2016 Washington State Legislative Report

Columbia River Basin

Long-Term Water Supply and Demand Forecast

EXECUTIVE SUMMARY

Publication No. 16-12-001

Submitted December 2016 Pursuant to RCW 90.90.040 by:

DEPARTMENT OF ECOLOGY
State of Washington

in collaboration with

Washington State University

The University of Utah

State of Washington Water Research Center

Aspect

Washington Department of Fish and Wildlife

This publication is available on the Department of Ecology website at:
http://www.ecy.wa.gov/programs/wr/cwp/2016Forecast.html

For additional copies of this publication, please refer to
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Cover photo: Columbia River below Wanapum Dam

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2016 Legislative Report

Submitted to Washington State Department of Ecology by:
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Ecology Publication No. 16-12-001

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Columbia River south of Goldendale, WA

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December 22, 2016

The Honorable Jay Inslee, Governor
and Honorable Members of the Washington State Legislature
Olympia, Washington

RE: 2016 Columbia River Basin Long-Term Water Supply and Demand Forecast

Since its creation in 2006, Washington Department of Ecology's Office of Columbia River (OCR) has been charged with a mission to aggressively pursue water supply development for both instream and out-of-stream uses to meet Eastern Washington's economic and environmental needs. To support this mission, every five years OCR prepares and submits to the state legislature a water supply and demand forecast. On our 10-year anniversary, I am pleased to submit to you, the third "Columbia River Basin Long-Term Water Supply and Demand Forecast" (Forecast).

OCR partnered with Washington State University (WSU) and the State of Washington Water Research Center; with additional contributions from the Department of Fish and Wildlife, the University of Utah and Aspect Consulting to provide this state-of-the-science forecasting of water supplies and demands 20 years into the future. This 2016 Forecast builds upon the previous two Forecasts by providing a system-wide assessment that combined field measurements, state-of-the-science economic, crop, climate, and water right modeling techniques.

This Forecast tells the story of Washington's water future; where current demand for water exists, the relative magnitude of instream versus out-of-stream demands, and how future environmental and economic conditions are likely to change water supply and demand by 2035. The Columbia River Policy Advisory Group, watershed planning units, sister state agencies, tribes, local governements and the general public provided valuable input that helped the researchers refine methodologies to conduct the agricultural, municipal and industrial, and hydropower components of the forecast.

In Washington State, mountain snowpack is the engine that makes the crops, habitat, and communities thrive – storing valuable winter water and then releasing it into streams and canals when farms, fish, and domestic supply needs are at a peak. This year's forecast confirms overall seasonal shifts in timing of water supply, and how this effects future demand and will be a dominant issue that will likely require area-specific management and adaptation strategies in the future. The droughts of today are likely the average water conditions we will face in the future.

Some of the recommendations outlined in the 2016 Forecast will require additional funding to implement, which OCR will consider as it prepares its future biennial budget requests, while others are policy or legislative in nature. The outcome of the Columbia River Treaty negotiations could also significantly alter how OCR directs its resources, manages its portfolio of water supply projects, and invests in new projects moving forward.

Over the past decade, OCR has invested in a variety of water supply projects to meet competing water management objectives. This has resulted in over 410,000 acre-feet of new water supplies in central and eastern Washington, with more water under long-term development tied to future demand projections. OCR will continue to utilize the 2016 Forecast as a capital investment planning tool, maintaining and enhancing the region's economic, environmental and cultural prosperity through development of future water supply projects.

Sincerely,

G. Thomas Tebb, Director
Office of Columbia River

DEFINITIONS OF WATER SUPPLY AND WATER DEMAND TERMS

Water Supply

Surface Water Supplies reflect the total amount of surface water generated in a watershed, quantifying the water available for in-stream and out-of-stream uses. Supplies reflect water availability prior to accounting for demands. They should not be compared to observed flows, which do account for demands through withdrawals for irrigation and other out-of-stream uses (see the **Stream Flows** definition, below). Supplies were estimated using an integrated modeling framework that incorporates the impacts of operations of major reservoirs on the Columbia and Snake Rivers, as well as the major reservoirs in the Yakima Basin. Regulated supplies represent water that has been stored and released from reservoirs, whereas unregulated supplies have not. Water supplies at the watershed (Water Resource Inventory Area, or WRIA) level are “natural supplies”, without consideration for reservoirs, with the exception of the Yakima watershed (WRIAs 37, 38, and 39).

Groundwater Supplies reflect the amount of groundwater (from aquifers) available to meet different water demands. Groundwater supplies were not modeled or quantified in the 2016 Forecast. Certain assumptions about existing groundwater supplies were made, described in the Groundwater Irrigation Demand definition, below. To address groundwater supply limitations in future Forecasts, an inventory of areas within the state where groundwater levels are known to be declining was created (see the *Integrating Declining Groundwater Areas into Supply and Demand Forecasting* module).

Historical Supplies indicate surface water supplies modeled for 1981-2011, based on historical climate data. To characterize variability in supplies, historical supply curves are provided for low, median, and high supply conditions. As supply cannot be straightforwardly measured, these different conditions were based on flow measurements. Low, median, and high flow conditions were determined as the 20th, 50th, and 80th percentile flows in the historical record, respectively.

Forecast Supplies indicate forecasted supplies for the year 2035. Models to quantify supply were run using projected climate information from the global Coupled Model Intercomparison Project Phase 5 (CMIP5) as inputs. These projections include results from five global climate models, obtained using two different assumptions as to how greenhouse gases in the atmosphere are expected to increase, leading to ten different future climate scenarios. Major reservoir rules were assumed not to change in response to changes in forecasted (2035) water supply.

Water Demand

Agricultural Water Demand represents the water needed to fulfill the needs of crops, often referred to as “top of crop” water use. This includes water that will be used consumptively by the crops, as well as irrigation application inefficiencies (such as evaporation, drift from sprinklers, or runoff from fields), but does not include conveyance losses (see the Conveyance Losses definition, below). This demand can be met by groundwater or surface water. In the case of surface water, it is considered an out-of-stream use, as water is diverted from rivers to croplands.

Conveyance Losses denote water that is lost as it travels through conveyance systems, which can occur to varying degrees in everything from unlined ditches to fully covered pipes. These losses vary widely and are difficult to assess, but have been estimated to average about 20% across the whole Columbia River Basin. Because of the greater uncertainty associated with these estimates, conveyance losses have been treated and shown separately from “top of crop” demands.

Non-Consumptive Return Flows are estimates of the water that is not consumptively used by crops (including irrigation application inefficiencies and conveyance losses), that percolates through the soil and returns to the groundwater or surface water system. Such flows may be available to users downstream, although the time-lags vary considerably both in time and location. Some of the upstream water demand will be counted towards supply downstream of the original place of use.

Groundwater Irrigation Demand represents the agricultural water demand that was met by groundwater supplies. Because this Forecast did not model groundwater supplies, the assumption was made that groundwater supplies would be sufficient to meet a fixed percentage of agricultural water demand, and that percentage would remain constant through 2035. The exception to this assumption was for the Odessa Subarea, where future groundwater supply was forecasted to decrease to zero. There is a recognition that these assumptions are not realistic everywhere, as watersheds with closed or regulated surface water bodies likely have limited groundwater supplies not available for new appropriation. The inventory of areas with declining groundwater levels (see the *Integrating Declining Groundwater Areas into Supply and Demand Forecasting* module) is a first step towards better incorporating groundwater into future forecasts.

Unmet Irrigation Requirements represent the difference between agricultural water needed for crops planted in a typical year to achieve maximum yield, and the water supply available for agricultural irrigation. In watersheds with adopted instream flow rules, curtailment of agricultural water use will occur when agricultural requirements exceed available water. The frequency and magnitude of such curtailments in historical and forecast time periods were quantified for those WRIAs with adopted instream flow rules (see the *Curtailments for WRIAs with Adopted Instream Flow Rules* section). In addition, a method for quantifying the economic impacts of curtailment was developed, and an example of its application is provided (see the *Exploring the Economic Benefits of More Water for Agriculture* section).

Municipal Demand includes estimates of water delivered through municipal systems, as well as self-supplied sources. Municipal demand was only estimated within Washington State. For each county in a WRIA, estimates of municipal demand were computed as the sum of water for domestic, commercial and industrial demands, as reported by the U.S. Geological Survey. The source of water can be surface or groundwater. Municipal demand also has a consumptive portion and a non-consumptive portion. The non-consumptive portion includes water that is lost through system leakages and water that returns for wastewater treatment. Together, the consumptive and the non-consumptive portion represent municipal demand.

Instream Water Demand was incorporated into water management modeling through state and federal instream flow targets. Within Washington's watersheds, the highest adopted state and federal instream flows for a given month were used to express current minimum flows for fish in both historical and forecasted instream demands. State and federal instream flows along the Columbia River mainstem were also compared to historical and future supplies.

Hydropower Water Demand represents the total amount of water that needs to flow through the dams to generate the electricity needed by the entities managing those dams to fulfill their clients' needs. This demand is not estimated with the integrated model, and accurate data to estimate hydropower demand is lacking.

Total Water Demand is the water needed for different instream and out-of-stream uses, including agricultural demand, conveyance losses, groundwater demand, municipal demand, and instream flow requirements. For purposes of this report, Total Water Demand does not include all existing demands for water. For example, it does not quantify water needed for hydropower, recreation, and navigation.

Historical Water Demands indicate demands modeled for 1981-2011, based on historical climate data. Low, average, and high demand conditions were determined as the 20th, 50th, and 80th percentile demands in the historical record, respectively.

Forecast Demands indicate demands projected for the 2020-2050 time period, evaluating year-to-year variability expected by 2035. These demands are expected to be strongly affected by climate change impacts on crops' water requirements, by trends in agricultural production, and by water management policies. The climate change effects were explored by modeling demands under ten climate change scenarios (described in the **Forecast Supplies** definition, above). The effects of trends in agricultural production were explored by modeling two additional scenarios: 1) assuming the current crop mix remains unchanged, and 2) under a projected crop mix that was developed by using a statistical model to extend recent trends in crop mix into the future. In both these scenarios the irrigated land base in agriculture is assumed to remain the same. The Forecast does not incorporate improvements in irrigation efficiency or changes in crop mix that might be adopted by producers in response to limitations in water availability. Finally, the effects of water management policies were explored by quantifying the economic benefits of more water for agriculture (see the *Forecasting Water Supply and Agricultural Demand – Exploring Water Management Scenarios* section).

Stream Flows represent streamflow conditions at specific locations in a watershed, as would be observed by a streamflow gauge. Flows at a particular location reflect the balance between supply and demand in the watershed upstream of that location. Whereas supply is the total amount of surface water generated in a watershed and does not account for the impacts of water use and withdrawals (see **Surface Water Supplies** definition, above), flows do account for consumptive use of water upstream of the specified location.

THE 2016 WATER SUPPLY AND DEMAND FORECAST

The Washington State Legislature recognized the complexities in the water supplies and needs of people and fish across the Columbia River Basin (Basin) in Washington, and identified the development of new water supplies as a water resource management priority. In 2006, it passed Chapter 90.90 RCW, directing the Department of Ecology to aggressively develop water supplies for instream and out-of-stream uses in the Basin. The Office of the Columbia River must develop a long-term water supply and demand forecast every five years, pursuant to RCW 90.90.040 *Columbia river water supply inventory—Long-term water supply and demand forecast*[1]*:*

> *RCW 90.90.040(1) To support the development of new water supplies in the Columbia river and to protect instream flow, the department of ecology shall work with all interested parties, including interested county legislative authorities and watershed planning groups in the Columbia river basin, and affected tribal governments, to develop a Columbia river water supply inventory and a long-term water supply and demand forecast.*
>
> *RCW 90.90.040(3) The department of ecology shall complete the first Columbia river long-term water supply and demand forecast by November 15, 2006, and shall update the report every five years thereafter.*

This 2016 Columbia River Basin Long-Term Water Supply and Demand Forecast is the third forecast submitted to the Washington State Legislature since 2006.

Meeting Eastern Washington's Water Needs

The Columbia River Basin, the fourth largest watershed in North America in terms of average annual flow, is intensively managed to meet a range of competing demands for water, including hydropower generation, irrigation, navigation, flood control, protection of salmonid species, municipal and industrial use, tribal treaty commitments, and recreation. Reliable access to water is essential for existing and future regional economic growth and environmental and cultural enhancement. Variations in water supply and demand across the Basin are increasingly leading to localized water shortages as populations grow, the climate changes, and regulatory flow requirements increase. Managing these multiple demands for fresh water requires understanding how future conditions will alter water supply and demand, and strategically investing in projects that meet competing water management objectives.

The water supply systems within the Columbia River Basin were built to reliably deliver water under historical conditions. Future changes in water supply and demand, therefore, have the potential to stress the system. This 2016 Long-Term Water Supply and Demand Forecast provides information that will help legislators, water managers, industry, and agency professionals plan for future conditions that will likely be quite different from those we have experienced in the past.

Many factors that influence water supply and demand—agricultural market conditions, input costs, production decisions, global trade conditions, temperature and precipitation patterns, water management policies, water storage capacity—need to be projected into the future. This 2016 Forecast explores three broad types of changes that are expected to occur:

- ***Climatic:*** Changes in precipitation and temperature affect water availability, agricultural growing conditions, and the season during which crops require water. The Pacific Northwest is expected to experience increasing temperatures and shifts in precipitation, leading to wetter winters and springs, drier summers, declining snowpack, earlier snowmelt and peak flows, and longer periods of low summer flows. Increasing temperatures also result in an earlier shift in the irrigation season. Increased concentrations in carbon dioxide also directly affect crops' water requirements. These climatic changes were explored using the results of global climate models downscaled to a regional level to represent the projected climate for 2035.

- ***Economic:*** Water demand depends on the mix of crops in the region, which in turn is responsive to consumer tastes, domestic food demand, export and import trends, and production technologies, among other factors. While some crop groups have seen relatively large changes within existing cropland, the relative acreage share for the region is expected to remain stable, with forage covering the most acreage. Changes in crop mix were explored using a statistical model to project to 2035 the trends in crop mix that are currently being observed.

1 The full text of RCW 90.90.040 (available at https://app.leg.wa.gov/rcw/default.aspx?cite=90.90.040) includes additional detail on the water supply inventory

- ***Water management:*** Changes in water availability, storage capacity, and programs that pass the cost of water supply development along to users affect water use. Increases in water storage capacity from planned projects can reduce the current users' vulnerability to drought, or can supply water to new uses, including the development of new irrigated acreage. Such water management changes were explored using estimates of the economic benefits of making additional water available for agriculture.

Other types of changes were beyond the scope of this Forecast, often because available data were not sufficient to develop feasible scenarios. By exploring these three dominant types of changes, however, this Forecast quantifies the likely range of water supply and demand across the Columbia River Basin in 2035, paying particular attention to the portion of the Basin in eastern Washington State.

Overview of the 2016 Forecast

Surface water supplies reflect the total amount of surface water generated in a watershed. Water demand is the total amount of water needed for total instream uses—including hydropower and instream flow requirements—and out-of-stream uses, including agricultural demand (the dominant out-of-stream use), conveyance losses, and municipal and domestic demand (hereafter called municipal demand; see details in the *Definitions of Water Supply and Water Demand Terms* section).

Water supply and demand impact each other. Out-of-stream diversions reduce supply downstream, while water that is diverted but not consumptively used—such as water that is lost through leaks in municipal systems or return flows from irrigated fields—may return to the system and provide water supply downstream.

The 2016 Forecast simulated surface water supply and agricultural irrigation demands with an integrated computer model that captures the relationships between climate, hydrology, water supply, irrigation water demand, crop productivity, economics, municipal water demand, and water management for three different geographic scopes (Figure ES-1):

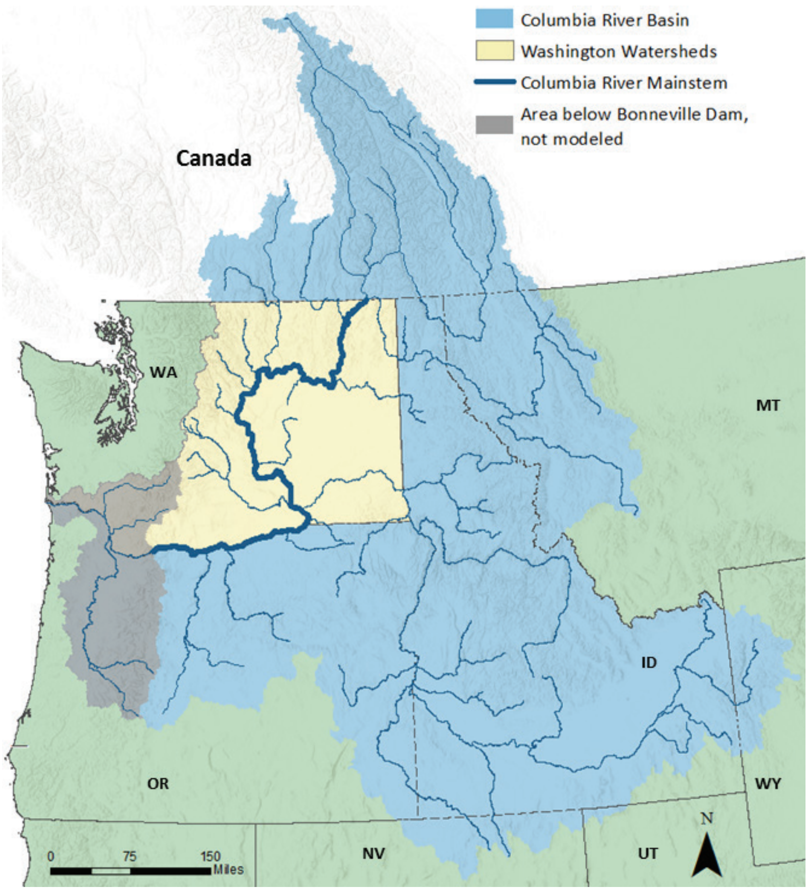

Figure ES-1. The 2016 Forecast results are provided for three different geographic scopes: Columbia River Basin, Washington's Watersheds, and the Columbia River Mainstem.

- **Columbia River Basin,** upstream of Bonneville Dam, across seven U.S. States and one Canadian Province.
- **Washington Watersheds,** as delineated by eastern Washington's 34 Water Resource Inventory Areas (WRIAs).
- **Mainstem,** from the Canadian border to Bonneville Dam.

The model used in the 2011 and 2016 Forecasts integrates and builds upon three existing models—VIC, CropSyst, and ColSim—that have been used independently in various published studies to simulate conditions in the Columbia River Basin. What distinguishes this 2016 Forecast from previous efforts is that:

- The hydrological (VIC) and crop production (CropSyst) models are more tightly integrated, so that the interactions between the hydrological cycle and crop growth processes are better captured. This improves the simulation of crop water requirements, particularly during drought conditions.
- Newer climate change projections (CMIP5) and improved downscaling methods were used, so that future climate scenarios are more appropriate for

the region, and are better able to capture changes in temperature and precipitation extremes, in addition to changes in average temperatures and precipitation.

- Improved historical climate and crop data were available, reducing the number of assumptions that were needed to model historical supply and demand across the region.
- Only one 2035 crop mix was projected, simplifying the assumptions made about future domestic economic growth and international trade. The 2011 Forecast demonstrated that scenarios based on varying economic growth and trade have relatively little effect on the future crop mix.
- In an attempt to improve curtailment modeling, a survey of watershed water masters was conducted by Ecology. While this process provided useful information it was only adequate for direct use in the curtailment modeling for the Yakima Basin, where Yakima RiverWare was used to better simulate prorationing.
- A method for using the value of water to explore responses to water shortages was developed and used to quantify upper and lower bounds of the negative impacts of reduced water availability on production and profitability. The upper-bound estimate was based on all crops suffering curtailment equally. For the lower-bound estimate, farmers were expected to fallow lower value crops first.


Columbia River at Hanford Reach

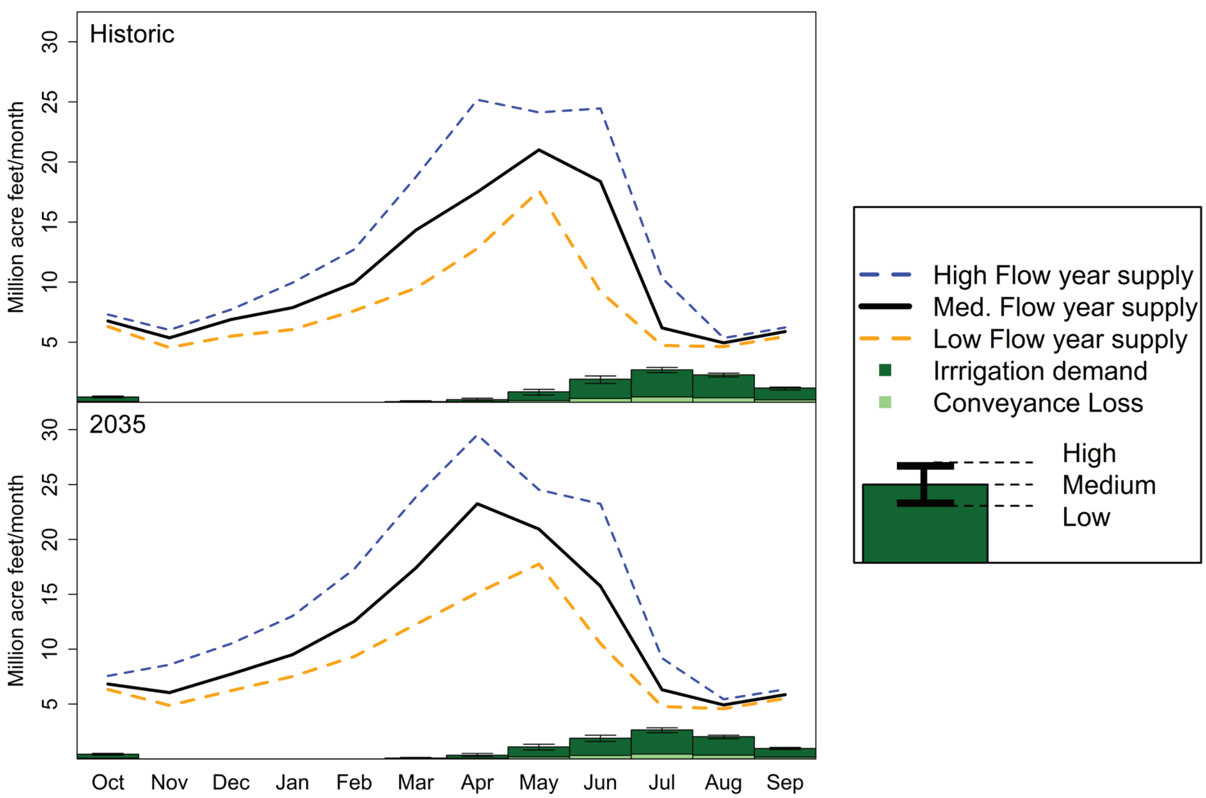

Figure ES-2. Comparison of regulated surface water supply and agricultural water demands for the historical (1981-2011; top panel) and forecast (2035; bottom panel) periods across the entire Columbia River Basin. Interannual variability is shown for both supply (dotted lines) and demand (error bars) (for details see Box 9 in the full Legislative Report). For detailed explanation of this figure, see the Columbia River Basin Surface Water Supply and Columbia River Basin Agricultural Water Demand sections in the full Legislative Report.

In addition to the abovementioned improvements, five complementary modules were produced, focusing on key policy issues whose prominence is expected to increase in the next five years. These modules are:

1. *Integrating Declining Groundwater Areas into Supply and Demand Forecasting:* In some areas of the State, basins are being closed to further groundwater withdrawals due to declining water levels. Where is it critical to integrate groundwater supply modeling into future Forecasts? Is there sufficient data available in those areas to do so?

2. *Pilot Application of METRIC Crop Demand Modeling in Washington State:* Estimating and tracking actual water use by crops may be useful in water right evaluations and adjudications, and to inform future Forecasts. Can agricultural water demands, non-consumptive return flows, and stream discharges be estimated at finer scales, to better assist in those decisions?

3. *Water Banking Trends in Washington and Western States:* Water banking is growing in areas of the State (and beyond) where there is a need to trade water, as no additional water is available—or expected—to support development. What can be learned from water banking across the West, that can help facilitate and increase the efficiency of water banking in Washington State?

4. *Effects of User-Pay Requirements on Water Permitting:* The State Legislature has moved towards an applicant-pays system for processing water rights applications, yet little information exists on how to effectively design such a system. What impacts do different user-pay systems for water right permitting have on the demands for water?

5. *Western Washington Supply and Demand Forecasting:* Policy issues can have statewide relevance, so consistency in planning and available information across the whole state can inform the need and impacts of proposed policies. Is it feasible to extend the modeling approach to western Washington, as the foundation for a complete Washington State water forecast?

In 2016, the Washington Department of Fish and Wildlife also updated and expanded the Columbia River Instream Atlas (CRIA; Ecology Publication No. 16-12-006), focused on instream water needs and priorities for conserving salmonid species in Washington State.

Feedback received on the previous Forecast (2011) along with interactions with the Columbia River Policy Advisory Group, the Water Resources Advisory Committee, the agriculture, hydropower, and municipal communities, and local, state, federal, and tribal governments in the intervening years were essential for planning for the 2016 Forecast.

Significant Findings

Columbia River Basin Water Supply

Forecasts for 2035 suggest that there will be an overall increase in annual water supplies across the Columbia River Basin, and a shift in supply timing away from times when demands are the highest. Unregulated surface water supply

Table ES-1. Modeled water supply in the historical (1981-2011) and forecast (2035) periods for the entire Columbia River Basin. Values between parentheses for 2035 represent confidence intervals around the average of future values in median flow years, due to range of supply values obtained under different climate scenarios (for details see Box 9 in the full Legislative Report). The "% Change" reflects the difference from the historical to the forecast values, and is also accompanied by confidence intervals associated with climate uncertainty.

	Historical (million ac-ft per year)	2035 Forecast (million ac-ft per year)	% Change
Entire Columbia River Basin	126.5	145(± 10.48)	14.63% (± 8.29%)

Table ES-2. Modeled agricultural water demands excluding conveyance losses (known as "top of crop"), in the historical (1981-2011) and forecast (2035) periods. Values between parentheses for 2035 represent confidence intervals around the average of future values in median demand years, due to the range of demand values obtained under different climate scenarios (for details see Box 9 in the full Legislative Report). The "% Change" reflects the difference from the historical to the forecast values, and is also accompanied by confidence intervals associated with climate uncertainty.

	Historical (1981-2011) (million ac-ft per year)	2035 Forecast (million ac-ft per year)	% Change
Entire Columbia River Basin	10.1	9.6 (± 0.08)	-4.96% (±0.81%)
Washington Portion of the Columbia River Basin	4.2	3.9 (± 0.04)	-6.87% (±0.98%)

between June and October is projected to decrease 10.28% (±7.86%[2]), on average[3]. Meanwhile, an average increase of 30.79% (±9.41%) is expected in unregulated surface water supply between November and May (Figure ES-2). These changes combine to produce an overall increase of approximately 14.63% (±8.29%) in average annual supplies relative to historical (1981-2011) supplies across the entire Columbia River Basin (Table ES-1). This shift in timing is in response to warming temperatures, which will result in a smaller snowpack, with more precipitation falling as rain and less as snow, and an earlier snowmelt peak. Even with an overall increase in annual water supplies, it is possible that this shift in supply away from the season of highest water demand has the potential to cause increased water scarcity in portions of the Columbia River Basin during the irrigation season, which may also shift earlier in the year.

Annual surface water supplies entering Washington will increase approximately 12.65% (±3.03%) by 2035, on average. This includes inflows into Washington along the Similkameen, Kettle, Columbia, Pend Oreille, Spokane, Clearwater, Snake, John Day, and Deschutes Rivers. Most of the rivers show increases in supply for each climate scenario. However, the direction of change varied across climate scenarios for the Columbia, the Spokane and the Kettle Rivers, particularly when the year-to-year variations were considered. For these three rivers, the supply decreased on average 3.53% (±2.82%), 2.70% (±4.50%), and 3.00% (±4.65%), respectively.

Annual surface water supplies generated within the Washington portion of the Columbia River Basin are expected to increase approximately 14.39% (±3.82%) by 2035, on average. This calculation includes the major watersheds of the Walla Walla, Palouse, Colville, Yakima, Wenatchee, Chelan, Methow, Spokane, and Okanogan Rivers. While most rivers show increases in supply regardless of the climate scenario used, three watersheds—Colville, Spokane, and Okanogan—showed mixed results, ranging from increasing to decreasing supplies, depending on the climate scenario used. The changes in supply for these major rivers in Washington ranged from 3.61% (±4.44%), on average, for the Spokane watershed to 51.4% (±4.00%), on average, for the Methow watershed. As with the supply forecast for the entire Columbia River Basin, these rivers will experience shifts in the timing of stream flow. The rivers experiencing the greatest shift in supply timing are those for which streamflow was predominantly derived from snowmelt during the historical period, such as the Methow River.

2 The values within parentheses reflect uncertainty due to projecting climate 20 years into the future. For details on how climate uncertainty was quantified please see the full Legislative Report.

3 For details on year-to-year variability and how it was quantified please see the full Legislative Report.

Columbia River Basin Water Demand

Even as water supplies are forecast to increase by 2035, agricultural water demand—which accounts for approximately 79.4% of total out-of-stream demand (agricultural plus municipal)—is forecast to decrease by approximately 4.96% (±0.81%) by 2035, across the entire Columbia River Basin. This decrease is somewhat greater within Washington, where it is forecast to reach 6.87% (±0.98%) (Table ES-2). These decreases in demand are due to a combination of (a) projected changes in climate toward warmer and slightly wetter conditions, leading to an earlier and wetter beginning to the growing season, a shorter irrigation season for most crops; and (b) projected changes in crop mix, where crops with lower water use are expected to replace high-water-use pasture. These results are consistent with current trends in agricultural water demand for non-drought years, which have shown reductions in diversions for irrigation. It is worth noting, however, that current trends may also be responding to changes in irrigation technology, a factor that is not included in the model, and therefore not contributing to the forecasted decrease in agricultural water demand.

Demand for energy generated at hydropower facilities across the Columbia River Basin is anticipated to increase by 2,200 to 4,800 megawatts (MW), on average, by 2035 (accounting for distribution and transmission system losses). Quantifying the demand for instream water at existing dams (or at points where future reservoirs could potentially be built) is challenging, as such a "conversion" of flows to energy produced depends on many factors, including dam design, peak power needs, efficiency, and availability of other energy sources. A preliminary conversion was attempted, with an estimated power-to-water conversion factor of approximately 16 ac-ft/MW, leading to projections of increases in hydropower water demand of as much as 75,000 ac-ft per year by 2035 (Table ES-3).

Demands within Washington State

Within the Washington State portion of the Columbia River Basin, historical (1981-2011) out-of-stream diversion demands for municipal and agricultural irrigation water (excluding irrigation conveyance losses) were estimated to be in the range of 3.82 million ac-ft. At the watershed scale, shifts in timing of water supply towards the winter and spring months by 2035 are similar to those observed for the entire Columbia River Basin. The details vary by watershed, however. The rivers experiencing the greatest shift in timing of supply are those for which streamflow was predominantly derived from snowmelt. The Forecast anticipates the following changes in water demand (Table ES-3):

- 291,432 (±41,405) ac-ft decrease in total (ground and surface) agricultural water demand annually. This number assumes no change in irrigated acreage. In addition to the demands for both surface and groundwater to be applied to crops, this number accounts for irrigation application inefficiencies. By 2035, surface, out-of-stream water demands across eastern Washington are forecast to increase by 6,644 (±34,645) ac-ft per year. This additional surface water would be needed to support current water use practices in the Odessa Subarea into the future, replacing water demand currently being met by declining groundwater.
- Production changes in Washington, such as double cropping, may increase as the climate changes and crops mature earlier in the season. Water development projects planned by the Office of the Columbia River would make "new" water available, leading to increased irrigated acreage. These two factors could, in combination, lead to the overall demand for irrigation water increasing by tens to hundreds of thousands of acre-feet per year by 2035 (Table ES-3).
- 80,000 ac-ft in additional total diversion demands for municipal and domestic water annually, which represents an 18% increase over 2015 (Table ES-3). This increase in municipal and domestic demand is due to a 17% increase in population expected between 2015 and 2035. Although some new municipal demands will likely be met by deep groundwater supplies, others will likely come from shallow groundwater or surface water.

Consistent with the results of the 2011 Forecast, the greatest concentrations of current and future agricultural irrigation and municipal water demand are in south-central Washington[4]. The forecast shift in peak flow to earlier in the spring will decrease future summer season water supply. This shift in timing is dominant in north-central and northeastern Washington watersheds and some southern watersheds. Although annual irrigation demand is forecast to decrease in the future, increases in early season irrigation demand are projected to occur in central Washington watersheds, with associated increased vulnerability to curtailments during droughts. Forecast out-of-stream demand estimates for 2035 do not account for potential water conservation improvements.

4 For details on each watershed, please see the full Legislative Report.

Table ES-3: Summary of changes in demands in eastern Washington between the historical (1981-2011) and forecast (2035) periods for different uses. Additional information on demands that will need to be met with surface supplies, that are not currently being met from this source, or not reliably, are included to provide context.

Water Use or Need	Estimated Volume (acre-feet)	Source
Projected changes in Agricultural Demand by 2035 [a]	-332,837 to -250,027	WSU Integrated Model
Projected changes in Agricultural Demand by 2035 with 10% Double Cropping [b]	-272,837 to -130,027	WSU Integrated Model + Coarse Estimate of 2nd Crop Water Needs
Projected changes in Agricultural Demand by 2035 with 10% Double Cropping and Planned Water Supply Projects [c]	27,163 to 169,973	WSU Integrated Model + Coarse Estimate of 2nd Crop Water Needs + Planned Water Supply Projects through 2026
Projected changes in Municipal and Domestic Demand (including municipally-supplied commercial) by 2035	80,000	Municipal Demand Projections
Projected changes in Hydropower Demand by 2035 [d]	35,000 to 75,000	Review of Projections by Power Planning Entities
Water Use or Need to be Met with Surface Supplies		
Unmet Columbia River Instream Flows [e]	13,400,000	Ecology data, McNary Dam, 2001 drought year
Unmet Tributary Instream Flows [f]	30,000 to 660,000	Ecology data, tributaries with adopted instream flows, on average, and for a drought year (generally 2001)
Unmet Columbia River Interruptibles	40,000 to 310,000	Ecology Water Right Database (depending on drought year conditions)
Yakima Basin Water Supply (pro-ratables, municipal/domestic and fish) [g]	450,000	Yakima Integrated Water Resource Management Plan (April 2011)
Alternate Supply for Odessa [h]	155,000	Odessa Draft Environmental Impact Statement (October 2010), adjusted based on consultations with the East Columbia Basin Irrigation District
Declining Groundwater Supplies (other than in the Odessa Subarea) [i]	750,000	*See Integrating Declining Groundwater Areas into Supply and Demand Forecasting* Module

a Additional agricultural demands were modeled assuming the land base for irrigated agriculture remains constant, and climate change is moderate (RCP 4.5 scenario). Projected changes in irrigation demand were estimated to decrease 291,432 ac-ft, with a confidence interval (reflecing uncertainty in climate) of ±32,260 ac-ft, for median demand years (the decrease is projected to be 251,368 ± 41,224 ac-ft for low demand years, and 239,388 ± 32,299 ac-ft for high demand years; see for details see Box 9 in the full Legislative Report). These decreases in demand were due to the combined impacts of climate change (wetter in the early growing season) and crop mix (projected shift to crops that use less water).

b The estimate of additional agricultural demands was increased by the coarse estimate of irrigation demand increases if 10% of eligible land is double cropped by 2035 (see *Potential Impacts of Double-Cropping on Agricultural Demand Estimates* section).

c The estimate of additional agricultural demands was increased by the double cropping estimate and by an additional 300,000 ac-ft. The latter reflects an estimated irrigation water supply development goal for the next 10 years (obtained based on the OCR agricultural water supply projects under development, which may include 508.14 Rule Changes, Regional Aquifer Storage and Recovery, Water Banking, and others).

d Hydropower projections are based on an average need of 2,200 to 4,800 MW by 2035 for the entire Columbia River Basin. This demand is historically expressed as a nonconsumptive water use. Net power generation and water right data for Grand Coulee, Rocky Reach, Rock Island and Lake Chelan were averaged to develop an approximate power-to-water conversion factor of approximately 16 ac-ft/MW. Because this projection is based on existing dams as opposed to new projects, and because these average numbers do not account for peak power needs, actual demand may be higher. Alternatively, if this demand is met via conservation, efficiency improvements, or non-hydro sources, the demand projections could be lower. Due to the coarse nature of the estimate, it was not possible to allocate a portion of this volume to Washington State at this time.

e Unmet Columbia River instream flows are the calculated deficit between instream flows specified in Washington Administrative Code (WAC) and actual flows at McNary Dam in 2001 under drought conditions. 2001 is the only year when Columbia River flows were not met and interruptible water users were curtailed.

f Unmet tributary instream flows in tributaries to the Columbia River are the combined deficits between current instream flows specified in WAC and actual flows, estimated as a range by comparing the 50% (average) exceedance curve, and the worst drought on record from 1981 to 2011, to adopted instream flow rules. Unquantified instream flow demand also exists in tributaries without adopted instream flow rules, but will be added in the future, as in the case of the Spokane Rule, which was adopted between the 2011 and 2016 Forecasts. These values include data from the following locations: Walla Walla River at East Detour Road, Wenatchee River at Monitor, Entiat River near Entiat, Methow River near Pateros, Okanogan River at Malott, Little Spokane River at Dartford, Spokane River at Spokane, Colville River at Kettle Falls. All drought year deficits are for 2001, with the exception of the Little Spokane and Colville Rivers, where the greatest unmet flows were in 1992, and the Walla Walla River, where data collection started in 2007.

g Range includes both the experienced curtailment from the 2001 drought, and the full water right value at risk of curtailment.

Table footnotes continued on bottom of next page.

The forecasted changes for supply and out-of-stream water demands can be expected to lead to changes in instream conditions by 2035, including:

- Almost 660,000 ac-ft per year of unmet tributary instream flow water demand, and 13.4 million ac-ft per year of unmet Columbia River mainstem instream flow water demand, based on observed deficits during the 2001 drought year.
- In many rivers in eastern Washington, including the mainstem Columbia River, stream flows are below state or federal instream flow targets on a regular basis, particularly in late summer. Surplus water exists in many of these same rivers at other times of year.
- Decreases in summer and early fall tributary streamflow may lead to longer periods with instream flows deficiencies by 2035. This may result in more frequent and potentially more severe curtailment of interruptible water right holders in basins with adopted instream flow rules.
- An evaluation of fish, flows, and habitat in twelve fish-critical subbasins (*Columbia River Instream Atlas*, Ecology Publication No. 16-12-006), will help target investments to maximize the positive impact on fish populations.

These changes in supply and demand are also projected to impact agricultural production, the main use of out-of-stream water in Washington State. A new insight from the 2016 Forecast is a trend in some areas toward increasing frequency and magnitude of irrigation curtailment in the spring, followed by a decrease in curtailments later in the irrigation season. These modeling results suggest that the shift toward increased spring irrigation water demand is projected to occur faster than the shift toward increased spring water supply. These projections vary across watersheds, were modeled under current dam operation schedules, and did not include potential increases in double-cropping, nor did they account for potential water conservation investments. Changes in these and other decisions would affect actual future curtailment patterns.

The economic impact of future curtailments could be significant. The 2016 Forecast quantified these economic impacts for one example: curtailment in the order of 100,000 ac-ft in the Walla Walla watershed could lead to losses ranging from $2 to $178 million in one year, depending on producers' ability to focus their use of available water on the highest-value crops grown in the watershed.

Conclusion

Seasonal shifts in timing of water supply and demand are expected to be a dominant issue as the climate changes, and will likely require area-specific management and adaptation strategies. However, irrigation demand was forecast to decrease on average, which could help to alleviate a reduction in summer water supply, at least in non-drought years.

Two important considerations that highlight the complexity of water management in the region are:

- Producers with existing water rights may respond to decreased crop irrigation demand by more frequently double-cropping or growing cover crops, which could offset the demand decreases projected in this Forecast. However, preliminary results suggest that double-cropping would need to occur over much more than 10% of the eligible acreage by 2035 to lead to an overall increase in irrigation demand.
- Agricultural production remains vulnerable to future changes in climate. Droughts are generally expected to occur more frequently and become more severe as the climate changes. And forecast results present a trend towards increasing frequency and intensity of curtailment in the spring.

This Forecast improves our understanding of future surface water supplies and instream and out-of-stream demands. Though it cannot answer all questions related to water supply and demand in the Columbia River Basin, it does provide projections 20 years into the future, and highlights the main changes that can be expected. It can therefore be a useful tool for water management as climate and water availability change, informing OCR's efforts so that they contribute to maintaining and enhancing eastern Washington's economic, environmental, and cultural prosperity in the future.

[h] Multiple water projects planned in the Yakima River Basin, as part of the Yakima Integrated Water Resource Management Plan, are expected to lead to decreases in the estimated volume needed by the 2021 Forecast. Examples include: Yakima Aquifer Storage and Recovery (ASR), Cle Elum Reservoir, and the Kachess Drought Relief Pumping Plant.

[i] Reports of Examination state that 164,000 ac-ft are needed to serve 70,000 acres. The East Columbia Basin Irrigation District is currently serving 3,000 acres of groudwater replacement via the Columbia Basin Project. Assuming these acres are served with an average 3 ac-ft/ac, the volume still needed was estimated. Two additional sources are expected to contribute to this alternate supply, the Odessa Subarea Special Study and the Lake Roosevelt Incremental Storage Releases Program. As the contributions of these two additional sources were not quantified at the time of this report, the volume estimated here should be considered a conservative estimate.

[j] This estimated need was calculated on the following basis: approximately 230,000 irrigated acres within areas affected by unreliable and/or declining groundwater supplies, an assumed average irrigation rate of 3 ac-ft/ac, and an approximate affected population of 200,000 with an average use of 200 gpcd. This estimate does not include the Odessa Subarea. Significant uncertainty exists in this estimate related to the geographic extent of the affected areas and other factors.

Next Steps—Building Towards the 2021 Forecast

Many of the improvements in the 2016 Forecast methods were made in response to recommendations made by both the Forecast team and the public in response to the 2011 Forecast. These 2016 improvements include steps towards integrating groundwater limitations in our understanding of future water supply and demand. The Legislature's mandate to update the forecast again in 2021 provides an opportunity for OCR to implement several of the recommendations arising from the 2016 Forecast and the public's response.

The OCR has prioritized the following recommendations on Forecast methodology for work over the next 5 years, in cooperation with partners:

Forecast Methodology:

- Better understanding of double-cropping patterns across the State, now and in the future.
- Better understanding of the frequency of curtailment priority calls, and the water rights that may be at risk of increased curtailment in the future.
- Improved municipal forecasting methodology, to better inform decisions on municipal water use as supplies and demands change.
- Greater input from hydropower providers, to improve understanding of water needs for hydropower production in the face of policy changes.
- Better integration of groundwater dynamics that impact availability of surface water for different uses.
- Better understanding of the effect of the International Columbia River Treaty on reservoir operations and on future water supply.

The OCR has also prioritized work arising from this Forecast's modules[5], which focused on emerging policy issues. Successfully completing the work embodied in these priorities will help Ecology's Office of the Columbia River fulfill its legislative-designated mandate, and support the science endeavors that provide the foundation for good decisions in the face of a changing climate, year-to-year variability, and the uncertainty inherent in making investments to sustain the region's economic growth and enhance its environmental and cultural resources 20 years into the future and beyond.

5 See full details on prioritized recommendations in the Conclusion section of the full Legislative Report.

MODULES

INTEGRATING DECLINING GROUNDWATER AREAS INTO SUPPLY AND DEMAND FORECASTING


Drilling near Dallesport Washington, Klickitat County

In both the 2006 and 2011 Water Supply and Demand Forecasts, groundwater supplies were presumed not to be limiting when supplying water rights, mainly due to modeling constraints. As a result, the economic implications of groundwater limitations were also not considered. Groundwater is declining in some areas in Washington, which could result in curtailment of water rights, delayed impacts on surface water sources in hydraulic continuity with groundwater, denial of groundwater right applications, and resulting changes in water right holder uses in response to an interruptible supply.

Ten areas of Washington State with groundwater declines documented by the Department of Ecology and the United States Geologic Survey were evaluated. Study of the groundwater areas included summaries of groundwater declines, geographic extent of the groundwater body, aquifer cross-sections and descriptions, groundwater model information, water right data, and supply-side and demand-side options to reducing groundwater declines.

Key findings:

- Declining groundwater areas should be incorporated into the 2021 Forecast.
- Greater monitoring of the declining groundwater areas is warranted, including aquifer levels, metering data, stream gauges, and pump testing.
- Public outreach to water right holders in declining groundwater areas should be implemented to incentivize demand-side conservation measures.
- State and County government should consider whether existing policies and regulations are sufficient in these areas to protect public water supplies and prevent unintended economic consequences.
- The State should consider water supply projects that could stabilize, reverse, or offset declining groundwater supplies.

Additional groundwater development is already limited in all areas in Washington where there are regulated or closed surface water bodies. The current focus on documented areas of decline is therefore a first step towards identifying the places where is it critical to integrate groundwater supply modeling into future Forecasts.

PILOT APPLICATION OF METRIC CROP DEMAND MODELING IN WASHINGTON STATE

Agricultural water use largely corresponds to evapotranspiration (ET), which is the sum of evaporation from the ground plus transpiration from plants. The aggregation of ET values across a watershed can be used to calibrate the integrated models used in the 2016 Forecast. Evapotranspiration is usually estimated using data from weather stations and making assumptions on stages of crop growth. Stages of crop growth vary significantly across a watershed, though, due to factors such as soil, management, and topography. To address this problem, a model—METRIC, which stands for Mapping Evapotranspiration at High Resolution and Internalized Calibration—was developed to calculate evapotranspiration using Landsat satellite images. This model has been successfully used in Idaho, California, New Mexico and other regions to monitor water rights, quantify net groundwater pumping and to determine irrigation uniformity. The first objective of this module was to develop and calibrate METRIC to estimate crop water use in three pilot watersheds in eastern Washington: Okanogan, Walla Walla, and Yakima.

A drawback to using Landsat images for METRIC is that the satellite provides images every 16 days, or less frequently if some images are blocked by clouds. The second objective, therefore, was to develop an algorithm to compare crop water use between CropSyst (the crop production model used in this Forecast) and Landsat-derived-METRIC. If the use values are consistent, this would allow the crop model to estimate crop water use between the dates for which images are available. CropSyst could then be used to model scenarios with changes in irrigation practices, crop management, or crop rotations, and to evaluate the effects of changes in water supply (e.g. curtailments) on crop water use during droughts.

Key Findings:

- METRIC was applied to apple orchards in the Roza Irrigation District, Yakima County. A similar analysis will be done for major crops in these three watersheds.
- Apple water use estimates from METRIC in Roza ranged around the value provided by the Washington Irrigation Guidelines (WIG) for apples, as the METRIC estimates capture the range of water use values specific to particular conditions (soil, slope, basin orientation, etc.) (Figure ES-3). For example, METRIC estimates quantify the difference in water used by apples in the upper Yakima relative to the lower Yakima WRIAs (Figure ES-3).
- CropSyst, if well-parameterized, can estimate crop growth—estimated using Leaf Area Index (LAI)—quite accurately (Figure ES-4).
- The METRIC model is now developed and calibrated for eastern Washington using freely or generally available software (Python and ESRI ArcGIS functions). Removing the platform dependence of the original model will make it easier and cheaper for users interested in water use in Washington to use this model.
- Automation of various processes involved in METRIC has reduced the necessity of highly trained experts to run this model. It has also made the model easier to use and less time consuming.

Comprehensive modeling of the dominant crops' water use across Washington's WRIAs using METRIC could help Ecology:

- Identify areas where the best solutions to water scarcity would be to invest in conservation projects, versus areas where additional storage projects would be needed.
- Quantify the amounts of water needed based on where the land is located within the WRIA, and
- Improve model estimates of consumptive use in future long term supply and demand forecasts.

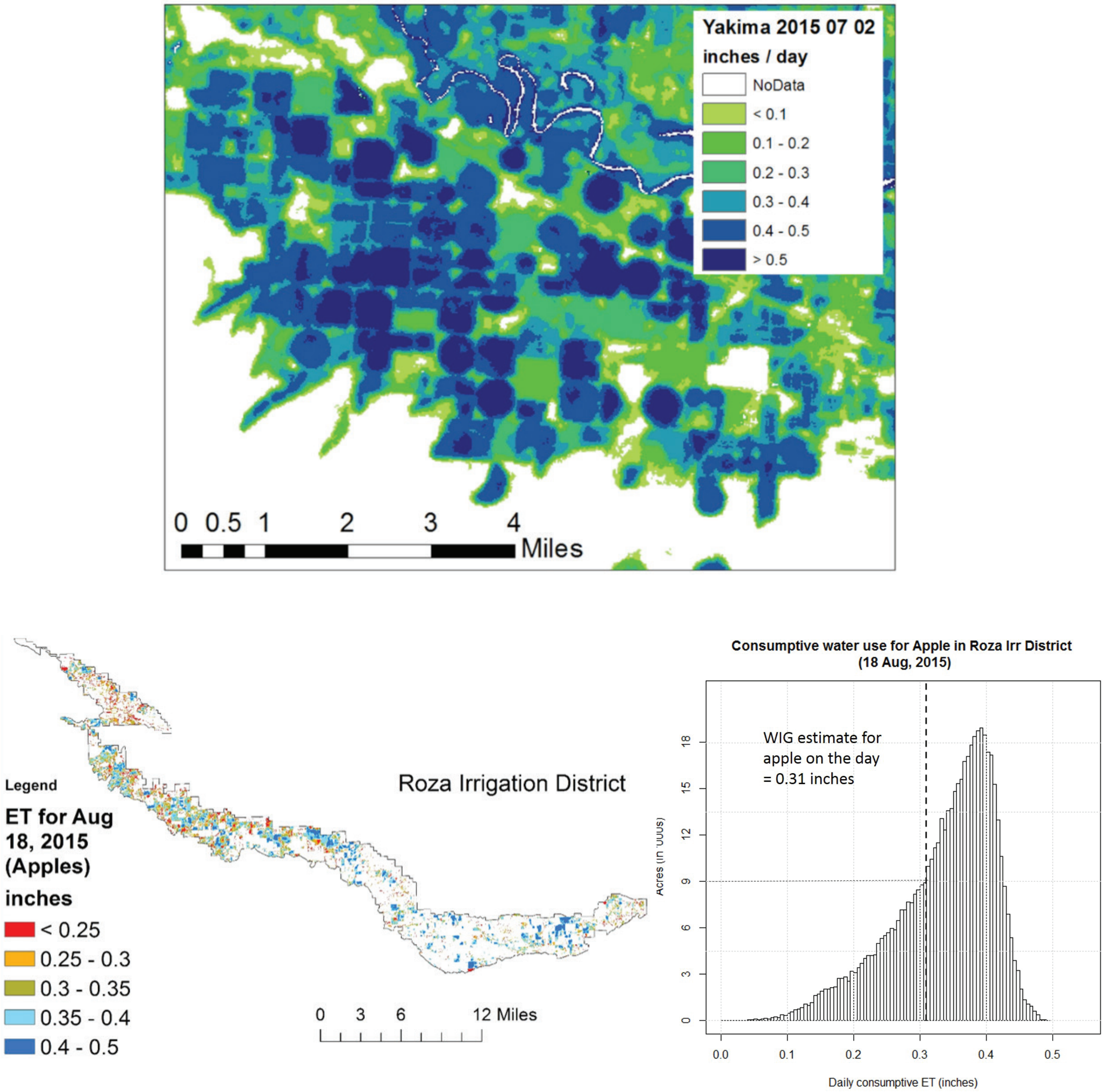

Figure ES-3: Pilot results from using METRIC in an eastern Washington Water Resource Inventory Area (WRIA). (a) METRIC can produce high resolution consumptive use maps, showing areas that use less water (green), and irrigated areas that use more water (dark blue). This is an example showing alfalfa near Prosser (Yakima River Basin). (b) Consumptive water use for apple orchards in Roza Irrigation District. Areas in red show apple orchards that use less water, and areas in blue show apple orchards that use more water per acre. (c) Acres of apple orchards in the Roza Irrigation District using different amounts of water (each bar reflects a different consumptive use). The bars to the right of the dotted line (which add up to about 75% of the total acres of apples) are using more water than recommended by Washington's Irrigation Guidelines (WIG).

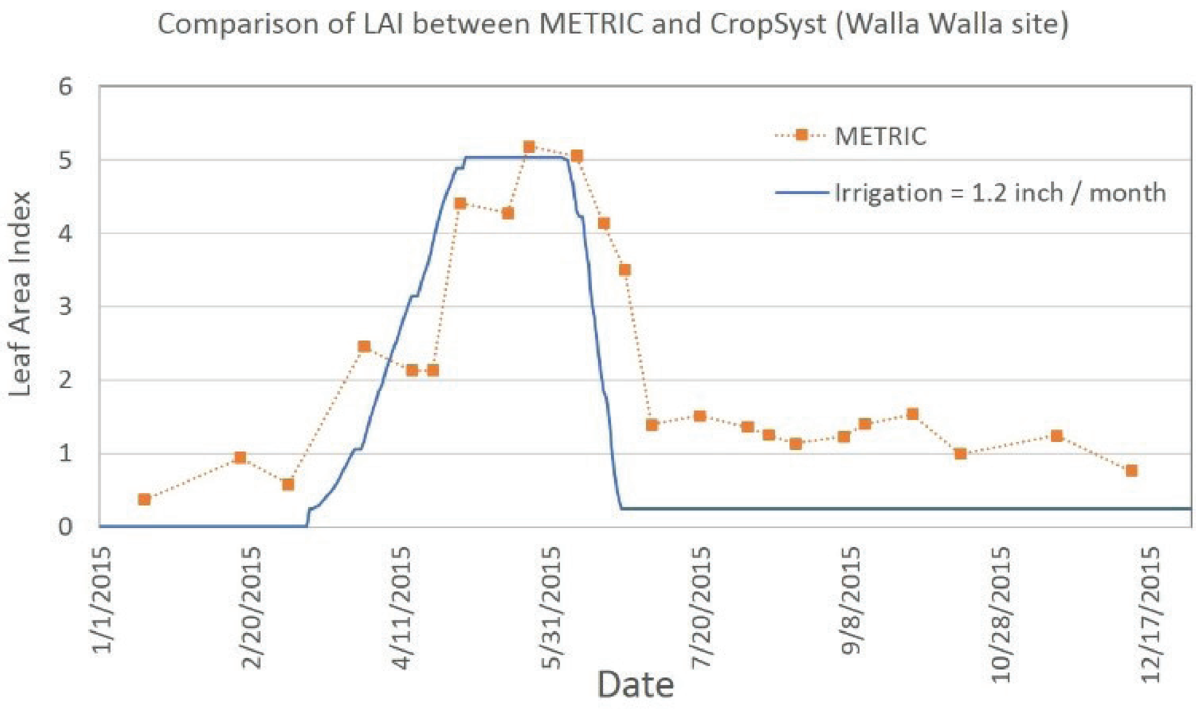

Figure ES-4: Comparison of METRIC's and CropSyst's leaf area index (LAI) estimates for a grape vineyard in Walla Walla.

WATER BANKING TRENDS IN WASHINGTON AND WESTERN STATES

Water banks and water markets allow people and farms who face water use restrictions to purchase mitigation credits to allow water use. Water banks and markets are among the critical portfolio of tools needed to help address the complexities of water management—including drought risk, surface water-groundwater interactions, and legal and regulatory disputes and restrictions over water markets—thereby allowing scarce water resources to be allocated more efficiently.

Understanding how water markets are working and maturing in Washington can help guide regulatory oversight and function of water banks, and clarify how water rights will move in response to water supply shortages, curtailments, demographic changes, and climate change. These are important elements that still need to be incorporated into the economic forecasting that influences the long-term supply and demand forecast for the Columbia River. This module describes water banking activities in Washington State and across the western United States—including the various administrative forms that water banks take, and the various forms that water transactions take in the context of water banking—and provides recommendations on how to improve and provide incentives for water banking in Washington.

Key findings:

- 24 banks currently operating (including self-mitigating banks), and seven developing water banks.
- Water banking activity across 11 western States has tended to increase in the last 12 years—since the publication of Clifford et al., 2004—in terms of the number of programs, the number of transactions, and the volume of water traded, with a great deal of variation in form, function, and growth across States.
- Water banking grew from two active banks in 2004 to 24 operating banks in 2016, with an additional seven banks in development (Figure ES-5). This expansion is driven primarily by regulatory imperatives such as groundwater closures (e.g. Upper Kittitas) and Supreme Court rulings (e.g. Postema v. Pollution Control Hearings Board), and encouraged by the need to maintain instream flows for fish.
- A number of options to improve water banking and water markets more generally in Washington exist, including:
    - Seek legislative clarity on mitigation criteria for streamlined bank operation. Mitigation criteria are currently in flux due to recent Supreme Court cases (Swinomish v. Ecology, Foster v. Ecology).
    - Clarify public interest criteria necessary for forming a water bank, since Ecology resources would be used to administer it. As currently structured, each new water bank creates new unfunded obligations on Ecology that detract from other legislatively-prioritized work.
    - Identify financing mechanisms appropriate for water banking, to provide Ecology cost-recovery for bank formation and operation.
    - Identify criteria for banks whose operation depends on water rights originating outside the watershed, to prevent unintended economic impacts.
    - Explore alternatives to conventional operations and monitoring for very small uses that drive bank costs up, including for metering and certified water right examinations.
    - Explore alternative contracting options, such as computer-aided transactions and options contracts for water.

This analysis provides a broad perspective on water bank and water market developments, which can provide ideas for future developments and improvements for the State of Washington.

Reference:

Clifford, P., C. Landry and A. Larsen-Hayden. 2004. Analysis of Water Banks in the Western States. Washington Department of Ecology. Publication number 04-11-011.

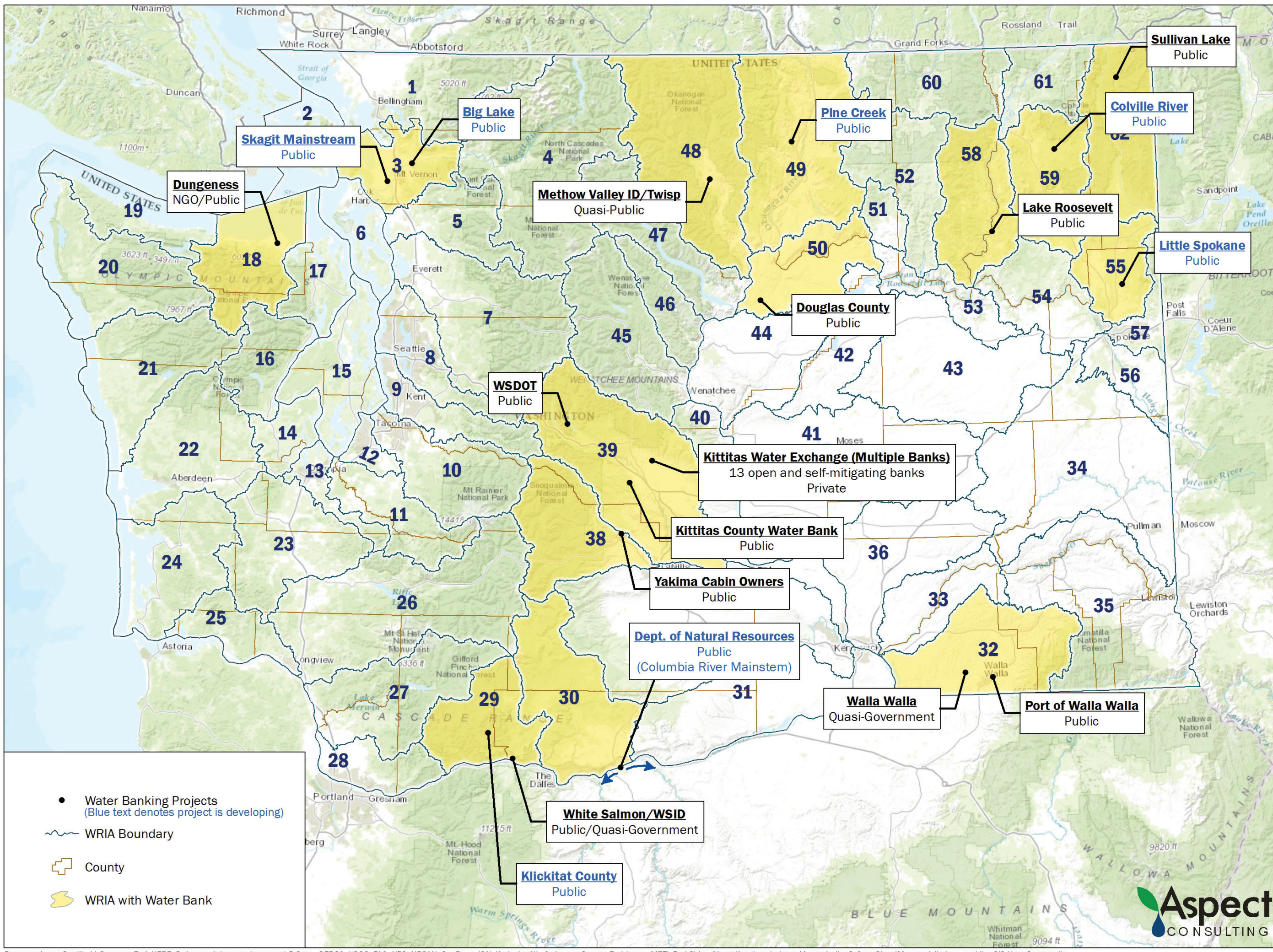

Figure ES-5. Location and extent of existing water banking projects across Washington State in 2016.

EFFECTS OF USER-PAY REQUIREMENTS ON WATER PERMITTING

Participation of applicants in water supply development cost-recovery programs affects both the extent of service provided by Ecology's projects, and Ecology's ability to recover the costs of providing these services. Water rights applicants seem more frequently to be declining the opportunity to have their applications processed and receive water through these programs when made available. These negative responses are adversely affecting Ecology's ability to reduce its backlog of water right applications in the face of Legislative mandates to meet annual permit processing targets.

Over the last 10 years, Ecology and OCR have offered six programs that included different kinds of cost-recovery user-pay responsibilities. These programs offer an opportunity to compare and contrast different business models and their relative successes in terms of program participation. Fee structure variants include:

a. A one-time processing fee for water supply development and administration,

b. Annualized payments for water service,

c. Specified program fees, and

d. Individualized mitigation without program fees.

The objective of this module was to better understand the importance of program characteristics, including fee structure, on program participation decisions. A survey was delivered to individuals who chose to or declined to participate in the different target programs, obtained from Ecology's water right application database. 192 of 678 initial survey requests were completed, for a response rate of 28.3%. This magnitude of response rate is not uncommon in social science surveys such as this. The survey data were evaluated statistically to identify the most important determinants of program participation, and to estimate the price-responsiveness of potential participants.

Key findings:

Although there are many possible reasons why individuals may choose not to participate, the analysis provided evidence of three primary reasons for program participation decisions in the Ecology programs examined:

1. *Time:* Many applications were submitted many years ago (Figure ES-6), and applicant circumstances have in many cases changed to the point that the water rights application itself is of relatively less value to the applicant.

2. *Cost:* Potential program participants respond to cost (Figure ES-7), and some potential participants opt out of the program due to the cost-recovery fees charged by Ecology.

3. *Uncertainty:* Applicants sometimes choose to keep applications on hold due to uncertainty about family or business situations, as well as uncertainty or lack of clarity of program costs or benefits. As there is no cost to keeping an application on file, there is no impetus not to simply leave it there even if it no longer represents a viable project.

These results suggest that waiting times, cost effects, and program uncertainty have impacts on participation rates and hold-times. This understanding can be helpful to Ecology in making policy and administrative decisions. To the extent that permit application backlogs are problematic for Ecology, filtering out likely non-participants from the future applicant pool may help. Some possible approaches include (1) requiring new applicants to submit additional information that is foundational to the application processing, such as a stamped hydrogeological report, or independent 3rd party beneficial use analysis; (2) increasing processing fees under RCW 90.03.470 to close the gap between applicant expectations and actual costs, thereby likely reducing speculative applications; (3) eliminating the opportunity for applicants who are offered water to remain in line with all other backlogged applications if they decline such an opportunity; or (4) modifying the cost-reimbursement application processing statute (RCW 90.03.265) to require applicants to immediately participate in a cost-reimbursement processing program to ensure timely processing and a closer tie to expectations around cost of processing.

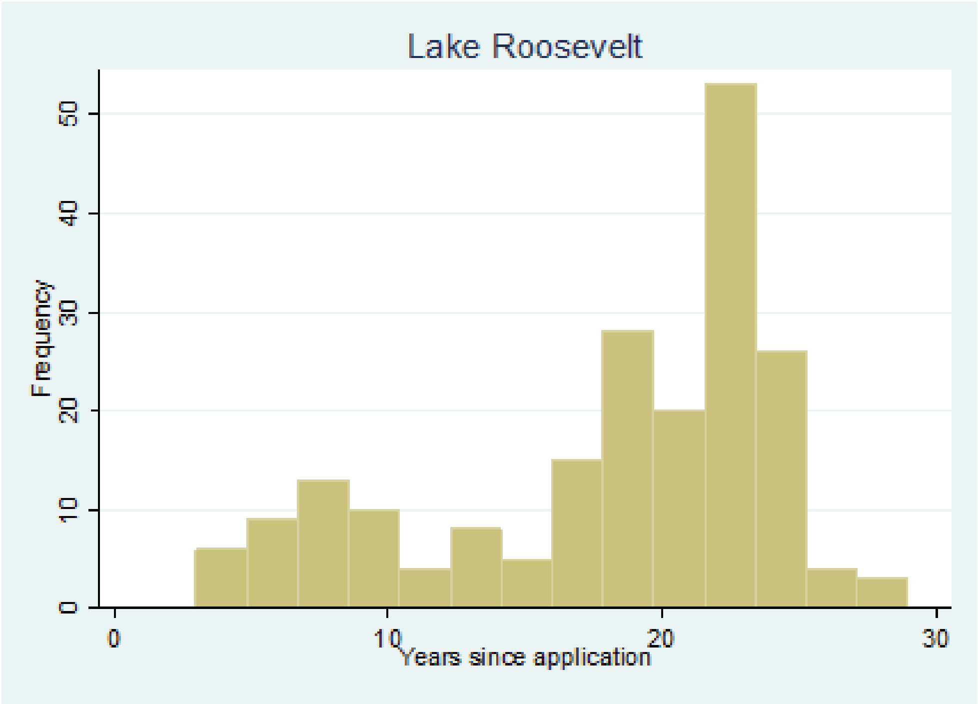

Figure ES-6. Distribution of time since applications were submitted to Ecology for the Lake Roosevelt cost-recovery program.

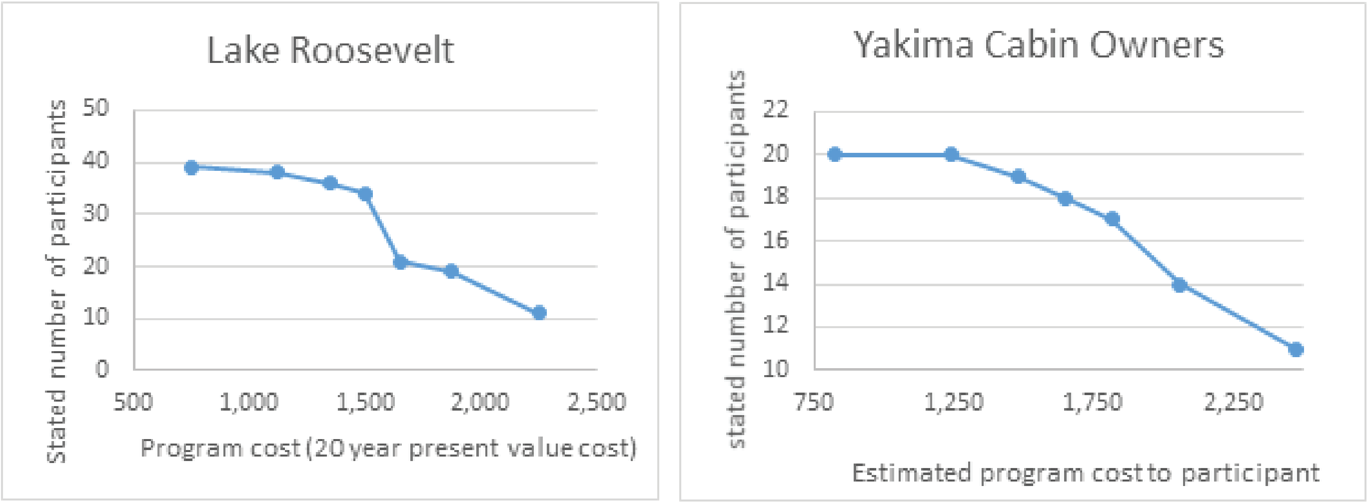

Figure ES-7. Responses to cost from potential participants in the Lake Roosevelt (left panel) and Yakima Cabin Owners (right panel) cost-recovery programs.

WESTERN WASHINGTON SUPPLY AND DEMAND FORECASTING

Local watershed planning in Washington started in 1997, with varying success. In some watersheds, the plans resulted in stakeholder collaboration and agreement on both out-of-stream needs and adoption of instream flow rules. In other watersheds, the process was less successful in bringing together coalitions and achieving consensus-based supply and demand solutions.

In 2006, the Legislature required the Office of Columbia River to integrate water supply and demand forecasting for eastern Washington and the entire Columbia River Basin, and harmonize it with local watershed planning efforts. The resulting forecasts provide coverage for watersheds without a plan, extend the momentum of successful plans, and inform water supply development. However, increasing demands on water are not limited to eastern Washington. The purpose of this module was to assemble information on available data, studies, and plans in western Washington, and evaluate the potential for a statewide Water Supply and Demand Forecast in 2021.

Key Findings:

- The primary datasets used as inputs to the integrated models used in eastern Washington extend to western Washington.
- The existing modeling framework developed for eastern Washington could be used to forecast water supply and agricultural demand across Washington State, and a process similar to that used in eastern Washington can be used to forecast municipal and hydropower demands.
- The existing modeling framework may not be ideal for all western Washington WRIAs, because of the existence of:
    - Smaller WRIAs than in eastern Washington,
    - Tidal effects in coastal WRIAs, not accounted for in this framework,
    - WRIA-specific groundwater–surface water interactions, as groundwater accounts for a higher proportion of water withdrawals,
    - Non-trivial small farm acreage missing in the WSDA land cover data, and
    - Livestock consumptive use, not accounted for in this framework, is a large fraction of agricultural water demands in certain WRIAs.
- Stakeholder input and local documents collected as part of this scoping effort should be used to evaluate the appropriateness of model results in western Washington WRIAs, and to identify WRIAs where additional modeling and data are needed.
- Western Washington has fewer interruptible water rights than eastern Washington, primarily because eastern Washington has several basins (e.g. Yakima, Walla Walla) where junior water rights are routinely called to curtail in favor of ensuring that the water needs of senior water rights are fully met. In comparison, Western Washington water right curtailment is instead focused on interruptible water users that are subject to instream flow provisions. Western Washington has a greater number of these kinds of interruptible users than eastern Washington (1373 and 909 interruptibles, respectively). This simplifies curtailment modeling for future Western Washington forecasting efforts if the modeling framework is able to provide realistic supply and demand estimates.
- For WRIAs with regulated supply, if the reservoir capacity is above a certain threshold, simple reservoir models that simulate the reservoir operation rules can be created.

In conclusion, it appears possible to extend the methods of the 2016 Forecast to provide a statewide long-term supply and demand forecast in 2021, though additional stakeholder input, modeling and data collection is likely needed to ensure results are accurate at the scale of Washington’s watersheds. Providing a statewide Water Supply and Demand Forecast in 2021 would allow Washington to:

1. Fill in data gaps in non-planning jurisdictions,
2. Take a holistic look at policies of statewide significance (e.g. declining groundwater and water banking), and
3. Achieve some parity with the other 33 states doing statewide water planning, which can be a factor (along with adjudications) when cross-state conflicts or issues arise.