Appendix A

Comments and Responses

To be included in the final environmental assessment.

Appendix B

Project Map

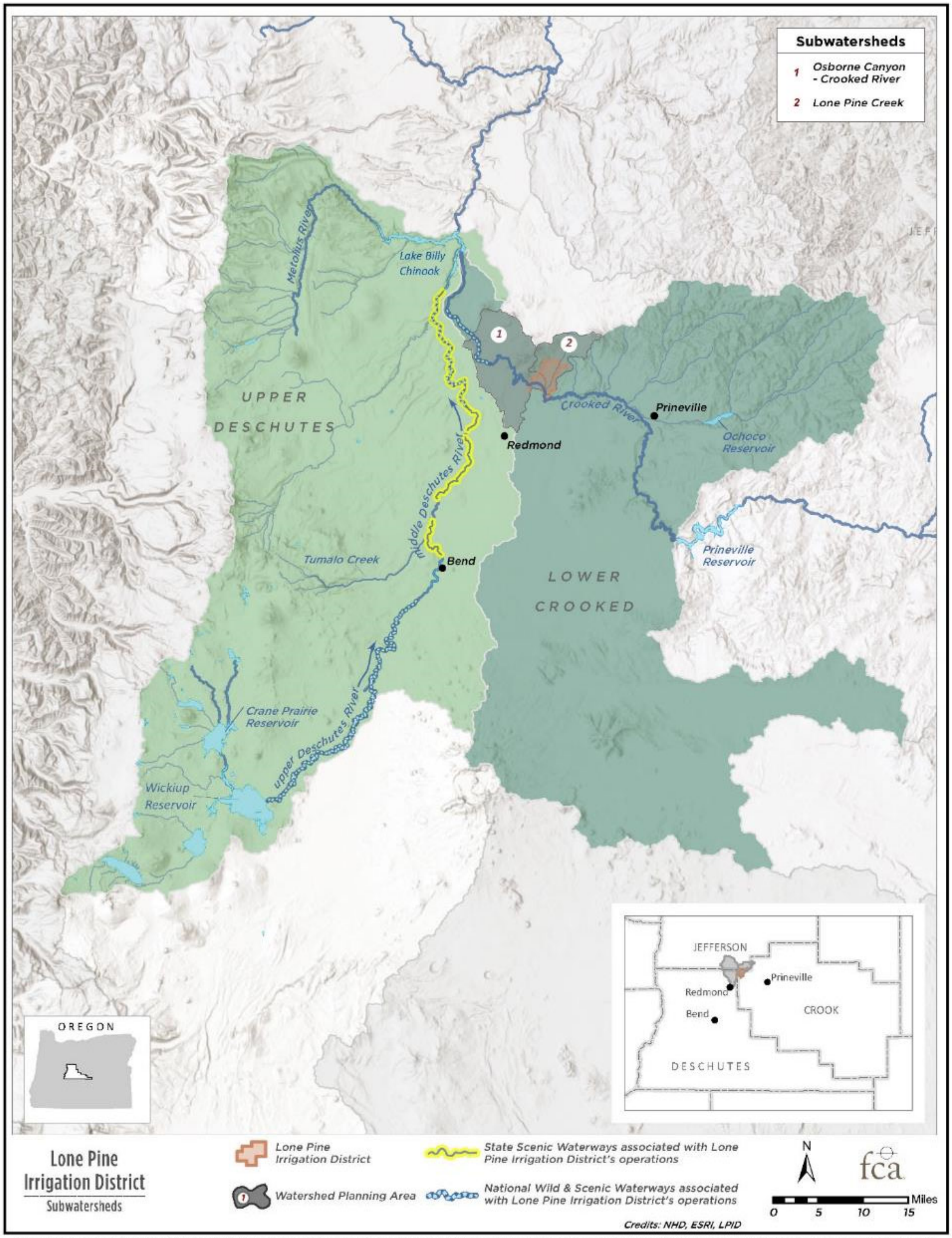

Figure B-1. The Upper Deschutes Watershed, Lower Crooked Watershed, and two subwatersheds comprising the Lone Pine Irrigation District Watershed planning area.

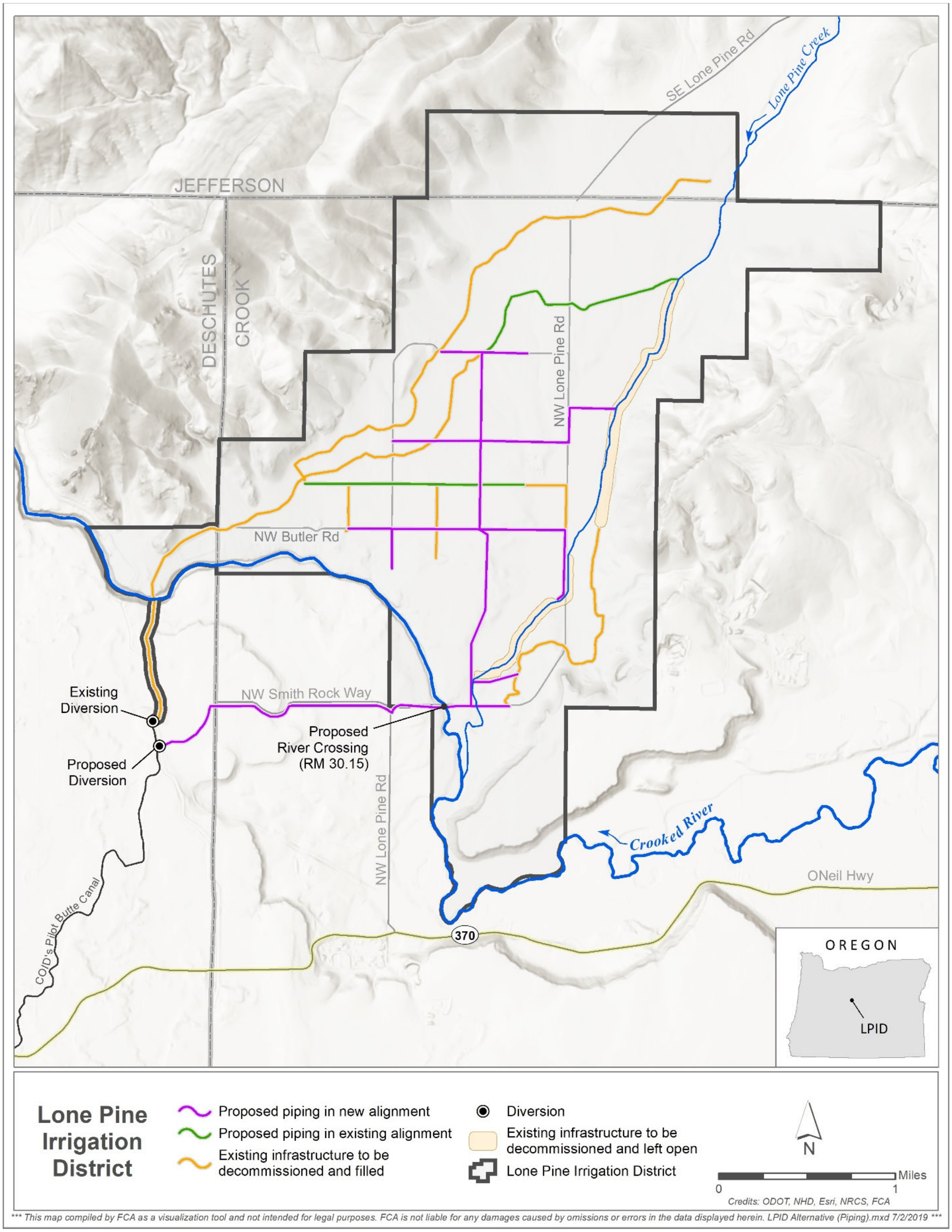

Figure B-2. Lone Pine Irrigation District's infrastructure modernization project area.

Appendix C

Supporting Maps

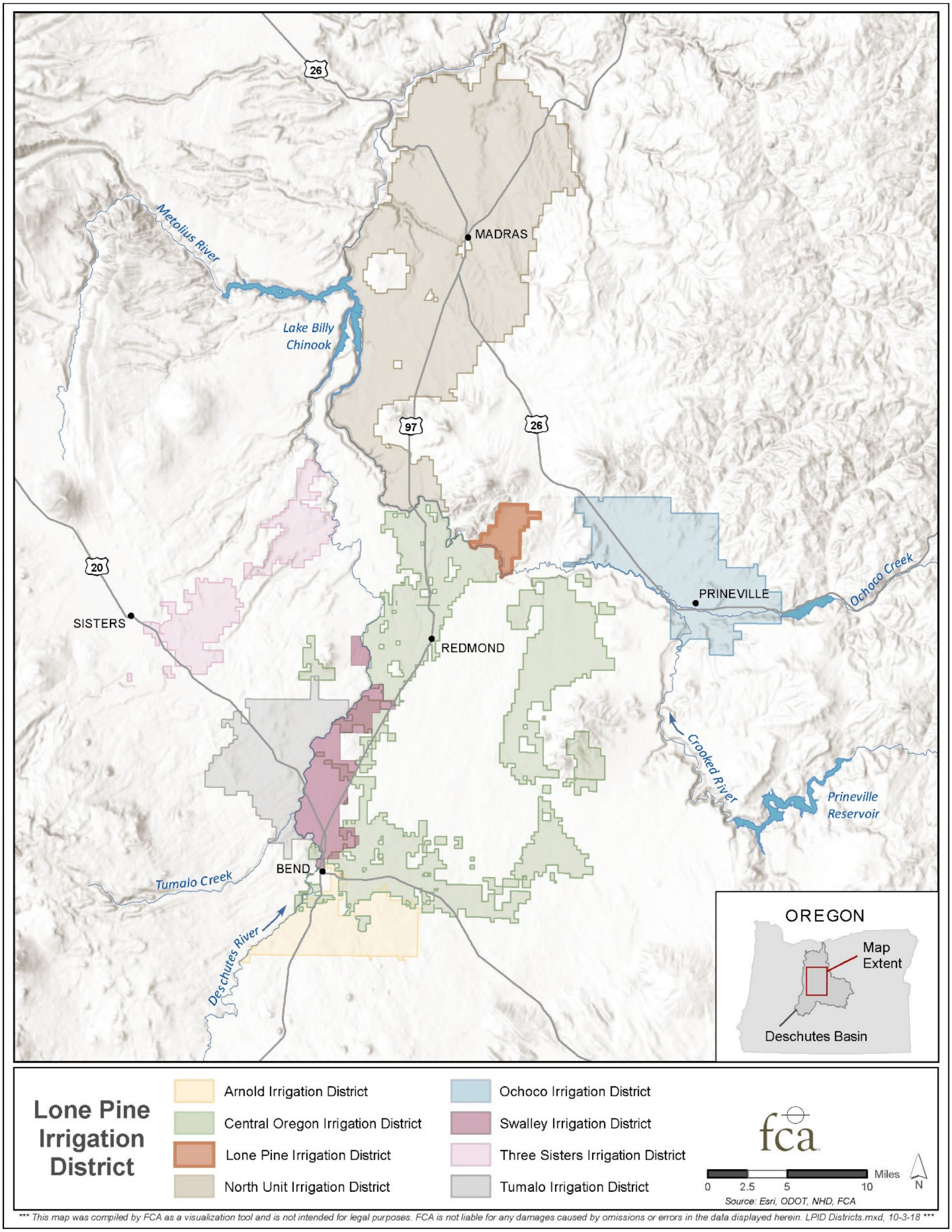

Figure C-1. Irrigation districts within the Deschutes Basin.

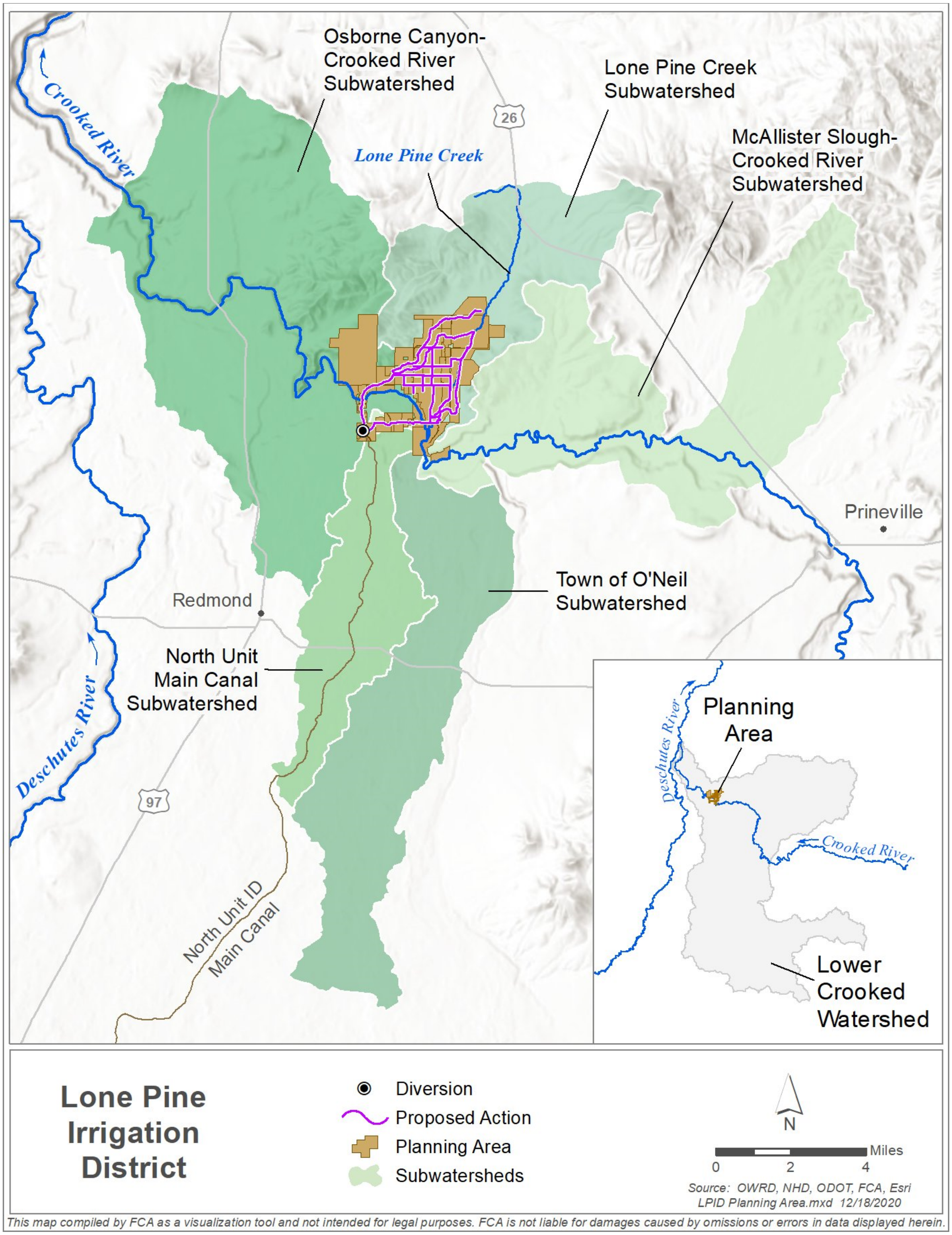

Figure C-2. Lone Pine Irrigation District planning area.

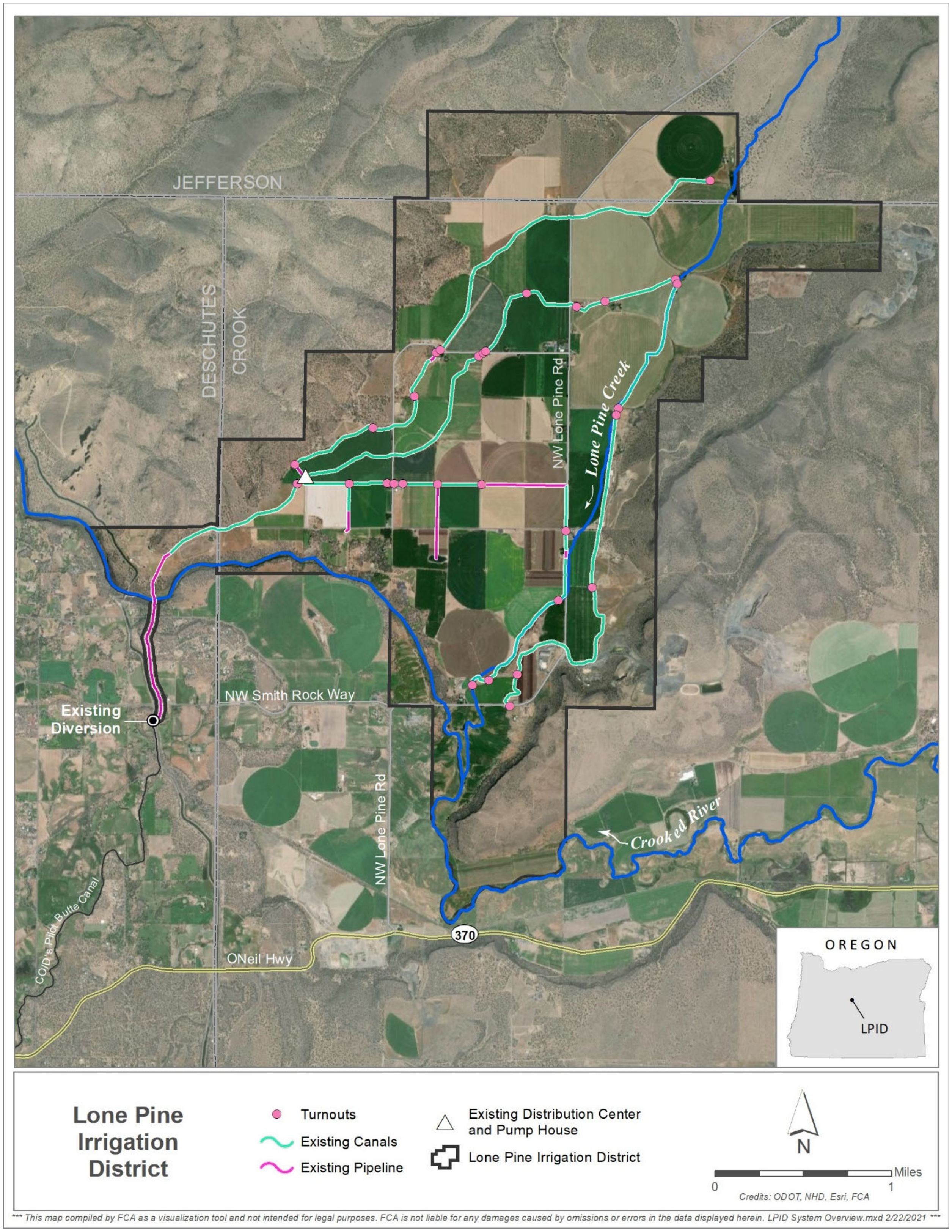

Figure C-3. Lone Pine Irrigation District's current infrastructure.

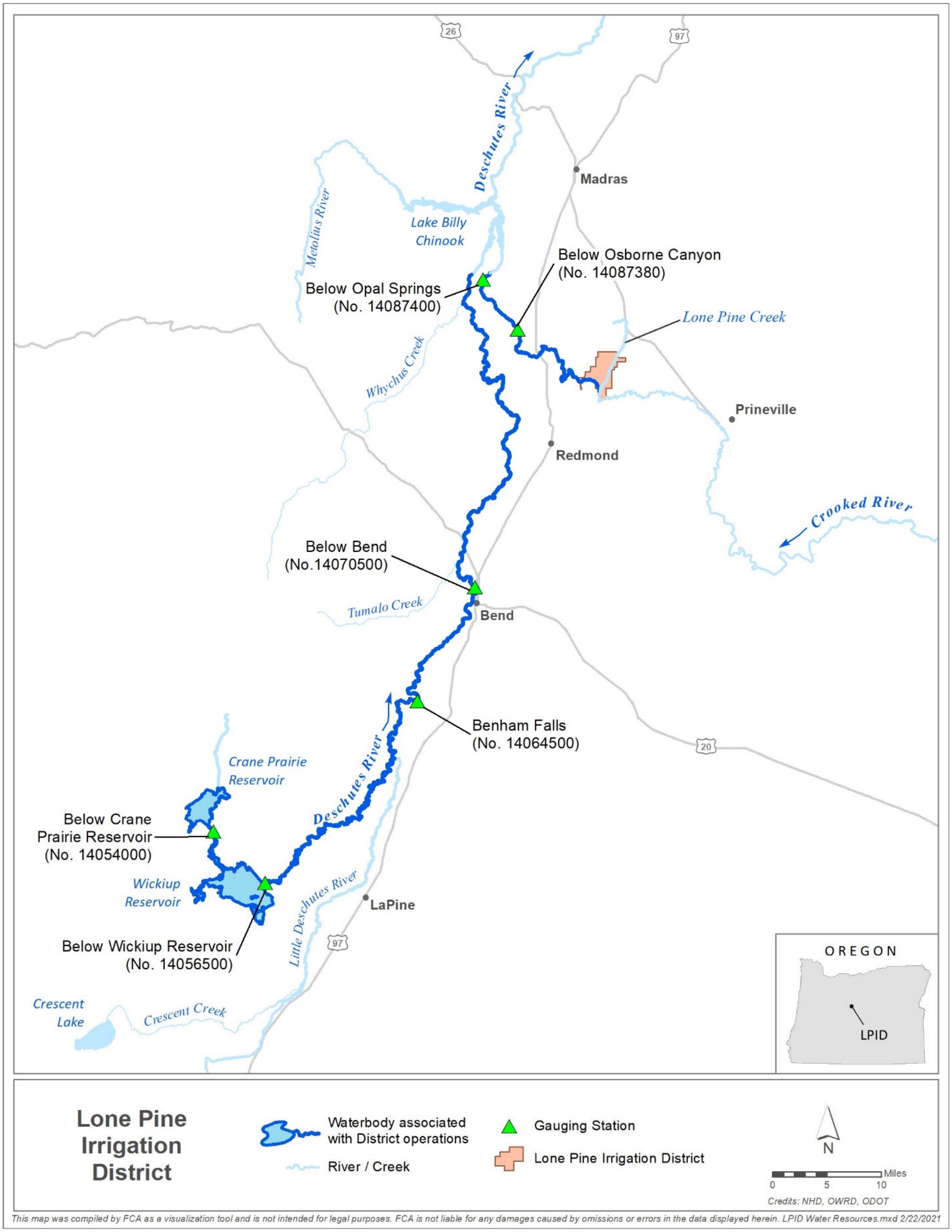

Figure C-4. Waterbodies and gauging stations associated with District operations.

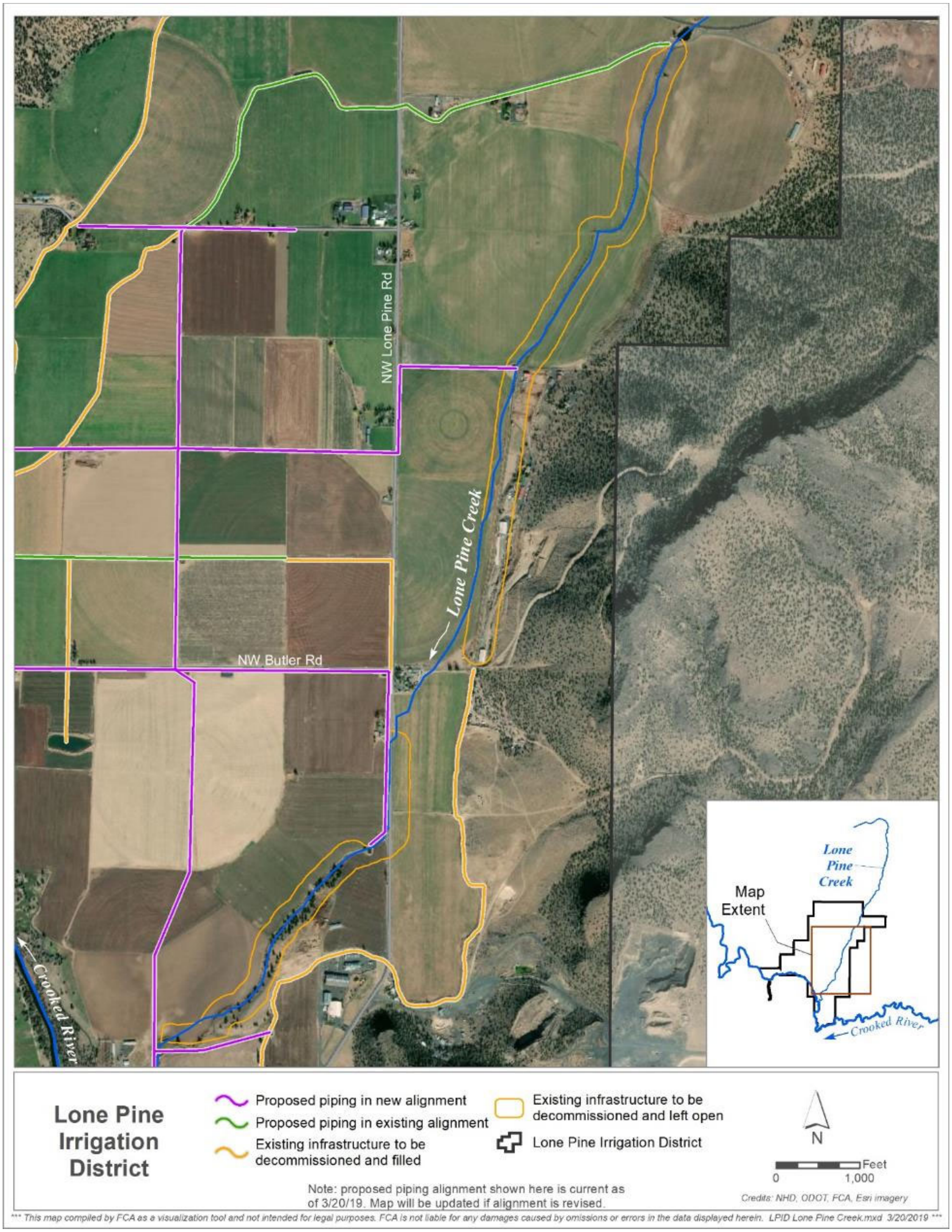

Figure C-5. Project area in relation to Lone Pine Creek.

Appendix D

Investigations and Analysis Reports

Highland Economics LLC

National Economic Efficiency Analysis

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Acronyms, Abbreviations, and Short-forms

AF	acre-foot
cfs	cubic feet per second
CO_2	carbon dioxide
District	Lone Pine Irrigation District
DBGM	Deschutes Basin Groundwater Mitigation
HCP	Habitat Conservation Plan
HDPE	high-density polyethylene
IWG	Interagency Working Group
kWh	kilowatt-hour
LPID	Lone Pine Irrigation District
Mt	metric ton
Mwh	megawatt-hour
N/A	not applicable
NASS	National Agricultural Statistics Services
NEE	National Economic Efficiency
NRCS	Natural Resources Conservation Service
NUID	North Unit Irrigation District
NWPM	National Watershed Program Manual
O&M	operation and maintenance
OM&R	operation, maintenance, and replacement
OSU	Oregon State University
OSF	Oregon spotted frog
OWRD	Oregon Water Resources Department
Plan-EA	Watershed Plan-Environmental Assessment
PPI	Producer Price Indices
PR&G	Guidance for Conducting Analysis Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water and Resource Investments
SCC	social cost of carbon
U.S.	United States
USEPA	United States Environmental Protection Agency
WSU	Washington State University

D.1 National Economic Efficiency Analysis

1.1 Introduction

This National Economic Efficiency (NEE) analysis evaluates the costs and benefits of the Piping Alternative compared to the No Action Alternative. The analysis uses Natural Resources Conservation Service (NRCS) guidelines for evaluating NEE benefits as outlined in the NRCS Natural Resource Economics Handbook and the United States (U.S). Department of Agriculture's *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; USDA 2017; herein referred to as PR&G).

All economic benefits and costs are provided in 2020 U.S. dollars and have been discounted and amortized to average annualized values using the 2021 federal water resources planning rate of 2.5 percent (NRCS, 2021).

1.2 Analysis Parameters

This section describes the general parameters of the analysis, the evaluation unit, the project implementation timeline, the period of analysis, and the project purpose.

1.2.1 Evaluation Unit

The proposed project is grouped into a single project group, which is the evaluation unit. There are no component pieces of the evaluation unit that have significant separate costs or benefits that make sense to evaluate independently. The project group serves one geographic area of clustered irrigated acreage (i.e., no section of acreage is isolated by itself with a significant length of lateral to reach it), and all of the elements of the proposed project combine to provide benefits to the same subset of acres.

1.2.2 Project Implementation

This analysis assumes that full benefits would be realized the year after construction is completed (i.e., construction begins in Year 0, is completed in Year 2, and full benefits are realized in Year 3). More information on the planned sequence of implementation can be found in Section 8.7.2 of the Watershed Plan-Environmental Assessment (Plan-EA).

1.2.3 Analysis Period

The analysis period for each project group is defined as 103 years; the installation period is 3 years, and the expected project life of buried pipe is 100 years. Construction and installation of the project is assumed to occur in Year 0 through Year 2, with project life from Year 3 through Year 103.

1.3 Costs of the Piping Alternative

1.3.1 Proposed Project Costs

National Watershed Program Manual (NWPM) 506.11, Economic Table 1 NWPM 506.12, Economic Table 2, and NWPM 506.18, Economic Table 4 found in Section 8.9 of the Plan-EA summarize installation costs, distribution of costs, and total annual average costs for the Piping

Alternative. In addition to the installation costs, the Piping Alternative could possibly entail slight costs associated with increased energy to pump groundwater in the basin. These costs are qualitatively discussed as "Other Direct Costs." The subsections included in this report provide detail on the derivation of the values in the tables of the Plan-EA. Based on past experience of piping irrigation canals, the District expects cost savings, not cost increases, for infrastructure maintenance, repair, and replacement of the Piping Alternative (Smith & Flitner, 2018).

1.3.2 Project Installation Costs

The cost of piping, farm turnouts, and the river crossing is estimated at $12,755,000 (2020 dollars) (Farmers Conservation Alliance, 2020). Adding an additional 3 percent for in-kind project administration from the Lone Pine Irrigation District (herein referred to as LPID or District), 8 percent technical assistance from NRCS, and permitting costs of $150,000, the total cost for the Piping Alternative in 2020 dollars is estimated at $13,893,000. See the subsection entitled "Modernization Alternative/Preferred Alternative Costs" in Section D.2 of this Appendix for detailed cost derivation (e.g., pipe size, cost category). All values in this analysis are presented in 2020-dollar values and rounded to the nearest $1,000 value. Of total estimated costs, 97 percent were projected to go to construction and 3 percent to engineering.

The average annual cost is shown in Economic Table 4 in Section 8.9 of the Plan-EA, with total average annual costs of $370,000 for the Piping Alternative.

1.3.3 Other Direct 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 increased pumping costs for all groundwater users in the basin. As such, it is possible that the Piping Alternative may result in a slight increase in pumping costs for groundwater users. The magnitude of this effect is evaluated based on data from a 2013 study by the U.S. Geological Survey that estimated the effects on Central Deschutes Basin groundwater recharge of changes in climate (reduced precipitation), groundwater pumping, and canal lining and piping (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 being 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 (AF) of reduced recharge annually by 2008.[2]

The Piping Alternative would reduce canal seepage and other conveyance inefficiencies and associated groundwater recharge by up to approximately 2,103 AF annually in this part of the Deschutes Basin once the project is completed (Farmers Conservation Alliance, 2021). Given the relatively small change in groundwater elevations estimated from 58,000 AF of reduced recharge annually, we expect very minor changes in local groundwater elevations and associated groundwater

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 AF, rising each year by another 4,833 AF until the reduced canal seepage in 2008 was 58,000 AF. Cumulatively, this represents 377,000 AF of reduced recharge from canals during this period.

pumping costs in the region due to the Piping Alternative, and thus do not quantify these potential other direct costs.

1.4 Benefits of the Piping Alternative

In the Plan-EA, Table 8-7 (NWPM 506.21, Economic Table 6) compares the project benefits (over No Action conditions) to the annual average project costs presented in Table 8-5 in the Plan-EA (NWPM 506.18 Economic Table 4). The remainder of this section provides detail on these project benefits.

The on-site damage reduction benefits that would accrue to agriculture and the local rural community include increased agricultural production, reduced power costs, and reduced operations and maintenance costs. Off-site quantified benefits include the value of reduced carbon emissions and the value of enhanced fish and wildlife habitat. Other benefits not included in the analysis that may result indirectly from the Piping Alternative include reduced risk of drownings in open canals and the potential for increased on-farm investment in irrigation efficiency (as patrons have more funds due to increased yields and reduced pumping costs).

The entire project area is located on private land and contains no recreational opportunities on or adjacent to LPID facilities. Therefore, we expect there would be no impacts to public recreation in the project area. The project would result in higher flows in the Deschutes River from Wickiup Reservoir to Lake Billy Chinook, which has adjoining recreational facilities that support camping, hiking, and onshore fishing. The river reach itself provides opportunities for rafting, swimming, fishing, kayaking, floating, and boating. However, interviews with recreation experts, guides, and facility managers suggest that the magnitude of flow changes expected under the Piping Alternative would not be large enough to significantly impact recreation in and along the river (Brown, 2017; Tamashiro, 2017; Smith C. , 2017; Houle, 2017; Krein, 2017; Renton, 2017). For these reasons, we did not model the impact of the project on recreation.

1.4.1 Benefits Considered and Included in Analysis

1.4.1.1 Agricultural Damage Reduction Benefits

LPID Agricultural Damage Reduction Benefits

Of the 2,103 AF projected to be conserved under the Piping Alternative, approximately 24 percent would be used within the District (approximately 503 AF per year), while the other 76 percent (about 1,600 AF) would be passed to North Unit Irrigation District (NUID). For the initial years (through project Year 8), the 1,600 AF per year that would go to NUID would enhance instream flows in the Deschutes River to benefit the Oregon Spotted Frog (OSF) and other species. Starting in project Year 9 the water passed to NUID would be used to enhance NUID's agricultural water supply. The additional water to LPID and NUID would provide agricultural damage reduction benefits, as is further explained in the following sections, beginning with LPID.

The conserved water going to the District would be used in dry water years (occurring approximately 35 percent of the time) to enhance the reliability of water supply for existing irrigated lands. In this section, we model the benefits of this conserved water that would be available to District patrons to supplement existing irrigation water supplies.

The District plans to use its portion of the conserved water from piping to supplement its existing water supplies during dry years (Smith, 2020). In approximately 35 percent of years, the District experiences water shortages that result in crop yield losses and changes to cropping patterns that result in lower revenues for growers (Smith, 2020). One common result of dry years is that hay growers are not able to supply enough water to produce a third and final cutting of hay. On average, the third hay cutting produces about 1.75 tons of hay per acre and requires 1.1 AF of water per acre (Smith, 2020). By providing the District with additional water supplies, the Piping Alternative would allow some lands to harvest a third hay cutting in dry years, which would not otherwise be harvested under the No Action Alternative. The remainder of this section outlines our methodology for estimating the potential economic benefits associated with avoiding these agricultural damages under the Piping Alternative.

Table D-1. Summary of LPID Cropland by Crop, Deschutes Watershed, Oregon.

Crop	Acres	Proportion of All Cropland
Alfalfa	527	22%
Mint	522	22%
Pasture	367	15%
Grass Hay	336	14%
Corn	200	8%
Wheat	192	8%
Triticale	185	8%
Carrot Seed	35	1%
Harvested Trees	10	0%
Total	2,369	100%

Note: Columns may not sum due to rounding. Prepared January 2021

As shown in Table D-1 above, alfalfa and grass hay acres comprise approximately 36 percent of the District's total cropped area, totaling around 860 acres. Of this, 527 acres are alfalfa and 336 acres are grass hay (Smith, 2020). At a rate of 1.1 AF per acre, the additional 503 AF per year delivered under the Piping Alternative would be able to provide 457 acres of hay with full irrigation that would have otherwise lost a third hay cutting during dry years.[3] (While all acreage would be allocated a portion of the increased water supply, we expect that growers would choose to focus this water on maximizing yields and net returns on certain acres rather than evenly irrigating all of their lands more.)

To estimate the difference in net returns (i.e., profits) from hay in water-short years versus years with full irrigation, we adjusted an existing crop enterprise budget for alfalfa produced by Washington State University (WSU) in 2012 (Norberg & Neibergs, 2012). We created budgets for

[3] 503 AF ÷ 1.1 AF/acre = 457 acres that could potentially be supplemented with full irrigation

alfalfa under full irrigation and under a water-shortage scenario with no third hay cutting (reducing yield by 27 percent, or 1.75 tons per acre). These budgets are shown in detail in Section 1.6 and summarized in the table below. Using these crop budgets, we estimate that alfalfa provides average annual net returns of $309 per acre under full irrigation and $89 per acre under deficit irrigation (as shown in Table D-2). As such, the avoided damage (i.e., net benefit) of having full irrigation is approximately $220 per acre (the difference between a profit of $309 and $89). Since the water deficit is 1.1 AF per acre (as outlined above), the value of the water is approximately $200 per AF.[4] We use this value to estimate the net benefits of additional irrigation water.

Table D-2. Summary of Per-Acre Hay Net Returns Under Full and Deficit Irrigation in LPID, Deschutes Watershed, Oregon, 2020$.

Economic Variable (Per Acre)	Irrigation Level	
	Deficit (No Action)	Full (Piping Alternative)
Production Year 1 Net Returns	$236	$467
Production Years 2-6 Net Returns	$59	$277
Weighted Average Net Returns [1]	$89	$309
Increased Value/Acre of Full Irrigation [2]	$220	
Increased Value/AF of Full Irrigation [3]	$200	

Note: Full crop budgets are provided in the NEE Apendix Prepared January 2021
1/ Averaged over a 6-year stand life with 5 years comprised of Years 2-6 returns.
2/ Equal to the difference of weighted average net returns between deficit and full irrigation.
3/ Calculated assuming a 1.1 AF/acre difference between full and deficit irrigation.

At $200 per AF, the additional 503 AF dedicated to LPID irrigation would generate $101,000 in net benefits during years of deficit irrigation. Since these years occur roughly 35 percent of the time, the average annual value of the additional irrigation water is around $35,000 (roughly $101,000 multiplied by 35 percent). When discounted and annualized, the avoided damage of water shortages is expected to bring average annual benefits of $33,000 under the Piping Alternative (as shown in Table D-3 below).

Table D-3. Annual Avoided Loss in Agricultural Production in LPID under the Piping Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Acres Impacted	Total Impact in Dry Years	Total Average Annual Impact	Average Annual NEE Benefit
Project Group 1	457	$101,000	$35,000	$33,000
Total	**457**	**$101,000**	**$35,000**	**$33,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

This estimate likely understates the total economic value of increasing the District's water supply reliability with conserved water for several reasons. In years when the District's water supply exceeds

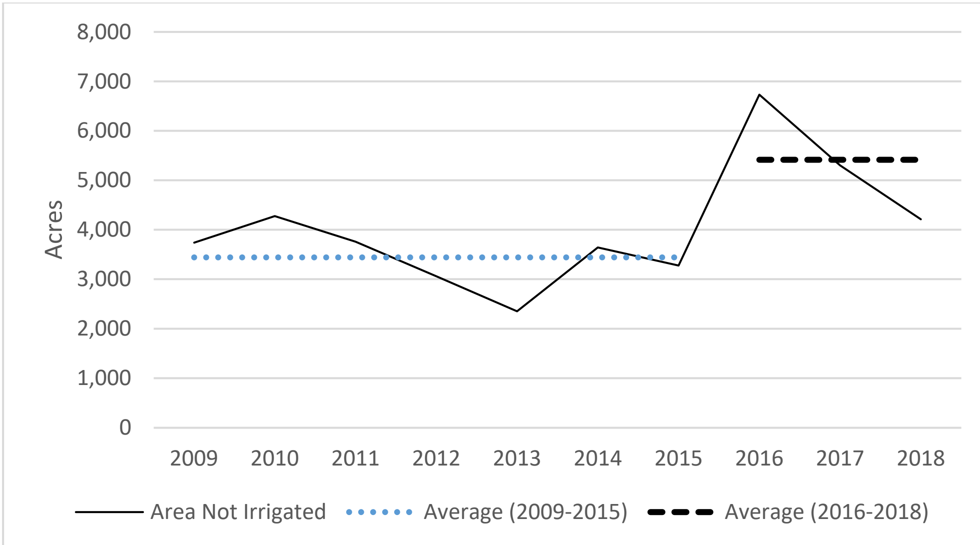
[4] $220/acre ÷ 1.1 AF/acre = $200/AF

its demand, it plans to store its excess conserved water in Crane Prairie Reservoir along with its other stored water rights. The District plans to use this water in subsequent dry years when the water supply is insufficient to meet demand (Smith, 2020). While hay is the only crop modeled in this analysis, LPID growers have other crops that may receive inadequate irrigation during dry years, and conserved water supplies may also increase yields and economic value from other, non-hay crops. For example, according to the LPID District Board member, in drought years, growers may forego planting winter wheat in the fall due to a lack of available water. Instead, growers will wait and plant spring wheat, which earns approximately $100 less per acre than winter wheat (Smith, 2020). Also, dry years can impact mint, which is a high-value crop that is grown in the District. A lack of water late in the season can reduce mint yield (Smith, 2020). Thus, to the extent that conserved water improves yield on additional acres or other crop types, the benefits may be higher than what are modeled in this analysis.

NUID Agricultural Damage Reduction Benefits

Under the Piping Alternative, LPID would pass about 76 percent of water saved from piping (1,600 AF per year) to NUID. This water would be used to supplement NUID's current water supply and alleviate agricultural damages due to water shortages (as further described below). However, due to evaporation and seepage in NUID canals, only a portion of the water passed by LPID would reach NUID farms. Of the 1,600 AF per year passed by LPID, it is estimated that approximately 64 percent, or 1,024 AF per year, would reach NUID farms (Farmers Conservation Alliance, 2021). We use this amount to estimate the benefits to NUID agriculture of the water conserved by piping in LPID.

The 1,024 AF increase in water availability is expected to reduce the agricultural damages associated with water shortages experienced currently in NUID, as well as mitigate future larger water shortages in NUID that are expected to occur due to changes in water management required as part of the Deschutes Basin Habitat Conservation Plan (HCP). Historically, NUID has experienced water shortages in which water supply is less than the total water demand in the district (Britton, 2019). Since the adoption of the 2016 Settlement Agreement, which includes provisions for irrigation districts in Central Oregon to increase instream flows to support the OSP (which reduces water availability for irrigation), water supply reliability to NUID irrigators has been further decreased. While there have been just a few years since the Settlement Agreement, and water year type and market conditions also affect acreage planted in any given year, Figure D-1 shows that the average fallowed acreage in NUID increased from the 2009 to 2015 period to the 2016 to 2018 period.



Source: (Bohle, 2019)

Figure D-1: NUID Agricultural Area Not Irrigated.

Based on these data and the analysis of changes in NUID water supply contained in the environmental impact statement for the HCP (Oregon Fish and Wildlife, 2020), this analysis assumes that the 1,024 AF of additional water would reduce the agricultural damages arising from decreased water availability. Specifically, the additional water would reduce deficit irrigation on hay acres that causes a loss of one hay cutting totaling 25 percent of the annual yield under full irrigation. Because this analysis focuses on the impacts to hay only and does not include potential impacts to specialty crops grown in NUID, the benefits presented in this section likely underestimate the benefits of additional water to NUID. Roughly one-quarter of NUID's irrigated acres are dedicated to high-value specialty crops, which, in the absence of water conservation projects like the proposed action, may be impacted by water shortages as the HCP changes in water management are phased into effect in future years[5]. In other words, if future NUID water shortages reduce acreage or yields of specialty crops, the value of additional water to NUID would be higher than what is presented here. Additionally, the value of water may also be higher to NUID than what is presented here for another reason: this analysis conservatively used published average hay yield data for Jefferson County where NUID is located, which indicate lower hay yields than those used for the agricultural damages estimated in LPID as reported by the LPID District Manager (Smith, 2020).

With these assumptions, to estimate the value of reduced damages from deficit irrigation, we adapted a published WSU crop budget (Norberg & Neibergs, 2012) to model the net revenues of agricultural production in NUID for alfalfa hay. From this source budget, we developed crop budgets to model net returns to hay under full irrigation and under deficit irrigation. We assume 25 percent deficit irrigation (0.6 AF per year of deficit irrigation, which equates to 25 percent of average NUID per acre allocation of 2.4)[6] and 25 percent yield reduction under deficit irrigation. These crop

[5] Source for crop mix came from (Bohle, 2019).

[6] Water allocations in NUID differ depending on the source: Deschutes River water rights get 2.5 AF per acre while Crooked River water rights get 1.5 AF per acre. Because there are 53,721 acres supplied by the Deschutes River and 5,164 acres supplied by the Crooked River, the weighted average allocation District-wide is 2.4 AF per acre (Britton, 2019).

budgets are provided in Section 1.6, with detailed explanation of the methods used to update revenues and costs to 2020-dollar values. The results of the crop budget analysis are summarized in Table D-4 below.

Table D-4. Summary of Per-Acre Hay Net Returns Under Full and Deficit Irrigation in NUID, Deschutes Watershed, Oregon, 2020$.

Economic Variable (Per Acre)	Irrigation Level	
	25% Deficit (No Action)	Full (Piping Alternative)
Production Year 1 Net Returns	$189	$361
Production Years 2-6 Net Returns	$26	$170
Weighted Average Net Returns [1]	$53	$202
Increased Value/Acre of Full Irrigation [2]	$149	
Increased Value/AF of Full Irrigation	$246	

Notes: Prepared January 2021

1/ Averaged over a 6-year stand life with 5 years comprised of Years 2-6 net returns.

2/ Equal to the difference of weighted average net returns between deficit and full irrigation.

3/ Calculated assuming a 0.6 AF/acre difference between full and deficit irrigation.

Results from the analysis in Section 1.6 indicate that alfalfa hay under full irrigation generates average annual net returns that are approximately $149 per acre higher than those under deficit irrigation (as shown in Table D-4). As noted above, with deficit irrigation at 75 percent of full irrigation, each acre would receive an additional 0.6 AF under full irrigation. Dividing the marginal net returns of full irrigation ($149 per acre) by the amount of additional water (0.6 AF per acre) provides the marginal net returns to water: almost $246 per AF. We use this amount to estimate the damage-reduction benefit of each AF of water going to NUID under the Piping Alternative.[7]

Under the Piping Alternative, LPID would pass water to NUID as water is conserved from piping (i.e., once the project finishes in Year 3). However, this analysis assumes the benefits to NUID agriculture would only accrue after year 2030 (Year 9 of this analysis) when the HCP instream requirements are scheduled to increase. The increased instream flow requirements will reduce water supply further for NUID under the No Action Alternative. Under the Piping Alternative, the water passed from LPID to NUID is expected to alleviate these shortages, as described above. Therefore, after Year 9 in the Piping Alternative, this analysis models an increase of approximately 1,024 AF per year to NUID farms. This volume of water valued at $246 per AF results in an undiscounted annual agricultural damage reduction value of about $252,000. When discounted and annualized, the value of the Piping Alternative in avoiding agricultural damages in NUID totals $204,000 (as shown in Table D-5).

[7] If 1,024 AF of additional water were distributed at 0.6 AF per acre (as is assumed in this analysis), less than 1,700 acres could receive additional water. Over the last 10 years, NUID has averaged about 37,000 acres in hay and grain, which the net returns analysis is meant to represent (Bohle, 2019). Because the total area receiving additional water is less than half the total area of relevant cropland, it is reasonable to apply the benefit per AF to all 1,024 AF.

Table D-5. Avoided Damages to NUID Agriculture Resulting from Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2020$. [1]

Project Group	Total delivered water to NUID farms (AF per year)	Undiscounted Annual Benefit to NUID Agriculture	Annualized Average Net Benefits of Piping
Project Group 1	1,024	$252,000	$204,000
Total	**1,024**	**$252,000**	**$204,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

1.4.1.2 Operations and Maintenance Cost Savings Benefit

The District currently incurs several costs associated with the operations, maintenance, and replacement (OM&R) of open canals, which would be avoided under the Piping Alternative. These costs include maintenance of canals, weed control in the canals, and certain capital improvements. The LPID board members estimate that these avoided OM&R expenses total roughly $78,000 each year (Smith & Flitner, 2018).[8]

Additionally, the Piping Alternative would eliminate the need for two District-owned pump stations. The cost to power these pump stations totals about $14,000 annually (Smith, 2020). Avoiding this cost would be an annual benefit of the Piping Alternative. Under the No Action Alternative, the pumps would need to be replaced after a 50-year life cycle at a cost of roughly $50,000 each.[9] Because of differing ages, one (newer) pump would need to be replaced in Year 49 and the other (older) pump would need to be replaced between Years 6 and 10 and every 50 years thereafter (Smith, 2020). This analysis assumes an equal probability the older pump will need to be replaced between Years 6 and 10 and apportions the replacement equally among those years (as well as subsequent replacements). Furthermore, under the Piping Alternative, the newer pump would have a salvage value of approximately $20,000 if replaced in Year 3 after the project is complete (Smith, 2020). Accordingly, this analysis incorporates a $20,000 benefit in Year 3 under the Piping Alternative. The avoided costs of replacing the pumps are counted as a benefit in the years of projected replacement.[10]

When the annual avoided costs of canal OM&R ($78,000) are combined with the avoided pump power costs ($14,000 per year), the gross annual savings to the District under the Piping Alternative is around $92,000. One additional OM&R cost of the Piping Alternative is maintaining a new siphon, which is expected to cost approximately $1,000 per year (Thalacker, Manager, Three Sisters Irrigation District, 2019). Weighing this cost against the OM&R savings, the net annual OM&R savings of the Piping Alternative are roughly $91,000. The intermittent savings of avoided pump replacements is in addition to these annual savings.

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[8] The OM&R costs were adjusting for inflation to 2020 dollars using the Consumer Price Index.

[9] Each pump would need to be replaced by a 50-horsepower pump (Smith T. , 2019). Pumps of this type typically cost about $1,000 per horsepower for a total cost of approximately $50,000 per pump (Cronin, Engineer, Bureau of Reclamation, 2020).

[10] One pump will be replaced in Years 49 and 100, and the other will be replaced between Years 6 and 10, and again between Years 57 and 61.

As shown in Table D-6, when discounted over the study period, these OM&R savings are expected to average $89,000 annually. The District does not plan to reduce staff or staff time in response to the avoided operation, maintenance, and replacement (OM&R) costs. Instead, the District plans to assign staff to other activities that will benefit the District and its patrons. By doing so, the District is implicitly indicating that these activities will generate additional benefits that are at least equal to the cost of the staff's time. As such, we assume that the value of avoiding canal O&M will bring benefits at least equal to its current cost.

Table D-6. Annual Reduced OM&R Costs to LPID Patrons of Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2020$[1].

Works of Improvement	Undiscounted OM&R Cost Savings Per Year	Discounted Annualized Benefit (OM&R Cost Reduction)
Project Group 1	$91,000	$89,000
Total	**$91,000**	**$89,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

1.4.1.3 Patron Pumping Cost Savings

The Piping Alternative would provide partial pressurization for approximately 45 turnouts in the LPID system (Cronin, Engineer, Bureau of Reclamation, 2020). For those turnouts, having partial pressurization would reduce the amount of energy use by irrigation pumps to move water onto growers' fields. This would provide growers with savings on energy. Partial pressurization would eliminate the need for approximately 1,163 megawatt-hours (MWh) per year in the District, which uses an estimated 3,130 MWh per year currently (Farmers Conservation Alliance, 2020). Central Electric Cooperative, which supplies electricity to LPID, charges irrigators $0.0512 per kilowatt-hour (kWh) for power during the summer season (Central Electric Cooperative, Inc, 2020). Growers currently spend roughly $64,000 annually on power for their irrigation pumps that would be avoided under the Piping Alternative. We assume this cost would be eliminated after the completion of the project (Year 3) and would continue throughout the project life. When discounted and amortized, these cost savings provide average annual NEE benefits of $61,000 (shown in Table D-7).

Table D-7. Annual Reduced Pump Energy Costs to LPID Patrons Under the Piping Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Energy Savings (kWh)	Undiscounted Annual Energy Cost Savings	Average Annual NEE Benefit of Energy Cost Reduction
Project Group 1	1,163,043	$64,000	$61,000
Total	**1,163,043**	**$64,000**	**$61,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

1.4.1.4 Carbon Benefits

Changes in energy use under the Piping Alternative would mean changes to carbon dioxide (CO_2) emissions from power generation. Every MWh of reduced on-farm energy use translates into an estimated reduction of 0.75251 metric tons (Mt) of carbon emissions.[11] Currently between the District's pump stations and patron pumping, LPID uses approximately 2 million kWh per year (Farmers Conservation Alliance, 2020; Smith, 2020). This translates to roughly 1,505 Mt of CO_2 produced by LPID annually (approximately 2,000 MWh multiplied by 0.7525). As pressurization reduces the power needed for patron irrigation pumping and District pump stations, energy use in the District would fall by a total of roughly 1,291 MWh per year, which would reduce CO_2 emissions by around 971 Mt per year (approximately 1,291 MWh multiplied by 0.7525). Table D-8 shows the net change in carbon emissions in the Deschutes Basin and within LPID.

Table D-8. Annual Average Carbon Emissions (Mt) in LPID, Deschutes Watershed, Oregon.

Works of Improvement	Annual Carbon Emissions, LPID Patron and District Pumping		
	No Action	Piping Alternative	Average Annual Net Change of CO_2 Emissions
Project Group 1	534	1,505	971
Total	**534**	**1,505**	**971**

Note: N/A = not applicable Prepared January 2021

To value the change in CO_2 emissions, this analysis uses an estimate of the social cost of carbon (SCC) (which is the estimated total cost to society of emitting carbon related to the expected damages associated with 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 $52.42 per Mt (2020 dollars).[12] However, in 2017, Executive Order 13783 disbanded the IWG, indicating 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 U.S. Environmental Protection Agency (USEPA) and other federal agencies 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 USEPA developed interim SCC values for the *Regulatory Impact*

[11] 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 then used), such that 100 percent of energy use reduction and green energy production results in reduced fossil fuel-powered generation. Furthermore, this estimate assumes 0.75251 Mt of carbon emitted from 1 MWh of fossil fuel powered electricity generation based on 1) the current proportion of fuel source–oil, natural gas, and coal–for fossil fuel-powered electrical power generation in the west, and 2) the associated Mt of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

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

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). However, in January of 2021 the administration issued another executive order re-establishing the IWG, and it is likely that the IWG will re-establish values similar to those used under the 2012 to 2016 administration.

As the new IWG has not yet issued new recommendations, this analysis uses the interim USEPA SCC established under the previous administration (2016 to 2020). This analysis uses the USEPA interim value of the SCC for 2020, based on a 3 percent discount rate and $7 per Mt of carbon. At this value, the estimated average annual benefit of avoided CO_2 emissions is $6,000, as shown in Table D-9.

Table D-9. Annual Increased Average Carbon Cost Savings of Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2020$.[1]

Works of Improvement	Energy Savings Under Piping Alternative (kWh/year)[2]	Annual Reduction in Carbon Emissions (Mt)	Average Annual NEE Benefit
Project Group 1	1,290,803	971	$6,000
Total	**1,290,803**	**971**	**$6,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021
2/ Comprised of 127,760 kWh from District energy savings and 1,163,043 kWh from patron energy savings.

1.4.1.5 Value of Instream Conserved Water

As described above in the Section 1.4, under the Piping Alternative, LPID would begin passing 1,600 AF per year of conserved water to NUID once the project is completed. Prior to 2030, NUID would release an equivalent amount of water from Wickiup Reservoir for instream flows during the non-irrigation (winter) season. Placing this water instream would provide instream flow benefits over the No Action Alternative in the years prior to 2030 (through Project Year 8), when the HCP governing flows on the Deschutes River requires wintertime instream flows to increase. Under the No Action Alternative, NUID would not be required to put this additional water instream until 2030.

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 rights 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 NUID (since NUID would be putting the water instream), as this indicates the potential cost of purchasing water rights from these irrigators.

Based on the following discussion, we estimate that the economic benefit of instream flow augmentation would be at least $75 per AF per year, such that this enhanced instream flow would have a value of approximately $120,000 per year once the project is complete under the Piping Alternative (because of the construction timing and because the instream benefits only accrue prior to Year 9, on an average annualized basis the NEE benefit is roughly $17,000 as presented in Table D-10). 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 salmon, trout, and other fish and wildlife populations, such as those that would benefit from the instream flows provided by the Piping 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 for environmental water in the Western United States. Table D-10 shows the estimated average annual benefits of enhanced instream flow for the Piping Alternative.

Table D-10. Annual Estimated Instream Flow Value of Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2020$. [1]

Project Group	Water Conservation Going Instream (AF/year)	Undiscounted Annual Benefit to Instream Flow	Discounted Annualized Benefit to Instream Flow
Project Group 1	1,600	$120,000	$17,000
Total	**1,600**	**$120,000**	**$17,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

The value of $75 per AF per year is based on the following information (see Table D-11):

1. **Prices paid for water by environmental buyers throughout the Western United States**—In the period 2000 to 2009, purchase price of environmental water varied from just over $0 to nearly $1,765 per AF per year, with an average permanent sale transaction price of $239 per AF 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 AF 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 the Deschutes Basin**—For low-value crop irrigators (likely the first to sell water for environmental purposes), this is estimated at approximately $60 to $250 per AF per year. This value is important because the value of water to local agriculture

is a key factor in determining the water sales and lease prices to environmental buyers in the project area (i.e., the marginal value of water to agriculture determines the agricultural sellers' willingness to accept a price for water), and because conserved water avoids potential future reductions in irrigation.

Table D-11. Value per AF 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 transaction in western U.S., 2000 to 2009 (*Converted to Annual Values*)	~$0	$1,765	~$75	$239
Value of water to Deschutes Basin irrigators (*Income Capitalization Approach*)	$60	$250	N/A	~$85

Past Costs Paid as a Proxy for Value

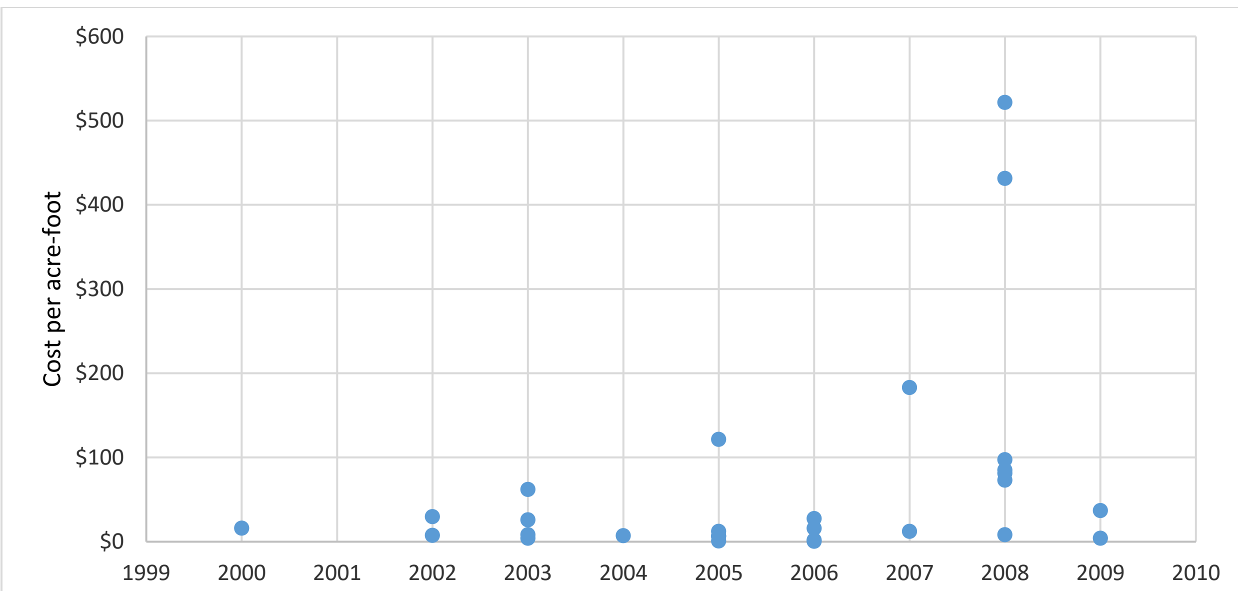
Past piping projects in the Deschutes Basin highlight the willingness of funding entities to pay for instream flow augmentation. These values are evidence of the *minimum* benefit of the instream flows purchased, as perceived and experienced by these entities. Project costs paid are indicative of the *minimum* perceived benefit as (barring very unusual circumstances) entities only pay for projects for which they believe the benefits exceed costs. Furthermore, funding organizations do not necessarily represent all individuals who value instream flow benefits. Only if all people who value instream flow were to pay their maximum willingness to pay for instream flow restoration, then the value paid would 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 rights transactions from agriculture to environmental flows).

In the Deschutes Basin, approximately 90 projects have restored approximately 80,000 AF of water instream (Central Oregon Irrigation District, 2016). Based on data from the Deschutes River Conservancy (2012), costs of instream flow augmentation from piping projects have ranged from approximately $105,000 to approximately $344,000 per cubic feet per second (cfs) conserved; this may equate to roughly $300 to $1,000 per AF conserved.

Water rights can be purchased or leased in Oregon. It is important to note that the value paid per AF 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 AF in Oregon, while five water right leases averaged $115 per AF 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 AF was $1,121, while across 35 lease transactions the annual price was $68 per AF.

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 AF per year basis. The figures show how water rights 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 AF per year (with several transactions showing prices rising over a $1,000 per AF 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 AF per year. However, it is also important to note that the amount paid per AF tends to decline with an increase in water volume traded; weighting the purchase price by the water volume sold decreases the average permanent sale transaction price to $20 per AF per year.



Note that dollar per AF purchase prices were amortized using a 2.5 percent interest rate and a 100-year period to derive dollar per AF per year values.

Figure D-2: Western water rights purchases for environmental purposes, 2000 to 2009, price paid per acre-foot per year.

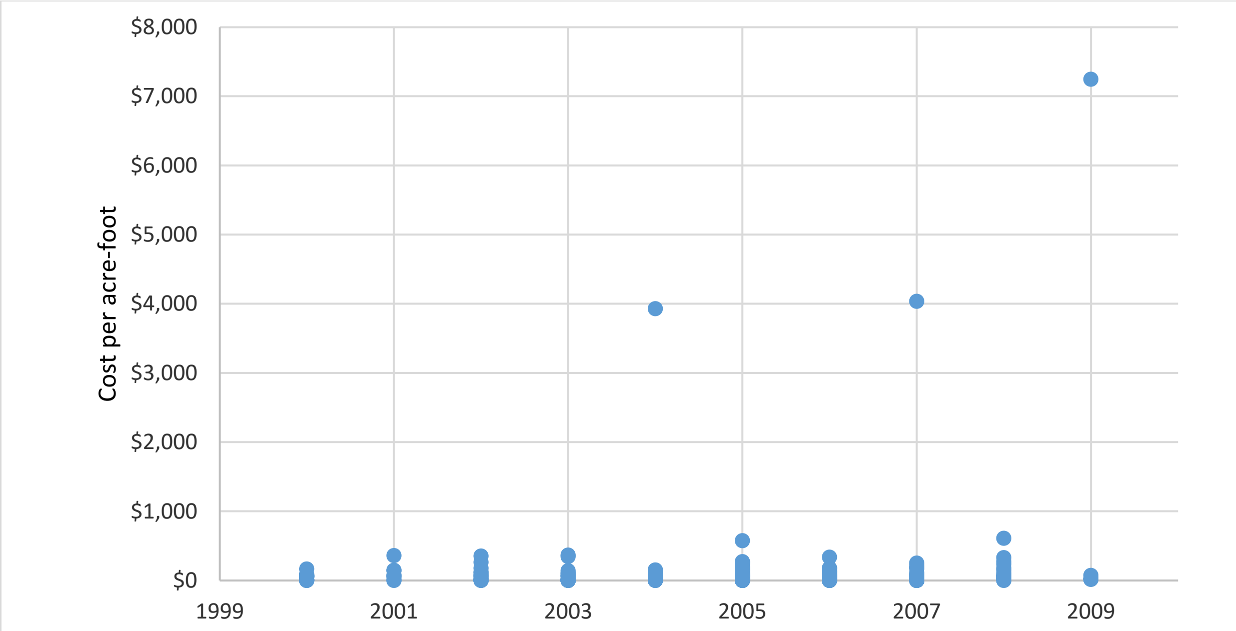


Figure D-3: 1-year water leases for environmental purposes, price paid per acre-foot in the Western United States.

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

The value of water to irrigators (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). Specific to the project area, water rights sold from one irrigator to another within the Tumalo Irrigation District (which is also located in the Deschutes Watershed) have typically had a purchase price between $5,310 to $7,970 per acre (Rieck, 2017).[13] These values are very similar to values provided by area real estate agents regarding the increased value of property with irrigation water rights, with all else equal. Assuming approximately 4 AF per year delivered on average to acreage in the District, this equates to approximately $1,330 to $1,990 per AF ($5,310 to $7,970 per acre divided by 4 AF per acre delivery), or a value of approximately $40 to $70 per AF per year.

Because NUID's crop mix has a higher proportion of high-value crops than Tumalo Irrigation District and higher yields, the value of NUID irrigation water is higher than Tumalo Irrigation District. Using the crop budgets created to model the agricultural benefits of the Piping Alternative (shown in detail in Section 1.6), we estimate that reduced irrigation of 0.6 AF per acre in a season causes hay growers in NUID to lose approximately $149 per acre in profits. This implies that NUID irrigators value water at the margin at approximately $246 per AF ($149 divided by 0.6). However, on average, NUID irrigators may be applying approximately 2.4 AF per acre to hay crops and getting profits of roughly $200, which implies approximately $84 per AF of value on average.

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

1.4.1.6 Value of Supporting the Oregon Spotted Frog Habitat

In many river systems, organizations that are leasing and purchasing water rights to restore instream flows are focused on the enhancement of fish populations. As such, water right transaction values for instream flow purchases presented in the above section may represent the value of the instream habitat enhancement for fish but may not include the value associated with conservation of other species, such as amphibians. In the Deschutes River, restoration of flows would benefit not only fish species but would also benefit and help recover the Deschutes River population of the threatened OSF and enhance water quality. In this section, we describe the potential additional value of OSF conservation based on values from the literature regarding ecosystem and species conservation.

Our use of existing literature and previous studies regarding the value of ecosystem restoration and species conservation to estimate the value of OSF habitat enhancement in the Deschutes Basin is done in accordance with a methodology known as benefits transfer. Values estimated through benefits transfer are less certain and reliable than would be values estimated through a specific study of the value of OSF habitat in the Deschutes Basin, as the resource being valued (OSF) and the population valuing the resource (the Deschutes County households) may differ in substantive ways that could significantly affect the value estimate. However, developing and implementing a new study of the value of OSF habitat in the Deschutes Basin through survey-based techniques such as contingent valuation or conjoint analysis would be very resource-intensive and costly. Consequently, this analysis uses benefits transfer in a manner intended to be cautious and conservative, with associated discussion on the lack of certainty in value estimates.

As an additional caveat, by estimating the habitat value of water for fish and also including a separate benefit related to the OSF, we may be over-estimating the conservation value of the enhanced instream flow. However, we believe that including both a general instream flow value and an OSF-specific value does not result in overestimation for three reasons: 1) organizations acquiring environmental water for instream flow purposes are generally focused on enhancing instream flows in order to benefit fish,[14] 2) as discussed in the preceding section, the price paid for environmental water is highly influenced by the cost to agriculture of reduced irrigation water supplies and does not necessarily reflect the total ecosystem service value of the instream flow, and 3) studies of the willingness to pay for all habitat benefits of enhanced instream flow indicate that the total value we derived by adding the per AF value from above with an OSF value (as derived below) is within the range of expected benefits to the public (on a per household per year willingness-to-pay basis) of restored aquatic ecosystems.

Long-term viability of the Deschutes population of OSF is threatened by the Deschutes River's highly modified hydrologic regime. High summer flows, rapid flow fluctuation in the fall and spring, and current low wintertime flows are incongruent with the needs of the OSF lifecycle (U.S. Fish and Wildlife Service, 2017). The U.S. Fish and Wildlife Service believes that for long-term species preservation, increased wintertime flows are necessary in the Deschutes River (the Piping Alternative would increase wintertime streamflow by up to 5.3 cfs). Although OSF and its habitat needs are still

[14] For example, the Freshwater Trust in Oregon, which has as its mission to preserve and restore freshwater ecosystems, emphasizes benefits of instream flows for fish on its website; it notes on its website that "We must implement practical, workable solutions that work for both fish and farmers"; presents a graphic showing that rivers sustain industry, drinking water, recreation, agriculture, and fisheries; and lists several fish-related benefits in its achievements but notes no other specific species.

under scientific investigation, U.S. Fish and Wildlife Service currently considers that 400 cfs is the minimum target winter instream flow in the upper Deschutes River necessary for beginning OSF recovery (Moran & O'Reilly, 2018). With restoration of streamflow and habitat on the Deschutes, the target flow may change as biologists monitor how the ecosystem and the OSF adjust to changes in flow management.

The economic value of conserving amphibian populations—and the OSF in particular—may stem from many types of benefits to society provided by these species. As summarized in Table D-12, social and economic benefits of OSF preservation may include enhanced cultural values, recreational values, educational values, public health values, environmental quality values, and intrinsic species existence values (i.e., the value to people of preserving the species, apart from any use of the species). Pertinent to potential medical and ecological values, researchers have identified that the OSF may have an antimicrobial chemical in its skin secretions that provides resistance to a fatal amphibian disease (chytridiomycosis), which is causing declines in many amphibian populations (Conlon, et al., 2013).

Table D-12. Sources of Economic Value from Amphibian Conservation.

Source of Value	Description
Cultural Value	Frogs have cultural value that is evident in their symbolism and use in literature, music, art, and jewelry.
Recreational Value	Wildlife viewing of frogs can enhance recreational value, while intact amphibian natural areas and wetlands can also enhance recreational value by providing aesthetically pleasing and diverse recreational environments.
Educational Value	Frogs provide an opportunity for research and education for ecology, biology, anatomy, and physiology.
Mosquito Control (Human Health, Well Being)	Amphibians reduce mosquito and other pest populations through predation and competition, which can provide social and economic values by reducing a nuisance as well as provide public health benefits by reducing the risk of mosquito-borne illnesses (thereby improving quality of life and reducing medical costs).
Pharmaceutical Drug Development (Human Health Value)	Amphibians produce chemicals for a variety of purposes, and these chemicals can provide the basis for new drugs.
Other Medical Advances (Human Health Value)	Amphibians' ability to regenerate limbs and tails may increase knowledge about physiology and lead to human medical advances.
Environmental Quality Value	Amphibians improve soil structure and fertility through soil furrowing, decomposition, and nutrient cycling.
Species Existence Value	In addition to and separate from their values for the above uses, preservation of frog populations provides intrinsic value to people related to enjoyment of knowing the species exists and the moral/ethical values associated with the conservation of the species for others, including future generations.

Source: (Hocking & Babbitt, 2013) Prepared January 2021

Value per Household

In terms of specific dollar values for the OSF, numerous studies are available in the economic literature that estimate the willingness to pay for individual species conservation. People's values for species conservation may arise from personal use (i.e., enjoying seeing the species and/or its habitat), personal beliefs and moral ethics (i.e., believe protecting a species and its habitat is the right thing to do), altruism (i.e., believing a resource should be protected so that others can use it or benefit from it), and/or a desire to bequest the resource (i.e., believing a resource should be protected for future generations). The most common way to measure value to people of species conservation is through surveys in which people are asked about their willingness to pay to protect a species. These surveys are highly challenging to develop and implement well; results from different surveys aiming to measure similar changes in resources can be highly variable.

While results are varied, several reviews of these types of survey studies have found that people's willingness to pay (i.e., the value they hold) for species conservation typically depends most heavily on the following factors: the type of species being conserved (in general, the larger and more iconic or charismatic the species, the higher the value, with species such as marine mammals tending to have the highest values), people's knowledge of the species (the more knowledge people have regarding the species, the higher the conservation value), the usefulness of the species to people, the level of threat and species population size (the smaller and more endangered the species population, the higher the value), whether the respondent is a visitor or a resident (recreational or tourist visitors tend to have higher values than residents), and survey design (Loomis & White, 1996; Martin-Lopez, Montes, & Benayas, 2008; Amuakwa-Mensah, Barenbold, & Riemer, 2018).

As noted above, values, particularly for iconic mammals, can be quite high. For example, household willingness to pay for enhancing or preserving a species such as elk, moose, or humpback whales have been estimated to average over $150 per household per year. Values for less iconic, non-mammal species, however, are more pertinent to the OSF. Preservation of non-mammal species that are much less iconic are often valued by U.S. households in the range of $15 to $35 or more per household per year (Loomis & White, 1996; Martin-Lopez, Montes, & Benayas, 2008).[15] For example, the Palouse giant earth worm is valued at approximately $20 per year per household in eastern Washington State based on a conjoint analysis study, while the Riverside fairy shrimp is valued at approximately $35 per household per year by households in Orange County, California, based on a contingent valuation study (Stanley, 2005; Decker & Watson, 2016). These two species may be similar to the OSF in that they are not iconic but may be symbols of preservation of a particular ecosystem.

While the literature does not include willingness-to-pay surveys specific to the Deschutes Basin, watershed and habitat protection are important to basin residents. A 2009 survey of 400 randomly selected Deschutes County voters highlights this (The Trust for Public Land, 2010). In terms of conservation projects, the top five ranking project types, all with 79 percent or more of Deschutes County respondents indicating an importance level of extremely important or very important, are 1) protecting water quality in rivers, creeks, and streams; 2) protecting and improving drinking water quality; 3) protecting wildlife habitat; 4) protecting natural areas; and 5) protecting natural

[15] Surveys that are conducted in other countries, including developing countries with lower incomes, often find lower willingness-to-pay values for species conservation. In general, willingness to pay for conservation increases with higher household income. For this reason, we focus on studies conducted in the United States and Canada.

watersheds. These priorities ranked more highly than protecting forests, protecting farmland, planting more trees, and improving recreational access and recreational amenities. Furthermore, the survey findings illustrate that natural environment and recreational opportunities are integral to the county's quality of life (The Trust for Public Land, 2010). In response to questions regarding the county's quality of life, the most commonly cited contributors to a high quality of life were regarding the natural environment, including outdoor recreation, open spaces, and natural areas.

Specific to values for OSF conservation in the Deschutes Basin, the species is not a large mammal and therefore its value to people would tend to be less. On the other hand, several factors would tend to increase its value to households in the Deschutes Basin: 1) many people know about the species, and its conservation has come to represent, to many people, the restoration of the Deschutes River ecosystem, 2) the OSF species population is threatened, and researchers have identified that the Deschutes population of OSF is genetically distinct from other OSF populations (Moran & O'Reilly, 2018),[16] such that the population size of the genetically distinct species benefiting from increased wintertime Deschutes River flows is quite small, and 3) there are many visitors to the Deschutes Basin, and visitors tend to have relatively higher values (compared to local residents) for preservations of ecosystems and species in the areas they visit.

As instream flow augmentation in the Deschutes aids not just the OSF but also improves ecological function and enhances habitat for other species, it is useful to consider studies that estimate value of local habitat restoration and species preservation more generally. As cited above, Orange County residents were estimated to value fairy shrimp recovery at $35 per household per year and $80 per household per year for preservation of all local endangered species (Stanley, 2005).[17] Perhaps more pertinently, a conjoint analysis study identifying the value of preserving one or multiple little-known fish species in Ontario, Canada, Rudd, Andres, and Kilfoil (2016) found that some improvement in the population of a single, little-known riverine species (i.e., channel darter) was valued at $11 per household per year, while conservation of three little-known riverine species (i.e., channel darter, eastern sand darter, and the spotted sucker) would increase value to $75 per household per year. The same study found that conservation action that resulted in a large improvement to the channel darter population was valued at $24 per household per year, while a large improvement to the three species populations resulted in value of $90 per household per year (Rudd, Andres, & Kilfoil, 2016).[18] In other words, in both studies, preserving a single species was valued at approximately $11 to $35, while preserving habitat for a broader range of species was valued at $75 to $90 per household. As shown in Table D-13, the highest values in the Ontario, Canada, study were found to be associated with water quality, which would also be improved in the Deschutes Basin due to the Piping Alternative.

[16] In terms of its uniqueness, the OSF is found in Oregon, Washington, and California, but the OSF population in the Deschutes Basin have been found to be genetically distinct. In fact, even within the Deschutes Basin, evidence indicates that there are numerous genetically distinct populations of OSF due to the large distances between OSF habitat sites and the relatively limited travel distances of the frog (Moran & O'Reilly, 2018). While Deschutes OSF is still considered the same species as OSF located elsewhere, its genetic uniqueness adds to the biological and potentially economic value of its continued survival.

[17] The original study cited values of $25.83 and $55.22 in 2001 dollars, which were converted into annual 2020 dollars in this study.

[18] The original values, presented in 2011 Canadian dollars, were converted to 2020 U.S. dollars using a conversion rate of 1.014 (the average for 2011) and the Consumer Price Index (Investing.com, 2021).

Table D-13. Economic Values (2020 values) for Little-Known Ontario, Canada, Aquatic Species at Risk.

Type of Benefit	Some Improvement	Large Improvement
1 Riverine Species (Channel Darter)	$11	$24
3 Riverine Species (Channel Darter, Eastern Sand Darter, Spotted Sucker)	$75	$90
Water Quality Index	$98	$122

Source: (Rudd, Andres, & Kilfoil, 2016) Prepared January 2021

Note: The original values, presented in 2011 Canadian dollars, were converted to 2020 U.S. dollars using a conversion rate of 1.014 (the average for 2011) and the Consumer Price Index (Investing.com, 2021).

The instream flow value of $75 per AF per year described in the previous section translates into approximately $38 per Deschutes County household per year of conservation value.[19] Including a value of $35 per household per year for OSF habitat in addition to the instream flow values cited above provides a cumulative value per household of instream flow augmentation/habitat conservation value of $73 per Deschutes County household and tourist households. Although, as discussed above, there is significant uncertainty regarding this value, the finding appears reasonable based on the above-cited literature addressing the value of a single species conservation compared to multiple species conservation and improvements to an aquatic ecosystem.

Number of Resident and Tourist Households Holding Value for OSF and Deschutes Basin Habitat Conservation

In addition to local households, there may be many households residing outside of Deschutes County that value preservation of OSF and Deschutes Basin habitat. Some studies have found that households throughout the nation located far from a wildlife habitat area may value species preservation efforts (Loomis J. , 2000). Additionally, as noted above, visitors to an area, particularly tourists participating in outdoor recreation, may have even higher species preservation values than residents. As such, we apply the estimated OSF species conservation value not only to Deschutes County households, but also to the estimated number of households who are tourists in Deschutes County each year that participate in outdoor recreation activities.[20] Based on overnight visitation data (Longwoods International , 2017) and tourism expenditure data in Central Oregon (Dean Runyan Associates, 2018), we estimate that there are 102,000 households that visit Deschutes County each year, with the main trip purpose being outdoor recreation. We focus on these visitor households because many of the surveys of visitor willingness to pay for conservation have been at outdoor

[19] Based on U.S. Census data, the population of Deschutes County in 2017 was 186,875 people; using the Census 2010 average household size of 2.44, this translates to approximately 76,600 households. Households visiting Deschutes County for recreation total approximately 102,000 per year, for a total of about 178,600 households. Assuming approximately 300 AF per cfs, the 300 cfs required to support the OSF equates to roughly 90,000 AF. As such, using $75 AF per year value, the average estimated value on a per household basis translates to $38 per year ($75 x 90,000 / 178,600 = $38/household).

[20] We use the Deschutes County population because the affected OSF habitat is primarily in Deschutes County.

recreation sites.[21] In sum, we estimate that approximately 178,600 households (76,600 resident households and 102,000 visitor households) may value OSF habitat conservation in the Deschutes Basin. This represents approximately 7 percent of Oregon households.

Estimated OSF Conservation Value of LPID Flow Augmentation

While there are numerous factors that create uncertainty in estimating the value of OSF habitat conservation,[22] the economic literature supports the notion that habitat conservation through flow augmentation in the Deschutes likely exceeds the instream flow values cited in the previous section that are based on market transaction data. Based on the species and habitat conservation literature as a whole, we find it reasonable that this additional value for OSF conservation may be approximately $35 per household per year. While people throughout Oregon and beyond may value OSF habitat conservation, we conservatively apply this value to the 76,600 Deschutes County households and approximately 102,000 tourism households who visit the county annually for the primary purpose of outdoor recreation, for a total of 178,600 households. In sum, this translates into an estimated value of Deschutes OSF preservation of approximately $6.25 million per year.

As discussed above, for OSF preservation, flow augmentation is needed to increase wintertime flows from the current 100 cfs to approximately 400 cfs, or an increase of 300 cfs. Under the Piping Alternative, NUID (in exchange for LPID passing it water conserved from the project) would match all water passed to it with wintertime releases from Wickiup Reservoir for the initial years of the analysis period (until 2030). These releases would total approximately 5.3 cfs once the project is complete, or approximately 1.8 percent of the additional flow anticipated to be required for OSF conservation. We thus apportion 1.8 percent of the estimated value of $6.25 million for OSF conservation to the LPID Proposed Project, or $111,000 per year. Similar to instream flow benefits, the additional flows that benefit OSF would be required starting in Year 9 of the No Action Alternative due to the increased HCP requirements. For that reason, this analysis only includes OSF benefits under the Piping Alternative prior to Year 9, when they would be additional over the No

[21] The tourism study by Longwoods Travel estimates that there were 4.5 million overnight person trips (a person trip is a trip of any length taken by one person) to Central Oregon in 2017. The Central Oregon region includes Deschutes, Jefferson, Crooked, and South Wasco counties. We use the proportion of visitor spending in each county to estimate the percent of the overnight person trips occurring to Deschutes County. According to the Oregon Travel Impacts report prepared for the Oregon Tourism Commission, 82 percent of 2017 visitor spending in Central Oregon occurs in Deschutes County. (Total estimated spending in Central Oregon is $776.6 million, of which $640.2 million, or 82 percent, is estimated to occur in Deschutes County.) Assuming 82 percent of Central Oregon overnight visits are in Deschutes County, there were approximately 3.71 million overnight person-visits in 2017 in Deschutes County. The Longwoods Travel survey indicates that the average household size of overnight visitors to Central Oregon is approximately 2.87 people, which translates then to approximately 1.293 million households with overnight trips to Central Oregon. The survey also indicates that approximately 62 percent of households had visited Central Oregon in the previous 12-month period. We assume that these households with previous visits to the region had visited, on average, three times per year. This translates to an average visitation rate of 2.24 across all households with overnight visits, for an estimated 577,000 separate households visiting Deschutes County. Of all visitors, the survey indicates that approximately 57 percent are tourists (i.e., not traveling for business or visiting family or friends). Of these, approximately 31 percent have outdoor recreation as the primary purpose of their visit. As such, we estimate approximately 102,000 households take at least 1 overnight tourist trip to Deschutes County annually with the primary purpose of their trip being outdoor recreation.

[22] This includes first and foremost the uncertainty in applying values from other contexts and species to the OSF, as well as the challenge in interpreting results from previous studies given the diversity of values found and the high sensitivity of findings to study design and implementation methods.

Action Alternative. When discounted and annualized, these benefits total $16,000 as shown in Table D-14).

Table D-14. Value of Supporting OSF Habitat under the Piping Alternative, Deschutes Watershed, Oregon, 2020$.[1]

Project Group	Water Conservation (cfs)	Undiscounted Annual Benefits	Annualized Average Net Benefits
Project Group 1	5.3	$111,000	$16,000
Total	**5.3**	**$111,000**	**$16,000**

1/ Price Base: 2020 dollars amortized over 100 years at a discount rate of 2.5 percent Prepared January 2021

1.4.2 Benefits Considered but Not Included in Analysis

1.4.2.1 Public Safety Avoided Costs

Piping irrigation water removes the hazard of drownings in canals and eliminates the potential for unlined canals to fail and cause potential damage to downstream property and lives. While LPID canal failure is possible, the extent of damage varies dramatically depending on the timing and location of the failure. Given the limited amount of available data on the cost of these canal failures, the public safety (and property damage reduction) benefit of piping is not included in this analysis. While there is no history of drownings in LPID canals (Smith, 2020), past drownings in other Central Oregon irrigation canals have demonstrated the danger inherent to open canals, which can have fast-moving water and present a threat to public safety.

In 2004, a toddler drowned in a Central Oregon Irrigation District canal; in 1996 and 1997, respectively, a 12-year-old boy and a 28-year-old man drowned in NUID 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 death per year during this period.

The Piping Alternative would pipe the remaining open canals in the District's system. This section qualitatively discusses the potential magnitude of the public safety benefit of piping the remaining exposed canals in LPID. The analysis presents some information on the potential public safety hazard of the existing irrigation canals in LPID proposed for piping (based on the recent history of drownings in Central Oregon and the mileage of exposed canals).

Level of Public Safety Hazard

This analysis estimates the public safety hazard of irrigation canals in LPID based on past drownings in Central Oregon irrigation canals. The drownings generally occurred in irrigation districts that surround the urban areas of Bend and Redmond. In contrast, LPID is located in a rural setting. Because higher populations in proximity to open canals increase the likelihood of drownings, using drowning rates from urban-adjacent districts likely overestimates the risk of open canals in LPID. However, the analysis is still illustrative of the potential increase in public safety associated with piping LPID canals.

Based on data from the Oregon Water Resources Department (OWRD) on canals in Central Oregon, there are 1,072 miles of irrigation canals in Central Oregon districts (see Table D-15). Starting in the late 1980s and early 1990s, sections of these canals began to be piped, with the result that today, the OWRD database records that approximately 209 miles have been piped. Assuming piping occurred uniformly across the 21-year period of 1996 to 2016, approximately 9.9 miles were piped each year, leaving approximately 973 miles unpiped on an average annual basis during this period. Given that an average of 0.143 drowning death occurred annually during this period (3 deaths over 21 years as described above), the annual drowning risk per mile of exposed canal was 0.000147 (0.143 divided by 973). This may be an overestimate of risk if there were an abnormally high number of drownings in the last 20 years or so, but may also be an underestimate of risk because the population of Bend continues to grow and the areas around irrigation canals continues to urbanize (thereby increasing the risks of drownings).

Table D-15. Irrigation Canal Mileage by District.

District	Canal and Lateral Mileage
Arnold Irrigation District	47.3
Central Oregon Irrigation District	430.0
Lone Pine	2.4
North Unit Irrigation District	300.1
Ochoco Irrigation District	100.3
Swalley Irrigation District	27.6
Tumalo Irrigation District	95.8
Three Sisters Irrigation District	68.7
Total	**1,072.2**

Source: OWRD, database maintained and provided by Jonathon LaMarche on March 9, 2017 Prepared January 2021

Under baseline conditions, LPID would continue to have approximately 11.1 miles of unpiped canals (Farmers Conservation Alliance, 2017). Assuming that the three drownings over the past 21 years are representative of future drowning risk, and that the 0.000147 death per mile of exposed canal experienced during this period is an appropriate estimate of future risk, the unpiped canals in LPID carry a risk of 0.0015 death per year.

1.4.3 Summary of Benefits

Table 8-6 (NWPM 506.20, Economic Table 5a) in the Plan-EA summarizes annual average NEE project benefits of the Piping Alternative that exceed the benefits under the No Action Alternative.

1.5 Incremental Analysis

As noted above, there are no component pieces of the proposed project that have significant separate costs or benefits that make sense to evaluate independently. The project group serves one geographic area of clustered irrigated acreage (i.e., no section of acreage is isolated by itself with a significant length of lateral to reach it), and all of the elements of the proposed project combine to provide benefits to the same subset of acres. Further, there is no standalone element of the proposed project that would be done independently, as benefits associated with pressurization to this area are co-dependent of all elements being completed. The project entails the construction of a new point-of-diversion and an almost-complete re-alignment of the District's conveyance system. While the proposed project would be constructed in phases, the District would continue using their existing diversion and system to serve their patrons until all phases of the project were complete. Because of the realignment, all parts of project are dependent on each other and benefits will only be achieved once the whole proposed project has been completed. As such, there is no incremental analysis associated with this project.

1.6 NEE Appendix

1.6.1 Crop Enterprise Budgets

This section presents the crop enterprise budgets used to estimate the benefits under the Piping Alternative of 1) avoiding agricultural damage to LPID and 2) avoiding agricultural damage to NUID. The analyses use a total of eight crop budgets, which are outlined in the table below. As the table illustrates, each budget models alfalfa production 1) in either LPID or NUID, 2) under either full irrigation or deficit irrigation, and 3) in either the first year of production or the subsequent years of production.

Table D-16. Diagram of Crop Budgets.

District	Scenario	Production Year	Budget Table
LPID	Deficit Irrigation	Year 1	Table
		Years 2-6	Table D-18.
	Full Irrigation	Year 1	Table
		Years 2-6	Table
NUID	Deficit Irrigation	Year 1	Table
		Years 2-6	Table D-
	Full Irrigation	Year 1	Table D-
		Years 2-6	Table D-

The costs and benefits of agricultural production are estimated using an enterprise budget that represents 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 conditions of any particular farm. As a starting point for the crop budgets in this analysis, we used a crop budget for alfalfa hay developed by WSU and then adjusted values in the budget to account for changes in prices through time and local conditions (in LPID or NUID, depending on the budget). A more recent published alfalfa hay budget for Central Oregon was not available from Oregon State or WSU. The following section outlines the data and assumptions used in adjusting the Washington State alfalfa hay budget.

1.6.2 Alfalfa Enterprise Budgets

The alfalfa hay enterprise budgets were based on a 2012 budget developed by WSU for establishing and producing alfalfa hay in the Washington Columbia Basin (Norberg & Neibergs, 2012). We selected these budgets as the basis for production costs because they are the most recent crop budgets developed for producing alfalfa hay in an area that is relatively close 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 the district being modeled. Returns to alfalfa were based on locally reported hay yields and 5-year normalized average hay prices in Oregon.

1.6.2.1 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 1-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. Alfalfa fields were assumed to have a 6-year stand life. Following the original budget, costs and returns are assumed to be similar in production years 2 through 6 but differ in the first production year.

1.6.2.2 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 of dry phosphate to produce 8 tons of hay per acre; in the LPID Production Budget, we model a yield of 6.5 tons per acre (81 percent of the original yield), so we reduce the amount of dry phosphate to 75 pounds (81 percent of 92 pounds). One exception to this method is the amount of dry sulfur applied, which is held constant at 30 pounds per acre during production years per guidance from an Oregon State University (OSU) Extension Agent in Central Oregon (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. 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, 2020). For example, there are price indices for fertilizer, herbicides, supplies, tractors, and custom work, as well as one for the farm sector in general. The PPI cost adjustments range from a 30 percent decrease in the price of Potash & Phosphorus to a 16 percent increase in Custom Work costs.

For land costs, we used the normalized average rental price for irrigated land in the county of the respective district (Crook County for LPID and Jefferson County for NUID).[23] Price data came from NASS and included the available data from 2012 to 2020. This resulted in a land cost of $110 per acre for LPID and $121 per acre for NUID (NASS, 2020). Because alfalfa is seeded in the fall after another crop has been harvested, we only ascribe 25 percent of the land costs to establishing alfalfa.

1.6.2.3 Labor Costs

Because most of the labor is provided by custom work, the only direct labor costs are for irrigation labor. For the cost of equipment operator labor, we use the median hourly wage rate for farmworkers in Central Oregon in 2019 and adjust it to 2020 dollars using the Consumer Price Index.[24] We further adjust this wage rate up by 20 percent to account for non-wage employment costs, such as health care and insurance. This results in total labor costs of $16.95 per hour for farmworkers.

We adjusted the cost of custom work using the Custom Work PPI. For the hay budgets under deficit irrigation, we adjust the labor costs (including custom, management, and other labor)

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[23] The normalized average is calculated by removing the high and low values from dataset and taking the mean of the remaining values.

[24] This is the average wage for the Farmworkers and Laborers, Crop, Nursery, and Greenhouse (occupation code 45-2092) in the Central Oregon non-metropolitan area according to the Bureau of Labor Statistics' Occupational Employment and Wage Estimates data in May 2019 (Bureau of Labor Statistics, 2018).

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 underestimate benefits (and vice versa).

1.6.2.4 Revenues

To estimate the gross revenues of alfalfa hay under full irrigation in LPID, we use the average alfalfa yield in LPID of 6.5 tons per acre (Smith, 2020). An Oregon State University Extension Agent and expert on forage crops in Central Oregon supported the fact that yields in this area generally reach up to 6.5 tons per acre (Bohle, 2018b). Roughly once every 3 years, water shortages cause alfalfa growers in LPID to forego their third and final hay cutting, which has an average yield of 1.75 tons per acre (Smith, 2020). We base our estimates of the net returns to alfalfa in LPID under deficit irrigation on this yield loss, for a total yield of 4.8 tons per acre.

Our total assumed yield is higher than the average yield in Crook County over the last 5 years of available data, which is 4.7 tons per acre (NASS, 2020). Based on information from published sources and interviews with local experts, which indicate the final hay cutting is approximately 25 percent of the total yield, a third cutting from this total yield would be roughly 1.25 tons per acre (Bohle, 2018a; Smith, 2020; Bulter & Oppenlander, 2015; Butler & Ralls, Alfalfa Variety Trials, Second Cutting Results, 2015; Butler & Ralls, Alfalfa Variety Trials, Third Cutting Results, 2015). If we were to assume this lower impact to hay yields in dry years, the net benefits of conserved water to agricultural would be slightly lower than those shown in Section 1.4. But because the value to water is based on the difference between the deficit and full irrigation net returns, the estimated value of water would change very little (by about $1 per acre) even if we assumed this lower yield.

For yields under full irrigation in NUID, we use the average yield in Jefferson County from 2013 to 2017: 5.4 tons per acre (NASS, 2020). Yields under deficit irrigation (which results in the loss of a third cutting) are assumed to be 25 percent lower than this average (4.06 tons per acre). This analysis conservatively used published average hay yield data for Jefferson County where NUID is located, which are lower than the district-specific LPID yields used. We expect that NUID average yields may also be higher than the reported county yields. To estimate the gross revenues of alfalfa hay (in both districts), we use the normalized average price per ton for alfalfa hay in Oregon from 2013 to 2019 according to NASS data: $195.20 (NASS, 2020).

1.6.2.5 Alfalfa Enterprise Budget Tables

The tables below present the four alfalfa hay enterprise budgets used to estimate the net returns under different irrigation scenarios.

Table D-17. Alfalfa Net Returns in LPID Under Deficit Irrigation, Production Year 1.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	4.8	ton	$195.20	$927.20
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	0.0	pound	$0.63	$0.00
Dry Potash	0.0	pound	$0.45	$0.00
Dry Sulfur	0.0	pound	$0.20	$0.00
Custom - Swath	2.0	acre	$23.22	$46.45
Custom - Rake	2.0	acre	$11.61	$23.22
Custom - Bail	4.8	ton	$19.74	$93.76
Custom - Haul & Stack	4.8	ton	$10.45	$49.64
Custom - Tarping	4.8	ton	$5.81	$27.58
Irrigation - power	1.0	acre	$45.09	$45.09
Irrigation - water access	1.0	acre	$65.00	$65.00
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.4	acre	$16.95	$6.19
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$3.29	$7.50
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Haystack Insurance	4.8	ton	$1.80	$8.57
Overhead	1.0	acre	$28.79	$28.79
Operating interest	1.0	acre	$10.68	$10.68
Total variable costs				$438.02
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$2.52	$2.52
Management (5% of total cost)	1.0	acre	$32.90	$32.90
Amortized establishment cost	1.0	acre	$97.54	$97.54
Land cost	1.0	acre	$109.83	$109.83
Total fixed costs				$252.82
Total costs				$690.84
NET RETURNS PER ACRE				**$236.36**

Table D-18. Alfalfa Net Returns in LPID Under Deficit Irrigation, Production Years 2-6.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	4.8	ton	$195.20	$927.20
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	54.6	pound	$0.63	$34.19
Dry Potash	83.1	pound	$0.45	$37.00
Dry Sulfur	30.0	pound	$0.20	$6.01
Zinc	3.0	pound	$2.03	$6.04
Boron	1.2	pound	$4.58	$5.44
Custom Application	1.0	acre	$10.45	$10.45
Soil Test	1.0	acre	$0.35	$0.35
Herbicide	2.0	pound	$16.97	$33.93
Custom Application	1.0	acre	$10.45	$10.45
Custom - Swath	2.0	acre	$23.22	$46.45
Custom - Rake	2.0	acre	$11.61	$23.22
Custom - Bail	4.8	ton	$19.74	$93.76
Custom - Haul & Stack	4.8	ton	$10.45	$49.64
Custom - Tarping	4.8	ton	$5.81	$27.58
Irrigation - water charge	1.0	acre	$50.73	$50.73
Irrigation - service charge	1.0	acre	$65.00	$65.00
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.4	acre	$16.95	$6.19
Haystack insurance	4.8	ton	$1.80	$8.57
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$3.29	$7.50
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Overhead	1.0	acre	$43.34	$43.34
Operating interest	1.0	acre	$14.78	$14.78
Total variable costs				$606.17
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$3.28	$3.28
Management (5% of total cost)	1.0	acre	$41.34	$41.34
Amortized establishment cost	1.0	acre	$97.54	$97.54
Land cost	1.0	acre	$109.83	$109.83
Total fixed costs				$262.03
Total costs				$868.21
NET RETURNS PER ACRE				**$58.99**

Table D-19. Alfalfa Net Returns in LPID Under Full Irrigation, Production Year 1.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	6.5	ton	$195.20	$1,268.80
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	0.0	pound	$0.63	$0.00
Dry Potash	0.0	pound	$0.45	$0.00
Dry Sulfur	0.0	pound	$0.20	$0.00
Custom - Swath	3.0	acre	$23.22	$69.67
Custom - Rake	3.0	acre	$11.61	$34.83
Custom - Bail	6.5	ton	$19.74	$128.31
Custom - Haul & Stack	6.5	ton	$10.45	$67.93
Custom - Tarping	6.5	ton	$5.81	$37.74
Irrigation - power	1.0	acre	$45.09	$45.09
Irrigation - water access	1.0	acre	$65.00	$65.00
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.5	acre	$16.95	$8.47
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$3.29	$7.50
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Haystack Insurance	6.5	ton	$1.80	$11.73
Overhead	1.0	acre	$28.79	$28.79
Operating interest	1.0	acre	$13.27	$13.27
Total variable costs				$543.87
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$2.52	$2.52
Management (5% of total cost)	1.0	acre	$38.19	$38.19
Amortized establishment cost	1.0	acre	$97.54	$97.54
Land cost	1.0	acre	$109.83	$109.83
Total fixed costs				$258.12
Total costs				$801.99
NET RETURNS PER ACRE				**$466.81**

Table D-20. Alfalfa Net Returns in LPID Under Full Irrigation, Production Years 2-6.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	6.5	ton	$195.20	$1,268.80
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	74.8	pound	$0.63	$46.79
Dry Potash	113.8	pound	$0.45	$50.63
Dry Sulfur	30.0	pound	$0.20	$6.01
Zinc	4.1	pound	$2.03	$8.26
Boron	1.6	pound	$4.58	$7.45
Custom Application	1.0	acre	$10.45	$10.45
Soil Test	1.0	acre	$0.35	$0.35
Herbicide	2.0	pound	$16.97	$33.93
Custom Application	1.0	acre	$10.45	$10.45
Custom - Swath	3.0	acre	$23.22	$69.67
Custom - Rake	3.0	acre	$11.61	$34.83
Custom - Bail	6.5	ton	$19.74	$128.31
Custom - Haul & Stack	6.5	ton	$10.45	$67.93
Custom - Tarping	6.5	ton	$5.81	$37.74
Irrigation - water charge	0.6	acre	$50.73	$31.88
Irrigation - service charge	1.0	acre	$65.00	$65.00
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.5	acre	$16.95	$8.47
Haystack insurance	6.5	ton	$1.80	$11.73
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$3.29	$7.50
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Overhead	1.0	acre	$43.34	$43.34
Operating interest	1.0	acre	$17.66	$17.66
Total variable costs				$723.92
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$3.28	$3.28
Management (5% of total cost)	1.0	acre	$47.23	$47.23
Amortized establishment cost	1.0	acre	$97.54	$97.54
Land cost	1.0	acre	$109.83	$109.83
Total fixed costs				$267.92
Total costs				$991.84
NET RETURNS PER ACRE				**$276.96**

Table D-21. Alfalfa Net Returns in NUID Under Deficit Irrigation, Production Year 1.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	4.1	ton	$195.20	$792.39
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	0.0	pound	$0.63	$0.00
Dry Potash	0.0	pound	$0.45	$0.00
Dry Sulfur	0.0	pound	$0.20	$0.00
Custom - Swath	2.0	acre	$23.22	$46.45
Custom - Rake	2.0	acre	$11.61	$23.22
Custom - Bail	4.1	ton	$19.74	$80.13
Custom - Haul & Stack	4.1	ton	$10.45	$42.42
Custom - Tarping	4.1	ton	$5.81	$23.57
Irrigation - power	1.0	acre	$45.09	$45.09
Irrigation - water access	1.0	acre	$3.10	$3.10
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.5	acre	$22.39	$11.19
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$2.69	$6.13
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Haystack Insurance	4.1	ton	$1.80	$7.33
Overhead	1.0	acre	$28.79	$28.79
Operating interest	1.0	acre	$8.57	$8.57
Total variable costs				$351.54
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$2.52	$2.52
Management (5% of total cost)	1.0	acre	$24.26	$24.26
Amortized establishment cost	1.0	acre	$93.82	$93.82
Land cost	1.0	acre	$121.20	$121.20
Total fixed costs				$251.84
Total costs				$603.38
NET RETURNS PER ACRE				**$189.01**

Table D-22. Alfalfa Net Returns in NUID Under Deficit Irrigation, Production Years 2-6.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	4.1	ton	$195.20	$792.39
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	46.7	pound	$0.63	$29.22
Dry Potash	71.0	pound	$0.45	$31.62
Dry Sulfur	30.0	pound	$0.20	$6.01
Zinc	2.5	pound	$2.03	$5.16
Boron	1.0	pound	$4.58	$4.65
Custom Application	1.0	acre	$10.45	$10.45
Soil Test	1.0	acre	$0.35	$0.35
Herbicide	2.0	pound	$16.97	$33.93
Custom Application	1.0	acre	$10.45	$10.45
Custom - Swath	2.0	acre	$23.22	$46.45
Custom - Rake	2.0	acre	$11.61	$23.22
Custom - Bail	4.1	ton	$19.74	$80.13
Custom - Haul & Stack	4.1	ton	$10.45	$42.42
Custom - Tarping	4.1	ton	$5.81	$23.57
Irrigation - water charge	1.0	acre	$50.73	$50.73
Irrigation - service charge	1.0	acre	$3.10	$3.10
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.4	acre	$16.95	$6.35
Haystack insurance	4.1	ton	$1.80	$7.33
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$2.69	$6.13
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Overhead	1.0	acre	$43.34	$43.34
Operating interest	1.0	acre	$12.25	$12.25
Total variable costs				$502.41
FIXED COSTS				
Machinery depreciation	1	acre	$6.37	$6.37
Machinery interest	1	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1	acre	$2.52	$2.52
Management (5% of total cost)	1	acre	$36.50	$36.50
Amortized establishment cost	1	acre	$93.82	$93.82
Land cost	1	acre	$121.20	$121.20
Total fixed costs				$264.07
Total costs				$766.49
NET RETURNS PER ACRE				**$25.90**

Table D-23. Alfalfa Net Returns in NUID Under Full Irrigation, Production Year 1.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	5.4	ton	$195.20	$1,056.52
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	0.0	pound	$0.63	$0.00
Dry Potash	0.0	pound	$0.45	$0.00
Dry Sulfur	0.0	pound	$0.20	$0.00
Custom - Swath	3.0	acre	$23.22	$69.67
Custom - Rake	3.0	acre	$11.61	$34.83
Custom - Bail	5.4	ton	$19.74	$106.84
Custom - Haul & Stack	5.4	ton	$10.45	$56.56
Custom - Tarping	5.4	ton	$5.81	$31.42
Irrigation - power	1.0	acre	$45.09	$45.09
Irrigation - water access	1.0	acre	$3.10	$3.10
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.5	acre	$22.39	$11.19
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$2.69	$6.13
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Haystack Insurance	5.4	ton	$1.80	$9.77
Overhead	1.0	acre	$28.79	$28.79
Operating interest	1.0	acre	$10.72	$10.72
Total variable costs				$439.67
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$2.52	$2.52
Management (5% of total cost)	1.0	acre	$28.67	$28.67
Amortized establishment cost	1.0	acre	$93.82	$93.82
Land cost	1.0	acre	$121.20	$121.20
Total fixed costs				$256.25
Total costs				$695.92
NET RETURNS PER ACRE				**$360.60**

Table D-24. Alfalfa Net Returns in NUID Under Full Irrigation, Production Years 2-6.

Item	Quantity	Unit	$/Unit	Total
REVENUE				
Alfalfa Hay	5.4	ton	$195.20	$1,056.52
VARIABLE COSTS				
Dry Nitrogen	0.0	pound	$0.34	$0.00
Dry Phosphate	62.2	pound	$0.63	$38.96
Dry Potash	94.7	pound	$0.45	$42.16
Dry Sulfur	30.0	pound	$0.20	$6.01
Zinc	3.4	pound	$2.03	$6.88
Boron	1.4	pound	$4.58	$6.20
Custom Application	1.0	acre	$10.45	$10.45
Soil Test	1.0	acre	$0.35	$0.35
Herbicide	2.0	pound	$16.97	$33.93
Custom Application	1.0	acre	$10.45	$10.45
Custom - Swath	3.0	acre	$23.22	$69.67
Custom - Rake	3.0	acre	$11.61	$34.83
Custom - Bail	5.4	ton	$19.74	$106.84
Custom - Haul & Stack	5.4	ton	$10.45	$56.56
Custom - Tarping	5.4	ton	$5.81	$31.42
Irrigation - water charge	1.0	acre	$50.73	$50.73
Irrigation - service charge	1.0	acre	$3.10	$3.10
Irrigation - repairs	1.0	acre	$16.88	$16.88
Irrigation - labor	0.5	acre	$16.95	$8.47
Haystack insurance	5.4	ton	$1.80	$9.77
Gopher control	1.0	acre	$5.72	$5.72
Fuel	2.3	gallon	$2.69	$6.13
Lubricants	1.0	acre	$0.92	$0.92
Machinery repairs	1.0	acre	$2.03	$2.03
Overhead	1.0	acre	$43.34	$43.34
Operating interest	1.0	acre	$15.05	$15.05
Total variable costs				$616.86
FIXED COSTS				
Machinery depreciation	1.0	acre	$6.37	$6.37
Machinery interest	1.0	acre	$3.66	$3.66
Machinery insurance, taxes, housing, license	1.0	acre	$2.52	$2.52
Management (5% of total cost)	1.0	acre	$42.22	$42.22
Amortized establishment cost	1.0	acre	$93.82	$93.82
Land cost	1.0	acre	$121.20	$121.20
Total fixed costs				$269.80
Total costs				$886.65
NET RETURNS PER ACRE				**$169.87**

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D.2 Alternatives Considered during Formulation

This 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 (PR&G; USDA 2017) (Table D-25). According to NEPA, agencies shall rigorously explore and objectively evaluate all reasonable alternatives (40 Code of Federal Regulations 1502.14). According to the PR&G DM9500-013, 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 that were eliminated during formulation are identified in the table and further discussion is provided below. Alternatives selected for further evaluation are discussed in the Plan-EA.

Table D-25. 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		
Voluntary Duty Reduction			X		
Exclusive or Partial Use of Groundwater					

Alternative	Which criteria in the PR&G does the alternative achieve?				Selected for Further Evaluation
	Completeness	Effectiveness	Efficiency	Acceptability	
Piping Private Laterals		X		X	
On-Farm Efficiency Upgrades		X		X	
Canal Lining	X	X		X	X
No Action (Future without Federal Investment)			X		X
Piping 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 together with hot temperatures, desiccating winds, and generally shallow and well to excessively drained soils with low storage potentials 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 the area is experiencing. Dryland farming would be inconsistent with ensuring agricultural production is maintained in an area undergoing rapid urbanization.

Conversion to dryland farming would not meet any of the purposes of the project. If water saved from conversion to dryland farming was put instream, it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because conversion to dryland farming would be voluntary, and any water saved would not necessarily be put in stream by the patrons. Conversion to dryland farming would not meet any of the other identified project needs.

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 be inconsistent with public policy supporting and maintaining existing agricultural land use; and it did 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 would not meet any of the project purposes. If water saved from fallowing was put instream, it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because fallowing would be voluntary, and any water saved would not necessarily be put instream by the patrons. Fallowing farm fields would not meet any of the other identified needs of the project.

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 and it could affect flow rates and water reliability to certain patrons; 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.

Voluntary Duty Reduction

Voluntary duty reduction refers to patrons voluntarily accepting less than their full water delivery rate from the District. A reduction in duty could mean the District diverts less water, which would leave more water instream. This water would not be permanently protected instream through a new instream water right.

Voluntary duty reduction would not meet any of the project purposes. If water saved from duty reduction was put instream, it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because duty reduction would be voluntary, and any water saved would not necessarily be put instream by the patrons. Voluntary duty reduction would not meet any of the other identified needs of the project. Voluntary duty reduction was eliminated from further evaluation because: it would not meet the project's purpose and need; its effectiveness would be uncertain since duty reduction 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.

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 alternative. 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 16.65 cfs[25] 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, March 11, 2021). Given only 16.65 cfs is available under this program, the District's exclusive use of groundwater to entirely replace their use of surface water is not feasible.

[25] Currently OWRD has 40.9 cfs left under the 200 cfs cap, however they have pending applications with the amount of 25.24 cfs. Although there is no guarantee that these applications will be approved or processed, it is suggested that the cap would be at 16.65 cfs remaining (S. Henderson, personal communication, March 11, 2021).

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[26] required by the DBGM program; however, the District would need the authority from each patron to convert surface 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.

Exclusive and partial use of groundwater would not meet any of the purposes of the project. If water saved from conversion to groundwater was put instream it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because switching to groundwater would be voluntary, and any water saved would not necessarily be put instream by patrons. Partially or exclusively switching to groundwater would not meet any of the other identified needs of the project. Additionally, the District lacks the statutory authority or responsibility to carry out, operate, and maintain groundwater wells on private lands owned by LPID patrons. Therefore, carrying out this alternative would be logistically complex. The exclusive and 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 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 and Piping Private Laterals

On-farm efficiency upgrades refer to LPID service area patrons upgrading their on-farm infrastructure to use irrigation technologies that provide a more precise application of water. Piping private laterals refers to piping ditches or laterals that are owned by private patrons and bring the water from the District's infrastructure to the patron's farm fields. On-farm infrastructure and private laterals are distinct from District canals and laterals because they are owned and operated by patrons. Once delivered by the District the water may have to be carried substantially further to fields, so the patron may have a long extent of private laterals and ditches they own and operate. Once 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 and piping private laterals would not meet any of the purposes of the project. If water saved from upgrades and piping of private laterals was put instream it could meet the need of improving instream flow for fish and aquatic habitat, but this is not certain to occur because upgrading on-farm systems would be voluntary, and any water saved would not necessarily

[26] LPID would not create groundwater mitigation credits under either the No Action or the Piping Alternatives analyzed in the Plan-EA.

be put instream by the patrons. On-farm efficiency upgrades and piping private laterals would not meet any of the other identified needs of the project.

On-farm upgrades and piping private laterals are not within the scope of actions that LPID can entertain as the project sponsor under PL-85-566 because LPID lacks the authority or responsibility to carry out, operate and maintain on-farm infrastructure owned and operated by LPID 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 Watershed Protection and Flood Prevention Program, Public Law 83-566 funds were used to develop and implement on-farm efficiency upgrades and piping private laterals, 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,[27] 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 and piping private laterals 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

Canal Lining Alternative Costs

The capital cost of the Canal Lining Alternative (Table D-26) 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). Safety ladders would be installed 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 were calculated for each corresponding pipe diameter size using transects on a digital elevation model, estimated from an irrigation district in Central Oregon.

Engineering, Construction Management, and Survey costs and Construction Manager/General Contractor costs were each estimated at 10 percent of subtotal costs. Permit costs were estimated at $150,000. Contingency cost was not included in this analysis.

[27] This could require LPID 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.

Table D-26. Canal Lining Alternative Costs.

Feature	Equivalent Pipe Diameter (in)	Length (feet) or Quantity	Cross section (feet)	Channel Width (feet)	Channel Depth (feet)	Materials & Construction ($)
Lining	48	11,043	25.9	23.5	4.4	$3,909,991
Lining	42	945	25.3	22.8	4.6	$324,826
Lining	36	914	22.2	19.5	4.9	$277,727
Lining	32	809	25.3	24.0	3.3	$277,971
Lining	30	1,061	25.3	24.0	3.3	$364,612
Lining	28	67	23.6	22.5	3.0	$21,403
Lining	26	1,607	23.6	22.5	3.0	$517,052
Lining	24	1,939	23.8	22.6	3.1	$627,994
Lining	16	3,157	14.8	14.1	2.3	$657,490
Lining	14	739	12.5	11.8	2.2	$132,057
Lining	12	5,625	12.7	11.8	2.4	$1,025,593
Lining	10	6,125	12.7	11.8	2.4	$1,116,856
Lining	8	3,007	12.3	11.6	2.0	$531,410
Lining	6	2,604	12.3	11.6	2.0	$460,267
Lining	4	1,425	10.7	10.5	1.0	$222,878

Feature	Equivalent Pipe Diameter (in)	Length (feet) or Quantity	Cross section (feet)	Channel Width (feet)	Channel Depth (feet)	Materials & Construction ($)
Turnouts	N/A	45	N/A	N/A	N/A	$45,000
Junctions	N/A	4	N/A	N/A	N/A	$32,000
River Crossing	N/A	1	N/A	N/A	N/A	$800,000
					Subtotal	$11,345,000
					Engineering, Construction Management, and Survey (10%)	$1,135,000
					Construction Manager/General Contractor (10%)	$1,135,000
					Permitting	$150,000
					Total	$13,765,000

Notes:
N/A = not applicable; Totals rounded to nearest $1,000

Prepared February 2021

Modernization Alternative/Preferred Alternative Costs

This section presents capital costs for the Piping Alternative, which is identified as the Preferred Alternative (Table D-27). In addition to the cost of pipe, the cost estimates also include fittings and other necessary appurtenances.

A wide variety of materials are available for piping; availability of piping materials, prices, and new products change over time. Materials that could be used for the Piping Alternative include, but are not limited to, polyvinyl chloride, steel, high-density polyethylene (HDPE), bar-wrapped concrete cylinder, fiberglass, and ductile iron. For the purpose of costing this alternative, the price of HDPE was used.

At the time of project implementation, the specific piping material would be selected based on a number of considerations: the cost of the project would meet the NEE requirements, meet construction requirements, be appropriate based on local conditions and risk factors, and result in a no or minor change to project effects described in Section 6 of the Plan-EA, as determined through the tiered decision framework approach outlined in Section 1.4 of the Plan-EA. The NRCS State Conservationist and the Sponsoring Local Organization would possess the final discretion to select the appropriate piping material.

Table D-27. Proposed Features for the Preferred Alternative within Lone Pine Irrigation District.

Type	Project Feature	Quantity	Total
Pipe	Pipeline Realignment	10.3 miles	$8,699,000
River Crossing	Bridge or Inverted Siphon	1	$800,000
Turnouts	Turnouts	45	$360,000
Junction	Junctions	4	$32,000
	Total infrastructure	**10.3 miles**	**$9,891,000**
Engineering, Construction Management, Survey[2]			$700,000
Construction Manager/General Contractor[2]			$989,000
Contingency[2]			$1,173,000
TOTAL			**$12,755,000**

Totals are rounded to the nearest $1,000. Prepared February 2021

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

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

Table D-28. Pipe Diameters and Lengths.

Area	Feature	Diameter (inches)	Length (feet)	Turnouts
LPID Main Pipeline	Pipe	16-48	28,455	16
Butler Spur Pipeline	Pipe	8	1,145	1
Core Botanic Spur Pipeline	Pipe	8	1,455	1
E. Butler Rd. Lateral Pipeline	Pipe	14	4,770	5
W. Butler Rd. Lateral Pipeline	Pipe	12	3,935	5
Legacy Ranches Spur Pipeline	Pipe	4	1,190	1
E. Low Ditch Lateral Pipeline	Pipe	12	1,330	1
W. Low Ditch Lateral Pipeline	Pipe	16	5,265	6
E. Mid Lateral Pipeline	Pipe	10	5,065	3
W. Mid Lateral	Pipe	12	2,645	3
E. Lone Pine Ln. Lateral Pipeline	Pipe	6	1,310	1
W. Lone Pine Ln. Lateral Pipeline	Pipe	10	1,250	1
Gregg Spur Pipeline	Pipe	4	845	1
		Total	**58,670**	**45**

Prepared February 2021

Net Present Value of the Preferred Alternative and the Canal Lining Alternative

This section presents the estimated net present value of the Preferred Alternative and the Canal Lining Alternative. This analysis compares installation and operation of pipes and canals only.

Discount Rate: 2.5%

Period of Analysis: 100 years

Table D-29. Net Present Value of the Preferred Alternative and the Canal Lining Alternative.

	Preferred Alternative	Canal Lining Alternative
Design Life (years)	100	33
Capital Costs[1]	$12,904,000	$13,764,000
Net Present Value of Replacement Costs[2]	N/A	$8,675,000
Annual O&M Costs	$97,000	$194,000
Net Present Value of O&M Costs	$3,176,000	$6,351,000
Total Net Present Value	$16,080,000	$28,790,000

Totals are rounded to the nearest $1,000. Prepared January 2021

Note:

[1] The cost of permitting was included in both alternatives

[2] For canal lining, 100 percent was replaced at both 33 years and 66 years.

References

Daly, C., R. Neilson, and D. Phillips. 1994. A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain. *Journal of Applied Meteorology* 33(2), 140-158. February.

Gannett, M.W., Lite, K.E. Jr., Morgan, D.S., & Collins, C.A. 2001. Ground-water hydrology of the upper Deschutes Basin, Oregon: U.S. Geological Survey Water-Resources Investigations Report 00–4162, p. 77.

Henderson, Sarah (ORWD). 2021. Personal Communication with Amanda Schroeder (FCA). March 11.

U.S. Department of Agriculture (USDA). 2017. Guidance for Conducting Analysis Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water and Resource Investments. DM 9500-013.

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

Appendix E

Other Supporting Information

Acronyms, Abbreviations, and Short-forms

B	Breeding
cfs	cubic feet per second
LPID	Lone Pine Irrigation District
N	Nonbreeding
O	Overwintering Habitat
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PCE	Primary Constituent Element
R	Rearing

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 Lone Pine 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 that only occur over a period of days or months
Short-term effect	Resource or resource related values recover in fewer than 5 years
Long-term effect	Resource or resource related values take greater than 5 years to recover

E.2 Supporting Calculations for Socioeconomics

This section presents supporting calculations used when evaluating effects of the proposed action with respect to socioeconomic resources.

Table E-2. Agricultural Statistics for Deschutes, Jefferson, and Crook Counties.

Agricultural Statistic	Deschutes County			Jefferson County			Crook County		
	2017 [1]	2012 [2]	Percent Change	2017 [1]	2012 [2]	Percent Change	2017 [1]	2012 [2]	Percent Change
Number of Farms	1,484	1,283	15.67%	397	474	-16.24%	620	551	12.52%
Land in Farms (acres)	134,800	131,036	2.87%	792,920	817,051	-2.95%	799,845	822,676	-2.78%
Harvested cropland (acres)	25,356	23,648	7.22%	48,092	43,955	9.41%	35,972	41,128	-12.54%
Average Size of Farm (acres)	91	102	-10.78%	1,997	1,724	15.84%	1,290	1,493	-13.60%
Median Size of Farm (acres)	11	20	-45.00%	80	69	15.94%	40	50	-20.00%
Market value of products sold	$28,769,000	$20,570,000	39.86%	$67,438,000	$65,032,000	3.70%	$44,563,000	$42,298,000	5.35%
Crop Sales	$16,543,000	$11,127,000	48.67%	$54,792,000	$47,249,000	15.96%	$12,094,000	$13,562,000	-10.82%
Livestock Sales	$12,226,000	$9,442,000	29.49%	$12,645,000	$17,783,000	-28.89%	$32,470,000	$28,736,000	12.99%
Average per Farm	$19,386	$16,033	20.91%	$169,868	$137,198	23.81%	$71,877	$76,765	-6.37%

Sources: [1] USDA 2017; [2] USDA 2012

References

U.S. Department of Agriculture (USDA). 2012. 2012 Census of Agriculture. Deschutes County, Oregon – Census of Agriculture County Profile. Retrieved from https://agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Oregon/

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E.3 Supporting Calculations for Water Resources

This section presents supporting calculations used when evaluating effects of the proposed action with respect to water resources.

Estimated Water Savings Method

This subsection describes the method used to quantify the average volume of water savings following completion of the proposed conservation project. For this calculation, FCA used data derived from the water loss assessment performed on July 27, 2020 by Oregon Water Resources Department (OWRD). The loss measured during this assessment was 6.8 cubic feet per second (cfs) (T. Smith, personal communication, September 3, 2020). The following paragraphs describe the method used to quantify the estimated savings that would be realized through the Lone Pine Irrigation District Modernization Project (herein referred to as the project or proposed action). Table E-3 and Table E-4 provide the data used in these calculations.

First, the irrigation season was divided into bimonthly increments to more accurately represent the Lone Pine Irrigation District's (herein referred to as LPID or the District) diversion rate across the irrigation season (first column of Table E-3). Next, the District's average daily mean diversion rate (second column of Table E-3) was calculated for each bi-monthly period. Data from the 2005 through 2019 irrigation years, for OWRD Gauge #14069700 were used for these calculations.

For the purpose of this analysis, FCA assumed that seepage varies proportionally with diversion rates. Using the average daily mean diversion rates, a percentage of the July 27, 2020 flow was calculated (third column of Table E-3). This percentage was then multiplied by the loss calculated during the July 27, 2020 OWRD Water Loss Assessment, 6.8 cfs, to determine an estimate loss rate for each bi-monthly period (fourth column of Table E-3).

To calculate a volume (acre-feet) of water lost in each bi-monthly period, the estimated loss rate (fourth column of Table E-3) was multiplied by the number of days in each period (fifth column of Table E-3) and again by the conversion factor of 1.9835 (acre-feet per cfs per day). The product is shown in the sixth column of Table E-3, Estimated Volume of Loss.

The District's diversion rates vary across the season and the start of the irrigation season is dependent on many external and internal factors. To calculate the volume as described in the paragraph before, the mean number of days during which the District diverted water during each bi-monthly period for the 2005 through 2019 irrigation years was determined using data from OWRD Gauge No. 14069700 (Table E-4). April and October were typically the only two months during the irrigation season when the number of days varied from year to year.

For purposes of quantifying volume of loss (acre-feet) in a system where loss is variable and dependent on many external factors, this appeared to be the most accurate approach for this level of analysis. All water savings will be verified following completion of the conservation project by OWRD.

Table E-3. Calculations for Estimating Volume of Water Savings following Completion of the Proposed Project.

Time Period	2005-2019 Average Daily Mean Diversion Rate (cfs)[1]	Percent of 7/27/2020 Flow[2]	Estimated Loss Rate (cfs)[3]	Number of Days used in Volume Calculation[4]	Estimated Loss Volume (acre-feet/time period)
April 1 - April 30	16.56	43%	2.95	18	105.26
May 1 - May 14	31.62	83%	5.63	14	156.29
May 15 - May 31	34.04	89%	6.06	17	204.30
June 1 - June 14	32.83	86%	5.84	14	162.31
June 15 - June 30	34.66	91%	6.17	16	195.79
July 1 - July 14	40.37	106%	7.19	14	199.56
July 15 - July 31	42.39	111%	7.55	17	254.42
Aug 1 - Aug 14	42.38	111%	7.54	14	209.50
Aug 15 - Aug 30	39.93	105%	7.11	16	225.58
Sept 1 - Sept 14	35.70	93%	6.35	14	176.46
Sept 15 - Sept 30	26.10	68%	4.65	16	147.46
Oct 1 - Oct 31	16.90	44%	3.01	11	65.65

[1] Average Daily Mean Diversion Rate used data from OWRD Gauge No. #14069700.
[2] Date of the OWRD water loss assessment. Average diversion flow on 7/27/2020 was 38.2 cfs.
[3] Loss measured on 7/27/2020 (6.8 cfs) multiplied by the percent of flow on 7/27/2020.
[4] The season average was only taken during the days the district was diverting water. See table below showing the length of irrigation season.

Table E-4. Length of Irrigation Season.

Year	Start Date	End Date	Length of Irrigation Season
2005	4/12/2005	10/13/2005	184
2006	4/23/2006	10/14/2006	174
2007	4/11/2007	10/12/2007	184
2008	4/11/2008	10/9/2008	181
2009	4/9/2009	10/5/2009	179
2010	4/19/2010	10/14/2010	178
2011	4/18/2011	10/15/2011	180
2012	4/15/2012	10/14/2012	182
2013	4/9/2013	10/15/2013	189
2014	4/11/2014	10/19/2014	191
2015	4/8/2015	10/8/2015	183
2016	4/6/2016	10/11/2016	188
2017	4/11/2017	10/12/2017	184
2018	4/11/2018	10/15/2018	187
2019	4/24/2019	10/9/2019	168

Note: Start date and end date were determined using data from OWRD Gauge No. 14069700.

Table E-5. Monthly Instream Flow Targets for the Deschutes River and Crooked River.

Source	From	To	Certificate	Priority Date	Instream Rates (cfs)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Deschutes R	Crane Prairie Reservoir	Wickiup Reservoir	73233	10/11/1990	130	130	130	130	130	130	130	130	130	130	130	130
Deschutes R	Wickiup Reservoir	Little Deschutes River	59776	11/3/1983	300	300	300	300	300	300	300	300	300	300	300	300
Deschutes R	Little Deschutes River	Spring River	59777	11/3/1983	400	400	400	400	400	400	400	400	400	400	400	400
Deschutes R	Spring River	North Canal Dam	59778	11/3/1983	660	660	660	660	660	660	660	660	660	660	660	660
Deschutes R	North Canal Dam	Lake Billy Chinook	70695	Pending	250	250	250	250	250	250	250	250	250	250	250	250
Crooked R	Bowman Dam	Lake Billy Chinook	70354	Pending	75	75/ 150	225	225	225	150	75	75	75	75	75	75

Deschutes River, Below Wickiup Reservoir

This subsection presents supporting calculations used when evaluating effects of the proposed action with respect to water resources in the Deschutes River below Wickiup Reservoir.

Table E-6. Deschutes River Average Daily Mean Streamflow below Wickiup Reservoir following the 2016 Settlement Agreement.

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Oct	107	9	116	477	592
Nov	119	6	125	54	178
Dec	103	48	151	44	195
Jan	104	51	155	47	202
Feb	103	48	151	50	201
Mar	99	95	194	140	334
Apr	601	23	624	9	633
May	760	425	1,185	155	1,340
Jun	937	373	1,310	162	1,472
Jul	1,430	100	1,530	130	1,660
Aug	1,500	30	1,530	48	1,578
Sep	864	256	1,120	194	1,314

Note: Streamflow in the Deschutes River downstream from Wickiup Reservoir at OWRD Gauge No. 14056500 from the October 2016 through September 2018 water years.

Table E-7. Deschutes River Post-Project Streamflow Below Wickiup Reservoir.

Month	Pre-Project Average Daily Mean Streamflow (cfs) [1]	Streamflow Restored Through Project (cfs)[2]	Post-Project Average Daily Mean Streamflow (cfs)[1,2,3]	Oregon Department of Fish and Wildlife (ODFW) Instream Water Right[3]	Post-Project Percentage Increase in Average Daily Mean Streamflow[3]
Oct[2]	116	0.00	116	300	0%
Nov	125	5.31	130.31	300	4%
Dec	151	5.31	156.31	300	4%
Jan	155	5.31	160.31	300	3%
Feb	151	5.31	156.31	300	4%
Mar	194	5.31	199.31	300	3%
Apr[2]	624	0.00	624	300	0%
May[4]	1,185	0.00	1,185	300	0%
Jun	1,310	0.00	1,310	300	0%
Jul	1,530	0.00	1,530	300	0%
Aug	1,530	0.00	1,530	300	0%
Sep[4]	1,120	0.00	1,120	300	0%

[1] Uses streamflow data in Table E-6 above.
[2] Post-Project Average Daily Mean Streamflow does not include water saved and allocated instream in this reach from other water conservation projects currently being implemented in the Upper Deschutes Basin.
[3] This additional flow would be beneficial to the Deschutes River until year 8 of the HCP when the minimum winter flow target is increased to 300 cfs.
[4] Certificate No. 59776

Deschutes River at Benham Falls

This subsection presents supporting calculations used when evaluating effects of the proposed action with respect to water resources in the Deschutes River at Benham Falls.

Table E-8. Deschutes River Average Daily Mean Streamflow at Benham Falls following to the 2016 Settlement Agreement.

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Oct	614	38	653	418	1,070
Nov	595	31	626	68	693
Dec	571	69	640	66	706
Jan	572	91	663	83	746
Feb	665	57	722	28	749
Mar	705	57	762	195	956
Apr	1,130	345	1,475	55	1,530
May	1,640	70	1,710	288	1,998
Jun	1,688	137	1,825	75	1,900
Jul	1,950	45	1,995	105	2,100
Aug	1,890	35	1,925	95	2,020
Sep	1,320	230	1,550	206	1,756

Note: Streamflow in the Deschutes River at Benham Falls at OWRD Gauge No. 14064500 vary within and between years. Data represent the October 2016 through September 2018 water years.

Table E-9. Deschutes River Post-Project Streamflow at Benham Falls.

Month	Pre-Project Average Daily Mean Streamflow (cfs)[1]	Streamflow Restored Through Project (cfs)[2,3]	Post-Project Average Daily Mean Streamflow (cfs)[2,4]	ODFW Instream Water Right[5] in the Deschutes River from the mouth of the Little Deschutes River to the confluence of Spring River	ODFW Instream Water Right[6] in the Deschutes River from the mouth of Spring River to the North Canal Dam at Bend	Post-Project Percentage Increase in Average Daily Mean Streamflow[2,4]
Oct	653.0	0.0	653.0	400	660	0.0%
Nov	626.0	4.6	630.6	400	660	0.7%
Dec	640.0	4.6	644.6	400	660	0.7%
Jan	663.0	4.6	667.6	400	660	0.7%
Feb	722.0	4.6	726.6	400	660	0.6%
Mar	762.0	4.6	766.6	400	660	0.6%
Apr	1,475.0	0.0	1,475.0	400	660	0.0%
May	1,710.0	0.0	1,710.0	400	660	0.0%
Jun	1,825.0	0.0	1,825.0	400	660	0.0%
Jul	1,995.0	0.0	1,995.0	400	660	0.0%
Aug	1,925.0	0.0	1,925.0	400	660	0.0%
Sep	1,550.0	0.0	1,550.0	400	660	0.0%

[1] Uses streamflow data in Table E-23 above.
[2] Post-Project Average Daily Mean Streamflow does not include water saved and allocated instream in this reach from other water conservation projects currently being implemented in the Upper Deschutes Basin.
[3] This additional streamflow includes an estimated 12.5 percent channel loss from Wickiup Reservoir to Benham Falls.
[4] This additional flow would be beneficial to the Deschutes River until year 8 of the HCP when the minimum winter flow target is increased to 300 cfs.
[5] Certificate No. 59777
[6] Certificate No. 59778

Deschutes River at Bend, Below North Canal Dam

This subsection presents supporting calculations used when evaluating effects of the proposed action with respect to water resources in the Deschutes River at Bend, below North Canal Dam.

Table E-10. Deschutes River Average Daily Mean Streamflow at Bend – Below North Canal Dam following the 2016 Settlement Agreement.

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Oct	82	447	528	45	573
Nov	515	49	564	44	607
Dec	500	81	581	71	652
Jan	487	12	499	179	677
Feb	509	117	626	42	667
Mar	607	61	668	184	851
Apr	163	328	491	234	725
May	95	20	116	15	131
Jun	122	9	131	4	135
Jul	128	5	133	3	136
Aug	122	9	131	3	134
Sep	91	42	133	18	151

Note: Streamflow in the Deschutes River downstream from the City of Bend at OWRD Gauge No. 14070500 from the October 2016 through September 2018 water years.

Table E-11. Deschutes River Post-Project Streamflow at Bend - Below North Canal Dam.

Month	Pre-Project Average Daily Mean Streamflow (cfs) [1]	Streamflow Restored Through Project (cfs)[2,3]	Post-Project Average Daily Mean Streamflow (cfs)[2,3,4]	Oregon Department of Fish and Wildlife Instream Water Right[5]	Post-Project Percentage Increase in Average Daily Mean Streamflow[2,4]
Oct	528	0.0	528	250	0.0%
Nov	564	4.3	568.3	250	0.8%
Dec	581	4.3	585.3	250	0.7%
Jan	499	4.3	503.3	250	0.9%
Feb	626	4.3	630.3	250	0.7%
Mar	668	4.3	672.3	250	0.6%
Apr	491	0.0	491	250	0.0%
May	116	0.0	116	250	0.0%
Jun	131	0.0	131	250	0.0%
Jul	133	0.0	133	250	0.0%
Aug	131	0.0	131	250	0.0%
Sep	86	0.0	86	250	0.0%

[1] Uses streamflow data in Table E-10 above.
[2] Post-Project Average Daily Mean Streamflow does not include water saved and allocated instream in this reach from other water conservation projects currently being implemented in the Upper Deschutes Basin.
[3] This additional streamflow includes an estimated 7 percent channel loss from Benham Falls to the City of Bend.
[4] This additional flow would be beneficial to the Deschutes River until year 8 of the HCP when the minimum winter flow target is increased to 300 cfs.
[5] Pending Instream Application #70695

Crooked River Below Osborne Canyon

This subsection presents supporting calculations used when evaluating effects of the proposed action with respect to water resources in the Crooked River below Osborne Canyon.

Table E-12. Crooked River Pre-Project Average Daily Mean Streamflow Below Osborne Canyon.

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Oct	208	31	239	55	294
Nov	186	17	203	33	236
Dec	173	19	192	44	236
Jan	180	40	220	220	440
Feb	191	42	233	291	524
Mar	200	68	268	804	1,072
Apr	269	304	573	1,079	1,652
May	150	164	314	515	829
Jun	136	66	202	177	378
Jul	114	29	143	41	184
Aug	124	32	156	33	189
Sep	166	56	222	56	278

Note: Streamflow in Crooked River at OWRD Gauge No. 14087380 from the 2003 through 2018 water years.

Crooked River Below Opal Springs

This subsection presents supporting calculations used when evaluating effects of the proposed action with respect to water resources in the Crooked River below Opal Springs.

Table E-13. Crooked River Pre-Project Average Daily Mean Streamflow Below Opal Springs.

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Oct	1,330	40	1,370	70	1,440
Nov	1,310	30	1,340	30	1,370
Dec	1,300	30	1,330	30	1,360
Jan	1,300	40	1,340	250	1,590
Feb	1,310	50	1,360	320	1,680
Mar	1,320	80	1,400	840	2,240
Apr	1,400	325	1,725	1105	2,830
May	1,260	220	1,480	540	2,020
Jun	1,260	75	1,335	195	1,530
Jul	1,240	20	1,260	60	1,320
Aug	1,240	30	1,270	50	1,320
Sep	1,280	70	1,350	70	1,420

Note: Streamflow in Crooked River at OWRD Gauge No. 14087400 from the 2003 through 2018 water years.

E.4 Supporting Information for Water Resources

This section presents a summary of the operation measures set forth by the HCP (AID et al. 2020). Figure C-3 in Appendix C includes locations of all the gauges described.

1) From April 1 through September 15, flow at OWRD Gage 14056500 will be at least 600 cfs. An adaptive management element will be used to test whether going directly to 600 cfs by April 1 provides enhanced survival of Oregon spotted frog. In coordination with USFWS, flows may be set at 400 cfs by April 1 and increased to 600 cfs within the first 2 weeks of April. Annual snow pack, weather and in-stream conditions will inform this decision.
2) From April 1 through April 30, flow at OWRD Gage 14056500 shall not exceed 800 cfs unless USFWS or a biologist approved by USFWS has verified that Oregon spotted frog eggs at Dead Slough in La Pine State Park have hatched or are physically situated in a portion of the slough where an increase in flow will not harm them.
3) If the flow at OWRD Gage 14056500 is increased above 600 cfs during the month of April, it will not subsequently be allowed to decrease more than 30 cfs, whether in a single flow adjustment or cumulatively over the course of multiple flow adjustments, until after April 30 or an earlier date approved after coordination with USFWS.
4) From May 1 through June 30, flow decrease at OWRD Gage 14056500 over any 5-day period shall be no more than 20 percent of total flow at the time the decrease is initiated.
5) Flow at OWRD Gage 14064500 shall be no less than 1,300 cfs from July 1 through at least September 15.
6) For the first 7 years of HCP implementation, flow at OWRD Gage 14056500 shall be at least 100 cfs from September 16 through March 31. Beginning in Year 1 of HCP implementation, minimum flow at OWRD Gage 14056500 from September 16 through March 31 shall be increased above 100 cfs in proportion to the amount of live Deschutes River flow made available to NUID during the prior irrigation season as a result of the piping of COID-owned canals. For each acre-foot (or portion thereof) of live flow made available to NUID as a result of the piping of COID-owned canals after the date of incidental take permit issuance, an equal volume of water shall be added to the minimum flow below Wickiup Dam from September 16 through March 31. This water shall be in addition to the amount of water needed to maintain a flow at OWRD Gage 14056500 of at least 100 cfs. The timing for release of the additional water shall be determined in coordination with USFWS for optimal benefit to Oregon spotted frogs.
7) Beginning no later than Year 8 of HCP implementation, flow at OWRD Gage 14056500 shall be at least 300 cfs from September 16 through March 31, and not more than 1,400 cfs for more than 10 days per year between April 1 and September 15. If NUID anticipates the need to exceed 1,400 cfs at OWRD Gage 14056500 in Years 8 through 12, it will contact USFWS in advance to discuss options for minimizing the adverse effects on the Deschutes River and Oregon spotted frogs, such as conditioning the rate or timing of flow increases above 1,400 cfs.
8) Beginning no later than Year 13 of HCP implementation, minimum flow at OWRD Gage 14056500 shall be between 400 cfs and 500 cfs from September 16 through March 31, with actual flow during this period determined according to the variable flow tool described in the

HCP, and not more than 1,200 cfs for more than 10 days per year between April 1 and September 15.

9) For all years, the volume of water equivalent to the amount scheduled for winter releases in excess of 100 cfs may be stored in Wickiup Reservoir for release later in the same water year. Water stored in this manner and released during the irrigation season will be treated as NUID storage and available for diversion by NUID at North Canal Dam. Water stored in this manner and not released for Oregon spotted frogs or fish by the end of the same water year can be used to meet the minimum flow requirements of this conservation measure at OWRD Gage 14056500 through March 31 of the subsequent water year. Any water stored in this manner and not released to meet HCP minimum flow requirements by March 31 will become NUID storage and available for irrigation use.
10) During the fall ramp-down, flow reductions at OWRD Gage 14056500 shall be halted for 5 days when the corresponding flow at OWRD Gage 14064500 reaches 1,200, and again for 5 days when the corresponding flow at OWRD Gage 14064500 reaches 1,100 cfs.

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. (2020). Deschutes Basin Habitat Conservation Plan (HCP). Retrieved from: https://www.fws.gov/Oregonfwo/articles.cfm?id=149489716

E.5 Supporting Information for Fish and Aquatic Resources

This section presents the Primary Constituent Elements for Oregon spotted frog and bull trout critical habitat.

Table E-14. Primary Constituent Elements for Oregon Spotted Frog Critical Habitat.

Primary Constituent Element (PCE) Number	Habitat Description	Characteristics
PCE 1	Nonbreeding (N), Breeding (B), Rearing (R), and Overwintering Habitat (O); Ephemeral or permanent bodies of fresh water, including, but not limited to natural or manmade ponds, springs, lakes, slow-moving streams, or pools within or oxbows adjacent to streams, canals, and ditches	Inundated for a minimum of 4 months per year (B, R) (timing varies by elevation but may begin as early as February and last as long as September)
		Inundated from October through March (O)
		If ephemeral, areas are hydrologically connected by surface water flow to a permanent waterbody (e.g., pools, springs, ponds, lakes, streams, canals, or ditches) (B, R)
		Shallow water areas (less than or equal to 30 centimeters (12 inches), or water of this depth over vegetation in deeper water (B, R)
		Total surface area with less than 50 percent vegetative cover (N)
		Gradual topographic gradient (less than 3 percent slope) from shallow water toward deeper, permanent water (B, R)
		Herbaceous wetland vegetation (i.e., emergent, submergent, and floating-leaved aquatic plants), or vegetation that can structurally mimic emergent wetland vegetation through manipulation (B, R)
		Shallow water areas with high solar exposure or low (short) canopy cover (B, R)

Primary Constituent Element (PCE) Number	Habitat Description	Characteristics
		An absence or low density of nonnative predators (B, R, N)
PCE 2	Aquatic movement corridors; Ephemeral or permanent bodies of fresh water	Less than or equal to 3.1 miles linear distance from breeding areas
		Impediment free (including, but not limited to, hard barriers such as dams, impassable culverts, lack of water, or biological barriers such as abundant predators, or lack of refugia from predators)
PCE 3	Refugia Habitat	Nonbreeding, breeding, rearing, or overwintering habitat or aquatic movement corridors with habitat characteristics (e.g., dense vegetation and/or an abundance of woody debris) that provide refugia from predators (e.g., nonnative fish or bullfrogs)

Table E-15. Primary Constituent Elements for Bull Trout.

Primary Constituent Element (PCE) 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.

Primary Constituent Element (PCE) Number	Habitat Description and Characteristics
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 36 to 59 degrees Fahrenheit, 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-16. Fish Species within the Area of Potential Effect for the Lone Pine Irrigation District – Infrastructure Modernization Project.

Fish Species	Scientific Name	Origin
Bridgelip sucker	*Catastomus columbianus*	indigenous
Brook trout	*Salvelinus fontinalis*	introduced
Brown bullhead catfish	*Ictalurus nebulosus*	introduced
Brown trout	*Salmo trutta*	introduced
Bull trout	*Salvelinus confluentus*	indigenous
Chinook salmon	*Oncorhynchus tshawyscha*	indigenous
Chiselmouth	*Acrocheilus alutaceus*	indigenous
Largescale sucker	*Catastomus macrocheilus*	indigenous
Longnose dace	*Rhinichthys cataractae*	indigenous
Mountain whitefish	*Prosopium williamsoni*	indigenous
Northern pike minnow	*Ptychocheilus oregonensis*	indigenous
Rainbow trout	*Oncorhynchus mykiss*	introduced
Redband trout	*Oncorhynchus mykiss*	indigenous
Sculpin spp.	*Cottus spp.*	indigenous
Sockeye salmon/Kokanee	*Oncorhynchus nerka*	indigenous
Summer Steelhead	*Oncorhynchus mykiss*	indigenous
Three-spined stickleback	*Gasterosteus aculeatus*	introduced
Tui chub	*Gila (Siphateles) bicolor*	introduced

Source: Adapted from Starcevich 2016

Reference

Starcevich, S. (2016). Technical Report Oregon Department of Fish and Wildlife. 2014 Deschutes River Fisheries Monitoring Report: Occupancy and Closed-Capture Modeling of Salmonids Using Boat Electrofishing in the Middle and Upper Deschutes River.

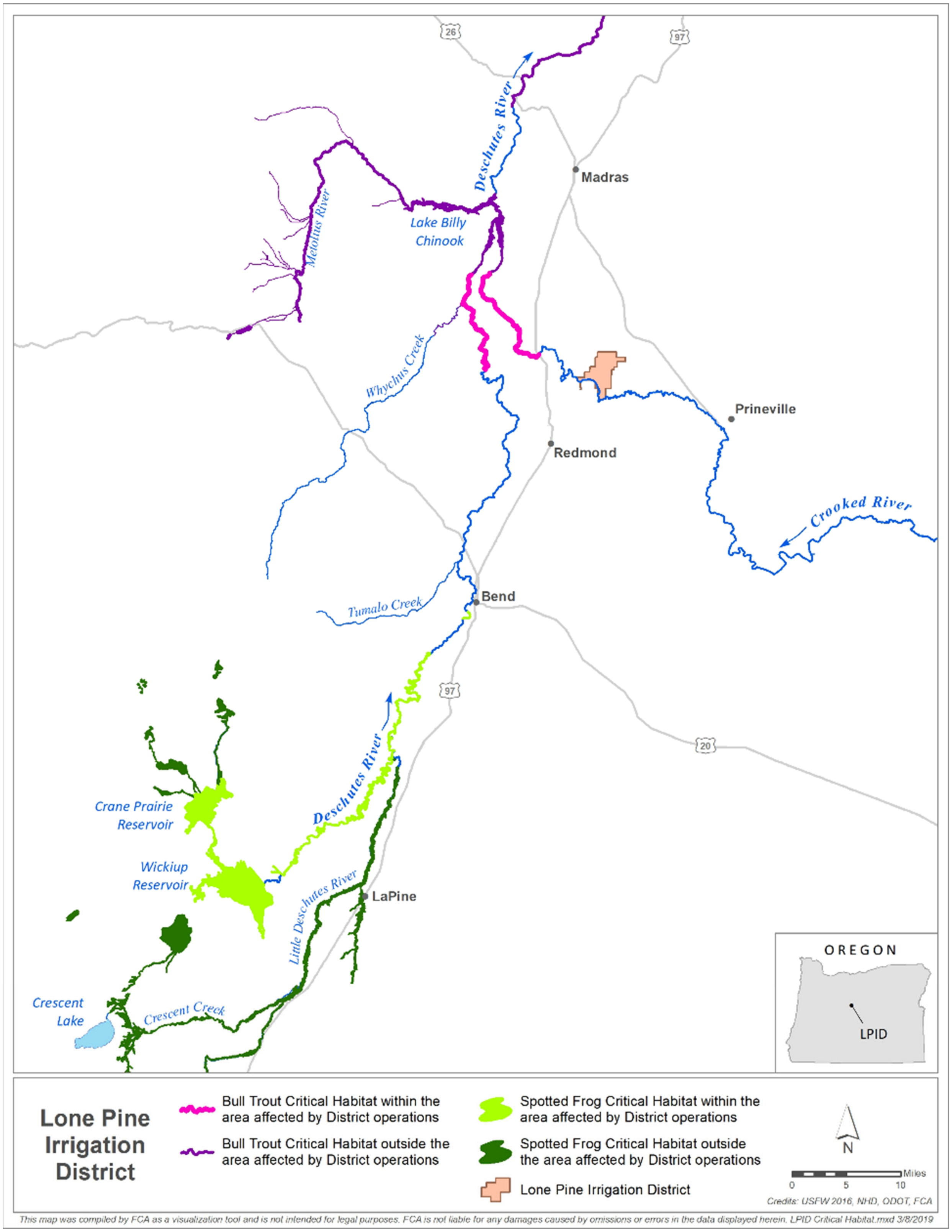


Figure E-1. Bull trout and Oregon spotted frog critical habitat within and outside of areas affected by District operations.

Figure E-2. Steelhead non-essential experimental population within and outside of area affected by District operations.

E.6 Supporting Information for Vegetation Resources

This section provides the list of vegetation species likely to occur within the LPID project area.

Table E-17. Vegetation Found within the Lone Pine Irrigation District Infrastructure Modernization Project Area.

Vegetation Species	**Scientific Name**
Big sagebrush	*Artemisia tridentata*
Bitterbrush	*Pseudoroegneria spicata*
Black cottonwood	*Populus balsamifera*
Bulrush	*Scirpus spp.*
Idaho fescue	*Festuca idahoensis*
Low sagebrush	*Artemisia arbuscula*
Rabbit brush	*Ericameria nauseosa*
Sandberg bluegrass	*Poa sandbergii*
Tall tumble mustard	*Sisymbrium altissimum*
Tufted hairgrass	*Deschampsia cespitosa*
Western juniper	*Juniperus occidentalis*
Wild rye	*Elyleymus* spp.

Source: Hartzell- Hill, personal communication, July 18, 2017

Table E-18. Weeds Known to Occur within the Lone Pine Irrigation District Infrastructure Modernization Project Area.

Vegetation Species	Scientific Name	Deschutes County Noxious Weed Rating (Deschutes 2017)[1]
Bull thistle	*Cirsium vulgare*	C
Cheatgrass	*Bromus tectorum*	C
Common mullein	*Verbascum thapsus*	C
Diffuse knapweed	*Centaurea diffusa*	B
Kochia	*Kochia scoparia*	B
Pond weed	*Potamogeton* spp.	Not applicable
Russian thistle	*Salsola spp.*	B
Spotted knapweed	*Centaurea stoebe*	B

Source: Hartzell- Hill, personal communication, July 18, 2017
[1] Noxious Weed Rating
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.

References

Deschutes. 2017. Deschutes County Noxious Weed List. Website. Retrieved from: https://www.deschutes.org/sites/default/files/fileattachments/road/page/567/deschutes_county_weed_list_updated_2017.pdf. Accessed on: August 8th, 2019.

Hartzell-Hill, Jenny (COID Executive Assistant). 2017. Personal communication (email) with Raija Bushnell (FCA). July 18.

E.7 Supporting Information for Wildlife Resources

This section provides the list of wildlife species likely to occur within the LPID project area.

Table E-19. Wildlife Species Likely to Occur within the Lone Pine Irrigation District Infrastructure Modernization Project Area.

Wildlife Species	Scientific Name
Bat	*Vespertilionidae* spp.
Coyote	*Canis latrans*
Desert horned lizard	*Phrynosoma platyrhinos*
Golden mantled ground squirrel	*Spermophilus lateralis*
Mule deer	*Odocoileus hemionus*
Northern flicker	*Colaptes auratus*
Osprey	*Pandion haliaetus*
Pygmy rabbit	*Brachylagus idahoensis*
Pygmy short-horned lizard	*Phrynosoma douglasii*
Raccoon	*Procyon lotor*
Red-tailed hawk	*Buteo jamaicensis*
Rufous hummingbird	*Selasphorus rufus*
Turkey vulture	*Cathartes aura*
Western gray squirrel	*Sciurus griseus*
Western rattlesnake	*Crotalus viridus*
Western skink	*Eumeces skiltonianus*
Yellow pine chipmunk	*Eutamias amoenus*

Source: USFWS 2017

Table E-20. 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

Reference

U.S. Fish and Wildlife Service (USFWS). 2017. IPaC ECOS (Environmental Conservation Online System). Retrieved from: https://ecos.fws.gov/ipac/. Accessed August 28, 2017.

E.8 Wild and Scenic Outstandingly Remarkable Values

This section presents supporting information associated with Outstandingly Remarkable Values identified for the upper and middle Deschutes River and the lower Crooked River.

Table E-21. Outstandingly Remarkable Values for the Upper Deschutes River.

Outstandingly Remarkable Value	Outstandingly Remarkable Value Description
Vegetative	Aquatic, riparian, and upland vegetation is a significant element of all other river values. The vegetating resource is an Outstandingly Remarkable Value in Segments 3[1] and 4[2] because of *Artemesia ludoviciana* spp. *Estesii*, a Federal Category 2 Candidate[3] for protection under the Endangered Species Act.
Cultural	The upper Deschutes Corridor contains more than 100 known prehistoric sites which are eligible for inclusion in the National Register of Historic Places, making the prehistoric resources an Outstandingly Remarkable Value. Until further research on historic and traditional uses of the corridor is complete, they will also be treated as Outstandingly Remarkable Values.
Fisheries	The brown trout fishery in segments 2[(4)] and 3 is an Outstandingly Remarkable Value. The determination of value of the native redband rainbow trout population in segment 4 has been deferred until a genetic study has been completed. Until that time the population is to treated as an Outstandingly Remarkable Value.
Geologic	The upper Deschutes River consists of two major features: the lava flows which have pushed the river west of earlier channels and created the stair step of falls and rapids, and the landforms created by the interaction of depositional and erosive actions. The river channel shape, size, and rate of change are not an outstandingly remarkable value within themselves, primarily because the dynamics are so affected by human controlled flows.
Hydrology	The hydrologic resource is a significant element of several Outstandingly Remarkable Values associated with the upper Deschutes River. Most Outstandingly Remarkable Values in and along the river are protected and enhanced by an abundant, stable flow of clear, clean water.
Recreational	Recreation is an Outstandingly Remarkable Value on the upper Deschutes River because of the range of activities, the variety of interpretive opportunities, and the attraction of the river for vacationers from outside of the region.

Outstandingly Remarkable Value	Outstandingly Remarkable Value Description
Scenic	The mix of geologic, hydrologic, vegetative, and wildlife resources found along portions of Segments 2 and 4 of the upper Deschutes makes scenery an Outstandingly Remarkable Value. Although the level and proximity of private development intrudes on the scenic quality of Segment 3, the scenic value is still a significant element of the recreational value.
Wildlife	Wildlife populations in Segments 2 and 4 were determined to be Outstandingly Remarkable Values because of the populations of nesting bald eagles and ospreys in Segment 2 and the diversity of the bird population in Segment 4. Despite extensive private development in Segment 3, the wildlife habitat was considered to be significant because it provides important nesting habitat for birds and travel corridors for migrating game animals such as deer and elk.

Source: USDA 1996

[1] Segment 3 includes the south boundary of LaPine State Recreation Area to north boundary of Sunriver.

[2] Segment 4 includes the north boundary of Sunriver to the Central Oregon Irrigation District Canal.

[3] The upper Deschutes Wild and Scenic River and State Scenic Water Management Plan was written in 1996. Since the time of the management plan, this species has been reclassified as Species of Concern – Taxa for which additional information is needed to support a proposal to list under the Endangered Species Act (ORBIC 2016).

[4] Segment 2 includes Wickiup Dam to east end of Pringle Falls Campground and the east end of Pringle Falls campground to south boundary of LaPine State Recreation Area.

Table E-22. Outstandingly Remarkable Values for the Middle Deschutes River and the Lower Crooked River.

Outstandingly Remarkable Value	Outstandingly Remarkable Value Description
Botany/ Ecology	The middle Deschutes River segments are in an ecological condition unusual for similar areas within the region and contain a significant portion of Estes' wormwood.
Cultural	Cultural resources on the middle Deschutes River include prehistoric and historic sites found along the corridor and traditional uses associated with the area. Evidence that rare and/or special activities took place in the river canyon areas is represented by lithic scatters or flaking stations, shell middens, rock shelters, rock features and rock art. These sites have the potential to contribute to the understanding and interpretation of the prehistory of the Deschutes River and the region and are considered to eligible for inclusion in the National Register of Historic Places.
Fisheries	Surveys have identified fishing as the number one recreation activity in the upper sections. Stories and pictures of huge catches are found in historical records of the early 1900's.
Geologic	Fifty million years of geologic history are dramatically displayed on the canyon walls of the middle Deschutes River and lower Crooked rivers. Volcanic eruptions which occurred over thousands of years created a large basin dramatized by colorful layers of basalt, ash and sedimentary formations. The most significant contributor to the outstandingly remarkable geologic resource are the unique intra-canyon basalt formations created by recurring volcanic and hydrologic activities.
Hydrology	Water from springs and stability of flows through the steep basalt canyons has created a stream habitat and riparian zone that is extremely stable and diverse, unique in a dry semi-arid climate environment. Features, such as Odin, Big and Steelhead Falls; springs and seeps; white water rapids; water sculpted rock; and the river canyons, are very prominent and represent excellent examples of hydrologic activity within central Oregon.
Recreational	These river corridors offer a diversity of year-round, semi-primitive recreation opportunities, such as fishing, hiking, backpacking, camping, wildlife and nature observation, expert kayaking and rafting, picnicking, swimming, hunting and photography. Interpretive opportunities are exceptional and attract visitors from outside the geographical area.
Scenic	The exceptional scenic quality along the middle Deschutes River is due to the rugged natural character of the canyons, outstanding scenic vistas, limited visual intrusions and scenic diversity resulting from a variety of

Outstandingly Remarkable Value	Outstandingly Remarkable Value Description
	geologic formations, vegetation communities and dynamic river characteristics. These canyons truly represent the spectacular natural beauty created by various forces of nature.
Wildlife	The river corridor supports critical mule deer winter range habitat and nesting/hunting habitat for bald eagles, golden eagles, ospreys and other raptors. Bald eagles are known to winter along the Deschutes River downriver from Lower Bridge and also within the lower Crooked River segment. Outstanding habitat areas include high vertical cliffs, wide talus slopes, numerous caves, pristine riparian zones, and extensive grass/sage covered slopes and plateaus.

Source: National Wild and Scenic Rivers System 2018 and BLM 1992

References

National Wild and Scenic Rivers System. 2018. Deschutes River, Oregon. Website. Retrieved from: www.rivers.gov/rivers/deschutes.php. Accessed September 10, 2018.

Oregon Biodiversity Information Center (ORBIC). 2016. Rare, Threatened and Endangered Vascular Plant Species of Oregon. Retrieved from: https://inr.oregonstate.edu/sites/inr.oregonstate.edu/files/2016-rte-vascs.pdf. Accessed November 26, 2018.

U.S. Department of Agriculture (USDA). 1996. Upper Deschutes Wild and Scenic River and State Scenic Water Way – Comprehensive Management Plan.

U.S. Department of the Interior, Bureau of Land Management BLM. (1992). Lower Crooked Wild and Scenic River (Chimney Rock Segment) Management Plan.

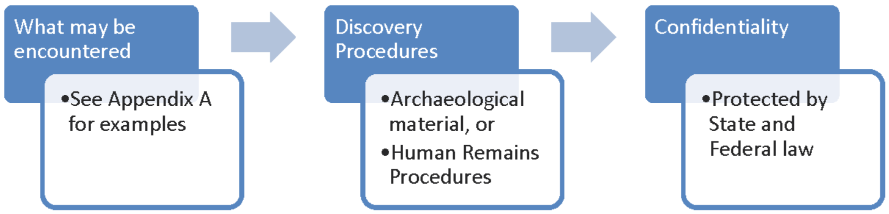
E.9 Supporting Information for Cultural Resources

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

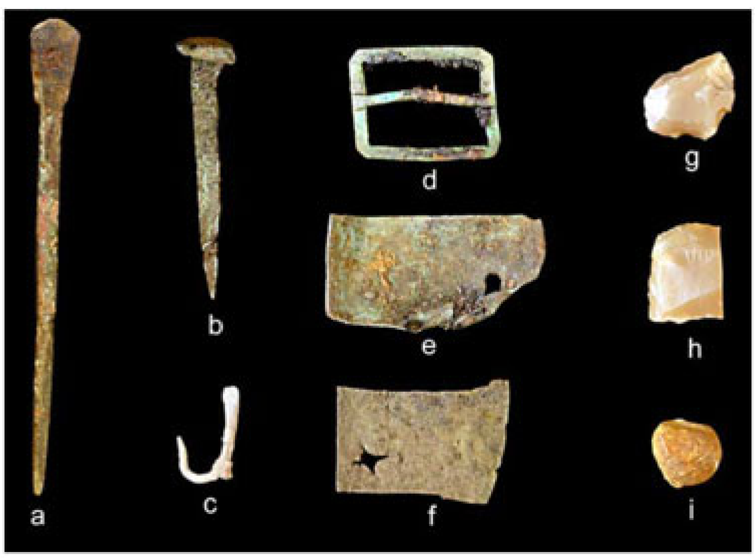


Figure 6: Historic metal artifacts

Figure 7: Historic building foundations

Figure 8: 18th Century ship

E.10 Guiding Principles

Guiding Principles (USDA 2017)

The Guiding Principles identified in the *Guidance for Conducting Analysis Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water Resource Investments* (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).

References

U.S. Department of Agriculture (USDA). 2017. Guidance for Conducting Analysis Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water and Resource Investments. DM 9500-013.