5.0 Tier I Results - Columbia River Basin

Tier I, the Columbia River basin, focused on a broad assessment of the basin as a whole, with in-depth analysis of the Washington portion of the basin. To accurately forecast Washington's water supply and demand, it is necessary to understand water supply and demand throughout the entire Columbia River basin. The major water contributors are British Columbia, Washington, Idaho, Montana and Oregon, while Wyoming, Utah and Nevada are minor contributors by area (Figure 43). The amount and timing of water entering Washington State within the Columbia River basin is highly impacted by existing infrastructure and management in British Columbia, Idaho, Montana, and Oregon.

Figure 43. Columbia River Basin.

Throughout this report, WSU modeling results are presented using specific definitions of supply and demand, described in Section 1.3 of this report.

5.1 Water Supplies Entering Washington

5.1.1 Modeled Surface Water Supplies Entering Washington

Modeling results indicated a number of important changes in surface water supply entering Washington between the historical period (1977-2006) and 2030. These changes reflect the impacts of climate change (Figure 44, Figure 45):

- Annual water supplies for most of the eastern incoming rivers, including the Columbia, Pend Oreille, Spokane, Clearwater, Snake, and John Day will increase by 2030, an average of 3.7 (±1.3)%.[1]
- The direction of change for annual water supplies entering Washington is unclear, 1.4 (±1.9)% on average, for the Similkameen and Kettle Rivers.
- Within a season, surface water supplies entering Washington will generally increase by 2030 in late fall, winter and spring, and decrease in the summer and early fall. This pattern applies to both eastern and western portions of the basin, and is evident at most points where significant amounts of water enter Washington, including the Columbia River and the Snake River. The exact timing may vary somewhat by river.

[1] When discussing modeled supply and irrigation demand results, "average flow conditions" refers to the 50th percentile (middle) value under the middle climate scenario. "Average" by itself refers to the average value over all climate scenarios and flow conditions, and a 90% confidence interval around that average.

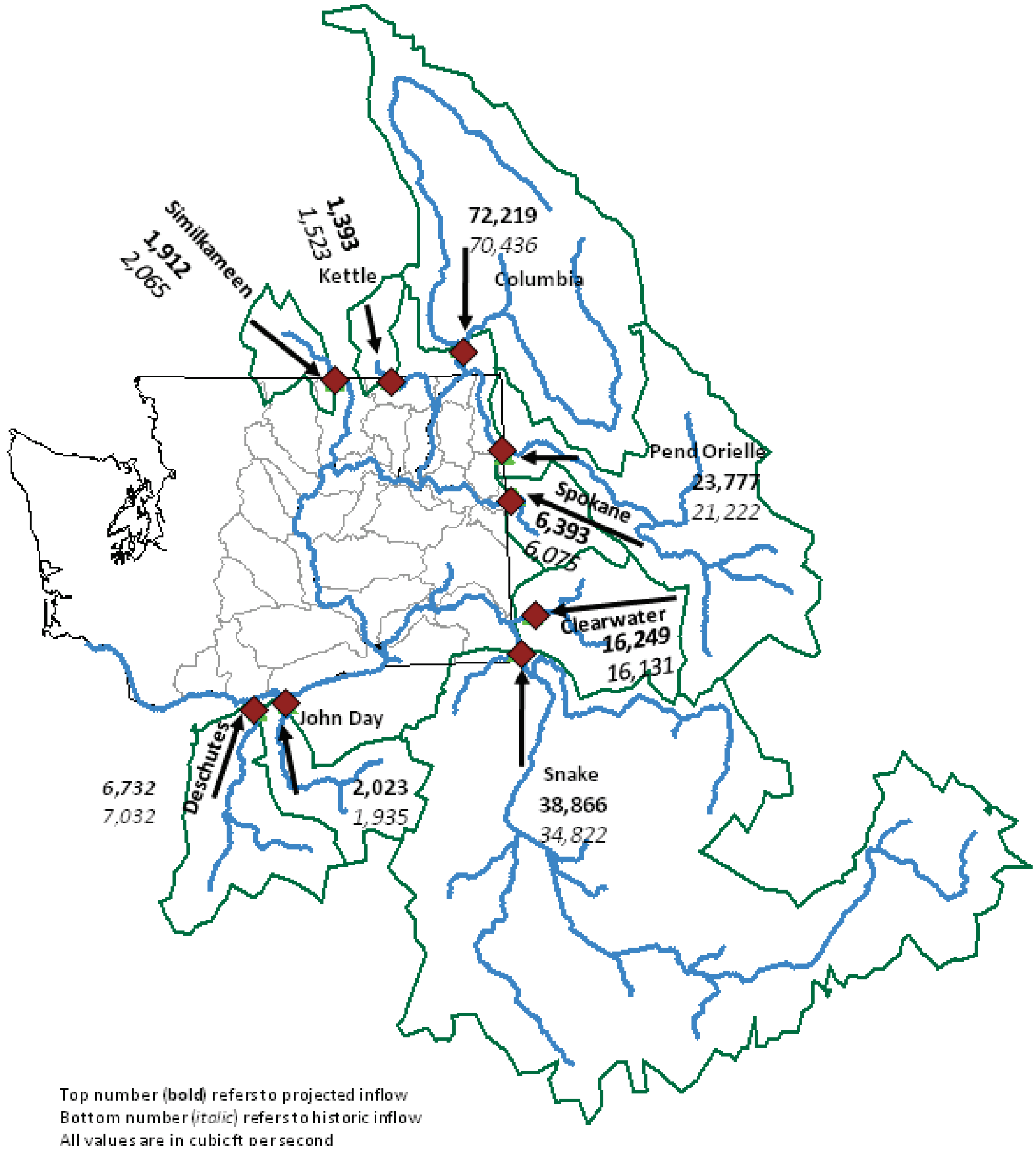

Figure 44. Surface water flows for major tributaries upstream of the point where the rivers enter Washington State. Top number (bold) refers to 2030 forecast water supplies for average (50th percentile) flow conditions and the middle climate change scenario, while the bottom number (italic) refers to historical (1977-2006) water supplies. All values are in cubic feet per second.

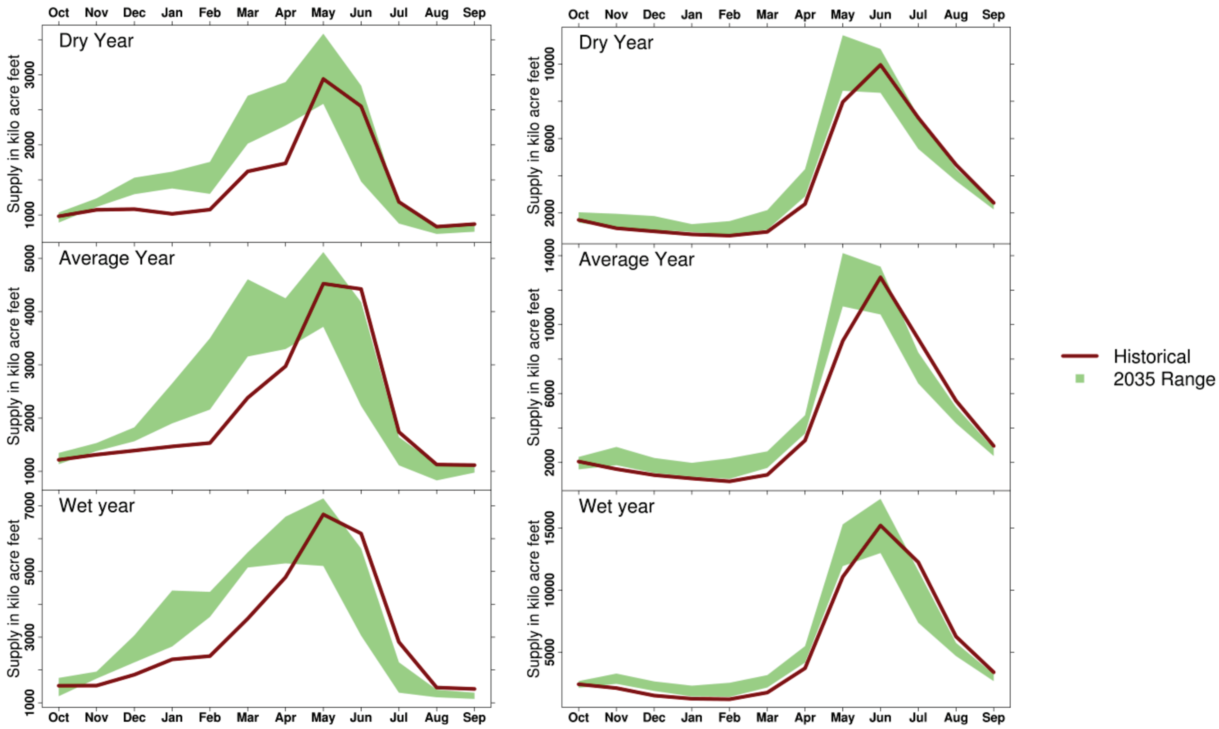

Figure 45. Historical (1977-2006) and 2030 forecast regulated surface water supplies on the Snake and Columbia Rivers upstream of the point where they enter Washington State for dry (20th percentile, top), average (middle), and wet (80th percentile, bottom) flow conditions. The spread of 2030 flow conditions is due to the range of climate change scenarios considered.

5.1.2 Columbia River Basin Surface Water Supply and Seasonal Availability

The forecast of surface water supply and timing in 2030 for all areas of the Columbia River basin upstream of the Bonneville Dam noted the following changes compared to the historical flows (1977-2006) (Figure 46):

- A small increase of around 3.0 (+/-1.2)% in annual supplies.
- Timing changes will shift water away from the times when demands are highest. Unregulated surface water supply at Bonneville will decrease an average of 14.3 (±1.2)% between June and October, and increase an average of (17.5 (±1.9)% between November and May.

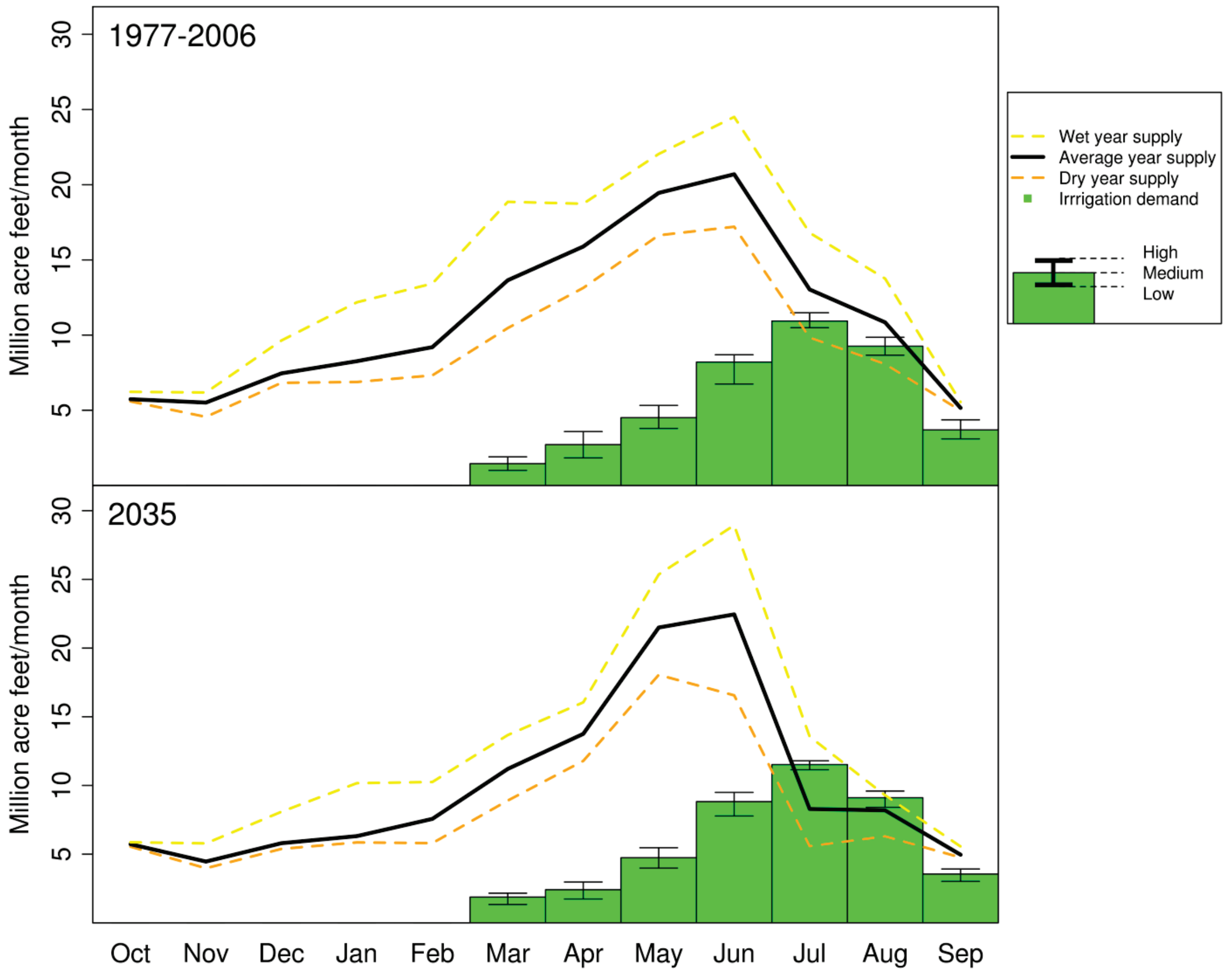

Figure 46. Comparison of regulated surface water supply and irrigation water demands for the historical (top) and 2030 forecast (bottom) periods under the medium-growth, medium-trade economic scenario across the entire Columbia River basin, including portions of the basin outside of Washington State. Wet, dry, and average flow conditions are shown for both supply (dotted lines) and demand (error bars).

5.1.3 Regional Survey Results

The 2010 regional survey to assess potential changes in Columbia River and tributary inflows into the State of Washington consisted of 29 questions covering water demand, water projects, and general plans for managing jurisdictional water supplies. The questions included in the survey are available in Appendix C.

5.1.3.1 Survey Results Regarding Water Supply and Demand

As discussed in the detailed methodology provided in Section 3.6, the survey questions on water supply and demand resulted in a wide range of answers reflecting the diversity of agencies and large geographical regions contacted. Nevertheless, several interesting themes surfaced.

- Only 52% felt that they currently had enough water supply to meet existing demands. (In some cases respondents knew only about out-of-stream demands; in other cases respondents included both out-of-stream and instream demands.) This was qualified by several respondents who pointed out that water supplies varied throughout the state with some areas having shortages and other areas having sufficient water. Some also stated that low-flow years posed problems for meeting the instream demands of fish.
- 40% reported that they already face water shortages in at least parts of their states.
- Nearly 88% expected that water demands for their states would increase in the future for a wide variety of reasons. Although population increase was most often cited (44 %), additional needs for environmental protection, agricultural expansion, high tech and industrial uses, micro hydro, and recreation demands were also mentioned.

When asked specifically about the implications of climate change, responses again varied widely. Overall, many agencies and groups were incorporating factors related to climate change into their forecasting efforts. Respondents whose agencies were incorporating climate change reported that their climate change forecasting efforts generally looked at time horizons of 20 to 50 years and nearly all acknowledged that assumptions had to be made in the process. Utah's political objections to climate change affects incorporation of climate change impact into their planning efforts.

5.1.3.2 Survey Results: Water Development Projects

Nearly half of those interviewed knew of future projects planned within their jurisdictions. Except for two aquifer storage and recovery projects, all of the other projects were either relatively small projects or projects primarily in the early planning stages. One project (USBR Hungry Horse) s looked at either the implications of operational changes, while several other projects proposed conservation efforts.

Because of the preliminary nature of the projects, it was too soon to tell if projects were feasible. However, most of the projects (including the aquifer storage and recovery projects) took water during high flow periods when it would be unlikely to impact water flows into Washington negatively, though it is worth monitoring future progress of these projects.

Although managers knew about planning efforts, often their responses indicated general awareness, without detailed knowledge of capacity and/or exact location. In part, this appears to be due to the conceptual and preliminary nature of new projects as well as diffuse nature of water management at the watershed scale.

5.1.3.3 Survey Results: Managing Jurisdictional Water Supplies

Changes in the management of existing water supplies were primarily focused on incremental evolution to improve efficiencies. A notable exception is the Okanagan Nation's legal actions to settle the dispute regarding their water right claim, which has the potential to change management of existing water supplies much more significantly. Litigation might change reservoir operations and a few respondents mentioned that state legislative changes may mandate development of state water management plans.

About 25% felt that increased water storage capacity would be needed in their regions. Several possible future projects appeared to be based on satisfying municipal demands. It was not immediately clear if this was due to economics, growth, or a combination of these and other factors.

The survey may not have reached the right people with respect to the topic of "Do you currently have plans to expand agricultural acreage?" (Question #22), and subsequent follow-up questions. This is something to consider in follow-up activities or future surveys where perhaps more irrigation districts, commodity groups, hydropower operators, or large farm operators are targeted.

On a more general note, it seemed that the survey did not always reach respondents with comprehensive knowledge of the variety of issues covered by the survey. Generally, the survey strategy began by targeting leads of heads within organizations, though interviewers were often referred to others with more specific program knowledge. Our mixed success may result from a combination of targeting the wrong individuals initially, as well as the fact that it is difficult to find individuals within agencies who have knowledge covering the wide breadth of the survey questions, and yet also with knowledge of specific details that were of interest (e.g. the specific capacity of proposed projects). In addition, agencies may not be aware of projects planned by private entities are planning until they submit a formal application.

Despite these limitations, the broad objectives of the regional survey were met. In summary, there did not appear to be any projects that would lead to significant changes in flows in the Columbia River or its tributaries. At the scale of the current modeling effort, we therefore did not feel the need to alter inflows due to upstream changes in demands. However, the implications of the Columbia River Treaty between the U.S. and Canada are not well understood at this time, and could significantly impact the timing of flows entering the State of Washington. Complete analysis of this was beyond the scope of this Forecast.

5.2 Water Demand Forecast

5.2.1 Columbia River Basin Agricultural Water Demand

The 2030 forecast of demand for agricultural irrigation water across the entire Columbia River basin was 13.6 million ac-ft per year under average (50^{th} percentile) flow conditions, with the range of low and high estimates under different weather conditions from 13.1–14.1 million ac-ft per year (20^{th} and 80^{th} percentile) (Figure 46). When compared to average historical (1977-2006) conditions, this represented an increase of 0.33 million ac-ft, or approximately 2.5% above estimated demands for the historical period of 13.3 million ac-ft per year (Table 12).

Table 12. Top of crop agricultural demands under the baseline economic scenario (medium domestic economic growth and medium growth in international trade), excluding conveyance losses, in the Columbia River basin in the historical and 2030 forecast period. Estimates are presented for average years, with low and high quantities in parentheses representing wet (80th percentile) and dry (20th percentile) years.

	Historical (1977-2006) **million ac-ft per year**	**2030 Forecast** **million ac-ft per year**	**% Change**
Entire Columbia River Basin	13.3 (12.6–13.9)	13.6 (13.1–14.1)	2%
Washington Portion of the Columbia River Basin	6.3 (6.0–6.5)	6.5 (6.2–6.6)	2%

These demand results should be thought of as the upper bound of "top of crop" water demand under the medium growth, medium trade scenario, assuming no change in the land base for irrigated agriculture. This is because this value represents water demand after changes in crop mix have occurred in response to changes in the domestic economy and international trade flows. As described more fully in Chapter 3, Methodology, constraints on water availability (including physical availability or regulatory curtailments) are assumed to result in deficit irrigation of nearby less profitable crops; other producer responses that would minimize the production impacts of water shortages are outside the scope of this Forecast. This would include strategies such as changes in crop mix to favor less water intensive crops, or investments to increase the efficiency of irrigation.

Results for the Washington State portion of the Columbia River basin are similar, suggesting that 2030 irrigation demands will be roughly 1.9% above historical. This change is due to a combination of two factors: climate change and changes in crop mix driven by the economic scenario considered. Considering the climate impacts of temperature and precipitation variations alone on the irrigation demand, there is a 3.7% increase in demand. When economic impacts resulting in a new crop mix are considered in addition to the climate effects, the increase in demand reduces to 1.9%.

These changes in total irrigation demand do not include additional surface water demands that may result from the need to supply water to agricultural producers in the Odessa area who currently receive groundwater. These demands were treated as groundwater demand in the historical case, and surface water demands in 2030. In the 2030 forecast, this area represented 240,000 ac-ft per year of surface water irrigation demand.

5.2.1.1 Impact of Variation in Assumptions about Economic Growth and Trade on Water Demand in Washington

The irrigation demands presented above were run under a medium growth, medium trade scenario, reflecting 'most likely' future conditions. Low and high alternate scenarios captured the range of possible future economic conditions within Washington, considering both growth of the domestic economy, and growth in international trade in agricultural goods. Overall, the low, and medium economic scenarios forecasted an estimated 6.5 million ac-ft of average irrigation demand and the high medium scenario forecasted an estimated 6.4 million ac-ft of average irrigation demand within the Washington portion of the Columbia River basin, assuming that the extent of irrigated acreage stayed constant (Table 13).

Table 13. Top of crop agricultural demands under the three economic scenarios (low, medium, and high), excluding conveyance losses, in the Columbia River basin for the 2030 forecast period. Estimates are presented for average years, with low and high quantities in parentheses representing wet (80th percentile) and dry (20th percentile) years.

	2030 Forecast Under Varied Economic Scenarios million ac-ft per year		
	Low	**Medium**	**High**
Washington Portion of the Columbia River Basin	6.5(6.2–6.6)	6.5(6.2–6.6)	6.4(6.2–6.6)

Over the range of scenarios considered, variation in assumptions about economic growth generally resulted in modest changes in production relative to the impact of international trade. Domestic income growth was projected to be 1.6% per year in real income per capita for the "medium" scenario, 1.3% under the low scenario, and 1.8% under the high scenario. Domestic income growth impacts water demand because consumers have more money to spend on food which places upward pressure on food prices which incentivizing producers to increase production. As a result of assumptions made in the economic model, population growth impacted all crops equally, while income growth had a larger impact on high value crops such as cherries and wine grapes. However, these changes still caused relatively small changes in total irrigation water demand. While many of the crops that are more sensitive to changes in income are irrigated, including apples, wine grapes, and cherries, they each occupy 200,000 acres or less in Washington. This is a relatively small area compared to wheat, cropland pasture, and forage crops, which together account for more than 80% of all cropland in the state. Among these latter crops, non-irrigated acreage will not significantly impact irrigation water demand, although it may influence water availability by influencing surface water flows.

Assumptions about international trade had a more significant influence on crop mix than assumptions about domestic income growth. The similarity in the income and trade scenarios is that higher rates of either resulted in increased substitution into high value crops. An exception to this was irrigated wheat production where there was little variation between the low and high scenarios, based on the expectation that export demand for wheat will remain fairly steady.[2] In contrast, fruit and vegetable production varied more between low and high scenarios because there has been robust growth in exports of these crops over the last decade.[3] In contrast to most fruit-based products, demand for Washington wine grapes and wine production is expected to be primarily dependent on growth in the domestic rather than foreign markets. For alfalfa, traditional exports to South Korea, Taiwan, and Japan are expected to stay at historic levels although new demand centers in other parts of Asia are likely to continue to grow exports.

The implication of assuming different rates of domestic economic growth and international trade is that it affects both the value of water associated with irrigated agriculture and the economic impact of irrigated agriculture. Basic economic theory says that the value of allocating additional water towards some productive use depends on the value of what is being produced. A change in crop mix towards crops like tree fruit and vineyards that are often processed off the farm affects economic impact estimates for water development. An important caveat is that the scope of the the economic analysis only considered the agricultural sector.

5.2.1.2 Impact of Additional Water Capacity Development and Cost Recovery for New Water Provision on Forecast 2030 Irrigation Water Demand in Washington

The baseline scenarios presented in this Forecast do not include any changes in water management. This was done to isolate the impact of changes due to larger market forces from those resulting from state level policy. It is also a prudent approach given the legal, political, and financial obstacles to changes in water management. As described more fully in Chapter 3, Methodology, in comparison with that baseline, OCR asked for analysis of a number of scenarios that included development of approximately 100,000, 200,000, and 500,000 ac-ft of additional

[2] Exports of Washington wheat have fluctuated around an average of $380 million for the last decade, and tend to spike when there are significant weather induced shocks to other major wheat growing regions. Climate change predictions suggest that weather-induced crop reductions could become more common in places like Russia and Australia, elevating the average level of Washington exports somewhat.

[3] Fruit and vegetable exports fruit and vegetable exports have grown at approximately 5% per year for fruit and 3% for vegetables over the last decade, with simultaneous growth in domestic markets.

water capacity at specific locations in the state, and potential recovery of development costs at a variety of prices, including zero. In interpreting the results of this analysis, it is important to recognize that this Forecast does not include benefit-cost studies for any particular water development projects.

Projects associated with the medium water capacity scenario of 200,000 ac-ft per year were estimated to lead to approximately 62,000 acres, including both newly irrigated lands, and replacement water for acreage in Odessa currently irrigated by groundwater. The economic impacts associated with production on this acreage would generate an estimated agricultural output of $169 million, or about $2,700 per acre. This estimate does not subtract the value of production if land were currently under dryland cultivation. Total economic impacts of the additional production were estimated with the Implan® economic input-output model to be an additional $120 million in indirect and induced effects.[4]

The economic impact of this increased production was estimated to be 6,600 jobs, which included employment related to crop production and food processing industries. State and local tax impacts were estimated at about $37 million, with most of this coming from indirect business taxes, including taxes incurred in the ordinary operation of business (such as sales taxes, excise taxes, and property taxes).[5] The values of output and other estimated economic outputs are reported in current terms, reflecting the fact that the input-output model shows the current economy in terms of wages, production technologies, and many other factors. To put this into perspective, there are approximately 62,000 jobs in Washington directly related to crop production and almost half are in fruit farming. There are an additional 31,000 jobs in agricultural support activities and 12,000 jobs in relevant food processing industries.

Information on the disposition of agricultural production to specific processing industries is not generally available so it was necessary to make a few general assumptions to include processing industry impacts. According to USDA statistics about 18% of apple and cherry production enters into processing. Thus, 18% of new fruit production was assumed to be processed within the state, in the canning industry. For vegetables, potatoes, sweet corn, and onions constitute more than 90% of Washington's vegetable acreage. About 75% of potato production is allocated to the frozen food industry. Nearly all sweet corn production is processed. Data is not available for onions, though it is likely that less are processed. Combining all this information, it was simplistically assumed that 75% of the additional vegetable production would be processed

[4] This estimate included additional economic activity generated through backward linked industries, such as machinery repair and fertilizer sales (indirect effects), and spending throughout the rest of the economy that are impacted by additional household income (induced effects).

[5] Total taxes also included employer contributions to social insurance, proprietor income, indirect business tax, taxes on household income, and taxes on corporate profits.

within the state and that all of it went towards frozen foods (though in reality there is some processing in other industries such as snack food manufacturing). Additional wine grapes were assumed to be processed in Washington by the wine industry.

While not quantified, it is recognized that maintenance of and improvement to instream flows would have positive economic impacts on tourism and recreation, generating additional jobs and tax revenues.

Cost recovery scenarios considered various possible scenarios of prices that could be charged for new water capacity for cost recovery purposes ($25, $100, and $200 per ac-ft per year). These prices correspond respectively to the range of prices being charged for projects in current development, a higher price that has been charged elsewhere for water projects, and a possible high price in the future. The total amount that could be generated for cost recovery purposes was determined by discounting the stream of payments received over time into a single present value. At low prices, agricultural producers are likely to use all water made available because their net revenue would still be greater by irrigating than under dryland production. At higher prices it is possible that not all of the water will be used.

As is typical for this type of analysis, results varied significantly depending on the assumption of the discount rate, which is usually based on either yields of long-term government bonds (low estimate) or on the rate of return on capital in private markets (high estimate). An assumption of a lower discount rate leads to a higher present value. Depending on whether the discount rate considered is 2%, 4%, or 6%, cost recovery from charging $25 per ac-ft for 200,000 ac-ft in perpetuity would be $250 million, $125 million or $83 million, respectively. The cost recovery estimates are shown in Table 14 and Table 15. Each table shows how results vary assuming the different discount rates for the low, medium, and high water capacity scenarios. The Office of Columbia River is considering charging until project construction costs are recovered. Because construction cost data was not available for this project, and it was impossible to determine when costs would be recovered, two different time frames were examined. Table 14 assumes that the unit price for new water continues to be charged in perpetuity. Table 15 assumes that new water users are charged for 20 years.

Table 14. Present value of cost recovery scenario from charging in perpetuity (units in millions of dollars).

	Discount Rate Low (2%)	Medium (4%)	High (6%)
100,000 ac-ft			
$25 ac-ft	$125,000,000	$62,500,000	$41,666,667
$100 ac-ft	$500,000,000	$250,000,000	$166,666,667
$200 ac-ft	$1,000,000,000	$500,000,000	$333,333,333
200,000 ac-ft			
$25 ac-ft	$250,000,000	$125,000,000	$83,333,333
$100 ac-ft	$1,000,000,000	$500,000,000	$333,333,333
$200 ac-ft	$2,000,000,000	$1,000,000,000	$666,666,667
500,000 ac-ft			
$25 ac-ft	$625,000,000	$312,500,000	$208,333,333
$100 ac-ft	$2,500,000,000	$1,250,000,000	$833,333,333
$200 ac-ft	$5,000,000,000	$2,500,000,000	$1,666,666,667

Table 15. Present value of cost recovery scenario from charging for 20 years (millions of dollars).

	Discount Rate Low (2%)	Medium (4%)	High (6%)
100,000 ac-ft			
$25 ac-ft	$40,878,583	$33,975,816	$28,674,803
$100 ac-ft	$163,514,333	$135,903,263	$114,699,212
$200 ac-ft	$327,028,667	$271,806,527	$229,398,424
$25 ac-ft	$81,757,167	$67,951,632	$57,349,606
$100 ac-ft	$327,028,667	$271,806,527	$229,398,424
$200 ac-ft	$654,057,334	$543,613,054	$458,796,849
500,000 ac-ft			
$25 ac-ft	$204,392,917	$169,879,079	$143,374,015
$100 ac-ft	$817,571,667	$679,516,317	$573,496,061
$200 ac-ft	$1,635,143,334	$1,359,032,634	$1,146,992,122

Table 14 and Table 15 show the net present value from charging $25, $100, and $200 per ac-ft for 100,000, 200,000, and 500,000 ac-ft. Each value is calculated for the low, medium, and high quantities of water and for a low, medium, and high discount rate.

5.2.2 Columbia River Basin Municipal Water Demand

The forecast of municipal demand in Washington should be understood within the context of likely increases in demand throughout the Columbia River basin. U.S. Census estimates show population growth over the next 20 years in Idaho (25.6%), Oregon (26.2%), and Montana (5.6%). Without concerted conservation efforts, population growth will certainly increase demands on water flowing into Washington State. Idaho has not released county-by-county growth projections, and it is difficult to predict which additional municipal demands will be met from deep groundwater supplies which would not impact surface water supplies. However, it is safe to assume that additional demands in Idaho will reduce inflows into some parts of Washington. A study of the Spokane River basin by the State of Idaho projected that they would place an additional demand of 31 cfs on the river by 2060.

WSU projected domestic and industrial diversion demands, excluding self-supplied industries, of 569,000 ac-ft per year in Washington in 2030, an estimated 26% increase over 2010 (Table 16). This increase of approximately 117,500 ac-ft per year compared to 2010 was driven by expected population growth. This expected population growth rate is similar to those estimated in the 2006 Forecast for 2005-2025.[6]

Per capita demands varied considerably throughout eastern Washington, with an average total demand (including system losses) of approximately 277 gpcd. These results are in line with a 2005 USGS study of domestic water use, which estimated 285 gpcd (Lane 2009), though higher than the estimates of 170 gpcd reported from the 2000 USGS study of domestic water use (Lane 2004).[7]

Table 16. Municipal diversion demands for the Washington portion of the Columbia River basin.

	2010 (ac-ft per year)	2030 Forecast (ac-ft per year)	% Change
Washington Portion of the Columbia River Basin	452,000	569,000	26%

Total consumptive demands for 2030 for eastern Washington were estimated to be 291,000 ac-ft per year in 2030, compared to 232,000 ac-ft per year in 2010. This represents approximately 51% of the total diversion quantity, which may be high compared to other investigations, but

[6] The forecast increase from 2006 through 2025 in the 2006 Forecast was 94,500 or 109,400 ac-ft per year, depending on the method used, as summarized in Section 2.3, Summary of 2006 Forecast, and described in detail in Golder and Anchor (2006).

[7] These estimates of 2000 water use carried out by the USGS were used in the 2006 Forecast.

nevertheless, represents an initial estimate. These amounts were distributed evenly throughout the year, with no attempt to account for seasonal variations in water use. Future analysis should examine monthly variations, and should also utilize the OFM's WRIA level population estimates to improve the assumed distribution of current and future populations by WRIA.

These estimates did not include the potential impacts of system repairs or conservation efforts on future demands. As an example of the impact this could have, eliminating system losses would result in a net savings of nearly 56,000 ac-ft per year currently and 70,000 ac-ft per year by 2030. Of equal importance is the potential impact of conservation practices. Reducing current demands by 10% would reduce current diversion requirements by 45,000 ac-ft per year and projected future diversion demand by 57,000 ac-ft per year and future consumptive use by approximately 29,000 ac-ft per year.

5.2.3 Columbia River Basin Instream Water Demand

Forecast changes in surface water supply timing are likely to increase the challenge of meeting instream demands throughout the Columbia basin river system. Increases in out-of-stream demands within and outside of Washington by 2030 are also likely to make it more difficult to meet instream demands by 2030. Lower flows, particularly in the summer and early fall, could negatively impact threatened and endangered fish in the Columbia River basin (Figure 10), as well as other fish important to the culture and economy of eastern Washington.

Several factors have the potential to impact future water supplies for meeting instream demands in ways that are difficult to predict, and thus were not feasible to capture in this analysis. The possibility for re-negotiation of the international Columbia River Treaty and unquantified tribal water rights, both discussed with water supply results in Section 5.1.2, could change the amounts and timing of water available to meet instream needs in the Columbia River mainstem.

5.2.3.1 Minimum Flows in the Columbia River Basin

The instream flow regulations and obligations of other states and BC were used to estimate the minimum quantities of water likely to enter Washington from upstream sources. For informational purposes, the legal process of adjudication is addressed in the section "Adjudicated Water Sources". The adjudication process is described as "a lawsuit to inventory the water rights of an entire stream system by deciding their nature, extent and priority" (SRBA Information). The Snake River is the only incoming source of water flow entering the State of Washington in the Columbia River basin that has been adjudicated. For comparison, to show the uncertainties of resolution (adjudication) of other water basins and water rights, a discussion of the current status of The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) water right claim is provided. All incoming flows into Washington in the Columbia River basin, adjudicated and non-adjudicated are addressed in the Sections "Minimum Instream Flows" and "Dams and Impoundments." In "Minimum Instream Flows," a categorical listing (state by state and one province) provides the sources of instream flows into the state of Washington. Minimum instream flow denotes the lowest legal flow, location, and time of year. In cases where the lowest flow is not legally binding (i.e., scenic waterway flows) it is noted. In "Dams and Impoundments," operational data which incorporates the Endangered Species Act (ESA), Biological Opinions (BiOps), and Federal Energy Regulatory Commission (FERC) requirements, were considered in a separate category due to federal mandates placed upon these facilities.

A summary of theoretical minimum flows set by statute or dam operating criteria is presented in Section 5.2.3.2**.**

Adjudicated Water Sources

Snake River Basin Adjudication

In addition to upholding the Swan Falls agreement, the Snake River Basin Adjudication (SRBA) framework addressed three separate components: (1) the Nez Perce Tribal component to resolve issues on and near lands ceded by the Tribe in the 1863 Treaty, (2) the Salmon/Clearwater component to protect flows and habitat within the Salmon and Clearwater River basins, and (3) the Snake River flow component to resolve issues involving the use of the Snake River above the Hells Canyon Complex.

Although, not directly related to the minimum flow entering the State of Washington, the Snake River segment of the SRBA anticipates 30-year Biological Opinions (BiOps) from the National Oceanic and Atmospheric Administration (NOAA) Fisheries and USFWS under the Endangered Species Act on continued operation of the Bureau of Reclamation's projects in the upper Snake River basin. These BiOps would address issues relating to flows from the Snake River above Brownlee Reservoir and the use of water for flow augmentation. The significant provisions of this component include the following:

- Minimum flows defined by the Swan Falls Agreement will be decreed by the SRBA Court to the Idaho Water Resources Board (Agreement Summary, May 2004).
- Instream flow cases related to the SRBA.

It was the determination of the Idaho State Court that the Idaho Department of Water Resources (IDWR) would aid (as technical experts) in the SRBA adjudication process and that individuals, companies, all levels of government, and tribes were compelled to participate. The IDWR represented permits, licenses, and beneficial use claims for the state, whereas the Attorney General represented federal interests (i.e., Tribal Rights, federal land holdings). For a complete list of SRBA minimum instream flows adjudicated for the State of Idaho their web site provides the pertinent information on a stream by stream basis at

http://www.idwr.idaho.gov/waterboard/WaterPlanning/nezperce/pdf_files/IWRB%2042-1507%20Recommendations.pdf (IDWR, 2005).

On the Federal side of the SRBA, the categories of reserved instream flow claims and reserved water right consumptive use claims were/are being adjudicated. As Table 17 indicates, all instream flow claims associated with this action have been settled (mostly dismissed) although in regard to consumptive use assertions, the National Park Service (Nez Perce National Monument), Nez Perce On-Reservation Claims (settlement signed, but pending), and the Army Corps at Dworshak Reservoir are still pending (Schaff, 2006).

Table 17. Summary of Federal Reserved Instream Flow Claims (Shaff 2006).

Agency	Allowed	Disallowed or Dismissed
Forest Service	7	3,762
Fish and Wildlife Service	0	4
Nez Perce/Bureau of Indian Affairs	0	1,133
Northwest Shoshoni	0	27
Shoshone Bannock Tribes	0	1,030
Shoshone-Paiute Tribes	0	7
TOTALS	7	5,963

<u>The Confederated Tribes of the Umatilla Indian Reservation</u>

When contacting other potential entities that may have minimum instream flow rights that could affect the volume of water entering the State of Washington in the Columbia River basin, we were directed to the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Their water status relating to minimum flows in Oregon and Washington was addressed in the following manner.

> "The CTUIR retains Treaty reserved instream flow water rights in the Walla Walla, Tucannon and mainstem Columbia Rivers to support the native fishery. In 2002, the CTUIR partnered with the [US Army] Corps of Engineers, States of Washington and Oregon, and basin stakeholders to restore flows in the Walla Walla basin and are currently preparing for a water rights settlement. The timeframe for settlement/adjudication completion is unknown at this time (Marks, 2011)."

At the present time, uncertainties in the quantities of water that will be allocated under this action make it impossible for us to accurately address this in the 2011 plan. This is, however, an issue that is potentially important for water managers to monitor for the future.

Minimum Instream Flows

<u>Oregon</u>

For the supply of water entering into Washington within the Columbia River basin from Oregon, the Deschutes, John Day, Umatilla, and Walla Walla Rivers were considered. The Grande Ronde is another major Oregon tributary to the Columbia River system, but since this flow is captured in the Snake River minimum flow requirement it was not examined separately. An individual at the department provided a map of Oregon instream water rights flowing into Washington (Figure 47), illustrating "minimum flow points" and "instream reaches," that enter Washington's Columbia River basin. Online searches at Oregon – Water Resource Department's "Water Rights Information Query" (http://apps.wrd.state.or.us/apps/wr/wrinfo/) verified the flow rates.

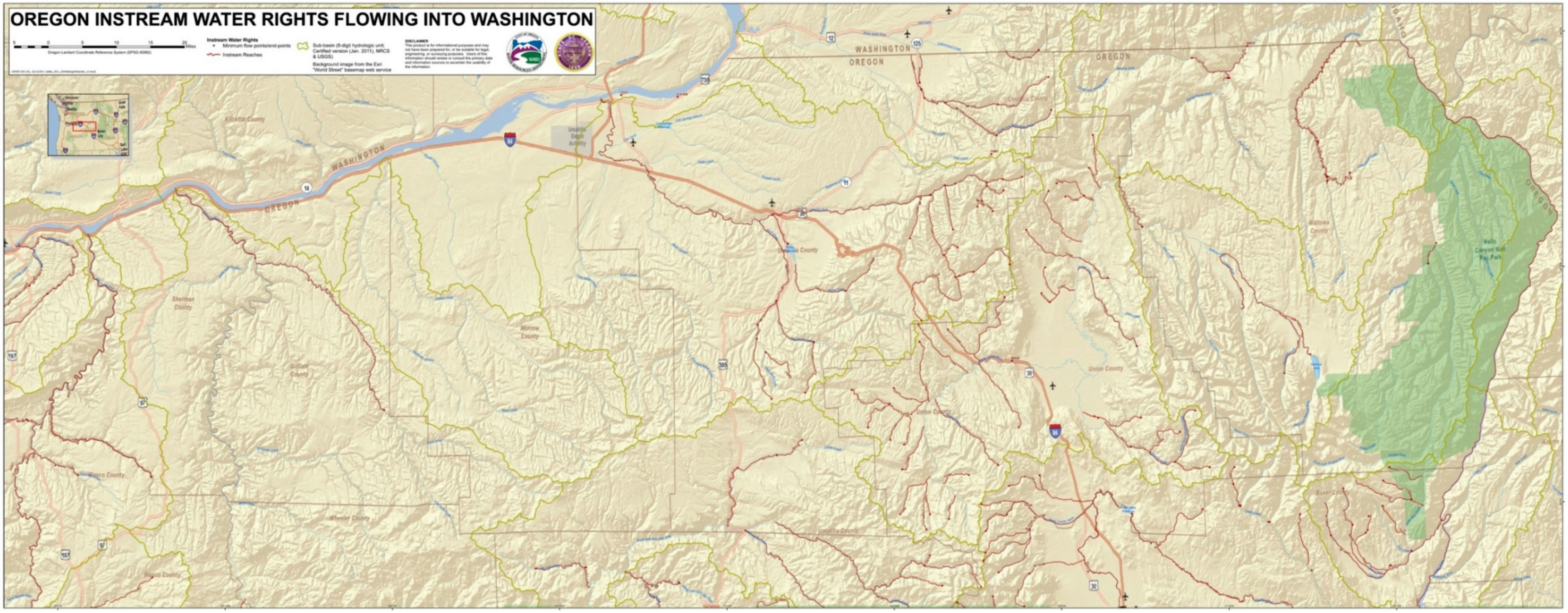

Figure 47. Oregon instream water rights flowing into Washington (from Harmon 2011 with permission).

Additional information was supplied on the mainstems of the Walla Walla, Umatilla, and Deschutes Rivers by Oregon Water Resource Department Field Offices and their associated personnel. The instream flow targets on the Walla Walla were considered insignificant in terms of flow into the Columbia River (e.g. < 1 cfs) and so are not presented in this document. Finally, instream flows for the John Day and Deschutes Rivers were supplied under the "Scenic Waterway Flows" category (Ladd, 2011). Information for the Deschutes and John Day Rivers were taken from their Certificate numbers because these represent guaranteed minimum flows whereas the "Scenic Waterway Flows" do not.

The results (flows and time periods) that were used for the final calculations are listed below in Table 18. The Oregon Water Resources Department (OWRD) uses the Willamette Meridian (WM) as their basis for location as indicated in Table 18. The values listed for the Deschutes represent the lesser of two certificates to insure the estimate was conservative. Other water sources that influence the amount of water entering the State of Washington but were not designated as "Scenic Waterway Flows" or are tributaries of the John Day and Deschutes Rivers can be found in Appendix E, Other Sources of Instream Flows.

Table 18. Minimum instream flows for the State of Oregon. (OWRD, 2011a).

River	Minimum Flow (cfs)	Location
Umatilla River > Columbia River		The Umatilla River from McKay Creek (SEC. 8, T 2N, R 32E, WM) to the mouth (SEC. 18, T 5N, R 28E, WM)
Certificate # 59837		
October 1 – November 15	300	
November 16 – November 30	250	
December 1 – June 30	250	
July 1 – July 31	120	
August 1 – September 15	85	
September 16 – September 30	250	
Walla Walla River		Flows in the Walla Walla River from the confluence of the North Fork and the South Fork (Section 22, T 5 N, R 36 E, WM) to the Little Walla Walla diversion (Section 12, T 5 N, R 35, E, WM)
Certificate # 59839		
October 1 – November 30	30	
December 1 – January 31	70	
February 1 - May 31	95	
June 1 – June 30	70	
July 1 – September 30	50	
John Day River		Scenic waterway flows at the mouth. Although not a guaranteed amount, “Scenic waterway flows are those flows necessary to maintain the free flowing characteristics of a scenic waterway.” Also, Certificate # 66609 is for a withdrawal amount (located in Appendix E).
Application # SY90605A		
October 1 – January 31	500	
February 1 – February 28 (29)	1,000	
March 1 – June 30	2,000	
July 1 – September 30	500	
Deschutes River		Deschutes River at Pelton regulation dam at river mile 100.1 (SESW, Section 1, T105, R12E, WM) to the confluence with the Columbia River (SWSW, Section 24, T2N, R15E, WM)
Certificates #73188 and 73237		
October 1 – February 28 (29)	3,000	
March 1 – June 30	3,500	
July 1 – September 30	3,000	
** taking the lesser flow amount from the two certificates		

Idaho

In Idaho, the Clearwater, Priest, Snake, and Spokane Rivers were examined for existing minimum flows within the State of Idaho. Initial information regarding the closest geographical location to the State of Washington for each or these rivers and their minimum flow points was provided by the Idaho Department of Water Resources (IDWR). A breakdown of the seasonal restrictions on the minimum flow rate was determined by going to the "IDWR Water Right and Adjudication" web-site (http://www.idwr.idaho.gov/apps/ExtSearch/SearchWRAJ.asp) and entering the proper basin and sequence information. Additional information was supplied by Avista Utilities regarding flow rates of the Spokane River at Post Falls, Idaho.

On the Snake River, after Idaho's Fifth District Judge John Melanson's written decision not to revisit Idaho Power Company's water rights in the Swan Falls agreement, the average minimum daily flow at the Murphy gage (southern Idaho) was increased to 3,900 cfs during the irrigation season and 5,600 cfs during the non-irrigation season. The State mandated that it would manage the Snake River to meet or exceed the minimum average daily flow at Milner, Murphy, and Weiser. When the Hells Canyon National Recreation Act of 1975 precluded future hydropower development and designated the reach from Hells Canyon to Pittsburg Landing as "scenic and wild," it preserved the free-flowing characteristics and unique environment while providing for public use. The Act provided that no flow requirements of any kind may be imposed on the waters of the Snake River below Hells Canyon Dam (State Water Plan). In the future, hydropower water rights of the Hells Canyon Complex are subordinated to all future upstream consumptive uses. This requirement, along with minimum flow requirements for navigation, is designated by the Federal Power Commission as part of the FPC license (State Water Plan). For comparison purposes, minimum flows for Snake River reaches above the Murphy gage in southern Idaho (near Boise, ID) are listed in Appendix E.

For the Spokane, in addition to state adopted instream flow requirements, dam operators often negotiate minimum releases as part of their relicensing authorization process or, in some cases, to assist in helping solve local and regional water issues. As indicated in Table 19, the State of Idaho has set instream flow targets but natural flows may fall below these levels due to variations in hydrologic events and diversions by senior water rights. In this case, the absolute minimum instream flow is governed by releases from Lake Coeur D'Alene. Avista owns and operates the dam on the Spokane River at Post Falls, Idaho. Avista has agreed to maintain a minimum discharge of 600 cfs from the Project as measured at the USGS gage 12419000 (Spokane River at Post Falls) beginning on June 7 each year provided that inflows to Lake Coeur D'Alene are sufficient to maintain reasonable lake levels. If the elevation of Lake Coeur D'Alene falls below 2,127.75 feet during July, August, or September prior to the Tuesday following Labor Day ("low flow conditions"), Avista immediately reduces the discharge from the Project to 500 cfs and maintains that discharge until fall draw down (after the Tuesday following Labor Day) unless operating for purposes of the monitoring program described in Section B.2 of their FERC license (Federal Energy Regulatory Commission, 2009). This lake level agreement helps maintain the economic base of Lake Coeur D'Alene with respect to recreational activities tied to boating through the peak summer period. For the purpose of this study we assumed Idaho requirement as the minimum flow while acknowledging the Avista contribution as a backstop in very dry years.

Table 19. Minimum instream flows for the State of Idaho.

River	Minimum Flow (cfs)	Location
Snake River		
October 1 – June 30	13,000*	Lime Point
July 1 – September 30	5,000	Snake River recorded at Johnson's Bar
Clearwater River		Begins at the Potlatch River confluence in Lot 13, Section 7, T36N, R3W, B.M. and extends downstream approximately 13 miles to the beginning of backwater from the reservoir behind Lower Granite Dam in Lots 1 and 6, Section 32, T36N, R5W, B.M.
October 1 – October 31	4,498	
November 1 – July 31	5,910	
August 1 – September 30	4,498	
Spokane River		Commencing downstream from the Post Falls Dam at which the overflow channels converge with the main channel below the dam in S4, T50N, R5W and extending downstream to the Idaho-Washington state line in S12, T50N, R6W, Kootenai County
October 1 – October 31	951	
November 1 – June 30	2,495	
July 1 – September 30	951	
Priest River		Beginning at the confluence with the East River in Lot 5, Section 28, T58N, R04W, B.M. and extending downstream approximately 21.4 miles to the mouth of the Priest River at the confluence with the Pend Oreille River in Lot 6, Section 30, T56N, R04W, B.M.
October 1 – October 31	300	
November 1 – March 31	700	
April 1 – June 30	1,500	
July 1 – July 31	700	
August 1 – September 30	300	

*"*The project shall be operated in the interest of navigation to maintain 13,000 cfs flow in the Snake River at Lime Point (river mile 172) a minimum of 95 percent of the time, when determined by the Chief of Engineers to be necessary for navigation. Regulated flows of less than 13,000 cfs will be limited to the months of July, August, and September, during which time operation of the project would be in the best interest of power and navigation mutually agreed to by the Licensee and the Corps of Engineers. The minimum flow during periods of low flow or normal minimum plant operations will be 5,000 cfs at Johnson's Bar…*" (IDWR, 2012, State Water Plan – Snake River Policy).

British Columbia

Four rivers were considered for minimum flows entering the State of Washington. The Columbia, Kootenai, Okanogan, and Similkameen Rivers currently have no minimum flow regulations within Canada (Boyer 2011 and Symonds 2011; e-mail correspondence). Upstream reservoir operations on the Columbia (including the Kootenai contribution) control the flows entering Washington. These are reported separately from instream flow requirements in the discussion of dam and impoundments.

The Okanagan River flows through Osoyoos Lake which is a trans-boundary lake, with approximately 2/3 of the lake in Canada, and 1/3 in the United States. The level of Osoyoos Lake is managed within a relatively small operating range by Zosel Dam near Orville by the Washington State Department of Ecology. The Dam is operated in accordance with the orders of the International Joint Commission (IJC) which specify lake level targets. The IJC orders do not specify any minimum transboundary or Okanagan River flows (Symonds) although these orders are currently being re-examined for the next 25 year agreement.

There exists a nonbinding British Columbia – Washington State Cooperation Plan for Osoyoos Lake levels and trans-border flows (Jan 175 cfs, Feb 200 cfs, Mar 200 cfs, Apr 200 cfs, May 250 cfs, Jun 250 cfs, Jul 250 cfs, Aug 340 cfs, Sep 320 cfs, Oct 300 cfs, Nov 175 cfs, and Dec 175 cfs) (Symonds). These flows are controlled by reservoir operations upstream of Zosel Dam as Osoyoos Lake has a very limited amount of storage. The Similkameen is largely in a natural state with only limited opportunities for regulating flows.

Montana

Montana has two rivers that ultimately contribute to flow in Washington; the Clark Fork and the Kootenay Rivers. According to the Montana Department of Water Resources, there are currently no adopted minimum instream flow requirements on either of these two rivers (T. Bryggman, MDWR, personal communication, October 5, 2011). However, the Clark Fork watershed contains 21 reservoirs with storage volumes greater than 5,000 ac-ft (DNRC, 2004). Consequently, streamflow in these watersheds are significantly impacted by operational constraints placed on reservoirs. For example, on the lower Clark Fork, the FERC license for Cabinet Gorge establishes that the project maintain a total minimum total project discharge 5,000 cfs. Similarly, the instream flow below Thompson Falls Dam is the lesser amount of 6,000 cfs or the entire reservoir inflow. The potential impacts of dam releases are discussed in the next section.

There are other potential decisions that could impact instream flows in the long run. Specifically, in the Clark Fork, the off-reservation reserved and aboriginal water right claims by the Confederated Salish and Kootenai Tribes could result in more water in the stream or different operation of the reservoirs. For proposed actions in the Clark Fork basin, the reader is directed to the Clark Fork River Basin Management Plan (DNRC, 2004). Libby Dam, on the Kootenay system, could be operated differently depending on U.S.-Canada Treaty negations.

Dams and Impoundments

The operational minimum flows from five dams were considered since they would ultimately contribute to water entering the State of Washington's Columbia River basin. These requirements are often specified in FERC agreements or as agreed upon operational constraints in the case of U.S. government facilities.

<u>Albeni Falls Dam and Pend Oreille Lake</u>

Albeni Falls Dam is located on the Pend Oreille River at the downstream end of Lake Pend Oreille near the Idaho/Washington border. The dam was built at the site of a natural falls called Albeni Falls, named after an early settler, Albeni Poirier. Albeni Falls Dam was authorized for construction under the Flood Control Act of 1950 in response to a great flood that swept over the river valleys of the Columbia basin in 1948. The Army Corps dam was built from January 1951 to December of 1955 at a total cost of 34 million dollars. Today, it produces over 200 million kilowatt hours of electrical energy each year. The spillway can either store water for downstream power production and irrigation at other dams along the Pend Oreille and Columbia Rivers, or release water for upstream flood control.

Albeni Falls Dam was designed for water to flow under a series of 10 gates that can be lifted and lowered by the gantry crane on top of the spillway. The entire length of the spillway is 472 feet (144 meters). The lake has a maximum pool elevation of 2,075.9 feet and a minimum pool elevation of 2,049.7 feet. In times of high flood danger, all 10 gates are opened and the spillway is in the free-flow condition. In this configuration the spillway can release a maximum of 350,000 cfs of water. In summer, the spillway gates are closed to bring Lake Pend Oreille up to the normal summer range of 2,062.0 to 2,062.5 feet above sea level for recreational and ecological purposes. Usable storage within the preferred operating levels of 2,051 and 2062.5 feet are 1,155,200 ac-ft (Army Corps 2011c).

The minimum release from the dam is specified as 4,000 cfs. In 1992, the Idaho Department of Water Resources issued the Idaho Water Resources Board an instream flow right of 10,655 cfs immediately downstream of the dam. The water right (Permit No. 96-8730) established a constant year-round flow for the 2.4 mile river reach in Idaho to protect fish and wildlife habitat, aquatic life, and recreational values. However this right is junior to the dam so an instream flow of 4,000 cfs was adopted for this reach.

Hungry Horse Dam and Lake

Hungry Horse Dam is in the Flathead National Forest on the South Fork of the Flathead River, 15 miles south of the west entrance to Glacier National Park and 20 miles northeast of Kalispell, Montana. The construction contract for the dam and powerhouse was awarded in 1948 and the project was completed in 1953. The dam site is in a deep, narrow canyon which creates an active storage capacity of 2,982,026 ac-ft in the normal operating pool range from 3,336 feet to 3,560 feet. At the maximum regulated pool elevation (3,565 feet) there is 3,568,000 ac-ft of storage. The specified minimum discharge from the facility is 400 cfs (U.S. Department of the Interior, USBR).

Under the Endangered Species Act (ESA) Hungry Horse Dam is required to provide instream releases for local bull trout populations in the lower South Fork and Flathead rivers and releases in July and August for anadromous salmon species downstream of Grand Coulee Dam. Operations must maintain a 400-900 cfs minimum flow below Hungry Horse Dam and 3,500 cfs in the mainstem of the river. Pursuant to the voluntary agreement between the state of Montana and the USBR, during drought years the 3,500 cfs requirement on the mainstem can be reduced to 3,200 cfs. Since the 1995 ESA biological opinion for Columbia River salmon, the top 20-25 feet of reservoir storage has been available for salmon flows. All constraints are combined in integrated rule curves that are used to govern operation. Pursuant to the 2002 Biological Opinion issued by the National Marine Fisheries Service, USBR releases approximately 4,000 cfs from the dam in the months of July and August and has increased flows in June over prior operating rules (Clark Fork River Basin Management Plan, 2004). The flows used for this study are shown in Table 20. As indicated, the smaller value (3,500 versus 4,000 cfs) was used to estimate minimum transboundary flows to be conservative. This acknowledges the possibility that the BiOp flows may adapt in the future to changing conditions in the watershed related to ESA species.

Table 20. Reservoir operation releases from Hungry Horse Dam.

River	Minimum Flow (cfs)	Location
South Fork of Flathead		Minimum flow of 400 cfs immediately downstream of the dam in combination with a 3,500 cfs amount measured at Columbia Falls on the mainstem Flathead River. During downstream flooding events, dam discharges can be reduced to the physical minimum of 145 cfs.
October 1 – June 30	400	
July 1 – August 31	3,500	
September 1 – September 30	400	

Libby Dam and Lake Koocanusa

Libby Dam on the Kootenai River in Montana is one of 14 Federal Columbia River Power Systems (FCRPS) projects that have altered the natural river hydrology of the Columbia River and some of its major tributaries. The FCRPS storage projects: Libby, Hungry Horse, Dworshak, Albeni Falls, and Grand Coulee dams each store the spring snowmelt runoff to control floods and release water for multiple uses. Libby Dam was completed in 1973 with the first 4 units of the powerhouse completed in 1976 and unit 5 installed in 1984. Within the usable minimum and maximum pool elevations of 2,287 feet to 2,459 feet, respectively, Lake Koocanusa stores 4,979,500 acre-feet. As a result of the 172 foot operating range, irrigation supplies, hydropower generation, and populations of threatened and endangered fish in the Columbia River basin are affected by the altered hydrograph. Also, because of its capacity for flood control, reservoir operation could change dramatically in the future depending on the outcome of the Columbia River Treaty negotiations.

According to Army Corps Project Data, the minimum instantaneous discharge from the facility is 2,000 cfs and the minimum daily flow is 3,000 cfs. However, the 2010 Water Management Plan for Libby specifies 4,000 cfs as the minimum discharge. This value was used in the initial analysis recognizing that flows are likely to be considerably higher than this most of the time. In fact, in terms of potential flows entering Washington, this instream value is trumped by a larger downstream flow requirement at Corra Linn Dam.

Because the reservoir is used for flood storage, a big concern is actually accounting for maximum flow releases rather than minimum flow requirements. The reservoir is drawn down over winter following elevation targets based on runoff projections. In accordance with the Endangered Species Act (ESA), the Army Corps, the USBR, and the BPA engaged in formal consultation regarding the effects of FCRPS operations on anadromous and resident fish species listed as threatened or endangered. In the most recent Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) (2008 NMFS BiOp3), the effects of FCRPS operation on ESA species resulted in recommendations to implement VARQ (1) Flood Control and certain flow operations at Libby and Hungry Horse Dams to benefit listed fish species. Additionally, the Fish and Wildlife Program and the 2003 Mainstem Amendments issued by the Northwest Power and Conservation Council (NPCC) included a recommendation to adopt VARQ Flood Control Procedures with Q representing engineering shorthand for discharge. Releases from the reservoir can vary from the powerhouse capacity of 25,000 cfs up to 35,000 cfs (including 10,000 cfs spill) for white sturgeon flow augmentation depending on reservoir level which may vary from year to year. A more thorough discussion can be found at the USBR web site (USBR, 2008).

Although VARQ discharges at Libby Dam can be quite high, the reservoir is operated under seasonal ramp up/ramp down restrictions. Table 21 shows summer and winter ramp rates for Libby Dam used to protect resident fish and prey organisms in the Kootenay River. Notice the lower ramping down rates to avoid stranding of fish in floodplain pools.

Table 21. Ramp up/ramp down flow rates for Libby Dam.

Period	Downstream Discharge (cfs)	Maximum Hourly Change (cfs)
Summer (May 1 – September 30)		
Ramping Up	4,000 – 9,000	2,500
	9,000 – 16,000	5,000
Ramping Down	4,000 – 9,000	500
	9,000 – 16,000	1,000
Winter (October 1 – April 30)		
Ramping Up	4,000 – 9,000	2,000
	9,000 – 16,000	3,500
Ramping Down	4,000 – 9,000	500
	9,000 – 16,000	1,000

Duncan Dam (six miles north of Kootenay Lake)

Duncan Dam was the first of the three Columbia River Treaty dams to be built in the Canadian section of the Columbia River basin. Construction began on the dam in 1965 and was completed and operational in 1967, ahead of schedule. It is an earthfill dam with no power generation facilities. Its purpose is to control the flow of water from the Duncan River into Kootenay Lake in conjunction with the Libby Dam to assure operational water levels for the Kootenay Canal and the Corra Linn projects downstream. Duncan Lake was originally 25 km (15.5 mile) long, the reservoir is now 45 km (28 miles) in length. Water fluctuates up to 30 meters (98 feet) in elevation annually (Balance of Power).

Under terms of the Columbia River Treaty the minimum average monthly discharge from Duncan Dam is 106 cfs (3.0 m^3/s). In a slightly more restricted constraint, to maintain continuity of fish habitat along the river between the dam and the confluence with the Lardeau River, a minimum average daily release from Duncan Dam of 106 cfs (3.0 m^3/s) has also been adopted (BC Hydro). The flow rate used for calculations was 100 cfs as a weekly average (Kanbergs, Army Corps). Again, this value is superseded by the flow requirement at Corra Linn.

Corra Linn Dam – Kootenay River

Corra Linn Dam is located on the lower Kootenay River and was the first dam to create water storage on the Kootenay River system. The Kootenai River basin has a total drainage area of 16,180 square miles (41,910 km^2) and comprises parts of British Columbia, Montana, and Idaho (70%, 23% and 7% of basin area, respectively) (Burke et al., 2009). Constructed between 1930 and 1932, it was built with the goals of supplying Cominco with electricity for its fertilizer plant in Trail, BC and ensuring a constant water supply for the downstream West Kootenay Power dams that would occasionally go dry during the winter months. Kootenay Lake wanted to become a temporary reservoir to store the fall runoff behind Corra Linn. This task required the consent of the International Joint Commission (IJC), as water storage in Kootenay Lake would affect areas on both sides of the international border. The request for storage by Canada was continually denied and West Kootenay Power let the issue drop until the devastating floods in 1938. Permission was granted by the IJC in the fall of 1938 and Kootenay Lake became a reservoir (Balance of Power) and was allowed to raise the level of Kootenay Lake by 6.5 feet (2 meters). The dam, owned by FortisBC since 2003, can generate 49 MW of power.

Since Corra Linn is the lowest storage facility on the Kootenay River system, outflows dictate the flow contribution to Washington from this watershed. This means that releases from both Duncan and Libby are re-regulated through this facility to some extent. The minimum instream flow from Corra Linn is 10,000 cfs (McCroskey, Army Corps).

Hugh Keenleyside Dam (Arrow Lakes Reservoir 5 miles west of Castlegar)

Originally known as the High Arrow Dam and renamed in 1969 after the co-chairman of BC Hydro, Hugh Keenleyside Dam was completed in 1968. The second of the three Columbia River Treaty dams, it was built to control water levels downstream for power production at the Grand Coulee Dam in Washington State and for flood control in both Canada and the U.S. The dam contained no power generation facilities, though it did provide a lock to allow both industrial and recreational boat access through the dam. In 1999, the Columbia Power Corporation (a crown corporation owned and controlled by the Province of BC) with its partner the Columbia Basin Trust began to construct the Arrow Lakes Generating Station, a two-turbine powerhouse immediately downstream of Hugh Keenleyside Dam. Completed in 2002, the station produces up to 185 Megawatts, using the water previously allowed to spill over the dam during high-water levels (Balance of Power). It is located downstream of Mica and Revelstoke and therefore controls the flow on the mainstem Columbia River upstream of its confluence with the Kootenay River.

The reservoir pool levels typically range from 1,377.9 feet to 1,444 feet which provides approximately 7,000,000 acre-feet of storage. Including surcharge, the maximum pool elevation is 1,449 feet however the normal maximum operating pool is kept at 1,446 feet. The minimum average weekly outflow is 5,000 cfs although typical minimum flow range are from 5,000 cfs to 20,000 cfs (McCroskey, Army Corps). To be conservative, 5,000 cfs was used in this study.

Dworshak Dam (North Fork of Clearwater River)

Dworshak Dam and Reservoir is located in northern Idaho on the North Fork of the Clearwater River, near Orofino and about 35 miles east of Lewiston, ID. The project includes Dworshak Dam and Reservoir lands, a powerhouse, recreation facilities, wildlife mitigation, and Dworshak National Fish Hatchery. The dam is a straight concrete gravity dam with a structural height of 717 feet and a crest length of 3,287 feet at an elevation of 1,613 feet. Completed in 1973, the dam is located on the North Fork Clearwater River at River Mile 1.9. The dam is the highest straight-axis concrete dam in the Western Hemisphere and the 22nd highest dam in the world. Only two other dams in the United States exceed it in height.

The reservoir has a gross storage capacity of 3,453,000 acre-feet, of which 2,000,000 acre-feet is used for local and regional flood control; and for at-site and downstream power generation. At an elevation of 1,600 feet, the reservoir is 53 miles long, has a surface area of 19,824 acres, and extends into the Bitterroot Mountains. The reservoir provides substantial recreational and wildlife benefits, and transportation for timber (Army Corps, 2011b). The specified minimum reservoir release is 1,000 cfs. However, since this is upstream of the Clearwater instream flow requirement, the Dworshak discharge would only help support the overall requirement.

Because the reservoir is deep, water temperature in the impoundment is generally cold compared to other nearby water bodies. Consequently, reservoir operations are used to help ESA listed species downstream in the Lower Snake River. Specifically,

- The Project will release 4,000 to 6,000 cfs from Dworshak, if necessary, in order to move juvenile fish into the mainstem Clearwater River during the spring hatchery releases.
- Summer flow augmentation provided from Dworshak may be used to cool water temperatures in the lower Snake River (BPA).

The Agency's Action (Army Corps) plan to draft Dworshak to 1,535 ft. in August and draft approximately 1,520 ft. in September. The extension of the draft limit into September reflects assumed releases of 200,000 ac-ft consistent with the agreement with the Nez Perce Tribe and the Snake River Basin Adjudication process (2010 Water Management Plan).

5.2.3.2 Summary of Theoretical Minimum Flows Set by Statute or Dam Operating Criteria for the Columbia River and Major Tributaries Entering Washington.

The minimum flows that could theoretically be released by statue for waters entering the State of Washington's Columbia River basin from Oregon, Idaho, and dams in Montana, British Columbia appear below in Table 22 through Table 27**.** These values represent the least amounts of flow that would enter the State of Washington assuming that all upstream sources released only the minimum flows. Often this would not be physically possible for extended periods of time because high runoff events would cause dams to overtop. Thus, in almost all cases, flows are considerably higher than the minimums listed here. Conversely, during low flow periods, it is possible that streamflows could be less than adopted instream requirements because of senior water rights or physical limitations due to drought. Overall, the values should be seen more as targets rather than pre-scripted or fixed quantities of water.

Table 22. Minimum flows allowed by statute for waters entering Washington from Oregon.

	Tributaries				
Month	Umatilla (cfs)	Walla Walla (cfs)	John Day (cfs)	Deschutes (cfs)	Total (cfs)
January	250	70	500	3,000	3,820
February	250	95	1,000	3,000	4,345
March	250	95	2,000	3,500	5,845
April	250	95	2,000	3,500	5,845
May	250	95	2,000	3,500	5,845
June	250	70	2,000	3,500	5,820
July	120	50	500	3,000	3,670
August	85	50	500	3,000	3,635
September	167.5	50	500	3,000	3,718
October	300	30	500	3,000	3,830
November	275	30	500	3,000	3,805
December	250	70	500	3,000	3,820

Table 23 and Table 24 show minimum instream flows for water entering Washington from three Idaho tributaries (Snake, Clearwater, and Spokane) for high and low flow years as well as two important caveats (SpokaneAvista and Priest River). The SpokaneAvista column reflects additional protection on the Spokane against natural flows falling below the Idaho instream flow targets. Similarly, Priest River (which flows into Lake Pend Oreille near Albeni Falls Dam) provides assurances for the Albeni Falls reservoir releases shown in Table 25. The total instream flow column sums the values listed in the Snake, Clearwater, and Spokane River tributaries.

Table 23. Minimum flows allowed by statute for waters entering Washington from Idaho (in a high flow year).

	Tributaries					
Month	Snake (cfs)	Clearwater (cfs)	Spokane (cfs)	Spokane Avista (cfs)	Priest (cfs)	Total[1] (cfs)
January	13,000	5,910	2,495	600	700	21,405
February	13,000	5,910	2,495	600	700	21,405
March	13,000	5,910	2,495	600	700	21,405
April	13,000	5,910	2,495	600	1,500	21,405
May	13,000	5,910	2,495	600	1,500	21,405
June	13,000	5,910	2,495	600	1,500	21,405
July	5,000	5,910	951	600	700	11,861
August	5,000	4,498	951	600	300	10,449
September	5,000	4,498	951	600	300	10,449
October	13,000	4,498	951	600	300	18,449
November	13,000	5,910	2,495	600	700	21,405
December	13,000	5,910	2,495	600	700	21,405

[1] Snake + Clearwater + Spokane only.

Table 24. Minimum flows allowed by statute for waters entering Washington from Idaho (in a low flow year).

Month	Tributaries					
	Snake (cfs)	Clearwater (cfs)	Spokane (cfs)	Spokane Avista (cfs)	Priest (cfs)	Total[1] (cfs)
January	5,600	5,910	2,495	600	700	14,005
February	5,600	5,910	2,495	600	700	14,005
March	5,600	5,910	2,495	600	700	14,005
April	5,600	5,910	2,495	600	1,500	14,005
May	5,600	5,910	2,495	600	1,500	14,005
June	5,600	5,910	2,495	600	1,500	14,005
July	3,900	5,910	951	600	700	10,761
August	3,900	4,498	951	600	300	9,349
September	3,900	4,498	951	600	300	9,349
October	5,600	4,498	951	600	300	9,349
November	5,600	5,910	2,495	600	700	14,005
December	5,600	5,910	2,495	600	700	14,005

[1] Snake + Clearwater + Spokane only.

Table 25. Minimum flows allowed by statute for waters entering Washington from dams in Montana and British Columbia.

Month	Dams Albeni (cfs)	Hungry Horse (cfs)	Keenleyside (cfs)	Corra Linn (cfs)	Libby (cfs)	Duncan (cfs)	Total[1] (cfs)
January	4,000	400	5,000	10,000	4,000	100	19,000
February	4,000	400	5,000	10,000	4,000	100	19,000
March	4,000	400	5,000	10,000	4,000	100	19,000
April	4,000	400	5,000	10,000	4,000	100	19,000
May	4,000	400	5,000	10,000	4,000	100	19,000
June	4,000	400	5,000	10,000	4,000	100	19,000
July	4,000	3,500	5,000	10,000	4,000	100	19,000
August	4,000	3,500	5,000	10,000	4,000	100	19,000
September	4,000	400	5,000	10,000	4,000	100	19,000
October	4,000	400	5,000	10,000	4,000	100	19,000
November	4,000	400	5,000	10,000	4,000	100	19,000
December	4,000	400	5,000	10,000	4,000	100	19,000

[1] Albeni Falls + Corra Linn + Keenleyside

As previously mentioned, programmatic reservoir releases are often specified in operating rules governed by licenses, treaty, or other obligation. The mainstem Columbia, Kootenay, and Pend Oreille River systems are prime examples. Table 25 summarizes the minimum flows from the most downstream major storage projects on each system. It is important to recognize that flows often exceed these values. The table also illustrates the potential contributions from several upstream facilities. In particular, Libby is important because its operation could potentially change significantly if it takes on an even larger flood control role as a result of ongoing Columbia River Treaty discussions.

Table 26 and Table 27 present summaries of the minimum instream flow requirements and reservoir releases governing flows into the State of Washington. Table 26 shows values for high flow years and Table 27 shows values for low flow years.

Table 26. Total average monthly minimum flows allowed by statute for waters entering Washington in high flow years.

Month	Oregon (cfs)	Idaho (cfs)	Dams (cfs)	Total (cfs)
January	3,820	21,405	19,000	44,225
February	4,345	21,405	19,000	44,750
March	5,845	21,405	19,000	46,250
April	5,845	21,405	19,000	46,250
May	5,845	21,405	19,000	46,250
June	5,820	21,405	19,000	46,225
July	3,670	11,861	19,000	34,531
August	3,635	10,449	19,000	33,084
September	3,718	10,449	19,000	33,167
October	3,830	18,449	19,000	41,279
November	3,805	21,405	19,000	44,210
December	3,820	21,405	19,000	44,225

Table 27. Total average monthly minimum flows allowed by statute for waters entering Washington in low flow years.

Month	Oregon (cfs)	Idaho (cfs)	Dams (cfs)	Total (cfs)
January	3,820	14,005	19,000	36,825
February	4,345	14,005	19,000	37,350
March	5,845	14,005	19,000	38,850
April	5,845	14,005	19,000	38,850
May	5,845	14,005	19,000	38,850
June	5,820	14,005	19,000	38,825
July	3,670	10,761	19,000	33,431
August	3,635	9,349	19,000	31,984
September	3,718	9,349	19,000	32,067
October	3,830	9,349	19,000	32,179
November	3,805	14,005	19,000	36,810
December	3,820	14,005	19,000	36,825

5.2.3.3 Instream Flows in Washington State

Ecology's OCR completed an independent analysis of site specific flow levels, drought occurences, and how often instream flows have been met for tributaries to the Columbia River in Washington, using their database of historical flow information. Full results are provided in Appendix D, Historic Stream Flow Data by WRIA. As one example of the type of information that can be gained from these results, by graphing the 1963-2009 flows of the Wenatchee River at Monitor gauge (USGS # 1246200) (Figure 48) it is shown that

- Historic mean annual flows generally varied between 1.5 and 3 million ac-ft.
- Over the last 30 years, dry years (20th percentile or lower) occurred 6 times, with the worst stretch being 3 consecutive dry years in 1992-1994. During this same time period, the availability of water during dry years worsened (18% decrease).
- The instream flow rule is almost always met in average years except in late summer. In dry years, the instream flow is met in early summer and in the winter.
- The magnitude of unmet instream flows is small in this location. For example, in average years, the instream flow deficit for the entire year totals 2,000 ac-ft. The total annual deficit grows to 84,000 ac-ft in dry years.
- Water is available in-basin that could be used to address these instream shortages through OCR-funded projects (e.g. storage, conservation, or pump exchanges). At Wenatchee at Monitor, the annual amount of water surplus to instream flows during an average water year is 1.5 million ac-ft.

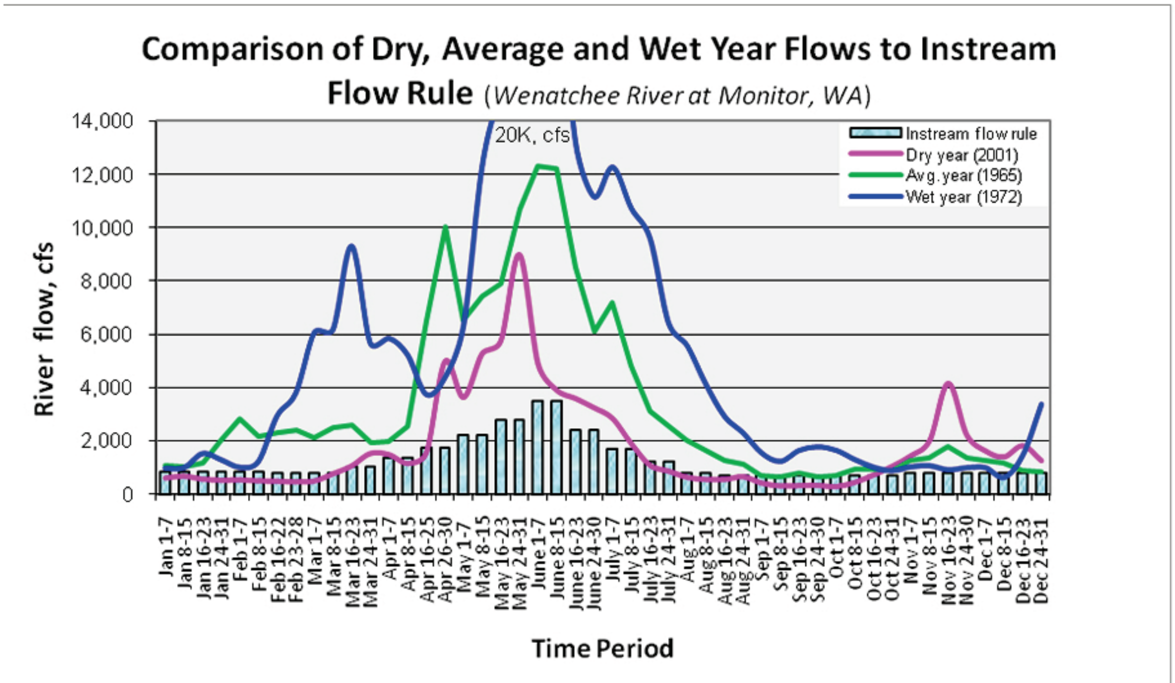

Figure 48. Comparison of actual (not modeled) historical flows (1963-2009) during dry (20th percentile), average (50th percentile), and wet (80th percentile) years to the instream flow rule for Wenatchee River at Monitor.

5.2.4 Columbia River Basin Hydropower Water Demand

Reports covering future hydropower demand for the Columbia River basin that were reviewed as part of the hydropower demand forecast are summarized below. This review included reports carried out in association with the Columbia River Treaty Review, by the Bonneville Power Administration (BPA), Northwest Power and Conservation Council (NWPCC), Avista, Idaho Power, Portland General Electric (PGE), British Columbia Hydro and Power Authority and public utility districts in Grant, Chelan, and Douglas counties in Washington State.

5.2.4.1 Columbia River Treaty Review, Phase 1 Report

In July of 2010, the United States and Canadian Entities of the Columbia River Treaty (Treaty)—Bonneville Power Administration and the Division Engineer of the Northwestern Division of the Army Corps for the U.S. and BC Hydro for Canada—released their Phase 1 Report for the 2014/2024 Columbia River Treaty Review. The Phase 1 Report only looked at future generation based on management of dams to meet power and flood control objectives, which were the two original purposes laid out in the Treaty (Canadian and United States Entities 2010). In September of 2010, the U.S. Entity independently released a Supplemental Report to the Phase 1 Report, which incorporates an additional management objective: the need to provide flows for fish as mandated under the Biological Opinion (BiOp) (NOAA 2008). Neither the Phase 1 Report nor the Supplemental Report incorporate effects of climate change or economic costs and benefits from hydropower, but the potential to include them in the future is there.

The Treaty's Flood Control Operating Plan (FCOP) specifies that flooding begins at approximately 450,000 ft^3/s as measured at The Dalles, Oregon and significant damages in the lower Columbia can occur at 600,000 ft^3/s. Management was assumed to keep flows below one or both of these two flood control thresholds under two alternate scenarios, one in which the Treaty was continued, and one in which the Treaty was terminated. Energy generation under continuation or termination of the Treaty, while keeping flows below the 600,000 ft^3/s flooding threshold is shown in Figure 49. Results which incorporated the 450,000 ft^3/s flood threshold level were generally the same as those that incorporated the 600,000 ft^3/s flood threshold.

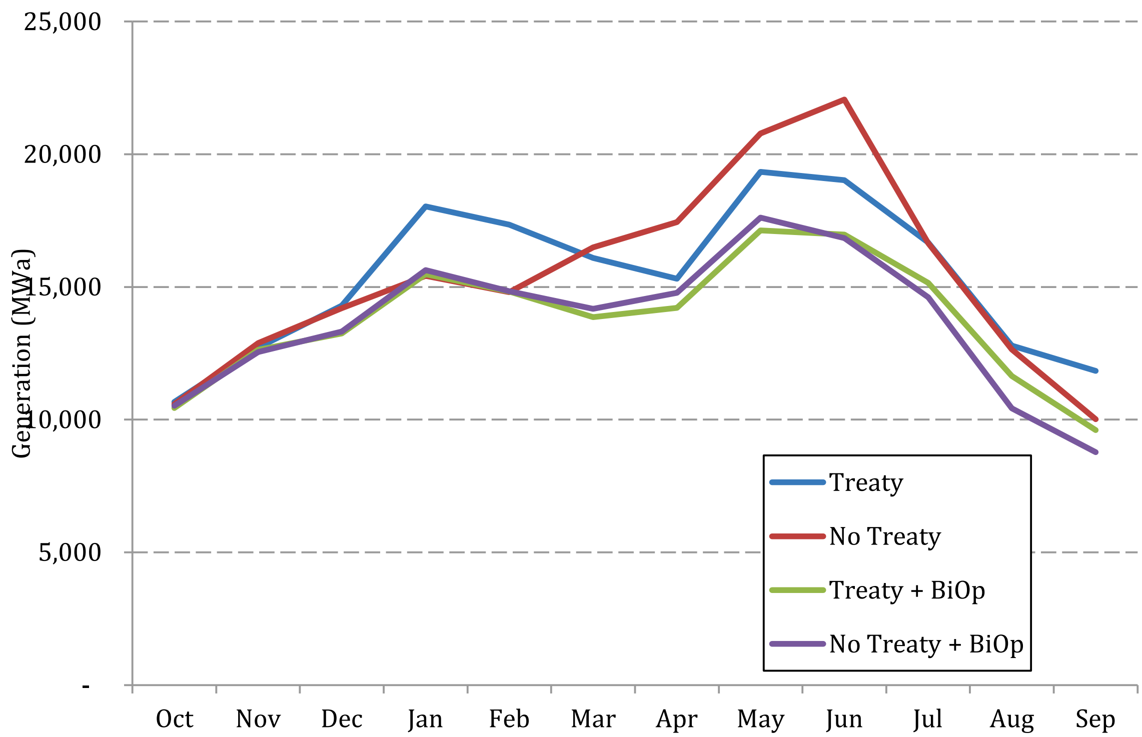

Figure 49. Seventy-year average U.S. system generation when managing dam operations to keep flows below a 600,000 ft^3/s flooding threshold at The Dalles, Oregon (Adapted from United States Entity 2010).

Under the scenarios analyzed, seventy year average U.S. system generation changed in the following ways compared to the baseline:

- Meeting the BiOp requirements and continuing the Treaty decreased U.S. generation potential by 85 to 2,500 aMW throughout the year with no seasonal increases.

- Meeting the BiOp requirements and terminating the Treaty decreased the U.S. generation potential
- In general, incorporating BiOp requirements decreased power generation potential in the U.S., whether or not the Treaty was terminated.

Assuming a goal of having a maximum 450k cfs at Bonneville then the difference between meeting the Biop requirements and not meeting the BiOp requirements is 1523 aMW (compared to 1572 aMW when the Bonneville flow target is 600k cfs) (United States Entity 2010).

Although climate change and economic cost/benefit analysis was not incorporated into the Phase 1 Report or Supplemental Report, the amount of hydropower generation projected by the U.S. Entity would likely be affected by this addition. For example, as temperatures increase, peak stream flows may occur earlier in the spring, and flows may be much lower in summer months. Because it is directly related to stream flows, hydropower production during summer could be further decreased.

5.2.4.2 Sixth Northwest Power Plan

Compounding the problem of decreased power generation is the projection of increased regional demands as discussed in the Northwest Power and Conservation Council's (NWPCC) Sixth Northwest Conservation and Electric Power Plan (2010). Their most recent 2020 and 2030 forecasts for average electricity demand in the region are shown in Table 28, reflecting increased demand due to economic and population growth. Their forecasts of peak power needs are higher than the average demand presented below; for example, winter-peak loads are projected to be approximately 43,000 MWa and summer-peak loads around 39,900 MWa under the medium growth scenario. The NWPCC reported that the current hydroelectric system has a 33,000 megawatt capacity, but it operates at about a 50 percent annual capacity factor because of limited water supply and storage. This may make it difficult for Pacific Northwest power providers to meet projected additional demand through hydropower alone.

Table 28. NWPCC 2010 average electricity demand forecast (MWa) (NWPCC 2010).

Economic Growth	2007 Actual	2010 Projected	2020 Projected	2030 Projected	Growth Rate 2010-2020	Growth Rate 2020-2030	Growth Rate 2010-2030
Low	19,140	18,860	20,463	22,010	0.8%	0.7%	0.8%
Medium	19,140	19,292	21,820	25,275	1.2%	1.5%	1.4%
High	19,140	19,591	22,651	27,761	1.5%	2.1%	1.8%

It may be possible to meet this additional demand through non-hydroelectric energy sources. However, other power sources have drawbacks, including a need for additional water for some sources. For instance, energy from biomass would require additional irrigation, while nuclear power would require water for cooling.

Another approach that could generate additional power to meet growing demand is pumped storage hydropower. Basically, these projects pump water during the winter-spring runoff season (when excess flows are spilled rather than used to generate power). Pumped water is then stored to generate electricity during times of the year when flows are lower. NWPCC reports that 13 pumped storage projects have been proposed in Idaho, Oregon, and Washington, suggesting no shortage of suitable sites. The projects range in size from 180 to 2,000 megawatts and total nearly 14,000 megawatts. Factors influencing the economic feasibility of the projects are site-specific and include the availability of water that can be used for one of the reservoirs (usually the lower), storage capacity, and transmission interconnection distance. Although $1,000 per kilowatt of installed capacity is often quoted as a representative cost of pumped storage hydroelectricity, NWPCC's review of available cost estimates suggests that $1,750 to $2,500 per kilowatt is more representative of current construction costs.

The primary constraints to pumped storage hydropower projects are the complexity and lead time of the development process, capital cost, operation and maintenance costs, and the recovery of revenues for the services provided. Use of renewable energy such as wind and solar to provide power for pumped storage has not been well studied at present but could be a means of lowering costs and providing integrated energy management.

5.2.4.3 Avista's Electric Integrated Resource Plan

In 2009, Avista released their Electric Integrated Resource Plan (IRP) outlining the economic growth forecasts for their service area (Avista Utilities 2009). Avista projects that due to the effects of climate change, summer demand for electricity in 20 years will be about 26 MWa higher than it has been over the last 30 years. Winter loads were forecasted to be approximately 40 MWa lower in 2029, resulting in a net decrease of 14 MWa due to the impacts of climate change alone. Nonetheless, Avista is expecting their annual electricity sales to rise by 1.7% over the next 20 years based on economic and population growth, with volumes increasing to an average value of 199 megawatts.

Avista maintains they will not need additional resources to meet new demands through 2017; however, they will need to change their energy mix in order to meet new regulatory requirements. Specifically, Initiative 937 (I-937), passed by Washington voters in 2006, requires power-generating entities to pursue Renewable Energy Certificates and other qualified renewable energy generation methods. Currently, existing or new hydropower is not considered renewable generation under I-937; however, efficiency improvements at existing facilities do qualify. To meet these requirements, Avista plans to add 150 MW of wind power by 2012 and an additional 200 MW over the resource plan timeframe of 20 years. Other proposed nonrenewable additions over this timeframe include the construction of 750 MW of clean-burning natural gas-fired plants and 5 MW of upgrades to the Little Falls and Upper Falls hydroelectric facilities on the Spokane River. Avista planned to examine larger hydropower upgrades in the 2011 IRP. Avista estimated that conservation could help reduce growth in power demands in their service area by up to 70-75 percent over the next twenty years. This aligns with the NWPCC's projection from its Sixth Power Plan that up to 85 percent of new demand over the next 20 years could be met by conservation.

5.2.4.4 Idaho Power's 2011 Integrated Resource Plan

In June of 2011, Idaho Power released its 2011 Integrated Resource Plan, which focuses on identifying the resources the investor-owned utility plans to utilize in serving their customers over a 20-year planning period. Idaho Power primarily serves Southwestern Idaho throughout the Snake River sub-basin. As outlined in their IRP, average monthly energy load is expected to increase from a median value of 1,819 MWa in 2011 to as much as 2,642 MWa by 2030, representing an average monthly increase of 1.0-1.8% annually from 2011 to 2030. Due to this increase in demand (driven by a projected rise in customers from 492,000 in 2010 to over 650,000 by 2030), Idaho Power believes it will require the addition of new resources to meet the increase in demand. Existing and new energy efficiency programs, which are expected to reduce average load by 233 MWa by 2030, will also be required.

For Idaho Power, development of new large hydroelectric projects is unlikely due to the low number of feasible sites and the environmental and permitting issues associated with the construction of new, large hydroelectric facilities. Small hydroelectric (small-hydro) facilities on the other hand have been widely developed in southern Idaho, namely on irrigation canals. Because small-hydro facilities generally use little to no impoundment of the waterbody (usually meaning a simpler permitting process than large hydroelectric), Idaho Power expressed an interest in evaluating it for its 2011 IRP. The Idaho Strategic Energy Alliance's Hydropower Task Force (2009) found that new small-hydro facilities could produce about 150 MW to 800 MW in Idaho. This was based on upgrading existing facilities, development of existing impoundments and water delivery systems (canals) without current generation, and in-stream flow opportunities.

5.2.4.5 Portland General Electric's Integrated Resource Plan

Portland General Electric's (PGE) 2009 Integrated Resource Plan outlines the investor-owned utility's power planning strategies for a 20-year timeframe. In regard to hydroelectric generation, PGE's two main plants, Pelton and Round Butte, are located on the Deschutes River near Madras, Oregon. PGE's share of output from these facilities is 73 MW and 225 MW, respectively. Pelton and Round Butte will account for about 15% of PGE's 2013 generation capacity, with another 25% coming from other PGE-owned hydroelectric generation and long-term contracts with Mid-Columbia entities. In exchange for paying a share of the plants' costs, PGE receives a proportional amount of output from Douglas County Public Utility District's Wells project and Grant County Public Utility District's Priest Rapids and Wanapum projects. The Wells contract, expiring in 2018, accounts for 147 MW of capacity and 85 MWa of energy under normal water conditions, while the contracts for output from Priest Rapids and Wanapum account for approximately 134 MW of capacity and 69 MWa of energy under normal water conditions (PGE 2009).

Although PGE anticipates needing more than 870 MWa of new resources by 2015 (2009), based on its 2009 IRP, it does not appear that PGE intends to expand its existing hydroelectric resources to achieve this goal.

5.2.4.6 British Columbia Hydro and Power Authority's Electric Load Forecast

Documentation available from BC Hydro is general in nature, but provides some information that helps shed light on future needs for hydroelectricity in Canada. BC Hydro expects that demands may grow as much as 40 percent across British Columbia over the next twenty years. Conservation and transmission improvements are described as playing an important role in meeting this anticipated new demand. Beyond that, Site C Clean Energy Project (outside the Columbia River basin, on the Peace River), if built, could provide up to 1,100 megawatts (MW) of capacity (450,000 homes). Additional capacity at Mica Dam on the Columbia River is anticipated to play a smaller role in meeting new demand; BC Hydro is currently working to add two new generation units (for a total of six). These additional units would not always operate, so although they will provide additional peak capacity of 1,000 megawatts, they are anticipated to serve only 80,000 homes.

5.2.4.7 Washington Public Utility Districts

To get a sense of whether small to medium-sized power providers were concerned about their ability to meet future power demands, we also examined the websites of Chelan, Douglas, and Grant County Public Utility Districts (PUDs) to see if they had any public information related to mitigating potential climate change impacts on hydrograph timing and power demands. Where necessary, this was supplemented with personal calls to selected individuals.

Chelan County Public Utility District

Chelan County Public Utility District (Chelan PUD) operates three hydropower projects: Rocky Reach and Rock Island on the Columbia River and Lake Chelan in WRIA 47. In 2006, a new 50-year license was issued to Chelan County PUD for the Lake Chelan Hydroelectric Project by the Federal Energy Regulatory Commission (FERC). A new 43-year FERC license to operate Rocky Reach Dam was granted in 2009. The license for the Rock Island Hydroelectric Project is valid through 2028. Through these facilities, conservation, and other ongoing activities, Chelan PUD currently feels it will be able to meet projected growth in local demand for electricity.

In 2009, Chelan PUD commissioners expressed interest in working with the Washington State Department of Ecology to identify water-storage sites in Chelan County that could also generate electricity, as part of an overall strategy to explore cost-effective solutions for future energy production.

Douglas County Public Utility District

Douglas County Public Utility District (Douglas PUD) owns and operates Wells Dam on the Columbia River. As anon-federal entity, Douglas PUD needs a license from FERC to operate the dam. As their current license expires on May 31, 2012, Douglas PUD is in the process of filing for a new 50 year FERC license for Wells Dam. Although Douglas PUD believes its resources are sufficient to meet projected future demands, they are considering alternative energy sources to supplement Wells Dam. Douglas PUD expects to receive 3 MWa annually from its shares in Energy Northwest's Nine Canyon Wind Project near Kennewick, Washington. It has also considered wind projects within Douglas County that could produce up to 80 MW at capacity if all sites are developed. While currently cost-prohibitive for Douglas PUD, fuel cell and solar generation are also being examined.

Grant County Public Utility District

Grant County Public Utility District (Grant PUD) operates two large run-of-the-river dams on the Columbia River mainstem, Priest Rapids and Wanapum. It also owns and operates two much smaller projects that are off the Columbia River mainstem, Potholes East Canal Headworks Project and the Quincy Chute Project. In 2008, Grant PUD received a new, 44-year license from FERC to continue operating both Columbia River dams. According to their integrated resource plan that was completed to meet the requirements of House Bill 1010 (HB 1010) concerning energy efficiency and renewable energy standards, peak power demand in Grant County can occur in summer or winter depending on annual temperatures (Figure 50).

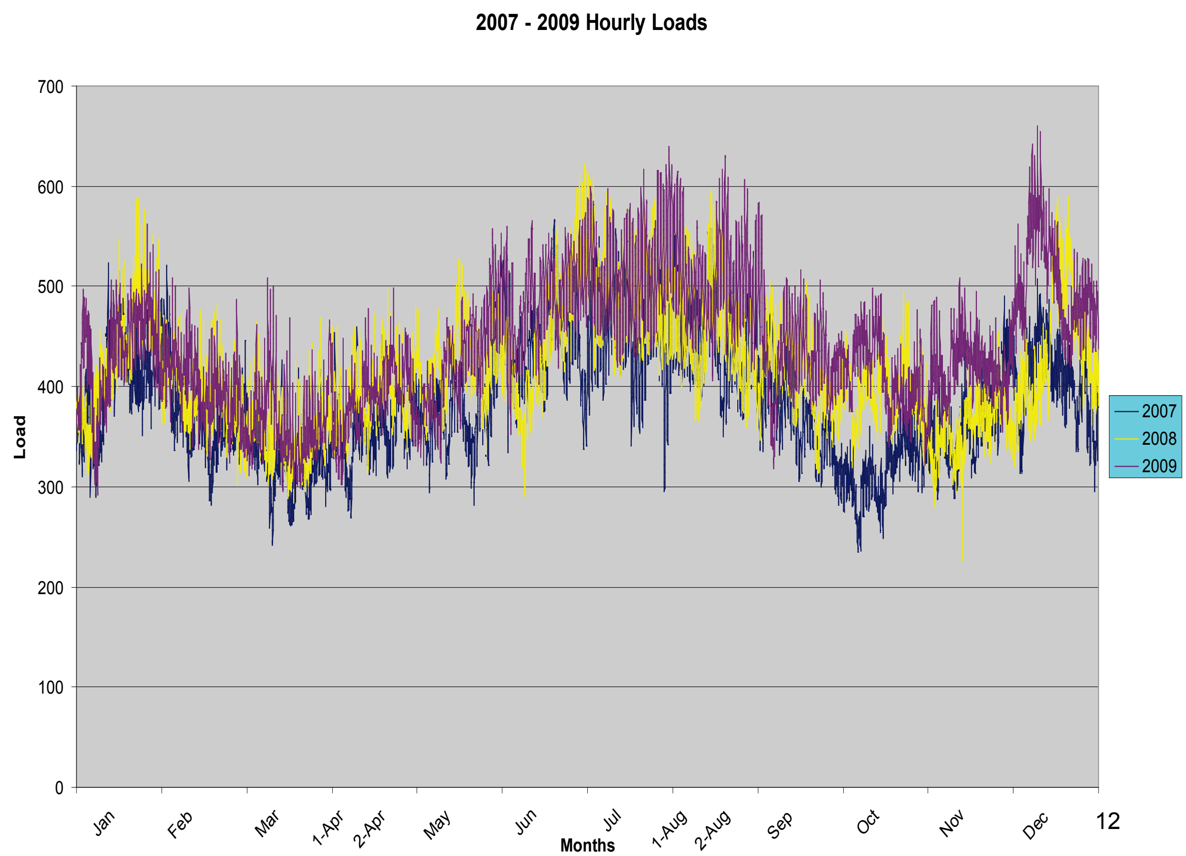

Figure 50. Variation in annual load shape for Grant PUD (from Grant PUD 2010 with permission).

With respect to I-937 and HB 1010, Grant PUD currently holds contracts for 12.54 percent of the power from the Nine Canyon Wind Project owned by Energy Northwest (Grant PUD 2010). This wind power, combined with conservation and improved efficiency efforts (incremental hydropower additions) will likely enable Grant PUD to meet its renewable energy obligations and its forecasted growth in power demands (Grant PUD, 2009). Other bioenergy, geothermal, natural gas, and solar options are constantly being evaluated.

The high capital costs associated with pumped storage hydro projects currently makes this option more expensive than natural gas options. As a result, Grant PUD is not focusing efforts on pumped storage projects at this time.

The PUD has expressed interest in interannual variability in amount and timing of runoff between years (whether or not they are tied to climate change), as this has the potential to impact their operation due to their limited storage potential. In average or above average water years, Grant PUD projects a surplus of energy through 2020. In critical water years, there is a slight deficit that it plans to make up from contract purchases and other options.

5.2.4.8 Review of FERC Licenses

The review of FERC licenses in Washington State found three large proposed projects as measured by proposed additional storage capacity, beyond what is currently in place (Table 29). All three of these projects have been issued a preliminary permit by FERC. Many other projects in the Pacific Northwest are listed on the FERC website. All proposed projects must ultimately obtain a license through FERC before construction. A preliminary permit, which is issued for up to three years, does not authorize construction; its purpose is to maintain priority of application for license while the prospective client studies the site and prepares their license application. It is not mandatory to obtain a preliminary permit in order to secure a license for the project, however, if another party does, they have first rights to the license and therefore the site. Thus, it is likely that projects that are being seriously considered and which are moving towards construction would be reflected in this list.

Table 29. Projects in Washington State issued preliminary permits by FERC (FERC 2011).

Project Name	Licensee	Waterway	Storage (AF)	MW	Iss. Date	Exp. Date
Shanker's Bend	PUD No. 1 of Okanogan County	Similkameen River	1,700,000	Varies	12/18/08	11/30/11
Banks Lake Pumped Storage	BPUS Generation Development	Banks Lake	700,000	1,040	03/06/09	02/28/12
JD Pool Pumped Storage	PUD No. 1 of Klickitat County	Closed System	22,025	1,129	05/05/09	04/30/12

FERC also lists many projects in the basin with pending preliminary permits. These represent preliminary permits which have yet to be approved by FERC. For Washington, the majority of projects at this stage are proposed for canals. The most notable proposed canal project is the Grand Coulee Irrigation District Kinetic Energy project from Pacific Rim Energy at a capacity of approximately 275 MW. Table 30 lists this project and the next five largest canal projects in terms of power generation in Washington. In addition to those listed, 11 other canal projects in Washington have pending preliminary permits, as well as 28 in Oregon and one in Idaho (a complete list can be found on the FERC website, www.ferc.gov). Because these projects are proposed for irrigation canals, they would only use slight changes in the elevation of the canals to produce power and do not intend to store water. In 2009, Grant PUD funded a study to look at the potential for additional hydrokinetic and conventional hydropower on Columbia Basin

Project canals and determined that expansion of the system beyond its current 145 MW could be viable (Knitter 2010).

Table 30. Canal projects in Washington State with pending preliminary permits (FERC 2011).

Project Name	Applicant	MW	Filing Date
Grand Coulee Irrigation District Kinetic Energy	Pacific Rim Energy	274.95	12/06/10
Sunnyside Valley Irrigation District KE	Pacific Rim Energy	27.60	12/06/10
Kittitas Reclamation District Kinetic Energy	Pacific Rim Energy	16.50	12/06/10
Roza Irrigation District Kinetic Energy	Pacific Rim Energy	11.10	12/06/10
Yakima-Tieton Irrigation District Kinetic Energy	Pacific Rim Energy	11.10	12/06/10
Ellensburg Water Company Kinetic Energy	Pacific Rim Energy	5.55	12/06/10

5.2.4.9 Conclusions of Hydropower Forecast

Based on the reviewed documents and FERC licenses, utilities throughout the U.S. portion of the Columbia River basin expect to be able to meet projected steady growth in peak winter and summer energy demands through conservation and integration of other energy sources. New non-hydroelectric projects will likely be needed to meet other requirements such as those in I-937.[8] In the Canadian portion of the Columbia River basin, BC Hydro expects that increases in demands will largely be met through conservation, transmission improvements, and potentially the Site C Clean Energy Project, if built (outside of the Columbia River basin). Two planned additional generation units at Mica Dam will also likely contribute.

Several power entities mentioned concerns about the potential for climate variability and possible renegotiation of the international Columbia River Treaty to disrupt or reduce

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[8] I-937 requires that power-generating entities pursue Renewable Energy Certificates and other qualified renewable energy generation methods. Qualified methods do not include existing hydropower, except for new conservation and efficiency measures.

hydropower generation capacity. Potential impacts of the Columbia River Treaty are discussed in Section 5.1.2, covering water supply results.

Power entities in the Columbia River basin think it is unlikely that new storage reservoir projects will be needed solely to meet growing power demands within the next two decades, but they may be needed to help meet other future surface water supply demands. If additional storage projects are built for water supply purposes, pumping associated with the storage will likely create additional power demands, justifying the expansion or upgrading of hydroelectric facilities. It may also be feasible to generate power as an ancillary benefit at a new storage project, if one is built.

5.3 Impact of Deficit Irrigation on Crop Yield and Production Value

5.3.1 Impacts of Deficit Irrigation on Crop Yield

Figure 51 through Figure 53 below show the impact of curtailment on the yields of several representative crops (averaged over 30 years). Results for additional crops can be found in Appendix F. The figures represent impacts for the historical as well as the middle 2030s climate scenario and the values represent the fraction of full yields that are obtained under curtailment (on average over 30 years). For example, a value of 0.9 should be interpreted as 90% of the full yield being obtained under curtailment.

It must be noted that the future 2030s scenario for the Odessa area assumes that groundwater sources for irrigation are unavailable and hence does not fulfill any irrigation requirement of the crops. However, the model does not alter the 2030s crop mix to account for any conversion to dryland agriculture. In reality, if groundwater is not available for irrigation, the crop mix in those areas can be expected to change to some form of dryland agriculture (e.g. dryland wheat).

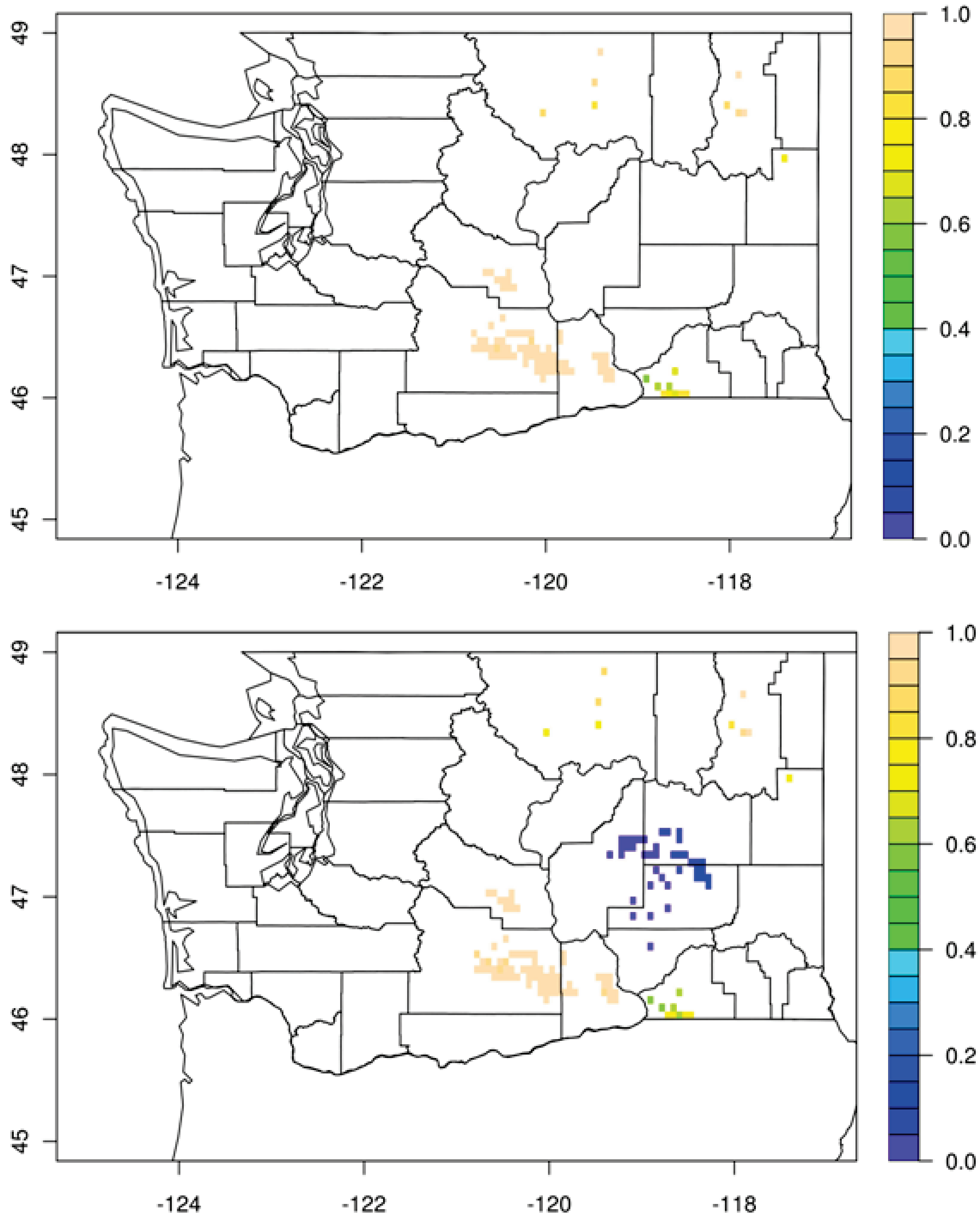

Figure 51. Impact of curtailment on alfalfa yields for the historical simulation (top) and future middle climate scenario (bottom).

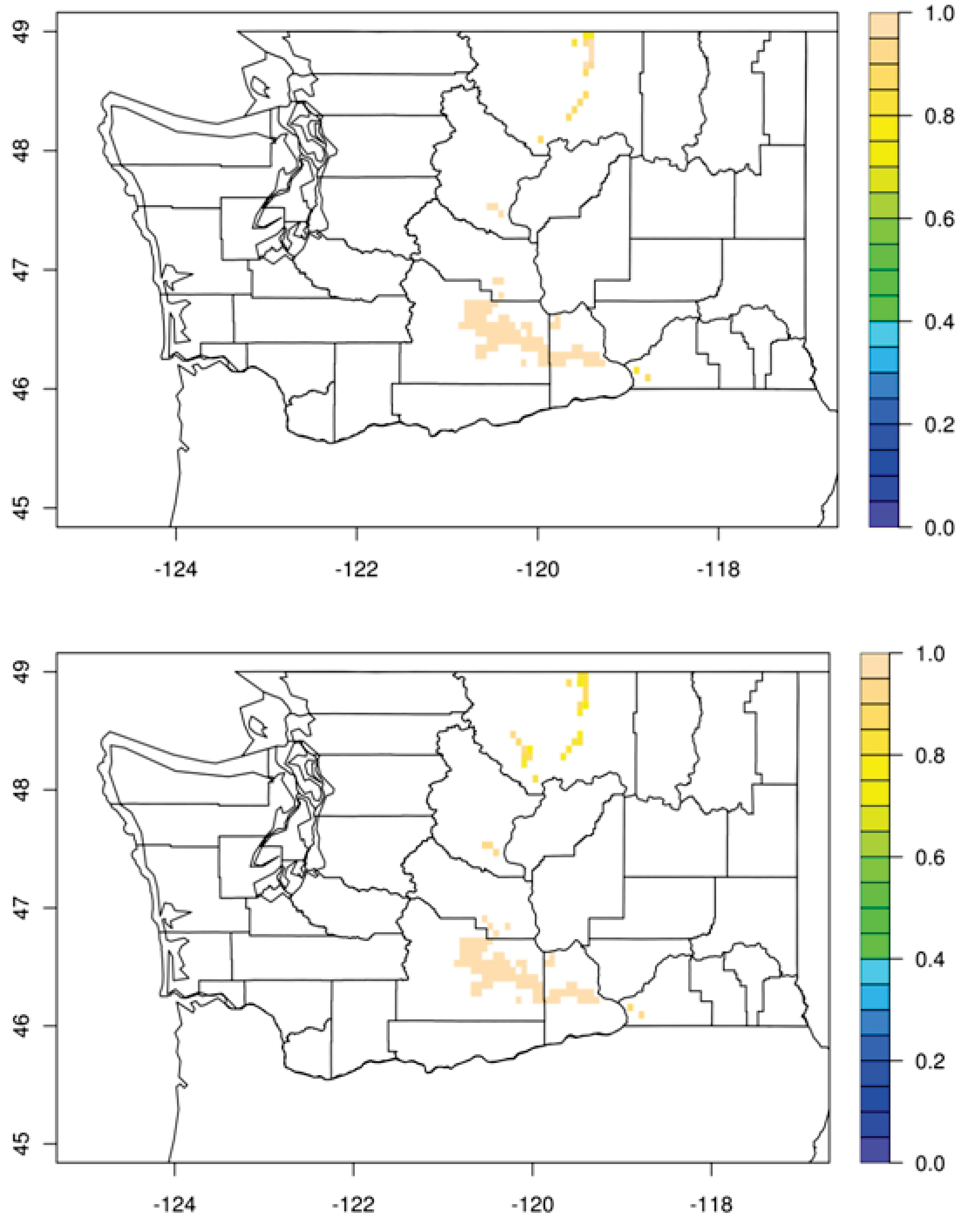

Figure 52. Impact of curtailment on apple yields for the historical simulation (top) and future middle climate scenario (bottom).

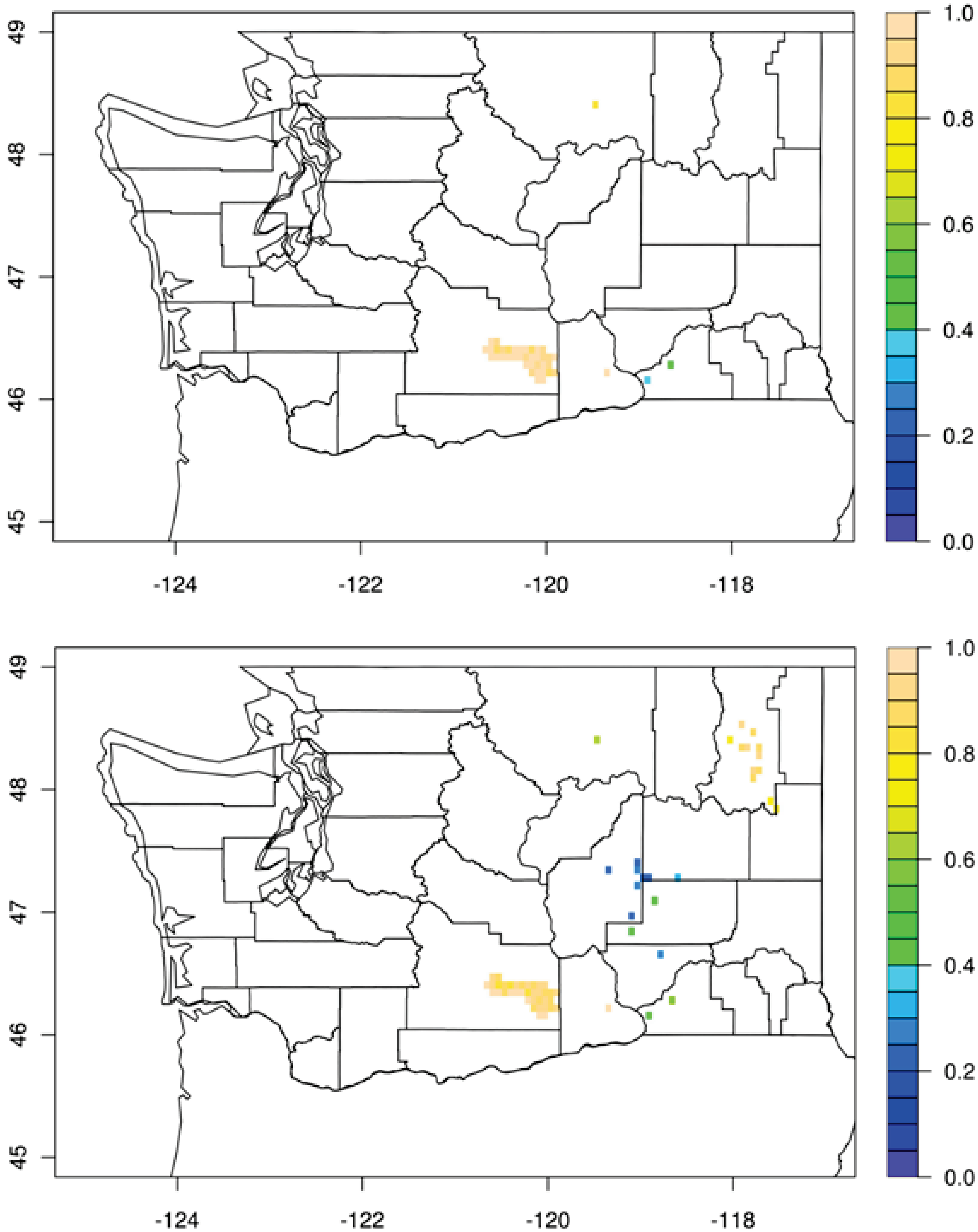

Figure 53. Impact of curtailment on corn yields for the historical simulation (top) and future middle climate scenario (bottom).

5.3.2 Impact of Deficit Irrigation on Production Value

Based on future yield and climate the value of lost production due to curtailment of interruptible rights holders was $80 million. These costs were concentrated in Walla Walla ($12 million), Yakima ($14 million), Grant ($12 million), and Lincoln ($30 million) Counties. Most of the lost revenue in Lincoln County was from winter wheat. Grant County primarily lost production of alfalfa. Lost production in Walla Walla and Yakima County was for forage crops.

There are contrasting reasons to suggest that these estimates could potentially be over or underestimated. They would be underestimated if there are a significant number of interruptible rights holders that only have land in high value crops and there is no potential for small scale water transfers. If they do not have low value crops to deficit irrigate and cannot obtain a one-time transfer of water from another rights holder then they would be forced to deficit irrigate a higher value crop. The rationale for these numbers being overestimated is that the potential for producers to increase the efficiency of their irrigation in the short was not considered. In some cases it is possible that production could be maintained with less water if a producer spent more time managing their irrigation schedule to improve efficiency. Of course, this additional time spent on managing irrigation scheduling would also represent a cost to the producer.