

BENEFIT-COST ANALYSES OF THE YAKIMA BASIN INTEGRATED PLAN PROJECTS

REPORT TO THE WASHINGTON STATE LEGISLATURE

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I. Executive Summary

The Yakima River Basin lies in semi-arid south central Washington and supports a growing population as well as \$3 billion agricultural industry that is heavily dependent on irrigation for production. The river system historically supported large runs of salmon and steelhead, but a variety of stressors both internal and external to the basin have reduced those populations substantially since the early 20th century. A reservoir system supplies water through the operation of five reservoirs with a combined storage totaling just over a million acre-feet (af). Stream flow is primarily derived from the spring snowmelt runoff. Precipitation in this area is winter-dominant, and is stored in the snowpack as a natural but seasonally declining reservoir for spring and summer water use. Water rights in the basin are over appropriated such that a number of droughts in the last few decades have led to curtailment of water to junior water rights holders. Historical drought impacts, concerns over the effects of climate change on snowpack, the potential for increasing anadromous fish abundance in the basin, and future municipal water demands have been the impetus for the development of the Yakima River Basin Integrated Water Resource Management Plan (“IP”). The IP includes the following elements:

- Reservoir Fish Passage
- Fish Habitat Enhancement
- Modifying Existing Structures and Operations
- Surface Storage
- Market-Based Reallocation
- Groundwater Storage
- Enhanced Water Conservation

Fish passage projects, habitat enhancements, and instream flow augmentation are designed to support increases in salmon, steelhead, and other fish populations in the basin. Proposed infrastructure and water market development are intended to mitigate instream and out-of-stream drought impacts through increased storage and improved water trading, respectively. In particular, the surface water and groundwater storage projects would increase cumulative water storage by 500,000 af for a total of 1.5 million af in the basin.

Many analyses of IP and its components have been published to date. One of them, the “Four Accounts analysis” (2012), compares the net benefits of the IP as a whole against a no-IP alternative, and reports benefits ranging from \$6.2 billion to \$8.6 billion, and costs ranging from \$2.7 billion to \$4.4 billion. The reported Benefit/Cost (B/C) ratios range above 1.4, suggesting that the benefits of the IP as a whole outweigh its costs in aggregate net present value. These B-C estimates are provided for the full proposed implementation of IP, but existing analyses do not provide estimates of the net benefits of the individual components of the IP.

Section 5057 of the State of Washington Capital Budget for 2013 charges the State of Washington Water Research Center “to prepare separate benefit-cost analyses for each of the projects proposed in the 2012 Yakima river basin water resource management plan [IP]”. It further stipulates that “To the greatest extent possible, the center must use information from existing studies, supplemented by primary research, to measure and evaluate each project’s benefits and costs.” This report is in response to and limited by this charge.

Existing hydrologic and water management models of the Yakima River basin are used to examine the impact of proposed IP water storage projects, conservation, and proposed instream flows on drought impacts under a limited set of climate scenarios. A crop production model is used assess the potential economic impact of IP projects and water market development on water curtailment risk. Municipalities in the basin are slated to receive water rights for future population growth under the IP, and these benefits to

municipalities are presented. The net benefits of fish passage for the five reservoirs in the basin, proposed IP instream flows, and habitat restoration in support of salmon and trout in the basin are assessed.

Because each of the proposed IP projects would operate within the Yakima Basin hydrologic system, there are extensive interdependencies among projects, so that the benefits of one project are often dependent on the implementation status of other projects. We show that the value of any given water storage projects is highest when no other water storage project is implemented, and that water market development also affects the value of water storage projects. The economic tradeoffs between instream flows for fish and out-of-stream water uses are also dependent on these factors. Selected specific results include the following:

- *The major storage projects of the IP, when implemented together, are unlikely to provide positive net benefits.* Based on moderate climate and market conditions, storage infrastructure projects implemented as part of the full IP would result in the following out-of-stream benefits:
 - Agricultural irrigation benefits: \$97.5 million
 - Municipal and domestic benefits: \$27 million
 - Net present value (NPV) of out-of-stream uses from the IP: -\$2,500 million (B/C = 0.04).
 - Benefits of proposed instream flow increases are very unlikely to make up for this shortfall.
- *Net benefits for individual water storage projects are negative, with some exceptions under the most adverse climate and water market conditions.* Based on moderate climate and market outcomes, storage infrastructure projects implemented alone and without proposed IP instream flow augmentation would result in the following (negative) estimated out-of-stream net present value and B/C ratios:
 - Bumping Lake Expansion: NPV= -\$380 million; B/C ratio of 0.16.
 - Cle Elum Pool raise: NPV= -\$6 million; B/C ratio of 0.65. Only the Cle Elum Pool raise would satisfy a B-C criterion under moderate market regime and the most adverse climate scenario (CMIP3 HADGEM1).
 - Keechelus to Kachess Conveyance: NPV= -\$110 million; B/C ratio of 0.21.
 - Kachess Drought Relief Pumping Plant: NPV= -\$121 million; B/C ratio of 0.38.
 - Wymer Dam and Reservoir: NPV= -\$981 million; B/C ratio of 0.06. This B/C ratio is lower than previous estimates for reasons explained in the report.
- *Instream flow benefits for fish are insufficient to support water storage infrastructure given the net benefit shortfall in out-of-stream use benefits, but proposed instream flows may be supportable through market purchases.*
 - The upper bound on benefits from proposed IP instream flows are insufficient to cover the \$2.0 to \$2.5 billion in net losses from IP storage infrastructure.
 - Purchases of senior water rights to implement proposed IP instream flows would be substantially less expensive than providing instream flows via IP storage infrastructure (at a lower bound cost of around \$100 million). Such purchases may be supportable if the market infrastructure develops to do so, but available estimates of instream flow benefits are imprecise. Further, the simulated reductions in diversions amount to about 80,000 af/year represents about 4% of the 2 million af of water rights held in the five major federal districts, and about 9% of nonproratable rights. Transfer of this amount of senior water rights out of irrigated agriculture may have important local economic and public finance consequences in the basin.
- *Insufficient evidence exists to assess the economic efficacy of fish habitat restoration with a useful degree of precision.* Results for the net benefits of instream flow purchases and restoration investment together are ambiguous in that the estimated range of B/C ratios spans 1.
- *Reservoir fish passage projects are likely to provide positive net benefits through their pivotal role in supporting wild Sockeye reintroduction into the basin.* A deconstruction of the Four Accounts analysis suggests that fish passage could contribute from \$4 billion to \$6 billion in net benefits at a cost of about 0.35 billion (\$350

million), and B/C ratio of 13 or higher. These benefit estimates are likely biased upward, but existing data are insufficient to convincingly refute them. Nonetheless, these estimates could be biased upward by a factor of 13 and still support investment in fish passage.

- *Water markets show potential for reducing the impacts of basin-wide curtailment.* We estimate net gains from trade to range between \$88 million and \$1.5 billion depending on climate and the extent of market development. Further, we show that markets act as a substitute for IP water storage infrastructure in that more active markets reduce the value of IP water storage infrastructure.

This report is not intended to be a review of prior benefit-cost estimates of the IP, but does utilize and modify existing IP analyses to varying degrees, and sheds some light on the sources and accuracy of the \$6 billion to \$8 billion in estimated benefits in the Four Accounts analysis.

This study shows that the assumed climate regime has substantial consequences for agricultural benefit estimates and drives some of the differences in results in this report compared to the Four Accounts analysis. Our estimate of municipal benefits is substantially lower than in the Four Accounts analysis and prior related reports.

This study also shows that based on the Four Accounts analysis, fish passage projects alone comprise 15% of median IP costs but provide about 75% of their estimated benefits of the IP. In contrast, IP investments for instream and out-of-stream uses account for about 66% of median costs but provide a small fraction of benefits. This distribution of costs and benefits drives the strong results for fish passage but is not apparent in the Four Accounts analysis. We also find that empirical uncertainty surrounding the impact of instream flows and restoration activities on fish abundance makes it difficult to provide usefully precise economic impact estimates or to refute the existing estimates.

In accordance to the legislative charge, this report focuses sharply on Benefit-Cost analysis to assess the economic efficacy of individual projects. It does not include an economic *impact analysis* to assess the broader economic impact of those investment decisions on the local or regional economy. Nor does this report cover existing costs and benefits from ongoing, non-IP programs within the basin whose outcomes may impact IP benefit metrics, such as fish supplementation or other hatchery operations.

Due to data limitations, the majority of the results are based on simulation methods rather than statistical analysis, though statistical analysis is provided when feasible and useful. The consequence is that although some robustness exercises are performed, the majority of our results do not lend themselves to statistical confidence assessment. Many necessary tradeoffs were made with respect to modeling approaches due to the scope of this research mandate. Refinements are certainly possible and may be warranted for any given modeling approach relied upon in this analysis. However, the nature of the benefit-cost outcomes suggests that the fundamental economic implications will be relatively robust to refinements.