Climate Change in Chelan County

Introduction

This storymap is built to provide information about the expected changes and impacts of climate change in Chelan County, explore what local agencies and organizations within the county are doing to build climate resilience and prepare for these changes, and show how you can get involved in the process.

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.

This storymap is divided into the following sections:

- Climate Change Overview
- Wildfire
- Snowpack & Streamflow
- Flooding
- Water Supply
- Climate Strategies

We welcome you to explore this storymap, and for questions about Chelan County's involvement in this effort, please view the County Natural Resource Department's webpage on the topic: https://www.co.chelan.wa.us/natural-resources/pages/county-wide-climate-resilience-planning.

> “
>
> 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

Climate Change Overview

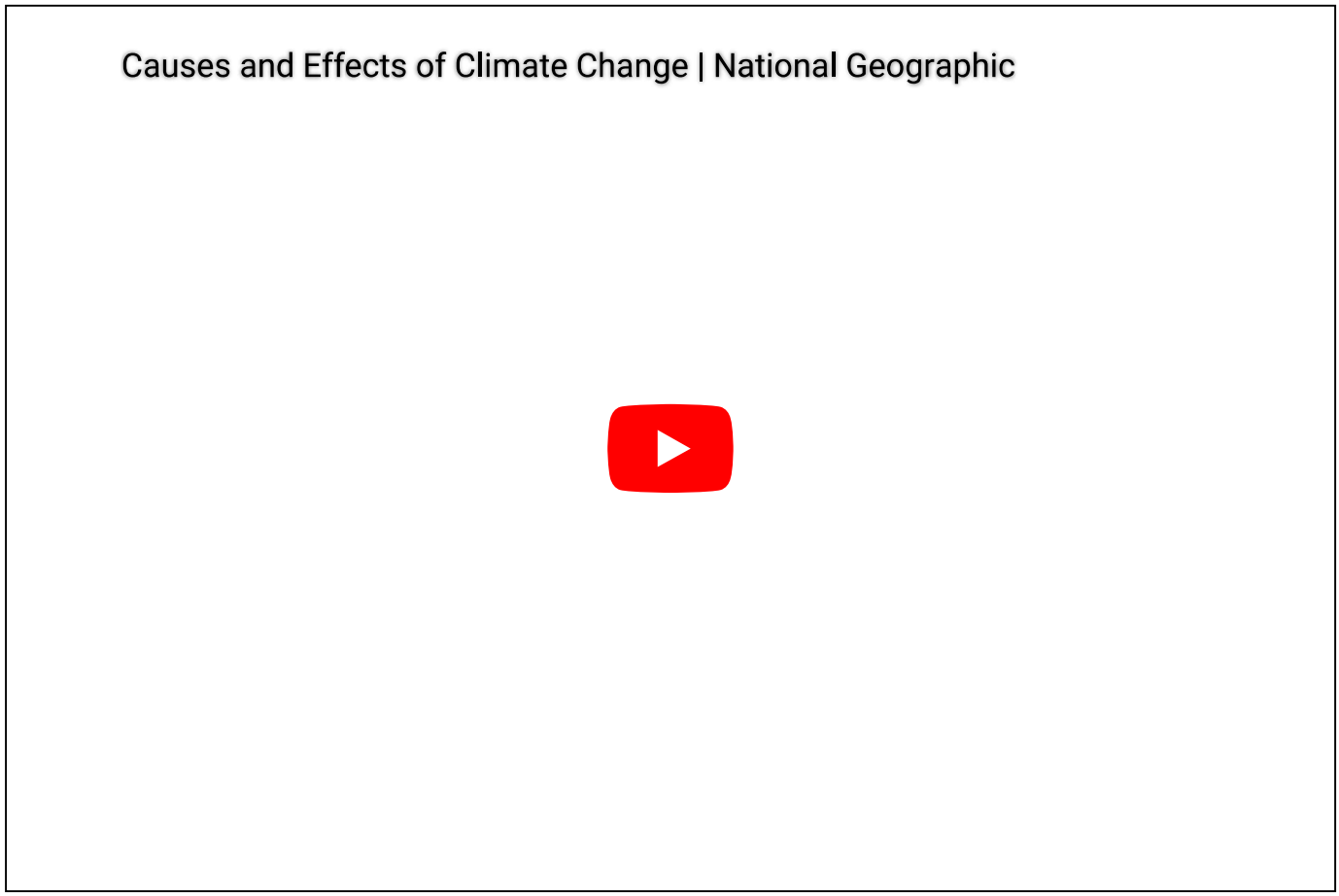
Overview

The information in this section presents scientific observations and expected climate changes in Chelan County and the region, and was developed by the University of Washington Climate Impacts Group (UW CIG) as part of the Chelan County Climate Resilience Strategy.

There are multiple climate change impacts expected across Washington state and the Pacific Northwest, most of which will have specific consequences for Chelan County. In some cases, the science is complex, and UW CIG have done great work in making this information accessible. The maps were made by BERK Consulting with data and guidance provided by UW CIG.

For more information about UW CIG and their work, visit https://cig.uw.edu/.

Click here to read the full Chelan County Climate Resilience Strategy



Greenhouse Gases

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.

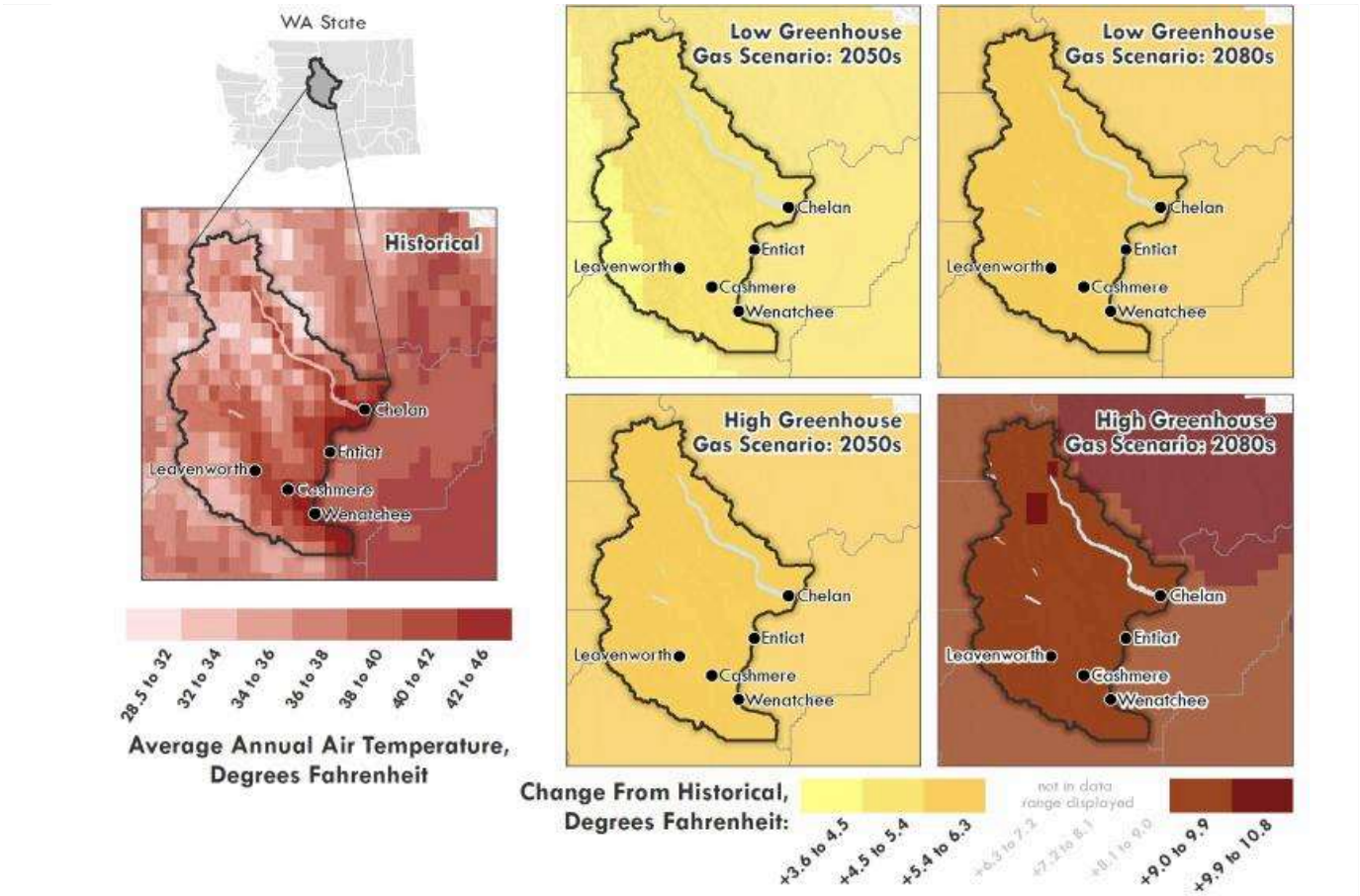
Greenhouse gas scenarios are plausible “what if” scenarios of future greenhouse gas concentrations in the atmosphere based on emissions and sequestration. These scenarios are used in climate models to determine how fast and how much the climate could change. Higher scenarios result in more warming at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

In this section 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.

Click play on the video shown to watch an overview of the greenhouse gas effect.

For more information about greenhouse gas scenarios, see Mauger et al. 2015. State of Knowledge: Climate Change in Puget Sound. **https://cig.uw.edu/resources/special-reports/ps-sok/**



Temperature

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.

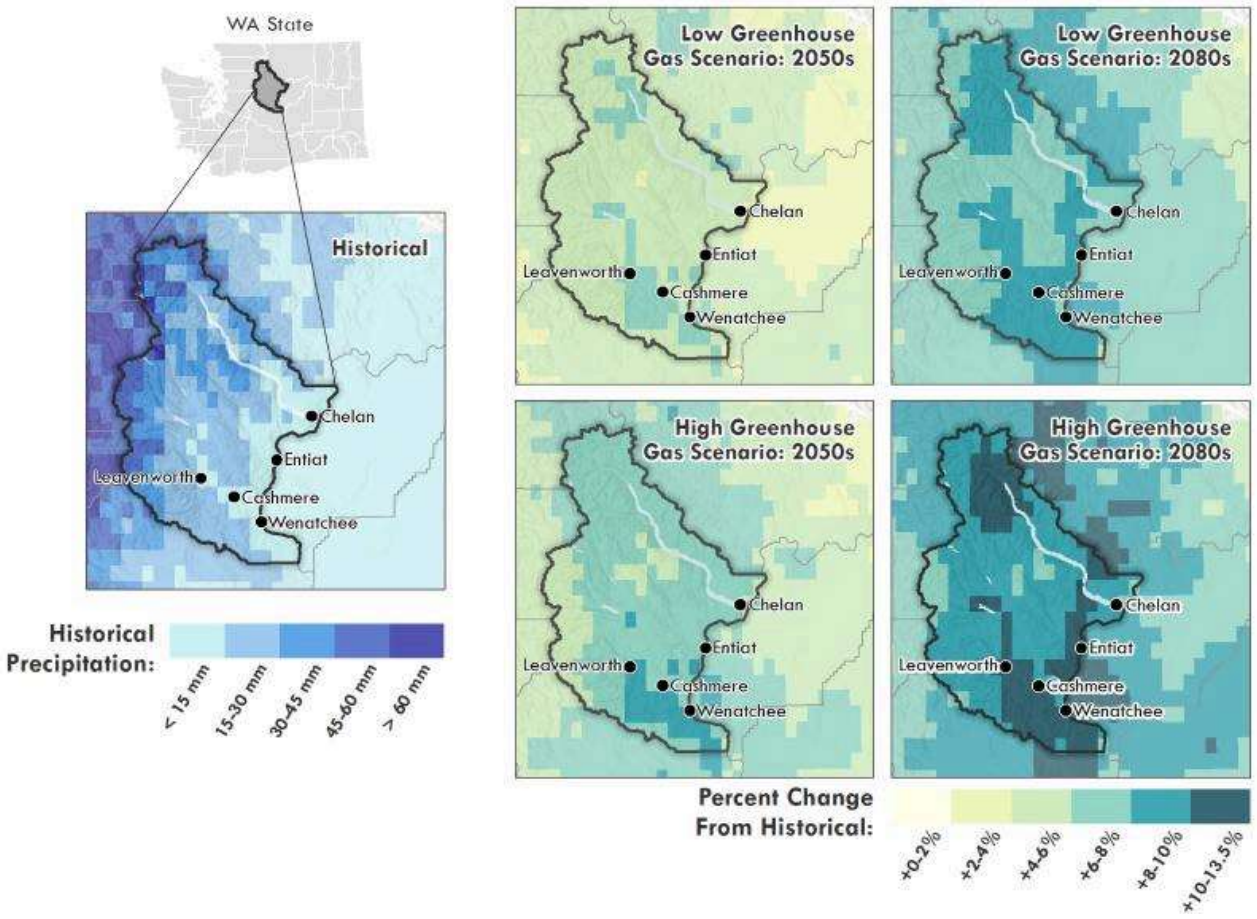
The maps displayed here show the projected average annual air temperature in Chelan County. Overall, temperatures are expected to increase across Chelan county by 2050s and warming is expected to be greater for a high greenhouse gas scenario and for the 2080s.

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.

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

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

The map displayed here shows that 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.

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 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 days with more than one inch of rain is projected to increase by 13% for the 2050s under a high greenhouse gas scenario. 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.

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.

Wildfire

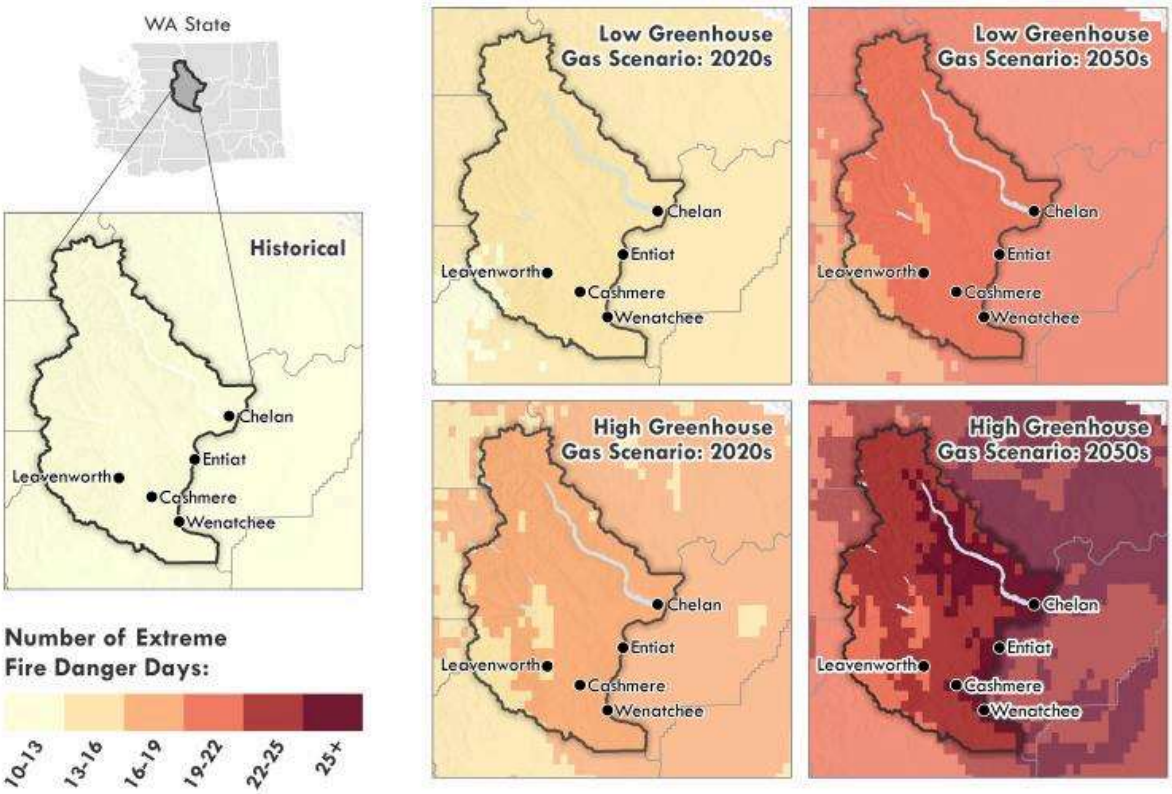
Observed / Current

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.

These wildfires are also unprecedented in terms of their impacts to the livelihoods and resources of the communities in which the 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.
- The number of large wildfires (> 100 acres) in the western US has increased by about seven fires per year from 1984 to 2011. 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.

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



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. 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.

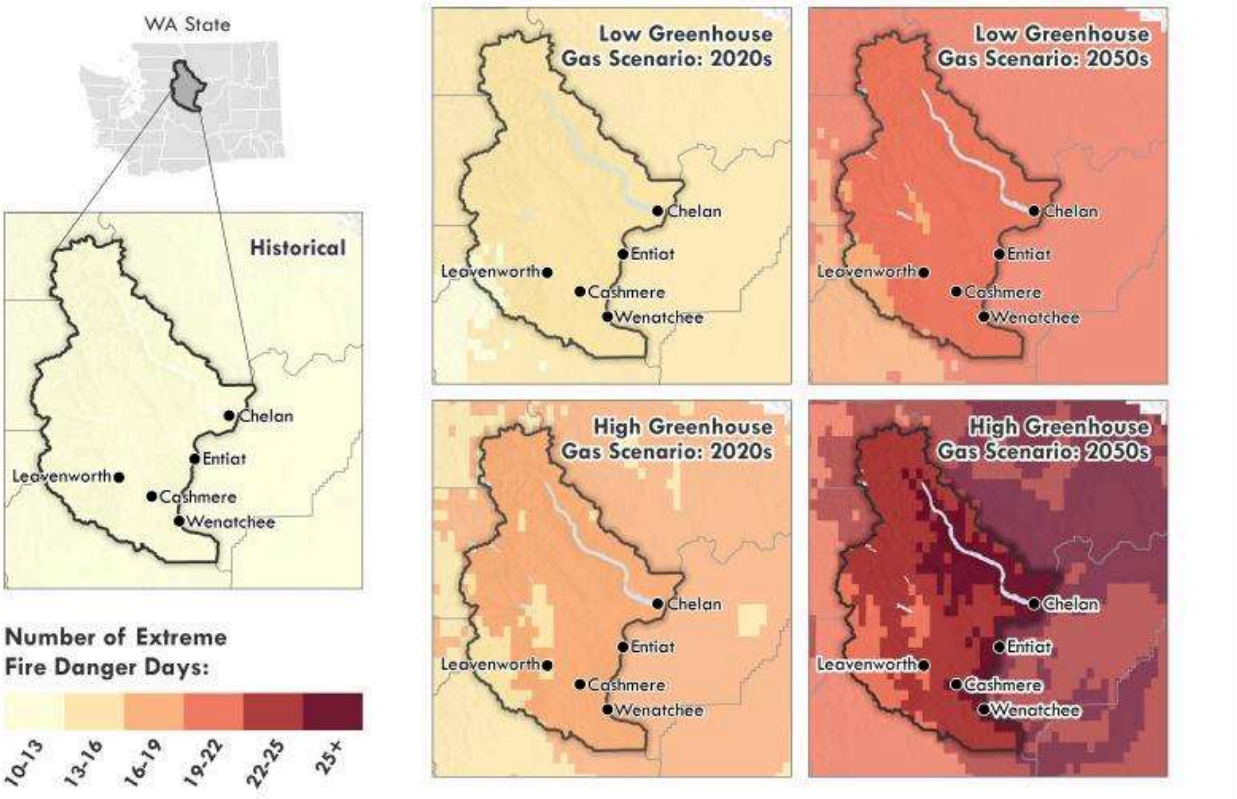
It is important to note that these projections are for increases in area burned on average -- predicting fire in any given year or how big any particular wildfire season will be is not possible, despite the clear trend towards increasing area burned.

Projected increases in area burned in grassland and shrub-steppe ecosystems are due to wetter winters and springs that increase growth of fine vegetation 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 moisture is projected to decrease across eastern Washington, particularly at higher elevations. 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 danger 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.

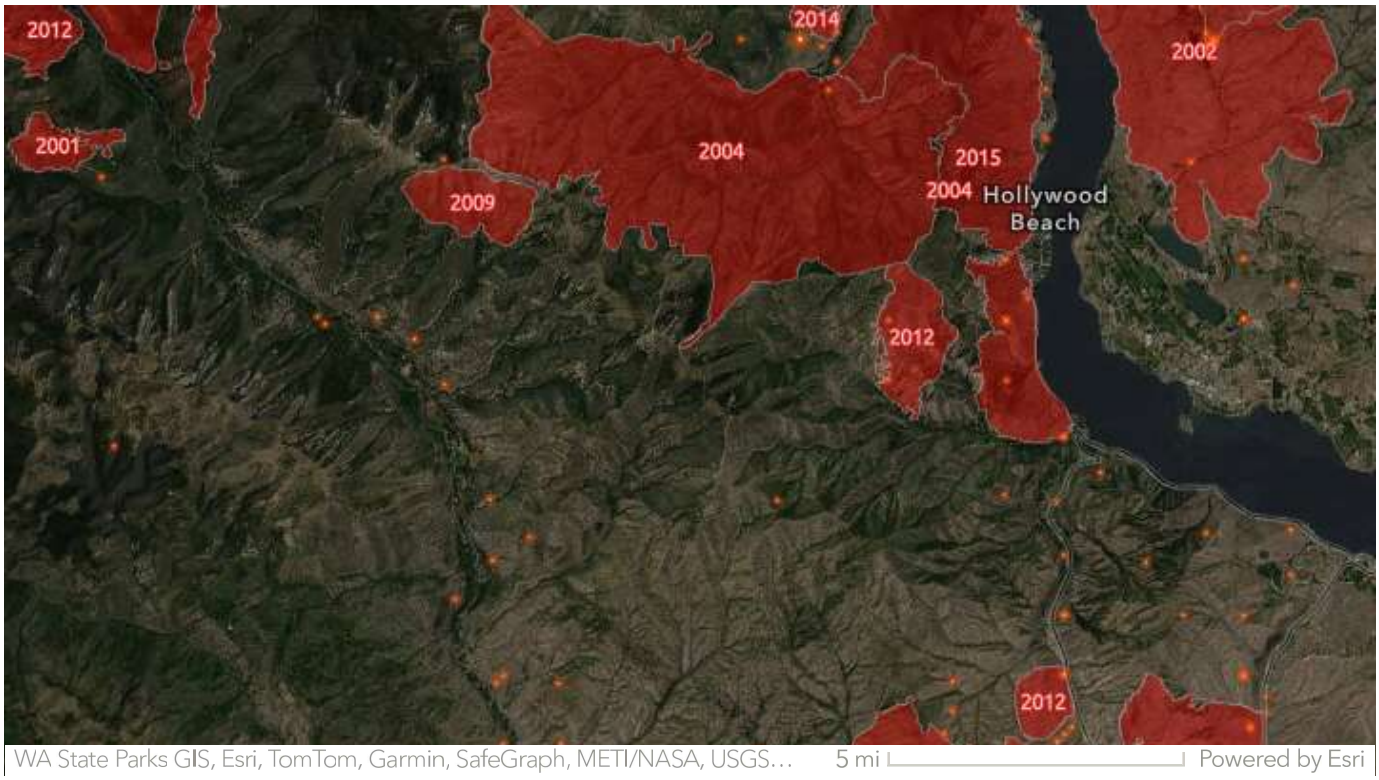


Click graphic to expand.

Wildfire Mapping

Below is an interactive map of wildfires in Chelan County over the past 20 years. The red polygons show fires that burned over 100 acres. The red/orange dots represent all fire statistics kept by the Washington State Department of Natural Resources.

Click on the map and use the cursor to navigate. You can click on points or polygons to learn more about the selected fire.



Wildfires in Chelan County

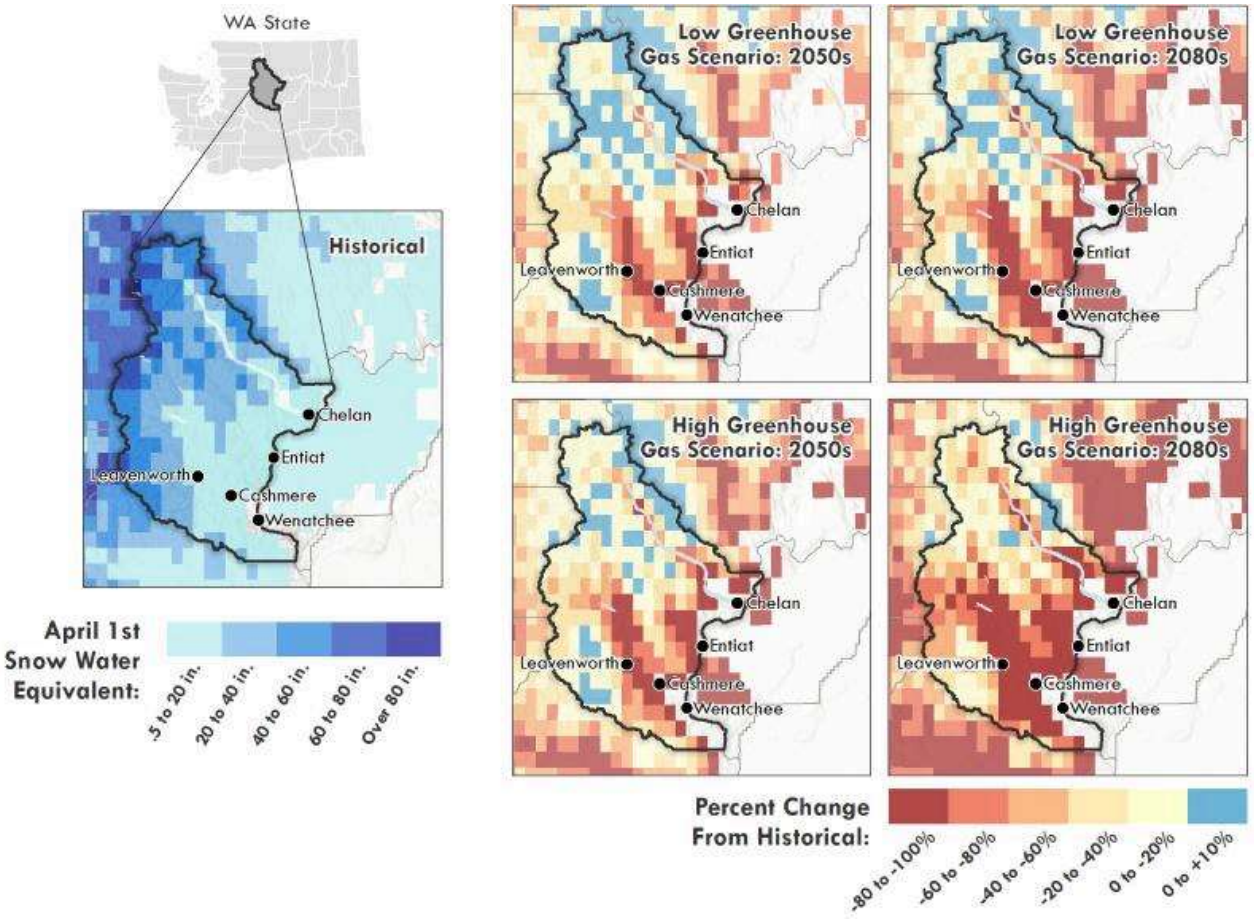
Snowpack & Streamflow

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. This decline in snowpack is primarily driven by rising temperatures, but also reflects natural variability in the climate over that period.

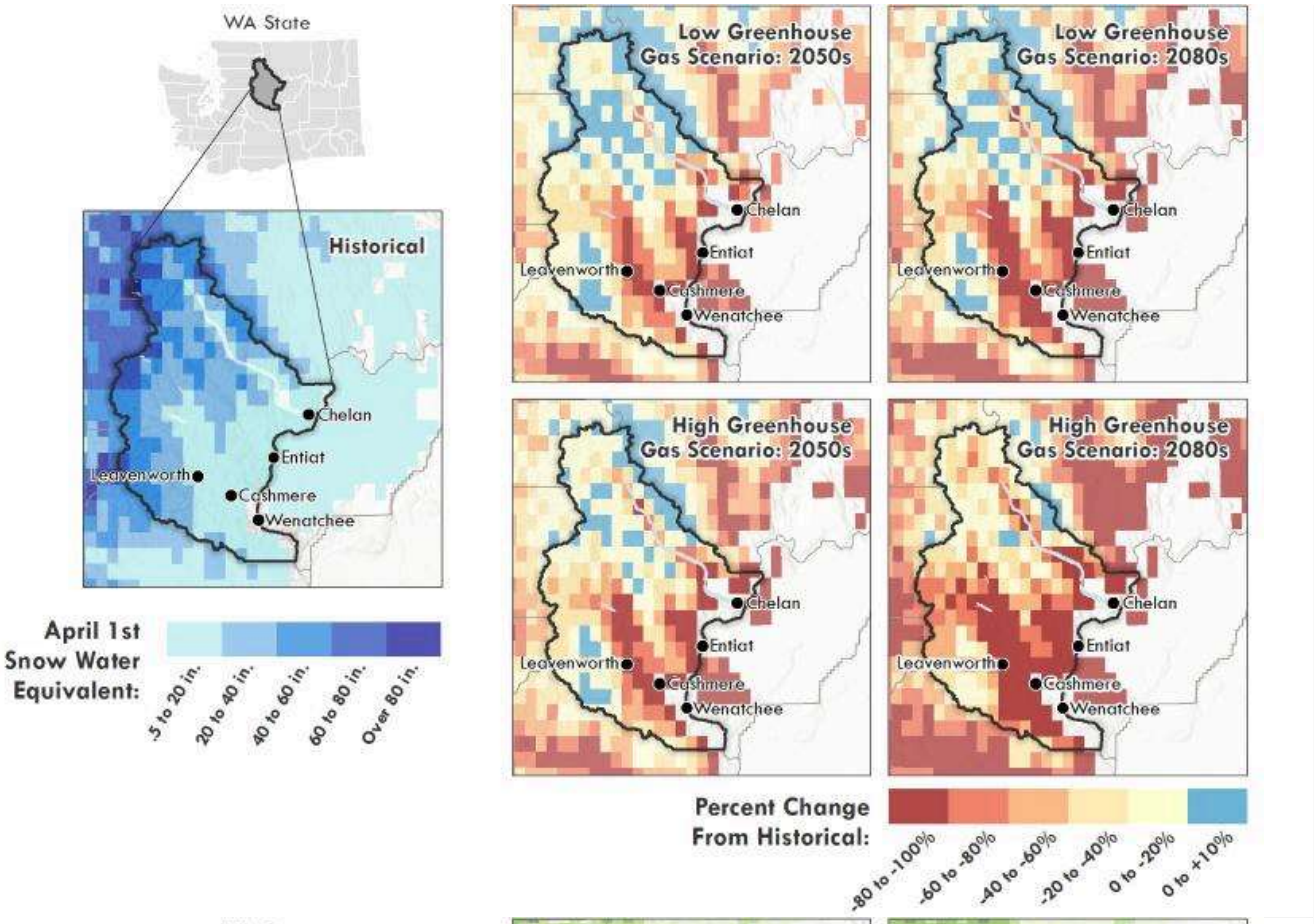
Glaciers in the North Cascades are also losing mass. Between 1900 and 2009, glacier area in the North Cascades decreased approximately 56% (+/-3%). Glacier meltwater contributes to streamflow particularly in summer months when runoff from precipitation and snowmelt are low. In the Stehekin River watershed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

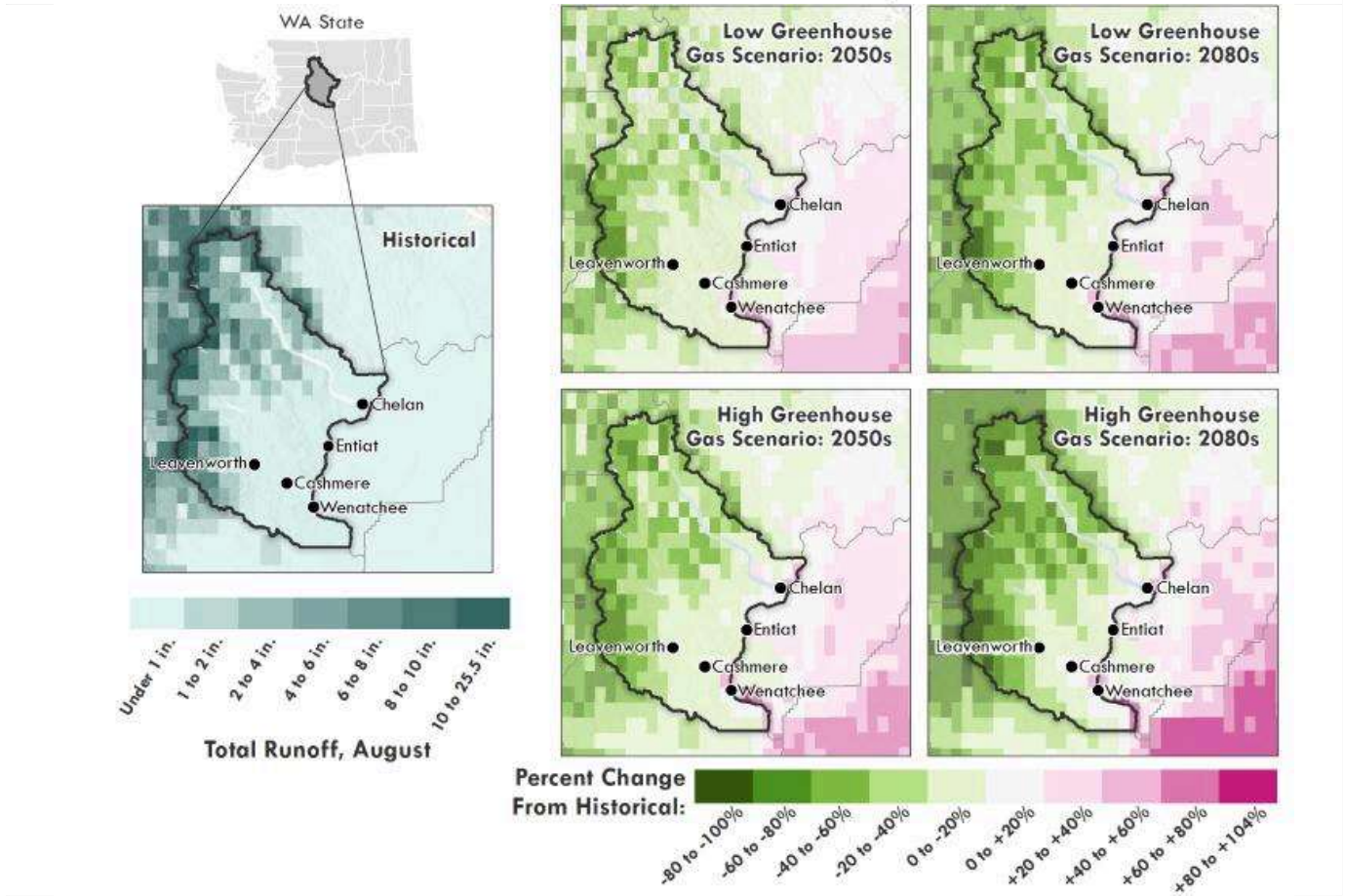


Snowpack - Expected Changes

The map here shows snow water equivalent. 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.

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.



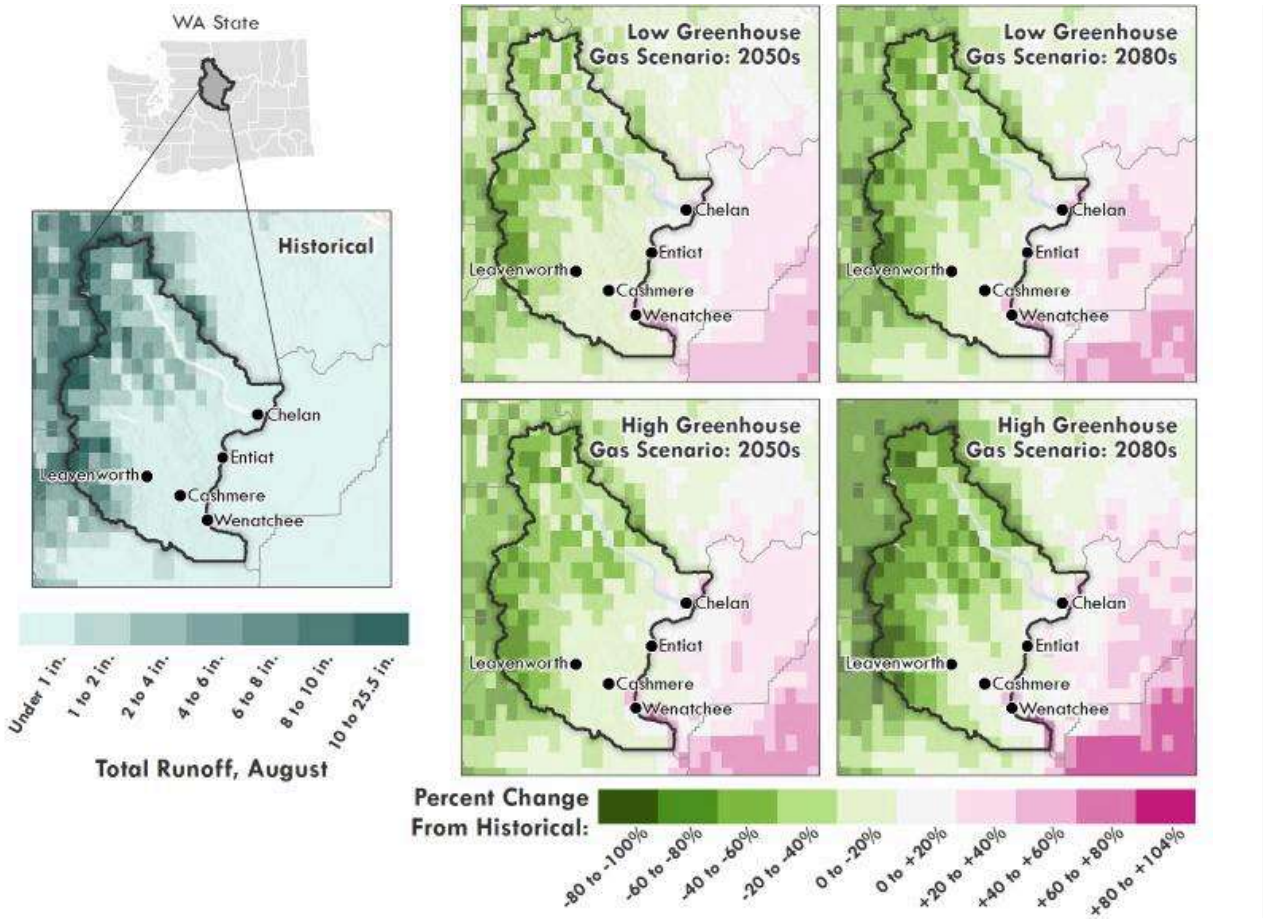


Streamflow - Expected Changes

The map here shows total August runoff. 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.

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.

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 on 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.


WA State
Historical
Chelan
Entiat
Leavenworth
Cashmere
Wenatchee
Under 1 in.
1 to 2 in.
2 to 4 in.
4 to 6 in.
6 to 8 in.
8 to 10 in.
10 to 25.5 in.
Total Runoff, August
Low Greenhouse Gas Scenario: 2050s
Low Greenhouse Gas Scenario: 2080s
High Greenhouse Gas Scenario: 2050s
High Greenhouse Gas Scenario: 2080s
Percent Change From Historical:
-80 to -100%
-60 to -80%
-40 to -60%
-20 to -40%
0 to -20%
0 to +20%
+20 to +40%
+40 to +60%
+60 to +80%
+80 to +104%

Click graphic to expand.

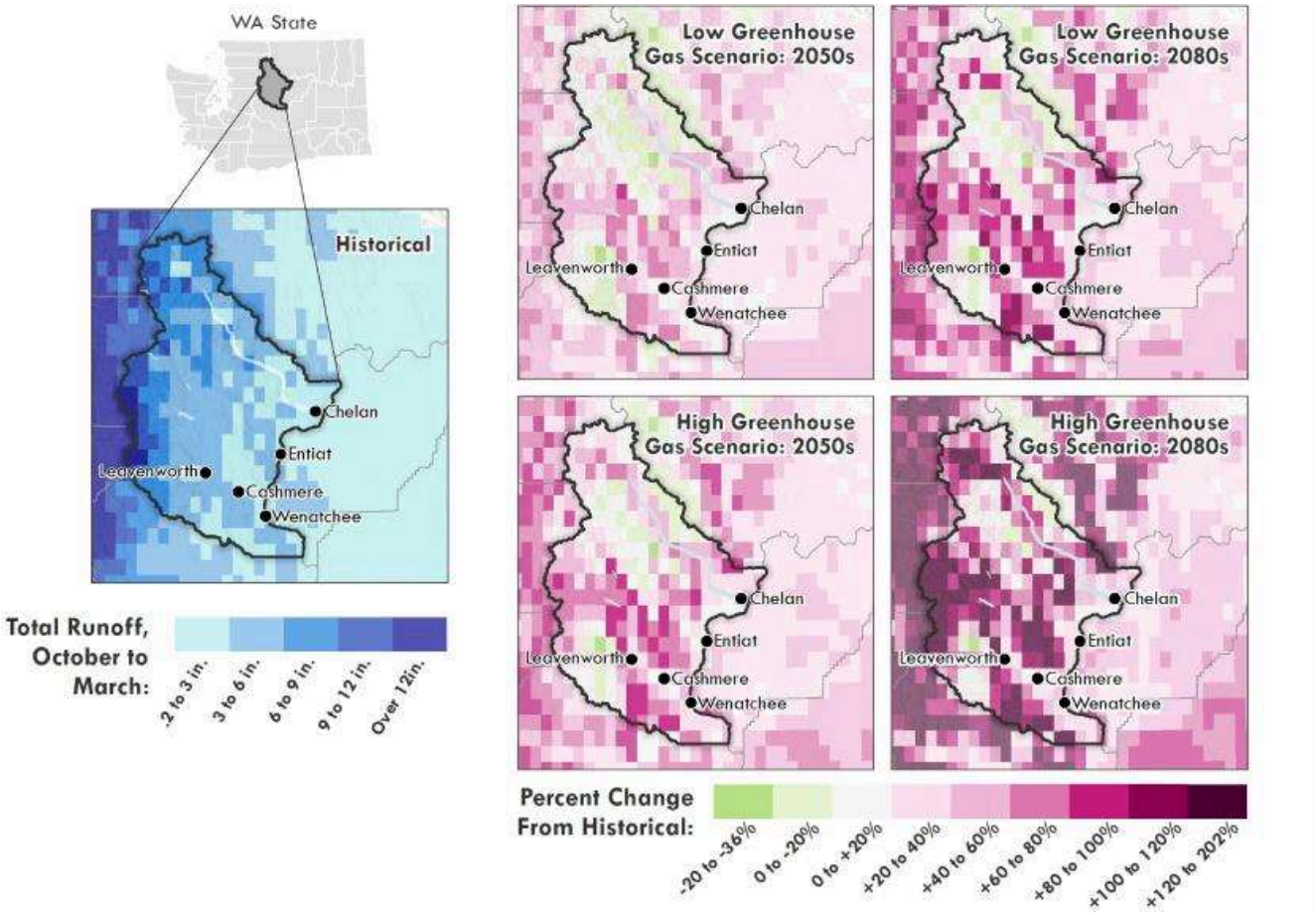
Flooding

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. 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.

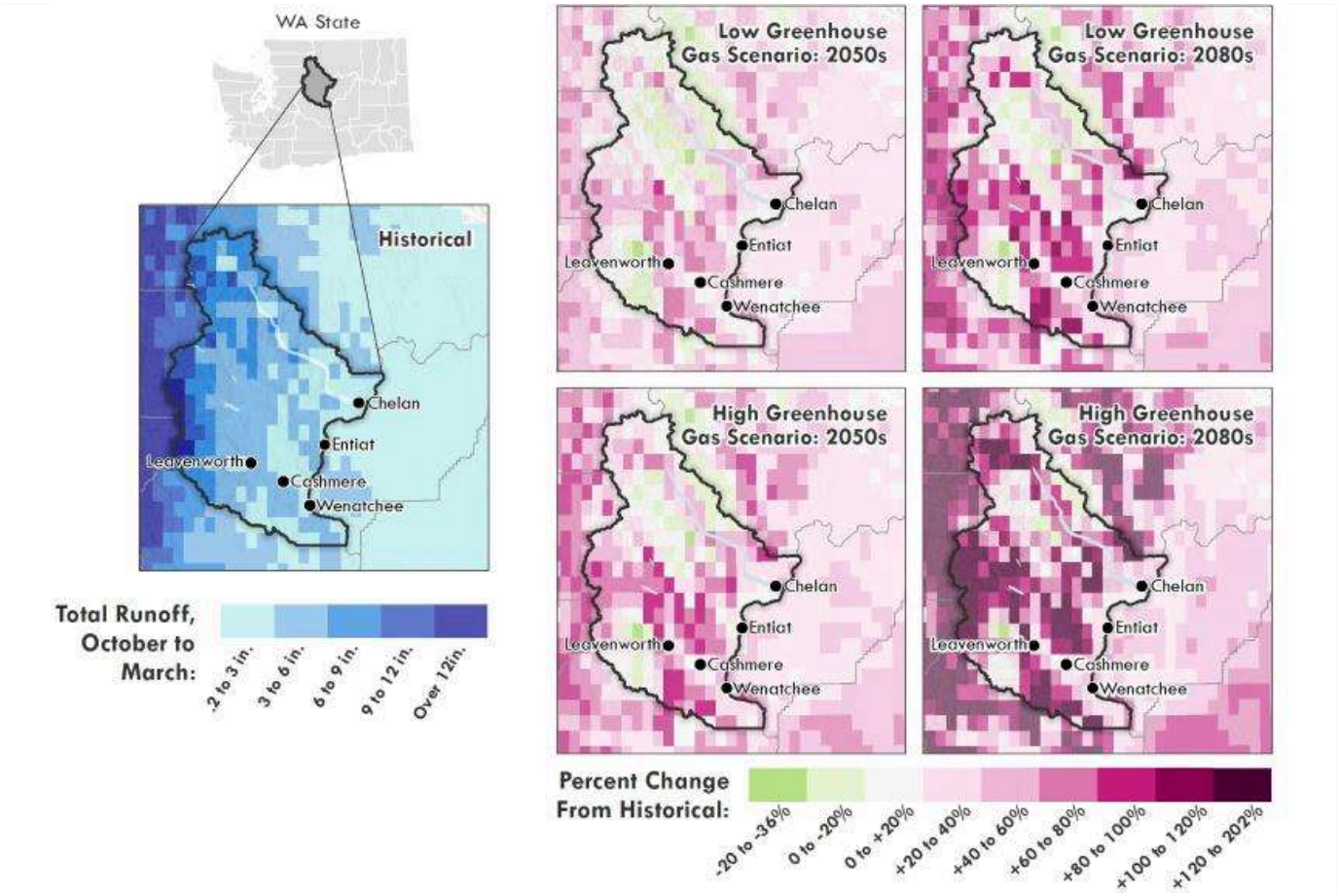


Expected Changes

The map here shows total runoff between October and March. 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.

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 runoff 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.

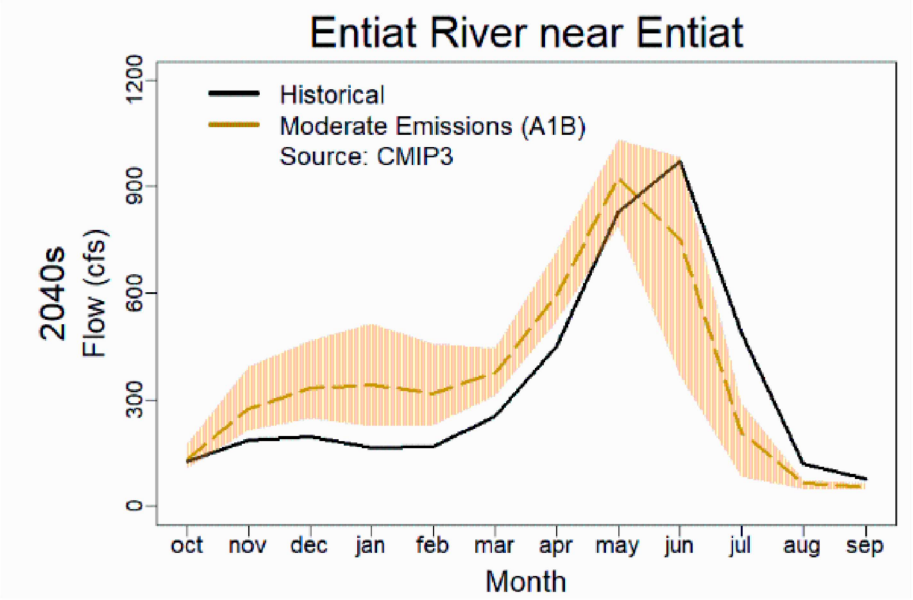


Changing Streamflow

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.

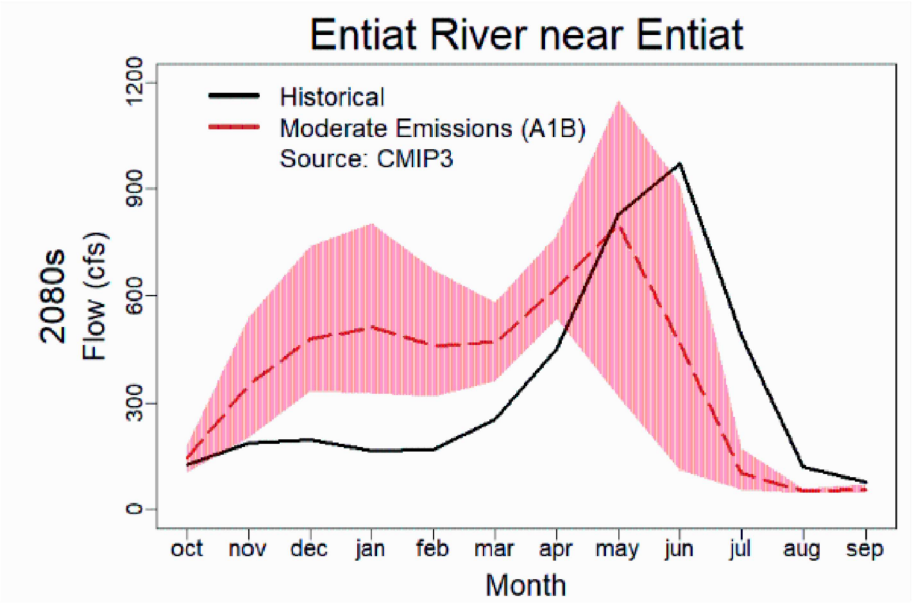
The charts below are hydrographs. Hydrographs describe the change in streamflow behavior throughout the water year. The black line on each graph represents the average monthly historical streamflow (1916-2006) at this location. The shaded areas show the range of projected changes in average monthly streamflow. These hydrographs illustrate an increase in winter streamflow and a shift in timing of peak streamflow to earlier in the year.

2040s



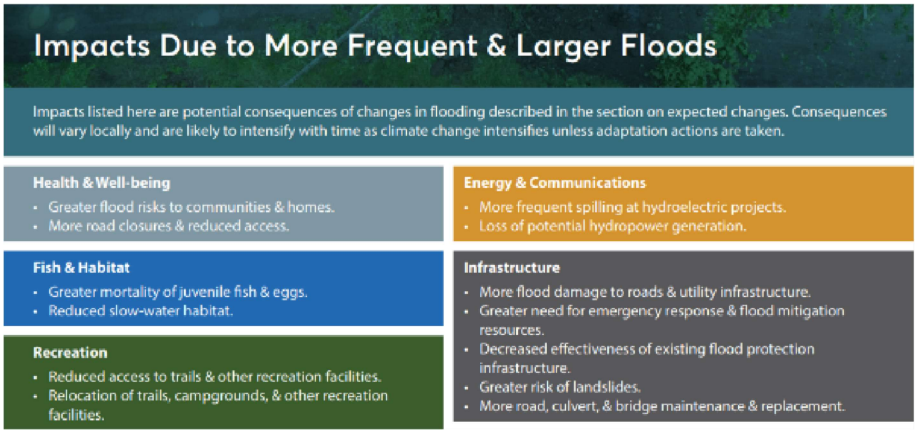
Source: Hamlet et al., 2013, hydrographs developed by UW CIG.

2080s



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

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



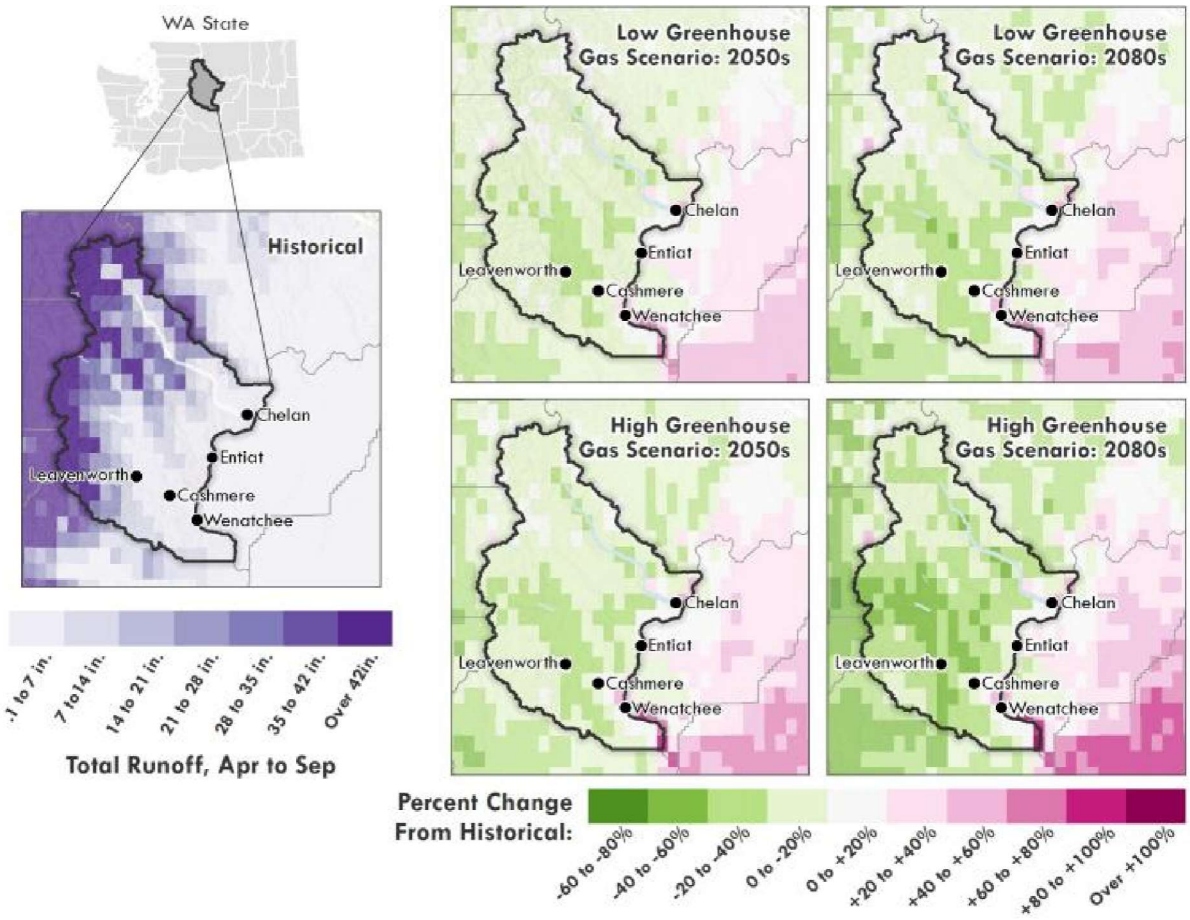
Click graphic to expand.

Water Supply

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.

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



Water Supply - 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. If unmitigated, this shift in the timing of water availability may create challenges for adequate water supply when water demand is greatest.

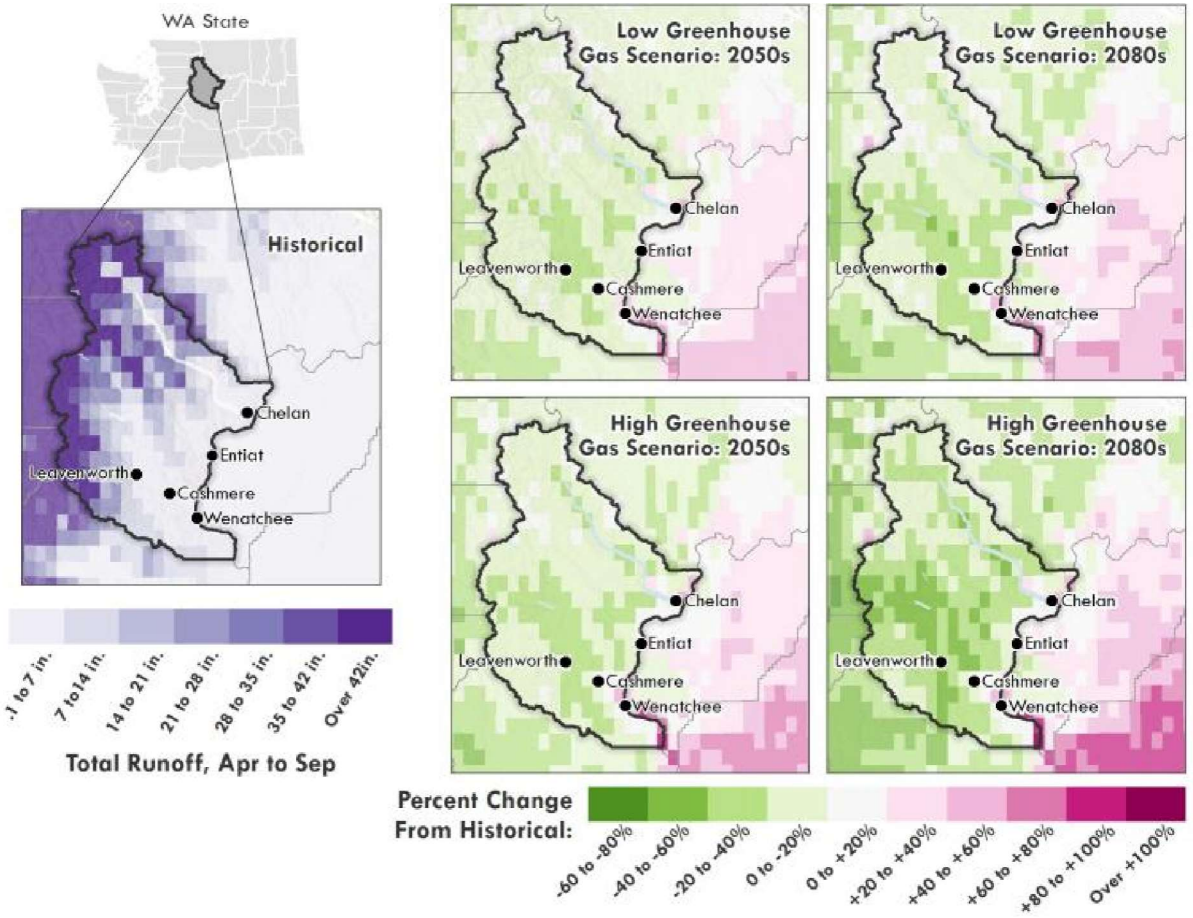
The map here shows total runoff from April to September. Total runoff in the warm season is an indicator of the water supply available for instream and out of stream uses. Total warm season runoff is expected to decrease across Chelan county by the 2050s, with larger decreases expected for a high greenhouse gas scenario and for the 2080s.

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 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). 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. 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. 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.


WA State
Historical
Chelan
Entiat
Leavenworth
Cashmere
Wenatchee
.1 to 7 in.
7 to14 in.
14 to 21 in.
21 to 28 in.
28 to 35 in.
35 to 42 in.
Over 42in.
Total Runoff, Apr to Sep
Low Greenhouse Gas Scenario: 2050s
Low Greenhouse Gas Scenario: 2080s
High Greenhouse Gas Scenario: 2050s
High Greenhouse Gas Scenario: 2080s
Percent Change From Historical:
-60 to -80%
-40 to -60%
-20 to -40%
0 to -20%
0 to +20%
+20 to +40%
+40 to +60%
+60 to +80%
+80 to +100%
Over +100%

Water Demand - Expected Changes

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. 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.

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.

Click graphic to expand.

Climate Strategies

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. The process was aimed at building climate resilience in Chelan County. As the WA Department of Natural Resources puts it, that means:

> Being prepared for, and adapting to, current and future climate-related changes.

In developing the Climate Resilience Strategy, the partner team attempted to answer the following questions:

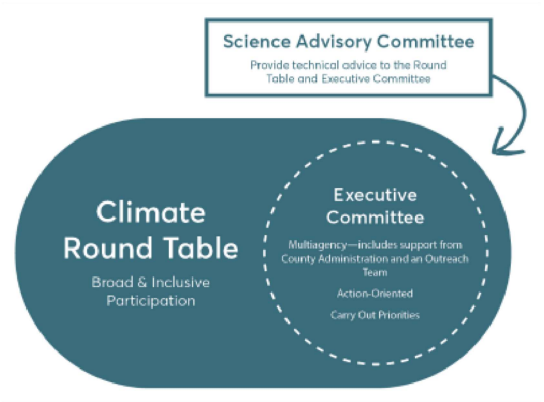
1. Where are we heading based on current trends and expected changes?
   What does that mean for commerce, communities, residents of Chelan County as well as visitors?
   What are steps Chelan County and the greater community can take to build climate resilience?

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.

There is a wealth of information contained within the document. While much of the climate science is summarized in this storymap, we encourage you to read the strategy document and learn about the strategies the team developed to help build climate resilience in Chelan County. Click the button below to open a PDF of the full Chelan County Climate Resilience Strategy:

Climate Resilience Strategy

Climate Roundtable



The Climate Resilience Strategy depends on multiple entities anticipating, managing, and responding to climate change in a coordinated fashion. 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.

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 will 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 information on how to participate in the Climate Round Table, click the button below to visit the County's webpage:

Chelan County Resilience Planning

Climate Grant

Chelan Co. Planning Meeting

In Summer 2020, the Washington State Department of Commerce allocated $100,000 in grant funding to assist with climate change planning. Five $20,000 grants were to be awarded through a competitive application process. Chelan County, with support from BERK Consulting, submitted an application and was awarded a $20,000 grant.

The purpose of this funding is to amend growth management act (GMA) comprehensive plans that integrate climate change planning into objectives, policies and related implementation projects achieving climate change planning goals. As part of this ongoing work, the County will be evaluating comprehensive plan policies to understand how climate change will affect how the County's planning process into the future.

This grant allows for a first look and audit of the current comprehensive plan, and allows the County to leverage work being done in other, similar counties across the region. It also allows for strategies developed throughout the Climate Resilience Strategy document to help complement the County planning process.

For up to date information on the process, visit the County's webpage on the Climate Resilience Planning process below:

Chelan County Resilience Planning

Sugarloaf Overlook, 2019. Photo Credit: Shaun Seaman.

Credits

This storymap was developed by BERK Consulting, with content produced throughout 2019-2021 as part of the Chelan County Climate Resilience Strategy development process. This process was a partnership among the following entities, with strong support from the greater Chelan County Community:

- 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