# SOUTH AREA (LATERAL 31, 32, 34) IMPROVEMENT EVALUATION

## A FEASIBILITY REPORT TO JEFFERSON SOIL AND WATER CONSERVATION DISTRICT AND NORTH UNIT IRRIGATION DISTRICT

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NORTH UNIT IRRIGATION DISTRICT

BLACK ROCK CONSULTING

# NORTH UNIT IRRIGATION DISTRICT
# SOUTH AREA IMPROVEMENT EVALUATION

## I. BACKGROUND

The Jefferson Soil and Water Conservation District, the Natural Resources Conservation Service (NRCS), the North Unit Irrigation District (NUID) and the Oregon Water Resources Department (OWRD) authorized this feasibility evaluation of the South Area. The South Area is located in the southern portion of the NUID service territory bounded by Juniper Butte to the north-west and the Crooked River to the south. The District's main canal borders the area on the east and north sides. The South Area is currently irrigated from main canal diversions into Lateral 31, 32, 34 and direct deliveries from the main canal (see South Area Base Map below). The purpose of the study was to gather existing open irrigation canal, irrigated acreage, tail water system, soil migration, and associated information to evaluate potential water conservation and piping feasibility for the area. Additionally, to evaluate the potential for energy savings based upon development of a pressurized piped system. Lastly, to assess the potential for tailwater storage and reuse.

The study focused on main lateral piping for feasibility purposes and not on-farm system across the study area. Should the project move forward, details of specific turnout locations and on-farm system hook-ups and optimization should be performed.

## II. BASE MAP OF EXISTING SOUTH AREA SYSTEM

Based upon the NUID database, GIS mapping files, available aerial imagery, and a headgate spreadsheet providing acreages served by headgate, a base map was developed for the existing study area (see South Area Base Map below). The map provides the basis for the balance of the work, establishing canal alignments and locations, properties irrigated, headgate locations, highway crossing locations and associated features. The South Area is bifurcated by a ridgeline that runs from north to south parallel to and just east of the old Culver Highway. This ridgeline separates the service areas of the 31 and 32 Laterals (west side of South Area) from the 34 Lateral (east side of South Area). The 31 and 32 Lateral sub-basin drains into an existing tail-water system as does the 34 Lateral sub-basin. These tail-water systems are indicated on the Base Map.

## III. FIELD SURVEY AND LiDAR IMAGERY

The Jefferson County Soil and Water Conservation District staff obtained existing LiDAR imagery for the study area. This data was layered over the South Area Base Map and was found to be concentrated in the far south end of the study area predominantly in the Crooked River Canyon. It was therefore determined to have a reconnaissance field survey performed. Staff of Black Rock Consulting, NUID and the NRCS visited the study area features to define the survey

elements. A survey plan was developed by Black Rock Consulting and carried out by NRCS staff during the Spring of 2013. The scope of the survey included survey-grade GPS survey of the 31, 32 and 34 Laterals and Sub-Laterals within the study area by incremental cross-sectional survey data gathering. It also included surveying of proposed pipeline alignments as they deviated from the existing canal alignments, survey of culvert crossings of study area roads and survey of tail-water ditches to try to determine sediment migration quantities.

The survey data was provided by the NRCS to BRC and was added to the study Base Map. A copy of the Base Map overlain with survey information is included below (South Area Survey Base Map). The extent of the data collection was high, thus providing excellent information for the study development. However, the mapping is difficult to read at 11x17 size, therefore a disk of the study mapping has been included for those that would like to "zoom-in" to the mapping for detailed observation.

## IV. TAIL-WATER WEIR MEASUREMENT

As indicated above and as identified on the South Area Base Map, the 31 and 32 Lateral irrigated area drains to a surface runoff system that parallels the ridgeline separating the area from the 34 Lateral area. The drain is an earthen ditch that conveys area tail-water to a pond that in turn spills to the Crooked River rim.

As part of this study, the NUID installed a temporary weir measurement device to try to determine the normal magnitude of the tail-water runoff flow rate. This weir was measured during the months of August and September, 2012 and May, 2013. The results of these measurements are indicated in the table below.

The 34 Lateral system also has a drainage associated with it that terminates in a small pond at the south end of the area at the Crooked River rim and then spills over the rim. This pond is fed by surface water runoff following the east side of highway 97 and ditch tail-water crossing highway 97 from west to east in an 18-inch culvert. The pond and runoff to the Crooked River is also fed by several Oregon Department of Transportation highway shoulder surface water downspouts. As we were not able to establish an effective measurement point on that tail-water system, we used visual observation and proportionality to estimate the tail-water produced from the 34 Lateral and Sub-lateral systems.

It was estimated that an average of 0.59 CFS may be found in the 31 and 32 Lateral tailwater system and an estimated average of 0.74 CFS exits the tail of the 34 Lateral system. The detailed results of estimated tail-water flows lost out of the system are indicated in the table below.

## NUID LATERAL 31 AND 32 TAIL-WATER ESTIMATE

North Unit Irrigation District

May, 2013 Black Rock Consulting

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Aug-12** | | | | | | | | | |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | |
| **1.04** | **1.11** | **0.37** | | **0.42** | **0.42** | **0.23** | **0.53** | **0.47** | |
| **Sep-12** | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **0.53** | | **0.08** | **0.19** | **0.27** | **0.27** | **0.11** | **0.19** | | **0.23** |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **0.71** | **0** | **0.08** | **0.19** | **0.05** | | **0.19** | **0.59** | **0.27** | **0.27** |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| **0.19** | **0.19** | | **0.27** | **0.11** | **0.19** | **1.19** | **0.19** | **0.65** | |
| **May-13** | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | | | | | **1.66** | **1.11** | **1.11** | **1.34** |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **1.58** | | **0.9** | **0.84** | **1.11** | **0.9** | **0.9** | **1.34** | | **1.34** |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| **1.11** | **0.15** | **0.32** | **0.23** | **0.9** | | **0.97** | **0.59** | **0.84** | **0.97** |

**AVERAGE TAIL WATER FLOW RATE= 0.59 CFS**

## NUID LATERAL 34 AND SUBLATERALS OF 34 TAIL-WATER ESTIMATE

No measurement device exists for tail-water from 34 Lateral system. Use proration of irrigated acres for assumed tail-water.

| | | |
|---|---|---|
| AREA 31/32 | 976 | Acres |
| AREA 34 | 1227 | Acres |
| Proration | =1227/976 | =1.26 |

1.26 x 0.59 CFS = 0.74 CFS

**AVERAGE TAIL-WATER FLOW RATE ESTIMATE= 0.74 CFS**

**GRAND TOTAL SYSTEM TAIL-WATER ESTIMATE = 1.34 CFS**

## V. SYSTEM SEEPAGE LOSS ESTIMATE AND TOTAL WATER LOSS ESTIMATE

The laterals within the project area are earthen canals excavated for the purpose of water conveyance when the District was established. Earthen canals seep water at varying rates depending upon soil type and subsurface geology. No direct seepage loss measurements were performed during the study. Estimates of water loss were performed using the NRCS soil type seepage method and based upon published estimates by the United States Bureau of Reclamation for the NUID. This information was then compared to the NUID transportation loss database for the month of May, 2012.

The NRCS soil-type seepage method utilizes the wetted cross section of the canal, the canal length, and the soil type (and associated loss coefficient), to estimate the loss due to seepage in a particular canal segment. It also estimates the vegetative uptake of surrounding vegetation using a vegetative loss factor from 0.5 to 1.0.

USDA soil mapping was used to determine the general soil type in the study area. This was found to be sandy-loam and a C-factor of 0.66 was used in the seepage loss calculation commensurate with this soil designation. An average value of 6-FT of wetted area was used for percolation estimation, an estimated velocity based upon observation of 2 FT/S for flow rate, and a calculated total project length of 39,000 FT were used over a 180 day irrigation season. A vegetative loss value of 1% was also used. The resulting estimate was a total of **981.6 AF** in seepage loss for the total NUID South Area (see table below).

The USBR also performed historical seepage loss estimates for various system canals and laterals of the NUID (see below). For the M-31, M-32 and M-34 Laterals, the loss estimated by the USBR was 150 AF, 110 AF and 700 AF respectively for a total study area loss of **960 AF** (see table below.)

The estimated seepage losses were found to be similar and were averaged to develop a final total seepage loss estimate for the study area as indicated below. In averaged flow rate, **970.8 AF** of seepage translates to approximately **2.72 CFS**.

NUID evaluated transportation losses for the month of May, 2013 by assessing diversion rates to the south area versus delivery measurements. This data indicated an average loss rate of **5.3 CFS** for the south area. For the purposes of this study, the **2.72 CFS** was used for estimating purposes (project benefit). Should this project be considered for further development, it is recommended that a regime of field flow measurements be performed to confirm actual seepage loss rates.

The following table represents an analysis by the BOR, of the district's conveyance and distribution system. Estimates for seepage rates for specific reaches of canals and laterals were used. The results compare reasonable close to the above analysis when actual records are used, i.e. within11%. This analysis presents an opportunity for the district to prioritize specific reaches of canals and laterals for potential lining or piping.

**Summary - Conveyance and Distribution Seepage Analysis 1/**
**North Unit Irrigation District**

| Item | Length (miles) | Seepage Rate (estimated) ($ft^3/ft^2/day$) | (acre-feet per year) |
|---|---|---|---|
| **Main Canal** | | | |
| Reach 1 | 24.5 | 1.0 | 33,480 AF/year |
| Reach 2 | 18.1 | 0.8 | 20,580 |
| Reach 3 | 12.2 | 0.66 | 9,450 |
| Reach 4 | 10.2 | 0.67 | 4,670 |
| **Lateral** | | | |
| Lateral M-31 | 0.9 | 0.97 | 150 |
| Lateral M-32 | 0.6 | 0.97 | 110 |
| Lateral M-34 | 2.0 | 1.40 | 700 |
| Lateral M-41 | 3.0 | 0.80 | 830 |
| Lateral M-41-1 | 7.0 | 0.80 | 1000 |
| Lateral M-43 | 6.5 | 0.80 | 1,770 |
| Lateral M-45 | 4.0 | 0.80 | 680 |
| Lateral M-48 | 0.5 | 0.64 | 90 |
| Lateral M-50 | 1.5 | 0.80 | 340 |
| Lateral M-51 | 5.5 | 0.80 | 1,450 |
| Lateral M-51 B | 1.5 | 0.97 | 270 |
| Lateral M-52 | 2.0 | 0.97 | 500 |
| Lateral M-53 | 0.5 | 0.97 | 130 |
| Lateral M-53 A | 0.1 | 0.97 | 20 |
| Lateral M-53 B | 0.1 | 0.97 | 20 |
| Lateral M-55 | 1.5 | 0.97 | 460 |
| Lateral M-56 | 0.8 | 0.97 | 130 |
| Lateral M-56 A | 0.1 | 0.97 | 10 |
| Lateral M-57 | 8.0 | 0.80 | 1,630 |
| Lateral M-58 | 17.0 | 0.59 | 3,730 |
| Lateral M-58 A | 1.3 | 0.97 | 310 |
| Lateral M-60 | 1.0 | 0.97 | 250 |
| Lateral M-61 | 3.4 | 0.97 | 1,010 |
| Lateral M-61 A | 0.9 | 0.64 | 80 |
| Lateral M-63 | 5.5 | 0.97 | 1,590 |

| NUID SOUTH AREA SEEPAGE LOSS ESTIMATE<br>North Unit Irrigation District<br><br>May, 2013 Black Rock Consulting | | | |
|---|---|---|---|
| LOSS BASED UPON NRCS METHOD (SEE TABLE)= | | **981.6 AF** | |
| LOSS BASED UPON USBR STUDY= | M-31 | 150 AF | |
| | M-32 | 110 AF | |
| | M-34 | 700 AF | |
| | | **960 AF** | |
| | **AVERAGE OF TWO METHODS=** | | **970.8 AF** |
| | **AVERAGE SEASON RATE (180 DAYS)=** | | **2.72 CFS** |

Based upon the study area tail water and seepage loss estimates, above, the total system water loss estimate was found to be 4.06 CFS as indicated below.

| NUID SOUTH AREA TOTAL WATER LOSS ESTIMATE<br>North Unit Irrigation District<br><br>May, 2013 Black Rock Consulting | |
|---|---|
| GRAND TOTAL TAIL-WATER LOSS ESTIMATE= | 1.34 CFS |
| GRAND TOTAL SEEPAGE LOSS ESTIMATE= | 2.72 CFS |
| **TOTAL WATER LOSS ESTIMATE=** | **4.06 CFS** |

## VI. SEDIMENT TRANSPORT ESTIMATES

The soils in the irrigated areas are generally classified as sandy loam in the NRCS database. Local knowledge shared by the NUID indicated that some soil depths within the 31 and 32 Lateral service area have been found to be as much as 60-FT in depth prior to hitting rock. This information is supported by visual observation of much of the irrigated area and the lack of evidence of rock surrounding fields, emanating from fields, or stacked in the vicinity. The fine-grained nature of the sandy loam soil gives it a propensity to migrate in the presence of moving water, even when water is moving at a slow rate. This propensity, combined with annual farming operations that disturb the soil, cause a situation wherein soils from the area are

continually migrating during irrigation season. This is evidenced by the observation of the tail-water ditch and evidence of deposited soils along the ditch that the NUID must routinely clean out. It is also evidenced by the mounding of sediments upstream of the temporary weir device that was installed during the summer of 2012.

During the NRCS field survey, the approximate 4,000-LF tail-water ditch was surveyed and observed for soil deposition from the top to the location of the temporary weir near the end of the ditch. Based upon this information, as further calculated below, an estimated 417 CY of material is moved annually in the 31 and 32 Lateral system.

For the purposes of study estimating, a proportion was again used to try to estimate the amount of soil migration attributed to the 34 Lateral and Sub-lateral systems. Based upon proportion of irrigated area, the 34 Lateral system was estimated to migrate 524 CY annually.

The estimated grand total of annual soil migration for the study area was estimated to be 940 CY as indicated in the table below. It should be noted that the mitigation of soil transport and conservation of soil is a significant consideration and benefit of the project.

## NUID LATERAL 31 AND 32 SEDIMENT TRANSPORT ESTIMATE

North Unit Irrigation District

May, 2013 Black Rock Consulting

| | |
|---|---|
| Surveyed Tail Ditch Length | 4500 LF |
| Ditch Bottom Width = | 5 FT |
| Estimated Sediment Deposit Depth | 6 IN |
| | |
| Estimated Soil Volume for 1 Season | 11250 CF |
| | **417 CY** |

## NUID LATERAL 34 AND SUBLATERALS OF 34 SEDIMENT TRANSPORT ESTIMATE

Use Irrigated Area Proration

| | | | | | | |
|---|---|---|---|---|---|---|
| AREA 31/32 | 976 Acres | | | | | |
| AREA 34 | 1227 Acres | | | | | |
| Proration | =1227/976 | | | | | |
| | 1.26 | | | | | |
| Estimated Soil Volume for 1 Season= | | 1.26 | X | 417 | = | **524 CY** |

**GRAND TOTAL ANNUAL SOIL MIGRATION ESTIMATE = 940 CY 31/32/34 LATERALS**

## VII. PIPING ALTERNATIVE ANALYSIS AND PUMPBACK OPTIONS

Utilizing the South Area Base Map, several pipeline alternatives were investigated to try to determine the most economical method of piping the South Area. The first alternative was to develop a single pipeline system to serve the entire area. The second was to provide one pipeline for the entire 31 and 32 Lateral area and one pipeline for the entire 34 Lateral area. The last was to maintain three major main canal connection points and to generally follow the existing canal alignments. Due to the length and diameter of required piping, the first two alternatives were found to be 66% and 32% more costly than the third alternative (maintaining the existing 3 main canal connection points and following existing canal alignments). These preliminary cost comparisons did not include the additional time and cost related to securing a variety of necessary new easements. For these reasons (i.e. cost and time), the selected alternative was to generally maintain the existing canal alignments and main canal connection locations.

Lining alternatives (geomembranes, shotcrete, polyurea over geotextiles) were not investigated as a seepage mitigation solution for these projects. Based upon several past studies by Black Rock Consulting for similar projects, 50-year life cycle analyses indicate that piping is more economical than lining alternatives. Additionally, having visually observed the specific project areas, animal and human damage to liners, accelerated water flow rates increasing safety risks, and difficulty for maintenance access were all additional contributing factors resulting in a piping solution decision. Lastly, piping is the required method to develop system pressure and although the study area topography does not generate sufficient pressures to fully irrigate, it does provide some pressure benefits and thus potential horsepower reductions.

Piping is a viable and much used solution to canal seepage mitigation. In Central Oregon, buried piping provides a stable environment much more protected from the harsh climate than exposed liner alternatives. Although many varieties of pipe materials have been used on canals in Central Oregon over the years including reinforced concrete, corrugated metal, ductile iron, spiral rib metal, coated and lined steel pipe, and reinforced concrete box culverts, the advent of High Density Polyethylene (HDPE) pipe has provided a product that works very well as a solution to large and small diameter and low and high head canal piping situations. HDPE is more abrasion resistant than steel, it is light weight, may be arced into a radius during installation, and may be welded into a fully sealed and watertight installation. For the purposes of this study, HDPE was assumed as the piping material of choice although other alternatives may be considered during final design and project bidding.

Pipe was assumed to be high density polyethylene solid wall fusion welded material installed in a compacted trench condition.

The South Area Piping Improvement Plan (see below) was developed based upon the preferred alternative and generally follows existing lateral alignments and associated easements. In some instances, additional laterals are shown to try to provide service to all NUID South Area irrigated properties/parcels.

Proposed pond options have been added to the South Area Improvement Plan mapping to indicate proposed potential locations for tail-water ponds. These ponds would be used to capture system irrigation tail-water runoff that may continue from on-farm sprinkling operations after piping the system. Captured runoff, if any, at these ponds would be pumped back to local farm interests and re-applied to the land. It is estimated that the potential rate of tail-water capture may be 0.15 CFS, average, for each of the tail-water ponds, thus providing irrigation for about 18 acres from each pond. These systems would be established as part of the project and associated land to apply the water would also be identified by the NUID at that time. Associated electrical and pumping systems would be sized commensurate with the actual flows observed.

In the absence of a near-term piping project, tail-water ponds may be implemented sooner to capture and reuse the water thus eliminating undesirable return flows to the Crooked River. Electrical and pumping systems would be sized to mitigate the 0.59 CFS (lateral 31 and 32 tail-water) and the 0.74 CFS average for lateral 34 tail-water.

To the extent that improvements are to be funded with federal dollars, the National Environmental Policy Act guidelines must be followed. The NRCS published an interim final rule of July 13, 2009 (7 CFR Part 650) that appears to qualify the south area project for a categorical exclusion and therefore neither an environmental assessment (EA) nor an environmental impact statement (EIS) are required.

## VIII. HYDRAULIC ANALYSIS

The estimated HDPE pipe diameter for this project study area based upon a conservative Hazen-Williams Coefficient of (C=130), the elevation profile developed from the field surveys, and estimated peak flow rates as indicated in the table below. The pipe product would be a solid wall, fusion welded, HDPE product with a dimension ratio selected based upon diameter and internal pressure. Generally DR 32.5 or DR 26 pipe wall thickness would be used for the range of diameters expected for the project study area. The associated pressure rating would be 65 PSI and 80 PSI for this product based upon a PE4710 molecular density. This rating well exceeds the expected system pressures.

A hydraulic analysis was performed for each major project lateral (31, 32 and 34). The analysis was based on a delivery rate of 9 gallons per minute per acre peak flow rate as provided by the NUID. This rate was applied to the gross acreages shown in each service area by proposed headgate. The results indicate that the project could provide irrigation service to all of the system properties without pumping and provide additional pressure to lower system areas.

### 31 LATERAL

The proposed 31 Lateral (see South Area Piping Improvement Plan below) begins at the existing main canal diversion point and follows the existing 31 Lateral ditch alignment, although it was extended southerly beyond the existing irrigation ditch as indicated. It additionally includes proposed laterals 31-1, 31-2 and 31-3 to irrigate all sublateral properties as indicated.

# NUID LATERAL 31

North Unit Irrigation District

May, 2013 — Black Rock Consulting — 9 GPM/Acre — 130 HWC

| Segment Description | Station Start (FT) | Elevation Start (FT) | Station End (FT) | Elevation End (FT) | Segment Length (FT) | Total Length (FT) | Elevation Differential (FT) | Current HGL Slope | Turnout Acres | Segment Flow Rate (CFS) | Hydraulic Segment Length | Pipe Material | Inside Diameter (IN) | Residual Pressure (PSI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start at NUID Main Canal** | 0 | 2868.4 | 390 | 2861.4 | 390 | 390 | 7.0 | 0.0178462 | | 13.0 | 390 | 24" DR 32.5 | 22.43 | |
| **Proposed Turnout 31-A** | 390 | 2861.4 | 1000 | 2856.0 | 610 | 1000 | 5.4 | 0.0088689 | 76.8 | 11.5 | 610 | 24" DR 32.5 | 22.43 | 2.5 |
| **Invert** | 1000 | 2856.0 | 1222 | 2854.5 | 222 | 1222 | 1.5 | 0.0068919 | | 11.5 | 222 | 24" DR 32.5 | 22.43 | 4.2 |
| **Proposed Turnout 31-B** | 1222 | 2854.5 | 1833 | 2845.0 | 611 | 1833 | 9.5 | 0.0155483 | 19 | 11.1 | 611 | 24" DR 32.5 | 22.43 | 4.6 |
| **Proposed 31-1 Sublateral** | 1833 | 2845.0 | 2000 | 2839.7 | 167 | 2000 | 5.3 | 0.0317365 | 31 | 10.5 | 167 | 24" DR 32.5 | 22.43 | 8.1 |
| **Proposed Turnout 31-C** | 2000 | 2839.7 | 3103 | 2829.7 | 1103 | 3103 | 10.0 | 0.0090662 | 80 | 8.9 | 1,103 | 20" DR 32.5 | 18.7 | 10.2 |
| **Proposed Turnout 31-D** | 3103 | 2829.7 | 3104 | 2829.6 | 1 | 3104 | 0.1 | 0.1 | 94 | 7.0 | 1 | 20" DR 32.5 | 18.7 | 12.8 |
| **Proposed Turnout 31-E** | 3104 | 2829.6 | 4398 | 2819.5 | 1294 | 4398 | 10.1 | 0.0078053 | 103.1 | 4.9 | 1,294 | 16" DR 26 | 14.7 | 12.8 |
| **Proposed Turnout 31-F** | 4398 | 2819.5 | 4399 | 2819.4 | 1 | 4399 | 0.1 | 0.1 | 100 | 2.9 | 1 | 16" DR 26 | 14.7 | 14.9 |
| **Proposed Turnout 31-G** | 4399 | 2819.3 | 5720 | 2802.6 | 1321 | 5720 | 16.7 | 0.0126419 | 60 | 1.7 | 1,321 | 12" DR 26 | 11.71 | 14.9 |
| **Proposed Tail of 31 Lateral** | 4398 | 2802.6 | | | | | | | 85 | | | | | 21.2 |
| | | | | | **SUBTOTAL** | **5720** | 65.7 | | 648.9 | | 5,720 | | | |
| **Proposed 31-1** | 0 | 2845.68 | 2700 | 2802.0 | 2700 | | 43.7 | 0.0161778 | 31 | 0.6 | 2,700 | 6" DR 26 | 6.1 | 19.48532 |
| **Proposed 31-2** | 0 | 2802.6 | 450 | 2790 | 450 | | 12.6 | 0.028 | 68 | 1.4 | 450 | 8" DR 26 | 7.9 | 25.1236 |
| **Proposed 31-3** | 0 | 2802.6 | 1450 | 2835 | 1450 | | -32.4 | -0.022345 | 17 | 0.3 | 1,450 | 6" DR 26 | 6.1 | 5.835346 |

32 LATERAL

The proposed 32 Lateral (see South Area Piping Improvement Plan below) begins at the existing main canal diversion point and follows the existing 32 Lateral aged low-head piping. It additionally extends to the south to irrigate additional properties as indicated. This system would replace existing aged piping with a new re-sized piped lateral system.

# NUID LATERAL 32

North Unit Irrigation District

May, 2013 | Black Rock Consulting | 9 GPM/Acre | 130 HWC

| Segment Description | Station Start (FT) | Elevation Start (FT) | Station End (FT) | Elevation End (FT) | Segment Length (FT) | Total Length (FT) | Elevation Differential (FT) | Current HGL Slope | Turnout Acres | Segment Flow Rate (CFS) | Hydraulic Segment Length | Pipe Material | Inside Diameter (IN) | Residual Pressure (PSI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start at NUID Main Canal** | 0 | 2866.9 | 10 | 2869.4 | 10 | 10 | -2.5 | -0.25 | | 6.6 | 10 | 20" DR 32.5 | 18.7 | |
| **Proposed Turnout 32-A** | 10 | 2869.4 | 11 | 2869.3 | 1 | 11 | 0.1 | 0.1 | 32.6 | 5.9 | 1 | 20" DR 32.5 | 18.7 | -1.1 |
| **Proposed Turnout 32-B** | 11 | 2869.3 | 1250 | 2844.0 | 1239 | 1250 | 25.3 | 0.0204197 | 21.5 | 5.5 | 1,239 | 20" DR 32.5 | 18.7 | -1.0 |
| **Proposed Turnout 32-C** | 1250 | 2844.0 | 3950 | 2812.0 | 2700 | 3950 | 32.0 | 0.0118519 | 40 | 4.7 | 2,700 | 16" DR 26 | 14.7 | 9.1 |
| **Proposed Turnout 32-D** | 3950 | 2812.0 | 3951 | 2811.9 | 1 | 3951 | 0.1 | 0.1 | 43 | 3.8 | 1 | 16" DR 26 | 14.7 | 18.6 |
| **Proposed Turnout 32-E** | 3951 | 2811.9 | 4604 | 2808.0 | 653 | 4604 | 3.9 | 0.0059724 | 70 | 2.4 | 653 | 12" DR 26 | 11.71 | 18.6 |
| **Proposed Turnout 32-F** | 4604 | 2808.0 | 4605 | 2807.9 | 1 | 4605 | 0.1 | 0.1 | 40 | 1.6 | 1 | 8" DR 26 | 7.9 | 19.4 |
| **Proposed Turnout 32-G** | 4605 | 2807.9 | 4606 | 2807.8 | 1 | 4606 | 0.1 | 0.1 | 81.1 | | 1 | 8" DR 26 | 7.9 | 19.4 |
| **Proposed Tail End of 32 Lateral** | 4606 | 2807.8 | | | | | | | | | | | | 19.4 |
| | | | | | **SUBTOTAL** | **4606** | 59.1 | | 328.2 | | 4,606 | | | |

34 LATERAL

The proposed 34 Lateral (see South Area Piping Improvement Plan below) begins at the existing main canal diversion point and follows the existing 34 Lateral and sublateral ditch alignments, although it was extended southerly beyond the existing irrigation ditch as indicated. It additionally includes proposed laterals 34-1, 34-2 and 34-3 to irrigate all sublateral properties as indicated.

# NUID LATERAL 34

North Unit Irrigation District

May, 2013 | Black Rock Consulting | 9 GPM/Acre | 130 HWC

| Segment Description | Station Start (FT) | Elevation Start (FT) | Station End (FT) | Elevation End (FT) | Segment Length (FT) | Total Length (FT) | Elevation Differential (FT) | Current HGL Slope | Turnout Acres | Segment Flow Rate (CFS) | Hydraulic Segment Length | Pipe Material | Inside Diameter (IN) | Residual Pressure (PSI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start at NUID Main Canal | 0 | 2865.4 | 1390 | 2867.6 | 1390 | 1390 | -2.2 | -0.001583 | | 24.6 | 1,390 | 42" DR 32.5 | 39.3 | |
| Proposed 34-1 Sublateral | 1390 | 2867.6 | 2000 | 2864.8 | 610 | 2000 | 2.8 | 0.0045902 | 194.9 | 20.7 | 610 | 42" DR 32.5 | 39.3 | -1.4 |
| Proposed Turnout 34-A | 2000 | 2864.8 | 2748 | 2863.0 | 748 | 2748 | 1.8 | 0.0024064 | 38.7 | 19.9 | 748 | 36" DR 32.5 | 39.3 | -0.3 |
| Proposed Turnout 34-B | 2748 | 2863.0 | 3726 | 2862.5 | 978 | 3726 | 0.5 | 0.0005112 | 16.1 | 19.6 | 978 | 36" DR 32.5 | 33.7 | 0.4 |
| Proposed Turnout 34-C | 3726 | 2862.5 | 4241 | 2862.8 | 515 | 4241 | -0.3 | -0.000583 | 34.4 | 18.9 | 515 | 36" DR 32.5 | 33.7 | 0.2 |
| Proposed Turnout 34-D | 4241 | 2862.8 | 5445 | 2856.0 | 1204 | 5445 | 6.8 | 0.0056478 | 34.6 | 18.2 | 1,204 | 36" DR 32.5 | 33.7 | -0.1 |
| Proposed Turnout 34-E | 5445 | 2856.0 | 5446 | 2855.8 | 1 | 5446 | 0.2 | 0.2 | 30.8 | 17.6 | 1 | 36" DR 32.5 | 33.7 | 2.4 |
| Proposed Turnout 34-F | 5446 | 2855.8 | 5447 | 2855.7 | 1 | 5447 | 0.1 | 0.1 | 27.3 | 17.1 | 1 | 36" DR 32.5 | 33.7 | 2.5 |
| Proposed 34-2 Sublateral | 5447 | 2855.7 | 6558 | 2844.4 | 1111 | 6558 | 11.3 | 0.010171 | 290.3 | 11.2 | 1,111 | 24" DR 32.5 | 22.4 | 2.5 |
| Proposed Turnout 34-G | 6558 | 2844.4 | 7555 | 2833.6 | 997 | 7555 | 10.8 | 0.0108325 | 135.8 | 8.5 | 997 | 20" DR 32.5 | 18.7 | 6.3 |
| Proposed Turnout 34-H | 7555 | 2833.6 | 7556 | 2833.5 | 1 | 7556 | 0.1 | 0.1 | 24 | 8.0 | 1 | 20" DR 32.5 | 18.7 | 9.4 |
| Proposed 34-3 Sublateral | 7556 | 2833.5 | 8464 | 2832.8 | 908 | 8464 | 0.7 | 0.0007709 | 37 | 7.3 | 908 | 20" DR 32.5 | 18.7 | 9.5 |
| Proposed Turnout 34-I | 8464 | 2832.8 | 11149 | 2827.4 | 2685 | 11149 | 5.4 | 0.0020112 | 14 | 7.0 | 2,685 | 20" DR 32.5 | 18.7 | 8.7 |
| Proposed Turnout 34-J | 11149 | 2819.5 | 11150 | 2819.4 | 1 | 11150 | 0.1 | 0.1 | 30 | 6.4 | 1 | 20" DR 32.5 | 18.7 | 8.3 |
| Proposed Turnout 34-K | 11150 | 2819.3 | 11151 | 2819.2 | 1 | 11151 | 0.1 | 0.1 | 35.2 | 5.7 | 1 | 20" DR 32.5 | 18.7 | 8.3 |
| Proposed Turnout 34-L | 11151 | 2819.2 | 11152 | 2819.1 | 1 | 11152 | 0.1 | 0.1 | 14.3 | 5.4 | 1 | 20" DR 32.5 | 18.7 | 8.3 |
| Proposed Turnout 34-M | 11152 | 2819.1 | 11153 | 2819.0 | 1 | 11153 | 0.1 | 0.1 | 75.1 | 3.9 | 1 | 20" DR 32.5 | 18.7 | 8.4 |
| Proposed Turnout 34-N | 11153 | 2819.0 | 13855 | 2817.4 | 2702 | 13855 | 1.6 | 0.0005922 | 36.9 | 3.2 | 2,702 | 16" DR 26 | 14.7 | 8.4 |
| Proposed Turnout 34-O | 13855 | 2817.4 | 13856 | 2817.3 | 1 | 13856 | 0.1 | 0.1 | 158.3 | | 1 | 16" DR 26 | 14.7 | 7.0 |
| Proposed Tail of 34 Lateral | 13856 | 2817.3 | | | | | | | | | | | | 7.0 |
| | | | | | SUBTOTAL | 13856 | 40.1 | | 1227.7 | | 13,856 | | | |
| Proposed 34-1 | 0 | 2865.4 | 1840 | 2863.4 | 1840 | 1840 | 2.0 | 0.001087 | 194.9 | 3.9 | 1,840 | 20" DR 32.5 | 18.7 | 0.0 |
| Proposed 34-2 | 0 | 2855.7 | 1389 | 2854 | 1389 | 1389 | 1.7 | 0.0012239 | | 5.8 | 1,389 | 24" DR 32.5 | 22.4 | 2.5 |
| 34-2-A | 1389 | 2854 | 3778 | 2846.2 | 2389 | 3778 | 7.8 | 0.003265 | 6.7 | 5.7 | 2,389 | 24" DR 32.5 | 22.4 | 2.3 |
| 34-2-B | 3778 | 2846.2 | 4556 | 2840 | 778 | 4556 | 6.2 | 0.0079692 | 7 | 5.5 | 778 | 20" DR 32.5 | 18.7 | 4.9 |
| 34-2-C | 4556 | 2840 | 4557 | 2839.9 | 1 | 4557 | 0.1 | 0.1 | 36.3 | 4.8 | 1 | 20" DR 32.5 | 18.7 | 7.1 |
| 34-2-1 Sublateral | 4557 | 2839.9 | 5870 | 2829 | 1313 | 5870 | 10.9 | 0.0083016 | 59.8 | 3.6 | 1,313 | 16" DR 26 | 14.7 | 7.1 |
| 34-2-D | 5870 | 2829 | 7196 | 2815.2 | 1326 | 7196 | 13.8 | 0.0104072 | 72.8 | 2.2 | 1,326 | 12" DR 26 | 11.7 | 10.5 |
| 34-2-E | 7196 | 2815.2 | 7197 | 2815.1 | 1 | 7197 | 0.1 | 0.1 | 55.1 | 1.1 | 1 | 12" DR 26 | 11.7 | 15.0 |
| 34-2-F | 7197 | 2815.1 | 8752 | 2788.3 | 1555 | 8752 | 26.8 | 0.0172347 | 36.4 | 0.3 | 1,555 | 6" DR 26 | 6.1 | 15.0 |
| 34-2-G | 8752 | 2788.3 | 8753 | 2788.2 | 1 | 8753 | 0.1 | 0.1 | 16.2 | | 1 | 6" DR 26 | 6.1 | 25.3 |
| Proposed Tail of 34-2 Sublateral | 8753 | 2788.2 | | | | | | | | | | | | 25.3 |
| Proposed 34-3 | 0 | 2833.6 | 1530 | 2833 | 1530 | | 0.6 | 0.0003922 | 37 | 0.7 | 1,530 | 12" DR 26 | 11.7 | 9.5 |

## IX. PROJECT BENEFIT

The project could provide significant benefits in several ways:

1) **Soil conservation** would benefit the study area by reduction in NUID O&M costs, and benefits to the farmers as crop surface topsoils are preserved. System piping is expected to reduce but not eliminate soil migration. Piping will eliminate ditch soil migration, and will deliver irrigation water to key irrigated water delivery points, thus also minimizing on-farm soil losses. For estimating purposes, we have assumed that ½ of the soil migration estimate (or 470 CY) will be reduced by the proposed project. Based upon an estimated top-soil value of $15/CY, this equates to $7,050. Additionally, the District would reduce its annual soil excavation and handling O&M cost by approximately three equipment and man-days for an estimated additional savings of $3,000. The total annual benefit of soil migration mitigation is therefore $10,050.

2) **To reduce operation and maintenance**.

3) **To conserve water lost in an estimated amount of 4.06 CFS (1,450 AF over 180 days).** Although the value changes over time, the value of conserved water currently ranges from $500/AF to nearly $2,000/AF given the perceived value of the conservation and willingness of investors, whether public or private, to compensate for the in-stream water. For the purposes of this study $1,000/AF has been used as an initial valuation estimate. It should be noted that reduced pumping at the Crooked River may also be a benefit of this project depending upon how the conserved water is addressed by the NUID.

4) **To reduce pumping energy costs**. As indicated on the hydraulic analyses of the proposed pipe laterals (above), varying pressure benefits are indicated in the final column. Based upon a power rate of $0.08/kWh, assumed pumping efficiency of 70%, and pump discharge of 60 PSI, the benefits of the incremental pressure delivered to each headgate was evaluated and an estimated annual energy benefit of $16,702 was calculated over the study area.

5) **To provide storage and reuse**. Tail-water may be impounded in tail-water ponds, pumped and re-applied to adjacent lands with irrigation water rights. This would serve to conserve water and to mitigate water and sediment transport from the area to the Crooked River

## X. COST ESTIMATE AND BENEFIT ESTIMATE

Generally, the cost table below is self explanatory regarding the various line-items included in the study-level budget. The project budget was established with the intent that the canal would be piped with HDPE solid-wall pipe, turnouts would be included at existing turnout locations with a tee, valve, and new weir or meter device, bedding and backfill for the pipeline would be predominantly imported yet some material would be borrowed from the banks, concrete inlet and outlet structures would be constructed to protect those critical hydraulic areas, a trash rack would be included at the intake, and contractor mobilization, bonds, insurance and profit are intended to be included. Surveying, engineering and geotechnical services were also included. Lastly, a 25% contingency was included to try to mitigate fluctuations in cost that may occur between the time of this report and the time of final design. It should be noted that the cost of pipe materials and labor may fluctuate significantly over time and therefore an updated cost estimate for this project should be prepared on an annual basis should the project not move forward within a year from the date of this study.

Pipe cost information was obtained from pipeline vendors familiar with delivery of pipe to Central Oregon. Installation cost information was obtained from a local contractor familiar with pipeline installations in Central Oregon in addition to estimates prepared by Black Rock Consulting, who is also very familiar and involved with current pipeline installations in Central Oregon.

Project Benefit was derived from the estimated loss information and converted to Acre-Feet roughly estimated from a 180 day irrigation season. This value should be confirmed and re-calculated by the District and consideration for District retained conserved percentage per Oregon Statute should also be considered. Lastly, the value of an acre-foot of permanently conserved NUID water was estimated as tabulated but should be considered a starting point for consideration by the NUID and interests that may financially participate in the project.

# NUID SOUTH AREA PIPING

RECONNAISSANCE COST ESTIMATE

BLACK ROCK CONSULTING

May, 2013

| Construction Item | Quantity | Units | Cost/Unit | Subtotal Cost |
|---|---|---|---|---|
| Earthwork and General Construction | | | | |
| 1. Mobilization | 10 | % | of Total | $313,753.92 |
| 2. Clearing and Grubbing | 1 | LS | $100,000.00 | $100,000.00 |
| 3. Excavation, Backfill, Compaction of Pipeline | 50 | % of Pipe | $20.00 | $819,231.00 |
| 4. Road Crossings | 7 | EA | $8,000.00 | $56,000.00 |
| 5. Restoration/Seeding | 1 | LS | $60,000.00 | $60,000.00 |
| | | | | |
| Pipe (HDPE) | | | | |
| 6. 42" DR 32.5 HDPE Including Welding and Delivery | 2,000 | LF | $120.00 | $240,000.00 |
| 7. 36" DR 32.5 HDPE Including Welding and Delivery | 3,447 | LF | $90.00 | $310,230.00 |
| 8. 24" DR 32.5 HDPE Including Welding and Delivery | 6,889 | LF | $50.00 | $344,450.00 |
| 9. 20" DR 32.5 HDPE Including Welding and Delivery | 7,728 | LF | $40.00 | $309,120.00 |
| 10. 16" DR 26 HDPE Including Welding and Delivery | 8,012 | LF | $30.00 | $240,360.00 |
| 11. 12" DR 26 HDPE Including Welding and Delivery | 4,831 | LF | $22.00 | $106,282.00 |
| 12. 8" DR 26 HDPE Including Welding and Delivery | 452 | LF | $18.00 | $8,136.00 |
| 13. 6" DR 26 HDPE Including Welding and Delivery | 5,706 | LF | $14.00 | $79,884.00 |
| TOTAL | 39,065 | LF | | |
| Pipe Appurtenances | | | | |
| 14. Fittings and Appurts. to Pipe | 10 | % | $16,384.62 | $163,846.20 |
| 15. Furnish and Install Air/Vacuum Relief Assemblies | 20 | EA | $2,000.00 | $40,000.00 |
| 16. Furnish and install turnout assemblies, complete | 43 | EA | $5,000.00 | $215,000.00 |
| | | | | |
| Proposed Intake at Main Canal | | | | |
| 17. Furnish and Install Reinforced Concrete Intake | 3 | EA | $15,000.00 | $45,000.00 |
| | | | | |
| Contingency | 25 | % | of Construction | $862,823.28 |
| Final Engineering, Permitting, Construction Management | 5 | % | of subtotal | $215,705.82 |
| Design/Construction Survey | | | | $40,000.00 |
| | | | **TOTAL** | **$4,569,822** |

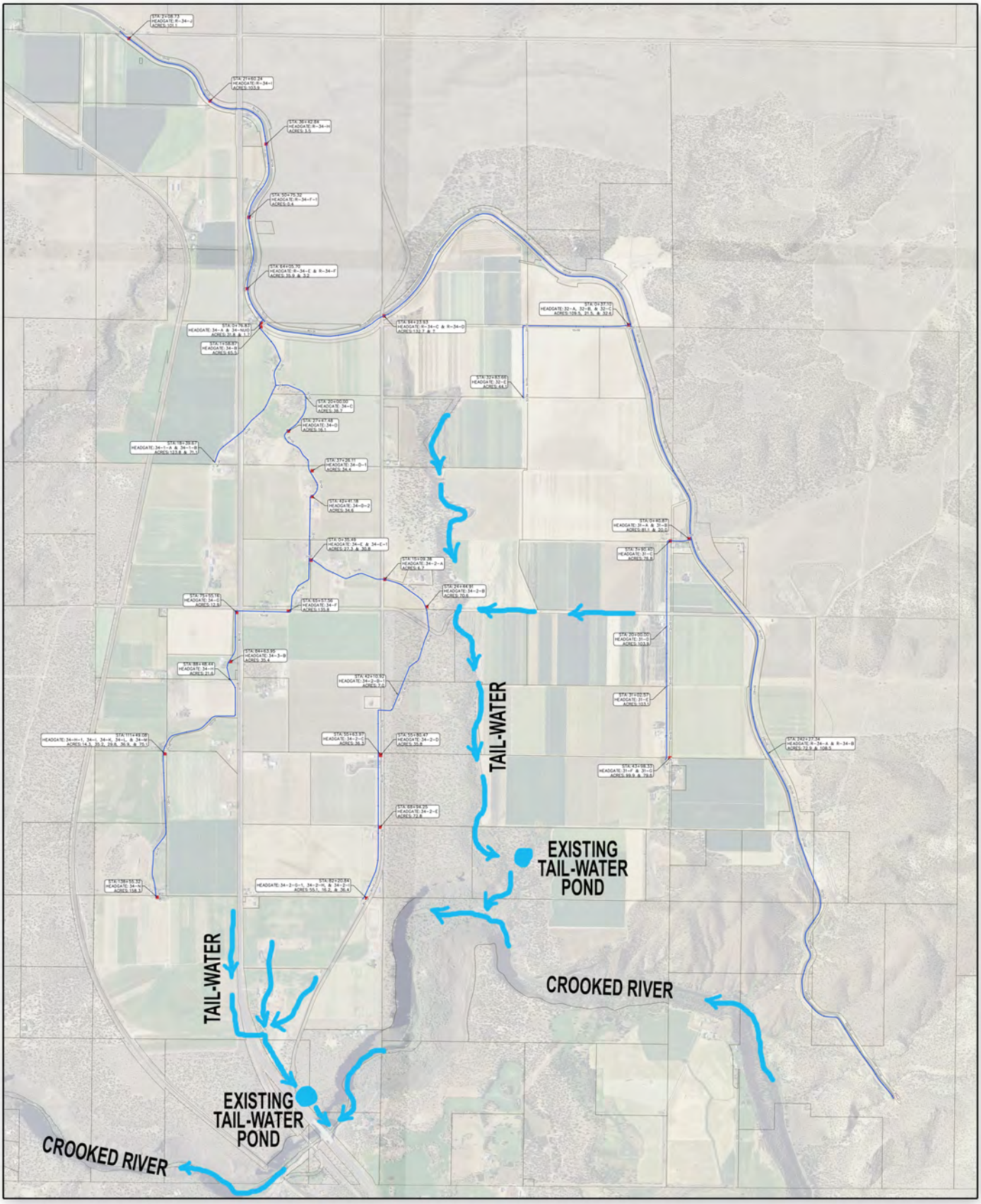
# NUID SOUTH AREA PIPING BENEFIT

| | | |
|---|---|---|
| Conservation | CFS | 4.06 |
| Acre/Feet Based Upon 180 Days | AF | 1449.52 |
| Estimated Value/AF Conserved | $/AF | 1,000 |
| Estimated Benefit from Water Savings | | $1,449,521 |
| Estimated O&M Reduction | | $5,000 |
| Estimated 20-Year Soil Mitigation Benefit | $10,050/yr | $201,000 |
| Estimated 20-Year Power Benefit | $16,702/yr | $334,040 |
| **ESTIMATED ENTIRE BENEFIT** | | **$1,989,561** |
| **ESTIMATED COST** | | **$4,569,822** |
| | **B/C RATIO** | **0.44** |

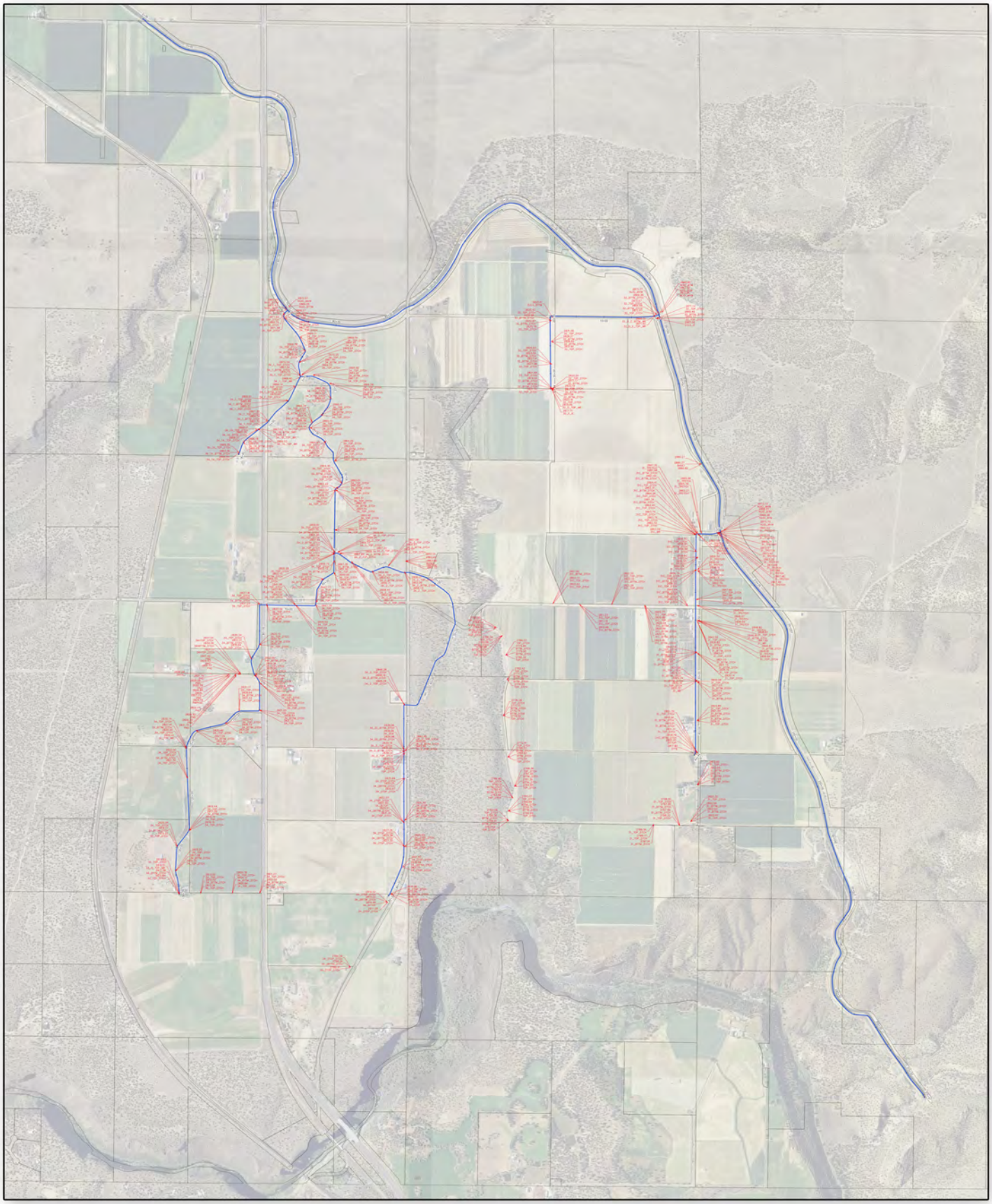
## XI. RECOMMENDATION

The benefit versus cost ratio calculated above is 0.44 whereas a benefit versus cost exceeding 1.0 is necessary to indicate a project that has more financial benefit than cost. It should be noted that in this instance, however, there are other project benefits such as minimization of soil migration to the Crooked River watershed that may carry investor benefits that are not quantified here. Given the project implementation costs as developed above and the benefit estimates for the project, the project is not financially viable over a 20-year payback period. Should additional public grant funds be available either to match or increase the potential conservation grant dollars, or if the value of conserved water increases, the project may become viable in time.

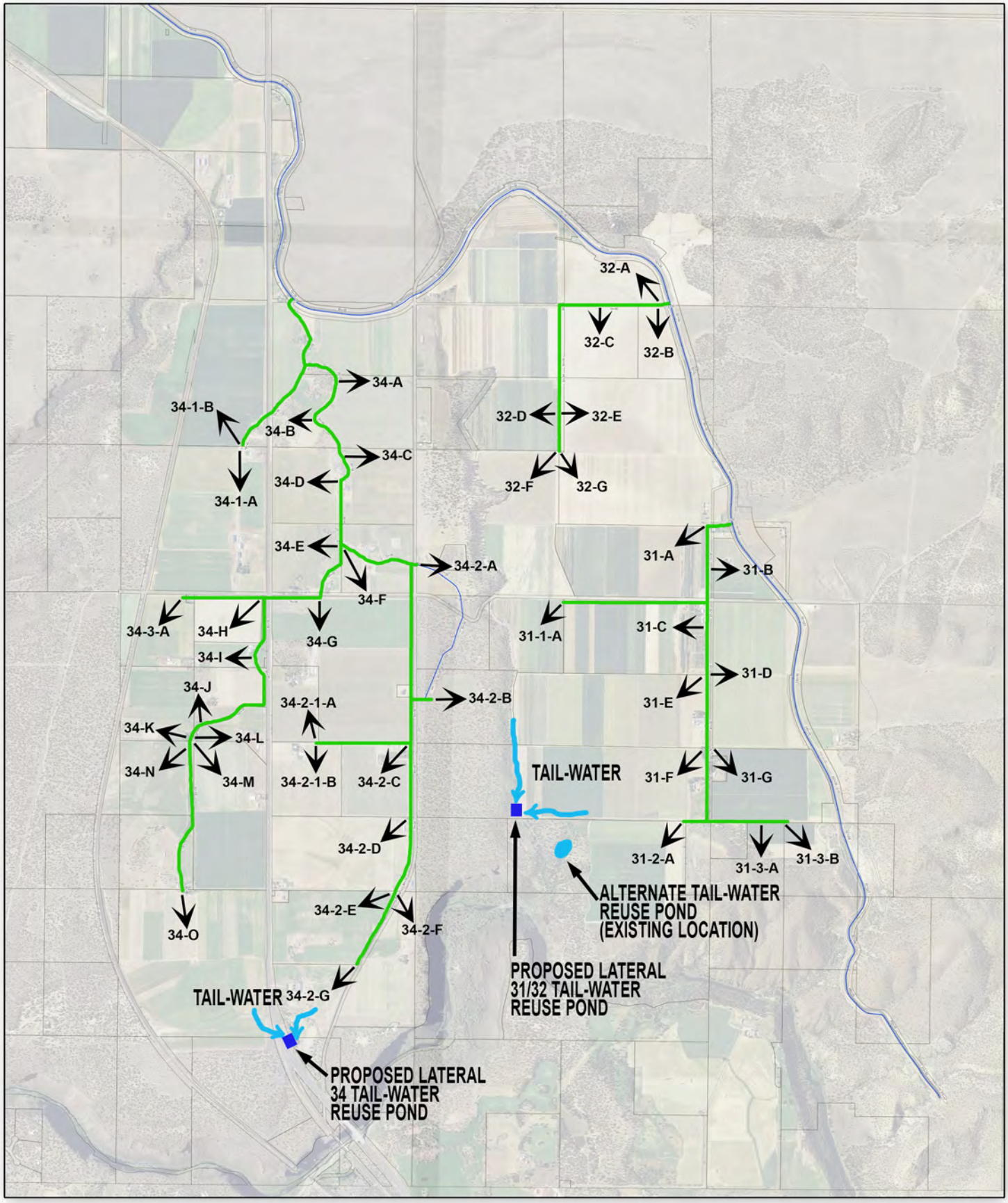
**SOUTH AREA BASE MAP**


TAIL-WATER
EXISTING
TAIL-WATER
POND
CROOKED RIVER
TAIL-WATER
EXISTING
TAIL-WATER
POND
CROOKED RIVER

**SOUTH AREA SURVEY BASE MAP**



**SOUTH AREA PIPING IMPROVEMENT PLAN**


32-A
32-B
32-C
32-D
32-E
32-F
32-G
34-A
34-B
34-C
34-D
34-E
34-F
34-G
34-H
34-I
34-J
34-K
34-L
34-M
34-N
34-O
34-1-A
34-1-B
34-2-A
34-2-B
34-2-C
34-2-D
34-2-E
34-2-F
34-2-G
34-2-1-A
34-2-1-B
34-3-A
31-A
31-B
31-C
31-D
31-E
31-F
31-G
31-1-A
31-2-A
31-3-A
31-3-B
TAIL-WATER
TAIL-WATER
ALTERNATE TAIL-WATER
REUSE POND
(EXISTING LOCATION)
PROPOSED LATERAL
31/32 TAIL-WATER
REUSE POND
PROPOSED LATERAL
34 TAIL-WATER
REUSE POND