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Chelan County Climate Resiliency Strategy

OCTOBER 2020 **DRAFT**



“Although the projected impacts of climate change can seem dire, our future doesn’t have to be.

We have choices that can prevent the worst impacts of climate change.”

-WA DNR Plan for Climate Resilience

Introduction

Climate change is expected to have wide-ranging impacts on life in Chelan County. In recent decades Washington State, including Chelan County, has experienced significant droughts, declining snowpack, and several extreme wildfire seasons. These events and conditions are expected to become more common as the climate continues to change. In early 2019, Chelan County began engagement with local and state partners aiming to build resilience to the impacts of climate change in the county.

This document is a result of multiple community workshops and community engagement throughout 2019 and 2020, and seeks to build a foundation for future climate resilience and adaptation work in Chelan County.

Purpose

What does building climate resilience mean? The Washington State Department of Natural Resources’ (DNR) Plan for Climate Resilience defines resilience as: **“Being prepared for, and adapting to, current and future climate-related changes.”** In alignment with DNR’s definition, this document attempts to answer these key driving questions:

- Where are we heading based on current trends and expected changes?
- What does that mean for commerce, communities, residents of Chelan County as well as visitors?
- What are steps Chelan County and the greater community can take to build climate resilience?



In answering these questions, the purpose of this document is to achieve two key benefits of county-wide climate resilience planning which were identified through community workshops: 1) improved communication and coordination, and 2) the opportunity to advance projects that provide multiple benefits.

This document is divided into four sections based on climate change impacts: Wildfire, Snowpack & Streamflow, Flooding, and Water Supply. For the given topic, each section presents an overview of observed and current trends, expected changes,

impacts, current initiatives, and resilience strategies. The description of impacts in each of the four sections are based on impacts described in the reports listed in the section “How Our Partners are Preparing for These Changes” with additional input on local impacts from the planning team and community engagement. Resilience strategies are drawn from stakeholder discussions of priorities and gaps as well as a review of current initiatives and potential strengthening of activities in Chelan County.

Regional Climate Change Overview

There are multiple climate change impacts expected across Washington state and the Pacific Northwest, most of which will have specific consequences for Chelan County. Two of the main concerns related to climate change are rising temperatures and changes in seasonal precipitation—more in winter, spring, and autumn, less in summer.

Temperature

The Northwest and Washington state have warmed over the last century and this warming is expected to continue in the next century at a faster rate. The average year in the Northwest is 1.54°F warmer than during the first half of the 20th century, and the coldest day of the year between 1986 and 2016 was 4.78°F warmer than the coldest day historically between 1901 and 1960.¹

Average annual temperature in Chelan County is expected to increase 4.6° F and 5.9° F by the 2050s² and 5.8° F and 9.7° F by the 2080s under a low and high greenhouse gas scenario respectively, relative to historical conditions.³ Warming is expected in all seasons, with the most warming in summer months.

Greenhouse Gas Scenarios

The amount of climate change we experience in the future depends on how much greenhouse gasses are emitted to the atmosphere. We cannot know how much greenhouse gases will be emitted or sequestered, so it is important to consider the range of potential impacts from different scenarios.

Greenhouse gas scenarios are plausible “what if” scenarios of future greenhouse gas concentrations in the atmosphere based on emissions and sequestration. These scenarios are used in climate models to determine how fast and how much the climate could change. Higher scenarios result in more warming at a faster rate, although warming is similar among the scenarios through mid-century.

In this report we describe impacts associated with low, moderate, and high scenarios. The low scenario refers to the Representative Concentration Pathway (RCP) 4.5, the moderate scenario refers to the Special Report on Emissions Scenarios (SRES) A1B, and the high scenario refers to RCP 8.5. The low scenario requires significant near-term reductions in greenhouse gas emissions, whereas the high scenario represents unbridled emissions through the end of the century. The scenarios referenced in this document are those used in the studies that generated the impacts information; not all studies used all scenarios.

For more information see Mauger et al. 2015. State of Knowledge: Climate Change in Puget Sound. <https://cig.uw.edu/resources/special-reports/ps-sok/>

1 USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.

2 Climate model projections are presented as 30-year averages centered on the given decade, e.g., the 2050s is the 30-year period from 2040 to 2069.

3 Projected changes in the climate described in this document are relative to the average of the historical period from 1971 to 2000 unless otherwise specified.

Extreme heat events are expected to become more frequent and extreme cold events are expected to become less frequent.

Natural climatic variability will continue to play an important role in the region's climate, amplifying or dampening the long-term trends driven by climate change. However, it should be noted that the magnitude of the projected change in temperature is large

when compared to the natural climatic variability observed in the 20th century.

Precipitation

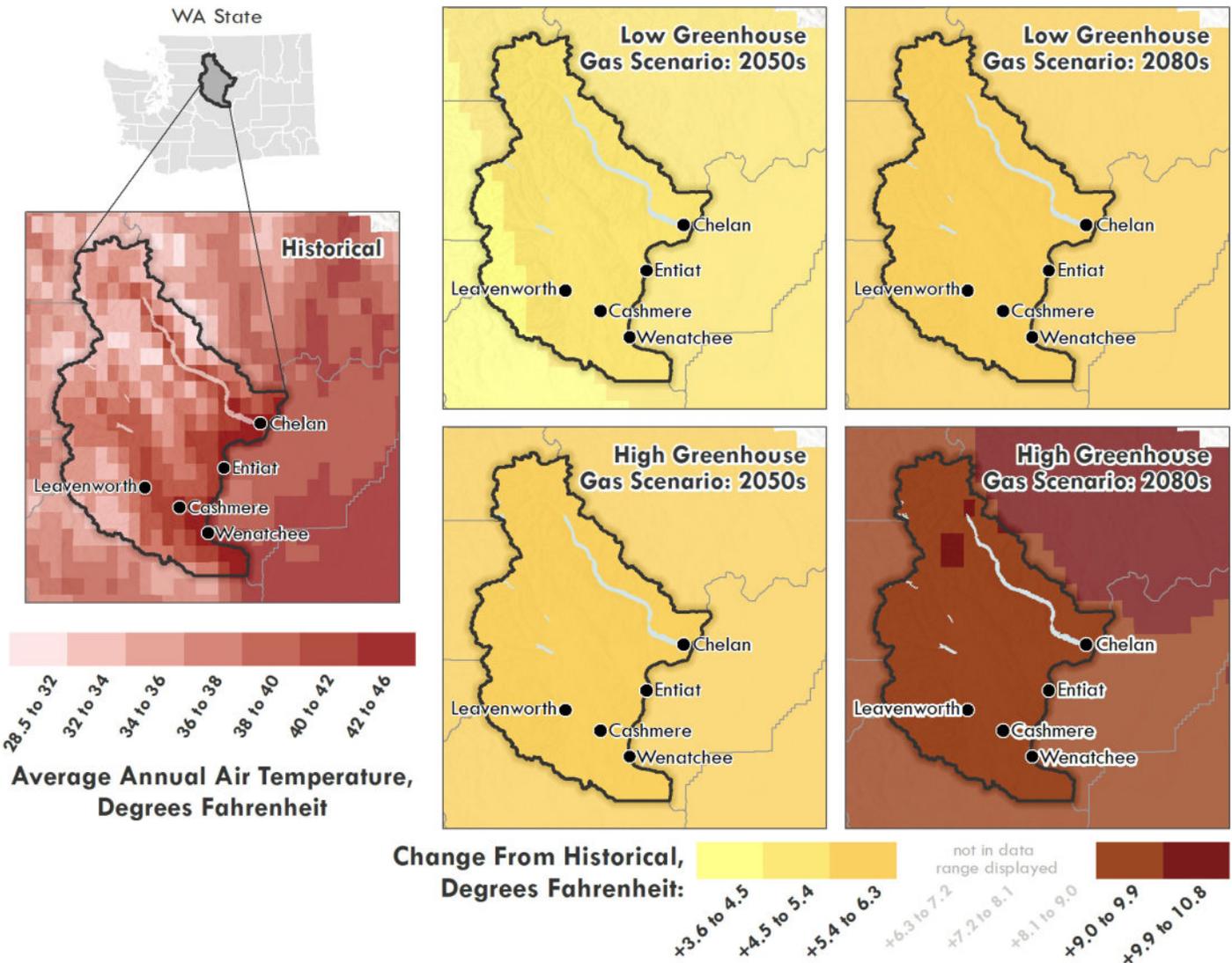
In Washington state, natural variability greatly influences regional precipitation patterns

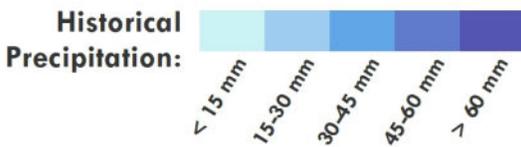
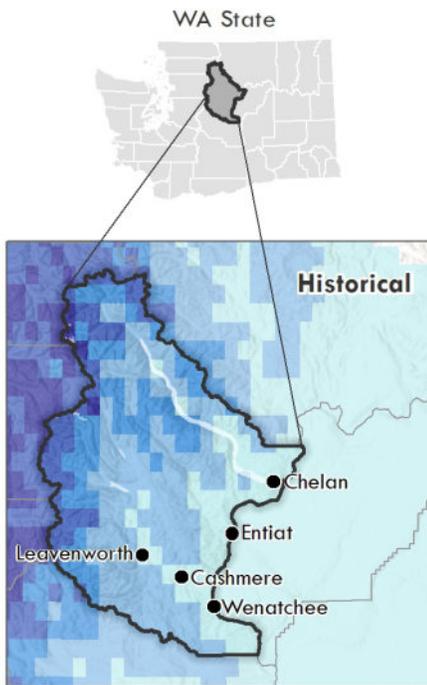
and year-to-year variability in precipitation is large compared to any long-term trend. Total precipitation for the year is expected to increase slightly on average, but will continue to be greatly influenced by year-to-year variability. Climate model projections of precipitation by

Exhibit 1. Projected Average Annual Air Temperature, Chelan County

Temperatures are expected to increase across Chelan county by 2050s and warming is expected to be greater for a high greenhouse gas scenario and for the 2080s.

Sources: Integrated Scenarios, 2015; BERK, 2020.





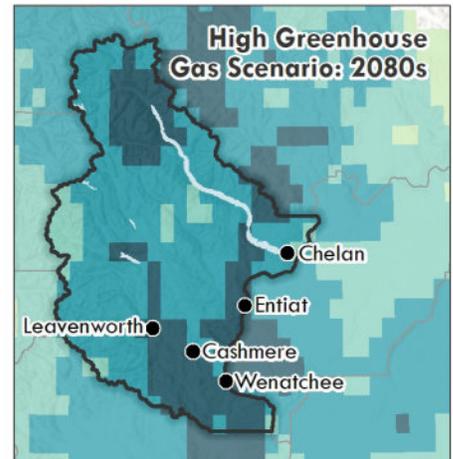
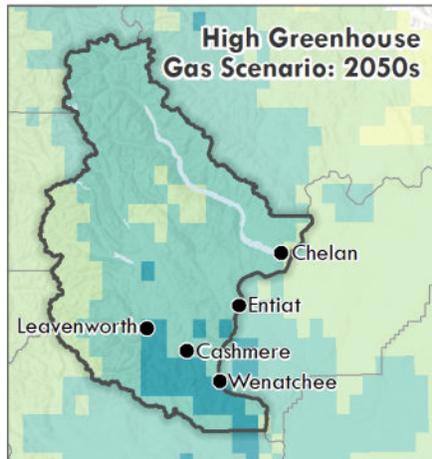
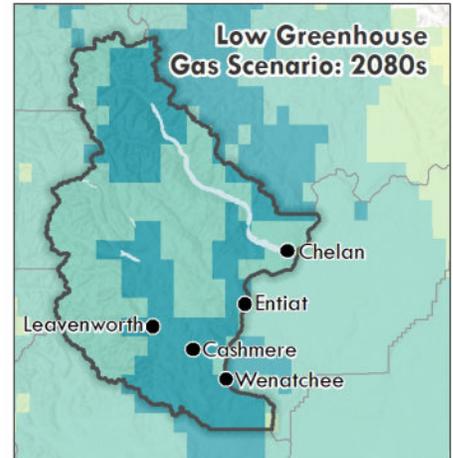
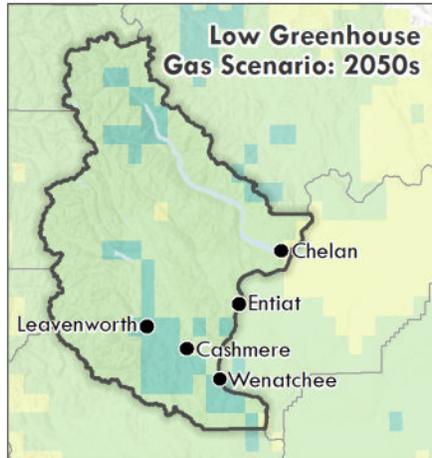
season are mixed. Most models project less precipitation in summer, decreasing 6% and 8% by the 2050s for a low and high greenhouse gas scenario, respectively. Conversely, most models project more precipitation in winter, spring, and autumn.

It is not only average precipitation that is expected to change, but short-term heavy rainfall events are also expected to become heavier and more frequent. Across Washington state, the number of

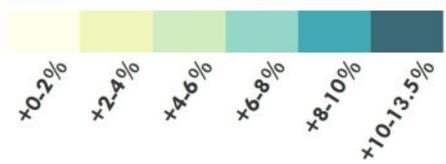
Exhibit 2. Total Annual Precipitation, Chelan County

Annual precipitation is expected to increase across Chelan county by 2050s and more precipitation is expected for a high greenhouse gas scenario and by the 2080s.

Sources: Integrated Scenarios, 2015; BERK, 2020.



Percent Change From Historical:



days with more than one inch of rain is projected to increase by 13% for the 2050s under a high greenhouse gas scenario.⁴ The heaviest 24-hour rainfall events are

expected to intensify by 22% and these events are expected to occur seven days per year on average by the 2080s compared to two days per year historically.⁵

⁴ Kunkel, K. E. et al., 2013: *Part 6. Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6.

⁵ Warner, M.D. et al. 2015. Changes in Winter Atmospheric Rivers along the North American West Coast in CMIP5 Climate Models. *J. Hydrometeorol*, 16, 118-128.

These changes in temperature and precipitation are expected to affect availability of water for fish, farming, and potable uses, fire and flood hazard potential, winter and summer recreation and tourism, and more as described later in this strategy.

How Our Partners are Preparing For These Changes

Building climate resilience depends not only on actions within and by Chelan County, but on the variety of agencies and landowners who have jurisdiction and ownership within the county. This section highlights the regional and statewide organizations who are developing plans and strategies, and taking actions to respond to climate change. Chelan County and partners can leverage these initiatives to build local resilience efforts.

National Park Service and US Forest Service (NPS and USFS): North Cascadia Adaptation Partnership and joint climate change vulnerability assessments on NPS and USFS land in and around Chelan County. See <http://adaptationpartners.org/ncap/>.

Washington State Department of Natural Resources (DNR): Recently released Plan for Climate Resilience in February 2020, a detailed agency-wide

climate resilience effort. This DNR plan also articulates a series of statewide systems-level needs and opportunities supporting and facilitating community-level resilience planning and implementation. See <https://www.dnr.wa.gov/climate-change>.

Washington State Department of Fish and Wildlife (WDFW): Climate-resilient floodplain restoration and guidelines for incorporating climate change into culvert design and water crossing structures.

Washington State Parks (WSP): Statewide Parks climate vulnerability assessment and adaptation plan. See <https://parks.state.wa.us/DocumentCenter/View/11074/01-WA-Parks-Vulnerability-PDF>.

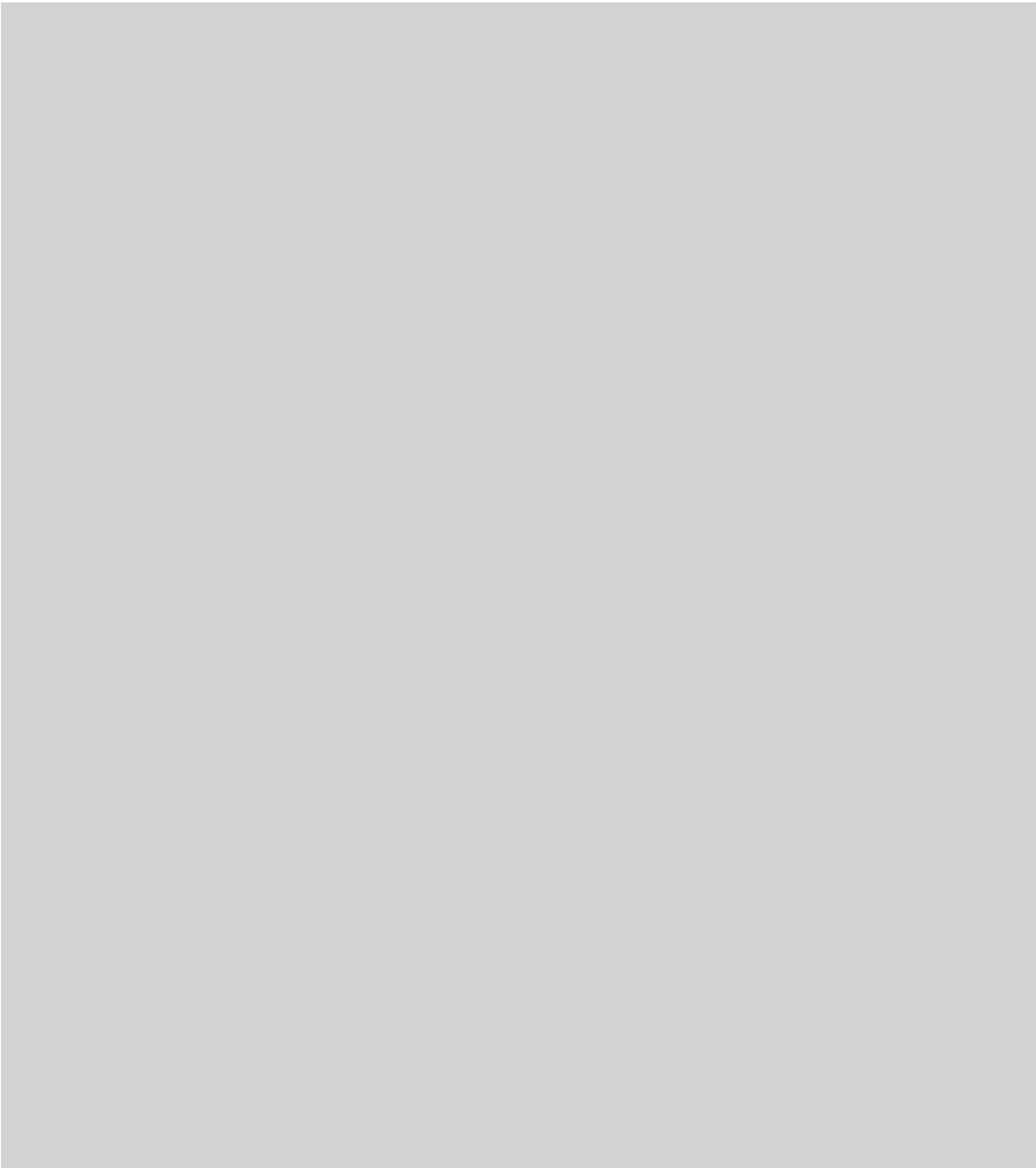
Washington State Department of Transportation (WSDOT): Incorporating climate smart design into roadways and culvert design, building resilient transportation systems, and undergoing climate impacts vulnerability assessment of WSDOT infrastructure and roadways. See <https://www.wsdot.wa.gov/construction-planning/environment/sustainable/climate-change>.

Confederated Tribes of the Colville Reservation: Natural resources vulnerability assessment completed to understand impacts

of climate change on priority plants and animals within the Colville Tribes Traditional Territory, including on-reservation land as well as Okanogan Highlands and other off-reservation land. See <https://www.colvilletribes.com/climate-change>.

University of Washington Climate Impacts Group (UW CIG): Driving the science of climate impacts, and assisting with technical implementation of climate resilience planning region-wide, UW CIG is a critical participant to all of the climate vulnerability and resilience planning listed above, as well as this strategy document. See <https://cig.uw.edu/>.

Washington Department of Ecology Office of the Columbia River: The Office of the Columbia River Water Management Program seeks to meet current and future water needs along the Columbia River and its tributaries. They are working to resolve conflicts over water and provide water security in the face of drought and changing climate. See <https://wrc.wsu.edu/project/water-supply-and-demand-forecast-2016/>.



Placeholder for Letter of Support, Chelan County Board of Commissioners

Photo: Chelan County, 2020

Acknowledgements

This strategy was developed throughout 2019-2020 as a partnership among the following entities:

- Chelan County Natural Resources Department
- Chelan County Public Utility District
- Washington State Department of Natural Resources
- University of Washington Climate Impacts Group
- BERK Consulting
- US Environmental Protection Agency, Region 10
- Federal Reserve Bank of San Francisco
- Federal Emergency Management Agency

Over 100 people from Chelan County organizations and the wider community participated in several workshops, providing in person and survey feedback on the developing strategy, ultimately contributing invaluable input that has been reflected in the final strategy.



CHELAN COUNTY



FEDERAL RESERVE BANK OF SAN FRANCISCO



FEMA



Lake Chelan

Photo: Unsplash, 2020

Wildfire

Community Feedback Highlights from Strategy Development Outreach

Success looks like, "...Building and communicating an awareness in our region that increased fire intensity and frequency is tied in part to climate change."

We need, "...Aggressive proactive thinning and burning, better/more outreach and education, reduced fuel loads, and more information-education about homeowner incentives to reduce fuels in the interface."

"As landowners, we become better neighbors by managing our properties to reduce the threat and impacts of wildfire, floods, invasive species, and other problems brought on by climate change."

Observed / Current

Washington and Chelan County specifically have experienced several large wildfires in recent years. In 2015, the state saw its worst wildfire season in recent history with over 1 million acres burned, followed by another million acres burned in 2017. These recent wildfire seasons are not unprecedented in terms of the amount of acreage that burned historically in eastern and central Washington prior to fire exclusion with settlement, but they are uncharacteristic in terms of the acreage that burned at high severity.⁶

These wildfires are also unprecedented in terms of their impacts to the livelihoods and resources of the communities in which they burned. Although it is difficult to characterize trends in wildfire at the small scale of Chelan County, several trends of increasing wildfire activity across the western U.S. are relevant to Washington and Chelan County.

- The area burned by wildfire in the western US has increased 12-fold from 1973 to 2012.⁷
- The number of large wildfires (> 100 acres) in the western US has increased by about seven fires per year from 1984 to 2011.⁸ This trend in large wildfires is critical because the largest wildfires burn 99% of the area burned each year.
- Wildfire season length, defined as the time between the date of the first reported wildfire and the date the last wildfire is controlled, has increased across the western US for forested areas; the average length of the fire season has increased by 84 days for 2003 to 2012 compared to the 1973 to 1982 average.⁹

These trends of increasing wildfire activity are due to a combination of factors including population growth and development in the wildland-urban interface, a legacy of forest management, and warmer and drier summers that lead to drier fuels (i.e., live and dead vegetation). Increasing temperatures and water balance deficit

6 Haugo, et al. 2019. The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA.

7 Westerling 2016. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring.

8 Dennison et al. 2014. Large wildfire trends in the western United States, 1984-2011.

9 Westerling 2016. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring.



2010 Swakane Fire

Photo: WA DNR



(atmospheric demand for water) due to climate change account for about half of the observed increase in fuel dryness since the 1970s.¹⁰

Expected Changes

Wildfire activity is expected to increase across central and eastern Washington as temperatures continue to increase. The area burned by wildfire in forested areas of central Washington is projected to double by the 2020s and increase *4-fold by the 2040s*, relative to the 1980-2006 average, for a moderate greenhouse

gas scenario.¹¹ Projected increases in area burned are less for grassland and shrub-steppe ecosystems in Washington, but these areas are still projected to see twice as much area burned by the 2040s.

It is important to note that these projections are for increases in area burned on average -- predicting fire in any given year or how big any particular wildfire season will be is not possible, despite the clear trend towards increasing area burned.

Projected increases in area burned in grassland and shrub-steppe ecosystems are due to wetter winters and springs that increase growth of fine vegetation

Impacts Due to Increasing Wildfire

Impacts listed here are potential consequences of changes in wildfire described in the section on expected changes. Consequences will vary locally and are likely to intensify with time as climate change intensifies unless adaptation actions are taken.

Health & Well-being

- More frequent evacuations.
- Economic losses due to property damage & business interruption.
- More hazardous air quality days.
- More smoke & fire exposure for agricultural workers.

Fish, Wildlife, & Habitat

- Habitat loss for species dependent on old forests.
- Reduced aquatic habitat quality due to sediment & warmer stream temperatures.
- More invasive species, especially in shrub-steppe ecosystems.

Recreation

- Closures & reduced access to recreation areas.
- Reduced tourism & outdoor recreation due to hazardous air quality.

Energy & Communications

- Increased damage to electric grid & communications infrastructure.

Agriculture

- Fire & smoke damage to agriculture infrastructure & crops .
- Crop loss & interruptions to the growing season.

¹⁰ Abatzoglou and Williams 2016. Impact of anthropogenic climate change on wildfire across western US forests.

¹¹ Littell et al. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Medium warming scenario is CMIP 3 emissions scenario A1B.



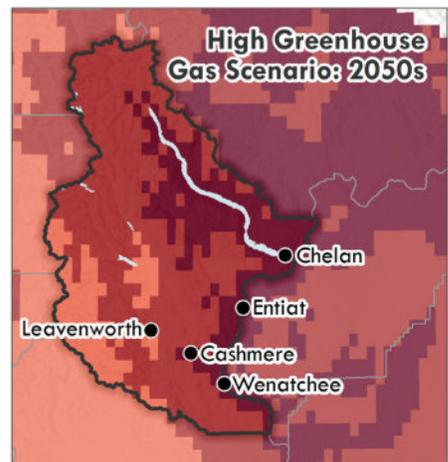
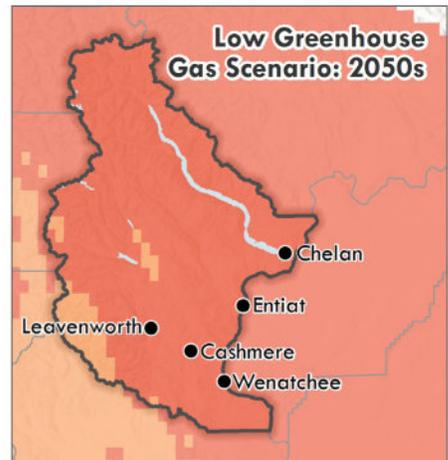
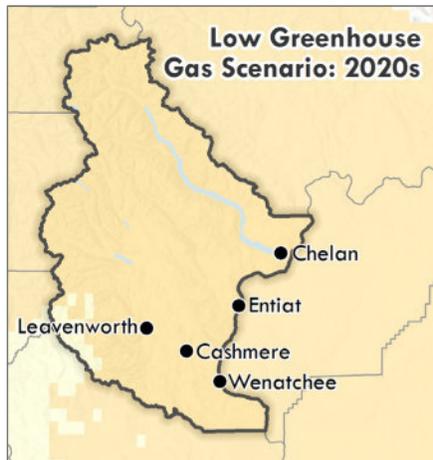
Number of Extreme Fire Danger Days:



fuels, which then dry and carry fire more easily in the summer. Projected increases in area burned in forested ecosystems are due to higher temperatures and drier summers that will dry fuels and enable wildfires to spread more easily. Fuel moisture in summer is an indicator of the climatic potential for wildfire. When fuel moisture is low there is significant potential for wildfires.

Summer (June–August) 100-hr fuel moisture¹² is projected to decrease

Exhibit 3. Extreme Fire Danger Days, Chelan County
 The number of extreme fire danger days per year is expected to increase across Chelan county by 2020s and increase more for a high greenhouse gas scenario and by the 2050s.
 Sources: Climate Toolbox, 2020; BERK, 2020.



across eastern Washington, particularly at higher elevations.¹³ By the 2050s, average 100-hr fuel moisture in summer in Chelan County is expected to decrease by -6% for a low greenhouse gas scenario and -8% for a high greenhouse gas scenario.

Warmer and drier conditions are projected to increase the number of

days with fire danger. By the 2050s, days with extreme fire danger¹⁴ are expected to increase by nine days for a moderate greenhouse gas scenario and 13 days for a high greenhouse gas scenario. More extreme fire danger days are expected throughout the wildfire season and will be most noticeable early and late in the season.

12 Fuel moisture means the amount of water in vegetation available to a fire, and is shown as a percent of the dry weight of that specific fuel. (NOAA, 2020).
 13 The Climate Toolbox: Climate Mapper (<https://climatetoolbox.org/tool/Climate-Mapper>).
 14 Extreme fire danger days are defined as the days when 100-hr fuel moisture is below the historical (1971 - 2000 average).

Current Initiatives

Below is a selection of initiatives and projects underway which are contributing to building resilience to a changing wildfire season and more wildfires.

Chelan County Multi-Jurisdictional Natural Hazard Mitigation Plan: Completed in May 2020, this plan specifically addresses wildfire as a key natural hazard to plan for in Chelan County, offering a comprehensive look at the effects of wildfire on the Chelan County communities.

Chelan County Community Wildfire Protection Plan: Updated and adopted in 2018, this is a multi-jurisdictional effort directly working towards wildfire protection. Specific goals include improving response capabilities, creating fire-resilient landscapes, and promoting fire adapted communities. These goals are consistent with the direction established in the Washington State Wildland Fire Protection 10-Year Strategic Plan.

Chelan County Public Utility District Fire Hardening: Multiple initiatives including hardening transmission infrastructure against fire risk (e.g., replacing wood with steel structures), clearing vegetation from high risk transmission infrastructure, and painting poles with fire retardant paint.

Cascadia Conservation District Wildfire Preparedness & FirewiseUSA®: Education and outreach materials focused on wildfire prevention and what to do when wildfire occurs. In coordination with the National Fire Protection Association (NFPA), Cascadia offers wildfire risk assessments, wildfire preparedness tips, wildfire toolkits, FirewiseUSA® landscape guides (i.e., fire-resistant vegetation), and other materials to help build homeowner and community resilience to wildfire.

Landowner Assistance: Financial assistance and cost sharing is available to landowners to help reduce fuels. There are programs administered through multiple organizations including Washington DNR's Landowner Assistance Program and Cascadia Conservation District.

Fire Districts: Fire Districts in Chelan County offer outreach and education, support community wildfire preparedness, and can

provide on-site wood chipping or fuel wood removal from properties, reducing the risk of wildfire spread (e.g., Fire District 1, Lake Wenatchee Fire and Rescue, and others).

Wildland Urban Interface Codes: Chelan County and the cities of Chelan and Wenatchee have adopted Wildland-Urban Interface standards. Chelan County regulates roofing materials, and the cities regulate roofing, siding, landscaping, access, and other provisions.

20-Year Forest Health Strategic Plan for Eastern Washington: Partners in the county are implementing multiple activities and initiatives linked to the 20-Year Forest Health Strategic Plan for Eastern Washington including landscape evaluations for forest health planning areas, forest health treatments by forest collaboratives, and landowner assistance.



2015 Chelan Complex Fire

Photo: Ben Brooks



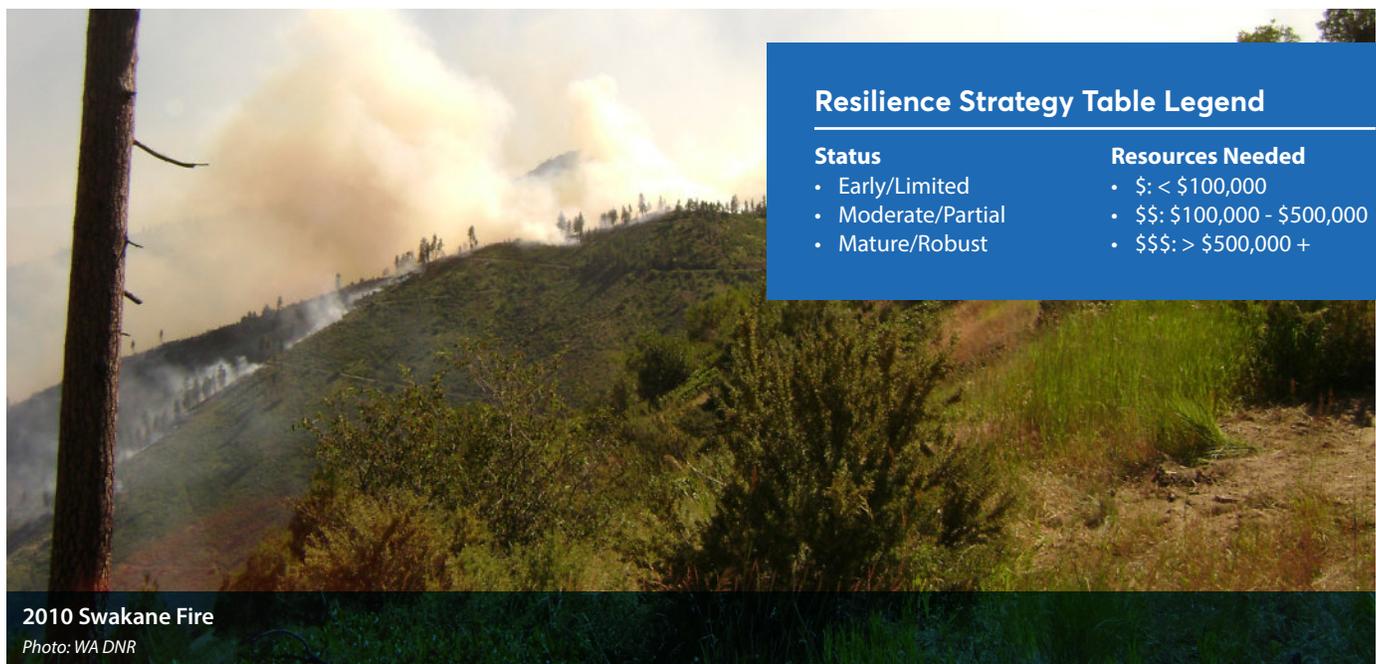
Resilience Strategies

The strategies presented in the section below are in alignment with goals already adopted as part of Chelan County’s wildfire response policy. Notably, the Chelan County Community Wildfire Protection Plan presents a number of goals related to building community resilience, including improving response

capabilities, creating fire resilient landscapes, promoting fire adapted communities, protecting the economy, and utilizing existing plans and guidelines. The strategies below build on these goals, and aim to tailor them to building climate resilience around increased wildfire in Chelan County.

Exhibit 4. Wildfire Climate Resilience Strategies

Strategy	Status	Leads and Partners	Resources Needed
Build awareness of increasing wildfire risk and preparedness of Chelan County Communities	Moderate/Partial	<ul style="list-style-type: none"> Chelan County Fire Marshall Cities Fire Districts Organizations serving vulnerable populations 	\$: Coordinator
Coordinate and improve emergency preparedness systems, particularly early detection ¹	Unknown	<ul style="list-style-type: none"> Chelan County Fire Marshall Fire Districts 	\$: Coordinator
Develop fire safe places in fire prone areas with wildland urban interface policies and codes ²	Moderate/Partial Varying levels of land use policies and development regulation oversight in rural and urban areas	<ul style="list-style-type: none"> Chelan County Community Development Department Individual city planning and building departments 	\$\$\$: Incentives, especially for upgrading existing structures for greater fire resilience \$: Staff



Resilience Strategy Table Legend

Status	Resources Needed
• Early/Limited	• \$: < \$100,000
• Moderate/Partial	• \$\$: \$100,000 - \$500,000
• Mature/Robust	• \$\$\$: > \$500,000 +

2010 Swakane Fire
Photo: WA DNR

Exhibit 4. Wildfire Climate Resilience Strategies (cont.)

Strategy	Status	Leads and Partners	Resources Needed
Create fire adapted communities	Moderate/Partial Chelan County Community Wildfire Protection Plan details a series of mitigation actions, and contains extensive wildfire hazard mapping Participation in Firewise USA® program	<ul style="list-style-type: none"> Chelan County (with many local and regional partners) Fire Departments Individual landowners 	<p>\$\$\$: Funding to implement mitigation goals</p> <p>\$: Education and outreach surrounding resources available to individual landowners for building local fire resilience (e.g., fuel reduction)</p>
Protect critical facilities (also see flooding)	Early/Limited Mapping of critical facilities has been prepared	<ul style="list-style-type: none"> Chelan County Cities Chelan PUD & Other Utilities School Districts Fire Districts 	\$\$\$: Funding to implement improvements
Coordinate ecological recovery programs for areas subject to fire in forested and shrub-steppe lands	Early/Limited Conservation practices funded in some burned areas (e.g., NRCS)	<ul style="list-style-type: none"> USFS WDNR WDFW Conservation District Chelan Co. Natural Resources Department 	\$\$\$: Planning and Reserve funding
Monitor exotic and invasive species on resource and natural lands and prioritize protection and enhancement of such areas	Moderate/Partial	<ul style="list-style-type: none"> USFS WDNR WDFW Conservation District Chelan Co. Natural Resources Department Chelan Co. Noxious Weed Board 	\$\$: Funding to implement improvements
Continue to build partnerships across agencies to monitor and respond to climate changes and vulnerabilities in forested and shrub-steppe lands	Early/Limited	<ul style="list-style-type: none"> USFS Bureau of Reclamation NRCS WDNR WDFW Conservation District Chelan Co. Natural Resources Department 	\$: Staff resources to develop and maintain partnerships
Proactively address fire resiliency through activities such as: pre-fire monitoring, maintenance/forest treatment, thinning, prescribed fire, and managed natural fire	Early/Limited	<ul style="list-style-type: none"> USFS WDNR Chelan Co. Fire Marshall Fire Districts 	\$\$\$: Program development and ongoing implementation
Air quality: education, training, and responses to protect people and communities during and after wildfire	Early/Limited	<ul style="list-style-type: none"> Washington Department of Ecology Central Regional Office Chelan-Douglas Health District Organizations serving vulnerable populations 	\$\$: Staff resources to plan and respond

1 This appears to be a proposal for Zone F Entiat in the Chelan County Community Wildfire Protection Plan 2018 Update. Here it is meant to be broader in application across county.

2 This is proposed as a business incentive for offering discounted materials in Zone G Fire Adapted Communities near Lake Wenatchee in the Chelan County Community Wildfire Protection Plan 2018 Update. Here it is meant to be broader in application across county.



Snowpack & Streamflow

Community Feedback Highlights from Strategy Development Outreach

We need "...prioritization of water use as snow packs decrease, and to investigate ways water can be stored near the source to hopefully utilize when runoff is low."

Support "...well-developed watershed planning groups in key watersheds and combined interagency long-term vision."

"I would like to see more urgency and recognition that declining snowpack and instream flow and seasonal changes in temperature and runoff are a major threat to our economy and quality of life."

Observed / Current

Washington's snowpack and glaciers are in decline due to rising temperatures. These changes will have consequences for streamflow across the state.

While snowpack varies year-to-year, spring snowpack in the Washington Cascades declined by about 30%, on average, between 1955 and 2016.¹⁵ This decline in snowpack is primarily driven by rising temperatures, but also reflects natural variability in the climate over that period.

Glaciers in the North Cascades are also losing mass. Between 1900 and 2009, glacier area in the North Cascades decreased approximately 56% (+/-3%).¹⁶ Glacier meltwater contributes to streamflow particularly in summer months when runoff¹⁷ from precipitation and snowmelt are low.¹⁸ In the Stehekin River watershed between 1993 and 2009, an average of 11% of total summer runoff originated from meltwater contributions from the three glaciers within the watershed.¹⁹

Expected Changes

Snowpack is expected to further decline with warming in the future. In Chelan County, average spring snowpack is projected to decline 26.9% and 33.5% by the 2050s and 36.2% and 53.5% by the 2080s under a low and high greenhouse gas scenario, respectively (Exhibit 5).

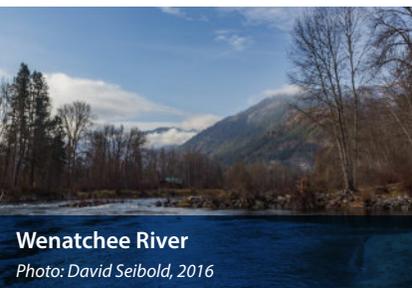
15 Mote et al. 2018. Dramatic declines in snowpack in the western US. *Nature Climate and Atmospheric Sciences*.

16 Dick, K. Glacier Change in the North Cascades, Washington: 1900-2009. *Dissertations and Theses* (2013) doi:[10.15760/etd.1062](https://doi.org/10.15760/etd.1062).

17 Runoff is all water originating from precipitation and snow and glacier melt that flows over land, subsurface, and into shallow groundwater.

18 Granshaw, F. D. & Fountain, A. G. Glacier change (1958–1998) in the North Cascades National Park Complex, Washington, USA. *Journal of Glaciology* 52, 251–256 (2006).

19 Riedel, J., and M. A. Larrabee. 2011. North Cascades National Park Complex glacier mass balance monitoring annual report, Water year 2009: North Coast and Cascades Network. Natural Resource Technical Report NPS/NCCN/NRTR—2011/483. National Park Service, Fort Collins, Colorado.



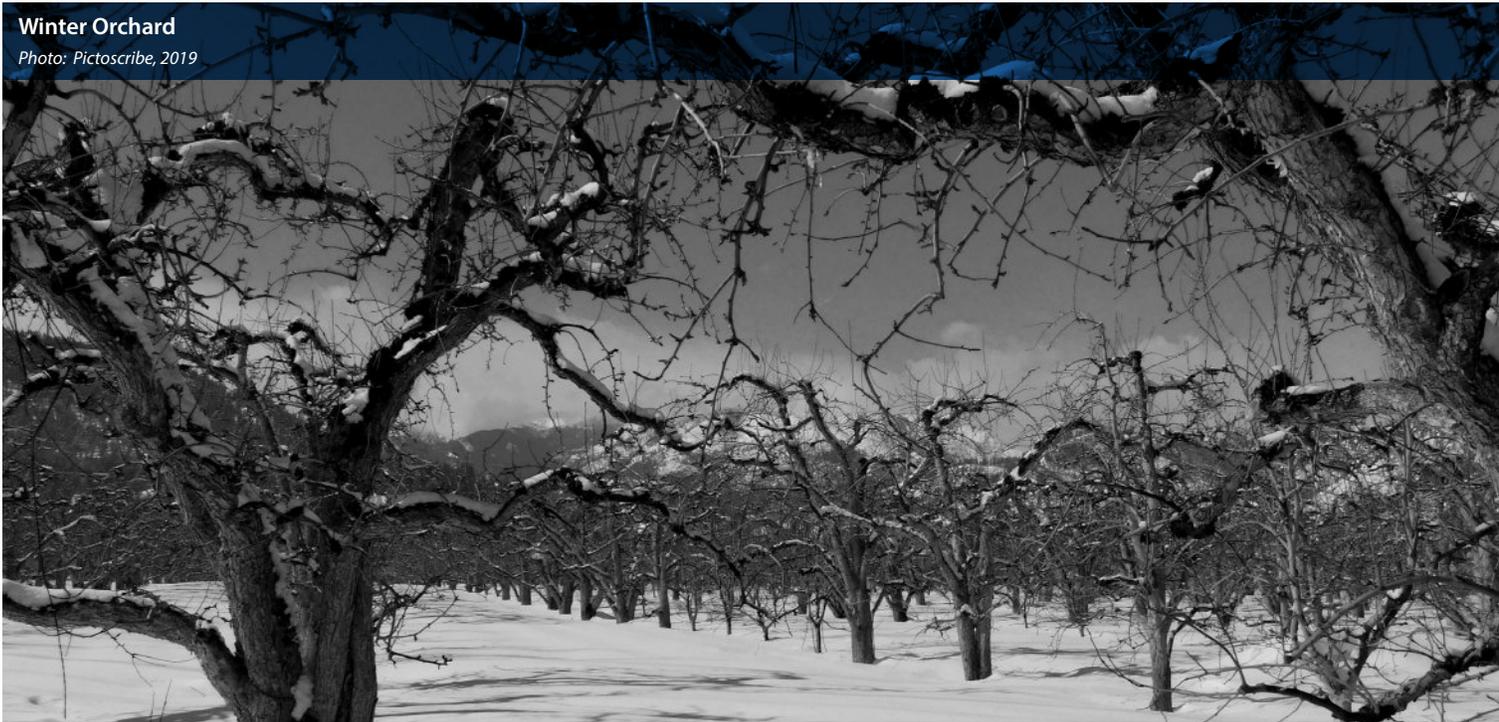
Wenatchee River

Photo: David Seibold, 2016



Winter Orchard

Photo: Pictoscribe, 2019



Impacts Due to Less Snowpack & Altered Streamflow

Impacts listed here are potential consequences of changes in snowpack and streamflow described in the section on expected changes. Consequences will vary locally and are likely to intensify with time as climate change intensifies unless adaptation actions are taken.

Health & Well-being

- Greater risk of waterborne diseases in drinking water due to pathogens in flood waters & high runoff events.

Fish, Wildlife, & Habitat

- Warmer stream temperatures during low flow periods.
- Reduced habitat quantity due to lower summer flows.
- Reduced aquatic habitat quality.
- More favorable conditions for invasive fish & aquatic species.

Recreation

- Less summer water availability for river recreation.
- Shorter & more limited winter recreation season.
- Less winter recreation tourism and revenue for businesses.
- Changes in inflows and reservoir elevations.

Energy & Communications

- More winter & less summer hydropower generation.

SNOWPACK & STREAMFLOW

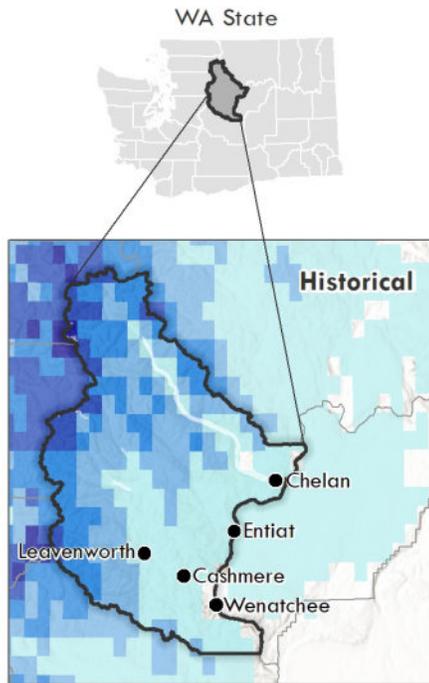
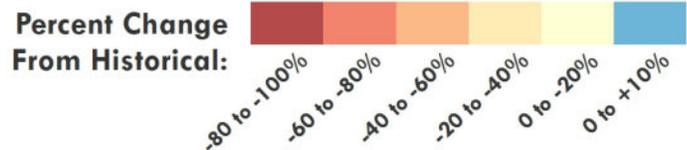
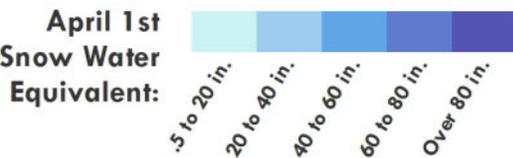
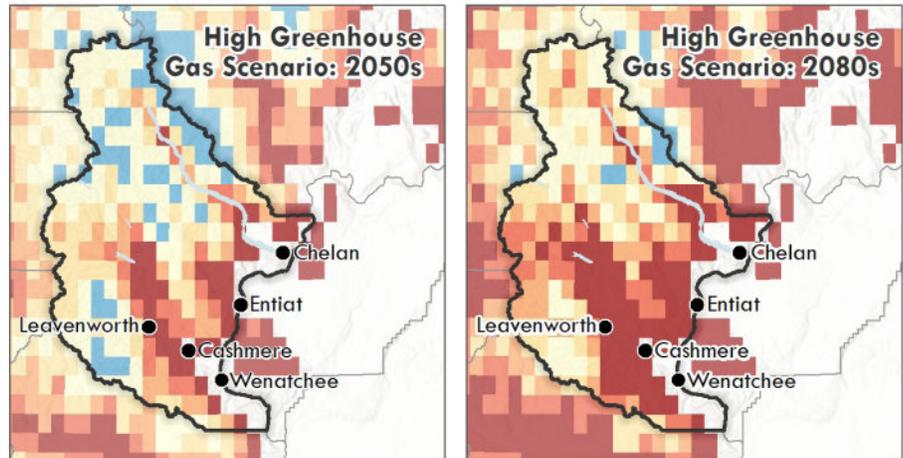
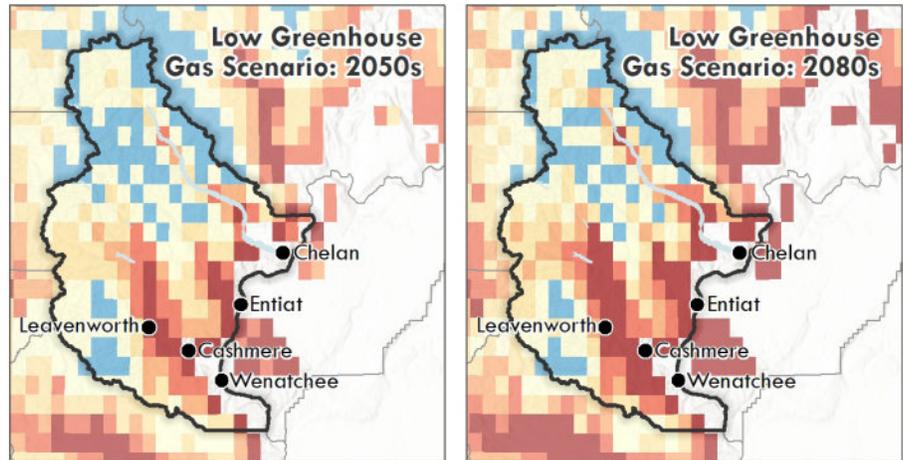


Exhibit 5. April 1st Snow Water Equivalent, Chelan County

Snow water equivalent is the total amount of water stored in the snowpack. This value on April 1st is a critical indicator of water availability for the upcoming dry season. April 1st snow water equivalent is expected to decrease across Chelan county (except at the highest elevations) by 2050s, with larger decreases for the high greenhouse gas scenario and by the 2080s.

Sources: Integrated Scenarios, 2015; BERK, 2020.



Streamflows are typically lowest and present the greatest challenges for competing instream and out of stream uses in late summer. Higher temperatures, less snowpack, earlier snowmelt, declining glacier mass, and less

summer rain are all expected to contribute to lower streamflows in summer months. Total runoff in August, which includes any surface water flows in addition to subsurface runoff in shallow groundwater, is projected to

decline 20.4 % and 26.1% by the 2050s and 27.2% and 36.1% by the 2080s, under a low and high greenhouse gas scenario, respectively (Exhibit 6).

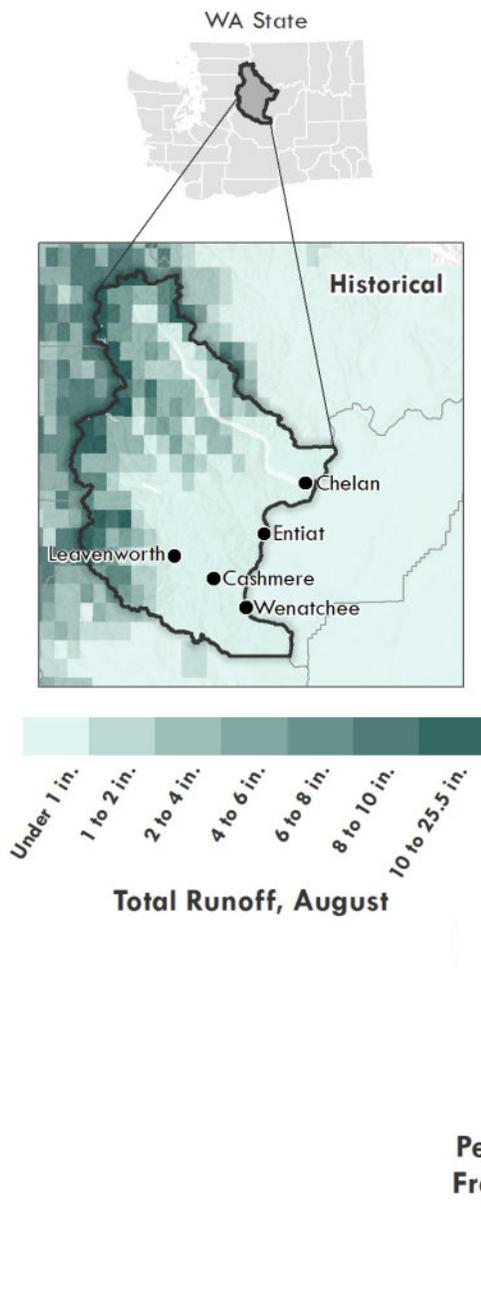
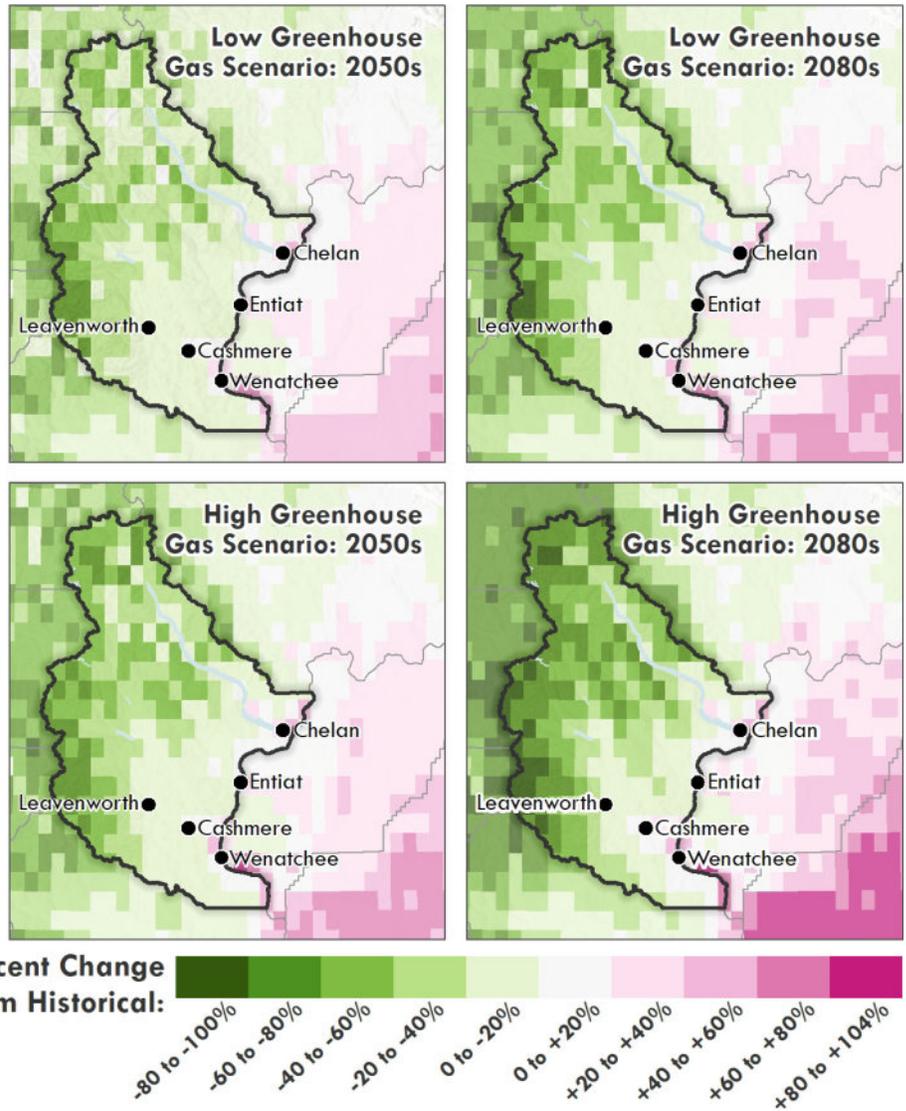


Exhibit 6. Total Runoff, August, Chelan County

Total runoff in August is an indicator of water availability during the driest time of the year. Total runoff in August is expected to decrease across Chelan county by 2050s, with larger decreases expected for a high greenhouse gas scenario and by the 2080s.

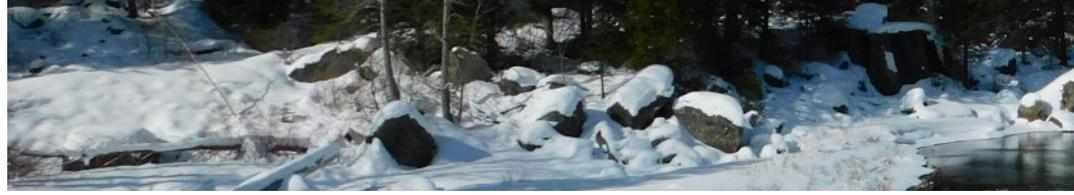
Sources: Integrated Scenarios, 2015; BERK, 2020.



In the Entiat River (near the City of Entiat) average summer streamflow (June - August) is projected to decline by 38% by the 2040s and 54% by the 2080s under a moderate greenhouse gas scenario, relative to the 1916-2006

average. The 7Q10 streamflow (the lowest 7-day average streamflow with a 10-year return interval) provides an indication of water quantity and habitat quality for fish and aquatic species. The 7Q10 flows are projected to decline in

the Entiat River. For a moderate greenhouse gas scenario, 7Q10 flows are projected to decline 3% by the 2040s and 7% by the 2080s, relative to 1916-2006.



Current Initiatives

Icicle Work Group: A joint effort between Chelan County and the Washington State Department of Ecology, this group seeks to find collaborative solutions for water management within the Icicle Creek Watershed. They are developing a water resource management strategy comprised of projects that, among other goals, protects streamflow that provides healthy habitat, meets water quality objectives, and is resilient to climate change. Asking the question, how do we hold back water in absence of snowpack to benefit streamflow and water supply?

City of Leavenworth Water Improvement Project: The City received grant funding to install widespread advanced metering

infrastructure, so customers can remotely detect leaks and monitor water usage in real time. One goal of this project is to reduce water demand as snowpack and streamflow changes.

WDFW Culvert Sizing Guidance:

The Washington Department of Fish and Wildlife is working with UW CIG to develop climate resilient culvert guidelines, which will help guide installation of new culverts and bridges in Chelan County (and statewide) in order to accommodate changing streamflow.

Mission Ridge Ongoing Snowpack Monitoring and Snow

Creation: As a recreation-based business based on snowpack, Mission Ridge is preparing for long-term changes by keeping

a close eye on year-to-year snowpack. While some recent years have had record snowfall, inconsistency is the consistency here, and they are seeing high variability in snowpack between seasons.

Stemilt-Squilchuck Water

Storage: This effort explores using water storage as streamflow shifts to capture water when it is more available.

Watershed Plans: Watershed plans are approved for Lake Chelan, Entiat, Wenatchee and Stemilt-Squilchuck with water quality and quantity and fish and wildlife habitat measures. Implementation strategies include streamflow monitoring and community water metering.



Winter on the White River

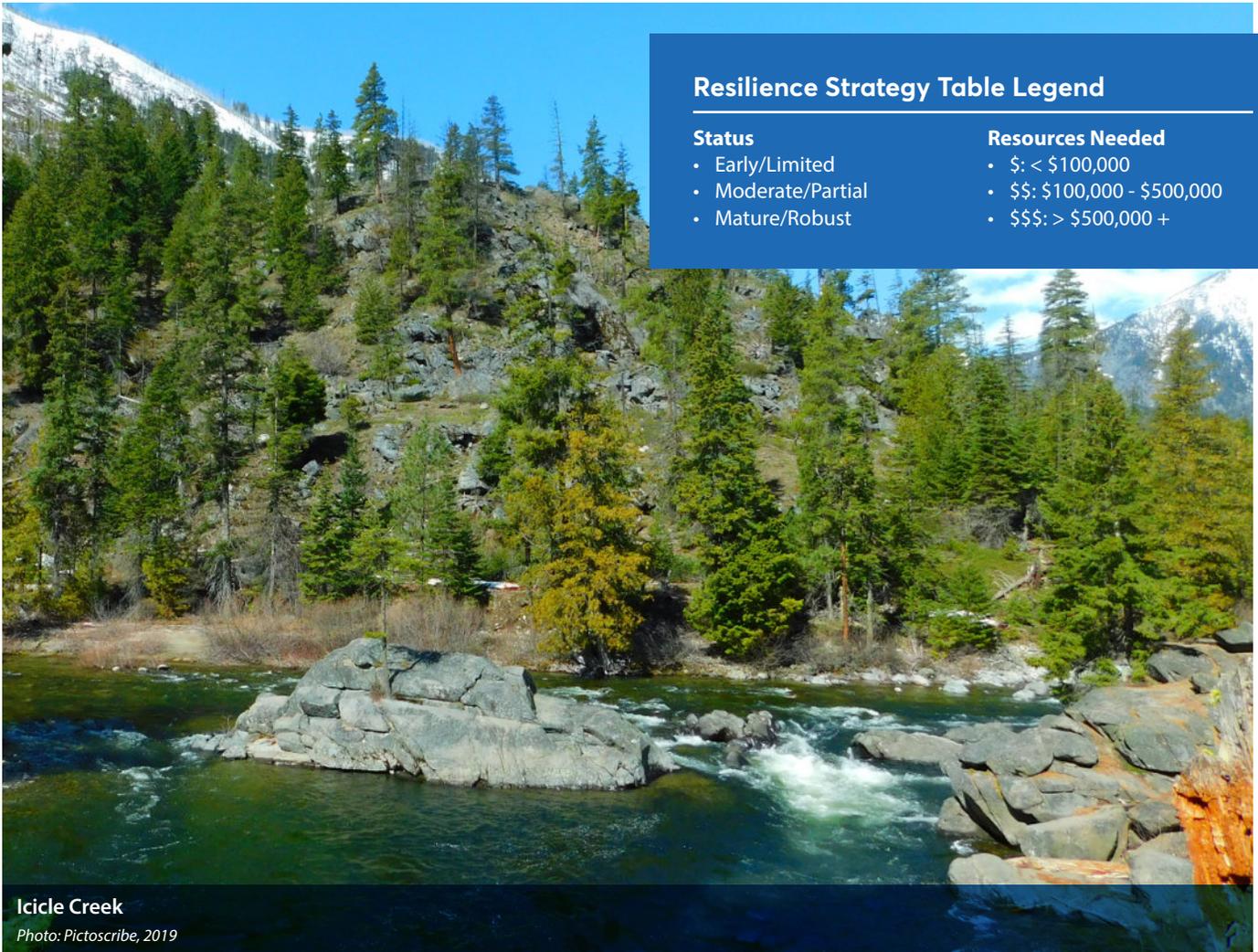
Photo: Pictoscribe, 2008



Resilience Strategies

The strategies in this section build upon policy and efforts already adopted throughout the county. Specifically, the Icicle Creek Work Group Vision & Guiding Principles provide a framework for thinking about building resilience to changing snowpack and streamflow. As stated in the vision, The Icicle Creek Work Group seeks to find collaborative solutions for

water management within the Icicle Creek drainage to provide a suite of balanced benefits for existing and new domestic and agricultural uses, non-consumptive uses, fish, wildlife, and habitat while protecting treaty and non-treaty fishing interests. This vision is largely in alignment with building climate resilience, and helped to frame the development of the below strategies.



Resilience Strategy Table Legend

Status

- Early/Limited
- Moderate/Partial
- Mature/Robust

Resources Needed

- \$: < \$100,000
- \$\$: \$100,000 - \$500,000
- \$\$\$: > \$500,000 +

Icicle Creek

Photo: Pictoscribe, 2019



Exhibit 7. Snowpack & Streamflow Climate Resilience Strategies

Strategy	Status	Leads and Partners	Resources Needed
Collect local data to support climate resiliency including weather stations/ SNOTEL, seasonal wind patterns, etc.	Early/Limited	<ul style="list-style-type: none"> Natural Resources Conservation Service (NRCS) 	\$\$: Funding for infrastructure improvements
Identify and support data collection opportunities to quantify forest management effects on snowpack in order to support development of forest-snow-streamflow model.	Early/Limited	<ul style="list-style-type: none"> Chelan Co. Natural Resources Department WDFW USFS (and other fed. Agencies) 	\$: Initial funding for identifying data needs; \$\$: Funding to implement data collection
Encourage watershed-scale community building to adapt to changing streamflow and snowpack within the watershed. For example: <ul style="list-style-type: none"> Irrigation efficiencies and returning diverted water back into streams during critical flow periods. Forestry practices and riparian enhancement that improve water-holding capacity and reduce stream temperatures. Critical areas restoration to maintain or reduce stream temperatures, and restore flow patterns. Management of invasive or non-native aquatic species that thrive in warmer waters. Prioritization of water use as snowpack decreases 	Early/Limited Limited watershed-scale community building implementation in Icicle Creek Watershed— extend to other priority areas of Chelan County.	<ul style="list-style-type: none"> Chelan County Chelan PUD UWCIG WDNR 	\$\$\$: Funding to develop climate resilience strategies that leverage watershed plans
Promote and encourage water efficiency and conservation	Moderate/Partial Ongoing	<ul style="list-style-type: none"> Chelan Co. Natural Resources Department Chelan PUD Conservation District Irrigation Districts Municipal Service Providers Agricultural Producers 	\$\$\$: Funding for infrastructure improvements \$\$: Funding for agricultural conservation practices
Reduce impacts of climate change to aquatic systems through stream-habitat improvement and connectivity	Moderate/Partial In progress Implementation of watershed plans	<ul style="list-style-type: none"> Chelan Co. Natural Resources Department Chelan PUD Conservation District WDNR WDFW Non-Governmental Organizations 	\$\$\$: Funding to implement watershed and habitat plans



Flooding

Community Feedback Highlights from Strategy Development Outreach

“Rebuild riparian plant communities, active floodplains, and buffer zones-- these all help ameliorate effects of floods.”

“The cascading effects that climate induced flood events could have on our environment could have cascading impacts to key ecosystem function and services.”

We need “...mechanisms for rapid-response to damaged areas and ability to leverage government resources at an accelerated rate to reduce the overall impacts.”

Observed / Current

In central Washington, floods often occur in the foothills of the Cascade Range as the snowpack rapidly melts in late spring and early summer. In some areas, flooding can also occur during winter when high temperatures cause heavy winter rainfall that also melts existing snowpack.²⁰ Small watersheds in central Washington can experience small-scale flash floods during summer thunderstorms or cloudburst events.

The convergence of Icicle Creek and the Wenatchee River in Leavenworth, the reach of the Wenatchee River between Cashmere and Wenatchee, and the Wenatchee River headwaters are areas particularly vulnerable to flooding in Chelan County.²¹

Expected Changes

Climate change is expected to increase both the frequency and magnitude of floods in and around Chelan County. A shift from snow to rain at mid-elevations, increasing cool season precipitation, greater sediment transport, and heavier rainfall will work in combination to increase the frequency of floods and volume of flood water. As warming continues, a greater fraction of winter precipitation will fall as rain rather than snow, increasing winter runoff²² and streamflow volumes. In Chelan County, total cool season (October to March) runoff is projected to increase 27% and 39% by the 2050s and 43% and 74% by the 2080s for a low and high greenhouse gas scenario, respectively.

At the Entiat River near the City of Entiat, natural streamflow volume associated with the 100-year flood event is projected to increase 41% by the 2040s and 88% by the 2080s under a moderate greenhouse gas scenario, relative to the 1916-2006 average.²³

20 What causes floods in Washington State? Fact Sheet 228-96. By: David L. Kresch and Karen Dinicola. <https://doi.org/10.3133/fs22896>.

21 Chelan County Flood Control Zone District. 2017. Chelan County Comprehensive Flood Hazard Management Plan. Chelan County Flood Control Zone District, Public Works Department. Wenatchee, Washington.

22 Runoff is all water originating from precipitation and snow and glacier melt that flows over land, subsurface, and into shallow groundwater.

23 Hamlet, A.F. et al., 2013. An overview of the Columbia Basin Climate Change Scenarios Project: Approach, methods, and summary of key results. Atmosphere-Ocean 51(4): 392-415, doi: 10.1080/07055900.2013.819555.



Turn Around, Don't Drown Outreach

Photo: WSDOT, 2020



Landslide and Highway Closure

Photo: WSDOT, 2020



Impacts Due to More Frequent & Larger Floods

Impacts listed here are potential consequences of changes in flooding described in the section on expected changes. Consequences will vary locally and are likely to intensify with time as climate change intensifies unless adaptation actions are taken.

Health & Well-being

- Greater flood risks to communities & homes.
- More road closures & reduced access.

Fish & Habitat

- Greater mortality of juvenile fish & eggs.
- Reduced slow-water habitat.

Recreation

- Reduced access to trails & other recreation facilities.
- Relocation of trails, campgrounds, & other recreation facilities.

Energy & Communications

- More frequent spilling at hydroelectric projects.
- Loss of potential hydropower generation.

Infrastructure

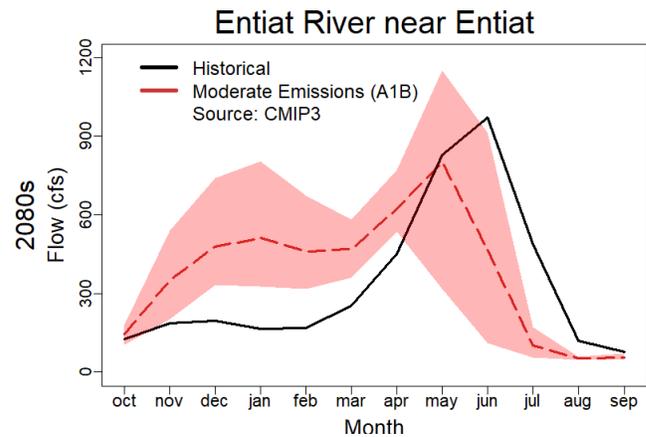
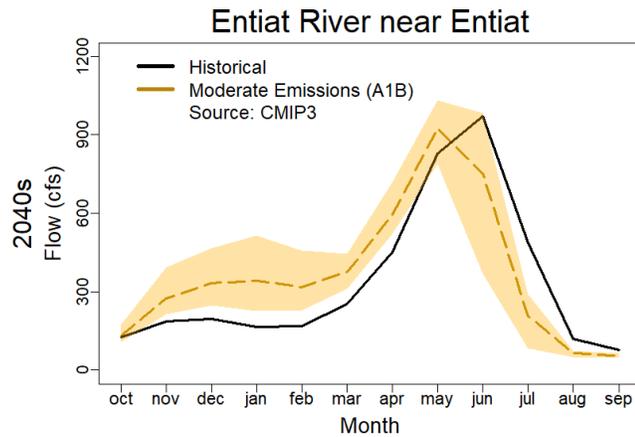
- More flood damage to roads & utility infrastructure.
- Greater need for emergency response & flood mitigation resources.
- Decreased effectiveness of existing flood protection infrastructure.
- Greater risk of landslides.
- More road, culvert, & bridge maintenance & replacement.



Exhibit 8. Average Monthly Streamflow of Entiat River

Hydrographs describe the change in streamflow behavior throughout the water year. The x-axis represents time, months of the year, and the y-axis shows streamflow in cubic feet per second. These hydrographs illustrate an increase in winter streamflow and a shift in timing of peak streamflow to earlier in the year.

Source: Hamlet et al., 2013, hydrographs developed by UW CIG.



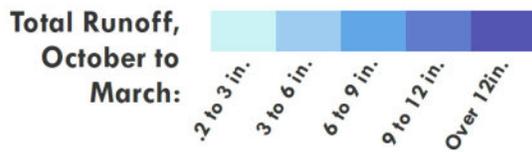
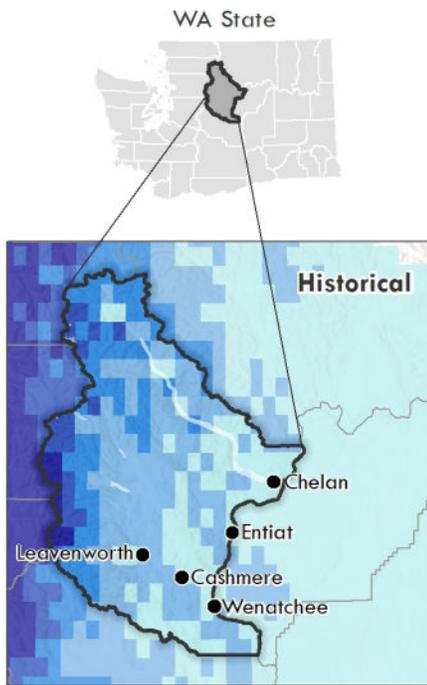
US 97 Washout
Photo: Randy Sears, 2009

Exhibit 8 shows hydrographs of the average monthly streamflow at the Entiat River near Entiat (left) for the 2040s and (right) the 2080s under a moderate greenhouse gas scenario. The black line on each graph represents the average monthly historical streamflow (1916–2006) at this location. The shaded areas show the range of projected changes in average monthly streamflow.

Monthly hydrographs illustrate projected changes in streamflow of the Entiat River, which include higher winter streamflow and earlier peak streamflow (Exhibit 9). These projected increases in winter and spring streamflow are expected to increase flooding.

Current Initiatives

Chelan County Comprehensive Flood Management Plan: This 2017 plan provides mitigation measures and actions around a wide range of alternatives, all aimed at protecting life and property within Chelan County. While limited in budget, it does address climate change specifically. Some objectives that build climate resilience are minimizing new development in high-risk areas, working cooperatively with public



agencies and stakeholders, and considering flood hazard management policies that promote resiliency and sustainable operations of critical facilities.

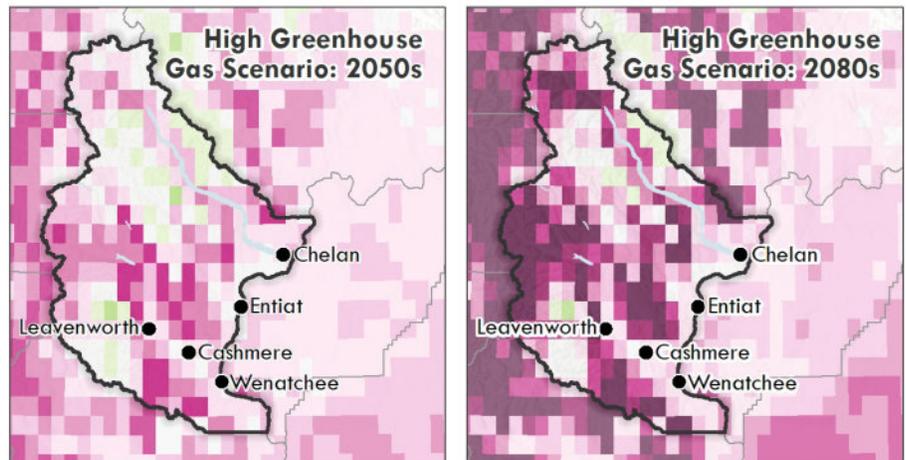
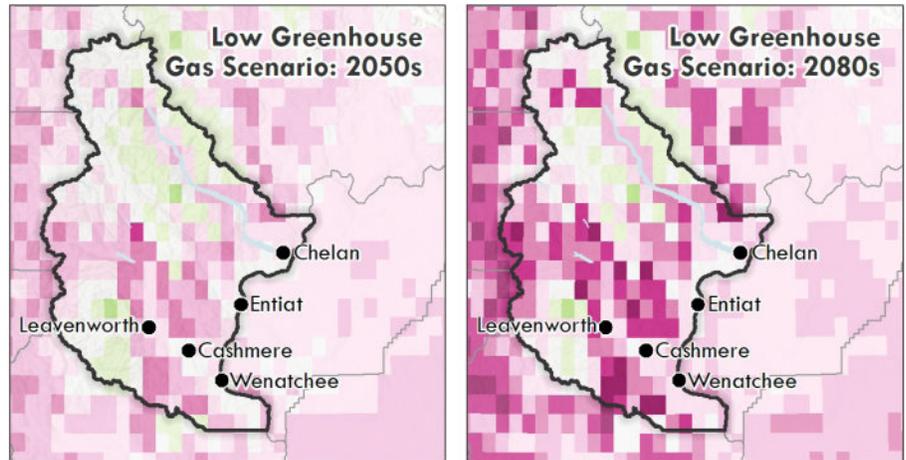
Culvert Sizing Guidance: Both WDFW and UW CIG are working on climate change adapted culvert design. The new culvert sizing guidance aims to better accommodate flood events which may be more extreme as a result of climate change impacts.

City of Cashmere Levee Management Plan: There are three major levees that protect

Exhibit 9. Total Runoff, 6-month October-March, Chelan County

Total runoff in the cool season is an indicator of the amount of water that can contribute to high stream flows and flooding during autumn and winter. Total cool season runoff is expected to increase in some areas of Chelan county by the 2050s, with larger and more widespread increases expected for a high greenhouse gas scenario and by the 2080s.

Sources: Integrated Scenarios, 2015; BERK, 2020.



Cashmere from major flood events. This is a joint project between Chelan County and Cashmere, this plan provides a maintenance, vegetation management, and capital improvement plan that balances the need of flood risk

reduction with aquatic species living in the Wenatchee River.

WDFW Emergency Hydraulic Project Approval (HPA) Permitting:

This is an effort by WDFW to streamline the



emergency HPA permitting process, which are needed for all building or other work related activities that divert or change the flow of water. In cases where flooding is happening or water diversion is quickly needed, WDFW can issue a verbal approval of a project.

WSDOT Climate Impacts Assessment: This statewide project assesses critical transportation routes and infrastructure within Chelan County in terms of vulnerability to climate impacts. WSDOT considers future climate risks during project design and when preparing long-term plans. They document how climate change and extreme weather variability are considered and propose ways to improve resilience.

Resilience Strategies

In 2017, the County adopted the Chelan County Comprehensive Flood Management Plan. The strategies below seek to build upon the goals already adopted within the Flood Management Plan. That plan aims to protect life, protect property, maintain operation of critical facilities, increase awareness of flood risk, and protect/restore the natural and beneficial functions of floodplains. All of these goals support building climate resilience, and the strategies below build upon those goals and put them in the context of climate resilience.



Rocky Reach Dam
Photo: Chelan PUD, 2016

Resilience Strategy Table Legend

Status

- Early/Limited
- Moderate/Partial
- Mature/Robust

Resources Needed

- \$: < \$100,000
- \$\$: \$100,000 - \$500,000
- \$\$\$: > \$500,000 +



Exhibit 10. Flood Resilience Strategies

Strategy	Status	Leads and Partners	Resources Needed
Improve flood warning and information dissemination.	Early/Limited Multi-jurisdiction coordination underway and continued dialogue needed	<ul style="list-style-type: none"> Chelan Co. Flood Control District Chelan PUD USACE USFS Washington Dept. of Ecology WDFW Irrigation and Reclamation Districts 	\$\$: Expanded regional funding among partners \$\$\$: Local and countywide grant funding
Assess risk management, and prepare for rapid response during the flood event.	Early/Limited Multi-jurisdiction coordination underway and continued dialogue needed	<ul style="list-style-type: none"> Chelan Co. Flood Control District Fire Districts Chelan Co. Public Works Cities Public Works 	\$\$\$: Local and countywide grant funding
Evaluate and improve stormwater management and infrastructure for high-intensity rainfall events	Moderate/Partial Variable based on stormwater management plans	<ul style="list-style-type: none"> Chelan Co. Public Works Departments Cities' Public Works Departments Chelan PUD WSDOT WDFW 	\$\$\$: Funding to implement improvements \$: Staff
Protect and upgrading or relocation of vulnerable critical facilities locations vulnerable to flooding ¹	Early/Limited Mapping has been prepared	<ul style="list-style-type: none"> Chelan County Cities Chelan PUD School Districts Fire Districts Telecommunication Providers 	\$\$\$: Funding to implement improvements
Revise transportation infrastructure: <ul style="list-style-type: none"> Improve transportation infrastructure where needed, e.g., enlarging road crossings Remove or redesign roads that disrupt floodplain function or intercept precipitation and ground water and accelerate its movement into stream systems. 	Early/Limited WSDOT Climate Smart Design initiated	<ul style="list-style-type: none"> Chelan Co. Public Works Cities Public Works WSDOT 	\$\$\$: Funding to implement improvements
Plan for post-flood restoration. Replant bare, disturbed, and recently burned areas to increase infiltration and slow movement of water. Provide restoration to stabilize ecosystems.	Moderate/Partial Watershed plans and riparian plantings in selected areas Conservation practices funded in some burned areas (e.g., NRCS)	<ul style="list-style-type: none"> Chelan Co. Natural Resources Department Conservation District USFS WDFW WDNR 	\$\$: Planning, and Reserve funding

¹ An objective in Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan.



Water Supply

Community Feedback Highlights from Strategy Development Outreach

Success looks like "...a county that uses water very efficiently so that even when the climate changes are in full force, we can have a high quality of life, strong economy, and great environment that supports fish, wildlife, and the rest of our ecosystem."

"Conservation and efficient use of water resources should be an explicit, high priority in all strategies and work regarding water resources."

"Chelan County has a good head start on developing water budgets and water banks. This strategy integrates increased planning efforts, leveraging resources to promote water storage solutions, and building public awareness around drought risk and mitigation."

Observed / Current

Significant changes in average annual streamflow have not been observed in rivers of central Washington including Stehekin River and the Wenatchee River in Chelan County. However, substantial declines in streamflow have been observed in the driest years. Between 1948 and 2006, streamflow declined in dry years by about 22% and 38% in these Chelan County rivers. These declines suggest that since mid-century, dry years have been getting drier.²⁴

Peak streamflow in spring is shifting earlier in the year in response to declines in snowpack. Between 1948 and 2002, the timing of peak spring streamflow advanced 16 days in response to warming and associated declines in snowpack.²⁵

Expected Changes

Total annual precipitation is not expected to change substantially, with only a marginal increase in average precipitation projected by most models. The most consequential change to water supply will be a shift in the timing of natural water availability throughout the year.²⁶ If unmitigated, this shift in the timing of water availability may create challenges for adequate water supply when water demand is greatest.

Water Supply

Higher winter temperatures are projected to increase the fraction of winter precipitation that falls as rain rather than snow, decreasing snowpack and shifting snowmelt earlier in spring (See [Snowpack and Streamflow](#) & [Floods](#) sections). Due to these changes in the climate, winter water supply is projected to increase and summer

²⁴ Luce, C. H. & Holden, Z. A. Declining annual streamflow distributions in the Pacific Northwest United States, 1948–2006. *Geophys. Res. Lett.* **36**, L16401 (2009).

²⁵ Stewart, I. T., Cayan, D. R. & Dettinger, M. D. Changes toward Earlier Streamflow Timing across Western North America. *J. Climate* **18**, 1136–1155 (2005).

²⁶ Snover et al. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers.



Lake Wenatchee

Photo: Pictoscribe, 2009



water supply is projected to decrease throughout the Columbia River Basin and in the watersheds of Chelan County specifically.

Based on the 2016 Columbia River Basin Long-term Water Supply and Demand Forecast, unregulated surface water supply in the Columbia River Basin for the wet season, November through May, is expected to increase by 31% (+/- 9%) by the 2030s (relative to the 1981-2011 average).²⁷ Conversely, unregulated surface water supply for the dry season, June through October, is expected to decrease by -10% (+/- 8%) for the same time period due to earlier spring runoff and drier summers.²⁸ The Columbia River Basin Long-term Water Supply and Demand Forecast will be updated in 2021; the specific numbers for these projections may change, but the seasonal pattern is unlikely to change.

The expected change in seasonal water supply for any watershed within the Columbia Basin, including the Wenatchee, Entiat, and Chelan watersheds, varies depending on local conditions and the elevation of the watershed.²⁹ Mid-elevation watersheds near the current snowline where snowmelt is a major contributor to streamflow are expected to experience the largest changes in streamflow timing and seasonal supply. The Wenatchee and Chelan watersheds are expected to see increases in surface water supply in October to March and decreases in June and July. The Entiat watershed shows more change in monthly average flows and slightly different timing, with increases in November to March and decreases in May to July.

Impacts Due to More Winter, Less Summer Water

Impacts listed here are potential consequences of changes in water supply described in the section on expected changes. Consequences will vary locally and are likely to intensify with time as climate change intensifies unless adaptation actions are taken.

Health & Well-being

- Less summer water availability for drinking water systems.
- Increases in municipal water demand.

Energy & Communications

- Greater demand for water to meet increasing hydropower demand with population growth.

Fish & Habitat

- Greater challenges to meeting instream flows for fish.

Agriculture

- Less summer water availability for irrigation.
- More frequent and higher magnitude water curtailments, especially in spring and summer.
- Seasonal changes in irrigation demand.

27 Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001.

28 Runoff is all water originating from precipitation and snow and glacier melt that flows over land, subsurface, and into shallow groundwater.

29 Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001.



Lake Chelan and Columbia River
Photo: Doc Searls, 2010

Across Chelan County specifically, total runoff during the cool season (October to March) is expected to increase 27% and 39% for the 2050s and 43% and 74% by the 2080s for a low and high greenhouse gas scenario, respectively. In contrast, total runoff during the warm season (April to September) is expected to decrease 8% and 11% for the 2050s and 12% and 22% by the 2080s for a low and high greenhouse gas scenario, respectively.

Water Demand

For Chelan County, maximum air temperatures in summer (June to August) are expected to increase by 6.3° F and 8.1°F by the 2050s, and by 7.5°F and 12.8°F under a low and high greenhouse gas scenario. Most climate models also show decreases in summer precipitation, although summer precipitation in this region is already low and is

difficult to project because much of it comes in convective storms which are challenging for climate models to simulate.

In the near-term (through the 2030s) agricultural water demand for the Columbia River Basin, which makes up about 80% of the water demand in the region, is forecasted to decrease slightly.³⁰ This decrease is primarily due to warmer and wetter conditions in spring that lead to an earlier and shorter growing season, with a resulting shift in the timing of water demand. Expected changes in the crop mix towards crops that require less water also contribute to this slight decrease. As temperatures continue to increase, this decline in water demand for irrigation may not continue as the gains made by shifting to lower-water-use crops diminish.

For Chelan County specifically and the watersheds within the

county, future changes in water demand for irrigation are less clear. The crop mix of Chelan County is dominated by fruit trees, rather than the mix of annual crops, fruit trees, and pasture seen across the Columbia River Basin as a whole. In addition, development pressures in Chelan County may lead to shifts in land use rather than shifts in crop mix in the future. Land use changes are not captured in the Long-Term Water Supply and Demand Forecast, yet could affect agricultural and municipal water demands in the future. Irrigation timing for fruit trees is also less flexible relative to annual crop mixes, as trees continue to need water after harvest so decreases in irrigation demand in response to changes in growing season and seasonal water supply are not as obvious. These changes in water supply and demand could lead to increased frequency of curtailment to water rights holders, particularly in the early irrigation season.³¹

30 Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001.

31 Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001.

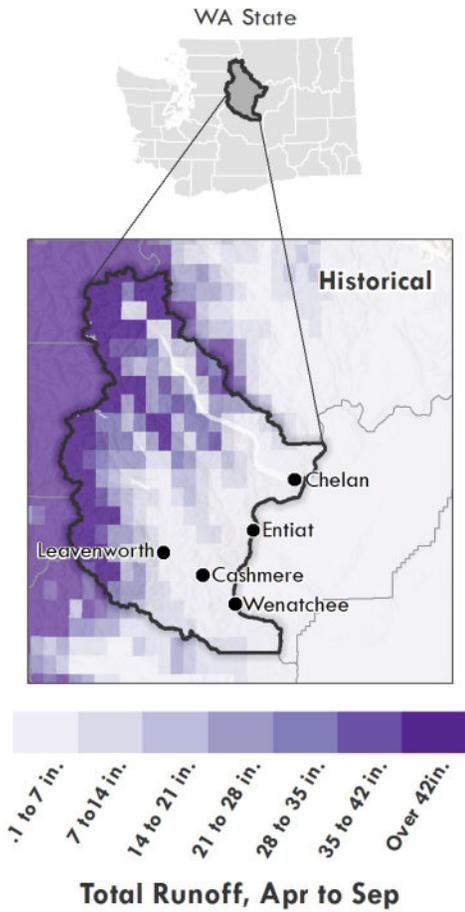
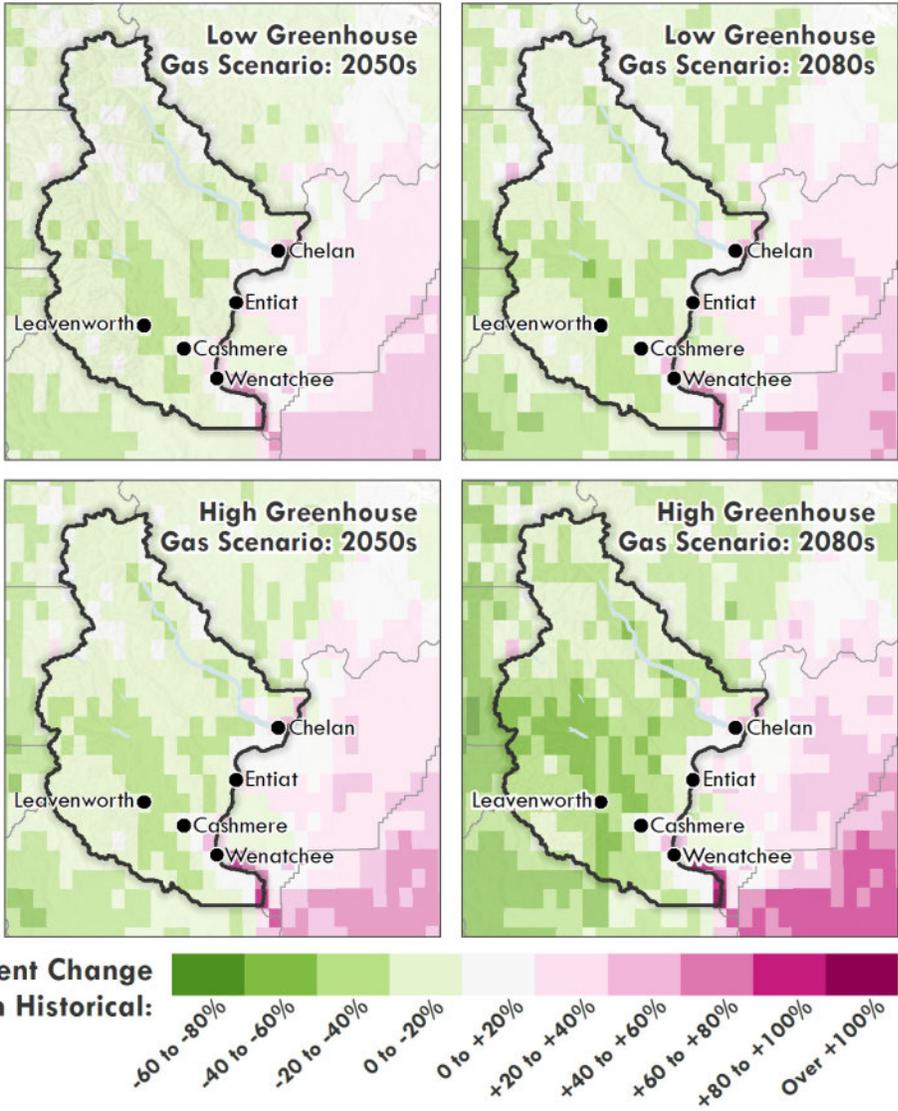


Exhibit 11. Total Runoff, 6-month April-September, Chelan County
 Total runoff in the warm season is an indicator of the water supply available for instream and out of stream uses. Total warm season runoff is expected to decrease across Chelan county by the 2050s, with larger decreases expected for a high greenhouse gas scenario and for the 2080s.
 Sources: Integrated Scenarios, 2015; BERK, 2020.



Communities and resources most vulnerable to the altered timing of water supply and demand will be those that depend on surface water from

mid-elevation watersheds, which are most susceptible to the effects of warmer temperatures on snowpack and streamflows. Additional vulnerability to the

altered timing of water supply and demand may be enhanced or mitigated depending on options for changing season of use in current water rights.



Current Initiatives

Icicle Work Group: As mentioned above, this is joint effort between Chelan County and the Washington State Department of Ecology, in addition to what is listed in the Snowpack and Streamflow section, the work group is also addressing water storage and supply. They are considering high-elevation small scale storage, groundwater recharge (flooding), and run-of-river dams to create hydroelectricity to reduce the costs of pumping.

City of Leavenworth Water Improvement Project: See [Snowpack and Streamflow](#).

Chumstick and Mission Creek Alluvial Storage: This is a series of projects to increase stream complexity in key watershed areas to slow flow and increase infiltration. The project is underway with county funding, and monitoring is in place to evaluate the goal of water conservation through stream restoration.

Chelan Natural Resources Department Wenatchee Basin Modeling: This alluvial water system model was implemented to determine the amount and severity of stream incision across the watershed, and to model the

potential benefit that could accrue to water supply from reducing stream incision.

Chelan County Voluntary Stewardship Program:

Agriculture producers in Chelan County can participate in an alternative approach to address critical area protection and promote viable agriculture. The producers have implemented a number of conservation practices including irrigation efficiencies, opting for less water intensive irrigation, and upgrading/ maintaining systems to minimize water waste.



Rock Island Dam
Photo: Chelan PUD, 2016

Resilience Strategies

The strategies for building a climate resilient water supply are in alignment with Water Supply Policy 3.1 of the Chelan County Comprehensive Plan (2017). This policy supports data collection for water quality and quantity which can be used to evaluate land uses and development, including improving county tracking and coordination efforts with public water providers, supporting varying regulations on a WRIA (Water Resource Inventory Area—watershed planning areas) or sub basin level, encouraging the development of

Resilience Strategy Table Legend

Status	Resources Needed
• Early/Limited	• \$: < \$100,000
• Moderate/Partial	• \$\$: \$100,000 - \$500,000
• Mature/Robust	• \$\$\$: > \$500,000 +

outreach/education materials, and analyzing water banks and other alternatives for areas where physical availability of water is at risk.

Exhibit 12. Water Supply Resilience Strategies

Strategy	Status	Leads and Partners	Resources Needed
Develop rural water management through water budgets, exempt well tracking, voluntary metering, water banks, water markets, or other measures	Moderate/Partial Partial tracking in various basins (e.g. WRIA 45 and 46); partial establishment of reserve quantities; no water banks.	<ul style="list-style-type: none"> • Chelan County • Chelan PUD • Irrigation Districts 	\$\$\$: Funding to implement watershed plans, well tracking program, and water bank
Promote increased water storage solutions that help agricultural producers adapt to changing conditions and decrease production losses due to lack of water availability	Moderate/Partial Watershed Plans, ongoing	<ul style="list-style-type: none"> • Chelan County • Irrigation Districts 	\$\$\$: Funding to implement watershed plans
Consider greywater systems and water re-use	Early/limited	<ul style="list-style-type: none"> • Chelan PUD • Municipal Water Providers • Irrigation Districts 	\$\$\$: Funding to implement
Agricultural and municipal water conservation and efficiency efforts in watersheds where these conservations efforts can lead to overall decreases in water demand	Moderate/Partial Awareness and information by special districts	<ul style="list-style-type: none"> • Municipal Water Providers • Irrigation Districts 	\$\$: Incentives, conservation practices
Drought planning to increase water conservation, plant drought-tolerant species, and build awareness around individual risk from drought	Moderate/Partial Multi-Jurisdiction Natural Hazard Mitigation Plan addresses Awareness and information by special districts	<ul style="list-style-type: none"> • Chelan County • Cascadia Conservation District • Chelan PUD • Municipal Water Providers • Irrigation Districts • Agricultural producers • Residents • Organizations serving vulnerable populations 	\$: Coordinator/staff \$\$: Incentives, conservation practices

Cross-Sector Strategies

Community Feedback Highlights from Strategy Development Outreach

"Build capacity to help the members of our community that are the most vulnerable."

We need to develop "...priorities for vulnerable populations, holistic measures for ecosystems and environment resilience, sustainable farming practices, and multi-lingual education and outreach."

This strategy "...will give clear expectations to all in the county as to how they can be a part in dealing with the Climate Crisis. Chelan County can become a leader in this goal being carried out throughout the region."

Following are strategies that cut across the subjects addressed in this Climate Resilience Strategy. These strategies would address multiple hazards or expected climate conditions. Because they address multiple needs and communities, they have the potential to be the most sustainable and cost-effective efforts.

Three activities stand out in terms of potential effectiveness and stakeholder interest:

1. Forest health as advancing water processes and fire resilience;
2. Water storage as a response to extreme low flow and flood water, fire response, and water supply; and
3. Community engagement and awareness efforts to advance all strategies and empower individuals and organizations.



Benson Vineyards, Mason
Photo: Unsplash, 2020



2015 Chelan Complex Fire
Photo: Ben Brooks



Exhibit 13. Cross-Sector Climate Resilience Strategies

Strategy	Status	Leads and Partners	Resources Needed
Coordinated Water Resources, Wildfire, and Flood Resilience Efforts			
Conduct research and modeling to understand relationship between snowpack, forest health, and water supply	Early/Limited	<ul style="list-style-type: none"> • USFS • WDNR • WDFW • Chelan Co. Natural Resources Department 	\$\$: Model and implementation strategy
Seek funding for measures to protect and restore fish and wildlife habitats and ecosystem function to support resilience in response to fire and flood events	Moderate/Partial	<ul style="list-style-type: none"> • USFS • WDNR • WDFW • Conservation District • Chelan Co. Natural Resources Department 	\$\$: Funding to implement improvements
Provide for water storage near sources to address low stream flow, flooding, fire-fighting, and water supply needs	Early/Limited	<ul style="list-style-type: none"> • Chelan Co. Natural Resources Department • Conservation District • Irrigation Districts • Municipal Service Providers 	\$\$\$: Funding for infrastructure improvements
Refine and leverage previously developed hydrologic model (DHSVM) for Chelan County to test relevant forest management scenarios to understand combined benefits for fire fuels reduction, snowpack retention, and summer streamflow	Moderate/Partial	<ul style="list-style-type: none"> • Chelan Co. Natural Resources Department 	\$\$: Ongoing funding needed to refine and produce test scenarios
Convene a panel of experts to review recent and on-going initiatives related to forest management effects on snowpack and water supply to synthesize current efforts and findings, identify critical data gaps, and prioritize next steps to transition from research efforts to forest management applications	Early/Limited	<ul style="list-style-type: none"> • Chelan Co. Natural Resources Department • USFS • WDNR • WDFW • UW CIG 	\$: Funding to coordinate expert panel



Exhibit 13. Cross-Sector Climate Resilience Strategies (cont.)

Strategy	Status	Leads and Partners	Resources Needed
Public Health and Safety			
Assess the capacity of health systems to respond to emerging health and safety threats and to integrate climate preparedness into their hazard response plans and daily operations	Early/limited	<ul style="list-style-type: none"> Chelan-Douglas Health District 	\$\$: Planning and education
Develop priorities and strategies to proactively implement climate change adaptation measures for the most vulnerable and underserved populations	Early/Limited	<ul style="list-style-type: none"> Chelan-Douglas Health District Organizations serving vulnerable populations 	\$: Staff resources to coordinate and engage
Build capacity to assist the most vulnerable people and communities to prepare and respond to threats such as wildfires and flooding.	Early/Limited Multi-jurisdiction coordination underway and continued dialogue needed	<ul style="list-style-type: none"> Chelan Co. Flood Control District Fire Districts Chelan County Public Works Cities Public Works Organizations serving vulnerable populations 	\$\$: Planning and education
Identify locations where changes in surface and groundwater flow due to climate change (e.g., larger floods, erosion, fire) could result in new or greater releases of toxic substances to the environment	Early/Limited Multi-jurisdiction coordination underway and continued dialogue needed	<ul style="list-style-type: none"> Chelan Co. Flood Control District Fire Districts 	\$\$: Planning and education
Sustainable Business			
Partner with agricultural producers to encourage sustainable farming practices that are aligned with future climate conditions to address adequate water supply and conservation, opportunities for voluntary ecological enhancements in climate vulnerable areas, and other strategies	Moderate/Partial Awareness and information by special districts	<ul style="list-style-type: none"> Irrigation Districts NRCS Conservation District Chelan Co. Natural Resources Department 	\$\$: Incentives, conservation practices
Improve and promote the range of weather-independent and all-season tourism and recreation opportunities.	Early/Limited	<ul style="list-style-type: none"> Chelan County Cities Wenatchee Valley Chamber of Commerce Chelan Douglas Regional Port Authority Recreation Providers 	\$\$: Evaluation, incentives

Exhibit 13. Cross-Sector Climate Resilience Strategies (cont.)

Strategy	Status	Leads and Partners	Resources Needed
Community Engagement and Awareness			
Education and outreach on collective and individual efforts to address water conservation, energy conservation, and fire and flood preparedness	Early/Limited	<ul style="list-style-type: none"> • Chelan PUD • Irrigation Districts • Municipal Water Providers • Chelan Co. Flood Control District • Fire Districts • Chelan County • Cities • Organizations serving vulnerable populations 	\$: Staff resources to coordinate and engage
Ensure climate resilience outreach and education efforts are multi-lingual to engage all members of the community	Early/Limited	<ul style="list-style-type: none"> • Chelan-Douglas Health District • Organizations serving vulnerable populations 	\$: Staff resources to coordinate and engage





Next Steps: Implementation & Coordination

This Climate Resilience Strategy depends on multiple entities anticipating, managing, and responding to climate change in a coordinated fashion. Implemented effectively, this climate resilience strategy will sustain the community, economy, and environment.

For the greatest chance at success, an inclusive and adaptive “Climate Round Table” would be formed to move this Climate Resilience Strategy forward. The Climate Round Table will be open to anyone with an interest in climate resilience. Governmental and non-governmental agencies and community stakeholders can take part. Exhibit 14 presents a possible structure for organizing implementation of this strategy and the Round Table moving forward.

Exhibit 14. Implementation Round Table Organizational Structure

Source: BERK, 2020.

Science Advisory Committee

Provide technical advice to the Round Table and Executive Committee

Climate Round Table

Broad & Inclusive Participation

Executive Committee

Multiagency—includes support from County Administration and an Outreach Team

Action-Oriented

Carry Out Priorities



Wenatchee Open House

Photo: Chelan PUD, 2019



The Climate Round Table will help prioritize and coordinate strategies and actions, and leverage existing resources. The Round Table will phase near-term and long-term activities, develop order of magnitude costs, identify lead entities, and develop metrics for evaluation and adaptive management. A “Science Advisory Committee” will provide technical advice to the Round Table and Executive Committee. An Executive Committee made up of a core group of the Round Table will be nimble and help carry out the Round Table direction.

The Round Table and Executive Committee will be supported by an Administrator and an Outreach Team. An early action of the Round Table would be to prioritize strategies within this document and delegate actions to members of the Round Table in order to build ownership over different strategic actions for building climate resilience.



For more information:

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<https://co.chelan.wa.us/natural-resources/pages/county-wide-climate-resilience-planning>