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EPA Region 10 Climate Change Adaptation Implementation Plan

June 2014

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Preface

The U.S. Environmental Protection Agency (EPA) is committed to identifying and responding to the challenges that a changing climate poses to human health and the environment.

Scientific evidence demonstrates that the climate is changing at an increasingly rapid rate, outside the range to which society has adapted in the past. These changes can pose significant challenges to the EPA's ability to fulfill its mission. The EPA must adapt to climate change if it is to continue fulfilling its statutory, regulatory and programmatic requirements. The Agency is therefore anticipating and planning for future changes in climate to ensure it continues to fulfill its mission of protecting human health and the environment even as the climate changes.

In February 2013, the EPA released its draft *Climate Change Adaptation Plan* to the public for review and comment. The plan relies on peer-reviewed scientific information and expert judgment to identify vulnerabilities to EPA's mission and goals from climate change. The plan also presents 10 priority actions that EPA will take to ensure that its programs, policies, rules, and operations will remain effective under future climatic conditions. The priority placed on mainstreaming climate adaptation within EPA complements efforts to encourage and mainstream adaptation planning across the entire federal government.

Following completion of the draft *Climate Change Adaptation Plan*, each EPA National Environmental Program Office, all 10 Regional Offices, and several National Support Offices developed a *Climate Adaptation Implementation Plan* to provide more detail on how it will carry out the work called for in the agency-wide plan. Each *Implementation Plan* articulates how the office will integrate climate adaptation into its planning and work in a manner consistent and compatible with its goals and objectives.

Taken together, the *Implementation Plans* demonstrate how the EPA will attain the 10 agency-wide priorities presented in the *Climate Change Adaptation Plan*. A central element of all of EPA's plans is to build and strengthen its adaptive capacity and work with its partners to build capacity in states, tribes, and local communities. EPA will empower its staff and partners by increasing their awareness of ways that climate change may affect their ability to implement effective programs, and by providing them with the necessary data, information, and tools to integrate climate adaptation into their work.

Each Program and Regional Office's *Implementation Plan* contains an initial assessment of the implications of climate change for the organization's goals and objectives. These "program vulnerability assessments" are living documents that will be updated as needed to account for new knowledge, data, and scientific evidence about the impacts of climate change on EPA's mission. The plan then identifies specific priority actions that the office will take to begin addressing its vulnerabilities and mainstreaming climate change adaptation into its activities. Criteria for the selection of priorities are discussed. An emphasis is placed on protecting the most vulnerable people and places, on supporting the development of adaptive capacity in the tribes, and on identifying clear steps for ongoing collaboration with tribal governments.

Because EPA's Programs and Regions and partners will be learning by experience as they mainstream climate adaptation planning into their activities, it will be essential to evaluate their efforts in order to understand how well different approaches work and how they can be improved. Each *Implementation Plan* therefore includes a discussion of how the organization will regularly evaluate the effectiveness of its adaptation efforts and make adjustments where necessary.

The set of *Implementation Plans* are a sign of EPA's leadership and commitment to help build the nation's adaptive capacity that is so vital to the goal of protecting human health and the environment. Working with its partners, the Agency will help promote a healthy and prosperous nation that is resilient to a changing climate.

Bob Perciasepe
Deputy Administrator

June 2014

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The U.S. Environmental Protection Agency (EPA) Region 10 serves Alaska, Idaho, Oregon, Washington, and 271 federally-recognized tribes.

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Section 1: Introduction

Executive Order EO13514 directed the U.S. Government to address the impacts of climate change, and form an Interagency Climate Change Adaptation Task Force. This task force is co-chaired by the White House Council on Environmental Quality (CEQ), the White House Office of Science and Technology Policy, and the National Oceanic and Atmospheric Administration. There are over 20 federal agencies represented on the task force, including the Environmental Protection Agency (EPA). The task force developed recommendations to the President regarding the integration of climate adaptation into planning, operations, policies, and programs, and each agency was required to develop a climate change adaptation plan.

> "Adaptation" refers to efforts by society or ecosystems to prepare for or adjust to future climate change. These adjustments can be protective (i.e., guarding against negative impacts of climate change), or opportunistic (i.e., taking advantage of any beneficial effects of climate change).

In response, EPA issued a climate change adaptation policy statement in June 2011, and completed an agency-wide Climate Adaptation Plan in June 2012. These documents directed every Program and Regional office within EPA to develop an Implementation Plan detailing how they will integrate climate adaptation into their work, and address the priorities identified in the agency-wide plan.

To promote consistency, these Implementation Plans have common areas of focus, as outlined below.

Common Areas of Focus for Implementation Plans

1. Vulnerability assessments
2. Priority actions on climate adaptation
3. Agency-wide strategic measures on climate adaptation
4. Legal and enforcement issues
5. Training and outreach
6. Partnerships with tribes
7. Evaluation and cross-office pilot projects

The Implementation Plans are complementary and are meant to work in conjunction with the Agency's Strategic Plan and Sustainability Plan, and the climate change plans developed by the individual EPA Program Offices. The Implementation Plan for Region 10 will be a living document to be updated over time.

I. Regional Overview

Region 10 serves Washington, Oregon, Idaho, Alaska and 271 Federally Recognized Tribes. In this report, Washington, Oregon, and Idaho are often referred to as the Pacific Northwest. EPA Region 10 represents a diverse geographic region with varying climate, geographic features, social, and ecological

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conditions. Region 10 is composed of eight landscape conservation cooperative[1] areas (five in Alaska and 3 in the Pacific Northwest) out of twenty-two Nationwide. This attests to the wide diversity of geographic regions within Region 10. The Pacific Northwest is bordered by the Pacific Ocean to the west and Canada to the north. The region includes the cities of Seattle, Portland, Spokane, Boise, and Tacoma with susceptible populations that are particularly vulnerable to a changing climate.

The Cascade Mountain Range runs north-south through Washington and Oregon, splitting the region. The climate on each side of the mountain range is very different. West of the mountains, temperatures are mild year-round (days below freezing or above 90°F are relatively rare), winters are wet, and summers are dry. East of the mountains, it is typically sunnier and drier over the course of the year, winters are colder, and summers can be significantly hotter. The Pacific Northwest contains many miles of coast line, contains high sage deserts, is composed of large tracks of forest, and consists of several mountain ranges that are critical to maintaining the water resources in the Region.

Alaska presents unique challenges given its geographic location, and that it is the only arctic region in United States. Issues related to permafrost thawing and sea ice melting are unique to Alaska and climate change impacts are being seen in many areas of Alaska and threatening coastal communities, habitats, and infrastructure. Alaska contains more coastline than the other 49 states combined. Alaska contains almost 40% (229 tribes) of the federally recognized tribes in the United States that are particularly vulnerable to climate change given their proximity to coastal areas.

II. Overview of Climate Change Impacts in Region 10

The climate of the Northwest is changing. According to the United States Global Change Research Program (USGCRP) the following changes have or are anticipated to occur in the region.[2] Over the last century, the average annual temperature rose by 1.5°F, with increases in some areas up to 4°F. Changes in snowpack, streamflows, and forest cover are already occurring. Future climate change will likely continue to influence these changes. Average annual temperature in the region is projected to increase by 3-10°F by the end of the century. Winter precipitation is projected to increase while summer precipitation is projected to decrease, though precipitation projections are less certain than those related to temperature. Future climate change impacts would be compounded by pressures related to the region's rapidly growing population.

[1] Landscape Conservation Cooperatives are public-private partnerships composed of states, tribes, federal agencies, non-governmental organizations, universities and others.
[2] U.S. Global Change Research Program (USGCRP). 2009. *Global Climate Change Impacts in the United States* . Karl, T.R., J. M. Melillo, and T. C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

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Impacts from climate change are being observed in Alaska. According to the Alaska Climate Change Strategy[3] recent decades of warmer temperature have produced extensive thawing of permafrost, which has resulted in increased coastal erosion, landslides, and sinking of the ground surface, as well as consequent disruption and damage to forests, buildings, infrastructure, and coastal communities. Sea ice off the Alaskan Coast is retreating and thinning, with widespread effects on marine ecosystems, coastal climate, human settlements, and subsistence activities. The Arctic Region, particularly Alaska, is already experiencing major ecological impacts such as the northward expansion of boreal forest in some areas, significant increases in fire frequency and intensity, and unprecedented insect outbreaks.

Section 2: Region 10 Vulnerability Assessment

This section contains an assessment of the vulnerabilities of Region 10 programs to the impacts of climate change. It builds on the work presented in Part 2 of EPA's Agency-Wide Implementation Plan, as well as the individual assessments completed by various Program Offices in Region 10. It also draws heavily from existing efforts from the four states in Region 10, as well as the work from the Landscape Conservation Cooperatives in Region 10 and from Tribal assessments. A summary of those efforts is provided below and a more detailed discussion can be found in Appendix A. The vulnerability assessment is structured by the goals in EPA's FY 2011-2015 Strategic Plan and includes a vulnerability assessment of EPA Region 10 facilities and Tribes. A more detailed discussion of the vulnerabilities and impacts is included in Appendix B. Appendix D provides a comparison of the vulnerabilities identified below with existing Region 10 actions. This information could be used to help focus future actions.

> Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

It is important to note that EPA Region 10 did not conduct a quantitative vulnerability assessment, but has qualitatively evaluated the nature and magnitude of risks associated with climate change impacts. The vulnerability assessment is based on the best available information, state and tribal vulnerability assessments, and our own best professional judgment. The assessment does not specifically distinguish timeframes (current, near-term, long-term) for impacts, although it mentions where impacts are already occurring, and it does provide judgments on the likelihood of the impact occurring in the Region. The assessment will need to be updated as our understanding of climate science evolves, and the Region will need to identify the important gaps in our scientific knowledge and technical analyses that are needed to assist in decision-making.

[3] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.

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The overall goal of the Region 10 vulnerability assessment and the detailed discussion of specific vulnerabilities contained in Appendix B and the comparison with vulnerabilities and existing actions in Appendix D are to:

1. Inform staff and managers in Region 10 about the most critical impacts from climate change for their programs;

2. Motivate staff and managers to continue with existing climate change and sustainability work and integrate climate change adaptation into their program work;

3. Serve as a starting point to engage in conversations with EPA partners, especially Tribes, on future actions that are needed to adapt to climate change; and

4. Serve as a qualitative assessment of the baseline set of vulnerabilities, which can be refined as new regional information on climate science and adaptation alternatives become available.

Vulnerable populations are mentioned throughout the document. Certain parts of the population, such as children, the elderly, minorities and the poor, persons with underlying medical conditions and disabilities, those with limited access to information, and tribal and indigenous populations, can be especially vulnerable to the impacts of climate change. Tribes may be more vulnerable to climate change impacts because of dependence upon a specific geographical area for their livelihood; and their unique cultural, economic, or political characteristics and contexts.[4]

Also, certain geographic locations and communities are particularly vulnerable, such as those located in low-lying coastal areas. One of the principles guiding EPA's efforts to integrate climate adaptation into its programs, policies and rules calls for its adaptation plans to prioritize helping people, places and infrastructure that are most vulnerable to climate impacts, and to be designed and implemented with meaningful involvement from all parts of society.

I. Region 10 General Vulnerabilities

All four States in Region 10 have identified vulnerabilities specific to their State. A summary of what is included in each State assessment is included below with a more detailed discussion in Appendix A.

[4] Cutter, S.L. and C. Finch. 2008. Temporal and spatial changes in social vulnerability to natural hazards. Proceedings of the National Academy of Science 105(7): 2301-2306.

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- The State of Oregon has developed a framework that condenses specific vulnerabilities and risks from climate change into 11 overarching categories. They then ranked these into three groups: very likely, likely, and more likely than not.[5]

- The Washington State Department of Ecology has summarized climate impacts in their response strategy.[6] Washington examined projected impacts for sector groupings – e.g., built infrastructure, wildlife & habitat, etc.

- Climate change planning in Idaho is conducted by the Idaho Experimental Program to Stimulate Competitive Research (EPSCoR).[7] The EPSCoR work addresses concerns about how the hydrology in Idaho will change as climate changes in the western U.S.

- The State of Alaska Adaptation Advisory Group describes vulnerabilities including effects that are already occurring in their document *Alaska's Climate Change Strategy: Addressing Impacts in Alaska*.[8]

- In an effort to understand Tribal cultural resource vulnerabilities, Region 10 reviewed the Swinomish Climate Change Initiative Impact Assessment Technical Report.[9]

- The Tribal Climate Change Adaptation Plan Template provides a summary of the Arctic vulnerabilities and those related to Alaskan Tribes.[10]

The following suite of climate change vulnerabilities and impacts, and their effects on Region 10 Programs is discussed in the sections below. They are discussed individually, or in combinations based on the focus of the Strategic Plan Goal under consideration. A more detailed discussion of the vulnerabilities is in Appendix B.

Based on the assessments described above we developed the following list of the most significant regional vulnerabilities.

1. Increase in average annual air temperature.
2. Decreased/loss of snowpack.
3. Sea level rise.
4. Permafrost thawing.

[5] http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf
[6] http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm
[7] http://www.idahoclimatechange.org/DrawOnePage.aspx?PageID=135
[8] http://www.climatechange.alaska.gov/aag/docs/aag_ES_27Jan10.pdf
[9] http://www.swinomish.org/departments/planning/climate_change/climate_main.html
[10] http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

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5. Sea ice melting.
6. Increase in wildfire frequency and intensity.
7. Increase in ocean temperatures.
8. Increase in ocean acidification.
9. Increase frequency of extreme precipitation events and flooding.
10. Increase in and changing mix of pests.
11. More frequent and severe drought.
12. Increase health impacts.

In addition to the vulnerabilities above, several cultural vulnerabilities were identified in the Swinomish Impact Assessment that may be relevant to other Tribes including:

- Shrinking land base (sea level rise).
- Inundation of coastal sites/artifacts.
- Exposure of burial sites and human remains from strong storm events.
- Loss of cultural use plants.
- Impacts within traditional use areas.
- Historic subsistent natural resources used by indigenous tribes such as fishery resources, wildlife, traditional foods, native plants, and holistic medicines are vulnerable.

These vulnerabilities are discussed when evaluating potential impacts on Regional Office programmatic areas of responsibility. The five goals discussed below are taken from the National Goals to facilitate comparisons across regions. The relationships to Region 10 Goals[11] are also given. Two additional areas of responsibility beyond the five National Goals that are addressed under vulnerabilities are facilities and operations and Tribes and vulnerable populations.

Cross Walk between National and Region 10 Goals	
National Goal	**Regional Goal**
Goal 1: Taking Action on Climate Change and Improving Air Quality	Goal 1: .Taking Action on Climate Change and Goal 2: Improving Air Quality
Goal 2: Protecting America's Waters	Goal 5: Protecting America's Waters
Goal 3: Cleaning Up Communities and Advancing Sustainable Development	Goal 4: Cleaning Up Our Communities
Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution	Goal 3: Assuring the Safety of Chemicals
Goal 5: Enforcing Environmental Laws	Goal 3: Assuring the Safety of Chemicals
Facilities and Operations	No specific goal.

[11] http://www.epa.gov/region10/pdf/regional_priorities_2011-2015.pdf

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Vulnerable populations	Goals 6: Expanding the Conversation on Environmentalism and Working for Environmental Justice Goal 7: Building Strong State and Tribal Partnerships.

1. Goal 1: Taking Action on Climate Change and Improving Air Quality

Many of the impacts from climate change including increased summer temperatures, increased wildfires, changes in precipitation, and severe weather events are likely to impact both ambient and indoor air quality in the Pacific Northwest and Alaska. These impacts will present new challenges to EPA Region 10 and its partners to ensure the continued protection of public health and the environment.

A. Increase in tropospheric ozone pollution may occur in certain areas due to increased average summertime temperature

There is the possibility that higher summertime temperatures would increase ozone productivity as well as emissions of volatile organic contaminant (VOC) precursors and, there is scientific consensus that climate change will decrease the background ozone in the lower troposphere where the water vapor effect is dominant.[12] However, from the available academic literature that includes results for the Pacific Northwest, there is no consistent finding about whether climate change will increase, decrease, or have no change on ozone in this region.[13,14] Potential ozone increases are more likely to occur in the larger metropolitan areas including Spokane, Tacoma, Portland, and Boise. Whether or not these increases will result in violations of the NAAQS health standards however is unknown.

B. Increase in air toxics from anthropogenic sources is uncertain due to variability in effects of temperature increase on individual air toxics.

Many hazardous air pollutants volatilize at higher temperatures, creating the potential for higher emission rates and higher concentrations in ambient air.[15] The higher concentrations could increase

[12] Jacob, DJ., and D.A. Winner. 2009. Effect of climate change on air quality. Atmos. Environ., 43 (56).
[13] Ibid Jacob and Winner 43 (51-63).
[14] USGCRP. 2009. Assessment of the impacts of global change on regional U.S. Air quality: a synthesis of climate change impacts on ground-level ozone, *EPA/600/R-07/094F*, Office of Research and Development, Washington, D.C.
[15] IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (Field, C.B., V. Barros, T.F. Stocker, D.Qin, D.J. Dokken, K.L. Ebi, M.D., Mastrandrea, K.J. Mach, G.K. Plattner, SlK. Allen, M. Tignor, and P.M. Midgley (eds.). A Special Report of Working Groups I & II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA pp. 1-19.

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public health risks, including risks for the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations. There is uncertainty however as to actual impacts on hazardous air pollutants (HAPs) concentrations since the boundary layer height will also likely be higher, adding more volume of air for the HAPs to mix into. It is also possible for pollutant removal mechanisms to increase as a result of climate change.

C. Particulate matter levels are likely to increase due to increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture.

Larger and more frequent wildfires are predicted throughout the region as a result of warmer summertime temperatures, decreased soil and fuel moisture, and increased pest infestations.[16] For example, in the Columbia Basin, the acres of forest burned are projected to double by the 2020s, and triple by the 2040s compared to average burned from 1916 to 2006.[17] This could complicate Agency efforts to protect public health and the environment from risks posed by particulate matter pollution in areas affected by more frequent wildfires. All four Region 10 States have a high percent of forested areas (about 50% for Washington and Oregon) and would all be adversely affected by an increase in wildfires.

D. Indoor air quality is very likely to be impacted, especially in Alaska, due to changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events.

Deterioration in indoor air quality will increase public health risks including those from respiratory illnesses such as asthma.[18] Public health risks from poor indoor air quality may also increase for susceptible populations - the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations across the region. Alaska's native and rural populations are very vulnerable to worsening indoor air quality with more insulated housing reducing air circulation - thereby increasing levels of both indoor and ambient pollution. [19] Increased flooding and melting permafrost also worsen indoor air

[16] Mote, P. K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder, 2014: Ch. 21: Northwest. Climate Change Impacts on the United States: The Third National Climate Assessment, J.M. Melilo, Terese (T.C.) Richmond and G.W Yohe, Eds., U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX. http://nca2014.globalchange.gov/report/regions/northwest#statement-1700.
[17] Littell, J.S. et. al. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102(1-2): 129-158.
[18] Reid, Colleen and Gamble, Janet. 2009. Aeroallergens, Allergic Disease, and Climate Change: Impacts and Adaptation, Ecohealth Vol 6(3):458-470, September, 2009.
[19] Institute of Medicine, *Climate Change, the Indoor Environment, and Health* (Washington, DC: The National Academies Press, 2011).

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quality by supporting mold growth.[20] This is an issue across the Region, but particularly important in environmental justice (EJ) areas and areas with a high density of more susceptible populations such as in Alaska's native villages[21] and on tribal reservations in Washington, Oregon and Idaho.

E. Stratospheric ozone layer is likely to be impacted in Alaska due to climate change effects.

This issue is important in the Arctic (Alaska) where severe depletion of stratospheric ozone has been observed during winter and spring months.[22] While there currently are no EPA Region 10 programs that directly deal with monitoring or restoring the stratospheric ozone layer, there is enforcement activity against violators related to use and disposal of chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) and their substitutes.

F. Increased rate and deposition of sulfates, nitrates, and mercury is uncertain due to changes in precipitation patterns.

Increased concentrations of sulfates, nitrates, and mercury could cause adverse effects on ecosystems throughout the region, particularly mountain ecosystems and freshwater ecosystems, and could contribute to accumulation of mercury in fish tissue. [23] However, overall effects are uncertain because higher temperatures drive increased chemical reactions and possibly more secondary organic carbon. [24] At the same time, there might be changes to the boundary layer height, airmass ventilation rate, and precipitation. We do not know the relative importance of these effects in Region 10 states.

2. Goal 2: Protecting America's Waters

There are many impacts that climate change may have on our water resources including drinking water and wastewater infrastructure, freshwater fisheries, terrestrial and marine ecosystems, water quality and water quantity, and agricultural and forestry production. These impacts will present challenges as there will be competing demands in some areas for water resources for agriculture, energy production, drinking water, and maintaining streamflows for fish. The section below highlights the main vulnerabilities and impacts identified in Region 10.

[20] Kovesi, Thomas MD et al. 2007. Indoor Air Quality and the Risk of lower respiratory tract infections in young Canadian Inuit children, Canadian Medical Association, 2007
[21] Bulkow, Lisa, et al. 2010. Risk Factors for Severe Respiratory Synctial Virus Infection Among Alaska Native Children, Pediatrics. 109 (2) 2010.
[22] Manney, G.L., et al., Unprecedented Arctic Ozone Loss in 2011. 2011. Nature 478, 469-475, October 27, 2011.
[23] Dawson, J.P., B.J. Bloomer, D.A. Winner, C.P. Weaver, 2013. Understanding the meteorological drivers of U.S. particulate matter concentrations in a changing climate, Bulletin of the American Meteorological Society, doi:10.1175/BAMS-D-12-00181.1, in press.
[24] Ibid. Dawson 2013.

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A. Drinking water, wastewater, stormwater, and agricultural infrastructure is likely to be impacted by increased heavy precipitation, more frequent flood events, storm surge, coastal erosion, and drought.

Impacts on water infrastructure may result in flooded facilities, an increased number of sewer overflows and wastewater bypasses, as well as increased pollutant loads in runoff, increased pollution of streams and threats to public health.[25] Climate change impacts drinking water by heightening risk of contamination of surface water sources due to higher temperatures, lower flows, and increased erosion/sedimentation.[26] Problems of safety as well as access to clean and safe water will be exacerbated for Tribal communities, and other vulnerable and economically depressed communities who have limited access to clean water supplies.[27] Agricultural productivity may be impacted in areas with inadequate water storage capacity and limited agricultural irrigation systems. Adequate summertime water supply for irrigation of crops is essential to agricultural communities east of the Cascades in Oregon, Washington, and Idaho. For tribes, who lack irrigation infrastructure and rely primarily on lakes and streams as water sources, availability of water for agriculture may be more severely impacted by climate change.

B. Impacts to freshwater fisheries is occurring now and is likely to increase due to earlier stream runoff and scouring of streambeds due to earlier snow melt, decreased summer stream flows and increased steam temperatures, and longer periods of low stream flow.

Impacts include loss of salmon habitat and increased stress on salmon reproduction throughout their entire lifecycle.[28] Salmon and other cold water fish constitute a large part of the marine fishery business in the Pacific Northwest, and loss of these fish would have a substantial impact on the Pacific Northwest economy. Coastal Native Americans depend on salmon as an essential part of their diets. There will be secondary impacts on other species in the ecosystem that benefit from salmon – e.g., forests that rely on decaying salmon for nutrients, and bears, eagles, others that feed on salmon. This also applies to other fresh cold water fish. Water resource decision-makers will need to modify watershed planning efforts to include projected impacts of altered stream flows and increased temperatures due to climate change.[29, 30]

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[25] USGCRP. 2009. Regional Impacts: Northwest. *EPA/600/R-07/094F*, Office of Research and Development, Washington, D.C.
[26] Ibid. USGCRP.
[27] http://www.climatechange.alaska.gov/aag/docs/aag_ES_27Jan10.pdf
[28] USGCRP. 2009. Regional Impacts: Northwest. *EPA/600/R-07/094F*, Office of Research and Development, Washington, D.C.
[29] Wenger, S.J., et al. 2011. Role of climate and invasive species in structuring trout distributions in the Interior Columbia Basin 2011, USA: Canadian Journal of Fisheries and Aquatic Sciences, v. 68, p. 988-1008. Catalog No: 2508.
[30] Wenger, S.J., et al. 2011. Flow regime, temperature and biotic interactions drive differential declines of trout species under climate change. Proceedings of the National Academy of Sciences, online. Catalog No: 2652.

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C. Estuarine watersheds, aquatic ecosystems, and wetlands are likely to be impacted by sea-level rise, sea surface temperature and increasing heavy precipitation events during the winter months, and decreasing precipitation days and increasing drought intensity during the summer months.

Changes in precipitation patterns, and increased drought intensity will cause stress on wetlands, and forest and mountain ecosystems, and pose challenges to migration of species in these ecosystems to more suitable habitats. Warmer sea surface temperature contributes to sea level rise, increased storm intensity, and greater stratification of the water column.[31] For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to change between -4 cm (sea-level fall) and +23 cm by 2030, -3 cm and +48 cm by 2050, and 10–143 cm by 2100.[32]

D. Forest ecosystems will likely be impacted by warming temperatures and more frequent and intense drought conditions.

Forest tree species are expected to shift their ranges northward and upslope in response to climate change and existing ecosystems will breakup as different species shift at different rates, resulting in the formation of new ecosystems, with unknown consequences.[33] Breakup of existing ecosystems and loss of biodiversity, in combination with increased drought conditions, can make forests more susceptible to destruction by wildfires and insect infestation. In the western United States, both the frequency of large wildfires, and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures.[34] Adverse effects are likely in forests across the region, but more immediately in low elevation forests, and forests in drier parts of the region, such as in Idaho eastern Washington and Oregon, and the interior of Alaska.[35]

E. Loss of sea ice is occurring now and will very likely increase in Alaska due to warming air and water temperatures.

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[31] Hoegh-Guldberg, Ove and Bruno, John F. 2010. The impact of climate change on the world's ecosystems. Science 328(1523-1528.

[32] National Research Council. 2012. Sea-level rise for the coasts of Washington, Oregon and California: Past, Present, and Future. Division on Earth and Life Studies Board on Earth Sciences and Resources and Ocean Studies Board. Committee on Sea Level Rise in California, Oregon, and Washington.

[33] ACIA. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, 139 pp.

[34] Westerling A.L., et. al. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science, 313(5789), 940-943.

[35] USGCRP. 2009. Regional Impacts: Pacific Northwest and Alaska. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.

Loss of arctic ice in the Bering Sea is adversely affecting Arctic sea ice ecosystems. The Bering Sea fishery is a very important source of seafood and an important factor to Alaska's economy. The earlier ice melt resulting from warming, however, leads to later phytoplankton blooms that are largely consumed by microscopic animals near the sea surface, vastly decreasing the amount of food reaching the living organisms on the ocean floor.[36] This will radically change the species composition of the fish and other creatures, with significant repercussions for both subsistence and commercial fishing.[37] Sea ice is forming later in the fall in Alaska, making the coastal communities more vulnerable to extreme storms causing coastal erosion in villages.[38]

F. Ocean acidification is occurring now and is very likely to increase due to increasing concentrations of CO_2 in the atmosphere.

Ocean acidification can lead to substantial decline of marine organisms that form their shells and skeletons from calcium carbonate in ocean waters.[39] Adverse effects of ocean acidification on marine organisms have already been documented.[40] Specifically, adverse effects of ocean acidification have been documented in pteropods (sea snails),[41] a primary food source for salmon in the Pacific Ocean, and in oyster larvae in estuaries on the coast of OR.[42] This is an important issue in coastal areas of the Pacific Northwest and Alaska.

G. Change in vegetation is likely in eastern Washington and Oregon and Idaho due to pest outbreaks, invasive species, increased fire, shifts in species ranges and increased erosion, drier soils, and depletion of water.

Climate warming is likely to increase the severity of West Nile Virus (WNv) outbreaks and to expand the area susceptible to outbreaks into areas that are now too cold for the WNv vector.[43] Observed and projected decreases in the frequency of freezing temperatures, lengthening of the frost-free season, and

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[36] USGCRP. 2009. Regional Impacts: Alaska. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.
[37] Janetos, A., et. al. 2008. Biodiversity. In: The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States. Synthesis and Assessment Product 4.3. U.S. Department of Agriculture, Washington, DC, pp. 151-181.
[38] http://www.stormsurge.noaa.gov/event_history.html
[39] Orr, J.C., et. al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437(7059), 681-686. 2005
[40] Feely, R.A., et. al. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. Science, 320(5882), 1490-1492.
[41] Bednaršek, N., et. al. 2012. Extensive dissolution of live pteropods in the Southern Ocean, Nature Geoscience, 5 (881–885).
[42] Barton, Alan, et. al. 2012. The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. Limnology and Oceanography. 57(3).
[43] Ibid Washington State Department of Fish and Wildlife. 2011.

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increased minimum temperatures can alter plant species ranges and shift the geographic and elevational boundaries of many arid lands. These changes are particularly relevant to the intermountain regions in western North America, the Palouse grassland bioregion, southeastern Washington, and northeastern Oregon.

3. Goal 3: Cleaning Up Communities and Advancing Sustainable Development

Contaminated site cleanup and waste/petroleum management occur under a variety of EPA programs, most commonly Superfund (i.e., remedial, time-critical and non-time critical removals, and emergency response), Resource Conservation and Recovery Act (RCRA), Toxic Substance Control Act (TSCA) (e.g., polychlorinated biphenyls – PCBs), Clean Air Act (CAA) (e.g., asbestos), and the Oil Pollution Act (OPA).

There are over 100 hazardous waste sites listed on the National Priority List, and many RCRA permitted and corrective action sites in Region 10. Many of these sites are especially vulnerable to impacts from climate change and the potential impacts to infrastructure and in place remedies at corrective action, remedial, removal, and brownfield sites. Also, there may be an increased need for Emergency Response as part of FEMA response.

Region 10 recognizes the importance of sustainable development, and the overlap and intersection with climate change issues. The Region is focusing on coordinating its sustainability efforts internally as well as with our external partners with a specific consideration of climate change.

A. Remedial, removal, brownfield, corrective action or permitted sites may be impacted due to flooding, sea level risk, storm surges, extreme events, and landslides.

There could be an increased risk of contaminant release from hazardous waste sites. Remedial project managers and corrective action project managers may need to alter selected remedies to ensure hazardous substances are not released. In situ remedies (e.g., stabilization, reactive barriers) and on-site above ground treatment systems (e.g., pump & treat, air sparging) could be compromised or overwhelmed if they are not designed to withstand the climate-related events. The net result could be release of contaminants.

Groundwater and subsurface contamination could be impacted by drought and flood conditions. There may be an increased risk of migration of contaminants from flooded containment facilities. Remedies such as caps in contaminated industrial waterways in Washington and Oregon could be subject to (and not designed to withstand) unanticipated scour events.

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Possible issues of nuclear waste disposal related to climate change (e.g., locations of storage facilities, appropriate containment, and risk management issues) would also be important at the DOE Hanford facility in Washington State, and the DOE Idaho National Lab facility in Idaho.

B. Increase in work for Alaska's Tribal and emergency response programs is occurring now and likely to increase due to thawing permafrost and changes in sea ice that leads to damage of roads, runways, water and sewer systems, and other infrastructure.

Melting sea ice and late formation in the fall is causing storms to move in close to shore as the natural buffering system disappears. That is causing rapid coastal erosion, with houses and infrastructure falling into the ocean in several communities. That, along with higher storm, tidal surges flood communities, is requiring more immediate evacuation needs. Open dumps are also impacted by storm surges, and flooding, which increases contamination risk. Permafrost temperatures have increased throughout Alaska since the late 1970s.[44] Land subsidence (sinking) associated with the thawing of permafrost presents substantial challenges to engineers attempting to preserve infrastructure in Alaska.[45]

C. EPA Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable development and materials management programs, partnerships and initiatives.

Existing trends will exacerbate the challenges of climate adaptation. For example, accelerating development (sustainable or otherwise) and the expected migration of people to Region 10 are issues of concern. It is projected that the population of the States in Region 10 will increase from 11.2 million in 2010 to 13.1 million in 2025.[46] Communities are struggling with how to manage the new people while protecting the environment and providing basic services like energy, water and waste management. In support of the increased sustainability of our communities, our investments in partnerships related to more sustainable materials management play an increasing role in preventing waste, conserving energy and reducing emissions of toxics as well as greenhouse gases. Waste management can be especially challenging in remote tribal communities in Alaska.[47]

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[44] Lettenmaier, D., et. al. 2008. The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States, Synthesis and Assessment Product 4.3. U.S. Department of Agriculture, Washington,DC, pp. 121-150.

[45] Instanes, A., et. al. 2005. Infrastructure: buildings, support systems, and industrial facilities. In: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, pp. 907-944

[46] U.S. Census Bureau. 2013. Current Population Report: Population Projections: States 1995-2025. Economics Statistical Administration. Department of Commerce. Website:http://www.census.gov/prod/2/pop/p25/p25-1131.pdf. Accessed May 23, 2013.

[47] U.S. EPA. 2011. National Priorities with a Local Focus – Region 10's Approach for Implementing Administrator Jackson's Seven Priorities – FY 2011-2015 November 2011. www.epa.gov.

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D. Availability of raw materials may decrease and the cost of mining and refining raw materials, producing products, transporting products, and disposing products may increase due to impacts of climate change.

EPA Region 10 will need to put more effort into advocating for sustainable materials management and pollution prevention with States, industry, communities and tribes as climate change affects the availability and cost of raw materials and products. This issue will impact the entire region but may have a greater impact on remote cities and villages in Alaska where transportation and disposal of products is more difficult and costly. For example, increasing pest infestations and forest fires can result in millions of acres of dead, dying, and burned trees in the Pacific Northwest and Alaska. This decreases the availability and drives up the costs of wood products. Thawing permafrost in Alaska results in infrastructure damage in the form of compromised or impassible haul roads for timber and ore, reducing the availability of these natural resources and driving up transportation costs.

4. Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

EPA and the states (usually the State Department of Agriculture) register or license pesticides for use in the United States. In addition, EPA must be notified of the importation of pesticides for use in the U.S. EPA receives its authority to register pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Climate change may lead to an increase in pesticide use, due to an increase in pests and diseases which favor warm and humid climates. Also, a changing climate can affect exposures to a wide range of chemicals not just pesticide. Exposures may change because of changing environmental conditions or changing use patterns.

A. Increased exposure and risk to hazardous chemicals may occur due to increasing extreme temperatures and heavy precipitation events, changes in storm intensities, and increasing frequency of floods.

The increased exposures and risk may require adjustments to the relevant risk assessment framework to determine public risk due to modified exposure scenarios and modified toxicity of chemicals due to climate change. Altered weather and severe climate events could also affect the interpretations of risk at RCRA/TSCA and Superfund sites. This is very relevant for permitting and planning activities, where facilities may not have previously required an awareness of risk management for water/flooding, or other climate change impacts. In particular, Puget Sound is vulnerable to these potential impacts of chemical pollution; restoration of Puget Sound is a key ecosystem-level activity in EPA Region 10.[48] This

[48] http://www.psp.wa.gov/downloads/AA2011/083012_final/Action%20Agenda%20Book%202_Aug%2029%202012.pdf

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is more relevant near sites with large densities of chemical manufacturers, processors and formulators, and RCRA and Superfund sites.

5. Goal 5: Enforcing Environmental Laws

EPA Region 10's Office of Compliance and Enforcement (OCE) is charged with ensuring compliance with environmental requirements and enforcing against violations to those requirements in the Pacific Northwest and Alaska. In that capacity, OCE's vulnerabilities are uniquely tied to interactions with the regulated community. Some types of vulnerabilities (e.g., difficulties with maintaining staff functionality due to power outages and physical damage to facilities due to extreme weather) would be similar to those experienced by all EPA programs and regions.

Other vulnerabilities are more specific to OCE, such as those which impact the ability of regulated entities to comply with environmental requirements and with our ability to determine such compliance and take appropriate action. The vulnerabilities of greatest importance for OCE are conditions/events which would compromise our ability to ensure compliance with environmental requirements by regulated entities and, where necessary, to take effective enforcement action in case of violations. The activities impacted would include: compliance assistance; compliance monitoring and civil enforcement.

A. Non-compliance at regulated entities may increase due to extreme weather events and changing weather patterns.

Compliance and enforcement programs under the Clean Water Act (CWA) have the potential to see an increase in violations from many situations including sanitary sewer and combined sewer overflows, violations of percent removal at wastewater treatment plants (due to limited water flow as a result of drought), violations in bypasses due to the inability of wastewater treatment plants to treat a flow in excess of the design capacity, and increased violations in numerous programs due to failure of existing infrastructure protecting against extreme weather events. In addition, CWA section 311 (Spill Prevention Control Countermeasures) may see an increase in non-compliance along Alaskan coastal areas that have oil storage containers, as a result of sea ice melting (thereby increasing storm surges along those coastal areas) and increased flooding.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) compliance and enforcement programs may see violations at Pesticides Producing Establishments as there is a shift toward increasing pesticide usage, productions and imports. As weather patterns change in the Region, the habitats of insects and pests may also change, bringing different pests and diseases to areas.

The RCRA program may see increased non-compliance at landfills due to changes in precipitation patterns (including more precipitation in some cases and more extreme precipitation events in other

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cases). Landfills may generate excessive hazardous leachate, see unexpected mobilization of contaminants in the waste column, and/or experience failure of the liner or leachate collection systems.

B. Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance due to extreme weather events and changing weather patterns.

If an increase in violations in various programs and industry are identified, OCE may shift the enforcement focus to address those violations. Conversely, OCE may use discretion to refocus enforcement priorities when localized extreme weather events (e.g., flooding) greatly impact the regulated community or when a change in weather patterns decreases the potential for non-compliance (e.g., less precipitation could decrease surface runoff). This will be most important in states where EPA has direct implementation of an enforcement program (e.g., Idaho for NPDES program), on Tribal lands, and non-delegable programs (e.g., Chlorofluorocarbons, CWA 311 (SPCC), and PCBs). In states with authorized program implementation, OCE's work share could change as a result of climate change shifting states' priorities.

OCE may need to make adjustments to normal workload to address an increase in industry's compliance inquiries. There may need to be reassignment or delay of normal work duties as staff provides response support to those inquiries in a timely manner. Requests may also be received from Regional state counterparts regarding guidance to address unique enforcement issues as a result of extreme weather events or changing weather patterns.

C. Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.

EPA has developed criteria for Class VI wells, used specifically for the injection of carbon dioxide into underground subsurface rock formations for long-term storage. As the need to reduce carbon dioxide emissions into the atmosphere increases, various technologies including Class VI wells will be deployed. OCE may need to reassign or delay other UIC permitting and enforcement work, as permit requests for Class VI wells increase. This will be seen across the Region, until permitting and enforcement of the Class VI well program is delegated to the states.

As the amount of stormwater increases with increased precipitation levels, industries regulated to manage stormwater and associated discharges may be faced with challenges surrounding the volume of stormwater to manage. Class V wells are designed to receive stormwater, as a substitution for or in addition to discharging stormwater through more traditional means. OCE may see an increase in permitting Class V wells, as challenges managing high volumes of stormwater increase. Permitting will

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be focused on Class V wells in Alaska and Tribal lands, as the Region implements this program in these areas.

D. An increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.

Sea ice off the Alaskan Coast is retreating and thinning. This reduction of sea ice is very likely to increase the navigation season and create a seasonal opening of the Northern Sea Route to likely make trans-arctic shipping and transport feasible during summer months. As areas and routes become more accessible, there is a potential for industrial activity (e.g., oil and gas extraction) to become more active in these areas. As a result, OCE may see an increase in regulated entities.

6. EPA Facilities and Operations

The main EPA Region 10 building is in Seattle with field offices in Olympia, Portland, Boise, Anchorage, and Juneau. The Region also maintains an environmental laboratory in Manchester, Washington. The Region has a Continuity of Operations Plan (COOP) that describes efforts to prepare and react to issues affecting the operation of our facilities and a Regional Incident Command Team (RICT) who is responsible for responding to any emergency situation. In general, the EPA Region 10 facilities are not uniquely vulnerable to climate change impacts. The Manchester Lab is located on the shoreline and could be more susceptible. They have an emergency operation plans in the event of extreme weather events or other possible impacts from climatic change.

A. Drinking water may be limited and an increase in demand for air conditioning is possible due to increasing drought frequency and intensity.

Facilities could be located in areas with water shortages, requiring water rationing. There is likely to be a greater demand for electricity for air conditioning during the summer months. Increased extreme temperature at any Region 10 office would put higher demand on drinking water and electricity for cooling. This could impact the regional office and all the operations office.

B. Operations of Region 10 facilities may be impacted by increasing risk of floods and increasing intensity of storms.

Facilities in flood-prone areas may have to temporarily close. Personnel engaged in field work may be more vulnerable to extreme temperatures or storm events. Personnel and real property supporting emergency response and management may be at risk during flooding or extreme weather events. Ongoing work at the Manchester Environmental Laboratory may be disrupted with effects on many different programs. Closure of regional offices due to climate change related damage could prevent

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staff from carrying out important functions. The Regional Office in Seattle is located in an area with low probability for flooding or sea level rise. Region 10 has flexiplace options available to staff and a COOP in place in case any Region 10 office is damaged by flooding or storms or transportation to/from offices are affected (e.g., flooded roadways; landslides on commuter train tracks).

7. Tribal and other Vulnerable Populations

As part of the EPA's direct federal implementation and oversight responsibilities, EPA Region 10 has a trust responsibility to each of the 271 federally recognized Indian tribes within the Region. Many Tribes are especially vulnerable to climate change impacts due to their reliance on traditional hunting and fishing and their connections to the land and sea. Climate change is threatening access to traditional foods such as salmon, marine mammals, shellfish, and terrestrial and aquatic plants which are used for cultural, medicinal, and economic purposes as well as a primary food source. Tribes have already experienced many climate-related changes including changes in salmon habitat, drought, declining water tables, increased wildfires that impact crops, wildlife, traditional foods and medicines, earlier spring snow melt, a decrease in sea ice, and permafrost thawing. EPA Region 10 is committed to work with the Tribes to adapt to these changing conditions.

The impacts of climate change can have unique effects on the health of children. Children are different from adults in how they interact with their environment and how their health may be affected. Because of their unique physical, biological, and social characteristics they are likely to suffer disproportionally from both the direct and indirect adverse health effects of climate change.[49]
The impacts of climate change raise environmental justice issues. Climate change is likely to exacerbate existing and introduce new environmental burdens and associated health impacts in communities dealing with environmental justice challenges across the nation.[50]

A. Food security for native Alaskans and Tribal people in the Pacific Northwest who live a subsistence lifestyle may be at risk due to warming associated with climate change.

Warming due to climate change reduces the availability and accessibility of many traditional food sources for Native Americans. People face losing their healthiest foods, their communities, and in some cases, their culture, since each of these depends on traditional ways of collecting and sharing food.[51]

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[49] Pediatrics, Global Climate Change and Children's Health, Committee on Environmental Health. 2007. Available at http://pediatrics.aappublications.org/content/120/5/1149.full.pdf
[50] USGCRP. 2009. *Global Climate Change Impacts in the United States* . Karl, T.R., J. M. Melillo, and T. C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA. 89–106.
[51] ACIA. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, 139 pp.

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Climate change will continue to impact and put stress on salmon in the Pacific Northwest along with other traditional foods such as wildlife, berries, and roots. In Alaska, climate change will reduce the availability and access to ice seals, walrus and caribou and access to shellfish and plants used for medicinal and cultural ceremonies.[52]

B. Increased erosion of shorelines is likely to increase risk to coastal native communities due to increased intensity of coastal storms and rising sea levels.

Coastlines and shorelines throughout the Pacific Northwest and Alaska are increasingly threatened by a combination of increasing storm activity, loss of its protective sea ice buffer, declining habitat, and thawing coastal permafrost.[53] In Alaska, over 100 villages on the coast and in low-lying areas along rivers are subject to increased flooding and erosion due to warming. Federal, state, and tribal officials have identified 31 villages that face imminent threats.[54] At least 12 of the 31 threatened villages have decided to relocate--in part or entirely--or to explore relocation options. Federal programs to assist threatened villages prepare for and recover from disasters and to protect and relocate them are limited and unavailable to the majority of villages. At least one Pacific Northwest Tribe, the Hoh Tribe is planning to relocate due to erosion and storm security.

C. Decreased access to clean drinking water is very likely due to loss of permafrost and reduced snowpack.

In many rural Alaskan tribal communities, the loss of permafrost can cause many problems including the loss of drinking water sources because tundra lakes, from which drinking water is drawn, are disappearing with the permafrost.[55] Also, melting permafrost destabilizes foundations, endangering the sewer and water infrastructure in these communities and without permafrost, the untreated leachate from open dumps may be a contamination risk for their water supply. Pacific Northwest Tribes may also experience water scarcity, due to failing aquifers and less rainfall. With the reduced snow pack and increased seasonal drought, many traditional drinking water sources are not being replenished.

D. Reduced availability of fish and shellfish resources is occurring now and is likely to increase due to changing water conditions.

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[52] Ibid ACIA. 2004.
[53] USGCRP. 2009. Regional Impacts: Pacific Northwest and Alaska. *EPA/600/R-07/094F*, Office of Research and Development, Washington, D.C.
[54] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.
[55] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.

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Climate change is bringing rapid and adverse habitat challenges, from changing stream flows to warming waters that are having an impact on the viability of juvenile salmon to the impacts of ocean acidification on salmon, crustacean, and shellfish food sources. Seafood is central to diet, physical, and cultural well-being of Tribal lifeways. Increasing ocean acidification threatens shellfish beds that Tribes have harvested for millennia. Ocean acidification may reduce rates of shellfish larval survival and weaken the shells of the adults, thus making them more vulnerable as well.[56]

E. Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.

Children playing in areas with higher ozone levels resulting from increased temperature will be at higher risk for experiencing asthma symptoms, although in Region 10 the impacts from higher ozone levels are not anticipated to be significant. The elderly are more vulnerable to heat stress because they are often in poorer health and are less able to regulate their body temperature during periods of extreme heat. Economic constraints can also place low-income households at disproportionate risk to extreme heat events due to lack of air condition or failure to use air-conditioning to cut down on associated energy costs.

Section 3: Region 10 Priority Existing Actions

The sections below present the existing actions EPA Region 10 is taking to address the identified vulnerabilities and their associated impacts. These existing actions are from commitments in the EPA Region 10 Strategic Alignment Plan and existing actions identified by the program offices in EPA Region 10. The actions are summarized below for each EPA Region 10 office. A more complete description of the actions can be found in Appendix C. Also, Appendix D compares the vulnerabilities identified in Section 2 with the existing Regional actions by National or Regional goals.

Appendix D indicates that there are Regional vulnerabilities where there are no existing actions. Since this documents focus is existing actions, EPA Region 10 will evaluate how to address critical vulnerabilities in the future. In addition, Region 10 will evaluate how to better integrate climate change into its existing core programs along with engaging states, Tribes and other partners to adapt to changing environmental conditions.

EPA Region 10 has developed the following criteria that can be used for evaluating priority actions in the future.

- Actions that address an identified vulnerability in Region 10.

[56] Orr, J.C., et. al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437(7059), 681-686.

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- Actions that align with EPA national or regional priorities for climate change.
- Actions that will assist tribes in adapting to climate change.
- Actions that are linked to sustainability and environmental justice.
- Actions that increase awareness of climate change for EPA Region 10 staff.
- Actions that promote integration of climate change into EPA Region 10 program operations.
- Actions that increase awareness and collaboration with outside partners including tribes.
- Actions where EPA has a unique role or capacity to address the issue.

1. Office of Air, Waste, and Toxics (OAWT)

EPA Region 10's Office of Air, Waste, and Toxics (OAWT) carries out air, waste and chemicals management programs under statutory authorities such as the Clean Air Act (CAA), Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), the Pollution Prevention (P2) Act, and the Diesel Emission Reduction Act (DERA), and carries out TSCA enforcement actions dealing with lead-based paint and asbestos. Many of OAWT activities reduce greenhouse gas emissions. OAWT is currently also involved in the following Region-specific actions that address the climate change vulnerabilities identified in the previous section for Goals 1, 3 and 4.

Indoor Air (Goal 1)

- Develop and host training for professionals (housing, medical, schools) on making indoor environments healthier for the most vulnerable.

Materials Management and Pollution Prevention (Goals 3 and 4)

- Work with our partners through the West Coast Climate and Materials Management Forum and our pollution prevention technical assistance providers and grants to assist in the transition to sustainable materials management processes and source reduction.
- Recruiting and retaining participants for the Federal Green Challenge and for the Food Recovery Challenge in support of the EPA's Sustainable Materials Management (SMM) Program.

Tribal Waste Management (Goal 3)

- Work with federally recognized tribes in Region 10 to address landfills and unconfined open dumps which are impacted by climate change and help develop appropriate responses to these threats.

RCRA Corrective Action and Permitting (Goal 4)

- Ensuring that Climate Change guidance and policy capture RCRA issues.
- Incorporating green remediation in corrective action decision-making.

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2. Office of Water and Watersheds (OWW)

EPA Region 10's Office of Water and Watersheds (OWW) implements programs under the CWA, Safe Drinking Water Act (SDWA), and parts of the National Environmental Policy Act (NEPA). Also, OWW provides funds for Puget Sound via the National Estuary Program to support climate change adaptation projects. OWW's current focus is on increasing awareness for Regional staff and partners on the science of climate change and strategies for adaptation to meet this goal. Many of these actions will benefit from the development and implementation of appropriate national guidance to promote consistency across the states. The Region will implement these actions in coordination with any related national guidance. The actions mainly focus on addressing the vulnerabilities for Goal 2.

Drinking water, wastewater, and stormwater infrastructure (Goal 2)

- Work with the State of Alaska to identify alternative technologies for providing first time service to unserved homes in a more sustainable way compared to a traditional piped system.
- Work with the Water Sense program to encourage water efficiency in homes, landscaping and commercial buildings with a focus on new homes.
- Continue implementing the Sustainable Energy Management Program with a Western Washington cohort of drinking water and wastewater utilities.

Freshwater fisheries (Goal 2)

- Continue with pilot program examining how to integrate climate change in an ongoing total maximum daily load (TMDL) by examining how temperature can be improved in the Nooksack watershed in order to support salmon restoration.

Puget Sound (Goal 2)

- Continue to support projects in Puget Sound related to climate change. There are several on-going projects that are highlighted in Appendix C.
- Work with the University of Washington to develop a system for visualizing and analyzing a variety of climate change-related features that are shifting with time and probability across the Region.

Training and Outreach (Goal 2)

- Inform and educate water program managers in the public and private sectors on climate change and water issues and EPA related activities such as the National and Regional climate change adaptation strategies.
- Work with States, Tribal governments, municipalities, non-profit organizations and businesses to promote the Climate Ready Water Utilities (CRWU) and Climate Ready Estuaries (CRE) Programs and new Climate Ready Resilience and Awareness (CREAT) Version 2.0.
- Support Development of a Climate Change Section in the "Green" Paper for the State Revolving Loan Funds and Annual Review Checklists.

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3. Office of Ecosystems, Tribal, and Public Affairs (ETPA)

EPA Region 10's Office of Ecosystems, Tribal, and Public Affairs (ETPA) implements cross-program efforts to protect the environment and engage communities and leads Regional efforts related to Freedom of Information Act requests, environmental justice, and sustainable agriculture. ETPA's focus is to ensure consideration of climate change on projects via NEPA review process, incorporating climate change science in wetlands management, providing assistance to Region 10 Tribes for climate change activities, and supporting activities that address children's health and other vulnerable populations.

NEPA Review (Goal 2)

- Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.
- Include ocean acidification language in NEPA review comment letters as appropriate and develop template language in letters and example NEPA analyses that include ocean acidification information.

Wetlands (Goal 2)

- Coordinate a *Wetlands and Climate Change Research Meeting* focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate.
- Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation.
- As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change.
- Integrate climate adaptation in the FFY14/15 Region 10 Wetland Program Development Grants RFP by considering how the design and installation of demonstration projects would take relevant potential impacts from climate change into account when considering long-term viability.[57]

Ocean Programs (Goal 2)

- Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan

Tribes (Multiple Goals)

- Support Tribes to develop adaptation actions (plans), to document impacts from climate change and to engage in the collaboration with local, state and federal agencies working on broad based adaptation plans.

[57] http://www.epa.gov/region10/pdf/wetlands/FY13_Wetland_Program_Development_Grants_Request_for_Proposals.pdf

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- Provide Indian General Assistance Program (IGAP) funding as appropriate to Tribes with climate change in their IGAP workplans to do baseline environmental assessments and support adaptation planning.
- Raise awareness by providing educational outreach, training, and webinars to Tribes and work with the Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.
- Support Tribal projects on climate change in Puget Sound through the National Estuary Program. A listing of those projects is included in Appendix C.
- Assist Tribes to build capacity and knowledge and assess and address air quality concerns including those related to climate change through the Regional Clean Air Act Grants.
- Support the Rural Alaska Children's Health Initiative which works to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change.

Community Health (Regional Goal 7)

- Through work on children's health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations.
- Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality (e.g., work with Tribal Air Program and convene Rural Alaska Children's Environmental Initiative).
- Outreach/risk communication to vulnerable and economically deprived communities.
- Work with Department of Housing and Urban Development, Department of Transportation, and Urban Sustainability Directors Network on promoting sustainable communities via housing, transportation, and transit.

4. Office of Environmental Clean-Up (ECL)

EPA Region 10's Office of Environmental Clean-Up (ECL) is responsible for investigating contaminated properties; cleaning up contaminated land, sediment, and water for appropriate uses; emergency response; emergency planning and spill prevention; and Homeland Security and counter terrorism preparedness. ECL works closely with communities and interested stakeholders, providing funding in some cases to facilitate meaningful engagement in the Superfund process. ECL has focused on green remediation strategies for specific sites, and the reduction of carbon and toxic emissions and reducing overall environmental footprint of clean-up activities. There are no specific adaptation activities currently underway in ECL.

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5. Office of Compliance and Enforcement (OCE)

EPA Region 10's Office of Compliance and Enforcement (OCE) provides enforcement, compliance monitoring, and compliance assistance for ground water, pesticides and toxics, wastewater (NPDES), air, and solid and hazardous waste (RCRA) programs. Regional and national enforcement priorities change. OCE is positioned to be flexible and use discretion when deciding those enforcement priorities, even as those priorities are influenced by climate change. OCE has several ongoing activities all of which fall under Goal 5.

- Continue to use an Environmental Justice Screening tool to identify regulated facilities located in overburdened communities.
- The UIC program will continue to permit several Class I wells for underground injection of wastes to reduce the need to establish waste retention ponds on the increasingly vulnerable permafrost.
- Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts.
- Continue to look for opportunities to encompass green infrastructure as part of settlement agreements.

6. Office of Regional Counsel (ORC)

The Region has broad legal mandates to protect human health and the environment and therefore, broad legal authority to support adaptation work. In the course of adaptation planning, specific questions will likely arise that will need legal review. As there is variation among the statutes EPA administers, as well as the regulatory programs EPA designs, implements, and enforces under those laws, the best way for ORC to support adaptation efforts is to provide legal analysis on a case by case basis. ORC will also support each of the regional program offices by coordinating with the Office of General Counsel, offices of Regional Counsel in other regions, and the Office of Enforcement and Compliance Assurance, as necessary to provide legal advice to the regional program offices.

7. Office of Environmental Assessment (OEA)

EPA Region 10's Office of Environmental Assessment (OEA) provides scientific and technical expertise in assessing the condition of the environment to support program decision-making and scientific initiatives. OEA collects and analyze data to characterize the environment, investigate environmental problems, and evaluate proposed solutions. A major emphasis of the OEA's activities are related to raising awareness on the science of climate change to staff in the Regional office, to integrate climate

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change into the core program work, and to work with external partners to better coordinate the work and increase collaboration. OEA has several ongoing activities that address of the goals.

- Provide outreach/trainings to increase awareness of climate science to regional staff and partners.
- Work with individual programs and cross-office projects to integrate climate science into core program work.
- Communicate with the public about hazards posed by climate change and actions being taken by the EPA to address climate change.
- Coordinate with other federal agencies by participating on the Climate Change Cooperative and supporting the Regional Landscape Conservation Cooperatives.
- Participate on the National Tribal Science Council, and support actions related to climate change and tribes.

Section 4: Developing Measures, Monitoring and Evaluating Performance

Evaluating progress is important because there will be "learning by doing" over time as we mainstream climate adaptation planning into our programs. We will monitor the outputs and outcomes of our actions so we can learn what works – and why, and what doesn't work – and why not. This will allow us to continually improve the effectiveness of our mainstreaming efforts and share our lessons learned with other regions and our national programs. An evaluation process will be developed during the first year of implementation to learn how to best capture desired outcomes, some of which will come as staff integrates climate science into programmatic work. Appendix C provides more details on the Region 10 approach to develop and measure specific metrics.

Section 5: Legal and Enforcement Issues

The legal and enforcement issues were discussed in Sections 2 under Goal 5: Enforcing Environmental Laws and in Section 3 under the Office of Compliance and Enforcement and Office of Regional Counsel.

Section 6: Training and Outreach

The specific actions related to training and outreach is discussed in Section 3. Training and outreach is a critical part of Region 10's Implementation Plan. One of the primary tasks of the Regional Climate Change Advisor is to provide training and outreach for both Regional staff and partners. The goal of the training and outreach is to provide the foundation for programs to integrate climate science into their core program work.

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Section 7: Partnerships with Tribes

As part of the EPA's direct federal implementation and oversight responsibilities, EPA Region 10 has a trust responsibility to each of the 271 federally recognized Indian tribes within the Region. EPA values its unique government-to-government relationship with Indian tribes in planning and decision making. This trust responsibility has developed over time and is further expressed in the *1984 EPA Policy for the Administration of Environmental Programs on Indian Reservations* and the *2011 Policy on Consultation and Coordination with Indian Tribes*. These policies recognize and support the sovereign decision-making authority of tribal governments.

Supporting the development of adaptive capacity among tribes is a priority for the EPA. Indigenous peoples are particularly vulnerable to the impacts of climate change due to the integral nature of the environment within their traditional lifeways and culture. There is a strong need to develop adaptation strategies that promote sustainability and reduce the impact of climate change on Tribes and tribal members.

EPA engaged tribes through a formal consultation process in the development of the Agency's *Climate Change Adaptation Plan*. Tribes identified some of the most pressing issues as erosion, temperature change, drought and various changes in access to and quality of water. Tribes recommended a number of tools and strategies to address these issues, including improving access to data and information; supporting baseline research to better track the effects of climate change; developing community-level education and awareness materials; and providing financial and technical support. At the same time, tribes challenged EPA to coordinate climate change activities among federal agencies so that resources are better leveraged and administrative burdens are reduced.

EPA Region 10 plans to partner with tribal governments, in collaboration with other Federal agencies, on an ongoing basis to increase their adaptive capacity and address their adaptation-related priorities. These collaborative efforts will benefit from the expertise provide by our tribal partners and the Traditional Ecological Knowledge (TEK) they possess. TEK is a valuable body of knowledge in assessing the current and future impacts of climate change and has been used by tribes for millennia as a valuable tool to adapt to changing surroundings. Consistent with the principles in the 1984 Indian Policy, TEK is viewed as a complementary resource that can inform planning and decision-making.

Networks and partnerships already in place will be used to assist tribes with climate change issues, including Regional Tribal Operations Committees, the Institute for Tribal Environmental Professionals and IGAP. Additionally, efforts will be made to coordinate with other Regional and Program Offices in EPA and other partners such as other federal agencies, since climate change has many impacts that transcend media and regional boundaries. Transparency and information sharing will be a focus, in order to leverage activities already taking place within EPA Offices and tribal governments.

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Section 8: Vulnerable Population and Places

As mentioned in Sections 1, 2 and 3, certain parts of the population, such as children, the elderly, minorities, the poor, persons with underlying medical conditions and disabilities, those with limited access to information, and tribal communities, can be especially vulnerable to the impacts of climate change. Also, certain geographic locations and communities are particularly vulnerable, such as those located in low-lying coastal areas. One of the principles guiding EPA's efforts to integrate climate adaptation into its programs, policies and rules calls for its adaptation plans to prioritize helping people, places and infrastructure that are most vulnerable to climate impacts, and to be designed and implemented with meaningful involvement from all parts of society.

This Implementation Plan identifies key programmatic vulnerabilities and the priority actions that will be taken to address those vulnerabilities over time. As the work called for in this Plan is conducted, the communities and demographic groups most vulnerable to the impacts of climate change will be identified. The Agency will then work in partnership with these communities to increase their adaptive capacity and resilience to climate change impacts. These efforts will be informed by experiences with previous extreme weather events (*e.g.,* Hurricane Katrina and Superstorm Sandy) and the subsequent recovery efforts.

Section 9: Cross-Office Pilot Projects

Developing cross-office pilot projects is a vital role for the Region 10 Climate Change Advisor. Region 10 has a TMDL pilot project described in Appendix C on the Southfork of the Nooksack River. We anticipate building on that success using the same approach of outreach at the unit or office/program level to increase awareness of vulnerabilities and available science. At the same time, we will collect input on climate science needs and ideas on how the science might be incorporated into day-to-day decisions. To keep the process sustainable, OEA provides some initial assistance and looks for partners to provide some further assistance.

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APPENDICIES

Appendix A: Vulnerabilities Identified by Region 10 States and Tribes

Appendix B: Detailed Description of EPA Region 10 Program Vulnerabilities

Appendix C: Detailed Description of EPA Region 10 Existing Actions

Appendix D: Comparison of Vulnerabilities and EPA Region 10 Existing Actions

Appendix E: EPA Region 10 Approach for Measuring Success

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Appendix A: Vulnerabilities Identified by Region 10 States and Tribes

Oregon

The State of Oregon has developed a framework[58] that condenses specific vulnerabilities and risks from climate change into 11 overarching categories. They then ranked these into three groups: very likely, likely, and more likely than not. While the framework does not indicate a formal peer review was conducted, the Oregon Climate Change Research Institute (OCCRI) assisted in the development of the framework and the risks are fully documented with extensive citations. The categories and ranked risks are:

Very Likely Risks:

- Increase in average annual air temperatures and likelihood of extreme heat events that also increase water temperatures
- Changes in hydrology and water supply; reduced snowpack and water availability in some basins; changes in water quality and timing of water availability

Likely Risks:

- Increase in wildfire frequency and intensity
- Increase ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification
- Increased incidence of drought
- Increased coastal erosion and risk of inundation from increasing sea levels and increasing wave heights and storm surges
- Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife
- Increase in diseases, invasive species, and insect, animal, and plant pests
- Loss of wetland ecosystems and services

More likely than not Risks:

- Increased frequency of extreme precipitation events and incidence and magnitude of damaging floods
- Increased incidence of landslides

Washington

Similarly, Washington State Department of Ecology has summarized climate impacts in Preparing for a Changing Climate: Washington States' Integrated Climate Response Strategy.[59] The information below is a summary of the Ecology document and the references are included in their document and they are not repeated here. Washington examined projected impacts for sector groupings – e.g., Built Infrastructure, Wildlife & Habitat, etc. They also worked with University of Washington's Climate Impacts Group to understand how the impacts might affect the different sector groups, with the goal of prioritizing actions within those groups and developing coordinated strategies. The impacts include the scientific evidence and are summarized into the following groups:

Warmer temperatures and more severe heat waves: In the Pacific Northwest, average annual temperature rose 1.5 °F between 1920 and 2003. Climate scientists' project average annual temperatures in the Pacific Northwest will rise 2°F by the 2020s and 3.2°F by the 2040s, compared with 1970-1999 averages. Heat waves are projected to occur more often and last longer.

Larger and more intense wildfires: Researchers project that the area burned by fire each year in the Columbia Basin will double or triple by the 2080s, compared to the 1916-2006 average. Costs of fighting wildfires are expected to rise and risks to communities, the environment, and wildlife are expected to increase.

[58] http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf
[59] http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm

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Drier summers and wetter autumns and winters: Downscaled climate models project that summer precipitation will decrease and autumn and winter precipitation will increase. Washington could experience more intense rainfall events more often.

Decreased snowpack and loss of natural water storage: In Washington's Cascades, average snowpack declined about 25 percent between 1950 and 2006. Spring snowpack across Washington State is projected to decrease 28 percent by the 2020s and 40 percent by the 2040s relative to the 1916-2006 average, and snowmelt is expected to occur earlier in the spring.

More frequent and severe drought: Increasing temperature, declining snowpack and earlier snowmelt will increase the risk of summer water shortages and increase the demand for water. The amount of water available for communities, irrigation, fish, hydropower generation, recreation, and other uses will be affected and competition for water will increase.

More severe winter flooding: Although the risks vary by location, Washington is expected to experience more severe winter flooding during the winter due to more precipitation falling as rain instead of snow in the mountains. More severe winter flooding poses challenges for managing reservoirs for flood control, fish, and hydropower production. Damages and repair costs for vulnerable homes, roads, and other infrastructure could increase. Extreme rainfall may place more stress on our stormwater infrastructure.

Sea level rise: Global sea level has risen about 7 inches during the 20th century and is projected to rise at a higher rate in the future. For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to rise 24 inches over the next century. In addition, an earthquake magnitude of 8 or greater along the Cascadia Subduction Zone would suddenly raise sea level along the coast of Washington and Oregon by an additional 3-7 feet, exacerbating the effects of sea level rise due to climate change.

Idaho

Climate change planning in Idaho is mainly led by the Idaho Experimental Program to Stimulate Competitive Research (EPSCoR). Two major river basins of national significance are in Idaho, the Snake River Plain (Snake) and the Salmon River Basin (Salmon). The EPSCoR work addresses concerns about how the hydrology in Idaho will change as climate changes in the western U.S. Of particular interest to EPSCoR is how the connection between surface water and groundwater in the Snake River Plain may change.[60]

According to EPSCoR, the National Ground Water Association has stressed that groundwater supplies might be used in the future to balance large swings in water supplies caused by drought and climate change. Despite this, the connections between climate change and groundwater is largely unexplored and poorly understood. The projected changes in the timing and magnitude of stream flows will affect ecosystems in sensitive areas. In addition, because Idaho's economy is strongly coupled to water and snowmelt, the proposed research has direct application to Idaho's citizens and implications for decision makers.

Concerns in Idaho center on:

Hydroclimatology and the connections between surface water and groundwater; understand how projected climate change might affect the timing and magnitude of mountain snow packs and snowmelt.

Hydro-economics/policy and changes in the timing and variability of water supply on land use, economic production, urban growth, and water management, and water rights.

Hydroecology and effects of climate change on natural ecosystems such as species shifts, and integrated relationships between climate, hydrology, fire, insects, ecology, and changing landscapes.

Alaska

The State of Alaska Adaptation Advisory Group describes vulnerabilities including impacts that are already occurring in their document, Alaska's Climate Change Strategy: Addressing Impacts in Alaska.[61] The information

[60] http://www.idahoclimatechange.org/DrawOnePage.aspx?PageID=135

[61] http://www.climatechange.alaska.gov/aag/docs/aag_ES_27Jan10.pdf

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below is from the executive summary of the document. The references are included in the document and are not repeated in this document.

Permafrost Thawing and Sea Ice Melting

Permafrost underlies most of Alaska. Air temperature, snow cover, and vegetation affect the temperature of the frozen ground and the depth of seasonal thawing. Recent decades of warmer temperatures have produced extensive thawing, which has resulted in increased coastal erosion, landslides, and sinking of the ground surface, as well as consequent disruption and damage to forests, buildings, infrastructure, and coastal communities. In addition, many industrial activities depend on frozen ground surfaces, and many northern communities rely on ice roads for transport of groceries and other materials. Continued warming will further impair transport by shortening the seasonal use of ice roads. Thawing is projected to accelerate under future warming, with as much as the top 10 to 30 feet of discontinuous permafrost thawing by 2100.

Sea ice off the Alaskan Coast is retreating and thinning, with widespread effects on marine ecosystems, coastal climate, human settlements, and subsistence activities. Recent studies estimate arctic-wide reductions in annual average sea-ice extent of about 5-10% and a reduction in average thickness of about 10-15% over the past few decades. Retreat of sea ice allows larger storm surges to develop, increasing the risk of inundation and increasing erosion on coasts already made vulnerable by permafrost thawing. Loss of sea ice also causes large scale changes in marine ecosystems, and threatens populations of marine mammals and polar bears that depend on ice. At the same time, the continued reduction of sea ice is very likely to increase the navigation season, and within several decades a seasonal opening of the Northern Sea Route is likely to make trans-arctic shipping feasible during summer months, although increasing ice movement will initially make shipping more difficult in some channels of the Northwest Passage.

Threats to Coastal Communities, Habitats, and Infrastructure

Alaska has more coastline than the other 49 states combined. Increases in the frequency and intensity of storm surges have triggered increased coastal erosion that is threatening a number of coastal villages. A recent report from the Government Accountability Office (GAO) indicated that 31 villages face imminent threats. Storm surges have also reduced the protection that barrier islands and spits provide to coastal habitats. Both coastal and inland infrastructure face threats due to the climate change. Thawing permafrost threatens water and sanitation infrastructure, and roads, buildings, pipelines, power lines and other infrastructure are threatened by coastal erosion and degrading permafrost.

Forest and Vegetation Changes

The Arctic region, particularly Alaska, is already experiencing major ecological impacts as a consequence of warming. Rising temperatures have caused northward expansion of boreal forest in some areas, significant increases in fire frequency and intensity, and unprecedented insect outbreaks. Current projections suggest that, due to increases in burn area per decade, the tundra-dominated landscape on Seward Peninsula will eventually be replaced by deciduous forest. In other areas, forested areas are likely to convert to bogs as permafrost thaws. Growing-degree days have increased by 20%, with benefits for agriculture and forest productivity on some sites, and reduced growth on others.

Sensitivity of Marine Ecosystems and Fisheries

The Gulf of Alaska and Bering Sea support marine ecosystems of great diversity and productivity as well as the nation's largest commercial fishery. Perhaps one of the most daunting threats lies in increasing acidification of the cold Alaskan waters. This would affect all organisms that possess calcifying shells, and these organisms play an integral role in the food web. Recent climate-related impacts observed in the Bering Sea include significant reductions in seabird and marine mammal populations, unusual algal blooms, abnormally high water temperatures, and low harvests of salmon on their return to spawning areas. Future projections for the Bering Sea suggest productivity increases at the base of the food chain, poleward shifts of some cold-water species, and negative effects on ice-dwelling species. Warmer temperatures will also affect commercial fisheries by inducing

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large northward shifts of fish and shellfish species. This would result in decreased harvesting of cold-water species such as salmon and pollock, and increased harvesting of other species.

Changes in the Diversity, Ranges, and Distributions of Species

The Arctic sub-region that includes Alaska, Chukotka, and the Western Canadian Arctic is home to over 70 percent of the rare plant species that occur only in the Arctic and a number of plant and animal species already classified as "threatened." Species concentrated in small areas, such as Wrangell Island, are particularly vulnerable to the direct effects of climate change combined with competition from migrating non-native species.

Increased Stress on Subsistence Livelihoods and Lifestyles

Subsistence makes an important contribution to livelihood in many isolated rural communities, especially but not exclusively for native peoples. Livelihoods that sustain indigenous communities include hunting, trapping, gathering, and fishing. These activities not only make significant contributions to the diet and health of many indigenous populations, but also play large and important social and cultural roles. Reduced or displaced populations of marine mammals, seabirds, and other wildlife, together with continuing thinning of sea-ice, have affected the safety and the dietary and economic well-being of subsistence communities.

Tribes

Among other effects of climate change, Tribes are concerned about declining stocks, changes in migration patterns, and other impacts on natural resources including endangered species.[62] In an effort to begin an understanding of Tribal cultural resource vulnerabilities, Region 10 reviewed the Swinomish Climate Change Initiative Impact Assessment Technical Report as a very useful resource.[63] Although peer review was not described, this report represents the work of a multidisciplinary team led by staff of the Swinomish Office of Planning & Community Development, in partnership with the University of Washington Climate Impacts Group (CIG), and with further scientific assistance from Skagit River System Cooperative (SRSC). CIG staff played a crucial role in reviewing scientific data, reports, and project documents, advising on the use of scientific data and information in the project, and in identifying probable local impacts and climate change scenarios. Scientific expertise was also provided by Skagit River System Cooperative, which partnered with Western Washington University and Battelle Northwest to model hydrologic impacts at the local level.

The cultural vulnerabilities identified in the Swinomish Impact Assessment included:

- Shrinking land base (sea level rise);
- Inundation of coastal sites/artifacts;
- Exposure of burial sites and human remains from strong storm events;
- Loss of cultural use plants; and
- Ecological Impacts on resources within the Swinomish traditional use areas.

In addition, Region 10 has funded two Indian General Assistant Program (IGAP) grants for the Jamestown and Port Gamble S'Klallam Tribes to develop a climate change vulnerability assessment template that other tribes could use. The work began in January 2012. The Jamestown Tribe Tribal Advisory committee was formed and identified four areas of concern for which they developed subcommittees: facilities/roads; economics; natural resources; and human health. The Tribe's process will be reported in a short stand-alone document that may be used by other Tribal Governments.

[62] James Woods, Region 10 Senior Tribal Policy Advisor

[63] http://www.swinomish.org/departments/planning/climate_change/climate_main.html

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Another useful description of vulnerabilities related to Alaskan Tribes, in particular, is the Tribal Climate Change Adaptation Plan Template[64] which references three sources.[65,66,67] A summary of the findings from the Template are included below. The specific references are included in the Template and are not repeated here.

Alaska has already experienced many climate-related changes including earlier spring snow melt, a decrease in sea ice, thawing permafrost, glacier retreat, changes in precipitation levels, and an increase in drought and wild fires. The annual average temperature has increased by 3.4°F, while winter temperatures have increased by 6.3°F during the last half century. The snow-free season lengthened by an average of 10 days throughout the state between 1970 and 2000; this continues to impact Alaska's soil moisture and consequently vegetation that is not accustomed to drought-like conditions.

Rising temperatures are creating a more hospitable habitat for spruce beetles resulting in a severe infestation in spruce forests in the south-central portion of Alaska; there has also been an increase in catastrophic wildfires throughout the state due to the warmer and drier conditions. Additionally Alaska is beginning to witness a thaw in permafrost which is affecting not only human-made infrastructure, but also forest health and lake area in wetland ecosystems.

Continued future warming in this region is inevitable, even if all greenhouse gas emissions were halted today. Temperatures are projected to increase anywhere between 5°F and 13°F by the end of the 21st century, depending on different emission scenarios. These increasing temperatures are expected to have major consequences on the different ecosystems in Alaska. This includes the warming of sea surface temperatures, further reductions in sea ice (impacting not only marine mammals but also eliminating a natural buffer to coastal storms), increased coastal erosion and flooding, an increase in catastrophic wildfires (models suggest that the yearly average area that burns may double by the middle of the century), and the warming and thawing of permafrost (Karl *et al.*, 2009).

The changes that are already occurring in Alaska, and that will continue to occur, have the potential to alter the landscape considerably and may have immeasurable implications for Alaska's plants, animals and people.

Alaska has already experienced many climate-related changes including: earlier spring snow melt; decrease in sea ice (important to marine mammals and a natural buffer to coastal storms); thawing permafrost, which makes tribal infrastructure (water, sewer, and foundations) designed for permafrost conditions extremely vulnerable to failure; glacier retreat; changes in precipitation levels; increase in drought, vegetation stress, and wild fires; severe infestation of spruce beetles in the south-central portion of Alaska; and increased coastal erosion and flooding.

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[64] http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

[65] USGCRP. 2009. *Global Climate Change Impacts in the United States* . Karl, T.R., J. M. Melillo, and T. C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.Karl, T. R., Melillo, J. M., & Peterson, T. (2009). Global Climate Change Impacts in the United States. New York, NY: Cambridge University Press.

[66] U.S. Department of Interior, Bureau of Indian Affairs website accessed on January 20, 2011 at: www.bia.gov/WhoWeAre/RegionalOffices/Alaska/index.htm

[67] U.S. Fish and Wildlife Service website accessed on January 20, 2011 at: http://alaska.fws.gov/climate/index.htm.

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Appendix B: Detailed Description of EPA Region 10 Program Vulnerabilities

In general, where possible, the sources cited by Region 10 use the Intergovernmental Panel on Climate Change (IPCC) likelihood of outcome terminology where 'very likely' means 90-100% probability, and the term 'likely' means 66-100% probability. Some likelihoods are noted as "Occurring now" where appropriate.

In addition, the use of terms are as follows: "High" assumes the program will be affected by the impact; "Medium" assumes the program could be affected under some conditions by the impact; "Low" assumes that there is a potential for the program to be impacted or uncertainty currently exists as to the potential nature and extent of the impact.

Goal 1: Taking Action on Climate Change and Improving Air Quality

1.A. <u>Increased tropospheric ozone pollution</u> in certain areas due to increased average summertime temperatures

Likelihood of Impact: Likely. Projections of future tropospheric ozone levels in the literature for the Pacific Northwest and Alaska are inconclusive at this time but the level of impact could change as new information becomes available. See further discussion below.

Focus of Associated EPA Program: Protecting public health and the environment by attaining the National Ambient Air Quality Standards (NAAQS) by implementing programs in States and Indian Country to help meet the standards

Likelihood of EPA Program Affected: High in large urban areas in the Pacific Northwest – Washington, Oregon, and Idaho, and Low in remaining rural areas and in Alaska.

Example of Risks if Program were Impacted: Could become more difficult to attain NAAQS for ozone in metropolitan areas where ozone design values are close to the NAAQS.

Regional Importance of Vulnerabilities: Washington, Idaho, and Oregon each have at least 1 metropolitan area that has ozone design values close to the ozone NAAQS. There is the possibility that higher summertime temperatures would increase ozone productivity as well as emissions of VOC precursors and, there is scientific consensus that climate change will decrease the background ozone in the lower troposphere where the water vapor effect is dominant.[68] Ozone in NOx-limited areas is projected to decrease as well as a result of climate change. From the available academic literature that included results for the Pacific Northwest, there is no consistent finding about whether climate change will increase, decrease, or have no change on ozone in this region.[69,70] Of potential greater concern for the Pacific Northwest and Alaska over the next several decades is the increase in transported ozone precursors from Asia. Asian transport of ozone will decrease with an increase in water vapor over the Pacific, but hydroxyl radicals will increase, potentially increasing ozone formation in PNW urban areas.[71]

Variation in importance across the Region: Ozone is more likely to increase with climate change in inland Idaho rather than Washington and Oregon due to coastal airflow. It is not an issue for Alaska since ozone formation is

[68] Jacob, DJ., and D.A. Winner. 2009. Effect of climate change on air quality, Atmos. Environ., *43,* 56.

[69] Ibid Jacob and Winter 51-63. Jacob, D.J., and D. A. Winner. 2009. Effect of climate change on air quality, *Atmos. Environ., 43*, 51-63.

[70] U.S. Global Change Research Program. 2009., Assessment of the impacts of global change on regional U.S. air quality: a synthesis of climate change impacts on ground-level ozone, *EPA/600/R-07/094F*, Office of Research and Development, Washington, D.C.

[71] Task Force on the Hemispheric Transport of Air Pollution. 2010. Hemispheric transport of air pollution 2010, Part A: ozone and particulate matter, *Air Pollution Studies No. 17*, United Nations, New York, USA and Geneva, Switzerland.

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limited by relatively low summertime temperatures. Potential ozone increases are more likely to occur in the larger metropolitan areas including Spokane, Tacoma, Portland, and Boise. Whether or not these increases will result in violations of the NAAQS health standards however is unknown.

1.B. Increase in summertime temperatures and extreme temperature events can potentially affect concentrations of air toxics from anthropogenic sources.
Likelihood of Impact: Impact uncertain due to variability in effects of temperature increase on individual air toxics in Region 10.
Focus of Associated EPA Program: Reducing risk from emissions of air toxics through Maximum Achievable Control Technology (MACT), National Emission Standards for Hazardous Air Pollutants (NESHAPS) and residual risk programs
Likelihood of EPA Program Affected: There is insufficient literature available on air toxics and climate change to project this likelihood for Region 10.
Example of Risks if Program were Impacted: Could increase public health risks, including risks for the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations
Regional Importance of Vulnerabilities: Many HAP chemicals volatilize at higher temperatures, creating the potential for higher emission rates and higher concentrations in ambient air.[72] There is uncertainty however as to actual impacts on HAP concentrations since the boundary layer height will also likely be higher, adding more volume of air for the HAPs to mix into. It is also possible for pollutant removal mechanisms to increase as a result of climate change. There is still considerable uncertainty about the effect of climate change on air toxics in Region 10. **Variation in importance across the Region:** Although we would expect air toxics to be most important in urban areas near large sources or a high density of sources, we cannot say that this will be the norm in Region 10. Potential variations by individual air toxic, location, and season were indicated in a continuous monitoring of atmospheric mercury study comparing high arctic, sub-Arctic, and temperate sites. While background mercury levels were shown to be decreasing at sub-Arctic and temperate sites, the levels at Alert (Nunavut, Canada – locationally and climatically comparable to arctic Alaska) indicated increases in both RGM (reactive gaseous mercury) and TPM (total particulate mercury) from 2002 – 2009 in the spring when concentrations are the highest. Background mercury had decreased at all other locations.[73]

1.C. Increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture may impact <u>Particulate Matter levels</u>.[74]
Likelihood of Impact: Likely
Focus of Associated EPA Program: Protecting public health and the environment by assuring that the National Ambient Air Quality Standards (NAAQS) are attained and assisting States and Tribes in the implementation of programs to help meet these standards.
Likelihood of EPA Program Affected: High.
Example of Risks if Program were Impacted: Could complicate Agency efforts to protect public health and the environment from risks posed by particulate matter (PM) pollution in areas affected by more frequent wildfires.

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[72] IPCC. 2012. Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (Field, C.B., V. Barros, T.F. Stocker, D.Qin, D.J. Dokken, K.L. Ebi, M.D., Mastrandrea, K.J. Mach, G.K. Plattner, SlK. Allen, M. Tignor, and P.M. Midgley (eds.). A Special Report of Working Groups I & II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA pp. 1-19.
[73] Cole, A.S., et. al. 2013. Ten year trends of atmospheric mercury in the high Arctic compared to Canadian sub-Arctic and mid-latitude sites, Atmospheric Chemistry and Physics, 13, 3, 1535-45.
[74] Mote, P. K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder, 2014: Ch. 21: Northwest. Climate Change Impacts on the United States: The Third National Climate Assessment, J.M. Melilo, Terese (T.C.) Richmond and G.W Yohe, Eds., U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX. http://nca2014.globalchange.gov/report/regions/northwest#statement-1700.

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Implications: increased concentrations of PM resulting in public health impacts and increasing responsibility of public agencies to protect public health.

Regional Importance of Vulnerabilities: Larger and more frequent wildfires are predicted throughout the region as a result of warmer summertime temperatures, decreased soil and fuel moisture, and increased pest infestations. For example, in the Columbia Basin, the acres of forest burned are projected to double by the 2020s, and triple by the 2040s compared to average burned from 1916 to 2006.[75] These large increases in annual acres burned will increase the number of airsheds and communities impacted by high summertime concentrations of Pm10 and PM2.5 from wildfires, impacting the health of more individuals who have preexisting respiratory conditions such as asthma, and preexisting heart conditions. State, local, and Tribal air agencies will also be impacted by these events and Region 10 will be obligated to assist them. More frequent and larger wildfires could result in agricultural and forestry slash burning permits not being issued at all, or issued later into the winter, where permitted burning would more likely overlap with home heating season and add to emissions from woodburning stoves. Although increased wildfire will have little impact on the attainment of the National Ambient Air Quality Standards (NAAQS) or the SIP State Implementation Plan (SIP) program, the Region 10 impact would be in workload to process Exceptional Event documentation and potentially in assisting States, local communities, and land managers in minimizing the impact of increased wildfire smoke on human health.

Variation in importance across the Region: All four R10 States have a high percent of forested areas (about 50% for States of WA and OR) and would all be adversely affected by an increase in wildfires

1.D. Changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events will impact <u>indoor air quality.</u>

Likelihood of Impact: Very Likely

Focus of Associated EPA Program: Protection of public health from exposure to indoor air pollutants which are concentrated in indoor environments many times above ambient air levels. Potential for increased mold growth, particularly among buildings without access to air conditioning. Indoor Air Quality, Children's Health and outreach programs will be impacted due to increased need for public education and guidance on reducing exposures to both indoor and ambient air pollutants.

Likelihood of EPA Program Affected: High.

Example of Risks if Program were Impacted: Will increase public health risks including those from respiratory illnesses including asthma[76], and risks for susceptible populations - the young, the elderly, the chronically ill, and socioeconomically disadvantaged populations across the region. Alaska's native and rural populations are very vulnerable to worsening indoor air quality with more insulated housing reducing air circulation- thereby increasing levels of both indoor and ambient pollution - and increasing flood risk and melting permafrost that will support more mold growth[77]. Also, though not directly related to climate change, increasing use of wood combustion as an indoor heat source (due to rising cost of home heating oil) further impairs indoor air quality.

Regional Importance of Vulnerabilities: Important across the Region. Susceptible individuals will be impacted by elevated temperatures, increasing pollutant levels, and therefore increasing exposures to both indoor and ambient air pollution.

Variation in importance across the Region: Particularly important in environmental justice (EJ) areas and areas with a high density of more susceptible populations such as in Alaska's native villages[78] and on tribal reservations in Washington, Oregon and Idaho.

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[75] J.S. Littell, et. al. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Climatic Change 102(1-2): 129-158.

[76] Reid, Colleen and Gamble, Janet. 2009. Aeroallergens, Allergic Disease, and Climate Change: Impacts and Adaptation, Ecohealth Vol 6(3):458-470.

[77] Kovesi, Thomas MD et al. 2007. Indoor Air Quality and the Risk of lower respiratory tract infections in young Canadian Inuit children, Canadian Medical Association.

[78] Lisa Bulkow et al., 2010. Risk Factors for Severe Respiratory Synctial Virus Infection Among Alaska Native Children, Pediatrics. 109 (2).

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1.E. Depletion of the stratospheric ozone layer due to climate change effects on the atmosphere
Likelihood of Impact: Likely – changes continue over the Arctic.
Focus of Associated EPA Program: Restoring the stratospheric ozone layer, preventing UV-related disease, and providing a smooth transition to safer alternatives to CFCs and HCFCs
Likelihood of EPA Program Affected: Low – there is no stratospheric ozone monitoring or restoration program in R10.
Example of Risks if Program were Impacted: May be unable to restore ozone concentrations to benchmark levels as quickly at some latitudes.
Regional Importance of Vulnerabilities: Not uniformly important across the region. Important in the Arctic (Alaska) where severe depletion of stratospheric ozone has been observed during winter and spring months.[79] While there currently are no EPA Region 10 programs that directly deal with monitoring or restoring the stratospheric ozone layer, there is enforcement activity against violators related to use and disposal of CFCs and HCFCs and their substitutes.
Variation in importance across the Region: Most important in Alaska, particularly in Arctic regions.

1.F. Changes in the rate and distribution of deposition of sulfates, nitrates, and mercury as a result of changes in precipitation patterns.[80]
Likelihood of Impact: Impact potentially ranges from Unlikely to Likely. Much uncertainty exists re: the overall impacts of changes in precipitation on sulfates, nitrates and mercury deposition in Region 10. We assume that there would be increased deposition of available sulfates, nitrates, and mercury with increased precipitation, but the availability of these pollutants in the atmosphere may be decreasing due to control measures.
Focus of Associated EPA Program: Agency programs to protect ecosystems from atmospheric deposition of pollutants such as sulfates, nitrates, and mercury. Deposition of pollutants may also impact compliance with water quality standards and Total Maximum Daily Loads (TMDLs).
Likelihood of EPA Program Affected: There is insufficient research on sulfate, nitrate, and mercury deposition and climate change to project this likelihood for Region 10, particularly in light of increasing wildfires and transport from Asia.
Example of Risks if Program were Impacted: Could cause adverse effects on ecosystems throughout the region, particularly mountain ecosystems and freshwater ecosystems, and could contribute to accumulation of mercury in fish tissue. This would disproportionally effect populations of people whose diet consists of a high percent of fish. Water quality impacted during summer due to lower stream flows. TMDLs may be more difficult to attain. An accurate assessment of impacts is difficult to determine at this time.
Regional Importance of Vulnerabilities: Accumulation of sulfates and nitrates may kill sensitive plant species and alter richness of species in sensitive ecosystems through the region. Mercury deposition in freshwater habitats could contribute to bioaccumulation of mercury in fish tissue, posing risks to humans who consume these freshwater fish. Lower stream flows during the summer months could make attainment of TMDLs associated with release of pollutants from point sources more difficult to attain, negatively impacting ecosystem health. Atmospheric deposition of sulfates, nitrates and mercury from Region 10 sources are expected to decrease over time due to compliance with the new air toxics rules (i.e. the Mercury Air Toxics Standard – MATS), the attainment of additional reductions through the residual risk and technology review program, and mobile source controls. Additional compliance activities resulting in decreases over time include sources meeting permit requirements or closing down. There is some uncertainty in this expected downward trend however due to potential increased mercury releases due to wildfires and transport from Asia. Global emissions of mercury continue to change at the same time as the Arctic is experiencing ongoing climatic changes. Multi-year trends analysis in reactive gaseous

[79] G.L. Manney et. al., 2011. Unprecedented Arctic Ozone Loss in 2011, Nature 478, 469-475. October 27, 2011.
[80] Dawson, J.P., B.J. Bloomer, D.A. Winner, C.P. Weaver, 2013. Understanding the meteorological drivers of U.S. particulate matter concentrations in a changing climate, Bulletin of the American Meteorological Society, doi:10.1175/BAMS-D-12-00181.1, in press.

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mercury (RGM) and total particulate mercury (TPM) at a Canadian Arctic site indicated increases from 2002 to 2009 in both RGM and TPM in the spring when concentrations are highest.[81]

Variation in importance across the Region: Sulfate and nitrate deposition is important across the region. Mercury deposition is highest close to mercury sources, such as mining operations. The issue is more important for parts of the Region containing mountain ecosystems and freshwater ecosystems and for parts of the Region where people's diets consist of a high percent of fish. While studies have shown that on the East Coast, sulfate concentrations increase with temperature due to faster SO2 oxidation (higher rate constants and higher oxidant concentrations)[82,83] no studies are available to indicate that the same is true for the Pacific Northwest and Alaska. In contrast, nitrate and organic semi-volatile components shift from the particle phase to the gas phase with increasing temperature.[84] Overall effects are uncertain however because higher temperatures drive increased chemical reactions and possibly more secondary organic carbon. At the same time there might be changes to the boundary layer height, airmass ventilation rate, and precipitation. We do not know the relative importance of these effects in R10 states.

[81] Cole, A.S., et. al. 2013. Ten-year trends of atmospheric mercury in the high Arctic compared to Canadian sub-Arctic and mid-latitude sites, Atmospheric Chemistry and Physics, Vol 13, Issue 3, pp. 1535-45.

[82] Aw, J., and Kleeman, M.J. 2003. Evaluating the first-order effect of intra-annual temperature variability on urban air pollution. J. Geophys. Res. 108, 4365.

[83] Dawson, J.P., et. al. 2007. Sensitivity of PM2.5 to climate in the Eastern US: a modeling case study. Atmos. Chem. Phys. 74,295–4,309

[84] Tsigaridis, K., and Kanakidou, M. 2007. Secondary organic aerosol importance in the future atmosphere. Atmos. Environ. 41, 4682–4692.

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Goal 2: Protecting America's Waters

2.A. Regional focus: Increasing heavy precipitation events and more frequent flood events may impact water systems and infrastructure.
Likelihood of Impact: Very Likely
Focus of Associated EPA Program: Protecting Water infrastructure: drinking water, wastewater, stormwater, and agricultural irrigation systems and infrastructure.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Water infrastructure could be overwhelmed or damaged. Impacts on water infrastructure may result in an increased number of sewer overflows and wastewater bypasses, as well as increased pollutant loads in runoff, increased pollution of streams and threats to public health.[85] Drinking water and wastewater utilities will need an integrated approach to planning for emergencies and extreme weather events.[86] Problems of safety as well as access to clean and safe water will be exacerbated for Tribal communities, and other vulnerable and economically depressed communities who have limited access to clean water supplies.[87] Agricultural productivity may be impacted in areas with inadequate water storage capacity and limited agricultural irrigation systems.
Regional Importance of Vulnerabilities: The Region will work with the Tribes and States to assist in water planning by sharing information on available downscaled models and tools and provide technical assistance, outreach, and education to further assist in the implement of state and tribal voluntary programs. Climate change impacts drinking water by heightening risk of contamination of surface water sources due to higher temperatures, lower flows, and increased erosion/sedimentation. For example, in Alaska, melting permafrost is causing sources of drinking water for rural communities to disappear altogether, plus increased erosion is causing more sediment.[88] Also road and bridge failures from more storms, erosion, etc. will result in more accidents and spills that threaten drinking water supplies. Groundwater sources could be impacted by changes in hydrology, also impacting changes in transport of potential contaminants.
Variation in importance across the Region: Important across the region, but especially in areas with ageing or inadequate water infrastructure. Adequate summertime water supply for irrigation of crops is essential to agricultural communities east of the Cascades in OR, WA, and ID. For tribes, who lack irrigation infrastructure and rely primarily on lakes and streams as water sources, availability of water for agriculture may be more severely impacted by climate change.

2.B. Regional focus: Earlier stream runoff and scouring of streambeds due to earlier snow melt, and decrease summer stream flows and increased steam temperatures will adversely impact fresh water fisheries
Likelihood of Impact: Occurring Now and very likely to increase
Focus of Associated EPA Program: Protection of Fresh water Fisheries: Loss and extinction of salmon species and other cold water fisheries due to seasonal changes in stream flows and increasing surface water temperatures. Important to the TMDL program, and salmon recovery programs
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Loss of salmon habitat and increased stress on salmon reproduction throughout their entire lifecycle. This also applies to other fresh cold water fish. Watershed planning efforts will

[85] USGCRP. 2009. Regional Impacts: Northwest. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.
[86] Ibid. UGCRP. 2009.
[87] http://www.climatechange.alaska.gov/aag/docs/aag_ES_27Jan10.pdf.
[88] Lettenmaier, D. et. al. 2008. Water resources. In: The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States, Synthesis and Assessment Product 4.3. U.S. Department of Agriculture, Washington, DC, pp. 121-150.

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need to be modified to include projected impacts of altered stream flows and increased temperatures due to climate change.[89,90]

Regional Importance of Vulnerabilities: Salmon and other cold water fish are a large part of the marine fishery business in the Pacific Northwest (PNW), and loss of these fish would have a substantial impact on the economy of the (PNW). Coastal Native Americans depend on salmon as an essential part of their diets. There will be secondary impacts on other species in the ecosystem that benefit from salmon – e.g., forests that rely on decaying salmon for nutrients, and bears, eagles, others that feed on salmon.

Variation in importance across the Region: Important across the region.

2.C. Regional focus: Sea-level rise, sea surface temperature and increasing heavy precipitation events during the winter months, and decreasing precipitation days and increasing drought intensity during the summer months, may have adverse impacts on estuarine watersheds, aquatic ecosystems, and wetlands.

Likelihood of Impact: Very Likely

Focus of Associated EPA Program: Restoring and protecting watersheds, aquatic ecosystems, and wetlands

Likelihood of EPA Program Affected: High

Example of Risks if Program were Impacted: Changes in precipitation patterns, and increased drought intensity will cause stress on wetlands, and forest and mountain ecosystems, and pose challenges to migration of species in these ecosystems to more suitable habitats. Sedimentation rates and organic matter (vegetative) accumulation rates also need to be taken into account for inland marine influenced ecosystems such as estuaries. Nyman et al[91] found that the vegetative component is the most significant of the two factors for the coasts of Oregon and Washington—i.e., accretion varied with organic accumulation rather than mineral sedimentation. Warmer sea surface temperature contributes to sea level rise, increased storm intensity, and greater stratification of the water column.

Regional Importance of Vulnerabilities: EPA may need to examine the use of more sophisticated models, and training to use the models, so that impacts to ecosystems due to Climate Change are addressed. Impact to states/tribes. Climate change impacts would make it more difficult for EPA to protect these ecosystems.

Variation in importance across the Region: Especially important in coastal areas of WA, OR, and Alaska due to increased extreme storm events and rising ocean levels and their impacts on coastal ecosystems. For the Washington, Oregon, and California coasts north of Cape Mendocino, sea level is projected to change between -4 cm (sea-level fall) and +23 cm by 2030, -3 cm and +48 cm by 2050, and 10–143 cm by 2100.[92] The effects will also be important to all non-coastal watersheds, aquatic ecosystems, and wetlands across the region.

2.D. Regional focus: Warming temperatures and more frequent and intense drought conditions will have adverse impacts on Forest Ecosystems

Likelihood of Impact: Very Likely

Focus of Associated EPA Program: Protecting Forest Ecosystems

Likelihood of EPA Program Affected: High

Example of Risks if Program were Impacted: Forest tree species are expected to shift their ranges northward and upslope in response to climate change and existing ecosystems will break up as different species shift at different

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[89] Wenger, S.J. et al. 2011. Role of climate and invasive species in structuring trout distributions in the Interior Columbia Basin 2011, USA: Canadian Journal of Fisheries and Aquatic Sciences, v. 68, p. 988-1008. Catalog No: 2508.

[90] Wenger, S.J., et. al.. 2011. Flow regime, temperature and biotic interactions drive differential declines of trout species under climate change. Proceedings of the National Academy of Sciences, online. Catalog No: 2652.

[91] Nyman, J.A et. al. 2006. Marsh vertical accretion via vegetative growth. Estuarine Coastal and Shelf Science 69:370-380. DOI: 10.1016/j.ecss.2006.05.041.

[92] National Research Council. 2012. Sea-level rise for the coasts of Washington, Oregon and California: Past, Present, and Future. Division on Earth and Life Studies Board on Earth Sciences and Resources and Ocean Studies Board. Committee on Sea Level Rise in California, Oregon, and Washington. .

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rates, resulting in the formation of new ecosystems, with unknown consequences.[93] Interactions among impacts of climate change and other stressors can increase the risk of species extinction.[94] Breakup of existing ecosystems and loss of biodiversity, in combination to increased drought conditions, can make forests more susceptible to destruction by wildfires and insect infestation.

Regional Importance of Vulnerabilities: In the western United States, both the frequency of large wildfires and the length of the fire season have increased substantially in recent decades, due primarily to earlier spring snowmelt and higher spring and summer temperatures.[95] Simulations of the impact of Climate Change on forest production in North America indicate that North American producers of lumber may suffer losses averaging $1 billion to $2 billion/yr over the 21st century[96].

Variation in importance across the Region: Adverse effects are likely in forests across the region, but more immediately in low elevation forests, and forests in drier parts of the region, such as in ID, eastern WA and OR, and the interior of AK

2.E. Regional focus: Loss of sea ice in Alaska due to warming air and water temperatures associated with Climate Change

Likelihood of Impact: Occurring Now and very likely to increase

Focus of Associated EPA Program: Protecting Marine Ecosystems and shorelines

Likelihood of EPA Program Affected: High

Example of Risks if Program were Impacted: Loss of arctic ice in the Bering Sea is adversely affecting Arctic sea ice ecosystems. Algae that bloom on the underside of the sea ice form the base of a food web linking microscopic animals and fish to seals, whales, polar bears, and people. The earlier ice melt resulting from warming, however, leads to later phytoplankton blooms that are largely consumed by microscopic animals near the sea surface, vastly decreasing the amount of food reaching the living organisms on the ocean floor.[97] This will radically change the species composition of the fish and other creatures, with significant repercussions for both subsistence and commercial fishing.[98] Sea ice is forming later in the fall in Alaska, making the coastal communities more vulnerable to extreme storms (e.g., the storm in 2011 that was a record low atmospheric pressure and caused winds up to 90 mph).[99]

Regional Importance of Vulnerabilities: Adverse impacts to the Bering Sea marine ecosystem would have profound effects on mammals and birds that migrate to feed in this area during the summer months. The Bering Sea fishery is a very important source of seafood and an important factor to Alaska's economy. Species composition in the Bering Sea ecosystem could be radically changed.

Variation in importance across the Region: This impact is specific to Alaskan ecosystems and shorelines, but could also have adverse effects on associated terrestrial ecosystems in Alaska.

2.F. Regional focus: Acidification of ocean water due to increasing concentrations of CO2 in the atmosphere

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[93] ACIA. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, 139 pp.

[94] Millennium Ecosystem Assessment, 2005: Ecosystems and Human Well-being: Biodiversity Synthesis. World Resources Institute, Washington, DC, 86 pp.

[95] Westerling A.L., et. al. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science, 313(5789), 940-943.

[96] IPCC, 2007, chapter 14

[97] USGCRB. 2009. Regional Impacts: Alaska. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.

[98] Janetos, A., et. al. 2008. Biodiversity. In: The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States. Synthesis and Assessment Product 4.3. U.S. Department of Agriculture, Washington, DC, pp. 151-181)

[99] http://www.stormsurge.noaa.gov/event_history.html

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Likelihood of Impact: Occurring Now and very likely to increase
Focus of Associated EPA Program: Protecting Marine Ecosystems
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Substantial decline of marine organisms that form their shells and skeletons from calcium carbonate in ocean waters.[100] Adverse effects of ocean acidification on marine organisms have already been documented.[101]
Regional Importance of Vulnerabilities: Specifically, adverse effects of ocean acidification have been documented in pteropods (sea snails)[102], a primary food source for salmon in the Pacific Ocean, and in oyster larvae in estuaries in Washington State and on the coast of OR.[103]
Variation in importance across the Region: Important in coastal areas of WA, OR and AK.

2.G. Regional focus: Pest outbreaks, invasive species, increased fire, shifts in species ranges and increased erosion, depletion of water and changes in riparian vegetation in Columbia basin Shrubsteppe/grassland eastern WA, OR, and ID.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Protecting watershed ecosystems.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Under projected future temperature conditions, the cover of sagebrush within the distribution of sage-grouse is anticipated to be reduced due to non-native grass invasions making the areas prone to destructive fires. Observed and projected decreases in the frequency of freezing temperatures, lengthening of the frost-free season, and increased minimum temperatures can alter plant species ranges and shift the geographic and elevational boundaries of many arid lands. The extent of these changes will also depend on changes in precipitation and fire. Increased drought frequency could also cause major changes in vegetation cover. Losses of vegetative cover coupled with increases in precipitation intensity and climate-induced reductions in soil aggregate stability will dramatically increase potential erosion rates. Transport of eroded sediment to streams coupled with changes in the timing and magnitude of minimum and maximum flows can affect water quality, riparian vegetation, and aquatic fauna. In particular, the climate-driven dynamic of the fire cycle is likely to remain the single most important feature controlling future plant distribution in U.S. arid lands. Riparian vegetation in arid lands can occur at scales from isolated springs to ephemeral and intermittent watercourses and perennial rivers.[104] This habitat is tightly associated with stream dynamics and hydrology.[105] The net result of climate warming is greater depletion of water along the riverine corridor.[106]

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[100] Orr, J. C. et. al., 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature, 437(7059), 681-686.
[101] Feely, R.A., et. al. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. Science, 320(5882), 1490-1492.
[102] Bednaršek, N. et. al. 2012. Extensive dissolution of live pteropods in the Southern Ocean, Nature Geoscience, Volume:5, Pages:881–885.
[103] Barton, A. et al. 2012. The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. Limnology and Oceanography, 2012; 57 (3).
[104] Ryan, M. et al. 2008. Land Resources. In: The effects of climate change on agriculture, land resources, water resources, and biodiversity. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC., USA, 362 pp.
[105] Chappell et al. 2001. Wildlife Habitats: Description, Status, Trends, and System Dynamics. Chapter 2 in: Wildlife-Habitat Relationships in Oregon and Washington.
[106] Ryan, M. et al. 2008. Land Resources. In: The effects of climate change on agriculture, land resources, water resources, and biodiversity. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC., USA, 362 pp.

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Regional Importance of Vulnerabilities: Note that the direct climate change effects of CO2 fertilization and increasing average temperatures may have contrasting influences on dominant functional types. Trees and C3 grasses may benefit from rising CO_2 but not from warming, whereas C4 grasses may benefit from warming but not from CO_2 fertilization. This may mean that uncertain, non-linear, and rapid changes in ecosystem structure and carbon stocks could occur.[107] The changes in the cycling of Nitrogen and to some extent Carbon due to climate change could alter the microbial and plant community structure and function of this ecosystem and cause it to move in the direction of desertification.[108] Large-scale conversion of grasslands to shrublands, coupled with anticipated changes in climate in the coming decades, and increases in wind speed, temperature, drought frequency, and precipitation intensity, contribute to greater wind erosion and dust emission from arid lands. In arid regions, erosion has been shown to increase sediment delivery to large rivers (e.g., the Rio Grande), and can change the flow conditions of those rivers. Transport of eroded sediment to streams can change conditions in waterways, impacting water quality, riparian vegetation, and water fauna.[109]

Variation in importance across the Region: specific to the shrubsteppe and grassland ecosystems which include (1) intermountain regions in western North America (well-vegetated semi desert scrub in lower elevations in basins, valleys, and lower plateaus foothills and lower mountain slopes and (2) the Palouse grassland bioregion covers approximately 6,200 mi^2 in west central Idaho, southeastern Washington, and northeastern Oregon between the western edge of the Rocky Mountains and the Columbia River basin. It encompasses the hills of the Palouse Prairie, the southerly Camas Prairie, and the forested hills and canyonlands of the area's rivers.[110]

[107] Parry et al. 2007, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report, section 4.4.3.

[108] Smith et al. 2002. Soil properties and microbial activity across a 500m elevation gradient in a semi-arid environment. Soil, Biology, and Biochemistry. 34(1749-1757).

[109] Ryan, M. et al. 2008. Land Resources. In: The effects of climate change on agriculture, land resources, water resources, and biodiversity. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC., USA, 362 pp.

[110] McWethy et al. 2010. Climate and Terrestrial Ecosystem Change in the U.S. Rocky Mountains and Upper Columbia Basin: Historical and Future Perspectives for Natural Resource Management. (NPS report).

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Goal 3: Cleaning Up Communities and Advancing Sustainable Development

3.A. Regional focus: Flooding, sea-level rise, storm surges, extreme events and landslides could mean site characterizations, risk assessments and selection of remedies are not protective or that existing remedies may be vulnerable
Likelihood of Impact: Likely
Focus of Associated EPA Program: Removal program, corrective action or permitted sites, cleanup of hazardous waste sites (Superfund), and management of waste containment facilities (RCRA).
Likelihood of EPA Program Affected: Medium
Example of Risks if Program were Impacted: Increased risk of contaminate release from hazardous waste Sites. RPMs and corrective action RPMs may need to alter selected remedies to ensure containment of hazardous substances. In situ remedies (e.g., stabilization, reactive barriers) and on-site above ground treatment systems (e.g., pump & treat, air sparging) could be compromised or overwhelmed if they are not designed to withstand the climate-related events. The net result could be release of contaminants.
Regional Importance of Vulnerabilities: Groundwater and subsurface contamination could be impacted by drought and flood conditions. There may be an increased risk of migration of contaminants from flooded containment facilities. Remedies such as caps in contaminated industrial waterways in WA and OR could be subject to (and not designed to withstand) unanticipated scour events. Any infrastructure whether for treatment or, say, green stormwater management such as pump and treat systems protecting drinking water wells have a potential to be at risk. Areas where permafrost has been assumed to work as a containment barrier would also be at risk.
Variation in importance across the Region: A high potential for impact could occur in the industrial waterways of WA and OR where industrial wastes have been capped in place, however could be a potential concern anywhere contaminants have been left in place. Possible issues of nuclear waste disposal related to climate change (e.g., locations of storage facilities, appropriate containment, and risk management issues) would also be important at the DOE Hanford facility in WA, and the DOE Idaho National Lab facility in ID.

3.B. Regional focus: Thawing permafrost and changes in sea ice leads to damage of roads, runways, water and sewer systems, and other infrastructure in Alaska affecting Tribal and Emergency Response
Likelihood of Impact: Occurring Now
Focus of Associated EPA Program: Emergency Response and Tribal Programs, Village Safe Water Program
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Melting sea ice and late formation in the fall is causing storms to move in close to shore as the natural buffering system disappears. That is causing rapid coastal erosion, with houses and infrastructure falling into the ocean in several communities. That, along with higher storm, tidal surges flood communities, is requiring more immediate evacuation needs. Open dumps are also impacted by storm surges, flooding, which increases contamination risk. Permafrost temperatures have increased throughout Alaska since the late 1970s.[111] Land subsidence (sinking) associated with the thawing of permafrost presents substantial challenges to engineers attempting to preserve infrastructure in Alaska.[112]
Regional Importance of Vulnerabilities: Substantial infrastructure damage in areas of Alaska built on permafrost. Release of methane contained in permafrost into the atmosphere would accelerate global warming since methane is a GHG.
Variation in importance across the Region: Important only in Alaska.

[111] Lettenmaier, D., et. al. 2008. Water resources. In: The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States, Synthesis and Assessment Product 4.3. U.S. Department of Agriculture, Washington,DC, pp. 121-150.
[112] Instanes, A., et. al. 2005. Infrastructure: buildings, support systems, and industrial facilities. In: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, pp. 907-944

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3C. Regional focus: Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable development and materials management programs, partnerships and initiatives.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Sustainability and Materials Management
Likelihood of EPA Program Affected: Medium
Example of Risks if Program were Impacted: Accelerating development (sustainable or otherwise) and the expected migration of people to Region 10 are issues of concern. It is projected that the population of the States in Region 10 will increase from 11.2 million in 2010 to 13.1 million in 2025.[113] Communities are struggling with how to manage the new people while protecting the environment and providing basic services like energy, water and waste management.
Variation in importance across the Region: In support of the increased sustainability of our communities, our investments in partnerships related to more sustainable materials management play an increasing role in preventing waste, conserving energy and reducing emissions of toxics as well as greenhouse gases. Waste management can be especially challenging in remote tribal communities in Alaska.[114]

3D. Regional focus: Climate change impacts on the availability of raw materials and the cost of mining and refining raw materials, producing products, transporting products, and disposing products.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Sustainability and Materials Management
Likelihood of EPA Program Affected: Medium
Example of Risks if Program were Impacted: EPA Region 10 will need to put more effort into advocating for sustainable materials management and pollution prevention with States, industry, communities and tribes as climate change affects the availability and cost of raw materials and products. Climate Change increasing temperature-related pest infestations and forest fires result in millions of acres of dead, dying, and burned trees in the Pacific NW and Alaska which decreases the availability and drives up the costs of wood products. Thawing permafrost in Alaska results in infrastructure damage in the form of compromised or impassible haul roads for timber and ore, reducing the availability of these natural resources and driving up transportation costs. Transportation of raw materials and products also becomes more costly and risky as thawing permafrost damages remote Alaskan airfields, and coastal erosion from storm surges and increased springtime flooding of river valleys damages coastal and inland river valley rail transport lines. Finally, damage to landfill infrastructure from thawing permafrost in Alaska makes disposal more costly due to the need for clean-up and fortification.
Variation in importance across the Region: This issue will impact the entire region but may have a greater impact on remote cities and villages in Alaska where transportation and disposal of products is more difficult and costly.

[113] U.S. Census Bureau. 2013. Current Population Report: Population Projections: States 1995-2025. Economics Statistical Administration. Department of Commerce. Website:http://www.census.gov/prod/2/pop/p25/p25-1131.pdf. Accessed May 23, 2013.
[114] U.S. EPA. 2011. National Priorities with a Local Focus – Region 10's Approach for Implementing Administrator Jackson's Seven Priorities – FY 2011-2015 November 2011. www.epa.gov.

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Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution
There are concerns for which we do not have sufficient scientific or programmatic information at this time to evaluate in our vulnerability analysis, some examples are:
(1) increased use of pesticides in response to increase in pests and vector borne diseases (see 2.G. which mentions invasive species, West Nile virus) and requests for emergency waivers.
(2) movement of volatile contaminants (pesticides, PCBs, mercury, etc.) into Alaska via global distillation.

4.A. Regional focus: Increasing extreme temperatures, increasing heavy precipitation events, changes in storm intensities, and increasing frequency of floods may increase the exposure to and risk associated with hazardous chemicals regulated by certain EPA programs
Likelihood of Impact: Likely
Focus of Associated EPA Program: Protecting human health and ecosystems from chemical releases regulated by the Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) programs
Likelihood of EPA Program Affected: Medium
Example of Risks if Program were Impacted: Adjustments to the relevant risk assessment framework to determine public risk due to modified exposure scenarios and modified toxicity of chemicals due to climate change.
Regional Importance of Vulnerabilities: Altered weather and severe climate events could also affect the interpretations of risk at RCRA/TSCA and Superfund sites. Very relevant for permitting and planning activities, where facilities may not have previously required an awareness of risk management for water/flooding, or other climate change impacts. In particular, Puget Sound is vulnerable to these potential impacts of chemical pollution; restoration of Puget Sound is a key ecosystem-level activity in R10.[115]
Variation in importance across the Region: More relevant near sites with large densities of chemical Manufacturers, Processors and Formulators (MPFs), and RCRA and Superfund sites

[115] (see the 2012/2013 Action Agenda for Puget Sound) http://www.psp.wa.gov/downloads/AA2011/083012_final/Action%20Agenda%20Book%202_Aug%2029%202012.pdf

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Goal 5: Enforcing Environmental Laws
EPA Region 10's Office of Compliance and Enforcement (OCE) is charged with ensuring compliance with environmental requirements and enforcing against violations to those requirements. In that capacity, OCE's vulnerabilities are uniquely tied to interactions with the regulated community. Some types of vulnerabilities (e.g., difficulties with maintaining staff functionality due to power outages, physical damage to facilities due to extreme weather) would be similar to those experienced by all EPA programs and regions. Other vulnerabilities are more specific to OCE such as those which impact the ability of sources to comply with environmental requirements and with our ability to determine such compliance and take appropriate action.

The vulnerabilities of greatest importance for OCE are conditions/events which would compromise our ability to ensure compliance with environmental requirements by regulated entities and, where necessary, to take effective enforcement action in case of violations. The programs impacted would include: compliance assistance; compliance monitoring and civil enforcement.

5.A. Regional focus: Increased non-compliance at regulated entities as a result of extreme weather events and changing weather patterns
Likelihood of Impact: Likely
Focus of Associated EPA Program: All regulatory programs
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Compliance and enforcement programs under the Clean Water Act (CWA) have the potential to see an increase in violations from many situations including sanitary sewer and combined sewer overflows, violations of percent removal at wastewater treatment plants (due to limited water flow as a result of drought), violations in bypasses due to the inability of wastewater treatment plants to treat a flow in excess of the design capacity, and increased violations in numerous programs due to failure of existing infrastructure protecting against extreme weather events. In addition, CWA section 311 (Spill Prevention Control Countermeasures) may see an increase in non-compliance along Alaskan coastal areas that have oil storage containers, as a result of sea ice melting (thereby increasing storm surges along those coastal areas) and increased flooding.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) compliance and enforcement programs may see violations at Pesticides Producing Establishments if there is a shift toward increasing pesticide usage, productions and imports. As weather patterns change in the Region, the habitats of insects and pests may also change, bringing different pests and diseases to areas.

The Resource Conservation and Recovery Act (RCRA) programs may see increased non-compliance at landfills due to changes in precipitation patterns (including more precipitation in some cases and more extreme precipitation events in other cases). Where more precipitation is seen in traditionally arid climates and little rainfall is assumed during landfill design, landfills may generate excessive hazardous leachate, see unexpected mobilization of contaminants in the waste column and/or experience failure of the liner or leachate collection systems.
Regional Importance of Vulnerabilities: May be most important in states where EPA has direct implementation of an enforcement program, on Tribal lands, and non-delegable programs.
Variation in importance across the Region: Relevant across the Region.

5.B. Regional focus: Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance
Likelihood of Impact: Likely
Focus of Associated EPA Program: All regulatory programs.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: If an increase in violations in various programs and industry are identified, OCE may shift the enforcement focus to address those violations. Conversely, OCE may use discretion

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to refocus enforcement priorities when localized extreme weather events (e.g., flooding) greatly impact the regulated community or when a change in weather patterns decrease the potential for non-compliance (e.g., less precipitation could decrease surface runoff). This will be most important in states where EPA has direct implementation of an enforcement program (e.g., Idaho for NPDES program), on Tribal lands, and non-delegable programs (e.g., Chlorofluorocarbons, CWA 311 (SPCC), PCBs). OCE may need to make adjustments to normal workload to address an increase in industry's compliance inquiries. There may need to be reassignment or delay of normal work duties as staff provides response support to those inquiries in a timely manner. Requests may also be received from Regional state counterparts regarding guidance to unique enforcement issues as a result of extreme weather events or changing weather patterns.
Regional Importance of Vulnerabilities: May be most important in states where EPA has direct implementation of an enforcement program, on Tribal lands and non-delegable programs.
Variation in importance across the Region: Relevant across the Region

5.C. Regional focus: Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.
Likelihood of Impact: Likely
Focus of Associated EPA Program: UIC permitting and enforcement programs
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: EPA has developed criteria for Class VI wells, used specifically for the injection of carbon dioxide into underground subsurface rock formations for long-term storage. As the need to reduce carbon dioxide emissions into the atmosphere increases, various technologies including Class VI wells will be deployed. OCE may need to reassign or delay other UIC permitting and enforcement work, as permit requests for Class VI wells increase. This will be seen across the Region, until permitting and enforcement of the Class VI well program is delegated to the states. As the amount of stormwater increases with increased precipitation levels, industries regulated to manage stormwater and associated discharges may be faced with challenges surrounding the volume of stormwater to manage. Class V wells are designed to receive stormwater, as a substitution for or in addition to discharging stormwater. OCE may see an increase in permitting Class V wells, as challenges managing high volumes of stormwater increase. Permitting will be focused on Class V wells in Alaska and Tribal lands, as the Region implements this program in these areas.
Regional Importance of Vulnerabilities: Across the Region, until permitting and enforcement of the Class VI well program is delegated to the states.
Variation in importance across the Region: Relevant across the Region.

5.D. Regional focus: Increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Oil and gas extraction.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Sea ice off the Alaskan Coast is retreating and thinning. This reduction of sea ice is very likely to increase the navigation season and create a seasonal opening of the Northern Sea Route to likely make trans-arctic shipping and transport feasible during summer months. As areas and routes become more accessible, there is a potential for industrial activity (e.g., oil and gas extraction) to become more active in these areas. As a result, OCE may see an increase in regulated entities.
Regional Importance of Vulnerabilities: Relevant in Alaska.
Variation in importance across the Region: Relevant in Alaska.

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EPA Facilities and Operations

6.A. Regional focus: Increasing drought frequency and intensity may limit drinking water at EPA facilities. Increased demand for air conditioning.
Likelihood of Impact: Likely
Focus of Associated EPA Program: Personnel Safety and security. Operations of Agency facilities, and ability to carry out emergency response actions
Likelihood of EPA Program Affected: Low
Example of Risks if Program were Impacted: Facilities could be located in areas with water shortages, requiring water rationing. There is likely to be a greater demand for electricity for air conditioning during the summer months. Increased extreme temperature at any R10 office would put higher demand on drinking water and electricity for cooling.
Regional Importance of Vulnerabilities: Could affect the regional office and all the operations offices
Variation in importance across the Region: Operation offices may not be as vulnerable as the regional office due to a smaller staff and less demand for cooling water, drinking water, and water for other personal uses.

6.B. Regional focus: Increasing risk of floods and increasing intensity of storms may adversely affect operations of agency facilities
Likelihood of Impact: Unlikely
Focus of Associated EPA Program: Operations of Agency facilities, personnel safety, physical security, and ability to carry out emergency response actions. In particular, Region 10 operates the Manchester Environmental Laboratory in Port Orchard. The lab is adjacent to Puget Sound.
Likelihood of EPA Program Affected: Low
Example of Risks if Program were Impacted: Facilities in flood-prone areas may have to temporarily close. Personnel engaged in field work may be more vulnerable to extreme temperatures or storm events. Personnel and real property supporting emergency response and management may be at risk during flooding or extreme weather events. Ongoing work at the Manchester Environmental Laboratory may be disrupted with effects on many different programs.
Regional Importance of Vulnerabilities: Closure of regional offices due to climate change related damage could prevent staff from carrying out important functions. The Regional Office in Seattle is located in an area with low probability for flooding or sea level rise.
Variation in importance across the Region: R10 has flexiplace options available to staff and a Continuity of Operations Plan in place in case any R10 office is damaged by flooding or storms or transportation to/from offices are affected (e.g., flooded roadways; landslides on commuter train tracks).

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Tribal and other vulnerable populations

7.A. Regional focus: Food security for Tribal communities that live a subsistence lifestyle may be at risk due to warming associated with climate change
Likelihood of Impact: Likely
Focus of Associated EPA Program: All R10 Programs working on issues that affect Tribal populations, potential link to permitting programs and actions
Likelihood of EPA Program Affected: Medium
Example of Risks if Program were Impacted: Warming due to climate change reduces the availability and accessibility of many traditional food sources such as ice seals, walrus and caribou.[116] For example, climate change decreases the amount and quality of food that grows in the summer months, preventing caribou from storing enough fat to survive the winter. People face losing their healthiest foods, their communities, and in some cases, their culture, since each of these depends on traditional ways of collecting and sharing food.[117]
Regional Importance of Vulnerabilities: The most vulnerable population would be the native Alaskan people. They face losing their current livelihoods, their communities, and in some cases, their culture.
Variation in importance across the Region: To some degree, this is also relevant to all the tribes in the rest of Region 10 (WA, OR, and ID).

7.B. Regional focus: An increase in intensity of coastal storms and rising sea levels would increase erosion of shorelines and pose risks to coastal native villages.
Likelihood of Impact: Occurring Now
Focus of Associated EPA Program: Tribal Programs, emergency response
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Alaska's coastline, much of which is close to sea level, is increasingly threatened by a combination of the loss of its protective sea ice buffer, increasing storm activity, and thawing coastal permafrost.[118] In Alaska, over 100 villages on the coast and in low-lying areas along rivers are subject to increased flooding and erosion due to warming. Federal, state, and tribal officials have identified 31 villages that face imminent threats.[119] At least 12 of the 31 threatened villages have decided to relocate--in part or entirely--or to explore relocation options. Federal programs to assist threatened villages prepare for and recover from disasters and to protect and relocate them are limited and unavailable to the majority of villages. The Federal Emergency Management Agency has several disaster preparedness and recovery programs, but villages often fail to qualify for them, generally because they may lack approved disaster mitigation plans or have not been declared federal disaster areas.[120]
Regional Importance of Vulnerabilities: Erosion of shorelines may require relocation of native villages. Loss of water infrastructure would require emergency water supplies. Flooding and storm events will require emergency management plans
Variation in importance across the Region: Greatest risks are to the shorelines in Alaska, but shorelines in WA and OR are also at a moderate risk

7.C. Regional focus: Loss of permafrost and reduced snowpack threatens access to clean water

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[116] ACIA. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK, and New York, 139 pp.
[117] Ibid ACIA. 2004.
[118] USGCRB. 2009. Regional Impacts: Alaska. EPA/600/R-07/094F, Office of Research and Development, Washington, D.C.
[119] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.
[120] U.S. General Accounting Office. 2003. Alaska Native Villages: Most Are Affected by Flooding and Erosion, but Few Qualify for Federal Assistance. GAO-04-142. U.S. General Accounting Office, Washington, DC, 82 pp.

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Likelihood of Impact: High
Focus of Associated EPA Program: Tribal Programs, Clean Water Indian set-aside program
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: In many Alaskan rural tribal communities, their water is drawn from tundra lakes and these are disappearing with the permafrost.[121] Another impact of melting permafrost is the loss of a stable foundation, endangering the sewer and water infrastructure that EPA, and the American taxpayer, has invested billions of dollars in.[122] Tribes in other parts of Region 10 may experience water scarcity, due to failing aquifers. With reduced snow pack and increased seasonal drought, traditional drinking water sources are not being replenished. This can affect individuals: a small well fails, or communities: a large aquifer does not recharge. In general, without access to clean water, tribal communities across Region 10 have greatly increased respiratory and gastrointestinal infections and skin diseases including methicillin-resistant Staphylococcus aureus (MRSA). These risks are increased by the open dumps that exist in close proximity to most rural communities. There is often human waste and solid waste comingled and when there are floods or storm surges from the loss of protective ice, viable bacteria and contaminants are carried through the community and into people's homes. Often times running water is not available for sanitation so these contaminants are making significant and dangerous impacts to both the environment and human health of rural Alaska communities. Most dumps are unlined, but permafrost has partially contained their toxic materials. Without permafrost, the untreated leachate may be a contamination risk for their water supply.
Regional Importance of Vulnerabilities: High. Costs to repair or replace water/sewer infrastructure damaged by thawing permafrost has been estimated at well over 6 billion dollars.[123]
Variation in importance across the Region: Permafrost thawing affects Alaskan tribes, some of whom already do not have access to clean water.

7.D. <u>Regional focus</u>: Changing water conditions <u>reduce availability of fish & shellfish resources</u>.
Likelihood of Impact: Occurring Now
Focus of Associated EPA Program: Tribal Programs, Ecosystems and public affairs.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Salmon of the PNW are central to the lives of all native peoples, they bring spiritual, physical and cultural well-being. Climate change is bringing rapid habitat challenges, from rapidly changing stream flows to warming waters that can no longer protect salmon fry. Agricultural runoff and clear-cut forests further degrade water quality. It is a mystery what is happening to the salmon in the ocean and scientists are concerned about the threat of ocean acidification to salmon food sources. Addressing these issues will require large scale cooperative restoration and enhancement projects between many partners.

The R10 Tribes' traditional shellfish use areas are on reserves, in ceded customary and traditional use areas. Increasing ocean acidification threatens shellfish beds that Tribes have harvested for millennia. Ocean acidification may reduce rates of shellfish larval survival and weaken the shells of the adults, thus making them more vulnerable as well.
Regional Importance of Vulnerabilities: High (Ocean acidification was a high priority in discussion groups at the 2012 Tribal Leaders Summit and was presented by both Makah and Tulalip tribes)
Variation in importance across the Region: high priority to all coastal tribes.

7.E. <u>Regional focus</u>: Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.

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[121] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.
[122] Alaska's Climate Change Strategy: Addressing Impacts in Alaska. http://www.climatechange.alaska/aag/docs/aag_ES_27Jan10.pdf.
[123] Institute of Social and Economic Research, University of Alaska. 2008. http://www.iser.uaa.alaska.edu/Publications/webnote/Web_Note4a.pdf

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Likelihood of Impact: Occurring Now
Focus of Associated EPA Program: Tribal Programs, Ecosystems and public affairs.
Likelihood of EPA Program Affected: High
Example of Risks if Program were Impacted: Children playing in areas with higher ozone levels resulting from increased temperature will be at higher risk for experiencing asthma symptoms and exacerbations. The elderly are more vulnerable to heat stress because they are often in poorer health and are less able to regulate their body temperature during periods or extreme health. Economic constraints can also place low-income households at disproportionate risk to extreme heat events due to lack of air condition or failure to use air-conditioning to cut down on associated energy costs.
Regional Importance of Vulnerabilities: Across the region.
Variation in importance across the Region: Across the region.

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Appendix C: Detailed Description of EPA Region 10 Existing Actions

The tables below include detailed information on existing actions in Region 10. It is organized by Office and includes the following columns

- Vulnerability: This identifies the vulnerability associated with each action. Many actions have multiple vulnerabilities.
- Relevant Agency Direction: This includes the EPA strategy from which the action is derived. For example, many of the actions come from the Region 10 Strategic Alignment Plan while other actions come from the Puget Sound Action Agenda or EPA National Water Program Strategy.
- Relevant EPA Goal: This identifies the EPA National or Regional Goal associated with the action. These goals were included in the vulnerability assessment.
- R10 Lead/Partners: This column includes the EPA person responsible for the action and the partners EPA is working with to accomplish the actions.
- Linked to Tribes, Sustainability, and EJ: This column indicates whether the action can be linked to EPA Region 10 tribes, related to sustainability, or environmental justice. These areas are very important to EPA Region 10 and we wanted to evaluate which actions could be identified with these three areas.

Office of Air, Waste, and Toxics

					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Indoor Air Training Develop and host training for professionals (housing, medical, schools) on making indoor environments healthier for the most vulnerable. This is a particularly important Climate Change Adaptation activity because of increasing mold problems following floods as well as increasing indoor levels of ambient pollutants due to wildfires, inversions with peak pollutant levels, and increased use of back-up power generators due to extreme weather events.	Changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events impact indoor air quality as ambient air is entrained indoors	R10 Strategic Alignment Plan	Support At-Risk Communities (for Air Quality)	R10 Lead: Davis Zhen: Indoor Air/Radon Partners: State, local air & Tribal agencies; At-Risk Communities: EPA HQ	•	•	•

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Tribal Waste Management Programs Work with federally recognized tribes in Washington, Alaska, Oregon and Idaho to address landfills and unconfined open dumps which are impacted by climate change and help develop appropriate responses to these threats. RCRA Tribal Team – 2013 ongoing work and beyond Continue to update 2011 Indian Health Service Indian Lands Open Dumps Inventory. In 2011 the EPA RCRA Tribal Team, RCRA Program Unit, Office of Air Waste and Toxics, completed an inventory of all open dumps in Washington, Oregon, Idaho and Alaska and posted this information on the national Indian Health Service Operations and Maintenance Database (OMDS). This database includes information on all open dumps on Tribal lands, including Alaska. Partner with Tribal communities, Tribal Consortia such as the Tribal Solid Waste Advisory Network, the EPA Tribal Trust and Assistance Unit and the Alaska Department of Environmental Conservation (ADEC) to develop appropriate responses to address the needs of tribal communities which are threatened by climate change impacts to their landfills and unconfined open dumps. Actions include: - Convening teleconferences with partners to ascertain the state of knowledge about climate impacts to tribal landfills and unconfined open dumps in Washington, Oregon, Idaho and Alaska and strategies to address these impacts. - Providing on-site technical assistance to interested tribal communities to help them to address climate change impacts to landfills and open dumps on their lands.	Increased precipitation and floods Increasing extreme temperatures, increasing heavy precipitation events, changes in storm intensities, and increasing frequency of floods may increase the exposure to and risk associated with hazardous chemicals (i.e. contained at RCRA sites. Thawing permafrost and sea ice changes lead to damaged roads, runways, water and sewer	R10 Strategic Alignment Plan	R10 Strategic Alignment Plan Goal 4.4 –See Existing Actions column to left	R10 Leads: Lisa McArthur UM Fran Stefan-Tribal SW Program Mgr Partners: Alaska Native Villages; rural communities	•	•	

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
	systems, and other infrastructure including solid waste landfills and RCRA containment sites.						
Materials Management and Pollution Prevention Program Climate change is expected to continue to adversely impact the cost of raw materials. Materials management enables the use of the highest and best substitutes for materials that may become scarce or too costly. Facilitate Climate Change Adaptation by: -Helping the public and regulated community adapt to the production and use of new materials, processes, and products that support the transition to sustainable materials management processes and away from: a) the use of more costly and limited natural resource based materials, and b) disposal- based systems with high uncontrolled emission and waste product management impacts. Materials Management Adaptation work includes: - Promoting More Sustainable Practices in Materials Management (SMM) and in Our Own Cleanup Work through: a) the recruitment and retaining participants for the Federal Green Challenge (helping our federal partners to reduce their GHG emissions through work on energy, transportation, waste and water), and b) recruiting for the Food Recovery Challenge in support of the EPA's Sustainable Materials Management (SMM) Program which seeks to reduce the environmental impact of a material throughout its entire life cycle - including how it is extracted, manufactured, distributed, used, recycled, and disposed (See Appendix E – Supporting Documentation).	Increased impacts from GHG emissions released from non-sustainable materials mgmt. practices.	R10 Strategic Alignment Plan WCMMF	Goal 4.6 – Sustainable Materials Mgmt	R10 Leads: Kris Colt UM Federal Green Challenge: Melissa Winters Food Recovery Challenge & WCMMF: Ashley Zanolli Partners: R9; state and local governments		•	

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
- Continuing to work with state and local governments through the West Coast Climate and Materials Management Forum (WCMMF) in their transition to materials management.							

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Office of Water and Watersheds

					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Water infrastructure							
Work with the State of Alaska in the R&D of alternative technologies with providing first time service to unserved homes in a more sustainable way compared to a traditional piped system. The State has provided $1M for this effort.. The most promising proposals for pilot system development will be identified in 2013. Systems approved for field installation and testing will be identified in 2014. Field testing is expected to begin in 2015 and be concluded by 2016.	Melting permafrost	R10 strategic alignment plan; sustainability	Building Strong State & Tribal Partnerships, EJ, Protecting America's Waters	R10 Lead: OWW-Dennis Wagner Partner: State of Alaska	•	•	•
Work with the WaterSense program to reach out to potential partners to encourage water efficiency in homes, landscaping and commercial buildings. A focus is new homes.	2A: Drought, floods,	R10 strategic alignment plan; National Water Program Strategy	Goals 1, 2, and 3	R10 Lead: Bevin Horn		•	
Continue implementing the Sustainable Energy Management Program with a Western Washington cohort of drinking water and wastewater utilities. This project is led by Washington State University-Energy Extension, with support from several partners.	2A: drought, floods, erosion, heavy precipitation	National Water Program Strategy; R10 strategic alignment plan;	Goals 1, 2, and 3	R10 Lead: Cyndi Grafe		•	
Freshwater fisheries							
Continue with pilot program for including Climate Change in an ongoing TMDL. EPA Region 10 and ORD Corvallis are working with the Washington Department of Ecology, the Lummi Nation and the Nooksack Tribe to identify the best way to integrate available climate change data into Ecology's TMDL for temperature stress on salmon in the South Fork Nooksack River, Washington. This will provide a case study of both process and climate change science as a basis to support	Increased temperatures.	R10 strategic alignment plan;	Goals 1 and 2 and Regional Goal 7	R10 Leads: OEA-Bruce Duncan; OWW-Laurie Mann	•	•	

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
future Tribal Consultation, Co-Management, Policy and Regulation Development as needed. Examining the way temperature can be improved in the Nooksack watershed in order to support salmon restoration is a high priority for the Nooksack and Lummi Tribes. The climate change pilot will identify available science for the watershed, and document technical issues in a parallel effort to the ongoing TMDL.				ORD-WED – Steve Klein Partners: WA Dept Ecology Nooksack Tribe Lummi Nation			
Training and Outreach							
Maintain current participation in the National Water Program Climate Change Workgroup, including identifying a single point of contact for the Regional water program.		OW Climate Strategy	Goals 1 and 2.	R10 Lead: Paula VanHaagen			
Help to develop and implement the Office of Water Climate Change Adaptation Implementation Plan (due to the Council on Environmental Quality in Fall 2013) and to coordinate between the National Water Program 2012 Strategy and the EPA Regional Adaptation Implementation Plans		OW Climate Strategy; R10 strategic alignment plan;	Goals 1 and 2.	R10 Lead: Paula VanHaagen			
After the Fall completion of the Office of Water Climate Change Adaptation Implementation Plan, provide training for water program staff on the challenges that climate change poses for water programs, and familiarize them with the National Water Program Climate Strategy and Regional Climate Adaptation Plans through a variety of means such as “all hands” meetings, webinars, seminars, and dissemination of the plans		OW Climate Strategy; R10 strategic alignment plan;	Goals 1 and 2.	R10 Lead: Mike Cox			
Support national program efforts to inform and educate water program managers in the public and private sectors on climate change and water issues through a variety of means such as identifying key stakeholders and expanding professional networks, improving educational outreach efforts on National and		OW Climate Strategy; R10 strategic alignment plan;	Goals 1 and 2.	R10 Lead: Mike Cox		•	

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Regional climate change websites and in other media, and disseminating clear and credible messaging on climate change science and impacts							
In program meetings with States and Tribes in 2013, include discussion of ongoing Agency and Region climate change adaptation planning, the new National Water Program climate change strategy, and climate change activities related to State water programs as appropriate		OW Climate Strategy	Goals 1 and 2 and Regional Goal 7	R10 Lead: Mike Cox	•		
Coordinate with the regional offices of other Federal agencies on climate change adaptation matters and participate, where appropriate, with related interagency cooperative and collaborative efforts to address climate change challenges on a regional scale		OW Climate Strategy	Goals 1 and 2.	R10 Lead: Mike Cox			
Work with municipal and private water utilities to promote their use of the new Climate Ready Resilience and Awareness (CREAT) Version 2.0 to recognize and respond to climate change risks, and with National Estuary Program partners to promote the use of the new Climate Ready Estuaries Vulnerability Assessment Handbook to develop local climate resilience plans		OW Climate Strategy; National Water Program Strategy	Goals 1 and 2 and sustainability.	R10 Lead: Paula vanHaagen		•	
Work with States, Tribes, municipalities, non-profit organizations and businesses to promote the Water Sense Program in the region		OW Climate Strategy; National Water Program Strategy	Goals 1 and 2 and sustainability.	R10 Lead: Bevin Horn	•	•	
Support the national Water Program in revising the State Revolving Loan Funds "Green" paper and the Annual Review Guidance for on-site reviews to incorporate climate change, including a new "Climate Change" checklist. The Green paper will provide information on best practices and tools to help state SRF programs support climate change activities. The guidance and checklist would identify opportunities for States to develop priorities and make investments that respond to the climate change risks in that State		OW Climate Strategy	Goals 1 and 2 and sustainability.	R10 Lead: Paula vanHaagen		•	•

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Office of Ecosystems, Tribal, and Public Affairs

					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
NEPA							
Through NEPA review comments, seek to protect waters of the United States and promote management of sustainable surface water resources. Encourage green infrastructure and low-impact development to protect water quality and make watersheds more resilient	Decreasing precipitation days and increasing drought intensity	National Water Program Strategy[124]	Goal 2.	R10 Lead: NEPA Review staff Partners: Lead federal agency (HUD, DOT, STB)			
Through NEPA review, ensure consideration of climate change on federal projects that may be at risk due to inundation, flooding, or salt water intrusion • Retention ponds at mine sites • Transportation/road infrastructure (road/rail/culvert failure) • Dam sites • Flood risk management (levies)	Increasing risk of floods		Goal 2.	R10 Lead: NEPA Review staff Partners: Lead federal agency (BLM,USFS FERC,USBR, DOT, STB)			
Work with federal partners through the NEPA process to identify, protect, and maintain a network of healthy watersheds and supportive habitat corridor networks • Collaborate with partners on terrestrial ecosystems and hydrology so that effects on water quality and aquatic ecosystems are considered.	Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife	National Water Program Strategy[125]	Goal 2.	R10 Lead: NEPA Review Staff Partners: Lead federal agency (USFS, BLM, NPS, USFWS)			

[124] Goal 12 SA 33. See http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf
[125] Goal 3 SA 9. See http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf

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	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Work with federal partners through the NEPA process to incorporate climate resilience into watershed restoration and floodplain management • Work with partners to protect and enhance buffers to rivers, streams, lakes, wetlands, and coastal resources as a means of building resiliency	Changes in abundance and geographical distributions of plant species and habitats for aquatic and terrestrial wildlife	National Water Program Strategy[126]	Goal 2.	R10 Lead: NEPA Review Staff Partners: Lead federal agency (Forest Service, BLM, Park Service, USFWS)			
Work with federal partners through the NEPA process to incorporate climate change adaptation into forest restoration plans • Encourage appropriate use of prescribed burning/thinning to reduce risk of uncharacteristic wildfire. Where appropriate, encourage managing for species best adapted to future climate	Increased frequency or intensity of wildfires	R10 Strategic Alignment.	Goal 1.	R10 Lead: NEPA Review Staff Partners: Lead federal agency (Forest Service, BLM, Park Service, USFWS)			
ETPA will include ocean acidification language in NEPA review comment letters as appropriate. • Refine template language in letters and example NEPA analyses that include ocean acidification information	Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification	R10 Strategic Alignment.	Goal 2.	R10 Lead: NEPA Review Staff Partners:			
Wetlands							
Wetlands and Climate Change Research Meeting focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate.	Loss of wetland ecosystems and services	U.S.EPA Climate Adaptation Plan[127]	Goal 2.	R10 ARU Lead: Linda Storm Partners:			

[126] Goal 4 SA 13. See http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf
[127] 3.3.4 Priority: Strengthen Adaptive Capacity of EPA Staff and Partners Through Training. http://www.epa.gov/climatechange/pdfs/EPA-climate-change-adaptation-plan-final-for-public-comment-2-7-13.pdf

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	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
				OEA and the R10 Science Advisory Council			
Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation • Consider the effects of climate change, as appropriate, when making significant degradation determinations in the CWA Section 404 wetlands permitting and enforcement program • Evaluate, in conjunction with the U.S. Army Corps of Engineers, how wetland and stream compensation projects could be selected, designed, and sited to aid in reducing the effects of climate change	Loss of wetland ecosystems and services	National Water Program Strategy[128]	Goal 2.	R10 Lead: Linda Storm Partners: USACE			
As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change • Expand wetland mapping by supporting wetland mapping coalitions and training on use of the new federal Wetland Mapping Standard. • Produce a statistically valid ecological condition assessment of the nation's wetlands	Loss of wetland ecosystems and services	National Water Program Strategy[129]	Goal 2.	R10 Lead: Maryann Thiesing Partners: ORD, USFWS, UW Wetlands Adaptation Group			
FY13 and FY14 Region 10 Wetland Program Development Grants RFP integrates climate adaptation by considering how the design							

[128]National Water Program 2012 Strategy: Response to Climate Change. Available at http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf

[129]National Water Program 2012 Strategy: Response to Climate Change. Available at http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
and installation of demonstration projects would take relevant potential impacts from climate change into account when considering long-term viability [130]							
Ocean Programs							
Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan	Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification	National Water Program Strategy[131]	Goal 2.	R10 Lead: Sediment Management Staff Partners: NOC			
Tribes							
Build the capacity of Tribes to develop adaptation actions (plans) and to engage in the collaboration with local, state and federal agencies.	All (mitigation)	Regional Tribal Operations Committee	Goal 1.	R10 Lead: Michelle Davis-TTAU;	•	•	
EPA R10 Tribal Trust and Assistance Program will provide GAP funding as appropriate to support Tribes who have climate change in their GAP workplans to learn how to research climate change impacts upon their environment, natural resources, infrastructure to be used for development of a planning mechanism for adaptation and mitigation.	All	RTOC	Goal 1.	R10 Lead: TTAU; AIEO/OITA Partners: R10 Tribal Governments			
Through the GAP program, Tribes may be able to do baseline environmental assessments that will add to documentation of the impact on climate change on Tribal communities and their ecosystems and support their adaptation planning.	All	National Tribal Science Council	Goal 1.		•		

[130] http://www.epa.gov/region10/pdf/wetlands/FY13_Wetland_Program_Development_Grants_Request_for_Proposals.pdf
[131] Goal 11 SA 28 and SA 31. See http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf

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	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Share information to support climate change educational outreach and adaptation activities within Tribal communities	All	National Tribal Science Council	Goal 1.		•		
Tribal Program staff will regularly submit articles on climate change to Tribal newsletters. Coordinate with other programs and their Tribal specialists on climate change info and resources to include in the EPA Tribal newsletter.	All	2010 Tribal Leader's Summit Action Plan	Goal 1.		•		
Continue to offer quarterly calls to Alaskan Tribes with Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.	All	2010 Tribal Leader's Summit Action Plan	Goal 1.	R10 Lead: Michelle Davis Partners: ITEP	•		
Puget Sound Program							
Address Climate change in Puget Sound Grants, consistent with the Puget Sound Action Agenda. Grant activities include: Conduct an erosion survey to evaluate sea level rise threat in San Juan County; b) Map habitat and infrastructure vulnerability in Puget Sound and restoration potential for reducing vulnerability; c) Several Tribes and counties will incorporate climate change in their plans and/or analyses. Puget Sound Grant partners include: *Puget Sound Partnership, Friends of the San Juan's, The Nature Conservancy, Snohomish County, Washington Dept. of Ecology, Samish Indian Nation, Swinomish Tribe, Nooksack Tribe, Suquamish Tribe, Port Gamble Indian Commission*.	Sea Level Rise/erosion	Puget Sound Action Agenda	Goal 2.	R10 Lead: ETPA/Puget Sound: Angela Bonifaci; See partner list under description	•	•	
Puget Sound Partnership is working to control source pollution. • No Discharge Zone Evaluation and Petition. Draft petition to EPA by September 2013	Increasing heavy precipitation events. Increased pollutant	Puget Sound Action Agenda[132]	Goal 2.	R10 Lead: EPA Team			

[132] http://www.psp.wa.gov/downloads/AA2011/083012_final/Action%20Agenda%20Book%201_Aug%2029%202012.pdf

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
• Pollution Control Action Team to respond quickly when areas are identified where water quality problems threaten shellfish areas. The first effort will be in Drayton Harbor and Portage Bay. • Pollution Identification and Correction Programs to identify and correct nonpoint source pollution sources.	loads in runoff and the velocity of runoff will scour and erode creek beds.			Partner: Puget Sound Partnership, Washington Department of Ecology, DOH,WSDA, Tribes			
The Puget Sound Partnership has developed climate change indicators which will allow them to track climate-driven changes and identify vulnerabilities or ecological thresholds	Increase in ocean temperatures, with potential for changes in ocean chemistry and increased ocean acidification	Climate Ready Estuaries[133] National Water Program Strategy[134]	Goal 2.	R10 Lead: Michael Rylko Partners: OCPD, National Estuary Programs, EPA Climate Change Division			
Puget Sound Grants process integrates climate adaptation concepts by considering how the design and installation of projects would take relevant potential impacts from climate change into account	All	U.S. EPA Climate Adaptation Plan/ FY 2011-2015 EPA Strategic Plan [135]	Goal 2.	R10 Lead: Puget Sound Grants Team			
A four part effort, comprising climate statistics, GIS visualization and analysis, data delivery platform development, and engagement with policy and management entities, will underlie the proposed development and delivery of information about the	All	Puget Sound NEP.	Goal 2.	R10 Lead: Jon Schweiss. Partners: UW			

[133]Climate Ready Estuaries 2012 Progress Report. Available at http://water.epa.gov/type/oceb/cre/upload/CRE_2012Report_122612a.pdf
[134] Goal 9, SA 23. See http://water.epa.gov/scitech/climatechange/upload/NWP_Draft_Strategy_03-27-2012.pdf
[135] 3.3.1 Priority: Fulfill Strategic Measures in *FY 2011-2015 EPA Strategic Plan.* Strategic Measure 2: Integrate climate adaptation into financial mechanisms. http://www.epa.gov/climatechange/pdfs/EPA-climate-change-adaptation-plan-final-for-public-comment-2-7-13.pdf

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
projected time of emergence of various elements of a changing climate in the Puget Sound Basin.							
Children's health and vulnerable populations							
Through work on children's health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations	Changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events will impact outdoor air quality and indoor air quality since ambient air is entrained indoors		Goal 1 and Regional Goal 7	R10 Lead: Margo Young			•
Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality • Work with Tribal Air Program • Convene Rural Alaska Children's Environmental Initiative			Goal 1 and Regional Goals 6 and 7.	R10 Lead: Margo Young, Erin Mader Partners: EPA Tribal Air Program, ANCH	•		•
Outreach/risk communication to vulnerable and economically deprived communities.	Decreasing precipitation days and increasing drought intensity	U.S.EPA Climate Adaptation Plan	Regional Goals 6 and 7.	R10 Lead: Sheryl Stohs Partners:			•

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	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
	Increasing risk of floods			Beyond Toxics, Eugene; Verde of Portland; DRCC of Seattle			
Regional Clean Air Act Grants are provided to Tribes to build capacity and knowledge and assess and address air quality concerns. Many grant-funded programs aim to prevent the presence of and exposure to indoor air pollution, for example, through supporting clean burning practices for wood stoves and adequate and effective ventilation in homes and public buildings. Ambient pollutants are also targeted, for example, from idling vehicles, diesel generators, outdoor burning, agricultural burning, wood stoves, and wildfires. Many of these factors will worsen with climate change, making tribal capacity building in these areas critical.	Indoor air quality	R10 Strategic Alignment Plan.	Regional Goals 6 and 7.	R10 Lead: Erin Mader Partners: Tribes	•		
Region 10's Children's Environmental Health and Tribal Air Program co-lead the Rural Alaska Children's Environmental Health Initiative and its two active workgroups, the Alaska Healthy Homes and the Alaska Healthy Schools Workgroups. These groups were established in December 2010 and work together regularly to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change.	All.	R10 Strategic Alignment Plan.	Goals 6 and 7.	R10 Lead: Erin Mader Partners: Tribes	•		•
The Tribal Air Program has an IPA position in the Anchorage office serving as the Alaska Tribal Air Liaison. She provides direct assistance to Alaska Tribes and GAP grantees to do air quality work, including climate change related topics.	Air quality	R10 Strategic Alignment Plan.	Goals 6 and 7.	R10 Lead: Michelle Davis Partners: Tribes	•		•
Other actions							
As appropriate, communicate with the public about hazards posed by climate change and EPA response/ remedies to events exacerbated by climate change (storm events, flood, drought)	All	U.S.EPA Climate	Goal 3.	R10 Lead: Public Affairs Unit			

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
		Adaptation Plan					
As appropriate, raise public awareness about climate change and actions being taken by the EPA to address climate change	All	U.S.EPA Climate Adaptation Plan	Goal 3.	R10 Lead: Public Affairs Unit			
Puget Sound Projects							
Vulnerability and Resilience of Puget Sound Estuaries to Climate Change. Vulnerability assessments will allow decision makers to understand known risks, key uncertainties and the level of vulnerability their habitats and communities face from future storms and elevated sea levels (Cooper et al. 2008).	In the Puget Sound basin these include increased winter precipitation, higher river flooding, lower summer low flows (Hamlet and Lettenmaier 2007), sea level rise (Mote et al. 2008), and uncertain effects on wind storms, sediment recruitment, and larger scale wind and ocean currents.	Puget Sound Action Plan. Objective 3. Vulnerability analysis	Goal 2.	R10 Lead: Michael Rylko Partners: The Nature Conservancy in collaboration with USGS and UW CIG			
The Puget Sound Partnership plans to launch a tree planting/canopy cover campaign in FY13	Increased stream temperatures	Puget Sound Partnership Stewardship grant	Goal 2.	R10 Lead: Partner: Puget Sound Partnership			
In FY13, Snohomish County's Department of Public Works will address the threats of climate change and increased population growth with a focus on addressing altered basin hydrology.	Change in basin hydrology	Puget Sound NEP.	Goal 2	R10 Lead:			

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					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
				Partner: Snohomish County's Department of Public Works			
The Washington State Department of Ecology will continue to work on a Puget Sound Circulation and Dissolved Oxygen Model (v2.0) in order to determine climate change effects on Puget Sound water quality.	Increase in ocean temperature.	Puget Sound NEP.	Goal 2.	R10 Lead: Ben Cope Partner: WA Ecology			
King County will produce modeled flow and water quality conditions in the rivers and streams of WRIA 9 for idealized fully forested conditions, and anticipated 2040 conditions considering population growth and climate change	Sea level rise.	Puget Sound NEP.	Goal 2.	R10 Lead: Michael Rylko Partner: King County.			
Tribal Related projects in Puget Sound							
The Samish Indian Nation will continue its climate change monitoring of Fidalgo Bay waters in FY13 providing continuous temperature data for trend analysis	Increasing ocean temperature.	Puget Sound NEP.	Goal 2 and Regional Goal 7.	R10 Lead: Lisa Chang Partner: Samish Indian Nation	•		
The Swinomish Tribe will hold its annual workshop on climate change issues in the Skagit, with a written report to follow	All.	Puget Sound NEP.	Goal 2 and Regional Goal 7.	R10 lead: Lisa Chang Partner: Swinomish Tribe	•		
The Nooksack Tribe will attend climate change conferences, meeting, and presentations, and review technical reports to evaluate the magnitude of expected local changes. This	All.	Puget Sound NEP.	Goal 2 and Regional Goal 7.	R10 lead: Lisa Chang	•		

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	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
information will be considered in the salmon recovery plan implementation for WRIA 1				Partner: Nooksack Tribe			
The Suquamish Tribe will continue to monitor the work of the Climate Change Study Group, review climate change related studies and documents, and attend related meetings in order to build tribal capacity with respect to climate change	All.	Puget Sound NEP.	Goal 2 and Regional Goal 7.	R10 lead: Lisa Chang Partner: Suquamish Tribe	•		
The Port Gamble Indian Commission of the Port Gamble Reserve plans to participate in climate change and ocean acidification programs in order to inform the development of a climate change program in FY13	Ocean acidification.	Puget Sound NEP.	Goal 2 and Regional Goal 7.	R10 lead: Lisa Change Partner: Port Gamble Indian Commission	•		

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Office of Environmental Assessment

					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Inreach Project – Meet with each unit within OEA (including our Manchester Environmental Laboratory Director) and determine where climate science can be used in our work for programs: e.g., EJ related apps and heat stress/vegetation; riparian setbacks and hyporheic flow models; TMDL models; Any modeling involving temperature or flow terms.	All	R10 Strategic Alignment plan		R10 Lead: Mike Cox Partners: POCs in Offices	•	•	•
Regional Outreach/Training – Continue to brief offices on vulnerabilities and tee up discussions where climate science can be used in decisions.	All	R10 Strategic Alignment plan		R10 Lead: Mike Cox Partners: POC in offices	•	•	•
Coordination with other federal agencies by participating on Climate Change Cooperative	All	R10 Strategic Alignment plan		R10 Lead: Mike Cox; Partners: Other federal agencies	•		
Support Pacific NW Landscape Conservation Cooperative - Steering Committee – OEA Director, Sci TEK subcommittee – CC Science Advisor	All coastal & marine-related	R10 Strategic Alignment plan		R10 Leads: Joyce Kelly an; Mike Cox; Partners: NPLCC participants.	•		
Participate on the National Tribal Science Council, and support actions related to climate change and tribes	All	National Tribal Science Council	Goal 1.	R10 Lead: Lon Kissinger Partners: RTOC	•		

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Office of Compliance and Enforcement

					Linked to		
	Vulnerability	**Relevant Agency Direction**	**Relevant EPA Goal**	**R10 Lead/ Partners**	**Tribes**	**Sustain-ability**	**EJ**
Climate change may have more impact on overburdened communities as these communities, due to various concerns, adapt less well than other communities. OCE is using an Environmental Justice Screening tool to identify regulated facilities located in these overburdened communities. This tool was nationally developed to screen for communities with environmental justice concerns for implementation in various EPA programs.	All	R10 Strategic Alignment plan	Goal 5	R10 Lead: Anne Dalrymple Partners: Running Grass			•
Permitting Class I Underground Injection Control (UIC) Wells in the North Slope of Alaska. The permafrost in the North Slope of Alaska has been identified as a vulnerable resource. In substitution for retention ponds used to store oil and gas industry's drilling wastes, the UIC program continues to permit several Class I wells for underground injection of those wastes. This reduces the need to establish waste retention ponds on the increasingly vulnerable permafrost.	Permafrost thawing.	R10 Strategic Alignment plan	Goal 5	R10 Lead: UIC Compliance Team Partners:	•		
Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts (e.g. Hurricane Katrina).	All	R10 Strategic Alignment plan	Goal 5 and Operations and Facilities.	R10 Lead: Wendy Adams Partners: Ann Williamson			
Continuing to look for opportunities to encompass green infrastructure as part of settlement agreements. An example of this is the City of Seattle, Washington and King County, Washington CSO settlement agreements. These settlements allow for the City of Seattle and King County to substitute green infrastructure projects for gray infrastructure projects (e.g. green roofs, permeable pavements, urban gardens).	All	R10 Strategic Alignment plan	Goal 5	R10 Lead: Depends on the case. Partners:		•	

Appendix D: Comparison of Vulnerabilities and EPA Region 10 Existing Actions

Appendix D compares the vulnerabilities identified in Section 2 and Appendix B with the existing actions identified in Section 3 and Appendix C. This comparison provides valuable information as EPA Region 10 evaluates how to best proceed to integrate climate change into the programs.

Goal 1: Taking Action on Climate Change and Improving Air Quality

Vulnerability	Action(s)
Increase in tropospheric ozone pollution may occur in certain areas due to increased average summertime temperature	No specific existing actions.
Increase in air toxics from anthropogenic sources is uncertain due to variability in effects of temperature increase on individual air toxics.	No specific existing actions.
Increase in particulate matter levels is occurring now and is very likely to increase due to increased frequency or intensity of wildfires due to increased summertime temperatures, prolonged droughts, and decreased soil moisture.	No specific existing actions.
Indoor air quality is very likely to be impacted, especially in Alaska, due to changes in precipitation, extreme temperatures, more frequent wildfires, and severe weather events.	Develop and host training for professionals (housing, medical, schools) on making indoor environments healthier for the most vulnerable. Assist Tribes to build capacity and knowledge and assess and address air quality concerns including those related to climate change through the Regional Clean Air Act Grants.
Stratospheric ozone layer is likely to be impacted in Alaska due to climate change effects	No specific existing actions.
Increased rate and deposition of sulfates, nitrates, and mercury is uncertain due to changes in precipitation patterns.	No specific existing actions.

Goal 2: Protecting America's Water

Vulnerability	Action(s)
Drinking water, wastewater, stormwater, and agricultural infrastructure is likely to be impacted by increased heavy precipitation, more frequent flood events, storm surge, coastal erosion, and drought.	Work with the State of Alaska to identify alternative technologies for providing first time service to unserved homes in a more sustainable way compared to a traditional piped system. Work with the Water Sense program to encourage water efficiency in homes, landscaping and commercial buildings with a focus on new homes.

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Vulnerability	Action(s)
	Continue implementing the Sustainable Energy Management Program with a Western Washington cohort of drinking water and wastewater utilities.
Impacts to freshwater fisheries is occurring now and likely to increase due to earlier stream runoff and scouring of streambeds due to earlier snow melt, decreased summer stream flows and increased steam temperatures, and longer periods of low stream flow.	Continue with pilot program examining how to integrate climate change in an ongoing TMDL by examining how temperature can be improved in the Nooksack watershed in order to support salmon restoration.
Estuarine watersheds, aquatic ecosystems, and wetlands are very likely to be impacted by sea-level rise, sea surface temperature and increasing heavy precipitation events during the winter months, and decreasing precipitation days and increasing drought intensity during the summer months.	Coordinate a *Wetlands and Climate Change Research Meeting* focused on new approaches and tools to better understand, manage, and conserve wetlands in a changing climate. Incorporate climate change considerations into the CWA 404 regulatory program as they relate to permit reviews and compensatory mitigation. As resources allow, improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change. Integrate climate adaptation in the FFY13/14 Region 10 Wetland Program Development Grants RFP.
Forest ecosystems will likely be impacted by warming temperatures and more frequent and intense drought conditions.	Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.
Loss of sea ice is occurring now and will very likely increase in Alaska due to warming air and water temperatures.	No specific existing actions.
Ocean acidification is occurring now and is very likely to increase due to increasing concentrations of CO_2 in the atmosphere.	Include ocean acidification language in NEPA review comment letters as appropriate and develop template language in letters and example NEPA analyses that include ocean acidification information. Participate in interagency development and implementation of federal strategies through the National Ocean Council (NOC) and the National Ocean Policy Implementation Plan
Change in vegetation is likely in eastern Washington and Oregon and Idaho due to pest outbreaks, invasive species, increased fire, shifts in species ranges and increased erosion, drier soils, and depletion of water.	Through the NEPA review process ensure consideration of climate change in review of all federal projects and incorporate climate change adaptation into land management planning and other projects as appropriate.

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Vulnerability	Action(s)
Puget Sound: Many of these projects address multiple vulnerabilities.	Support Tribal projects on climate change in Puget Sound through the National Estuary Program. A listing of those projects is included in Appendix C. Continue to support projects in Puget Sound related to climate change. There are several on-going projects that are highlighted in Appendix C. Work with the University of Washington to develop a system for visualizing and analyzing a variety of climate change-related features that are shifting with time and probability across the Region.
Training and Outreach	Inform and educate water program managers in the public and private sectors on climate change and water issues and EPA related activities such as the National and Regional climate change adaptation strategies. Work with States, Tribes, municipalities, non-profit organizations and businesses to promote the Climate Ready Water Utilities (CRWU) and Climate Ready Estuaries (CRE) Programs and new Climate Ready Resilience and Awareness (CREAT) Version 2.0. Support Development of a Climate Change Section in the "Green" Paper for the State Revolving Loan Funds and Annual Review Checklists.

Goal 3: Cleaning Up Communities and Advancing Sustainable Development

Vulnerability	Action(s)
Remedial, removal, brownfield, corrective action or permitted sites may be impacted due to flooding, sea level risk, storm surges, extreme events, and landslides.	No specific existing actions.
Increase in work for Alaska's Tribal and emergency response programs is occurring now and likely to increase due to thawing permafrost and changes in sea ice that leads to damage of roads, runways, water and sewer systems, and other infrastructure.	Work with federally recognized tribes in Region 10 to address landfills and unconfined open dumps which are impacted by climate change and help develop appropriate responses to these threats.
EPA Region 10, Tribal and state partners will have increasing workloads in many aspects of site and waste management as well as work related to the formation and implementation of sustainable	Work with our partners through the West Coast Climate and Materials Management Forum and our pollution prevention technical assistance providers and grants to assist in the transition to

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development and materials management programs, partnerships and initiatives.	sustainable materials management processes and source reduction.
Availability of raw materials and the cost of mining and refining raw materials, producing products, transporting products, and disposing products may increase due to impacts of climate change.	Recruiting and retaining participants for the Federal Green Challenge and for the Food Recovery Challenge in support of the EPA's Sustainable Materials Management (SMM) Program.

Goal 4: Ensuring the Safety of Chemicals and Preventing Pollution

Vulnerability	Action(s)
Increased exposure and risk to hazardous chemicals is likely due to increasing extreme temperatures and heavy precipitation events, changes in storm intensities, and increasing frequency of floods.	Incorporating green remediation in corrective action decision-making and raising issues nationally regarding the potential impacts of climate change on alternative landfill covers.

Goal 5: Enforcing Environmental Laws

Vulnerability	Action(s)
Non-compliance at regulated entities may increase due to extreme weather events and changing weather patterns.	Continue to use an Environmental Justice Screening tool to identify regulated facilities located in overburdened communities. Continue to look for opportunities to encompass green infrastructure as part of settlement agreements.
Shift in regional enforcement priorities due to changes in compliance (both increased compliance and non-compliance in different sectors) and increased number of inquiries from industry about maintaining compliance due to extreme weather events and changing weather patterns.	No specific existing actions.
Increased permitting of Class VI Underground Injection Control (UIC) wells for Carbon Dioxide sequestration and Class V UIC wells for stormwater management.	No specific existing actions.
An increase in regulated industrial activities in Alaska may result as the melting of sea ice opens new areas for activities.	No specific existing actions.

Facilities and Operations

Vulnerability	Action(s)
Drinking water may be limited and an increase in demand for air conditioning is possible due to increasing drought frequency and intensity.	No specific existing actions.

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Operations of Region 10 facilities may be impacted by increasing risk of floods and increasing intensity of storms.	Continuing to support the Regional Support Corps by deploying staff for varying emergency response efforts

Tribal and Vulnerable Populations

Vulnerability	Action(s)
Vulnerable population such as children, the elderly, poor, and the infirm may be at increased health risk due to increased temperatures, failing infrastructure, and extreme weather events.	Support the Rural Alaska Children's Health Initiative which works to protect children from harmful environmental exposures in rural Alaska, including factors related to climate change. Through work on children's health, develop and host training for professionals in the housing, health and educational fields on making indoor environments healthier for the most vulnerable populations. Provide technical assistance and training to affected communities on risks associated with poor outdoor air quality (e.g., work with Tribal Air Program and convene Rural Alaska Children's Environmental Initiative). Outreach/risk communication to vulnerable and economically deprived communities.
Food security for native Alaskans and Tribal people in the Pacific Northwest who live a subsistence lifestyle may be at risk due to warming associated with climate change.	Support Tribes to develop adaptation actions (plans), to document that impact from climate change and to engage in the collaboration with local, state and federal agencies working on broad based adaptation plans. Provide GAP funding as appropriate to Tribes with climate change in their GAP workplans to do baseline environmental assessments and support adaptation planning.
Increased erosion of shorelines is likely to increase risk to coastal native villages due to increased intensity of coastal storms and rising sea levels.	No specific existing actions.
Decreased access to clean drinking water is very likely due to loss of permafrost.	No specific existing actions.
Reduced availability of fish and shellfish resources is occurring now and is likely to increase due to changing water conditions.	No specific existing actions.
Training and Outreach which will address all vulnerabilities.	Raise awareness by providing educational outreach, training, and webinars to Tribes and work with the Institute for Tribal Environmental Professionals on tribal climate change adaptation models and resources.

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Training and Outreach (supports all the goals)

Vulnerability	Action(s)
General training and outreach that supports all the goals and programs	Provide outreach/trainings to increase awareness of climate science to regional staff, and work with staff to incorporate climate science into their work programs. Communicate with the public about hazards posed by climate change and actions being taken by the EPA to address climate change. Coordinate with other federal agencies by participating on Climate Change Cooperative and supporting the Regional Landscape Conservation Cooperatives.

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Appendix E: EPA Region 10 Approach for Measuring Success

Several key steps to developing the Region 10 approach to meeting our Strategic Alignment Plan, measuring our progress, and adapting as we go are discussed below. In Region 10 we have identified a point of contact (POCs) for each of our offices to assist with developing the Implementation Plan and they will have a critical role in collecting measures from their offices.

Collate the measures and reporting requirements for the existing actions.
Section 3 identifies existing actions that Region 10 has underway. Many actions are part of the Region 10 Strategic Alignment Plan and SMART (Specific, Measurable, Attainable, Relevant and Time-sensitive) and some may have measures associated with them. These available measures will be collated. For all other actions, we will seek clarification through our POC network on the status of development of SMART measures and how to prioritize completion of the SMART process.

Consider developing Logic Model as the underlying framework for Measures.
Under a Logic Model, the ultimate goal is to measure changes, commonly called outcomes, which often are changes in behavior. In the figure below shared nationally by the Office of Water, goals of awareness are followed by the desired behavior that climate science is incorporated into federal policies and programs. Measures of outcomes also benefit from determining a baseline condition as well as benchmarks for success. Both of these will be considered in implementing the Region 10 approach.

The Logic Model example below is based on the following considerations:

- Diagram/Text illustrating the relationships among program elements
- Identifies key activities, "players", and expected results
- Identifies program span of control and external influences
- Span of control: Region 10 only has direct influence over key activities & outputs

The model is developed keeping in mind that:

- To meet ultimate goals, Region 10 will seek to change the attitudes, knowledge, and behavior of others (outcomes).
- The challenge of the measurement approach is to balance output vs outcome measurement.
- In order to obtain Buy-In we will clearly define the purpose of the measurement effort to staff (how will the information be used) and minimize staff time needed to report the measures.
- We will need to address Measurement "apprehension": Programs recognize progress toward outcomes is important, but hesitate to be held "accountable" for things outside their direct control.

Consider existing climate vulnerabilities in refining/selecting Measures.
For climate change adaptation, successful adaptation would be measured against conditions we do not expect to face for several decades. However, some conditions are occurring now and actions in response to these conditions are ones where meaningful measures of outcomes could be generated. In Region 10, particularly Alaska, we are seeing accelerated changes that are documented in our vulnerability analysis. And, in Puget Sound, ocean acidification is already affecting larval cultures of oyster growers.

Include other considerations in refining/selecting Metrics:
How many measures are too many?
How "measureable" are the metrics (precision of language, access & availability of data)?
Output (short term) vs. Outcome (longer term) Focus
Challenges to Analysis:
How will reporting and analysis take place (process)

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How information can/will be presented to meet the needs of key stakeholders (utility)
Retaining the flexibility to modify the measurement framework as the program "learns" vs. need to retain core metrics for comparability.

Learn from other regions and the national program.
The key areas Region 10 will look for concerning measures are specific benchmarks/ commitments, ease of reporting, matching with national and regional reporting requirements, ability to adapt/adjust measures in the future, how closely measures relate to outcomes, and how other efforts have developed measures based on immediacy of vulnerabilities (for example, how hurricane Sandy and other recent extreme events have shaped measures developed for the east coast).

How to track and report progress

- Consider an annual *Highlights of Progress* document that is excerpted from the existing Region 10 reporting requirements and provided in a useful format common to other regions and national programs
- Consider how our strategic action contacts would report internally on adaptive management phase, with guidance provided from the Climate Change Science Advisor
- Region 10 Strategic Alignment could include an adaptive management phase at the Goal level in Highlights of Progress.
- The Climate Change Science Advisor will use the Evaluation and state of management phase to:
    - Inform any needed changes to the Region 10 Climate Change Adaptation Strategy.
    - Identify appropriate performance measures for measuring the effectiveness of the Strategy.

Document regional program awareness and use of climate science even as we develop measures.
Even without a logic model structure in place for climate change adaptation actions, in Region 10 we are seeing awareness of the availability and use of climate science increasing, and can begin to document this trend. An example is awareness and use of climate science and tools in our Office of Water and Watersheds TMDL program. For approximately the past two years, we have been conducting an ongoing pilot project where we have been incorporating climate science into an ongoing temperature TMDL. As follow-on to this process, the TMDL unit in March 2013, held an internal demonstration of where to find downscaled 7Q10 flow data projections under climate change scenario models on an interactive website. Similarly, our regional wetlands program led (co-sponsored with our Region 10 Science Steering Council) a workshop on new tools to assess the impact of climate change on wetlands.

Office of Water, Logic model example:

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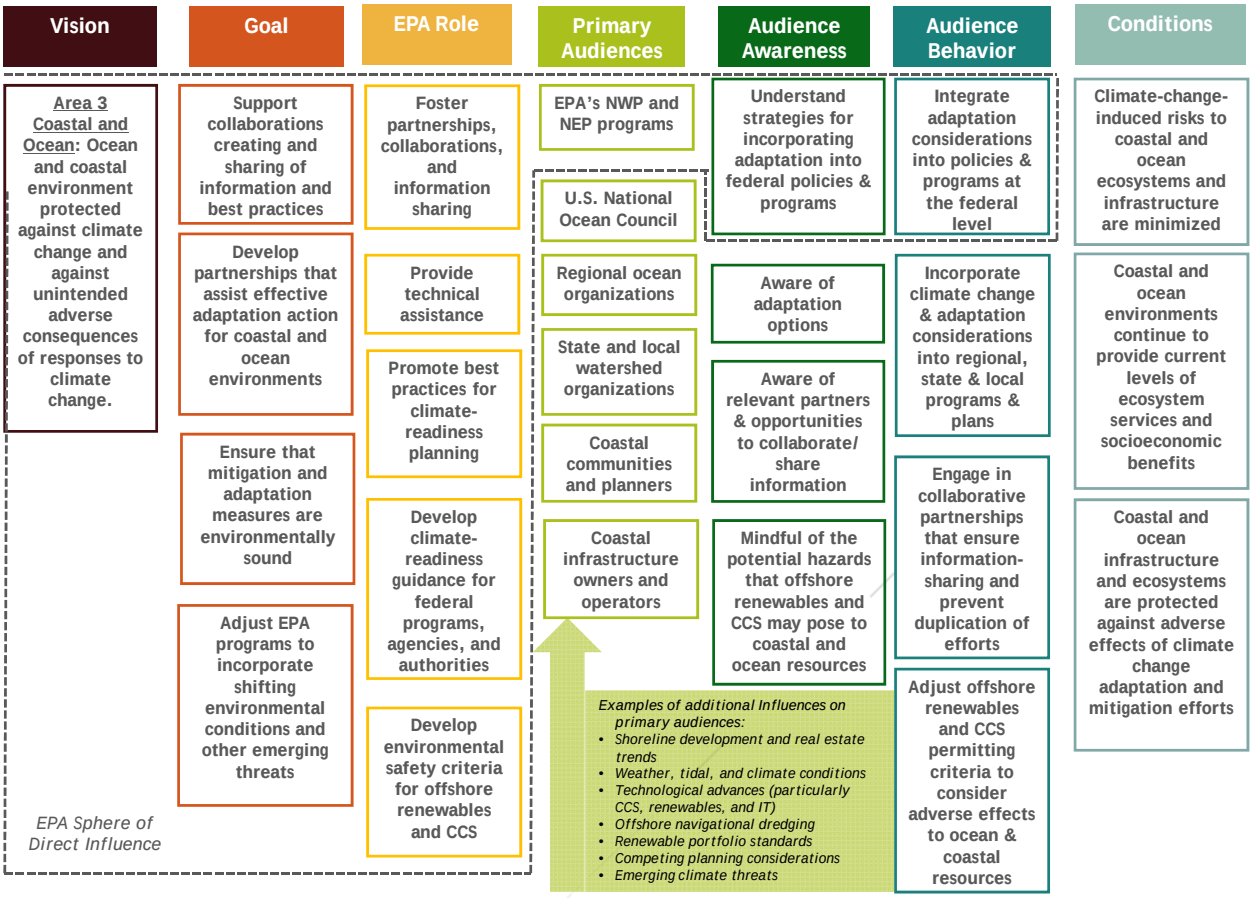

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