STATE OF COLORADO

Colorado Water Conservation Board
Department of Natural Resources
1313 Sherman Street, Room 721
Denver, Colorado 80203
Phone: (303) 866-3441
Fax: (303) 866-4474
www.cwcb.state.co.us

TO: Colorado Water Conservation Board Members

FROM: Todd Doherty, Water Supply Planning Section

DATE: March 9, 2012

SUBJECT: **Agenda Item 15.b, March 20-21, 2012 Board Meeting**
Finance Section/Water Supply Planning Section
North Delta Irrigation Company—Tunnel Reconstruction Project
Water Supply Reserve Account Application

Introduction and Background

Please refer to the attached Water Activity Summary Sheet, basin roundtable approval letter, and application materials for details on the North Delta Irrigation District's request for funds from the Water Supply Reserve Account.

Staff Recommendation

Staff recommends approval of up to $370,000 of Statewide WSRA funds and up to $40,000 of Gunnison Basin WSRA funds to help complete the Tunnel Reconstruction Project. This is contingent upon the resolution of items under the issues/additional needs section of the attached Water Activity Summary Sheet.

Water Supply Reserve Account – Grant and Loan Program
Water Activity Summary Sheet
Agenda Item 15b

Applicant: North Delta Irrigation Company

Water Activity Name: Tunnel Reconstruction Project

Water Activity Purpose: Structural Activity

County: Delta

Drainage Basin: Gunnison

Water Source: Gunnison

Amount Requested: $800,000

Source of Funds: $760,000 Statewide Fund, $40,000 Gunnison Basin Fund and $800,000 CWCB Loan

Matching Funds: $800,000 CWCB Loan

Staff Recommendation
Staff recommends approval of up to $370,000 from the Statewide Account and up to $40,000 from the Gunnison basin account to help fund the North Delta Irrigation Company's Tunnel Reconstruction Project contingent upon resolution of the items listed in the issues/additional needs section below.

Water Activity Summary: The North Delta Irrigation Company (NDIC) is a Colorado Non-Profit Corporation which operates the North Delta Canal which delivers 49.675 CFS from a headgate located east of Austin, Colorado, on the Gunnison River. The North Delta Irrigation Company (Company) is responsible for supplying water to its 174 shareholders for the irrigation of 2,300 acres of agricultural lands. The water is delivered through the North Delta Irrigation Canal. A two-mile stretch of the seventeen mile canal is located along the steep hillside paralleling the Gunnison River, and includes three tunnels. The longest tunnel, 1,450 feet in length, experienced a collapse in July 2011, blocking deliveries to 94% of its shareholders. The remainder of the stretch is open channel ditch that is heavily vegetated, difficult to access and showing signs of instability. This project will repair the collapsed tunnel by installing 1,500 LF of 54" pipe.

Discussion: The North Delta Irrigation Company is in clear need of assistance as the century old tunnel that historically delivered water to the majority of the fields has collapsed. Considering that it is March and the irrigation season is quickly approaching, there is a significant probability that these lands would not receive irrigation water during this season without repairing the tunnel.

This application is requesting that grant funds be used for tunnel reconstruction ($1,210,000) and for piping of the ditch ($1,140,000). In February, the Gunnison basin roundtable approved funding of up to $40,000 of basin funds and $760,000 of statewide funds for the tunnel reconstruction project. Considering that the Gunnison BRT approved an application that was subsequently amended to add the piping work, staff believes that these grant funds should be limited to the tunnel project. If the Applicant would like to receive grant funding for the piping work, staff believes that a new application be developed and presented to the roundtable and then the CWCB for consideration.

It should be noted that the Applicant is requesting that the Board's 60 day application deadline requirement be waived due to the emergency circumstances. Staff believes that a waiver of this requirement is justified for the tunnel reconstruction component to allow the irrigators to receive water this upcoming season. Staff believes that some additional time should be taken to consider the other project improvements, including consideration of other funding options.

Evaluation Criteria:
As stated above, the project appears to meet a few of the evaluation criteria for the WSRA program. Namely, agriculture in the Gunnison Basin is identified as an important activity for the basin and this project would help ensure that approximately 2500 acres of irrigated lands stay in production. The applicant did state that these rights have a 1914 adjudication date which makes them pre-Colorado River Compact rights, an important statewide consideration. The most significant criteria that is met is under the "Tier 2: Facilitating Water Activity Implementation." The NDIC is not able to undertake this project without grant funds due to their shareholders inability to take on more debt than the $800,000 being requested by the CWCB loan program. The applicant's response to how they meet the evaluation criteria is included on the last page of this summary sheet (Exhibit B).

Issues/Additional Needs: The Water Supply Planning and Finance staffs have worked closely on this project and believe that more refined cost estimates for this project are necessary prior to contracting for the CWCB loan or the WSRA grant. Currently, the application provides a cost estimate for the tunnel restoration work at $1,210,000. With a CWCB loan amount of $800,000, the grant amount necessary to make up the difference is $410,000 ($370,000 of Statewide Funds and $40,000 of Basin Funds) which provides for a loan/grant ratio of approximately 2:1. While this project is necessary and meets some of the evaluation criteria in the WSRA criteria and guidelines, staff feels that it is relatively narrow in the benefits it provides and that a loan/grant ratio of 2:1 is appropriate for this project. Upon receiving a revised cost estimate, if the project is at or below the $1,210,000 amount, staff recommends that the loan/grant ratio be maintained at a 2:1 ratio or higher. If the cost estimate exceeds $1,210,000, then staff recommends maintaining the loan amount at $800,000 and using up to $800,000 in WSRA funds to make up the difference. If the revised costs estimate exceeds $1.6 million, then the applicant will need to provide staff with documentation that they have the funds available through other sources to complete the project prior to contracting with the CWCB.

Reporting and Deliverables: All products, data and information developed as a result of this grant must be provided to the CWCB in hard copy and electronic format as part of the project documentation. This information will in turn be made widely available to Basin Roundtables and the general public and will help promote the development of a common technical platform.

In accordance with the revised WSRA Criteria and Guidelines, staff would like to highlight additional reporting and final deliverable requirements. The specific requirements are provided below.

Reporting: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of the executed contract. The progress report shall describe the completion or partial completion of the tasks identified in the scope of work including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Deliverable: At completion of the project, the applicant shall provide the CWCB a final report that summarizes the project and documents how the project was completed. This report may contain photographs, summaries of meetings and engineering reports/designs.

Engineering: All engineering work (as defined in the Engineers Practice Act (§12-25-102(10) C.R.S.)) performed under this grant shall be performed by or under the responsible charge of professional engineer licensed by the State of Colorado to practice Engineering.

EXHIBIT B
EVALUATION CRITERIA

TIER 1: Meeting Water Management Goals and Identified Water Needs.

c. Agricultural Water Shortages:
The proposed Tunnel Reconstruction Project will implement the Gunnison Basin Roundtable Assessment for the preservation of agricultural use for the 171 members of the North Delta Irrigation Company (NDIC) by allowing water to again flow through the tunnel that has failed. Without this project these members will have no reliable source of irrigation water for their crops which include beans, corn and alfalfa. This project will ensure that there is no agricultural water shortage in the area served by the North Delta Irrigation Company. The water right owned by NDIC is for 49.675 feet with a headgate in the Gunnison River and an adjudication date of June 23, 1914.

Rehabilitation and Maintenance of Existing Infrastructure:
The tunnel that has failed is 1450 feet long and was dug by hand and completed in 1901 through a layer of shale. Over the years this layer of shale has started to fail caused by the flow of water and exposure to air and the tunnel has far exceeded its useful life. At the end of July 2011 a portion of this tunnel, approximately 40 feet in length, collapsed and blocked all water flow through the tunnel, creating an emergency situation. The Board of Directors of NDIC explored alternate means of delivery of its water right including pumping water out of the Gunnison River, boring a new tunnel, lining the tunnel with steel tunnel liner, using concrete box tunnel construction and using HDPE pipe. Pumping and boring a new tunnel were eliminated as choices as the cost of pumping would be prohibitive and the cost of boring a new tunnel would be prohibitive in addition to the problem that NDIC does not have an easement for boring. The steel tunnel lining system is comparable in price to the HDPE but was eliminated from consideration due to its limited life. The box tunnel method was eliminated due to the concern of its stability. NDIC has determined that the method of slip lining the tunnel with HDPE pipe is the best method available under the circumstances. This tunnel reconstruction project is absolutely essential for the flow of water to the 171 members of NDIC downstream.

Efficiency:
The grade through the tunnel is virtually flat for the first half of the tunnel and then there is a slight downhill grade for the second half of the tunnel. Slip lining the tunnel with HDPE pipe will greatly increase the flow of water through the tunnel.

TIER 2: Facilitating Water Activity Implementation.

d. Funding from the GBRT and Statewide Account will reduce the uncertainty that the Tunnel Project will be implemented. Without this funding this project cannot proceed. Other funding is not available.
e. The applicant is planning on borrowing $800,000.00 from the Colorado Water Conservation Board as its matching funds.

TIER 3: The Water Activity addresses other issues of statewide value and maximize benefits.

f. As mentioned above in Tier 1 this project is necessary to sustain agriculture in the area served by the NDIC canal.

i. Sustaining agriculture provides a high level of benefit to Colorado in relationship to the funds requested.

The Gunnison Basin Roundtable
P. O. Box 544
Lake City, CO 81235

February 7, 2012

Mr. Todd Doherty
Intrastate Water Management and Development Section
COLORADO WATER CONSERVATION BOARD
1580 Logan Street, Suite 600
Denver, CO 80203

Re: Grant Request from the Water Supply Reserve Account
North Delta Irrigation Company
Tunnel Reconstruction Project

Dear Mr. Doherty:

This letter is presented to advise you that the grant application submitted by the North Delta Irrigation Company for $40,000 from Basin Account funds and $760,000 from Statewide Account funds from the Water Supply Reserve Account for the Tunnel Reconstruction Project on the North Delta Canal was reviewed by the Gunnison Basin Roundtable and its Project Screening Committee, recommended for approval by that committee, and approved by a unanimous vote of the Gunnison Basin Roundtable during our meeting on February 6, 2012. The approval of the grant of $40,000 from Basin Account funds is contingent upon all remaining funding for the project being first secured.

This water activity meets the provisions of Section 37-75-104(2), Colorado Revised Statutes. The requirements/language from the statute is provided in Part 3 of the Criteria and Guidelines.

This activity furthers the Gunnison Basin Roundtable's ongoing basin-wide water needs assessment process in that it addresses the need to rehabilitate and maintain existing and aging infrastructure within the basin.

Sincerely,

Michelle Pierce
Chair

Cc: Tom Alvey (e-mail)

Beavers Construction Co.
We Move Mountains

February 25, 2012

North Delta Irrigation Company
ATTN: Ken Nelson
858 1600th Rd.
Delta, CO 81416

RE: Ditch Improvements Project Proposal - Revised
Estimate #2012-12 (Firm Bid)

Dear Ken,

Beavers Construction Company has been in business serving Delta County and surrounding areas for 60 years. We currently have on staff many skilled heavy equipment operators, a large fleet of good condition heavy equipment and trucks, and the proper management to easily satisfy the requirements of your project.

Beavers Construction Company proposes to provide all material, equipment, and labor necessary to complete the ditch improvements portion of the project as described by the "Feasibility Study" dated 12/20/2011, provided by Westwater Engineering, and also as outlined in your "Bid Request" dated 2/21/2012, for a firm price of $1,140,000. If Beavers Construction Company is allowed to start this project on or before 4/15/2012, then the project shall be completed by 6/1/2012.

Thank you for considering Beavers Construction Company for your project. If you have any questions, please give me a call.

Best Regards,

Tim Malone
General Manager
Beavers Construction Company, Inc.

ATTACHMENTS: 1

CC: Lynn French

35305 Hwy. 133
Hotchkiss, CO 81419

(970) 872-2323, Office
(970) 872-2576, Fax
info@beaversconstructionco.com

Beavers Construction Co.
35305 Hwy. 133
Hotchkiss, CO 81419

Proposal and Acceptance

Date	Estimate #
2/25/2012	2012-12

E-mail
info@beaversconstructionco.com

Name / Address
North Delta Irrigation Co. ATTN: Ken Nelson 858 1600th Rd. Delta, CO 81416

Project
Ditch Improvements (Firm Bid)

Description	Qty	Rate	Total
7175' DITCH Beavers Construction Co. proposes to provide all material, equipment, and labor necessary to complete the ditch improvements portion of the project as described by "Feasibility Study" dated 12/20/2011, provided by Westwater Engineering, and also as outlined in the bid request dated 2/21/2012. This section of work starts at the east portal of the tunnel and proceeds approximately 7175 ft. east to existing bridge at 2100 Rd. (Please note that payment & performance bonding are not included.)	1	1,045,400.00	1,045,400.00
450' DITCH Beavers Construction Co. proposes to provide all material, equipment, and labor necessary to complete the ditch improvements portion of the project as described below: • Re-grade ditch flow line from west portal of tunnel to east end of siphon. • Install approx. 450' of 60" ADS low head irrigation pipe per the manufacturer's specs of compaction, and install a minimum of 12" of cover. • Install one manhole at west portal of tunnel. • Install transition pieces at both ends. • Install one 8" headgate to replace existing supply. PLEASE NOTE: This proposal supersedes previous Estimates #2012-10 and #2012-11.	1	94,600.00	94,600.00

All material is guaranteed to be as specified. All work to be completed in a workmanlike manner according to standard practices. Any alteration or deviation from above specifications involving extra costs will be executed only upon written orders, and upon strikes, accidents, or delays beyond our control. Owner to carry fire and other necessary insurance. Beavers Construction Co. is fully covered by Workmen's Compensation Insurance, General Liability Insurance, and Cargo Insurance. A FINANCE CHARGE of 2% PER MONTH (which is an ANNUAL PERCENTAGE RATE of 24%) will be added to all account balances that exceed 30 days. Should collection become necessary, customer will pay all collection and attorney fees.

We look forward to working with you!

Total $1,140,000.00

Phone #	Fax #
(970) 872-2323	(970) 872-2576

Authorized Signature

Date of Acceptance ____________________

Signature ____________________

2-25-12

RE: North Delta Irrigation Co. Ditch Improvements Project
Material, Labor, & Equipment Breakdown
Per Unit Pricing

	Material	Labor & Equip	Total	$/ft
7175’ Ditch	$717,300	$328,100	$1,045,400	$145.70
450’ Ditch	$63,400	$31,200	$94,600	$210.22
Total Project	$780,700	$359,300	$1,140,000	

35305 Hwy. 133
Hotchkiss, CO 81419

(970) 872-2323, Office
(970) 872-2576, Fax
info@beaversconstructionco.com

From: Kevin Wodlinger <kevinwodlinger@pettyconstruction.com>
To: FLF450 <FLF450@aol.com>
Cc: 'Loren Petty' <lorenpetty@pettyconstruction.com>; 'Tom petty' <tompetty@pettyconstruction.com>; 'Cindy Coop' <cindycoop@pettyconstruction.com>
Subject: Delta Tunnel Project
Date: Mon, Feb 20, 2012 4:39 pm

Dear Lynn,

Please accept this as our formal and complete bid to slip line the failed tunnel. $1,210,000.00 includes:

1. Placement of 1500 Feet of 54"DR17 HDPE, with 25 feet showing at each end of the 1450 foot tunnel
2. Bore and ream tunnel
3. Provide up to 10,500 feet of 2" poly needed to fully deliver grout deliver grout throughout tunnel
4. Grout entire length of tunnel
5. Place 12" PVC (french drain type) toe drain along bottom of tunnel
6. Properly seal ends of tunnel
7. Perform all work per Westwater Engineering Feasibility Study dated 12-20-2011

Timeline: Using March 26 as the "go ahead" date, we would mobilize and start bore by April 2. Estimated total time needed to bore, fuse, pull poly and grout is 30 days. It is our understanding that you will be able to provide and divert water necessary for the bore and completion.

Kevin Wodlinger
Gen Mgr Petty Construction Co.
Grand Junction, CO/Dickinson, ND
Cell 970-623-1717
GJ 970-241-3133/ DIX 701-225-6516

Pipeline and Facility Construction/ Poly-Fusion
Water Management/Directional Bore

kevinwodlinger@pettyconstruction.com
www.pettyconstruction.com

"Something can always be better." –Mark Zuckerberg

North Delta Irrigation Company-Tunnel Reconstruction Project

Scope of work:

Dewatering and Site Prep-

Clean out cave in area

1500' of 54" HDPE DR 17 pipe

Install Pipe

Bulkheads at both portals

Grouting of entire pipe.

From: Tom Petty <tompetty@pettyconstruction.com>
To: FLF450 <FLF450@aol.com>
Cc: kevinwodlinger <kevinwodlinger@pettyconstruction.com>
Subject: Estimate.
Date: Sat, Feb 11, 2012 10:33 am
Attachments: Tom_Petty.vcf (2K)

Lynn,

The following are some preliminary numbers for the 54" pipe insertion project on Cory Hill.

Labor, Equipment and mobilization ------- $210,000

HDPE pipe delivered to site--------$450,000

I have not been able to get an estimate on the grouting from our subcontractor but should have a number first of the week.

The method we propose is to utilize our 100k # directional bore machine to bore through the cave in. We will use a back reamer to wash and drag out the spoils from the tunnel on the Hwy 65 side of the tunnel.
We will use water from the open irrigation ditch to help carry the spoils out of the tunnel. We anticipate this process will take several passes in order to get enough spoils out for the pipe to be inserted.
The HDPE will be carried down the existing service road and fused together in the open ditch and pulled into the tunnel using our directional drill to pull and possibly an excavator to assist pushing the pipe.

When we get the grouting numbers in, we will forward them to you.

Thanks
Tom Petty

Tom Petty
Petty Construction Company, LLC
Managing Member
(970) 241-3133 Work
(970) 250-4005 Mobile
tompetty@pettyconstruction.com
714 Arrowest Court
Grand Junction, CO 81505
www.pettyconstruction.com

WestWater Engineering

2516 FORESIGHT CIRCLE, #1 GRAND JUNCTION, COLORADO 81505 (970) 241-7076 FAX (970) 241-7097

December 20, 2011

Ken Nelson, President
North Delta Irrigation Company
1221 Highway 50
Delta, Colorado 81416

RE: Feasibility Study of Upper Portion of Canal System
Consisting of Inverted Siphon, Unlined Tunnel and Open Ditch Canal

Dear Ken,

This letter represents a feasibility study and capital improvement plan of the NDIC's canal system along a segment taken out of service during the 2011 irrigation season. The basis for our evaluation includes preliminary field data collected September 19 and 28 by WestWater Engineering (WWE), geotechnical engineering input from Dennis Lambert, P.E. of Lambert & Associates (attached letter dated November 22, 2011), construction expertise from Tim Malone of Beavers Construction Company, and detailed field survey data provided by Mountain Valley Survey (MVS) of Paonia (attached e-mail transmission December 14, 2011). We have also addressed review comments on draft interim reports dated November 30 and December 5, 2011 from the Board.

Preliminary design criteria is also provided for suggested improvements to reinstate full utilization of the canal system for long-term serviceability in future irrigation seasons. It is intended that the NDIC can utilize information contained herein for financial planning, and to coordinate applicable permits for construction with regulatory agencies in advance of the construction schedule.

Summary of Irrigation System Failure

A 1-mile stretch of the NDIC canal system was taken out of service during the 2011 irrigation season due to rock and soil debris from a collapse within an irrigation tunnel. The tunnel is located directly east of Highway 65, beneath a residential development along 1950 Lane between the Gunnison River and Cory in Delta County, Colorado.

The attached 24" x 36" Plan sheet, labeled Figure 1, generally shows the subject segment of the canal system on an aerial photo based map. The inverted siphon, open ditch canal and tunnel are shown with different line types to distinguish unique methods of flow conveyance. Approximate cross sections of the tunnel and the open ditch are also presented to further describe existing configurations. The lower portion of the Plan sheet includes a profile of the existing flowline, hydraulic gradient, and ground surface. The profile and cross sections utilize standard engineering scales that are exaggerated, where elevation (vertical) dimensions are 10 times greater than the horizontal dimensions, i.e., vertical scale is 1"=40', horizontal scale is 1"=400'. The canal system profile flowline presented in black represents preliminary field measurements collected by WWE's engineering technicians for preliminary report basis in September 2011. Canal flowline presented in red represents subsequent field data collected by MVS during December 2011 for final hydraulic assessment and design confirmation. The MVS data may be more representative of actual conditions, since the measure-down at the tunnel vertical shaft was taken with personnel inside the tunnel (as compared to preliminary measurement using a weighted survey tape), and since the field crew included a professional land surveyor (PLS). The basis of vertical datum control is apparently different between WWE and MVS surveys, however, the difference in relative elevations is not great enough to substantially impact the hydraulic assessment herein.

The irrigation tunnel shut-down affected several other NDIC irrigation facilities including an inverted siphon to the west that crosses Tongue Creek and Highway 65, and reaches of open ditch each side of the tunnel. To provide irrigation water service in the canal system west of Highway 65, the NDIC purchased and diverted water from Tongue Creek. With one (1) exception, the alternative Tongue Creek diversion provided a nominal level of service to the approximate 171 headgates downstream from the tunnel. Normal flow of irrigation water from Marshall Road located upstream from the tunnel's east entrance portal to the main intake off the Gunnison River above Austin remained in service, and was diverted back to the Gunnison River at an existing overflow upstream from the Marshall Road canal bridge. This maintained normal service to all headgates upstream from the tunnel. Diverting Gunnison River at the intake also fully utilized decreed water rights for the 2011 irrigation season.

Upcoming emergency repairs of the tunnel has raised other issues related to a) annual maintenance, b) the remaining useful service life of the subject stretch of the irrigation system, c) potential impacts of open channel flow on water quality, and d) efficiency of open channel flow. The canal system was constructed during the early 1900's using construction materials and technology available at that time. The composite system has since required seasonal maintenance and repairs at increasing frequency and urgency, but has been subject to very few major upgrades to improve management and maintenance.

Evaluation Methodology

Hydraulic analysis begins at the downstream limit of an approximate 2-mile stretch of the canal system and proceeds upgradient. Although this is opposite of the direction of flow, it is consistent with system hydraulics that are downstream controlled; i.e., existing flow conditions and any modifications or improvements made downstream will impact the flow regime upstream. This sequence of discussion is not intended to imply an order of priority for needed improvements, nor a sequence for construction while the system is not in service between agricultural seasons.

The subject segment of the canal system flows in a westerly direction north of the Gunnison River. The downstream limit is approximately ⅓ mile west of Highway 65, and the upstream limit is about 1¾ miles east of the highway. Since only three (3) headgates are serviced along this section of the canal system, and because there are only a few water users between this segment and the intake above Austin, flow conveyance through this segment closely matches decreed water rights of almost 50 cfs.

Evaluation of the canal system is based on providing long-term management, reliable operation and routine maintenance needed for efficient, uninterrupted, and the reliable conveyance and delivery of irrigation water to agricultural and residential users.

Condition of Existing System

General Operating Parameters. The NDIC provides irrigation water to approximately 183 headgates during the growing season from April through October. Peak irrigation usage generally occurs in August and September. Irrigation flow is diverted from the Gunnison River above Austin, and is conveyed through open ditches, several tunnels and buried conduit(s).

According to the local Water Commissioner, Steve Tuck, the 2011 alternative diversion from Tongue Creek was able to provide approximately 25 to 30 cfs during the height of the irrigation season. Although the full 50 cfs was not available to divert into the canal system for the use by a majority of headgates, loss of crops was not an issue. Mr. Tuck also noted that 2011 was an atypically high water year; with flow in Tongue Creek well above its more typical 2 to 3 cfs in August and September.

Inverted Siphon. The inverted siphon was constructed as a part of the original irrigation system during the early 1900's. It is buried 48" diameter pipe at each end, and is approximately 1,700 feet in length between concrete inlet and outlet structures. The majority of its length is reportedly constructed of aged timber and concrete, and is aligned across private property in the shortest distance between inlet and outlet locations. Details of construction beneath Highway 65 are unknown. The inverted siphon is subject to at least 22 psi pressure at the lowest elevation beneath Tongue Creek. It is estimated that the 50 cfs decreed water right flows at a velocity of about 4 fps, which is adequate to maintain solid material (i.e., sediment or mud) in suspension. A headgate is installed at Tongue Creek for seasonal draining.

The outlet structure is 18.5-feet deep at the pipe connection, and includes two (2) raised steps prior to discharging to the open ditch. The inlet structure has a concrete flowline and wing wall approaches adjacent to the canal, and a drop structure at the pipe connection that is 8.25-feet below timber planks across the top. Inlet and outlet pipes are submerged when water flows. Elevation differential between the upstream and downstream canal flowlines is 2.2-feet. The depth of flow in the upstream canal provides the hydraulic pressure gradient necessary to overcome headlosses through the inverted siphon.

The NDIC has experienced a few ruptures of the inverted siphon across agricultural field(s) west of Highway 65. These failures are reportedly easy to locate because of water rising from the ground surface at the failed section. The method of repair has generally been concrete patches at isolated failures. There has fortunately, been no reported failure within Highway right-of-way, which could impact the safety of the traveling public and require emergency repairs.

Because of the age and condition of its construction materials, it is uncertain how long the inverted siphon can continue to provide service with nominal repairs and maintenance. Since the siphon is a key component in conveying irrigation water to the majority of NDIC users, serious consideration should be given to replacing the siphon before a major failure occurs that could shut down this segment of the canal system without advance warning.

Tunnel. Hand dug as a part of the original canal system through shale, the tunnel is about 1,430 to 1,450 foot long and is approximately 95-foot from ground surface to the tunnel floor at the only known point. The tunnel is shored with timber lintels and beams, and is at least 5'-5" high and 6'-1" wide at the most limited points. It is 12- to 14-foot at its widest span. A small diameter vertical shaft with casing pipe(s), located approximately mid-length, can be accessed at the ground surface from inside a shallow manhole. The vertical shaft was drilled in 1991 in conjunction with a shot-crete tunnel repair project, to provide a conduit for delivering cementitious material into the tunnel. The vertical shaft has also reportedly been used to deploy electrical power cords during maintenance and inspection activities, and may provide some ventilation to workers. This shaft also provided access for recent field surveys.

The west outlet portal is located approximately 500-feet east of Highway 65 along a dead-end maintenance road, about 450-feet from the Gunnison River channel. The west portal tunnel opening is secured with timber framing and cross members intended to prevent human access, that is clearly marked with warning signs stating "Keep Out" and "Posted - No Trespassing". Although posting and security efforts have been made, there may be some liability issues during the interim of tunnel repairs.

The east inlet portal is not as apparent and accessible to the public, however vehicle access can be made off Marshall Road, across a narrow bridge constructed of concrete and steel that spans the open ditch canal upstream from tunnel entrance portal. The east portal includes a single concrete wingwall along the exposed side of the canal above the Gunnison River. The east portal tunnel entrance is not timber framed or posted to preclude unauthorized access.

When not in service, the tunnel has a light, steady flow of water discharging out of each portal, and some ground water seepage along the soil side slopes and roof span. An excavated channel in the ditch embankment at the west portal drains seep flows across the access road. Seep water is drained from the east portal through a 12-inch CMP penetration through the concrete wingwall. Ground water reportedly seeps relatively unconfined in and out of tunnel walls, roof and/or floor, however, water reportedly ponds in short segments, that indicates either low point(s) or less pervious soil material(s) along the length of the tunnel.

According to the MVS survey, the tunnel floor (flowline) may be slightly higher in elevation than the inlet. Since there are only the three points of access along the tunnel, the consistency of slope is unknown along the entire length of the tunnel.

The debris pile at the tunnel's failure has been inspected and is described by the ditch rider and other NDIC representatives, as ceiling or roof failure. Descriptions of cobble rock debris and tunnel structure do not indicate horizontal movement, but rather, failure of the tunnel roof span. There is no obvious evidence of subsidence at the ground surface above the tunnel in the vicinity of the horizontal movement. This is of particular importance, because a residential development exists directly above the tunnel.

The tunnel should not be placed in service until debris is removed, and the tunnel is reinforced to prevent a recurrence of the 2011 irrigation season shut-down. The NDIC has indicated that alternatives for tunnel repair do not need to provide for future physical access into the tunnel for routine inspections or maintenance, however, inspection manholes should be considered.

Open Ditches. The majority component of the subject canal system consists of open ditches, hand excavated into native soils. A combined 7,640 lineal foot length of dirt lined ditch is encompassed within the study reach. This includes a short 460-foot length of ditch between the inlet of the inverted siphon and the outlet portal of the tunnel with one (1) headgate. The remaining length of ditch is approximately 7,180 lineal feet, and located between the tunnel and 2100 Road. It includes two bridges and one culvert for cross vehicular access, an overflow structure, and two (2) headgates. Observations along the segments of ditch that were shut down during the 2011 irrigation season indicate that the flowline slope is inconsistent with low points and/or reverse slope. This is not uncommon for early 1900's construction, since the overall slope is very nominal at 0.04% (4¾-inch in 1,000 feet).

With few exceptions, the ditch is excavated into an existing hillside with side slopes along the canal north bank, and overburden placed on the southern, down-slope ditch bank that provides a narrow bench for limited maintenance and vehicular access. An approximate 1-mile stretch of the ditch upstream from the tunnel is along a very steep embankment that rises upwards of 100-feet between the river bottom and the plateau above. This segment of ditch was constructed about 20- to 30-feet above the toe of the lower bench of the river bottom. There are several isolated areas of roadway erosion of this segment of the canal that should be repaired. Near the east tunnel portal, narrow cracks at the road surface are a potential precursor of a weakness that could fail in the future. Although the NDIC has not experienced ditch overflow leading to a catastrophic breach and substantial erosion along the steep embankment, such an event could cause future seasonal shut down of the canal system, and related emergency reconstruction.

The segment of the canal upstream from the tunnel to the bridge at 2100 Road supports a prolific growth of filamentous algae or moss. Other segments of the ditch system appear to be unaffected. Aquatic vegetation requires several chemical treatments and/or harvesting each season. The chemical herbicide currently used, Hydrothol 191, is reportedly not regulated or considered toxic to aquatic life at low doses, therefore, tailwater can be discharged to the Gunnison River. The herbicide label indicates that the product is highly corrosive, and may not be fully compatible with crop irrigation immediately following application, depending on the dosage. This seasonal maintenance is also relatively costly. If aquatic weed control is not conducted or is postponed, overgrown vegetation effectively reduces the ditch flow capacity, causing water levels to rise to the extent of breaching the canal bank and eroding the access road used for maintenance.

The Marshall Road bridge may also have limited remaining service life. Structural steel members, beams and columns show signs of rust, and are visible through spalling edges of the concrete deck. In addition, the bridge is just wide enough for safe passage of a maintenance vehicle provided the driver is paying close attention. The culvert at Longs Road and bridge crossing at 2100 Road have no known structural or flow conveyance capacity issues, and are wide enough for vehicular traffic.

The NDIC is also concerned that ditch flow may contribute to increased salinity and/or selenium loadings on the Gunnison River. These are naturally occurring elements in soil, that are readily dissolved and transported by water. Earthen lined ditches that convey water, and surface flow across adjacent land (irrigation tailwater, snow melt and runoff from rainstorms) are primary potential sources. Increased salinity loading is not regulated in irrigation systems, yet it is a primary reason for major capital improvement projects along irrigation ditches in areas of shale formations. However, there is a threshold limit assigned to domestic wastewater systems to the extent that total dissolved solids (TDS, also referred to as salinity) of treated effluent that is discharged to rivers and streams is no greater than the TDS of the raw water supply of the public drinking water system plus 500 mg/l. Open ditches of the entire canal system are very likely to increase TDS and/or selenium, especially through the area beyond the study limits to the west to the Trap Club. Soils along an approximate 3-mile reach of ditch between the Trap Club and the inverted siphon outlet primarily consist of Persayo silty clay loam. According to web soil survey of the Natural Resources Conservation Services (NRCS), this soil type can have salinity levels upward of 8 Mmhos/cm.

Finally, natural water loss through evaporation and seepage were reviewed to provide estimated theoretical losses in the open ditch system. Accordingly, it is estimated that peak seasonal evaporation of ¼" per day (NOAA Climatography Data) may represent water loss of about 1 cfs per mile of open ditch. Furthermore, NRCS general assessment of Persayo soil series permeability ranges from 0.2 to 0.6 inches per hour (4.8 to 12 inches per day), which would equate to a theoretical seepage loss substantially greater than what has been observed. In the event design criteria for needed capacity of canal system improvements would need to account for historic (actual) water loss through the open ditch system, site specific permeability data should be developed. Lambert and Associates could collect samples for laboratory analysis of parameters such as permeability, porosity and void ratio in this event.

Development and Assessment of Alternative Improvements

No Action. This alternative is commonly referred to as the "do nothing" alternative and simply means that no actions are taken. Under existing conditions of the tunnel, combined with the system's age, deterioration, and maintenance required for vegetation control, the no action alternative is contrary to the NDIC's dedication to responsible management of the irrigation system. For reasons stated below, the no action alternative is not considered viable.

No action requires future operation of two independent conveyance systems similar to the 2011 irrigation season. The western portion of the canal system downstream from the inverted siphon would need to be supplied through negotiated purchase of water shares if/when water is available each irrigation season. This not only adds to normal annual budget expenses, but also does not guarantee water will be available to the majority of headgates on the system.

No action also creates safety and liability concerns with respect to taking the inverted siphon and tunnel out of service. If these were abandoned in-place, an effort to close off all openings should be considered, to prevent unauthorized and unsafe entry into pipes, structures and the tunnel portals. The inverted siphon and tunnel may also need to be filled to eliminate the existing below ground voids to further prevent potential future collapse or catastrophic failure.

Recommended Capital Improvement Plan. The second attached 24" x 36" Plan sheet, Figure 2, generally shows the recommended minimum capital improvement plan for the study reach of the canal system. Improvements are needed to provide long-term irrigation service for the inverted siphon, tunnel and open ditch components of the system are further discussed below. Improvements identified describe minimum requirements. The NDIC could increase dimensions, upgrade structure strength, or extend the limits of improvements, at their discretion.

Inverted Siphon Replacement. Two alternative alignments were developed for replacing the inverted siphon. The first follows the existing alignment, in order to maintain existing hydraulics, and to utilize existing easements and structures. The existing pipe/conduit would be removed in conjunction with installing the new pipe, and could better facilitate permit approvals that would be categorized as maintenance and repairs of existing facilities. The second alternative alignment represents a new pipe from the tunnel's outlet portal in a straight alignment beneath Highway 65, along an existing improved driveway and fence lines to a new outlet structure about 900 feet downstream from the existing outlet. Although the second alignment is about 100 feet longer than the existing, it would eliminate about 500 feet of open ditch. However, the second alignment does not gain sufficient elevation differential to allow for a smaller pipe diameter. It also would require removing or filling the abandoned siphon to reclaim the former easement, and obtaining a new easement. Relocation of one headgate and service pipe would also be required. It may also be more difficult to obtain permits needed for construction. Preliminary assessment of alternative alignments indicates that implementation costs, and administrative and permitting issues would likely make the existing alignment most feasible.

New pipe for the inverted siphon will need a pressure rating greater than 22 psi at the Tongue Creek crossing. Large diameter PVC pipe would be suitable, but is limited to 48-inch diameter and is typically more costly than other pipe materials. High density polyethylene (HDPE) pipe is available in increments of 48", 54", 63" and 65", based on outside dimensions (O.D.). Inside dimensions are reduced by pipe wall thickness. HDPE pipe strength is specified as a dimension ratio (DR) that is the outside diameter divided by wall thickness, i.e., lower DR ratios indicate thicker wall and stronger pipe. Large diameter HDPE is available in DR17 (125 psi) through DR32.5 (65 psi). DR32.5 would be a suitable pipe selection for the inverted siphon, with a safety factor of 3.0.

A minimum 54-inch diameter pipe is needed based on existing hydraulics and 50 cfs capacity. 54-inch DR32.5 HDPE butt fused pipe has a 1.662" wall thickness for an equivalent inside diameter (I.D.) of 50.676", and weighs 120 pounds per lineal foot. At 50 cfs, velocity would be 3.7 feet per second which is sufficient to prevent settling out suspended matter such as silt or mud that would otherwise be a concern following a rainfall event. The next larger pipe diameter (63" O.D., 59.124" I.D.) would also be acceptable, with a velocity of 2.6 fps. The larger pipe requires slightly less surcharge at the inlet structure, that may be a benefit in conjunction with tunnel improvements. The next smaller pipe diameter (48" O.D., 45" I.D.) is not compatible with existing system hydraulics, since it would require additional depth of water at the inlet of the siphon, which could overflow the canal bank at the siphon inlet, and also has adverse impacts on tunnel hydraulics.

Existing concrete inlet and outlet structures appear to be in good condition, and could remain in place with special details for watertight connections with the new pipe. The new pipe will need to be fitted with a pressure rated operable drain at Tongue Creek, similar to the existing siphon drain assembly. Other details for construction include suitable backfill material within 12" of the pipe to provide a stable pipe foundation, to provide lateral support since HDPE is a flexible conduit, and to prevent point loadings of oversized rock. The Tongue Creek crossing may also require ballast anchor(s) pending verification of subsurface soil conditions and/or seasonal groundwater elevations to prevent floatation when the pipe is drained.

Design and construction of a new siphon pipe will require coordination with the Colorado Department of Transportation (CDOT). CDOT design criteria typically includes bored and encased construction methods, a minimum 5-foot depth of bury within 15-feet of the asphalt road surface for sign post clearance. A steel casing pipe is typically required the full width of CDOT right-of-way, large enough to install the carrier pipe with pipe skids inside, and with sufficient structural strength to push or jack through conventional boring. Open cuts across the asphalt normally are not approved except in special cases where roadway maintenance such as an overlay, patch, or chip seal is planned during that construction season. Open cuts may also be considered in locations where rock or other natural features are identified that may make boring unfeasible based on geotechnical subsurface investigations.

Design and construction in the vicinity of Tongue Creek may also require wetland delineation to determine whether the US Army Corps of Engineers (COE) has jurisdiction over the work. If jurisdictional wetland areas exist, construction activities to replace the siphon pipe must be authorized under Section 12 of the Nationwide Permit for utilities. This process typically involves submittal of a formal Wetland Delineation Report and Preconstruction Notification to the COE. The COE may also request consultation from the Colorado Division of Fish and Wildlife with respect to potential environmental impacts of the proposed construction activity.

Tunnel Repair and Liner Upgrade. The NDIC conducted preliminary investigations for tunnel rehabilitation as compared to constructing an entirely new tunnel offset from the existing alignment prior to this feasibility study. At that preliminary level of analysis, alternative construction methods for offsetting a new tunnel included conventional excavation (100-feet deep) and new tunnel construction (road header, tunnel boring machine, micro tunneling or drill/blast). Tunnel rehabilitation alternatives included slip-lined pipe, precast concrete box culvert and structural tunnel liner plate, each with grout backpacking. The preliminary analysis did not include engineering assistance, but did represent a comprehensive range of construction methods. Based on input from local Contractors related to construction costs, and input from affected property owners above the tunnel alignment, horizontal tunneling along a new alignment was determined unfeasible not only because of significantly higher construction and administrative costs, but also due to major complications with obtaining new easement(s) for the tunnel realignment.

Alternatives for removing the spalled debris and for tunnel rehabilitation need to consider methods of construction that protect the health and safety of personnel. Based on the apparent instability, physical entry into the tunnel must either be avoided, or conducted with structural tunnel reinforcement. A viable preliminary alternative method to reach the debris included installation of fabricated corrugated metal liner plate beginning at the west portal and proceeding toward the debris in approximate 18" segments. The void between tunnel and structural plate is backpacked with grout as the plate is installed and allowed to cure. A bulkhead at the open end of pipe would be needed to prevent grout from spilling into the working area. This liner system is considered safe and stable to work within, so long as grout installation proceeds immediately behind steel plate installation, for tunnel depths up to 80-feet. Installation at additional depth requires geotechnical engineering with respect to mechanics of the overlying soils, discussed below. Based on inspection of the debris and roof span failure by NDIC maintenance personnel, it may be possible to remove fallen material with a dragline attached to a plow/bucket mechanism without personnel access to the debris site.

Structural strength requirements of tunnel liner, and/or slip-line pipe, relate to the soil mechanics of the tunnel overburden and probable soil pressure/pipe loading. The critical issues are whether the tunnel is excavated through solid, formational material or less stable geomorphology. Since a spall did occur, it is understood that at least a portion of the tunnel is not in solid rock and is less stable. It is this non-formational material that is the basis for liner design criteria. Overburden is then either categorized as "passive", "at rest", or "active". Passive earth pressure generally describes a worst case scenario of greatest loading on a tunnel liner/pipe, where the overlying soil has no long-term structural integrity, and the full weight of overburden is the basis for the conduit strength requirements. In this event, the soil column above the tunnel would impose the maximum vertical prism load on the tunnel insert. Active earth pressure generally describes a best case scenario of the lowest loading, where the overlying soil has bridging or arching characteristics that minimize earth forces on the tunnel conduit. Depending on soil reactions, active earth pressure may be about 50% of passive earth pressure. At rest earth pressure generally describes conditions between the two extremes.

Project geotechnical engineers visually inspected the ground surface around the tunnel portals, and the exposed hillsides, to ascertain whether overlying soils may be categorized as passive, at rest, or active. According to the geotechnical engineers' assessment of the visual and anecdotal evidence, portions of the tunnel may be stable, but the history of rockfall strongly indicates that the tunnel structure is weathered, and less stable material. Consequently, the theoretical maximum vertical load of passive soil mechanics is the recommended design criteria for the entire length of tunnel.

At the maximum known depth, theoretical vertical load on the liner/pipe will be upwards of 11,000 pounds per square foot 75 psi). Filling the annulus between the tunnel and new liner with grout or other stable and impervious material will not only spread the surcharge load over a larger area, it would also prevent further spalls and/or subsidence which effectively enhances soil arching characteristics.

Active ground water seepage is also a concern with respect to soil strength. Saturated soil material is substantially less stable than dry/moist soil. Recommendations for providing a positive means for collecting, conveying and removing ground water seepage are noted in the geotechnical assessment. Since ground water can theoretically migrate along the interface of native tunnel excavation and grout fill, a clean sand or pea gravel along the tunnel floor would provide the needed conveyance and could be configured as a horizontal layer of subbase for liner/conduit, or wrapped in filter fabric ("burrito" style) and laid end-to-end along the bottom edge of liner/conduit.

Alternative materials of tunnel liner conduit include concrete and steel which are highly vulnerable to corrosion, and HDPE which is considerably more resistant to chemical degradation. Although this feasibility study did not include sampling and laboratory testing of native soil and groundwater, there is a relatively high possibility some level of corrosive conditions exist. In the event concrete or steel pipe structures are preferred alternatives, laboratory analysis should be conducted to verify whether special coatings or thicker structural sections will be necessary to extend the useful service life of final improvements.

Tunnel hydraulics are first based on maintaining an equivalent surcharge at the inverted siphon inlet, to maximize the available energy gradient. The tunnel conduit may also flow under low pressure as compared to gravity flow, depending on whether inconsistent slope exists in areas not currently accessible for survey. Tunnel hydraulics are also based on aged pipe rather than new pipe conditions, since repeated seasonal cycles of fill and drain of irrigation water tends to roughen the pipe surface and deposit sediment. Both of these factors degrade pipe capacity over time. Additionally, the tunnel (conduit) is not entirely straight line or grade, which also reduce hydraulic capacity. Based on the nominal slope available, and roughness factors for aged material, a minimum 58" inside diameter, smooth wall conduit or equivalent, will be needed through the tunnel. The equivalent corrugated plate is 64".

Alternatives for needed hydraulic capacity and structural strength using tunnel liner plate, include circular, arch, and horseshoe (bottomless) shapes. A round tunnel liner has the greatest structural integrity for both vertical and horizontal soil loading, and conforms best with the existing tunnel dimensions. Since the depth of overburden exceeds standard design tables, and because soil mechanics are based on passive earth pressures, a round tunnel liner appears to be the only viable option. Round tunnel liner is available in standard 2" increments of diameter to the neutral axis. In this event, a 64" diameter tunnel liner is recommended. Corrugated plates are also manufactured in 2-flange and 4-flange configurations. Joints of 2-flange connections are lapped, with deep, full length corrugations to provide maximum stiffness and ring compression. Butt (hinged) joints of 4-flange connections have less strength and are not suitable for this application. Corrugated liner plate is available in thicknesses from 14 gauge (0.0747") to 3 gauge (0.2391"), and uncoated black steel, galvanized steel and asphalt coated. A minimum 5 gauge is needed for structural reasons, and asphalt coating is highly recommended for corrosion protection to extend the useful service life. Coated 3 gauge corrugated plate would theoretically increase the service life. However, regardless of how well protected the metal plate material is, manufacturers do not claim service life greater than 50 years.

A second alternative for slip-lining the tunnel utilizes HDPE pipe. HDPE has a higher resistance to corrosion than coated steel in most cases, pending soil and water pH and resistivity. A minimum 63" O.D. DR17 HDPE provides needed flow conveyance capacity to match existing hydraulics. Installation of HDPE pipe would require staging pipe at one end of the tunnel, and heat fusing joints. As pipe is assembled at the staging end, it is pulled/pushed through the tunnel. Assembled pipe could theoretically clear tunnel timbers at the most restrictive locations (within 1" to 2"), but may be very difficult to position at the center of restrictions without some physical entry and labor. Needed pipe strength is based on the most demanding of either stresses during installation, or ultimate potential soil bearing pressure. During installation, the estimated maximum pulling force will be 944,400 pounds (472 ton). Properly fused pipe has sufficient strength to be pulled a greater distance than the tunnel length. Pulling fused pipe through the tunnel will likely require some form of bottom roller system. The void between tunnel shell and DR17 HDPE pipe will need to be filled with a material having at least 500 psi compressive strength for needed long-term resistence to potential soil pressure. Suitable fill material includes flowable grout or fly ash slurry, installed either by pumping through a horizontal hose, or vertical through the existing and/or supplemental vertical shafts. Bulkheads with air vents would need to be constructed at each end of the tunnel as a stop for flowable backfill material. Estimated volume of the void area is approximately 2,300 cubic yards (470,000 gallons). HDPE pipe is generally more resistant to corrosion and many chemical compounds than coated metal, yet manufacturers do not have sufficient historical data to claim service life greater than 50-years.

The NDIC requested hydraulic evaluation based on new pipe characteristics as a comparison to aged pipe to ascertain whether the next smaller HDPE pipe size would have sufficient capacity upon installation. Hydraulic analysis of new 54" O.D. DR 17 HDPE, installed with nominal horizontal or vertical offsets under the same available slope and pressure head, indicated that new pipe would have sufficient capacity to convey 50 cfs. The smaller diameter pipe may be considered viable with extreme caution, since its performance over time is expected to degrade to the extent flow capacity diminishes well below the needed capacity for downstream users. If the timely availability, capital cost, or other factor(s) for the recommended 63" HDPE pipe size render the smaller 54" HDPE more desirable, the NDIC will need to monitor the canal system downstream from the tunnel to ensure adequate flow capacity is maintained. This may require additional routine maintenance and cleaning. It may also elevate the need to confirm evaporation and seepage loss downstream from the tunnel and inverted siphon in the event loss of tunnel flow capacity could be offset in the future by reducing natural losses by piping open ditches downgradient.

Because the tunnel has at least one high point along its length that may become completely submerged when irrigation water is conveyed, an air vent may be needed for all alternative liner/conduit alternatives. Although the NDIC has no known historic problems with entrapped air, either upon filling the irrigation system, or under normal flow through the exposed soil matrix, a new closed conduit may develop complications. This is especially critical if the new conduit size is selected based on ideal characteristics of new pipe rather than aged pipe. Air vent(s) should be considered as a contingency if necessary, in the event the flow capacity is diminished, or if the hydraulic grade line at tunnel inlet causes surcharging or overflow upstream from the tunnel after the tunnel liner conduit is completed.

Other considerations for tunnel rehabilitation construction include adequate fresh air ventilation for workers inside the tunnel, and additional shoring along the tunnel length as necessary. For long-term management, access manholes such as a vertical tee fitting with vented cover, should be installed outside each the tunnel bulkhead for unforeseen future need to access the tunnel liner conduit.

Canal Ditch. Alternatives for lining dirt ditches for the primary purpose of preventing vegetative growth and preventing overflow and erosion are limited to closed pipe. Concrete, shot-crete, gunite, or other impervious material may be effective in controlling salinity, but may not effectively eliminate growth of aquatic plants, and do not protect against bank overflows.

ADS low-head irrigation pipe has been suggested as a cost effective alternative to the open ditch system. It is available in 42", 48" and 60" diameter. It is a dual walled pipe with corrugated outer shell for structural strength and smooth interior wall for improved flow characteristics. ADS pipe is intended for gravity flow applications having less than 10.5 psi internal pressure, and requires nominal backfill where it is not subject to vehicular traffic loadings. At roadway crossings, traffic rated box culvert structures could be used, or the pipe would need to be backfilled in a concrete encasement for structural support to prevent collapse.

The existing hydraulic grade line from the tunnel outlet to the inverted siphon, and from tunnel inlet to 2100 Road is very limited at 0.05% with siphon and tunnel inlets surcharged to historic limits, and open channel canal gravity flow to 2100 Road. The largest ADS pipe available (60") could convey the full 50 cfs, but will flow about 60% to 90% full depending on the pipe roughness factor after years of service.

The NDIC may also want to determine whether there is a substantial increase in TDS or selenium between the Trap Club and inverted siphon to warrant installing a pipe in the ditch system as a part of a long-range capital improvement plan. This would be in addition to collecting additional information to characterize evaporative and seepage losses as necessary, if the tunnel rehabilitation conduit uses the smaller alternative 54" O.D. HDPE as future flow capacity degrades.

Summary of Recommended Improvements:

In summary, the recommended capital improvements plan generally consists of three components of the canal system: 1) replace the inverted siphon in its existing alignment and salvage existing inlet and outlet structures, 2) clear debris from the tunnel and reinforce the tunnel with HDPE pipe with toe drain and grout backfill, and 3) upgrade open ditch canal with closed pipe. Design criteria and general construction details are listed below for each component of the improvement plan.

Design Criteria:

- 50 cfs flow capacity
- 100-year service life
- Inverted siphon 22 psi internal pressure
- Tunnel liner conduit vertical loading 75 psi
- Provide drainage from tunnel, separate from irrigation conveyance
- Fill tunnel void outside liner conduit
- Provide contingency to install air vent(s) in tunnel liner conduit at high and low point(s)
- Install access manholes outside the tunnel as a future contingency
- Provide continuous, nominal slope for piped ditch with no sags or humps
- Provide traffic rated road crossings for piped ditch
- Provide cross surface drainage at piped canal and maintenance road
- Provide overflow along piped ditch upstream from tunnel
- Provide a method for diverting flow (to overflow) prior to tunnel
- Maintain construction areas safe for personnel

Improvements to Inverted Siphon:

- Remove and replace existing conduit with 54-inch DR32.5 HDPE
- Connect new pipe to existing concrete inlet and outlet structures
- Install a drain assembly at Tongue Creek
- Verify whether jurisdictional wetlands exist along Tongue Creek
- Coordinate Highway 65 crossing with CDOT permit requirements

Improvements to Tunnel:

- For maximum service life with adequate future capacity, slipline with 63" HDPE DR17

or

- If higher level of future maintenance, monitoring and canal system management is acceptable including possible future improvements to reduce natural losses downgradient, slipline with 54" DHPE DR17

- Install filter drainage toe drain along tunnel floor adjacent to liner plate
- Remove spalled debris, dragline, or as encountered by progress of liner plate installation
- Install air vent(s) at high or low point(s) in tunnel as necessary in the future
- Install bulkheads at each portal, with 12" connection for toe drain
- Extend 12" drain pipe from toe drain at each tunnel portal bulkhead to daylight discharge

Improvements to Open Ditches:

- Regrade ditch flowline to provide continuous slope
- Install 60-inch ADS pipe with nominal backfill to bury new pipe
- Consider 54" HDPE DR32.5 as acceptable alternative between inverted siphon and tunnel for contiguous construction materials
- Concrete encase pipe at driveway/road crossings
- Provide new headgate connections to replace existing services
- Reconstruct maintenance road
- Provide for cross drainage from major upgradient point sources
- Reconstruct overflow structure near Marshall Road

Future Open Ditch Improvements:

In the event installation of 60-inch ADS pipe in open ditches of the capital improvement plan effectively reduce salinity or selenium levels, and/or if smaller diameter tunnel liner conduit is selected and noticeable capacity degradation is observed over time, consider future extension of the piped ditch improvements in the approximate 3-mile reach between the Trap Club and the inverted siphon outlet

We believe this information can be used as the basis for financial planning purposes. Feel free to contact our office if additional detail is needed, or if you have any questions or comments on the alternative development and assessment. We would be happy to provide cost estimates of any component of the capital improvements plan to supplement costs previously received, or to develop a set of design-build Plans and Specifications for implementing the capital improvements plan.

Respectfully,

C. Kellie Knowles

C. Kellie Knowles, P.E.

Attachments

cc: Dennis Lambert, P.E., Lambert & Associates
Tim Malone, Beavers Construction