ECONorthwest
ECONOMICS • FINANCE • PLANNING

DATE: May 6, 2018
TO: Rebecca McCoun
FROM: ECONorthwest Project Team (Kristin Lee, Laura Marshall, and Sarah Reich)
SUBJECT: NORTH SANTIAM BASIN ECONOMIC ANALYSIS
PHASE 1 SUMMARY MEMO—ANNOTATED LIST OF RESOURCES REVIEWED

Introduction and Background

This memo presents an annotated list of potential sources of data and information that will support the economic analysis in Phase 2. We organize these resources around the analytical questions that will guide the assessment, as outlined in the Phase 2 scope of work:

1. **Water Supply**: Resources that describe the quantity and quality of water available in the North Santiam basin.
2. **Water Use and Demand**: Resources that describe the characteristics of demand for water for various uses, including primarily consumptive (i.e., irrigation and municipal/industrial) and primarily non-consumptive (i.e., recreation and fish). The list of uses is not exhaustive, but covers the major categories of uses that we will include in the analysis.
3. **Water Value:** Resources that focus on describing the economic value associated with various uses of water.
4. **Future Trends**: Resources that describe expected future changes in water supply, water use, and value of water, including potential changes resulting from climate change. This category also includes the extensive set of resources resulting from drought and resiliency planning in the basin.

We have organized these resources into the categories described above to begin to assess the availability and quality of data to support our analysis related to each question. However, many of the resources will contribute information and data to multiple categories. We have listed each resource only once according to the primary category of data it would support, but the annotation notes the full range of topics covered.

This list is preliminary; we will continue to identify and review data sources useful to our economic analysis in Phase 2. The purpose of listing and annotating them here is to provide project partners with an overview of what our data searches in Phase 1 yielded, to illuminate data gaps, and to provide an opportunity for project partners to identify any resources not listed here that we should review and incorporate into the analysis.

Annotated List of Data and Resources

1. Water Supply

Water Quantity/Water Budget

Oregon State University. *Hydrology*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1376.

This document provides an overview of the estimated water budget in the Willamette River basin, including an infographic showing magnitudes of water use by type. The largest consumptive use in the system is evapotranspiration. Municipal, industrial, and agriculture use is both consumptive and non-consumptive, and represent relatively small uses compared to non-consumptive environmental flows.

Mucken, A., and B. Bateman. 2017. *Oregon's 2017 Integrated Water Resources Strategy*. Oregon Water Resources Department.

Oregon's Integrated Water Resources Strategy was released in 2012 and offers a multi-purposed state-wide planning framework. The document contains substantial historical information about water in Oregon and identifies 16 critical issues facing Oregon's water resources.

Oregon State University. *Willamette Flows*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://hydro-prod.library.oregonstate.edu/figures/willamette_flows/waterchart.html.

Oregon State University. *WW2100 Scenarios*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1226.

Description of the 22 scenarios developed and utilized in the Willamette Water 2100 modeling.

Santiam Water Control District. 2015. *E. Technical Proposal & Evaluation Criteria. Executive Summary*. June 25.

This document is a proposal for a Drought Contingency Plan submitted by Santiam Water Control District. Components of the plan are stakeholder engagement, monitoring, vulnerability assessment, and mitigation actions. Description of drought conditions are also provided.

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

There is approximately 1,590,000 acre-feet of storage in the Willamette Valley Project, with 75,000 acre-feet with a current irrigation contract. From this study, the selected plan was for increased flexibility in stored water and proportional reduction in uses during drought years. Big Cliff has a flow objective of 1000 – 1500 cfs, depending on the time of year. Projected residential demand for water for the Willamette River basin is in Table 3-6. Supply deficits are estimated in Table 3-7. Increases in diverted agricultural demand are in Table 3-11. This document analyzes current and future water uses in the basin for fish and wildlife, municipal and industrial and agricultural irrigation.

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/.

General information about Big Cliff dam, including hydropower generating capacity (18 mw).

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/.

General information about Detroit dam, including hydropower generating capacity (100 mw).

Water Quality

Oregon Department of Environmental Quality. 2016. "Chapter 8: North Santiam Subbasin TMDL". *Willamette Basin TMDL*. September.

The current TMDL listings for the North Santiam basin are temperature and there is a detailed description of temperature limits and pollution sources detailed in this document. Although there is no TMDL for bacteria, proactive planning around fecal bacteria can help prevent a future listing. Mercury is a contaminant of concern for the entire Willamette Basin, but there are currently no effluent limitations. Dissolved oxygen is a listed TMDL for the mainstem Santiam but not the North Santiam.

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

The regulations applying to the Willamette Basin TMDL for bacteria are discussed in this chapter. Note that there is not currently a TMDL for bacteria on the North Santiam, but there is a monitoring station that collections E. coli samples from the North Santiam. The Santiam River is viewed as "relatively uncontaminated" and serves as a dilution mechanism for the relatively more contaminated Willamette River.

Oregon Department of Environmental Quality. 2006. *North Santiam and South Santiam Subbasin Water Quality Overview*. September.

Map and summary of water quality concerns in the subbasins.

Drinking Water Providers Partnership. 2017. *North Santiam Basin Resiliency Action Plan: 2017 Application for Funding*.

The grant application is for funds for restoration and capital improvement project to protect drinking water quality. A description of public water systems in the North Santiam is provided in Table 1. Sources of contaminants are listed by ranking of contaminant potential for surface water and groundwater in Table 2.

2. Water Use, Demand, and Value

Water Rights

Oregon Water Resources Department. 2013. *Water Rights in Oregon: An Introduction to Oregon's Water Laws*. November.

This reference guide summarizes the regulations regarding water rights in Oregon.

Oregon Water Resources Department. 2018. *Oregon Water Resources Department Water Right Point of Diversion Summary Report*. Retrieved May 3, 2018 from: https://apps.wrd.state.or.us/apps/wr/wrinfo/wr_summary_pod.aspx .

Water right summary for North Santiam that details the number of water rights by type and use.

Santiam Water Control District. 2015. *North Santiam Watershed Management Program*. Prepared for North Santiam Watershed Stakeholders.

This grant application seeks to incorporate all stakeholders into planning processes for the North Santiam in order to have a more collaborative approach to watershed management. The "Background Data" section includes water right and historical information.

Agricultural Water Use and Demand

Oregon Department of Agriculture. 2018. *Oregon Agripedia 2017*. January.

This reference tool provides a record of crop prices and statistics for Oregon through 2017. County specific data for Marion county includes plantings, harvestings, and yields for winter wheat, spring wheat, barley, alfalfa, all other hay. Additional Marion county specific data is cash rent, all cattle and calves, beef cows, and milk cows.

Oregon Department of Agriculture. 2017. *State of Oregon Agriculture*. Industry Report from the State Board of Agriculture. January.

As an industry report, this resource summarizes statistics and information about agriculture in Oregon. A specific section on the Willamette valley includes commentary about the state

of agriculture in this region, including challenges from invasive species, land use change, and recreational users.

USDA Agricultural Census. "County Summary Highlights 2012". Retrieved May 3, 2018 from: https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Oregon/.

Summary of results from the 2012 agricultural census at the county level for Oregon.

Santiam Water Control District. Retrieved May 3, 2018 from: *http://www.santiamwater.com/.*

The website of the Santiam Water Control District (SWCD) details the rates and fees, applicable water rights, and district maps.

U.S. Department of Agriculture. "Soil Survey Geographic Database (SSURGO)". *Web Soil Survey*.

For the North Santiam hydrologic unit 17090005, this spatial dataset is compiled by the USDA and includes multiple soil characteristics, including slope, drainage class, erosion hazard, ratings for use (buildings, septic, sewage, road, sand), and other variables. GIS version of data is available at: http://www.arcgis.com/home/item.html?id=cdc49bd63ea54dd2977f3f2853e07fff.

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.

See Kalinin (2013) and Jaeger et al. (2017) for further discussion. This article provides an overview of crop and irrigation choices projected to year 2100. Findings are that there will be an 8% decline in farmland acres due to land use change, leading to 5% reduction in irrigated acres. Due to climatic changes, irrigation is projected to begin earlier in the season, which will change the timing of demand for water.

Municipal and Industrial Water Use and Demand

U.S. Census Bureau. "American Community Survey 2012 – 2016 for Marion and Linn Counties". *American Community Survey*.

Survey results for Marion County and Linn County provide information on industry composition, incomes, and other demographic information.

City of Albany, City of Millersburg, and the Dumbeck Lane Water District. 2015. *2015 Annual Water Quality Report*.

These municipalities receive their water from the Santiam River system. This document contains documentation that levels for all regulated and detected contaminants met EPA water quality standards in 2015.

City of Salem Public Works Department. 2017. *Water Quality Report: Drinking Water Quality Data from 2016*.

The City of Salem receives water from the North Santiam as well as aquifer storage and recovery. This document contains documentation that levels for all regulated and detected contaminants met EPA water quality standards in 2016. Additional facts in this document are that 9.52 billion gallons of water were provided to city water users in 2016.

City of Stayton. 2016. *2016 Annual Report on Stayton's Drinking Water Quality*.

The City of Stayton receives their water from a canal from the North Santiam. This document contains documentation that levels for all regulated and detected contaminants met EPA water quality standards in 2016. Additional facts provided are that the City of Stayton annually serves 2,643 customers with over 704,364,000 gallons of water. NORPAC Foods, Inc. is the largest customer – the company used 319,037,000 gallons of water in 2016 (almost half of total water use).

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

List of the most intensive water users with amount and user description within the City of Salem for July, August, and September 2016.

GSI. 2014. *Water Management and Conservation Plan*. Prepared for City of Salem, Oregon. November.

Oregon Water Resources Department (OWRD) required a Water Management and Conservation Plan (WMCP) as part of the approval process for Salem's water use permit. Salem possesses five water right certificates for a total of 239 cubic feet per second (cfs) from the North Santiam River for municipal use, in addition to surface water rights from the Willamette River and groundwater permits. Exhibit 2-23 lists the threatened and endangered species in the North Santiam and Willamette. The Geren Island Water Treatment Facility and transmission system are also described. Additionally, this WMCP contains the five-year benchmarks for conservation which includes leak detection programs to address the 22.9 percent of unaccounted water in fiscal year 2011-2012; surveys of the entire municipal systems occur continuously and are completed every ten years. Detailed descriptions of expected future water supply and demand are also addressed by this document, as well as plans for curtailed water supplies. Section four of the document details the contingency plans in different water supply curtailment scenarios. Section five provides forecasts of future water demand.

Keller Associates. 2006. *Water Distribution Facilities Planning for Stayton, Oregon.*

Table 2.5 lists the city's top 30 water users as of 2006. As part of this planning study, additional information about Stayton's water use is detailed.

Marion County. *Marion County Annual Budget Fiscal Year 2017-2018.*

In addition to budget allocations, see pages 14 – 22 for economic information about Marion County, including the largest individual taxpayers.

Oregon State University. *Urban Water Use*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1331.

An overview of how urban water use was calculated for the Willamette Water 2100 model. The authors used coefficients from the literature and the averages of water quantity, price, income, population, and density for Portland, Salem, Eugene, Springfield, and Corvallis to calculate baseline averages. Urban water demand for these cities is estimated as 330,000 ccf/day (305,000 acre-feet/year) as of 2015.

City of Detroit Socioeconomic Information.

Information sheet about City of Detroit demographics and municipal priorities. Of the priorities, the first is wastewater/sewer system and the second is water system improvements.

Maul Foster Alongi. 2017. *North Santiam Canyon Regional Land Inventory. Summary Report*. Prepared for Marion County and Business Oregon. January 9.

This report summarizes the project by Maul Foster Alongi to develop a geodatabase of regional land inventory, regional growth projections, and analysis of redevelopment opportunities. Demographics including population trends (2000 and 2015) and employment by industry (2002 and 2014) for each of the canyon communities (Detroit, Idanha, Gates, Mill City, Lyons/Mehama), as well as other demographic projections. Based upon this information, future development and employment is projected through 2035. A finding from this report is that current urban growth boundaries may be able to contain projected growth.

Mid-Willamette Council of Governments. 2014. *North Santiam Canyon Economic Opportunity Study.*

This report provides discussion of past economic stressors, description of the study area, and employment demographics. Tables 8 and 9 list the economic opportunities and threats. Additional information provided in this document are industrial/commercial land, development constraints, historical and cultural resources, and public infrastructure. The

"Economic Development Strategy" provides a final summary of the issues and then describes investment needs for the region.

Oregon Department of Transportation. 2015. *2014 Transportation Volume Tables.*

Data for 2014 annual average daily traffic counts for the North Santiam Highway. The city of Detroit had approximately 5200 vehicles pass at the counting site in 2014.

Wastewater

Gonzales, D. 2018. "Brownfields through a Public Health Lens: The fight for clean water and economic opportunity in the North Santiam Watershed". Economic Development Marion County. April.

This presentation describes the social and public health concerns about wastewater in the North Santiam canyon. Costs comparisons of sewer and septic systems are provided on slide 29 and 30 – the assertion is that sewer will be less costly in the long term than septic (a well maintained septic system). End user fees for the sewer system are estimated as $44 per person for local residents.

HBH Consulting Engineers. 2014. *Wastewater Feasibility Study*. Prepared for City of Detroit. September.

This engineering report is a technical analysis of feasibility options for wastewater in Detroit. Number of accounts serviced by the Detroit water system are 359, including 50 commercial and 309 residential. Estimated costs of wastewater systems is provided with the engineering alternatives.

Keller Associates. 2017. *North Santiam Canyon Regional Wastewater Analysis*. January.

Motivated by the limitations to development in the North Santiam Canyon, this document is meant to assist communities in planning around the Three Basin Rule to implement upgraded wastewater treatment infrastructure. The Three Basin Rule "prohibits communities from surface discharge of wastewater [into the North Santiam], requires the protection of groundwater, and requires new treatment systems to provide better treatment than the current means of disposal. If the Three Basin Rule cannot be modified, it is most likely that subsurface discharge with water that meets the DEQ requirements for Class A Recycle Water will be the required means for community wastewater disposal." This study found that the lowest cost alternative for the communities would be three new wastewater treatment plants. Other alternatives considered ranged from two to five plants (see Table 6.7). Commentary on legal and governance considerations are also provided.

Recreation

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.

National Forest visitation data which includes total visits by forest and in aggregate for Mt. Hood and Willamette National Forest. Income, spending, and demographic data for visitors is also available.

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.

From data obtained from questionnaires and surveys in summer 2013, this report summarizes the most popular activities, average time spent, distance traveled, frequency of visitation, group size, alternative park preferences, reason for visitation, spending, and many other data points for visitors to Detroit Lake State Recreation Area. From the survey, management recommendations are made to improve park facilities based upon survey findings.

Rosenberger, R. and K. Lindberg. 2012. Oregon Resident Outdoor Recreation Demand Analysis. Oregon State University College of Forestry. 12 November.

The summary data compiled in this report was for the 2013- 2017 Oregon Statewide Comprehensive Outdoor Recreation Plan Survey (SCORP). For both Marion and Linn county, data on number and percentage of population participating in various outdoor recreation. Additional survey responses are available to rank recreation investment priorities, benefits from parks and recreation services, and delivery of benefits for parks and recreation services.

Sorte, D. and C. Buerger 2006. *Economic Impact Study for Detroit Lake and the Upper North Santiam Canyon.* Oregon State University Extension Service.

Under the hypothesis that uncertainty in the water level of Detroit Reservoir has hindered development and tourism, this study estimates the economic impacts of the low water levels. Population growth is calculated through 2003, employment and income characteristics are summarized through the year 2000. Using a survey of business owners, the authors calculated a percent reduction in industries due to low water levels. Employment was estimated to drop by 127 total jobs and output was estimated to drop 2.45 perfect due to low water levels. Multipliers are calculated on Table 6 and are less than the state-level multipliers.

See also Moore (2015) in the Water Supply/Demand/Value section of this report.

Fish and Fish Habitat

North Santiam Watershed Council. 2014. *Watershed Restoration Action Plan*. October.

This guiding document provides an overview of limiting factors and potential projects in the watershed. Table 1 gives a summary of high priority issues, the agencies, drivers, and the related documents. Primary restoration priorities are described in Table 6 and 7 and

include creating aquatic habitat, creating floodplain/riparian habitat, and fish species recovery. Tables 10 – 16 describe how issues are being addressed by the watershed council and specific projects.

Carpenter, D. Native Fish Society River Steward. *North Santiam Native Fish Species*. PowerPoint.

Commentary about native fish in the North Santiam and the issues they face in the subbasin. Offers a historical prospective and thorough background summary.

Gregory. S. 2015. Fish & Stream Temperature. Oregon State University. http://inr.oregonstate.edu/book/export/html/1326.

As part of the Willamette Water 2100 project, surveys were conducted to locate native and non-native fish to determine how future water temperatures might affect fish populations. Findings suggest substantial decreases in populations of native cold-water species would occur with a 2-degree Celsius warming of river temperatures.

National Marine Fisheries Service. 2008. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation.* Consultation on the "Willamette River Basin Flood Control Project". July.

This Biological Opinion as required by the Endangered Species Act covers the Willamette Valley Project for the 13 federally operated dams in the Willamette River Basin for the 13 listed species of salmon and steelhead, green sturgeon, and Southern Resident killer whales. NMFS concluded that the proposed actions were likely to jeopardize and adversely affect habitat for the Upper Willamette River Chinook salmon and steelhead. Because of this finding of jeopardy, the reasonable and prudent alternatives require upgrades to fish passage in the North Santiam. The reasonable and prudent alternatives implemented since 2008 are projected to lower streamflow temperatures in the North Santiam.

Section 4.6 North Santiam Basin: Historical populations of Upper Willamette River Chinook are estimated as 8,250, but it is estimated that the habitat can support about 30,000 adults. Historical populations of Upper Willamette River steelhead are estimated as at least 2,000 prior to 1940. Habitat is blocked by Detroit and Big Cliff dams. Hydrographs of natural and dammed flow are provided in figures 4.6-5A-C. Water quality, habitat, and fish hatcheries are also discussed in this section.

Section 5.6 North Santiam Basin: The continued operation and maintenance of dams and fish hatchery in North Santiam was found to adversely affect Upper Willamette River Chinook and steelhead.

Section 9 Reasonable and Prudent Alternative: Minimum flow requirements at Big Cliff dam are found in Table 9.2-2. Requirements were stipulated to upgrade fish collection and handling

facilities (9.4.6); for Minto the operation was to begin in March 2013. Fish passage upgrades are required to be completed by 2023 as part of the reasonable and prudent alternatives (see section 9.4.12.3 for Detroit Reservoir).

Oregon Department of Fish & Wildlife. 2017. *Minto Fish Facility Counts*. Retrieved May 3, 2018 from: https://myodfw.com/minto-fish-facility-counts.

Counts of migrating fish up the North Santiam River downstream of Big Cliff and Detroit Reservoir dams.

Oregon State University. *Willamette Fish Database*. Retrieved May 3, 2018 from: http://gis.nacse.org/wrfish/.

Geospatial data on native and non-native fish counts and floodplain locations for the Willamette River.

OWEB Focused Investment Partnership Priority. *Aquatic Habitat for Native Fish Species*.

North Santiam is in the highest priority for OWEB investments in aquatic species habitat. Additional details are provided in this document regarding the priority areas and justification for OWEB grant funding.

Willamette National Forest. Detroit Ranger District. 2011. *North Santiam Headwaters Hazards to Habitat*.

This document details the 2011 project to restore habitat along the North Santiam and remove hazardous trees from the highway corridor.

North Santiam Watershed Council. *Willamette Model Watershed Program*. Retrieved May 3, 2018 from: http://northsantiam.org/projects/willamette-model-watershed-program/.

The Willamette Model Watershed Program, funded by Meyer Memorial Trust and the Oregon Watershed Enhancement Board, has provided 10 years of funding to the North Santiam Watershed Council for restoration and water quality improvements on three tributaries: Stout Creek, Valentine Creek, and Bear Branch Creek.

Forests

Ecosystem Workforce Program. 2018. *The Forest Service and Partners: Working Together to Restore Pacific Northwest National Forests.*

Chapter 1 details the Forest Service area, budget, and personnel for each national forest.

Ecosystem Workforce Program. 2018. *The Forest Service and Communities: The Relationships Between Land and People in the Pacific Northwest Region.*

Chapter 1 details the number of average annual visitors, timber volume sold, personnel, budget, and area for each National Forest in the Pacific Northwest.

***North Santiam Fire Statistics*. Grady McMahan, District Ranger, U.S. Forest Service, Detroit Ranger District, Willamette National Forest. October 25, 2017.**

From 1996 - 2016 a total of 54,000 acres of wildfires occurred on the Willamette National Forest. In 2017 alone, the Willamette had 70,000 acres of wildfires.

Oregon State University. *Upland Forest Change*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1276.

This Willamette Water 2100 summary of results estimates that lower snowpack and warmer temperatures will result in a two to nine-times increase in the area burned by forest wildfire. Descriptions of vegetation cover and land use changes are also provided for multiple climate projections.

U.S. Forest Service. North Santiam Watershed Council. *Breitenbush Watershed Collaborative Potential Projects*. Map.

Map of potential projects, roads, and trails in the Breitenbush Watershed.

U.S. Department of Agriculture. 2017. *Pacific Northwest Regional Annual Report 2017.*

This publication contains general information about the state of the national forests in the Pacific Northwest.

See also "Turner et al." in *Climate Change* section of this document.

Hydroelectricity

Federal Columbia River Power System. *FY 2016 and FY 2017 Hydro Generation statistics*.

Data on monthly megawatt hours and price per megawatt for Big Cliff and Detroit dams, in addition to other Federal Columbia River Power Systems dams.

Land Use

Hulse, D. *Conservation 2050*. Willamette River Basin Atlas 2nd Edition.

This document is a tool for conservation planning. Projections to 2050 for urban, rural, agriculture, forestry, and water availability are used to prioritize ecological services. Tier 1 priority areas seek to achieve a naturally functioning landscape, while tier 2 areas are used for the production of goods and services.

Oregon Parks and Recreation Department. 2015. *Oregon Natural Areas Plan*.

The West Cascades Ecoregion contains sites near the North Santiam River (Bagby RNA, Middle Santiam RNA, Carolyn's Crown RNA). Descriptions of ecosystems in this region are provided, including forest types, geology, invertebrate species, fish, amphibians, reptiles, birds, mammals, plants, and fungi.

US Geological Service. *Boundary Descriptions and Names of Regions, Subregions, Accounting Units and Cataloging Units*.

The North Santiam is 771 square miles in Region 17 (Pacific Northwest), subregion 1709 (Willamette River basin), catalog unit 17090005.

3. Value of Water

Jaeger, W., et al. 2013. "Toward a formal definition of water scarcity in natural-human systems," *Water Resources Research*. Vol. 49, pages 4506 – 4517.

In this paper, water scarcity is defined as the marginal value of a unit of water. This interdisciplinary definition is found to vary greatly across space and time due to high transportation and storage costs. Included in this discussion is how geography, institutions, and engineered solutions can both exacerbate and ameliorate water scarcity.

Jaeger, W. 2014. *Modeling Human Side of Water Scarcity in the Willamette Basin*. Oregon State University. Video Presentation. October 8. https://media.oregonstate.edu/media/t/0_d5bbiufd.

See above Jaeger et al. 2013 – this webinar is a presentation of the content of that article.

Jaeger, W., et al. 2017. "Water, Economics, and Climate Change in the Willamette Basin, Oregon". *Oregon State University Extension Service*. EM 9157. February.

This paper summarizes the findings from Willamette Water 2100 that modeled future climate conditions, supply, and demand for the basin. There is extensive research on projections for future populations and land use change that may occur by 2100. Instream flows for Endangered Species Act compliance and state minimum flows accounted for the largest current and designated uses of water in the Willamette Basin. The projected increase in wildfires may contribute significantly to water supplies due to less forest evapotranspiration leading to augmented streamflow. Flood protection from reservoir storage is expected to increase in value by 2100 because of increased municipal populations creating potential for higher flood damages. From the literature, the authors believe the urban water long-term price elasticity of demand is -0.6 and the income elasticity is 0.13 – 0.8; baseline prices for urban water in Portland, Salem-Keizer, Corvallis, and Eugene-Springfield are estimated (p. 72). Irrigation will be affected by future climate conditions which will likely cause the irrigation season to start two weeks earlier. The prohibitive cost of conveyance and added storage capacity does not make it likely that irrigation will be

expanded to lands which are currently unirrigated. Note that findings from Moore (2015) and Kalinin (2013) are incorporated in this publication.

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

Using a hedonic analysis, this master's thesis determined the value of water based upon county assessor estimates at different values of temperature, precipitation, soil quality and elevation in the Willamette Valley. Findings from this portion of the research were that the value of a water right depends of soil class and ranges from 10.49 to 23 $/year per acre foot, an average value of $16.74 (see Table 7). A logistical model was also used to model farmer's decisions to exercise their water right or not based upon a theory of inelastic demand. The value of precipitation in the Willamette valley was found to be $16.44 per acre foot. It should be noted that the values for an acre/foot of precipitation and a water right were almost equal and within standard errors.

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.

This doctoral dissertation estimated the value of Willamette River basin reservoirs for reducing flood damages by storing water. As part of this pursuit, the value of recreation at the reservoirs was calculated using a travel cost method. The value of water in the reservoirs for recreation was estimated at $0.10 to $78.00 per acre foot – with Detroit reservoir being at $11 (see Table 3.8). The value of stored water to mitigate flood damage varies by month, and was highest in January at $304 – $1,284 million, and lowest in May at a value of zero. This dissertation also estimates the optimal rule curve (fill path) for the reservoirs in aggregate.

Oregon State University. *Reservoir Economics*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1296.

Based upon future climate projections, the lost recreation opportunities in Willamette Basin reservoirs are estimated to be up to $12 million by 2100. This change is estimated to occur due to warmer and drier summers, coupled with increased environmental flow requirements and higher demand for non-stored water. Flood control benefits from the reservoirs are also estimated at $1 billion currently and are estimated to increase to $3 billion by 2100.

Willamette Master Manual. *Tables of Willamette Projects*.

Table 3-1 describes physical characteristics for each subbasin (area, perimeter, streams, etc.). Table 7-1 lists minimum flow guidelines for Big Cliff (not Detroit). Table 8-1 monetizes prevented flood damages from 1942 to 2013 – nominal value of flood damage prevented for

Detroit is $763,238,673. Table 8-6 compares regulated and natural flow levels for the North Santiam. Tables for average runoff and peak flow are also included for North Santiam.

Ernster, T. Personal Email. "USACE re: Detroit & Big Cliff – Number of Jobs". December 28, 2017.

There are fourteen full-time positions physically located at Detroit and Big Cliff dams and additional jobs at the Minto fish operating facility. Additional personnel provide support for the dams but are not physically located there and work on other dams as well (see "Organization Chart" attachment).

4. Future Trends

Climate Change

Oregon State University. *Reservoir Operational Performance*. Institute for Natural Resources: Willamette Water 2100. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1306.

Willamette Water 2100 found that climate change will have only a limited effect on reservoir storage and that spring/summer flow targets should be generally met in the future using reservoir storage. See Moore (2015) for additional discussion.

Oregon State University. *Reservoir Operations and Climate Change in the Willamette Basin*. Video Presentation. Willamette Water 2100. https://media.oregonstate.edu/media/t/0_qrvmvk9h.

See Moore (2015) – this webinar is a summary of her findings.

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

Using three future climate scenarios, the Willamette Water 2100 research team estimated changes in snow-water equivalent for high and low elevations. All future scenarios saw decreases in snowpack and a conclusion from the research is that winter flows will increase, spring runoff will occur earlier in the season, and timing of reservoir fill operations will need to be adjusted.

P. Mote, D. Rupp, J. Vano, and N. Gilles. *Future Climate*. Institute for Natural Resources: Willamette Water 2100. Oregon State University. Retrieved May 3, 2018 from: http://inr.oregonstate.edu/book/export/html/1241

This document details the scientific evidence and choices incorporated in climate models used for Willamette Water 2100.

Rupp, D., et al. 2013. "Evaluation of CMIP5 20th century climate simulations for the Pacific Northwest USA," *Journal of Geophysical Research: Atmospheres*, VOL. 118, 10,884–10,906

Global climate models have been used for regional climate projections, but there is uncertainty about how well these global simulations can be applied at the regional level. This study finds variation in model performance and emphasizes the need for localized sampling.

Sproles, E., et al. 2017. "Future snow? "A spatial-probabilistic assessment of the extraordinarily low snowpacks of 2014 and 2015 in the Oregon Cascades," *Cryosphere*, 11, 331-341.

In the Pacific Northwest, the winters of 2013-2014 and 2014-2015 fell short of historical snowpack averages. Based on climate change projections, this article finds that the probability of snowpack levels at the same magnitude of these references years will increase.

Turner, D., et al. 2016. "Assessing mechanisms of climate change impact on the upland forest water balance of the Willamette River Basin, Oregon," *Ecohydrology*. 10.

Turner et al. (2016) is a publication that resulted from the Willamette Water 2100 study. The article uses three reference scenarios for future climate to predict how forest evapotranspiration (ET) will impact water budgets in the Willamette River Basin. All three models predicted declines in ET; coupled with additional causes of ET, increase in annual streamflow are expected to exceed historical levels.

U.S. Forest Service. Pacific Northwest Research Station. 2016. "Flows of the Future — How Will Climate Change Affect Streamflows in the Future in the Pacific Northwest?" Science Findings, 187, July.

This US Forest Service report is motivated by the fact that half the water in the Pacific Northwest originated on national forests. The impact of climate change on streamflow is dependent upon the geology of the system (groundwater vs. surface water fed streams), as well as the "precipitation regime" (timing and quantity of water). Policy implications of these findings include enhanced planning, restoration investments, infrastructure upgrades, and modified dam operations.

Resiliency

GSI and David Evans Associates. 2017. *North Santiam Watershed Drought Contingency Plan*. Prepared for North Santiam Watershed Drought Contingency Plan Task Force.

Contained in this planning document are frameworks for drought monitoring, vulnerability assessments, mitigation actions, and response actions for the Drought Contingency Plan

developed by the North Santiam Watershed Task Force. Limitations to the plan are described as uncertainty about US Army Corps of Engineers actions, late season precipitation events, climate change, and unknown groundwater levels. A vulnerability assessment was conducted (results in Figure 2 and 3); some of the most vulnerable sources as municipal water use among the canyon communities. Underlying causes of vulnerability are provided in Table 7. Capital projects to mitigate drought are prioritized in Table 8.

North Santiam Watershed Council. 2016. *6th Annual North Santiam Watershed Summit. Drought Contingency Planning*. May 12.

The agenda for this summit includes descriptions of participants and their surveyed responses about values, vulnerability assessments, lessons learned from the 2015 drought, and desired outcomes from the drought contingency planning process. The PowerPoint from the summit is also included.

North Santiam Watershed Council. 2017. *7th Annual North Santiam Watershed Summit. Introducing the North Santiam Drought Contingency Plan*. April 17.

A list of participants, the agenda, and feedback received from the summit are included in this document.

Covey, S. 2016. North Santiam Water, Aquatic, Riparian and Terrestrial Resiliency Analysis. Map.

Compiled by Sandra Covey, this map shows resiliency indicators for riparian buffers and watershed HUC12 zones. The least resilient zones are near Detroit Lake and the zone near the confluence with the Willamette.

David Evans and Associates. 2017. *North Santiam Watershed Resiliency Action Plan*. Prepared for Partners of the North Santiam Watershed. December.

The Partners of the North Santiam Watershed have commissioned this resiliency action plan as a starting point for a shared dialogue to promote coordinated actions within the watershed.

Mazur, L. 2016. "Bounce Forward: Building Resiliency for Dangerous Times," *Solutions*, Vol. 6: Issue 6, Pages 13-19. Jan 30.

A definition of resilience is defined as "the capacity of a community to anticipate, plan for, and mitigate the risk – and seize the opportunities - associated with environmental and social change". This author pushes back against the idea that resiliency is merely bouncing back, which reinforces behaviors which led to the original disaster – instead propagating win-win solutions by "bouncing forward". A list of characteristics of resilient communities is provided.

North Santiam Resiliency Action Plan Values Survey 1.

This document contains results from North Santiam Resiliency Action Plan survey. Background information is provided on habitat, aquatic species, and water quality, as well as socioeconomic factors. The WATR Model Tool provides a ranking of most to least resilient (see Covey 2016). The remainder of the document lays out resiliency goals, values, and a mechanism for project prioritization.

Tyler, S., S. Chandra, and G. Grant. 2017. "Management Strategies for Sustainable Western Water," *Eos*. Vol. 98. April 25.

This summary of an August 2016 U.S. National Science Foundation Workshop "Quenching a Thirsty West; Lake Tahoe, Nevada/California". The workshop concluded that "it is time for a western-focused, integrated center to develop science- and social science–based solutions for addressing water scarcity and resilience to change in the West". This science based central planning entity would be integrated with public planning to create water resiliency.