Appendix A

Comments and Responses

To be included in the final environmental impact statement or assessment.

Appendix B

Project Map

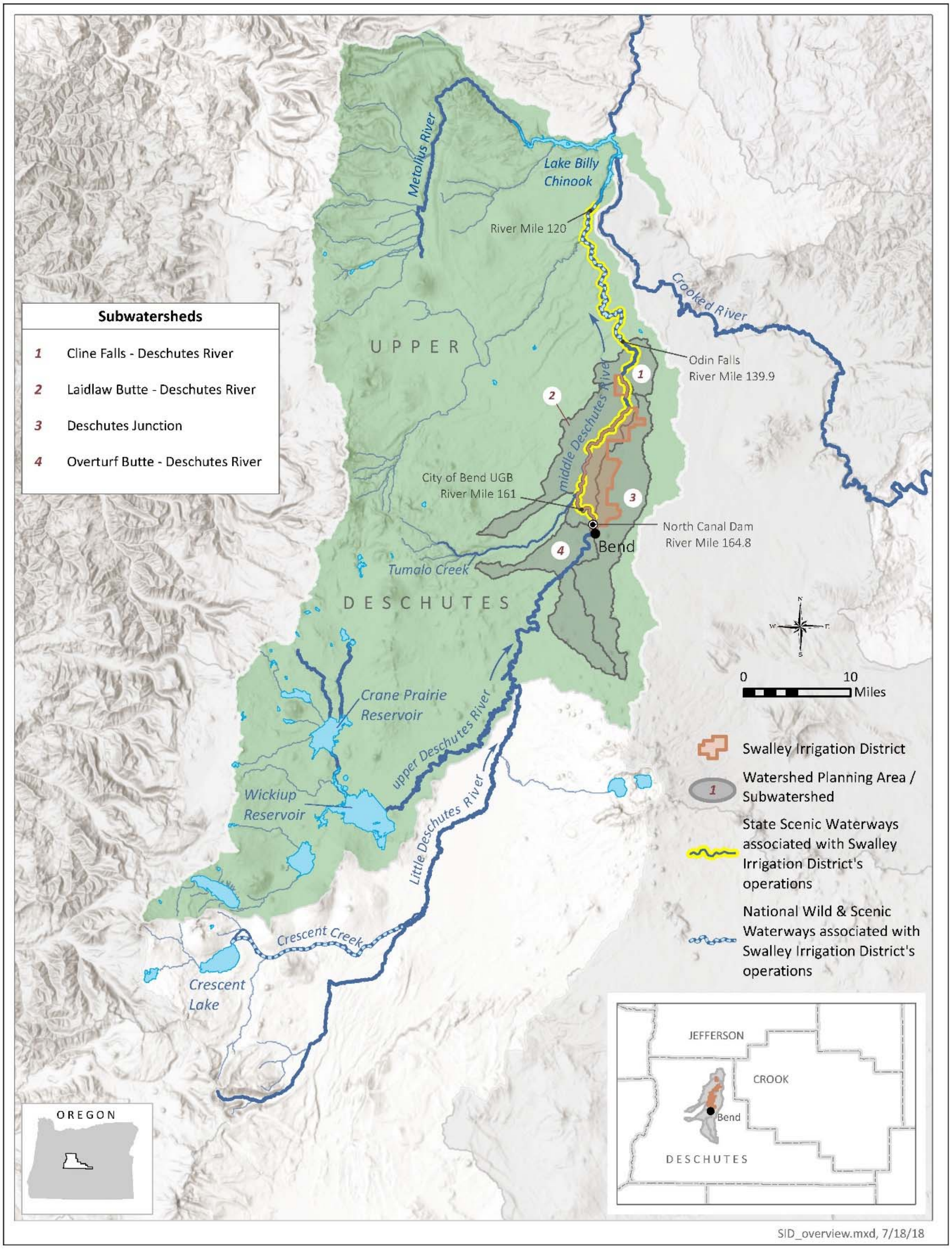

Figure B-1. The four watersheds within the Swalley Irrigation District watershed planning area.

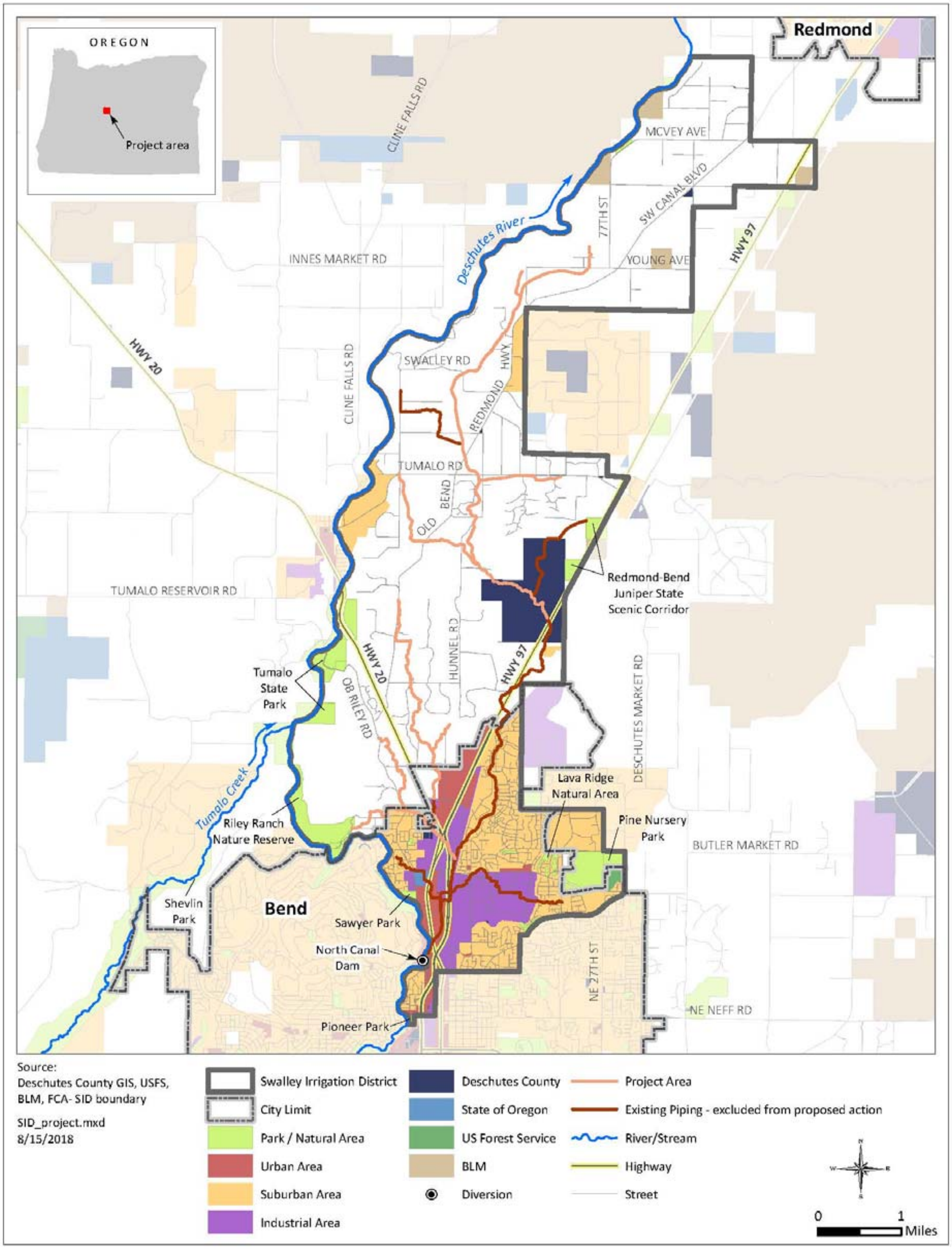

Figure B-2. Location of the Swalley Irrigation District Irrigation Modernization Project.

Appendix C

Supporting Maps

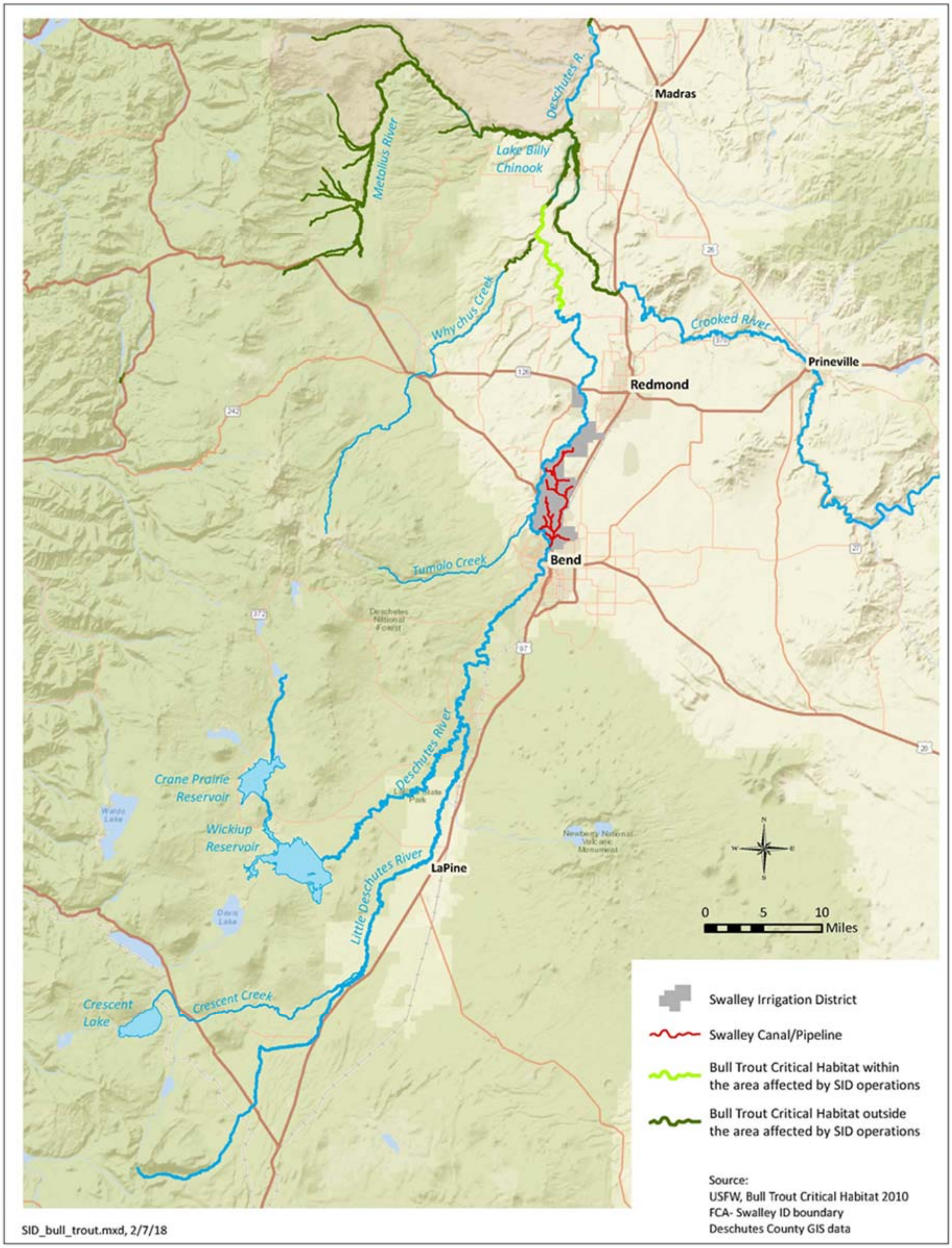

Figure C-1. Bull trout critical habitat near Swalley Irrigation District.

Figure C-2. Middle Columbia River steelhead population boundaries near Swalley Irrigation District.

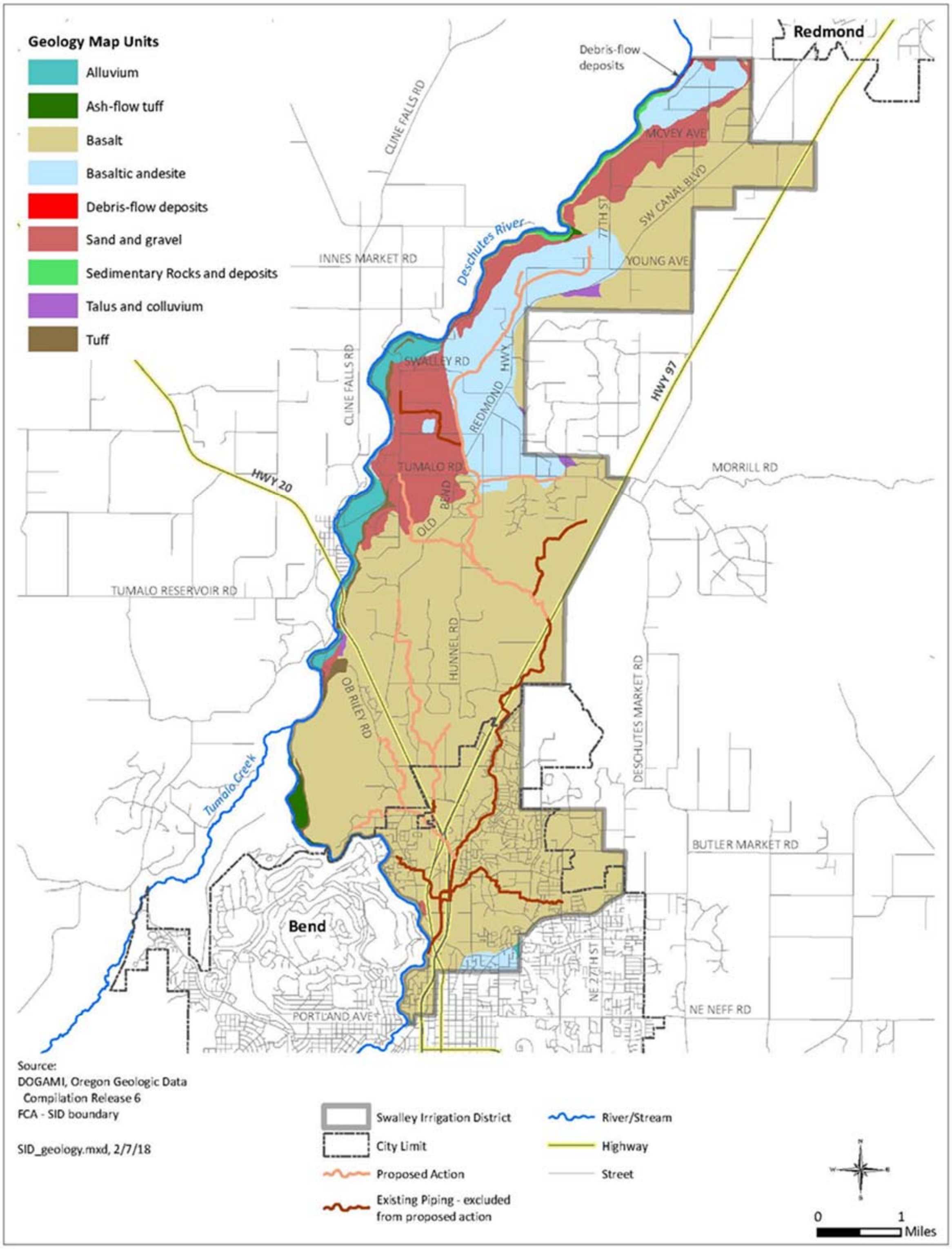

Figure C-3. Geologic formations in Swalley Irrigation District.

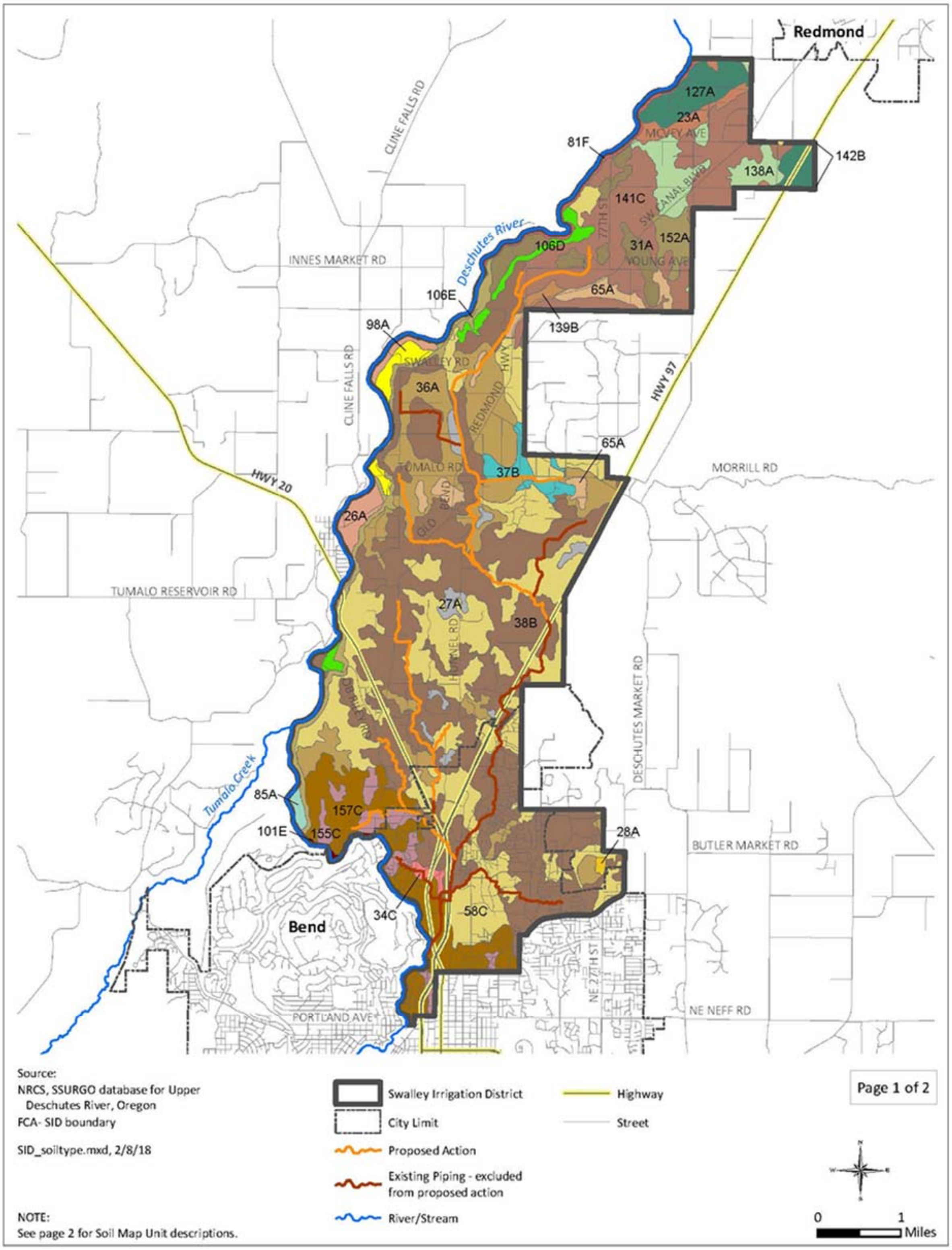

Figure C-4. General soil types in Swalley Irrigation District.

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NRCS Map Unit Descriptions

Map Unit Symbol		Map Unit Name
23A		Buckbert sandy loam, 0 to 3 percent slopes
26A		Clinefalls sandy loam, 0 to 3 percent slopes
27A		Clovkamp loamy sand, 0 to 3 percent slopes
31A		Deschutes sandy loam, 0 to 3 percent slopes
31B		Deschutes sandy loam, 3 to 8 percent slopes
34C		Deschutes-Stukel complex, 0 to 15 percent slopes
36A		Deskamp loamy sand, 0 to 3 percent slopes
37B		Deskamp sandy loam, 3 to 8 percent slopes
38B		Deskamp-Gosney complex, 0 to 8 percent slopes
57B		Gosney stony loamy sand, 3 to 8 percent slopes
58C		Gosney-Rock outcrop-Deskamp complex, 0 to 15 percent slopes
61C		Henkle-Fryrear-Lava flows complex, 0 to 15 percent slopes
62D		Henkle-Lava flows-Fryrear complex, 15 to 50 percent slopes
65A		Houstake sandy loam, 0 to 3 percent slopes
67A		Houstake sandy loam, very gravelly substratum, 0 to 3 percent slopes
72C		Laidlaw sandy loam, 0 to 15 percent slopes
78C		Lickskillet-Deschutes complex, 0 to 15 percent slopes
81F		Lickskillet-Rock outcrop complex, 45 to 80 percent slopes
85A		Lundgren sandy loam, 0 to 3 percent slopes
98A		Plainview sandy loam, 0 to 3 percent slopes
98B		Plainview sandy loam, 3 to 8 percent slopes
100C		Redcliff-Lickskillet complex, 0 to 15 percent slopes
101D		Redcliff-Lickskillet-Rock outcrop complex, 15 to 30 percent south slopes
101E		Redcliff-Lickskillet-Rock outcrop complex, 30 to 50 percent south slopes
106D		Redslide-Lickskillet complex, 15 to 30 percent north slopes
106E		Redslide-Lickskillet complex, 30 to 50 percent north slopes
127A		Statz sandy loam, 0 to 3 percent slopes
128C		Statz-Deschutes complex, 0 to 15 percent slopes
128D		Statz-Deschutes complex, 15 to 30 percent slopes
141C		Stukel-Deschutes-Rock outcrop complex, 0 to 15 percent slopes
151D		Tetherow-Clovkamp complex, 8 to 50 percent slopes
152A		Tumalo sandy loam, 0 to 3 percent slopes
152B		Tumalo sandy loam, 3 to 8 percent slopes
155C		Wanoga sandy loam, 0 to 15 percent slopes
155D		Wanoga sandy loam, 15 to 30 percent slopes
156D		Wanoga-Fremkle-Henkle complex, 15 to 30 percent slopes
157C		Wanoga-Fremkle-Rock outcrop complex, 0 to 15 percent slopes
159C		Wilt sandy loam, 0 to 15 percent slopes
W		Water

Source:
NRCS, SSURGO database for Upper Deschutes River, Oregon

TID_soiltypelegend.mxd, 08/09/17

Figure C-5. Legend for general soil types in Swalley Irrigation District.

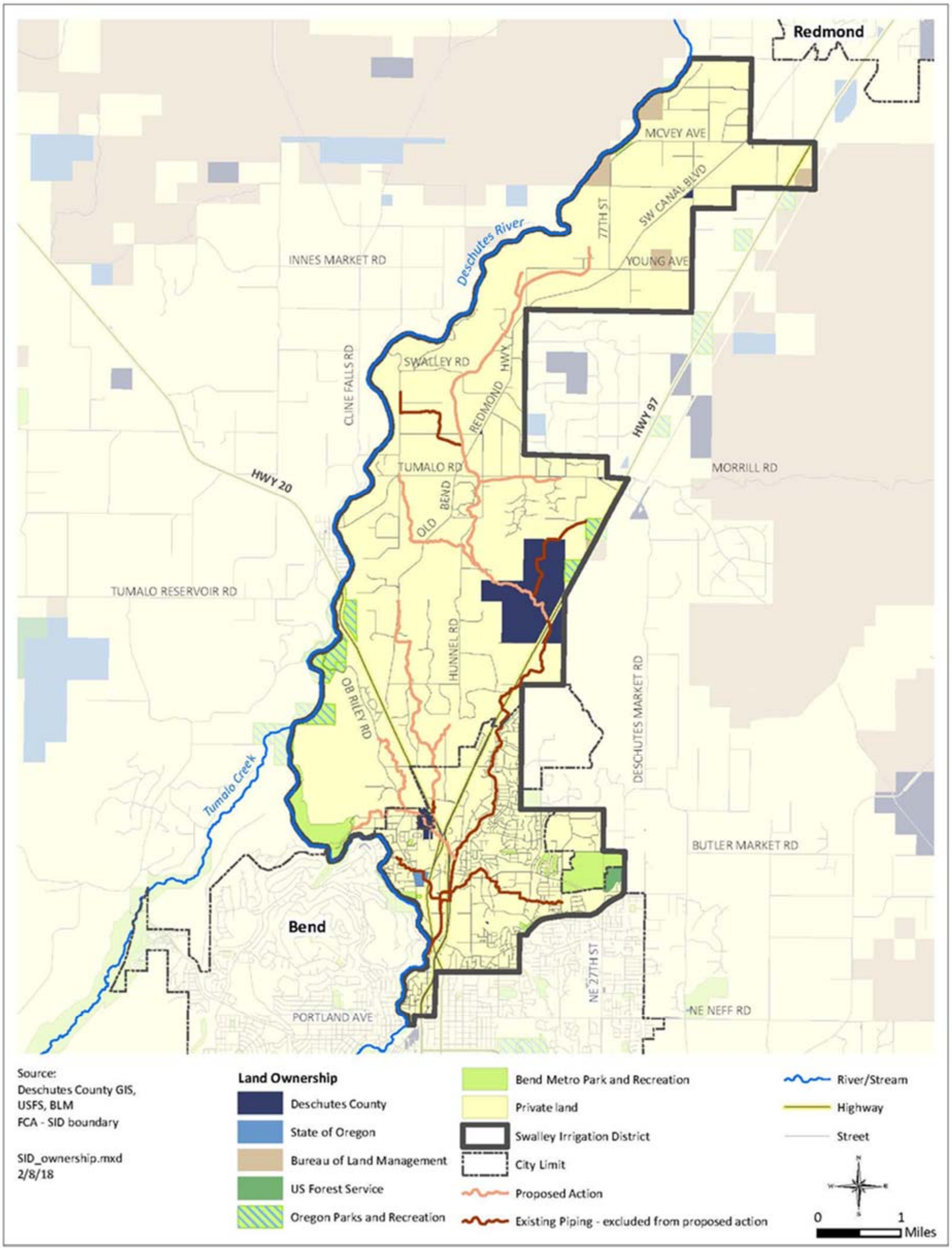

Figure C-6. Land ownership within Swalley Irrigation District.

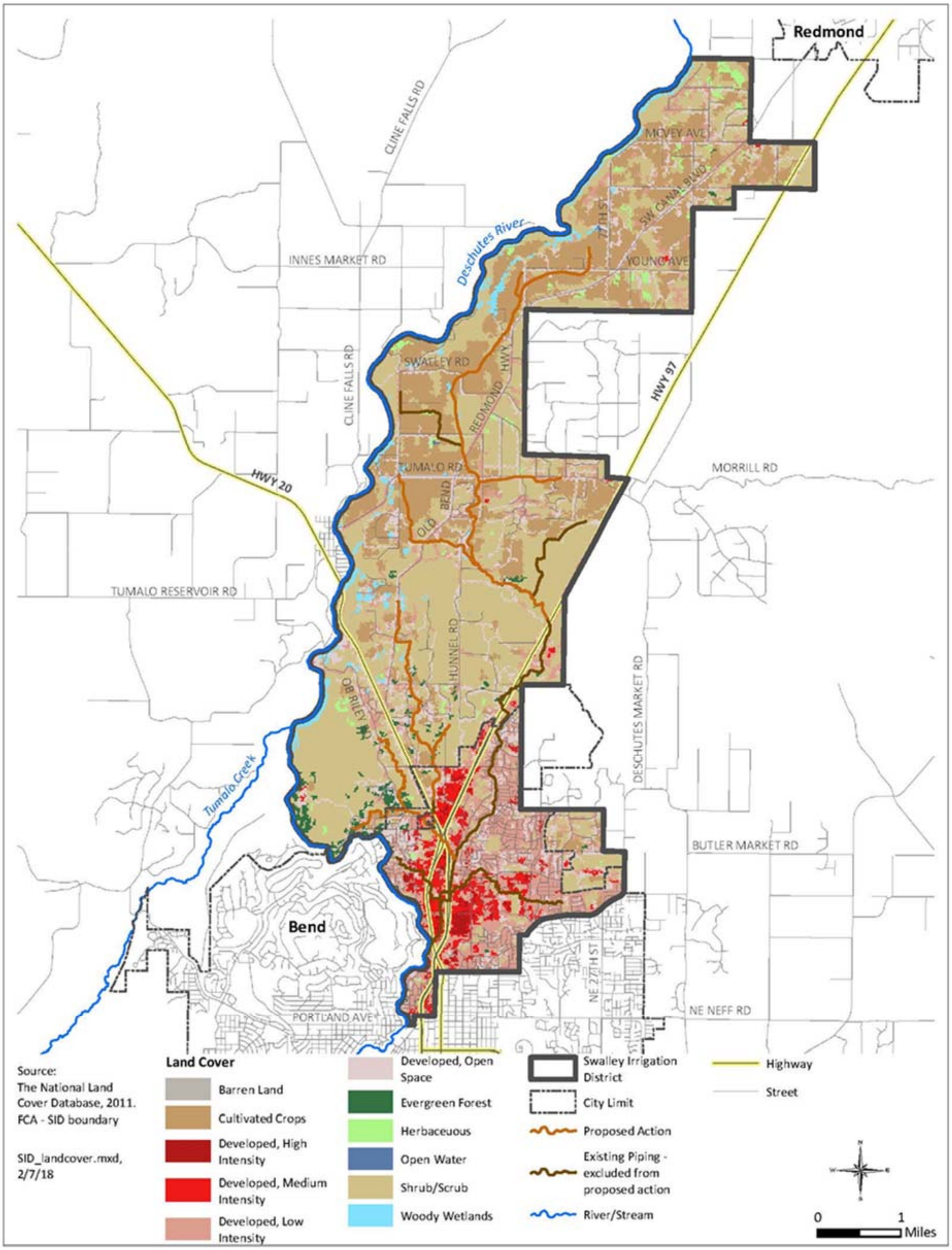

Figure C-7. Land cover/use within Swalley Irrigation District.

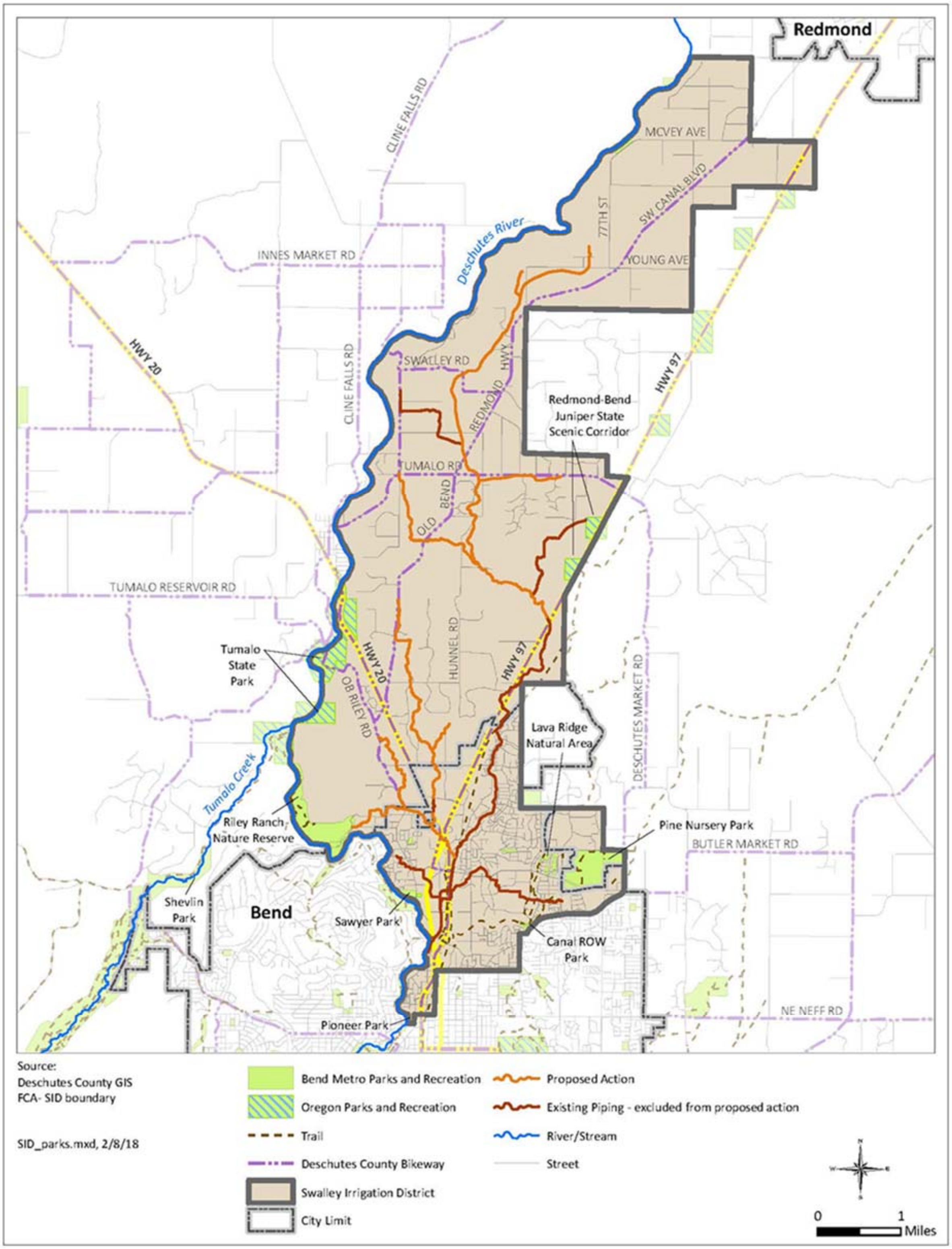

Figure C-8. Recreation map of parks, trails, and bikeways in Swalley Irrigation District.

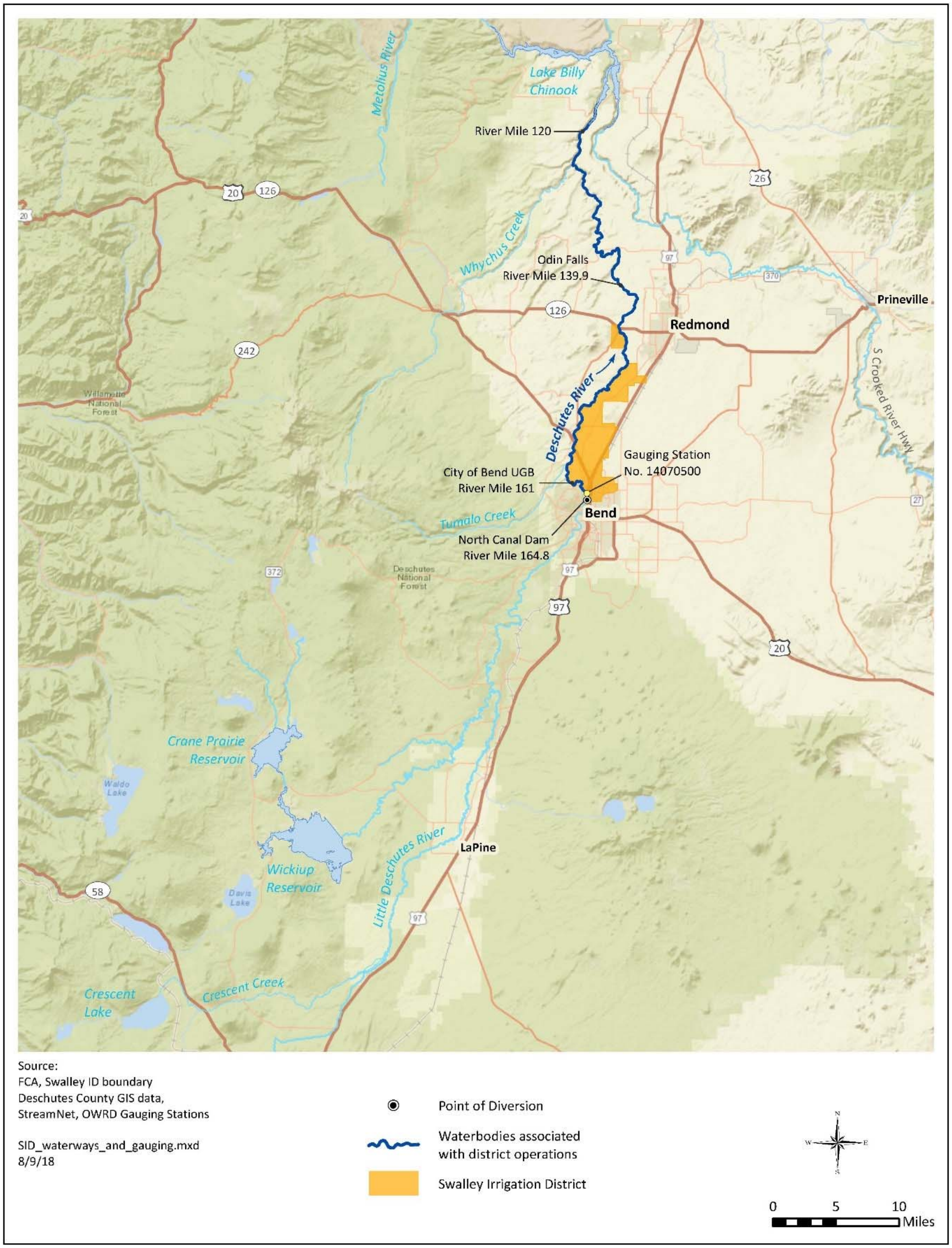

Figure C-9. Waterbodies and location of the OWRD streamflow gaging station associated with district operations.

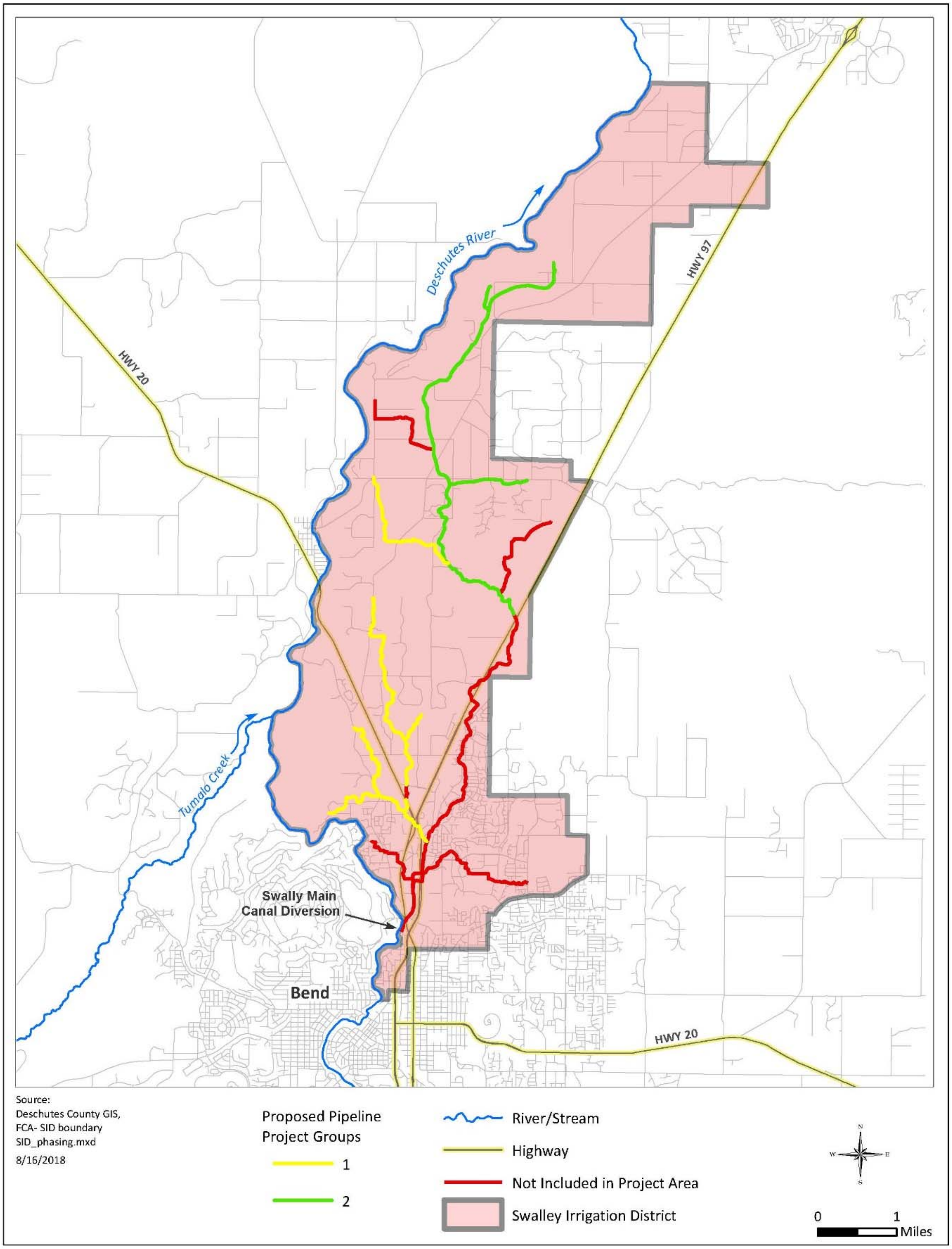

Figure C-10. The HDPE Piping Alternative project groups for the Swalley Irrigation District Irrigation Modernization Project.

Appendix D

Investigations and Analysis Reports

D.1 National Economic Development Analysis

Highland Economics LLC

National Economic Development Analysis

Barbara Wyse and Winston Oakley
9/5/2018

1 Benefits and Costs

This section provides a National Economic Development (NED) analysis that evaluates the costs and benefits of the high-density polyethylene (HDPE) Piping Alternative compared to the No Action Alternative (referred to as No Action). The analysis uses Natural Resources Conservation Service (NRCS) guidelines for the evaluation of NED benefits as outlined in the NRCS Natural Resources Economics Handbook and the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

All economic benefits and costs are provided in 2018 dollars, and have been discounted and amortized to average annualized values using the 2018 federal water resources planning rate of 2.75 percent.

1.1 Analysis Parameters

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

1.1.1 Funding

Funding is expected to be provided through a combination of loans, such as the Clean Water State Revolving Fund, and grants through organizations such as the Oregon Watershed Enhancement Board and Oregon Water Resource Department. All funding sources other than the Watershed Protection and Flood Prevention Program, Public Law 83-566 are from non-federal funds.

1.1.2 Evaluation Unit

There are two proposed Project Groups[1] in the HDPE Piping Alternative. Each of the Project Groups could be completed as a stand-alone project and accrue the same benefits. As such, the Project Groups are defined as the evaluation unit, in which benefits and costs of implementation are assessed. Note that for the incremental analysis, costs for constructing any given Project Group would not change if it were the only Project Group constructed.

1.1.3 Project Implementation Timeline

At present, the timing of implementation of the HDPE Piping Alternative or whether implementation will occur in Project Groups is unknown, as this depends on the level and timing of project funding. Assuming SID is granted the funds, construction could be started as early as 2019 (Table 1-1). Based on conversations with the District manager, it is likely that construction will be completed over approximately 9 years. Both Project Group 1 and Project Group 2 are likely to be constructed over several years. In most cases, the analysis assumes that full benefits are realized the year after the lateral or canal construction is completed (e.g., for the Rogers Sublateral Work of Improvement in Project Group 1, which is completed in Construction Year 0, full benefits are realized in Year 1). Exceptions to this are further described below. The analysis also assumes that Project Groups are completed in numeric order (i.e., Project Group 1 is completed first, followed by Project Group 2). This approach is expected to slightly understate the net present value of the HDPE Piping Alternative because benefits are slightly over-discounted compared to costs since it is expected that only 6 months (rather than 1 year) will lapse between incurring construction costs

[1] "Project Group" refers to canals and laterals that undergo construction during the same period.

for each Work of Improvement[2] and realizing benefits from each Work of Improvement (as construction is expected to occur during the winter months, with benefits accruing the following summer). Table 1-2 below outlines the year each benefit or cost begins to accrue by lateral.

1.1.4 Period of Analysis

The period of analysis for each Work of Improvement identified in Table 1-1 is defined as 101 years since the installation period is 1 year and 100 years is the expected project life of buried HDPE pipes. Across the two Project Groups, the period of analysis is 107 years (Year 0 to Year 106). Project construction timing is shown in Table 1-2. Project life of other key project infrastructure, such as pumps, are 15 to 25 years; as such, they do not affect the period of analysis.

1.1.5 Project Purpose

The piping infrastructure is multipurpose, providing habitat benefits, agricultural production benefits, patron energy cost saving benefits, and potentially recreation benefits. As there are no project cost items that separately serve a single purpose, this analysis does not allocate costs or benefits by purpose.

Table 1-1. Construction Timeline and Construction Costs by Funding Source, Deschutes Watershed, Oregon, 2018$ [1]

Construction Year	Works of Improvement	Public Law 83-566 Funds	Other, Non-Federal Funds	Total Construction Costs
0	Project Group 1: Rogers Lateral	$2,099,000	$646,000	$2,745,000
0	Project Group 1: Rogers Sub-lateral	$95,000	$32,000	$127,000
1	Project Group 1: Elder Lateral	$694,000	$215,000	$909,000
2	Project Group 1: Riley Lateral	$730,000	$227,000	$957,000
2	Project Group 1: Riley Sub-lateral	$187,000	$60,000	$247,000
2	Project Group 1: Riley Turnout	$124,000	$37,000	$161,000
3	Project Group 2: Butte Lateral	$192,000	$62,000	$254,000
4	Project Group 2: Mickelson Lateral	$79,000	$27,000	$106,000
5	Project Group 2: Main Canal	$3,407,000	$1,045,000	$4,452,000
6	Project Group 2: Main Canal Pump	$3,624,000	$1,393,000	$5,017,000
Total project		**$11,231,000**	**$3,744,000**	**$14,975,000**

1/ Price Base: 2018 dollars — Prepared August 2018

[2] "Work of Improvement" refers to the specific Project Group, lateral, canal, or pump station that would be installed as part of the HDPE Piping Alternative.

Table 1-2. The Timing of Project Costs and Benefits, Deschutes Watershed, Oregon

Works of Improvement	Year Benefits and Costs Begin								
	Project Group	Operation & Maintenance	Pump Station Energy Costs 1	Groundwater Pumping Costs	Hydropower Loss Costs 2	Irrigation Energy Savings	Carbon Emissions 3	Instream Flow	Maintaining Irrigation Pumps
Rogers Lateral	1	1	N/A	1	N/A	1	Varies	1	1
Rogers Sublateral	1	1	N/A	1	N/A	1	Varies	1	1
Elder Lateral	1	2	7	2	2	7	Varies	2	7
Riley Lateral	1	3	N/A	3	N/A	3	Varies	3	3
Riley Sublateral	1	3	N/A	3	N/A	3	Varies	3	3
Mickelson Lateral	2	5	7	5	N/A	7	Varies	5	7
Butte Lateral	2	4	7	4	4	7	Varies	4	7
Main Canal	2	6	7	6	6	7	Varies	6	7
Main Canal Pump Station	2	7	7	7	7	7	Varies	7	7

1/ Rogers and Riley do not receive pressurization from the pump station.
2/ Only Elder, Butte, Main Canal, and Main Canal Pump Station impact hydropower production. Hydropower production is fully restored in Year 8 once a new runner has been installed.
3/ The timing of changes in carbon emissions differs depending on the source of emissions. Avoided emissions from energy use begin to change according to the timeline under Irrigation Energy Savings (column 8). Increased emissions from reduced groundwater recharge begin to change according to the timeline under Groundwater Pumping Costs (column 5). Increased emissions from reduced hydropower change according to the timeline under Hydropower Loss Costs (column 6). Increased emissions from District Pumping begin to change according to the timeline under Pump Station Energy Costs (column 4).

2 Proposed Project Costs

2.1 Costs Considered and Quantified

Table 2-1 (NWPM 506.18, Economic Table 4) below summarizes installation costs, distribution of costs, and total annual average costs for the HDPE Piping Alternative. Table 2-2 and Table 2-3 present other direct costs associated with changes in operation, maintenance, and replacement (OM&R) costs. Table 2-4 and Table 2-5 show other direct costs associated with reduced groundwater recharge resulting from piping, while Table 2-6 shows other direct costs associated with short-term reduced hydropower generation. The subsections below provide details on the derivation of the values in the tables. Average annual costs include those associated with installation, OM&R costs, and other direct costs. OM&R costs include general SID operational expenses, operational energy costs of the proposed pump station, replacement costs for pump infrastructure, and replacement costs for hydropower infrastructure called a “runner.” There are three primary types of other direct costs: increased pumping costs from increased depth to groundwater due to reduced recharge, reduced energy sales resulting from a temporary loss of hydropower production, and potential reduction in aesthetic values to area residents due to the removal of canals. As the aesthetic costs are not quantifiable with the available information, they are not quantified in this NED. Table 2-1 summarizes the quantified other direct costs.

2.1.1 Project Installation Costs

According to Farmers Conservation Alliance estimates, the cost of installing piping, associated farm turnouts, and the pump station is $13,468,000 (2018 dollars). See Appendix D.1 for detailed cost derivation by pipe size, cost category, etc. All values in this analysis are presented in 2018 dollar values and rounded to the nearest $1,000 value. Of total estimated costs, Farmers Conservation Alliance estimates that construction accounts for 75 percent and engineering accounts for 25 percent.

Adding 3 percent for in-kind project administration from SID, 8 percent for technical assistance from NRCS, and $27,000 for permitting costs results in an estimated total cost of $14,975,000 for the HDPE Piping Alternative in 2018 dollars. The average annual cost by Project Group is shown in Table 2-1, with total average annual project outlays (amortized installation costs) in 2018 dollars totaling to $399,000 for the HDPE Piping Alternative (assuming works of improvement are completed according to the timeline shown in Table 1-1).

Table 2-1. Economic Table 4—Estimated Average Annual NED Costs for HDPE Piping Alternative, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement[2]	Project Outlays (Amortization of Installation Cost) [2]	Project Outlays (Operation, Maintenance, and Replacement cost) [3]	Other Direct Costs [4]	Total
Project Group 1	$149,000	$18,000	$5,000	$172,000
Project Group 2	$250,000	$74,000	$8,000	$332,000
Total	**$399,000**	**$92,000**	**$13,000**	**$504,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent.
2/ This assumes project construction timing as shown in Table 1-1.
3/ This includes the expense of running SID and maintaining District infrastructure, increased energy costs associated with a proposed pump station, and the costs of replacing the pump station pump and the runner.
4/ Other direct costs include the uncompensated economic losses due to changes in resource use or associated with installation, operation, or replacement of project structures. These include: increased pumping costs elsewhere in the basin from reduced groundwater recharge (i.e., seepage from unlined canals), any increased carbon emissions, and a temporary reduction in hydropower generation.

2.1.2 Project Outlays for OM&R Costs

The current annual OM&R costs for SID are roughly $370,000.[3] The District expects that these costs will remain constant (in real dollar terms) in the future under the No Action Alternative, and that implementing the HDPE Piping Alternative will reduce operation and maintenance (O&M) costs of the canals and laterals but increase energy costs and replacement costs due to the installation of the pump station (for a net decrease in OM&R costs for Project Group 1 and a net increase in OM&R costs for Project Group 2). The decreases in O&M of canals and laterals are discussed in Section 3.2.1.

In order to pressurize the piped conveyance system, the District plans to install a pump station downstream of the hydropower plant as part of the HDPE Piping Alternative. This station will require additional energy, estimated at 1,308,960 kWh per year (Black Rock Consulting, 2017). The pump station would provide pressure to pipelines located downstream of the hydropower plant, all of which are in Project Group 2 except for the Elder Lateral (part of Project Group 1). The energy use is valued at the same rate as the hydropower sales rate: $0.0765 per kWh (as increased District energy usage translates into lower District hydropower sales). Because the pump station would not be constructed unless the canals were piped, under the No Action Alternative, there would be no energy costs associated with the pump station. Table 2-2 outlines the energy costs for the pump station by Project Group. When discounted and amortized, the costs to power the pump station are roughly $85,000 per year.

[3] This value has been adjusted for inflation to 2018 using the Consumer Price Index.

Table 2-2. Annual Pump Station Energy Costs of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Total Annual Energy Costs Under No Action (kWh)	Annual Pump Station Energy Use Under HDPE Piping (kWh)	Increased Annual Energy Use (kWh)	Undiscounted Annual Cost of Pump Station Energy	Average Annual NED Cost (Discounted and Amortized)
Project Group 1	0	255,407	255,407	$20,000	$17,000
Project Group 2	0	1,053,553	1,053,553	$81,000	$68,000
Total	**0**	**1,308,960**	**1,308,960**	**$101,000**	**$85,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

While the OM&R expenses for existing infrastructure will decrease (as shown in Table 3-4), the HDPE Piping Alternative will result in additional replacement costs for two pieces of new infrastructure. Namely, the pump for the pump station has a 25-year life and carries a replacement cost of $55,113, and the runner for the hydropower plant has a 15-year life and a replacement cost of $95,166 (Farmers Conservation Alliance, 2018a).[4] The initial costs to install the pump in the pump station (which is projected to be installed in Year 7) is included under the installation cost for Project Group 2 as presented in the first column of Table 2-1. The initial installation of the runner (also projected to occur in Year 7) is not part of the funding applied for through the Watershed Protection and Flood Prevention Program, Public Law 83-566, and is therefore included as an OM&R cost in Table 2-3 rather than an installation cost in Table 2-1. The replacement costs after Year 7 have been incorporated at their respective intervals during the 107-year study period; the resulting average annual NED replacements cost is presented under the Project Group 2 OM&R costs in the third column of Table 2-3.[5]

Table 2-3. Annual Operations, Maintenance, and Replacement Costs of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Average Annual NED Replacement Cost (Discounted and Amortized)[2]	Average Annual NED Energy Operations Cost (Discounted and Amortized)	Average Annual NED OM&R Cost (Discounted and Amortized)[3]
Project Group 1	$1,000	$17,000	$18,000
Project Group 2	$6,000	$68,000	$74,000
Total	**$7,000**	**$85,000**	**$92,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent
2/Maintenance costs are presented as negative costs (benefits) as maintenance costs are expected to decrease due to the HDPE Piping Alternative.
3/OM&R is presented as a cost for Project Group 2 above in Table 2-1. However, as OM&R costs are expected to decrease (i.e., be a benefit) for Project Group 1, OM&R cost savings are shown as a benefit in Table 3-1.

[4] These values have been adjusted for inflation to 2018 dollars using the Consumer Price Index.
[5] Both the pump and the runner are assumed to last their full expected lives, providing 25 and 15 years of full benefits respectively before needing replacement.

2.1.3 Other Direct Costs: Groundwater Recharge Costs

Seepage of water from canals is one source of recharge for groundwater in the Deschutes Basin. Reduced recharge from canals may lead to groundwater declines, and thereby increase pumping costs for all groundwater users in the basin. This section estimates this potential project cost. A 2013 study by the U.S. Geological Survey (USGS) estimated the effects on groundwater recharge due to changes in climate (reduced precipitation), groundwater pumping, and canal lining and piping. The study used data for 1997 to 2008; an important caveat to using the data and findings from this study is that the localized effects of lining SID canals may be different than previous lining projects that have occurred throughout the central basin. These disparities could arise from differences in local geology that change the rate of seepage from surface water.

The study indicates that since the mid-1990s, groundwater levels have dropped by approximately 5 to 14 feet in the central part of the Deschutes Basin that extends north from near Benham Falls to Lower Bridge, and east from Sisters to the community of Powell Butte. It also finds that approximately 10 percent of this decline in groundwater level is due to canal lining/piping during this period, or approximately 0.5 to 1.4 feet. This is modeled as a result of a reduction of recharge from irrigation canal leakage of 58,000 acre-feet (AF) annually. This NED analysis uses these data to first estimate the effect of reduced irrigation canal seepage on groundwater levels, and second to roughly approximate the change in the cost of pumping for all groundwater users in the Deschutes Basin due to the HDPE Piping Alternative.

By 2008, the cumulative effect of piping over the 12-year period of study (1997 to 2008) reached 58,000 AF per year of reduced recharge. Assuming a uniform increase in canal lining/piping over this timeframe, in 1997 there was a decreased canal seepage of 4,833 AF, rising each year by another 4,833 AF until there was a reduced canal seepage in 2008 of 58,000 AF. Cumulatively then, this report estimate that this represents 377,000 AF of reduced recharge from canals during this time period. The USGS study finds that this level of reduced recharge caused an overall groundwater decline in the central part of the Deschutes Basin of 0.5 to 1.4 feet. These data suggest that the average relationship between canal recharge and groundwater levels in this part of the basin is approximately 1 foot of groundwater elevation drop per 377,000 AF of reduced canal recharge, though local effects may be much higher or lower.

The HDPE Piping Alternative would reduce canal seepage and associated groundwater recharge by up to approximately 3,721 AF annually in this central part of the Deschutes Basin once all Project Groups are complete (see Appendix D for detailed derivation of reduced canal seepage) (Farmers Conservation Alliance, 2018b). On average, this translates into a decreased groundwater elevation of approximately 0.01 foot annually (based on information presented above that a 1-foot groundwater elevation drop is expected to result from reduced recharge of approximately 377,000, so the corresponding drop from 3,721 AF is 0.01 foot (where 3,721 AF divided by 377,000 AF is 0.01). Over the course of approximately 100 years, this annual drop results in a cumulative decreased average groundwater elevation in the central part of the Deschutes Basin of approximately 1 foot (note that this slight drop in pumping elevation would have small effects on pumping costs, but would not be expected to result in the need for drilling deeper wells or replacing pumps at a faster rate).

This analysis combines the estimated decreased groundwater elevation for each year in the 100-year analysis period with the estimated annual volume of groundwater pumping in the central part of the Deschutes Basin during this time period to estimate the total increased cost of groundwater pumping in the Basin over time due to decreased recharge from the HDPE Piping Alternative. The USGS report identified approximately 25,000 AF per year of groundwater pumping for public supply and about 25,000 AF per year of groundwater pumping for irrigation use. A 2006 report for the Deschutes Water Alliance on future groundwater use indicates that public supply use may increase by an average of 2.5 percent annually (the report projected in increase of consumptive groundwater use from 35,895 to 58,594 over the 20-year period from 2005 to 2025) (Newton Consultants, 2006). Generously assuming this growth rate in pumping for public supply stays constant over the analysis period (and assuming no growth in irrigation pumping), total groundwater pumping by analysis year 106 may rise to 368,000 AF annually.

In terms of power rates, according to the 2010 *Water System Master Plan Update Optimization Study*, most of the City of Bend's 25 groundwater wells fall under Pacific Power's Rate Schedule 28, while 3 wells fall under Rate Schedule 30 (Optimatics, 2010). The current marginal cost for the City to pump groundwater is expected to be approximately $0.05970 per kWh under Schedule 28 (Pacific Power, 2017). Farmers who use electricity to pump irrigation water pay according to the rates established under Schedule 41, which applies the same price to all electricity used during the summer (April 1 to November 30). This rate is $0.09624 per kWh, which this analysis assumes is the marginal cost to farmers for electricity used to pump groundwater.[6]

Under the No Action Alternative, groundwater levels would still decline but at a slower rate than with the project. The USGS study cited above notes that groundwater levels in the area between Clines Butte and Redmond (the closest area in the study to the HDPD Piping Alternative) fell approximately 12 to 14 feet from 1994 to 2008 from a combination of climate, increases in groundwater pumping, and reduced groundwater recharge from canal lining (Gannett & Lite, 2013). This is an average drop of roughly one foot per year, which we assume will continue under the No Action Alternative. Data from the Oregon Water Resources Department indicate that depths to groundwater vary widely within the areas around Bend and Redmond; depths in Bend are around 740 feet, while depths near Redmond are about 265 feet (Oregon Water Resources Department, 2016). For the No Action Alternative, we assume a current average groundwater pumping depth within SID of 500 feet; assuming a 1-foot drop in groundwater depth in each year, in 100 years in the future under the No Action Alternative, groundwater depths will be approximately 600 feet. Over the course of 100 years, the HDPE Piping Alternative results in a pumping depth of approximately 601 feet, or an increased depth to groundwater of one foot compared to the No Action Alternative.

[6] The costs to power a pump represent the vast majority of variable costs of irrigation pumping. Maintenance costs on electric pumps are minimal. One study estimated that maintenance costs represented only 1 to 4 percent of the variable costs of pumping, with electricity costs comprising the other 96 to 99 percent (Robinson, 2002). The costs of diesel pumps show a similar pattern. Because maintenance costs are such a small part of the variable costs of irrigation pumping and would have a small effect on expected average annual values, only energy costs are included in this analysis.

Table 2-4. Approximate Depth to Groundwater in Central Deschutes Basin, Deschutes Watershed, Oregon

Year	Volume Pumped (acre-feet per year)	Average Depth to Groundwater (feet)	
		No Action	HDPE Piping Alternative (NED Alternative)
1	51,000	501	501
10	57,000	510	510
20	66,000	520	520
30	77,000	530	530
40	92,000	540	541
50	111,000	550	551
60	135,000	560	561
70	166,000	570	571
80	205,000	580	581
90	256,000	590	591
100	320,000	600	602
106	368,000	606	608

Prepared August 2018

Applying the electricity prices, assuming a pump irrigation efficiency of 70 percent[7], and using the volume of pumping and pumping depths shown in Table 2-4, the total cost of groundwater pumping under No Action is projected to grow from around $2.9 million in Year 1 to $21.3 million in Year 106.

The increased depth to groundwater due to reduced recharge results in higher pumping costs in the HDPE Piping Alternative. The increased cost to groundwater pumpers over the 100-year evaluation period rises in each year as the cumulative effect of reduced recharge may cause the groundwater elevation to continue to decline. For example, as a result of reduced recharge due to installation of the Rogers Lateral component of Project Group 1, the groundwater elevation may decline 0.0016 foot in Year 1, increasing to a 0.16-foot decline by Year 100 (0.0016 multiplied by 100), with associated annual costs rising from approximately $9 to $5,000. In total, after discounting and amortizing these costs across all Project Groups, the estimated total annual average NED cost across the 107 years of analysis is $6,000 per year for the HDPE Piping Alternative (see Table 2-5).

[7] As assumed in the Swalley Irrigation District System Improvement Plan completed by Black Rock Consulting in 2017.

Table 2-5. Other Direct Cost of Reduced Recharge under HDPE Piping Alternative, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Water Conservation (cfs)	Water Conservation (AF/year)	Change in Groundwater Depth (ft/year)	Annual Average NED Cost
Project Group 1	7.0	2,250.1	0.006	$2,000
Project Group 2	12.2	3,922	0.010	$4,000
Total	**19.2**	**6,172**	**0.016**	**$6,000**

Note: Totals may not sum due to rounding Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

2.1.4 Other Direct Costs: Decreased Hydropower Revenue

In the short-term, installing Project Group 2 of the HDPE Piping Alternative would decrease energy generation by the Ponderosa Hydroelectric Plant. Specifically, the construction of Project Group 2 would reduce water flows through the plant, such that power generation would fall by 384,910 kWh per year (Farmers Conservation Alliance, 2017). However, this will be a temporary loss as the District plans to install a new turbine runner that would increase power production efficiency over a wider range of flows such that energy generation would return to its pre-project level. This runner would be installed in Year 8 and become operational in Year 9 (Camarata, Swalley Irrigation District General Manager & Board Secretary, 2018). Under the No Action Alternative, the hydropower plant produces an estimated 2,539,372 kWh per year (Swalley Irrigation District, 2017). As the District sells this hydropower for $0.07650 per kWh, the lost annual electricity sales from the plant would cost the District roughly $29,000 once Project Group 2 is installed (prior to the installation of the runner, as shown in Table 2-6). Because the energy losses only affect five years, the average annual NED costs fall to $2,000 per year. This District would not be compensated for this lost revenue through the Watershed Protection and Flood Prevention Program, Public Law 83-566 funds.

Table 2-6. Annual Hydropower Generation Costs of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Total Annual Energy Generation Under No Action (kWh)	Annual Energy Generation Under HDPE Piping (prior to runner installation)	Reduced Annual Energy Generation (prior to runner installation) (kWh)	Undiscounted Annual Cost of Lost Hydropower Generation (prior to runner installation)	Average Annual NED Cost (includes the cost of the runner) (Discounted and Amortized)
Project Group 1	240,534	172,609	67,925	$5,000	$1,000
Project Group 2	2,298,838	1,981,853	316,985	$24,000	$1,000
Total	2,539,372	2,154,462	384,910	$29,000	$2,000

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

2.2 Costs Considered but Not Quantified

2.2.1 Other Direct Costs: Change in Aesthetics and Associated Property/Recreation Values

A potential direct cost is that some local residents may experience adverse effects on property values and quality of life due to the change in aesthetics from piping the canals (as many people enjoy the aesthetics of the open canals). According to real estate agents in the area, many people interested in purchasing property in the area are willing to pay more for properties that have a view of a canal. On the other hand, some property owners or potential property owners may not want to have a canal adjacent to their property because of the safety hazard an open canal poses, potentially limiting the effect on property values. There should not be any impacts to recreation as there is currently no recreation on or near the canals (Camarata J. , Swalley Irrigation District General Manager & Board Secretary, 2017).

The potential aesthetic cost to residential landowners and recreationists is not quantified due to a lack of available data. Interviewed real estate agents were not able to quantify the potential effect of a view of the canal. Furthermore, quantification is difficult due to scarce information in the economic literature. While the economic value of many natural views has been studied (such as for ocean front property or other scenic natural areas), the value of irrigation canals has been studied little, if at all. There are no hedonic studies looking at the water attribute for loss of irrigation canal aesthetics on residential properties. As such, while this effect is recognized as a likely cost[8], this analysis does not quantify the potential change in aesthetic values of the HDPD Piping Alternative.

3 Proposed Project Benefits

Table 3-1 (NWPM 506.20, Economic Table 5a) summarizes annual average NED project benefits, while Table 3-2 (NWPM 506.21, Economic Table 6) compares them to the annual average project costs presented in Table 2-1. Onsite damage reduction benefits that will accrue to agriculture and the local rural community include increased agricultural production (increased net returns), reduced OM&R costs (only in the case of Project Group 1), and reduced power and maintenance costs for patron pumping; 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 HDPE Piping Alternative include the potential for increased on-farm investment in increased irrigation efficiency (as patrons have more funds to increase investment in irrigation from increased yields and reduced pumping costs). The analysis recognizes that instream flows may affect recreation, both in-river and adjacent land-based recreation. However, aside from positive impacts on fish and wildlife-related recreation (both wildlife viewing and fishing) from improved species populations, it is not clear how recreation may be impacted. Numerous interviews with recreation planners and recreation industry professionals in the area indicate that effects on boating and in-water recreation of enhanced instream flows resulting from the HDPE Piping Alternative may be both positive and adverse (depending on the timing and magnitude of the flows), with no indication of whether there may be net benefits or net costs to recreation. As such, this analysis assumes no net impact on recreation. Table 3-1 presents total annual NED benefits, and Table 3-2 compares annual NED benefits and costs.

[8] Note that increased agricultural production value due to a more reliable water supply to SID patrons may tend to increase property values (all else equal), which could offset the effect on property values. The value of increased water supply reliability is quantified and captured below in the discussion on the benefits of increased agricultural production value. While the aesthetic value and the agricultural production value are not necessarily similar in magnitude, the population affected (patrons of SID) is largely the same (however, there may be some residents in the area who benefit from canal views who are not patrons of SID).

Table 3-1. Economic Table 5a—Estimated Average Annual Watershed Protection Damage Reduction Benefits of HDPE Piping Alternative for Swalley Irrigation District 2018 Watershed Plan, Deschutes Watershed, Oregon, 2018$ [1]

Item	Damage Reduction Benefit, Average Annual	
	Agricultural- related	**Non-Agricultural- related**
Project Group 1		
On-Site Damage Reduction Benefits		
Other - Reduced O&M	$5,000	
Other - Irrigation Pump Cost Savings	$171,000	
Subtotal	$176,000	
Off-Site Damage Reduction Benefits		
Other - Social Value of Carbon [2]		$19,000
Water Conservation		$125,000
Subtotal		$144,000
Total Quantified Benefits	**$176,000**	**$144,000**
Project Group 2		
On-Site Damage Reduction Benefits		
Other - Reduced O&M	$5,000	
Other - Irrigation Pump Cost Savings	$239,000	
Subtotal	$244,000	
Off-Site Damage Reduction Benefits		
Other - Social Value of Carbon [2]		$17,000
Water Conservation		$190,000
Subtotal		$207,000
Total Quantified Benefits	**$244,000**	**$207,000**
Project Total Quantified Benefits		**$771,000**

Prepared August 2018

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent.
2/ Indicates the benefit of avoided carbon emissions. These benefits would also accrue to local residents, but the majority of the value would be experienced outside the proposed project area.

Table 3-2. Economic Table 6—Comparison of Average Annual NED Benefits and Costs Under the HDPE Piping Alternative, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Agriculture-related		Nonagricultural		Average Annual Benefits	Average Annual Cost[2]	Benefit Cost Ratio
	Reduced O&M	Power Cost Savings	Carbon Value	Instream Flow Value			
Project Group 1	$5,000	$171,000	$19,000	$125,000	$320,000	$172,000	1.86
Project Group 2	$5,000	$239,000	$17,000	$190,000	$451,000	$332,000	1.36
Total	**$10,000**	**$410,000**	**$36,000**	**$315,000**	**$771,000**	**$504,000**	**1.53**

Note: Totals may not sum due to rounding Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent
2/ From Table 2-1 Economic Table 4

3.1 Incremental Analysis

The HDPE Piping Alternative is also evaluated using an incremental analysis, which identifies how total costs and benefits change as Project Groups are added. In the incremental analysis, Project Group pipe sizes and costs remain the same for each Project Group assessed.

The engineering pipeline design (e.g., pipe diameters and pressure ratings) is independent of the number of Project Groups and the order that the Project Groups are installed. The District's System Improvement Plan (Swalley Irrigation District, 2017) describes how the District designed modern pipelines to replace its open canals and laterals. The District mapped and collected digital elevation data along its entire delivery system. The District determined that the system needed to be able to deliver 7 gallons per minute per acre served. The system also needed to be able to handle an upper limit of 9 gallons per minute per acre served.

As the pipeline is installed from the "top down" (from the diversion at higher elevations to the lowest elevations in the district), the design had to account for the entire irrigation demand in the system. That is, the system had to be designed for the future full demand rather than the current Project Group demand.

For example, assume that there are two planned Project Groups for a 2-mile pipeline to replace a leaky canal. Project Group A construction is the upper 1 mile of pipeline starting at the diversion gate. Project Group B construction is the lower 1 mile. The irrigation demand (water right) for the Project Group A construction is 5 cubic feet per second (cfs). The irrigation demand for the Project Group B construction is 15 cfs. Total irrigation demand for the pipeline equals 20 cfs.

If the engineer designs a pipeline for 5 cfs for Project Group A, this will be a relatively small pipeline. This pipeline will then be connected to the larger Project Group B pipe. Therefore, the Project Group A pipeline will have to convey 20 cfs of flow through a pipeline designed for 5 cfs. This will result in a pipeline that does not meet NRCS design standards, and will likely not function and meet the goals of the project.

Pipelines typically decrease in size as the irrigation demand decreases with the number of acres served at lower elevations in the system. Project Groups are not considered when determining when to reduce from a larger to smaller pipe.

The District used the information and assumptions above to create a hydraulic model that determined pipe sizes for each pipeline (canal or lateral to be piped) in the system. The District designed each pipeline to deliver water under its existing water rights, and these pipelines are not designed to deliver water under any additional water rights. The District does not discharge to any waterbodies or connect with any other district's canals, laterals, or pipelines.

Table 3-3 shows the incremental analysis by lateral. The costs are the same for each Project Group in the incremental analysis as presented in Table 2-1 above, and the benefits are the same as in Table 3-1 above.

Table 3-3. Incremental Analysis of Annual NED Costs and Benefits under the HDPE Piping Alternative for Swalley Irrigation District 2018 Watershed Plan, Deschutes Watershed, Oregon, 2018$[1]

Lateral	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
1	$82,000		$173,000		$91,000
1,2	$86,000	$4,000	$185,000	$12,000	$99,000
1-3	$134,000	$48,000	$287,000	$102,000	$153,000
1-4	$153,000	$19,000	$304,000	$17,000	$151,000
1-5	$180,000	$27,000	$325,000	$21,000	$145,000
1-6	$187,000	$7,000	$337,000	$12,000	$150,000
1-7	$191,000	$4,000	$337,000	$0	$146,000
1-8	$197,000	$6,000	$357,000	$20,000	$160,000
1-9	$345,000	$148,000	$574,000	$217,000	$229,000
1-10	$504,000	$159,000	$771,000	$197,000	$267,000

Note: Totals may not sum due to rounding Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

3.2 Benefits Considered and Quantified for Analysis

3.2.1 Canal and Lateral O&M Cost Savings

The District estimates that O&M costs of canals and laterals will fall by roughly $10,000 per year as a result of reduced maintenance and overtime expenses (Camarata, Swalley Irrigation District General Manager & Board Secretary, 2018).[9] This analysis assumes that these cost savings are proportional to the mileage piped, and accordingly allocate the cost savings to each Project Group based on relative mileage (i.e., Project Group 1 with 8.7 miles of pipe represents 53 percent of the 16.6 miles of proposed pipe, and is therefore assumed to provide 53 percent of the cost savings, or approximately $5,000 annually). Table 3-4 allocates these savings to each Project Group.

[9] Estimated O&M savings for the HDPE Piping Alternative include a reduction in equipment usage, fuel, repairs, and labor. For example, to ensure the irrigation ditch operates properly, open ditch canals require cleaning to allow unobstructed water delivery, and infrastructure requires repair when there is a blowout. Labor includes both administration and field time.

Table 3-4. Annual Reduced Maintenance Costs to SID from the HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Mileage	Undiscounted Annualized Cost of No Action	Undiscounted Annualized Cost under HDPE Piping Alternative	Undiscounted Annual Benefit	Average Annual NED Benefits (Discounted and Amortized)
Project Group 1	8.7	$195,000	$190,000	$5,000	$5,000
Project Group 2	7.9	$175,000	$170,000	$5,000	$5,000
Total	**16.6**	**$370,000**	**$360,000**	**$10,000**	**$10,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

3.2.2 Patron Irrigation Pump Cost Savings and Carbon Benefits

The System Improvement Plan for SID estimates that, compared to No Action Alternative, the HDPE Piping Alternative would result in a net energy savings of 2,365,438 kWh per year since it is much more efficient for patrons to receive pressurized water than to pressurize it themselves (Farmers Conservation Alliance, 2018c). This cost savings from this energy savings is evaluated based on a cost of summer irrigation pumping of $0.09624 per kWh (the marginal cost for summer irrigation pumping, as noted above). Table 3-5 presents the energy use under the No Action Alternative, and displays the savings to SID patrons for each Project Group under the HDPE Piping Alternative. Once all Project Groups are complete, the savings to SID patrons would be approximately $228,000 each year; the average annual NED benefits (after discounting and amortizing) are estimated at $201,000.

Table 3-5. Annual Increased Average Energy Cost Savings to SID Patrons of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Total Annual Energy Use Under No Action (kWh)	Annual Energy Use Under HDPE Piping Alternative	Reduced Annual Energy Use (kWh)[2]	Undiscounted Annual Energy Cost Savings	Average Annual NED Benefits (Avoided Energy Costs, Discounted and Amortized)
Project Group 1	1,307,500	539,392	768,107	$74,000	$71,000
Project Group 2	1,838,566	241,235	1,597,331	$154,000	$130,000
Total	**3,146,066**	**780,628**	**2,365,438**	**$228,000**	**$201,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent
2/ As estimated by Black Rock Consulting in the SID System Improvement Plan, 2017

Because the HDPE Piping Alternative will create a pressurized conveyance system, it will eliminate the need for some District patrons to maintain irrigation pumps. Of the estimated 555 pumps being used by SID patrons, 369 are projected to be eliminated as a result of the HDPE Piping Alternative (Farmers Conservation Alliance, 2018d). Pumps incur annual maintenance costs and service charges from power providers. Avoiding these costs would represent a benefit to District patrons.

Under Schedule 41, Pacific Power charges a minimum of $55 per year to service a single phase pump (Pacific Power, 2017). Annual maintenance on a pump is roughly 4 percent of the pump's initial cost (around $13,000), for a total of approximately $520 per year (Martin, Dorn, Melvin, Corr, & Kranz, 2011).[10] Annual maintenance on an electric motor is roughly one percent of the initial cost of the motor (around $6,200), totaling approximately $60 per year (National Resources Conservation Service, 2016).[11] Totaling the maintenance costs and service charge, the annual costs of maintaining an irrigation pump are around $635, which this analysis used to estimate the annual benefit of each pump eliminated in the study area as a result of the HDPE Piping Alternative. The table below outlines these benefits. On average during the study period, District patrons save a total of roughly $209,000 each year by avoiding the costs of maintaining irrigation pumps.

Table 3-6. Estimated Cost Savings from Eliminated Irrigation Pumps under the HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Pumps in Use Under No Action	Pumps Eliminated Under Piping Alternative	Annual Service Charges Avoided by Piping Alternative	Average Annual Avoided Cost Under Piping Alternative
Project Group 1	322	168	$106,000	$100,000
Project Group 2	233	201	$129,000	$109,000
Total	**555**	**369**	**$235,000**	**$209,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018

Energy changes from reduced pumping, temporarily reduced hydropower generation, and increased energy use from the pump station will also cause changes in carbon dioxide (CO_2) emissions. Every megawatt hour (MWh) of decreased energy use is estimated to translate into an estimated reduction of 0.75251 metric ton of carbon emissions.[12] However, because hydropower does not emit CO_2, any reduction of hydropower will have to be replaced with carbon-emitting sources. As shown in Table 3-7, reduced pumping due to pressurization decreases CO_2 emissions by approximately 1,780 metric tons per year. Increased pumping energy due to lowered groundwater depth increases CO_2 emissions by 279 tons per year on average over the 100-year period. Before the runner is installed, replacing lost hydropower will increase CO_2 emissions by roughly 290 tons per year. The energy needed to power the pump station will generate about 985 tons of CO_2 per year. The net decrease in CO_2 emissions is estimated to be 227 tons per year prior to the runner's installation, which will increase to 517 tons of CO_2 avoided after the runner is installed. The emissions avoided by reduced pumping outweigh the increased emissions from hydropower loss and powering the pump station; for this reason, the avoided emissions are included as a benefit in Table 3-1.

Under the No Action Alternative, District carbon emissions are estimated to be 2,367 tons per year, which is generated by using 3,146,066 kWh per year to power irrigation pumps. As a result of the

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[10] The original source cited a cost of $11,163 in 2009 dollars, which was adjusted for inflation to 2018 dollars using the Consumer Price Index.

[11] The original source cited $6,000 in 2016 dollars, which was adjusted for inflation to 2018 dollars using the Consumer Price Index.

[12] This assumes that marginal changes in energy demand are met with fossil fuel-based production (renewable energy is typically used first and then fossil fuel powered generation is used), such that 100 percent of energy use reduction and green energy production results in reduced fossil fuel-powered generation. Furthermore, this estimate assumes 0.75251 metric tons 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 metric tons of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

changes described above, these emissions will fall to roughly 2,141 tons per year prior to the runner's installation, and fall further to 1,851 tons per year after the runner has been installed. To value the reduced carbon emissions, this analysis uses an estimate of the social cost of carbon (which is the estimated total cost to society of emitting carbon related to the expected damages associated with future climate change). The Environmental Protection Agency and other federal agencies use a social cost of carbon estimate recommended by the federal Interagency Working Group on the Social Costs of Greenhouse Gases of approximately $43 per metric ton (2018 dollars) (Interagency Working Group on Social Cost of Greenhouse Gases, 2013). At this value, the avoided carbon emissions from the HDPE Piping Alternative provide an estimated average annual benefit of approximately $36,000, as shown in Table 3-8.

Table 3-7. Annual Average Carbon Emission Changes (Metric Tons) by Project Group, Deschutes Watershed, Oregon

Works of Improvement	Annual *Avoided* Emissions from Reduced SID Patron Energy Use	Average Annual *Increased* Emissions from Reduced Groundwater Recharge [1]	Average Annual *Increased* Emissions from Reduced Hydropower (prior to runner installation)	Average Annual *Increased* Emissions from District Pumping	Net Average Annual Emissions *Reduction* (prior to runner installation)	Net Average Annual Emissions *Reduction* (after runner installation)
Project Group 1	578	94	51	192	241	292
Project Group 2	1,202	185	239	793	-14	225
Total	**1,780**	**279**	**290**	**985**	**227**	**517**

Note: Totals may not sum due to rounding. Prepared August 2018

1/Additional energy use elsewhere rises through time as the effects of reduced recharge accumulate and cause groundwater depths to drop over time. The average annual energy use increase elsewhere in the basin represents the average change in energy use across the 100 project years for each Project Group.

Table 3-8. Annual Average Carbon Emissions (Metric Tons) by Project Group, Deschutes Watershed, Oregon, 2018$

Works of Improvement	No Action		HDPE Piping Alternative (NED Alternative)			Net Annual Carbon (Compared to No Action Alternative)		Average Annual NED Benefits [2,3]
	Average Annual Carbon Emissions, Basin-wide Energy Use	Annual Carbon Emissions, SID Energy Use	Average Annual Carbon Emissions, Basin-wide Energy Use	Annual Carbon Emissions, SID Energy Use (prior to runner installation)	Annual Carbon Emissions, SID Energy Use (after runner installation)	Prior to Runner Installation	After Runner Installation	
Project Group 1	N/A	984	N/A	743	692	241	292	$19,000
Project Group 2	N/A	1,384	N/A	1,397	1,159	-14	225	$17,000
Total	**92,879 [1]**	**2,367**	**96,879**	**2,141**	**1,851**	**227**	**516**	**$36,000**

Note: Totals may not sum due to rounding. Prepared August 2018

1/ Note this values rises from 27,920 in Year 1 to 245,162 in Year 106. The average value is 92,879. Carbon emissions rise over time because groundwater pumping volume increases throughout the basin through time, and the depth to groundwater also increases through time due to reduced recharge from canals.

2/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

3/Note that the average annual NED benefits differ from the change in tons of carbon emitted multiplied by the $43 value per metric ton of carbon. The increased emissions rise through time (and are thus highest at later time periods when the values are most discounted, while the decreased carbon emissions are the same through time).

3.2.3 Value of Conserved Water

This analysis focuses on the value of instream flow, as the conserved water from the HDPE Piping Alternative will be used to augment instream flows. However, this analysis also presents the value of water to agriculture as the HDPE Piping Alternative also enhances water supply reliability to the District.

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 and, similar to the data on costs of water conservation projects, may significantly underestimate the full value of instream flow augmentation. This analysis also presents market information on the value of water rights to irrigators in SID, as this indicates that potential cost of purchasing water rights from these irrigators.

Based on the following discussion, this analysis assumes that the economic benefit of instream flow augmentation would be at least $75/AF/year (see Table 3-9), such that this enhanced instream flow is estimated to have a value of approximately $347,000 per year once all Project Groups are complete under the HDPE Piping Alternative (because of the timing, the NED benefit is $315,000 on an average annualized basis, as presented in Table 3-10). This value is expected to be reasonable as a proxy for the value to the public of enhanced fish and wildlife populations (which is the true measure of the economic benefit of enhanced instream flow to benefit fish and wildlife populations). Values published in the economic literature are often quite high for enhancements to trout and other fish and wildlife populations, such as those that would benefit from the instream flows provided by the action alternatives.[13] As quantitative information on how instream flows will 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 directly estimated using the value of water transactions in the western United States.

This value of $75 per AF per year is based on the following information:

- **Prices paid for water by environmental buyers throughout the Western United States.** In the period 2000 to 2009, the purchase price of environmental water varied from just over $0 to nearly $1,665 per AF per year, with an average permanent sale transaction price of $165 per AF per year. Amongst 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. There are water transactions in the Deschutes Basin purchased through the Deschutes River Conservancy, but these are not used as an estimate of instream flow value in the Basin. While these values

[13] For examples of this literature see Section 5.2 of the Appendix.

are specific to the study area, they do not represent the value of increased instream flows for two reasons: 1) there are regulatory limitations on the amount paid for leased water, and 2) most of the water is temporarily leased to instream flows by water right holders who temporarily do not need the water (i.e., have little to no opportunity cost of leasing the water) and are leasing it so that they retain the water right for future use. For these reasons, the local basin transaction prices do not reflect the true instream flow value of the water or the cost to irrigators of fallowing land.

- **Value to irrigators in SID of water.** Depending on the method used, this is estimated at $40 to $110 per AF per year (for an average value of water to agriculture of approximately $75 per AF). This value is important, as the value of water to local agriculture is a key factor determining water sales and lease prices to environmental buyers in the project area (i.e., the marginal value of water to agriculture will determine agricultural sellers' willingness to accept a price for water), and because conserved water avoids potential future reductions in SID deliveries.

Table 3-9. Value per AF per Year of Water (Market Prices and Value to Agriculture), Deschutes Watershed, Oregon, 2018$

Type of Value	Low Value	High Value	Median Value	Average Value
Permanent Water Right Transaction in Western US, 2000 to 2009 *(Converted to Annual Values)*	~$0	$1,665	~$75	$165
Value of Water to Deschutes County Irrigators *(Income Capitalization Approach and Sales Price of Water in Ag to Ag Transfers, Converted to Annual Values)*	$40	$110	N/A	~$75

Table 3-10 shows the estimated average annual benefits of enhanced instream flow for the HDPE Piping Alternative.

Table 3-10. Annual Estimated Instream Flow Value of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Project Group	Water Conservation Under HDPE Piping Alternative (AF/year)	Instream Flow Value Under No Action	Annualized Average Net Benefits of HDPE Piping Alternative
Project Group 1	1,688	$0	$125,000
Project Group 2	2,941	$0	$190,000
Total	**4,629**	**$0**	**$315,000**

Note: Totals may not sum due to rounding. Prepared August 2018
1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent

Past Costs Paid as a Proxy for Value

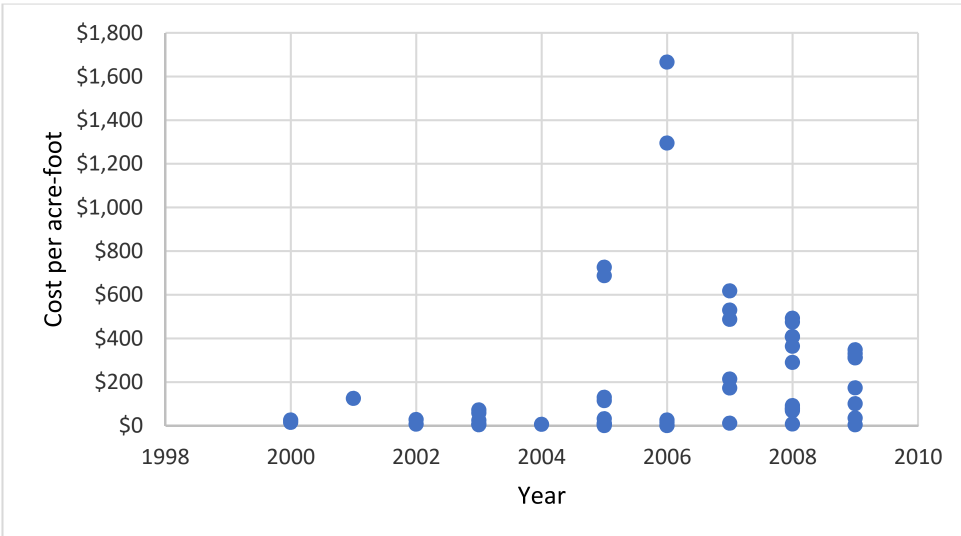
Past piping projects in the Deschutes Basin highlight the willingness of funding entities to pay for instream flow augmentation. These values are evidence of the *minimum* benefit of the instream flows purchased, as perceived and experienced by these entities. Project costs paid are indicative of the *minimum* perceived benefit as (barring very unusual circumstances) entities only pay for projects for which they believe benefits exceed costs. 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 for instream flow restoration, 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 right 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, costs of instream flow augmentation from piping projects have ranged from approximately $104,000 to approximately $342,000 per 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. As described below, this analysis relies on water rights leased and purchased for instream flow augmentation throughout the Western United States. Water right transactions typically reflect the cost to irrigated agriculture of reduced water use, rather than the full economic benefit of increased instream flow. The value of instream flow is also location-specific, but given the high level of interest and focus on ecosystem restoration in the Deschutes, it is expected that the value of instream flow in the Deschutes may be similar to other basins in the west where water rights are being acquired to restore instream flows (i.e., the willingness to pay for instream flow water may be similar in the Deschutes Basin).

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 timeframe between 1995 and 1999, six transactions of water right purchases averaged $360 per AF in Oregon, while five water right leases averaged $114 per AF per year on average. The paper also shows lease and purchase price by environmental use, including for riparian areas, for wetlands, for recreation, and for instream flow. For instream flows, the average purchase price across 18 transactions was $1,114, while across 35 lease transactions the annual price per acre foot was $68.

The Bren School of Environmental Science & 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 sector of the buyer and seller (e.g., agricultural or environmental) (Bren School of Environmental Science & Management, University of California, Santa Barbara, 2017). Figure 3-1 and Figure 3-2 below show more recent sales and leases of water rights by environmental buyers from 2000 to 2009 on a price per AF per year basis. The figures show how water right transaction values vary widely, but sale prices (amortized to an annual price) typically are less than $200 per year while 1-year leases typically fall below $800 per AF per year (with several transactions showing prices rising over a $1,000 per AF per year). Amongst 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 volume of water sold decreases the average permanent sale transaction price to $20 per AF per year.



1/Note that dollar per AF purchase prices were amortized using a 2.75 percent interest rate and a 100-year time period to derive dollar per AF per year values.

Figure 3-1. Western Water Right Purchases for Environmental Purposes, 2000 to 2009, Price Paid per AF per Year[1]

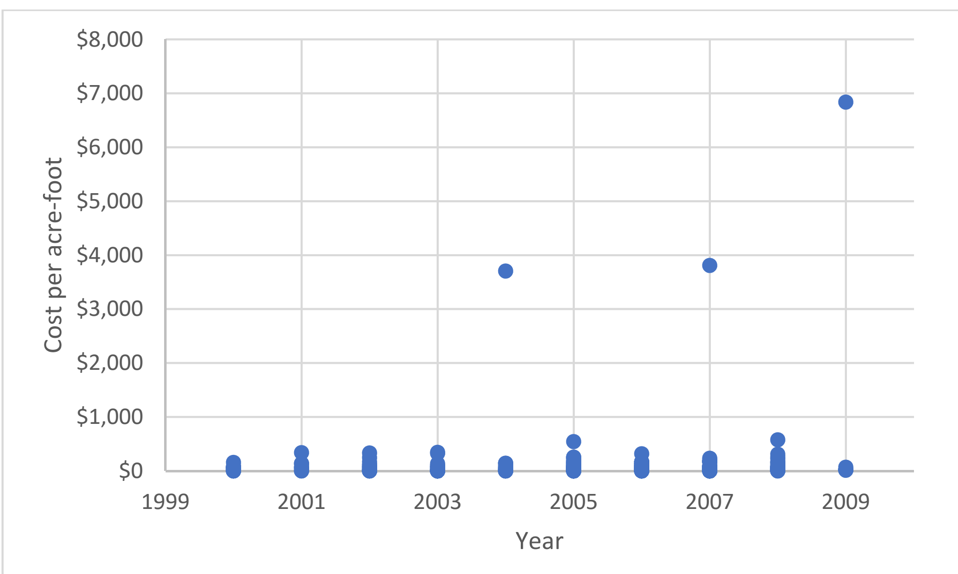


Figure 3-2: 1-Year Water Leases for Environmental Purposes, Price Paid Per AF in Western United States

Current and Potential Future Water Right Purchase Values in SID

In a neighboring irrigation district, water rights sold from one irrigator to another have typically had a purchase price between $5,000 to $7,500 per acre (Rieck, Tumalo Irrigation District Manager, 2017). These values are very similar to values provided by area real estate agents regarding the increased value of property with irrigation water rights, all else equal. Assuming approximately 4 AF per year delivered on average to acreage, this equates to approximately $1,250 to $1,875 per AF ($5,000 to $,7500 per acre divided by 4 AF per acre delivery), or a value of approximately $40 to $60 per AF per year.

Prices paid for the limited number of agricultural water right sales may not reflect the average value of water to irrigators in SID and the cost of acquiring water in the future. The value of water to irrigators in SID (i.e., the increased farm income from having access to water) is important, as it is a key determinant of the price at which irrigators would be willing to sell water rights (and the price at which environmental water buyers could obtain water from agricultural water right holders, which are the primary water right holders that could sell water rights to augment instream flows). The price paid per AF in the limited number of current SID water transactions is lower than the value derived from the effect on farm income of more reliable access to irrigation water (income capitalization approach), which indicates that if additional water were available it would raise farm income by approximately $100 per AF per year.[14]

Current water right transactions in the area trade for a lower value than derived through the income capitalization approach; this may be because some farms in the area are not commercial farms or are not farming all of their lands, and therefore derive less income from some of their water rights than commercial farms producing grass hay or other crops. This indicates that while some water may trade for the lower value of approximately $40 to $60 per AF, if instream flow buyers were to purchase water rights, then as more water rights were acquired, the cost per AF would likely rise to the level as derived through the income capitalization approach.

3.3 Benefits Considered but not Quantified for Analysis

3.3.1 Agricultural Intensification Benefit

The District's antiquated canal and laterals make it difficult to deliver the correct amount of water to patrons at the correct time, particularly early and late in the irrigation season. During these periods, the District's water rights require it to divert water at a reduced rate. At these reduced flow rates, the canals and laterals are more sensitive to small changes in streamflow at the diversion or deliveries at each point-of-delivery. The reduced flow rates in the open canal and laterals make it much more challenging for the District to deliver the sufficient amount of water that patrons need when they need it. For example, a point-of-delivery near the end of a lateral may receive no water in the morning and excess water in the evening. The District also has to pass excess water, known as carry water, to ensure that adequate water reaches all points-of-delivery when required by patrons according to their water rights. When the patrons' demand subsides, this excess water operationally

[14] This estimate is based on an analysis of the net returns to water of grass hay. An agricultural expert in the area estimated that (assuming there is not already a full water supply) an additional AF of water would increase grass hay yields by approximately 0.5 ton per acre (Bohle, 2018). Assuming that each ton of grass hay generates $200 in revenue after harvest costs are subtracted, an AF of water is worth approximately $100 to growers (Painter, 2015; NASS, 2017). However, we do not assume these yield benefits will accrue to District patrons under the HDPE Pressurized Piping Alternative.

spills onto non-productive lands at the ends of the conveyance system. Through enhanced operational flexibility and efficiency, reduced canal breaches, and keeping 25 percent of saved water from the project (approximately 1,544 AF per year) to shore up supplies, the HDPE Pressurized Piping Alternative could increase water supply reliability to District patrons. Given the limited amount of available data on current delivery and delivery capabilities after piping, although this is identified as a potential benefit that could increase agricultural yield on existing irrigated lands, it was not included in the analysis.

3.3.2 Public Safety Avoided Costs

Piping irrigation water removes the hazard of drownings in canals, and eliminates the potential for unlined canals to fail, with potential damages to downstream property and lives. While SID canal failure is very possible, the extent of damage varies depending on the amount of water in the canal, the location of failure, and the value of adjacent property (Camarata, Swalley Irrigation District General Manager & Board Secretary, 2017; Camarata, Swalley Irrigation District General Manager & Board Secretary, 2018). Given the limited amount of available data on the cost of these canal failures, this public safety (and property damage reduction) benefit of piping is not analyzed in this analysis. However, a history of recent drownings and near drowning events in Central Oregon irrigation canals provides evidence that fast moving water in irrigation canals, often with steep and slippery banks, can be a threat to public safety (Beechem, 2018) (Matsumoto, 2016). In 2004, a toddler drowned in a Central Oregon Irrigation District canal, and in 1996 and 1997, respectively, a 12-year old boy and a 28-year old man drowned in North Unit Irrigation District canals (Flowers, 2004). Other drownings may have occurred in the past, as a comprehensive list of drownings in Central Oregon irrigation canals was not available from the Bureau of Reclamation or other sources. However, the data indicate at least 3 drownings over the last 21 years (1996 through 2016), or 0.143 death per year during this time period. As the population in Central Oregon continues to grow and areas surrounding irrigation canals continue to urbanize, the risk to public safety will increase.

The HDPE Piping Alternative would pipe approximately 16.6 miles of canals at SID. This section qualitatively discusses the potential magnitude of the public safety benefit of piping the remaining exposed canals in SID. The analysis presents some information on the potential public safety hazard of the existing unlined irrigation canals (based on the recent history of drownings and the mileage of exposed canals) at SID proposed for piping.

Level of Public Safety Hazard

This analysis estimates the public safety hazard of unlined canals in SID based on past drownings in unlined canals in Central Oregon. Based on data from Oregon Water Resources Department on canals in Central Oregon, there are 1,072 miles of irrigation canals in Central Oregon districts (see Table 3-11). Starting in the late 1980s and early 1990s, sections of these canals began to be piped, with the result that today the Oregon Water Resources Department (OWRD) database records that approximately 209 miles have been piped. Assuming piping occurred uniformly across the 21-year period of 1996 to 2016, there were approximately 9.9 miles piped each year, leaving approximately 973 miles unpiped on an average annual basis during this period. Given that there was an average of 0.143 drowning death annually during this period (3 deaths over 21 years as described above), during that timeframe 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 as the population of Bend continues to grow and the areas around irrigation canals continues to urbanize (thereby increasing the risks of drownings).

Under No Action, SID would continue to have approximately 16.6 miles of unpiped canal. Assuming that the 3 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 SID carry a risk of 0.002 death per year.

Table 3-11. 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**

Note: Totals may not sum due to rounding. Prepared August 2018
Source: Oregon Water Resources Department, database maintained and provided by Jonathon LaMarche on March 9, 2017.

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5 NED Appendix

5.1 Supplementary Tables

Table 5-1. Estimated Average Annual NED Costs for HDPE Piping Alternative by Lateral, Deschutes Watershed, Oregon, 2018$

Lateral Name	Year Costs Begin [1]	Project Outlays (Installation)	Project Outlays (OM&R) [2]	Other Direct Costs [2,3]	Total [2,4]
Rogers Lateral	Varies	$81,000	$0	$1,000	$82,000
Rogers Sublateral	Varies	$4,000	$0	$0	$4,000
Riley Lateral	Varies	$27,000	$0	$0	$27,000
Riley Sublateral	Varies	$11,000	$0	$0	$11,000
Mickelson Lateral	Varies	$3,000	$3,000	$0	$6,000
Elder Lateral	Varies	$26,000	$18,000	$4,000	$48,000
Butte Lateral	Varies	$7,000	$9,000	$3,000	$19,000
Main Canal	Varies	$114,000	$31,000	$3,000	$148,000
Main Canal Pump Station	Varies	$126,000	$31,000	$2,000	$159,000
TOTAL	**N/A**	**$399,000**	**$92,000**	**$13,000**	**$504,000**

Prepared August 2018

1/ The year costs begin to be incurred differs between the type of cost. Refer to individual cost tables for the beginning year of specific costs.
2/ The total in this column differs from the total NED costs in Table 2-1 of Appendix D because it does not include those Project Groups that have a net cost savings. When the entire analysis is broken-down by lateral, these savings appear as benefits that exactly offset the additional costs shown in this table.
3/ OM&R costs include the expense of running SID and maintaining District infrastructure, increased energy costs associated with a proposed pump station, and the costs of replacing the pump station pump and the runner.
4/ Other direct costs include the uncompensated economic losses due to changes in resource use or associated with installation, operation or replacement of project structures. These include: increased pumping costs elsewhere in the basin from reduced groundwater recharge (i.e. seepage from unlined canals), an increase in carbon emissions for Elder and Mickelson lateral that is not offset by decrease in pumping, and a temporary reduction in hydropower generation.

Table 5-2. Annual Reduced Maintenance Costs to SID Patrons of HDPE Piping Alternative by Lateral, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Benefits Begin [2]	Mileage	Undiscounted Annualized Cost of No Action	Undiscounted Annualized Cost under HDPE Pressurized Piping Alternative	Undiscounted Annual Benefit	Average Annual NED Benefits (Discounted and Amortized, 2018$)
Rogers Lateral	1	3.8	$84,000	$82,000	$2,000	$2,000
Rogers Sublateral	1	0.4	$9,000	$9,000	$0	$0
Riley Lateral	3	1.4	$31,000	$30,000	$1,000	$1,000
Riley Sublateral	3	1.3	$28,000	$27,000	$1,000	$1,000
Mickelson Lateral	5	0.4	$8,000	$8,000	$0	$0
Elder Lateral	2	1.9	$42,000	$41,000	$1,000	$1,000
Butte Lateral	4	1.0	$23,000	$22,000	$1,000	$1,000
Main Canal	6	3.2	$72,000	$70,000	$2,000	$2,000
Main Canal Pump Station	7	3.2	$72,000	$70,000	$2,000	$2,000
TOTAL	**N/A**	**16.6**	**$370,000**	**$359,000**	**$10,000**	**$10,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ Changes to maintenance costs begin the year after each lateral is completed.

Table 5-3. Annual Pump Station Energy Costs of HDPE Piping Alternative by Lateral, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Costs Begin [2]	Total Annual Energy Costs Under No Action (kWh)	Annual Energy Use Under HDPE Piping (kWh)	Increased Annual Energy Use (kWh)	Undiscounted Annual Cost of Pump Station Energy	Average Annual NED Cost (Discounted and Amortized)
Rogers Lateral	1	0	0	0	$0	$0
Rogers Sublateral	1	0	0	0	$0	$0
Riley Lateral	3	0	0	0	$0	$0
Riley Sublateral	3	0	0	0	$0	$0
Mickelson Lateral	7	0	47,668	47,668	$4,000	$3,000
Elder Lateral	7	0	255,407	255,407	$20,000	$17,000
Butte Lateral	7	0	138,002	138,002	$11,000	$9,000
Main Canal	7	0	433,941	433,941	$33,000	$28,000
Main Canal Pump Station	7	0	433,941	433,941	$33,000	$28,000
TOTAL	**N/A**	**0**	**1,308,960**	**1,308,960**	**$101,000**	**$85,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ For the laterals that impact pump station energy costs, energy costs start the year the pump station is completed.

Table 5-4. Annual Operations, Maintenance, and Replacement Costs of HDPE Piping Alternative by Lateral, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Costs Begin [2]	Average Annual NED Replacement Cost (Discounted and Amortized)*	Average Annual NED Energy Cost (Discounted and Amortized)	Average Annual NED OM&R Cost
Rogers Lateral	Varies	$0	$0	$0
Rogers Sublateral	Varies	$0	$0	$0
Riley Lateral	Varies	$0	$0	$0
Riley Sublateral	Varies	$0	$0	$0
Mickelson Lateral	Varies	$0	$3,000	$3,000
Elder Lateral	Varies	$1,000	$17,000	$18,000
Butte Lateral	Varies	$0	$9,000	$9,000
Main Canal	Varies	$3,000	$28,000	$31,000
Main Canal Pump Station	Varies	$3,000	$28,000	$31,000
TOTAL	**N/A**	**$7,000**	**$85,000**	**$92,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ Maintenance costs changes (column 3) begin according to the timeline in Table 5-2. Replacement costs (column 3) are incurred according to the schedule described in Appendix D Section 3.2.2. Energy costs (column 4) begin to change according to the timeline in Table 5-3.
* When OM&R costs are expected to decrease due to the HDPE Piping Alternative, they are shown as benefits in Table 5-7 below.

Table 5-5. Other Direct Costs of Reduced Recharge under HDPE Piping Alternative, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Costs Begin [2]	Water Conservation (cfs)	Water Conservation (AF/Year)	Change in Groundwater Depth (ft/year)	Annual Average NED Cost
Rogers Lateral	1	3.2	1,028.6	0.003	$1,000
Rogers Sublateral	1	0.2	64.3	0.000	$0
Riley Lateral	3	0.7	225.0	0.001	$0
Riley Sublateral	3	0.3	96.4	0.000	$0
Mickelson Lateral	5	0.0	0.0	0.000	$0
Elder Lateral	2	2.6	835.7	0.002	$1,000
Butte Lateral	4	0.2	64.3	0.000	$0
Main Canal	6	6.0	1,928.6	0.005	$2,000
Main Canal Pump Station	7	6.0	1,928.6	0.005	$2,000
TOTAL	**N/A**	**19.2**	**6,172**	**0.016**	**$6,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ Increased energy costs begin to change after each lateral is completed.

Table 5-6. Annual Hydropower Generation Costs of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Costs Begin [2]	Year Costs End [3]	Total Annual Energy Generation Under No Action (kWh)	Annual Energy Generation Under HDPE Piping (prior to runner installation)	Reduced Annual Energy Generation (prior to runner installation) (kWh)	Undiscounted Annual Cost of Lost Hydropower Generation (prior to runner installation) (2018$)	Average Annual NED Cost (Discounted and Amortized, 2018$)
Rogers Lateral	N/A	N/A	0	0	0	$0	$0
Rogers Sublateral	N/A	N/A	0	0	0	$0	$0
Riley Lateral	N/A	N/A	0	0	0	$0	$0
Riley Sublateral	N/A	N/A	161,466	161,466	0	$0	$0
Mickelson Lateral	N/A	N/A	462,452	462,452	0	$0	$0
Elder Lateral	2	8	79,068	11,143	67,925	$5,000	$1,000
Butte Lateral	4	8	205,654	199,185	6,469	$0	$0
Main Canal	6	8	209,475	54,217	155,258	$12,000	$1,000
Main Canal Pump Station	7	8	1,421,257	1,265,999	155,258	$12,000	$0
TOTAL	**N/A**	**N/A**	**2,539,372**	**2,154,462**	**384,910**	**$29,000**	**$2,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent　　Prepared August 2018
2/ For those laterals that impact hydropower energy use, changes to costs begin after the lateral is constructed.
3/ Changes to hydropower costs end after the runner is constructed and pre-project hydropower production is restored.

Table 5-7. Estimated Average Annual Watershed Protection Damage Reduction Benefits of HDPE Pressurized Piping Alternative for Swalley Irrigation District 2017 Watershed Plan, Deschutes Watershed, Oregon, 2018$ [1]

Damage Reductions Categories	Agricultural Benefit Swalley ID Patrons/ Surrounding Community	Non-Agricultural Benefit	Total
Rogers Lateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$2,000		$2,000
Pumping Cost Savings	$100,000		$100,000
Onsite Subtotal	$102,000		$102,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$13,000	$13,000
Fish and Wildlife Habitat / Instream Flows		$58,000	$58,000
Offsite Quantified Subtotal		$71,000	$71,000
Total Quantified Benefits	**$102,000**	**$71,000**	**$173,000**
Rogers Sublateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$0		$0
Pumping Cost Savings	$6,000		$6,000
Onsite subtotal	$6,000		$6,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$2,000	$2,000
Fish and Wildlife Habitat / Instream Flows		$4,000	$4,000
Offsite Quantified Subtotal		$6,000	$6,000
Total Quantified Benefits	**$6,000**	**$6,000**	**$12,000**
Riley Lateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$1,000		$1,000
Pumping Cost Savings	$6,000		$6,000
Onsite subtotal	$7,000		$7,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$2,000	$2,000
Fish and Wildlife Habitat / Instream Flow		$12,000	$12,000
Offsite Quantified Subtotal		$14,000	$14,000
Total Quantified Benefits	**$7,000**	**$14,000**	**$21,000**

Damage Reductions Categories	Agricultural Benefit Swalley ID Patrons/ Surrounding Community	Non-Agricultural Benefit	Total
Riley Sublateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$1,000		$1,000
Pumping Cost Savings	$4,000		$4,000
Onsite subtotal	$5,000		$5,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$2,000	$2,000
Fish and Wildlife Habitat / Instream Flows		$5,000	$5,000
Offsite Quantified Subtotal		$7,000	$7,000
Total Quantified Benefits	**$5,000**	**$7,000**	**$12,000**
Mickelson Lateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$0		$0
Pumping Cost Savings	$17,000		$17,000
Onsite subtotal	$17,000		$17,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$3,000	$3,000
Fish and Wildlife Habitat / Instream Flows		$0	$0
Offsite Quantified Subtotal		$3,000	$3,000
Total Quantified Benefits	**$17,000**	**$3,000**	**$20,000**
Elder Lateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$1,000		$1,000
Pumping Cost Savings	$55,000		$55,000
Onsite subtotal	$56,000		$56,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$0	$0
Fish and Wildlife Habitat / Instream Flows		$46,000	$46,000
Offsite Quantified Subtotal		$46,000	$46,000
Total Quantified Benefits	**$56,000**	**$46,000**	**$102,000**
Butte Lateral			
On-Site Damage Reduction Benefits			
Reduced OM&R	$1,000		$1,000

Damage Reductions Categories	Agricultural Benefit Swalley ID Patrons/ Surrounding Community	Non-Agricultural Benefit	Total
Pumping Cost Savings	$13,000		$13,000
Onsite subtotal	$14,000		$14,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$0	$0
Fish and Wildlife Habitat / Instream Flows		$3,000	$3,000
Offsite Quantified Subtotal		$3,000	$3,000
Total Quantified Benefits	**$14,000**	**$3,000**	**$17,000**
Main Canal			
On-Site Damage Reduction Benefits			
Reduced OM&R	$2,000		$2,000
Pumping Cost Savings	$119,000		$119,000
Onsite subtotal	$121,000		$121,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$1,000	$1,000
Fish and Wildlife Habitat / Instream Flows		$95,000	$95,000
Offsite Quantified Subtotal		$96,000	$96,000
Total Quantified Benefits	**$121,000**	**$96,000**	**$217,000**
Main Canal Pump Station			
On-Site Damage Reduction Benefits			
Reduced OM&R	$2,000		$2,000
Pumping Cost Savings	$90,000		$90,000
Onsite subtotal	$92,000		$92,000
Off-Site Damage Reduction Benefits			
Social Value of Carbon (Avoided Carbon Emissions)[2]		$13,000	$13,000
Fish and Wildlife Habitat / Instream Flows		$92,000	$92,000
Offsite Quantified Subtotal		$105,000	$105,000
Total Quantified Benefits	**$92,000**	**$105,000**	**$197,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent
2/ Indicates the benefit of avoided carbon emissions. These benefits would also accrue to local residents, but the majority of the value would be experienced outside the proposed project area.

Table 5-8. Comparison of Average Annual NED Benefits and Costs Under the HDPE Piping Alternative, Deschutes Watershed, Oregon, 2018$ [1]

Works of Improvement	Agriculture-related		Nonagricultural		Average Annual Benefits	Average Annual Cost[2]	Benefit cost ratio
	Reduced OM&R	Pumping Cost Savings	Carbon Value	Instream Flow Value			
Rogers Lateral	$2,000	$100,000	$13,000	$58,000	$173,000	$82,000	2.11
Rogers Sublateral	$0	$6,000	$2,000	$4,000	$12,000	$4,000	3.00
Riley Lateral	$1,000	$6,000	$2,000	$12,000	$21,000	$27,000	0.78
Riley Sublateral	$1,000	$4,000	$2,000	$5,000	$12,000	$11,000	1.09
Mickelson Lateral	$0	$17,000	$3,000	$0	$20,000	$6,000	3.33
Elder Lateral	$1,000	$55,000	$0	$46,000	$102,000	$48,000	2.13
Butte Lateral	$1,000	$13,000	$0	$3,000	$17,000	$19,000	0.89
Main Canal	$2,000	$119,000	$1,000	$95,000	$217,000	$148,000	1.47
Main Canal Pump Station	$2,000	$90,000	$13,000	$92,000	$197,000	$159,000	1.24
TOTAL	**$10,000**	**$410,000**	**$36,000**	**$315,000**	**$771,000**	**$504,000**	**1.53**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent
Prepared August 2018
2/ From Table 5-1

Table 5-9. Estimated Cost Savings from Eliminated Irrigation Pumps under the HDPE Piping Alternative by Lateral, Deschutes Watershed, Oregon, 2018$ [1]

Project Group	Year Benefit Begins [2]	Pumps in Use Under No Action	Pumps Eliminated Under Piping Alternative	Annual Service Charges Avoided by Piping Alternative	Average Annual Avoided Cost Under Piping Alternative
Rogers Lateral	1	155	109	$69,000	$69,000
Rogers Sublateral	1	30	0	$0	$0
Riley Lateral	3	41	0	$0	$0
Riley Sublateral	3	12	0	$0	$0
Mickelson Lateral	7	9	9	$6,000	$5,000
Elder Lateral	7	84	59	$37,000	$31,000
Butte Lateral	7	17	15	$10,000	$8,000
Main Canal	7	166	141	$90,000	$76,000
Main Canal Pump Station	7	41	36	$23,000	$20,000
Total	**N/A**	**555**	**369**	**$235,000**	**$209,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018

2/ Irrigation pumps will be eliminated after each lateral receives pressurization. For Rogers and Riley (and their sublaterals), this begins after each lateral is constructed. For Michelson, Elder, Butte, Main Canal, and Main Canal Pump Station, pressurization occurs after the construction of the pump station is complete.

Table 5-10. Annual Increased Average Energy Cost Savings to SID Patrons of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Benefits Begin [3]	Total Annual Energy Use Under No Action (kWh)	Annual Energy Use Under HDPE Piping	Reduced Annual Energy Use (kWh)[2]	Undiscounted Annual Energy Cost Savings (2018$)
Rogers Lateral	1	458,037	137,411	320,626	$31,000
Rogers Sublateral	1	96,794	38,718	58,076	$6,000
Riley Lateral	3	229,842	172,382	57,460	$6,000
Riley Sublateral	3	113,447	68,068	45,379	$4,000
Mickelson Lateral	7	142,936	0	142,936	$14,000
Elder Lateral	7	409,380	122,814	286,566	$28,000
Butte Lateral	7	69,994	6,999	62,995	$6,000
Main Canal	7	629,074	94,361	534,713	$51,000
Main Canal Pump Station	7	996,562	139,875	856,687	$82,000
TOTAL	**N/A**	**3,146,066**	**780,628**	**2,365,438**	**$228,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ As estimated by Black Rock Consulting in the SID System Improvement Plan, 2017.
3/ Energy cost savings begin after each lateral receives pressurization. For Rogers and Riley (and their sublaterals), this begins after each lateral is constructed. For Michelson, Elder, Butte, Main Canal, and Main Canal Pump Station, pressurization occurs after the construction of the pump station is complete.

Table 5-11. Annual Average Carbon Emission Changes (Metric Tons) by Project Group, Deschutes Watershed, Oregon

Lateral Name	Year Benefits or Cost Begin [2]	Annual Avoided Emissions from Reduced SID Patron Energy Use (Metric Tons Carbon)	Average Annual Increased Emissions from Reduced Groundwater Recharge (Metric Tons Carbon) [1]	Average Annual Increased Emissions from Reduced Hydropower (prior to runner installation) (Metric Tons Carbon)	Average Annual Increased Emissions from District Pumping (Metric Tons Carbon)	Net Average Emissions Reduction (prior to runner installation)	Net Average Emissions Reduction (after runner installation)
Rogers Lateral	Varies	241	42	0	0	199	199
Rogers Sublateral	Varies	44	3	0	0	41	41
Riley Lateral	Varies	43	10	0	0	34	34
Riley Sublateral	Varies	34	4	0	0	30	30
Mickelson Lateral	Varies	108	0	0	36	72	72
Elder Lateral	Varies	216	35	51	192	-63	-12
Butte Lateral	Varies	47	3	5	104	-64	-59
Main Canal	Varies	402	90	117	327	-131	-14
Main Canal Pump Station	Varies	645	92	117	327	109	226
TOTAL	**N/A**	**1,780**	**279**	**290**	**985**	**227**	**517**

Prepared August 2018

1/Additional energy use elsewhere rises through time as the effects of reduced recharge accumulate and cause groundwater depths to drop over time. The average annual energy use increase elsewhere in the basin represents the average change in energy use across the 100 project years for each Project Group.

2/ The timing of changes in carbon emissions differs depending on the source of carbon. Avoided emissions from energy use (column 3) begin to change according to the timeline in Table 5-10. Increased emissions from reduced groundwater recharge (column 4) begin to change according to the timeline in Table 5-5. Increased emissions from reduced hydropower (column 5) change according to the timeline in Table 5-6. Increased emissions from District Pumping (column 6) begin to change according to the timeline in Table 5-3.

Table 5-12. Annual Average Carbon Emissions (Metric Tons) by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Benefits or Cost Begin[2]	No Action		HDPE Pressurized Piping Alternative (NED Alternative)			Net Carbon		Average Annual NED Benefits[4]
		Average Annual Carbon Emissions, Basinwide Energy Use	Annual Carbon Emissions, SID Energy Use	Average Annual Carbon Emissions, Basinwide Energy Use	Annual Carbon Emissions, SID Energy Use (prior to runner installation)	Annual Carbon Emissions, SID Energy Use (after runner installation)	Net Annual Carbon Reduction Prior to Runner Installation	Net Annual Carbon Reduction After Runner Installation	
Rogers Lateral	Varies	N/A	345	N/A	146	146	199	199	$13,000
Rogers Sublateral	Varies	N/A	73	N/A	32	32	41	41	$2,000
Riley Lateral	Varies	N/A	173	N/A	139	139	34	34	$2,000
Riley Sublateral	Varies	N/A	85	N/A	55	55	30	30	$2,000
Mickelson Lateral	Varies	N/A	108	N/A	36	36	72	72	$3,000
Elder Lateral	Varies	N/A	308	N/A	371	320	-63	-12	-$2,000
Butte Lateral	Varies	N/A	53	N/A	117	112	-64	-59	-$3,000
Main Canal	Varies	N/A	473	N/A	604	487	-131	-14	$1,000
Main Canal Pump Station	Varies	N/A	750	N/A	641	524	109	226	$13,000
TOTAL	**N/A**	**92,879[3]**	**2,367**	**96,879**	**2,141**	**1,851**	**227**	**517**	**$31,000[5]**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018

2/ See footnote in Table 5-11 for an explanation of the timing of carbon changes.

3/ Note this values rises from 27,920 in Year 1 to 245,162 in Year 106. The average value is 92,879. Carbon emissions rise over time because groundwater pumping volume increases throughout the basin through time, and the depth to groundwater also rises through time due to reduced recharge from canals.

4/ Note that the average annual NED benefits differs from the change in tons of carbon emitted multiplied by the $43 value per metric ton of carbon. The increased emissions rise through time (and are thus highest at later time periods when the values are most discounted, while the decreased carbon emissions are the same through time).

5/ Note that the $31,000 presented is $5,000 less than the $36,000 presented elsewhere in the document. That is because Elder and Butte laterals have a negative benefit, therefore they were included under costs rather than benefits.

Table 5-13. Annual Estimated Instream Flow Value of HDPE Piping Alternative by Project Group, Deschutes Watershed, Oregon, 2018$ [1]

Lateral Name	Year Benefits or Cost Begin[2]	Water Conservation Under HDPE Pressurized Piping Alternative (AF/year)	Instream Flow Value Under No Action	Annualized Average Net Benefits of HDPE Pressurized Piping Alternative
Rogers Lateral	1	771	$0	$58,000
Rogers Sublateral	1	48	$0	$4,000
Riley Lateral	3	169	$0	$12,000
Riley Sublateral	3	72	$0	$5,000
Mickelson Lateral	5	0	$0	$0
Elder Lateral	2	627	$0	$46,000
Butte Lateral	4	48	$0	$3,000
Main Canal	6	1,446	$0	$95,000
Main Canal Pump Station	7	1,446	$0	$92,000
TOTAL	**N/A**	**4,629**	**$0**	**$315,000**

1/ Price base: 2018 dollars amortized over 100 years at a discount rate of 2.75 percent Prepared August 2018
2/ Benefits from instream flow begin the year after each lateral is constructed.

5.2 Literature on Fish Values

Table 5-14. Studies Examining Fish Values in the Western U.S.

Study Authors	Year of Data	Type of Analysis	Values	Value (2018$)	Value Description
Bell, Huppert, and Johnson	2003	Contingent Valuation	$24 - $122	$35 - $175	Annual WTP per household to either increase salmon population by 100% or enough that it would be protected from extinction (in WA and OR)
Richardson & Loomis	2006	Meta-analysis	$43 - $121	$53 - $149	Annual WTP per household that never fishes to increase population 100% or to increase population 600% (WA and U.S.)
Layton, Brown, and Plummer	1998	Discrete Choice Conjoint Analysis	$119 - $250	$181 - $380	Marginal value to anglers of an additional steelhead caught in OR
Alexander	1989	Random utility	$10 - $16	$20 - $31	Marginal value to anglers of an additional steelhead caught in OR
Loomis	2004	Contingent Valuation	$36 - $149	$47 - $196	Mean net WTP per angler-day (Snake River in ID and WY)
Johnson & Adams	1987	Contingent Valuation	$2 - $14	$5 - $30	Marginal WTP to increase summer flows by one AF in order to increase steelhead populations, or increase populations by 33 - 100% (OR)
ECONorthwest	2007	Contingent Valuation / Travel Cost	$34 - $320	$40 - $383	Sport angler WTP per fish (OR)
Dalton, Bastian, Jacobs, & Wesche	1998	Contingent Valuation	$64 - $227	$97 - $345	Angler consumer surplus per day for an unidentified increase trout population or doubling the change of catching a large trout (WY)

D.2 Engineering

This appendix section presents the System Improvement Plan.

Swalley IRRIGATION DISTRICT

System Improvement Plan

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Executive Summary

This study was commissioned by Farmers Conservation Alliance with support from Energy Trust of Oregon. The purpose of this System Improvement Plan (SIP) was to develop a well-considered evaluation of the District's primary and secondary canal systems, a mitigation plan for the seepage losses, and consideration of resulting pressurized deliveries. System piping was the primary method proposed for such mitigation.

In August and September of 2016, two meetings were held with District staff to confirm approach on the SIP. Data requests were fulfilled by the District. The District also determined that it planned to provide patron delivery pressurization where possible. The District determined that a value of 7 GPM/Acre should be used for hydraulic modeling and pipe sizing purposes. Lastly, that the cost estimating resulting from the SIP should provide District flexibility, therefore should provide lateral by lateral seepage loss and cost of mitigation (through piping) information.

The District's approximate 4,333 acres (excluding banked acres) are served by one primary diversion and canal and with approximately 328 of those acres being served directly from Deschutes River withdrawals. The primary canal and laterals were evaluated for seepage loss using state-of-the-art measurement equipment and it was found that approximately 20.1 CFS were being lost at the time of measurements. Of the 20.1 CFS, it was determined that approximately 16 CFS (Table 1.1, page 4) might be conserved if the system were completely piped (assuming certificated peak flows of 7.64 GPM/Acre delivered). See Section 3.3 (page 17) and Appendix A (page 54) for further details.

The District chose to consider pressurization to patron deliveries as it rolls-out its System Improvement Plan. To accomplish this in the north area of the District, future hydroelectric power plant modification or the installation of a pump station downstream of the hydroelectric power plant would be required. This was the assumed method for the purposes of this SIP. Given this approach, fully piping the District system will accomplish significant pressurization of the District resulting in the estimated reduction of 2.45gWh in patron pumping costs each season. The addition of pumping will require an estimated 1.3gWh each season for a net potential 1.15gW of savings (see Section 4.2, page 22). No pressure reducing valves except for the existing hydroelectric power plant were found to be necessary.

A Pipe manufacturer/vendor was contacted to provide budgetary pipe cost information for pipe delivered to Central Oregon. This information was used to develop reconnaissance-level cost estimates to design and construct the entire piped system to all patron and private delivery points. The cost estimates were evaluated and broken into lateral-by-lateral cost elements. An At-A-Glance Map and Summary Table are provided below indicating the summary results of this System Improvement Plan.

D.3 Capital Cost for the Preferred Alternative

This appendix section presents dimensions and capital costs for the Preferred Alternative, the HDPE Piping Alternative.

HDPE Piping Alternative

Project Group	Name	Feature	Diameter (in)	Length (ft)	Turnout Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	ROGERS	PIPE	30	2,559	NA	LF	$119	$303,651	8%	12%	30%	$24,292	$36,438	$109,314	$473,695
1	ROGERS	PIPE	24	4,728	NA	LF	$75	$355,356	8%	12%	30%	$28,429	$42,643	$127,928	$554,356
1	ROGERS	PIPE	20	3,902	NA	LF	$54	$209,693	8%	12%	30%	$16,775	$25,163	$75,490	$327,122
1	ROGERS	PIPE	18	1,340	NA	LF	$54	$72,789	8%	12%	30%	$5,823	$8,735	$26,204	$113,551
1	ROGERS	PIPE	16	1,927	NA	LF	$43	$81,898	8%	12%	30%	$6,552	$9,828	$29,483	$127,760
1	ROGERS	PIPE	14	1,120	NA	LF	$34	$38,282	8%	12%	30%	$3,063	$4,594	$13,781	$59,719
1	ROGERS	PIPE	12	435	NA	LF	$33	$14,303	8%	12%	30%	$1,144	$1,716	$5,149	$22,312
1	ROGERS	PIPE	12	2,372	NA	LF	$32	$76,900	8%	12%	30%	$6,152	$9,228	$27,684	$119,964
1	ROGERS	PIPE	10	1,509	NA	LF	$25	$37,514	8%	12%	30%	$3,001	$4,502	$13,505	$58,521
1	ROGERS	TURNOUT	1	NA	49	EA	$8,000	$392,000	8%	12%	30%	$31,360	$47,040	$141,120	$611,520
1	ROGERS-SUB	PIPE	10	1,313	NA	LF	$19	$24,422	10%	15%	30%	$2,442	$3,663	$9,158	$39,685
1	ROGERS-SUB	PIPE	8	922	NA	LF	$13	$12,207	10%	15%	30%	$1,221	$1,831	$4,578	$19,837
1	ROGERS-SUB	TURNOUT	1	NA	4	EA	$8,000	$32,000	10%	15%	30%	$3,200	$4,800	$12,000	$52,000
1	RILEY	PIPE	20	2,449	NA	LF	$55	$135,038	12%	15%	30%	$16,205	$20,256	$51,449	$222,948
1	RILEY	PIPE	16	1,113	NA	LF	$36	$40,313	12%	15%	30%	$4,838	$6,047	$15,359	$66,557
1	RILEY	PIPE	14	2,972	NA	LF	$29	$86,664	12%	15%	30%	$10,400	$13,000	$33,019	$143,081
1	RILEY	PIPE	12	738	NA	LF	$25	$18,302	12%	15%	30%	$2,196	$2,745	$6,973	$30,217

Project Group	Name	Feature	Diameter (in)	Length (ft)	Turnout Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	RILEY	TURNOUT	1	NA	30	EA	$8,000	$240,000	12%	15%	30%	$28,800	$36,000	$91,440	$396,240
1	RILEY-SUB	PIPE	12	4,994	NA	LF	$22	$111,866	12%	15%	30%	$13,424	$16,780	$42,621	$184,690
1	RILEY-SUB	PIPE	8	1,629	NA	LF	$13	$20,916	12%	15%	30%	$2,510	$3,137	$7,969	$34,533
1	RILEY-SUB	TURNOUT	1	NA	11	EA	$8,000	$88,000	12%	15%	30%	$10,560	$13,200	$33,528	$145,288
1	ELDER	PIPE	18	4,305	NA	LF	$43	$186,665	8%	12%	30%	$14,933	$22,400	$67,199	$291,197
1	ELDER	PIPE	16	1,183	NA	LF	$36	$42,446	8%	12%	30%	$3,396	$5,094	$15,281	$66,216
1	ELDER	PIPE	14	1,530	NA	LF	$28	$42,136	8%	12%	30%	$3,371	$5,056	$15,169	$65,732
1	ELDER	PIPE	12	604	NA	LF	$26	$15,716	8%	12%	30%	$1,257	$1,886	$5,658	$24,517
1	ELDER	PIPE	10	882	NA	LF	$18	$16,176	8%	12%	30%	$1,294	$1,941	$5,823	$25,234
1	ELDER	PIPE	8	1,553	NA	LF	$13	$20,251	8%	12%	30%	$1,620	$2,430	$7,290	$31,592
1	ELDER	TURNOUT	1	NA	25	EA	$8,000	$200,000	8%	12%	30%	$16,000	$24,000	$72,000	$312,000
2	MICKELSON	PIPE	10	1,877	NA	LF	$20	$38,403	15%	18%	30%	$5,761	$6,913	$15,323	$66,400
2	MICKELSON	TURNOUT	1	NA	2	EA	$8,000	$16,000	15%	18%	30%	$2,400	$2,880	$6,384	$27,664
2	BUTTE	PIPE	8	4,378	NA	LF	$13	$57,089	12%	15%	30%	$6,851	$8,563	$21,751	$94,254
2	BUTTE	PIPE	8	1,056	NA	LF	$15	$15,650	12%	15%	30%	$1,878	$2,347	$5,963	$25,838
2	BUTTE	TURNOUT	1	NA	8	EA	$8,000	$64,000	12%	15%	30%	$7,680	$9,600	$24,384	$105,664
2	MAIN	PIPE	48	2,094	NA	LF	$307	$643,863	6%	12%	30%	$38,632	$77,264	$227,928	$987,686
2	MAIN	PIPE	42	4,560	NA	LF	$252	$1,148,755	6%	12%	30%	$68,925	$137,851	$406,659	$1,762,190
2	MAIN	PIPE	36	6,709	NA	LF	$170	$1,138,249	6%	12%	30%	$68,295	$136,590	$402,940	$1,746,074

Project Group	Name	Feature	Diameter (in)	Length (ft)	Turnout Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
2	MAIN	PIPE	34	1,933	NA	LF	$151	$291,612	6%	12%	30%	$17,497	$34,993	$103,231	$447,333
2	MAIN	PIPE	32	831	NA	LF	$133	$110,357	6%	12%	30%	$6,621	$13,243	$39,066	$169,287
2	MAIN	PIPE	28	3,086	NA	LF	$104	$319,956	6%	12%	30%	$19,197	$38,395	$113,265	$490,813
2	MAIN	PIPE	28	1,665	NA	LF	$127	$210,722	6%	12%	30%	$12,643	$25,287	$74,596	$323,248
2	MAIN	PIPE	26	2,746	NA	LF	$110	$302,719	6%	12%	30%	$18,163	$36,326	$107,163	$464,371
2	MAIN	PIPE	24	2,534	NA	LF	$93	$235,510	6%	12%	30%	$14,131	$28,261	$83,371	$361,272
2	MAIN	PIPE	20	1,283	NA	LF	$66	$84,858	6%	12%	30%	$5,091	$10,183	$30,040	$130,172
2	MAIN	PIPE	18	344	NA	LF	$59	$20,447	6%	12%	30%	$1,227	$2,454	$7,238	$31,366
2	MAIN	PIPE	18	320	NA	LF	$51	$16,390	6%	12%	30%	$983	$1,967	$5,802	$25,143
2	MAIN	PIPE	16	3,039	NA	LF	$71	$215,951	6%	12%	30%	$12,957	$25,914	$76,447	$331,269
2	MAIN	PIPE	14	1,566	NA	LF	$39	$61,826	6%	12%	30%	$3,710	$7,419	$21,886	$94,841
2	MAIN	PIPE	12	66	NA	LF	$91	$6,021	6%	12%	30%	$361	$722	$2,131	$9,235
2	MAIN	PIPE	10	872	NA	LF	$17	$15,208	6%	12%	30%	$912	$1,825	$5,384	$23,329
2	MAIN	PIPE	8	526	NA	LF	$21	$11,141	6%	12%	30%	$668	$1,337	$3,944	$17,090
2	MAIN	TURNOUT	1	NA	49	EA	$8,000	$392,000	6%	12%	30%	$23,520	$47,040	$138,768	$601,328
2	Pump Station	Mobilization	NA	NA	NA	1	$20,000	$20,655	12%	18%	30%	$2,479	$3,718	$6,196	$33,048
2	Pump Station	Civil Works	NA	NA	NA	1	$100,000	$103,275	12%	18%	30%	$12,393	$18,589	$30,982	$165,240
2	Pump Station	Pump/Motor	NA	NA	NA	1	$54,502	$55,113	12%	18%	15%	$6,614	$9,920	$8,267	$79,914
2	Pump Station	Controls	NA	NA	NA	1	$35,000	$36,146	12%	18%	30%	$4,338	$6,506	$10,844	$57,834

Project Group	Name	Feature	Diameter (in)	Length (ft)	Turnout Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
2	Pump Station	Electrical	NA	NA	NA	1	$75,000	$77,456	12%	18%	30%	$9,295	$13,942	$23,237	$123,930
2	Pump Station	Building	NA	NA	NA	1	$30,000	$30,982	12%	18%	30%	$3,718	$5,577	$9,295	$49,572
Total Capital Cost of All Project Groups															**$13,465,491** [1]

Note: [1] $13,468,000 is presented elsewhere in the document due to rounding.

D.4 Capital Costs for the Eliminated Alternatives

This appendix section presents dimensions and capital costs for the eliminated alternatives, which includes canal lining, PVC piping, steel piping and partial groundwater use.

Canal Lining Alternative

Project Group	Name	Feature	Length (ft)	Turnout Quantity	Channel perimeter (ft)	Turnout Cost	Geotextile Costs	Geotextile overlap costs	Shotcrete Costs	Fence Costs	Ladder Costs	Constr factor	Subtotal Cost	Engineering, CM, Survey	CMGC	Contingency	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	Elder	Channel	10,056	NA	16.00	NA	$239,294	$957	$884,693	$137,964	$0	1.5	$1,894,363	8%	12%	30%	$151,549	$227,324	$681,971	$2,955,206
1	Elder	Turnout	NA	25	NA	$25,000	NA	NA	NA	NA	NA	1.5	$37,500	8%	12%	30%	$3,000	$4,500	$13,500	$58,500
1	Riley	Channel	5,350	NA	17.48	NA	$134,040	$536	$514,211	$73,403	$0	1.5	$1,083,285	12%	15%	30%	$129,994	$162,493	$412,732	$1,788,504
1	Riley Sublateral	Channel	5,598	NA	16.42	NA	$135,230	$541	$505,552	$76,804	$0	1.5	$1,077,190	12%	15%	30%	$129,263	$161,578	$410,409	$1,778,441
1	Riley Sublateral	Turnout	NA	11	NA	$11,000	NA	NA	NA	NA	NA	1.5	$16,500	12%	15%	30%	$1,980	$2,475	$6,287	$27,242
1	Riley turnouts	Turnout	NA	30	NA	$30,000	NA	NA	NA	NA	NA	1.5	$45,000	12%	15%	30%	$5,400	$6,750	$17,145	$74,295
1	Rogers North	Channel	9,372	NA	16.83	NA	$229,694	$919	$867,704	$128,584	$0	1.5	$1,840,351	8%	12%	30%	$147,228	$220,842	$662,526	$2,870,947
1	Rogers South	Channel	6,466	NA	23.43	NA	$194,737	$779	$833,309	$88,714	$4,311	1.5	$1,682,775	8%	12%	30%	$134,622	$201,933	$605,799	$2,625,129
1	Rogers Sublateral	Channel	2,056	NA	11.44	NA	$40,966	$164	$129,366	$28,211	$0	1.5	$298,060	10%	15%	30%	$29,806	$44,709	$111,773	$484,348
1	Rogers Sublateral	Turnout	NA	4	NA	$4,000	NA	NA	NA	NA	NA	1.5	$6,000	10%	15%	30%	$600	$900	$2,250	$9,750
1	Rogers	Turnout	NA	49	NA	$49,000	NA	NA	NA	NA	NA	1.5	$73,500	8%	12%	30%	$5,880	$8,820	$26,460	$114,660
2	Butte	Channel	5,433	NA	15.47	NA	$126,858	$507	$462,253	$74,544	$0	1.5	$996,245	12%	15%	30%	$119,549	$149,437	$379,569	$1,644,800
2	Butte	Turnout	NA	8	NA	$8,000	NA	NA	NA	NA	NA	1.5	$12,000	12%	15%	30%	$1,440	$1,800	$4,572	$19,812
2	Main Canal north of Mickelson	Channel	6,388	NA	20.62	NA	$187,990	$752	$724,531	$87,643	$0	1.5	$1,501,375	6%	12%	30%	$90,083	$180,165	$531,487	$2,303,109
2	Main Canal south of Mickelson	Channel	27,782	NA	28.50	NA	$1,003,625	$4,014	$4,354,829	$381,169	$18,521	1.5	$8,643,237	6%	12%	30%	$518,594	$1,037,188	$3,059,706	$13,258,726
2	Main	Turnout	NA	49	NA	$49,000	NA	NA	NA	NA	NA	1.5	$73,500	6%	12%	30%	$4,410	$8,820	$26,019	$112,749
2	Mickelson	Channel	1,882	NA	18.19	NA	$48,285	$193	$188,246	$25,816	$1,254	1.5	$395,691	15%	18%	30%	$59,354	$71,224	$157,881	$684,149

Project Group	Name	Feature	Length (ft)	Turnout Quantity	Channel perimeter (ft)	Turnout Cost	Geotextile Costs	Geotextile overlap costs	Shotcrete Costs	Fence Costs	Ladder Costs	Constr factor	Subtotal Cost	Engineering, CM, Survey	CMGC	Contingency	Engineering, CM, Survey	CMGC	Contingency	Total Cost
2	Mickelson	Turnout	NA	2	NA	$2,000	NA	NA	NA	NA	NA	1.5	$3,000	15%	18%	30%	$450	$540	$1,197	$5,187
Total Capital Cost of All Project Groups																				**$30,815,554**

Steel Piping Alternative

Project Group	Name	Feature	Dia. (in)	Length (ft)	Turnout/Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	ELDER	PIPE	18	4,305	43	LF	$122	$569,693	8%	12%	30%	$45,575	$68,363	$205,089	$888,720
1	ELDER	PIPE	16	1,183	12	LF	$109	$140,243	8%	12%	30%	$11,219	$16,829	$50,488	$218,779
1	ELDER	PIPE	14	1,530	15	LF	$95	$160,290	8%	12%	30%	$12,823	$19,235	$57,704	$250,053
1	ELDER	PIPE	12	604	6	LF	$81	$54,952	8%	12%	30%	$4,396	$6,594	$19,783	$85,726
1	ELDER	PIPE	10	882	9	LF	$67	$68,088	8%	12%	30%	$5,447	$8,171	$24,512	$106,217
1	ELDER	PIPE	8	1,553	16	LF	$53	$98,480	8%	12%	30%	$7,878	$11,818	$35,453	$153,629
1	ELDER	TURNOUT	1	NA	25	EA	$8,000	$200,000	8%	12%	30%	$16,000	$24,000	$72,000	$312,000
1	RILEY	PIPE	20	2,449	24	LF	$136	$357,840	12%	15%	30%	$42,941	$53,676	$136,337	$590,794
1	RILEY	PIPE	16	1,113	11	LF	$109	$131,945	12%	15%	30%	$15,833	$19,792	$50,271	$217,841
1	RILEY	PIPE	14	2,972	30	LF	$95	$311,361	12%	15%	30%	$37,363	$46,704	$118,629	$514,057
1	RILEY	PIPE	12	738	7	LF	$81	$67,144	12%	15%	30%	$8,057	$10,072	$25,582	$110,855
1	RILEY	TURNOUT	1	NA	30	EA	$8,000	$240,000	12%	15%	30%	$28,800	$36,000	$91,440	$396,240
1	RILEY-SUB	PIPE	12	4,994	50	LF	$81	$454,358	12%	15%	30%	$54,523	$68,154	$173,111	$750,146
1	RILEY-SUB	PIPE	8	1,629	16	LF	$53	$103,300	12%	15%	30%	$12,396	$15,495	$39,357	$170,548
1	RILEY-SUB	TURNOUT	1	NA	11	EA	$8,000	$88,000	12%	15%	30%	$10,560	$13,200	$33,528	$145,288
1	ROGERS	PIPE	30	2,559	26	LF	$205	$550,279	8%	12%	30%	$44,022	$66,033	$198,100	$858,435
1	ROGERS	PIPE	24	4,728	47	LF	$164	$821,181	8%	12%	30%	$65,694	$98,542	$295,625	$1,281,043
1	ROGERS	PIPE	20	3,902	39	LF	$136	$570,147	8%	12%	30%	$45,612	$68,418	$205,253	$889,430
1	ROGERS	PIPE	18	1,340	13	LF	$122	$177,326	8%	12%	30%	$14,186	$21,279	$63,837	$276,628
1	ROGERS	PIPE	16	1,927	19	LF	$109	$228,444	8%	12%	30%	$18,275	$27,413	$82,240	$356,372

Project Group	Name	Feature	Dia. (in)	Length (ft)	Turnout/Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	ROGERS	PIPE	14	1,120	11	LF	$95	$117,337	8%	12%	30%	$9,387	$14,080	$42,241	$183,045
1	ROGERS	PIPE	12	435	4	LF	$81	$39,577	8%	12%	30%	$3,166	$4,749	$14,248	$61,740
1	ROGERS	PIPE	12	2,372	24	LF	$81	$215,807	8%	12%	30%	$17,265	$25,897	$77,690	$336,658
1	ROGERS	PIPE	10	1,509	15	LF	$67	$116,490	8%	12%	30%	$9,319	$13,979	$41,936	$181,725
1	ROGERS	TURNOUT	1	NA	49	EA	$8,000	$392,000	8%	12%	30%	$31,360	$47,040	$141,120	$611,520
1	ROGERS-SUB	PIPE	10	1,313	13	LF	$67	$101,359	10%	15%	30%	$10,136	$15,204	$38,010	$164,709
1	ROGERS-SUB	PIPE	8	922	9	LF	$53	$58,467	10%	15%	30%	$5,847	$8,770	$21,925	$95,008
1	ROGERS-SUB	TURNOUT	1	NA	4	EA	$8,000	$32,000	10%	15%	30%	$3,200	$4,800	$12,000	$52,000
2	BUTTE	PIPE	8	4,378	44	LF	$53	$277,622	12%	15%	30%	$33,315	$41,643	$105,774	$458,353
2	BUTTE	PIPE	8	1,056	11	LF	$53	$66,964	12%	15%	30%	$8,036	$10,045	$25,513	$110,558
2	BUTTE	TURNOUT	1	NA	8	EA	$8,000	$64,000	12%	15%	30%	$7,680	$9,600	$24,384	$105,664
2	MAIN	PIPE	48	2,094	21	LF	$329	$710,059	6%	12%	30%	$42,604	$85,207	$251,361	$1,089,231
2	MAIN	PIPE	42	4,560	46	LF	$288	$1,357,696	6%	12%	30%	$81,462	$162,924	$480,624	$2,082,706
2	MAIN	PIPE	36	6,709	67	LF	$246	$1,720,110	6%	12%	30%	$103,207	$206,413	$608,919	$2,638,649
2	MAIN	PIPE	34	1,933	19	LF	$233	$468,955	6%	12%	30%	$28,137	$56,275	$166,010	$719,376
2	MAIN	PIPE	32	831	8	LF	$219	$190,150	6%	12%	30%	$11,409	$22,818	$67,313	$291,690
2	MAIN	PIPE	28	3,086	31	LF	$191	$621,066	6%	12%	30%	$37,264	$74,528	$219,857	$952,715
2	MAIN	PIPE	28	1,665	17	LF	$191	$335,086	6%	12%	30%	$20,105	$40,210	$118,620	$514,021
2	MAIN	PIPE	26	2,746	27	LF	$177	$514,789	6%	12%	30%	$30,887	$61,775	$182,235	$789,686
2	MAIN	PIPE	24	2,534	25	LF	$164	$440,117	6%	12%	30%	$26,407	$52,814	$155,801	$675,139

Project Group	Name	Feature	Dia. (in)	Length (ft)	Turnout/Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
2	MAIN	PIPE	20	1,283	13	LF	$136	$187,468	6%	12%	30%	$11,248	$22,496	$66,364	$287,576
2	MAIN	PIPE	18	344	3	LF	$122	$45,522	6%	12%	30%	$2,731	$5,463	$16,115	$69,831
2	MAIN	PIPE	18	320	3	LF	$122	$42,346	6%	12%	30%	$2,541	$5,082	$14,991	$64,960
2	MAIN	PIPE	16	3,039	30	LF	$109	$360,270	6%	12%	30%	$21,616	$43,232	$127,535	$552,654
2	MAIN	PIPE	14	1,566	16	LF	$95	$164,062	6%	12%	30%	$9,844	$19,687	$58,078	$251,671
2	MAIN	PIPE	12	66	1	LF	$81	$6,005	6%	12%	30%	$360	$721	$2,126	$9,211
2	MAIN	PIPE	10	872	9	LF	$67	$67,316	6%	12%	30%	$4,039	$8,078	$23,830	$103,262
2	MAIN	PIPE	8	526	5	LF	$53	$33,355	6%	12%	30%	$2,001	$4,003	$11,808	$51,167
2	MAIN	TURNOUT	1	NA	49	EA	$8,000	$392,000	6%	12%	30%	$23,520	$47,040	$138,768	$601,328
2	MICKELSON	PIPE	10	1,877	19	LF	$67	$144,899	15%	18%	30%	$21,735	$26,082	$57,815	$250,530
2	MICKELSON	TURNOUT	1	NA	2	EA	$8,000	$16,000	15%	18%	30%	$2,400	$2,880	$6,384	$27,664
2	Pump Station	Mobilization	NA	NA	NA	NA	NA	$20,655	12%	18%	30%	$2,479	$3,718	$6,196	$33,048
2	Pump Station	Civil Works	NA	NA	NA	NA	NA	$103,275	12%	18%	30%	$12,393	$18,589	$30,982	$165,240
2	Pump Station	Pump/Motor	NA	NA	NA	NA	NA	$55,113	12%	18%	15%	$6,614	$9,920	$8,267	$79,914
2	Pump Station	Controls	NA	NA	NA	NA	NA	$36,146	12%	18%	30%	$4,338	$6,506	$10,844	$57,834
2	Pump Station	Electrical	NA	NA	NA	NA	NA	$77,456	12%	18%	30%	$9,295	$13,942	$23,237	$123,930
2	Pump Station	Building	NA	NA	NA	NA	NA	$30,982	12%	18%	30%	$3,718	$5,577	$9,295	$49,572
Total Capital Cost of All Project Groups															**$23,466,383**

PVC Piping Alternative

Project Group	Name	Feature	Material	Dia. (in)	Length (ft)	Turnout /Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	ELDER	TURNOUT	HDPE	1	NA	25	EA	$8,000	$200,000	15%	12%	30%	$30,000	$24,000	$76,200	$330,200
1	ELDER	PIPE	PVC	8	1,553	16	LF	$6	$24,412	15%	12%	30%	$3,662	$2,929	$9,301	$40,304
1	ELDER	PIPE	PVC	12	604	6	LF	$13	$13,591	15%	12%	30%	$2,039	$1,631	$5,178	$22,439
1	ELDER	PIPE	PVC	16	1,183	12	LF	$22	$37,602	15%	12%	30%	$5,640	$4,512	$14,326	$62,081
1	ELDER	PIPE	PVC	18	4,305	43	LF	$27	$160,872	15%	12%	30%	$24,131	$19,305	$61,292	$265,600
1	ELDER	PIPE	PVC	10	882	9	LF	$9	$16,650	15%	12%	30%	$2,497	$1,998	$6,344	$27,489
1	ELDER	PIPE	PVC	14	1,530	15	LF	$17	$41,057	15%	12%	30%	$6,159	$4,927	$15,643	$67,785
1	RILEY	TURNOUT	HDPE	1	NA	30	EA	$8,000	$240,000	15%	12%	30%	$36,000	$28,800	$91,440	$396,240
1	RILEY	PIPE	PVC	12	738	7	LF	$13	$16,606	15%	12%	30%	$2,491	$1,993	$6,327	$27,417
1	RILEY	PIPE	PVC	14	2,972	30	LF	$17	$79,752	15%	12%	30%	$11,963	$9,570	$30,386	$131,671
1	RILEY	PIPE	PVC	16	1,113	11	LF	$22	$35,377	15%	12%	30%	$5,307	$4,245	$13,479	$58,408
1	RILEY	PIPE	PVC	20	2,449	24	LF	$34	$106,738	15%	12%	30%	$16,011	$12,809	$40,667	$176,224
1	RILEY-SUB	TURNOUT	HDPE	1	NA	11	EA	$8,000	$88,000	15%	12%	30%	$13,200	$10,560	$33,528	$145,288
1	RILEY-SUB	PIPE	PVC	8	1,629	16	LF	$6	$25,607	15%	12%	30%	$3,841	$3,073	$9,756	$42,277
1	RILEY-SUB	PIPE	PVC	12	4,994	50	LF	$13	$112,372	15%	12%	30%	$16,856	$13,485	$42,814	$185,526
1	ROGERS	TURNOUT	HDPE	1	NA	49	EA	$8,000	$392,000	15%	12%	30%	$58,800	$47,040	$149,352	$647,192
1	ROGERS	PIPE	PVC	10	1,509	15	LF	$9	$28,486	15%	12%	30%	$4,273	$3,418	$10,853	$47,030
1	ROGERS	PIPE	PVC	12	435	4	LF	$13	$9,788	15%	12%	30%	$1,468	$1,175	$3,729	$16,160
1	ROGERS	PIPE	PVC	12	2,372	24	LF	$13	$53,373	15%	12%	30%	$8,006	$6,405	$20,335	$88,119
1	ROGERS	PIPE	PVC	14	1,120	11	LF	$17	$30,055	15%	12%	30%	$4,508	$3,607	$11,451	$49,620

Project Group	Name	Feature	Material	Dia. (in)	Length (ft)	Turnout /Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
1	ROGERS	PIPE	PVC	16	1,927	19	LF	$22	$61,251	15%	12%	30%	$9,188	$7,350	$23,336	$101,125
1	ROGERS	PIPE	PVC	18	1,340	13	LF	$27	$50,074	15%	12%	30%	$7,511	$6,009	$19,078	$82,672
1	ROGERS	PIPE	PVC	20	3,902	39	LF	$34	$170,066	15%	12%	30%	$25,510	$20,408	$64,795	$280,778
1	ROGERS	PIPE	PVC	24	4,728	47	LF	$48	$273,809	15%	12%	30%	$41,071	$32,857	$104,321	$452,058
1	ROGERS	PIPE	PVC	30	2,559	26	LF	$74	$215,330	15%	12%	30%	$32,300	$25,840	$82,041	$355,510
1	ROGERS-SUB	TURNOUT	HDPE	1	NA	4	EA	$8,000	$32,000	15%	12%	30%	$4,800	$3,840	$12,192	$52,832
1	ROGERS-SUB	PIPE	PVC	8	922	9	LF	$6	$14,493	15%	12%	30%	$2,174	$1,739	$5,522	$23,928
1	ROGERS-SUB	PIPE	PVC	10	1,313	13	LF	$9	$24,786	15%	12%	30%	$3,718	$2,974	$9,443	$40,921
2	BUTTE	TURNOUT	HDPE	1	NA	8	EA	$8,000	$64,000	15%	12%	30%	$9,600	$7,680	$24,384	$105,664
2	BUTTE	PIPE	PVC	8	4,378	44	LF	$6	$68,819	15%	12%	30%	$10,323	$8,258	$26,220	$113,620
2	BUTTE	PIPE	PVC	8	1,056	11	LF	$6	$16,600	15%	12%	30%	$2,490	$1,992	$6,324	$27,406
2	MAIN	TURNOUT	HDPE	1	NA	49	EA	$8,000	$392,000	15%	12%	30%	$58,800	$47,040	$149,352	$647,192
2	MAIN	PIPE	PVC	8	526	5	LF	$6	$8,268	15%	12%	30%	$1,240	$992	$3,150	$13,651
2	MAIN	PIPE	PVC	10	872	9	LF	$9	$16,461	15%	12%	30%	$2,469	$1,975	$6,272	$27,177
2	MAIN	PIPE	PVC	12	66	1	LF	$13	$1,485	15%	12%	30%	$223	$178	$566	$2,452
2	MAIN	PIPE	PVC	14	1,566	16	LF	$17	$42,023	15%	12%	30%	$6,303	$5,043	$16,011	$69,380
2	MAIN	PIPE	PVC	16	3,039	30	LF	$22	$96,596	15%	12%	30%	$14,489	$11,592	$36,803	$159,480
2	MAIN	PIPE	PVC	18	344	3	LF	$27	$12,855	15%	12%	30%	$1,928	$1,543	$4,898	$21,223
2	MAIN	PIPE	PVC	18	320	3	LF	$27	$11,958	15%	12%	30%	$1,794	$1,435	$4,556	$19,743
2	MAIN	PIPE	PVC	20	1,283	13	LF	$34	$55,919	15%	12%	30%	$8,388	$6,710	$21,305	$92,322

Project Group	Name	Feature	Material	Dia. (in)	Length (ft)	Turnout /Elbow Quantity	Unit	$/Unit	Subtotal Cost	Engineering, CM, Survey (%)	CMGC (%)	Contingency (%)	Engineering, CM, Survey	CMGC	Contingency	Total Cost
2	MAIN	PIPE	PVC	24	2,534	25	LF	$48	$146,749	15%	12%	30%	$22,012	$17,610	$55,912	$242,283
2	MAIN	PIPE	PVC	26	2,746	27	LF	$56	$181,303	15%	12%	30%	$27,196	$21,756	$69,077	$299,332
2	MAIN	PIPE	PVC	28	3,086	31	LF	$65	$230,738	15%	12%	30%	$34,611	$27,689	$87,911	$380,948
2	MAIN	PIPE	PVC	28	1,665	17	LF	$65	$124,491	15%	12%	30%	$18,674	$14,939	$47,431	$205,534
2	MAIN	PIPE	PVC	32	831	8	LF	$84	$78,243	15%	12%	30%	$11,736	$9,389	$29,811	$129,180
2	MAIN	PIPE	PVC	34	1,933	19	LF	$95	$202,573	15%	12%	30%	$30,386	$24,309	$77,180	$334,447
2	MAIN	PIPE	PVC	36	6,709	67	LF	$106	$778,720	15%	12%	30%	$116,808	$93,446	$296,692	$1,285,666
2	MAIN	PIPE	PVC	42	4,560	46	LF	$144	$700,809	15%	12%	30%	$105,121	$84,097	$267,008	$1,157,036
2	MAIN	PIPE	PVC	48	2,094	21	LF	$187	$412,501	15%	12%	30%	$61,875	$49,500	$157,163	$681,040
2	MICKELSON	TURNOUT	HDPE	1	NA	2	EA	$8,000	$16,000	15%	12%	30%	$2,400	$1,920	$6,096	$26,416
2	MICKELSON	PIPE	PVC	10	1,877	19	LF	$9	$35,433	15%	12%	30%	$5,315	$4,252	$13,500	$58,499
2	Pump Station	Mobilization	NA	NA	NA	NA	NA	NA	$20,655	12%	18%	30%	$2,479	$3,718	$6,196	$33,048
2	Pump Station	Civil Works	NA	NA	NA	NA	NA	NA	$103,275	12%	18%	30%	$12,393	$18,589	$30,982	$165,240
2	Pump Station	Pump/Motor	NA	NA	NA	NA	NA	NA	$55,113	12%	18%	15%	$6,614	$9,920	$8,267	$79,914
2	Pump Station	Controls	NA	NA	NA	NA	NA	NA	$36,146	12%	18%	30%	$4,338	$6,506	$10,844	$57,834
2	Pump Station	Electrical	NA	NA	NA	NA	NA	NA	$77,456	12%	18%	30%	$9,295	$13,942	$23,237	$123,930
2	Pump Station	Building	NA	NA	NA	NA	NA	NA	$30,982	12%	18%	30%	$3,718	$5,577	$9,295	$49,572
															Total Capital Cost of All Project Groups	**$10,826,123**

Groundwater Pumping Alternative

Construction Cost for 1 Patron Well				
Item	**Unit**	**Quantity**	**Unit Cost**	**Total cost**
Install Conductor Casing	ft	50	$175	$8,750
Drill Pilot Hole	ft	240	$45	$10,808
E-log	ea	1	$1,500	$1,500
Ream Pilot Hole	ft	240	$60	$14,410
Install Blank Casing	ft	182	$7	$1,228
Install Screen	ft	240	$2	$480
Install Gravel Pack	ft	240	$15	$3,603
Grout Seal	ft	240	$15	$3,603
Plumb & Alignment Test	ea	1	$1,500	$1,500
Surge/Airflit Development	ea	1	$1,500	$1,500
Pumping Development	ea	1	$1,500	$1,500
Step Test	ea	1	$1,500	$1,500
Constant Q Test	ea	1	$1,500	$1,500
Pump Cost	ea	1	$21,000	$21,000
Install Pump	ea	1	$1,500	$1,500
Electric & Wellhead Finish	ea	1	$1,500	$1,500
			Total Cost per Well	**$75,881**

Total Well Construction Cost for All Patrons			
	Project Group 1	**Project Group 2**	**Total**
Number of Patrons	119	10	129
Total Cost	**$9,029,860**	**$8,774,860**	**$17,804,720**

Ongoing Annual Groundwater Energy Costs	
	Total
Acreage Served	1,753
Patron Demand (gpm)	12,271
Number of Patrons	129
Flow Requirements (cfs)	27.4
Total acre-feet used per year	11,572
Patron Demand per patron (gpm)	95
Acre-feet used per patron per year	90
kwh per year	45,234
Cost per patron year	$2,783
Total Operating Costs	**$358,979**

D.5 Net Present Value of Alternatives

This section presents the calculations used to estimate the net present value of the Preferred Alternative and the eliminated alternatives.

Discount Rate: 2.750%

Period of Analysis: 100 years

Project Groups	Alternatives				
	HDPE Piping	PVC Piping	Steel Piping	Canal Lining	Groundwater & HDPE Piping
Design Life (years)	100	33	50	33	50
Capital Costs					
1	$4,623,000	$4,217,000	$10,259,000	$12,787,000	$9,030,000
2	$8,845,000	$6,609,000	$13,207,000	$18,029,000	$8,775,000
Total:	**$13,468,000**	**$10,826,000**	**$23,466,000**	**$30,816,000**	**$17,805,000**
Net Present Value of Replacement Costs					
1	N/A	$2,794,000	$2,807,000	$8,902,000	$4,035,000
2	$49,000	$4,090,000	$3,558,000	$12,603,000	$339,000
Total:	**$49,000**	**$6,884,000**	**$6,365,000**	**$21,505,000**	**$4,374,000**
Annual Operation and Maintenance Costs					
1	$183,000	$183,000	$183,000	$237,000	$309,000
2	$165,000	$165,000	$165,000	$222,000	$186,000
Total:	**$348,000**	**$348,000**	**$348,000**	**$459,000**	**$495,000**
Total Percent Change in O&M:	-3%	-3%	-3%	28%	38%
Total Net Present Value of O&M Costs					

Project Groups	Alternatives				
	HDPE Piping	**PVC Piping**	**Steel Piping**	**Canal Lining**	**Groundwater & HDPE Piping**
1	$6,213,000	$6,213,000	$6,213,000	$8,046,000	$10,491,000
2	$5,602,000	$5,602,000	$5,602,000	$7,537,000	$6,315,000
Total:	**$11,815,000**	**$11,815,000**	**$11,815,000**	**$15,583,000**	**$16,806,000**
Total Net Present Value of Project					
1	$10,836,000	$13,224,000	$19,279,000	$29,735,000	$23,556,000
2	$14,496,000	$16,301,000	$22,367,000	$38,169,000	$15,429,000
Total:	**$25,332,000**	**$29,525,000**	**$41,646,000**	**$67,904,000**	**$38,985,000**

Appendix E

Other Supporting Information

E.1 Intensity Threshold Table

This section presents the intensity threshold table used to quantify effects to resources of concern as a result of the proposed action.

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

	Intensity Threshold			
Resource	**Negligible**	**Minor**	**Moderate**	**Major**
Cultural Resources	No known, eligible resources are adversely affected or are at the lowest levels of detection or barely perceptible, and not measurable.	Affects a cultural site, structure or feature with little data potential. The historic context of the affected site(s) would be local. Not affect the contributing element of a property eligible for the National Register of Historic Places. Causes a slight change to a natural or physical ethnographic resource, if measurable and localized.	Affects a cultural site, structure or landscape with modest data potential of local, regional or state significance. Changes a contributing element but would not diminish resource integrity or jeopardize National Register eligibility. Localized and measurable change to a natural or physical ethnographic resource.	Affects a cultural site or landscape with high data potential of national context Diminishes the integrity of the resource to the extent that affects cannot be mitigated, would permanently impact the historic register eligibility of the resource, prevent a resource from meeting criteria for listing in a historic register, or reduce the ability of a cultural resource to convey its historic significance. Permanent severe change or exceptional benefit to a natural or physical ethnographic resource.
Fish and Aquatic Species	No discernable short- or long-term impacts to fish life or habitat.	Changes in watershed conditions that cause non-measurable change in existing hydrology or sediment functions. Direct or indirect habitat changes that result only in	Changes in watershed conditions that cause measurable change to hydrology or sediment functions. Direct or indirect habitat changes that cause	Changes in watershed conditions that cause high impairment to hydrology or sediment functions that affects population viability. The proposed action would likely jeopardize a species’

Resource	**Intensity Threshold**			
	Negligible	**Minor**	**Moderate**	**Major**
		non-measurable, short-term change in risk to ESA-listed and other fish species at the population or ESU scale.	measurable-, short- or long-term change in risk to ESA-listed or other fish species at the population or ESU scale.	continued existence or destroy or adversely affect a species' critical habitat.
Geology and Soils	Project activities would not disturb soils or underlying geology.	Short-term erosion during construction at project and clearing sites that would be mitigated through BMPs. Changes to primarily previously disturbed soil profiles or underlying geology.	Short-term erosion during construction at project and clearing sites that could not be mitigated. Changes to primarily undisturbed soil profiles or underlying geology.	Continued erosion during and after construction at project and clearing sites. Permanent changes to undisturbed soil profiles or underlying geology.
Land Use	Existing land uses or ownership would continue as before. A short-term change or interruption to land use or access to existing land uses.	Land use changes that are consistent with existing ownership, easements, or right-a-way.	Land use changes that are inconsistent with existing ownership, easements, or right-a-way but are compatible to adjacent.	A new unauthorized land use or access that is not compatible with adjacent land use.
Public Safety	No change in risk to human health and safety.	Any short-term risks to public health and safety could be mitigated. Eliminate a known health and safety condition in localized areas.	Any short-term risks to public health and safety could not be mitigated. Eliminate a known health and safety condition in the area affected by District operations.	Create a permanent and known health and safety condition. Eliminate a known health and safety condition on a regional level.
Recreation	No effect on the location, timing, or quality of recreation facilities and uses during and after construction.	Temporarily preclude or limit dispersed and dedicated recreational opportunities during off-peak use periods during project construction.	Temporarily preclude or limit dispersed and dedicated recreational opportunities during peak use periods during project construction.	Obstruct legally existing or planned dispersed recreational uses after project construction.

Resource	**Intensity Threshold** **Negligible**	**Minor**	**Moderate**	**Major**
		Require relocation of dispersed recreational activities to an equal or better location after project construction. Expand to a limited degree existing recreational areas or opportunities.	Create or encourage new unauthorized land uses along the right-of-way for recreational purposes, such as ATV use in unauthorized areas. Create limited dispersed new recreational areas or opportunities.	Alter or eliminate dedicated recreation opportunities after project construction. Create extensive new recreational opportunities or areas.
Socioeconomics	No reduction in the yield of agricultural products or timber Non-measurable change to income and/or employment levels.	Little effect on the yield of agricultural products or timber. Temporary changes to income and/or local employment levels.	A change to the yield of agricultural products or timber at the local level Permanent changes to local employment and/or levels.	A change to the yield of agricultural products or timber at the regional or national level. Permanent changes to regional employment and/or income levels.
Vegetation	Project activities would not affect vegetation or it is limited to small areas.	Most effects would be localized and/or temporary. While individual plants could be affected there would be no effects on a population scale. Any permanent effects would not be widespread nor affect sensitive species or populations.	A large proportion of one or more populations are affected but relatively localized and could be mitigated. Any effects to sensitive species could be mitigated	Considerable effects on plant populations over large areas. Extensive mitigation required offsetting adverse effects to sensitive species, but success not assured.
Visual Resources	Project features are visually negligible or not visible.	Landscape is a designated scenic area and project features do not attract attention to the landscape.	Landscape is a designated scenic area and some project features attract attention to the landscape.	Landscape is a designated scenic area and the majority of project features attract attention to the landscape.

Resource	Intensity Threshold			
	Negligible	**Minor**	**Moderate**	**Major**
		The majority of project features do not attract attention to the landscape. Short-term visual changes during project construction.	A majority of project features attract attention to the landscape.	Project features create a disruptive change and dominate the landscape.
Water Resources	Project activities would not disturb or alter water quantity, water quality, or groundwater quantity.	*Surface Water Quantity:* Less than 10 percent change in volume of streamflow. *Water Quality:* Short-term or non-measurable changes to water quality in waterbodies that is unlikely to result in excursions to water quality standards on the Oregon's 303(d) list. *Ground Water:* Long-term, less than 10 percent change in depth to groundwater.	*Surface Water Quantity:* Greater than 10 percent and less than 20 percent change in volume of streamflow. *Water Quality:* Permanent measurable changes to water quality in waterbodies that is unlikely to result in excursions to water quality standards on the Oregon's 303(d) list. *Ground Water:* Short-term, greater than 10 percent change in depth to groundwater.	*Surface Water Quantity:* Greater than 20 percent change in volume of streamflow. *Water Quality:* Permanent measurable changes to water quality in waterbodies that results in excursions to water quality standards on the Oregon's 303(d) list. *Ground Water:* Long-term, greater than 10 percent change in depth to groundwater.
Wetland, Flood Plains, Riparian Zones	Doesn't alter wetlands or change the hydraulic capacity of floodplains.	Alteration of non-jurisdictional wetland hydrology, vegetation, and/or soils changes water quality, hydrologic, and/or habitat functions. Altered hydraulic function or hydraulic capacity of floodplains to a degree that does not increase or decrease the potential for	Mitigated alteration of jurisdictional wetland hydrology, vegetation, and/or soils that changes water quality, hydrologic, and/or habitat functions.	Permanent, non-mitigated alteration of jurisdictional wetland hydrology, vegetation, and/or soils that causes changes to water quality, hydrologic, and/or habitat functions. Altered hydraulic function or changes to hydraulic capacity of floodplains to a degree that changes the

Resource	Intensity Threshold			
	Negligible	Minor	Moderate	Major
		flooding and damage to personal property.		potential for flooding and damage to personal property.
Wildlife	Temporary or short-term change in wildlife populations and/or habitats would not be of measurable.	Long-term changes in wildlife populations or habitats would not be measurable. Any adverse effects can be effectively mitigated.	Long-term measurable changes in local wildlife populations or habitats. Mitigated effects to sensitive species.	Long-term measurable changes to regional wildlife populations or habitats. Effects to sensitive species could not be mitigated successfully.
Wild and Scenic Rivers	No effects to the resources determining the designation of Wild and Scenic Rivers.	Any effects to resources would be compatible with the designation of the Wild and Scenic River reaches.	An effect to resources that would be incompatible with the designation but could be mitigated.	Effects to resources that would change the designation of a Wild and Scenic River reach.

Duration of Effects	
Temporary	Transitory effects which only occur over a period of days or months.
Short-term	Effects lasting 1-5 years.
Long-term	Effects lasting greater than 5 years.

E.2 Fish and Aquatic Resources Supporting Information

This appendix section presents supporting information associated with Primary Constituent Elements for bull trout critical habitat.

Table E-2. Primary Constituent Elements for Bull Trout.

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

Primary Constituent Element Number	Habitat Description and Characteristics
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.

E.3 Geology and Soils Supporting Calculations

This appendix section presents supporting calculations used to evaluate effects of the Preferred Alternative with respect to geology and soil resources.

Table E-3. Detailed Calculations to Estimate Quantity of Soil Disturbed Under the HDPE Piping Alternative.

Diameter (ft)	Sum of Length (ft)	Excavation Width (ft)	Bedding Volume (CY)	Pipe Trench Volume		Canal Volume			Total Volume Disturbed (CY) ~excluding volume of pipe~
				Pipe Trench Depth	Pipe Trench Volume (CY)	Canal Top Width (ft)	Canal Bottom Width (ft)	Canal Volume (CY)	
0.67	10,064	4	683	0.3	456	2.3	1.3	445	1,454
0.83	6,453	4	478	0.4	398	2.8	1.7	446	1,192
1.00	9,209	4	682	0.5	682	3.4	2.0	917	2,013
1.17	7,188	4	532	0.6	621	3.9	2.3	974	1,843
1.33	7,262	4	538	0.7	717	4.5	2.7	1,286	2,165
1.50	6,309	5	584	0.8	876	5.1	3.0	1,414	2,461
1.67	7,634	5	707	0.8	1,178	5.6	3.3	2,112	3,380
2.00	7,262	5	672	1.0	1,345	6.8	4.0	2,893	4,065
2.17	2,746	5	254	1.1	551	7.3	4.3	1,284	1,714
2.33	4,751	5	440	1.2	1,026	7.9	4.7	2,576	3,290
2.50	2,559	6	284	1.3	711	8.4	5.0	1,593	2,123
2.67	831	6	92	1.3	246	9.0	5.3	588	755

Diameter (ft)	Sum of Length (ft)	Excavation Width (ft)	Bedding Volume (CY)	Pipe Trench Volume		Canal Volume			Total Volume Disturbed (CY) ~excluding volume of pipe~
				Pipe Trench Depth	Pipe Trench Volume (CY)	Canal Top Width (ft)	Canal Bottom Width (ft)	Canal Volume (CY)	
2.83	1,933	6	215	1.4	609	9.6	5.7	1,545	1,917
3.00	6,709	6	745	1.5	2,236	10.1	6.0	6,013	7,238
3.50	4,560	7	591	1.8	2,069	11.8	7.0	5,563	6,598
4.00	2,094	7	271	2.0	1,086	13.5	8.0	3,336	3,719
								Total	**45,928**

Note: Pipe length and diameter information from the SID 2018 updated SIP.

E.4 Land Use Supporting Calculations

This appendix section presents supporting calculations used to evaluate effects of the Preferred Alternative with respect to land use.

Table E-4. Land Ownership in Swalley Irrigation District

Ownership	Percentage of Area	Acres
Bend Metro Park and Recreation	2%	389
Bureau of Land Management	1%	208
Deschutes County	4%	602
Oregon Parks and Recreation	1%	229
Private	91%	14,805
State of Oregon	0%	20
U.S. Forest Service	0%	33
Total	**100%**	**16,285**

Note: Acreage data comes from the attribute table corresponding to Figure 4-6, which used GIS data from Deschutes County, BLM, USFS, and the FCA provided SID Boundary.

Table E-5. Land Zoning in Swalley Irrigation District

Zoning	Acres	Percentage of total area
EFUAL	55	1%
EFUTRB	5,977	57%
MUA10	4,510	43%
Total	**10,543**	**100%**

Note: Acreage data comes from the GIS data from Deschutes County clipped to the FCA provided SID Boundary.

Table E-6. Land Cover in Swalley Irrigation District

Land Cover Type	Acres	Percent of the total area
Barren Land	5	0%
Cultivated Crops	3,449	21%
Developed, High Intensity	103	1%
Developed, Low Intensity	2,555	16%
Developed, Medium Intensity	647	4%
Developed, Open Space	1,809	11%
Evergreen Forest	274	2%
Herbaceous	177	1%
Open Water	6	0%
Shrub/Scrub	6,839	42%

Land Cover Type	Acres	Percent of the total area
Woody Wetlands	422	3%
Total	**16,285**	**100%**

Note: Acreage data comes from the attribute table corresponding to Figure 4-7, which used GIS data from the 2011 National Land Cover Database clipped to the FCA provided SID Boundary.

E.5 Vegetation Supporting Calculations

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

Table E-7. Calculations to Estimate Vegetation Disturbed by Construction

System Element	Proposed Piping (ft)	Land affected on both sides of the canal (ft)	Additional affected land between canal affected area and maintenance road (ft)	Subtotal affected area (sq ft)
Canals	34,174	16	15	1,059,394
Laterals	53,390	10	8	961,020
System Element	**Units**	**Land affected width (ft)**	**Land affected length (ft)**	**Subtotal affected area (sq ft)**
Turnouts	178	10	30	53,400
			Total (sq ft)	**2,073,814**
			Total (ac)	**46**

Table E- 8. Calculations to Estimate New Vegetation Area Created by the Conversion of Open Canals and Laterals to a Buried System

Pipe Diameter (ft)	Sum of Length (ft)	Canal Top Width (ft)	Total Area Converted (sq ft)
0.67	10,062	2.3	22,656
0.83	11,446	2.8	32,214
1.00	4,218	3.4	14,247
1.17	7,187	3.9	28,321

Pipe Diameter (ft)	Sum of Length (ft)	Canal Top Width (ft)	Total Area Converted (sq ft)
1.33	7,261	4.5	32,695
1.50	6,313	5.1	31,980
1.67	6,757	5.6	38,037
2.00	8,261	6.8	55,801
2.17	2,746	7.3	20,092
2.33	4,751	7.9	37,438
2.50	2,559	8.4	21,606
2.67	831	9.0	7,480
2.83	1,932	9.6	18,490
3.00	6,709	10.1	67,974
3.50	4,560	11.8	53,902
4.00	2,094	13.5	28,291
		Total	**511,223**

Note: Pipe length and diameter information from the SID 2017 SIP.

E.6 Water Resources Supporting Calculations

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

Table E-9. Monthly Instream Flow Requirements for the Deschutes River.

Source	From	To	Certificate	Priority Date	Instream Rates (cfs)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Deschutes River	North Canal Dam	Lake Billy Chinook	Pending	Pending	250	250	250	250	250	250	250	250	250	250	250	250

Table E-10. Deschutes River Daily Average Streamflow Below North Canal Dam Prior 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	94	256	350	200	550
Nov	334	130	464	284	747
Dec	419	118	537	366	903
Jan	403	207	610	384	994
Feb	424	145	569	547	1,116
Mar	466	216	682	458	1,140
Apr	87	211	298	380	678
May	48	59	107	130	237

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Jun	51	57	108	52	160
Jul	49	54	103	41	144
Aug	48	52	100	50	150
Sep	52	53	105	57	161

Note: Streamflow in the Deschutes River downstream from the City of Bend at Oregon Water Resources Department Gauge No. 14070500 are from the 1994 through 2014 water years.

Table E-11. Deschutes River Daily Average Streamflow 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	90	447	537	40	577
Nov	504	29	533	21	554
Dec	488	18	506	27	533
Jan	483	15	498	186	684
Feb	468	88	556	71	627
Mar	591	98	689	255	944
Apr	474	187	662	298	959
May	101	12	113	10	123

Month	Low Streamflow (cfs) - 80% Exceedance	Lower Bar	Average Streamflow (cfs) - 50% Exceedance	Upper Bar	High Streamflow (cfs) - 20% Exceedance
Jun	117	7	124	10	133
Jul	125	3	128	2	130
Aug	119	4	123	3	126
Sep	126	13	139	48	187

Note: Streamflow in the Deschutes River downstream from the City of Bend at Oregon Water Resources Department Gauge No. 14070500 are from the October 2016 through September 2017 water year.

Table E-12. Distribution of the Project's Total Saved Water between Instream and District Use

Diversion Rates (cfs)					Delivery Rates (cfs)					
Season	Certificate Rate (cfs)[1]	Estimated System Losses from the 2016 Loss Assessment (cfs)[2]	Project Water Allocated Instream (cfs)[3]	Post-project Certificated Diversion Rate (cfs)[4]	Pre-project Delivery Rate (cfs)[5]	Desired Delivery Rate (cfs)[6]	Pre-project Shortage (cfs)[7]	Project Water to Shore Up District Supply (cfs)[8]	Post-project delivery rate (cfs)[9]	Post-project shortage (cfs)[10]
1	32.50	7.60	4.80	27.70	24.90	27.82	-2.92	2.80	27.70	-0.12
2	43.50	10.18	6.18	37.33	33.33	38.37	-5.05	4.00	37.33	-1.05
3	82.08	19.20	15.20	66.88	62.88	67.15	-4.28	4.00	66.88	-0.28

Notes: This information is strictly for the use of providing possible outcomes of alternatives and in no way prescribes, suggests, or promises specific allocations on conserved water to instream water rights. Following the completion of each Project Group, SID would work with OWRD and its partners to measure and verify all water savings.
1. Max rate on certificate for all acres.
2. From SIP less water already restored instream. Based on measured losses.
3. Estimated system losses (cfs) - project water to shore up district supply (cfs).
4. Estimated post-project delivery rate following completion of entire project.

5. Certificate rate (cfs) - Estimated System Losses from the 2016 Water Loss Assessment.
6. Desired per acre rate (gpm/acre) / 448.83 gpm/cfs * total acres.
7. Pre-project delivery rate (cfs) - pre-project shortage (cfs).
8. Assumes that measured losses are correct. Represents additional water to district post-project.
9. Pre-project delivery rate (cfs) + project water to shore up district supply (cfs).
10. Post-project delivery rate (cfs) - desired delivery rate (cfs). Difference between desired rate and post-project rate.

Table E-13. Distribution of the Project's Total Saved Water between Instream and District Use - Continued

Delivery Rates (gpm/acre)						
Season	**Pre-project Delivery Rate (gpm/acre)[1]**	**Desired Delivery Rate (gpm/acre)[2]**	**Pre-project Shortage (gpm/acre)[3]**	**Project Water to Shore Up District Supply (gpm/acre)[4]**	**Post-project delivery rate (gpm/acre)[5]**	**Post-project shortage (gpm/acre)[6]**
1	2.60	2.90	-0.30	0.29	2.89	-0.01
2	3.47	4.00	-0.53	0.42	3.89	-0.11
3	6.55	7.00	-0.45	0.42	6.97	-0.03

Notes: This table continues from E-12. This information is strictly for the use of providing possible outcomes of alternatives and in no way prescribes, suggests, or promises specific allocations on conserved water to instream water rights. Following the completion of each Project Group, SID would work with OWRD and its partners to measure and verify all water savings.
1. Pre-project delivery rate (cfs) / acres * 448.83 gpm/cfs.
2. Identified by SID staff on 7/31/18.
3. Pre-project rate (gpm/acre) - desired rate (gpm/acre).
4. Project water to shore up supply (cfs) / acres * 448.83 gpm/cfs.
5. Pre-project delivery rate (gpm/acre) + project water to shore up district supply (gpm/acre).
6. Post-project delivery rate (gpm/acre) - desired delivery rate (gpm/acre). Difference between desired rate and post-project rate.

Table E-14. Seasonal Allocation of Saved Water between Instream and District Use

Season	Instream		District	
	Volume (acre-feet/year)	Proportion (%)	Volume (acre-feet/year)	Proportion (%)
1	581	63	339	37
2	368	61	238	39
3	3,678	79	968	21
Total	**4,627**	**75**	**1,545**	**25**

Table E-15. Deschutes River Post-Project Streamflow Below North Canal Dam

Month	Pre-Project Median Daily Average Streamflow	Streamflow Restored Through Project (cfs)[1]	Post-Project Median Daily Average Streamflow instream (cfs)	ODFW Instream Water Right[2]	Restored Streamflow Percentage Increase in the upper Deschutes Basin Annual Discharge[3]
Oct	350.0	4.8	354.8	250	0.1%
Nov	463.5	0.0	463.5	250	0.0%
Dec	537.0	0.0	537.0	250	0.0%
Jan	610.0	0.0	610.0	250	0.0%
Feb	569.0	0.0	569.0	250	0.0%
Mar	682.0	0.0	682.0	250	0.0%

Month	Pre-Project Median Daily Average Streamflow	Streamflow Restored Through Project (cfs)[1]	Post-Project Median Daily Average Streamflow instream (cfs)	ODFW Instream Water Right[2]	Restored Streamflow Percentage Increase in the upper Deschutes Basin Annual Discharge[3]
Apr	298.0	4.8	302.8	250	0.1%
May[4]	107.0	6.18/15.2	113.18/122.2	250	0%/0.3%
Jun	108.0	15.2	123.2	250	0.3%
Jul	103.0	15.2	118.2	250	0.3%
Aug	99.9	15.2	115.1	250	0.3%
Sep[4]	104.5	15.2/6.18	119.7/110.7	250	0.3%/0%

Notes:
1. This information is strictly for the use of providing possible outcomes of alternatives and in no way prescribes, suggests, or promises specific allocations on conserved water to instream water rights. Following the completion of each Project Group, SID would work with OWRD and its partners to measure and verify all water savings.
2. Pending Instream Application # IS-70695
3. According to "Groundwater Hydrology of the Upper Deschutes Basin and its Influence on Streamflow" by Marshall Gannett, Michael Manga, and Kenneth Lite, Jr., the upper Deschutes Basin has a mean annual discharge of 6003.5 cfs.
4. These months are split between two irrigation seasons: Season 2 (May 1 - May 15 and September 15 – September 30) and Season 3 (May 16 – September 14).

E.7 Allocation of Conserved Water Program

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

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

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

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

After mitigating the effects on any other water rights, the Water Resources Commission allocates 25 percent of the conserved water to the state (for an instream water right) and 75 percent to the applicant, unless more than 25 percent of the project costs come from federal or state non-reimbursable sources or the applicant proposes a higher allocation to the state. A new water right certificate is issued with the original priority date reflecting the reduced quantity of water being used with the improved technology. A certificate is issued for the state's instream water right, and, if requested, a certificate is issued for the applicant´s portion of the conserved water. The priority dates for the state's instream certificate and the applicant's portion of conserved water must be the same date and will be either the same date as the original water right or one-minute junior to the original right.

Reference

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

E.8 Consultation Letters

To be added in the final plan.

E.9 Cultural Resources Memorandum of Agreement

This appendix section provides the SID Resolution and Amendment to Memorandum of Agreement between SID and the Oregon State Historic Preservation Office.

SWALLEY IRRIGATION DISTRICT
RESOLUTION 18-01

RESOLUTION ACCEPTING AMENDMENT TO MEMORANDUM OF AGREEMENT BETWEEN THE SWALLEY IRRIGATION DISTRICT & THE STATE HISTORIC PRESERVATION OFFICE

BE IT RESOLVED that the Board of Directors of Swalley Irrigation District accepts and approves the attached Amendment to Memorandum of Agreement (MOA Amendment) between the District and the State Historic Preservation Office, and

FURTHER RESOLVED that President McCarrel is hereby approved to execute the attached MOA Amendment in full and attached hereto.

BE IT SO RESOLVED this 21st day of March, 2018, by unanimous vote of the board of directors.

President McCarrel

ATTEST:

Secretary Camarata

AMENDMENT TO

MEMORANDUM OF AGREEMENT

BETWEEN THE SWALLEY IRRIGATION DISTRICT & THE STATE HISTORIC PRESERVATION OFFICE

FOR THE PIPING OF THE SWALLEY IRRIGATION DISTRICT MAIN CANAL PIPING PROJECT, SWALLEY IRRIGATION DISTRICT, BEND VICINITY, DESCHUTES COUNTY, OREGON

WHEREAS, the Agreement was executed on January 10, 2007; and

WHEREAS, the Agreement was further interpreted in a letter from SHPO to Swalley (SID) on May 2, 2017; and

WHEREAS, Swalley Irrigation District now intends to convert the last 4.5 miles of open canal to a fully closed pressurized piped system; and

WHEREAS, a typographical error was made on the 2007 MOA in reference to a "1903" map, which should read "1908"; and

NOW, THEREFORE, in accordance with Stipulation 2 of the Agreement, the Swalley Irrigation District, and the State Historic Preservation Office agree to amend the Agreement as follows:

1. Amend Stipulation 2 so it reads as follows:

   a. Within one (1) year of piping the last 4.5 miles of the Main Canal and all other canal segments, SID will erect no less than five (5) interpretive signs along the original Main Canal footprint. The signs will be no smaller than 2 ft. x 3 ft. in size and must be weatherproof or built to withstand outdoor installation. The interpretive signs will describe the history of the canal and its role in the development of Deschutes County using no less than 300 words and will include the original 1908 map, representative modern and historical photos of the ditch including any segments or features of particular interest or significance, that convey the Swalley Canal story. The interpretive signs are intended to be permanent fixtures along the original Main Canal footprint and will be located in areas easily accessible to the public.
   b. In addition, SID will create a "Historical Records" section on its website to house original maps, photos, written history, century-old ledger books, and other primary documents that demonstrate the history of SID; this website will be available to the public for a minimum of five (5) years.
   c. Lastly, SID will display a section of historic wood stave pipe in front of their office for a minimum of five (5) years with an interpretive sign measuring no less than 2 ft. by 3ft. explaining its cultural significance with a narrative of no less than 300 words regarding water management and development in The West.
   d. The interpretive signs will be prepared by persons that possess the skills of either a Secretary of the Interior's Standards qualified Historian, Architectural Historian, Cultural Resource Specialist, Exhibit Specialist/Graphic Artist, or by an organization that has the ability to create and design professional quality interpretive panels.
   e. SID will provide the SHPO at least one (1) opportunity lasting a minimum of thirty (30) calendar days to comment and suggest applicable revisions to the interpretive signs and narratives as specified above before the signs are finalized and installed. Comments provided by the

signatories and consulting parties shall be taken into consideration within the limits of the project as described in the Stipulations.

f. Stipulation 2 will not be considered fulfilled until items 2.a through 2.d have been completed.

2. Amend the MOA to include the following administrative clauses:

a. DISPUTE RESOLUTION

Signatories to this MOA may object at any time to any actions proposed or the manner in which the terms of this MOA are implemented by submitting the concern in writing to the other signatory. Upon receipt, the receiving party shall consult with the other party for sixty (60) calendar days, or another time period agreed to by all signatories, to resolve the objection. If SID determines that such objection cannot be resolved, SID will:

i. Forward all documentation relevant to the dispute, including the other signatory's proposed resolution, to the Advisory Council on Historic Preservation (ACHP). The ACHP shall provide SID with its advice on the resolution of the objection within sixty calendar (60) days, or another time period agreed to by all signatories, of receiving adequate documentation. Prior to reaching a final decision on the dispute, SID shall prepare a written final decision that takes into account any timely advice or comments regarding the dispute from the ACHP, signatories and Concurring Party as set forth in the original MOA, and provide the signatories and Concurring Party with a copy of this written response within thirty (30) calendar days of receiving a response from the ACHP. SID will then proceed according to its final decision.

ii. If the ACHP does not provide its advice regarding the dispute within the thirty (30) calendar day time period, SID shall provide the signatories and Concurring Party a final written decision within thirty additional (30) calendar days that takes into account any timely comments regarding the dispute from the signatories and Concurring Party to the MOA, and provide them and the ACHP with a copy of such written response.

iii. SID's responsibility to carry out all other actions subject to the terms of this MOA that are not the subject of the dispute remain unchanged.

b. AMENDMENTS

Any signatory may request that this MOA be amended by submitting such a request to the other signatory in writing. SID shall consult with the signatory for up to sixty (60) calendar days, or another time period agreed to by all signatories, concerning the necessity and appropriateness of the proposed amendment. Any signatory may request the involvement of the ACHP during the amendment process. At the end of the consultation period SID shall provide an amended MOA for signature by the signatories or a written statement describing why SID choose not to pursue an amendment to this MOA. Amendments shall be effective on the date a copy of the MOA signed by all of the signatories is filed with the ACHP.

c. TERMINATION

If any signatory to this MOA determines that its terms will not or cannot be carried out, that party shall immediately consult with the other signatories to attempt to develop an amendment per Stipulation b, above. If within sixty (60) days, or another time period agreed to by all signatories, an amendment cannot be reached, any signatory may terminate the MOA upon written notification to the other signatory.

Once the MOA is terminated, and prior to work continuing on the undertaking, SID must either (a) execute an MOA pursuant to 36 CFR § 800.6 or (b) request, take into account, and respond to the comments of the ACHP under 36 CFR § 800.7. SID shall notify the signatories as to the course of action it will pursue.

d. DURATION

This MOA will expire if its terms are not carried out within ten (10) years from the date of its execution. At the close of ten years, signatories may review the existing MOA and choose to extend the duration another ten years without mandatory changes or renegotiation of the document if acceptable to all signatories. Prior to such time, SID may consult with the other signatories to reconsider the terms of the MOA and amend it in accordance with Stipulation b above should such action be necessary.

e. EXECUTION

Execution of this MOA by the SID and SHPO and implementation of its terms evidence that SID took into account the effects of the undertaking on historic properties and afforded the ACHP an opportunity to comment.

Signatories

Swalley Irrigation District

By: [signature] 3/21/18

Board of Directors Chairman, Swalley Irrigation District — Date

Oregon State Historic Preservation Office

By: Christine Curran 3.21.18

Deputy Oregon State Historic Preservation Officer — Date

SID MOA Amendment *Page 3 of 3*

E.10 Historical Background

This appendix section provides information on the federal Carey Desert Lands Act of 1894 and irrigation development in Central Oregon.

At the turn of the twentieth century, Central Oregon, known then as the Deschutes country, was one of the most remote regions in the nation. Settlers were enticed with opportunities to capitalize on the Deschutes River, promising lands for agriculture, and immense pine forests. Two major factors contributed to the settlement and agricultural development of Central Oregon: the arrival in 1900 of the Columbia Southern railroad, and the State of Oregon's acceptance in 1901 of the 1894 federal Carey Act which encouraged states to pursue development of arid lands (NPS 2015). In exchange for up to 1 million acres of federal land, states made up to 160 acres available to settlers who agreed to improve and cultivate the land. The Carey Act enabled states to issue irrigation contracts to private developers who were expected to design and build irrigation projects, as well as recruit settlers to farm the new areas. The State would issue a water right to the private developer for a particular project, but the State would not be responsible for financing or construction. If an irrigation project failed, the State reassigned the contract to another development company. While limited irrigation in Central Oregon had begun before these changes, the Carey Act helped spur the creation of more irrigation companies and investment in large scale irrigation projects (NPS 2017).

References

U.S. Department of the Interior, National Park Service (NPS). (2015). National Register of Historic Places Registration Form, Pilot Butte Canal Historic District (Cooley Road-Yeoman Road Segment). Retrieved from: https://www.nps.gov/nr/feature/places/pdfs/15001052.pdf. Accessed September 7, 2017.

U.S. Department of the Interior, National Park Service (NPS). (2017). National Register of Historic Places Registration Form, Pilot Butte Canal: Downtown Redmond Segment Historic District. Retrieved from: http://www.oregon.gov/oprd/HCD/NATREG/docs/national_register_recent/OR_DeschutesCo_PilotButteDowntownRedmondSegment.pdf. Accessed September 7, 2017.

E.11 Wild and Scenic Outstandingly Remarkable Values

This appendix section presents supporting information associated with Outstandingly Remarkable Values identified for the middle Deschutes River.

Table 5-15 Outstandingly Remarkable Values for Middle Deschutes River[15]

Outstandingly Remarkable Value (ORV)	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,

[15] ORV descriptions gathered from www.rivers.org/rivers/deschutes.php accessed September 10, 2018.

Outstandingly Remarkable Value (ORV)	Outstandingly Remarkable Value Description
	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 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.