Yakima River Basin Integrated Water Resource Management Plan

Four Accounts Analysis of the Integrated Plan

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ

Prepared by

ECONorthwest
Natural Resources Economics
ESA

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

October 2012

MISSION STATEMENTS

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The Mission of the Washington State Department of Ecology is to protect, preserve and enhance Washington's environment, and promote the wise management of our air, land and water for the benefit of current and future generations.

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1.0 Introduction

The Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan) identifies a range of projects and programs to address long-standing needs for ecological restoration and water supply in the Yakima River Basin (Reclamation and Ecology, 2012a). This *Four Accounts Analysis of the Integrated Plan Technical Memorandum* is prepared as supporting technical information included in the *Framework for Implementation Report* and supplements prior economic analysis of the Integrated Plan by providing more extensive analysis of its costs and benefits compliant with Federal guidelines for analysis of water resource projects.

1.1 Overview of the Integrated Plan

The Integrated Plan addresses a variety of water resource and ecosystem problems in the Yakima River Basin using a comprehensive approach to water resource management and habitat enhancement. The seven elements of the Integrated Plan and summary of all of the projects and programs under each element are listed in Table 1. Figure 1 shows the geographic distribution of these elements of the Plan.

1.2 Economic Analysis in the Context of the Integrated Plan

The analysis of the Integrated Plan's economic characteristics presented in this report is consistent with the Federal objective of water and related land resources project planning. The *Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*) distinguishes between four accounts: the National Economic Development (NED) account, the Regional Economic Development (RED) account, the Environmental Quality (EQ) account, and the Other Social Effects (OSE) account. As stated in the *Principles & Guidelines*, the NED account is required, while the other accounts may contain additional materials relevant to the decision-making process.

More specifically, the *Principles & Guidelines* describes the four accounts as follows:

- **The National Economic Development (NED) account** displays changes in the economic value of the national output of goods and services. The Federal objective is to contribute to national economic development consistent with protecting the Nation's environment. The NED account measures the beneficial and adverse monetary effects of each alternative in terms of changes in the value of the national output of goods and services.
- **The Regional Economic Development (RED) account** registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population. This account evaluates the beneficial and adverse impacts of each alternative on the economy of the affected region, with particular emphasis on income and employment measures. The affected region reflects the geographic area where significant impacts are expected to occur. Impacts can be measured in both monetary and nonmonetary terms.

- **The Environmental Quality (EQ) account** displays nonmonetary effects on significant natural and cultural resources. This account displays the effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources which cannot be adequately measured in monetary terms within the NED and RED accounts.
- **The Other Social Effects (OSE) account** registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

Table 1. Elements and Associated Actions Included in Integrated Plan

Action	Description
Fish Passage	
Clear Creek Dam passage	Improve upstream and downstream fish passage at Clear Lake
Cle Elum Dam passage	Add upstream and downstream fish passage facilities at other existing dam sites
Bumping Dam passage	
Tieton Dam passage	
Keechelus Dam passage	
Kachess Dam passage	
Structural and Operational Changes	
Raise Pool at Cle Elum Dam	Three-foot increase in storage pool elevation
KRD Canal Changes	Reduce seepage and enhance tributary flows
Keechelus to Kachess Pipeline	Optimize storage between two reservoirs
Subordinate Power at Roza Dam and Chandler Power Plants	Reduce water diversions to support fish migration
Wapatox Canal Improvements	Improve efficiency and consolidate diversions
Surface Water Storage	
Wymer Dam	New off-channel reservoir (162,500 acre-feet). Also investigate removal of Roza Dam
Lake Kachess Inactive Storage	Tap inactive storage volume (up to 200,000 acre-feet)
Enlarged Bumping Lake Reservoir	Enlarge reservoir to 190,000 acre-feet
Columbia River Pump Exchange with Yakima Basin Storage	Conduct feasibility study; and periodically evaluate need for additional supplies
Groundwater Storage	
Shallow Aquifer Recharge	Late winter/early spring infiltration prior to storage control
Aquifer Storage and Recovery	Off-season recharge of municipal supplies
Habitat Protection and Enhancement	
Mainstem Floodplain Restoration	Program to fund a range of fish habitat projects
Tributaries Habitat Enhancement	Program to fund a range of fish habitat projects
Targeted Watershed Protection and Enhancements	Program to acquire and protect sensitive lands, including aquatic and terrestrial habitats
Enhanced Water Conservation	
Agricultural Water Conservation	Program to fund a range of projects
Municipal Water Conservation	Program to fund a range of projects and encourage conservation by residents
Market Reallocation	
Near-term Effort	Reduce barriers to trading
Long-term Effort	Additional steps to reduce barriers
Source: Reclamation and Ecology, 2012a Notes: KRD = Kittitas Reclamation District	

Figure 1. Distribution of Projects Proposed under the Integrated Plan, by Component Group

Source: Reclamation and Ecology, 2012a

2.0 National Economic Development Account

This section focuses on the NED account, which measures the benefits and costs to the Nation. The *Principles & Guidelines* expresses this definition of the Federal objective: "to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements." The Water Resources Development Act of 2007 (Sec. 2031) updates the Federal objective and specifies that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

- Seeking to maximize sustainable economic development.
- Seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used.
- Protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

This Federal objective, when applied in the context of the complex water management challenges addressed by the Integrated Plan and the competing demands for limited Federal resources, means that Federal investments in water resources should consider the net public benefits resulting from them. Reclamation has offered this explanation of the public benefits from water-related investments:

> *Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the inclusion of quantified and non-quantified measures. .... [I]n addition to traditional, monetized economic development, projects that contribute to Federal ecosystem and species restoration goals are relevant components of water project planning and development. Economic evaluation provides a way to understand and evaluate trade-offs that must be made between alternatives with respect to objectives, investments, and other social goals. It also provides a means to identify the plan that is acceptable, effective, efficient, and complete, and contributes the most favorably to national priorities*. (Reclamation, Mid-Pacific Region, 2011)

NED benefits are increases in the total value of the national output of goods and services that can be expressed in monetary units. They include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed. NED costs are the opportunity costs of resources used in implementing the Integrated Plan. Opportunity costs could reflect decreases in output, or employment losses resulting from the Integrated Plan.

The NED analysis reported here for the Integrated Plan describes three categories of economic benefits: increases in fish populations, improvements in municipal and domestic water supply; and increases in the reliability of irrigation water during severe drought years. The computation of the different categories of benefits involves analytical methods recommended by the *Principles & Guidelines*.

Fish-Related Benefits: The computation of the value of the fish-related benefits applies the *Principles & Guidelines*' preferred indicator for measuring the value of economic benefits: society's willingness to pay (WTP) for the benefits. The computation employs an analytical approach called benefit transfer. It involves computing the value of the fish-related benefits that would be produced by the Integrated Plan using values determined in a separate study that addressed similar issues in a broader region (the Columbia River Basin) that includes the Yakima River Basin.

Applying the results of a study conducted in one setting to estimate the value of economic benefits in another setting introduces uncertainty about the reliability of the results, with the uncertainty increasing as the similarity between the two settings diminishes. In this instance, though, the reliability of the estimates of the Integrated Plan's fish-related benefits is enhanced because the benefit-transfer process applies the results of a highly regarded study (Layton et al., 1999) that estimated households' average willingness to pay for actions similar to those included in the Integrated Plan to bring about similar increases in salmon populations in the Columbia River Basin, which encompasses the Yakima River Basin. This analysis transfers that study's results to estimate households' average willingness to pay for the future increases in salmon/steelhead populations expected to result from the Integrated Plan, and multiplies this amount times the number of households to estimate the total value of the expected increases. The analysis uses two groups of households for the computation: one includes only households in Washington, the other uses households in Washington and Oregon.

Irrigation-Related Benefits: The computation of irrigation-related benefits focuses on the increase in farmers' net income expected to result from the Integrated Plan. The analysis first determines the expected increase in crop yield for those farmers who would receive additional water supplies during severe drought years in the Yakima River Basin. It then multiplies the increase times an estimate of the net farm income per unit of each crop. This calculation provides the net benefits to farmers receiving the additional water. The analysis then considers potential impacts on farmers elsewhere, recognizing that the increase in crop yield by the farmers receiving additional water may decrease the price farmers elsewhere receive for their crop. The final result represents the overall net change in crop value, from a national perspective.

Municipal and Domestic Benefits: The computation of the Integrated Plan's benefits associated with water for municipal and domestic uses has two components. One estimates the market price of the additional water the plan would make available to support anticipated population and economic growth in the basin. It first determines the amount of additional water that would be available in future years for municipal and domestic use, if the Integrated Plan were implemented. It then multiplies this amount times an estimate of the wholesale price of water for municipal and domestic use. The other estimates the willingness of current municipal and domestic groundwater users above Parker Gage to pay for increased security in their water supplies. It first measures the amount of senior water rights these users would have to acquire to prevent legal action that would disrupt their consumptive use of groundwater during drought years. It then estimates the groundwater users' willingness to pay for the senior water rights and subtracts the value of the agricultural production that would be lost when senior rights are transferred from irrigation to municipal and domestic uses. It then multiplies the difference between these two values, which represents the net economic benefit of the transfer of water rights, times the amount of senior water rights the municipal and domestic users would have to acquire to prevent legal action that would disrupt their consumptive use of groundwater during drought years. The sum of the values for the two components of the computation provides the total economic benefit of the increased supply of water for municipal and domestic uses.

The Integrated Plan likely would produce other types of benefits important to national economic well-being. This report does not include them in the NED account, however, because insufficient information currently exists to describe them in the monetary terms required by the *Principles & Guidelines*. These additional expected benefits include, but are not limited to:

- **Unquantified salmon/steelhead benefits.** These benefits would include the unquantifiable cultural and spiritual values that members of the Yakama Nation and others associate with increases in salmon/steelhead populations. These are in addition to the quantified benefits.
- **Unquantified benefits from increases in the populations of other valuable species.** This category includes species other than salmon/steelhead. The Integrated Plan, for example, is expected to help increase populations of bull trout, a species listed as threatened under the Federal Endangered Species Act.
- **Unquantified irrigation-related benefits.** The additional benefits likely would materialize in several ways. The Integrated Plan likely would enable irrigators in beneficiary districts to have access to additional water supplies during years with less than a severe drought. It also likely would result in greater net farm earnings by stimulating market-based water reallocation across the basin, not just for irrigators in the five beneficiary districts, and in all future years, not just those with a severe drought. Reductions in barriers to market-based water transfers, together with increased water supplies, would increase the security of water supplies for irrigators currently using groundwater. If drought conditions become even more severe than assumed, irrigators outside the five beneficiary districts might also realize benefits from the Integrated Plan.
- **Unquantified benefits from increases in the net value of recreational opportunities.** This category includes recreational benefits other than those already incorporated in the valuation of larger fish populations. They might occur, for example, as recreation opportunities in upland forests improve as a result of the Integrated Plan.
- **Unquantified benefits from improved resiliency and adaptability of the water system.** The Integrated Plan is expected to improve the ability of water users and water management agencies in the Yakima River Basin to respond successfully to a wider set of disturbances, such as more severe drought than is currently expected, or more diverse demands for water.
- **Unquantified climate-change benefits.** Climate change is expected to increase the frequency and severity of droughts in the Yakima River Basin. The economic analysis of irrigation-related benefits and costs focuses on recent drought frequency and severity, with a sensitivity analysis that considers alternative assumptions about the future severity of severe droughts. Other components of the analysis do not directly consider the other benefits that would materialize from the Integrated Plan’s impacts on water supply and quality with increased drought frequency or severity.

This section describes the economic value, over the next 100 years, of three potential benefits associated with the Integrated Plan: (1) fish benefits, (2) irrigation benefits, and (3) municipal and domestic water supply benefits. The memorandum also describes the economic value, over the next 100 years, of the anticipated costs of implementing the Integrated Plan in terms of capital costs, operation and maintenance costs, and the costs associated with periodic replacement of major components. Table 2 summarizes the overall present value[1] of the benefits and costs over the next 100 years for each benefit/cost category.

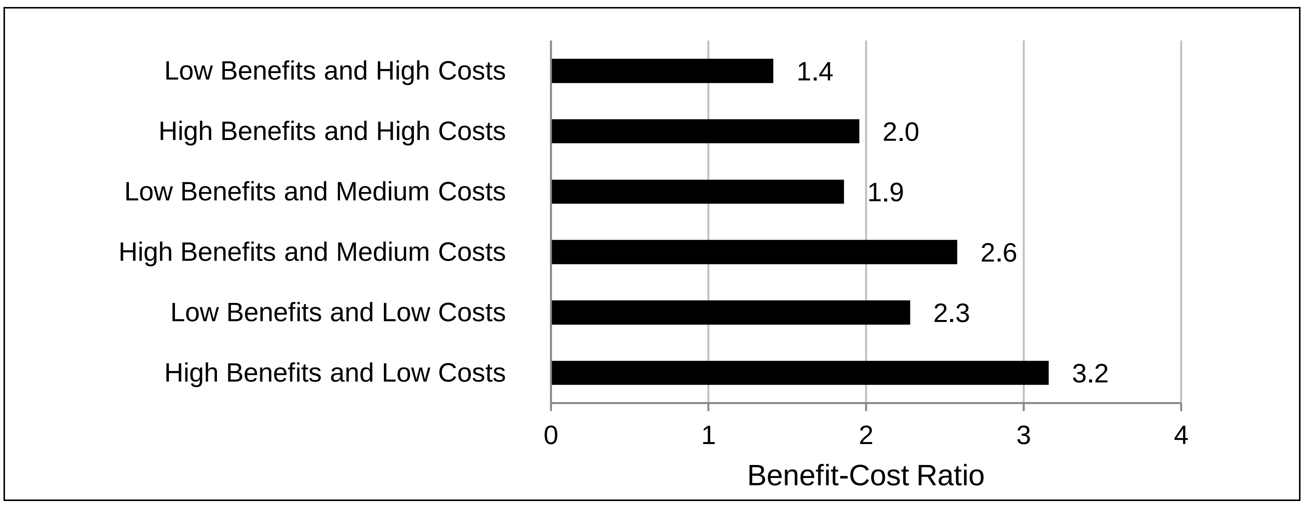
Table 2. Summary of Benefits and Costs

Benefit/Cost Category	Overall Present Value over 100 Years (2012$)
Fish Benefits	$5.0 billion - $7.4 billion
Irrigation Benefits	$0.8 billion
Municipal and Domestic Water Supply Benefits	$0.4 billion
Costs	$2.7 billion - $4.4 billion

When comparing the benefits and costs of a project, a benefit-cost ratio is used to determine the extent to which the benefits outweigh the costs, or vice-versa. If the benefit-cost ratio is greater than one, the benefits outweigh the costs; if it is less than one, the costs outweigh the benefits. In this instance, where there are several ranges of potential benefits and potential costs, several benefit-cost ratios must be calculated. Figure 2 summarizes the full range of benefit-cost ratios.

Using the high-end value of benefits and the low-end value of costs generates the largest benefit-cost ratio, 3.2. Using the low-end value of benefits and the high-end value of costs generates the smallest benefit-cost ratio, 1.4. In all cases, however, the benefit-cost ratio is greater than one, which means that the value of the benefits associated with the Integrated Plan outweighs the value of its costs.

Figure 2. Summary of Benefit-Cost Ratios

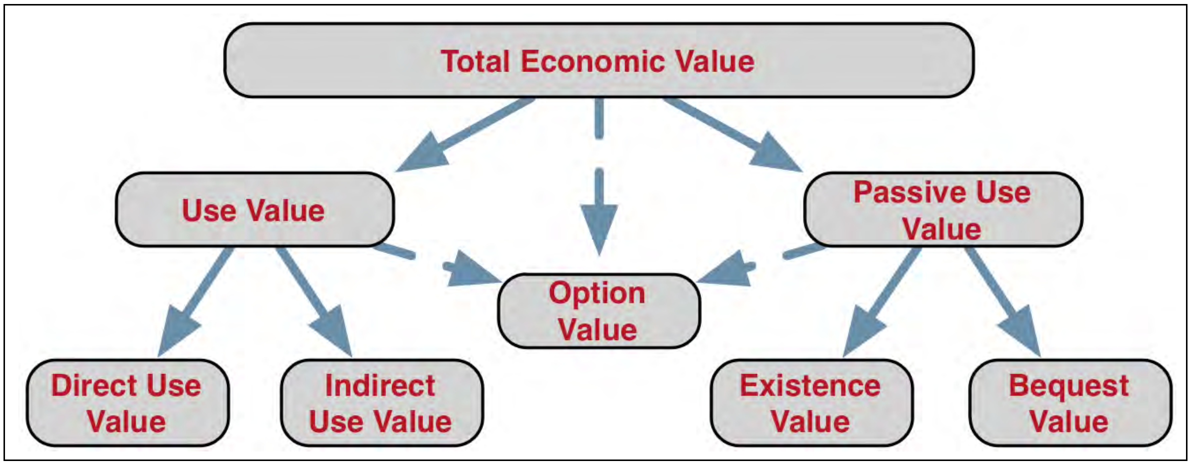


[1] "Present value" is a standard concept used in economics to compare costs or benefits that would occur at different times in the future. It is computed by discounting future costs and benefits by a percentage rate that compounds over time. The overall effect is that, all else equal, costs or benefits that occur in the present or near future are valued more than costs or benefits that will occur in the more distant future.

2.1 Fish Benefits

The Integrated Plan would potentially generate economic benefits by increasing future populations of young salmon/steelhead (fish) produced in the Yakima River Basin as well as the numbers of adult fish returning to the basin. Increases in fish populations can yield economic benefits in several ways. Economists often distinguish among the categories of value shown in Figure 3. One general category, called "use value," concerns activities such as commercial and recreational fishing, during which individuals directly interact with and can extract fish from the environment. It also includes values generated indirectly by salmon/steelhead, as when the carcasses of salmon that have spawned and died provide nourishment for other fish and wildlife important to humans.

Figure 3. Components of Total Economic Value



The other general category, called "passive-use value," (or, sometimes, "non-use value") does not require this direct interaction and use. It occurs when people place importance on the continued existence of fish and on ensuring that fish would be available for the enjoyment of others, such as future generations. People can assign a use value or a passive-use value, or both, to a resource to represent their current relationship with the resource. People can also assign value to maintaining the option of establishing the relationship in the future. When combined, use values and passive-use values (together with their option values) sum to total economic value (Tietenberg, 2000).

This section describes the potential fish-related economic benefits of the Integrated Plan.[2] It first describes the Integrated Plan's potential impact on future fish populations, and then estimates the total economic value of the potential increase in fish populations. The basis for the calculation of total economic value is a valuation model derived from survey-based research, which estimates households' willingness to pay (WTP) for future increases in fish populations in the Columbia River Basin. The section concludes with an exercise that estimates the size of the use-value portion of the total economic value, applying a methodology used by Reclamation in a prior analysis of water storage projects in the Yakima River Basin (Reclamation, 2008).

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[2] All values in this section are in 2012 dollars. Values from previous years are brought to 2012 dollars using the U.S. Bureau of Labor Statistics' Consumer Price Index.

2.1.1 The Integrated Plan's Potential Impact on Future Fish Populations

The Integrated Plan would increase future salmon/steelhead populations in the Yakima River Basin through the combined effects of diverse actions addressing multiple factors that negatively affect these populations. Improvements in streamflows and habitat would be accomplished through:

- Investments to provide fish passage around all five of the major dams in the Yakima River Basin. (These investments also would reduce the impacts of dams on salmon/steelhead.)
- Structural and operational changes at existing facilities that would improve streamflow conditions.
- Development of new surface water storage to increase water supplies and improve streamflow.
- Development of ground water storage that would improve streamflow conditions.
- Targeted watershed protections and enhancements that would improve habitat in forested watersheds.
- Mainstem floodplain and tributary habitat enhancements.
- Promotion of municipal and domestic water conservation and direct investment in agricultural conservation that would improve streamflows.

Current production of salmon and steelhead in the Columbia River Basin is on the order of 2 million fish per year, on average (Fish Passage Center, 2011; Oregon Department of Fish and Wildlife 2012). Biological modeling indicates that, when fully implemented, the Integrated Plan would increase the number of adult salmon and steelhead in the Columbia River Basin by 181,650 to 472,450 fish a year (see Table 3). For the purposes of this analysis, "adult" fish represents the biological concept of recruitment (i.e., fish mature enough to be exploitable from commercial, subsistence, or sport fisheries, or to spawn, minus the fish that die, prior to spawning, by non-human causes). This analysis assumes fish populations would increase linearly over a 30-year period (from 2013 to 2042) and remain stable after 2042. The actual growth in fish populations may occur faster or slower depending on a number of factors. As explained below, however, the rate of growth does not affect the computation of households' willingness to pay for the growth, because the method used for the computation depends on the 20-year total growth rather than on the annual rate of growth.

It is assumed that each year, commercial and recreational fisheries would harvest about 21 percent of the additional adult fish resulting from the Integrated Plan. This harvest rate reflects current compliance with fishery management compacts and regulations established under the Federal Endangered Species Act. By 2042, the change in fish harvest associated with the Integrated Plan would stabilize at 37,997–102,603 fish a year (see Table 3). The increase in fish populations would affect several species: spring, summer, and fall Chinook salmon, coho salmon, steelhead, and sockeye salmon. Sockeye salmon represent about 80–94 percent of the overall expected increase in adult fish population, and 77–92 percent of the increase in fish harvest (see Table 3).

Table 3. Expected Increases in Salmon and Steelhead Populations Resulting from the Integrated Plan at Full Implementation

	Recruitment (2042)	Harvest (2042)
Spring/Summer Chinook	6,000–46,700	1,497–12,524
Fall Chinook	1,600–16,150	664–6,342
Coho	1,650–10,700	420–2,786
Steelhead	2,400–18,900	316–2,451
Sockeye	170,000–380,000	35,100–78,500
Total	181,650–472,450	37,997–102,603
Source: Adapted from Hubble, 2012.		

2.1.2 Total Economic Value of the Integrated Plan's Potential Impact on Future Fish Populations

In 1999, the Washington Department of Ecology commissioned the development and application of a model (*LBP Study)* for estimating the total economic value of benefits derived from potential future programs to increase fish populations in waterways across the state (Layton et al., 1999). Though never published in an academic journal, the *LBP Study* has received considerable peer review through other channels.[3] One review "recommend[s] that any reliable estimates of impacts on salmon and steelhead [in the Columbia River Basin] should be assigned values based upon the methodology developed in [the *LPB Study*]" (Huppert et al., 2004). This conclusion is reinforced insofar as the values developed in the LBP study are similar to those found in other comparable peer reviewed studies, as discussed below. This section applies the *LBP Study* model to data specific to the Integrated Plan to estimate the economic benefits associated with increases in fish populations resulting from it. Specifically, this section (1) describes the *LBP Study*'s methodology and findings, (2) summarizes the parameters for applying its model to the Integrated Plan, and (3) summarizes the total economic value of the Integrated Plan's fish-related benefits.

2.1.2.1 The LBP Study

The *LBP Study* surveyed Washington residents and used the results to develop a model for estimating the total economic value associated with potential future increases in five different fish populations in Washington. This analysis employs the findings for what the *LBP Study* calls

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[3] Examples of peer review include Richardson, L., and J. Loomis. 2009. "The Total Economic Value of Threatened, Endangered and Rare Species: An Updated Meta-Analysis." *Ecological Economics*. 68: 1535-1548; Goodstein, E. and L. Matson. 2007. "Climate Change in the Pacific Northwest: Valuing Snowpack Loss for Agriculture and Salmon Frontiers." *Environmental Valuation and Policy.* Edward Elgar New York; and Niemi, E. 2009. *An Overview of Potential Economic Costs to Washington of a Business-As-Usual Approach to Climate Change*. University of Oregon, Climate Leadership Initiative. The last report included review by these members of an Economics' Steering Committee: Katie Baird, *U. of Washington, Tacoma,* William Barnes, *U. of Portland,* Randall A. Bluffstone, *Portland State U.,* Gardner Brown, *U. of Washington,* Trudy Ann Cameron, *U. of Oregon,* Janie Chermak, *U. of New Mexico,* Bonnie G. Colby, *U. of Arizona,* Paul N. Courant, *U. of Michigan,* Peter Dorman, *Evergreen State College,* Kristine M. Grimsrud, *U. of New Mexico,* David Ervin, *Portland State U.,* Joel Hamilton, *U. of Idaho,* Hart Hodges, *Western Washington, U.* Daniel Huppert, *U. of Washington,* Don Negri, *Willamette U.,* Andrew Plantinga, *Oregon State U.,* Michael J. Scott, *PNW National Laboratory, and* W. Douglass Shaw, *Texas A&M U.*

Eastern Washington and Columbia River migratory fish (i.e., salmon and steelhead originating from Eastern Washington and the Columbia River Basin). The survey presented each respondent with historical fish populations, current fish populations (as of 1999, the year of the survey), and projected future fish populations (20 years in the future) assuming no efforts to increase fish populations. For projected future fish populations, half the respondents saw a baseline (no-action) scenario in which future fish populations would remain stable while the other half saw a baseline scenario in which future fish populations would decline at the same rate they declined over the prior 20 years. Table 4 summarizes the fish population estimates respondents saw on the survey.

Table 4. Fish Populations in the *LPB Study*: Past, Current, and Baseline Scenarios for Eastern Washington and Columbia River Migratory Fish

Past Population	Population in Survey Year	Population 20 Years After Survey
8 million	2 million	0.5 million or 2 million
Source: Layton et al., 1999		

The survey then presented respondents with general program options that would have different impacts on future fish populations. The survey also told respondents that Washington households would fund each program and indicated the amount each household would pay through surcharges on its monthly water/utility bills. Specifically, the survey provided this text to respondents:

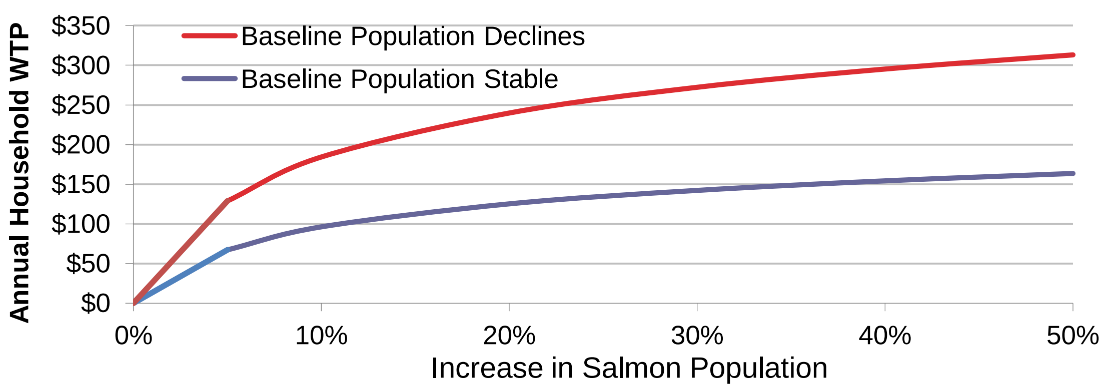
> *The state of Washington is considering a variety of ways for improving fish populations, ranging from reductions in toxic contamination of water bodies to improvements in river flows and fish habitat. As mentioned earlier, fish populations are affected by a number of factors, including urban development, agricultural practices, timber harvesting, pollution, and hydroelectric dams. A new state program might affect some of these more than others. And in some cases, a program would affect one region of the state differently from another, or would affect one species differently from others.*
>
> *We want your opinion of four possible new programs, which are listed below. Rather than spelling out each program in detail, we want you to focus on the effects they will have over the next 20 years, which we have listed for each program. The effects listed are the best estimates fishery biologists can make.*
>
> *We have also listed for each program the amount it will cost your household each month, for the next twenty years. This cost will come in the form of a surcharge on your water bill (or other utility bill if you have no water bill).*

By providing this information, the researchers sought to obtain information from respondents solely about their willingness to pay for improvements in fish populations, separate from their beliefs about specific factors that have depressed these populations, their preferences for specific ameliorative actions, relative to others, or for who should pay for different types of actions.

The researchers used survey responses to develop a model of households' willingness to pay (WTP) for increases in fish populations. Figure 4 describes the model for salmon/steelhead populations in the Columbia River and Eastern Washington (in 2012 dollars). The model has two components, corresponding to the different baseline scenarios, and each component has two functions. Figure 4 shows the functions and a graph with their corresponding curves. The first row shows the functions for the blue curve, which describes households' average annual WTP for increases in salmon populations when the baseline fish population remains stable over the next 20 years. The second row shows the functions for the red curve, which describes households' average annual WTP for increases in salmon populations when the baseline fish population declines over that period.

Figure 4. Annual Household Willingness to Pay for an Increase in the Columbia River and Eastern Washington Salmon/Steelhead Population

Baseline Future Fish Population	Willingness to Pay Function
Stable over time at 2 million	f(X)=12*1.06X*1.377, 0% ≤ X < 5% f(X)=12*-(0.0673/-0.0266)*LN(X*100)*1.377, 5% ≤ X
Declining over 20 years from 2 million to 0.5 million	f(X)=12*2.04X*1.377, 0% ≤ X < 5% f(X)=12*-(0.1003/-0.0207)*LN(X*100)*1.377, 5% ≤ X
Where: f(X)= Annual household WTP in 2012 dollars X=Percent increase in Eastern Washington, Columbia River migratory fish	



Source: Adapted from Layton et al., 1999

As the curves show, households are willing to pay more when baseline fish populations would decline than when they would remain stable. This outcome is consistent with expectations, insofar as the declining baseline represents a greater risk of extinction, absent a fish-enhancement program; heightened scarcity of the goods and services associated with the region's salmon/steelhead populations; and, hence, higher willingness to pay for a program that would yield an incremental increase in fish population. Furthermore, moving from left to right (from smaller to larger increases in future fish populations), the curves show that households' average annual WTP increases, but at a decreasing rate. This trend suggests that respondents were willing to pay more, per fish, for small increases in future fish populations than for large increases, consistent with theoretical expectations.

2.1.2.2 Applying The LBP Study's Results to the Integrated Plan

The process used to apply the *LBP Study* to the Integrated Plan is known as benefit transfer. This section describes the applicability of using this process to determine the value of the Integrated Plan's fish-related benefits. It also examines three potential differences between the focus of the

LBP Study and the Integrated Plan's impacts that may affect the applicability of the *LBP Study's* results to the total economic value of the Integrated Plan's impact on fish populations. These potential differences are: 1) the timing of increases in fish populations, 2) the baseline fish populations, and 3) households and their preferences. The differences are small relative to the overlap between the *LBP Study* and the Integrated Plan, and, their overall effect may be to overestimate or underestimate the actual value of the Integrated Plan's impact on fish populations. In either case, the available evidence—which includes similarities between the results of the *LBP Study* and other, comparable studies, as well as empirical data that support a sensitivity analysis—suggests the impact likely is small relative to the core estimate of the Integrated Plan's fish-related benefits. The significance of the fish-related benefits also indicates the potential importance of conducting future research to determine how the economic value of salmon/steelhead populations in the Columbia River Basin evolves in response to factors such as changes in fish population, human population, household income, and climate. Such research would support monitoring of the Integrated Plan's outcomes.

2.1.2.2.1 Applicability of the Benefit-Transfer Process

The benefit-transfer process entails using the *LBP Study's* findings, regarding the relationship between households' willingness to pay for a program to increase fish populations and the extent of the increase that would result from the program, to compute the value of the increase in fish populations expected to result from the Integrated Plan. The *LBP Study* is particularly suitable for benefit transfer in this setting. Its applicability stems from the high technical quality of its research design and the close similarity between its scope and focus and the scope and focus of the Integrated Plan. In particular, the *LBP Study* satisfies these criteria, expressed by the Federal Office of Management and Budget (2003), for assessing the applicability of a study used in a benefit-transfer process:

- *The selected studies should be based on adequate data, sound and defensible empirical methods and techniques.*

  The *LBP Study* employed standard experimental design principles to develop and secure sufficient data to support a Censored Ranking Model for Stated Preference Ratings. It elicited responses via a mail survey, mailed to randomly selected households in Washington. Of 2,819 surveys delivered to potential respondents, the researchers received 1,917 responses, for a response rate of 68 percent. Of the responses received, 1,611 provided complete and usable responses to the fish-valuation questions, of which 801 addressed the scenario assuming a stable baseline fish population and 810 addressed the scenario assuming declining baseline fish population.

- *The selected studies should document parameter estimates of the valuation function.*

  The *LBP Study* fully documents the parameter estimates of two valuation functions, as shown in the equations in Figure 4.

- *The study context and policy context should have similar populations (e.g., demographic characteristics). The market size (e.g., target population) between the study site and the policy site should be similar.*

  The study context, policy context, and market size of the *LBP Study* incorporate those of the Integrated Plan. The *LBP Study* estimated the willingness of Washington households to pay for programs that would yield increases in salmon/steelhead fish populations in

Eastern Washington and the Columbia River Basin. This analysis applies a valuation function from the *LBP Study* to the same Pacific migratory fish in one part of this region, the Yakima River Basin. The analysis also extends the scope to include both Washington and Oregon households, recognizing the significant similarities between them. These are indicated by the two states' sharing of the Columbia River Basin, shared responsibility for managing its fish populations, and similar goals and policies for increasing salmon/steelhead populations.

- *The good, and the magnitude of change in that good, should be similar in the study and policy contexts.*

  A decision to implement the Integrated Plan would yield the benefit measured by the *LBT Study*, an expectation of future increases in salmon/steelhead populations in Eastern Washington and the Columbia River Basin[4]—and the percentage increase in these populations falls within the range considered by the *LBP Study*. It would produce this good through actions similar to those considered in the *LBP Study*. The study gauged households' willingness to pay for a program, implemented by the State of Washington, that would yield a future increase in salmon/steelhead populations "*considering a variety of ways for improving fish populations, ranging from reductions in toxic contamination of water bodies to improvements in river flows and fish habitat. As mentioned earlier, fish populations are affected by a number of factors, including urban development, agricultural practices, timber harvesting, pollution, and hydroelectric dams. A new state program might affect some of these more than others.*" The Integrated Plan similarly represents a program that involves the State of Washington's participation and includes a variety of ways for improving fish populations. Proposed actions include improvements in river flows and fish habitat, as well as reductions in the effects on fish populations of urban development, agricultural practices, timber harvesting, and dams. The range of expected percentage increases in fish populations resulting from the Integrated Plan falls within the range considered in the *LBP Study*. The *LBP Study* considered increases ranging from zero to 150 percent; the Integrated Plan is expected to yield increases ranging from 9.1 percent to 23.6 percent.

- *The relevant characteristics of the study and the policy contexts should be similar.*

  The *LBP Study* did not specifically ask survey respondents for their willingness to pay for a fish-enhancement program identical to that of the Integrated Plan. Nonetheless, the characteristics and policy context of the *LBP Study* closely resemble and overlap with those of the Integrated Plan. This similarity is not an accident. The *LBP Study* was designed to facilitate measurement of multiple fish-enhancement programs in the Eastern Washington, Columbia Basin region, anticipating the fish-enhancement program the Integrated Plan proposes for the Yakima River Basin. The characteristics of the *LBP Study* relevant for estimating the value of the Integrated Plan's fish benefits fully embrace those of the Integrated Plan. Implementation of the Integrated Plan, and its effects on fish populations would occur in geographic, economic, and policy contexts that closely

[4] The Yakima River Basin is part of the larger Columbia River Basin. The Yakima River flows into the Columbia River at Kennewick, Washington.

resemble those of the *LBP Study*. The geographic setting, from the headwaters of the Yakima River Basin to the mouth of the Columbia River, is a major subset of the area—Eastern Washington and the Columbia River Basin—the *LBP Study* considered. The overall framework of the economy within the Yakima River Basin, Columbia River Basin, and the State of Washington remains essentially the same. These areas have experienced broad economic growth since the *LBP Study,* and, although the rate of growth varied across sectors, no major sector was displaced and no major industry emerged. Implementation of the Integrated Plan would occur in a similar policy setting: current fish populations are essentially the same as those that existed when the *LBP Study* was conducted, the overall process for producing salmon/steelhead in the region remains unchanged, and the general framework of fish-management policies in the Columbia River Basin has changed little. The Integrated Plan aims to accomplish the same outcomes (increased future salmon/steelhead populations) in the same place (Eastern Washington and the Columbia River Basin), using policies and actions similar to those in the *LBP Study*. The no-action, baseline scenario applicable to the Integrated Plan is the same as the one that, in the *LBP Study*, generated the valuation function representing the lower bound of households' willingness to pay for programs that would yield increases in salmon populations in Eastern Washington and the Columbia River Basin.

- *The distribution of property rights should be similar so that the analysis uses the same welfare measure.*

  The Integrated Plan and the *LBP Study* reflect the same framework of property rights associated with increases in salmon/steelhead populations resulting from Federal and state investments in fish enhancement. In both, salmon and steelhead are publicly owned resources, jointly managed by Federal, state, and tribal authorities. The management of salmon/steelhead populations, as well as the conversion to private ownership through commercial, sport, or ceremonial catch, is regulated under treaties and laws that have remained essentially unchanged since the *LBP Study* was conducted. Although the regulations derived from the treaties and laws can vary from year to year, their overall framework has remained stable. Within this context, both the *LBP Study* and this analysis of the Integrated Plan's fish-related benefits measure value in terms of households' willingness to pay for expected increases in salmon/steelhead populations.

- *The availability of substitutes across study and policy contexts should be similar.*

  The similarity of substitutes applies both to the target outcomes, increases in salmon/steelhead populations, and to the programs that would yield them. The *LBP Study* measured households' willingness to pay for a program that would yield an increase in salmon/steelhead populations in Eastern Washington and the Columbia River Basin. The Integrated Plan would yield an increase in salmon/steelhead populations in a major portion of this area. The general substitutes for the increased populations are the same. For example, households that place a value on the fish as a target for recreational fishing have alternative recreational opportunities, such as fishing for salmon/steelhead elsewhere or fishing for other species. Some difference in substitutes exists insofar as the *LBP Study* covered the all of Eastern Washington and the Columbia River Basin and the Integrated Plan covers only a portion of this area. Hence, an increase in salmon/steelhead populations resulting from the scenarios defined in the *LBP Study* might have attracted anglers from outside the Columbia River Basin, whereas an increase in fish populations resulting from the Integrated Plan might attract anglers from both outside the Columbia River Basin and from other areas within the basin. These differences would be constrained, however, insofar as most of the angling activity generated by an increase in salmon/steelhead populations, whether generated by the program defined by the *LBP Study* or the Integrated Plan would occur downstream from the Yakima River and in the Pacific Ocean.

The Integrated Plan would generate increases in salmon/steelhead populations through a program that contains a subset of the actions defined by the *LBP Study* for increasing fish populations and, hence, it has similar substitutes. The *LBP Study* defined the set of actions that would yield increased fish populations in these terms:

> *The state of Washington is considering a variety of ways for improving fish populations, ranging from reductions in toxic contamination of water bodies to improvements in river flows and fish habitat. As mentioned earlier, fish populations are affected by a number of factors, including urban development, agricultural practices, timber harvesting, pollution, and hydroelectric dams. A new state program might affect some of these more than others.*

With few exceptions, the elements of the Integrated Plan's program for generating increased salmon/steelhead populations fall within the boundaries identified by the *LBP Study*. It does not expressly identify actions to reduce toxic contamination of water flows or hydroelectric dams, but it does incorporate actions to improve river flows and fish habitat, and to correct the effects on fish populations of urban development, agricultural practices, forest management, and water-storage dams. Hence, the set of substitute programs for the Integrated Plan closely resembles that of the *LBP Study.*

2.1.2.2.2 Timing of Increases in Fish Populations

In the *LBP Study's* survey, respondents were asked how much money they would be willing to pay each month, for the next 20 years, for a program, with components similar to those of the Integrated Plan, that, after 20 years, would result in the specified increases in fish populations. The survey did not describe the rate at which fish populations would increase. In stating their WTP, respondents were committing to 20 years of monthly payments attached to the specified increase in fish population after 20 years, regardless of how quickly or slowly populations would increase.

The biological modeling underlying the Integrated Plan indicates that salmon/steelhead populations would increase linearly over a 30-year period (from 2013 to 2042), after which they would stabilize (Hubble 2012). Year-to-year growth could vary from the linear path, but the modeling anticipates the long-term variation, looking out 20-40 years, would be small. To apply the model developed in the *LBP Study,* this analysis divides the Integrated Plan's impact on fish populations into two groups: one describing the increase in fish populations that occurs over the next 20 years (2012–2031), the other describing the increase in fish populations that occurs in the following 20 years (2032–2051). In other words, this analysis assumes households in 2012 are asked how much they would be willing to pay for the increase in fish populations expected in 2031. Then, in 2032, households are asked how much they would be willing to pay for additional increases in fish populations expected by 2051. These assumptions ensure the analysis closely follows the assumptions and structure of the *LBP Study's* model and yields reasonable estimates of the total economic value associated with the Integrated Plan's fish-related benefits.

2.1.2.2.3 Baseline Fish Populations, without the Integrated Plan

As previously described, the *LBP Study* estimated households' WTP for increases in salmon/steelhead populations within the context of three fish population estimates shown to survey respondents—a historical population of 8 million; a current population of 2 million; and two baseline scenarios. In one, absent a program to increase the population, the population would remain stable over the 20-year period; in the other, it would decline over the period to 0.5 million. This analysis incorporates the assumptions underlying the first of these scenarios, employing from the *LBP Study* the valuation function that represents the lower bound of households' willingness to pay for programs that would yield increases in salmon populations in Eastern Washington and the Columbia River Basin against a baseline scenario of stable populations.

Historical fish populations correspond to those represented in the *LBP Study*: the Columbia River Basin and Eastern Washington produced about 8 million adult salmon/steelhead per year.[5] The current salmon/steelhead population in this region is about 2 million: fish counts at Bonneville Dam and on the Willamette River have fluctuated between 1.0 and 2.0 million since 2000, and these counts do not incorporate fish that return to the Lower Columbia River after maturing in the ocean, but do not pass the counting stations (Fish Passage Center, 2011; Oregon Department of Fish and Wildlife 2012).

Many factors are likely to influence future fish populations in the Columbia River Basin and Eastern Washington. Many of those factors indicate that, absent the Integrated Plan, fish populations may decline. For example, a 2004 examination of the factors that influence instreamflows and water temperatures concluded:

> *Columbia River salmon today are at a critical point. The basin's salmon populations have been in steady decline over the past century, and scientific evidence demonstrates that environmental and biological thresholds important to salmon—such as water temperature—are being reached or in some cases exceeded. Salmon are more likely to be imperiled during late summer on the Columbia River, as they experience pronounced changes in migratory behavior and survival rates when river flow becomes critically low or water temperature becomes too high. Further decreases in flows or increases in water temperature are likely to reduce survival rates. Trends such as human population growth in the region and prospective regional climate warming further increase risks regarding salmon survival.* (National Research Council, 2004)

Against this backdrop, it seems reasonable to conclude that the Integrated Plan's impact on fish populations would occur in the context of the same baseline expectations specified in the *LBP Study*. That is, absent the Integrated Plan, future fish populations in the region likely would fall on or between the two baseline scenarios specified in the *LBP Study*. One of these projects stable populations; the other projects fish populations declining at historical rates. By employing the

[5] See, for example, National Marine Fisheries Service (NMFS), Northwest Region, 2011; Northwest Power and Conservation Council, 2000.

valuation function associated with the stable baseline (the blue line in Figure 4) from the *LBP Study*, this analysis computes the value of the Integrated Plan's fish-related benefits using the lower bound of the *LBP Study's* estimates of households' willingness to pay for programs that would yield increases in salmon populations in Eastern Washington and the Columbia River Basin.

2.1.2.2.4 Households and their Preferences

The *LBP Study* applied its models in the context of a series of program examples resulting in different increases in fish populations. Each of the programs would contain "a variety of ways for improving fish populations, ranging from reductions in toxic contamination of water bodies to improvements in river flows" recognizing that "fish populations are affected by a number of factors, including urban development, agricultural practices, timber harvesting, pollution, and hydroelectric dams." To estimate the total economic value of increases in fish populations, the *LBP Study* modeled the average WTP per household in Washington, and then multiplied this average by 2 million, the estimated number of households in Washington in 1999. Applying the results to determine the fish-related NED benefits of the Integrated Plan requires accounting for any identifiable change in households' preferences and WTP for future increases in fish populations and for changes in the number of households since 1999.

Households' average willingness to pay may fluctuate, from year to year, representing changes in economic conditions[6] and other factors. Over the 40-year period of analysis, however, households' willingness to pay for increases in salmon/steelhead populations in Eastern Washington and the Columbia River Basin likely will increase—barring unexpected events, such as a major restructuring of the region's economy—in response to potential increases in average household incomes,[7] increased willingness to pay for fish-related recreation,[8] or other factors.

The U.S. Census shows that the number of households in Washington increased from the 2 million used in the *LBP Study* to 2,620,076 in 2010 (U.S. Census Bureau, 2010). Projections of the state's population indicate the number of households will continue to increase. Projections show a 1.4 percent increase in Washington's population from 2010 to 2012 (the beginning of the first 20-year period) and a 23.3 percent increase from 2010 to 2032 (the beginning of the second 20-year period) (Office of Financial Management, 2011).

The overall value of the expected increases in salmon/steelhead populations resulting from the Integrated Plan depends on the importance that all U.S. households place on conserving this resource. Applying the results from the *LBP Study* to just Washington households likely underestimates the actual value, from a national perspective, since this overlooks the value to households in other states. Research conducted in the 1990s in California's Central Valley found that households' willingness to pay for increases in salmon populations may decline with distance between the household and the location of the increase in salmon populations. This does not suggest, however, that distant households place no value on increases in salmon populations,

[6] See, for example, Montgomery and Helvoigt, 2006

[7] See, for example, Horowitz and McConnell, 2000

[8] See, for example, Rosenberger and Loomis, 2001

or that the value declines rapidly with distance.[9] More recent and proximate research reinforces this finding. A 2011 study of the nationwide willingness of households to pay for a program that would increase the populations of salmon/steelhead and other fish species in the Klamath River Basin, about 300–400 miles away from the Yakima River Basin, found households' WTP declined only slightly with distance (RTI International, 2012).[10]

Households in Oregon likely have a willingness to pay similar to that of Washington households, given their sharing of the Columbia River Basin, and similarities in the historical and current importance of salmon and steelhead to the culture and economy of the two states.[11] (The discussion, below, of factors that may affect the accuracy of the estimates considers the possibility that Oregon households are less willing than Washington households to pay for increases in fish populations.) Adding Oregon households to the analysis increases the total number of 2012 households by about 60 percent. If Washingtonians and Oregonians share the same WTP for increased fish populations in the Columbia River Basin and Eastern Washington, incorporating Oregon households into the computation would increase the total economic value of the Integrated Plan's impact on fish populations by the same percentage, all else equal. Accounting for the value households in Washington and Oregon would realize from the increases in fish populations expected from the Integrated Plan does not account for the value households in other states would realize, however, and, hence, it underestimates the total value from a national perspective that is relevant to the NED account.

2.1.2.3 The Total Economic Value of Increases in Fish Populations Resulting from the Integrated Plan

The Integrated Plan would increase the number of adult salmon and steelhead produced by the Columbia River Basin and Eastern Washington over time, with the maximum increase of 181,650–472,450 fish per year beginning in 2042 and continuing for the remainder of the 100-year period of analysis. This range yields two estimates of the Integrated Plan's fish-related benefits: the bottom of the range yields the "low-end" estimate, the top yields the "high-end" estimate. Applying the results of the *LBP Study* to Integrated Plan entails several assumptions:

- Absent the Integrated Plan, the number of adult salmon and steelhead in the Columbia River Basin and Eastern Washington would remain stable at 2 million.
- The increase in fish populations resulting from the Integrated Plan would occur linearly from 2013 to 2042. (This assumption affects the estimate of the increase in fish population occurring in 2031.)

[9] See, for example, Pate and Loomis, 1997

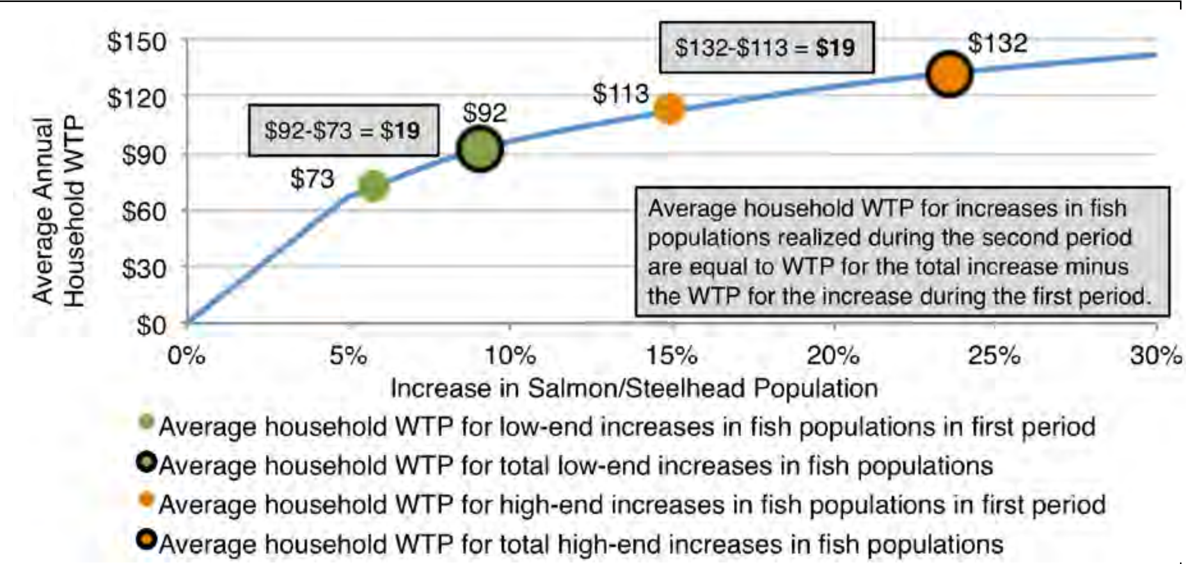
[10] The survey research underlying these results for the Klamath River Basin asked respondents to consider a wide range of issues facing governmental decisions about managing the basin's salmon/steelhead, other fish and wildlife, and affecting the livelihoods and well-being of households. In many ways, the setting is similar to what exists in the Yakima River Basin, with competing demands for water and other resources, and consideration of ecosystem restoration requirements that involve diverse, integrated actions. In some ways, it is different. Restoration proposals for the Klamath River Basins for example, include removal of several hydroelectric dams. The survey research focused on measuring households' willingness to pay for increased protection for salmon/steelhead and other fish species, however, so the differences likely have little impact on the research findings.

[11] See, for example, Bell et al., 2003; DHM Research and Earthfix, 2011

- In effect, the Integrated Plan comprises two programs analogous to those examined in the *LBP Study*: one extending over the first 20 years, from 2012 to 2031, and another extending over the next 20 years, from 2032 to 2051. Applying the stable-population valuation function from the *LBP Study* (the blue line in Figure 4) entails computing the value of the growth in salmon/steelhead populations associated with each of these two periods using the lower bound of the study's estimate of households' willingness to pay for programs that would yield increased fish populations. The value of the first would be realized in 2012 and reflects the expected increase in fish populations for 2031 relative to 2012, and the willingness of the households in 2012 to pay for the increase in the context of a baseline scenario that would see stable fish populations. The value of the second period would be realized in 2032 and reflects the expected increase in fish populations between 2032 and 2051 relative to the baseline scenario and the willingness of the households in 2032 to pay for the increase.
- Households today and in 2032 have the same preferences and WTP for increases in fish populations as households participating in the *LBP Study*.
- At the end of the first 20 years (in 2031), the Integrated Plan would increase the salmon/steelhead population, relative to the stable-population baseline, to 2.1 million (low-end) – 2.3 million (high-end). The increase represents a low-end increase of 5.8 percent increase over the next 20 years and a high-end increase of 15.0 percent, relative to the current population of salmon and steelhead.
- Over the second 20-year period, the Integrated Plan would increase the fish population to 2.2 million (low-end) – 2.5 million (high-end). The increase represents a low-end increase of 3.3 percent and a high-end increase of 8.7 percent, relative to the stable-population baseline of 2 million fish. The overall increase in fish populations, from 2012 to 2051, represents an additional low-end increase of 9.1 percent and a high-end increase of 23.6 percent, relative to the 2012 baseline population of 2 million.

Figure 5 shows the average annual willingness to pay, per household, associated with the low- and high-end percentage increases in fish populations, relative to the stable-population baseline (2 million fish), that households in 2012 and 2032 would expect from the Integrated Plan in 2012 and 2032. The line in the figure is the same as the blue line in Figure 4, representing the *LBP Study's* estimate of the households' average annual WTP for a continuum of potential increases in fish populations if the baseline (no action) scenario predicts stable fish populations into the future. The green dots represent households' average annual willingness to pay for the low-end estimate of increases in fish population that would result from the Integrated Plan. The orange dots represent the WTP for the high-end potential increases. The small dots represent the benefits that would materialize in 2012, and reflect the willingness of 2012 households to pay for the expected increase in salmon/steelhead populations expected in 2031. The large dots represent the Integrated Plan's total fish-related benefits, and reflect the amounts represented by the small dots plus the willingness of 2032 households to pay for the increase expected between 2032 and 2051. The text boxes in the figure shows the calculation of households' average annual WTP for the additional increase in fish populations expected in the second period, 2032–2051.

Figure 5. Average Annual Household WTP for the Integrated Plan's Potential Impact on Fish Populations



Source: Adapted from Layton et al., 1999; Hubble, 2012

Table 5 summarizes the results shown in Figure 5. For each period, 2012-2031, and 2032-2051, it shows households' average annual WTP, throughout the period, for the fish-population increase expected at the end of the period. For example, in 2012, the average WTP per household is $73 per year, for 20 years, for the expected low-end increase in fish populations achieved by 2031; in 2032, the average WTP per household is $19 per year, for 20 years, for the expected low-end increase in fish populations achieved by 2051. (All monetary amounts are in 2012 dollars.) The table also shows the present value, in 2012, equivalent to the 20-year stream of payments for each period, using a discount rate of 4.0 percent per year, the rate applicable to NED calculations in 2012.[12] Thus, the present value of households' average willingness in 2012 to pay $73 per year for 20 years for a program that would yield the low-end increase in fish populations expected in 2031 is $1,030. The present value of households' average willingness in 2031 to pay $19 per year for 20 years for an additional program that would build on the success of the first program and yield the low-end increase in fish populations expected in 2051 is $120. The corresponding numbers for the high-end increase are $1,600 for the first period, and $120 for the second period.

[12] This is the discount rate applicable to NED analysis of water-resource projects in 2012 retrieved from: 76 Federal Register 73674 (November 29, 2011).

Table 5. Average WTP per Household for Low- and High-End Expected Increases in Fish Population Resulting from the Integrated Plan: Annual and Present Value

20-Year Analysis Period	Year Benefits are Realized	Average Household WTP for Low- and High-End Increases in Fish Populations			
		Annual		Present Value	
		Low-end Increase	High-end Increase	Low-end Increase	High-end Increase
2012-2031	2012	$73	$113	$1,030	$1,600
2032-2051	2032	$19	$19	$120	$120

The total present value of the increase in fish populations expected from the Integrated Plan equals the average present value per household for each period, times the number of households at the beginning of the period. Table 6 shows the computations for two alternatives. One alternative considers the value of the expected increases in fish populations to households in Washington State only. Data from the 2010 Census, plus projected growth into the future, yields the estimated number of households in Washington: 2.66 million in 2012 and 3.23 million in 2032 (Office of Financial Management, 2011). The other alternative considers the value of the expected increases in fish populations to households in both Washington and Oregon, and assumes that both exhibit the same average WTP for increases in fish populations derived from the *LBP Study*. Data from the 2010 Census, plus projected growth into the future, yields the estimated number of households in Oregon: 1.56 million in 2012 and 1.97 million in 2032 (Oregon Office of Economic Analysis, 2004). The combined number of households for the two states is 4.21 million in 2012 and 5.20 million in 2032.

Table 6. Present Value of the Integrated Plan's Fish-Related Benefits

Region	Year Benefits are Realized	Present Value per Household		Number of Households (millions)	Total Present Value (billions)	
		Low-end Increase	High-end Increase		Low-end Increase	High-end Increase
Washington Only	2012	$1,030	$1,600	2.66	$2.8	$4.3
	2032	$120	$120	3.23	$0.4	$0.4
	Total	- -	- -	N/A	$3.1	$4.6
Washington and Oregon	2012	$1,030	$1,600	4.21	$4.4	$6.7
	2032	$120	$120	5.20	$0.6	$0.6
	Total	- -	- -	N/A	$5.0	$7.4
Rounding may cause a total to differ from the sum of its elements.						

For Washington households only, the overall present value of the increases in fish populations expected from the Integrated Plan is $3.1 billion for the low-end of the expected increase and $4.6 billion for the high-end. Considering the combined households of Washington and Oregon, the total economic value of the fish-related benefits of the Integrated Plan is $5.0 for the low-end increase and $7.4 billion for the high-end.

2.1.2.4 Factors Affecting the Accuracy of the Estimated Fish-Related Benefits

The values reported in Table 6 likely underestimate the total fish-related NED benefits of the Integrated Plan for three reasons:

- The values in Table 5 and Table 6 show the value households in Washington and Oregon would realize from the expected increases in fish populations. They do not, however, include the value that households in the rest of the Nation would realize.
- The values in Table 5 and Table 6 reflect an assumption that salmon/steelhead populations in the Columbia River Basin would remain stable into the future without the Integrated Plan. As previously noted, however, research suggests that these fish populations are likely to decline in the future due to several factors, such as climate change and increases in human populations. In addition to the model applied above, the *LBP Study* developed another model that generates higher WTP values for increases in fish populations (that model is based on a baseline fish population that declines over time from 2 million to 0.5 million). Using that model, the overall present value of the increases in fish populations expected from the Integrated Plan rises to $10.7 billion (low-end increase) and $13.7 billion (high-end increase) among Washington households and to $17.0 billion (low-end increase) and $21.8 billion (high-end increase) among Washington and Oregon households. All else equal, the potential for future declines in the baseline fish populations suggests the overall present value likely lies somewhere between these values and those shown in Table 6.
- The values in Table 5 and Table 6 assume benefits are realized only at the beginning of each 20-year period, in 2012 and 2032, to reflect households' expectation of increases in fish populations at the end of each period. In reality, however, some households likely would derive additional benefits throughout each of the two 20-year analysis periods, insofar as they would derive some use or non-use benefits from actual increases in fish populations in interim years that complement the benefits associated with the expectation of increases at the end of the 20-year period. On average, all households likely would continue deriving benefits beyond 2051, although the discounting process would reduce its present value considerably.

Other factors, though, create uncertainty about the accuracy of the estimated value of the Integrated Plan's fish-related benefits, and some may influence the process used to produce the estimate toward overestimating the total fish-related NED benefits of the Integrated Plan. Some of these factors arise from the *LBP Study* itself. Although the research design of the *LBP Study* reflects widely accepted standards for this type of research, some uncertainty remains regarding the accuracy of its findings. The uncertainty can arise from several sources. Experiments to test this type of research have found that, when asked how much they would be willing to pay for a hypothetical increase in a good, respondents often overstate the amount they actually would pay if they were faced with their budget constraints or with a moral commitment to avoid overstatement (Jacquemet et al. 2010). The average willingness of respondents to the *LBP Study's* survey to pay for a program to increase fish populations may differ from that of those who were selected randomly for the survey but did not respond. Because households generally have little or no experience making a commitment to make monthly payments over 20 years for a new program to increase fish populations, respondents to the survey may have had limited ability to predict accurately what they would be willing to pay for such a program. Because the researchers provided survey respondents with only a general description of the program that would yield increased fish populations, the magnitude of the population increase by species, and the location, and timing of the increase, uncertainty exists about what, exactly, respondents believed their (hypothetical) monthly payments over 20 years would yield.

Several circumstances diminish the extent of the uncertainty and bias from these factors, however. Perhaps the most important is that residents of Washington (and Oregon) have a high level of awareness of declining salmon/steelhead populations and of efforts to arrest and reverse them in the Columbia River Basin. Moreover, they have long made commitments to pay to protect and restore fish populations. Salmon/steelhead are iconic species for the Pacific Northwest, and have high cultural/spiritual value, especially for the basin's tribal communities. Numerous lawsuits waged over salmon/steelhead, as well as disputes over Federal policies regarding salmon harvest, forest management, and the operation of the region's hydroelectric system affect nearly all parts of the Pacific Northwest and ensure that the importance of restoration is reported frequently by the news media and addressed by political leaders. Electric utilities, landowners, and communities are funding restoration programs, so that many households in the region already are making monthly payments to support programs—broadly defined as in the *LBP Study*—to protect and increase salmon/steelhead populations. Opinion polls consistently report findings, such as these from Washington Department Fish and Wildlife (1997): "Washington citizens cherish their fish and wildlife and most people are willing to pay higher taxes to protect them."

The high quality of its research design also diminishes the uncertainty and potential for overestimation of value in the *LBP Study's* results. The research employed widely accepted protocols for survey research of this type and realized a response rate of 68 percent. It considered two alternative baseline scenarios, with fish populations stable or declining at historical rates, that generally bound the range of recent experience and expectations. It produced willingness-to-pay functions over a range of potential increases, from zero to 150 percent, in fish populations, consistent with general expectations for the region's restoration programs, and it produced results exhibiting diminishing marginal returns for population increases, consistent with theoretical expectations. Similarities between the results of the *LBP Study* and those of other, similar studies, as discussed below, reinforce the conclusion that it does not embody peculiarities that increase the uncertainty inherent in its findings or the likelihood that it has overestimated households' WTP for increases in fish populations.

Additional uncertainty and potential for overestimating the Integrated Plan's fish-related benefits stem from the benefit-transfer process, i.e., using the *LBP Study* to compute the value of the increase in fish populations expected to result form the plan. The transfer of the *LBP Study's* results to the Integrated Plan necessarily entails greater uncertainty than would exist if the same research methods were applied directly to the plan. This uncertainty is diminished, however, because the researchers designed the *LBP Study* to provide Washington's Department of Ecology with a tool for assessing the economic benefits of multiple programs implemented over time and space to increase fish populations in the state. The Integrated Plan's fish-enhancement program closely resembles the types of programs for which this analytical tool is intended. Accordingly, as discussed above, there is extensive overlap between the assumptions underlying the *LBP Study* and the characteristics of the Integrated Plan. Reinforcing the significance of this overlap, the benefit-transfer process applies the *LBP Study's* valuation functions, not point estimates, to the Integrated Plan.

Nonetheless, some uncertainty may arise insofar as the *LBP Study* asked respondents to the survey about their willingness to pay for generic, future increases in salmon/steelhead populations, but the Integrated Plan focuses on increasing the adult populations of these species. The direction of this discrepancy's impact on the estimate of the plan's fish-related benefits is, itself, uncertain, however. Additional uncertainty exists because the generic fish-enhancement programs identified in the *LBP Study* are not precisely the same as the Integrated Plan's program.

Differences in household income also add some uncertainty to the benefit-transfer process. The demand for protecting and enhancing populations of at-risk species generally increases or decreases with income, and a recent meta-analysis of the literature found the elasticity of demand with respect to income is about 0.38 (Jacobsen and Hanley 2008). This finding suggests that, all else equal, an increase/decrease in households' income of 1.0 percent would increase/decrease their WTP for larger fish populations by 0.38 percent. Median household income in Washington, measured in constant dollars, is about five percent lower than it was when the *LBP Study* was conducted (U.S. Census Bureau 2012). This change likely has depressed the average willingness of Washington's households to pay for increases in fish populations, all else equal, by about two percent below the figures shown in Table 5 and Table 6. Median household income is currently about 10 percent lower in Oregon than in Washington, or about 15 percent below what existed in Washington when the *LBP Study* was conducted. This difference suggests that the current, average willingness of Oregon's households to pay for increases in fish populations is about six percent lower than the level derived from the *LBP Study* and reflected in Table 6. If median incomes in the two states were to remain at these levels over the next 40 years, and the effect of income on willingness to pay for increases in fish populations were to remain at the level reported by Jacobsen and Hanley (2008), the total present value of the Integrated Plan's fish-related benefits would decline about 3.5 percent, from the $5.0–$7.4 billion shown in Table 6 to about $4.8–$7.1 billion.

2.1.3 Comparison with Results from Other Studies

The results shown in Table 6 are consistent with the findings of related research on the value of potential increases in salmon/steelhead populations in the Pacific Northwest. Table 7 summarizes the results from three studies of the economic value associated with increases in salmon populations in this region. Olsen et al. (1991) found households willing, on average, to pay about $100 per year for doubling salmon/steelhead populations in the Columbia River Basin, from 2.5 million to 5 million. The other two studies examined increases in fish populations about the same as those expected to result from the Integrated Plan but for areas outside, though nearby the Columbia River Basin. Loomis et al. (1996) found households willing, on average, to pay about $100 per year for an increase in fish populations similar to what is expected of the Integrated Plan; Bell et al. (2003) found households willing, on average, to pay about $120 per year for a smaller increase in fish populations.

Table 7. Comparative Findings on Household Willingness to Pay for Increased Salmon Populations

Source	Olsen et al. 1991	Loomis 1996	Bell et al. 2003	NED Analysis of Integrated Plan
Geography	Columbia River	Elwha River	Coastal OR and WA	Columbia River
Change in Fish Population	2,500,000	300,000	165,000	115,045–299,218* 66,605–173,232**
Average Annual Household WTP (2012 dollars)	$100	$100	$120	$73–$113* $19**
Source: Olsen et al., 1991; Loomis, 1996; Bell et al., 2003 * Increase in fish population from 2012-2031 and average annual WTP in 2012 for that increase. ** Increase in fish population from 2032-2051, above the increase occurring in the prior 20 years, and average annual WTP in 2032 for that additional increase.				

The similarities among the figures in Table 7 and the values derived for the Integrated Plan provide reassurance about the robustness of the computation of the overall value of the Integrated Plan's fish-related benefits. The consistency in the values also raises some questions, however, about the nature of these benefits. The similar willingness to pay for wide differences in fish-population increases may indicate that the marginal value is high for a small increase in fish population but drops quickly for subsequent increases. Alternatively, the similarities in households' average willingness to pay for different levels of increase in fish population may indicate that the benefit is something other than the specific increase in salmon/steelhead populations expected to result from the Integrated Plan. When households indicate a willingness to pay for a program to increase fish populations, for example, they may have in mind not a desire to increase fish numbers, *per se*, but something more general, such as an improvement in the ecological conditions that support fish. If households do have a preference for greater increases in fish population, they may find it difficult to express this preference quantitatively and past studies, as well and the *LBP Study,* have been unable to elicit this information. Or, there may be some other explanation for the similarities in the values shown in Table 7 and derived for the Integrated Plan's fish-related benefits. Ambiguity about the goods and services households might expect to accompany increases in salmon/steelhead populations may create uncertainty about their willingness to pay for these increases, *per se*. The uncertainty is inconsequential, however, to the extent that households see these goods and services as perfect complements to increased fish populations. This outcome would occur, for example, if they see the interconnection between improvements in ecological conditions, such as improved water quality in streams, and the increases in fish populations that result from them, and are willing to pay for the whole bundle.

2.1.4 The Use-Value Component of the Integrated Plan's Fish-Related Benefits

This section employs a separate analytical method to estimate the use-value component of the Integrated Plan's fish-related benefits that were computed in the previous section. The intent of this section is not to estimate additional fish-related values. Instead, this effort aims to isolate the portion of the total value, estimated above, that would be captured by activities that entail direct use of the potential increase in fish populations resulting from the Integrated Plan. Specifically in this analysis, use value is the value associated with harvesting adult fish produced as a result of the Integrated Plan. The use values described here are a component of and, therefore, should not be added to the estimate of total value presented above. The harvesting might occur in several ways: commercial, sport, subsistence, and Tribal ceremonial. Using demarcations and methodologies established by Reclamation for previous economic evaluation of potential investments in the Yakima River Basin (Reclamation, 2008), the analysis distinguishes among eight fisheries comprising four types of fish harvesting across four geographic regions:

- Pacific Ocean Commercial
- Pacific Ocean Sport
- Lower Columbia River (zones 1–5) Commercial
- Lower Columbia River (zones 1–5) Sport
- Columbia River (zone 6) Tribal Commercial
- Columbia River (zone 6) Tribal Ceremonial and Subsistence
- Yakima River Sport
- Yakima River Tribal Ceremonial and Subsistence

The analysis generally proceeds in three steps. First, it estimates the use value per fish for each fishery, except the Tribal Ceremonial and Subsistence Fisheries. The analysis does not attempt to estimate the use value for these purposes, recognizing that, because the existence of salmon/steelhead and the ceremonial and subsistence uses of these fish are intertwined with the cultural, nutritional, and economic well-being of tribal people, their value is incalculable, as indicated by this statement:

> *The importance of fish, especially salmon, to our tribes cannot be overstated. In U.S. v. Winans, the U.S. Supreme Court stated that fishing was "not much less necessary to the existence of the Indians than the atmosphere they breathed." The salmon are an integral part of our cultural, economic and spiritual well-being. They are a major food source and our consumption is nearly ten times higher than the national average. Salmon is fundamental to a healthy tribal diet and it plays a significant role in combating the risks of heart disease and diabetes in our communities.* (Lewis, 2011)

The second step entails estimating the number of additional fish that would be harvested in each fishery, by year, because of the Integrated Plan. For the fisheries other than Tribal Ceremonial and Subsistence, the analysis then multiplies the use value per fish by the additional catch, with the product of the multiplication representing the overall annual use value for each fishery. The third step entails discounting the stream of future annual values to compute the equivalent present value.

2.1.4.1 Use Values per Fish, by Fishery

The analysis includes several important assumptions that are further clarified in Appendix A. All assumptions follow the methodology and assumptions previously used by Reclamation (Reclamation, 2008):

- Commercial use values represent the estimated profits associated with harvest. The literature suggests that profitability in the relevant industries ranges from 43 percent to 99 percent. This analysis assumes a profitability percentage of 80 percent. It uses weighted 5-year averages to estimate harvest value and catch in each fishery. It assumes the

Integrated Plan's impact on fish populations would not affect prices in the relevant fishery markets.

- Sport use values represent both expenditures and consumer surplus associated with sport fishing in the relevant geographies. The literature describes these values per fishing day. This analysis uses sport-fishing data to estimate the number of days spent fishing per fish harvested in the different geographies. It applies the days spent fishing, per fish harvested, to the increase in fish populations, and then multiplies by the daily use value associated with sport fishing. Furthermore, it assumes that use values associated with sport fisheries are directly related to the number of fish harvested. The literature supports the assumption that sport fishermen fish more often as their harvest rate (fish caught per day spent fishing) increases, with their consumer surplus directly proportional to their harvest rate.[13]

Table 8 summarizes the use values (per fish in 2012 dollars) this analysis applies to the increase in fish harvests attributable to the Integrated Plan. The per-fish values represent updated data but remain similar to those used by Reclamation in similar analyses for this area (Reclamation, 2008). Use values range from about $10 to about $750 per fish, with the variation representing several factors, such as species, size of fish, location of the fishing site, catch rate, time of year, and fishing regulations. The use values associated with sport fishing are higher than those associated with commercial fishing, which is consistent with the literature (Anderson and Scott, 1993). The remainder of this section briefly describes how use values for each fishery are calculated. Details describing the data used and the functions applied to calculate these values are provided in Appendix A.

Table 8. Economic Use Value per Fish by Species and Fishery (2012 dollars)

Harvest Category	Coho	Spring Chinook	Fall Chinook	Steelhead	Sockeye
Ocean Commercial	$10	$50	$50	-	-
Ocean Sport	$160	$120	$120	-	-
Lower Columbia Commercial	$10	$60	$30	-	$10
Lower Columbia Sport	$330	$330	$330	-	$330
Columbia Tribal Commercial	$10	$50	$20	$10	$10
Columbia Tribal Ceremonial and Subsistence	Value is incalculable				
Yakima Sport	$420	$750	$420	-	$330
Yakima Tribal Ceremonial and Subsistence	Value is incalculable				
See Appendix A for more detail.					

2.1.4.2 Pacific Ocean Commercial

The method used to calculate the average use value per fish caught in the commercial ocean fishery has two components: (1) the average profit per fish caught by commercial ocean fisheries

[13] See, for example, Loomis, 2006

in Alaska, Washington, Oregon, and California, and (2) the distribution across the fisheries of fish originating from the Yakima River Basin. The average profit per Chinook ranged from about $50 per fish in Alaska to about $60 in Oregon, and average profit per Coho ranged from about $8 per fish in Alaska to about $10 per fish in Oregon. The distribution of fish originating in the Yakima River Basin that were harvested by these fisheries was calculated using historical tracking records (Webb, 2012). For example, from 1984–2011, Alaska accounted for about 90 percent of the Chinook that originated in the Yakima River Basin and were harvested in the commercial ocean fishery. These distribution ratios were used to weigh state-level profits. The economic use value, per fish, in the commercial ocean fishery is about $10 for Coho and $50 for Spring and Fall Chinook. Steelhead and Sockeye are not harvested in the Pacific Ocean commercial fishery.

2.1.4.3 Pacific Ocean Sport

The method used to calculate the average use value per fish caught in the ocean sport fishery has three components: (1) the average value per fishing day (which includes expenditures and consumer surplus), (2) the number of sport fishing days off the California, Oregon, and Washington coasts, and (3) the number of fish caught by recreational fishermen off the California, Oregon, and Washington coasts. A literature review of studies estimating the total use value associated with ocean sport fishing in the region concluded that each fishing day is worth about $128 (Reclamation, 2008). This value includes expenditures (e.g., fishing gear, fuel, transportation, fishing guides) and consumer surplus. The average number of days it took for anglers to catch a Coho or Chinook ranged from 0.7 days in Washington to 3.2 days in California. Each state's catch rate (days per fish harvested) was weighted by the percentage of fish harvested in the ocean sport fishery off each state's coast, then multiplied by the average value per fishing day to calculate the average value per fish. The economic use value, per fish, in the ocean sport fishery is about $160 for Coho and $120 for Spring and Fall Chinook. Steelhead and Sockeye are not harvested in the Pacific Ocean sport fishery.

2.1.4.4 Lower Columbia River Commercial (zones 1–5)

The method used to calculate the average use value per fish caught in the Lower Columbia River's commercial fishery has two components: (1) the average profit per pound of Chinook and Coho harvested in the Lower Columbia River commercial fishery, and (2) the average weight per fish. From 2007–2011, the average Coho harvested in the Lower Columbia commercial fishery weighed about 10 pounds, the average Fall Chinook weighed about 18 pounds, and the average Winter/Spring/Summer Chinook weighed about 14 pounds. The economic use value, per fish, in the Lower Columbia River commercial fishery is about $10 for Coho, $60 for Spring Chinook, and $30 for Fall Chinook. Steelhead and Sockeye are not targeted in the Lower Columbia River commercial fishery. Some Sockeye will be caught as incidental catch, however. The analysis assumes those Sockeye have a use value of about $10 per fish.

2.1.4.5 Lower Columbia River Sport (zones 1–5)

The method used to calculate the average use value per fish caught in the Lower Columbia River sport fishery has three components: (1) the average value per fishing day (which includes expenditures and consumer surplus), (2) the number of sport fishing days on the Lower Columbia River, and (3) the number of fish caught by recreational fishermen in this area. A literature review of studies estimating the total use value associated with sport fishing in the region concluded that each fishing day is worth about $76 (Reclamation, 2008). This value includes expenditures (e.g., fishing gear, fuel, transportation, fishing guides) and consumer surplus. From 2007–2011, anglers spent about 351,500 days per year fishing on the Lower Columbia River. Each year, they caught an average of 81,500 fish. In other words, they caught one fish every 4.3 days. These numbers indicate the economic use value, per fish, is about $330 for each fish species in the analysis.

2.1.4.6 Columbia River Tribal Commercial (zone 6)

The method used to calculate the average use value per fish caught in the Columbia River's Tribal commercial fishery has two components: (1) the average profit per pound of Chinook and Coho harvested in the Columbia River (zone 6), and (2) the average weight per fish. The average Coho harvested in the Lower Columbia commercial fishery (zone 6) weighed about 10 pounds, the average Fall Chinook weighed about 17 pounds, and the average Winter/Spring/Summer Chinook weighed about 14 pounds. The economic use value, per fish, is about $10 for Coho, $50 for Spring Chinook, and $20 for Fall Chinook. Sockeye and steelhead have not been harvested in this fishery for several years. With no data from which to derive Sockeye- and steelhead-specific values, this analysis assumes they have the same value as the Coho harvest, $10 per fish.

2.1.4.7 Yakima River Sport

The method used to calculate the average use value per fish caught in the Yakima River Basin sport fishery has three components: (1) the average value per fishing day (which includes expenditures and consumer surplus), (2) the number of sport fishing days on the Yakima River, and (3) the number of fish caught by anglers. A literature review of studies estimating the total use value associated with sport fishing in the region (Reclamation, 2008) provides the basis for the calculation. It concluded that each fishing day is worth about $76, and found that, during the period, 2007–2011, fishermen spent about 3,200 days per year fishing for Fall Chinook and Coho, and about 7,600 days per year fishing for Spring Chinook on the Yakima River. Each year, they caught an average of 573 Fall Chinook and Coho, and 772 Spring Chinook. In other words, they caught one Fall Chinook or Coho every 5.6 days, and one Spring Chinook every 9.9 days. The economic use value, per fish, is about $420 for Fall Chinook and Coho, and about $750 for Spring Chinook. Sockeye have not been harvested in this fishery for several years. With no data from which to derive a Sockeye-specific value, this analysis assumes Sockeye have the same value as they do in the Lower Columbia River sport fishery, about $330 per fish. Any steelhead harvested in the Yakima River Sport fishery would be harvested illegally. As such, this analysis does not assign a value to steelhead harvested in this fishery.

2.1.5 Additional Annual Fish Harvest by Fishery Resulting from the Integrated Plan

Table 9 summarizes each fishery's anticipated percentage of the expected total increase in harvest resulting from the Integrated Plan. The last column in the table shows the total annual increase in harvest, by fishery, associated with the Integrated Plan once populations stabilize (in 2042). The bottom row in the table shows the total annual increase in harvest by species, at the stabilized population after 2042.

Table 9. Distribution of Harvest Across Fisheries by Species

Harvest Category	Coho	Spring Chinook	Fall Chinook	Steelhead	Sockeye	Total Increase in Harvest[a]
Ocean Commercial	24%	4%	3%	-	-	179–1,341
Ocean Sport	36%	-	3%	-	-	170–1,177
Lower Columbia Commercial	10%	5%	8%	3%[b]	2%	948–3,237
Lower Columbia Sport	15%	12%	8%	3%[b]	2%	1,077–4,279
Columbia Tribal Commercial	11%	7%	53%	62%	30%	11,377–29,919
Columbia Tribal Ceremonial and Subsistence	> 1%	27%	3%	3%	-	429–3,601
Yakima Sport	3%	10%	23%	28%[c]	65%	23,291–54,640
Yakima Tribal Ceremonial and Subsistence	-	35%	-	-	-	527–4,408
Total Increase in Harvest[a]	420–2,786	1,497–12,524	664–6,342	316–2,451	35,100–78,500	37,997–102,603

Source: Hubble, 2012

[a] Values may not sum to the totals presented here due to rounding.

[b] Steelhead are not targeted in the Lower Columbia River. The incidental harvest, shown in this table, is not considered in the economic analysis.

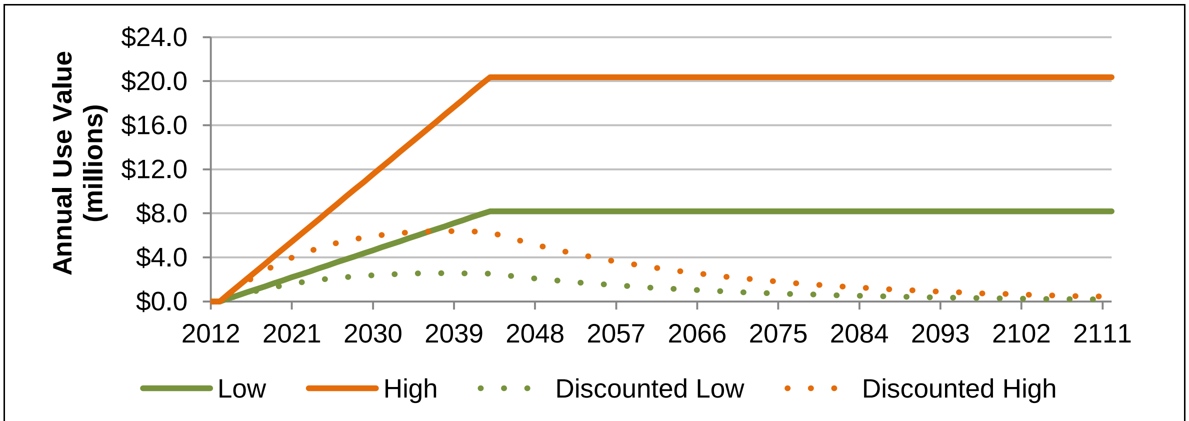
[c] While steelhead harvest in the Yakima Sport fishery are included in this table, they are not considered in the economic analysis because they are harvested illegally.

2.1.6 Total Use Value

To estimate the total use value associated with the Integrated Plan's impact on fish populations, the annual species- and fishery-specific harvests are multiplied by the relevant use values. These annual use values accumulate over time. The present value of the future stream of values reflects a discount rate of 4.0 percent per year.[14] Figure 6 shows the annual use values of the Integrated Plan's fish-related benefits over a 100-year period (2012–2111). The solid lines represent un-discounted annual values in 2012 dollars. The dashed lines represent discounted annual values. Orange lines represent high-end potential increases in fish populations and green lines represent low-end potential increases in fish populations. As shown at the bottom of Figure 6, the present value of use values attributable to the Integrated Plan's impact on fish populations for the 100-year period is about $0.1–$0.3 billion. As noted previously, this is a component of the total fish-related benefits, rather than an additional benefit.

[14] This is the discount rate applicable to NED analysis of water-resource projects in 2012 retrieved from: 76 Federal Register 73674 (November 29, 2011).

Figure 6. Annual Use Values Derived from the Implemented Plan's Potential Impact on Fish Populations



Overall Present Value (discounted)	$0.1–$0.3 billion

2.1.7 Summary of Fish-Related Benefits

Fish-population modeling determined that it is reasonable to assume implementation of the Integrated Plan would cause annual populations of catchable adult salmon/steelhead produced by the Columbia River Basin to increase beginning in 2013, with the increase leveling off at 181,650–472,450 additional fish in 2042 (Hubble, 2012). Table 10 shows two estimates of the present value of households' willingness to pay for the expected increases in salmon/steelhead populations: $3.1–$4.6 billion, accounting for only households in Washington, and $5.0–$7.4 billion accounting for households in Washington and Oregon. Both estimates underestimate the full value, from a national perspective, of the increase in salmon/steelhead populations.

Table 10. Summary of Fish-Related Benefits

Value Category	Washington Only	Washington and Oregon
Total Economic Value	$3.1–$4.6 billion	$5.0–$7.4 billion
Use Value	$0.1–$0.3 billion	$0.1–$0.3 billion
Passive-Use Value	$3.0–$4.3 billion	$4.9–$7.1 billion

The increases in future salmon/steelhead populations would potentially support increases in fish harvests and in the associated use values. Under expected fish-harvest regimes, annual fish harvests would increase to 37,997–102,603 fish by 2042. Table 10 shows the use values associated with the additional annual harvests have a present value of $0.1–$0.3 billion. This estimate is independent of the estimate of total economic value and, hence, of the number of households used to calculate total economic value. The estimate of use value is a component of, not an addition to the estimate of total value. The difference between total value and use value represents the passive-use value of the increases in salmon/steelhead populations expected to result from the Integrated Plan. The passive use value is estimated to be $3.0–$4.3 billion, when total value reflects just Washington households, and $4.9–$7.1 billion, when total value reflects Washington and Oregon households combined.

2.2 Irrigation Benefits

If implemented, the Integrated Plan would generate two types of irrigation-related benefits that are considered in this analysis: (1) it would stimulate market-based reallocation of water between irrigators, resulting in more transfers than otherwise would occur, and moving water from production of lower-valued crops to higher-valued crops; and (2) it would increase the supply of water available to irrigators during a severe drought. This section first describes the setting and outlines the analytical approach, assumptions, and scenarios applied in the analysis. Then it describes the anticipated annual net farm earnings under two scenarios, with and without the Integrated Plan, and projects those benefits over the next 100 years. The section concludes with a discussion of the Integrated Plan's potential effects on the broader market for agricultural products during severe droughts.

The results of this analysis show that, once fully implemented, the Integrated Plan could increase annual net farm earnings during a severe drought year to very near the values expected during an average non-drought year without the Integrated Plan. Over the next 100 years, the overall present value of the Integrated Plan's irrigation-related benefits, discounted at 4.0 percent, is about $0.8 billion (in 2012 dollars).

2.2.1 Setting

Irrigated agriculture is the largest user of water in the Yakima River Basin. Most of the water used for irrigation is provided by the Yakima Irrigation Project (Yakima Project), which is operated by Reclamation. The Yakima Project provides water to six irrigation divisions: Kittitas, Roza, Tieton, Wapato, Sunnyside, and Kennewick. The first five in this list, except Kennewick, would be most directly affected by the Integrated Plan. They have 81 percent (1,938,300 acre-feet) of the total entitlements (2,406,917 acre-feet) to water in the Yakima, Tieton and Naches Rivers above the Parker gage (Reclamation and Ecology, 2011a).

The amount of land that can be irrigated in the Yakima River Basin is limited. Federal law constrains the amount of land served by the Yakima Project, and the available water supply limits the amount of land that can be irrigated outside the Yakima Project. The Yakima Project currently supports irrigation for 383,000 acres (Reclamation and Ecology, 2011a). Because of the constraints on irrigated acreage, the Integrated Plan assumes acreage available for irrigated agriculture in the basin would not expand in the future, and it aims to improve reliability of irrigation supplies, but not to bring about expansion of irrigated acreage.

The reliability of water supplies for irrigators served by the Yakima Project differs considerably for two groups of irrigators. Water rights associated with the Yakima Project fall into two classes: non-proratable and proratable. Non-proratable water rights are more senior and have priority dates prior to May 10, 1905. These rights are served first from the Total Water Supply Available (TWSA), which Reclamation defines each year based on reservoir storage, runoff forecast, and return flow estimates. Proratable water rights, however, have a priority date of May 10, 1905. When the TWSA cannot fully serve both groups, it goes first to satisfy the non-proratable water rights insofar as possible, with any remainder shared by the proratable water rights. In each of the droughts occurring in recent decades, Reclamation has been able to fully supply non-proratable water rights, but proratable water rights have received reduced (prorated) supplies, as low as 37% of normal supply. The Integrated Plan aims to improve the reliability of supplies for irrigation users with proratable water rights.

The primary concern about water-supply reliability involves the five irrigation districts above the Parker gage: Roza Irrigation District (Roza), Kittitas Reclamation District (Kittitas), Sunnyside Valley Irrigation District (Sunnyside), Wapato Division (Wapato), and Yakima-Tieton Irrigation District (Tieton).[15] To facilitate the presentation, the following discussion refers to each of these entities as a district. The concern narrows further, to Roza, Kittitas, and Wapato Districts, insofar as Sunnyside and Tieton have stated they do not need additional water during drought periods even though they have proratable entitlements (Reclamation and Ecology, 2011a). Table 11 compares the proratable water rights for the three districts with the rest of the Yakima Project entitlements above the Parker gage. Kittitas, Roza, and Wapato Districts hold 82 percent of the total proratable water rights above the Parker gage. They hold 96 percent of the proratable water rights above the Parker gage, exclusive of Sunnyside and Tieton Districts.

Table 11. Proratable Water Rights above Parker Gage

Irrigation Districts	Proratable Entitlements (acre-feet)	% of Total Proratable Entitlements	
		Total	Not Including Sunnyside and Tieton
Roza	393,000	30%	35%
Wapato	350,000	27%	31%
Kittitas	336,000	26%	30%
Subtotal	*1,079,000*	*82%*	*96%*
Sunnyside	157,776	12%	0
Tieton	30,425	2%	0
Subtotal	*1,267,201*	*97%*	*96%*
Non-Division Entitlements	42,874	3%	*4%*
Total	1,310,075	100%	100%
Source: Adapted from Reclamation and Ecology, 2011a.			

2.2.2 Analytical Approach

To estimate the irrigation-related economic benefits of the Integrated Plan, this analysis describes its potential impacts on net farm earnings, consistent with the *Principles & Guidelines*. As described in the *Principles & Guidelines*, the Integrated Plan's potential impacts on net farm earnings represent damage reduction benefits in the form of increased agricultural production in the form of a more reliable water supply. The analysis first computes the direct increase in net farm earnings for irrigators in the Yakima Project who would enjoy greater reliability of water supplies because of the Integrated Plan. It then considers the potential for indirect impacts on the net farm earnings of other crop producers who might see lower prices for their crops because of the higher production of the direct beneficiaries.

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[15] The analysis does not include Kennewick Irrigation District because it typically does not experience reduced water availability during a severe drought that affects other districts.

The analysis has these four components (additional details are available in Appendix B):

1. Scenarios that support comparison of net farm earnings with vs. without the Integrated Plan.
2. A spreadsheet model that estimates each district's net farm earnings by simulating irrigated acreage and net farm earnings, by crop, by district, for a specified level of water availability and a given extent of market reallocation of water from lower- to higher-value crops.
3. Current data on crops, crop-irrigation requirements, crop prices, and variable crop-production costs.
4. Estimates of the elasticity of price with respect to level of production, by crop.

The following discussion presents information on the scenarios and spreadsheet model.

2.2.2.1 Scenarios

The analysis incorporates the two scenarios summarized in Table 12. The top section shows the Baseline Scenario, without the Integrated Plan. In a non-drought year all irrigators in the five districts would have enough water to satisfy their irrigation requirements. During a severe drought year, water supplies would satisfy the entitlements of non-proratable irrigators, but proratable irrigators would receive less than their full entitlement. Recent severe droughts have seen proratable irrigators receive as little as 37 percent of their full entitlement. With expectations that future droughts may be exacerbated by changes in climate, this analysis assumes future severe droughts would see proratable irrigators receiving only 30 percent of their full entitlements. To lessen the impacts of the severe drought, irrigators would lease 30,000 acre-feet of water to other irrigators, with the water shifting from lower-value to higher-value crops.

The bottom section of Table 12 describes conditions with implementation of the Integrated Plan. This scenario entails staged implementation of different components of the Integrated Plan, involving increased market-based reallocation of water from lower- to higher-value crops during severe drought years, as well as increased water supplies, so the amount of water available to proratable irrigators during severe drought years rises from 30 percent to 70 percent of their full entitlements.

Table 12. Scenarios Used in the Analysis of Irrigation-Related Benefits

Baseline Scenario (without the Integrated Plan)

• During non-drought years, TWSA would be sufficient to satisfy the full entitlement for all non-proratable and proratable irrigators in the Yakima Project.
• Consistent with historical experience, severe, 1-year droughts would occur every 5 years. A severe, 3-year drought would occur every 20 years.
• During a severe drought year:
  o TWSA would be sufficient to satisfy all non-proratable irrigators in the Yakima Project, but proratable irrigators would only receive 30 percent of their full entitlement.
  o Inter-district leasing of water would reallocate about 30,000 acre-feet of water among Kittitas, Roza, and Sunnyside Districts. Additionally, intra-district trading would occur in all five districts.

Integrated Plan Scenario

• During non-drought years, TWSA would be sufficient to satisfy the full entitlement for all non-proratable and proratable irrigators in the Yakima Project.
• Frequency and duration of severe droughts would be the same as in the Baseline Scenario.
• During a severe drought year:
  o All irrigators in the five districts would be willing to sell or buy water for short-term lease when the water supply available to them falls below crop-irrigation requirements of the crops they are producing.
  o Irrigators experiencing reduced supplies would use water to satisfy crop-irrigation requirements of their higher-valued crops as much as possible, leaving other acreage fallow, and would receive no net farm earnings from fallowed land.
  o Because of their topographical and infrastructure characteristics, Tieton and Wapato Districts would conduct only intra-district trading within each district; Kittitas, Roza, and Sunnyside Districts would conduct both intra- and inter-district trading. Buyers would lease water only for crops with annual net farm earnings of at least $150 per acre-foot. Irrigators in Roza, Kittitas, and Sunnyside Districts would lease no more than 10 percent of each district's water supply to irrigators in another district.
  o The Integrated Plan would increase the supply of water beginning in 2018, with the amount ramping-up, as the various storage projects come on line under the schedule in the proposed Integrated Plan until 2026, when the Yakima Project would deliver 70 percent of proratable entitlements during a severe drought year.
  o The Integrated Plan would yield no irrigation-related benefits until 2013. Potential benefits from market-based reallocation of water would ramp up, beginning in 2013, rising to one-half of the full potential in 2017 and remain constant thereafter. This represents an assumption that it will take approximately five years to bring market reallocation practices to full implementation, and that achievement of the market reallocation potential as modeled may not be fully achievable.

2.2.2.2 Spreadsheet Model of Direct Irrigation Benefits

A spreadsheet model was developed to estimate each district's net farm earnings, with and without the Integrated Plan, under non-drought and severe drought conditions. The model identifies the allocation of available water across crops and districts that, given identified constraints, would maximize annual net farm earnings under optimal market conditions. The model structure is adapted from a model developed by researchers at the Pacific Northwest National Laboratory, who used it to describe opportunities for market-based transfers to mitigate the impacts of drought on agricultural production in the Yakima River Basin and to increase the overall value of agricultural earnings derived from the basin's water resources (Scott et al., 2004; Vano et al., 2009).

Crops. The model assumes irrigators in the five districts grow these 17 different crops (in some cases, types of crops) and that irrigators do not change what crops they grow over time.

- Other vegetables
- Other grain
- Concord grapes
- Sweet corn
- Other hay
- Alfalfa hay
- Wine grapes
- Hops
- Miscellaneous
- Asparagus
- Timothy hay
- Pasture
- Apples
- Potatoes
- Other tree crops
- Mint
- Wheat

The model assumes crops have different water needs, depending on the district in which they're grown and reflecting past water demand and irrigation technology. During an average, non-drought year, the model assumes all irrigators have sufficient water to satisfy their irrigation requirements. During drought years, when water supplies are restricted, the model assumes water is traded from crops with low annual net farm earnings to crops with high annual net farm earnings (within the constraints of the given scenario).

Fixed Variables. The model relies primarily on annual net farm earnings (in terms of dollars per acre-foot) to distribute water from low-value crops to high-value crops. The model also directly or indirectly uses several other fixed variables, by crop, including:

- Total irrigable acres
- Average yield (output units/acre)
- Annual variable cost (dollars/acre)
- Average price (dollars/output unit)
- Water diversion demand (acre-feet/acre)

Consistent with the *Principles & Guidelines,* whenever possible this analysis uses normalized crop prices issued by the U.S. Department of Agriculture for all relevant crops (U.S. Department of Agriculture, National Agricultural Statistics Service, 2011a). For some crops, however, the U.S. Department of Agriculture does not provide normalized crop prices. In those instances, this analysis uses statewide average prices over the previous three years (U.S. Department of Agriculture, National Agricultural Statistics Service. 2011b). Annual variable costs were compiled from crop-specific enterprise budgets (Washington State University Extension, Various Years) and from Reclamation (2008). In all cases, crop prices and variable costs were adjusted to 2012 dollars using the commodity-specific producer price index from the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2012).

Adjustable Variables. The model has three adjustable variables, which it uses in accounting for the different components of the Integrated Plan as they are implemented.

1. The degree of the constraint on water supply during a severe drought year (percentage of full entitlement available to proratable irrigators).
2. Minimum annual net farm earnings (dollars per acre-foot) for crops receiving water through market-based water reallocation. This variable recognizes that irrigators are unlikely to purchase water during a severe drought to irrigate low-value crops.
3. Maximum volume of inter-district trading for Roza, Kittitas, and Sunnyside Districts (percent of available water that can be traded outside the district). This variable recognizes and avoids the potential adverse impacts on the districts' operations that can occur if trades disrupt normal operating procedures and characteristics.

Output Variables. The model has three output variables: (1) annual net farm earnings, (2) volume of intra-district trading, and (3) volume of inter-district trading. The model produces these output variables, at the district level, for the Baseline and Integrated Plan Scenarios described in Table 12.

Additional details describing the spreadsheet model and the data it uses are in Appendix B.

2.2.3 Direct Irrigation-Related Benefits

This section describes the effects of the Integrated Plan on the net farm earnings of irrigators in the five districts. It first describes what the effects would be during a severe drought year if the Integrated Plan were fully implemented. It then describes the expected effects over the next 100 years, as different elements of the Integrated Plan become operational and severe drought years occur at a rate similar to recent experience. It concludes with a sensitivity analysis describing the irrigation-related benefits, over the next 100 years, assuming higher and lower restrictions during severe droughts, accounting for the potential impact of climate change.

2.2.3.1 Benefits of the Integrated Plan During a Severe Drought Year

The first two rows in Table 13 summarize net farm earnings in the five districts under the Baseline Scenario during drought and non-drought years. During an average non-drought year, all irrigators would receive water equal to their full entitlement and net farm earnings would total $480 million. During a severe drought year, non-proratable irrigators would receive water equal to their full entitlement, but proratable irrigators would receive water equal to 30 percent of their entitlement, market-based reallocation of water would result in inter-district trading of 30,000 acre feet, and net farm earnings would fall $160 million, to $320 million. With full implementation, the Integrated Plan would generate direct economic benefits by eliminating these losses. Under the Integrated Plan, non-proratable irrigators would receive water equal to their full entitlement during a severe drought year; proratable irrigators would receive water equal to 70 percent of their entitlement, which would be sufficient for them to sustain output; market-based reallocation of water (beyond what would occur in the Baseline Scenario) would involve inter-district trades of 30,000 acre-feet and intra-district trades of about 110,000 acre-feet; and annual net farm earnings would fall $10 million, to $470 million (see the third row in Table 13). The increase, relative to the Baseline Scenario, of $150 million in net farm earnings during a severe drought year, from $320 million to $470 million, represents the direct-irrigation benefit of the Integrated Plan.

The Integrated Plan would achieve net earnings under drought conditions that are nearly equivalent to non-drought conditions under the Baseline Scenario by providing additional water supply, concentrating production under scarce conditions in the most profitable crops, and temporarily eliminating production of the least profitable crops. In particular, it results in reducing the application of water to irrigate crops that would generate little or no net farm income and using the water, instead, to irrigate crops that can generate substantial net farm income.

Table 13. Annual Net Farm Earnings during a Severe Drought Year for Baseline and Integrated Plan Scenarios

Scenario	Percent of Proratable Entitlements Received	Water Traded (acre-feet)		Total Annual Net Farm Earnings (millions)	
		Intra-District	Inter-District	Total	Loss from Drought
Baseline Scenario (Average Non-Drought Year)	100%	-	-	$480	Zero
Baseline Scenario (Severe Drought Year)	30%	-	30,000	$320	-$160
Integrated Plan Scenario (Severe Drought Year)	70%	110,000	30,000	$470	-$10

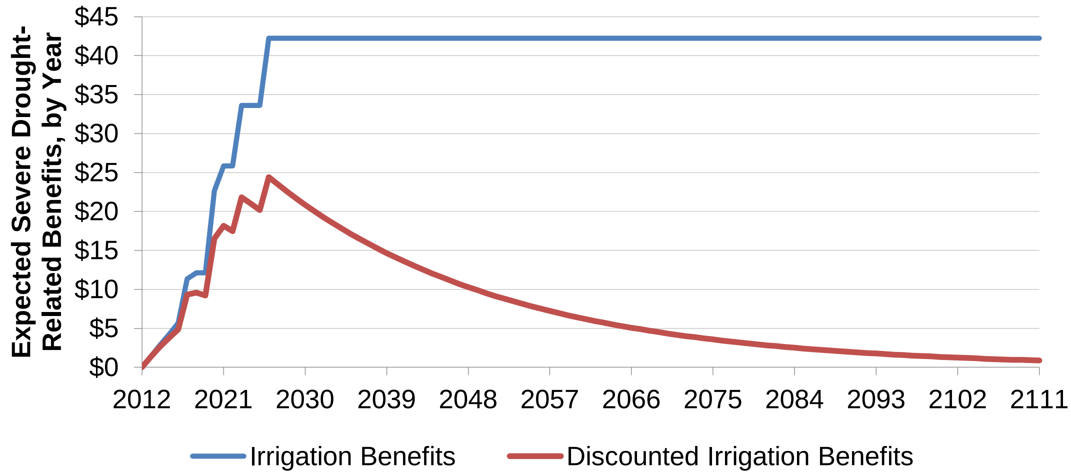
These results are sensitive to the absolute and relative net earnings per acre of each crop and district combination. Net earnings are a function of costs and prices. As costs rise, or prices fall, net earnings fall, and *vice versa*. If net earnings rise uniformly across crops and districts, the model assumes water allocation would not change, and overall net earnings would increase. If net earnings uniformly fall, overall net earnings would fall and the water allocation can change if individual crops drop below the net earnings threshold that makes purchasing water feasible, so that the irrigator makes the water available for other crops. If relative net earnings values among different crops change, water allocation and overall net earnings can change. For any particular scenario, there is a threshold, for each crop-district combination that determines if the crop is irrigated or not. If the net farm earnings of a crop-district combination fall above the threshold, the model assumes irrigators apply water for which they have rights, or purchase water to produce the crop. Conversely, if the net farm earnings of a crop-district combination fall below the threshold, it assumes irrigators forgo production of the crop and an irrigator with rights to water makes it available for irrigating another crop with higher net farm earnings. Hence, the overall net earnings will move in concert with net farm earnings for each irrigator, all else held constant, and if that movement leads to crossing the buyer-seller threshold, water allocation among crop-district combinations can change as well.

2.2.3.2 Benefits of the Integrated Plan over the Next 100 Years

Once it is fully implemented, the Integrated Plan would increase annual net farm earnings for the beneficiary irrigators by $150 million during a severe drought year. Based on conditions in the Yakima Project since the 1970s, the model assumes drought years would occur, on average, every five years, with a three-year severe drought occurring every 20 years. The full benefits of the Integrated Plan would not materialize immediately, but ramp-up until 2026. Figure 7 accounts for these factors and shows the anticipated pattern of the Integrated Plan's irrigation-related benefits over the next 100 years.[16] The blue line shows those values in undiscounted 2012 dollars. The red line shows the present values, discounted at 4.0 percent per year to 2012. The overall, present value of the potential, irrigation-related benefits over the 100-year period is about $0.8 billion (in 2012 dollars).

[16] See Appendix B for more details.

Figure 7. Potential Irrigation-Related Benefits of the Integrated Plan (millions)



See Appendix B for more details.

2.2.3.3 Sensitivity Analysis – Climate Change

Without the Integrated Plan, the Baseline Scenario assumes that, during severe drought years, water supplies would be sufficient to satisfy all non-proratable irrigators in the Yakima Project and 30 percent of all proratable entitlements. Severe droughts could, however, result in more or less intense restrictions on proratable irrigators. Models estimating the potential impacts of climate change on water supply availability in the Yakima Project suggest that proratable irrigators could receive only 9 percent of their entitlements during severe droughts (under a moderately adverse climate change scenario) or no water at all (under a more extreme climate change scenario) (Reclamation and Ecology, 2011b).

In this section, the amount of water available to proratable irrigators during severe drought years is adjusted to account for the potential impacts of climate change (see Table 14). As previously described, assuming that proratable irrigators receive 30 percent of their entitlements during severe drought years without the Integrated Plan, the 100-year net present value (NPV) of irrigation-related benefits derived from Integrated Plan (which would provide proratable irrigators with 70 percent of their entitlements) is about $0.8 million. If, however, proratable irrigators were to receive only 20 percent of their entitlements during severe drought years without the Integrated Plan, the 100-year NPV of irrigation-related benefits rises to $0.9 billion. If proratable irrigators were to receive 40 percent of their entitlements during severe drought years without the Integrated Plan, the 100-year NPV of irrigation-related benefits falls to $0.6 billion.

Table 14. Irrigation-Related Benefits Assuming a Range of Severe Drought Conditions

Percent of Entitlements Proratable Irrigators Receive during Severe Drought Years		100-Year NPV of Irrigation Related Benefits
Without the Integrated Plan	With the Integrated Plan	
30%	70%	$0.8 billion
20%	70%	$0.9 billion
40%	70%	$0.6 billion

2.2.4 Benefits from the National Perspective

If the increased value of crop production realized by beneficiary irrigators in the five districts would have no effect on the value of crop production elsewhere, then the direct benefits described in the preceding section would equal the irrigation-related benefits from the national perspective prescribed for the NED account by the *Principles & Guidelines*. If the Integrated Plan would affect not just the value of crop production in the Yakima Project but also the value outside it, then the NED benefits would differ from the direct benefits. An effect outside the Yakima Project could occur through the so-called price effect, with an increase in the supply of a given crop resulting from the Integrated Plan lowering the market price for the crop in a larger market and, hence, lowering the value of the crop produced elsewhere.

The Integrated Plan would both increase the water available for irrigation during drought conditions, and change the composition of crop production during drought conditions. The net effect would be an increase in the total value, relative to the Baseline Scenario, of crop production in the project area during drought conditions, and an increase in the share of high value crops relative to low value crops. In theory, for a given market demand for these crops, increased crop availability would lead to decreased prices for them, and *vice versa*. Several factors, however, determine whether or not this price effect would actually occur and its effect on producers across the U.S.

If the price effect were to materialize under the Baseline Scenario, a severe drought year would result in reduced production of a given crop within the project area and, hence, a higher price in the regional market. This effect would depend on the extent to which demand is inelastic[17] with respect to price. Inelasticity can occur because the cost, even with increased prices, is not a substantial share of budget for consumers, or the cost is not high relative to the benefit consumers derive from the crop. Inelasticity also can stem from limited availability of adequate substitute goods, so that buyers are willing to maintain their purchases despite higher prices because they do not have good alternatives. To the extent that none of these conditions hold, prices are less likely to change with changes in supply. Other factors, such as long-term contracts between farmers and processors, can also maintain price stability over short periods of time.

Beyond the local region, reductions in the supply of a given crop produced in the Yakima River Basin likely would influence prices elsewhere in a similar manner, to the extent the above conditions hold and the basin represents a substantial share of the overall market. Staple agricultural goods, such as grains, corn, and soybeans tend to have particularly inelastic demand, while non-staples, such as fruits and vegetables tend to have more elastic demand.

The first step in considering the potential for the Integrated Plan to affect prices within the Yakima River Basin and beyond entails considering, for each crop, the basin's share of production relative to the overall production in the state, multi-state area, and nation as a whole. Table 15 shows agricultural production by crop in the project area and beyond, in terms of acres, in 2007. The first column shows a range of crop types that include many crops grown in the five

[17] "Inelastic" with respect to price means that the quantity purchased by customers does not change very much with a change in the price of a product.

affected irrigation districts. The other columns depict the production in the three counties that overlap with the Yakima River Basin—Kittitas, Yakima, and Benton—and the percentage that this production represents of the total production of the State of Washington, the three-state region (Washington, Oregon, and Idaho) and the Nation.

In general, the three counties' production of each crop represents a small percentage of national production. Table 15 shows that the 3-county area's production of staple crops, such as the grasses and grains, makes up a moderate share of state and regional total production, but relatively small shares at the national level. Other, more specialized crops make up an increasing share of the regional and national share of production, topped by hops at 77 percent of national production originating in the 3-county area, followed by apples at 23 percent. These suggest that changes resulting from the Integrated Plan in the production of crops, such as hops and apples, are most likely to influence national prices. If so, then the plan's irrigation-related benefits from a national perspective would be smaller than shown above, because the increase in crop production resulting from the plan during a severe drought year would be offset to the extent that the lower prices would reduce the value of the same crop grown elsewhere in the U.S.

Table 15. 2007 Agricultural Production

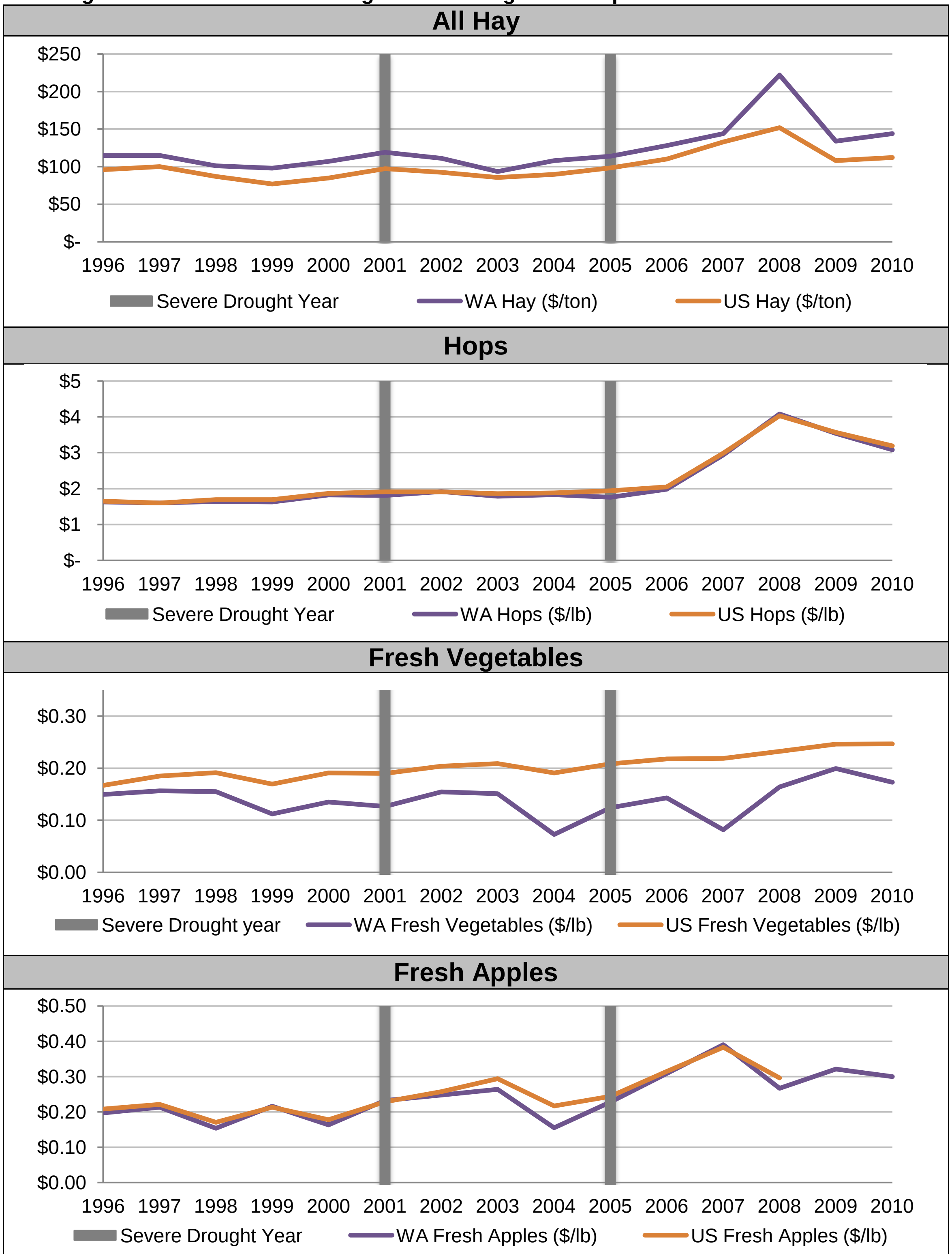
Crop	3-County Total	3-County as % of Washington	3-County as % of 3-State	3-County as % of Nation
Apples (millions of pounds produced)	2,062	40%	38%	23%
Hops (millions of pounds harvested)	47	100%	77%	77%
Mint for Oil (millions of pounds of oil)	2	43%	24%	20%
Asparagus (millions of pounds)	11	36%	N/A	9%
Alfalfa Hay (millions of dry tons)	< 1	13%	4%	> 1%
All Hay (millions of dry tons)	< 1	14%	4%	> 1%
Wheat for Grain (millions of bushels)	7	6%	3%	> 1%
Potatoes (millions of pounds)	1,866	20%	< 1%	> 1%

Source: Adapted from U.S. Department of Agriculture, National Agricultural Statistics Service, 2009a; U.S. Department of Agriculture, National Agricultural Statistics Service, 2009b; U.S. Department of Agriculture, National Agricultural Statistics Service, Economic Research Service, 2012.

Notes: This table contains only a subset of the crops grown in the Yakima Project. Data are insufficient to calculate production volumes for all crops grown in the Yakima Project for all of the relevant geographies (Washington, the three-state area, and the Nation). Table B-6 in Appendix B contains more data describing the crops grown and harvested across the Nation in terms of acres.

The Integrated Plan likely would not have national price effects, however, if local crop prices are not sensitive to changes in water scarcity typically experienced during severe droughts. Severe droughts occurred in the Yakima River Basin in both 2001 and 2005. Crop prices locally, and nationally, however, did not demonstrably increase during those years relative to existing trends, as Figure 8 shows.

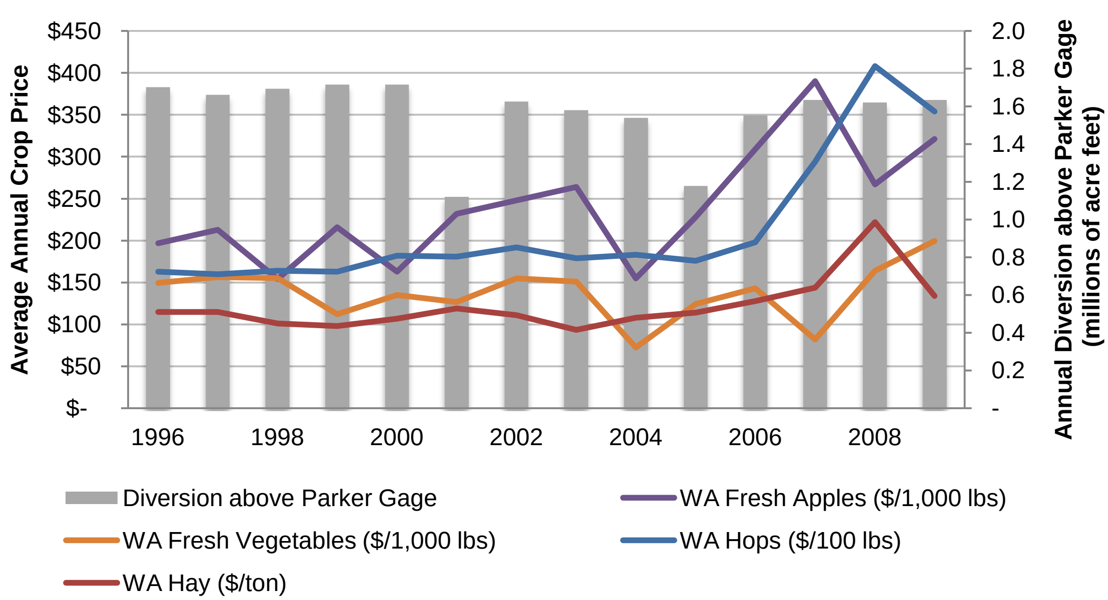
Figure 8. Average Annual U.S. and Washington Marketing Year Crop Prices



Source: Adapted from Hop Growers of America, 2005; U.S. Department of Agriculture, National Agricultural Statistics Service, 1999-2011a; U.S. Department of Agriculture, National Agricultural Statistics Service, 1999–2011b; U.S. Department of Agriculture, National Agricultural Statistics Service, 1999-2011c; U.S. Department of Agriculture, National Agricultural Statistics Service, Washington Field Office, *No Date*.

To the contrary, Figure 9 suggests that, for the State of Washington as a whole, drought years did not result in price peaks, or decadal maxima, and generally fell below the average for the period of 1996-2010. The data in these figures do not demonstrate that, but for the droughts, prices would not have been even lower during those years, but they do not suggest as much. The data do show that local and national prices have tended to be closely correlated for the crops, hops and apples, where the state's production represents a large share of national production. But non-drought factors seem likely to be the primary drivers for the pattern of fluctuation in prices for these crops. Overall, these data suggest that drought conditions in the Yakima River Basin do not tend to drive up crop prices in the 3-county area; the State of Washington; the three-state region of Washington, Oregon and Idaho; or the Nation as a whole. Overall, these data suggest that the Integrated Plan, by increasing the supply of water available to proratable irrigators in the three districts, relative to recent historical market and drought conditions, would not substantially reduce crop prices, relative to the Baseline Scenario, at the national, regional, or local scale.

Figure 9. Water Availability and Washington Crop Prices



Source: Adapted from Reclamation, 2010; Reclamation and Ecology, 2011a; and data from previous figures.

These historical data collectively suggest that water scarcities experienced in the Yakima River Basin over the last 10 years have not resulted in price increases locally or nationally, relative to existing trends. A more comprehensive econometric assessment could include a more complete production model for each crop to assess the trends in scarcity and cost of other agricultural inputs, to assess if countervailing trends in these other inputs mask water scarcity effects. Currently available literature, however, does not reveal any obvious candidates for such countervailing trends, and data for such production function modeling at the basin-level are not readily available. Alternatively, empirical crop-specific elasticity estimates could support estimation of national level price effects. Recent demand elasticity estimates for the irrigated crops produced in the Yakima Project are not available, however.

In sum, the available evidence supports the conclusion that the irrigation benefits of the Integrated Plan, viewed from the national perspective of the NED account are the same as, or close to, the direct benefits realized by the beneficiary irrigators in the three irrigation districts. The overall, present value of the potential, irrigation-related benefits over the 100-year period is about $0.8 billion. Several factors create uncertainty regarding the accuracy of this estimate. They include the possibility that future years will see irrigators planting a different mix of crops, selling their crops for different prices, and incurring different variable production costs than those incorporated into the analysis. Insufficient data currently exist to quantify these factors. They are unlikely, in the aggregate, to yield a lower value for the irrigation-related benefits of the Integrated Plan, however. The U.S. Department of Agriculture projects that "following near-term reductions from record levels reached in 2011, the values of U.S. agricultural exports and net farm income each rise over the rest of the decade," and there are no apparent reasons to expect this trend would reverse itself in subsequent years (U.S. Department of Agriculture, 2012).

2.3 Municipal and Domestic Water Supply Benefits

This section describes the NED benefits associated with municipal and domestic uses expected to result from implementation of the Integrated Plan. In this study municipal uses refer to all residential, commercial, industrial, and government uses of the community water systems in the Yakima River Basin that supply drinking water to consumers. Domestic uses refer to the household consumption of water supplies by the owners of domestic wells in the basin.

2.3.1 Future Without the Integrated Plan

In 2010, municipal and domestic users in the Yakima River basin used approximately 91,000 acre-feet of water. Of this amount, 46 percent (42,000 acre-feet) represents municipal demand of the six main cities in the basin, 17 percent (15,000 acre-feet) is demand of small public water systems, and 37 percent (34,000 acre-feet) represents the use of domestic-well owners. The municipal users obtain water from surface and groundwater, while domestic wells rely exclusively on groundwater. Sixty percent of the supplies that go to municipal and domestic uses are non-consumptive and either return to stream channels in the Yakima River Basin as return flow or recharge the underlying aquifer (Reclamation and Ecology, 2011a).

Future changes in municipal and domestic uses will likely be highly dependent on population growth, land use types, and type of infrastructure used to convey water from the source to the points of demand. The current population served by municipal public water systems and domestic in the basin was estimated at 326,000 in the year 2010 and includes the populations of Benton, Kittitas, and Yakima counties. This estimate excludes the populations of Kennewick, Richland, and West Richland (all located in Benton County), as their potable water comes from the Columbia River and groundwater outside the Yakima River Basin. By 2060, the population is projected to increase to 590,000 if no constraints on growth from water supplies occur (Reclamation and Ecology, 2011a). While the latest recession may have decreased the population growth below the moderate rate of one percent per year assumed in this estimate, future rates of household formation may accelerate and make up for the decrease.

Over the next 50 years, if municipal and domestic uses increase at the same rate as the assumed population growth, the water use rate would increase to approximately 163,000 acre-feet annually. The impact on the basin's overall water supplies likely would not reach this level, because of the effects of anticipated municipal water conservation programs. In addition, some municipal/domestic growth likely would involve urban development on agricultural lands, with some of the water that otherwise would be used for irrigation instead being used for municipal/domestic purposes and the remainder being available for other purposes. Current assumptions about expected population, economic activity, and conservation in the basin suggest that actual municipal/domestic use will rise 48,900 acre-feet above the 2010 level, to 140,000 acre-feet per year, by 2060. Conservation trends independent of the Integrated Plan that improve the technology related to the delivery of municipal water supplies and that include a shift from open canals to piped systems are expected to reduce the daily water use from the current 250 gallons to 234 gallons per-capita by 2060 (Reclamation and Ecology, 2011a).

Water supplies become restricted during dry years when low flows cannot meet all demands. Municipal and domestic uses in the basin are typically junior to irrigation water rights, so their supplies can be reduced when drought occurs (Reclamation, 2008). These circumstances have the potential to cause major disruption of service during severe drought years (Reclamation and Ecology, 2011a). Water shortages for municipal and domestic users occur especially during the irrigation season, when non-proratable water rights tied to agricultural irrigation in the basin have first call on available supplies.

Without the Integrated Plan, municipal and domestic water users who use groundwater above Parker Gage would be particularly vulnerable to disruptions, with major disruptions during severe drought years. In 2010, three municipal systems above Parker Gage—City of Ellensburg, Nob Hill Water Association, and Yakima County Public Works' Terrace Heights system—served about 48,000 people, providing them with about 10,000 acre-feet of water per year. Of these, about 4,000 acre-feet were used consumptively. Domestic wells and small systems using groundwater above Parker supplied about 58,000 people with about 16,000 acre-feet of water per year, of which about 6,500 acre-feet were used consumptively (Graham 2012). The sum of the municipal and domestic consumptive use is about 10,500 acre-feet per year.

Ongoing investigations demonstrate that the groundwater supplies are connected to the basin's surface waters (Vacarro 2011). Under the laws and regulations that allocate the basin's surface water, the municipal and domestic users of groundwater generally have water rights junior to those of proratable irrigators. Therefore, proratable irrigators have the ability to demand that consumptive use of groundwater cease when surface water supplies are insufficient to satisfy their entitlements. Hence, continuation of current groundwater use would require mitigation of its impacts on surface-water users with more senior water rights. Emerging concern about conflict between groundwater users and irrigators with more senior water rights induced Ecology to adopt a permanent rule in December 2010 that allows new groundwater withdrawals in Upper Kittitas County only if they are mitigated and backed by senior water rights (Ecology, 2010).

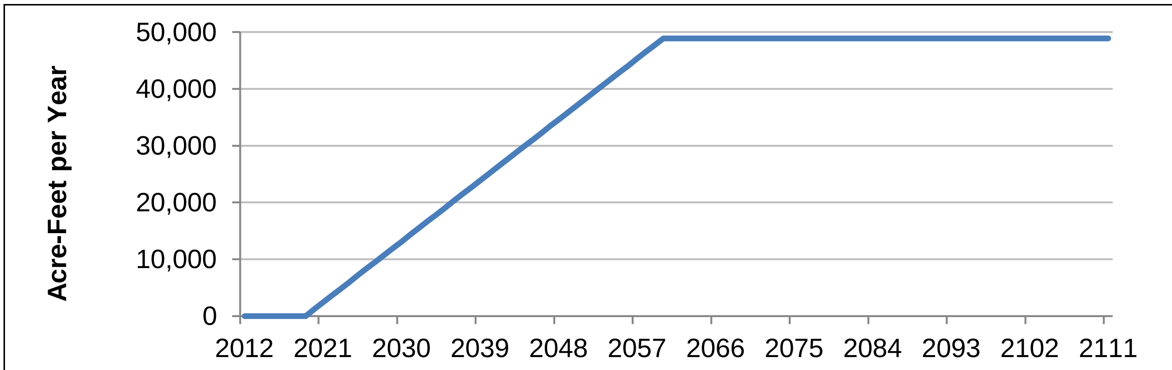
Ecology also has taken steps to facilitate groundwater users' acquisition of senior water rights through voluntary, market-based transactions, but progress has been slow. Such transactions likely would remain severely limited, absent implementation of the Integrated Plan, however, because of structural impediments, which arise from the absence of smoothly operating, permanent institutions—including an information clearinghouse and brokerage, experts providing technical support to buyers and sellers, and an authority to verify the conveyance of transferred water—that are required for a smoothly functioning water market or water bank (Ecology, 2007). The Integrated Plan includes actions to encourage increased market transactions involving water supplies between willing sellers and willing buyers.

Uncertainties about the future reliability of water supplies during drought and non-drought years become more important when accounting for shifts in the variability of precipitation and plant water demand due to climate change. By 2040, climate change is expected to increase the water demand for landscaping and other municipal and domestic outdoor uses by five percent. This rise would reduce return flows and increase the consumptive uses portion of the municipal and domestic water supplies (Reclamation and Ecology, 2011a).

2.3.2 Expected Municipal and Domestic Benefits of the Integrated Plan

The Integrated Plan would yield municipal and domestic economic benefits in two ways. One would materialize as the area's population and economy grow and the Integrated Plan provides water to satisfy demands that otherwise would remain unmet and by increasing the reliability of future water supplies. Increases in supply for municipal and domestic uses are expected to start materializing in 2020 and continue increasing with population growth through 2060, reaching 48,900 acre-feet annually. This study assumes municipal and domestic benefits of the Integrated Plan would continue at the same rate from 2060 through the end of the analysis period in 2111. Figure 10 shows the distribution of municipal and domestic benefits over the 100 years included in this analysis.

Figure 10. Annual Distribution of the Integrated Plan's Municipal and Domestic Water Benefits Associated with New Water Supplies for Future Growth



Source: Adapted from Reclamation and Ecology, 2011a

The Integrated Plan would increase water availability to satisfy future growth in demand for municipal water systems across all three counties in the basin. Half of the new water allocated for municipal needs would be distributed to users across the three counties based on projected growth, while the other half would be made available on a first-come, first-served basis regardless of county (Reclamation and Ecology, 2012a).

The other way in which the Integrated Plan would provide municipal and domestic benefits is by increasing the security of water supplies for the current population and economy. This is especially the case for current municipal and domestic water users above Parker Gage, whose supplies may be affected in light of research findings confirming their water supplies are connected the basin's surface water (Vacarro 2011). Their water rights are generally junior to those of proratable irrigators and most other water users and continued groundwater use may require mitigation of its impacts during future droughts on surface-water users with more senior water rights. Mitigation typically entails acquiring a senior water right for the consumptive use of groundwater. If current municipal/domestic users of groundwater above Parker Gage do not acquire sufficiently senior water rights, they would be vulnerable during future droughts to demands that they reduce water use that impairs the access of proratable irrigators to their full entitlements. Implementation of the Integrated Plan would facilitate the voluntary transfer of senior water rights to cover existing municipal and domestic systems (including small systems) that currently provide groundwater to about 106,000 individuals above Parker Gage who use about 26,000 acre-feet and consume about 10,500 acre-feet per year. By improving the supply of water to proratable irrigators during drought years, the Integrated Plan would lower the risk of litigation against junior ground water users.

The benefits from increased security for existing municipal and domestic users of groundwater above Parker Gage would materialize as implementation of the Integrated Plan lowers three types of barriers to voluntary market-based transactions through which these users would acquire water rights with sufficient seniority to eliminate, or at least greatly reduce, the risk that their use of water would be curtailed during future droughts. The first of these barriers is structural: the absence of a water information clearinghouse and brokerage; legal, hydrological, and other technical expertise; and mechanisms for conveying and verifying the outcomes of water-right transfers. The second is economic: the absence of sufficient water during severe drought years for there to be a large enough pool of irrigators willing to sell water rights with sufficient seniority to provide secure water supplies to municipal and domestic groundwater users above Parker Gage. The third is legal: by increasing the supply of water available to proratable irrigators during drought years, the Integrated Plan would reduce the likelihood that the irrigators would take legal action to force groundwater users to reduce or suspend pumping. Reducing or eliminating the uncertainty and risk associated with legal action would enable municipal and domestic groundwater users to avoid legal expenses and other risk-avoidance costs.

These water-security benefits would materialize as implementation of the Integrated Plan strengthens the basin's water-market institutions and provides additional water supplies. This analysis assumes they would begin in 2013, with the initial implementation of the plan's market-reallocation elements, and grow linearly until they reach the maximum, 10,500 acre-feet in 2030, when additional water supplies from dam construction would become available. The Integrated Plan would produce similar benefits by increasing the security of water supplies for irrigators who currently use groundwater, but insufficient data exist to support calculation of the value of these benefits in this analysis.

2.3.3 NED Value of Municipal and Domestic Water Benefits Associated with New Water Supplies for Future Growth

The calculation of municipal and domestic water benefits associated with future growth in the Yakima River basin entails three steps: (1) estimating the level of benefits and the timeline for the benefit stream; (2) calculating the value of benefits each year they materialize; and, (3) calculating the present, discounted value of the benefits.

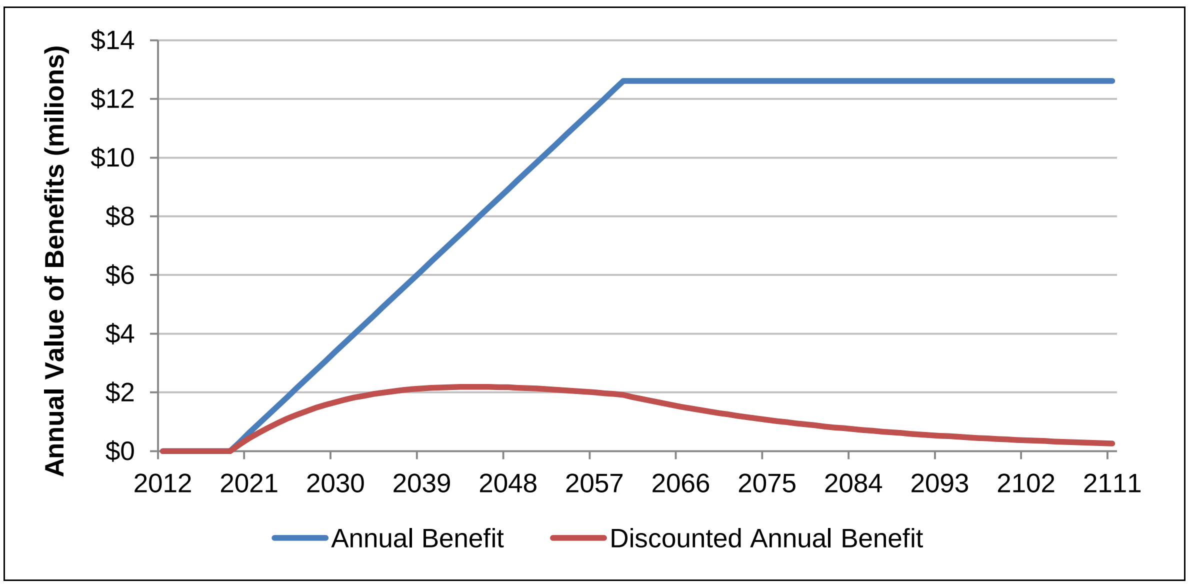
2.3.3.1 Municipal and Domestic Water Benefits Associated with New Water Supplies for Future Growth

These municipal and domestic benefits would start to accrue in 2020 and reach a maximum value of 48,900 acre-feet per year in 2060. This maximum value is maintained through 2111.

2.3.3.2 Annual Value of Municipal and Domestic Water Benefits Associated with Future Growth

For the purposes of this analysis, it is assumed that, absent the Integrated Plan, the water to meet new municipal and domestic demand would come from another source. The most likely alternative is purchasing or leasing water rights from other users in the Yakima River Basin or in other parts of the Columbia River Basin. The value of the municipal/domestic benefits of the Integrated Plan reflects the avoidance of costs to purchase or lease water. This analysis assumes that, absent the Integrated Plan, municipal/domestic users would obtain water from alternative sources at the average wholesale price of municipal water as reflected in transactions in the Pacific Northwest (U.S. Water Resources Council, 1983). This approach is modeled after Reclamation (2008), which estimated the wholesale price of municipal to be $235.66 per acre-foot (in April 2007 dollars). Adjusting for inflation to reflect prices in March 2012 converts this price to about $258 per acre-foot. This is the value employed in the calculations of the value of the Integrated Plan's municipal/domestic benefits associated with future growth.[18] The blue line in Figure 11 represents the value of these benefits, expressed in 2012 prices, as they accrue each year of the analysis period.

Figure 11. Annual and Discounted Value of Expected Municipal and Domestic Benefits Associated with New Water Supplies for Future Growth



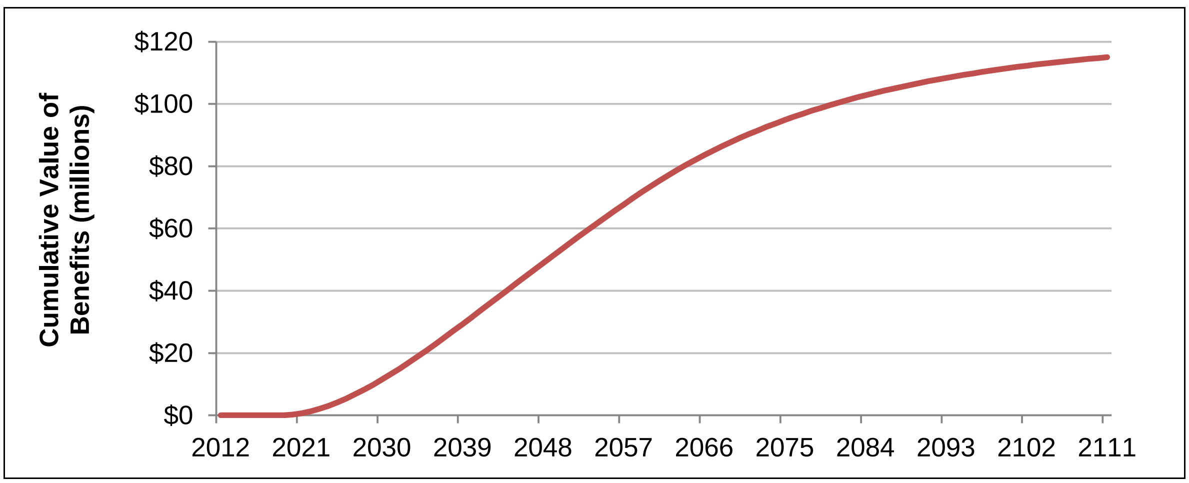
[18] This price represents the value of each acre-foot of water that would be made available for future growth in municipal and domestic use. It is distinct from the price $2,500 per acre-foot for a water right that would give current municipal and domestic water users of groundwater the right (subject to water-allocation rules) to use that amount of water per year, into the future.

2.3.3.3 Present Value of Municipal and Domestic Benefits Associated with New Water Supplies for Future Growth

Assuming a linear increase of water use between 2020, when this category of municipal and domestic benefits start accruing, and 2060, when they peak at 48,900 acre-feet per year, the municipal/domestic uses would grow 1,193 acre-feet per year during this period. Multiplying this rate by the March 2012 water price of $258 per acre-foot means that the value of the benefits would increase by about $308,000 annually. The maximum annual value would be reached in 2060, at about $12,600,000, and would continue at the same value until the end of 2111. As Figure 11 shows, discounting these benefits to 2012 reduces their value.

To estimate the present value of this stream of annual municipal and domestic benefits, this analysis applies a discount rate of 4 percent per year, equal to the discount rate for Federal water resources planning for FY 2012 (Federal Register, 2011). The red line in Figure 11 shows the discounted value of the expected benefits for each year. The overall present value of the municipal-supply benefits is about $115 million in 2012 dollars. Figure 12 presents the accumulation of benefits through 2111.

Figure 12. Cumulative Discounted Benefits of the Integrated Plan Associated with Future Growth in Municipal and Domestic Water Users



2.3.3.4 Sensitivity Analysis of the Economic Values of Municipal and Domestic Benefits Associated with New Water Supplies for Future Growth

The actual value of these benefits could be higher or lower than the estimated value. The estimated value reflects the avoided costs of acquiring water from another source, absent the Integrated Plan. In general, using the avoided costs to estimate the value of these benefits underestimates the true value, all else equal, to the extent that consumers' willingness to pay for new water supplies to satisfy the demands associated with future growth exceeds these costs. The validity of this conclusion is clouded, however, because the data underlying the estimate of avoided costs generally represent administrative prices set by water utilities, rather than market prices, determined under competitive conditions, that indicate consumers' true willingness to pay for the water.

The slowing of population growth associated with the current weakness in the national economy may lead to overestimation of the benefits resulting from new water supplies the Integrated Plan would make available for future population and economic growth. The long-run perspective on growth represented in the analysis assumes that future acceleration in growth will offset, and may exceed, the current, temporary slowing of growth, so that the overall outcome reflects the long-run trend. The timing of the swings in short-run growth rates could cause the present value of these benefits to be higher or lower than the estimated value. If future accelerations in growth occur soon and are large, their positive impact on the present value may more than offset the decrease resulting from the current slower-than-trend growth. The further in the future the occurrence of the accelerations, the more the discounting process would diminish their ability to offset the current decrease.

To capture some of the possible increases in the benefits of new water supplies for future growth in municipal and domestic uses in the future, this analysis estimates the economic value of the benefits by assuming an increase in the real rate of municipal benefits of 1 percent and 2 percent, respectively (Reclamation, Mid-Pacific Region, 2011). Such increases in the price of water for municipalities represent moderate estimates for a period of 100 years but have little impact on the overall present, discounted value. The resulting range in overall discounted benefits is $116-$117 million.

2.3.4 NED Value of Municipal and Domestic Water Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

The calculation of this category of municipal and domestic water benefits associated with current municipal/domestic groundwater users in the Yakima River basin entails three steps: (1) estimating the level of benefits and the timeline for the benefit stream; (2) calculating the value of benefits each year they materialize; and, (3) calculating the present, discounted value of the benefits.

2.3.4.1 Municipal and Domestic Water Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

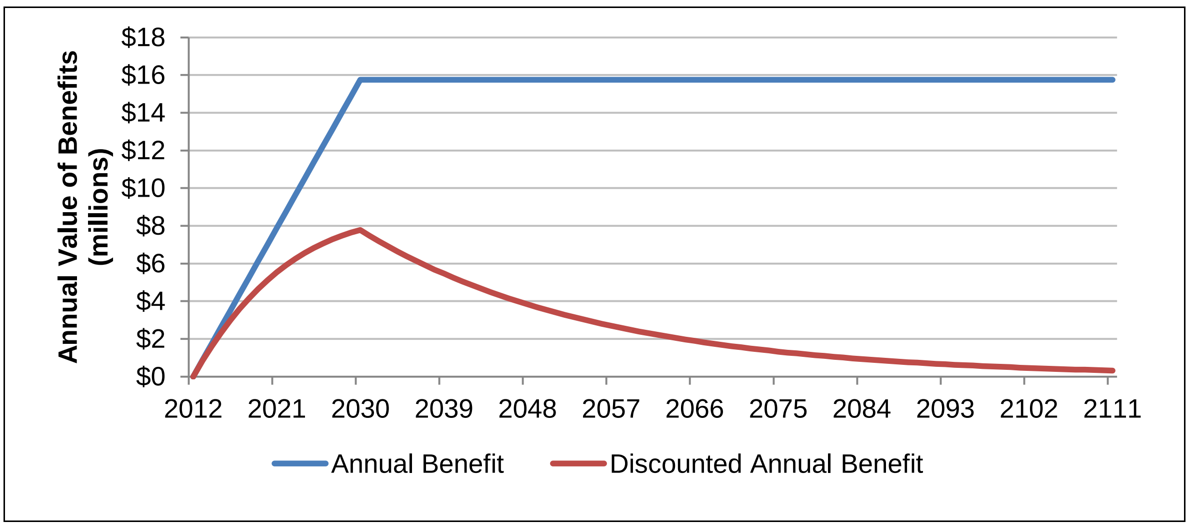
These municipal and domestic benefits would start to accrue in 2013 and reach a maximum value of 10,500 acre-feet per year in 2030. This maximum value is maintained through 2111.

2.3.4.2 Annual Value of Municipal and Domestic Water Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

For the purposes of this analysis, it is assumed that, absent the Integrated Plan, current municipal and domestic users of groundwater would not be able to secure senior water rights for 10,500 acre-feet of consumptive use per year. They therefore would face the risk of curtailment of this water use during future drought years. Implementation of the Integrated Plan would reduce or eliminate this risk by improving the institutional infrastructure for the basin's water market. This would facilitate the acquisition of senior water rights, increasing the supply of water available to proratable irrigators, thus reducing the likelihood that they would take legal action to curtail more junior municipal/domestic consumptive groundwater use during drought years. To calculate the value of the increased security of water supplies for current municipal/domestic groundwater users above Parker Gage, this analysis estimates these users' willingness to pay for senior water rights. From this amount, the analysis subtracts the value of the crop production that would be lost when an irrigator sells a water right to the groundwater users. The difference equals the value of the NED benefits associated with current municipal/domestic groundwater users.

Recent small transactions to mitigate the impacts of residential development have occurred with prices equivalent to about $30,000 per acre-foot, but information obtained during efforts by Ecology and others to expand the amount of market activity suggests the price will likely fall to about $2,500 per acre-foot (Barwin, 2012). This value, which represents the buyers' willingness to pay for senior water rights, would be offset by the value of the forgone irrigation-related benefits that would be lost when the seller, typically an irrigator, no longer has the water available to produce irrigated crops. The value of the forgone benefits is indicated by the price of irrigator-to-irrigator transactions. The information obtained during efforts by Ecology and others to expand the amount of market activity suggests the price of these transactions will likely average about $1,000 per acre-foot (Barwin, 2012). Accounting for this offset indicates the net economic benefit of voluntary transactions, resulting from the Integrated Plan, to increase the security of water supplies for municipal and domestic groundwater users would be about $1,500 per acre-foot. The blue line in Figure 13 represents the value of these benefits, expressed in 2012 prices, as they accrue each year of the 100-year analysis period.

Figure 13. Annual and Discounted Value of Expected Municipal and Domestic Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

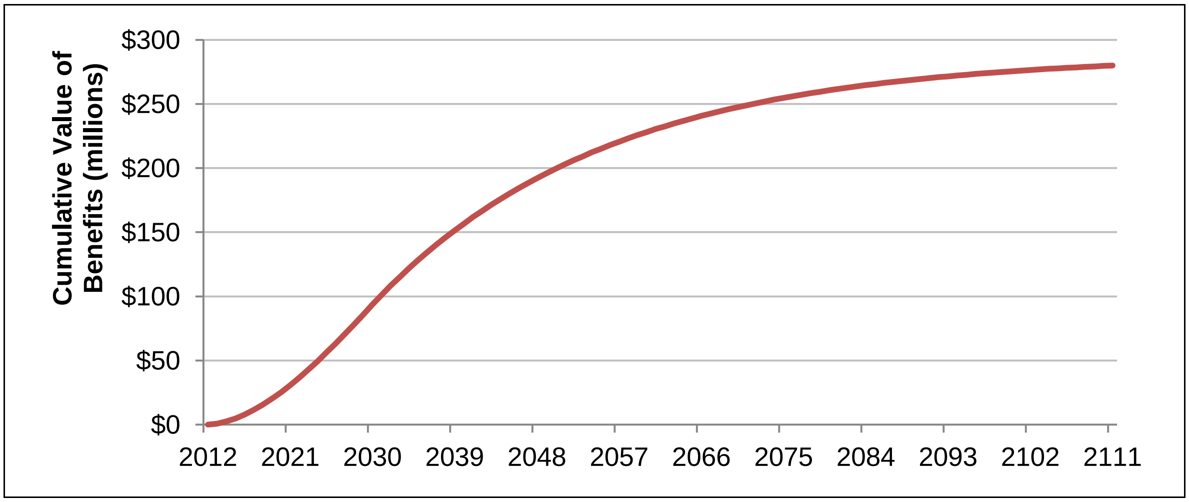


2.3.4.3 Present Value of Municipal and Domestic Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

Assuming a linear increase of water use between 2013, when the municipal and domestic benefits start accruing, and 2030, when they peak at 10,500 acre-feet per year, the municipal/domestic uses would grow about 583 acre-feet per year. Multiplying this rate by the estimated value of $1,500 per acre-foot means that the value of the benefits would increase by about $875,000 annually. The maximum annual value, reached in 2060, would be about $16,000,000, and continue at the same value until the end of 2111.

The red line in Figure 13 shows the discounted value of the expected benefits for each year, as determined using a discount rate of 4 percent per year, equal to the discount rate for Federal water resources planning for FY 2012 (Federal Register, 2011). The overall present value of these municipal-supply benefits is about $280 million in 2012 dollars. Figure 14 presents the accumulation of discounted benefits through 2111.

Figure 14. Cumulative Discounted Benefits of the Integrated Plan Associated with Increased Security for Current Municipal and Domestic Groundwater Users



2.3.4.4 Sensitivity Analysis of the Economic Values of Benefits Associated with Increased Security for Current Municipal and Domestic Groundwater Users

The actual benefits associated with current municipal and domestic use of groundwater may be lower or higher than indicated. A recent compilation of data on water-market activity in western states found that the mean price for a one-acre-foot per year water right was about $4,400 for an agriculture-to-urban transaction and about $1,700 for an agriculture-to-agriculture transaction, with the difference between the two about $2,700 (Brewer et al. 2007). Using this value in the calculation increases the present value of the increased security for current municipal/domestic groundwater users to about $500 million. Brewer et al. (2007) also found that the median price for a one-acre-foot per year water right was about $2,600 for an agriculture-to-urban transaction and about $1,200 for an agriculture-to-agriculture transaction, with the difference between the two about $1,400 (Brewer et al. 2007). Using this value in the calculation decreases the present value of the increased security for current municipal/domestic groundwater users to about $260 million.

2.3.5 Total Municipal and Domestic Water Supply Benefits.

Implementation of the Integrated Plan would yield two types of NED benefits associated with municipal and domestic water supplies. One, an increase the supply of water to support anticipated population and economic growth, has a present value of about $115 million. The other, an increase in the security of water supplies for current municipal and domestic groundwater users, has a present value of about $280 million. The sum of these two amounts, $395 million, is the total value of the Integrated Plan's NED benefits associated with municipal and domestic water supplies.

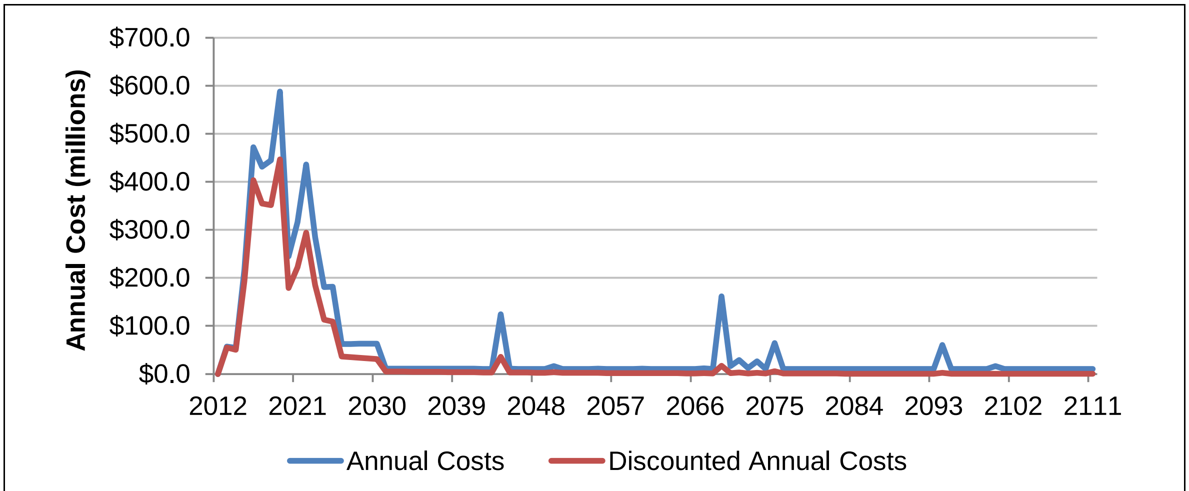
2.4 Costs of the Integrated Plan

Implementation of the Integrated Plan would generate economic costs to the extent that it would decrease: (1) the value of goods and services derived from the Yakima River Basin's water and related resources, (2) the value of similar goods and services, or (3) the value of financial and other types of capital.[19] Current information indicates the Integrated Plan's economic costs would fall into these categories:

- The consumption of financial capital to implement programs and construct, operate, and maintain structures.
- Reduction in the value of environmental or other goods and services that otherwise would be derived from lands that would be inundated by reservoirs under the plan.

Available information supports monetary quantification for only the consumption of financial capital. Figure 15 shows the financial costs to implement the Integrated Plan, by year, for the next 100 years (see Appendix D for more details). These costs include capital costs, operations and maintenance costs, and costs associated with periodic replacement of major components. Nearly all the costs would occur during the first 20 years. Figure 15 also shows the present value of the annual financial costs (the blue line), using a discount rate of 4.0 percent per year, equal to the discount rate for Federal water resources planning for FY 2012 (Federal Register, 2011). The overall present value of the 100-year stream of expected costs is about $3.3 billion.

Figure 15. Potential Financial Costs to Implement the Integrated Plan

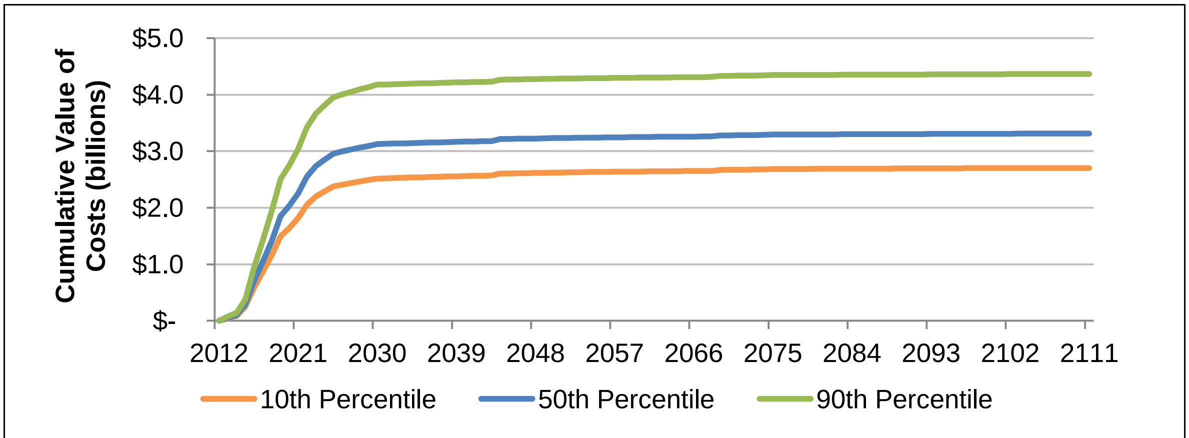


Source: CRA 2012

[19] Capital is the term used for assets capable of contributing to the future production of valuable goods and services. Economists distinguish among five types of capital: (1) *financial capital* (money used by businesses, governments, or other entities to buy the inputs they require to make their products or provide their services); (2) *natural capital* (the component parts, structure, and diversity of ecosystems capable of providing valuable goods or services; (3) *human capital* (the skills and capabilities of individuals); (4) *built capital* (assets, such as infrastructure, plant, and equipment, that can contribute to the production of valuable goods or service); and (5) *social capital* (the social relations among individuals, organizations, and communities that facilitate their production of valuable goods or services).

The costs summarized in Figure 15 represent the 50th percentile of costs as estimated using the Cost Risk Assessment methodology on the Integrated Plan's various components (Reclamation and Ecology 2012 b). The Cost-Risk Assessment results also generated annual costs at the 10th percentile and 90th percentile levels. These additional reference points provide a range within which the costs associated with the Integrated Plan would likely fall. Figure 16 shows the accumulation of annual costs, discounted at a rate of 4.0 percent per year, based on 10th percentile, 50th percentile, and 90th percentile cost estimates. The overall present value of the 100-year stream of expected costs ranges from about $2.7 billion to $4.4 billion.

Figure 16. Cumulative Discounted Financial Costs of Implementing the Integrated Plan



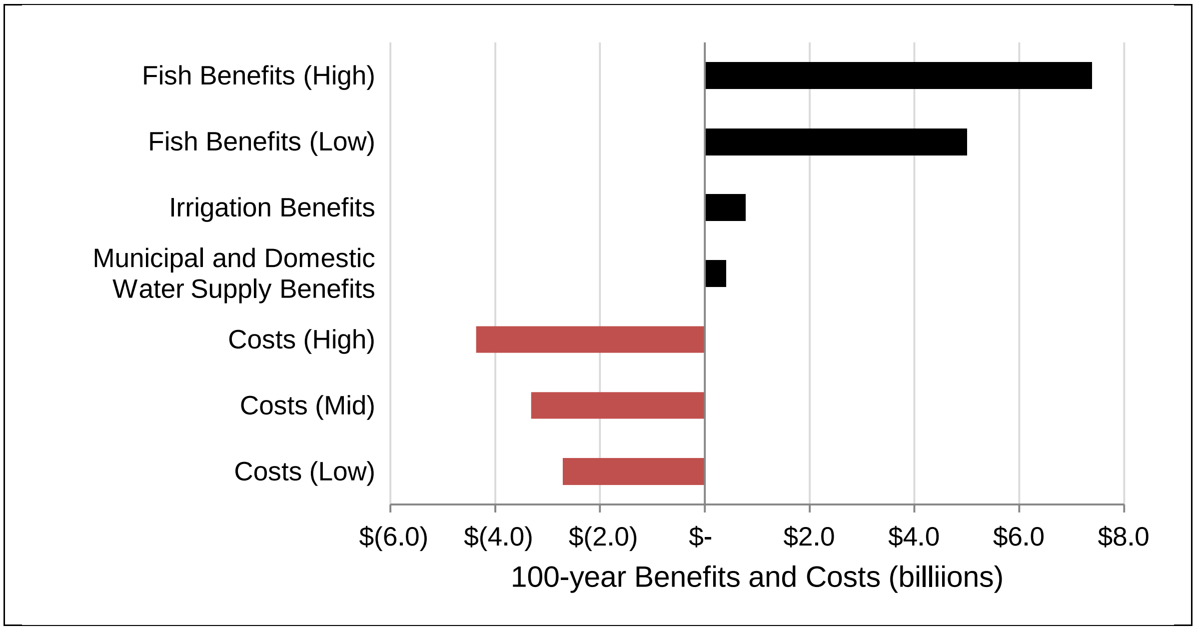
Source: CRA 2012

2.5 Comparison of Benefits and Costs

This memorandum describes the economic value, over the next 100 years, of three potential benefits associated with the Integrated Plan: (1) fish benefits, (2) irrigation benefits, and (3) municipal and domestic water supply benefits. The memorandum also describes the economic value, over the next 100 years, of the anticipated costs of implementing the Integrated Plan in terms of capital costs, operation and maintenance costs, and the costs associated with periodic replacement of major components. Figure 17 summarizes the overall present value of the stream of benefits and costs, over the next 100 years, as described in this memorandum.

Figure 17. Summary of Benefits and Costs

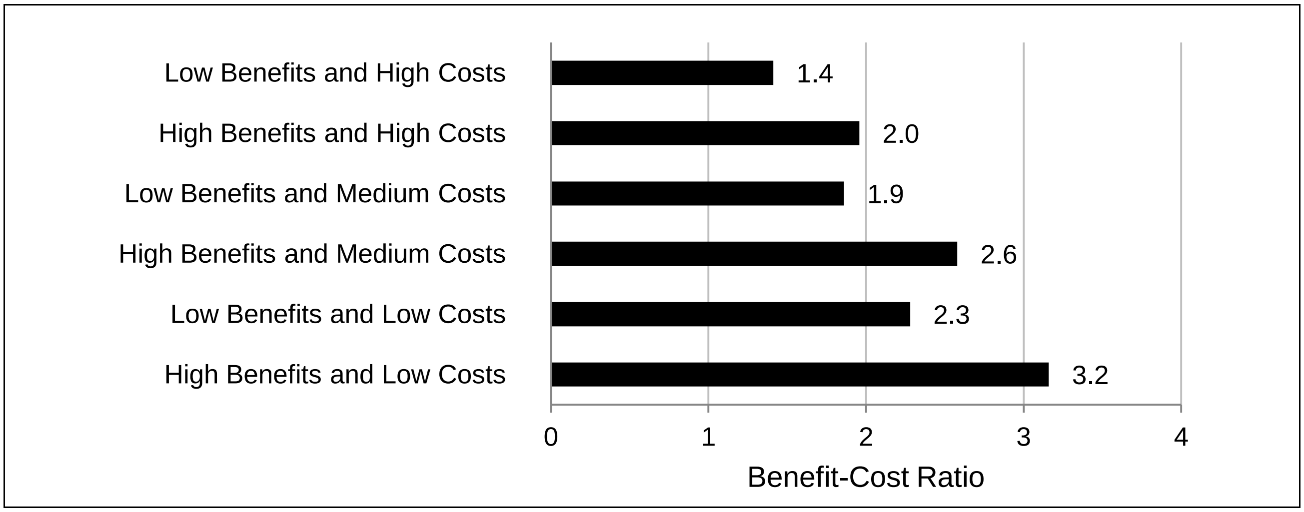
Benefit/Cost Category	Overall Present Value over 100 Years
Fish Benefits	$5.0 billion - $7.4 billion
Irrigation Benefits	$0.8 billion
Municipal and Domestic Water Supply Benefits	$0.4 billion
Costs	$2.7 billion - $4.4 billion



The range of relationships shown in Figure 17 reflects all the benefits and costs for which sufficient information exists to estimate their economic importance in monetary terms. As noted above, the Integrated Plan would have additional benefits and costs, but these have not been monetized. Some of the omitted benefits likely have substantial economic value. They include the unquantifiable cultural and spiritual values that members of the Yakama Nation and others associate with increases in salmon/steelhead populations; benefits of the Integrated Plan for other species, including bull trout, which has been listed as threatened under the Endangered Species Act; benefits to irrigators who would have a more reliable water supply in years with less than a severe drought; increases in the net value of recreational opportunities; improved resiliency and adaptability of the water system; and potential benefits that would emerge as changes in climate affect both the supply of and demand for water in the basin. The omitted costs likely would be small in relation to those that have been monetized and small in relation to the omitted benefits. These include the loss of ecosystem services that would result from construction activities and the inundation of lands and habitat by Bumping Reservoir Enlargement and Wymer Reservoir. These lands have resources with high scarcity value, including some habitat for threatened or endangered species. However, the affected lands are of limited extent and other aspects of the Integrated Plan would improve protections of similar land and habitat resources. Moreover, environmental mitigation costs have been included in the monetized costs discussed in this analysis.

When comparing the benefits and costs of a project, a benefit-cost ratio can be used to determine the extent to which the value of the benefits outweighs the value of the costs, or vice-versa. If the benefit-cost ratio is greater than one, the value of the benefits outweighs the value of the costs; if it is less than one, then the value of the costs outweighs the value of the benefits. In this instance, where there are several ranges of potential benefits and potential costs, several benefit-cost ratios must be calculated. Figure 18 summarizes the benefit-cost ratios associated with the full range of benefits and costs. Using the high-end value of benefits and the low-end value of costs generates the largest benefit-cost ratio, 3.2. Using the low-end value of benefits and the high-end value of costs generates the smallest benefit-cost ratio, 1.4. In all cases, however, the benefit-cost ratio is greater than one, which means that the value of the benefits associated with the Integrated Plan outweighs the value of its costs.

Figure 18. Summary of Benefit-Cost Ratios



3.0 Regional Economic Development Account

The analysis of the Integrated Plan's regional economic effects presented in this report is consistent with the requirements of the Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*Principles & Guidelines*), which calls for the description of all significant effects of the Integrated Plan on the human environment, separated into four accounts. This section presents the Regional Economic Development (RED) account, which shows regional incidence of the plan's effects on national economic development, income transfers, and employment.[20] It describes the effects on personal income, jobs, and economic output stemming from changes in construction expenditures, operation and maintenance (O&M) expenditures, and gross farm earnings that would occur with implementation of the Integrated Plan, relative to what would materialize without it. More specifically, the *Principles & Guidelines* describes the RED account as follows:

> *The RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Two measures of the effects of the plan on regional economies are used in the account: regional income and regional employment. The regions used for RED analysis are those regions within which the plan will have particularly significant income and employment effects. Effects of a plan not occurring in the significantly affected regions are to be placed in a "rest of nation" category. Effects that cannot be satisfactorily quantified or described with available methods, data and information or that will not have a material bearing on the decisionmaking process may be excluded from the RED account.*

Consistent with the *Principles & Guidelines* (p. 11), this RED analysis focuses on "those regions within which the plan will have particularly significant income and employment effects…[where] all or almost all of the NED [National Economic Development] benefits for the plan will accrue." The analysis above shows the Integrated Plan would yield NED benefits in many different ways. The analysis computes the value of some of the benefits: the increased numbers of salmon and steelhead produced by the Yakima River Basin, the increased production of irrigated crops during severe drought years, the increased supply of municipal and domestic water to support population and economic future growth, and the increased security of water supplies for current municipal and domestic users of groundwater above Parker Gage. The Integrated Plan also would yield several other improvements in national economic well-being, but the currently available information is insufficient to support quantification. These unquantified benefits are described in Section 2.0.

These different types of NED benefits would materialize primarily in the Yakima River Basin, as implementation of the Integrated Plan generated more salmon/steelhead and crops, and supported efficient economic development in the basin. The fish-related benefits, however, would materialize largely outside the basin, as they would accrue to households willing to pay for the

[20] The other three accounts are the National Economic Development (NED) account, which shows effects on the national economy, the Environmental Quality (EQ) account, which shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms, and the Other Social Effects (OSE) account, which shows urban and community impacts and effects on life, health and safety.

increases in future salmon/steelhead populations. The NED estimates the benefits considering all households in Washington as well as all households in Washington and Oregon. Most of these households lie outside the Yakima River Basin.

This distribution of NED benefits warrants examining the RED benefits for two areas: the Yakima River Basin region and the State of Washington. The Yakima River Basin is located in three counties: Kittitas, Yakima, and Benton. Because Benton County is part of the Kennewick-Richland-Pasco metropolitan area, the analysis expands the study area to include the other county in this metropolitan area, Franklin County. This analysis focuses on the Yakima River Basin region, and also describes the Integrated Plan's potential RED effects on the state as a whole.

3.1 Analytical Approach

The RED analysis reported here examines three elements of the Integrated Plan that likely would generate economic impacts in the region and across the state: (1) spending associated with construction and program implementation (although only a portion of these expenditures would be spent on construction activities, *per* se, we refer to them all as "construction expenditures"), (2) spending associated with operations and maintenance (O&M), and (3) changes in agricultural production during severe drought years. Changes in spending and agricultural production are measures in 2012 dollars. This analysis uses IMPLAN (IMpact Analysis for PLANning) modeling software to examine the economic impacts of the Integrated Plan across the region. IMPLAN is an input-output model that works by tracing how spending associated with a specific project circulates through the defined impact area. For this impact analysis, the study area is defined as the Yakima River Basin region, encompassing Benton, Kittitas, Yakima, and Franklin Counties in the State of Washington (hereafter referred to as the 4-county study area). The analysis also describes economic impacts across the rest of the State of Washington. Input-output models were built for both study areas using 2009 IMPLAN data.

Because of limitations in the available, relevant data, the RED analysis does not quantify the economic impacts of other changes in spending or production that would result from the Integrated Plan. Most notably, it does not quantify the economic impacts of changes in spending associated with three types of economic benefits quantified in the NED analysis. One, it does not show the economic impacts of spending in recreational and commercial fisheries that would accompany future increases in salmon/steelhead populations. Two, it does not quantify the economic impacts of spending associated with the construction and other economic activity that would be generated as new water supplies support future economic and population growth in the Yakima River Basin. Three, it does not show the economic impacts of changes in spending that would accompany the increased security of water supplies for current municipal and domestic users of groundwater above Parker Gage, including the changes that would occur as the Integrated Plan reduced litigation over demands to curtail these uses during drought years and facilitated the groundwater-users' voluntary acquisition of senior water rights from irrigators. Because of these omissions, the analysis below understates the Integrated Plan's overall, expected impacts on the economies of the 4-state study region, the rest of the State of Washington, and the state as a whole.

The results of this RED analysis are grouped into three types of economic impacts attributable to the Integrated Plan:

- **Direct Impacts**. These impacts describe changes in economic activity directly tied to spending associated with the Integrated Plan (e.g., wages paid to local construction workers).
- **Indirect Impacts**. These impacts occur as businesses buy from other businesses. They are oftentimes referred to as "supply-chain" impacts. They begin with changes in economic activity for businesses that supply directly-affected businesses (e.g., the welding supply business that supplies or rents equipment to construction contractors). They continue as these businesses, in turn, purchase goods and services necessary to operate.
- **Induced Impacts**. These impacts describe changes in economic activity attributable to changes in household income generated by direct and indirect impacts of the Integrated Plan (e.g., spending by local construction labor and workers on consumer goods and services). Because induced impacts are associated with an increase in income and additional spending by households, they are often called "consumption-driven" impacts.

Each of these three types of economic impacts are described in terms of three different variables that measure economic activity:

- **Output** is the broadest measure of economic activity and represents the value of production. Output includes intermediate goods plus the components of value added (including personal income), so the two measures (output and personal income) are not additive. All output described in this analysis is measured in 2012 dollars
- **Personal income** consists of personal income and business income. Personal income represents wages and salaries, as well as other payroll benefits such as health and life insurance, retirement payments, and non-cash compensation. Business income (also called proprietor's income) represents the payments received by small-business owners or self-employed workers (doctors, accountants, lawyers, etc.). All personal income described in this analysis is measured in 2012 dollars.
- **Jobs** are full-and part-time jobs. In some instances, this analysis refers to "job years", which represents the equivalent of one job for one year. Ten job years, for example, could refer to one job for 10 years, five jobs for two years, 10 jobs for one year, etc.

Table 16 summarizes the overall economic activity in 2009 in the 4-county study area and across the State of Washington. The values presented in the table are useful in understanding the context within which the Integrated Plan's economic impacts would occur.

Each of the three sections that follow describes one of the three elements of the Integrated Plan that likely would generate changes in economic activity: construction expenditures, annual operations and maintenance (O&M) expenditures, and changes in agricultural production. Each section begins with a description of how each element generates economic impacts in the study area and across the state as well as a short summary of the input data used in the IMPLAN analysis. Next, it summarizes the impacts in terms of direct, indirect, and induced output, income, and employment (both in the 4-county study area, as well as in the rest of the State of Washington). Each section concludes with a discussion of how the economic impacts would roll out over time.

Table 16. Economic Activity in 2009 in the 4-County Study Area and Across Washington

Aggregate Industry Sector	4-County Study Area			Washington State		
	Output (millions)	Personal Income (millions)	Total Jobs	Output (millions)	Personal Income (millions)	Total Jobs
Agriculture	$3,433	$899	38,200	$11,084	$2,591	116,900
Mining	$43	$4	400	$1,511	$163	6,300
Construction	$1,753	$632	13,500	$31,490	$11,125	234,100
Manufacturing	$6,094	$813	15,400	$121,407	$21,547	276,700
Transportation, Information, Utilities	$1,098	$295	7,200	$21,091	$5,889	115,700
Trade	$2,730	$1,154	35,000	$52,450	$20,891	514,800
Service	$13,718	$4,551	110,500	$276,992	$80,839	1,925,500
Government	$3,522	$2,438	41,900	$62,570	$43,752	649,000
Totals	$32,392	$10,788	262,000	$578,595	$186,796	3,839,000
Notes: Calculated with 2009 IMPLAN base data.						

To distinguish between impacts occurring within the 4-county study area and those occurring elsewhere, the analysis applies IMPLAN's multiregional input-output (MRIO) modeling component. MRIO tracks expenditures as they move within and across study area boundaries. For example, wages earned by workers living within the 4-county study area would be spent on goods and services produced within the 4-county study area as well as on goods and services produced elsewhere in the State of Washington or outside the state. Similarly, wages earned by Washington workers living outside the 4-county study area would be spent on goods and services produced in the 4-county study area as well as on goods and services produced elsewhere in the State of Washington or outside the state.

3.2 Impacts of Construction Expenditures

Expenditures to implement the Integrated Plan would occur in 26 distinct components. Some of these components involve specific construction efforts (e.g., building a fish passage past a dam), while others are less tangible (e.g., grant funds for mainstem floodplain restoration and future feasibility studies). Reclamation and Ecology (2011c) provides line-item cost estimates for 14 of these components. It describes the costs of the other 12 components in more qualitative terms. Table 17 identifies all 26 of the Integrated Plan's expenditure components and differentiates those with line-item expenditure data from those with qualitative descriptions of expenditures.

Table 17. Components of the Integrated Plan

Components with Line-Item Expenditure Data	Components with Qualitative Description of Expenditures
Bumping Lake Reservoir Enlargement	Market Reallocation
Fish Passage - Box Creek	Agricultural Conservation
Cle Elum Raise Pool Level	Municipal Conservation
Keechelus to Kachess Pipeline	Tributaries Habitat Enhancement
Wapatox Canal Improvements	Mainstem Floodplain Restoration
Kachess Inactive Storage Alternative 1	GW Infiltration
KRD Canal South Branch Modification	Municipal ASR Opportunities
Wymer Dam	Update Water Needs Assessment
Fish Passage – Bumping Lake	Periodic Review of IP
Fish Passage – Clear Lake	Columbia River Pumping & Storage Feasibility Study
Fish Passage – Cle Elum	Roza Alternate Supply & Dam Feasibility Study
Fish Passage – Tieton*	Land Acquisition Program
Fish Passage – Kachess*	
Fish Passage – Keechelus*	

Source: Reclamation and Ecology, 2011c.

*Line-item expenditures for these components are based on data describing Fish Passage – Cle Elum.

Table 18 summarizes the construction expenditures of all the Integrated Plan's components. The expenditures identified in Table 18 are based on data from Reclamation (2011c) and Reclamation and Ecology (2012b). In some instances, data were not sufficient to categorize the expenditures according to the specific inputs IMPLAN requires to calculate economic impacts. In those instances, data were extrapolated based on patterns and trends elsewhere in the dataset. For example, several components had line-item expenditures categorized as subcontractor costs. For this analysis, those expenditures were distributed across different categories based on the known distribution of similar line-item expenditures. Several expenditure categories were incorporated into the categories presented in Table 18. For example, this analysis assumes that (1) all contractor field overhead is paid out in per diem payments to non-local workers, (2) all mobilization expenditures are spent on labor, (3) all expenditures on unlisted items and cost estimate refinements are spent on materials and equipment, and (4) all contingencies are distributed across labor, materials, and equipment proportionate to their pre-contingency values.

Table 18 shows that $1.01 billion of expenditures were excluded from the analysis. This amount covers (1) design and scope changes, (2) contractor fees, (3) contractor bonds and insurance, (4) additional non-contract costs (such as expenditures spent on design, permitting, and regulatory compliance), and (5) land acquisition. Excluding these expenditures from this analysis is necessary because there are no data describing how these expenditures would be allocated across industry sectors, or which spatial economy would experience their impacts. It is possible, for example, that government employees or private firms from outside Washington would do the design work, or that all the contractor fees (profits for the companies performing the work) would go to head offices elsewhere in the country and be spent there.

Table 18. Construction Expenditures of the Integrated Plan (2012 Q1 Dollars)

Expenditure Category	Total Expenditures (billions)
On-Site Labor	$0.81
Off-Site Labor	$0.39
Materials and Equipment	$1.92
Per Diem Payments	$0.04
Subtotal	$3.17
Costs Excluded	$1.01
Total	**$4.18**
Source: Adapted from Reclamation and Ecology, 2011c; Reclamation and Ecology. 2012b.	

3.2.1 Economic Impacts of Construction Expenditures

Construction expenditures associated with each of the Integrated Plan's various components would fuel economic activity in the 4-county study area and across the State of Washington. These expenditures likely would also support economic activity outside of Washington, however those impacts lie beyond the scope of this analysis, and so are excluded. Isolating the economic impacts associated with construction projects is particularly challenging due to uncertainty regarding where labor, materials, and equipment are sourced. Before presenting the results of the analysis, it is important to understand the assumptions regarding several important inputs.

- **Labor**. By definition, all on-site construction jobs are direct jobs in the 4-county study area. The estimate of direct, construction-related employment was estimated by dividing total labor expenditures by the average wage for a general construction worker in Washington. Some of the workers in these jobs would reside in the 4-county area, while others would reside in the rest of Washington or outside the state. The judgment of the construction professionals who estimated construction costs for this analysis supports the assumption that, for all components with line-item expenditure data (see Table 17), 20 percent of the workers would live in the 4-county study area, 70 percent would live elsewhere in Washington, and the remaining 10 percent would come from outside Washington. For all components with qualitative descriptions of expenditure data (see Table 17), the expert judgment of the economists familiar with the local economy who conducted this analysis supported assumptions about the amount of direct labor expenditures occurring within the 4-county study area, elsewhere in Washington, and outside Washington with the percentages varying among the different types of expenditure. Direct labor for some of these components would not necessarily take place within the 4-county study area (or even within Washington), represented by the $0.39 billion in off-site labor expenditures (see Table 18).[21] In all cases, the analysis accounted for the location of the direct labor expenditures and the residency of the workers to properly track worker spending in geographic terms. All construction-related direct labor expenditures, regardless of geographic location, result in direct economic impacts.

[21] In this context, direct, off-site labor is attributable to materials, equipment, and soft costs associated with direct construction expenditures.

- **Materials and Equipment**. IMPLAN's Regional Purchase Coefficients (RPCs)[22] were used to determine the extent to which suppliers within the 4-county study area could provide the materials and equipment required for construction, and the extent to which suppliers from elsewhere in Washington or other states would be required. All purchases, regardless of geographic location, have direct economic impacts.
- **Per Diem Payments**. These are payments made to non-local workers for food, lodging and other expenses while they are staying within the 4-county study area. This analysis uses an average breakdown of per diem rates in Washington, as described by the U.S. General Services Administration (2012), to allocate spending across different industries within the 4-county study area. These payments have direct economic impacts within the 4-county study area.

Table 19 summarizes the economic impacts associated with the Integrated Plan's construction expenditures. The impacts summarized in the table represent the sum of the economic impacts of construction expenditures from 2013 to 2030. They do not represent annual impacts. Direct output represents spending on labor, materials, equipment, and per diem that takes place in each of the study areas. About $1.7 billion would be spent within the 4-county study area, and about $0.9 billion would be spent across the rest of Washington. Direct personal income is a subset of direct output. It represents the portion of direct output going toward labor. In this case, labor includes workers working on the construction site as well as the workers responsible for manufacturing and supplying the materials and equipment purchased for construction. Direct job years represent the years of full- and part-time employment supported by construction expenditures, including both workers on the construction site as well as the workers responsible for manufacturing and supplying the materials and equipment purchased for construction. Indirect impacts represent output, personal income, and employment responsible for supporting the direct economic impacts. Induced impacts represent the spending flowing from direct and indirect output and income.

As discussed previously, indirect impacts summarize the supply-chain effects and represent the output, personal income, and employment for workers and business owners in industries that support the direct economic activity. Induced impacts summarize consumption-driven effects and represent the additional spending by households attributed to the direct and indirect changes in personal income.

The impacts in Table 19 are split into three geographic categories in terms of where the impacts would take place: those that would occur within the 4-county study area, those that would occur elsewhere in Washington, and those that would occur in Washington as a whole. In other words, the 21,700 direct job years in the 4-county study area represent the workers that construction expenditures would support within the 4-county study area. Some of those workers, however, would come from outside the 4-county study area. Workers traveling to the 4-county study area for work would spend some money in the 4-county study area, but they would spend most of it at home. Of those 21,700 jobs years occurring in the 4-county study area, about 60 percent would accrue to individuals living within the 4-county study area. The rest would accrue to individuals

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[22] RPC's describe the proportion of local demand for a commodity that is accommodated by local suppliers. The IMPLAN model has RPC's for each of the 440 commodities in the model, and these RPC's are tailored for each study area.

traveling to the 4-county study area from elsewhere in Washington, and from other states. This analysis does not examine the extent to which the Integrated Plan's construction expenditures would affect the supply of labor or other inputs for other construction projects in the 4-county study area.

Table 19. Summary of Economic Impacts, by Type, from Construction Expenditures

Region / Impact Measure	Direct	Indirect	Induced	Total
4-County Study Area				
Output	$1,740,000,000	$207,000,000	$399,000,000	$2,346,000,000
Personal Income	$1,129,000,000	$67,000,000	$120,000,000	$1,316,000,000
Job Years	21,700	1,700	3,500	26,900
Rest of Washington				
Output	$911,000,000	$387,000,000	$1,030,000,000	$2,328,000,000
Personal Income	$450,000,000	$99,000,000	$288,000,000	$837,000,000
Job Years	6,000	2,000	7,100	15,100
Total Washington State				
Output	$2,651,000,000	$593,000,000	$1,430,000,000	$4,674,000,000
Personal Income	$1,579,000,000	$166,000,000	$408,000,000	$2,153,000,000
Job Years	27,700	3,600	10,700	42,000
Notes: Calculated with cost estimates for the Integrated Plan and 2009 IMPLAN base data.				

To calculate the indirect and induced impacts associated with the Integrated Plan's construction expenditures, the expenditures on material and equipment were mapped to their relevant industry sectors and run through IMPLAN. Personal income for the direct labor associated with the Integrated Plan was modeled through an IMPLAN consumption function that describes the spending, savings, and taxes of households in the 4-county study area and across the rest of Washington. The IMPLAN model then applies multipliers describing cross-county and cross-region purchasing and spending trends to calculate output, personal income, and jobs attributable to the Integrated Plan's direct spending on construction.

In total, the Integrated Plan's construction expenditures would support about $2.3 billion in output within the 4-county study area. Of that output, about $1.3 billion would go toward personal incomes that would support about 26,900 job years, only a portion of which would accrue to the labor force residing locally. Additional impacts would spread across the rest of the state (about $2.3 billion in output, of which about $0.8 billion would go toward personal incomes that would support about 15,100 job years).

Table 20 shows how all of these impacts (direct, indirect, and induced) would be distributed across different industry sectors within the 4-county study area. While all these impacts would occur within the 4-county study area, they would not necessarily support individuals living in the 4-county study area. As described earlier, labor in the 4-county study area represents labor that takes place within that area. Some of this labor would be supplied be individuals living elsewhere in Washington or outside the state.

These impacts, however, would be spread out over an 18-year period, from 2013 to 2030, so the actual impacts in any given year during this period would be much lower than the values presented in the table. For example, if the total effects shown in Table 20 for the 4-county study area were spread evenly over the 2013-2030 period, the annual effects would be about $130 million (output), $73 million (personal income), and 1,500 (job years). Actual effects each year would be higher or lower than this average, as shown below.

Table 20. Distribution of Construction Impacts across Aggregate Industry Sectors, 4-County Study Area

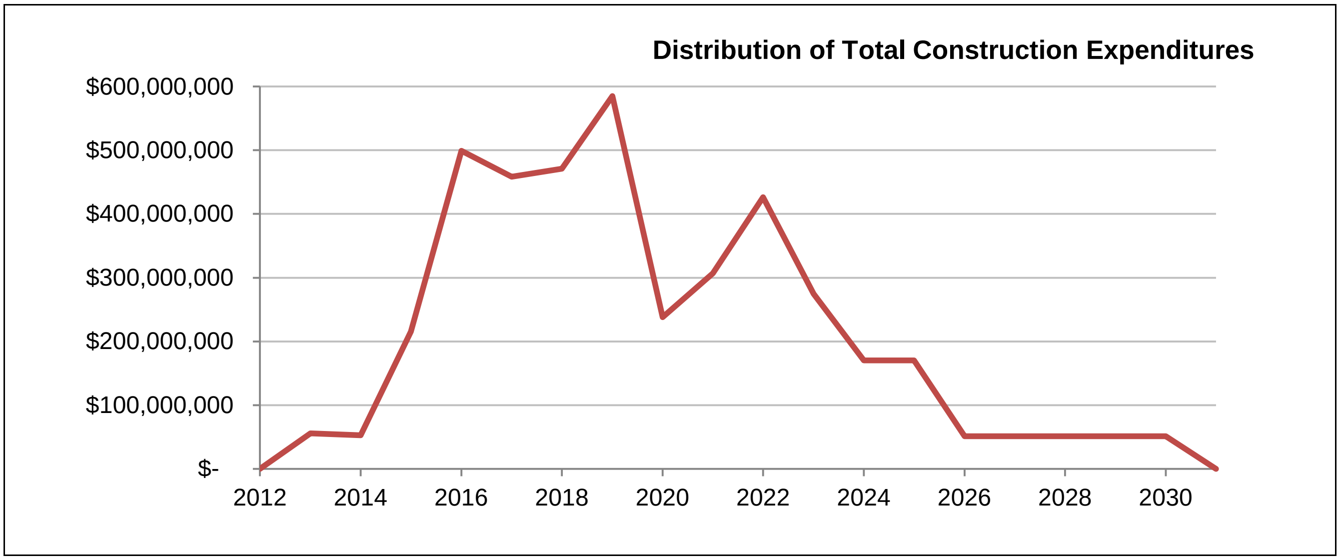
Aggregate Industry Sector	Total Output	Total Personal Income	Total Job Years
Agriculture	$59,000,000	$11,000,000	500
Mining	$115,000,000	$29,000,000	2,600
Construction	$815,000,000	$810,000,000	12,000
Manufacturing	$206,000,000	$36,000,000	600
Transportation, Information, Utilities	$210,000,000	$58,000,000	1,400
Trade	$461,000,000	$230,000,000	5,800
Service	$439,000,000	$128,000,000	3,900
Government	$41,000,000	$14,000,000	100
Total Economic Impact in the 4-County Study Area	$2,346,000,000	$1,316,000,000	26,900
Notes: Calculated with estimated costs for the Integrated Plan and 2009 IMPLAN base data.			

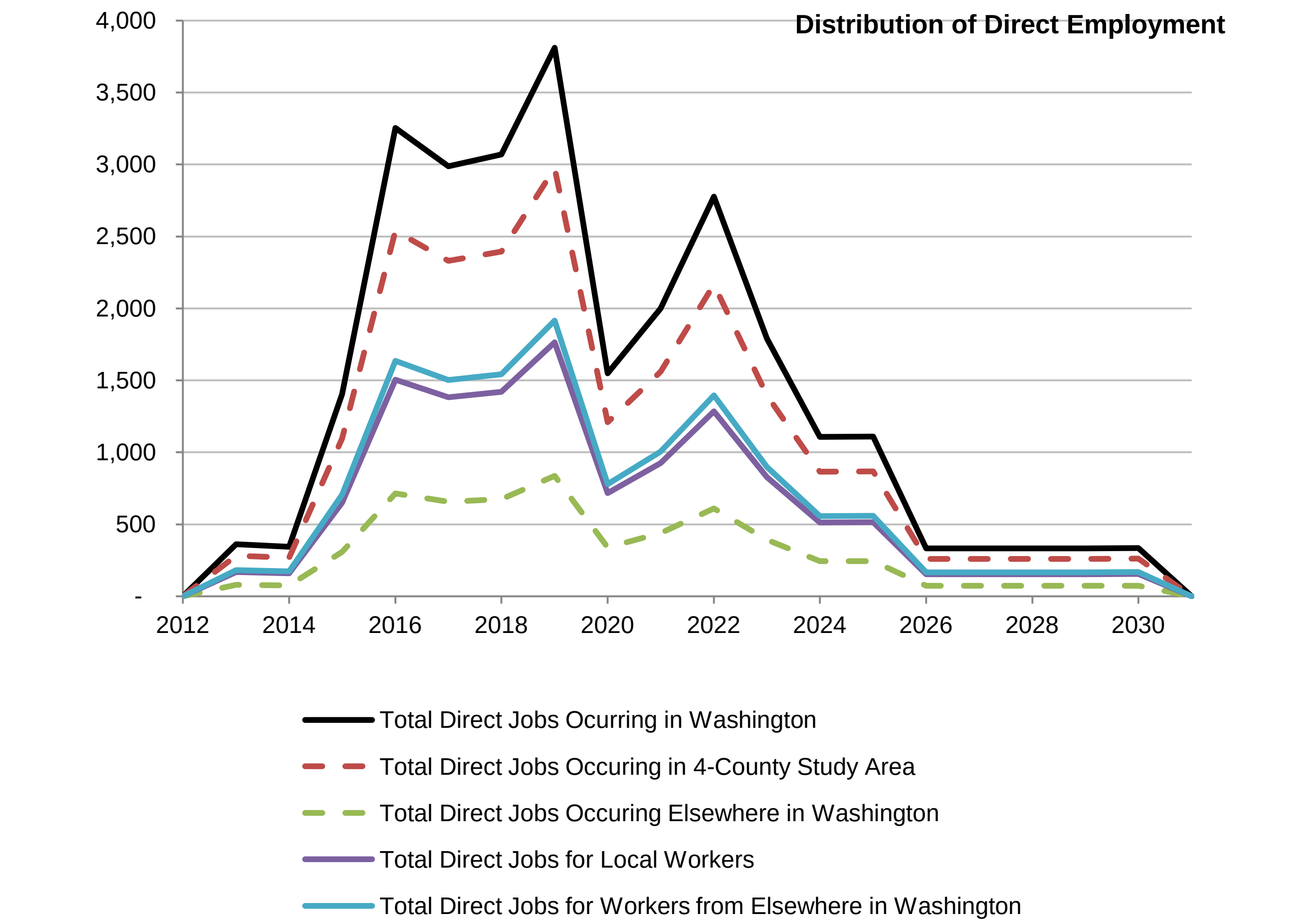
3.2.2 Timing of Construction Expenditures

The construction expenditures described in Table 18 and the economic impacts associated with those expenditures would begin in 2013 and end in 2030. Given the magnitude of these construction expenditures, it is useful to consider how they would affect the economy over time. Given the complexity of these construction efforts and their interwoven timelines, a year-by-year analysis of each component's impacts is not feasible. Instead, the analysis looks at the overall impacts over the 18-year period, assuming that the impacts would occur in the same year as the construction expenditures. For example, data from Reclamation and Ecology (2012b) show that construction-related expenditures in 2019 would account for about 14 percent of the Integrated Plan's total construction expenditures from 2013-2030. As such, this analysis assumes that 14 percent of the Integrated Plan's overall, construction-related output, labor income, and job years would occur in 2019. The actual impacts occurring in any given year may lag behind that year's expenditures. This is especially true of the indirect and induced impacts.

Figure 19 shows the distribution over time of total, construction-related expenditures and the direct, construction-related employment by location, assuming that employment would occur in the same year as expenditures. Total construction-related expenditures over time, shown in the top graph, serve as the basis for distributing all the economic impacts over time. The second graph shows the distribution of direct, construction-related employment that would accompany the construction-related expenditures. The black line shows the overall direct, construction-related employment occurring in the State of Washington. The workers represented by the black line could come from within the 4-county study area, elsewhere in Washington, or from outside Washington. Some direct, construction-related employment would occur outside Washington, and that employment is not included in the black line. The red and green dashed lines disaggregate the in-state total by location: employment occurring within the 4-county study area, and employment occurring elsewhere in Washington. The light blue and purple solid lines disaggregate the employment occurring in the 4-county area, by place of the workers' residence.

Figure 19. Distribution of Construction Expenditures and Economic Impacts over Time



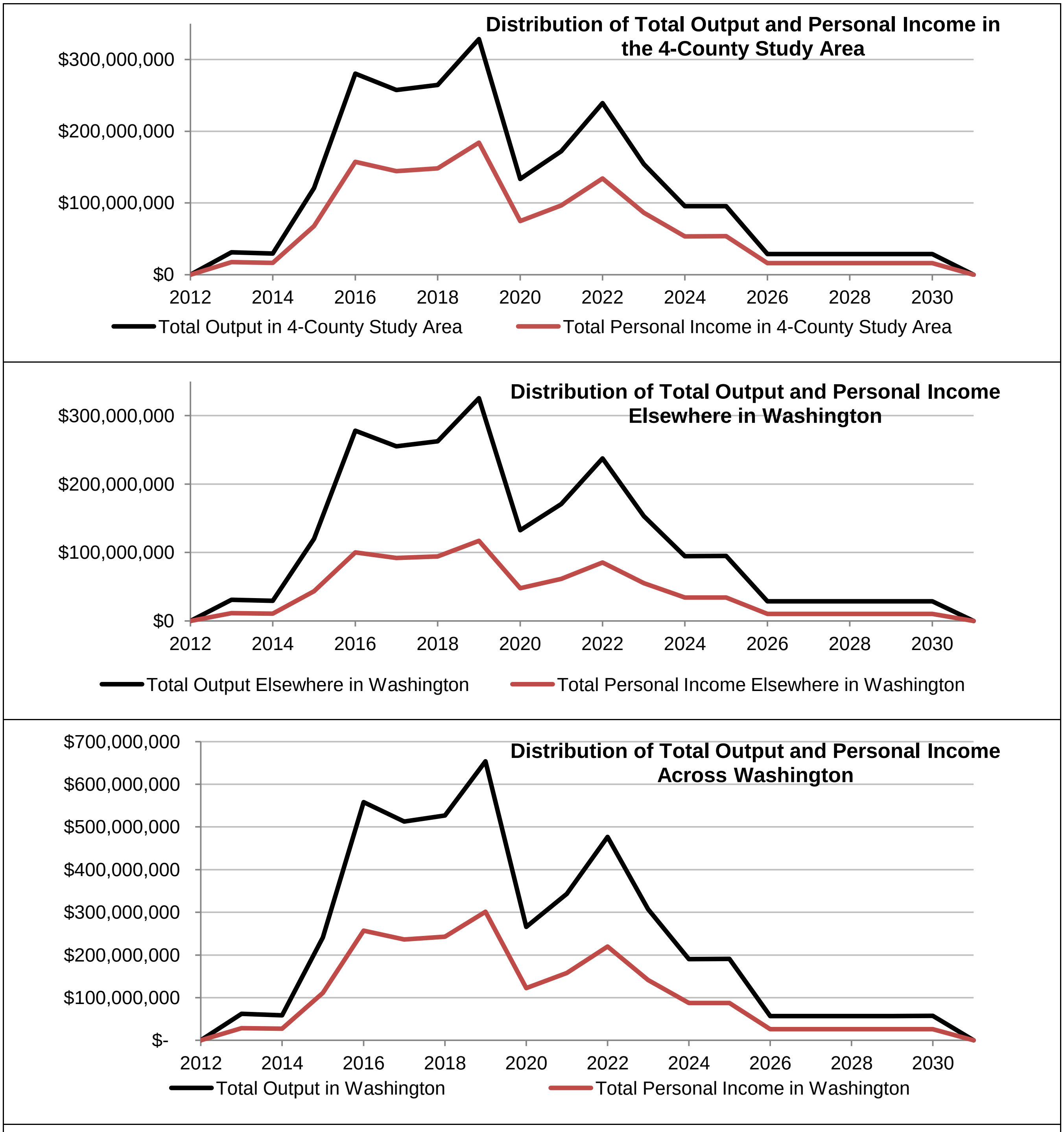


Source: Adapted from Reclamation and Ecology, 2012b.

Notes: Calculated with estimated costs for the Integrated Plan and 2009 IMPLAN base data.

Figure 20 shows the distribution over time of the overall economic impacts—direct, indirect, and induced—of construction-related expenditures. The graphs in this figure also assume that economic impacts would occur in the same year as expenditures. The top graph shows the impacts for the 4-county study area, and the middle graph shows the impacts for the rest of the state. The bottom graph shows the sum of the other two, i.e., the overall direct, indirect, and induced impacts of the Integrated Plan's construction-related expenditures on the State of Washington's economy.

Figure 20. Distribution of Construction Expenditures and Economic Impacts over Time



Source: Adapted from Reclamation and Ecology, 2012b.

Notes: Calculated with estimated costs for the Integrated Plan and 2009 IMPLAN base data.

The graphs indicate that the impacts would rise sharply from 2013 to 2019. At the peak, total construction expenditures would equal almost $600 million per year, which would support a total of about 3,800 direct job-years per year, with about 3,000 of these in the 4-county study area.

Total direct output and personal income would equal about $650 million and $300 million, respectively. The impacts would then drop sharply, rebound to a somewhat lower peak in 2022, and then taper off.

3.3 Operations and Maintenance Expenditures

In addition to the construction expenditures described above, several of the Integrated Plan's components would require annual O&M activities that would fuel economic activity in the 4-county study area and across the state. Table 21 summarizes the highest level of annual O&M expenditures over the next 100 years. Later in this section, the distribution of O&M expenditures and their potential economic impacts are described over time. The allocation of total O&M costs across the three categories shown in Table 21 involved assigning line-item data for several of the Integrated Plan's components (Reclamation and Ecology, 2011c) based on qualitative descriptions of the O&M activities or line-item data describing similar components.

Table 21. Highest Level of Annual O&M Expenditures (2012 Q1 Dollars)

Expenditure Category	Total Expenditures (millions)
Labor	$4.6
Materials and Equipment	$3.1
Other	$3.5
Total	$11.2
Source: Adapted from Reclamation and Ecology. 2011c; Reclamation and Ecology. 2012b.	

3.3.1 Economic Impacts of O&M Expenditures

The direct spending associated with O&M would support additional supply-chain (indirect) and consumption-driven (induced) impacts for workers and business owners in the 4-county study area and elsewhere in Washington. Table 22 summarizes the direct, indirect, and induced economic impacts attributed to O&M spending when it reaches its highest level.

Table 22. Summary of the Economic Impacts of the Highest Level of Annual O&M Expenditures

Region / Impact Measure	Direct	Indirect	Induced	Total
4-County Study Area				
Output	$11,000,000	$5,000,000	$4,000,000	$20,000,000
Personal Income	$5,000,000	$1,000,000	$1,000,000	$7,000,000
Jobs	60	20	30	110
Rest of Washington				
Output	$0	$300,000	$600,000	$900,000
Personal Income	$0	$100,000	$100,000	$200,000
Jobs	0	< 10	< 10	< 10
Total Washington State				
Output	$11,000,000	$5,300,000	$4,600,000	$20,900,000
Personal Income	$5,000,000	$1,100,000	$1,100,000	$7,200,000
Jobs	60	25	35	120
Notes: Calculated with cost estimates for the Integrated Plan and 2009 IMPLAN base data.				

Given the types of O&M activities the Integrated Plan would require, this analysis assumes all direct impacts would occur within the 4-county region. Direct output represents the sum of all O&M expenditures, about $11 million at their highest annual level. Direct personal income represents the portion of those expenditures spent on labor, about $5 million. To calculate the number of direct jobs supported by O&M expenditures (60), labor expenditures were divided by average annual wages from relevant occupations in Washington.[23] These 60 jobs represent an equivalent of 60 full- and part-time jobs for one year.

Running the direct effects of the Integrated Plan's O&M expenditures, mapped to their relevant industry sectors, through IMPLAN produced an estimate of the indirect and induced impacts. The IMPLAN model for this task consists of a consumption function that describes the spending, savings, and taxes of households in the 4-county study area and across the rest of Washington.

In total, the Integrated Plan's highest level of annual O&M expenditures would generate about $20 million in output within the 4-county study area. Of that output, about $7 million would go toward personal incomes that would support about 110 jobs. Additional impacts would spread across the rest of the state (about $0.9 million in output, of which about $0.2 million would go toward personal incomes that support fewer than 10 jobs).

Table 23 shows how all of these impacts (direct, indirect, and induced) would be distributed across different industry sectors within the 4-county study area. The bottom section of the table shows, for the highest level of annual O&M spending, the overall economic activity (output, income, and jobs) in the 4-county study area along with the economic impact of O&M expenditures as a percent of the current annual economic activity within this area. Across each variable, the total economic activity the Integrated Plan's O&M expenditures supports would

[23] Average wages, across the state, for different occupations were compiled from U.S. Bureau of Labor Statistics (2012).

account for less than 0.1 percent of the current annual economic activity in the 4-county study area.

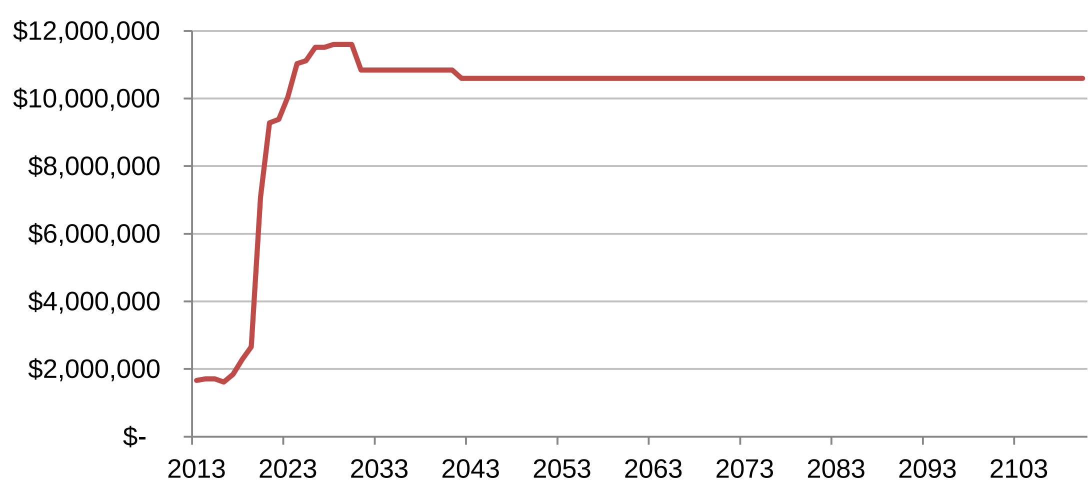
Table 23. Distribution of Impacts of the Highest Level of Annual O&M Expenditures across Industry Sectors, 4-County Study Area

Aggregate Industry Sector	Total Output	Total Personal Income	Total Jobs
Agriculture	$100,000	$20,000	< 1
Mining	$20,000	$2,000	< 1
Construction	$600,000	$200,000	5
Manufacturing	$200,000	$20,000	< 1
Transportation, Information, Utilities	$14,500,000	$5,300,000	60
Trade	$600,000	$300,000	10
Service	$3,900,000	$1,200,000	30
Government	$300,000	$80,000	< 1
Total Economic Impact in the 4-County Study Area	$20,000,000	$7,000,000	110
All Economic Activity in the 4-County Study Area	$32.4 billion	$10.8 billion	260,000
Economic Impact as a Percent of Economic Activity	< 0.1%	< 0.1%	< 0.1%
Notes: Calculated with cost estimates for the Integrated Plan and 2009 IMPLAN base data.			

3.3.2 Timing of O&M Expenditures

The O&M expenditures summarized in Table 22 and Table 23 represent the highest level of annual expenditures. The O&M expenditures for the different components of the Integrated Plan would not, however, begin at the same time, nor would they all continue indefinitely into the future. Figure 21 shows the timing of the total, annual O&M expenditures. These expenditures represent O&M activities only. They do not include expenditures associated with the replacement of plant and equipment that would occur in future years, because currently available information about the magnitude and timing of the replacement costs is not sufficient to incorporate them into the analysis.

Figure 21. Annual O&M Expenditures over Time



Source: Adapted from Reclamation and Ecology, 2012b.

3.4 Changes in Agricultural Production

As described in the NED analysis, the Integrated Plan would increase market-based reallocation of water from lower- to higher-value crops. It would also increase the overall water supply so the amount of water available to proratable irrigators during severe drought years rises from 30 percent to 70 percent of their full entitlements. With more water available during severe drought years, and with more market-based reallocation of water, the Integrated Plan would increase agricultural production during severe drought years, relative to the Baseline Scenario without the Integrated Plan. To model the economic impacts of changes in agricultural output during severe drought years, the analysis estimates the Integrated Plan's effects on gross farm earnings, distributes them across different types of crops, and maps them to the corresponding agricultural industry sectors in the IMPLAN model.

Table 24 summarizes gross annual farm earnings for different crops during a severe drought year under the Baseline Scenario (when the water available to proratable irrigators equals 30 percent of their full entitlements) and with the Integrated Plan (when the water available to proratable irrigators equals 70 percent of their full entitlements). The final column shows the change in gross annual farm earnings associated with each agricultural sector. The first column identifies the agricultural sector within which each of the crop-specific impacts was allocated. In total, the Integrated Plan would increase gross farm earnings by about $400 million during a severe drought year.

Table 24. Gross Farm Earnings (2012 Q1 Dollars)

Type of Crop	Gross Farm Earnings (30% of Proratable Entitlements Received)	Gross Farm Earnings (70% of Proratable Entitlements Received)	Difference
Grains (wheat, other grain, miscellaneous grain)	$56,000,000	$178,000,000	$122,000,000
Vegetables and Melons (asparagus, potatoes, sweet corn, other vegetables)	$29,000,000	$191,000,000	$161,000,000
Fruits (apples, concord grapes, wine grapes, other tree crops)	$472,000,000	$616,000,000	$144,000,000
All Other Crops (alfalfa hay, hops, mint, other hay, pasture, timothy hay)	$238,000,000	$211,000,000	($27,000,000)
Total	$796,000,000	$1,196,000,000	$400,000,000
Source: Derived from the analysis of NED irrigation benefits, in this report.			

3.4.1 Economic Impacts of Changes in Agricultural Production

Table 25 summarizes the economic impacts associated with this change in agricultural production. Since the entirety of the change in agricultural production occurs within the 4-county study area, by definition, all direct economic impacts also occur within the 4-county study area. Direct output (about $400 million) represents the difference between gross farm earnings during a severe drought year with the Integrated Plan and gross farm earnings without it. Changes in direct output for each affected agricultural sector were fed into IMPLAN, and the model estimated the associated changes in direct personal income and jobs. These 7,200 jobs represent both full-time and part-time jobs.

Table 25. Summary of Economic Impacts of Changes in Agricultural Production, Severe Drought Year

Region / Impact Measure	Direct	Indirect	Induced	Total
4-County Study Area				
Output	$400,000,000	$137,000,000	$153,000,000	$690,000,000
Personal Income	$87,000,000	$52,000,000	$46,000,000	$185,000,000
Jobs	7,200	1,500	1,400	10,100
Rest of Washington				
Output	$0	$64,000,000	$36,000,000	$100,000,000
Personal Income	$0	$14,000,000	$9,000,000	$23,000,000
Jobs	0	500	200	700
Total Washington State				
Output	$400,000,000	$201,000,000	$189,000,000	$790,000,000
Personal Income	$87,000,000	$66,000,000	$55,000,000	$208,000,000
Jobs	7,200	2,000	1,600	10,800
Notes: Calculated with data described previously in this analysis and 2009 IMPLAN base data.				

To calculate the indirect and induced impacts of this change in agricultural production, the direct impacts were run through IMPLAN. The impacts in the table do not include downstream impacts tied to agricultural production, such as food processing, transportation, and restaurant sales. In total, the Integrated Plan's impact on agricultural production during a severe drought year would generate about $690 million in output within the 4-county study area. Of that output, about $185 million would go toward personal incomes that support about 10,100 jobs. Additional impacts would spread across the rest of the state (about $100 million in output, of which about $23 million would go toward personal incomes that support about 700 full- and part-time annual jobs).

Table 26 shows how all of these impacts (direct, indirect, and induced) in the 4-county study area during a severe drought year would be distributed across different industry sectors. The bottom section of the table shows the current annual economic activity (output, income, and jobs) in the 4-county study area, along with the economic impact of the anticipated changes in agricultural production resulting from the Integrated Plan as a percent of the area's current annual economic activity. These changes in agricultural activity represent about 2.1 percent of current annual output, 1.7 percent of current personal income, and 3.9 percent of current jobs in the 4-county study area. As suggested by the first row in the table, the majority of the economic impacts of changes in agricultural production would occur in the agricultural sector. Across the 4-county study area, the agricultural sector currently supports about $3.4 billion in annual output, $0.9 billion in annual personal income, and about 38,200 jobs. In this context, the economic impacts associated with changes in agricultural production during a severe drought year resulting from the Integrated Plan would be equivalent to about 13 percent of current annual agriculture-related output, 13 percent of current annual agriculture-related personal income, and 21 percent of current annual agriculture-related jobs.

Table 26. Distribution of Agricultural Impacts By Aggregate Industry Sector, 4-County Study Area

Aggregate Industry Sector	Total Output	Total Personal Income	Total Jobs
Agriculture	$438,000,000	$119,000,000	8,200
Mining	$400,000	$30,000	4
Construction	$4,000,000	$1,000,000	30
Manufacturing	$30,000,000	$2,000,000	40
Transportation, Information, Utilities	$17,000,000	$5,000,000	100
Trade	$35,000,000	$16,000,000	450
Service	$146,000,000	$38,000,000	1,200
Government	$20,000,000	$5,000,000	60
Total Economic Impact in the 4-County Study Area	$690,000,000	$185,000,000	10,100
All Economic Activity in the 4-County Study Area	$32.4 billion	$10.8 billion	260,000
Economic Impact as a Percent of Economic Activity	2.1%	1.7%	3.9%
Notes: Calculated with data described previously in this analysis and 2009 IMPLAN base data.			

3.4.2 Timing of Changes in Agricultural Production

As described in the NED analysis, the Integrated Plan's irrigation-related benefits would not occur every year. Rather, the Integrated Plan would increase agricultural production during severe drought years.[24] The results of this analysis describe the economic impacts associated with changes in agricultural production attributable to the Integrated Plan during a severe drought year. While these impacts do represent annual impacts, insofar as they accumulate within a given year, they do not represent a continuous stream of annual impacts.

3.5 Summary of Findings

This analysis describes the Integrated Plan's economic impacts in terms of direct, indirect, and induced output, income, and employment in the 4-county study area (Kittitas, Yakima, Benton, and Franklin Counties) and across the State of Washington. Table 27 summarizes the findings for the 4-county study area and Table 28 summarizes the findings for the statewide economy. In interpreting the results, it is important to understand and consider the timing of the impacts. Each table shows separately the economic impacts of construction expenditures, O&M expenditures, and changes in agricultural production during severe drought years. The values describing construction-related impacts represent the Integrated Plan's average annual effects from 2013 to 2030. In reality, these economic impacts would fluctuate from year to year as the overall construction effort varies. The values describing O&M-related impacts represent the plan's effects during the year in which O&M expenditures are expected to reach their maximum. In all

[24] As described in the NED analysis, severe, one-year droughts are assumed to occur every five years with a severe, three-year drought occurring every 20 years.

other years, the economic impacts tied to O&M expenditures would be less than those in the tables. The values describing agriculture-related impacts represent the plan's effects during a severe drought year. During non-drought years, agricultural production would be similar to production without the Integrated Plan.

Each table represents a different geographic region within which the economic impacts would materialize. As described earlier, the economic impacts in the 4-county study area represent output, personal income, and employment within the 4-county study area. These impacts would not, however, necessarily accrue to individuals living within the 4-county study area. Some of them may accrue to individuals traveling to the area from elsewhere in Washington or from other states.

Table 29 summarizes the findings in the 4-county study area and across the state. It also puts the findings in perspective by showing their values as a percentage of the overall economy. For example, the findings suggest that average annual construction-related expenditures would support about $130 million in output in the 4-county study area per year, which represents about 0.4 percent of the 4-county study area's current total annual output.

Table 27. Summary of Economic Impacts in the 4-County Area, by Type of Expenditure

Type of Expenditure	Direct	Indirect	Induced	Total
Construction (2013-2030 average)				
Output	$97,000,000	$11,000,000	$22,000,000	$130,000,000
Personal Income	$63,000,000	$4,000,000	$7,000,000	$73,000,000
Jobs	1,200	100	200	1,500
O&M (maximum annual)				
Output	$11,000,000	$5,000,000	$4,000,000	$20,000,000
Personal Income	$5,000,000	$1,000,000	$1,000,000	$7,000,000
Jobs	60	20	30	110
Agricultural Production (severe drought year only)				
Output	$400,000,000	$137,000,000	$153,000,000	$690,000,000
Personal Income	$87,000,000	$52,000,000	$46,000,000	$185,000,000
Jobs	7,200	1,500	1,400	10,100
Notes: Based on data described previously in this analysis and calculated with 2009 IMPLAN base data.				

Table 28. Summary of Economic Impacts in Washington, by Type of Expenditure

Type of Expenditure	Direct	Indirect	Induced	Total
Construction (2013-2030 average)				
Output	$147,000,000	$33,000,000	$79,000,000	$260,000,000
Personal Income	$88,000,000	$9,000,000	$23,000,000	$120,000,000
Jobs	1,500	200	600	2,300
O&M (maximum annual)				
Output	$11,000,000	$5,300,000	$4,600,000	$20,900,000
Personal Income	$5,000,000	$1,100,000	$1,100,000	$7,200,000
Jobs	60	25	35	120
Agricultural Production (severe drought year only)				
Output	$400,000,000	$201,000,000	$189,000,000	$790,000,000
Personal Income	$87,000,000	$66,000,000	$55,000,000	$208,000,000
Jobs	7,200	2,000	1,600	10,800
Notes: Based on data described previously in this analysis and calculated with 2009 IMPLAN base data.				

Table 29. Summary of Economic Impacts Relative to the Greater Economy

	4-County Study Area		Washington	
Type of Expenditure	Total Impacts	Total Impacts as a Percentage of Overall Economy	Total Impacts	Total Impacts as a Percentage of Overall Economy
Construction (2013-2030 average)				
Output	$130,000,000	0.4%	$260,000,000	< 0.1%
Personal Income	$73,000,000	0.7%	$120,000,000	< 0.1%
Jobs	1,500	0.6%	2,300	< 0.1%
O&M (maximum annual)				
Output	$20,000,000	< 0.1%	$20,900,000	< 0.1%
Personal Income	$7,000,000	< 0.1%	$7,200,000	< 0.1%
Jobs	110	< 0.1%	120	< 0.1%
Agricultural Production (severe drought year only)				
Output	$690,000,000	2.1%	$790,000,000	0.1%
Personal Income	$185,000,000	1.7%	$208,000,000	0.1%
Jobs	10,100	3.9%	10,800	0.3%
Notes: Based on data described previously in this analysis and calculated with 2009 IMPLAN base data.				

4.0 Environmental Quality and Other Social Effects Accounts

This section describes the Environmental Quality (EQ) and Other Social Effects (OSE) accounts, the methods used for the evaluations, and the results of those accounts.

4.1 Environmental Quality

The Environmental Quality (EQ) evaluation was conducted in a workshop setting by a team of staff from Reclamation and Ecology along with senior environmental consultants to the agencies. Members of the team had all worked on the PEIS for the Integrated Plan and have expertise in environmental analysis, engineering, and Yakima Project operations.

The process used during the EQ workshops involved five major steps:

1. Identifying environmental resource categories from the PEIS that were most important for decision-making;
2. Prioritizing the resource categories;
3. Dividing some resource categories into subcategories to better capture the benefits and impacts of the alternative;
4. Weighting the EQ categories or subcategories; and
5. Scoring the benefits and impacts of the EQ categories or subcategories.

The EQ resource categories selected by the team are listed in Table 30 along with a brief explanation of the resource categories. The categories identified were those that have the most effect on the purpose and need[25] for the Integrated Plan and those that would potentially be most impacted by the plan. The PEIS identified the needs of the Yakima River basin as improvements to resident and anadromous fish populations and irrigation and municipal and domestic water supply; as well as the ability to adapt to climate change.

The team considered the need for creating subcategories of the resource categories to allow for more refined evaluation of the benefits and impacts. Subcategories were assigned as shown and further explained in Table 30.

There are a number of resources that were discussed in the PEIS that are not included in the EQ evaluation. The Reclamation and Ecology team decided to focus the EQ evaluation on those resources that would be most important in deciding whether to implement the Integrated Plan. Other resources such as water quality, groundwater, air quality, visual resources, noise, transportation and utilities were not considered to have a significant effect on decision making at the programmatic level. Individual projects implemented under the Integrated Plan may

[25] The purposes of the Integrated Plan are to implement a comprehensive program of water resource and habitat improvements in response to existing and forecast needs of the Yakima River basin and to develop an adaptive approach for implementing these initiatives and for long-term management of basin water supplies that contributes to the vitality of the regional economy and sustains the health of the riverine environment.

significantly affect those resources and they may be important for decision-making at a project-specific level; those effects would be considered during project level analyses.

The team discussed whether to include hydropower and private property acquisition in the EQ evaluation, but decided against including them. Hydropower impacts identified in the PEIS are those that would occur from subordinating power at the Roza and Chandler Powerplants, and those impacts can be monetized. The Integrated Plan requires the acquisition of considerable amounts of private property; however, Reclamation and Ecology are committed to only acquiring private property from willing sellers. Also, the costs of property acquisition are included in the NED analysis and have been monetized. Therefore, hydropower was not considered a category in the analysis and property acquisition was not included as a subcategory used to evaluate impacts to Land Use.

The team prioritized the six resource categories based on two criteria. Four resource categories that most affect the purpose and need were rated as being of primary priority—water resources, fish, threatened and endangered species, and land use. The other two categories were rated as being of secondary priority. The categories with the highest priority were weighted higher than the two secondary priority resources. All resource categories were assigned weights based on their priority and so that the numbers totaled to 1.0.

Table 30. EQ Resource Categories

EQ Resource Category	EQ Resource Subcategories	Background
Water Resources	Agriculture	The water resource category is intended to capture the non-monetized benefits of improved water supply and to incorporate instream flows which are not monetized. As used here, agriculture and municipal water includes the benefits that would occur from improved water supplies that have not been monetized in the NED or RED, such as benefits of a more stabilized economy. Instream flows are included to represent the benefits other than fish that accrue from improved streamflows, such as improved water quality, aesthetics, etc.
	Municipal	
	Instream Flows	
Fish	Fish Abundance	Fish abundance accounts for overall improvements in fish populations, health, and distribution that will occur under the plan. Fish passage refers to ecosystem benefits of providing fish with access to more habitat.
	Fish Passage	
Threatened and Endangered Species	Spotted Owl	Spotted owl, steelhead, and bull trout are federally listed species. Greater sage-grouse is a federal candidate species.
	Steelhead	
	Bull Trout	
	Greater Sage-Grouse	
Land Use	Protection and Enhancement of Ecosystems and Biodiversity	Protection and enhancement of ecosystems and biodiversity refers to the impact of the alternatives on overall ecosystem preservation and restoration in the basin as it relates to land use.
Vegetation and Wildlife Habitat	Shrub-Steppe	Shrub-steppe, old growth, and riparian areas are the primary vegetation and habitat types that would be affected by the Integrated Plan.
	Old Growth Forest	
	Riparian	
Recreation	Water-Based	Water-based recreation includes recreation opportunities on or around reservoirs and rivers. Land-based recreation includes recreation activities on land such as hiking, camping, horseback riding, and off-road vehicle use.
	Land-Based	

The team then weighted the EQ subcategories. Similar to the prioritization process, the subcategories were assigned weights based on how the subcategories would meet the purpose and need of the Integrated Plan and potential impacts of the plan on the resources. The subcategory weights also total to 1.0. The category weights were then multiplied by the subcategory weights to obtain the final weights for the EQ resources. Table 31 presents the weights of the categories and subcategories.

Table 31. EQ Categories and Weightings

Category	Category Weight	Subcategories	Subcategory Weight	Final Weight
Water Resources	0.2	Agricultural Water	0.40	0.08
		Municipal Water	0.20	0.04
		Instream Flows	0.40	0.08
Fish	0.2	Fish Abundance	0.50	0.10
		Fish Passage	0.50	0.10
Threatened and Endangered Species	0.2	Spotted Owl	0.30	0.06
		Steelhead	0.30	0.06
		Bull Trout	0.30	0.06
		Greater Sage-Grouse	0.10	0.02
Land Use	0.2	Protection and enhancement of ecosystems and biodiversity	1.0	0.2
Vegetation and Wildlife Habitat	0.1	Shrub Steppe	0.333	0.033
		Old Growth	0.333	0.033
		Riparian	0.333	0.033
Recreation	0.1	Water-Based	0.50	0.05
		Land-Based	0.50	0.05
TOTALS	1			1

After the EQ resource categories were identified, ranked, and weighted, the team rated the impacts. Typically EQ evaluations compare the impacts between action alternatives of a proposal. For this proposal, there is only one action alternative and a no action alternative that includes ongoing activities that would have some effect on the purpose and need. The team decided that impacts would be rated based on comparing the impacts of the Integrated Plan and the No Action alternatives to existing baseline conditions.

During the rating process, the Reclamation and Ecology team rated the No Action alternative based on the conditions that would result from the habitat and conservation projects included in the No Action alternative. For the Integrated Plan alternative, the team considered the effects of the combined package of elements. For example, the rating of fish benefits and impacts included the effects of the storage, conservation, and fish passage elements, as well as watershed improvements that would accrue under the habitat/watershed protection and enhancement element. Throughout the rating, the team assumed that the Integrated Plan included mitigation measures that were identified in the PEIS as being required by regulations for individual projects. For both alternatives, the team considered impacts and benefits over a 50-year time frame to be consistent with the time frame used for the PEIS modeling of water supply and instream benefits. The team also considered potential impacts of climate change, changes in vegetation and wildlife, and anticipated development that would occur in the next 50 years for both alternatives.

To compare the effects of the two alternatives, the team developed a scale which accounts for both positive and negative impacts. The scale uses a 0 rating to indicate no change relative to existing conditions. The scale is listed below:

0 = no change from existing conditions

3 = major positive impact	-3 = major negative impact
2 = moderate positive impact	-2 = moderate negative impact
1 = minor positive impact	-1 = minor negative impact

The impacts were scored using the same consensus-based approach as the prioritizing and weighting process. Resource subcategories were assigned an impact rating from +3 for a major positive impact to -3 for a major negative impact with a 0 rating indicating no overall change to existing conditions. For example, agricultural water was rated +3 under the Integrated Plan because agricultural water needs would be met under most which meets the objective of providing a water supply of 70 percent proratable water rights during drought years under most modeling scenarios, while the No Action alternative was rated -3 because prorationing would get worse under most scenarios.

To determine the final EQ score, the team multiplied the resource category significance scores for both the Integrated Plan and No Action alternative by the subcategory weight. This resulted in a +0.24 score for agricultural water under the Integrated Plan and a -0.24 score under the No Action Alternative. The resulting numbers reflect both the significance of the effect and the relative importance of the resource category and subcategory for the Yakima River basin as a whole. Table 32 displays the final results of the EQ evaluation.

Table 32. EQ Evaluation Results

EQ RESOURCE CATEGORY			No Action Alternative		Integrated Plan	
		Weight	Significance	Score	Significance	Score
Water Resources	Agriculture	0.08	-3	-0.24	3	0.24
	Municipal	0.04	-3	-0.12	3	0.12
	Instream Flows	0.08	-2	-0.16	3	0.24
	Subtotal	0.2		-0.52		0.60
Fish	Fish Abundance	0.1	1	0.1	3	0.30
	Fish Passage	0.1	0	0	3	0.30
	Subtotal	0.2		0.1		0.60
Threatened and Endangered Species	Spotted Owl	0.06	-1	-0.06	1	0.06
	Steelhead	0.06	-1	-0.06	2	0.12
	Bull Trout	0.06	-1	-0.06	2	0.12
	Greater Sage-Grouse	0.02	-1	-0.02	1	0.02
	Subtotal	0.2		-0.2		0.32
Land Use Management	Protection and Enhancement of Ecosystems and Biodiversity	0.20	0	0	3	0.60
	Subtotal	0.2		0		0.60
Vegetation and Wildlife Habitat	Shrub Steppe	0.033	-1	-0.03	1	0.03
	Old Growth Forest	0.033	-1	-0.03	1	0.03
	Riparian	0.033	1	0.03	3	0.10
	Subtotal	0.1		-0.03		0.17
Recreation	Water-Based	0.05	0	0	2	0.10
	Land-Based	0.05	0	0	2	0.10
	Subtotal	0.1		0		0.20
Total		1		-0.65		2.49

To portray the scoring results on a relative basis, the category scores for each resource were normalized so that they are compared to the -3 to 3 scale. On this normalized scale, the highest negative impact for each category would be scored -3 and the highest positive impact would be scored +3. The normalized score does not include the weightings shown on Table 32. Table 33 shows the normalized results for the EQ Category scores. Figure 22 graphically portrays those results.

Table 33. Normalized EQ Category Scores

Category	No Action Alternative	Integrated Plan
Water Resources	-2.61	3.00
Fish	0.51	3.00
Threatened and Endangered Species	-1.00	1.59
Land Use	0	3.00
Vegetation and Wildlife	-0.30	1.68
Recreation	0	2.01

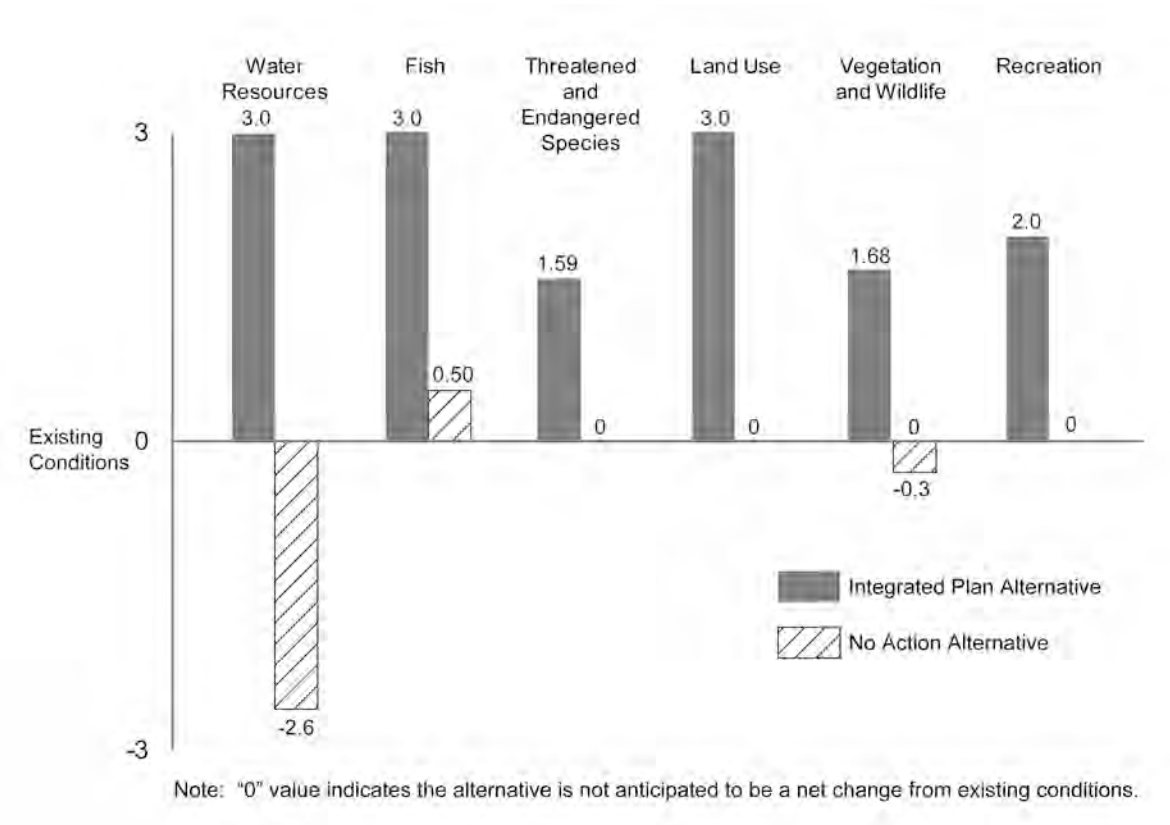


Figure 22. Environmental Quality Scores for the Integrated Plan and No Action Alternatives

For all categories considered, the Integrated Plan provides improvements over existing conditions whereas the No Action alternative would have negative effects except for a minor improvement to fish.

4.2 OSE Evaluation

Other Social Effects (OSE) were analyzed by the same team and at the same workshops and meetings as the EQ analysis. The OSE account is intended to include perspectives that are not included in the NED, RED or EQ accounts. The team identified two resource categories to include in the OSE account—cultural resources and sustainability benefits. Cultural resources were included in the OSE account rather than the EQ account in an attempt to represent the

Plan. OSE accounts often include environmental justice, but the team decided not to include that category since the Integrated Plan PEIS did not identify the potential for environmental justice impacts. The OSE categories are listed and described in Table 34.

Table 34. OSE Resource Categories

OSE Resource Category	OSE Resource Subcategories	Background
Cultural Resources	Historic Structures	Three subcategories are included under cultural resources. Impacts to historic structures and cultural and archaeological resources are those that would occur during project construction when historic structures such as Yakima Project dams are modified or cultural resources are disturbed. The subsistence subcategory is included to capture the impacts or benefits to culturally important resources such as salmon and hunting, fishing, and gathering.
	Cultural and Archaeological Resources	
	Subsistence Resources	
Sustainability Benefits	Improve Water Resource Reliability	Sustainability benefits are intended to capture overall benefits of the Integrated Plan to water resource reliability and ecosystem resilience to climate change. The category is divided into two subcategories—improved water resource reliability and increased resistance of the ecosystem to climate change.
	Overall System Resilience to Climate Change	

The OSE categories and subcategories were weighted as shown in Table 35 along with the weights assigned to each. Sustainability benefits were weighted higher than cultural resources because of their overall potential to influence long term resilience to climate change. The subsistence resources subcategory was weighted slightly higher than impacts to historic and cultural resources while the sustainability subcategories were given equal weight.

Table 35. OSE Categories and Rankings

Category	Category Weight	Subcategories	Subcategory Weight	Final Weight
Cultural	0.40	Historic Structures	0.30	0.12
		Cultural and Archaeological Resources	0.30	0.12
		Subsistence Resources	0.40	0.16
Sustainability Benefits	0.60	Improve Water Resource Reliability	0.50	0.30
		Overall System Resilience to Climate Change	0.50	0.30
TOTALS	1			1

The team used the same scale as described in Section 3.3 to evaluate the effects to OSE under the Integrated Plan and No Action Alternative. Table 36 displays the final results of the OSE evaluation.

Table 36. OSE Evaluation Results

OSE RESOURCE CATEGORY			No Action Alternative		Integrated Plan	
		Weight	Significance	Score	Significance	Score
Cultural	Historic Properties	0.12	0	0.00	-1	-0.12
	Cultural and Archaeological Resources	0.12	0	0.00	-1	-0.12
	Subsistence Resources	0.16	1	0.16	3	0.48
	Subtotal	0.40		0.16		0.24
Sustainability Benefits	Improve Water Supply Reliability	0.30	-2	-0.60	3	0.90
	Overall System Resilience to Climate Change	0.30	0	0.00	2	0.60
	Subtotal	0.60		-0.60		1.50
Total		1.00		-0.44		1.74

To portray the scoring results on a relative basis, the category scores for each resource were normalized to the -3 to 3 scales. On this normalized scale, the highest negative impact for each category would be scored -3 and the highest positive impact would be scored +3. The normalized score does not include the weightings shown on Table 36. Table 37 shows the normalized results for each OSE Category score. Figure 23 shows the results in graphical format.

Table 37. Normalized OSE Category Scores

Category	No Action Alternative	Integrated Plan
Cultural	0.40	0.60
Sustainability Benefits	-1.00	2.50

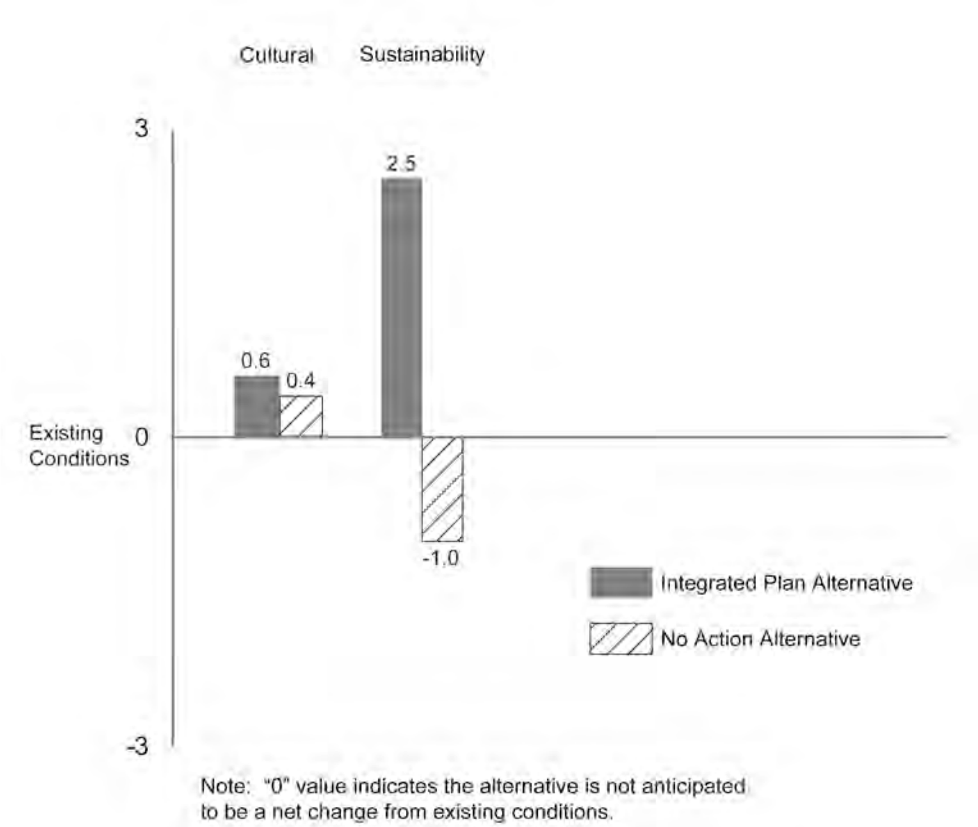


Figure 23. Other Social Effects Scores for the Integrated Plan and No Action Alternatives

The Integrated Plan would have minor positive benefits to cultural resources, primarily from benefits to subsistence resources. For sustainability benefits, the Integrated Plan provides minor improvements while the No Action alternative would have minor negative impacts.

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Appendix A. Fish Benefits

Section 2.2 describes the total economic value and the use value derived from the Integrated Plan's expected impact on fish populations in the Yakima River and Columbia River Basins. It also outlines the analytical approach for estimating each type of value, and provides justification for the approaches within the context of the NED account. This appendix provides additional details describing the calculations and assumptions used in the analysis. All values calculated in this analysis are in 2012 dollars. Values from previous years were brought to 2012 dollars using the U.S. Bureau of Labor Statistics' Consumer Price Index.

A.1 Estimating Total Economic Value

Table A- 1 provides a summary of the calculations used to estimate the overall present value of the total economic value associated with the Integrated Plan's fish-related benefits.[26] The first three rows show the calculations for the low-end potential increase in fish populations applied to Washington households only. The next three rows show the calculations for the high-end potential increase in fish populations applied to Washington households only. The same pattern is then followed for Washington households plus Oregon households. Below, the contents of each column are described in turn:

- **Geographic scope.** As described in Section 2.2, the analysis first calculates the total economic value derived by Washington households alone. Then, it calculates the total economic value derived by both Washington and Oregon households.
- **Range of increase in fish populations.** The Integrated Plan is expected to increase future fish populations, but the precise number of additional fish is unknown. On the low end of expectations, fish populations would increase by 181,650 fish between 2013 and 2042. On the high end, they would increase by 472,450 fish (Hubble, 2012). The analysis assumes fish populations increase linearly[27], then remain stable after 2042.
- **20-year period.** For analytical purposes, the Integrated Plan comprises two sequential programs analogous to those examined in the *LBP Study*: one extending over the first 20 years, from 2012 to 2031, and another extending over the next 20 years, from 2032 to 2051. Applying the results from the *LBP* Study entails computing the value of the growth in salmon/steelhead populations associated with each of these two programs, relative to a baseline scenario with stable fish populations. The

[26] Table A- 1 demonstrates how the overall present value for Oregon and Washington households was calculated using the model relating to the stable fish-population baseline scenario model in the *LBP Study*. The same general approach was used to calculate the value for Washington households only, and to examine the effects on the computations of using the model relating to the declining fish-population baseline scenario if the *LBP Study*.

[27] The actual growth in fish populations may occur faster or slower.

benefits of the first 20-year program would be realized in 2012, reflecting households' expressed willingness to pay for the expectation of higher fish populations in 2031 relative to 2012. The benefits of the second program would be realized in 2032, reflecting households' expressed willingness to pay for the expectation of higher fish populations in 2051 relative to 2032.

- **Increase in fish population at the end of the 20-year period.** The average annual WTP per household is directly tied to the change in fish population at the end of each 20-year period as a percentage of the baseline fish population, 2 million fish.
- **Annual WTP per household.** With implementation of the Integrated Plan, fish populations would increase by 115,045–299,218 fish during the first 20-year period, or 5.8–15.0 percent relative to a baseline of 2 million fish. They would increase by an additional 66,609–173,232 fish during the second 20-year period, or 3.3–8.7 percent relative to a baseline of 2.0 million fish. The analysis applied these percentages to the model described in Section 2.2 to estimate average annual household WTP.
- **Present value of 20-year WTP per household.** At the beginning of each 20-year period, the analysis measures the value of the fish-related benefits looking at households' average willingness to pay for the indicated percentage change in fish populations expected to materialize at the end of the 20-year period. the *LBP Study* measured household willingness to pay by asking survey respondents to assume they would make monthly payments throughout the 20-year period. The analysis converts the stream of annual payments to the equivalent present value using a discount rate of 4 percent per year.
- **Number of households.** As described in Section 2.2, the future number of households across Washington and Oregon was estimated by applying projected population growth rates to data from the 2010 US Census (U.S. Census Bureau, 2010; Office of Financial Management, 2011; Oregon Office of Economic Analysis, 2004). The number of households was assumed to increase at the same rate as the increase in population.
- **Overall present value.** The overall present value is calculated by multiplying the present value of households' average willingness to pay for the indicated expected percentage increase in fish population by the number of households associated with each 20-year period.
-

Table A- 1. Total Economic Value of Expected Increases in Fish Populations

Geographic scope	Range of increase in fish populations	20-year period	Increase in fish populations at the end of the 20-year period	Annual WTP per household	Present value of per Household over the 20-year period	Number of households	Overall present value
Washington Only	Low-end Increase	2012-2031	115,045	$73	$1,030	2,655,945	$2.8 billion
Washington Only	Low-end Increase	2032-2051	66,605	$19	$120	3,229,953	$0.4 billion
Washington Only	Low-end Increase	Total	181,650	--	--	--	$3.1 billion

Geographic scope	Range of increase in fish populations	20-year period	Increase in fish populations at the end of the 20-year period	Annual WTP per household	Present value of per Household over the 20-year period	Number of households	Overall present value
Washington Only	High-end Increase	2012-2031	299,218	$113	$1,600	2,655,945	$4.3 billion
Washington Only	High-end Increase	2032-2051	173,232	$19	$120	3,229,953	$0.4 billion
Washington Only	High-end Increase	Total	472,450	--	--	--	$4.6 billion
Oregon & Washington	Low-end Increase	2012-2031	115,045	$73	$1,030	4,214,685	$4.4 billion
Oregon & Washington	Low-end Increase	2032-2051	66,605	$19	$120	5,204,407	$0.6 billion
Oregon & Washington	Low-end Increase	Total	181,650	--	--	--	$5.0 million
Oregon & Washington	High-end Increase	2012-2031	299,218	$113	$1,600	4,214,685	$6.7 billion
Oregon & Washington	High-end Increase	2032-2051	173,232	$19	$120	5,204,407	$0.6 billion
Oregon & Washington	High-end Increase	Total	472,450	--	--	--	$7.4 billion
Source: Hubble, 2012; Layton et al., 1999; U.S. Census Bureau, 2010; Office of Financial Management, 2011; Oregon Office of Economic Analysis, 2004							

A.2 Estimating Use Value

The methodology for estimating the use values derived from the Integrated Plan's impact on fish populations is described in Section 2.2. It closely follows the methodology used by Reclamation in a prior analysis of water storage projects in the Yakima River Basin (Reclamation, 2008). This appendix provides additional details describing the data used to estimate use values in the eight different fisheries. A year-by-year look at the calculations over time, is presented at the end of this section.

A.2.1 Ocean Commercial Fishery

The analysis assumes that use values derived by the ocean commercial fishery are equal to the profits (80 percent of revenue) associated with the increase in harvest attributable to the Integrated Plan's impact on fish populations. The analysis has three steps:

1. Estimate the real price per dressed fish caught off the coasts of four states (California, Oregon, Washington, and Alaska) by species (Chinook and Coho).

Table A- 2 shows the calculations (2007-2011).

2. Determine the distribution of fish, originating in the Yakima River Basin, harvested by each state. Table A- 3 shows the number of tagged Chinook and Coho caught by fisheries in different states since the early 1980s that originated in the Yakima River Basin. Fish harvested by Canadian fisheries (BC) are excluded. The bottom row shows the distribution of fish harvests by relevant states.

3. Multiply the 5-year weighted average profit associated with each state's commercial ocean fishery by the percentage of Yakima-spawned fish they catch relative to other states. Table A- 4 summarizes these results.

Table A- 2. Ocean Commercial Fishery - Landings and Prices

Column Label			A	B	C	D	E	F	G	H	I	J	K
Column Calculation						D = C/E			G = C/E	H = D/E	I = E/F	J = G*I	K = H*I
Table Source					Table IV-4		Table IV-8	Table A-13					
State	Species	Year	Annual CPI	CPI Factor	Nominal Value ($1,000s)	Real Value ($1,000s)	Dressed Pounds Landed (1,000s)	# of Fish Harvested	Nominal Price per Dressed Pound	Real Price per Dressed Pound	Pounds per Fish	Nominal Value per Fish	Real Value per Fish
CA	Chinook	2007	207.342	0.904	$7,902	$8,742	1,525	114,141	$5.18	$5.73	13.36		
		2008	215.303	0.939	$0	$0	-	-	$0.00	$0.00	-		
		2009	214.537	0.935	$0	$0	-	-	$0.00	$0.00	-		
		2010	218.056	0.951	$1,246	$1,311	228	15,088	$5.46	$5.75	15.11		
		2011	224.939	0.981	$5,113	$5,214	988	69783	$5.18	$5.28	14.16		
Revenue 5-year wtd average									$5.20	$5.57	13.77	$71.66	$76.72
Profit 5-year wtd average												$57.33	$61.37
OR	Chinook	2007	207.342	0.904	$2,630	$2,910	464	35,487	$5.67	$6.27	13.08		
		2008	215.303	0.939	$484	$516	66	5,954	$7.33	$7.81	11.08		
		2009	214.537	0.935	$77	$82	15	1,149	$5.13	$5.49	13.05		
		2010	218.056	0.951	$2,775	$2,919	506	39,433	$5.48	$5.77	12.83		
		2011	224.939	0.981	$2,385	$2,432	400	31,934	$5.96	$6.08	12.53		
Revenue 5-year wtd average									$5.76	$6.11	12.73	$73.28	$77.74
Profit 5-year wtd average												$58.63	$62.19
WA	Chinook	2007	207.342	0.904	$905	$1,001	184	14,268	$4.92	$5.44	12.90		
		2008	215.303	0.939	$673	$717	100	8,636	$6.73	$7.17	11.58		
		2009	214.537	0.935	$893	$955	155	12,316	$5.76	$6.16	12.59		
		2010	218.056	0.951	$3,083	$3,243	522	45,099	$5.91	$6.21	11.57		
		2011	224.939	0.981	$1,652	$1,685	322	26,902	$5.13	$5.23	11.97		
Revenue 5-year wtd average									$5.62	$5.92	11.97	$67.21	$70.89
Profit 5-year wtd average												$53.77	$56.71
AK	Chinook	2007	207.342	0.904	$18,596	$20,574	5,283	359,000	$3.52	$3.89	14.72		

Column Label			A	B	C	D	E	F	G	H	I	J	K
Column Calculation						D = C/E			G = C/E	H = D/E	I = E/F	J = G*I	K = H*I
Table Source					Table IV-4		Table IV-8	Table A-13					
State	Species	Year	Annual CPI	CPI Factor	Nominal Value ($1,000s)	Real Value ($1,000s)	Dressed Pounds Landed (1,000s)	# of Fish Harvested	Nominal Price per Dressed Pound	Real Price per Dressed Pound	Pounds per Fish	Nominal Value per Fish	Real Value per Fish
		2008	215.303	0.939	$22,104	$23,550	4,056	271,000	$5.45	$5.81	14.97		
		2009	214.537	0.935	$11,970	$12,799	3,759	267,000	$3.18	$3.40	14.08		
		2010	218.056	0.951	$15,772	$16,592	3,742	260,000	$4.21	$4.43	14.39		
		2011	224.939	0.981	$16,788	$17,120	4,416	326000	$3.80	$3.88	13.55		
Revenue 5-year wtd average									$4.01	$4.26	14.33	$57.47	$61.12
Profit 5-year wtd average												$45.98	$48.89
CA	Coho	2007	207.342	0.904	$0	$0	-	-	$0.00	$0.00	-		
		2008	215.303	0.939	$0	$0	-	-	$0.00	$0.00	-		
		2009	214.537	0.935	$0	$0	-	-	$0.00	$0.00	-		
		2010	218.056	0.951	$0	$0	-	-	$0.00	$0.00	-		
		2011	224.939	0.981	$0	$0	-	-	$0.00	$0.00	-		
Revenue 5-year wtd average									$0.00	$0.00	$0.00	$0.00	$0.00
Profit 5-year wtd average												$0.00	$0.00
OR	Coho	2007	207.342	0.904	$193	$214	101	17,095	$1.91	$2.11	5.91		
		2008	215.303	0.939	$10	$11	4	435	$2.50	$2.66	9.20		
		2009	214.537	0.935	$267	$285	131	21,968	$2.04	$2.18	5.96		
		2010	218.056	0.951	$16	$17	7	1,038	$2.29	$2.40	6.74		
		2011	224.939	0.981	$5	$5	3	464	$1.67	$1.70	6.47		
Revenue 5-year wtd average									$2.00	$2.16	6.00	$11.98	$12.97
Profit 5-year wtd average												$9.58	$10.37
WA	Coho	2007	207.342	0.904	$48	$53	33	5,886	$1.45	$1.61	5.61		
		2008	215.303	0.939	$36	$38	14	1,706	$2.57	$2.74	8.21		
		2009	214.537	0.935	$176	$188	136	20,055	$1.29	$1.38	6.78		
		2010	218.056	0.951	$32	$34	15	2,104	$2.13	$2.24	7.13		
		2011	224.939	0.981	$35	$36	17	3,053	$2.06	$2.10	5.57		
Revenue 5-year wtd average									$1.52	$1.62	6.55	$9.97	$10.64
Profit 5-year wtd average												$7.97	$8.51

Column Label			A	B	C	D	E	F	G	H	I	J	K
Column Calculation						D = C/E			G = C/E	H = D/E	I = E/F	J = G*I	K = H*I
Table Source					Table IV-4		Table IV-8	Table A-13					
State	Species	Year	Annual CPI	CPI Factor	Nominal Value ($1,000s)	Real Value ($1,000s)	Dressed Pounds Landed (1,000s)	# of Fish Harvested	Nominal Price per Dressed Pound	Real Price per Dressed Pound	Pounds per Fish	Nominal Value per Fish	Real Value per Fish
AK	Coho	2007	207.342	0.904	$16,941	$18,743	12,834	2,063,000	$1.32	$1.46	6.22		
		2008	215.303	0.939	$31,217	$33,260	19,001	2,382,000	$1.64	$1.75	7.98		
		2009	214.537	0.935	$17,615	$18,835	16,770	2,635,000	$1.05	$1.12	6.36		
		2010	218.056	0.951	$24,735	$26,021	19,444	2,578,000	$1.27	$1.34	7.54		
		2011	224.939	0.981	$17,337	$17,680	13,610	2,268,000	$1.27	$1.30	6.00		
Revenue 5-year wtd average									$1.32	$1.40	6.85	$9.04	$9.60
Profit 5-year wtd average												$7.23	$7.68
Source: Pacific Fishery Management Council, 2011; U.S. Bureau of Labor Statistics, 2012													

Table A- 3. Ocean Commercial Fishery - Distribution of Harvest

Chinook							Coho						
Year	AK	BC	CA	OR	WA	Total	Year	AK	BC	CA	OR	WA	Total
1983	-	-	-	-	-	-	1983	-	-	-	-	-	-
1984	-	2	-	-	1	3	1984	-	-	-	-	-	-
1985	2	6	-	1	-	9	1985	-	-	-	-	-	-
1986	6	14	-	1	-	21	1986	-	-	-	-	-	-
1987	19	25	-	3	3	50	1987	-	-	-	-	-	-
1988	18	15	1	-	1	35	1988	-	1	-	-	-	1
1989	11	22	1	1	2	37	1989	-	10	2	64	5	81
1990	53	39	-	1	-	93	1990	-	2	13	26	9	50
1991	23	30	-	1	1	55	1991	-	2	16	63	3	84
1992	9	7	-	-	3	19	1992	-	1	-	5	1	7
1993	28	18	-	3	-	49	1993	-	-	-	1	1	2
1994	32	18	-	-	-	50	1994	-	-	-	-	-	-
1995	3	4	-	2	1	10	1995	-	1	-	-	1	2
1996	13	-	-	-	-	13	1996	-	-	-	-	-	-
1997	10	6	-	1	-	17	1997	-	-	-	-	-	-

Chinook							Coho						
Year	AK	BC	CA	OR	WA	Total	Year	AK	BC	CA	OR	WA	Total
1998	49	16	-	3	1	69	1998	-	-	-	-	-	-
1999	102	41	1	-	5	149	1999	-	-	-	-	1	1
2000	46	-	-	1	-	47	2000	-	-	-	1	1	2
2001	26	3	-	4	2	35	2001	-	-	-	-	3	3
2002	86	12	-	2	4	104	2002	-	-	-	-	-	-
2003	80	6	-	-	2	88	2003	-	-	-	-	1	1
2004	21	8	-	-	3	32	2004	-	-	-	-	3	3
2005	17	16	-	-	1	34	2005	-	-	-	-	-	-
2006	6	5	-	-	-	11	2006	-	-	-	-	-	-
2007	3	5	-	1	1	10	2007	-	-	-	-	-	-
2008	5	12	-	8	4	29	2008	-	-	-	-	-	-
2009	13	28	-	3	3	47	2009	-	-	-	-	-	-
2010	25	17	1	2	4	49	2010	-	-	-	-	-	-
2011	43	18	1	2	2	66	2011	-	-	-	-	-	-
Total	749	393	5	40	44	1,231	Total	-	17	31	160	29	237
% of Total	0.893	-	0.006	0.047	0.052	1.000	% of Total	-	-	-	0.846	0.153	1.000
Source: Webb, 2012													

Table A- 4. Ocean Commercial Fishery - Summary

	Chinook						Coho					
	AK	BC	CA	OR	WA	Total	AK	BC	CA	OR	WA	Total
% of Total States Only	0.893	-	0.006	0.047	0.052	1.000	-	-	-	0.846	0.153	1.000
5-year weighted average (Profit) ($ per fish)	$48.89	-	$61.37	$62.19	$56.71	N/A	-	-	-	$10.37	$8.51	N/A
5-year weighted average (Profit) weighed by distribution ($ per fish)	$43.70	-	$0.37	$2.97	$2.98	$50.01	-	-	-	$8.78	$1.31	$10.09

A.2.2 Ocean Sport Fishery

The analysis assumes that use values derived by the ocean sport fishery equal the use values associated with increases in sport fishing harvests and effort attributable to the Integrated Plan's impact on fish populations. This analysis has three steps:

1. Estimate the number of days spent fishing per fish harvested by each relevant state (California, Oregon, and Washington). Table A- 5 shows the data used in the analysis. The last column shows the total Chinook and Coho fishing days per fish harvested.

2. Determine the distribution of fish, originating in the Yakima River Basin, harvested by each state.

Table A- 6 shows the number of tagged Chinook and Coho harvested by different states since the early 1980s. The bottom row shows the distribution of fish harvests by relevant states.

3. Calculate the 5-year weighted average number of fishing days per fish harvested in each state from Table A- 5. These averages are weighted by the state- and species-level distribution of Yakima-spawned fish. The resulting coefficients are multiplied by the recreational use value, $127.54 per fishing day (Reclamation 2008), to estimate a species-specific use value relevant to sport fishing in the region (see Table A- 7).

Table A- 5. Ocean Sport Fishery - Effort and Harvest

Label	A	B	C	D	E	F	G	H	I	J	K	L	M
Calc				D = B+C			G = E+F			J = H+I	K = G+J	L = K/D	M = D/K
State	Year	Charter boat Ocean Sport Salmon Days (1,000s)	Private Boat Ocean Sport Salmon Days (1,000s)	Total Ocean Sport Salmon Days (1,000s)	Charter boat Chinook Ocean Landings (1,000s of Fish)	Private Boat Chinook Ocean Landings (1,000s of Fish)	Total Chinook Ocean Landings (1,000s of Fish)	Charter boat Coho Ocean Landings (1,000s of Fish)	Private Boat Coho Ocean Landings (1,000s of Fish)	Total Coho Ocean Landings (1,000s of Fish)	Total Chinook & Coho Ocean Landings (1,000s of Fish)	Total Chinook & Coho Harvest Rate per Day	Total Chinook & Coho Days per Fish Harvested
CA	2007	31.4	74.5	105.9	12.4	-	12.4	-	0.7	0.7	13.1	0.124	8.084
	2008	0.1	0.3	0.4	-	0.6	0.6	-	-	-	0.6	1.500	0.667
	2009	0.6	4.7	5.3	0.1	10.1	10.2	-	-	-	10.2	1.925	0.520
	2010	13.6	35.0	48.6	4.7	31.1	35.8	-	0.2	0.2	36.0	0.741	1.350
	2011	28.9	62.2	91.1	17.9		17.9	-	0.3	0.3	18.2	0.200	5.005
5-year wtd average												0.3	3.2
OR	2007	11.4	76.9	88.3	0.6	6.4	7.0	10.6	50.1	60.7	67.7	0.767	1.304
	2008	1.9	28.5	30.4	0.2	1.4	1.6	1.0	11.1	12.1	13.7	0.451	2.219

Label	A	B	C	D	E	F	G	H	I	J	K	L	M
Calc				D = B+C			G = E+F			J = H+I	K = G+J	L = K/D	M = D/K
State	Year	Charter boat Ocean Sport Salmon Days (1,000s)	Private Boat Ocean Sport Salmon Days (1,000s)	Total Ocean Sport Salmon Days (1,000s)	Charter boat Chinook Ocean Landings (1,000s of Fish)	Private Boat Chinook Ocean Landings (1,000s of Fish)	Total Chinook Ocean Landings (1,000s of Fish)	Charter boat Coho Ocean Landings (1,000s of Fish)	Private Boat Coho Ocean Landings (1,000s of Fish)	Total Coho Ocean Landings (1,000s of Fish)	Total Chinook & Coho Ocean Landings (1,000s of Fish)	Total Chinook & Coho Harvest Rate per Day	Total Chinook & Coho Days per Fish Harvested
	2009	12.6	71.9	84.5	0.2	1.3	1.5	14.2	75.4	89.6	91.1	1.078	0.928
	2010	5.0	48.3	53.3	0.6	4.4	5.0	2.8	15.5	18.3	23.3	0.437	2.288
	2011	5.9	42.8	48.7	0.6	4.6	5.2	3.5	15.3	18.8	24.0	0.493	2.029
5-year wtd average												0.7	1.4
WA	2007	26.7	45.9	72.6	3.1	5.9	9.0	33.7	50.1	83.8	92.8	1.278	0.782
	2008	14.2	22.2	36.4	6.0	87.6	93.6	8.3	10.5	18.8	112.4	3.088	0.324
	2009	29.4	69.5	98.9	3.1	9.2	12.3	47.9	90.0	137.9	150.2	1.519	0.658
	2010	26.5	54.4	80.9	15.4	21.5	36.9	14.1	22.2	36.3	73.2	0.905	1.105
	2011	22.2	49.2	71.4	9.8	19.3	29.1	15.1	24.4	39.5	68.6	0.961	1.041
5-year wtd average												1.4	0.7
Source: Pacific Fishery Management Council, 2012													

Table A- 6. Ocean Sport Fishery - Distribution of Harvest

Chinook							Coho						
Year	AK	BC	CA	OR	WA	Total	Year	AK	BC	CA	OR	WA	Total
1983	-	-	-	-	-	-	1983	-	-	-	-	-	-
1984	-	-	-	-	-	-	1984	-	-	-	-	-	-
1985	-	1	-	-	-	1	1985	-	-	-	-	-	-
1986	-	2	-	-	-	2	1986	-	-	-	-	-	-
1987	-	2	-	-	2	4	1987	-	-	-	-	-	-
1988	-	1	-	-	-	1	1988	-	-	-	-	-	-
1989	-	2	1	-	5	8	1989	-	1	8	77	69	155
1990	3	1	-	-	1	5	1990	-	-	14	82	59	155
1991	-	-	-	-	2	2	1991	-	-	44	85	78	207
1992	-	-	-	-	-	-	1992	-	-	-	16	10	26
1993	-	-	-	-	3	3	1993	-	-	3	10	7	20

Chinook							Coho						
Year	AK	BC	CA	OR	WA	Total	Year	AK	BC	CA	OR	WA	Total
1994	1	-	-	-	-	1	1994	-	-	-	-	1	1
1995	-	-	1	-	-	1	1995	-	-	-	5	17	22
1996	1	-	-	-	-	1	1996	-	-	1	-	5	6
1997	2	-	-	-	-	2	1997	-	-	-	1	17	18
1998	1	3	-	-	3	7	1998	-	-	-	1	11	12
1999	6	5	-	1	4	16	1999	-	-	-	12	26	38
2000	8	4	-	-	1	13	2000	-	-	-	25	25	50
2001	-	1	-	1	1	3	2001	-	1	-	1	12	14
2002	6	6	-	-	3	15	2002	-	-	-	-	-	-
2003	6	-	-	-	-	6	2003	-	-	-	1	6	7
2004	-	3	-	-	1	4	2004	-	-	-	1	6	7
2005	1	1	-	-	-	2	2005	-	-	-	-	4	4
2006	1	1	-	-	-	2	2006	-	-	-	-	-	-
2007	-	-	-	-	-	-	2007	-	-	-	-	-	-
2008	-	1	-	-	1	2	2008	-	-	-	-	-	-
2009	1	2	-	-	-	3	2009	-	-	-	-	-	-
2010	2	2	-	-	2	6	2010	-	-	-	-	-	-
2011	14	9	-	1	1	25	2011	-	-	-	-	-	-
Total	53	47	2	4	30	136	Total	-	2	70	317	353	742
% of Total	-	-	0.055	0.111	0.833	1.000	% of Total	-	-	0.094	0.428	0.477	1.000
Source: Webb, 2012													

Table A- 7. Ocean Sport Fishery - Summary

	CA	OR	WA	AK	Canada	Total
Weighted Average Chinook & Coho Days/Fish Harvested (from Table A-5)	3.2	1.4	0.7	0	0	
Re-Weighted % Chinook Harvest By State (from Table A-6)	0.055	0.111	0.833			
Re-Weighted % Coho Harvest by State (from Table A-6)	0.094	0.428	0.477			
CA/OR/WA Weighted Average Days/Fish Harvest Chinook	0.1787	0.1542	0.6038			0.936
CA/OR/WA Weighted Average Days/Fish Harvest Coho	0.3034	0.5932	0.3446			1.244

A.2.3 Lower Columbia River Commercial Fishery

The analysis assumes that use values derived by the Lower Columbia River commercial fishery are equal to the profits (80 percent of revenue) associated with the increase in harvest attributable to the Integrated Plan's impact on fish populations. This analysis has three steps:

1. Estimate the real price per dressed fish caught by Oregon and Washington fisheries in the Lower Columbia River by species (Chinook and Coho). Table A- 8 shows the calculations (2007-2011).
2. Estimate the number of fish (by species) from the last several years and their average weight. Table A- 9 shows the calculations (2006-2010).
3. Multiply the 5-year weighted average real price per dressed pound (by species) by the 5-year weighted average pounds per fish (by species). Table A-10 shows the calculations.

Table A- 8. Lower Columbia River Commercial Fishery - Landings and Prices

Column Label		A	B	C	D	E	F	G	H	I	J
Column Calculation					D = C/B		F = C/E	G = F/B		I = F*H	J = G*H
Table Reference				Table IV-9		Table IV-9					
Species	Year	Annual CPI	CPI Factor	Nominal Value ($1,000s)	Real Value ($1,000s)	Round Pounds Landed (1,000s)	Nominal Price per Pound (Round)	Real Price per Pound (Round)	Round Pounds per Fish	Nominal Value per Fish	Real Value per Fish
Spring Chinook	2007	207.342	0.904	$952	$1,053	160	$5.95	$6.58			
	2008	215.303	0.939	$1,075	$1,145	163	$6.60	$7.03			
	2009	214.537	0.935	$777	$831	156	$4.98	$5.33			
	2010	218.056	0.951	$2,483	$2,612	490	$5.07	$5.33			
	2011	224.939	0.981	$1,519	$1,549	308	$4.93	$5.03			
Revenue 5-year wtd average							$5.33	$5.63	13.51	$72.00	$76.07
Profit 5-year wtd average										$57.60	$60.86
Fall Chinook	2007	207.342	0.904	$624	$690	226	$2.76	$3.05			
	2008	215.303	0.939	$1,676	$1,786	724	$2.31	$2.47			
	2009	214.537	0.935	$1,579	$1,688	906	$1.74	$1.86			
	2010	218.056	0.951	$1,601	$1,684	945	$1.69	$1.78			
	2011	224.939	0.981	$2,319	$2,365	1,249	$1.86	$1.89			
Revenue 5-year wtd average							$1.93	$2.03	18.31	$35.27	$37.14
Profit 5-year wtd average										$28.21	$29.71
Coho	2007	207.342	0.904	$596	$659	343	$1.74	$1.92			
	2008	215.303	0.939	$989	$1,054	731	$1.35	$1.44			

	2009	214.537	0.935	$1,366	$1,461	1,108	$1.23	$1.32			
	2010	218.056	0.951	$1,127	$1,186	807	$1.40	$1.47			
	2011	224.939	0.981	$954	$973	589	$1.62	$1.65			
Revenue 5-year wtd average							$1.41	$1.49	9.65	$13.58	$14.39
Profit 5-year wtd average										$10.86	$11.51
Source: Pacific Fishery Management Council, 2012											

Table A- 9. Lower Columbia River Commercial Fishery - Landings (Number of Fish and Weight)

Year	Winter/Spring/Summer Chinook			Fall Chinook			Coho		
	Number of Fish	Pounds	Pounds per Fish	Number of Fish	Pounds	Pounds per Fish	Number of Fish	Pounds	Pounds per Fish
2006	16,453	249,269	15.2	30,568	583,787	19.1	66,025	701,722	10.6
2007	10,846	170,407	15.7	16,683	261,510	15.7	40,709	354,674	8.7
2008	11,808	165,449	14.0	42,049	743,599	17.7	68,258.0	740,173	10.8
2009	10,714	152,195	14.2	46,970	934,397	19.9	126,191.0	1,117,434	8.9
2010	38,653	484,913	12.5	51,807	945,096	18.2	77,679	807,764	10.4
5-year wtd average			13.51			18.31			9.65
Source: Oregon Department of Fish and Wildlife, 2012									

Table A- 10. Lower Columbia River Commercial Fishery - Summary

	Real Price per Round Pound	Round Pounds per Fish	Real Revenue per Fish	Real Profit per Fish
Spring Chinook	$5.63	13.51	$76.07	$60.86
Fall Chinook	$2.03	18.31	$37.14	$29.71
Coho	$1.49	9.65	$14.39	$11.51

A.2.4 Lower Columbia River Sport Fishery

The analysis assumes that use values derived by the Lower Columbia River sport fishery are equal to the use values associated with increases in sport fishing harvests and effort attributable to the Integrated Plan's impact on fish populations. Table A- 11 shows the average number of days spent fishing in the Lower Columbia River per fish harvested. To estimate the value per fish, the 5-year weighted average number of days spent fishing per fish harvested (4.313) is multiplied by the use value (from the literature) associated with each fishing day, $76.03 (Reclamation, 2008). There are insufficient data to derive species-specific use values for this fishery.

Table A- 11. Lower Columbia River Sport Fishery - Summary

Year	Salmon and Steelhead Effort (Days)	Salmon and Steelhead Harvest (No. of Fish)	Harvest per Day	Days per Fish Harvested
2007	238,635	42,417	0.178	5.626
2008	267,499	62,984	0.235	4.247
2009	400,393	113,881	0.284	3.516
2010	423,378	86,371	0.204	4.902
2011	427,465	101,804	0.238	4.199
5-Year Weighted Average	351,474	81,491	0.232	4.313
Source: Watts, 2012				

A.2.5 Upper Columbia River Tribal Commercial Fishery

The analysis assumes that use values derived by the Upper Columbia River tribal commercial fishery are equal to the profits (80 percent of revenue) associated with the increase in harvest attributable to the Integrated Plan's impact on fish populations. This analysis has three steps:

1. **Estimate the real price per dressed fish harvested in the Upper Columbia River by species (Chinook and Coho).**

   Table A- 12 shows the calculations (2007-2011).

2. Estimate the number of fish (by species) from the last several years and their average weight. Table A- 13 shows the calculations (2007-2011).

3. Multiply the 5-year weighted average real price per dressed pound (by species) by the 5-year weighted average pounds per fish (by species). Table A- 14 shows the calculations.

Table A- 12. Upper Columbia River Tribal Commercial Fishery - Landings and Prices

Column Label		A	B	C	D	E	F	G	H	I	J
Column Calculation					D = C/B		F = C/E	G = F/B		I = F*H	J = G*H
Table Reference				Table IV-9		Table IV-9					
Species	Year	Annual CPI	CPI Factor	Nominal Value ($1,000s)	Real Value ($1,000s)	Round Pounds Landed (1,000s)	Nominal Price per Pound (Round)	Real Price per Pound (Round)	Round Pounds per Fish	Nominal Value per Fish	Real Value per Fish
Spring Chinook	2007	207.342	0.904	$68	$75	17	$4.00	$4.43			
	2008	215.303	0.939	$1,351	$1,439	288	$4.69	$5.00			
	2009	214.537	0.935	$785	$839	247	$3.18	$3.40			
	2010	218.056	0.951	$2,630	$2,767	666	$3.95	$4.15			
	2011	224.939	0.981	$1,850	$1,887	526	$3.52	$3.59			
Revenue 5-year wtd average							$3.83	$4.02	14.29	$54.76	$57.41
Profit 5-year wtd average										$43.81	$45.93
Fall Chinook	2007	207.342	0.904	$1,712	$1,894	801	$2.14	$2.36			
	2008	215.303	0.939	$2,707	$2,884	1,667	$1.62	$1.73			
	2009	214.537	0.935	$1,465	$1,566	1,383	$1.06	$1.13			
	2010	218.056	0.951	$2,331	$2,452	1,887	$1.24	$1.30			
	2011	224.939	0.981	$3,526	$3,596	1,889	$1.87	$1.90			
Revenue 5-year wtd average							$1.54	$1.62	17.41	$26.80	$28.29
Profit 5-year wtd average										$21.44	$22.63
Coho	2007	207.342	0.904	$71	$79	80	$0.89	$0.98			
	2008	215.303	0.939	$207	$221	228	$0.91	$0.97			
	2009	214.537	0.935	$51	$55	70	$0.73	$0.78			
	2010	218.056	0.951	$56	$59	42	$1.33	$1.40			
	2011	224.939	0.981	$263	$268	183	$1.44	$1.47			
Revenue 5-year wtd average							$1.07	$1.13	9.58	$10.29	$10.81
Profit 5-year wtd average										$8.23	$8.65
Source: Pacific Fishery Management Council, 2012											

Table A- 13. Upper Columbia River Tribal Commercial Fishery - Landings (Number of Fish and Weight)

Year	Winter/Spring/Summer Chinook			Fall Chinook			Coho		
	Number of Fish	Pounds	Pounds per Fish	Number of Fish	Pounds	Pounds per Fish	Number of Fish	Pounds	Pounds per Fish
2007	3,972	71,014	17.9	35,105	579,540	17.2	7,051	56,376	8.3
2008	17,880	247,004	14.2	97,479	1,766,117	18.2	18,307	216,814	12.0
2009	10,769	175,116	16.3	95,042	1,618,917	17.2	9,737	79,498	8.2
2010	40,278	549,712	13.6	118,447	2,111,518	17.9	9,060	89,318	9.9
2011	28,040	399,342	14.2	114,247	1,938,887	17.0	22,941	200,605	8.7
5-year wtd average			14.29			17.41			9.58
Source: Department of Fish and Wildlife, 2012									

Table A- 14. Upper Columbia River Tribal Commercial Fishery - Summary

	Real Price per Round Pound	Round Pounds per Fish	Real Revenue per Fish	Real Profit per Fish
Spring Chinook	$4.02	14.29	$57.41	$45.93
Fall Chinook	$1.62	17.41	$28.29	$22.63
Coho	$1.13	9.58	$10.81	$8.65

A.2.6 Yakima River Sport Fishery

The analysis assumes that use values derived by the Yakima River sport fishery are equal to the use values associated with increases in sport fishing harvests and effort attributable to the Integrated Plan's impact on fish populations. Table A- 15 shows the average number of days spent fishing in the Yakima River per fish harvested. To estimate the value per fish, the 5-year weighted average number of days spent fishing per fish harvested (9.861 for Spring Chinook and 2.709 for Fall Chinook and Coho) is multiplied by the use value (from the literature) associated with each fishing day, $76.03 (Reclamation, 2008). There are insufficient data to derive species-specific use values for this fishery.

Table A- 15. Yakima River Sport Fishery - Summary

Year	Species	Effort (Hours)	Hours per Trip	Effort (Day Trips)	Catch	Catch per Trip	Trips per Fish
2007	Spring Chinook	-	-	-	-	-	-
2008	Spring Chinook	18,560.0	3.2	5,800.0	586	0.101	9.898
2009	Spring Chinook	20,853.0	3.2	6,516.6	541	0.083	12.045

2010	Spring Chinook	47,108.0	3.2	14,721.3	1,154	0.078	12.757
2011	Spring Chinook	35,279.0	3.2	11,024.7	1,579	0.143	6.982
5-year Weighted Average	Spring Chinook						9.861
2007	Fall Chinook & Coho	7,535.9	3.2	2,355.0	393	0.167	5.992
2008	Fall Chinook & Coho	9,991.0	3.2	3,122.2	647	0.207	4.826
2009	Fall Chinook & Coho	11,454.0	3.2	3,579.4	611	0.171	5.858
2010	Fall Chinook & Coho	8,734.0	3.2	2,729.4	393	0.144	6.945
2011	Fall Chinook & Coho	13,272.0	3.2	4,147.5	821	0.198	5.052
5-year Weighted Average	Fall Chinook & Coho						2.709
Source: Easterbrooks, 2012							

A.2.7 Summary of Results

To estimate the total use value associated with the Integrated Plan's impact on fish populations, the species- and fishery-specific use values (the first set of columns in Table A- 16) are multiplied by the anticipated distribution of each harvested fish across the different fisheries (the second set of columns in Table A- 16). By summing these products (by species) the weighted average use value per harvested fish by species (see the bottom row in Table A- 16) is calculated.

Table A- 17 provides a year-by-year look at the analysis of use values over time (from 2012 to 2111). The first column shows the year. The next six columns project the increase in fish harvest (number of fish by species) associated with the Integrated Plan. The final two columns show the annual use values as calculated by multiplying the total number of fish harvested by the weighted values in Table A- 16. The final column shows the annual values discounted at a rate of 4.0 percent. The values in the final column are summed to calculate the overall present value over the 100-year period.

Table A- 16. Estimating Total Use Value

	Use Value per Fish Harvested					Distribution of Harvest Across Fisheries				
Harvest Category	Coho	Spring Chinook	Fall Chinook	Steelhead	Sockeye	Coho	Spring Chinook	Fall Chinook	Steelhead	Sockeye
Ocean Commercial	$10	$50	$50	-	-	24.1%	4.0%	2.7%	-	-
Ocean Sport	$159	$119	$119	-	-	36.2%	0.0%	2.7%	-	-
Lower Columbia River (zones 1-5) Commercial	$12	$61	$30	-	$12	10.2%	5.3%	8.1%	-	2.2%
Lower Columbia River (zones 1-5) Sport	$328	$328	$328	-	$328	15.4%	12.4%	8.1%	-	2.2%

Columbia River (zone 6) Tribal Commercial	$9	$46	$23	$9	$9	10.5%	6.6%	53.2%	62.3%	30.4%
Columbia River (zone 6) Tribal Ceremonial & Subsistence	Value of incalculable					0.6%	26.6%	2.8%	3.3%	0.0%
Yakima River Sport	$423	$750	$423	-	$328	3.0%	9.9%	22.5%	-	65.2%
Yakima River Tribal Ceremonial & Subsistence	Value of incalculable					0.0%	35.2%	0.0%	-	-
Weighted Value per Fish Harvested						$125.23	$123.22	$140.43	$5.39	$223.87

Table A- 17. Summary of Total Use Value

Year	Change in Coho Harvest	Change in Spring Chinook Harvest	Change in Fall Chinook Harvest	Change in Steelhead Harvest	Change in Sockeye Harvest	Change in Total Harvest	Annual Use Value (Un-discounted millions)	Annual Use Value (Discounted millions)
2012	0-0	0-0	0-0	0-0	0-0	0-0	$0.0-$0.0	$0.0-$0.0
2013	14-93	50-417	22-211	11-82	1,170-2,617	1,267-3,420	$0.3-$0.7	$0.3-$0.7
2014	28-186	100-835	44-423	21-163	2,340-5,233	2,533-6,840	$0.5-$1.4	$0.5-$1.3
2015	42-279	150-1,252	66-634	32-245	3,510-7,850	3,800-10,260	$0.8-$2.0	$0.7-$1.8
2016	56-371	200-1,670	89-846	42-327	4,680-10,467	5,066-13,680	$1.1-$2.7	$0.9-$2.3
2017	70-464	250-2,087	111-1,057	53-409	5,850-13,083	6,333-17,101	$1.4-$3.4	$1.1-$2.8
2018	84-557	299-2,505	133-1,268	63-490	7,020-15,700	7,599-20,521	$1.6-$4.1	$1.3-$3.2
2019	98-650	349-2,922	155-1,480	74-572	8,190-18,317	8,866-23,941	$1.9-$4.8	$1.5-$3.6
2020	112-743	399-3,340	177-1,691	84-654	9,360-20,933	10,133-27,361	$2.2-$5.4	$1.6-$4.0
2021	126-836	449-3,757	199-1,903	95-735	10,530-23,550	11,399-30,781	$2.5-$6.1	$1.7-$4.3
2022	140-929	499-4,175	221-2,114	105-817	11,700-26,167	12,666-34,201	$2.7-$6.8	$1.8-$4.6
2023	154-1,022	549-4,592	243-2,325	116-899	12,870-28,783	13,932-37,621	$3.0-$7.5	$2.0-$4.9
2024	168-1,114	599-5,010	266-2,537	126-980	14,040-31,400	15,199-41,041	$3.3-$8.1	$2.0-$5.1
2025	182-1,207	649-5,427	288-2,748	137-1,062	15,210-34,017	16,465-44,461	$3.5-$8.8	$2.1-$5.3
2026	196-1,300	699-5,845	310-2,960	147-1,144	16,380-36,633	17,732-47,881	$3.8-$9.5	$2.2-$5.5
2027	210-1,393	749-6,262	332-3,171	158-1,226	17,550-39,250	18,999-51,302	$4.1-$10.2	$2.3-$5.7
2028	224-1,486	798-6,679	354-3,382	169-1,307	18,720-41,867	20,265-54,722	$4.4-$10.9	$2.3-$5.8
2029	238-1,579	848-7,097	376-3,594	179-1,389	19,890-44,483	21,532-58,142	$4.6-$11.5	$2.4-$5.9
2030	252-1,672	898-7,514	398-3,805	190-1,471	21,060-47,100	22,798-61,562	$4.9-$12.2	$2.4-$6.0
2031	266-1,764	948-7,932	421-4,017	200-1,552	22,230-49,717	24,065-64,982	$5.2-$12.9	$2.5-$6.1

Year	Change in Coho Harvest	Change in Spring Chinook Harvest	Change in Fall Chinook Harvest	Change in Steelhead Harvest	Change in Sockeye Harvest	Change in Total Harvest	Annual Use Value (Un-discounted millions)	Annual Use Value (Discounted millions)
2032	280-1,857	998-8,349	443-4,228	211-1,634	23,400-52,333	25,331-68,402	$5.5-$13.6	$2.5-$6.2
2033	294-1,950	1,048-8,767	465-4,439	221-1,716	24,570-54,950	26,598-71,822	$5.7-$14.3	$2.5-$6.3
2034	308-2,043	1,098-9,184	487-4,651	232-1,797	25,740-57,567	27,864-75,242	$6.0-$14.9	$2.5-$6.3
2035	322-2,136	1,148-9,602	509-4,862	242-1,879	26,910-60,183	29,131-78,662	$6.3-$15.6	$2.5-$6.3
2036	336-2,229	1,198-10,019	531-5,074	253-1,961	28,080-62,800	30,398-82,082	$6.6-$16.3	$2.6-$6.4
2037	350-2,322	1,248-10,437	553-5,285	263-2,043	29,250-65,417	31,664-85,503	$6.8-$17.0	$2.6-$6.4
2038	364-2,415	1,297-10,854	575-5,496	274-2,124	30,420-68,033	32,931-88,923	$7.1-$17.7	$2.6-$6.4
2039	378-2,507	1,347-11,272	598-5,708	284-2,206	31,590-70,650	34,197-92,343	$7.4-$18.3	$2.6-$6.4
2040	392-2,600	1,397-11,689	620-5,919	295-2,288	32,760-73,267	35,464-95,763	$7.6-$19.0	$2.5-$6.3
2041	406-2,693	1,447-12,107	642-6,131	305-2,369	33,930-75,883	36,730-99,183	$7.9-$19.7	$2.5-$6.3
2042	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.5-$6.3
2043	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.4-$6.0
2044	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.3-$5.8
2045	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.2-$5.6
2046	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.2-$5.4
2047	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.1-$5.2
2048	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$2.0-$5.0
2049	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.9-$4.8
2050	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.8-$4.6
2051	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.8-$4.4
2052	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.7-$4.2
2053	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.6-$4.1
2054	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.6-$3.9
2055	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.5-$3.8
2056	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.5-$3.6
2057	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.4-$3.5
2058	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.3-$3.4
2059	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.3-$3.2
2060	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.2-$3.1
2061	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.2-$3.0
2062	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.2-$2.9
2063	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.1-$2.8
2064	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.1-$2.6

Year	Change in Coho Harvest	Change in Spring Chinook Harvest	Change in Fall Chinook Harvest	Change in Steelhead Harvest	Change in Sockeye Harvest	Change in Total Harvest	Annual Use Value (Un-discounted millions)	Annual Use Value (Discounted millions)
2065	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.0-$2.5
2066	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$1.0-$2.5
2067	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.9-$2.4
2068	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.9-$2.3
2069	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.9-$2.2
2070	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.8-$2.1
2071	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.8-$2.0
2072	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.8-$1.9
2073	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.7-$1.9
2074	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.7-$1.8
2075	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.7-$1.7
2076	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.7-$1.7
2077	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.6-$1.6
2078	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.6-$1.5
2079	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.6-$1.5
2080	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.6-$1.4
2081	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.5-$1.4
2082	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.5-$1.3
2083	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.5-$1.3
2084	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.5-$1.2
2085	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.5-$1.2
2086	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$1.1
2087	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$1.1
2088	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$1.0
2089	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$1.0
2090	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$1.0
2091	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$0.9
2092	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.4-$0.9
2093	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.8
2094	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.8
2095	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.8
2096	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.8
2097	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.7

Year	Change in Coho Harvest	Change in Spring Chinook Harvest	Change in Fall Chinook Harvest	Change in Steelhead Harvest	Change in Sockeye Harvest	Change in Total Harvest	Annual Use Value (Un-discounted millions)	Annual Use Value (Discounted millions)
2098	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.7
2099	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.7
2100	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.3-$0.6
2101	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.6
2102	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.6
2103	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.6
2104	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.6
2105	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.5
2106	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.5
2107	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.5
2108	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.5
2109	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.5
2110	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.4
2111	420-2,786	1,497-12,524	664-6,342	316-2,451	35,100-78,500	37,997-102,603	$8.2-$20.4	$0.2-$0.4

Appendix B. Irrigation Benefits

Section 2.3 describes the irrigation-related benefits of the Integrated Plan. The Integrated Plan would generate irrigation-related benefits in two ways: (1) it would stimulate market-based reallocation of water between irrigators, resulting in more transfers than otherwise would occur, thereby moving water from production of lower-valued crops to higher-valued crops, and (2) it would increase the supply of water available to irrigators during a severe drought. Section 2.3 presents irrigation-related benefits (in terms of annual net farm earnings) under different scenarios (with and without the Integrated Plan) and describes those benefits in the context of the national market for agricultural products. This appendix describes how the spreadsheet model that is the core of the analysis works, the data it uses to estimate potential irrigation-related benefits associated with the Integrated Plan, and the process of calculating the overall present value of irrigation-related benefits over time. It also provides data about how agricultural production in the Yakima Project compares to production elsewhere.

B.1 Description of Model

The spreadsheet model portrays the allocation of available water across crops and districts while maximizing annual net farm earnings under optimal market conditions. During an average non-drought year, the model assumes all irrigators have all the water they require to satisfy crop-irrigation requirements. During drought years, the model assumes restrictions are placed on proratable water users and that irrigators trade water from low-value crops to high-value crops, where value is measured as annual net farm earnings per acre-foot. The data used in the model are described later in this appendix. The model has three adjustable variables, and three output variables.

- **Adjustable Variables**. The model has three adjustable variables:

  1. The degree of the constraint on water supply during a severe drought year (percentage of full entitlement available to proratable irrigators).
  2. Minimum annual net farm earnings (dollars per acre-foot) for crops receiving water through market-based water reallocation. This variable recognizes that irrigators are unlikely to purchase water during a severe drought to irrigate low-value crops.
  3. Maximum volume of inter-district trading for Roza, Kittitas, and Sunnyside Districts (percent of available water that can be traded outside the district). This variable recognizes and avoids the potential adverse impacts on the districts' operations that can occur if trades disrupt normal operating procedures and characteristics.

- **Output Variables**. The model has three output variables: (1) annual net farm earnings, (2) volume of intra-district trading, and (3) volume of inter-district trading. The model produces these output variables, at the district level, for each scenario.

B.2 Description of Data

The spreadsheet model relies on three types of data: (1) data describing the crops grown in the five irrigation districts and the amount of water needed to satisfy each crop's irrigation requirements, (2) proratable and non-proratable entitlements across the five districts, and (3) annual net farm earnings, by crop, across the five districts. Each type of data is described below.

B.2.1 Crops and Water Demand

Table B- 1 identifies the crops used in the model, their distribution across the five districts, and water demand (by crop) in each district. The values in Table B- 1 rely on data from district-level surveys and the Washington State Department of Agriculture, collected over the past decade, and represent the most recent data available. The irrigation districts and other relevant agencies were contacted to identify any potential updates to the data. In all cases, no district or agency had any updated data for use in this analysis. The model assumes irrigators in each district continue using the same amount of land to produce the same mix of crops every year, and that water demand (in terms of acre-feet per acre, by crop) remains constant into the future. For example, the model assumes that 548 acres are used to grow apples in Kittitas Reclamation District and that production requires 5.6 acre-feet per acre, both now and in the future.

Table B- 1. Crops and Water Demand by District

	Kittitas		Roza		Sunnyside		Tieton		Wapato	
Crop	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre
Alfalfa Hay	1,778	4.8	2,878	4.7	12,219	4.8	124	3.1	12,939	5.6
Apples	548	5.6	23,969	5.6	6,720	5.8	17,288	3.7	10,445	7.0
Asparagus	-	-	635	4.2	2,657	4.4	-	-	1,831	5.2
Concord Grapes	-	-	11,913	3.3	20,784	3.8	-	-	4,954	4.7
Hops	-	-	3,540	3.4	10,955	3.7	-	-	15,350	4.3
Mint	-	-	137	4.9	1,770	5.1	-	-	9,424	6.1
Miscellaneous	81	4.7	3,613	3.9	21,050	4.0	355	3.3	24,017	5.0
Other Grain	1,963	4.6	2,670	3.0	3,246	3.2	21	2.1	662	4.0
Other Hay	4,971	5.5	431	4.8	3,719	5.0	1,058	3.2	3,204	6.2
Other Tree Crops	256	5.3	8,797	5.5	9,534	5.8	2,729	3.6	3,211	6.7
Other Vegetables	6	4.1	270	2.5	525	3.0	-	-	3,286	4.1
Pasture	13,129	4.5	62	3.8	1,141	3.7	-	-	1,960	4.8
Potatoes	89	4.3	72	4.2	-	-	-	-	1,161	5.1
Sweet Corn	1,368	3.1	173	3.1	39	2.8	-	-	912	3.3
Timothy Hay	29,607	5.6	-	-	-	-	-	-	126	6.4

Crop	Kittitas		Roza		Sunnyside		Tieton		Wapato	
	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre	Acres	Acre-feet/Acre
Wheat	1,710	4.4	1,333	3.0	2,892	3.2	-	-	15,621	4.0
Wine Grapes	10	3.1	11,998	3.3	1,992	3.8	9	2.1	12	4.7
Total	55,516	N/A	72,491	N/A	99,243	N/A	21,584	N/A	109,115	N/A
Source: Adapted from Washington State Department of Agriculture, 2010; Reclamation and Ecology, 2011a.										

B.2.2 Entitlements

Existing data describing water entitlements (in terms of acre-feet) were used to estimate the percentage of each district's water supply that is proratable and the percentage that is non-proratable (Reclamation and Ecology, 2011a). These percentages (proratable and non-proratable) were applied to crop acres in each district to distinguish entitlements by crop type. If, for example, 70 percent of a district's water entitlements are proratable, the analysis assumes that 70 percent of the water allotted for each crop in that district is proratable.

B.2.3 Annual Net Farm Earnings

Table B- 2 summarizes the data used in the model to derive annual net farm earnings. For each crop, the model uses average yield . (Scott et al., 2004; Vano et al., 2009), price (U.S. Department of Agriculture, National Agricultural Statistics Service, 2011a, 2011b), and variable cost values (Washington State University Extension, Various Years; Reclamation, 2008) relevant to the five districts. Annual net farm earnings per acre were calculated by multiplying average yield by average price (to get annual gross farm earnings) then subtracting annual variable cost. There are insufficient data to distinguish between annual net farm earnings associated with different crops grown in different districts, so the same values are used across the five districts. Values were adjusted to 2012 dollars using the commodity-specific producer price index from the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2012).

Annual net farm earnings ($/acre) from Table B- 2 were divided by water demand (acre-feet/acre) for each crop in each district (from Table) to calculate irrigation-related annual net farm earnings ($/acre-foot). Table B- 3 summarizes these values.

Table B- 2. Annual Net Farm Earnings ($/Acre) by Crop

Crop	Output Units	Average Yield (Units/Acre)	Average Price ($/Unit)	Annual Variable Cost ($/Acre)	Annual Net Farm Earnings ($/Acre)
Alfalfa Hay	Tons	5.6	$231	$605.93	$678
Apples	Tons	16.1	$527	$6,220.93	$2,248
Asparagus	Cwt	37.2	$53	$1,741.26	$238
Concord Grapes	Tons	8.6	$244	$587.18	$1,509

Crop	Output Units	Average Yield (Units/Acre)	Average Price ($/Unit)	Annual Variable Cost ($/Acre)	Annual Net Farm Earnings ($/Acre)
Hops	Pounds	1,976.2	$3	$3,274.19	$3,481
Mint	Pounds	124.9	$23	$2,075.78	$804
Miscellaneous	Bushels	200.0	$8	$729.55	$785
Other Grain	Bushels	141.5	$5	$729.55	$(3)
Other Hay	Tons	4.7	$211	$749.84	$240
Other Tree Crops	Tons	13.6	$406	$4,694.58	$833
Other Vegetables	Cwt	500.0	$13	$979.48	$5,422
Pasture	Tons	4.7	$231	$605.93	$479
Potatoes	Cwt	546.1	$6	$2,182.03	$1,155
Sweet Corn	Cwt	193.9	$4	$360.45	$436
Timothy Hay	Tons	3.8	$286	$384.88	$701
Wheat	Bushels	103.4	$5	$451.05	$40
Wine Grapes	Tons	4.0	$979	$1,286.34	$2,630
Source: Adapted from Scott et al., 2004; Vano et al., 2009; U.S. Department of Agriculture, National Agricultural Statistics Service, 2011a, 2011b; Washington State University Extension, Various Years.					

Table B- 3. Annual Net Farm Earnings ($/Acre-foot) by Crop

Crop	Kittitas	Roza	Sunnyside	Tieton	Wapato
Alfalfa Hay	$140	$144	$141	$217	$121
Apples	$404	$403	$390	$604	$323
Asparagus	-	$57	$54	-	$46
Concord Grapes	-	$457	$400	-	$321
Hops	-	$1,036	$933	-	$815
Mint	-	$165	$157	-	$131
Miscellaneous	$168	$202	$195	$236	$157
Other Grain	$(1)	$(1)	$(1)	$(2)	$(1)
Other Hay	$44	$50	$48	$75	$39
Other Tree Crops	$157	$151	$145	$233	$125
Other Vegetables	$1,310	$2,195	$1,807	-	$1,322
Pasture	$107	$128	$129	-	$99
Potatoes	$268	$274	-	-	$229
Sweet Corn	$139	$141	$153	-	$131
Timothy Hay	$126	-	-	-	$109

Crop	Kittitas	Roza	Sunnyside	Tieton	Wapato
Wheat	$9	$14	$13	-	$10
Wine Grapes	$862	$797	$698	$1,270	$560
Source: Adapted from previous tables.					

B.3 Calculating Present Value of Benefits over Time

As described in Section 2.3, irrigation-related benefits associated with the Integrated Plan would accrue over time. Calculating the overall present value of irrigation-related benefits relies on three assumptions:

- With or without the Integrated Plan, a severe drought would occur every five years and would persist for one year. Every twenty years, the severe drought would persist for three years. Over the next 100 years, there is a 30 percent chance that a severe drought will occur in any given year.
- The Integrated Plan would yield irrigation-related benefits from the market reallocation component beginning in 2013. This component would reach half its full potential by 2017, and remain constant after that.
- The Integrated Plan would yield irrigation related benefits from increases in the water supply beginning in 2018. This component would reach its full potential by 2026.

Table B- 4 shows the value of these irrigation-related benefits over time. The last column shows the total annual value of irrigation-related benefits associated with the Integrated Plan discounted at 4.0 percent.

Table B- 4. Annual Value of Irrigation-Related Benefits associated with the Integrated Plan

	Market Reallocation		Water Supply		Total Annual Value (millions)	
Year	% Completion	Total Annual Value (millions)	% Completion	Total Annual Value (millions)	Not Discounted	Discounted
2012	0%	-	0%	-	-	-
2013	6.25%	$1.4	0%	-	$1.4	$1.4
2014	12.5%	$2.8	0%	-	$2.8	$2.6
2015	18.76%	$4.3	0%	-	$4.3	$3.8
2016	25%	$5.7	0%	-	$5.7	$4.9
2017	50%	$11.4	0%	-	$11.4	$9.3
2018	50%	$11.3	2%	$0.8	$12.1	$9.6
2019	50%	$11.3	2%	$0.8	$12.1	$9.2
2020	50%	$10.0	30%	$12.6	$22.6	$16.5

Year	Market Reallocation		Water Supply		Total Annual Value (millions)	
	% Completion	Total Annual Value (millions)	% Completion	Total Annual Value (millions)	Not Discounted	Discounted
2021	50%	$9.5	39%	$16.4	$25.9	$18.2
2022	50%	$9.5	39%	$16.4	$25.9	$17.5
2023	50%	$6.7	66%	$26.9	$33.6	$21.8
2024	50%	$6.7	66%	$26.9	$33.6	$21.0
2025	50%	$6.7	66%	$26.9	$33.6	$20.2
2026	50%	$3.1	100%	$39.2	$42.2	$24.4
2027	50%	$3.1	100%	$39.2	$42.2	$23.5
2028	50%	$3.1	100%	$39.2	$42.2	$22.6
2029	50%	$3.1	100%	$39.2	$42.2	$21.7
2030	50%	$3.1	100%	$39.2	$42.2	$20.9
2031	50%	$3.1	100%	$39.2	$42.2	$20.1
2032	50%	$3.1	100%	$39.2	$42.2	$19.3
2033	50%	$3.1	100%	$39.2	$42.2	$18.5
2034	50%	$3.1	100%	$39.2	$42.2	$17.8
2035	50%	$3.1	100%	$39.2	$42.2	$17.1
2036	50%	$3.1	100%	$39.2	$42.2	$16.5
2037	50%	$3.1	100%	$39.2	$42.2	$15.8
2038	50%	$3.1	100%	$39.2	$42.2	$15.2
2039	50%	$3.1	100%	$39.2	$42.2	$14.7
2040	50%	$3.1	100%	$39.2	$42.2	$14.1
2041	50%	$3.1	100%	$39.2	$42.2	$13.5
2042	50%	$3.1	100%	$39.2	$42.2	$13.0
2043	50%	$3.1	100%	$39.2	$42.2	$12.5
2044	50%	$3.1	100%	$39.2	$42.2	$12.0
2045	50%	$3.1	100%	$39.2	$42.2	$11.6
2046	50%	$3.1	100%	$39.2	$42.2	$11.1
2047	50%	$3.1	100%	$39.2	$42.2	$10.7
2048	50%	$3.1	100%	$39.2	$42.2	$10.3
2049	50%	$3.1	100%	$39.2	$42.2	$9.9
2050	50%	$3.1	100%	$39.2	$42.2	$9.5
2051	50%	$3.1	100%	$39.2	$42.2	$9.2
2052	50%	$3.1	100%	$39.2	$42.2	$8.8
2053	50%	$3.1	100%	$39.2	$42.2	$8.5

Year	Market Reallocation		Water Supply		Total Annual Value (millions)	
	% Completion	Total Annual Value (millions)	% Completion	Total Annual Value (millions)	Not Discounted	Discounted
2054	50%	$3.1	100%	$39.2	$42.2	$8.1
2055	50%	$3.1	100%	$39.2	$42.2	$7.8
2056	50%	$3.1	100%	$39.2	$42.2	$7.5
2057	50%	$3.1	100%	$39.2	$42.2	$7.2
2058	50%	$3.1	100%	$39.2	$42.2	$7.0
2059	50%	$3.1	100%	$39.2	$42.2	$6.7
2060	50%	$3.1	100%	$39.2	$42.2	$6.4
2061	50%	$3.1	100%	$39.2	$42.2	$6.2
2062	50%	$3.1	100%	$39.2	$42.2	$5.9
2063	50%	$3.1	100%	$39.2	$42.2	$5.7
2064	50%	$3.1	100%	$39.2	$42.2	$5.5
2065	50%	$3.1	100%	$39.2	$42.2	$5.3
2066	50%	$3.1	100%	$39.2	$42.2	$5.1
2067	50%	$3.1	100%	$39.2	$42.2	$4.9
2068	50%	$3.1	100%	$39.2	$42.2	$4.7
2069	50%	$3.1	100%	$39.2	$42.2	$4.5
2070	50%	$3.1	100%	$39.2	$42.2	$4.3
2071	50%	$3.1	100%	$39.2	$42.2	$4.2
2072	50%	$3.1	100%	$39.2	$42.2	$4.0
2073	50%	$3.1	100%	$39.2	$42.2	$3.9
2074	50%	$3.1	100%	$39.2	$42.2	$3.7
2075	50%	$3.1	100%	$39.2	$42.2	$3.6
2076	50%	$3.1	100%	$39.2	$42.2	$3.4
2077	50%	$3.1	100%	$39.2	$42.2	$3.3
2078	50%	$3.1	100%	$39.2	$42.2	$3.2
2079	50%	$3.1	100%	$39.2	$42.2	$3.1
2080	50%	$3.1	100%	$39.2	$42.2	$2.9
2081	50%	$3.1	100%	$39.2	$42.2	$2.8
2082	50%	$3.1	100%	$39.2	$42.2	$2.7
2083	50%	$3.1	100%	$39.2	$42.2	$2.6
2084	50%	$3.1	100%	$39.2	$42.2	$2.5
2085	50%	$3.1	100%	$39.2	$42.2	$2.4
2086	50%	$3.1	100%	$39.2	$42.2	$2.3

Year	Market Reallocation		Water Supply		Total Annual Value (millions)	
	% Completion	Total Annual Value (millions)	% Completion	Total Annual Value (millions)	Not Discounted	Discounted
2087	50%	$3.1	100%	$39.2	$42.2	$2.2
2088	50%	$3.1	100%	$39.2	$42.2	$2.1
2089	50%	$3.1	100%	$39.2	$42.2	$2.1
2090	50%	$3.1	100%	$39.2	$42.2	$2.0
2091	50%	$3.1	100%	$39.2	$42.2	$1.9
2092	50%	$3.1	100%	$39.2	$42.2	$1.8
2093	50%	$3.1	100%	$39.2	$42.2	$1.8
2094	50%	$3.1	100%	$39.2	$42.2	$1.7
2095	50%	$3.1	100%	$39.2	$42.2	$1.6
2096	50%	$3.1	100%	$39.2	$42.2	$1.6
2097	50%	$3.1	100%	$39.2	$42.2	$1.5
2098	50%	$3.1	100%	$39.2	$42.2	$1.4
2099	50%	$3.1	100%	$39.2	$42.2	$1.4
2100	50%	$3.1	100%	$39.2	$42.2	$1.3
2101	50%	$3.1	100%	$39.2	$42.2	$1.3
2102	50%	$3.1	100%	$39.2	$42.2	$1.2
2103	50%	$3.1	100%	$39.2	$42.2	$1.2
2104	50%	$3.1	100%	$39.2	$42.2	$1.1
2105	50%	$3.1	100%	$39.2	$42.2	$1.1
2106	50%	$3.1	100%	$39.2	$42.2	$1.1
2107	50%	$3.1	100%	$39.2	$42.2	$1.0
2108	50%	$3.1	100%	$39.2	$42.2	$1.0
2109	50%	$3.1	100%	$39.2	$42.2	$0.9
2110	50%	$3.1	100%	$39.2	$42.2	$0.9
2111	50%	$3.1	100%	$39.2	$42.2	$0.9

B.3.1 Potential Uncertainty Projecting Benefits into the Future

In some cases, the data used in this analysis may not reflect (1) potential changes in the crops produced by irrigators in the districts, (2) the water required to grow certain crops in future years, or (3) the costs and revenues associated with growing crops in future years. Table B- 5 describes the crop diversity in the three counties that contain the Yakima Project (Benton, Kittitas, and Yakima Counties). The crops listed in Table B- 5 are similar to the crops grown in the five districts and likely represent how irrigators in the districts are changing what they grow.[28] The last column in Table B- 5 shows how crop diversity changed from 2002 to 2007. In many cases, the acres of specific crops grown in the three counties changed by less than 10 percent during the five-year period (e.g., apples, grapes, orchards, alfalfa hay). In some cases, however, the acres devoted to certain crops changed by more than 10 percent (e.g., mint for oil, asparagus, vegetables for sale, potatoes).

The data currently available are insufficient to project potential changes in crop diversity across the five irrigation districts, and to apply those changes to the model used in this analysis. In some instances, barriers exist to producing specific crops that likely will limit crop conversion in the future. Fruit trees, for example, require several years of growth before they produce merchantable products. Wine grapes require specific climatic conditions to produce high-value products for their specific market. Other crops, such as hay and vegetables, pose fewer barriers to crop conversion. Irrigators can adjust production to different crops based on water availability, prices, or other factors.

Table B- 5. Change in Crop Diversity (2002-2007) in Benton, Kittitas, and Yakima Counties

Crop	2002	2007	% Change (2002-2007)
Apples (bearing age acres)	59,366	60,402	1.7%
Grapes (bearing age acres)	41,841	40,004	-4.4%
Orchards (irrigated acres)	141,453	135,834	-4.0%
Hops (acres harvested)	20,833	22,907	10.0%
Mint for Oil (acres harvested)	9,334	12,561	34.6%
Asparagus (acres harvested)	6,546	2,540	-61.2%
Sweet Corn for Sale (acres harvested)	32,370	26,089	-19.4%
Vegetables for Sale (acres harvested	58,830	85,410	45.2%
Other Vegetables (acres harvested)	45	133	195.6%
Alfalfa Hay (acres harvested)	60,942	58,496	-4.0%
All Hay (acres harvested)	120,019	112,530	-6.2%
Wheat for Grain (acres harvested)	138,295	115,606	-16.4%
Potatoes (acres harvested)	26,163	32,170	23.0%
Source: Adapted from U.S. Department of Agriculture, National Agricultural Statistics Service, 2004; U.S. Department of Agriculture, National Agricultural Statistics Service, 20091.			

[28] In some instances, crop types are grouped, which does not allow for side-by-side comparison between the crops at the district-level and crops at the county-level.

B.4 Additional Agricultural Production Data

As previously described, the potential price effect associated with the Integrated Plan's impact on agricultural production in the Yakima Project during severe drought years is, to some extent, dependent on the volume of production in the Yakima Project relative to the volume of production elsewhere. Data were insufficient to calculate production volumes in the Yakima Project, the State of Washington, the three-state area (Washington, Oregon, and Idaho), and the Nation specific to the types of crops grown in the Yakima Project. Table B- 6 provides additional data describing agricultural production in the Yakima Project relative to production elsewhere, in terms of acres.

Table B- 6. 2007 Agricultural Production (acres)

Crop	3-County Total	3-County as % of Washington	3-County as % of 3-State	3-County as % of Nation
Apples (acres of bearing age acres)	60,402	40%	38%	17%
Grapes (bearing age acres)	40,004	70%	55%	4%
Noncitrus (bearing age acres)	125,213	46%	37%	6%
Hops (acres harvested)	22,907	100%	74%	74%
Mint for Oil (acres harvested)	12,561	43%	19%	14%
Asparagus (acres harvested)	2,540	36%	34%	6%
Sweet Corn for Sale (acres harvested)	26,089	28%	20%	4%
Vegetables for Sale (acres harvested	85,410	25%	10%	2%
Other Vegetables (acres harvested)	133	9%	7%	< 1%
Alfalfa Hay (acres harvested)	58,496	13%	3%	< 1%
All Hay (acres harvested)	112,530	14%	4%	< 1%
Wheat for Grain (acres harvested)	115,606	6%	3%	< 1%
Potatoes (acres harvested)	32,170	20%	6%	3%
Source: Adapted from U.S. Department of Agriculture, National Agricultural Statistics Service, 2009a and 2009b.				

Appendix C. Municipal and Domestic Water Supply Benefits

Section 2.4 describes the benefits of the Integrated Plan that would accrue to the municipal and domestic users in the Yakima River Basin. The Integrated Plan is expected to increase water supplies to accommodate increases in population and conversions of land use from agricultural to urban. The Plan is also expected to facilitate the voluntary transfer of senior water rights to secure water supplies for about 106,000 individuals above Parker Gauge who are currently receiving their municipal and domestic water from groundwater sources.

The estimates of municipal and domestic benefits described in Section 4 are the results of several assumptions made about trends in water use and the future price of water, including:

- **Increased municipal and domestic water use.** This study assumes municipal and domestic water use will increase from an annual rate of 91,000 acre-feet in 2010 to 140,000 acre-feet in 2060, and that these benefits will be maximized in 2060. The Integrated Plan will provide municipal and domestic benefits at a constant rate through 2111 (Reclamation and Ecology, 2011a). This study also assumes that current municipal and domestic groundwater users will increase the security of their supplies starting in 2013, maximizing this benefit in 2030 at a value of 10,500 acre-feet annually. This benefit will continue to accrue at this constant rate through 2111.
- **Real rate of municipal and domestic benefits.** The price of municipal and domestic water used in this study is equal to that estimated by Reclamation (2008) based on average wholesale prices of municipal water transactions in the Pacific Northwest, adjusted to March 2012 dollars. For the municipal and domestic groundwater benefits, this study uses a value of $1,500 per acre-foot water market transactions.
- **Sensitivity analysis of municipal and domestic benefits.** Following the analytical framework in Reclamation (2011A), this study investigates the extent to which possible changes in future prices of water transactions due to an increase of water demand relative to the supply would affect the net present value of the municipal and domestic benefits. The sensitivity analysis that examines the impact of these possible market conditions assumes two rates of increase above the real rate of benefits, 1 percent and 2 percent, respectively. For the municipal and domestic groundwater benefits, this study estimates how the benefits of the Integrated Plan change when transaction prices on the water market range between $1,400 per acre-foot and $2,700 per acre-foot annually.

Table C- 1 shows the value of the municipal and domestic water supply benefits of the Integrated Plan. The column entitled "Discounted Annual Benefit" shows the annual value of the municipal and domestic benefits in 2012 dollars. The last two columns show the value of these benefits assuming that real water prices will increase in the future by 1 percent and 2 percent, respectively.

Table C- 1. Annual Municipal and Domestic Benefits of the Integrated Plan

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit	Sensitivity Analysis	
				Discounted Annual Benefit (1% above Real Benefit Rate)	Discounted Annual Benefit (2% above Real Benefit Rate)
2012	0	$0	$0	$0	$0
2013	0	$0	$0	$0	$0
2014	0	$0	$0	$0	$0
2015	0	$0	$0	$0	$0
2016	0	$0	$0	$0	$0
2017	0	$0	$0	$0	$0
2018	0	$0	$0	$0	$0
2019	0	$0	$0	$0	$0
2020	1,193	$307,581	$224,746	$226,994	$229,241
2021	2,385	$615,162	$432,205	$436,527	$440,849
2022	3,578	$922,743	$623,372	$629,606	$635,840
2023	4,771	$1,230,324	$799,195	$807,187	$815,179
2024	5,963	$1,537,905	$960,571	$970,177	$979,782
2025	7,156	$1,845,486	$1,108,351	$1,119,435	$1,130,518
2026	8,349	$2,153,067	$1,243,343	$1,255,776	$1,268,209
2027	9,541	$2,460,648	$1,366,310	$1,379,974	$1,393,637
2028	10,734	$2,768,229	$1,477,980	$1,492,760	$1,507,540
2029	11,927	$3,075,810	$1,579,039	$1,594,829	$1,610,619
2030	13,120	$3,383,391	$1,670,137	$1,686,838	$1,703,540
2031	14,312	$3,690,972	$1,751,892	$1,769,411	$1,786,930
2032	15,505	$3,998,553	$1,824,887	$1,843,136	$1,861,385
2033	16,698	$4,306,134	$1,889,676	$1,908,573	$1,927,470
2034	17,890	$4,613,715	$1,946,782	$1,966,250	$1,985,718
2035	19,083	$4,921,296	$1,996,699	$2,016,666	$2,036,633
2036	20,276	$5,228,877	$2,039,897	$2,060,296	$2,080,695

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit	Sensitivity Analysis	
				Discounted Annual Benefit (1% above Real Benefit Rate)	Discounted Annual Benefit (2% above Real Benefit Rate)
2037	21,468	$5,536,458	$2,076,818	$2,097,587	$2,118,355
2038	22,661	$5,844,039	$2,107,882	$2,128,961	$2,150,040
2039	23,854	$6,151,620	$2,133,484	$2,154,819	$2,176,153
2040	25,046	$6,459,201	$2,153,998	$2,175,538	$2,197,078
2041	26,239	$6,766,782	$2,169,778	$2,191,476	$2,213,174
2042	27,432	$7,074,363	$2,181,158	$2,202,970	$2,224,781
2043	28,624	$7,381,944	$2,188,453	$2,210,338	$2,232,222
2044	29,817	$7,689,525	$2,191,960	$2,213,880	$2,235,799
2045	31,010	$7,997,106	$2,191,960	$2,213,880	$2,235,799
2046	32,202	$8,304,687	$2,188,718	$2,210,605	$2,232,492
2047	33,395	$8,612,268	$2,182,482	$2,204,307	$2,226,132
2048	34,588	$8,919,849	$2,173,488	$2,195,223	$2,216,958
2049	35,780	$9,227,430	$2,161,958	$2,183,577	$2,205,197
2050	36,973	$9,535,011	$2,148,099	$2,169,580	$2,191,061
2051	38,166	$9,842,592	$2,132,108	$2,153,429	$2,174,750
2052	39,359	$10,150,173	$2,114,170	$2,135,312	$2,156,453
2053	40,551	$10,457,754	$2,094,457	$2,115,402	$2,136,346
2054	41,744	$10,765,335	$2,073,134	$2,093,865	$2,114,596
2055	42,937	$11,072,916	$2,050,352	$2,070,855	$2,091,359
2056	44,129	$11,380,497	$2,026,256	$2,046,518	$2,066,781
2057	45,322	$11,688,078	$2,000,980	$2,020,990	$2,041,000
2058	46,515	$11,995,659	$1,974,652	$1,994,398	$2,014,145
2059	47,707	$12,303,240	$1,947,388	$1,966,862	$1,986,336
2060	48,900	$12,610,821	$1,919,301	$1,938,494	$1,957,687
2061	48,900	$12,610,821	$1,845,482	$1,863,936	$1,882,391
2062	48,900	$12,610,821	$1,774,502	$1,792,247	$1,809,992

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit	Sensitivity Analysis	
				Discounted Annual Benefit (1% above Real Benefit Rate)	Discounted Annual Benefit (2% above Real Benefit Rate)
2063	48,900	$12,610,821	$1,706,252	$1,723,314	$1,740,377
2064	48,900	$12,610,821	$1,640,626	$1,657,033	$1,673,439
2065	48,900	$12,610,821	$1,577,525	$1,593,301	$1,609,076
2066	48,900	$12,610,821	$1,516,851	$1,532,020	$1,547,188
2067	48,900	$12,610,821	$1,458,511	$1,473,096	$1,487,681
2068	48,900	$12,610,821	$1,402,414	$1,416,439	$1,430,463
2069	48,900	$12,610,821	$1,348,475	$1,361,960	$1,375,445
2070	48,900	$12,610,821	$1,296,611	$1,309,577	$1,322,543
2071	48,900	$12,610,821	$1,246,741	$1,259,209	$1,271,676
2072	48,900	$12,610,821	$1,198,790	$1,210,778	$1,222,765
2073	48,900	$12,610,821	$1,152,682	$1,164,209	$1,175,736
2074	48,900	$12,610,821	$1,108,348	$1,119,432	$1,130,515
2075	48,900	$12,610,821	$1,065,720	$1,076,377	$1,087,034
2076	48,900	$12,610,821	$1,024,730	$1,034,978	$1,045,225
2077	48,900	$12,610,821	$985,318	$995,171	$1,005,024
2078	48,900	$12,610,821	$947,421	$956,895	$966,369
2079	48,900	$12,610,821	$910,982	$920,091	$929,201
2080	48,900	$12,610,821	$875,944	$884,703	$893,463
2081	48,900	$12,610,821	$842,254	$850,676	$859,099
2082	48,900	$12,610,821	$809,859	$817,958	$826,057
2083	48,900	$12,610,821	$778,711	$786,498	$794,285
2084	48,900	$12,610,821	$748,761	$756,248	$763,736
2085	48,900	$12,610,821	$719,962	$727,162	$734,361
2086	48,900	$12,610,821	$692,271	$699,194	$706,117
2087	48,900	$12,610,821	$665,645	$672,302	$678,958
2088	48,900	$12,610,821	$640,044	$646,444	$652,844

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit	Sensitivity Analysis	
				Discounted Annual Benefit (1% above Real Benefit Rate)	Discounted Annual Benefit (2% above Real Benefit Rate)
2089	48,900	$12,610,821	$615,427	$621,581	$627,735
2090	48,900	$12,610,821	$591,756	$597,674	$603,591
2091	48,900	$12,610,821	$568,996	$574,686	$580,376
2092	48,900	$12,610,821	$547,112	$552,583	$558,054
2093	48,900	$12,610,821	$526,069	$531,330	$536,591
2094	48,900	$12,610,821	$505,836	$510,894	$515,952
2095	48,900	$12,610,821	$486,381	$491,244	$496,108
2096	48,900	$12,610,821	$467,674	$472,350	$477,027
2097	48,900	$12,610,821	$449,686	$454,183	$458,680
2098	48,900	$12,610,821	$432,391	$436,714	$441,038
2099	48,900	$12,610,821	$415,760	$419,918	$424,075
2100	48,900	$12,610,821	$399,769	$403,767	$407,765
2101	48,900	$12,610,821	$384,394	$388,238	$392,081
2102	48,900	$12,610,821	$369,609	$373,305	$377,001
2103	48,900	$12,610,821	$355,394	$358,947	$362,501
2104	48,900	$12,610,821	$341,725	$345,142	$348,559
2105	48,900	$12,610,821	$328,581	$331,867	$335,153
2106	48,900	$12,610,821	$315,944	$319,103	$322,262
2107	48,900	$12,610,821	$303,792	$306,830	$309,868
2108	48,900	$12,610,821	$292,108	$295,029	$297,950
2109	48,900	$12,610,821	$280,873	$283,681	$286,490
2110	48,900	$12,610,821	$270,070	$272,771	$275,471
2111	48,900	$12,610,821	$259,683	$262,279	$264,876
Total Benefit	**-**	**-**	**$115,008,577**	**$116,158,663**	**$117,308,749**
Source: Adapted from Reclamation and Ecology (2011a), Reclamation (2008), and Reclamation (2011).					

Table C- 2 shows the annual flow of benefits associated with securing senior water rights for the users who rely exclusively on municipal and domestic groundwater sources. The column entitled "Discounted Annual Benefits" represents this flow of benefits in 2012 dollars, assuming a price of $1,500 per acre-foot. The last two columns represent the results of the sensitivity analysis, which varies the water transaction prices between $1,400 and $2,700 per acre-foot annually.

Table C- 2. Annual Discounted Benefits for Municipal and Domestic Groundwater of the Integrated Plan

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit ($1,500/ acre-foot)	Sensitivity Analysis	
				Discounted Annual Benefit ($1,400/ acre-foot)	Discounted Annual Benefit ($2,700/ acre-foot)
2012	0	$0	$0	$0	$0
2013	583	$875,000	$841,346	$785,256	$1,514,423
2014	1,167	$1,750,000	$1,617,973	$1,510,108	$2,912,352
2015	1,750	$2,625,000	$2,333,615	$2,178,041	$4,200,508
2016	2,333	$3,500,000	$2,991,815	$2,792,360	$5,385,266
2017	2,917	$4,375,000	$3,595,931	$3,356,202	$6,472,676
2018	3,500	$5,250,000	$4,149,151	$3,872,541	$7,468,472
2019	4,083	$6,125,000	$4,654,497	$4,344,197	$8,378,094
2020	4,667	$7,000,000	$5,114,831	$4,773,843	$9,206,697
2021	5,250	$7,875,000	$5,532,871	$5,164,013	$9,959,167
2022	5,833	$8,750,000	$5,911,186	$5,517,107	$10,640,136
2023	6,417	$9,625,000	$6,252,216	$5,835,402	$11,253,990
2024	7,000	$10,500,000	$6,558,269	$6,121,051	$11,804,884
2025	7,583	$11,375,000	$6,831,530	$6,376,095	$12,296,754
2026	8,167	$12,250,000	$7,074,070	$6,602,465	$12,733,326
2027	8,750	$13,125,000	$7,287,847	$6,801,990	$13,118,124
2028	9,333	$14,000,000	$7,474,714	$6,976,400	$13,454,486
2029	9,917	$14,875,000	$7,636,427	$7,127,332	$13,745,569
2030	10,500	$15,750,000	$7,774,643	$7,256,333	$13,994,357
2031	10,500	$15,750,000	$7,475,618	$6,977,244	$13,456,113
2032	10,500	$15,750,000	$7,188,094	$6,708,888	$12,938,570

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit ($1,500/ acre-foot)	Sensitivity Analysis	
				Discounted Annual Benefit ($1,400/ acre-foot)	Discounted Annual Benefit ($2,700/ acre-foot)
2033	10,500	$15,750,000	$6,911,629	$6,450,854	$12,440,933
2034	10,500	$15,750,000	$6,645,797	$6,202,744	$11,962,435
2035	10,500	$15,750,000	$6,390,190	$5,964,177	$11,502,342
2036	10,500	$15,750,000	$6,144,413	$5,734,786	$11,059,944
2037	10,500	$15,750,000	$5,908,090	$5,514,217	$10,634,561
2038	10,500	$15,750,000	$5,680,855	$5,302,132	$10,225,540
2039	10,500	$15,750,000	$5,462,361	$5,098,204	$9,832,250
2040	10,500	$15,750,000	$5,252,270	$4,902,119	$9,454,086
2041	10,500	$15,750,000	$5,050,260	$4,713,576	$9,090,468
2042	10,500	$15,750,000	$4,856,019	$4,532,284	$8,740,834
2043	10,500	$15,750,000	$4,669,249	$4,357,966	$8,404,648
2044	10,500	$15,750,000	$4,489,663	$4,190,352	$8,081,393
2045	10,500	$15,750,000	$4,316,983	$4,029,184	$7,770,570
2046	10,500	$15,750,000	$4,150,945	$3,874,216	$7,471,702
2047	10,500	$15,750,000	$3,991,294	$3,725,207	$7,184,329
2048	10,500	$15,750,000	$3,837,782	$3,581,930	$6,908,008
2049	10,500	$15,750,000	$3,690,175	$3,444,164	$6,642,316
2050	10,500	$15,750,000	$3,548,246	$3,311,696	$6,386,842
2051	10,500	$15,750,000	$3,411,775	$3,184,323	$6,141,194
2052	10,500	$15,750,000	$3,280,552	$3,061,849	$5,904,994
2053	10,500	$15,750,000	$3,154,377	$2,944,086	$5,677,879
2054	10,500	$15,750,000	$3,033,055	$2,830,851	$5,459,499
2055	10,500	$15,750,000	$2,916,399	$2,721,973	$5,249,519
2056	10,500	$15,750,000	$2,804,230	$2,617,281	$5,047,614
2057	10,500	$15,750,000	$2,696,375	$2,516,617	$4,853,475
2058	10,500	$15,750,000	$2,592,668	$2,419,824	$4,666,803
2059	10,500	$15,750,000	$2,492,950	$2,326,754	$4,487,310

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit ($1,500/ acre-foot)	Sensitivity Analysis	
				Discounted Annual Benefit ($1,400/ acre-foot)	Discounted Annual Benefit ($2,700/ acre-foot)
2060	10,500	$15,750,000	$2,397,068	$2,237,263	$4,314,722
2061	10,500	$15,750,000	$2,304,873	$2,151,214	$4,148,771
2062	10,500	$15,750,000	$2,216,224	$2,068,475	$3,989,203
2063	10,500	$15,750,000	$2,130,984	$1,988,919	$3,835,772
2064	10,500	$15,750,000	$2,049,023	$1,912,422	$3,688,242
2065	10,500	$15,750,000	$1,970,215	$1,838,867	$3,546,387
2066	10,500	$15,750,000	$1,894,437	$1,768,141	$3,409,987
2067	10,500	$15,750,000	$1,821,574	$1,700,136	$3,278,834
2068	10,500	$15,750,000	$1,751,514	$1,634,746	$3,152,725
2069	10,500	$15,750,000	$1,684,148	$1,571,871	$3,031,466
2070	10,500	$15,750,000	$1,619,373	$1,511,415	$2,914,871
2071	10,500	$15,750,000	$1,557,089	$1,453,283	$2,802,761
2072	10,500	$15,750,000	$1,497,201	$1,397,388	$2,694,962
2073	10,500	$15,750,000	$1,439,617	$1,343,642	$2,591,310
2074	10,500	$15,750,000	$1,384,247	$1,291,964	$2,491,644
2075	10,500	$15,750,000	$1,331,007	$1,242,273	$2,395,812
2076	10,500	$15,750,000	$1,279,814	$1,194,493	$2,303,665
2077	10,500	$15,750,000	$1,230,590	$1,148,551	$2,215,063
2078	10,500	$15,750,000	$1,183,260	$1,104,376	$2,129,868
2079	10,500	$15,750,000	$1,137,750	$1,061,900	$2,047,950
2080	10,500	$15,750,000	$1,093,990	$1,021,058	$1,969,183
2081	10,500	$15,750,000	$1,051,914	$981,786	$1,893,445
2082	10,500	$15,750,000	$1,011,456	$944,025	$1,820,620
2083	10,500	$15,750,000	$972,553	$907,717	$1,750,596
2084	10,500	$15,750,000	$935,148	$872,804	$1,683,266
2085	10,500	$15,750,000	$899,180	$839,235	$1,618,525
2086	10,500	$15,750,000	$864,596	$806,957	$1,556,274

Year	Municipal and Domestic Water Benefit (acre-feet)	Annual Benefit	Discounted Annual Benefit ($1,500/ acre-foot)	Sensitivity Analysis	
				Discounted Annual Benefit ($1,400/ acre-foot)	Discounted Annual Benefit ($2,700/ acre-foot)
2087	10,500	$15,750,000	$831,343	$775,920	$1,496,417
2088	10,500	$15,750,000	$799,368	$746,077	$1,438,862
2089	10,500	$15,750,000	$768,623	$717,382	$1,383,522
2090	10,500	$15,750,000	$739,061	$689,790	$1,330,309
2091	10,500	$15,750,000	$710,635	$663,260	$1,279,143
2092	10,500	$15,750,000	$683,303	$637,750	$1,229,946
2093	10,500	$15,750,000	$657,022	$613,221	$1,182,640
2094	10,500	$15,750,000	$631,752	$589,635	$1,137,154
2095	10,500	$15,750,000	$607,454	$566,957	$1,093,417
2096	10,500	$15,750,000	$584,090	$545,151	$1,051,363
2097	10,500	$15,750,000	$561,625	$524,184	$1,010,926
2098	10,500	$15,750,000	$540,024	$504,023	$972,044
2099	10,500	$15,750,000	$519,254	$484,637	$934,658
2100	10,500	$15,750,000	$499,283	$465,997	$898,709
2101	10,500	$15,750,000	$480,080	$448,074	$864,143
2102	10,500	$15,750,000	$461,615	$430,841	$830,907
2103	10,500	$15,750,000	$443,861	$414,270	$798,949
2104	10,500	$15,750,000	$426,789	$398,337	$768,220
2105	10,500	$15,750,000	$410,374	$383,016	$738,673
2106	10,500	$15,750,000	$394,591	$368,284	$710,263
2107	10,500	$15,750,000	$379,414	$354,120	$682,945
2108	10,500	$15,750,000	$364,821	$340,500	$656,678
2109	10,500	$15,750,000	$350,790	$327,404	$631,421
2110	10,500	$15,750,000	$337,298	$314,811	$607,136
2111	10,500	$15,750,000	$324,325	$302,703	$583,784
Total Benefits	-	-	**$279,890,890**	**$261,231,497**	**$503,803,602**

Appendix D. Costs

Section 2.5 describes the costs of implementing Integrated Plan. The discussion of costs is limited to capital costs, operations and maintenance costs, and potential future costs associated with replacement of major components. The CRA methodology used to estimate annual costs generated a range of costs: 10th percentile, 50th percentile, and 90th percentile. Table D- 1 summarizes the annual costs of implementing the Integrated Plan over the next 100 years. The first set of columns shows the range of annual costs in real terms. The second set of columns shows the range of annual costs discounted at a rate of 4.0 percent.

Table D- 1. Annual Costs of Implementing the Integrated Plan (millions)

	Not Discounted			Discounted		
Year	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs
2012	--	--	--	--	--	--
2013	$46.5	$57.3	$78.8	$44.8	$55.1	$75.7
2014	$43.7	$54.4	$75.9	$40.4	$50.3	$70.2
2015	$194.1	$217.3	$263.9	$172.5	$193.2	$234.6
2016	$384.8	$471.9	$656.2	$328.9	$403.4	$560.9
2017	$352.4	$431.5	$599.5	$289.7	$354.6	$492.7
2018	$354.0	$444.5	$627.4	$279.8	$351.3	$495.9
2019	$448.1	$587.6	$765.1	$340.5	$446.6	$581.4
2020	$190.9	$245.0	$324.6	$139.5	$179.0	$237.2
2021	$257.2	$316.2	$413.5	$180.7	$222.1	$290.5
2022	$349.7	$435.7	$564.3	$236.3	$294.4	$381.2
2023	$226.6	$284.8	$378.6	$147.2	$185.0	$245.9
2024	$143.7	$181.1	$233.2	$89.7	$113.1	$145.7
2025	$144.2	$181.6	$233.7	$86.6	$109.1	$140.4
2026	$52.2	$62.6	$83.5	$30.1	$36.1	$48.2
2027	$52.2	$62.6	$83.5	$29.0	$34.8	$46.3
2028	$52.3	$62.7	$83.5	$27.9	$33.5	$44.6
2029	$52.3	$62.7	$83.5	$26.8	$32.2	$42.9
2030	$52.5	$63.0	$83.8	$25.9	$31.1	$41.4

Year	Not Discounted			Discounted		
	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs
2031	$10.8	$10.8	$10.8	$5.1	$5.1	$5.1
2032	$10.8	$10.8	$10.8	$4.9	$4.9	$4.9
2033	$10.8	$10.8	$10.8	$4.8	$4.8	$4.8
2034	$10.8	$10.8	$10.8	$4.6	$4.6	$4.6
2035	$11.1	$11.1	$11.1	$4.5	$4.5	$4.5
2036	$10.8	$10.8	$10.8	$4.2	$4.2	$4.2
2037	$10.8	$10.8	$10.8	$4.1	$4.1	$4.1
2038	$10.8	$10.8	$10.8	$3.9	$3.9	$3.9
2039	$10.8	$10.8	$10.8	$3.8	$3.8	$3.8
2040	$11.1	$11.1	$11.1	$3.7	$3.7	$3.7
2041	$10.8	$10.8	$10.8	$3.5	$3.5	$3.5
2042	$10.6	$10.6	$10.6	$3.3	$3.3	$3.3
2043	$10.6	$10.6	$10.6	$3.1	$3.1	$3.1
2044	$124.4	$124.4	$124.4	$35.5	$35.5	$35.5
2045	$10.9	$10.9	$10.9	$3.0	$3.0	$3.0
2046	$10.6	$10.6	$10.6	$2.8	$2.8	$2.8
2047	$10.6	$10.6	$10.6	$2.7	$2.7	$2.7
2048	$10.6	$10.6	$10.6	$2.6	$2.6	$2.6
2049	$10.6	$10.6	$10.6	$2.5	$2.5	$2.5
2050	$16.3	$16.3	$16.3	$3.7	$3.7	$3.7
2051	$10.6	$10.6	$10.6	$2.3	$2.3	$2.3
2052	$10.6	$10.6	$10.6	$2.2	$2.2	$2.2
2053	$10.6	$10.6	$10.6	$2.1	$2.1	$2.1
2054	$10.6	$10.6	$10.6	$2.0	$2.0	$2.0
2055	$10.9	$10.9	$10.9	$2.0	$2.0	$2.0
2056	$10.6	$10.6	$10.6	$1.9	$1.9	$1.9
2057	$10.6	$10.6	$10.6	$1.8	$1.8	$1.8

Year	Not Discounted			Discounted		
	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs
2058	$10.6	$10.6	$10.6	$1.7	$1.7	$1.7
2059	$10.6	$10.6	$10.6	$1.7	$1.7	$1.7
2060	$10.9	$10.9	$10.9	$1.7	$1.7	$1.7
2061	$10.6	$10.6	$10.6	$1.6	$1.6	$1.6
2062	$10.6	$10.6	$10.6	$1.5	$1.5	$1.5
2063	$10.6	$10.6	$10.6	$1.4	$1.4	$1.4
2064	$10.6	$10.6	$10.6	$1.4	$1.4	$1.4
2065	$10.6	$10.6	$10.6	$1.3	$1.3	$1.3
2066	$10.6	$10.6	$10.6	$1.3	$1.3	$1.3
2067	$11.4	$11.7	$12.1	$1.3	$1.3	$1.4
2068	$14.0	$10.6	$16.1	$1.6	$1.2	$1.8
2069	$161.4	$161.4	$161.4	$17.3	$17.3	$17.3
2070	$13.7	$16.1	$19.7	$1.4	$1.7	$2.0
2071	$28.7	$28.7	$28.7	$2.8	$2.8	$2.8
2072	$11.7	$12.0	$12.6	$1.1	$1.1	$1.2
2073	$23.1	$26.3	$32.5	$2.1	$2.4	$3.0
2074	$10.6	$10.6	$10.6	$0.9	$0.9	$0.9
2075	$64.2	$64.2	$64.2	$5.4	$5.4	$5.4
2076	$10.6	$10.6	$10.6	$0.9	$0.9	$0.9
2077	$10.6	$10.6	$10.6	$0.8	$0.8	$0.8
2078	$10.6	$10.6	$10.6	$0.8	$0.8	$0.8
2079	$10.6	$10.6	$10.6	$0.8	$0.8	$0.8
2080	$10.6	$10.6	$10.6	$0.7	$0.7	$0.7
2081	$10.6	$10.6	$10.6	$0.7	$0.7	$0.7
2082	$10.6	$10.6	$10.6	$0.7	$0.7	$0.7
2083	$10.6	$10.6	$10.6	$0.7	$0.7	$0.7
2084	$10.6	$10.6	$10.6	$0.6	$0.6	$0.6

Year	Not Discounted			Discounted		
	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs
2085	$10.6	$10.6	$10.6	$0.6	$0.6	$0.6
2086	$10.6	$10.6	$10.6	$0.6	$0.6	$0.6
2087	$10.6	$10.6	$10.6	$0.6	$0.6	$0.6
2088	$10.6	$10.6	$10.6	$0.5	$0.5	$0.5
2089	$10.6	$10.6	$10.6	$0.5	$0.5	$0.5
2090	$10.6	$10.6	$10.6	$0.5	$0.5	$0.5
2091	$10.6	$10.6	$10.6	$0.5	$0.5	$0.5
2092	$10.6	$10.6	$10.6	$0.5	$0.5	$0.5
2093	$10.6	$10.6	$10.6	$0.4	$0.4	$0.4
2094	$60.6	$60.6	$60.6	$2.4	$2.4	$2.4
2095	$10.6	$10.6	$10.6	$0.4	$0.4	$0.4
2096	$10.6	$10.6	$10.6	$0.4	$0.4	$0.4
2097	$10.6	$10.6	$10.6	$0.4	$0.4	$0.4
2098	$10.6	$10.6	$10.6	$0.4	$0.4	$0.4
2099	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2100	$16.1	$16.1	$16.1	$0.5	$0.5	$0.5
2101	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2102	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2103	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2104	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2105	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2106	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2107	$10.6	$10.6	$10.6	$0.3	$0.3	$0.3
2108	$10.6	$10.6	$10.6	$0.2	$0.2	$0.2
2109	$10.6	$10.6	$10.6	$0.2	$0.2	$0.2
2110	$10.6	$10.6	$10.6	$0.2	$0.2	$0.2
2111	$10.6	$10.6	$10.6	$0.2	$0.2	$0.2

Year	Not Discounted			Discounted		
	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs	10th Percentile Costs	50th Percentile Costs	90th Percentile Costs
Total Cost	**$4.7 billion**	**$5.5 billion**	**$6.9 billion**	**$2.7 billion**	**$3.3 billion**	**$4.4 billion**

Source: Adapted from spreadsheet, "Cost by Year – Yakima IP" provided by HDR Engineering on May 31, 2012.