RJH CONSULTANTS, INC.

GEOTECHNICAL AND
WATER RESOURCES ENGINEERING

FEASIBILITY STUDY APPROVAL
Pursuant to Colorado Revised Statutes 37-60-121 &122, and in accordance with policies adopted by the Board, the CWCB staff has determined this Feasibility Study meets all applicable requirements for approval.

Signed 3.20.12 Date

FEASIBILITY STUDY

NORTH LAKE DAM REHABILITATION PROJECT

LAS ANIMAS COUNTY, COLORADO

Submitted to
City of Trinidad
P.O. Box 880
Trinidad, Colorado 81082

Submitted by
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July 2011
Project 07104

Robert J. Huzjak, P.E.
Project Manager

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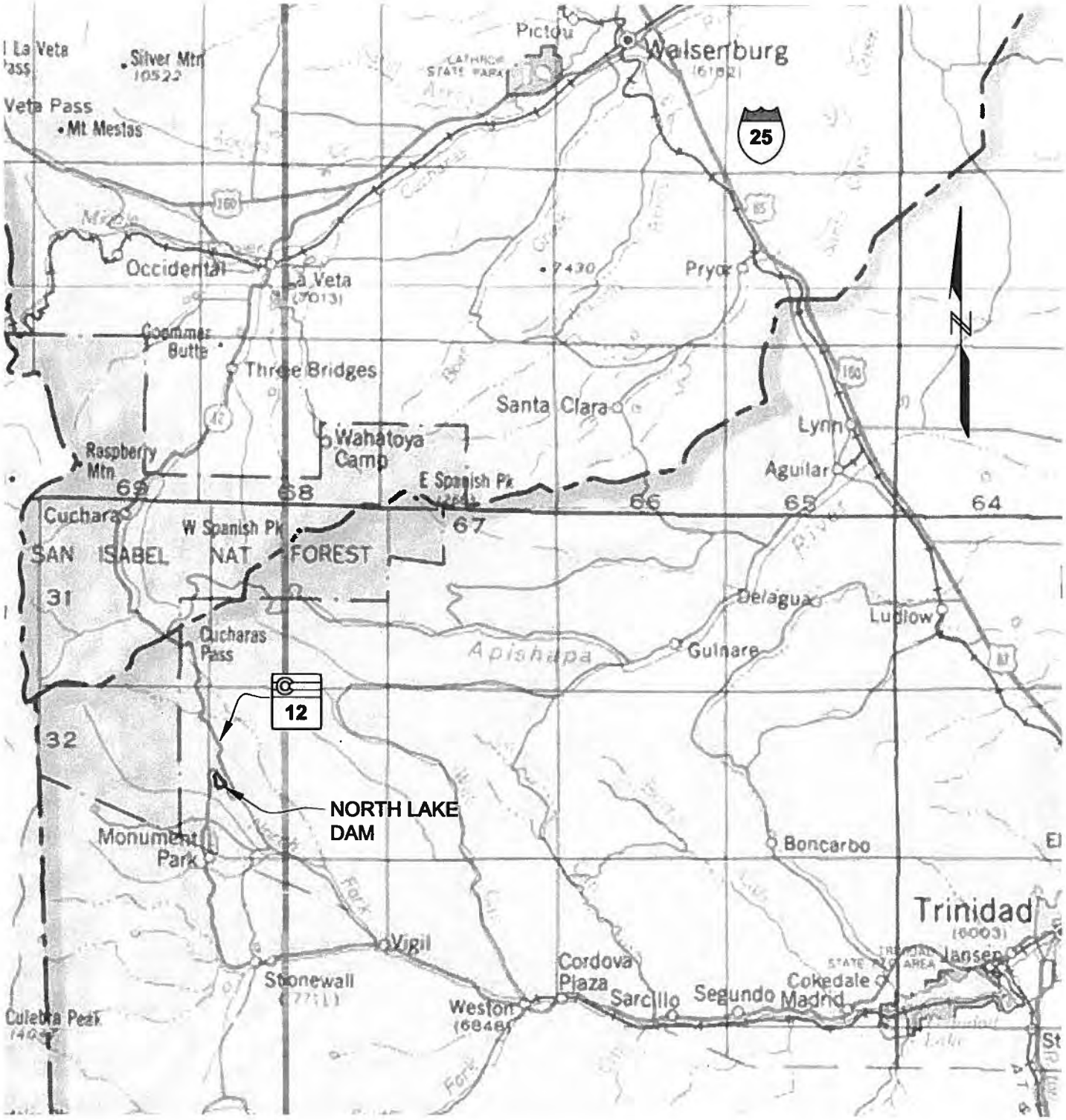
SECTION 1 - INTRODUCTION

The City of Trinidad (City) owns and operates North Lake Dam to provide raw water storage for municipal use. Multiple evaluations and repairs have been performed at the dam since dam safety concerns were first identified by the Colorado Office of the State Engineer (SEO) in 1998. The proposed North Lake Dam Rehabilitation Project (Project) addresses the remaining outstanding dam safety issues. Additional background information on the Project sponsor, site description, and field inspections are provided in Section 2. A detailed description of the Project is provided in Section 3. Information on alternatives evaluated and the selected Project components that address dam safety concerns are provided in Section 4 and Section 5, respectively.

The Project design documents were submitted to the SEO in 2009. As of June 2011, the SEO had not finalized their review and the Project was not scheduled for construction. Therefore, the SEO issued a reservoir restriction order limiting the maximum reservoir elevation to 5 feet below the emergency spillway crest. The restriction resulted in a loss of approximately 512 acre-feet (ac-ft) in municipal water storage capacity. If no action is taken to repair the dam safety deficiencies, further restrictions may be imposed by the SEO resulting in additional loss of municipal water storage. North Lake Reservoir is the primary source of municipal water for the City and the construction of the Project will address the dam safety concerns, lift the current reservoir restriction, and prevent further restrictions.



NOTE: IMAGE PROVIDED BY USGS 500K MAP SERIES
USING TOPO! MAPPING SOFTWARE

0 2.5 5 10 15
SCALE IN MILES

RJH CONSULTANTS, INC.

FEASIBILITY STUDY NORTH LAKE DAM REHABILITATION PROJECT	SITE VICINITY MAP
PROJECT NO. 07104	JULY 2011 **Figure 1.1**

P:\07104 – NORTH LAKE DAM\CAD\FIGURES\LOAN_FEASIBILITY_STUDY\07104 SITE LOCATION MAP.DWG 7/28/2011 8:16 AM

SECTION 2 - BACKGROUND INFORMATION

2.1 Sponsor

The City of Trinidad is a Home Rule Municipality of Colorado incorporated in 1876. As stated in the municipal code, "The City Manager is authorized to hire such employees and to perform all acts that may be necessary for the prudent, efficient, and economical management and protection of the Water Department. City Council has the power to prescribe rates, rules and regulations by resolution as it may deem necessary. Rates for outside customers not living in the corporate limits of the City shall be set by ordinance." The City municipal code is provided at the following website: http://trinidad.co.gov/code.html.

The City Council is comprised of the following members:

Jennie Garduno	Mayor
Liz Aragon	Council Member
Frank Shew	Mayor Pro-Tem
Alfredo Pando	Council Member
Jim Toupal	Council Member
Linda Velasquez	Council Member
John Rino	Council Member

2.2 Project Service Area and Facilities

The City provides water service within its service area, which includes the City limits and a substantial part of the developed rural area outside the City. The service area extends east to a prison facility and the Piñon Canyon Maneuver Site. Currently, the City serves about 3,540 residences and 440 businesses, of which approximately 550 accounts are rural customers.

Maintained by the Utilities Department, the City-owned water system includes water supply, treatment, storage, and distribution facilities. These primary facilities include two raw water supply reservoirs, distribution pipelines, and a water filtration and treatment plant. City policy stipulates water rates, plant investment fees, and line extensions, which are the responsibility of the developer. The reservoirs providing raw water storage for the City consist of North Lake and Monument Lake, located

approximately 40 miles west of the City. North Lake, which serves as primary storage, contains approximately 4,300 ac-ft of water generated by flows from the North Fork stream, which are governed by senior water rights (1861 to 1905). Modifications to improve the safety of the North Lake Dam have been ongoing for several years and are documented in Section 3. Monument Lake is ancillary storage, containing approximately 1,400 ac-ft of water controlled by senior water rights (1881 to 1906).

Both Monument Lake and North Lake have a pipeline that carries water from these reservoirs to the Trinidad Filtration Plant, located approximately 2 miles east of Monument Lake, which provides water treatment for the City and its service area. The Trinidad Filtration Plant has a design capacity of 8.4 million gallons per day (MGD). Modifications needed to maintain the treatment operations in the future include: flocculation system upgrades, sludge collections and storage, chemical feed upgrades, filter media replacement, and instrumentation and control upgrades. Additional treatment capacity will also be necessary to serve the City in the future.

From the plant, treated water is delivered to the City of Trinidad from the Mountain Water System, a 36-mile transmission pipeline that has a hydraulic capacity of approximately 9 MGD. With future expansion of the water filtration plant capacity, this transmission pipeline will need to either be replaced or paralleled to convey additional flow. Due to the potential of a water main break on this conduit, the City is vulnerable to a major disruption in treated water supply. Treated water is stored in several storage tanks with a total existing storage capacity of 9.46 million gallons. The primary tank is the Jansen storage tank, which holds 5 million gallons and supplies water to the North, South, and Allendale tanks through a series of pump stations. The excess storage capacity allows time to implement water treatment capacity upgrades. Improvements to the water distribution system will be required to meet future needs.

Additional facilities owned and operated by the City Utilities Department not discussed in this study include a Waste Water Treatment Plant, natural gas distribution plant, an electrical power distribution system, and a solid waste reuse service and landfill.

2.3 Existing Project Site Description

North Lake Dam is located about 40 miles west of Trinidad, Colorado, in Las Animas County, as shown on Figure 1.1. The dam was constructed in 1964, submerging an older, smaller dam located upstream of the existing dam. The dam is a 72-foot-high, high hazard, earthen embankment with a total storage capacity of about 4,214 ac-ft at maximum normal pool Elevation (El.) 8586.5, which corresponds to a gage height of 67

feet. The dam crest is at about El. 8591.5. The crest is about 20 feet wide and 630 feet long, with an upstream slope at approximately 3 horizontal to 1 vertical (3H:1V) and a downstream slope at approximately 2H:1V as shown on Figure 2.1.

Based on construction drawings and borings, the dam has a low permeability upstream shell, a very low permeability core extending to bedrock, and a random-fill downstream shell. There are no internal drains or filters. Significant seepage occurs through the right abutment and the area along the toe of the dam contains seepage areas and ponded water. This seepage presents a dam safety concern.

The spillway is a reinforced concrete chute at about the maximum section of the dam. The spillway has a crest width of about 6 feet at El. 8586.5. The spillway concrete has experienced severe damage and deterioration and presents a dam safety issue.

The outlet works consists of a concrete wetwell gate tower located in the upstream face of the dam. The gate tower has three inlet pipes at different elevations and a single outlet pipe. The inlet pipes are 20-inch steel pipes with 24-inch butterfly valves located in the gate tower. The upper inlet pipe has a separation in the embankment near the gate tower rendering the pipe non-operational. The outlet pipe is a 30-inch-diameter, concrete-lined, welded steel pipe. Near the downstream toe of the embankment, the outlet pipe transitions to a 24-inch-diameter pipe.

One 15-inch pipe extends from the older dam within the reservoir to the downstream toe of the existing dam. The upstream end of the pipe is about 920 feet upstream of the existing dam centerline. The old dam 15-inch pipe has been partially abandoned by previous grouting operations.

A 24-inch CMP auxiliary outlet located to the left of the spillway has been abandoned by grouting and the outlet structure and grouting apparatus have been removed.

2.4 Water Demands

The purpose of this Project is strictly limited in scope to improvements to the dam to address dam safety issues. No additional water supplies will be developed in connection with this Project and no new or increased diversion will be made into the reservoir. Increasing the storage volume at North Lake Dam has been discussed by the City; however, this is part of long-term planning and increased storage is currently not required by the City.

According to the City's Comprehensive Plan (2008) the City has a population of approximately 9,500 residents. The population has experienced boom and bust cycles since 1870; however, the population has increased and stabilized based on a growth rate of 3.9 percent between 2000 and 2006.

2.5 Water Quality

The portion of the Purgatoire River upstream of Interstate 25 has been classified by the State of Colorado as a cold water stream and a source of public water supply. This portion of the river should support agriculture, Class 1 coldwater aquatic life (trout and other coldwater species), and primary contact recreational uses such as swimming. The highly erodible soils found in the vicinity of Trinidad contribute to relatively high loads of sediment, dissolved solids, and heavy metals in the Purgatoire River, primarily downstream of City limits. High concentrations of sulfate and manganese in the river below Trinidad preclude its use as a drinking water source. Sedimentation in Trinidad Lake was reported to be an issue in the 1987 Section 208 Water Quality Plan.

The water quality in North Lake Reservoir is very high because of the undisturbed watershed and its high elevation at the upstream reaches of the Purgatory River Basin.

2.6 Project Lands

The use of water from North Lake Dam is not changing as a result of this Project and this Project will not broaden the City service area.

2.7 Hydrology and Water Rights

The reservoir impounded by North Lake Dam is filled from two sources: North Fork of the Purgatoire River through an aqueduct, and precipitation from a 0.76 square-mile watershed basin upstream of the dam. The Project consists of rehabilitation of existing facilities and no additional water supply sources will be utilized; therefore, hydrologic information is not pertinent for this Project. However, if information on the reservoir inflow design flood (IDF) is required, please refer to the *Hydrology Report* prepared by RJH in 2008. The peak inflow to the reservoir from the IDF is 1,298 cubic feet per second (cfs). The dam has the attenuation capacity to store the entire IDF volume so the spillway was designed to draw down the reservoir within 7 days to ensure enough storage capacity to safely store a 100-year storm. If additional information is required on the City drainage system, a *Master Drainage Study* was prepared by RG Consulting Engineers, Inc.

The water rights for North Lake Dam consist of a Priority 1, 3, 4, 6, and 13 from 1861 to 1864 senior water rights for a total of 8.17 cfs. The City also has a Priority 155 (1905) water right for 57.6 cfs. This project requires no change in the water rights for North Lake Dam.

2.8 Field Investigations

Subsurface characterization for the Project is based on three geotechnical investigations. Each investigation included field and laboratory testing. The investigations are summarized as follows:

- Five borings in the embankment and near the downstream toe of the embankment in 1999.
- Three borings in the upstream slope of the embankment in 2001.
- Four borings in the locations of the proposed structures in 2007.
- Six test pits in the proposed borrow area in 2007.

LEGEND

- — x — x — WIRE FENCE
- —— OHE —— OVERHEAD POWER LINES
- —— W —— BURIED WATER LINE
- —— · · —— SEEPAGE BOUNDARY AS OF 5/16/2000
- ⓦ MONITORING WELL

DAM CREST
EL 8591.5

SPILLWAY

GATE TOWER
INLET PIPES

NORTH LAKE
MAX NORMAL POOL
EL 8586.5

2H:1V

APPROXIMATE
LIMIT OF SEEPAGE

FENCE AND
LIMIT OF STATE HIGHWAY
RIGHT-OF-WAY

12

OUTLET
STRUCTURE

℄ OUTLET
WORKS

ACCESS ROAD

VALVE HOUSE

ACCESS ROAD

END OF
VISIBLE ROADWAY

ROADWAY
AND GATE

0 50 100 200 300
SCALE IN FEET

N

NOTE:

1. TOPOGRAPHIC SURVEYING WAS PERFORMED BY TERRY LAND SURVEYING, INC. IN MAY, 2000 AND JULY, 2007. COORDINATES WERE OBTAINED BY GPS AND PROJECTED TO A LOCAL COORDINATE SYSTEM.

RJH CONSULTANTS, INC.

FEASIBILITY STUDY NORTH LAKE DAM REHABILITATION PROJECT	GENERAL PLAN OF EXISTING CONDITIONS	
PROJECT NO. 07104	July 2011	**Figure 2.1**

P:\07104 - NORTH LAKE DAM\CAD\FIGURES\LOAN_FEASIBILITY_STUDY\07104 EXISTING PLAN OF DAM.DWG 7/28/2011 8:32 AM

SECTION 3 - PROJECT DESCRIPTION

3.1 Purpose

The purpose of the Project is to resolve outstanding dam safety issues at North Lake Dam, which include high foundation water pressures, insufficient slope stability, seepage, structural and hydraulic spillway deficiencies, deterioration of the auxiliary outlet conduit, a pipe separation in the upper inlet pipe to the gate tower, and a partially abandoned pipe.

3.2 Dam Classification

North Lake Dam is a large, high hazard dam as designated by the SEO.

3.3 Previous Studies and Repairs

Modifications to improve the safety of North Lake Dam have been on-going since the SEO identified dam safety issues in 1998. The following general repairs and analyses have been completed:

- Replaced the three water control valves in the outlet tower.
- Constructed a new stream release facility.
- Performed an underwater survey and developed an updated elevation-capacity curve for the reservoir.
- Completed upstream slope stability analyses and concluded that the stability of the upstream slope was acceptable.
- Completed Phase 1 grouting of the 15-inch-diameter pipe from the original dam.
- Completed evaluation of the condition of the spillway and conceptual evaluations of a new spillway located on the left abutment instead of the existing location near the center of the dam embankment.

Investigations and engineering evaluations were performed starting in 1999 and repair work was performed on the outlet works in 2002. The auxiliary outlet conduit was abandoned by grouting. Later in 2002, a design was prepared for a proposed relief well project to address downstream slope stability and seepage concerns; however, the associated construction cost was considered prohibitive (over $1.2 million) and there were serious safety issues with construction of relief wells with the reservoir nearly full

and the high foundation water pressures. Spillway investigation and analyses were also completed in 2005. A recommendation from this investigation was to abandon the existing spillway and construct a new spillway.

The City retained RJH Consultants, Inc. (RJH) to provide final design engineering services for the Project to address the combined outstanding dam safety issues. RJH evaluated the outstanding dam safety issues and the general approach to improve the safety of the dam was as follows:

- Additional grouting of the 15-inch-diameter pipe from the original dam is required to completed abandonment of the pipe.
- Seepage and high embankment foundation pressures exist downstream of the dam resulting in unacceptable seepage and slope stability factors of safety. Based on discussions with the City and through engineering evaluations, a seepage collection system and stability berm is the preferred alternative to address these issues.
- The upper inlet pipe to the gate tower is separated and this pipe needs to be abandoned or repaired. An evaluation of technical and operational advantages and disadvantages of alternatives with associated construction cost comparison were developed and the preferred repair was to abandon the upper inlet pipe.

SECTION 4 - FORMULATION OF ALTERNATIVES

4.1 General

Alternatives were considered throughout the design process. The following sections describe the alternatives considered for various aspects of the Project, and the No Action alternative.

4.2 No Action Alternative

Dam safety concerns have been identified at the site. These concerns are not resolved by maintaining the reservoir at the currently restricted elevation. The reservoir would need to be lowered significantly to remediate the dam safety issues. A long-term reduction in storage volume would impact the City's ability to provide a reliable water supply. Because this work is needed to address safety issues with an existing high hazard dam and significant restriction would impact the City's ability to provide a reliable water supply, a No Action alternative was not considered viable.

4.3 Spillway Alternatives

The Project requires a berm to be constructed in the location of the existing spillway to address stability and seepage concerns. Therefore, all alternatives require demolition of a major part of the existing spillway. The new downstream stability berm prevented replacement of the existing spillway over the top of the dam, because of settlement issues associated with construction of a rigid structure above the new berm. The geological and topographic conditions in the right abutment and the topographical conditions in the left abutment are adverse to construction of a traditional open channel spillway. If an open channel spillway was constructed in the left abutment at the location of the pipe spillway, large retaining walls would be needed, which would increase the cost significantly above the cost for the selected alternative, which is a pipe spillway in the left abutment.

4.4 Stability Berm and Seepage Collection System Alternatives

Four repair alternatives were considered in 2002 prior to the spillway assessment. The alternatives were identified to manage seepage, reduce the potential for piping, and increase the downstream slope stability. At that time, the hydraulic, structural, and hydrologic concerns with the spillway were not considered. The primary purpose was to relieve high pore pressures in bedrock that is overlain by 10 to 45 feet of clayey alluvium

at the downstream toe of the dam. The alternatives included: 1) reduce the seepage flow volume and water pressures below the dam by constructing a seepage cutoff below the central select core of the dam to depths of about 20 to 50 feet into bedrock, 2) reduce water pressures at the toe of the dam by installing a series of relief wells along the downstream toe of the dam and abutments penetrating through the intensely weathered and fractured bedrock, 3) lengthen the flow path by placing a blanket drain and improve stability by constructing a berm on the downstream slope, and 4) restrict the reservoir level at a lower level to reduce water pressures below the dam. Based on several meetings the between the engineer , the City, and the SEO, and an evaluation of the expected degree of improvement to the safety of the dam, the expected costs, and constructability of the four alternatives, installing relief wells was selected at that time as the preferred alternative. The estimated construction cost to implement the relief well system was about $1.2 million. This alternative was not implemented in 2003 because of a) the high estimated construction costs, b) technical issues with constructing relief wells with over 40 feet of uplift pressure and when the reservoir is near full, and c) concerns with the need to rehabilitate the spillway. The blanket drain and downstream slope stability berm was ultimately selected to address the seepage and stability dam safety issues.

4.5 Outlet Works Modification Alternatives

Four alternatives were considered to address the dam safety issue associated with the separated upper intake pipe: three of the alternatives identified methods to repair the pipe and one alternative identified a method to abandon the pipe. Abandonment of the pipe was significantly less expensive and the City concluded that abandonment would not adversely impact the operational use of the reservoir. Based on cost and feasibility, the City selected the abandonment alternative. A letter detailing the inlet pipe alternatives analysis is provided in Appendix A.

Also, approximately a 150-foot-long portion of the lower 24-inch-diameter downstream outlet pipe will have to be removed because the proposed stability berm will cause settlement of alluvial materials under the exiting outlet pipe. Based on available information, this portion of the pipe is thin walled (less than 1/2 inch), has suffered severe corrosion, and had not been designed to withstand the new vertical loads from the additional fill or for the stresses that would be applied from deformation of the foundation.

SECTION 5 - SELECTION OF ALTERNATIVE

5.1 Project Components

The general configuration of the primary project components are shown on Figures 5.1 through 5.4 and are as follows:

- DOWNSTREAM STABILITY BERM. An 80-foot-wide berm with a crest at about El. 8550 and a downstream slope of 2.75H:1V will be constructed on the downstream slope of the dam across the entire valley. A filter drain system will be placed below the berm.
- SPILLWAY. The existing spillway will be demolished. A new spillway will be constructed, including a reinforced concrete intake structure, a 36-inch-diameter reinforced concrete pipe (non-pressurized), and a reinforced concrete stilling basin in the left abutment.
- UPPER INLET PIPE ABANDONMENT. The separated upper inlet pipe to the gate tower will be abandoned by grouting.
- SECONDARY GROUTING OF THE OLD DAM 15-INCH PIPE. Abandonment will be completed by injecting grout into the pipe to plug voids that resulted from previous grouting work.

Additional site work will include instrumentation, crest regrading, riprap-lined ditches for surface runoff collection, relocation of a segment of the access road, and reclamation of work areas.

5.2 Basis of Design

The regulatory authority for this Project is the SEO. The regulatory criteria governing the dam rehabilitation design was based on the SEO *Rules and Regulations for Dam Safety and Dam Construction*, effective January 1, 2007 (SEO, 2007), and the SEO *Dam Safety Project Review Guide*, effective June 1, 2000.

The key operational requirements established by the City and RJH for the Project include the following:

- For normal operations, the reservoir will typically be maintained at or near the maximum normal water surface at El. 8586.5.

- The City will have access to approximately 3,702 ac-ft of storage through the outlet works during construction of the rehabilitation. At all other times, the City will have access to approximately 4,214 ac-ft of storage.
- The spillway design is required to pass the IDF event with 1.0 foot of residual freeboard to meet SEO Dam Safety requirements.
- The spillway must safely pass the IDF event without creating any dam safety concerns or damaging any spillway components; however, minor maintenance of riprap and concrete surfaces could be required for this design level release.
- The outlet works connects to a raw water pipeline that provides delivery to the City's water treatment plant. Interruptions of the delivery system must be kept to the following maximum shut-down schedule for repairs/tie-ins:
  - September through May – 20 hours
  - June through August – 10 hours

Additional specific engineering design criteria is documented in the *Design Summary Report* (RJH, 2009).

5.3 Land and Right-of-Way Requirements

Majority of the proposed Project construction is on City property; however, the limit of site disturbance crosses into the Right-of-Way for State Highway 12 and will require a construction easement from Colorado Department of Transportation (CDOT). The construction easement will be required to construct an approximately 160-foot-long segment of the spillway conduit. The Project restores the reservoir to its original maximum normal water surface, which is already owed by the City so no additional land purchases are required for the high water pool.

5.4 Cost Opinion

The engineer's opinion of probable construction costs (OPCC) for the Project was submitted to the SEO (updated June 2010) for an amount of $1,848,086. The OPCC was based on the SEO submitted design drawings and technical specifications. RJH developed the OPCC based on professional opinion and actual costs would be affected by a number of factors beyond current control such as supply and demand for the types of construction required at the time of bidding and in the project vicinity, changes in material supplier costs, changes in labor rates, the competitiveness of contractors and suppliers, changes in applicable regulatory requirements, and changes in design

standards. Therefore, conditions and factors that arise as project development proceeds through bidding and construction may result in construction costs that differ from the stated estimate. A copy of the OPCC is provided in Appendix B.

5.5 Project Implementation Schedule

The Project design is complete and construction documents were prepared and submitted to the SEO. The SEO has completed their review and provided comments to RJH on July 20, 2011. The comments are relatively minor and RJH intends to finalize the documents when directed by the City. Securing financing for this Project will allow the construction drawings to be finalized and the bidding process to begin. Construction is anticipated to begin in spring 2012 as weather permits and be completed by December 2012.

5.6 Permitting Considerations

The City is required to obtain a permit from the SEO to implement the required improvements. As stated previously, the SEO has reviewed the documents and has submitted comments. RJH has been working with the SEO over the past few years to develop the design and finalization of this permit is not expected to impact the schedule.

The City expects to be exempt from USACE 404 permitting since the Project re-establishes the maximum normal water surface and no other wetlands or protected areas are impacted.

No other permits have been identified that will be required to implement this Project.

NORTH LAKE
MAX NORMAL POOL
EL 8586.5

NEW INTAKE STRUCTURE

CREST IMPROVEMENTS NOT SHOWN

DAM CREST
EL 8591.5

SECONDARY GROUTING

℄ NEW SPILLWAY

NEW STABILITY BERM

EXISTING SPILLWAY (TO BE REMOVED)

GATE TOWER
UPPER INLET PIPE
ABANDONMENT

℄ EXISTING OUTLET WORKS

80.0'

BENCH

2.75H:1V

FENCE AND
LIMIT OF STATE HIGHWAY
RIGHT-OF-WAY

12

MANHOLE

LIMIT OF SITE DISTURBANCE

MAIN DRAIN OUTLET

EXISTING OUTLET STRUCTURE

ACCESS ROAD

RIGHT DRAIN OUTLET

ROCK-LINED DITCH

ACCESS ROAD REALIGNMENT

NEW OUTLET WORKS PIPE

NEW STILLING BASIN

EXISTING VALVE HOUSE

ACCESS ROAD

BORROW AREA

END OF VISIBLE ROADWAY

ROADWAY AND GATE

OHE

N

0 50 100 200 300
SCALE IN FEET

LEGEND

- EXISTING WIRE FENCE
- OVERHEAD POWER LINES
- BURIED WATER LINE
- SEEPAGE BOUNDARY AS OF 5/16/2000
- EXISTING MONITORING WELL

NOTE:

1. TOPOGRAPHIC SURVEYING WAS PERFORMED BY TERRY LAND SURVEYING, INC. IN MAY, 2000 AND JULY, 2007. COORDINATES WERE OBTAINED BY GPS AND PROJECTED TO A LOCAL COORDINATE SYSTEM.

RJH CONSULTANTS, INC.

FEASIBILITY STUDY
NORTH LAKE DAM
REHABILITATION PROJECT

GENERAL PLAN OF MODIFICATIONS

PROJECT NO. 07104

July 2011

Figure 5.1

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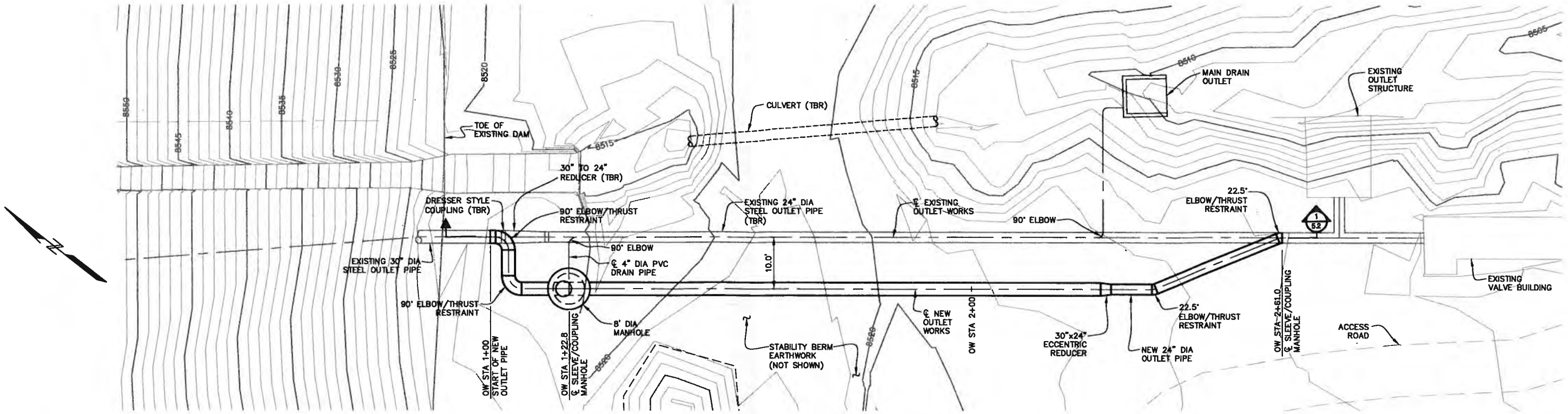

PLAN

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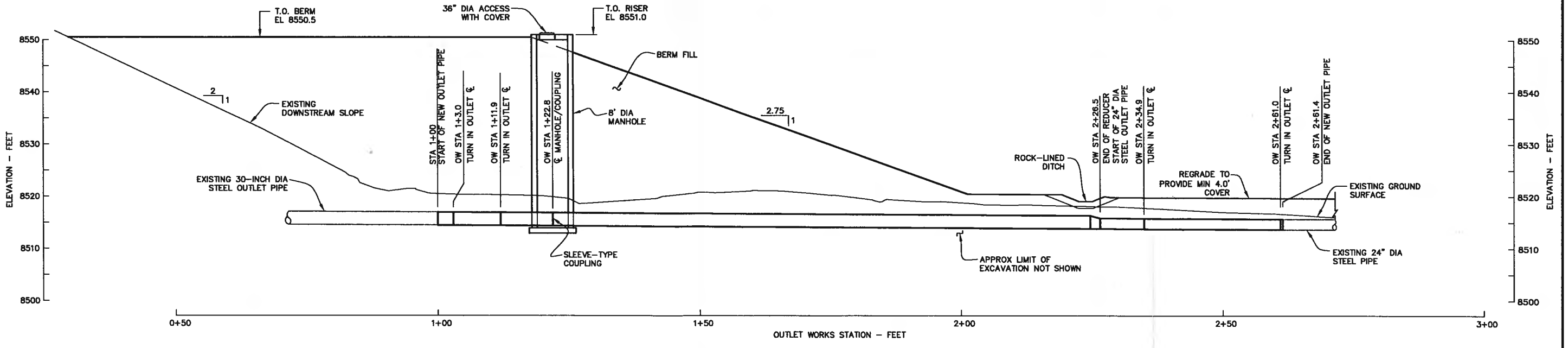

PROFILE ALONG NEW OW ℄

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NOTE:

1. TBR: TO BE REMOVED/DISPOSED OF OFF-SITE.

RJH CONSULTANTS, INC.

FEASIBILITY STUDY NORTH LAKE DAM REHABILITATION PROJECT	OUTLET WORKS REPLACEMENT PLAN AND PROFILE
PROJECT NO. 07104	July 2011 **Figure 5.2**

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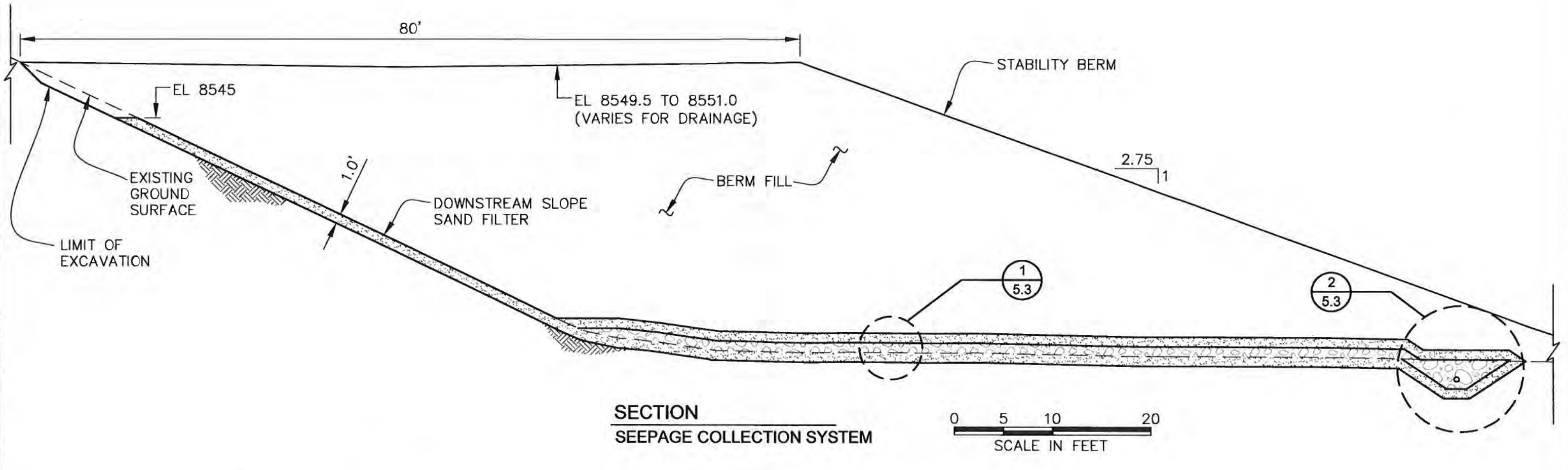

SECTION
SEEPAGE COLLECTION SYSTEM

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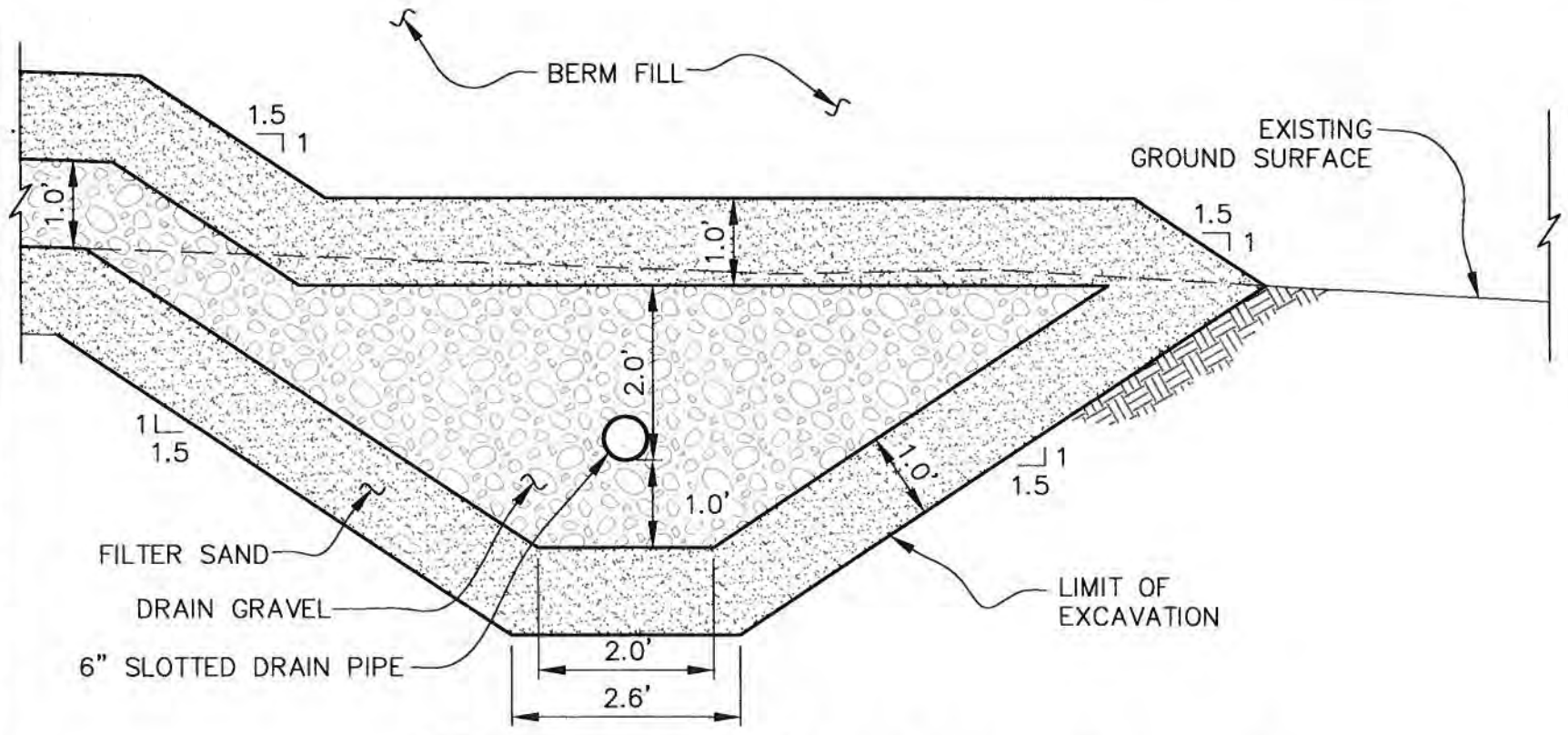

DETAIL 2 / 5.3
TOE DRAIN

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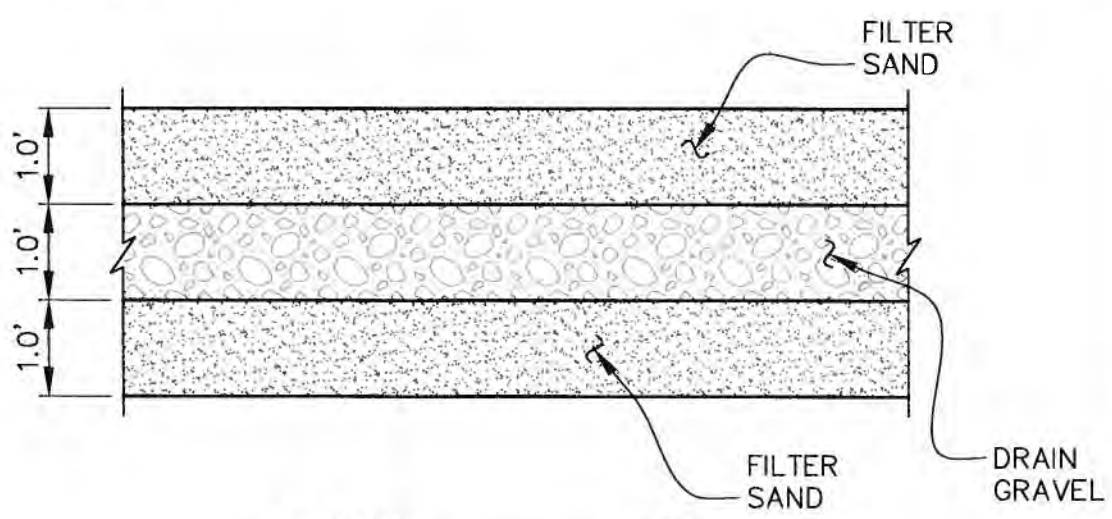
SCALE IN FEET



DETAIL 1 / 5.3
BLANKET DRAIN

0 1 2 4
SCALE IN FEET

RJH CONSULTANTS, INC.

FEASIBILITY STUDY NORTH LAKE DAM REHABILITATION PROJECT		BERM AND SEEPAGE COLLECTION SYSTEM
PROJECT NO. 07104	JULY 2011	**Figure 5.3**

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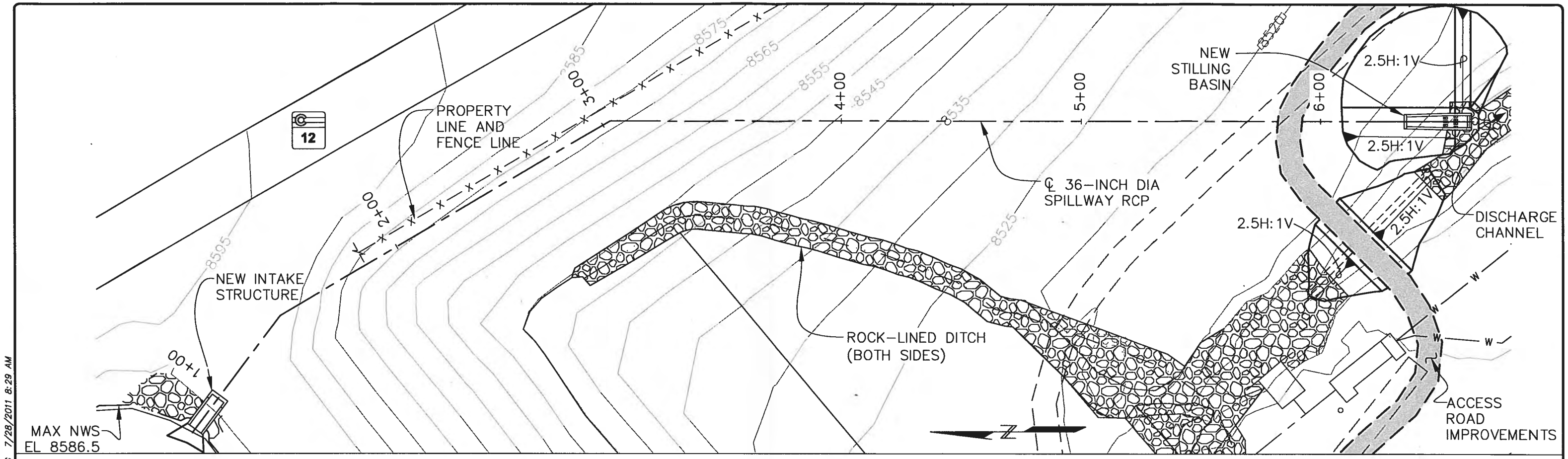

PLAN

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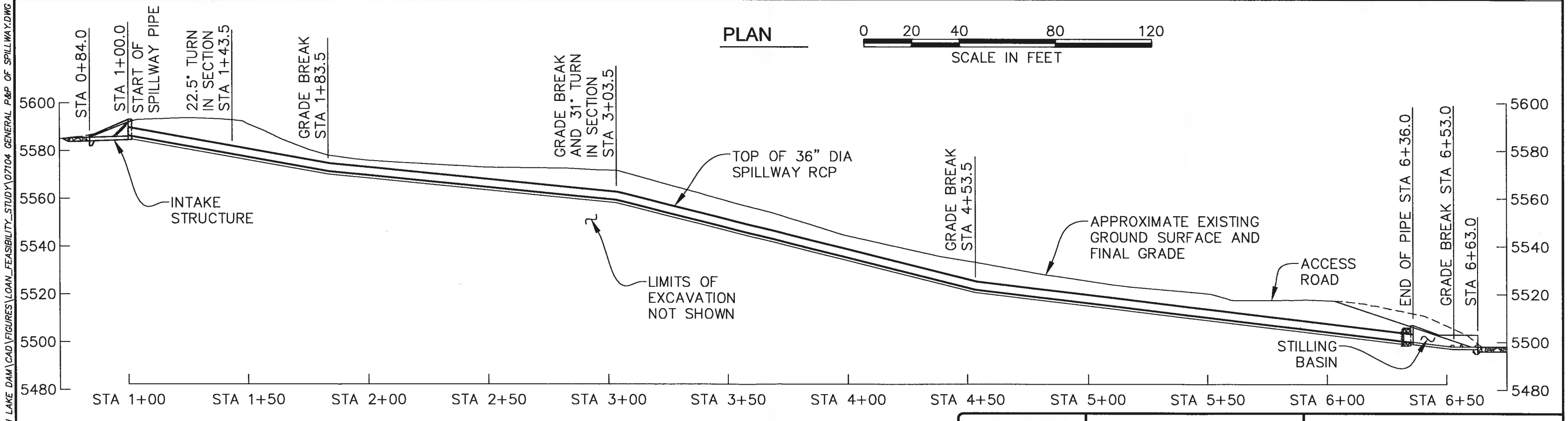
SCALE IN FEET



PROFILE

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SCALE IN FEET

RJH CONSULTANTS, INC.

FEASIBILITY STUDY NORTH LAKE DAM REHABILITATION PROJECT	SPILLWAY REPLACEMENT PLAN AND PROFILE
PROJECT NO. 07104	July 2011 **Figure 5.4**

P:\07104 - NORTH LAKE DAM\CAD\FIGURES\LOAN_FEASIBILITY_STUDY\07104 GENERAL P&P OF SPILLWAY.DWG 7/28/2011 8:29 AM

SECTION 6 - LOAN PROGRAM CONSIDERATIONS

6.1 Financial Analysis

Based on RJH's OPCC, the cost of this Project is estimated at $1,848,086. Anticipated sources of funding are as follows:

Source of Funding	Percent	Amount ($)
City of Trinidad	20	369,616
Proposed Colorado Water Conservation Board Grant (CWCB)	40	739,235
Remaining Balance[1]	40	739,235
	TOTAL	**1,848,086**

Note:
1. The source of the remaining balance will be either from other grant funds or low interest loan funds secured by the City.

6.2 Institutional Considerations

Upon incorporation of the SEO review comments on the design package, the SEO will issue a construction permit for the Project, which is considered open for 5 years or until the Project is complete. There are standards for this type of construction and little difficulty is foreseen in obtaining all required permits, agreements, or approvals.

The City will be the lead for financing, design, and construction of the Project and will be the entity entering into contracts and agreements with the various entities for the services provided by each. In addition to the design already provided, RJH is anticipated to provide construction engineering for the Project.

6.3 Credit Worthiness

At the end of the fiscal year 2010, the City of Trinidad water fund operating revenues exceeded expenses. The City retains an adequate reserve fund. If expenses exceed the projected amount , the City draws from the reserve account. Loan amounts would be included in the next year's project expenses and paid from the reserve fund if required.

6.4 Alternate Financing Considerations

The City has investigated alternate financing sources, but has determined the CWCB program to be the most favorable source. Other sources were not developed in detail because of the preference to work with the CWCB.

The City has looked into possible loan funding through USDA, attempted to seek Department of Local Affairs funding, and sought to secure grant funds through State legislative grant funding.

6.5 Collateral

The City pledges as security for this loan the assessment of water fees associated with the Project, as necessary, and the Project itself.

6.6 Economic Analysis

The economic benefit for the Project is considerable. By rehabilitating the North Lake Dam the reservoir will regain over 500 ac-ft of storage and more if the SEO decides on further, more severe restrictions. The current storage cost for this Project is about $430 per ac/ft. This is considerably more economical then building a new dam and reservoir of similar size, which would have a current storage cost of about $3,000 to $6,000 per ac-ft.

6.7 Social and Physical Impacts

The Project will have no significant social impacts as the reservoir will continue to operate as it has in the past. Physical impacts includes the work identified within the limits of site disturbance, which is contained with City property and the proposed construction easement area.

The reservoir provides a significant recreational resource for the region. Reservoir restrictions will have a negative impact on the recreational use of the reservoir and possible future reductions in reservoir storage volume that will be required if the repairs are not implemented, are anticipated to adversely impact the established fishery in the reservoir.

SECTION 7 - CONCLUSIONS

- The City of Trinidad is an incorporated entity in the State of Colorado with the ability to enter into a contract with the CWCB for the purpose of obtaining a Construction Fund loan.
- The City is in the process of finalizing the construction documents submitted to the SEO. Construction advertisement and bidding is anticipated in the spring of 2012.
- The City shall obtain a Right-of-Way construction easement from the CDOT for the proposed dam rehabilitation.
- The Project would provide a safe and reliable dam and re-establish the maximum normal water surface. The City would then have access to about 4,300 ac-ft of raw water storage at North Lake Dam and retain its full decree of water dating back to the 1800s.
- The total opinion of probable construction costs for the Project is $1.85 million, of which 20 percent will be funded by the City, 40 percent will be funded by a loan from the CWCB Construction Fund, and the remaining 40 percent funded by either other grant funds or low interest loan funds secured by the City.
- The Project is technically and financially feasible.

SECTION 8 - REFERENCES

Colorado Office of the State Engineer (SEO) (2000). *Dam Safety Project Review Guide*, June.

Colorado Office of the State Engineer (SEO) (2007). *Rules and Regulations for Dam Safety and Dam Construction*, January.

RG Consulting Engineers, Inc. (2000). *Coastal/Trinidad Drainage Master Plan.*

RJH Consultants, Inc. (RJH) (2008). *Hydrology Report, North Lake Dam Rehabilitation Project*, June.

RJH Consultants, Inc. (RJH) (2009). *Design Summary Report, North Lake Dam Rehabilitation Project*, October.

APPENDIX A

UPPER LEVEL PIPE REPAIR OPTIONS

July 2, 2008
Project 07104

Mr. Jim Fernandez
Utility Superintendent
City of Trinidad
P.O. Box 880
Trinidad, CO 81082

Re: North Lake Dam Rehabilitation Project
Upper-Level Outlet Pipe Repair Options

Dear Mr. Fernandez:

The purpose of this letter is to present the results of our conceptual evaluation of options to either repair or abandon the upper-level intake pipe for the outlet works at North Lake Dam. This work was performed in accordance with the scope of work for Task 3 of the contract between RJH Consultants, Inc. (RJH) and the City of Trinidad (City) for the North Lake Dam Rehabilitation Project. The objectives of this task were to identify options, advantages and disadvantages, and estimated costs to repair and to abandon the upper-level intake pipe and work with the City to select a preferred option to move forward into design.

Background

During inspections of the dam in 2001, soil material was observed flowing through the upper-level intake pipe into the outlet works tower. Subsequently, a camera inspection of the pipe was performed and the pipe was identified to be separated about 3 to 4 inches vertically at a pipe joint near the pipe bend in alignment. The separation is located about 4 to 5 feet from the outlet works tower. The City has operated the reservoir since 2001 without using the upper-level intake pipe. The intake pipe is not being used to convey water because operation of the pipe will cause additional embankment material to flow through the pipe, which would cause internal erosion of the upstream slope of the dam and adversely impact dam safety. As part of the North Lake Dam Rehabilitation Project, the City will either repair the upper-level intake pipe or permanently abandon the pipe.

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Repair Options

RJH has developed four options to address the dam safety concerns with the separated upper-level intake pipe. The options are presented below with a brief description of the primary components of work, advantages, disadvantages, and conceptual costs for each option. The comparison of alternatives includes consideration of cost, reservoir operations, long-term maintenance, construction difficulty, and risk.

The conceptual cost estimate was developed based on anticipated major construction items for each option. RJH developed the costs based on an assumption that the repairs to the outlet works would be completed concurrent with the work associated with the North Lake Dam Rehabilitation Project. We also included a 20 percent cost contingency to account for unidentified items. The cost estimate was based on RJH's database of bid price data for similar projects, cost data publications, and our previous experience and judgment.

Option 1 – Traditional Excavation Repair (Lower the reservoir, traditional excavation, and replacement of the intake pipe)

Option 1 would require lowering the reservoir to about 2 feet below the invert of the upper-level intake pipe, excavating to expose the pipe, repairing/replacing the damaged pipe segment, encasing the repaired section of pipe in concrete, backfilling the excavation, and replacing riprap slope protection. The excavation would be performed with safe excavation side slopes with minimal to no excavation support shoring. The estimated construction cost for Option 1 is approximately $35,000.

This cost does not include costs for lowering or refilling the reservoir. RJH understands that the City would prefer not to lower the reservoir and lose the use of that storage. However, it may be possible to plan reservoir lowering and the repair early in the spring (prior to runoff) and in a year with a high snowpack to reduce the risk of losing that storage for a season. This would allow for the construction work for Option 1, which is estimated to be approximately 1 month long, to occur before snowpack runoff starts and the reservoir begins to fill. However, if this option is performed outside the scheduled North Lake Dam Rehabilitation Project construction work then the cost would likely increase by about $10,000 to cover additional mobilization and demobilization.

Advantages

- Restores original delivery capacity.
- Repairs the intake pipe in the dry with very low risk.
- Standard construction methods with no specialty contractor required.
- Long-term, low-maintenance repair.
- Relatively minimal construction difficulty and risk.

- Most economical repair option.

Disadvantages

- Requires lowering the reservoir to about 23 feet below normal pool (El. 8586.5) and loss of about 2,000 acre-feet of storage, which represents about 47 percent of the total reservoir storage volume.
- Requires the reservoir to be drawn down during the construction period (about 30 days).
- Construction could be adversely impacted by a sudden extreme storm event that could cause a sudden rise in reservoir elevation.

OPTION 2 – SHORED EXCAVATION REPAIR (CONSTRUCT SHEETPILE WALL, SPECIALTY EXCAVATION, AND REPLACEMENT OF THE INTAKE PIPE)

Option 2 would require construction of about a 120-foot long and 15-foot-high steel sheetpile wall (6 feet embedded into dam, 6 feet retention of reservoir, and 3 feet of freeboard), shored excavation, dewatering of the excavation pit, repairing/replacing the damaged pipe segment, encasing the repaired pipe in concrete, removing sheetpile and backfilling of the excavation, and replacing riprap slope protection. The upstream end of the pipe would need to be temporarily plugged with a redundant system of internal or external plugs and the existing trashrack would need to be removed and replaced. This work would be performed with divers. The bottom of the excavation would be about 23 feet below the surface of the reservoir if the reservoir is at normal pool. This work will result in an excavated pit that will require significant dewatering to complete the repairs. The estimated construction cost for Option 2 is approximately $110,000.

Advantages

- Restores original delivery capacity.
- No loss of reservoir storage during construction.
- Minimal impacts to reservoir operation during construction.
- Long-term, low-maintenance repair.

Disadvantages

- Requires construction of a sheetpile wall and dewatering, which may require a specialty contractor.
- Relatively severe construction difficulty and high risk because work is performed behind a cofferdam and up to about 23 feet below the surface of the reservoir.
- Most expensive repair option.

OPTION 3 – PIPE LINING REPAIR

Option 3 provides a repair concept that would not require excavation or lowering of the reservoir; however, this option does require the use of divers. RJH evaluated several pipe lining alternatives and concluded that a traditional slip lining of placing a smaller diameter pipe inside the existing pipe and grouting of the annular space between the new and existing pipe is the preferred lining alternative. Other lining methods such as In-Situ Form and Cured-In-Place Pipe (CIPP) were eliminated because both ends of the pipe would need to be exposed (above water) and these alternatives were more expensive.

Option 3 requires the existing 20-inch-diameter pipe to be slip-lined with a 10- or 12-inch-diameter HDPE pipe. One concern is that the pipe and 45-degree elbow would have to be slip-lined by divers on the upstream end and then a plug would have to be installed to allow the contractor to "stab" the pipe segment from the outlet tower to the elbow. RJH is concerned that this repair concept is complicated and that there is a high degree of risk associated with making this type of repair using divers. After the pipe is slip-lined, grout would be pumped into the annular space between the existing 20-inch pipe and the new slip-lining with 2-inch PVC pipes. The grout pipes would be withdrawn during grouting. This operation could be difficult because it requires inserting a solid pipe through the damaged (offset) section of the original intake pipe. The estimated construction cost for Option 3 is approximately $50,000.

Advantages

- No loss-of-reservoir during construction.
- Minimal impacts to reservoir operations during construction.
- Long-term, low-maintenance repair (assuming full grouting of the pipe).
- Moderate to severe construction difficulty and risk depending on work around the separated pipe joint.
- More economical than Option 2 – Shored Excavation Repair; however, more expensive than Option 1 – Traditional Excavation Repair.

Disadvantages

- Reduced Delivery Capacity Option - The current hydraulic capacity of the upper-level inlet pipe is 52 cfs. The hydraulic capacity of the re-lined upper-level intake pipe would be 17 cfs.
- Difficult to confirm complete grouting of pipe.
- Unable to confirm or repair any voids or low density material in the embankment above the pipe.

- Requires divers and specialty construction methods.
- Could be difficult to slip-line the pipe through damaged section of intake.
- Construction cost contingency is difficult to assess.

OPTION 4 – GROUT THE PIPE (PIPE ABANDONMENT)

Option 4 provides a repair concept that is the lowest cost with the quickest repair timetable. The major disadvantage is that the City would loose the use of the upper-level intake pipe and access to raw water within the upper zone of the reservoir. This option would require a dive crew to bulkhead ("plug") the upstream end of the pipe for grouting. Once plugged, grout would then be pumped into the 20-inch-diameter pipe until completely full of concrete. The butterfly valve would then be permanently shut and disconnected from the hydraulic system. The estimated construction cost for Option 4 is approximately $18,000.

Advantages

- No loss-of-reservoir during construction.
- Minimal impacts to reservoir operations during construction.
- Most economical of all options.
- Relatively minimal construction difficulty and risk.
- No long-term maintenance concerns.
- Shortest construction schedule.

Disadvantages

- Loss of use of pipe and reservoir operation for the upper reservoir level, since the pipe is abandoned and not repaired.
- Requires divers and specialty construction methods.

Conclusions

Based on the work competed for this evaluation we offer the following conclusions:

- The costs for the four options vary from approximately $18,000 to $110,000 as summarized in Table 1:

TABLE 1
UPPER-LEVEL OUTLET PIPE
REPAIR OPTIONS - COST COMPARISON

Option	Type	Cost ($)
1	Repair	35,000
2	Repair	110,000
3	Repair	50,000
4	Abandonment	18,000

- The preferred option from a cost perspective is Option 4; however, the City will lose use of the upper-level intake and selective withdrawal of the upper approximately 20 feet of the reservoir. However, this may not adversely impact operations or use of the reservoir because the City has not been using this intake since 2001.
- The most cost effective repair concept is Option 1. This repair option also has a lower risk for unanticipated costs and uncertainties that the other identified repair options. However, this option requires lowering of the reservoir pool to below the elevation of the upper-level intake, which is about 23 feet below normal pool. This results in loss of about 2,000 acre-feet of storage, which represents about 47 percent of the total reservoir storage volume.
- Option 2 should not be further considered since it is the most expensive repair option and would have a relatively severe degree of constructability uncertainly and risk.
- Option 3 should not be considered unless Options 1 and 4 are eliminated because this repair option would result in reduced delivery capacity and construction uncertainty regarding confirmation of pipe grouting at the damaged section and construction cost contingencies.

Recommendations

Based on the information from the evaluations presented in this letter, our understanding of the dam and reservoir and the City's past operation of the reservoir, we recommend that the City implement Option 4 – Pipe Abandonment. This alternative is recommended for the following reasons:

- This intake conduit is not required to meet any dam safety requirement.
- The City has operated the reservoir for approximately 7 years without withdrawing water through this pipe without any adverse impacts to water quality or water treatment costs.
- This is the least costly option to correct the dam safety concern with the broken pipe.
- All of the repair options have a higher construction cost and most have a high risk for construction uncertainty.

- Although the risk for future differential movement between the tower and embankment fill that supports the pipe is considered low, long-term settlement data for the dam is not available. Also, based on piezometer data the core is not fully saturated and the piezometric level through the dam may not yet be at steady-state. Changes in the water level through the dam could cause future settlement of the embankment. If the pipe is repaired and future settlement of the dam occurs, it is possible that the repaired pipe could become damaged in the future.

Please call if you have any questions or require additional information.

Sincerely,

RJH CONSULTANTS, INC.

Robert J. Huzjak, P.E.
Project Manager

RJH/jmm

APPENDIX B

OPINION OF PROBABLE CONSTRUCTION COSTS

June 28, 2010
Project 07104

Mr. Jim Fernandez
City of Trinidad
P.O. Box 880
Trinidad, CO 81082

Re: North Lake Dam Rehabilitation Project
Opinion of Probable Construction Costs

Dear Jim:

RJH Consultants, Inc. (RJH) developed an Opinion of Probable Construction Cost (OPCC) to implement the modifications described in the SEO Submittal design drawings and technical specifications for the North Lake Dam Rehabilitation Project.

This OPCC is based on professional opinion. Actual costs would be affected by a number of factors beyond current control, such as supply and demand for the types of construction required at the time of bidding and in the project vicinity; changes in material supplier costs; changes in labor rates; the competitiveness of contractors and suppliers; changes in applicable regulatory requirements; and changes in design standards. Therefore, conditions and factors that arise as project development proceeds through bidding and construction may result in construction costs that differ from the estimate provided in this letter.

The lump sum item costs are based on qualitative estimates of the summation of the various activities required for a particular item of work. Quantities for unit price items are based on the drawings. The line items in the attached cost opinion correspond to the items in the bid tabulation that will be used for bidding. Estimated unit prices and costs of the listed work items were derived from the following sources:

- Published and non-published bid price data for similar work from similar projects.
- R.S. Mean Heavy Construction Cost Data for 2009.
- Manufacturer's budgetary price quotes.
- Engineering News Record (ENR).

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- RJH's experience on similar construction work and engineering judgment.

The sum of the bid items is defined for this study as the "Direct Construction Subtotal" (DCS). We anticipate the DCS would represent a contractors' "bid price." We have included allowances to the DCS to account for other project costs. These allowances include the following:

- 15 percent of the DCS to account for construction contingencies. This allowance is intended to cover unanticipated items and issues that may arise during construction.
- 3 percent of the DCS for City administration.
- Approximately 20 percent of the DCS for construction engineering.
- Approximately 3 percent of the DCS for materials testing during construction.

The Opinion of Probable Construction Costs (OPCC) is the sum of the DSC and the above allowances. A summary of our OPCC for this project is presented in the following table.

OPINION OF PROBABLE CONSTRUCTION COST

Item	Quantity	Unit	Unit Price ($)	Total Cost ($)
1 – Mobilization	1	LS	75,000.00	75,000.00
2 – Erosion Protection and Sediment Control	1	LS	20,000.00	20,000.00
3 – Clearing and Grubbing	9	Acre	2,500.00	22,500.00
4 – Reservoir Control	1	LS	55,000.00	55,000.00
5 – Dewatering	1	LS	70,000.00	70,000.00
6 – Site Access Road Improvements	1	LS	12,500.00	12,500.00
7 – Crest Earthwork	1	LS	7,500.00	7,500.00
8 – New Spillway Structure	1	LS	60,000.00	60,000.00
9 – Spillway Pipe	536	LF	200.00	107,200.00
10 – Removal of Existing Spillway	1	LS	25,000.00	25,000.00
11 – Secondary Pipe Grouting	1	LS	5,000.00	5,000.00
12 – Gate Tower Repair	1	LS	15,000.00	15,000.00
13 – Outlet Works Disposal	1	LS	30,000.00	30,000.00
14 – Furnishing and Placing Low-Permeability Fill	210	CY	12.50	2,625.00
15 – Furnishing and Placing Berm Fill	32,000	CY	3.00	96,000.00
16 – Furnishing and Placing Filter Sand	3,700	CY	50.00	185,000.00
17 – Furnishing and Placing Drain Gravel	1,550	CY	50.00	77,500.00
18 – Topsoil	7,300	CY	5.50	40,150.00
19 – Type M Riprap	220	CY	70.00	15,400.00
20 – Type L Modified Riprap	410	CY	170.00	69,700.00
21 – Riprap Bedding	85	CY	60.00	5,100.00
22 – Outlet Works Pipe	1	LS	120,000.00	120,000.00
23 – Manhole	1	LS	15,000.00	15,000.00
24 – Toe Drain Pipe	525	LF	100.00	52,500.00
25 – Instrumentation	1	LS	15,000.00	15,000.00
26 – Seeding	9	Acre	2,500.00	22,500.00
27 – All Other Work Not Listed Separately	1	LS	95,000.00	95,000.00
Direct Construction Subtotal (DCS)				1,316,175.00
Construction Engineering and Administration				260,000.00
Materials Testing				35,000.00
City Administration at 3 Percent of DCS				39,485.00
Construction Contingencies at 15 Percent of DCS				197,426.00
Opinion of Probable Construction Cost (OPCC, 2010)				**$1,848,086.00**

Please call if you have any questions or require additional information.

Sincerely,

RJH CONSULTANTS, INC.

Robert J. Huzjak, P.E.
Project Manager

RJH/jmm