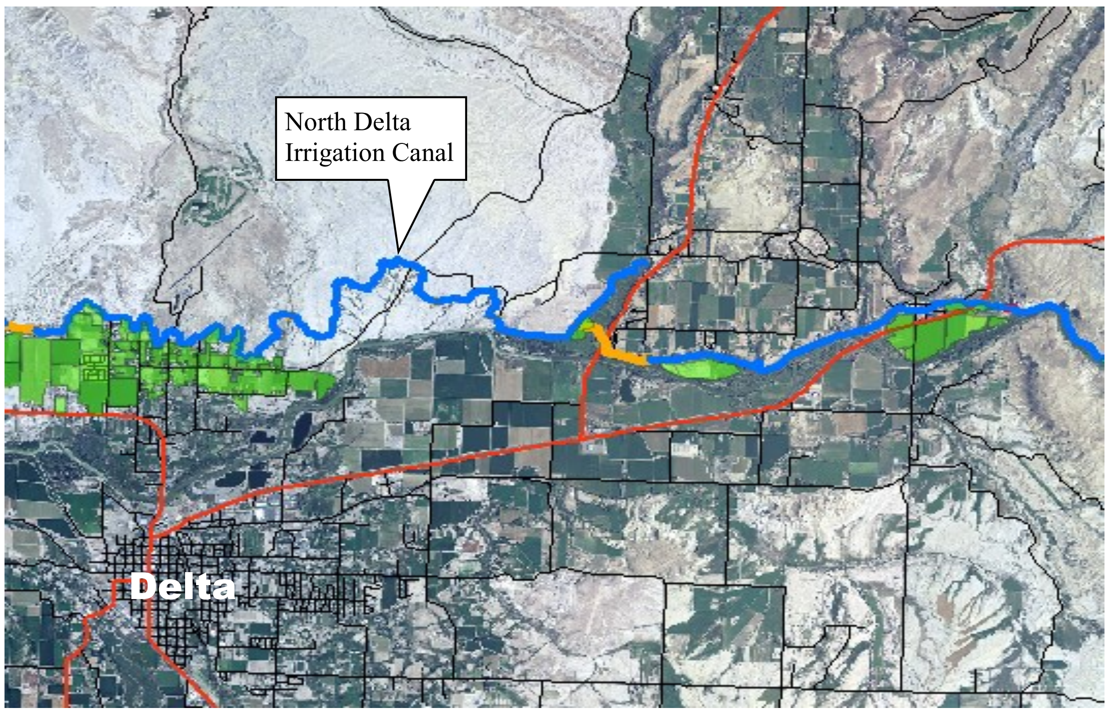
Master Plan—Phase I

Master Plan Study—Phase I
Tunnel Pipe Repair

North Delta Irrigation Company



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INTRODUCTION

This report aims to address capacity issues associated with the main tunnel of the North Delta Irrigation Company. The tunnel is no longer able to carry the canal's full decree following construction of Tunnel Rehabilitation and Canal Upgrade project installed in 2012. Applegate Group has been tasked with identifying options to increase the hydraulic capacity of the tunnel. A map depicting this reach of canal is located in Appendix A.

CURRENT TUNNEL CONDITION

The Tunnel Rehabilitation and Canal Upgrade project included construction of a concrete flow control structure at the upstream end of the pipeline located on a natural drainage crossing. This structure allows NDIC to regulate flows downstream and return any excess water to the Gunnison River. From this structure 60 inch ADS Low-Head pipe was installed along the canal alignment as it approaches the tunnel section of the NDIC system. The 60 inch ADS Low-Head pipe transitions to 54 inch HDPE prior to entering the tunnel section. The 54 inch HDPE pipe was drug through the tunnel and spans a length of about 1,500 feet from the entrance to the exit of the tunnel. Upon exiting the tunnel the HDPE pipe transition back to 60 inch ADS pipe which continues 500 feet until it connects with the existing inverted siphon that passes under North Forked Tongue Creek. Construction plans prepared by the Westwater Engineering are included in Appendix A.

Upon startup of the system it was discovered that the hydraulic capacity of the tunnel section was significantly reduced and was no longer able to carry the systems historic flow rate. Due to a lack of measuring devices near the tunnel section the exact capacity of the tunnel pipe is unknown. Independent measurements taken by Steve Tuck with the Colorado Division of Water Resources and Cary Denison with Trout Unlimited indicate that the tunnel capacity is between 18 and 23 cfs. The canal is currently decreed for 50 cfs at the headgate. After accounting for deliveries upstream of the tunnel the required design flowrate of the tunnel is approximately 46 cfs.

The original construction documents for the project indicate that the pipe going through the tunnel be graded at consistent -0.014% slope, however the plans also state that no survey of the tunnel was performed. An as-built survey performed by Southwest Land Surveying LLC revealed that the pipe alignment through the tunnel contained four distinct high spots. The figure below displays the proposed and existing elevation profile of the pipe section spanning the tunnel section. A copy of the pipe survey by Southwest Land Surveying LLC is located in Appendix A.

The difference between what was proposed in the plan set and what was actually installed explains why the tunnel pipe doesn't perform as expected. The high spots in the pipe profile effectively pinch the flow thus reducing the hydraulic capacity of the pipe. NDIC drilled twenty seven ¾ inch and 1 inch holes in the top of the tunnel pipe in an attempt to evacuate excess air out of the pipe and increase the capacity of the pipeline. This had no noticeable effect on the flowrate and the holes have since been filled in by NDIC with liquid nails adhesive.

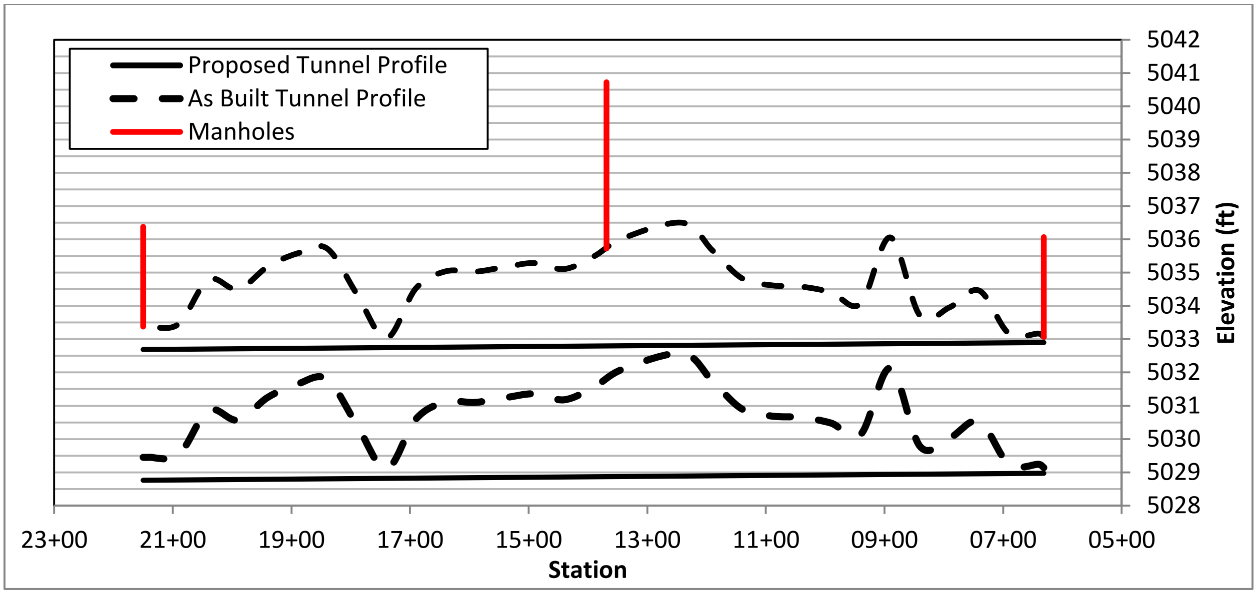


FIGURE 1 AS BUILT VS PROPOSED TUNNEL PROFILE

TUNNEL OPTIONS

Applegate Group investigated various methods of increasing the capacity of the tunnel pipe including:

- Converting the pipe to a True siphon
- Increase the upstream head pressure on the tunnel pipe by:
    - Installing a very low head pump at the pipeline entrance
    - Pipe the canal upstream with low pressure pipe

Our analysis indicates that the first option above is by far the most economical in the long run. This option is discussed in detail below and the other options are mentioned briefly.

SIPHON CONFIGURATION

True siphons operate under vacuum pressure, unlike inverted siphons which operate under positive pressure. Siphon capacity is determined by the pipe size, type, and the head differential between the upstream and downstream ends. To operate this pipe as a siphon at 46 cfs will require the upstream water level to be 1.78 feet higher than the downstream water level. The downstream water level for the tunnel siphon was determined by calculating the water level in the canal downstream of the existing Tongue Creek Siphon and adding in estimated hydraulic losses through the inverted siphon to the downstream end of the Tunnel Siphon. This analysis indicates that the calculated water surface at 46 cfs in the existing control structure would be approximately the same level as the top of the existing 60 inch pipe in that structure. According to NDIC this corresponds to the maximum level they are comfortable operating the canal at which implies that the tunnel pipe is hydraulically capable of carrying 46 cfs operating as a siphon.

According to the pipe manufacturer the 54 inch HDPE DR17 tunnel pipe can tolerate a long term vacuum pressure of -7.0 psi. The maximum operational vacuum pressure expected would be approximately -3.0 psi in a low flow condition; therefore the tunnel pipe is structurally able to withstand the vacuum pressure if operated as a siphon.

Applegate Group is not confident in the ability of liquid nails to maintain an air tight seal with the HDPE pipe, especially when considering differing expansion rates of the materials when exposed to changing temperatures. Applegate Group strongly recommends that the liquid nails be replaced with a more robust solution. An extrusion welder or an eletro-fusion patch are typically recommended when fixing damaged HDPE pipe, but these fixes can only be applied from outside of the pipe. This method is unfeasible in this circumstance due to limited clearance between the outside of the HDPE pipe and the tunnel walls. The HDPE pipe supplier, ISCO, was contacted and recommended using HDPE plugs specially designed for filling holes in HDPE pipe. The product offers high pressure capacity and is able to be installed from within the pipe. A third option would involve tread tapping each hole and inserting a threaded stainless steel plug with thread tape.

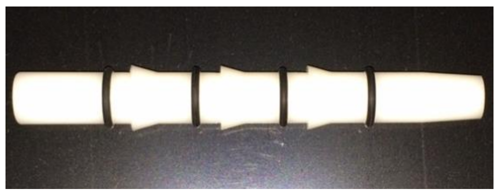


FIGURE 2 ACETYL PLUG WITH O-RING SEALS

SIPHON PRIMING

Operating the pipe as a siphon will require physical changes to the pipeline in order to allow the following:

1. Initial Priming - At the beginning of the season all air must be removed from the pipeline
2. Continuous Priming - The siphon must be able to maintain its prime by prohibiting air entry at either end and removing any air that accumulates at the high points

INITIAL PRIMING

In order to operate the existing tunnel pipe as a siphon all air must be expelled from the line. Multiple methods of priming the siphon were investigated and evaluated based on ease of operation and the ability to assist with the continuous priming discussed in the next section of this report. The recommended modifications to the existing pipeline are sketched in a Figure located in Appendix A. Basically, 2 inch HDPE priming lines would need to be installed on the inside of the 54 inch HDPE and anchored to the pipe using stainless steel straps held in place by screws. The initial priming procedure for this system would be as follows:

1. Set the stoplogs in the upstream control structure near the crown of the 60 inch pipe
2. Divert 5-10 cfs at the river headgate
3. Close the downstream 60 inch slide gate
4. Open all 2 inch priming lines to drain
5. Allow siphon to fill until water spills at the upstream control structure.
6. Close the upstream 60 inch slide gate (all water will spill over stoplogs and return to the river)

7. Divert water from natural drainage (or pump from the upstream control structure) into the vent/fill pipe located immediately downstream of the 60 inch slide gate.
8. Close the 2 inch priming lines once a continuous flow of water is observed
9. Fully open the upstream slide gate
10. Fully open the downstream slide gate
11. Increase the canal flowrate as desired

Continuous Priming

Once the siphon is operating there are still two potential sources of air which could accumulate at high points and reduce the capacity of the pipeline if not removed. The first is air entering the siphon at the upstream entrance due to turbulence at that location or air entering at either end due to a drop in canal levels resulting from a reduction in flow. The upstream entrance would be modified as shown in Appendix A to provide a smooth transition from the 60 inch corrugated HDPE to the 54 inch fusion welded HDPE and minimize any turbulence at that location. In order to limit the amount of air entering the pipeline both ends would also need to be lowered in order to keep them submerged regardless of the flowrate.

The second source of air is within the water itself. Water contains dissolved air in varying amounts dependent on many factors such as temperature and pressure of the water. This dissolved air has the potential to come out of solution when the water undergoes a reduction in pressure such as in a true siphon. When siphons operate over long periods of time and long distances this dissolved air tends to come out of solution and accumulate at high points. The amount of air that may accumulate can depend on the length of time water is exposed to vacuum pressure and the velocity of the pipeline, however, our research indicates that it is difficult to predict the amount of air to be expected. The only method found to estimate the amount of air that could potentially come out of solution was Henry's Law. Henry's Law can calculate the amount of dissolved air in water at various temperatures and pressures. Applying Henry's Law to this case we estimate that up to 41 gallons per minute of air could potentially be produced by the siphon. As mentioned earlier, however, the amount of time the water is exposed to vacuum pressure is another factor affecting how much of this air will actually come out of solution. No method or guideline could be found relating the time of exposure to the amount of accumulated air.

Typically siphons are designed so that the internal pipe velocity at high points is sufficient to scour out any air pockets. For a nearly horizontal pipeline of this diameter various literature suggests that a minimum velocity of 3.50 to 5.29 feet per second is necessary to remove air from the siphon. This guideline is not a firm number but has been determined based on past experience on other siphons and various theoretical equations. Under a full decree the actual pipe velocity is 3.48 feet per second. This is right at the lower limit required to remove the air and another source for removing the air is recommended.

The 2 inch priming lines installed inside the pipe could potentially be used to remove this air by adding a self-priming centrifugal pump to the end of the priming lines. This pump would run continuously during the irrigation season and continuously remove water and air bubbles from the high points. Discharge water from the pump could then be returned to the canal in the downstream siphon structure. This pump would need to be connected to a reliable power supply. During our site visit we noted that there were existing electric lines at the downstream end of the siphon and therefore we recommend locating the pump there. The selected pump would have a capacity of approximately 50 gallons per minute and a suction lift capacity of about 15 feet. Valves on the individual priming lines could be adjusted to result in an even flowrate distribution among the four 2 inch priming lines. Running this pump continuously will require a new electric service to be installed and payment of a monthly power bill. Assuming a ¾ horsepower pump was installed and operated from mid-April to early November the annual energy consumption would be approximately 2,662 Kilowatt-Hours. At an electric rate of $0.08 per KWH this equates to $213 per year. There would also be a monthly base charge of $40 for the account in addition to the use charge. Therefore, the total annual cost of the pump would be approximately $663.

SIPHON CONVERSION COST

The installed cost for the system described above is estimated to be $167,000. This includes construction, final engineering design, construction plans and specifications, a 15% contingency and construction oversight. A detailed breakdown of estimated costs is located in Appendix C.

INCREASED UPSTREAM HEAD PRESSURE

Increasing the upstream head pressure would essentially drive more water through the existing pipeline without any modifications to the tunnel pipeline itself. Currently the canal upstream is very flat and operates with no excess freeboard. The canal cannot be simply backed up further without increasing the height of the canal banks. Increasing the canal bank height was not considered due to the amount of raise that would be required, approximately 3 feet, and significant concerns regarding the stability of an enlarged canal on the steep hillsides. Other methods of increasing the upstream head pressure include adding a low head pump at the pipeline entrance or piping the upstream canal to a point where the upstream pressure would be provided by gravity.

LOW HEAD PUMP

The simplest method of increasing the tunnel capacity would be to install a very low head pump such as the one shown in Figure 3 at the entrance to the pipeline. The pump manufacturer Flygt makes a simple pump for high flows and very low heads. This pump is typically used in water treatment facilities or water parks for moving up to 60 cfs at heads of 0-6 feet. This pump would require power to be extended to the existing flow control structure. The minimum distance to a power line appears to be 300 feet but it is unknown if this line has the capacity of serve this pump. For cost estimating purposes it was assumed that a 300 foot extension would be required. The cost of purchasing and installing a pump system such as this would be approximately $275,000. This includes all engineering costs, construction oversight and a 15% contingency.

FIGURE 3 LOW HEAD PUMP

Assuming an operational period of 6.5 months the 40 horsepower pump would consume approximately 24 KW of energy per hour which results in an annual electricity demand of 114,192 KWH. At an electric rate of $0.08 per KWH the annual operating cost would be $9,135. This is obviously a large annual burden on the ditch company. It is likely that this amount could be reduced by only operating the pump when the demand on the system required the full decree to be diverted.

The total system demand below the tunnel was calculated by calculating the crop water demand using evapotranspiration data from the CoAgMet station located on Rogers Mesa. This analysis assumes that diversions from Forked Tongue Creek would be utilized first. Diversion records for were obtained from the Division of Water Resources in order to reflect the amount of water available on an average year from this source. If additional water was required to meet demands and additional 18 cfs could be diverted through the tunnel under gravity. If these two sources were insufficient then the pump would need to be operated. Figure 4 displays the calculated system demand below the tunnel assuming an irrigated area of 1500 acres and an overall efficiency of 40% and depicts when the pump would need to be operated and at what capacity. The pump flowrate would be adjusted using a Variable Frequency Drive (VFD) to better match system demands. Combining this information with the pump power curves results in and annual electric cost of $2,500. Therefore the average annual electric cost for this option would range from $2,500 to $9,135 depending on how the pump was operated. During wet years the pumping costs could be less and in dry years it would be more since the water availability on Forked Tongue Creek is highly variable.

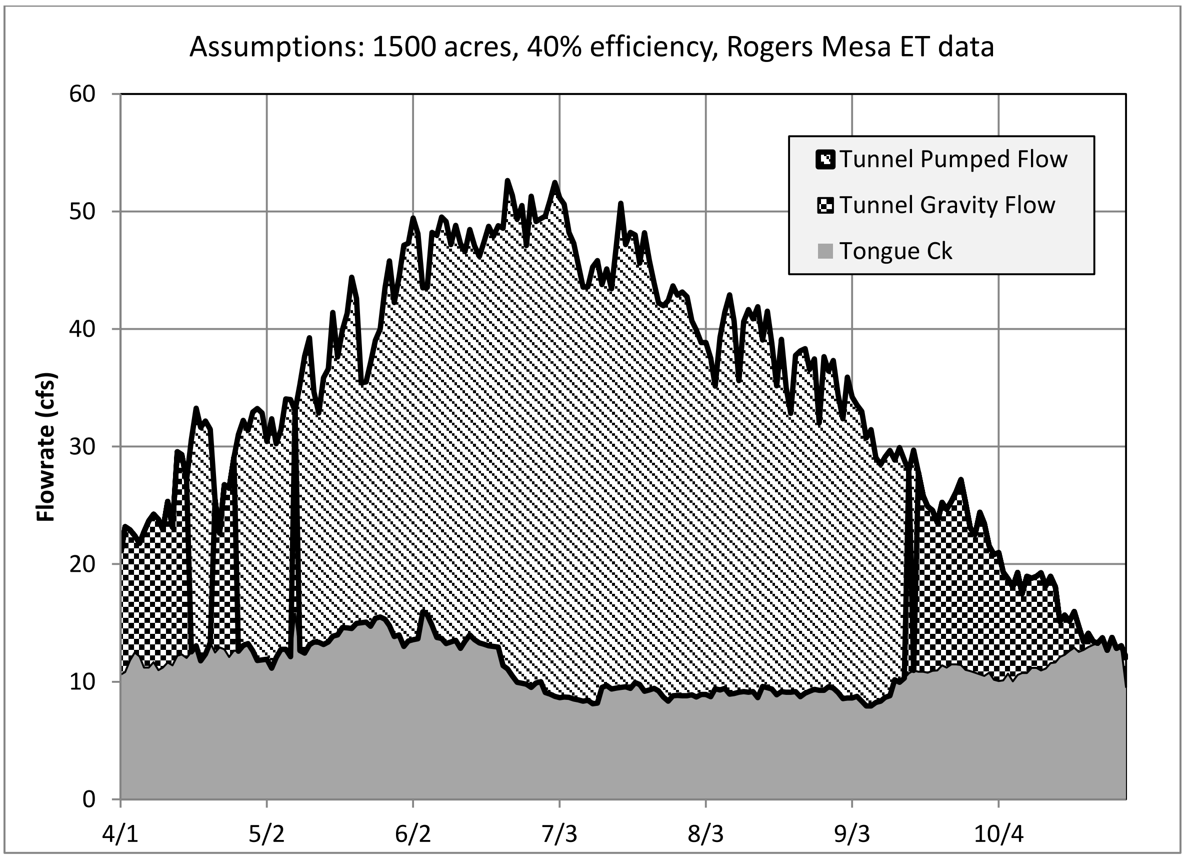


FIGURE 4 NDIC REQUIRED FLOWRATE BELOW TUNNEL

One significant concern with this option relates to its ability pass moss and debris; removing it from the pump would be difficult. If debris accumulation required the pump to be removed for cleaning then the canal flowrate would need to be reduced while it was offline in order to prevent the upstream canal from overtopping. A trashrack could be installed upstream of the pump but then that would need regularly cleaned as well in order to prevent overtopping.

Pipe Canal Upstream

The last option evaluated for increasing the upstream head on the tunnel pipe was to pipe the canal with low head pipe upstream to a point where the necessary head is provided by gravity. This will require approximately 6,600 feet of pipe. Based on other canal pipe projects we have worked on we estimate the cost of this infrastructure to be approximately $1,746,000 including a 15% contingency and construction oversight. This has the benefit of low annual maintenance; however, the capital costs are large. A USBR salinity grant is unlikely to be able to provide much assistance with piping this section of canal due to the close proximity of the canal to the river. Without much land in between the canal and the river the seepage would not have much chance to pick up much salt and therefore salt contributions would be very low.

CONCLUSIONS

The existing NDIC tunnel presents a unique challenge for future operation of the canal system. Converting the pipeline into a true siphon is the most economical option to restore the capacity of this section of canal. Such a system, however, would result in a fairly unique structure and does not represent a typical engineered siphon system. True siphons are rarely used due to complexities in addressing negative pressure and air accumulation within the system, therefore there is very limited guidance and case studies on their operation and design. Based on available information it appears likely that the proposed solution will restore the system to near full capacity.

Converting the tunnel pipe to a siphon would have one remaining risk that has not been discussed. The annular space between the pipe and the tunnel is not grouted as the original plans depict. Future collapses of the old tunnel will deposit more material around the pipe. It is our opinion that a collapse large enough to completely crush the pipe and pinch it closed is unlikely and smaller collapses will likely slough around the pipe and slowly bury the pipe over time. A sudden partial collapse that could squeeze the pipe far enough to significantly reduce the capacity is also unlikely but cannot be completely discounted based on the limited geotechnical information regarding the current tunnel condition.

The capital and annual costs of the three options are compared in the Table 1 below.

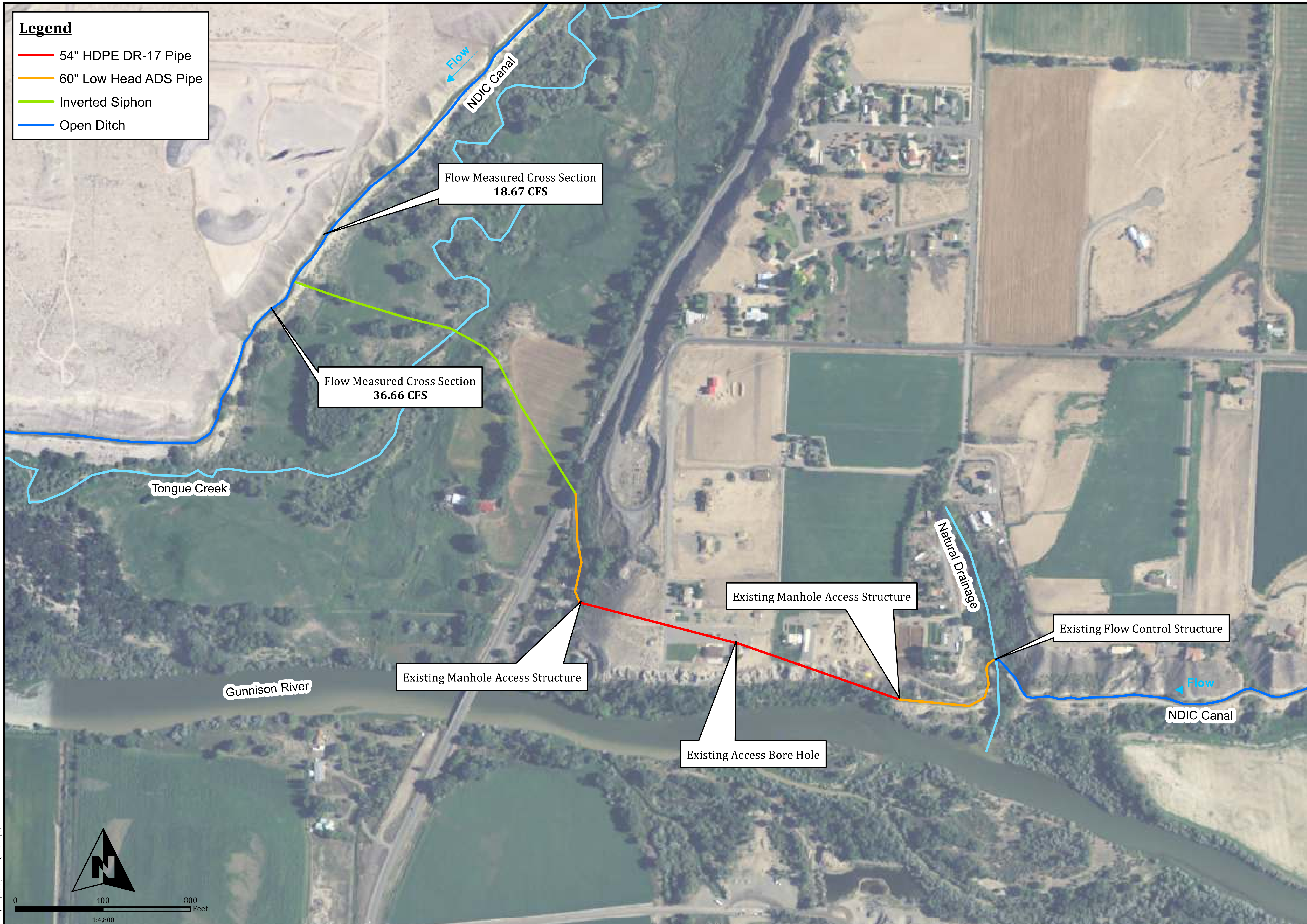
TABLE 1 COST SUMMARY

Option	Estimated Project Cost	Estimated Annual Cost
Siphon Conversion	$167,000	$667
Low Head Pump	$275,000	$2,500 to $9,135
Pipe Canal Upstream	$1,746,000	$0

In summary, converting the tunnel pipe to a siphon appears to be a viable solution to the current capacity issue. Should NDIC choose to pursue this option they should do so fully aware of the risks discussed above. Utilizing a propeller pump at the tunnel entrance would also provide the extra capacity but has a higher capital cost and higher annual cost.

APPENDIX A

MAPS, PLANS, AND SURVEY



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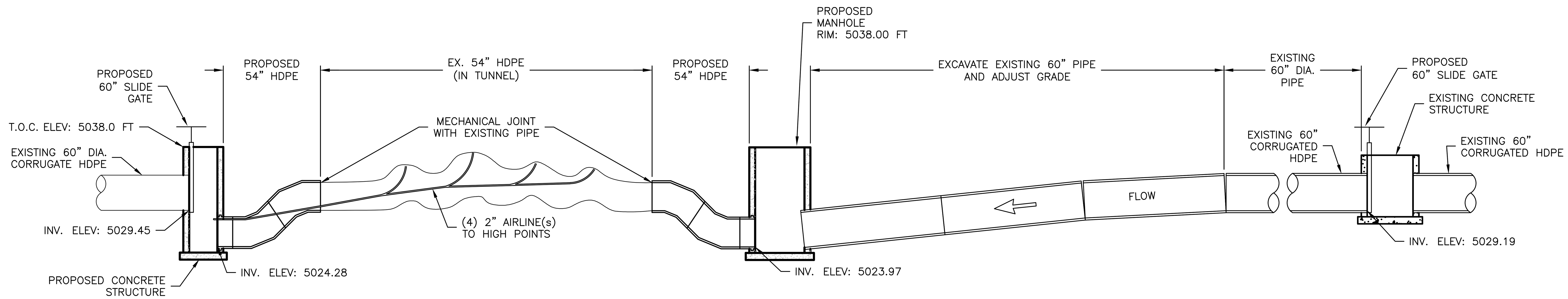
NDIC Tunnel Rehabilitation

Site Map

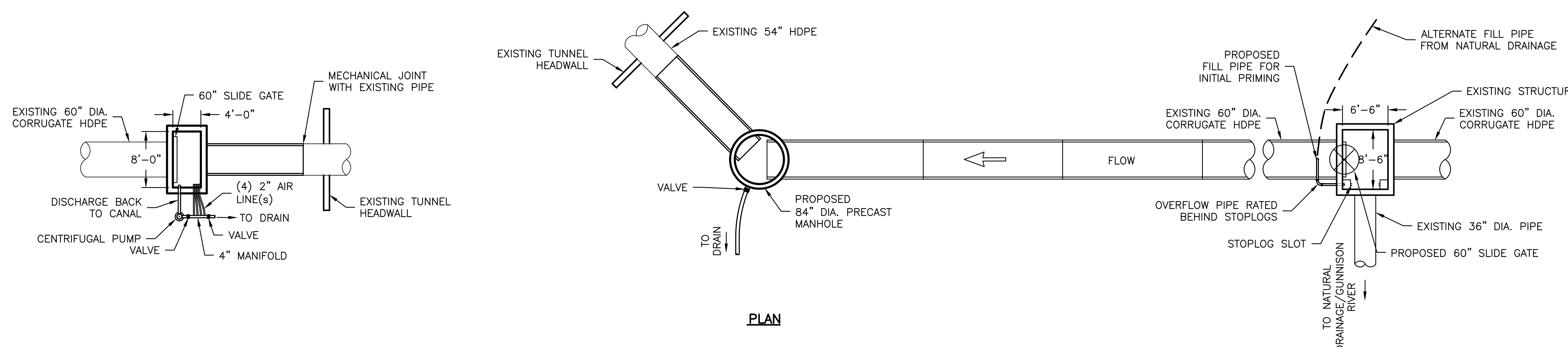
No.	Rev. Date	Revision Description

Date: 16 Dec 2014
Job #: 14-121
Drawn By: TJD

Figure: 1
Of: 1



PROFILE



PLAN

NOT FOR CONSTRUCTION

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TUNNEL SIPHON CONVERSION

SCHEMATIC LAYOUT

NORTH DELTA IRRIGATION COMPANY

NO	DATE	BY	CHK'D	DESCRIPTION

REVISIONS

Date:	09/18/14
Job No:	14-121
Drawn:	TD/LD
Design:	CMU
Checked:	
Scale:	1" = 10'

Sheet: 1

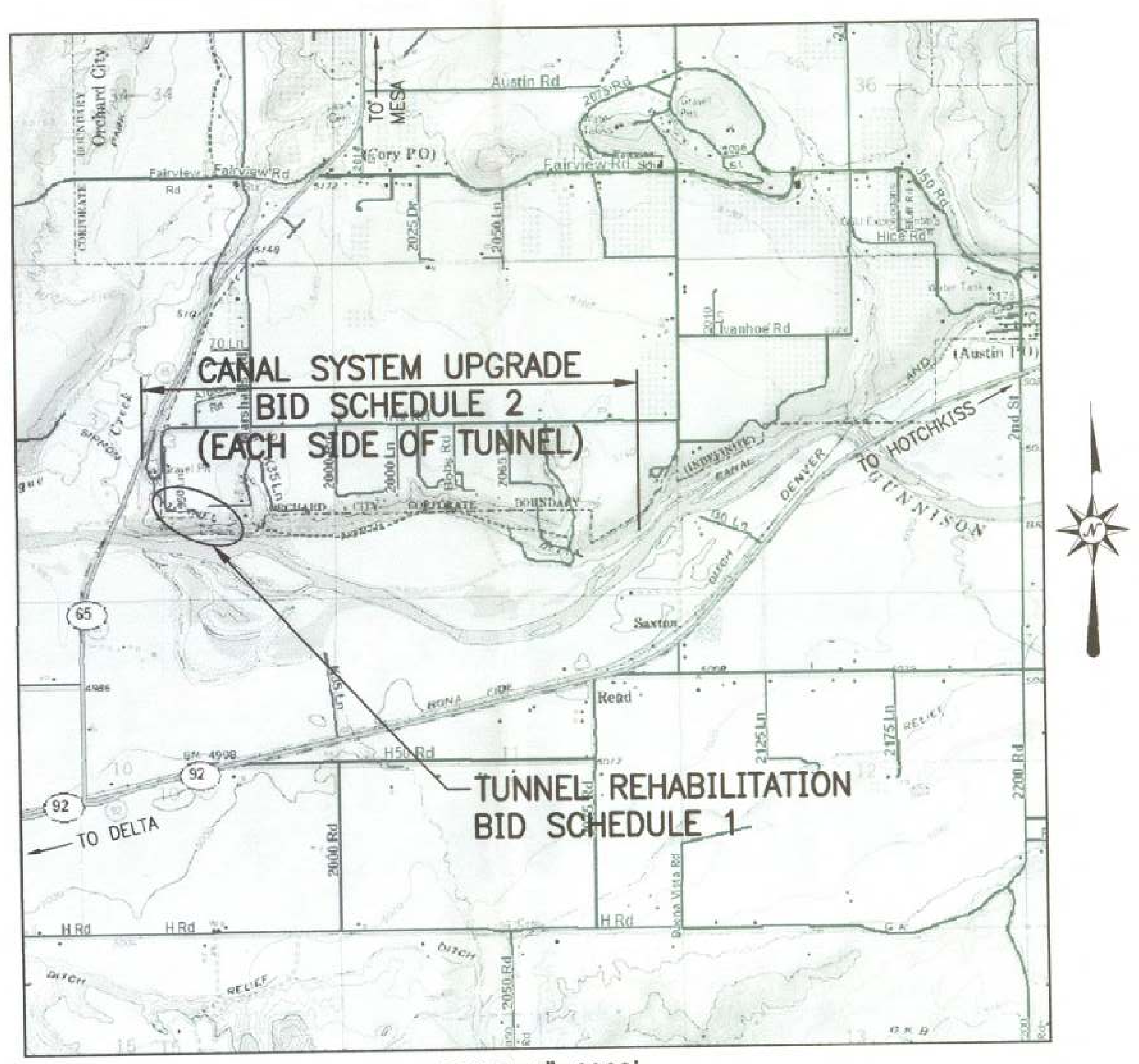
Of: 1

NORTH DELTA IRRIGATION COMPANY

TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADES

DELTA COUNTY, COLORADO

MARCH 2012



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3	BID SCHEDULE 1 – TUNNEL REHABILITATION DETAILS
4	BID SCHEDULE 2 – CANAL SYSTEM UPGRADE PLAN AND PROFILE
5	BID SCHEDULE 2 – CANAL SYSTEM UPGRADE PLAN AND PROFILE
6	BID SCHEDULE 2 – CANAL SYSTEM UPGRADE PLAN AND PROFILE
7	BID SCHEDULE 2 – CANAL SYSTEM UPGRADE DETAILS

PREPARED FOR:
NORTH DELTA IRRIGATION COMPANY
Delta County, Colorado

PREPARED BY:
WESTWATER ENGINEERING
Consulting Engineers
Grand Junction, CO

SCALE:	HORIZONTAL AS SHOWN
	VERTICAL AS SHOWN

REVISIONS	DATE

PROJECT SITE PLAN

GENERAL NOTES

The following notes apply to the entire project, in full or in part. They are summarized on this Plan Sheet to avoid repeating them on applicable Sheets that follow. Refer to individual Plan Sheets for alignment and profile design, and details of construction for each Bid Schedule.

1. All materials, workmanship and methods of construction shall be subject to inspection by the North Delta Irrigation Company (NDIC, or Owner). Owner reserves the right to accept or reject any materials and workmanship that does not conform to the Plans and Specifications.
2. The Contractor shall have one set of Plans and Specifications at the job site at all times.
3. Direct vehicular access to the project is available a) from State Highway 65 along the NDIC maintenance road that terminates near the west tunnel portal, b) from Longs Road to the NDIC maintenance road that extends adjacent to the southerly bank of the canal, and c) from 2100 Road to the same NDIC maintenance road. The maintenance road is unimproved, not recommended in wet weather. Due to the steep grade and switchback along Iris Road above State Highway 65, heavy material delivery vehicles may consider site access from Marshalls Road in Cory.
4. Limited access to the project is available through private property at the southern termination of Marshalls Road. The NDIC has an agreement with this property owner that allows limited access to the canal system from driveways at the homesite on the plateau above the canal system, and along an unimproved driveway and restricted bridge across the canal.
5. Staging areas for Contractors equipment and supplies are available a) along the non-vegetated areas adjacent to and including the deadend maintenance road off State Highway 65 near the tunnel west portal, b) on the private property at the south termination of Marshalls Road above the tunnel east portal as coordinated and approved by the property owner, and c) in non-agricultural and unimproved land in the northeasterly quadrant at Longs Road and the NDIC canal. Any additional area needed for staging or conducting the Work shall be the Contractor's responsibility to secure.
6. Clean water is available to a limited extend through the public water system of Orchard City. Contractor shall coordinate any requirements for location(s) of approved flush hydrants, air gap and backflow protection, metering and/or fees with Orchard City.
7. No other utilities of convenience are available. Contractor shall provide generator(s) and fuel for any electrical equipment, fuel driven pumps as necessary for dewatering or concrete delivery, and portable sanitation facilities for personnel, including weekly maintenance thereof.
8. The Contractor shall be responsible for all construction staking and surveying based on the existing coordinate system and datum for the project, including but not limited to alignment and grade of new pipe systems, structures, manholes, pipe deflection and elbows, service connections and pipe terminal ends.
9. This project is separated into two (2) Bid Schedules that require specialized construction experience, qualifications, equipment and methods.

   Bid Schedule 1 includes Work required to rehabilitate an existing unlined tunnel that is used to convey upwards of 50 cfs irrigation water. Tunnel rehabilitation includes back dragging and backreaming to displace and/or remove soil, cobble and rock debris from spalls that occurred during the 2011 irrigation season to the extent that the tunnel was taken out of service. The cleared tunnel will then be improved by slipline pipe installation and filling of the annular space.

   Bid Schedule 2 has (2) Phases that include extending irrigation pipe from ends of slipline pipe and tunnel toe drain pipe under Bid Schedule 1, backfill of tunnel bulkhead walls and pipe stub-outs. Also includes canal system upgrades to enclose existing earthen lined irrigation ditches in a closed pipe system, with manholes, elbow fittings, flow control structure, service connections, roadway crossings, pipe backfill, headwalls at terminal ends of improvements (rock rip rap and concrete styles), cross drainage improvements, and restoration.
10. The NDIC will place the canal system in service in conjunction with the growing season, estimated around April 15, 2012, under an Interim Plan of Operation (IPO) to facilitate priority construction to the extent possible. Under the IPO, there will be no irrigation water flow at the tunnel until about June 1. An interim supply of irrigation water downstream from the tunnel will be diverted out of Tongue Creek and into the canal system west of State Highway 65. This interim irrigation water supply is estimated to be sufficient only during April and May, and is highly dependent upon the time frame and duration of snow melt and runoff from the Grand Mesa.

    Also under the IPO, the NDIC will continue to divert their full water right out of the Gunnison River above Austin into the canal system in order to maintain irrigation service to all service connections upstream from the tunnel, including one (1) headgate located approximately 100 feet east of the canal crossing at Longs Road and another headgate located approximately 1,700 feet west of Longs Road crossing. The NDIC will place an earthen dam across the canal upstream from the crossing at Marshalls Road, to divert irrigation water through the existing overflow structure located approximately 100 feet upstream from Marshalls Road.

    Only one (1) service connection and headgate will be without service while the IPO is in place. This headgate is located approximately 460 feet downstream from the tunnel west portal along the west canal pipe (noted in above Site Plan), and provides service to the property west of State Highway 65. The NDIC will coordinate the IPO with the affected property owner.

CONSTRUCTION SCHEDULES

1. Time is of the essence to rehabilitate the existing tunnel and restore normal irrigation service to agricultural land and all system users.
2. The Notice of Award, and Notice to Proceed for Bid Schedule 1 are anticipated to be issued no later than April 2, 2012 in order for the Contractor to arrange for the fabrication and delivery of HDPE slipline pipe, to begin Work to clear debris in the tunnel, and to complete the Work no later than May 15, 2012.
3. The Notice of Award for Bid Schedule 2 – Phase 1 are also anticipated to be issued no later than April 2, 2012, to be completed in conjunction with Bid Schedule 1 by May 31, 2012. The Notice of Award and Notice to Proceed for Bid Schedule 2 – Phase 2 will likely be post poned until after the 2012 irrigation season since irrigation water will need to be supplied through the rehabilitated tunnel (BS 1) after May 31, 2012.

PROJECT CONTROL

The bearings for this project are geodetic bearings based on a single point GPS calibration at the C¼ corner of S3, T15S, R95W, 6th Principal Meridian, Delta County, Colorado LS12766, also known as Delta County Mapping Control Grid Program Point S115.

The project Benchmark is the above described Point S115, elevation 5126.70 NAVD88.

The project coordinate system is an assumed local coordinate system projected to a plane at elevation 5126.70–feet, with Point S115 at N 50,000.00 and E 100,000.00.

AERIAL PHOTO BASED PLAN VIEWS

Aerial photos are not ortho rectified to a true horizontal scale. Canal pipe alignment is drawn to scale as noted on each sheet. Due to photo distortion, plan views may incorrectly appear to place the new canal pipe outside the foot print of existing ditch.

ABBREVIATIONS

NDIC	North Delta Irrigation Company (Owner)
IPO	Interim Plan of Operation
ADS	Advance Drainage Systems
HDPE	High density polyethylene
ST	Soil tight
WT	Water tight
BS	Bid Schedule
HG	Head Gate

COLORADO REGISTERED PROFESSIONAL ENGINEER
Kellie Knowles
03/24/2012

BID SCHEDULES

BID SCHEDULE 1

Tunnel rehabilitation generally will consist of the following Work.

1. Mobilize equipment and personnel, and procure materials to be incorporated into the project.
2. Prepare staging areas for equipment and materials. Provide positive and controlled diversion of seep water at each tunnel portal to protect the work zone and staging areas. Flow from the west tunnel portal may be diverted toward existing borrow ditch along State Highway 65 by cutting a surface ditch. Flow from the east tunnel portal may be diverted to existing 12–inch CMP at concrete wing wall that discharges above the Gunnison River upland. Install and maintain temporary filter material to remove sediment, and provide erosion control as necessary.
3. Advance the smallest, first stage bore/reamer head into the tunnel, taking special precaution to closely monitor thrust gauges on the boring machine, through the entire length of existing tunnel. This step, and subsequent work inside the tunnel, may require multiple forward push and back pull actions, and shall be conducted under meticulous oversight and supervision to prevent inadvertent disturbance to existing tunnel structure.
4. Continue bore/reaming with incrementally larger heads, to further displace loose debris toward tunnel walls, into low spots in tunnel floor, and out of tunnel as necessary.
5. Assemble heat fuse joints of HDPE slipline pipe, and inspect each for consistency, square alignment, integrity, and proper bead thickness.
6. Make solid attachment between first pipe segment and the steel pull head.
7. Calculated safe pull force for estimated field conditions using pulls up to 12 hours is 578,000 foot–pounds. Safe pull length is 3,700, and minimum long–term bending radius is 121.5–feet.
8. Pull joined segments of HDPE slipline pipe, complete with concrete delivery pipes, into and through the tunnel in strict conformance with the Plastics Pipe Institute, and safe pulling force. Pulling pipe through visible offset alignment in tunnel near the east portal is anticipated to require special attention during pulling operations. Also install the fabricated eccentric pipe connectors at each terminal end of HDPE slipline pipe.
9. Install toe drain collector pipe at each tunnel portal.
10. Form and construct bulkheads at each portal around stubbed out slip lined pipe, toe drain and concrete delivery pipes.
11. Pump cellular pervious concrete to line tunnel floor.
12. Pump cellular nonpervious concrete to fill annular space between HDPE slipline pipe and tunnel shell.

BID SCHEDULE 2

Canal Pipe generally will consist of the following Work.

1. Extend tunnel toe drain pipe stubs to final discharge to daylight points.
2. Backfill and compact tunnel bulkheads, HDPE pipe stubs and toe drain pipes.
3. Extend ADS low pressure irrigation pipe along west canal segment beginning at the fabricated eccentric pipe connector installed under Bid Schedule 1, complete with manhole, elbow fittings, service connection and rock rip rap pipe outlet headwall, including cut and fill along canal to establish pipe subgrade, pipe installation, pipe backfill and restoration of the west staging area and maintenance road. Pipe will be installed unconventionally, with spigot ends facing upgradient and bell ends facing downgradient. Pipe to be laid to grade using a surveyor's level and rod to set and check each segment of pipe due to the nominal slope available. Refer to Sheet 4 for Phase 1 and Phase 2.
4. Extend ADS low pressure irrigation pipe along east canal segment beginning at the fabricated eccentric pipe connector installed under Bid Schedule 1, complete with manhole, elbow fittings, flow control structure, service connections, road crossing, and pipe concrete inlet headwall, including cut and fill along canal to establish pipe subgrade, pipe installation, pipe backfill, cross drain piping, restoration of the east staging area, and reconstruction of maintenance road. Pipe to be laid to grade using a surveyor's level and rod to set and check each segment of pipe due to the nominal slope available. Refer to Sheets 4, 5 and 6 for Phase 1 and Phase 2.

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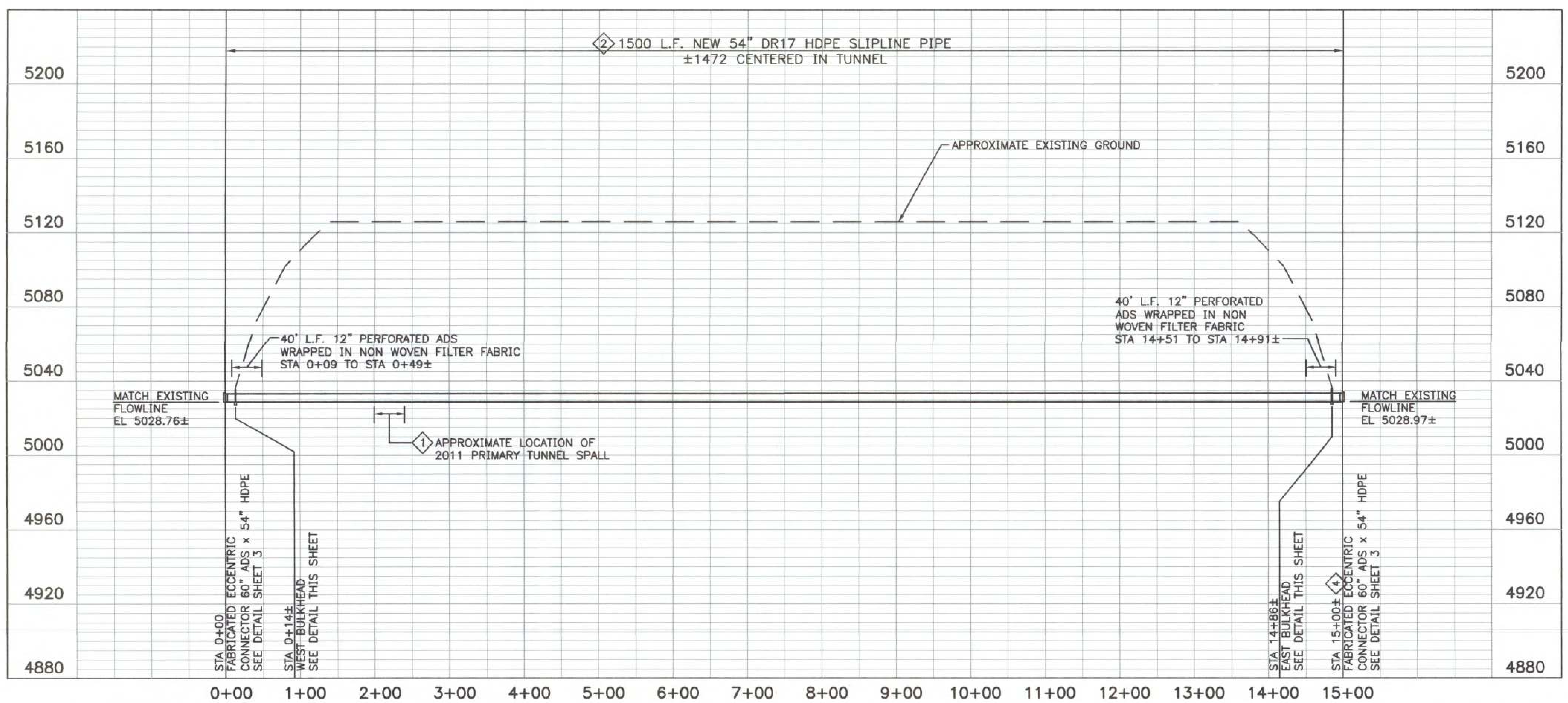
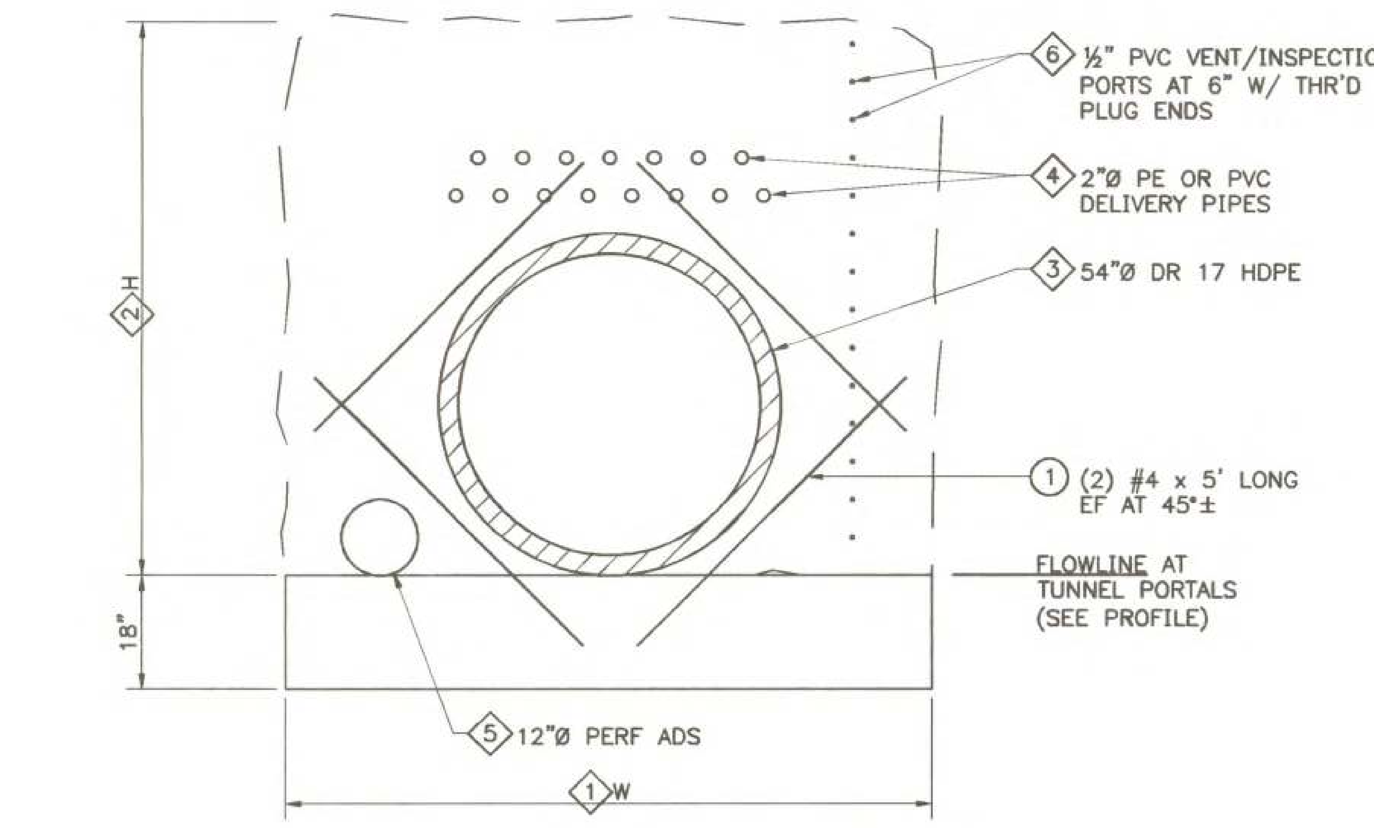
NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

SITE PLAN AND GENERAL CONSTRUCTION REQUIREMENTS

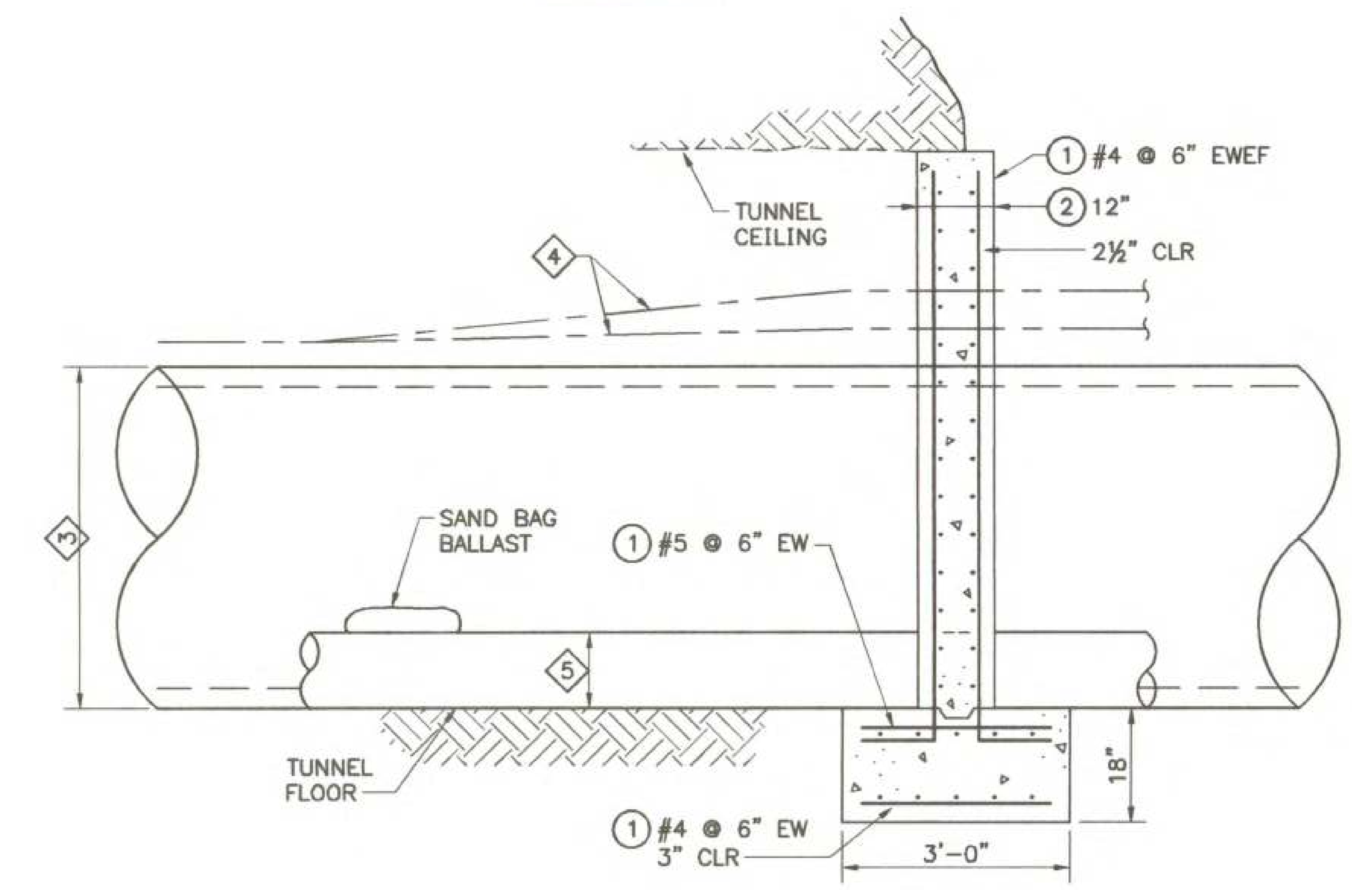
Design by:	Drafted by:	Date:	Project No.	Sheet 1
CKK	JCG	03–12	1111NDI	of 7



TUNNEL REHABILITATION PROFILE



ELEVATION



SECTION

TUNNEL BULKHEADS

BID SCHEDULE 1
SCALE: ½"=1'-0"

LIST OF MATERIALS

1. Grade 60 reinforcing steel, epoxy coated.
2. 3,000 psi concrete with 2% air entrainment, or equivalent shotcrete for ease of installation.

BULKHEAD GENERAL NOTES

1. Two (2) bulkheads are required, one at each tunnel portal. Excavate footing for bulkhead to match dimension across tunnel portal openings, being careful to prevent disturbance to tunnel structure.
2. Form wall of bulkhead to conform with shape and dimensions of existing tunnel portal openings to the extent possible to avoid anchor or bracing pressure against tunnel structure. Provide cutouts in form work configured to accommodate pipe penetrations. Height and width are variable, approximately 8' x 10' at east portal and approximately 7' x 8' at west portal.
3. 54" DR17 HDPE slipline pipe for tunnel rehabilitation. Additional details for inside and outside of tunnel are shown on Sheet 3.
4. 2-inch delivery pipes for cellular concrete fill between existing tunnel shell and new slipline pipe are required only at the bulkhead located at the tunnel portal used for slipline pipe entry, that is opposite the bore machine. Delivery pipe to be abandoned in place when the Work is completed. See Sheet 3 for additional details.
5. 12-inch perforated ADS toe drain to be located along the southern side of the 54-inch HDPE slipline pipe in order for Contractor of Bid Schedule 2 to add pipe extension and drain to daylight. See Sheet 3 for additional details.
6. Install ½-inch PVC vent and observation ports through bulkhead, to observe depth of cellular concrete fill in the tunnel annular space, and to vent air during filling, with FPT ends at exposed face of bulkhead. Install ½-inch MPT plugs as necessary during the tunnel backfill process.

SCALE:	
HORIZONTAL	1"=100'
VERTICAL	1"=40'
REVISIONS	DATE

GENERAL NOTES

1. Existing tunnel was hand excavated into native material approximately 100 years ago. Exposed material is primarily weathered shale with isolated sand and cobble lenses. Refer to Standard and Supplemental Drawings section of the Specifications for limited NRCS information available on the tunnel, and Owner's measurements of tunnel shell and timber locations. The primary debris pile near the west portal does not entirely block line of sight or personal passage, but is estimated to be 50-80 feet in length and was substantial enough to require shutting down the tunnel during the 2011 irrigation season.
2. 1,500 L.F. new 54-inch HDPE slipline pipe to be pulled through the tunnel such that the assembled pipe length is approximated centered, with equal length of pipe stubbed out at each portal (approximately 14 feet each end).
3. No underground survey of tunnel alignment and grade was conducted. However, visible alignment offset is documented at the east portal, the extent of which is unconfirmed. Inspection inside the tunnel by Owner also identifies isolated segments of pooled water, approximately 20-30 feet in length and 2-3 feet in depth, perhaps indicating scour or erosion of the tunnel floor.
4. Coordinate location of fabricated eccentric connector with Contractor of Bid Schedule 2 prior to heat fusing connector to slipline pipe. End of slipline pipe may need to be cut closer to east bulkhead due to limited canal footprint for extension of 60" ADS pipe, elbows, and manhole at east tunnel portal.

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03/26/2012

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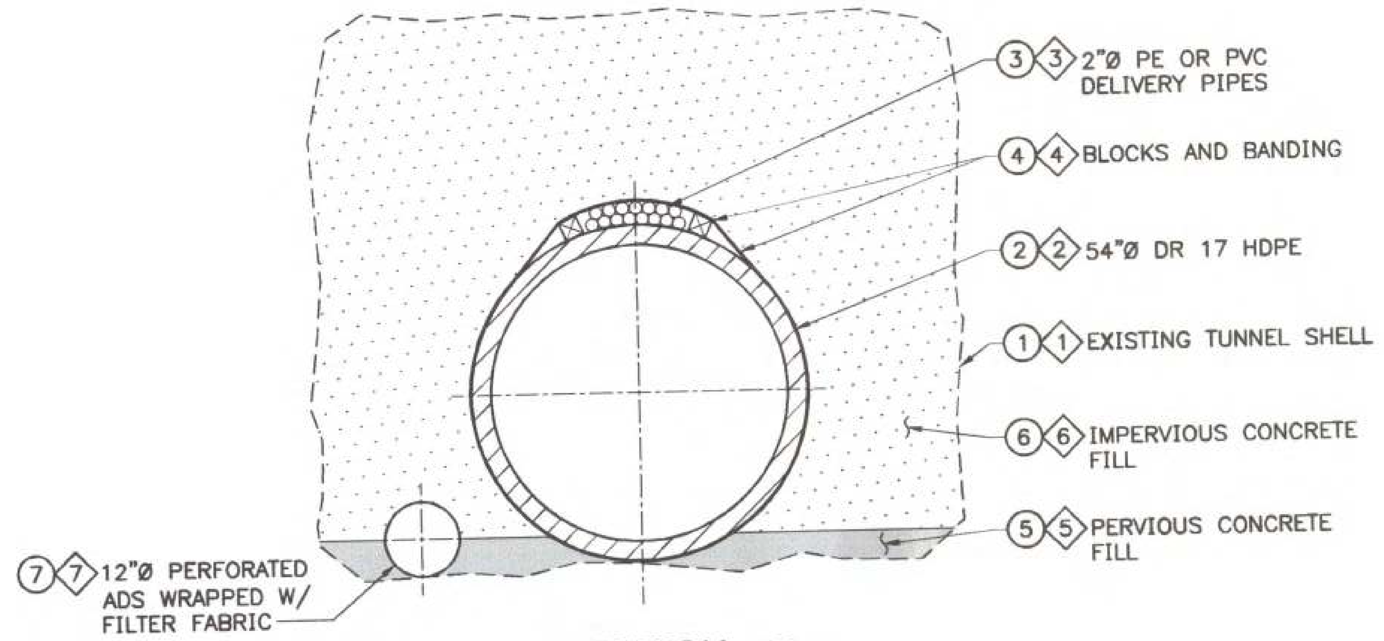
NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE
BID SCHEDULE 1
TUNNEL REHABILITATION PLAN AND PROFILE AND DETAILS

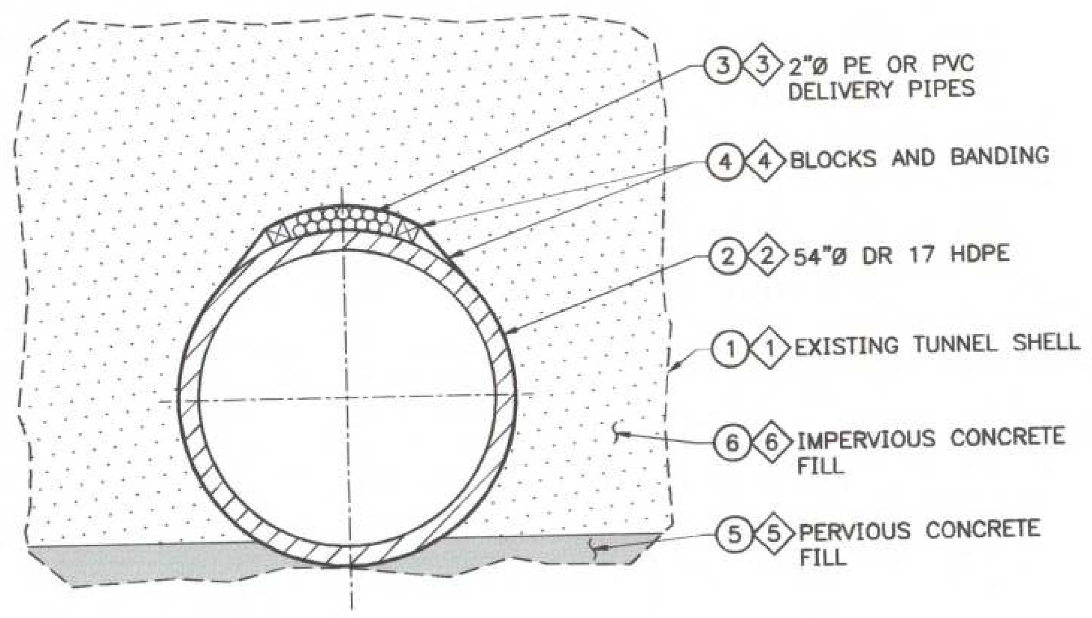
Design by:	Drafted by:	Date:	Project No.	Sheet 2
CKK	JCG	03-12	1111 NDI	of 7

SCALE:	HORIZONTAL	AS SHOWN
	VERTICAL	AS SHOWN
REVISIONS		DATE



SECTION 1/3

APPLIES TO TUNNEL BULKHEADS
SCALE: ½"=1'-0"

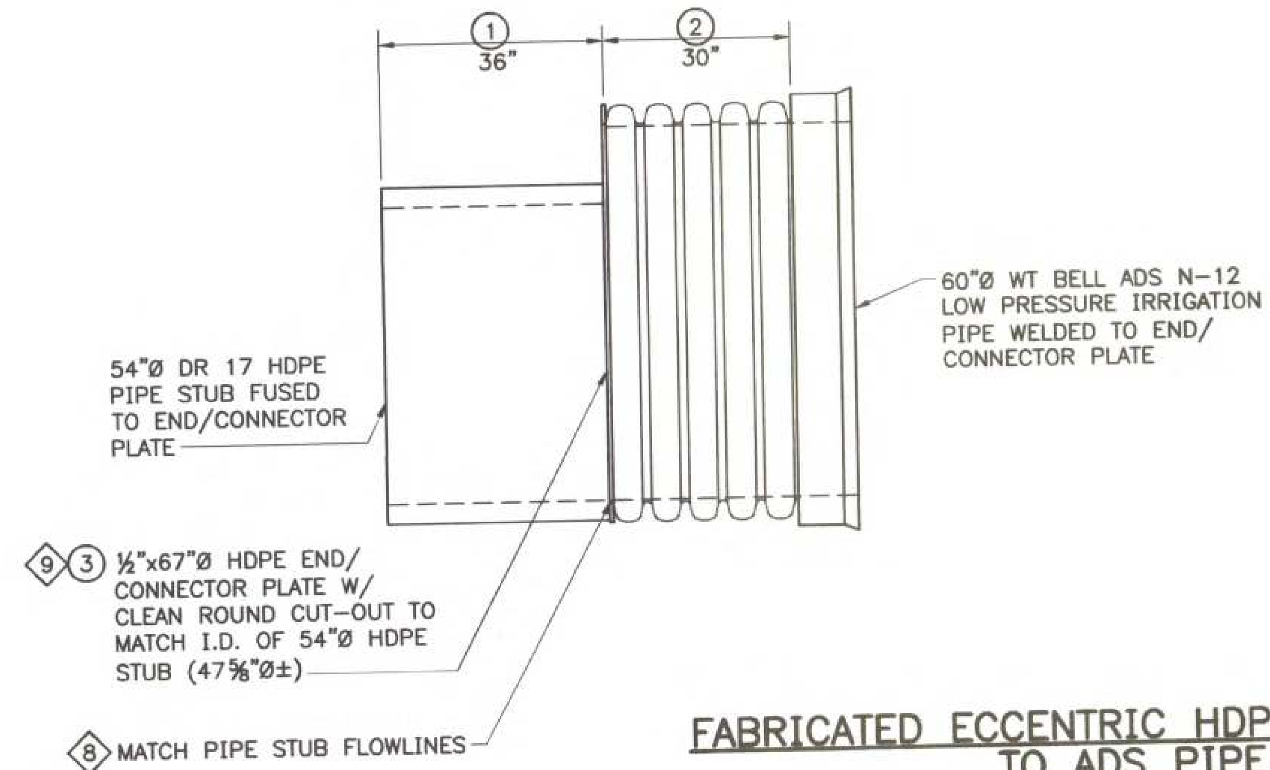


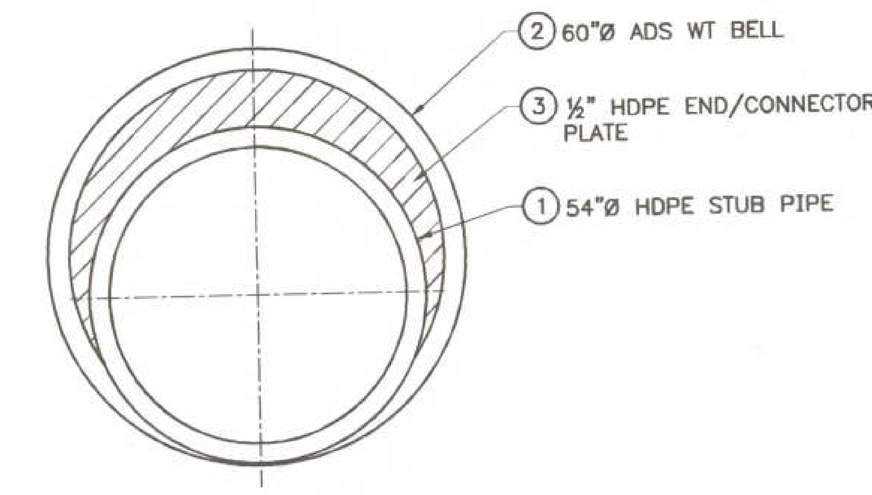
SECTION 2/3

APPLIES THROUGH FULL LENGTH OF TUNNEL
SCALE: ½"=1'-0"

LIST OF MATERIALS

1. Rotating backream head attachment(s) for bore machine shall be custom designed to displace loose debris from tunnel spalls without cutting teeth or edges, capable of pushing debris toward tunnel walls, filling low points in tunnel floor, and/or dragging out of tunnel. Multiple diameters of backream heads is recommended, staring with a relatively small unit for nominal displacement of loose material, and incrementally proceeding to one large enough to provide sufficient cleared pathway for sliplined 54-inch HDPE pipe and pullhead attachment.
2. 54-inch diameter, smooth wall, high density polyethylene (HDPE) DR17, PE3408, having flow coefficients of 0.009 (Manning's "n") and/or 150 (Hazen-Williams "C"), and coefficient of thermal expansion of 0.0001 inch per inch length per °F. 1,500 L.F. continuous length.
3. Minimum (14) continuous lengths 2-inch PE or PVC with restrained joints (fused or solvent weld) for pumped delivery of cellular concrete fill, or as needed for capacity of concrete pump. Total cumulative length approximately 10,500 L.F.
4. 4x4 wood blocks x 8" long notched for banding strap and corners rounded if necessary. Use minimum ¾ inch galvanized or SS banding and clips with minimum 2,500 pound breaking strength.
5. Pervious cellular lightweight concrete, cement slurry wet density 40-44 pcf, with permeability of 5 to 20 inches per hour and minimum 320 psi compressive strength.
6. Nonpervious cellular concrete, cement slurry wet density 65 pcf, expansion factor 1.7 and minimum compressive strength 900 psi.
7. 12-inch perforated ADS N-12 pipe wrapped in non-woven filter fabric. 40 L.F. pipe segment at each bulkhead.





FABRICATED ECCENTRIC HDPE CONNECTION TO ADS PIPE

10 (2) REQUIRED, (1) EACH END OF BID SCHEDULE 1
SCALE: ½"=1'-0"

LIST OF MATERIALS

1. 36" long pipe stub by 54-inch diameter, smooth wall, high density polyethylene (HDPE) DR17, PE3408.
2. 30" long pipe bell end stub by 60-inch diameter ADS low pressure irrigation pipe for water tight gasketed spigot end.
3. Minimum ½" thick by 67-inch diameter HDPE end plate with clean round cutout to match inside diameter of HDPE pipe stub.

COLORADO REGISTERED PROFESSIONAL ENGINEER
03/24/2012

GENERAL NOTES

1. Existing tunnel shell reportedly consists of hand excavated native material, primarily weathered shale with isolated sand and cobble lenses. No geotechnical test borings were completed to estimate the stability or competence of native overburden soils. Aged wood timbers have been installed for supplemental support along outer walls and across the ceiling, with angled bracing members. The primary debris pile from tunnel shell spalling near the west portal is estimated to be comprised of upwards of 70 to 85 c.y. loose material. Minor spalls near the east portal are also evident.

   Contractor shall exercise extreme care to prevent inadvertent disturbance of the tunnel shell and timber supports while executing the Work. Boring machine used to advance drill steel through the tunnel for backreaming shall have accurate gauges to monitor thrust, and be capable of directional adjustments. Machine shall have sufficient torque, with monitors and controls to prevent impingement during backreaming process, and sufficient thrust for pulling the entire length of slipline pipe and tubing.
2. Complete each 54" DR17 HDPE heat fused joint in strict accordance with manufacture's written instructions for heating time, temperature, bead size and cooling time, with appropriate adjustments for ambient weather conditions. Carefully pull assembled pipe through tunnel with terminal ends protruding approximately 14-feet beyond east and west bulkheads. Install fabricated eccentric connection at each terminal end, for 54" HDPE to 60" dual wall, low pressure ADS N-12 pipe connections (heat fused plain end x bell for gasketed spigot).
3. Concrete delivery pipes to extend through the tunnel bulkhead opposite of the bore/pull machine. Terminal ends of individual pipe lengths to be staged at approximate 100-foot increments along the length of tunnel slipline pipe, such that the longest continuous run is approx. 1,400 L.F with the open (delivery) pipe end starting about 100 feet from the furthest bulkhead and the shortest run is approx. 100 L.F. with the open pipe end about 100-feet from the closest bulkhead.
4. Secure delivery pipes in a bundle along the top of 54" HDPE as the slipline pipe is heat fused and assembled prior to pulling through tunnel, at 25-foot spacing, or as necessary to contain the bundle.
5. Pervious cellular concrete to be incrementally pumped through delivery pipes to provide a thin pervious base in the annular space between tunnel shell and new HDPE slipline pipe. Install the first lift at a maximum rate of 12 to 16 c.y. (delivered concrete without foam additive) per delivery pipe while monitoring vent ports. Estimated installed depth at this range is about 10" to 14" if floor and walls of tunnel are impervious, based on expansion factor of 2.3, and average tunnel width dimension. Do not exceed 16 c.y. per 100-foot length of tunnel in the first lift, because the 54-inch HDPE pipe will become buoyant at 18" depth of wet cellular concrete, and the permeability of tunnel floor is unknown. Installed depth of pervious cellular concrete to be minimum 4" and maximum 8". Control pumping and number of lifts to achieve the minimum depth to the extent possible.
6. Nonpervious cellular concrete to be pumped through delivery pipes after the pervious bottom layer has set. Control the rate of application and wet depth of material to prevent floatation of the 54" HDPE slipline pipe. Coordinate the schedule for installation with the Owner and Engineer so that test specimens can be collected for compressive strength testing.
7. Install each 40 L.F. length of 12-inch perforated, fabric wrapped ADS toe drain outlet pipe with bell end and 5-foot length protruding through bulkhead and 35 L.F. inside tunnel with (2) sandbag ballasts to prevent floatation prior to installation of pervious cellular concrete.
8. Fabricated eccentric connector shall be assembled to match the flowline of each pipe stub.
9. Heat fuse each pipe stub to HDPE end plate in accordance with manufacturer's written instructions.
10. Two fabricated connectors required. Install one (1) fabricated eccentric connector to each end of new 54-inch HDPE slipline pipe, for extension of 60-inch ADS low pressure irrigation pipe under Bid Schedule 2. Coordinate location of coupling at east tunnel portal with Contractor of Bid Schedule 2 prior to completing final heat fused connection to end of slipline tunnel pipe.

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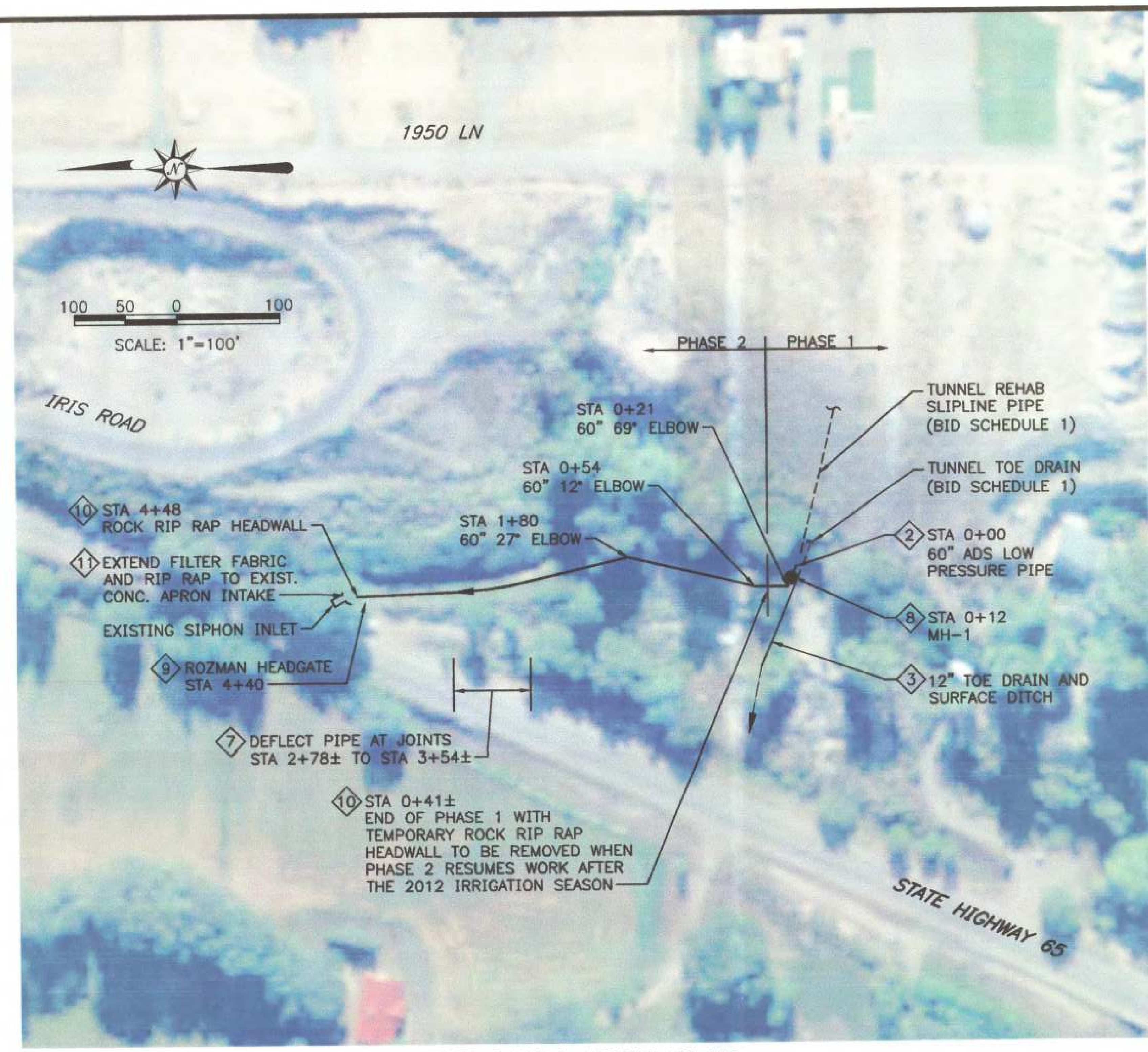
NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

BID SCHEDULE 1
TUNNEL REHABILITATION DETAILS

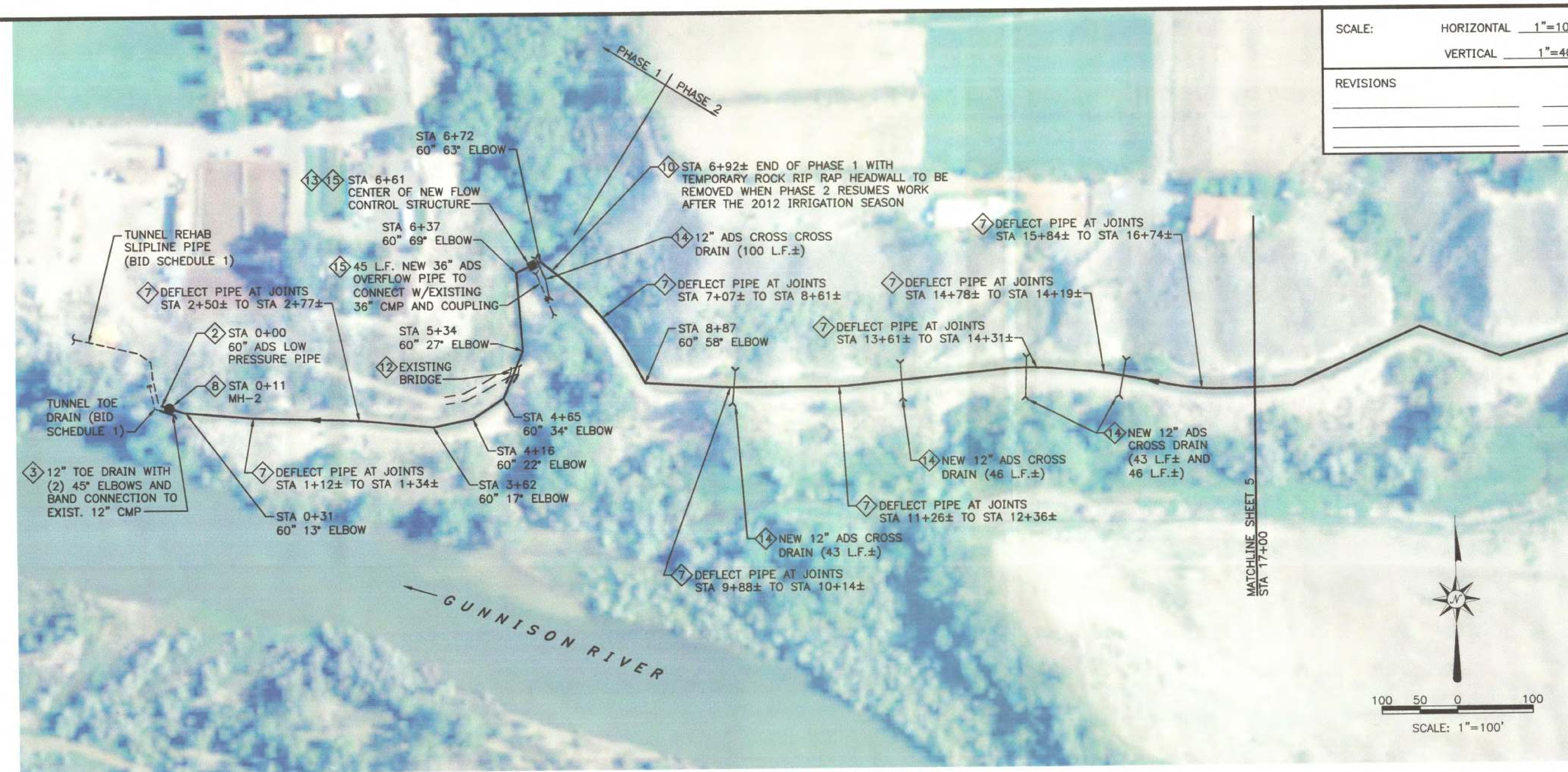
Design by:	Drafted by:	Date:	Project No.	Sheet
CKK	JCG	03-12	1111NDI	3 of 7

SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=40'

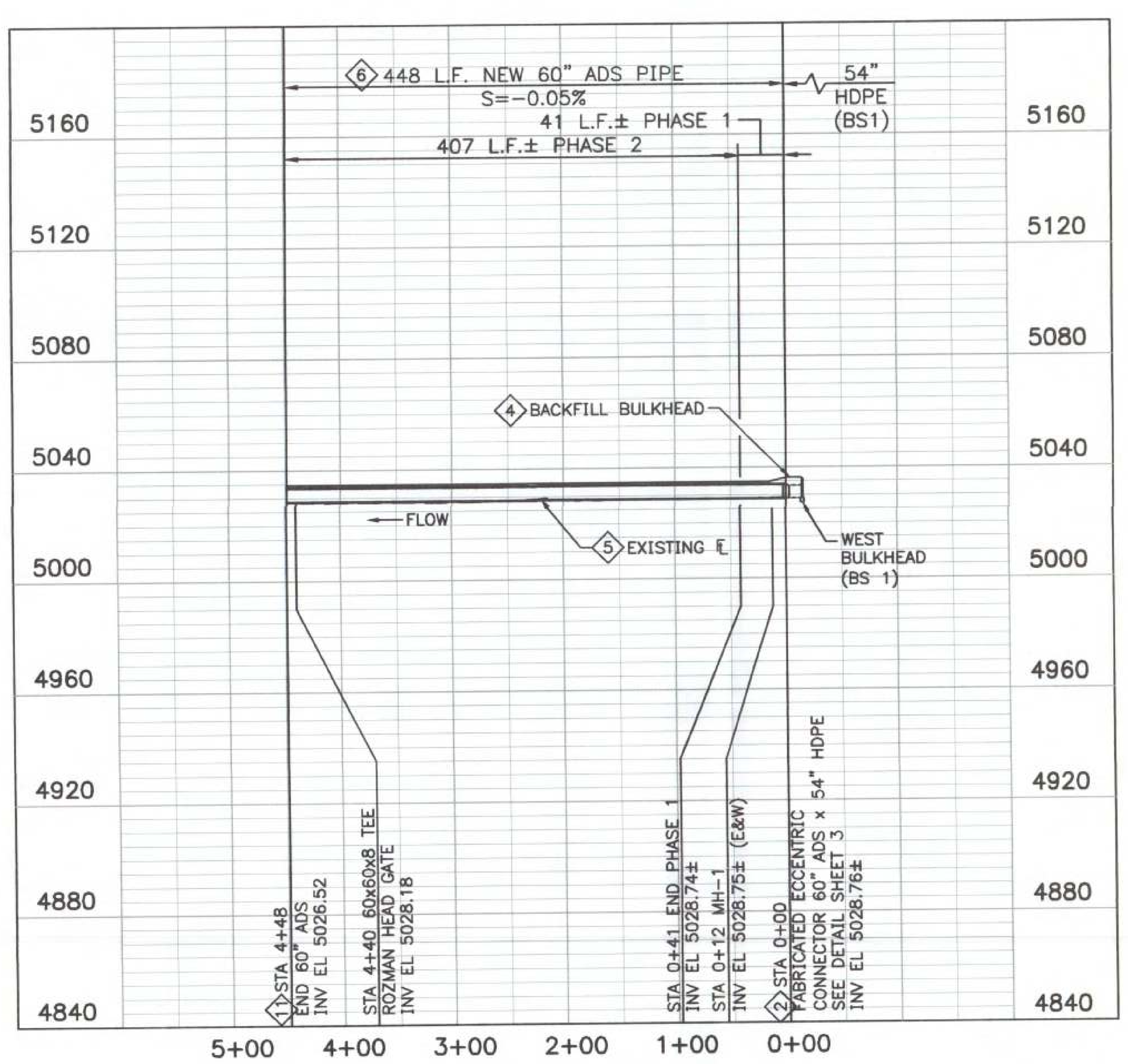
REVISIONS | DATE



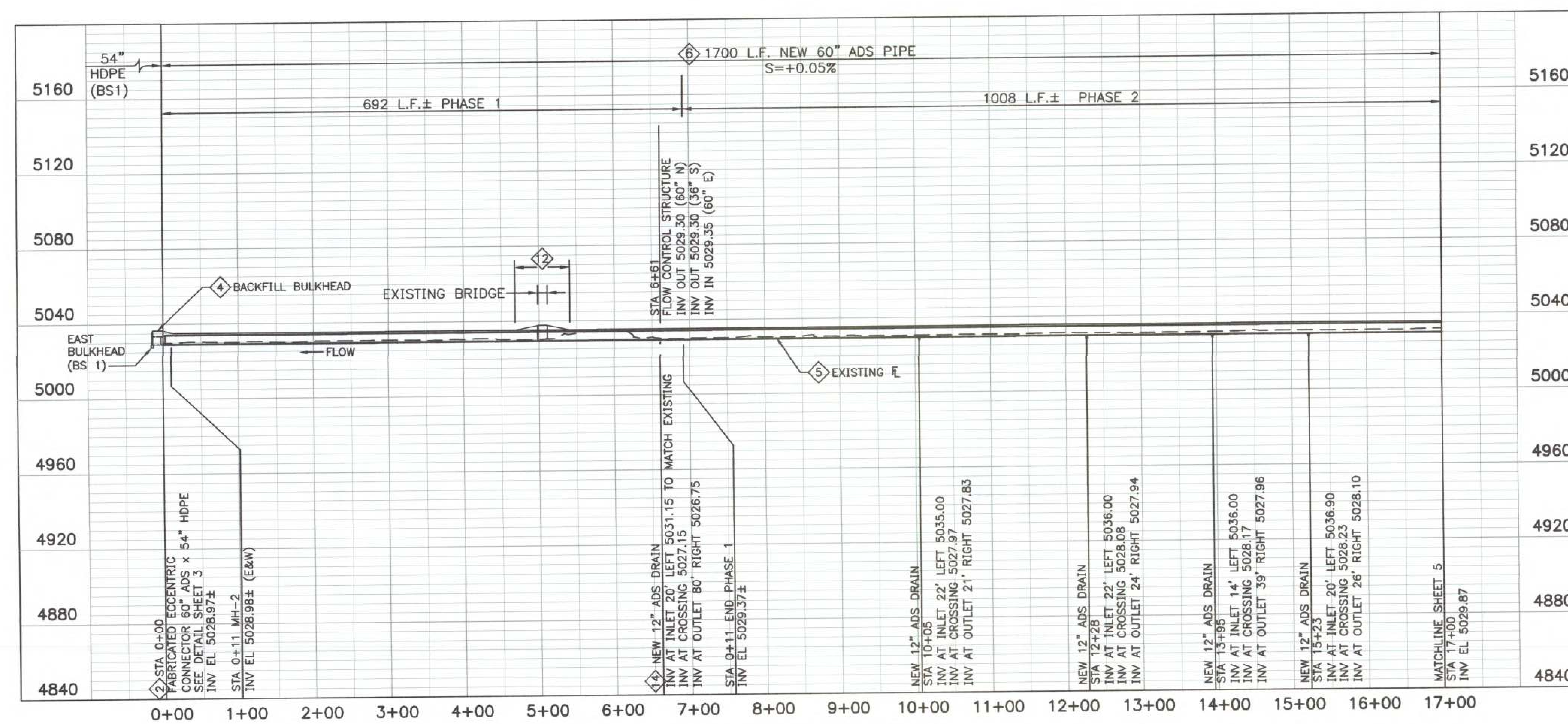
WEST CANAL PIPE PLAN



EAST CANAL PIPE PLAN



1 WEST CANAL PIPE PROFILE



EAST CANAL PIPE PROFILE

GENERAL NOTES

1. West Canal Profile is Stationed opposite from conventional Stationing, from south to north, that is also upstream to downstream, and right to left on the profile.
2. Station 0+00 is defined as a 60" ADS bell x 54" HDPE transition coupling supplied and installed under Bid Schedule 1, is an approximate location and invert elevation only, and will be dependent upon the as-built length of 54" HDPE pipe stub outs from the tunnel rehabilitation. The stub out length is estimated to be 14-feet, and invert elevation is estimated to match the existing tunnel flowline at the portal. Field adjustment to Station and invert elevation may be necessary.
3. Extend 12-inch ADS drain pipe with ST gasketed joints from end of tunnel toe drain stubbed out approx. 5 L.F. beyond tunnel bulkheads (Bid Schedule 1) to daylight. West tunnel drain extension will require approx. 120 L.F. aligned westerly toward the east right-of-way of State Highway 65. East tunnel drain extension will require approx. 20 L.F and (2) 45 degree elbow to connect to existing 12-inch CMP drain at existing concrete wingwall at tunnel approach.
4. Backfill 54-inch HDPE stub out from tunnel bulkheads to provide minimum 36" cover from bulkhead to the HDPE x ADS coupling at Sta 0+00. Provide a maximum 10:1 (horizontal to vertical) transition to minimum 12" bury over the new 60" ADS pipe from Sta 0+00 to Sta 0+20.
5. Prepare existing canal for pipe installation by removing existing saturated soil that cannot be blended with adjacent dry soil to achieve optimum moisture for compaction, cut and fill canal flowline for pipe subgrade based on profile elevations and slope, and on alignment as shown. Existing maintenance road will be lowered as a source of borrow material to be used for grading the new pipe subgrade, and to provide minimum cover over new irrigation pipe. Contractor shall import clean fill material to supplement on-site material as necessary.
6. Install new 60-inch ADS low pressure pipe in accordance with manufacturer's written instructions. Pipe shall be laid to grade using a surveyors level and rod for each joint, due to the nominal slope available. Backfill pipe with 12" minimum cover. Also refer to Detail 1 on Sheet 7.
7. Maximum deflection at pipe joints is 3 degrees. Refer to Standard and Supplement Drawings Section of Specifications for joint offset dimensional tolerances.
8. Refer to Detail 2 on Sheet 7 for configuration of MH-1 (west canal) and MH-2 (east canal).
9. Refer to Detail 3 on Sheet 7 for service connection.
10. Refer to Detail 4 on Sheet 7 for end of pipe rock rip rap headwall/wingwall detail.
11. End of West canal pipe invert will be below existing concrete apron at the inlet to existing inverted siphon. Reconstruct canal flowline from end of new pipe to existing concrete to provide smooth transition in flowline elevation, with non-woven filter fabric and rock rip rap erosion protection.
12. Install new canal pipe through existing clearing beneath existing bridge. Backfill the new pipe to springline using native compacted soil. Backfill top half of pipe beneath the existing bridge with 3,000 psi compressive strength concrete mix with reinforcing fibers to the bridge decking. Place additional native soil fill material along the new canal pipe to transition 10:1 from minimum 12" bury to match elevation of existing road.
13. New flow control structure. Refer to Detail 5 on Sheet 7.
14. New 12-inch ADS drain pipe with ST gasketed joints and flare inlet end section to divert surface drainage from the north across new canal pipe. See profile for invert elevations at inlet, at 60" ADS canal pipe crossing, and at outlet. Also refer to Detail 1 on Sheet 7.
15. Carefully remove existing gate lift mechanism at existing concrete overflow structure and salvage (store on-site) for Owner's reuse. Remove existing concrete structure and appurtenances and dispose of at an off-site facility accepting said waste materials. Also remove existing 36" CMP that is in conflict with alignment of new overflow pipe (approximately 45 L.F.), to the point at which the new pipe can be connected to the existing pipe prior to the southern edge of the maintenance road.

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03/24/2012

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NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

BID SCHEDULE 2
CANAL SYSTEM UPGRADE PLAN AND PROFILE

Design by:	Drafted by:	Date:	Project No.	Sheet
CKK	JCG	03-12	1111NDI	4 of 7

SCALE:	
HORIZONTAL	1"=100'
VERTICAL	1"=40'

REVISIONS	DATE

EAST CANAL PIPE PLAN

EAST CANAL PIPE PROFILE

BID SCHEDULES

1. Prepare existing canal for pipe installation by removing existing saturated soil that cannot be blended with adjacent dry soil to achieve optimum moisture for compaction, cut and fill canal flowline for pipe subgrade based on profile elevations and slope, and on alignment as shown. Existing maintenance road will be lowered as a source of borrow material to be used for grading the new pipe subgrade, and to provide minimum cover over new irrigation pipe. Contractor shall import clean fill material to supplement on-site material as necessary.
2. Install new 60-inch ADS low pressure pipe in accordance with manufacturer's written instructions. Pipe shall be laid to grade using a surveyors level and rod for each joint, due to the nominal slope available. Backfill pipe with 12" minimum cover. Also refer to Detail 1 on Sheet 7.
3. Maximum deflection at pipe joints is 3 degrees. Refer to Standard and Supplement Drawings Section of Specifications for joint offset dimensional tolerances.
4. Refer to Detail 3 on Sheet 7 for service connection.
5. New 12-inch ADS drain pipe with ST gasketed joints and flare inlet end section to divert surface drainage from the north across new canal pipe. See profile for invert elevations at inlet, at 60" ADS canal pipe crossing, and at outlet. Also refer to Detail 1 on Sheet 7.

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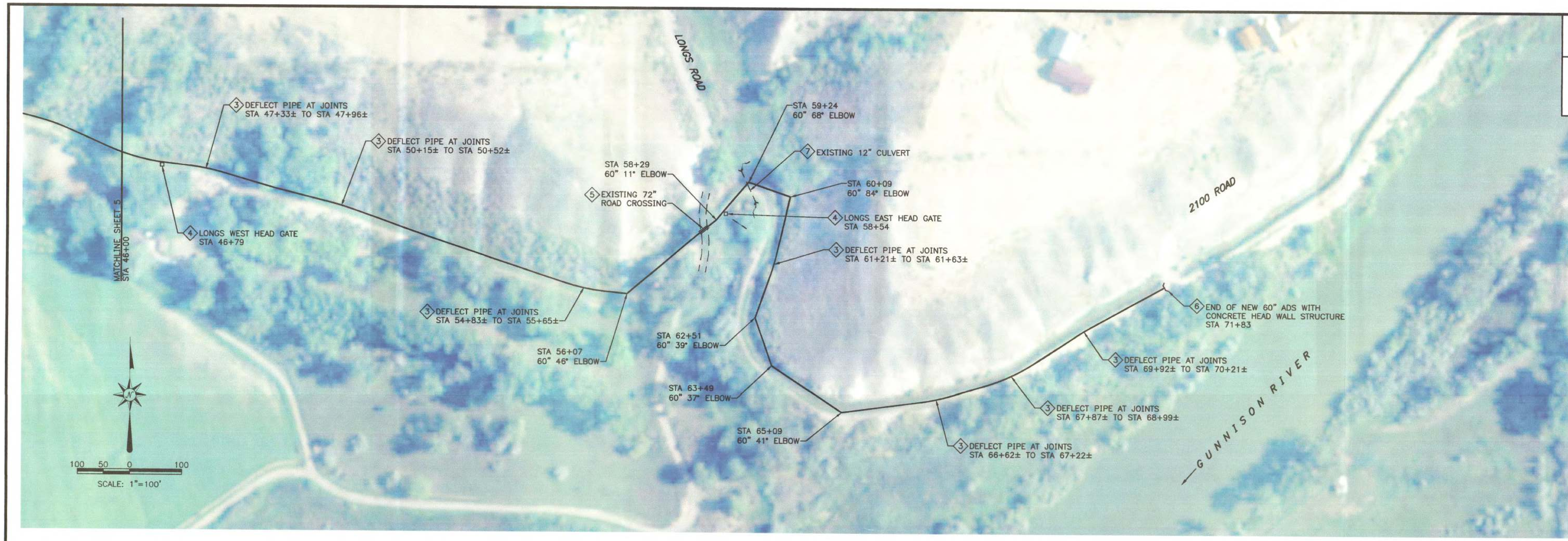
NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

BID SCHEDULE 2
CANAL SYSTEM UPGRADE PLAN AND PROFILE

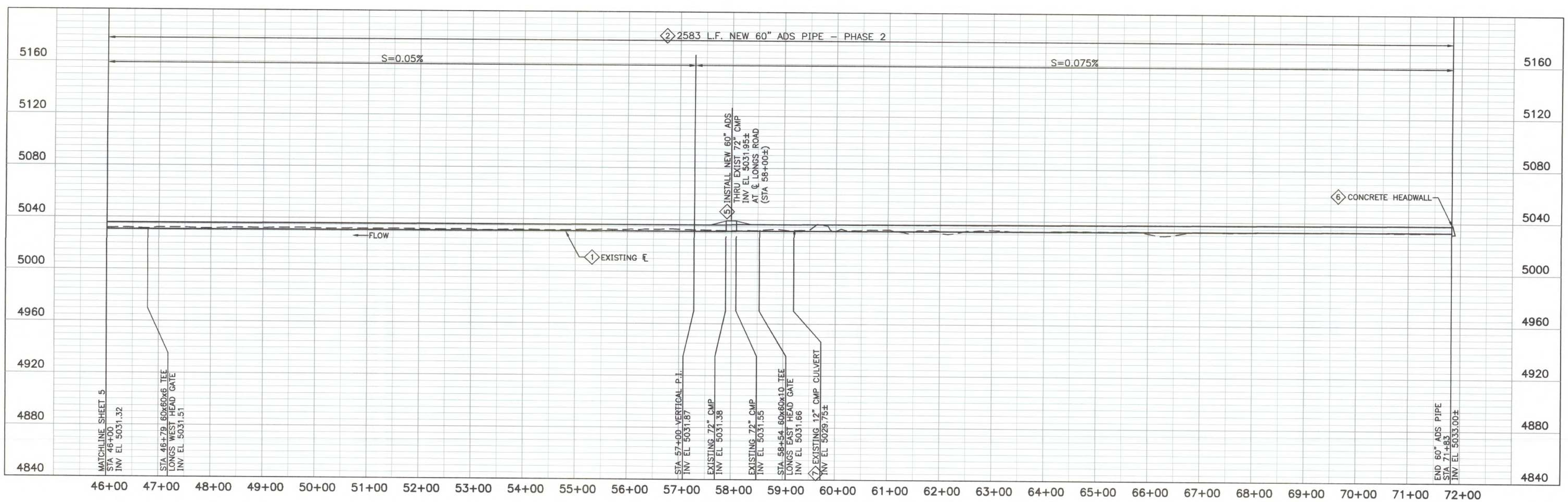
Design by:	Drafted by:	Date:	Project No.	Sheet 5
CKK	JCG	03-12	1111NDI	of 7

SCALE:	HORIZONTAL 1"=100'
	VERTICAL 1"=40'

REVISIONS	DATE



EAST CANAL PIPE PLAN



EAST CANAL PIPE PROFILE

BID SCHEDULES

1. Prepare existing canal for pipe installation by removing existing saturated soil that cannot be blended with adjacent dry soil to achieve optimum moisture for compaction, cut and fill canal flowline for pipe subgrade based on profile elevations and slope, and on alignment as shown. Existing maintenance road will be lowered as a source of borrow material to be used for grading the new pipe subgrade, and to provide minimum cover over new irrigation pipe. Contractor shall import clean fill material to supplement on-site material as necessary.
2. Install new 60-inch ADS low pressure pipe in accordance with manufacturer's written instructions. Pipe shall be laid to grade using a surveyors level and rod for each joint, due to the nominal slope available. Backfill pipe with 12" minimum cover. Also refer to Detail 1 on Sheet 7.
3. Maximum deflection at pipe joints is 3 degrees. Refer to Standard and Supplement Drawings Section of Specifications for joint offset dimensional tolerances.
4. Refer to Detail 3 on Sheet 7 for service connection.
5. Install new canal pipe through existing 72" CMP at road crossing. Backfill the new pipe to springline using native compacted soil, hand tamped as necessary. Backfill top half of pipe beneath the existing culvert with 3,000 psi compressive strength concrete mix containing reinforcing fibers. Place additional native soil fill material along the new canal pipe to transition 10:1 from minimum 12" bury to match elevation of existing road.
6. Install new concrete headwall/wingwall at end of new canal pipe in accordance with Colorado Department of Transportation Standard M-601-10. Refer to Standard and Supplemental Drawings Section of Specifications.
7. Protect existing culvert from damage during construction.

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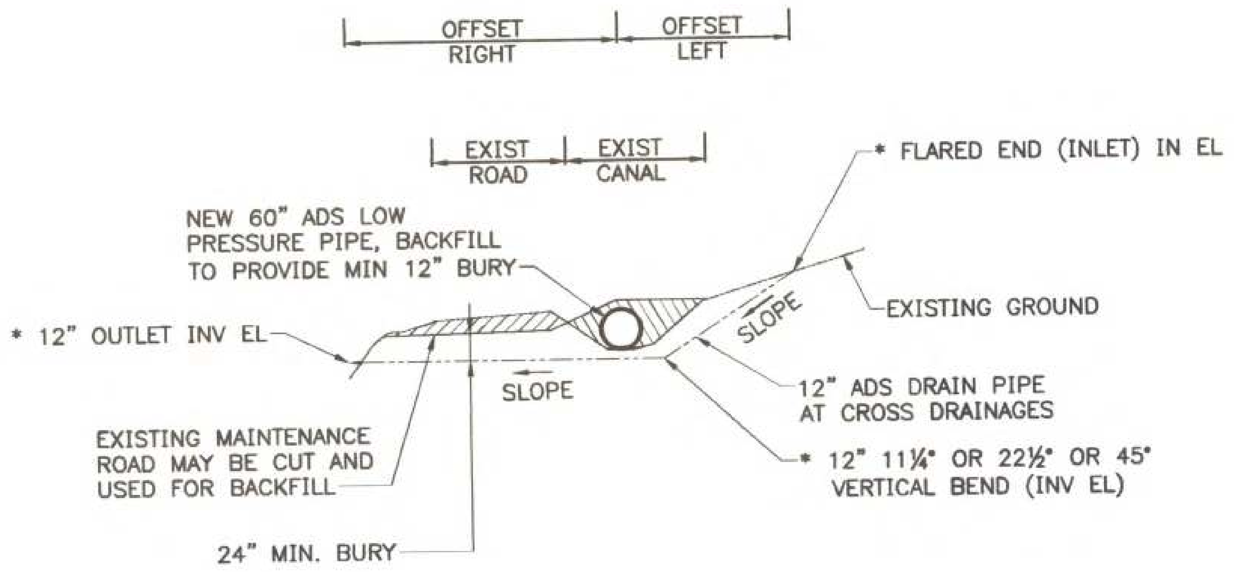
NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

BID SCHEDULE 2
CANAL SYSTEM UPGRADE PLAN AND PROFILE

Design by:	Drafted by:	Date:	Project No.	Sheet 6
CKK	JCG	03-12	1111NDI	of 7

SCALE:	HORIZONTAL AS SHOWN
	VERTICAL AS SHOWN

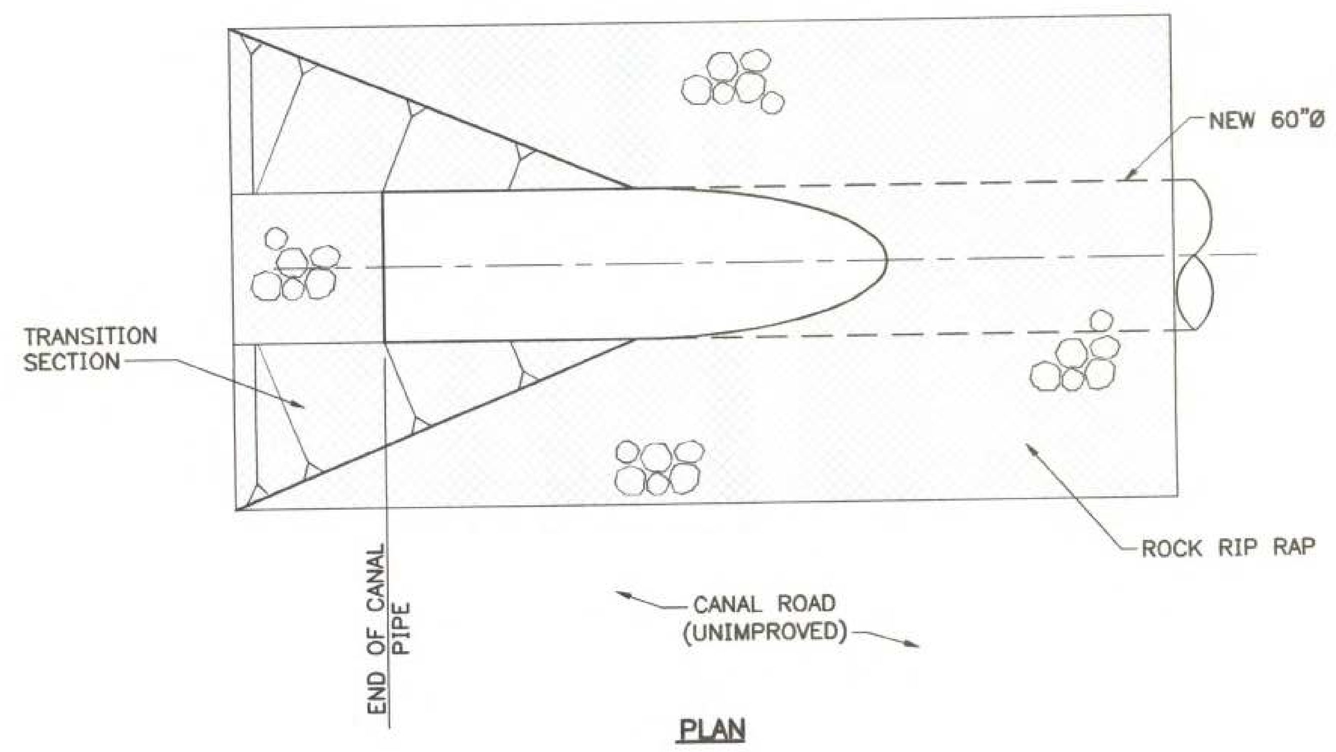
REVISIONS	DATE



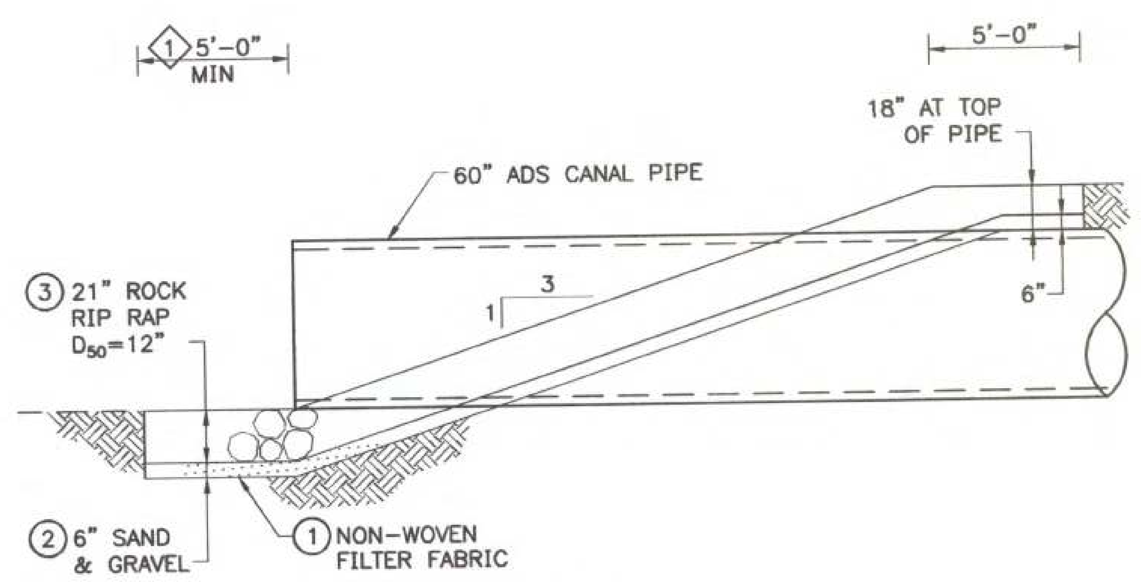
DETAIL 1
TYPICAL CANAL PIPE SECTION

HORZ & VERT SCALE: 1"=20'

* REFER TO PLAN AND PROFILE SHEETS 4 AND 5 FOR 12" CROSS DRAIN PIPES OFFSET DIMENSION FROM CANAL PIPE AND INVERT ELEVATIONS



PLAN



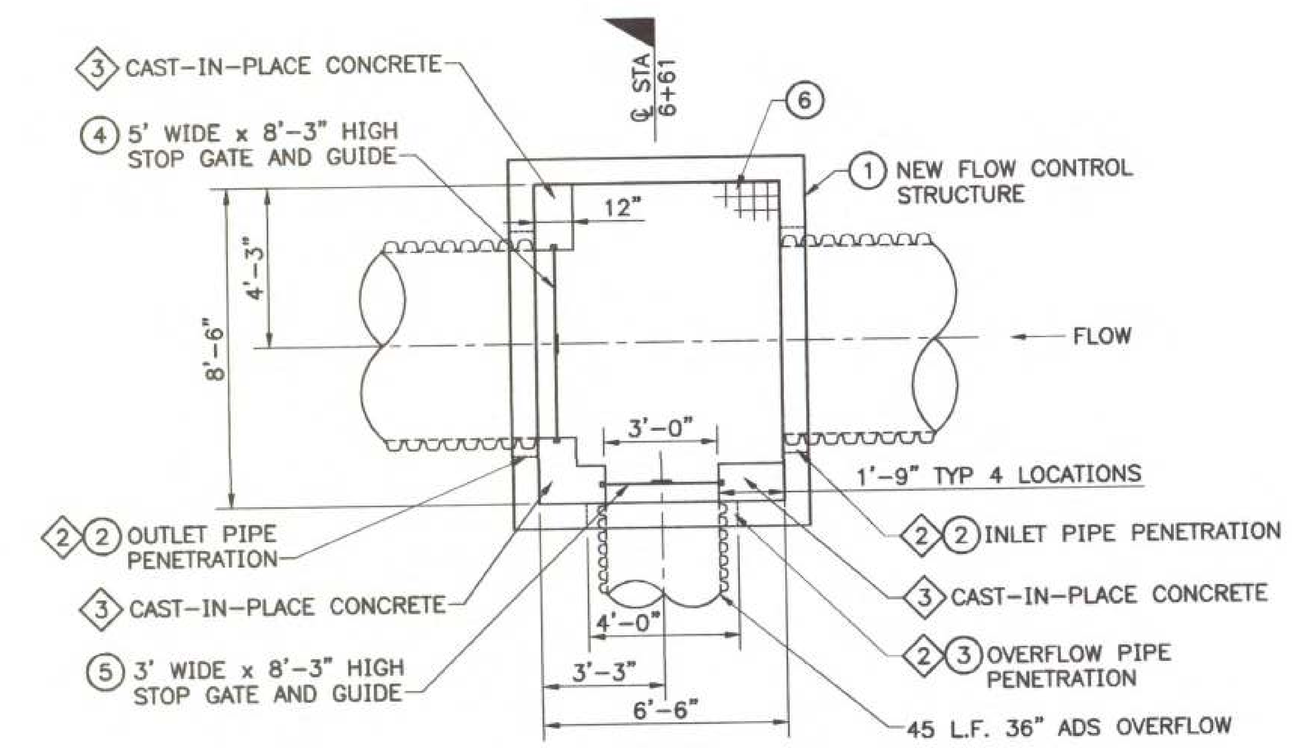
SECTION

2 DETAIL 4
ROCK RIP RAP HEADWALL

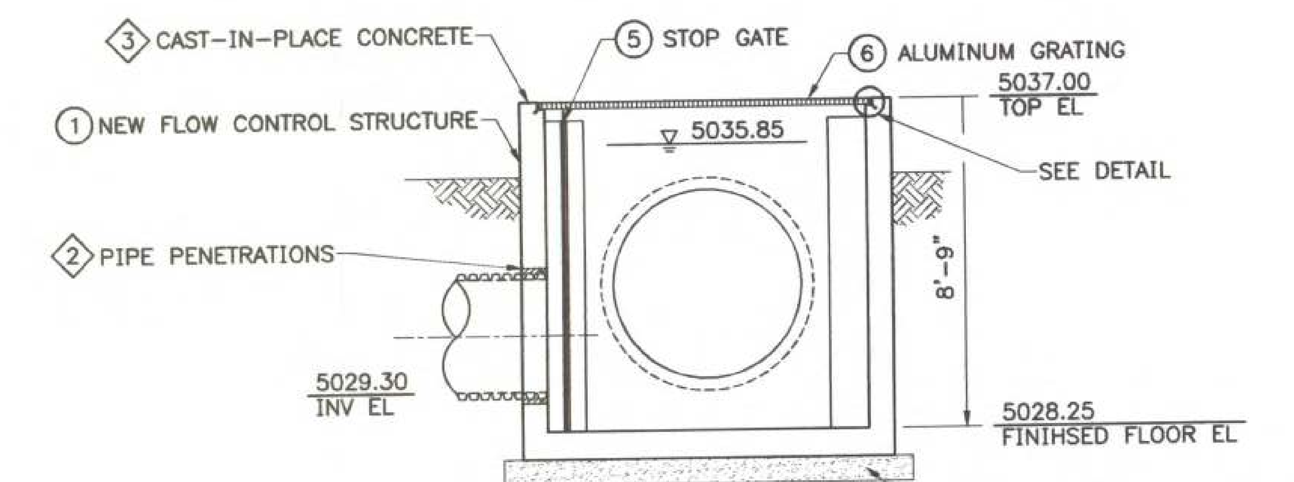
SCALE: 1"=5'-0"

LIST OF MATERIALS

1. Non-woven polypropylene geotextile for soil separation, filtration and protection, Mirifi 140N or equal.
2. Aggregate filter material, Class 4 (1½" minus) per CDOT Table 703-2.
3. Graded rock rip rap erosion protection, D_{50}=12" (18" minus) per CDOT Table 506-2E.



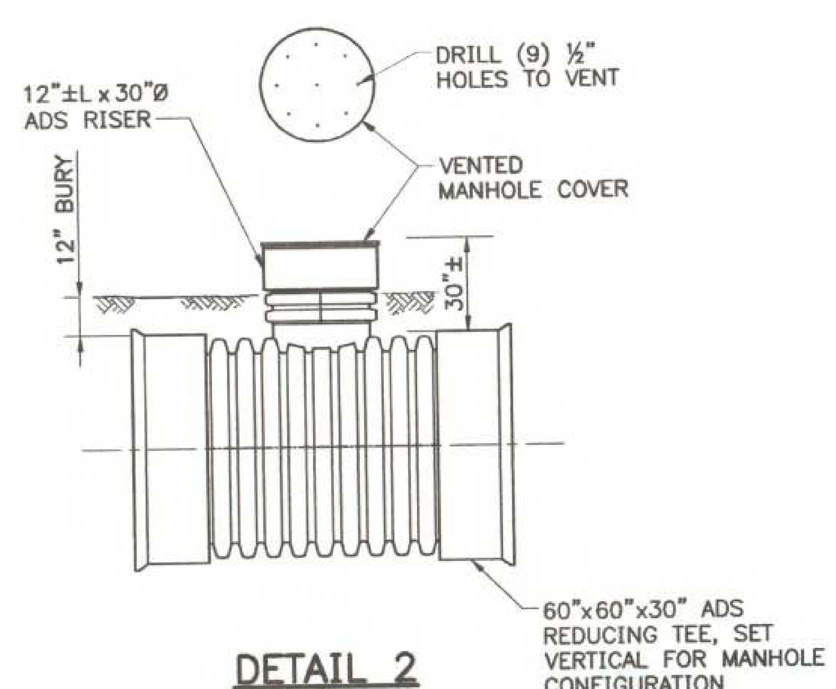
PLAN



SECTION

DETAIL 5
FLOW CONTROL STRUCTURE

SCALE: ¼"=1'-0"

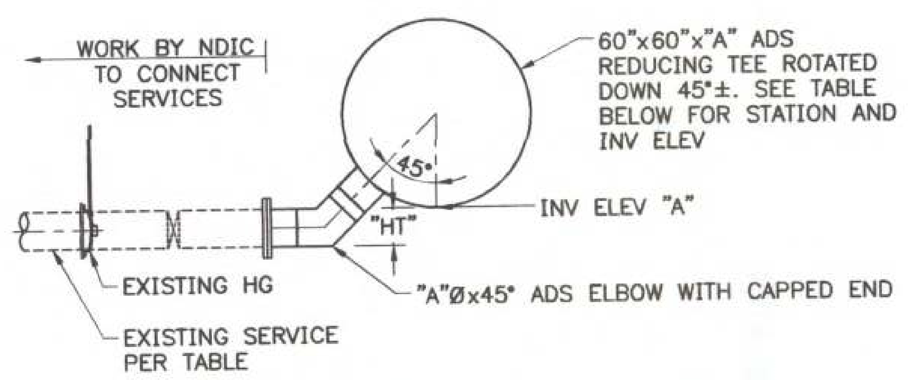


DETAIL 2
MANHOLES

(2) REQUIRED, (1) NEAR EACH END OF TUNNEL
SCALE: ¼"=1'-0"

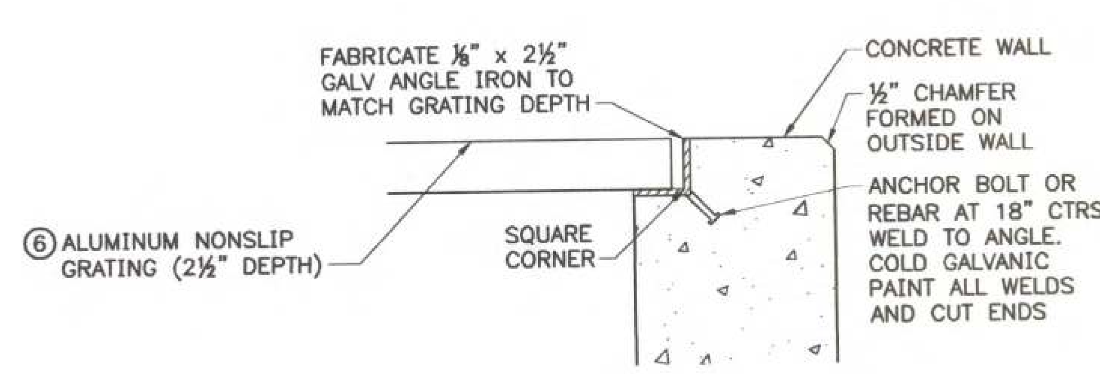
LIST OF MATERIALS

1. Precast concrete vault, 6'-6" wide by 8'-6" long by 8'-9" high inside dimensions. Provide grating support around inside of perimeter walls, with bituminous coating at surface in contact with concrete.
2. Provide (2) 72" diameter cored or block-out holes for 60" ADS inlet/outlet pipe penetrations, with centerline of 60" inlet 3'-7 1/4" above floor and centerline of 60" outlet 3'-6 5/8" above floor.
3. Provide (1) 48" diameter cored or block-out hole for 36" ADS overflow pipe penetration, centerline at 2'-6 5/8" above floor.
4. 5'-0" x 8'-3" reinforced fiberglass stop gate and cast-in gate guide, Plasti-Fab or equal. Stop gate is removed to allow flow to tunnel, or installed to divert flow to overflow.
5. 3'-0" x 8'-3" reinforced fiberglass stop gate and cast-in gate guide, Plasti-Fab or equal. Stop gate is installed to allow flow to tunnel, or removed to divert flow to overflow.
6. Aluminum non-slip grating, 6'-6" span, 2 ½" x 3/16" (or I-bar) for less than 1/4" deflection under uniform load of 100 psf.



DETAIL 3
SERVICE CONNECTION

(3) REQUIRED. SEE TABLE BELOW
SCALE: ¼"=1'-0"



GRATING SUPPORT DETAIL

NTS

DETAIL 3 – SERVICE CONNECTION

CUSTOMER	"A" SERVICE	STA 60" ADS	INV ELEV 60" ADS	"HT"
ROZMAN	8" CMP INV 5028.18	WEST CANAL 4+40.00	5028.54	0.36
LONG (WEST)	6" CMP INV 5031.51	EAST CANAL 46+79.00	5031.35	-0.16
LONG (EAST)	10" CMP INV 5031.66	EAST CANAL 58+54.00	5031.95	0.29

GENERAL NOTES

1. Rock rip rap headwall to be installed as temporary end of pipe transitions between canal flow and new pipe (Phase 1) and as permanent end of pipe transition at discharge end of new 60" ADS west canal pipe (Phase 2). Invert of pipe will be approximately 6" below existing concrete apron at inverted siphon inlet. Slope outlet transition flowline channel up (6" vertical in 5'-0" horizontal) to match existing flowline of canal and siphon inlet apron.
2. Stub pipes through wall of structure, flush with inside wall. Place O-ring gasket around pipe and seal annular space with non-shrink grout for watertight seal.
3. 12" thick by 8'-3" high cast-in-place interior walls for stop gate and gate guides, with epoxy coated #5 reinforcing bars @ 12" each way, and cast-in frames for stop gates.

WestWater Engineering
2516 Foresight Circle, #1
Grand Junction, CO 81505
(970) 241-7076

NORTH DELTA IRRIGATION COMPANY TUNNEL REHABILITATION AND CANAL SYSTEM UPGRADE

BID SCHEDULE 2
CANAL SYSTEM UPGRADE DETAILS

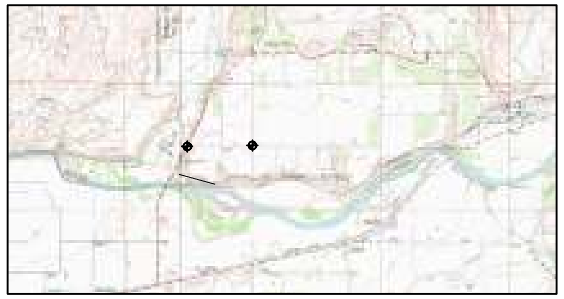
Design by:	Drafted by:	Date:	Project No.	Sheet
CKK	JCG	03-12	1111NDI	7 of 7

As Built

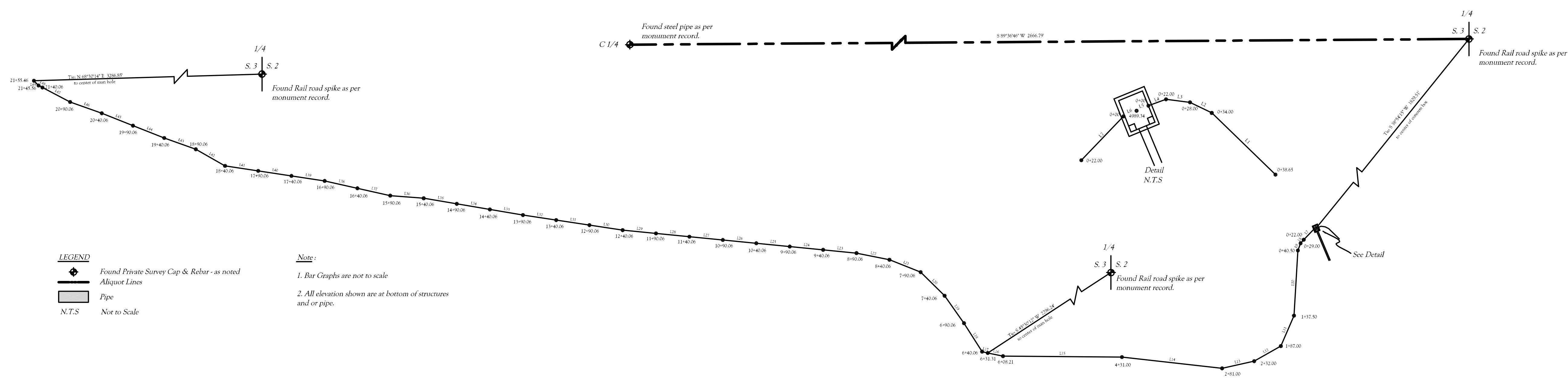
for a portion of the underground pipe North Delta Canal

Section 3, Township 15 South, Range 95 West, of the 6th Principal Meridian
Delta County, Colorado

VICINITY and CONTROL MAP



LINE	BEARING	DISTANCE
L1	S 45°56'01" E	22.00'
L2	S 63°56'01" E	6.00'
L3	S 82°56'01" E	6.00'
L4	N 70°03'59" E	4.65'
L5	S 66°52'28" W	3.20'
L6	N 66°52'28" E	3.50'
L7	N 43°54'46" E	22.00'
L8	S 41°54'46" W	7.00'
L9	N 20°25'48" E	11.50'
L10	N 03°25'48" E	97.00'
L11	N 23°25'48" E	49.50'
L12	N 60°25'48" E	45.50'
L13	N 77°25'48" E	49.00'
L14	S 83°34'12" E	150.00'
L15	S 89°34'12" E	177.21'
L16	S 77°58'59" E	23.10'
L17	S 77°03'52" E	8.76'
L18	S 32°24'32" E	50.13'
L19	S 35°24'32" E	50.00'
L20	S 45°24'32" E	50.00'
L21	S 68°24'32" E	50.00'
L22	S 78°24'32" E	50.00'
L23	N 84°24'32" W	50.00'
L24	S 84°24'32" E	50.00'
L25	N 84°24'32" W	50.00'
L26	S 84°24'32" E	50.00'
L27	S 84°24'32" E	50.00'
L28	S 84°24'32" E	50.00'
L29	N 84°24'32" W	50.00'
L30	S 81°24'32" E	50.00'
L31	S 81°24'32" E	50.00'
L32	N 81°24'32" W	50.00'
L33	S 80°24'32" E	50.00'
L34	N 80°24'32" W	50.00'
L35	S 80°24'32" E	50.00'
L36	S 85°24'32" E	50.00'
L37	S 77°24'32" E	50.00'
L38	S 77°24'32" E	50.00'
L39	S 81°24'32" E	50.00'
L40	S 81°24'32" E	50.00'
L41	N 81°24'32" W	50.00'
L42	N 60°24'32" W	50.00'
L43	S 70°24'32" E	50.00'
L44	S 68°24'32" E	50.00'
L45	S 68°24'32" E	50.00'
L46	S 70°24'32" E	50.00'
L47	S 62°24'32" E	46.51'
L48	N 62°24'32" W	6.50'
L49	S 44°24'32" E	9.90'



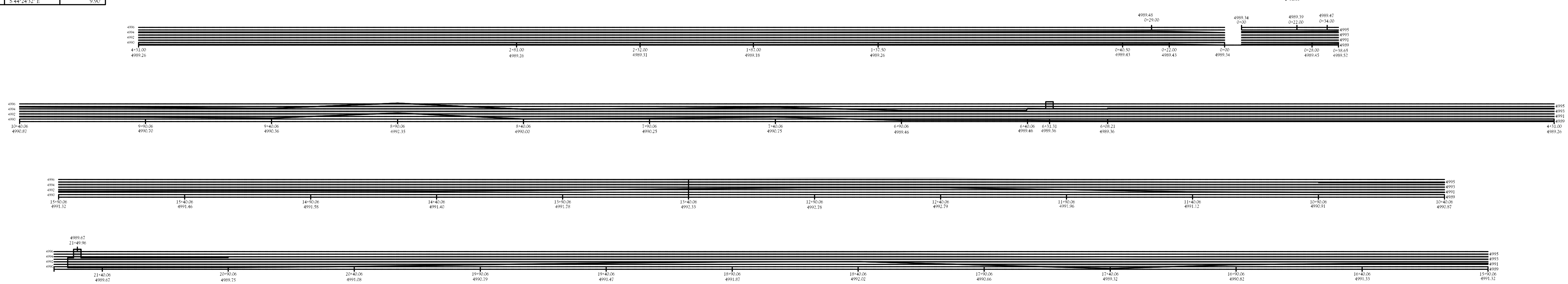
LEGEND

- Found Private Survey Cap & Rebar - as noted
- Aliquot Lines
- Pipe
- N.T.S — Not to Scale

Note :

1. Bar Graphs are not to scale

2. All elevation shown are at bottom of structures and or pipe.



BASIS OF BEARING :

The North line of the SE 1/4 of section 3 is assumed to bear S. 89°36'46" W. and is monumented as shown hereon. All other bearings are relative thereto.

NOTICE 13-80-105 C.R.S, as amended:

ACCORDING TO COLORADO LAW YOU MUST COMMENCE ANY LEGAL ACTION BASED UPON ANY DEFECT IN THIS SURVEY WITHIN THREE YEARS AFTER YOU FIRST DISCOVERED SUCH DEFECT. IN NO EVENT MAY ANY ACTION BASED UPON ANY DEFECT IN THIS SURVEY BE COMMENCED MORE THAN TEN YEARS FROM THE DATE OF THE CERTIFICATION SHOWN HEREON.

CERTIFICATE OF SURVEY :

I, Kenneth E. Schaaf, a Registered Land Surveyor in the State of Colorado, do hereby certify that this plat accurately represents that the surveying services addressed herein have been performed by the professional land surveyor or under the professional land surveyor in charge.

Signature Date Seal
PLS No. 38114

U.S. MINERAL SURVEYORS
REGISTERED LAND SURVEYORS
IN COLORADO

SOUTHWEST LAND SURVEYING LLC
1315 Snowden St., Silverton, CO 81433
(970) 387-0600...Silverton (970) 874-2880...Delta
(970) 874-0883...fax EMAIL: kennscha@aol.com

PLAN SCALE: 1"=100' U.S.S.F	REVISIONS:	As Built for a portion of under ground pipe
FIELD CREW: K.E.S, T.T.S		North Delta Irrigation Company P.O. Box 804 Delta Colorado, 81416
DRAFTER: KES		FW: 4/24/14
SHEET 1 of 1		JOB #: 07-14

APPENDIX B

CALCULATIONS

Flow Measurement Calculations

Midsection Method Stream Flow Calculations

Cross Section A

Length	Depth	$V_{.2D}$	$V_{.8D}$	$V_{.6D}$	V_{avg}	$q_{n+/-}$
(ft)	*(ft)*	*(fps)*	*(fps)*	*(fps)*	*(fps)*	*(cfs)*
0	0	e			0	0
0.5	1.64	-	-	0.69	0.69	0.8487
1.5	2.2	-	-	0.86	0.86	1.892
2.5	2.32	-	-	1.19	1.19	2.7608
3.5	2.55	1.33	0.96	-	1.145	2.91975
4.5	2.7	1.56	1.39	-	1.475	3.9825
5.5	2.75	1.62	1.45	-	1.535	4.22125
6.5	2.8	1.48	1.29	-	1.385	3.878
7.5	2.83	1.36	1.33	-	1.345	3.80635
8.5	2.8	1.25	1.25	-	1.25	3.5
9.5	2.7	0.95	1.38	-	1.165	3.1455
10.5	2.65	1.09	1.09	-	1.09	2.8885
11.5	2.29	-	-	0.67	0.67	1.5343
12.5	1.6	-	-	0.8	0.8	1.28
13.5	0	e			0	0
					Total	**36.66**

Cross Section B

Length	Depth	$V_{.2D}$	$V_{.8D}$	$V_{.6D}$	V_{avg}	$q_{n+/-}$
(ft)	*(ft)*	*(fps)*	*(fps)*	*(fps)*	*(fps)*	*(cfs)*
0	0	e			0	0
0.5	1.7	-	-	0.27	0.27	0.34425
1.5	2.22	-	-	0.84	0.84	1.8648
2.5	2.3	-	-	1.22	1.22	2.806
3.5	2.22	-	-	1.22	1.22	2.7084
4.5	2.12	-	-	1.66	1.66	3.5192
5.5	2.1	-	-	1.53	1.53	3.213
6.5	2	-	-	1.14	1.14	2.28
7.5	1.9	-	-	0.51	0.51	0.969
8.5	1.3	-	-	0.47	0.47	0.611
9.5	0.8	-	-	0.26	0.26	0.208
10.5	0.5	-	-	0.3	0.3	0.15
11.5	0	e			0	0
					Total	**18.67**

Siphon Back-Water Calculations

Air Bleed/ Drain Lines		
Diameter	Number of Lines	Total Area
0.3333	4	0.34906585

Tongue Creek Siphon

Inputs			Inputs		
Discharge	17.99	(cfs)	Discharge	46	(cfs)
Inside Pipe Diameter	48	(in)	Inside Pipe Diameter	48	(in)
Manning's n	0.012		Manning's n	0.012	
Siphon Length	1722	(ft)	Siphon Length	1722	(ft)
Entrance Loss Coeff	0.5	*Small Canal Structures*	Entrance Loss Coeff	0.5	*Small Canal Structures*
Exit Loss Coeff	1.0	*Small Canal Structures*	Exit Loss Coeff	1	*Small Canal Structures*
Total Bend Loss Coeff	0.4	*AWWA M 11*	Total Bend Loss Coeff	0.4	*AWWA M 11*
Misc. Fitting Loss Coeff	0	*AWWA M 11*	Misc. Fitting Loss Coeff	0	*AWWA M 11*
Upstream Channel Velocity	0	(ft/s)	Upstream Channel Velocity	0	(ft/s)
Dowstream Channel Velocity	0.00	(ft/s)	Dowstream Channel Velocity	0.00	(ft/s)
Dowstream Channel WSE	5028.833	(ft)	Dowstream Channel WSE	5030.11	(ft)
Calculated Values			**Calculated Values**		
Flow Area	12.57	(ft^2)	Flow Area	12.57	(ft^2)
Pipe Velocity	1.43	(ft/s)	Pipe Velocity	3.66	(ft/s)
Friction Loss	0.23	(ft)	Friction Loss	1.51	(ft)
Entrance Loss	0.02	(ft)	Entrance Loss	0.10	(ft)
Exit Loss	0.03	(ft)	Exit Loss	0.21	(ft)
Fitting Loss	0.01	(ft)	Fitting Loss	0.08	(ft)
Total Loss X 1.1 FOS	0.32	(ft)	Total Loss X 1.1 FOS	2.10	(ft)
Results			**Results**		
Upstream WSE	**5029.15**	(ft)	Upstream WSE	**5032.21**	(ft)
Required Hydraulic Seal	**0.25**	(ft)	Required Hydraulic Seal	**0.31**	(ft)
Siphon Pipe Invert Elev.	**5024.90**	(ft)	Siphon Pipe Invert Elev.	**5027.89**	(ft)

Tunnel Siphon

Inputs			Inputs		
Discharge	17.99	(cfs)	Discharge	46	(cfs)
Inside Pipe Diameter	47.16	(in)	Inside Pipe Diameter	47.16	(in)
Manning's n	0.01		Manning's n	0.01	
Siphon Length	1518.7	(ft)	Siphon Length	1518.7	(ft)
Entrance Loss Coeff	0.5	*Small Canal Structures*	Entrance Loss Coeff	0.5	*Small Canal Structures*
Exit Loss Coeff	1	*Small Canal Structures*	Exit Loss Coeff	1	*Small Canal Structures*
Total Bend Loss Coeff	1.2	*AWWA M 11*	Total Bend Loss Coeff	1.2	*AWWA M 11*
Misc. Fitting Loss Coeff	0	*AWWA M 11*	Misc. Fitting Loss Coeff	0	*AWWA M 11*
Upstream Channel Velocity	0	(ft/s)	Upstream Channel Velocity	2.5	(ft/s)
Dowstream Channel Velocity	0.00	(ft/s)	Dowstream Channel Velocity	2.50	(ft/s)
Dowstream Channel WSE	5029.15	(ft)	Dowstream Channel WSE	5032.21	(ft)
Calculated Values			**Calculated Values**		
Flow Area	11.78	(ft^2) *	Flow Area	11.78	(ft^2) *
Pipe Velocity	1.53	(ft/s)	Pipe Velocity	3.90	(ft/s)
Friction Loss	0.17	(ft)	Friction Loss	1.12	(ft)
Entrance Loss	0.02	(ft)	Entrance Loss	0.07	(ft)
Exit Loss	0.04	(ft)	Exit Loss	0.14	(ft)
Fitting Loss	0.04	(ft)	Fitting Loss	0.28	(ft)
Total Loss X 1.1 FOS	0.30	(ft)	Total Loss X 1.1 FOS	1.78	(ft)
Results			**Results**		
Upstream WSE	**5029.45**	(ft)	Upstream WSE	**5033.98**	(ft)
Required Hydraulic Seal	**0.25**	(ft)	Required Hydraulic Seal	**0.25**	(ft)
Siphon Pipe Invert Elev.	**5025.27**	(ft)	Siphon Pipe Invert Elev.	**5029.80**	(ft)

* Includes priming line area reduction

Applegate Group, Inc.
Water Resource Advisors for the West

Client: NDIC
Job No:
Project: Tunnel Siphon Eval
By: Date:
Description: Scouring Velocity
Chk: Date:
Page: of:

$\mathbb{F}$ = Froude number $= \dfrac{V}{\sqrt{gD}}$

where V = velocity

g = gravity constant = 32.2

D = mean depth = $\sqrt{\text{Area}}$ for pipes

$$D = \sqrt{A} = \sqrt{\pi \frac{3.93^2}{4}} = 3.48 \text{ ft}$$

$$V = Q/A = 46/12.12 = 3.8 \text{ ft/s}$$

$$\mathbb{F} = \frac{3.8}{\sqrt{32.2 \cdot (3.48)}} = 0.35$$

References + Forums indicate $\mathbb{F} > 0.35$ in order to remove air pockets

If $\mathbb{F} \sim 0.5$; $0.5 = \dfrac{V}{\sqrt{32.2(3.48)}} \Rightarrow V = 5.29 \text{ ft/s} > 3.48$

Siphon will not self scour.

Gandenberger's results also show the critical velocity to be dependent on the volume of the bubble for n = 0.02 to 1.0. Wisner et al found that for n > 0.8 the velocity was independent of bubble volume, and Kent's results do not show any strong dependence between the two parameters. Only Kent gives any details of the bubble volumes used in his tests.

For the horizontal pipe there appears to be the greatest confusion. Falvey suggests that the critical velocity is zero for movement of both bubbles and air pockets in horizontal pipes. In the discussion by Mechler of Gandenberger's work he continues the curves, given in Figure 13, to zero for horizontal slopes. As shown in the Figure, other authors suggest however, that there is some minimum velocity greater than zero for movement of air bubble and pockets in horizontal pipes. The values range from $V_c/\sqrt{(gD)} = 0.35$ to around 0.8. For a 200mm diameter horizontal pipe this gives a critical velocity range of 0.49 to 1.12m/s.

Notes for Figure 13: n is the bubble size, defined as $\frac{4\nabla_b}{\pi D^3}$ (Equation 16)

E is the surface tension parameter $\frac{g\rho_l D^2}{\sigma}$ (Equation 2)

*no information available as to basis of the equations

APPENDIX C

COST ESTIMATES

Engineers Opinion of Probable Construction Cost

Applegate Group, Inc.

1490 W. 121st Ave. Suite 100
Denver, CO 80234
Phone: (303) 452-6611
Fax: (303) 452-2759

North Delta Irrigation Company

Siphon

Job No. :	14-121
By:	TJD/CMU
Date:	10/9/2014
Client:	North Delta Irrigation Company

Description of Work	Item	Units	Quantity	Unit Cost	Total Cost
	54" HDPE DR-17 Pipe Elbows and Wall Anchors	EA	4	$ 4,600.00	$ 18,400.00
	54" HDPE DR-17 Wall Anchors	EA	2	$ 3,850.00	$ 7,700.00
	Pipe Eblow & Wall Anchor Installation (to be performed by ISCO)	EA	1	$ 13,500.00	$ 13,500.00
	Manhole (pre-cast), 84" diameter	EA	1	$ 7,000.00	$ 7,000.00
	2" Priming Line	LF	4,250	$ 2.00	$ 8,500.00
	2" Pipe Tee	EA	4	$ 2.50	$ 10.00
	Valve, 2"	EA	6	$ 150.00	$ 900.00
	Centrigal Pump	EA	1	$ 3,500.00	$ 3,500.00
	Power Line Extension, single phase	LF	440	$ 15.00	$ 6,600.00
	Transformer and Meter	EA	1	$ 5,000.00	$ 5,000.00
	Slide Gate, 60", installed	EA	2	$ 10,000.00	$ 20,000.00
	Outlet Structure (cast in place)	CY	14	$ 1,200.00	$ 16,800.00
	HDPE hole plugs	EA	27	$ 170.00	$ 4,590.00
	Air Vent	EA	1	$ 30.00	$ 30.00
	Inserta-Tee, 12N1260N12	EA	1	$ 300.00	$ 300.00
	8" PVC Tee	EA	1	$ 150.00	$ 150.00
	8" Pipe Pipe	LF	50	$ 13.00	$ 650.00
	Vault Drain Valve	EA	2	$ 500.00	$ 1,000.00
	Excavate & Remove existing 60" ADS-N12 Pipe	LF	60	$ 17.00	$ 1,020.00
	60" ADS-N12 Low Head Pipe (installation only)	LF	60	$ 75.00	$ 4,500.00
	Construction Subtotal				**$ 120,150.00**
	Mobilization	%		6%	$ 8,000.00
	Contingency/Missing Items	%		15%	$ 19,000.00
	Construction Total				**$ 147,150.00**
	Final Engineering & Const Plans	%		8%	$ 12,000.00
	Construction Observation	%		5%	$ 8,000.00
	Total				**$ 167,150.00**

Engineers Opinion of Probable Construction Cost

Applegate Group, Inc.

1490 W. 121st Ave. Suite 100
Denver, CO 80234
Phone: (303) 452-6611
Fax: (303) 452-2759

North Delta Irrigation Company

Propeller Pump

Job No. : 14-121
By: TJD/CMU
Date: 10/9/2014
Client: North Delta Irrigation Company

Description of Work	Item	Units	Quantity	Unit Cost	Total Cost
	Propeller Pump w/ controller and fittings	EA	1	$ 65,000.00	$ 65,000
	Variable Frequency Drive	EA	1	$ 10,000.00	$ 10,000
	Pump Install including electic hookup of pump	EA	1	$ 15,000.00	$ 15,000
	Concrete Structure modification	CY	10	$ 1,200.00	$ 12,000
	Power line extension, Three Phase	LF	2,900	$ 30.00	$ 87,000
	Transformer and Meter	EA	1	$ 15,000.00	$ 15,000
	Construction Subtotal				**$ 204,000**
	Mobilization	%		3%	$ 7,000
	Contingency/Missing Items	%		15%	$ 31,000
	Construction Total				**$ 242,000**
	Final Engineering & Const Plans	%		8%	$ 20,000
	Construction Observation	%		5%	$ 13,000
	Total				**$ 275,000**

Engineers Opinion of Probable Construction Cost

Applegate Group, Inc.

1490 W. 121st Ave. Suite 100
Denver, CO 80234
Phone: (303) 452-6611
Fax: (303) 452-2759

North Delta Irrigation Company

Propeller Pump

Job No. :	14-121
By:	TJD/CMU
Date:	10/9/2014
Client:	North Delta Irrigation Company

Description of Work	Item	Units	Quantity	Unit Cost	Total Cost
	60" Low Head Pipe (installed)	LF	6,600	$ 210.00	$ 1,386,000
	Construction Subtotal				**$ 1,386,000**
	Mobilization	%		6%	$ 84,000
	Contingency/Missing Items	%		15%	$ 208,000
	Construction Total				**$ 1,678,000**
	Final Engineering & Const Plans	%			$ -
	Construction Observation	%		4%	$ 68,000
	Total				**$ 1,746,000**