Appendix A

System Improvement Plan

Lone Pine Irrigation District

System Improvement Plan

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Executive Summary

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

In February of 2017, a meeting was held with District staff to confirm the approach for this SIP. Data requests were fulfilled by the District. The District determined that a value of 7 GPM/Acre should be used for hydraulic modeling and pipe sizing purposes. Project groups created for cost estimating will provide the District flexibility in implementing future projects with respect to seepage loss estimates.

Irrigation water is supplied by surface water from the Deschutes River and surface water collected in the Crane Prairie Reservoir, discharged into the Deschutes River system. Water for LPID is diverted in conjunction with Central Oregon Irrigation District (COID) at COID's headworks. Water for the District is conveyed through the COID Pilot Butte Canal system and ultimately diverted into the LPID main canal. The District's 19 patrons are currently served by one primary, gravity-fed diversion from COID's Pilot Butte Canal. LPID's main canal conveys water across the Crooked River, and splits into three laterals that serve the entirety of the District. The Crooked River crossing is a suspension bridge that supports a wood stave pipe with PVC liner. The suspension bridge is in serious need of renovation or repair. For this reason, this SIP investigates two alternatives to route water across the Crooked River (Alternative A and Alternative B). Alternative A involves conveyance of the LPID delivery via the North Unit Irrigation District's (NUID) main canal, which spans the Crooked River in a concrete flume and bridge structure. LPID's allocated irrigation water would then be pumped from NUID's main canal shortly after the flume crosses the Crooked River. Alternative B involves diverting water from the existing location on COID's Pilot Butte Canal, and renovating or replacing the existing suspension bridge.

Currently the main canal splits into three laterals (Upper, Middle, and Lower) roughly a mile northeast of the bridge spanning the Crooked River. The Middle and Lower laterals are subsequently fed by gravity. The Upper lateral includes a pump station that raises the water 45 feet in elevation and is then fed by gravity. Since the District is investigating full pressurization of the system, it was determined that the Upper lateral could be eliminated and all users currently served by the Upper lateral would then be served via a takeoff from the Middle lateral, once piped.

A majority of the Lone Pine distribution system is open earthen ditch; although a few segments have been piped. The canals which remain open earth ditch were evaluated for seepage loss using state-of-the-art measurement equipment, and it was found that approximately 8.8 CFS were being lost at the time of the measurement. It was determined that 5.2 CFS of the 8.8 CFS could be conserved if the system were completely piped (assuming peak flows of 7 GPM/Acre delivered).

The District chose to consider pressurization to all patron deliveries as it implements its SIP. Centralized variable speed pumps would be utilized to accomplish full pressurization of the District. With respect to the relatively flat topography of the District, it was determined that there was no appreciable energy savings with a centralized pumping plant.

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 for each alternative were evaluated and broken into grouped cost elements. An At-A-Glance Map (Figure 1.0.1 and Figure 1.0.2) and associated summary tables (Table 1.0.1 and Table 1.0.2) are provided to detail the cost estimate, length of pipe, and water conservation of each alternative in this SIP.

Section 1

At-A-Glance System Modernization Summary

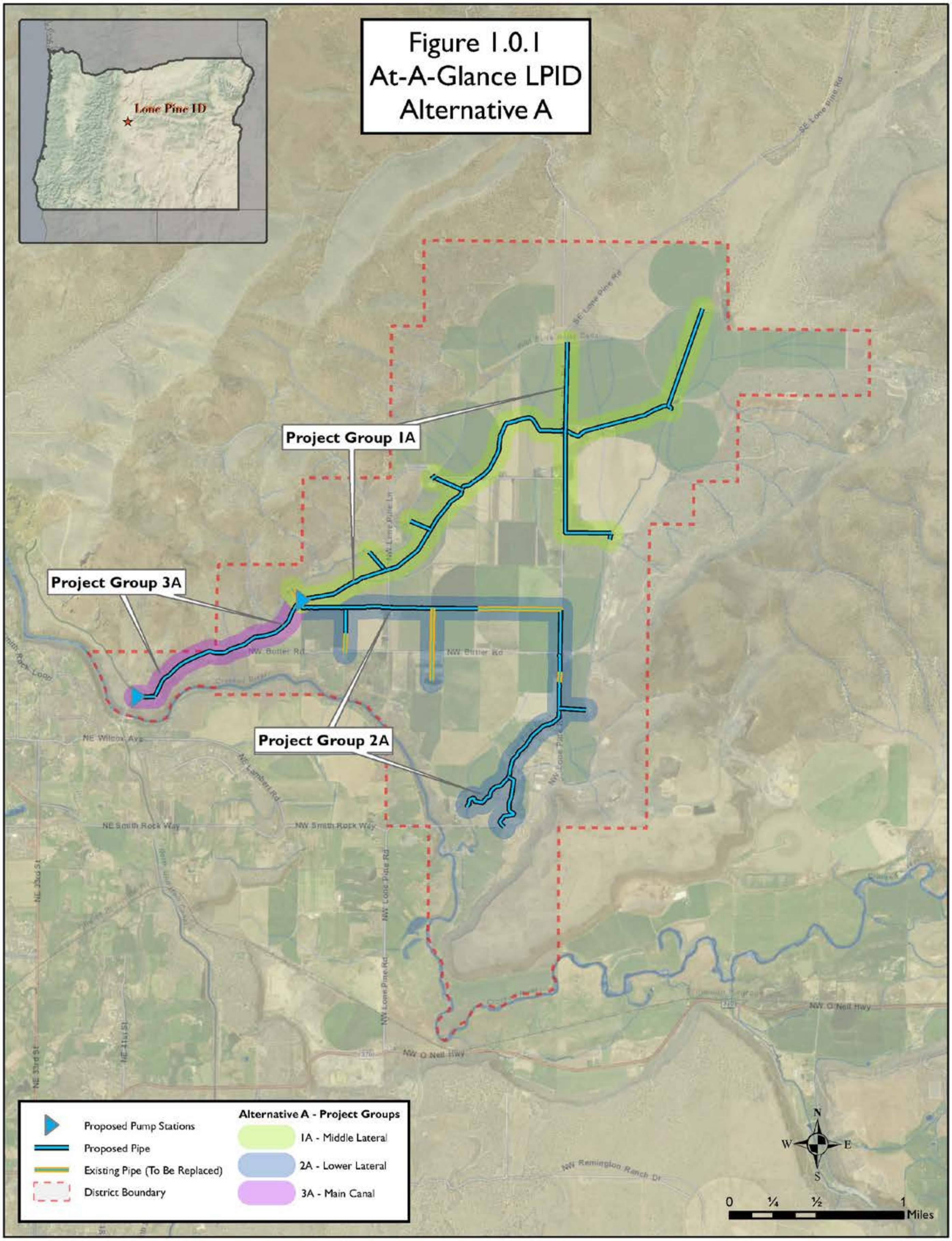


Figure 1.0.1 At-A-Glance LPID Alternative A

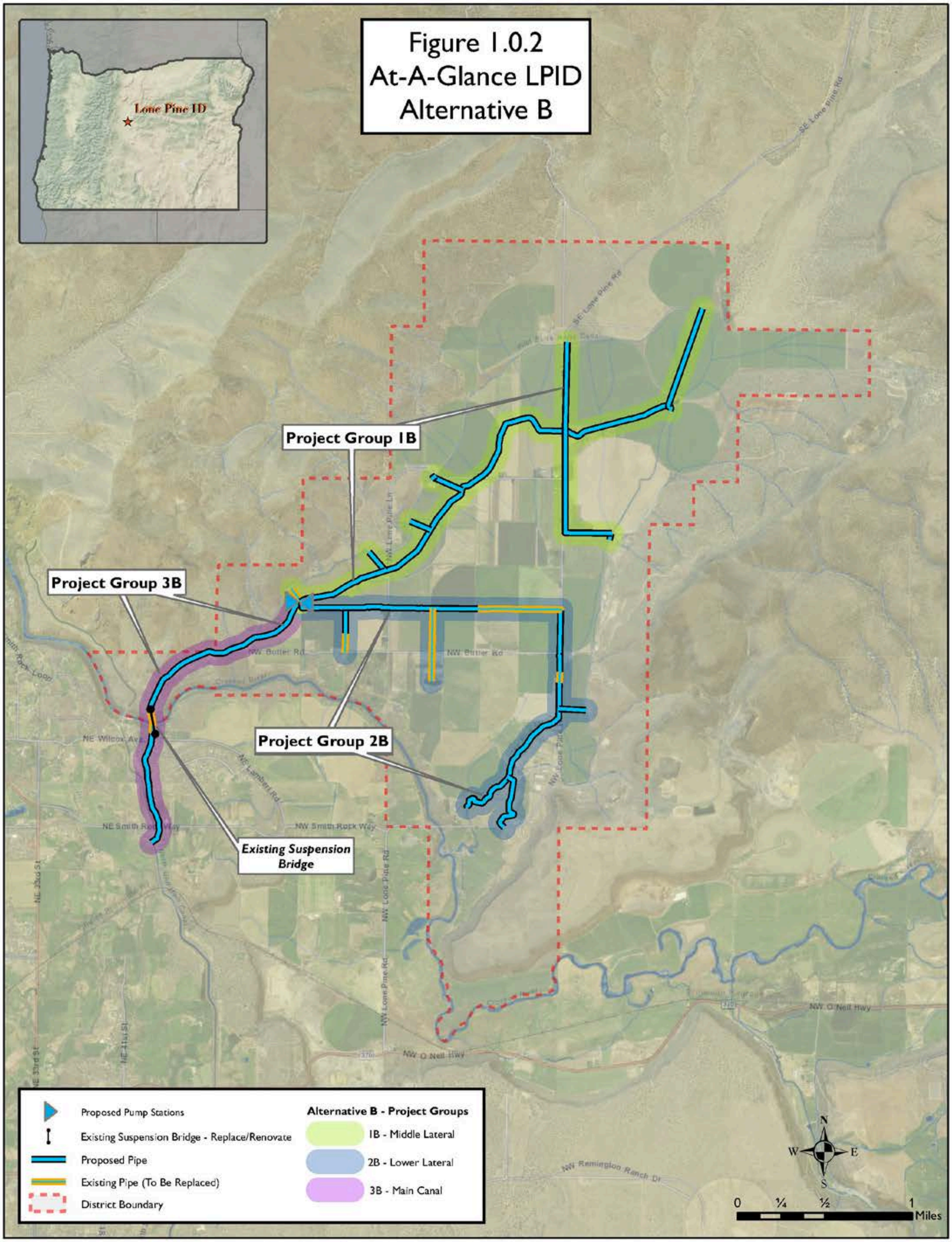


Figure 1.0.2 At-A-Glance LPID Alternative B

Table 1.0.1 At-A-Glance LPID Alternative A

AT-A-GLANCE - LPID ALTERNATIVE A						
PROJECT GROUP	**CANAL/LATERAL**	**EST. WATER CONSERVATION (CFS)**	**EST. ENERGY CONSERVATION (kWh/YR)**	**PUMP STATION INPUT POWER (HP)**	**LENGTH PIPED (FT)**	**RECON- ESTIMATED COST**
A1	Middle Lateral	2.3	N/A	335	27,847	$3,308,703
A2	Lower Lateral	1.0	N/A	N/A	17,542	$1,056,767
A3	Main Canal	1.9	N/A	670	6,222	$2,477,919
TOTAL		**5.2**	**N/A**	**1,005**	**51,610**	**$6,843,390**

Table 1.0.2 At-A-Glance LPID Alternative B

AT-A-GLANCE - LPID ALTERNATIVE B						
PROJECT GROUP	**CANAL/LATERAL**	**EST. WATER CONSERVATION (CFS)**	**EST. ENERGY CONSERVATION (kWh/YR)**	**PUMP STATION INPUT POWER (HP)**	**LENGTH PIPED (FT)**	**RECON- ESTIMATED COST**
B1	Middle Lateral	2.3	N/A	715	27,847	$3,730,885
B2	Lower Lateral	1.0	N/A	210	17,542	$1,581,193
B3	Main Canal	1.9	N/A	N/A	10,287	$4,438,376
TOTAL		**5.2**	**N/A**	**925**	**55,676**	**$9,750,454**

Section 2

Project Overview and Description

2.0 Authorization

Farmers Conservation Alliance commissioned this System Improvement Plan with support from the Energy Trust of Oregon and authorized September 20, 2015 through a Consultant Services Agreement by and between Lone Pine Irrigation District (LPID), Farmers Conservation Alliance (FCA), and Black Rock Consulting (BRC).

2.1 Purpose

Lone Pine Irrigation District currently serves approximately 19 users over 2,369 acres on the lands East of Terrebonne. Generally speaking, the District spans roughly 4 miles east of Smith Rocks State Park, is bounded by the Crooked River on the south side, and extends 5 miles north. Water rights for the District date back to October 3, 1900 for natural flow diversion from the Deschutes River, and water storage rights in Crane Prairie Reservoir date back to February 28, 1913.

The District operates and maintains over 15 miles of canals and laterals, including a few existing pipe segments and a pumping plant. The main canal conveys water by means of an open earthen ditch from the tail end of COID's Pilot Butte Canal, across the Crooked River in a PVC lined wood stave pipe, and northeast to a main distribution point. At this location three laterals branch to serve the entirety of the District: Middle, Lower, and Upper. The Middle and Lower laterals are subsequently fed by gravity. The Upper lateral utilizes a pump station which raises the water 45 feet in elevation in a 500-foot pipe, and is then fed by gravity. The volcanic nature of Central Oregon geology presents fractured basalt, cinder, and varied substrates that results in a propensity for seepage loss in many areas of LPID's canal system. A loss assessment program was orchestrated to estimate water loss throughout the District and is discussed further in this SIP.

The purpose of this SIP is to develop a well-considered evaluation of the District's primary and secondary canal system, a mitigation plan for seepage losses, and consideration of resulting pressurized deliveries. Consistent with its existing modernization program under way, system piping is to be the primary method proposed for such mitigation.

This SIP will become a key element of the District's planning documents and is expected to become the basis for future phased construction of the District's conveyance system.

2.2 Scope of Services

A joint partnership between FCA and BRC was employed to provide the following services and deliverables in conjunction with this plan.

Kickoff Meeting -

Met with District staff February 14, 2017 to confirm approach to the study. FCA and BRC developed a list of questions to review with District staff. At these meetings FCA and BRC requested documents for major system elements that affected system hydraulic modeling, a copy of the District Water Conservation Plan, water diversion/water right information, and associated operational input from the District.

FCA and BRC discussed seepage loss information with the District and the concluded loss assessment program implemented by BRC within the District.

FCA and BRC inquired about system wide pressurization and energy dissipation approach preferences of the District, if applicable (i.e. hydroelectric power generation and pressurized delivery preferences).

FCA and BRC inquired about the existing wooden stave pipe supported by the suspension bridge and the necessary steps for future renovation.

Review of Materials -

FCA and BRC reviewed materials obtained from the District following the kick-off meetings to ensure that required materials for moving the study forward were obtained or readily supplemented during the study to develop the deliverables indicated below. Data gaps that were found during the meeting process were identified and resolved with District staff.

Coordination -

FCA and BRC coordinated with LPID staff at various project milestones to confirm that the SIP continued to be developed in accordance with the direction of the District.

Seepage Loss Study -

BRC coordinated the development of seepage loss study with LPID staff. The seepage loss study identified a program of seepage loss measurements for the LPID delivery system to support loss assumptions to be used in the SIP. Results from the seepage loss study were used to assist with water conservation estimates and phasing of the modernized system implementation.

Review of Provided Flow Data -

FCA and BRC provided a thorough review of diversion data and on-farm delivery rates (per water right certificates) to ensure a clear understanding of delivery approach. BRC coordinated with the District to ensure rates used in system evaluation and modeling were as agreed by the District.

LPID SIP Base Map Development -

In conjunction with LPID staff, and direction from FCA, FireWhat developed a primary and secondary canal and lateral system base map. This map identifies the primary and secondary canal system in its existing state.

LPID SIP Proposed Map Development -

FCA and BRC (with LPID input) developed a proposed primary and secondary system piping overlay on the base map. To the extent possible, existing mapping obtained as described above was used for this purpose. This map included an aerial underlay as available and as practical to manage file size.

LPID SIP Hydraulic Model -

FCA and BRC confirmed approach regarding system pressurization with LPID. Following the agreed approach discussed with LPID and elevation information from FireWhat, FCA modeled the primary and secondary system elements (i.e. primary and secondary system canals and laterals) with EPANET hydraulic modeling software. Flow assumptions were based upon the rates agreed with LPID staff. FCA and BRC ran multiple iterations on the model to most effectively develop system elements, if applicable` (i.e. piping, pressure reducing elements - PRV stations, hydroelectric power plant locations, etc). Pipe materials and associated diameters were determined during this analysis.

LPID SIP Phasing Approach -

In conjunction with the system model and upon review with LPID, FCA and BRC developed a system improvement cost estimate that was broken down by District laterals and the main canal. This will allow the District flexibility in implementation development and design considerations based upon funding availability and other critical considerations.

LPID SIP Conservation Table -

FCA and BRC developed a table indicating water conservation estimates based upon historic diversions, desired delivery rates within a fully piped system, and also corroborated by the loss assessment program results.

Final SIP Mapping -

In conjunction with LPID staff, FCA and BRC developed a final modernization map indicating primary and secondary canal system elements, indicating existing and proposed piping, and other key system elements.

Reconnaissance-Level Cost Estimate -

FCA and BRC coordinated with a reputable material vendor and developed reconnaissance-level cost estimating for the proposed piping system and pumping identified for the District.

SIP Reporting -

FCA and BRC compiled the results of the SIP study into this System Improvement Plan draft report for review and comment by LPID. Comments received were incorporated as appropriate into the Final SIP Report. The report summarizes all findings for elements identified above and includes mapping.

2.3 Goals and Objectives – District Meeting(s)

As indicated in the scope, BRC and FCA met with District staff on February 14, 2017. FCA, BRC, and District staff discussed key project parameters required to establish the approach for the SIP.

The meeting was attended by:

Terry Smith, Lone Pine District Manager
Dan Kaler, FCA Staff Engineer
Jer Camarata, Swalley District Manager
Kevin L. Crew, Principal, Black Rock Consulting

Key agenda items addressed were as summarized below:

1) Data Needs: District Water Right Certificates, District's Water Management and Conservation Plan, District's Most Recent Irrigated Acre Accounting (Direct River Points of Delivery and Primary Diversion).

   These materials were either provided to FCA or BRC and discussed in some detail, or direction was provided on where to obtain these materials. Clarifications were provided by the District.

2) What are the plans for piping and pressurization of the District?

   The District has some segments of piping already in place. Certain segments of existing pipe may tolerate pressurization whereas others likely will not. For the purpose of the study, the entire system was proposed to be replaced with HDPE pipe. During the design phase, existing pipe can be evaluated to remain as is on a case-by-case basis. The District will evaluate what pipes it may wish to preserve once it has the model results, including anticipated pressures, etc. and as it designs and implements its improvements.

   An evaluation should be provided on whether the District will renovate or replace the existing wooden stave pipe spanning the Crooked River or construct a new system served by the North Unit main canal.

   Generally, the District plans to pipe a majority of its system, however, the prioritization and timing of piping will be an ongoing consideration by the District.

   It was noted that total system pressurization for all patrons on the system would be preferred. FCA and BRC were to model the system with a minimum of 60 PSI to all users. After initial review of the SIP and the high pumping input power *requirements, a minimum 40 PSI should be evaluated. The SIP has been revised in to provide a minimum 40 PSI.*

3) For peak delivery flow rate to the District's irrigated properties, what flow rate should be used in the model for peak flow rates?

   The model should use 7 GPM/Acre for normal delivery modeling at 5 FT/S velocities or less in system elements per NRCS guidelines. It must also be confirmed that one additional condition will work within the proposed systems: an uncommon high flow rate of 9 GPM/Acre with allowance for velocities to exceed 5 FT/S should be evaluated. This would ensure that the system will operate satisfactorily under future scenarios if additional irrigated lands were attributed to the canal system and furthermore, to address climate change scenarios.

4) FCA and BRC indicated that it planned to break the canal piping cost estimates into groups for flexibility in modernizing the system. Each project group may be broken down into smaller increments if necessary to provide the District with a high level of flexibility in project financial planning and implementation packaging.

   The District agreed with this approach.

5) Does the District anticipate any shift of acreage or flow rates within the District boundary and service areas?

   Yes, the District indicated that 100 Acres of irrigated farmland could potentially be added to the north end of the District.

Section 3

Existing System

3.0 Existing System Description

Please refer to Figure 3.0.1 regarding the existing District Delivery System that indicates the District's service territory boundary, measurement points, and the primary/secondary canal system.

Under its water rights, LPID diverts water from the Deschutes River which is conveyed via the COID distribution system. The primary transmission canal for LPID diverts water near the termination of COID's Pilot Butte Canal. The source of diverted water is based on two water right certificates which govern the District's storage and direct river diversion limitation, as indicated in Section 3.1 below. For storage withdrawals, the District cooperates with COID and AID for water provided from Crane Prairie Reservoir.

As indicated on Figure 3.0.1, the LPID main canal conveys water north over the Crooked River before veering east to split into 3 laterals (Upper, Middle, and Lower). The bridge which spans the Crooked River is an antiquated suspension type bridge supporting a 36-inch wood stave pipe with a PVC "ultraliner." The PVC Alloy Liner is a low pressure rated pipe material that is inserted into wood stave pipe to mitigate losses. It has been indicated that this pipe is not rated for pressure, and the liner relies on the host (wood-stave) pipe to withstand any significant pressure.

Water delivered by the main canal diverges into three laterals: Upper, Middle, and Lower, roughly a mile after it crosses the Crooked River. The Middle and Lower laterals are gravity-fed, while the Upper lateral is served by a pump station at the split. Water is pumped approximately 45 feet to the Upper lateral which then operates via gravity serving the patrons along the lateral. Piping has occurred in some locations within the District (see Figure 3.0.1), and retention of these pipes will occur on a case-by-case basis. In all, the District operates over 15 miles of canals and laterals.

The topography of Lone Pine is relatively flat. The main canal falls about 20 feet from the point of diversion located at the tail end of the Pilot Butte Canal to where it splits into the three laterals. The Upper lateral rises 45 feet in elevation initially and drops 15 feet over the length of the lateral. The Middle lateral drops 86 feet and the Lower lateral drops 20 feet.

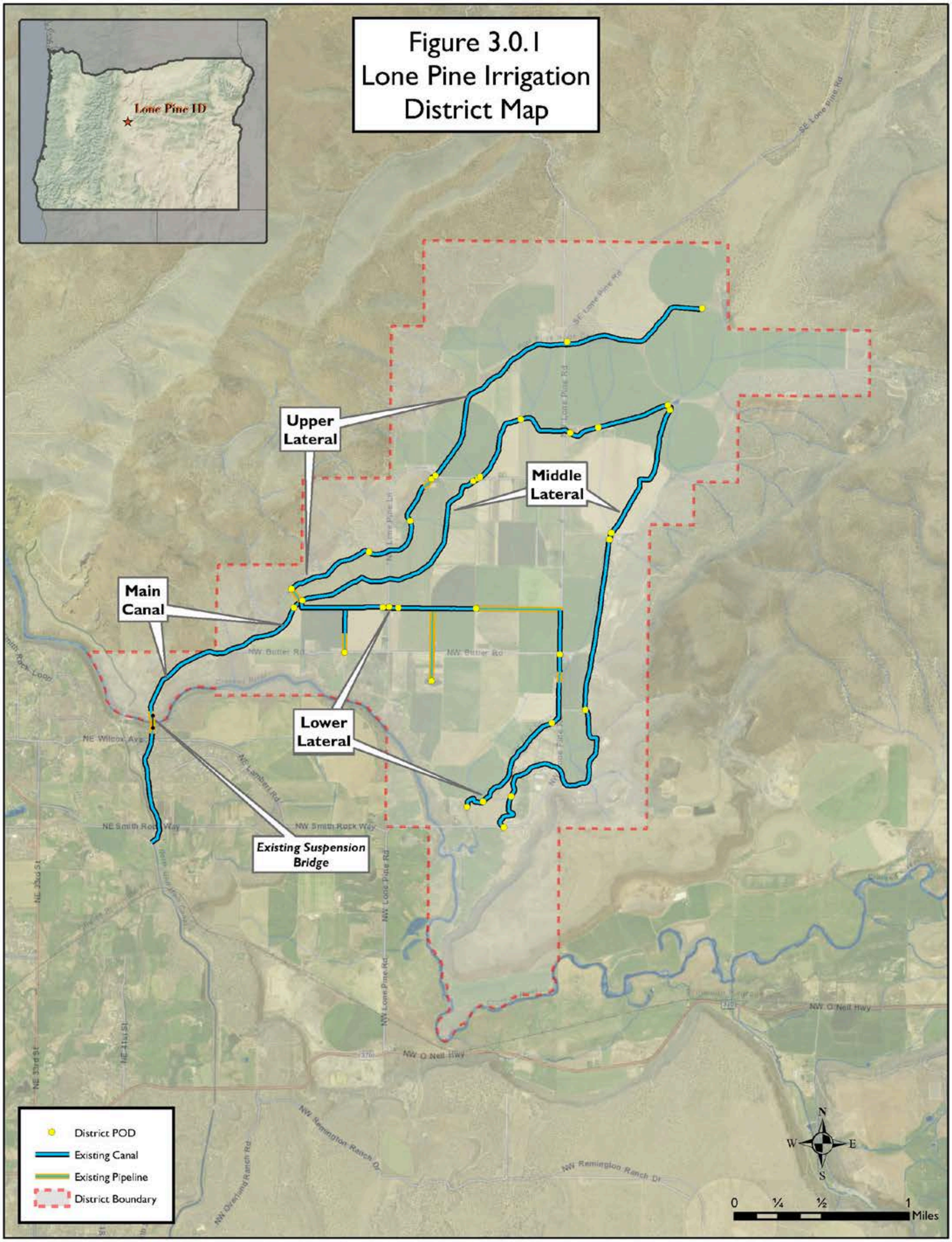


Figure 3.0.1 Lone Pine Irrigation District Map

3.1 Water Supply and Certificates

Lone Pine Irrigation District operates based on two water right certificates. Complete water right information is not included in this SIP but may be obtained from the Oregon Water Resources Department or the District's Water Management and Conservation Plan. It should be noted that the District's water rights change from time to time with conservation activities, hydroelectric power development, transfers, and other water right activities. For the purposes of this SIP, the primary goal is to evaluate the modernization of the District's conveyance system, therefore, information regarding Water Right Certificates #72197 & 76685 is as follows:

<u>Certificate 72197</u>

Source: Deschutes River, a tributary of the Columbia River
Priority: October 31, 1900
Use: Primary irrigation of 2,369 acres
Duty: 1 CFS to 137.0 acres 4/1 - 5/1 and 10/1 – 11/1
1 CFS to 109.0 acres 5/1 – 5/15 and 9/15 – 10/1
1 CFS to 86.6 acres 5/15 – 9/15
Not to exceed 4.2 acre-feet per acre per year
Maximum Rate: 29.1 CFS

<u>Certificate 76685</u>

Source: Deschutes River, a tributary of the Columbia River
Priority: February 28, 1913
Use: Storage of 50,000 acre-feet in Crane Prairie Reservoir. To be used in conjunction with Arnold and Central Oregon Irrigation Districts
Duty: N/A
Maximum Rate: N/A

For the purposes of this SIP, the most critical elements of this certificate are the duty and the rates allowable for diversion and District use. No water transmission loss assumption was noted in the certificates. The extent of water loss mitigation is further discussed in the System Loss Assessment section of this SIP.

3.2 On-Farm Water Demand Analysis - Acreage and Duty

As indicated above, in combination with water right #72197, the current cumulative allowable diversion during peak irrigation season is 5.18 GPM/Acre for a vast majority of the District. However, LPID receives supplemental water as part of the agreement with water right #76685. A specified rate was not provided in the storage water right.

For the purposes of this SIP, and based upon District input, a SIP design delivery flow rate was established at the calculated on-farm rate of 7 GPM/Acre. At this flow rate per acre, and based upon the Natural Resources Conservation Service criteria, 5 FT/S was used as a maximal velocity criterion for proposed piping of the system. The pipe models were also evaluated to an extreme value of 9 GPM/Acre to ensure that the system would still function properly and to provide future flexibility to the District. Under this higher flow rate, velocities were evaluated to ensure that they did not dramatically exceed the 5 FT/S criteria. It should be noted that at 9 GPM/Acre, the minimum pressure of 40 PSI would not be met.

3.3 System Loss Assessment

Black Rock Consulting worked with the District to coordinate a seepage loss study performed by Farmers Conservation Alliance staff under the direction of Black Rock Consulting principal, Kevin L. Crew, P.E and David C. Prull, P.E. During the summer of 2016, the Seepage Loss Assessment Program (LAP) funded by the Farmers Conservation Alliance the Energy Trust of Oregon and supported by Oregon State University and the Oregon Water Resources Department was implemented in 7 of the 8 Central Oregon Irrigation Districts. The outcome of the LAP was used to inform the Districts of current system losses and to enhance SIP development for these Districts. The program included the use of newly purchased and calibrated Flowtracker II technology, manual, office and field training, all in accordance with the United States Geological Survey and United States Bureau of Reclamation "Discharge Measurements at Gauging Stations – Chapter 8 of Book 3, Section A, Techniques and Methods 3-A8". The program was managed by Oregon Registered Professional Engineers, Kevin L. Crew, P.E. and David C. Prull, P.E.

The primary purpose of the LAP program, as applied to the Districts, was to perform a one-time measurement program in each District to inform the District SIPs of approximate water losses throughout the system. With the vast number of measurements that needed to be collected, measurements were performed at different times of the irrigation season within each District. This resulted in data that was not always obtained during peak conditions. Results of the study were used to provide a strong indication of losses. The results were interpolated or extrapolated based upon the maximal expected loss within each District as indicated in the SIP below. The final loss information was used to identify losses associated by project phase or lateral depending upon each specific District SIP. In instances where grants are to be allocated in direct exchange for conserved irrigation water (dedicated by revised water rights certificates to instream flow), the grantor may be compelled to confirm these seepage loss results. This can be accomplished by conducting a subsequent loss measurement program performed by the USGS and/or the Oregon Water Resources Department prior to project implementation.

For LPID, the LAP was implemented throughout the District's primary canal and system laterals. Results for the LAP study within LPID are included in Appendix A to this SIP. A tabulated summary of the results is provided in Table 3.3.1.

Table 3.3.1 Lone Pine Irrigation District Water Loss Assessment

LONE PINE IRRIGATON DISTRICT WATER LOSS ASSESSMENT				
Canal/Lateral	Measured (Y/N)	Loss Measured (CFS)	Adjustment Factor	Adjusted Conservation Estimate (CFS)
Upper Canal	Y	1.4	0.59	0.8
Middle Canal	Y	2.5	0.59	1.5
Lower Canal	Y	1.7	0.59	1.0
Main Canal	Y	3.2	0.59	1.9
Total		**8.8**		**5.2**

The adjustment factor provided in the table is the simple ratio of the estimated total piped conservation (fully piped system) at a delivery rate of 7 GPM/Acre, 5.2 CFS (see Table 3.3.2 below), versus the measured system loss of 8.8 CFS.

Total piped system conservation estimates were developed as a comparison between anticipated peak delivery and peak historical delivery rates over the last 10 years. Delivery acreages assessed for the LPID system were used to estimate the fully piped system flow rates at the peak certificate rate (7 GPM/Acre). Flow diversion data for the District was evaluated to determine the peak diverted flow rate (43.5 CFS) over the last ten years of operation. Additionally, the district verified this was the maximum capacity of the distribution system. This peak was compared to the peak piped flow rate to estimate potential conservation based upon a completely piped delivery system (including all laterals and private laterals down to the individual patron turnouts). The results of this total conservation estimate are tabulated in Table 3.3.2.

Table 3.3.2 Lone Pine Irrigation District Conservation Estimates

LONE PINE IRRIGATION DISTRICT WATER CONSERVATION ESTIMATE			
Acreage	Maximum Diversion (CFS)	Diversion Rate at 7 GPM/ACRE (CFS)	Estimated Max Conservation at 7 GPM/ACRE (CFS)
2,469	**43.5**	**38.3**	**5.2**
Notes: 1. Acreage includes future predicted acreage of 100 acres 2. Maximum Diversion is peak flow rate over the last 10 years and verified by district observations			

Section 4

System Improvement

4.0 System Improvement Approach

The primary purpose of this SIP was to identify water conservation, hydroelectric power and pumped power conservation possibilities for the District, and to develop a mitigation strategy for system water losses. Although some limited piping has already occurred in the District, there remains a significant open canal system allowing for mitigation through piping. Consistent with its Scope of Services and the subsequent goals and direction provided by the District, FCA in concert with BRC, performed a comprehensive hydraulic model and associated piping/pressurization evaluation of the District.

There are two primary alternatives for the mitigation of seepage losses. The first is canal lining and the second is canal piping. Within each of these alternatives there are a variety of material choices. Canal lining involves the installation of an impervious system to cover the canal bottom and banks. Materials typically employed include geomembranes, rubber liners, shotcrete, or similar materials. Canal lining does not provide pressurization of the irrigation system, and lining also increases canal velocities, thus increasing risk to people. Over a 50-year life cycle, it was found that canal lining may be less expensive to implement in its first installation cycle than piping, however, canal lining requires significant maintenance and replacement cycles that ultimately cause it to exceed the cost of piping over time. Also, given the desire of the District to optimize pressurized deliveries to its patrons, piping was chosen as the District's preferred choice for canal water loss mitigation.

FCA commenced the process of hydraulic modeling for LPID by receiving base EPANET (.INP) files from FireWhat in electronic form. The files were generated by FireWhat by including spatially (i.e. northing, easting, and elevation) correct patron turnout locations and the associated delivery flow rates at each turnout. Updated acreages, by patron, were provided by the District for this purpose. EPANET modeling is discussed further in Section 4.5 of this SIP. From the base files, FCA modified the data using Microsoft Excel 2016 to calculate pipe size based on flow rate. Modified data was input in EPANET and used to determine the static and dynamic pressure throughout the system. The District was modeled based on existing conditions with an intake at the Deschutes River and incremental gravity pressurization of the system.

The system was evaluated as a completely closed system, i.e. fully piped and pressurized to its extremities. The completed model was calibrated and pipes were sized based upon a peak velocity of 5 FT/S for proposed piping at 7 GPM/Acre and selected pipe manufacturer information.

Two alternatives were evaluated to convey water to the District: Alternative A – pumping water from the North Unit main canal just north of the Crooked River and Alternative B – renovating or replacing the existing suspension bridge. Both alternatives involve abandoning the Upper lateral and serving patrons via the Middle lateral.

Once this process was completed, the system was evaluated for cost as detailed below. "Project Groups" were developed in incremental segments, piping each lateral and associated main canal from the bottom up. This approach is subject to modification based upon available funding and District operation and preference over time.

4.1 Pipe and Valve Materials

Pipe material selections were made by Dan Kaler, E.I.T, with guidance from Kevin L. Crew, P.E., based upon 29 years of experience with large diameter piping systems including 20 years of experience in Central Oregon. From the hydraulic model, both static and dynamic pressures were evaluated throughout the system to select appropriate pipe material options. For pipe up to 63-inches in diameter, high density polyethylene solid-wall pipe was selected due to its outstanding abrasion resistance, longevity, and ability to be pulled into canal curve alignments.

Valves for pressure reducing stations were technically assessed and narrowed down to plunger valves and Cla-Val valves. Both use internal energy dissipation within the valve to accomplish the needed pressure-sustaining function downstream of the valves. Cla-Val valves use a control tubing and a diaphragm/bonnet arrangement to adjust pressures within the pressure reducing apparatus. No power is necessary for the operation of a Cla-Val. With the strategy laid out in this report, pressure reducing valves should not be necessary. However, should pressure reducing valves be required in the future, Cla-Val E-90-01 pressure reducing valves should be considered.

4.2 Hydroelectric Power Potential, Pumping Mitigation, and Pressurization Approach

The hydraulic analysis for the District indicates that there is no appreciable hydroelectric power potential.

The District has indicated that they would like to pursue full pressurization of the piped system. In order to do so, centralized pump stations must be utilized to pressurize the system. This approach would negate the need for individual pumps throughout the District. However, there would be no appreciable energy conservation with respect to pump energy.

4.3 Elevation Data

Quantum Spatial of Corvallis, Oregon, was commissioned to fly LiDAR over the entirety of LPID. Elevation data and spatial layout of the District's delivery system was derived from the LiDAR data flown in November 2016. The data was post-processed to the requirements of FCA and BRC. Specifications for the data collection are provided in Table 4.3.1.

Table 4.3.1 LiDAR Flight Parameters

Multi-Swath Pulse Density	≥ 8 pulses/m^2
Scan Angle	≤30^o (+/-15^o from Nadir)
Returns Collected Per Laser Pulse	Up to 4
Intensity Range	1-255
Swath Overlap	50% side-lap (100% overlap)
Maximum GPS Baseline	13 nautical miles

With the use of on-ground RTK and OPUS corrections, the data was provided in 1-foot contour interval format and was considered better than 1-foot accuracy vertically.

Units for the elevation information were reported and used in the following systems:

- Horizontal Projection: Oregon State Plane (ORSP) South Zone. International Feet
- Horizontal Datum: NAD83(2011)(Epoch2010.00)
- Vertical Datum: NAVD88 using Geoid12A

4.4 District Flexibility

The District has requested system flexibility to insure, within reason, system changes, added and subtracted irrigated acreage, effects of climate change, effects in cropping patterns, and similar system demands may be addressed in this SIP.

The system was modeled with demands for on-farm delivery rates of 7 GPM/Acre. This in and of itself is conservative because it is unlikely that every patron within the District is irrigating at the same moment at full water right demand.

The system was modeled with additional acreage to account for future demand increases. It was indicated by the District that 100 acres on the north side of the District be included during the modeling analysis.

Piping proposed in this SIP and base hydraulic model will accommodate this additional acreage that was assigned at the end of the Middle lateral.

Modeled system demands were increased to 9 GPM/Acre. At 9 GPM/Acre there were multiple system locations where the minimum 40 PSI pressure was not met. This is due to the fact that the pumps were sized to provide a minimum 40 PSI operating at 7 GPM/Acre. The system would still operate in this scenario; however, the minimum pressure of 40 PSI would not be met.

4.5 Hydraulic Modeling

EPANET –

EPANET was used to model the District's proposed piped network. EPANET is a free-ware product that is maintained by the EPA. The Natural Resources Conservation Service technical offices in Oregon use EPANET exclusively for hydraulic modeling. For these reasons, EPANET was selected as the modeling software of choice for this SIP.

EPANET modeling capabilities go beyond steady-state hydraulic modeling. The software is capable of chemical transport analysis and variable flow modeling. A description of some of its capabilities follows:

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated.

EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems analysis. Sampling program design, hydraulic model calibration, chlorine residual analysis, and consumer exposure assessment are some examples. EPANET can help assess alternative management strategies for improving water quality throughout a system. These can include:

- altering source utilization within multiple source systems,
- altering pumping and tank filling/emptying schedules,
- use of satellite treatment, such as re-chlorination at storage tanks, and
- targeted pipe cleaning and replacement.

Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include color-coded network maps, data tables, time series graphs, and contour plots.

Hydraulic Modeling Capabilities –

Full-featured and accurate hydraulic modeling is a prerequisite for doing effective water quality modeling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- places no limit on the size of the network that can be analyzed,
- computes friction headloss using the Hazen-Williams, Darcy- Weisbach, or Chezy-Manning formulas,
- includes minor head losses for bends, fittings, etc.,
- models constant or variable speed pumps,

- computes pumping energy and cost,
- models various types of valves including shutoff, check, pressure regulating, and flow control valves,
- allows storage tanks to have any shape (i.e., diameter can vary with height),
- considers multiple demand categories at nodes, each with its own pattern of time variation,
- models pressure-dependent flow issuing from emitters (sprinkler heads), and
- can base system operation on both simple tank level or timer controls and on complex rule-based controls.

Velocity Criteria –

As stated above, the maximum velocity criteria was set at 5 FT/S for on-farm deliveries at 7 GPM/Acre. The peak evaluated flow rate was 9 GPM/Acre for future system flexibility and was allowed to increase beyond 5 FT/S in modeling as indicated above.

Elevations –

As indicated above, elevation data was derived from a 2016 LiDAR flight.

Spatially Correct Layout –

Horizontal information for the various system elements and patron turnouts was collected through a field survey performed by District staff and FireWhat in 2016. Turnout locations were "snapped" to the canal centerline (perpendicular to the centerline) as determined through post-processing of the LiDAR data and locating canal and lateral centerlines. The "snapped" locations represented turnout node locations used during hydraulic modeling of the system and were represented in the model by Northing and Easting coordinates of the Oregon State Plane South Zone.

Pipe Diameter Selection –

Pipe diameter selections were derived iteratively in the hydraulic model with the first iteration being a rough estimate. The second iteration utilized actual pipe diameters for high density polyethylene pipe material at the appropriate dimension ratio and pressure rating for each model "link" (pipe). Generally, the third iteration adjusted all pipes in the system to a range of 4 FT/S to 5 FT/S at the peak system flow rates based upon 7 GPM/ Acre.

Pipe Pressure Rating Selection –

HDPE solid-wall pipes (PE4710 resin) were sized from HDPE pipe sizing tables for the expected static pressure for each pipe segment.

The model for the LPID is included in Appendix B of this SIP.

4.6 Cost Estimating by Lateral (and Main Canal)

Pipe Estimates –

Pipe material estimates were provided by reputable vendors that routinely supply pipe materials to Central Oregon projects. Pipe material budgetary estimates are provided in Appendix C for reference.

Turnouts –

For the purposes of this SIP, patron turnouts were assumed to be converted to pressurized delivery systems. A standard pressurized irrigation delivery turnout was assumed to include an appropriately sized tee from the mainline or lateral, a pressure relief valve, a gear-actuated plug valve (or gate or possibly butterfly valve in smaller turnout situations), a magnetic meter, a combination air and vacuum relief valve and associated hardware, and spool pipe segments. Based upon experience with similar installations at irrigation districts in Central Oregon, the cost of installation of a turnout was set at an estimated average cost of $8,000 per installation.

Construction –

Contractor procurement may come in several forms in Oregon. Design-Bid-Build is a conventional process wherein the survey and design is developed first, and then a traditional competitive bid is held to obtain the lowest-cost responsive and responsible bidding contractor. In this process, typically the design-engineering firm will serve as the inspection/construction management firm during the course of construction. Given the magnitude of the project phases and for the purposes of this SIP, a Construction Manager General Contractor (CMGC) model was assumed. In this contractor procurement method, design would precede obtaining the contractor, however, the contractor would include construction management in its delivery of the constructed project. An estimated contractor fee structure of 12% of the project value was assumed for this construction delivery method depending upon the size of the lateral or main canal project being evaluated.

Engineering, Construction Management –

Engineering and Owner's Representative/Inspection services typically range as high as 10%-18% of construction value. For the purposes of this SIP, and assuming that project phases are constructed sequentially and annually, it was assumed that a total fee of 10%-12% for survey, engineering design, and inspection/owner's representative services would be appropriate depending upon the scale of the particular lateral or main canal project. This was based upon the experience of Black Rock Consulting on similar projects deployed in Central Oregon.

Contingency –

The contingency percentage was carefully considered. The Association for the Advancement of Cost Engineering (AACE) is a nationally recognized organization that has developed an accepted system of contingency ranges based upon project specificity level "Class". There are 5 project Classes starting from Class 5 with only conceptual project definition to Class 1 where a project has been completely developed and bid. This SIP was considered to fall within the Class 4 definition. The AACE Class 4 project specificity level (i.e. a project at 1%-15% definition) carries an anticipated contingency range from -15% to -30% on the low end of the range to +20% to +50% on the high end of the range. We selected a contingency value of +30% that is in the middle of the positive contingency range provided by AACE. It should be noted that the phased cost estimate is based largely upon the cost of pipe materials. Budgetary pricing for high density polyethylene pipe was found to be very competitive at the time of development of this SIP. High density polyethylene solid-wall pipe is manufactured from an oil-based pelletized product. The pellet pricing is tied directly to the cost of oil at the time of pipe manufacture ordering. Given that oil prices have been reduced in the past two years and will likely rebound, it should be anticipated that pipe material pricing will increase significantly with time. The timing of such increases will be dependent upon oil pricing, the economic conditions at the time of order, and the demand for pipe at the time of order. Steel pipe pricing was provided at anticipated rates. Steel commodity pricing and manufacturing also fluctuates significantly over time. For construction that is completed soon after the development of this SIP, the cost estimates should remain robust. For work lagging several years beyond the development of this SIP, the risk of cost change is greater. For this reason, it is recommended that every 2 years a cost evaluation be performed to update the phased construction cost estimates.

Section 5

Lone Pine System Improvements by Project Group

5.0 System Improvement Operational Description and Assumptions

In order to provide LPID with a comprehensive plan to modernize their irrigation system, this SIP investigates two alternative methods of providing the District with water. Both options outline a similar distribution system to provide pressurized water to all patrons of the system. This plan proposes removing the existing Upper lateral. All patrons currently served by the Upper lateral would receive pressurized water from the Middle lateral once fully piped. Supply water must first cross the Crooked River, as outlined by Alternative A and Alternative B.

Alternative A utilizes the NUID flume over the Crooked River to supply their main source of irrigation water. Water for the main canal of LPID would be pumped out of the NUID main canal immediately after crossing the Crooked River. This distribution pump is sized to pressurize the entire Lower lateral with a minimum pressure of 40 PSI. An additional booster pump would be required for the Middle lateral to provide a minimum pressure of 40 PSI to all patrons. It should be noted that for pump sizing purposes there are a select few locations at the far reaches of the district that do not meet the 40 PSI minimum when the system is operating at full capacity.

Alternative B utilizes the existing suspension bridge to supply their main source of irrigation water from the tail end of COID's Pilot Butte Canal. It has been noted that this bridge is in need of renovation or replacement. A cost estimate for renovation or replacement of the bridge was beyond the scope of this SIP, therefore, it is not included herein. Should Alternative B be selected for system modernization, further analysis should be performed on the bridge and any associated costs included in the modernization strategy. Pipes were sized to handle a fully pressurized system via COID's Pilot Butte Canal; however, the system was still laid out to operate as a standalone system.

COID is undergoing a similar modernization strategy. If the Pilot Butte Canal is piped as outlined in the COID SIP, there is potential to pressurize the entire Lone Pine system via the Pilot Butte Canal. An agreement between LPID and COID would be required for this to occur. The pipe sizing and associated estimates for Alternative B account for the potential pressure from COID. The model was analyzed with the potential static pressure of 96 psi at the origin of the LPID system. Pipes were sized accordingly to handle this pressure throughout the system. It should be noted, that if this were the case a pressure reducing station for the lower lateral would be required.

Although the pipes were sized to handle pressurization from COID, the system was still designed to operate as a standalone system. In order to provide pressurized water to all patrons, two pumps would be required at the split between the middle and lower lateral. Water supplied from the Pilot Butte Canal would be gravity-fed to the point of diversion of the Middle and Lower lateral. At this location a booster/distribution pump would be required for each respective lateral. These pumps were sized to provide a minimum pressure of 40 PSI to all users on each lateral.

Each alternative has been separated into three project groups (1, 2, & 3). These project groups provide the District with the most flexibility to modernize the system. It should be noted again that cost estimates incorporate replacing all existing pipe with HDPE. During the design phase, retention of existing pipe segments may be analyzed further by the District. Cost estimates and overview maps are provided below for each alternative and respective project group.

Figure 5.1.1
Project Group 1A Area Map

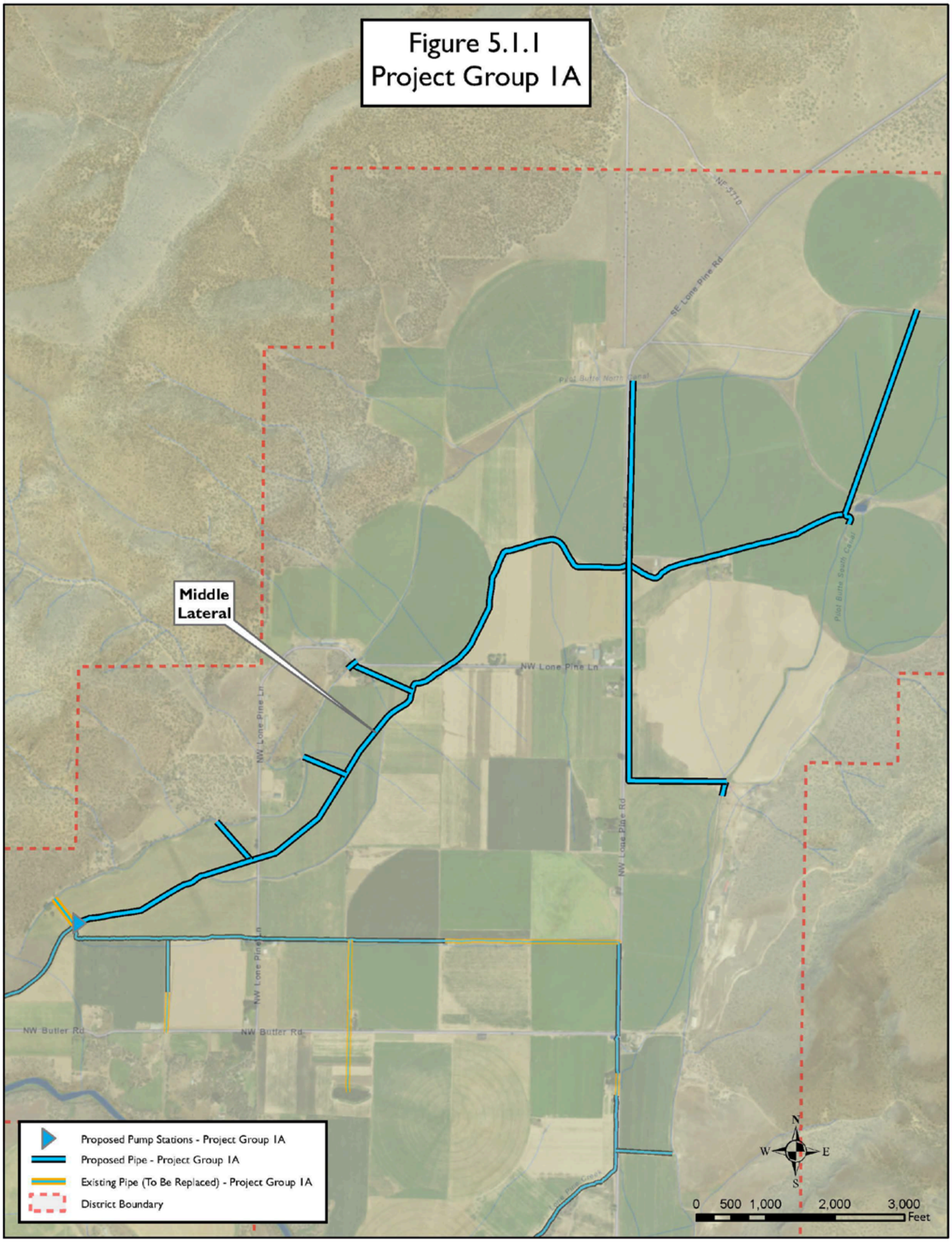


Table 5.1.1 Project Group 1A Cost Estimates

Project Group 1A - Middle Lateral Lone Pine Irrigation District Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Middle Lateral	32	21	2,750	LF	$155.39	$427,367
Pipe	Middle Lateral	30	26	1,907	LF	$111.44	$212,475
Pipe	Middle Lateral	30	21	2,033	LF	$136.60	$277,653
Pipe	Middle Lateral	26	21	2,405	LF	$102.55	$246,581
Pipe	Middle Lateral	28	21	168	LF	$118.93	$19,970
Pipe	Middle Lateral	20	26	943	LF	$49.52	$46,692
Pipe	Middle Lateral	14	26	2,222	LF	$24.24	$53,859
Pipe	Middle Lateral	24	21	1,545	LF	$87.40	$135,056
Pipe	Middle Lateral	20	21	183	LF	$60.67	$11,094
Pipe	Middle Lateral	8	26	864	LF	$9.21	$7,962
Pipe	Middle Lateral	4	26	472	LF	$2.50	$1,179
Pipe	Middle Lateral	6	26	746	LF	$5.43	$4,052
Pipe	Middle Lateral	8	32.5	3,675	LF	$7.42	$27,258
Pipe	Middle Lateral	4	32.5	84	LF	$2.01	$169
Pipe	Middle Lateral	10	32.5	3,125	LF	$11.56	$36,127
Pipe	Middle Lateral	10	21	4,511	LF	$17.55	$79,166
Pipe	Middle Lateral	8	21	212	LF	$11.29	$2,399
Turnouts	Middle Lateral		-	16	EA	$8,000	$128,000
	SUBTOTAL						$1,717,062
	ENGINEERING, CM, SURVEY				10%		$171,706
	GMGC				14%		$240,389
	CONTINGENCY				30%		$638,747
	335 HP PUMP STATION						$540,800
	TOTAL						**$3,308,703**

Table 5.1.2 Project Group 1A - Pump Station 1 - Cost Estimates

Lone Pine Pump Station 1 - Alternative A (335 HP VFD) Lone Pine Irrigation District Reconnaissance-Level Construction Cost Estimate					8/14/2017
Feature	**Size**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
Mobilization		1	EA	$20,000	$20,000
Civil Works		1	EA	$100,000	$100,000
Pump/Motor	335 HP	1	EA	$75,000	$75,000
Controls		1	EA	$30,000	$30,000
Electrical		1	EA	$65,000	$65,000
Building		1	EA	$30,000	$30,000
	SUBTOTAL				$320,000
	ENGINEERING, CM, SURVEY		12%		$38,400
	CMGC		18%		$57,600
	CONTINGENCY		30%		$124,800
	TOTAL				**$540,800**

Figure 5.2.1
Project Group 2A Area Map

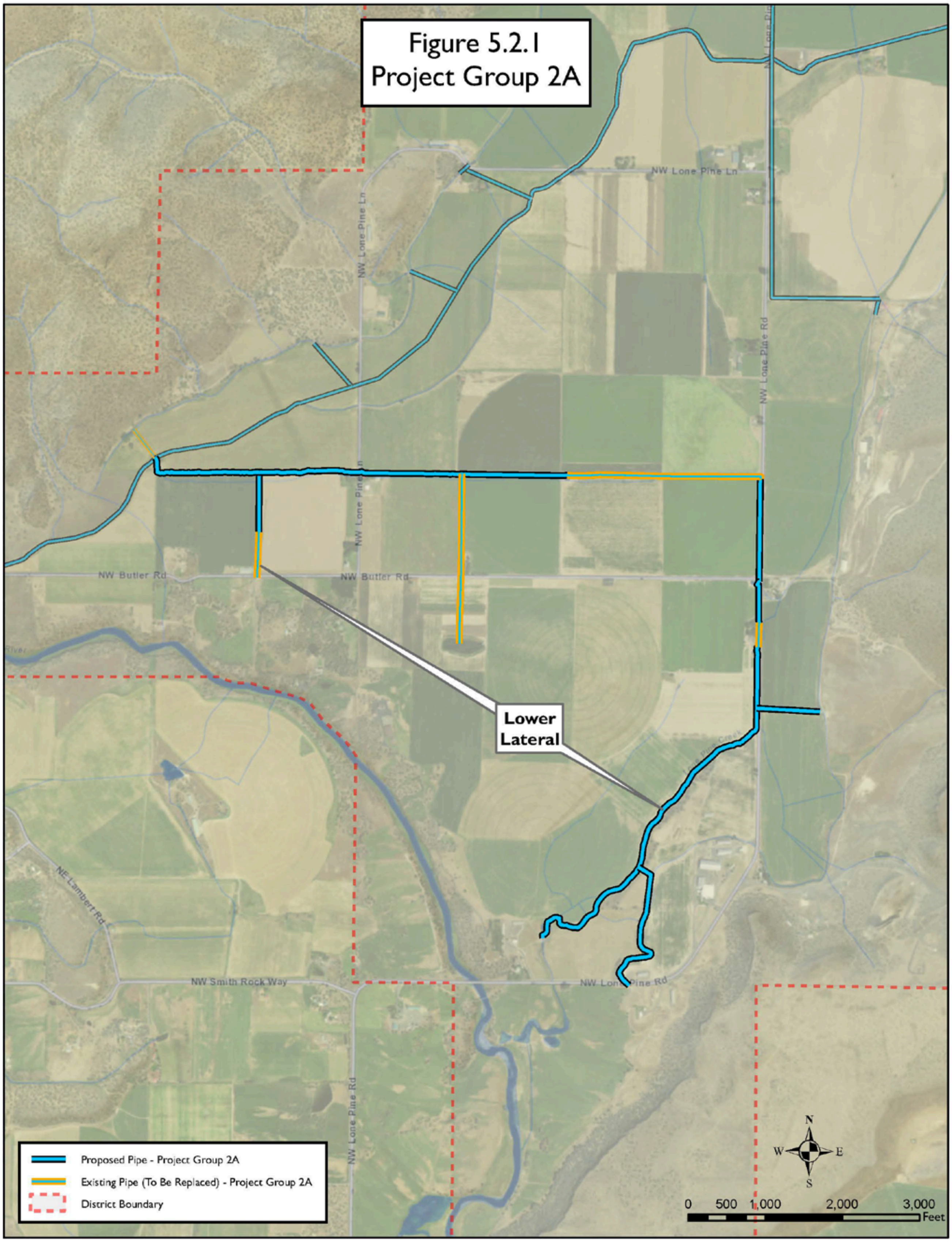


Table 5.2.1 Project Group 2A Cost Estimates

Project Group 2A - Lower Lateral							
Lone Pine Irrigation District							
Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Lower Lateral	24	32.5	1,139	LF	$57.49	$65,494
Pipe	Lower Lateral	24	26	1,510	LF	$71.31	$107,657
Pipe	Lower Lateral	20	26	1,327	LF	$49.52	$65,729
Pipe	Lower Lateral	16	26	2,246	LF	$31.68	$71,144
Pipe	Lower Lateral	12	26	4,432	LF	$20.12	$89,156
Pipe	Lower Lateral	8	26	2,486	LF	$9.21	$22,898
Pipe	Lower Lateral	26	32.5	1,546	LF	$67.53	$104,422
Pipe	Lower Lateral	8	32.5	1,498	LF	$7.42	$11,111
Pipe	Lower Lateral	6	32.5	1,357	LF	$4.39	$5,953
Turnouts	Lower Lateral		-	14	EA	$8,000	$112,000
	SUBTOTAL						$655,563
	ENGINEERING, CM, SURVEY				10%		$65,556
	GMGC				14%		$91,779
	CONTINGENCY				30%		$243,869
	TOTAL						**$1,056,767**

Figure 5.3.1
Project Group 3A Area Map

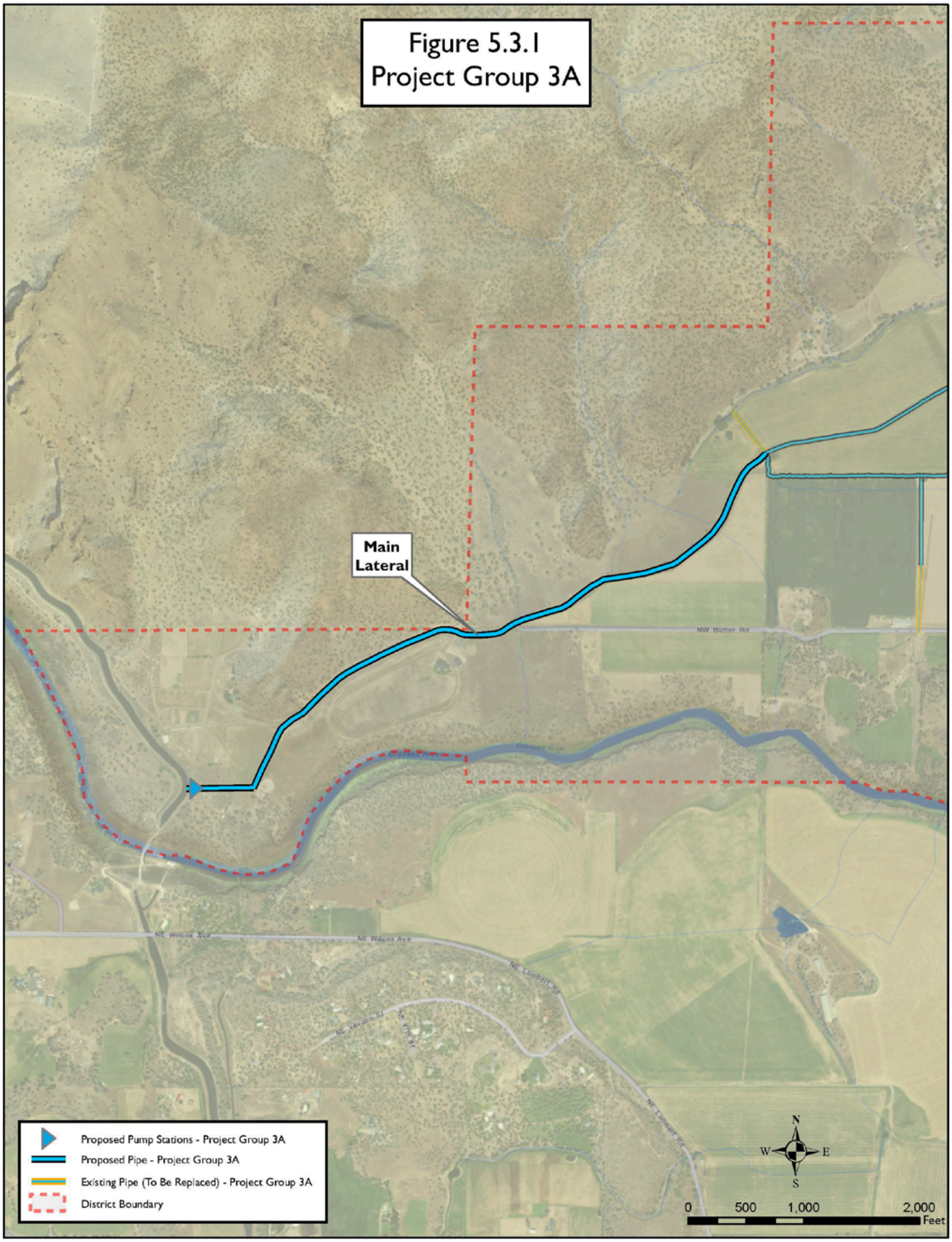


Table 5.3.1 Project Group 3A Cost Estimates

Project Group 3A - Main Canal Lone Pine Irrigation District Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Main Canal	42	32.5	6,222	LF	$176.16	$1,096,062
Turnouts	Main Canal		-	0	EA	$8,000	$0
	SUBTOTAL						$1,096,062
	ENGINEERING, CM, SURVEY				10%		$109,606
	GMGC				14%		$153,449
	CONTINGENCY				30%		$407,735
	670 HP PUMP STATION						$711,068
	TOTAL						**$2,477,919**

Table 5.3.2 Project Group 3A - Pump Station 2 - Cost Estimates

Lone Pine Pump Station 2 - Alternative A (670 HP VFD) Lone Pine Irrigation District Reconnaissance-Level Construction Cost Estimate					8/14/2017
Feature	**Size**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
Mobilization		1	EA	$20,000	$20,000
Civil Works		1	EA	$100,000	$100,000
Pump/Motor	670 HP	1	EA	$150,750	$150,750
Controls		1	EA	$40,000	$40,000
Electrical		1	EA	$80,000	$80,000
Building		1	EA	$30,000	$30,000
	SUBTOTAL				$420,750
	ENGINEERING, CM, SURVEY		12%		$50,490
	CMGC		18%		$75,735
	CONTINGENCY		30%		$164,093
	TOTAL				**$711,068**

Figure 5.4.1
Project Group 1B Area Map

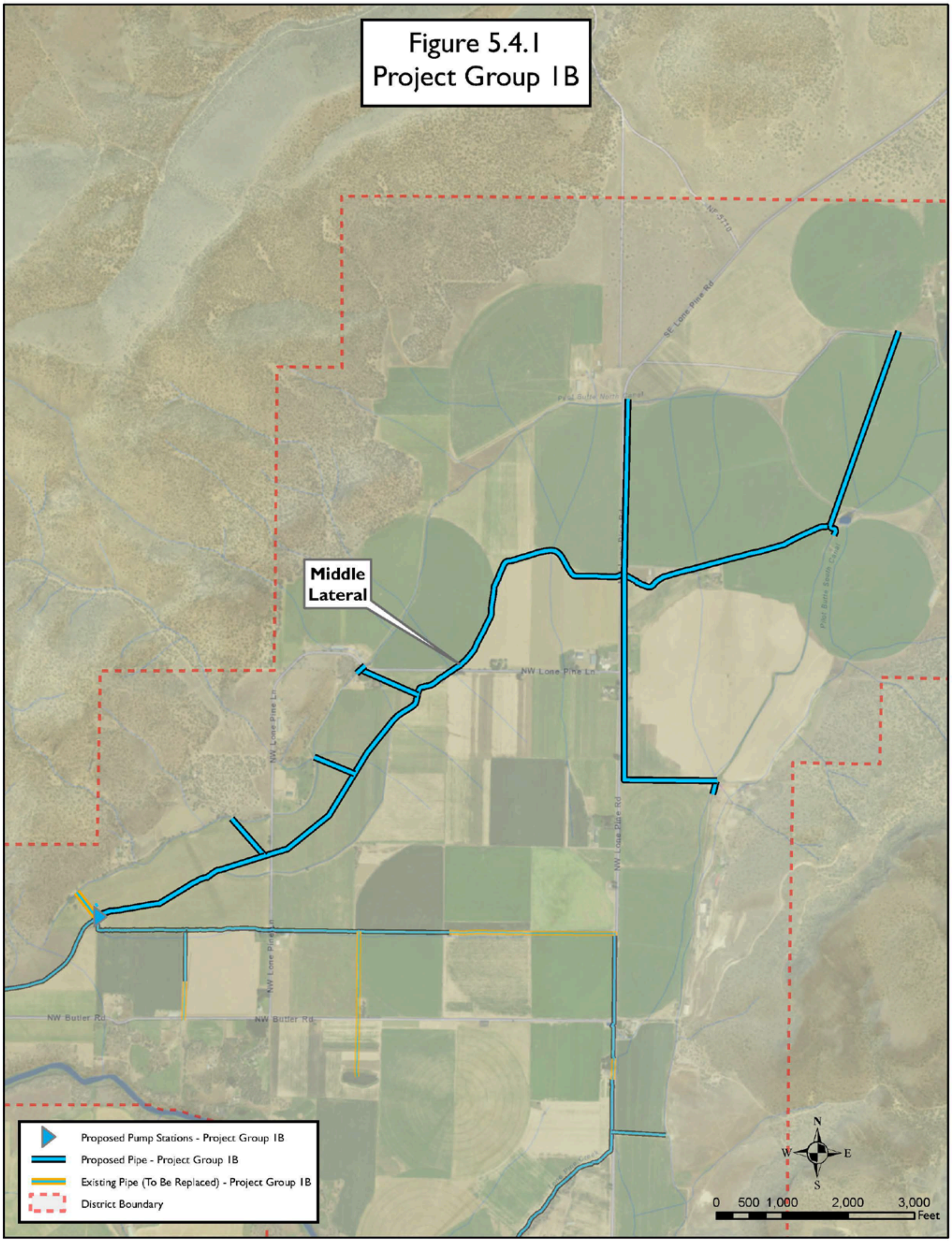


Table 5.4.1 Project Group 1B Cost Estimates

Project Group 1B - Middle Lateral Lone Pine Irrigation District Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Middle Lateral	32	21	2759	LF	$155.39	$428,638
Pipe	Middle Lateral	30	21	4107	LF	$136.60	$561,032
Pipe	Middle Lateral	26	21	2405	LF	$102.55	$246,581
Pipe	Middle Lateral	20	21	1126	LF	$60.67	$68,300
Pipe	Middle Lateral	14	26	2222	LF	$24.24	$53,859
Pipe	Middle Lateral	24	21	1545	LF	$87.40	$135,056
Pipe	Middle Lateral	8	21	421	LF	$11.29	$4,750
Pipe	Middle Lateral	42	32.5	464	LF	$176.16	$81,813
Pipe	Middle Lateral	6	26	746	LF	$5.43	$4,052
Pipe	Middle Lateral	8	26	1679	LF	$9.21	$15,464
Pipe	Middle Lateral	4	26	84	LF	$2.50	$210
Pipe	Middle Lateral	8	32.5	2653	LF	$7.42	$19,673
Pipe	Middle Lateral	10	32.5	3125	LF	$11.56	$36,127
Pipe	Middle Lateral	10	21	4511	LF	$17.55	$79,166
Turnouts	Middle Lateral		-	16	EA	$8,000	$128,000
	SUBTOTAL						$1,862,721
	ENGINEERING, CM, SURVEY				10%		$186,272
	GMGC				14%		$260,781
	CONTINGENCY				30%		$692,932
	715 HP PUMP STATION						$728,179
	TOTAL						**$3,730,885**

Table 5.4.2 Project Group 1B - Pump Station 1 - Cost Estimates

Lone Pine Pump Station 1 - Alternative B (715 HP VFD) Lone Pine Irrigation District Reconnaissance-Level Construction Cost Estimate					8/14/2017
Feature	**Size**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
Mobilization		1	EA	$20,000	$20,000
Civil Works		1	EA	$100,000	$100,000
Pump/Motor	715 HP	1	EA	$160,875	$160,875
Controls		1	EA	$40,000	$40,000
Electrical		1	EA	$80,000	$80,000
Building		1	EA	$30,000	$30,000
	SUBTOTAL				$430,875
	ENGINEERING, CM, SURVEY		12%		$51,705
	CMGC		18%		$77,558
	CONTINGENCY		30%		$168,041
	TOTAL				**$728,179**

Figure 5.5.1
Project Group 2B Area Map

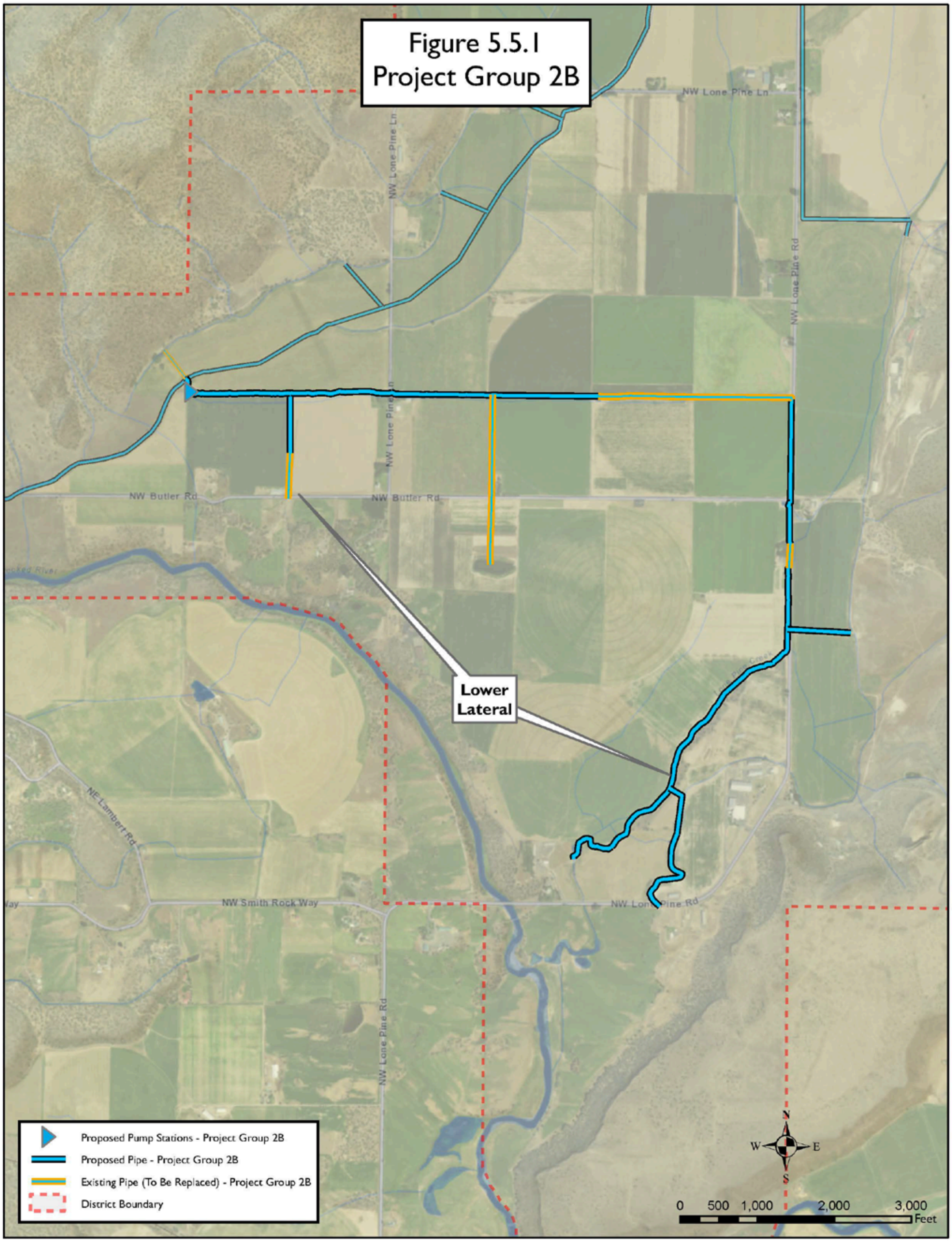


Table 5.5.1 Project Group 2B Cost Estimates

Project Group 2B - Lower Lateral Lone Pine Irrigation District Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Lower Lateral	24	32.5	2648.98	LF	$57.49	$152,292
Pipe	Lower Lateral	20	26	1327.41	LF	$49.52	$65,729
Pipe	Lower Lateral	16	26	2245.84	LF	$31.68	$71,144
Pipe	Lower Lateral	12	26	4431.88	LF	$20.12	$89,156
Pipe	Lower Lateral	8	26	1898.58	LF	$9.21	$17,486
Pipe	Lower Lateral	26	32.5	1546.71	LF	$67.53	$104,442
Pipe	Lower Lateral	8	32.5	2085.72	LF	$7.42	$15,469
Pipe	Lower Lateral	6	32.5	1356.88	LF	$4.39	$5,953
Pipe	Lower Lateral	12	21	2230	LF	$24.65	$54,968
Turnouts	Lower Lateral		-	14	EA	$8,000	$112,000
	SUBTOTAL						$688,639
	ENGINEERING, CM, SURVEY				10%		$68,864
	GMGC				14%		$96,409
	CONTINGENCY				30%		$256,174
	210 HP PUMP STATION						$471,107
	TOTAL						**$1,581,193**

Table 5.5.2 Project Group 2B - Pump Station 2 - Cost Estimates

Lone Pine Pump Station 2 - Alternative B (210 HP VFD) Lone Pine Irrigation District Reconnaissance-Level Construction Cost Estimate					8/14/2017
Feature	**Size**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
Mobilization		1	EA	$20,000	$20,000
Civil Works		1	EA	$100,000	$100,000
Pump/Motor	210 HP	1	EA	$47,250	$47,250
Controls		1	EA	$30,000	$30,000
Electrical		1	EA	$65,000	$65,000
Building		1	EA	$30,000	$30,000
	SUBTOTAL				$292,250
	ENGINEERING, CM, SURVEY		10%		$29,225
	CMGC		14%		$40,915
	CONTINGENCY		30%		$108,717
	TOTAL				**$471,107**

Figure 5.6.1
Project Group 3B Area Map

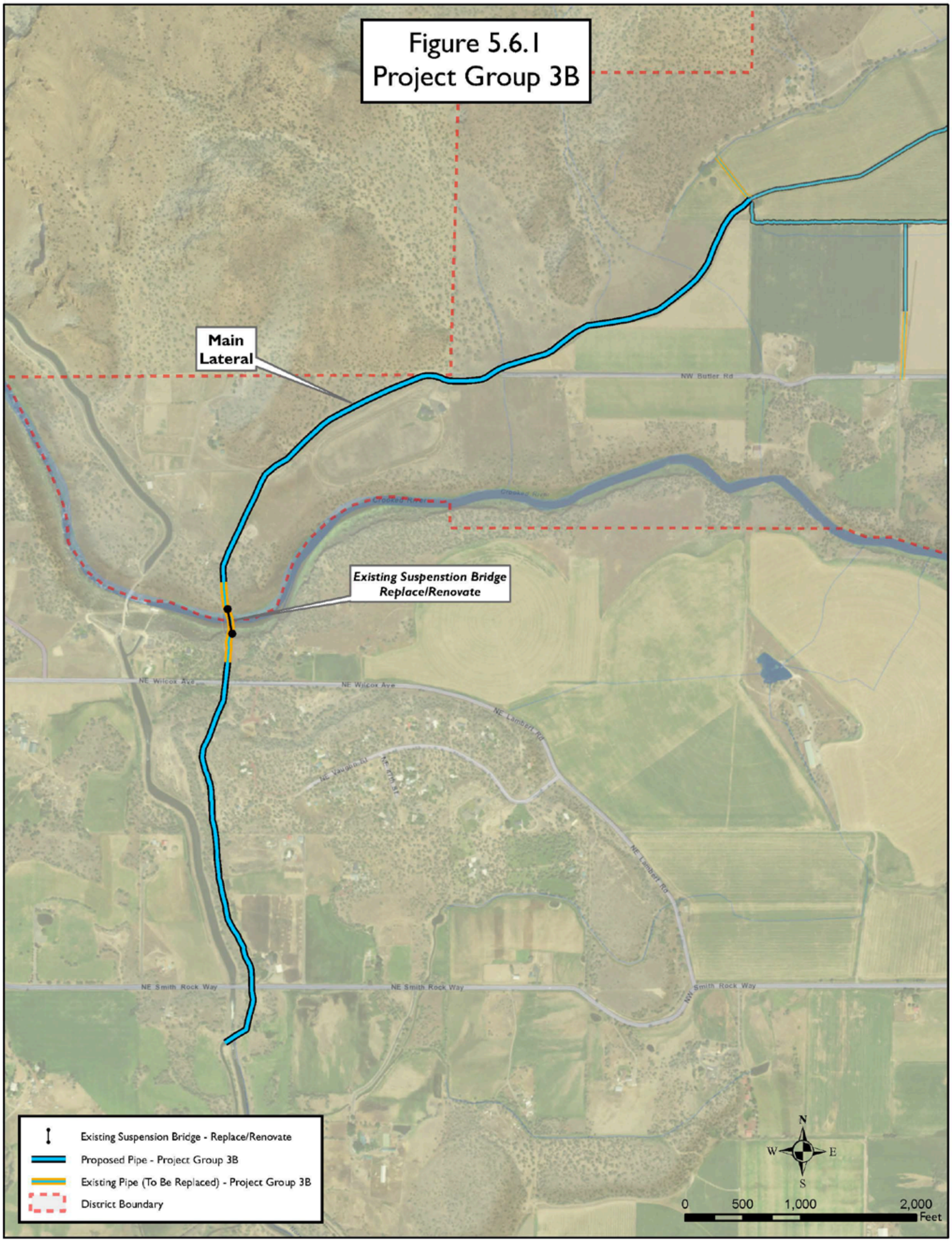


Table 5.6.1 Project Group 3B Cost Estimates

Project Group 3B - Main Canal Lone Pine Irrigation District Reconnaissance - Level Construction Cost Estimates							8/14/2017
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	Main Canal	42	21	10,287	LF	$267.65	$2,753,335
Turnouts	Main Canal		-	0	EA	$8,000	$0
	SUBTOTAL						$2,753,335
	ENGINEERING, CM, SURVEY				10%		$275,333
	GMGC				14%		$385,467
	CONTINGENCY				30%		$1,024,241
	TOTAL						**$4,438,376**

Notes: Existing suspension bridge is need of renovation or replacement. Cost estimates for this were not included in this System Improvement Plan.

APPENDIX A

TABULATED SEEPAGE LOSS DATA

LONE PINE IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS 2016

(green)	= Spill (Loss)
(yellow)	= Not Measured or Estimated
(red)	= Return Flow
(purple)	= Turn-outs to Laterals and Sub Laterals

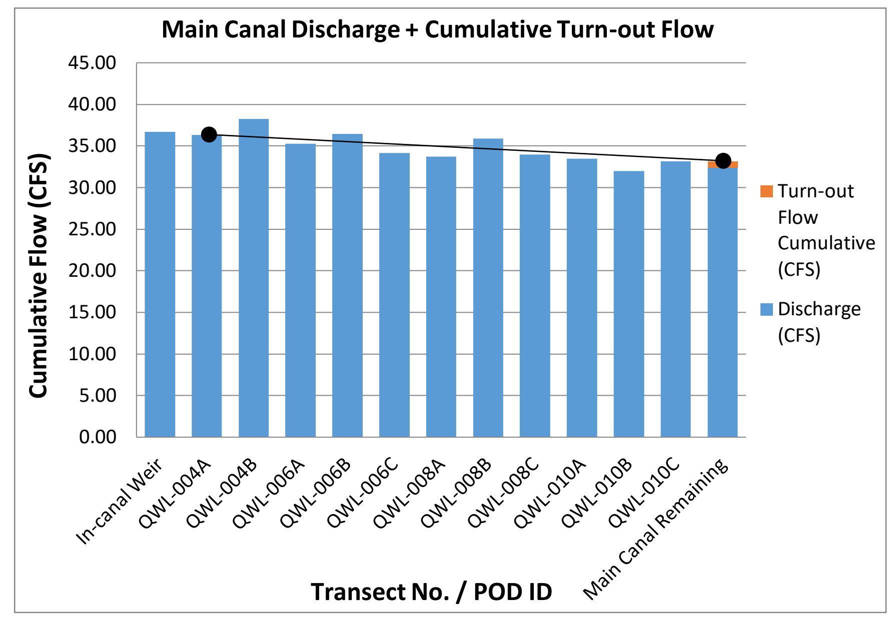
Transect No. POD #ID	**Discharge (CFS)**	**Turn-out Flow Rate (CFS)**	**Turn-out Flow Cumulative (CFS)**	**Comments**
Lone Pine Main Canal				
In-canal Weir	**36.72**		0.00	10 ft width Cipolletti weir, 1.08 ft depth at crest
QWL-004A	**36.32**		0.00	8-22-16, Measurement rated as "Good"
QWL-004B	**38.27**		0.00	8-22-16, Measurement rated as "Fair"
QWL-006A	**35.28**		0.00	8-22-16, Measurement rated as "Good"
QWL-006B	**36.46**		0.00	8-22-16, Measurement rated as "Good"
QWL-006C	**34.16**		0.00	8-24-16, Measurement rated as "Good"
QWL-008A	**33.71**		0.00	8-22-16, Measurement rated as "Good"
QWL-008B	**35.88**		0.00	8-22-16, Measurement rated as "Good"
QWL-008C	**33.98**		0.00	8-24-16, Measurement rated as "Good"
QWL-010A	**33.49**		0.00	8-22-16, Measurement rated as "Good"
QWL-010B	**31.97**		0.00	8-22-16, Measurement rated as "Good"
QWL-010C	**33.14**		0.00	8-24-16, Measurement rated as "Good"
Delivery Gate M-1		-0.72		Right side, flow assumed 80% of rights
Main Canal Remaining	**32.42**		0.72	
Lone Pine Upper Canal				
Delivery Gate U-1		-0.02		Left side, flow assumed 80% of rights
QWL-012	**6.36**		0.02	8-22-16, Measurement rated as "Good"
QWL-014	**5.92**		0.02	8-22-16, Measurement rated as "Poor"
Delivery Gate U-2		0.00		OFF - field observation
Delivery Gate U-3		-0.66		ON, estimated flow at 80% of rights
QWL-016	**4.32**		0.68	8-22-16, Measurement rated as "Fair"
QWL-018	**4.23**		0.68	8-22-16, Measurement rated as "Excellent"
Delivery Gate U-4		-0.71		Est flow at 0.5 x (QWL-018 minus QWL-019)
Delivery Gate U-5		-0.71		Est flow at 0.5 x (QWL-018 minus QWL-019)
QWL-019	**2.82**		2.09	8-22-16, Measurement rated as "Excellent"
QWL-020	**3.01**		2.09	8-22-16, Measurement rated as "Good"
QWL-022	**3.03**		2.09	8-22-16, Measurement rated as "Good"
QWL-024	**2.88**		2.09	8-22-16, Measurement rated as "Fair"
Delivery Gate U-6		-1.13		Est flow calc (In-canal Weir minus QWL-024)
In-canal Weir	**1.75**		3.22	4 ft wide Cipolletti, 3.1 inch depth at crest
Upper Canal Remaining	**1.75**		3.22	

Main Canal

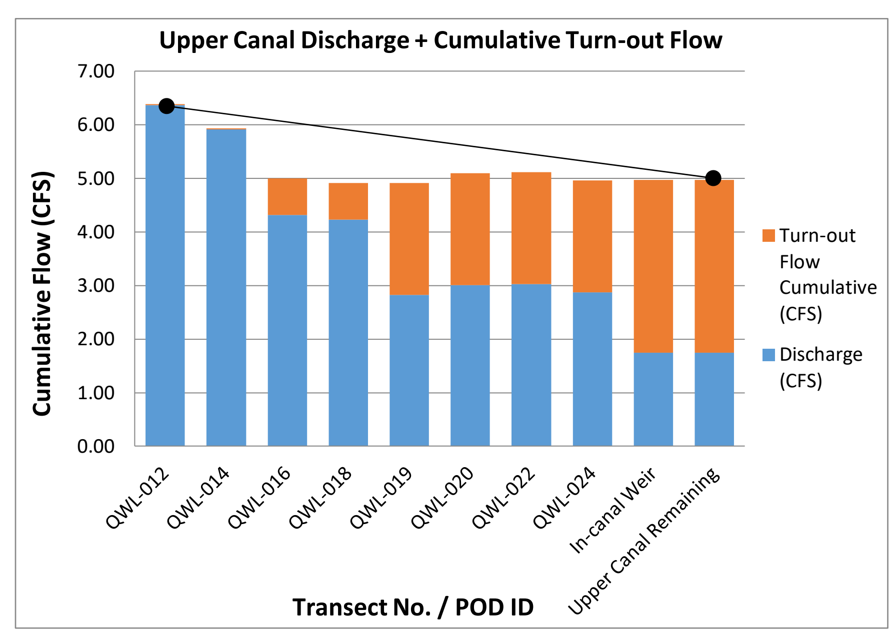
Upper Canal

Over-all Lone Pine Irrigation District Discharge Measurements

Over-all System Intake to the Study Reaches	=	65.43		
Over-all System Spill from the Study Reaches	=	0.00		
Over-all System Turnouts + Flow Remaining	=	-56.62		
Over-all System Seeapge Loss in Study Reaches	=	8.81	=	13.47%



Main Canal Intake to the Study Reach	=	36.32		
Main Canal Spill from the Study Reach		0.00		
Main Canal Lateral Turnouts + Flow Remaining	=	-33.14		
Main Canal Seepage Loss in the Study Reach	=	3.18	=	8.77%

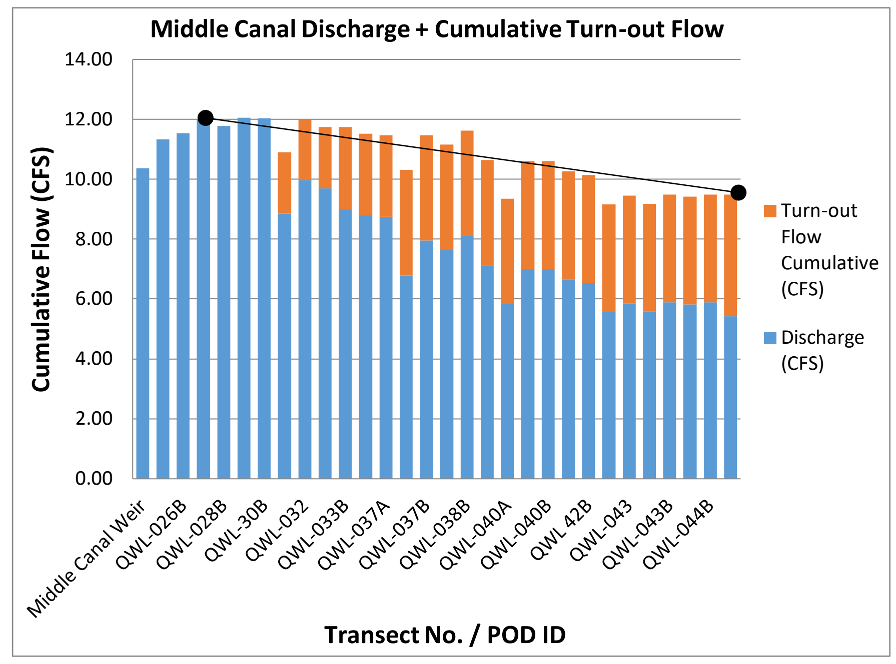


Upper Canal Intake to the Study Reach	=	6.36		
Upper Canal Spill from the Study Reach	=	0.00		
Upper Canal Turnouts + Flow Remaining	=	-4.95		
Upper Canal Seepage Loss in the Study Reach	=	1.41	=	22.20%

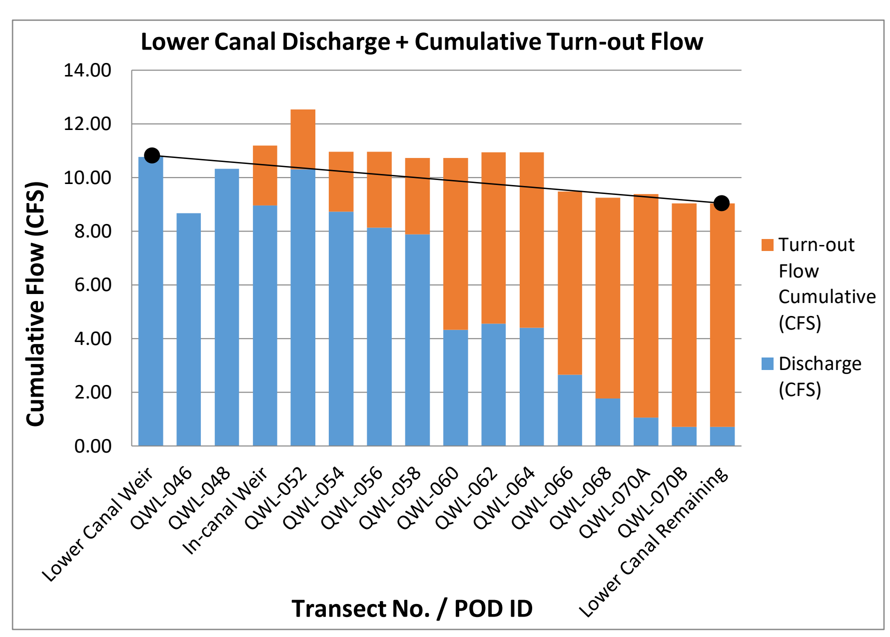
Final Rev.3
07-20-2017

LONE PINE IRRIGATION DISTRICT - DISCHARGE FLOW MEASUREMENTS 2016

Transect No. POD #ID	Discharge (CFS)	Turn-out Flow Rate (CFS)	Turn-out Flow Cumulative (CFS)	Comments	
Lone Pine Middle Canal	**(Supplemental Data 9-12-16 and 9-13-16)**				
Delivery Gate M-2		-0.17		Right side, flow assumed 80% of rights	
Middle Canal Weir	**10.36**		0.00	6 ft width Cipolletti, 0.65 ft depth	
QWL-026A	**11.33**		0.00	9-12-16, Measurement rated as "Fair"	
QWL-026B	**11.54**		0.00	9-12-16, Measurement rated as "Fair"	
QWL-028A	**11.99**		0.00	9-12-16, Measurement rated as "Fair"	
QWL-028B	**11.76**		0.00	9-12-16, Measurement rated as "Fair"	
QWL-30A	**12.05**		0.00	9-12-16, Measurement rated as "Fair"	
QWL-30B	**12.02**		0.00	9-12-16, Measurement rated as "Fair"	
Delivery Gate M-3		-0.68		Calc. (1/3) x 100% QWL-030B minus QWL-032	
Delivery Gate M-4		-0.68		Calc. (1/3) x 100% QWL-030B minus QWL-032	
Delivery Gate M-5		-0.68		Calc. (1/3) x 100% QWL-030B minus QWL-032	
In-canal Weir	**8.85**		2.04	5 ft width Cipolletti, 0.66 ft depth	
QWL-032	**9.96**		2.04	9-12-16, Measurement rated as "Good"	
QWL-033A	**9.69**		2.04	9-12-16, Measurement rated as "Fair"	
Delivery Gate M-6		-0.68		Calc. 100% of QWL-033A minus QWL-033B	
QWL-033B	**9.01**		2.73	9-12-16, Measurement rated as "Fair"	
QWL-036A	**8.79**		2.73	9-12-16, Measurement rated as "Poor"	
Delivery Gate M-7		0.00		OFF	
QWL-037A	**8.74**		2.73	9-12-16, Measurement rated as "Poor"	
Delivery Gate M-8		-0.80		Calc. 100% of QWL-037A minus QWL-037B	
In-canal Weir	**6.78**		3.52	4 ft width Cipolletti, 0.64 ft depth	
QWL-037B	**7.95**		3.52	9-12-16, Measurement rated as "Good"	Middle Canal
QWL-038A	**7.63**		3.52	9-12-16, Measurement rated as "Poor"	
Delivery Gate M-9		0.00		Assumed OFF calc QWL-38A minus QWL38B	
Delivery Gate M-10		0.00		Assumed OFF calc QWL-38A minus QWL38B	
QWL-038B	**8.10**		3.52	9-12-16, Measurement rated as "Fair"	
QWL-38B(2)	**7.11**		3.52	9-13-16, Measurement rated as "Fair"	
QWL-040A	**5.83**		3.52	9-13-16, Measurement rated as "Poor"	
Delivery Gate M-11		-0.04		Calc. 0.5 x 80% QWL-038B2 minus QWL-040B	
Delivery Gate M-12		-0.04		Calc. 0.5 x 80% QWL-038B2 minus QWL-040B	
In-canal Weir	**7.00**		3.60	6 ft width Cipolletti, 0.5 ft depth	
QWL-040B	**7.01**		3.60	9-13-16, Measurement rated as "Fair"	
QWL-042A	**6.65**		3.60	9-13-16, Measurement rated as "Good"	
Delivery Gate M-13		0.00		Right side, 20 HP Pump OFF	
QWL 42B	**6.53**		3.60	9-13-16, Measurement rated as "Good"	
In-canal Weir	**5.55**		3.60	4 ft width Cipolletti, 0.56 ft depth	
QWL-043	**5.85**		3.60	9-13-16, Measurement rated as "Fair"	
QWL-043A	**5.58**		3.60	9-13-16, Measurement rated as "Good"	
Delivery Gate M-14		0.00		Left side, Pump OFF	
QWL-043B	**5.88**		3.60	9-13-16, Measurement rated as "Good"	
QWL-044A	**5.81**		3.60	9-13-16, Measurement rated as "Good"	
QWL-044B	**5.89**		3.60	9-13-16, Measurement rated as "Good"	
Delivery Gate M-15		-0.46		Centered, flow assumed 80% of rights	
Mid Canal Remaining	**5.43**		4.06	= QWL-044B-flow rate Delivery M-15	
Lone Pine Lower Canal					
Lower Canal Weir	**10.76**		0.00	6 foot Cipolletti weir, 8 inch depth	
QWL-046	**8.66**		0.00	8-24-16, Measurement rated as "Poor"	
QWL-048	**10.32**		0.00	8-24-16, Measurement rated as "Fair"	
Delivery Gate L-1		-2.22		2 foot Cipolletti weir, 5.75 inch depth	
In-canal Weir	**8.96**		2.22	4 foot Cipolletti, 9.25 inch depth; "Good" weir	
QWL-052	**10.31**		2.22	8-24-16, Measurement rated as "Fair"	
Delivery Gate L-2		-0.01		Right side, flow assumed 80% of rights	
QWL-054	**8.74**		2.23	8-24-16, Measurement rated as "Good"	
Delivery Gate L-3		-0.30		Est flow at 0.5 x (QWL-054 - QWL-056)	
Delivery Gate L-4		-0.30		Est flow at 0.5 x (QWL-054 - QWL-056)	
QWL-056	**8.13**		2.84	8-24-16, Measurement rated as "Good"	
QWL-058	**7.89**		2.84	8-24-16, Measurement rated as "Good"	
Delivery Gate L-5		-3.56		Est flow at QWL-058 minus QWL-060	
QWL-060	**4.33**		6.39	8-24-16, Measurement rated as "Good"	
QWL-062	**4.55**		6.39	8-24-16, Measurement rated as "Good"; backf	Lower Canal
Delivery Gate L-6		-0.14		Est flow at QWL-062 minus QWL-064	
QWL-064	**4.41**		6.53	8-24-16, Measurement rated as "Good"	
Delivery Gate L-7		-0.28		Right side, flow assumed 80% of rights	
QWL-066	**2.66**		6.81	8-24-16, Measurement rated as "Fair"	
Delivery Gate L-8		-0.67		Centered, flow assumed 80% of rights	
QWL-068	**1.76**		7.48	8-24-16, Measurement rated as "Good"	
Delivery Gate L-9		-0.08		Left side, flow assumed 80% of rights	
Delivery Gate L-10		-0.76		Centered, tail water, flow assumed 80% of right	
QWL-070A	**1.05**		8.32	8-24-16, rated as "Good" (Ave 2 measures)	
QWL-070B	**0.72**		8.32	8-24-16, Measurement rated as "Poor"	
Lower Canal Remaining	**0.72**		8.32		



Middle Canal Intake into the Study Reach	=	11.99		
Middle Canal Spill from the Study Reach	=	0.00		
Middle Canal Turnouts + Flow Remaining	=	-9.49		
Middle Canal Seepage Loss in the Study Reach	=	2.50	=	20.85%

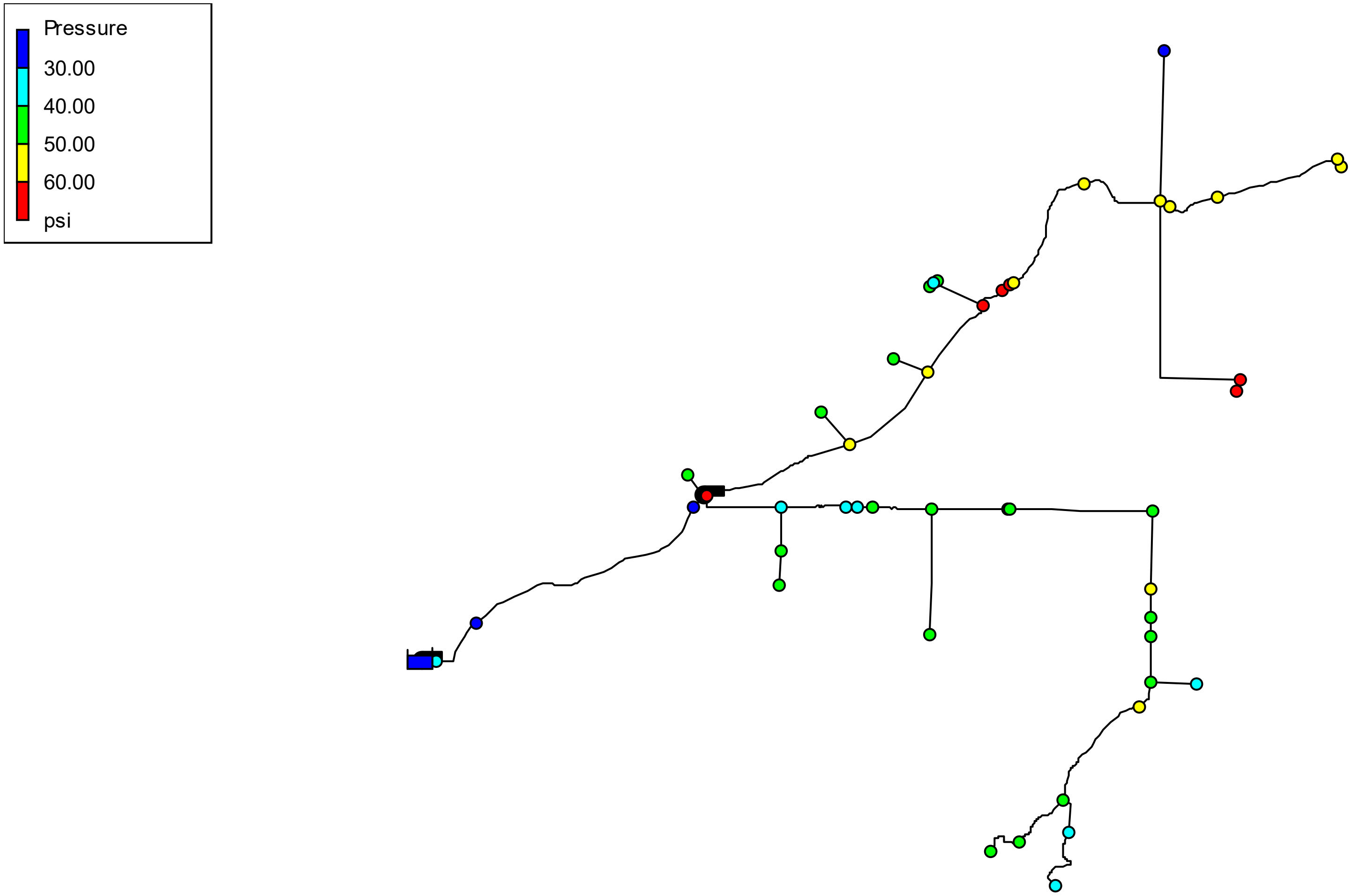


Lower Canal Intake into the Study Reach	=	10.76		
Lower Canal Spill from the Study Reach	=	0.00		
Lower Canal Turnouts + Flow Remaining	=	-9.05		
Lower Canal Seepage Loss in the Study Reach	=	1.71	=	15.94%

APPENDIX B

EPANET HYDRAULIC MODEL OUTPUT

LPID - Alternative A



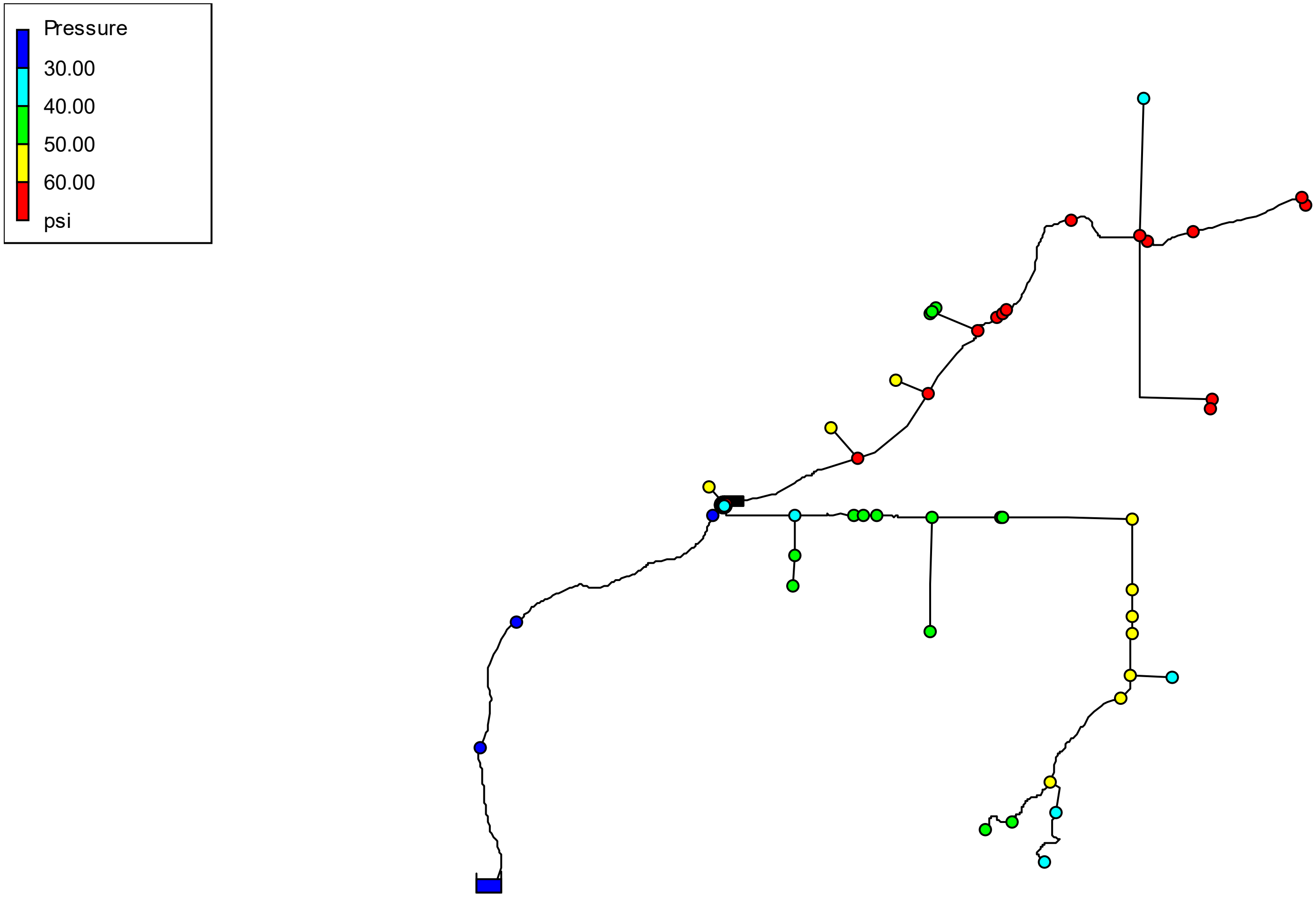
EPANET LINKS OUTPUTS - ALTERNATIVE A						
Link ID	**Length ft**	**Diameter in**	**Roughness**	**Flow GPM**	**Velocity fps**	**DR Rating**
Pipe L-1_0000	778.2	7.92	135	761.6	4.96	8DR26
Pipe Main-002	4,552.2	39.26	135	17,213.0	4.56	42DR32.5
Pipe Main-0003	289.8	39.26	135	16,662.8	4.42	42DR32.5
Pipe NL-3B	1,356.9	6.19	135	347.2	3.7	6DR32.5
Pipe NL-1B	212.4	7.75	135	738.5	5.02	8DR21
Pipe Middle_0006	2,320.0	23.38	135	6,271.7	4.69	26DR21
Pipe Middle_0007	84.6	23.38	135	6,754.6	5.05	26DR21
Pipe Middle_0008	167.9	25.17	135	7,830.2	5.05	28DR21
Pipe Middle_0009	943.0	18.37	135	3,882.3	4.7	20DR26
Pipe Middle_0010	2,222.1	12.86	135	1,740.3	4.3	14DR26
Pipe Middle_0011A	1,545.3	21.58	135	5,452.7	4.78	24DR21
Pipe Middle_0013	208.1	7.92	135	560.0	3.65	8DR26
Pipe Lower_0001	1,139.2	22.44	135	6,022.5	4.89	24DR32.5
Pipe Lower_0002	278.6	22.04	135	5,828.2	4.9	24DR26
Pipe Lower_0003	195.4	22.04	135	6,017.2	5.06	24DR26
Pipe Lower_0013	1,035.9	22.04	135	5,558.7	4.67	24DR26
Pipe Lower_0004	1,327.4	18.37	135	4,185.3	5.07	20DR26
Pipe Lower_0005	39.6	14.70	135	2,555.0	4.83	16DR26
Pipe Lower_0007	1,342.8	14.70	135	2,555.0	4.83	16DR26
Pipe Lower_0008	547.3	14.70	135	2,345.0	4.43	16DR26
Pipe Lower_0010A	806.9	14.70	135	2,345.0	4.43	16DR26
Pipe Lower_0011	765.4	7.92	135	579.6	3.77	8DR26
Pipe Lower_0012A	2,229.9	11.71	135	1,323.0	3.94	12DR26
Pipe NL-9	472.4	4.13	135	15.4	0.37	4DR26
Pipe L-1_0001	587.6	7.92	135	761.6	4.96	8DR26
Pipe L-4_0000	2,201.9	11.71	135	1,373.4	4.09	12DR26
Pipe Lower_0006	2,528.4	14.70	135	2,555.0	4.83	16DR26
Pipe Lower_0009	316.1	14.70	135	2,345.0	4.43	16DR26
Pipe 36A	41.5	39.26	135	17,248.0	4.57	42DR32.5
Pipe Middle_0003A	2,698.4	28.73	135	9,732.6	4.82	32DR21
Pipe Middle_0011B	182.9	17.98	135	3,904.7	4.93	20DR21
Pipe NL-1A	4,511.4	9.66	135	847.9	3.71	10DR21
Pipe Lower_0010B	529.0	12.86	135	1,835.4	4.53	14DR26
Pipe NL-2	814.9	8.06	135	509.6	3.2	8DR32.5
Pipe Lower_0012B	1,120.4	7.92	135	639.8	4.17	8DR26
Pipe NL-3A	683.2	8.06	135	683.2	4.3	8DR32.5
Pipe Middle_0003B	1,906.6	27.55	135	9,302.7	5.01	30DR26
Pipe NL-4	746.4	6.08	135	429.9	4.75	6DR26
Pipe Middle_0003C	1,568.2	26.97	135	8,798.7	4.94	30DR21
Pipe NL-5	656.3	7.92	135	504.0	3.28	8DR26
Pipe Middle_0003D	464.4	26.97	135	8,173.2	4.59	30DR21
Pipe NL-6	940.5	8.06	135	625.5	3.93	8DR32.5
Pipe NL-6A	84.1	4.21	135	40.6	0.94	4DR32.5
Pipe NL-6B	82.2	8.06	135	584.9	3.68	8DR32.5
Pipe NL-7	2,652.6	8.06	135	700.0	4.4	8DR32.5
Pipe 36B	1,073.9	39.26	135	17,213.0	4.56	42DR32.5
Pipe NL-20	264.6	39.26	135	17,248.0	4.57	42DR32.5

Pipe Middle_0000	52.0	28.73	135	9,863.4	4.88	32DR21
Pipe Lower-0000	1,546.4	24.30	135	6,784.1	4.69	26DR32.5

EPANET NODE OUTPUTS - ALTERNATIVE A				
Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc HG-2	2,906.7	0.0	2,974.5	29.4
Junc L-1	2,885.0	0.0	2,970.4	37.0
Junc L-10	2,790.2	579.6	2,903.5	49.1
Junc L-2	2,876.2	5.3	2,966.8	39.3
Junc L-3	2,874.8	189.0	2,966.2	39.6
Junc L-4	2,871.6	269.5	2,965.3	40.6
Junc L-5	2,868.5	0.0	2,962.2	40.6
Junc L-6	2,857.1	1,630.3	2,956.6	43.1
Junc L-7	2,820.9	210.0	2,937.1	50.3
Junc L-8	2,811.2	512.4	2,927.2	50.3
Junc L-9	2,803.3	60.2	2,908.5	45.6
Junc M-1	2,907.6	550.2	2,974.8	29.1
Junc M-10	2,884.7	560.0	3,010.4	54.5
Junc M-11	2,851.1	109.4	3,003.8	66.1
Junc M-12	2,848.0	738.5	3,001.3	66.4
Junc M-13	2,845.2	509.6	2,926.1	35.1
Junc M-14	2,826.4	336.0	2,911.7	37.0
Junc M-15	2,826.4	347.2	2,900.4	32.0
Junc M-2	2,905.8	130.8	3,054.4	64.4
Junc M-3	2,899.8	343.0	3,038.3	60.0
Junc M-4	2,899.3	1,075.6	3,037.8	60.0
Junc M-5	2,899.4	482.9	3,037.6	59.9
Junc M-6	2,897.3	819.0	3,031.2	58.0
Junc M-7	2,897.8	22.4	3,025.6	55.4
Junc M-8	2,895.5	2,142.0	3,022.1	54.9
Junc M-9	2,891.3	1,180.3	3,011.7	52.2
Junc NODE1	2,914.8	0.0	2,981.3	28.9
Junc NODE3	2,861.8	0.0	2,962.0	43.4
Junc NODE4	2,859.2	761.6	2,955.6	41.8
Junc NODE5	2,851.5	1,373.4	2,951.7	43.4
Junc NODE6	2,855.8	0.0	2,956.5	43.6
Junc NODE7	2,829.8	0.0	2,943.8	49.4
Junc NODE8	2,821.5	0.0	2,934.8	49.1
Junc NODE9	2,819.6	0.0	2,933.4	49.3
Junc U-1	2,950.1	15.4	3,054.5	45.2
Junc U-2	2,944.6	429.9	3,038.1	40.6
Junc U-3	2,941.2	504.0	3,040.1	42.9
Junc U-4	2,939.9	584.9	3,032.4	40.1
Junc U-5	2,940.2	40.6	3,032.8	40.1
Junc NODE-NL-1	2,896.0	0.0	3,026.3	56.5
Junc NODE-NL-2	2,816.0	0.0	2,930.0	49.4
Junc NODE-NL-3	2,803.0	0.0	2,917.3	49.5
Junc NODE-NL-4	2,918.9	0.0	3,048.3	56.1
Junc NODE-NL-5	2,921.7	0.0	3,043.4	52.7

Junc NODE-NL-6A	2,900.4	0.0	3,039.4	60.2
Junc NODE-NL-6B	2,941.9	0.0	3,032.9	39.4
Junc FE-1	2,938.3	700.0	3,003.8	28.4
Junc PumpOutlet	2,894.5	0.0	2,983.3	38.5
Junc PumpInlet	2,901.8	0.0	2,891.5	-4.5
Junc Hollander	2,896.9	35.0	2,982.9	37.3
Junc Pump2_outlet	2,906.0	0.0	3,054.5	64.4
Resvr headworks	2,891.6	#N/A	2,891.6	0.0

LPID - Alternative B



EPANET 2

EPANET LINKS OUTPUTS - ALTERNATIVE B						
Link ID	**Length ft**	**Diameter in**	**Roughness**	**Flow GPM**	**Velocity fps**	**DR**
Pipe Main_0000	2,829.4	37.76	135	17,213.0	4.93	42DR21
Pipe Main_0001	2,636.7	37.76	135	17,213.0	4.93	42DR21
Pipe Main_0002	4,538.5	37.76	135	17,213.0	4.93	42DR21
Pipe Main_0003	282.4	37.76	135	16,662.8	4.77	42DR21
Pipe L-1_0000	778.2	7.92	135	761.6	4.96	8DR26
Pipe NL-3B	1,356.9	6.08	135	347.2	3.84	6DR26
Pipe NL-1B	212.4	7.55	135	738.5	5.29	8DR17
Pipe Middle_0006	2,320.0	23.38	135	6,271.7	4.69	26DR21
Pipe Middle_0007	84.6	23.38	135	6,754.6	5.05	26DR21
Pipe Middle_0008	167.9	26.97	135	7,830.2	4.4	30DR21
Pipe Middle_0009	943.0	17.98	135	3,882.3	4.91	20DR21
Pipe Middle_0010	2,222.1	12.59	135	1,740.3	4.49	14DR21
Pipe Middle_0011A	1,545.3	21.58	135	5,452.7	4.78	24DR21
Pipe Middle_0013	208.1	7.75	135	560.0	3.81	8DR21
Pipe Lower_0001	1,139.2	22.44	135	6,022.5	4.89	24DR32.5
Pipe Lower_0002	278.6	22.44	135	5,828.2	4.73	24DR32.5
Pipe Lower_0003	195.4	22.44	135	6,017.2	4.88	24DR32.5
Pipe Lower_0013	1,035.9	22.44	135	5,558.7	4.51	24DR32.5
Pipe Lower_0004	1,327.4	18.37	135	4,185.3	5.07	20DR26
Pipe Lower_0005	39.6	14.70	135	2,555.0	4.83	16DR26
Pipe Lower_0007	1,342.8	14.38	135	2,555.0	5.05	16DR21
Pipe Lower_0008	547.3	14.38	135	2,345.0	4.63	16DR21
Pipe Lower_0010A	806.9	14.38	135	2,345.0	4.63	16DR21
Pipe Lower_0011	765.4	7.75	135	579.6	3.94	8DR21
Pipe Lower_0012A	2,229.9	11.46	135	1,323.0	4.12	12DR21
Pipe L-1_0001	587.6	7.92	135	761.6	4.96	8DR26
Pipe L-4_0000	2,201.9	11.71	135	1,373.4	4.09	12DR26
Pipe Lower_0006	2,528.4	14.70	135	2,555.0	4.83	16DR26
Pipe Lower_0009	316.1	14.38	135	2,345.0	4.63	16DR21
Pipe Middle_0003A	2,698.4	28.73	135	9,732.6	4.82	32DR21
Pipe Middle_0011B	182.9	17.98	135	3,904.7	4.93	20DR21
Pipe NL-1A	4,511.4	9.41	135	847.9	3.91	10DR17
Pipe Lower_0010B	529.0	12.59	135	1,835.4	4.73	14DR21
Pipe NL-2	814.9	7.92	135	509.6	3.32	8DR26
Pipe Lower_0012B	1,120.4	7.75	135	639.8	4.35	8DR21
Pipe NL-3A	683.2	7.92	135	683.2	4.45	8DR26
Pipe Middle_0003B	1,906.6	26.97	135	9,302.7	5.22	30DR21
Pipe NL-4	746.4	6.08	135	429.9	4.75	6DR26
Pipe Middle_0003C	1,568.2	26.97	135	8,798.7	4.94	30DR21
Pipe NL-5	656.3	7.92	135	504.0	3.28	8DR26
Pipe Middle_0003D	464.4	26.97	135	8,173.2	4.59	30DR21
Pipe NL-6	940.5	7.92	135	625.5	4.07	8DR26
Pipe NL-6A	84.1	4.13	135	40.6	0.97	4DR26
Pipe NL-6B	82.2	7.92	135	584.9	3.81	8DR26
Pipe NL-7	2,652.6	7.92	135	700.0	4.56	8DR26
Pipe NL-9	464.4	39.26	135	15.4	0	42DR32.5
Pipe Middle_0000	60.1	28.73	135	9,863.4	4.88	32DR21

Pipe Lower-0000	1,556.7	24.30	135	6,784.1	4.69	26DR32.5

EPANET NODE OUTPUTS - ALTERNATIVE B				
Node ID	Elevation ft	Base Demand GPM	Head ft	Pressure psi
Junc HG-2	2,906.6	0.0	2,906.3	0.1
Junc M-1	2,906.2	550.2	2,906.8	0.3
Junc NODE1	2,909.5	0.0	2,914.6	2.2
Junc NODE2	2,915.5	0.0	2,919.2	1.6
Junc L-1	2,885.0	0.0	2,975.1	39.0
Junc L-10	2,790.2	579.6	2,904.1	49.4
Junc L-2	2,876.2	5.3	2,971.6	41.3
Junc L-3	2,874.8	189.0	2,970.9	41.7
Junc L-4	2,871.6	269.5	2,970.1	42.7
Junc L-5	2,868.5	0.0	2,967.3	42.9
Junc L-6	2,857.1	1,630.3	2,961.8	45.3
Junc L-7	2,820.9	210.0	2,941.5	52.2
Junc L-8	2,811.2	512.4	2,930.5	51.7
Junc L-9	2,803.3	60.2	2,909.7	46.1
Junc M-10	2,884.7	560.0	3,030.3	63.1
Junc M-11	2,851.1	109.4	3,022.2	74.1
Junc M-12	2,848.0	738.5	3,019.5	74.3
Junc M-13	2,845.2	509.6	2,929.3	36.5
Junc M-14	2,826.4	336.0	2,913.4	37.7
Junc M-15	2,826.4	347.2	2,901.0	32.3
Junc M-2	2,905.8	130.8	3,076.4	73.9
Junc M-3	2,899.8	343.0	3,059.7	69.3
Junc M-4	2,899.3	1,075.6	3,059.4	69.4
Junc M-5	2,899.4	482.9	3,059.1	69.2
Junc M-6	2,897.3	819.0	3,052.7	67.4
Junc M-7	2,897.8	22.4	3,047.1	64.7
Junc M-8	2,895.5	2,142.0	3,043.3	64.1
Junc M-9	2,891.3	1,180.3	3,031.7	60.8
Junc NODE3	2,861.8	0.0	2,966.7	45.5
Junc NODE4	2,859.2	761.6	2,960.4	43.8
Junc NODE5	2,851.5	1,373.4	2,956.8	45.7
Junc NODE6	2,855.8	0.0	2,961.6	45.8
Junc NODE7	2,829.8	0.0	2,948.9	51.6
Junc NODE8	2,821.5	0.0	2,938.9	50.8
Junc NODE9	2,819.6	0.0	2,937.4	51.0
Junc U-1	2,950.1	15.4	3,076.5	54.8
Junc U-2	2,944.6	429.9	3,060.1	50.1
Junc U-3	2,941.2	504.0	3,061.5	52.1
Junc U-4	2,939.9	584.9	3,053.2	49.1
Junc U-5	2,940.2	40.6	3,053.6	49.1
Junc NODE-NL-1	2,896.0	0.0	3,047.9	65.8
Junc NODE-NL-2	2,816.0	0.0	2,933.5	50.9
Junc NODE-NL-3	2,803.0	0.0	2,919.4	50.5
Junc NODE-NL-4	2,918.9	0.0	3,070.2	65.6

Junc NODE-NL-5	2,921.7	0.0	3,064.8	62.0
Junc NODE-NL-6A	2,900.4	0.0	3,060.8	69.5
Junc NODE-NL-6B	2,941.9	0.0	3,053.7	48.5
Junc FE-1	2,938.3	700.0	3,023.4	36.9
Junc Pump1Outlet	2,906.0	0.0	3,076.5	73.9
Junc Pump2Outlet	2,906.0	0.0	2,979.2	31.7
Resvr Headworks	2,924.1	#N/A	2,924.1	0.0

APPENDIX C

PIPE BUDGET ESTIMATES FROM VENDORS

Dan Kaler

From: Ken.Douglas@Ferguson.com
Sent: Wednesday, March 22, 2017 1:19 PM
To: daniel.kaler@fcasolutions.org
Cc: blackrockci@gmail.com; Aaron.Bondi@Ferguson.com
Subject: RE: North Unit

Dan
For budgetary purposes, please see attached pipe sizing chart link for budgetary purposes.

http://www.performancepipe.com/en-us/Documents/PP%20152%204710%20IPS%20Size%20and%20Dimension%20Sheet.pdf

For the freight estimates use $1400.00 to $1500.00 per truck, Reno to Madras.

For your sizes of 4" to 54" use 1.10 per lb (54" can ship with 2ea sticks per truck)

For the 63" pipe use $1.20 per lb and I have the weights listed below. (63" can only ship 1ea stick per truck)

63" SDR21- 248.72LBS/FT

63" SDR26- 202.94LBS/FT

63" SDR32.5- 163.73LBS/FT

63" SDR41- I will forward you the pounds per foot as soon as I get it.

Please feel free to contact me with any questions

Thanks

Ken Douglas
Branch Manager
Ferguson Waterworks, a Wolseley company 3292 S. Hwy 97 Redmond, Or. 97756
T: (541) 548-2865 C: (541) 948-0922 F: (541) 548-2664
www.ferguson.com

From: Dan Kaler [mailto:daniel.kaler@fcasolutions.org]
Sent: Thursday, March 16, 2017 12:49 PM
To: Douglas, Ken [Ferguson] - 1614 Redmond
Cc: blackrockci@gmail.com; Bondi, Aaron [Ferguson] - 1614 Redmond
Subject: FW: North Unit

Ken,

I sent the message below to Aaron and received an auto reply saying he was out until 3/22. Would you be able to assist with the cost estimates outlined in the attached document?

I am working with Kevin Crew on a System Improvement Plan for North Unit Irrigation District. At this point in the study, I am running through cost estimates for piping the entire district. For preliminary calcs, I have been using a $/lb per foot based on antiquated data (I'm guessing it's still pretty darn close though). Could you please provide cost estimates for the HDPE pipe in the attached document? Also, please let me know if these are bid type prices or budgetary. Please include in the estimate, freight to Madras, OR (or Bend is fine).

Thanks!
Dan Kaler

From: Dan Kaler [mailto:daniel.kaler@fcasolutions.org]
Sent: Thursday, March 16, 2017 12:23 PM
To: Aaron.Bondi@Ferguson.com
Cc: blackrockci@gmail.com
Subject: North Unit

Good Afternoon Aaron,

I am working with Kevin Crew on a System Improvement Plan for North Unit Irrigation District. At this point in the study, I am running through cost estimates for piping the entire district. For preliminary calcs, I have been using a $/lb per foot based on antiquated data (I'm guessing it's still pretty darn close though). Could you please provide cost estimates for the HDPE pipe in the attached document? Also, please let me know if these are bid type prices or budgetary. Please include in the estimate, freight to Madras, OR (or Bend is fine).

Thanks,
Dan Kaler

……………………………………………………………………………………….
daniel kaler | fca | cell 952.215.7493 | office 541.716.6085 | farmerscreen.org

blog | instagram | facebook | twitter | linkedin

Lone Pine Irrigation District

System Improvement Plan
Addendum - Alternative C

Prepared by:
Dan Kaler,
Farmers Conservation Alliance,
and
Kevin L. Crew, P.E.
Black Rock Consulting

BLACK ROCK

320 SW Upper Terrace Drive Suite #102, Bend, Oregon 97702
(541) 480-6257

&

fca

Farmers Conservation Alliance
101 3rd Street Suite #101, Hood River, Oregon 97031
(541) 716-6085

Prepared for:

Lone Pine Irrigation District

June 15, 2018

REGISTERED PROFESSIONAL ENGINEER
17,425
OREGON
SEPT. 28, 1994
KEVIN L. CREW
RENEWS 12-31-19

6/22/18

Lone Pine System Improvement Plan Addendum – Alternative C

This document serves as an addendum to the Lone Pine Irrigation District (LPID) System Improvement Plan (SIP). Further development of the Central Oregon Irrigation District (COID) distribution system and the analysis of a new location for the LPID Crooked River crossing led to the development of this new system layout alternative for LPID. This new layout has been termed Alternative C. Included in this addendum are a description of these developments, a hydraulic model of the new alternative, an overview map of the system, associated cost estimates, an energy analysis, and pumping contingencies.

The existing suspension bridge spanning the Crooked River is aged, though currently required for irrigation water supply to be delivered to LPID. Elements of the bridge are in need of repair or replacement, and a complete analysis of the bridge is recommended, should the District continue to use the bridge for irrigation delivery. Maintenance, repair, or replacement are challenging and costly at the existing location due to the depth of the gorge. A new crossing location, approximately 2.5 miles upstream of the existing suspension bridge, was investigated. Preliminary analysis of the proposed location, as outlined in Figure 1, indicates that a siphon under the river would be a feasible solution. The proposed location provides better access for district personnel, and the installation of a siphon would greatly reduce maintenance issues in comparison to the suspension bridge.

Discussions between LPID and COID concluded that a new point of diversion, upstream of the existing point of diversion on COID's Pilot Butte Canal, would be a preferred location. This location on the Pilot Butte Canal is known as the L Lateral. The L Lateral runs west to east and terminates near the new, proposed Crooked River crossing. The proposed Alternative C option would divert the entirety of LPID's water supply through a piped system following the layout of the L Lateral, along with conveying COID's L Lateral flows to a branch point downstream, and then continue on to the proposed river crossing. Following the river crossing, the LPID system would turn north supplying the entirety of the district from one main distribution line. See Figure 1 for an overview map of Alternative C.

While completing the SIP hydraulic model for COID, Kevin Crew (Black Rock Consulting) determined that once the Pilot Butte Canal is fully piped, there will be an available pressure of 67 psi at the point of diversion of the L Lateral. For the purposes of this addendum, system pipe sizing and associated energy analyses were completed assuming an inlet design condition of 67 psi. Construction cost estimates can be found in Table 1. If the LPID system is installed prior to piping COID's Pilot Butte Canal, and consequently the inlet pressure of 67 psi not available, a centralized pump station would be required. See the subsequent section below for cost estimates and location of the proposed centralized pump station.

A primary benefit of the new layout, diverting water at the L Lateral in conjunction with the 67 psi inlet pressure, is that all patrons on the system would have a minimum working pressure of 35 psi at the turnouts. This would result in a reduction of energy necessary for pumping, conserving an estimated 1,325,708 kWh. See Table 2. It should be noted, the 35 psi working pressure is only applicable to the turnouts shown on the overview map. Working pressures spread across the on-farm system may be less at the extremities depending on the on-farm topography.

The proposed river crossing provides ancillary benefits as well. The main distribution system can be reduced to a single main line with secondary branches serving the patrons of the system. The proposed layout reduces the need for multiple pump stations and maintenance of multiple distribution lines, compared to Alternative A or Alternative B.

The price of HDPE is quite volatile and can vary depending on different economic trends. For example, the newly imposed steel tariff has led to an increase in the use of HDPE, and consequently the demand has increased HDPE costs. The price of HDPE also saw a large increase in refinery pricing following Hurricane

Irma and Harvey in 2017 due to increase demand of HDPE. While acknowledging these temporal factors, the cost estimates of HDPE pipe used in this Alternative C Addendum are the same as those used in the original SIP; this allows for direct comparison between the cost estimates for Alternatives A and B in the original SIP and Alternative C. For construction that is completed within two years of when this report is published, the cost estimates include a 30 percent contingency value, and therefore are considered reasonable. It is recommended that projects planned 2 years or more from the published date will require updated cost estimates prior to obtaining financing.

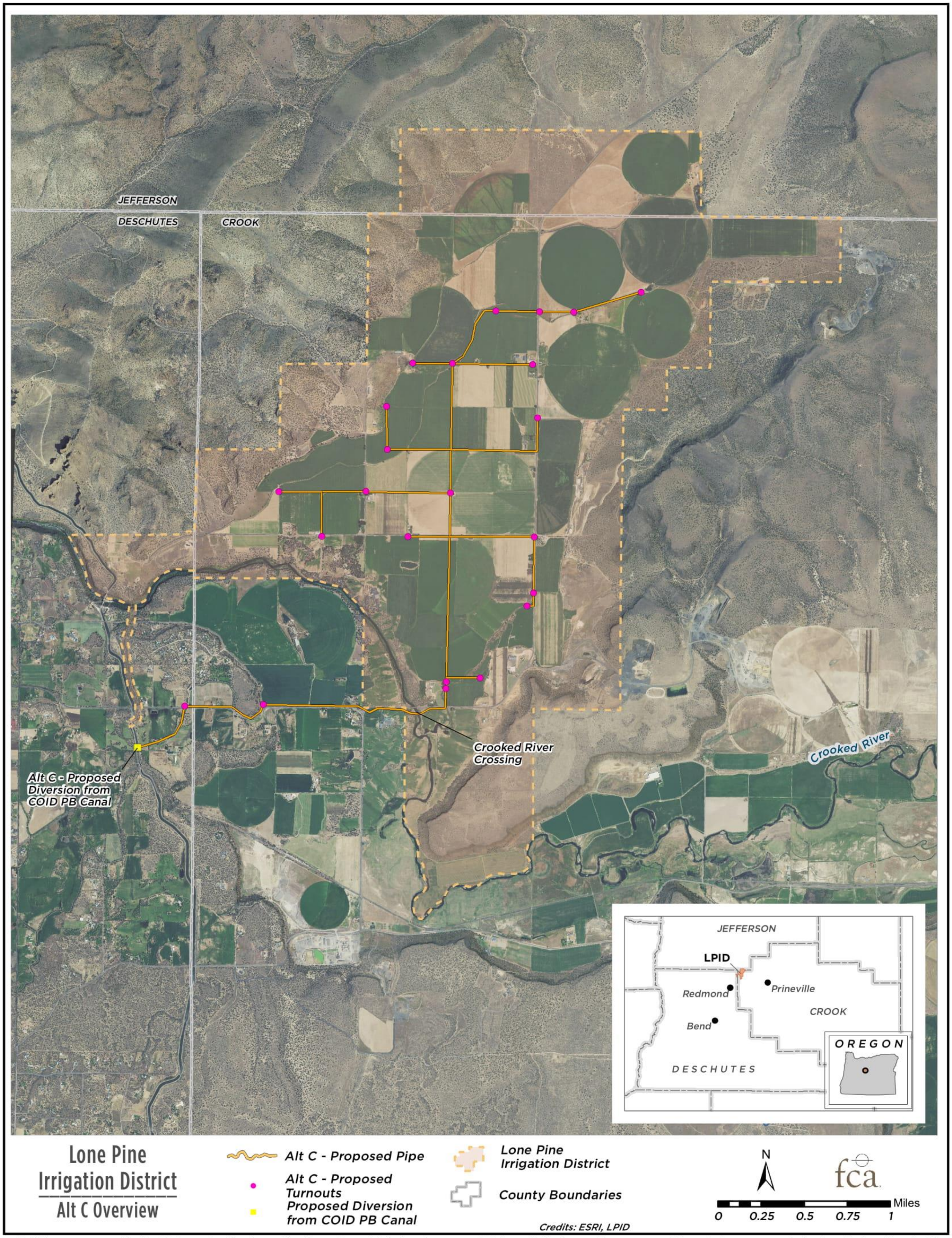
Estimated water conservation of a fully piped system would remain the same as outlined in the original SIP at 5.2 CFS.

The hydraulic model and resulting analyses were created using the following criteria/assumptions. Results from the hydraulic model can be found in Appendix A.

- Turnouts as shown in Figure 1, denoted by the nodes, were placed in accordance with direction from district personnel.
- Patrons on the COID L Lateral were included in the hydraulic model for pipe-sizing purposes. An additional 4,300 gpm was added to account for those patrons.
- An inlet pressure of 67 psi from the L Lateral was assumed for pipe-sizing purposes.
- An additional 160 acres of future capacity was added for the Lone Pine District.
- For the energy analysis, it is assumed that all users are pumping to a minimum 35 psi.
- All other design criteria remains as outlined in the original LPID SIP. Please refer to the SIP for any information pertaining to the design criteria and assumptions.

Appendix B

Other Supporting Information



*** This map was compiled by FCA as a visualization tool and is not intended for legal purposes. FCA is not liable for any damages caused by omissions or errors in the data displayed herein. ***

Figure 1. Alternative C - Overview Map

Table 1. Lone Pine Irrigation District – Alternative C Cost Estimates

Lone Pine Irrigation District - Alternative C							
Reconnaissance - Level Construction Cost Estimates							5/31/2018
Feature	**Location**	**Dia (in)**	**Rating (DR or Steel)**	**Quantity (ft. or #)**	**Unit**	**$/Unit**	**Total Cost**
Pipe	LPID	42	17	10,979	LF	$326.53	$3,585,043
Pipe	LPID	42	21	4,064	LF	$267.65	$1,087,690
Pipe	LPID	42	26	2,127	LF	$218.33	$464,348
Pipe	LPID	32	21	1,329	LF	$155.39	$206,540
Pipe	LPID	30	21	2,643	LF	$136.60	$361,024
Pipe	LPID	24	21	4,188	LF	$87.40	$366,066
Pipe	LPID	20	21	1,457	LF	$60.67	$88,414
Pipe	LPID	14	21	5,775	LF	$29.76	$171,892
Pipe	LPID	12	17	3,624	LF	$30.08	$109,014
Pipe	LPID	12	19	1,792	LF	$27.10	$48,556
Pipe	LPID	12	21	1,891	LF	$24.65	$46,617
Pipe	LPID	10	17	1,728	LF	$21.38	$36,938
Pipe	LPID	10	19	4,716	LF	$19.27	$90,865
Pipe	LPID	10	21	5,190	LF	$17.55	$91,078
Pipe	LPID	8	17	2,133	LF	$13.77	$29,368
Pipe	LPID	8	21	4,432	LF	$11.29	$50,053
Pipe	LPID	8	26	1,328	LF	$9.21	$12,232
River Crossing	LPID		-	1	LS	$800,000	$800,000
Rock Removal	LPID			1	LS	$500,000	$500,000
Turnouts	LPID		-	16	EA	$8,000	$128,000
	SUBTOTAL						$8,273,739
	ENGINEERING, CM, SURVEY				5%		$413,687
	CMGC				14%		$1,158,323
	CONTINGENCY				30%		$2,953,725
	TOTAL						**$12,799,474**

Table 2. Alternative C – Energy Savings Potential

Ditch/Pipeline	Irrigated Acres	Potential Pumping Energy Reduction	Existing Pump Energy Requirements (kWh)	Pressurized Pump Energy Requirements (kWh)	Potential Energy Savings (kWh)
LPID System	2,619	100.0%	1,325,708	0	1,325,708
Total	**2,619**		**1,325,708**	**0**	**1,325,708**

Notes:
-Energy savings outlined in this table assume a fully modernized system with an inlet pressure of 67 psi from COIDS L Lateral.
-Assumes all users irrigate to a minimum of 35 psi.

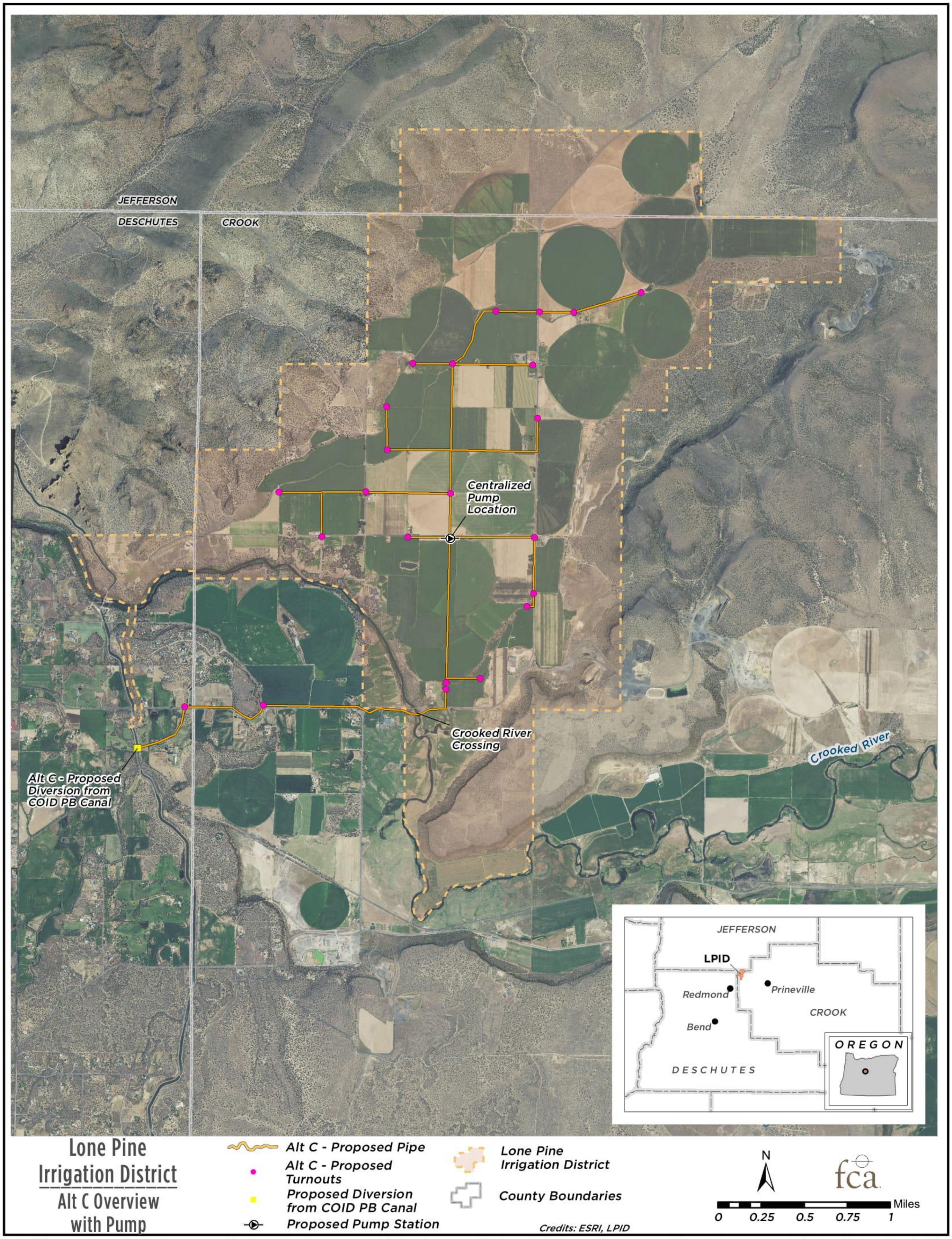
Centralized Pump Station

Another hydraulic model was created to analyze contingency options in the event that LPID is modernized prior to the completion of COID's Pilot Butte Canal modernization. The model was run with an assumed inlet pressure of 0 psi at the L Lateral versus 67 psi. The results of the hydraulic model indicate that a centralized pump station would be required roughly halfway up the LPID main distribution network. Refer to Figure 2 for the exact location of the pump station. See Appendix B for hydraulic model results.

A centralized pump station would need to be approximately 750 hp (to be confirmed in design) in order to provide the equivalent minimum pressure of 35 psi to all turnout locations. Table 3 outlines the cost estimates associated with a centralized pump station. All piping cost estimates would remain the same as outlined in Table 1. There would be no appreciable energy savings with a centralized pump station; it would simply be required to supply water to the entirety of the district until the Pilot Butte Canal is fully piped.

Table 3. Lone Pine Central Pump Station Cost Estimate

Lone Pine Pump Station - Alternative C (750 HP VFD)					
Lone Pine Irrigation District					
Reconnaissance-Level Construction Cost Estimate					5/31/2018
Feature	**Size**	**Quantity**	**Unit**	**$/Unit**	**Total Cost**
Mobilization		1	EA	$20,000	$20,000
Civil Works		1	EA	$100,000	$100,000
Pump/Motor	750 HP	1	EA	$168,750	$168,750
Controls		1	EA	$30,000	$30,000
Electrical		1	EA	$65,000	$65,000
Building		1	EA	$30,000	$30,000
	SUBTOTAL				$413,750
	ENGINEERING, CM, SURVEY		10%		$41,375
	CMGC		14%		$57,925
	CONTINGENCY		30%		$153,915
	TOTAL				**$666,965**

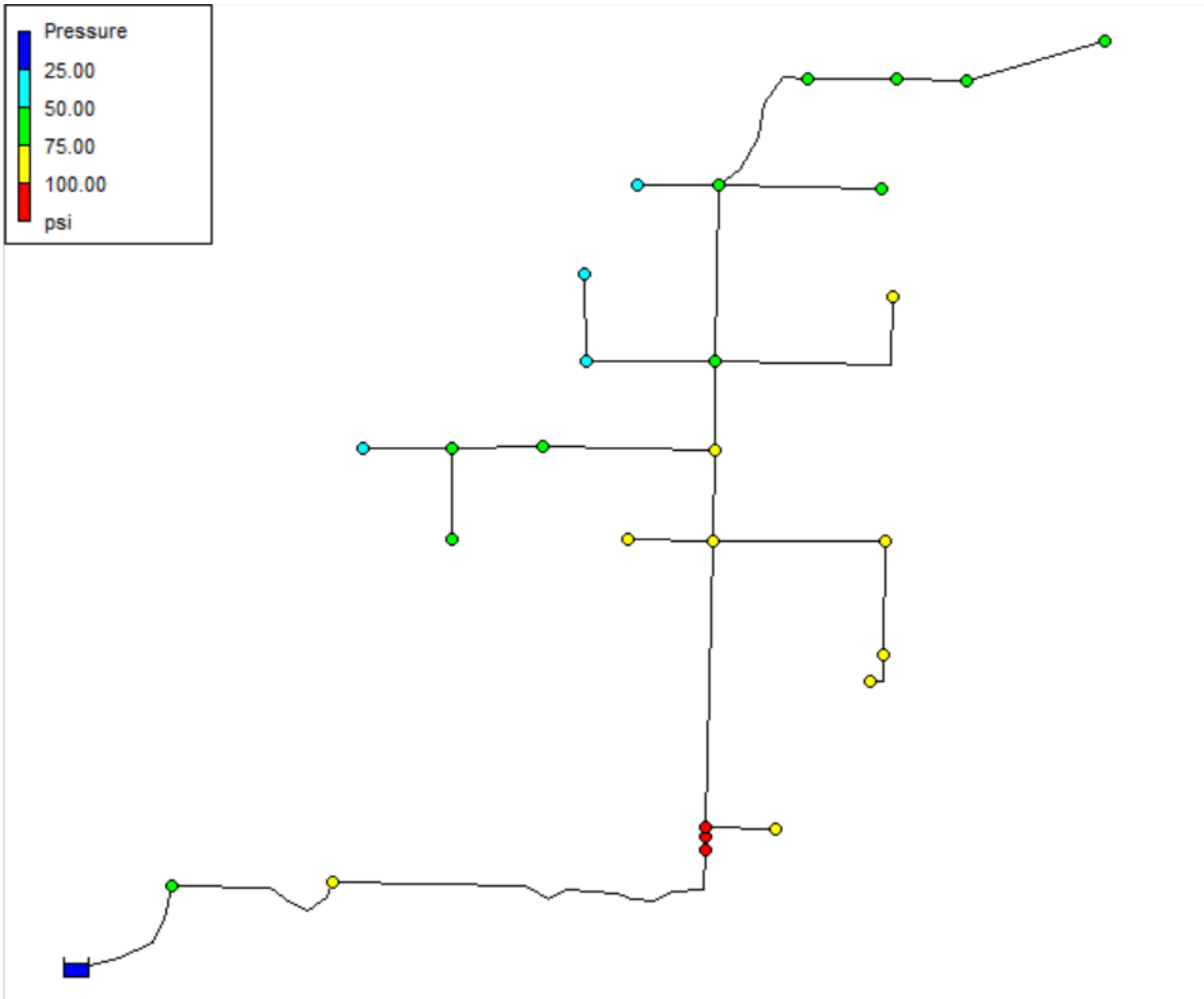


*** This map was compiled by FCA as a visualization tool and is not intended for legal purposes. FCA is not liable for any damages caused by omissions or errors in the data displayed herein. ***

Figure 2. Alternative C – Overview Map with Centralized Pump Station

Appendix A Hydraulic Model Results

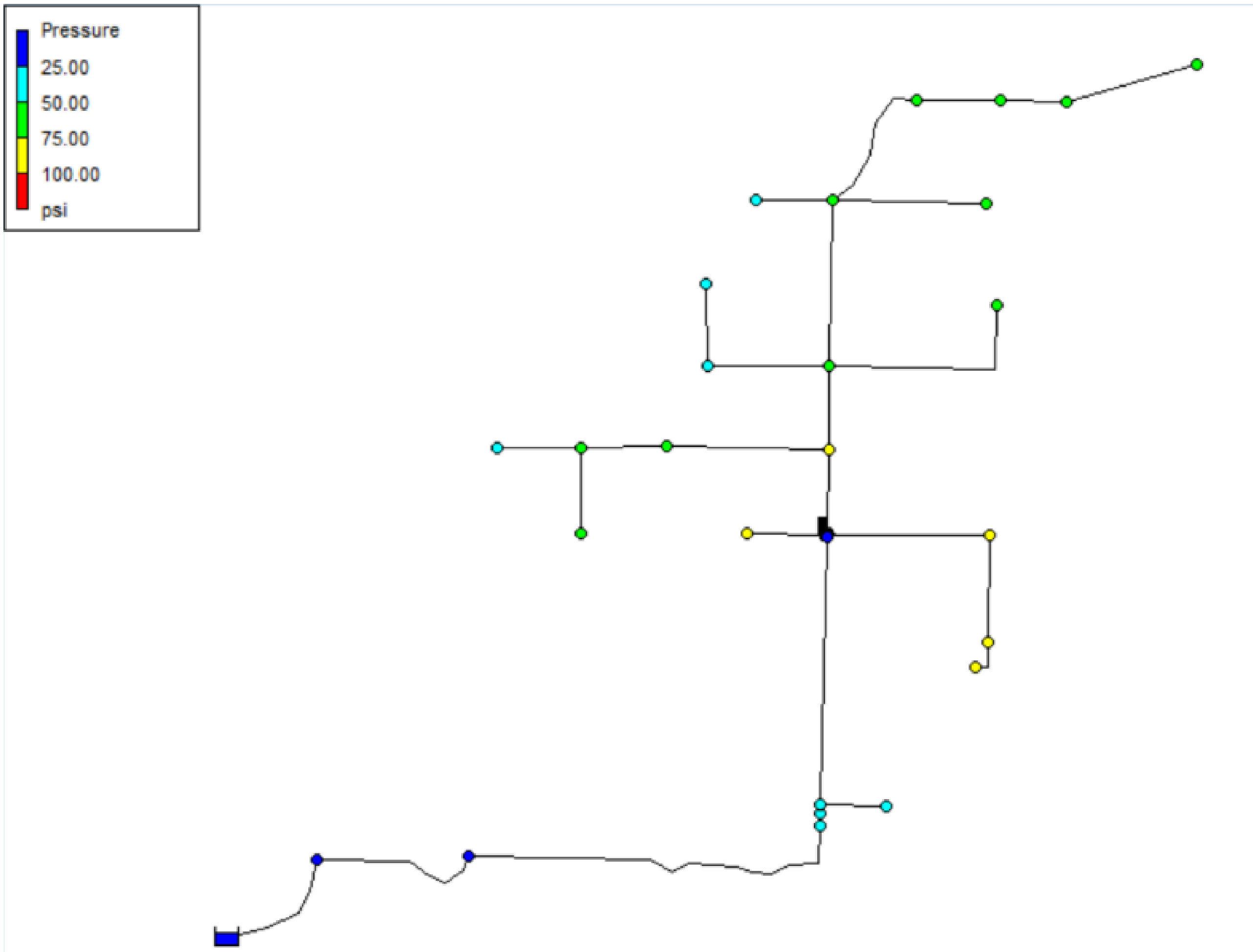
Alternative C – Hydraulic Model



Alternative C - Node Pressures				
Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc L-10	2795.79	579.6	3059.43	114.23
Junc L-3	2874.79	463.75	3028.27	66.5
Junc L-6	2859.5	1630.3	3048.74	82
Junc L-7	2825.07	210	3032.47	89.87
Junc L-8	2811.15	512.4	3014.1	87.94
Junc L-9	2799.49	60.2	3058.99	112.44
Junc M-11	2846.57	847.91	3020.07	75.18
Junc M-4	2904.82	1901.55	3037.86	57.65
Junc M-6	2895.97	819	3030.68	58.37
Junc M-7	2901.09	722.4	3026.38	54.29
Junc M-8	2897.21	2142	3020.45	53.4
Junc M-9	2891.3	1740.34	3009.19	51.08
Junc L-1	2859.19	761.6	3000.59	61.27
Junc L-5	2843.94	1373.4	3040.34	85.1
Junc U-3	2941.16	504	3022.01	35.03
Junc U-4	2940.69	625.45	3027.71	37.7
Junc Junc_Main_001	2797.65	0	3058.74	113.13
Junc M-14_M-15	2819.73	683.2	3042.56	96.55
Junc Junc_Main_002	2845.33	0	3050.42	88.87
Junc M-1_M-2_U-1	2900.59	696.36	2998.26	42.32
Junc M-13	2814.23	509.6	3018.57	88.54
Junc Junc_Main_003	2875.14	0	3045.04	73.62
Junc U-2	2916.64	429.94	3028.69	48.55
Junc Future_School	2879.51	1120	3017.22	59.67
Junc Junc_Lateral_02-2_001	2884.74	0	3017.03	57.32
Junc COID_1	2927	2800	3079.51	66.08
Junc COID_2	2873	1500	3073.42	86.84

Alternative C - Links					
Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps
Pipe Future_School_Lateral	2460.97	9.66	135	1120	4.9
Pipe Lateral_02-2_002	1891.22	11.46	135	1457.96	4.53
Pipe Main_003	122.63	36.761	135	17693.2	5.35
Pipe Main_004	4319.23	36.761	135	17010	5.14
Pipe Main_006	1329.21	28.73	135	10852.59	5.37
Pipe Lateral_02-2_003	1368.92	7.75	135	761.6	5.18
Pipe Lateral_02-2_011	3618.38	12.86	135	1921.71	4.75
Pipe Lateral_02_001	1791.9	11.33	135	1373.4	4.37
Pipe Main_005	1354.91	37.76	135	14404.6	4.13
Pipe Lateral_03_001	3624.32	11.16	135	1232	4.04
Pipe Lateral_03_004	682.81	7.55	135	512.4	3.67
Pipe Main_002	208.36	36.761	135	17753.4	5.37
Pipe Lateral_02-2_004	1844.78	7.75	135	696.36	4.74
Pipe Lateral_05_001	4715.69	9.55	135	847.91	3.8
Pipe Lateral_03_002	1727.93	9.41	135	1022	4.71
Pipe Lateral_01_001	1450.47	7.55	135	683.2	4.9
Pipe Main_007	2642.9	26.97	135	9070.74	5.09
Pipe Main_008	2314.69	21.58	135	5423.74	4.76
Pipe Main_009	1873.72	21.58	135	4604.74	4.04
Pipe Main_010	1457.39	17.98	135	3882.34	4.91
Pipe Main_011	2156.9	12.59	135	1740.34	4.49
Pipe Lateral_04_001	2729.28	9.66	135	933.94	4.09
Pipe Lateral_04_002	1328.11	7.92	135	504	3.28
Pipe Lateral_06_001	1217.89	7.75	135	625.45	4.25
Pipe Main_001-1	2126.82	38.58	135	22633	6.21
Pipe Main_001-2	2708.9	37.76	135	19833	5.68
Pipe Main_001-3	6329.16	36.761	135	18333	5.54

Alternative C – Hydraulic Model W/Pumps



Alternative C (W/Pump) - Node Pressures				
Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc L-10	2795.79	579.6	2907.43	48.37
Junc L-3	2874.79	463.75	3027.44	66.14
Junc L-6	2859.5	1630.3	3047.91	81.64
Junc L-7	2825.07	210	3031.64	89.51
Junc L-8	2811.15	512.4	3013.27	87.58
Junc L-9	2799.49	60.2	2906.99	46.58
Junc M-11	2846.57	847.91	3019.24	74.82
Junc M-4	2904.82	1901.55	3037.03	57.29
Junc M-6	2895.97	819	3029.84	58.01
Junc M-7	2901.09	722.4	3025.55	53.93
Junc M-8	2897.21	2142	3019.62	53.04
Junc M-9	2891.3	1740.34	3008.36	50.72
Junc L-1	2859.19	761.6	2999.76	60.91
Junc L-5	2843.94	1373.4	3039.51	84.74
Junc U-3	2941.16	504	3021.18	34.67
Junc U-4	2940.69	625.45	3026.88	37.35
Junc Junc_Main_001	2797.65	0	2906.74	47.27
Junc M-14_M-15	2819.73	683.2	2890.56	30.69
Junc Junc_Main_002	2845.33	0	3049.59	88.51
Junc M-1_M-2_U-1	2900.59	696.36	2997.43	41.96
Junc M-13	2814.23	509.6	3017.74	88.18
Junc Junc_Main_003	2875.14	0	3044.21	73.26
Junc U-2	2916.64	429.94	3027.86	48.19
Junc Future_School	2879.51	1120	3016.39	59.31
Junc Junc_Lateral_02-2_001	2884.74	0	3016.2	56.96
Junc COID_1	2927	2800	2927.51	0.22
Junc COID_2	2873	1500	2921.42	20.98
Junc Pump1_inlet	2845.5	0	2898.42	22.93

Alternative C (W/Pump) - Links					
Link ID	Length ft	Diameter in	Roughness	Flow GPM	Velocity fps
Pipe Future_School_Lateral	2460.97	9.66	135	1120	4.9
Pipe Lateral_02-2_002	1891.22	11.46	135	1457.96	4.53
Pipe Main_003	122.63	36.761	135	17693.2	5.35
Pipe Main_004	4319.23	36.761	135	17010	5.14
Pipe Main_006	1329.21	28.73	135	10852.59	5.37
Pipe Lateral_02-2_003	1368.92	7.75	135	761.6	5.18
Pipe Lateral_02-2_011	3618.38	12.86	135	1921.71	4.75
Pipe Lateral_02_001	1791.9	11.33	135	1373.4	4.37
Pipe Main_005	1354.91	37.76	135	14404.6	4.13
Pipe Lateral_03_001	3624.32	11.16	135	1232	4.04
Pipe Lateral_03_004	682.81	7.55	135	512.4	3.67
Pipe Main_002	208.36	36.761	135	17753.4	5.37
Pipe Lateral_02-2_004	1844.78	7.75	135	696.36	4.74
Pipe Lateral_05_001	4715.69	9.55	135	847.91	3.8
Pipe Lateral_03_002	1727.93	9.41	135	1022	4.71
Pipe Lateral_01_001	1450.47	7.55	135	683.2	4.9
Pipe Main_007	2642.9	26.97	135	9070.74	5.09
Pipe Main_008	2314.69	21.58	135	5423.74	4.76
Pipe Main_009	1873.72	21.58	135	4604.74	4.04
Pipe Main_010	1457.39	17.98	135	3882.34	4.91
Pipe Main_011	2156.9	12.59	135	1740.34	4.49
Pipe Lateral_04_001	2729.28	9.66	135	933.94	4.09
Pipe Lateral_04_002	1328.11	7.92	135	504	3.28
Pipe Lateral_06_001	1217.89	7.75	135	625.45	4.25
Pipe Main_001-1	2126.82	38.58	135	22633	6.21
Pipe Main_001-2	2708.9	37.76	135	19833	5.68
Pipe Main_001-3	6329.16	36.761	135	18333	5.54

Alternative C (W/Pump) - Node Pressures				
Node ID	Elevation ft	Demand GPM	Head ft	Pressure psi
Junc L-10	2795.79	579.6	2907.43	48.37
Junc L-3	2874.79	463.75	3027.44	66.14
Junc L-6	2859.5	1630.3	3047.91	81.64
Junc L-7	2825.07	210	3031.64	89.51
Junc L-8	2811.15	512.4	3013.27	87.58
Junc L-9	2799.49	60.2	2906.99	46.58
Junc M-11	2846.57	847.91	3019.24	74.82
Junc M-4	2904.82	1901.55	3037.03	57.29
Junc M-6	2895.97	819	3029.84	58.01
Junc M-7	2901.09	722.4	3025.55	53.93
Junc M-8	2897.21	2142	3019.62	53.04
Junc M-9	2891.3	1740.34	3008.36	50.72
Junc L-1	2859.19	761.6	2999.76	60.91
Junc L-5	2843.94	1373.4	3039.51	84.74
Junc U-3	2941.16	504	3021.18	34.67
Junc U-4	2940.69	625.45	3026.88	37.35
Junc Junc_Main_001	2797.65	0	2906.74	47.27
Junc M-14_M-15	2819.73	683.2	2890.56	30.69
Junc Junc_Main_002	2845.33	0	3049.59	88.51
Junc M-1_M-2_U-1	2900.59	696.36	2997.43	41.96
Junc M-13	2814.23	509.6	3017.74	88.18
Junc Junc_Main_003	2875.14	0	3044.21	73.26
Junc U-2	2916.64	429.94	3027.86	48.19
Junc Future_School	2879.51	1120	3016.39	59.31
Junc Junc_Lateral_02-2_001	2884.74	0	3016.2	56.96
Junc COID_1	2927	2800	2927.51	0.22
Junc COID_2	2873	1500	2921.42	20.98
Junc Pump1_inlet	2845.5	0	2898.42	22.93

B.1 Supporting Calculations for Water Resources

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

Table B-1. ODFW Instream Water Rights for the Deschutes River and the Crooked River.

Source	From	To	Certificate	Priority Date	Instream Rates (cfs)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Deschutes R	Crane Prairie Reservoir	Wickiup Reservoir	73233	10/11/1990	130	130	130	130	130	130	130	130	130	130	130	130
Deschutes R	Wickiup Reservoir	Little Deschutes	59776	11/3/1983	300	300	300	300	300	300	300	300	300	300	300	300
Deschutes R	Little Deschutes	Spring River	59777	11/3/1983	400	400	400	400	400	400	400	400	400	400	400	400
Deschutes R	Spring River	North Canal Dam	59778	11/3/1983	660	660	660	660	660	660	660	660	660	660	660	660
Deschutes R	North Canal Dam	Round Butte Reservoir	Pending	9/24/1990	250	250	250	250	250	250	250	250	250	250	250	250
Crooked River	Bowman Dam	Mouth	Pending	10/11/1990	75	75/150	225	225	225	150	75	75	75	75	75	75

Deschutes River below Crane Prairie Reservoir

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the Deschutes River below Crane Prairie Reservoir. Streamflows from the 1994 to 2014 water years represent average baseline conditions. Streamflows in the October 2016 to September 2017 water year represent modified baseline conditions following the Stipulated Settlement Agreement with the Center for Biological Diversity. Data are sourced from OWRD Gauge No. 14054000.

Table B-2. Deschutes River below Crane Prairie Reservoir - Stream Flow Prior to the 2016 Settlement Agreement and Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement (cfs).

Month	Low Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 20% Exceedance	Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement.
Oct	151	94	245	74	319	196
Nov	95	82	177	63	239	204
Dec	98	61	159	41	200	179
Jan	110	38	148	61	209	178
Feb	89	36	125	64	189	148
Mar	79	46	125	47	172	80
Apr	89	54	143	54	197	271
May	196	89	285	127	412	410
Jun	239	148	387	71	458	430
Jul	239	129	368	108	476	319
Aug	231	80	311	128	439	434
Sep	208	75	283	99	382	461

Deschutes River below Wickiup Reservoir

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the Deschutes River below Wickiup Reservoir. Streamflows from the 1994 to 2014 water years represent average baseline conditions. Streamflows in the October 2016 to September 2017 water year represent modified baseline conditions following the Stipulated Settlement Agreement with the Center for Biological Diversity. Data are sourced from OWRD Gauge No. 14056500.

Table B-3. Deschutes River below Wickiup Reservoir - Stream Flow Prior to the 2016 Settlement Agreement and Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement (cfs).

Month	Low Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 20% Exceedance	Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement.
Oct	36	263	299	545	844	111
Nov	30	17	47	238	284	119
Dec	30	26	56	321	376	103
Jan	30	57	87	362	449	105
Feb	31	97	128	397	525	101
Mar	32	220	252	262	514	99
Apr	338	244	582	223	805	617
May	824	266	1090	240	1330	786
Jun	1000	270	1270	160	1430	1080
Jul	1340	110	1450	150	1600	1460
Aug	1290	130	1420	90	1510	1590
Sep	967	203	1170	170	1340	1150

Deschutes River at Benham Falls

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the Deschutes River at Benham Falls. Streamflows from the 1994 to 2014 water years represent average baseline conditions. Streamflows in the October 2016 to September 2017 water year represent modified baseline conditions following the Stipulated Settlement Agreement with the Center for Biological Diversity. Data are sourced from OWRD Gauge No. 14064500.

Table B-4. Deschutes River at Benham Falls - Stream Flow Prior to the 2016 Settlement Agreement and Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement (cfs).

Month	Low Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 20% Exceedance	Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement.
Oct	504	375	879	481	1360	640
Nov	460	76	536	339	875	596
Dec	492	102	594	476	1070	573
Jan	501	205	706	434	1140	577
Feb	540	191	731	499	1230	688
Mar	559	265	824	456	1280	841
Apr	954	316	1270	270	1540	1500
May	1600	250	1850	140	1990	1700
Jun	1660	230	1890	210	2100	1790
Jul	1850	120	1970	120	2090	1980
Aug	1820	90	1910	110	2020	2010
Sep	1450	230	1680	170	1850	1640

Deschutes River below North Canal Dam

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the middle Deschutes River below North Canal Dam. Streamflows from the 1994 to 2014 water years represent average baseline conditions. Streamflows in the October 2016 to September 2017 water year represent modified baseline conditions following the Stipulated Settlement Agreement with the Center for Biological Diversity. Data are sourced from OWRD Gauge No. 14070500.

Table B-5. Deschutes River below North Canal Dam - Stream Flow Prior to the 2016 Settlement Agreement and Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement (cfs).

Month	Low Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs) Prior to the 2016 Settlement Agreement. Data are derived from water years 1994-2014 - 20% Exceedance	Daily Average Stream Flow (cfs) following the 2016 Settlement Agreement.
Oct	504	447	537	40	577	350
Nov	90	29	533	21	554	464
Dec	504	18	506	27	533	537
Jan	488	15	498	186	684	610
Feb	483	88	556	71	627	569
Mar	468	98	689	255	944	682
Apr	591	187	662	298	959	298
May	474	12	113	10	123	107
Jun	101	7	124	10	133	108
Jul	117	3	128	2	130	103
Aug	125	4	123	3	126	100
Sep	119	13	139	48	187	105

Crooked River below Osborne Canyon

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the Crooked River below Osborne Canyon. Streamflows from the 2003 to 2014 water years represent average baseline conditions. Data are sourced from OWRD Gauge No. 14087380.

Table B-6. Crooked River below Osborne Canyon - Daily Average Stream Flow (cfs) between 2003-2014.

Month	Low Stream Flows (cfs) Data are derived from water years 2003-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs). Data are derived from water years 2003-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs). Data are derived from water years 2003-2014 - 20% Exceedance
Oct	211	46	257	46	303
Nov	188	21	209	38	246
Dec	176	26	202	47	249
Jan	181	45	226	298	524
Feb	195	32	227	271	498
Mar	204	64	268	493	761
Apr	345	299	644	1076	1720
May	159	241	400	495	895
Jun	142	95	237	183	419
Jul	110	31	141	43	184
Aug	117	46	163	35	198
Sep	177	53	230	47	276

Crooked River below Opal Springs

This appendix subsection presents supporting calculations used when evaluating the affected environment with respect to water resources in the Crooked River below Opal Springs. Streamflows from the 1984 to 2014 water years represent average baseline conditions. Data are sourced from OWRD Gauge No. 14087400.

Table B-7. Crooked River below Opal Springs - Daily Average Stream Flow (cfs) between 1984-2014.

Month	Low Stream Flows (cfs) Data are derived from water years 1984-2014 - 80% Exceedance	Lower Bar	Daily Average Stream Flows (cfs). Data are derived from water years 1984-2014 - 50% Exceedance	Upper Bar	High Stream Flows (cfs). Data are derived from water years 1984-2014 - 20% Exceedance
Oct	1310	60	1370	90	1460
Nov	1300	40	1340	30	1370
Dec	1280	40	1320	80	1400
Jan	1280	50	1330	152	1482
Feb	1270	80	1350	0	1350
Mar	1280	150	1430	786	2216
Apr	1280	350	1630	1050	2680
May	1220	130	1350	550	1900
Jun	1210	80	1290	190	1480
Jul	1200	50	1250	50	1300
Aug	1210	50	1260	70	1330
Sep	1240	90	1330	80	1410

B.2 Allocation of Conserved Water Program

This appendix section presents information on the State of Oregon's Allocation of Conserved Water Program. Oregon Revised Statutes 537.455-500 authorize this program. Per OWRD (2017),

> 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 certicate[sic] 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[sic] junior to the original right.

References

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.