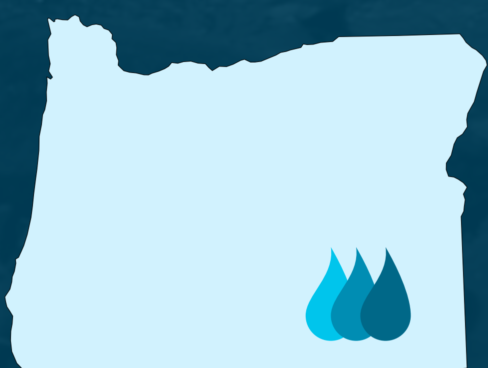
The Business Case for Investing in Water in Oregon

July 2023



AMP Insights

ONEWATER ECON

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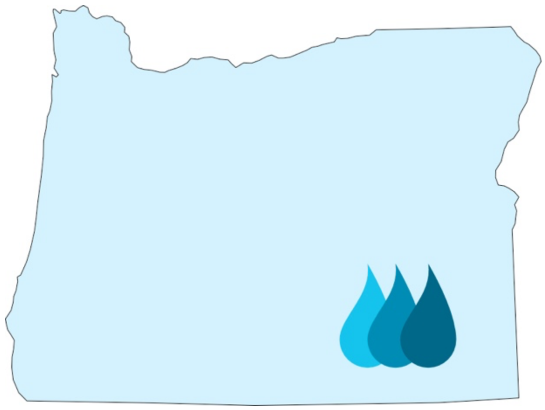


EXECUTIVE SUMMARY

Beginning with Indigenous cultures since time immemorial, Oregon's land, people and environment have always been deeply connected to water. The objective of this report is to highlight the critical value of water to Oregon, and clearly articulate the case for making and sustaining investments to protect and manage Oregon's water assets — to make the business case for investing in water in Oregon.

Applying a *business case* perspective provides an objective approach for assessing the beneficial returns that potential water investments might generate, and how those benefits are likely to be distributed across Oregon's people, regions, economic sectors and ecosystems. At its core, a business case is about considering risks, opportunities and benefits to make an informed decision about the wisdom of investment(s).

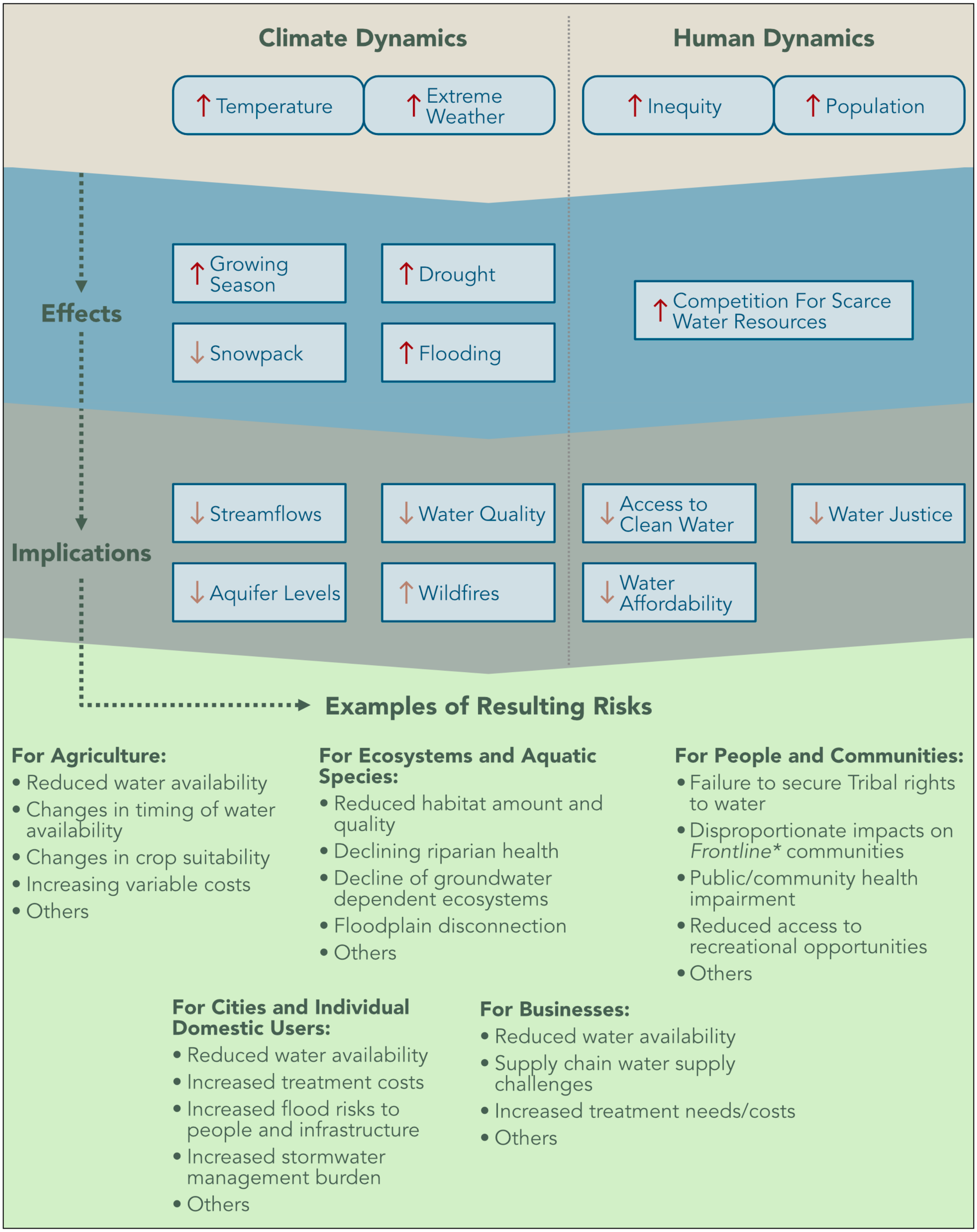
More specifically this report builds the business case for investing in water in Oregon in six parts:

- discussing risks facing Oregon and the opportunities and benefits that investing in water can provide;
- detailing Oregon's demographic and water use context, providing important background on the people of the state and their connections to water;
- describing the methods and approaches used to estimate the value of water and investments in water;
- presenting the baseline economic value of water-related sectors in Oregon — a snapshot of the role of water in Oregon's economy — along with a discussion of other water values including cultural and spiritual value;
- highlighting the unique role of Tribal sovereignty and connection to water resources in Oregon;
- developing eight case studies highlighting a range of investments that have been made or planned in Oregon and discussing the benefits of these investments or consequences of not investing.

Oregon Faces Challenges in Managing Water

Freshwater makes up a vanishingly small portion of total water on earth. Of the water that is available, not all is accessible to humans and much of what might be accessible is needed not only by people, but also to sustain a diverse range of ecosystems. A changing climate coupled with anthropogenic stressors are changing the task of managing water resources at a rapid pace with major implications for all water users and water-relates sectors including the natural environment (Figure ES-1).

Figure ES-1: Examples of Water Supply Risks in Oregon



*Frontline communities are those who experience impacts "first and worst;" this includes people most exposed to water risks due to where they live and due to a lack of resources, safety nets, political influence, etc. (Stacey Dalgaard 2022).

Oregon's Water Assets Support Many Values

While risk is one part of the business case for water in Oregon, another part is the benefits and opportunities that investing in water affords. Water provides an array of essential and highly valuable services to Oregon's natural and human communities including but not limited to:

- protecting and enhancing key fisheries and aquatic ecosystems (including threatened and endangered salmonids and other species);
- providing reliable, high quality and affordable potable water supplies for the state's households;
- honoring and preserving spiritual and cultural values for Indigenous people;
- supplying water to farmers, ranchers, orchardists and others;
- supporting agricultural activity throughout the state;
- supporting a wide array of water dependent industries, from health care, to microchip manufacturing, to microbreweries and others;
- providing an array of existence, bequest, spiritual and other nonuse values for residents and visitors;
- providing high-quality recreation and tourism experiences and related economic activity;
- supporting a sustainable commercial fishery;
- enabling water-based navigation and shipping;
- managing flood risks and adverse impacts from stormwater runoff;
- providing an abundant source of economical and low carbon hydropower energy;
- supporting healthy forests, grasslands, and other terrestrial ecosystems, and related timber and agricultural enterprises, and enhancing carbon sequestration; and
- defining an identity and quality way of life for Oregonians.

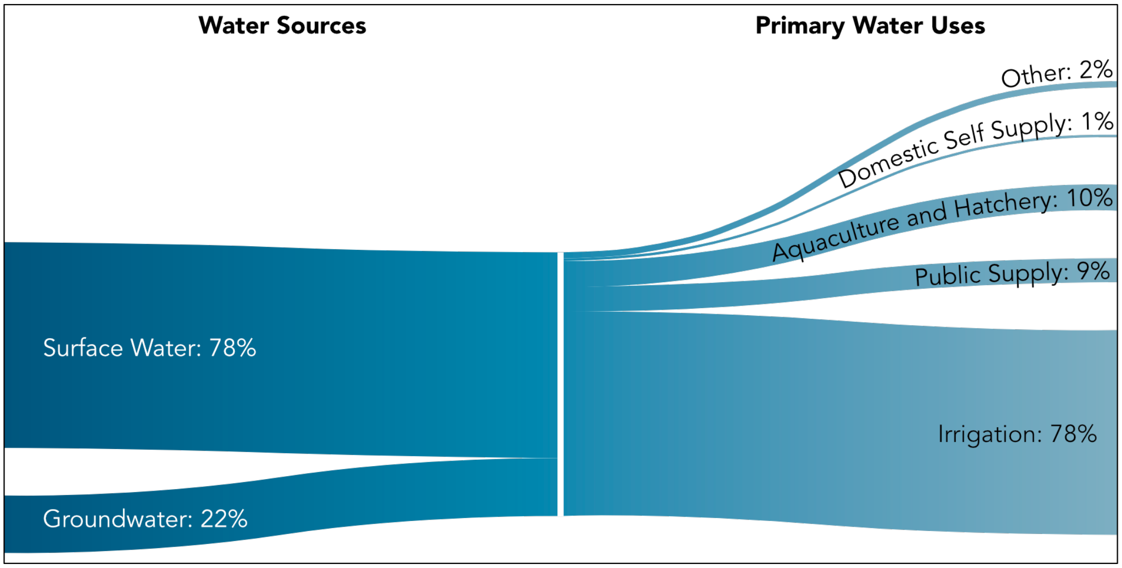
Making a Business Case

Developing a business case is a well-established approach for evaluating whether potential investments are likely to provide beneficial returns to the state through a systematic assessment of the costs and benefits of investment alternatives. The objective is to identify options with high returns on investment while recognizing that many returns are *not* monetary. When weighing investments, fiscal and economic considerations are critical but so too are intangible factors. The business case for investing in water in Oregon is in large part based on economic considerations but is not constrained by that frame of reference. Compelling reasons to invest in water in Oregon are as diverse as the benefits water provides and as numerous and serious as the risks the state is facing. This report is an attempt to capture and articulate all these reasons through quantitative analysis, qualitative discussion and storytelling, and to do so in a way that inspires a collective commitment to investing in Oregon's most precious resource.

Oregon Water Use and Demographic Context

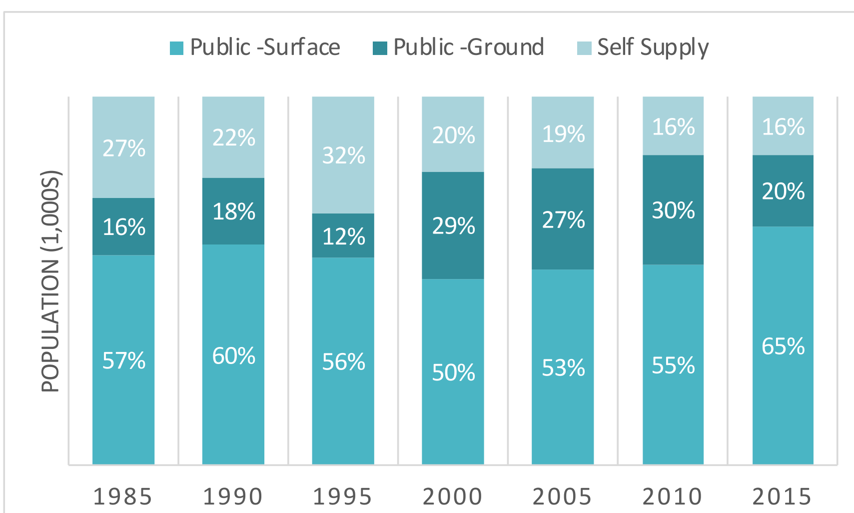
Approximately 78% of total water withdrawals in Oregon are from surface water sources while 22% come from groundwater. (USGS 2023). Of the water withdrawn, 78% is used for irrigation. Figure ES-2 shows the source of withdrawals in Oregon on the left side and how the total withdrawn water is used on the right side.

Figure ES-2: Water Withdrawals by Source and Use Across Oregon



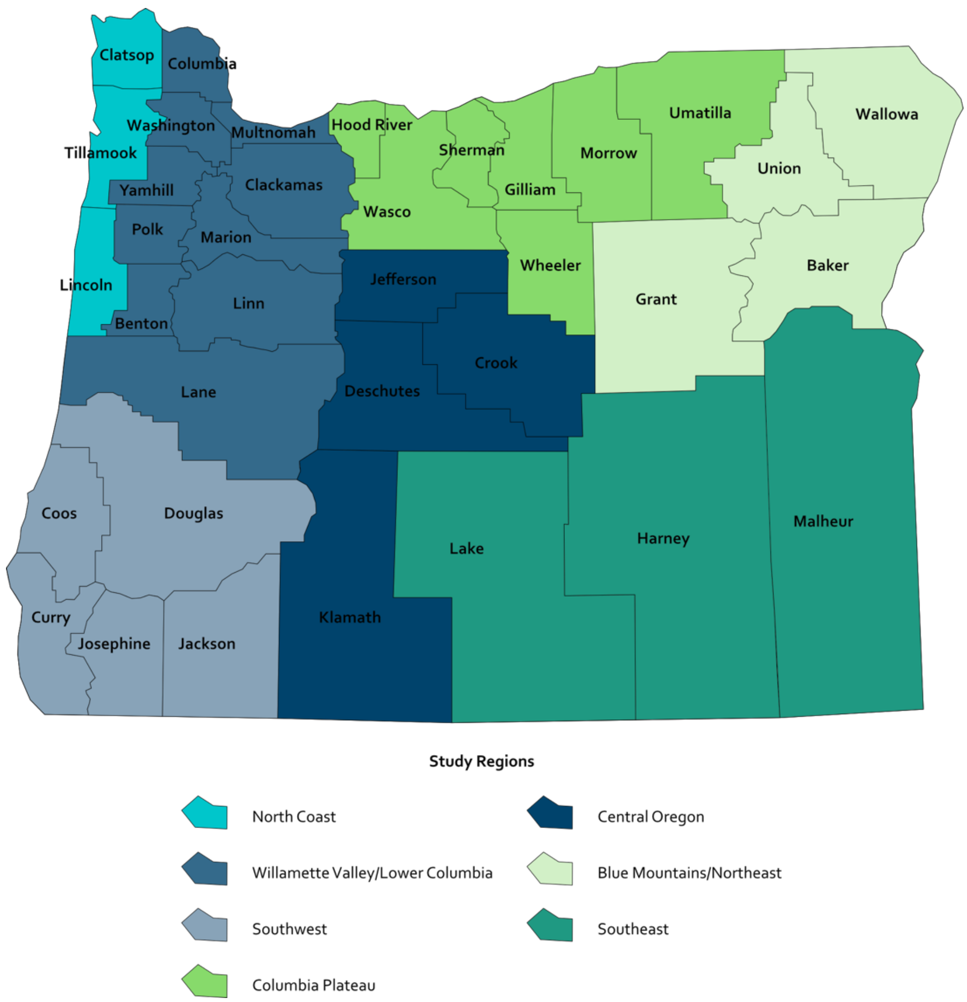
Most of Oregon's population relies on public supply from surface water sources for household and other domestic uses (Figure ES-3). The proportions of public surface, public groundwater and self-supply have changed over time; self-supply today is lower than in 1985 while public groundwater use has increased (USGS 2023).

Figure ES-3: Water Withdrawals by Source and Use Across Oregon



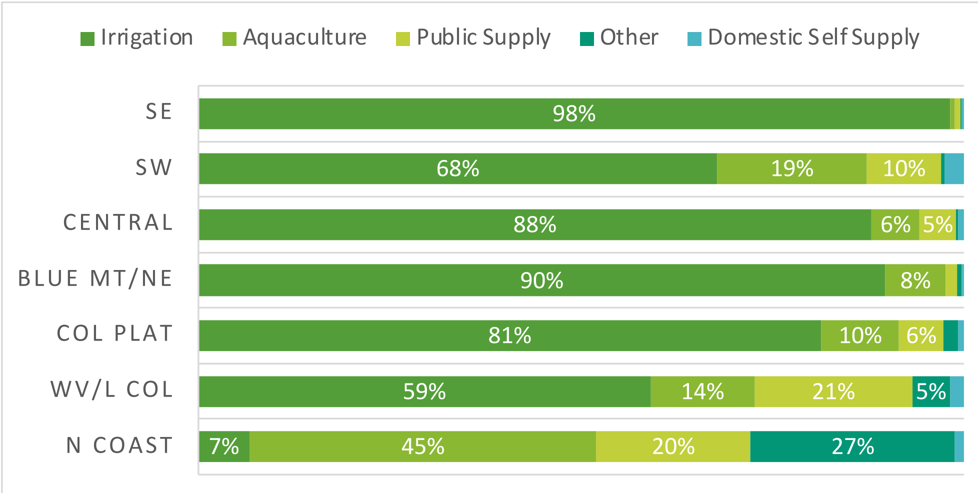
This report also examines various economic, water use and demographic data at the regional scale (Figure ES-4). County boundaries were used for regional grouping to align the analyses with the geographic scope of the most widely available data sources. The choice of what counties to group together balanced efficiency (i.e., limiting the number of total regions) with an attempt to group counties together that share physical, demographic, climate and water use characteristics.

FIGURE ES-4: REGIONS USED IN THIS REPORT



Water use varies substantially across the regions (Figure ES-5). Irrigated agriculture represents more than 80% of total water use in the Columbia Plateau, Blue Mountain/Northeast, Central and Southeast regions. While irrigated agriculture still accounts for most of the water use in the Willamette Valley/Lower Columbia and Southwest regions, use for aquaculture and public supply are proportionally higher. The North Coast region is distinct among regions in this report in its limited use of water for irrigated agriculture.

FIGURE ES-5: WATER USE BY REGION



Economic Baseline for Water Dependent Sectors in Oregon

This report analyzes uses and economic values associated with sectors that are highly dependent on water resources including:

- irrigated agriculture;
- water dependent industries such as manufacturing, health care, wineries and other businesses that rely heavily on water for key aspects of production;
- recreation and tourism;
- commercial fishing;
- hydropower;
- thermoelectric power; and
- households dependent on safe and reliable water supplies for drinking water and sanitation.

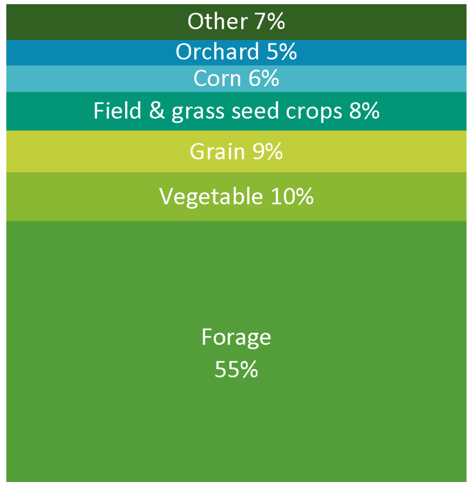
Agriculture

Irrigated agriculture makes vital economic contributions to the state.

The total annual economic contribution of irrigated agriculture to Oregon's economy is $7.3 billion.

Figure ES-6 shows the makeup of harvested irrigated acreage by crop type based on the most recent National Agricultural Statistics Service (NASS) Census of Agriculture (CoA), conducted in 2017. Forage crops make up the largest percentage of irrigated acreage at 55%. Vegetables, grains, field and grass seed together account for an additional 27%, while the remaining 19% of irrigated acreage is made up of a variety of crops, including corn, orchards (fruit and nut trees), berries, mint, hops, dry beans, sugar beets and other (miscellaneous) crops.

FIGURE ES-6: HARVESTED IRRIGATED ACREAGE BY CROP TYPE



Source: USDA NASS 2017.
Notes: Forage crops include alfalfa and other hay, as well as haylage, grass silage, and greenchop.

Irrigation is used to produce many of Oregon's highest value crops, accounting for approximately 80% of economic output associated with total cropped acreage.[1] As shown in Table ES-1, many of the state's leading crops (in terms of direct economic output) rely heavily on irrigation, including hay, vegetables, fruits, nuts, berries, hops and corn.

[1] Estimated based on the ratio of cash rents for irrigated and non-irrigated land (NASS 2022) and the amount of cropped acreage in each crop category. Ratio was applied to value added estimates for cropped agriculture from IMPLAN to determine total value added of irrigated agriculture. The ratio of value added to economic output for each crop sector was then applied to determine total economic output by sector.

TABLE ES-1: HIGH VALUE CROPS – DIRECT ECONOMIC OUTPUT AND ACRES IRRIGATED

Crop	Economic Output ($M)	% of Cropland Irrigated
Greenhouse & nursery	1,344	N/A
Hay	643	67%
Grass seed	518	25%
Wheat	310	11%
Vegetables		86%
Potatoes	245	
Onions	135	
Crops in orchards		53%
Grapes for wine	179	
Cherries	152	
Hazelnuts	149	
Apples	44	
Pears	111	
Blueberries	136	100%
Christmas trees	121	1%
Corn, grain	88	75%
Hops	85	100%
Sweet corn	46	100%

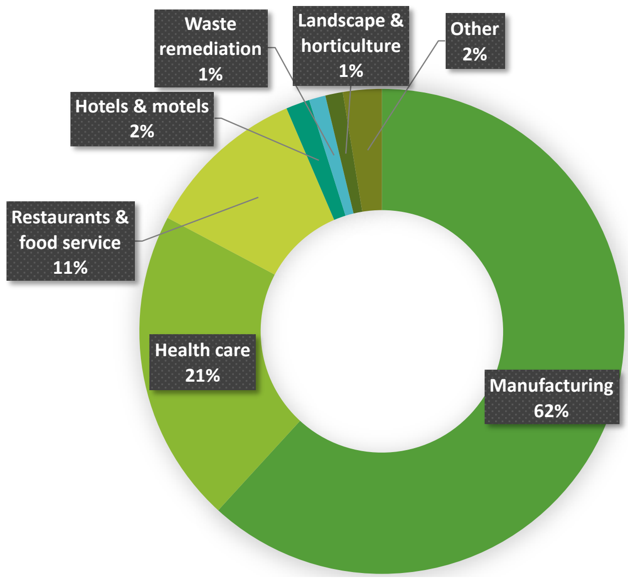
Source: Oregon Department of Agriculture 2021; USDA NASS 2017.

Water Dependent Industries

Figure ES-7 shows the relative direct contribution of water dependent industries by industry category for the state.[2] Manufacturing is by far the largest economic contributor and employer, with an annual economic output of $88.8 billion, accounting for 18.3% of the total state output and 61.8% of output from only water dependent industries. Health care services such as hospitals, physicians' offices and nursing homes contribute $39 billion to the state's economy annually (or 7.5% and 21.0% of total output and water dependent industries output, respectively). Manufacturing and health care services collectively employ over 400,000 people, making up about 16% of the state's total workforce.

[2] Water dependent industries include: manufacturing, hospitals and health care facilities, junior colleges, colleges, universities and professional schools, hotels and motels, restaurants and other food service industries, car washes, dry-cleaning and laundry services, landscaping and horticulture services, breweries and wineries and waste remediation.

FIGURE ES-7: WATER DEPENDENT INDUSTRIES OUTPUT



Source: IMPLAN.

Beyond direct economic contribution, water dependent businesses create additional economic activity in the form of indirect and induced spending. Together, these industries support $221 billion in economic output (46% of the state's total) and $111 billion in total value added (40% of the state's total), supporting just over 1 million jobs (41% of the state's total).

Freshwater-Related Recreation and Tourism

Oregon's diverse geography and ecology create opportunities for a range of outdoor recreation activities including hiking, boating, swimming, fishing, camping, skiing and more. The state's clean and abundant water sources — including its lakes, rivers, and streams — underpin the values and economic activity associated with many outdoor recreational activities. The inherent value that individuals place on outdoor recreational activities can be difficult to measure. However, economists have developed non-market valuation techniques to estimate the value of recreational experiences across a range of activities. These studies yield what economists refer to as *direct use values,* which reflect the maximum amount that individuals would be willing to pay to participate in a recreational activity.[3] Applying this methodology to a statewide survey of participation in outdoor recreational activities, Rosenberger (2018) estimated that in 2017, Oregonians participated in 1.4 billion outdoor recreation activity days, with a total net economic value of $63.2 billion.

Commercial Salmon Fishing

The coastal waters off Oregon's shores support vibrant fisheries and fishing communities. Among the iconic commercial fisheries are the six runs of anadromous salmonids, including Coho, Chinook, Chum, Pink and Sockeye salmon and steelhead trout. In 2021, Oregon's fishing fleet landed close to 1.8M pounds of salmon, producing more than $6.5 million in revenue (NOAA Fisheries 2021). Salmon fishing

[3] The net economic value of a recreation activity equals maximum willingness-to-pay minus any costs incurred to participate.

accounted for just over 3% of direct revenues (or ex-vessel sales) from onshore landings along the coast in 2021. Based on data from the IMPLAN model, the salmon fishery supported an estimated 151 direct jobs and $5.2 million in labor income (including proprietor income).[4] The direct economic activity associated with salmon fishing – $23.5 million – is concentrated in the coastal regions of the state, and in particular, the North Coast region, which is responsible for 89% of total on shore landings across its five ports (ECONorthwest 2019).

Hydropower

Oregon's rivers provide the state with an immense amount of hydropower. Oregon is the second largest producer of hydroelectric power in the US after Washington. In recent years, approximately half of Oregon's electricity generation has come from over 100 hydroelectric facilities located within the state or on its shared borders with Washington and Idaho. This energy has two primary economic signatures; first, and most importantly, it powers homes, businesses and industries across the state, contributing to statewide and regional economic productivity. Second, hydropower is an industry, with revenues and employment levels that also contribute to the state's economic well-being. The hydropower industry in Oregon employs approximately 1,500 people across the state. (Oregon Department of Energy 2022)

Thermoelectric Power Generation

Compared to the number of hydroelectric generating facilities, Oregon has relatively few thermoelectric generation stations. There are 13 natural-gas fired facilities, several with multiple generating units, located within the state (Northwest Power and Conservation Council (NPCC) 2023). These plants rely on consistent supplies of fresh water for cooling and steam generation. Water withdrawals from rivers, as well as discharges of heated water by these facilities, can have adverse effects on aquatic fish and habitat. (Mehaffey, Neale, and Horvath 2017). Despite their small numbers, thermoelectric generating facilities produced approximately 20 million megawatt hours (MWh) in 2020, or about 30% of the electricity generated within the state. Oregon power producers also exported approximately 7.5M MWh of natural gas fueled electricity in 2020 (Oregon Department of Energy 2022). In addition, the State's thermoelectric facilities are important contributors to the State and regional economies. In 2022, natural gas fired power plants directly employed nearly 500 Oregonians, with most of these positions concentrated in the Willamette Valley/Lower Columbia and Columbia Plateau.

Potable Water Supply

Understanding water use by households and businesses for drinking water and sanitation purposes, as well as the water systems that provide these services is critical to making the business case. Very small public water systems serve 12%–16% of the population in all regions but Willamette Valley/Lower Columbia, which leans on large and very large systems to serve water to 86% of the population. Most of the population in the Blue Mountains/NE, Columbia Plateau, North Coast and Southeast regions get their water from systems that serve under 10,000 people. (EPA 2023)

[4] Employment and labor income are estimated based on industry patterns for the commercial fishing sector.

TABLE ES-2: SHARE OF REGIONAL POPULATION SERVED BY SYSTEM TYPE

Region	Very Small	Small	Medium	Large	Very Large
N Coast	12%	30%	27%	31%	0%
WV/L Col	4%	5%	5%	43%	43%
Col Plat	16%	18%	31%	35%	0%
Blue Mt/NE	15%	25%	34%	26%	0%
Central	12%	15%	11%	62%	0%
SE	14%	43%	0%	43%	0%
SW	12%	12%	19%	57%	0%

Table ES-3 provides a snapshot of each region's relative dependence on public water systems vs. domestic self-suppliers. Self-supply is most often from groundwater. These data reveal to what degree regions rely on domestic self-supplied water sources instead of public water sources. The Willamette Valley/Lower Columbia region, with its large population and large and very large water systems is one of the least dependent on domestic self-supply, along with the North Coast region. On the other side of the spectrum, regions like the Southeast (38% domestic self-supply), Blue Mountains/NE (28%) and Southwest (28%) are relatively more dependent on domestic self-supply and thus groundwater.

TABLE ES-3: SHARE OF POPULATION SERVED BY DOMESTIC SELF-SUPPLY VS. PUBLIC WATER SYSTEMS

Region	Domestic Self-Supply	Public Water Systems	Domestic Self-Supply
N Coast	9,741	104,549	9%
WV/L Col	379,902	2,694,413	12%
Col Plat	35,226	117,254	23%
Blue Mt/NE	16,013	42,212	28%
Central	64,071	248,564	20%
SE	17,968	29,492	38%
SW	144,873	363,777	28%

Source: USGS 2018.

Other Water Values

In addition to the sectors described above, the benefits of water uses that either 1) do not fall neatly into a single industry sector (e.g., golf courses, navigation and transport); 2) represent only a portion of an industry sector (e.g., freshwater aquaculture); or 3) require non-market valuation approaches to estimate are also discussed. These benefits include:

- spiritual and symbolic values;
- ecological function values;
- Tribal values;
- aquaculture values;
- navigation and transport values;
- aesthetic property values; and
- golf courses.

Economic Baseline Summary

From the data analyzed in this report, a conservative estimate is that businesses, including agriculture, that depend on water for production and output in Oregon contribute approximately half (48%) of the state's total economic output and close to half (44%) of the state's employment (Table ES-4).

This estimate is conservative because – due to differences in how output in these sectors is calculated, differences in available data sources and to avoid risk of double counting some sectors – it does not include economic contributions from recreation, commercial fishing, hydroelectric power generation or thermoelectric power generation.

TABLE ES-4: TOTAL COMBINED ECONOMIC CONTRIBUTION OF WATER-DEPENDENT INDUSTRIES AND AGRICULTURE IN OREGON

Impact Type	Employment (jobs)	Labor Income ($B)	Value Added ($B)	Output ($B)
Direct	686,364	$46.3	$68.4	$147.4
Indirect	229,221	$18.6	$26.7	$48.5
Induced	167,359	$9.6	$19.4	$32.3
Total	1,082,944	$74.5	$114.5	$228.2
Percent of state total	44%	43%	41%	48%

Investing in Water in Oregon: Regional Case Studies

After presenting the baseline section, the next step in making the business case is analyzing different ways to invest in water in Oregon. In the business case framework, these analyses describe possible investments the state might undertake, using a combination of quantitative economic analysis and qualitative discussion to weigh costs and benefits of investing. Lessons drawn from these case studies provide a platform for demonstrating potential returns, both economic and non-economic, from investing in Oregon's water assets.

This approach to analyzing and discussing investment in Oregon's water assets is not exhaustive. Many types of investments are not discussed and there are cases that could be highlighted in every region and at the state level that are likewise left out. Selection of case studies is not meant to promote the specific investments described and analyzed in each study. Rather, the project team prioritized replicability, regional diversity and cases that represent key issues for each region and the state.

The dominant theme that emerges from the investments analyzed below is that they increase *resiliency and flexibility*, enhancing Oregon's ability to withstand or recover from shocks and challenges, both predictable and unpredictable. Case studies are summarized below in Table ES-5.

TABLE ES-5: CASE STUDY SUMMARIES

Region	Case Study	Water Use Sector(s)	Investment Focus
North Coast	Addressing Flooding, Diminished Critical Habitat and Other Impacts of Declining Watershed Health	Municipal, Aquatic Species/Habitat	Floodplain restoration and upland forest restoration
Willamete Valley/Lower Columbia	Investing in Water Reuse for Supply Diversification and Reliability to Support Households, Businesses, Agriculture and the Environment	Municipal, Aquatic Species/Habitat, Wetland Restoration	Using highly purified wastewater for various fit-for-purpose irrigation uses
Columbia Plateau	Farmer's Irrigation District Reservoir Expansion Project	Agriculture, Aquatic Species/Habitat	Expanding existing reservoir storage
	Nitrate Contamination in Groundwater-Sourced Drinking Water	Indivdiual Domestic Use, Municipal, Agriculture	Immediate treatment technology and long-term best management practices; water justice
Blue Mountains/Northeast	Investing in Conservation and Environmental Water Transactions to Support Farms Culturally and Ecologically Important Chinook Salmon	Agriculture, Aquatic Species/Habitat	On-farm water conservation and environmental water transactions
Southeast	Groundwater Overdraft and Threats to the Local Economy and Environment	Agriculture, Individual Domestic, Wildlife, Wildlife Vieiwing	Payments to retire groundwater rights
Central	Addressing Impacts to Agriculture and Aquatic Species from Long-Term Drought Through Conservation and Innovative Governance	Agriculture, Aquatic Species/Habitat	Piping large irrigation canals and developing innovative governance approaches (water banking)
Southwest	Characterizing the Value of Water for Recreation on the Rogue River	Recreation	River restoration actions to address water quality, quantity and instream barriers

The purpose of these case studies is to test the business case hypothesis that investing in water can help Oregon overcome current and future water-related challenges. Important high-level observations from these cases include:

- Aridification may be the new normal for much of Oregon east of the Cascades, underlining the importance of aggressive conservation and flexible innovations in governance to weather unpredictable future changes.
- Too much water (flooding), not just drought, will stress public water systems and watersheds as the climate changes.
- Wildfires impact watersheds in many ways that can harm water quality and reduce the landscape's ability to store water in soils. Limiting wildfire risk is critical to limiting risks to both human and natural communities that depend on forested watersheds.
- Whole-watershed and nature-based approaches are effective *and* leverage investment by generating co-benefits.

- Modernizing infrastructure across the landscape, from diversions and canals to farm fields to dams supports a range of productive economic water uses.
- In many places in Oregon, agriculture can benefit from testing more heat and drought tolerant crops and cropping patterns, including dryland agriculture, to keep agriculture viable despite growing water scarcity.
- Even partial solutions to some of Oregon's water supply challenges are likely to be expensive.
- Groundwater is one of the most difficult resources to manage because it is hidden, and some impacts of groundwater pumping don't manifest immediately or in the places they are expected.
- Frontline communities are especially vulnerable. Due to language and other barriers, some members of these communities may not know a problem exists while those who are aware may not have the resources, time or capacity to access information and assistance.
- Indigenous Tribes face similar water risks as all Oregonians but with enhanced urgency and import because of their especially deep cultural and spiritual ties to water and fish species that rely on water.
- Many uses of water have lagged impacts or impacts that compound over time and it is critical to identify these types of potential impacts (for example groundwater pumping that can impact surface water long after a pump is turned on) and design approaches for managing them now rather than waiting for their full impact to appear years later.
- Collaboration is powerful; trust built over time between collaborators increases resiliency by reducing conflict and providing a basis for the level of commitment that is required to tackle future challenges.

These observations can be further distilled into five guideposts that support the business case for investing to increase resiliency and flexibility with the urgency that Oregon's current and future water-related challenges merit:

- Invest in whole-watershed and nature-based approaches for a range of benefits including future including avoided costs of potential negative impacts from climate change.
- Fund innovative governance and policy adaptations to increase the flexibility of water management and capitalize on collaboration and creativity.
- Focus on modernizing infrastructure across the landscape in ways that help address specific risks like flooding, stormwater management, reduced summer baseflow, shrinking glaciers, fish passage, etc.
- Enhance water justice by authentically engaging frontline communities in policy and power and targeting investment so that benefits are distributed to these communities equitably with others.
- Recognize and invest to support Tribal economic, spiritual and cultural values for water and fish and engage with Tribes as sovereign co-managers of the resource.

Conclusions

The business case that emerges from the analysis and discussion in this report is straightforward. Water provides countless benefits – economic and non-economic – and defines Oregon's sense of place; it has been this way since the ancestors of Oregon's Indigenous people first called the land home. But these benefits are at risk; Oregon faces significant threats to its environment, economy and way of life from current and future water-related risks and challenges. Oregonians have demonstrated that they have many of the required strategies and tools at hand and have the expertise and motivation to develop new approaches when necessary. Wielding the tools and deploying the strategies, however, requires major investment not just once, but for the foreseeable future. The necessary investment cannot be underestimated and requires determination, commitment and engagement across all sectors, agencies, communities and levels of government and power. Importantly, it also requires inclusion of frontline communities that have been traditionally left out of decision-making and power over water including Tribes, low-income communities, rural communities, communities of color and others. If the aim of a business case assessment is to answer the question of whether investment is wise, the answer to whether Oregon should invest in its water resources is an emphatic yes.

At its core, the business case for investing in water is that Oregon simply is not Oregon without clean, abundant water.

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LIST OF ACRONYMS

AF	Acre-Foot/Feet
AFA	Acre Feet per Acre
AFY	Acre-Foot/Feet per year
B	Billion
BEA	Bureau of Economic Analysis
BCA	Benefit-Cost Analysis
BCE	Business Case Evaluation
BIL	Bipartisan Infrastructure Law
Blue Mt	Blue Mountain
BLS	Bureau of Labor Statistics
BMPs	Best Management Practices
BT	Benefit Transfer
C-E	Cost Effectiveness
CAFOs	Confined Animal Feeding Operations
CGWAs	Critical Groundwater Areas
CLNP	Crater Lake National Park
CoA	Census of Agriculture
COID	Central Oregon Irrigation District
Col Plat	Columbia Plateau
CP	Conservation Practices
CREP	Conservation Reserve Enhancement Program
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWS	Confederated Tribes of Warm Spring
CWS	Community Water System
DPR	Direct Potable Reuse
DRC	Deschutes River Conservancy
DWB	Deschutes Water Bank
EPA	Environmental Protection Agency
ESA	Endangered Species Act
EUAC	Equalized Unified Annual Cost
EWT	Environmental Water Transaction
FEMA	Federal Emergency Management Agency
FID	Farmers Irrigation District
FMAG	Fire Management Assistance Grant
FTE	Full-time equivalent
GDP	Gross Domestic Product
GDE	Groundwater Dependent Ecosystem
GHVGAC	Greater Harney Valley Groundwater Area of Concern

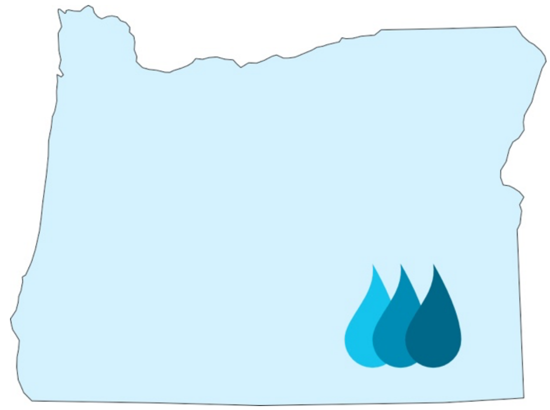
HCBWPC	Harney Community-Based Water Planning Collaborative
HCP	Habitat Conservation Plan
IPR	Indirect Potable Reuse
IRA	Inflation Reduction Act
L	Liter
L Col	Lower Columbia
LCA	Life Cycle Analysis
LCOW	Levelized Cost of Water
LUBGWMA	Lower Umatilla Groundwater Management Area
M	Million
MCDA	Multi-Criteria Decision Analysis
Mg	Milligrams
MHI	Median Household Income
MWh	Megawatt hours
N Coast	North Coast
NASS	National Agricultural Statistics Service
NOAA	National Oceanic and Atmospheric Administration
NE	Northeast
NED	National Economic Development
NEE	National Economic Efficiency
NGF	National Golf Foundation
NPS	National Park Service
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
NRI	National Risk Index
NTNCWS	Non-Transient Non-Community Water System
NUID	North Unit Irrigation District
O&M	Operations and Maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OMB	Federal Office of Management and Budget
OPH	Oregon Public Health
OSF	Oregon Spotted Frog
PWB	Portland Water Bureau
Reclamation	Bureau of Reclamation
RO	Reverse Osmosis
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SDWIS	Safe Drinking Water Information System
SE	Southeast

SRF	State Revolving Fund
SW	Southwest
SWE	Snow Water Equivalent
TBL	Triple Bottom Line
TMDL	Total Maximum Daily Load
TNCWS	Transient Non-Community Water System
US	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
WARRF	Well Abandonment, Repair and Replacement Fund
WRRF	Wastewater Resource Recovery Treatment Facility
WV	Willamette Valley
WWSP	Willamette Water Supply Program

AUTHORS' NOTE

This report was researched and written during an intense 81-day sprint from April 11th, 2023, through June 30th, 2023. The short timeframe limited our efforts in several ways that impacted the final product. First and foremost, it limited our ability to engage deeply over time with community members, water users, individuals and organizations who could have provided valuable feedback on report drafts, presentations and the overarching approach. The limited window for completing the report also meant that we could only do basic, if any, data manipulation. For example, with more time, we could have taken data that is most easily accessible at the county level and converted it so that we could conduct analyses at the watershed and/or river basin scale. Also, with a longer window in which to work, we could have conducted outreach to communities that have traditionally been left out of water policy and decision-making; adding more voices from these communities would help this report immeasurably. With all that said, we are proud of what we accomplished here and sincerely hope that this *Business Case for Investing in Water in Oregon* can have a meaningful impact on Oregon's water future.

1 INTRODUCTION



Beginning with Indigenous cultures since time immemorial, Oregon's land, people and environment have always been deeply connected to water. Availability and access to clean, plentiful water underlies the state's identity, environment, culture and economy. Water sustains the needs of humans and ecosystems, drives productivity and helps define Oregon's sense of place. Water is also a shared, public resource and one for which scarcity and competition are growing. As this occurs, the urgency and need for careful stewardship and proactive investment to sustain the state's water resources grows apace.

Oregon's rivers, streams, lakes, wetlands, aquifers, and coasts (i.e., its supply of available and useable water, above and below ground), along with systems of management, governance and the built and natural infrastructure used to manage water, make up the state's *water assets*. Prudent investments in Oregon's water assets — be they financial, physical (both built and natural) or policy-related — are essential for sustaining and enhancing the value of water to Oregon.

> **The objective of this report is to highlight the critical value of water to Oregon, and clearly articulate the case for making and sustaining investments to protect and manage Oregon's water assets — to make the business case for investing in water in Oregon.**

Applying a *business case* perspective provides an objective approach for assessing the beneficial returns that potential water investments might generate, and how those benefits are likely to be distributed across Oregon's people, regions, economic sectors and ecosystems. The business case approach developed for this study also provides insights into the costs that may be incurred by Oregon's residents, enterprises and ecosystems from under-investment in water assets.

1.1 REPORT ORGANIZATION

This report is organized into six main sections following this introduction:

- **Section 2** describes Oregon's current water use and demographic context.
- **Section 3** provides a primer on how to develop and use a business case analysis and then details the approach taken for conducting technically sound, transparent and objective business case evaluations (BCEs) for potential water-related investments in this report; a set of technical appendices offer additional guidance and detail on the methods and approaches used.
- **Section 4** presents the current economic value of water benefits to the state — the baseline for analysis. This analysis is applied at both the state and regional levels and focuses on key water-related sectors such as agriculture, recreation and industry, among others. Other water uses not included in the quantitative baseline analysis — including aesthetics, spiritual, cultural and other values for water — are also characterized.
- **Section 5** characterizes Tribal connections to water in Oregon.

- **Sections 6 through 14** explores a set of illustrative case studies of specific investments drawn from regional examples and the state. The case studies were strategically selected to span the geographic breadth of the state and focus on a diverse range of water use sectors and water resource challenges. They are not exhaustive of all possible investments and all regions of the state but were chosen to be representative of ways for Oregon to invest in creating a resilient water future.
- **Section 15** discusses cost-effectiveness and Levelized Cost of Water for select case studies.
- **Section 16** concludes the report by drawing lessons from the case studies and the broader analysis to concisely articulate a compelling case for immediate, significant and sustained investment in water in Oregon.

1.2 Key Findings

This report provides clear, detailed support for investing in water in Oregon. The water use and demographic data examined below illuminates the diversity of landscapes and people in Oregon and paints a vivid picture of a population that depends extensively on water for its economic, environmental and cultural well-being. The economic analysis of key water-dependent sectors takes this further, demonstrating how water drives the state's economy. Water drives the economy in obvious ways like watering valuable crops and generating electricity to power businesses, and it does so in less obvious but no less important ways like providing habitat for commercially and culturally valuable fish species and securing aesthetic benefits and peace of mind. The eight case studies offer real-world examples of investments, supported by quantitative analysis to show monetary returns on investment and detailed qualitative discussions highlighting non-monetary returns and other benefits.

Analyzing specific case studies provides a platform for testing the business case hypothesis that Oregon should invest in its water resources. Not only do the cases help test the high-level theory that Oregon *should* invest, but they also help to draw the contours of what investments can provide the largest range of beneficial outcomes.

The key finding of this analysis is that Oregon should invest in ways that increase resiliency and flexibility and should do so in advance of crises rather than in response to crises.

Further, five guideposts can help steer investment toward the most diverse and broad monetary and non-monetary returns:

- Invest in whole-watershed and nature-based approaches for a range of benefits.
- Fund innovative governance and policy adaptations to increase the flexibility of water management and capitalize on collaboration and creativity.
- Focus on modernizing infrastructure across the landscape in ways that help address specific risks like flooding, stormwater management, reduced summer baseflow, shrinking glaciers, fish passage, etc.
- Enhance water justice by engaging frontline communities in policy and power and targeting investment so that benefits are distributed to these communities equitably with others.
- Recognize and invest to support Tribal economic, spiritual and cultural values for water and fish and engage with Tribes as sovereign co-managers of the resource.

1.3 Making the Business Case for Investing in Water in Oregon

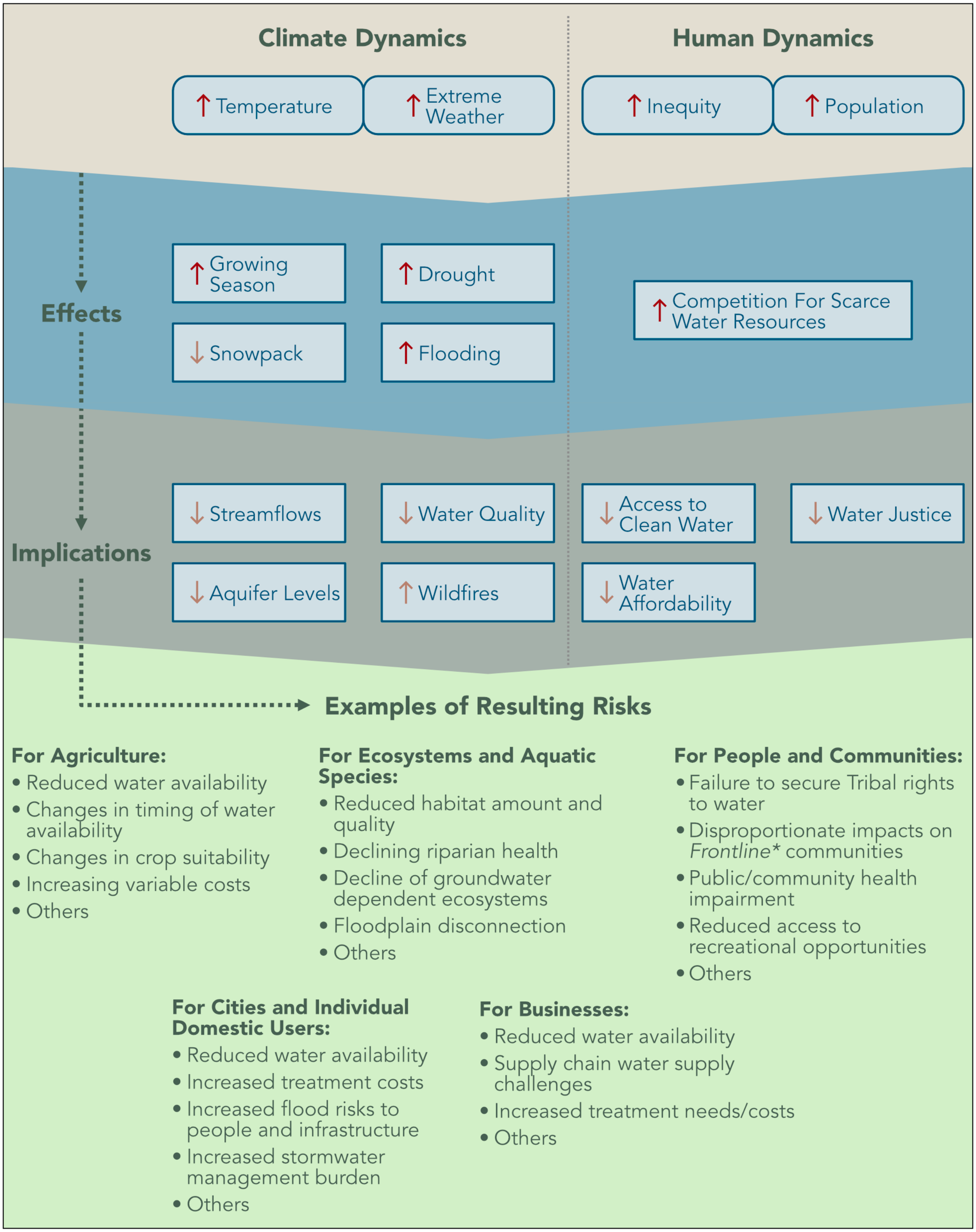
This section articulates at a high level what a business case is and importantly, why one is needed to inform decisions about investing in Oregon's water assets. At its core, a business case is about considering risks, opportunities and benefits to make an informed decision about the wisdom of investment(s). The business case for water begins with the risks Oregon faces in maintaining and equitably distributing access to clean, abundant, reliable water supplies and then describes the opportunities and benefits of doing so.

1.3.1 Oregon Faces Challenges in Managing Water

Freshwater makes up a vanishingly small portion of total water on earth. Of the water that is available, not all is accessible to humans and much of what might be accessible is needed not only by people, but also to sustain a diverse range of ecosystems. Water management is the term used to describe a broad array of actions humans take to find, access and use water — ideally in a way that recognizes and manages for the needs of all species and cultures, including those who were historically left out of the exercise of power over water resources.

A changing climate coupled with anthropogenic stressors means that water management is changing. While the water cycle itself is immutable, where water is found in the cycle, especially when and in what form, are being altered, often in unpredictable ways. Population growth and structural inequities in the distribution of power over water and related resources exacerbate the stressors and resulting risks facing modern water management across all sectors (Figure 1).

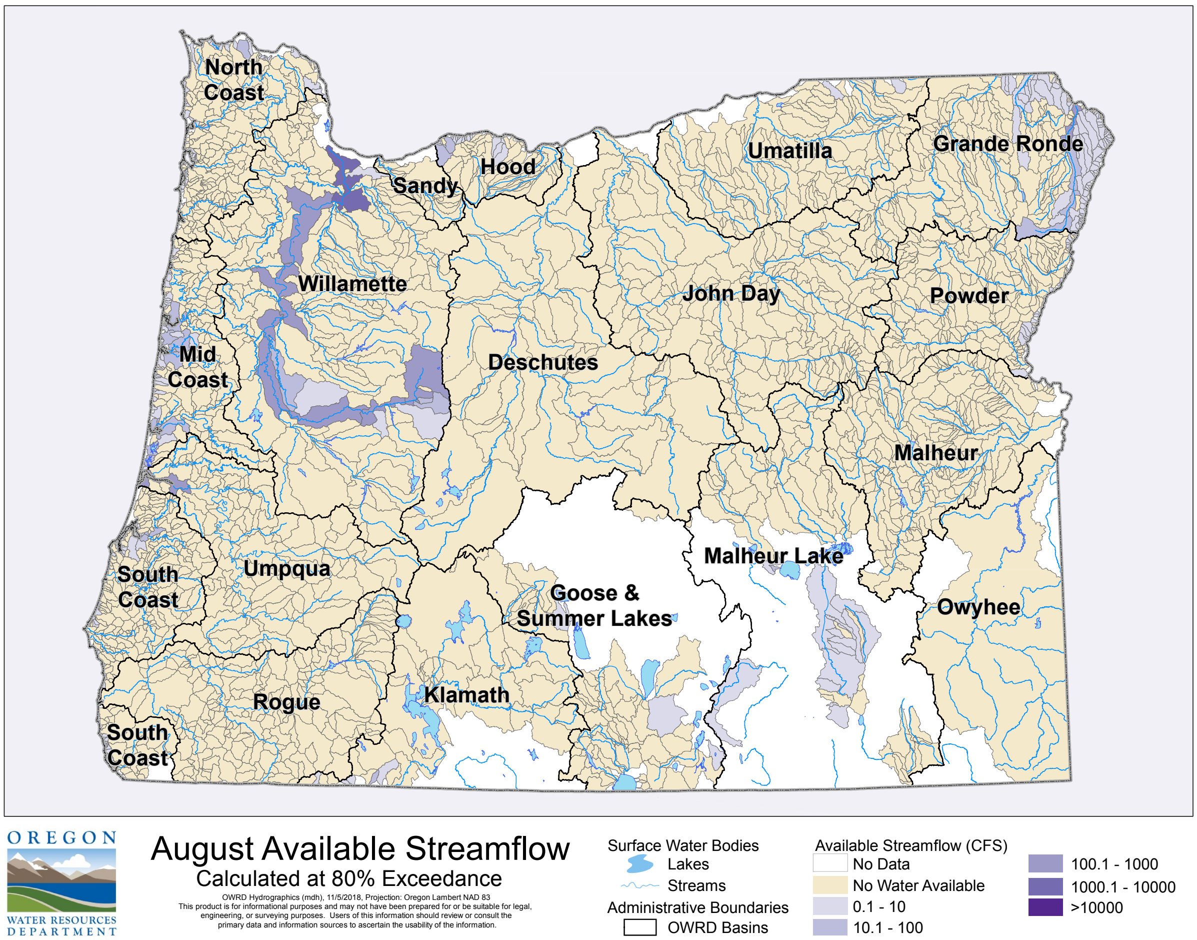
FIGURE 1: EXAMPLES OF WATER SUPPLY RISKS AND ROOT CAUSES IN OREGON



*Frontline communities are those who experience impacts "first and worst;" this includes people most exposed to water risks due to where they live and due to a lack of resources, safety nets, political influence, etc. (Stacey Dalgaard 2022).

In Oregon, climate and human-related stressors manifest in numerous ways, but several implications are noteworthy. Under the Oregon Water Resources Department's (OWRD) approach for determining the availability of surface water for new water rights, most of the state has no water available in August (Figure 2). In other words, most of Oregon's streams and rivers are fully or over appropriated. For example, dry and nearly dry streambeds are common in arid parts of the state during the late summer as are irrigated fields lacking the water to support a third or fourth cutting of hay or alfalfa.

FIGURE 2: SURFACE WATER AVAILABILITY FOR NEW WATER RIGHTS IN LATE SUMMER



Groundwater is not a viable alternative for new water uses in many parts of the state (Figure 3). Formal regulatory designations like Critical Groundwater Areas and Serious Water Management Problem Areas and others are used in regions across the state to slow rapid groundwater depletion or more closely monitor the resource. The future will likely see new regions added to the list for enhanced groundwater protection, monitoring and regulation. OWRD will also likely enact new rules for analyzing new groundwater right applications.

FIGURE 3: GROUNDWATER AVAILABILITY FOR IRRIGATION IN OREGON

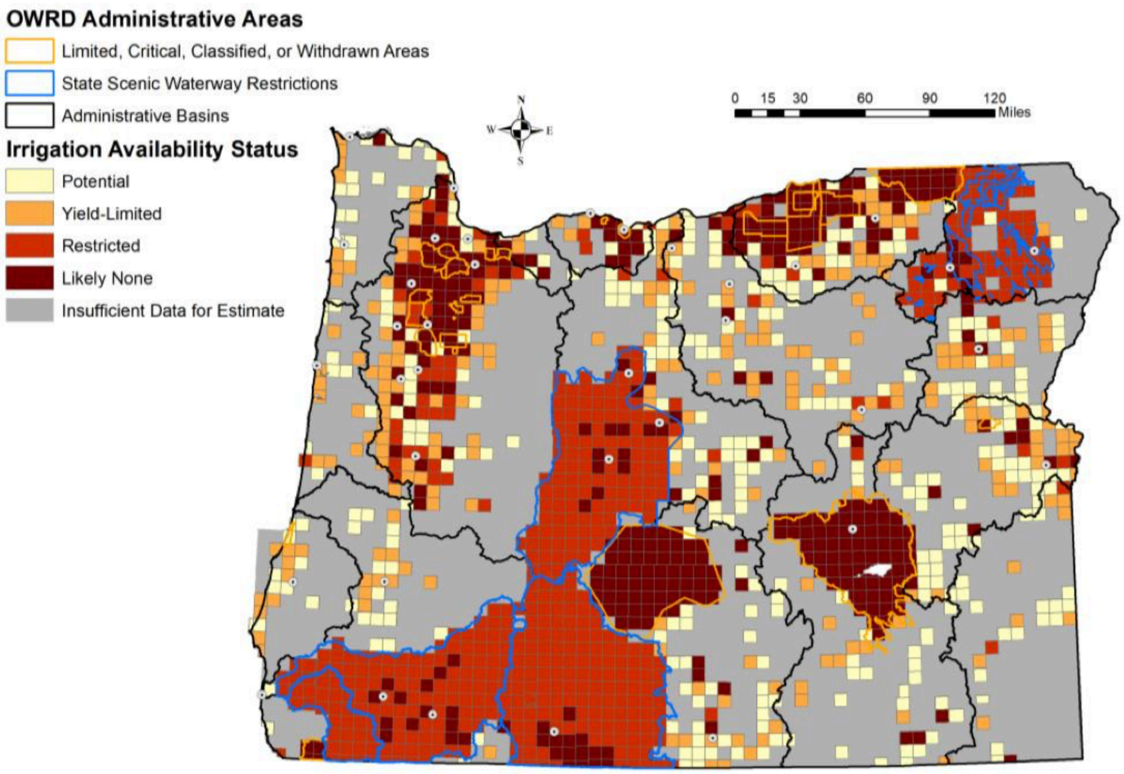
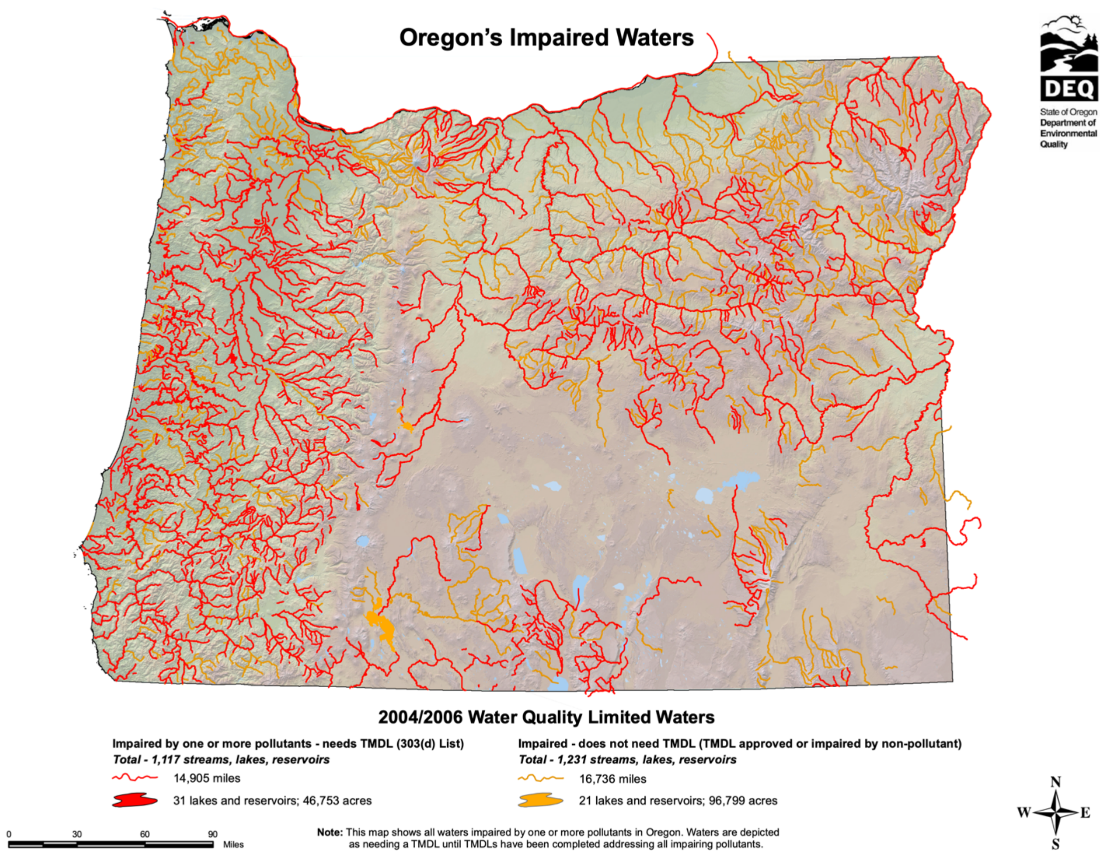


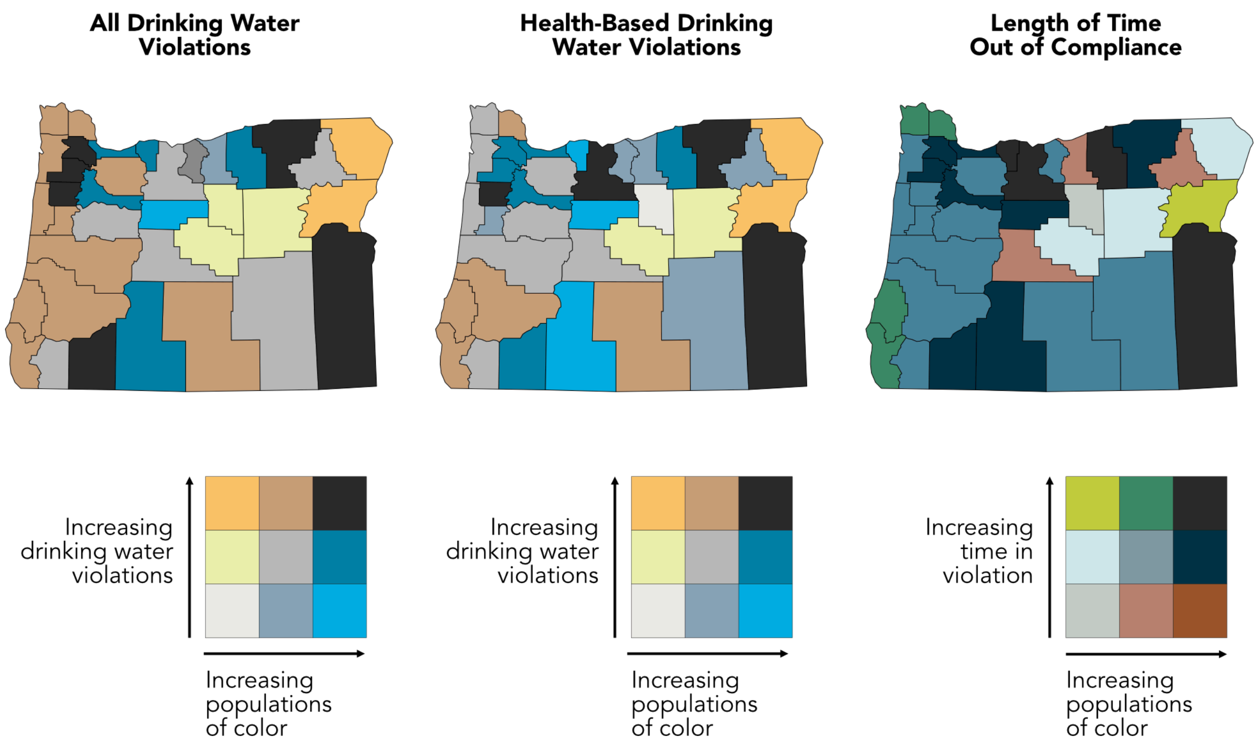
FIGURE 4: PAST WATER QUALITY IMPAIRMENT IN OREGON



Another growing water stress for the state is impairment of water quality in Oregon's streams. Though the data in Figure 4 are out of date, very few of the streams portrayed have been removed from the list of water quality limited streams. Poor water quality, including elevated water temperatures impact the health of natural ecosystems, fish and wildlife and can impact community health too.

Aside from physical stressors related to climate and hydrology, historic and persistent inequities in access to clean, plentiful water and influence over water decision-making also have implications for Oregon's water future. Oregon's Tribes have had their access and rights to water severely curtailed by treaties and are experiencing negative impacts to culturally, economically and nutritionally important fish species like Chinook salmon, Pacific Lamprey and others because of streamflow and water quality depletion. Oregon's rural populations, lower income populations and populations of color also are often exposed to greater water risks including unsafe drinking water. Figure 5 shows the relationship between increasing populations of color and three different drinking water statistics across the state.

FIGURE 5: COMMUNITY DRINKING WATER VULNERABILITY BY COUNTY



Source: Fedinick, Taylor, and Roberts (2019)

In sum, both climate-related and human-related dynamics have significant implications for Oregon's water future and are driving increased risks for all economic sectors, people and ecosystems that rely on water.

The heart of the business case for investing in water in Oregon is recognizing these challenges and developing a sense of shared commitment in working to address them.

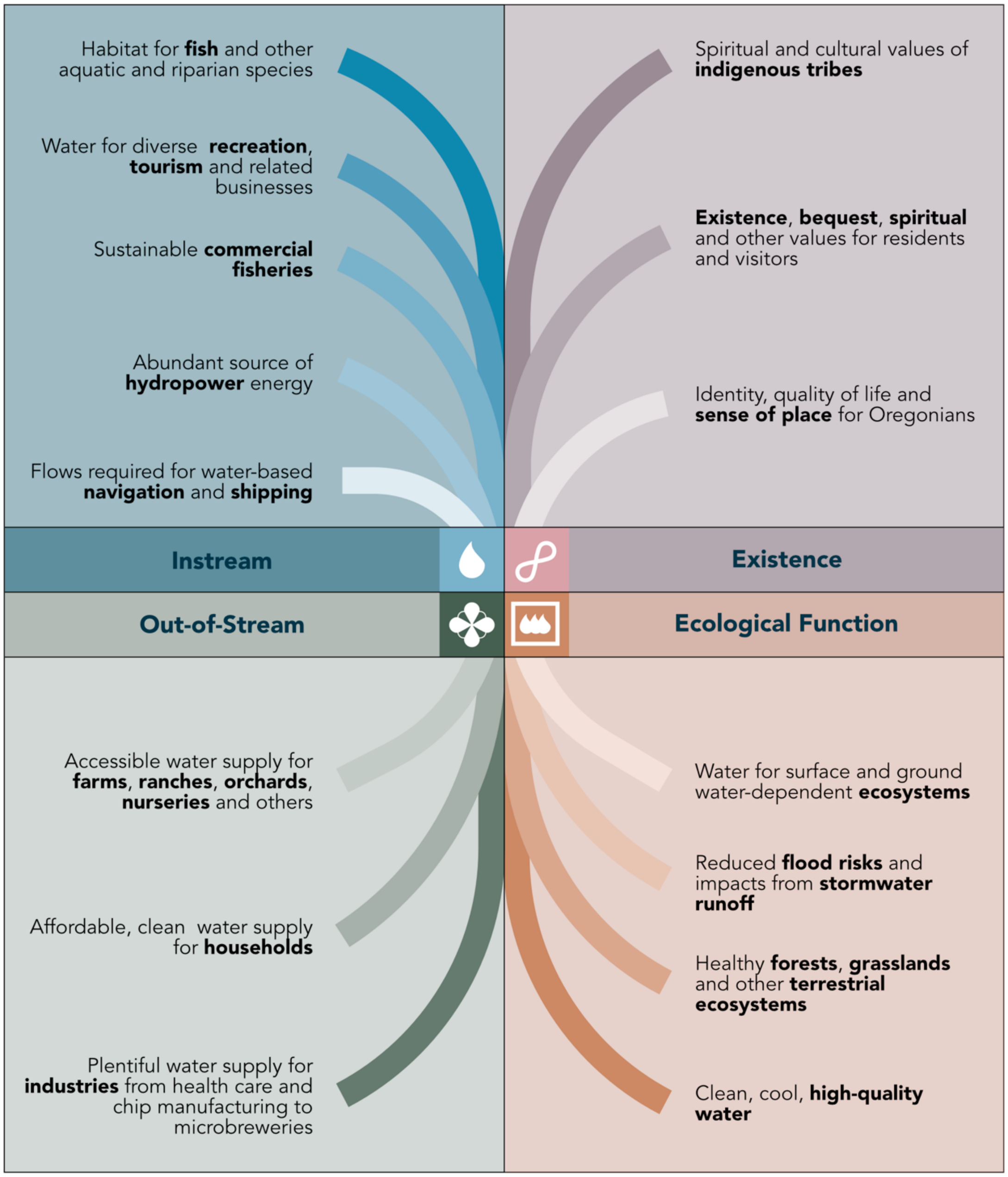
1.3.2 Oregon's Water Assets Support Many Values

While risk is one part of the business case for water in Oregon, the other part is the benefits and opportunities that investing in water affords. Water assets — in concert with the infrastructure and institutional systems that manage the location, timing, quality, and uses of that water — provide an array of essential and highly valuable services to Oregon's natural and human communities (Figure 6). These water-related services include but are not limited to:

- protecting and enhancing key fisheries and aquatic ecosystems (including threatened and endangered salmonids and other species);
- providing reliable, high quality, and affordable potable water supplies for the state's households;
- honoring and preserving spiritual and cultural values for Indigenous people;
- supplying water to farmers, ranchers, orchardists and others; supporting agricultural activity throughout the state;
- supporting a wide array of water dependent industries, from health care, to microchip manufacturing, to microbreweries;
- providing an array of existence, bequest, spiritual and other nonuse values for residents and visitors;
- providing high-quality recreation and tourism experiences and related economic activity;
- supporting a sustainable commercial fishery;
- enabling water-based navigation and shipping;
- managing flood risks and adverse impacts from stormwater runoff;
- providing an abundant source of economical and low carbon hydropower energy;
- supporting healthy forests, grasslands and other terrestrial ecosystems, and related timber and agricultural enterprises, and enhancing carbon sequestration; and
- defining an identity and quality way of life for Oregonians.

The diverse suite of water-provided use and nonuse benefits are described further in Section 3. Also provided in Section 4 are high-level estimates of the economic and related values that water and associated systems generate for key water-dependent economic sectors across Oregon.

FIGURE 6: OREGON'S DIVERSE WATER VALUES



1.3.3 Water Values Stem from the Mix of Natural and Built Assets and Governance Systems

Water in its various forms and settings is a "natural asset," which includes aquifers, wetlands, rivers and streams, lakes, estuaries and coastal waters. The riparian and marine ecosystems that inhabit and sustain these waters — as well as their associated terrestrial ecosystems — also are important natural assets. For example, forested watersheds providing source waters to a river or reservoir are important natural assets that regulate the timing, quantity and quality of runoff into receiving waters.

The human-provided and governance systems that support and enhance the valuable services and benefits provided by water include "built assets" and "institutional assets." Built assets include:

- **gray infrastructure** (e.g., hatcheries, dams, water treatment facilities, canals, pumps and pipelines); and
- **green infrastructure** (e.g., floodplains, permeable walkways, bioswales, artificial wetlands, rain gardens and other urban "green stormwater infrastructure").

Institutional assets include:

- **cultural infrastructure** (e.g., spiritual and other practices that involve water and aquatic species, public awareness of the value of water and support for expending resources to preserve these values); and
- **governance systems/institutions** (e.g., legislative, administrative and regulatory processes, policy development and implementation; data management, regulatory, permitting and enforcement systems and public outreach and engagement).

1.4 Summary: Making a Business Case

Given limited fiscal and other resources, potential water-related investments need to be evaluated and prioritized to ensure the highest beneficial values are generated for Oregon including ecosystems, Tribal communities, residents, businesses and visitors. Developing a business case is a well-established approach for evaluating whether potential investments are likely to provide beneficial returns to the state through a systematic assessment of the costs and benefits of investment alternatives. The objective is to identify options with high returns on investment while recognizing that many returns are *not* monetary.

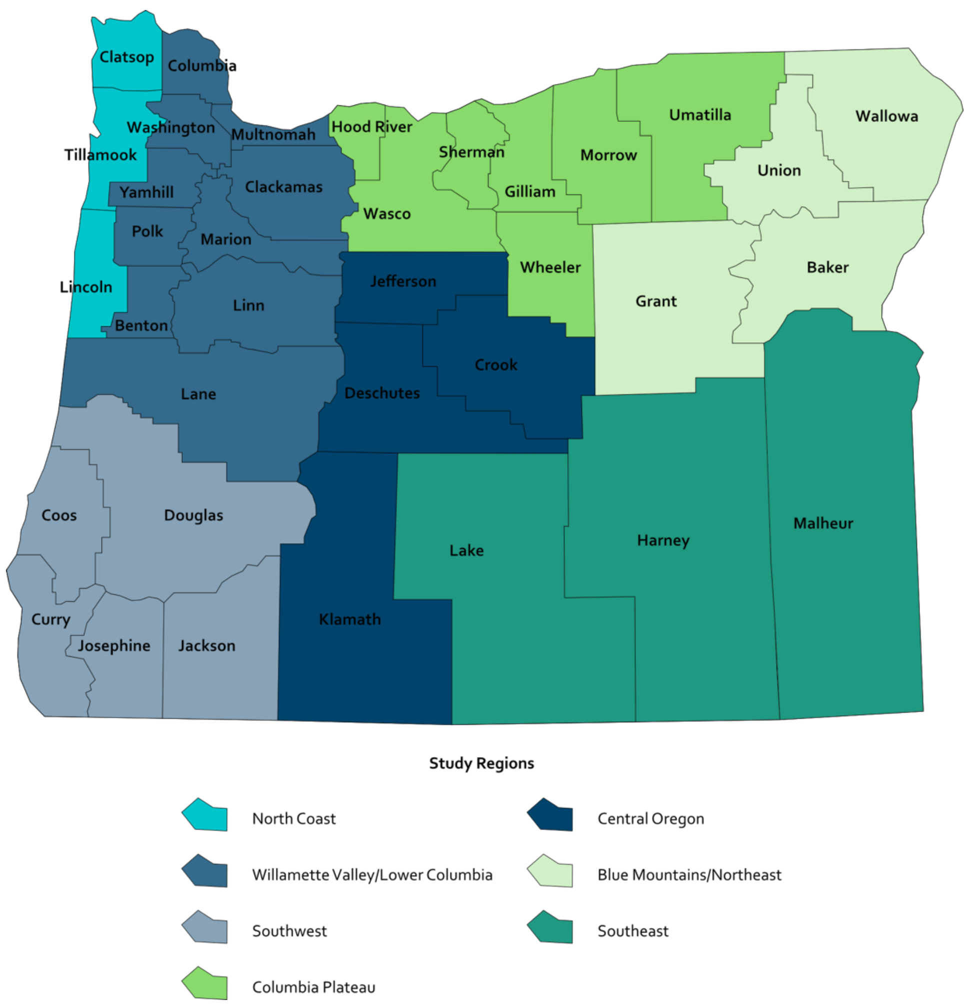
When weighing investments, fiscal and economic considerations are critical but so too are intangible factors. The business case for investing in water in Oregon is in large part based on economic considerations but is not constrained by that frame of reference. Compelling reasons to invest in water in Oregon are as diverse as the benefits water provides and as numerous and serious as the risks the state is facing.

This report is an attempt to capture and articulate these reasons through quantitative analysis, qualitative discussion and storytelling, and to do so in a way that inspires a collective commitment to investing in Oregon's most precious resource.

2 Oregon's Current Demographic and Water Use Context

This section provides descriptions of the physical setting, current socioeconomic conditions and the most recent data on water use by source and use for Oregon overall and seven study regions — which are broadly based on geography, climate and socioeconomic conditions and use of water resources (Figure 7). The descriptions below provide a basic understanding of the current demographic and economic conditions of each region, supported and constrained by the physical characteristics of the land and the water resources contained therein. The water use data provide insight into the magnitude of the State's and each region's demand on water resources, the sources of water that satisfy those demands and uses that benefit from the water resources. This background information provides context and a foundation for making the business case for investing in water in Oregon.

Figure 7. Study Regions



County boundaries were used for regional grouping to align the current conditions and water value analyses with the geographic scope of the most widely available data sources. The choice of what counties to group together balanced efficiency (i.e., limiting the number of total regions) with an attempt to group counties together that share physical, demographic, climate and water use characteristics. An analysis of the value of water to Oregon would ideally be aligned with boundaries that are more tightly linked to underlying water resources, such as watershed and river basin boundaries. However, the scope and timeframe for this analysis did not allow for the more extensive data manipulation that would be needed to use regions that deviated from county boundaries.

Current socioeconomic and demographic data were used to characterize the seven regions identified for this study, focusing on factors related to water resources. Socioeconomic and demographic data were sourced from the most recent updates of publicly available data sources (Table 1). There is variation in the timelines of data presented because not all sources update on the same schedule (for example, the US Census and Census of Agriculture (COA) are produced every ten year and five years, respectively). Unless explicitly mentioned, 1) data are presented from the year referenced for each source in Table 1; and 2) dollar values are presented in constant 2022 dollars.

TABLE 1. DATA SOURCES

Data Type	Source	Year
Land use and land cover	USGS	2019
Population and population density	US Census Bureau	2020
Median income and poverty rate	US Census Bureau	2021
GDP	US BEA	2021
Employment	US BEA	2021
Agriculture	USDA	2017

Total water use is inconsistently tracked in Oregon. The USGS Water Use Data for the Nation (USGS n.d.) tracks water withdrawals, which are used in this study as a proxy for water use. USGS provides county-level estimates of water withdrawals by sector at five-year intervals. Although water use data have been reported in some areas of the United States (US) since 1950, data for Oregon is only available from 1985 onward and data collection (both naming conventions and thoroughness of water use reporting) varies among different compilations. Because information is only tracked every five years, assessing long-term trends is likely a more useful exercise than relying on a single year of data. Finally, USGS data is best used for high-level characterization because the data lacks the specificity of state water rights data and other site-specific data sets.

The estimates presented here represent volumes withdrawn for use rather than consumptive use — as consumptive use data are not available for all years. This is an important distinction as the consumptively used portion of withdrawals varies by use type.

It should be noted that, although demographic, socioeconomic and water use data are presented at the state, region or county level, access to water and its associated economic, environmental, health and other impacts is neither equal nor equitable across the landscape. Disproportionate access to clean and sufficient volumes of drinking water or water to support hygiene, as well as exposure to water-related risks such as floods and drought, is associated with specific geographies — as influenced by sources of pollution, overuse of local water resources and other factors — as well as minority, undocumented, non-English speaking or unhoused populations; rural communities reliant on small community water systems, including mobile home parks; residents with self-supplied water from domestic wells or surface water sources; home renters; and areas with aging infrastructure, among other factors. While the discussion below does not address issues of inequitable exposure to water-related costs and benefits in detail, some case studies presented in this report provide illustrative examples of some water equity issues in the state. (Stacey Dalgaard 2022)

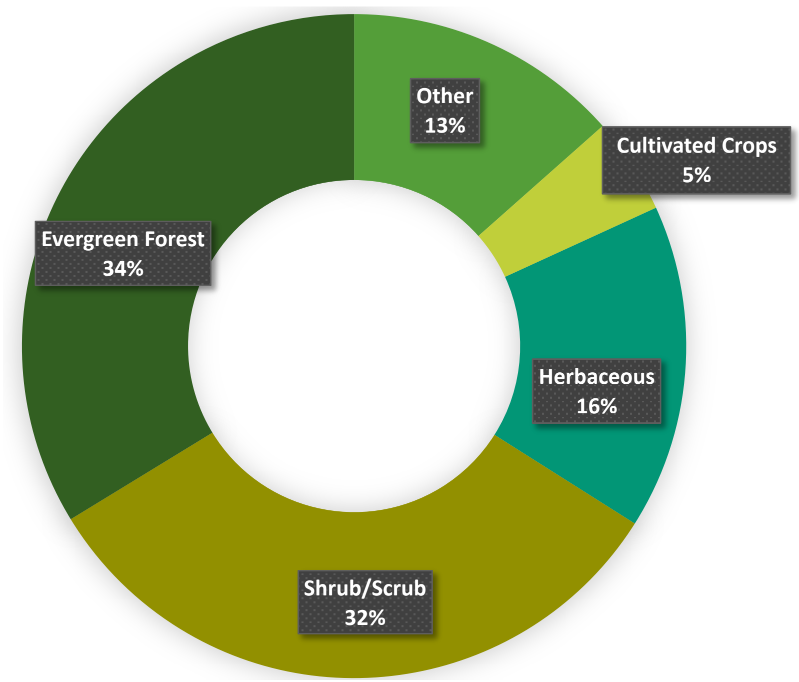
2.1 Statewide Overview

Water is part of a natural resources heritage in Oregon, which has long sustained the people and communities who live here, from consumption of salmon by Tribes since time immemorial, to the historic strength of the logging industry, to the breadth and diversity of irrigated agriculture and the rise of the outdoor recreation industry.

2.1.1 Land

Oregon spans just over 98,000 square miles of which 98% is land and 2% is water (Figure 8). The state is characterized by its undeveloped landscapes, with two-thirds of the state covered in evergreen forest and shrub/scrub and developed land[5] representing only 3% of total land cover. (USGS 2021)

Figure 8. Oregon Land Cover and Land Cover Classes



Land Cover Classes
Barren Land
Cultivated Crops
Deciduous Forest
Developed
Emergent Herbaceous Wetlands
Evergreen Forest
Hay/Pasture
Herbaceous
Mixed Forest
Open Water
Perennial Snow/Ice
Shrub/Scrub
Unclassified
Woody Wetlands

Note: The category "Other" includes classes with less than 2% cover. Open water includes the area within territorial sea that extends seaward from the State's coastline.

While all land cover is dependent on water resources, this dependence differs by both degree and source. Open water is inclusive of streams and lakes as well as bays and offshore territorial sea. Wetlands may be groundwater-dependent systems, while most evergreen forests are rain-fed or rely on

[5] The National Land Cover Database classifies "developed land" into four classes: 1) Developed, Open Space - areas with some constructed materials, but mostly vegetation in the form of lawn grasses, such that impervious surfaces account for less than 20% of total cover ; 2) Developed, Low Intensity - areas with a mixture of constructed material and vegetation such that impervious surfaces account for 20%-49% of total cover; 3) Developed, Medium Intensity - areas with a mixture of constructed material and vegetation such that impervious surfaces account for 50%-79% of total cover; and 4) highly developed areas such that impervious surfaces account for 80%-100% of total cover.

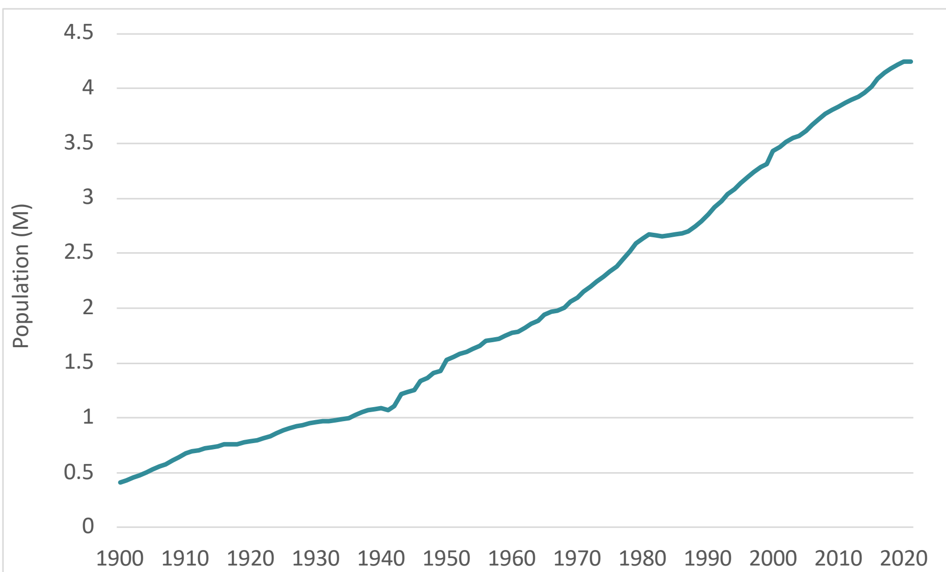
snowpack. Even within a land cover type, there may be differences, for example cultivated crops may be rain-fed or irrigated with surface water and/or groundwater.

Over 40% of land in the State is privately owned. Of the remainder, over half is federally owned, a portion of which is held in trust in reservations and services areas for Tribal members of the nine federally recognized Tribes in the state and only 3% is owned by the state government. (US DOI 2023; OR DHS 2023)

2.1.2 Demographics

Since the turn of the century, both population and population density have increased steadily in Oregon (Figure 9). As of the 2020 Census, Oregon was home to a population of 4.2 million (M) people, an increase of 11% since the 2010 census. At that time, 75% of the state population identified as white; 5% as Asian; 2% as black or African American; 1% as American Indian or Alaskan Native; less than 1% Hawaiian or Pacific Islander; and 17% as another/multiple races. Of the portion of the population identifying as white, 14% further identify as Hispanic of Latino. Since the previous decadal census in 2010, the population identifying as white has decreased by 9%, a difference which was redistributed amongst portions of the population that identify as Asian or another/multiple races. (US Census Bureau 2020b)

FIGURE 9. OREGON LONG-TERM POPULATION TRENDS

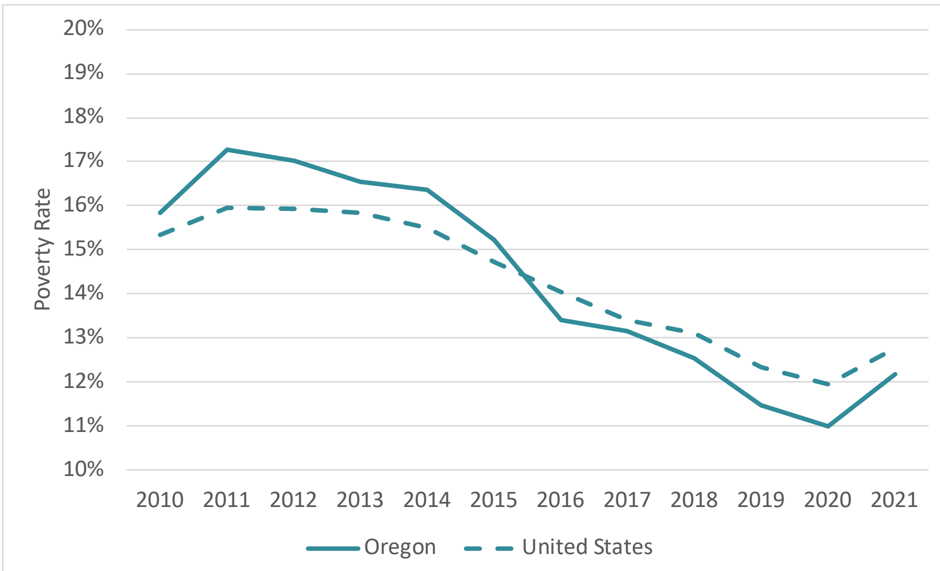


Source: Data Commons (2023).

The state has a population density of 43 people per square mile, an increase from 2010 when population density was 39 people per square mile. Population density, however, is far from uniform across the state, with county-level densities — within which there is still great variability — ranging from 0.73 people per square mile (Harney County) to 1,753 people per square mile (Multnomah County). Large population centers — cities with populations over 100,000 — include the cities of Portland, Salem, Eugene, Gresham, Hillsboro and Bend. (US Census Bureau 2020a)

In 2021, the median household income (MHI) in Oregon was $77,176 and the poverty rate was 12%. Oregon had a higher median income than the national average of $75,314 and a marginally lower poverty rate compared to the national rate of 13%. From 2010, when Oregon's poverty rate exceeded that of the nation, to 2020, Oregon has mimicked the national trend in declining poverty rate, such that Oregon's poverty rate fell below the national average (Figure 10). Similarly, Oregon's MHI has generally tracked the national trend, increasing from 2010, when it was below the national value, to exceeding it in 2021. (US Census Bureau 2021)

FIGURE 10. POVERTY RATE (2010-2021)



Source: US Census Bureau (2021).
Note: Y-axis does not begin at zero

BOX 1: FRONTLINE COMMUNITIES AND THE DEFINITION OF WATER JUSTICE

Frontline communities are defined as those who experience impacts *first and worst*. A recent report on the State of Water Justice in Oregon (Stacey Dalgaard 2022) provided a fuller definition: "Frontline communities throughout the state have elevated water priorities that are central to envisioning a more just water future. This includes the right to a healthy and functioning ecosystem, safe access to First Foods in waterways, the right to access information about water, tribal sovereignty and treaty rights, impacts of water-related natural disasters (e.g., flooding, harmful algal blooms), and capacity to influence water decision-making."

While the specifics of who makes up a frontline community can change with context and conditions, the report also noted that "tribes, people of color, immigrant, low-income communities, people who have disabilities and other groups who have been oppressed or overlooked. . . consistently face greater exposure to environmental risks." Finally, the report offered a full definition of the term *Water Justice*: "For the purposes of this report, water justice requires equal protection from environmental and health hazards, universal and affordable access to safe drinking water and sanitation, equitable investments that create economic opportunity and community resilience for historically marginalized and excluded communities, and meaningful engagement of frontline communities in developing solutions to the water challenges people experience daily."

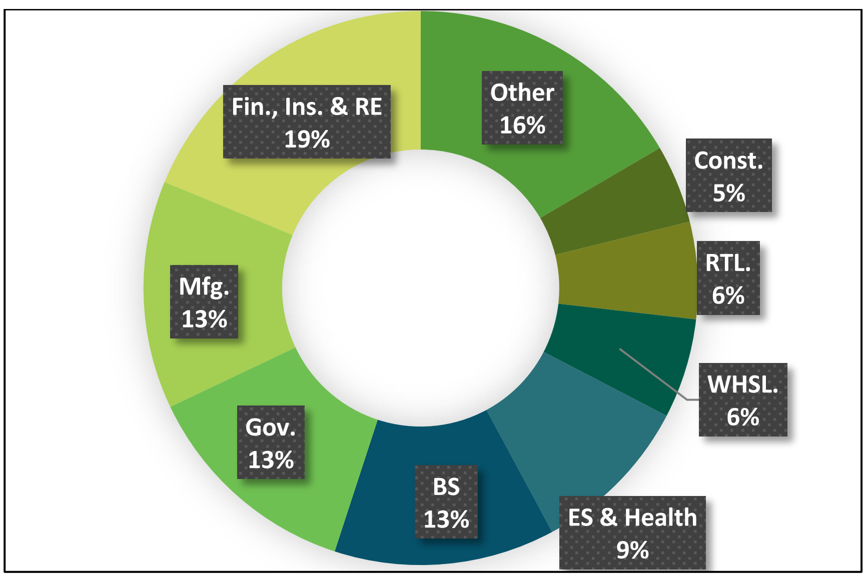
2.1.3 Economy

In 2021 Oregon's Gross Domestic Product (GDP) was $272 billion (B) — 87% of which came from the private sector (Figure 11) (BEA 2021). Exports comprised 11% of total GDP in 2021, which is consistent with the range over the past decade (9.4% in 2018 to 11.1% in 2014) (Rogoway 2023b). Bureau of Economic Analysis (BEA) sector[6] categories are provided in Table 2 along with the acronym for each sector used throughout this section (BEA 2021).

TABLE 2. BEA SECTORS

Industry Name	Industry Acronym
Agriculture, forestry, fishing and hunting	Ag., For. & Hunt
Mining, quarrying, and oil and gas extraction	Extract.
Utilities	Util.
Construction	Const.
Manufacturing	Mfg.
Wholesale trade	WHSL.
Retail trade	RTL.
Transportation and warehousing	Transp.
Information	Info.
Finance, insurance, real estate, rental and leasing	Fin., Ins. & RE
Professional and business services	BS
Educational services, health care and social assistance	ES & Health
Arts, entertainment, recreation, accommodation and food services	Art, Rec. & Accom.
Other services (except government and government enterprises)	Other
Government and government enterprises	Gov.

FIGURE 11. OREGON GDP BY SECTOR



Source: BEA (2021a.

Note: The category "Other" includes sectors with contributions of less than 5% of GDP.

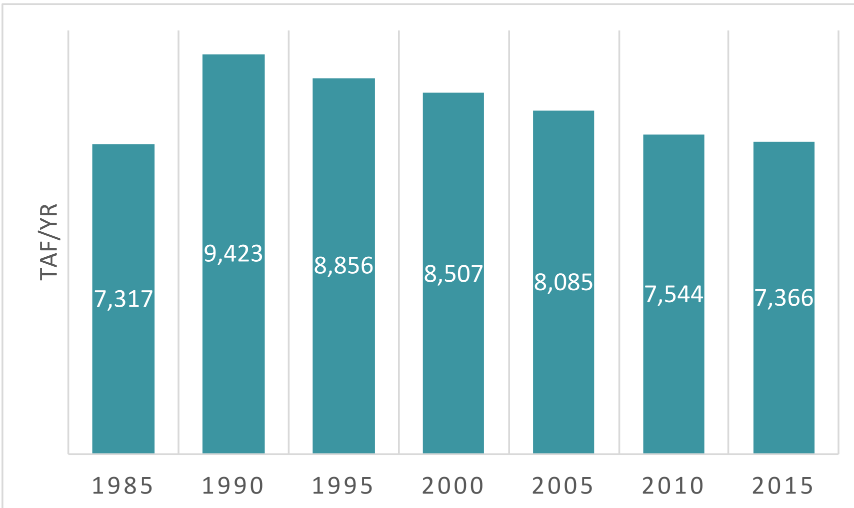
[6] BEA refers to these categories as "industries." This report used "sectors" for to align with other terminology used in the report.

The primary sector by GDP is the finance, insurance, real estate, rental and leasing category (19%). In contrast, the primary sector by employment was health care and social assistance (12%), followed by government and government enterprises (11%) and retail trade (10%).

2.1.4 Water Use

Annual water withdrawals in Oregon since 1985 have ranged from 7.3M to 9.4M acre-feet (AF), with total withdrawals trending downward since 1990 (Figure 12).

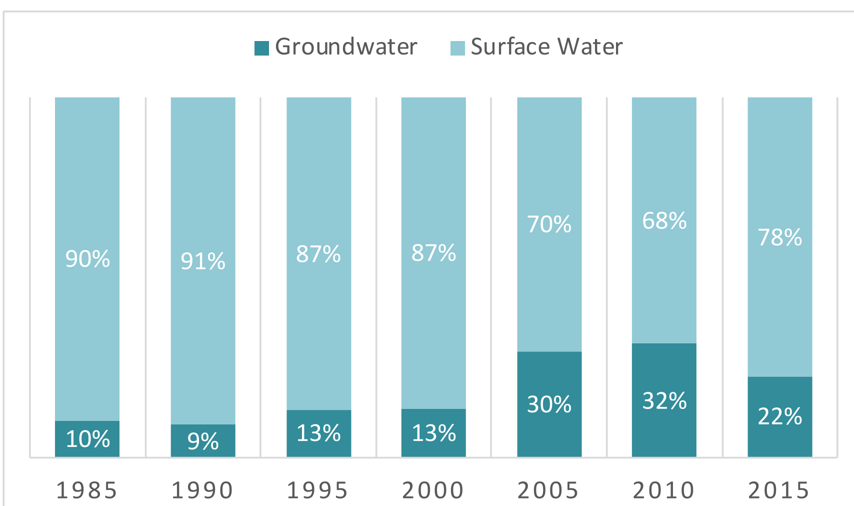
FIGURE 12. TOTAL WATER WITHDRAWALS ACROSS OREGON



Source: USGS (n.d.)

An important consideration is water source dependence (i.e., reliance on groundwater versus surface water versus another source) as each has different potential implications for ecosystem service function and sustainability. In Oregon, surface water has historically accounted for most withdrawals, however, groundwater withdrawals, as a proportion, have increased since 2000 (Figure 13).

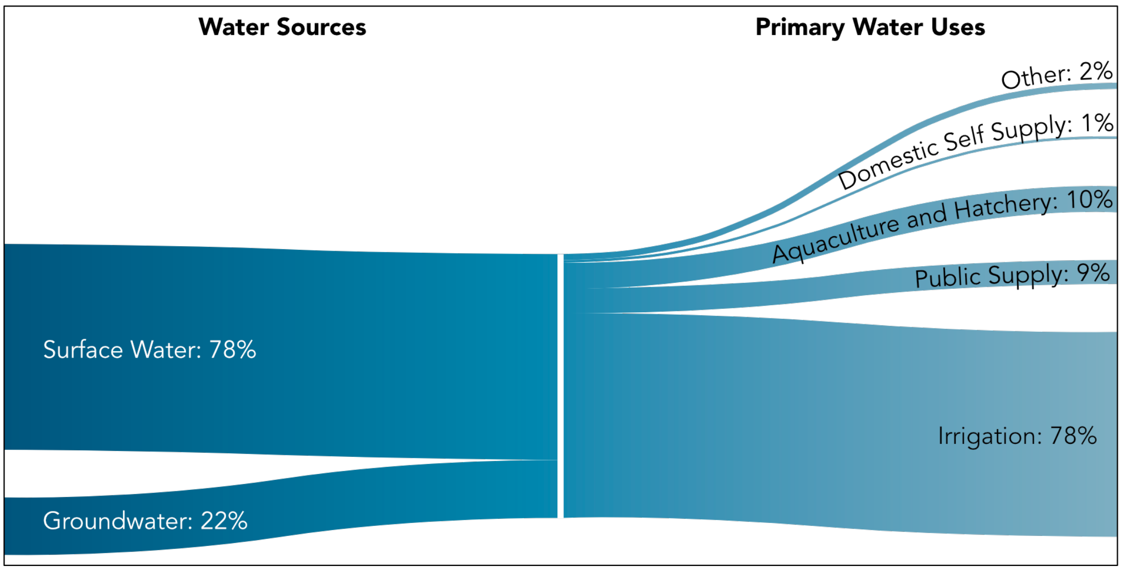
FIGURE 13. WATER WITHDRAWALS BY SOURCE ACROSS OREGON



Source: USGS (n.d.)

In years data were collected, withdrawals for irrigation represent, on average, approximately 80% of total withdrawals — with three-quarters of water withdrawn for irrigation coming from surface water sources. It is important to note that 1) the self-supply category (water users typically drawing from a private source such as a well or rainwater cistern) represents self-supply for domestic use only; and 2) aquaculture includes fish hatcheries (USGS 2023). Figure 14 below shows the source of withdrawals in Oregon on the left side and how the total withdrawn water is used on the right side.

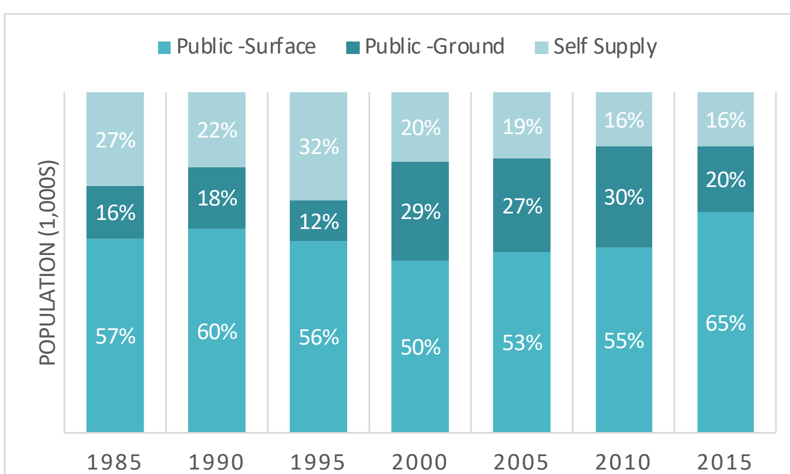
FIGURE 14. WATER WITHDRAWALS BY SOURCE AND USE ACROSS OREGON



Note: Public supply can represent water withdrawn for domestic, industrial, commercial and other uses.

In terms of domestic water use, most of the population has historically relied on public supply (Figure 15). The Oregon Public Health (OPH) Drinking Water Data Online site currently includes more than 2,500 active water providers in the state, of which only 244 are listed as supplying populations of 1,000 or more. Many water providers in the state are serving small populations. Domestic self-supply comes largely from private wells used to extract groundwater (~80%). (OPH n.d.)

FIGURE 15. POPULATION SERVED BY SOURCE ACROSS OREGON



Source: USGS (n.d.)

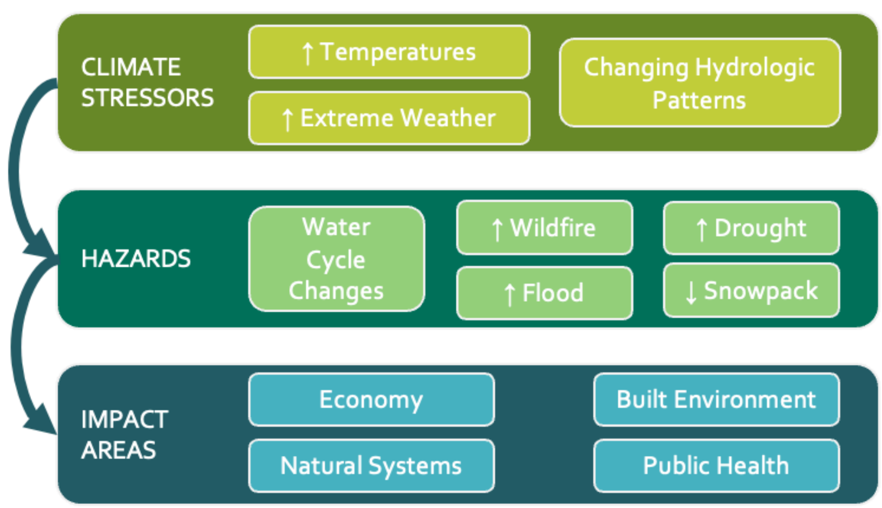
2.2 Climate Change and Oregon's Water Resources

Before discussing regional demographic and water use context, this section briefly discusses some specific potential impacts of climate change on Oregon's water resources. In addition to an observed upward trend in average annual temperature over the last century, the frequency and intensity of extreme heat events have also increased — and these trends are expected to continue at an accelerated rate. Since 1895, the state's average annual temperature increased each century by approximately 2.2°F and under current greenhouse gas emission levels is expected to increase an additional 5 °F by the 2050s. (Fleishman 2023)

Across the period of record, no statistically significant trends in precipitation have been observed — likely due in part to the fact that precipitation in Oregon is historically highly variable both seasonally and interannually. Furthermore, many climate models predict that by 2100, mean annual precipitation will increase in Oregon. At the same time, "the incidence, extent and severity of drought has increased throughout the western US, including the Pacific Northwest," highlighting changing patterns of precipitation even as total precipitation remains similar (Fleishman 2023). Indeed drought was declared for at least one, and often times many, counties in 15 of the last 20 years (OWRD 2023b). This trend is expected to continue, with precipitation events increasing in intensity while also becoming more seasonal — with more precipitation in the winter and less in the summer. Regardless of the season, the proportion of precipitation falling as rain as opposed to snow is expected to increase. This has implications for snowpack, with projections suggesting that snow water equivalent may decline by up to 25% by 2050 (relative to the 1950-2000 period) (Fleishman 2023).

In short, Oregon is expected to experience warming temperatures, declining snowpack, more frequent droughts and more intense precipitation events in the future, all of which pose threats to the environment, human populations, infrastructure and economies across the state (Figure 16).

Figure 16. Climate Stressors for Oregon Water Resources

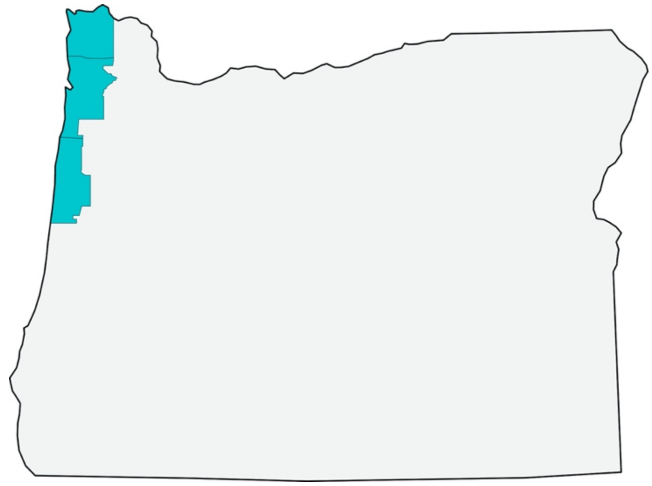


Climate change also has the potential to affect water resources indirectly both in terms of quantity and quality. Of particular concern in Oregon is wildfire, which may indirectly affect water resources in a variety of ways — damage to infrastructure or loss of reservoir storage capacity from sediment and debris; decreased water quality; increased risk of landslides and/or flooding and closure of recreational activities, among others.

The following sections provide socioeconomic, demographic and current water use profiles of the seven regions defined for this study. This section concludes after the region profiles with a brief discussion highlighting similarities and differences between the regions.

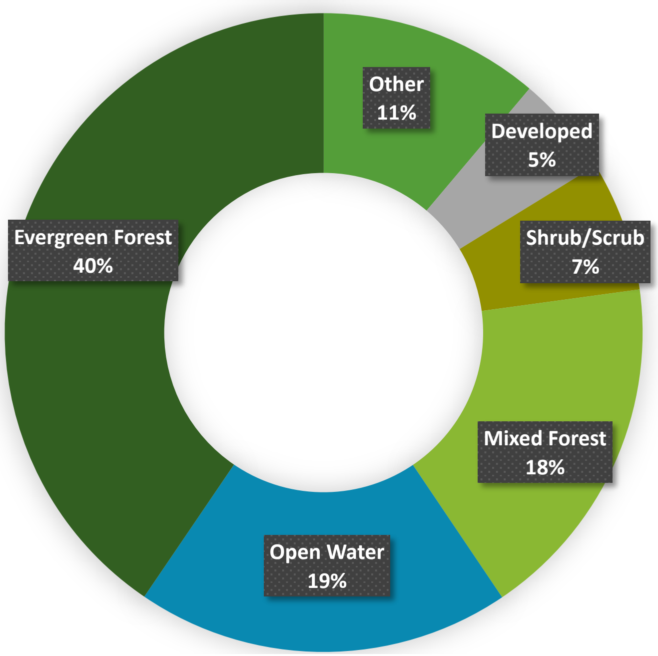
2.3 North Coast Regional Profile

The North Coast region (N Coast) is made up of Clatsop, Lincoln and Tillamook counties. Stretching from Cape Perpetua northward to the city of Astoria at the mouth of the Columbia River, this region is the wettest in Oregon. Numerous rivers and streams originate on the westside of the Coast Range, starting in densely forested mountains, then flowing either directly to the ocean or through coastal plains and bays on the way to the ocean. The region is dotted with numerous towns, with an economy historically based on fishing, forestry and tourism.



Land Cover and Land Ownership

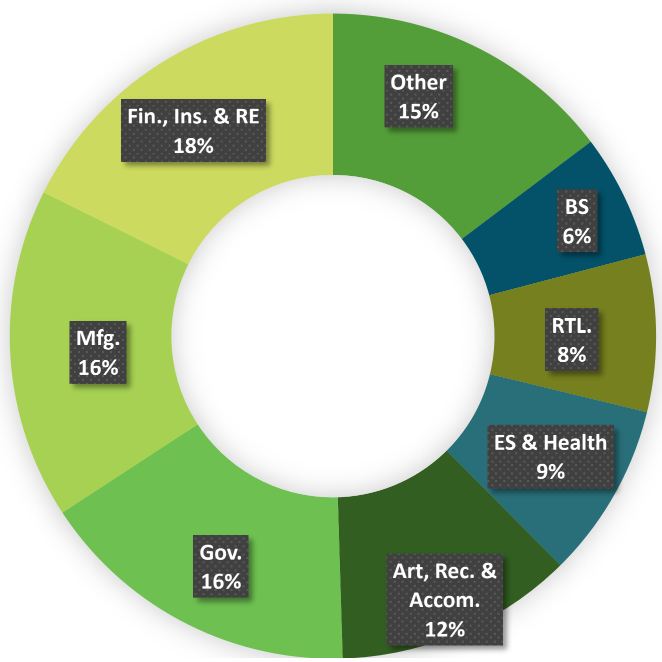
The region spans over 3,600 square miles along the coast in the north-western part of the state. Its land area is defined by its evergreen forests (41% of land cover), but the region also is heavily influenced by its coastline and bays. It is also the second most developed region in the state (5% of land area). (USGS 2021)



Just over half of the region is privately owned (55%) and another 26% is owned by the state. The remaineder is owned by the federal (18%) and local (1%) government. Proportionally, the North Coast has the lowest amount of federally owned land and the highest amount of State-owned land of the regions. It also is home to the Siletz Reservation of the Confederated Tribes of Siletz and a portion of the services area for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians — with 0.2% of land owned by the Bureau of Indian Affairs (BIA). (US DOI 2023; OR DHS 2023)

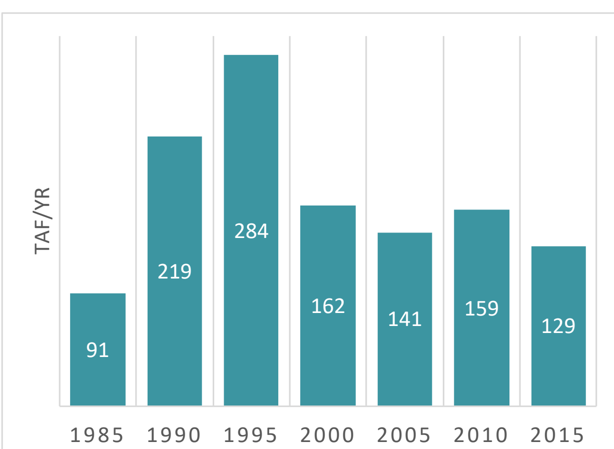
Population	MHI and Poverty Rate
• Approximately 119,000 inhabitants • 10% increase since 2010 • 33 inhabitants per sq. mile • Increasing racial diversity (82% white in 2020 compared to 90% in 2010)	• $60,657 – lower than state average • 14% poverty rate – 2% higher than state average

GDP and Employment

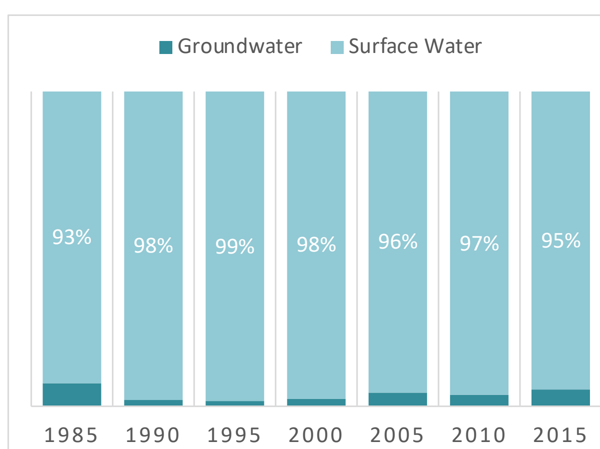


In 2021, the region's ***GDP was $5.8B*** with the finance, insurance, real estate, rental and leasing sector contributing the largest proportion (18%). The sectors that employ the largest percentage of the workforce generally relate to coastal tourism: accommodation and food services (16%); government and government enterprises (13%) and retail trade (13%).

Total Water Use

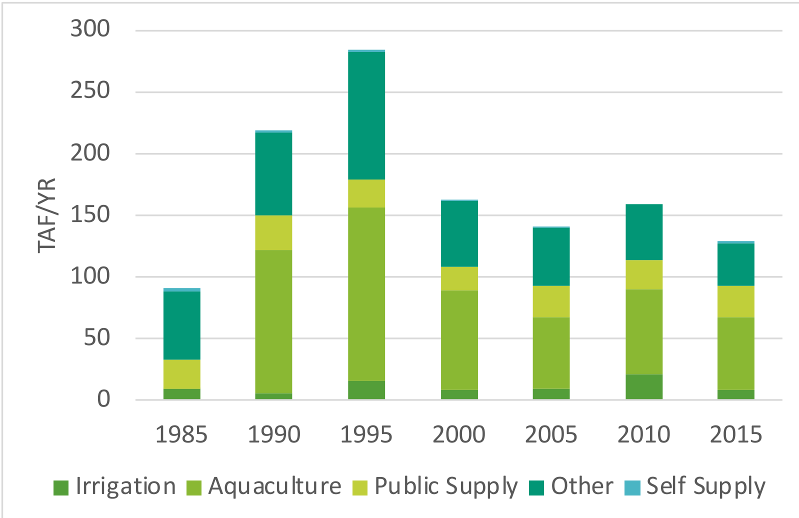


Proportion of Surface vs. Groundwater



The North Coast region's annual water use has been variable over the period of record, but, regardless of the year or volume, withdrawals are ***almost entirely supplied by surface water sources***.

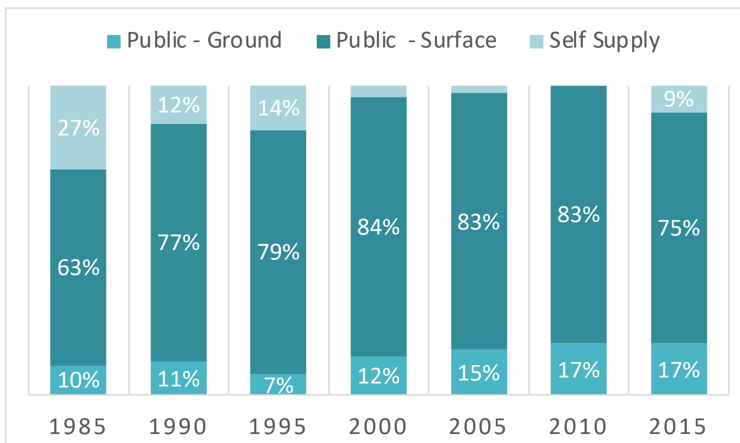
Water Withdrawals by Type of Use



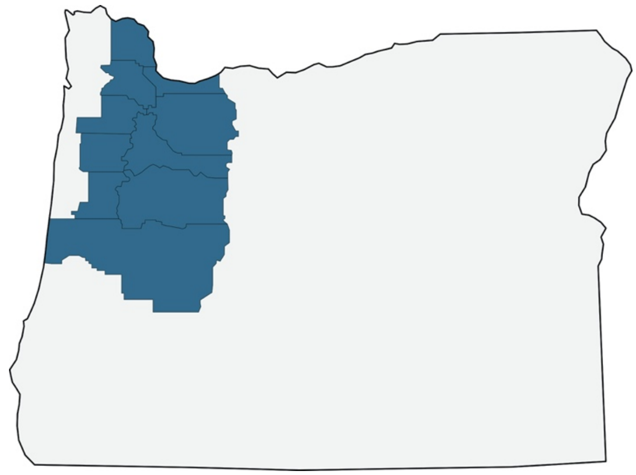
The North Coast is the ***only region where the primary water use is not agriculture***, which accounts for a relatively small proportion of total water use. Instead, water use is dominated by aquaculture (primarily fish hatcheries run by the state) and industry.

Public Water Supply by Source

Much of the population relies on public providers for domestic supply — mostly coming from surface water sources. At present, ***there are 29 active water providers serving populations of 1,000 or more***, with most being run by local governments. The cities of Lincoln, Astoria and Newport are the three largest providers in the region, all of which use surface water as their primary source (OPH n.d.).



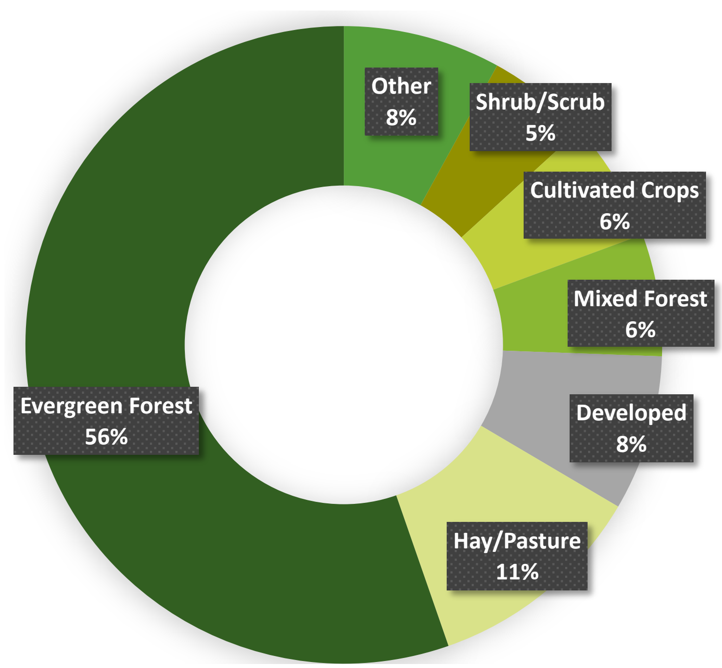
2.4 Willamette Valley/Lower Columbia Regional Profile



The Willamette Valley/Lower Columbia region (WV/L Col) is made up of Benton, Clackamas, Columbia, Lane, Linn, Marion, Multnomah, Polk, Washington and Yamhill counties. Bounded on the east by the Cascade Range and on the west by the Coast Range, the Willamette Valley is at the center of the region, a long, level alluvial plain some 120 miles long and 20-40 miles wide. The Willamette River is fed by numerous tributary systems originating in both mountain ranges and flowing through all counties in the region. The Willamette Valley contains nearly three quarters of Oregon's population and is the engine of Oregon's economy. Downstream of Portland, the Willamette flows into the lower Columbia River as it heads towards the Pacific Ocean. The lower Columbia is a major shipping channel, serving numerous ports, including the Port of Portland.

Land Cover and Land Ownership

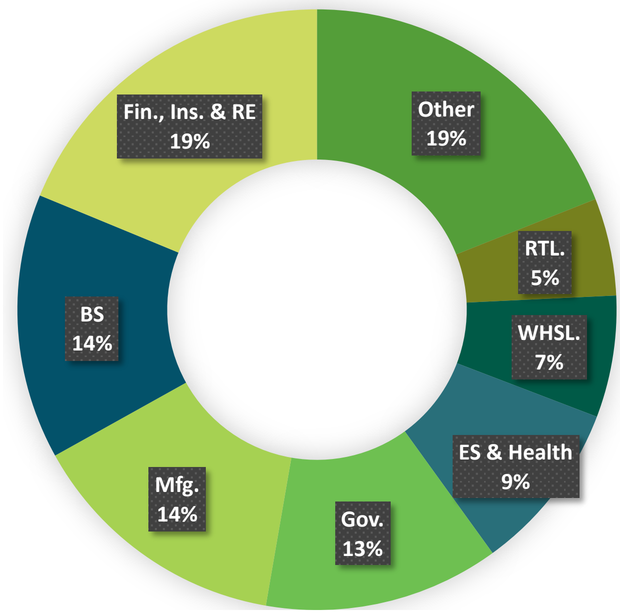
The region spans 14,126 square miles in the north-western part of the state. The region is defined by its evergreen forests (56% of land cover) and its water bodies, primarily the Columbia and Willamette Rivers. It also has the most land in hay/pasture (11%) of any region. With 8% of its land area developed, it is also the most urbanized region. (USGS 2021)



Land ownership in the Willamette Valley/Lower Columbia region is dominated by private land (58%) with 39% of land federally owned and only 2% owned by the State and 1% by local government. The BIA owns 0.4% of the region's land, which contains service areas and reservation lands for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians; Coquille Tribe; Federated Tribes of Grande Ronde Community of Oregon; and Confederated Tribes of Warm Springs. (US DOI 2023; OR DHS 2023)

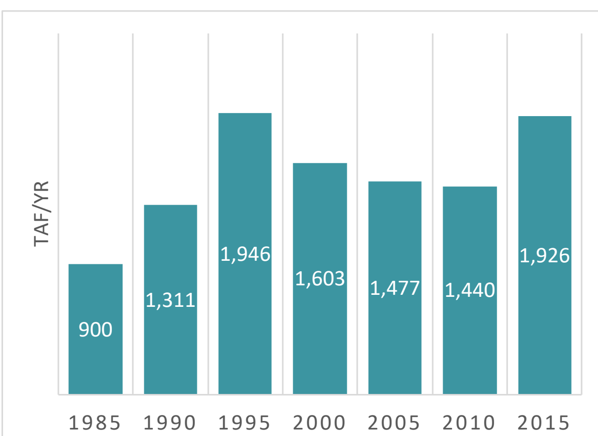
Population	MHI and Poverty Rate
- Most populous region – more than 3M inhabitants 11% increase since 2010 - Most densely populated region – 215 inhabitants per sq. mile - Increasing racial diversity (72% white in 2020 compared to 80% in 2010)	$80,176 – higher than state average 11% poverty rate – 1% lower than state average

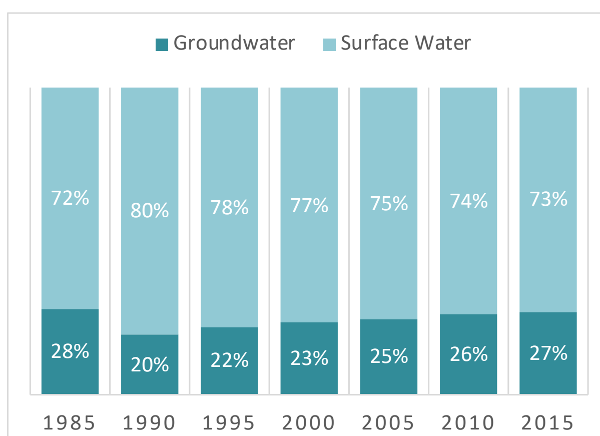
GDP and Employment



In 2021, the region's GDP was $211B, or 39% of the State's total GDP. The finance, insurance, real estate, rental and leasing sector was the largest contributor — accounting for 19% of GDP. The sector employing the largest percentage of the workforce was health care and social assistance (12%). Other sectors employing high percentages of the workforce included government and government enterprises (11%) and retail trade (9%).

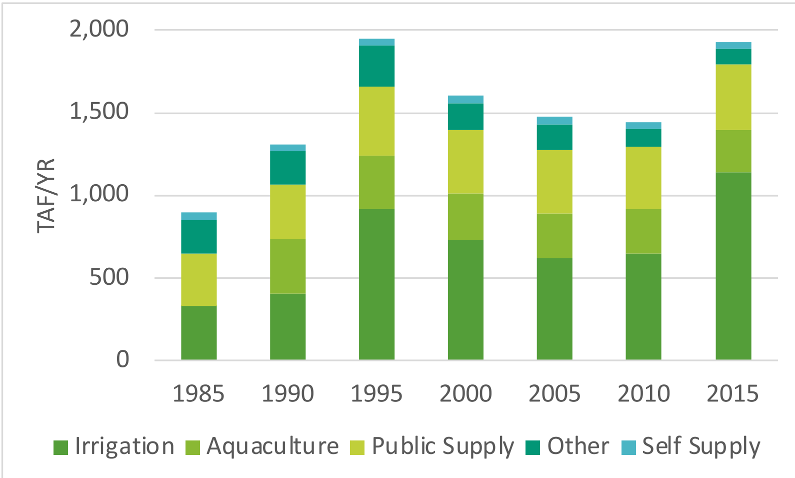
Total Water Use	Proportion of Surface vs. Groundwater





Most water withdrawals in the Willamette Valley/Lower Columbia region come from surface water sources and the proportion of groundwater versus surface water withdrawals has remained relatively consistent over the period of record.

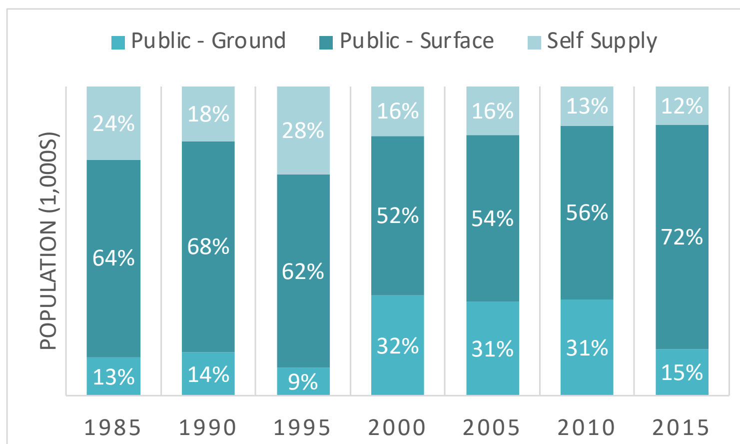
Water Withdrawals by Type of Use



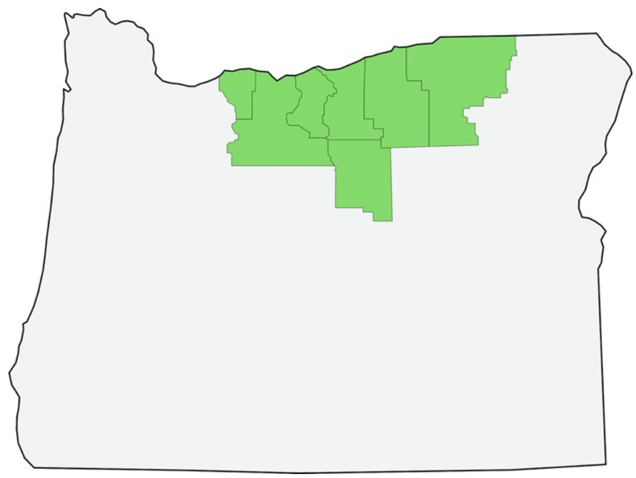
While irrigation is the largest water user in the region, approximately ***one-quarter of total withdrawals are used for public supply***. This is consistent with the Willamette Valley/Lower Columbia being the most populous region in the state.

Public Water Supply by Source

Most of the population relies on public providers for domestic supply — primarily drawn from surface water sources. Groundwater is the primary source for domestic self-supply (~90%). Many water providers are active in the region, with over 100 serving populations of 1,000 or more. The two largest providers are Portland Water Bureau and Joint Water Commission (Washington County), which together serve a population of ***more than one million***. Surface water is the primary source for both providers (OPH n.d.).



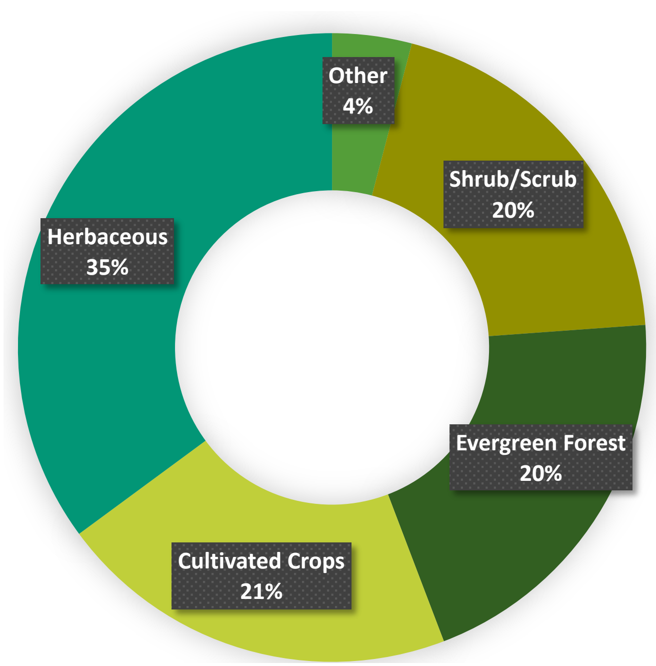
2.5 Columbia Plateau Regional Profile



The Columbia Plateau region (Col Plat) is made up of Gilliam, Hood River, Morrow, Sherman, Wasco and Wheeler counties. Extending from the eastern slopes of the Cascade Mountain to the Blue Mountains, the region contains the confluences of major eastside rivers like the Hood, Deschutes, John Day and Umatilla with the Columbia River. The region is made up almost entirely of lowlands containing deep soil, creating ideal conditions for agriculture in all the region's counties. The Columbia Plateau produces most of Oregon's grain and has the second-highest agricultural sales of any region in the state. Small and mid-size towns dot the region, including The Dalles, Hermiston and Pendleton.

Land Cover and Land Ownership

The region spans nearly 12,000 square miles in the north-central part of the state. Land cover in the Columbia Plateau region is more evenly distributed amongst classes than other regions with a mix of herbaceous land cover (35%,), cultivated crops (21%), evergreen forest (20%) and shrub/scrubland (20%). The region also has the ***highest proportional share of cultivated cropland of all the study regions***. (USGS 2021)



Land ownership in the Columbia Plateau region is dominated by private land (71%), the highest percentage of any of the study regions. Federal land makes up 28% of land with less than 2% State and local government lands. ***The BIA owns 7.3% of the region's land, the largest percentage of all the study regions.*** These lands include the Umatilla Reservation of the Confederated Tribes of the Umatilla Indian Reservation and the Warm Springs Reservation of the Confederated Tribes of Warm Springs. (US DOI 2023; OR DHS 2023)

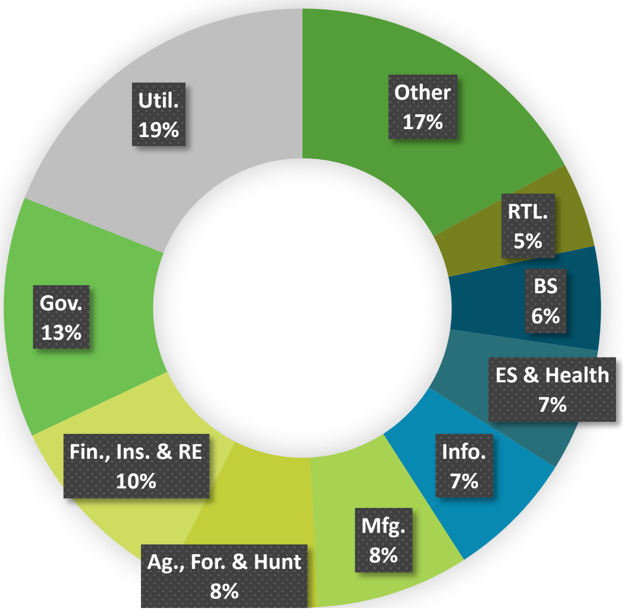
Population

- Approximately 148,000 inhabitants
- 10% increase since 2010
- 12 people per sq. mile
- ***Highest percentage (31%) of inhabitants identifying as non-white***

MHI and Poverty Rate

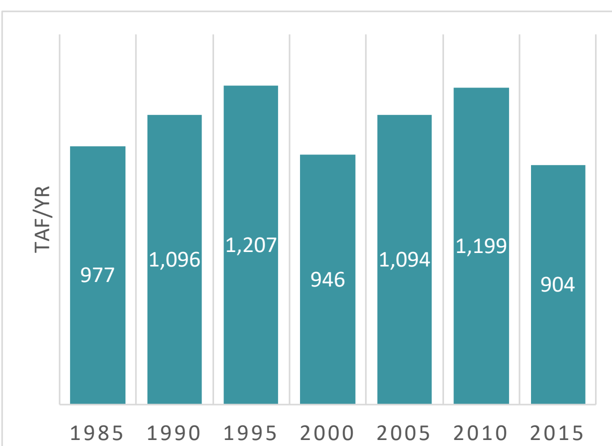
- $67,761 – lower than state average
- 13% poverty rate – 1% higher than state average

GDP and Employment

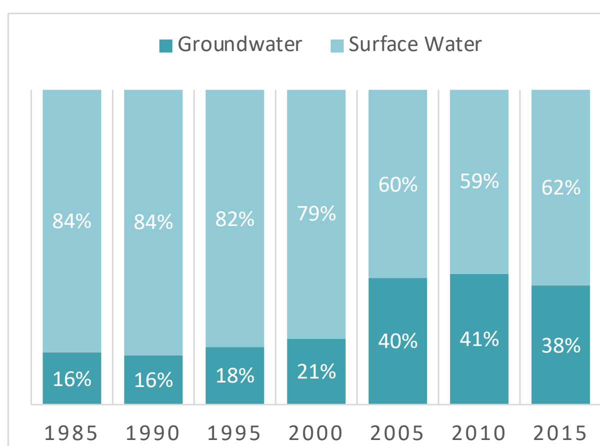


In 2021, the region's GDP was $9.9B and the largest sector was utilities (19% of GDP), which does not similarly contribute to other regions' GDP. Other large sectors include government and government enterprises (13%) and finance, insurance, real estate, rental and leasing (11%). The contribution to GDP from the agriculture, forestry, fishing and hunting is the second highest of the regions at 8%. Government and government enterprises employs the largest percentage of the workforce (14%). Farm employment (11%) and healthcare and social assistance (11%) also are large employers

Total Water Use

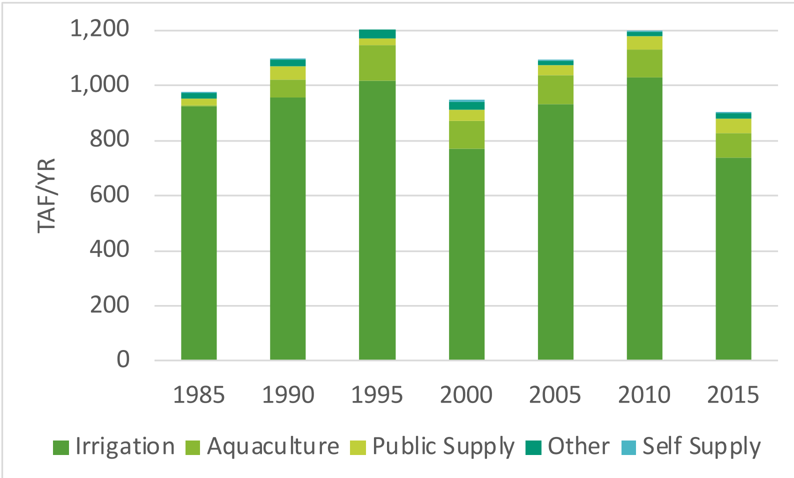


Proportion of Surface vs. Groundwater



Historically, more water withdrawals in the Columbia Plateau region come from surface water sources than from groundwater; however, ***groundwater use appears to have increased in recent years***.

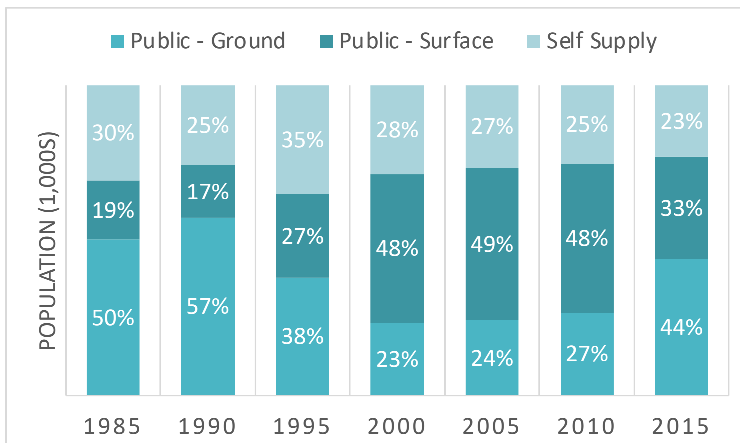
Water Withdrawals by Type of Use



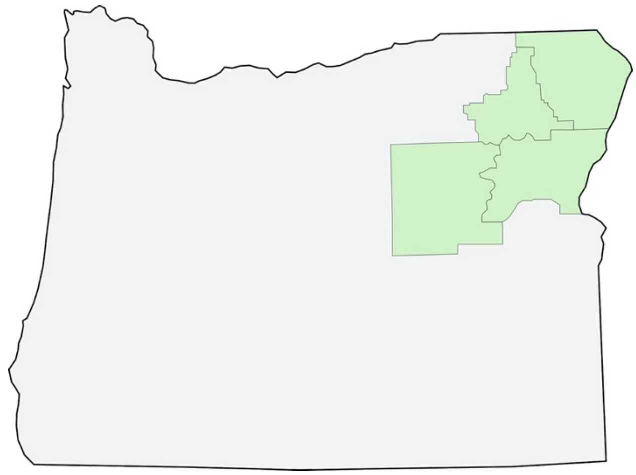
Water use in the region is ***dominated by irrigation*** — with withdrawals for irrigated agriculture accounting for over 80% of total annual withdrawals. The Irrigon fish hatchery is also one of the larger hatcheries in the state.

Public Water Supply by Source

The population relies primarily on public providers for domestic supply — which in turn rely on a mix of surface water and groundwater sources. Groundwater is the primary source for domestic self-supply although some surface water is also used. ***Nineteen water providers serve populations of 1,000 or more***. The three largest are managed by the cities of Hermiston, Pendleton and The Dalles. (OPH n.d.).



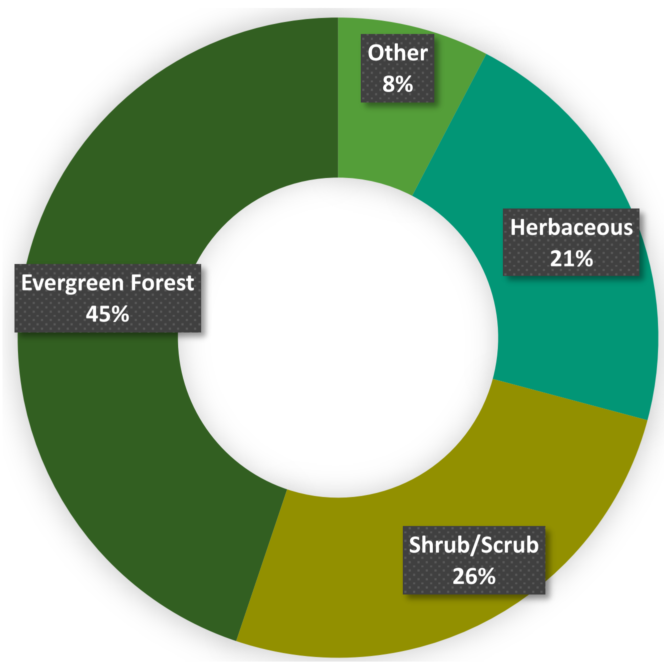
2.6 Blue Mountains/Northeast Regional Profile



The Blue Mountains/Northeast region (Blue Mt/NE) is made up of Baker, Grant, Union and Wallowa counties. The Blue and Wallowa Mountains are at the heart of the region, from which headwater stream reaches of the region's major rivers begin. The rivers flow out of the Blue Mountains in different directions, with the Burnt and Powder flowing eastward to the Snake River in Union County, the Grande Ronde (and its largest tributary the Wallowa) flowing in a northerly direction from Union and Wallowa counties to the Snake River and the John Day flowing westward out of Grant County before turning north to its confluence with the Columbia River. The middle reaches of the rivers flow through broad valleys containing agricultural lands and the region's major towns.

Land Cover and Land Ownership

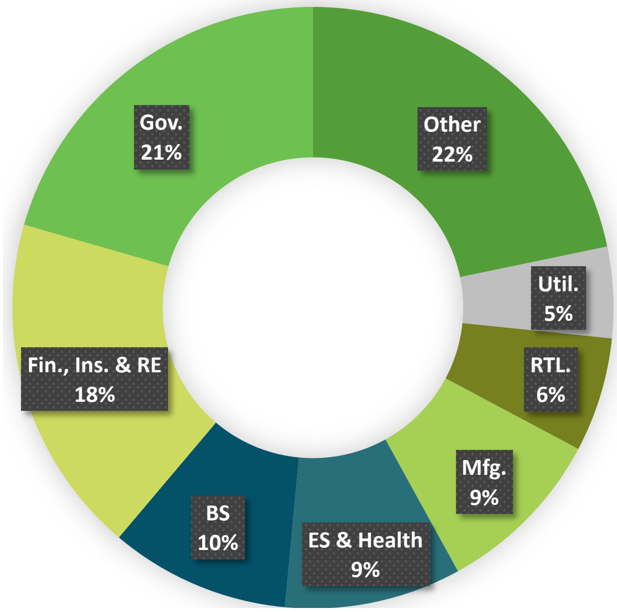
The region spans 12,779 square miles in the north-eastern part of the state and is defined by its evergreen forests (45% of land cover), scrub and shrub land (26%) and a lack of development — only 1% of land is developed. Relative to the state as a whole, the Blue Mountains/Northeast region has proportionally more evergreen forest and herbaceous wetland. (USGS 2021)



Land ownership in the Blue Mountains/Northeast region is split between federally owned land (56%) and privately owned land (43%) with less than 1% owned by state or local government. A portion of the Umatilla Reservation also is located in this region. (US DOI 2023; OR DHS 2023)

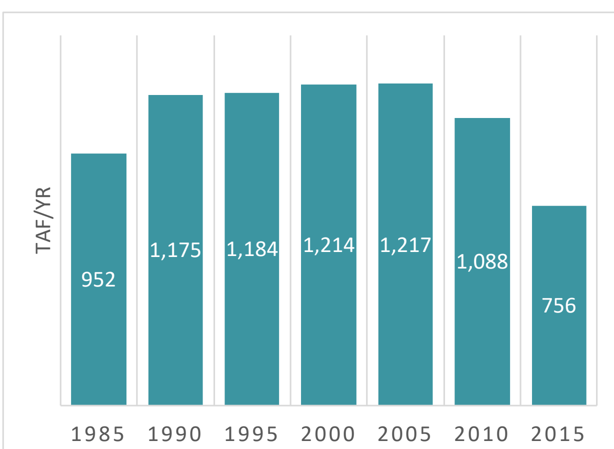
Population	MHI and Poverty Rate
• Approximately 57,500 inhabitants • 2% increase since 2010 • 4.49 people per sq. mile • Increasing racial diversity (88% white in 2020 compared to 94% in 2010)	• $58,819 – lower than state average • 16% poverty rate – 4% higher than state average

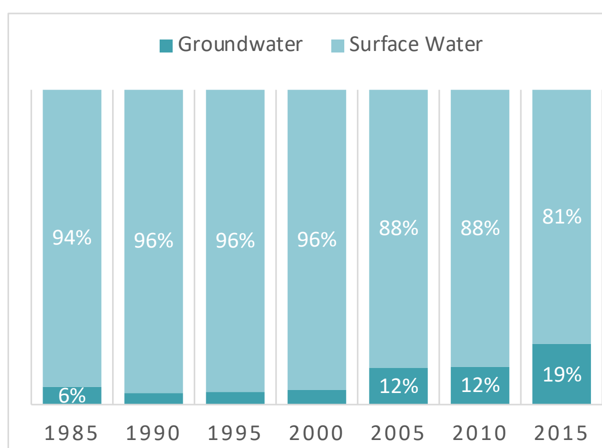
GDP and Employment



In 2021, the region's GDP was $2.5B and government and government enterprises was the largest contributing sector (21%). Mirroring contribution to GDP, government and government enterprises also employs the largest percentage of the workforce (16%), followed by retail trade (11%) and farm employment (10%).

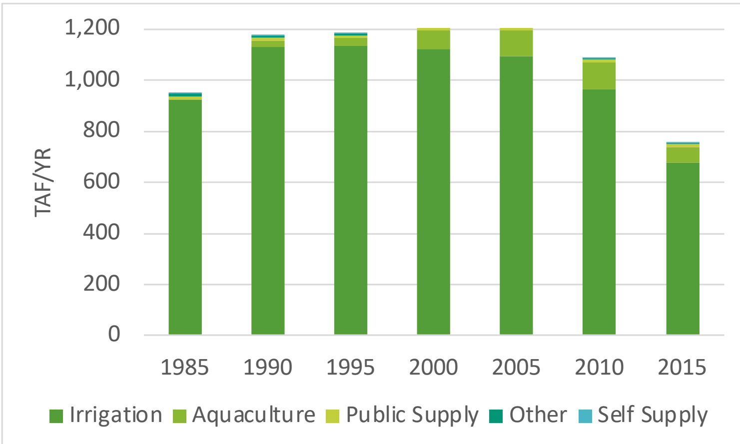
Total Water Use	Proportion of Surface vs. Groundwater





The majority of water withdrawals in the Blue Mountains/Northeast region comes from surface water sources. The increase in the use of groundwater in 2010 and 2015 are likely associated with the hydrologic conditions of those years, which resulted in decreased availability of surface water for irrigation.

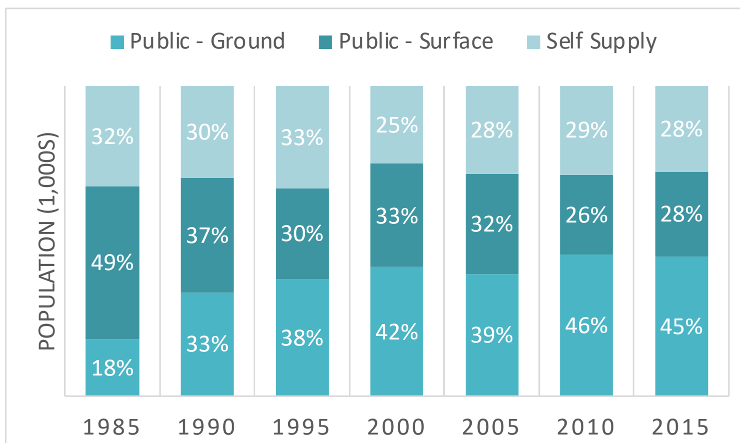
Water Withdrawals by Type of Use



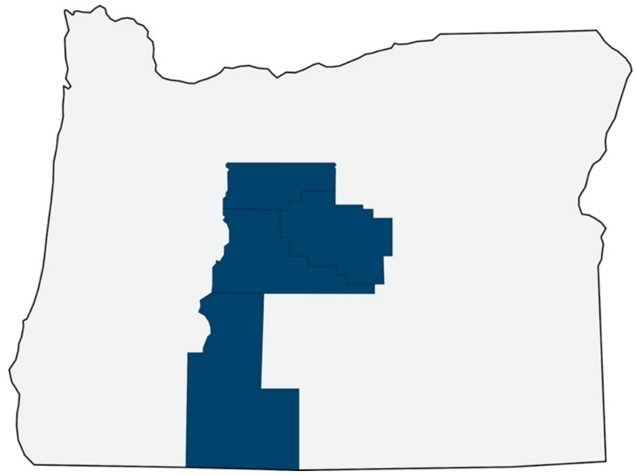
Water use in the region is dominated by irrigation — with ***withdrawals for agriculture accounting for, on average, 93% of total annual withdrawals***.

Public Water Supply by Source

The majority of the population relies on groundwater for domestic supply. One-third of the population self-supplies, which comes almost entirely from groundwater. In recent years, groundwater has accounted for almost half of total public supply. Only eight providers serve populations of more than 1,000 and the cities of La Grande, Baker City and Union are the largest providers in the region. Surface water is the primary source for Baker City, while the other two rely primarily on groundwater. (OPH n.d.)



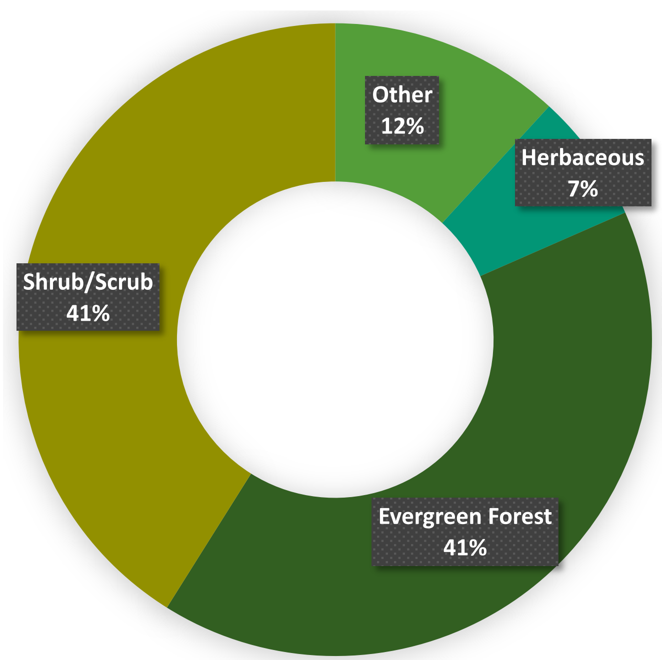
2.7 Central Regional Profile



The Central region (Central) is made up Crook, Deschutes, Jefferson and Klamath counties. Situated on the eastern slope of the Cascade Range, the region primarily consists of the Upper Deschutes and Klamath watersheds. Both basins are situated in Oregon's high desert, with a water supply primarily dependent on snowpack that accumulates in the Cascades on their western edge and groundwater that has been fed for eons by melting snow. This water supports irrigated agriculture, both groundwater and surface water-dependent ecosystems and some of the fastest growing communities in the state. Given the potential for one of the counties — Deschutes County — to exert influence over the demographic and socioeconomic statistics at the regional scale, some key statistics are presented for the region, consistent with other sections, while others are also discussed at the county-level.

Land Cover and Land Ownership

The region spans nearly 14,000 square miles and is defined by its shrub/scrubland (41%) and evergreen forests (41%) (USGS 2021). The "other" category is made up of developed land, hay/pastureland, cultivated crops, wetlands and a catchall "other" category.



Land in the Central region is split between federally owned land (59%) and privately owned land (38%) with less than 2% owned by state or local government. The BIA owns 2.9% of land, which makes up a portion of the Warm Springs Reservation of the Confederated Tribes of Warm Springs. Although there is no reservation, the Klamath Tribes are one of the nine federally recognized Tribes with ancestral land in and beyond this region. (US DOI 2023; OR DHS 2023)

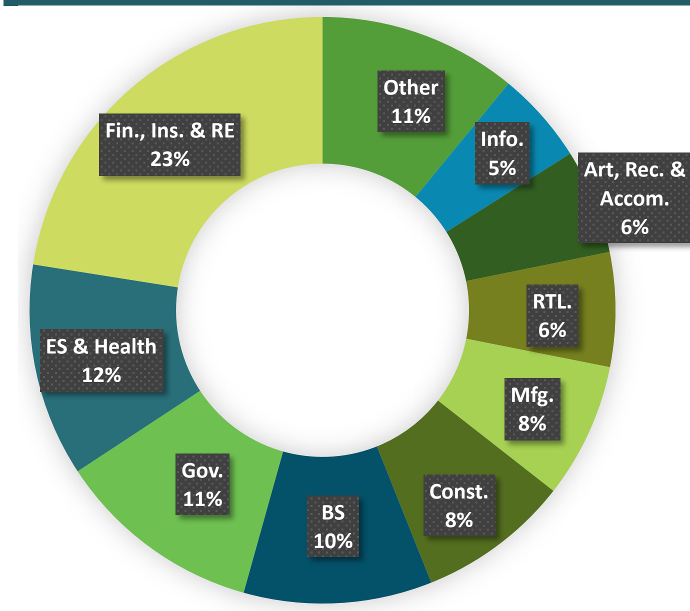
Population

- ***Approximately 317,000 inhabitants; fastest growing of all study regions***
- 19% increase since 2010
- 23 people per sq. mile
- Increasing racial diversity (82% white in 2020 compared to 88% in 2010)

MHI and Poverty Rate

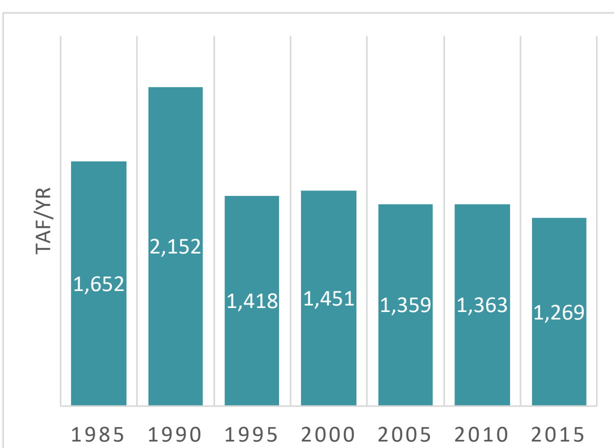
- $68,700 – lower than state average
- 12% poverty rate – in line with the state average

GDP and Employment

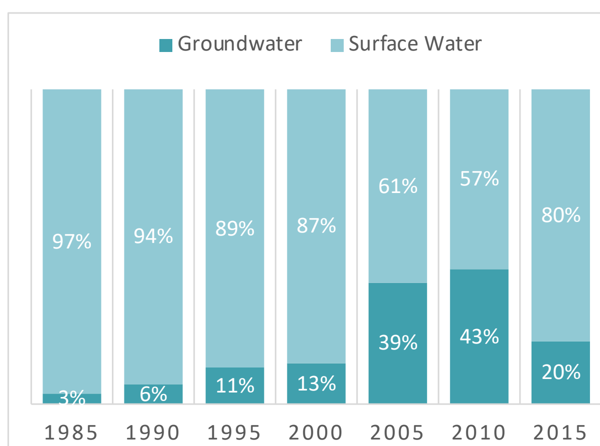


In 2021, the region's GDP was $17.6B with the finance, insurance, real estate, rental and leasing sector contributing 23% of total GDP. Other large sectors include educational services, health care and social assistance (12%) and construction (8%) — proportionally the highest contribution from this sector across all regions. Health care and social assistance employs the highest percentage (12%) of the workforce. Retail trade (11%) and government and government services (10%) also are large employers in the region.

Total Water Use

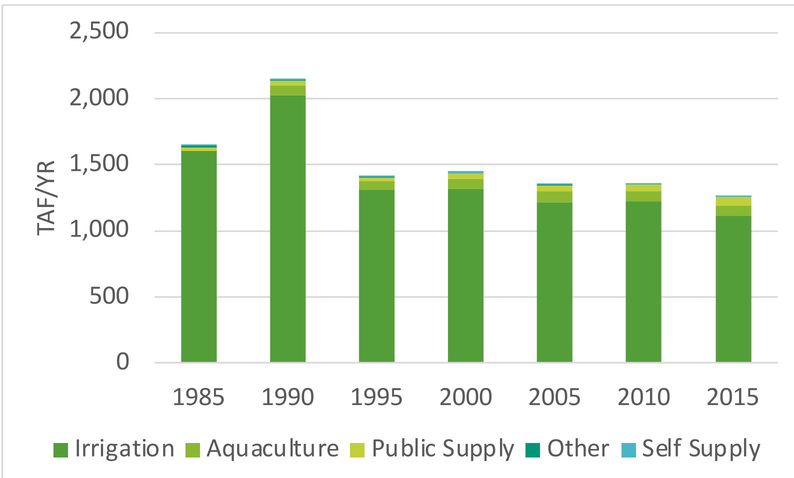


Proportion of Surface vs. Groundwater



Except for 1990, the Central region's ***annual water use has been relatively consistent*** over the period of record. Water demand for certain uses has increased in areas of the region — in the Deschutes Basin, which covers large portions of Deschutes and Crook counties and parts of Jefferson and Klamath counties — demand for groundwater mitigation credits, which can be a proxy measure for increasing water use, is projected to experience a 20 fold increase from the time period 2005-2014 compared to the time period 2016-2035 across all uses (irrigation, domestic, industrial, commercial, etc.) (Bureau of Reclamation and Oregon Water Resources Department 2019a) The Central region contains one of the counties — Deschutes County — projected to have one of the highest volumetric increases in municipal and industrial water demand by 2050 as a result of population increase, and two of the counties projected to have some of the highest percent increases in municipal and industrial water demand by 2050 — Deschutes (54%) and Jefferson (35%) (MWH 2015).

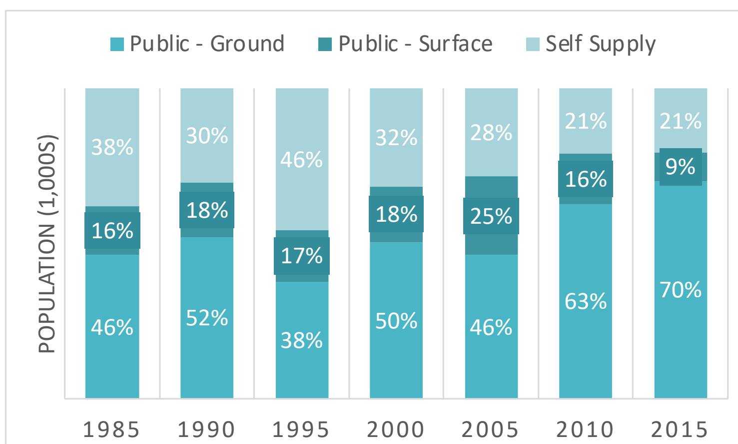
Water Withdrawals by Type of Use



Like much of the state, ***irrigated agriculture is the primary water user in the Central region*** — accounting for approximately 90% of total water use.

Public Water Supply by Source

Much of the population relies on public providers for domestic supply — mostly from groundwater sources. The primary source for domestic self-supply is also groundwater (~90%). There are 23 water providers serving populations of 1,000 or more in the region. The four largest providers are three local governments (i.e., Bend, Klamath Falls and Redmond) and Avion, a private entity (OPH n.d.).

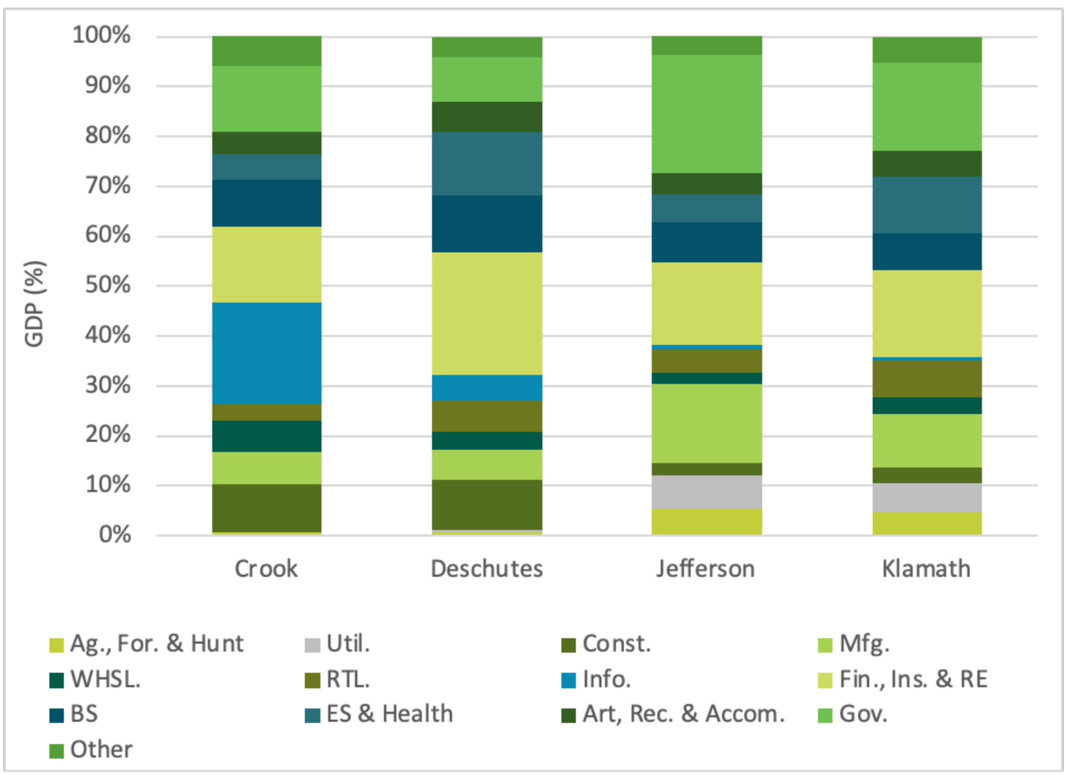


Because Deschutes County may be an outlier in this region, the statistics presented above at a regional level may provide a skewed profile of the region. Although the region is growing, the 19% population increase since 2010 is not consistent amongst counties, with an 18% increase in Crook County, 26%

Deschutes, 13% Jefferson and only 5% Klamath. The population density varies across the region, ranging from 8.3 people per square mile in Crook County to 64 people per square mile in Deschutes County.

Similarly, the MHI in the Central region is heavily influenced by Deschutes County, with MHI in Crook, Jefferson and Klamath ($65,755, $59,317 and $49,660, respectively) falling far below the state average and the MHI in Deschutes County ($79,648) falling above the state average. This variation is mirrored in the poverty rate across the counties with both Crook and Deschutes counties having lower poverty rates (12% and 9%, respectively) than Jefferson and Klamath counties (16% and 19%, respectively). Deschutes County also produces the largest share of the region's GDP ($12.6B of the total $17.6B), followed by Klamath County ($2.9B), Crook County ($1.1B) and Jefferson County ($0.9B). Agriculture, forestry, fishing and hunting makes up a larger share of GDP in Jefferson and Klamath counties (both 5%) than in either Crook or Deschutes counties (both 1%)Figure 17.

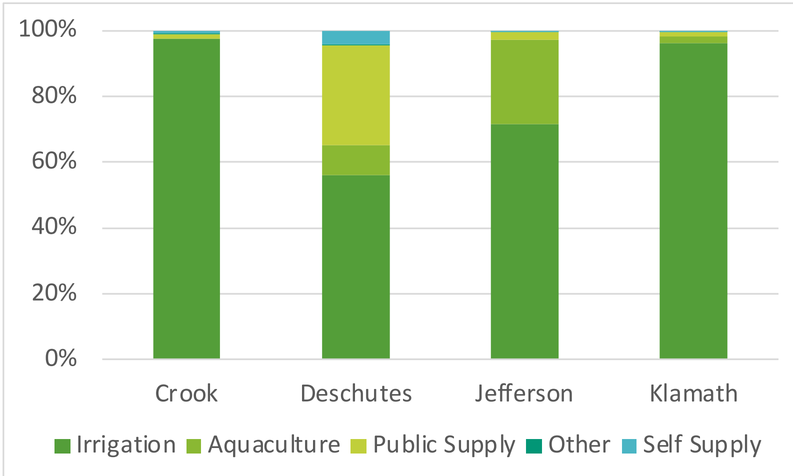
FIGURE 17: GDP BY SECTOR FOR CENTRAL REGION COUNTIES



Although most water across the counties is used for agriculture, Klamath County uses 60% of the total water used in the region with the other counties splitting the remainder relatively evenly. The influence of Deschutes County in the region, however, does skew the amount of water use by public supply and

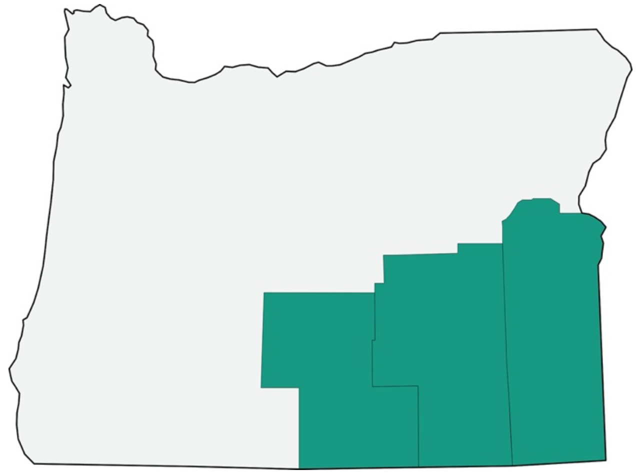
Jefferson County does the same for aquaculture, two uses that are marginal in the other counties (Figure 18).

FIGURE 18: WATER USE BY SECTOR IN CENTRAL REGION COUNTIES



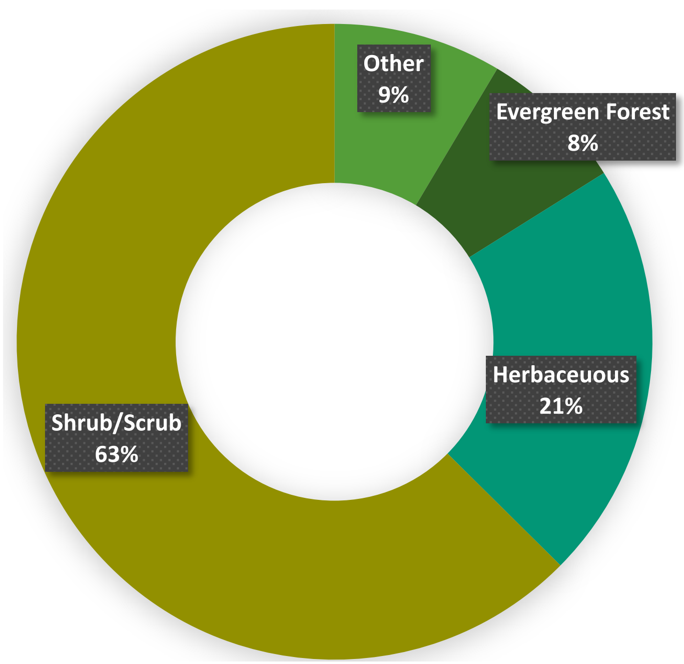
2.8 Southeast Regional Profile

The Southeast region (SE) is made up of Harney, Lake and Malheur counties. Located in the southeastern corner of Oregon, much of the region sits in the Great Basin where water flows to interior lakes and wetlands instead of to the ocean. The exceptions include the Malheur and Owhyee rivers, both of which flow to the Snake River. Home to the three geographically largest counties in the state, it is also the least populated region. The Southeast is defined by a dry, arid landscape with limited surface water sources. Irrigated agriculture draws from those sources as well as from groundwater in Harney County.



Land Cover and Land Ownership

The region spans over 28,500 square miles in the southwest part of the state. The land cover of the Southeast region is distinct from the other study regions. It is dominated by shrub/scrubland (63%)and proportionally, evergreen forest (8%) and developed land cover (<1%) are the lowest of all the regions. (USGS 2021)



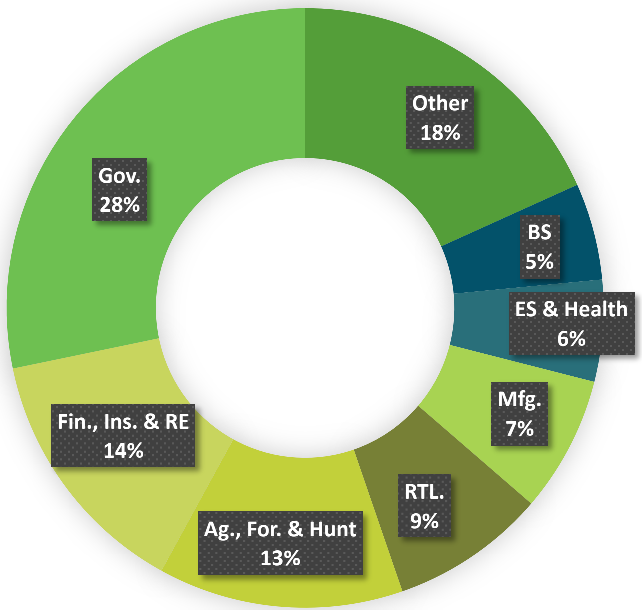
Land in the Southeast region is predominately federally owned (73%), with 23% of land privately owned and 3% owned by the State. The BIA owns 0.1% of land on which the Burns Paiute Indian Colony of the Burns Paiute Tribe and a portion of the Fort McDermitt Reservation of the Fort McDermitt Paiute and Shoshone Tribes are located. (US DOI 2023; OR DHS 2023)

Population	MHI and Poverty Rate

- ***Approximately 47,000 inhabitants; least populous study region***
- 1% increase since 2010
- Less than two people per sq. mile
- Increasing racial diversity (74% white in 2020 compared to 82% in 2010)

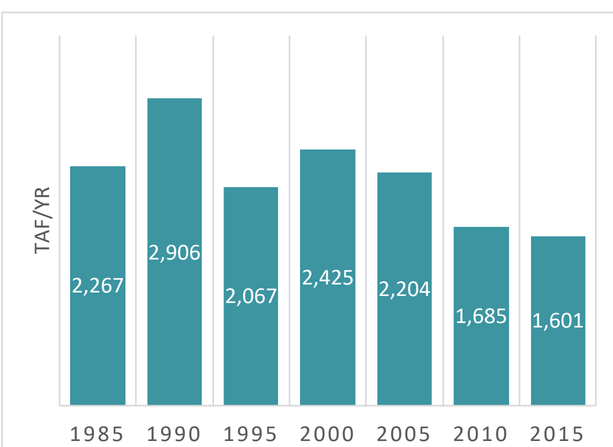
- $55,307 – lower than state average and the lowest of any region
- 19% poverty rate – 7% higher than the state average and the highest for any region

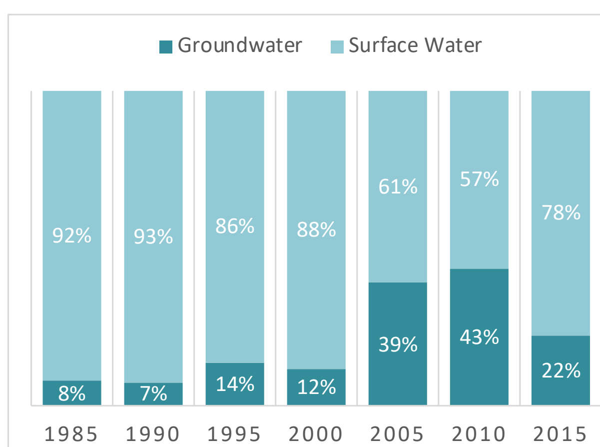
GDP and Employment



In 2021, the region's GDP was $2.1B, the smallest of the study regions. The largest contributing sector was government and government enterprises (28%). The proportional contribution by agriculture, forestry, fishing and hunting was higher (13%) than in any of the other study regions. Government and government enterprises is the sector that employs the highest percentage (21%) of the workforce. Proportionally, farm employment is higher than in any other region (14%).

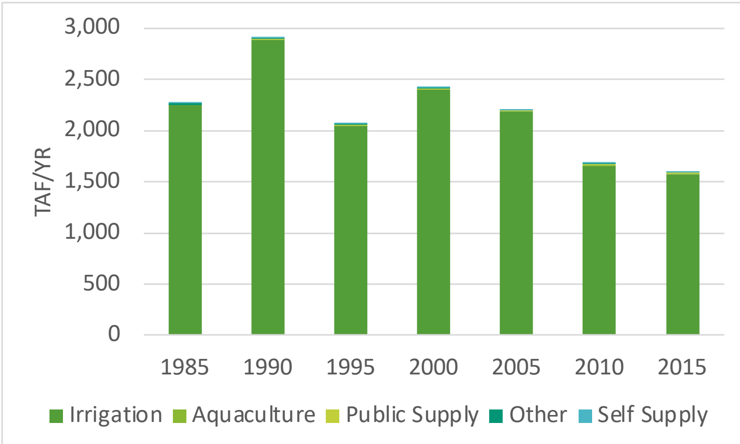
Total Water Use	Proportion of Surface vs. Groundwater





The majority of water withdrawals in the Southeast region come from surface water sources, although ***use of groundwater has increased in recent years***.

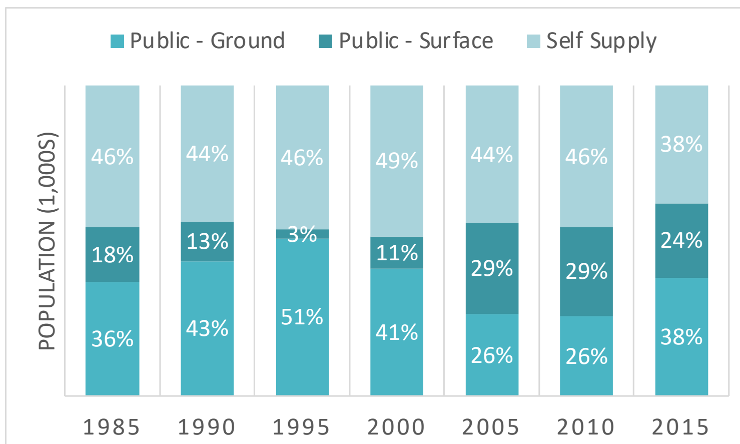
Water Withdrawals by Type of Use



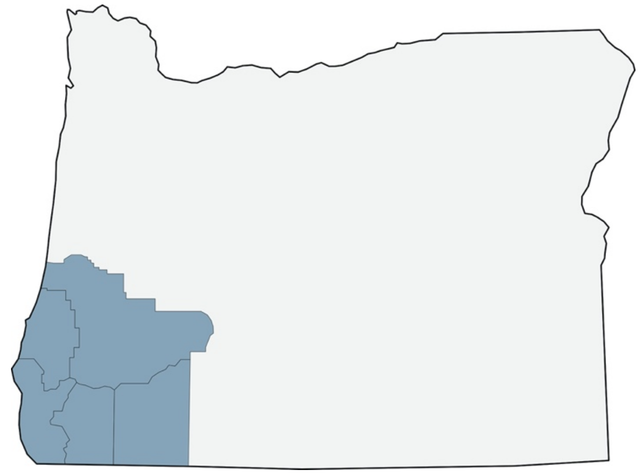
Irrigated agriculture is the dominant water user in the region — accounting for over 98% of total water use in most years.

Public Water Supply by Source

Unlike most of the other regions, almost half of the population relies on self-supplied water for domestic purposes — most, if not all, of which comes from groundwater. Public water supply is also highly dependent on groundwater. Only six water providers in the region serve a population of more than 1,000. The City of Ontario is the largest provider — serving just under 15,000 residents. (OPH n.d.).



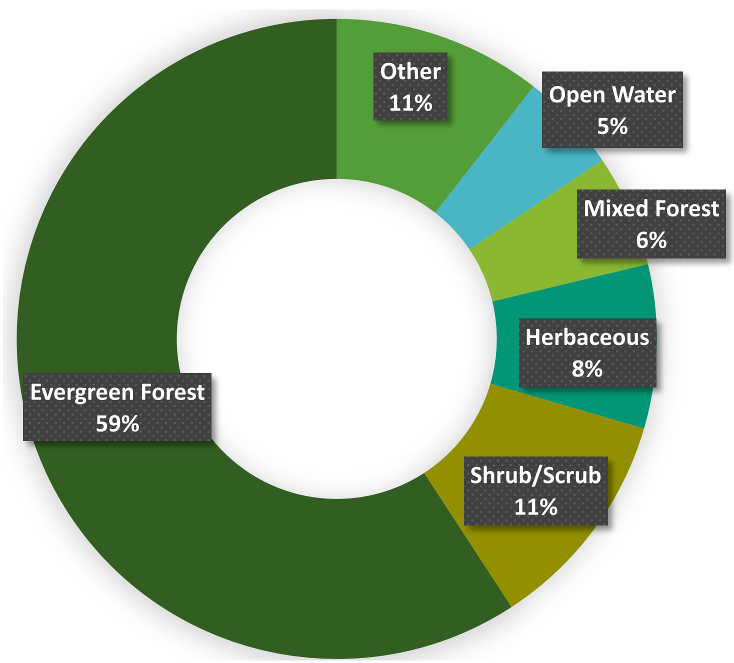
2.9 Southwest Regional Profile



The Southwest region (SW) is made up Coos, Curry, Douglas, Jackson and Josephine counties. Situated south of the Willamette Valley, the region is home to two major watersheds, the Rogue and Umpqua, that flow from the Cascade Mountains to the ocean. Both watersheds are fed by substantial snowpack that accumulates in the Cascades, then flows downstream through valleys containing the region's largest communities of Roseburg, Grants Pass and Medford. From there, the rivers and their tributaries carve a path through the Coast Range before flowing into the Pacific Ocean. Numerous other small watersheds flow from the west side of the Coast Range to the ocean in Coos and Curry counties.

Land Cover and Land Ownership

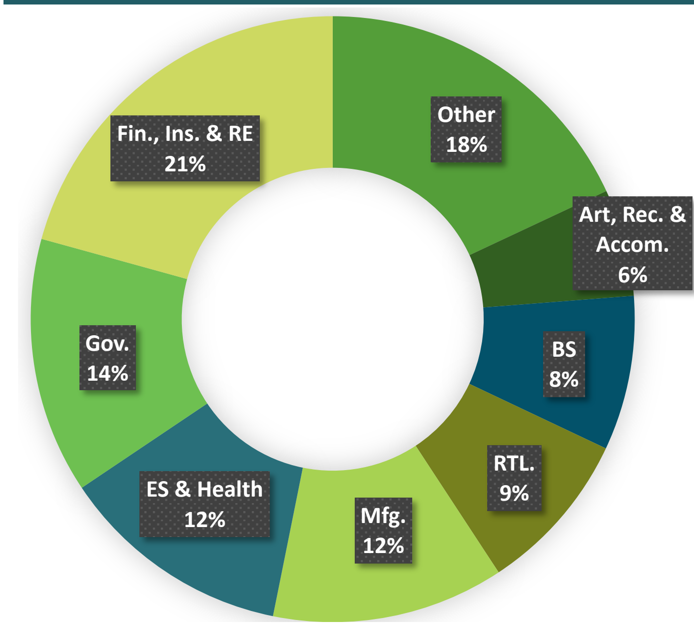
The region spans over 13,000 square miles in the southwest part of the state. The land cover in the Southwest region is dominated by evergreen forest with the ***greatest percentage land cover by evergreen forest*** of all of the study regions (59%). (USGS 2021)



Land in the Southwest region is split between federally owned land (52%) and privately owned (46%) with less than 2% owned by state or local government. The BIA owns 0.4% of land on which is the Coquille Reservation of the Coquille Tribeis found. The region also contains a portion of the service area for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians and the Cow Creek Band of Umpqua Indians ancestral lands. (US DOI 2023; OR DHS 2023)

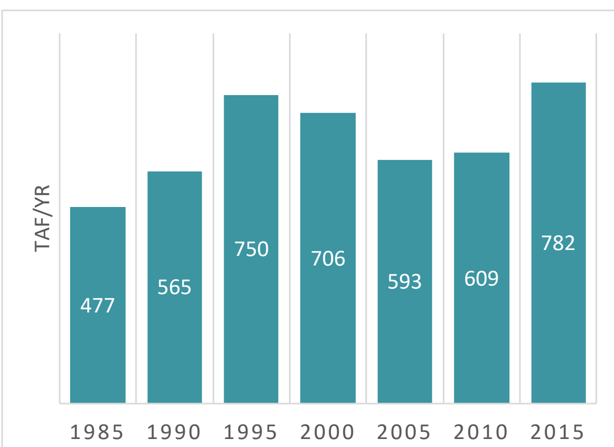
Population	MHI and Poverty Rate
• Approximately 500,000 inhabitants • 7% increase since 2010 • 38 people per sq. mile • Increasing racial diversity (83% white in 2020 compared to 90% in 2010)	• $58,732 – lower than state average • 15% poverty rate – 3% higher than the state average

DP and Employment

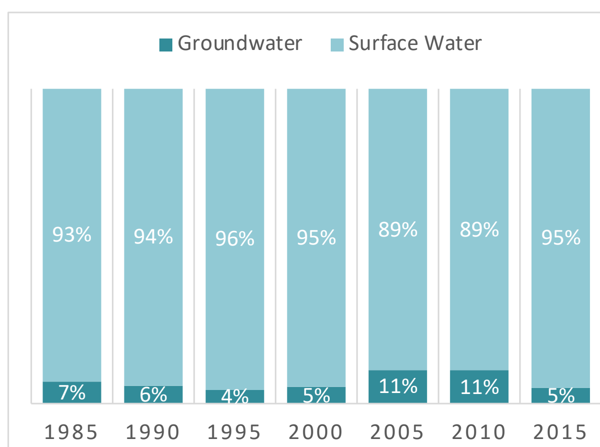


In 2021, the region's GDP was $23B, the second largest of the study regions. Finance, insurance, real estate, rental and leasing was the largest sector — contributing 19% of GDP. Other large sectors included government and government enterprises (14%), educational services, health care and social assistance (12%) and manufacturing (12%). Health care and social assistance employs the highest percentage (14%) of the workforce. Retail trade (13%) and government and government enterprises (11%) also are large employers.

Total Water Use

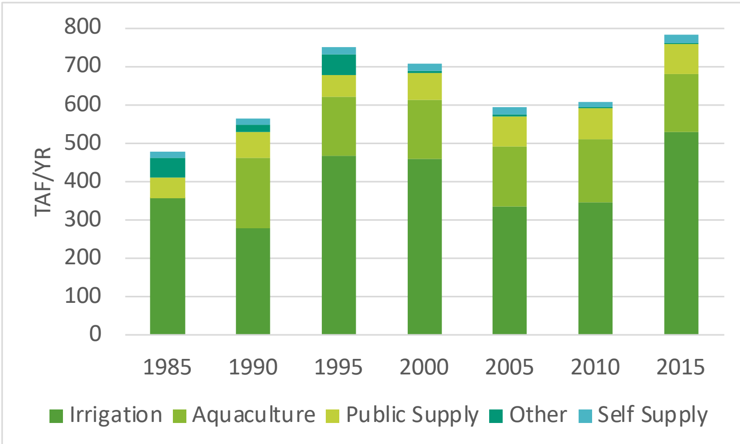


Proportion of Surface vs. Groundwater



Substantially more water withdrawals in the Southwest region come from surface water sources than groundwater and the proportion of groundwater versus surface water withdrawals has remained relatively consistent over the period of record.

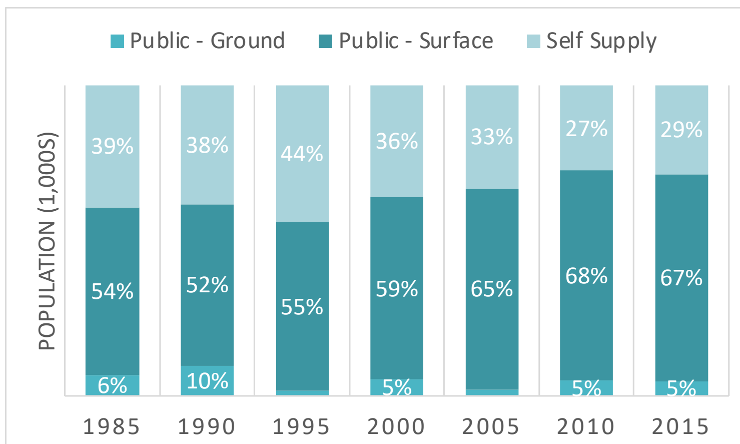
Water Withdrawals by Type of Use



While ***irrigated agriculture is the largest water user in the region***, approximately one-quarter of water is used for aquaculture. The Cole Rivers facility is one of the largest in the state.

Public Water Supply by Source

The majority of the population relies on public providers for domestic supply — mostly from surface water sources. Groundwater is the primary source for domestic self-supply. Forty water providers serve populations of 1,000 or more, most of which are run by local governments. The largest provider is Medford Water Commission, which serves a population of just over 30,000 and relies on surface water as its primary source (OPH n.d.).



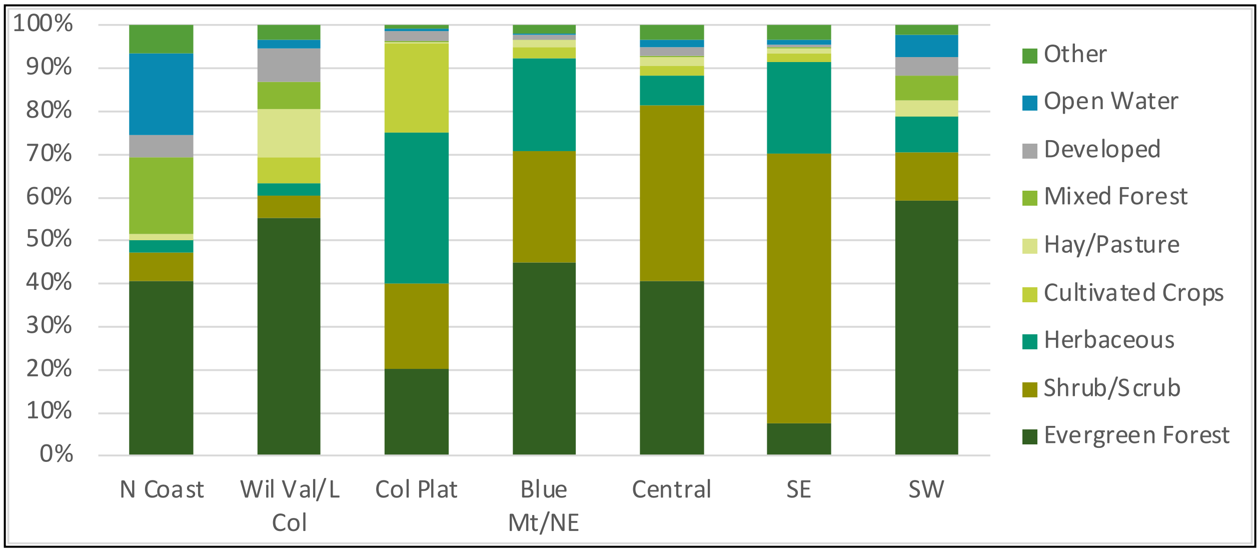
2.10 Regional Comparison

The study regions exhibit differences across their physical and socioeconomic characteristics, as well as the way in which they utilize water resources, which informs how investments in water assets and subsequent economic impacts may differ across the regions.

Land cover by region provides context for the natural systems that depend on water as well as provide insight into the human demands on water resources. Some land cover classes, like hay/pasture and cultivated crops imply high water use levels while others like shrub/scrub imply low water use and likely represent un-irrigated land. Except for the Southeast region, the land cover in each region is dominated by evergreen forest (Figure 19). Shrub/scrubland, dominates in the Southeast region and is present in all other regions.

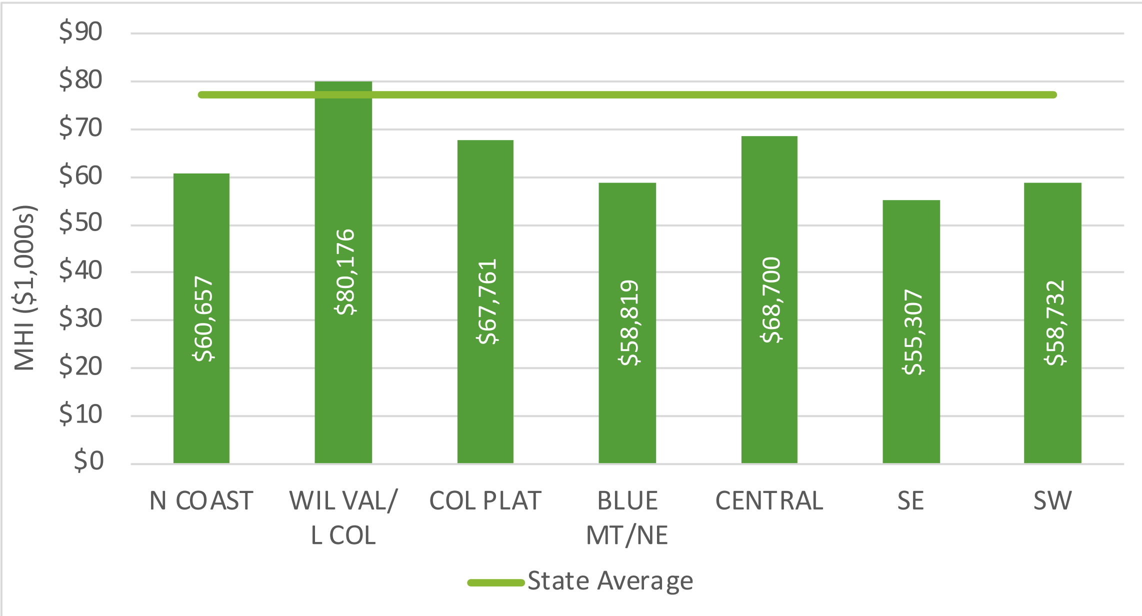
For inland regions, open water is descriptive of lakes, rivers and other freshwater features, whereas, for coastal regions, open water primarily describes territorial offshore water. Land in agriculture (i.e., cultivated crops and hay/pasture land) differs substantially across the regions — representing 21% of Columbia Plateau land cover to only 1% of land cover in the North Coast. The footprint of developed land across the state is conspicuously small, with the greatest developed land in the Willamette Valley/Lower Columbia region (8%).

FIGURE 19. LAND COVER ACROSS ALL STUDY REGIONS



Demographic information, such as population and population density, can be proxies for human demands on water resources. MHI has, in some studies of residential water demand, also been found to correlate positively with water use (Mini, Hogueand Pincetl 2014; Gonzales and Ajami 2017; Willamette Water 2100 n.d.). The Willamette Valley/Lower Columbia region has the highest population and population density of the study regions, while the Southeast region has the lowest. Population in the study regions tracks closely with total regional GDP, with the highest GDP ($211M) in the Willamette Valley/Lower Columbia region, followed by the study regions in order of decreasing population — Southwest, Central, Columbia Plateau, North Coast, Blue Mountains/Northeast and the Southeast region. MHI is highest in the Willamette Valley/Lower Columbia region and lowest in the Southeast region (Figure 20).

FIGURE 20. MHI ACROSS ALL STUDY REGIONS



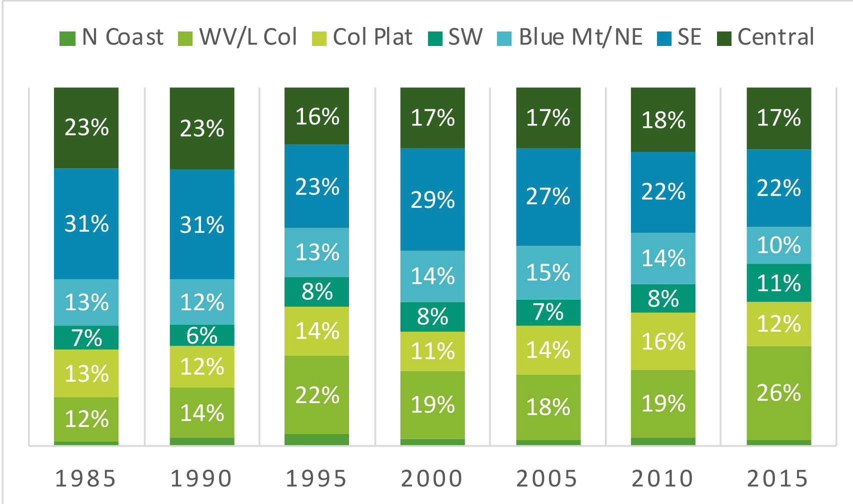
Similarly, the proportional contribution of economic sectors can also inform human demands for water as well as how water-related investments may produce economic impacts. Variation in GDP contribution by sector was limited across the seven study regions with the finance, insurance, real estate, rental and leasing; government and government enterprises and manufacturing sectors consistently contributing large shares of regional GDP.

Some notable variations include:

- educational services, health care and social assistance in the Central and Southwest regions (12%);
- utilities sector in the Columbia Plateau (19%);
- arts, entertainment, recreation, accommodation and food services in the North Coast (12%); and
- agriculture, forestry, fishing and hunting in the Columbia Plateau (8%) and Southeast (13%) regions.

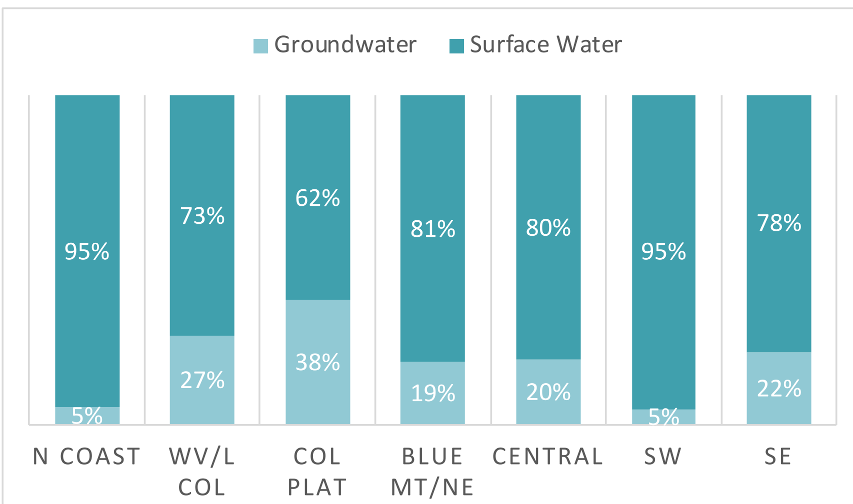
Water use in the study regions varies substantially — not only by total volume used, but also by source and use type. In terms of total water use by region, the Southeast region has historically been the largest water user — accounting, on average, for approximately one-quarter of total use annually (Figure 21). This is at least partially attributable to Southeast region being the largest region by land area. In contrast, water use in the North Coast region represents only 2% of statewide total annual water use. Proportional water use by region has remained relatively constant over the period of record, although there does appear to be a somewhat downward trend in the proportion used by the Southeast region and possibly an upward trend in the Columbia Plateau region.

FIGURE 21. WATER USE BY REGION



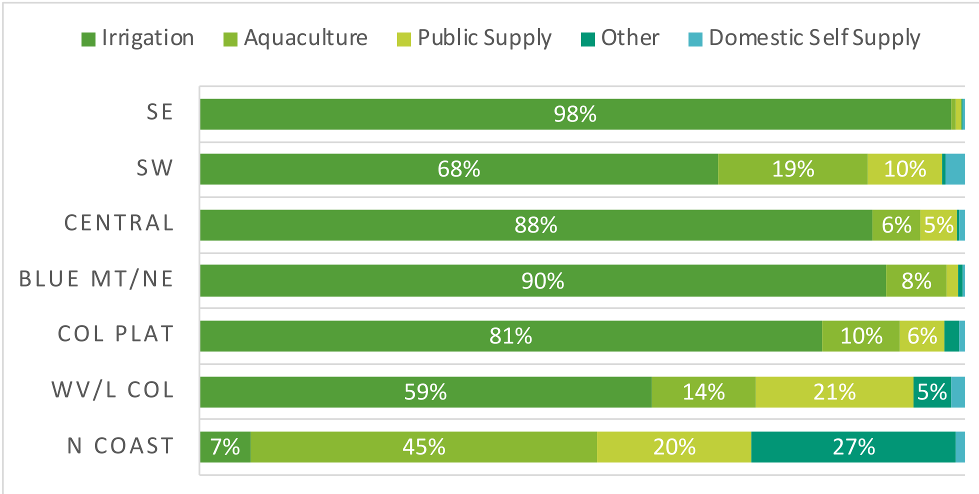
While surface water is the primary source in all regions, there are still notable differences in the proportion of surface water versus groundwater used across the regions. The Columbia Plateau region relies on groundwater to the greatest degree overall, while the North Coast and Southwest regions almost exclusively use surface water sources (Figure 22). From the perspective of public water supply however, the Central region is most dependent on publically-supplied groundwater while the Southwest region is least dependent (Figure 24).

FIGURE 22. WATER USE BY SOURCE (2015)



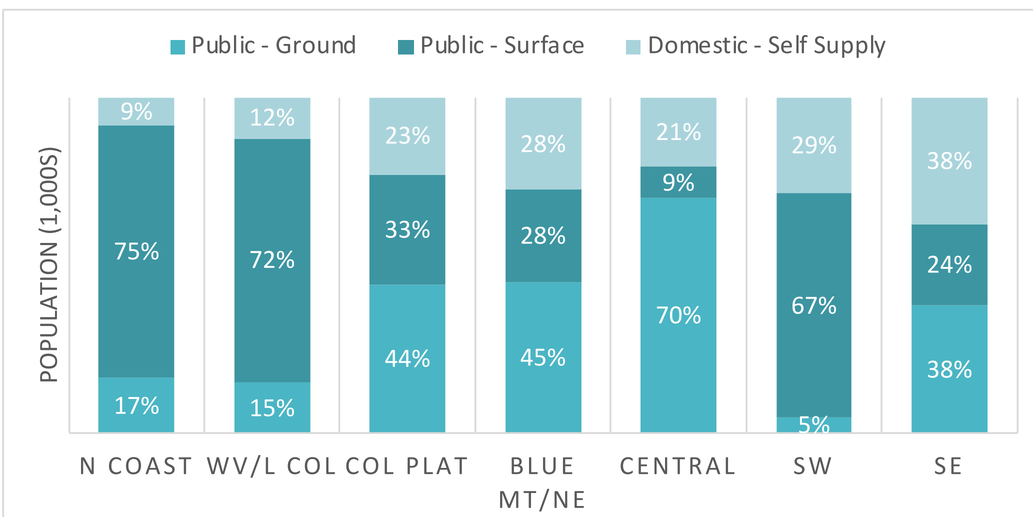
How water is used also varies substantially across the regions (Figure 23). Irrigated agriculture represents more than 80% of total water use in the Columbia Plateau, Blue Mountain/Northeast, Central and Southeast regions. While irrigated agriculture still accounts for most of the water use in the Willamette Valley/Lower Columbia and Southwest regions, use for aquaculture and public supply are proportionally higher. The North Coast region is distinct in its limited use of water for irrigated agriculture.

Figure 23. Water Use by Type (2015)



Water for domestic purposes varies across the regions both by source type and from whom it is supplied (Figure 24). The North Coast, Willamette Valley/Lower Columbia and Southwest rely primarily on surface water sources for domestic supply, while the remaining regions rely more heavily on groundwater. Self-supply across all regions comes almost exclusively from groundwater. Self-supply is likely made up mostly of small exempt wells serving individual properties, with an estimated 230,000 exempt wells in 2008 and an increase of 3,800 per year (Oregon State Legislature 2016; OWRD 2008)

Figure 24. Population Served by Source (2015)



3 The Benefits of Water and Water Investments

Water provides countless benefits. These benefits may be derived both from water resources as they currently exist and from investment in protecting, maintaining, restoring or enhancing these resources. Highlighting and analyzing the benefits provided by water are at the heart of the business case for water in Oregon. However, not all benefits are obvious, not all benefits are valued or analyzed in the same way and not all benefits are equally distributed across the state and across the population. This section therefore provides important background information, beginning by describing how freshwater resources contribute to human well-being (including how human well-being is enhanced by freshwater contributions to ecosystem health) and the relationship between those benefits and economic value. The section concludes with an overview of the diversity of methods that can be used to estimate the economic value of water resources and/or water-related investments along with a discussion of uncertainty and risk.

3.1 Overview of Water Benefits

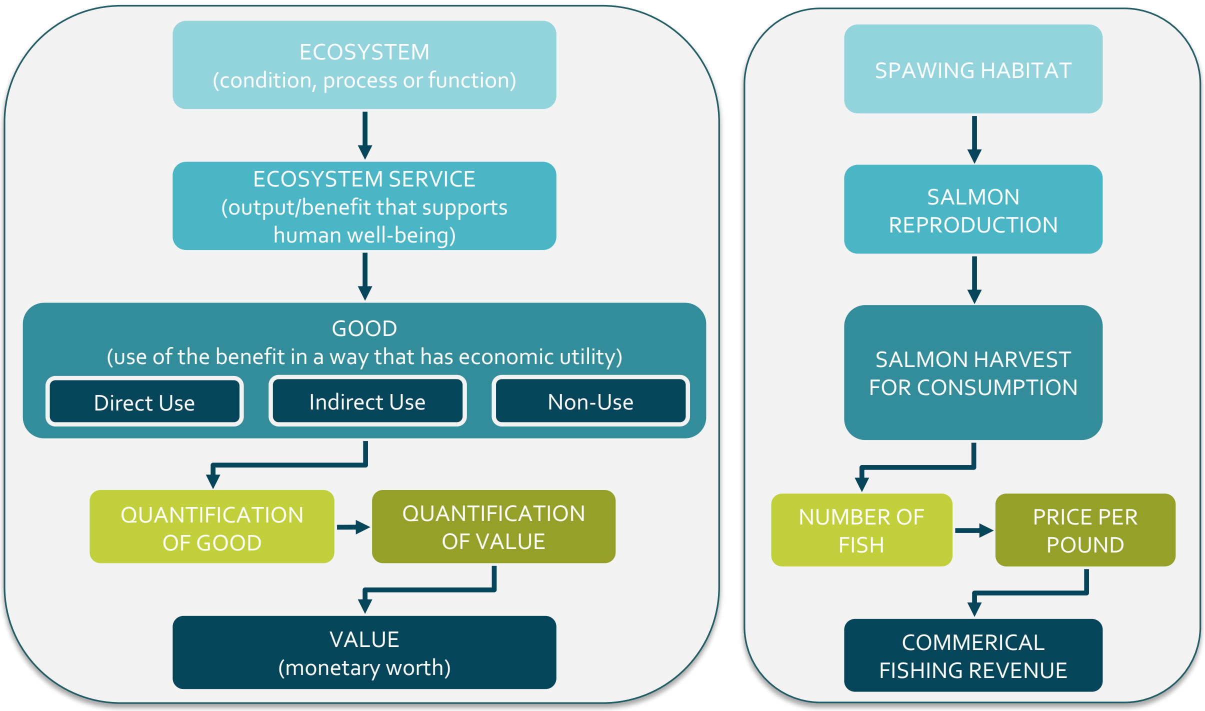
Freshwater-related ecosystem services are provided by rivers, lakes, floodplains, wetlands, riparian areas and connected groundwater systems. The use of these ecosystem services provides economic utility; the worth or value associated with the benefit, which can vary based on the quantity or quality of the benefit is depicted in Figure 25. Furthermore, the value or values placed by society on a benefit can be affected by a variety of factors including the way in which water is used (e.g., direct, indirect); socio-demographic conditions; knowledge and awareness levels; and geographic proximity, among others (Obeng and Aguilar 2021).

> **Economic valuation, therefore, is the set of methods used to assign quantitative values to benefits provided by water and other natural resources (Tegenie 2015).**

Ecosystem services[7] are a useful concept for connecting people to the natural world and can "help make visible the key role of ecosystem functioning and biodiversity to support multiple benefits to humans" and thus contribute to more sustainable management of ecosystems (Grizzetti et al. 2016). It is important to realize, however, that this is an anthropocentric approach to the value of natural resources. It is important to also acknowledge that natural resources have intrinsic value (i.e., value independent of human use).

[7] "Ecosystem services are the benefits people obtain from ecosystems. These include **provisioning** services such as food and water; **regulating** services such as flood and disease control; **cultural** services such as spiritual, recreational and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth." (Alcamo 2003, emphasis added)

FIGURE 25. RELATIONSHIP BETWEEN ECOSYSTEM SERVICES AND ECONOMIC VALUE



While benefits provided by water resources typically come from using water for a specific purpose — either directly or indirectly as a use benefit — important "nonuse" benefits also are provided by water. Figure 26 expands on that component of Figure 25 — note that this is not an exhaustive list of all water-related benefits, but rather highlights those most relevant to Oregon and more specifically, to making the business case for water-related investments in the state.

FIGURE 26. EXAMPLES OF USE BENEFITS DERIVED FROM WATER RESOURCES

DIRECT - INSTREAM
- Aesthetics
- Commercial Fishing
- Hydropower
- Navigation & Transport
- Recreation & Tourism
- Spiritual & Symbolic
- Tribal

DIRECT - OUT OF STREAM
- Aquaculture
- Domestic Use
- Industry
- Irrigation – Ag
- Irrigation – Golf Courses
- Livestock
- Mining
- Thermoelectric

INDIRECT - INSTREAM
- Climate Regulation
- Erosion Control
- Flood Protection
- Aquatic Habitat
- Water Filtration
- Wildfire Prevention

Use benefits can further be categorized by where the use occurs — instream and out-of-stream. Perhaps the most obvious use benefit is drinking water for humans - a primary building block of life. Another example, previously highlighted in Figure 25, is that many rivers and streams in the Pacific Northwest provide one or many of the critical components that allow salmon to live and reproduce — without which for example, the commercial salmon industry would not exist.

Instream uses generally do not affect or diminish flow downstream of the location of use. Common examples of benefits associated with instream use include recreational activities (e.g., kayaking, swimming, fishing), navigation and run-of-river hydropower. Water resources also provide a variety of ecological functions that indirectly benefit society — from flood protection to wildfire prevention, among many others.

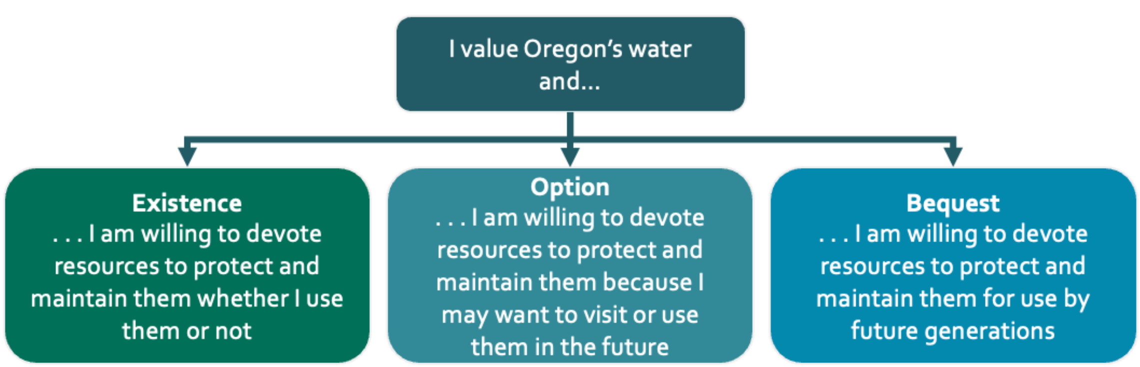
Some benefits associated with instream use of water resources can easily be quantified in monetary terms. Commercial salmon fishing and the supply chain associated with delivering salmon products to consumers provide revenue, income, employment and substantial contributions to local economies, particularly along the Oregon coast. Recreational activities, however, may have both monetary and non-monetary benefits. Consider a whitewater rafting example — booking a private whitewater rafting tour on the Deschutes River contributes to the local economy not only through the direct cost of the tour, but also any costs associated with lodging, dining and travel required to participate in the tour. In addition, the costs actually paid by the individuals to participate in this recreational activity may not be the amount they were willing to pay.

> **The difference between what the trip cost and what an individual would be willing to pay is called consumer surplus — a value which cannot be directly observed but can be estimated indirectly using market information.**

To realize benefits or value, out-of-stream uses remove water from its source (e.g., river, lake or aquifer), thereby diminishing the volume or flow of water available for use by others. Irrigated agriculture and municipal water supply are common examples of out-of-stream uses. Many benefits associated with out-of-stream use can be quantified in economic terms — as the water is being used to produce a good or service. For example, irrigated agriculture could not occur if water resources were not diverted and applied to agricultural lands. In 2017, the CoA reported that Oregon had over 1.6 million irrigated acres. Removing these acres from production would have a significant impact on not just farmers but also on regional economic output, personal incomes, jobs and taxes.

Water resources also provide benefits to human populations even if they are not currently interacting with or directly consuming those resources. The benefits that individuals receive from their preservation, protection and/or maintenance, therefore, is described as a "passive" or "nonuse" benefit (hereafter referred to as "nonuse"). While providing monetary estimates of the value of nonuse benefits is outside the scope of this report, this section defines the different types of nonuse values and highlights several more widely recognized/researched nonuse values related to water resources in Oregon. Values associated with nonuse benefits generally fall within three categories: Existence, Option and Bequest values (Figure 27).

FIGURE 27. NONUSE VALUES



By their nature, the full spectrum of potential nonuse benefits provided by water resources is not only difficult to identify, but it is also challenging to assess the extent to which individuals hold values for these benefits; how strongly they hold those values; and the monetary value they may ascribe to them. While methods and techniques have been developed to estimate willingness-to-pay (WTP) for nonuse benefits (e.g., contingent valuation method), their application can often be time-consuming and costly (see Appendix B for additional information). In addition, estimates of willingness-to-pay, by the nature of the good being valued, cannot be verified or confirmed using market information.

Nonuse value is often mentioned in the context of endangered resources or species, or when a proposed action has the potential to affect a resource in an irreversible way. At present, 13 species of fish are threatened or endangered in Oregon — most of which provide a variety of use values to different stakeholders (e.g., commercial fishermen, consumers of salmon, Tribal communities) (ODFW 2021). Salmon has long been recognized as an iconic species in the Pacific Northwest not only because of its cultural importance to Tribal communities since time immemorial, but also because of its contribution to commercial and recreational fishing activities in the state. In much of the Pacific Northwest, it also serves as a keystone species on which other pieces of the ecosystem are highly dependent (for example Orcas in Washington's Puget Sound).

Several recent studies indicate that there is substantial public support and willingness-to-pay for 1) the existence of salmon; 2) activities directed at recovery of salmon populations; and 3) activities focused on preventing further declines in current salmon populations (ECONorthwest 2009; Niemi, Fouty and Trask 2020).

Cultural and heritage sites are another landscape feature for which nonuse values are commonly identified, of which Oregon has many that contain a water feature — Crater Lake, Multnomah Falls and the Columbia River Gorge to name just a few. While not specific to Oregon, a recent study by Haefele, Loomis and Bilmes (2016) estimated the total economic value of the National Park Service, of which an important component was nonuse value. Their approach involved a contingent valuation survey that measured "what the American public would pay to avoid being deprived of these assets."

Survey results found that over 94% of respondents agreed with the following two statements:

- "It is important to me that historic sites are protected for current and future generations whether I visit them or not;" and
- "It is important to me that National Parks are preserved for current and future generations whether I visit them or not."

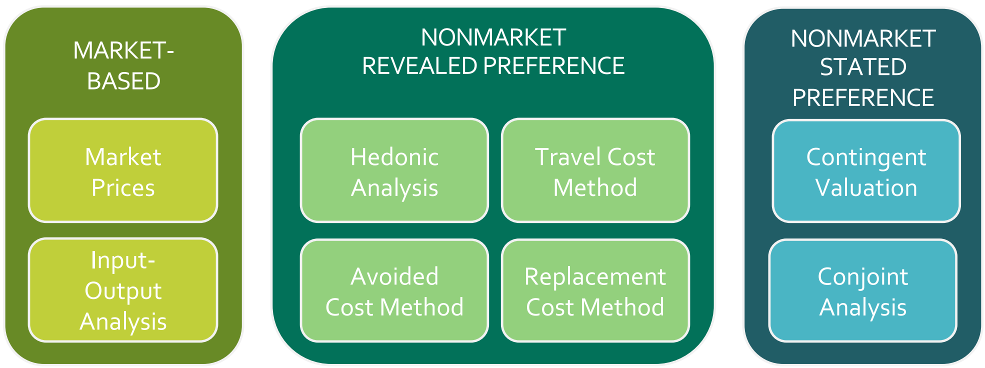
It is also noteworthy that willingness-to-pay was found to be higher for water-focused National Parks, like Crater Lake, when compared nature-focused parks. (Haefele, Loomisand Bilmes 2016)

Finally, nonuse values often exist not only for free-flowing rivers, but also restoration of them. Loomis (2009) not only identified nonuse values associated with lake and river restoration, but also made a compelling argument for including nonuse values in decision-making processes on whether to fund (or not) restoration activities.

3.2 Methods for Estimating Water Benefits and Investments in Water Resources

This section describes at a high-level methods for estimating the value of water benefits and investments in water resources and water-related assets. More in-depth descriptions of methods are found in Appendices A-C. Recognizing and accounting for the benefits water resources provide can increase understanding of the economic benefits of water-related investments. There are numerous approaches for developing monetary estimates of the benefits water provides and these same approaches can be used to estimate the benefits and costs associated with a potential water resource investment (Figure 28).

Figure 28. Economic Valuation Methods



3.2.1 Market- Based Valuation

Where there is a well-functioning market for a good or service that is reliant on water resources (e.g., agricultural production, commercial fishing) or impacted by a water resources investment project (e.g., upgrading to more efficient agricultural irrigation technologies and practices), the observed market price can be used to illustrate economic value. Market prices also are applicable for valuing changes in production (e.g., crop yields, commercial salmon harvest) and other benefits that are routinely traded in competitive markets. The direct costs of an investment project (or its alternatives), such as the cost of capital equipment or labor can also be estimated using market prices. Some adjustments may need to be considered for markets that are impacted by tariffs, trade rules or other factors that distort the relationship between prices and economic value.

While market prices measure the direct benefit of water resources or a related investment, input-output (I-O) analysis estimates the benefit (or cost) to the broader economy of a resource or investment by modeling the interrelationships of economic sectors and describing how changes in one sector “ripple” across the economy — impacting employment and income levels across various sectors of the regional economy. This approach is frequently used to assess the potential economic impact of a new program or investment.

3.2.2 Nonmarket Valuation

In addition to market-based benefits, water provides many “nonmarket” goods and services. For example, there are not well-defined markets for many water-based recreational activities. This means that there are no market prices to observe for many key outcomes (e.g., for a day enjoying improved angling and water quality conditions on a lake or stream in which water quality and fishery conditions have been protected or enhanced by a state or other investment). Likewise, many individuals derive enhanced wellbeing knowing that investments are being made to protect and enhance salmon populations and habitats, even if they do not actually "use" the fishery (i.e., these individuals derive nonuse values such as spiritual and/or existence values, which are a form of nonmarket value).

Because many of the important benefits provided by water resource management involve nonmarket goods and services, monetary estimates are derived using various well-established economic methods for *nonmarket valuation*. These nonmarket valuation approaches can help develop dollar estimates for some important types of water resource-related benefits and, thereby, help decision-makers and the public better recognize the value of a water resource investment option.

There are two main approaches economic researchers can use to estimate nonmarket values via primary research: *stated preference* methods and *revealed preference* methods. Stated preference methods are survey-based and include contingent valuation and conjoint analysis. Revealed preference methods include travel cost and hedonic modeling. Nonmarket valuation methods also include secondary methods, such as benefits transfer — in which the results of one or more studies are applied to a different geographic region. The various nonmarket valuation methods are described in greater detail in Appendix B.

3.2.3 Discounting and Present Value

The benefits and costs of water investments (or failure to invest) often occur as a series of values that accrue and change over time (often decades). Because of this, economists deploy techniques for estimating the monetary value or cost *today* of benefits and costs that can change in the future. To compare costs and benefits over time, the stream of values for each project option is discounted to their *present value* using the *discount rate*. The present value of costs can be subtracted from the present value of benefits to derive the Net Present Value (NPV) of a potential water investment. If the NPV of a project is greater than zero, then the present value of the benefits is greater than the present value of the costs. Calculating the NPV of projects allows apples-to-apples comparisons of projects' values regardless of possible differences in the timing of benefits and costs or lifespan of different projects.

Another metric used in this report is the levelized cost of water (LCOW). The LCOW metric takes the notion of present value one step further — dividing the NPV of costs less the NPV of any monetizable benefits by the NPV of physical units of water benefits to derive a value per unit of water, for example $/AF (used in this report). LCOW analyses can help compare the cost-effectiveness of projects designed to conserve water for example, or projects designed to lease water from farmers for instream flow dedication (See Section 15 below for a summary of the LCOW for investments analyzed in this report).

> **The primary benefits of the LCOW is that it distills several complex considerations into a standardized result that can be compared across projects with differing durations and cost/benefit streams.**

An important consideration in calculating NPV or LCOW is the choice of a *discount rate*. There are two interrelated factors that influence this choice — inflation and the "time value of money." Economic analyses to evaluate public sector investments in water are generally not inflation-adjusted; using *real* dollars (i.e., not inflation-adjusted) simplifies the analysis. The second factor to account for in comparing values over time is the fact most people prefer a dollar today more than an inflation adjusted dollar in the future because they prefer to use that dollar to consume a good today, or they prefer to invest that dollar today to yield a future return. This preference for near-term consumption is commonly called the *time value of money*.

The annual rate at which present (near-term) values are preferred to deferred values is known as the *discount rate* (and is like an interest rate). The greater the preference for immediate benefits (time preference), or the greater expected rate of return on other investments today (known as the opportunity cost of capital), then the greater the discount rate.

The choice of what discount rate to apply can be complex and controversial (as discussed in Appendix C). There are philosophical and practical aspects to the choice of discount rate and there is not always general agreement among economists or policymakers about the correct discount rate to apply to evaluating projects. The Office of Management and Budget (2003) recommends that as part of any regulatory analysis, benefits be estimated using both a 3% and 7% discount rate, however, the Biden Administration recently proposed a discount rate of 1.7% (Office of Management and Budget 2023).

> **Therefore, for this business case evaluation of Oregon's potential water asset investment projects, which are generally investments made for broad public benefit, a 3% real discount rate is recommended — a real discount rate being a discount rate that does not include the projected rate of inflation.**

However, justifications can be made for a range of rates, from no discount rate to a discount rate reflecting the private cost of capital. Because a discount rate may impact the NPV, an example is provided below (see Appendix C for further discussion).

TABLE 3: EXAMPLE OF THE IMPACT OF NPV ON COST OF CAPITAL

The NPV of a project that requires upfront costs of $10M and produces total monetized benefits of $50M realized in equal annual amounts over the project lifespan is assessed below under different discount rates and project lifespans to illustrate how discount rate may impact NPV.		
Discount Rate	Project Lifespan	NPV
• 0% • 3% • 3% • 5% • 7% • 10%	• 100 years • 100 years • 20 years • 100 years • 100 years • 100 years	• $40M • $5.8M • $27.2M • ($0.08M) • ($2.9M) • ($5.0M)

3.3 ADDRESSING UNCERTAINTY, VARIABILITY AND RISK

An array of uncertainties and data gaps inevitably arise when estimating the benefits and costs of water resources and related investments. There are various ways to address uncertainties and data gaps, including providing a clear qualitative discussion of key investment outcomes and impacts that may be difficult (or impossible) to quantify in a reliable manner. Techniques such as sensitivity analysis, scenario analysis and break-even analysis can provide informative and transparent results for policymakers and stakeholders, given uncertainty.

Sensitivity Analysis: In many cases it is useful to explore the impact on the estimated benefits and costs arising from uncertainties or key assumptions (such as the choice of discount rates) by applying sensitivity analysis. Sensitivity analysis involves systematically changing the value of some key input variable to see how it affects the outcome of the analysis. The change in results arising with the change in inputs can illuminate how large an impact the uncertainty for a specific variable has on the overall outcome of the business case.

Scenario Analysis: Scenario analysis is a form of sensitivity analysis in which multiple uncertain variables may be altered concurrently. The purpose of this analysis is to examine whether uncertainty in the underlying variables is important to the ultimate outcome of the analysis. Knowledge of whether uncertainty regarding key variables is likely to affect the outcome of analysis or the decisions to be made can help focus future research efforts on the most productive topics.

3.4 Summary

In evaluating the value of water resources and related investments, it is important to develop a clear and meaningful comparison of the alternatives. One alternative is always the “do nothing” status quo baseline, reflecting a future without any new investment. There are various approaches that may be usefully deployed in an analysis of alternatives and some of the key points to consider regardless of the method applied include:

- Comparing apples to apples, so that decision-makers can focus on true alternatives and their respective abilities to meet key objectives (and/or understand key ways in which the alternatives may yield different types or levels of key outcomes).
- Paying careful attention to identifying and describing all the important benefits and costs (pros and cons), so that nothing of significance is omitted (even if the benefits cannot be quantified or monetized).
- Clearly identifying where there are large uncertainties, unquantified benefits and costs, externalities, or other factors that are important to consider for decision-makers.
- Articulating key uncertainties and using sensitivity analyses and other suitable methods to assess and communicate the size and implications of those uncertainties.
- Recognizing that the analysis is a tool to inform decision making (it is not a rule to determine a decision).
- Keeping the analysis and the results as transparent and replicable as possible, so that they can be effectively communicated with decision-makers and stakeholders.

4 Economic Baseline

This section describes the various uses and economic values associated with water resources across Oregon and within each study region. Specifically, this section focuses on the economic values and contributions of sectors that are highly dependent on water resources, including:

- irrigated agriculture;
- water dependent industries such as manufacturing, health care, wineries and other businesses that rely heavily on water key aspects of production;
- recreation and tourism;
- commercial fishing;
- hydropower;
- thermoelectric power; and
- households dependent on safe and reliable water supplies for drinking water and sanitation.

The remainder of this section discusses each of these sectors in turn, providing a current economic baseline value of water in Oregon.

4.1 Irrigated Agriculture

Water is vital to the production of food, feed, fiber, seed, livestock and horticultural products in Oregon, and more broadly provides for the unique diversity of agricultural production throughout the state (ODA 2021). The impacts of climate change, compounded by competing demands for water, have widely affected Oregon farmers. In many regions, farmers irrigate their land with surface water sources that are dependent on melting snowpack. With warmer temperatures in early spring, the snowpack melts sooner and faster than it did in the past, meaning the availability of water throughout the summer is not as reliable as it once was (Waldroupe 2021). In other areas, particularly west of the Cascades, watersheds are dependent upon winter rains, mid-elevation storage, and groundwater for summer irrigation. These watersheds are particularly susceptible to drought. Statewide, having an adequate water supply is one of the biggest challenges the sector will face in the future. As a recent example, the impacts of drought and increased temperatures had a devastating effect on many of Oregon's crops in the summer of 2021, when according to the Raspberry and Blackberry Commission, berry farmers lost 50% of their crop (Waldroupe 2021).

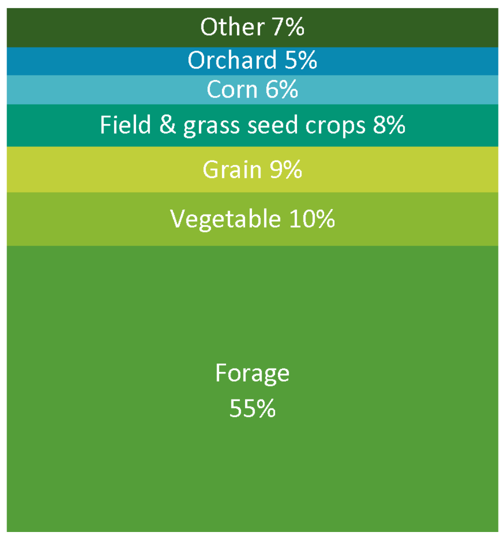
In its 2021 report on the State of Oregon Agriculture, the State Board of Agriculture called for continued discussions to address the need for new water storage projects and investments in modernization of irrigation systems. Others have acknowledged the need for additional strategies, including crop switching and dry farming to adapt to changing conditions. While needs will vary throughout the state, future investments in infrastructure and/or on-farm practices are crucial to ensuring a robust agricultural economy for future generations. Understanding the value of irrigated agriculture is key to making the business case for these future investments.[8]

[8] Unless otherwise noted, all dollars values are presented as constant 2022 dollars ($2022).

Irrigated agriculture accounts for 80% to 85% of total water use in Oregon (USGS 2020; NOAA 2022). Across the state, 45% of harvested cropland is irrigated, totaling more than 1.3M acres (USDA NASS 2017). An additional 338,900 acres of pastureland is also irrigated, although this makes up a very small percentage of the 10.5M total acres of pastureland across the state.

Figure 29 shows the makeup of harvested irrigated acreage by crop type based on the most recent National Agricultural Statistics Service (NASS) CoA, which was conducted in 2017. As shown, forage crops make up the largest percentage of irrigated acreage, at 55%. Vegetables, grains, field and grass seed together account for an additional 27%, while the remaining 19% of irrigated acreage is made up of a variety of crops, including corn, orchards (fruit and nut trees), berries, mint, hops, dry beans, sugar beets and other (miscellaneous) crops.

FIGURE 29. IRRIGATED CROPS BY TYPE (% OF TOTAL IRRIGATED ACRES HARVESTED)



Source: USDA NASS 2017.

Notes: Forage crops include alfalfa and other hay, as well as haylage, grass silage, and greenchop.

Irrigation is used to produce many of Oregon's highest value crops, accounting for approximately 80% of economic output associated with total cropped acreage in the state.[9] As shown in Table 4, many of the state's leading crops (in terms of direct economic output) rely heavily on irrigation, including hay, vegetables, fruits, nuts, berries, hops and corn.

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[9] Estimated based on the ratio of cash rents for irrigated and non-irrigated land (NASS 2022) and the amount of cropped acreage in each crop category. Ratio was applied to value added estimates for cropped agriculture from IMPLAN to determine total value added of irrigated agriculture. The ratio of value added to economic output for each crop sector was then applied to determine total economic output by sector.

TABLE 4. HIGH VALUE CROPS - DIRECT ECONOMIC OUTPUT AND ACRES IRRIGATED

Crop	Economic Output ($M)	% of Cropland Irrigated
Greenhouse & nursery	1,344	N/A
Hay	643	67%
Grass seed	518	25%
Wheat	310	11%
Vegetables		86%
Potatoes	245	
Onions	135	
Crops in orchards		53%
Grapes for wine	179	
Cherries	152	
Hazelnuts	149	
Apples	44	
Pears	111	
Blueberries	136	100%
Christmas trees	121	1%
Corn, grain	88	75%
Hops	85	100%
Sweet corn	46	100%

Source: Oregon Department of Agriculture 2021; USDA NASS 2017.

Notes: Irrigation estimates for greenhouse and nursery crops not available from NASS; however, these crops are largely irrigated (OSU Extension, n.d.). Information is not available for individual crops that fall within NASS orchard and vegetable categories. This table shows the average across all orchard and vegetable categories.

NASS CoA data on the value and irrigation of various crops throughout the state was used to estimate the direct value of irrigated agriculture as a percentage of total cropped agricultural production. IMPLAN was then used to estimate the overall economic contribution of irrigated agriculture to Oregon's economy. IMPLAN quantifies the direct economic activity associated with different sectors in terms of economic output (e.g., total sales), employment, value added (or GDP) and labor income. It also estimates the economic activity generated by the purchase of intermediate inputs from different sectors (indirect effects) and by spending from individuals employed in affected sectors (induced effects). Table 5 shows the total economic contribution of irrigated agriculture across the state, including direct, indirect and induced effects. Figure 30 shows the percent economic contribution of each cropped agricultural sector in IMPLAN.

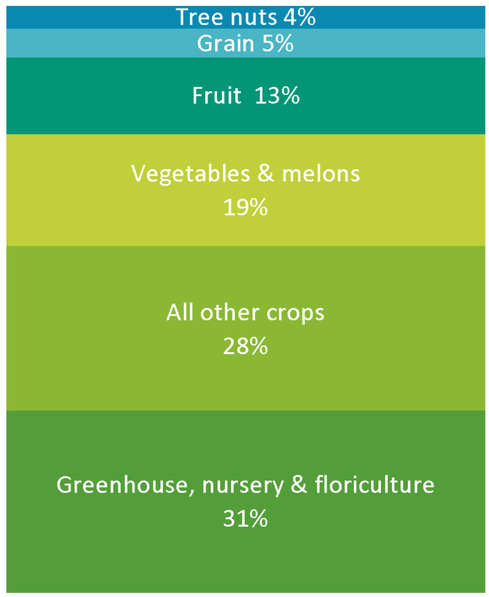
TABLE 5. ECONOMIC CONTRIBUTION OF IRRIGATED AGRICULTURE TO OREGON'S ECONOMY

Impact Type	Employment	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct	42,964	$1,494	$1,682	$3,763
Indirect	12,621	$787	$1,041	$1,792
Induced	10,259	$622	$1,077	$1,813
Total - Irrigated Ag	65,844	$2,903	$3,800	$7,368
Irrigated Ag as a % of State Total	2.6%	1.6%	1.4%	1.5%

Source: IMPLAN.

Note: Value added is equivalent to GDP. It includes labor income, taxes and subsidies, and other property income.

FIGURE 30. SECTOR CONTRIBUTION IRRIGATED AGRICULTURE ECONOMIC IMPACT



Source: IMPLAN.

Notes: Oilseed and sugarcane farming account for 0.5% of total irrigated acreage, not shown. Percentages reflect direct, indirect and induced economic impacts from IMPLAN irrigated agriculture contribution analysis.

On its own, irrigated agriculture accounts for a relatively small percentage of the state's GDP, equivalent to value added in IMPLAN and total economic output. However, the role of irrigated agriculture in supporting food security for Oregon's residents cannot be understated.

According to data from the IMPLAN model, fruits grown in Oregon meet 34% of total demand from businesses and residents in the state, while vegetable and nut production meet 57% and 48% of total demand, respectively.

While many irrigated agriculture commodities may be used in the production of goods that are exported from the state, the relatively high percentage of local demand met by local production includes demand from households.

In addition, IMPLAN only captures the backward linkages associated with a particular sector. Irrigated agriculture has important forward linkages in that it supports many other industries throughout the state, including wineries and associated tourism activities; breweries; cattle ranching and farming; dairy cattle and milk production; and the fruit farms and related specialty products for which Oregon is famous. For example, agricultural production in the IMPLAN category "all other crop farming," which includes all hay crops (e.g., alfalfa, other hay), meets 86% of demand for this sector in the state. This indicates a high reliance on growers for beef and dairy cattle feed.

Table 6 shows the amount of money spent on irrigated agriculture commodities by several different industries that are heavily reliant on irrigated agriculture. Together, these industries account for approximately 4% of direct economic output in the state and are responsible for purchasing 14.5% of the total output from fruit, vegetables, grains, tree nuts, greenhouse/nursery, and all other crop farming sectors.

TABLE 6. IRRIGATED AGRICULTURE COMMODITY PURCHASES AND ECONOMIC OUTPUT FOR SELECT INDUSTRIES

Oregon Irrigated Agriculture Commodity Purchases ($M)	Wineries	Breweries	Food Manufacturing	Beef & Dairy Cattle Ranching	Landscape/ Horticultural Services
Fruit	$52.3	—	$165.1	—	—
Vegetables/melons	—	—	$137.8	—	—
Tree nuts	—	—	$14.4	—	—
Grains	—	$6.6	$85.0	$8.3	—
Greenhouse, nursery, floriculture	—	—	$13.5	—	$26.3
All other crop farming	—	$0.9	$59.1	$5.8	—
Total Industry Output	$1,255.0	$963.9	$16,919.9	$1,514.3	$1,801.6

Note: Purchase value estimated from IMPLAN by applying ratio of total value of irrigated agriculture commodities to value of all agricultural commodities (by agricultural sector) to IMPLAN regional purchase data.

The forward linkages continue as industries that rely on irrigated agriculture commodities generate additional economic activity.

> **For example, a recent study on Oregon's wine industry found that economic output related to wine production in Oregon amounted to $8.2B in 2019. Wine-related activities supported 40,047 jobs and more than $1.7B in wages. These impacts include wine-related tourism, which contributed $1B in revenues to the Oregon economy in 2019, supporting 8,600 jobs and over $309M in wages specific to wine-related travel.**

Although some growers do not irrigate wine grapes, many do, and wineries depend heavily on local supplies from irrigated vineyards. Data from IMPLAN indicates that 72% of supply from the fruit farming sector (which includes grapes) is used to meet local demand.

Finally, in addition to consumptive use of irrigation water by agricultural crops, water increases the value of the land itself. Agricultural land with appurtenant water rights has a substantially higher value than non-irrigated acreage. In 2021, the average per acre value for irrigated land was $5,800 — more than double the value of non-irrigated land ($2,340/acre) and more than seven times the value of pastureland ($830/acre). As noted above, Oregon had over 1.3M irrigated acres in 2017 (excluding irrigated pastureland).

Based on this, the contribution of water to real estate value — calculated by multiplying irrigated acres by the difference in value between irrigated and non-irrigated acreage — is an estimated $4.6B.

4.1.1 Irrigated Agriculture Across Study Regions

The following tables and figures characterize irrigated agriculture and associated water use by study region. Table 7 shows total and irrigated (harvested) acres, based on data from the 2017 NASS CoA, as well as the average irrigated acres per irrigated farm. As shown, the Southeast region contains the greatest number of irrigated acres, followed by Willamette Valley. As a percentage of total cropland, the Central Oregon and Southeast regions have the highest relative amounts of irrigated acres. On average, irrigated farms across the state irrigate approximately 170 acres per farm. The Southeast region, where much of the state's forage and hay crops are produced (Table 7) is characterized by farms that irrigate much larger areas.

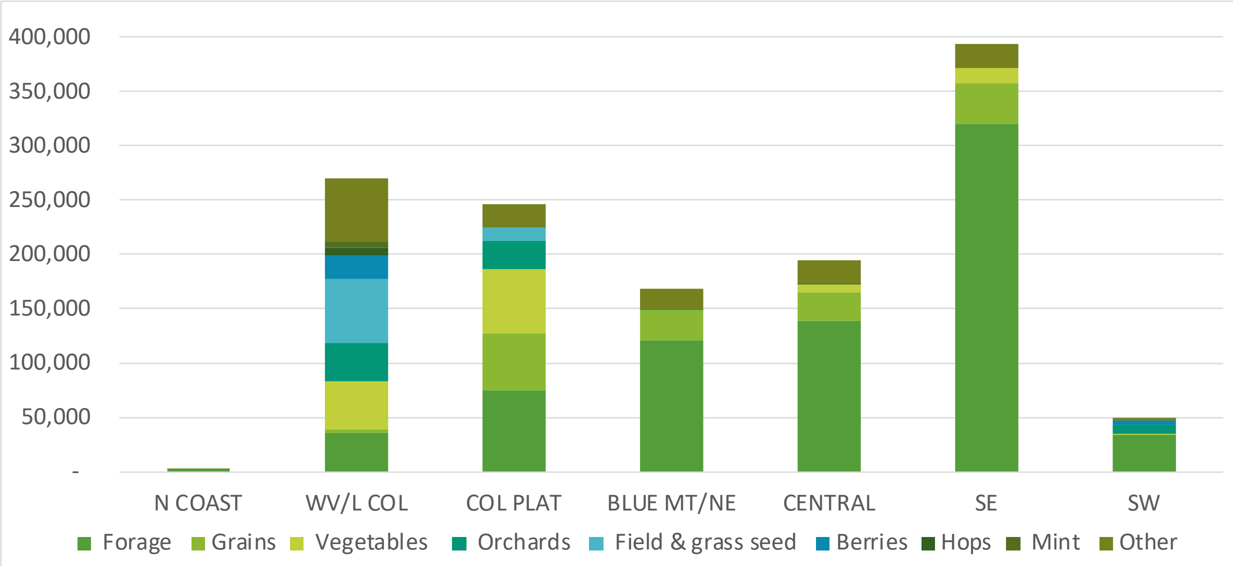
TABLE 7. TOTAL IRRIGATED CROPLAND BY STUDY REGION

Region	Harvested Cropland	Irrigated Cropland	Cropland as % of Total	Acres per Irrigated Farm
N Coast	15,417	2,706	18%	19
WV/L Col	862,476	270,349	31%	57
Col Plat	1,027,766	246,074	24%	177
Blue Mt/NE	253,886	168,742	66%	171
Central	226,679	194,959	86%	122
SE	492,677	393,984	80%	348
SW	86,491	49,298	57%	25
Total	2,965,392	1,326,112	45%	172

Source: USDA NASS 2017.

The makeup of irrigated acreage varies across regions (Figure 31). The Willamette Valley/Lower Columbia and the Columbia Plateau regions both contain a more varied crop mix and are home to many of Oregon's specialty and high value crops, including orchards (grapes and fruits), vegetables, and field and grass seed. The Willamette Valley/Lower Columbia region is also home to much of the state's irrigated hops, mint and berry acreage. The Southwest region, while containing substantially fewer irrigated acres overall, also grows berries and orchard crops. In the other regions of the state, irrigated acreage is largely dominated by forage, hay and grain crops.

FIGURE 31. IRRIGATED ACRES BY CROP TYPE AND STUDY REGION



Source: USDA NASS 2017.

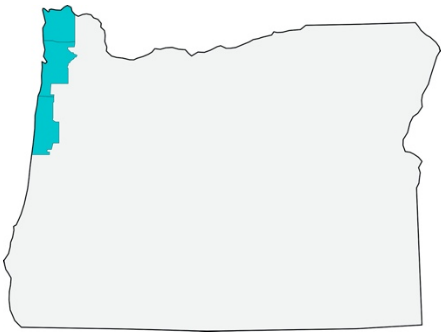
Across the state, irrigation needs vary based on crop type and local climate. As shown in Table 8, The Southeast has the highest consumptive use of water, consistent with its overall irrigated acreage. Across the state, irrigators are highly dependent on surface water sources, which make up 76.5% of total water withdrawals for irrigated agriculture statewide.

TABLE 8: CONSUMPTIVE USE AND IRRIGATION FROM SURFACE WATER SOURCES

Region	Crop Consumptive Use of Water (TAF/year)	% of Irrigation Withdrawals from Surface Water Sources
N Coast	6	90%
WV/L Col	874	64%
Col Plat	535	61%
Blue Mt/NE	440	80%
Central Oregon	738	83%
SE	953	79%
SW	300	98%
Total	3,847	77%

Source: USGS 2015.

The following pages highlight key agricultural data and information by study region.

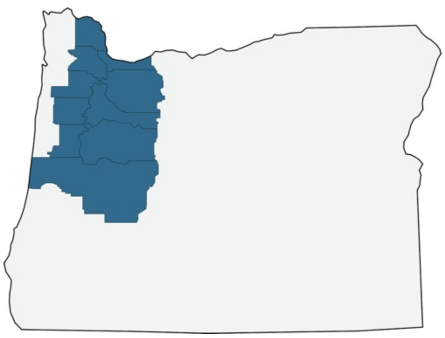


NORTH COAST

Counties: Clatsop, Tillamook, Lincoln

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
2,706	18%	19	$13.3

Primary irrigated crops: Forage, corn for silage, berries

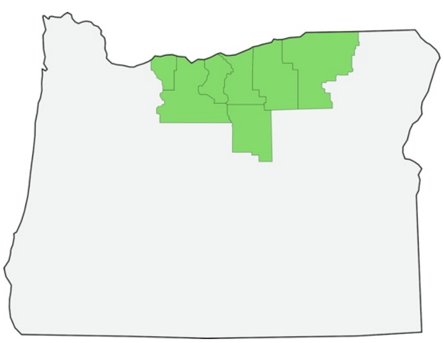


WILLAMETTE VALLEY/LOWER COLUMBIA

Counties: Columbia, Washington, Yamhill, Polk, Benton, Lane, Linn, Marion, Clackamas, Multnomah

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
270,349	31%	57	$3,112.4

Primary irrigated crops: Field and grass seed, vegetables, orchards, forage, berries

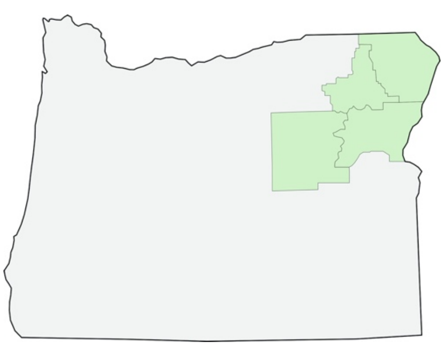


COLUMBIA PLATEAU

Counties: Wasco, Sherman, Gilliam, Wheeler, Morrow, Umatilla

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
246,074	24%	177	$1,095.1

Primary irrigated crops: Forage, vegetables, wheat, orchards

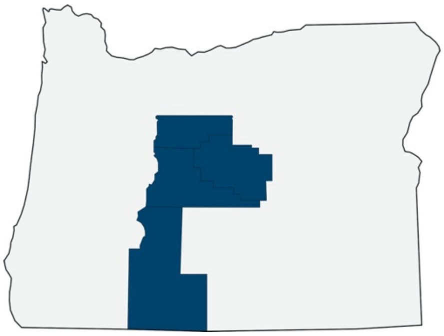


BLUE MOUNTAINS/NORTHEAST

Counties: Wallowa, Baker, Grant, Union

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
168,742	66%	171	$162.0

Primary irrigated crops: Forage and wheat

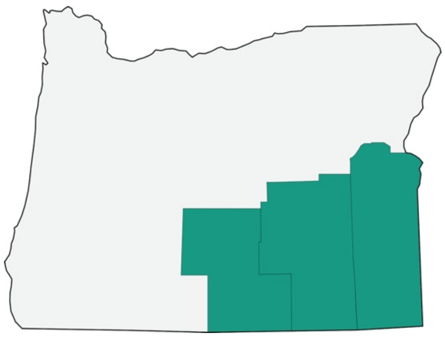


Central Oregon

Counties: Jefferson, Deschutes, Crook

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
194,959	86%	122	$322.5

Primary irrigated crops: Forage, barley, wheat, vegetables

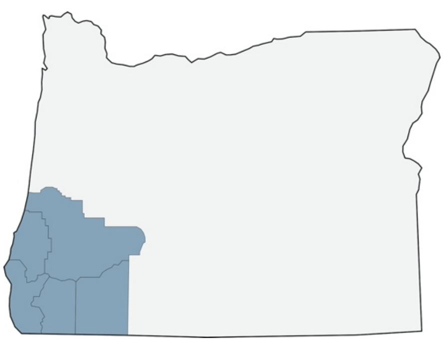


Southeast

Counties: Lake, Harney, Malheur

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
393,984	80%	348	$419.3

Primary irrigated crops: Forage, grains, vegetables



Southwest

Counties: Coos, Curry, Douglas, Josephine, Jackson

Total irrigated cropped acres	% of total cropped acreage that is irrigated	Irrigated acres per irrigated farm (avg.)	Total economic output of cropped acres ($M)
49,298	57%	25	$177.0

Primary irrigated crops: Forage, orchards, berries

Note: Forage includes hay crops, grass silage and green chop

4.2 Water Dependent Businesses and Industries

Water is an essential input for many industries and commercial businesses. Beyond the need for water to meet the basic needs of employees and visitors, many industries and businesses rely on water as a key input into their processes and/or products. These so-called “water-dependent” industries rely on the services of water utilities to support and grow their business (Value of Water Campaign (VOWC) 2016). Having a clean, reliable water supply can be a key factor for these businesses when deciding where to locate or whether to expand.

Several studies (e.g., Raucher et al. (2015)) have identified water dependent industries by comparing water use to industry output or sales. Based on these studies, Box 2 shows a list of industries that are widely recognized as being highly dependent on water. Several of these industries or sectors, including hospitals and other health care facilities, universities, restaurants and hotels and motels, rely on water to support large numbers of users and/or for important sanitation services. Others use water as part of the manufacturing process (e.g., for cleaning equipment or for process cooling water) or as a direct input into products or processes (e.g., car washes, laundry mats, and beverage manufacturers, including breweries and wineries).

Box 2: Key Water-Dependent Industries

- Manufacturing (e.g., semiconductors, machinery & devices, food and beverage, sawmills, metal smelting)
- Hospitals and other health care facilities
- Junior colleges, colleges, universities and professional schools
- Hotels and motels
- Restaurants and other food service industries
- Car washes
- Dry-cleaning and laundry services
- Landscaping and horticulture services
- Breweries and wineries
- Waste remediation

Note: Greenhouse, nursery, and floriculture production has been removed from this list because it is included in the irrigated agriculture section.

In Oregon, many water-dependent industries and businesses receive water from public or private water utilities, relying on the network of pipes, storage facilities, treatment plants and other water infrastructure that play a critical role in supporting public health and economic development.

> **In addition to the effects of climate change, population growth and competing demands, Oregon's utility-managed water infrastructure systems are in significant need of repair, upgrade and investment (League of Cities 2021).**

This includes the need for seismic upgrades to better ensure that some of the critical components of water systems will be able to withstand a Cascadia earthquake. (Intel, n.d.; Rogoway 2017)

BOX 3: WATER-DEPENDENT HIGH-TECH INDUSTRY GROWTH

Computer technology and internet services play an increasingly important role in Oregon's economy. The state hosts over two dozen data centers and is home to several semi-conductor manufacturing facilities. Semiconductor fabrication is Oregon's largest manufacturing sector in terms of numbers of employees, exports and contribution to the state's economy (Zhang 2022). In addition, the recently adopted OR Chips Act (SB4) provides $200M in grants and forgivable loans to spur investment in new or expanded facilities.

Both data centers and semi-conductor "fabs" are intensive water users, relying on large volumes of high-quality water. Typically, a semiconductor manufacturing facility uses 2M to 4M gallons of high-quality water per day (Zhang 2022). Intel's Hillsboro facility has historically consumed 2B gallons per year, although an on-site water recycling system may cut that amount in half (Intel, n.d.; Rogoway 2017). Data centers' water use can vary depending on size and type of facility. Average water consumption for facilities in this sector ranges from 1M to 5M gallons per day. Google's data center in The Dalles is reported to have used 355M gallons for evaporative cooling and other purposes in 2021 (Rogoway 2023a).

Advances in cooling technology have the potential to dramatically decrease water consumption, and many technology-dependent companies have made commitments to reduce their water impacts. While many data centers use treated potable water for "once-through" evaporative cooling, recirculating water through cooling systems and utilizing reclaimed (or, recycled) water can significantly reduce water consumption. Other technologies, such as free-air cooling and adiabatic cooling have been employed by Amazon Web Services and Microsoft in their efforts to meet water sustainability goals (Zhang 2022).

Some commercial and industrial water use is self-supplied, representing industries and businesses that are separate from utility systems and hold their own water rights. According to OWRD's 2015 Statewide Long-Term Water Demand Forecast, self-supplied industrial water use accounted for approximately 44% of the state's total estimated municipal and industrial water demand;[10] this is expected to decrease to 36% by 2050 (MWH 2015). There is some uncertainty and conflicting data related to self-supplied industrial use. Based on USGS data (2015), the majority (97%) of self-supplied industrial withdrawals are from surface water sources. However, the state's 2015 demand forecast notes that between 2008 and 2015, approximately 100 water use applications were filed and approved for self-supplied industrial and commercial use. Most of these requests were for groundwater and the locations geographically dispersed, with the largest for heating and cooling projects in Klamath, Lake, Harney and Lane Counties (MWH 2015).

Using IMPLAN, it is possible to perform an industry contribution analysis to better understand how water-dependent industries contribute to Oregon's statewide and regional economies. An industry contribution analysis identifies the associated level of production (or output) that is supported by these

[10] This estimate includes municipal service water use, self-supplied domestic use, and self-supplied industrial use.

industries, including direct, indirect and induced impacts. For this assessment, the project team included those industries identified in Box 2 above. Note that agriculture, hydropower, thermoelectric generation, recreation and commercial fishing industries are not included in this as they are addressed independently in this report.

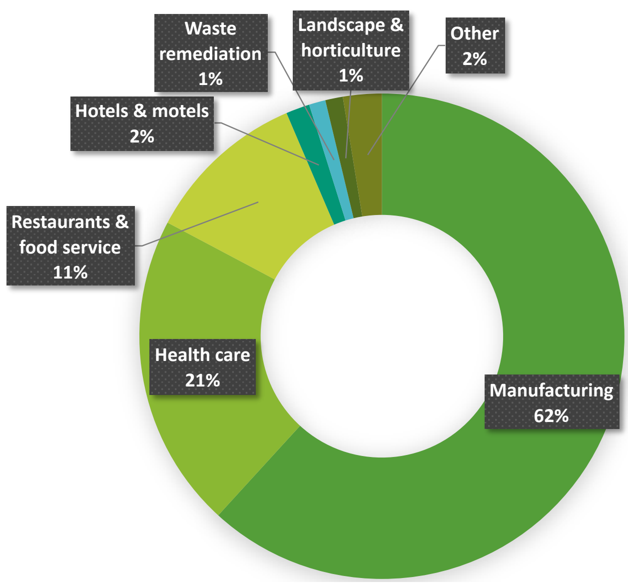
4.2.1 Economic contribution of water dependent industries: statewide overview

Top water dependent industries (i.e., those identified in Figure 32) comprise a vital portion of economic activity across the state.

> **Together, these industries generate $143.6B in direct economic output — nearly 30% of the state's total.**

Figure 32 shows the relative direct contribution of water dependent industries by industry category for the state. Manufacturing is by far the largest economic contributor and employer, with an annual economic output of $88.8B, accounting for 18.3% of the total state output and 61.8% of output from only water dependent industries. Some of the highest output manufacturing businesses include semiconductor and related manufacturing, sawmills, food processing, plywood and plastics manufacturing and metal refining. Health care services such as hospitals, physicians' offices and nursing homes contribute $39B to the state's economy annually (or 7.5% and 21.0% of total output and water dependent industries output, respectively). Manufacturing and health care services collectively employ over 400,000 people, making up about 16% of the state's total workforce.

FIGURE 32. WATER DEPENDENT INDUSTRIES OUTPUT



Source: IMPLAN.

Note: Wineries, universities/colleges car washes, dry cleaning and laundry services are included in "Other" category.

Beyond direct economic contribution, water dependent businesses create additional economic activity in the form of indirect and induced spending. Table 9 shows the total contribution of water dependent industries in Oregon.

Together, these industries support $221B in economic output (46% of the state's total) and $111B in total value added (40% of the state's total), supporting just over 1M jobs (41% of the state's total).

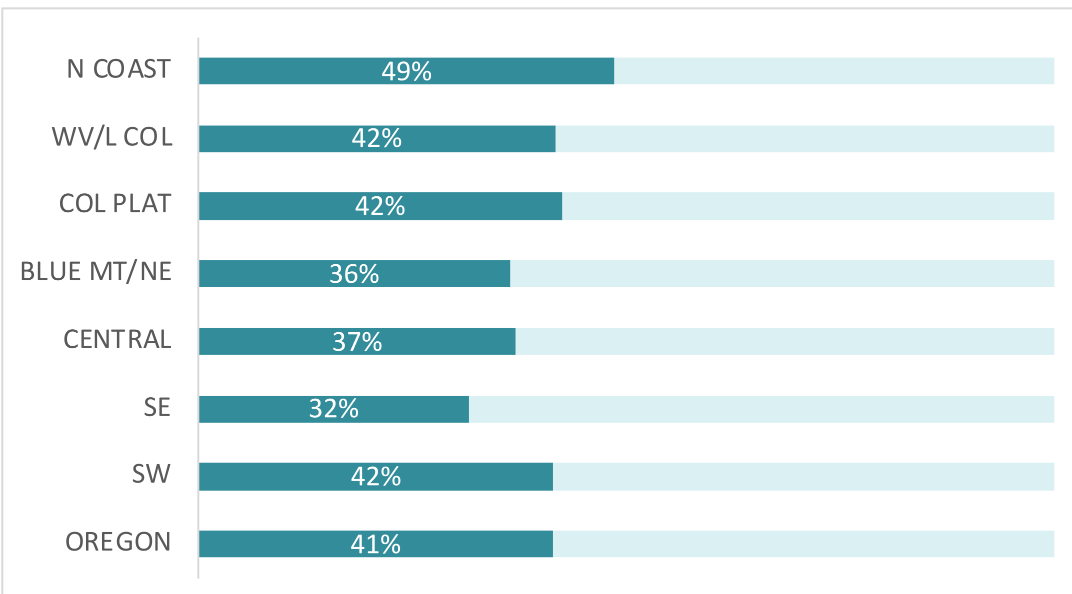
TABLE 9. ANNUAL CONTRIBUTION OF WATER DEPENDENT INDUSTRIES TO OREGON'S ECONOMY

Impact Type	Employment (jobs)	Labor Income ($B)	Value Added ($B)	Output ($B)
Direct	643,400	$44.8	$66.7	$143.6
Indirect	216,600	$17.8	$25.7	$46.7
Induced	157,100	$9.0	$18.3	$30.5
Total	1,017,100	$71.7	$110.7	$220.8
Percent of state total	41%	41%	40%	46%

Source: IMPLAN.

Figure 33 demonstrates the percentage of economic output that the water dependent industries discussed in this section contribute to each region. Although water dependent industries contribute only $5.6B in economic output in the North Coast, these industries account for 49% of total economic output. Conversely, although the Central region water dependent industries generate $12.1B in economic output, these industries make up only 37% of the total economic output of the region. These numbers help illuminate the relative importance of water dependent industries to regional economies.

FIGURE 33. WATER DEPENDENT INDUSTRIES' CONTRIBUTION (% OF TOTAL OUTPUT BY REGION)

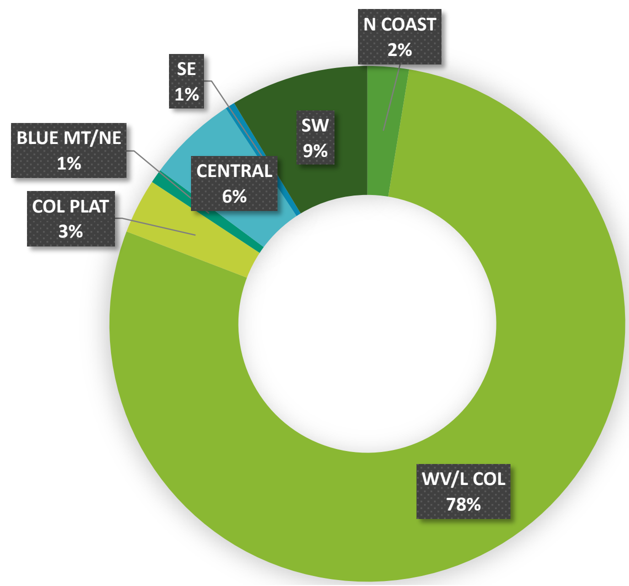


Source: IMPLAN.

As in other industries, the contribution of each region to Oregon's total output for water dependent industries differs dramatically. Figure 34 shows the portion of water dependent industry output of each region. The Willamette Valley/Lower Columbia region contributes most of the output for manufacturing, health care and food and accommodation services. This region in conjunction with the Southwest and Central regions collectively contributes 94% of the total water dependent industry output for the state.

Knowing relative regional distribution of economic contribution to water dependent industry output demonstrates how infrastructure investments in specific geographic locations will have varying impact on the economic output for the state in this sector.

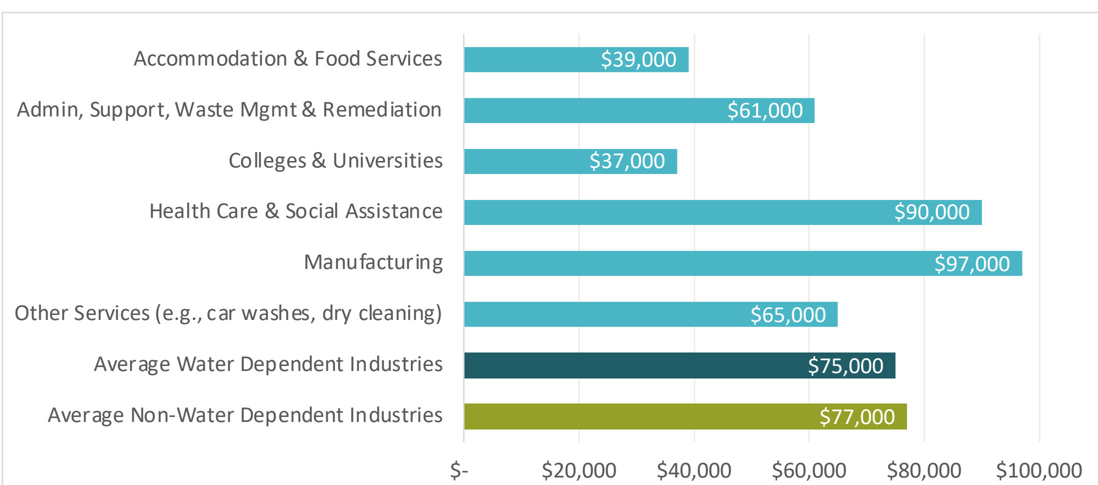
FIGURE 34. TOTAL OUTPUT OF WATER DEPENDENT INDUSTRIES BY REGION



Source: IMPLAN.

It is also important to note that water dependent industries such as manufacturing and health care offer significantly higher wages than many other sectors. In Oregon, average annual salaries in these two sectors are between $90,000 and $100,000. Accommodation and food service positions consistently offer lower salaries, averaging $39,000 across the state. These three sectors make up the bulk of water dependent industries in each region. Collectively, water dependent industries wages average about $75,000 annually, which is nearly equivalent to the non-water dependent industries average annual wage of $77,000.

FIGURE 35. AVERAGE ANNUAL WAGES FOR WATER AND NON-WATER DEPENDENT SECTORS



Source: IMPLAN.

4.3 Freshwater-Related Recreation and Tourism

Oregon's diverse geography and ecology create opportunities for a range of outdoor recreation activities including hiking, boating, swimming, fishing, camping, skiing and more. Oregonians who participate in these activities value them for several reasons, including for physical and mental health benefits, and for building social capital. Outdoor recreation also generates economic activity in both urban and rural communities, as residents and visitors spend money on gear, hotels, restaurants and other trip-related activities. The state's clean and abundant water sources — including its lakes, rivers, and streams — underpin the values and economic activity associated with many outdoor recreational activities.

The inherent value that individuals place on outdoor recreational activities can be difficult to measure. However, economists have developed non-market valuation techniques to estimate the value of recreational experiences across a range of activities (see Appendix B). These studies yield what economists refer to as *direct use values,* which reflect the maximum amount that individuals would be willing to pay to participate in a recreational activity.[11]

> **Applying this methodology to a statewide survey of participation in outdoor recreational activities, Rosenberger (2018) estimated that in 2017, Oregonians participated in 1.4B outdoor recreation activity days, with a total net economic value of $63.2B (R. Rosenberger 2018).**

The economic activity generated by outdoor recreation is reflected in spending by people enjoying Oregon's outdoors and its' associated ripple effects (i.e., indirect and induced impacts). A 2021 study commissioned by Travel Oregon, in partnership with Oregon Parks and Recreation Department (OPRD), Oregon Office of Outdoor Recreation, Oregon Department of Fish and Wildlife (ODFW), and Earth Economics demonstrated the importance of Oregon's outdoor recreation opportunities to the state's economy.

> **The study estimated that outdoor recreation supported $17.9B in direct spending in 2019, resulting in a total economic impact of $27.9B (including indirect and induced effects). In addition, the industry was responsible for creating 224,000 full- and part-time jobs and supporting $10.7B in wages. (Mojica, Cousins, and Madsen 2021)**

This section draws on the two economic studies referenced above to paint a broad picture of the economics of outdoor recreation in Oregon, specifically focusing on the value and economic activity generated by recreational activities relying on *freshwater* resources. Because these studies use different data and methods, their results cannot be directly compared. See Box 4 below for additional information.

4.3.1 Freshwater Activities

Freshwater resource management is critical to several of the state's outdoor recreation opportunities. Activities such as boating on reservoirs or whitewater rafting rely on freshwater resources managed by

[11] The net economic value of a recreation activity equals maximum willingness-to-pay minus any costs incurred to participate.

both state and private entities and require clean and adequate water supply, which is threatened by both anthropogenic and environmental factors including climate change, out-of-stream diversions, aging infrastructure and water pollution.

Of the 56 recreation activities identified in the Statewide Comprehensive Outdoor Recreation Plan (SCORP), eight are directly influenced by freshwater resource management (Table 10). Many of the other 43 activities, such as hiking, camping, and picnicking, are often enhanced by water-related amenities; however, this assessment focuses solely on activities that are directly dependent on freshwater resources. (Oregon State Parks, n.d.)

TABLE 10. SCORP WATER-RELATED OUTDOOR ACTIVITIES IN OREGON[12]

SCORP Activity	Shorthand
Beach activities - lakes, reservoirs, rivers	Beach
Downhill (alpine) skiing/snowboarding	Alpine
Fishing	Fishing
Flat-water canoeing, rowing, stand-up paddling, tubing/floating	Flatwater
Personal watercraft/jet ski	Watercraft
Power boating (cruising or water skiing)	Powerboating
Swimming/playing in outdoor pools/spray parks	Swimming
White-water canoeing, kayaking, rafting	Whitewater

BOX 4: STUDIES ON ECONOMIC ACTIVITY FROM RECREATION

This section mainly draws on two different economic studies that each evaluated a different economic indicator. Both provide valuable data but **data from one study cannot be compared with data from the other**.

- In 2018, as part of the 2019-2023 SCORP Supporting Documentation, Rosenberger (2018) evaluated the total net economic value of residents' outdoor recreation. This report used a meta-regression analysis benefit transfer function to estimate the economic value of outdoor recreation, or a "monetary measure of the benefits received by an individual or group who participates in outdoor recreation" (pg. 6). These data reflect the amount people are willing to pay for outdoor recreation or the value of outdoor recreation beyond its traditional market value. The results of this approach, therefore, are higher than those in Mojica, Cousins, and Madsen (2021), which reflect direct spending on outdoor recreation. Rosenberger's analysis used results from the SCORP's recreation survey of Oregon residents, so outdoor recreation values for out-of-state visitors are not included in the analysis.
- A team from Earth Economics led a study in 2021 (Mojica, Cousins, and Madsen 2021) that evaluated total spending on outdoor recreation-related activities by residents and visitors, as

[12] SCORP data does not delineate freshwater and saltwater use for fishing, flatwater, personal water craft or power boating activities so it is difficult to say what portion of these activities can be attributed to freshwater alone.

well as the associated indirect and induced effects that the spending generates. Results include effects related to economic output, employment, labor income, and value added.

4.3.2 Net Economic Value of Freshwater Recreation

Table 11 reflects data from Rosenberger (2018), showing net economic value for all outdoor recreation activities as well as for activities that directly rely on freshwater resources. Together, the eight activities that depend on freshwater resources account for 9% of the total statewide net economic value of all outdoor recreation activities.

TABLE 11. NET ECONOMIC VALUE OF OUTDOOR RECREATION ACTIVITIES

Activity	Net Economic Value
All outdoor recreation	$63.2B
Freshwater recreation	$5.5B
Freshwater % of total	9%

Source: Rosenberger 2018.

Table 12 shows the net economic value estimated by Rosenberger (2018) for each freshwater activity.

Fishing is by far the state's most economically valuable freshwater activity.

While it was not the most popular activity as measured by user occasions, the value of each occasion was higher than that for other freshwater activities. The net economic value of fishing contributes almost the same amount as the next five highest value activities combined. Beach activities at lakes, reservoirs, and along rivers - the most popular user activity - contributed the next highest total net economic value, followed by swimming and playing in outdoor pools or spray parks, the second most popular user activity.

TABLE 12. TOTAL USER OCCASIONS AND NET ECONOMIC VALUE OF FRESHWATER-RELATED OUTDOOR RECREATION

Activity	User Occasions (M)	Net Economic Value ($M)	Total Freshwater Activity Value (%)
Fishing	12.4	$2,581.1	47%
Beach	22.0	$807.4	15%
Swimming	14.0	$670.3	12%
Alpine	4.2	$410.0	7%
Whitewater	2.6	$392.6	7%
Powerboating	7.0	$313.0	6%
Flatwater	3.7	$215.6	4%
Watercraft	3.1	$141.4	3%
Total	69.0	$5,531.4	—

Source: Rosenberger 2018.

4.3.3 Spending on Freshwater Recreation

Table 13 summarizes data from Mojica, Cousins, and Madsen (2021) on the economic impacts associated with outdoor recreation. As shown, freshwater activities account for 16% of total trip-related spending on outdoor recreation. In terms of participation, residents and visitors spent 13% – or 20.8M – of total outdoor recreation activity days on freshwater-related pursuits. People also spent an average of $14 more per day on freshwater activities than they did on other outdoor activities. These estimates do not include additional spending on purchases throughout the year on equipment for outdoor recreation activities.

TABLE 13. ACTIVITY DAYS AND SPENDING ON ALL FRESHWATER OUTDOOR RECREATION ACTIVITIES

Activity	Activity Days (M)	Average Spending ($/activity day)	Direct Trip-Related Spending ($B)
All outdoor recreation	157	$79	$12.40
Freshwater recreation	21	$91	$1.90

Source: Mojica, Cousins, and Madsen 2021.

Mojica, Cousins, and Madsen (2021) findings on activity days, dollars spent per activity day, and total spending for each activity are summarized in Table 14. Power boating and beach activities had the highest total spending - each almost twice as much as spending on fishing, the third highest spending activity. People logged the most activity days engaging in these two activities, as well: almost 7M for power boating and 5.6M for beach activities. Downhill skiing and snowboarding, which was only the fifth most popular activity, had the highest expenditure per activity day at $205.

TABLE 14. TOTAL ACTIVITY DAYS AND SPENDING BY FRESHWATER-RELATED RECREATION ACTIVITY

Activity	Activity Days (M)	Average Spending ($/activity day)	Total Direct Spending ($M)
Powerboating	6.9	$103	$706.3
Beach	5.6	$124	$693.7
Fishing	3.6	$127	$454.3
Alpine	0.7	$205	$139.2
Swimming	2.5	$46	$115.1
Whitewater	0.5	$103	$51.7
Flatwater	0.7	$69	$44.7
Watercraft	0.5	$55	$25.2
Total	20.8	104	2230.1

Source: Mojica, Cousins, and Madsen 2021.

Mojica, Cousins, and Madsen (2021) do not report indirect and induced effects by activity type. However, the analysis found that for every $1 spent on outdoor recreation, an additional $0.52 of revenue is generated in terms of indirect and induced impacts, for a total economic effect of $1.52 per $1. This multiplier effect is even greater when looking at out-of-state visitors only – the report estimates that for $1 spent on outdoor recreation by out-of-state visitors, $0.74 is re-spent with Oregon's economy for a total spending impact of $1.74. Another key estimate from Mojica, Cousins, and Madsen (2021) is that outdoor recreation accounted for 6% of Oregon's GDP in 2019. Again, this was not specifically reported by activity type.

4.3.4 Freshwater Recreation by Region[13]

The seven study regions offer different freshwater outdoor recreation activities and associated economic values. Table 15 provides an overview of the total value of freshwater activities in each region, as well as the percentage contribution of freshwater activities to the overall value of outdoor recreation in each region. Figure 36 shows the percentage that each region's freshwater activities contribute to the State's total net value associated with freshwater activities. Totals vary significantly between regions – from $80M to $2.8B – but freshwater activities contributed similar percentages to the total net economic value of outdoor recreation in each region, ranging between 7% and 12%. Although freshwater activities only contribute 8% to the total net economic value of outdoor recreation in the Willamette Valley/Lower Columbia region, the region alone is responsible for almost 60% of the statewide net economic value from freshwater activities. Freshwater activities are more valuable to the regional economy of Central Oregon and the Southeast.

TABLE 15. NET ECONOMIC VALUE OF FRESHWATER ACTIVITIES BY REGION

Region	Net Economic Value ($M)	Proportion of Total for Outdoor Recreation (%)
N Coast	$188	7%
WV/L Col	$3,247	8%
Col Plat	$232	11%
Blue Mt/NE	$163	10%
Central	$701	12%
SE	$94	12%
SW	$907	11%

[13] Unless otherwise noted, data presented in the regional breakdowns were calculated using data from Rosenberger (2018).

FIGURE 36. NET ECONOMIC VALUE OF FRESHWATER ACTIVITIES BY REGION

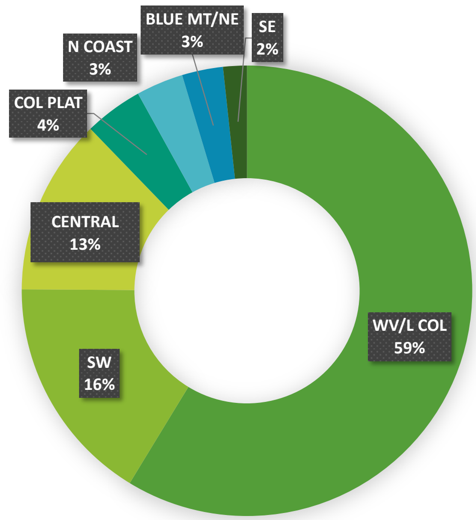


Table 16 shows the regional breakdown of economic value of each activity. Fishing was the most valuable activity in every region and beach activities were in the top three in every region. Swimming was also a highly valuable activity in almost every region, coming in the top three in four regions. Even in three regions where it did not make the top three, swimming was the 4th most valuable activity in two of them. Alpine activities only arose as a top three activity in Central Oregon; powerboating was in the top three for the North Coast and Blue Mountains/Northeast. Watercraft, whitewater and flatwater activities were not in the top three most valuable activities for any region.

TABLE 16. ECONOMIC VALUE BY FRESHWATER-RELATED RECREATION ACTIVITY BY REGION ($M)

Region	Watercraft	Powerboat	Alpine	Fishing	Whitewater	Flatwater	Beach	Swimming
N Coast	$6.7	$13.8	$2.3	$99.9	$7.6	$5.3	$40.4	$11.5
WV/L Col	$64.7	$198.1	$261.7	$1,362.5	$251.9	$145.9	$496.2	$466.7
Col Plat	$4.1	$10.7	$17.2	$129.3	$7.3	$6.0	$25.0	$32.0
Blue Mt/NE	$3.7	$11.5	$8.7	$109.3	$3.4	$2.3	$13.2	$10.8
Central	$12.2	$25.2	$91.1	$368.2	$59.1	$24.5	$72.7	$48.0
SE	$1.4	$4.2	$2.6	$71.4	$1.3	$0.8	$5.3	$7.3
SW	$48.6	$49.5	$26.3	$440.5	$62.0	$30.9	$154.7	$93.9

Note: The data for freshwater activities in coastal regions may be over reported as SCORP does not delineate between freshwater and saltwater use for four of the eight activities – fishing, flatwater, watercraft and powerboating.

4.4 COMMERCIAL FISHING

The coastal waters off Oregon's shores support vibrant fisheries and fishing communities. Among the iconic commercial fisheries are the six runs of anadromous salmonids, including coho, Chinook, chum, pink and sockeye salmon and steelhead trout. Anadromous species spend a portion of their lifespans in Oregon rivers before making their way to the ocean. Healthy rivers, creeks, tidal wetlands and riparian habitat are all essential for thriving salmon and steelhead fisheries. Rivers and creeks provide cold water refugia during summer months and spawning and rearing habitat during other times of year; coastal wetlands support rearing habitat for juvenile fish, providing shelter and food; pulse flows from winter rains remove beach and estuary barriers allowing young and mature fish to transit to and from the ocean. These environmental benefits translate into important commercial fishery and seafood processing industries in Oregon.

Oregon's salmon populations are under increasing pressure. The longstanding impacts caused by riverine habitat loss, dam operations and water withdrawals have been compounded by adverse effects associated with climate change, including drought, wildfire-induced sedimentation, increased stream temperatures and fishing pressures on declining stocks.

> **Commercial salmon landings have measurably declined over the past decade, from 2.4M pounds in 2011 to 1.5M pounds in 2020 (a low of 0.96M pounds was experienced in 2018) (NOAA Fisheries 2021).**

While Coho salmon runs remain relatively healthy, the commercially important chinook fishery has been subject to closures in recent years, including in 2023 (ODFW 2023). There is a pending petition to list two chinook salmon runs as endangered under the Endangered Species Act (ESA) (Battaglia 2023). Significant investments in water and natural infrastructure are necessary to forestall further loss and restore healthy salmon stocks.

4.4.1 Economic Value of Commercial Salmon Fishing: Statewide Overview

In 2021, Oregon's fishing fleet landed close to 1.8M pounds of salmon, producing more than $6.5M in revenue (NOAA Fisheries 2021). Salmon fishing accounted for just over 3% of direct revenues (or ex-vessel sales) from onshore landings along the coast in 2021. Based on data from the IMPLAN model, the salmon fishery supported an estimated 151 direct jobs and $5.2M in labor income (including proprietor income).[14] For employees, average wages amount to just over $60,000 per year (BLS 2022). The direct economic activity associated with salmon fishing is concentrated in the coastal regions of the state, and in particular, the North Coast region, which is responsible for 89% of total on shore landings across its five ports (ECONorthwest 2019).

Table 17 shows the economic contribution of the salmon fishing industry statewide, as well as for the state's coastal regions. As shown, there are relatively few indirect impacts – this is because the industry purchases very few intermediate inputs from other local businesses. Instead, most of the direct output is translated into labor income and other value-added components.

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[14] Employment and labor income are estimated based on industry patterns for the commercial fishing sector.

TABLE 17. ESTIMATED ECONOMIC IMPACT OF OREGON'S COMMERCIAL SALMON FISHING INDUSTRY

Impact	Employment (#)	Labor Income ($M)	Value Added ($M)	Output ($M)
Statewide				
Direct	151	5.2	6.5	6.5
Indirect	0	0.0	0.0	0.1
Induced	24	1.5	2.5	4.3
Total	**175**	**6.7**	**9.0**	**10.9**
North Coast				
Direct	118	4.1	5.8	5.9
Indirect	0	0.0	0.0	0.0
Induced	14	0.7	1.2	2.1
Total	**132**	**4.7**	**7.0**	**8.0**
Southwest				
Direct	17	0.5	0.7	0.7
Indirect	0	0.0	0.0	0.0
Induced	2	0.1	0.2	0.3
Total	**19**	**0.6**	**0.9**	**1.0**

Note: Estimates based on the proportion of salmon landings to all fish landings. IMPLAN results for indirect and induced effects are based on estimates/spending pattern for commercial fishing sector, not salmon fishing specifically.

The commercial salmon industry not only supports fishermen and women, but also supplies Oregon's seafood processing industry and is a vital part of Oregon's export economy. Seafood processing and canning businesses are the largest industry affected by commercial fishery activities in Oregon. Most of the commercial harvest in Oregon is sold to processors who then sell the processed products to wholesalers, retailers, restaurants and consumers. Oregon's processers are located throughout the state, although the majority are in coastal counties. In 2022, there were 36 processors in Oregon with 1,060 employees. (ECONorthwest 2019)

Using IMPLAN it is possible to estimate the effect of the salmon fishery and associated seafood processing industry (i.e., salmon processing) on statewide economic activity. After accounting for salmon exports from the state, Table 18 shows the economic contribution of these two industries combined.

TABLE 18. ECONOMIC IMPACT OF SALMON FISHING AND RELATED SEAFOOD PROCESSING STATEWIDE

Impact	Employment (#)	Labor Income ($M)	Value Added ($M)	Output ($M)
Direct	170	$6.2	$8.0	$15.0
Indirect	11	$1.0	$1.4	$2.5
Induced	33	$2.0	$3.5	$5.9
Total	215	$9.3	$12.8	$23.5

Note: Analysis shows contribution of portion of seafood processing industry that purchases Oregon onshore salmon landings.

4.5 Hydropower

Oregon's rivers provide the state with an immense amount of hydropower — electricity generated from water stored in on-channel reservoirs — which makes up a considerable portion of the energy generated and consumed in the state. This energy has two primary economic signatures; first, and most importantly, it powers homes, businesses and industries across the state, contributing to statewide and regional economic productivity. Second, hydropower is an industry, with revenues and employment levels that also contribute to the state's economic well-being. Climate change has the potential to significantly impact some of Oregon's hydroelectric generating capacity, particularly for the smaller facilities located in the Cascade Range. Prolonged drought in the watersheds supporting these facilities may reduce reservoir levels, leading to a drop in electricity generation potential. On the other hand, increasing storm severity, frequency and duration may stress reservoir capacity, raising dam safety concerns. (Turner et al. 2022; Nagel and Ptak 2021)

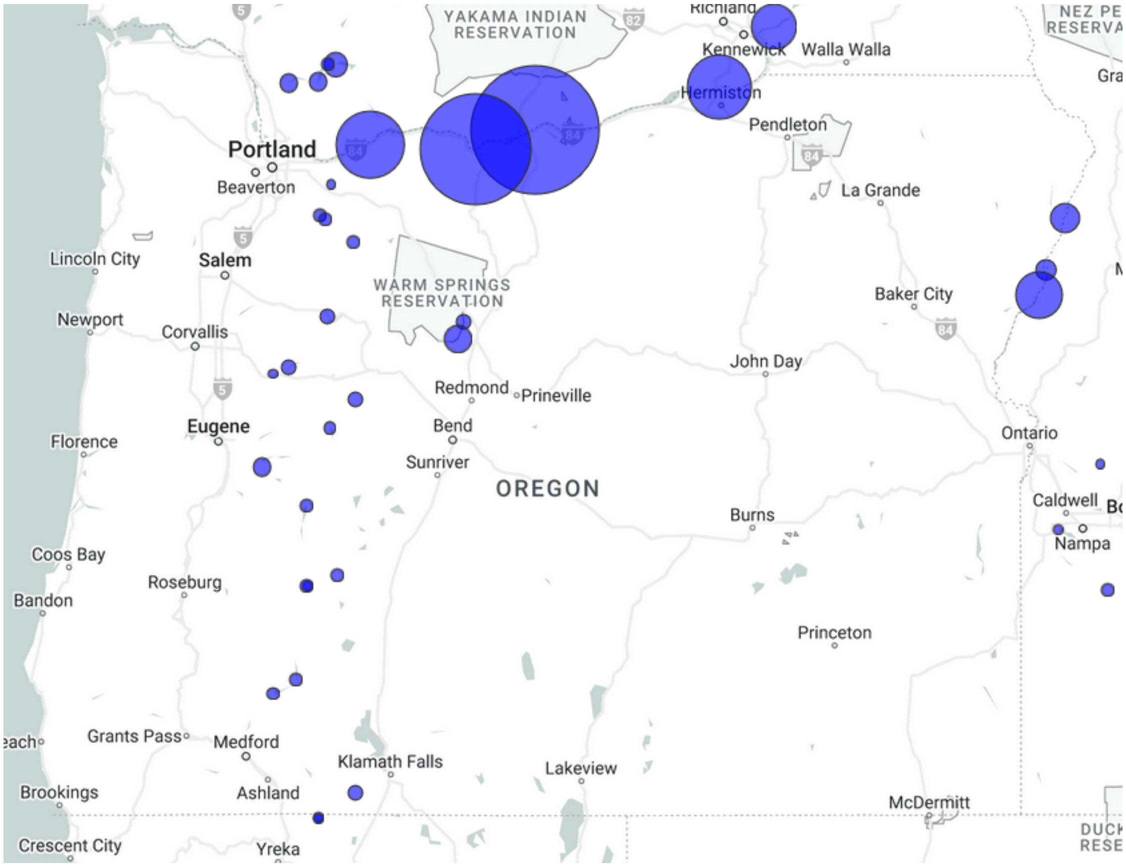
4.5.1 Hydroelectricity Powers Oregon

Oregon is the second largest producer of hydroelectric power in the US after Washington.

> **In recent years, approximately half of Oregon's electricity generation has come from over 100 hydroelectric facilities located within the state or on its shared borders with Washington and Idaho.**

Combined, hydropower facilities in Oregon generate approximately 21M megawatt hours (MWh) per year, or 39% of the total electricity generated within the state (Oregon Department of Energy 2022). The federally owned dams on the Columbia River operated by the Bonneville Power Administration (BPA) are the state's largest electricity generating facilities. Smaller federally and privately owned facilities dot the rivers of the Cascade Range. See Figure 37.

FIGURE 37. HYDROPOWER GENERATION FACILITIES BY CAPACITY AND LOCATION



Source: Northwest Power and Conservation Council (NPCC) 2023.

Three investor-owned utilities (Pacific Power, Portland General Electric and Idaho Power) deliver approximately 67% of electricity to Oregon residents, industries and businesses. All have a significant amount of hydropower in their generation portfolios. Portland General Electric has the largest share, approximately 18% of the electricity it provided in 2020 was generated by hydropower. Pacific Power has less than 6%. Eugene Water & Electric Board owns three hydropower plants which generated over 9% of its 2020 portfolio; BPA-supplied power (including hydropower) provided another 85%. (Oregon Department of Energy, n.d.)

With this generation capacity, it is unsurprising that hydropower provides a considerable portion of the energy *consumed* in Oregon. Electricity makes up 45% of the total energy consumed in Oregon; hydroelectricity accounts for nearly 39% of this amount, or 53.8M MWh. Oregon's commercial and industrial sectors rely on electricity for 29% and 20% of their energy consumption, respectively. With the prominence of hydropower within the electrical power portfolio, there is a clear linkage between hydropower and Oregon's overall economic health. Thirty-four percent, or 10.9M MWh, of the hydropower generated electricity in Oregon is exported into neighboring states or the national grid. (Oregon Department of Energy 2022)

4.5.2 Hydropower's Economic Contribution

As an industry sector, hydropower generation produces its own direct and indirect economic outcomes, both at a statewide level and within several of the regions examined through this report. Combined across all types, the electricity generation sector in Oregon employed 10,196 people in 2021, 1,529 of them at hydropower facilities (Oregon Department of Energy 2022). Data available through the Bureau of Labor Statistics (BLS) measures the effect of 47 hydropower facilities within the state (see Table 19) These data suggest that hydropower facilities employ 1,429 people across the state, in line with the Oregon Department of Energy identification of 1,589 hydropower full-time equivalent employees.[15] The distribution of hydroelectric facilities in the north and western regions of Oregon provide important contribution to local economies.

TABLE 19. HYDROELECTRIC POWER ESTABLISHMENTS BY REGION

Region	Hydroelectric Power Facilties	Privately Owned	Publicly Owned	Employment	Total Annual Wages ($M)
WV/L Col	22	9	13	993	—
Central	7	2	5	46	$7
Unknown	7	1	6	8	$11
Blue Mt/NE	4	3	1	-	$2
SW	4	2	2	17	$1
Col Plat	3	-	3	78	$125
Oregon	47	17	30	1,429	$180

Source: BLS 2022.

4.5.3 Hydropower Impacts and Mitigation Investments

Hydro-electric power is often celebrated as a carbon-free, renewable energy source. However, its environmental impacts should not be overlooked as they point to opportunities for investments that improve hydropower management and the overall health of Oregon rivers.

Accelerating concerns about carbon emissions have prompted deeper analysis of hydropower's contribution of carbon to the atmosphere. Microbial action in reservoirs and decay of algae and plant matter in impoundments releases carbon, however, there is considerable uncertainty about the scale of these emissions. Research indicates that hydropower induced emissions could account for a range of 0.14% to 6.6% of global carbon emissions, a range that points to the need for refined analytical tools and further research (Oak Ridge National Laboratory, n.d.). Improved information about hydropower carbon emissions can be important to efforts to secure additional funding for mitigation measures.

More dramatically, and obviously, construction and operation of hydropower facilities have significant impacts on riverine hydrology and ecosystems. Of relevance for this report and the operation of Oregon hydropower, dams and hydroelectric power infrastructure have had a strongly negative impact on native salmon and other fish populations over time. (e.g., Northwest Power and Conservation Council

[15] Given the discrepancy between federal and State of Oregon facility counts, it's possible that the data presented in Table 19 underrepresents the full economic effects of the hydroelectric sector in Oregon.

(NPCC), n.d.). It is beyond the scope of this report to deeply discuss these impacts and the complex inter-governmental, Tribal and private sector efforts to manage the protection and restoration of Oregon's salmon runs. Relevant to this report are the considerable expenditures made by those sectors to restore salmon habitat, from coastal wetlands to forested headwaters, and the economic signature of those investments. A more detailed exploration of the economic benefits of some types of restoration investments is included within several case studies in this report (see Section 7 through 14 below).

4.5.4 Climate Resilience Investments

Dam safety is a substantial concern in Oregon. OWRD has rated 76 dams in Oregon as "high hazard," with another 151 rated as "significant concern." Publicly available information suggests that several hydropower facilities fall within these categories. (OWRD 2023a)

In recent years, OWRD's Dam Safety Program has benefitted from increased budget and staffing resources, and the state compares favorably to national averages for regulatory investment (Association of State Dam Safety Officials 2022). More resources for the program would improve the State's ability to track dam safety concerns and prioritize response. Critically, additional funding from state, federal and private sources are necessary to rehabilitate or replace hazardous hydroelectric dams.

4.6 Thermoelectric Power Generation

Compared to the number of hydroelectric generating facilities, Oregon has relatively few thermoelectric generation stations. There are 13 natural-gas fired facilities, several with multiple generating units, located within the state; with the exception of a small facility near Corvallis and a larger one near Klamath Falls, all are located on or near the Columbia River along Oregon's northern border (Northwest Power and Conservation Council (NPCC) 2023). These plants rely on consistent supplies of fresh water for cooling and steam generation. Water withdrawals from rivers, as well as discharges of heated water, can have adverse effects on aquatic fish and habitat. (Mehaffey, Neale, and Horvath 2017).

Despite their small numbers, thermoelectric generating facilities produced approximately 20M MWh in 2020, or about 30% of the electricity generated within the state. Oregon power producers also exported approximately 7.5M MWh of natural gas fueled electricity in 2020 (Oregon Department of Energy 2022). In addition, the State's thermoelectric facilities are important contributors to the State and regional economies. In 2022, natural gas fired power plants directly employed nearly 500 Oregonians, with most of these positions concentrated in the Willamette Valley/Lower Columbia and Columbia Plateau (Table 20).

Table 20: Thermoelectric Generation Employment Distribution and Outputs

Region	Total Output ($M)	Total Employment	Labor Income ($M)	Value Added ($M)
Oregon	$368	206	$58	$198
Col Plat	$278	154	$45	$151
WV/L Col	$90	52	$13	$47

Source: BLS 2022.

4.6.1 Thermoelectric Generation Impacts on Oregon Rivers

Natural gas fired generating plants require water for two purposes. First, these facilities burn gas to convert water to steam which then spins the electricity-producing generators. Second, they typically use water as part of their cooling system, reconverting steam to water and cooling. To varying degrees, thermoelectric power plants consume a portion of this water, with the amount of consumption (loss) generally depending on the type of cooling technology employed. Facilities employing evaporative cooling towers withdraw less water, but more of it is consumed. Conversely, plants that rely on once-through cooling withdraw more water but consume less of it through the cooling process. In addition, these plants can release significant amounts of highly heated water into rivers, with negative impacts to aquatic ecosystems (Mehaffey, Neale, and Horvath 2017). Advances in cooling technology, such as dry cooling, have the potential to reduce the impacts of thermoelectric generation on rivers and other water bodies.

Three of the Oregon regions described in this study are home to thermoelectric power generation facilities, all of which withdraw surface water or use water provided by a local public agency as part of closed-loop cooling systems (Table 21).

TABLE 21. FRESH WATER WITHDRAWALS AND CONSUMPTIVE USE BY THERMOELECTRIC FACILITIES

Region	Surface-Water Withdrawals (AF)	Deliveries from Public Supply (AF)	Consumptive Use (AF)	Facilities (#)
WV/L Col	4.6	0.0	4.6	3
SW	0.0	1.6	1.2	1
Col Plat	25.5	12.3	36.1	5

Source: Harris and Diehl 2021.

Climate change forecasts raise the possibility of increased drought conditions in Oregon, which may strain the availability of water for power plant operations while simultaneously increasing impacts on Oregon's freshwater ecosystems. Scarcity of water resources may lead to conflicts between electric power generators and other users, particularly agriculture (USDOE 2018). Investments in cooling technology advancements, improved water management strategies, and state agency governance and analysis capabilities may become important to reduce future impacts and conflicts.

4.7 POTABLE WATER USE

This section characterizes water use by households and business for drinking water and sanitation purposes, as well as the water systems that provide these services. Data used to characterize water systems in Oregon — and understand where opportunities may occur for investments that help secure the state's potable water resource — come primarily from the Safe Drinking Water Information System (SDWIS) database (EPA 2023).

The EPA has classified three types of water systems that provide potable water in the US, each of which have distinct user bases:

- "Community Water System (CWS): A public water system that supplies water to the same population year-round.
- Non-Transient Non-Community Water System (NTNCWS): A public water system that regularly supplies water to at least 25 of the same people at least six months per year. Some examples are schools, factories, office buildings, and hospitals which have their own water systems.
- Transient Non-Community Water System (TNCWS): A public water system that provides water in a place such as a gas station or campground where people do not remain for long periods of time." (EPA 2022)

Table 22 summarizes the population served by each of the types of water systems in Oregon.

TABLE 22. WATER SYSTEMS IN OREGON

Water System	Quantity	Population Served
CWS	933	3,611,475
NTNCWS	347	91,982
TNCWS	1,258	181,922
Total	2,538	3,885,379

Source: EPA 2023.

CWS serves the largest population, representing 93% of the population served in the data. The remaining 7% of the population are served by NTNCWS and TNCWS, which together account for 63% of total systems in service. This population is not the same as the population of water users in Oregon, which is larger. This is partly because one key user group is excluded from SDWIS (but is explored separately in Section 1.6) — those who self-supply their water, typically from wells or perhaps surface water sources like springs. Of the population served by water systems, CWS serve the most people.

Water systems are divided into different size categories by SDWIS according to the number of people they serve. These are:

- **very small systems**, serving less than 500 people;
- **small systems**, serving 501–3,300 people;
- **medium systems**, serving 3,301–10,000 people;
- **large systems**, serving 10,001–100,000 people; and
- **very large systems**, serving more than 100,000 people.

These three water system types describe complete systems for collecting, treating and distributing water and can be made up of many different components, called facilities.[16] In Oregon, there are 2,538 water systems made up of 13,961 facility types, which provides a sense for the quantity and different forms of infrastructure that compose these systems.

[16] Facility types: clear well, common headers, consecutive connection, distribution system/zone, infiltration gallery, intake, non-piped, other, pump facility, reservoir, roof catchment, sampling station, spring, storage, treatment plant, well.

4.7.1 Community Water Systems

Providing water year-round to communities and serving 93% of the population arguably makes CWS the most important type of EPA-defined system.

Fundamentals

These systems supply water year-round to the primary residences of more than 3.6M Oregonians, or 95% of the population served by water systems. CWS are owned by different entities and operate at different scales (Table 23).

TABLE 23. COMMUNITY WATER SYSTEMS (N=933) BY OWNER TYPE AND POPULATION SERVED

Community Water System Owner	System Ownership (%)	Total Population Served (#)	Avg. Population Served (# per System)
Private	61%	172,842	303
Local Government	37%	3,425,131	9,871
Native American	1%	6,036	1,006
Federal Government	1%	1,366	273
Public/Private	<1%	5,150	1,717
State Government	<1%	1,366	475

Source: EPA 2023.

Note: Due to the method of aggregation in SDWIS, the share of Native American water systems presented here is undercounted. Looking instead at "primacy," another way of understanding who has control over the water, Tribal primacy increases the figures from 6 CWS to 9 CWS (+50%), and population supported from 6,036 to 6,916 (+15%).

Understanding the relative size of each CWS provides insight into the number of discrete systems (Table 24) and the population supported by each (Table 25).

TABLE 24. COMMUNITY WATER SYSTEMS (N=933) BY SYSTEM SIZE AND OWNERSHIP

CWS Size	Federal Government	Local Government	Native American	Private	Public/Private	State Government
Very Small	<1%	13%	<1%	56%	<1%	<1%
Small	<1%	13%	<1%	4%	-	<1%
Medium	-	5%	<1%	<1%	<1%	-
Large	-	6%	-	<1%	-	-
Very Large	-	<1%	-	-	-	-

Source: EPA 2023.

TABLE 25. POPULATION SERVED BY COMMUNITY WATER SYSTEMS

CWS Size	Federal Government	Local Government	Native American	Private	Public/Private	State Government
Very Small	<1%	1%	<1%	2%	<1%	<1%
Small	<1%	5%	<1%	1%	-	<1%
Medium	-	8%	<1%	1%	<1%	-
Large	-	47%	-	1%	-	-
Very Large	-	33%	-	-	-	-

Source: EPA 2023.

Another important variable that illustrates the distinct water resource challenges faced by CWSs is the water source (Table 26).

TABLE 26. CWS WATER SOURCE AND POPULATION SERVED

Water Source	Population Served
Groundwater	871,077
Groundwater	822,282
Groundwater purchased	8,563
Groundwater under influence of surface water	40,232
Surface water	3,014,302
Surface water	2,031,123
Surface water purchased	983,179
Total	3,885,379

Source: EPA 2023.

Surface water and groundwater sources face different challenges that influence the quality and quantity of the supply, including land use change, population growth and the effects of climate change.

4.7.2 Non-Transient Non-Community Water Systems

These water systems are often attached to critical facilities like schools, daycare facilities, nursing homes, prisons, and hospitals. NTNCWS regularly provide water to the same 25 or more people each day for at least six months out of the year. This also includes places of work and leisure, like factories, office buildings, large hotels and resorts and restaurants. Much of an individual's water use occurs outside the home; the NTNCWS designation was created to protect against any health effects of long-term water consumption outside the home. (Baltay 1987)

Fundamentals

These 347 systems serve 2% of Oregon's population. However, because NTNCWS are regular sources of water supply for people outside the home, their water quality and quantity carry great potential for impacts to human health and critical services.

NTNCWS provide water on an intermittent basis to different people and are characterized by the small business community. Collectively, they are owned by different entities and operate at different scales (Table 27).

TABLE 27. NTNCWS (N=347) BY OWNER TYPE AND POPULATION SERVED

NTNCWS Owner	System Ownership (%)	Total Population Served (#)	Avg. Population Served (# per System)
Private	53%	33,310	181
Local Government	36%	37,650	299
Federal Government	5%	2,855	159
Public/Private	2%	488	70
State Government	2%	3,776	539
Native American	1%	13,903	2,781

Source: EPA 2023.

Note: Due to the method of aggregation in SDWIS, the share of Native American water systems presented here is undercounted. Looking instead at "primacy," another way of understanding who has control over the water, Tribal primacy increases the figures from 5 NTNCWS to 6 NTNCWS (+20%), and population supported from 13,903 to 13,973 (+.5%).

Understanding the relative size of each NTNCWS provides insight into the number of discrete systems (Table 28) and the share of the population supported by each (Table 29). As with CWS, local government NTNCWS and private CWS make up most systems, and they skew small (no large or very large systems exist).

TABLE 28. NTNCWS (N=347) BY SYSTEM SIZE AND OWNERSHIP

NTNCWS Owner	System Ownership (%)	Total Population Served (#)	Avg. Population Served (# per System)
Private	53%	33,310	181
Local Government	36%	37,650	299
Native American	1%	13,903	2,781
Federal Government	5%	2,855	159
Public/Private	2%	488	70
State Government	2%	3,776	539

Source: EPA 2023.

Note: No large or very large NTNCWS exist, and are omitted from the table

TABLE 29. POPULATION SERVED BY NTNCWS BY SIZE

NTNCWS Size	Federal Government	Local Government	Native American	Private	Public/Private	State Government
Very Small	1%	24%	<1%	24%	1%	1%
Small	2%	17%	7%	12%	-	4%
Medium	-	-	8%	-	-	-

Source: EPA 2023.

Note: No large or very large NTNCWS exist, and are omitted from the table

Another important variable that illustrates the distinct water resource challenges faced by NTNCWS is the water source (Table 30). Of note here is that — in contrast to CWS which skews heavily towards surface water — NTNCWS skews heavily towards groundwater, which could inform different investment strategies.

TABLE 30. NTNCWS WATER SOURCE AND POPULATION SERVED

Water Source	Served
Groundwater	74,992
Groundwater	70,918
Groundwater purchased	2,474
Groundwater under influence of surface water	1,600
Surface water	16,990
Surface water	14,548
Surface water purchased	2,442
Total	91,982

Source: EPA 2023.

Additionally, SDWIS tracks water systems that support schools, which are in the domain of NTNCWS. Investments that protect these systems protect the wellbeing of students and teachers (Table 31).

TABLE 31. SCHOOLS AND POPULATION SUPPORTED BY NTNCWS

NTNCWS Owner	Schools (#)	Population Served (#)
Local Government	120	35,436
Private	35	5,382
Public/Private	3	320
State Government	3	3,490

Source: EPA 2023.

Note: Native American and Federal NTNCWS do not serve any schools.

4.7.3 Transient Non-Community Water Systems

These water systems provide water to 25 or more different people on an intermittent basis for at least 60 days out of the year. This contrasts with the CWS (year-round, regular water provision to the same people) and with the NTNCWS (half-year, regular water provision to the same people). The intermittent nature of water provision and rotating population served by TNCWS mean that, relative to the other types of systems, any human health impacts or service disruptions to the population of people “just passing through” are likely to be minimal. TNCWS are not critical facilities or primary residences, and so it is the business community that owns these systems who would feel losses associated with service disruptions most acutely. Examples of TNCWS include smaller businesses: gas stations, hotels, campgrounds, rest areas and restaurants with their own water supplies (Washington State Department of Health n.d.).

Fundamentals

These 1,258 systems only serve 5% of the population according to SDWIS. However, this category of water system is dominated by small businesses — a frequent target of investments to support local and regional economic activity — so TNCWS may be ripe with opportunities for a certain type of investor to build resilience to water resource challenges in the business community.

As with the other water systems, TNCWS are owned by different entities and operate at different scales. Altogether, 1,258 systems serve a total population of 181,922. As mentioned, TNCWS are dominated by private owners, who account for two-thirds of systems (n=839) and half the total population served (91,314). TNCWS are the smallest of the three water system types. Of all 1,258 systems, they are all classified as very small or small, meaning they serve under 3,300 people.

4.8 Water System Facilities

The resiliency or vulnerability of a water system depends on its component parts. There are 2,538 water systems statewide made up of 13,961 unique facilities (Table 32).

Table 32. Component Facility Types of All Water Systems

Facility Type	Quantity
Treatment Plant	3,150
Well	3,069
Sampling Station	2,883
Distribution System/Zone	2,545
Common Headers	1,620
Intake	277
Spring	171
Consecutive Connection	154
Storage	43
Non-Piped	19
Pump Facility	12
Infiltration Gallery	11
Other	4

Source: EPA 2023.

Note: Roof catchment, reservoir and clear well (all n=1) were omitted from this table

After identifying a threatened water system (or group of systems) according to population served, ownership type, potential funding source and the set of water resource challenges relevant to the source water supply, a next step would be to understand the component parts of each targeted system. These components — called facilities — will be affected differently by different water resource challenges and will map to different investment opportunities that act on each of the facility types and water resource challenges.

- **Treatment plants** are the most common facility type. Investments in maintaining, expanding or modernizing these helps to protect water quality and limit the risk of boil water advisories or other disruptions to the system's ability to supply clean water for commercial and household use. Many communities, small and large, depend on treatment plants, and investing in them supports water security.
- **Wells** are the next most common facility type, drawing on groundwater sources to provide potable water to those that depend on the water system. These are vulnerable to groundwater contamination, and connecting smaller systems to comprehensive water quality testing and

treatment capability may be expensive or otherwise difficult, suggesting an investment opportunity.

- **Intakes** draw water from above-ground sources like reservoirs and lakes. Raw water entering the water system via these intakes may be more vulnerable to the impacts of algal blooms than swiftly flowing water. This hazard is driven by temperature and excess nutrients like nitrogen and phosphorus runoff from agricultural lands that can cause service disruptions (Alliance for the Great Lakes, 2019). Potential investments to protect raw water quality at key intake sites include incentive or subsidy programs for edge of field nutrient management BMPs.
- **Springs** occur where groundwater bubbles up and reaches the surface and can be dependable sources of clean water. Restoration or preservation of the land around these sites is one example of an investment to preserve source water before it is degraded.
- **Storage** can take different forms — covered reservoirs, storage tanks and more. These are designed to disburse water through the water system by maintaining sufficient water pressure, meet fluctuating demand and to hold an emergency supply of water. Like all built infrastructure, these have a limited useful life and may require periodic major maintenance that may present affordability concerns for some water systems. Investments in storage capacity can support water quality and sufficient supply.

4.9 Private Water Supply

As previously mentioned, the SDWIS dataset omits one key user group: those who self-supply their water from groundwater or, less commonly, surface water. Since these individual water users are not part of a public water system covered by SDWIS, it is necessary use a USGS dataset to gain basic insight into the domestic, self-supplied water users in Oregon (Dieter et al. 2018). The source is dated — 2015 — but is the best available data. The ratio of public water supply users to domestic, self-supplied water users with the given population in this dataset are applied to updated population estimates to provide an estimate of the total population served by private supply (Oregon Secretary of State 2022). This fills an important gap by providing a sense of the number of domestic, self-supply water users relative to the populations served by the public water systems outlined in the prior sections.

Domestic, self-supply water users are a distinct population from the populations served by the CWS, NTNCWS, and TNCWS public water systems described in earlier sections (Table 33).

Table 33. Public Water Systems in Oregon Plus Domestic Self-Supply

Water System	Population Served (#)	Population Served (%)
CWS	3,611,475	79%
NTNCWS	91,982	2%
TNCWS	181,922	4%
Domestic Self-Supply	667,793	15%
Total	4,553,172	—

Source: EPA 2023; USGS 2018.

Including domestic-self suppliers in the total population served in Oregon reveals that they are a large user group unaccounted for in SDWIS. Altogether, domestic self-supply serves a population that is nearly 2.5 times greater than the populations served by NTNCWS and TNCWS combined. [17]

Domestic self-suppliers draw their water from the same source waters as public water systems. Consequently, they face the same challenges to the quality and quantity of their supply, and these are highly site dependent. However, as individuals, they have no economies of scale, shouldering the cost burden for any maintenance, on-site water treatment or water quality monitoring.

> **Arguably, domestic self-suppliers are the most vulnerable of all the water users in Oregon. Domestic self-supply presents a unique set of challenges which are magnified for Oregon's lower income population.**

4.10 Regional Summary

This section provides summary statistics by region from SDWIS and USGS and is followed by selected insights into regional patterns of water use that contextualize and interpret these tables. Table 34 provides a snapshot of the number and size of public water systems by region. This table reveals that regions with high populations have a higher count of water systems and regions with lower populations have a lower count of water systems.

Table 34. Count of System Size by Region

Region	Very Small	Small	Medium	Large	Very Large	Total
N Coast	112	29	6	3	-	150
WV/L Col	1,034	104	23	38	4	1,203
Col Plat	146	24	7	3	-	180
Blue Mt/NE	57	11	2	1	-	71
Central	285	35	6	5	-	331
SE	52	8	-	1	-	61
SW	491	33	12	6	-	542

Source: EPA 2023.

Table 35 provides a snapshot of the share of a region's population served by all public water systems. These data show how relatively important to a region public water systems of different sizes are by normalizing for population. Very small public water systems serve 12%–16% of the population in all regions but Willamette Valley/Lower Columbia, which leans on large and very large systems to serve

[17] The population as of 2022 in Oregon is 4,268,055 (Oregon Secretary of State 2022), so the total population served in Table 33 exceeds the state's population. Reasons for this may include:

Double counting: some people supplied by CWS may also show up if they work in an office building supplied by an NTNCWS.

Mixing data sources: combining two different data sets from two different years will produce inconsistencies. Despite this, the data from the USGS source broadly track with the data from SDWIS, and though there are error bars of unknown size around the total population served by domestic self-supply, it is likely that it is the second largest water system by population served.

water to 86% of the population. Most of the population in the Blue Mountains/NE, Columbia Plateau, North Coast and Southeast regions get their water from systems that serve under 10,000 people.

TABLE 35. SHARE OF REGIONAL POPULATION SERVED BY SYSTEM TYPE

Region	Very Small	Small	Medium	Large	Very Large
N Coast	12%	30%	27%	31%	0%
WV/L Col	4%	5%	5%	43%	43%
Col Plat	16%	18%	31%	35%	0%
Blue Mt/NE	15%	25%	34%	26%	0%
Central	12%	15%	11%	62%	0%
SE	14%	43%	0%	43%	0%
SW	12%	12%	19%	57%	0%

Source: EPA 2023.

Table 36 provides a snapshot of each region's relative dependence on public water systems vs. domestic self-suppliers. The percentage of self-supply in the SE region is notable and is discussed in further detail below in the Southeast Regional Case Study (Section 12). This table reveals how much different regions rely on domestic self-supplied water sources instead of the public water sources described in SDWIS. This is an important distinction because it is connected to agriculture and groundwater depletion, as most domestic self-supply comes from groundwater rather than surface water. The Willamette Valley/Lower Columbia region, with its large population and large and very large water systems is one of the least dependent on domestic self-supply, along with the North Coast region. On the other side of the spectrum, regions with a significant agricultural presence like the Southeast (38% domestic self-supply), Blue Mountains/NE (28%) and Southwest (28%) are relatively more dependent on domestic self-supply and thus groundwater, implying investments to support the quantity and quality of groundwater resources in these areas might be relatively more important.

TABLE 36. REGIONAL RELIANCE ON DOMESTIC SELF-SUPPLY VS. PUBLIC WATER SYSTEMS

Region	Domestic Self-Supply	Public Water Systems	Domestic Self-Supply
N Coast	9,741	104,549	9%
WV/L Col	379,902	2,694,413	12%
Col Plat	35,226	117,254	23%
Blue Mt/NE	16,013	42,212	28%
Central	64,071	248,564	20%
SE	17,968	29,492	38%
SW	144,873	363,777	28%

Source: USGS 2018.

Returning to public water systems, Table 37 provides a snapshot of each region's relative dependence on groundwater vs. surface water sources. This table highlights that four of the five public water systems in the regions with the lowest population rely most heavily on groundwater sources (the exception is the North Coast region), largely mirroring the regions that are relatively more dependent on domestic self-supply. This is likely due to a combination of population density and ability to extend public water systems to multiple connections, differences in hydrology and recharge rates and availability of surface water sources. These regions that rely least on public water systems drawing on groundwater sources are in the wettest regions of Oregon west of the Cascade Range: North Coast, Southwest and Willamette Valley/Lower Columbia.

TABLE 37. POPULATION SERVED BY PUBLIC WATER SYSTEMS AND RELIANCE BY WATER SOURCE

Region	Total Population	Served by Groundwater Source	Served by Surface Water Source
N Coast	133,519	17%	83%
WV/L Col	2,824,955	14%	86%
Col Plat	139,584	63%	37%
Blue Mt/NE	52,673	60%	40%
Central	291,295	75%	25%
SE	33,726	57%	43%
SW	409,627	14%	86%

Source: EPA 2023.

4.11 OTHER WATER VALUES

This section describes the benefits of water uses that either 1) do not fall neatly into a single industry sector (e.g., golf courses, navigation and transport); 2) represent only a portion of an industry sector (e.g., freshwater aquaculture); or 3) require non-market valuation approaches to estimate. Unless otherwise noted, all dollar values are presented in constant 2022 dollars ($2022)

4.11.1 Spiritual and Symbolic Values

Individuals and communities hold different spiritual and symbolic values for rivers, lakes, wetlands, coastal areas and other water bodies and simply for water itself. Spiritual and symbolic water values play a critical role in many people's and communities' lives and well-being but are difficult to quantify. Even attempting to quantify these benefits would defeat the purpose to some; spiritual and symbolic values are related to one's sense of place, one's happiness and other intangible, subjective feelings. Nonetheless, the spiritual and symbolic value provided by clean, plentiful water is of critical importance to Oregon. When many people, both Oregonians and others, think of Oregon, rivers, rain, lakes and coastlines are among the first things that come to mind. This water symbolism has become an integral part of Oregon's reputation and sense of place.

As an example, Oregon has more miles of federally designated Wild and Scenic Rivers than any other state in the nation (Oregon Wild 2021). One the one hand, this has immense symbolic value. It symbolizes that Oregon, perhaps more than anywhere else, places great importance in preserving rivers in as close to a natural state as possible. In turn, this symbolic value likely attracts visitors who spend money in the state. Oregon was also the first state in the nation, in 1987, to enact comprehensive instream water rights legislation allowing for creation of legal water rights to protect flowing water; this led to the creation of the first *water trust* in the nation in 1993 (the Oregon Water Trust), an organization dedicated to creating instream water rights to protect fish and other natural values. Taken together, these are additional indications of the value Oregonians and their elected officials have long placed on the existence of and symbolism surrounding streams, rivers and lakes. A final example of the symbolic power of water is the oft-repeated phrase in farming and ranching communities that water is the "lifeblood" of a community; that water is "like gold;" or that water, simply put is "life."

4.11.2 Ecological Function Values

Water resources also provide regulating and supporting services — or benefits derived from ecosystem processes or ecological function. These include, but are not limited to:

- climate regulation;
- erosion control;
- flood protection;
- habitat;
- water filtration; and
- wildfire prevention.

While these benefits create and provide real and quantifiable value, the benefits are not readily traded and valued in markets (i.e., non-market goods/services) and therefore their value has to be estimated. If their value is not estimated, these benefits are essentially assigned a value of zero and may be, in essence, ignored in economic valuations as well as policy, regulatory and decision-making processes which rely on those valuations.

As described in Section 3.2.2 above, there are methods for estimating the value of these non-market benefits. In cases where primary data collection is not an option, estimates can be assigned through benefits transfer — the valuing of a non-market goods at a site of interest through an estimate developed for a different site. FEMA regularly produces a report on the value of different land cover types with an understanding that nature-based solutions often provide ecosystem services that mitigate the natural disasters to which the agency responds. While these numbers are generalized to the greater US, key water-dependent land covers in Oregon, such as riparian land cover, wetland and forest currently are valued at $32,643, $5,361 and $3,767 per acre per year (Table 38).[18]

[18] FEMA's estimates also include aesthetic, existence and recreation/tourism value estimates of the land cover, which, in this report, are included in other sections. Values associated with these benefits, therefore, have been removed from the estimates presented in this section.

TABLE 38. VALUE OF ECOSYSTEM SERVICES BY LAND COVER TYPE

Ecosystem Service	Value ($/acre/year)		
	Riparian	Wetland	Forest
Climate Regulation	$104	$60	$215
Erosion Control	$14,933	-	$1,806
Flood & Storm Hazard Reduction	$6,538	$1,365	$398
Habitat	$2,751	$1,530	-
Water Filtration	$6,740	$1,711	$470
Water Supply	$294	$695	$111
Other Ecosystem Services	$1,283	-	$767
Total	$32,643	$5,361	$3,767

Across the Oregon landscape, wetlands cover nearly 20,000 acres and forests cover nearly 36,000 acres. Riparian land cover is abundant surrounding the State's miles of river and lake coastlines, which are not valued by FEMA. Based on the FEMA estimates, ecosystem services provided by water-dependent land covers in Oregon — not including the water resources themselves — would be valued in the billions.

One Oregon-specific valuation is consistent with the FEMA estimates — estimating the ecosystem service-related benefits of the Columbia River Basin alone at $189.9B. Forests and rivers were valued at approximately $3,200/acre and almost $20,000/acre, respectively. It is worth noting that the values vary drastically depending on the site assessed. For example, wetlands in this study were valued between $11,000/acre and $140,000/acre, underscoring the variation that could occur for site-specific valuations of ecosystem services.[19]

4.11.3 Tribal Values

Tribal values for water in many ways mirror many other values discussed in this section. Tribes need water for drinking, for irrigating crops and golf courses, watering livestock and for use in industries and power generation. Tribes also rely on healthy water bodies to support aquatic species for sustenance, spiritual and cultural reasons. For many Tribes, water, fish or both play important roles in their origin stories and in ceremonies and culturally important practices still in place today (see Section 5 below for a fuller discussion of Tribal water values and connections).

4.11.4 Aquaculture Values

Aquaculture is defined as the controlled cultivation of aquatic organisms for commercial purposes; however, fish hatcheries designed to breed and rear fish for eventual release (whether for commercial or other purposes) also fall under this USGS water use category.

The majority of commercial aquaculture in Oregon occurs along the coast and focuses on production of cultured shellfish (i.e., clams and oysters). Freshwater aquaculture is an out-of-stream but non-consumptive use — moving water into tanks or ponds for rearing fish and other aquatic species. At

[19] Values are inclusive of aesthetic and recreation and tourism benefits, which could not be removed based on the data as presented in the report.

present, commercial freshwater aquaculture in the state is relatively limited in both scope and scale. The primary fish grown for human consumption is trout, while other species including finfish, shellfish and aquatic plants are grown and sold as stock for other water bodies (e.g., private pond).

In 2021, fish sales by private hatcheries were reported by fewer than 20 farms and of the 1.3 million fish sold, 87% were Eastern Brook Trout sold by a single farm (ODFW 2022). Given this market dominance by a single farm, the USDA annual report on trout production withheld information for the State in order to avoid disclosing data for individual operations.

The Oregon Department of Fish and Wildlife (ODFW) operates more than 30 fish hatcheries along with additional rearing, acclimation and trapping facilities. Most of these hatcheries raise salmon and steelhead to support species restoration and sport as well as commercial and Tribal fisheries. In 2021, over 40 million fish were raised at ODFW facilities alone (ODFW 2022). There are also private, Tribal and federally run hatcheries in the state. In addition, fish hatcheries are popular tourist destinations. Bonneville Hatchery, the largest run by ODFW, receives over 1M visitors per year (ODFW n.d.).

4.11.5 Navigation and Transport Values

Inland waterways play a pivotal role, not just in Oregon, but globally, in facilitating trade among different regions and transporting locally grown and processed agricultural products, raw materials and manufactured goods from the State’s (and neighboring states’) interior to coastal ports. While the economic value of the goods and products moved through the waterways, as well as that of the vessels used to move them and the ports through which they move, the value of the waterways themselves is not captured in that information.

The US Army Corps of Engineers (USACE) is the federal agency responsible for managing and maintaining inland waterways for use as a transportation system. One USACE Coastal Navigation District is the Portland District, which includes ports in both Washington and Oregon primarily along the Columbia River. The USACE estimates the annual National Economic Development (NED) benefit of their work, which in the case of the Portland District is largely associated with “transportation cost savings realized from the more efficient use of existing and larger vessels” compared to pre-project conditions. In 2020, the NED benefit estimate for the Portland District was $259M. (USACE 2020)

4.11.6 Aesthetics – Property Values

While some aesthetic benefits of water resources fall under other benefit categories such as recreation and tourism (e.g., driving the Columbia River Gorge) or non-use values (e.g., knowing that Crater Lake exists), water resources also generate aesthetic benefits to property values. Numerous studies have confirmed that proximity to water generally has a positive, and often significant, impact on residential property values (see Nicholls and Crompton 2017; Rouwendal, Van Marwijk, and Levkovich 2014 and references therein). The degree of impact, however, may be influenced by several factors — the location, water body type, distance to the water body, etc. The value of properties on or near water bodies has also been shown to positively correlate with water quality (Nicholls and Crompton 2018)

4.11.7 Golf Courses

While golf contributes economic value in a variety of ways that can be measured using market information (e.g., purchase of golf clubs, golf course fees, etc.), the sport, and in particular golf courses, are distinct from other water-related recreational activities in two ways: 1) the water is used out-of-stream; and 2) much of the water withdrawn is consumptively used (i.e., evapotranspiration by grass or other plant materials on a golf course make the water unavailable for immediate use by others).

In 2020, the National Golf Foundation (NGF) assessed the contribution of golf to the State. At that time, Oregon had 177 golf facilities. These facilities collectively supported over $1.8B in total annual economic impact (i.e., direct, indirect and induced) and more than 16,500 jobs. In addition, they contributed more than $78M to local and state taxes. (National Golf Foundation 2020)

A survey conducted by NGF as part of that same effort found that:

- in the past five years, almost one-quarter of facilities had conducted an irrigation audit; and
- over half of those conducting an audit (57%) made adjustments to their irrigation system and/or practices, resulting in an average decrease of 9% in total water use. (National Golf Foundation 2020).

These findings suggest growing awareness and concern regarding water usage in the industry. The same study reported average annual water use of 43.7 million gallons per facility or approximately 134 AF; however, 2019 was also a notably wet year. The most recent point of comparison is a 2014 study, which estimated average annual water use from 2011-2013 of 147 AF per course.

5 Water and Oregon Tribes

Before presenting this discussion, it is critical to acknowledge that the information in this section is drawn from publicly available sources and presents a non-Tribal perspective and interpretation of these materials for the purposes of bringing attention to Tribal cultural and other relationships with water. Where available, the words of Indigenous people are presented without interpretation so that their voices rather than the authors' can be heard.

Water is an essential and integrated part of life for Oregon Tribes and has been forever. In a physical sense, water is critical to sustaining basic health needs, livelihoods and the ecosystems that comprise Oregon's landscapes. Beyond that, however, water is deeply woven into Tribal cultural, spirituality, society, identity and the nourishment of homelands. Broadly speaking, the relationship between Oregon's Indigenous people and water goes beyond viewing water as a resource for human use and is rooted in stewardship, community and reverence.

As a component of the importance of water, the culture, health and well-being of many Indigenous communities in the modern state of Oregon are integrally tied to salmon. In turn, declining salmon populations directly endanger the health and vitality of these communities. Despite the interlinkages between the health of Tribes and salmon populations, there is a general lack of public awareness amongst non-Tribal communities about the scope, nature and value of the identities and practices that are connected to salmon (Earth Economics 2021a). This section aims to offer a general overview of the role that water plays in Tribal cultural practices and perspectives.

This section first provides an overview of the federally recognized Tribes with current reservations and homelands within Oregon (a more detailed, but still high-level summary of each of these Tribes is provided in Appendix D). Next, two examples of Tribal cultural connections to water are highlighted: the First Foods approach to managing natural resources used by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR); and the seasonal food celebrations of the Confederated Tribes of the Warm Springs (CTWS). Finally, a brief discussion of Tribal water rights is presented, highlighting the Tribal water right settlements of the CTUIR, CTWS and the Klamath Tribes.

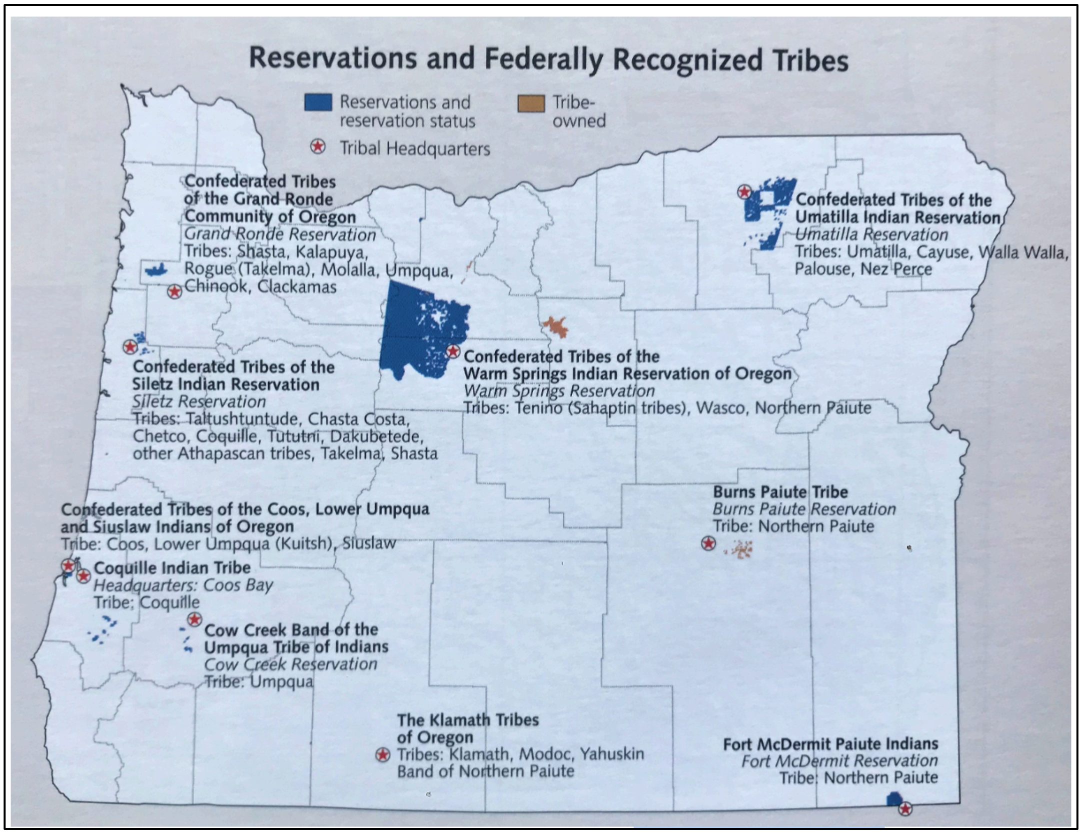
5.1 Overview of Federally Recognized Oregon Tribes

The borders of modern-day Oregon are home to nine federally recognized Tribal nations (Figure 38) as well as several Tribes that are not recognized by the US government. The nine recognized Tribes (hereafter Oregon Tribes) are today comprised of historically distinct bands and communities with common regional homelands and include:

- Burns Paiute of Harney County;
- Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians;
- Confederated Tribes of Grand Ronde;
- Confederated Tribes of Siletz;
- Confederated Tribes of Umatilla Reservation;
- Confederated Tribes of Warm Springs;

– Cow Creek Band of Umpqua Indians;
– Coquille Indian Tribe; and
– Klamath Tribes.

FIGURE 38. FEDERALLY RECOGNIZED TRIBES AND RESERVATIONS IN OREGON



Source: Loy et al. 2011.

In September 2021, Oregon's Tribes signed a joint letter to then-Governor Kate Brown that articulated the extent and importance of Tribal connections to water in Oregon. In their words:

> "Water is sacred. Water is life. Water is the heartbeat of our culture. Our understanding of these truths is based upon a legacy of survival and reliance on our Oregon oceans, rivers and lakes. . . Our tribes and their fisheries lived together before Oregon existed. Our ancestors understood that they had to live in a balanced relationship with oceans, rivers, creeks, lakes, springs, marshes, and the flora and fauna that depend upon them. There was, and is, no other way to survive." (The Nine Sovereign Tribes of Oregon 2021)

The Oregon Tribes also detailed how deep their connection is and has always been with steelhead, salmon, lamprey, suckers and other species:

> "*The extinction of these vital fisheries would equate to the genocide of our people* and the end of our irreplaceable lifeways — because these resources form essential parts of who we are" [emphasis added]. (The Nine Sovereign Tribes of Oregon 2021)

5.2 Water-Related Challenges and Tribal Solutions

Indigenous communities living in Oregon face the same water-related risks as all Oregonians, but due to the relationship of Tribal history, culture and health with water resources and aquatic species, these risks take on special urgency. Many Indigenous people express their connection to water by exercising traditional means of providing for themselves, their families and their communities. The Fourth National Climate Assessment (Reidmiller et al. 2018) noted that a changing climate, "threatens these delicately balanced subsistence networks by, for example, changing the patterns of seasonal timing and availability of culturally important species in traditional hunting, gathering, and fishing areas" (Jantarasami et al. 2018). In addition to dependence on water and natural resources for subsistence, Indigenous people rely on water for economic uses like agriculture, irrigation of parks and recreational facilities like golf courses and hydropower, that may be adversely impacted by changing patterns of precipitation, drought, fire and other climate-driven dynamics (Jantarasami et al. 2018).

Jantarasami et al. (2018) also noted that the interplay of federal, state and Tribal legal frameworks can be a barrier to climate adaptation for Indigenous people. For example, while the ESA is intended to protect species against impacts that can be exacerbated by climate change, the policies can impact Indigenous subsistence economies that rely on the same species. A second relevant example is quantifying and securing water rights for Tribes. Complex overlays of federal and state law determine whether and how much water Tribes are legally entitled to within the framework of western water law.

To underline the importance of water and the risks that Tribes face more broadly, the Fourth National Climate Assessment discussed "certain factors, known as the social determinants of health, [that] are unique and contribute to the increased vulnerability of Indigenous people to adverse and potentially severe or fatal health outcomes," related to climate change (Jantarasami et al. 2018). Put simply, water and salmon are, for many Indigenous people in Oregon, inextricably linked to their individual and community health and longevity.

5.2.1 Cultural Connection to Place and Water

As Oregon's Tribes made clear in their 2021 letter to the governor, the importance of water runs through Tribal culture like threads in a tapestry – each piece contributing to the whole of Tribal history, culture, well-being and way of being. Water plays an integral role in origin stories and beliefs, often providing the medium from which all life arises. In supporting all facets of life, water sustains and nourishes culturally important and sacred foods, around which ceremonies and rituals revolve. Some Tribes also ascribe duties to water itself, moving through rivers, groundwater and oceans to support terrestrial and aquatic plants and animals.

This section provides two examples of ways in which water and salmon are woven into the culture of two Tribes in Oregon, the CTUIR and CTWS, and actions these Tribes are taking to ensure the continued existence of that relationship.

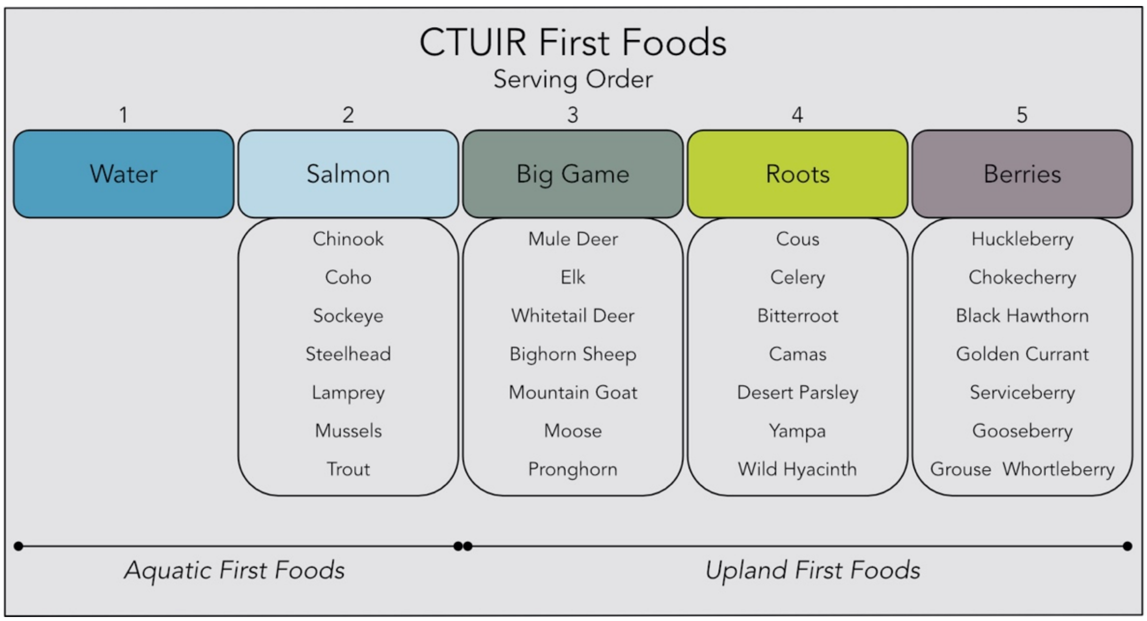
CTUIR First Foods

The Tribe explains their view and connection to water on their website, describing that:

> "Water was created first, life and land were created next, land promised to take care of all life, all life promised to take care of the land. Across generations of the CTUIR, Indigenous people promised to…protect the land and have the responsibility to care for her. Water represents an integral link in a world view where water is sacred and extremely important in preserving precious balance. Water is the origin of and essential for the survival of all life."(CTUIR n.d.)

In the CTUIR creation belief, the Creator spoke to the foods, asking "Who will take care of the Indian people?" Salmon stepped forward first with a promise of care, followed by other fish. Then deer, cous (a type of root) and huckleberry stepped forward. Each of these *First Foods* are grouped with other ecologically related foods and form the basis of the ceremonial and ritualistic serving order of meals (Figure 39) (Jones et al. 2008).

FIGURE 39. FIRST FOODS SERVING ORDER WITH A PARTIAL LIST OF ECOLOGICALLY RELATED SPECIES



Source: Adapted from (Jones et al. 2008; Endress, Quaempts, and Steinmetz 2019)

For CTUIR, the long-term protection of water relies on an ecologically healthy and robust watershed, beginning with the Umatilla River that runs through the Tribe's reservation. From the perspective of the river, a dynamic and healthy watershed is rooted in ecological processes and patterns that support enduring production and utilization of First Foods by the CTUIR community. (Endress, Quaempts, and Steinmetz 2019). In this sense, care of the Umatilla River extends to care of the CTUIR community, and vice-versa. Reliable availability of First Foods, beginning with water and salmon, contributes to the continuation of Tribal ceremonies, knowledge and traditions that support the physical, mental, spiritual and relational health of Tribal members. On the other hand, a degraded river leads to loss and decreasing production and availability of First Foods. A reduction in practices around First Foods is linked to a wider and more severe array of health issues for Tribal and community members (Jones et al. 2008).

Therefore, the CTUIR Department of Natural Resources established a mission focused on caring for the minimum ecological products necessary to nourish CTUIR subsistence and cultural needs (Endress, Quaempts, and Steinmetz 2019). The mission has a long-term goal of restoring a network of related foods to continue community expressions of First Foods traditions, provide a diverse table setting of native foods for the Tribal community and restore First Foods for their respectful use now and into the future (Jones et al. 2008).

CTUIR Department of Natural Resources' mission is:

> "To protect, restore, and enhance the First Foods — water, salmon, deer, cous, and huckleberry — for the perpetual cultural, economic, and sovereign benefit of the CTUIR. We will accomplish this utilizing traditional ecological and cultural knowledge and science to inform: 1) population and habitat management goals and actions; and 2) natural resource policies and regulatory mechanisms." To accomplish this mission and move from concept to application, the CTUIR Department of Natural Resources published a Umatilla River Vision to provide guidance to Tribal and non-Tribal land managers within the Umatilla River and adjacent basins." (Jones et al. 2008)

Today, water is honored first at feasts and recognized as a medicinal source to build both physical and spiritual strength. It serves as both a First Food and provides the nourishment required to support all other First Foods. In essence, it is the source, seed and sustenance of CTUIR culture, traditions, health and future.

CTWS Seasonal Ceremonies

The CTWS' ceremonies and traditions revolve around the recognition that plants, animals and fish require water and that all life forms are more than the nutritional value of the foods they provide. To bring honor to life and the web of connections that sustain life, the Tribe offers ceremonies and prayers of thanks and gratitude to the Creator. These ceremonies also help members share and pass down traditions and knowledge to young members. ("Honoring the Foods: Berries, Salmon, Deer and Roots" n.d.; Altman 2023)

Before annual harvesting of the foods that are central to the Tribe's spiritual and culture heritage, three feasts are held — the Wild Celery Feast (in February), the Salmon and Root Feast (in spring) and the Huckleberry Feast (in mid- to late-summer). These feasts anchor the yearly calendar, pace and rhythm of life. The timing of the feasts varies year to year, based on the prevailing weather, growth cycles of each food and harvest timing. Additional external influences — early snow melt, drought and extreme weather events driven by climate change or river, watershed and ocean conditions — can impact when, where and how much of each food can be harvested. ("Honoring the Foods: Berries, Salmon, Deer and Roots" n.d.; Altman 2023)

By tradition, until the feast is held, the roots, berries and salmon cannot be harvested or eaten. Once the community is gathered in longhouses, a small amount of the food that is to be honored is collected and prepared. Before it is served, water is poured into a glass to call forth the importance of water to all of life. Then the food is served, with everything flowing to the right. In addition to honoring water and food, these ceremonies also help remind people of their individual and collective responsibility and contribution towards protecting, utilizing and preserving the honored foods for current and future generations. ("Honoring the Foods: Berries, Salmon, Deer and Roots" n.d.; Altman 2023)

To further underscore the importance of water and salmon to the CTWS, the Tribe also maintains a Fisheries Department. The department has management responsibilities across the reservation, ceded lands and usual and accustomed stations. Its mission focuses on ensuring fisheries populations remain at harvestable levels and allow Tribal members to exercise their treaty rights of harvest using information gained from research, management and habitat programs within the Fisheries Department. They have also established five goals:

1. Protect and enhance fisheries habitat on the reservation and within the ceded territories to improve carrying capacity of culturally significant aquatic species. Ensure a properly functioning watershed.
2. Monitor natural production of anadromous and resident fish populations on reservation streams and Tribally managed conservation areas throughout the ceded territories. Provide technical support for external organizations and agencies monitoring projects in the ceded territories and usual and accustomed locations.
3. Enhance and supplement populations of Chinook salmon and steelhead trout in streams within the reservation and in coordination with state and federal agencies on streams within the ceded territories and usual and accustomed locations.
4. Improve Tribal resource management capabilities through participation of interagency committees, local watershed councils and soil and water conservation districts. Provide increased communication with reservation fish and wildlife committees, and support at policy forums with Columbia River Inter-Tribal Fish Commission, Columbia Basin Fish and Wildlife Authority, Northwest Power and Conservation Council and Federal Executive meetings.
5. Provide educational outreach opportunities for Tribal members interested in a natural resources field after high school graduation. Provide cross training opportunities for natural resource staff. (Confederated Tribes of Warm Springs n.d.)

5.3 Tribal Water Rights

Legal recognition of Tribal water rights stems from a US Supreme Court decision in 1908, *Winters v. United States* (referred to today as the *Winters* decision)(Anderson 2015). In *Winters*, the Supreme Court described water rights for Tribes as *reserved rights*, meaning that when the federal government created Tribal reservations, it is implied that water rights sufficient to fulfill the purpose of using the reservation as a homeland were reserved (Anderson 2015). These rights generally include water for domestic, municipal and industrial purposes, but also for irrigation. Importantly, some Tribal water rights can include instream flows to support culturally important fish species and treaty-reserved fishing rights (Sudbury 2004).

This section briefly discusses the status of water rights for three of Oregon's federally recognized Tribes: the CTUIR, the CTWS and the Klamath Tribes.

5.3.1 CTUIR's Ongoing Water Rights Settlement Process

Between 1906 and 1927 the Bureau of Reclamation (Reclamation) built the Umatilla Basin Project, a series of reservoirs and canal systems, to help provide water for irrigation in and around the towns of Pendleton, Hermiston and the Port of Morrow (Guaio 2012). The project, combined with increased water use by irrigation and industry in the area decimated the Umatilla River's Chinook and Coho salmon runs. By 1926, experts observed that the two fish had been extirpated from the river (Guaio 2012). Speaking of this loss, and others, Antone Minthorn, a CTUIR member noted:

> "The CTUIR lost a tremendous amount of resources and culture from the time of Lewis and Clark in 1804 and the 1855 Treaty signing, but we can never go backward to make things right. That is done. It is over. The only way we are going to recover what we have lost of our original reservation promise is to move forward using the sovereign powers we have retained. We have to learn how to use our sovereign powers to rebuild our nation and take our place in this world." (Minthorn 2006)

CTUIR applied this practical approach to their water rights in the Umatilla Basin, working with area irrigation districts, the State of Oregon and the federal government in the 1980s and '90s, to develop what are now called the Umatilla Basin Project Phases I and II. These projects were a massive investment in instream flow restoration to allow for reintroduction of salmon in the Umatilla River. They involve two water *exchanges* whereby farms that formerly diverted from (and dewatered) the Umatilla River for irrigation are provided with water pumped from the nearby Columbia River in exchange for letting water flow in the Umatilla to its confluence with the Columbia (Pagel 2016). The result of the exchanges has been a successful restoration of a productive salmon fishery in the Umatilla River (Pagel 2016). Despite the success of these projects, CTUIR does not yet have settled water rights.

In 2011, the federal government appointed a team to negotiate with CTUIR, Oregon and others to settle CTUIR's water rights in the basin. CTUIR is entitled to reserved water rights sufficient to fulfill the purposes of their reservation including reserved rights to support fish populations (Confederated Tribes of the Umatilla Indian Reservation 2020). The negotiations are ongoing as of the writing of this report (June 2023).

5.3.2 CTWS Water Rights Settlement

Unlike CTUIR, the Warm Springs Tribes settled their water rights in the mid 1990s. CTWS had several advantages in negotiating their water right settlement compared to many other Tribes in the West. For example, all of the rivers that begin on the reservation also end within the reservation's boundaries; other facets of the CTWS' location, geography, hydrology and land ownership also made negotiating their water rights less likely to conflict with other water users in the watershed (Guaio 2012). Speaking of their perspective on water and natural resources, CTWS state in 1992:

> "Ultimate sovereignty is vested in the people, who received that sovereign authority in the . . . laws given by the Creator and by the land itself . . . The Confederated Tribes shall always exercise our sacred national sovereignty in or to achieve the highest of all goals: to preserve our traditional cultural ways that have existed for so many centuries in harmony with our

> homeland; and to provide for the well-being of our people for the many centuries that lie ahead. We shall, as we always have, live in balance with the land and never use more of our precious natural resources than can be sustained forever." (Guaio 2012).

The CTWS along with the State of Oregon and the US agreed to a settlement of the Tribe's water rights in 1997 (Brunoe, Newton, and Seales 2023). An important focus of the agreement was cooperative management of the Deschutes River and its tributaries for long-term protection of fisheries. The Tribe negotiated water rights with two basic components: a consumptive use component and an instream component. A unique facet of the CTWS water rights settlement is that the Tribe agreed that, while the priority date for their reserved water rights would be the earliest in the basin, existing state water rights with a priority prior to January 15th, 1991 would not be curtailed to satisfy the Tribal reserved right (Guaio 2012). The Tribe also negotiated the ability to be the sole administrators of their reserved rights on the reservation and to have authority over state water rights on the reservation. (Guaio 2012)

5.3.3 Klamath Tribes' Water Rights

The story of the Klamath Tribes water rights began with an 1864 treaty in which the Tribes gave up their interest in their 22-million-acre homeland to the US government but reserved "the exclusive right of taking fish in the streams and lakes (of the Reservation) . . ." (Sudbury 2004). More than 100 years later, in 1979, after many of the fish populations on which the Klamath Tribes traditionally depend were in steep decline, a federal District Court in Oregon ruled that the Klamath Tribes' treaty guaranteed an implied right to protect their hunting and fishing rights with a priority date of *time immemorial* (United States v. Adair 1979).

After almost four decades and numerous additional court cases, in 2013 the Klamath Tribes were finally able to enforce their water rights to protect fish in Klamath Basin rivers and streams (Sudbury 2004). The Klamath Tribes hold instream water rights in the Williamson, Sycan, Sprague and Wood Rivers along with the Klamath Marsh and 140 springs located in the former Klamath Reservation (Native American Rights Fund n.d.). As of this writing (June 2023), the Klamath Tribes' water rights are moving through the final stages of the adjudication process (a court-led process for finalizing all valid water right claims in a watershed or basin).

5.4 Conclusion

Water takes on a special importance for the Indigenous people who live in Oregon because of the implications water has for their culture and their spiritual, economic and subsistence needs. Tribal communities are also often frontline communities in Oregon, meaning that they experience impacts from degradation of water resources *first and worst*. It is impossible to make the business case for investing in water in Oregon without recognizing Tribal sovereignty and the imperative of co-managing water resources that sovereignty implies.

6 Investing in Water in Oregon: Regional Case Studies

This section turns to analyses of different ways to invest in water in Oregon. In the business case framework, this section describes possible investments the state might undertake, using a combination quantitative economic analysis and qualitative discussion to weigh costs and benefits of investing.

Lessons drawn from these case studies are used in the final section of this report to develop a set of conclusions and recommendations; in other words, they provide a platform for demonstrating potential returns, both economic and non-economic, from investing in Oregon's water assets.

These case studies illuminate a variety of specific investment examples along with the costs and benefits of each; several of the case studies also provide insight into costs associated with not investing, meaning they explore impacts and related costs in contexts where previous investment could have mitigated or prevented some or all impacts and related costs. Where applicable, distributional issues also are highlighted (i.e., to whom do the costs and benefits of an investment accrue).

It is critical to note that this approach to analyzing and discussing investment in Oregon's water assets is not exhaustive. Many types of investments are not discussed and there are cases that could be highlighted in every region and at the state level that are likewise left out.

> **Selection of case studies is not meant to promote the specific investments described and analyzed in each study. Rather, the project team prioritized replicability, regional diversity and cases that represent key issues for each region and the state.**

The dominant theme that emerges from the investments analyzed below is that they increase *resiliency and flexibility*, enhancing Oregon's ability to withstand or recover from shocks and challenges, both predictable and unpredictable. Cases are distributed across all the study regions and the project team also attempted to highlight a diverse range of water use sectors and types of investment that are applicable both to the regions in which they are discussed and to the state. Case studies are summarized below in Table 39.

Before presenting the case studies, it is important to note the following:

- Dollar values are presented in constant 2022 dollars ($2022);
- Not all benefits derived from each investment could be monetized — those that could are **bolded** in each summary figure (though two cases do not include summary figures).
- Summary figure estimates of costs and benefits are totals across the life of the investment and are discounted using a 3% discount rate.

TABLE 39: CASE STUDY SUMMARIES

Region	Case Study	Water Use Sector(s)	Investment Focus
North Coast	Addressing Flooding, Diminished Critical Habitat and Other Impacts of Declining Watershed Health	Municipal, Aquatic Species/Habitat	Floodplain restoration and upland forest restoration
Willamete Valley/Lower Columbia	Investing in Water Reuse for Supply Diversification and Reliability to Support Households, Businesses, Agriculture and the Environment	Municipal, Aquatic Species/Habitat, Wetland Restoration	Using highly purified wastewater for various fit-for-purpose irrigation uses
Columbia Plateau	Farmer's Irrigation District Reservoir Expansion Project	Agriculture, Aquatic Species/Habitat	Expanding existing reservoir storage
	Nitrate Contamination in Groundwater-Sourced Drinking Water	Indivdiual Domestic Use, Municipal, Agriculture	Immediate treatment technology and long-term best management practices; water justice
Blue Mountains/Northeast	Investing in Conservation and Environmental Water Transactions to Support Farms Culturally and Ecologically Important Chinook Salmon	Agriculture, Aquatic Species/Habitat	On-farm water conservation and environmental water transactions
Southeast	Groundwater Overdraft and Threats to the Local Economy and Environment	Agriculture, Individual Domestic, Wildlife, Wildlife Vieiwing	Payments to retire groundwater rights
Central	Addressing Impacts to Agriculture and Aquatic Species from Long-Term Drought Through Conservation and Innovative Governance	Agriculture, Aquatic Species/Habitat	Piping large irrigation canals and developing innovative governance approaches (water banking)
Southwest	Characterizing the Value of Water for Recreation on the Rogue River	Recreation	River restoration actions to address water quality, quantity and instream barriers

7 North Coast Regional Case Study: Addressing Flooding, Diminished Critical Habitat and Other Impacts of Declining Watershed Health

This case study discusses the impacts of degraded natural drainage functions in the North Coast Region, so named because its watersheds flow from the northernmost portion of Oregon's Coast Range encompassing Lincoln, Tillamook, and Clatsop counties. Human alterations to the landscape leave the region exposed to the risk of economic and other damage resulting from flooding, degraded spawning habitat for key fish species (i.e., salmonids) and disruptions to the supply of clean, potable water. These risks to the region are magnified by the effects of climate change, which is projected to affect the timing and intensity of rainfall, snowmelt and drought cycles, as well as population growth and tourism. These forces all interact with knock-on effects like increased wildfire activity and erosion from post-fire landscapes to pose lasting water resource challenges.

This business case example focuses on investments in riparian and floodplain restoration and upland forest restoration that can provide multiple benefits to municipal drinking water supply and ecosystem and community health. Rather than focusing on a quantitative business case example, this section characterizes the potential benefits and uses both local and other examples to portray the types and magnitude of economic and other benefits of these actions.

FIGURE 1. NORTH COAST REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Riverine flooding and associated damages to people, property, infrastructure and agriculture - Water supply insecurity - Compromised salmonid habitat	- Reduced flood heights - Reduced sediment loads - Increased groundwater infiltration
Cause(s)	**Beneficiaries**
- Wetland filling / draining, riparian floodplain loss - Industrial logging in drinking water watersheds - Climate change impacts	- Communities that depend on salmon for cultural and economic reasons - Locals and tourists that count on a stable water supply - Communities (reduced flood risk) - Local business and industry (avoided damages
Investment(s)	**Key Takeaways**
- Riparian restoration - Floodplain restoration and reconnection - Forest acquisition and restoration	- Restoration projects are multi-benefit — they may target flood risk reduction, but will also benefit the water supply and salmonid habitat

7.1 CHALLENGES

The North Coast region is characterized by a narrow coastal strip at the base of the mid-elevation crest of the Coast Range. Rivers and streams, largely fed by winter rainfall and surfacing groundwater, flow down from the mountains to enter the Pacific Ocean either directly or through a series of bays. In the coastal lowlands, human development, land use patterns and logging in riparian areas and floodplains contribute to wintertime flooding in North Coast communities and reduced habitat quantity and quality for terrestrial, avian and aquatic wildlife. The bays and estuaries of the lowlands were formerly defined by extensive tidal wetlands, which provided both flood attenuation and rich habitat for wildlife and fish. While some estuaries in the region retain functioning wetland systems, a considerable portion of have been lost over the past two centuries of settlement activity:

> "(a)gricultural and logging practices along low gradient river reaches in lower basins have greatly decreased the complexity and productivity of juvenile salmonid rearing areas. Wetlands, marshes and braided channels have been straightened, channelized, diked, drained and deforested to create croplands, pastures, and urban areas. Summer flows and water quality have also decreased and summer water temperatures have increased in these areas." (E&S Environmental Chemistry 2002)

Logging activity on public and private lands high in the watershed has reduced the extent of forest cover, altering the hydrology and ecological functioning of the region's rivers and streams. Rainfall in the upper portions of the watershed that is not slowed by forest cover races downstream where it poses risks to people and property and carries sediment that harms water quality.

Climate change is the other major force driving the water resource challenges in the North Coast region. As with many other parts of Oregon, predicted climate impacts to the North Coast include a warming trend during all seasons, increased fire risk, and changes in rainfall patterns towards drier summers and wetter, more intense periods of rain in the winter which can cause slope instability and threaten property, roads and bridges (Mote et al. 2019).

7.1.1 Flooding

Vegetated landcover (i.e., forests) — especially in mountainous terrain — prevents flooding and erosion by slowing and storing rainfall and helping infiltrate water into the ground to keep it from racing all at once to the drainage as floodwater. Healthy coastal floodplains and wetlands allow floodwater to spread out over a large area, lessening the impact of floodwater on people and property. These functions take on extra importance when considering that climate change is expected to produce periods of more intense wintertime rainfall (Mote et al. 2019) that can contribute to increased flooding, which is caused by intense rainfall that surpasses the ability of the soil to absorb it (National Oceanic and Atmospheric Administration, n.d.). This effect is exacerbated by saturated soils (common during the wet winters of the North Coast region), steep terrain typical of the Coast Range and recent wildfire activity (National Oceanic and Atmospheric Administration, n.d.). Development and logging activities have reduced the ecosystem's ability to lessen flood risks, exposing people, property and coastal infrastructure to additional flood risk.

Flooding in January 2012 in Tillamook and Lincoln counties resulted in FEMA declaring a major disaster. This flooding was caused by sustained wintertime rainfall and produced flooding, landslides and mudslides. The preliminary damage assessment pointed to significant damage to roads and bridges, and unlocked individual assistance, public assistance and hazard mitigation grant program funding for the area (Federal Emergency Management Agency (FEMA) 2012).

Flooding impacts people (as loss of life and injury), property (private residences and businesses) and agriculture (losses to crops or livestock). FEMA's National Risk Index (NRI) quantifies the expected annual losses to these categories based on the magnitude of prior losses, expected frequency of flooding and quantity of people, property and agriculture exposed to the flooding. The majority of coastal Census tracts in the North Coast region have "relatively high" flood risk (per NRI categorization) when compared against all other Census tracts in the US, with only two coastal Census tracts having flood risk below the US median (Federal Emergency Management Agency (FEMA) 2023b).

Damage to public infrastructure — not considered in FEMA's NRI building value calculation — is another important flood impact to consider. Communities of the North Coast are connected by US Highway 101, which supports intrastate commerce and connects residents to their jobs, schools, hospitals and emergency services. Damage to roads and bridges from floodwaters and landslides is both expensive to repair and imposes costs on the people who live in and visit these communities in the form of delays and access to critical services.

Though it was not officially declared a disaster by FEMA, flooding in 2006 along the Wilson and Trask Rivers caused millions of dollars of property damage and disrupted life in Tillamook enough to catalyze public and private support for restoration projects aimed at mitigating future flooding (Shaw and Dundas 2021). Similarly, flooding in the Necanicum River valley has repeatedly obstructed US Highway 101, caused property loss and adversely impacted the economies of coastal communities. The region already suffers from some of the highest rates of "high water" incidents and will require additional strategies and investments to reduce or mitigate future impacts. (Oregon Department of Transportation 2021).

7.1.2 Disrupted Salmonid Habitat

Pacific salmon and salmonids are a keystone species, meaning they are an integral part of the ecosystem's food web (National Oceanic and Atmospheric Administration 2022). When they migrate upstream and die, they decompose, providing essential nutrients to plants and animals across the watershed. Beyond sustaining the ecosystem, salmon are important to Indigenous communities in the region, for whom salmon hold tremendous cultural importance (Earth Economics 2021b).

So too are salmon important for local economies. The commercial salmon fishery, which depends in part on adequate habitat provided by the rivers and streams of the North Coast, is an important contributor to the local and state economy and provides important recreational value to anglers. The Chinook, coho, steelhead and many other species that are sustained by the watersheds of the North Coast are also under threat from disruptions to their spawning streams. Flooding causes erosion, which sends sediment-laden water downstream. High sediment loads in the water negatively impact water quality, which is harmful to anadromous fish. The effects of climate change are predicted to lead to increased periods of intense rainfall in the wintertime, leading to faster flows and lower water quality, as well as to lower water volumes and warmer temperatures in spawning streams during the summer — two additional factors that negatively impact salmon runs.

These factors are all compounded by a secondary effect of climate change — wildfire. Though relatively rare on the western slope of the Coast Range, wildfire activity is projected to grow with climate change. In 2020, the Echo Mountain Complex wildfire was part of the major disaster declaration for the wildfires in Oregon. It affected Lincoln County west of the Coast Range crest, burning through more than 300 structures and 2,500 acres (Smith 2020). Wildfires like the Echo Mountain Complex damage vegetation that stabilizes the soil and alters soil conditions. Rain that falls on top of burned areas leads to erosion, sedimentation, and landslide activity (E&S Environmental Chemistry 2002).

7.1.3 Disruptions to Water Quality and Supply

As population in the region grows, so too does visitation. This is driven by population increases in the greater Portland area, which is a short daytrip from much of the region. Growing permanent and seasonal populations have created additional stress on the region's ecosystems. In the off-season, intense periods of rain may send additional sediment to water treatment facilities, which then incur additional costs from treating raw water with lower water quality by operating for longer periods, activating additional treatment technologies or simply through added wear and tear on the system. In high season, reduced stream volumes pose a challenge in balancing the need for potable water with the need for sufficient in-stream flows to support salmon habitat.

7.2 Investments

Investments in a range of project types are needed throughout the North Coast's watersheds, from the mountain slopes of the coastal range to river estuaries, to simultaneously increase water supply reliability, reduce flood risks to communities and improve habitat and rearing conditions for endangered salmon species and other wildlife. Implementation of nature-based restoration of floodplains, riparian areas, and forests has already shown considerable potential for addressing these challenges throughout the region. Available evidence suggests that these types of projects can be cost-effective and provide multiple benefits. Since 1997, the Oregon Watershed Enhancement Board has been funding community-driven restoration projects across the state that simultaneously support healthy ecosystems and local economies and is a potential funder for these types of multi-benefit watershed enhancing investments.

7.2.1 Lowland Investments: Riparian and Floodplain Restoration

One local example of a successful model for community-driven, nature-based solutions to flooding and habitat loss is the Southern Flow Corridor Restoration Project. This $11.2M project restored 443 acres of tidal wetlands and channels in Tillamook Bay and has been credited with reducing flood levels during storms since its completion (Shaw and Dundas 2021). An economic assessment estimated total project benefits of between $5.8M to $33.9M, driven largely by increased real estate values due to reduced threat of flooding plus additional benefits including more productive local fisheries, enhanced recreational hiking and kayaking opportunities, the value of time saved due to avoided travel delays, carbon storage value and avoided dredging costs (Shaw and Dundas 2021).

A similar 2013 restoration of wetlands and floodplains along the Necanicum River near the City of Seaside has contributed to reduced flooding of US Highway 101, limiting economic and social disruption to that coastal community (Georgetown Climate Center 2014). Developed by the North Coast Land Conservancy on property it owns, the project reconnected the river to 125 acres of floodplain adjacent to the highway. Upon completion its performance was scrutinized, and during a single storm event the restoration project was credited with reducing peak flood height by 1.8 feet and successfully preventing flooding and closure of the highway (Pickering et al. 2018).

In recent years, government agencies, regional conservation organizations and collaborations between these entities have restored riparian areas and wetlands, removed barriers to fish passage and constructed habitat improvements with the goal of improving breeding and rearing areas for the coast's major salmon runs. These projects also aim to reduce erosion along creek and riverbanks, enhance or restore the function of floodplains and safeguard water supplies.

7.2.2 Upland Investments: Forest Restoration

The threat of wildfire and ongoing logging operations on public and private lands high in the watersheds of the North Coast region reduce the ecosystem's ability to slow and store floodwater. Rain falling on denuded slopes quickly rushes to the drainage, causing erosion and downstream flooding, and carrying sediment loads that negatively impact water quality.

One response to this concern may be acquisition, protection and restoration of commercial (private) timber lands within critical watersheds that supply drinking water to coastal communities. The City of Port Orford, on Oregon's southern coast, has recently pioneered the use of Clean Water State Revolving Loan (CWSRF) funds to acquire and protect parcels of land owned by an industrial timber operator. This innovative use of the CWSRF will not only help ensure the availability of high-quality drinking water, it will also secure long-term forest and watershed resilience as impacts of climate change create additional challenges for the region (Oregon Department of Environmental Quality 2023).

Another potential funding stream in the aftermath of wildfire is FEMA's Hazard Mitigation Grant Program (Post Fire) pool of funds. These are unlocked in the aftermath of fire management assistance grant (FMAG) declarations and are designed to kickstart rapid restoration activities like soil stabilization, flood diversion and reforestation projects that benefit the landscape before wintertime rains set in (Federal Emergency Management Agency (FEMA) 2023a).

7.3 Analysis

As explained in the prior sections, restoration projects on riparian, floodplain and forested areas are multi-benefit solutions that can address multiple water resources challenges at once. The following subsections explore potential costs and benefits associated with each, leaning on examples from similar project types in Oregon and elsewhere.

7.3.1 Benefits: Restoration for Flood Mitigation

The City of Tillamook provides a useful lens for understanding the benefits of floodplain restoration. To begin, it is important to understand the baseline flooding condition. In the North Coast region, the census tract that includes Tillamook is the most vulnerable to riverine flooding. Its flood risk is extremely high — greater than the 98th percentile of all census tracts in the contiguous US (Federal Emergency Management Agency (FEMA) 2023a). The census tract covers nearly 10 square miles, with approximately 2.5 square miles expected to be impacted by flooding. It is home to 4,828 people and holds a total value of building and agricultural assets of more than $1.2B. Total expected annual losses due to riverine flooding in Tillamook amount to more than $900,000. This reflects losses to building value, agricultural value and population equivalence (i.e., personal deaths and injuries calculated using the value of a statistical life, or VSL, method mapped onto injuries and deaths).

Restoration opportunities across the Wilson River watershed have the potential to provide avoided cost benefits by lowering flood heights and reducing flood risk to the collection of assets currently exposed in Tillamook. Without specific hydraulic and hydrologic modeling, an exact description of restoration activities, and site-specific engineering data, it is not possible to estimate exactly how much a given restoration intervention would reduce flood heights, but it is possible to model costs and benefits for different project types in general terms.

Additionally, money spent on restoration projects in the region is spent and re-spent, supporting jobs, wages, additional economic output, and tax revenue for local governments (see Table 40). Research from the University of Oregon on forest and watershed restoration projects in Oregon finds that these investments do a similar job of supporting employment and economic output as expenditures on traditional infrastructure projects (Nielsen-Pincus and Moseley 2010), which are often held up as vital job creation engines. Importantly, these benefits accrue in areas in need of restoration, which are typically rural areas of Oregon in need of economic development opportunities (Nielsen-Pincus and Moseley 2010).

TABLE 40. MULTIPLIER EFFECTS PER $1M INVESTED IN FOREST AND WATERSHED PROJECTS

Multiplier	Project Type						
	All (Aggregate)	In-stream	Riparian	Wetland	Fish Passage	Upland	Other
Jobs	2.7–3.8	2.3–3.2	2.4–3.1	2.4–3.4	2.3–3.3	2.9–4.0	2.4–3.4
Economic Output	1.9–2.4	1.7–2.2	1.7–2.4	1.8–2.4	1.8–2.3	2.0–2.6	1.8–2.3

Source: Adapted from Nielsen-Pincus and Moseley (2010).

Note: Multipliers reflect the additional economic activity generated by direct spending by a given sector, including indirect economic activity (which represents business to business purchases for intermediate inputs); and induced economic activity (which represents spending by households employed in affected economic sectors).

7.3.2 Benefits: Restoration to Benefit Salmonid Populations

Healthy riparian areas in the uplands and lowlands are of vital importance for securing a future for these species. Salmon populations, as reflected by volume of the commercial catch, have been declining in recent years. Chinook salmon are the most commercially valuable of the salmon species, and in 2022 they recorded only 1.48M pounds landed, down from 4.83M pounds in 2014 (Smith 2023). In the Newport area of Lincoln County, the salmon catch represented ten percent of the total landings revenue in 2014, but that fell to three percent by 2019 (The Research Group, LLC 2021).

Despite a general decline in commercial landings, salmon remain important to the coastal economy, so much so that disruptions to the fishery or reduced landings prompt the federal government to unlock emergency funds to help support the communities that depend on the fishery. The 2023 Chinook season has been cancelled, and Governor Kotek has requested a federal fishery resource disaster declaration under the Magnusson-Stevens Fishery Conservation and Management Act. Unfortunately, 2023 is no outlier — the 2016 and 2017 Chinook seasons in southern Oregon were declared federal disasters (National Oceanic and Atmospheric Administration 2023) and the 2018, 2019 and 2020 seasons are all awaiting a disaster declaration decision (their status is "pending"). The request letter from then-Governor Kate Brown cites poor fishery performance "… leading to severe effects on already distressed rural communities and the businesses that depend upon these fisheries" (K. Brown 2021).

Focusing again on the Newport area of Lincoln County, nearly 19,000 salmon fishing trips were recorded in 2019, accounting for 30% of all recreational ocean finfish trips in the area (The Research Group, LLC 2021). Statewide in 2020, 195,000 recreational anglers spent more than $45M on their fishing trips, which in turn supported 569 jobs and $59M of sales, $22.5M in wages, and added $36M of value to the state's GDP (U.S. Department of Commerce 2023). While these values include other recreational fish like trout, salmon does account for a significant proportion of total recreational fishing. If the proportion of salmon fishing trips relative to all other finfish trips holds for the entire state, about 30% of the reported statewide economic impact figures could be attributed to the recreational salmon fishery.

Recreational anglers also receive economic value from the chance to fish for salmon. This value is often determined using revealed preference studies, typically the travel cost method. Though this case study did not identify recent studies of salmon fishers from the Pacific Northwest that would pinpoint willingness to pay, it is possible to understand the economic value of salmon fishing in general terms. First, a study from the 1980s by the USFS found consumer surplus values in the hundreds of dollars for sport-caught salmon (Hueth, Strong, and Fight 1988). A doctoral thesis from Colorado looked at the consumer surplus of trout and non-trout fishing and found trout values to be well over $100 ($2009) and non-trout values to be approaching $100 ($2009) (Ng, 2011). In Colorado, trout is a “premium” fish, in the same way that salmon is highly desired by anglers and is an iconic fish in the region. These data points suggest that it would not be unreasonable to conclude that a low-bound on consumer surplus values for salmon fishers is $100 per day; at a minimum then, the 19,000 salmon fishers in Newport would see $1.9M in economic value for recreational salmon fishing — value that is at risk as the salmon fishery dwindles.

Finally, even those that do not fish for salmon hold economic non-use value. A recent choice experiment focused on willingness to pay for habitat restoration programs that would support Coho salmon on the Oregon Coast revealed that households were willing to pay between $60 and $179 dollars per year for slower and more aggressive restoration scenarios, respectively (Lewis et al. 2019). The authors point out that restoration projects designed to more rapidly restore salmon populations tend to have higher up-front costs, so this finding may be useful to project designers and government entities when scoping projects and identifying funding sources (Lewis et al. 2019).

7.3.3 Benefits: Restoration to Protect Drinking Water in Coastal Communities

The City of Seaside provides a useful lens for understanding the source water protection benefits of floodplain, forest, and riparian restoration activities. The city takes its water from a year-round stream in the Necanicum River watershed. On an average day, residents, visitors and businesses use about 1 million gallons of treated water. On a peak summer day in the height of tourism season, that number can balloon to more than 2.5 million gallons daily. A total of 8 million gallons of clean drinking water can be stored in the city’s holding tanks. (City of Seaside, n.d.)

During a Regional Community Conversation connected to the Oregon Integrated Water Resources Strategy, Seaside Mayor Steve Wright said, “our biggest concern is making sure that our municipal system, including our watershed, is capable of providing adequate clean water to both our residents and visitors into the future.”

Due to the nature of the forces stressing the quality and quantity of the water supply, effects are likely to be felt somewhat gradually and intermittently as the water authority imposes restrictions or raises prices to balance supply and demand or pass along increased water treatment costs to consumers. At least in the near-term, water supply shortages are likely to be experienced by coastal communities as a steady drip of policies aiming to harvest low-hanging fruit to further stretch existing water supplies. These range from voluntary water restrictions and conservation incentives to measures like prescriptive outdoor watering schedules and water rate increases.

Individuals and different sectors of the local economy will respond to these policies differently — for some, changes will be more costly to implement than others. For low-income members of frontline communities, this can exacerbate affordability challenges. Research examined seven years of drought policies and responses is Northern California and found that "… many drought resilience strategies raise water bills for low-income households and lower them for high-income households"(Rachunok and Fletcher 2023). This finding poses important affordability and water justice concerns and makes the case for investing in multi-benefit watershed protection and restoration projects prior to implementing drought restrictions to support infiltration, reduce erosion, and help guarantee sufficient water for coastal communities and riparian ecosystems across the Oregon North Coast region.

The Cedar River watershed outside Seattle, Washington provides an example of how a healthy watershed can provide a dependable supply of clean water. The City of Seattle owns and manages the entirety of the 90,000-acre watershed, which provides clean water to more than 1.5 million people. (Seattle Public Utilities 2021). It is one of the only water utilities in the nation to not have to use any additional filtration. Prior to 1964, the watershed was heavily logged, losing 30,000 acres of forest lands in 25 years (Seattle Public Utilities 2021). Recognizing that the health of the watershed was directly related to the quantity and quality of water emerging from it, a process — the Cedar River Watershed Cooperative Agreement — was signed by landowners to facilitate the transfer of lands from private ownership to the City. This was completed in 1996 when the USFS transferred over the last remaining parcel (Seattle Public Utilities 2021). Over time, acquired lands have been carefully restored to optimize the ecosystem's ability to provide a steady supply of clean water for the growing metropolis that depends on it.

7.4 Discussion

Throughout the degraded and flood-prone watersheds of the North Coast region, investments in natural infrastructure have high potential to provide multiple benefits while addressing chronic water management challenges. As demonstrated by the Southern Flow Corridor and Necanicum River floodplain restoration projects, nature-based responses can diminish flood risks, improve salmon habitat, protect property values and business activity and provide recreational opportunities. As climate change impacts place increasing stress on wildlife, ecosystems and human communities, investments in natural infrastructure can provide additional economic and environmental security to the region.

The State of Oregon is well placed to provide partnership, leadership and funding for future projects. The Port Orford CWSRF loan is, in some respect, a pioneering use of this financing; this approach is worth celebrating and replicating where appropriate. All the restoration projects reviewed for this report have depended, in whole or in part, upon grants from State of Oregon agencies. These funds have been "repaid" through positive returns on the initial investments.

Three high-level takeaways come from this case study:

- **Nature based solutions can be (or more) effective than traditional infrastructure projects.** They can often be more cost-effective than traditional infrastructure projects and they also provide a diverse range of co-benefits for community well-being and ecosystem health. In this way they create multiple returns on the capital investment.

- **Investing in water often requires investing in watersheds.** All water is part of the water cycle and in many instances, as with water that reaches coastal towns like Tillamook, investing in upland watershed health or in floodplain health can provide more benefit than simply focusing on managing the water that is flowing past a point of diversion or place of use.
- **Too much water (flooding), not just water scarcity, will stress water systems as the climate changes.** The future is likely to involve cycles of drought mixed, possibly at random, with cycles of over-abundance. Nature base solutions like floodplain reconnection and upland restoration can provide resiliency in both instances; functioning floodplains and uplands help store water and support base flows during scarcity while also helping to mitigate the worst effects of flooding.
- **Wildfire risk is water risk.** Wildfires impact watersheds in many ways that can harm water quality and reduce the landscape’s ability to store water in soils. Limiting wildfire risk is critical to limiting risks to both human and natural communities that depend on forested watersheds.

8 Willamette Valley/Lower Columbia Regional Case Study: Reusing Treated Wastewater to Help Meet Water Quality Standards and Reduce Demands on Potable Water Supplies

The Willamette Valley/Lower Columbia region (WV/L Col) is bounded on the east by the Cascade Range and on the west by the Coast Range. The Willamette River Valley is at the center of the region and includes the greater Portland metropolitan area. At Portland's northwest corner, the Willamette River flows into the last primary reach of the Columbia River — the largest river in the Pacific Northwest and a major shipping channel serving numerous ports enroute to the Pacific Ocean. The Willamette Valley contains nearly three quarters of Oregon's population and is a major engine of Oregon's economy, generating nearly 40% of the state's economic output, and providing 74% of the state's employment (Bureau of Economic Analysis 2021).

Projections suggest both population and economic activity will continue to grow at a strong rate in the region in the coming years. This rapid growth, coupled with climate change impacts, may put substantial strain on the region's water resources in terms of providing not only sufficient water quantity and quality to meet local demands and needs, but also ensuring the supply is reliable and affordable for the region's households and businesses. The combination of these environmental and economic factors provides a foundation for discussing water-related investments that have the potential to help minimize and/or mitigate anticipated impacts. The business case example in this section looks at addressing water quality impacts, specifically temperature impacts, via water reuse instead of by building cooling infrastructure.

FIGURE 40. WILLAMETTE VALLEY/LOWER COLUMBIA CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Elevated instream water temperatures - Water scarcity, affordability & reliability	- Instream water temperature standards met - Additional water for non-potable use - Cost savings for wastewater utilities
Cause(s)	**Beneficiaries**
- Rapid population growth - Economic development - Climate change impacts in the form of drought & increasing air/water temperatures	- Salmonids & other temperature-sensitive species - Non-potable water users - Wastewater utilities (& their customers)
Investment(s)	**Key Takeaways**
- Expansion of water reuse (non-potable applications)	- Multiple important benefits can be attained, beyond cost-effective compliance with thermal discharge limits

8.1 CHALLENGES

While the Willamette Valley is considered relatively water abundant, the combination of rapid growth and anticipated climate change impacts is likely to give rise to numerous water-related challenges. The water challenges will tend to be multi-faceted and interwoven. Given its substantial population and economic activity, the region's waters, water-related infrastructure and water governance systems are essential for the economic, environmental and social well-being of not only the region's local communities, but also Oregon as a whole. The region's population is projected to continue its rapid growth rate — 11% growth occurred between 2010 and 2020 (US Census Bureau 2020b). Economic growth is also anticipated to endure, especially for key water-dependent sectors including chip manufacturing, data centers and medical/health care services. .

Box 5 provides additional detail on the region's rapid growth and development.

BOX 5: POPULATION GROWTH AND DEVELOPMENT IN THE WILLAMETTE RIVER BASIN

The total population of the Willamette Basin has increased every decade from 1850 to present-day. By 1990, population had reached 2 million people, and by 2010 it had increased to 2.5 million. In 2011, the Oregon Office of Economic Analysis projected the future population of the Willamette Basin to increase to 4 million people by the year 2050 — doubling the 1990 population (Oregon Office of Economic Analysis 2011). Projections from the Willamette Water 2100 project forecasted that the total basin population would increase by 3.05 million people from 2010 to 2100 — a gain of 111%. Population is projected to increase in every county in the basin, although the increases in absolute terms are largest for Washington, Multnomah and Clackamas counties. Over the same time, the study also projected the area of developed land in the basin to increase by 54% from 2010 to 2100. This is paired with projected declines in agricultural (-8% change) and forest land (-1% change). Much of the projected increase in developed land will occur within the Portland Metropolitan Area (Bigelow and Plantinga 2016).

Population growth and new housing need not mean a corresponding increase in water use. Many cities in the arid West — Las Vegas and Tucson are leading examples — experience declines in total water use as populations grow due to ambitious water efficiency standards in plumbing codes; aggressive water conservation; innovative tapping of water reuse as a sustainable and cost-effective portion of their water supply portfolios; and other management efforts. In the Willamette Valley specifically, projections indicate that, in the future, the region will experience increased "location- and time-specific" water scarcity (Jaeger et al. 2017). In other words, due to elevated temperatures, changes in the timing of precipitation and other alterations in climate and hydrologic patterns, water resources may be strained to provide a reliable and affordable supply to meet the region's growing residential, business, agricultural and ecosystem demands. Water governance and utility systems also will be challenged to maintain critical temperature and water quality standards for the region's watersheds and for their many instream and out-of-stream uses and users.

8.2 Investments

Various opportunities exist to invest in supporting the region's water supply reliability and instream water quality objectives in the face of climate change and altered hydrology. Some are programmatic or governance related (e.g., planning and permitting), and some are financial investment opportunities for specific water-related programs and assets (e.g., water treatment and distribution, existing water storage improvements and water recycling and reuse).

The investment explored in this case study is water reuse (also referred to as water recycling). Specifically, investment in providing recycled water as part of the overall water supply portfolio to meet demand in the growing region as compared to a "baseline" of meeting all new demands by increasing draws from the potable supply. Water reuse can take several forms. In-place or readily developed regulatory systems in the state may be applied to enable uses for non-potable reuse (NPR) purposes that may include:

- land application for lawn, sports field, golf turf and agricultural irrigation;
- cooling and process waters for various industrial and commercial purposes (e.g., car wash facilities); and
- environmental and ecosystem restoration, such as wetland enhancement or creation.

Recycled, highly purified water may also be applied to provide potable water supplies. Many states have regulatory systems and processes for "indirect potable reuse" (IPR), wherein recycled water meeting specific treatment requirements and finished water quality standards may be reintroduced into the environment (e.g., recharging a groundwater basin or augmenting a surface water reservoir or reach) for subsequent planned extraction and use as a source of drinking water. Drawing on the experiences and programs successfully developed and in practice in California and several other states (e.g., (Mosher 2021), Oregon may be able to develop a robust regulatory program relatively quickly to govern potentially valuable IPR opportunities to enhance public water supplies.[20]

8.2.1 Potential Benefits from Investing in Water Reuse

Water reuse investments can yield a wide array of benefits. The types and levels of benefits depend on the specific setting and context of the reuse application. For the illustrative business case developed in this section, the primary focus is on expanding water reuse as an effective and beneficial option for meeting critical instream water temperature standards (i.e., keeping rivers and streams from getting too warm to support critical salmonid and other species).

In many settings, water reuse provides an array of benefits associated with reducing demands on potable water supply systems which in turn often provides cost savings (avoided costs). For example, for planned new development of residential and mixed use land areas in a growing urban-rural interface, such as the planned "urban reserve district" areas currently being considered for portions of Washington County (e.g., City of North Plains 2023), recycled water may be made available for turf and crop irrigation and for business process purposes.

An investment in providing recycled water as part of the overall water supply portfolio to meet demand in the growing region — compared to a "baseline' of meeting all new demands by increasing draws from the potable supply — provides several additional benefits, including:

- Reducing the amount of raw water extracted from regional watersheds by local water supply utilities and irrigation districts, enabling greater instream flows and cooler water temperatures (i.e., providing instream benefits, to the extent reuse water offsets demand for waters otherwise supplied by water supply utilities or irrigation districts).
- Avoiding the expense of treating and conveying the extracted raw water for potable use. Also, using reclaimed water reduces the need to potentially invest in expanding the region's potable supply system intakes and/or treatment facilities. For context, (Box 6) provides information on the considerable expense of two ongoing water supply enhancement projects in the region: Portland Water Bureau's Bull Run Filtration Project and the Willamette Water Supply Program (WWSP) being developed by a collection of Washington County water supply utilities known as the Joint Water Commission (Box 6).
- Providing residents, homeowner associations, municipalities, school districts, golf courses and other businesses with a relatively low-cost supply for turf and other outdoor irrigation and business process purposes. Reuse can lower the overall costs of water for customers who can

[20] There also are opportunities for developing regulatory systems for "direct potable reuse" (DPR), wherein highly purified recycled water is introduced directly into a water supply system using an engineered buffer (rather than an environmental buffer such as a reservoir or aquifer, as would occur under IPR). California is in the final stages of developing its regulatory system for DPR. Texas has already adopted DPR rules and procedures, and DPR is in use in the state).

take advantage of recycled water, as well as for those who rely exclusively on potable supplies, contributing to a more affordable, equitable community.

- Installing "purple pipe" systems to deliver reclaimed water, when planned in concert with new area development, is cost-effective as it can be well integrated with installation of potable and wastewater conveyance systems — avoiding the often-considerable expense of retrofitting a reuse system pipeline through an already developed area.
- Reducing wastewater discharges by the regional utility (e.g., as done in Washington County, described below in Section 8.3). This can reduce a utility's costs and reduce pollutant loading and thermal impacts on the temperature-sensitive receiving waters (providing an array of instream benefits as described later in the case study).
- Increasing the overall reliability, resilience and sustainability of the region's water supply, by diversifying the supply portfolio with a climate-insensitive supply that provides a relatively firm yield.[21]

Box 6: Investments to Enhance Portland's Existing Water Treatment Facilities

The Portland Water Bureau's (PWB) $840M (2019$) capital investment in the Bull Run Filtration Project is estimated to support:

- Approximately 4,600 jobs in Multnomah, Clackamas and Washington counties — increasing regional labor income by $970M and increasing regional economic output by $1,600M during the construction phase; and
- 53 jobs, $8M in labor income and $14.9M of added regional economic output during operational phases, from an estimated $13.7M annual in operation and maintenance O&M expenditures. (ECONorthwest 2021)

Of course, the water reuse approach also imposes costs. There are expenses associated with:

- Constructing and operating a water reclamation treatment facility, if needed, to polish wastewater treatment plant effluent to meet suitable water quality standards for the intended uses of the recycled water. For our case study, the existing wastewater resource recovery treatment facility (WRRF) already produces "Class A" approved water for non-potable applications.
- Permitting, routing, building and operating a pump and pipeline system to convey recycled water to its locations of planned use.

The business case for a potential investment in water reuse is thus an evaluation of how the multiple benefits of the reuse option (including water quality and ecosystem benefits for surface waters, as well

[21] Recycled water is sourced from indoor water uses, as collected in each building and transmitted by sewer line to a wastewater treatment plant. Indoor water use remains relatively stable across weather conditions (especially compared to outdoor water uses), providing a reliable quantity of source water supply.

as potential avoided costs for the water supply and wastewater treatment utilities and customers) compares to the costs of developing, constructing and operating the reuse system.

8.3 Analysis

The BCE illustrated here reflects a proposed project to meet thermal discharge permit limits in Washington County by diverting a portion of the region's highly treated wastewater effluent to various irrigation purposes. This option reduces the amount of thermal load to the temperature-sensitive Tualatin River while also providing a beneficial use of the highly treated waters from the regional wastewater and stormwater management agency, Clean Water Services. The option thereby also reduces demands on raw water to the extent reuse water replaces applications of potable or irrigation district supplies. The offset of potable and irrigation district source waters can instead be retained in existing storage and used as needed for timed cooling water releases to the Tualatin River, among other beneficial uses.

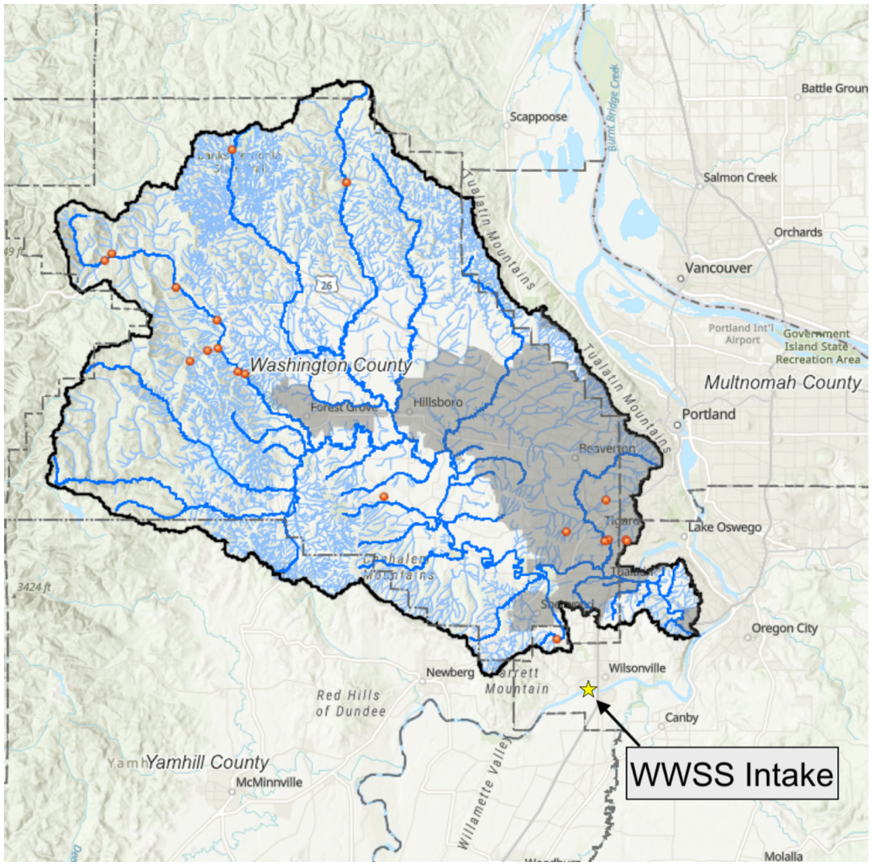
Note that there is not a viable "no action" option, as compliance with thermal discharge limits is necessary for the relevant utilities, and critical for ensuring the protection of federally listed salmonids in the receiving watersheds (i.e., Chinook and steelhead salmon, federally designated as threatened species) (NOAA n.d.; n.d).

8.3.1 Water Temperature Challenges for the Tualatin River

The 80-mile-long Tualatin River's headwaters are in the Coast Range of western Oregon and pass through rapidly growing Washington County's mix of forest, agricultural and urban landscapes before ultimately joining the Willamette River near Oregon City (Figure 41). The Tualatin River serves as a major source of water supply for several area water utilities and the Tualatin Valley Irrigation District. It is also Washington County's only river and provides critical habitat to special status salmonids and recreational opportunities,[22] along with its heavy use as a regional source of drinking water and agricultural irrigation supplies.

[22] Thirty miles of the Tualatin River are officially designated by the NPS as a "National Recreation Trail," noted for its contributions to nature education.

FIGURE 41. MAP OF THE TUALATIN RIVER WATERSHED AND LOCATION OF THE WWSS INTAKE



Source: (Tualatin River Watershed Council 2022)

The Tualatin River is replenished with highly treated wastewater effluent released by Clean Water Services, discharging an average of more than 60 million gallons per day from its four wastewater resource recovery facilities (Clean Water Services n.d.).[23] Instream temperatures are a major concern for the Tualatin River, as maintaining suitably cool thermal conditions is critical for protecting migrating and resident salmonids — including Chinook and steelhead — and other species. Thermal conditions also contribute to toxic algae growth, which is another water quality concern for the watershed (nutrient loads are another concern).

Instream temperatures are of greatest concern in summer and autumn months, when air temperatures are highest, and the river is in seasonal low flow stage (meaning Clean Water Services discharges represent a disproportionately high percentage of flow). Protecting temperature-sensitive salmonids and other species is a public priority, and discharges into the Tualatin River are subject to strict thermal

[23] Clean Water Services provides surface water management, stormwater, flood management and wastewater services, serving more than 600,000 residents and businesses in urban Washington County and portions of surrounding areas. Clean Water Services operates in partnership with 12 member cities including Beaverton, Tigard, Tualatin, Hillsboro, King City, Forest Grove, Sherwood, Cornelius, Banks, Gaston, Durham and North Plains.

limits under a watershed-based regulatory discharge (National Pollutant Discharge Elimination System or NPDES) permit. For Clean Water Services, these thermal permit limits are viewed as integral to their mission of protecting fish habitat and water quality, though the requirements pose a significant technical challenge with high compliance cost implications.

As early as 1991, Clean Water Services worked with Oregon Department of Environmental Quality (ODEQ) to negotiate an innovative water quality trading compliance strategy wherein the utility committed to planting and maintaining native vegetation along riverbanks in the Tualatin watershed to provide cooling shade, and providing cool water releases from stored waters upstream, in lieu of investing $150M (1991$) in an expensive and energy intensive chilling system to cool their effluent to meet discharge permit limits. The compliance agreement requires seasonal stored water releases of Clean Water Services-owned rights to 14,200 AF of relatively cool upstream waters held in Hagg Lake and Barney Reservoir. (CWS 2023)

8.3.2 Meeting Thermal Limits: Defining the Baseline and an Investment Alternative

Today, Clean Water Services faces emerging challenges in meeting its required thermal discharge limits. In addition to climate change creating additional heat stresses on the river, regional growth leads to larger wastewater volumes with a projected doubling of Washington County's population by 2070 and a doubling of current wastewater loads by 2050 (CWS 2023).

To meet its thermal discharge limits under these emerging, dynamic conditions, Clean Water Services would traditionally be required to install and operate a costly and energy intensive cooling tower system. As an innovative and multi-benefit alternative to the standard compliance approach, however, Clean Water Services is exploring an option of reducing its thermal load by reducing its discharge volume and doing so by directing a portion of its growing treated effluent flows to water reuse applications. The illustrative BCE is thus set up to include both baseline and alternative investment scenarios.

Baseline: Clean Water Services pursues a traditional compliance approach of purchasing, installing and operating a chilling system at its Rock Creek facility to reduce effluent temperatures and thereby maintain compliance with the thermal limits of its discharge permits. This is the "*without* water reuse baseline."

Alternative Investment: The alternative investment scenario entails Clean Water Services expanding water reuse (i.e., the "*with* water reuse option" scenario) as the utility's means to attaining regulatory compliance for thermal discharge.

Clean Water Services' Reuse Water Feasibility Study (2023) provides critical information for assessing the costs of the reuse project in comparison to those of the cooling tower. Costs of the project are compared based on Reclamation's Equalized Unified Annual Cost (EUAC) methodology that allows for the comparison of project options with different cost profiles, using an annualized cost estimate adjusted to reflect different component lifetimes and replacement intervals.[24] The EUAC values reveal the reuse option is less costly ($301,000 compared to $373,000 in estimated total annualized cost, based on EUAC method).

The cost comparison also can be presented using the NPV of the costs incurred for each option over its lifespan. To assess this, the following assumptions were made:

- both investment options were assessed over a 50-year timeframe (as a conservative estimate of the life of the reuse pipeline) at a 3% discount rate;
- costs for the baseline (cooling tower) option include capital costs of $6.9M, annual O&M costs of $110,000 and 20-year major equipment replacement costs of $3.0M; and
- costs for the reuse option include capital costs of $5.9M, annual O&M costs of $135,000 and 10-year pump replacement costs of $0.5M.

Using these assumptions, the water reuse project is still less costly with a NPV cost of **$10.5M** as compared to the baseline (cooling tower) cost of **$12.3M**. Also, if Reclamation approves the Clean Water Services request for grant funding, the capital costs borne by Clean Water Services and its customers will be reduced by 25%, providing additional cost advantages relative to the cooling tower option.

The LCOW — a measure of the average NPV lifetime cost of the water saved or generated by a project — also was calculated to provide an indication of the cost-effectiveness of the investment in the reuse project. The assumptions regarding cost were the same as described above in the calculation of NPV project costs. Additionally, it was assumed that the water reuse project generated 2,340 AFY of water for use, reducing reliance on water withdrawals from the Tualatin or other sources. Based on these assumptions, the LCOW of the water reuse project is **$174/AF**. As the cooling tower does not result in water benefits beyond compliance with water temperature standards, no water is assumed to be generated by the project and an LCOW was not calculated.

8.3.3 Benefits of Baseline and Water Reuse Options

The baseline option of a purely technology and infrastructure-based solution of the cooling tower system is not expected to produce any benefits apart from its ability to attain compliance with the applicable NPDES discharge permit for Clean Water Services.

In contrast, the proposed water reuse alternative can generate an array of valuable benefits, above and beyond attaining compliance with the thermal restrictions in the NPDES permit. The anticipated benefits and co-benefits of the reuse option are numerous and are described in Table 41.

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[24] The EUAC methodology applied by Reclamation calculates the annualized present value of constructing, operating and maintaining components of a system. The approach includes the initial and replacement cost of capital, annual operations and maintenance costs and annual energy costs. It also considers varied life spans for infrastructure. The EUAC method enables the direct comparison of costs associated with each alternative.

Table 41. Estimated Benefits of Water Reuse Option

Type of Benefit	Description	Level and Value	Beneficiaries
Avoided costs from not needing to install & operate Rock Creek cooling tower	Reuse option has lower total annualized and NPV lifecycle costs than cooling tower. Reuse also may receive Title XVI federal grant funds to further reduce costs to Clean Water Services and its customers	$72,000 total savings in annualized cost for Clean Water Services $1.8M estimated savings in NPV costs over 50-year project lifetime	Clean Water Services customers' cost savings and greater affordability, from reduced wastewater service bills
Increased stored upstream water available for seasonal releases to help manage instream temperature	Reduced diversions from river (offset by reuse water) when reuse water replaces existing potable or irrigation demand	Up to 2,340 AFY of use replaced by reuse supply Potential cost savings for water supply & Tualatin Valley Irrigation District	Salmonid & other key temperature-sensitive species and recreational users
Increased wetland & floodplain restoration; cultivation of native vegetation for regional restoration projects	Several new reuse application sites restored to original wetland or flood-plain conditions	More than 700 acres of marginal farmlands to be restored, providing ecosystem services to watershed	Ecosystem & related "greening" benefits from riparian enhancements
Improved affordability of regional water services & related contributions to affordable housing	Reuse water costs less than new potable water sources; e.g., WWSP or PWB Bull Run filtration	WWSP cost and filtration upgrade at Bull Run, each estimated to cost ~$1,000/AF (Table 41). Cost of reuse option is ~$76/AF	Regional residents dealing with escalating costs of housing and associated living expenses (included all water-related services)
Enhanced regional water supply & wastewater services	Increased ability of "one-water" supply system to meet demands in times of drought & other supply risks	Reuse water provides a locally controlled, predictable & relatively stable supply volume, and reduces thermal and other pollutant loads to local watersheds.	All water users relying on Washington County & other regional water utilities
Increasing the public's experience with & acceptance of 'fit-for-purpose" water reuse applications	Expanding number of locations & purposes for which reuse water is likely to be considered & beneficially applied	Numerous opportunities exist to expand suitable 'fit-for-purpose" uses & locations for recycled water	Entire region benefits from movement toward "one-water" management of instream, water supply, wastewater & stormwater issues

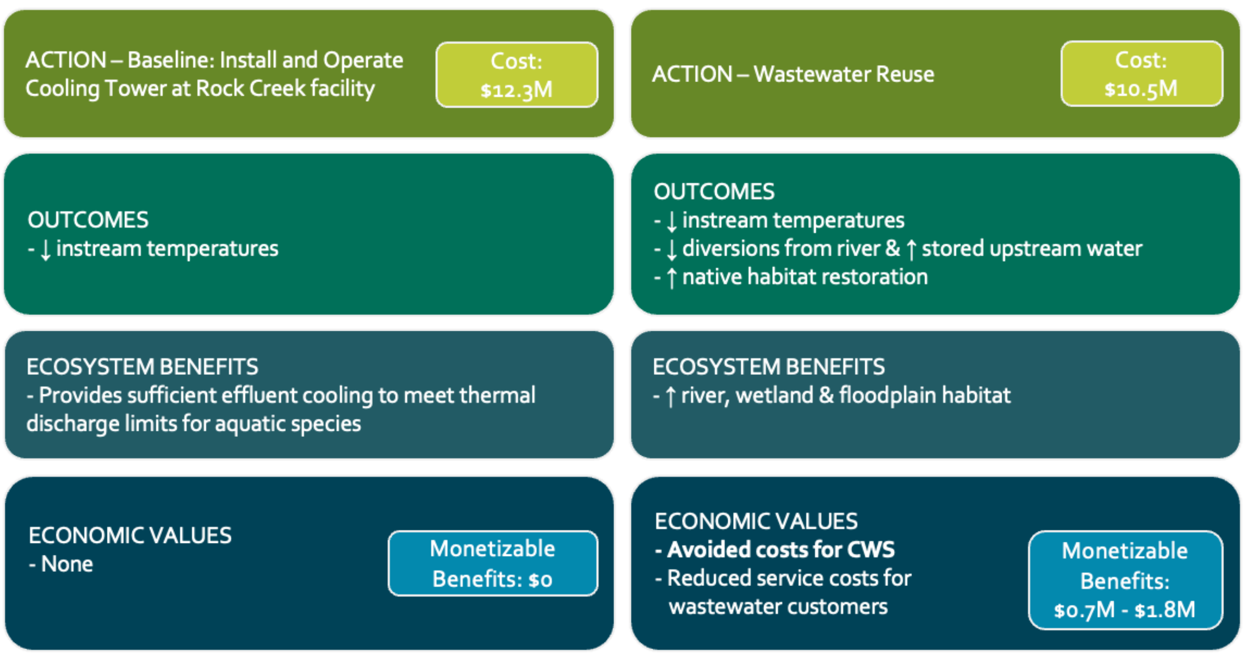
Note: Many of the anticipated nonmarket benefits are not readily amenable to monetization given data and/or methodologies currently available.

Some details on the project's proposed reuse applications, associated water reuse volumes, acres treated and key types of uses and benefits are as follows:

- Potential conversion of a 225-acre golf course (should Clean Water Services purchase it) to floodplain revegetated with native plants and reconnected to the floodplain (a dike currently surrounds the property). The remaining undeveloped 125 acres above the floodplain would be converted to agricultural production irrigated with 265 AF per year of reuse water.
- Application of 874 AF per year of recycled water to 363 acres for ecological restoration at two sites, through irrigation of a mix of native grasses and shrub vegetation and decreasing competition from invasive plants. A portion of the native plants and seeds to be harvested for use in other regional restoration projects.
- Restoring wetland conditions and functions on 162 acres of degraded jurisdictional wetlands currently leased for agriculture and converting the area to native plants and grasses using 368 AFY recycled water.
- Replacing 246 AFY extracted river water with reuse water, for agricultural irrigation on 94 acres of farmland.

Figure 42 provides a summary of the investments reviewed in the BCE.

FIGURE 42. WILLAMETTE VALLEY/LOWER COLUMBIA CASE STUDY SUMMARY



8.4 DISCUSSION

Strategic long-term planning is essential to meet the expected service needs of a growing population and expanding economy, particularly in the face of climate change and population growth. By pursuing a wide variety of water management strategies — including the addition of water reuse — to the water supply and wastewater management portfolio, local and state officials will be better positioned to dynamically manage the demands of growth and climate change in the region.

While the Willamette Valley/Lower Columbia region may appear to have a relatively abundant supply of available water, there are several emerging challenges. Many of these challenges are related to the growing water demands and associated wastewater loads that accompany rapid population and economic growth. These challenges are magnified by the changing climate and associated elevated air and instream temperatures, likely increases in the severity (and perhaps frequency) of periodic droughts, increased risks of high-intensity wildfires and other pressures. Several lessons can be drawn from this case:

- **Water reuse is a potentially valuable investment, offering an array of potential fiscal, environmental, and sustainability benefits.** The business case illustration developed in this chapter revealed the multiple types of benefits that expanded water recycling may provide to this and other regions across Oregon.
- **Water affordability, especially for frontline communities, should be considered in investment decisions.** Several of the region's largest water utilities currently are investing in expensive new water supply or treatment projects, with anticipated impacts on the region's overall cost of living and affordability for the area's current and new residents and businesses. Reducing costs of water treatment can help reduce costs to customers, especially those who can least afford higher rates.
- **Water reuse can help meet future demand without further stressing existing water resources.** Instream water quality, temperature and fisheries are showing evidence of the growing stress in the region's watersheds, and increased water extractions — in concert with climate change impacts — will likely exacerbate these stresses. Rather than further taxing the region's freshwater sources, innovating approaches like water reuse can help meet water needs for cities and businesses.

9 Columbia Plateau Regional Case Study #1: Farmers Irrigation District Kingsley Reservoir Expansion Project

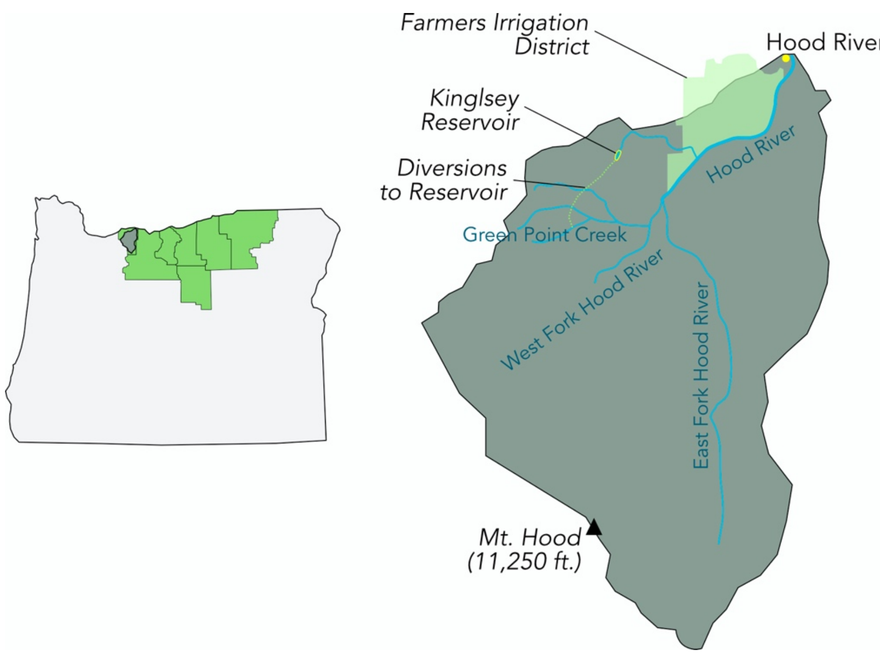
The Hood River watershed is in northern Oregon, east of the Portland metropolitan area. The Hood River and its tributaries begin from glaciers and snow melt on Mount Hood, Oregon's tallest peak, and flow north to a confluence with the Columbia River. The entirety of the watershed is located in Hood River County and accounts for the majority of the county's area (Figure 44) (Coccoli 1999). Known largely for its views and recreational opportunities, Hood River County is also Oregon's top fruit growing region and the largest pear exporter in the US (USDA, NASS 2017a; Visit Hood River Oregon, n.d.). The Hood River watershed is also part of the ancestral homelands of the Confederated Tribes of the Warm Springs (CTWS). CTWS works with ODFW, OWRD and others to monitor and manage ESA listed and other important fish species in the watershed.

Farmers Irrigation District (FID) is one of five major irrigation districts in the Hood River basin and provides water to almost 6,000 acres, predominantly planted in pear orchards, on the basin's west side. This case study discusses the impacts of changing climate on water supply for irrigated agriculture in FID and on the prospect of enhancing existing water storage facilities to help mitigate these impacts. Potential instream flow benefits from storage releases for four species listed as threatened under the ESA are also discussed.

FIGURE 43. COLUMBIA PLATEAU REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Water scarcity - Low instream flows	- Enhanced water supply reliability for irrigated agriculture - Increased streamflow
Cause(s)	**Beneficiaries**
- Climate change driven reductions in natural storage and changes in precipitation timing and amount	- Agricultural producers - Aquatic species including ESA listed species
Investment(s)	**Key Takeaways**
- Reservoir expansion - Irrigation infrastructure modernization	- Expanding existing reservoirs may help some locations adapt to changes in precipitation timing and form (i.e., shift from snow to rain)

FIGURE 44: MAP OF FARMERS IRRIGATION DISTRICT AND KINGSLEY RESERVOIR LOCATION



9.1 CHALLENGES

Climate change is driving hydrologic change in the Hood River watershed that is impacting the region's irrigators as well as its fish populations. Conducted in 2015, the Hood River Basin Study concluded that streamflow in summer months is already inadequate to meet all water demands and, furthermore, that climate change will exacerbate this imbalance (Reclamation 2015). At present, between 50%-70% of critical flow for the watershed comes from glacial melt, which along with snowpack, is anticipated to decrease as temperatures warm (Reclamation 2015). According to a 2016 study, this important contribution of glaciers to the basin's water supply is anticipated to diminish by the end of the 21st century by 14-63% under a lower carbon emission projection and by 18-78% under a higher scenario

(Frans et al. 2016). The same study predicted increases in the frequency of drought impacts including low summer soil moisture, low spring snowpack and low summer runoff.

Since 1998, four fish species that live in the Hood River Basin — bull trout, resident cutthroat trout, steelhead, and Chinook salmon — have been listed as threatened under the ESA. In the Hood River Basin, summer steelhead are limited to the West Fork Hood River sub-basin, which is one of the weakest native stocks in the entirety of the basin (Coccoli 2004). Despite this, Green Point Creek, a West Fork Hood River tributary, has some of the highest native fish densities in the sub-basin and is a high priority for instream flow augmentation. Spawning and rearing habitat of summer/winter steelhead, resident cutthroat and potentially coho salmon are impacted by current diversions for irrigation that substantially reduce flows in the summer. A minimum summer instream flow of 25 cfs has been recommended for Green Point Creek to support native fish populations, but current late summer streamflow averages only 20 cfs (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014).

While flow itself is important for various life history stages of native fish, it also impacts water temperature, which, when elevated, can cause mortality or impacts to productivity (Siegel and Crozier 2018). With climate change creating additional stress on flow and water temperature in the Hood River watershed, “the loss of streamflow could mean the complete collapse of already teetering salmonid runs, leading to cultural and economic impoverishment” (Ross and Chang 2021).

The health and persistence of fish species in the basin is important to Tribal members of the CTWS. The Hood River basin is part of the ceded lands of the CTWS people and remains a region with high cultural value to Tribal members.

FID is one of five major irrigation districts in the basin and provides water to almost 6,000 acres, predominantly planted in pear orchards, on the basin’s west side. Portions of FID already experience chronic water shortages, which are expected to increase under future climate scenarios, even after significant investment in on-farm water conservation (i.e., irrigation infrastructure upgrades to high-efficiency micro-sprinklers). FID has made investments in modernizing the district’s infrastructure by piping open canals and pressurizing its systems. (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014).

The upper and lower Kingsley Reservoirs, which provide much of FID’s water, are supplied with waters diverted from Gate and Cabin Creeks and transported via pipe to the off-channel reservoir (See Figure 44 above).[25] Fed by glacial melt, these creeks are experiencing drastic flow impacts from climate change (Reclamation 2015). Starting in early June all live flow is diverted from the Gate and Cabin Creeks to the reservoirs, however, as reservoir storage itself is no longer sufficient, Ditch Creek natural flow is also diverted for irrigation. This dewaters Green Point and Ditch Creeks to levels below those recommended

[25] Gate and Cabin Creeks are tributaries to North Green Point Creek, which flows into Green Point Creek and then the West Fork Hood River.

for threated native fish species. (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014)

9.2 INVESTMENTS

Especially in watersheds like the Hood River Watershed that are losing significant natural storage from melting glaciers and declining snowpack, water storage is one tool that can help lessen impacts on water dependent sectors like agriculture. Human-built storage facilities can mimic a glacier by storing freshwater and releasing it over time, as needed for irrigation. Storage can increase water availability for human, environmental and economic uses while also reducing flood impacts and providing other benefits like recreational opportunities (Burke et al. 2023). Increasing storage does not only mean building new dams and reservoirs. Construction of new large dams around the world peaked in the 1970s and has declined every year since (Burke et al. 2023). Environmental and other public interest protections make developing new built storage projects, especially large projects, difficult and impractical.

Other opportunities exist however, to increase storage capacity with fewer environmental and other impacts. Burke and her colleagues (2023) promote *The 5 R's*: reoperation, rehabilitation, retrofitting, reform and raising new storage. The first four in this list involve changing existing facilities in one or more ways to meet modern water management challenges. When considering new storage, a range of storage options including nature-based solutions like reconnecting floodplains and creating wetlands, and other solutions like urban stormwater capture and managed aquifer recharge are more viable than proposals to build dams on rivers with important cultural, Tribal, recreation and environmental values.

To address the coming water supply challenges for FID patrons and instream flows from glacial melt and other climate change impacts, FID explored options for increasing supply reliability by developing the Kingsley Reservoir Expansion and Pipeline project. In 2014, FID received a grant from OWRD to conduct a feasibility analysis and in 2015 successfully applied for $3M in funding from OWRD to build the project (as part of its Water Conservation, Storage and Reuse Grant Program). The district also secured an additional $3M match in the form of a low interest loan from the CWSRF. Upon completion of the project, total costs were estimated as $6.9M. (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014; FID 2022)

The project had two distinct components. The first entailed replacing the Lowline Pipeline, a damaged pipeline that was leaking approximately 3 cfs. In addition to increasing water reliability for irrigators in the middle portion of the district, replacement of this pipe increased Green Point Creek's instream flow by 1.5 cfs through a critical reach. At the time of completion, the total cost for this portion of the project was $1.2M ($1.5M in 2022 dollars). (FID 2022)

The second component increased storage capacity in Kingsley Reservoir by raising the height of the dam by 11-feet, which added an additional 650 AF of storage (a more than 50% increase in total storage volume). Additional storage water would not come from new diversions, but rather, from water that currently passes through the reservoir in the winter and is used for hydropower generation. (Farmers Irrigation District 2014; 2022). It is worth noting that no additional lands were to be brought under irrigation with the increase in storage (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014).

The reservoir expansion was originally slated for completion in 2017, but unexpected obstacles slowed the project including regulatory hurdles, COVID-19 shutdowns, supply chain issues and inclement weather/wildfire-risks, among others. The expansion was completed in 2021 and the reservoir, along with the Kingsley Recreation Day Use Area and Campground — which were also redesigned, improved and upgraded by Hood River County — was reopened in summer 2022. (Mitchell 2022)

9.3 Analysis

The business case example examined here involves analyzing the costs and benefits of investment in the Kingsley Reservoir Expansion and Pipeline project compared to the no-action alternative that involves continuing to operate under the status quo but with a changing climate impacting water availability.

No-Action Alternative: While the no-action alternative may not have an investment cost, there are economic costs of not investing — which in this case study are relatively straightforward. FID patrons would not benefit from increased storage and irrigation water reliability, additional flow would not be permanently dedicated instream reducing one pathway to improve habitat conditions for ESA listed species.

Kingsley Reservoir Expansion & Pipeline Project: This alternative includes the two components of the FID project — pipeline replacement and reservoir expansion — and examines each separately given the specific benefits produced by each. Total costs for replacement of the Lowline Pipeline were $1.4M, which resulted in permanent instream dedication of all the conserved water (1.5 cfs or 357 AF for the reach from North Green Point Creek to the mouth of Green Point Creek) through Oregon's Allocation of Conserved Water Program. The primary benefit of the pipeline replacement is the volume of the water permanently restored instream, which will increase flow and likely also reduce instream temperature. Summer streamflow in the reach is already recognized as impacted relative to both historic and optimal conditions for native fish and with the projected impacts of climate change, actions will have to be undertaken to augment flow if native fish populations are going to be preserved (Hood River Soil & Water Conservation District and Farmers Irrigation District 2014; Ross and Chang 2021). As such, the pipeline replacement increases the resiliency of this system and supports fisheries popular for recreational fishing and critical to local Indigenous people (CTWS)— for which it could be argued the economic value is infinite. Reduced O&M costs for FID were also recognized as a benefit of the project, but no detailed information could be located on the actual amount of cost savings (FID 2022).

As some investment likely would be needed in the future to increase instream flow if this project had not been funded, it can be useful to assess the cost-effectiveness of this investment relative to other investment options. Given that the volume is restored instream permanently, a 100-year lifespan is used to evaluate the benefits of the flow. Using a 100-year lifespan, reflective of the permanent dedication of the water instream, and a 3% discount rate, the LCOW of the pipeline replacement is **$131/AF**.

Total costs for expansion of the Kingsley Reservoir and actions required to achieve the expansion (i.e., permitting, acquisition of additional storage rights, construction, etc.) were an estimated $6.6M.[26] The primary benefit of the reservoir expansion is additional storage water availability for agricultural production. There are 400 acres of pear orchards in the upper portion of FID that are almost completely reliant on storage water from the reservoir.

Pears are an iconic, heritage crop in Oregon, having been brought to the state by pioneers on the Oregon Trail. In addition to being the number one fruit tree crop in the state, pears were also recognized as the state fruit in 2005. (Food Hero and Oregon Harvest for Schools n.d.)

A recent study by Oregon State University extension researchers showed however, that, on paper at least, at 2021 prices and costs, some medium and high-density approaches to managing pear orchards are break-even or not profitable enterprises. Admittedly, there are nuances to this finding as the analysis was based on a "typical farm" that likely does not fully represent the range of farms in the watershed. The authors noted that lack of profitability may be particularly true for new growers, whereas multi-generation farms with established orchards may have fewer loans and associated expenses, grow their own nursery trees and even have a different view on farming — one about lifestyle rather than strictly about profit. Based on this study only, the data do not support the conclusion that, by themselves, on-farm benefits of additional water supply for irrigation of pears outweigh the cost of the reservoir expansion. (Courtney and Mullinax 2021; Seavert and Castagnoli 2021). It is important to look beyond this one study with its limited perspective.

On-farm profit from pear production is far from the only benefit of greater reliability of water supply for pear growers. First, many pear growers likely are profitable because their farming operation differs from the typical farm in the study described above. For these growers, enhanced water security helps ensure ongoing profitability. In addition, the Fruit Loop — a well-advertised, well-traveled and scenic 35-mile loop that connects 28 on-the-farm fruit stands, wineries, breweries, cideries and fields of flowers in the Hood River area— brings opportunities for agritourism that would be lost were family farms to go out of business (Hood River Fruit Loop n.d.). A recent study of agritourism and on-farm direct sales in Oregon, in which fruit was the most common crop grown by respondents (over 50%), found that more than half of respondents produce value-added products such as preserves or ciders; nearly 90% offer on-farm direct sales (e.g., farm stands, U-pick, etc.); and 64% offer some on-farm educational experiences (e.g., tours, classes, tastings, etc.). For those respondents who indicated that they were motivated to pursue agritourism to increase farm/ranch revenue, over 85% indicated that they were somewhat or very successful in doing so. (Steward et al. 2021).

Another benefit of the reservoir expansion is a small potential increase in instream flows during the release of the stored water. The proposal for the project mentions that 25% of additional stored water from the project must be dedicated instream — for Green Point Creek, this could represent up to a 10%

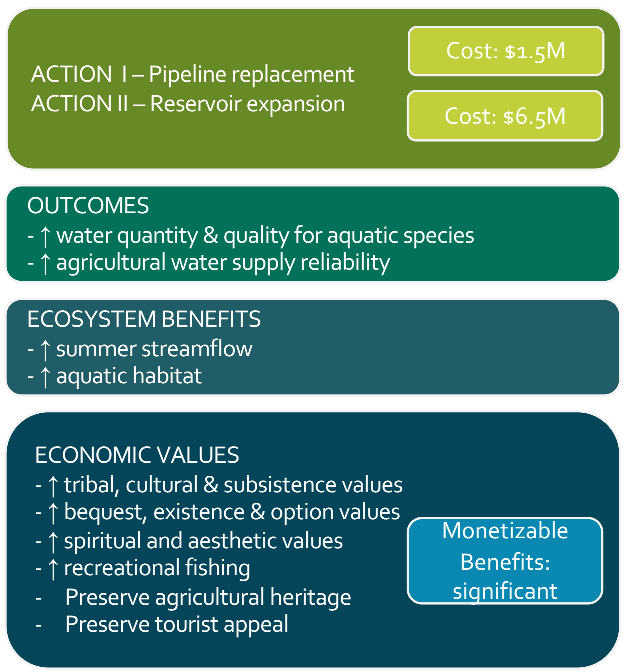
[26] As it was not clear in which year(s) costs were incurred, inflation across the years of the project (i.e., 2016-2022) was averaged to estimate total costs in constant 2022 dollars.

increase in summer flow and 4% increase in habitat (FID 2016). Given the broad importance of salmon to the region, the benefits of increasing stream and species resiliency cannot be overstated (Figure 45).

Among the many things visitors flock to Hood River to see are salmon, pastoral scenery and family farm-stands. While ascribing a monetary value to these things may not be straightforward, estimating the impacts of travel and tourism to the region is. In 2021, resident and non-resident visitors spent an estimated $474M (of which 98% came from non-residents) while visiting Hood River and the Columbia River Gorge — in turn generating thousands of jobs and an estimated $25M in local and state taxes (Dean Runyan Associates 2021). Some portion of this, possibly a significant portion, is attributable to irrigated agriculture, especially the iconic pear orchards in the region.

As a point of comparison with other projects, the LCOW of the project also was calculated. Assuming a 50-year lifespan and a 3% discount rate, the LCOW of the reservoir expansion component is **$393/AF**.

FIGURE 45. FID SUMMARY



9.4 DISCUSSION

As Oregon loses sources of natural storage like glaciers and winter snowpack, water users will need to find ways to adapt. Many of these adaptations will involve reducing demand through conservation and other actions. However, supply-side adaptations are also possible when calibrated with instream and other values for water (Box 7).

BOX 7: WALLOWA LAKE DAM REHABILITATION

Wallowa Lake is a glacial lake in northeast Oregon that was dammed to enhance its capacity to store water in the early 1900s. Since that time, the lake has provided drinking water, water for irrigation, flood control and has been a vibrant recreational resource for nearby communities and visitors. Outflow from the lake forms the Wallowa River, a Grande Ronde River tributary. Prior to building the dam, the lake and the tributaries that feed it provided habitat for sockeye salmon a species of vital cultural importance to the Nez Perce Tribe and the Confederated Tribes of the Umatilla Indian Reservation. The dam does not provide passage for sockeye migration in or out of the lake which has led to the extinction of sockeye salmon from the system. In the 1990s, Wallowa Lake dam was deemed unsafe and storage in the lake was reduced to help allay these concerns. Ever since that time, the irrigators who own the dam have been looking for funding to rehabilitate the dam, thereby increasing its storage capacity back to the original level. Recently, the Nez Perce and Umatilla Tribes have been working with the irrigators and the state to reach an agreement to fund rehabilitation of the dam, including fish passage that would allow for reintroduction of sockeye salmon; fixing the dam would also help increase water available for: instream flow in the Wallowa River and its tributaries; irrigation water; drinking water; and increased flood control capacity. Rehabilitating Wallowa Lake dam is another example of a storage project that could provide multiple benefits with the highlight being reintroduction of an extirpated species of immense cultural value to the Indigenous people of the area. (Page 2022)

Two important lessons emerge from this case study:

- **In certain contexts, storage may be a viable supply strategy for the future**. The most feasible and replicable storage-related investments are enhancement and rehabilitation of existing storage facilities. Feasibility of approval is increased when co-benefits like recreation and, especially, instream flow or fish passage, reintroduction or both can be accomplished.
- **Many investments made in water provide positive returns when you widen the consideration of benefits beyond agricultural production**. From a strict farm budget and income perspective, enhancing the reliability of pear growers' water rights in FID through the investment made in Kingsley Reservoir may only break even or not show positive return on investment. But compared to the option of not investing — a watershed that can no longer grow the state's official fruit, lead the nation in pear exports, promote tourism, provide value-added farm enhancements like farm stands and sustain a region's deep agricultural heritage and culture — the investment makes sense from an economic and non-monetary perspective.

10 Columbia Plateau Regional Case Study #2: Nitrate Contamination in Groundwater-Sourced Drinking Water in the Lower Umatilla Basin Groundwater Management Area

This case study discusses investments to help address nitrate contamination of groundwater in the Lower Umatilla Basin Groundwater Management Area (LUBGWMA) and the resulting impacts on access for residents to safe water for drinking and domestic use. Two water-related investments that have the potential to help minimize and/or mitigate these impacts are assessed: 1) improving access to safe drinking water through short-term actions (providing bottled water and installing reverse osmosis (RO) filters); and 2) reducing nitrogen loading at its source by implementing agricultural best management practices (BMPs).

The LUBGWMA is home to a diverse population with a significantly higher percentage of Hispanic/Latino-identifying people than the state average. The median household income in the region is also significantly lower than in the neighboring counties and the state overall. This case study therefore highlights an important water justice issue, namely, the impact of nitrate contamination on the frontline communities of the LUBGWMA. Nitrate contamination is a complex issue without simple solutions but the potential costs in terms of public health, property values and economic output from agriculture in the region (including both irrigated agriculture and dairies) are immense. In this case study format, it is impossible to do the topic full justice; limited quantitative analysis is applied and bolstered with qualitative discussion and data points from other parts of the US where available.

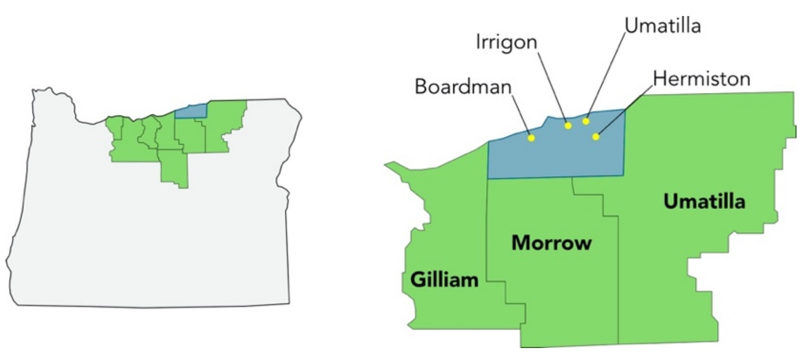
FIGURE 46. COLUMBIA PLATEAU REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Nitrate contamination of groundwater - Increased health risks, especially for pregnant women	- Improved access to safe drinking water - Improved public health outcomes - Reduced nitrogen loading & improvement of groundwater quality
Cause(s)	**Beneficiaries**
- Nitrogen loading of groundwater from agricultural application of fertilizer and other sources	- LUBGWMA residents and workers - Agricultural producers
Investment(s)	**Key Takeaways**
- Improving access to safe drinking water: provision of bottled or trucked water, installation of RO systems - Reducing nitrogen loading: implementation of BMPs	- Drinking nitrate-contaminated groundwater is a public health emergency that demands immediate action - Investment in access to clean water immediately should also be accompanied by a larger effort to prevent additional contamination

10.1 CHALLENGES

The LUBGWMA is a 550 square mile region covering parts of Umatilla and Morrow counties (Figure 47). The area has a documented history of high nitrate concentrations in groundwater since 1980s.

FIGURE 47. MAP OF THE LUBGWMA IN THE COLUMBIA PLATEAU REGION

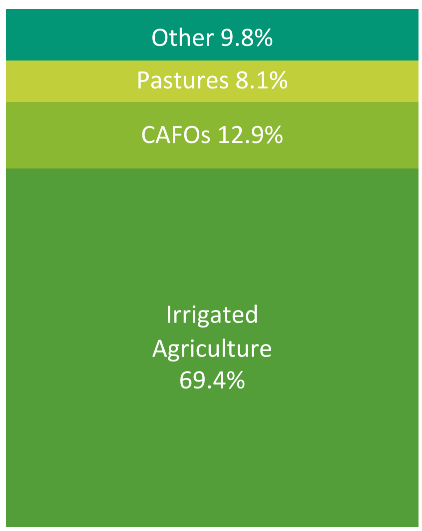


In drinking water, high nitrate concentrations pose a wide range of serious health problems, especially to vulnerable populations like babies, pregnant women and women who are nursing (Grondin et al. 1995; ODEQ 2020). Drinking water contaminated with nitrate poses increased risk of certain cancers and fetal development issues —and in the 1960s the US Department of Health, Education and Welfare set the US drinking water standard as 10mg/L for nitrate (as nitrogen) (Mathewson et al. 2020). A recent study in California's Central Valley found that groundwater depletion may be related to groundwater quality degradation (Levy et al. 2021), opening the possibility that groundwater overdraft in and around the LUBGWMA could exacerbate contamination issues.

The region was officially designated as a Groundwater Management Area in 1990, which "was established to allow for the identification and implementation of practices that will reduce nitrate loading and ultimately reduce groundwater nitrate concentrations below 7 [milligrams/liter] mg/L"; the 1990 designation was triggered by findings that nitrate contamination in groundwater exceeded a 7 mg/L threshold (ODEQ 2020). Since then, nitrate contamination has been increasing, with a 55% increase since 1997 (ODEQ 2020).

Nitrate contamination of groundwater in the LUBGWMA is caused by several factors likely including the natural presence of nitrates in soil. In 2011 DEQ, Oregon State University Extension and the Oregon Department of Agriculture estimated that agricultural application of fertilizer and management of animal waste from large dairies — some of which are also referred to as Confined Animal Feeding Operations (CAFOs) — are the largest contributors in the area (Figure 48) (ODEQ 2020). Other contributors include pasture and land application of food processing industrial wastewater (ODEQ 2020).

FIGURE 48. ESTIMATE OF SOURCES OF NITROGEN LEACHED TO GROUNDWATER IN THE LUBGWMA



Source: ODEQ 2020.

The impacts of nitrate contamination in the LUBGWMA fall on low income, racially diverse frontline communities. Summary demographic statistics are provided below for both Umatilla and Morrow counties as well as census tracts covered by the LUBGWMA (Table 42). County data were obtained from the US Census Bureau data tables (US Census Bureau 2020b) and US Census Bureau Quick Facts website (US Census Bureau, n.d.), while census tract data were obtained from US Census Data website tables (American Community Survey S0601). The two sources of information are not directly comparable but are correlated and provide a representation of demographic statistics for the specific area of interest.

Umatilla County: Hispanic/Latino inhabitants represent almost one-third of the total population (28.6% compared to Oregon, which has 14%) and almost one-quarter of the population speaks a language other than English at home. The percentage of the population in Umatilla County under 65 without health insurance is higher than the state-wide percentage (11.4% compared to 7.3%) as is the percentage of the population living in poverty (13.2% compared to 12.2%).

Morrow County: 39% of the population is Hispanic/Latino and over one-third of the population speaks a language other than English at home. The percentage of the population in Morrow County under 65 without health insurance is higher than the state-wide percentage (12.6% compared to 7.3%) as is the percentage of the population living in poverty (13.8% compared to 12.2%).

TABLE 42. DEMOGRAPHIC COMPARISON

	Morrow County	Umatilla County	LUBGWMA	Oregon
Population	12,186	80,075	47,829	4,237,256
Race				
White (including Hispanic or Latino)	61.3%	66.8%	75.7%	74.8%
Black or African American	0.5%	0.9%	1.0%	2.0%
American Indian and Alaska Native	1.4%	3.8%	1.1%	1.5%
Asian	0.3%	0.9%	1.1%	4.6%
Native Hawaiian and Other Pacific Islander	0.0%	0.2%	0.1%	0.5%
Some Other Race	22.8%	15.6%	10.6%	6.3%
Two or More Races	13.7%	11.8%	10.5%	10.5%
Ethnicity				
Hispanic or Latino	39.0%	28.6%	42.0%	14.0%
White alone, not Hispanic or Latino	56.3%	64.1%	52.7%	74.1%
From 2017-2021				
Foreign born persons	17.9%	9.2%	—	9.8%
Language other than English spoken at home	35.5%	22.6%	35.0%	15.3%
High school graduate or higher	77.5%	83.2%	77.4%	91.5%
Persons w/o health insurance (under 65)	12.6%	11.4%	—	7.3%
Median household income	$61,659	$63,123	$31,327	$75,712
Per capita income in past 12 months	$28,223	$27,140	—	$40,853
Persons in poverty	13.80%	13.20%	13.20%	12.20%

Note: As a result of data availability at different geographic scales, county- and state-level data are sourced from the 2020 Census, whereas census tract data that make up the LUBGWMA statistics are sourced from the American Community Survey 5-year estimates. Differences in source data mean that data are not directly comparable. All dollar figures presented in constant 2022 dollars. The value for MHI represents the 2017-2021 value.

Agriculture and related industries are major drivers of the region's economy — in 2022, agriculture (including wineries), and food processing accounted for 19% and 38% of Morrow County's total economic output. These two sectors also employed 36% of the workforce. Similarly, in Umatilla county, agriculture and food processing contributed 16% of total output and employed 10% of the workforce. The Port of Morrow is a major economic hub; it is the second largest port in Oregon (after the Port of Portland) (FCS Group 2021). The Port is responsible for total annual economic output of $2.5B dollars;

leading sectors driving this economic output include frozen food manufacturing, data centers, vegetable and melon farming, cattle and milk production and grain farming (FCS Group 2021).

10.2 Investments

There are two primary methods for addressing nitrate contamination of groundwater — methods that involve treatment of drinking water and methods that do not treat drinking water itself but attempt to avoid contamination in the first place (called non-treatment methods). Treatment, as the name implies, involves directly treating the contaminated water itself — ideally to levels that are safe for drinking and domestic use. The method most used by water supply utilities is ion exchange, which removes nitrate by displacing chloride on an anion exchange resin. The second most used method, and the one most used in households, is reverse osmosis, which forces water through a semi-permeable membrane to remove contaminants, such as, but not limited to, nitrates (Center for Watershed Sciences, UC Davis 2012). Other, less common, treatments include electrodialysis/ electrodialysis reversal, biological denitrification and chemical denitrification. (Center for Watershed Sciences, UC Davis 2012)

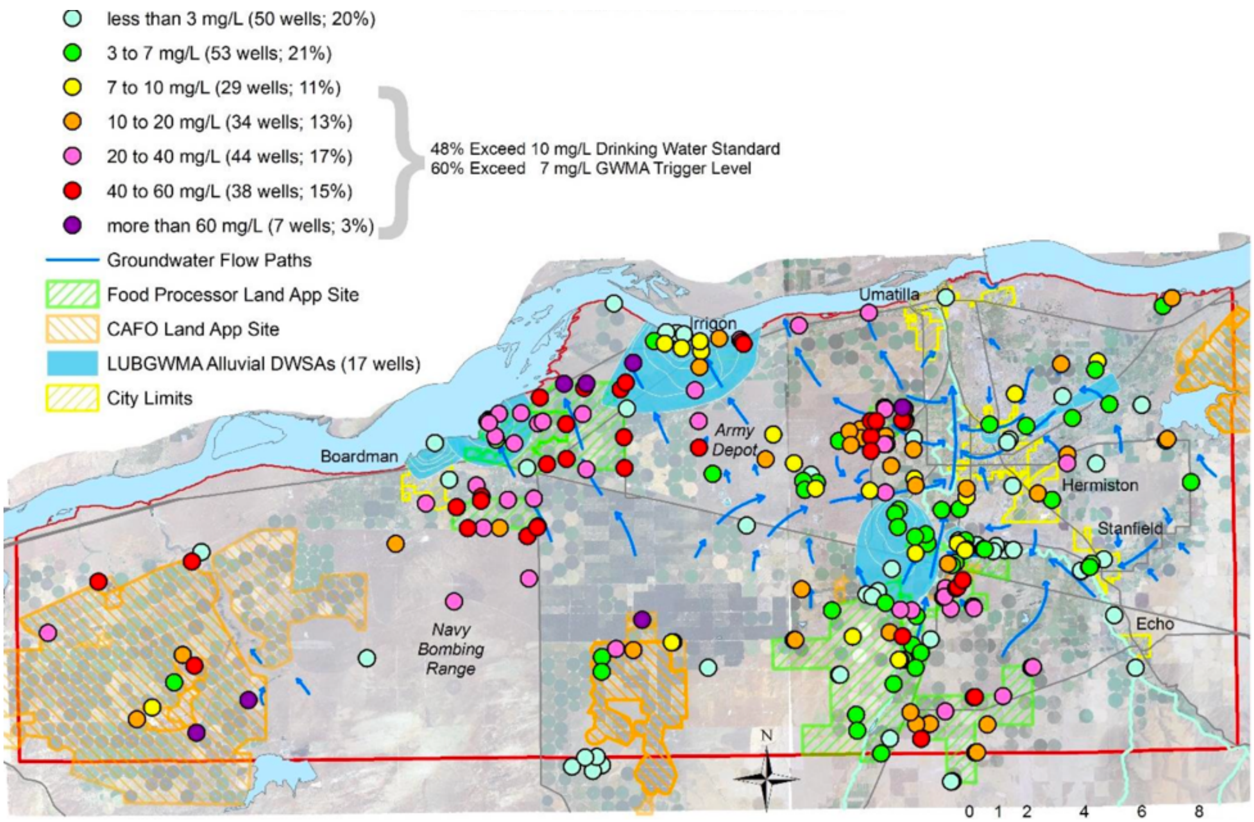
Non-treatment options focus on treating and avoiding nitrate contamination at the source— in the case of LUBGWMA, this primarily would be at the farms, CAFOs and food processing facilities in the region. A variety of non-treatment options exist, including:

- Blending – to dilute nitrate impacted water with another water source to achieve acceptable concentration levels (this is the most common method);
- Wellhead protection and land use management – implementing BMPs to reduce nitrate-loading from agriculture, CAFOs and other land uses through alternative measures and practices, discharge control and septic tank remediation, among other activities;
- Well inactivation – to abandon and destroy a contaminated wells in favor of another source of water; and
- Source modification and development of alternative sources – to access higher quality source water. (Center for Watershed Sciences, UC Davis 2012)

Currently, the region's water supply utilities (Hermiston, Umatilla City, Boardman, Irrigon, etc.) meet water quality requirements for nitrate. However, of the nearly 48,000 residents in the LUBGWMA, 14,830 (over 30% as of the 2010 census) rely on wells rather than water supply utilities for drinking water and domestic use (Ostrom 2023; Morrow County, Oregon n.d.). Recent testing has shown that 70%-90% of rural domestic wells test over the 10 mg/L maximum contaminant level (Ostrom 2023; Wright 2022). The counties are, at present, providing impacted residents with bottled drinking water and in-home point-of-use RO systems (i.e., at a specific faucet rather than a full home or point-of-entry system).

Evidence does, however, exist that nitrate levels in some areas of the LUBGWMA and/or at some times, exceed the 27 mg/L limit above which the provided RO systems cannot sufficiently treat water (Ostrom 2023) (Figure 49). The counties also are appealing to the State to provide relief, primarily in the form of better RO systems (Wright 2022). Finally, due to language and other barriers, some residents are not fully aware of the extent of the problem nor the availability of assistance, highlighting the potential for disproportionate impacts on vulnerable communities.

FIGURE 49. COMPOSITE OF AVAILABLE NITRATE DATA FROM 255 WELLS (2015-2016)



Source: (ODEQ 2020)

While the need for access to safe water is immediate, requiring investments in development of alternative sources (e.g., bottled water, trucked water and RO systems), there are longer term actions that may need to occur to ensure sustainable and reliable access to safe drinking water. These actions include the potential for water supply utilities, who are currently in compliance with water standards, to update their facilities as the population to whom they provide water increases and/or source water becomes increasingly contaminated; as well as actions to directly reduce nitrogen loading from primary sources — agriculture and CAFOs (ODEQ 2020).

BMPs to reduce nitrogen-loading are varied and site-specific and the current approach in the LUBGWMA is to rely on voluntary actions to reduce nitrogen loading from these sources. In order to realize long-term, sustainable improvements in groundwater quality, investments and technical assistance are needed to increase the scale of these efforts (ODEQ 2020). While studies have shown that the implementation of certain BMPs are some of the more cost-effective actions in reducing nitrogen loading and can produce cost-savings for farm and CAFO operators, the voluntary nature of the current effort combined with the barriers of upfront investment and knowledge may inhibit the pace and scope of uptake (Govindasamy et al. 2023; Gu et al. 2023; Christianson, Tyndall, and Helmers 2013).

10.3 Analysis

The business case illustration in this case study focuses on comparing investment in two alternatives to provide immediate access to clean, safe drinking water:

Bottled water: The State provides bottled water to all impacted residents over the long-term to ensure access to safe water for drinking and domestic use.

RO systems: The State provides higher quality RO systems to all impacted residents and supports the long-term maintenance costs of those systems to ensure access to safe water for drinking and domestic use.

In addition to these investments, the potential costs and benefits associated with BMP implementation are discussed qualitatively. This case does not include a no-action alternative. Taking no action is simply not an option in the face of the public health and other risks present in the LUBGWMA. Nor is there benefit in comparing costs of the short-term fixes and longer-term implementation of BMPs. While BMPs have the potential to fix the root cause of the problem over time, the public health risks are immediate so the option to wait for long-term outcomes does not exist. This is a case where investment is needed immediately to address the current crisis *and* investment is needed to move long-term solutions forward.

This analysis estimates the economic costs and benefits of the providing bottled water and installing RO systems. For both bottled water and RO, it is assumed that all rural residents in LUBGWMA reliant on private wells (estimated as 14,830 residents in 2010) would participate and are able to do so despite language and other barriers. The primary benefit of both investments is immediate access to safe water for all residents, thereby improving health outcomes and helping address impacts to the region's frontline communities.

Bottled Water: Under this alternative, the investment would be a program to provide two gallons of bottled water per person per day. No other action is presumed to be taken. The costs of this investment are the provision of bottled water only, which are quantified below. The cost of bottled water comes from Desert Springs Bottled Water, with whom Morrow County has contracted for similar purposes, for delivery of 5-gallon bottles (Baumhardt 2022). There may be cheaper water options available, but the cost of transportation would likely be borne by the individual. Based on current costs, providing bottled water to all identified individuals would cost approximately $17M per year until alternatives could be developed or groundwater nitrate levels are sufficiently reduced.

RO Systems: This alternative would cover the purchase, installation and associated maintenance costs for point-of-use RO systems (of a better quality than those currently provided by the counties) for an estimated 4,500 households (Ostrom 2023). No other action is presumed to be taken. The costs of this investment are the provision of RO systems and associated maintenance only and are quantified below. Purchase and installation of each system is assumed to be $1,800, with average maintenance costs of $200 per year (Wright 2022; Oregon State University Extension Service 2023). The lifespan of a system is assumed to be 10 years. Based on these assumptions, this alternative would cost $8.1M in upfront capital costs and $0.9M per year in maintenance costs.

To compare the two alternatives, the NPV of each was calculated using a 3% discount rate. As there are no upfront costs for the bottled water alternative, both alternatives are assumed to have a lifespan of 10 years (the average expected life of an RO system). Based on these assumptions, the estimated NPV of the alternatives are **$202.9M** for bottled water and **$17.7M** for RO, both over a ten-year period.

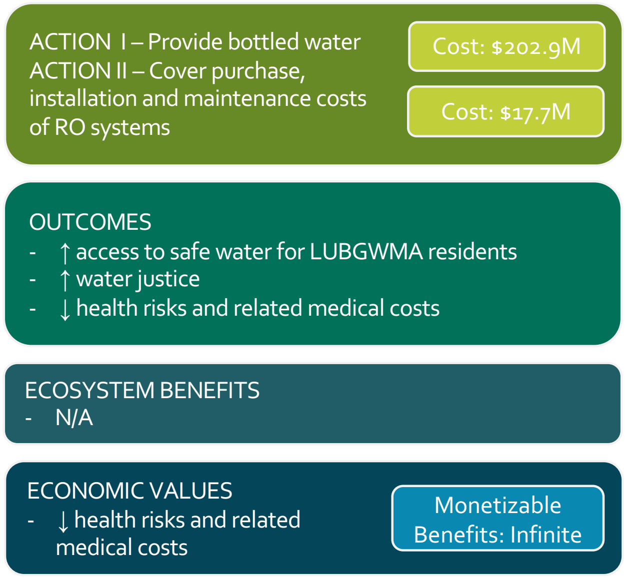
Avoided medical costs associated with health risks from exposure to high nitrate concentrations were not quantified for this case study, however, a study of nation-wide exposure to nitrate in drinking water (typically of concentrations much less than those found in parts of the LUBGWMA) found that nitrate in drinking water can increase the risk of multiple types of cancer (ovarian, colorectal, thyroid, kidney and bladder) as well as neural tube defects, very preterm birth and very low birthweight in infants. Each of these conditions is associated with both direct medical costs as well as loss in productivity. Although the number of cases of these conditions in Morrow and Umatilla counties may not be high (data was only accessible for cancer-related illnesses), and therefore the cases attributable to nitrate in drinking water are not high, they can still have real economic costs to both the affected individual(s) and the region at-large (Table 43). (Mathewson et al. 2020; Temkin et al. 2019; National Cancer Institute 2019)

Table 43. Nitrate-Related Conditions, Cases in Morrow and Umatilla Counties and Costs

Condition	Average Annual Cases (#)	Attributable to Drinking Water Nitrate (%)	Direct Medical Costs ($M/Case)
Ovarian Cancer	5	0.6% - 3.2%	$0.2
Colorectal Cancer	38	1% - 8.2%	$0.2
Thyroid Cancer	10	0.8% - 2.2%	--
Kidney Cancer	12	1%	$0.2
Bladder Cancer	20	0%	$0.1
Neural Tube Defects	--	1%	$0.7
Very Preterm Birth	--	3%	$0.4
Very Low Birthweight	--	5%	$0.3

Source: (Mathewson et al. 2020; Temkin et al. 2019; National Cancer Institute 2019)

FIGURE 50. LUBGWMA SUMMARY



10.3.1 Investment in BMP Implementation

Investments in BMP implementation and related economic benefits and impacts are not quantified. However, this section provides a brief qualitative discussion of these actions. To date, the approach in two Action Plans issued by the Lower Umatilla Basin Groundwater Management Committee has been to propose the voluntary adoption of BMPs for nutrient management:

- For agriculture, BMPs involve efficient application of both irrigation water and nutrients "at the right time, location, type and rates." Examples of BMPs in this context include irrigation efficiency upgrades; changes in timing or volume of fertilizer application; and planting field buffers. Winter cover crops may also help prevent nitrogen from moving deeper into the soil.
- For CAFOs, BMPs include appropriate management and conveyance of manure and treated wastewater as well as management of surface water sources that may contact potential pollutant sources. Examples include construction of ODA-compliant facilities and irrigation efficiency upgrades. (ODEQ 2020)

Improved irrigation and nutrient management for irrigated agriculture provides the "greatest potential to improve groundwater quality on a regional scale" (ODEQ 2011). In many geographies, these have already been proven to be viable (and often cost-effective) options for reducing nitrogen losses on cropland (Govindasamy et al. 2023; Gu et al. 2023; Manaaki Whenua 2019; Christianson, Tyndall, and Helmers 2013). In some studies, crop yield has increased and on-farm costs have decreased as a result (Christianson, Tyndall, and Helmers 2013; Govindasamy et al. 2023). Assuming similar results in the LUBGWMA, potential investments include funding for increased outreach and technical assistance to farms and dairies, alongside fertilizer application technologies, inclusive of complementary irrigation technology upgrades (as of 2015, data suggests that the majority of irrigation (68%) uses sprinkler systems and 2% micro-irrigation (USGS n.d.)).

There are, however, many factors that can impact the success of and rate at which BMP implementation reduces groundwater nitrate contamination. BMPs can be site-specific, and the scale of BMP implementation of different types will determine the potential decrease in nitrogen loading from agricultural lands. In addition to this, farmers and landowners may have affinity for or rejection of specific BMPs or BMPs altogether. These two factors impact the potential reduction in nitrogen loading. Layered on top of this is the timescale at which reductions in nitrogen applied to fields will impact nitrogen levels in groundwater, which is dependent on the hydrogeology of the region.

The benefits of BMP implementation are the avoided costs of providing access to safe drinking water through purchases of bottled water and/or RO systems as well as the potential costs of water supply utilities making future investments in system upgrades. However, some investments will need to be made to provide access to safe drinking water in the near-term because of the area- and time-scale considerations mentioned previously. Additionally, BMP implementation has the potential for environmental benefits, including improvement of water quality in streams, aquatic habitats and groundwater-dependent ecosystems. Water bodies in Morrow and Umatilla County have experienced overgrowth of algae (growths that are not harmful to humans but may impact aquatic habitat and species) as well as harmful algal blooms that produce cyanotoxins harmful to humans (Plaven 2018; Oregon Health Authority 2023).

10.4 Discussion

Even a high-level glimpse at the issues surrounding nitrate contamination in the LUBGWMA shows the vast complexity of the problem. On one hand, the immediate need is to invest in providing bottled water and/or RO systems as much and as quickly as possible and to do so in a way that is targeted at reaching vulnerable frontline community members — low-income residents who may lack access to traditional communication channels and non-English speaking residents. Catalyzing funding for and adoption of BMPs is no less urgent, though outcomes from these strategies will, by their nature take time.

Two challenges to success stand out. First, the LUBGWMA and surrounding counties are major economic centers for Oregon; the industries whose historical practices caused significant amounts of contamination are drivers of this economic activity. Solutions need to be found that combine aggressive BMP implementation and accountability with continued economic productivity. Second, nitrate contamination of groundwater sits at the intersection of many agencies' jurisdictions: ODA, ODEQ, OWRD, Morrow and Umatilla County, just to name few. Coordination and accountability are therefore a major hurdle that must be overcome.

Four important lessons emerge for Oregon from this examination of nitrate contamination in the LUBGWMA:

- **Frontline communities are especially vulnerable to water related challenges**. Due to language and other barriers, some members of these communities may not know a problem exists while some who do know of the problem may not have the resources, time or capacity to take the steps necessary to access aid. Simply offering aid is not sufficient; it may take a house-by-house approach to ensure that all residents have access to bottled water, RO treatment systems, or both.

- **Some problems, like nitrate contamination of groundwater cannot be fixed on a timeline that matters.** Residents of the LUBGWMA cannot wait for the effects of BMPs implemented today to result in cleaner groundwater in a decade. Where problems like this exist, **funding and capacity need to be dedicated as quickly as possible to providing short-term fixes**.
- Though it is of no help to current residents, the LUBGWMA case is a cautionary tale and provides support for **acting today whenever possible to avoid impacts in the future**. This lesson applies more broadly than in the groundwater contamination context though it is particularly relevant there.
- **Many uses of water have lagged impacts or impacts that compound over time.** It is critical to identify these types of potential impacts (for example groundwater pumping that can impact surface water long after a pump is turned on) and design approaches for managing them now rather than waiting for their full impact to appear years later.

11 Blue Mountains/Northeast Regional Case Study: Investing in Conservation and Environmental Water Transactions to Support Farms and Culturally and Ecologically Important Chinook and Coho Salmon

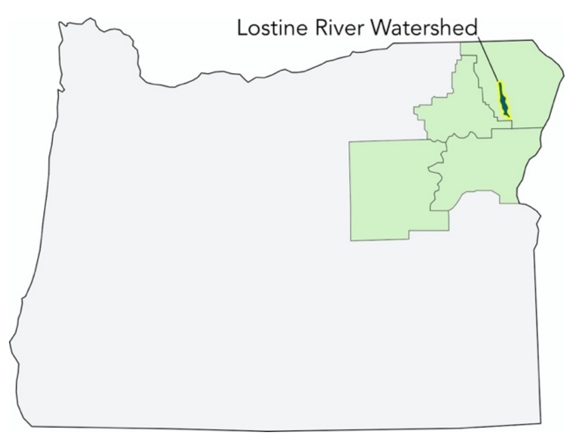
The Lostine River begins in the high mountains of the Eagle Cap Wilderness and flows into the Wallowa River near the town of Lostine (Figure 52). The Wallowa River is a tributary of the Grande Ronde River, itself a tributary of the Snake River. The wide valley into which the Lostine River flows is part of the ancestral homelands of the Nez Perce Tribe and the CTUIR. Though Wallowa County is not part of either Tribes' current reservation, both Tribes reserved the right to hunt and fish there (among other lands) as part of treaties signed in the mid-1800s.

This case study describes two types of investments to increase instream flow in the Lostine River: environmental water transactions (EWTs); and irrigation infrastructure modernization on family farms. In turn, these investments support and increase the resiliency of a vital Tribal fishery and recovery of ESA-listed Chinook salmon and reintroduced Coho salmon populations. Given that many of the beneficial outcomes of these investments are non-market or non-use in nature, this case study provides a business case example only for investments in irrigation efficiency upgrades as this particular investment also provides monetizable on-farm benefits (Figure 51).

FIGURE 51. BLUE MOUNTAIN/ NORTHEAST REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Low instream flows - Impacts to native fish & habitat	- Increased streamflow - Improved aquatic habitat - Improved agricultural production & yield
Cause(s)	**Beneficiaries**
- Irrigation withdrawals - Climate change impacts	- Aquatic species including ESA-listed Chinook salmon & reintroduced coho salmon - Agricultural producers
Investment(s)	**Key Takeaways**
- On-farm irrigation infrastructure modernization	- Investing in on-farm irrigation modernization can improve productivity & increase profitability - Investing in environmental water transactions can catalyze creative new management approaches

FIGURE 52: MAP OF LOSTINE RIVER WATERSHED LOCATION



11.1 CHALLENGE

The Lostine River provides critical spawning and rearing habitat for spring and fall Snake River Chinook salmon (listed as threatened under ESA), recently reintroduced coho salmon, steelhead and bull trout. Salmon hold deep cultural importance for the Nez Perce and CTUIR and have been a primary source of food supply since time immemorial. Chinook salmon exhibit a unique migration pattern on the Lostine. The fish return in two pulses, with the second pulse of returning fish occurring in late August and lasting through the end of September. This migration of Chinook salmon coincides with low late summer stream flow in the Lostine River. The period is also a time of year when local farms and ranches rely most heavily on the river for water for irrigated agriculture.

Since the late 1800s, water from the Lostine River has been used to irrigate farms growing mostly hay and alfalfa as well as small grains. Diversions from the river can completely de-water the river just above the town of Lostine, making upstream passage to the Lostine River's ideal spawning habitat difficult or impossible for returning adult salmon. Low flows, coupled with changing ocean conditions, the presence of dams on the Snake and Columbia Rivers and other alterations on the Lostine River, resulted in the disappearance of Coho salmon from the river and severely impacted the spring Chinook salmon population (NOAA 2020). The Nez Perce and the state of Oregon manage a hatchery supplementation program for Chinook salmon on the river and recently worked with CTUIR to successfully reintroduce coho salmon.

Water in the Lostine River is in high demand for both farms and fish and has significant economic and cultural value. The challenge for the region is keeping the agricultural heritage and economy of the region whole while better providing for the needs of ESA-listed Chinook salmon, reintroduced coho salmon and the cultural and sustaining role these species play for the region's indigenous Tribes.

11.2 Investments

While the business case is evaluated only for the on-farm irrigation infrastructure modernization investments, the investment in an EWT is also described in detail here as it provides a point of comparison for assessing cost-effectiveness of public investments.

Environmental Water Transaction: Starting in 2005, a unique, voluntary and cooperative effort was started by the Oregon Water Trust, working with local partners including the Nez Perce to increase instream flows in the Lostine River during the late summer through an innovative environmental water transaction. Funded by the Columbia Basin Water Transactions Program with money from Bonneville Power Administration, the Oregon Water Trust initiated an agreement with approximately one hundred local landowners organized into five irrigation companies. The agreement provides a minimum flow in the Lostine River of 15 cfs from mid-August through September. This is accomplished by the five irrigation companies reducing and otherwise managing their diversions to ensure that at least 15 cfs and up to 20 cfs stay in the river through a reach that was once dry.

The terms of the agreement evolved over time, but for several years, settled on a payment of $164,000 per year if the minimum flow was met during the defined late-summer period. This payment amounted to approximately $138/AF. A lump sum payment was made each year by the Oregon Water Trust (later The Freshwater Trust and then Trout Unlimited) to the irrigation ditch companies in proportion to the number of participating acres within each company. Payments were then made to individual landowners by the ditch companies on a per-acre basis. Approximately 4,000 acres were enrolled each year.

This innovative and successful long-term agreement laid the groundwork for subsequent investments to further increase instream flow in the Lostine River, thereby ensuring that Chinook salmon can reach their spawning grounds in the late summer.

Irrigation Infrastructure Modernization: Building on the success of the Lostine River minimum flow agreement, in 2016, the Wolfe Ranch, a multi-generational family farm that diverts and uses water from the Lostine River, worked with The Freshwater Trust and other partners to upgrade to center pivot irrigation on several parcels of land. This project was followed by two additional, similar projects. The benefits of these investments are increased on-farm productivity and increased instream flow in the Lostine River to support fish.

11.3 Analysis

The business case illustration in this section focuses on the economic costs and benefits of investing in on-farm irrigation infrastructure modernization. The benefits of environmental water transactions are discussed qualitatively but are not directly quantified.

No-Action Alternative: The no-action alternative is for farms to continue their current on-farm irrigation practices with no upgrades. While this no-action alternative does not have an investment cost, there are economic costs of not investing. The costs of not investing are the inability to realize the benefits the investment: additional water permanently conserved instream, increased hay yields (and associated revenue) and increased value for irrigated acreage. The cost then, is the lost opportunity for greater productivity, revenue and property value.

Irrigation Infrastructure Modernization: To date, investments have been made in three irrigation efficiency projects on farms that divert water for irrigation from the Lostine River:

- In 2016, the Wolfe Family Farm Water Conservation Project was funded by OWRD to improve on-farm irrigation efficiency and increase instream flows in the Lostine River. A total of 16 center pivots and nearly 30,000 feet of mainline pipes were installed on 872 acres that had been flood irrigated. This resulted in 1,166 AF of conserved water. The project also freed up 102.3 acres for conversion to wildlife habitat and dryland farming; water rights from these lands were permanently transferred instream resulting in an addition 460 AF (2.5 cfs) restored to the river in May through July and 102.3 AF (0.8 cfs) restored to the river in August and September. In total, the project cost just over $2.5M. (The Freshwater Trust 2018)
- In 2020, the Johnston Lane Conservation Project was funded by OWRD to improve on-farm irrigation efficiency and increase instream flows in the Lostine River. Five center pivots were installed, converting 277 acres of formerly flood irrigated land. Through the project, 353.4 AF (1.94 cfs) were restored to the Lostine River from May through July. In addition, the landowners permanently transferred water rights associated with corners of their fields not accessible by center pivots, to instream flow for an additional 77.55 AF (0.36 cfs) restored instream from May through July and 0.12 cfs in August and September. In total, the project cost just over $930,000. (The Freshwater Trust 2020)

- In 2021, the Fitzpatrick Conservation Project was funded by OWRD with a two-part goal of improving the efficiency of on-farm irrigation infrastructure and permanently transferring water savings instream. More specifically, the project will pipe 3,100 feet of irrigation ditch and replace flood irrigation with center pivot irrigation on 127 acres owned by the Rocking M Cattle Company. All water conserved as part of the irrigation infrastructure modernization will be permanently protected instream resulting in improved flow and aquatic habitat. The project is projected to saved 207 AF of (senior priority) water that will be protected at a rate of 1.13 cfs from May to July in the Lostine River. At the time the OWRD grant proposal was submitted, the estimated total cost for the project was just over $763,000 in $2022. (Trout Unlimited 2021)

Total costs for all three projects is just over $4.2M and with at least 25% of costs covered by match funding and/or in-kind contributions from the landowners — leveraging other sources of funding.

According to documentation provided to OWRD, land converted from flood to pivot irrigation is expected to be more productive, with hay yields increasing from 1.5 to 3 tons per acre depending on the farm (each farm reported different increases in their funding proposals); additionally, hay quality can be improved because of better moisture management. Finally, the new efficient irrigation infrastructure is also expected to increase the value of the irrigated land itself — by as much as 5%-20%. (Trout Unlimited 2021; The Freshwater Trust 2020; 2018)

Using price data from the 2022 Oregon Annual Statistical Bulletin, the impact of increased yield on farm revenues was estimated using the following assumptions for two scenarios. These price data may underestimate true conditions for some of the farms described here in some years.

TABLE 44. SCENARIO ASSUMPTIONS

Scenario	Price ($/ton)	Pivot System Lifespan (years)
Low	$215	19
High	$255	27.5

Based on the assumptions in Table 44 and the expected yield increase for each farm, total on-farm benefits for all three projects is estimated to be over $500,000 per year even under the low scenario and as high as $630,000 under the high scenario (Table 45).

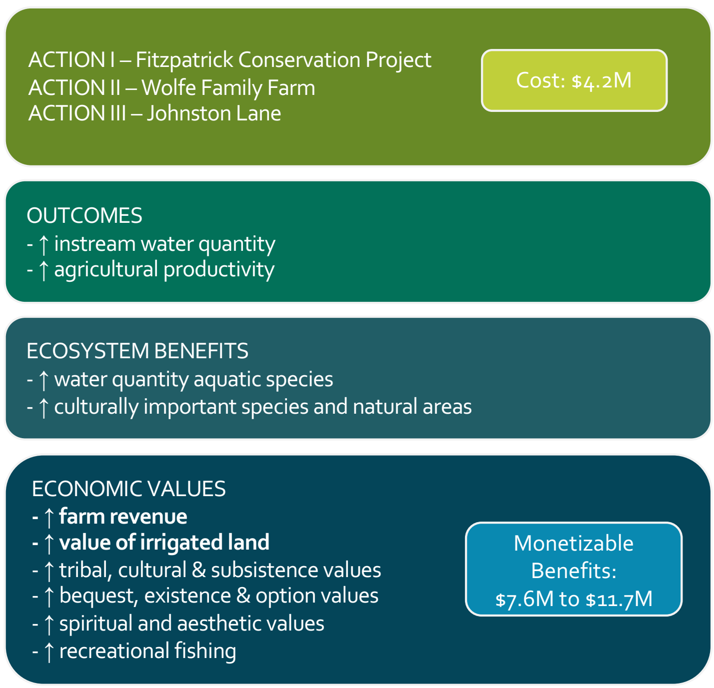
TABLE 45. ESTIMATED ANNUAL ON-FARM BENEFITS

Project	Acres	Increased Yield (tons/acre)	Scenario	
			Low	High
Fitzpatrick	127	2.5	$68,260	$80,960
Wolfe Family Farm	872	2	$374,960	$444,720
Johnston Lane	277	1.5	$89,330	$105,950
		Total	$532,550	$631,630

Assuming a 19-year lifespan for center pivot irrigation infrastructure, the estimated NPV of these direct benefits are **$7.6M** for the low scenario and **$9.0M** for the high scenario, both of which are greater than the investment cost of the project. Assuming a longer lifespan of 27 years for the irrigation infrastructure, the estimated NPV of direct benefits ranges from **$9.9M** to **$11.7M.** The increased value of the land itself could only be realized if the land were sold, however, based on 2022 irrigated land prices for the state of Oregon (i.e., $6,350 per acre), a 10% increase in value would be worth an over $800,000 increase across all three farms (USDA, NASS 2022).

As highlighted in Figure 53, there are also numerous benefits that are not easily monetizable including, perhaps most importantly, the cultural and subsistence values of the Lostine River and its salmon runs to the local Tribes. In the Pacific Northwest, salmon is also an iconic species and popular for both recreational and commercial fishing.

FIGURE 53. LOSTINE SUMMARY



Using a 3% discount rate and a conservative 19-year lifespan for center pivots, the LCOW for each project was calculated (Table 46).

TABLE 46. PROJECT COMPARISON

Project	Cost ($2022M)	Water Conserved (AF/year)	LCOW ($/AF)
Fitzpatrick	0.8	207	$257
Wolfe Family Farm	2.5	1,167	$152
Johnston Lane	0.9	431	$151

If 27 years were used for the lifespan of the center pivot (in place of the 19 years used in the analysis above), the LCOW for the irrigation efficiency projects decreases (i.e., $116/AF to $199/AF).

Even though slightly more expensive than the EWT ($138/AF), there are additional benefits to investing in the irrigation efficiency projects, namely:

- conserved water is *permanently* protected instream;
- on-farm productivity and revenues increase, which also has broader impacts in the local economy;
- irrigators are incentivized to use water more efficiently not just as part of the project, but also going forward; and
- both rivers and farms are more resilient in the face of climate change.

11.3.1 Benefits of Environmental Water Transactions

The benefits of the Lostine Minimum Flow Agreement are improved conditions for ESA-listed Chinook Salmon and recently reintroduced coho salmon, along with other aquatic species like steelhead. These fish are of immense cultural importance to the Nez Perce Tribe and CTUIR and are a key part of both Tribes' traditional diets and practices. The Tribes, along with ODFW have invested heavily in hatchery augmentation of Chinook and reintroduction of Coho, investments that are partially secured by instream flows from EWTsc

In addition, supporting ESA listed Chinook salmon by implementing EWTs alongside other conservation actions can help avoid private liability under the ESA. While not likely, individual liability, including fines and other punitive remedies can be levied under the ESA for so called *take* of listed species. In an extreme scenario where low flows persist and seriously jeopardize listed Chinook, diversion and irrigation from the Lostine River could be curtailed, resulting in devastating economic impacts for the local community from crop losses and property devaluation. While unlikely, the history of successfully restoring flows through the Lostine Minimum Flow Agreement provides a layer of informal protection against this worst-case outcome.

Finally, the Lostine's fish species are important to the region's non-Tribal residents. Many area farmers recall being able to see and fish for abundant salmon in the Lostine and want their children and visitors to have the same experience.

11.4 Discussion

The Lostine River does double duty as a vital water source for area farms and as habitat for fish species that have, culturally and literally, sustained both the Nez Perce and Umatilla Tribes since time immemorial. For much of the 19th and 20th centuries, diversions from the river decimated Chinook and coho salmon populations, effectively extirpating coho and coming close to the same for Chinook. The community upset the status quo in 2005 by agreeing to an innovative water use agreement to try to reset the balance between fish and farms. The success of this EWT led to more water in the Lostine during critical times of year but also catalyzed additional investment in on-farm efficiency upgrades. Key takeaways from this case study include:

- In the right conditions, **investments in irrigation infrastructure modernization make economic sense simply in the context of farm profitability** — making the argument that this might be a prudent investment even if the farmer were pursuing it on his or her own. These results suggest that even if the farmer pays the full cost, over the lifespan of the upgraded irrigation system the resulting increase in yield (and profitability) could outweigh the initial cost of installation. This finding suggests that farmers in similar situations should consider upgrading their irrigation infrastructure even if their only motivation is financial. State support, however, may be necessary to lower the barriers to entry presented by the large upfront costs for these projects.
- Farmers may not be aware that **efficiency upgrades can result in improved yield** and profitability, therefore, outreach and technical information may be useful.
- Farmers may not have the upfront capital to cover the cost of upgrades, which this case study showed can be substantial. **Assistance in covering costs (even partially) and/or providing low- or no-interest loans may be beneficial**.
- **Farming communities value rivers for more than irrigation water.** Close to one hundred individual landowners signed the original Lostine Minimum Flow Agreement, demonstrating that they were willing to try something different. Memories of a river full of Chinook salmon inspired not only the area's Indigenous people, but also many in the farming and ranching community.
- **Environmental Water Transactions are innovation catalysts**. Engaging with farms and communities on innovative, voluntary agreements to restore instream flow inspire creativity; when people see positive results from giving back to the river, their willingness to consider innovation increases.

12 Southeast Regional Case Study: Threats to Local Economy and Environment from Groundwater Overdraft

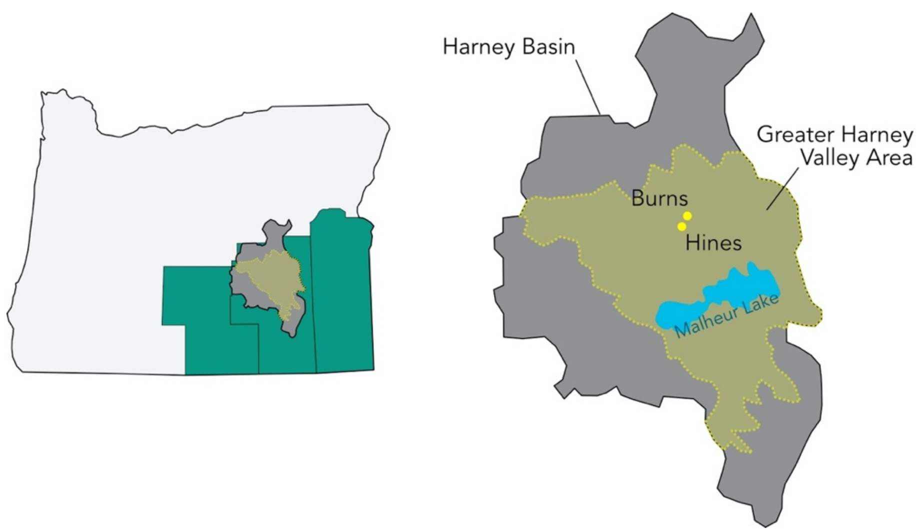
The Harney Groundwater Basin, located in Oregon's sparsely populated southeast, lies predominantly beneath Harney County, an arid, generally high altitude (above 4,200 feet) region consisting of both high desert and forested uplands (Figure 55). In a few short decades, aggressive pumping of shallow and deep groundwater has rapidly depleted groundwater resources across the Basin. A consensus-driven plan released in 2023 through the Harney Community-Based Water Planning Collaborative (HCBWPC or Collaborative) has identified a range of strategies to reduce groundwater withdrawals and protect local ecosystems, economies and well users who have suffered negative impacts. At the same time, OWRD has embarked on regulatory processes that may lead to curtailment of groundwater pumping. This case study discusses the impacts of severe and ongoing groundwater depletion in the Harney Groundwater Basin, its actual and potential effects on private property owners, the local economy and important environmental resources. Also discussed are the State of Oregon's efforts to manage and regulate groundwater extraction in the region.

Harney County's current population is approximately 7,500, located primarily in the communities of Burns and Hines, with the remainder scattered in individual ranches, farms and small hamlets across the basin. The County is home to the Burns Paiute Tribe's reservation. According to the most recent census, approximately 14% of residents identify as a race other than white and/or as having Hispanic/Latino origins. 16.2 % of residents live at or below the poverty line.

FIGURE 54. SOUTHEAST REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Groundwater depletion	- Stabilize ag-dominated local economy through transition from unsustainable irrigation & groundwater depletion
Cause(s)	**Beneficiaries**
- Irrigation withdrawals - Insufficient agency resources & legal authority to protect resources - Climate change	- Regional farmers & ag-sector economy - Local residential well-supplied households - Ecological resources & related tourism - County governments
Investment(s)	**Key Takeaways**
- Land-use conversion - Alternative water supply - Increased water use efficiency - Water right retirement	- Multiple fiscal & governance strategies & investments are needed to end, & then initiate recovery from, groundwater overdraft

FIGURE 55: MAP OF HARNEY BASIN AND GREATER HARNEY VALLEY AREA LOCATION



12.1 CHALLENGES

While use of groundwater for irrigation in the Harney Basin dates from the mid-20th century, extensive expansion of irrigated agriculture in the 2010s quickly led to noticeable effects on groundwater levels (Teague and Burright, 2020). Between 2016 and 2018, annual extraction of groundwater for irrigation and other uses averaged more than 140,000 AF per year. The total amount of groundwater withdrawals for human use is closely related to the amount of imbalance between annual pumping and annual recharge, contributing to an annual overdraft of approximately 110,000 AFY (HCBWPC 2023).

Groundwater overdraft is causing problems for domestic well users, Groundwater Dependent Ecosystems (GDEs) and for agriculture; each of these are discussed in turn.

12.1.1 Impacts to Private Domestic Wells

Private wells in Harney County have experienced declines in static water levels by as much as 140 feet and some shallow wells have gone dry. Reports indicate that a significant number of private wells that supply water for domestic and stock uses, have experienced declining levels in recent years (Oregon State University, 2019). These impacts undermine rural property owners' quality of life, property values and, ultimately, ability to remain on their land and pass their land and business to the next generation. (HCBWPC 2023; Cook, Steele, and Montague 2020; Gingerich et al. 2022)

Total groundwater withdrawals for domestic water use equals 3.5% of the total volume of groundwater used in the Basin (compared to nearly 96% of groundwater being tapped for cropland irrigation) (HCBWPC 2023). Domestic well concerns include uncertainty about the cost and availability of replacement water supplies, the effects of declining well levels on property values, and the ability of property owners to remain in their homes and transfer their properties to the next generation (HCBWPC 2023). As shown in Box 8, one study explored options to provide alternative water supplies to 1,100 households, with a preliminary cost estimate ranging from $7.5M to more than $10M per year.

BOX 8: RESIDENTIAL WELL IMPACTS AND POTENTIAL INVESTMENT REMEDIES

Residential wells in portions of the Harney County have been adversely affected by the rapid expansion of groundwater extraction in the area. An estimated 1,200 households rely on private wells, and many have been impacted by a loss of their residential well supplies (Anderson Perry & Associates, Inc. 2019). Self-supplied domestic well users are more likely than those supplied by public systems to be members of frontline communities (Stacey Dalgaard 2022); in Harney County this could include Tribal members and other minority groups as well as low-income households. By 2019, more than 40% of surveyed households in the Harney-Malheur subbasin reported adverse impacts on their well yields (Oregon State University, 2019). The number of impacted households and entities may be under-estimated and may grow over time as groundwater depletion continues. Groundwater quality issues may also become more evident, such as elevated levels of arsenic in well waters (HCBWPC 2023)(Aspect Consulting, 2021).

Initial efforts to assess the extent of the residential well impacts and evaluate potential remedies were supported by the Collaborative. The remedial alternatives investigated sought to provide water to residences that have lost access to potable water from their wells. The options explored apply different approaches for providing water, each with an estimated cost and number of households served. The options are not mutually exclusive (i.e., a combined mix of strategies may be most practical and cost-effective, depending on the locations of impacted households and other relevant factors). Per Anderson Perry & Associates, Inc. 2019, the basic options, costs and other relevant details are presented in Table 47 below and include:

1. Building cisterns for all 1,086 targeted households and filling them 26 times per year with 4,000 gallons of potable water obtained from one of two constructed fire truck fill stations

and delivered by a fleet of 12 or more trucks (with drive distances varying between 1 and 50 miles).
   - The estimated total annualized cost is $10.5M, driven largely by high O&M costs.
   - The average annualized cost per household served is $9,600 per year.
2. Applying a mix of approaches, including: 1) the cistern and trucked water approach for 60% of impacted households; 2) developing a series of dispersed community wells (which may be precluded by potential OWRD action to stop new wells being developed in the area), at a 300-foot depth, and associated distribution systems to serve 35% of impacted households; and 3) connecting the remaining 40 households, located in proximity to Hines or Burns, to the cities' water supply systems.
   - The estimated total annualized cost for the combination of approaches is $7.5M.
   - The average annualized cost per household served is $6,800, although the per household costs vary widely depending on which remedial approach is applied (ranging from $1,200 per year for connecting to a city system, to more than $10,000 annually for cistern-served households).

TABLE 47: PRIVATE WELL REMEDY OPTIONS AND ESTIMATED COSTS

		Cistern Option (all 1,086 Householdss)		Mix of Community Wells, Cisterns, and City Tie-Ins	
Unit Capital Costs		# units	Cost ($M)	# units	Cost ($M)
Cisterns (4,000 gallon)	$ 11,344	1086	$12.3	654	$7.4
Community Wells	$ 43,900	0	$0.0	392	$17.2
Fire Truck Fill Stations	$ 17,171	2	$0.03	2	$0.03
Burns/Hines CWS Tie In	$ 12,222	0	$0.0	40	$0.5
Total Initial Capital Costs			$12.3		$25.1
Annual O&M costs per Unit (2022 $s)					
Cisterns (4,000 gallon)	$ 8,924	1086	$9.7	654	$5.8
Community Wells (O&M cost not provided		0	$0.0	392	$0.0
Fire Truck Fill Stations	$ 1,145	2	$0.002	2	$0.002
Burns/Hines CWS Tie In	$ 330	0	$0.0	40	$0.01
Total Annual O&M Cost			$9.7		$5.8
Annualized Capital Costs			$0.8		$1.6
Total Annualized Cost			$10.5		$7.4

Source: Based on data in Anderson Perry (2019)

Notes: 1,086 total households: 654 on cisterns and trucked water, 392 served by community wells, and 40 connected to city water supply systems in Hines or Burns. Capital recovery factor reflecting 5% interest charges over 30-year capital repayment period.

12.1.2 Impacts to Groundwater Dependent Ecosystems

Groundwater is also connected to the health of GDEs — springs, ponds and lakes that support the region's ecosystems. For example, groundwater fed springs and ponds provide habitat on the Malheur Lakes Wildlife Refuge, which is an important ecological resource for migratory bird populations on the Pacific Flyway. While the ecological effects of groundwater overdraft are not fully understood, there is evidence that long term depletion will lead to reduced spring flows and declines in health of groundwater dependent plant and animal populations (HCBWPC 2023). The Refuge also is a large draw for birdwatching and other nature-based tourism activities. Refuge-supported tourism provides a valuable economic driver for the county, diversifying the region's dependence on irrigated agriculture, and contributing more than $36M to regional economic output, including $9.6M in labor income and 387 jobs (additional detail provided below in Box 9). (Mojica, Cousins, and Madsen 2021)

BOX 9: VALUE OF GROUNDWATER-DEPENDENT ECOSYSTEMS: MALHEUR NATIONAL WILDLIFE REFUGE

In addition to providing water for private wells and agriculture, Harney Basin's aquifers support key ecosystems, including those on the Malheur National Wildlife Refuge. These ecosystems sustain migratory birds and other wildlife, which in turn draw a significant number of visitors to Harney County annually.

A 2019 US Fish and Wildlife Service analysis determined that there were over 210,000 recreational visits to the Refuge in 2017, with the vast majority made by non-residents. Assuming that visitor expenditures were made primarily within Harney County, non-resident visitations to the Refuge contributed $36.3M to the local economy. Through this spending, the Refuge supported 387 jobs, over $9.55M in wages and employment income and $1.8M in local tax revenue. (USFWS 2019)

Compared to information contained in a state wide analysis of the economic value of outdoor recreation, it appears that visits to the Refuge support 36% of the outdoor recreation jobs in Harney County and contribute to 39% of the economic output associated with recreational spending (Mojica, Cousins, and Madsen 2021). The significance of the Refuge in the local economy adds importance to efforts to substantially reduce groundwater overdrafts within the Basin.

12.1.3 Impacts to Agriculture

Finally, the region's economic dependence on the agricultural business of alfalfa and hay production raises additional concerns. Approximately 70% of the surface area of the county is publicly owned and managed by federal and state agencies. The remaining privately owned acreage is predominantly used for livestock grazing and irrigated agriculture. (Gingerich et al. 2022). According to the most recent CoA, 83% of farmland is used as pasture for livestock, primarily cattle, and only 11% of farmland is irrigated (approximately 166,500 acres). The majority of irrigated acres are used for hay and/or forage crops (142,000 acres), while some pastureland is also irrigated (24,500 acres) (USDA, NASS 2017b). Most of the local demand (86%) for hay and forage is met by locally grown crops (IMPLAN 2021). Even then, local use accounts for a relatively small percentage of total supply generated within the County (17%), leaving a significant amount for export to other counties, states, and countries.

Gross revenue from irrigated cropland in the basin exceeds $50M per year, while net cash farm income amounts to more than $12.5M annually; property taxes accrued from these lands constitute two-thirds of the county's total annual property tax revenues (Aspect Consulting, 2021). In Harney County, agriculture accounts for 24% of economic output (Figure 56) and 33% of total employment. As shown in Table 48, most agriculture-related economic activity can be attributed to hay and forage farming and beef/cattle ranching. Large-scale limitations on groundwater use for cropland irrigation — whether due to dwindling supplies and an elevated expense for pumping groundwater, or due to future regulatory restrictions on aquifer use — may have a large adverse impact on the incomes, property values, tax revenues and overall economic well-being of the area's residents. Thus, there is a concern for how to reduce groundwater withdrawals and provide a "soft landing" for hay and alfalfa growers, their employees and the businesses that are economically linked to and dependent on the agricultural sector (i.e., cattle ranchers).

FIGURE 56: SECTOR CONTRIBUTIONS TO HARNEY COUNTY'S ECONOMY

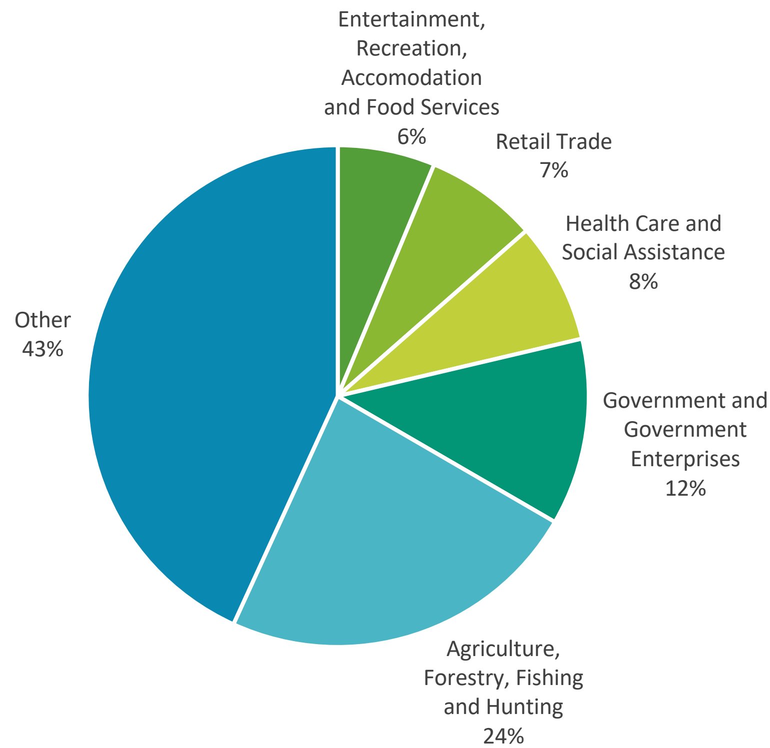


TABLE 48: ECONOMIC OUTPUT AND EMPLOYMENT BY SECTOR IN HARNEY COUNTY

Sectors	Economic Output ($M)	Employment (#)
All other crop farming (primarily hay and forage)	$49	673
Beef cattle ranching/farming, feedlots & dual-purpose ranching/farming	$66	108
Support activities for agriculture and forestry	$6	84
Other agriculture, forestry, fishing, and hunting	$7	44
Total - agriculture, forestry, fishing, and hunting	$128	909
Total - Harney County (all sectors)	$547	2,723

BOX 10: ECONOMIC IMPLICATIONS OF IRRIGATION RESTRICTIONS ON CROPLAND ACREAGE

Given the extent of the groundwater overdraft in the Harney Basin (110,000 AFY, per Garcia et al., 2022), potential future policy responses may include large-scale restrictions that greatly reduce (or potentially eliminate) rights for groundwater extraction for cropland irrigation. Given the prominent role agriculture has in the local economy, this Box explores the economic implications of potential future curtailment of groundwater-dependent cropland irrigation. The results are cast on a county-wide as well as on a per acre basis, to provide useful benchmarks for evaluating future policy options for the state.

The local economy of Harney County reflects a complex interaction across its important economic sectors, in which agriculture plays a key role. Restrictions on cropland irrigation will have significant associated economic impacts on farmland owners, agricultural workers, and related and interconnected sectors (including county tax revenues).

The analysis here is based on a simplified and streamlined preliminary assessment of economic impacts and does not reflect the likely but uncertain adjustments that may occur through the local economy (such as the potential price impacts of reduced crop yields on local buyers and sellers or shifts in the farm-related supply and labor markets). The intent of this analysis is to provide an initial though simplified glimpse at the potential regional economic impacts on a per acre basis of eliminating (or greatly curtailing) groundwater-based irrigation. The focus is on hay and alfalfa farming, as it is the dominant local irrigated crop. The potential scale of the economic impacts is informed largely by information developed by ECONorthwest, as reported within the context of the potential for groundwater rights market. (Aspect Consulting, 2021, Marshall et al. 2021)

Groundwater Extraction for Cropland Irrigation, and the Extent of Groundwater Overdraw
There are approximately 108,760 acres of agriculture irrigated with groundwater in the Harney Basin, of which 80% (87,265 acres) rely exclusively or predominantly on groundwater; The remaining 20% of acres rely on groundwater as a supplemental source (Bierly & Associates LLC 2021)

A recent study suggests the consumptive use of groundwater within the Greater Harney Valley (Figure 55 above) is 140,000 AFY on approximately 67,400 acres of groundwater-irrigated agriculture, which implies a water use of about 2.1 AF per acre (Beamer and Hoskinson 2020). Older research suggests Harney County irrigators use approximately 3 AFY per acre, although actual irrigation rates vary due to climate conditions (temperature, precipitation), crop type and number of cuttings (Cuenca et al. 1992). These data imply that Harney County cropland irrigators are extracting approximately 183,000 AFY to 262,000 AFY of groundwater on all cropland that is primarily dependent on groundwater irrigation (i.e., 87,265 acres), and between 228,000 AFY and 326,000 AFY if the 20% of croplands using groundwater as a supplemental source also are included.

The current estimate of the extent to which groundwater extractions from the Harney Basin exceed recharge is 110,000 AFY (Garcia et al. 2022). To end the over-extraction of groundwater, approximately 37,000 to 53,000 acres of predominantly groundwater-irrigated cropland would need to be retired or converted to non-irrigated cropland use (based on average irrigation rates of 3.0 and 2.1 AFY/acre, respectively). This reflects retiring or converting between 42% and 61% of the croplands currently relying primarily on groundwater, to keep the groundwater levels from further decline. If state policymakers eliminate access to groundwater for all cropland irrigation in the basin, then all 100% of croplands would be retired or converted.[27]

Cropland Irrigation with Groundwater and the Regional Economy[28]

Agricultural activities based on groundwater irrigation make an important contribution to the economy of the Harney Basin. Irrigated agriculture generates a gross production estimated at $94M per year. Assuming all 108,760 acres of irrigated cropland are dependent on groundwater withdrawals, the estimated gross revenue from lands irrigated with groundwater is approximately $59.4M, and the estimated net cash farm income on these lands is $14.5M (Aspect Consulting 2021).

Further, the estimated 2020 property tax payments from these lands totalled $1.7M, representing approximately 65 percent of total annual property tax collections for the county. Total employment on these lands is 720 jobs (based on the proportion of groundwater irrigated agriculture: 108,760 acres), accounting for approximately 16 percent of total employment (4,353 jobs) in Harney County. (Aspect Consulting, 2021)

In addition to the above impacts from farm-related sales and income, there also are beneficial economic impacts from farm spending on production. Data suggest $5.86M is spent on farm production costs on the groundwater-irrigated cropland acres in the Basin (updated from USDA, 2017).

- For every $1M spent on crop farming production in Harney County, ECONorthwest's 2021 assessment -- using 2019 IMPLAN data -- calculated there was an additional $397,732 in economic activity supported (Aspect Consulting, 2021).
- On average, $1M in spending by the industry supports a total of $329,420 in direct labor income, plus an additional $163,440 in labor income in secondary effects for things like farm suppliers, grocery stores, and other supply chain and household purchases (Aspect Consulting 2021).

Table 49 provides a summary of the economic impacts associated with irrigated cropland in the Harney Basin, based on the discussion above. Values are presented for the Basin as a whole, as well as on a per acre basis.

[27] Note that if CREP is implemented as proposed by USDA and as described elsewhere in this chapter, then the targeted cropland retirement is projected to reduce groundwater extraction for cropland irrigation by an estimated 40,000 AFY to 50,000 AFY (USDA 2023). CREP's estimated contribution to reducing groundwater extraction would thus leave a balance of 60,000 AFY to 70,000 AFY needed to end aquifer overdraw (e.g., 110,000 – 50,000 = 60,000 AFY). At 2.1 to 3.0 AFY/acre, the implied additional cropland retirement needed would be approximately 20,000 to 30,000 acres.

[28] Values reported in this section are drawn from Aspect Consulting (2021), using data and analyses reported in Appendix A of that document (prepared by ECONorthwest), and updated from 2020 to 2022 dollars. For example, gross revenues from irrigated cropland were calculated by multiplying the 108,760 irrigated acres times $474.24 per acre in average commodity sales as reported in the Appendix A in the 2021 Aspect Consulting report, and then updated here from 2020 to 2022 dollars using the consumer price index (CPI) of 1.151 (BLS, 2023). Values for net cash farm income and property taxes also were calculated using per acre values and updated to 2022 values using the CPI.

TABLE 49: ECONOMIC IMPACTS OF ELIMINATING GROUNDWATER IRRIGATION OF HARNEY BASIN CROPLANDS

Economic Factor	Countywide ($M)	Per Acre ($)
Impacts from Farm Production Sales		
Ag Sector Gross Production	$94.0	$864
Gross Revenue	$59.4	$546
Net Cash Farm Income	$14.5	$133
Property Tax Payments	$2.0	$18
Jobs	720	0.007
Impacts from Farm Production Expenditures		
Economic Output	$2.3	$21
Direct Labor Income	$1.9	$18
Secondary Labor Income	$1.0	$9

Source: Based on IMPLAN results as reported in Aspect Consulting (2021).
Note: Incurred from Eliminating Crop Production on 108,760 Groundwater-Irrigated Acres in Basin.

Using the estimates in Table 49, and data from Garcia et al. (2022), retiring 37,000 to 53,000 acres of groundwater-irrigated cropland to eliminate annual overdraft would reduce gross production from agriculture in the region by between $32M and $45.7M. This impact would ripple through the regional economy in the form of lost jobs, reduced property taxes and in other ways too; frontline communities in the region could be particularly hard-hit by job losses and losses in labor income.

12.1.4 State and County Governance Responses to the Challenges

Declining groundwater levels led OWRD to impose a moratorium on new groundwater permitting in 2016 and on extensions for undeveloped well permits in 2019 (OWRD, n.d.). By 2016, the Harney County Watershed Council and Harney County Court began to co-convene the Collaborative under OWRD's Place Based Integrated Water Resource Planning program.

The Collaborative delivered a final *Harney Basin Groundwater Portion of Integrated Water Plan* (HCBWPC 2023) (referred to here as the Plan) in April 2023, which identifies 31 strategies and associated recommendations across four categories: Foundational, Operational, Tactical and Organizational/Infrastructure. Many of these strategies rely on voluntary adoption of more efficient irrigation, crop switching and other measures to reduce reliance on groundwater (Perkowski 2022). There is an expectation within the Collaborative that these recommendations will inform OWRD's future work in the basin.

In parallel with the Collaborative's effort, OWRD has embarked upon a pair of rulemakings:

- The first rulemaking is an update of OWRD's Division 10 rules, which govern groundwater appropriation and use, to be consistent with a process outlined by statute for designating Critical Ground Water Areas (CGWAs). This rule update will include a series of corrective actions that the Water Resources Commission can take to protect groundwater in designated CGWAs. OWRD anticipates that it will finalize this update in September 2023.

- Second, OWRD plans to initiate a Division 512 rulemaking that will apply the updated Division 10 rules to the use of groundwater in the Harney-Malheur Lakes Basin, including use within the Greater Harney Valley Groundwater Area of Concerns. (OWRD, n.d.)

There is also the possibility that OWRD will opt to declare the Basin a CGWA and curtail previously permitted pumping. Box 10 above provides a preliminary evaluation of the regional economic impacts that may arise from comprehensive restrictions on cropland irrigation. Under either the Plan or a CGWA designation, senior water rights holders may be less affected than more junior users. Such an outcome could lead to potential inequities and challenges in implementing voluntary incentive programs. (Perkowski 2022).

12.2 Investments

Given the severity and complexity of groundwater challenges facing the Harney region, a combination of investments will be required to address the problems effectively and equitably. There is a sense of urgency about implementing these incentives; the Collaborative's Plan notes that "near term strategies," those that can be initiated in the next three years, will make the most difference to reductions in groundwater overdraft.

A range of potential investments would assist OWRD and community stakeholder efforts to reduce the rate of groundwater depletion in the Basin and promote water supply security for both irrigators and residents. Investments could be used to develop and fund market-based mechanisms to incentivize irrigators to make voluntary changes to irrigation or cropping practices (e.g., modernize irrigation infrastructure). An example is a Natural Resources Conservation Service (NRCS) incentive program to encourage irrigators to switch to lower elevation spray application equipment that could cut groundwater use by approximately 38,000 AF per year (HCBWPC 2023). Alternative cropping could also potentially save significant amounts of water (Box 11).

Box 11: Crop Choice Alternatives to Fallowing

A compelling dilemma in Harney County is how to reduce irrigated water consumption while preserving an agriculture-based economy. A desired outcome is to keep as much land in production while significantly reducing, or eliminating, application of groundwater irrigation. There are three potential pathways to achieve this end: implementing 'deficit irrigation' strategies which forego application of water after a specified point in the crop cycle, switching from high water use alfalfa and hay to forage crops that require less water and switching from forage crops to dryland farming of non-irrigated crops.

Under a deficit irrigation scenario, growers could be incentivized to forego irrigation after a certain date (e.g., June 20th) or at a point in the forage crop cycle (e.g., after a second cutting.) On average, Harney County alfalfa growers apply 2.1-3 AF/acre; dropping this by 0.7-1.0 AF/acre could result in significant progress toward meeting the overdraft reduction goal. Applied over 87,300 acres of Harney Basin cropland that is predominantly irrigated by groundwater (Bierly & Associates LLC., 2021), this approach may save between 61,000 AFY and 87,000 AFY per year of groundwater.

The second pathway could entail moving farmers away from alfalfa toward drought tolerant forage crops and others with reduced irrigation demand. Oregon State University has, in years past, studied the feasibility of sainfoin and teff production as alfalfa alternatives. (OSU, n.d.) Additional research and grower engagement in field trials could, over time, lead to improved understanding of alternative forage production. Incentives for the conversion, paid by state and/or federal agencies, could provide compensation based on quantified water savings, rather on than on a per acre basis.

The second pathway represents something of a return to Eastern Oregon's farming history. Dryland wheat farming has been a staple crop in eastern Oregon for generations. However, much of this production has been focused in areas that receive somewhat more rainfall than the Harney Basin. Oregon State University maintains a program focused on supporting dryland farmers (OSU 2023). Rye and barley may be feasible dryland crops. More research into cropping and field management strategies may contribute to the development of dryland farming options that are appropriate for the arid regions of south-eastern Oregon.

Another idea developed by the Collaborative is to implement a groundwater market. The proposed concept is a share-based system where the basin would be delineated into discreet zones and *shares* of groundwater would be distributed to current groundwater right owners. The number of shares would vary each year depending on measured water levels and thresholds set by a governing body; shareholders would be able to save, use or sell/trade the shares they hold. An economic study accompanying the groundwater market proposal found that a groundwater market could help preserve economic value compared to a future without a market and incentivize water conservation. (Aspect Consulting 2021)

Funding needs have also been identified to support private well owners affected by declining groundwater levels. As described previously (in Text Box 8 above), the total annualized cost to remedy lost residential wells may exceed $10M per year for an indefinite period (i.e., decades, until groundwater levels recover). While some funding has been approved by the State, OWRD has not yet begun implementation of a private well mitigation program. Financial investments are also needed to improve knowledge and data about aspects of groundwater recharge and ecosystem dependence, and to update technology related to measuring groundwater usage and levels. (HCBWPC 2023)

Finally, OWRD also needs adequate budget allocations to support the completion and implementation of its twin rulemakings, and to continue to gather and analyze data about groundwater in the Harney Basin. Press reports about the groundwater crisis in the Harney Basin have highlighted funding challenges as a hurdle for the Department in effectively stewarding Oregon's groundwater resources (House and Graves 2016). OWRD also has a role in gathering and analyzing data related to future management of the Basin's groundwater resources.

12.3 Analysis

This business case illustration focuses on an investment option aimed at reducing *a portion* of the estimated annual overdraft of the deep groundwater system. The overdraft is associated with large-scale irrigation for hay, alfalfa and other animal feed crops in the region. The investment option examined here currently is being considered by the federal government and would provide farmers with incentive payments to voluntarily retire 20,000 acres of silage cropland from production. Cropland retirement at the proposed scale is estimated to eliminate 40,000 to 50,000 AFY of groundwater currently drawn for irrigation (USDA 2023).

The business case illustration provided here consists of comparing the proposed USDA CREP program to a no action baseline:

No Action Baseline: Largescale farm irrigation from groundwater continues at its current pace but does not grow. Groundwater overdrafts continue at annual levels of 110,000 AFY beyond the estimated average level of annual recharge. Continued overdraft results in continued aquifer level decline, with associated adverse impacts on residents, farms, ranches, local businesses, GDEs and others reliant on relatively shallow wells or spring-fed wetlands and streams.

The total value of the adverse impacts associated with inaction are not known but are likely to be extremely costly in terms of impacts on people's lives, property values, the regional economy and local ecosystems. Conditions of the aquifer would continue to decline, ultimately hindering long-term sustainability of the groundwater supply and potentially the long-term viability of local agriculture and associated impacts to the regional economy.

Investment Option: The US Department of Agriculture (USDA) proposes offering incentive payments to farmers to retire cropland from irrigated uses, under the Harney County CREP. The proposed program aims to induce farmers to retire 20,000 acres over a 15-year period, with a resulting estimated reduction of groundwater-based irrigation of 40,000 to 50,000 AFY (USDA 2023).

The CREP program proposed by USDA is estimated to cost $58.6M over a 15-year period and would be primarily funded by the federal government (i.e., USDA). The program is intended to enroll agricultural irrigators within the OWRD-established Greater Harney Valley Groundwater Area of Concern (GHVGAC). The proposed program is intended to reduce groundwater use for irrigation by offering CREP payments to farmers for enrolling groundwater irrigated agricultural lands. The program as proposed also entails requiring the associated water rights to be voluntarily cancelled permanently via a partnership with OWRD (USDA 2023).

12.3.1 Benefits and Costs of the Proposed CREP

CREP is intended to enroll 20,000 acres of the 95,000 irrigated cropland acres within the target area, with an objective of reducing groundwater irrigation while also maintaining the potential for a transition to dryland agricultural production throughout the GHVGAC area. CREP-established contracts with the producers would also require that enrollees implement approved Conservation Practices (CPs), including use of introduced or native grasses and legumes, establishing permanent wildlife habitat and/or wetland restoration (USDA 2023)

While the primary objective of the Harney Basin CREP is to conserve groundwater, there are additional objectives and associated anticipated benefits. By providing incentive payments and technical assistance to farmers enrolled in the program and by managing the scale of acreage retired, CREP will minimize the adverse economic consequences associated with reduced farm income and reduced ag-related expenditures on labor and supplies across the region. The program will also provide a blueprint for possible future expansion to further reduce groundwater over extraction. Irrigators who may hesitate to be part of the initial program could enroll in a future expansion, if available, after having the opportunity to observe the experiences of their neighbors.

Additional anticipated benefits include reduced soil erosion, improved water quality, enhanced protection of GDEs and energy conservation. The 20,000 acres of enrolled cropland would become permanent upland vegetation and serve as native cover for wildlife. The conversion of cropland also is projected to reduce sulfur, phosphorus and nitrogen inputs to the basin by respectively 1,000, 780 and 165 tons for the first three years the program is in place (USDA 2023). A summary of the range of anticipated benefits and costs are shown in Figure 57.

Figure 57: Summary of Project Investment

ACTION – Conservation Reserve Enhancement Program (CREP)

Cost: $59M (USDA payments over 15 years)

OUTCOMES
- ↑ Reduced groundwater overdraft
- ↑ Water supply security
- ↑ Long-term agricultural sustainability
- ↓ Negative impacts to frontline communities

ECOSYSTEM BENEFITS
- ↑ Water for GDEs (e.g., Malheur Wildlife Refuge)
- ↑ Sustain critical stopover on Pacific Flyway
- ↑ Additional terrestrial wildlife habitat from cropland conversion
- ↑ Reduced land application of agricultural chemicals

ECONOMIC VALUES
- **↑ Avoided cost of providing alternative residential water supply for failing private wells**
- ↑ Sustain and enhance wildlife tourism
- ↑ Stabilize long-term regional farm income
- ↑ Cushion impact on ag-dependent economy
- ↑ Bequest, existence &option values

Monetizable Benefits: $7.5M to $10.5M/yr

The LCOW — a measure of the average NPV lifetime cost of the water saved by the project — also was calculated to provide an indication of the cost-effectiveness of the public investment. To calculate the LCOW of the project, the following assumptions were made:

- the project lifetime is 15 years (i.e., in Year 1 there is full enrollment);
- capital costs are $58.6M in total (and are divided equally across the 15 years of the project)
- annual water benefits are 45,000 AF; and
- a discount rate of 3% is used.

Based on these assumptions, the LCOW of the project is **$87/AF**.

12.4 Discussion

The Harney region faces large-scale and complex economic, social and environmental challenges. The County and its community members are highly dependent on agriculture and its associated contributions to the local economy. Yet current agricultural irrigation practices across basin have severely impacted the region’s water resources, creating a multitude of adverse consequences. Unsustainable overuse of groundwater resources has adversely impacted the homes, livelihoods and natural systems that define the region.

Significant investments in remedial programs — both fiscal and governance — are required to reduce the growing level of harm, provide remedies and support for those already impacted and anticipate the needs of those who may face additional negative consequences in the future. Takeaways from this case study include:

- **Groundwater overdraft in the Harney Basin is a cautionary tale**. Failure to manage the region's scarce groundwater at a time when some consequences could have been avoided shows the risks the rest of the state faces from **not or under investing in water**.
- As the CREP $59M proposal reveals, **even partial solutions are likely to be expensive**. A comprehensive suite of additional remedial actions will likely require a very considerable level of fiscal and other investment.
- **Groundwater is one of the most difficult resources to manage because it is hidden**. Some impacts of groundwater pumping don't manifest immediately or in the places they are expected. Domestic well impacts and impacts to GDEs can be difficult to predict, especially in a spatially complex aquifer.
- **Impacts on domestic wells pose especially difficult challenges** especially with water affordability and the implications this has for property values, generational wealth and water justice.
- **Groundwater dependent ecosystems** are critical resources that are imperiled when not considered as part of groundwater management decisions. GDEs provide critical habitat for important aquatic and other species and support economic benefits from recreation and tourism.
- **Increasing aridity and frequency of severe, long-lasting droughts** means that in many places in Oregon, agriculture can benefit from testing more heat and drought tolerant crops and cropping patterns, including dryland agriculture, to keep agriculture viable despite growing water scarcity.

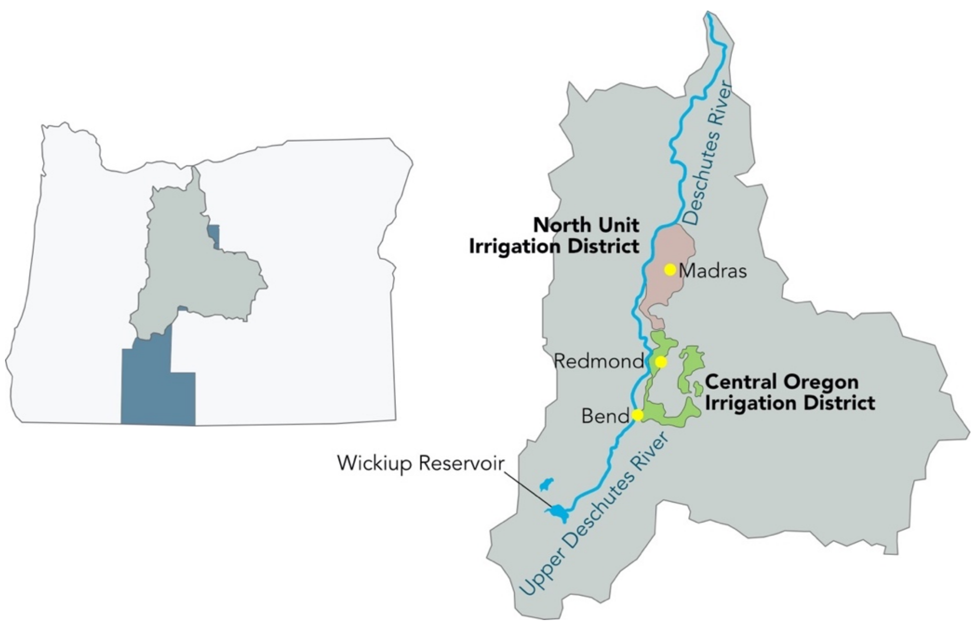
13 Central Oregon Regional Case Study: Addressing Impacts to Agriculture and Aquatic Species from Long-Term Drought Through Conservation and Innovative Governance

This case study discusses the impacts of drought on water supply and demand for North Unit Irrigation District (NUID) and instream flows for aquatic species in the Deschutes River, one of Oregon's most iconic and hardworking rivers (Figure 58). It examines the impacts resulting from reductions in both water supply and reliability to a highly productive agricultural region coupled with the recent listing of Oregon Spotted Frog (OSF) as threatened under the ESA. These impacts provide a foundation for discussing two water-related investments, water conservation and innovative governance, that have the potential to help minimize and/or mitigate these impacts. Two business case illustrations are provided; the first quantifies the benefits to NUID of investment within the district; the second case quantifies the benefits of investment to modernize neighboring Central Oregon Irrigation District (COID). Benefits to the OSF and other aquatic species from both cases are not quantified but are discussed in detail.

FIGURE 58. CENTRAL OREGON CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Water scarcity - Water reliability	- Additional water for irrigated agriculture - Increased streamflow
Cause(s)	**Beneficiaries**
- Climate change impacts in the form of drought, decreased snowpack & increasing temperatures	- Agricultural producers - Aquatic species, including ESA listed OSF
Proposed Investment(s)	**Key Takeaways**
- Water conservation: piping irrigation canals - Flexible governance: water bank	- Modernizing large transmission & delivery systems can be expensive - Pairing this work with innovative governance to leverage conserved water for additional benefits (like instream flow restoration) adds value to help justify the expense

FIGURE 59: MAP OF NUID, COID AND THE UPPER DESCHUTES RIVER

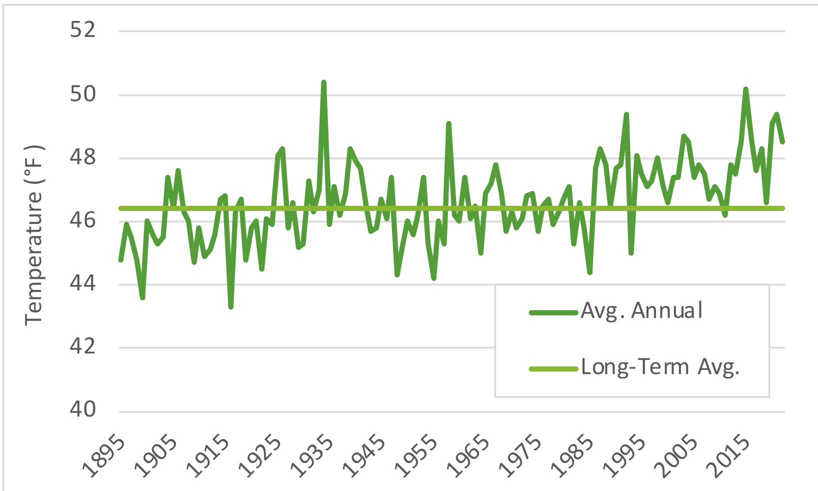


13.1 CHALLENGES

Over the decade spanning 2012-2022, drought conditions became more common and more intense in Central Oregon; six of the ten years prior to 2022 were declared severe, extreme or exceptional droughts in Deschutes and Crook Counties, and five of the last ten years were declared droughts in

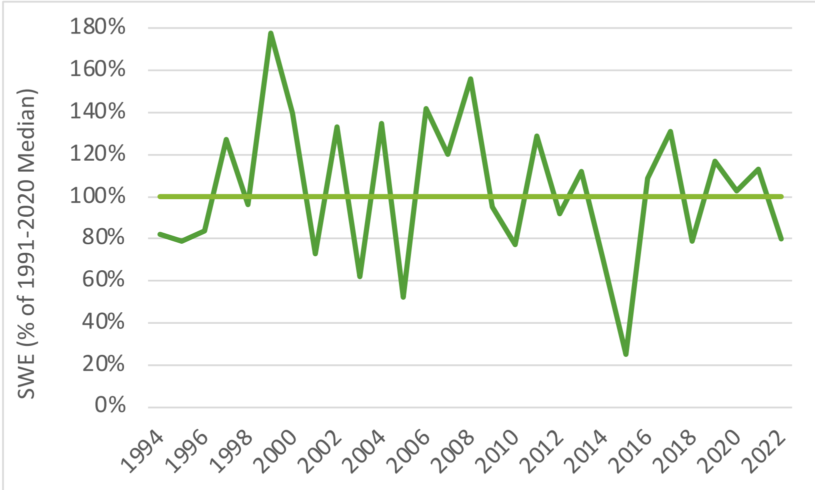
Jefferson County. For Deschutes and Crook Counties, 2021 was the fourth driest year in the 127-year record and it was the sixth driest on record for Jefferson County. (Deschutes River Conservancy and Deschutes Basin Board of Control 2021; "U.S. Drought Monitor" 2023). At the same time, the region is getting warmer with average annual temperatures over the past 30 years in Deschutes, Crook, Jefferson and Klamath counties consistently exceeding the counties' long-term average (1901-2022). In Jefferson County, where NUID is located, average annual temperatures have exceeded the County's long-term average by over 1.25°F, and, over the last 20 years, by over 1.5°F (Figure 60). This trend is mirrored across the counties of the Central Region. (National Centers for Environmental Information, NOAA 2023)

FIGURE 60. JEFFERSON COUNTY ANNUAL TEMPERATURE (1895-2022)



The region has experienced marginal decreases in precipitation compared to long-term averages, but more importantly, there has been a decrease in snowpack that feeds the Deschutes River (National Centers for Environmental Information, NOAA 2023; NRCS, USDA 2023a). Snowpack is measured by snow-water equivalent (SWE) and often related to a long-term median. Not only has SWE been declining relative to the long-term median (1991-2020), but the median for the last 30 years itself is lower than the median for the time period 1981-2010 (NRCS, USDA 2023a).

FIGURE 61. SWE AT CASCADE SUMMIT SNOTEL SITE



NUID encompasses nearly 59,000 acres of land with appurtenant water rights. Approximately 82% of NUID's irrigated acres are irrigated with water stored in Wickiup Reservoir in the headwaters of the Deschutes River with the remaining 18% irrigated with surface water from the Crooked River, a primary tributary to the Deschutes. The annual initial allotment to irrigators of water from Wickiup Reservoir on the Deschutes River is determined by the NUID board in March of each year based on projected water year conditions. In over half the years between 1990-2020 (16 of 31), the allocation was restricted to below NUID's full paper water rights. The initial allotment under restricted conditions has averaged 1.87 acre-feet (AF) per acre (AFA), less than half of their 5.25 AFA Deschutes River storage water right (North Unit Irrigation District 2020). During a restricted water year, on average, an NUID farmer receives only about 47% of their maximum water right (Kaler and Crew 2017).

Against this backdrop, the OSF was listed as Threatened under the ESA in 2014. Among the primary causes that led to listing the OSF were management of reservoir releases and irrigation diversions in the Upper Deschutes River by NUID and other area irrigation districts. NUID's storage of water in Wickiup Reservoir in the winter reduces river flows, resulting in habitat loss for the OSF. In 2019, after years of negotiation and threats of litigation, eight irrigation districts, including NUID, and the National Fish and Wildlife Service agreed on a Habitat Conservation Plan (HCP). The heart of the HCP is a set of reservoir release and diversion restrictions meant to increase instream flow in the Upper Deschutes in the winter and decrease reservoir releases in the summer to limit impacts to the OSF. The HCP flows will also benefit other important aquatic species, especially fish species important both for recreation (fishing) and for the people of the CTWS whose reservation includes long portions of the lower Deschutes River and for whom the Upper Deschutes area represents ceded lands once occupied and used by the Tribe.

13.2 INVESTMENTS

Investments are needed to simultaneously increase water supply and reliability for NUID during the irrigation season and instream flow in the Upper Deschutes River in the winter. While these goals seem at odds, two strategies are being pursued to reconcile them: increasing diversion, transmission and on-farm water use efficiency and implementing innovative governance in the form of a water bank to help facilitate water sharing both between NUID and other districts, and between irrigation districts and the river. Each of these investments is briefly described below:

NUID Irrigation Infrastructure Modernization: NUID recently received final approval from NRCS Oregon for a project to modernize irrigation infrastructure within the district. In addition to converting 27.5 miles of open-ditch irrigation canal to gravity-pressurized, buried pipe, the project also will upgrade 153 turnouts and construct four 1,000 cubic-yard retention ponds. In total, the project will conserve an estimated 6,089 AF of water annually, with 25% (i.e., 1,522 AF) allocated for instream purposes and the remaining amount being used to augment NUID's water supply. (NUID 2023)

Irrigation Infrastructure Modernization in Other Districts and Water Bank: In addition to finding ways to use water more efficiently, investments also are needed to facilitate opportunities for water sharing between irrigation districts — specifically between NUID and the other districts, all of which have more senior water rights. For this alternative to be successful, investment is needed in both water conservation and development of a water bank — the former of which creates water savings, and the latter helps shepherd conserved water between the districts and also helps implement other creative, voluntary, market-based approaches to move water around the basin when and where it is needed.

Piping projects in COID are underway with plans for further piping. Altogether, piping in COID would convert open-ditch irrigation canals to gravity-pressurized, buried pipe resulting in an estimated 89,000 AF of conserved water annually. These water savings would be shared with NUID as live flow during the irrigation season in return for a release of the same volume from Wickiup Reservoir during the winter to satisfy instream flow requirements for the OSF and other species under the HCP. (Bureau of Reclamation and Oregon Water Resources Department 2019b)

A water bank is one way to allow for water sharing between irrigation districts in the region and facilitate instream flow restoration. The developing Deschutes Water Bank (DWB) could be a platform to share water conserved through piping projects between districts, as well as allow some COID and other irrigation district patrons to receive compensation for temporary fallowing and other conservation actions that free up water for NUID and the Deschutes River. Conserved water would then be provided to NUID to both augment supply for irrigation in summer months and allow for releases from Wickiup Reservoir in the following winter to increase instream flows on the Upper Deschutes River as required under the HCP. In addition to facilitating the transfer of water between irrigation districts, an additional benefit, which is not the focus of this case study, is that the DWB has the potential to help transfer water from irrigation districts directly to instream flow or to support the region's municipal water supplies.

13.3 Analysis

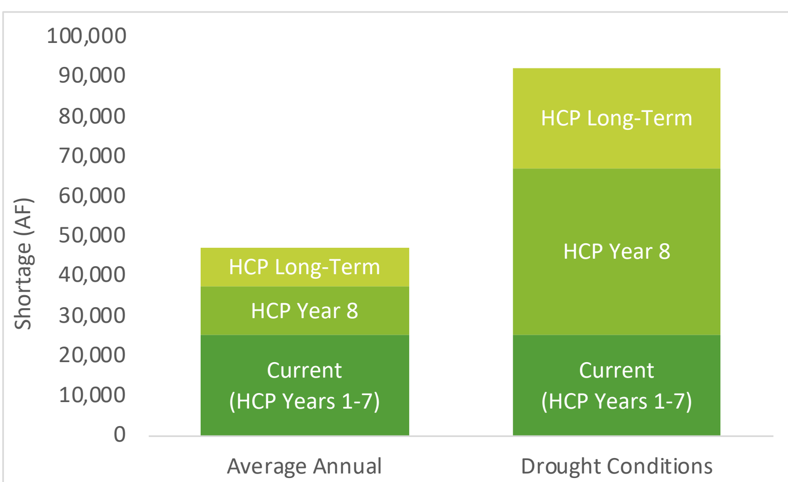
In this section, the economic costs and benefits of investments in irrigation district modernization and innovative governance are estimated and compared to a no-action alternative — that is, continuing to operate under the status quo. Each of the analyses quantifies benefits, costs and/or avoided costs as compared to baseline conditions, which are the current irrigation, agricultural production and instream conditions in the absence of both these investments and with the HCP in place. Unless otherwise noted, all analyses use a 3% discount rate and 100-year lifespan for pipe[29] — starting the year in which it is installed.

No-Action Alternative: While the no-action alternative may not have an investment cost, there are economic costs of not investing — which in this case study involves taking no action to 1) minimize/mitigate impacts that have already occurred because of water scarcity; and 2) avoid impacts that will occur in the future if the requirements of the HCP are not met. Without significant investments, NUID and their neighbors are unlikely to be able to implement water conservation projects at the scale needed to meet HCP requirements. If NUID fails to satisfy its requirements under the HCP, it may face additional involuntary curtailment leading to even more drastic reductions in agricultural production than the district faces today. Therefore, one way to characterize the economic impact of the no action alternative is by estimating the economic impact of decreased agricultural production resulting from additional involuntary curtailment of NUID water allotments.The Environmental Assessment for NUID's Irrigation District Infrastructure Modernization Project (2023) provides critical data on baseline irrigation water shortages and associated fallowing, as well as projected future conditions under the HCP. Shortages under the HCP are projected to:

- stay at the current average annual shortage of 25,500 AF/year until 2028;
- then increase to 37,600 AF/year from 2028-2033; and
- level off at an average 47,300 AF/year in the long-term, without considering any additional long-term impacts of climate change (Figure 62). (NRCS, USDA 2023b)

The average value used in the analysis masks the likely interannual variability of shortages — with annual shortages projected to be as high as 92,400 AF per year under drought conditions (NRCS, USDA 2023b), the impact of which might extend beyond that year. Therefore, the use of the average value results in a conservative estimate of likely impacts.

FIGURE 62. CURRENT AND PROJECTED NUID WATER SHORTAGES



[29] The 100-year lifespan is used to be consistent with what NRCS Oregon used in their Environmental Assessment.

The current shortages experienced by NUID (an average of 25,500 AF/year) and the resulting impacts to agricultural production are not included in the economic impacts of the no-cost alternative as they represent the baseline conditions. Therefore, to estimate the economic impacts of reduced agricultural production resulting from non-investment, the following assumptions were made:

- additional water shortages experienced by NUID result in a proportional increase in fallowed and deficit irrigated acres of alfalfa;[30]
- land fallowed is acres previously in deficit irrigated alfalfa;
- deficit irrigated acres are cropped with alfalfa;
- the marginal value of water on deficit irrigated alfalfa land is $228/AF as determined by the National Economic Efficiency (NEE) analysis developed as part of the final plans for NUID's Irrigation District Infrastructure Modernization Project (NRCS, USDA 2023b);
- the annual yield per acre of alfalfa in NUID is 4.06 tons, with a market value of approximately $201/ton and variable costs of $565/acre (NRCS, USDA 2023b); and
- the timeframe over which costs were assessed is 100 years to allow for comparison with the piping alternative.

Assessing the foregone production value of fallowed and deficit irrigated land, the estimated NPV impact of non-investment is **$64.8M** or, on average, **$0.65M** per year. These costs represent just the direct impact of non-investment; the loss of these dollars produce further impacts to the local economy including indirect (e.g., fewer purchases of seed and fertilized) and induced (e.g., farmers choosing to eat out less frequently) impacts.

It is important to note that this value is likely conservative for several reasons as the analysis does not account for:

- the additional impacts of future droughts and climate change on water supply (NRCS, USDA 2023b);
- the potential for increased O&M costs for canals, laterals and other district infrastructure above the baseline due to the need to remove higher sediment loads resulting from more fallowed acreage (NUID 2023);
- the potential for increased electricity costs, and associated social cost of carbon, resulting from pumping; and
- the potential for increased weeds, erosion, and air pollution associated with larger amount of fallowed land (and the costs to mitigate these impacts).

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[30] Deficit irrigation is the practice of providing a crop with less than the optimal amount of water for maximum yield. It is often used on alfalfa, a drought-tolerant species —irrigation generally can be stopped at almost any point in the growing season without permanent damage to the crop (Orloff, Putnam, and Bali 2015).

Additionally, because the projected shortages to NUID's water rights have the potential to be both substantial and highly variable, not investing in water conservation and/or governance actions may result in conditions that make farming untenable for the majority of NUID patrons. Were this to occur and subsequently cause the district to fail, agricultural production on a large scale would cease in the district — resulting in the loss of millions of dollars per year in foregone agricultural production as well as impacts to the broader regional economy.

Irrigation Infrastructure Modernization – NUID: In early 2023, final plans were approved for NUID's Irrigation District Infrastructure Modernization Project, meaning the project is now eligible for federal funding. The Environmental Assessment of the project provides, among other things, a comprehensive overview of the water challenges faced, the alternatives considered for addressing those challenges and a detailed assessment of the potential environmental and economic impacts under the preferred alternative. The preferred alternative — piping 27.5 miles of open canal and building four retaining ponds — will cost $37.5M. (NRCS, USDA 2023b)

The study concluded that the project will produce a variety of long-term monetizable and non-monetizable benefits, the former of which alone outweigh the initial investment costs (with a benefit-cost ratio of 1.2). Monetized benefits considered in the NEE analysis included reduced agricultural impacts associated with fallowing of fields due to water scarcity, reduced electrical costs related to pumping, reduced O&M costs for the district, avoided carbon emissions and instream flow value (Table 50).

TABLE 50. SUMMARY OF ESTIMATED BENEFITS

Benefit Category	Annual Benefits ($/yr)
Agriculture (Avoided Damages)	$731,000
Increased Instream Flow	$122,000
Energy Savings	$218,000
O&M Savings	$66,000
Carbon Emission Reduction	$116,000
Total	$1,253,000

The estimated annual non-discounted benefits included in the Environmental Assessment were used to calculate the NPV across the lifespan of the project, resulting in total direct benefits of **$35.9M.**[31]

There are several assumptions of the NEE that are worth noting:

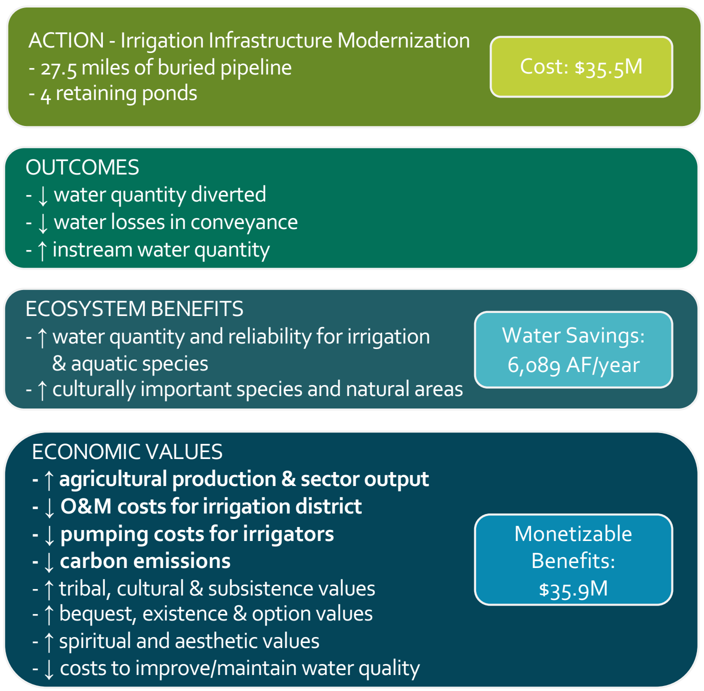
- Additional water for irrigated agricultural was assumed to reduce deficit irrigation on acres in hay. Deficit irrigation results in the loss of one hay cutting or 25% of annual yield per year. Given that roughly one-quarter of irrigated land in NUID produces high-value specialty crops, the estimated value of water savings from this project are likely conservative.

[31] Detail on the methods for calculation of annual benefits can be found in USDA - NRCS 2023.

- Economic benefits to irrigated agriculture appear to be limited to on-farm benefits and do not consider how these direct benefits would provide additional indirect and induced benefits to the local economy.
- The economic value of water for instream flow was calculated at $80/AF, which may represent a low value given prices paid for water right leases and transfers instream across the West, and, more importantly, the potential impacts of involuntary curtailment to achieve instream flow targets under the HCP.

Figure 63 provides a summary of the project actions, outcomes, ecological benefits and resulting economic values for piping NUID's system. Note that estimated monetized benefits presented here do not align with those in the Environmental Assessment as costs were discounted over time and a 3% discount rate was used (as opposed to a 2.5% discount rate).

FIGURE 63. SUMMARY OF NUID IRRIGATION INFRASTRUCTURE INVESTMENT



Source: Adapted from USDA-NRCS (2023)

The LCOW — a measure of the average NPV lifetime cost of the water saved or generated by a project — also was calculated to provide an indication of the cost-effectiveness of the public investment in NUID's infrastructure modernization project. To calculate the LCOW of the project, the following assumptions were made:

- the project lifetime is 100 years;
- capital costs are $37.5M in total ($33.5M in Year 1 and $4M in Year 6);[32]
- annual water benefits are 6,089 AF; and

[32] There are no O&M costs associated with the project itself.

- a discount rate of 3% is used.

Based on these assumptions, the LCOW of the project is **$207/AF**.

Irrigation Infrastructure Modernization in COID and Water Bank: Extensive irrigation infrastructure modernization is planned for other irrigation districts in the region to increase efficiency of water use and meet the requirements of the HCP. A comprehensive long-term plan calls for piping over 150 miles of COID district canals and laterals; when complete this work can conserve an estimated 89,000 AF (Bureau of Reclamation and Oregon Water Resources Department 2019b).

COID has already begun to pipe its two primary district canals, the Pilot Butte and Central Oregon canals. The first phase of the Pilot Butte project was completed in 2022. The cost of the entire Pilot Butte project is an estimated $220M and will conserve over 55,000 AF of water per year. In the future, piping the remaining 80 miles of the Central Oregon Canal will likely occur. This phase could cost over $300M and would conserve an additional 35,000 AF per year once completed. (Crew 2016; Bureau of Reclamation and Oregon Water Resources Department 2019b)

Irrigation infrastructure modernization within COID will conserve large amounts of water, however, for that water to 1) help COID meet flow requirements under the HCP; and 2) increase water supply and reliability for NUID, an additional piece is being developed — a water bank, which will allow for sharing water between districts, particularly COID and NUID. The water bank, which is being designed and led by a local non-profit group the Deschutes River Conservancy (Box 12), will also facilitate moving water between the districts generated by temporary fallowing of irrigated land within COID and other area irrigation districts. Through the water bank, conserved water from piping and fallowing would be shared with NUID during the irrigation season in exchange for equal releases from Wickiup Reservoir in the winter to satisfy a portion of the flow requirements under the HCP.

BOX 12: THE DESCHUTES RIVER CONSERVANCY

The **Deschutes River Conservancy** (DRC) was founded in 1996 as a collaborative, multi-stakeholder group with the mission of *restoring streamflow and improving water quality in the Deschutes River Basin*. DRC works with local water users including irrigation districts, cities and individuals, as well as the Confederated Tribes of The Warms Springs and others to find creative ways to restore instream flows in the Deschutes Basin's rivers. DRC uses a combination of tools from Oregon's Instream Water Rights Law along with other tools to protect instream flow temporarily and permanently for fish and other aquatic species like the OSF. Among these tools, the Allocation of Conserved Water Program is of particular importance. This program allows for dedication of water conserved from efficiency upgrades like canal piping to protected instream flow (Amos 2009). DRC has worked with both NUID and COID for decades to support the districts' modernization efforts and forge creative governance pathways to dedicate water instream in the Deschutes River and its tributaries.

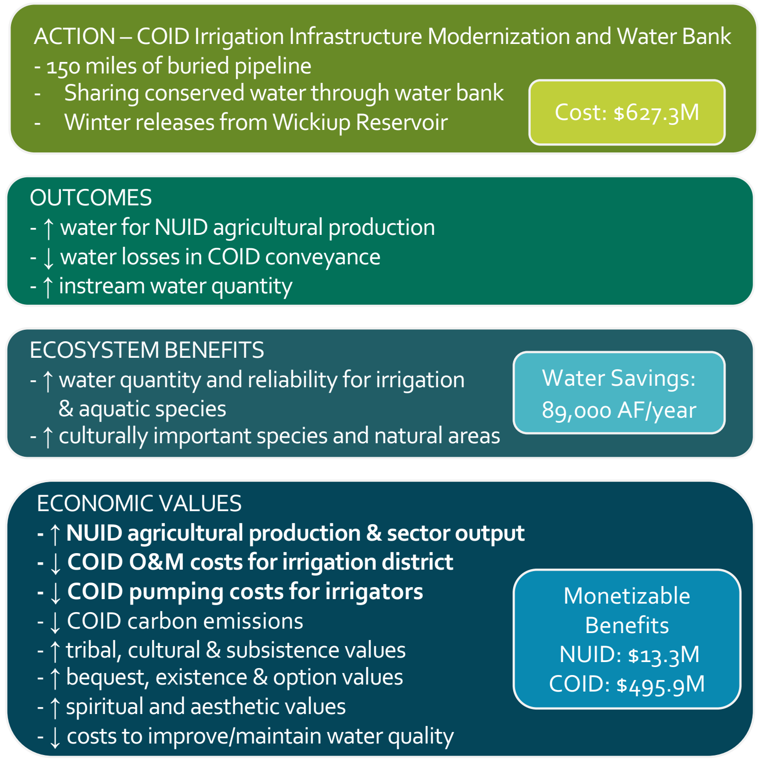
The water bank that facilitates sharing conserved water between districts — and may facilitate other methods of sharing water such as leases from fallowing, duty reductions and on-farm efficiency measures — may also require a public investment. The level of public investment required is likely driven more by transactions that may occur beyond the sharing of conserved water from piping projects. More specifically, the DWB may require one or more full-time equivalent (FTE) staff to manage the bank in addition to costs associated with office space and equipment. This report assumes that water bank staff are paid an estimated combined salary (including a 25% adjustment for benefits and office supplies) of approximately $165,000/year. This can be used to represent the annual investment in the water bank for the purposes of sharing conserved water.

The draft Environmental Assessment (Farmers Conservation Alliance 2020) for one portion of the COID piping project (i.e., Smith Rock-King Way) included estimates of the benefits to NUID and COID from that project. As part a result of the project, NUID would receive water from COID via the Pilot Butte Canal, reducing its diversion rate at North Canal Dam by an equal amount, such that the water would experience reduced seepage losses. Water saved — an estimated 888 AF of per year — could be used by NUID. This reliable source of water — available in "every type of water year" — would likely be better utilized for long-term planning of all crops in NUID (as opposed to being used to support an additional cutting of deficit irrigated hay, an assumption used for the circumstances analyzed in the NUID canal piping described in the previous section). For this reason, a weighted average value (~$512/AF) that included alfalfa hay and carrot seed as representative crops for the district was used to estimate benefits. In total, over the assumed 100-year lifespan of the pipe, the estimated NPV of direct benefits to NUID from the Smith Rock-King Way project is **$13.3M**.

While the focus of this analysis is on the economic benefits of increased water supply for NUID, many benefits resulting from piping COID canals and laterals would accrue to COID itself — primarily in the form of avoided costs resulting from failing to meet the requirements of the HCP. Other key benefits to COID include reduced O&M costs for the district and reduced pumping costs for patrons. Total estimated benefits for all COID piping projects were assumed to be proportional to the estimated benefits for the Smith Rock-King Way Infrastructure Modernization Project and were extrapolated using data from the Environmental Assessment for that project. The estimated NPV of direct benefits to COID over the assumed 100-year life of the pipe is **$496M**. (Farmers Conservation Alliance 2020)

While the impact of the public investment in the water bank is not assessed, the economic benefits of investing in the water bank would likely not be limited to those analyzed here. In the future, the water bank may facilitate transfer of conserved water from piping projects in other irrigation districts in the region and/or district patrons in the form of voluntary leases, etc., which would have their own positive economic impacts. Figure 64 provides a summary of the project actions, outcomes, ecological benefits and resulting economic values.

FIGURE 64. SUMMARY OF COID IRRIGATION INFRASTRUCTURE INVESTMENT



To calculate the LCOW of the project, the following assumptions were made:

- piping of the Pilot Butte Canal and laterals would occur first and be completed before Year 8 of the HCP (2028), when HCP flow requirements increase to 300 cfs in the Upper Deschutes River;
- Central Oregon Canal piping and laterals would occur after Year 8 of the HCP;
- as project plans are still being developed, piping of the Central Oregon Canal was assumed to take 10 years;
- as information is not available on when and how quickly piping would occur, it was divided evenly across the length of each project — 15 miles over 5 years for the Pilot Butte Canal project and 8 miles over 10 years for the Central Oregon Canal project;
- costs and water savings were similarly distributed using the average cost and water savings per mile of pipe installed;
- water savings for each mile of pipe laid would be realized in the following year;
- the project lifetime is 100 years; and
- a discount rate of 3% is used.

Based on these assumptions, the LCOW of the COID irrigation district piping project is **$267/AF**.

13.4 DISCUSSION

This case study analyzed a no-action alternative and two potential investments. The no-action alternative — in which NUID's water supply is further curtailed to meet the requirements of the HCP —

provides a point of comparison for the other two investments: 1) piping NUID district-owned canals; and 2) piping COID district-owned canals and laterals and then sharing the conserved water with NUID through a water bank, which may occur separately or in tandem. While the no action alternative results in negative economic impacts to NUID, both piping projects have the potential to provide substantial net economic benefits to NUID, not including benefits that were not monetized.

FIGURE 65. SUMMARY OF POTENTIAL INVESTMENTS AND OUTCOMES

NO ACTION
- Cost: $0
- Monetizable Benefits: $64.8M
- LCOW: N/A

NUID PIPING
- Cost: $35.5M
- Monetizable Benefits: $35.9M
- LCOW: $207/AF

COID PIPING & WATER BANK
- Cost: $627.3M
- Monetizable Benefits:
    - COID: $496M
    - NUID: $13.3M
- LCOW: $267/AF

The analyses are limited in several ways, perhaps most importantly by their lack of ability to account for uncertainty. Infrastructure projects of this scale are often plagued by delays and unforeseen costs. These factors could affect both timing and magnitude of both costs and benefits — increasing costs relative to benefits and pushing the realization of benefits further into the future. The analyses also are based on projected average annual volumes of water (both conserved and shorted), which are not only likely conservative, by nature of not accounting for the additional effects of climate change, but also smooth over interannual variation that is likely to occur for both. The interannual variability could have outsized impacts on farmers' contracts for seed crops, which often are signed over a year in advance, and their general livelihood, such that the economic analyses may underestimate the impacts of water right shortages (M. Britton, personal communication, 6/24/2020). On the other hand, there are many benefits produced by the investments that have not been monetized, such as the existence value of the OSF, improved water quality and aquatic habitat and cultural and subsistence benefits to CTWS.

Finally, as previously mentioned, the impact of the investments themselves have not been included even though funding to support the projects comes from, and will likely continue to come from, primarily public sources outside the region. In the case of piping projects, the bulk of identified funds would come from federal sources with most matching funds likely to come from state sources. The investments themselves, therefore, bring new money to the region and have subsequent regional economic impacts. There are, however, opportunity costs associated with federal/state funds being spent on these projects rather than supporting other sectors/projects, and for this reason the economic benefits associated with the investments themselves are not included in this analysis.

Investments in irrigation district modernization and innovative governance in Central Oregon will help to preserve the area's agricultural economy and character while also helping increase instream flows for the threatened OSF. Beyond these benefits to the region, these investments also provide a blueprint for investments in agricultural reliability more broadly. Reductions in water supply for agriculture in Oregon are being driven by changes in changes in climate that are altering water supply timing and exacerbating drought. Across the state, these changes are happening at the same time as a growing acceptance of the need to provide water to ecosystems and species that have been severely impacted by water withdrawals. Central Oregon is helping to pioneer a collaborative approach that takes these goals as compatible rather than in conflict. Three takeaways are important to highlight:

- **Investing in governance alongside infrastructure can be a powerful combination** when the paired efforts result in more than the sum of their parts. Without creative governance, investments in piping and modernization in NUID and COID could not be leveraged for instream flow to benefit the OSF.
- **Aridification may be the new normal** for much of Oregon east of the Cascades. While there will also continue to be years with high precipitation, the overall trend for the foreseeable future could be toward increased water supply scarcity. This underlines the importance of aggressive conservation and flexible innovations in governance to weather unpredictable future changes.
- **Collaboration is powerful**. As demonstrated by the Central Oregon irrigation districts, the Deschutes River Conservancy and other basin partners, collaboration opens the door for funding; trust built over time between collaborators increases resiliency by reducing conflict and providing a basis for the level of commitment that will be required to tackle the coming challenges.
- **Collaboration is the backbone of successful funding**. The costs of large irrigation modernization projects like piping 150 miles of COID’s canals, are immense. Federal funders along with state and other sources are more likely to consider funding projects of this scale when they are supported by a broad coalition; in the case of the Central Oregon, long-term collaboration between the irrigation districts, the DRC and the CTWS, along with area cities and others, provide a compelling case for funding requests.

14 Southwest Regional Case Study: Characterizing Recreational Value in the Rogue River from its Headwaters to the Ocean

The Rogue River Basin spans a large swath of southwestern Oregon from the crest of the Cascade Range to the Pacific Ocean; it is one of the most “biologically, botanically and geologically diverse areas of the country” (ODEQ 2007). The Rogue River’s source is Boundary Springs located on the western border of Crater Lake National Park. From there the river flows generally westward for more than 200 miles before it reaches the Pacific Ocean. Along with seven other rivers, a portion of the Rogue River was designated “Wild & Scenic” as part of the original 1968 National Wild and Scenic Rivers Act (US Congress 1968). Known for its beauty, rugged landscapes and diversity of recreational activities, the region is popular with residents and visitors alike. Importantly, all outdoor recreation and other activities in this region occur on the ancestral lands of multiple Indigenous peoples who were the original inhabitants and caretakers of the land.

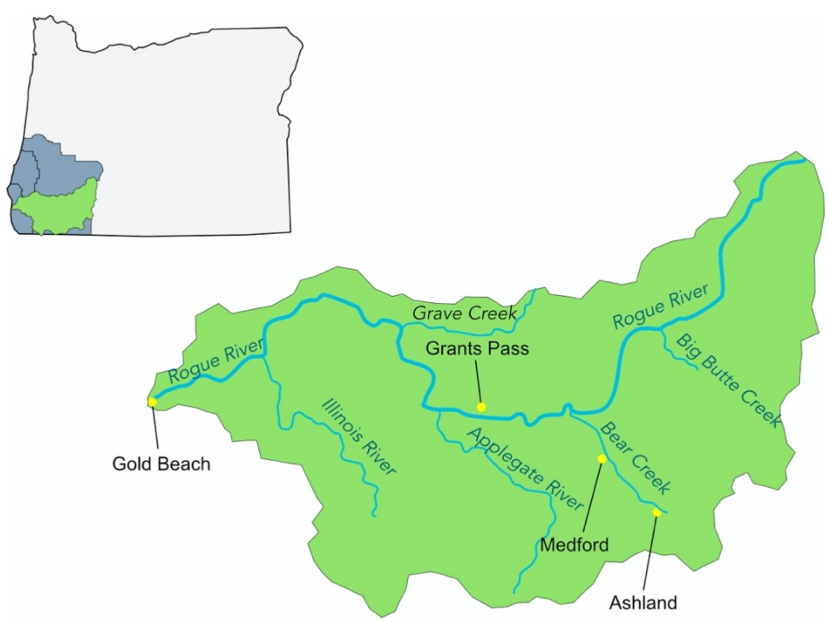
The Rogue River is a quintessential hard-working western river. On the journey from its headwaters to the ocean, the Rogue River and its tributaries generate power, provide water to irrigate valuable crops, supply cities and businesses, afford recreational opportunities and provide critical habitat for anadromous and resident fish populations. While the Rogue provides a range of benefits, this case study is focused on the immense instream value of water in the Rogue and its tributaries. Specifically, this case study characterizes the numerous ways in which water is used for recreation in the Rogue River Basin and their associated values — both in terms of economic activity (i.e., the contribution to the regional economy) and non-market values (i.e., the experiences and enjoyment derived by recreators).

In contrast to the other regional case studies, this study does not focus on a specific water-related challenge and an investment to overcome that challenge, but rather, indirectly makes the business case for continued investment in restoring and preserving the quantity and quality of flow in the region's streams, rivers and lakes; this case is made by characterizing — with reference to quantitative data when possible and qualitatively otherwise — the range of existing benefits.

FIGURE 66. SOUTHWEST REGION CASE STUDY SUMMARY

Water Resource Challenges	Outcomes
- Water temperature - Habitat quality & access - Low and/or constrained instream flows	- Increased instream flow - Improved habitat - Higher % of river is free-flowing
Cause(s)	**Beneficiaries**
- Climate change impacts - Man-made barriers & discharges - Diversions for out of stream use	- Recreators & tourism-related businesses - Aquatic species including ESA listed Coho salmon
Investment(s)	**Key Takeaways**
- Projects: streamside revegetation, habitat restoration/reconnection, barrier removal - Environmental water transactions - Policy: "Wild & Scenic" designation, Total Maximum Daily Loads (TMDLs)	- The idea of "value" should include both economic and societal values of experience/enjoyment/well-being - Negative impacts to the water resources on which recreation depends do not just impact the economy, but also well-being of residents and visitors

FIGURE 67. THE ROGUE RIVER BASIN AND KEY RIVERS AND TRIBUTARIES IN THE SOUTHWEST REGION



14.1 Challenges

The primary water-related challenge currently facing the region is a common one across the state — managing water to balance in and out of stream water needs. More specifically, the challenge is managing water in a way that balances the needs of users like cities and farms with the needs of ecosystems and people and communities who enjoy a clean, flowing river. As a result of diversions for agriculture, drinking water and industry "lack of adequate instream flow is a critical limiting factor in every subbasin of the Rogue River watershed" — affecting not only native fish populations, but also instream recreational activities (Davidson 2021).

Another challenge for the Rogue River and its tributaries is water quality, particularly elevated water temperatures. Even with TMDLs in place for bacteria and temperature, among others, it is currently listed as an impaired body of water (ODEQ 2022). Elevated water temperatures have the potential to affect water-based recreation by 1) reducing rearing and spawning habitat for cold-water species such as Chinook and Coho salmon, steelhead and rainbow trout — popular recreational fisheries; and 2) increasing the risk of toxic algal blooms that harm fisheries and limit human access (Crown et al. 2008).

While investments have been made to lower water temperatures (see next section), the Rogue's current listing as impaired, coupled with climate change impacts in the form of increased ambient air temperatures, drought and precipitation variability, indicate that ongoing investment will be needed (Climate Wise, n.d.).

14.2 Investments

Investments (physical projects and policy-based actions) already have been and continue to be made in the basin to address elevated temperature levels and other water quality concerns. Investments range from policy-based investments such as Wild & Scenic designation and TMDLs determination, to physical projects, such as barrier removal, revegetation and infrastructure projects, to market-based investments such as environmental water transactions (EWTs).

14.2.1 Wild & Scenic Designation

In 1968, 84 miles of the mainstem Rogue River — from the mouth of the Applegate River (seven miles west of Grants Pass) to Lobster Creek Bridge (11 miles east of Gold Beach) — was designated a Wild & Scenic River (US Congress 1968). Such a designation is divided into three classes: 1) Wild, defined as free of impoundments and generally accessible only by trail representing vestiges of primitive America; 2) Scenic, defined as free of impoundments, with shorelines and watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads; and 3) Recreational, defined as readily accessible by road that may have some development along the shoreline, and that may have undergone some impoundment or diversion in the past (BLM and USFS 2004). The river designations starting inland and flowing toward the Pacific Ocean are as follows:

- Recreation – Applegate River to Grave Creek (27 miles);
- Wild – Grave Creek to Watson Creek (33.8 miles);
- Recreation – Watson Creek to Blue Jay Creek (8.9 miles);

- Scenic – Blue Jay Creek to Slide Creek (7.6 miles); and
- Recreation – Slide Creek to Lobster Creek (7.1 miles) (BLM and USFS 2004).

14.2.2 Total Maximum Daily Loads (TMDLs)

TMDLs were approved by the EPA for Bear Creek (1992), Upper Sucker Creek (1999), Lower Sucker Creek and Lobster Creek Watershed (2002), the Applegate Subbasin (2004) and Bear Creek Watershed (2007), with a catch-all TMDL approval for the remainder of the Rogue Basin approved in 2008. There are both temperature TMDLs to protect salmon, steelhead, trout and other cold-water fishes and bacteria TMDLs to support safe recreation. Both TMDLs aim to bring wastewater discharge and sewage treatment facilities into compliance as well as address sources of nonpoint runoff such as cities, rural areas, working and natural forests, agricultural lands, irrigation districts and CAFOs. Temperature TMDLs additionally focus on federally managed dams/reservoirs. TMDLs also are intended to reduce other water quality parameters for which sufficient data did not exist, but are defined as TMDLs in specific watersheds/subbasins and include: dissolved oxygen, pH and sedimentation. (ODEQ 2008)

Approval of TMDLs spurred the implementation of efforts to reduce temperature loading through streamside revegetation projects, planned reservoir releases, changes to wastewater treatment facility infrastructure and operations, as well as other sources of pollutant runoff. A few specific examples, include:

- The City of Ashland is currently in the process of relocating the outfall from their wastewater treatment facility from a smaller tributary (i.e., Ashland Creek) to a larger one (i.e., Bear Creek) — a project expected to cost upwards of $4M (P. Brown 2017; Kathol and Fleury 2021; 2022).
- The Freshwater Trust, along with numerous local, state and federal partners, have completed streamside revegetation on more than 120 riparian acres (The Freshwater Trust, n.d.) — one such project, a six-year project to implement revegetation and establish a water quality trading program, is expected to cost nearly $3M (Kathol and Brown 2019).
- The City of Ashland is also exploring the feasibility of cold-water releases from Reeder Reservoir as a last resort action to achieve compliance with their NPDES permit when other mitigation efforts are not sufficient — a feasibility study has been proposed which will help establish project potential and costs (Fleury 2023).

14.2.3 Barrier Removal

Second only to the Columbia River Basin, the Rogue River Basin produces the most salmon in the state, however, development on the rivers and tributaries (by limiting the existence of and access to cold water refugia) has resulted in sharp declines for salmon populations. Barriers, such as dams, even just three inches in height, can impact the movement of salmonids. Of the over 600 barriers remaining in the basin, ODFW has identified almost 90 that are high priority for removal. The largest dams in the basin were removed in the early 2000s, with progress continuing on the smaller, tributary dams. (Rogue Basin Partnership n.d.). While barrier removal can be controversial, it is important to note that efforts in the Rogue Basin have been collaborative efforts where barriers have been replaced with more functional alternatives.

A few specific examples include:

- the removal of the Gold Hill Diversion Dam — an eight foot high concrete dam spanning the Rogue River, which impeded spawning and injured juvenile salmon — was completed in 2008 following the construction of a new municipal water supply intake that rendered the dam obsolete (WaterWatch n.d.);
- the removal of the Savage Rapids Dam — a 39 foot high, 500 foot long diversion dam, which, at times completely blocked upstream fish passage and impeded access to approximately 500 miles of spawning habitat — was completed in 2009 (WaterWatch n.d.);
- the notching of the partially constructed Elk Creek Dam was completed in 2009 to allow fish passage for the estimated 30% of the Rogue Basin's coho salmon that spawn in the creek (WaterWatch n.d.);
- the Gold Ray Dam — a 38 foot high, 360 foot long dam on the mainstem, which became obsolete in 1972 when power generation at the dam ceased being economically viable — was removed in 2010 (WaterWatch n.d.);
- the removal of Fielder and Wimer dams on Evans Creek was completed in 2015 restoring miles of spawning habitat for Chinook salmon, coho salmon, summer and winter steelhead, cutthroat trout, suckers and lamprey; and
- the replacement of diversion dams on Welter Creek with screened pumps in 2021 restored access to Slate Creek, a key spawning tributary (WaterWatch n.d.).

14.2.4 Environmental Water Transactions

Environmental water transactions are defined as agreements by which a water user commits to a change in their water use, water rights (legal documents required for using water in Oregon), or both, leading to legal or de facto dedication of water to environmental purposes (Aylward 2013). Oregon became a pioneer in the western US when, in 1987, the state enacted the Instream Water Rights Act, the first of its kind in the nation (Pilz 2006). Shortly after, in 1993, water users, Tribal representatives and environmentalists joined together to form the Oregon Water Trust to put the Instream Water Rights Act into practice.

The Act allowed for creation of instream water rights in two ways: 1) through application by one of three state agencies (ODFW, ODEQ, Oregon Parks and Recreation Department) for a new water right for instream flows; or 2) by transferring an existing water right from its current use to an instream water right. The second method enables creation of senior water rights to protect instream flows by preserving the priority date of the original water right after it is transferred to become an instream water right.

For rivers with inadequate instream flow, like the Rogue River and its tributaries, transfers, either temporary or permanent, of an out-of-stream use water right to an instream one can help increase instream flow. A few specific examples include:

- In 1996, 1999 and 2005 multiple conservation projects resulted in water transferred instream to Evans Creek and Little Butte Creek (both tributaries to the mainstem Rogue) through the Allocation of Conserved Water Program, an addition to the Instream Water Rights Act (OWRD n.d.).

- In 1999 the Oregon Water Trust (now The Freshwater Trust) permanently transferred a water right for 0.48 cfs on Little Butte Creek, a tributary to the Rogue River mainstem and subsequently permanently transferred 0.091 cfs on Chaney Creek, tributary to the Applegate River, in 2003 (OWRD n.d.).
- In 2009, Grants Pass Irrigation District, as part of the removal of Savage Rapids dam, agreed to transfer a water right associated with the dam to an instream water right (Sienicki 2009).
- Short (one year) and long-term (up to ten years) temporary instream water right changes (referred to as *leases*), obtained through donations as well as payments, were completed on Evans Creek, Emigrant Creek, Salt Creek, Maple Creek and Ashland Creek, among others over the past 20 years (OWRD n.d.).
- In 2022, Trout Unlimited purchased Butte Creek Mill's water right and permanently transferred a portion of it (6.6-8.4 cfs depending on the season) for instream flow, which will help prevent potential de-watering during the summer of approximately 12 miles of Little Butte Creek, a Rogue River tributary (Van Dyke 2023).

14.3 Analysis

The investments described above all help keep water in the Rogue River and its tributaries, help keep that water clean and remove barriers that impact the region's important fisheries. In turn, abundant, clean, free-flowing rivers support a vibrant and diverse water-related recreation economy. This section describes and analyzes the ways in which water-related recreation contributes to the economy of southwestern Oregon and the overall well-being of residents and visitors who engage in water-based recreation in the region.

In addition to estimating contributions to the economy, the "experience/enjoyment" value of recreation can be estimated in monetary terms using the idea of *consumer surplus*, which in this context is simply the difference between the maximum amount an individual would be willing to pay to participate in recreational activity and the actual cost of participation. The information needed to estimate consumer surplus is typically gathered through primary data collection, but when insufficient resources are available to do this, consumer surplus may be inferred from previous studies — an approach known as benefit transfer (see Appendix B).

A recent study on consumer surplus in Oregon drew on information from the Recreation Use Values Database, which includes estimates from over 400 studies on use values. While the study included activity-specific consumer surplus estimates, the visitor information available for the Southwest region was not also broken out by activity type. As such, the mean value across all activities per person per activity day ($85.61) is used as the basis for all consumer surplus estimates calculated in this case study. (R. Rosenberger 2018)

The remainder of this analysis starts at the top of the Rogue River Basin and works downstream — assessing the value of key water-related recreational areas in the basin from headwaters to ocean.

Given the multitude of tributaries, lakes and other waterbodies in the region combined with a lack of visitor/use data for some locations (e.g., the Bear Creek Greenway), this analysis does not attempt to capture all water-related recreation in the region; rather, it illustrates the value of those for which data and information are readily available.

14.3.1 Crater Lake

While not connected to the river itself, Crater Lake is in the Rogue River Basin and the headwaters of the Rogue River (i.e., Boundary Springs) are located within Crater Lake National Park (CLNP). Established in 1902, CLNP is Oregon's only national park and, on average, is visited by more than half a million people each year. In addition to sight-seeing, the park is popular for a wide range of summer activities and programs, as well as snowshoeing and cross-country skiing in the winter. (USGS, n.d.)

According to the National Park Service (NPS), in 2021 648,000 people visited CLNP, spending an estimated $62M in "gateway regions."[33] This spending supported almost 900 jobs and generated $90.5M in total economic output in the local economy (NPS 2022). In addition, using the conservative assumption that each visitor stayed only one day at the park, estimated annual consumer surplus (i.e., the value of the experience enjoyed by the visitors) is $55.5M.

14.3.2 Upper Rogue

Roughly between the Rogue River's headwaters and the beginning of the river's Wild & Scenic reach are both Valley of the Rogue State Park and the Rogue River Basin Project Area.

In 2021, the Valley of the Rogue State Park near Gold Hill welcomed over 2M visitors — making it the most popular state park in Oregon (Hale 2022). Located along the banks of the Rogue River and adjacent to Interstate 5, it offers yurts and individual/group campsites for overnight stays along with boating, fishing, hiking and picnicking. According to a recent assessment of economic activity associated with recreation in Oregon State Parks, the 1.9M visitors in 2016 spent an estimated $46M — with more than half the spending coming from in-state residents (White 2015). Again, using a conservative assumption that each visitor only stays one day, particularly with all the overnight stay options available at the park, estimated annual consumer surplus (using 2021 visitor estimates) is over $171M.

The Rogue River Basin Project Area is a US Army Corps of Engineers (USACE) water resource management system that includes two man-made reservoirs — Lost Creek Lake on the mainstem Rogue near CLNP and Applegate Reservoir high up on the Applegate River just north of the California/Oregon border. Both reservoirs support a variety of day and overnight recreational activities including swimming, boating, water-skiing, cycling, hiking, picnicking/viewing and camping. ODFW also stocks both lakes with trout making them popular fishing areas (Best Fishing in America 2023). In 2012, the most recent year available, Reclamation reported 505,000 visitors and $14M (almost $18M in 2022$) in

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[33] **Gateway regions** are defined by the NPS as the areas directly surrounding National Park Service sites. Gateway economies include the cities and towns where visitors typically stay and spend money while visiting National Park Service sites.

annual economic impacts from recreation in the Rogue River Basin Project area. Estimated annual consumer surplus for that year was $43M.

14.3.3 Hellgate Recreation Area (Applegate River to Grave Creek)

In addition to 27 miles of Class I and II rapids, the Hellgate Recreation Area is home to county parks (including four campgrounds), boat ramps, picnic areas and scenic overlooks (BLM, n.d.) In addition to instream recreational activities like commercial jetboating, driftboat fishing and rafting, this area is also popular for bank fishing, camping, swimming, picnicking and scenic driving.

In 2013, the BLM reported that almost 65,000 commercial motorized tour boat passengers, almost 5,000 commercial floating or fishing passengers and a conservatively estimated 45,800 private individuals boated the Hellgate Recreation Section of the Rogue River (BLM, n.d.). While activity categories included in the report did not perfectly align with those reported by the BLM, spending per day per activity estimates from the recent study by Mojica, Cousins and Madsen (2021) combined with visitor counts resulted in estimated spending of $11.9M in 2013. This finding is consistent with a 2009 study that estimated direct recreational spending associated with both commercial and non-commercial fishing and rafting as well as jet-boat tours of $9.8M and statewide total economic output of $16.4M (ECONorthwest 2009a).

Consumer surplus estimates for whitewater rafting and floating/fishing (averaged) were multiplied by the estimated number of visitors resulting in total estimated annual consumer surplus of $10.6M for these activities alone. Annual visitor estimates to county parks and participation rates in other activities could not be located, therefore, spending and consumer surplus estimates represent only a limited set of the recreational activities for which this area is known.

14.3.4 Wild and Scenic Section (Grave Creek to Watson Creek)

The Wild and Scenic section of the Rogue River is popular for multi-day rafting/floating trips, which require a permit, and the Rogue River Trail, a challenging point-to-point hike following the river through the entire Wild and Scenic section.

In 2007, 13,147 individuals floated this section of the river and spent an estimated $16.4M, which in turn created $25.6M in statewide total economic impact (ECONorthwest 2009a). According to the BLM, approximately 20,000 people raft this section each year, suggesting the estimates from the 2007 study are likely conservative (BLM, n.d.). Estimated consumer surplus is approximately $3M per year. Estimates of individuals hiking the Rogue River Trail or other activities (e.g., fishing) could not be located.

14.3.5 Lower Rogue

Jetboating is a popular activity on the lower section of the river beginning at the river mouth. Over the last five years, Jerry's Rogue Jets, the sole commercial jetboat operator on the Lower Rogue, averaged 33,000 passengers per year on their Rogue River tours (McNair, N. Personal communication 2023)

Using estimates from Mojica, Cousins and Madsen (2021), jet boat passengers spend, on average, $3.4M per year, with estimated consumer surplus of $1.5M. Information on participation in other recreational activities in this portion of the river could not be located.

14.3.6 Summary of Findings

The numerous and diverse recreational activities, combined with the many locations and sites available at which to do them, makes it difficult to provide a comprehensive summary of the value of the Rogue River Basin for recreation. Furthermore, recreational sites are managed by a variety of local, state and federal entities, all of whom track visitor information in different ways at different times. As such, the summary information presented here on recreational spending and related economic impacts comes from Mojica, Cousins and Madsen (2021) and was calculated at the county-level for all outdoor recreational activities, not just water-related ones, and presented for counties with substantial land area in and/or influence from the Rogue River Basin (Table 51).

TABLE 51. SUMMARY OF COUNTY-LEVEL ECONOMIC IMPACTS

County	Trip-Related Spending ($M)	Employment (#)	Economic Output ($M)
Curry	$713	5,137	$488
Jackson	$362	3,225	$359
Josephine	$204	1,701	$175
Total	$1,279	10,063	$1,022

Estimates of consumer surplus are based on the water-related recreation — but only the activities for which estimates of annual participants were available. As such, the estimates, presented here by region/river section, are conservative (Table 52).

TABLE 52. SUMMARY OF CONSUMER SURPLUS ESTIMATES

Region/River Section	Consumer Surplus ($M)
Crater Lake	$55.5
Valley of the Rogue State Park	$171.2
Rogue River Basin Project	$43.2
Hellgate Recreation Area	$10.6
Wild Section	$3.0
Lower Rogue	$1.5
Total	$285.0

Source: Mean consumer surplus value from (R. Rosenberger 2018) (Hale 2022; NPS 2022; Best Fishing in America 2023; BLM, n.d.).

The example of the Rogue River provides a clear example that Oregon’s waters provide immense recreation- and tourism-related value for the state's residents, visitors and businesses. Investments in preserving and enhancing waters for recreation are likely to return substantial economic dividends for the state in both market and non-market values.

14.4 Discussion

The Rogue River is an iconic feature of Oregon's landscape and Oregon asks so much of the river. This case study focused not on what is diverted from the river (though there is tremendous economic value in crops, business and communities supported by its waters), but rather on the value generated by using the river in its place. Recreation and tourism on the Rogue River, as with other rivers in the state, are significant economic sectors that drive visitation and spending and epitomize Oregon's connections to its waters. The Rogue River is also a symbol for the threat that rivers face when they are overworked — watering crops, providing clean drinking water, generating power and fueling business and industry — and they are expected to do this over and over from their headwaters to their mouth.

- **Investments in watershed health are critical to supporting everything that rivers provide.** Recreational use of rivers is important economically, but it is also important symbolically because it shows that allowing water to flow from headwaters to the ocean has value. Continued investments in watershed health, instream flow and passage barrier removal are critical for maintaining a strong water-based recreational economy specifically and a strong water-based economy generally.
- **Non-use values "represent the vast majority of the economic value of Rogue River salmon"** (ECONorthwest 2009b). Though this case study focused largely on use values of the Rogue, non-use values have immense power (Table 53).

Table 53. Value of Rogue River Salmon

Salmon Use	Value ($M)
Commercial Fishing	$2.0
Sport Fishing	$22.6
Nonuse	$2,117.6

Source: Adapted from ECONorthwest (2009)

- **Enjoyment derived from participating in water-related outdoor recreational activities is important to consider.** It may be difficult to quantify in monetary terms but should not be overlooked. In addition to supporting general well-being, the ability to participate in these activities is one of the reasons individuals and businesses move to and choose to stay Oregon. Drawing potential employees to a region and keeping them happy is important to all businesses and water-related outdoor recreation in Oregon is a significant draw. Oregon's reputation and reality as an outdoor-lover's paradise is inextricably linked to water.

15 Levelized Cost Of Water (LCOW)

Before concluding, this section provides a brief analysis of the LCOW of the business case illustrations in the case studies above. Only five of the eight case studies contained examples with enough data to calculate a LCOW and these five cases are discussed here. In water funding and finance, there is growing acceptance that projects should no longer be planned and selected solely based on financial or economic considerations (Gebre, Cattrysse, and Van Orshoven 2021). Instead, potential alternatives should be assessed using a multi-criteria evaluation of economic costs and benefits alongside social and environmental criteria.

In a multicriteria project evaluation process, economic data can be used to evaluate economic feasibility of available alternatives to inform project design and selection, *alongside other criteria*. As noted by the Pacific Institute (2016), who conducted an LCOW analysis of water projects in California, economic feasibility is often the primary determinant in prioritizing water-related investments, however, economic feasibility can be measured a variety of ways, making it difficult or impossible to compare alternatives in an effective and useful way.

The LCOW metric is the most robust approach to estimate cost-effectiveness across projects with differing lifespans and cost/benefit streams and is straightforward to apply in practice. LCOW is calculated as the NPV of costs less the NPV of any monetizable benefits, divided by the NPV of physical units of water benefits. In this report, $/AF is the chosen LCOW metric.

While the LCOW may be used as a point of comparison across all project types, there are many different types of water-related investments and so ideally the LCOW of an individual project would be compared with the LCOWs of similar type projects for the best results. For example, comparing the LCOW of a project focused on instream flow restoration for endangered species to that of an investment in alternatives sources of clean drinking water for disadvantaged communities would have limited utility given both the different nature of the outcome and the intended beneficiary of each project. But comparing a canal lining project meant to conserve water to dedicate to instream flow, with an EWT done for the same purpose could provide useful insight.

Table 54 below presents summary information on case study investments for which calculation of the LCOW was possible.

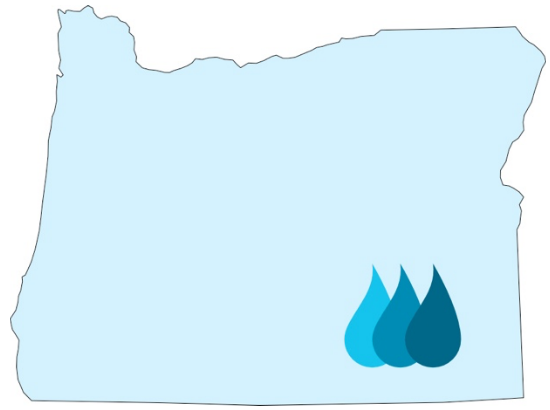
Table 54: Summary of Case Study investment LCOWs

Region	Project	LCOW ($/AF)
SE	Harney County CREP	$87
Col Plat	FID Irrigation Piping	$131
Blue Mt./NE	Annual Minimum Flow Agreement	$138
Blue Mt./NE	Johnston Lane Irrigation Infrastructure Upgrades	$151
Blue Mt./NE	Wolfe Family Farm Irrigation Infrastructure Upgrades	$152
WV/L Col	Water Reuse	$174
Central	NUID Irrigation Piping	$207
Blue Mt./NE	Fitzpatrick Irrigation Infrastructure Upgrades	$257
Central	COID Irrigation Piping	$267
Col Plat	Kingsley Reservoir Expansion	$393

Most investments considered as part of this report focused on demand-side measures for addressing water challenges (i.e., ways to reduce demand on water supply). Because it is a relatively new metric in the water context (it is used extensively in the energy field), limited references exist for LCOW of other water-related investments, making it difficult to assess whether the LCOW of the case study investments investigated here are *good* or *bad*. That is not the purpose of conducting LCOW analysis anyway; the purpose is to provide a data point that can be used in a multi-criteria analysis comparing investment alternatives.

The results here are consistent with the results of the Pacific Institute (2016) assessment in which the demand-side projects analyzed tended to have a lower LCOW than their supply-side counterparts. This makes intuitive sense: as water becomes scarcer, developing new sources of supply becomes more expensive while working to conserve existing sources can be cheaper per volume of water resulting from investment. Within the data in Table 54 above for example, developing *new* supply via enhancing Kingsley Reservoir is more expensive than freeing up water from piping and on-farm conservation projects. To be clear, this does not mean that projects with higher LCOW should not be targets of investment. LCOW is only one consideration that can be paired with others, for example the provision of co-benefits from investment (like recreational and reputational value derived from an expanded Kingsley Reservoir).

16 Conclusion



The high-level objective of this report was to make the business case for investing in water in Oregon by highlighting the critical value of water and articulating the case for investing to protect, restore, and sustainably manage Oregon's water assets. This report built the business case for investing in water in six parts:

- Discussing risks facing Oregon and the opportunities and benefits that investing in water can provide (Section 1.3);
- Detailing Oregon's demographic and water use context, providing important background on the people of the state and their connections to water (Section 2);
- Describing the methods and approaches used to estimate the value of water and investments in water (Section 3);
- Presenting the baseline economic value of water-related sectors in Oregon — a snapshot of the role of water in Oregon's economy — along with a discussion of other water values including cultural and spiritual value (Section 4);
- Highlighting the unique role of Tribal sovereignty and connection to water resources in Oregon (Section 5);
- Developing eight case studies highlighting a range of investments that have been made or planned in Oregon and discussing the benefits of these investments or consequences of not investing (Sections 7 through 14); and
- Briefly examining the LCOW of some of the specific investments detailed in this report (Section 15).

The business case that emerges from these components is straightforward. Oregon faces imposing threats from current and future water supply challenges and must invest in water now and sustain investment over time.

> **There is a strong business case for prioritizing investments that increase resiliency and flexibility as well as timely investments that address risks today rather than waiting for crises in the future. Oregon should also invest in ways that enhance water justice and recognize the importance of water and water-dependent species to Indigenous people.**

16.1 High-Level Review of Findings

The demographic and background analysis above highlighted the diversity of Oregon's physical landscape; how densely (or not) people are distributed across the landscape; and illuminated that Oregon is becoming more racially and culturally diverse as a state and within every region examined in this report. The most recent census showed that the proportion of Oregonians identifying as white decreased by 9% from 2010 to 2020. The demographic analysis section also introduced and discussed the importance of the concepts of *frontline communities* and *water justice*.

The high-level analysis of water use in Oregon showed that as a state, 78% of water supply comes from surface water while 22% comes from groundwater and that, of total water use, approximately 80% is used for irrigation. Regional variations in water use were also highlighted. For example, the Columbia Plateau region relies on groundwater to the greatest degree overall, while the North Coast and Southwest regions almost exclusively use surface water sources (95% in each region); from the perspective of public water supply, Central Oregon depends most on publicly supplied groundwater (70%) while the Southwest region depends least on that source (5%). These and other insights provide critical context for the business case analysis.

The economic baseline delved into the economics of water use across seven sectors that are highly dependent on water resources:

- **Irrigated agriculture:** This section highlighted the diversity of crops grown in the state from greenhouse and nursery crops to fruits, vegetables and hay and forage for livestock. While irrigated agriculture accounts for a relatively small percentage of Oregon's GDP (approximately 1.5%), the importance of the sector for the state should not be understated because it meets significant statewide demands for food and fiber and provides inputs to other highly valuable industries. Irrigated agriculture is also deeply ingrained in Oregon's spirit and sense of place and farmers and ranchers play an important role in managing both land and water across the landscape.
- **Water dependent industries such as manufacturing, health care, wineries and other businesses:** Together, water dependent industries (listed in Box 2 on page 65) generate $143.6B in direct economic output, nearly one third of the state's total output. This powerful economic contribution is led by manufacturing ($88.8B) including semiconductor and related manufacturing.
- **Recreation and tourism:** Oregon's geographic diversity and environment make it ideal for a range of outdoor recreation activities which generate economic activity in both urban and rural areas. According to one estimate, Oregonians collectively participated in 1.4B outdoor recreation activity days with a total net economic value attributable to freshwater recreation of more than $60B. This figure likely underestimates total economic contribution of water to recreation because many other forms of recreation (hiking for example), do not take place in water but are enhanced by rivers and lakes. Relatedly, rivers and lakes are likely a primary draw for activities like hiking and therefore some amount of economic value could be ascribed to freshwater for these activities.
- **Commercial fishing:** This sector analysis highlighted both the economic importance of commercial fishing (for example, $23.5M total economic output for salmon fishing and related seafood processing statewide) and the precariousness of the fish populations that support it – commercial salmon landings have measurably declined over the past decade from 2.4M pounds in 2011 to 1.5M pound in 2020.

- **Hydropower:** Water is critical in Oregon for producing power and for the economic contributions of marketing that power; in recent years about half of Oregon's electricity generation came from over 100 hydroelectric facilities, making Oregon the second largest producer of hydroelectric power behind only Washington.
- **Thermoelectric power:** Despite the prevalence of hydropower in Oregon, significant amounts of energy are generated from natural gas plants that can use significant amounts of water. This sector analysis highlighted the potential for investment in new technology to reduce the dependence of this sector on water.
- **Households dependent on safe and reliable water supplies for drinking water and sanitation:** The final sector analyzed, this section described Oregon's public and private water supply landscape, highlighting the role of both large and small water providers as well as the extent and some of the risks of private self-supply.

Benefits of water uses that do not fall into one of the sectors described above or that require non-market valuation approaches to estimate economic contributions were also discussed including spiritual and symbolic values, ecological function, Tribal values, aquaculture, navigation and transport, aesthetics and golf courses. Even though these water use values are not easily quantified with broadly accessible public datasets like the sectors above, they nonetheless provide immense value to Oregon in both monetary and non-monetary ways.

From the data analyzed in this report, a conservative estimate is that businesses, including agriculture, that depend on water for production and output in Oregon contribute approximately half (48%) of the state's total economic output and close to half (44%) of the state's employment (This estimate is conservative because – due to differences in how output in these sectors is calculated, differences in available data sources and to avoid risk of double counting some sectors – it does not include economic contributions from recreation, commercial fishing, hydroelectric power generation or thermoelectric power generation.

Table 55).

This estimate is conservative because – due to differences in how output in these sectors is calculated, differences in available data sources and to avoid risk of double counting some sectors – it does not include economic contributions from recreation, commercial fishing, hydroelectric power generation or thermoelectric power generation.

TABLE 55: TOTAL COMBINED ECONOMIC CONTRIBUTION OF WATER-DEPENDENT INDUSTRIES AND AGRICULTURE IN OREGON

Impact Type	Employment (jobs)	Labor Income ($B)	Value Added ($B)	Output ($B)
Direct	686,364	$46.3	$68.4	$147.4
Indirect	229,221	$18.6	$26.7	$48.5
Induced	167,359	$9.6	$19.4	$32.3
Total	1,082,944	$74.5	$114.5	$228.2
Percent of state total	44%	43%	41%	48%

Note: Due to differences in data availability and how total output is calculated, this table does not include economic contributions from recreation, commercial fishing or hydroelectric and thermoelectric power generation.

After the economic baseline, eight case studies were used to illustrate a range of specific conditions and investments across the study regions. The purpose of these case studies was to examine past and planned investments to test the business case hypothesis that investing in water could help Oregon overcome current and future water-related challenges. Important high-level observations from these cases include:

- Aridification may be the new normal for much of Oregon east of the Cascades, underlining the importance of aggressive conservation and flexible innovations in governance to weather unpredictable future changes.
- Too much water (flooding), not just drought, will stress public water systems and watersheds as the climate changes.
- Wildfires impact watersheds in many ways that can harm water quality and reduce the landscape's ability to store water in soils. Limiting wildfire risk is critical to limiting risks to both human and natural communities that depend on forested watersheds.
- Whole-watershed and nature-based approaches are effective *and* leverage investment by generating co-benefits.
- Modernizing infrastructure across the landscape, from diversions and canals to farm fields to dams supports a range of productive economic water uses.
- In many places in Oregon, agriculture can benefit from testing more heat and drought tolerant crops and cropping patterns, including dryland agriculture, to keep agriculture viable despite growing water scarcity.
- Even partial solutions to some of Oregon's water supply challenges are likely to be expensive.
- Groundwater is one of the most difficult resources to manage because it is hidden, and some impacts of groundwater pumping don't manifest immediately or in the places they are expected.
- Frontline communities are especially vulnerable. Due to language and other barriers, some members of these communities may not know a problem exists while those who are aware may not have the resources, time or capacity to access information and assistance.
- Indigenous Tribes face similar water risks as all Oregonians but with enhanced urgency and import because of their especially deep cultural and spiritual ties to water and fish species that rely on water.
- Many uses of water have lagged impacts or impacts that compound over time and it is critical to identify these types of potential impacts (for example groundwater pumping that can impact surface water long after a pump is turned on) and design approaches for managing them now rather than waiting for their full impact to appear years later.
- Collaboration is powerful; trust built over time between collaborators increases resiliency by reducing conflict and providing a basis for the level of commitment that will be required to tackle the coming challenges.

These observations can be further distilled into five guideposts that support the business case for investing to increase resiliency and flexibility with the urgency that Oregon's current and future water-related challenges merit:

- Invest in whole-watershed and nature-based approaches for a range of benefits including future including avoided costs of potential negative impacts from climate change.
- Fund innovative governance and policy adaptations to increase the flexibility of water management and capitalize on collaboration and creativity.
- Focus on modernizing infrastructure across the landscape in ways that help address specific risks like flooding, stormwater management, reduced summer baseflow, shrinking glaciers, fish passage, etc.
- Enhance water justice by authentically engaging frontline communities in policy and power and targeting investment so that benefits are distributed to these communities equitably with others.
- Recognize and invest to support Tribal economic, spiritual and cultural values for water and fish and engage with Tribes as sovereign co-managers of the resource.

16.2 Summarizing the Business Case for Investing in Water in Oregon

Water provides countless benefits – economic and non-economic – and defines Oregon's sense of place; it has been this way since the ancestors of Oregon's Indigenous people first called the land home. But these benefits are at risk; Oregon faces significant threats to its environment, economy and way of life from current and future water-related risks and challenges. Oregonians have demonstrated that they have many of the required strategies and tools at hand and have the expertise and motivation to develop new approaches when necessary. Wielding the tools and deploying the strategies, however, requires major investment not just once, but for the foreseeable future. The necessary investment cannot be underestimated and requires determination, commitment and engagement across all sectors, agencies, communities and levels of government and power. Importantly, it also requires inclusion of frontline communities that have been traditionally left out of decision-making and power over water including Tribes, low-income communities, rural communities, communities of color and others.

If the aim of a business case assessment is to answer the question of whether investment is wise, the answer to whether Oregon should invest in its water resources is an emphatic yes.

At its core, the business case for investing in water is that Oregon simply is not Oregon without clean, abundant water.

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18 Appendix A: Overview of Various Business Case Evaluation Approaches[34]

Developing a business case generally entails relying on a form of economic analysis that provides a comparison of the level of investment (i.e., its cost) to the positive returns anticipated from the investment (i.e., its benefits). Results may be portrayed in various forms.

For private sector financial investments in a business setting, a typical outcome is portrayed as the rate of return on the investment, stated in percentage terms. The rate of return is calculated as the net benefit (benefits minus cost or, in the case of business terms, anticipated "profits"), divided by the cost. For private businesses, investment opportunities can then be ranked according to their rates of return (e.g., generally preferring investments with the highest relative expected rates of return).

For public policy investments for public goods and services such as derived from potential Oregon investments in water and related assets, a more suitable perspective is to examine the net return. That is, examining investment opportunities to focus on ones with relatively high net benefits (benefits minus costs).

Types of economic analyses that typically are applied to such public investments are described below. The objective in each approach is to provide a systematic process through which the relative advantages and costs of an option can be evaluated and compared to a baseline (no action) scenario, as well as to other options that may be available.

Benefit-cost analysis (BCA) is intended to reflect the broad range of outcomes and impacts of a potential investment. The typical output is to consider which option provides the greatest "net social benefit" which means the option where the overall benefits exceed costs by the greatest amount (this is also where marginal costs equal marginal benefits).

Often mis-characterized as including only monetary measures, a good BCA should be comprehensive, and include all outcomes, even if some cannot be readily quantified and/or monetized. This means that some important benefits or costs may need to be described in qualitative terms, and it is then up to the analyst to help reviewers understand how the qualitative outcomes may or may not sway the outcome relative to the monetized results.

BCA is a well-known approach, and there are many references that can provide useful practical guidance and examples. There are challenges associated with estimating values for nonmarket outcomes, but there also are good resources and tools available to assist in this, as described in Appendix B.

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[34] This Appendix draws on materials prepared for American Water Works Association (2015) by Bob Raucher, the author of this Appendix.

Triple Bottom Line (TBL) assessment is an approach that can be applied in many forms, ranging from highly descriptive and subjective to more objective and quantified outcomes. As implied by the name, the impacts are organized and portrayed according to three bottom lines:

- Financial: reflecting the cash flow implications of an alternative, such as revenues gained, and expenditures or other costs incurred.
- Social: reflecting impacts of the alternative on the broader community, such as public health and welfare, water system reliability, contributions to employment or other community values, affordability and so forth.
- Environmental: reflecting impacts of the alternative to watersheds and other ecosystems, carbon footprints and other consequences for natural systems.

The TBL concept emerged from the sustainability field, as a suggested approach for corporations and other entities to expand how they conduct their annual reporting (Elkington, 1998). In lieu of reporting a single financially oriented, accounting-based bottom line in an annual report, the suggestion was made to have businesses and public sector entities report annually on how their activities also affected social and environmental matters.

Cost-effectiveness (C-E) analysis is typically a simpler, partial form of BCA, in which the costs of options are compared, when those options essentially produce the same type and level of desired outcome. The types of outcomes may be cast, for example, as number of pounds of contaminant removed, number of acre feet (AF) of water delivered and so forth. Thus, a typical C-E outcome may be a comparison of two treatment options where one costs $X per mg of TDS removed, and another option has a cost of $Y per mg removed. If $X < $Y, then that option is more cost-effective. C-E is thus a very useful approach for considering where one gets the “greatest bang per buck” when the alternatives under consideration provide a true apples-to-apples comparison (i.e., where the alternatives yield identical outcomes, and only vary in cost).

However, C-E has limitations, especially when alternative options have a variety of different outcomes, For example, one water option may cost $100 less per AF of water produced than a second alternative, but if the second alternative provides higher quality water (thus enabling saving treatment costs), or will provide a more reliable, drought-resistant yield (i.e., providing a more consistent supply yield, even in dry years when the water is most needed), then the comparison becomes more of an apples-to-oranges situation, and it may be more suitable to move from C-E to BCA or TBL.

Lifecycle analysis (LCA) is another term often used and refers to the desire to capture the full spectrum of outcomes from a cradle-to-grave perspective. It is not a distinct type of analysis per se; rather, it provides a basis for how to set the boundaries — temporal and often spatial — for a BCA or similar analysis.

For example, the initial cost of building a water treatment plant does not reflect the full lifecycle costs of that facility. At a minimum, one needs to also consider the annual O&M expenses and periodic replacement costs that accrue in operating the facility over its expected lifetime. This provides the lifecycle costs of building and operating the facility.

LCA can be expanded in many ways to account for other types of impacts, across time and space. For example, a lifecycle accounting of the carbon impacts of a project might consider the energy and greenhouse gases embedded in the production of the materials used to build the facility, the chemicals used in operating it, the transport of all inputs to the facility and so forth. The nature and fate of residuals also should be factored into a comprehensive LCA.

Multi-Criteria Decision Analysis (MCDA) is another form of analysis often used to evaluate alternative options. It is a useful tool that can be used in group settings, because it is driven by the subjective weights and scorings that are assigned by the "participants" in the process (e.g., a committee) to the various outcomes or attributes for each option under consideration. In essence, MCDA entails defining what factors or attributes to use as the basis for evaluating alternatives, and then assigning weights and scores to the factors and options.

The evaluation factors typically include things like cost, operational ease, yield, energy use and so forth. In MCDA, each factor (criteria) is assigned a subjective weight, reflecting how important the scorekeepers feel that factor is relative to the others (e.g., if "cost" is more important than "operational considerations", then the evaluating group would place higher weight on cost outcomes, perhaps a 10 on a ten-point scale, whereas other factors may get weights ranging from 1 to 9). Then, each option is given a "score" for how well it performs relative to each factor (e.g., a high-cost option may get a score of "2" on a ten-point scoring scale, and a relatively low-cost alternative may get a "9"). Then, each option has its overall MCDA score developed by multiplying each criterion's score by its weight, and then adding up scores across the criteria.

In essence, MCDA is a subjective form of BCA, where the factors important to the decision makers are considered and weighed, and a final score is given to each alternative. It can produce relatively easy-to-understand results and does not entail a lot of sophisticated analysis. The main limitation is that the weights and scores are all subjective, and the values are assigned by a limited group of selected individuals.

19 APPENDIX B: NON-MARKET VALUATION METHODS[35]

Many of the benefits and related outcomes from potential water investments are for goods and services that are not generally traded — and hence valued — in a well-functioning marketplace. For example, improving instream flows and other riparian conditions is likely, among other benefits, to enhance the quality of recreational fisheries. As a result, the state can anticipate an increase the number of recreational angling outings on the improved waterways, as well as an increase the typical level of enjoyment (value) each participant experiences from each outing.

Recreational angling is an example of a "nonmarket good." There is no market determining a price to collect from anglers per recreational fishing day to balance supply with demand and, thereby, provide an indication of value relative to marginal cost. Thus, recreational fishing benefits derived from enhanced instream conditions need to be valued using nonmarket valuation methods, such as by deploying a "travel cost model" to infer anglers' willingness to pay. Below, a discussion is provided of the various nonmarket valuation methods.

19.1 PRIMARY METHODS

Many goods and services associated with water-related impacts are not traded in markets. For example, well-defined markets do not exist for nonuse values, or for many water-based recreational activities.

There are two main approaches that economic researchers can use to estimate nonmarket values via primary research. These are known as *stated preference* methods and *revealed preference* methods. Stated preference methods are survey-based and include contingent valuation and conjoint analysis. Revealed preference methods include travel cost and hedonic modeling. Table B-1 provides additional information.

[35] This Appendix draws on materials prepared for the American Water Works Association (2015)by Bob Raucher, the author of this appendix.

Table B-1. Primary Economic Valuation Methods for Nonmarket Goods and Services, Comparative Advantages and Disadvantages	
Travel cost	
+	Uses observed tourist and recreation trip-taking behavior
-	Measures use values only, often expensive and time-intensive to collect adequate data
Hedonic pricing	
+	Uses observed housing, property, or labor market behavior to infer values for environmental quality changes
-	Measures use values only, requires extensive market data, assumes market prices capture the environmental good's value
Contingent valuation	
+	Only method that can estimate nonuse values, also can estimate use values
-	Time-intensive and expensive to implement, challenges in framing survey questions to elicit valid responses, potential response biases
Conjoint/stated choice	
+	Like contingent valuation, except respondents are surveyed about a set of choices instead of a single willingness-to-pay question
-	Time-intensive and expensive to implement, challenges in framing survey questions to elicit valid responses, potential response biases

Revealed preference methods are based on observing individuals' behavior and associated voluntary cost bearing to infer the value of a nonmarket good or service. While there may not be active markets to buy and sell days of outdoor recreation, there are often costs that individuals incur to undertake direct use activities. For these types of uses, incurred costs can be applied to develop proxy "prices" for the activity, and that information is used in developing the demand curve, and thus value for recreation-related services. This approach uses observations on people's behavior, or their associated expenditures, as indications of "revealed preferences" for the good. Methods have been developed that apply revealed preferences to develop estimates of the value of several water-related nonmarketed goods and services.

The most common revealed preference methods are the hedonic pricing method and the travel cost method. The *travel cost* method is used to value recreational uses of natural and environmental resources. The *hedonic pricing* method can be used to value a wide variety of factors that influence observed prices, such as how environmental quality or proximity to a desirable water resource (e.g., a beach or stream bank) may add to the market value of a residential property.

Stated preference methods typically are applied to goods and services where there is no direct use of the resource (i.e., non-use values). In such cases, there are no behaviors or expenditures available as a measure of preferences and values. Methods have been developed to directly elicit preferences and estimate value. These direct methods are often described as stated preference methods because they most commonly elicit value through direct statements on value rather than using observations on behavior or expenditures to infer value.

Two common stated preference methods are the *contingent valuation* method and the *conjoint/stated choice* method. The contingent valuation method can value not only direct use values, but also nonuse (e.g., existence and bequest) values for natural and environmental resources. The conjoint/stated choice method asks for a ranking of choices instead of an answer to one willingness-to-pay question and can also be applied to derive estimates of either use or nonuse values.

19.2 Secondary Methods

Primary research is often expensive to execute correctly, and often not feasible due to budgeting, scheduling and the other constraints. It is often more practical to turn to secondary methods (described below), and to use an approach that helps identify the critical values in the BCE. If a specific type of beneficial value is identified as critical to decision-making, then it may will become desirable to invest in a primary research study to more definitively determine that value.

Benefits Transfer (BT) An expeditious method for valuing nonmarket environmental resource services is known as BT. The BT approach involves taking the results of existing valuation studies and transferring them to another context, e.g., a different geographic area or policy context (Bergstrom and De Civita 1999). Under suitable circumstances (as described below), estimates for use or nonuse values may be derived, for example, using BT by applying an annual willingness-to-pay estimate per household to all the households in the geographic area in question with the same use or nonuse motives for the resource.

There are numerous challenges and cautions to consider when using BT. While it is relatively simple to develop a BT-based value monetary estimate of many types of benefits (e.g., there is a large literature on user day values for recreational experiences associated with improved surface water or wetland conditions), there are numerous ways in which the approach can generate potentially inaccurate (and misleading) results, even when a well- intentioned and objective analysis is being attempted. The most significant challenges to the accuracy and credibility of BT-generated findings are that there often are important differences between what type of natural resource conditions were studied in the primary empirical research (i.e., the study context for the published monetary estimate), and the water resource context and site to which an analyst may wish to transfer the results.

BT is commonly used in economics, and literature on correctly applying this method is well developed (e.g., Rosenberger and Loomis (2003)). Federal guidelines for economic analysis discuss how and when BT should be applied U.S. Office of Management and Budget 2003). When implemented correctly, the

BT approach is accepted as a suitable nonmarket estimation method for estimating the use and nonuse benefits of changes in the level or quality of environmental resources, especially when used cautiously and transparently, and with a recognition that the estimates are not intended to be precise. However, primary research is broadly considered a far better alternative when time and resources allow.

Societal Revealed Preference Nonuse values may be deduced (under limited circumstances) using voluntarily incurred restoration-based costs as a proxy for the value of the change in resource conditions. For example, for threatened or endangered species, the costs of voluntary or consensus-driven restoration programs and the costs imposed by various widely endorsed resource use restrictions may indicate the revealed preference value of restoring species populations to sustainable levels.

Avoided Costs (Cost Offsets) Avoided costs may be an important part of valuing the range of benefits likely to be generated by a water resource project. For example, developing local water reuse program to supplement the potable supply may help avoid or defer the fiscal and environmental expense of developing a surface water storage reservoir, and/or avoid the adverse economic impact that water supply shortfalls and related curtailments might have on regional businesses and households.

However, there are potential issues to be alert to when using avoided costs as a proxy for benefits values. Avoided costs can be used as measures of benefits when they would be incurred in the absence of the water resource project. There is a potential for double counting avoided costs in a BCE, and analysts need to be alert to this possibility when defining the baseline (and determining that costs of some options do not simultaneously appear as cost savings benefits of their alternatives).

Replacement Costs In some cases, a lower bound value for a lost resource can be estimated according to the costs necessary to replace the resource. For example, with loss of wetlands, an estimate can be derived for the cost to replace that habitat. Using cost-based measures as proxies or lower bounds for values can be tricky, however. Costs should only be used in this manner if they have been incurred voluntarily or through a consensus-based process. Otherwise, it is inappropriate to assume that costs also reflect beneficial values.

Response Cost: Averting or Mitigating Behavior The averting behavior approach examines the expenditures people make to avoid damages that result from environmental degradation. The mitigation approach examines the expenditures people make to correct a problem after the potential impact has occurred. This could include measures such as installing water purification or filtering devices in one’s home to improve tap water taste because a low aesthetic quality source water is available for use by the local utility.

20 Appendix C: The Discount Rate and Other Considerations

As noted in Section 3, a discount rate is used to calculate the present value of the stream of benefits and costs that accrue across the years of an investment project's lifetime. The discount rate selected can have a significant impact on how some potential investments are ranked and can impact whether a project is seen as providing positive or negative Net Present Value (NPV).

The discount rate can be expressed in nominal or real terms (i.e., net of inflation). A real discount rate is the nominal discount rate with the inflation rate subtracted out. Apply a real discount rate when analyzing dollars in real terms, and a nominal discount rate when analyzing values in nominal terms.

Economic theory suggests that in a world with no taxes, no financial transaction costs and zero risk, there would be a clear signal about what discount rate to use.

- If consumption today would come at the expense of investments in the future, then the opportunity cost of capital should be used to discount the stream of future benefits and costs. In that case, the discount rate should be equal to the rate of return that could be earned by investing the money in the marketplace.
- If inflation is expected to be 4% in the future, and there is a 3% risk free real return on capital, then the real discount rate would be 3%, and the nominal discount rate should be 7% (3% + 4%).
- If instead the use of funds or resources today predominantly displaces future consumption (instead of investments), then a social rate of time preference is more suitable as the discount rate.

There is not always general agreement among economists or policymakers about the correct discount rate to apply to evaluating projects. For BCEs of Oregon's potential water asset investment projects -- which are generally investments made for broad public benefit -- it may be most appropriate to use a rate of 3% (and that rate was chosen for use in this report), reflecting a real, net of tax, social rate of time preference as a real discount rate to convert all values to their present worth.

However, justifications can be made for a range of rates, from no discount rate to a discount rate reflecting the private cost of capital.

- The argument for no rate is that discounting distorts project benefits that may occur far into the future and thus affect future generations, or that include irreversible outcomes (e.g., species extinctions).
- Others suggest that the discount rate should reflect prevailing interest rates on low-risk bonds because such risk-free, net of tax rates best reflect the rate of social time preference. This might be reflected by the real cost of capital to municipal agencies in raising capital through bonds, or the cost of long-term federal government bonds.
- Another argument is that for projects that will be paid for through water or wastewater utility rates, the cost of capital to ratepayers is the appropriate measure. This cost of capital might reflect an average of credit card debt rates, home and automobile finance rates and other consumer rates—and may average around 8 to 10% in nominal terms.

- The argument for using the private cost of capital is that the project's funds might be otherwise invested in private ventures, and therefore reflects the true opportunity cost.

Various governmental entities have specified discount rates to be used in analyses. The federal Office of Management and Budget (OMB) regularly updates discount rates in Appendix C to its Circular Number A-94 on *Guidelines and Discount Rates for Cost Benefit Analyses of Federal Programs* (U.S. Office of Management and Budget 2014). OMB recommends using real interest rates on Treasury notes and bonds matched to the project period for the real discount rate. The real interest rate on a 30-year note as of February 2014 was 3.5%. Federal water resource agencies also are directed to use specific rates to evaluate water project alternatives by the Federal Code of Regulations, Plan Formulation and Procedures, and for federal fiscal year 2014, the general planning rate is also 3.5% (NRCS, USDA 2014).

The choice of discount rate can have a significant impact on the size of a project's NPV or whether a potential investment is shown to have a positive or negative NPV. Sensitivity analysis is often performed by varying a particular input by equal amounts greater to and less than the initial value applied (e.g., plus and minus 10%, 20%).

For example, if a discount rate of 6% has been chosen for the main analysis, that value might be varied in increments of 3 percentage points from 0 to 12% for the sensitivity analysis. Table 3-2 shows an example of a sensitivity analysis for the discount rate applied in this fashion to an example project. In this example, the discount rate would need to be 12% or greater to result in a significant potential for deriving a negative NPV, hence the project is likely to have a positive NPV across more appropriate, lower discount rates.

Table C-1. Sensitivity Analysis Applied to Discount Rate ($M)

Discount Rate	PV Monetized Benefit	PV Cost	Monetized Net Benefit (NPV)
0%	49-51.5	30	19-21.5
3%	39.5-41.7	26	13.5-15.7
6%	29.5-34	2	7.5-12
9%	16-21.3	16	(0.05)-5.3
12%	8.5-14	11	(3.5)-3

21 Appendix D: Overview of Federally Recognized Oregon Tribes

The borders of modern-day Oregon are home to nine federally recognized Tribal nations (Figure D-1) as well as several Tribes that are not recognized by the US government. The nine recognized Tribes are today comprised of historically distinct bands and communities with common regional homelands, and include:

- Burns Paiute of Harney County
- Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians
- Confederated Tribes of Grand Ronde
- Confederated Tribes of Siletz
- Confederated Tribes of Umatilla Reservation
- Confederated Tribes of Warm Springs
- Cow Creek Band of Umpqua Indians
- Coquille Indian Tribe
- Klamath Tribes

Figure D-1 Map of Federally Recognized Tribes and Reservations in Oregon

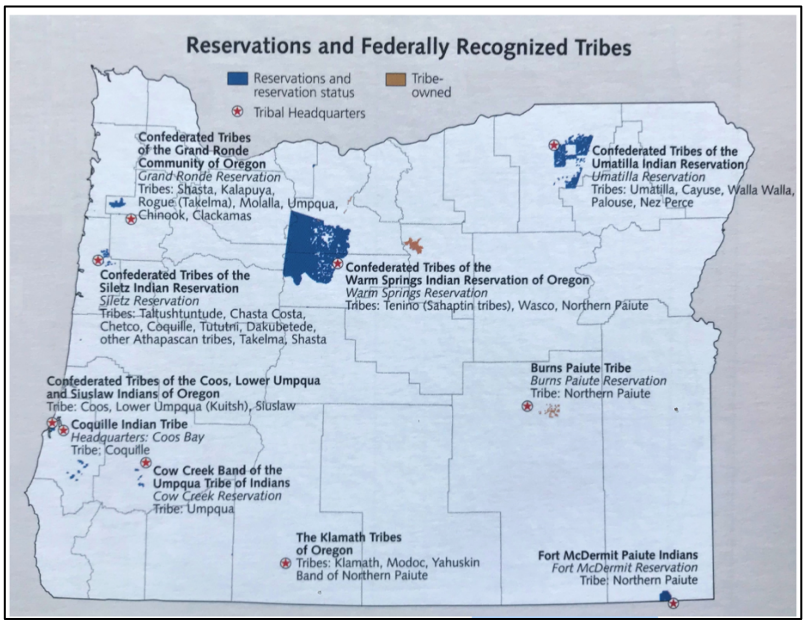
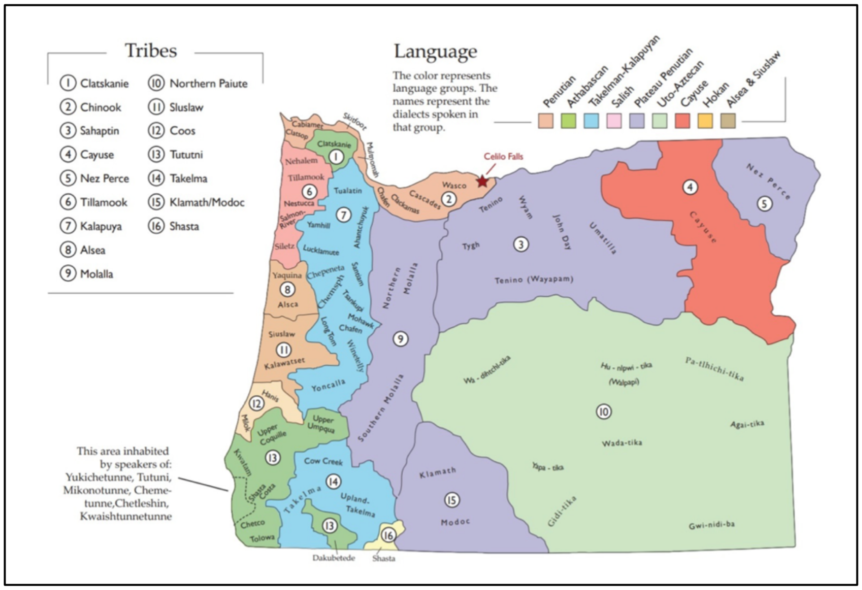


FIGURE D-2: MAP OF HISTORIC INDIGENOUS LANGUAGE GROUPS IN OREGON



Burns Paiute of Harney County

The Burns Paiute Reservation is located north of Burns, Oregon in the Southeast region of the state. Current Tribal members descended primarily from the "Wadatika" band of Paiute Indians. "Wadatika" refers to the wada seeds that were collected as a food source near the shores of Malheur Lake- a GDE. Bands were usually named after an important food source in their area.

The Wadatika's territory included approximately 5,250 square miles between the Cascade Mountain Range in central Oregon and the Payette Valley north of Boise, Idaho, and from southern parts of the Blue Mountains near the headwaters of the Powder River north of John Day, to the desert south of Steens Mountain. The Burns Paiute retain and maintain aboriginal title to much of their aboriginal territory. There are currently 402 enrolled members of the Tribe and 142 people call the Reservation their home.

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians

The Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians are made up of three Tribes (four Bands): two bands of Coos Tribes: Hanis Coos (Coos Proper), Miluk Coos; Lower Umpqua Tribe; and Siuslaw Tribe. The Tribes five-county service area is made up of Coos, Curry, Lincoln, Douglas and Lane counties, spanning the Southwest and part of the Willamette Valley study regions. While these bands and communities lived in relative proximity to each other along the Oregon coast and Coos River watershed, the various bands each had their own history, cultural distinctions and languages.

The Tribes trace their ancestry back to the Indigenous inhabitants of the South-Central coast of Oregon, encompassing roughly 1.6 million acres that included the densely forested regions of the Coast Range in the east to the rocky shoreline of the Pacific Ocean in the west. This region was distinguished by a rich diversity of habitats that included fish, shellfish, wildlife and numerous edible plants.

Water is integrally important, as told in the Coos cosmology (https://ctclusi.org/history):

> Two young men from Sky World looked down below and saw only water. Blue clay they laid down for land, and tule mats and baskets they laid down to stop the waves from running over the land. Eagle feathers they planted and they became trees. As they were thinking, it was happening. All kinds of vegetation grew; animals came. The world became beautiful. The world became as it is now.

Confederated Tribes of Grand Ronde

The Confederated Tribes of the Grande Ronde Community of Oregon is a federally recognized Tribe that is comprised of over 30 Tribes and Bands from western Oregon, northern California and southwest Washington. These communities lived in this region since time immemorial and today occupy an 11,500-acre reservation in Yamill County (in the Wilamette Valley study region). There are approximately 5,400 enrolled Tribal members. The Tribe is governed by a nine-member voter-elected Tribal Council.

The Confederated Tribes of Grand Ronde have a long and deep relationship with, and as caretakers of, Willamette Falls, as they explain on their Tribal website:

> "Willamette Falls represents many things to the Confederated Tribes of Grand Ronde. The existence of Willamette Falls on the landscape represents the physical realization of our oral history and stories. Willamette Falls represents home — the home of our ancestors from the Charcowah village of the Clowewalla (Willamette band of Tumwaters) and the Kosh-huk-shix Village of Clackamas people. They are a portion of our homelands that were ceded to the United States Government in 1855 under the Willamette Valley Treaty (signed January 22, 1855 and ratified March 3, 1855) and where our ancestors were forcibly removed from to the Grand Ronde Reservation. The historical and cultural connection between the Grand Ronde Tribe and Willamette Falls is defined by our ties to this place persisting through generations through forced removal of our tribal members and our own termination by the United States Government."

There is a shared history of Tribal connection to the area based upon the respect of a guest-host relationship. Our ancestors welcomed guests to Willamette Falls and today we honor that same relationship.

> "Keowewallahs, alias Tummewatas [Tumwater] or Willhametts. This tribe, now nearly extinct, was formerly very numerous, and live at the falls of the river, 32 miles from its mouth, on the right bank. They claim the right of fishing at the falls, and exact a tribute from other tribes who come hither in the salmon season (from May till October)." -William A. Slacum- Observations made in 1837 as an Agent of the US Military.

Confederated Tribes of Siletz

The Confederated Tribes of Siletz is a federally recognized confederation of 27 bands, originating from Northern California to Southern Washington. Ancestors of the current confederated Tribes spoke 10 different languages with multiple dialects. Each of the bands were rooted in a deep connection to more than 20 million acres of ancestral homelands, which included all of Western Oregon, from the summit of the Cascade Mountains to the Pacific Ocean, and from southwestern Washington to northern California.

In 1955, termination was imposed upon the Siletz by the US government. In November of 1977, they were the first Tribe in the state of Oregon and second in the US to be fully restored to federal recognition. In 1992, the Confederated Tribes of Siletz achieved self-governance. They occupy and manage a 3,666-acre reservation in Lincoln County, Oregon that includes water, timber and fish resources.

Confederated Tribes of Umatilla Reservation

The Confederated Tribes of the Umatilla Indian Reservation is a union of three Tribes: Cayuse, Umatilla and Walla Walla. As self-described river people, the Tribes lived around the confluence of the Yakima, Snake and Walla Walla Rivers with the Columbia River (D-3).

The CTUIR has 2,965 Tribal members, with about 30% of the membership comprised of children under the age of 18. Nearly half of those Tribal members live on or near the Umatilla Reservation which lies in the Columbia Plateau study region near the town of Pendleton. The Umatilla Reservation is also home to another 300 residents who are members of other Tribes. CTUIR is governed by a constitution and by-laws adopted in 1949. The governing body is made up of a nine-member board of trustees, elected every two years by the general council (Tribal members aged 18 and older).

The Tribe is at the forefront of fish restoration activities in the Columbia River Basin, focusing much of their attention on the Umatilla and Grande Ronde Rivers. Driven in large part by the Tribe's leadership, salmon were reintroduced to the Umatilla River in the early 1980s after 70 years of local extinction. In collaboration with the state of Oregon, the Tribe manages and operates egg-taking, spawning and other propagation facilities that assist in restoring salmon runs. The Tribe also maintains salmon co-management responsibilities in the Columbia, Snake, Walla Walla, Tucannon, Grande Ronde, John Day and Imnaha River Basins.

FIGURE D-3: UMATILLA TRIBAL LANDS

Note: reservation is highlighted in dark red and the land that was ceded to the US Government is denoted in brown. The orange/tan area highlights the watershed of the Columbia Basin. (Source: Columbia River Inter-Tribal Fish Commission)

Confederated Tribes of Warm Springs

The Confederated Tribes of Warm Springs was organized in 1937 among the Warm Springs, Wasco and Paiute Tribes. Wasco bands on the Columbia River were the eastern-most group of Chinookan-speaking peoples. They were active fisherman and were in frequent trading contact with other bands throughout the region. The Warm Springs bands lived primarily along Columbia River tributaries and spoke the Sahaptin language. They moved among summer and winter villages and utilized game, roots, berries and salmon. Both Wasco and Warm Springs bands built impressive scaffolding structures over waterfalls to allow for harvesting fish with long-handled dip nets. The Paiutes lived in southeastern Oregon and spoke a dialect of the Shoshonean language. Their lifestyle was distinct from the Wasco and Warm Springs bands, as they occupied lands in the high desert and plains. They migrated larger distances and relied more on land game than on salmon and fish for sustenance.

The Cascade Mountains sit to the west of the Warm Springs Reservation while the Deschutes River establishes the reservation's eastern border (Figure D-4). The Deschutes River provides important habitat to Chinook, fall Chinook and steelhead fish. Today Tribal members continue to fish with dip nets from wooden scaffolding in the traditional ways.

FIGURE D-4: WARM SPRINGS TRIBAL LANDS

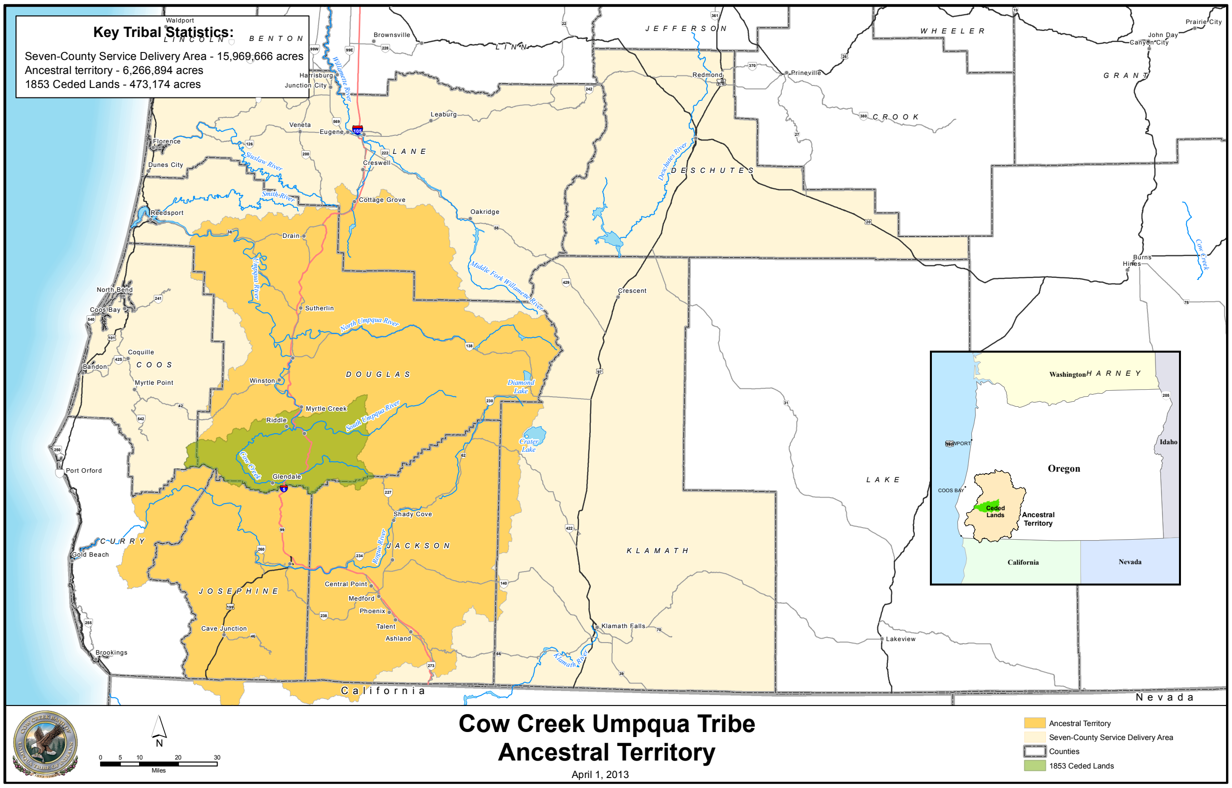
Note: The reservation is highlighted in dark blue and the land that was ceded to the US Government is denoted in lighter blue. The orange/tan area highlights watershed of the Columbia Basin. (Source: Columbia River Inter-Tribal Fish Commission)

Cow Creek Band of Umpqua Indians

The Cow Creek Band of Umpqua Tribe has traditionally lived between the Cascade and Coast Ranges in southwestern, Oregon, along the South Umpqua River and its primary tributary Cow Creek (Figure D-5). Within this rich ecological region, salmon and steelhead were an important source of food and cultural significance and supported seasonal migrations into the Willamette Valley, Crater Lake, the Klamath Marsh area and the Rogue River Watershed in the Siskiyou region. The South Umpqua Falls were important for fishing, as were salmon runs on rivers throughout the region.

Today, the Cow Creek Band is a federally recognized Tribe with a formal Tribal government based in Roseburg, Oregon.

FIGURE D-5: COW CREEK BAND OF UMPQUA INDIANS' TRIBAL LANDS



Note: Ceded Lands are highlighted in green and ancestral lands are shown in yellow. (Source: Cow Creek Band of Umpqua Indians)

Coquille Indian Tribe

Comprising a people whose ancestors lived in the lands of the Coquille River watershed and lower Coos Bay, the Coquille Indian Tribe today has over 1,000 members and a land base of 7,043 acres. After the US reinstituted federal recognition to the Tribe and restored its full sovereignty rights in 1989, the Coquille Tribal government created an administrative program that now provides housing, health care, education, elder care, law enforcement and judicial services to its members. Approximately 538 Tribal members and their families live in the Tribe's five county service area covering 15,603 square miles of Coos, Curry, Douglas, Jackson and Lane counties. An additional 350 Tribal members live in Coos County. The Coquille Tribe is part of a cooperative effort with the Oregon Department of Fish and Wildlife (ODFW) and five counties (Coos, Curry, Douglas, Jackson and Lane) to co-manage the Coquille watershed. The goal is to enhance fish and wildlife resources for the benefit of both the Tribe and all residents of Oregon. In collaboration with ODFW, the Tribe can pursue traditional subsistence fishing and hunting activities that are regulated and managed by the Tribe.

Klamath Tribes

The Klamath Tribes are comprised of the Klamath, the Modoc and the Yahooskin-Paiute People, known as the mukluks and the numu (the people). Traditionally and today, the Klamath Tribes believe everything that is needed for life was provided in the rich lands east of the Cascades. Their annual rhythms included fishing and waiting for large fish runs, including salmon, to surge up the Williamson, Sprague and Lost Rivers in the spring. In 1988 on the Sprague River, Klamath Tribal elders reintroduced the Return of the C’waam (Lost River sucker) Ceremony. Today, the Lost River Sucker is federally listed as an endangered species and the Klamath Tribes have responded by developing and operating a Research Fish Hatchery.

Tribal Websites

- Burns Paiute Tribe: https://burnspaiute-nsn.gov
- Confederated Tribes of Coos-Lower Umpqua-Siuslaw: https://ctclusi.org
- Confederated Tribes of Grand Ronde: https://www.grandronde.org
- Confederated Tribes of Siletz: https://www.ctsi.nsn.us
- Confederated Tribes of Umatilla Reservation: https://ctuir.org
- Confederated Tribes of Warm Springs: https://warmsprings-nsn.gov
- Cow Creek Band of Umpqua Indians: https://www.cowcreek-nsn.gov
- Coquille Indian Tribe: https://www.coquilletribe.org
- Oregon Tribes (https://www.oregon.gov/dhs/ABOUTDHS/TRIBES/Pages/Tribes.aspx)
- Oregon Environmental Council: https://oeconline.org/water-culture-tradition-protection/