Yakima River Basin Study

Economic Effects of Yakima Basin Integrated Water Resource Management Plan Technical Memorandum

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ, Task 2.2

Prepared by

ECONorthwest

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

June 2011

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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

This memorandum describes the potential economic effects of the Yakima Basin Integrated Water Resources Management Plan (Integrated Plan). The memorandum focuses on describing the potential costs and benefits of the Integrated Plan and, where suitable information is available, it estimates some types of costs and benefits in monetary terms. It also discusses other types of effects, such as potential impacts on jobs and incomes.

Implementing the Integrated Plan would yield economic costs or benefits to the extent that it respectively decreases or increases (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 produced outside the boundaries of the planning area, or (3) the value of financial and other types of capital.

Available information supports estimation of financial costs to implement conservation and other proposed programs, and to construct, operate, and maintain Wymer Dam, an enlarged Bumping Lake Dam, and other proposed facilities. It also supports estimation of benefits arising from increases in the value of three types of goods and services associated with increases in (1) production of irrigated crops during future severe droughts; (2) future populations of salmon and steelhead resulting from improvements in fish habitat; and (3) the supply of water for municipal/industrial use.

The discussion is consistent with guidance provided by the main set of guidelines, commonly referred to as the *Principles and Guidelines,* for economic analyses of Federal water-resource planning (US Water Resources Council 1983). The *Principles and Guidelines* recognizes (p. iv) that the "The Federal objective of water and related land resources project planning is to contribute to national economic development.... Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also those that may not be marketed."

The *Principles and Guidelines* also recognizes that other effects may be important, and calls for considering them separate from the effects on the NED, through an accounting of the environmental quality, regional economic development, and other social effects. This memorandum includes information regarding the Integrated Plan's potential impacts on national and regional economic development.

2.0 Summary of the Potential Economic Effects of the Integrated Plan

Implementation of the Integrated Plan would involve several types of economic costs and benefits. Sufficient information currently exists to quantify only some of these; the others are described qualitatively. Currently available information also is sufficient only for a qualitative discussion of the plan's potential effects on jobs, incomes, and economic output.

2.1 Quantified Potential Costs and Benefits

The potential financial costs to implement the Integrated Plan over a 100-year period, through 2110, would have a present value of about $3.0 billion.[1] These costs primarily involve expenditures for capital, operations, and maintenance of new facilities. Lesser amounts represent planned expenditures to implement the Integrated Plan's programs to promote conservation and market-based reallocation.

Sufficient information exists to describe the present value of three types of benefits in monetary terms:

- Increased net farm earnings from irrigated crops during future severe droughts: about $0.4 billion.
- Increased supply of up to 50,000 acre-feet of water for municipal use: about $0.1 billion.
- Increased production of salmon and steelhead: about $1.7 – $3.3 billion.

The present values for these three benefits total about $2.2 billion to $3.8 billion.

2.2 Unquantified Potential Costs and Benefits

Sufficient information does not exist to quantify the value of many categories of costs and benefits, notably those that are not traded in markets and, hence have no price data indicating their value. As a consequence, it currently is not possible to determine if the plan's overall potential benefits are smaller than, equal to, or larger than its overall potential costs.

Insufficient information exists to calculate the value of two categories of potential costs that likely would accompany implementation of the Integrated Plan:

- Loss of services, such as the provision of recreational opportunities and habitat for species, from lands that would be occupied by new or expanded reservoir sites under the Integrated Plan.
- Reduced net farm earnings for farmers who compete with those who would benefit directly from the Integrated Plan.

Implementation of the plan also would yield several types of economic benefits that cannot be quantified with existing information. This list summarizes these additional potential benefits:

- Increases in net farm earnings from irrigated farming in the basin in years with drought less intense than the severe drought that is the basis for the quantified benefits above.
- Unquantifiable benefits of higher fish populations. These benefits likely would include the cultural and spiritual values associated with increases in salmon/steelhead populations.
- Increases in the net value of recreational opportunities, other than those already reflected in the valuation of higher fish populations.

[1] The present value is an amount, measured today, that is equivalent in value to an anticipated future stream of costs or benefits. Calculation of the present value involves discounting the cost or benefit in a future year to its equivalent present value. The current discount rate applicable to Federal water-resources planning is 4.375 percent per year.

- Increases in the populations of valuable species other than salmon/steelhead.
- Improved resiliency and adaptability of the water system.
- Additional benefits associated with the Integrated Plan's impacts on the production of irrigated crops, salmon/steelhead, and other goods or services in the context of anticipated changes in climate.

3.0 Potential Economic 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.[2] Current information indicates the plan's economic costs would fall into these three categories:

- The consumption of financial capital to implement programs and construct, operate, and maintain structures.
- Reduction in the value of irrigated crops produced by farmers other than those inside the Yakima Project who would benefit from the plan's provision of water to offset the losses from severe drought.
- 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 1 shows the financial costs to implement the Integrated Plan, by year, for the next 100 years (see appendix for more detail). Nearly all the costs would occur during the first 50 years of the period. Figure 1 also shows the present value of the annual financial costs, using a discount rate of 4.375 percent per year, the discount rate currently applicable to Federal water-resources planning (Federal Register 2010). The overall present value of the 100-year stream of expected costs is about $3.0 billion.

Implementation of the Integrated Plan also would generate two additional categories of costs, but currently available information is insufficient to quantify their value. The first would involve loss of services such as recreational opportunities and habitat for species from land that would be occupied by new or expanded reservoir sites under the Integrated Plan.

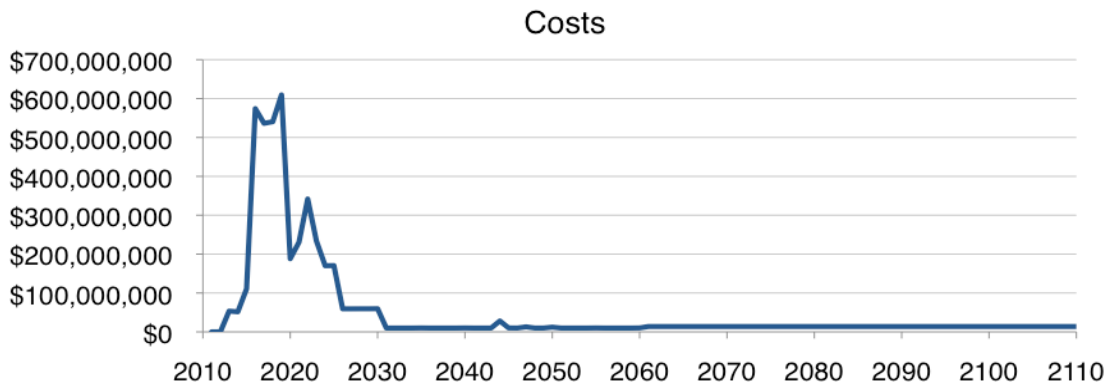
The second category of unquantified costs would likely be reduced net earnings for farmers who compete with those who would benefit directly from the Integrated Plan. The competing farmers would incur economic losses due to lower prices for their crops as the Integrated Plan increases

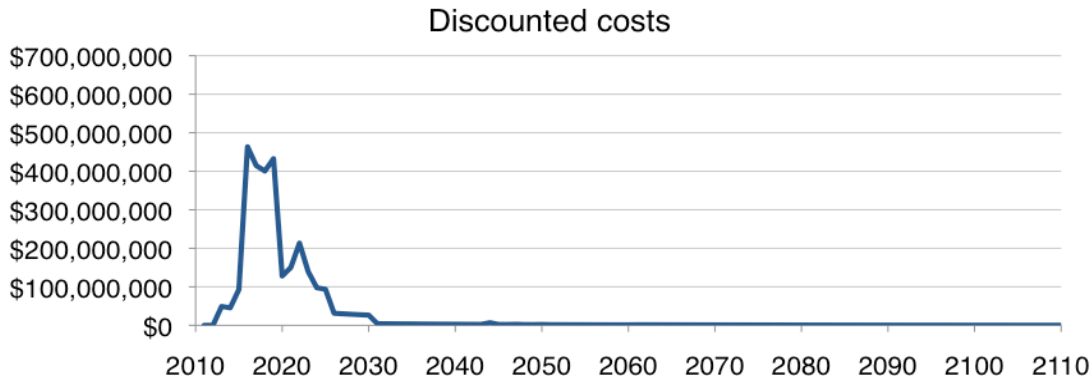
[2] Capital is the term used for assets capable of contributing to the future production of valuable goods and services. Economists distinguish among five types of capital: (1) *financial capital* (money used by businesses, governments, or other entities to buy the inputs they require to make their products 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 supply of water for some irrigators during drought years and thus reduces crop prices in relevant local, statewide, or national markets. The *Principles and Guidelines* recognizes that, when a water resources project results in an increase in the production of some crops – especially those that are not traded in global commodity markets – the accompanying impact on the crops' prices in local, regional, and national markets may reduce the value of crops produced by farmers elsewhere in the U.S.

Recent analyses of proposals to increase the supply of water available for irrigation in Washington's Columbia River Basin concluded that they likely would have such impacts, with the benefits to those receiving the additional water being fully offset by the lower prices for crops produced by other farmers in the State (Huppert et al. 2004, Griffin 2005, Williams and Capp 2005). This general conclusion likely applies to the Integrated Plan, even though the analyses focused on proposed projects that would increase irrigated acreage rather than on providing water during drought years to acres already being irrigated, as would occur under the Integrated Plan.

Hence, implementation of the plan likely would generate costs for farmers outside the districts that would directly benefit from it. The extent of the costs, however, cannot be determined from existing information.





Source: ECONorthwest, with data from HDR Engineering, Inc.

Figure 1. Potential Financial Costs to Implement the Integrated Plan, 2010–2110, by Year

4.0 Potential Economic Benefits of the Integrated Plan

Currently available information supports quantification of the value for three important categories of potential benefits of the Integrated Plan. Several other categories of important potential benefits can be described only qualitatively.

4.1 Quantified Potential Benefits

Currently available information supports quantification of the value for three categories of the Integrated Plan's potential economic benefits: (1) increases in net farm earnings for some irrigators during future years with severe drought; (2) increases in the value of higher populations of salmon/steelhead; and (3) increases in the value of additional supplies of water for municipal/industrial use.

Irrigation-Related Potential Benefits

If implemented, the Integrated Plan would increase the net farm earnings of irrigators receiving proratable water supplies through the Yakima Project. The plan would generate these benefits in two ways. One would increase the supply of water available to these irrigators during a severe drought. The other would stimulate market-based reallocation of water within the Yakima Project, resulting in more transfers than otherwise would occur, and moving water from production of lower-valued crops to higher-valued crops.

The underlying data, assumptions, and analytical model for assessing the potential irrigation-related benefits of the Integrated Plan are the same as those used to assess the potential benefits of the market-based reallocation element of the plan (subtask 4.4 of the Yakima Basin Study). The model estimates the net farm earnings for irrigators in Roza, Kittitas, Sunnyside, Tieton, and Wapato districts under two scenarios, one with the levels of water supplies and trading expected to occur with implementation of the plan, and the other with the levels expected to occur without it.[3] The difference in net farm earnings between the two represents potential benefits.

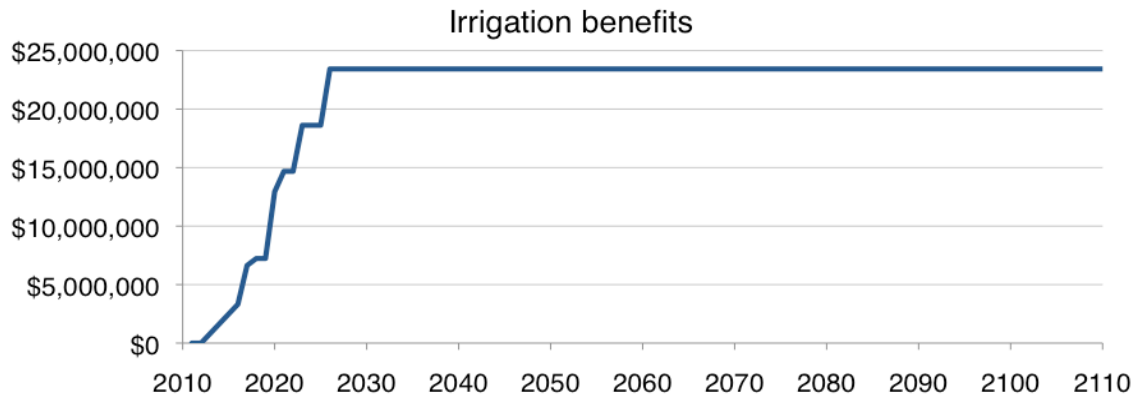
The analysis assumes that, without the Integrated Plan, a severe drought (when proratable irrigators receive only 30 percent of their full entitlement) would occur every five years, and would persist for three years every 20 years. Implementation of the Integrated Plan would yield no irrigation-related benefits during 2011-2012. For 2014-2016, it would yield one-quarter of the full potential benefits from market-based reallocation of water, 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 market reallocation potential as modeled may not be fully achievable.

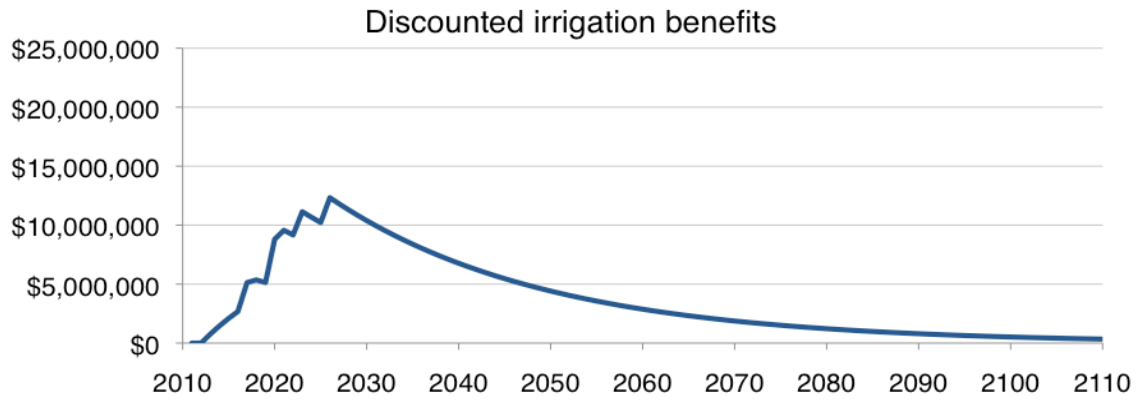
The plan would increase the supply of water beginning in 2018, with the amount ramping-up until 2026 as the various storage projects are brought on line under the schedule in the proposed Integrated Plan. With these supply improvements, it is assumed that at 2026 the Yakima Project would deliver 70 percent of proratable entitlements during a severe drought year. The analysis

[3] To facilitate the presentation, the text uses "District" to describe each of the five entities, even though some have other legal structures. Kennewick Irrigation district is excluded from the analysis, even though it receives water from the Yakima Project, because it generally experiences smaller impacts than the other districts during drought years.

carried out under Task 4.4 indicated that implementation of the plan would raise net farm earnings for the beneficiary irrigators by $80 million per year during a severe drought year.

The top of Figure 2 shows the anticipated pattern of the Integrated Plan's irrigation-related benefits (see appendix for more detail). The bottom of Figure 2 shows the present values, discounted back to 2010 at 4.375 percent per year. The annual (undiscounted) benefits would remain constant during the years following 2060; the discounted values would trend toward the x-axis. The overall, present value of the potential, irrigation-related benefits over the 100-year period is about $0.4 billion.





Source: ECONorthwest.

Figure 2. Potential Irrigation-Related Benefits of the Integrated Plan

Salmon/Steelhead-Related Potential Benefits

The Integrated Plan would potentially generate economic benefits by increasing future populations of young salmon/steelhead produced in and the numbers of adult fish returning to the Yakima River basin. Increases in salmon/steelhead populations can yield economic benefits in several ways. Economists often distinguish between two general categories of value. One, called "use values," concerns activities such as commercial and recreational fishing that directly interact with and can extract fish from the environment. The other, called "non-use values" (or "passive-use values"), does not require this direct interaction and use. It occurs when people

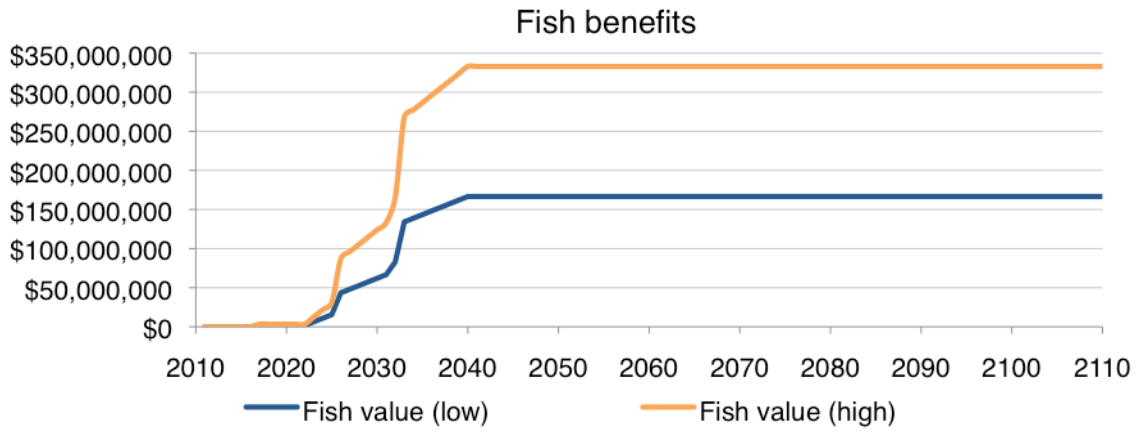
place importance on the continued existence of fish and on ensuring that fish will be available for the enjoyment of others such as future generations.

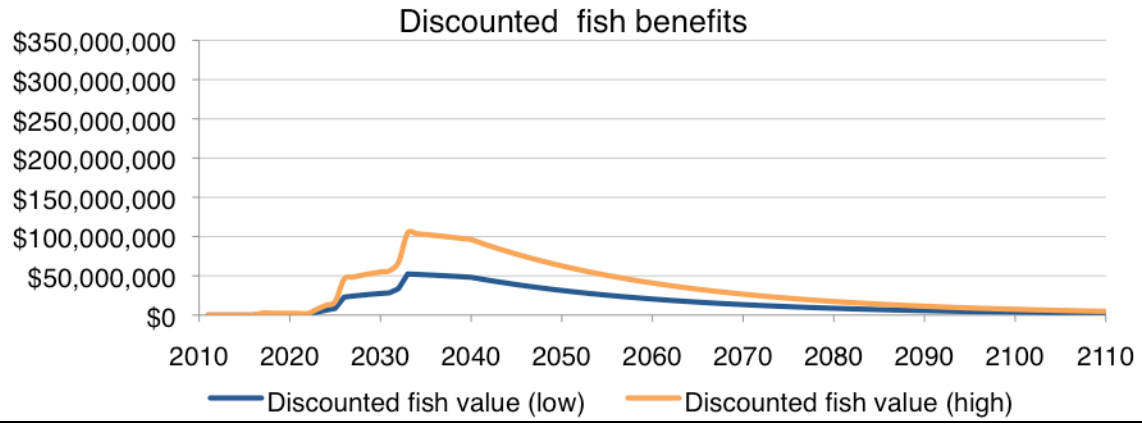
Estimating use values associated with potential increases in salmon/steelhead populations typically involves analyzing market data such as the net earnings of commercial fishing enterprises or the expenditures of anglers. Non-use values typically are not associated with market transactions and, hence, economists must rely on non-market techniques such as sophisticated interviews to elicit information about the size of these values and their sensitivity to factors such as changes in fish populations and the risk of future extinctions.

Because of a lack of familiarity with non-market techniques for estimating the value of the continued existence of fish and related values, some past studies of the value of potential increases in salmon/steelhead populations in this region have focused solely on use values, despite acknowledging that doing so might capture only a small portion of the total value (for example, Reclamation 2008). Others, however, have concluded that the results from applying non-market techniques to assess the non-use values derived from water likely have greater reliability than the results from applying market-based techniques to estimate the use-values (for example, Young 2005).

One important study estimated the overall value of potential changes in salmon/steelhead populations in the Columbia River basin without distinguishing between use- and non-use values. (Layton et al. 1999). The study's results estimate Washingtonians' willingness to pay for a given increase in fish populations from an assumed current population level. A subsequent review of the study (Huppert et al. 2004) "recommend[s] that any reliable estimates of impacts on salmon and steelhead should be assigned values based upon the methodology developed in Layton, Brown, and Plummer (1999)." The economic analysis in this report applies the Layton, Brown, and Plummer methodology to estimate the value of the potential increases in salmon/steelhead population that might result from implementation of the Integrated Plan.

The analysis of the plan's potential impacts on fish populations concludes that, when fully implemented, it would increase the number of adult salmon and steelhead returning to the Columbia River by 126,000 to 791,000 fish a year (Volume 2 technical memorandum: *Fish Benefits Analysis*). These increases would begin in 2017 and reach their full potential in 2040. Applying the methodology of Layton, Brown, and Plummer yields the annual and discounted benefits shown in Figure 3 (see appendix for more detail). The overall present value of the potential salmon/steelhead-related benefits for the 100-year period is about $1.7 billion to $3.3 billion.



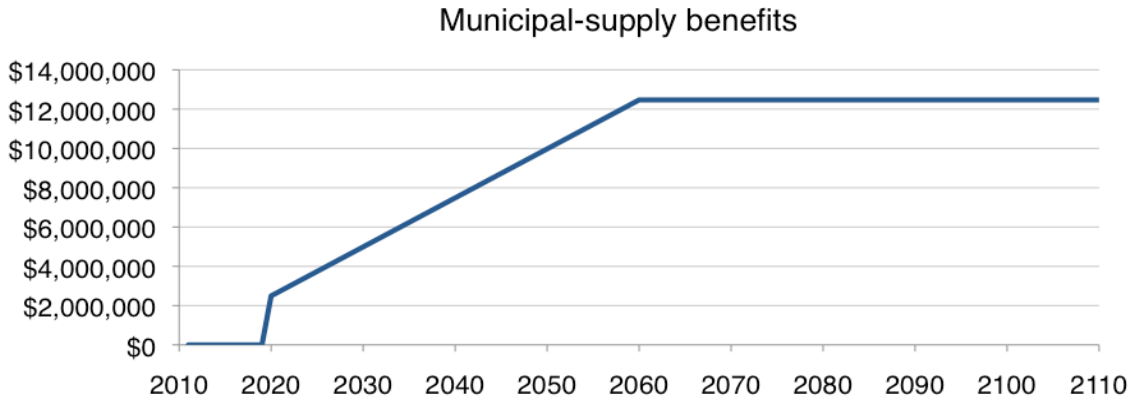


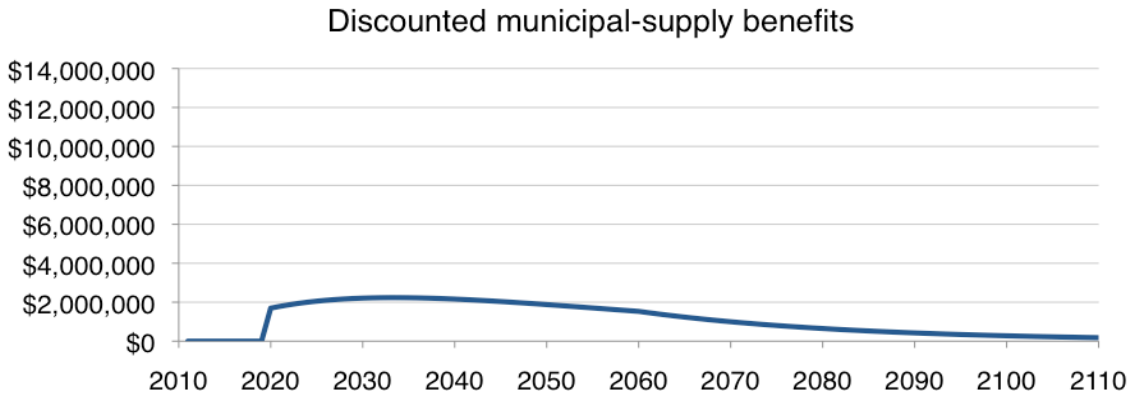
Source: ECONorthwest.

Figure 3. Potential Benefits from Increases in Salmon/Steelhead Populations

Municipal-Supply Potential Benefits

If implemented, the Integrated Plan would begin supplying water for municipal/industrial use and mitigation for domestic wells in 2020, with the level of additional use increasing to 50,000 acre-feet in 2060 and subsequent years. The analysis assumes that the value of this water is about $240 per acre-foot, reflecting Reclamation's estimate of the wholesale price of municipal water in the Pacific Northwest Region (Reclamation 2008). Figure 4 shows the annual and discounted value of the expected benefits (see appendix for more detail). The overall present value of the municipal-supply benefits is about $0.1 billion.





Source: ECONorthwest.

Figure 4.Potential Benefits from Increased Water Supplies for Municipal/Industrial Use

Summary of Quantified Benefits

The present values for the irrigation-related benefits, salmon/steelhead-related benefits, and municipal-supply benefits total about $2.2 billion to $3.8 billion

4.2 Unquantified Potential Benefits

Implementation of the plan also would yield several types of economic benefits that cannot be quantified with existing information, including the following:

- **Unquantified Irrigation-Related Benefits.** Implementation of the Integrated Plan likely would yield benefits to irrigators in addition to the quantified benefits described, above. The quantified benefits would occur in Roza, Kittitas, Sunnyside, Tieton, and Wapato Districts during years when (without the plan) severe drought would limit proratable irrigators to 30 percent of their full entitlement. The additional benefits likely would occur in several ways. The Integrated Plan likely would enable irrigators in these districts to have access to water supplies during years with less than a severe drought. Implementation of the Integrated Plan 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 districts, and in all future years, not just those with a severe drought.

If drought conditions become even more severe than assumed, irrigators in Kennewick Irrigation District might also realize benefits from the Integrated Plan.

- **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 described previously (the survey of willingness-to-pay described previously does not adequately estimate this benefit).
- **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 benefits from increases in the net value of recreational opportunities.** This category includes recreational benefits other than those already reflected in the valuation of higher fish populations. They might occur, for example, as opportunities for reservoir fishing and boating increase on Bumping Lake.
- **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 management agencies in the Yakima Basin to successfully respond to a wider set of disturbances such as more severe drought 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 Basin. The economic analysis considers only recent drought frequency and severity, and does not consider the increased benefits of additional water supply with increased drought frequency and severity.

4.3 Use of Cost and Benefit Estimates

The estimates presented above do not provide sufficient information to reach a definitive conclusion about the extent to which the overall potential benefits of the Integrated Plan are smaller than, equal to, or larger than the potential costs. Instead, they indicate that the present value of the expected financial cost roughly equals the sum of the estimated values for three categories of expected benefit: increases in the supply of irrigation water during severe drought, increased salmon/steelhead populations, and increases in the supply of municipal-industrial water. These estimates, however, do not include the values of other important categories of costs and benefits that can be described only qualitatively given the information that was available for this analysis.

5.0 Other Potential Economic Impacts of the Integrated Plan

Implementation of the Integrated Plan likely would alter the levels and distribution of jobs, incomes, and economic output in the local and statewide economies. These effects are distinct from the plan's potential costs and benefits. For example, as the plan increases the supply of water for municipal/industrial use, one community may respond with increases in residential development and another with increased industrial/commercial development. If the two

communities have the same willingness to pay for the additional water, they would realize identical benefits from implementation of the plan, but would experience different patterns of change in population, jobs, incomes, output, and related variables. Currently available information is insufficient to quantify these potential effects, but this section provides some relevant background information.

Changes in the local and statewide economies resulting from the Integrated Plan would occur as the plan alters expenditures on plan-related activities and changes the supply and price of goods and services derived from the Yakima River Basin's water and related resources. These effects are discussed below.

5.1 Potential Impacts of Plan-Related Expenditures

Plan-related expenditures on construction, operations and maintenance, and program-implementation would affect jobs, incomes, and output in the local and statewide economies. The level and distribution of the effects would depend on several variables, including the timing of the expenditures and the status of the overall economy. For example, concentration of construction expenditures over a short period could create demand for workers, supplies, and equipment that overwhelm local supplies, so more of the expenditures would go to workers and vendors from outside the area or even from out of State. If the expenditures occur when unemployment is low and the economy has little excess capacity, the plan would be implemented only by drawing workers, supplies, and equipment from other projects. Therefore, the overall net effect on jobs, incomes, and output would be considerably less than would occur if unemployment were high and the economy had a lot of excess capacity.

Another important variable that would influence the effects of plan-related expenditures is the source of the funding. If funding comes from outside the local area, it would stimulate additional local or State economic activity. However, if the funds come from within the local area, or would be spent elsewhere in the local area or in the State without the Integrated Plan, then spending on plan-related activities would occur only by depressing expenditures on other activities. The decreases would more or less offset the effects of the plan-related activities.

Reclamation's assessment of an earlier proposal to develop Wymer Dam and Reservoir provides some general context for the potential effects of plan-related expenditures on construction, operation, and maintenance of major facilities (Reclamation 2008). It found that, during a 10-year construction period, expenditures of about $420 million would result in about 255 annual jobs directly related to construction, and an additional 315 jobs indirectly related to construction, which is less than 1 percent of total employment in the local area. The assessment also found that annual expenditures of about $1 million for operations and maintenance would result in about nine annual jobs.

However, these numbers provide only a rough approximation of the potential effects of the proposed Integrated Plan since the current plan involves different elements than those considered by Reclamation in its earlier Wymer Dam and Reservoir proposal. In addition, the analytical methods used in the earlier assessment did not fully address the influence of timing, the status of the overall economy, and the distribution of the sources of funding. It also used an analytical tool (an input-output model) that can yield misleading results about the total (direct plus indirect) impacts of expenditures. The model assumes that the effects of a change in expenditures would

closely resemble the economy's response to ongoing expenditures, even though widely accepted economic theory indicates that its response to a change might be markedly different.[4]

Because of these issues, the results from the earlier assessment cannot reliably be used to quantify the Integrated Plan's potential effects on the local and statewide economies. However, they do indicate that expenditures on the plan likely would constitute a small percentage of total economic activity in the local economy. Although the assessment did not examine statewide effects, it supports the conclusion that the Integrated Plan would affect an even smaller percentage of the statewide economy.

5.2 Changes in Output of Goods and Services

Although currently available information is insufficient to quantify specific effects of the Integrated Plan on jobs, income, and output in the local and statewide economies, we can assume it would increase the supply and value of goods and services derived from the basin's water and related resources. In particular, it would increase the supply of irrigated crops from the Yakima Project; the number of salmon and steelhead produced in and returning to the basin; and the supply of water for municipal/industrial use. Each of these impacts likely would affect jobs, incomes, and output in the local and statewide economies.

Reclamation's assessment of an earlier proposal to develop Wymer Dam and Reservoir provides some general context for the potential effects of plan-related increases in irrigated crops during years with severe drought (Reclamation 2008). It found that the plan would increase annual jobs in the local economy by about 1,300 to 1,400, labor income by about $42 to $44 million, and output by about $121 to $234 million if proratable irrigators served by the Yakima Project received at least 70 percent, rather than about 30 percent, of their full entitlement during a drought year similar to 2001 and 2005.

These results provide context for understanding the scale of the potential irrigation-related economic effects of the proposed Integrated Plan, but they do not provide a reliable estimate for the following reasons:

- They are limited by the input-output models described above.
- They overestimate drought-related losses and the benefits of increasing water supplies to offset the drought because they do not anticipate the steps governments, businesses, and households likely would take to mitigate adverse effects of a short-term, severe drought.
- The hydrologic analysis reflects a different level of severe drought that would reduce proratable water supplies to 30 percent of full entitlements.

[4] Misleading results can arise when such models incorporate assumptions that the incremental output, employment, and value-added per-unit change in the water supply for agriculture, or other use, would resemble the average levels of these variables associated with existing water supplies, and that labor, capital, and other inputs would be available for increased agricultural production without affecting production of other sectors of the economy. These assumptions generally lack validity in a dynamic, full-employment economy where relationships between production factors can vary over time and in response to price changes, and where the economy realizes opportunity costs when factors of production are shifted from one industry or application to another. See, for example, "Limitations of Input-Output Impact Analysis." *Chapter 3: The Washington Input-Output Tables for Impact Analysis*. Washington Office of Financial Management. 2008. Retrieved 14 December 2010 from http://www.ofm.wa.gov/economy/io/2002/default.asp.

While currently available information is insufficient to estimate specific economic effects of anticipated increases in salmon/steelhead populations resulting from implementation of the Integrated Plan, it would likely affect jobs, incomes, and output in several ways. Direct impacts could occur as larger fish populations induce greater commercial and recreational fishing activity and expenditures. Indirect impacts could occur as some people opt to live in this area rather than elsewhere because they see increased fish populations as an indicator of improvements in the supply of amenities such as recreational opportunities, healthy aquatic habitats, and improved water quality. This would, in turn, induce economic activity by simultaneously increasing the supply of labor in the local market and the size of the market for consumer goods and services (the process by which such indirect effects occur is explained in Hand et al. 2008).

Currently available information is also insufficient to estimate the potential impacts on jobs, incomes, and output that might result from anticipated increases in the supply of municipal water. However, the Integrated Plan could have impact if it lowers the price of water or relaxes potential water-supply constraints on future residential and industrial/commercial development in the area.

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7.0 List of Preparers

NAME	BACKGROUND	RESPONSIBILITY
ECONORTHWEST		
Ernie Niemi	MCRP (Harvard University)	Co-author
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Appendix of Tables

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Table A-1. Anticipated Increases in Salmon/Steelhead Population

	Future without Plan			Integrated Plan			Difference		
Annual Run Size	**Min**		**Max**	**Min**		**Max**	**Min**		**Max**
Recruitment	18,581	to	131,343	131,135	to	857,621	112,554	to	726,278
Harvest	5,148	to	37,260	28,021	to	187,192	22,873	to	149,932
Yakima R. Mouth	15,103	to	106,619	107,816	to	706,099	92,713	to	599,480
Total Escapement	12,139	to	91,228	87,400	to	576,792	75,261	to	485,564

Source: Andrew Graham, HDR Engineering, 2011. Personal Communication. February 15.

Table A-2. Annual Implementation Costs for the Integrated Plan

Year	Annual Cost	Year	Annual Cost	Year	Annual Cost	Year	Annual Cost
2011	$0	2036	$9,915,000	2061	$9,915,000	2086	$9,915,000
2012	$0	2037	$9,915,000	2062	$9,915,000	2087	$9,915,000
2013	$53,366,667	2038	$9,915,000	2063	$9,915,000	2088	$9,915,000
2014	$51,666,667	2039	$9,915,000	2064	$9,915,000	2089	$9,915,000
2015	$110,583,333	2040	$10,165,000	2065	$9,915,000	2090	$9,915,000
2016	$574,133,333	2041	$9,915,000	2066	$24,915,000	2091	$9,915,000
2017	$536,343,333	2042	$9,915,000	2067	$12,715,000	2092	$9,915,000
2018	$540,505,000	2043	$9,915,000	2068	$14,715,000	2093	$9,915,000
2019	$609,505,000	2044	$28,115,000	2069	$97,915,000	2094	$28,115,000
2020	$188,145,000	2045	$10,165,000	2070	$13,665,000	2095	$9,915,000
2021	$230,561,667	2046	$9,915,000	2071	$9,915,000	2096	$9,915,000
2022	$341,811,667	2047	$12,915,000	2072	$14,265,000	2097	$12,915,000
2023	$233,646,667	2048	$9,915,000	2073	$19,665,000	2098	$9,915,000
2024	$170,146,667	2049	$9,915,000	2074	$9,915,000	2099	$9,915,000
2025	$170,479,167	2050	$12,165,000	2075	$17,015,000	2100	$11,915,000
2026	$59,339,167	2051	$9,915,000	2076	$9,915,000	2101	$9,915,000
2027	$59,339,167	2052	$9,915,000	2077	$9,915,000	2102	$9,915,000
2028	$59,421,667	2053	$9,915,000	2078	$9,915,000	2103	$9,915,000
2029	$59,421,667	2054	$9,915,000	2079	$9,915,000	2104	$9,915,000
2030	$59,671,667	2055	$10,165,000	2080	$9,915,000	2105	$9,915,000
2031	$9,915,000	2056	$9,915,000	2081	$9,915,000	2106	$9,915,000
2032	$9,915,000	2057	$9,915,000	2082	$9,915,000	2107	$9,915,000
2033	$9,915,000	2058	$9,915,000	2083	$9,915,000	2108	$9,915,000
2034	$9,915,000	2059	$9,915,000	2084	$9,915,000	2109	$9,915,000
2035	$10,165,000	2060	$10,165,000	2085	$9,915,000	2110	$9,915,000

Source: Andrew Graham, HDR Engineering, 2010. Personal Communication. December 10.

Table A-3. Quantifiable Annual Benefits of the Integrated Plan

Year	Irrigation	Fish – Low Population Increase	Fish – High Population Increase	Municipal Supply
2011	$0	$0	$0	$0
2012	$0	$0	$0	$0
2013	$829,559	$0	$0	$0
2014	$1,659,118	$0	$0	$0
2015	$2,488,677	$0	$0	$0
2016	$3,318,237	$0	$0	$0
2017	$6,636,473	$1,666,265	$3,329,331	$0
2018	$7,232,597	$1,666,265	$3,329,331	$0
2019	$7,232,597	$1,666,265	$3,329,331	$0
2020	$12,941,028	$1,666,265	$3,329,331	$2,493,700
2021	$14,679,436	$1,666,265	$3,329,331	$2,743,070
2022	$14,679,436	$1,666,265	$3,329,331	$2,992,440
2023	$18,617,785	$6,294,779	$12,577,473	$3,241,810
2024	$18,617,785	$10,923,293	$21,825,614	$3,491,180
2025	$18,617,785	$15,551,806	$31,073,756	$3,740,550
2026	$23,431,859	$43,508,030	$86,932,531	$3,989,920
2027	$23,431,859	$48,136,544	$96,180,673	$4,239,290
2028	$23,431,859	$52,765,058	$105,428,815	$4,488,660
2029	$23,431,859	$57,393,572	$114,676,956	$4,738,030
2030	$23,431,859	$62,022,085	$123,925,098	$4,987,400
2031	$23,431,859	$66,650,599	$133,173,240	$5,236,770
2032	$23,431,859	$82,942,968	$165,726,698	$5,486,140
2033	$23,431,859	$134,226,901	$268,196,108	$5,735,510
2034	$23,431,859	$138,855,415	$277,444,249	$5,984,880
2035	$23,431,859	$143,483,929	$286,692,391	$6,234,250

Source: ECONorthwest.

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Table A-3. Quantifiable Annual Benefits of the Integrated Plan (cont. from previous page)

Year	Irrigation	Fish - Low Population Increase	Fish – High Population Increase	Municipal Supply
2036	$23,431,859	$148,112,443	$295,940,533	$6,483,620
2037	$23,431,859	$152,740,957	$305,188,674	$6,732,990
2038	$23,431,859	$157,369,471	$314,436,816	$6,982,360
2039	$23,431,859	$161,997,984	$323,684,957	$7,231,730
2040	$23,431,859	$166,626,498	$332,933,099	$7,481,100
2041	$23,431,859	$166,626,498	$332,933,099	$7,730,470
2042	$23,431,859	$166,626,498	$332,933,099	$7,979,840
2043	$23,431,859	$166,626,498	$332,933,099	$8,229,210
2044	$23,431,859	$166,626,498	$332,933,099	$8,478,580
2045	$23,431,859	$166,626,498	$332,933,099	$8,727,950
2046	$23,431,859	$166,626,498	$332,933,099	$8,977,320
2047	$23,431,859	$166,626,498	$332,933,099	$9,226,690
2048	$23,431,859	$166,626,498	$332,933,099	$9,476,060
2049	$23,431,859	$166,626,498	$332,933,099	$9,725,430
2050	$23,431,859	$166,626,498	$332,933,099	$9,974,800
2051	$23,431,859	$166,626,498	$332,933,099	$10,224,170
2052	$23,431,859	$166,626,498	$332,933,099	$10,473,540
2053	$23,431,859	$166,626,498	$332,933,099	$10,722,910
2054	$23,431,859	$166,626,498	$332,933,099	$10,972,280
2055	$23,431,859	$166,626,498	$332,933,099	$11,221,650
2056	$23,431,859	$166,626,498	$332,933,099	$11,471,020
2057	$23,431,859	$166,626,498	$332,933,099	$11,720,390
2058	$23,431,859	$166,626,498	$332,933,099	$11,969,760
2059	$23,431,859	$166,626,498	$332,933,099	$12,219,130
2060	$23,431,859	$166,626,498	$332,933,099	$12,468,500

Source: ECONorthwest.

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Table A-3. Quantifiable Annual Benefits of the Integrated Plan (cont. from previous page)

Year	Irrigation	Fish - Low Population Increase	Fish – High Population Increase	Municipal Supply
2061	$23,431,859	$166,626,498	$332,933,099	$12,468,500
2062	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2063	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2064	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2065	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2066	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2067	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2068	$23,431,860	$166,626,498	$332,933,099	$12,468,500
2069	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2070	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2071	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2072	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2073	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2074	$23,431,861	$166,626,498	$332,933,099	$12,468,500
2075	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2076	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2077	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2078	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2079	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2080	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2081	$23,431,862	$166,626,498	$332,933,099	$12,468,500
2082	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2083	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2084	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2085	$23,431,863	$166,626,498	$332,933,099	$12,468,500

Source: ECONorthwest.

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Table A-3. Quantifiable Annual Benefits of the Integrated Plan (cont. from previous page)

Year	Irrigation	Fish - Low Population Increase	Fish – High Population Increase	Municipal Supply
2086	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2087	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2088	$23,431,863	$166,626,498	$332,933,099	$12,468,500
2089	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2090	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2091	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2092	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2093	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2094	$23,431,864	$166,626,498	$332,933,099	$12,468,500
2095	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2096	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2097	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2098	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2099	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2100	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2101	$23,431,865	$166,626,498	$332,933,099	$12,468,500
2102	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2103	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2104	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2105	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2106	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2107	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2108	$23,431,866	$166,626,498	$332,933,099	$12,468,500
2109	$23,431,867	$166,626,498	$332,933,099	$12,468,500
2110	$23,431,867	$166,626,498	$332,933,099	$12,468,500

Source: ECONorthwest.