Importance of Water in the North Santiam Basin

An Economic Description

January 30, 2019

Prepared for:

North Santiam Watershed Council

Final Report

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Acknowledgments

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ECONorthwest prepared this report to the North Santiam Watershed Council and the Oregon Business Council. We received substantial assistance from the many individuals and organizations who live in or make their living in the North Santiam Watershed, and we appreciate their willingness to share data, stories, and provide thoughtful feedback.

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That assistance notwithstanding, ECONorthwest is responsible for the content of this report. The staff at ECONorthwest prepared this report based on their general knowledge of the economics of water, and on information derived from government agencies, private statistical services, the reports of others, interviews of individuals, or other sources believed to be reliable. ECONorthwest has not independently verified the accuracy of all such information, and makes no representation regarding its accuracy or completeness. Any statements nonfactual in nature constitute the authors' current opinions, which may change as more information becomes available.

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Summary

People have enjoyed relatively clean, reliable flows from the North Santiam Watershed (NSW) for many generations. In the last 100 years, the intensity of demand for water has increased, and the NSW has met those demands. However, larger trends affecting water resources in the NSW and throughout Oregon are generating concern that the NSW may in the future not be able to meet the full range of demands without changing the way the people who depend on the watershed's resources think about its management. Climate change, population growth, and declining populations of threatened salmon are among these pressing trends.

It is against this backdrop that the North Santiam Watershed Council and the Oregon Business Council approached ECONorthwest to compile economic information about water use and value in the NSW. Assembling this information will help watershed managers, water users, and other stakeholders identify and prioritize actions intended to improve the quantity, quality, and distribution of water or water-related goods and services in the NSW. It may also help managers secure resources for and justify investments in the watershed's water-related built and natural infrastructure.

This report presents the results of research in which we compiled important findings from other studies, interviewed over a dozen stakeholders, and engaged many more in providing information. The goal of this report is not to produce a single value of the water flowing out of the NSW. The demand for and value of water varies depending on time, place, and character of use. The data we have compiled reflects some, but almost certainly not all of this variability. The information provided here is appropriate for informing planning-level decisions to identify opportunities for better management outcomes, understand potential tradeoffs, support priorities for future investments, and to serve as a starting point for more detailed study of the economic outcomes of specific projects.

The table below summarizes the economic information available to characterize the value associated with each category of demand included in the analysis. The categories reflect the major uses designated by OWRD on water rights, and the demands for water that do not require a water right but benefit from water available instream. In all cases, ***the estimates represent the general scale of value associated with each use of water***, rather than precise estimates. Wherever possible, we used assumptions that likely yield conservative estimates of value, and describe factors that may indicate the likelihood of additional, unquantified value. For this reason, we discourage readers from summing these values into a total. Instead, we provide these values to illustrate the general magnitude of value water users derive from different uses of water from the NSW.

Table S1. Summary of Demand for and Associated Economic Value of Water from the NSW

Description of Use[1]	Percent of Total Surface Water Rights	Scale of Quantified Economic Value (2018 Dollars) and Unquantified Economic Importance
Instream Flows for Aquatic Species and Habitat[2]	42%	The value Oregon households place on recovery of Upper Willamette River Chinook across their range within 50 years is estimated at **$621 million**. Recovery in the NSW is necessary but not sufficient for delisting. Research shows that households outside of Oregon also value recovery and delisting of the species, and to the extent their value is included in the estimate, it would be higher. Recovery of salmon is likely to some extent a proxy for people's value of healthy ecosystems that sustain life in many forms.
Water-Related Recreation	No Right Required[3]	Estimated annual visitation at recreation sites throughout the NSW is at least 500,000 visits per year, with an estimated value (not including spending on trip-related expenses) of **$36.5 million.**
Aesthetics	No Right Required[4]	Property value uplift from proximity to waterways varies by characteristics of the property and waterway, with higher contributions in urban areas and lower contributions in rural areas. An important aesthetic value supported by the NSW is flow augmentation of Mill Creek, which runs through Salem and would otherwise be dewatered during the summer months when workers, residents, and visitors are most likely outdoors enjoying it. Research indicates that riverfront views may add between **10 and 30 percent** to the value of property in places where there is differentiation in quality of scenic character across properties.
Electricity Generation	26%	The estimated value of hydropower generated at Detroit and Big Cliff Dams in 2017 was **$7.8 million**. This amount varies somewhat from year to year based on flows. The estimated value of the avoided CO_2 emissions associated with the power generated in 2017 was **$19.8 million**. Smaller hydropower facilities in the NSW generated electricity, the value of which is not included in these totals.
Municipal and Industrial	19%	The estimated value, in terms of the annual amount invested in water supply infrastructure and water availability by the users of water in the NSW communities and Salem is **$66 million.** This does not include the value associated with diversions from the Santiam River for Jefferson, Albany, and Millersburg, or direct diversions for industrial use. The value of the goods and services produced with this water is likely much higher, but that production is the product of many more inputs in addition to water. The value to residential households of avoiding shortages of water in the future that would impose mandatory curtailment for outdoor use ranges from **$2.0 to $3.6 million** per year that shortages are avoided.
Irrigated Agriculture	8%	At least 23,867 acres of land in Marion and Linn Counties are irrigated with water from the NSW. The estimated annual value of crops produced on these acres is **$59.8 million.** The actual value is almost certainly higher because this does not include acres of irrigated land outside of the two districts for which we had data.
Cultural and Tribal	No Right Required[5]	Cultural values for natural resources held by members of Tribal nations are distinct from instream values, recreational use, and aesthetic use. Tribal cultural well-being is the product of intensive and complex uses of resources, knowledge and relationships with the natural environment. Interaction with water resources in the NSW provides goods and services and additional cultural services including a sense of place and the sharing of cultural experiences between generations. This value is unquantifiable in monetary terms, but considered in this report of significant importance.
Public Health and Well-being	No Right Required	Ecosystem-mediated effects link water to public health and well-being through air quality improvement and access to "green" and "blue" spaces, generating improvements in mental and physical health and enhancements to individual and community identity and cohesion. While these are not distinct "uses" of water, they are effects not captured in other categories. Limitations in data and methods prevent quantification of most of these benefits at a watershed scale at this time, but the research suggests positive economic effects likely exist that are not otherwise accounted for in this report.

Notes: [1]We derived these categories from the use codes in OWRD's database of water rights (WRIS) and organized into these groupings based on similarity of demand, to simplify the analysis. [2] Includes Instream, Fish, and Wildlife use codes from OWRD's database of water rights. [3] Recreation is identified as a use in OWRD's database and has a small amount of flow associated with it, but most recreation demand does not require a water right, and derives from instream flows. [4] Aesthetics is identified as a use in OWRD's database and has a small amount of flow associated with it, but most aesthetic demand does not require a water right, and derives from instream flows. [5] While a water right is not required, tribes do have trust responsibility for natural resources and treaty rights.

Towards a Regional Water Management Plan

The information we provide here can inform decisions about future water policies and investment decisions. By having a better understanding of how water is used today and how important trends may impact the value of water from the NSW in the future, managers can look for opportunities to protect and enhance the value people derive from water. The case studies in Section 5 of this document illustrate some of these potential opportunities. Several themes emerged from these case studies that may have implications for future regional planning efforts and management decisions in the NSW:

- Many of the uses of water from the NSW are inherently complementary, meaning increasing demand for one will not increase scarcity or reduce the value of the others. For example, instream flows for fish also support recreation demands and aesthetic values. Because of the way infrastructure is currently designed, instream flows also facilitate efficient operation of Salem's diversion and treatment systems.
- Identifying how water use generates economic value helps to illuminate how economic sectors that demand water for different purposes are dependent on each other. For example, demand for irrigation water produces crops that are processed by companies that demand water for cooling and sanitation. Both sectors are dependent on water for different purposes, and dependent on each other to remain productive. Similarly, demand for municipal water in the canyon communities supports services for recreation users, who demand water for swimming, boating, and enjoy water near recreation areas.
- The distribution of costs and benefits arising from changes in management of the NSW over the years have not necessarily been equitable, meaning the beneficiaries of the actions have not borne the same share of costs as they have enjoyed in benefits. Many of the challenges the communities in the NSW face are the result of increased costs resulting from management actions taken to provide benefits to communities downstream. Future trends and actions may reinforce or even increase the disparity. Understanding who enjoys the benefits and who bears the costs of actions is critical to addressing many of the economic challenges facing the communities in the NSW, and this report helps to document this.

The "baseline" values reported here provide information about the relative magnitude of demand from different sectors and the general scale of value under current conditions. This information is useful for supporting regional planning efforts and developing high-level strategies that require some level of common understanding and shared purpose across a broad set of interrelated stakeholders. Additional analysis would be required to understand how specific policies or management actions affect specific users and the value they derive from water at a specific time and place. That is a different undertaking, which would yield more precise estimates of the net economic value (benefits minus costs) of actual changes in the timing and availability of water for specific users. Additional economic analysis may be warranted to understand implications of decisions on the jobs, incomes, and tax revenues arising from changes in supply of and demand for water. Thus, the information and conclusions provided here should be taken as a starting point toward deeper understanding of a complex system.

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1 Introduction

1.1 Background

The North Santiam watershed (NSW) is a tributary within the Willamette River Basin in western Oregon. The North Santiam River flows through the watershed east-west for approximately 100 miles, draining an area approximately 766 square miles (almost 500,000 acres). Its headwaters are located in the central Oregon Cascades, much of which is part of the Willamette National Forest on the western slopes between Mount Jefferson and Three-Fingered Jack. Its confluence with the Willamette River is at the Willamette Valley floor.

Highway 22, a primary transportation route connecting population centers in the Willamette Valley with those in central Oregon, follows the North Santiam for much of its length. Small communities are located along Highway 22 and the river. Popular recreation sites and access points connect people to the river and its tributaries. In the heart of the watershed is Detroit Dam, managed by the U.S. Army Corps of Engineers, which provides flood control and energy production, and offers recreation opportunities. As the river reaches the western half of the watershed, farmland of orchards, pastures, and annual field crops largely replace forests. Here, several smaller dams divert water into pipes and canals conveying it north, west, and south for irrigation, municipal, and aesthetic uses. Twelve miles before its confluence with the Willamette River, the North Santiam is joined by the South Santiam, forming the Santiam River. The NSW includes this portion of the Santiam River.

Within this portrait of the NSW, people have enjoyed relatively clean, reliable flows for many generations. In the last 100 years, the intensity of the demands for water has increased, and the NSW has met those demands. However, larger trends affecting water resources in the NSW and throughout Oregon are generating concern that the NSW may in the future no be able to meet the full range of demands without changing the way the people who depend on the watershed's resources think about its management.

- Salmon recovery efforts have mandated actions to improve habitat and remove barriers to migration and survival, including minimum dedicated streamflow, fish passage improvements, and investments in temperature control measures at Detroit Dam that could result in temporary drawdowns of Detroit Lake.
- Climate change has the potential to change the timing and form of precipitation the NSW receives, shifting more precipitation from snow to rain. This loss of snowpack could shift the quantity and timing of runoff, with implications for how water is stored, and the potential to increase the frequency and magnitude of water scarcity, especially during the summer months.
- Patterns of population and development have shifted, as communities in the lower reaches of the NSW and downstream on the Willamette River grow, and communities in the upper reaches of the NSW experience declines and shifts in economic opportunities

away from timber-dependent industries. Combined with climate change-induced physical changes, increasing population demands from downstream communities may increase the economic importance of the North Santiam to the whole Willamette Basin.

It is against this backdrop that the North Santiam Watershed Council and the Oregon Business Council approached ECONorthwest to compile economic information about water use and value in the NSW. Assembling this information will help watershed managers, water users, and other stakeholders identify and prioritize actions intended improve the quantity, quality, and distribution of water or water-related goods and services in the NSW. It may also help managers secure resources for and justify investments in the watershed's water-related built and natural infrastructure.

1.2 Methods

This report describes the economic importance of water originating in the NSW. Understanding the economic importance of water entails identifying the many ways water is used, both directly (e.g., for drinking or boating) and as an input into other goods and services people find valuable (e.g., food production or habitat for species that people care about). Water has economic importance to the extent that it contributes to things that people care about.[1] To describe the economic importance of water, we step through an analysis in three parts.

- In the first step, we identify the characteristics of the supply of water in the North Santiam Basin: how much water is available at what times? What is the quality of the water?
- In the second step, we identify the ways people use water from the NSW, or allocate water to specific uses (e.g., for instream flows). In economic terms, these uses represent demand for water. The amount of water demanded is specific to water with a specific characteristic (e.g., quality) at a particular time, place, and price. To the extent possible, we identify information relevant to understanding these dimensions of demand.
- In the third step, we provide information to help understand the value of water associated with each demand. For some uses of water, the economic value can be quantified in monetary terms. For other uses, the value may not be quantifiable in monetary terms, but can be described qualitatively. Where local information about value is not available, we use an economic technique called benefit transfer to apply relevant values from studies of similar uses elsewhere.

The goal of this report is not to produce a single value of the water flowing out of the NSW. To do so in an academically rigorous and defensible way would require a much more comprehensive and analytical exercise involving original data collection that is beyond the

[1] Some people may argue that water has intrinsic value, independent of how people use or value it. This project takes an anthropocentric view that water is important because people use it or otherwise care about things dependent on it. For example, water for habitat has importance because people care about the habitat and the things it produces (e.g., fish, a place to relax, an opportunity for experiencing connection to nature). This framework employs a broad definition of "use" or "things dependent on it," including intangible "things," such as experiences.

scope of this project. Instead, we compile available information about the quantity of use and the general magnitude of value based on observed prices or values quantified in other studies. The information provided here is appropriate for planning-level decisions to help weigh certain tradeoffs, identify opportunities and priorities for future investments, and to serve as the basis for more detailed study of specific projects. To illustrate how information may be used in the context of specific challenges the NSW is currently facing, the last section of this report provides brief examples of how the information may be relevant to specific topics.

> *A Note about Jobs: From an economist's perspective, while labor is an important input in the production of goods and services, jobs are not a measure or indicator of the economic value of goods and services. Thus, when we talk about "benefits" or "value" of water, we do not include jobs in that discussion. While employment outcomes can be one dimension of the economic importance of water to a community—and we discuss the topic in several places within this report—it is not the focus of this report.*

This report is the culmination of Phase 2 of a two-phased project. In the first phase, ECONorthwest staff reviewed relevant data and reports on the NSW, and discussed with staff and stakeholders of the North Santiam Watershed Council their priorities and needs to support future planning and management efforts. Out of that process, we collectively concluded that a baseline economic description of water uses was missing among the information currently available, and ECONorthwest developed the Phase 2 scope of work to develop this information.

To complete this report, ECONorthwest, Oregon Business Council, and the North Santiam Watershed Council convened a stakeholder meeting to present the project plan and identify potential sources of information missing from the Phase 1 review.[2] During that meeting, numerous individuals offered, on behalf of their organizations, to provide specific data. ECONorthwest followed up with these individuals, and conducted additional interviews to compile a more complete picture of water use in the NSW. The results of those interviews are folded into the sections that follow. A list of individuals contacted in the scope of the research is included in Appendix A.

[2] Phase 1 deliverables are available upon request from the North Santiam Watershed Council.

1.3 Organization of this Report

This report begins in **Section 2** with a description of the NSW: its physical characteristics, including water supply and water quality, socioeconomic setting (land use, political jurisdictions, demographics), and the regulatory/policy landscape as it applies to water resources. This information provides context for the rest of the report.

Section 3 describes the demand for water and estimated economic value associated with each use. This section also describes current and expected future trends that may affect the demand and value of water in the NSW.

Section 4 provides illustrative case studies of three water-related issues that NSW stakeholders and water users have expressed concern about during our initial reconnaissance efforts in Phase 1 and interviews in Phase 2.

The **Summary** at the beginning of this document summarizes the major findings of the report and offers suggestions about how the information might be used in the future as part of the ongoing planning and management efforts underway in the NSW.

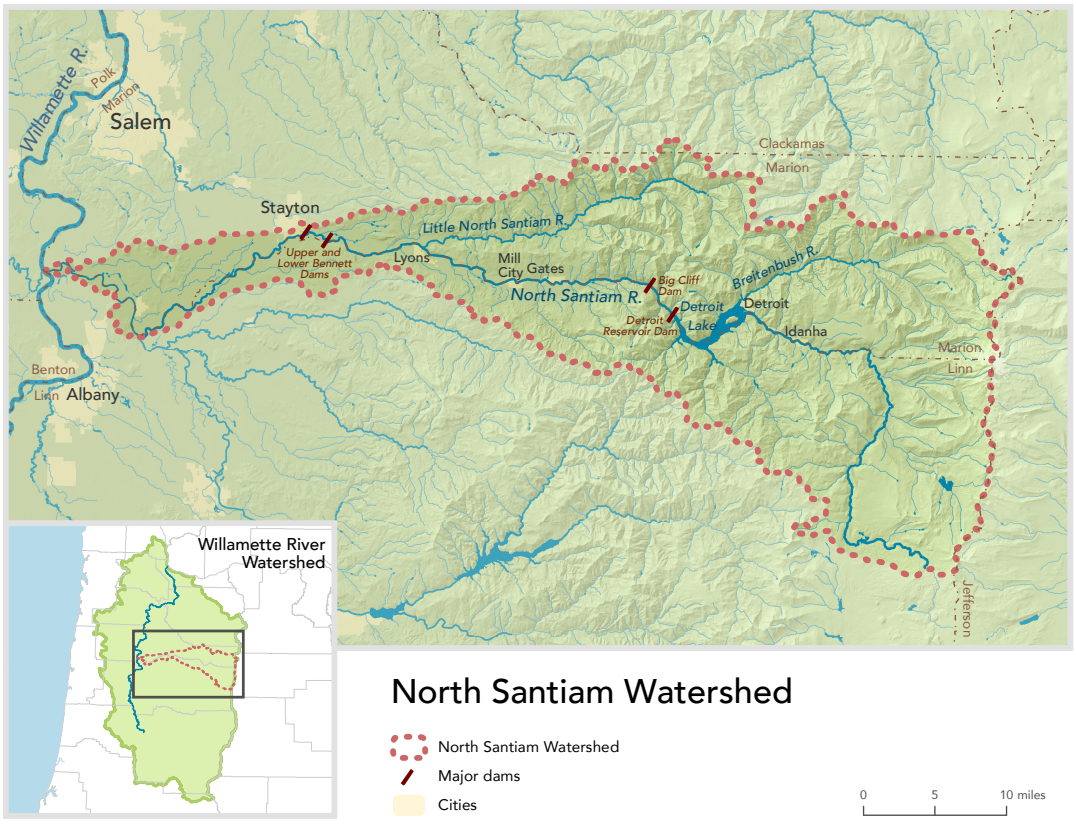
2 Description of the North Santiam Watershed

In this section, we describe the characteristics of the NSW that are relevant to understanding its economic importance. This includes physical characteristics that both support and limit the economic productivity of the watershed, and the socioeconomic systems that interact with and depend on the resources produced within the watershed.

2.1 Physical Description

The NSW occupies about 490,000 acres within the larger Willamette Watershed, located in the heart of northwestern Oregon. It represents about 6.6 percent of the total area of the Willamette Watershed. The NSW headwaters flow from the flanks of Mount Jefferson and Three Fingered Jack, in the Willamette National Forest and the Jefferson Wilderness Area. The North Santiam River traverses about 100 miles as it flows to the west, joining the Santiam River about 12 miles before the Santiam's confluence with the Willamette River between Salem and Albany. Figure 1 shows the boundaries of the NSW, and the major hydrologic and political features.

Figure 1. Map of the North Santiam Watershed



Source: ECONorthwest

2.1.1 Precipitation

Reaching from the Willamette Valley (nearly sea level) to the peaks of the Cascade Mountains (3,200 meters above sea level), the NSW receives precipitation in the form of both rain and snow.[3] Average annual precipitation ranges from 40 inches at the Valley floor, to 90 inches at Detroit Dam.[4] Average annual snowpack in the mountains is 91 inches; much of the precipitation that falls in the upper watershed is stored as snowpack and released as meltwater, contributing runoff to streams and infiltrating to groundwater with the spring thaw. The U.S. Geological Survey (USGS) estimates that up to one-half of the precipitation in the high Cascade Mountains seeps into the groundwater system.[5]

2.1.2 Water Storage

At least four significant dams serve multiple purposes within the NSW (Figure 1). These dams change the natural flow regimes of the North Santiam River by storing water and discharging it later in the year, and by diverting water for consumption and use within and outside of the NSW.

In the middle of the NSW sit two U.S. Army Corps of Engineers (USACE) dams: Detroit Dam and Big Cliff Dam. Constructed in 1953 as part of the larger Willamette Valley Project (Willamette Project),[6] the U.S. Congress authorized these dams and several fish hatchery projects within the NSW with a primary purpose to store spring runoff and mitigate downstream flooding.[7] Both dams also generate hydropower. Detroit Dam has a hydropower generation capacity of 100 megawatts; Big Cliff Dam has a capacity of 18 megawatts. Big Cliff dam is a re-regulation dam and is directly downstream of Detroit Dam to adjust water levels.[8] Behind Detroit Dam sits Detroit Lake, which has a storage capacity of 455,000 acre-feet when full and 281,600 acre-feet when drawn down in the summer, with a useable storage capacity of 321,000 acre-feet.[9] In addition to providing flood control and hydropower, the Bureau of Reclamation manages some of the water for irrigation and the lake itself provides opportunities for flat-water recreation. The recreation infrastructure associated with Detroit Lake is discussed in more detail below. Finally, the USACE built Minto Dam (not shown in Figure 1), a 10-foot

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[3] U.S. Geological Survey. 2017. *North Santiam River Basin, Oregon.* Retrieved September 24, 2018, from https://or.water.usgs.gov/proj/or00311/detroit_lake/nsantiam_basin.html

[4] U.S. Geological Survey. 2007. *Description of the North Santiam River Basin.* Retrieved September 24, 2018, from https://pubs.usgs.gov/sir/2007/5178/section3.html

[5] Ibid.

[6] Congress authorized Detroit Dam as part of the Willamette Valley Project in the Flood Control Act of 1938.

[7] U.S. Army Corps of Engineers. 2018. Detroit Dam and Lake. Retrieved May 3, 2018 from: http://www.nwp.usace.army.mil/Locations/Willamette-Valley/Detroit/.

[8] U.S. Army Corps of Engineers. 2018. Big Cliff Dam and Reservoir. Retrieved May 3, 2018 from: http://www.nwp.usace.army.mil/Locations/Willamette-Valley/Big-Cliff/.

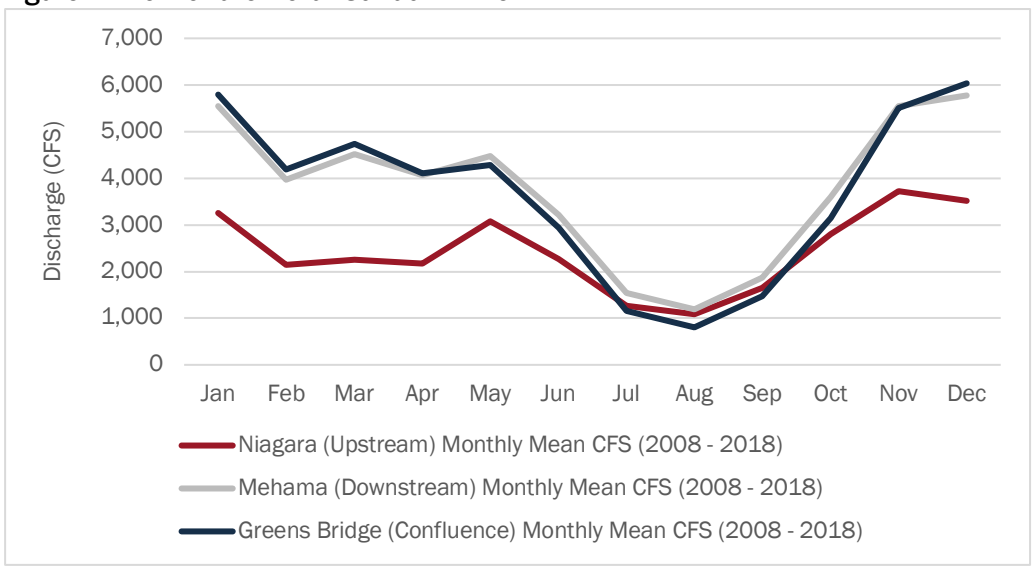
[9] Risley, J.C. et al. 2012. *An Environmental Streamflow Assessment for the Santiam River Basin, Oregon.* U.S. Geological Survey and U.S. Army Corps of Engineers. Open-File Report 2012-1133. Retrieved October 3, 2018, from https://pubs.usgs.gov/of/2012/1133/pdf/ofr20121133.pdf

fish diversion structure, to support the fish hatchery operations that mitigate the effect on fisheries from the Willamette Project.[10] In addition to the USACE dams, there are two dams used for water diversion that are owned by the City of Salem and Santiam Water Control District at river miles 29 and 31.5: Lower Bennett Dam (5.3-feet high) and Upper Bennett Dam (5.7-feet high).[11] These dams also divert water used by the Santiam Water Control District.

2.1.3 Water Supply

The water that accumulates in the North Santiam River and its tributaries is a combination of runoff from precipitation and snowmelt, and seepage from groundwater springs. This, coupled with flow-regulation provided by the dams, ultimately results in an average rate of streamflow in the North Santiam River of between 1,086 and 6,036 cubic feet per second (CFS), depending on the season and location. Figure 2 shows the discharge at three stream gages on the North Santiam River.

Figure 2. Flow of the North Santiam River



Source: ECONorthwest, with data from U.S. Geological Survey. 2018. *National Water Information System: Mapper.* Retrieved September 24, 2018, from https://maps.waterdata.usgs.gov/mapper/?state=or

The Niagara gage is located just downstream of Big Cliff Dam. The Mehama gage is located mid-way along the river course toward its confluence with Willamette River, after joining with the Little North Santiam, which is the largest tributary to the North Santiam. The Greens Bridge gage is located just upstream of the confluence with the South Santiam River.[12] Streamflow declines and reaches its lowest levels during the dry season between July and September.

[10] Ibid.

[11] U.S. Army Corps of Engineers. 2018. North Santiam Subbasin Fish Operations Plan.

[12] U.S. Geological Survey. 2018. *National Water Information System: Mapper.* Retrieved September 24, 2018, from https://maps.waterdata.usgs.gov/mapper/?state=or

These streamflow measurements are all below Detroit and Big Cliff Dams. Since they began operating in 1953, these dams have regulated the flow regimes in the North Santiam River, providing baseflow during the summer months that is higher than pre-dam flows, and reducing the flow levels during the winter and spring.

2.1.4 Groundwater

Groundwater resources are most plentiful in the lower reaches of the NSW, in alluvial aquifers. Aquifers in the upper reaches of the NSW are volcanic in nature and are highly variable in supply and productivity.[13] The Oregon Water Resources Department has classified areas near the North Santiam Basin as groundwater restricted areas. These classified designations include South Salem Hills, Kingston, and Stayton-Sublimity. There are limitations to new groundwater uses in these areas to protect against groundwater level declines.[14] Marion County also has a Sensitive Groundwater Program which it uses when reviewing land use applications within the monitored areas.[15]

2.1.5 Water Quality

As required by the Clean Water Act, the Oregon Department of Environmental Quality (DEQ) assesses water bodies statewide for water quality issues through its Integrated Water Quality Assessment process.[16] This process identifies water bodies in which regulated pollutants may adversely affect water quality. Impaired water bodies are listed on the 303(d) list, and DEQ must develop a Total Maximum Daily Load limit for the relevant pollutant to improve water quality. In the NSW, there are 24 listings requiring TMDLs, shown in Table 1.

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[13] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

[14] Oregon Water Resources Department. 2018. *Groundwater Restricted Areas.* February 23. Retrieved September 27, 2018, from http://apps.wrd.state.or.us/apps/gis/gis_map_library/gis_view_image.aspx?gis_library_image_id=1136

[15] Marion County. 2015. *Sensitive Groundwater Program.* Retrieved September 27, 2018, from https://www.co.marion.or.us/PW/Planning/zoning/Pages/Sensitive-Groundwater-Program.aspx

[16] Oregon DEQ completed the most recent water quality assessment in 2012. Data collection efforts are underway for the 2018 Integrated Assessment, but result are not yet available. See Oregon Department of Environmental Quality. 2018. *Water Quality Assessment.* Retrieved September 24, 2018, from https://www.oregon.gov/deq/wq/Pages/2018-Integrated-Report.aspx

Table 1. Waterbodies in the NSW Listed by DEQ for Pollutants in 2012

Pollutant	Criteria	Water Body	Status
Temperature	Core cold water habitat: 16.0 degrees Celsius 7-day-average maximum Salmon and trout rearing and migration: 18.0 degrees Celsius 7-day-average maximum Salmon and steelhead spawning: 13.0 degrees Celsius 7-day-average maximum	Bear Branch	TMDL Approved
		Big Creek	TMDL Approved
		Chehulpum Creek	TMDL Approved
		Elkhorn Creek	TMDL Approved
		Little North Santiam River	TMDL Approved
		Marion Creek	TMDL Approved
		North Santiam River	TMDL Approved
		Santiam River	TMDL Approved
		Sinker Creek	TMDL Approved
		Stout Creek	TMDL Approved
Biological Criteria	Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.	Blowout Creek	TMDL Needed
		Breitenbush River	TMDL Needed
		South Fork Breitenbush River	TMDL Needed
Aquatic Weeds Or Algae	The development of fungi or other growths having a deleterious effect on stream bottoms, fish or other aquatic life, or which are injurious to health, recreation or industry may not be allowed.	Marion Creek/Marion Lake	TMDL Needed
		North Santiam River/ Detroit Reservoir	TMDL Needed
Dissolved Oxygen	Spawning: Not less than 11.0 mg/L or 95% of saturation	North Santiam River	TMDL Needed
		Santiam River	TMDL Needed
Mercury	Human Health Criteria for Toxic Pollutants	Santiam River	TMDL Needed
Sedimentation	The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed.	South Fork Breitenbush River	TMDL Needed

Source: ECONorthwest, with data from Oregon Department of Environmental Quality. 2012. *2012 Integrated Report*. Retrieved September 24, 2018, from https://www.deq.state.or.us/wq/assessment/rpt2012/results.asp

Although DEQ has identified six pollutants that impair waters to an extent that a TMDL is required, it has only developed allocations for a TMDL for temperature.[17] The temperature criteria set depends on the water bodies, but ranges from 13.0°C (55.4°F), which is based on salmon and steelhead spawning needs, 16.0°C (60.8°F), which is based on core cold water habitat needs, or 18.0°C (64.4°F), which is based on salmon and trout rearing and migration needs. The Willamette Basin Biological Opinion, which assessed the effect of the Willamette Project's effects on survival of several anadromous species, set monthly temperature targets for the North Santiam River below Big Cliff Dam, ranging from 38°F to 42°F in January and February to 52°F to 55°F in July and August.[18] These targets are driving the temperature control tower retrofit plans at Detroit Dam, discussed in more detail elsewhere in this report.

[17] Oregon Department of Environmental Quality. 2006. "North Santiam Subbasin TMDL." *Willamette Basin TMDL*. Retrieved September 24, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[18] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion.* Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion/

DEQ has listed Detroit Lake for algae, but has not yet developed a TMDL. Like many other water bodies in Oregon, blue-green algae is a persistent issue at Detroit Lake. When levels of cyanotoxins resulting from the algae blooms reach a high level, generally in the summer months as water temperatures increase, the Oregon Health Authority will issue advisories to avoid drinking or contacting the water, especially for children and pets.[19] Before 2018, only recreational advisories had ever been listed. In the summer of 2018 both a recreational and drinking water advisory were issued. It is unclear what is causing the algae blooms in Detroit Lake, but increased phosphorous and temperatures are known to lead to algae blooms.[20] Much of the phosphorous in the lake is naturally occurring, but some is anthropogenically introduced from runoff due to timber harvest activities and road construction.[21]

Despite a TMDL for bacteria being in place for the Willamette River, there is not currently an allocated TMDL for bacteria on the North Santiam. Through the Willamette TMDL, DEQ established targeted reductions for fecal bacteria from agricultural areas, ranging from 66 to 83 percent, and urban areas, ranging from 80 to 94 percent relative to current concentrations. According to the DEQ, the North Santiam River is "relatively uncontaminated" with fecal bacteria and serves as a dilution mechanism for the relatively more contaminated Willamette River.[22]

2.1.6 Terrestrial and Aquatic Habitat and Species

The North Santiam Watershed Council's *Watershed Restoration Action Plan* identifies the types of habitat within the NSW that provide conservation opportunities for terrestrial and aquatic species consistent with the Oregon Department of Fish and Wildlife's Conservation Strategy. These range from the aquatic and riparian habitat provided by the North Santiam River and its tributaries, to the oak savannah and woodlands in the uplands of the lower and middle reaches of the watershed, to the late successional Douglas-fir forests in the upper portions of the watershed. These habitats support a range of species, including fish and amphibians, birds, and plants.

[19] Wang, A. 2018. "Detroit Lake Residents, Visitors Warned of Toxic Algae Bloom." *The Oregonian.* May 18. Retrieved September 24, 2018, from https://www.oregonlive.com/pacific-northwest-news/index.ssf/2015/05/detroit_lake_algae_bloom.html

[20] Personal communication with Kurt Carpenter, Hydrologist, U.S. Geological Survey, on June 1st, 2018.

[21] Ibid.

[22] Oregon Department of Environmental Quality. 2016. "Chapter 2: Willamette Basin Bacteria TMDL". *Willamette Basin TMDL.* September.

Table 2. Key Habitats and Species within the NSW

Location within the NSW	Key Habitat	Key Species
Lower NSW and NS River	Aquatic Floodplain and forests Riparian Wetlands and Wet Prairie	Riparian Birds Oregon Chub (fish) Winter Steelhead (fish)
Lower NSW	Grassland and Oak Savanna Oak Woodlands	Western Meadowlark (bird) Bradshaw's Lomatium (plant) Oregon Larkspur (plant) White-topped Aster (plant) Willamette Valley Daisy (plant)
Upper NSW	Aquatic Late Successional Douglas-Fir Forest Montane Grasslands Wetlands and Wet Meadows	Cascade Torrent Salamander (amphibian) Cascades Frog (amphibian) Coastal Tailed Frog (amphibian) Oregon Slender Salamander (amphibian) Oregon Spotted Frog (amphibian) Black Swift (bird) Bufflehead (bird) Northern Goshawk (bird) Sandhill Crane(bird) American Marten (bird) Fisher (bird) Great Gray Owl (bird) Northern Goshawk (bird)

Source: North Santiam Watershed Council. 2011. *Watershed Restoration Action Plan.* Retrieved September 27, 2018, from http://northsantiam.org/wp-content/uploads/policy-general/2011-02-North-Santiam-Watershed-Council-Watershed-Restoration-Action-Plan-Review-Draft.pdf

The NSW is home to sensitive, threatened, and endangered species that depend on high-quality riparian and aquatic habitat for survival. Within the NSW there are two federal endangered species, which were listed in the 1990s: Upper Willamette River (UWR) winter steelhead and UWR spring Chinook salmon.[23] The listing of these species triggered recovery planning efforts that drive water management and use throughout the NSW (see discussion of the Biological Opinion later in this Section). Oregon chub is also present in the basin, and was the first fish ever to be delisted in 2015 due to significant population increases.[24]

2.1.7 Future Trends in Water Supply and Quality with Climate Change

Climate scientists expect that future trends in climate (including temperature and precipitation) likely will affect the water supply availability, streamflows, and ecosystems in the NSW. Projected future climate scenarios that were developed as part of the Willamette Water 2100 project[25] suggest that by 2100 the average surface temperature in the Willamette River Basin

[23] U.S. Army Corps of Engineers. 2018. *North Santiam Subbasin Fish Operations Plan.*

[24] https://www.fws.gov/oregonfwo/articles.cfm?id=149489414

[25] Willamette Water 2100 was a multi-year, interdisciplinary study on future water in the Willamette River Basin. More information can be found at https://inr.oregonstate.edu/ww2100.

could be between 1°C (2° F) to 7°C (13° F) warmer than current temperatures.[26] With warmer ambient air temperatures, annual snowpack levels are expected to decline, with snowfall converting to rain more often at lower elevations. Researchers predict that the North Santiam River subbasin, along with the McKenzie River subbasin, likely will experience the largest total loss of snowpack relative to the rest of the Willamette River basin.[27] Warmer temperatures and less snowpack are also expected to impact stream temperatures in the North Santiam River, and Detroit Lake is expected to see temperature rises between 1.1°C (2° F) and 1.5°C (3° F).[28]

Expected changes in temperature, precipitation, and snowpack have the potential to affect water supply and water quality indirectly as well, by changing the ecosystem in ways that increase the risk of wildfire and toxic algae blooms, and potentially other as-yet unforeseen effects. Increased wildfire incidence and intensity has the potential to change runoff patterns and infiltration capacity, and increase sediment loading and nutrient deposition to waterbodies.[29] Increased water temperature, changes in precipitation patterns, and increased nutrient deposition may increase the frequency and magnitude, and change the timing of toxic algae blooms compared to historical conditions.[30]

2.2 Political Boundaries, Ownership, and Land Use

As the NSW stretches from the Willamette Valley floor to the crest of the Cascade Mountains, patterns of land ownership and land use vary from west to east. This variation reflects the underlying physical features of the landscape, and drives variation in demand for water, discussed in more detail in Section 4.

2.2.1 Political Boundaries

Native Americans populated the area prior to settlement by Europeans and others. Indigenous people lived on and frequented the area to fish, harvest food, collect materials, and engage in activities throughout the year. Based on research collected by the NSWC, the Kalapuya people inhabited and land and utilized the resources in the NSW. Other indigenous people in the Willamette Valley, including the Mollala, frequented the area and interacted with the Kalapuya.[31] Both the Confederated Tribes of the Grande Ronde and Confederated Tribes of the

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[26] Oregon State University, Institute for Natural Resources. No Date. *Future Climate.* Retrieved September 24, 2018, from https://inr.oregonstate.edu/ww2100/analysis-topic/future-climate

[27] Oregon State University. *Snow.* Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1291.

[28] Buccola, N. L., Risley, J. C., & Rounds, S. A. (2016). Simulating future water temperatures in the North Santiam River, Oregon. *Journal of Hydrology*, 535, 318-330.

[29] Turner, D. P., Conklin, D. R., & Bolte, J. P. (2015). *Projected climate change impacts on forest land cover and land use over the Willamette River Basin, Oregon, USA*. Climatic change, 133(2), 335-348.

[30] O'Neil, J. M., Davis, T. W., Burford, M. A., & Gobler, C. J. (2012). "The rise of harmful cyanobacteria blooms: the potential roles of eutrophication and climate change." *Harmful Algae*, 14, 313-334.

[31] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

Siletz continue to rely on the water in the NSW and are actively involved in management and restoration of the lands in the NSW.

The NSW intersects primarily with Marion and Linn Counties, and to a very small extent with Clackamas County. Table 3 shows that over half of the NSW is in Marion County and just under half is in Linn County, while less than one percent is in Clackamas County. It also shows that of the total county area, about one-third of Marion County is located within the NSW, while only about 15 percent of Linn County is in the NSW.

Table 3. Counties in the North Santiam Watershed

County	Total County Acres	Acres of County in Watershed	Percent of County in NSW	Percent of NSW in County
Clackamas	1,204,596	1,071	0.1%	0.2%
Marion	762,037	254,213	33.4%	52.0%
Linn	1,475,545	233,575	15.8%	47.8%

Source: ECONorthwest GIS Analysis

There are eight cities and census-designated places within the NSW.[32] In addition to the communities within the NSW, four cities outside the watershed rely on water from the NSW. Figure 1 shows both the communities within the NSW and the communities outside its boundaries that depend on its water. Table 4 shows the water source and the most recent population estimates.

Table 4. Communities Within and Outside the NSW that Use Water from the NSW

Community	County	Water Source	2017 Population Estimate[1]
		Communities within the NSW (Listed West to East)	
Jefferson	Marion	Santiam River (Below confluence of N. and S. Santiam)	3,235
Stayton	Marion	North Santiam Intake (below Salem's intake)	7,770
Mehama[2]	Marion	North Santiam River	
Lyons	Linn	North Santiam River	1,180
Mill City	Marion	Well	1,860
Gates	Marion	North Santiam River	485
Detroit	Marion	Mackey Creek, Breitenbush River	210
Idanha	Marion	Spring, Rainbow Creek, Mud Puppy Creek	140
		Communities that Use Water from the NSW	
Salem[3]	Marion	North Santiam River	163,480
Turner	Marion	North Santiam River (Purchases water from Salem)	2,005
Albany	Linn	Santiam River (Santiam-Albany Canal)	52,710
Millersburg	Linn	Santiam River (Santiam-Albany Canal)	1,835

Source: ECONorthwest, with data from Oregon Drinking Water Data Online, Personal Communications, and Portland State University
Notes: [1]2017 Population estimates come from the Portland State University Population Research Center, Certified Population Estimates, July 1, 2017; [2] Mehama population estimate is included with Lyons. [3] The Salem water service area is larger than the city limits of Salem, including also the areas east of Salem. Salem's city website estimates that they serve over 178,000 customers (https://www.cityofsalem.net/Pages/public-works-department.aspx)

[32] In addition to the cities and census-designated places, there are several unincorporated communities within the NSW, including Talbot, Marion, West Stayton, Fox Valley, Niagara, and Marion Forks.

2.2.2 Land Ownership

Across the entire NSW, the federal government is the largest landowner, at about 65 percent of the land area. The U.S. Forest Service (USFS) manages most of the federal land, or almost 60 percent of all land in the NSW. Private land owners hold the next largest share, at 28 percent. Other federal agencies (the Bureau of Land Management [BLM], Bonneville Power Administration [BPA], and the U.S. Army Corps of Engineers [USACE]), the state, county and other local governments, and the tribes own or manage the rest. Table 5 shows the distribution of ownership by acres and percent of the NSW land area.

Table 5. Land Ownership in the North Santiam Watershed

County	Acres	Percent of Land Area
Total Federal Government	**320,677**	**65.6 Percent**
U.S. Forest Service	292,627	59.8 Percent
U.S. Bureau of Land Management	20,499	4.2 Percent
Other (BPA, U.S. Army Corps of Engineers)	7,551	1.5 Percent
Total Private	**136,833**	**28 Percent**
Total State of Oregon	**29,874**	**6.1 Percent**
Department of Forestry	29,216	6 Percent
Other (State Parks, ODFW)	658	0.1 Percent
Total County and Local	**880**	**0.2 Percent**
Total Tribal	**716**	**0.1 Percent**

Source: ECONorthwest, with data from Oregon Bureau of Land Management USDI edited by the Oregon Department of Forestry, 2015

The distribution of land ownership varies considerably from the lower reaches of the NSW to the upper reaches. In the lower reaches, private ownership dominates, making up almost 90 percent of the land area. The middle portion of the NSW is more diverse, with private land still comprising over half of the acreage, but state land (both Oregon Department of Forestry [ODF] and State Parks [OSP]) and federal land managed by the BLM making up almost a quarter of the ownership. In the upper reaches of the NSW, the U.S. Forest Service manages the majority of the area, primarily within the Willamette National Forest, but also in the Mt. Hood National Forest in the northern portion of the NSW. About 8 percent of the upper reaches are in private ownership occurring in close proximity to Highway 22 and along the North Santiam River.[33]

2.2.3 Land Use

Land ownership and land use are closely correlated, and land use throughout the basin is patterned after geography. In the upper, higher elevations of the NSW, forest land cover dominates, and land use is consistent with the Forest Service's multiple use objectives. There are over 50,000 acres of wilderness in the upper reaches of the watershed, where uses and management activities are more restricted.[34] Public forested land is dedicated to timber harvest,

[33] Oregon Department of Environmental Quality. 2006. *Willamette Basin TMDL: North Santiam Subbasin.* September. Retrieved September 26, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[34] U.S. Forest Service, Willamette National Forest, Detroit Ranger District. 2007. *Upper North Santiam Watershed Revision.* September, Retrieved September 27, 2018, from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5435084.pdf

recreation, and wildlife habitat. Private land interspersed with public forested land is used for rural residential and commercial/industrial development. In the middle reaches of the NSW, USFS and BLM-managed forest land becomes more interspersed with private land. Private land in this stretch of the watershed is dedicated to rural residential, urban development, and some agriculture. As the elevation declines, private land in agricultural use dominates the landscape.[35,36]

2.3 Population Characteristics

Data are unavailable to estimate the population of the NSW directly. Table 6 shows that almost 15,000 people live in the incorporated cities within the NSW. The population of the NSW is undoubtedly higher because these estimates don't capture populations living in unincorporated areas of Marion or Linn Counties within the watershed. The population of communities that depend on water from the NSW is an order of magnitude higher, at about 220,000, as shown in Table 6. Adding these numbers together, about 6 percent of Oregon's population obtains drinking water from the NSW.

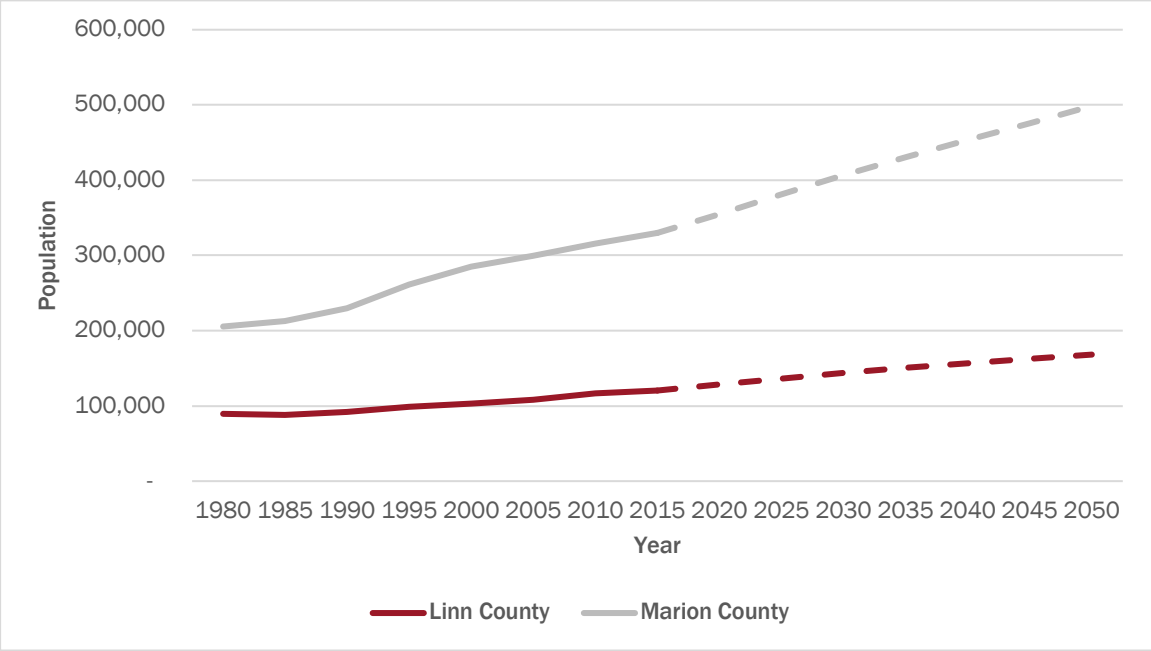
This population that depends on water from the NSW is likely to grow. The population in Marion County has grown by 64 percent since 1980, while the population of Linn County has grown by 37 percent during the same period. The population of both counties is predicted to continue to increase, as Figure 3 shows.[37]

[35] Oregon Department of Environmental Quality. 2006. *Willamette Basin TMDL: North Santiam Subbasin.* September. Retrieved September 26, 2018, from https://www.oregon.gov/deq/FilterDocs/chpt8nsantiam.pdf

[36] U.S. Geological Survey. 2016. "Description of the North Santiam River Basin." *Scientific Investigations Report No. 2007-5178.* Retrieved September 26, 2018, from https://pubs.usgs.gov/sir/2007/5178/section3.html

[37] Oregon Department of Administrative Services. (2013). "Oregon's long-term county population forecast, 2010-2050". Retrieved from https://www.oregon.gov/das/OEA/Pages/forecastdemographic.aspx

Figure 3. Population Growth and Projections in Marion and Linn Counties, 1980-2050



Source: ECONorthwest, with data from the U.S. Census Bureau, American Community Survey 2012-2016, and the Oregon Office of Economic Analysis, 2013.

This growth is driven by increases in urban and suburban areas—areas that are primarily outside of but obtain water from the NSW. The data in Table 6 show that population has increased since 1990 in all communities inside and outside the NSW, except for in Gates, Detroit, and Idanha. It has increased fastest for those communities closest to the larger population centers of Salem and Albany.

Table 6. Population of Communities within the NSW and Outside that Use Water from the NSW, 1990-2017

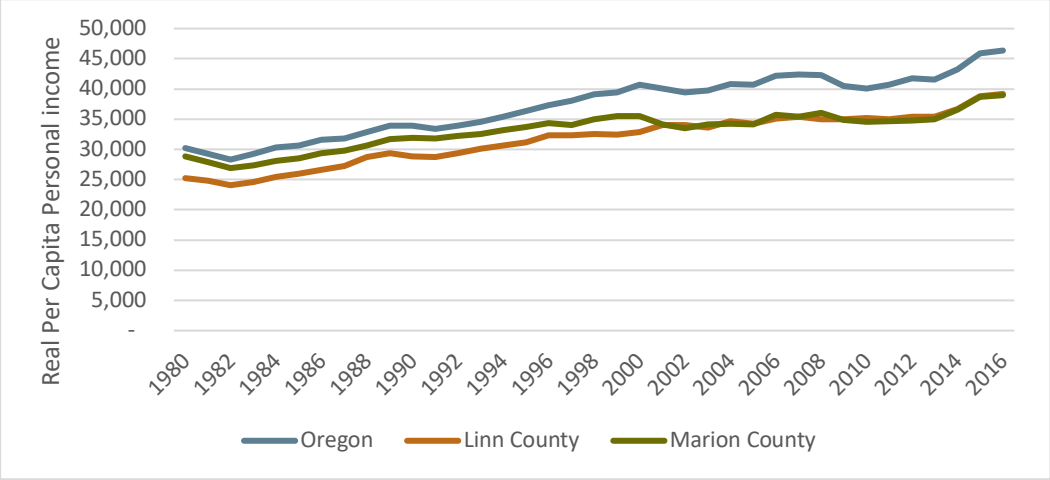
Community	1990	2000	2010	2011	2012	2013	2014	2015	2016	2017	Change 2010-2017	Change 1990-2017
Communities within the NSW (Listed West to East)												
Jefferson	1,792	2,480	3,115	3,135	3,140	3,150	3,165	3,165	3,195	3,235	3.9%	80.5%
Stayton	5,003	6,840	7,645	7,660	7,660	7,685	7,700	7,725	7,745	7,770	1.6%	55.3%
Lyons[1]	938	1,008	1,160	1,160	1,160	1,160	1,160	1,160	1,165	1,180	1.7%	25.8%
Mill City	1,555	1,537	1,855	1,865	1,870	1,870	1,875	1,855	1,860	1,860	0.3%	19.6%
Gates	499	471	475	475	485	485	485	485	485	485	2.1%	-2.8%
Detroit	331	262	205	205	205	205	210	210	210	210	2.4%	-36.6%
Idanha	289	232	135	135	135	135	140	140	140	140	3.7%	-51.6%
Communities that Use Water from the NSW												
Salem	109,651	137,659	155,100	155,710	156,455	157,770	159,265	160,690	162,060	163,480	5.4%	49.1%
Turner	1,287	1,206	1,855	1,860	1,865	1,865	1,900	1,920	1,945	2,005	8.1%	55.8%
Albany	33,424	41,134	50,325	50,520	50,710	50,720	51,270	51,670	52,540	52,710	4.7%	57.7%
Millersburg	670	668	1,345	1,375	1,375	1,430	1,505	1,620	1,730	1,835	36.4%	173.9%

Source: ECONorthwest, with data from Portland State University Population Research Center, Certified Population Estimates, July 1, 2017, and the U.S. Census Bureau
Notes: [1] Includes the population of Mehama

2.4 Economic Characteristics

In 2016, the estimated real per capita personal income for Marion County was $38,981 (2018 dollars) and for Linn County was approximately $39,182 (2018 dollars).[38] Both Marion County and Linn County have lower per capita personal income levels than the statewide average (Figure 4). Real per-capita income has risen since 1980 in all three geographies, but grew faster for Oregon as a whole than for people in Linn and Marion counties.

Figure 4. Historical real per capita personal income for Linn County, Marion County, and the State of Oregon



Source: ECONorthwest, with data from the Bureau of Economic Analysis

The economic characteristics of the population within the NSW and in communities that use water from the NSW are shown in Table 7. As of 2015, the median household income of communities within the NSW ranged from $29,083 in Idanha to $61,848 in Mehama. Median household incomes are generally higher in communities in the western portion of the watershed, and lower to the east. The median household income in 2016 for Marion County was $50,775, and for Linn County was $46,782. These values fall within the middle of the range of household incomes represented in the communities associated with the NSW. Both are lower than the same for the state of Oregon, at $53,270.[39]

The proportion of employed persons in communities within the NSW is higher to the west and lower to the east, and unemployed persons the opposite. Percent of the population collecting social security is higher in the eastern portion of the NSW, which correlates to a lower portion of the population in the labor force.

[38] U.S. Department of Commerce, Bureau of Economic Analysis. "Personal Income, Population, per Capita Personal Income (CA1)". Retrieved from https://www.bea.gov/iTable/iTable.cfm?reqid=70&step=1&isuri=1&acrdn=4#reqid=70&step=1&isuri=1

[39] U.S. Census Bureau. 2012-2016. *American Community Survey.* Table DP03. Results for Marion County, Linn County, and Oregon.

Communities outside the NSW that use water from the NSW tend to have higher rates of employment, lower rates of unemployment, higher median household income, and a lower percent of the population dependent on social security income compared to communities within the watershed, particularly those to the east.

Table 7. Economic Characteristics of the Population of Communities within the NSW and Outside that Use Water from the NSW, 2015

Community	Population (16 Years and over)	Population in Labor Force (%)	Employed (%)	Unemployed (%)	Median Household Income	Social Security (%)	Retirement Income (%)	Cash Public Assistance (%)	SNAP Benefits (%)
Communities within the NSW (Listed West to East)									
Jefferson	2,320	60.9%	56.2%	4.8%	$47,849	31.8%	15.4%	8.9%	24.9%
Stayton	5,837	67.8%	58.8%	9.0%	$43,636	30.6%	15.8%	12.2%	34.4%
Mehama	126	76.2%	69.0%	7.1%	$61,848	27.0%	20.3%	0.0%	0.0%
Lyons	968	62.1%	55.4%	6.7%	$57,750	35.8%	20.4%	2.1%	13.5%
Mill City	1,419	55.1%	44.0%	11.1%	$38,438	45.9%	18.4%	7.0%	36.1%
Gates	409	47.2%	41.1%	6.1%	$35,833	44.1%	25.8%	13.1%	26.7%
Detroit	89	51.7%	49.4%	2.2%	$36,000	59.5%	19.0%	0.0%	14.3%
Idanha	148	58.1%	42.6%	15.5%	$29,083	38.4%	19.2%	24.7%	45.2%
Communities that Use Water from the NSW									
Salem	124,459	61.7%	55.0%	6.5%	$47,191	28.8%	19.5%	6.6%	24.4%
Turner	2,026	65.7%	56.5%	9.2%	$57,850	39.5%	24.2%	4.4%	14.2%
Albany	40,083	62.4%	54.9%	7.3%	$47,150	31.2%	20.8%	5.9%	22.9%
Millersburg	1,287	62.1%	61.3%	0.8%	$72,778	30.1%	24.5%	2.4%	19.6%

Source: ECONorthwest, with data from the U.S. Census Bureau, American Community Survey 2011-2015, Table DP03
Note: In the smaller communities, the percent margin of error in the ACS data may be larger than the percent reported (for example, with unemployed population). For this reason, caution should be taken in drawing precise conclusions from the data, and instead, are shown to illustrate general trends across the study area.

The Mid-Willamette Council of Governments conducted an Economic Opportunity Study for the North Santiam Canyon communities in 2014, which stated that "inadequate infrastructure and basic community facilities prevent businesses from expanding or locating in the area and creating a diverse economic base."[40] The economies of the North Santiam canyon communities were dominated by logging and wood product manufacturing and declines in these industries in recent decades have had direct economic impacts on these communities. Table 8 shows the number of establishments, employment, and percent of total employment for each of the sectors represented in the North Santiam Canyon communities in 2016. The manufacturing sector (primarily wood-products manufacturing) was the largest employer in the region, with 46.1 percent of jobs; other major sectors for employment include government (17.2 percent), leisure and hospitality (16 percent), and trade, transportation, and utilities (8.4 percent).

[40] Mid-Willamette Council of Governments. 2014. *North Santiam Canyon Economic Opportunity Study.* Pg. 4.

Table 8. Employment by Industry for North Santiam Canyon Communities (Detroit, Gates, Idanha, Lyons, Mehama, Mill City)

Industry	Establishments	Average Employment	% of Total Employment
Manufacturing	15	679	46.1%
Government	22	253	17.2%
Leisure and Hospitality	28	236	16.0%
Trade, Transportation, and Utilities	20	124	8.4%
Natural Resources and Mining	9	58	3.9%
Other Services	36	40	2.7%
Education and Health Services	6	27	1.8%
Professional and Business Services	12	25	1.7%
Construction	16	21	1.4%
Financial Activities & Information	5	10	0.7%
Total	**169**	**1,473**	**100.0%**

Source: Created by ECONorthwest with data from Oregon Employment Department. "Employment and Wages by Industry (QCEW)". Retrieved from QualityInfo.org

Compared to the NSW communities in the canyon (i.e., communities within the NSW, east of Stayton), employment in Marion and Linn counties is more heavily weighted towards education and health services, followed by trade, transportation, and utilities (Table 9). Agricultural employment is included in the natural resources and mining category, and makes up about 80 percent of all employment in the category in Linn County and 90 percent in Marion County. Food processing is included in the manufacturing category and includes about 35 percent of jobs in the manufacturing sector in Marion County and just under 10 percent of the jobs in the category in Linn County. Additional jobs closely linked to agriculture and food processing are in warehousing, which is a sub-sector of trade, transportation, and utilities. Together, agriculture-related and food-processing employment make up 8 percent of total employment in Marion County and 5 percent in Linn County.

As expected since Salem is the capital of Oregon, there is a higher portion of jobs in Public Administration in Marion County. Manufacturing, which is the largest sector in the NSW canyon communities, ranks third in Linn County and even lower in Marion County.

Table 9. Proportion of Total Employment by Industry for Linn and Marion Counties, Oregon, 2018

Industry	Marion County	Linn County
Education and health services	24%	23%
Trade, transportation and utilities	18%	22%
Public administration	12%	5%
Professional and business services	9%	7%
Leisure and hospitality	9%	8%
Construction	7%	6%
Manufacturing	7%	17%
Natural resources and mining (including agriculture)	5%	5%
Financial activities	4%	3%
Other services	4%	4%
Information	1%	1%
Unclassified	0%	0%

Source: Created by ECONorthwest with data from Oregon Employment Department

Marion County collects property taxes to fund county government and operations. As part of the Fiscal Year 2017-2018 budget, Marion County identified the 10 largest taxpayers in the

county.[41] Of these large taxpayers, NORPAC Foods, Inc. is the eight largest tax payer, and directly relies on water from the North Santiam for food production by its cooperative of farmers.

2.5 Built Infrastructure

As the Land Use discussion above shows, people use the land and water resources within the NSW in a diverse array of ways. Many of these uses require human-built capital to fully utilize the available natural capital (e.g., the water, forests, and soils). Human-built capital includes anything that people construct or modify, including structures (e.g., buildings, dams), routes of conveyance (e.g., roads, pipelines, transmission lines), and equipment or technology not affixed to the land. The most relevant of these forms of built capital within the watershed to the economic analysis in Section 4 is infrastructure related to water conveyance and recreation. Roads and electricity transmission and distribution infrastructure are also important to facilitate access to water resources, but are used for many other purposes as well, so are not discussed here. The dams in the NSW also count as built capital, and are discussed above in the physical description because of their direct relationship to the quantity of water available in the watershed.

2.5.1 Water Supply Infrastructure

As described above, many types of users use water from the NSW. All of these users have developed infrastructure that facilitates their use, including water intakes, pipelines and distribution systems, and treatment facilities. The scale of these varies, but all represent significant investment and require routine maintenance. Water in the NSW would not be available to support the production of goods and services without these forms of human-built capital. There are at least eight major water intakes throughout the watershed, and likely many more small, private intakes, which typically include at various scales and in different combinations, water control structures (e.g., diversion structures and dams), pumps, and pipes.

The most significant of these investments in terms of overall investment and scale is the City of Salem's water system. The City of Salem and the Santiam Water Control District jointly own both Upper and Lower Bennett Dams, which serve several purposes to control and divert flows to water intake structures. Transmission pipelines convey treated water from the water treatment facility at Geren Island—located in the North Santiam River upstream of the City of Stayton—to the City of Salem, a distance of over 20 miles.[42]

The Santiam Water Control District (SWCD) also depends on built infrastructure to convey water to its agricultural customers. SWCD uses a combination of live flow from the North

[41] Marion County. *Marion County Annual Budget Fiscal Year 2017-2018*. Retrieved September 27, 2018, from https://www.co.marion.or.us/FIN/budget/Documents/FY%2017-18%20Budget/FY17-18%201-Table%20of%20Contents%20and%20Introduction.pdf

[42] GSI Water Solutions, Inc. 2014. *Water Management and Conservation Plan.* The City of Salem. Retrieved September 27, 2018, from https://www.cityofsalem.net/CityDocuments/water-management-conservation-plan.pdf

Santiam River and stored water from the Detroit Lake Reservoir system to serve its customers. Water is diverted and then flows through a network of 90 miles of canals and ditches. On the 24,000 acres that the district occupies, approximately 17,000 acres are irrigated using 53,000 acre-feet of water. Hydropower is also produced by the district, currently by one hydropower plant; approximately 236,000 acre-feet of water was used in 2015 for hydropower production by SWCD.[43]

2.5.2 Recreation Infrastructure

The NSW hosts a variety of infrastructure that supports water-related recreational pursuits throughout the watershed. Water-related recreation in the NSW includes motor boating and personal motorized watercraft use; canoeing, kayaking, and rafting; fishing; swimming and soaking in hot springs; camping nearby waterbodies; hiking nearby waterbodies; and enjoying nature through watching, photographing, etc. Infrastructure provides access and facilities that allow people to engage in these activities, and thus in part dictates the supply of recreational opportunities available to people. Some infrastructure (e.g., campgrounds) provide harder limits on participation at any given time than others (e.g., trails). Table 10 summarizes the quantity of several types of recreation infrastructure in the NSW. Figure 5 shows the location of major recreation facilities.

Table 10. Supply of Recreation Infrastructure in the NSW

Recreation Infrastructure	Quantity
Boat Ramps	15
Marinas	2
Campgrounds	17
Picnic Areas	6
Developed Hot Springs	1
Hiking Trails	Unknown number of miles

Source: ECONorthwest, based on GIS analysis and personal communications with land and park managers.

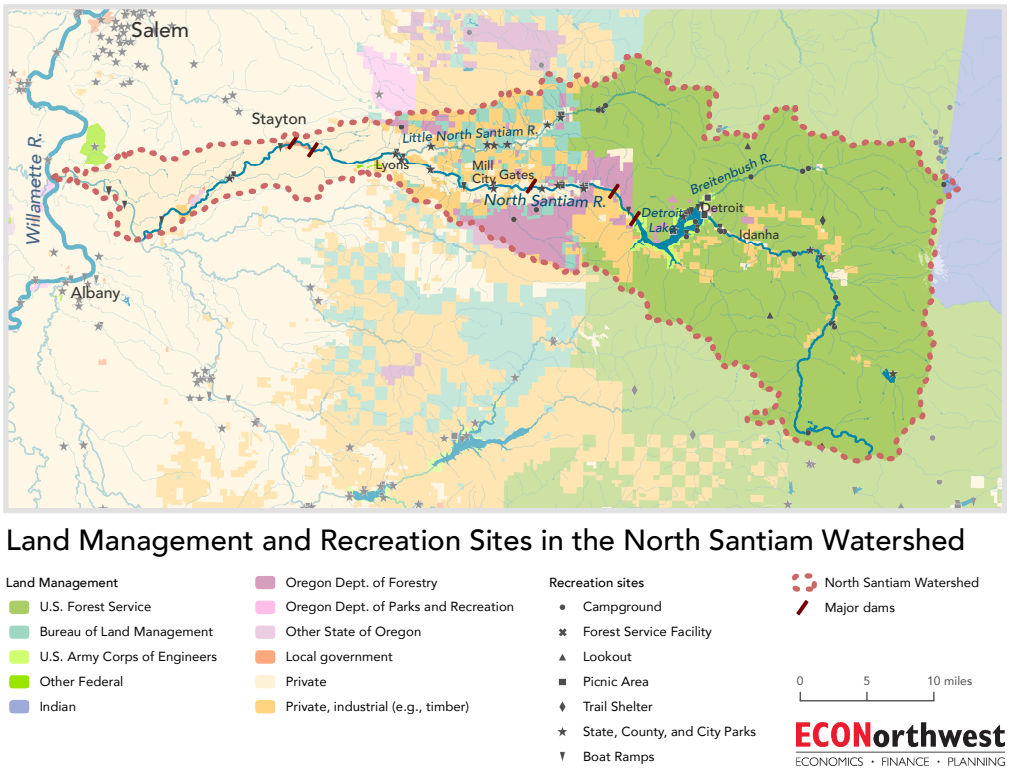
Most of the recreation infrastructure in the NSW is located adjacent to the watershed's water bodies.

- Detroit Lake, the reservoir created by Detroit dam is a popular recreational spot for boating, fishing, and camping.
- Breitenbush Hot Springs Retreat and Conference Center is located on the Breitenbush River, a tributary to the North Santiam, and offers resort-like amenities and access to hot springs.
- There are three state parks, two on Detroit Lake and one on the North Santiam River, which offer boat access, shore access, campground, restroom, as well as hiking and biking.

[43] Santiam Water Control District. (2015). *Application for U.S. Bureau of Reclamation 2015 Drought Contingency Planning Grant.* Prepared for U.S. Bureau of Reclamation.

- There are six Marion County parks, all of which are adjacent to the North Santiam or a tributary.
- Multiple private recreation facilities are located on the mainstem Santiam and tributaries, including Camp Taloali, a facility adjacent to the North Santiam River that provides summer camp opportunities for deaf and hard of hearing and disabled youth and adults in the region.[44] The camp facility is also available for private events throughout the year, and attracts thousands of people annual for camp and private events.

Figure 5. Map of Land Ownership and Recreation Facilities in the NSW



Source: ECONorthwest, with GIS data

In addition to these facilities, the public land throughout the watershed (described above in Table 5) offers dispersed recreation that isn't directly associated with developed infrastructure (except, perhaps, hiking trails which may or may not be maintained regularly). People engage in hiking, dispersed and developed camping, fishing, exploring, biking, hunting, and other activities on these lands.

[44] Camp Taloali. No Date. *About Us.* Retrieved January 10, 2019, from http://www.taloali.org/about-us

2.6 Policy Landscape

Regulations and policies shape and limit how water is used, distributed, treated, and discharged in the NSW. While it is beyond the scope of this study to identify all of the ways that regulations potentially limit or expand how water can be put to economic use, three policies are particularly relevant for understanding the current supply and demand for water in the NSW. One governs how water is regulated to protect endangered anadromous fish and sets limits on future appropriations within the NSW, another influences potential allocation of stored water in the NSW, and the third addresses water quality and sets limits on wastewater discharge into the NSW.

2.6.1 Endangered Species Management and the Biological Opinion

As discussed above, there are two species of anadromous fish in the NSW that are listed as threatened. In response to these listings, public and private land owners have changed the way they use and manage water to avoid causing further harm to the population. In 2008, the National Marine Fisheries Service (NMFS), which is responsible for oversight of anadromous fish under the federal Endangered Species Act, issued a Biological Opinion (Bi-Op) that outlined a set of management actions governing operations for the entire Willamette Project that it deemed would be protective of the threatened species. Within the North Santiam Subbasin, NMFS stated that "Habitat loss due to blockages has been especially severe in the North Santiam…" and found the risk of losing the North Santiam population subgroup of Upper Willamette River Spring Chinook to be "very high," while the risk of losing the Upper Willamette River Steelhead NMFS identified as "moderate."[45] In response to the Bi-Op the USACE developed the Willamette Fish Operations Plan (WFOP), and revises it annually as necessary. The WFOP outlines minimum streamflows, sets monthly temperature targets downstream of Big Cliff Dam, and describes hatchery and fish passage operations plans.[46] The Bi-Op also established a limit on future contracts for water within the North Santiam subbasin in tributaries below project dams, to ensure adequate streamflows.[47]

2.6.2 Willamette River Basin Stored Water Reallocation

In 2015, the U.S. Army Corps of Engineers restarted a joint effort with Oregon Water Resources Department to review the feasibility and options for stored water in the Willamette River Basin reservoirs to be reallocated for municipal and industrial use, irrigation, and endangered species. The first attempt at the reallocation process, which was not completed, was in 1996. Detroit

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[45] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion.* Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion/, Pgs. 8.13-4, 8.13-10, 8.14-9.

[46] U.S. Army Corps of Engineers. 2018. *Willamette Fish Operations Plan, Willamette Valley Project.* Retrieved September 28, 2018, from http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/WFOP/2018/final/2018%20WFOP%20Final.pdf

[47] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Executive Summary, Willamette Project Biological Opinion.* Page. 13.

Lake and Big Cliff dam are two of the thirteen reservoirs, called the Willamette Valley Project (WVP), being considered in the study for reallocation potential.[48] Ultimate approval of the reallocation will require authorization from Congress, and due to this requirement and other uncertainties the timeline and certainty of approval is unknown.

- Of the 1,590,000 acre-feet of WVP conservation storage, approximately 75,000 acre-feet of stored water (roughly five percent of total WVP conservation storage) is currently contracted through Reclamation for irrigation.[49]

- While the Corps has been operating the WVP to meet flow objectives since the year 2000 for ESA listed fish, releases of WVP stored water are not protected instream. Reallocation would allow for legal protections of the water for instream purposes.

- Currently no portion of the WVP stored water is authorized for municipal and industrial uses. The reallocation would obtain authorization to allow for storage agreements for municipal and industrial water use.

The reallocation is being considered for the entire Willamette River Basin and Detroit Lake represents about 300,000 acre-feet of the 1.6 million acre-feet of conservation storage.[50] Although Detroit Lake is a relatively large portion, it is unclear to what extent the reallocation will affect water rights and permits for this specific reservoir at this time because not all reservoirs are expected to be reallocated equally. The reallocation for Detroit Lake is also complicated by the 2008 Bi-Op, which does not allow for new stored water contracts to be issued in the NSW. This limitation would need to change in order for new contracts for stored water to be issued within the NSW as part of the reallocation, but could potentially be issued for users downstream in the Willamette Basin.[51]

2.6.3 Three-Basin Rule

The three-basin rule went into effect January 29, 1994 and stipulates that there can be no new or increased wastewater discharges in the North Santiam, Clackamas, and McKenzie River subbasins. This rule applies to NPDES permit, Water Pollution Control Facility for discharge to groundwater, and 401 Certifications. Effectively this means that no new NPDES permits can be issued, meaning a new Wastewater Treatment Plant that would discharge into the North Santiam cannot be built, regardless of the quality of the water being put back. There are exceptions to the three-basin rule for wastewater discharge to groundwater for domestic sources less than 5,000 gal/day.

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[48] Additional information about the WVP reallocation study can be found on the U.S. Army Corps of Engineers website: http://www.nwp.usace.army.mil/willamette/basin-review/

[49] U.S. Army Corps of Engineers. 2017. *Willamette Basin Review Feasibility Study: Integrated Feasibility Report and Environmental Assessment.* November.

[50] Ibid

[51] Personal communication with Mike McCord, Oregon Water Resources Department, on July 19th, 2018.

3 Demand for Water and Value

In this section, we describe the demand for water from the NSW. We begin with an assessment of the water rights in the NSW. While an imperfect relationship exists between water rights and demand for water,[52] the comprehensive database maintained by Oregon Water Resources Department (OWRD) provides a snapshot of the ways that water is used in the NSW, and serves as a starting point for the economic analysis.

Our assessment of demand includes demand from populations within the watershed (e.g., the communities in the canyon and agricultural users who draw water out of the North Santiam and its tributaries), and demand from populations that live elsewhere but derive value from the water resources in the NSW. This includes people traveling to the watershed to enjoy recreational opportunities, and people outside of the watershed who use water that originates from the North Santiam, Santiam, and tributaries within the NSW.[53] For each of these types of demand, we describe the economic value the users place on the water under current conditions. In some cases, we are able to estimate the economic value in monetary terms. In other cases, we describe the economic value qualitatively, because of limitations in the available data.

The analysis provided for each of these sources of demand together illustrates the economic importance of water in the NSW under current climate and population conditions. Where data permit, we describe the expected trends in demand that may affect the value of water in the future: in most cases, the data suggest that the value of water likely will increase as the population grows, as preferences for the types of goods and services produced from water in the North Santiam increase among the population, and as the overall availability and distribution of water and water-related goods and services changes throughout the Willamette Basin with climate change.

3.1 Water Rights

The OWRD oversees the system that governs and authorizes the right to use water in Oregon. Most uses of water in Oregon must have a water right, which identifies the point of diversion,

[52] This statement cannot be emphasized enough. One of the strongest criticisms of the legal system governing water allocation in the west is that it does not adequately take into account economic considerations, such as demand and price, and results in economically inefficient allocations of water.

[53] It does not include demand from downstream users who withdraw water from the Willamette River, which may be of incrementally better quality or more plentiful because of the contributions of the Santiam River as it flows into the Willamette River. Agencies have identified in several cases that some water quality parameters in the Willamette River may improve after its confluence with the Santiam south of Salem. It also does not include the value of flood control, which is a benefit not of the water itself, but of the infrastructure designed to control the water. This value is important and described elsewhere as providing annual benefits between $0 and $23.5 million. See, for example, U.S. Army Corps of Engineers and Oregon Water Resources Department. 2011. *Small-Scale Water Supply Allocation Process in the Willamette River Basin.* Retrieved September 28, 2018, from https://www.oregon.gov/OWRD/WRDPublications1/2011_01_Small_Scale_White_Paper.pdf

place of use, type of use, and priority date (i.e., the date when the right was granted, which assigns priority for who gets water during times of scarcity). Thus, understanding how water is used in Oregon's water basins (i.e., the sources of demand for water) begins by examining water rights. These records, however, do not reflect current demand, for several reasons. The most important issue for this analysis is that the water rights certificates on record (sometimes referred to as paper water) do not reflect actual quantity water used or demanded (in some cases, demand may be higher than actual use, or lower and the user takes the water to preserve the option to use more water in the future). In some cases, owners of water rights in OWRD's database may not have exercised their right (i.e., withdrawn water) in many years, and their rights are no longer legally valid (i.e., they could not be renewed if the owner decided to start using water again). In some cases, especially at the urban fringe, a water right certificate associated with a particular property can no longer be used because development has occurred on the land, rendering the point of diversion and/or point of use unavailable.

Thus, the picture assembled for water use in the NSW from OWRD's database of water rights certificates likely overestimates the actual quantity of use, and does not accurately serve as a measure actual use of water. This situation is not unique to the NSW due to the reasons cited previously. In the aggregate, however, we believe the water rights records provide a reasonable picture of the types of demand for water that occur in the basin, and the relative magnitude of demand across different types of users. The overview of water rights that follows comes from the OWRD's online Water Right Information Search Query (WRIS).[54]

3.1.1 Surface Water

Surface water rights refer to live flow in the North Santiam or its tributaries. There are 827 surface water rights certificates in the database for the NSW. Table 11 shows the types of uses, ranked by quantity of water authorized under the water rights certificates (but not necessarily actually used). The largest use represents rights granted for instream purposes (36 percent). Surface water rights for the North Santiam River have the largest variety of uses; uses on tributaries are more limited.

[54] ECONorthwest confirmed with Mike McCord at Oregon Water Resources Department that this was the most comprehensive way using available data to summarize the water rights in the NSW, and within reason, accurately represented the types of use in the NSW. ECONorthwest used the "search by stream function" in the WRIS to isolate rights for the NSW. We then cleaned the data to remove duplicate values and any rights that were not within the North Santiam basin. Based on our interviews, we understand that some rights may be missing from the database, and we did not attempt to resolve issues related to individual rights. The Water Rights Information Query is available at: https://apps.wrd.state.or.us/apps/wr/wrinfo/Default.aspx?t=0

Table 11. Surface Water Rights by Type in the NSW

Description	Number of Rights	Quantity of Water Permitted (CFS)[1]	Percent of Total
Instream	9	2167.0	36%
Power	17	1562.2	26%
Industrial	34	822.3	14%
Irrigation	456	478.5	8%
Municipal	26	301.8	5%
Fish	24	236.3	4%
Wildlife	3	139.5	2%
Miscellaneous	20	132.6	2%
Domestic	168	57.1	1%
Livestock	51	40.0	1%
Recreation	11	27.5	<1%
Agriculture	8	3.7	<1%
Total	**827**	**5968.4**	**100%**

Source: ECONorthwest analysis of WRIS data
Note: [1]This is the variable "PODMaxRate" from the WRIS

3.1.2 Groundwater

A water right for groundwater is required for most wells providing water for agricultural and municipal/industrial purposes. The State of Oregon has identified certain uses as exempt from requiring a permit to use groundwater, and most domestic wells fall under this exemption.[55] Due to the hydrologic connection between groundwater and surface water, wells must be a minimum of one-quarter mile away from surface water.[56] According to the WRIS, there are 294 groundwater rights in the NSW. The overall quantity of water in groundwater permits is less than one percent of the quantity in surface water rights. The distribution is very different as well: the majority of groundwater rights are for irrigation (61 percent), followed by industrial uses (29 percent). Given that irrigation is the largest use and has many landowners who irrigate, private users overall are the largest users of groundwater (59.31 percent). The largest individual users are the City of Salem, followed by the City of Stayton, and Mill City.

As described in Section 3, the OWRD has classified areas in the lower (western) portions of the NSW as groundwater restricted. There are limitations to new groundwater permits in these areas to protect against groundwater-level declines.[57]

[55] See ORS 537.545 for more information on exempt groundwater uses. In general, these represent small volumes of water for agricultural and domestic purposes. Examples include domestic purposes not exceeding 15,000 gallons per day, water lawns not exceeding one-half acre in area, and stockwatering,

[56] Personal conversation with Mike McCord, OWRD, on Thursday, July 19th, in Salem, Oregon.

[57] Oregon Water Resources Department. 2018. *Groundwater Restricted Areas*. February 23. Retrieved September 27, 2018, from http://apps.wrd.state.or.us/apps/gis/gis_map_library/gis_view_image.aspx?gis_library_image_id=1136

Table 12. Groundwater Rights by Type in the NSW

Description	Number of rights	Quantity of Water Permitted (CFS)[1]	Percent of Total
Irrigation	257	126.2	61%
Industrial	10	61.0	29%
Agriculture	10	13.6	7%
Industrial	13	5.4	3%
Miscellaneous	2	0.6	0%
Fish	1	0.0	0%
Domestic	1	0.0	0%
Total	**294**	**206.9**	**100%**

Source: ECONorthwest analysis of WRIS data
Note: [1]This is the variable "PODMaxRate" from the WRIS

3.1.3 Storage Water

Storage water rights refer to the right to store water and are important in the context of the dams on the North Santiam River. There are 187 storage water rights in the NSW, and the vast majority of these are rights stored by the U.S. Bureau of Reclamation in Detroit Reservoir.

Table 13. Storage Water Rights by Type in the NSW

Description	Number of rights	Maximum Acre-feet[1]	Percent of Total
Miscellaneous[2]	67	95463.1	98.8%
Industrial	12	436.7	0.5%
Fish	31	349.4	0.4%
Wildlife	17	159.0	0.2%
Recreational	18	116.0	0.1%
Livestock	37	111.0	0.1%
Industrial	3	5.1	0.0%
Agriculture	2	2.3	0.0%
Total	**187**	**96642.5**	**100.0%**

Source: ECONorthwest analysis of WRIS data.
[1]This is the variable "POD Max AF" from the WRIS. Storage water rights are measured in terms of acre-feet rather than CFS, as surface and groundwater rights are reported in the other tables. Direct comparisons cannot be made against the other tables for this reason.
[2] The majority of the Miscellaneous rights, 95000 AF, are held by the U.S. Bureau of Reclamation

We organize the following sections roughly to reflect the uses identified in Table 11. The order of these sections follows the relative level of use of water in each category (recall, in the best professional judgement of OWRD and ECONorthwest staff, although the quantity identified in the water right and used in Table 11 does not indicate the actual quantity of water use at any given time, the relative proportions likely approximate the distribution of water across uses in the NSW). Furthermore, some categories of demand do not require a water right to use the water. These include uses that are not consumptive and don't require diversion of water—primarily recreation and aesthetics. These demands are satisfied by water flowing instream, and represent "co-users" of the largest category of water rights: water for aquatic life (instream) and anadromous and resident fish habitat (instream). Thus, we address these three uses first, sequentially.

3.2 Instream Flows for Aquatic Species and Habitat

In this section, we describe the demand for and value of maintaining aquatic and riparian habitat at a quality and quantity sufficient for supporting and ensuring the continued survival of threatened fish species in the NSW. Maintaining this habitat produces ecosystem service benefits for other species as well, but a large share of its economic importance derives from its capacity to protect the populations that are at the greatest risk. Thus, we focus on benefits arising from instream flows to protect ESA-listed species. We describe the value associated with the water in terms of the value people assign to recovering the threatened fish populations that live in the water and depend on water-related aquatic and riparian habitat.

3.2.1 Current Demand

Demand, in this case, is indicated by regulatory requirements set by federal and state agencies acting in their capacity as trustees of endangered species, as outlined in state and federal Endangered Species Acts. In theory, these legal obligations reflect demand by Oregonians and the people of the United States to protect species for future generations.[58] The quantity of water demanded (reserved for fish populations) is defined through regulatory processes in which scientists and managers identify the amount of water needed to maintain conditions that are consistent with fish survival at different life stages throughout the year, and put the species on a trajectory for recovery.

In Section 3, we identify two fish species that are protected under the ESA: Upper Willamette River Chinook (threatened) and Upper Willamette River steelhead (threatened). Table 14 shows the counts of adult fish from both species returning to the NSW between 2014 and 2018. The number of adult fish returning fluctuates over time, and is a function of many factors in the ecosystems they pass through during their migratory lifecycle, including the Willamette and Columbia Rivers, and the Pacific Ocean. Thus, the counts in Table 14 reflect population levels influenced by factors that impact survival within and outside the NSW. The trend in population is generally downward, with more dramatic declines in 2017 that may be short-term in nature, reflecting the cyclical nature of the populations. It is these population levels in the NSW and throughout their range that continue to qualify the species for listing under the ESA.

[58] This construction is consistent with Footnote 1, which requires that demand originate from anthropogenic (human) needs and desires. In this case, the fish do not demand water, people demand water for the ongoing survival of fish populations. Water for fish has value that derives from the ways that people "use" the fish, by directly interacting with them through consumption or observation (use value), desiring to potentially interact with them in the future (option value), desiring that future generations may experience them (bequest value), or simply knowing that they exist (existence value).

Table 14. Fish Counts at Upper and Lower Bennett Dams for 2014 - 2018

Species	2018 Count[1]	2017 Count	2016 Count	2015 Count	2014 Count
Hatchery Steelhead	1634	590	5362	905	4202
Wild Steelhead	401	185	866	865	943
Hatchery Chinook	2934	4223	3945	6687	5421
Wild Chinook	411	987	838	1074	1630

Source: Oregon Department of Fish and Wildlife (https://myodfw.com/upper-and-lower-bennett-dams-fish-counts)
Note: [1]Year-to-date as of August 2018.

To protect the species from extinction, the ESA dictates that any water management action, public or private, be evaluated against its potential to "jeopardize the continued existence" of these species. Any state or federal permit (for a public or private action) related to water management where species live is subject to scrutiny under the ESA. Through this mechanism, the NMFS, which has jurisdiction to review actions for potential harm to anadromous fish, issued a Biological Opinion (Bi-Op) in 2008, in response to consultation with the USACE, USBOR, and BPA regarding their operation of the Willamette Project.[59] Among other actions to set the species on a path to recovery, the Bi-Op requires the USACE to set flow targets protective of the species in several locations that impact management of the North Santiam River.

The goal of the regulatory standards established in the Bi-Op is to protect existing populations of Upper Willamette River Chinook and Upper Willamette River steelhead, and to eventually support their recovery and removal from the ESA list. Instream flow targets are a necessary, but partial, component of the overall recovery strategy. To this end, the Bi-Op also requires that USACE manage aquatic resources for specific temperature targets, and manage hatchery operations consistent with species recovery efforts.

3.2.2 Economic Importance

Over several decades, economists have developed and refined methods to estimate the value people are willing to pay to fund actions that protect species from extinction and recover their populations. These approaches are the only way to measure the "non-use" or "existence" values for natural resources. These methods (including contingent valuation, contingent choice, and conjoint analysis) rely on carefully designed and implemented surveys to elicit responses from representative samples of the population about their willingness to pay for specific actions and outcomes that generate public benefits. The responses are statistically assessed to yield mean values applicable to the sampled population. These methods have undergone extensive scrutiny and have evolved over time to address critiques.[60]

[59] The legal history of this Biological Opinion is far more convoluted and complicated. For a detailed description, see the 2008 Biological Opinion: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. 2008. *Willamette Project Biological Opinion.* Retrieved September 24, 2018, from https://www.westcoast.fisheries.noaa.gov/fish_passage/willamette_opinion

[60] For a broad overview of the history and best practices for these types of studies, *see* Johnston, R.J., K.J. Boyle, W. Adamowicz, et al. 2017. "Contemporary Guidance for Stated Preference Studies." *Journal of the Association of Environmental and Resource Economists* 4(2): 319-405. Retrieved October 2, 2018, from

In 2012, NOAA economists published the results of a national survey that measured the values for recovery of several marine species, including the Upper Willamette River Chinook salmon.[61] This study used state-of-the-art techniques and a large sample of households across the U.S. to estimate their willingness to pay for recovery of each species. The researchers designed the survey to estimate nonconsumptive values, such as the value members of a household placed on being able to observe the species, or to know that they exist now and for future generations. The survey design specifically attempted to examine only these nonconsumptive values, and excluded the value households place on consumptive or other direct-use values, such as being able to fish. The study found that U.S. households were, on average, willing to pay $45.75 (in 2018 dollars) per year for 10 years for additional protection actions that would result in the recovery of the Upper Willamette River Chinook and delisting from the ESA in 50 years.

Applying this mean household value to the household population in Oregon, and adjusting it using the parameters described in the study, yields a per-household willingness-to-pay value over 10 years of $401.96.[62] There are about 1.5 million households in Oregon. Applying this average value to these households yields a total willingness to pay to recover the Upper Willamette River Chinook salmon of $621 million. Applying the value to the estimated 117 million households in the U.S. yields a value of $47 billion.

These values should be viewed as demonstrative of the scale of non-use values people place on species recovery resulting from the ESA-mandated instream flow requirements, assuming these requirements ultimately will allow the species to recover and be delisted. While the recovery efforts in the NSW may be necessary for Upper Willamette River Chinook salmon to be delisted,[63] they may not be sufficient for recovery of all genetically distinct units. This value applies to efforts taken across the Willamette Basin to further the recovery of the Upper Willamette River Chinook salmon. These values are consistent with economic theory and include considerations of the household budget constraints and the full set of public and private goods that a household can consume over a 10-year period of time.

Furthermore, these values are consistent with the results of other large-scale and well-designed surveys conducted at a national level to estimate the value of species protection and recovery in Oregon. In 2010, researchers estimated households' willingness to pay each year over 20 years for actions that would result in a 30-percent increase in wild Chinook salmon and steelhead

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https://aaec.vt.edu/content/dam/aaec_vt_edu/people/faculty/URLs/boyle/boyle-kevin-contemporary-guidelines-2017-jaere.pdf

[61] Wallmo, K. and D. Lew. 2012. "Public Willingness to Pay for Recovering and Downlisting Threatened and Endangered Marine Species." *Conservation Biology* 26(5): 830-839.

[62] Adjusting the annual study value from 2011 to 2018 dollars using the CPI and discounting the value over 10 years at 3 percent.

[63] NOAA Fisheries, Protected Resource Division. 2005. "Appendix C: CHART Assessment for the Upper Willamette River Chinook Salmon ESU." In *Final Assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams For 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead*. August. Retrieved October 5, 2018, from https://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/critical_habitat/chart_report/2005_chart_uwr_chinook.pdf

trout in the Klamath River (Oregon and California). The study found that households in Oregon and California would pay over $10 billion (in 2018 dollars) and households in the U.S. would pay about $96 billion (in 2018 dollars) to achieve this outcome.[64] Just as in the NOAA study, these represent nonuse values.

In addition to instream flows for threatened salmon, the NSW produces fish that are not protected under the ESA, and contribute value to the economy. The Minto Fish Hatchery is part of the mitigation required for operation of the Willamette Project. It produces stocks of spring Chinook and summer Steelhead. The hatchery stocks intended to help restore wild populations of fish, but are available for harvest in tribal, commercial, and recreational fisheries in the Pacific Ocean, Columbia, and Willamette Rivers on their return to the NSW. The production of these hatchery fish is controversial, and some have suggested they continue to pose risks to the recovery of native fish.[65] Other native and non-native resident and migratory fish live in the NSW, including rainbow trout, cutthroat trout, mountain whitefish, lamprey and Coho.[66] These species support primarily freshwater recreation opportunities discussed in greater detail in the next section. Some of these species are also important to the Native American people who traditional lived in the area, and support subsistence, cultural, and spiritual values described in later sections.

3.2.3 Expected Future Trends in Demand and Value

Achieving species recovery goals advanced by the 2008 Bi-Op framework will take decades. Values derived from survey research of willingness to pay are typically only valid for a period of a few years, as the risk that the population's preferences diverge from survey responses increases with time.[67] Results from the Oregon Population Survey between 1996 and 2002 found that the importance Oregonians place on salmon recovery fell—that is, Oregonians became less supportive toward salmon recovery, were less likely to say salmon recovery is important, and chose lower willingness to pay responses in 2002 than in 1996. The study found that attitudes appear to correlate with economic conditions and demographic composition. Specifically, local unemployment rates and rural county residence were significantly negatively correlated with

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[64] Mansfield, C., et al. 2012. *Klamath River Basin Restoration Nonuse Value Survey.*

[65] National Marine Fisheries Service, West Coast Region. 2018. *Draft Environmental Impact Statement (DEIS) to Analyze Impacts of NOAA's National Marine Fisheries Service Proposed Approval of Hatchery and Genetic Management Plans for spring Chinook salmon, steelhead, and rainbow trout in the Upper Willamette River Basin Pursuant to Section 4(d) of the Endangered Species Act*. March. Retrieved October 5, 2018, from https://www.westcoast.fisheries.noaa.gov/publications/nepa/hatchery/upperwillamettehatcheries_deis_march2018.pdf

[66] Native Fish Society. 2018. *North Santiam River.* Retrieved October 5, 2018, from https://nativefishsociety.org/watersheds/north-santiam-river

[67] Lew, D.K. 2015. "Willingness to pay for threatened and endangered marine species: a review of the literature and prospects for policy use." *Frontiers in Marine Science.* 16 November. Retrieved October 2, 2018, from https://www.frontiersin.org/articles/10.3389/fmars.2015.00096/full#B148

expressed support for salmon recovery and education level positively correlated with support. Much of the decline in support, however, was unexplained by the data.[68]

Follow-up research is not available to indicate whether this trend has strengthened or weakened among Oregonians. However, national survey research completed in 2015 found that support among Americans for the Endangered Species Act was consistently strong between 1996 and 2015. Over that time, support remained high among the public at 80 and 90 percent of the population. This support transcended political affiliation.[69]

If the patterns in these studies bear out in the future, to the extent that future population growth occurs primarily in urban areas, and local economic conditions remain favorable, current levels of demand for fish protection and recovery—and thus maintaining instream flows—may continue. As population grows, the overall number of households increases, which may offset declining per-household willingness to pay, should that be a prevailing trend.

Climate change may also affect demand, in several ways: to the extent that climate change increases air temperatures and water temperatures, maintaining instream flows may become even more critical for fish recovery, especially in basins that reach into the higher elevations, such as the NSW. If the public understands these vulnerabilities and their implications for species recovery, demand may remain steady or increase.

In summary, multiple trends may affect demand for and economic value of maintaining instream flows for salmon recovery. Some of these factors may increase demand and value, while others may decrease demand and value. The cumulative effect on the direction and magnitude of demand and value remains somewhat uncertain.

3.3 Water-Related Recreation

Recreation opportunities abound on public and private land and at both managed and more dispersed sites in the North Santiam watershed. Many sites are concentrated near Detroit Lake, the North Santiam river and its tributaries. Boating, fishing, swimming, hiking, camping, picnicking, biking, and hunting are all popular activities.

3.3.1 Current Demand

In this section we report demand for recreational opportunities based on current levels of recreational use, relying on the most recent data available. In many cases, recreational use is not

[68] Montgomery, C. and T. Helvoigt. "Changes in attitudes about importance of and willingness to pay for salmon recovery in Oregon." *Journal of Environmental Management* 8 (4): 330-340.

[69] Bruskotter, J.T., et al. 2018. "Support for the U.S. Endangered Species Act over time and space: Controversial species do not weaken public support for protective legislation." *Conservation Letters* July 19. Retrieved October 2, 2018, from https://onlinelibrary.wiley.com/doi/full/10.1111/conl.12595

reported at the watershed level, so we adjust the available data to estimate the levels of use within the watershed.

Ultimately, we aim to identify the demand for recreational uses related to water in the North Santiam watershed. Such uses are not limited to swimming, boating, and fishing, however. In the North Santiam watershed, nearly all of the developed recreational sites are along water bodies, and even remote hiking trails are typically located along headwater streams. Therefore, we find that water is an integral part of the equation when it comes to demand for recreation in the North Santiam watershed, and we report all the available recreation data without attempting to exclude uses based on types of activities or distances from a water feature.

Researchers at Oregon State University conducted a statewide survey of Oregon residents for the Oregon Parks and Recreation Department to estimate outdoor recreation participation in Oregon as of 2011.[70] This survey calculated the number of user occasions (the number of times people engage in an activity) and participation rates for residents of Marion County for various freshwater recreation activities; Table 15 reports the results of the survey for activities directly related to water.

Table 15. Participation in freshwater activities by residents of Marion County and state averages

Activity	User Occasions in Marion County[1]	% of Statewide Occasions	% of Marion County Residents Participating	% of Oregon Population Participating
Swimming/playing in outdoor pools/spray parks[2]	922,822	6.0	22.7	20.7
Power boating (cruising/water skiing)	476,198	7.0	16.9	15.3
Fishing from a bank or shore (other than Fly Fishing)	458,273	5.0	12.0	17.3
Beach activities - lakes, reservoirs, rivers	425,451	3.0	30.2	32.5
Fishing from a boat (other than Fly Fishing)	157,595	2.0	16.7	15.3
Personal water craft - jet ski	112,016	7.0	6.7	4.2
Flat-water canoeing, rowing, paddling tubing/floating	67,937	2.0	7.2	11.7
White-water canoeing, kayaking, rafting	30,947	1.0	10.6	12.5
Fly Fishing	23,175	1.0	4.7	5.6

Source: Rosenberger and Lindberg 2012, Data for Marion County
Note: [1]User Occasions are defined as the number of times people engage in an activity. The same person can contribute multiple user occasions.
[2]The SCORP survey of recreation users does not define where swimming occurs. It categorizes swimming as a non-motorized water-based and beach activity. Survey respondents could report swimming activities in natural areas under this category. They also could have included swimming activities in natural areas under beach activities—lakes, reservoirs, rivers. Because of this ambiguity, we cannot rule out that the user occasions for swimming/playing in outdoor pools/spray parks did not include swimming in the waterways of the NSW.

Some of these activities include user occasions that occur somewhat or primarily in urban areas (e.g., playing in outdoor pools and spray parks), so may overstate the occurrence related to the NSW resources (although a swimming pool filled with water from Salem's municipal supply comes from the NSW). After swimming (the most frequently-engaged in activity), power boating, fishing, and beach recreation were the most frequently participated in activities in Marion County. The user occasions includes participation in Marion County by residents across Oregon, so includes Marion County residents as well as people who travel to Marion County to

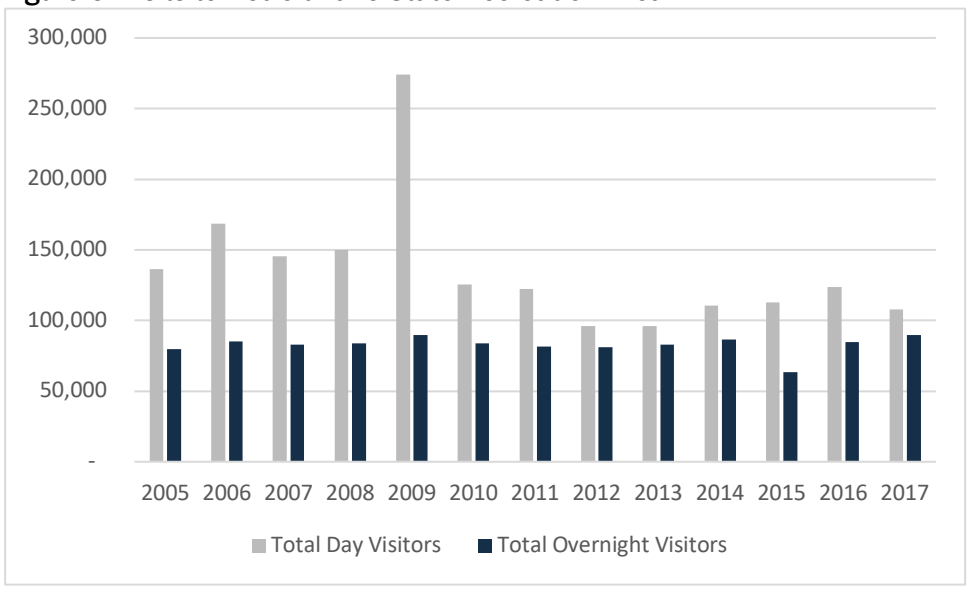
[70] Rosenberger, R., & Lindberg, K. 2012. *Oregon Resident Outdoor Recreation Demand Analysis*. 2013-2017 Oregon Statewide Comprehensive Outdoor Recreation Plan Supporting Documentation. Prepared for Oregon Parks and Recreation Department. Oregon State University. November 12. Retrieved from https://www.oregon.gov/oprd/PLANS/Pages/ORORDA.aspx

recreate. About 30 percent of Marion County and Oregon residents participate in beach activities at lakes, reservoirs, and rivers, and 3 percent of the visits in Oregon occur in Marion County. For power boating and personal water craft use, up to 7 percent of the user occasions occur in Marion County. These data demonstrate that people in Marion County engage in many forms of freshwater-related recreation, and people throughout Oregon come to Marion County to participate in these activities.

State Parks

There are three Oregon State Parks within the North Santiam watershed: Detroit Lake State Recreation Area, North Santiam State Recreational Area, and Mongold Day Use Area. Detroit Lake State Recreation Area has recorded average annual day-use visitation of 110,000 visitors and overnight visitation of approximately 82,000 over the 5-year period 2013-2017.[71] Figure 6 displays day-use visitation for the months June through September at Detroit Lake Recreation Park between 2005 and 2017. North Santiam State Recreational Area recorded average annual day-use visitation for 2015 to 2017 of 72,000 visitors and overnight visitation of approximately 2,400 (camping is available during May through September only).[72] Visitation data are not available for Mongold State Day Use Area, but day-use visitation is thought to be similar to levels at Detroit Lake Recreational Area.[73] As we understand, overnight visitors are likely at least partly counted in the day-use totals for these recreational areas. Based on this information, we estimate annual visitation to the two state parks with visitor counts at approximately 182,000 visitors per year.

Figure 6. Visits to Detroit Lake State Recreation Area



Source: Oregon Parks & Recreation Dept Visitor Counts for Detroit Lake State Recreation Area

[71] Based on Oregon Parks & Recreation Department data for 2005-2017.

[72] Based on Oregon Parks & Recreation Department data for 2015-2017.

[73] Personal communication with Oregon Parks & Recreation Department on August 9th, 2018.

County Parks

Marion County Parks and Recreation maintains several parks in the NSW. The parks offer picnic sites, water activities, trails, and other amenities. Most parks are day-use only, but one (Bear Creek) includes a campground.

Marion County collects fees at three of the parks: North Fork, Bear Creek and Salmon Falls. All three of these parks are on the Little North Santiam River. As a result of the fee collection system, the County tracks visitation at these parks, as shown in Table 16. There are no visitation data available for any of the other Marion County parks, but the County notes that Niagara Park attracts the most visitors of any other Marion County park in the area. Based on these data, we estimate annual July through September visitation of 14,350 at the three parks with visitor counts.

Table 16. Visitors at Three Marion County Parks, 2017

	July	August	September	Total
North Fork	3,451	3,409	1187	8,047
Bear Creek	1,124	998	210	2,331
Salmon Falls	1,796	1,551	627	3,973
Total	**6,370**	**5,957**	**2,023**	**14,350**

Source: Email from Marion County Parks on August 9th, 2018

Bureau of Land Management Lands

The Bureau of Land Management manages a number of recreation areas within the North Santiam watershed. These include Fishermen's Bend, Elkhorn Valley, Canyon Creek, and other dispersed areas along the Little North Santiam River. The BLM collects data on the number of recreational visits, the types of recreational activities visitors pursue, and the amount of time visitors spend on the land it manages. For 2017, the BLM reports approximately 140,000 visits to BLM lands and recreational sites in the North Santiam watershed. A "visit" is a trip of any length—an hour, a day, a week—by an individual to BLM land for recreational purposes.

The BLM also prepares annual estimates of the number of participants in a variety of recreational activities and reports participation levels in these activities in units of "visitor days"—defined as aggregated 12-hour periods of time. Table 17 shows a total of 170,484 visitor days spent in a variety of recreational activities, with camping and picnicking representing over 80 percent of the time spent on BLM lands.

Table 17. Visitation at BLM-Managed Sites in the North Santiam Region, 2017

Activity	Participants	Visitor Days
Camping and Picnicking	130,071	137,229
Fishing	67,846	12,188
Hiking/Walking/Running	63,319	5,758
Nature Study/Environmental Education	35,428	2,342
Biking – Road and Mountain	34,125	2,965
Viewing Wildlife, Flowers, Scenery	26,157	1,271
Swimming	24,108	3,736
Row/Float/Raft	18,296	1,560
Specialized Sport/Event (Non-motor)	10,893	908
Other	10,421	1,081
OHV	2,948	786
Hunting	1,531	660
Total	**425,143**	**170,484**

Source: ECONorthwest based on data from the BLM's Recreation Management Information System (RMIS)

U.S. Forest Service Lands

The majority of the land upstream of Detroit Lake is forested and managed by the U.S. Forest Service. The majority of this land lies within the Willamette National Forest, with some lying in the Mt. Hood National Forest. Developed USFS sites and trailheads are generally located along waterways.

Visitation data for national forests is collected by the USFS through visitor surveys.[74] Visitation data is generally reported at the scale of the entire national forest, and the USFS has been unable to provide data on the visits that occurred on the portion of national forest land within the North Santiam watershed. Therefore, we estimate visitation levels for the NSW based on broad data from the Willamette National Forest (WNF), which stretches 110 miles north to south along the western ridge of the Cascade Mountains (see Table 18).

Table 18. Visitation to Willamette National Forest

Category of Visitation	Number of Visits
Total Estimated Site Visits[1]	**1,387,000**
Day Use Developed Site Visits	522,000
Overnight Use Developed Site Visits	161,000
General Forest Area Visits	599,000
Designated Wilderness Visits	105,000
Total Estimated National Forest Visits[2]	**938,000**

Source: USDA Forest Service National Visitor Use Monitoring retrieved from https://apps.fs.usda.gov/nvum/results/A06018.aspx/FY2012
Note: [1]A Site Visit is the entry of one person onto a National Forest site or area to participate in recreation activities for an unspecified period of time. A National Forest Visit is defined as the entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. [2] A National Forest Visit can be composed of multiple Site Visits.

We scaled annual visitation in the WNF to visits on USFS lands in the NSW based on the average number of visits per acre in the WNF. There were 938,000 visits across nearly 1.7

[74] U.S. Department of Agriculture. "USDA Forest Service National Visitor Use Monitoring" Accessed May 3, 2018 from: https://apps.fs.usda.gov/nvum/results/A06110.aspx/FY2012.

million acres in the WNF in 2012, for an average of .56 visits per acre. This equates to about 164,000 visits to the 292,627 acres of national forest within the NSW each year.

River Recreation—Privately Guided Fishing and Boating Trips

The North Santiam supports a multi-season river-based recreation industry. A variety of businesses, some based within the watershed and some based elsewhere, provide equipment rentals, transportation, and guided trips. Guided kayaking, rafting, and fishing (both fly fishing and bait-and-tackle) attract visitors from outside of the local area. Fishing trips, in particular, have attracted people from across the U.S., drawn to the North Santiam's fishing opportunities. No comprehensive data are available across this industry in the region. Information from representatives from this industry, however, suggests that there are over a dozen businesses that provide trips on the North Santiam (some based outside of the area), with five hundred to possibly a thousand individual participants and a number of large events each year. Because this industry uses public boat launches, the recreation usage should largely be included in visitation data reported by public agencies.

Breitenbush Hot Springs

Breitenbush Hot Springs is a private retreat and conference center located approximately 10 miles from Detroit on the Breitenbush River, which flows into Detroit Lake. The Center hosts overnight guests and day-use visitors throughout the year. Guests are drawn to the many natural amenities of the area—the hot springs, the river, the forest—as well as the lodging and other services provided by the facility. Information provided by Breitenbush personnel indicates that visitation is approximately 32,000 guest nights per year, with 130 overnight guests per day during the summer months and 90 overnight guests per day during the rest of the year and an average of 20 day-use only guests per day.[75]

Camp Taloali

Founded in 1973 as a camp for deaf and hard-of-hearing children, this camp located on the North Santiam River continues to provide summer camp opportunities to this community. It also hosts other camp programs, private events, and recreation events throughout the year for the larger population. During the summer, the facility averages 100 to 150 people a day, and larger international events attract up to 3,000 attendees.[76]

3.3.2 Economic Importance

Recreation in the NSW has many economic dimensions. For example, studies show that recreation generates local expenditures for items such as food, lodging, supplies, gas, equipment, and fees for guides and outfitters. These expenditures help support local economic activity. Recreation opportunities also attract new residents and firms, who bring income and

[75] Interview with Peter Moore, Breitenbush Hot Springs, on August 15th, 2018, and Personal email from Breitenbush Hot Springs on August 14th, 2018.

[76] Personal communication with Janet Johanson, Chairperson, Camp Taloali Board of Directors. December 3, 2018.

economic opportunities with them. These types of effects are generally called the *economic impacts* of an activity.

To those engaged in recreational pursuits, the recreational opportunities increase overall well-being. We report these benefits as *economic value,* which is a measure used in benefit-cost analyses to weigh the tradeoffs associated with a policy or decision. Economic value is calculated as the willingness to pay minus the cost of participating in an activity. Table 19 summarizes results from research on the economic value of a variety of outdoor recreation activities in the Pacific Northwest. For example, the average economic value of nonmotorized boating is $116 (2018 dollars) per person per day. These values can be used to estimate the economic value associated with annual recreational visitation.

Table 19. Estimates of the average daily economic value of recreation benefits by primary activity in the Pacific Northwest, 2018 dollars

Primary Activity	Rounded Dollars
Backpacking	$35
Biking	$92
Cross-country skiing	$60
Developed camping	$38
Downhill skiing	$87
Fishing	$76
Hiking	$90
Hunting	$82
Motorized boating	$62
Nature related	$64
Nonmotorized boating	$116
OHV or snowmobiling	$54
Other recreation	$69
Picnicking	$52
Weighted Average	**$73**

Source: Rosenberger, R.S.; White, E.M.; Kline, J.D.; Cvitanovich, C. 2017. *Recreation economic values for estimating outdoor recreation economic benefits from the National Forest System*. Gen. Tech. Rep. PNW- GTR-957. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

The information agencies collect about recreational visitation on public lands in the NSW is not complete. For example, county and state parks do not even track visitation at some of the parks, and we have not attempted to estimate usage at the parks without data. Table 20 shows estimated visitation on public lands in the NSW of approximately 500,000 visitors per year. We emphasize that these are estimates—and likely underestimates—of use.[77] Using the data on the economic value of recreational activities, above, we estimate the overall value associated with recreational visits within the NSW, based on a weighted average value per day of $73. This yields a total value of about $36.5 million (in 2018 dollars).

[77] County Parks tracks usage at only 3 of the 6 parks in the NSW, and the park with the highest usage has no visitation tracking. State Parks does not track usage at one of the three parks. We have excluded overnight visitation estimates, as they may be partly included in the day-use estimates. USFS estimates are based on scaling down data from the Willamette National Forest.

Table 20. Estimated Annual Recreational Visitation on Public Lands in the North Santiam Watershed and Associated Economic Value (2018 Dollars)

	County Parks	State Parks	BLM Lands	USFS Lands	Total
Estimated Annual Visitation	14,350	182,000	140,000	164,000	500,350
Economic Value	$1,048,000	$13,286,000	$10,220,000	$11,972,000	$36,526,000

Source: ECONorthwest

Research conducted by economists at Oregon State University on the Willamette River Basin reservoirs used a travel cost method to estimate the value of recreation at these locations, and correlate recreation demand with levels in the reservoir. The study found that reservoir level positively correlated with demand: for every foot of drop in water level below full pool, visitor days declined by 2 percent.[78] The researchers found that the estimated value of each acre-foot of stored water at Detroit Lake for reservoir recreation use is $11 per month.

Economic Contribution of Recreation to the Economy

While this report does not focus on the jobs and incomes associated with water use in the NSW, during the course of our interviews with business owners engaged in providing recreation services including resort management and guided boating and fishing, we heard that recreation-related spending bolsters the economies of communities within the NSW. The leisure and hospitality sector accounts for 16 percent of employment in the North Santiam Canyon communities, employing over 200 people. Recreation drives economic activity in other sectors, including Government; and Trade, Transportation, and Utilities, through spending on retail goods, and via fee and tax payments to support ongoing management of recreation facilities. Breitenbush Hot Springs generates over $5 million in annual revenues. These revenues ripple through the local economy through purchases from local supplies and through wages paid to staff, who also spend money locally. Visitors to Breitenbush also make local expenditures in the communities in the North Santiam Canyon communities in conjunction with their visits. The same is true for visitors to Camp Taloali and other private facilities with identities closely linked to the water resources in the NSW.

3.3.3 Expected Future Trends in Demand and Value

Studies show that demand for outdoor recreation, in general, is expected to grow into the future. A variety of factors influence demand for recreation. Population growth is a primary driver of overall demand, and expected population growth in Oregon will result in higher levels of demand for recreational uses of land and water resources. We expect demand to grow in the NSW for this reason as well. Quality of recreation experience also drives demand. Factors that influence quality of recreation in the NSW include reservoir levels, water quality, fish abundance, and availability and upkeep of infrastructure.

[78] Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation*. Oregon State University.

A national assessment of recreation trends found that even with overall growth in recreation participation, some types of recreational activities are expected to grow more quickly than others.[79] Some activities are expected to become more popular on a per capita basis while others are expected to become less popular on a per capita basis. After accounting for population growth, however, the number of people participating in most outdoor recreation activities will continue to grow.

Table 21 summarizes forecasts of participation levels for several recreational categories. In each of these categories, recreational use is expected to increase, although at different rates depending on the type of use. These are national trends, but they are also relevant for understanding trends in the NSW.

Table 21. U.S. Participation Forecasts, Select Recreational Activities, 2008-2060

Activity	Forecast
Developed Camping & Picnicking	Participation rate will keep pace with population, with an overall increase in the number of participants of 42 to 77%.
Motorized Water Activities	Forecasts range from keeping pace with population to a 15% per capita increase in participation, for an overall increase of 41 to 81%.
Fishing	Participation rate will decline, but the overall amount of participation will increase by 28 to 56% due to population growth.
Swimming	The number of adult participants will increase slightly faster than the rate of population growth, for an overall increase of 47 to 85%.
Canoeing, Kayaking, Rafting	Projections range from an increase slightly less than to more than the rate of population, with overall participation increasing 30 to 62%.

Source: ECONorthwest, based on Cordell (2012)

The Oregon Statewide Comprehensive Outdoor Recreation Plan (SCORP, 2013-2017) found that recreation trends in Oregon followed similar patterns as the nation, with developed camping more popular in Oregon and swimming and fishing less popular.[80] The most recent survey of Oregonians, conducted in 2017, found that when asked about their priorities for future state investment both within and outside their communities, Oregon residents identified access to waterways and nature and wildlife viewing areas among their top demands.[81]

A 2013 study of recreation use in NSW at Detroit Lake provides a limited snapshot of trends within the region. The study identified crowding as a concern for visitors, with indications that day-use areas were experiencing "high normal" levels of crowding, and overnight areas at

[79] Cordell, H.K. 2012. *Outdoor recreation trends and futures: a technical document supporting the Forest Service 2010 RPA Assessment*. Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

[80] Oregon Parks and Recreation Department. 2012. *2013-2017 Statewide Comprehensive Outdoor Recreation Plan.* Retrieved October 3, 2018, from https://www.oregon.gov/oprd/PLANS/docs/scorp/2013-2018_SCORP/2013-2017_Oregon_SCORP.pdf

[81] Bergson, T. 2018. *2017 Oregon Resident Outdoor Recreation Survey.* 2018-2022 Oregon Statewide Comprehensive Outdoor Recreation Plan Supporting Documentation. Oregon Parks and Recreation Department. February 22. Retrieved October 3, 2018, from https://www.oregon.gov/oprd/PLANS/docs/scorp/2017_Oregon_Resident_Outdoor_Recreation_Survey.pdf

"more than capacity." In addition, approximately 75 percent of visitors surveyed expressed support for more opportunities to escape crowds.[82] Other factors that influence the quality of recreation in the NSW include reservoir levels and quality of water at Detroit Lake and downstream in the North Santiam. An analysis of visitation found that across all the Willamette Valley projects a one-foot decrease in water levels was associated with a 0.3 percent decrease in visitation.[83] During algae blooms that produce toxins, the Oregon Department of Health recommends reducing contact with the water. To the extent that reservoir levels are lower for longer periods during the summer recreation season, and toxic algae blooms increase in frequency or duration, the value of recreation in the NSW likely will decrease and users will look elsewhere for opportunities.

The economic value associated with recreational opportunities is influenced by a number of factors, including the overall quality of the recreation site and the relative abundance or scarcity of such opportunities. Rising incomes and increasing population growth in the Willamette Valley and Portland metro region are likely to lead to increased values for high-quality recreational opportunities. The conclusions of a report written by researchers in 1951 at Oregon State College (before it was designated Oregon State University) about the utilization of resources in the Little North Santiam River Basin still hold today:

> *"As the urban centers of the Willamette Valley grow, this accessible basin with its forest, streams and wildlife will be increasingly used by the people from these more crowded areas."*[84]

3.4 Aesthetics

Water in the NSW provides value by enhancing resident's and visitors' experience of their surroundings. This category of value is often referred to as aesthetic value. OWRD has identified aesthetic use as a beneficial use for water rights, defining it as the use of water for scenic, beautification, and enhancing the appeal of an area. However, a water right is not required to generate aesthetic use value: instream flows in the North Santiam and its tributaries also support this use and value. Aesthetic values can sometimes be difficult to disentangle from demand for other amenities provided by waterways, such as passive recreation and fish and wildlife habitat, discussed in more detail in Sections 4.2 and 4.3.

3.4.1 Current Demand

Demand for aesthetic resources tied to water is typically most strongly expressed through the market for property nearby waterways. While demand for these properties is often also driven

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[82] Bergerson, T. and W. Mouw. 2013. Visitor Survey of Day-use and Overnight Visitors at Detroit Lake State Recreation Area. Oregon Parks and Recreation Department. p. 45.

[83] Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation.* Oregon State University.

[84] Jenson, J.G., and R.M. Highsmith. 1951. *The Little North Santiam River Basin: Its Resources and Their Utilization.* Oregon State College, School of Science.

by easier access to recreation opportunities, especially in popular recreation areas, part of the appeal comes from the views and natural setting provided by the river and riparian ecosystem.

A detailed analysis of the quantity and characteristics of properties adjacent to the river is beyond the scope of this report. Marion and Linn County assessor records indicate that private property abuts the North Santiam River from Idanha to Jefferson. Many of these parcels are divided in ways to maximize the number of lots with river front access (i.e., they are long and skinny), and some include homes that serve as primary or secondary residences. Some of these riverfront lots, especially in the communities in the North Santiam Canyon, appear from assessor records to be undeveloped. This may indicate that demand for developing river front property in the NSW is weak, or, more likely, that other attributes which would affect demand for residences in the NSW, such as access to services and infrastructure, are underdeveloped. Further study would be required to determine all of the multiple factors driving demand for residential development of riverfront property in the NSW, and how aesthetic characteristics factor into this demand.

Though Detroit Lake is a popular recreation amenity in the NSW, there are few private residential properties with lake frontage, because of the topography and land ownership patterns surrounding the reservoir. These are concentrated in the community of Detroit. Development on these parcels tends to be modest, with real market value estimated in the range of less than $100,000 to (a few) around $600,000.[85] As with riverfront property throughout the watershed, some of the parcels are not developed.

Markets for river-front property in the NSW do not appear to be robust. However, some evidence indicates that people are choosing to live in communities close to the North Santiam River, even though they work in Salem and elsewhere, and incur extra costs of commuting. Census data describing commuting patterns reveal that in Lyons, where median household incomes are among the highest in the NSW, 20 percent of workers commute to Salem, and almost 50 percent of workers commute more than 10 miles to work.[86] The relationship between environmental amenities, including of water-related resources (especially lakes), on household location decisions, quality of life, and economic growth has been well-documented in the literature,[87] and it seems likely that at least some of the people who work in Salem and live in places like Lyons and Mehama are choosing to do so in part because of the aesthetic values provided by the waterways and water-related ecosystems.

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[85] Marion County Assessor's Office. 2018. *Property Records Database* (Access via interactive map). Retrieved October 3, 2018, from http://www.co.marion.or.us/AO/

[86] U.S. Census Bureau. 2015. "Job Counts Where Workers Live." *On the Map*. Retrieved October 3, 2018, from https://onthemap.ces.census.gov/

[87] *See*, e.g., Hill, E., J. Bergstrom, K. Cordell, and J.M. Bowker. 2009. *Natural Resource Amenity Service Values and Impacts in the U.S*. A Demographic Research Report in the IRIS Series. U.S. Department of Agriculture, Forest Service. April. Retrieved October 3, 2018, from https://www.srs.fs.usda.gov/trends/pdf-iris/IRISDemo2rptfs.pdf

The NSW also supports aesthetic uses in Mill Creek, which is a tributary to the Willamette River. Water is diverted from the North Santiam River into Salem Ditch, and enters Mill Creek upstream of Aumsville. During the dry summer season, water from the NSW substantially augments flows in Mill Creek. Demand for aesthetics along Mill Creek are particularly strong, as it flows through Oregon's capitol grounds and, via the Mill Race, through the campus of Willamette University. These waterways are enjoyed by employees, residents, and visitors to Salem, especially during the summer months when people spend more time outside. The timing of relatively higher demand coincides with the period when flows from the NSW make up a greater share of Mill Creek's flow.

3.4.2 Economic Importance

A detailed review of the effect of rivers, streams, and canals on property values indicates that there is generally a positive relationship between proximity to a linear waterway and property values. These relationships are generally stronger in urban settings than in rural settings.[88] For example, research in Portland (OR) found that location within a quarter-mile of a creek was strongly associated with property prices. The effect diminished for properties more distant, and was insignificant when the distance reached a mile.[89] Across the studies reviewed, the premium associated with river views for property in urban settings was typically in the range of 10 to 30 percent. These values are likely most appropriate to indicate the potential value of aesthetic benefits to properties enhanced by Mill Creek in Salem.

In rural settings, the effect of river view/access was less definitive. The authors conclude that the supply of aesthetic amenities in rural areas tends to be higher, so there is relatively less scarcity for these kinds of amenities. Property adjacent to reservoirs also benefits from the aesthetic qualities of views and natural surroundings. Fluctuations in reservoir levels, and thus the aesthetic quality of the surroundings, tend to temper the effect.[90]

3.4.3 Expected Future Trends in Demand and Value

Increasingly, people are able to live further from their place of work, because access to communication networks, technology, and workplace culture (i.e., working fewer days per week and working remotely) reduces the cost of commuting. For this reason, the proportion of households able to relocate to places they enjoy being, because of their aesthetic and amenity value, may increase over time. This would increase the demand for, and value of the aesthetic resources provided by the NSW. Future actions that affect the pattern, timing, and magnitude of

[88] Nicholls, S. and J.L. Crompton. 2017. "The Effects of Rivers, Streams, and Canals on Property Values." *River Reservoir Applications.* 2017(33): 1377-1386. Retrieved from https://rpts.tamu.edu/wp-content/uploads/sites/21/2015/05/The-Effect-of-Rivers-Streams-and-Canals-on-Property-Values.pdf

[89] Netusil, N.R., M. Kincaid, and H. Chang. 2014. "Valuing water quality in urban watersheds: A comparative analysis of Johnson Creek, Oregon and Burnt Ridge Creek, Washington." *Water Resources Research* 50(5): 4254-4268.

[90] Loomis, J. and M. Feldman. 2003. "Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method." *Water Resources Research* 39(9):1259.

reservoir levels in Detroit Reservoir may adversely impact property values adjacent to the lake, to the extent they increase periods of drawdown.

3.5 Electricity Generation

Development of Detroit and Big Cliff Dams in the 1950s added the capacity to use the water in the NSW for electricity generation. In this section, we describe the demand for electricity from the Columbia River system, generation capacity, and value of power generated from these hydropower facilities.[91]

3.5.1 Current Demand

Detroit Dam and Big Cliff Dam are operated by the U.S. Army Corps of Engineers and are considered part of the Federal Columbia River Power System. Power generated by these facilities is transported and marketed by Bonneville Power Administration. Detroit Dam has two generators, which at full production can produce 100 MW. Big Cliff Dam has one generator which at full production can produce 18 MW. Together, generators at Detroit and Big Cliff generated 405 GWh of electricity in 2017. The amount of electricity generated in any given year fluctuates based on flow conditions and reservoir operations. Demand for the power generated from these facilities comes from residential, commercial, and industrial customers in Oregon, Washington, and California.

In addition to these two large federal dams, Breitenbush Hot Springs operates a hydroelectric facility on the Breitenbush River which is used to provide power to the resort. Demand for this power comes directly from Breitenbush customers and owners and all power is consumed on site. The Santiam Water Control District operates a small hydropower project as well (less than 5 MW), and is in the process of licensing additional generation capacity.

3.5.2 Economic Importance

According to the USACE, the value of the power generated in 2017 was $7.8 million. Generating electricity via hydropower does not emit significant carbon dioxide emissions, thus another value of generating hydropower is in avoiding CO_2 emissions associated with climate change.[92] Applying the social cost of carbon of $48 per metric ton of CO2 (adjusted to 2018 dollars), used by the Northwest Power and Conservation Council in its *Seventh Northwest Conservation and Electric Power Plan*, the annual value of avoided CO_2 emissions at these power generation rates is $19.8 million.

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[91] This section focuses on the values associated with hydropower production, and does not address the potential opportunity costs and direct costs associated with the dams. For example, it does not capture the value lost due to more limited opportunities for whitewater kayaking, or the cost of the dams in terms of diminished fish populations. Evaluating these opportunity costs is beyond the scope of this report, but could be explored in future research.

[92] Generating electricity with hydropower generates costs not reflected in these values, including the costs related to harm to fish: reduced value of commercial and recreational fisheries, nonuse values, and the costs required to manage and mitigate harm via ESA listing decisions.

Table 22. Amount and Value of Power Generated at Big Cliff and Detroit Dams

	GWh Generation	Value[1]	Avoided CO2 Emissions (k-ton)	Value of Avoided CO2 Emissions
Detroit Dam	315.4	$6,129,000	321	$15,408,000
Big Cliff Dam	90.1	$1,716,000	92	$4,416,000
Total	**405.5**	**$7,845,000**	**413**	**$19,824,000**

Source: Federal Columbia River Power System. FY 2017 Hydro Generation statistics.
Notes: [1] Represents the yearly value at daily net price.

3.5.3 Expected Future Trends in Demand and Value

According to the Northwest Power and Conservation Council's electricity demand analysis in its *Seventh Northwest Conservation and Electric Power Plan*, demand for electricity is increasing, but at lower rates than have occurred historically. The Council estimates that regional demand will grow by 1,800 megawatts between 2015 and 2035, with increases of between 90 and 220 megawatts per year. The Council expects to meet these increases with efficiency improvements, rather than new generation capacity. While demand for electricity overall may be increasing at a diminishing rate, the demand for low-carbon electricity is likely to increase as regional, national, and international carbon regulation policies restrict the use or increases the cost of high-carbon generation options. Thus, the overall value of the electricity produced in the NSW is likely to increase over time, especially as the real value of avoiding CO2 emissions increases each year as the social cost of carbon rises with concentrations of CO2 in the atmosphere.

3.6 Municipal and Industrial

The NSW supports municipal and industrial demands for water both within and outside the watershed. Water from municipal systems provides water for many purposes, including household demands (e.g., drinking, cooking, bathing) to commercial demands (e.g., food preparation, sanitation), to industrial demands (e.g., cooling, production, and sanitation). Water from municipal sources also serves an important public health and safety purpose when it is used for fire suppression and street sweeping. Finally, water from municipal systems is used to irrigate lawns and landscaping, which provides aesthetic benefits on public and private properties. The value of municipal and industrial water supply is a combination of the infrastructure investment and the water itself. The water would not have the same utility without treatment and distribution infrastructure. The treatment and distribution infrastructure would be useless without water at sufficient quantity and quality. The NSW contributes the water, but clearly investment in infrastructure is critical for households and businesses to generate economic value from water. We discuss demand for and importance of both in the following subsections.

3.6.1 Current Demand

There are eight communities which use water directly from the North Santiam or nearby groundwater as their primary municipal water source (Mill City is the only municipality which uses groundwater as its primary water source). In addition, three communities use water drawn from the Santiam that includes a mix of water from the North Santiam and South Santiam Rivers. Table 23 shows the characteristics of use for the communities that rely on water from the

NSW (excluding those that use a significant proportion of water from the South Santiam as well). Of these, Salem is by far the largest user of water from the NSW, and correspondingly has the largest water right.

Table 23. Characteristics of Municipal Systems that Rely on Water from the NSW

Community	Number of Connections	Average Annual Water Use (Gallons)	Percent of Total Use	Maximum Water Rights Available (Million Gallons)
Communities within the NSW (Listed West to East)				
Stayton	2,700	698,100,000	4.06%	1,825
Lyons-Mehama	855	56,000,000	0.33%	927
Mill City	830	131,400,000	0.76%	420
Gates	239	25,600,000	0.15%	401
Detroit	393	28,300,000	0.24%	217
Idanha	90	5,100,000	0.03%	91
Communities that Use Water From the NSW				
Salem	49,304	16,253,000,000	94.4%	56,210
Turner	798	With Salem	-	With Salem
Total	**55,209**	**17,197,500,000**	**100%**	**-**

Source: ECONorthwest, with data from personal correspondence and community websites.
Note: This table does not include Jefferson, Albany, and Millersburg. While these cities use water from the North Santiam, it is mixed with water from the South Santiam, and data were not available to describe the amount of water used exclusively from the North Santiam. Excluding these communities underestimates the use and importance of water from the NSW for municipal and industrial use.

The largest 100 municipal users of water for Salem are available in a 2016 report.[93] This listing of customers provides a snapshot of the types of demand for Salem's water. The largest customer is a wholesale customer (Suburban East Salem Water) that supplies water to households and businesses. Apart from that, all of the users in the top 10 are food processors and large institutions: Oregon Department of Corrections is the largest individual user of Salem's water, followed by Creekside Golf Operations, Rainsweet (a processor of local fruits and vegetables), Kettle Foods, Willamette University, and Oregon Cherry Growers. Many of these food processors are located in Salem because of their proximity to the crops they use as inputs to their products. For example, the Willamette Valley Fruit Company paid growers in the region $15 million in 2018 for fruit they processed.[94] Similarly, In Stayton, NORPAC Foods is the largest single user of water at 319,037,000 gallons per year, roughly half of the city's total use. The presence of these large industrial water users in Salem and Stayton reinforces the conclusions in the previous section that water used for agriculture is closely linked to other demands for water, including municipal and industrial sources.

3.6.2 Economic Importance

There are a variety of approaches to describe the economic importance of water supply from municipal and industrial sources. As discussed in the introduction to this section, demands from these customers are supplied through a combination of investment in infrastructure and investment in the water itself. To produce the highest utility from this water, it must be supplied reliably at a high quality. This requires ongoing investment in the treatment and distribution infrastructure, but also in planning for water scarcity and quality issues that arise at

[93] Garlinghouse, K. 2016. Top 100 Water Customers for July, August, and September 2016. City of Salem, Oregon.

[94] Personal communication with Dave Dunn, Willamette Valley Fruit Company. October 18, 2018.

the source: within the NSW. Determining the optimal level of investment in each of these aspects of municipal and industrial water supply lies at the heart of many of the difficult decisions that managers must make, and for which we hope this report will provide useful information.

One way to describe the economic importance of the municipal and industrial water is to identify what its customers pay to receive it. In theory, this cost covers the annual cost to secure and maintain both the water supply at its source, and the infrastructure required to deliver it to customers. In fact, these costs may not always be aligned because financial planning for infrastructure investments is a long-run process, and water rates may not always be in step with current and expected future costs. More often, they reflect past costs of investment to cover financed capital costs, as well as annual operation and maintenance activities. Table 24 shows that customers pay an estimated amount of about $66.8 million per year to use water from their municipal providers. This cost is made up of a fixed base charge, which typically varies by type of user (though we use a flat residential rate assumption due to data limitations) and a variable charge for water (we also make simplifying assumptions for the rate we apply here: in reality, it typically decreases or increases by quantity of use). This total annual charge for water should be viewed as consistent with the scale of value, as estimated by the cost to provide water to customers, and is just one indication of the value of municipal and industrial water supply.

Table 24. Annual Water Rates and Estimated Charges to Municipal Customers (2018 Dollars)

Community	Annual Base Charge (Residential)	Number of Connections	Water Rate (Per 1,000 Gallons)	Annual Water Use (1,000 Gallons)	Total Annual Charge for Water
Communities within the NSW (Listed West to East)					
Stayton	$289.44	2,700	$1.18	698,100	$1,605,246
Lyons-Mehama	$387.00	855	$1.50	56,000	$414,885
Mill City	$192.00	830	$3.61	131,400	$633,632
Gates	$538.20	239	$3.00	25,600	$205,430
Detroit	$660.00	393	$1.50	28,380	$301,830
Idanha	$636.48	90	$2.85	5,100	$71,818
Communities that Use Water From the NSW					
Salem	$92.64	49,304	$3.50	16,253,000	$61,492,526
Turner	$270.00	798	-	With Salem	$215,460[1]
		(Total) 55,209	**(Average) $2.45**	**(Total) 17,197,500**	**(Total) $66,879,968**

Source: ECONorthwest, with data from personal correspondence and community websites.
Note: We have standardized data to rate per gallon. Actual rates are often in terms of cost per hundred cubic feet or ccf. This table does not include Jefferson, Albany, and Millersburg. While these cities use water from the North Santiam, it is mixed with water from the South Santiam, and data were not available to describe the amount of water used exclusively from the North Santiam. Excluding these communities underestimates the use and importance of water from the NSW for municipal and industrial use.
[1] Only includes base charge. Water use rate included with Salem due to data limitations.

Another way to look at the value of water for municipal and industrial sources is to ask people what they would be willing to pay to avoid going without water under different circumstances. Economists who value water supply reliability have done just that. In a study that evaluated water supply reliability among residential customers in five communities throughout the U.S.,

researchers asked people what they would be willing to pay to avoid two stages of water use restrictions:[95]

- Stage 1 restrictions included limitations on outdoor irrigation, filling swimming pools, and using ornamental water features.
- Stage 2 restrictions included mandatory prohibitions of outdoor uses of water, and some water rationing for other uses.

In all communities but one, people were not willing to pay to avoid Stage 1 restrictions. This suggests people have some willingness to accept temporary water use restrictions for some uses. However, when faced with mandatory restrictions, households were willing to pay between $23 and $42 (in 2018 dollars) per year, for each year of avoided Stage 2 restrictions. Using population data from Table 4 and 2.75 people per household, which was the average household size in Marion County in 2017, there are 85,421 households that depend on water from the NSW. This yields a value of between $2.0 and $3.6 million that residential households in the NSW would be willing to pay to avoid curtailment of some uses of water in a year. If these curtailments were more extreme and required mandatory water rationing of all uses of water, these values would be higher.

This finding only applies to residential customers. The value commercial and industrial customers would be willing to pay would depend on the expected loss of revenue or costs incurred resulting from water supply curtailments. These are specific to each business, and depend on how sensitive the business is to water supply disruptions. This sensitivity depends on the nature of the disruption (quality, quantity, or both), how long the disruptions last, how prepared the business is to manage disruptions (e.g., do they have a backup water supply), and what kind of risks accompany the disruption (water supply disruptions due to quality issues may come with additional risks and costs, especially for businesses involved in food processing or service).

Additional research would be required to determine the potential economic value of reduced water reliability for the commercial and industrial customers dependent on water from the NSW. During our interviews, one business offered their perspective on this issue, however. The NORPAC facility in Stayton relies on water from the NSW for their freezer defrost cycle. NORPAC estimates the replacement cost of alternative sources of cooling at $2 to $3 million. This represents just one portion of NORPAC's operations that relies on water from the NSW: the total cost they could incur related to water curtailments is likely much higher.

[95] Raucher, R.S., J. Clements, C. Donovan, et. al. 2013. *The Value of Water Supply Reliability in the Residential Sector.* WateReuse Research Foundation, Bureau of Reclamation, and San Francisco Public Utilities. Retrieved October 5, 2018, from https://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/research/value_water_supply_reliability.pdf

Economic Contribution of Investments in Municipal Water Supply Infrastructure to the Economy

Many studies have explored the relationship between investments in public infrastructure, including water supply infrastructure, and economic growth. With few exceptions, they have found a positive relationship: public spending on infrastructure increases the productivity of private capital investment. One nationwide study found that investments in water and sewer systems provide greater returns than other public investments, such as highways.[96]

3.6.3 Expected Future Trends in Demand and Value

The Willamette Water 2100 project predicts that urban water demand will increase, driven both by overall population growth and expected increases in household income, which tends to positively correlate with increased water use.[97] While existing water supplies and water rights appear to be sufficient to support current and expected future population growth in communities dependent on water in the NSW, several issues may increase the risk of water supply shortages in the future:

- The frequency and magnitude of droughts may increase with climate change, as described elsewhere in this report, and in the NSW's *Drought Contingency Plan*.[98] This increases the risk of shortages and increased competition among water rights holders for available water. OWRD has never had to make a call on junior water rights holders in the NSW, but is increasing its attention to the issue given the potential future prolonged drawdown of Detroit Reservoir, which may result in a "regulatory drought" for some period of time while the USACE makes modifications to the Dam to comply with the 2008 Bi-Op.
- The City of Salem's water supply intake requires a certain minimum flow to operate efficiently. Although Salem's priority date on its water rights is old, meaning other water users likely wouldn't have priority over Salem in times of water scarcity, the intake requires higher flows for the City to exercise its rights. Releases of stored water behind Detroit Dam augment natural summer flows, ensuring the intake operates properly in some years and supplies water of sufficient quality for the treatment plant to operate optimally.[99] Reduced flows due to real or regulatory droughts may require

[96] Krop, R.A., C. Hernick, C. Frantz. 2008. *Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Value to the National Economy.* August 14. Retrieved October 5, 2018, from https://www.cadmusgroup.com/wp-content/uploads/2012/11/Krop-et-al-2008-LocalGovt-InvtInMunicipalWaterandSewerInfrastructure.pdf

[97] Jaeger W.K, Plantinga A.J., Langpap C., Bigelow DP, Moore KM. 2017. *Water, Economics, and Climate Change in the Willamette Basin, Oregon*. OSU Extension Service Publication EM 9157.

[98] GSI Water Solutions, Inc and David Evans and Associates. 2017. *North Santiam Drought Contingency Plan.* North Santiam Watershed Drought Contingency Plan Task Force. July.

[99] Personal communication with Lacy Goeres-Priest, City of Salem Water Quality Supervisor, and Brent Stevenson, SWCD Manager.

Salem to make additional investments in its intake infrastructure to ensure it will be able to operate its water intake in the future.

- During the summer of 2018, algae blooms in Detroit Lake produced cyanotoxins that were concentrated enough downstream at the water intakes in the lower NSW that cities had to issue drinking water advisories for vulnerable populations. This meant that for some users, it was not safe to drink or use water from the tap. Some businesses opted to not serve water or food made with water until the advisory was lifted. Some food processors halted production until the risk of using contaminated water was better understood. Some businesses incurred costs related to additional testing of products to ensure safety before release to customers.[100] The City of Salem is beginning to study the factors that led to higher than average toxin levels, to better predict when they may cause problems to the water supply in the future. It is also studying potential investments to its treatment system to reduce toxin levels in finished water.

In addition to these factors that may increase the risk of water supply shortages, due to quantity or quality issues, many communities need to address aging infrastructure, to avoid future service disruptions from failing pipes, and increase the efficiency of their systems. For example, leaking pipes are a problem throughout the NSW that contribute to substantial loss of treated water. According to a report in 2014, 22.9 percent of Salem's water was lost within their system in FY 2011-2012 due to deteriorating infrastructure and compromised connections. Surveys are ongoing to repair any leaks detected through their monitoring program.[101] A large portion of Salem's unaccounted water is believed to be caused by the transmission line between Geren Island WTP and Turner Control.[102] The City of Detroit also has documented high water loss due to leaks. In 2018, they received a $3 million loan to begin repairs to fix the large water losses.[103] The City of Idanha also has documented leaks of 15.6 to 18.1 million gallons a year in 2007, which would be approximately 30 to 35 percent of the annual water use.[104]

Addressing these and other issues will require financial investments that water users may or may not be able to afford. Affordability challenges are especially acute in the North Santiam Canyon communities, where there are fewer customers among which to distribute new capital costs and debt burdens.

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[100] Poehler, B. and C. Radnovich. 2018. "Salem Water Crisis Puts Businesses Big and Small in a Bind." *Statesman Journal*. June 9. Retrieved from https://www.statesmanjournal.com/story/news/2018/06/09/salem-water-crisis-advisory-business-pinch/683704002/

[101] GSI Water Solutions, Inc. 2014. Water Management and Conservation Plan. Prepared for City of Salem, Oregon. November.

[102] Ibid.

[103] Personal conversation with Detroit Public Works on August 29th, 2018.

[104] Mid-Willamette Council of Governments. (2014). *North Santiam Canyon Economic Opportunity Study.*

3.7 Irrigated Agriculture

Both irrigated and non-irrigated agriculture occur in the NSW, and both require water to generate economic value. For irrigated crops, the water is diverted from surface or ground water and distributed to the crop. To a large extent, the water from the NSW is diverted outside the basin to irrigate crops to the north and south of the NSW. Non-irrigated crops rely on precipitation that falls within the NSW to grow. While non-irrigated crops require water and produce economic value associated with that water and we discuss these briefly, this section focuses on irrigated agriculture, because it is most vulnerable to changes in water supply, allocation, and competing demands for water. Comprehensive data about agricultural produce and land use are unavailable at the watershed scale, so we look to county data to describe broad trends in demand, use, and value in the NSW. We rely on private information provided by the two irrigation districts relying on NSW and one of the region's largest agricultural-industrial food processors to help fill in details on the value of agricultural production in the NSW specifically.

3.7.1 Current Demand

As described in Section 3, agriculture dominates land use in the western portion of the NSW. Two districts that provide water for irrigation have water rights to stored and live flows in the North Santiam River, and divert water for their customers. The Santiam Water Control District diverts water at Stayton to the north, within and outside of the NSW, and the Sidney Irrigation Cooperative diverts water to customers south of the river near Jefferson.

The most recent data available to describe agriculture at the county level in Oregon comes from the 2012 Agricultural Census, which the U.S. Department of Agriculture implements every five years. Data from the 2017 census are not yet available at the county level in Oregon.

Table 25. Selected characteristics of agriculture in Linn County and Marion County, Oregon

2012 Agricultural Census Characteristics	Linn County	Marion County	Linn & Marion	Oregon	% of Oregon
Farms	2,083	2,567	4,650	35,439	13.1%
Land in farms (acres)	331,316	286,194	617,510	16,301,578	3.8%
Average size of farm (acres)	159	111	135	460	-
Total cropland acres	227,547	213,788	441,335	4,690,420	9.4%
Irrigated acres	28,687	84,916	113,603	1,629,735	7.0%

Source: USDA Agricultural Census. "County Summary Highlights 2012: Oregon"

Table 25 presents selected data from the 2012 Agricultural Census for Marion and Linn Counties, and the state of Oregon. In 2012, about 13 percent of Oregon's farms were in Marion and Linn counties, but those farms included only about 4 percent of the total land in farms across Oregon. This is because the average size of a farm in Marion and Linn Counties tends to be smaller than the Oregon average (which makes sense, especially considering that farms and ranches in Eastern Oregon, where land is less productive, tend to be much larger). The average size of a farm in Linn and Marion counties is about 135 acres. Of the total land in farms in Linn and Marion counties (617,510 acres), 71 percent is cropland. About 25 percent of the cropland is

irrigated, and about 18 percent of the total land in farms is irrigated. This is a smaller percent than the entire state, where about 35 percent of all cropland is irrigated. Again, this makes sense: in the western valleys more crops can be grown without irrigation because of the overall amount of precipitation the area receives during the wet October to April period. In the Willamette valley, the irrigation season typically lasts from April to October. The proportion of cropland that is irrigated is higher in Marion County (almost 40 percent) than in Linn County (12 percent). This is because crop production in Linn County is weighted toward sod and grass seed, which tends to be unirrigated.

According to data from the USDA, there are just over 26,000 acres of cropland within the boundary of the NSW. However, just like for municipal use, water is diverted outside the boundaries of the NSW for irrigation. Much of this land is located within two districts withdrawing water from the NSW for irrigation: the Santiam Water Control District (SWCD), which diverts water to the north of the NSW and the Sidney Irrigation Cooperative (SIC), which diverts water to the south. Table 26 provides data for farms within these districts. Between the two of them, there are 23,867 acres of irrigated land.

Because of the complexity of accounting for irrigated cropland both within and outside the NSW, and the risk of double-counting across the available data sets, we were unable to estimate exactly how many acres of cropland are irrigated with water from the North Santiam River and groundwater wells within the NSW. It is likely more than 24,000 acres—the approximate number of irrigated acres within the districts—and almost certainly less than 50,000, which is the approximate total of cropland within the NSW and irrigated cropland within the districts, and thus includes some overlap between the two geographies, as well as some non-irrigated cropland acres within the NSW.

Table 26. Demand from the Irrigation Districts that rely on water from the NSW

	SWCD	SIC
Customers Served	485	220
Irrigated Acres	16,880	6,987
Number of Water Rights	35	6
Quantity of Water in Rights (cfs)	875	266
Priority Date Range	1909-1996	1870-1991

Source: ECONorthwest, with data from OWRD (WRIS) and Crew, K.L., J. Lee, and D.Prull. 2010. *Irrigation Water Providers of Oregon: Hydropower Potential and Energy Savings Evaluation.* Black Rock Consulting and Energy Trust of Oregon. Retrieved October 4, 2018, from https://www.energytrust.org/wp-content/uploads/2010/09/HydropowerPotential_1.pdf

According to Brent Stevenson, who manages the SWCD, some of the farms in the district have water rights that supplement water purchased from the district, including rights to withdraw groundwater for irrigation purposes. SWCD works cooperatively with the City of Salem to manage the point of diversion at Lower Bennet Dam, after which water is diverted into approximately 90 miles of canals and ditches (including Salem Ditch) that distribute water to farms. A large percent of the farms produce crops for the NORPAC cannery in Stayton,

including corn, beans, and squash.[105] NORPAC is one of the largest single customers for crops grown using water from the NSW. According to calculations by NORPAC, there are 33 farmers on 7,962 acres who have North Santiam water rights. Many, if not most of these farms are within the SWCD.[106]

In addition to these customers, individual irrigators divert water from the NSW. A 2002 assessment found that there are almost 1,000 points of diversion associated with irrigation water rights in the lower and middle reaches of the NSW.[107] Of the 63 primary and supplemental irrigation water rights for the North Santiam, 42.6 percent are held by SWCD, 29.5 percent are held by SIC, 15.4 percent are held by other private, non-corporate irrigators, and the remainder are held by other companies.

Figure 7 shows the top ten crops grown in the NSW in terms of percent of total acreage, and the same for Marion and Linn Counties (acres by crop as a percent of total acreage in each county). These include both irrigated and non-irrigated crops. Traditionally non-irrigated crops, such as grass seed and hazelnuts are increasingly transitioning to partially or fully-irrigated crops. Historically, filbert (hazelnut) crops tend not to be irrigated, especially after the first few years when they are being established, but this is changing.[108] Hazelnut growers inside and outside the NSW are investing in irrigation infrastructure to increase yield and quality and provide resilience against disease. According to one source, all new orchards are being installed with drip irrigation systems.[109] The crops with the highest acreage that are primarily irrigated include corn, beans,[110] mint, and blueberries. These are all crops identified by SWCD and NORPAC as important irrigated crops within the area irrigated by water from the NSW.

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[105] Personal conversation with Brent Stevenson, North Santiam Water Control District, on August 16th, 2018.

[106] Personal communication with Randy Bentz, Director of Operational Improvement, NORPAC Foods LLC. on September 11, 2018.

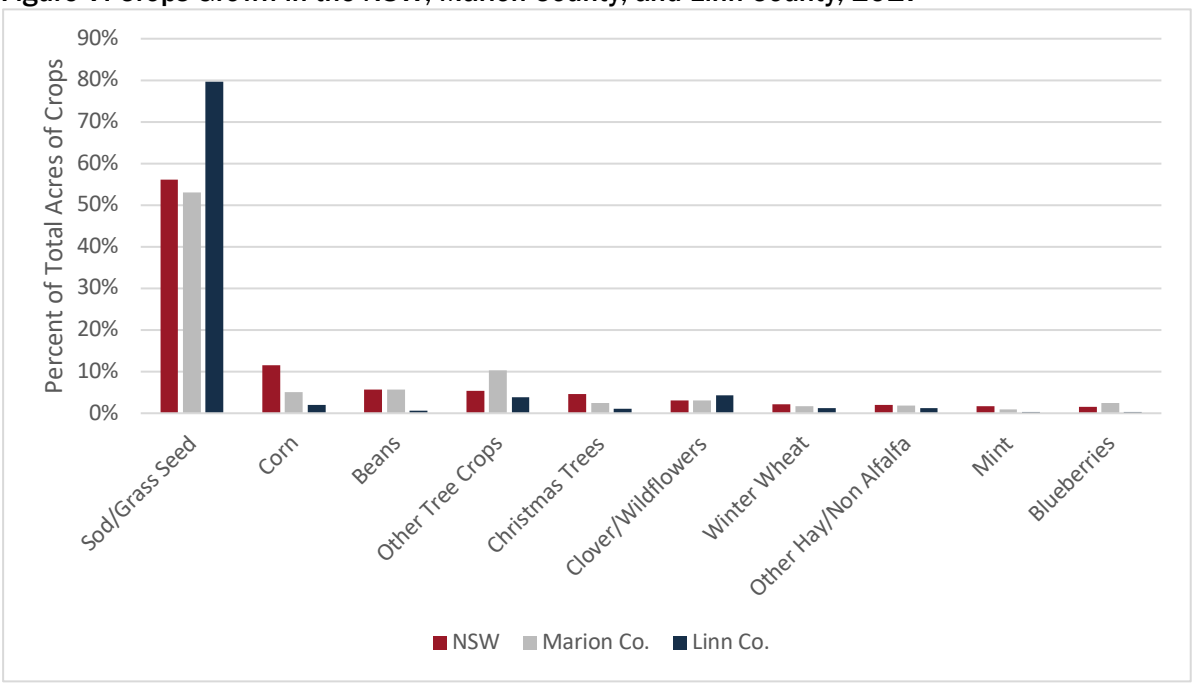
[107] E & S Environmental Chemistry, Inc. 2002. *North Santiam Watershed Assessment: Lower and Middle Reach Subwatersheds.* June.

[108] Oregon Hazelnut Commission. 2013. *Hazelnut Industry Good Agricultural Practices Manual.* Retrieved October 4, 2018, from http://oregonhazelnuts.org/wordpress/wp-content/uploads/2016/05/Haz-GAP-8-12-13.pdf

[109] Carter, B. 2017. "Successful Hazelnut Grower Champions Drip Irrigation." *Willamette Hazelnut Growers First.* Retrieved from https://www.willamettehazelnut.com/single-post/2017/04/06/Successful-Hazelnut-Grower-Champions-Drip-Irrigation

[110] This category is labeled "dry beans" in the USDA CropScape dataset. However, interviews with local producers and NORPAC staff suggest that the primary bean crop in the watershed is fresh green beans, and dried beans are not produced in this area (personal communication with Mark Steele, NORPAC).

Figure 7. Crops Grown in the NSW, Marion County, and Linn County, 2017



Source: ECONorthwest, with data from USDA CropScape 2017 (https://nassgeodata.gmu.edu/CropScape/)
Note: The category "Beans" is labeled "Dry Beans" in the CropScape data. However, interviews with local producers and NORPAC staff suggest that the primary bean crop in the watershed is fresh green beans, and dried beans are not produced in this area (personal communication with Mark Steele, NORPAC).

3.7.2 Economic Importance

The market value of agricultural products sold in Marion County was almost $593 million in 2012. Linn County's total was less than half of that, at $241 million. This includes the gross value of all products sold, before taxes and production expenses. Marion and Linn together accounted for about 17 percent of the value in all of Oregon. In Marion County, crops (including those produced from both irrigated and non-irrigated land) accounted for about 80 percent of the market value, and in Linn County, it accounted for about 77 percent. Gross income from farm related sources includes all income associated with farm operations that does not come directly from marketed agricultural products, such as agri-tourism and recreation, state and local agricultural program payments, cash rent, and sales of forest products. While these data provide information about the importance of agricultural production in these counties, some of which is certainly made possible by access to water for irrigation, they don't point directly to the value of irrigated agriculture tied directly to water in the NSW.

Table 27. Economic Characteristics of Agriculture in Marion and Linn Counties and Oregon, 2018 dollars

2012 Agricultural Census Characteristics	Linn County	Marion County	Linn & Marion	Oregon	% of Oregon
Market Value of Ag Products Sold ($)	267,385,982	657,121,590	924,507,573	5,413,064,262	17.1%
Crops, including nursery and greenhouse crops ($)	206,230,012	535,367,176	741,597,188	3,599,453,629	20.6%
Gross Income from Farm-Related Sources ($)	12,112,595	21,572,789	33,685,384	258,632,948	13.0%
Land in farms (acres)	331,316	286,194	617,510	16,301,578	3.8%
Total cropland (acres)	227,547	213,788	441,335	4,690,420	9.4%
Average value per acre of cropland ($)	$906	$2,504	$1,680	$767	-
Principal operator with primary occupation farming	48%	47%	48%	50%	-

Source: USDA Agricultural Census. "County Summary Highlights 2012: Oregon". Updated to 2018 dollars using the BLS CPI Inflation Calculator available at https://data.bls.gov/cgi-bin/cpicalc.pl
Note: The USDA Agricultural Census is taken every 5 years. As of the publication of this report, data for the 2017 Census are not yet publicly available.

To account for some of the value, we look to data supplied by NORPAC, which is the largest single buyer of agricultural products from farmers using water from the NSW. The 33 farms that NORPAC works with directly cover 7,962 acres, much of which is within the SWCD (SWCD does not keep systematic data on the crops grown within the district). For farmers who produce agricultural crops for NORPAC, the combined value of their crops (not including grain, seed, or nuts) is estimated at almost $7.5 million. This figure represents the raw product price that NORPAC pays the farmers, and is consistent with gross values reported in the Census of Agriculture. Table 28 shows the farm characteristics and market value of products sold to NORPAC, and equivalent data for Marion County as a whole, for comparison.

Table 28. Market Value of Crops Irrigated by Farms Contracted by NORPAC

Description	NORPAC Farms	Marion County	NORPAC's Percent of County
Number of Farms	33	2,567	1.29%
Total Number of Acres	7,962	286,194	2.78%
Market Value of Crop Production	$7,490,393	$657,121,590	1.14%
Average Market Value per Farm	$226,982	$255,988	88.67%
Average Size of Farm (Acres)	241	111	217.36%
Market Value Beans	$4,046,925	N/A	-
Market Value Cauliflower	$122,473	N/A	-
Market Value W Squash	$127,357	N/A	-
Market Value Blueberries	$106,918	N/A	-
Market Value Corn	$3,086,720	$3,297,154	93.62%
Total Number of Acres of Crops (Beans, Cauli, W Squash, Blueberries, and Corn)	7,962	17,835	44.64%

Source: USDA Agricultural Census (2012) and NORPAC Foods, LLC. Marion County results are from the 2012 USDA Agricultural Census, adjusted to 2018 dollars. Market value or economic value for NORPAC refers to the raw product price that is paid to the farmers in 2017 (adjusted to 2018 dollars) and for Marion County is the market value of agricultural products sold from the 2012 Agricultural Census (adjusted to 2018 dollars).
Note: N/A indicates that data are not available from the Census of Agriculture.

Based on the data in Table 28, the average value per acre for the NORPAC acres is $940.[111] This result—$940—is considerably less than the average value of crop production per acre of

[111] This is based on the $7,490,393 in market value of crop production as reported by NORPAC and the total number of acres of crops at 7,962.

cropland in Marion County. The data in Table 27 from the 2012 Agricultural Census indicate that average value of crop production (both irrigated and non-irrigated) per acre of cropland (both irrigated and non-irrigated) in Marion County is $2504, and $906 in Linn County. This suggests the average value of crop production per year based on NORPAC data may underestimate the total value of production from lands irrigated with water from the NSW, possibly by a significant margin. There may be several reasons for this: acres contracted for NORPAC production may accommodate other crops during the growing season, producing additional value from the same acre that is not reported in the NORPAC data; or the types of crops farmers grow for NORPAC are not representative in terms of market value of the crops grown in Marion County overall.

If the NORPAC data are representative of the value of crop production on lands irrigated with water from the NSW, the total value produced from irrigated lands within the two districts would be $22.4 million per year ($940 per acre * 23,867). This likely underestimates the total value of irrigation from the NSW for two reasons: first, almost certainly there are irrigated acres of cropland receiving water from the NSW that are located outside the two irrigation districts. Using the sum of district acres (23,867) and acres within the NSW (26,000), which more than likely double counts some acres, increases the total value of irrigated agriculture to $47 million. Second, the value of $940 per acre is less than the average value of crop production per acre of cropland in Marion County, but more than Linn County's average value. Using the average market value per acre harvested in Marion County for the 23,867 acres yields a total value for the acres within the districts of $59.8 million, and using the average of Marion and Linn Counties ($1,680 per acre) yields a total value of $40 million. Multiplying the Marion County per-acre value by the upper bound of acres (50,000) yields $125.2 million—almost certainly an overestimate. These values ($22.4 million to $125.2 million) more than likely bound the range of the value of crop production irrigating with water from the NSW. For the purpose of this analysis, we use the $59.8 million value per year, which incorporates Marion County's per-acre crop value (likely an overestimate for all acres in the NSW) and the district-only acreage (likely an underestimate of all acres irrigated by water from the NSW).

Research shows that irrigated farmland is higher value than non-irrigated farmland, and this reflects the additional value of production that access to irrigation allows. In an analysis of property values in the Willamette Valley, a study by an Oregon State University student found that value of a water right depends on soil class (which also impacts productivity and crop value) and derived a value for irrigation water that ranges from about $10 to $23 per acre foot. Using economic and statistical methods, the researcher also found that the value of precipitation in the Willamette valley is $16.44 per acre foot.[112]

In addition to the value of irrigated crop production, water from the NSW supports agricultural processing and the production of value-added agricultural products, such as frozen vegetables.

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[112] Kalinin, A. 2013. *Right as Rain? The Value of Water in Willamette Valley Agriculture*. Master's thesis. Oregon State University.

NORPAC operates facilities in Stayton and Salem that depend on process water from the NSW, sourced primarily through municipal supplies. The value of this production is incorporated into the value of municipal supply, discussed in previous sections. NORPAC has stated that they rely on water from the NSW for their freezer defrost cycle. NORPAC estimates the replacement cost of alternative sources of cooling at $2 to $3 million.[113]

Economic Contribution of Agriculture to the Economy

Agricultural production contributes to local economies in a variety of ways. Farm operations create direct jobs, but also demand goods and services from and direct spending to other sectors of the economy, such as wholesale trade, transportation and warehousing. The goods produced from Oregon farms are sold nationally and internationally, bringing dollars into Oregon that are spent and re-spent, generating jobs and additional income along the way.

The data from the 2012 Agricultural Census also show that almost 50 percent of the farms in Linn and Marion counties are operated by people who make their living primarily through their farm (i.e., their primary occupation is farming). Those represent jobs (often sole proprietors and small businesses) in Oregon's economy. This also implies that 50 percent of farms are not the primary source of income or employment for the operator. This is typical of Oregon farms. It strongly suggests that agricultural production, even when it is not the sole source of income for a household, allows some Oregon families to maintain their rural property and lifestyle, and supports Oregonian's quality of life by maintaining the pastoral landscape so many residents enjoy.

3.7.3 Expected Future Trends in Demand and Value

Climate change may impact demand for irrigation: as average temperatures rise, evapotranspiration and crop water demand during the drier summer months may increase.[114] Research from the Willamette Water 2100 project found that some farmers may respond to climate change by irrigating earlier, which may change the timing of demand for water in the future. As water supplies for irrigation become more scarce in other basins or stressed groundwater basins surrounding the NSW, demand for water from the NSW may increase among farmers in surrounding areas. Irrigation demand may also increase as farmers continue to develop irrigation infrastructure for crops that have historically been unirrigated or minimally irrigated, such as hazelnuts and grass seed. For both crops, yields decrease during times of drought, so if drought becomes more frequent or severe, farmers may mitigate the increase risk of crop loss by investing in irrigation.

Population growth and urban development in the future may also change demand for irrigation, by shifting land use from crop production to housing production. This trend would

[113] Ibid.

[114] Jaeger, W. K., Amos, A., Bigelow, D. P., Chang, H., Conklin, D. R., Haggerty, R., Langpap, C., Moore, K., Mote, P., Nolin, A., Plantinga, A. J., Schwartz, C. L., Tullos, D., & Turner, D. P. (2017). Finding water scarcity amid abundance using human–natural system models. Proceedings of the National Academy of Sciences, 201706847.

have the opposite effect, potentially reducing demand for irrigation. Findings from the Willamette Water 2100 project suggest that over the rest of this century, land use change may result in an 8 percent decline in farmland acres, leading to a 5 percent reduction in irrigated acres.[115] If this trend occurs at the same time that demand for irrigation expands the number of irrigated acres supported by water from the NSW, the increase in demand may be offset somewhat.

3.8 Cultural and Tribal Use

Cultural values for natural resources held by members of Tribal nations are distinct from recreational use, aesthetic use, and non-use values. Tribal cultural well-being is the product of intensive and complex uses of resources, knowledge and relationships with the natural environment. Interaction with water resources in the NSW provides goods and services and additional cultural services including a sense of place and the sharing of cultural experiences between generations.

As documented in Section 3, native tribal people traditionally used and continue to use areas within the NSW. Until wide-spread European settlement and tribal removal to reservations, native people occupied large, semi-permanent winter villages in the lower reaches of the NSW, along the valley bottom of the North Santiam and Santiam Rivers. Throughout the spring, summer, and fall, people migrated into higher elevations to gather food and materials, to fish, and to hunt. People followed tributaries, and evidence of past habitation is found along streams.

Water provided—and continues to provide—important cultural value by sustaining fish and ecosystems they depend on; riparian vegetation used as food, medicine, and fiber for clothing, baskets, and tools; and other organic and non-organic materials used for subsistence and cultural purposes. The cyclical availability of these resources traditionally supported people throughout the year. Settlements concentrated around water in part also because water modulated the environment during both the hot summer and cold winter.

The cultural importance of water goes deeper than subsistence and physical environment, however. From water, native people derive cultural services that connect them to the earth and to each other. Water and water-related ecosystems contribute to individual and group identity, sense of place, spirituality, and serve to link past and future generations.

Traditional monetary measures of economic importance are inappropriate to describe the value of cultural and tribal use of water from the NSW. Monetization implies substitutability (i.e., that monetary compensation at some level can make whole the loss of the service, because equivalent services may be purchased). Given that many, if not all, cultural services are defined by place, tradition, and continuity of use and practice, no alternative resource could provide a

[115] Oregon State University. *Agricultural Land & Water Use*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1301

sufficient substitute for the resources in question. Because of the uncertainty, complexity, and inadequacy involved with identifying a monetary measure for cultural values, they are considered in this report of significant importance, and included qualitatively.

3.9 Public Health and Well Being

The water from the NSW supports ecosystems, as described in previous sections. Ecosystems regulate elements of the environment and provide goods and services that are connected to public health and well-being in several ways:

- Trees and vegetation within the NSW help regulate air quality, removing pollutants that have adverse impacts on public health. Economic benefits are greatest in areas with high concentrations of pollution sources, and where people—especially sensitive populations, such as elderly and children—spend time.[116,117] Thus trees within the NSW are likely most valuable from an air-quality perspective in communities and along major roadways, such as Highway 22.
- Natural spaces that are accessible to and used by people have numerous positive effects on mental and physical health, including ADHD, school performance, and cardiovascular disease.[118] One study found a relationship between tree die-offs in the Midwest and an increase in cardiovascular and respiratory tract illness.[119]
- Low-cost, accessible opportunities for recreation may increase people's activity levels, producing positive effects on indicators of physical health.[120] Some of the economic value associated with health improvements may be captured in the *consumer surplus* value described in the recreation section above (e.g., people enjoy recreation because it makes them feel good or helps them achieve health and wellness goals). However, consumer surplus value does not typically reflect avoided health care costs that may arise from improved health outcomes associated with outdoor recreation.
- Connection to place, mediated by access to natural spaces that enhance individual and community identity, may increase social capital (the interconnections between people

[116] Nowak, D.J., S. Hirabayashi, A. Bodine, and E. Greenfield. 2014. "Tree and Forest Effects on Air Quality and Human Health in the United States." *Environmental Pollution* 193 (2014): 119-129.

[117] Baldauf, R. et al. 2013. "Integrating Vegetation and Green Infrastructure into Sustainable Transportation Planning." *TR News* September-October.

[118] Wolf, K.L., M.K. Measells, S.C. Grado, and A.S.T. Robbins. 2015. "Economic values of metro nature health benefits: a life course approach." *Urban Forestry & Urban Greening* 14(2015): 694-701.

[119] Donovan, G.H., et al. 2013. "The relationship between trees and human health: Evidence from the spread of the Emerald Ash Borer." *American Journal of Preventive Medicine* 44(2): 139-145.

[120] Godbey, G. and A. Mowen. 2010. *The Benefits of Physical Activity Provided by Park and Recreation Services: The Scientific Evidence.* National Recreation and Park Association. Research Series.

and institutions), which has been shown to positively impact individual well-being through myriad direct and indirect effects.[121]

Water is an essential ingredient in producing all of these effects. Economists have attempted to measure some of them in monetary terms. Air quality effects on public health are probably the most well-developed area of research. Considerable attention is currently being applied to measuring the economic effects of ecosystems and "green" and "blue" spaces on mental and physical health, but the relationships are complex and interrelated with many other factors that influence health outcomes. Attributing specific health and well-being outcomes (either in physical or economic terms) to a particular area or resource, such as water within the NSW is beyond the current state of the science. However, the relationships outlined above strongly suggest that human interactions with water in the NSW—both directly and indirectly—result in positive economic outcomes in terms of public health and well-being that are not otherwise accounted for in this report.

[121] Capaldi, C. A., Passmore, H.-A., Nisbet, E. K., Zelenski, J. M., & Dopko, R. L. 2015. "Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention." *International Journal of Wellbeing* 5(4), 1-16.

4 Illustrative Case Studies

In the following sketches, we illustrate how the economic information presented in the previous section can be used to identify the tradeoffs and investment decisions facing communities and managers in the North Santiam Watershed.

4.1 Wastewater Infrastructure in the North Santiam Canyon Communities

Communities in the canyon are experiencing degrading wastewater treatment infrastructure, in the form of aging septic systems. No centralized wastewater treatment exists in Idanha, Detroit, Gates, Mehama, and Lyons, and Mill City's wastewater system needs upgrades. Other studies have found that the lack of community wastewater systems are a limiting factor in economic and community development in the canyon.[122]

Although fecal bacteria has not been identified at levels requiring regulation in the upper reaches of the watershed, it could become a problem if enough systems fail. It is unclear the extent to which failing septic systems may be contributing to toxic algae blooms in Detroit Lake. Failure of these systems has several effects that could result in negative economic consequences:

- If failure of the existing septic systems increases water pollution in the form of nutrients and fecal bacteria to waterbodies within the watershed, the value of water for recreation and municipal uses could decline. Water-contact recreation may become riskier, and costs for municipal water treatment could increase. It may also impose additional treatment costs for industrial or agricultural users.
- If levels increase to the point where additional regulation is required, it could increase costs to current NDPES dischargers and other non-point source dischargers.
- Undertaking development and redevelopment requires that property owners provide sufficient capacity to treat waste generated by the use of the development. Without access to adequate and affordable wastewater treatment systems, either in the form of new septic systems or centralized treatment, development is unlikely to occur in the canyon communities. As existing infrastructure ages and demand for services increases with populations—particularly outside the NSW that contribute recreation visitors within the NSW—the communities will be unable to serve these populations. It is possible that recreation visitation will stagnate or increase at slower rates than if services were available. More certainly, businesses in the canyon communities will capture less of the spending by recreation visitors—they will spend their money elsewhere. For

[122] Keller Associates. 2017. *North Santiam Canyon Regional Wastewater Analysis.* January. Marion County, Oregon. Retrieved October 5, 2018, from https://www.co.marion.or.us/CS/EconomicDevelopment/Documents/Keller%20Associates-NSC%20-%20Regional%20Wastewater%20Analysis%201-12-17.pdf

example, a recreation visitor heading to camp at Detroit Lake for the weekend may purchase firewood in Salem instead of in Detroit, knowing that retail services are not available in Detroit.

Regulatory constraints, fiscal constraints, and land constraints make addressing this problem through conventional means (e.g., building a centralized wastewater treatment system) difficult. Current estimates indicate that the investment to upgrade wastewater treatment for the canyon communities could range from $8.4 million for investments in Detroit[123] to $100 million for investments in all of the canyon communities[124] (adjusted to 2018 dollars).

To the extent that people outside of the canyon communities benefit from the goods and services available within the NSW, there may be justification for outside funding or subsidies to support investment in wastewater infrastructure. There are several ways non-local users benefit:

- Municipal and industrial water providers using water from the NSW may be able to avoid expensive upgrades to water treatment facilities or reduce costs associated with water treatment processes, if the water quality remains high and does not degrade from upstream infrastructure failures.
- Recreation visitors from within and outside the NSW may be willing to pay more for their trip if additional services are available closer to their recreation destination, saving time and resources to travel west to resupply or have dinner out.
- Currently permitted wastewater dischargers downstream of failing infrastructure may be willing to pay to avoid stricter controls on discharge.

This study demonstrates that demand for diverse recreation opportunities and services in the canyon is strong, and likely increasing as population in Oregon increases. Growing demand for clean water also exists from municipalities downstream. As long as the quality of the resource remains consistent with current levels, this economic value will continue to materialize at steady or growing levels. If it degrades, fewer people may come to the NSW to recreate and costs of using the water will increase, reducing its value to municipal and industrial customers.

Key questions to answer to inform the design and implementation of investment strategies include:

- To what extent will failing septic systems in the canyon compromise surface water quality for other users in the future?

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[123] HBH Consulting Engineers. 2014. *City of Detroit Wastewater Feasibility Study.* September.

[124] Keller Associates. 2017. *North Santiam Canyon Regional Wastewater Analysis.* January. Marion County, Oregon. Retrieved October 5, 2018, from https://www.co.marion.or.us/CS/EconomicDevelopment/Documents/Keller%20Associates-NSC%20-%20Regional%20Wastewater%20Analysis%201-12-17.pdf

- What other factors may impact water quality, and how do they compare to potential future impacts from failing septic systems?
- To what extent is economic development in the canyon communities hampered by the lack of access to wastewater infrastructure?
- Are there other factors acting to constrain economic development in the communities that should be addressed to maximize benefits from potential future sewer investments?

Addressing these questions in more detail will help clarify the problem, and may illuminate additional issues that should be addressed in tandem with wastewater infrastructure deficiencies. It may also suggest opportunities to leverage additional resources and achieve greater benefits from future investments.

4.2 Municipal and Irrigation Systems: Relationships Between Water Availability and Efficiency

Quality concerns aside, water from the North Santiam is generally available to meet current demands for agriculture, municipal purposes, domestic use, manufacturing, etc., at current levels of supply. Parties throughout the watershed, however, are cautious about what the future may hold. Given the many factors affecting the availability of adequate quantities of high quality water, many water users are interested in taking measures to secure supplies and reduce the possibility that they might be left without enough water under a variety of potential future scenarios. Stakeholders throughout the watershed recently convened and prepared a Drought Contingency Plan that addressed the risks and potential mitigation actions.[125]

The information presented throughout the previous sections of this report can help water users develop strategies by helping parties throughout the watershed develop a common understanding of both a) the trends affecting the *supply* of water, such as anticipated changes in the timing and quantity of flows due to climate change, and b) the trends affecting the various sources of *demand*, such as population growth. Together with this information, water users must operate within the system of water rights adjudication, to envision how the supply and demand scenarios might affect individual users of NSW water. For example, users with junior water rights may have concerns not only about overall water availability within the NSW but also about users with more senior water rights exercising more of their right than they do today.

To senior water rights holders, the difference between the full water right and their current (lower) level of usage provides some security and flexibility in planning for future water supply and demand scenarios. To junior water rights holders, however, the potential for increased water usage by more senior water rights holders, particularly during periods of water scarcity, creates uncertainty and poses the potential for the future loss of investments.

[125] GSI Water Solutions, Inc and David Evans and Associates. 2017. *North Santiam Drought Contingency Plan.* North Santiam Watershed Drought Contingency Plan Task Force. July.

With an eye toward maximizing the economic value of water in the NSW, as described throughout this report, water users can begin to see the interconnected nature of water throughout the NSW. For example, as residential demand grows in response to population growth in Salem, those residents are also likely to value access to recreational opportunities in the NSW. Some of those residents will work in sectors of the water economy that have water rights that are junior to the City of Salem's rights. The effects of expenditures related to recreation and other water-dependent sectors of the economy, such as agriculture, likely ripple through Salem's economy. Water available for irrigation provides security for farmers, and also increases the opportunities for generating value from their land: irrigated land can produce a wider variety of higher-valued crops than land without access to reliable water supplies.

The reverse is also true: without a reliable water supply, an urban area such as the City of Salem can be constrained economically. The people and businesses in Salem are important inputs—for example, as labor, consumers, and suppliers—to the economic activity related to other water users in the NSW. Without a reliable water supply, farmers may not be able to grow higher-valued crops, a situation that may be exacerbated in the future under expected climate-change conditions. An understanding of all these relationships can provide an incentive for all parties to find economically efficient solutions to water management throughout the NSW.

Some potential questions to explore:

- Are there inefficiencies within the current system that could be addressed, in preparation for future periods of scarcity—leaking pipes, water usage during peak periods, etc.?
- Are there opportunities to make adjustments in water use that reflect the relative values of use? For example, could any irrigated acreage be converted to non-irrigated acreage, with compensation for the difference in value paid by other users that would benefit from the access to additional supplies?
- Are there opportunities to increase the certainty of supplies for both senior and junior water rights holders by negotiating payments for options to sell, transfer, or limit use under certain water supply scenarios?

4.3 Management of Detroit Reservoir: Economic Importance of Distributional Effects

While the Willamette Project Dams have not always been a part of the NSW, since the 1950s, they have had a tremendous influence on the way people use water throughout the watershed, by changing the availability and distribution of water-related goods and services. Through these changes, they have generated both benefits and costs, at a scale and scope that has influenced the decisions of most, if not all water users dependent on water from the NSW.

The dams generate flood control benefits estimated in the millions of dollars each year, largely to beneficiaries downstream of the NSW, in the Willamette Basin. The dams created one of the

most popular summer reservoir recreation destinations in Oregon.[126] They generate hydropower to satisfy peak demands of the region's population. And by storing water and changing the timing of flows in the North Santiam River, the dams increased water availability when farmers' and communities' demands are highest: during the dry summer season. The dams also generated costs, by blocking access to historically productive salmon and steelhead habitat in the Willamette Basin and changing the characteristics of flow and habitat downstream. The cumulative effect of these dams, along with the other dams in the Willamette Basin and changes in land use over the 20th century, caused the populations of steelhead and Chinook to fall to levels that NOAA Fisheries deemed required protection under the ESA. This has led to increased costs for water users and land managers in the form of mitigation requirements for all actions that have the potential to harm the species.

To maintain the benefits while addressing the costs of the dams, the USACE and other federal agencies involved in their operation have developed options that would mitigate harm and speed recovery of the fish populations. Implementing these various changes (including changing the timing and quantity of reservoir releases, infrastructure improvements, and habitat investments) influence water users: changing reservoir levels (especially those that exceed the magnitude and timing of historical fluctuations) alternately increase and decrease the value recreational users derive from water-related recreation; minimum instream flow releases augment flows downstream of the dam from what they may otherwise be, especially during the summer, benefiting water users and property owners in the lower watershed.

The requirement structurally modify the dam to provide better control over downstream water temperatures, however, has led the USACE to propose draining Detroit Reservoir for some period of time during construction. This action would produce greater potential variability and uncertainty about water availability downstream of the dams than management actions to date, and has generated considerable concern about the potential costs. This report does not evaluate the USACE proposed action or recommend any specific outcome. It does, however, provide information that may be used to deepen understanding about the potential economic effects of changes in water supply arising from the proposed action.

One important dimension of economic importance that the USACE proposal illuminates, and is at play whenever there are multiple users attempting to access scarce resources, is that distribution of costs and benefits is not always equal or equitable. Distribution of costs and benefits varies spatially and temporally. A large portion of the value provided by the water-management infrastructure in the NSW accrues to beneficiaries outside of the NSW:

- Flood control value is concentrated in the communities along the Willamette River, downstream of the NSW (communities in the lower reaches within the NSW also

[126] Based on the recreation figures reported in Moore, L. 2015. "Optimizing Reservoir Operations to Adapt to 21st Century Expectations of Climate and Social Change in the Willamette River Basin, Oregon". *PhD Dissertation*. Oregon State University.

experience flood reduction benefits, but communities above the dams don't benefit at all).

- Over 90 percent of the water used for municipal and industrial purposes is used outside of the NSW (communities within the NSW use water too).
- Clean water from the North Santiam flowing in the Willamette has a diluting effect downstream of the confluence, improving water quality parameters in the Willamette River.
- Visitors to recreation sites within the NSW, including Detroit Lake are predominately from communities outside the NSW (people within the NSW also recreate here, perhaps at greater per-user frequencies because of their proximity to opportunities).
- The hydropower produced from Detroit and Big Cliff generators is transmitted outside the NSW (although electric utility customers within the NSW share in value of the region's hydropower generating capacity).
- Water stored in Detroit Lake is currently under review for reallocation to new water uses. Users downstream of the NSW may potentially be able to claim this water, but regulatory barriers may preclude users within the NSW from obtaining new rights.

The costs of management actions intended to maintain the quality and quantity of water from the NSW in the long run accrue disproportionately to communities and populations within the NSW:

- Reductions in recreation opportunity arising from water quality concerns or reservoir dewatering impact recreation users, who won't be able to recreate in their desired location. However, many will go elsewhere and substitute other experiences that will offset the loss in value somewhat. Communities dependent on the economic activity generated through recreation visitation cannot as easily substitute other economic activity to make up for the loss, especially in the short term.
- The Three Basin Rule and 2008 Bi-Op impose restrictions on discharges into and diversions from the NSW to protect water quality and salmon habitat. These restrictions have the potential to increase costs of development in the communities within the NSW, where populations are smaller and have lower median household incomes compared to larger communities downstream. While these actions serve to protect the quality of the resources that these communities depend on, the value of high-quality water and species recovery improvements accrue to a much broader population downstream of the NSW.
- All Oregon households (and likely households throughout the Pacific Northwest and the United States) will benefit from recovery of the Upper Willamette River Chinook (and steelhead as well), as evidenced by the research and values detailed in Section 3.2. However, most of the recovery actions must occur within the NSW and other watersheds in the Upper Willamette basin where the fish reproduce, imposing disproportionate costs on the land owners and water users within the NSW.

That these distributional inequities occur does not mean that actions taken to protect values that are enjoyed by wider populations should be abandoned. It does mean, however, that policy makers and managers may consider looking for opportunities to spread costs more widely as well. Mechanisms to do this include tapping outside funding to subsidize activities within the NSW (ideally from sources related to beneficiaries), and establishing user fees to capture revenue to pay for the services people enjoy. Carefully documenting these relationships through an equity frame may provide credibility toward and help justify future investment decisions. Actions and policies that have the potential to impose additional costs within the NSW may provide opportunities for addressing equity and distributional issues.

Appendix A. Key-Informants

Name	Position	Affiliation	When Contacted	Who Contacted	Type of Contact
Randy Bentz	Director of Operational Improvement	NORPAC	7/10/18 (email), 7/25/18 (email), 8/7/18 (phone and email), 9/11/18 (email), 9/25/8 (email)	Laura Marshall	Data Request
Daniel Holbrook	Industrial Lands Specialist	Business Oregon	7/10/18 (email), 7/17/18 (email), 7/18/18 (email)	Laura Marshall	Data Request
Robert Gentry	Natural Resources Staff	USFS - Detroit RD	7/11/18 (email) and follow-ups	Kristin Lee	Data Request
Suzanne Cable	Santiam River Zone Recreation, Lands, and Minerals Staff	USFS - Detroit RD	8/6/18 (email) and follow-ups	Kristin Lee	Data Request
Mike McCord	NW Region Manager	OWRD	7/10/18 (email), 7/19/18 (in person in Salem), 8/2/18 (email), 8/6/18 (email)	Laura Marshall	Informational Interview
Dave Carpenter	Owner	Oregon Outdoor Excursions	7/10/18 (phone)	Kristin Lee	Informational Interview
Russ Foltz	Public Works Supervisor	Mill City Public Works	8/8/18 (phone)	Laura Marshall	Informational Interview
Deborah Hastings	City Clerk	City of Detroit	8/27/18 (phone), and 8/29/18 (phone)	Laura Marshall	Data Request
Will Summers	Workforce Analyst	Oregon Employment Department	8/22/18 (email)	Laura Marshall	Data Request
Caleb Dickson	Marketing Research Analyst	Oregon Parks and Recreation Department	8/9/18 (email)	Laura Marshall	Data Request
Russell Dilley	Parks Program Coordinator	Marion County Parks & Recreation	8/9/18 (email)	Laura Marshall	Data Request
Brett Stevenson	District Manager	Santiam Water Control District	8/16/18 (phone), follow-up emails	Kristin Lee & Laura Marshall	Informational Interview
Louis Landry	Project Manager	US Army Corps of Engineers	8/15/18 (in person), 8/27/18 (email)	Sarah Reich & Laura Marshall	Informational Interview
Peter Moore	Business Director	Breitenbush Hot Springs	8/15/18 (phone)	Kristin Lee	Informational Interview
Lacey Goeres-Priest	Water Quality Supervisor	City of Salem	9/6/18 (phone)	Kristin Lee	Informational Interview
Kurt Carpenter	Hydrologist	USGS	6/1/18 (email)	Sarah Reich (via Danielle Gonzalez)	Information
Brinton Foy Reed	Director of Marketing, Events and Hospitality	Breitenbush Hot Springs	8/14/18 (email)	Laura Marshall	Data Request
Sam Drevo	Director	eNRG Kayaking	8/12/18 (email) and follow-ups	Kristin Lee	Informational Interview

Bill Jaeger	Researcher	Oregon State University	4/17/18 (in person) and follow-ups	Sarah Reich, Kristin Lee, and Laura Marshall	Informational Interview
David Conklin	Researcher	Oregon Freshwater Simulations	4/19/18 (email), 4/24,18 (phone), 4/30/18 (in person)	Sarah Reich and Laura Marshall	Informational Interview
Danielle Gonzalez	Economic Development	Marion County	6/1/2018 (in person)	Sarah Reich	Informational Interview