Appendix A

Comments and Responses

Table A-1. Topics and Associated Codes.

[To be completed after public review of the Draft EA.]

Table A-2. Responses to Comments Received During the Public Comment Period for Ochoco Irrigation District Watershed Plan-EA.

[To be completed after public review of the Draft EA.]

Appendix B

Project Maps

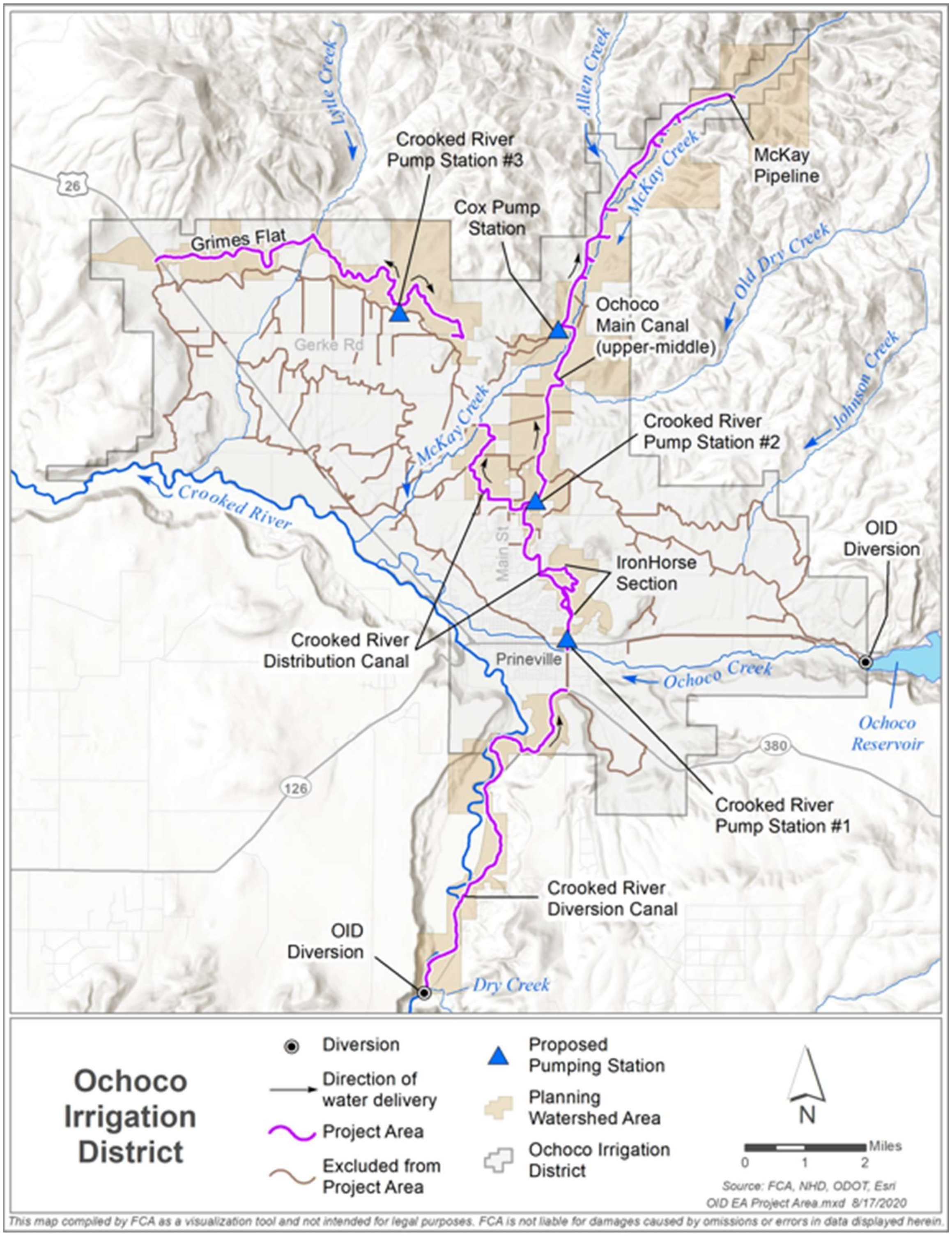


Figure B-1. Ochoco Irrigation District Infrastructure Modernization Project area.

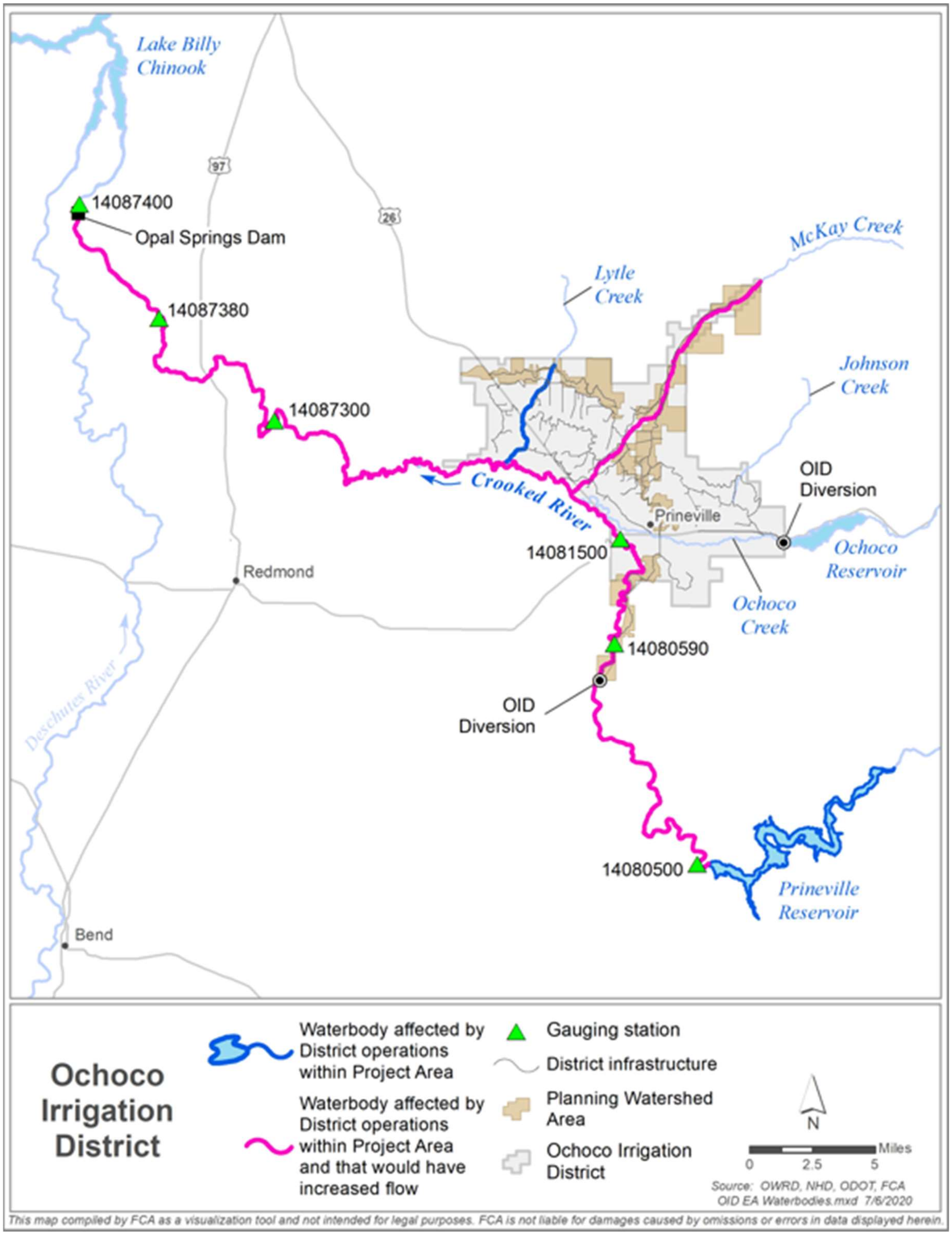


Figure B-2. Ochoco Irrigation District Infrastructure Modernization Project benefitted waterbodies

Appendix C

Supporting Maps

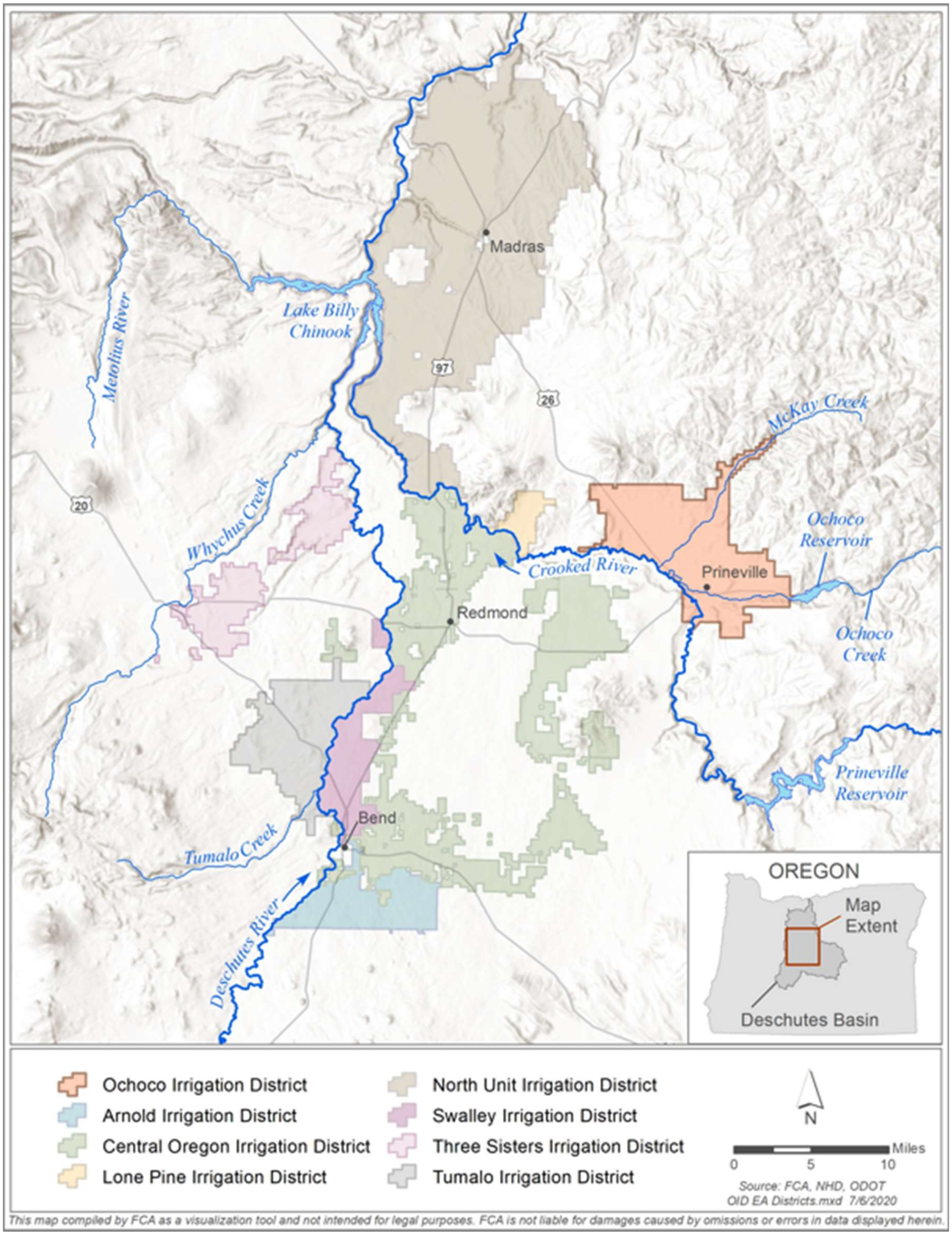


Figure C-1. Irrigation districts within the Deschutes Basin.

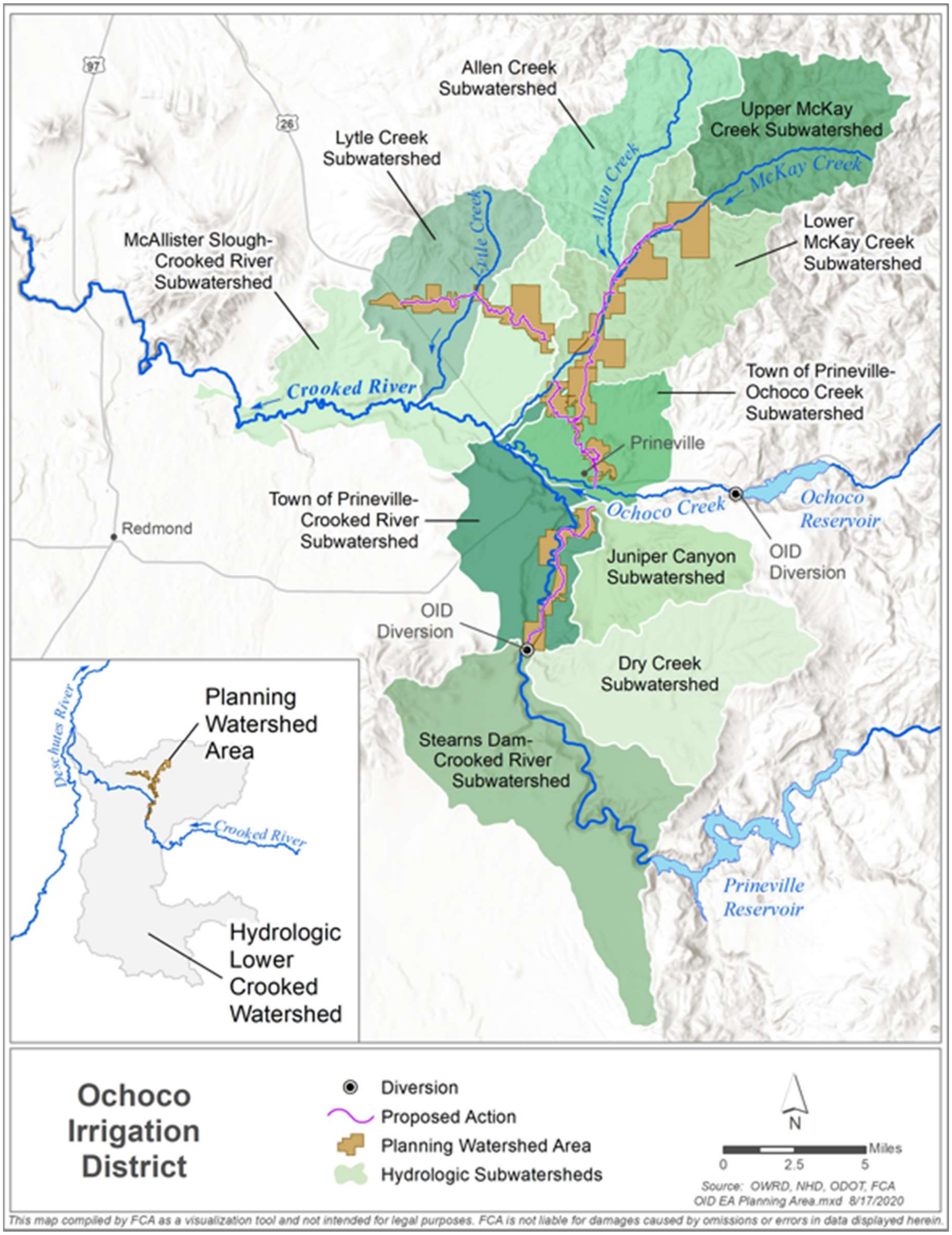


Figure C-2. The Ochoco Irrigation District Planning Watershed area.

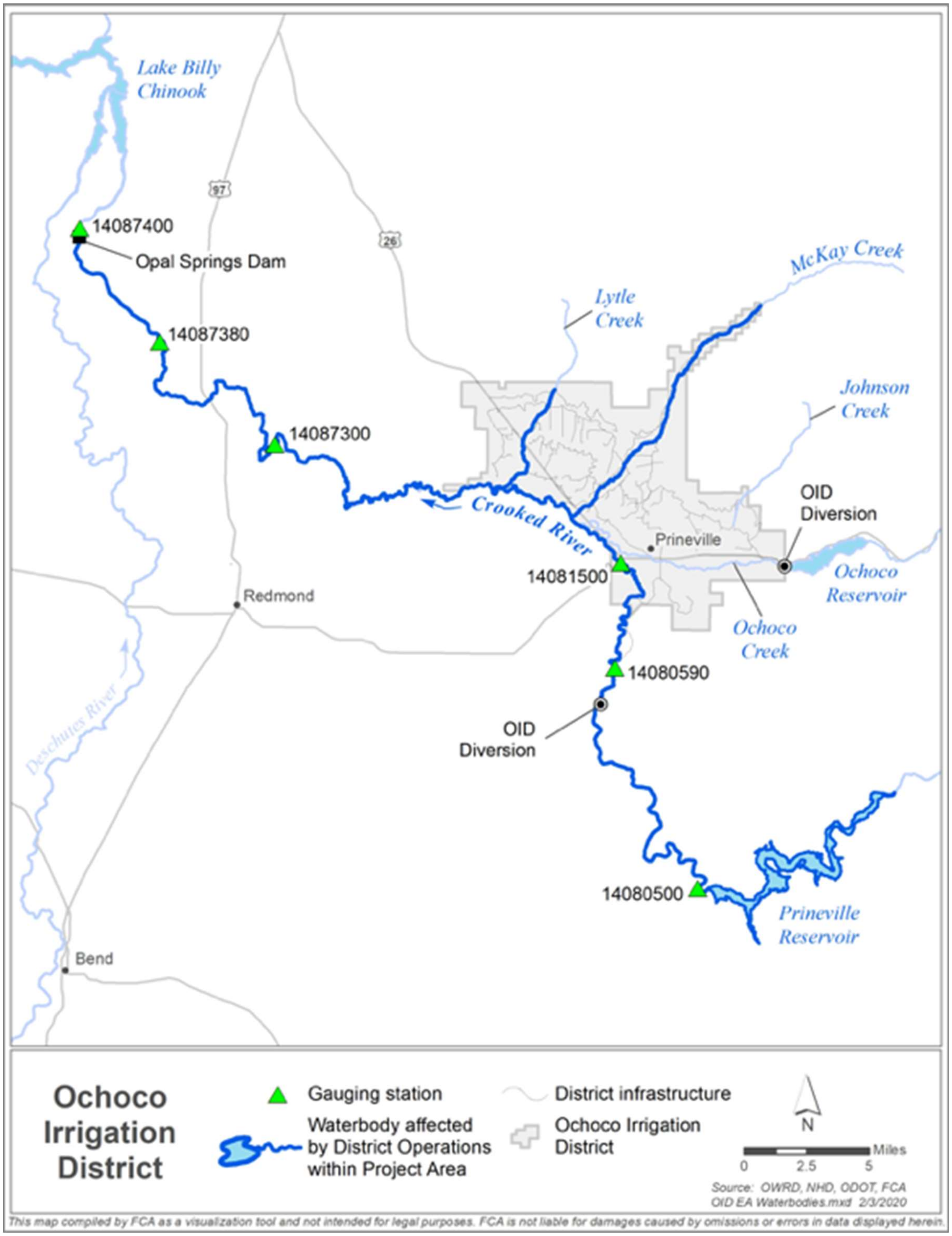


Figure C-3. Waterbodies associated with District operations in the project area and locations of streamflow gauging stations.

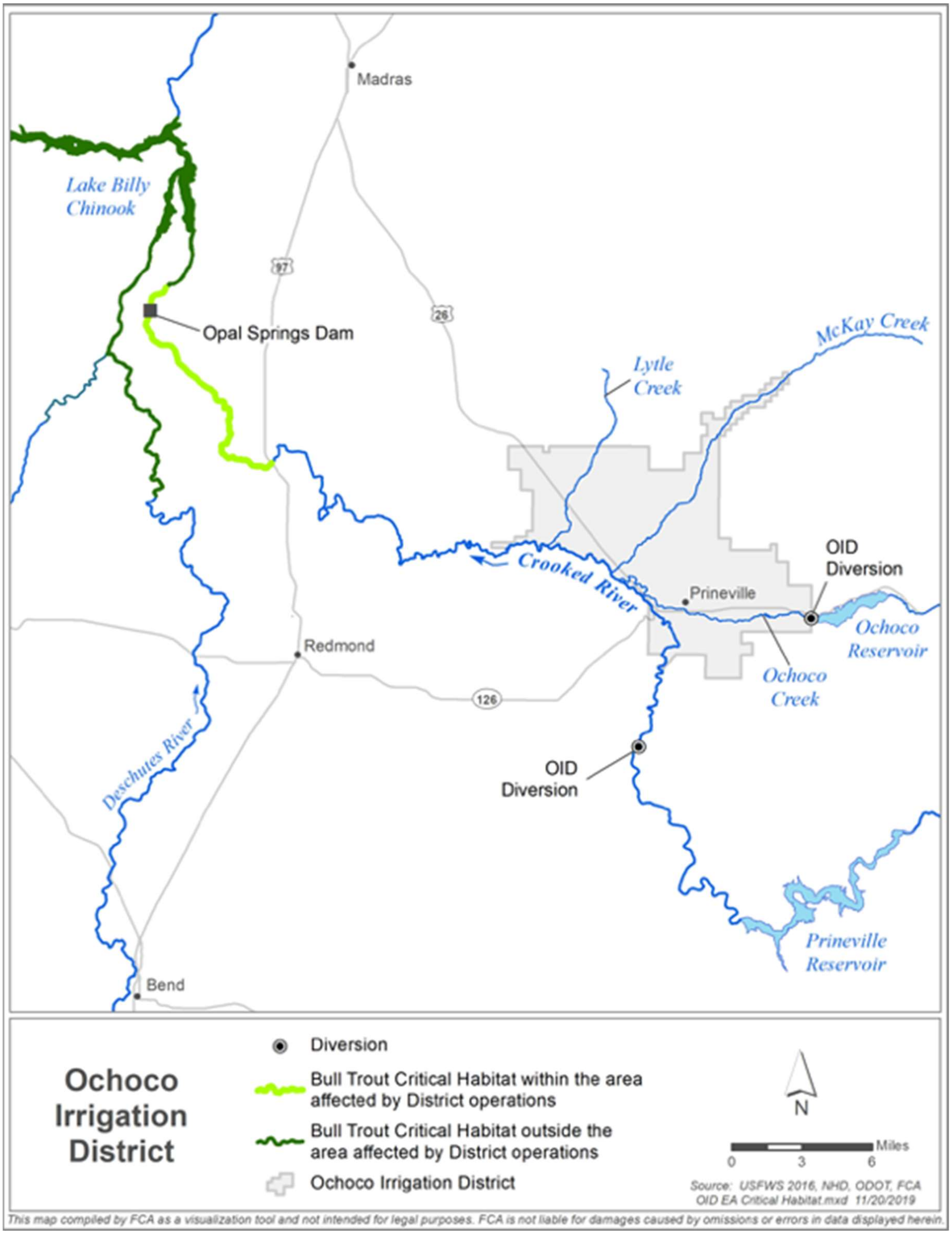


Figure C-4. Bull trout critical habitat within and outside of areas affected by District operations.

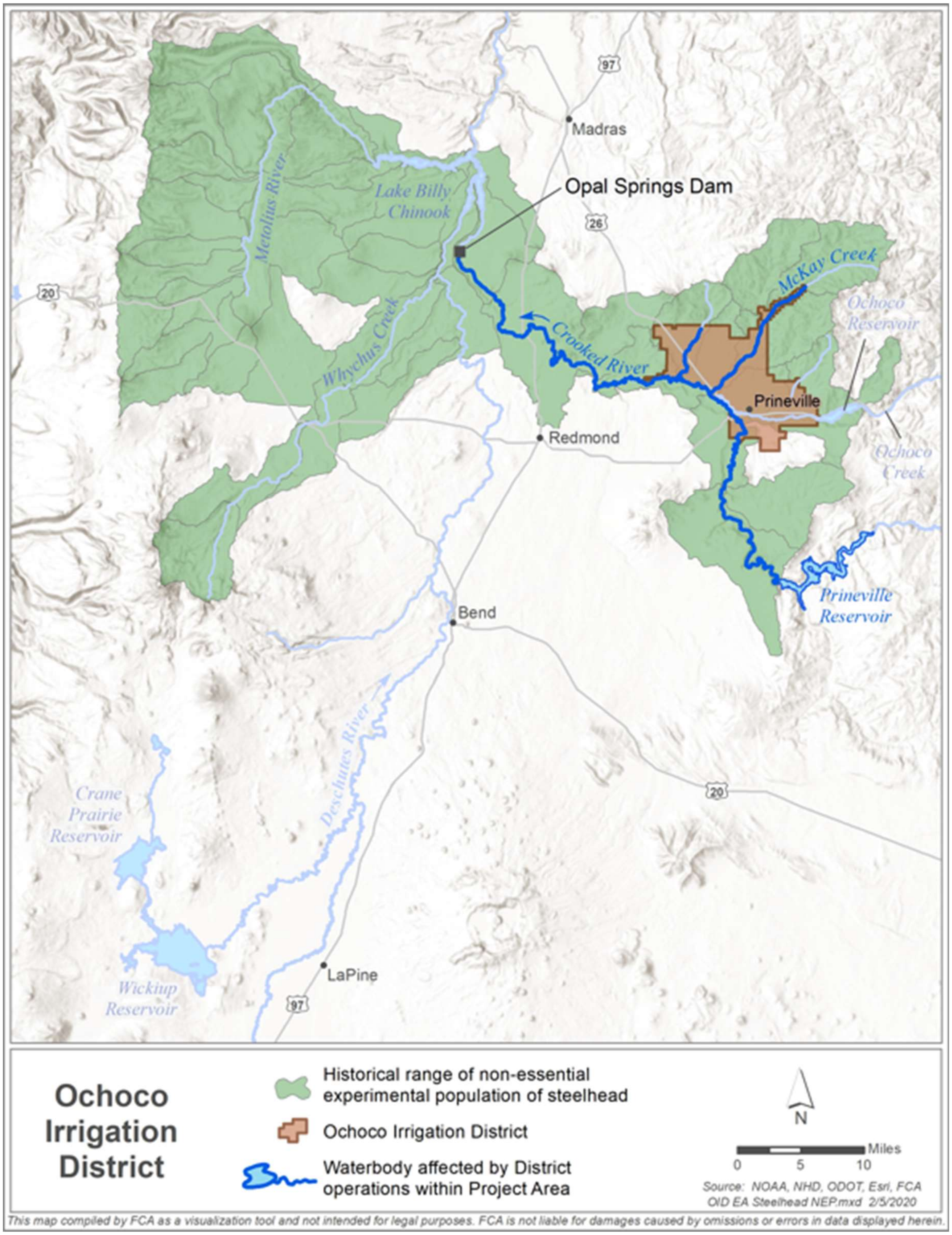
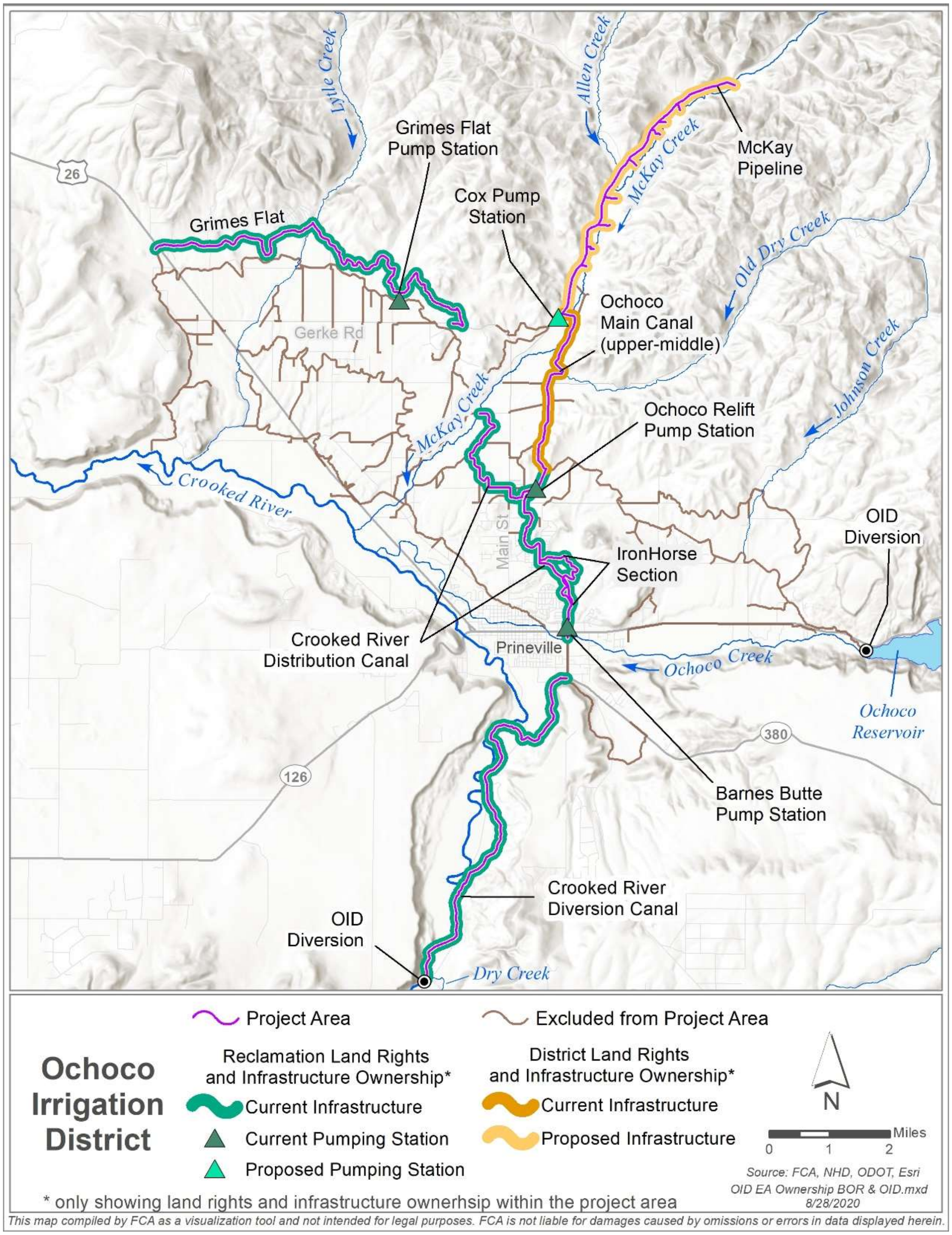


Figure C-5. Steelhead non-essential experimental population within and outside of area affected by District operations.



Note: Current pump station infrastructure including Barnes Butte Pump Station, Ochoco Relift Pump Station, and Grimes Flat Pump Station are owned by Reclamation and would be decommissioned following installation of proposed pump stations Crooked River Pump Station No. 1-3 (Figure B-1). Reclamation would also own and hold title to the new pump station installations.

Figure C-6. District and Reclamation land rights and infrastructure ownership within the project area.

Appendix D

Investigation and Analysis Report

D.1 National Economic Efficiency Analysis

Highland Economics LLC

National Economic Efficiency Analysis

Barbara Wyse and Winston Oakley
1/20/2020

1. Introduction

This section provides a National Economic Efficiency (NEE) analysis that evaluates the costs and benefits of the Modernization Alternative over the No Action Alternative for the Ochoco Irrigation District (OID) Infrastructure Modernization Project (herein referred to as 'Project'). The analysis uses Natural Resources Conservation Service (NRCS) guidelines for evaluating NEE benefits as outlined in the NRCS Natural Resources Economics Handbook and the U.S. Department of Agriculture's (USDA) Guidance for Conducting Analyses Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water Resource Investments (DM 9500-013).

All economic benefits and costs are provided in 2020 dollars and have been discounted and amortized to average annualized values using the fiscal year 2020 federal water resources planning rate of 2.75 percent. All values in this analysis are rounded to the nearest $1,000

2. Costs of the Modernization Alternative

This section evaluates the costs of the Modernization Alternative over the No Action Alternative. Under the No Action Alternative, the District would continue to operate and maintain the existing canal and lateral system in its current condition and configuration. However, in the No Action Alternative, the District's pumping stations are projected to be entirely replaced in project Year 10 (instead of in Years 0-2 in the Modernization Alternative). In the meantime, over the next 10 years, if the District pumping stations experience operational problems or failure, the District would repair the problem to the extent that funds are available. The installation of pumps under the No Action Alternative have been included as a benefit from avoided costs under the Modernization Alternative. See Section D.3.1.2 for further discussion.

2.1 Analysis Parameters

This section describes the general parameters of the analysis, including funding sources and interest rates, the evaluation unit, the project implementation timeline, the period of analysis, and the project purpose.

2.1.1 Funding

Public Law (PL) 83-566 funds would cover $23,061,000 or 75 percent of the project cost. OID would be required to fund $7,727,000 or 25 percent of the project. OID would cover their funding through a combination of sources including grants, partnerships, and loans. OID would pursue loan funding through the Oregon Department of Environmental Quality's Clean Water State Revolving Fund. OID expects that funding from this source would be at an interest rate of 2.5 percent with a 0.5 percent annual fee paid on the remaining loan balance. These financing costs are not included in the NEE analysis. All funding sources other than PL 83-566 are from non-federal funds.

2.1.2 Evaluation Unit

The proposed project is grouped into three project groups, each of which is defined as the evaluation unit. Each of the project groups could be completed as stand-alone projects and have a positive net benefit. All elements in each project group are required in order to produce the benefits from each project group (i.e., no elements should be separated into further sub-evaluation units for incremental analysis). Note that for the incremental analysis, costs for constructing any given project group would not change if it were the only project group to be constructed.

2.1.3 Project Implementation Timeline

Based on conversations with the District manager and staff, if PL 83-566 funds are made available, it is likely that construction would be completed over approximately three years. Project Group 1 is expected to begin construction in Year 0 and be completed in Year 2. Project Group 2 is expected to begin in Year 2 and finish the same year. Project Group 3 is expected to begin in Year 1 and be completed in the same year. The analysis assumes that full benefits would be realized the first year after construction is completed. Table summarizes the approximate construction timeline and the breakdown of funding for construction.

Table D-1. Construction Timeline and Installation Costs by Funding Source for the Modernization Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Construction Year	Works of Improvement	Public Law 83-566 Funds	Other, Non-Federal Funds	Total Construction Costs
0-2	Project Group 1	$10,454,000	$3,525,000	$13,979,000
2	Project Group 2	$8,507,000	$2,836,000	$11,343,000
1	Project Group 3	$4,100,000	$1,366,000	$5,466,000
Total Project		**$23,061,000**	**$7,727,000**	**$30,788,000**

1/ Price Base: 2020 dollars. Prepared August 2020

2.1.4 Analysis Period

The analysis period for each project group is defined as 101 to 103 years since the installation period is one to three years and 100 years is the expected project life of buried high-density polyethylene (HDPE) pipe. Construction and installation of Project Group 1 is assumed to occur from Year 0 to Year 2, with project life from Year 3 through Year 102. Project Group 2 would be constructed during Year 2 and have a project life from Year 3 to Year 102. Project Group 3 would be constructed in Year 1 and have a project life from Year 2 to Year 101.

2.1.5 Project Purpose

The purpose of this project, as identified in the Watershed Plan-EA, is to:

- Provide the ability for District infrastructure to convey and pump additional water to meet the needs of McKay Creek irrigators.
- Improve water delivery reliability to McKay Creek and Grimes Flat irrigators.
- Conserve water along the District-owned Grimes Flat laterals and IronHorse section of the Crooked River Distribution canal (herein referred to as IronHorse section).

The project is multipurpose, that is, it provides multiple benefits. Because no project cost items serve a single purpose separately, this analysis does not allocate costs or benefits by purpose.

2.2 Proposed Project Costs

Table 8-3 (NWPM 506.11, Economic Table 1) and Table 8-4 (NWPM 506.12, Economic Table 2) in Section 8 of the Plan-EA summarize installation costs, distribution of costs, and total annual average costs for the Modernization Alternative. Table D-2 summarizes the average annual costs of the Modernization Alternative over No Action Alternative. Table D-3 and Table D-4 present other direct costs associated with the Modernization Alternative.

Average annual costs of the Modernization Alternative include those associated with installation and other direct costs. There are four potential types of other direct costs: increased pumping costs from increased depth to groundwater due to reduced recharge from unlined canals, costs of increased District pumping, social costs of increased carbon emissions (from increased pumping energy use), and potential reduction in aesthetic values to area residents due to the removal of canals. Of these, groundwater recharge costs and aesthetic costs are qualitatively discussed but not quantified in this analysis due to a lack of available quantitative information and likely insignificant economic impacts. District pumping and carbon emissions act as either a cost or a benefit depending on whether they increase or decrease under the Modernization Alternative; this is further discussed in their respective sections. As OID expects cost savings, not cost increases, for infrastructure maintenance, repair, and replacement of the Modernization Alternative, these are included as benefits in this analysis (Scanlon, 2020).

2.2.1 Project Installation Costs

According to estimates by Black Rock Consulting, Inc., the cost of piping and associated turnouts, pump station installation, and improvements to OID's infrastructure is projected to be approximately $29,556,00. See Appendix D.4 for detailed cost derivation by pipe size, cost category, etc. All values in this analysis are presented in 2020-dollar values and rounded to the nearest $1,000. Adding three percent for project administration from OID and NRCS, $300,000 for technical assistance from NRCS, and $41,000 for permitting costs, the total cost for the Modernization Alternative is estimated at $30,788,000. The average annual cost of installation is $871,000 for the Modernization Alternative, as shown in Table D-2.

The Modernization Alternative would install a total of four pump stations, three of which would replace existing District pump stations and one would be a new pump station. The three existing pump stations would be decommissioned after being replaced. Two of the pump stations, Crooked River Pump Station (CRPS) No. 1 and CRPS No. 2, help transport water from the Crooked River to both Project Group 1 and Project Group 2. In fact, District infrastructure could not deliver Crooked River water to Project Group 2 without these two pumps. For this reason, the analysis apportions the costs of these two pumps among the project groups according to the proportion of water they deliver to each project group. In total, the pump stations move around 11,097 acre-feet of Crooked River water annually, of which 47 percent supports Project Group 1 and 53 percent supports Project Group 2 (Farmers Conservation Alliance, 2020). Accordingly, we apportion 47 percent of the installation costs to Project Group 1 and 53 percent of costs to Project Group 2. We also apportion the avoided operations, maintenance, and replacement (OMR) costs (discussed in Section 0 of the Plan-EA) of the replacement pump stations using this same percent allocation.

Table D-2. Estimated Average Annual Costs for Modernization Alternative Above No Action Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Project Outlays (Amortization of Installation Cost)	Other Direct Costs[2]	Total
Project Group 1	$398,000	$86,000	$484,000
Project Group 2	$316,000	$0	$316,000
Project Group 2	$157,000	$0	$157,000
Total	**$871,000**	**$86,000**	**$957,000**

Prepared August 2020

1/Price base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.
2/ Other direct costs include the uncompensated economic losses due to changes in resource use or associated with installation, operation, or replacement of project structures. Other direct costs are presented for increased pumping costs for the District (discussed in Section 0 of the NEE) and increased carbon emissions (discussed in Section 0 of the NEE). This does not include operations, maintenance, and repair costs because these decline under the Modernization Alternative, so these are presented as a benefit.

2.2.2 Other Direct Costs

2.2.2.1 Groundwater Recharge Costs

Water seepage from canals is one source of recharge for groundwater in the Deschutes Basin. Reduced recharge from canals may lead to groundwater declines, and thereby increase pumping costs for all groundwater users in the basin. A 2013 study by the U.S. Geological Survey estimated the effects of changes in climate (reduced precipitation), groundwater pumping, and canal lining and piping on Central Deschutes Basin groundwater recharge (Gannett & Lite, 2013). The U.S. Geological Service estimated that since the mid-1990s, groundwater levels have dropped by approximately 5 to 14 feet in the central part of the Deschutes Basin[1], with approximately 10 percent of this decline (0.5 to 1.4 feet) in groundwater level due to canal lining and piping during this period. The cumulative effect of piping over the 12-year study period (1997 to 2008) was 58,000 acre-feet of reduced recharge annually by 2008.[2] The Modernization Alternative would reduce canal seepage and other conveyance inefficiencies, and associated groundwater recharge, by up to approximately 2,513 acre-feet annually in this part of the Deschutes Basin. However, the additional water being delivered to McKay irrigators would increase seepage loss during conveyance by an estimated 210 acre-feet of water annually in the open canals and laterals. Once the project is completed, a net 2,303 acre-feet of groundwater recharge would be reduced. Given the relatively small change in groundwater elevations estimated in other parts of the basin from the 58,000 acre-feet of reduced recharge annually, we expect very minor changes in local groundwater elevations and associated groundwater pumping costs in the region due to the Modernization Alternative and the associated reduced recharge of 2,303 acre-feet annually.

2.2.2.2 District Pumping Costs

Two factors are expected to increase the District's demand for energy under the Modernization Alternative. First, new pumps would be installed along the McKay Pipeline, increasing energy demand. Second, some

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[1] The portion of the basin that extends north from near Benham Falls to Lower Bridge, and east from Sisters to the community of Powell Butte.

[2] Assuming a uniform increase in canal lining/piping over this timeframe, in 1997 the decreased canal seepage was 4,833 acre-feet, rising each year by another 4,833 acre-feet until the reduced canal seepage in 2008 was 58,000 acre-feet. Cumulatively, this represents 377,000 acre-feet of reduced recharge from canals during this period.

existing District pumps in Project Group 1 are expected to increase their horsepower under the Modernization Alternative, thereby also increasing energy demand. However, the pump station in Project Group 2 (CRPS No. 3) is expected to decrease its energy demand, acting as a cost-saving benefit of the project. In total, the annual electricity demand for District pumping in Project Group 1 is expected to increase by 5,138,171 kWh under the Modernization Alternative, while annual demand in Project Group 2 is expected to decrease by 88,589 kWh.[3]

The District receives its power under an agreement with the U.S. Bureau of Reclamation and pays $0.01255 per kWh under a 2019 supplemental power rate for all electricity use exceeding 5,000,000 kWh per year (U.S. Bureau of Reclamation, 2019).[4] At this rate, the District would pay an additional $64,000 for pumping energy to supply Project Group 1 under the Modernization Alternative, while Project Group 2 would see a savings of roughly $1,000 (as shown in Table D-3). Project Group 1's cost increase is included as an "Other Direct Cost" in Table D-2. Project Group 2's energy savings is included as a benefit under "Pumping Cost Savings" in Table D-5.

Table D-3. District Energy Cost Changes under Modernization Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	District Energy Changes Under Modernization Alternative (kWh)	Undiscounted Annual Energy Cost Changes	Discounted Average Annual Change in Energy Costs[1]
Project Group 1	5,138,171	$64,000	$61,000
Project Group 2	-88,589	-$1,000	-$1,000
Project Group 3	0	$0	$0
Total	**5,049,582**	**$63,000**	**$60,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

2.2.2.3 Carbon Costs

Changes in energy use are expected to result in changes in carbon dioxide emissions from power generation. Every MWh change of energy use is estimated to translate into a change of 0.7521 metric tons (Mt) of carbon emissions.[5] The Modernization Alternative would decrease some carbon emissions (from reducing some pumping energy use by District patrons and a District pump station) and increase other emissions (by increasing some District pump station energy use). Compared to the No Action Alternative, under the Modernization Alternative, the on-farm annual energy savings (described in Section 0 in the Plan-EA) would reduce CO_2 emissions by approximately 392 Mt (approximately 521 MWh multiplied by 0.7521). District

3 Analysis conducted by FCA and Kevin Crew of Black Rock Consulting.

4 Because OID uses roughly 10.5 million kWh per year, the additional electricity demanded by the District would fall under the supplement power rate (U.S. Bureau of Reclamation, 2019).

5 This assumes that marginal changes in energy demand are met with fossil fuel-based production (renewable energy is typically used first, and then fossil fuel powered generation is used), such that 100 percent of energy use reduction and green energy production result in reduced fossil fuel powered generation. Furthermore, this estimate assumes 0.7521 metric tons of carbon emitted from one MWh of fossil fuel powered electricity generation based on 1) the current proportion of fuel sources–oil, natural gas, and coal–for fossil fuel powered electrical power generation in the West, and 2) the associated metric tons of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

pumping in Project Group 1 would increase emissions by 3,867 Mt per year, while reduced District pumping in Project Group 2 would reduce emissions by 67 Mt per year. No change in emissions would be expected in Project Group 3 from reduced District pumping. In sum, when combined with changes in patron energy use, there would be a net average annual increase of 3,408 Mt of emissions (see Table D-4).

To value the reduced carbon emissions, this analysis uses an estimate of the social cost of carbon (SCC). The SCC represents the estimated total cost to society of emitting carbon, based on the expected economic damages of future climate change. There are many estimates of the SCC, and the estimates vary based on what types of damages are included, the discount rate chosen, the geographic area under consideration (such as global damages versus U.S. domestic damages), and the projected level of global warming and associated damages. SCC damage values used by federal agencies have varied over the years. At first, federal agencies developed and applied their own estimates. Then, the Office of Management and Budget convened an Interagency Working Group (IWG) on the Social Costs of Greenhouse Gases, which developed a set of SCC estimates that could be used across federal agencies. In the year 2020, the IWG estimate for SCC was estimated to be approximately $52.28 per Mt (2020 dollars) (Interagency Working Group on Social Cost of Greenhouse Gases, 2013).[6] However, in 2017, Executive Order 13783 disbanded the IWG, indicated that IWG estimates were not representative of government policy, and removed the requirement for a harmonized federal policy for SCC estimates in regulatory analysis.

Since this time, the Environmental Protection Agency (EPA) and other federal agencies have developed interim alternative estimates of the SCC, largely relying on the methodology used by the IWG, but using different discount rates and focusing on direct damages projected to occur within the borders of the United States. For example, the EPA developed interim SCC values for the *Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units* published in June of 2019 (Environmental Protection Agency, 2019). As these interim EPA SCC estimates are indicative of current federal agency policy on SCC applications for federal cost benefit analysis, they are employed in this analysis. This analysis uses the EPA interim value of the SCC for 2020, based on a 3 percent discount rate, which is $7 per metric ton of carbon. We apply this value to the net change in carbon emissions each year throughout the project life to estimate the change in carbon emissions from the Modernization Alternative.

As Table D-4 below shows, there is a net increase in carbon emissions in Project Group 1, resulting in an annualized cost of $25,000. This cost is included as an “Other Direct Cost” in Table D-2 above. Project Group 2 has a net decrease in carbon emissions, representing an annualized benefit of $2,000. This benefit is included under “Carbon Emissions” in Table D-5. There is no cost or benefit associated with Project Group 3. Overall, the Modernization Alternative increases carbon emission for a net annualized cost of $23,000.

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[6] We adjusted the original cost of $42 in 2007 dollars to 2020 dollars using the Consumer Price Index.

Table D-4. Annual Change in Carbon Costs of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Annual Avoided Emissions from Reduced OID Patron Energy Use (Mt Carbon)	Annual Emissions Change from OID Pump Station Changes (Mt Carbon)	Annual Net Change in Emissions	Average Annual NEE Carbon Cost Change (Social Cost of Carbon)
Project Group 1	144	3,867	3,723	$25,000
Project Group 2	210	-67	-277	-$2,000
Project Group 3	38	0	-38	$0
Total	**392**	**3,800**	**3,408**	**$23,000**

Prepared August 2020

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

2.2.2.4 Change in Aesthetics and Associated Property/Recreation Values

The project is located in a mix of rural and urban areas. A potential direct cost is that some local residents may experience adverse effects on property values and quality of life due to the change in aesthetics from piping the canals (as some people enjoy the aesthetics of the open canals). According to real estate agents in the region, many people interested in purchasing property in the area are willing to pay more for properties that have a view of a canal. On the other hand, some property owners or potential property owners may not want to have a canal adjacent to their property because of the safety hazard an open canal poses, potentially limiting the effect on property values. Some OID patrons and community members have expressed concerns regarding the safety risk posed by open canals (Scanlon, 2020).

The potential aesthetic cost to residential landowners is not quantified due to a lack of available data. Interviewed real estate agents were not able to quantify the potential effect of a view of the canal. Furthermore, quantification is difficult due to scarce information in the economic literature. While the economic value of many natural views has been studied (such as for ocean front property, or other scenic natural areas), the value of irrigation canals has been studied little, if at all. As such, while this effect is recognized as a likely cost, this analysis does not quantify the potential change in aesthetic values of the proposed project. Regarding recreational effects, there are recreational opportunities in the area of Project Group 3 (but not the other project groups). As piping the District canal in Project Group 3 would increase access to these recreational opportunities from residential areas (the lack of bridges over the open canal currently increases the distance that residents have to travel to access the recreation areas), we expect that Project Group 3 would increase recreational values, although the effect is not quantified due to the lack of quantitative information on recreational usage in or adjacent to the project area.

3. Benefits of the Modernization Alternative

Table D-5 compares the project benefits (over the No Action Alternative) to the annual average project costs presented in Table D-2. The remainder of this section provides details on these project benefits. Table D-5 presents on-site damage reduction benefits that would accrue to agriculture and the local rural community, including increased agricultural yields and associated net income; reduced pumping costs; and reduced operations, maintenance, and replacement (OMR) costs. It also presents off-site quantified benefits, which consist of the value of enhanced fish and wildlife habitat, reduced carbon emissions (where there are emission reductions), savings on transportation infrastructure, and increased land values. Another benefit not included in the analysis, but which may result indirectly from the Modernization Alternative, is the potential for increased on-farm investments in irrigation efficiency (as patrons have more funds due to increased yields and reduced pumping costs).

The analysis recognizes that instream flows may affect recreation, both in-river and adjacent land-based recreation. However, aside from potential positive impacts to fish and wildlife-related recreation (both fishing and wildlife viewing) from improved species populations and improved access to recreation areas in Project Group 3 as noted above, it is not clear how recreation may be affected. As such, this analysis assumes no net impact to recreation.

Table D-5. Comparison of Average Annual NEE Benefits and Costs of the Modernization Alternative Compared to No Action Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Agriculture-Related			Non-Agricultural				Average Annual Benefits	Average Annual Cost [2]	Benefit–Cost Ratio
	Damage Reduction	Reduced OMR	Pumping Cost Savings	Carbon Emissions	Instream Flow Value	Transportation Infrastructure Savings	Increased Land Values			
Project Group 1	$207,000	$153,000	$21,000	$0	$144,000	$0	$0	$525,000	$484,000	1.1
Project Group 2	$4,000	$185,000	$25,000	$2,000	$115,000	$0	$0	$331,000	$316,000	1.0
Project Group 3	$0	$65,000	$4,000	$0	$32,000	$166,000	$8,000	$275,000	$157,000	1.8
Total	**$211,000**	**$403,000**	**$50,000**	**$2,000**	**$291,000**	**$166,000**	**$8,000**	**$1,131,000**	**$957,000**	**1.2**

Notes: Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

2/From Table D-2.

3/Values may not sum due to rounding.

3.1 Benefits Included in Analysis

3.1.1 Agricultural Damage Reduction Benefit

The Modernization Alternative would reduce agricultural damage in two ways: 1) it would provide a more reliable source of water to irrigators on McKay Creek, increasing their yields by avoiding damages from water shortages, and 2) it could avoid the loss of agricultural production that would occur if one of the District's current pump stations were to fail, causing a water shortage to agriculture in the District. We examine both potential benefits of agricultural reduction in this section, beginning with those to McKay growers.

The Modernization Alternative (Project Group 1) would implement the McKay Switch Project, which would increase water supply reliability and reduce agricultural damages to irrigators on McKay Creek. Currently, irrigators on McKay Creek begin drawing water from the creek in early April. Around mid-July, the creek runs dry and the irrigators have no other means of watering their crops for the rest of the season. This allows hay growers in the area to get only one cutting of alfalfa, on average, while a full irrigation season would allow growers to get up to three cuttings per year (Scanlon, 2020).

The McKay Switch Project (under the Modernization Alternative) would add District infrastructure that would deliver an alternative source of water to McKay Creek irrigators. This new infrastructure would allow these growers, who manage 686 acres of irrigated lands, to switch their source of water from McKay Creek to Prineville Reservoir storage. The stored water would provide water for the full growing season and allow the growers to avoid the agricultural damage associated with water shortages (Scanlon, 2020).

Almost all irrigators in the McKay Creek area grow hay crops (Scanlon, 2020). Accordingly, to estimate the benefits of these avoided damages, we adjusted an existing crop enterprise budget for alfalfa developed by Washington State University in 2012 (Norberg & Neibergs, 2012). We developed one budget for alfalfa under full irrigation (yield of 5.5 tons per acre) and one budget for alfalfa under a water shortage scenario with only one hay cutting (yield of 2.5 tons per acre). These budgets are shown in detail in Appendix 1. Using these crop budgets, we estimate that alfalfa provides average net returns of $231 per acre under full irrigation and -$82 per acre under deficit irrigation.[7] As such, the avoided damage (i.e., net benefit) of having full irrigation is approximately $313 per acre.

To estimate the reduction in agricultural damages in the McKay Creek area, we apply the net reduced agricultural damage benefit per acre ($313) to all 686 acres on McKay Creek that would receive water under the Modernization Alternative. In total, the McKay Switch Project is expected to yield net benefits of $214,000 per year (before discounting). These benefits all accrue to Project Group 1, which includes the McKay Creek Switch Project.

The other way the Modernization Alternative could avoid agricultural damages is by preventing a pump failure that results in water shortages. As described in the next section (0), the District's pumps are well past their useful life and are at significant risk of failing prior to their projected replacement in Year 10 under the No Action Alternative. District engineers and managers estimate that each year prior to replacement there is a

7 The net returns under deficit irrigation are negative, implying that growers would not grow alfalfa under these economic conditions. However, despite using the best available information, this may be because fixed costs to growers are lower than modeled. For example, land costs are modeled at the average rental rate for irrigated cropland in Oregon, which is likely to be higher than the rate for hay acres in the McKay Creek area because the average includes acres that grow high-value crops. The fixed costs do not affect the benefits of the Project, as this is based on the difference between deficit irrigation of hay and full irrigation of hay (and fixed costs are nearly the same in both scenarios).

10 percent chance a pump will fail (Crew, 2020; Scanlon, 2020). If a pump were to fail, it would reduce water deliveries to Project Groups 1 and 2 by 40 cubic feet per second (cfs) until replacement parts could be procured. Because the parts would have to be custom manufactured, the failed pump would be in inoperable for the remainder of the irrigation season as a complete repair would likely take up to a year (Crew, 2020; Scanlon, 2020). We assume that it is equally likely for a pump to fail at any point during the irrigation season; as such, we assume that it fails at the mid-point of the 26-week irrigation season and that there are 13 weeks of the irrigation season when the pump is inoperable.

During the outage, the District would likely convert to a different water source and draw additional stored water from the Ochoco Reservoir in order to replace the Crooked River water that would have been available from the pump (Scanlon, 2020). At 40 cfs over 13 weeks, the volume of stored water needed to make up for the shortage would be 7,220 acre-feet. As long as the Ochoco Reservoir contained this amount of water during the pump outage, there would be no water shortage for growers in the season when the pump failed (which we assume is the case in this analysis). However, drawing down the Ochoco Reservoir would significantly increase the risk of a water shortage in the year following the pump failure. The Ochoco Reservoir only fills to capacity 50 to 60 percent of years; the remainder of years leave the District short of their full allocation of water (Scanlon, 2020). Accordingly, we assume, on average, there is a 45 percent chance a pump failure would result in a water shortage in the District equal to the amount lost during the pump outage (7,220 acre-feet) in the year following a pump failure.

A 7,220-acre-foot shortage would represent an approximate 13 percent reduction in the District's total water use.[8] Since most of the District grows hay, the consequence of the water shortage is likely to be reduced hay yields. Since the relationship between water applications and hay is roughly linear (Bohle, 2020), we assume the shortage would cause a 13 percent reduction in hay yields. To estimate the value of this reduction, we created a crop budget (detailed in NEE Appendix 1) that models the net returns to hay with a yield that is 13 percent lower than with full irrigation. This method indicates that a 13 percent yield reduction would lower the net returns per hay acre from $231 to $187, a loss of $44 per acre. When applied to the roughly 90 percent of the District's acres that grow hay and considering the annual risk of pump failure (10 percent) and the Ochoco Reservoir not filling (45 percent), the annual risk of pump failure to hay net revenues is around $43,000. As described in Section 0, we apportion these benefit of avoiding this risk to Project Group 1 and 2 according to the amount of water served by the pumps (47 percent to Project Group 1 and 53 percent to Project Group 2). Since the District anticipates replacing the pumps in Year 10 under the No Action Alternative, we assume these benefits accrue through Year 10.

Table D-6 summarizes the benefits of avoiding agricultural damage under the Modernization Alternative, including the benefits to McKay Creek growers (Project Group 1) and the benefits of avoiding a pump failure (Project Groups 1 and 2). When discounted and annualized, the avoided damage to agriculture is expected to bring average annual benefits of $211,000 under the Modernization Alternative (as shown below).

8 Assuming the District's 20,062 irrigated acres use, on average, 2.8 acre-feet per acre each year.

Table D-6. Reduced Agricultural Damages Under the Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Acres Benefitting from Increased Yield	Undiscounted Annual Benefit of Increased Yield in McKay Creek	Undiscounted Annual Benefit of Reduced Yield Losses Due to Pump Failure	Annualized Average Net Benefits of Modernization Alternative
Project Group 1	686	$214,000	$20,000	$207,000
Project Group 2	0	$0	$23,000	$4,000
Project Group 3	0	$0	$0	$0
Total	**686**	**$214,000**	**$43,000**	**$211,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.2 District OMR Cost Savings Benefit

Under the Modernization Alternative, the District would experience OMR savings from two primary sources: Avoided canal maintenance costs and avoided pump OMR. This section explores these two benefits separately, beginning with the avoided canal O&M costs.

The District's canal O&M costs arise from transportation and labor costs to inspect the canals, conduct weed treatments, and excavate the canals. These costs occur in Project Groups 2 and 3, but not Project Group 1 since McKay Creek (which comprises Project Group 1) is not currently part of the District. There may be canal O&M costs to McKay Creek growers, and to the extent that there are, this analysis would underestimate the benefits of the Modernization Alternative. In Project Group 2, inspecting the canals require about 45 minutes of labor and 8 miles of driving every day during the irrigation season (which averages 190 days per year) (Scanlon, 2020). Project Group 3 requires about 1 hour of labor and 3 miles of driving each day for inspections every day of the irrigation season (Scanlon, 2020). With labor costing the District $20 per hour (including payroll taxes and wages), and valuing the vehicular costs at $0.575 per mile,[9] the annual cost of inspecting the canals totals approximately $3,700 for Project Group 2 and $4,300 for Project Group 3.

Regarding weed control costs, the District estimates it would save roughly $10,000 per year in Project Group 2 and $30,000 per year in Project Group 3 as a result of the Modernization Alternative. In addition, both project groups require 8 hours of excavation about every 3 years to maintain the canals, and renting the excavator costs $150 per hour (Scanlon, 2020). At these rates, the annual average cost of excavating the canals is roughly $1,200 per project group.

Additionally, under the No Action Alternative, Project Group 3 would require a fence be built for public safety. The project group is located in a suburban area where housing developments are expanding, and the canal in this project group runs adjacent to an elementary school. The associated public safety concerns are expected to result in the District installing fencing along the canal, which it expects would occur around Year 5 at a quoted cost of $50 per foot (Scanlon, 2020). Project Group 3 is approximately 1.2 miles long, which would result in total fencing costs of $312,500. After discounting and annualizing, the cost to install fencing is roughly $7,500 per year in present-value terms.

[9] This is the 2020 Internal Revenue Service standard mileage rate for travel (Internal Revenue Service, 2020).

As shown in Table D-7, the annualized avoided costs of canal O&M under the Modernization Alternative would be roughly $14,000 for Project Group 2 and $43,000 for Project Group 3, for a total annualized O&M savings of $57,000 per year.

Table D-7. Annual Reduced Canal O&M Costs to OID of Modernization Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Undiscounted Annual O&M Savings	Undiscounted Avoided Cost of Fencing [2]	Discounted Annualized O&M Cost-Saving Benefit
Project Group 1	$0	$0	$0
Project Group 2	$15,000	$0	$14,000
Project Group 3	$36,000	$312,500	$43,000
Total	**$51,000**	**$312,500**	**$57,000**

Prepared August 2020

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.
2/ A one-time cost assumed to occur in Year 5.

Under the No Action Alternative, the District would need to replace three existing pump stations (CRPS No.1, CRPS No.2, and CRPS No.3, as previously discussed in Section 0). These pumps lift water from the Crooked River to Project Groups 1 and 2, a function that would continue under both the Modernization and No Action Alternatives. The District's pump stations CRPS No.1 and No.2 are at least 55 years old and well past their expected useful life (Crew, 2020). Currently, the District lacks the available funding to replace the pumps and is only able to conduct the minimum level of maintenance to keeping the pumps functioning (Crew, 2020; Scanlon, 2020). This situation makes it very possible the pumps could fail prior to replacement under the No Action scenario, which is expected to occur around Year 10 as long as the pumps do not fail prior to that (Scanlon, 2020). The cost of replacing the pump stations is assumed to be the same under both scenarios: $11,950,000 (2020 dollars), as the type of pump and use of the pump (to pump water from the Crooked River) is the same under all Alternatives.

The pumps have a useful life of about 50 years given proper maintenance, which means they would need to be replaced more than once during the project life (Crew, 2020). In this way, the Modernization and No Action Alternatives would incur the same replacement costs at different times, which, due to discounting, would cause the costs to have different present values. Similarly, the O&M costs, which tend to increase during the life of the pumps (as further explained below), would be similar between the two alternatives but occur at different times, which would also have different present values. The avoided pump OMR costs of the No Action Alternative (in present value terms) are benefits of the Modernization Alternative.

Under the Modernization Alternative, the cost of replacing the pumps is included in the project installation costs, and additional costs are incurred associated with project administration, technical assistance, and permitting costs, as described above, and are included in Table and Table D-2. These additional costs are assumed to not be incurred under the No Action Alternative.[10] This analysis assumes installation costs of

[10] Permitting costs in the case of the Modernization Alternative are associated with permitting cost above general construction costs, such as potentially special in-water work that would need to occur with the Crooked River Diversion weir raise. Because this work would not occur under the No Action Alternative, special permitting costs are not applicable.

pumps under No Action Alternative would occur in Year 10 and in Year 61, while, under the Modernization Alternative, replacement would occur in Year 51 and Year 102 (assuming replacement after 50 operating years).

The lifetime O&M costs of the pump are estimated to total 30 to 40 percent of the costs of initial installation (Crew, 2020). Given the initial installation costs of the pumps is estimated to be $11.9 million, the lifetime O&M costs are projected to be $3.59 - $4.78 million. We assume the average of this range: $4.18 million. In the years immediately following replacement, O&M costs are expected to be at least $3,500 per year and rise in approximately an exponential pattern afterwards, with the total over the 50-year period summing to $4.18 million (Crew, 2020). Accordingly, we model the O&M costs using the timeline in Figure D-1 below, with the highest costs being incurred near the end of the pumps' life. The total costs over the pumps' life ($4.18 million) is represented by the area below the curve.

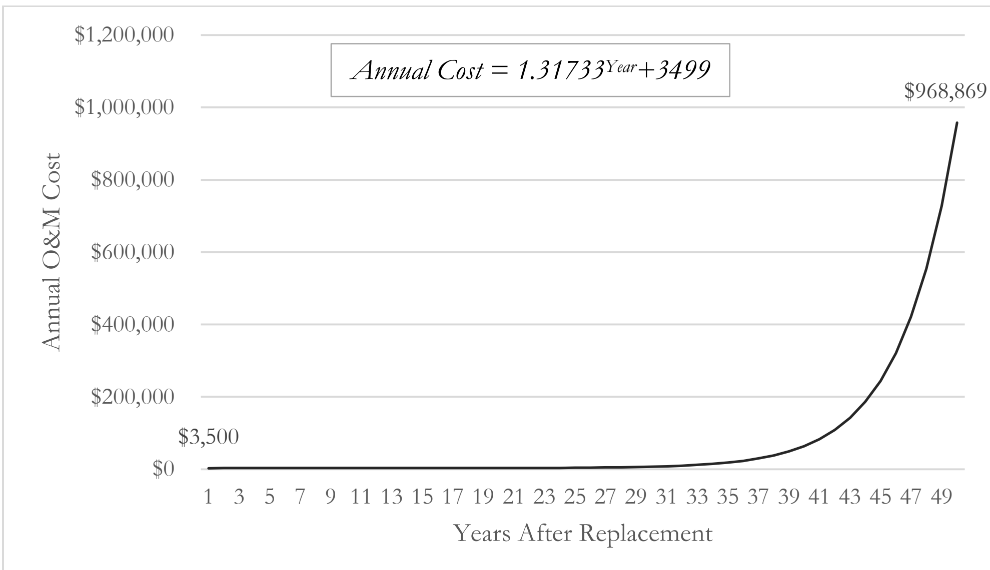

Figure D-1: Annual pump O&M costs for Crooked River Pump Stations 1, 2, and 3.

As the pumps are assumed to be the same, we assume the same costs for each year of pump life in all Alternatives. However, because pump replacement would occur in different years under the No Action Alternative and Modernization Alternative, the cost curve above would occur at different times. Specifically, the cost curve under the No Action Alternative would be 7 years behind the Modernization Alternative (since the pumps would be replaced in Year 3 under the Modernization Alternative and Year 10 under the No Action Alternative). The OMR savings resulting from the Modernization Alternative is represented by the difference between the costs under the two scenarios for any given year. For example, in Year 3, the pump OMR costs under the Modernization Alternative would be $3,500 and $188,226 under the No Action Alternative, resulting in a savings of $184,726 for that year. In total, including both the replacement cost of the pumps under No Action and the lifetime reduced O&M costs of replacing the pumps earlier under the Modernization Alternative, the undiscounted savings during the life of the project is a net benefit of $11,807,000.[11] As described in Section 0, we apportion the benefit of avoided OMR costs according to the proportion of water served to each project group: 47 percent to Project Group 1 and 53 percent to Project

[11] This includes some years where the OMR costs under the Modernization Alternative exceed the OMR costs under the No Action Alternative (i.e., a net cost of the proposed project for those years).

Group 2. As Table D-8 shows, after discounting and amortizing, the estimated benefits of reducing the lifetime OMR costs of the pumps (through replacing the costly-to-maintain existing, old pumps more rapidly) are roughly $324,000 annualized.

Table D-8. Annual Reduced Pump OMR Costs to OID of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$[1]

Works of Improvement	Apportioned Undiscounted Total OMR Cost Savings (Relative to No Action)	Total Annualized Pump OMR Savings
Project Group 1	$5,575,000	$153,000
Project Group 2	$6,232,000	$171,000
Project Group 3	$0	$0
Total	**$11,807,000**	**$324,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.3 Patron Irrigation Pumping Cost Savings

OID patrons in Project Groups 1, 2, and 3 currently use an estimated 1,377,814 kWh annually to power irrigation pumps (Farmers Conservation Alliance, 2020). System improvements associated with the Modernization Alternative would result in an estimated net energy savings of 520,751 kWh per year, since it is much more efficient for patrons to receive pressurized water than to pressurize it themselves.[12] This energy cost savings is evaluated using Pacific Power's Schedule 41 rate for irrigation pumping: $0.0913 per kWh (Black Rock Consulting, 2017). Table D-9 presents the energy use and cost savings to OID patrons under the Modernization Alternative. After the project is complete, the average annual NEE savings to OID patrons would be approximately $45,000 each year.

Table D-9. Annual Average Energy Cost Savings to OID Patrons of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Annual Energy Use Under No Action Alternative (kWh)	Annual Energy Use Under Modernization Alternative (kWh)	Reduced Annual Energy Use (kWh)[2]	Undiscounted Annual Energy Cost Savings	Average Annual Discounted NEE Benefits (Avoided Energy Costs)
Project Group 1	212,466	21,197	191,269	$17,000	$17,000
Project Group 2	842,906	563,974	278,932	$25,000	$24,000
Project Group 3	322,442	271,892	50,550	$5,000	$4,000
Total	**1,377,814**	**857,063**	**520,751**	**$47,000**	**$45,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.
2/As estimated by FCA (Farmers Conservation Alliance, 2020).

12 This is a based on an FCA analysis of OID data on energy savings.

The Modernization Alternative would provide pressurization to some irrigators on McKay Creek (Project Group 1), which would eliminate the need for these patrons to maintain irrigation pumps. Of the estimated 15 pumps being used by McKay Creek irrigators, eight are projected to be eliminated as a result of the Modernization Alternative. Pumps incur annual maintenance costs, service charges from power providers, and require replacement at the end of their useful life. Avoiding these costs would represent a benefit to District patrons.

Under Schedule 41, Pacific Power charges $90 to supply an electrical connection for a three-phase pump (Pacific Power, 2014). We use an average pump size of 10 horsepower (hp), requiring a 7.5-kW power connection. A 10-hp pump typically costs roughly $550 in repairs every four years, for an average annual maintenance cost of $138 (Mark, 2019; Scarborough, 2019). A 10-hp pump typically has a 10-year useful life and costs approximately $3,000 (Haun, 2019; Fey, 2019). Amortizing these replacement costs results in an annualized replacement cost of $347. Summing the service charges, maintenance costs, and annualized replacement costs results in a total estimated annual cost of $575 to own and operate an irrigation pump. This analysis uses $575 as the annual benefit of each pump eliminated in the study area as a result of the Modernization Alternative. Table D-10 outlines these cost-saving benefits. When discounted and amortized, District patrons would save roughly $4,000 per year on pump OMR costs (excluding energy, which is separately estimated in Table D-9).

Table D-10. Annual Pump OMR Cost Savings to OID Patrons of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Patrons Pumps Eliminated through Piping	Undiscounted Annual Patron Pump OMR Savings	Average Annual Benefit of OMR Cost Savings
Project Group 1	8	$5,000	$4,000
Project Group 2	0	$0	$0
Project Group 3	0	$0	$0
Total	**8**	**$5,000**	**$4,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.4 Avoided Transportation Infrastructure Costs

The Modernization Alternative Project Group 3 allows the City of Prineville to avoid transportation infrastructure costs. Under the No Action Alternative, the City of Prineville would have to build multiple bridges over the District's canal in Project Group 3 in order to connect expanding suburban development (Brooks Resources Development, 2017). The City would likely build two bridges around Year 3 and at least three more bridges around Year 7, with each bridge costing approximately $1.3 million (Hannas, 2020). At this rate, the total (undiscounted) cost for the five bridges would be approximately $6.5 million.

Under the Modernization Alternative, the canal in Project Group 3 would be piped, eliminating the need to build these bridges and avoiding the additional cost to the City. As shown in Table D-11, when discounted and annualized, the benefit of avoiding the transportation infrastructure costs is estimated at $166,000 annually.

Table D-11. Transportation Infrastructure Savings of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Number of Bridges Built in Each Project Group	Undiscounted Transportation Infrastructure Costs	Total Annualized Transportation Infrastructure Savings
Project Group 1	0	$0	$0
Project Group 2	0	$0	$0
Project Group 3	5	$6,500,000	$166,000
Total	**5**	**$6,500,000**	**$166,000**

Prepared August 2020

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.5 Avoided Cost of Canal Failure

The District experiences canal failures in roughly one out of every three years in areas with fine sand soils (Scanlon, 2020). Earthen canals lined by fine sand are especially vulnerable to failure, and comprise about 17.2 miles of the District's canals, which includes the 1.1 miles of canal in Project Group 3 (Farmers Conservation Alliance, 2020). Assuming the probability of canal failure is equal across all 17.2 high-risk miles of canal, Project Group 3 has a 2.3 percent chance of a canal failure in any given year.[13] The economic consequences of a canal failure include the costs to clean up and repair the breach, and the associated property damage that results from flooding the area surrounding the breach. In Project Group 3, the Modernization Alternative would avoid the economic losses associated with canal failure by piping the canals, and thereby provide an economic benefit.

The costs to clean up and repair a canal breach vary widely but a conservative estimate is $10,000 per incident (Scanlon, 2020). The costs of property damage also vary widely but are generally higher when failures occur near more developed areas with built infrastructure, such as housing developments, which is the situation surrounding the canal in Project Group 3. A canal breach in this area could cause flood damage to homes and/or public buildings, including the adjacent elementary school.

To estimate the value of these potential damages, we assume they are the same as the costs of a canal breach in Central Oregon Irrigation District (COID), which occurred in similar circumstances to those in Project Group 3 (i.e., canal flow levels, proximity to development, type of development, and likely timing of response are all similar). The breach occurred on COID's Pilot Butte Canal in November 2005 during a time when the flow in the canal was comparable to the typical flow in Project Group 3 (roughly 140 cfs) (Scanlon, 2020). The subsequent flooding damaged five homes and resulted in a liability claim of $650,000 (2005 dollars) against COID (Scanlon, 2020). Adjusting these costs for inflation to 2020 dollars, similar damages in 2020 would cost around $972,000 to repair.[14] Because of the similarity of the situation to Project Group 3, we adopt this value as the potential damage to property from a canal failure in Project Group 3. Adding in the approximately $10,000 per incident costs to clean up and repair the canal itself (described above), total costs are estimated at approximately $982,000 per incident. To adjust this to an annual risk value, we multiply it by the estimated likelihood a canal failure would happen in Project Group 3 (2.3 percent), resulting in a value of

[13] This is calculated as 1.2 miles divided by 17.2 miles, multiplied by a 33% annual chance of failure.

[14] These costs were adjusted using the U.S. Bureau of Reclamation's Construction Cost Trends index (Bureau of Reclamation, 2020).

about $21,000. In total, the annual risk of clean up and property damage costs due to a canal failure are about $23,000. When discounted and annualized, the benefit of avoiding these costs under the Modernization Alternative is estimated at $22,000 annually (Table D-12).

Table D-12. Avoided Costs of Canal Failure Under the Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$ [1]

Works of Improvement	Undiscounted Annual Canal Failure Savings	Discounted Annualized Canal Failure Cost-Saving Benefit
Project Group 1	$0	$0
Project Group 2	$0	$0
Project Group 3	$23,000	$22,000
Total	**$23,000**	**$22,000**

Prepared August 2020

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.6 Increased Land Value

Piping under the Modernization Alternative would allow currently undevelopable lands immediately proximate to the canal to be developed, thereby increasing the land's value. Currently in Project Group 3, the District's canal prevents roughly 35.7 acres from being developed (Hannas, 2020). This is in a suburban area with active residential development occurring nearby. Under the Modernization Alternative, the canal in Project Group 3 would be piped, which would allow the 35.7 acres to be developed into approximately 143 single family home lots (Hannas, 2020).

To estimate the economic value of making this development possible, we take the approximate sale value of each lot and subtract the costs to make it developable, to estimate the net value of the raw land. The estimated cost to develop each lot is approximately $53,100, which includes utility hook-ups, fees, permits, and other miscellaneous costs (Hannas, 2020). The market value of the lots would be roughly $55,000 (Scanlon, 2020; Peddicord, 2020). This means that the value of the raw land for development may be approximately $1,900, which totals $272,000 for all 143 lots that would become developable under the Modernization Alternative. We assume this value would be generated the year after Project Group 3 is completed (Year 2). As shown in Table D-13, when discounted and annualized, the benefit of the increased land value under the Modernization Alternative is worth $8,000 annually.

Table D-13. Increased Land Value of the Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Undiscounted Value of Land Improvement	Discounted Annualized Land Improvement Benefit
Project Group 1	$0	$0
Project Group 2	$0	$0
Project Group 3	$272,000	$8,000
Total	**$272,000**	**$8,000**

Prepared August 2020

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

3.1.7 Value of Conserved Water

The value of the conserved irrigation water can be looked at in two ways: the value of increased water instream or the value of maintaining irrigated agricultural production. This analysis focuses on the value of instream flow, as the conserved water from the Modernization Alternative would be used to augment instream flows. However, this analysis also presents the value of water to agriculture as the Modernization Alternative also enhances water supply reliability to irrigators.

This section provides several types of information on the value of instream flow. First, this analysis examines the value that environmental groups, federal agencies, and other funders of conservation have been willing to pay for water conservation projects that restore flow in the Deschutes Basin. While these values are in fact costs, rather than a measurement of benefit, the amounts paid in the past for water conservation projects to enhance instream flow represent the minimum value to the funding entities of conserved water projects (benefits as perceived by funding entities are expected to at least equal costs or funding would not be provided). Similarly, there is some limited water market data available for what environmental or governmental groups have paid to directly purchase water rights and dedicate the water to instream flow. These values also represent the cost of increasing instream flow, similar to the data on costs of water conservation projects and may significantly underestimate the full value of instream flow augmentation. Data on water right transactions in the Deschutes Basin were not available for this study. However, prices of water rights are often based on the value of water to agriculture (as agriculture is the most common seller of water rights for environmental or other water uses). We therefore present market information on the value of water rights to irrigators in OID, as this indicates the potential cost of purchasing water rights from these irrigators.

Based on the following discussion, we assume that the economic benefit of instream flow augmentation would be at least $75 per acre-feet per year, such that this enhanced instream flow is estimated to have a value of approximately $305,000 per year once all project groups are complete under the Modernization Alternative (because of the timing, on an average annualized basis the NEE benefit is roughly $291,000 as presented in Table D-15). As most water right transactions for environmental purchases are to enhance fish habitat, this value is expected to be a conservative proxy for the value to the public of enhanced fish habitat and fish populations. The full measure of the economic benefit of enhanced instream flow is the benefit to the public of enhanced fish and wildlife populations, water quality, ecosystem function, etc.

Values published in the economic literature are often quite high for enhancements to trout and other fish and wildlife populations (see Table D-14), like those that would benefit from the instream flows provided by the Modernization Alternative. As quantitative information on how instream flows would improve fish and wildlife populations is not available, the analysis is not able to directly measure the economic benefit of enhanced instream flow. As such, the value of conserved water is estimated in this section using the prices of water from transactions in the Western United States. Transaction values from the Deschutes Basin itself are not used, as there are regulatory limitations on the amount paid for leased water and much of the water is temporarily leased and donated to instream flows, not reflecting the true instream flow value of the water. Table D-15 shows the estimated average annual benefits of enhanced instream flow for the Modernization Alternative.

Table D-14. Studies and Values Used to Estimate the Value of Fish Enhancement.

Author(s)	Study Year	Original Value Per Household (Dollar Year)	Value Per Household Adjusted to 2019 dollars	Restoration Location	Fish Enhancement	Survey Respondents
Bell, Huppert, & Johnson	2003	$24 - $122 (2000$)	$36 - $179	Coastal WA and OR	Annual willingness to pay (WTP) per household to increase local Coho salmon populations by 100%	Households in Grays Harbor, WA; Willapa Bay, WA; Coos Bay, OR; Tillamook Bay, OR; Yaquina Bay, OR
Olsen, Richards, & Scott	1991	$43 (2006$)	$54	Columbia River Basin	Annual WTP per household to increase salmon and steelhead population by 100%	Pacific Northwest households that never fish
Loomis	1996	$59 - $73 (1994$)	$101 - $125	Elwha River, Olympic Peninsula, WA	Annual WTP per household to restore a salmon and steelhead population in its historic habitat on the Elwha River	Households in Clallam County, WA; WA state; U.S.
Layton, Brown, & Plummer	1999	$119 - $250 (1998$)	$185 - $388	Eastern WA and Columbia River; Western WA and Puget Sound	Annual WTP per household to increase migratory fish populations by 50%	Households in WA state

Prepared August 2020

Sources: (Bell, Huppert, & Johnson, 2003); (Loomis, 1996); (Layton, Brown, & Plummer, 2001); (Olsen, Richards, & Scott, 1991) as cited in (Richardson & Loomis, 2009).

Table D-15. Annual Estimated Instream Flow Value of Modernization Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Project Group	Water Conservation Under Modernization Alternative (acre-foot/year)	Undiscounted Annual Benefits of Additional Instream Flow	Annualized Average Net Benefits of Modernization Alternative
Project Group 1	2,021	$152,000	$144,000
Project Group 2	1,613	$121,000	$115,000
Project Group 3	432	$32,000	$32,000
Total	**4,066**	**$305,000**	**$291,000**

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

This value of $75 per acre-foot per year is based on the following information (see Table D-16):

1. Prices paid for water by environmental buyers throughout the Western United States: In the period 2000 to 2009, the purchase price of environmental water varied from just over $0 to nearly $1,676 per acre-foot per year, with an average permanent sale transaction price of $166 per acre-foot per year. Among the 51 permanent water right purchases with the sales price and volume recorded in the database, the permanent sales price value in 27 transactions (53 percent) was above $75 per acre-foot per year. As discussed at length below, these values paid are expected to provide a low range estimate of instream flow value to society.
2. Value of water to irrigators in OID: Using crop budget approach, we estimate that each acre-foot of water generates approximately $60 to $120 for hay growers in the District, depending on yields. This value is important, as the value of water to local agriculture is a key factor determining water sales and lease prices to environmental buyers in the project area (i.e., the marginal value of water to agriculture would determine agricultural sellers' willingness to accept a price for water), and because conserved water avoids potential future reductions in OID's deliveries.

Table D-16. Value per Acre-Foot per Year of Water (Market Prices and Value to Agriculture), Deschutes Watershed, Oregon, 2020$.

Type of Value	Low Value	High Value	Median Value	Average Value
Permanent water right transactions in Western U.S., 2000 to 2009 (*Converted to Annual Values*)	~$0	$1,676	~$75	$166
Value of water to OID irrigators (*Income Capitalization Approach and Sales Price of Water in Ag to Ag Transfers, Converted to Annual Values*)	$60	$120	N/A	$80

Prepared August 2020

3.1.7.1 Past Costs Paid as a Proxy for Value

Past piping projects in the Deschutes Basin highlight the willingness of funding entities to pay for instream flow augmentation. These values are evidence of the *minimum* benefit of the instream flows purchased, as perceived and experienced by these entities. Project costs paid are indicative of the *minimum* perceived benefit as (barring very unusual circumstances) entities only pay for projects for which they believe benefits exceed costs. The perceived value may be higher than the price paid in cases where the funding organization was willing to pay more than the actual price paid by one organization for instream benefits. Furthermore, because instream benefits can be valued and enjoyed by people other than the funding organization, society's value of instream benefits is likely higher than the price paid for instream flow. Only if all people who value instream flows were to contribute their maximum willingness to pay for instream flow restoration would the value paid equal the benefits received. Finally, it is important to recognize that these values fundamentally represent *costs* and not benefits; the values paid are based on the cost to conserve water or for agriculture to reduce their use of water (as evident through water right transactions from agriculture to environmental flows).

In the Deschutes Basin, around 90 projects have restored approximately 80,000 acre-feet of water instream (Central Oregon Irrigation District, 2016). Based on data from the Deschutes River Conservancy, costs of instream flow augmentation from piping projects have ranged from approximately $105,000 to approximately $344,000 per cubic foot per second (cfs) conserved; this may equate to roughly $300 to $1,000 per acre-foot conserved.

Water rights can be purchased or leased in Oregon. It is important to note that the value paid per acre-foot depends on many variables, including the value of water to the seller, funding available to the buyer, characteristics of the affected stream/river (including current flow levels, flow targets, and presence of threatened or endangered species), characteristics of the water right (seniority, time of use, point of diversion, etc.), and the size of the water right.

Water right leases and purchases for environmental purposes across the Western United States were analyzed in a 2003 paper (Loomis, Quattlebaum, Brown, & Alexander, 2003). During the period between 1995 and 1999, six transactions of water right purchases averaged $362 per acre-foot in Oregon, while five water right leases averaged $115 per acre-foot per year. The paper also shows lease and purchase price by environmental use, including for riparian areas, wetlands, recreation, and instream flow. For instream flows, the average purchase price across 18 transactions per acre-foot was $1,121, while across 35 lease transactions the annual price was $68 per acre-foot.

The Bren School of Environmental Science and Management at the University of California, Santa Barbara, maintains a database of water transfers in the Western United States, and distinguishes between the terms of the transaction (i.e., sale or lease) and the sector of the buyer and seller (e.g., agricultural or environmental) (Bren School of Environmental Science & Management, University of California, Santa Barbara, 2017). The two graphs shown below in Figure D-2 and Figure D-3 show more recent (from 2000 to 2009) sales and leases of water rights by environmental buyers on a price per acre-foot per year basis. The figures show how water right transaction values vary widely, but sale prices (amortized to an annual price) typically are less than $200 per year while 1-year leases typically fall below $800 per acre-foot per year (with several transactions showing prices rising over a $1,000 per acre-foot per year). Among the 51 permanent water right purchases with the sales price and volume recorded in the database, the sales price value in 27 transactions (53 percent) was above $75 per acre-foot per year. However, it is also important to note that the amount paid per acre-foot tends to decline with an increase in water volume traded; weighing the purchase price by the water volume sold decreases the average permanent sale transaction price to $20 per acre-foot per year.

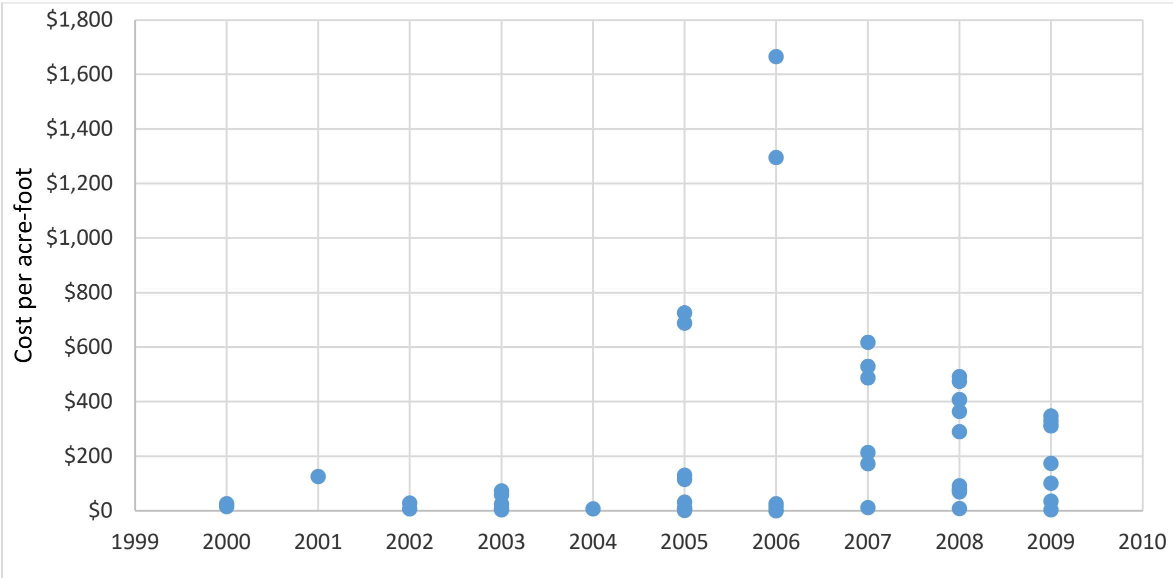

Figure D-2: Western Water Right Purchases for Environmental Purposes, 2000 to 2009, Price Paid per Acre-Foot per Year.[15]

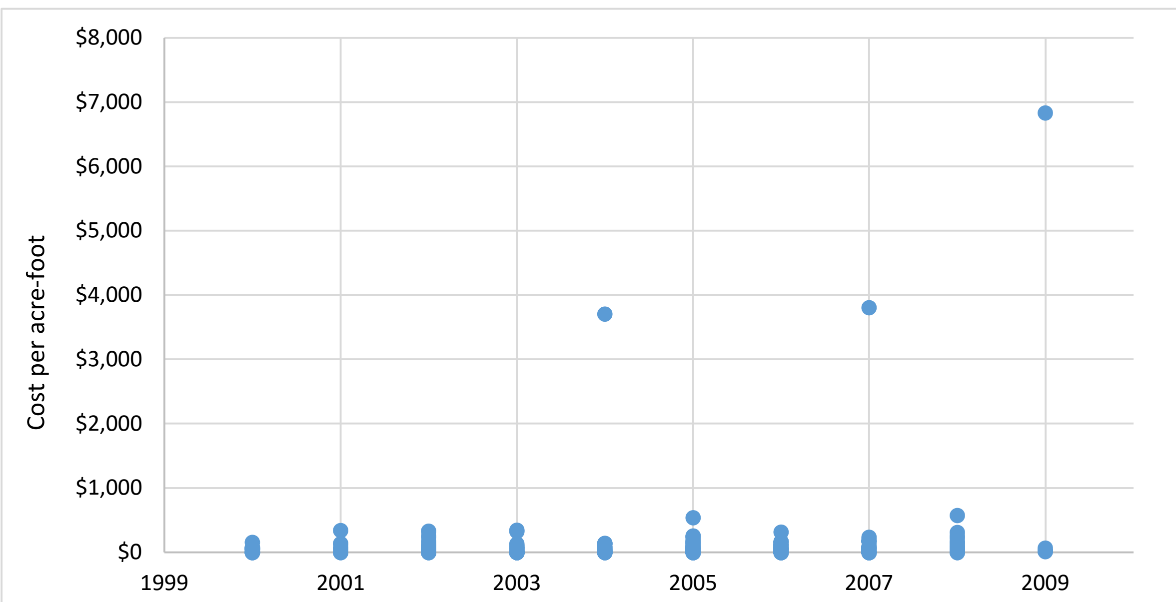

Figure D-3: One-Year Water Leases for Environmental Purposes, Price Paid Per Acre-Foot in Western United States.

3.1.7.2 Current and Potential Future Water Right Purchase Values in the Surrounding Area

Water sales in the District are not common and there is very little information available regarding transaction prices. However, to provide a reference for the value of water based on purchases in neighboring districts, water rights sold from one irrigator to another within Tumalo Irrigation District (which is also located in

[15] Note that dollar per acre-foot purchase prices were amortized using a 2.75 percent interest rate and a 100-year period to derive dollar per acre-foot per year values.

Central Oregon and has a similar crop mixture of predominantly forage crops) have typically had a purchase price between $5,080 to $7,620 per acre (Rieck, 2017).[16] These values are very similar to values provided by real estate agents in the region regarding the increased value of property with irrigation water rights, with all else equal. Assuming the certificated rate of 5.45 acre-feet per year delivered on average to acreage in Tumalo Irrigation District, this equates to approximately $941 to $1,399 per acre-foot ($5,080 to $7,620 per acre divided by 5.45 acre-feet per acre delivery), or a value of approximately $30 to $40 per acre-foot per year.

Prices paid for the limited number of agricultural water right sales may not reflect the average value of water to irrigators in OID and the cost of acquiring water in the future. The value of water to irrigators in OID (i.e., the increased farm income from having access to water) is important as it is a key determinant of the price at which irrigators would be willing to sell water rights (and the price at which environmental water buyers could obtain water from agricultural water right holders, which are the primary water right holders that could sell water rights to augment instream flows). The price paid per acre-foot in the limited Tumalo Irrigation District water transactions cited above is lower than the value derived from the effect on on-farm income from changes in access to irrigation water (income capitalization approach). The change in on-farm income from changes in access to irrigation water may be $80 per acre-foot per year.[17]

The fact that current water right transactions trade for a lower value than derived through the income capitalization approach may be because some farms in the region are not commercial farms or are not farming all their lands, and so derive less income from some of their water rights than commercial farms producing grass hay or other crops. This indicates that while some water may trade for the lower value, if instream flow buyers were to purchase water rights, then as more water rights were acquired, the cost per acre-foot would likely rise to the level as derived through the income capitalization approach.

3.2 Benefits Considered but Not Included in Analysis

3.2.1 Public Safety Avoided Costs

Piping irrigation water removes the hazard of drownings in canals and also eliminates the potential for earthen canals to fail, which could potentially cause a live-threatening situation. As discussed in Section 0, canal failures occur approximately once every three years in OID, and the fine sand canals in Project Group 3 are especially vulnerable to failure (Scanlon, 2020). In that section, we estimated the likely damage to property given a canal failure, but we did not estimate the potential threat to lives. This threat is relevant given the fact that the canal in Project Group 3 runs adjacent to an elementary school and a growing suburban neighborhood.

A history of recent drownings in Central Oregon irrigation canals provides evidence that fast-moving water in irrigation canals, often with steep and slippery banks, can be a threat to public safety. In 2004, a toddler drowned in a Central Oregon Irrigation District canal, and in 1996 and 1997, respectively, a 12-year old boy and a 28-year old man drowned in North Unit Irrigation District canals (Flowers, 2004). Other drownings may have occurred in the past, as a comprehensive list of drownings in Central Oregon irrigation canals was not available from the Bureau of Reclamation or other sources. However, the data indicate at least three drownings over the last 21 years (1996 through 2016), or 0.143 deaths per year during this period. As the population in Central Oregon continues to grow and areas surrounding irrigation canals continue to urbanize,

[16] These values have been adjusted for inflation to 2020 dollars using the Consumer Price Index.

[17] We based this estimate on an analysis of the net returns of water for alfalfa hay. Alfalfa makes up about 90 percent of farmed cropland in OID (Scanlon, 2020). We estimate that in an average year, alfalfa hay may provide a net return of about $231 per acre and requires approximately 2.9 acre-feet of water per acre. This results in an average net returns per acre-foot of water of approximately $80.

including Prineville, the risk to public safety would increase. The Modernization Alternative would pipe or fill 10.1 miles of open canals in OID's current system and an additional 6.6 miles of canals that are not currently part of OID.[18] This piping is expected to increase public safety.

4. Incremental Analysis

The Modernization Alternative is evaluated using an incremental analysis, which identifies how total costs and benefits change as project groups are added (Table D-17). In the incremental analysis, project group pipe size and costs remain the same for each project group assessed. The engineering pipeline design (pipe diameters, pressure ratings, etc.) is independent of the number of project groups and the order that the project groups are installed. In engineering the design of the system, the District and Black Rock Consulting mapped and collected digital elevation data to create a hydraulic model that determined pipe sizes for each pipeline (canal or lateral to be piped) in the system.

Table D-17. Incremental Analysis of Annual NEE Costs and Benefits Under the Modernization Alternative for Ochoco Irrigation District, Deschutes Watershed, Oregon, 2020$.[1]

Project Groups	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
1	$484,000	--	$525,000	--	$41,000
1, 2	$800,000	$316,000	$856,000	$331,000	$56,000
1,2,3	$957,000	$157,000	$1,131,000	$275,000	$174,000

Prepared August 2020

1/Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.75 percent.

18 McKay Creek is not currently part of OID but would become part of the District under the Modernization Alternative.

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6. NEE Appendix Crop Enterprise Budgets

This appendix presents the crop enterprise budgets used in estimating agricultural NEE benefits under the Modernization Alternative resulting from reduced damages associated with water shortages. The agricultural production benefits are estimated using enterprise budgets that represent typical costs and returns of producing crops in the Deschutes Watershed of Central Oregon. Enterprise budgets aim to reflect common practices and relevant costs for production in the region, but do not necessarily represent the conditions of any particular farm.

6.1 Alfalfa Enterprise Budgets

We used a crop budget for alfalfa hay developed by Washington State University, and then adjusted values in the budget to account for changes in prices through time and local conditions in OID. A more recent published alfalfa hay budget for Central Oregon was not available from Oregon State or Washington State University. Due to the need to model conditions with different water availability, we developed three crop budgets. One budget models the net returns under full irrigation, a second models the net returns under a water deficit that results in only a single cutting, and the third models a 13 percent water shortage. We use the budgets to estimate the net benefits of piping to agricultural production in the NEE. The following section outlines the data and assumptions used in adjusting the Washington State alfalfa hay budget.

The alfalfa hay enterprise budgets were based on a 2012 budget developed by Washington State University (WSU) for establishing and producing alfalfa hay in the Washington Columbia Basin (Norberg & Neibergs, 2012). We selected these budgets as the basis for OID crop production costs because they are the most recent crop budgets developed for producing alfalfa hay in an area that is relatively close and similar to Central Oregon.

We updated the costs presented in the original budgets to account for changing values over time and to reflect conditions specific to OID. Returns to alfalfa were based on locally reported hay yields and five-year normalized average hay prices in Oregon. We developed three hay budgets: one budget to model production under full irrigation (Table D-18), and one for hay under deficit irrigation that results in a single cutting for the season (Table D-19), and one for hay under a 13 percent water shortage (Table D-20).

6.2 Modeled Farm

The modeled farm is 120 acres. The hay field is seeded in the fall following a grain crop such as wheat or barley and is harvested using one-ton bales. Other than labor for irrigation, all labor is provided by hiring custom work (includes harvest, fertilizer application, and herbicide application). Irrigation is delivered by a center pivot.

6.2.1 Input Costs

For fertilizers, we adjust the amount used proportionally according to differences in yield from the original budget. For example, the original budget calls for 92 pounds (lbs) of dry phosphate to produce 8 tons of hay per acre; under full irrigation, we model a yield of only 5.5 tons per acre (69 percent of the yield), so we reduce the amount of dry phosphate to 63 lbs (69 percent of 92 lbs). For sulfur, we input a specific amount based on local expert guidance, which suggests 30 lbs must be used for the soils in the study area (Bohle, 2020).

All costs are adjusted from the original values in the WSU budget. We used area-specific values for fuel prices, irrigation charges, and land costs. OID charges $7 per year for dam and construction fees and plans to charge new McKay patrons assessment fees of $170 per year for patrons with more than 10 acres. For the average-sized plot in OID (22.3 acres), these fees average about $8 per acre. The original WSU budget did not include the costs of land; however, we added it to the budget used in this analysis. We used the average rental rate for irrigated cropland in Oregon: $150 per acre (NASS, 2017).

For costs that did not have area-specific values, we adjusted the value in the original budget using the national Producer Price Indices (PPI) produced by the National Agricultural Statistics Services (NASS), which are published for a variety of farm expenses (NASS, 2018). For example, there are prices indices for fertilizer, herbicides, supplies, tractors, custom work, as well as one for the farm sector in general. The PPI cost adjustments range from an 8 percent decrease in the price of fertilizer to a 16 percent increase in machinery costs. For a few costs, such as crop insurance and overhead expenses, we adjusted them by the Consumer Price Index (CPI), as we expect they would follow inflation patterns more closely than any of the PPI categories.

Establishment costs are derived from the same WSU budget and adjusted using the techniques described in this appendix. Establishment costs are amortized using a 2.75 percent interest rate and a 6-year payback period, which is roughly the average productive life of alfalfa stands in the area (Bohle, 2020).

6.2.2 Labor Costs

Because most of the labor is provided by custom work, the only direct labor costs are for an agricultural equipment operator to move the center pivots. For the cost of equipment operator labor, we use the median hourly wage rate for this occupation in Oregon in 2018, and adjust it to 2020 dollars using the CPI.[19] We further adjust this wage rate up by 20 percent to account for non-wage employment costs, such as health care and insurance.[20] This results in total labor costs of $21.65 per hour for equipment operators.

We adjusted the cost of custom work using the Custom Work PPI. For the hay budget under deficit irrigation (Table D-19), we adjust some labor costs (including custom bailing, hauling, staking, and tarping) proportionally to the change in yield (e.g., if yield falls by 10 percent, the amount of labor also falls by 10 percent). To the extent that labor costs fall less than this, our results would under-estimate benefits (and vice versa). Management labor costs are estimated at 5 percent of total costs. Other custom labor, including swathing and raking, are adjusted based on the number of hay cuttings. Under the single-cutting scenario, we reduce irrigation labor and repair costs by two-thirds to account for reduced irrigation, and by 13 percent under the 13 percent water shortage budget.

6.2.3 Revenues

To estimate the gross revenues of alfalfa hay under full irrigation (Table D-18), we use the average alfalfa yield in the McKay Creek area as reported by an Oregon State University (OSU) Extension Agent expert on forage crops in Central Oregon: 5.5 tons per acre (Bohle, 2020). We estimate the yield under the single-cutting scenario by assuming the first hay cutting (which is typically the only cutting McKay growers currently get) is roughly 45 percent of the total annual yield, or 2.5 tons per acre (Table D-19). Because the water-yield relationship for hay is roughly linear, we assume the 13 percent water shortage in the third scenario will lead to a 13 percent reduction in yield, for a total yield of 4.8 tons per acre under this scenario (Table D-20).

[19] This is the average wage for the Agricultural Equipment Operators (occupation code 45-2091) in the Central Oregon non-metropolitan area according the Bureau of Labor Statistics' Occupational Employment and Wage Estimates data in May 2018 (Bureau of Labor Statistics, 2017).

[20] This is roughly the average proportion of non-wage labor costs for all private, part-time workers in the United States in December 2012 (Bureau of Labor Statistics, 2018).

To estimate the gross revenues per ton, we use the normalized average price per ton for hay in Oregon reported by the Economic Research Service of the USDA in 2019: $193.20 (Economic Research Service, 2018). Because the average price of alfalfa tends to be higher than the average price of other hay in Oregon, by using the normalized average price for all hay, we may be understating the net benefits to alfalfa hay acres.[21]

6.3 Alfalfa Enterprise Budget Tables

The tables below present the three alfalfa hay enterprise budgets used to estimate the net returns to under different irrigation scenarios: one budget under full irrigation (Table D-18), one budget modeling returns under a single cutting (Table D-19), and one budget under a 13 percent water deficit scenario (Table D-20).

[21] From 2013 to 2017, the average price for alfalfa ($194 per ton) was seven percent higher than the average price for other kinds of hay ($180 per ton) (NASS, 2017).

Table D-18. Alfalfa Net Returns Under Full Irrigation.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	5.5	ton	$193.20	$1,062.60
VARIABLE COSTS				
Dry Nitrogen	0.0	lb	$0.34	$0.00
Dry Phosphate	63.3	lb	$0.58	$36.59
Dry Potash	96.3	lb	$0.41	$39.60
Dry Sulfur	30.0	lb	$0.20	$5.87
Zinc	3.4	lb	$1.98	$6.82
Boron	1.4	lb	$4.47	$6.14
Custom Application	1.0	ac	$9.90	$9.90
Soil Test	1.0	ac	$0.33	$0.33
Herbicide	2.0	lb	$19.14	$38.28
Custom Application	1.0	ac	$9.90	$9.90
Custom - Swath	3.0	ac	$22.00	$66.00
Custom - Rake	3.0	ac	$11.00	$33.00
Custom - Bail	5.5	ton	$18.70	$102.85
Custom - Haul & Stack	5.5	ton	$9.90	$54.45
Custom - Tarping	5.5	ton	$5.50	$30.25
Irrigation - water charge	1.0	ac	$53.60	$53.60
Irrigation - service charge	1.0	ac	$7.92	$7.92
Irrigation - repairs	1.0	ac	$16.53	$16.53
Irrigation - labor	0.5	ac	$22.10	$11.05
Haystack insurance	5.5	ton	$2.25	$12.37
Gopher control	1.0	ac	$5.58	$5.58
Fuel	2.3	gal	$2.69	$6.13
Lubricants	1.0	ac	$0.89	$0.89
Machinery repairs	1.0	ac	$1.98	$1.98
Overhead	1.0	ac	$43.23	$43.23
Operating interest	1.0	ac	$16.48	$16.48
Total variable costs				$615.74
FIXED COSTS				
Machinery depreciation	1.0	ac	$6.31	$6.31
Machinery interest	1.0	ac	$3.68	$3.68
Machinery insurance, taxes, housing, license	1.0	ac	$2.62	$2.62
Management (5% of total cost)	1.0	ac	$39.61	$39.61
Amortized establishment cost	1.0	ac	$13.85	$13.85
Land cost	1.0	ac	$150.00	$150.00
Total fixed costs				$216.07
Total costs				$831.81
NET RETURNS PER ACRE				**$230.79**

Prepared August 2020

Table D-19 Alfalfa Net Returns with a Single Cutting.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	2.5	ton	$193.20	$478.17
VARIABLE COSTS				
Dry Nitrogen	0.0	lb	$0.34	$0.00
Dry Phosphate	28.5	lb	$0.58	$16.47
Dry Potash	43.3	lb	$0.41	$17.82
Dry Sulfur	30.0	lb	$0.20	$5.87
Zinc	1.5	lb	$1.98	$3.07
Boron	0.6	lb	$4.47	$2.76
Custom Application	1.0	ac	$9.90	$9.90
Soil Test	1.0	ac	$0.33	$0.33
Herbicide	2.0	lb	$19.14	$38.28
Custom Application	1.0	ac	$9.90	$9.90
Custom - Swath	1.0	ac	$22.00	$22.00
Custom - Rake	1.0	ac	$11.00	$11.00
Custom - Bail	2.5	ton	$18.70	$46.28
Custom - Haul & Stack	2.5	ton	$9.90	$24.50
Custom - Tarping	2.5	ton	$5.50	$13.61
Irrigation - water charge	1.0	ac	$0.00	$0.00
Irrigation - service charge	1.0	ac	$0.00	$0.00
Irrigation - repairs	0.7	ac	$16.53	$11.02
Irrigation - labor	0.3	ac	$22.10	$7.37
Haystack insurance	2.5	ton	$2.25	$5.56
Gopher control	1.0	ac	$5.58	$5.58
Fuel	2.3	gal	$2.69	$6.13
Lubricants	1.0	ac	$0.89	$0.89
Machinery repairs	1.0	ac	$1.98	$1.98
Overhead	1.0	ac	$43.23	$43.23
Operating interest	1.0	ac	$8.35	$8.35
Total variable costs				$311.90
FIXED COSTS				
Machinery depreciation	1.0	ac	$6.31	$6.31
Machinery interest	1.0	ac	$3.68	$3.68
Machinery insurance, taxes, housing, license	1.0	ac	$2.62	$2.62
Management (5% of total cost)	1.0	ac	$26.67	$26.67
Amortized establishment cost	1.0	ac	$58.88	$58.88
Land cost	1.0	ac	$150.00	$150.00
Total fixed costs				$248.16
Total costs				$560.06
NET RETURNS PER ACRE				**-$81.89**

Prepared August 2020

Table D-20. Alfalfa Net Returns Under 13-Percent Deficit Irrigation.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	4.8	ton	$193.20	$926.03
VARIABLE COSTS				
Dry Nitrogen	0.0	lb	$0.34	$0.00
Dry Phosphate	63.3	lb	$0.58	$36.59
Dry Potash	96.3	lb	$0.41	$39.60
Dry Sulfur	30.0	lb	$0.20	$5.87
Zinc	3.4	lb	$1.98	$6.82
Boron	1.4	lb	$4.47	$6.14
Custom Application	1.0	ac	$9.90	$9.90
Soil Test	1.0	ac	$0.33	$0.33
Herbicide	2.0	lb	$19.14	$38.28
Custom Application	1.0	ac	$9.90	$9.90
Custom - Swath	3.0	ac	$22.00	$66.00
Custom - Rake	3.0	ac	$11.00	$33.00
Custom - Bail	4.8	ton	$18.70	$89.63
Custom - Haul & Stack	4.8	ton	$9.90	$47.45
Custom - Tarping	4.8	ton	$5.50	$26.36
Irrigation - water charge	1.0	ac	$0.00	$0.00
Irrigation - service charge	1.0	ac	$0.00	$0.00
Irrigation - repairs	0.9	ac	$16.53	$14.40
Irrigation - labor	0.4	ac	$22.10	$9.63
Haystack insurance	4.8	ton	$2.25	$10.78
Gopher control	1.0	ac	$5.58	$5.58
Fuel	2.3	gal	$2.69	$6.13
Lubricants	1.0	ac	$0.89	$0.89
Machinery repairs	1.0	ac	$1.98	$1.98
Overhead	1.0	ac	$43.23	$43.23
Operating interest	1.0	ac	$13.98	$13.98
Total variable costs				$522.48
FIXED COSTS				
Machinery depreciation	1.0	ac	$6.31	$6.31
Machinery interest	1.0	ac	$3.68	$3.68
Machinery insurance, taxes, housing, license	1.0	ac	$2.62	$2.62
Management (5% of total cost)	1.0	ac	$39.61	$39.61
Amortized establishment cost	1.0	ac	$13.85	$13.85
Land cost	1.0	ac	$150.00	$150.00
Total fixed costs				$216.07
Total costs				$738.55
NET RETURNS PER ACRE				**$187.48**

D.2 Alternatives Considered During Formulation

This appendix section presents the alternatives considered in the formulation phase.

During the formulation phase, alternatives were evaluated based on meeting both NEPA and environmental review requirements specific to NRCS federal investments in water resources projects (Table D-21). According to NEPA, "agencies shall rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR 1502.14). According to the PR&G DM 9500-013, alternatives should reflect a range of scales and management measures and be evaluated against the Federal Objective and Guiding Principles; against the extent to which they address the problems and opportunities identified in the purpose and need; and against the criteria of completeness, effectiveness, efficiency, and acceptability:

1. Completeness is the extent to which an alternative provides and accounts for all features, investments, and/or other actions necessary to realize the planned effects, including any necessary actions by others. It does not necessarily mean that alternative actions need to be large in scope or scale.
2. Effectiveness is the extent to which an alternative alleviates the specified problems and achieves the specified opportunities.
3. Efficiency is the extent to which an alternative alleviates the specified problems and realizes the specified opportunities at the least cost.
4. Acceptability is the viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing Federal laws, authorities, and public policies. It does not include local or regional preferences for particular solutions or political expediency.

Alternatives eliminated during formulation are discussed below the table. Alternatives selected for further evaluation are discussed in the Plan-EA.

Table D-21. Alternatives Considered During the Formulation Phase.

Alternative	Which criteria in the PR&G does the alternative achieve?				Selected for Further Evaluation
	Completeness	Effectiveness	Efficiency	Acceptability	
Conversion to Dryland Farming			X		
Fallowing Farm Fields			X		
Market Based Approaches to include Voluntary Duty Reduction					
Partial Use of Groundwater					
On-Farm Efficiency Upgrades				X	

Canal Lining	X	X		X	X
No Action (Future without Federal Investment)			X		X
Modernization Alternative	X	X	X	X	X

Conversion to Dryland Farming

Dryland farming is a non-structural alternative. This method of farming uses no irrigation and drought-resistant crops and practices to conserve moisture. The lack of rainfall throughout the growing season (approximately 12 inches per year) coupled with hot temperatures, desiccating winds, and generally shallow and well- to excessively drained soils with low storage potential, makes dryland farming infeasible within the District (Daly et al. 1994; Gannett et al. 2001). In the District, agricultural production would substantially decrease if dryland farming were implemented. With decreased production and income, farmers could potentially sell their land due to the development pressure; however, dryland farming would be inconsistent with ensuring agricultural production is maintained in an area undergoing urbanization.

Conversion to dryland farming was eliminated from further evaluation because it would not meet the project's purpose and need; its effectiveness would be uncertain since conversion to dryland farming would be voluntary; it would not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use; and because it would not achieve the Federal Objective and Guiding Principles.

Fallowing Farm Fields

Fallowing farm fields is a non-structural alternative that includes permanently transferring or temporarily leasing water rights from irrigated lands or otherwise not using water rights appurtenant to irrigated lands. Fallowing farm fields would use less irrigation water within the District and would therefore allow more water to remain instream for fish, wildlife, and habitat.

Fallowing farm fields was eliminated from further evaluation because it would not meet the project's purpose and need; its effectiveness would be uncertain since fallowing fields would be voluntary; it would not be acceptable because it is inconsistent with public policy supporting and maintaining existing agricultural land use; and because it would not achieve the Federal Objective and Guiding Principles.

Market-Based Approaches to include Voluntary Duty Reduction

Market-Based Approaches for the purpose of this analysis refers to patrons voluntarily accepting less than their full water delivery rate from the District, or patrons transferring water from the farm to the river temporarily or permanently. Although permanently dedicating water for instream use by the District is part of the proposed action, it utilizes established authorities and is not a part of the following discussion.

Market-based incentives as a stand-alone alternative do not address the underlying purpose and need of the project. Incorporating market-based solutions into the proposed action without corresponding regulatory and policy changes, which would be required to provide the District with the authority to carry out the transfer of patron water instream, is not ripe for consideration as an alternative at this time. Without a change in the framework of current lawful authorities on the part of the District, incorporating market-based incentives into the proposed action is not within the District's ability or capacity to undertake, nor is it logistically or technically feasible.

For example, a reduction in duty by a patron could mean the District diverts less water, which would leave more water instream. Because the District is obligated to provide a certain amount of water to patrons to meet associated rights, this alternative would be voluntary and at the discretion of individual landowners. For this reason, there would be no certainty that water would be saved, and that streamflow would be restored. Furthermore, OID lacks the statutory authority or responsibility to carry out, operate and maintain voluntary duty reduction by its patrons, creating a logistically complex situation for OID to implement. Further, because the system has open canals, subject to certain operating inefficiencies, the District would still have to divert enough water, accounting seepage, to ensure those deliveries. Therefore, carrying out this alternative would be logistically complex and technically infeasible

Market based incentives were eliminated from further evaluation because they would not meet the project purpose; its effectiveness would be uncertain since reducing one's duty would be voluntary; the District lacks the ability to carry out patron duty reductions; it would not achieve the Federal Objective and Guiding Principles; and given current water delivery technology it is technically infeasible by the District to accommodate.

Exclusive or Partial Use of Groundwater

The exclusive or partial conversion from surface-water-sourced to groundwater-sourced irrigation was also initially considered as possible alternatives. To use groundwater in the Deschutes Basin, the District would have to apply for groundwater rights under OWRD's Deschutes Basin Groundwater Mitigation (DBGM) program pursuant to OAR 690-505-0500. The DBGM program is part of OWRD's goal to limit groundwater use by imposing restrictions to new users obtaining groundwater rights. Under the DBGM program, only 32.98 cfs is available for the whole Deschutes Basin, and it is unlikely the District could obtain rights to all the remaining water (S. Henderson, personal communication, August 14, 2017). Given only 32.98 cfs is available under this program, the District's exclusive use of groundwater to entirely replace their use of surface water is not feasible.

The partial use of groundwater for irrigation would have logistical and legal constraints. The District and patrons could use their surface water rights for groundwater mitigation credits[22] required by the DBGM program; however, the District would need the authority from each patron to convert surface water rights to groundwater rights; there would be no guarantee of gaining this approval from patrons. Converting from surface water rights to groundwater rights would also affect the seniority and, therefore, the reliability of the District's water rights. The District currently has senior surface water rights that minimize the chance of being impacted during drought years; however, new groundwater rights would be junior (dated the year of the application and construction) and could be subject to curtailment.

Additionally, the District lacks the statutory authority or responsibility to carry out, operate and maintain groundwater wells on private lands owned by OID patrons. Therefore, carrying out this alternative would be logistically complex. The partial use of groundwater was eliminated from further evaluation because it would not meet the project's purpose and need; its effectiveness would be uncertain since conversion to

[22] OID will not create groundwater mitigation credits under either the No Action or the Modernization Alternative analyzed in this Plan-EA.

groundwater would be voluntary; of inefficiencies associated with logistical and legal constraints obtaining groundwater rights; of low acceptability since converting to groundwater rights would result in junior water rights; and because it would not achieve the Federal Objective and Guiding Principles.

On-farm efficiency upgrades

On-farm efficiency upgrades refer to OID service area patrons upgrading their on-farm infrastructure to use irrigation technologies that provide a more precise application of water. On-farm infrastructure is distinct from District canals and laterals because it is owned and operated by patrons. Once delivered by the District and arriving on-farm, water can either be released to flow over the land for flood irrigation or stored in a holding pond and later pumped out for sprinkler irrigation systems. Typical on-farm irrigation systems include center-pivots, wheel-lines, hand-lines, K-lines, drip systems, and flood irrigation. Each irrigation system has a different application efficiency (i.e., its ability to deliver the irrigation water to the crop root system across the full field being irrigated).

On-farm efficiency upgrades would not meet the purpose and needs of the project. Upgrading on-farm efficiency would not conserve water along District-owned infrastructure, improve water delivery reliability and operation efficiency, or increase conveyance and pumping capacity of District infrastructure. Furthermore, the objective to improve fish and aquatic habitat would not be certain to occur because upgrading on-farm systems would be voluntary, and any water saved would not necessarily be put in stream by the patrons.

On-farm upgrades are not within the scope of actions that OID can entertain as the project sponsor under PL-85-566 because OID lacks the authority or responsibility to carry out, operate and maintain on-farm infrastructure owned by OID patrons. Similarly, as part of this project the District would not be able to pursue other mitigation or incentive actions related to patron water use and farming.

In addition, if PL 83-566 funds were used to develop and implement on-farm efficiency upgrades, the use of these funds would require the District to complete a State Historic Preservation Office/National Historic Preservation Office analysis on a private tax lot-by-tax lot basis[23], as well as receive permission to then operate and maintain the system, including acquiring easements to do so. This approach is logistically complex and would increase the costs of the project.

On-farm efficiency upgrades were eliminated from further evaluation because it would not meet the project's purpose and need; its effectiveness would be uncertain since any water saved would not necessarily be put in stream by patrons; and because it did not achieve the Federal Objective and Guiding Principles.

D.3 Capital Costs for the Canal Lining Alternative

The capital cost of the Canal Lining Alternative (Table D-22) was estimated by calculating the length of geotextile membrane in existing open canals, assuming an anchor of membrane extending 7 feet on either side. The membrane would be covered by a 1-inch layer of shotcrete (fine-aggregate concrete sprayed in place). This estimate also includes fencing along both sides of the canal, and safety ladders every 750 feet in channels deeper than 2.5 feet. Costs related to earthwork and labor are estimated by a construction cost multiplier of 2. Turnouts were estimated using the same assumptions as the Preferred Alternative. The cross-section dimensions for lining the canals was calculated for each corresponding pipe diameter size using

[23] This could require OID to mitigate cultural resources on private property, potentially resulting in the District having to develop long-term maintenance or preservation agreements on lands not subject to District control.

transects on a digital elevation model, estimated from an irrigation district in Central Oregon. The McKay Switch alignment was not included for canal lining as no open canal currently exists. Other costs such as junctions, pumps, weirs, and siphon upgrades are the same as the Preferred Alternative (for cost details see Table D-24).

Table D-22. Canal Lining Alternative Costs.

Feature	Diameter (in)	Length (ft)	Cross section to be lined (ft)	Channel depth (ft)	Geomembrane total ($)	Shotcrete total ($)	Fencing total ($)	Ladder total ($)	Subtotal
Lining	4	944	10.7	1.0	$18,211	$55,546	$12,948	$0	$173,411
Lining	8	1,847	12.3	2.0	$38,152	$124,949	$25,344	$0	$376,892
Lining	12	5,118	12.7	2.4	$107,628	$358,599	$70,225	$0	$1,072,903
Lining	16	7,796	14.8	2.3	$177,441	$633,630	$106,957	$0	$1,836,056
Lining	18	163	14.5	2.8	$3,674	$13,014	$2,236	$109	$38,065
Lining	20	5,070	22.2	3.2	$147,225	$618,040	$69,555	$3,380	$1,676,401
Lining	24	18,130	23.8	3.1	$551,245	$2,370,326	$248,738	$12,086	$6,364,791
Lining	26	4,098	23.6	3.0	$124,051	$532,208	$56,226	$2,732	$1,430,434
Lining	72-90	53,210	33.7	4.3	$2,155,129	$9,847,783	$730,041	$35,473	$25,536,854
Subtotal									**$38,506,000**
Engineering, Construction Management, Survey (6%)									$2,310,000
Construction Management / General Contractor (12%)									$4,621,000
Contingency (30%)									$13,631,000
Cost of non-lining features – same as Preferred Alternative									$14,868,000
TOTAL									**$73,936,000**

Totals are rounded to nearest $1,000. Prepared August 2020

D.4 Modernization Alternative/Preferred Alternative Costs

This section presents capital costs for the Modernization Alternative, which is identified as the Preferred Alternative (Table D-23). The Modernization Alternative was priced using HDPE pipe, which was, at the time of this analysis, considered to be the most cost-effective material (Table D-24). The cost estimates also include fittings and other necessary appurtenances. This section also includes a discussion of other piping materials that were considered.

Table D-23. Proposed Features for the Preferred Alternative within Ochoco Irrigation District.

Type	Project Feature	Quantity	Total
Pipe	McKay Creek Pipeline	6.6 miles	$3,735,000
Pipe	Grimes Flat piping	8.2 miles	$2,831,000
Pipe	IronHorse piping realignment	1.2 miles	$4,271,000
Decommission	IronHorse canal decommission	1.9 miles	--[1]
Pipe	Pipe replacement	0.1 miles	$535,000
Canal improvement	Canal bank raises	15.2 miles[2]	$1,501,000
	Total new or improved canal infrastructure	**33.2 miles**	**$12,873,000**
Pump Station	Cox Pump Station	1	$1,287,000
Pump Station	Crooked River No. 1 Pump Station/ associated pipe	1/ 0.2 miles	$4,711,000
Pump Station	Crooked River No. 2 Pump Station/ associated pipe	1/ 0.3 miles	$4,097,000
Pump Station	Crooked River No. 3 Pump Station	1	$512,000
	Total pump stations installed/ associated pipe	**4/ 0.5 miles**	**$10,607,000**
General infrastructure improvement	Crooked River Diversion Weir Raise	1	$61,000
General infrastructure improvement	Crooked River Diversion Canal Drum Screen	1	$82,000
General infrastructure improvement	Ochoco Creek Weir/ Spill Structure	1	$26,000
General infrastructure improvement	Ochoco Siphon Size Increase	1	$133,000
	Total general infrastructure improved	**4**	**$302,000**
		Subtotal	$23,782,000
		Engineering, Construction Management, Survey[3]	$1,776,000
		Construction Contractor Markup[3]	$887,000
		Contingency[3]	$3,111,000
		TOTAL	**$29,556,000**

Totals are rounded to the nearest $1,000. Prepared August 2020

[1] Cost of IronHorse canal decommissioning is included in IronHorse pipe realignment.

[2] Canal improvements would occur over an estimated 9 miles of 15.2 miles of open canal or where necessary.

[3] Percentages for Engineering, Construction Contractor, and Contingency vary across project features.

Table D-24. HDPE Pipe Diameters and Lengths.

Area	Feature	Diameter (in)	Length (feet)	Length (miles)
Grimes Flat	Pipe	4	944	0.18
Grimes Flat	Pipe	8	1,847	0.35
Grimes Flat	Pipe	12	5,118	0.97
Grimes Flat	Pipe	16	7,796	1.48
Grimes Flat	Pipe	18	163	0.03
Grimes Flat	Pipe	20	5,070	0.96
Grimes Flat	Pipe	24	18,130	3.43
Grimes Flat	Pipe	26	4,098	0.78
McKay Pipeline	Pipe	4	1,159	0.22
McKay Pipeline	Pipe	6	6,697	1.27
McKay Pipeline	Pipe	8	4,432	0.84
McKay Pipeline	Pipe	12	2,342	0.44
McKay Pipeline	Pipe	16	5,415	1.03
McKay Pipeline	Pipe	20	7,925	1.50
McKay Pipeline	Pipe	24	6,948	1.32
IronHorse	Pipe	78	6,250	1.2
		Total	**84,334**	**16.00**

Prepared August 2020

Other Piping Materials Considered

In addition to HDPE, using steel or polyvinyl chloride (PVC) was also explored. A cost analysis was completed for each material. The costs of junctions, pumps, and other non-pipe costs are the same as the Preferred Alternative. The lengths and diameters, and range of pressure ratings used for these piping alternatives were estimated based on the engineering analysis completed in the District's System Improvement Plan (SIP). Annual operating costs and material design life were also taken into consideration. Annual operating costs (equipment, maintenance, and labor costs) were assumed to decrease 15 percent because a fully piped system would reduce the need to inspect, repair, remove obstructions, and make manual adjustments to the system. See the tables below for steel and PVC cost details and pipe specifications.

Steel Piping Alternative

The lengths, diameters, and range of pressure ratings used for this alternative were estimated based on the engineering analysis completed in the District's SIP. Spiral-welded steel was selected that conforms to requirements of the American Water Works Association C200 standard. This pipe was selected because it is considered an industry consensus standard and is a prominent guide for the manufacture of steel pipe for water and wastewater applications in North America (Bambie and Keil 2013). Steel pipe typically has a design life of 50 years under irrigation water delivery applications (Table D-25).

Unlike HDPE, which typically does not need fittings to conform to most canal alignments, steel pipe cannot be shaped to conform into canal alignments; therefore, elbows would be required. The cost of elbow fittings was estimated by assuming one elbow every 100 feet at a cost of $100 per 1 inch of pipe diameter. The same construction multipliers for labor and installation were used as the Preferred Alternative.

Table D-25. Steel Piping Alternative Costs.

Feature	Diameter (in)	Quantity	Units	Unit Cost	Elbow Qty	Subtotal
Steel Pipe	4	2,103	Ft	$16.56	21	$130,000
Steel Pipe	6	6,697	Ft	$25.39	67	$631,000
Steel Pipe	8	6,279	Ft	$34.23	63	$795,000
Steel Pipe	12	7,460	Ft	$51.89	75	$1,430,000
Steel Pipe	16	13,211	Ft	$69.55	132	$3,391,000
Steel Pipe	18	163	Ft	$78.39	2	$47,000
Steel Pipe	20	12,995	Ft	$87.22	130	$4,180,000
Steel Pipe	24	25,078	Ft	$104.88	251	$9,696,000
Steel Pipe	26	4,098	Ft	$113.72	41	$1,431,000
Steel Pipe	72	8,030	Ft	$316.86	80	$7,806,000
Steel Pipe	78	6,250	Ft	$343.36	63	$6,584,000
Steel Pipe	90	38,930	Ft	$396.35	390	$47,334,000
	Subtotal	**131,293**	**Ft**	**N/A**	**1,315**	**$83,455,000**
Engineering, Construction Management, Survey (6%)						$5,003,000
Construction Management / General Contractor (12%)						$10,006,000
Contingency (30%)						$29,518,000
Cost of non-pipe features – same as Preferred Alternative						$14,868,000
TOTAL						**$142,850,000**

Totals are rounded to the nearest $1,000. Prepared August 2020

PVC Piping Alternative

The lengths, diameters, and range of pressure ratings used for this alternative were estimated based on the engineering analysis completed in the District's SIP. PVC would be used for all pipe up to 26-inch diameter, and steel would be used for 72-inch diameter and greater. PVC is not manufactured in diameters larger than 48 inches.

The lifespan of a piping system depends on many different factors. Proper installation and operation of the piping system are key to achieving a long service life. Assuming a piping system is ideally installed and operated, the main factor affecting the pipe's service life is the number and magnitude of surge/water hammer events the system experiences. Surge/water hammer events are caused by valve operations, changing irrigation demand in the system, pump startup and shutdown, quick hydropower turbine shutdowns due to power failures, and any other factors causing fast changes in the piping system flow rate (B. Cronin P.E., personal communication, July 27, 2018).

USDA-NRCS's practice standard lifespan for irrigation pipeline is 20 years (NRCS n.d.). This lifespan is based on long-term experience with primarily PVC pipe irrigation system installations (B. Cronin P.E., personal communication, July 27, 2018). The Plastics Pipe Institute's online software indicates that with the average number of surge/water hammer events expected in a pipeline network, the lifespan of a typical 24-inch, 125-psi-pressure-rated PVC pipe would 14 years with a safety factor of two (Plastics Pipe Institute 2015). PVC is also more prone to failure under freezing conditions and the Ochoco system is used to deliver water several times during the winter. During these periods, a PVC pipe system would be more likely to freeze and potentially rupture and fail. PVC piping has been installed in irrigation districts in the Deschutes Basin and experienced premature failure, especially in Districts where water is delivered during the winter. Considering the information above, a PVC design life of 33 years was assumed for this analysis.

Unlike HDPE, PVC pipe cannot be shaped to conform into canal alignments; therefore, elbows would be required. The cost of elbow fittings was estimated by assuming one elbow every 100 feet at a cost of $100 per 1 inch of pipe diameter. To account for additional PVC costs, an additional 5 percent cost was added (Table D-26). The same construction multipliers for labor and installation were used as the Preferred Alternative.

Table D-26. PVC Piping Alternative Costs.

Feature	Diameter (in)	Quantity	Units	Unit Cost	Elbow Qty	Subtotal
PVC Pipe	4	2,103	Ft	$1.90	21	$38,000
PVC Pipe	6	6,697	Ft	$3.90	67	$205,000
PVC Pipe	8	6,279	Ft	$6.70	63	$284,000
PVC Pipe	12	7,460	Ft	$14.40	75	$604,000
PVC Pipe	16	13,211	Ft	$16.77	132	$1,350,000
PVC Pipe	18	163	Ft	$19.72	2	$19,000
PVC Pipe	20	12,995	Ft	$30.40	130	$2,049,000
PVC Pipe	24	25,078	Ft	$40.04	251	$5,155,000
PVC Pipe	26	4,098	Ft	$44.08	41	$718,000
PVC Subtotal		**78,083**	**Ft**	**N/A**	**782**	**$10,422,000**
Steel Pipe	72	8,030	Ft	$316.86	80	$7,806,000
Steel Pipe	78	6,250	Ft	$343.36	63	$6,584,000
Steel Pipe	90	38,930	Ft	$396.35	390	$47,334,000
Steel Subtotal		**53,210**	**Ft**	**N/A**	**533**	**$61,724,000**
Steel + PVC Subtotal		**131,293**	**Ft**	**N/A**	**1,315**	**$72,146,000**
Engineering, Construction Management, Survey (6%)						$4,329,000
Construction Management / General Contractor (12%)						$8,658,000
Contingency (30%)						$25,540,000
Cost of non-pipe features – same as Preferred Alternative						$14,868,000
TOTAL						**$125,541,000**

Totals are rounded to the nearest $1,000. Prepared August 2020

D.5 Net Present Value of the Preferred Alternative and Other Piping Materials Considered

This section presents the estimated net present value of the Preferred Alternative, eliminated alternatives, and other piping materials considered. This analysis compares installation and operation of pipes and canals only. The following features are not included in this analysis: 10.5 miles of canal bank raises, pump stations, and general infrastructure improvement such as weirs and siphons. The Preferred Alternative is HDPE pipe for McKay, Grimes Flat, and IronHorse, which is shown in green.

Discount Rate: 2.75%

Period of Analysis: 100 years

Table D-27. Net Present Value of the Preferred Alternative and the Eliminated Alternatives.

	HDPE Piping Alternative	PVC Piping Alternative	Steel Piping Alternative	Canal Lining Alternative
Design Life (years)	100	33	50	33
Capital Costs				
McKay	$4,212,000	$6,816,000	$12,790,000	N/A
Grimes Flat	$4,170,000	$9,173,000	$20,545,000	$19,894,000
Crooked River Canal	$29,009,000	N/A	$57,633,000	$23,133,000
IronHorse	$5,177,000	N/A	$10,099,000	$5,235,000
Ochoco Main Canal – Upper Middle	$12,860,000	N/A	$26,952,000	$12,971,000
Net Present Value of Replacement Costs[1]				
McKay	N/A	$2,101,000	$2,597,000	N/A
Grimes Flat	N/A	$2,828,000	$4,172,000	$14,308,000
Crooked River Canal	N/A	N/A	$11,702,000	$16,638,000
IronHorse	N/A	N/A	$2,051,000	$3,765,000
Ochoco Main Canal – Upper Middle	N/A	N/A	$5,473,000	$9,329,000
Annual O&M Costs				
McKay	$19,000	$19,000	$19,000	N/A
Grimes Flat	$23,000	$23,000	$23,000	$34,000
Crooked River Canal	$17,000	N/A	$17,000	$25,000
IronHorse	$3,000	N/A	$3,000	$5,000

	HDPE Piping Alternative	PVC Piping Alternative	Steel Piping Alternative	Canal Lining Alternative
Ochoco Main Canal – Upper Middle	$9,000	N/A	$9,000	$13,000
Percent Change in O&M from current system	-15%	-15%	-15%	25%
Net Present Value of O&M Costs				
McKay	$645,000	$645,000	$645,000	N/A
Grimes Flat	$781,000	$781,000	$781,000	$1,154,000
Crooked River Canal	$577,000	N/A	$577,000	$849,000
IronHorse	$102,000	N/A	$102,000	$170,000
Ochoco Main Canal – Upper Middle	$306,000	N/A	$306,000	$441,000
Total Net Present Value				
McKay	$4,857,000	$9,562,000	$16,032,000	N/A
Grimes Flat	$4,951,000	$12,782,000	$25,498,000	$35,356,000
Crooked River Canal	$29,586,000	N/A	$69,912,000	$40,622,000
IronHorse	$5,279,000	N/A	$12,252,000	$9,170,000
Ochoco Main Canal – Upper Middle	$13,166,000	N/A	$32,731,000	$22,739,000

Totals are rounded to the nearest $1,000. Prepared August 2020

Note:

[1] For PVC pipe, 33 percent of the pipe was replaced at 33 years and 67 percent replaced at 66 years. For steel pipe, 25 percent was replaced at 50 years and 75 percent replaced at 75 years. For canal lining, 100 percent was replaced at both 33 years and 66 years.

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Watershed Protection and Flood Prevention Act of 1954, Pub. L. No. 83-566, 68 Stat. 666.

Appendix E

Other Supporting Information

E.1 Intensity Threshold Table

This section presents the intensity threshold table used to quantify effects on resources of concern because of the proposed action.

Table E-1. Intensity Threshold Table for the Ochoco Irrigation District Irrigation Modernization Project.

Negligible	Changes in the resource or resource related values would be below or at the level of detection. If detected, the effects on the resource or environment would be considered slight with no perceptible impacts.
Minor	Changes in resource or resource related values would be measurable but small. The effects on the resource or the environment would be localized.
Moderate	Changes in the resource or resource related values would be measurable and apparent. The effects on the resource or the environment would be relatively local.
Major	Changes in resource or resource related values would be measurable and substantial. The effects on the resource or the environment would be regional.
Impact Duration Definitions	
Temporary	Transitory effects which only occur over a period of days or months
Short-term effect	Resource or resource related values recover in fewer than five years
Long-term effect	Resource or resource related values take greater than five years to recover

E.2 Supporting Calculations for Soils

Table E-2. Project Area Length Crossing Farmland.

NRCS Farmland Class	Project Area (percent)	Project Area (miles)
Prime farmland if irrigated	41.4%	13.2
No digital data available[1]	33.9%	10.8
Farmland of statewide importance	13.4%	4.3
Not prime farmland	10.8%	3.5
Prime farmland if irrigated and drained	0.4%	0.1
Total	**100%**[2]	**31.9**

Source: NRCS gSSURGO FY2018 data.

[1] The area for which data are not available consists mostly of the area along McKay Creek and the Grimes Flat laterals.

[2] May not sum due to rounding.

References

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). 2018. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov/. Accessed August 28, 2020.

E.3 Supporting Calculations for Land Use

Table E-3. Project Area Length Crossing Land Use Classes.

Land Use	Percent of the Project Area Length	Project Area Length Crossing each Land Use Class (miles)
Agriculture[1]	19%	6.1
Developed Use[2]	36%	11.3
Non-cultivated Use[3]	45%	14.5
Total	**100%**	**31.9**

Source: USGS 2016.
[1] Hay/Pasture, Cultivated Crops.
[2] High, medium, low intensity development, developed open space.
[3] Shrub/scrub, barren land, evergreen forest, woody wetlands.

Table E-4. Project Area Length Crossing Land Ownership.

Land Ownership	Percent of the Project Area Length	Project Area Length Crossing each Land Use Class (miles)
City	4%	1.5
County	0%	0.1
Private	91%	28.8
Tax lot gap[1]	4%	1.4
Reclamation	0%	0.2
Total	**100%[2]**	**32**

Source: Crook County GIS
[1] The majority of tax lot gaps consist of roadways.
[2] May not sum due to rounding.

References

U.S. Geological Survey (USGS). 2016. National Land Cover Database (2016 Edition). U.S. Geological Survey, Sioux Falls, SD. Website: https://www.mrlc.gov/data. Accessed January 13, 2019.

Crook County GIS. 2017. Crook County GIS Open Data Portal: Taxlots. Prineville, OR. Website: https://data-crookcounty.opendata.arcgis.com/. Accessed December 2019.

E.4 Supporting Information for Vegetation Resources

This appendix section presents supporting data used to evaluate effects of the Preferred Alternative with respect to vegetation resources.

The Deschutes Basin Board of Control determines a weed to be noxious if it is "injurious to public health, agriculture, recreation, wildlife, or any public or private property," and "impacts and displaces desirable vegetation." Furthermore, it is recognized that certain noxious weeds are so pervasive that they have been classified by ORS 569.350 to be a menace to public welfare. The Crook County Noxious Weed Policy and Classification System designates three weed categories. "A" designated weeds are of highest priority for control and are subject to intensive eradication, containment, or control measures using county resources. "B" designated weeds have a limited distribution; intensive containment control and monitoring by landowners is required, and support from the County is provided when resources allow. "C" designated weeds are the lowest priority for control and have a widespread distribution; landowner control and monitoring is recommended (Deschutes County 2020; Crook County 2018).

Table E-5. Weeds Known to Occur within the Ochoco Irrigation District Infrastructure Modernization Project Area.

Vegetation Species	Scientific Name	Crook County Noxious Weed Rating (Crook 2018)
Bull thistle	*Cirsium vulgare*	C
Canada thistle	*Cirsium arvense*	B
Canary reed grass	*Phalaris arundinacea* L.	B†
Cheat grass	*Brachypodium sylvaticum*	B†
Dalmatian toadflax	*Linaria dalmatica*	A
Diffuse knapweed	*Centaurea diffusa*	B
Gorse	*Ulex europaeus* L.	B†
Kochia	*Kochia scoparia*	B†
Leafy spurge	*Euphorbia esula*	A
Medusahead rye	*Taeniatherum caput-medusae*	B
Perennial pepper weed	*Lepidium latifolium*	B
Poison hemlock	*Conium maculatum*	B
Puncture vine	*Tribulus terrestris*	B
Russian knapweed	*Acroptilon repens*	B

Vegetation Species	Scientific Name	Crook County Noxious Weed Rating (Crook 2018)
Scotch thistle	*Onopordum acanthium*	A
Spotted knapweed	*Centaurea stoebe*	B
Whitetop-hoary cress	*Lepidium draba*	B
Yellow starthistle	*Centaurea solstitialis*	A
Sago pond weed*	*Stuckenia pectinate* L.	Nuisance weed or noxious weed in irrigation canals‡
Horned pond weed*	*Zannichellia palustris* L.	Nuisance weed in irrigation canals
Finamentous algae*	Various species	Nuisance weed in irrigation canals

Source: D. Wood, personal communication, October 30, 2019
Noxious Weed Rating [Source: Crook County Noxious Weed List 2018 (Crook County 2018)]
A: Highest priority noxious weed designated by the Board
B: Distribution is limited in the county, region, or state. Intensive control to limit or eliminate reproduction and spread will occur at the county level as resources and situation allow.
C: Distribution is widespread in the county, region, or state, therefore eradication is unlikely and treatment is a lower priority.
Not applicable because pond weed is not classified as a noxious weed. However, it is present throughout the project area.
† Noxious weed according to Oregon Department of Agriculture
‡ USDA Plant Guide https://plants.sc.egov.usda.gov
*Found in District canals and laterals (FCA 2018)

References

Crook County. 2018. Crook County Noxious Weed List. List provided by Debbie Wood Crooked River Weed Management Area Coordinator. October 30, 2019.

Deschutes County. 2020. Deschutes County Weed List. Website: https://www.deschutes.org/sites/default/files/fileattachments/road/page/567/20170123_deschutes_county_weed_list.pdf. Accessed: August 27, 2020.

Farmers Conservation Alliance (FCA). 2018. Preliminary Investigative Report Questionnaire for Ochoco Irrigation District.

Wood, Debbie (Crooked River Weed Management Area Coordinator). 2019. Personal communication (email) with Kristin Alligood (FCA) October 30, 2019.

E.5 Supporting Information for Fish and Aquatic Resources

This appendix section presents supporting information associated with Primary Constituent Elements for critical habitat of federally listed species.

Table E-6. Primary Constituent Elements for Bull Trout.

Primary Constituent Element Number	Habitat Description and Characteristics
PCE 1	Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to contribute to water quality and quantity and provide thermal refugia.
PCE 2	Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
PCE 3	An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
PCE 4	Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
PCE 5	Water temperatures ranging from 2 to 15 °C (36 to 59 °F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
PCE 6	In spawning and rearing areas, substrate of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. A minimal amount of fine sediment, generally ranging in size from silt to coarse sand, embedded in larger substrates, is characteristic of these conditions. The size and amounts of fine sediment suitable to bull trout will likely vary from system to system.
PCE 7	A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, minimal flow departure from a natural hydrograph.
PCE 8	Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
PCE 9	Sufficiently low levels of occurrence of nonnative predatory (e.g., lake trout, walleye, northern pike, smallmouth bass); interbreeding (e.g., brook trout); or competing (e.g., brown trout) species that, if present, are adequately temporally and spatially isolated from bull trout.

Table E-7. Fish and Aquatic Species within the Area of Potential Effect for the Ochoco Irrigation District Infrastructure Modernization Project.

Species Common Name	Scientific Name	Crooked River	Prineville Reservoir	McKay Creek	Lower Deschutes
Bull trout	*Salvelinus confluentus*	X		X	X
Steelhead trout	*Oncorhynchus mykiss*	X		X	X
Spring Chinook salmon	*Oncorhynchus tshawytscha*	X			X
Sockeye salmon	*Oncorhynchus nerka*	X			X
Redband trout	*Oncorhynchus mykiss gairdnerii*	X	X	X	X
Summer/ Fall Chinook Salmon	*Oncorhynchus tshawytscha*				X
Mountain whitefish	*Prosopium williamsoni*	X	X	X	X
Pacific lamprey	*Entosphenus tridentatus*				X
Largescale sucker	*Catostomus marcocheilus*	X	X	X	X
Bridgelip sucker	*Catostomus columbianus*	X	X	X	X
Chiselmouth	*Acrocheilus alutaceus*	X	X	X	X
Dace species	*Rhinichthys* (spp.)	X	X	X	X
Northern pikeminnow	*Ptychocheilus oregonensis*	X	X		X
Sculpin species	Family Cottidae	X	X	X	X
Brook trout	*Salvelinus fontinalis*	X	X	X	X
Brown trout	*Salmo trutta*	X	X	X	X
Floater species mussels	*Anodonta* (spp.)	X			
Western pearlshell mussel	*Margaritifera falcata*	X		X	X
Western ridged mussel	*Gonidea angulata*	X	X		

Source: Adapted from DRAFT Deschutes Basin Habitat Conservation Plan October 2019

References

Arnold Irrigation District (AID), Central Oregon Irrigation District (COID), Lone Pine Irrigation District (LPID), North Unit Irrigation District (NUID), Ochoco Irrigation District (OID), Swalley Irrigation District (SID), Three Sisters Irrigation District (TSID), Tumalo Irrigation District (TID), City of Prineville. 2019. Draft Deschutes Basin Habitat Conservation Plan.

E.6 Supporting Information for Water Resources

This appendix section presents the methodology and data included in the Ochoco Irrigation District (OID) System Improvement Plan (Black Rock 2018). The findings presented in Black Rock (2018) were used to evaluate the potential effects of the Preferred Alternative on water resources.

Black Rock Consulting worked with the District to coordinate a seepage loss study performed by Farmers Conservation Alliance staff under direction from Black Rock Consulting/Kevin L. Crew, P.E and David C. Prull, P.E.. During the summer of 2016, the Seepage Loss Assessment Program (LAP), supported by Oregon State University and the Oregon Water Resources Department, was implemented in 7 of the 8 Central Oregon irrigation districts, including OID, to inform the districts of current system losses. The program included the use of newly purchased and calibrated Sontek Flowtracker II and Doppler-Boat technology, manual, and office and field training, all in accordance with the United States Geological Survey and United States Bureau of Reclamation (USGS 2010). The program was managed by Oregon Registered Professional Engineers, Kevin L. Crew, P.E. and David C. Prull, P.E.

The primary purpose of the LAP was to perform a one-time measurement program in each District. The program provided the approximate seepage losses in elements of each system. The measurements were performed at different times of the irrigation season within each District. Therefore, the percentage of peak flow at the time of measurement varied by District as the LAP team entered, measured, and exited each District. The results were used to provide a strong indication of losses. The results were interpolated or extrapolated based upon the maximal expected loss within each District. The final loss information was used to identify losses by project phase or lateral.

Flow diversion data for the District over the last seven years of operation were also evaluated to determine a historical peak diversion rate of approximately 350 cfs (approximately 350 cfs peak from Ochoco Reservoir and the Crooked River Diversion including 20 cfs supply to the Breese Lateral and 4 cfs supply to the Rye Grass Canal). The District identified a desired delivery rate of up to 7.5 GPM/Acre, its peak certificate rate. The total acreages assessed for the OID system were used to estimate that a 309 cfs peak diversion rate would allow the District to deliver 7.5 GPM/Acre with a fully piped system (including all laterals and private laterals down to the individual patron turnouts). A fully piped conveyance system would typically no longer lose any water to seepage, evaporation, and end spills. With no water loss to due to seepage, evaporation, or end spills, the District could reduce its peak diversion by 41 cfs, reducing it from 350 cfs to 309 cfs, and still deliver up to 7.5 GPM/Acre.

For OID, the LAP was implemented throughout the District's primary canal and system laterals. Direct measurements identified a total seepage loss of approximately 53 cfs in the District's system. The District could allocate 41 cfs, or 77 percent, of the water saved through modernization instream and still maintain its ability to deliver its desired rate of 7.5 GPM/Acre. The District could retain 23 percent of the water saved through modernization to maintain its ability to deliver its desired rate under its existing water rights.

To determine water savings for the Grimes Flat Laterals, the direct loss measurements were used for greater precision (see Table E-7). 4.9 cfs of loss were identified in the Grimes Flat laterals by the LAP. This loss due to seepage and evaporation would be eliminated under the Preferred Alternative. All of the loss and associated savings would be water from the Crooked River: 77 percent of the water saved through the Preferred Alternative, or 3.8 cfs, would be allocated for instream use; 23 percent of the water saved through the Preferred Alternative, or 1.1 cfs, would be retained by the District to maintain its ability to deliver its desired rate under its existing water rights.

To determine water savings for the IronHorse section, the direct loss measurements of the Crooked River Distribution Canal were used for greater precision. The loss of the entire Crooked River Distribution Canal section was then prorated based on the linear feet of the proposed project (8,800 LF) resulting in an estimated 1.02 cfs of loss. This loss due to seepage and evaporation would be eliminated under the Preferred Alternative. All of the loss and associated savings would be water from the Crooked River. The District has agreed to allocate 100 percent of the water saved in this Section through the Preferred Alternative.

Table E-8. Ochoco Irrigation District Water Loss and Conservation in the Project Area.

Canal/Lateral	Seepage Loss Measured (cfs)	Water Conserved for Instream Use (cfs)[1]	Water Conserved for Instream Use (acre-feet)	Water Savings Retained by the District (cfs)[1]	Water Savings Retained by the District (acre-feet)
Grimes Flat Laterals	4.9	3.8	1,613	1.1	467
IronHorse section of the Crooked River Distribution Canal	1.02	1.02	433	0.0	0
Total	**5.92**	**4.82**	**2,046**	**1.1**	**467**

[1] While water loss must be initially calculated in cfs, the total volume of water lost through the season is calculated to be 2,046 acre-feet. It may be that upon further discussion with ODFW, OWRD, and other stakeholders, the rate protected instream may change, but the volume would remain the same.

Crooked River Reach

This section presents supporting calculations used when evaluating effects of the proposed action with respect to water resources. See Figure C-3 in Appendix C for location of gauges.

Crooked River Below Prineville Reservoir

This subsection presents supporting calculations used when evaluating the effects of the Preferred Alternative with respect to water resources in the Crooked River below Prineville Reservoir at OWRD Gauge No. 14080500.

Table E-9. Streamflow metrics for the Crooked River below Prineville Reservoir at OWRD Gauge No. 14080500.

Month	Pre-Project Median Daily Average Streamflow (cfs)[1]	Streamflow Protected Instream Through Project (cfs)[2,3]	Streamflow Released from Prineville Reservoir for the McKay Switch Project (cfs)[4]	Post-Project Median Daily Average Streamflow (cfs)[2,3,4]	Post-Project Percentage Increase in Median Daily Average Streamflow
Oct	103.0	4.82	16	119.0	15.5%
Nov	72.0	0	0	72.0	0.0%
Dec	69.0	0	0	69.0	0.0%
Jan	75.0	0	0	75.0	0.0%
Feb	79.0	0	0	79.0	0.0%
Mar	109.0	0	0	109.0	0.0%
Apr	340.0	4.82	16	356.0	4.7%
May	261.0	4.82	16	277.0	6.1%
Jun	231.0	4.82	16	247.0	6.9%
Jul	228.0	4.82	16	244.0	7.0%
Aug	229.0	4.82	16	245.0	7.0%
Sep	213.0	4.82	16	229.0	7.5%

[1] Streamflow statistics represent data collected during water years 1988 through 2018.
[2] These data include 3.8 cfs protected instream through the Grimes Flat Lateral improvements and 1.02 cfs protected instream through the IronHorse section improvements.
[3] The distribution of conserved water over the year is for illustrative purposes. While water loss must be initially calculated as a rate (cfs), the total volume of water lost through the season is calculated to be 2,046 acre-feet. It may be that, upon further discussion with ODFW, OWRD, and other stakeholders, the rate protected instream each month may change. The total volume protected instream would remain the same.
[4] The conserved water protected instream through the project, which appears as "Streamflow Protected Through Project" would have been released for diversion by the District prior to the completion of the project and would not contribute to increased streamflow in this reach.

Crooked River at Prineville, Oregon

This subsection presents supporting calculations used when evaluating the effects of the Preferred Alternative with respect to water resources in the Crooked River at Prineville, Oregon at OWRD Gauge No. 14081500.

Table E-10. Streamflow metrics for the Crooked River at Prineville, Oregon at OWRD Gauge No. 14081500.

Month	Pre-Project Median Daily Average Streamflow (cfs)[1]	Streamflow Protected Through Project (cfs)[2,3]	Post-Project Median Daily Average Streamflow (cfs)[1,2,3]	Post-Project Percentage Increase in Median Daily Average Streamflow
Oct	80.0	4.82	84.82	6.0%
Nov	84.0	0	84.0	0.0%
Dec	88.0	0	88.0	0.0%
Jan	90.0	0	90.0	0.0%
Feb	101.0	0	101.0	0.0%
Mar	536.0	0	536.0	0.0%
Apr	187.5	4.82	192.32	2.6%
May	78.0	4.82	82.82	6.2%
Jun	65.5	4.82	70.32	7.4%
Jul	75.0	4.82	79.82	6.4%
Aug	84.5	4.82	89.32	5.7%
Sep	77.0	4.82	81.82	6.3%

[1] Streamflow statistics represent data collected during water years 2015 through 2018.
[2] These data include 3.8 cfs protected instream through the Grimes Flat Lateral improvements and 1.02 cfs protected instream through the IronHorse section improvements.
[3] The distribution of conserved water over the year is for illustrative purposes. While water loss must be initially calculated as a rate (cfs), the total volume of water lost through the season is calculated to be 2,046 acre-feet. It may be that, upon further discussion with ODFW, OWRD, and other stakeholders, the rate protected instream each month may change. The total volume protected instream would remain the same.

Crooked River near Terrebonne, Oregon

This subsection presents supporting calculations used when evaluating the effects of the Preferred Alternative with respect to water resources in the Crooked River near Terrebonne, Oregon at OWRD Gauge No. 14087300.

Table E-11. Streamflow metrics for the Crooked River near Terrebonne, Oregon at OWRD Gauge No. 14087300.

Month	Pre-Project Median Daily Average Streamflow (cfs)1	Streamflow Protected Downstream from Prineville Reservoir through Project (cfs)2,3	Minimum Streamflow Protected Through McKay Switch Project (cfs)4	Post-Project Median Daily Average Streamflow (cfs)1,2,3	Post-Project Percentage Increase in Median Daily Average Streamflow
Oct	174.0	4.82	0.18	179.00	2.9%
Nov	142.0	0	0	142.0	0.0%
Dec	135.0	0	0	135.0	0.0%
Jan	160.0	0	0	160.0	0.0%
Feb	202.5	0	0	202.5	0.0%
Mar	253.0	0	0	253.0	0.0%
Apr	420.5	4.82	11.2	436.52	3.8%
May	185.0	4.82	7.0	196.82	6.4%
Jun	118.5	4.82	1.7	125.02	5.5%
Jul	70.0	4.82	0.23	75.05	7.2%
Aug	81.0	4.82	0	85.82	6.0%
Sep	146.5	4.82	0	151.32	3.3%

[1] Streamflow statistics represent data collected during water years 1993 through 2018.
[2] These data include 3.8 cfs protected instream through the Grimes Flat Lateral improvements and 1.02 cfs protected instream through the IronHorse section improvements.
[3] The distribution of conserved water over the year is for illustrative purposes. While water loss must be initially calculated as a rate (cfs), the total volume of water lost through the season is calculated to be 2,046 acre-feet. It may be that, upon further discussion with ODFW, OWRD, and other stakeholders, the rate protected instream each month may change. The total volume protected instream would remain the same.
[4] These live flow water rights created through the McKay Switch Project would protect up to 11.2 cfs instream, with streamflow benefits varying based on water availability in McKay Creek. Using data from Gauge No. 14085700, a minimum post-project streamflow was determined and is used for analyses on minimum protected inflows to the Crooked River at the mouth of McKay Creek.

McKay Creek Reach

This subsection presents supporting calculations used when evaluating the effects of the Proposed Action on water resources in McKay Creek. OWRD Gauge No. 14085700 is located on McKay Creek at Poppy Creek, just upstream of the upstream extent of the project area at River Mile (RM) 12.0. Streamflow at this gauge approximates streamflow entering the project area. Several tributaries enter McKay Creek downstream of this gauge and provide additional streamflow between the gauge and RM 6.0, the downstream extent of the irrigation diversions included in the McKay Creek Switch. It is assumed that McKay Creek irrigators have diverted up to 11.2 cfs from the creek between RM 12.0 and RM 6.0 whenever that water is available. It is also assumed that pre-project streamflow statistics at Gauge No. 14085700 approximate minimum (i.e., without any additional tributary inputs) post-project streamflow statistics between RM 12.0 and RM 0.0.

Table E-12. Streamflow Metrics for McKay Creek.

Month	Pre-Project Median Daily Average Streamflow (cfs) Upstream from the Project Reach[1]	Water Rights Protected Instream Through Project (cfs)[2]	Minimum Post-Project Median Daily Average Streamflow Through the Project Reach (cfs)[3]	Oregon Department of Fish and Wildlife Instream Water Right on the Lower Reach of McKay Creek [3,4]
Oct	0.18	11.20	0.18	0.51
Nov	0.61	0	0.61	1.59
Dec	1.90	0	1.90	6.16
Jan	6.20	0	6.20	11.00
Feb	13.00	0	13.00	26.0 / 28.4
Mar	21.00	0	21.00	33.70
Apr	25.50	11.20	25.50	34.40
May	7.00	11.20	7.00	21.20
Jun	1.70	11.20	1.70	6.37
Jul	0.20	11.20	0.20	1.16
Aug	0	11.20	0	0.36
Sep	0	11.20	0	0.36

[1] Streamflow statistics represent median daily average streamflow by month in McKay Creek above Poppy Creek near Prineville, Oregon at OWRD Gauge No. 14085700. Data were collected during water years 2009 through 2018.
[2] Theses live flow water rights would protect up to 11.2 cfs instream, with streamflow benefits varying based on water availability in McKay Creek
[3] ODFW Certificate 73200
[4] Instream flow numbers for February 1-14 are 26 cfs; for February 15-28, flow numbers are 28.4 cfs.

Allocation of Conserved Water Program

This section presents information on the State of Oregon's Allocation of Conserved Water Program.

The Oregon Water Resources Department manages the Allocation of Conserved Water Program. The Allocation of Conserved Water Program allows a water user who conserves water to use a portion of the conserved water on additional lands, lease or sell the water, or dedicate the water to instream use. Use of this program is voluntary and provides benefits to both water right holders and instream values.

The statutes authorizing the program were originally passed by the Legislative Assembly in 1987. The primary intent of the law is to promote the efficient use of water to satisfy current and future needs—both out-of-stream and instream. The statute defines conservation as "the reduction of the amount of water diverted to satisfy an existing beneficial use achieved either by improving the technology or method for diverting, transporting, applying or recovering the water or by implementing other approved conservation measures."

In the absence of Department approval of an allocation of conserved water, water users who make the necessary investments to improve their water use efficiency are not allowed to use the conserved water to meet new needs; instead, any unused water remains in the stream where it is available for the next appropriator. In exchange for granting the user the right to "spread" a portion of the conserved water to new uses, the law requires allocation of a portion to the state for instream use.

After mitigating the effects on any other water rights, a new water right certificate is issued with the original priority date reflecting the reduced quantity of water being used with the improved technology. A certificate is issued for the state's instream water right, and, if requested, a certificate is issued for the applicant´s portion of the conserved water. The priority dates for the state's instream certificate and the applicant's portion of conserved water must be the same date and is be either the same date as the original water right or 1-minute junior to the original right.

References

Black Rock Consulting and Farmers Conservation Alliance (Black Rock). 2018, Ochoco Irrigation District System Improvement Plan.

Oregon Water Resources Department (OWRD). 2017. Allocation of Conserved Water. Retrieved from: http://www.oregon.gov/owrd/pages/mgmt_conserved_water.aspx. Accessed November 10, 2017.

U.S. Geological Survey (USGS). 2010. Discharge Measurements at Gaging Stations – Chapter 8 of Book 3, Section A. Retrieved from: https://pubs.usgs.gov/tm/tm3-a8/tm3a8.pdf. Accessed January 31, 2020,

E.7 Supporting Information for Wildlife Resources

Table E-11. Migratory Bird Treaty Act/Bald and Golden Eagle Protection Act Species Potentially Occurring within the Project Area.

Migratory Bird Treaty Act/Bald and Golden Eagle Protection Act Species	Scientific Name
Bald eagle	*Haliaeetus leucocephalus*
Brewer's sparrow	*Spizella breweri*
Calliope hummingbird	*Stellula calliope*
Cassin's finch	*Carpodacus cassinii*
Eared grebe	*Podiceps nigricollis*
Flammulated owl	*Otus flammeolus*
Fox sparrow	*Passerella iliaca*
Golden eagle	*Aquila chrysaetos*
Green-tailed towhee	*Pipilo chlorurus*
Lewis's woodpecker	*Melanerpes lewis*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed curlew	*Numenius americanus*
Olive-sided flycatcher	*Cantopus cooperi*
Peregrine falcon	*Falco peregrinus*
Pinyon jay	*Gymnorhinus cyanocephalus*
Rufous hummingbird	*Selasphorus rufus*
Sage thrasher	*Oreoscoptes montanus*
Short-eared owl	*Asio flammeus*
Swainson's hawk	*Buteo swainsoni*
Western grebe	*Aechmophorus occidentalis*
White-headed woodpecker	*Picoides albolavatus*
Williamson's sapsucker	*Sphyrapicus thyroidus*
Willow flycatcher	*Empidonax traillii*

Source: USFWS 2017

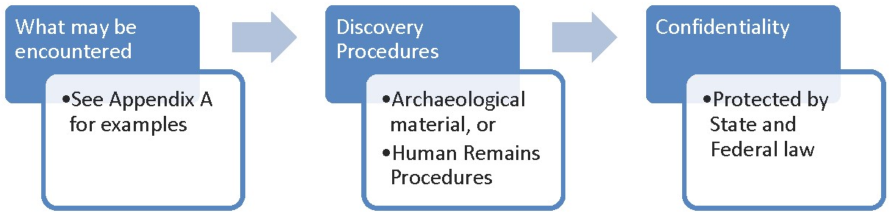
E.8 Supporting Information for Cultural Resources

ARCHAEOLOGICAL INADVERTENT DISCOVERY PLAN (IDP)

PROJECT NAME: OCHOCO IRRIGATION DISTRICT INFRASTRUCTURE MODERNIZATION PROJECT

PROJECT MANAGER, Bruce Scanlon July 1, 2020

HOW TO USE THIS DOCUMENT



Archaeology consists of the physical remains of the activities of people in the past. This IDP should be followed should any archaeological sites, objects, or human remains are found. These are protected under Federal and State laws and their disturbance can result in criminal penalties.

This document pertains to the work of the Contractor, including any and all individuals, organizations, or companies associated with Ochoco Irrigation District (OID) Infrastructure Modernization Project.

WHAT MAY BE ENCOUNTERED

Archaeology can be found during any ground-disturbing activity. If encountered all excavation and work in the area MUST STOP. Archaeological objects vary and can include evidence or remnants of historic-era and precontact activities by humans. Archaeological objects can include but are not limited to:

- **Stone flakes, arrowheads, stone tools, bone or wooden tools, baskets, beads.**
- Historic building materials such as **nails, glass, metal** such as cans, barrel rings, farm implements, **ceramics, bottles, marbles, beads.**
- Layers of **discolored earth** resulting from hearth fire
- Structural remains such as **foundations**
- **Shell** Middens
- **Human skeletal remains** and/or **bone fragments** which may be whole or fragmented.

For photographic examples of artifacts, please see Appendix A. (Human remains not included)

If there is an inadvertent discovery of any archaeological objects see procedures below.

If in doubt call it in.

DISCOVERY PROCEDURES: WHAT TO DO IF YOU FIND SOMETHING

1. Stop ALL work in the vicinity of the find

2. Secure and protect area of inadvertent discovery with 30 meter/100 foot buffer—work may continue outside of this buffer
3. Notify Project Manager and Agency Official
4. Project Manager will need to contact a professional archaeologist to assess the find.
5. If archaeologist determines the find is an archaeological site or object, contact SHPO. If it is determined to *not* be archaeological, you may continue work.

HUMAN REMAINS PROCEDURES

1. If it is believed the find may be human remains, stop ALL work.
2. Secure and protect area of inadvertent discovery with 30 meter/100 foot buffer, then work may continue outside of this buffer with caution.
3. Cover remains from view and protect them from damage or exposure, restrict access, and leave in place until directed otherwise. **Do not take photographs. Do not speak to the media**.
4. Notify:
    - Project Manager
    - Agency Official
    - Oregon State Police **DO NOT CALL 911**
    - SHPO
    - LCIS
    - Appropriate Native American Tribes
5. If the site is determined not to be a crime scene by the Oregon State Police, do not move anything! The remains will continue to be *secured in place* along with any associated funerary objects, and protected from weather, water runoff, and shielded from view.
6. Do not resume any work in the buffered area until a plan is developed and carried out between the State Police, SHPO, LCIS, and appropriate Native American Tribes and you are directed that work may proceed.

CONTACT INFORMATION

- Project Manager, Bruce Scanlon: (541) 447-6449
- NRCS Agency Official, Ron Alvarado: (503) 414-3201
- Reclamation Agency Official: Leah Meeks (208) 378-5025
- NRCS Archaeologist, Michael Petrozza: (503) 414-3212
- Reclamation Archaeologist, Chris Horting-Jones (503) 389-6541 ext. 236
- Oregon State Police, Sgt. Chris Allori: (503) 731-4717 Cell: (503) 708-6461
- Oregon State Historic Preservation Office (SHPO),
    - Jason Allen: (503) 986-0579
    - State Archaeologist, Dennis Griffin: (503) 986-0674
    - Asst. State Archaeologist, John Pouley: (503) 986-0675
- LCIS, Mitch Sparks: (503) 986-1086
- Appropriate Tribes
    - Confederated Tribes of the Warm Springs Reservation of Oregon
      Tribal Historic Preservation Officer, Robert Brunoe: (541) 553-2015

Confidentiality

The OID Infrastructure Modernization Project and employees shall make their best efforts, in accordance with federal and state law, to ensure that its personnel and contractors keep the discovery confidential. The media, or any third-party member or members of the public are not to be contacted or have information regarding the discovery, and any public or media inquiry is to be reported to the Natural Resources Conservation Service (NRCS). Prior to any release, the responsible agencies and Tribes shall concur on the amount of information, if any, to be released to the public.

To protect fragile, vulnerable, or threatened sites, the National Historic Preservation Act, as amended (Section 304 [16 U.S.C. 470s-3]), and Oregon State law (ORS 192.501(11)) establishes that the location of archaeological sites, both on land and underwater, shall be confidential.

Appendices and Supplementary Materials

B. Visual reference and examples of archaeology

Appendix A

Visual Reference Guide to Encountering Archaeology

Figure 1: Stone flakes

Figure 2: Stone tool fragments

Figure 3: Cordage

Figure 4: Shell midden

Figure 5: Historic glass artifacts

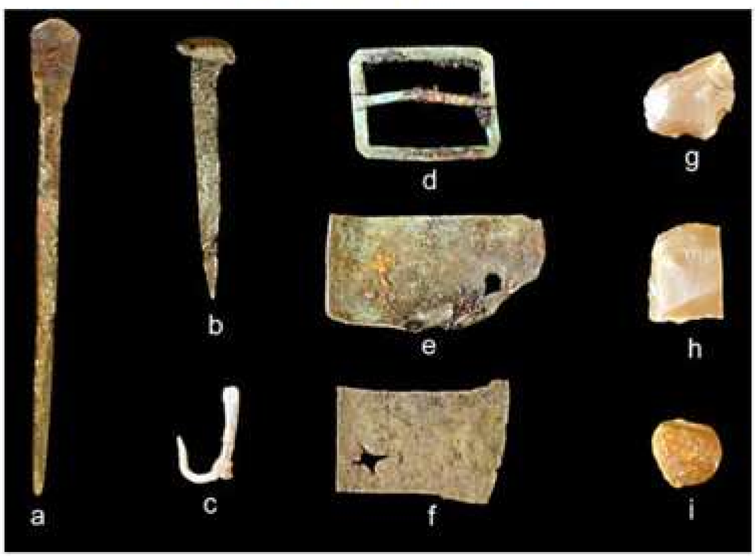


Figure 6: Historic metal artifacts

Figure 7: Historic building foundations

Figure 8: 18th Century ship

E.9 Guiding Principles

Guiding Principles (USDA 2017) The Guiding Principles identified in the PR&G are considered when developing and evaluating alternatives, as described below	
Healthy and Resilient Ecosystems	A primary objective of the PR&G analysis is the identification of alternatives that will protect and restore the functions of ecosystems. Alternatives should first avoid adverse impact. When environmental consequences occur, alternatives should minimize the impact and mitigate unavoidable damage. If damage occurs, mitigation to offset environmental damage must be included in the alternative's design and costs.
Sustainable Economic Development	Alternatives for resolving water resources problems should improve the economic well-being of the Nation for present and future generations. The PR&G analysis will consider the effects of alternatives on both water availability and water quality to evaluate the sustainability of economic activity and ecosystem services. Water use or management factors that provide improved sustainability or reduced uncertainty should be identified in alternatives.
Floodplains	The PR&G seek to avoid unwise use of floodplains and flood prone areas. Alternatives should avoid investments that adversely affect floodplain function, such that the floodplain is no longer self-sustaining. If an alternative impacts floodplain function, then the alternative should describe efforts to minimize and mitigate the impact and the residual loss of floodplain function. The PR&G investment evaluation of alternatives must be consistent with Executive Order 11988 of May 24, 1977 (Floodplain Management), as modified by Executive Order 13690 of January 30, 2015 (Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input), and the Federal Flood Risk Management Standard, which require executive departments and agencies to avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. The PR&G investment evaluation is informed by the processes to evaluate the impacts of Federal actions affecting floodplains consistent with Executive Order 11988, as amended.
Public Safety	An objective of the PR&G is to reduce risks to people, including life, injury, property, essential public services, and environmental threats concerning air and water quality. These risks to public health and safety must be evaluated and documented for all alternatives, including those using nonstructural approaches. The residual risks to public health and safety associated with each of the water investment alternatives should be described, quantified if possible, and documented.
Environmental Justice	An objective of the PR&G investment evaluation process is the fair treatment of all people including meaningful involvement in the public comment process. Any disproportionate impact to minority, Tribal, and low-income populations should be avoided. In implementing the PR&G, agencies should seek solutions that would eliminate or avoid disproportionate adverse effects on these communities. For watershed investments, particular attention should be focused to downstream areas. The study area may need to be reexamined to include the concerns of affected communities downstream of the immediate investment area. The PR&G process should document efforts to include the above-mentioned populations in the planning process. The PR&G process must be in compliance with Executive Order 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations). Applications of the PR&G process in USDA agencies must be in compliance with USDA DR 5600-002 (Environmental Justice).

Watershed Approach	A watershed approach must be used when completing a PR&G analysis. This approach recognizes that there may be upstream and downstream impacts of a water resources activity that may be outside of the applicable political or administrative boundaries. A watershed approach is not necessarily limited to analyzing impacts within a specific hydrologic unit. Rather, it is broad, systems- based framework that explicitly recognizes the interconnectedness within and among physical, ecological, economic, and social/cultural systems. A watershed approach enables examination of multiple objectives, facilitates the framing of water resources problems, incorporates a broad range of stakeholders, and allows for identification of interdependence of problems and potential solutions. In many instances, a specific hydrologic unit may be the appropriate scale to examine alternatives to address water resources problems and opportunities. In this case, the watershed would become the study area. In other cases, environmental, economic, or social conditions may merit a study area that is combination of various hydrologic units or other geographic groupings. Ideally, the area of analysis should represent a geographical area large enough to ensure plans address cause and effect relationships among affected resources, stakeholders, and investment options, both upstream and downstream of an investment site. The watershed approach also establishes the framework to examine cumulative effects and the interaction of a potential Federal investment with other water resources projects and programs. When considering the impact of Federal investments against some economic and ecological measures, the analysis may need to be expanded to include regional markets and habitat considerations beyond the initial study area (e.g., beyond the immediate hydrologic unit).

E.10 Consultation Letters

[These will be included in the Final Plan-EA.]