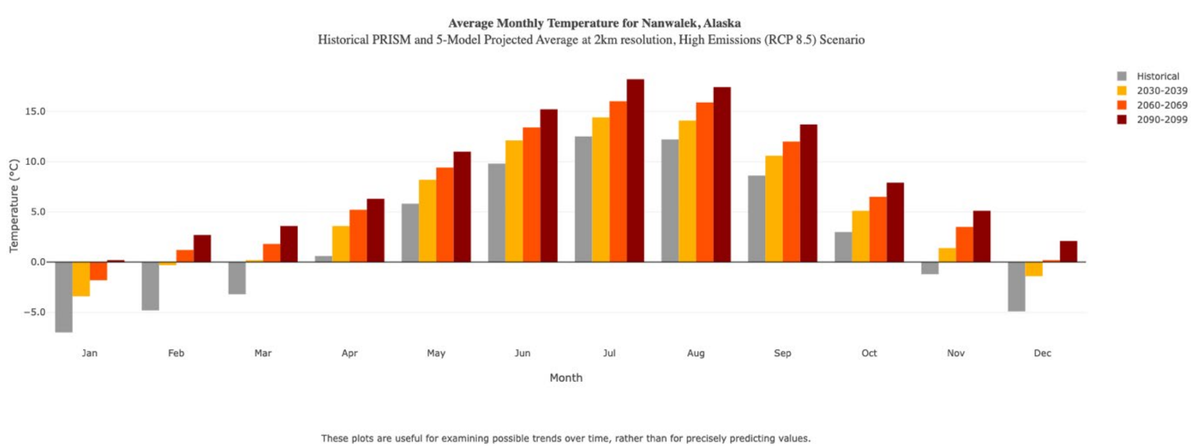
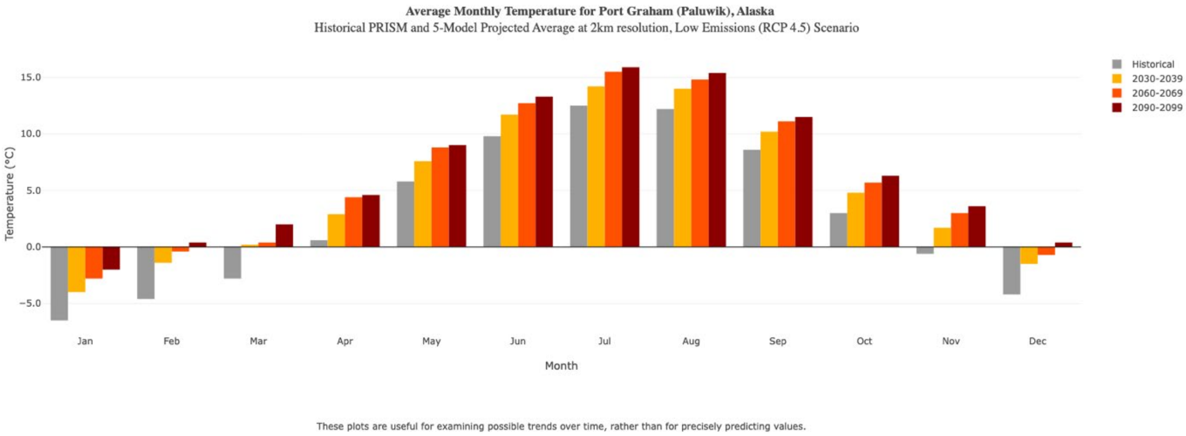


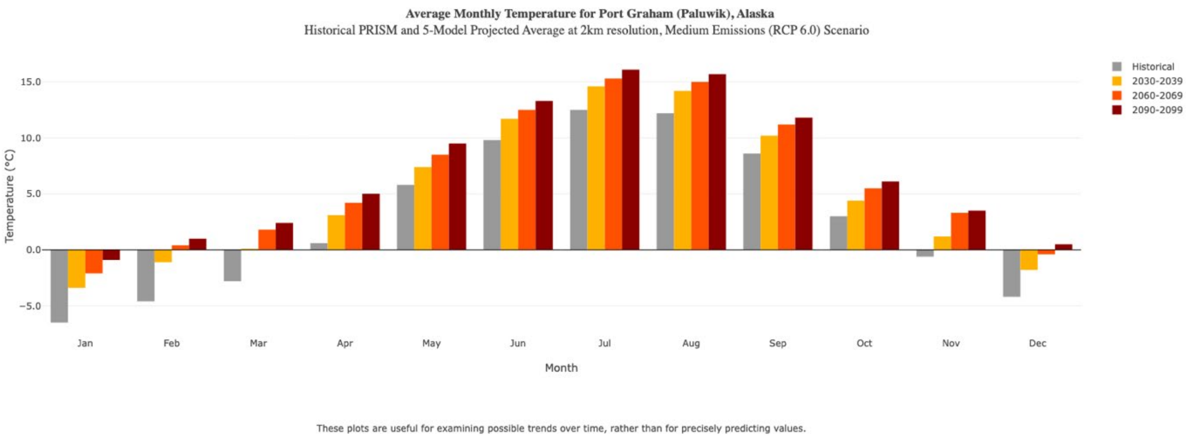

Figure 3. Average Monthly Temperature Projection: Nanwalek, Alaska.

# Average Monthly Temperature Projection: Port Graham, Alaska

## Low Emission Scenario




## Medium Emission Scenario




## High Emission Scenario

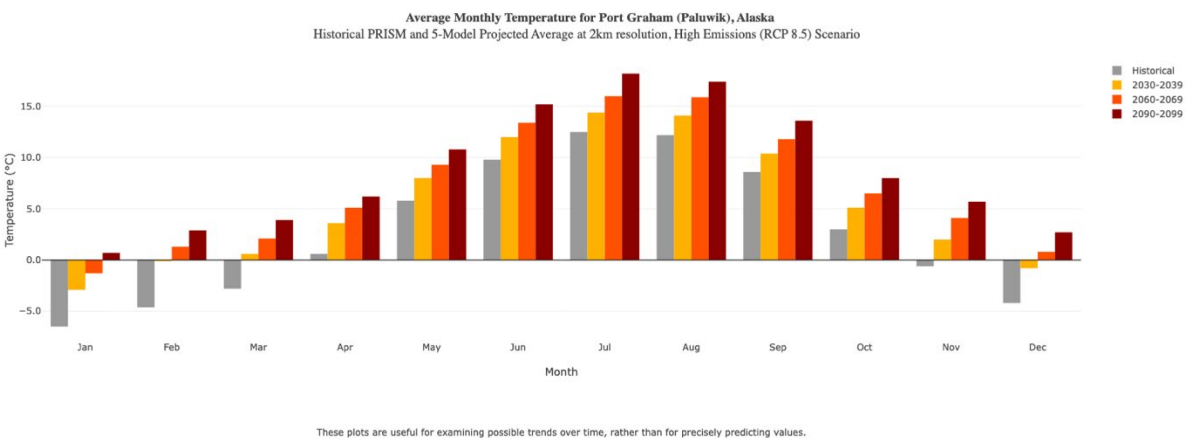
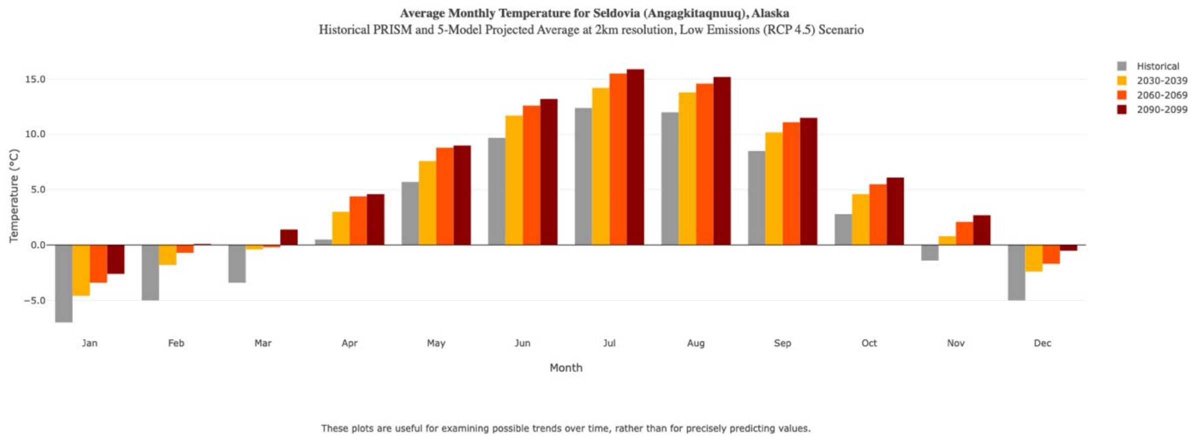


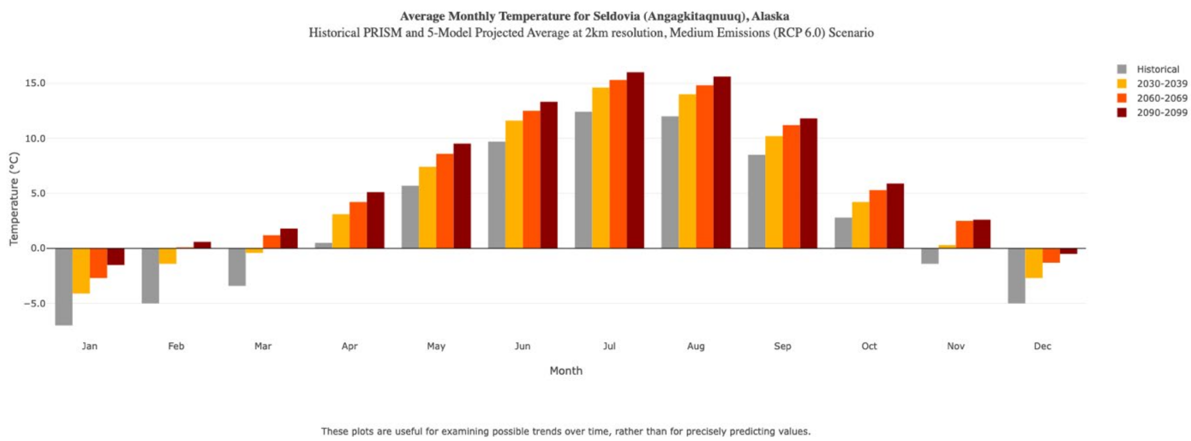

Figure 4. Average Monthly Temperature Projection: Port Graham, Alaska. .

# Average Monthly Temperature Projection: Seldovia, Alaska

## Low Emission Scenario




## Medium Emission Scenario




## High Emission Scenario

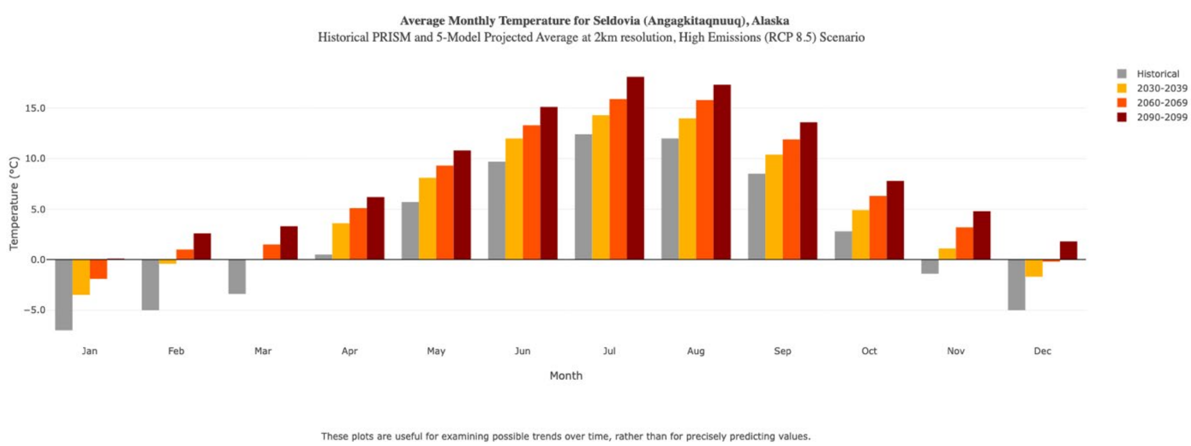



Figure 5. Average Monthly Temperature Projection: Seldovia, Alaska. .

## Precipitation

A primary threat to the Watershed is warming freshwater habitat. In the summer of 2019, for example, some areas of Southcentral Alaska had less than two inches of rain between June 1 and September, which qualified the region for an “extreme drought” for much of the summer.

Alaska’s water year typically starts in the fall when it’s time to start recording snowpack accumulation. However, the state’s snowpack—which has been reduced by 50 percent in the southern regions compared to a decade ago—currently develops about a week later in the fall and melts almost two weeks earlier in the spring. Because the village communities on the south side of Kachemak Bay rely almost entirely on rivers and streams for their drinking water supply, both Port Graham and Nanwalek were severely impacted by the 2019 drought when satellite images showed that the snowpack in the Kenai Mountain Range had disappeared which was the first time in recording history. As a result, one of the tributaries - Jakolof Creek, which contains a fall run of Coho and Pink Salmon, rain completing dry in late August of that year for the second time in four years causing a die-off of thousands of returning salmon. Similarly, during the summers of 2019 and 2020, the community water supply in the village of Nanwalek was impacted by drought in Southcentral Alaska requiring the village to have water flown in for sixty households. Figures 6 and 7 show the accumulation of precipitation in both Port Graham (Figure 6) and Nanwalek (Figure 7).

*Precipitation Accumulation at Port Graham, Alaska (Snotel Station #987)*

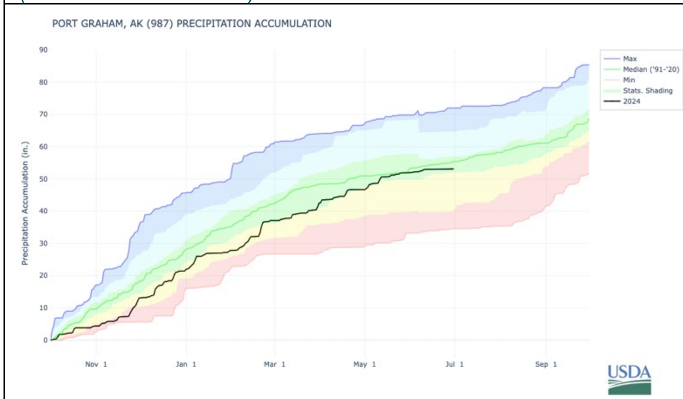



Figure 6 NRCS AWS plot of precipitation accumulation in Port Graham (Paluwik), Alaska.

*Precipitation Accumulation on the Kenai Peninsula*

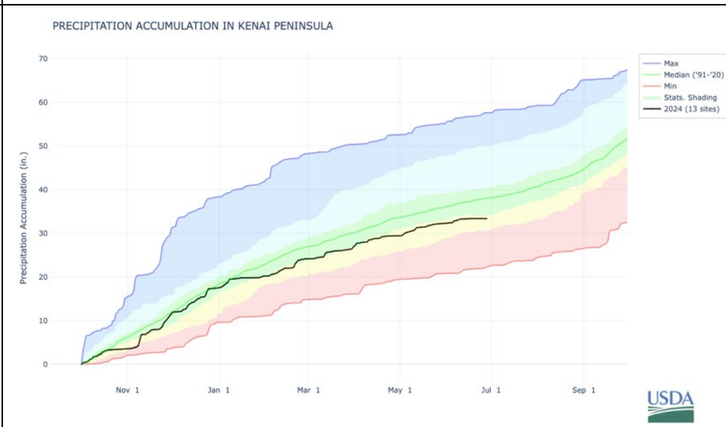


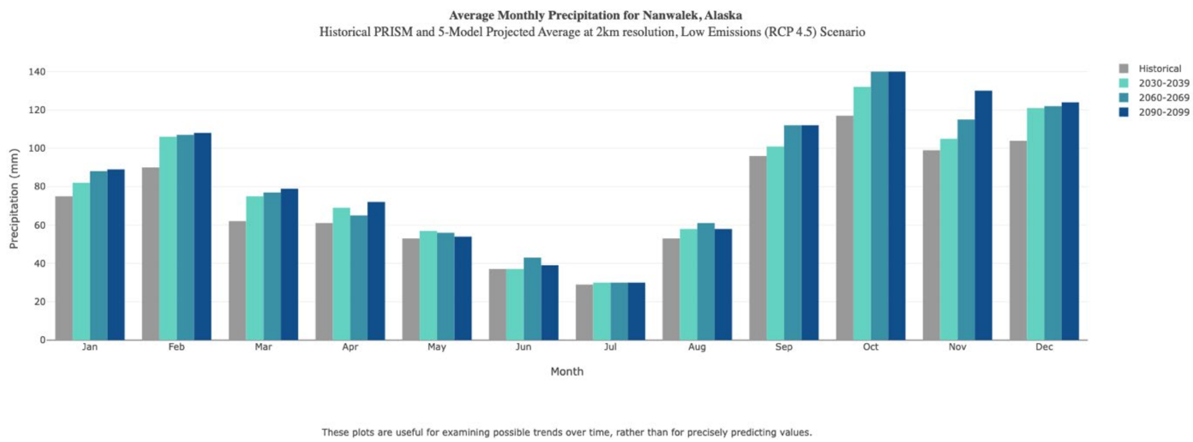

Figure 7 NRCS AWS plot of precipitation accumulation on the Kenai Peninsula.

### *Future Precipitation Projections*

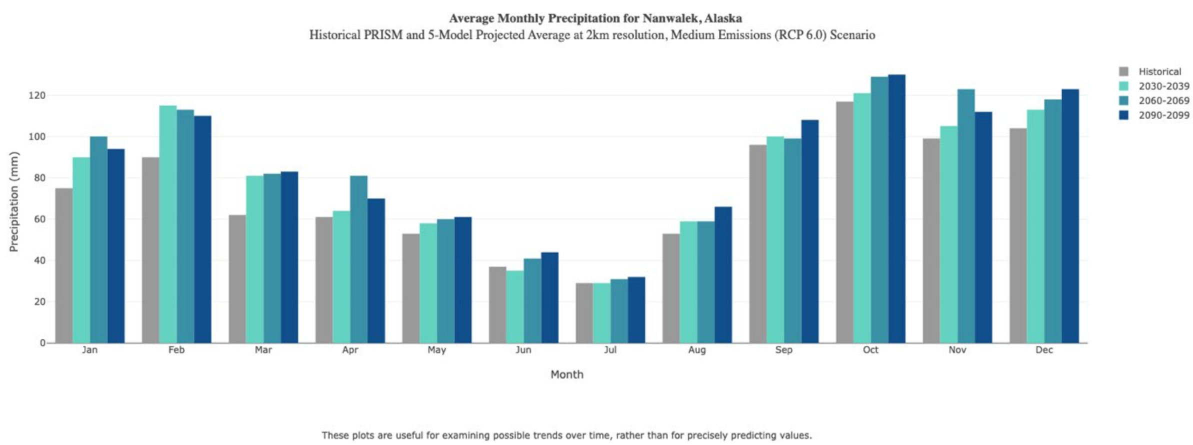
Future precipitation projections for each community are on the following pages.

## Average Monthly Precipitation Projection: Nanwalek, Alaska

### Low Emission Scenario




### Medium Emission Scenario




### High Emission Scenario

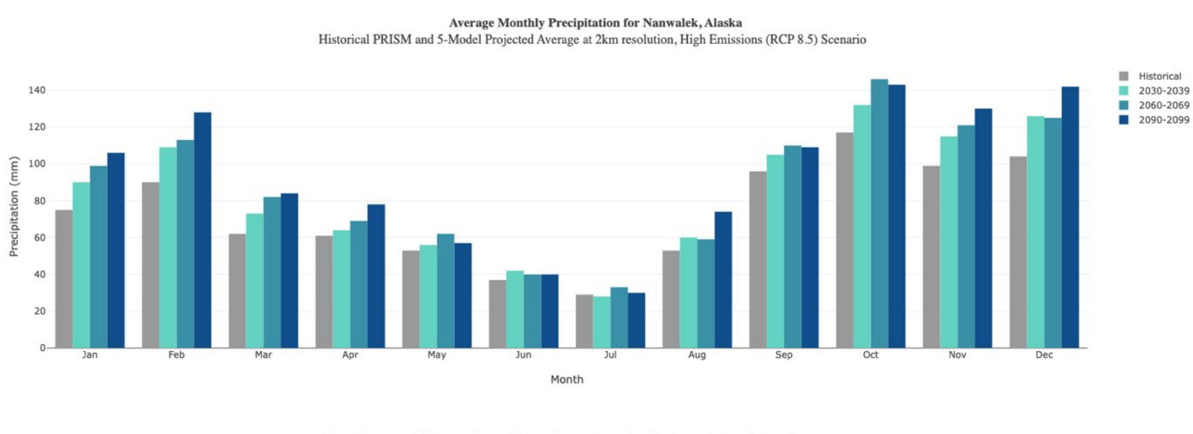
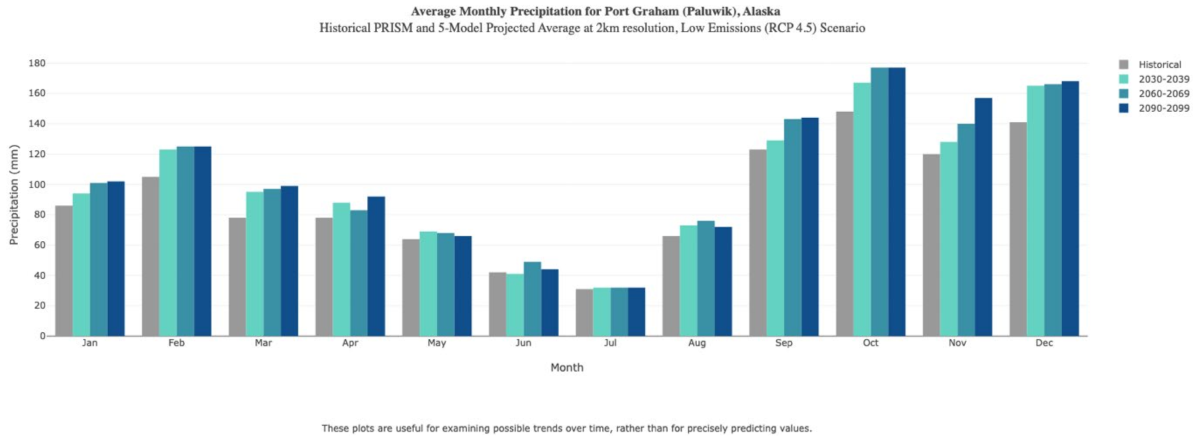


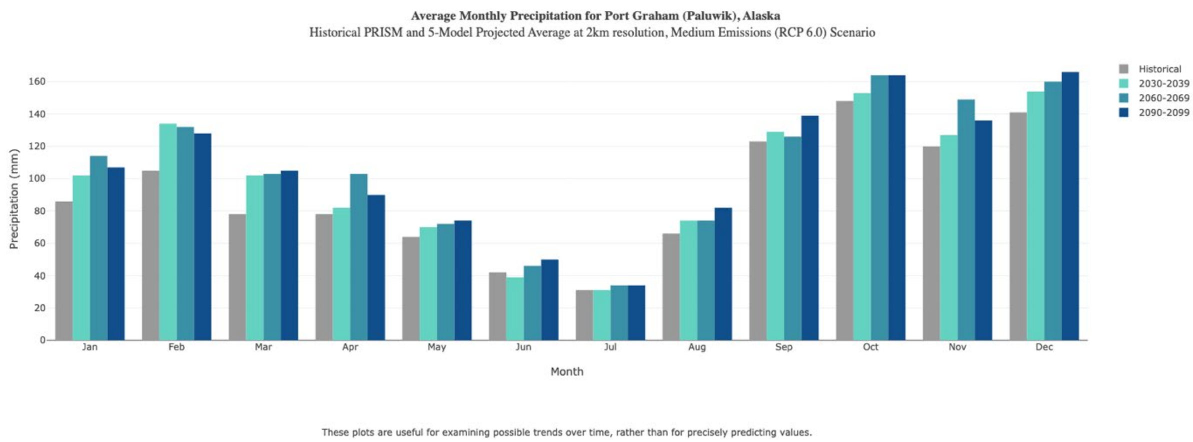

Figure 8. Average Monthly Precipitation Projection: Nanwalek, Alaska .

# Average Monthly Precipitation Projection: Port Graham, Alaska

## Low Emission Scenario




## Medium Emission Scenario




## High Emission Scenario

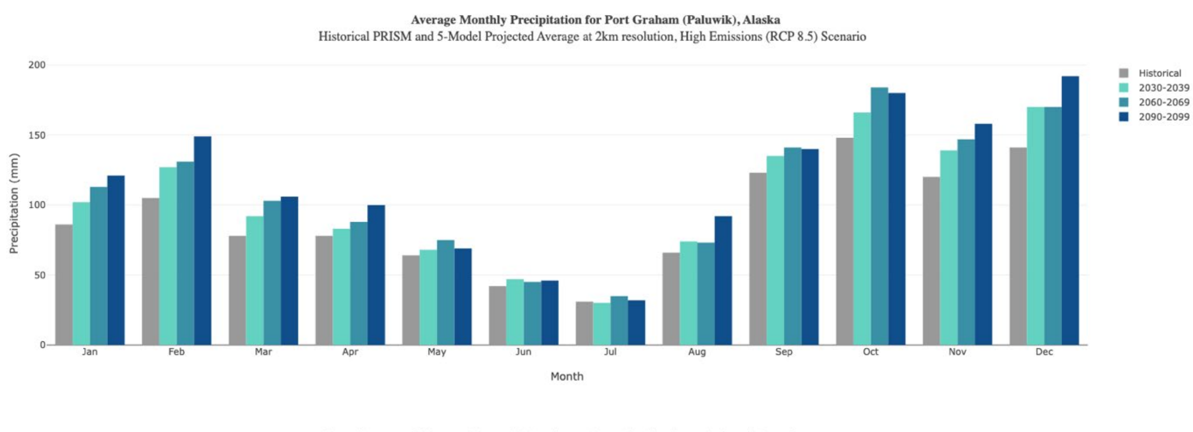
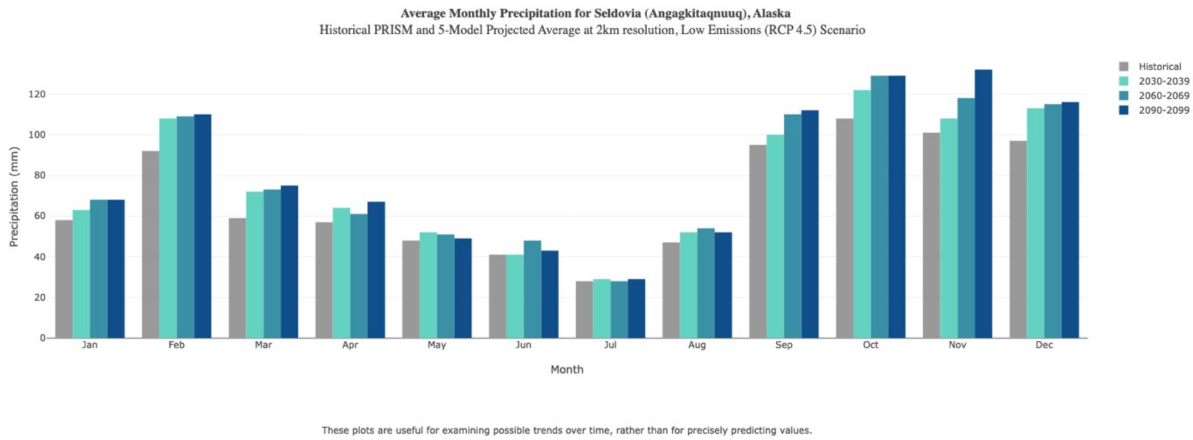


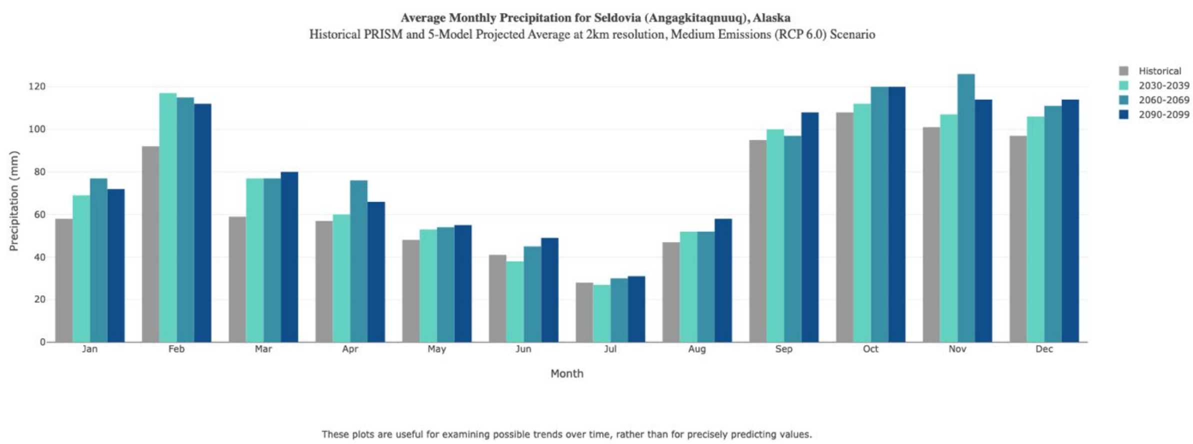

Figure 9. Average Monthly Precipitation Projection: Port Graham, Alaska .

# Average Monthly Precipitation Projection: Seldovia, Alaska

## Low Emission Scenario




## Medium Emission Scenario




## High Emission Scenario

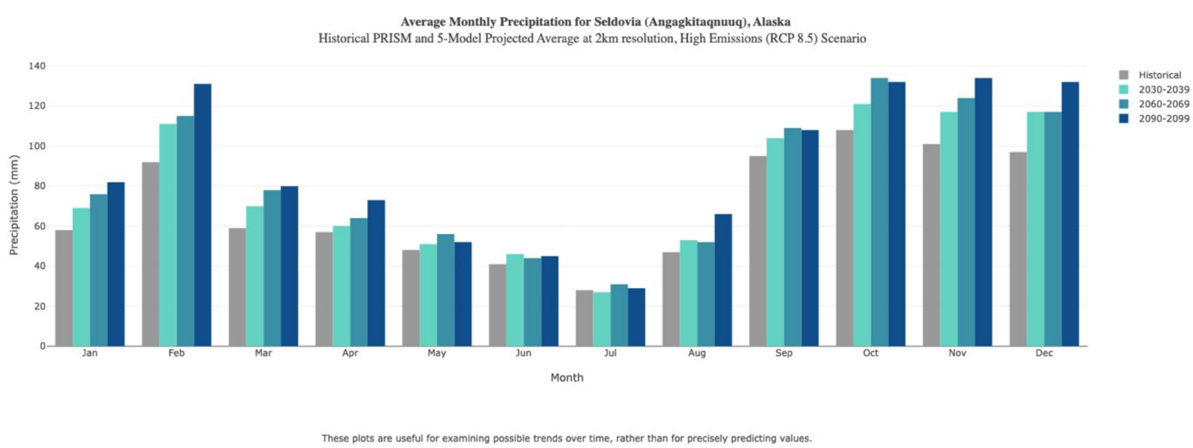



Figure 10. Average Monthly Precipitation Projection: Seldovia, Alaska .

## WATER QUALITY

### South Kachemak Contaminated Sites

There are three active contaminated sites in the south Kachemak Bay planning region shown in Figure 11 and Table 2. The Hopkins Construction Company Site was added to the ADEC contaminated sites in 1994. During the excavation of a culvert, petroleum was encountered in the groundwater. It is surmised that the contamination was released in 1974 during a Housing and Urban Development (HUD) project. The concentration of petroleum hydrocarbons at this site is not listed.

The Seldovia Tank Farm contaminate site was added to the ADEC database in 2009. Diesel contamination was found on-site during utility excavation. DRO are present on-site at a concentration of 7,900 mg/kg, GRO at 1,110 mg/kg, and benzene at 3.39 mg/kg. A transfer of ownership occurred in 2011.

The diesel spill at the village dock tank farm was added to the ADEC contaminated sites database in 1993. There are at least three known sources of diesel fuel leaks from the farm and its auxiliary piping. Chloroform is present at this site in low concentrations (0.01 mg/kg). Napthalene is also present on-site at concentrations of 0.09 mg/kg. The site characterization workplan for this site was approved in 2023, and the report was approved in March of 2024.

| Site Name | Hazard ID | File Number | Status | Contaminant | Concentration | Units |
|---|---|---|---|---|---|---|
| Hopkins Construction Company | 1824 | 2331.38.004 | Active | Petroleum | | unknown |
| Port Graham Village Corp. Diesel Sp | 1278 | 2327.38.002 | Active | Chloroform | 0.01 | mg/kg |
| Port Graham Village Corp. Diesel Sp | 1278 | 2327.38.002 | Active | DRO | 4960 | mg/kg |
| Port Graham Village Corp. Diesel Sp | 1278 | 2327.38.002 | Active | Napthalene | 0.09 | mg/kg |
| Seldovia Tank Farm | 25357 | 2331.38.007 | Active | Benzene | 3.39 | mg/kg |
| Seldovia Tank Farm | 25357 | 2331.38.007 | Active | DRO | 7900 | mg/kg |
| Seldovia Tank Farm | 25357 | 2331.38.007 | Active | GRO | 1110 | mg/kg |

Table 2. South Kachemak Bay ADEC-Registered Contaminated Sites.

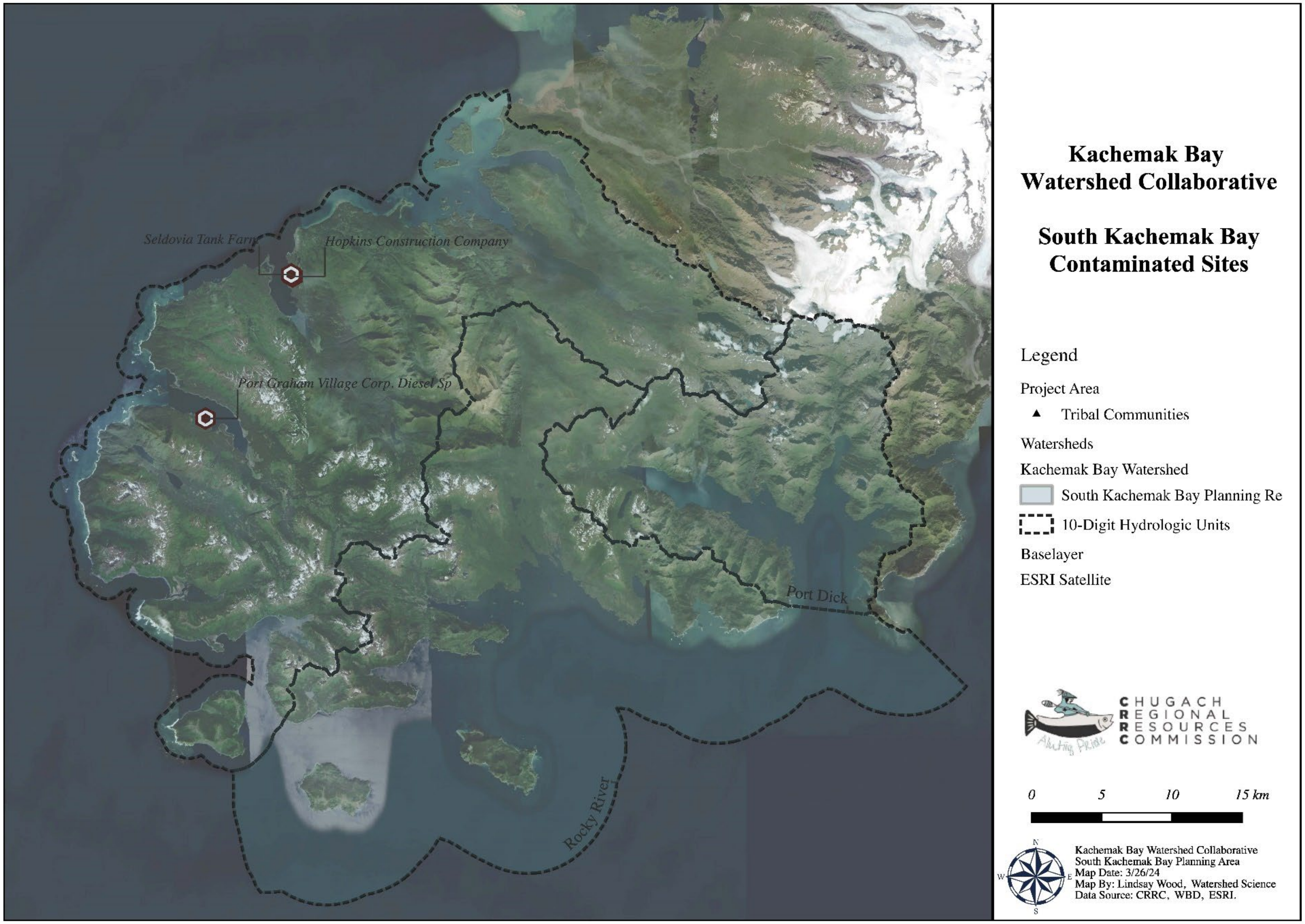



Figure 11. South Kachemak ADEC-Registered Contaminated Sites.

## FOREST HEALTH

Global forest loss was calculated using Hansen et. al (2017) global dataset and is visually presented in Figure 12 (units in square meters). The global dataset was clipped to the Kachemak Bay Watershed and processed to delineate areas of loss and gain within the watershed. Being at a 30x30 scale, satellite imagery does not detect small-scale nuance.

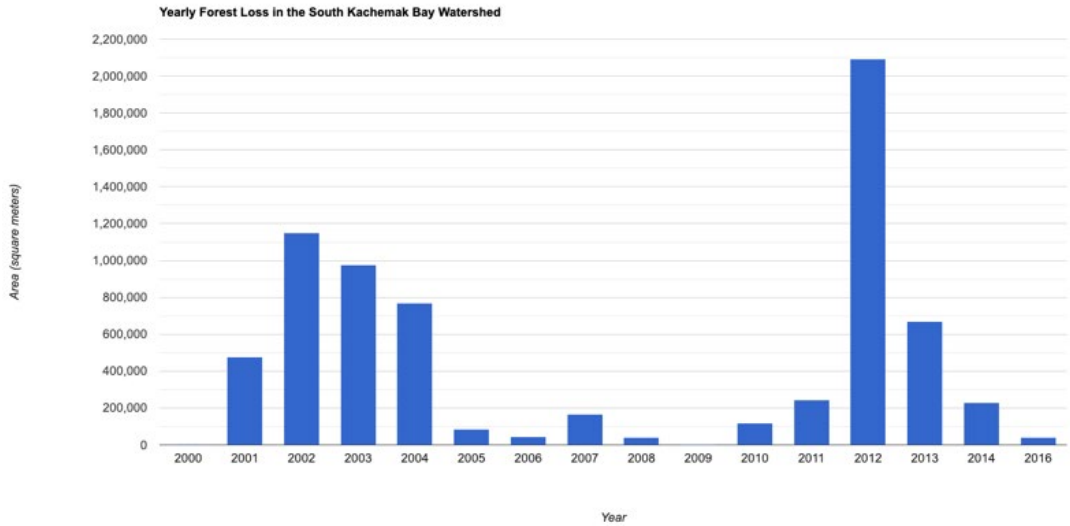



Figure 12 Annual Forest loss in the south Kachemak Bay planning region.

A global satellite dataset of forest loss, modeled from 2000-2016 shows significant loss across the catchment. Forest loss appears to be on a roughly five-year cycle over the study period with increased losses from 2001 – 2005, followed by minimal losses from 2006 – 2010, and a reduction of losses beginning again in 2014.

There is forest loss on the north facing tribal lands in Seldovia (Angagkitaqnuuq) (Figure 13) uphill from the lagoon. Forest gain on north facing lopes south or port graham and throughout the drainage basin. There are some minor losses north of Nanwalek (Figure 14), but they are minim al on the east side of the Peninsula, there is significant forest gain in the drainage leading to Windy Bay, with some minor losses in North Chugach Bay (Figure 15).

A geospatial analysis of forest change data from Hansen et al was conducted using Google Earth Engine. In this analysis, forest coverage is green, forest loss is depicted in red, while forest gain is in blue.

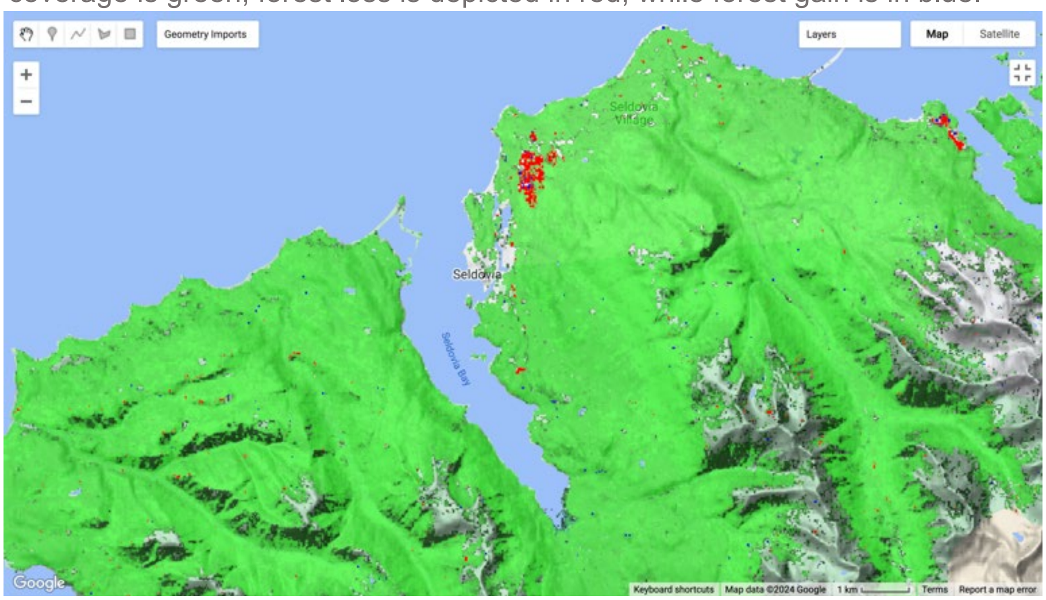



Figure 13. Forest gain and loss in the Seldovia area.

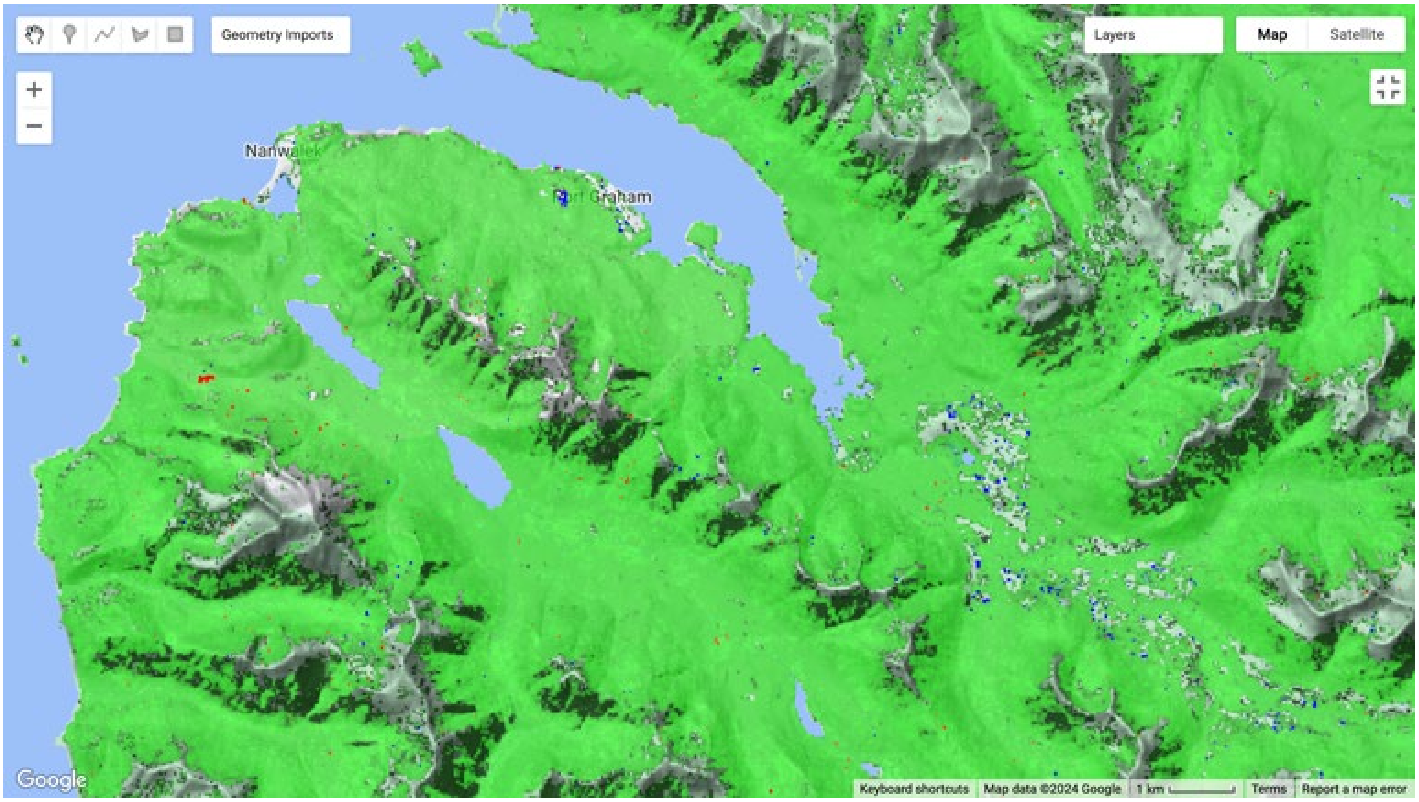


Figure 14. Forest gain and loss in the Paluwik (Port Graham) and Nanwalek area.

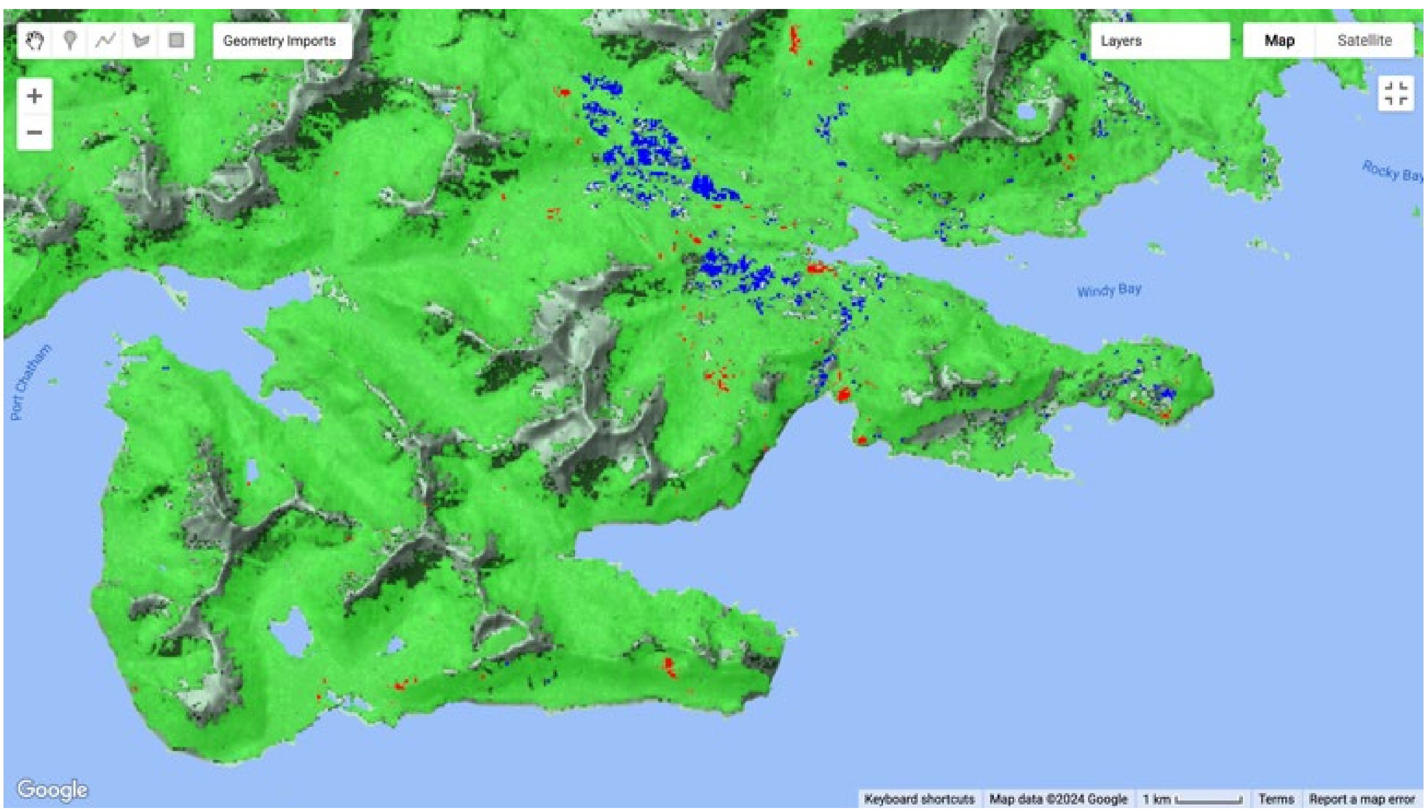


Figure 15. Forest gain and loss in the Rocky River region.

## Forest Loss due to Insect Damage and Disease

Kachemak forests face several ecological challenges, including insect infestation. According to the Alaska Department of Natural Resources (ADNR), Spruce Bark Beetle. (*Dendroctonus rufipennis*) spruce bark beetles have historically impacted forests in the region, leading to widespread tree mortality in susceptible stands. These beetles have a complex life history that requires bark of mature spruce trees for egg deposition. Upon hatching, the larvae feed on the inner bark, creating galleries that disrupt the tree's ability to transport nutrients and water, ultimately leading to tree mortality. The Spruce beetle primarily targets mature spruce trees, The Alaska Division of Forestry (ADOF) monitors insect infestation and publishes the results to the State of Alaska Geoportal (ADOF, 2020). Figure 16 shows the likelihood of spruce bark beetle infestation in Alaska. An analysis of the most recent survey completed in 2020 finds that insect damage and disease primarily impact the south Kachemak Bay planning region. A total of 15.5 square kilometers (3,822.5 acres) of spruce forest have been impacted by Spruce Bark Beetle in this region (Figure 17; Table 3). In south Kachemak forests, there are a total of 18 stands with intensive mortality, with an average area of 212.4 acres.

Infestations of spruce bark beetles have led to widespread tree mortality, impacting forest health and ecosystem dynamics. According to ADOF these infestations pose a serious threat to the spruce-dominated forests of the region, affecting not only the ecological balance and local economies dependent intertwined with the natural community.

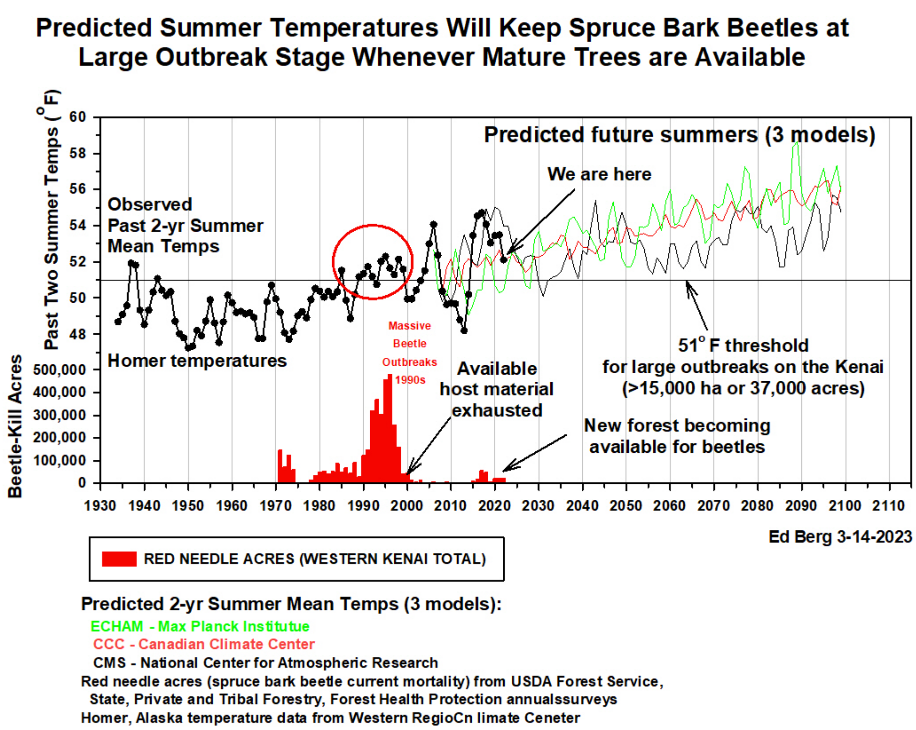


Figure 16. Predicted Summer Temperatures and Spruce Bark Beetle Infestation Likelihood.

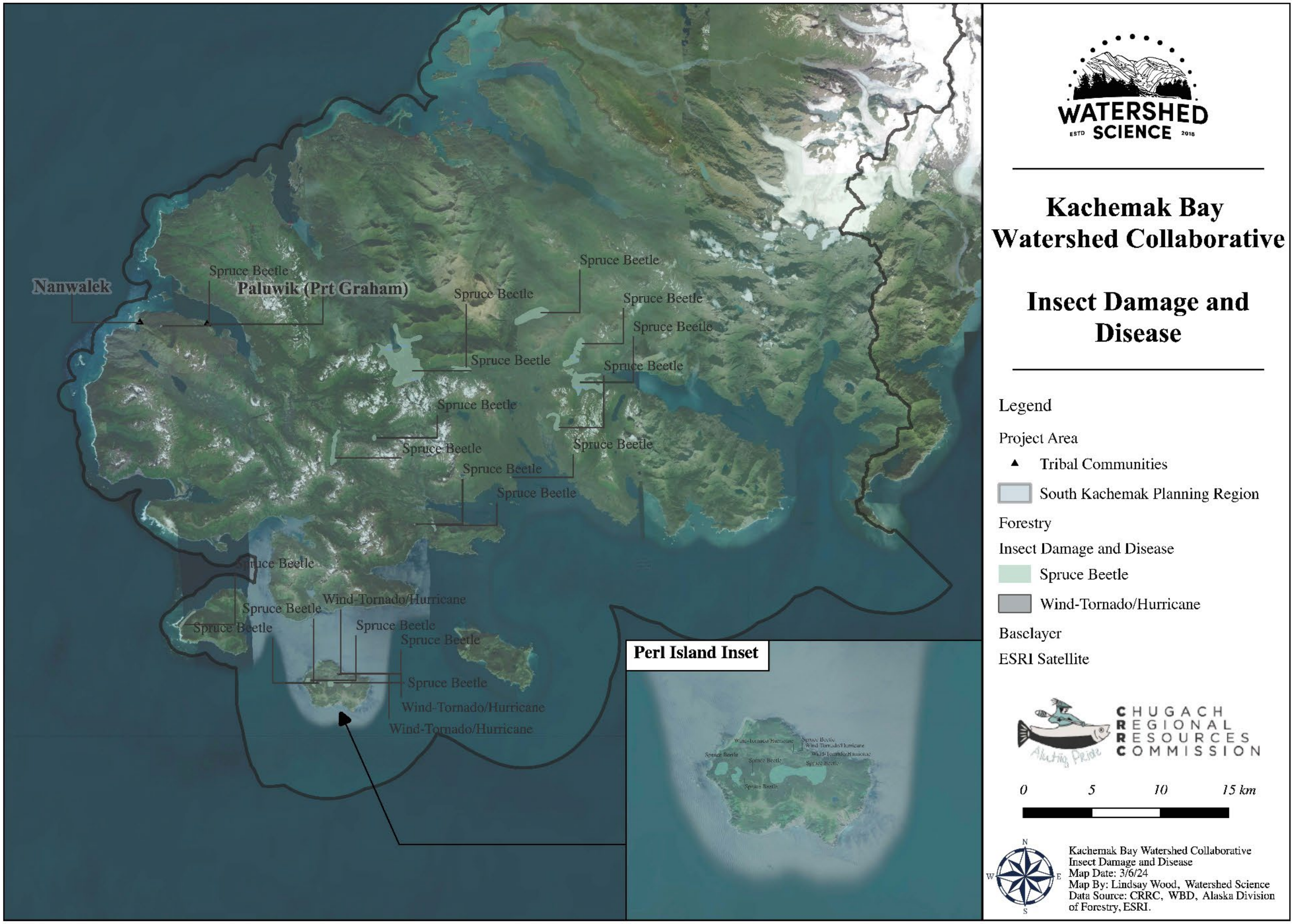



Figure 17. Insect Damage and Disease in the South Kachemak Watershed Planning Area.

| Damage Agent | Host Species | Damage Type | Intensity | Damage Area (acres) |
|---|---|---|---|---|
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 1.6 |
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 2.13 |
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 2.16 |
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 2.41 |
| Spruce Beetle | Sitka spruce | Mortality | 11-29 | 2.82 |
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 24.82 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 26.66 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 30.96 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 36.58 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 61.99 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 118.76 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 143.57 |
| Spruce Beetle | Sitka spruce | Mortality | 4-10 | 160.1 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 192.45 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 306.94 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 390.84 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 626.09 |
| Spruce Beetle | Sitka spruce | Mortality | 1-3 | 1691.59 |
| Wind-Tornado/Hurricane | All tree species | Mortality | 30-50 | 1.41 |

Table 3. South Kachemak Watershed Planning Area Insect Damage and Disease.

### Forest Loss due to Fire

The fire regime in the Kachemak Bay watershed is largely dependent on the hydrography of the region. Fire history for the watershed was assessed using MODIS infrared satellite imagery and the FireCCI51 dataset on Google Earth Engine. The analysis was run from 2000 to present, and no wildfires were recorded in the watershed. Existing wildfire protection plans include collaborative efforts between local communities, fire departments, and state agencies. These plans prioritize early detection, rapid response, and community resilience to wildfires. Through prescribed burns, fuel reduction, and community education initiatives, stakeholders aim to enhance forest resilience to fire events. However, ongoing monitoring and adaptive management remain crucial for sustaining forest health in the face of evolving environmental challenges.

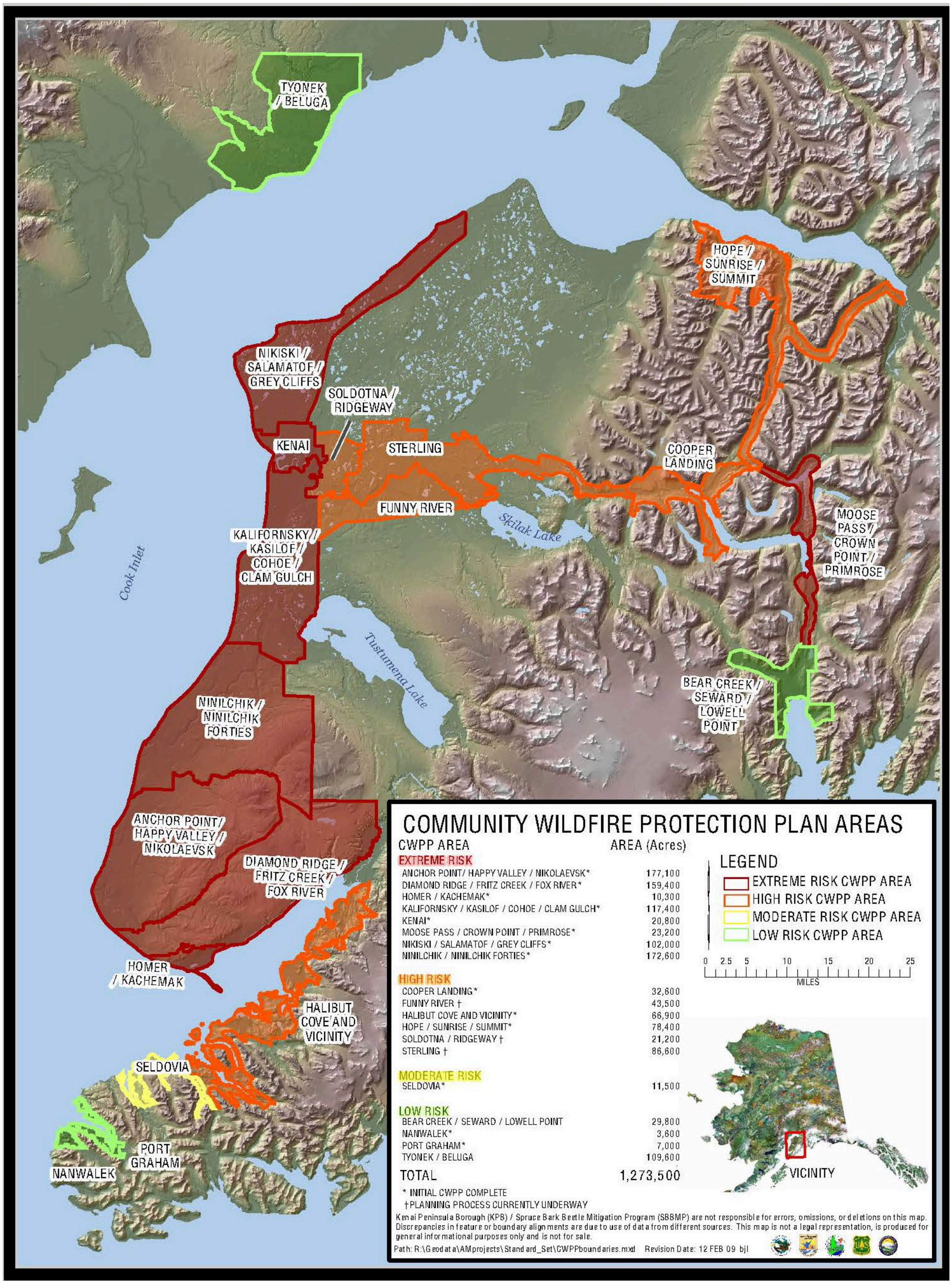



Figure 18. Community Wildfire Protection Plan Areas.

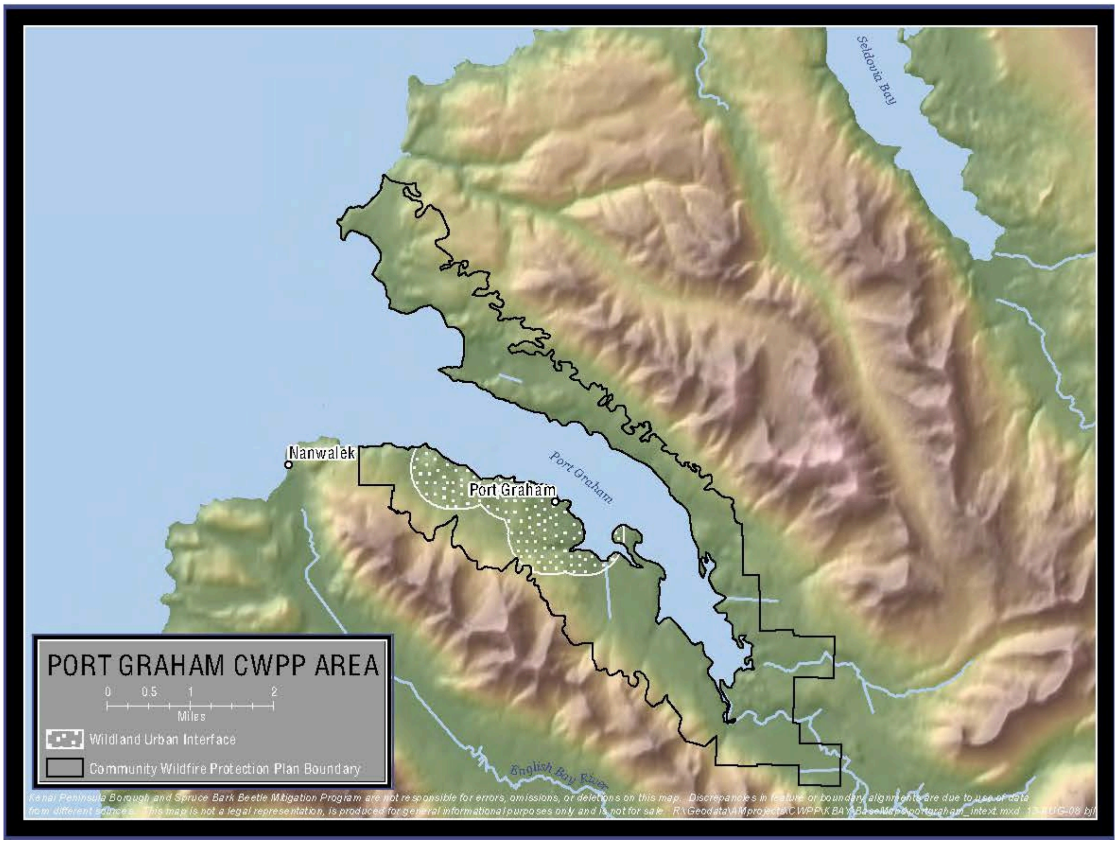



Figure 19. Port Graham Community Wildfire Protection Plan Area.

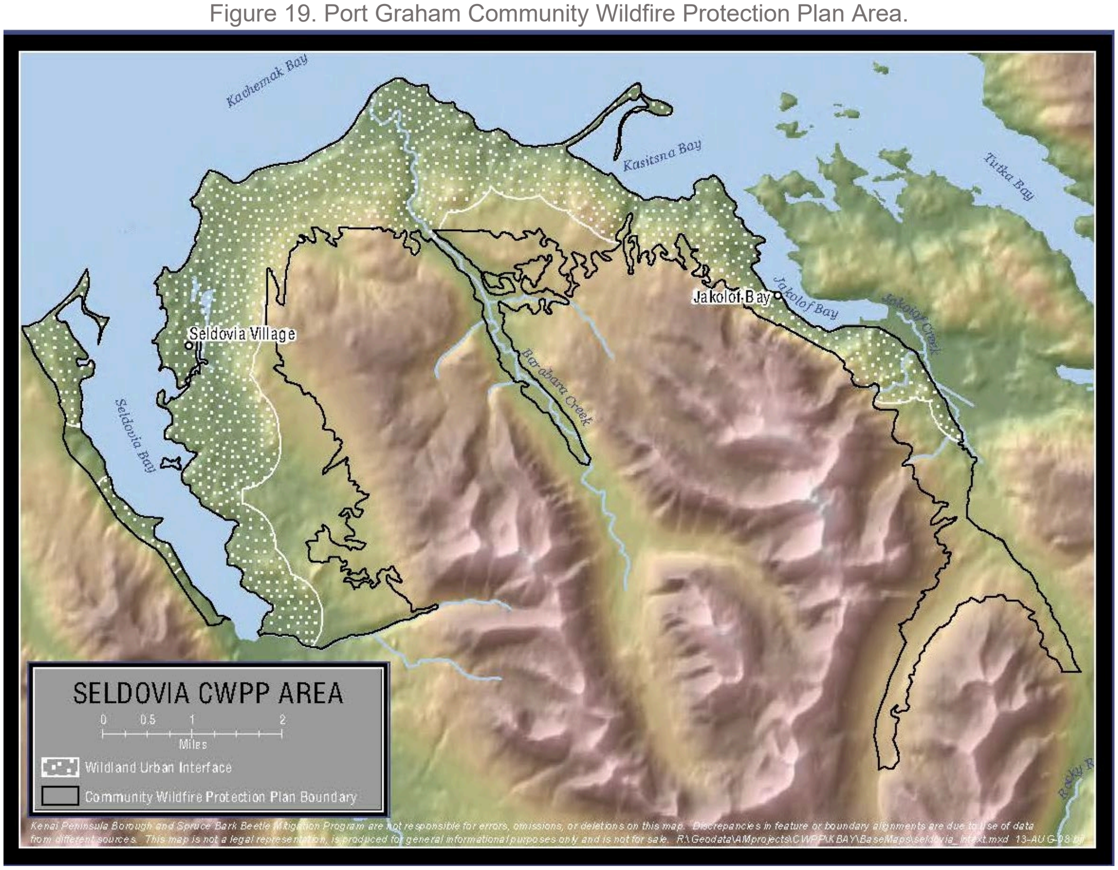



Figure 20. Seldovia Community Wildfire Protection Plan Area.

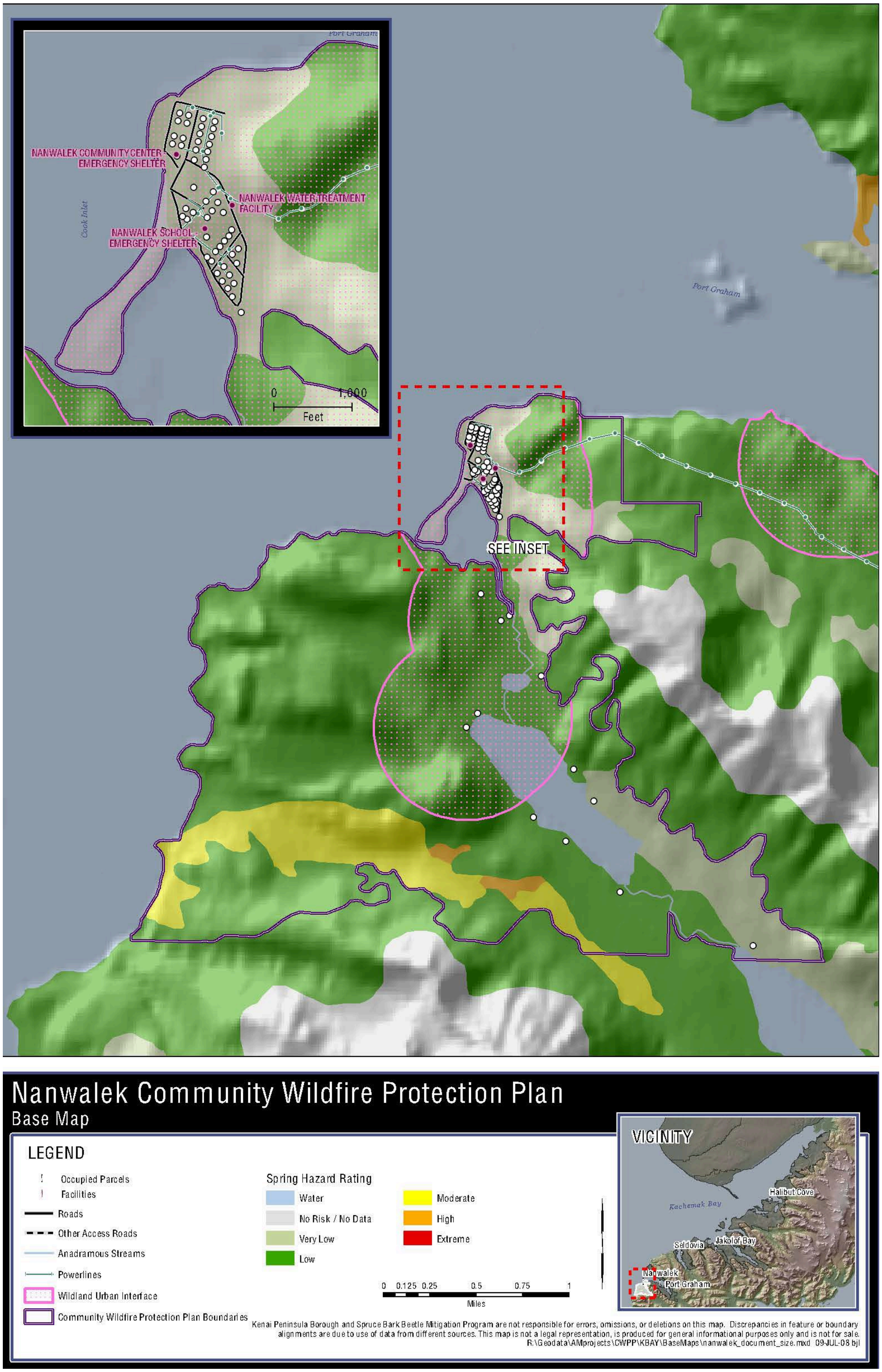


Figure 21. Nanwalek Community Wildfire Protection Plan Area.

## SOUTH KACHEMAK WATERSHED CRITICAL WATERSHED NEEDS

The SKWRP summarizes programmatic elements of environmental monitoring and recommends project-based activities to further protection of ecologically and culturally significant resources in the region.

### ENVIRONMENTAL MONITORING

Environmental Monitoring is a critical long-term programmatic approach to watershed management. Environmental Monitoring is implemented by the Community Catalyst Program in the field. Environmental parameters which should be monitored over the long-term to include climate, ecological, hydrographic, and water quality over time. Quantifying the water quality and soil impacts at known contaminated sites before and after remediation allows managers to accurately assess the efficacy of treatments implemented. Ongoing measurement of climate data at each community can be normalized with existing data to make retrodictions about past climatic conditions in the absence of data and predict future climatic conditions locally. Below is a list of climatic, ecological, hydrologic, and water quality parameters needed to implement a complete environmental monitoring program (Table 4).

| Kachemak Bay Watershed Collaborative Plan Environmental Monitoring Parameters | | |
|---|---|---|
| Climate | Measure | Monitoring Instrument |
| | Temperature (C) | Weather Station |
| | Precipitation (mm) | **Recommendation**: Davis Vantage Pro2 Plus Weather Station |
| | Relative Humidity (%) | |
| | Wind Speed (km/h) | |
| Ecological | | |
| | Habitat Structure | Field Surveys |
| | Vegetation Composition | |
| | Wildlife Populations | |
| Hydrology | | |
| | Lake elevation (m) | Staff Gage or Water Level Sensor |
| | Groundwater Elevation (m) | Leveloggers |
| | Soil Infiltration (mm/h) | **Recommendation**: Solinst Levelogger Edge with Baro Merge Functionality |
| Water Quality | | |
| | Streamflow (m/s) | Flowmeter |
| | Water Temperature (C) | **Recommendation**: EXO2 Multiparameter Sonde |
| | pH | |
| | Turbidity | |
| | Dissolved Oxygen | |
| | Conductivity | |
| | Nutrient Load | |

Table 4 South Kachemak Watershed Restoration Plan environmental monitoring parameters.

Establishing baseline conditions is the first step in developing an Environmental Monitoring program. Once baseline conditions have been shared with the community, they can proceed in defining water quality standards and environmental monitoring priorities. Following prioritization, CRRC will pursue funding to install a network of environmental monitoring instrumentation to increase access to climate, hydrologic, and water quality data. Installation of water quality monitoring sites in strategic locations will enhance safety and potability of community water resources, while also filling major data gaps, which limit modeling capability.

## Data Gaps

### *LiDAR Data*

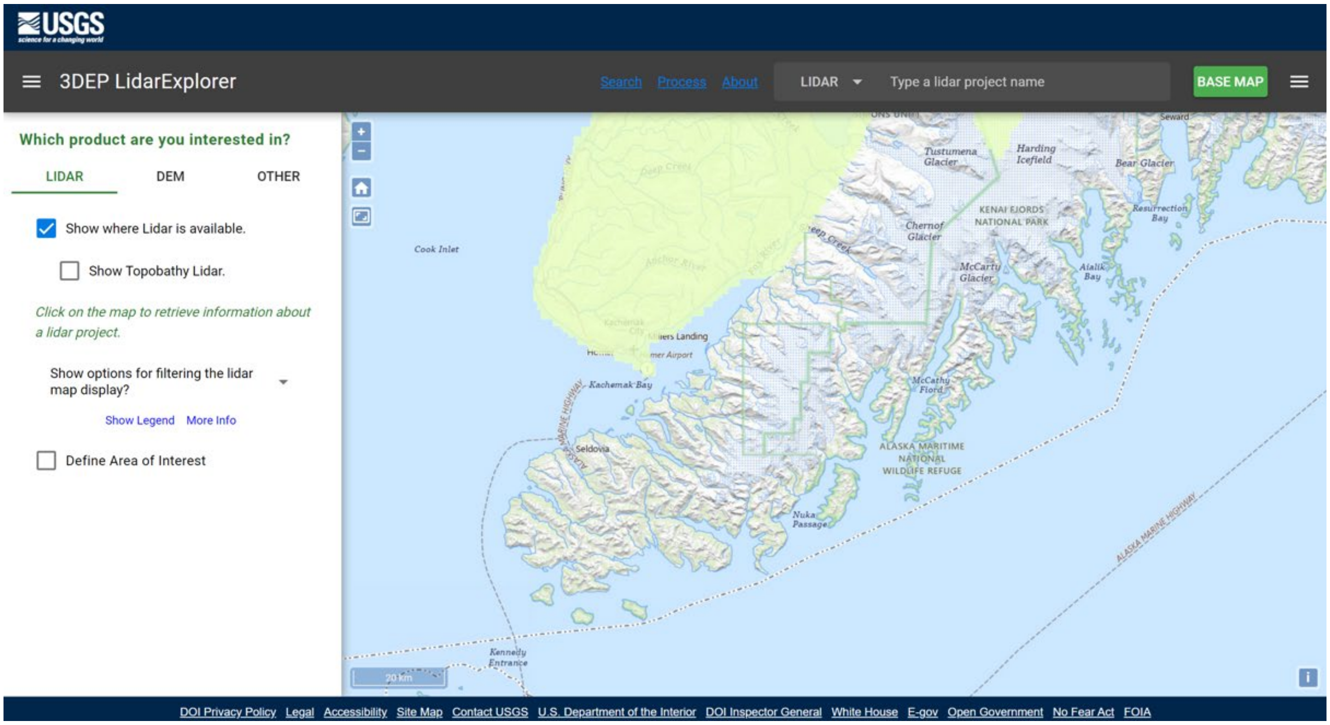


Figure 22 The south Kachemak planning region lacks LIDAR data entirely.

### *Terrestrial Bathymetric Data*

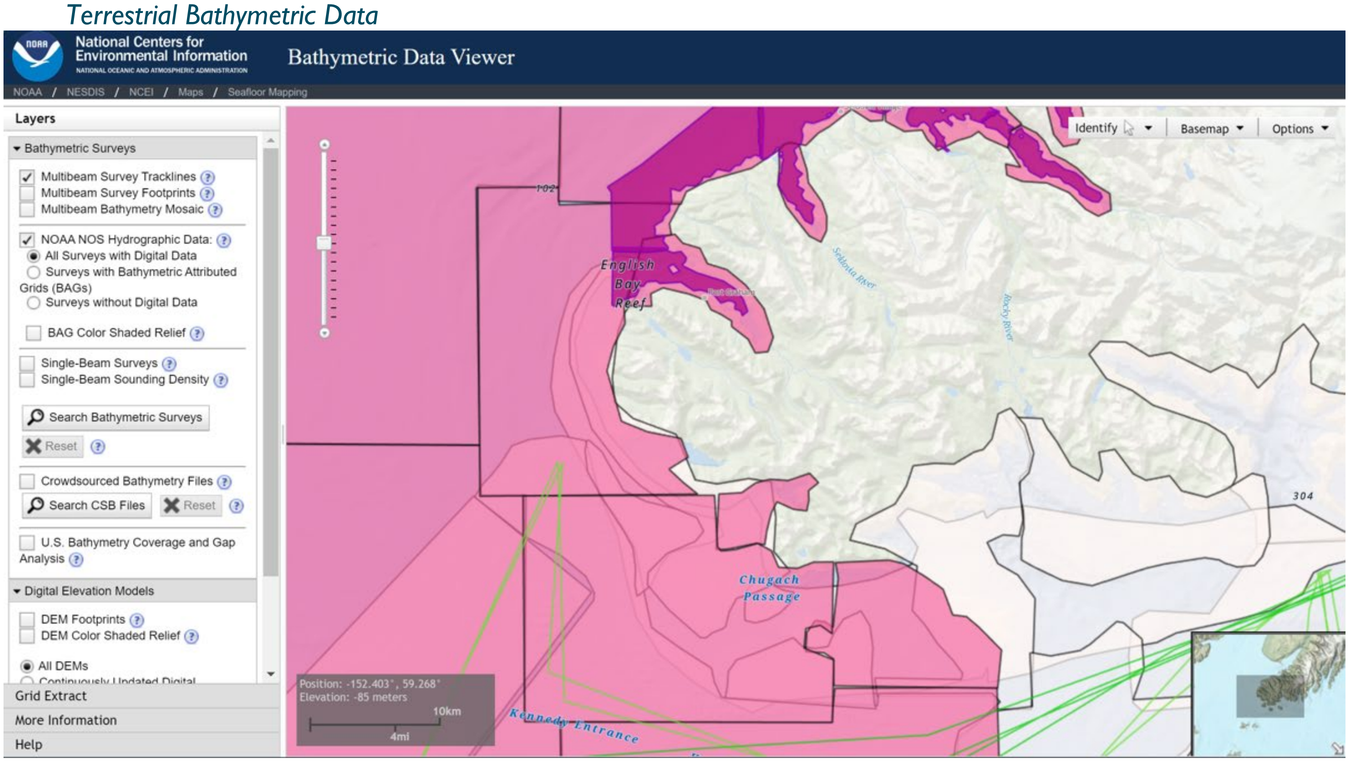


Figure 23 South Kachemak watersheds lack bathymetric data for freshwater resources.

## COMMUNITY CATALYST PROGRAM

The Community Catalyst Program is the field component of the Environmental Monitoring Program, responsible for implementation, regularly assessing of aquatic ecosystems, monitoring biodiversity with an emphasis on subsistence resources, and tracking changes in indicators of environmental health. Through ongoing data collection, Community Catalysts proactively protect their tribal lands, adaptively managing as issues arise. Following the development of the Environmental Monitoring Plan, a Work Plan for the Community Catalyst Program will be developed which integrates monitoring with projects to preserve indigenous traditions, stories, and practices, contributing to cultural revival and enhancing the deep connection between communities and their country. The Community Catalyst Program work plan will provide a clear vision and guidance implementation, outlining the objectives, tasks, and timelines for the program's activities, ensuring a loosely structured approach to environmental and cultural conservation.

Professional training and capacity building will enhance the skillset of Community Catalysts while providing a foundation of knowledge to effectively manage and protect tribal lands. Once Community Catalysts feel prepared, they will begin to lead the workshops for the local community, encouraging active participation in conservation and stewardship of tribal lands.

### Old Growth Carbon Credit Program

The Old Growth Carbon Credit Program is an ongoing effort of the Port Graham Corporation. The existing project protects old growth forests on tribal lands, while also offering credits on the carbon market. This effort can be amplified across the watershed to preserve important stands of old growth forest in perpetuity.

### Energy Supply Reliability

The electrical systems in Nanwalek and Port Graham, both operated by the Homer Electric Association (HEA), primarily rely on hydropower generated from the Bradley Lake Dam. This renewable energy source plays a crucial role in providing electricity to these remote native villages on Alaska's Kenai Peninsula. The electrical systems in both communities are essential for powering homes, schools, businesses, and other vital infrastructure. However, due to their remote locations and reliance on hydropower, the electrical systems may face challenges related to maintenance, reliability, and resilience, particularly in the face of extreme weather events or natural disasters.

### South Kachemak Energy Storage Project

The most critical element of energy security for these remote communities is the establishment of a battery bank to store power in the event of an outage. Inverter selection is a critical design element for remote villages. It is ideal to select a model that allows input from multiple types of power generation systems, including generators as a back-up. A number of established companies build shipping containers with a complete system of batteries and inverters wired and ready to pair with energy generating systems. This type of system can be connected to Homer Electric Authority’s existing grid, as a failsafe measure to ensure reliable energy distribution, even in the event of an outage.

### South Kachemak Renewable Energy Security Project

The South Kachemak Energy Security Project is a phased project involving the development of renewable energy systems like micro-hydropower systems, solar panels, and wave energy generation for remote tribal communities. During the planning phase of this project, a number of renewable energy technologies will be assessed for feasibility and capacity to generate sufficient energy for the community. While both microhydro and solar have seasonal limitations, wave energy has the potential to be a year-round energy solution.

### *Micro-hydropower*

Microhydro systems offer a promising renewable energy solution for remote communities in the South Kachemak region. Topography plays a crucial role in determining the feasibility of microhydro development, as steep gradients are needed to provide the necessary hydraulic head for electricity generation. North-facing, steep slopes like those found near the townsite of Port Graham (Paluwik) create ideal hydrological conditions for microhydro systems. Depending on the selected design, microhydro projects require the construction of small dams or diversion structures, as well as integration with existing power systems to distribute electricity to the community. Materials for the selected design must resilient to fluctuations in precipitation, snowmelt, and stream flow and be able to withstand subarctic temperatures. Community needs and priorities should guide the development of microhydro projects, with an emphasis on culturally appropriate site selection and economically viable solutions. Regulatory compliance and permitting processes also play a crucial role in ensuring that microhydro development aligns with state and federal regulations.

### *Solar Panels*

The installation of solar panels is another path to energy security. Newer panels have wafer-based solar cells with an increased capacity to absorb solar radiation, especially under cloudy conditions. A wafer design is vital to maximizing solar energy generation during the winter when the photoperiod is reduced. It is critical to place solar panels on south-facing slopes with minimal canopy to maximize solar exposure, so several sites will need to be analyzed to determine the most suitable location. One installation in remote Alaska found that the increased canopy cover from solar panel installation created thriving cloudberry (*Rubus chamaemorus*) patches (Mulder, 2024).

### *Offshore Wave Energy Farm*

Finally, wave energy is another potential source of renewable energy for south Kachemak communities. Renewable wave energy presents an invaluable opportunity to harness an available energy source for sustainable, low-maintenance energy addressing the challenges posed by the long, dark winters of subarctic climates (Falnes, 2002). By tapping into the kinetic energy of ocean waves, this wave energy reduces dependence on traditional fossil fuels while supporting the resilience of remote communities by establishing a consistent, year-round energy supply.

## FOREST HEALTH

Maintaining understory vegetation the WUI (wildland-urban interface) is important for protecting remote tribal villages from wildfire. Proper management of the forest understory reduces fuel loading in the event of an ignition. Dead limbs that extend to the ground creates “ladder fuel,” providing a path for fire to expand to the forest canopy. The remote geography creates a unique vulnerability to fire, as community-level evacuation response is limited by resources in the community. Proactively managing the understory along forest edges can safeguard lives, homes, and essential infrastructure in the event of fire. The Nanwalek and Paluwik WUI projects address fuel buildup in the understory of the forest edge adjacent to the community.

To mitigate the impact of these infestations, various methods have been employed. These include forest management practices such as sanitation logging to remove infested trees, thinning to reduce tree stress and competition, and promoting the growth of less susceptible tree species. Additionally, proactive monitoring and early detection efforts can help identify and address beetle outbreaks before they become widespread.

Efforts to control Spruce beetle populations may also involve the application of insecticides to targeted areas, although this approach is often logistically challenging and may have limited effectiveness in large, forested areas. Integrated pest management strategies, which incorporate a combination of cultural, biological, and chemical control methods, offer a holistic approach to managing Spruce beetle infestations while minimizing environmental impacts.

Overall, addressing the threat of Spruce beetle infestations in the South Kachemak Bay planning region requires a coordinated and adaptive approach that considers the ecological dynamics of forest ecosystems, the socio-economic implications for local communities, and the broader environmental context.

## INFRASTRUCTURE DEVELOPMENT

Ensuring water supply reliability, energy security, and modernizing electrical infrastructure are paramount for remote native villages in Alaska. These communities face unique challenges due to their isolation, harsh environmental conditions, and dependence on limited resources. Access to clean and reliable water is essential for health, sanitation, and overall well-being, while energy security and modernized electrical infrastructure are critical for powering homes, schools, healthcare facilities, and economic activities. Addressing these needs not only improves the quality of life for residents but also strengthens community resilience and sustainability in the face of changing climate patterns and environmental pressures.

## WATER SUPPLY RELIABILITY

The concern of people in Nanwalek village, as presented in the article, revolves around the severe drought leading to water scarcity. Residents are facing significant challenges in conserving water, resorting to extreme measures such as eating off paper plates, collecting water from the ocean for toilet flushing, and washing with limited water supplies. The village has implemented water shutdowns for 12 hours every night, and a boil water notice has been issued by the state. The shortage has prompted some residents to incur significant expenses by traveling to nearby cities for access to water. The situation has raised fears and uncertainties among residents about the future sustainability of their community, with concerns about the availability of water for drinking, sanitation, and cultural practices deeply rooted in Sugpiaq traditions.

The Nanwalek Water Supply Reliability Project will augment the storage at the Nanwalek Water Plant, while modernizing diversion infrastructure to accommodate shifting precipitation patterns. To ensure community health, an upgraded water filter will be integrated into the system. The community may also consider the possibility of drilling a well to diversify the source of the community's water. As surface water becomes scarcer over time, drilling a well is a proactive way to provide reliable drinking water to the community.

## WATER QUALITY MONITORING

### Integrated Water Quality and Climate Monitoring Network

Access to water quality data to enhance the safety and potability of community water resources should be prioritized. By establishing monitoring sites in strategic locations throughout each basin, the water quality impact of existing contaminants can be quantified, and managers will be able to identify the need for treatment in real time. This will protect community members from potential health hazards while contributing to the overall health and gradually improving the water quality of wetlands in the region over time. A network of gages, flowmeters, weather stations, and water quality monitoring states will be established to measure flow rates, water chemistry, and localized climate conditions. Installing this infrastructure will create a continuous data stream for parameters like pH, dissolved oxygen, conductivity, and nutrients. This information will guide manager decision-making, allowing for quick detection of any water quality anomalies.

### Port Graham Bioremediation Project

In-situ phytoremediation offers a sustainable approach for remediating diesel oil spills, such as the one present on Port Graham Tribal Village lands (Figure 24). This remediation treatment can be implemented without construction of wetlands, by leveraging plants' natural abilities to absorb and metabolize contaminants. One effective method involves planting species known for their high uptake and degradation capabilities of hydrocarbons present in diesel oil. Species such as willows (salix spp.) and *Populus* spp. have demonstrated significant potential for diesel oil remediation due to their ability to absorb, metabolize, and break down hydrocarbons through rhizosphere processes and microbial interactions (Starsman, J., 2016). By establishing these plant species in the affected area, their root systems facilitate the breakdown of diesel oil contaminants in the vadose zone of the soil, effectively reducing their concentration over time through natural means. Monitoring the contaminant levels in the soil and plant health on-site annually after treatment can assess the efficacy of the phytoremediation process and make any necessary adjustments to optimize its performance (Leewis, M. C., et al. 2013, 2023).

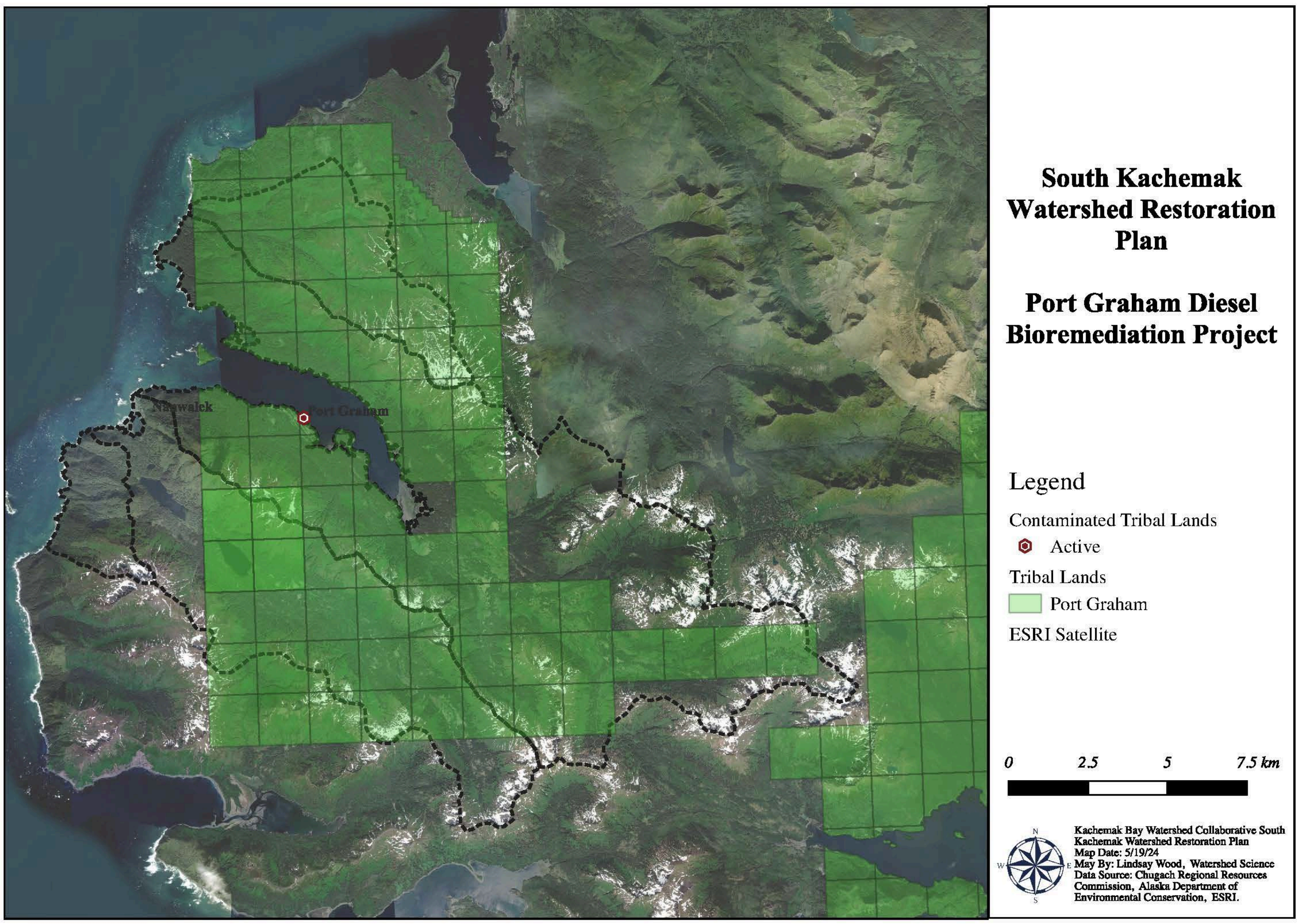



Figure 24. Port Graham Bioremediation Project.

### Other Treatments as Determined

The SKWRP is an adaptable framework designed to address watershed management issues. This plan takes an integrated approach to watershed management, offering communities the flexibility to select environmental monitoring parameters to monitor and prioritize projects based on their specific needs. The SKWRP outlines several key components, including the establishment of an environmental monitoring program to assess watershed health and changes over time, a Community Catalyst Program to implement environmental monitoring, and a number of projects to address issues facing both each community. It's important to emphasize that this program is a living document, subject to periodic updates and adjustments to accommodate evolving needs of each community. Furthermore, the framework allows for the integration of additional treatments and actions not explicitly detailed in the current document, reflecting a commitment to ongoing adaptation and improvement based on the unique needs of each region in response to a changing landscape.

## PROJECT IMPLEMENTATION

Beyond the programmatic elements of the SKWRP, a comprehensive suite of projects is recommended to protect the critical resources while strengthening resilience of Lower Cook Inlet Kachemak communities (Table 5). Suggested and ongoing projects addresses challenges unique to the region.

| South Kachemak Bay Watershed Restoration Plan Project List | | | |
|---|---|---|---|
| **Carbon Market Protection** | **Site Name** | **Proponent** | **Objective** |
| Old Growth Carbon Credit Program | Port Graham Village Lands | Port Graham Village | ongoing since (year) |
| | | | |
| **Energy Supply Reliability** | **Site Name** | **Proponent** | **Objective** |
| South Kachemak Energy Storage Project | Nanwalek + Port Graham | in partnership with HEA | Installation of a network of battery banks to ensure energy reliability throughout the winter. |
| South Kachemak Renewable Energy Project | Nanwalek + Port Graham | in partnership with ANTHC | Alternatives analysis for renewable energy: solar, wind, wave, bioreacto |
| Rocky Lake Off-grid Energy Project | Port Graham | Port Graham Village | Installation of renewable energy system to provide electricity at Rocky L |
| | | | |
| **Forest Health** | **Site Name** | **Proponent** | **Objective** |
| Nanwalek Vegetation Management Project | Nanwalek Wildland Urban Interface | CRRC | Vegetation management within the wildland urban interface. |
| Paluwik Vegetation Management Project | Paluwik Wildland Urban Interface | CRRC | Vegetation management within the wildland urban interface. |
| | | | |
| **Infrastructure Development** | **Site Name** | **Proponent** | **Objective** |
| Rocky Road Subsistence Access Project | Rocky Road | Port Graham Village | Reopening of 26 miles of road to Rocky Lake; including 29 bridges and 100+ culverts. |
| | | | |
| **Water Supply Reliability** | **Site Name** | **Proponent** | **Objective** |
| Nanwalek Water Supply Reliability Improvement Project | Nanwalek Water Plant | Nanwalek, CRRC, ANTHC | Modernize diversion infrastructure, augment storage, add filtration. |
| | | | |
| **Water Quality Monitoring** | **Site Name** | **Proponent** | **Objective** |
| Integrated Water Quality and Climate Monitoring Network | Nanwalek + Port Graham | Ranger Program | Daily Monitoring, Monthly and Annual Reporting |
| Port Graham Diesel Spill Remediation Project | Port Graham Village Lands | Port Graham Village | DRO - Diesel Range Organics |
| Integrated Watershed Monitoring | Regional | Ranger Program | Wildlife and vegetation monitoring; ongoing. |

Table 5 Project recommendations for the South Kachemak Watershed Restoration Plan.

## PROJECT TIMELINE

| Kachemak Bay Watershed Collaborative Plan Timeline | | | | | |
|---|---|---|---|---|---|
| Programmatic Component | 2024 | 2025 | 2026 | 2027 | 2028 |
| South Kachemak Watershed Restoration Plan | | | | | |
| Environmental Monitoring Plan | | | | | |
| Indigenous Ranger Work Plan | | | | | |
| | | | | | |
| Regulatory Components | | | | | |
| Nanwalek Wetland Mitigation Bank Pilot Project | | | | | |
| Old Growth Carbon Credit Program | | | | | |
| Marine Protection Area Designation Project | | | | | |
| RAMSAR Wetlands of International Importance | | | | | |
| | | | | | |
| Project Implementation | | | | | |
| Indigenous Ranger Program | | | | | |
| Environmental Monitoring | | | | | |
| South Kachemak Energy Storage Project | | | | | |
| South Kachemak Renewable Energy Project | | | | | |
| | | | | | |
| Nanwalek Vegetation Management Project | | | | | |
| | | | | | |
| Paluwik Vegetation Management Project | | | | | |

Table 6. South Kachemak Bay Watershed Collaborative Plan Timeline.

# REFERENCES

Falnes, J. (2002). Ocean Waves and Oscillating Systems: Linear Interactions Including Wave-Energy Extraction. Cambridge University Press.

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Leewis, M. C., Reynolds, C. M., & Leigh, M. B. (2013). Long-term effects of nutrient addition and phytoremediation on diesel and crude oil contaminated soils in subarctic Alaska. Cold regions science and technology, 96, 129-137.

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Mulder, C. Alaska Berries and Climate Change. Alaska Forum on the Environment. Anchorage, Alaska, United States.

Starsman, J. (2016). Assessing the potential of Salix alaxensis for the rhizoremediation of diesel contaminated soil. University of Alaska Fairbanks.

## ACKNOWLEDGEMENTS

This collaborative framework has been developed as an assessment of existing data and reports throughout the Kachemak Region, with an emphasis on tribal communities in the south Kachemak region: Nanwalek, Paluwik, commonly referred to as Port Graham, and Seldovia.

The SKBWC is intended to compile existing data and reports pertaining to natural resources in the watershed and may not be conflated with tribal council or the collective traditional ecological knowledge of each tribe. This document may be used for background information on tribal programs and projects but may not be substituted for tribal consultation. To consult with the villages described in this document, contact the Chugach Regional Resource Commission directly.

# Appendix A

Kachemak Bay Watershed Collaborative
Compendium of Existing Reports

**Kachemak Bay Watershed Collaborative**
**Summary of Existing Reports and Plans**

December 1993. Kachemak Bay and Fox River Flats Critical Habitat Areas Management Plan. Alaska Dept of Fish and Game, Divisions of Habitat, Restoration, and Wildlife Conservation. Anchorage, AK.

> The two Critical Habitat Areas are managed according to the Plan which was adopted in 1993. The Goals and Policies of the plan provide long-term guidance to the Habitat Section's special area permitting decisions within the CHAs (5 AAC 95) and ADF&G's other management decisions.

Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes. Alaska Dept of Fish and Game, Anchorage, AK. Updated May 2022.

> The Catalog and its associated Atlas (the Catalog and Atlas, respectively) currently list almost 20,000 streams, rivers or lakes around the state which have been identified as being important for the spawning, rearing or migration of anadromous fish which are protected under State of Alaska law.

2022 Annual Management Plan - Port Graham Hatchery, Cook Inlet Aquaculture. Alaska Dept of Fish and Game, Hatcheries Division, Juneau, AK.

> Prepared in order to fulfill the requirements of 5 AAC 40.840. This plan must organize and guide the hatchery's operations for each calendar year, regarding production goals, brood stock development, and harvest management of hatchery returns. Egg take through release details are included in planning for succeeding calendar years.

2022 Annual Management Plan - Tutka Bay Lagoon Hatchery, Cook Inlet Aquaculture. Alaska Dept of Fish and Game, Hatcheries Div. Juneau, AK.

> Prepared to fulfill the requirements of 5 AAC 40.840. This plan organizes and guide the hatchery's operations, for each calendar year, regarding production goals, broodstock development, and harvest management of hatchery returns.

Brabets, T.P., et al. 1999. Water-Quality Assessment of the Cook Inlet Basin, Alaska Environmental Setting. US Geological Survey, National Water-Quality Assessment Program, Water-Resources Investigations Report 99-4025. Anchorage, AK.

> The Cook Inlet Basin study unit encompasses the fresh surface and ground waters in the 39,325 square-mile area that drains into Cook Inlet, but does not include the marine waters of Cook Inlet. This report describes the natural factors (climate, physiography, geology, soils, land cover) and the human factors (population, land use, water use) that affect water quality, which is the first step in designing and conducting a multidisciplinary regional water-quality assessment. The surface and ground-water hydrology, and the aquatic ecosystems of the Cook Inlet Basin are described. The report provides an overview of existing water-quality conditions and summarizes the results of selected water-quality studies of the basin.

Division of Sportfish, Strategic Plan 2022-2027. Alaska Dept of Fish and Game, Tom Brookover, Director. Juneau, AK.

Measurable activities that will help ADF&G better understand and manage the resources and identify ways to keep improving services to anglers and stakeholders. The agency is engaged in a continual process of improvement and this plan not only serves as a guidepost for future efforts, but it holds ADF&G, as a public service agency, accountable for what they do.

Field, C. and C. Walker, 2003. A Site Profile of the Kachemak Bay Research Reserve: A Unit of the National Estuarine Research Reserve System. Kachemak Bay Research Reserve, Homer AK.

The Kachemak Bay National Estuarine Research Reserve program is administered through the National Atmospheric and Oceanic Administration (NOAA). As part of the Research Reserve system, each reserve is required to prepare a site profile that summarizes the existing state of knowledge for research, monitoring and education activities, and identify some of the research needs that should be addressed in the future. The intent in preparing this document was to meet that requirement. In order to develop this document, the authors referred to the Kachemak Bay Ecological Characterization, a digital source of information important to the ecological understanding and management of the Kachemak Bay area.

Gracz, M., April 2017. Wetlands of the Cook Inlet Basin, Alaska: Classification and Contributions to Stream Flow. PhD thesis, University of Minnesota.

A new Cook Inlet Classification system (CIC) organized around the hydrogeologic settings of wetlands in the Cook Inlet Basin (CIB). The variables most strongly correlated with ecological differences within major geomorphic classes were used to construct a system supported by ample field data. The CIC produced greater within-class similarity than other widely-used systems, likely due to the overriding importance of the seasonal variability of water levels in CIB peatlands. The CIC has been mapped over an area of 7600 km2 and has guided wetland functional assessments in the CIB, and may be adaptable to any region supporting peatlands on glacial landforms.

Hammarstrom, L., January 2007. Cook Inlet Regional Salmon Enhancement Planning, Phase II 2006-2025. Alaska Dept of Fish and Game, Anchorage, AK.

Comprehensive, coordinated, long-range plan for the orderly present and long-range rehabilitation of all aspects of the state's fishery.

Hartwell, S.I. et al, 2009. Sediment Quality Triad Assessment in Kachemak Bay: Characterization of Soft Bottom Benthic Habitats and Contaminant Bioeffects Assessment. NOAA Technical Memorandum NOS NCCOS CCMA 104. 85pp.

Baseline environmental characterization of the inner Kachemak Bay using the sediment quality triad approach based on sediment chemistry, sediment toxicity, and benthic invertebrate community structure.

Holen, D. July 2019. Coastal Community Vulnerability Index and Visualization of Change in Cook Inlet, Alaska. Final Report OCS Study BOEM 2019-031. Coastal Marine Institute, University of Alaska, Fairbanks.

The Cook Inlet Response Tool (CIRT) is a web-based data integration and visualization platform designed to assist with planning for oil and gas extraction activities in the region and to improve outcomes in the event of an environmental crisis. The CIRT is a component of the Alaska Ocean Observing System (AOOS) portal, which provides interactive public access to environmental data for Cook Inlet and other regions around Alaska. This project added to the CIRT by creating an integrated human-dimension, socio-economic data layer titled Wild Resource Harvest and Use by Cook Inlet Communities.

December 2014. Managing Kenai Peninsula Wetlands. Homer Soil and Water Conservation District, Homer, AK.

An online report describing (a) the collaborative process used to develop management strategies, (b) the strategies themselves, and (c) the steps and rationale for "assigning" particular strategies to specific wetlands. Incorporation of wetlands management information into the Kenai Peninsula Borough (KPB) online "interactive parcel viewer" (IPV). The IPV will make it easy for landowners, managers, government officials, and others to find which management strategies have been recommended for which wetlands, plus why and how strategies could be implemented.

National Centers for Coastal Ocean Science, 2024: NCCOS Project: Kachemak Bay Ecological Assessment.. KBNERR (aka KBRR), Alaska Dept Fish and Game, Habitat and Restoration Division with NOAA Coastal Services Division, Charleston, SC. Originally issued on CD, digital copy hosted by Indiana University Digital Library Program.

Helps to inform resource and coastal managers of estuarine and coastal habitat issues affecting not only Kachemak Bay, but also other coastal areas in Cook Inlet and across the Gulf of Alaska. Results and products from the Kachemak Bay ecological assessment will also identify gaps in available information and help NCCOS and partners set priorities for future research efforts.

Kenai Peninsula Fish Habitat Partnership (KPFHP) 2011. Strategic Plan v3.2.

To create and foster effective collaboration to maintain healthy fish, people, habitat and economies in the Kenai Peninsula Borough through the protection, maintenance, restoration and enhancement of fish habitat in order for future generations to have healthy, sustainable fish and aquatic ecosystems.

Strategic Plan for foster effective The purpose of the Kenai Peninsula Fish Habitat Partnership is to create and

KPFHP 2011. Marine Conservation Action Plan, 2022 update

The Plan addresses the following:

1) Draft of Marine Targets – what we want to conserve
2) Marine target viability – present condition of target habitats
3) Marine Potential Threats over the next 10 – 20 years

4) Potential Threats to our Partnership's Geography

Kenai Peninsula Fish Habitat Partnership  2022  Freshwater Conservation Action Plan

A plan to protect Fish and Fish habitat in the rivers, lakes, and streams of the Kenai Peninsula to ensure that the Borough's freshwater fish habitat remains resilient and productive for current and future generations through self-sustaining fish populations.

Kenai Peninsula Fish Habitat Partnership Climate Change and the Future of Freshwater Fish Habitat on the Kenai Peninsula Supplemental document accompanying the Kenai Peninsula Fish Habitat Partnership 2022 Freshwater Conservation Plan.

The 2022 Kenai Peninsula Fish Habitat Partnership Conservation Action Planning workshop generated a great deal of discussion and information regarding climate change and its effects on local ecological systems, so much as to merit this accompanying supplemental document. Here we provide a formal threat description of climate change, a list of observed and ongoing climate-related ecological changes, and a collection of case studies that highlight the state of knowledge on climate change and freshwater fish ecology in the Kenai Peninsula region.

Mauger, S., October 2003.  A Preliminary Water Quality Assessment of  Lower Kenai Peninsula Salmon-bearing Streams. Cook Inlet Keeper & Homer Soil and Water Conservation District, Homer, AK, August 1998 – June 2004.

Through the Lower Kenai Peninsula Watershed Health Project, Cook Inlet Keeper (Keeper) and the Homer Soil and Water Conservation District (HSWCD) are jointly collecting reliable baseline water quality data on the Ninilchik River, Deep Creek, Stariski Creek, and Anchor River and educating local citizens about water quality issues. This report is the sixth published by the two partners and presents water quality data collected from August 1998 through June 2004. The report offers a preliminary water quality assessment of the four rivers and is produced to partially fulfill the requirements of a Section 319 Clean Water Act grant from the Alaska Department of Environmental Conservation and a Regional Geographic Initiative grant from the Environmental Protection Agency.

Mauger, S., October 2013.  Stream Temperature Monitoring Network, Synthesis Report 2008-2012. Cook Inletkeeper, Homer, AK.

Describes implementation of a Stream Temperature Monitoring Network for Cook Inlet salmon streams to describe current water temperature profiles and identify watershed characteristics that make specific streams more sensitive to climate change impacts. Beginning in the summer of 2008, we collected continuous water and air temperatures in 48 non-glacial salmon streams during open-water periods. This report presents a summary of five years of data (2008-2012) from this collaborative project.

Mauger, S. et al, October 2015.  Science-based Land Conservation: Conservation Strategies to Protect Key Salmon Habitat in Lower Kenai Peninsula Watersheds.  Cook Inletkeeper, Homer AK.

Cook Inletkeeper, Kachemak Heritage Land Trust and Kenai Watershed Forum developed the Science-based Land Conservation project with a goal of improving landscape-scale resilience for salmon on Alaska's lower Kenai Peninsula. Project objectives were to: identify critical salmon habitat in the Anchor River, Stariski Creek, Deep Creek, and Ninilchik River watersheds; create land conservation strategies for riparian areas on the lower Kenai Peninsula based upon local research for the protection of salmon habitat; educate landowners of priority conservation land about conservation options available to them; and work with public and private landowners to protect land determined to be significant for salmon habitat on the lower Kenai Peninsula.

Mauger, S. et al, 2015. Stream temperature data collection standards for Alaska: Minimum standards to generate data useful for regional-scale analyses. Journal of Hydrology: Regional Studies 4 (2015) 431–438.

Defines 10 minimum data collection standards for continuous stream temperature data in Alaska. The standards cover data logger accuracy and range, data collection sampling frequency and duration, site selection, logger accuracy checks, data evaluation, file formats, metadata, and data sharing. We hope that the adoption of minimum standards will encourage rapid, but structured, growth in comparable stream temperature monitoring efforts in Alaska that will be used to understand current and future trends in thermal regimes.

Kachemak Heritage Land Trust, et al 2015. Kenai Mountains to Sea: A Land Conservation Strategy to Sustain Our Way of Life on the Kenai Peninsula. February 2015 (Updated November 2016).

The Kenai Mountains to Sea partnership proposes to leverage existing land conservation by focusing on interjurisdictional anadromous stream corridors that pass from the Federal conservation estate through nonfederal lands (including private parcels) to reach the sea. Our goal is to build a broad-based partnership to support and strengthen long-standing and effective private-public partnerships dedicated to voluntarily conserving and enhancing fish and wildlife habitats for the continuing economic, recreational and cultural benefits to residents and visitors of the Kenai Peninsula Borough.

Saupe, S.M., J. Gendron, and D. Dasher. 2005. The Condition of Southcentral Alaska Coastal Bays and Estuaries. A Statistical Summary for the National Coastal Assessment Program. Cook Inlet Regional Advisory Council for the Alaska Department of Environmental Conservation, March 15, 2006.

Summary report for the ecological conditions in Alaska's coastal bays and estuaries along the southcentral coast of Alaska based on data collected in June, July, and August 2002. Sampling was conducted in accordance with the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) design and standardized protocols. Typically, the EMAP Western Pilot Coastal Monitoring (EMAPWPCM) design incorporates all U.S. West Coast estuaries in which a large portion of the extensive population is sampled annually.

The Nature Conservancy of Alaska, August 2003. Cook Inlet Ecoregional Assessment. Anchorage, AK.
Wilson, L. March 2022. Alaska Salmon Fisheries Enhancement Annual Report 2021. Alaska Dept of Fish and Game, Div Commercial Fisheries, Regional Information Report 5J22-02. Juneau, AK.

Assesses the ecoregion's biodiversity and identifies areas of biological significance. The Cook Inlet Basin ecoregion is the first terrestrial ecoregion assessed by the Conservancy in Alaska. With some modifications in order to adapt the frameworks to the unique characteristics of Alaska, Assessment was guided by the methodology outline in "Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning.

Evaluation of Nearshore Communities and Habitats: Ecological Processes in Lower Cook Inlet, Bureau of Ocean Energy Management January 2020.

Quantitative and qualitative data about sensitive nearshore habitats that are near the federal lease sale area in lower Cook Inlet. Updated information regarding the physical and biological environment, including variability in oceanographic conditions, nearshore benthic communities, as well as data related to sensitive species, may be used to support NEPA analyses conducted for future environmental analysis. The results of these studies may be used to inform subsequent NEPA analyses and documentation for other lease sales, and potential future Explorations Plans (EPs), and Development and Production Plans.

Integrated Cook Inlet Environmental Monitoring and Assessment Project (ICIEMAP) Cook Inlet Regional Citizens Advisory Council (2012).

Program goals: Identify and evaluate risks and potential impacts of oil industry operations to ecosystem components of the Cook Inlet RCAC area of concern. Assess and monitor status and trends of biological and chemical components in the Cook Inlet RCAC area of concern. Make data accessible to stakeholders to improve our understanding of biological and chemical environments in the Cook Inlet RCAC area of concern.

Alaska EPSCoR's Fire and Ice: Navigating Variability in Boreal Wildfire Regimes and Subarctic Coastal Ecosystems

A 5-year, $20 million effort by the Alaska National Science Foundation's Established Program to Stimulate Competitive Research (EPSCoR) to conduct research into climate-related changes to fire risk and behavior in Alaska's boreal forest, and changes to physical and chemical variables that influence biological communities in Kachemak Bay's freshwater ecosystems. It evaluates changes in ocean temperature and chemistry by monitoring temperature, sedimentation, and flow measurements for streams in glacial and non-glacial coastal watersheds. Project researchers are modeling lightning probabilities, assessing available fuels, and applying climate forecasting in order to better understand how freshwater and climate change affects Alaska's estuarine biologically rich ecosystems.

**We are still gathering information and reports and will include them in the final summary.**