CDM

In Association With:

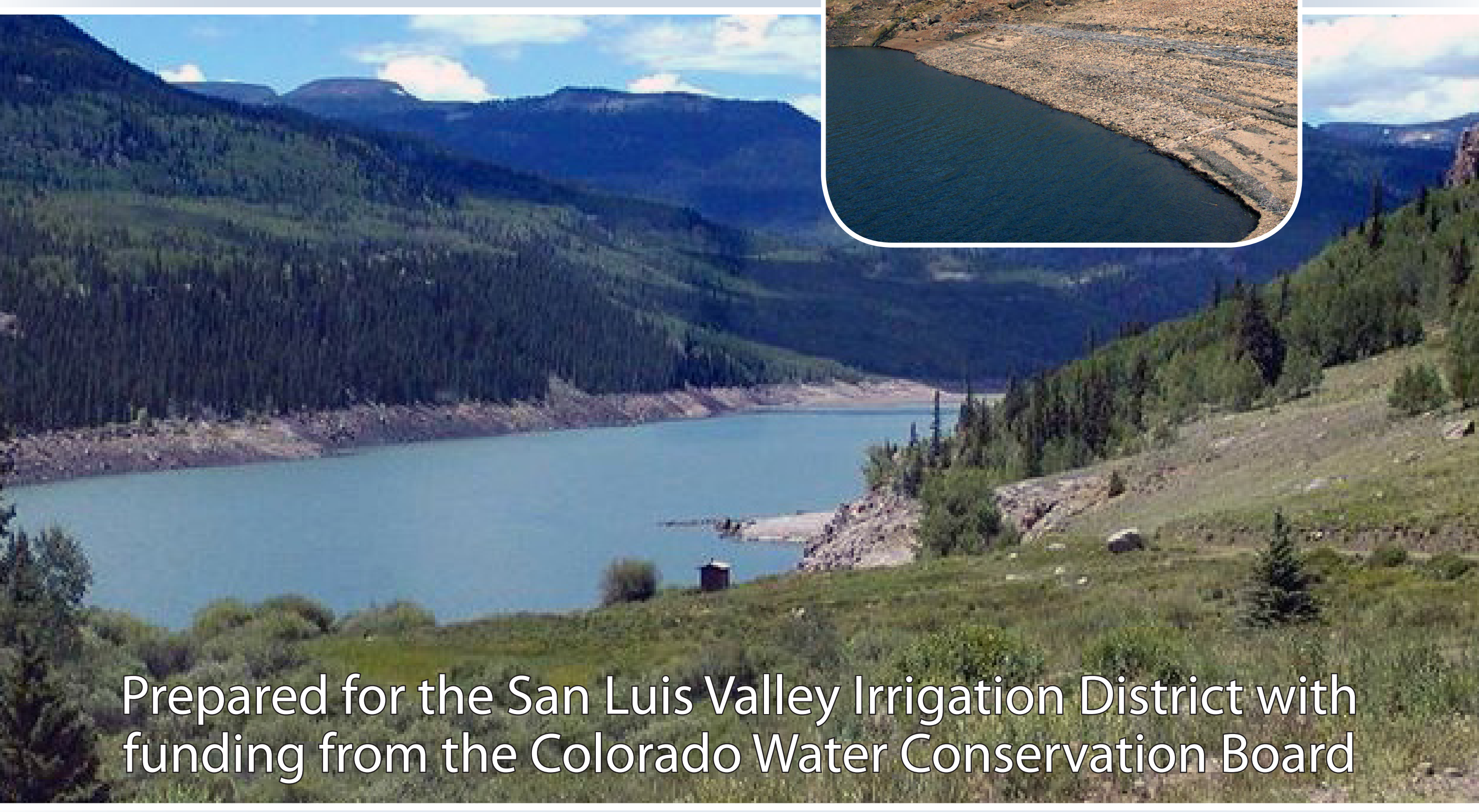
SUGNET & MOORE ENVIRONMENTAL, INC.

DEERE & AULT CONSULTANTS, INC.
Water Resources, Civil & Geotechnical Engineering

Rio Grande Reservoir

Multi-Use Rehabilitation and Enlargement Study Phase II

October 10, 2008



Prepared for the San Luis Valley Irrigation District with funding from the Colorado Water Conservation Board

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Section 1
Introduction

The San Luis Valley Irrigation District (District) serves and delivers water to land located in the San Luis Valley in Alamosa, Rio Grande, and Saguache Counties. Its office is located in Center, Colorado. The District diverts its water from the Rio Grande through the Farmers Union Canal. It also owns and operates Rio Grande Reservoir (Reservoir). The Reservoir is located on the headwaters of the Rio Grande in Hinsdale County, Colorado, with a storage capacity of approximately 54,000 acre-feet (AF). It provides a unique on-stream, pre-compact storage facility available to better manage Colorado's apportionment of water under the Rio Grande Compact (Compact) for the benefit of the State of Colorado (State), the San Luis Valley, and the river corridor.

This report, a follow up to the feasibility report (Phase I report) was funded by a grant from the Colorado Water Conservation Board (CWCB) through its Water Supply Reserve Account for 2007-2008. This report documents the findings of the study including analysis of the feasibility of rehabilitating and enlarging the Reservoir to better allocate storage for the management of Colorado's share of the Rio Grande and to address the growing multiple-use needs for water in the Rio Grande Basin (Basin) including:

- Providing storage space to assist the State in administration and management of the river under the Rio Grande Compact to maximize the beneficial use of Colorado's share of water under the Compact for the benefit of the State
- Providing space for the storage and regulation of transmountain water to meet the growing demand for augmentation water for municipal, domestic, and commercial development in the Basin
- Providing storage space to the Colorado Division of Wildlife (DOW) for a conservation pool and the storage of its transmountain water to better meet the Division's water demands throughout the Basin
- Storage and regulation of decreed direct flow storage, to better meet irrigation demands
- Re-regulation of flows to better meet recreational and environmental needs
- Re-regulation of flows for flood protection

A pool in the Reservoir for the storage of Compact water will provide the State of Colorado with a tool to better manage, retain, and utilize the State's share of Rio Grande water while assuring that the State meets its water delivery obligations under the Compact at the Colorado-New Mexico border. The storage and re-regulation of the delivery of Compact water to the state border can help to enhance instream flows for fish and riparian habitat particularly at low flow periods late in the irrigation season and during the winter. It will also provide the State Engineer with a tool to help reduce the wide fluctuation in curtailments – the percentage reduction in the flow available at the Del Norte gage allocated for diversion to assure Colorado meets its water delivery obligations to the New Mexico border. This will provide irrigators with a more consistent water supply during the irrigation season while assuring that Colorado has stored a sufficient amount of water that, if needed, can be released to meet any remaining Compact obligation after the irrigation season ends. Proper accounting of stored Compact water, particularly if there is a surplus pool at the end of the year, will be required. While storing Compact water will not yield a surplus every year, the Compact pool at the Reservoir provides a buffer against the uncertainties inherent in streamflow forecasting, summer and fall precipitation and runoff patterns. Transmountain water stored by DOW and by the San Luis Valley Water Conservancy District may also be re-regulated and delivered at times better suited to enhance instream flows. Enlargement to store new water supplies for irrigation is not being considered because previous studies have concluded that there is insufficient firm yield available for this purpose.

Recommendations from Phase I of this study were implemented in this report. These recommendations included:

- Generate a preliminary design of dam rehabilitation and enlargement options. Preliminary design should include the key reservoir facilities including dam embankment, seepage reduction, outlet works, and spillway (Section 5 of this report).

- Undertake further geological and geotechnical investigation of the Reservoir site and West Lost Trail Creek landslide, including seepage, slope stability analyses (Section 6 of this report).

- Perform spillway sizing for both the rehabilitation and enlargement options. The State's Extreme Precipitation Analysis Tool (EPAT) should be used to generate a design storm. Reservoir inflows and outflows should be routed through the Basin and Reservoir using a HEC-HMS model, including modeling of the spillway chute (Section 7 of this report).

- A water use model should be developed to address possible changes in operation and reallocation of storage in the Reservoir. This should include potential impacts on Compact administration, augmentation water storage, environmental and recreational flows, and water rights. Additionally, the hydropower analysis from Phase I was revisited in light of Governor Ritter's interest in developing sustainable power supplies in Colorado. Evaluate and use data from the Rio Grande Decision Support System (RGDSS) where appropriate (Section 8 of this report).

- Perform a detailed wetlands investigation, including a formal wetlands delineation in accordance with U.S. Army Corps of Engineers (USACE) standards, wetland mitigation plan, cultural resources report, and evaluation of the potential impact on endangered species (Section 9 of this report).

- Further legal analysis should be performed to finalize several issues, including any impacts to the 1891 Right-of-Way, the Forest Service's instream flow decree, the CWCB's instream flow right on tributaries to the Reservoir, and potential legal issues associated with the National Environmental Policy Act (NEPA) process (Section 10 of this report).

- Draft preliminary storage agreements pursuant to discussions with other entities including the Colorado Division of Water Resources (DWR), the DOW, and the San Luis Valley Water Conservancy District (Section 11 of this report).

Preliminary design drawings and model documentation are provided as appendices to this report.

The scope of this Phase II study included addressing issues and generating preliminary designs for both the rehabilitation and enlargement options. During the course of the Phase II study, the District's Board of Director decided to pursue the rehabilitation only project due to concerns over the legal and regulatory issues involved in pursing the enlargement and the additional cost of the enlargement. The decision of the District's Board, however, does not preclude the possibility of pursing an enlargement in the future. Detailed analysis of the design, cost, and legal implications of both options are provided in this report and summarized in the Conclusions and Recommendations section.

Section 2
Background

Rio Grande Reservoir is located approximately 30 miles southwest of Creede, Colorado, as shown in Figure 2-1. The Reservoir is located on the headwaters of the mainstem of the Rio Grande and has a storage capacity of 54,082 AF. Although water from the Reservoir could be delivered via the Rio Grande mainstem for use in Hinsdale, Mineral, Alamosa, Rio Grande, Costilla, Conejos, and Saguache Counties, all of the water that is presently used is for irrigation and augmentation in Mineral, Rio Grande, and Alamosa Counties. The Reservoir is located at an altitude of approximately 9,500 feet, and has a drainage area of approximately 165 square miles. The two water storage rights for the Reservoir are 45,833 AF under Priority No. 1916-63A and 5,280 AF under Priority No. 1934-2 for a total of 51,113 AF (Helton and Williamsen 2003). Both of these water storage rights pre-date the Rio Grande Compact. Based on a capacity survey from November 1998 provided by the District, it was determined that the existing actual capacity of the Reservoir exceeds the District's decreed storage capacity by 2,969 AF. However, some of this excess may be diminished by sediment accumulation on the bottom of the Reservoir. For the purposes of this report, the Reservoir capacity will be approximated at 54,000 AF, but the District's storage is limited to the decreed amount in the storage model.

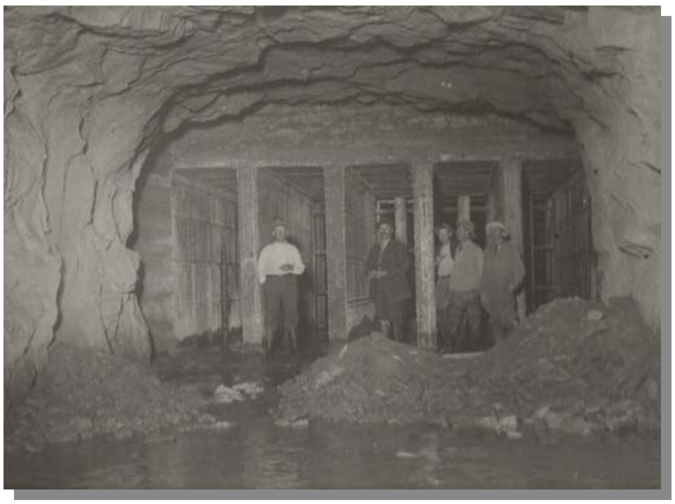

Photo courtesy San Luis Valley Irrigation District

The original outlet gates were damaged due to vibration and two were plugged with concrete.

Construction plans for the dam were submitted to the State Engineer's Office (SEO) in 1910 and construction was completed in 1914. The earthen and rockfill dam crest stood 100 feet above the river channel. The original outlet works as constructed in 1914 had five slide gates that almost immediately sustained severe damage due to vibration and erosion (Miller 2003). The gates were shortly thereafter repaired and two were permanently plugged with concrete.

The dam embankment and outlet works have been modified on several occasions since the initial construction. The spillway, which is 32 feet wide and 600 feet long, was excavated in rock and lined with concrete. Spillway capacity was increased in 1962 through the construction of a side channel ogee spillway weir (Deere & Ault 2006). The spillway was repaired in 1970 and again in 1972. In 1979, the dam crest was raised an additional 5 feet due to overtopping concerns given that year's large snowpack (Miller 2003). In 1982, the dam crest was raised to its current height of

111 feet, and the downstream slope of the dam was flattened from 1:1.5 to 1:2. The gate structures were repaired in 1983 and then again in 1987 to correct problems associated with the 1983 work. Continuing repairs to the outlet tunnel and gate chamber area have occurred since. The primary cause of the recurring repairs is that the original gate design of the early 20th century is antiquated and would not be used in a modern setting given the pressures and release rates required for the Reservoir (Miller 2003). The high pressures and release rates have caused extensive and recurring erosion to the outlet works chamber and structure.


Photo courtesy San Luis Valley Irrigation District

The emergency spillway in 1958.

The left abutment of the dam is a landslide from the mountain to the north of the dam. Seepage through the left abutment has been an issue since construction. To reduce seepage through the abutment, cutoff trenches up to 17 feet deep were cut across the valley floor up into the abutments during original construction. These trenches were filled with low permeability clay, and thin clay puddle was run into the left abutment in an attempt to seal off seepage paths. The entire left abutment was covered with this thin clay puddle during original construction (Engineering Record 1912).

The existing dam site and outlet works are shown in Figure 2-2. The capacity of the outlet works is the subject of continued discussion with the SEO. The DWR requires that the outlet works have a discharge capacity of 2,500 cubic feet per second (cfs); however, only about 1,200 cfs can currently be discharged before serious vibrations begin to occur (Deere & Ault 2006). These vibrations subside when flow reaches approximately 1,800 cfs. Additionally, the current spillway capacity is less than the previously calculated probable maximum flood (PMF). DWR has since developed the EPAT for mountainous basins. The spillway capacity has been analyzed using EPAT in this report (Section 7).

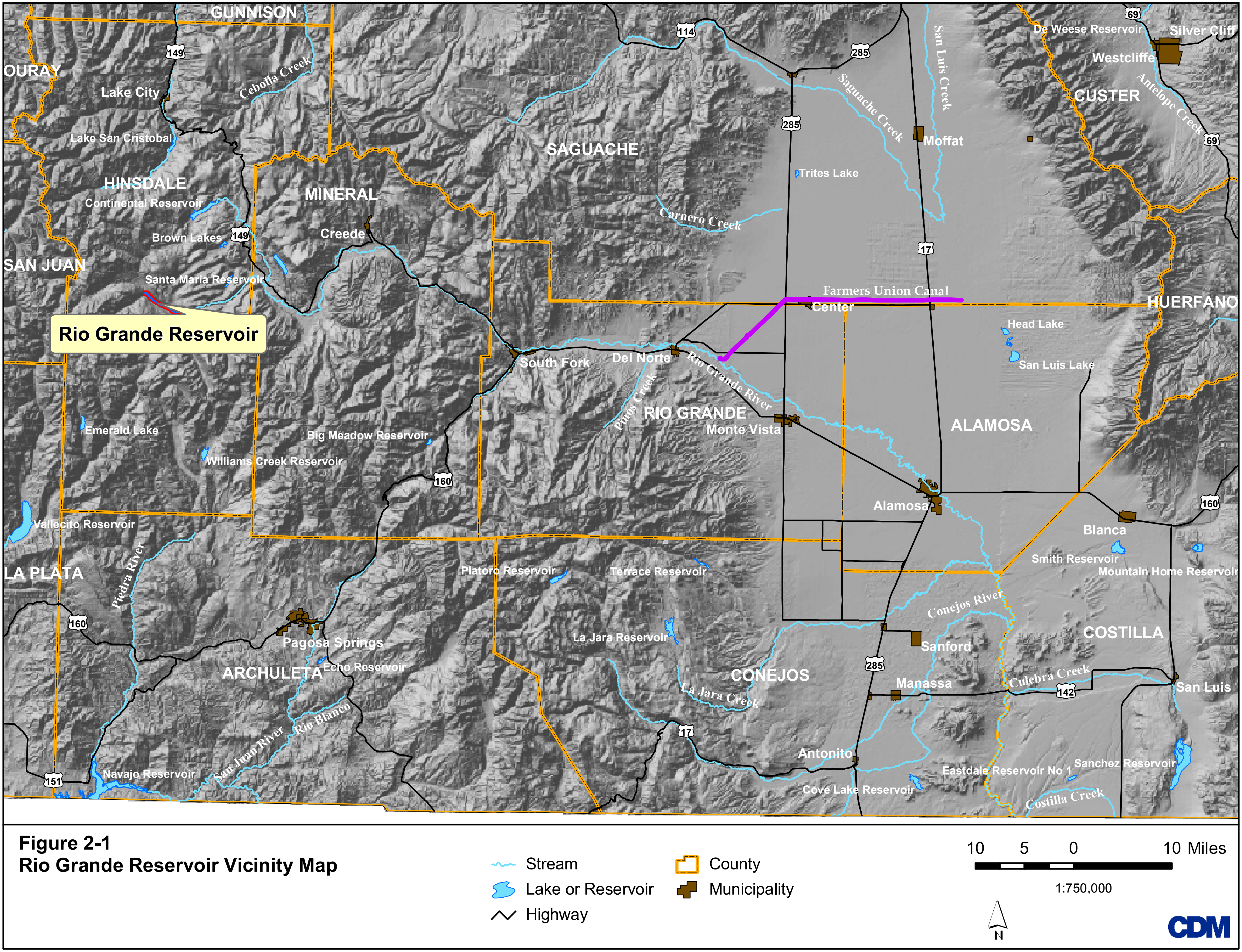

Figure 2-1
Rio Grande Reservoir Vicinity Map

Rio Grande Reservoir Existing Dam Site

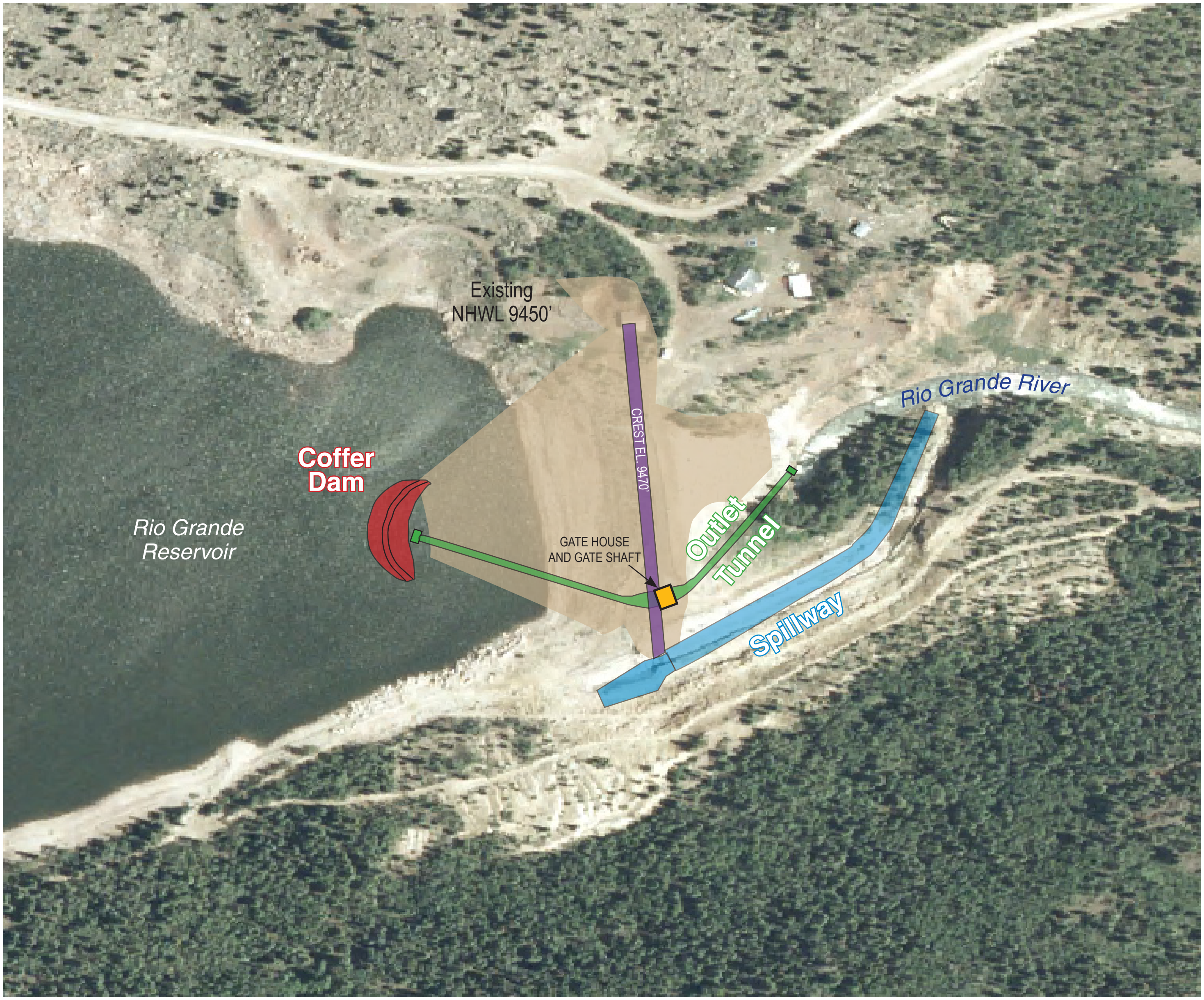

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FIGURE 2-2

Section 3
Potential Benefits of Rehabilitation or Enlargement

Many of the potential benefits of an enlarged Reservoir identified in Phase I of this study (Camp Dresser & McKee Inc. [CDM] 2007) were investigated in greater detail during this phase (see Sections 5 through 12). This investigation confirmed that many of the benefits achieved with an enlarged Reservoir can be achieved with a rehabilitated Reservoir with no increase in storage capacity. However, this will require that the District dedicate a portion of its existing storage space for use by other entities. Since the Reservoir is generally full for only short periods of time during periods of the highest inflows, a portion of the District's storage space can be allocated to other entities without (at most times) a significant loss in available water to the District's landowners.

Many of the objectives set out in the Statewide Water Supply Initiate (SWSI) Report (CDM 2004) can be achieved with either a rehabilitated or enlarged Reservoir. Additionally, at the time of the writing of this report, the CWCB is considering a draft "Policy 18" for the "application and approval process for use of investments and loans from the severance tax trust fund perpetual base account funding water management partnership projects and special dam rehabilitation projects." The draft sets forth the benefits a project should provide to qualify for funding. The rehabilitation or the enlargement of Rio Grande Reservoir provides nearly all of the benefits listed in the draft Policy 18. This section details the objectives and benefits that will be achieved if this project is funded and completed and storage agreements developed with various entities. Table 3-1 identifies the SWSI objectives that are met by the rehabilitation or enlargement of Rio Grande Reservoir. (The SWSI objectives identified here correspond with the project benefits set out in the draft Policy 18.) Several benefits listed and discussed below were further evaluated in the water use model discussed in Section 8.

Table 3-1 Benefits of Rehabilitation or Enlargement

	SWSI Objectives								
Enlargement Benefits	Sustainably Meet M&I Demands	Sustainably Meet Agricultural Demands	Optimize Existing and Future Water Supplies	Enhance Recreational Opportunities	Provide for Environmental Enhancement	Promote Cost Effectiveness	Protect Cultural Values	Provide for Operational Flexibility	Comply with All Applicable Laws, Regulations, and Water Rights
Provide flexibility to store water used for Compact administration	✓	✓	✓			✓		✓	✓
Reduce fluctuations in curtailments	✓	✓	✓			✓		✓	✓

Table 3-1 Benefits of Rehabilitation or Enlargement

	SWSI Objectives								
Enlargement Benefits	**Sustainably Meet M&I Demands**	**Sustainably Meet Agricultural Demands**	**Optimize Existing and Future Water Supplies**	**Enhance Recreational Opportunities**	**Provide for Environmental Enhancement**	**Promote Cost Effectiveness**	**Protect Cultural Values**	**Provide for Operational Flexibility**	**Comply with All Applicable Laws, Regulations, and Water Rights**
Deliver water at periods of low-flow reducing conveyance losses	✓	✓	✓			✓	✓	✓	✓
Deliver water later in season following more definite annual flow projections	✓	✓	✓			✓		✓	✓
Storage of credit water upstream with reduced evaporation charges	✓	✓	✓			✓		✓	✓
Storage of additional transmountain water	✓	✓	✓			✓	✓	✓	✓
Meet rapidly growing demand for augmentation water	✓	✓	✓				✓		✓
Preserve existing agricultural lands		✓	✓				✓		✓
Storage and release of water for environmental and riparian enhancements				✓	✓		✓	✓	✓
Re-regulation of flows for recreational purposes				✓	✓	✓	✓	✓	✓
Permanent conservation pool				✓	✓		✓		✓

3.1 Optimize Rio Grande Compact Administration and River Management

Storage space allocated for Compact storage will provide the State of Colorado the opportunity to store Compact water at times determined appropriate by the Division Engineer for release later in the year or in subsequent years once Colorado's delivery obligation can be determined with more certainty. If needed, that water can be released late in the irrigation season and/or during the winter months, providing increased instream flows during historically low flow periods, benefitting fish, other

riparian needs, and recreation uses. Winter time releases are difficult to alter once icing begins to occur, so flows set in the late fall would continue through to the spring. This problem is further addressed in Section 8 through the Reservoir operation model. The rehabilitated outlet works, with a new pressurized tunnel, will allow the safe, controlled release of Compact water from the Reservoir ranging from very low to high flow rates. If Compact water is not needed during the year in which it is stored, it can be held over to either provide early deliveries prior to the following irrigation season, which again provides enhanced environmental benefits, or utilized for other purposes at the discretion of the Division Engineer. The ability to regulate and manage Compact water in this manner will help to assure that Colorado retains for use in Colorado its apportionment of the Rio Grande water in compliance with the Compact. Additionally, having storage space available will allow the Division Engineer to better manage the fluctuations in the curtailments that result from widely varying monthly flow projections that are presently used to estimate the State's Compact delivery requirements. Those fluctuating curtailments have often reduced the flow available for diversion during the peak of the runoff, thereby reducing or eliminating diversions by more junior water rights. Having storage space available can provide the Division Engineer with additional flexibility to maintain a fixed or less variable curtailment during the rising and peak flows, providing a buffer against uncertainty in runoff predictions. Under certain hydrologic conditions, this may provide a more consistent water supply to a greater number of irrigators and assuring that water users are able to divert and beneficially use Colorado's full entitlement when it is most beneficial. Further details on Compact administration options are provided and modeled in Section 8.

3.2 Regulation of Transmountain Water to Meet Domestic, Commercial, Fish, and Wildlife Demand in the Rio Grande Basin

The Reservoir is situated at the headwaters of the Rio Grande and transmountain deliveries owned by the San Luis Valley Water Conservancy District and the DOW flow into and through, or are exchanged into the Reservoir and have been stored in the Reservoir under temporary storage agreements. Transmountain water is not subject to the terms of the Compact and is fully consumable in the Basin.

Providing a long-term storage agreement with the Conservancy District will allow it to meet its annual delivery obligations under its Augmentation Program, which facilitates and meets the rapidly increasing demand for augmentation of the depletions resulting from domestic and related commercial development throughout its service area in the Basin. The Conservancy District will utilize storage in the Reservoir to meet obligations even in drought years when its transbasin and/or converted native water rights do not yield sufficiently. It also will facilitate the Conservancy District's role as the principal provider of augmentation water throughout the Basin, thereby reducing the need for a multitude of single-entity augmentation plans and simplifying administration. Finally, to the extent needed to replace downstream depletions occurring during the non-irrigation season, the Conservancy District's transmountain water may be released from a rehabilitated Reservoir in small increments that will add to the instream flows during low flow periods.

The DOW also has stored transmountain water in the Reservoir. Through a long-term agreement, this water can be utilized to provide a permanent conservation pool in the Reservoir for fish and recreation purposes. A storage agreement could also provide DOW with space to store additional transmountain water assisting the DOW in fully exercising its water rights and providing the maximum environmental and recreational benefits. The DOW's transmountain water is subsequently delivered to DOW fish and wildlife habitat areas and agricultural users throughout the Basin. There is the possibility of making some of those deliveries at times when it will provide better fish and riparian habitat benefits as it flows down the river to various points of diversion in the San Luis Valley.

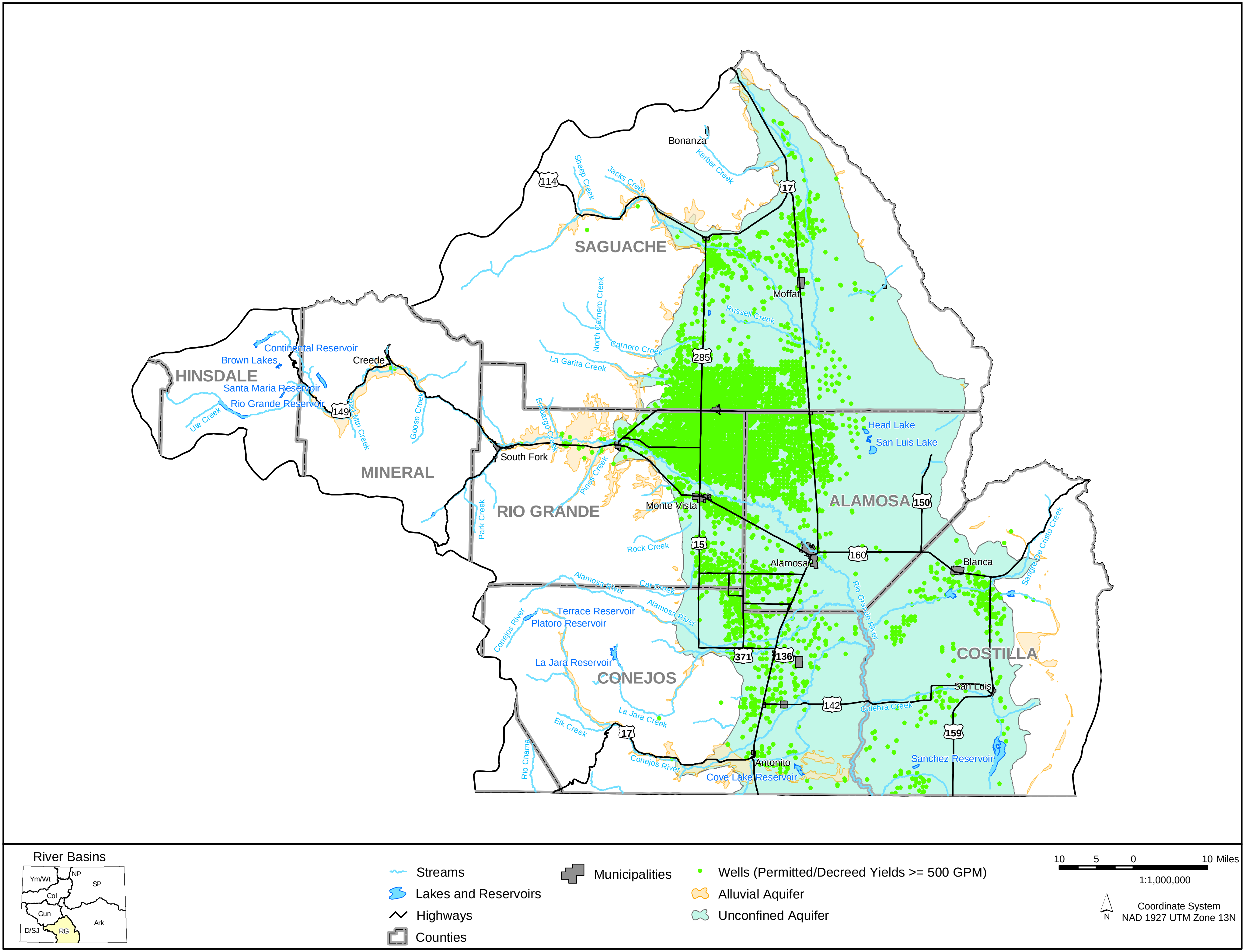
3.3 Storage for Groundwater Augmentation

As discussed in the SWSI Report, in recent years there have been substantial declines in the groundwater levels in the unconfined aquifer of the Closed Basin. The location of the unconfined aquifer is shown in Figure 3-1. Storage in the Reservoir could provide regulation of supplies that can be utilized to replenish and augment withdrawals from the groundwater aquifer, including water rights decreed for direct flow storage. Water rights acquired by Groundwater Subdistrict No. 1 could be stored as suits the needs of the Subdistrict, potentially reducing the number of acres of agricultural land that may have to be taken out of production in the San Luis Valley because of the limited groundwater water supply and amount and timing of augmentation requirements.

3.4 Storage and Flow Regulation for Environmental and Recreational Purposes

In coordination with the other benefits of a rehabilitated or enlarged Reservoir, reregulated releases of water stored in the Reservoir by multiple entities can be used, without impairing existing water rights, to enhance streamflows along the main channel of the river as well as addressing riparian needs and riparian restoration. While deliveries from many of such entities may not reach the State line, releases may indirectly provide benefits for instream environmental purposes for large stream reaches without impacting existing water rights. The water allocation model developed for this study illustrates the potential flow benefits of retiming these releases (Section 8)

Recreational uses of the river are rapidly increasing, particularly from the headwaters downstream to South Fork, which provides a world class fishery and Class III and IV rapids for rafting and kayaking. Regulation of water delivered from the Reservoir for meeting Compact delivery obligations and the delivery of irrigation water by the District can, at times, be re-timed and coordinated to enhance flows for recreational purposes without impacting existing water rights.



SAGUACHE
HINSDALE
MINERAL
RIO GRANDE
ALAMOSA
CONEJOS
COSTILLA
Bonanza
Moffat
Creede
South Fork
Monte Vista
Alamosa
Blanca
San Luis
Antonito
Continental Reservoir
Brown Lakes
Santa Maria Reservoir
Rio Grande Reservoir
Head Lake
San Luis Lake
Terrace Reservoir
Platoro Reservoir
La Jara Reservoir
Sanchez Reservoir
Cove Lake Reservoir
Kerber Creek
Sheep Creek
Jacks Creek
North Carnero Creek
Carnero Creek
La Garita Creek
Russell Creek
Ute Creek
Red Mtn Creek
Goose Creek
Embargo Creek
Pinos Creek
Park Creek
Rock Creek
Alamosa River
Cat Creek
Conejos River
La Jara Creek
Elk Creek
Rio Chama
Rio Grande River
Culebra Creek
Sangre De Cristo Creek
114
17
285
149
150
160
15
371
136
142
159
River Basins
Ym/Wt
NP
SP
Col
Gun
Ark
D/SJ
RG
Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Unconfined Aquifer
10 5 0 10 Miles
1:1,000,000
N
Coordinate System
NAD 1927 UTM Zone 13N

Section 4
Stakeholder Involvement

A rehabilitated or enlarged Reservoir will benefit a variety of stakeholders with water related interests within the Basin. Key stakeholders were informed and consulted during the study. During the initial phase of the study in early August 2006, over 40 interested persons and stakeholders visited the Reservoir, including representatives from the U.S. Forest Service (USFS), Colorado Division Engineer, water users, elected officials, landowners, environmental, and recreational interests in the Basin. The site visit was followed by a presentation of the study's purposes and goals to the Rio Grande Basin Roundtable (RGBRT), which includes a variety of environmental, recreational, agricultural, municipal, and industrial water interests throughout the Basin. A follow-up presentation was made on January 8, 2007, in which the initial results of the study were presented to the RGBRT and the participants provided additional input and discussed the work that would be required to complete the second phase of the study. The RGBRT unanimously approved submission of an application for a grant from the State's Water Supply Reserve Account funds for the second phase of study (this report).

Photo courtesy of Rio de la Vista

Reservoir site visit August 2008

Throughout the course of the second phase of the study, the project team has had additional meetings with the USFS, Division 3 Engineer's Office, Conservancy District, DOW, Senator Ken Salazar's Office, Congressman John Salazar's Office, and the CWCB. The District's superintendent and its Board president presented the first phase findings to the State Legislative Water Resources Committee in January 2008. A site visit with several environmental interests was held on August 11, 2008, and included representatives from The Nature Conservancy, Trout Unlimited, and members of the environmental subcommittee of the RGBRT.

During the course of the study, the project team met with representatives of the following stakeholder/interest groups:

- San Luis Valley Water Conservancy District
- Colorado Division of Wildlife
- Rio Grande Water Users Association
- Rio Grande Water Conservation District
- Colorado Division of Water Resources,
  - State Engineer's Office Staff
  - Division Engineer, Water Division No. 3

- Colorado Water Conservations Board
- Rio Grande Basin Roundtable
- United States Forest Service
- The Nature Conservancy
- Trout Unlimited
- Environmental Subcommittee members of the RGBRT
- Town of South Fork
- Rio Grande/Rio Bravo Basin Coalition and Colorado Rio Grande Headwaters Foundation
- San Luis Valley Wetlands Focus Area Committee
- Entz Farms
- U.S. Senator Ken Salazar's Office
- U.S. Representative John Salazar's Office
- Colorado State University Cooperative Extension
- Creede America Group
- Broad Acres Ranch
- Colorado Legislature Water Resources Committee

Reservoir site visit August 2006

Photo courtesy of Rio de la Vista

Reservoir site visit August 2008

Section 5
Preliminary Design

This section presents the preliminary design for the rehabilitation and enlargement of the Rio Grande Reservoir. The preliminary design of the dam embankment and outlet works was conducted by Deere & Ault Consultants and large portions of this section are taken from their design report (Deere & Ault 2008). The preliminary design of the spillway structure was completed by CDM. Geotechnical investigation to support the dam embankment design can be found in Section 6. Hydrologic and hydraulic analysis and modeling to support the spillway design modifications can be found in Section 7. The rehabilitation will allow for the Reservoir to be safely operated at higher storage stages that can be carried over from one year to the next by addressing seepage issues and correcting the existing outlet works problems. A rehabilitation and enlargement will provide an additional 11,000 AF of storage capacity, as well as carry-over storage. The spillway improvements will safely pass the inflow design flood (IDF).

Preliminary design plans for embankment improvements, seepage control, and outlet works are presented in Appendix A. Preliminary design plans for spillway structure improvements are presented in Appendix B. These plan sheets are based on survey data from plan sets prepared for previous reservoir repairs, and some survey discrepancies exist. For the purposes of this report and the preliminary plans, the dam crest is assumed to be elevation 9,470 feet (gage height 111 feet) and the spillway crest at elevation 9,450 feet (gage height 91 feet). Future design studies will require a complete survey of the dam and appurtenant structures.

5.1 Existing Conditions and Problems

The Reservoir is a 111-foot high earth and rockfill dam that lies in a narrow valley of the Rio Grande at a river elevation of approximately 9,360 feet. The dam has a crest elevation of approximately 9,470 feet at gage height 111. A plan, profile, and section of the dam are presented on sheets 1 and 2 of Appendix A. A detailed drawing of the existing spillway structure is presented on sheet C-1 in Appendix B. The capacity of the Reservoir is approximately 54,000 AF at the spillway gage height of 91 feet.

5.1.1 Embankment and Seepage

The dam embankment contains two primary zones. The water barrier is provided by the upstream earthfill zone (Zone 1) constructed from approximately 1909 through 1913. This zone was constructed partially as a hydraulic puddle fill using the basin and embankment method (Engineering Record 1912). Data from Chen (1983) indicate this material is a clayey and silty sand. The downstream zone (Zone 2) consists of a dumped rockfill section completed during the original construction and a compacted rockfill section constructed in 1983. The upstream slope is 4:1 (horizontal to vertical) and the downstream slope is 2:1. Nearly all modern dams over 100 feet high on rock and permeable foundations contain a low permeability grout curtain. Rio Grande

Reservoir does not have a grout curtain, as this technology was not available at the time of construction of the dam.

There are two sets of drains that collect seepage from the Reservoir. Eight-inch diameter polyvinyl chloride (PVC) drains were installed under the downstream rockfill raise in 1983. Horizontal drilled slope drains were installed in the left abutment in 1993. When the water level in the Reservoir is high, there is a significant amount of seepage through the abutments and the dam embankment. Seepage as high as 2,500 gallons per minute (gpm) has been recorded. Further details are provided in Section 6.

5.1.2 Outlet Works

The outlet tunnel is an unlined 11-foot high by 15-foot wide rock tunnel that curves through the right abutment. Three gates mounted near the dam centerline are controlled via a gate house and gate shaft. The unlined intake tunnel upstream of the centerline gates is pressurized. Since the dam embankment has no core but rather an upstream sloping earthfill low permeability barrier, there is the potential for a short circuit of water through the right abutment from the tunnel through fractures in the bedrock.

The hydraulics of the existing outlet gates and downstream tunnel have never operated as designed. Engineering Record (1912) quotes a capacity of 5,500 cfs and the actual capacity is less than half of that flow rate. The existing guard gates are not considered functional (Passage 2008). Up to 1,800 cfs can be discharged when the tunnel downstream of the gates flows under gravity conditions. The transition to downstream pressurized flow at flow rates between 1,200 and 1,800 cfs results in severe hydraulic surging and intense vibration that reportedly can be felt on the dam crest (Miller 2003). The Reservoir currently operates under an agreement with the State Engineer restricting the release rates due to safety concerns. It is believed that under full pressurized flow the capacity of the tunnel under full reservoir head is about 2,500 cfs.

5.1.3 Spillway Structure

The spillway structure is a side channel, ogee weir that spills into a large concrete trough. There is a secondary controlling weir that leads to the spillway chute. The controlling weir is 32 feet wide and is located at the base of two bridge piers that appear to have supported a bridge spanning the spillway chute at some time. There is no longer a bridge there. The spillway chute is an approximately 600-foot long channel excavated in rock and lined with concrete. The chute is 32 feet wide where it meets the trough and narrows to approximately 20 feet at the downstream end. Photographs of the spillway chute show cracking and spalling that appear to be superficial.

The current spillway structure is not sufficient to pass the IDF within the existing spillway channel. Under IDF conditions, the water surface elevation will overtop the existing bridge piers adjacent to the spillway and the spillway chute. Overtopping the existing bridge piers could result in erosion of the dam embankment potentially leading to dam failure. Overtopping of the spillway chute may undercut the spillway chute, causing erosion around the chute, leading to cracking and shifting. It should be noted that the IDF does not account for outlet capacity of the dam per policy of the State Engineer. If the full estimated existing outlet capacity of 2,500 cfs were considered, the existing spillway would be sufficient to pass the IDF, but would likely lead to significant scour, erosion, and damage to the spillway chute on the south side of the structure. Further details are provided in Section 7.

5.2 Dam Rehabilitation

The rehabilitation only option has three key components: improved outlet works, seepage control, and spillway modifications. The designs proposed in this report are intended to provide a safe and fully functional reservoir for the next century. Drawings of the dam rehabilitation are shown on sheets 3 and 4 in Appendix A and sheets C-2, CD-1, and CD-3 of Appendix B. Further details on the design recommendations can be found in Chapter 6 for the seepage control and outlet works, and Chapter 7 for the spillway structure recommendations.

5.2.1 Seepage Control

Seepage control in an earthen dam is important to prevent piping failure and sliding failures of embankments and abutments. Although seepage appears to be controlled by drains under the existing reservoir operations, a change in operation to longer periods of full storage could change the phreatic surface and result in increased seepage. A grout curtain is proposed to reduce the seepage, and is shown on Sheet 3 in Appendix A.

The proposed grout curtain in the right abutment will be a conventional permeation grout curtain in the rock. Primary holes will be drilled at 40-foot centers and injected under pressure in 20-foot stages with a stable mix of cement, water, and super plasticizer. After the primary holes are grouted, secondary holes will be drilled and grouted between the primary holes. Any secondary holes with high grout takes will be supplemented with tertiary holes on either side. For clarity, only primary holes are shown on Sheet 3 in Appendix A.

Grouting of the left abutment rock slide, the primary seepage concern, may require other specialized techniques. At this level of preliminary design, the proposal is to use a single row of jet grouted columns. Jet grouting performs deep soil mixing with cement to form a treated column about 3 feet in diameter. Thus, jet grouting requires drilling holes on very close centers. The jet grouting may have to be supplemented with an additional pass of conventional permeation grouting to seal off flow between and underneath the columns. A test grouting section should be conducted on the left abutment with both permeation grouting and jet grouting prior to final design to evaluate the success of each technique.

During final design, other methods for seepage control in the left abutment should be evaluated. This could include a clay or synthetic liner to act as a blanket. Placement of a synthetic liner on the upstream face of the dam to reduce seepage through the dam and reduce piping potential should also be evaluated. This is also proposed for the enlargement as discussed in Section 5.3.1.

5.2.2 Outlet Works for Rehabilitation

As discussed above, the existing intake tunnel and outlet gates are in need of repair. The unlined, fully pressurized intake tunnel above the gate chamber has the potential to short circuit water through the right abutment. At this level of preliminary design, the proposal is to use a simple 4-inch thick fiber-reinforced shotcrete liner in the upstream tunnel. A micro-silica or silica-fume admixture for high strength, durability, and low permeability is recommended. The area of shotcrete treatment is shown on Sheet 4 in Appendix A.

In order to provide reliable operations, a new outlet gate system is proposed as shown on Sheet 4 in Appendix A. The proposed system is modern and reliable and has been utilized on several reservoirs in this country. An existing similar system is functional at Button Rock Dam built in 1968 for the City of Longmont, Colorado.

The preliminary design proposal is to modify the outlet works, bypassing the existing gate chamber, and provide flow control at the downstream end. The key to the hydraulics of this system is that the flow is fully pressurized until release of the water through a fixed cone valve at the end of the tunnel near the river. In the proposed design, a new tunnel approximately 700 feet in length will be constructed to bypass the existing gate chamber. Within this bypass, a gate chamber will be constructed to house two 5.5-foot diameter guard gates. The two 5.5-foot diameter intake pipes connect the inlet tunnel to the guard gate chamber through a concrete bulkhead and will be controlled by the two 5.5-foot diameter guard gates within the new gate chamber downstream of the bulkhead. Two gates are proposed because a single large gate is more difficult to procure and install. The guard gate chamber excavation will be supported by 10-foot long rock bolts on a 5-foot by 5-foot pattern and 6 inches of shotcrete. Access to the new gate chamber will be through the existing outlet tunnel and then through a cross-over tunnel. Downstream of the guard gate, approximately 550 feet of 9-foot diameter steel pipe within a new tunnel will be constructed and grouted in place. At the downstream end, the 9-foot diameter pipe will split into two 7-foot diameter pipes with a fixed cone valve (Howell-Bunger valves) on each pipe, housed in the discharge structure.

With only a single cone valve discharging, the maximum release will be approximately 1,700 cfs at a full reservoir head. With both cone valves operating, the combined maximum discharge will increase to approximately 2,500 cfs at a full reservoir head. These capacities rely solely on conveyance of outflow through the new gate chamber and new fixed cone valves. The existing gate chamber and downstream tunnel remain intact and can be used to bypass flows in excess of 2,500 cfs and in emergency situations. To prevent flooding of the new gate chamber when the existing outlet tunnel is in operation, it may be desirable to install a bulkhead doorway within the cross-over tunnel. The old outlet combined with the new outlet will provide a total release capacity of approximately 4,300 cfs.

In correspondence from James T. Passage to the State Engineer Hal Simpson dated September 21, 1998, the State requested a minimum outlet capacity of 2,500 cfs. The State determined that a release capacity of 2,544 cfs is required to release the top 5 feet of reservoir storage within 5 days while passing the historical inflow. The top 5 feet of the existing Reservoir contains a storage volume of approximately 5,319 AF. Over 5 days, this storage volume would have to be released at an average flow rate of 536 cfs. With the proposed rehabilitated outlet, the emergency drawdown can be achieved while also passing a reservoir inflow of approximately 2,000 cfs without using the existing outlet tunnel. Using the existing outlet tunnel in conjunction with the proposed rehabilitated outlet will allow for the emergency drawdown and will also pass a reservoir inflow of approximately 3,800 cfs.

5.2.3 Spillway Improvements for Rehabilitation

The hydrologic and hydraulic modeling (see Section 7) indicate that the existing spillway structure is insufficient to safely pass the IDF as required for a high hazard dam. The preliminary design drawings for the rehabilitated spillway are shown in Appendix B, sheets C-2, CD-1, and CD-3. At this level of preliminary design, rehabilitation of the spillway structure to safely pass the IDF will involve the following enhancements:

1. Structural and cosmetic repairs on the existing ogee spillway will be performed. Based on recent photographs, the existing spillway appears to have surficial cracking and spalling. It is unknown at this time the extent and severity of the cracks and spalls; however, it was assumed that the structural integrity of the spillway has not been compromised. Further site investigation and structural analysis during the final design process needs to be performed in order to properly assess the spillway integrity, including the compressive strength of the concrete.

2. Both existing bridge abutments will be raised by 5.50 feet to gage height 104. The approximate maximum water surface elevation is gage height 102.0 under IDF conditions. Further site investigation and structural analysis needs to be performed in order to properly buttress the main wall against water loads during the final design stages. Drain pipes will be installed at the walls to avoid hydrostatic pressure build-up.

3. A training wall on the left bridge abutment will be constructed with a top elevation of gage height 104. The training wall will direct flow into the side channel spillway and will stop water from overtopping the bridge piers near the upstream end of the spillway. The training wall will be extended both vertically

and laterally into the crest of the dam. This wall as designed will not be sufficient in the enlargement option. The cost of upgrading this wall to function for both the rehabilitation and enlargement options is larger than the cost of demolition and reconstruction of the enlargement option training wall, should an enlargement occur after the rehabilitation.

4. The height of the spillway side wall on the south end of the spillway trough will be increased by 9.50 feet to gage height 104.0. The IDF flow requires that the trough side wall be extended to prevent erosion up to elevation 104.0. A 5-foot bench will be constructed just above the current south trough wall and a slab sloping at 1:1 will be constructed above the bench to gage height 104.0.

5. The height of the spillway chute walls will be increased by 4 feet the entire length of the chute, an approximate distance of 600 feet. During final design, after a new survey of the spillway chute has been performed, the spillway chute wall height may be evaluated further and may be reduced in certain sections of the chute if the water level is determined to decrease sufficiently. Chute wall extension will be cast 25-foot panels matching the existing expansion joint spacing using either fully supported or fully unsupported walls. The fully supported walls will be generally located on the mountain side (south side) of the chute, but may be used on the north side where the chute is cut deeply into the bedrock. Fully unsupported walls will be generally located on the river-side (north side) of the chute where the existing soils and rock extend only to the top of the existing wall. Bracing and reinforcement will be designed to support a future two foot raise in the chute walls should the Reservoir be enlarged at a later date.

5.3 Reservoir Enlargement

Enlarging the Reservoir will be accomplished by raising the spillway crest elevation by 10 feet, increasing storage capacity by approximately 11,000 AF. Drawings of the enlarged spillway plans are shown on sheets C-3, CD-2, and CD-3 in Appendix B. Enlarging the Reservoir will inundate federal lands that will trigger an environmental assessment. Section 6 addresses geologic and geotechnical issues associated with an enlarged Reservoir; Section 7 addresses the hydrologic and hydraulic issues; Section 9 addresses the potential wetlands impacts of an enlarged Reservoir; and Section 10 addresses legal issues associated with enlarging the Reservoir.

5.3.1 Dam Embankment for Enlargement

The dam embankment will be raised 10 feet by constructing a 10-foot downstream raise of the embankment. The dam crest will shift downstream approximately 100 feet. The downstream slope will be constructed of rockfill, and a well-graded gravel filter zone will be placed over all new foundation areas of the enlargement to reduce piping potential. Material for the enlargement, primarily rockfill, will be borrowed from the tunnel excavation and the rock slide within the reservoir area.

A synthetic liner will be placed on the upstream dam slope to reduce seepage through the embankment. Synthetic liners have been used successfully to reduce seepage on existing earth dams in Colorado (Johnson, et.al. 1997; Hatton and Johnson 1997). The design life of a non-exposed synthetic liner such as HDPE is predicted to exceed 200 years (Koerner and Hsuan 2003). The same grouting program of the foundations and abutments proposed in the rehabilitation only option will also be constructed for the enlargement option.

Recent meteorological and hydrological modeling (see Section 7) indicate that the IDF could be passed by the existing spillway with only approximately 10 feet of freeboard rather than the existing 20 feet. Thus, from a strictly hydraulic perspective, a dam raise is not required in order to raise the spillway crest 10 feet. However, there are other factors that should be considered before a reduction in freeboard is considered. The 20 feet of freeboard in the existing dam provides several dam safety benefits for a large reservoir in a large basin with significant downstream development. These include supplemental freeboard for waves that could be generated by a reservoir rim rockslide, clogging of the spillway from logs and other debris, and flood attenuation downstream of the dam. Thus, at this level of preliminary design, the proposal is to raise the spillway crest 10 feet and raise the dam embankment by 10 feet to preserve the 20 feet of existing freeboard. During final design of an enlargement, the safety factors and costs associated with maintaining 20 feet of freeboard should be re-evaluated

5.3.2 Outlet Works for Enlargement

In order to construct a downstream raise efficiently, the River should be diverted around the work area. This will be accomplished by constructing a new outlet tunnel that exits near the spillway chute terminus as described for the dam rehabilitation option (see Section 5.2.2 and Appendix A, sheets 5 and 6). In addition, a new upper level inlet tunnel would be constructed that will provide water quality and temperature control of reservoir releases. Pipe and tunnel sizing will be similar to the rehabilitation only option (Section 5.2.2). As in the rehabilitation only option, the outlet will contain a 9-foot diameter steel pipe that would allow pressurized release through two fixed cone valves at the downstream end. Using only one cone valve, the maximum release will be approximately 1,800 cfs; using both cone valves, the capacity will increase to 2,700 cfs.

Once the new tunnel is operational and able to divert the River around the work area, the dam raise and the old outlet tunnel extension can be constructed. As with the rehabilitation only option, the hydraulic capacities discussed above rely solely on conveyance of outflow through a new gate chamber and a new pipeline. Similar to the rehabilitation option, the existing gate chamber and downstream tunnel will remain intact and can be used to bypass flows greater than 2,700 cfs and in emergency situations if a bulkhead door is constructed in the cross-over tunnel. The old outlet will also be used to access the new gate chamber. The old outlet combined with the new outlet would provide a maximum total release capacity of approximately 5,200 cfs at a full reservoir head.

The top 5 feet of the enlarged reservoir contains a storage volume of approximately 5,000 AF. Over 5 days, this storage volume would have to be released at an average flow rate of 605 cfs. With the proposed new outlet, the emergency drawdown can be achieved while also passing a reservoir inflow of approximately 2,100 cfs without using the existing outlet tunnel. Using the existing outlet tunnel in conjunction with the proposed rehabilitated outlet will allow for the emergency drawdown and will also pass a reservoir inflow of approximately 4,600 cfs

5.3.3 Spillway Improvements for Enlargement

Enlargement of the Reservoir requires a new, raised spillway crest and rehabilitation of the existing spillway trough and chute. The Preliminary design drawings for the enlarged spillway are shown in Appendix B, sheets C-3, CD-2, and CD-3. At this level of preliminary design, the proposed construction of a new spillway and rehabilitation of the existing spillway structure to safely pass the IDF will involve the following:

1. Structural and cosmetic repairs on the existing ogee spillway will be performed as in the rehabilitation only option.

2. A new side channel spillway will be constructed. The new spillway will consist of a second "L-shaped" ogee weir approximately 135 feet long, with a new crest elevation at gage height 101. The new weir will wrap around the perimeter of the existing spillway weir. The existing downstream control weir will remain to control flow into the spillway chute and provide proper hydraulic conditions in the trough.

3. Both existing bridge abutments will be raised by 5.50 feet to gage height 104 as in the rehabilitation only option.

4. A new training wall on the left bridge abutment will be constructed to a gage height of 109.5 feet to direct flow into spillway and prevent water from circumventing the spillway weir to the east (maximum water level is 107.4 at the new spillway crest under IDF conditions). The training wall will be extended vertically and laterally into the crest of the dam to train the water over spillway. The foundation and seepage control requirements differ for the two training walls in the rehabilitation only and enlargement options and a retrofit of the rehabilitation training wall is not feasible with the current preliminary design.

5. The height of the spillway side wall on the south end of the spillway trough will be increased by 9.50 feet to gage height 104.0 as in the rehabilitation only option. Additional riprap will be installed above the top of the slap to prevent erosion near the crest of the raised spillway crest.

6. Increase the height of the spillway chute walls by 6 feet in a similar manner as described in the rehabilitation only option. Final design should incorporate bracing and reinforcement in the rehabilitation only option to support a 2-foot raise of the river-side walls should the rehabilitation option be constructed first and an enlargement at a later date.

5.4 Design Alternatives

The proposed new tunnel alignment shown on sheets 3 and 5 of Appendix A for the rehabilitation and enlargement options, respectively, simply presents a technically feasible alignment. This alignment provides for a portal away from the existing tunnel discharge and has sufficient rock cover over the tunnel and pillar width to the existing tunnel. Other alignments, either shorter or longer (for cost reduction or to address property ownership constraints) can be investigated during final design.

Refitting of the existing tunnel with new gates and a pressurized pipe was evaluated as well. This alternative presents problems due to the need to bypass river inflows during construction. For example, the gate repairs designed by Harza had to be constructed over a 2-year period in the winters of 1986 and 1987. River flows were temporarily stored during the day behind the cofferdam and then released every evening. The time required to demolish the existing gates and associated mass concrete and install the new gates and pipes would be extensive. Given the on-channel nature of the Reservoir, inflow rates, limited storage volume behind the cofferdam, and downstream water demands, this option is less desirable.

Other options for the enlarged spillway design should be evaluated during final design, including shortening the weir length. A shorter weir length would decrease flows through the chute, which would make chute wall extensions to 6 feet unnecessary, and the 4-foot walls from the rehabilitation option would suffice. The cost and constructability of a shorter weir can be investigated during final design.

5.5 Engineer's Opinion of Costs

Engineer's opinion of construction costs were prepared for the rehabilitation option and the enlarged dam option. The costs were developed from previous experience and bid tabulations for other construction projects inflated to January 2008 dollars. Gate and pipe material prices were provided from suppliers. The rehabilitation option costs are estimated as approximately $19.2 million dollars. Rehabilitation only costs are summarized on Table 5-1. The dam enlargement costs are estimated as approximately $33.9 million and are summarized on Table 5-2.

Table 5-1
Rio Grande Reservoir Rehabilitation
Engineer's Opinion of Costs - *DRAFT*

April 2008

	Construction Item	*Quantity*	*Unit*	*Cost*	*Extension*
1	**Mobilization (@5%)**	1	LS	$562,000	$562,000
				Subtotal	*$562,000*
2	**Dam Embankment**				
	a. Construct Coffer Dam	1	LS	$200,000	$200,000
	b. Foundation Grouting	1	LS	$400,000	$400,000
	c. Access for Grout Operations	1	LS	$50,000	$50,000
				Subtotal	*$650,000*
3	**Left Abutment**				
	a. Clearing/Grubbing/Stripping (for Grouting)	1	LS	$30,000	$30,000
	b. Jet Column Grouting	7,500	CY	$300	$2,250,000
				Subtotal	*$2,280,000*
4	**Outlet Works**				
	a. Construct New Outlet Tunnel with 9 ft. Diameter Steel Pipe	480	LF	$4,600	$2,208,000
	b. Construct New Lower Bypass Outlet and Cross Over Tunnel (11 ft by 15 ft.)	200	LF	$3,500	$700,000
	c. Gate Chamber	1	LS	$1,000,000	$1,000,000
	d. Existing Tunnel Rehabilitation (4 inch Shotcrete)	350	LF	$2,000	$700,000
	e. Gate Chamber Gates and Pipe Work	1	LS	$500,000	$500,000
	f. New Discharge Structure and Piping	1	LS	$1,500,000	$1,500,000
	g. Intake Structure with Bulkhead Gate	1	LS	$200,000	$200,000
				Subtotal	*$6,808,000*
5	**Spillway**				
	a. Concrete training wall, bridge pier abuttments and spillway trough improvements	1	LS	$220,000	$220,000
	b. Spillway chute wall extentions	1	LS	$590,000	$590,000
	c. Concrete Batch Plant	1	LS	$150,000	$150,000
				Subtotal	*$960,000*
6	**Miscellaneous**				
	a. Instrumentation	1	LS	$300,000	$300,000
	b. Seeding and Fertilizing	5	Acre	$8,000	$40,000
	c. Care of the River	1	LS	$200,000	$200,000
				Subtotal	*$540,000*
				Total Construction Items	**$11,800,000**
				Misc and Unlisted Items @ 5%	$590,000
				Permitting @ 5%	$590,000
				Engineering @ 15%	$1,770,000
				Subtotal	$14,750,000
				Contingency @ 30%	$4,430,000
				ESTIMATED TOTAL (rounded to nearest $100,000)	***$19,200,000***

Table 5-2
Rio Grande Reservoir Enlargement
Raise 10 feet
Engineer's Opinion of Costs - *DRAFT*

April 2008

	Construction Item	*Quantity*	*Unit*	*Cost*	*Extension*
1	**Mobilization (@5%)**	1	LS	$887,000	$887,000
				Subtotal	*$887,000*
2	**Dam Embankment**				
	a. Foundation Preparation (upstream)	10,000	CY	$10	$100,000
	b. Foundation Preparation (downstream)	10,000	CY	$15	$150,000
	c. Remove Existing Rip & Rip Rap bedding	15,000	CY	$4	$60,000
	d. Construct Coffer Dam	1	LS	$400,000	$400,000
	e. Foundation Grouting	1	LS	$400,000	$400,000
	f. Dam Rockfill (for Dam Raise)	115,000	CY	$8	$920,000
	g. Extend Existing Toe Drains	500	LF	$100	$50,000
	h. PVC bedding	5,000	CY	$20	$100,000
	i. PVC lining	100,000	SF	$4	$400,000
	j. Riprap bedding	5,000	CY	$25	$125,000
	k. Riprap	25,000	CY	$40	$1,000,000
	l. Crest Road (Paved)	670	LF	$100	$67,000
				Subtotal	*$3,772,000*
3	**Left Abutment**				
	a. Clearing/Grubbing/Stripping (for Grouting)	1	LS	$30,000	$30,000
	b. Jet Column Grouting	7,500	CY	$300	$2,250,000
	c. Extend existing drains	1	LS	$100,000	$100,000
				Subtotal	*$2,380,000*
4	**Outlet Works**				
	a. Construct New Outlet Tunnel with 9 ft. Diameter Steel Pipe	480	LF	$4,600	$2,208,000
	b. Construct New Lower Bypass Outlet and Cross Over Tunnel (11 ft by 15 ft.)	200	LF	$3,500	$700,000
	c. Gate Chamber	1	LS	$1,000,000	$1,000,000
	d. Existing Tunnel Rehabilitation (4 inch Shotcrete)	350	LF	$2,000	$700,000
	e. Gate Chamber Gates and Pipe Work	1	LS	$500,000	$500,000
	f. New Discharge Structure and Piping	1	LS	$1,500,000	$1,500,000
	g. Intake Structure with Bulkhead Gate	1	LS	$200,000	$200,000
	h. Construct New Upper Intake Tunnel (11ft by 11ft)	225	LF	$3,500	$787,500
	i. Existing Outlet Tunnel Extension	150	LF	$2,500	$375,000
	j. New Shaft Structure	1	LS	$600,000	$600,000
	k. Demo and Raise existing Outlet Building	1	LS	$500,000	$500,000
				Subtotal	*$9,070,500*
5	**Spillway**				
	a. Concrete training wall, bridge pier abuttments and spillway trough improvements	1	LS	$340,000	$340,000
	b. New Spillway Weir	1	LS	$560,000	$560,000
	c. Spillway chute wall extentions	1	LS	$670,000	$670,000
	d. Concrete Batch Plant	1	LS	$150,000	$150,000
				Subtotal	*$1,720,000*
6	**Miscellaneous**				
	a. Instrumentation	1	LS	$300,000	$300,000
	b. Seeding and Fertilizing	10	Acre	$8,000	$80,000
	c. Care of the River	1	LS	$200,000	$200,000
	d. Tree Removal Reservoir Perimeter	30	Acre	$7,500	$225,000
				Subtotal	*$805,000*
				Total Construction Items	**$18,634,500**
				Misc and Unlisted Items @ 5%	$930,000
				Permitting @ 20%	$3,730,000
				Engineering @ 15%	$2,800,000
				Subtotal	$26,094,500
				Contingency @ 30%	$7,830,000
				ESTIMATED TOTAL (rounded to nearest $100,000)	***$33,900,000***

Section 6
Geologic and Geotechnical Investigation

Phase I of this study recommended that the geology and geotechnical aspects of the Reservoir rehabilitation and enlargement options be investigated in further detail. Geologic mapping of the Reservoir site and a comparison with the geology in Upper West Lost Creek Trail landslide was performed. The Reservoir area landslide investigation was conducted independently by Mr. Robert Kirkham, P.G., C.P.G. (Kirkham 2008). Selected conclusions and recommendations from that report are presented in Section 6.1. Additionally, the geotechnical investigation, including seepage and stability analyses of the dam embankment and the surrounding rock formations, were performed by Deere & Ault Consultants, Inc. The seepage analysis and stability portions of their report (Deere & Ault 2008) are reproduced in Sections 6.2 and 6.3. The work performed for the geotechnical investigation was primarily a desk study. For example, no geotechnical borings or laboratory testing was performed and previously compiled data were analyzed. No surveying was conducted for this study, and the figures and plan sheets represent compilations of maps and survey data from previous work performed by others.

6.1 Geologic Investigation

View of the landslide area that forms the left abutment

Mr. Robert Kirkham, P.G., C.P.G performed geologic mapping of the Reservoir area and surrounding cliffs. He also compared the geology of the Upper West Lost Creek Trail landslide with the Reservoir geology to determine the likelihood of a similar catastrophic landslide falling into the Reservoir. Selected conclusions and recommendations from that report are presented below. Figure 6-1 is the geologic map of the Reservoir site from the Kirkham report (Kirkham 2008).

6.1.1 Selected Conclusions

- Landslides are widespread on the mountain slopes adjacent to the Rio Grande Reservoir. Most of these slope failures probably were moderate to slow moving, translational, and rotational slumps, slides, and block spreads. The rock slide that forms the left abutment of the dam is the only large landslide on the hill slopes adjoining the Reservoir that appears to have moved very rapidly or extremely rapidly. The lateral block spread, especially its southeast corner, is postulated as the most significant slope stability threat to the Reservoir.

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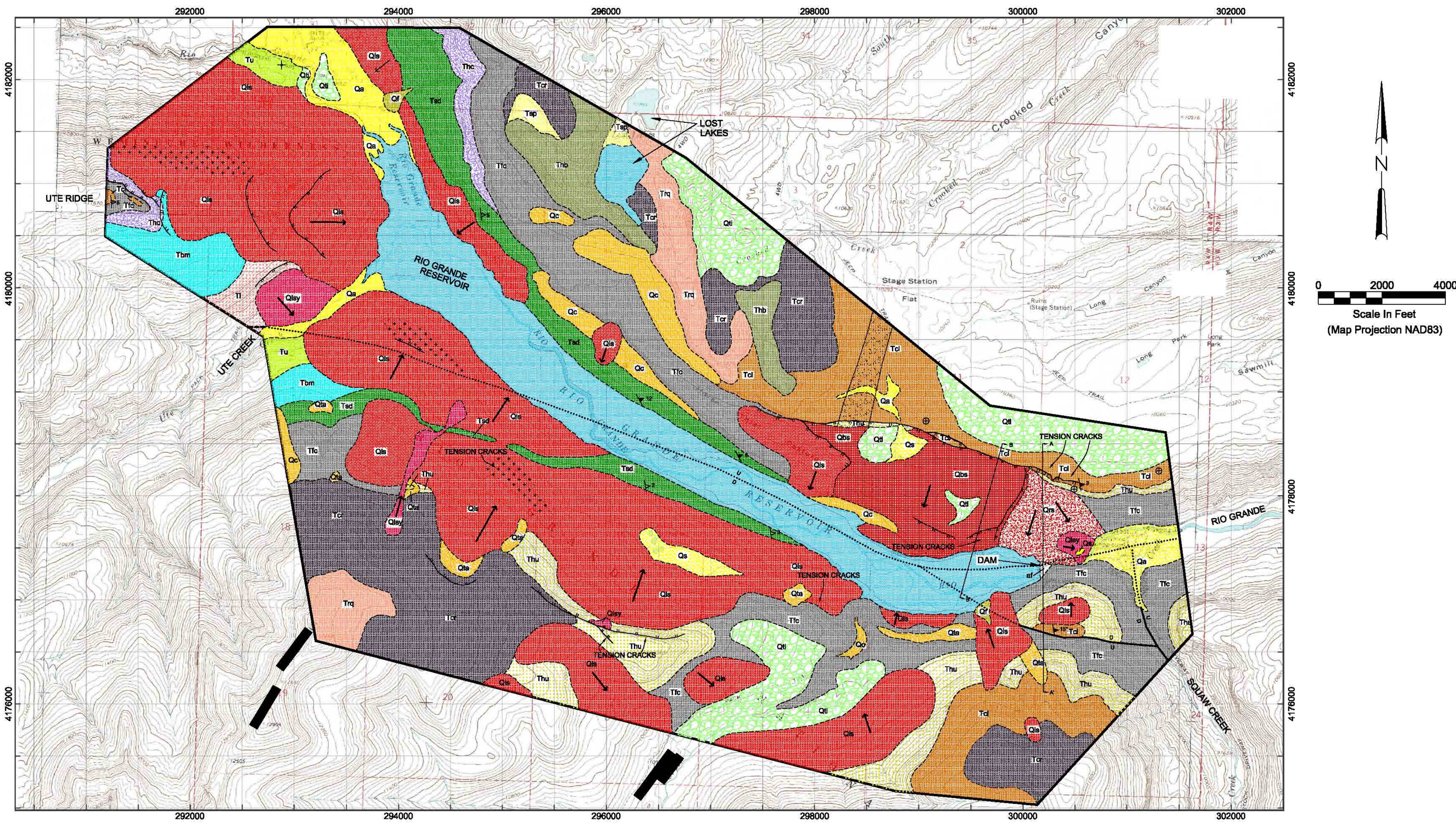

LEGEND

SURFICIAL DEPOSITS:

- af — ARTIFICIAL FILL (HISTORIC)
- Qf — FAN DEPOSITS (HOLOCENE)
- Qta — TALUS (HOLOCENE)
- Qlsy — YOUNG LANDSLIDE DEPOSITS (HOLOCENE)
- Qrs — ROCK SLIDE DEPOSITS (HOLOCENE OR LATEST PLEISTOCENE)
- Qs — SAG DEPOSITS (HOLOCENE & LATE PLEISTOCENE?)
- Qa — ALLUVIUM (HOLOCENE & LATE PLEISTOCENE)
- Qc — COLLUVIUM (HOLOCENE & LATE PLEISTOCENE)
- Qls — LANDSLIDE DEPOSITS (HOLOCENE & LATE PLEISTOCENE)
- Qbs — LATERAL BLOCK SPREAD DEPOSITS (LATE OR MIDDLE PLEISTOCENE)
- Qtl — GLACIAL TILL (LATE AND MIDDLE PLEISTOCENE)

BEDROCK:

- Thb — HINSDALE FORMATION (MIOCENE)
- Tsp — SUNSHINE PEAK TUFF (MIOCENE)
- Trq — QUARTZ LATITE FLOWS (OLIGOCENE)
- Tcr — CARPENTER RIDGE TUFF (MIOCENE)
- Tcl — CRYSTAL LAKE TUFF (OLIGOCENE)
- Thu — HUERTO ANDESITE (OLIGOCENE)
- Tfc — FISH CANYON TUFF (OLIGOCENE)
- Ti — RHYOLITIC INTRUSION (OLIGOCENE)
- Thc — SILVERTON VOLCANICS - HENSON MEMBER (OLIGOCENE)
- Tsd — SAPINERO MESA AND DILLON MESA TUFFS (OLIGOCENE)
- Tbm — BLUE MESA TUFF (OLIGOCENE)
- Tu — UTE RIDGE TUFF (OLIGOCENE)

- 3 — FLOW FOLIATION FROM LIPMAN (1976) OR FLOW LAYERING INTERPRETED FROM AERIAL PHOTOGRAPHY OR GEOMORPHOLOGY
- 8 — MEASURED FLOW FOLIATION
- FAULT; DASHED WHERE APPROXIMATELY LOCATED; DOTTED WHERE CONCEALED BY YOUNG DEPOSITS; "U" AND "D" INDICATE UPTHROWN AND DOWNTHROWN SIDES OF FAULT.
- UPPER END OF LANDSLIDE HEADSCARP OR RELEASE ZONE
- GEOLOGIC CONTACT; APPROXIMATELY LOCATED; TICK MARKS DENOTE LOCATIONS WHERE THE CONTACT COINCIDES WITH THE TOP OF A LANDSLIDE HEADSCARP.
- HORIZONTAL FLOW FOLIATION FROM LIPMAN (1976)
- SUBHORIZONTAL FLOW LAYERING
- APPROXIMATE LOCATION OF WESTERN END OF STRUCTURAL TERRACE
- GENERAL MOVEMENT DIRECTION OF LANDSLIDE
- LARGE BLOCK OF SLUMPED BEDROCK WITHIN A LANDSLIDE COMPLEX

Figure 6-1

GEOLOGIC MAP OF RIO GRANDE RESERVOIR

PREPARED BY: ROBERT M. KIRKHAM, P.G., C.P.G. 5253 COUNTY ROAD 1 SOUTH ALAMOSA, CO 801101		DEERE & AULT CONSULTANTS, INC. 600 S. AIRPORT RD., BLDG. A, SUITE 205 LONGMONT, CO 80503 TEL 303.651.1468 FAX 303.651.1469	
DESIGNED BY:	APPROVED BY: RMK	JOB NO.	DWG:
DRAWN BY: IR	DATE: 11-9-07	0246.001.00	SHEET:
CHECKED BY: VDW	SCALE: AS NOTED		–

- Most of the landslides in the vicinity of the Reservoir are suspected to have initially formed shortly after the end of the last major ice age about 13,000 years ago. Many of the landslides appear to be in a quasi-stable condition and may not have moved for hundreds of years, perhaps even thousands of years. Other landslides or portions of landslides within the Reservoir area possess features such as open tension cracks, incipient scarps, pistol-butted trees, and swallow holes that suggest recent or ongoing movement. None of the landslides in the vicinity of the Reservoir have been monitored or instrumented to determine their modern rates of movement.

- On the basis of limited available information, it appears that the left abutment rock slide has not stressed or deformed the dam. However, no quantitative monitoring of the rock slide or dam has been conducted. Two inclinometers were installed in the rock slide near the dam by Chen and Associates in 1982, but no post-installation surveys of the inclinometers were found. Apparently the inclinometers were never monitored after installation. Efforts were made during this investigation to locate the inclinometers, but they were unsuccessful.

- Climate also plays a role in the relative abundance of landslides in the vicinity of the Reservoir. The San Juan Mountains, including the Reservoir area, receive significant amounts of precipitation. Increased rainfall and/or the melting of a snow pack, particularly the rapid melting of a snow pack by rainfall, can trigger landslides.

- The July 30, 1991 West Lost Trail Creek landslide was an extremely rapid composite landslide that failed suddenly, but not without prior warnings. The landslide is located about 5 miles west of the Rio Grande Reservoir. This massive slope failure occurred following a calendar year of unusually high precipitation. Three weeks of heavy summer rain also preceded the slope failure.

Swales and leaning trees above the Reservoir

- The geology in the vicinity of the Reservoir is significantly different from that of the West Lost Trail Creek landslide. The probability of an extremely rapid debris avalanche or sturzstrom that is similar to the West Lost Trail Creek landslide failing into the Reservoir appear to be low. The West Lost Trail Creek landslide formed in a thick sequence of weakly lithified volcaniclastic rocks in the Conejos Formation. The Conejos Formation does not crop out on the hill slopes adjacent to the

Reservoir, and the beds of weakly lithified volcaniclastic rocks that are present in the Reservoir area are thin.

- The greatest potential threat of a large, catastrophic, rapidly moving landslide on the hill slopes adjacent to the Reservoir relates to the lateral block spread on the north side of the Reservoir, especially its southeast corner. A 1,000-foot-long swale cuts across the southeast corner of the lateral block spread. If the block of rock between the swale and the cliff at the edge of the block spread fails, it probably would move very rapidly or extremely rapidly as a rock topple or rock slide. The failure potentially could involve more than 1 million cubic yards of debris. Part of the debris would fall onto and be retained on the rock slide or the U.S. Forest Service road, but part also would move into the Reservoir, in a direction towards the dam.

6.1.2 Recommendations

- The lateral block spread, especially its southeast corner, is postulated as the most significant slope stability threat to the Reservoir. Detailed geologic, geomorphic, and geotechnical study of the entire lateral block spread is warranted. Also, the modern rate of movement of the block spread, in particular its southeast corner, should be determined in the very near future. Ideally, several inclinometers should be installed in the block spread to provide data from all parts of this landslide. The inclinometers should extend through the block spread and into underlying in-place bedrock. Data from the drill holes can also be used to characterize and evaluate the basal failure plane for the block spread. The installation of an inclinometer in the block of rock between the swale and cliff face at the southeast corner of the block spread may not be feasible. Getting a drill rig to this location would be difficult and potentially could even affect the stability of the rock slope. Also, the entire block spread is public land administered by the U.S. Forest Service, therefore permits will be required.

Tension cracks at the top of the lateral block spread

- If inclinometers are not feasible, then several permanent benchmarks could be installed on the block spread. Regularly conducted, high-precision surveying of the benchmarks will yield data that can be used to evaluate the modern movement of the block spread. Survey-quality GPS equipment could be utilized for this purpose, although conventional surveying could easily be used for the southeast corner of the block spread, especially if prisms that were visible from a convenient location were installed in the cliff face. Monitoring of the block spread is especially important during and subsequent to periods of above normal precipitation.

- The modern rate of movement of the left abutment rock slide also needs to be quantified. Efforts should be undertaken to relocate and make readings of the two inclinometers installed by Chen and Associates in 1982. If found, they should be periodically inspected for evidence of movement in the rock slide. If not found, new inclinometers should be installed in the rock slide near the dam. Preferably, the drill holes for the inclinometers should penetrate through the rock slide debris and into underlying bedrock, although drilling through the type of debris in the rock slide is challenging. A program should be developed to ensure that the inclinometers are read regularly and are preserved for long-term future studies of the rock slide.

- The age of formation of the rock slide also is important. If the rock slide formed immediately after the last major ice age, it probably poses less of a hazard than if it formed more recently. The organic-rich sediment that accumulated in the sag within the young rotational slump at the toe of the rock slide could be age dated using carbon-14 or luminescence techniques. The age of this sediment should constrain the time of formation of the young landslide, which in turn provides a minimum age for the rock slide. The rock slide would be older than the age obtained on the lowermost sediment from the sag.

- Consideration should be given to directly age dating the rock slide. Cosmogenic or exposure dating of the rock exposed near the base of the headscarp could yield results that closely constrain the time of formation of the rock slide. Cosmogenic dating techniques rely on the measurement of cosmogenic nuclides that begin to build up in the rock as soon as it is exposed to cosmic rays. The rock at the base of the headscarp would have been first exposed to cosmic rays after failure of the rock slide. If new inclinometers are installed in the rock slide, the cuttings from the drill holes should be closely inspected for organic material that might have been incorporated into the rock slide debris when it failed. Carbon-14 dating techniques could be used on the organic material to date the age of the rock slide.

- All of the landslides on the hill slopes adjacent to the Reservoir should be periodically inspected for changed conditions and an assessment of their potential impact on the Reservoir. The small, precariously perched landslide at an elevation 11,200 to 11,400 feet high on the hillslope south of the dam should be examined in the field because it was detected too late during the investigation to be visited during this study. Locations where evidence of recent landslide activity such as tension cracks and swallow holes were discovered during this investigation also should be re-examined. When the U.S. Forest Service files new aerial photography that includes the Reservoir area, that photography should be viewed and interpreted for evidence of recent landslide activity. Occasional aerial overflights, especially in helicopters, are very useful when looking for evidence of recent or changed landslide activity. Reports of frequently occurring unusual noises that might be due to falling rock, similar to the precursor events to the 1991 West Lost Trail Creek landslide, should be investigated, as should any reports of new ground cracks. Potential sources for these reports include dam personnel, permanent and seasonal residents, U.S. Forest Service personnel, and those who recreate in the area.

- A recently developed tool that offers greatly enhanced characterization and monitoring capabilities for landslides is airborne LIDAR, which is an acronym for Light Detection and Ranging. LIDAR is an optical remote sensing technology that measures properties of scattered light, oftentimes laser pulses, to quantify the distance to and other information about a remote target. The technique can produce very accurate models of the earth's surface. It is especially valuable in densely forested areas, as it can see through the trees. Subtle topographic features with as little as one foot of relief can be imaged with LIDAR. The hummocky ground and ground cracks associated with landslides should be easy to identify. If LIDAR surveys are repeated, they can be quantitatively compared to assess changes in the ground configuration over time (e.g., landslide movement). LIDAR would be especially useful for evaluating the block spread, in particular the southeast corner of the block spread, but it also would be worthwhile to use on all the hill slopes adjacent to the Reservoir. LIDAR can be very expensive, particularly for small independent projects, but opportunities to partner with other projects can significantly reduce costs.

6.2 Seepage Analysis

Significant seepage has occurred for many years at Rio Grande Dam. This seepage occurs primarily through the landslide mass that forms the left abutment, but significant seepage also occurs through the dam embankment, bedrock foundation, and right abutment.

Total seepage flows range from about 200 gpm when the Reservoir is at mid-height, or gage height 45, to approximately 2,500 gpm at the normal water line at the spillway elevation or gage height 91.

Good monitoring of piezometer levels and seepage flows has been conducted since 1993, when horizontal drains were installed in the left abutment. Figures 6-2 and 6-3 present piezometer and reservoir stage data for 1993 through mid-2007. Seepage flow measurements for the same period are presented on Figures 6-4 and 6-5. Plots of seepage versus reservoir stage are presented on Figures 6-6 and 6-7.

RIO GRANDE DAM PIEZOMETER LEVELS

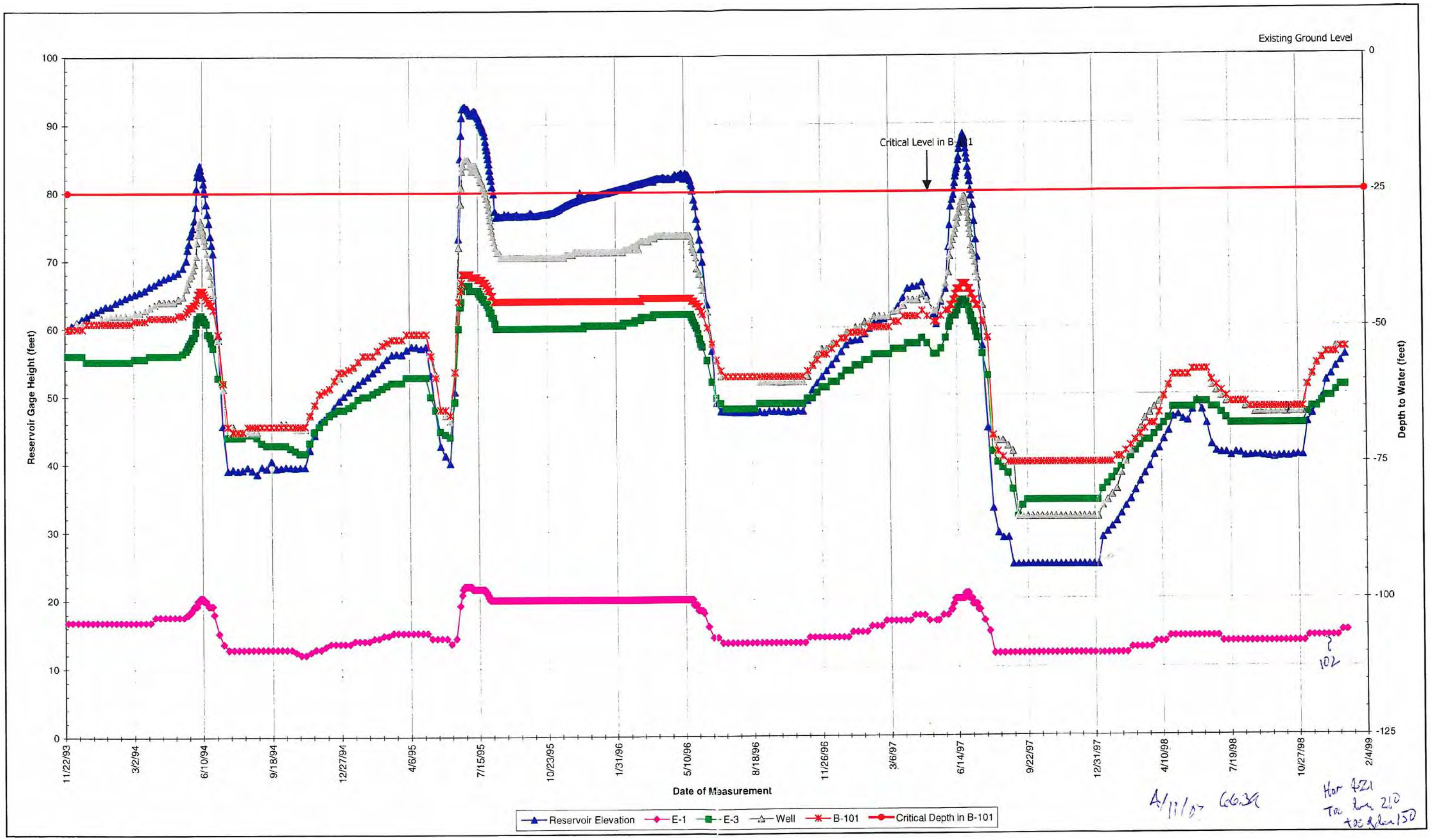

FIGURE 6-2

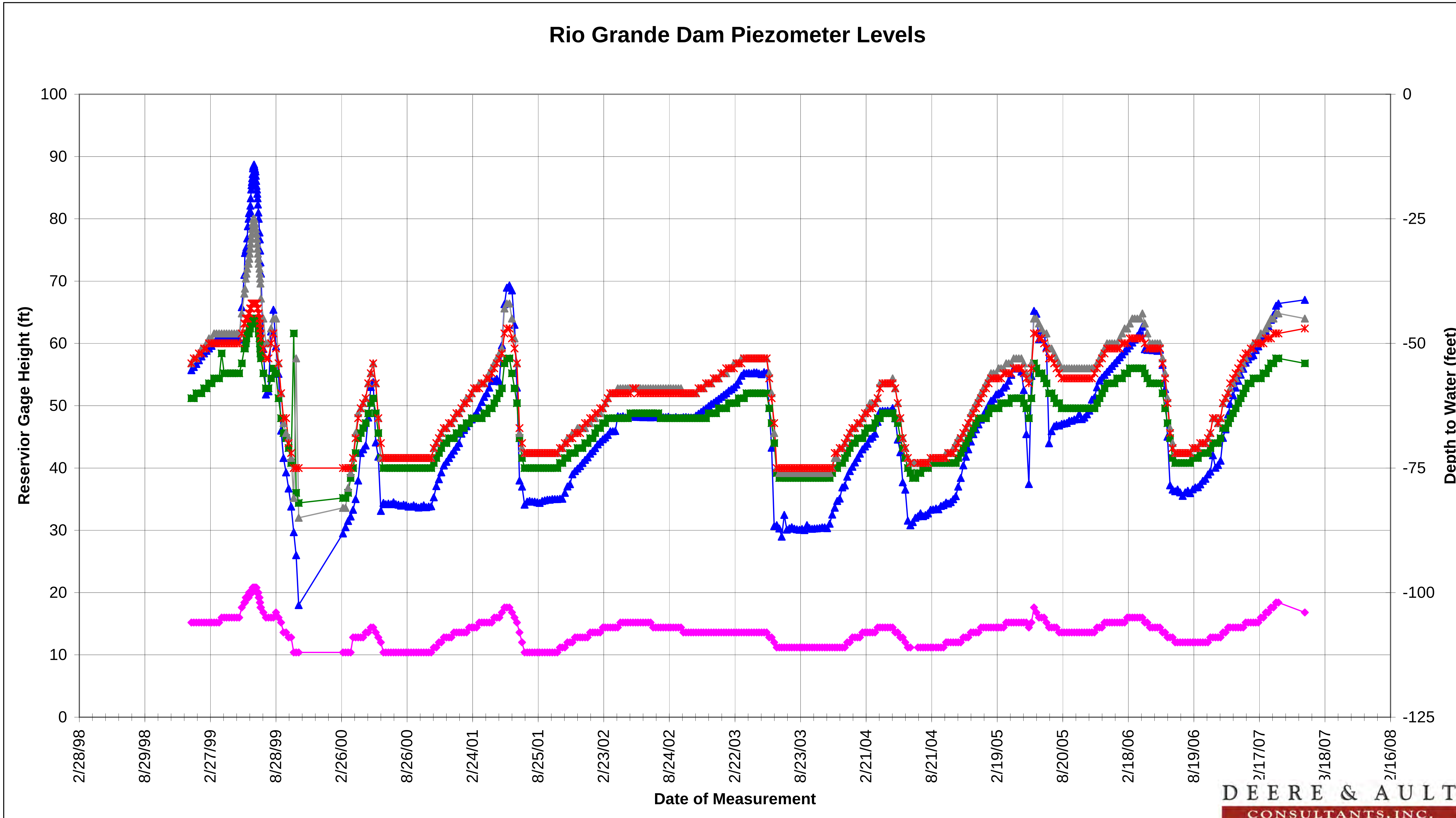

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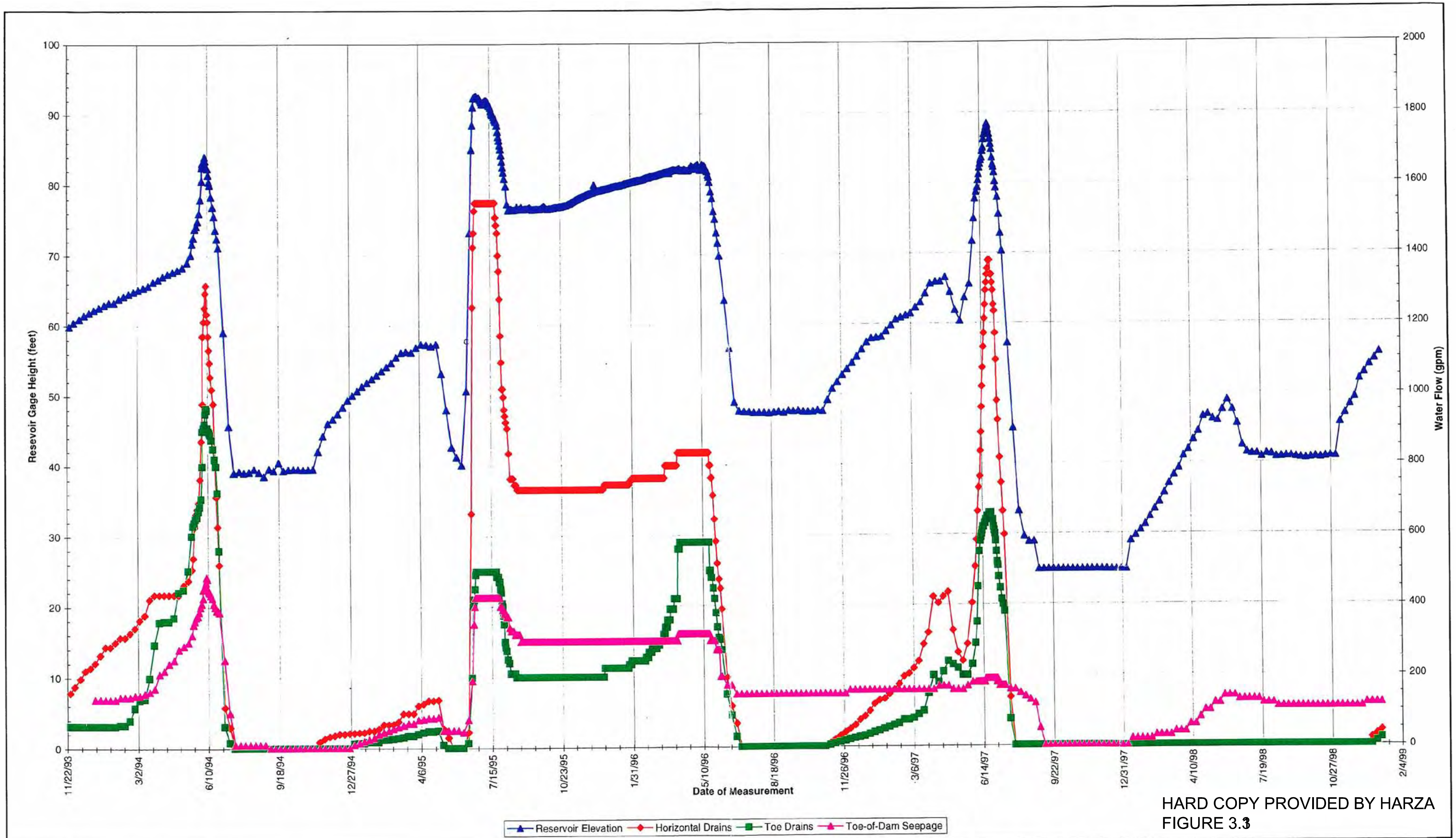
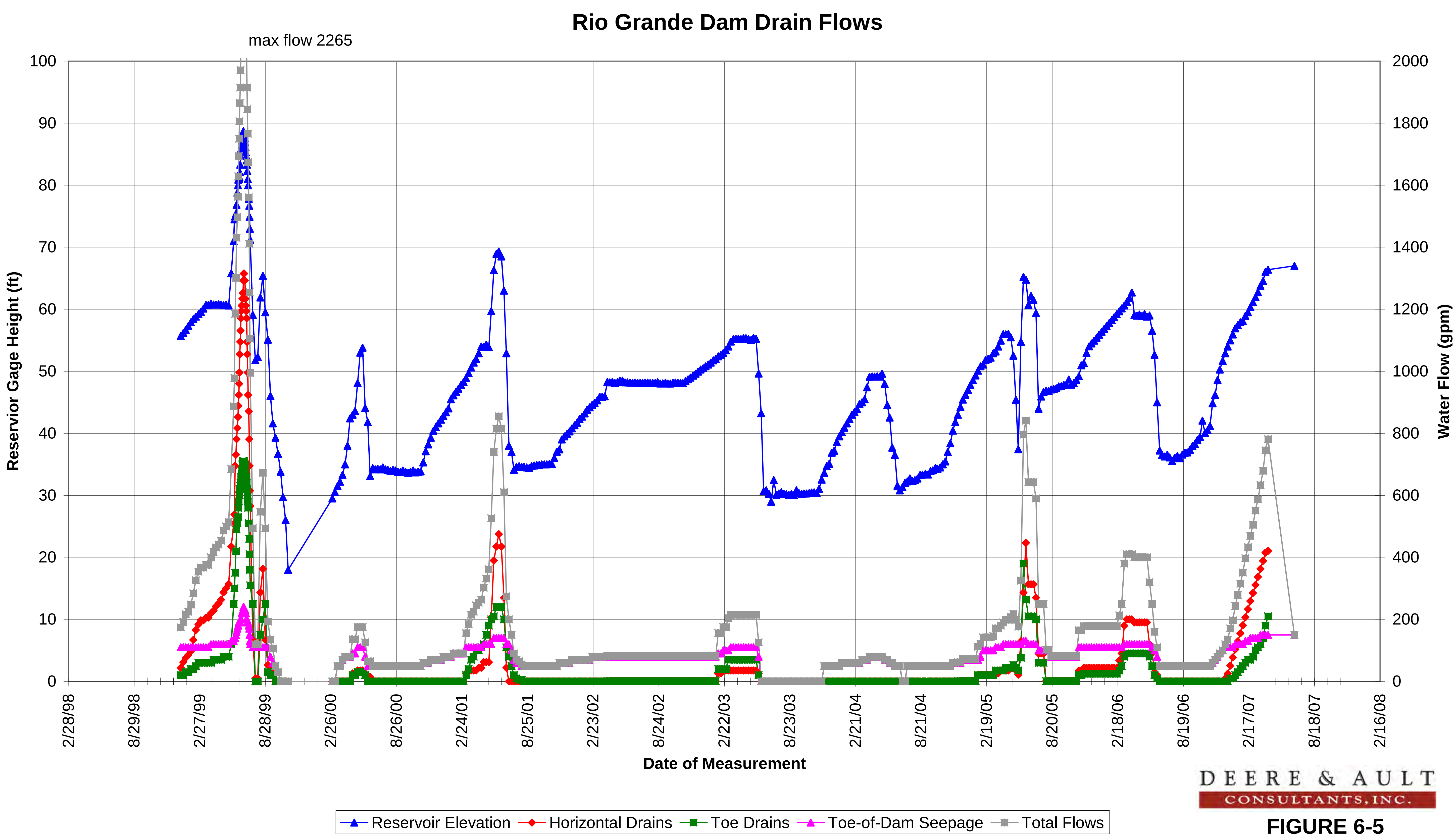
FIGURE 6-3

RIO GRANDE DAM DRAIN FLOWS



HARD COPY PROVIDED BY HARZA
FIGURE 3.3

FIGURE 6-4



DEERE & AULT CONSULTANTS, INC.

FIGURE 6-5

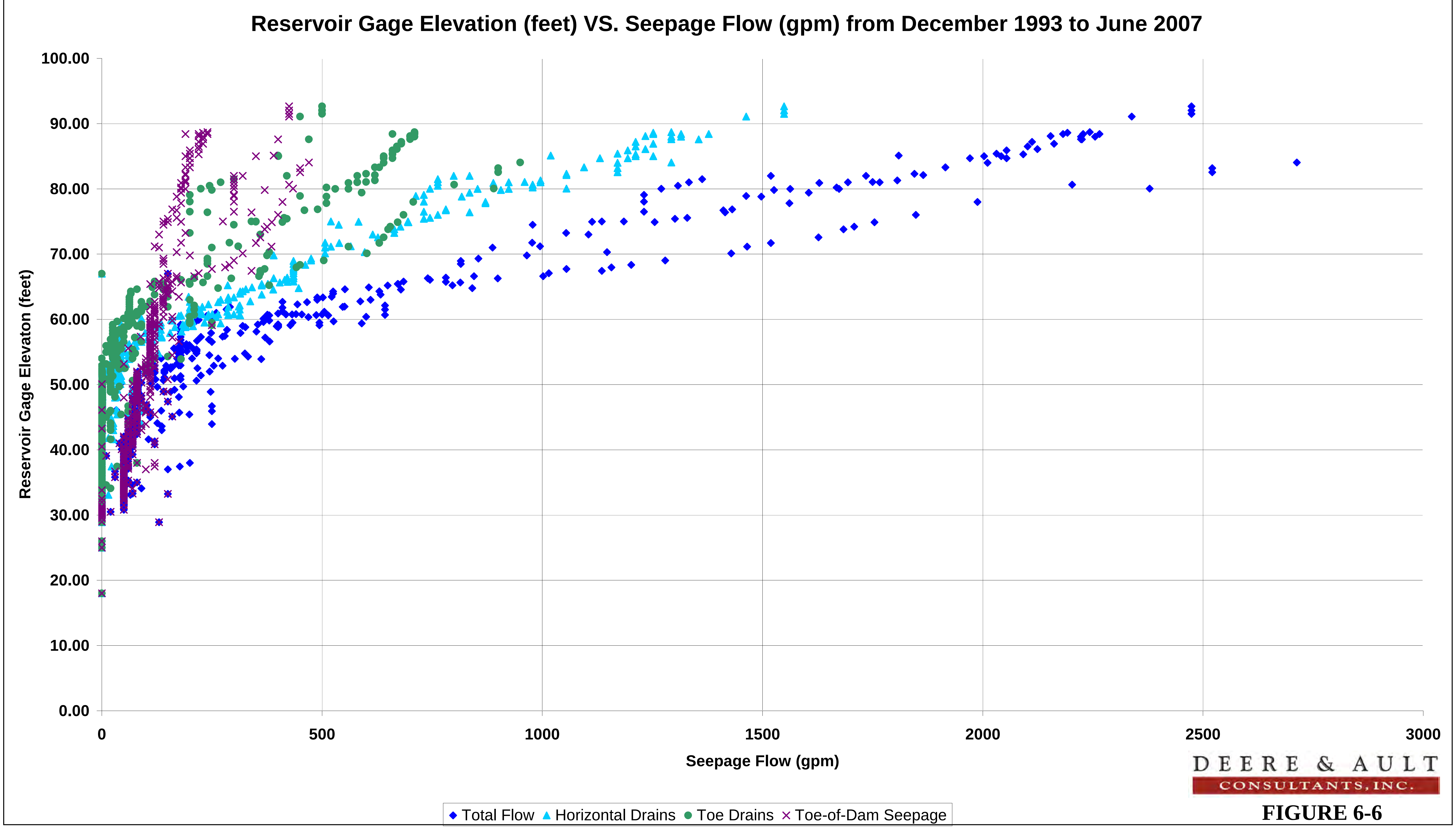


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FIGURE 6-6

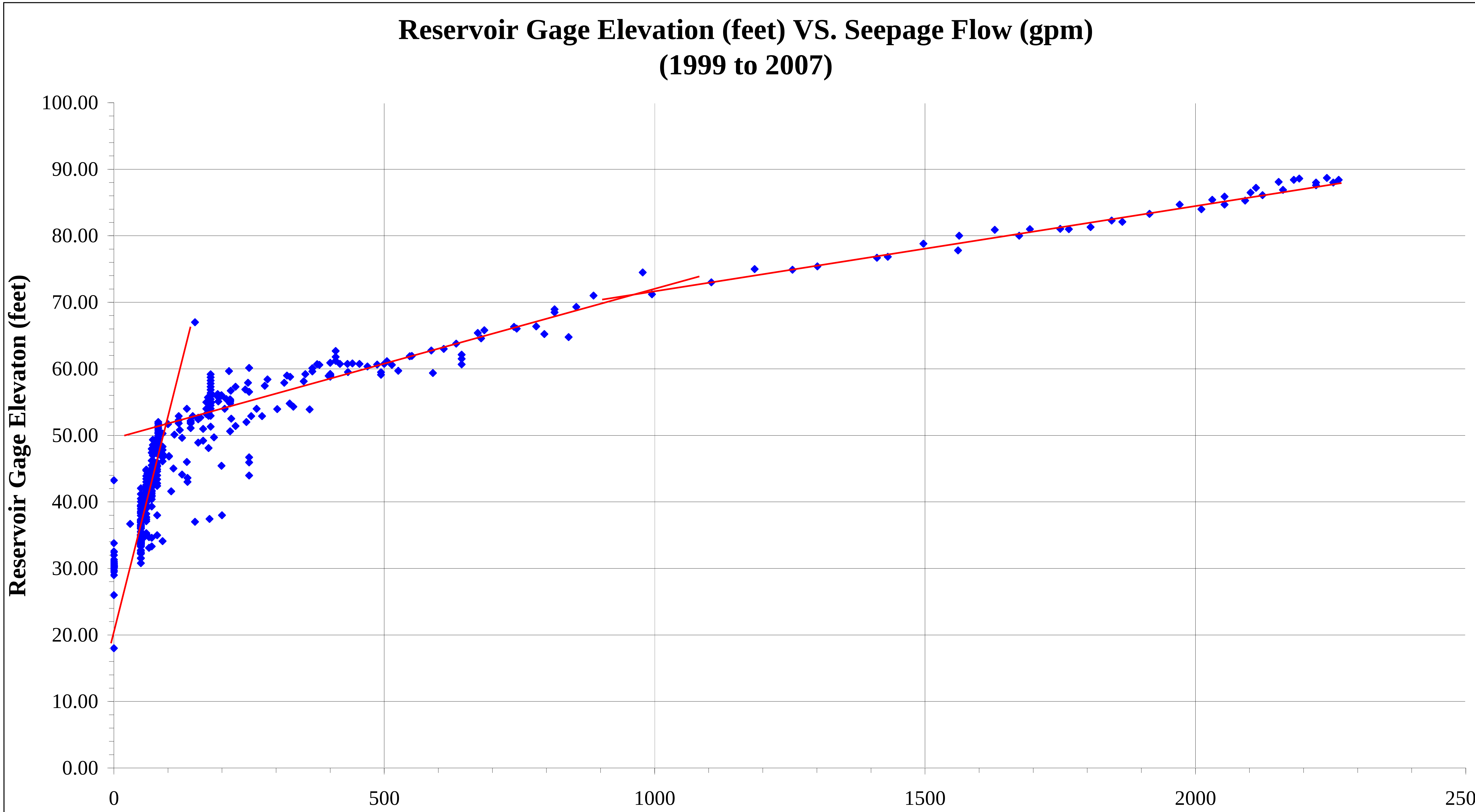

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FIGURE 6-7

6.2.1 Left Abutment Seepage

Seepage through the landslide mass that forms the left abutment has been noted since the dam was constructed (Atwood 1918). He remarked that "seepage was notably free" in June 1916 when the Reservoir was "far below the maximum possible height." He noted four areas of seepage extending some 500 feet downstream of the dam. He noted that an exploration tunnel excavated prior to construction of the dam about 500 feet downstream of the dam "had become the channel of an underground stream which issued here."

Seepage was also noted by Chen and Associates (1983). Their Plate I geologic map shows 10 areas of reported springs that similarly extend for about 500 feet downstream of the dam on the left abutment. The largest springs were shown just downstream of the dam at elevation 9,380 to 9,390 feet.

In 1993, due to a restriction put on storage by the SEO, a series of nine horizontal drains ranging from 32 feet to 82 feet long were constructed. These were installed in the area just downstream of the dam on the left abutment at elevation 9,380 to 9,390 feet. The areas' stability was enhanced by construction of a rockfill buttress. Although no previous slides or slumps had occurred in this area, the seepage had caused some erosion of the slope.

There are three piezometers or monitoring wells in the left abutment (see sheet 1 in Appendix A). The most upstream well located on top of the left abutment upstream of the dam crest is simply designated as "old well." It apparently was used historically as a water supply well for the dam caretaker's house. The second piezometer, E-3, is located on the top of the left abutment just downstream of the dam crest. It was installed by Chen and Associates in 1981. The last well, B101, was installed by Harza in 1993. It is located several feet downstream of E-3. The piezometer data over time, as shown on Figures 6-2 and 6-3, illustrate that the water levels in these wells mimic the Reservoir level.

Low flows downstream of the dam

The seepage versus time is plotted on Figures 6-4 and 6-5. No flow of the horizontal drains occurs below gage height 48 (elevation 9,407 feet). There is a steady increase of flow up to 300 gpm to gage height 60. From this elevation and higher, a breakout in flow rate occurs to 500 additional gpm per 10 feet of reservoir elevation. This relationship is shown on Figure 6-6. The maximum measured flow rate is approximately 1,500 gpm from the horizontal drains when the Reservoir is full at gage height 91, and total flow through the dam is approximately 2,500 gpm.

Above gage height 48 the Reservoir begins to be impounded on the 3:1 (horizontal to vertical) slopes of the landslide debris that form the left abutment. Based on geologic mapping and review of drilling logs, the material in the landslide deposit consists of a heterogeneous mass of silty sandy gravel with large angular boulder fragments. Chen and Associates (1983) performed Packer permeability testing in hole E-3 at a depth of 6 to 22 feet, and calculated a permeability of 2,000 feet/year (2×10^{-3} cm/second). This represents material of moderately high permeability.

6.2.2 Dam Seepage

The upstream half of the dam was constructed of earthfill placed by the "basin-and-embankment method" (Engineering Record 1912). Small embankments of clayey silty and gravelly sand were built by compaction by horse and wagon, and sandy clayey silt was "puddled" in between the small embankments. The small embankments and a 6-foot high puddle trench was staggered as construction progressed. The final configuration resulted in a composite honeycomb fill. This forms the lower permeability zone of the dam (Zone 1). Packer permeability of this material was calculated by Chen and Associates (1983) in hole E-2 as 261 to 448 feet/year (4×10^{-4} cm/second). This can be considered material of moderate permeability. The fines content of this zone (Chen and Associates 1983) ranged from 25 percent to 55 percent.

The downstream rockfill zone ranges from 10 percent to 22 percent fines (Chen and Associates 1983) and is relatively free draining. Piezometer E-1 drilled at the dam crest is screened within the rockfill zone. As shown on Figures 6-2 and 6-3, it fluctuates by about 10 feet as the Reservoir fluctuates 70 feet. This indicates that the rockfill zone is behaving as a drain.

When the dam was enlarged to provide more freeboard in 1983, toe drain pipes were installed under the new downstream slope rockfill. These collect the majority of the seepage through the dam or right abutment. Some seepage also exists near the toe of the dam through rockfill.

The seepage from the toe drain and dam toe are plotted versus time on Figures 6-4 and 6-5. Toe drain flow is negligible up to gage height 50, and reaches a maximum of about 700 gpm at normal water line, or gage height 91. The toe of the dam flow ranges from 0 to 500 gpm with most occurring above gage height 60. The toe of the dam, unlike the drain measurements, is not measured by a weir and is a rough estimate of more diffuse flows in the area of the toe that are not collected by the toe drain pipes.

6.2.3 Right Abutment Seepage

Some of the seepage measured in the toe drains and toe of the dam is related to flow through the right abutment tuff bedrock. Atwood (1918) noted that "waters came through the much fractured rock near the lower tunnel opening and issued as a cascade 6 to 8 feet wide." A photograph of this area is presented in his report and a white water cascade is apparent just downstream of the dam about at elevation 9,380.

This area was subsequently covered by the 1983 enlargement with rockfill. It appears that a toe drain was constructed to this general area in 1983. Thus seepage from the right abutment bedrock appears to be measured in the toe drain flow and the toe of the dam diffuse seepage. The source of the seepage may be the unlined pressurized outlet tunnel upstream of the gates.

6.2.4 SeepW Modeling

The two dimensional flow model SeepW, was utilized to evaluate seepage in the left abutment and through the dam. Permeability data from Packer testing performed by Chen (1983) was initially used as well as permeabilities calculated from the D_{10} of gradation tests in the report. The model was calibrated by comparing model results with actual measured flows and piezometric levels. Permeabilities were thus adjusted in order to approach measure values for flow rates and piezometric levels.

Left Abutment Modeling

The initial modeling was conducted with a rockslide permeability of $2x10^{-3}$ cm/second by the Chen permeability test in hole E-3. The modeled flows were quite low in comparison to measured flows. The best calibration was obtained with a high assumed permeability of $2x10^{-1}$ cm/second.

The section modeled is shown on Figure 6-8. The total flux with the Reservoir at normal water line was calculated as 0.045 cfs. For the 80-foot wide area with drains, this converts to 1,600 gpm, which compares to 1,500 gpm measured in the drains.

The modeling illustrates two facts. First, that the permeability of the left abutment is very high, $2x10^{-1}$ cm/second, in order to account for the measured flow in the horizontal drains. Total water loss through the left abutment may be three to five times higher than what is measured by the drains as noted by the historical reporting of seeps occurring over a 500-foot segment downstream of the drains.

Second, grouting of the left abutment will only be partially effective in reducing seepage. Flow will still go around the grout curtain because the landslide extends for several thousand feet north of the dam. A longer section through the left abutment was modeled to review the effect of an extended flow path and is presented in Figure 6-9. The flux or flow rate is reduced by 7 percent by doubling the flow path from 225 feet (Figure 6-8) to 450 feet (Figure 6-9). Most importantly, the gradient is significantly flattened, reducing the potential for soil piping of the rock slide mass. The grout curtain as shown on sheet 2 in Appendix A would extend the seepage path to over 700 feet.

Rio Grande Reservoir
Left Abutment Short Seepage Path

Name: Rock Slide Kh = 2.00e-01 cm/sec

Name: Bedrock Kh = 7.00e-05 cm/sec

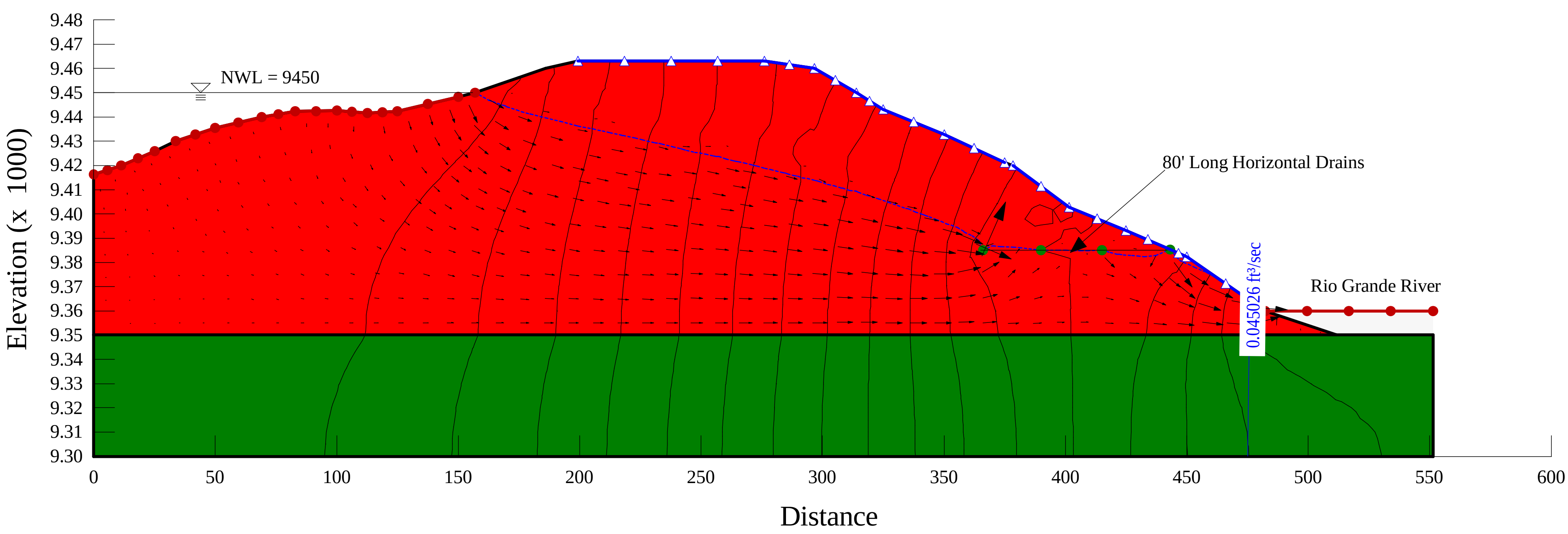


Figure 6-8

Rio Grande Reservoir
Left Abutment Long Seepage Path

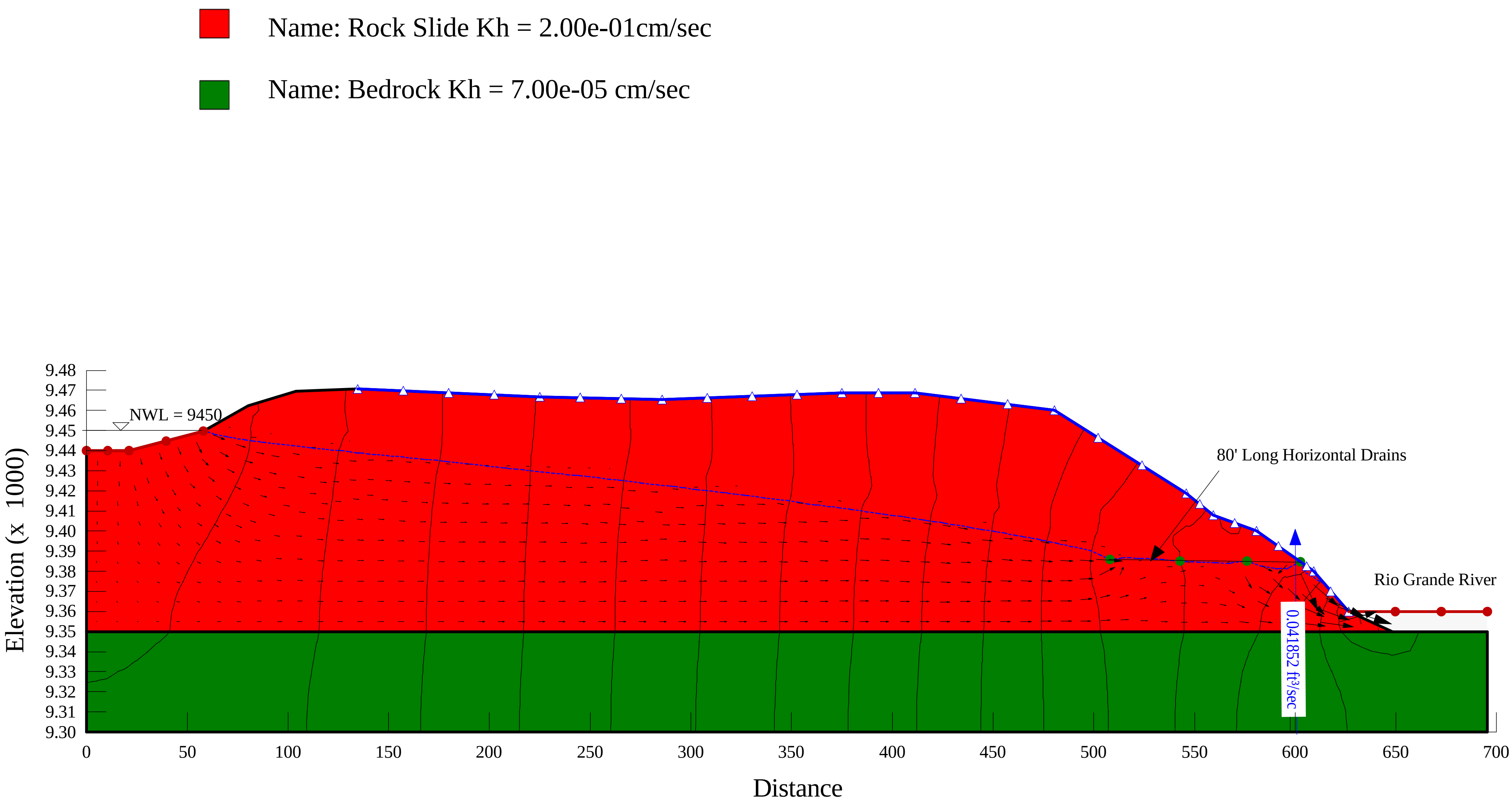


Figure 6-9

Dam SeepW Modeling

SeepW modeling of the dam is presented on Figure 6-10. The upstream earthfill was modeled with a permeability of $4x10^{-4}$ cm/second based on a Chen Packer test in boring E-2. The rockfill is quite permeable based on the fact that piezometer E-1 displays such a low water level, indicating that it is an effective drain. Even using a high permeability, proper mathematical convergence of the model was not achieved. The highest rockfill permeability that provided convergence was $5x10^{-3}$ cm/second for the rockfill. The phreatic line modeled is higher on Figure 6-10 than measured in E-1. Nevertheless, the calculated seepage was 95 gpm over the 200-foot wide main dam section. This probably represents a lower bound limit of through-the-dam seepage.

Other sources of seepage into the dam rockfill zone are from the left abutment and right abutment. The left abutment seepage was modeled and is shown on Figure 6-11. This is seepage flow not collected by the left abutment drain (discussed in Section 6.2.4), but rather seepage that short circuits back into the rockfill zone of the dam. This model converged with a higher rockfill permeability of $5x10^{-2}$ cm/second. It also closely agreed with measure piezometric levels in piezometers E-1 and E-3. The total flow into the rockfill dam zone through a 100-foot section in the left abutment was calculated at 429 gpm.

Total measured flows at the toe of the dam peak near 1,000 gpm. The right abutment seepage through the rock probably accounts for the remaining 476 gpm (1,000 gpm - 95 gpm - 429 gpm = 476 gpm). The photograph by Atwood (1918) shows a flow of the order of 1 cfs (449 gpm) through the right abutment.

An enlarged dam without an upstream membrane was also modeled and is shown in Figure 6-12. The 10-foot raise in water surface without installing an upstream membrane resulted in more than doubling the flow through the dam from 95 gpm to 205 gpm. This flow increase is justification for placing an upstream impermeable membrane on the dam. A modern dam of this height would contain a chimney filter within the dam to prevent piping. Since flow cannot be filtered by construction of an internal chimney filter, it should be reduced by a membrane placed on the upstream dam surface.

Rio Grande Reservoir - Existing Dam
Maximum Embankment Section Seepage Analysis

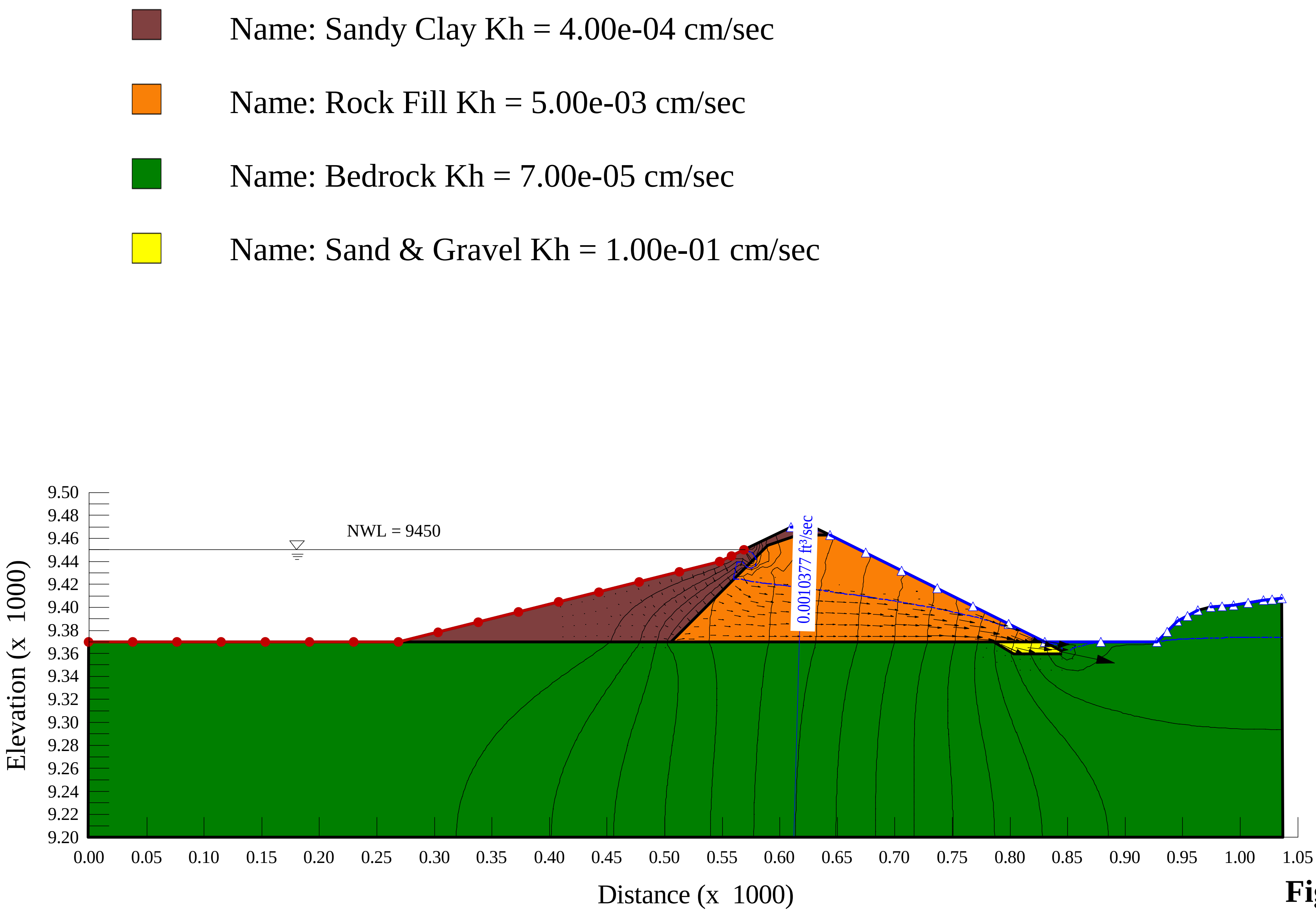


Figure 6-10

Rio Grande Reservoir - Existing Dam
Dam Centerline Cross Section

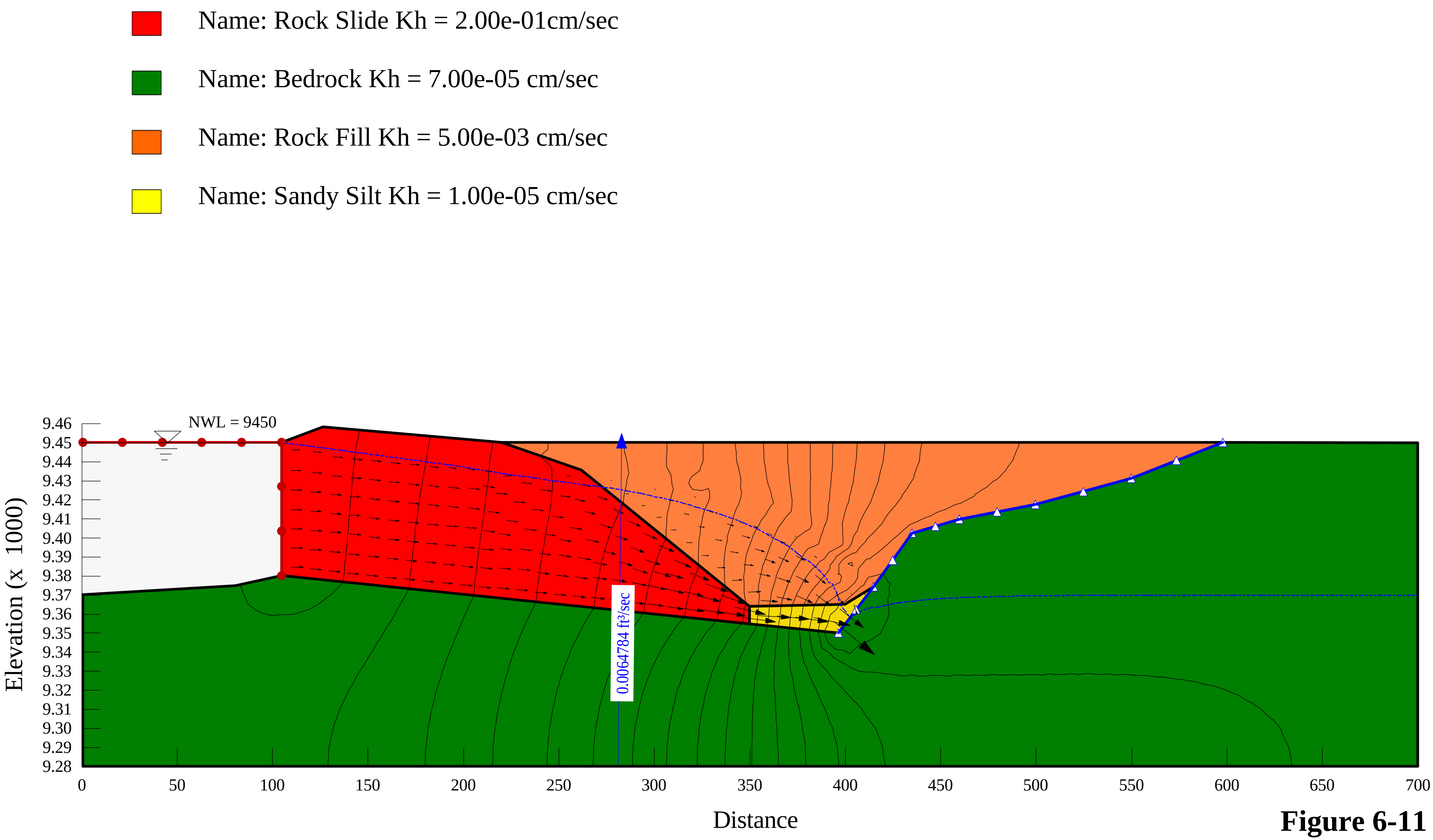


Figure 6-11

Rio Grande Reservoir - Existing Dam
Maximum Embankment Section Seepage Analysis Enlargement w/o Geomembrane Liner

Name: Sandy Clay Kh = 4.00e-04 cm/sec

Name: Rock Fill Kh = 5.00e-03 cm/sec

Name: Bedrock Kh = 7.00e-04 cm/sec

Name: Sand & Gravel Kh = 1.00e-01 cm/sec

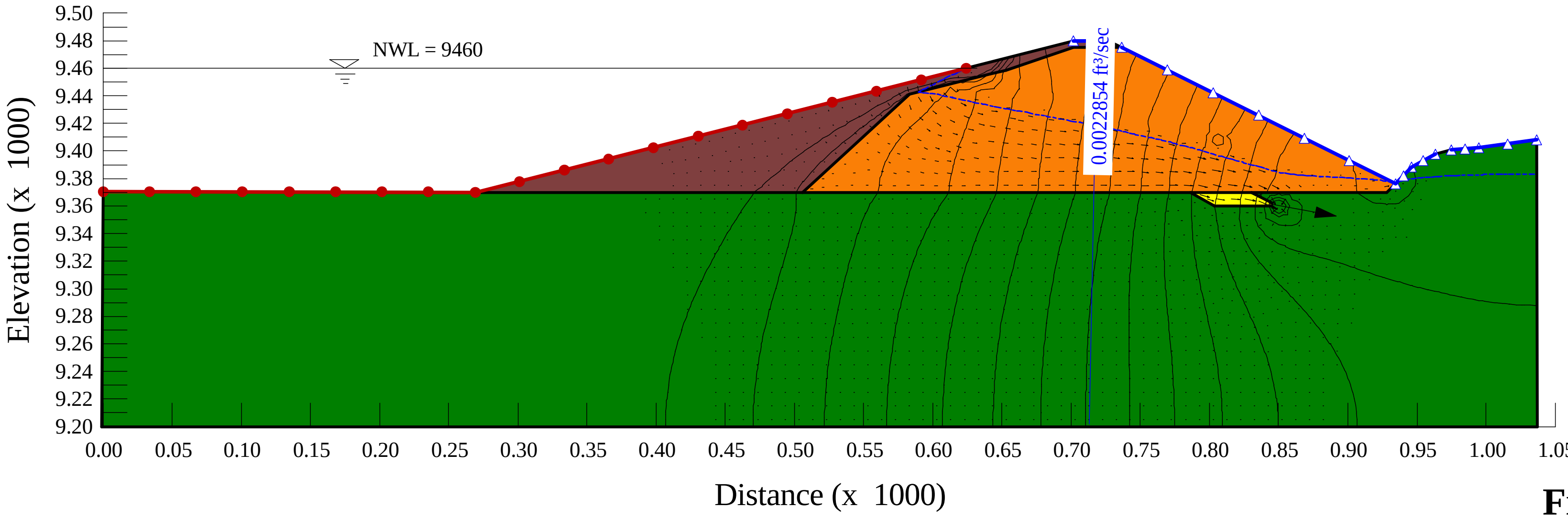


Figure 6-12

6.3 Stability Analysis

6.3.1 Dam Embankment

The existing dam is 111 feet high with 4:1 (horizontal to vertical) upstream and 2:1 downstream slopes. The top 30 feet of the upstream slope has a 2:1 slope. The dam was constructed of two primary zones. Zone 1 earthfill, the lower permeability barrier, forms the upstream half of the dam. Chen and Associates (1983) completed a boring, E-2, in this zone and encountered primarily clayey silty sand. Blow counts average 21 (this blow count correlates with a "medium dense sand") with -200 average of 25 percent. Zone 2, the rockfill, forms the downstream half of the dam. This zone is relatively high strength and free draining.

Chen and Associates performed a slope stability analysis in 1983 for the original enlargement. A slope stability analysis of the existing dam and the proposed 10-foot high raise was conducted as part of this Phase II analysis. The strength values utilized by Chen (1983) appeared too high for some soil material types, especially for puddled construction, and some values were adjusted downward (primarily effective cohesion) based on experience. A more extensive subsurface drilling and testing program of the dam embankment would be required to better identify the extent of the puddled construction and the associated soil strength values. In addition, a dynamic analysis evaluating liquefaction potential of the hydraulic puddled fill should be conducted for final design. A comparison table of strength values utilized, versus Chen, is given on Table 6-1. The phreatic surface was based on historical records from crest piezometer E-1. This is a reasonable assumption since grouting of the abutments is planned for rehabilitation or enlargement, and will reduce seepage through the dam.

Existing Dam

The existing upstream slope had a calculated factor of safety of 3.14 at normal water level of 9,450 (Figure 6-13). The State Engineer's minimum criterion is 1.5. The rapid draw down calculated factor of safety was 1.45 versus the SEO criteria of 1.2 (Figure 6-14).

A pseudostatic earthquake analysis was performed. Under State Engineer's criteria, the applicable pseudostatic horizontal load for the site is 0.28g. This is a relatively high value for Colorado. The calculated factor of safety for earthquake loading on the upstream face is 1.45 with a minimum of 1.0 required (Figure 6-15).

The downstream factor of safety for NWL was 1.82 (Figure 6-16), which exceeds the SEO minimum criteria of 1.5. The factor of safety for earthquake loading was calculated as 1.03 for a slip circle that entered into the dam (Figure 6-17) and the minimum SEO criteria is 1.0. Thus, the existing dam meets all minimum required factors of safety.

Table 6-1

Slope Stability Material Properties Comparison

	Chen and Associates (1983)			Deere and Ault 2008)		
Material	**Unit Weight (pcf)**	**Effective Friction Angle Φ' (Degrees)**	**Effective Cohesion c' (psf)**	**Unit Weight (pcf)**	**Effective Friction Angle Φ' (Degrees)**	**Effective Cohesion c' (psf)**
Clayey Silty Sand Zone 1	129	36	240	129	32	50
Rock Fill	125	40	0	125	40	0
Sandy Silt	115	30	400	115	30	50
Bedrock	125	45	2000	125	45	2000
Downstream Rock Fill/ Enlargement Fill	125	40	0	125	40	0
Zone 1	129	36	240	129	32	50
Sand and Gravel	129	36	240	129	36	0

Rio Grande Reservoir
Maximum Section Existing Dam Upstream

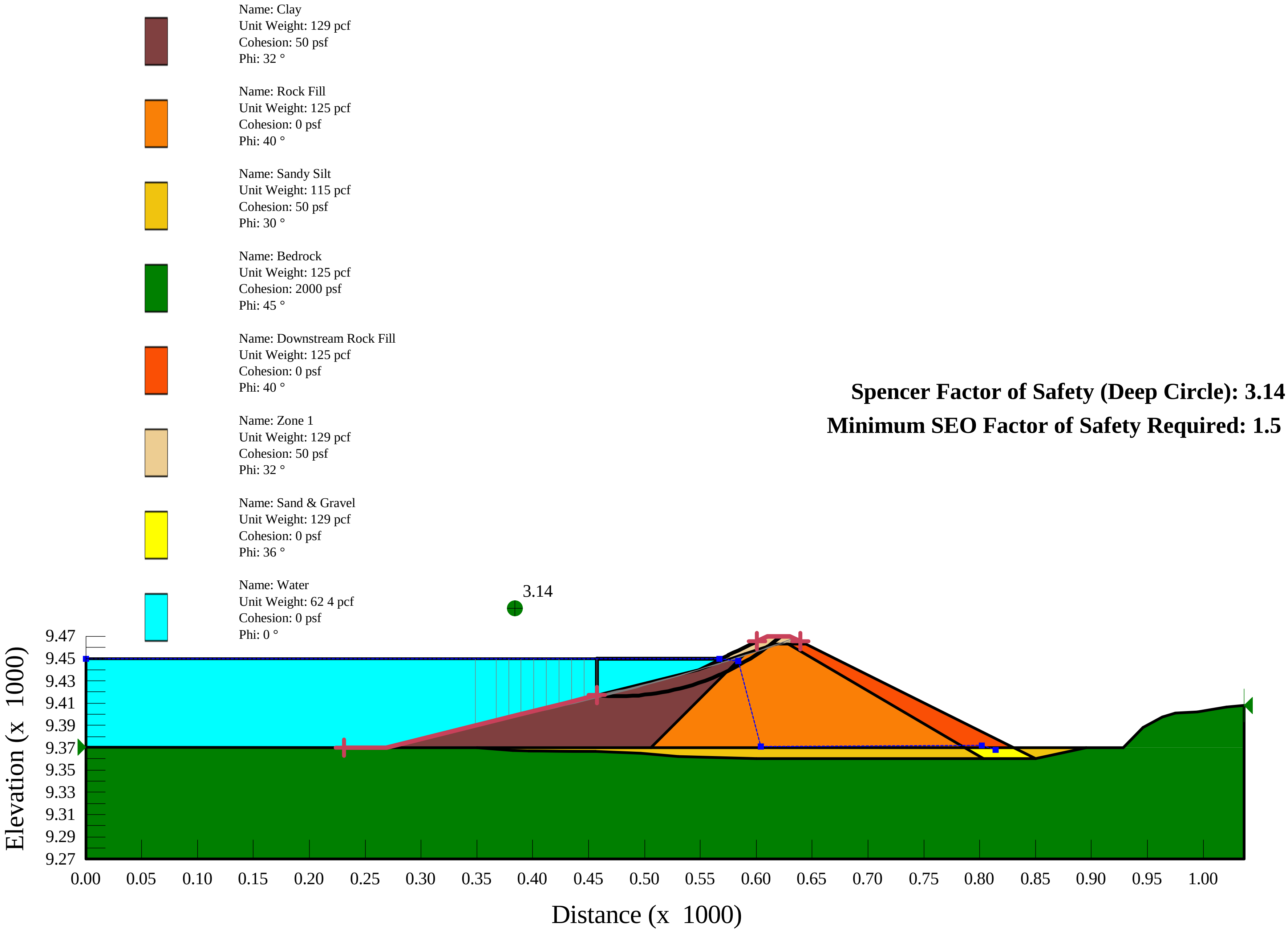


Figure 6-13

Rio Grande Reservoir
Maximum Section Existing Dam Rapid Drawdown

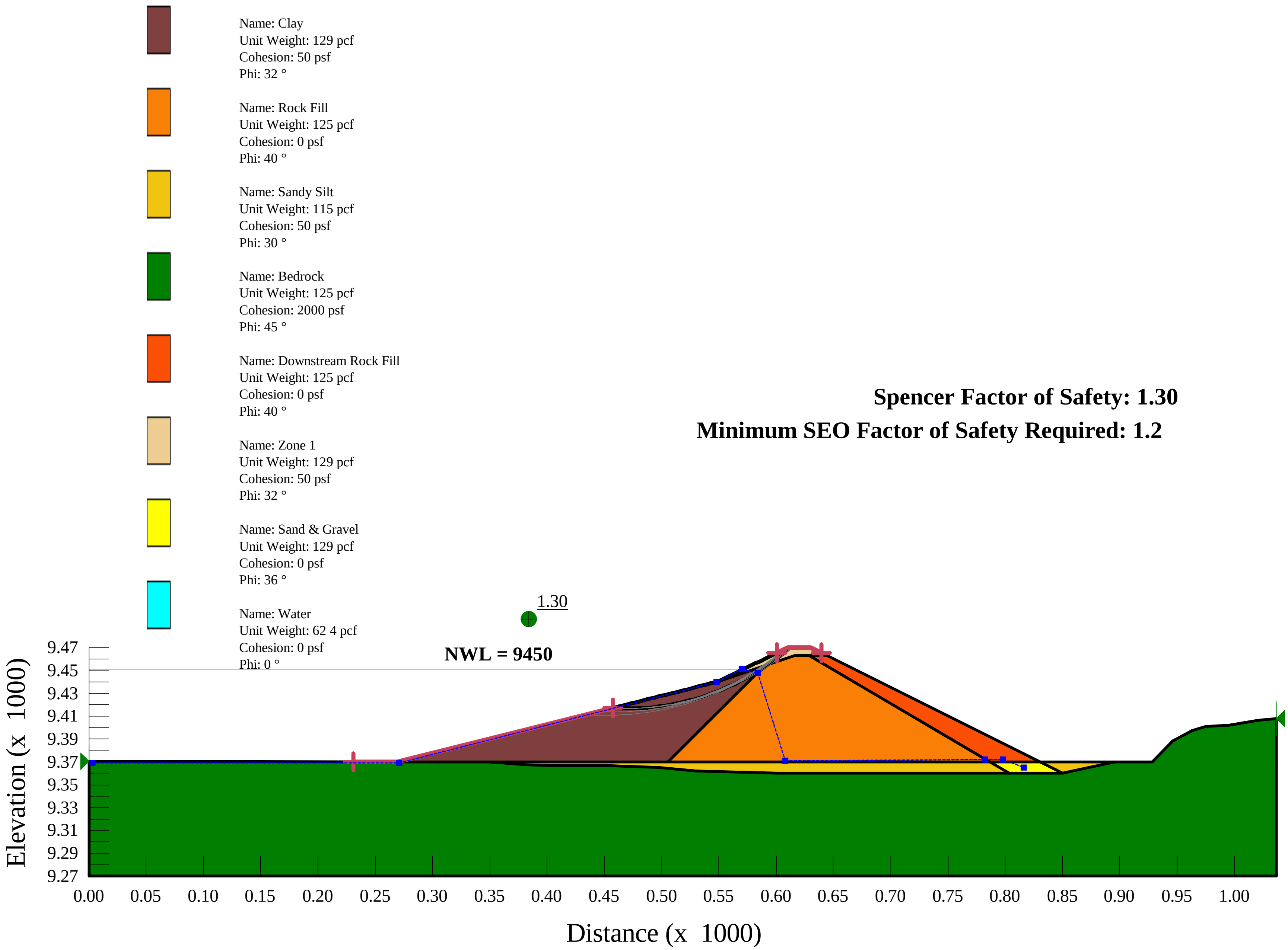


Figure 6-14

Rio Grande Reservoir
Maximum Section Existing Dam Upstream Seismic Loading

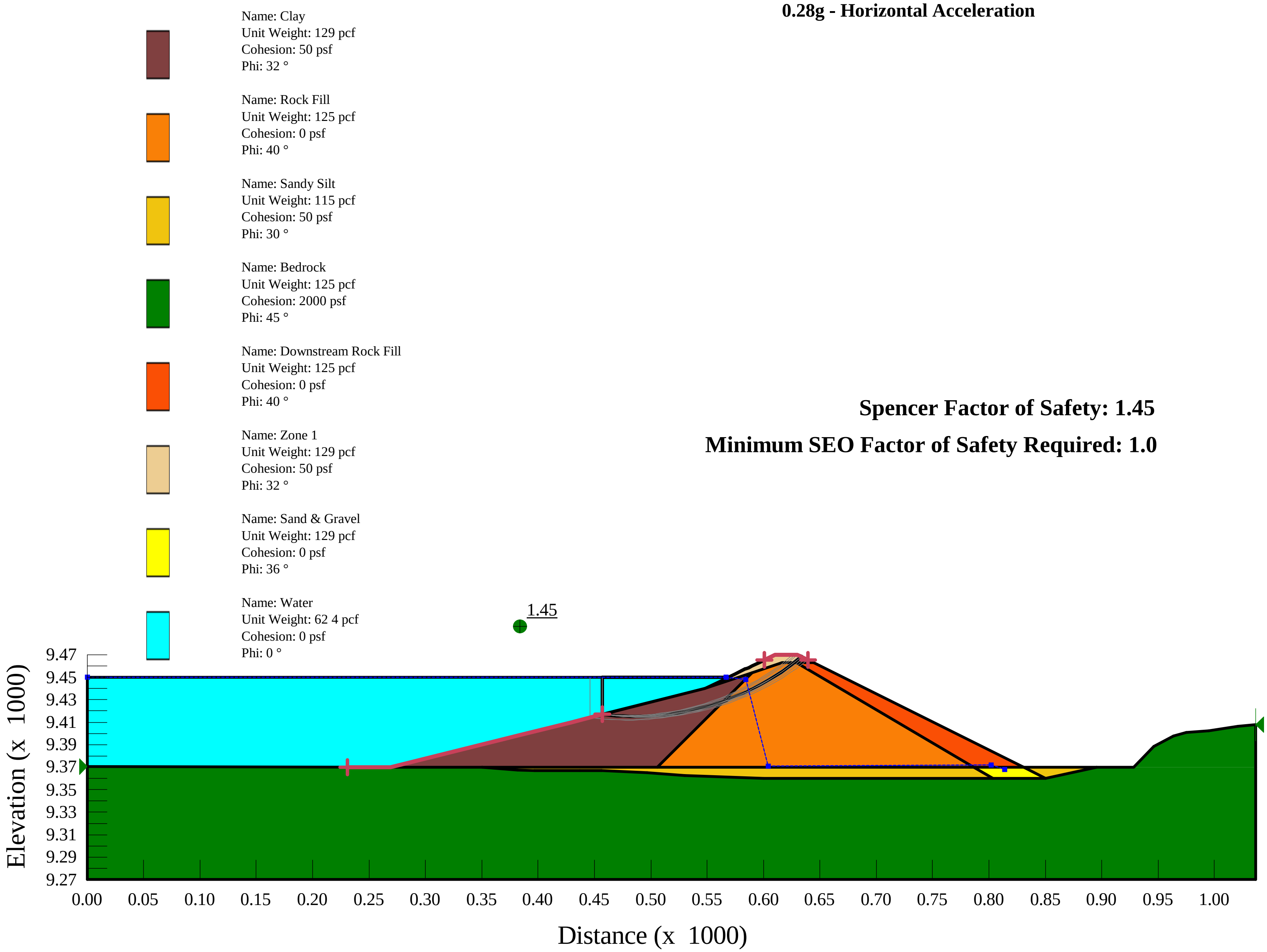


Figure 6-15

Rio Grande Reservoir
Maximum Section Existing Downstream

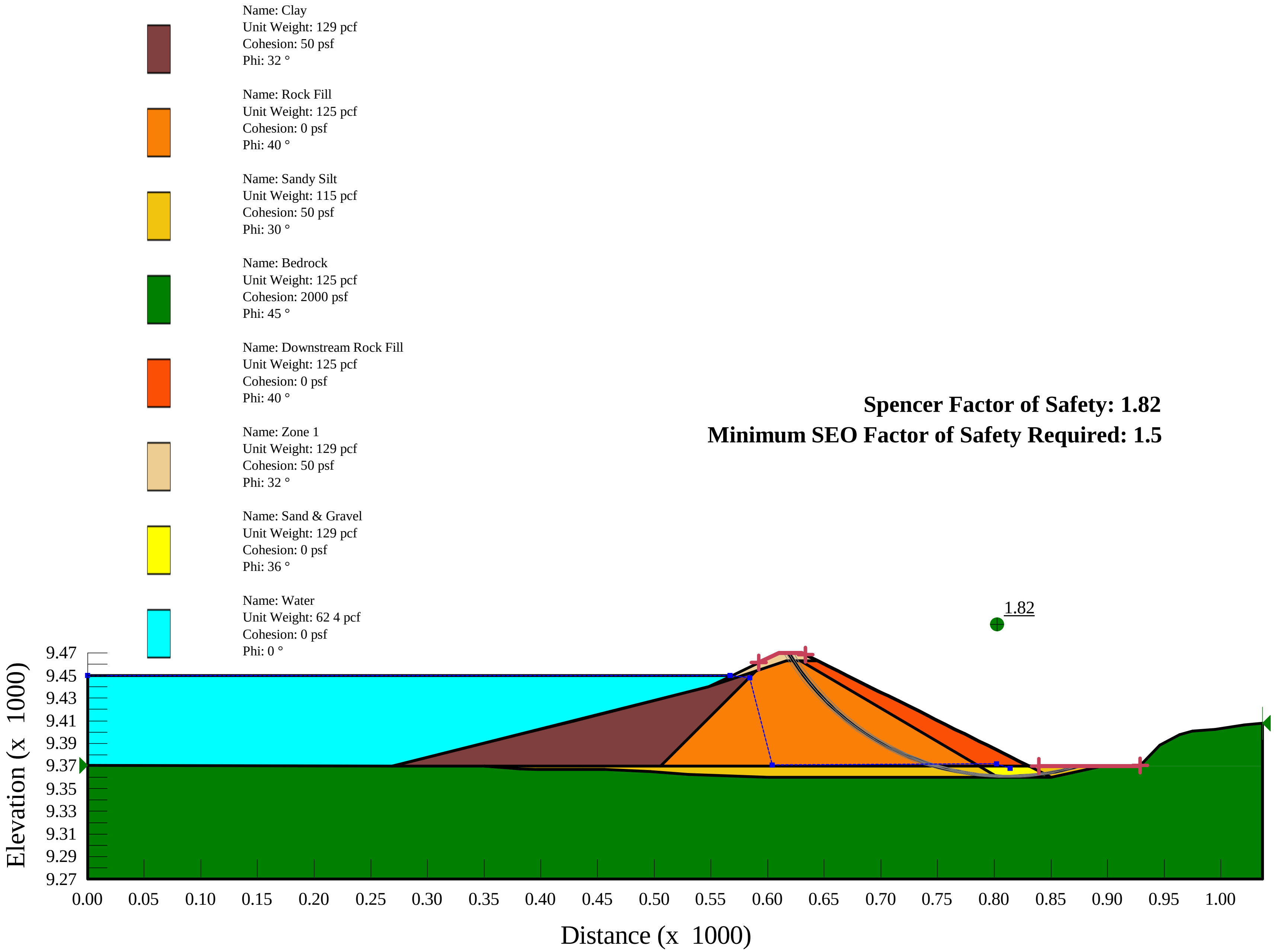


Figure 6-16

Rio Grande Reservoir
Maximum Section Existing Dam Downstream Seismic Loading

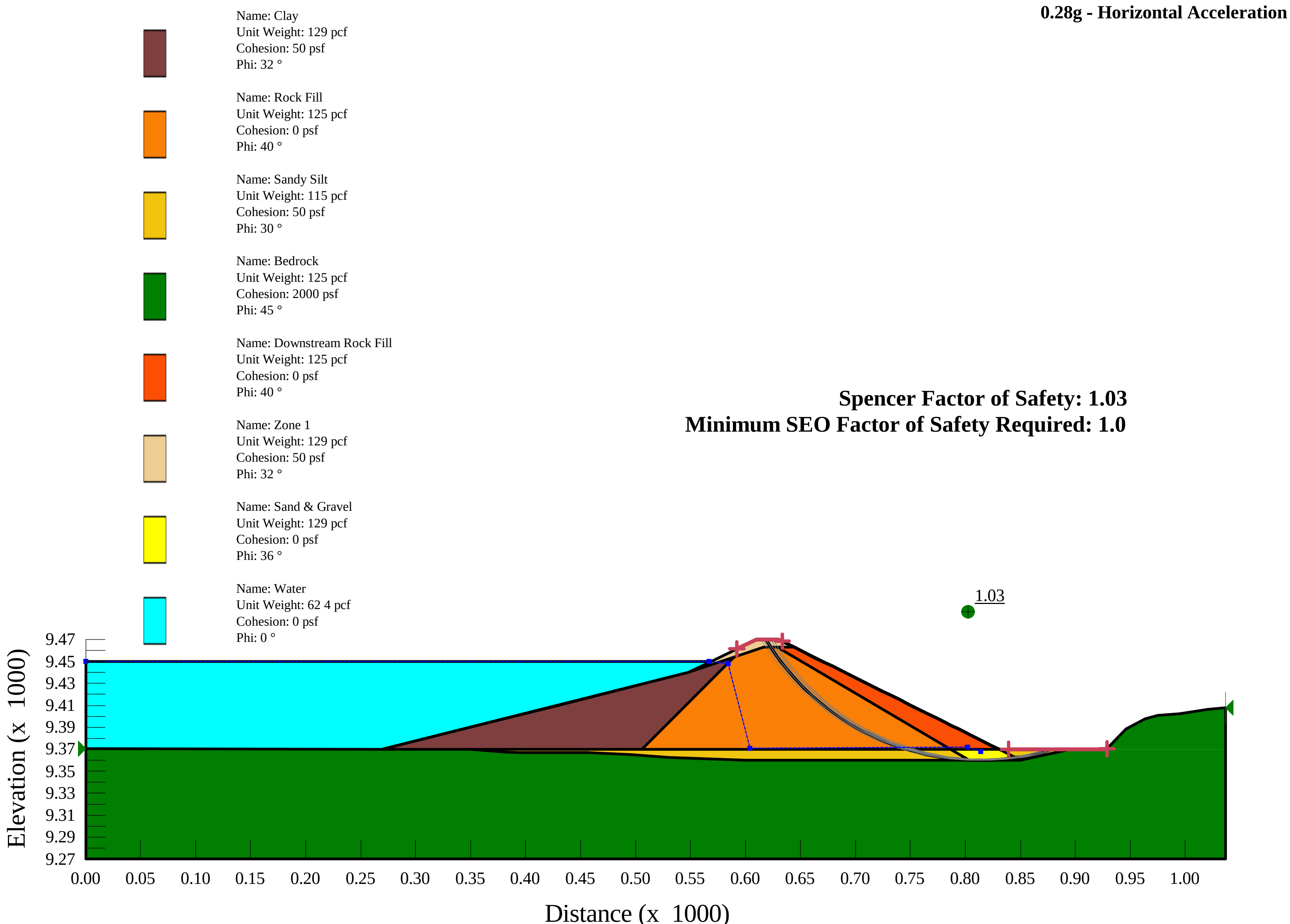


Figure 6-17

Enlarged Dam

The proposed 10-foot enlargement would be best accomplished through a downstream raise. The crest would be shifted downstream, utilizing the existing 4:1 (horizontal to vertical) upstream and 2:1 downstream slopes.

The enlarged dam would have an upstream impermeable membrane to control seepage because there is no filter zone between the upstream earthfill and the rockfill. The contact between rockfill and earthfill was constructed as hand placed rock (Engineering Record 1912). The abutments would be grouted as well to control seepage. For this analysis, we also assumed the phreatic surface would remain similar to historically measured surface that is high in the earthfill and low in the rockfill.

The stability analysis is presented in Figures 6-18 through 6-22. An enlarged dam will meet all minimum required safety factors.

6.3.2 Reservoir Rim Stability Analysis

Robert Kirkham performed a landslide investigation of the Reservoir area, which is summarized in Section 6.1. He states "The greatest potential threat of a large, catastrophic, rapidly moving landslide on the hill slopes adjacent to the Reservoir relates to the lateral block spread on the north side of the Reservoir, especially its southeast corner."

A slope stability analysis of the southeast corner was conducted and is presented on Figures 6-23 through 6-26. An analysis of Section B-B of Kirkham's geologic report (Kirkham 2008; Figure 12), was conducted and placed open tension cracks with no strength at the back of the analyzed block near the cliff edge. This matches Kirkham's observations shown on Figure 13 of his report (Kirkham 2008).

In order to perform a stability analysis, assumptions were made regarding:

1. The location of a basal failure plane,
2. Strength along the plane, and
3. The phreatic water surface.

A subsurface drilling and testing program would be needed to more accurately assess the actual conditions. Thus, the factors of safety calculated in the analysis should not be considered absolute firm values. Rather the usefulness of the analysis is only to check the relative importance or sensitivity of the slope to changes in: 1) Reservoir water levels; 2) natural groundwater phreatic levels in the cliff side; and, 3) earthquake loads.

Rio Grande Reservoir
Maximum Section Enlargement Upstream NWL

Name: Clay
Unit Weight: 129 pcf
Cohesion: 240 psf
Phi: 36 °

Name: Rock Fill/Enlargement Fill
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 40 °

Name: Sandy Silt
Unit Weight: 115 pcf
Cohesion: 400 psf
Phi: 30 °

Name: Bedrock
Unit Weight: 125 pcf
Cohesion: 2000 psf
Phi: 45 °

Name: Downstream Rock Fill
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 40 °

Name: Sand & Gravel
Unit Weight: 129 pcf
Cohesion: 240 psf
Phi: 36 °

Name: Water
Unit Weight: 62 4 pcf
Cohesion: 0 psf
Phi: 0 °

Spencer Factor of Safety: 3.52

Minimum SEO Factor of Safety Required: 1.5

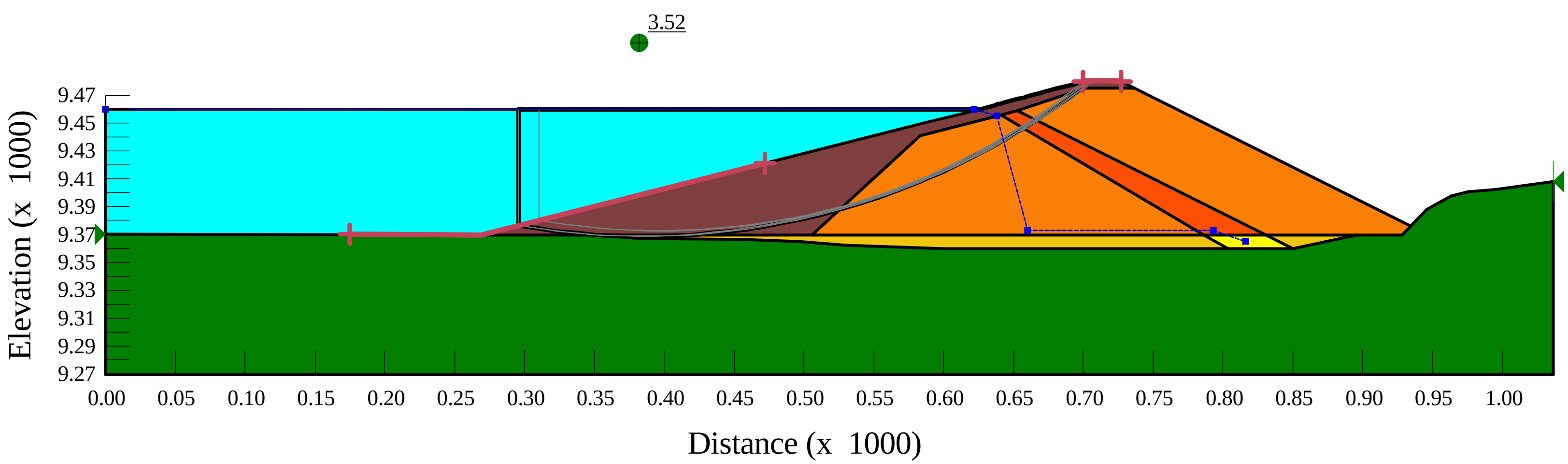
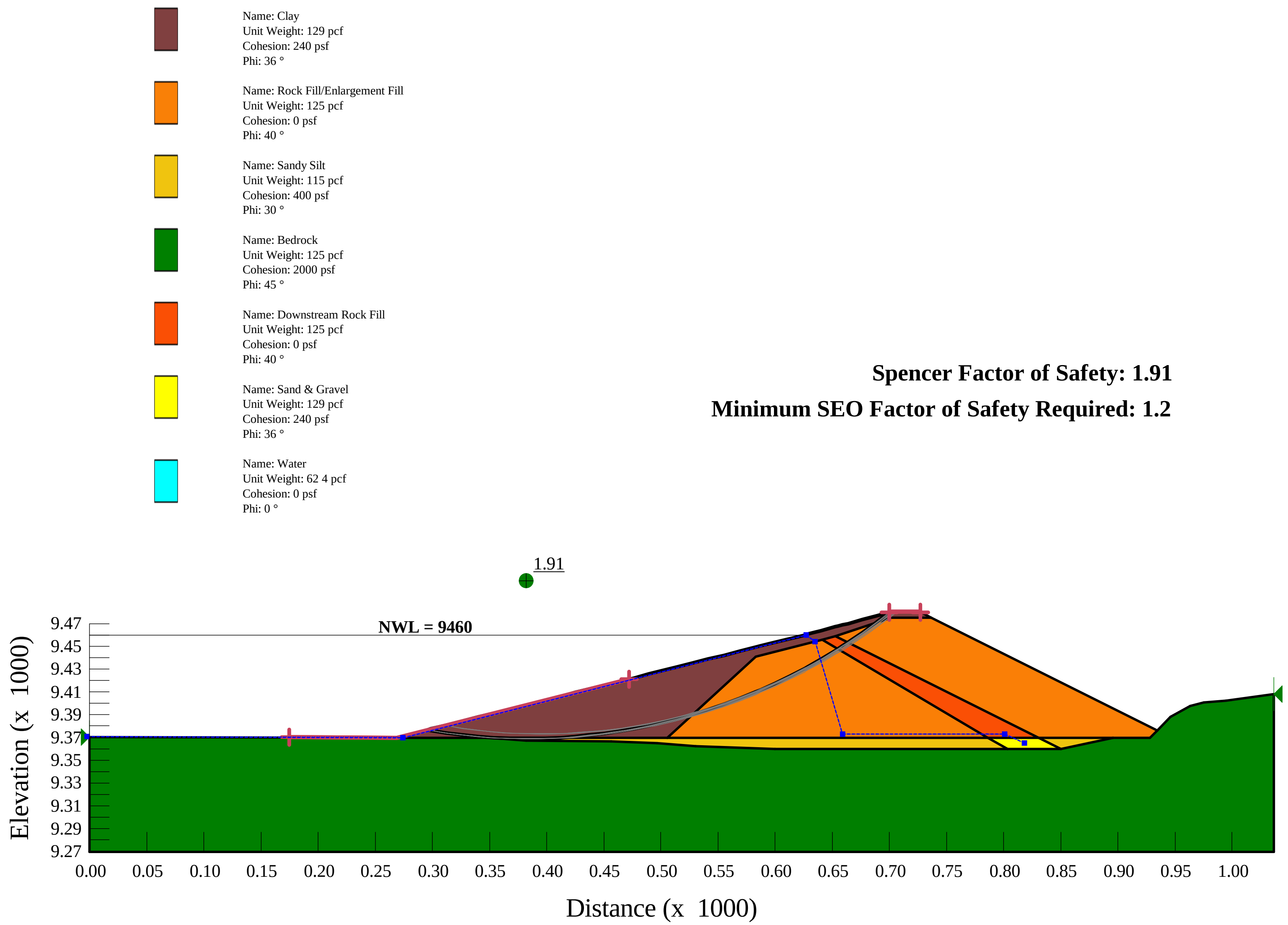


Figure 6-18

Rio Grande Reservoir
Maximum Section Enlargement Upstream Rapid Drawdown



Spencer Factor of Safety: 1.91

Minimum SEO Factor of Safety Required: 1.2

Figure 6-19

Rio Grande Reservoir
Maximum Section Enlargement Upstream NWL Seismic Loading

0.28g - Horizontal Acceleration

Name: Clay
Unit Weight: 129 pcf
Cohesion: 240 psf
Phi: 36 °

Name: Rock Fill/Enlargement Fill
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 40 °

Name: Sandy Silt
Unit Weight: 115 pcf
Cohesion: 400 psf
Phi: 30 °

Name: Bedrock
Unit Weight: 125 pcf
Cohesion: 2000 psf
Phi: 45 °

Name: Downstream Rock Fill
Unit Weight: 125 pcf
Cohesion: 0 psf
Phi: 40 °

Name: Sand & Gravel
Unit Weight: 129 pcf
Cohesion: 240 psf
Phi: 36 °

Name: Water
Unit Weight: 62 4 pcf
Cohesion: 0 psf
Phi: 0 °

Spencer Factor of Safety: 1.06

Minimum SEO Factor of Safety Required: 1.0

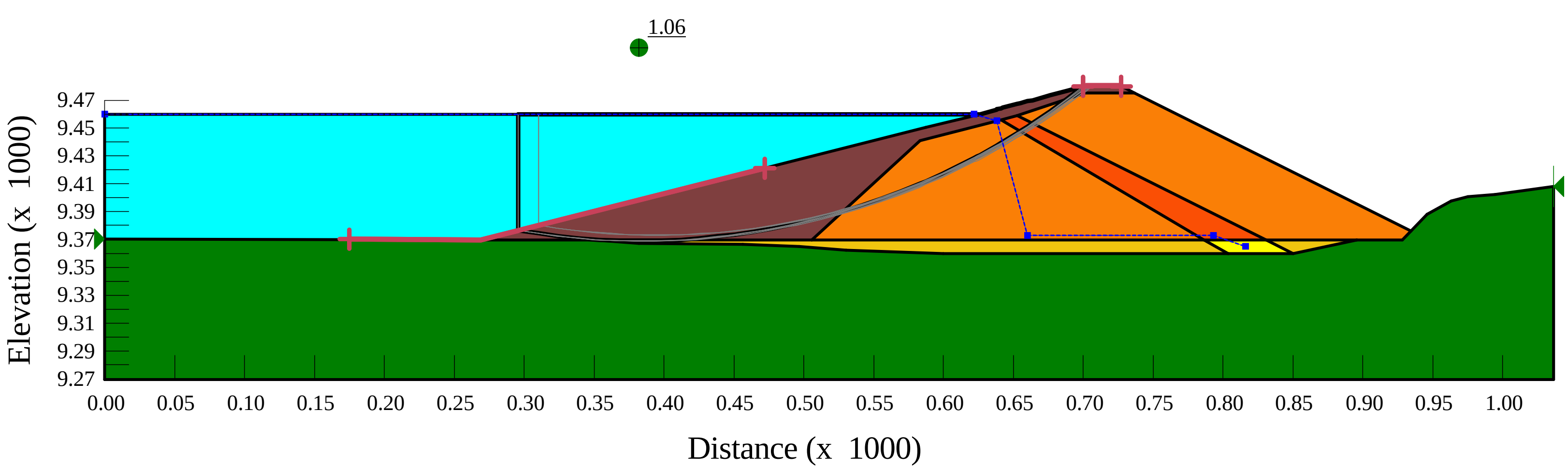


Figure 6-20

Rio Grande Reservoir
Maximum Section Enlargement Downstream NWL

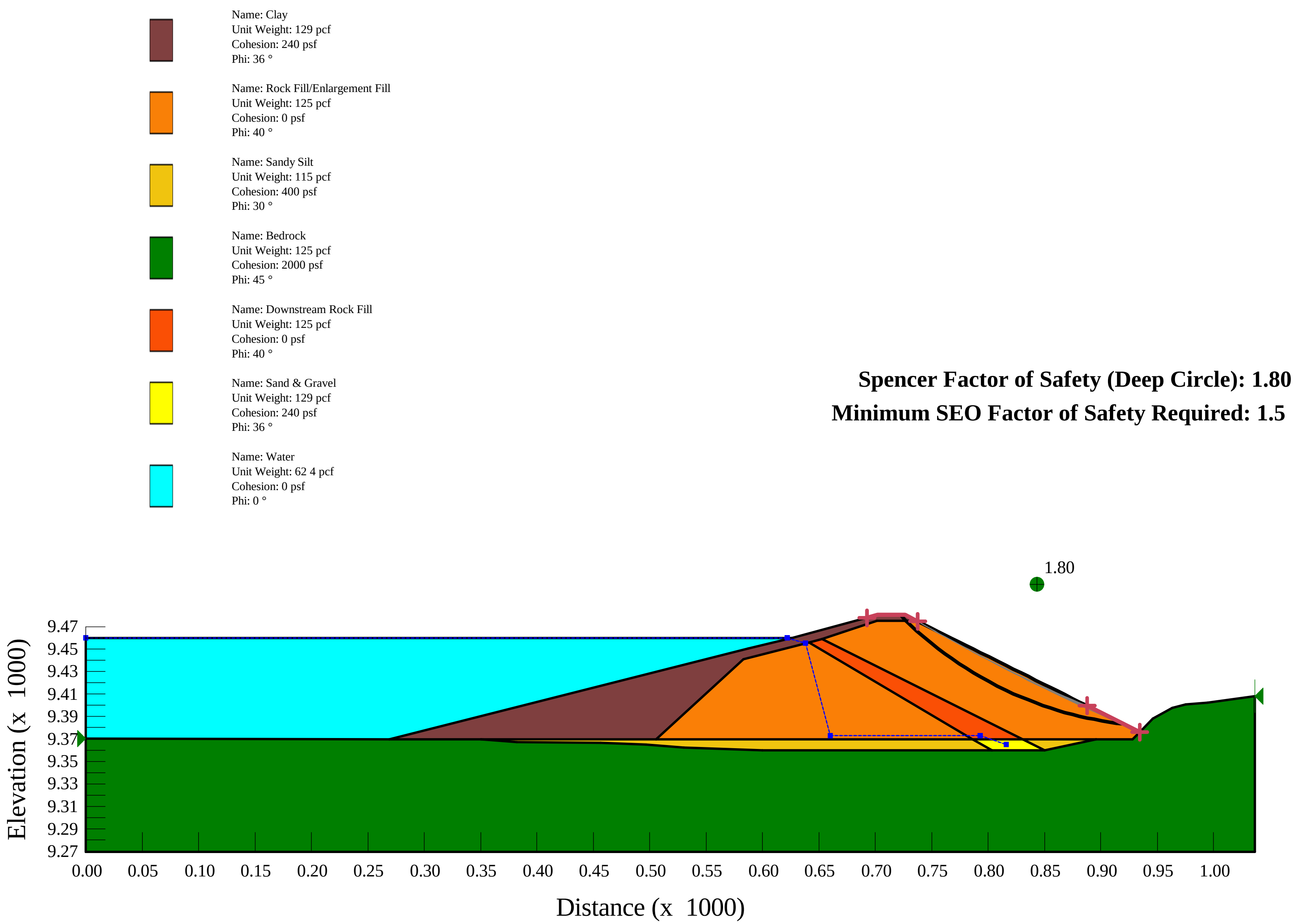


Figure 6-21

Rio Grande Reservoir
Maximum Section Enlargement Downstream NWL Seismic Loading

0.28g - Horizontal Acceleration

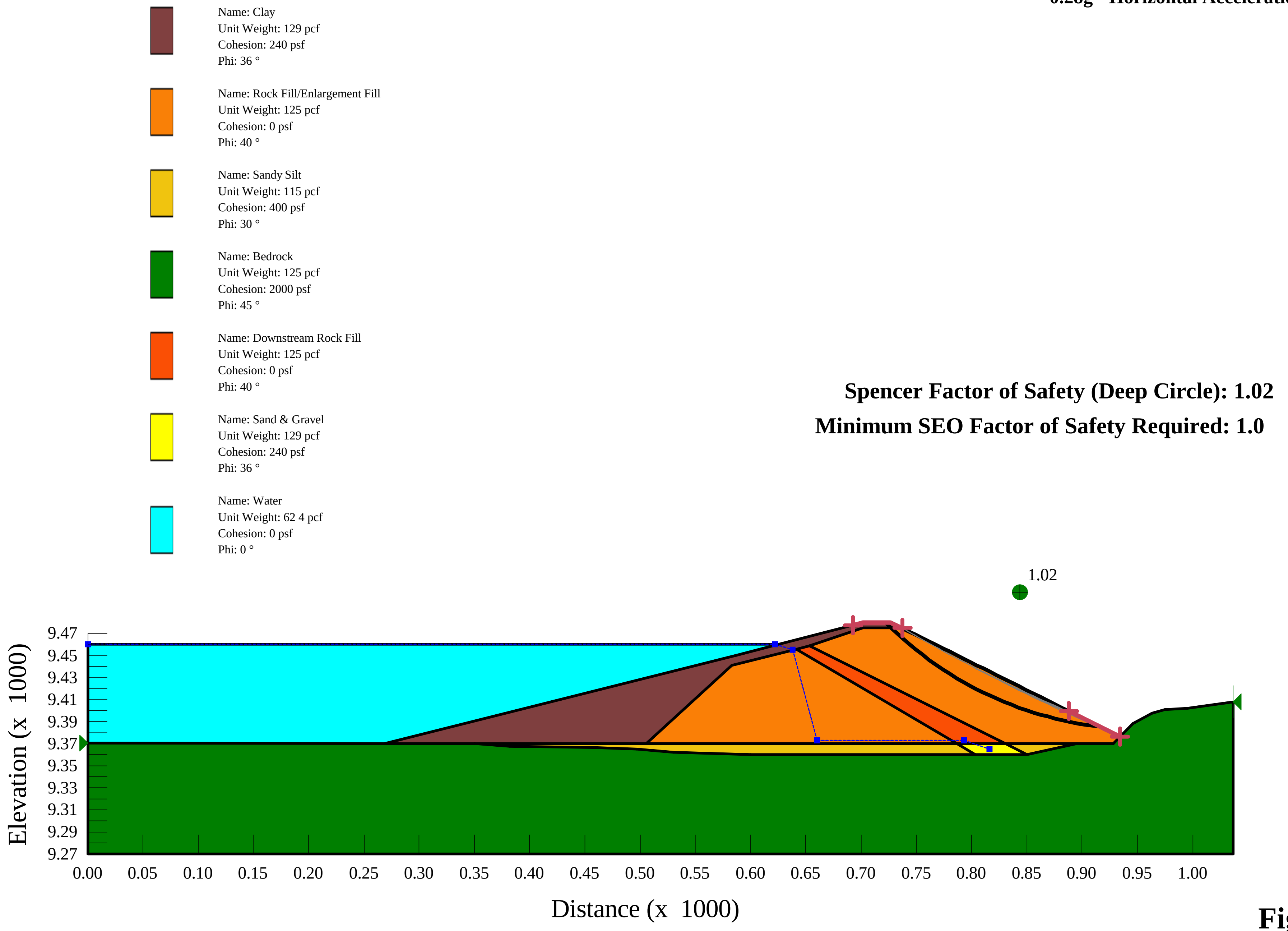


Figure 6-22

Rio Grande Reservoir
Lateral Block Spread - SE Corner Slope Stability of Reservoir Rim
Average Reservoir Elevation = 9410 ft

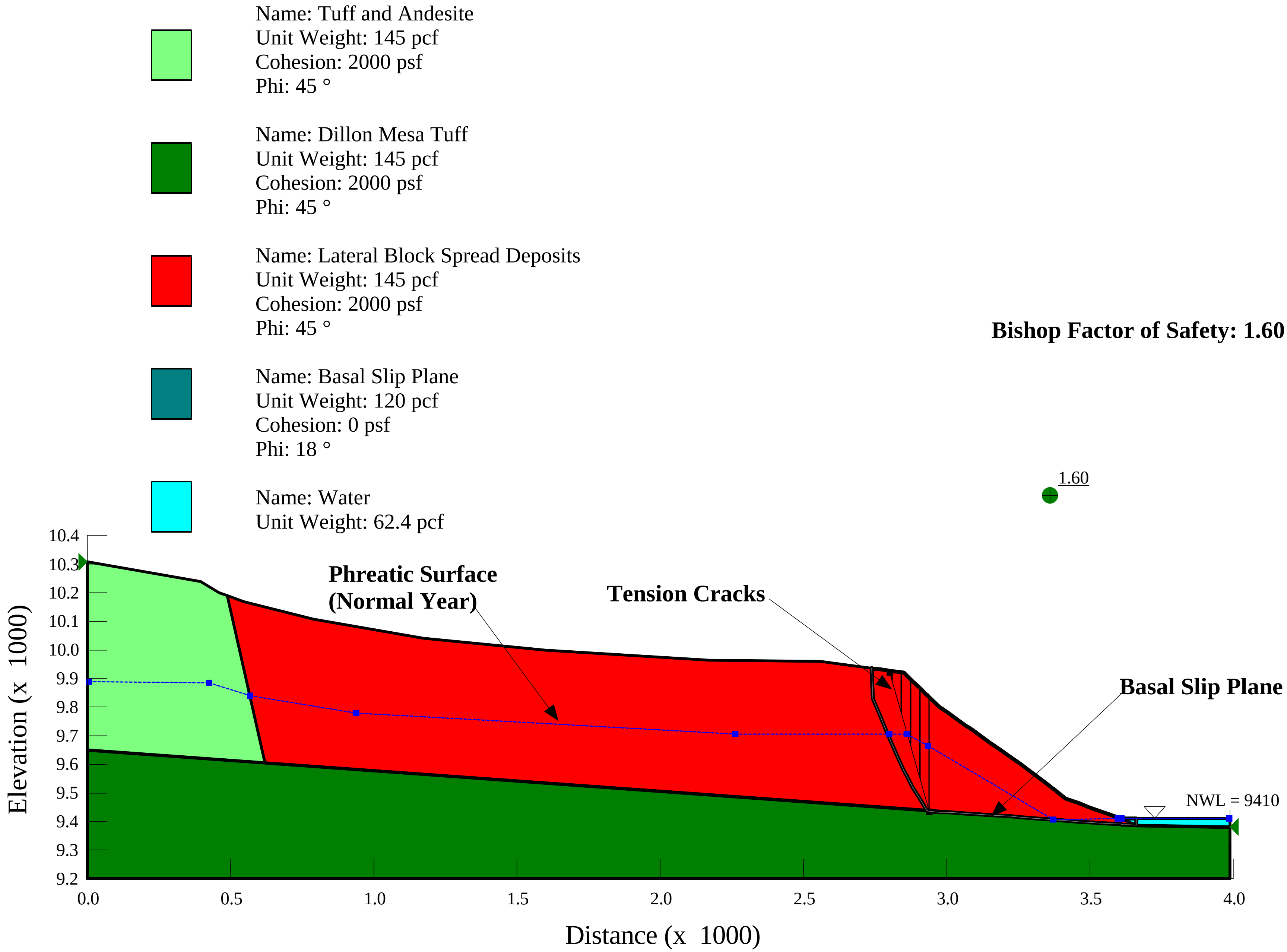


Figure 6-23

Rio Grande Reservoir
Lateral Block Spread - SE Corner Slope Stability of Reservoir Rim
Rapid Drawdown from Elevation 9460 ft

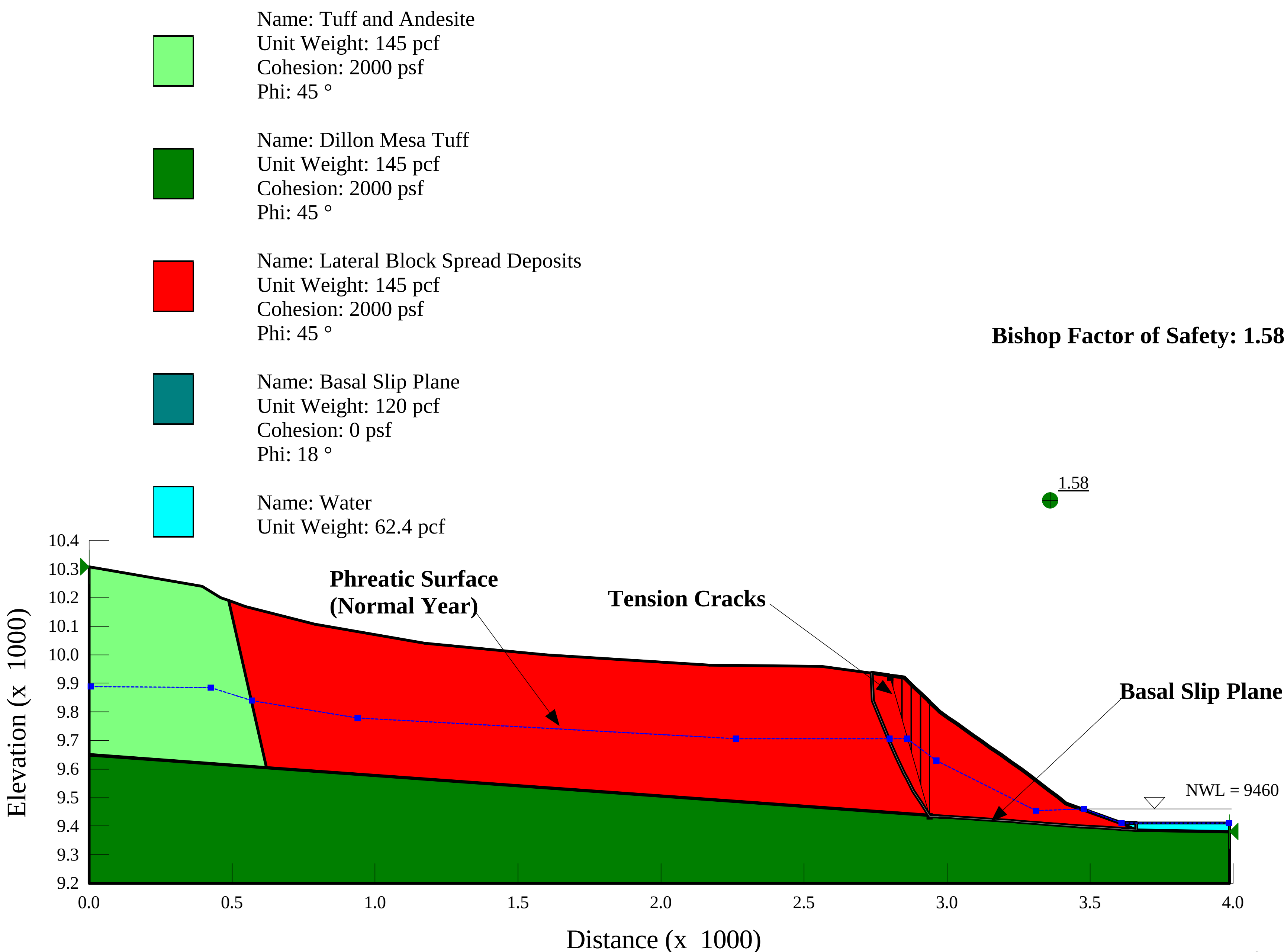


Figure 6-24

Rio Grande Reservoir
Lateral Block Spread - SE Corner Slope Stability of Reservoir Rim
Average Reservoir Elevation = 9410 ft High Precipitation Year

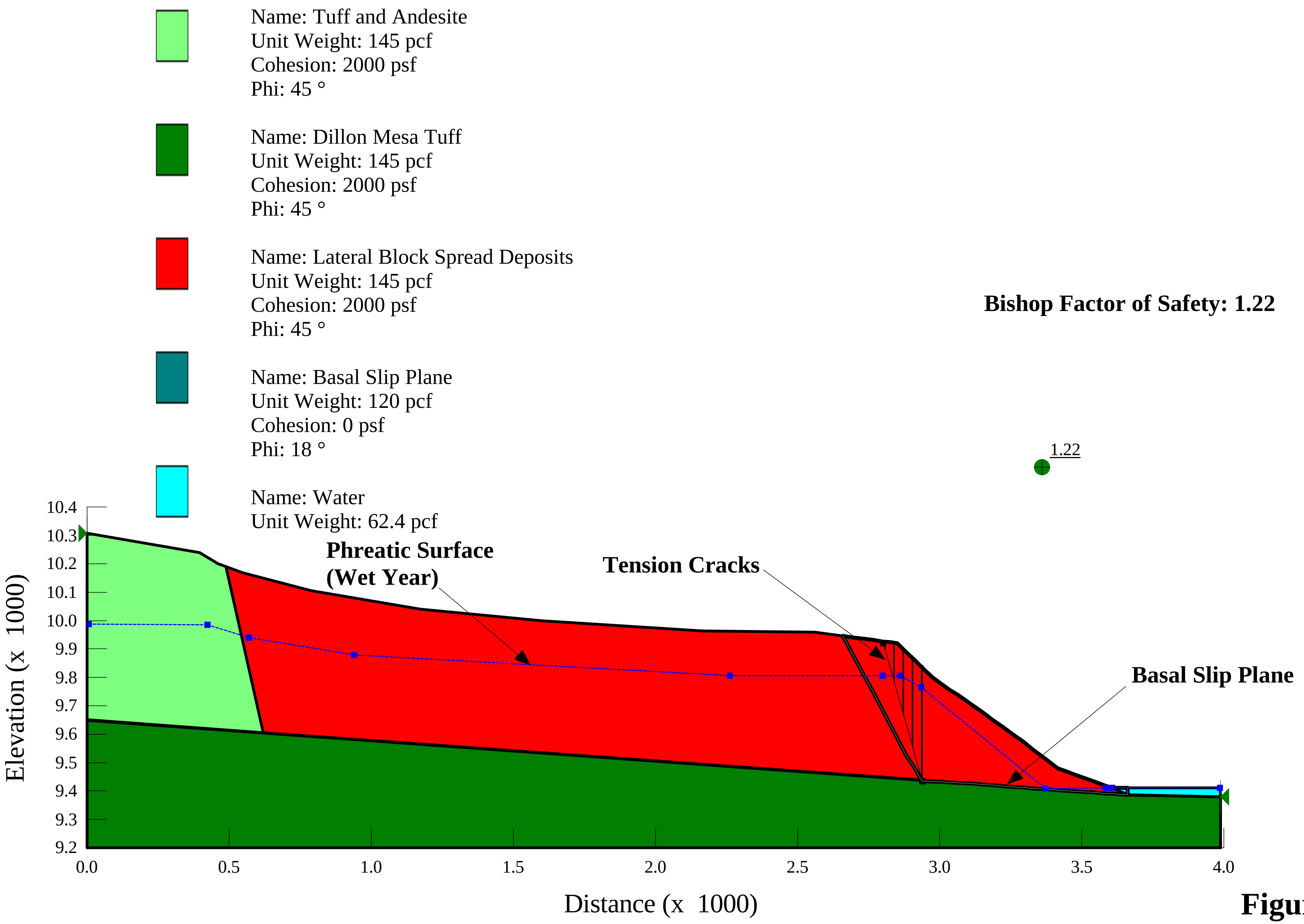


Figure 6-25

Rio Grande Reservoir
Lateral Block Spread - SE Corner Slope Stability of Reservoir Rim
Average Reservoir Elevation = 9410 ft Seismic Loading

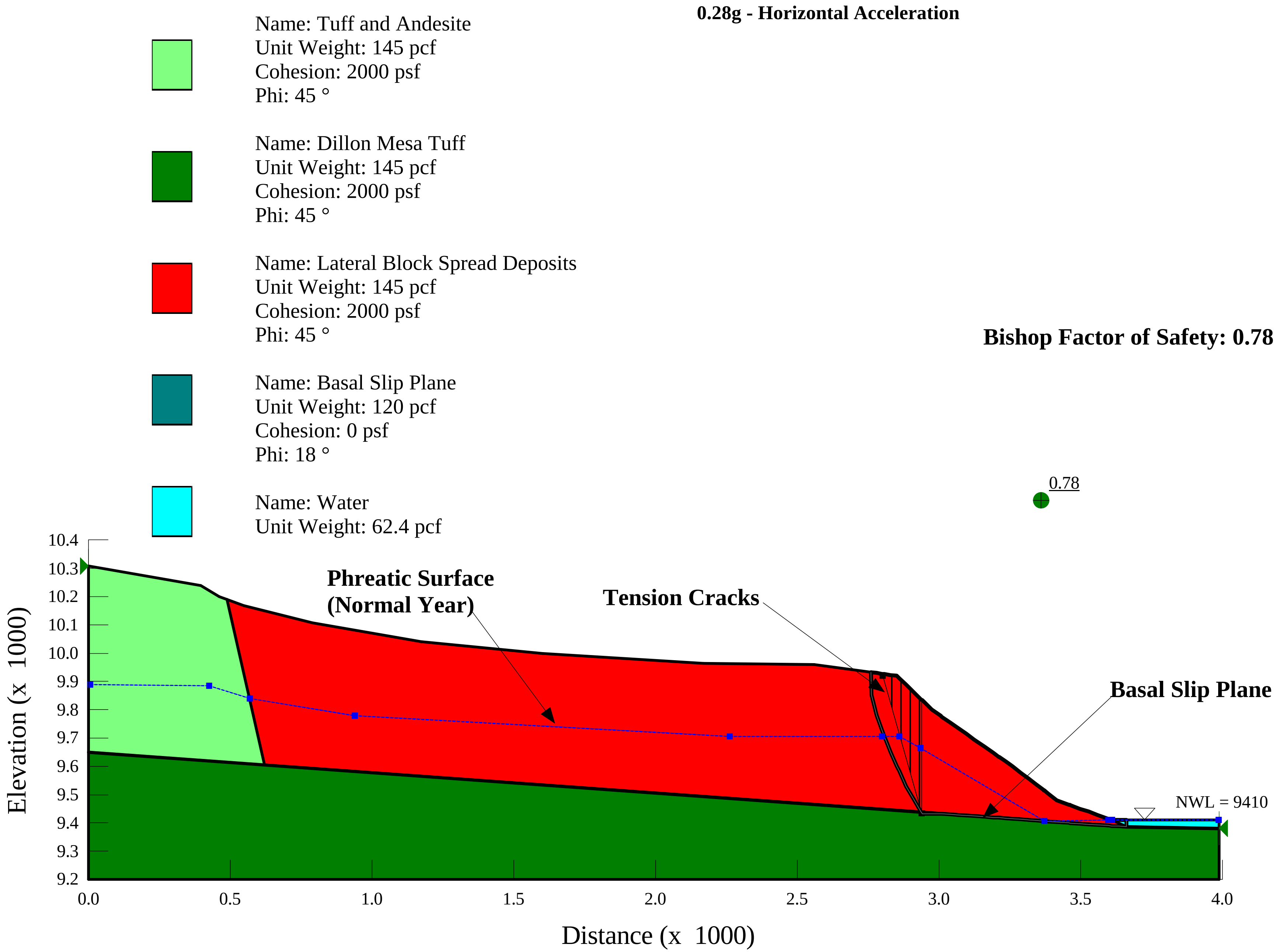


Figure 6-26

Based on experience and general literature review, the value of the residual strength of the basal plane was given an effective friction value of 18 degrees. The location of the basal slip plane was assumed to be a contact between two tuff formations that dip slightly (about 4 degrees) down slope as shown on Kirkham's Section B-B (Kirkham 2008; Figure 12). The phreatic water surface was initially assumed to generally parallel the ground surface at about the middle of the block.

Initially the Reservoir surface was assumed to be at elevation 9,410, which is the average historical reservoir level. As shown on Figure 6-22, the calculated factor of safety is 1.60. This indicates a stable slope under the assumed conditions. That is, the stabilizing forces are 1.60 times larger than the driving forces. A factor of safety greater than one indicates it will not move and a factor of safety of 1.5 is used for dam embankment design.

In the second analysis (Figure 6-24) the Reservoir was assumed to be enlarged and kept full to elevation 9,460 and then drawn down rapidly to 9,410, resulting in a change to the phreatic surface at the toe of the block. This produced a factor of safety of 1.58 or a reduction of stability of only 1.31 percent. This appears intuitively correct because the reservoir stage change is small when compared to the size of the block.

The effects of natural hazards on the stability of the block were also analyzed. An extremely wet year that raises the groundwater level 100 feet in the block would reduce the factor of safety to 1.22 (Figure 6-25). This indicates it would not fail but the factor of safety is reduced 24 percent by a 100-foot rise in groundwater levels.

Finally, a large earthquake was modeled by applying a horizontal acceleration of 0.28g. This induced failure as the Factor of Safety was 0.78 (Figure 6-26).

In summary, the analysis illustrates that operation of the Reservoir in a fuller condition and raising it 10 feet appears to have little negative effect on the stability of the block spread. Remobilization of this block could occur in a major earthquake.

Section 7
Hydrologic and Hydraulic Analyses

Hydrologic and hydraulic analysis of the Reservoir was preformed to determine the inflow design flood (IDF), routing capacity, and existing hydraulic conditions existing spillway structure. Similar analysis of an enlarged reservoir option was performed to develop a preliminary routing capacity and the hydraulic conditions for a new spillway structure for the enlargement option. Both analyses focused on the ability of the Reservoir and spillway to meet the State Engineer's Rules and Regulations for Dam Safety and Dam Construction (2007). Recommendations and preliminary design for both options are based on the results of the hydrologic and hydraulic analyses presented in this section. Preliminary design of the spillway improvements is presented in Section 5, with drawings presented in Appendix B.

7.1 Summary

The purpose of the hydrologic and hydraulic analyses was to develop the inflow design flood and required routing capacity for the rehabilitation only and enlargement options. The following is a summary of the analysis:

1. Both local and general extreme storm events were developed for the basin above the Reservoir. The results indicated that a general storm was more critical than a local storming in determining flood routing through the Reservoir. The general storm produces 6.22 inches of rainfall and 4.50 inches of runoff in 84 hours. The resulting flood has a peak reservoir inflow of 13,300 cfs and a runoff volume of 38,100 AF. Beginning with the Reservoir at capacity and the existing spillway structure, the water surface elevation reaches a maximum gage height of 102.10. When modeled with the enlargement, the maximum reservoir stage is 107.4.

View of spillway - note people standing near concrete wall for scale

2. Routing the inflow design flood (IDF) through the existing spillway structure shows that the existing spillway weir and chute are incapable of safely passing the IDF if the Reservoir is at full capacity at the beginning of the storm. Outlet capacity was not considered in the overall reservoir discharge capacity during the extreme storm event, per the State Engineer's policy.

3. Spillway modifications are proposed to provide the required flood routing capability for the IDF. The modifications include constructing a training wall,

raising the abutments, and increasing the spillway chute walls. Wall sizes and locations are different for the rehabilitation and enlargement options, but are conceptually similar.

7.2 Design Storm – Extreme Storm Event

An extreme storm event is described as the most severe combination of hydrologic and meteorological conditions considered reasonably possible for the Rio Grande drainage basin tributary to the Reservoir. The extreme storm event was used to develop the IDF hydrograph described in Section 7.3.

7.2.1 Climate and Meteorology

The mean basin elevation of the Reservoir drainage is approximately 11,700 feet, with a minimum elevation of 9,400 feet at the dam and the maximum over 13,000 feet along the Continental Divide. The climate is typically mountainous or alpine. Annual precipitation generally exceeds 18 inches per year, with more than 50 percent of this falling as snow from mid-October to late April.

Two unique storm types were identified as data sources for estimates of extreme storm precipitation – general and local. General storm precipitation is precipitation occurring from atmospheric/orographic processes that cover large areas and persist for long durations. Local storm precipitation is restricted in both duration and areal extent since it is isolated from strong atmospheric circulations. Local storms are often referred to as thunderstorms.

General rainstorms in the region typically occur after the spring runoff season. These storms can move into the upper Basin either from the southwest over the Continental Divide or from the southeast over the Sangre de Cristo Mountains. The amount of moisture that results from this type of storm movement is limited by the mountain ranges at elevations between 13,000 and 13,500 feet, which effectively form an inflow barrier. Analysis of the meteorology indicates that, typically, the general storm would be relatively long in duration but low to medium intensity.

The moisture supply for a high intensity local storm generally comes up the Rio Grande valley and enters the Basin at or near the mean elevation of the valley floor; 9,400 feet. This low level moisture will deplete rapidly and no immediate recharge will be available. Therefore, the local storm is characterized by high intensity rainfall of short duration. The local storms generally predominate from late June to late September (Wheeler, 1981).

7.2.2 Extreme Storm Precipitation

The design rainfall event for generating the IDF is traditionally termed the probable maximum precipitation (PMP) event. Sources for the PMP rainfall data have been the appropriate Hydrometeorological Reports (HMRs) by the National Oceanic and Atmospheric Administration (NOAA). However, the Colorado State Engineer, Dam

Safety Branch recently developed the Extreme Precipitation Analysis Tool (EPAT) to provide site specific PMP (SSPMP) estimates for the State of Colorado. EPAT is geographic information system (GIS)-based software that provides SSPMP estimates specific to a basin based on analyses of state approved extreme precipitation event climatology. Specifically, EPAT uses site-specific storms and incorporates recent research on storm characteristics while also considering the characteristics of specific basins. SSPMP estimates from EPAT are considered more accurate by the State Engineer's Office (SEO), especially for mountainous regions. PMP estimates developed by the traditional HMR generally overestimate rainfall in the upper Rio Grande basin since it does not account for wind patterns that circulate near the Continental Divide. Thus, the IDF is reduced when using EPAT results as compared to the traditional HMR results.

The maximum precipitation possible, as predicted by EPAT, is termed extreme storm precipitation (ESP) rather than PMP. EPAT produces watershed peak rainfall amounts, total volumes, and temporal distributions for both general and local storms by adjusting historical storm events to the local geography of the basin of interest. A general storm event occurring in 1927, which produced widespread heavy high elevation rain over southwest Colorado, was the ESP event used to generate the IDF for the Reservoir.

EPAT determined that had the 1927 general storm occurred over the Reservoir Basin, the storm would have produced 6.22 inches of rain in 84 hours. A local storm event occurring in 1924, which produced 3.50 inches of rain at Mesa Verde National Park in 45 minutes, was also examined. The general storm and local storm ESP hyetographs are shown in Figure 7-1 and Figure 7-2, respectively. EPAT Basin Analysis Results Reports from the State Engineer are included in Appendix C.

7.3 Inflow Design Flood

The IDF hydrograph represents the maximum runoff condition resulting from either the general or local ESP event. When the IDF is developed through EPAT it is simply referred to as the IDF hydrograph, rather than the probable maximum flood (PMF).

The IDF hydrograph is required to determine routing capacity and sizing of the hydraulic features of the spillway structure. The IDF was used in this analysis to determine the ability of the existing and enlarged Reservoir options to safely route the extreme storm event.

Figure 7- 1
EPAT General Storm Hyetograph
(Original Event: Palisade Lake)

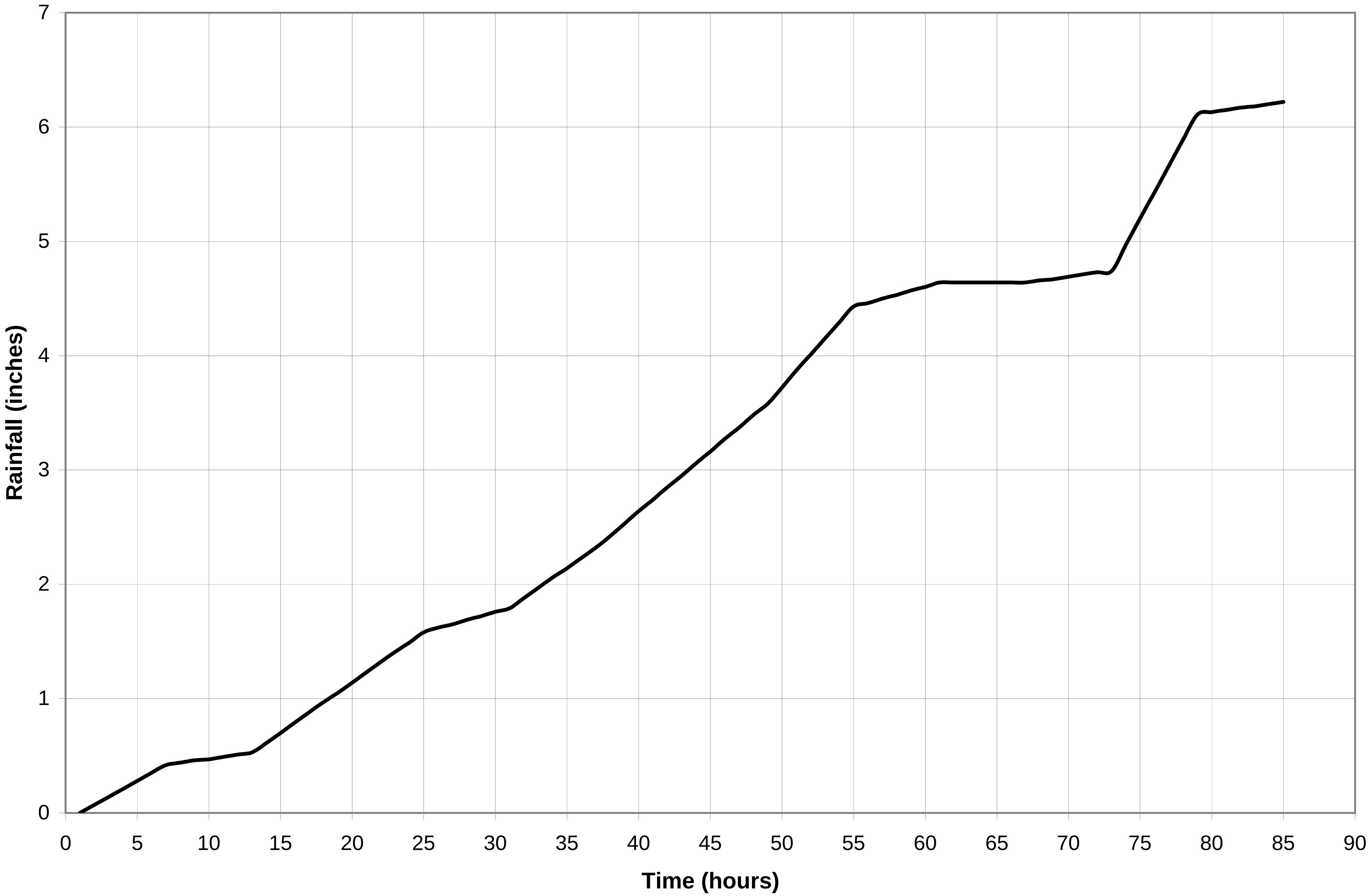
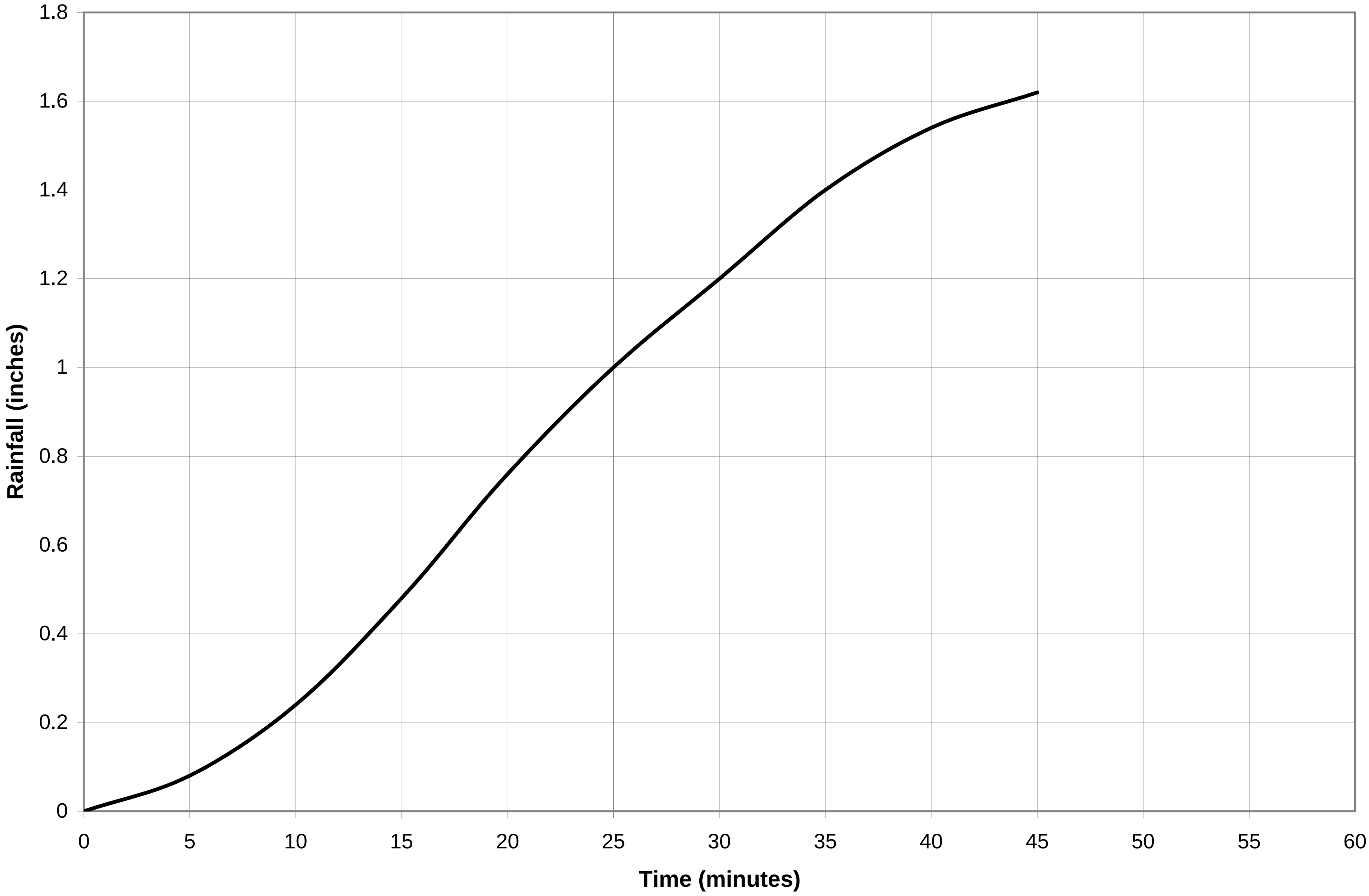


Figure 7-2
EPAT Local Storm Hyetograph
(Original Event: Mesa Verde)



Development of the IDF included:

1. Determination of the IDF parameters, which include drainage basin hydrologic and geologic factors.

2. Calculation of sub-drainage basin dimensionless unit hydrographs.

3. Calculation of existing reservoir routing capacity, which includes the reservoir storage and spillway capacity.

4. Preliminary design of improved Reservoir spillway structure, which includes calculation of enlarged reservoir routing capacity.

5. Development of independent hydrologic models to determine the IDF for both the existing and enlargement options.

7.3.1 IDF Parameters

The IDF parameters were used in the development of runoff lag time necessary for the unit hydrograph. Runoff in the basin is a mix of overland and concentrated flow, with clearly defined flow paths (perennial streams). The same IDF parameters were used for both options.

Drainage Basin Delineation

The 160-square-mile drainage basin sits at the base of the Continental Divide. The drainage basin was divided into five sub-basins based on topography and independent tributary watershed characteristics (Figure 7-3). Each sub-basin represents an area of the watershed, which, on average, has the same hydraulic/hydrologic properties. The area of each sub-basin area was determined using GIS. The values are summarized in Tables 7-1 and 7-2.

Sub-Basin Drainage Characteristics

Sub-basin drainage characteristics determine the probable future flow of water and are based on hydrologic and geologic factors, vegetation, and land use. These characteristics were used in the calculation of the lag time for each sub-basin unit hydrograph (Section 7.3.2) using the following equation (USBR, 1987):

$$L_g = 26K_n\left(\frac{LL_{ca}}{S^{0.5}}\right)^{0.33}$$

Where:

L_g = lag time (hours)
L = the length of the longest water course (miles)

L_{ca} = length of the longest watercourse from the point of concentration to the intersection of a point perpendicular from the centroid of the drainage basin to the stream (miles)

S = overall slope of the longest watercourse (feet/mile)

K_n = drainage sub-basin resistance factor

Table 7-1 and Table 7-2 list the sub-basin drainage characteristics and associated lag times for the general and local extreme storm events, respectively. The spatial characteristics were determined using a GIS database and are illustrated on Figure 7-3.

Table 7-1 General Storm IDF Parameters

Basin	Drainage Area A (Sq Mi)	Stream Length - L (mi)	Stream Centroid - L_{ca} (mi)	Stream Slope - S (ft/mi)	Resistance Factor - K_n	Lag Time - L_g (hours)
Reservoir Tributaries	7.6	2.0	0.6	1100	0.13	1.13
Weminuche Creek	11.8	6.2	3.2	618	0.13	3.14
Lost Trail Creek	25.4	9.9	6.8	395	0.13	5.06
Ute Creek	41.3	11.8	6.3	284	0.13	5.52
Rio Grande Mainstem	70.9	16.6	9.5	241	0.13	7.26

Table 7-2 Local Storm IDF Parameters

Basin	Drainage Area A (Sq Mi)	Stream Length - L (mi)	Stream Centroid - L_{ca} (mi)	Stream Slope - S (ft/mi)	Resistance Factor - K_n	Lag Time - L_g (hours)
Reservoir Tributaries	7.6	2.0	0.6	1100	0.05	0.43
Weminuche Creek	11.8	6.2	3.2	618	0.05	1.21
Lost Trail Creek	25.4	9.9	6.8	395	0.05	1.94
Ute Creek	41.3	11.8	6.3	284	0.05	2.12
Rio Grande Mainstem	70.9	16.6	9.5	241	0.05	2.79

K_n is a measure of the hydraulic roughness characteristics of the drainage network of the sub-basin. It estimates the resistance of water to flow in a drainage network. K_n has a direct relationship to the peak inflow. Higher K_n values indicate more resistance and thus longer lag times. Longer lag times decrease the overlap of sub-basins' peak flows and cause an overall lower peak inflow at the Reservoir. A lower K_n value indicates less resistance and thus shorter lag times. Shorter lag times increase the overlap of sub-basins peak flows and cause an overall higher peak inflow at the Reservoir. The overall inflow volume remains constant since the water still flows to the Reservoir, just at different runoff rates.

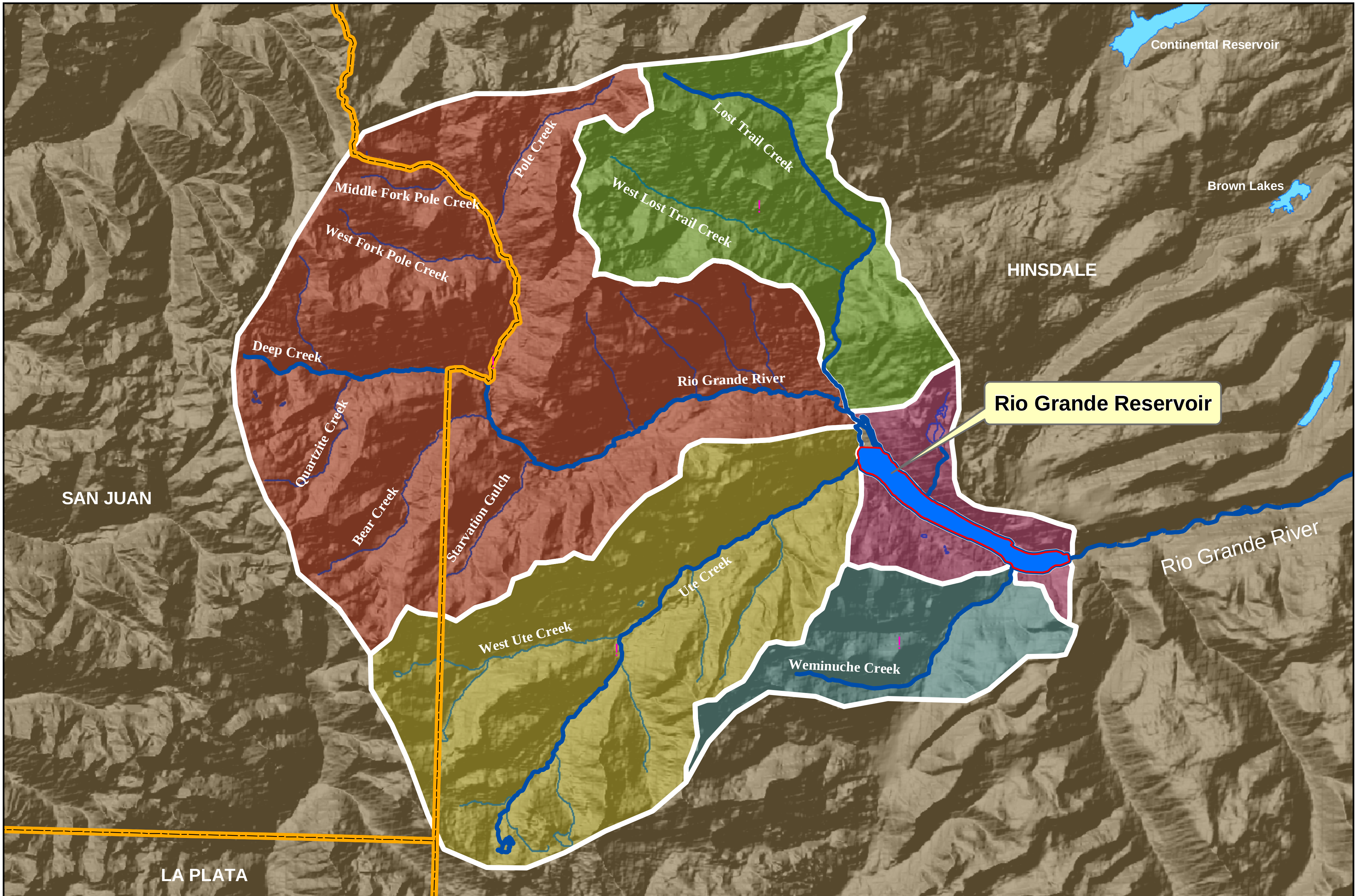


Figure 7-3
Sub-Basin Drainage Map

The U.S. Bureau of Reclamation (USBR) Design of Small Dams (USBR 1987) indicates that, for basins located in the Rocky Mountains, K_n for general storms range from 0.260 to 0.130 and 0.073 to 0.050 for local storms. In selecting a K_n value for the Reservoir drainage, consideration was given to the topography and flow paths. A significant portion of the drainage basin has large rock outcroppings, steep slopes, and limited vegetation. These features suggest that a lower K_n value is appropriate. Similarly, the steep topography and clearly defined flow paths indicate high stream velocities and corresponding lower lag times, also suggesting that it is appropriate to use a lower K_n value.

Accordingly, the lowest value in each of the recommend USBR ranges was adopted: a K_n of 0.13 for the general storm; and, 0.05 for the local storm. Because the five sub-basins are similar in topography and drainage conditions, the same K_n value was used for each sub-basin. These drainage basin characteristics were used for both the existing and enlarged option unit hydrographs.

A sensitivity analysis was performed by varying the K_n value in the hydrologic model because of the uncertainty associated with selection of a K_n value. The sensitivity analysis confirmed the variance of the peak inflow and the constant inflow volume. The peak outflow from the spillway also varied; however, the range was significantly less than the peak inflow variance For example, using a K_n value equal to 0.26 (the upper end of the USBR range), the peak inflow is 28 percent lower, while the spillway discharge is only 1.5 percent lower. The selected K_n values mentioned above provide the highest peak inflow and therefore the most conservative design flood. Lower K_n values would result in lower flows at the spillway, so the current design will pass IDFs developed with higher K_n. Given the results of the sensitivity analysis, further refinement of the K_n value will likely not affect the design of the spillway structure and does not need to be further refined.

Precipitation Abstractions

In any storm event, the entire rainfall does not contribute to runoff. The volume of runoff is the volume of precipitation minus abstractions (e.g., infiltration, surface storage) – also known as rainfall excess. Runoff does not occur until the rainfall rate exceeds abstractions rate. The Soil Conservation Service (SCS) Curve Number (CN) method was selected as the most appropriate method to estimate precipitation abstraction. The CN is related to the drainage characteristics of the sub-basin soil cover, land use type, and antecedent moisture condition. A CN of 85 was selected for each sub-basin based on the broken rock (scree) and limited vegetation in each sub-basin.

7.3.2 Unit Hydrograph

A unit hydrograph is the method used to convert rainfall on a drainage basin to runoff. Generally, unit hydrographs are developed through analysis of observed rainfall and observation of the resulting flood hydrograph. The USBR has performed extensive analyses of rainfall and stream hydrographs in Colorado. For this reason, the State Engineer recommends the USBR unit hydrograph for development of the IDF runoff hydrograph.

However, no observed rainfall records exist for the Reservoir drainage basin and a synthetic unit hydrograph was required. Synthetic unit hydrograph procedures reconstruct unit hydrographs for nearby watersheds of similar topographic characteristics based on rainfall-runoff phenomena. The USBR often reconstructs observed flood hydrographs using the synthetic unit hydrograph technique. Further details regarding the development of the unit hydrographs for each subbasin is presented in Appendix D.

7.3.3 Routing Capacity

Routing capacity is defined as the capability of the reservoir and spillway structure to attenuate flood inflows. It is the combination of the spillway discharge and reservoir surcharge storage capacity. The reservoir is able to temporarily store water during flood events which reduces the peak spillway outflow. The volume of water entering a reservoir during the peak inflow goes into storage above the spillway crest and gradually discharges through the spillway rather than instantaneously.

Existing Reservoir

The existing Reservoir includes 20 feet of freeboard, which provides surcharge storage during flood events. The current outlet works can discharge approximately 1,800 cfs under gravity conditions and estimated at 2,500 cfs under pressurized conditions, though outlet capacity is not generally accounted for in IDF analyses per State Engineer policy.

Reservoir Capacity

The storage capacity has been studied several times since the Reservoir was completed in 1914. The latest survey provided by the District shows the maximum storage capacity at 54,082 AF at the spillway crest (gage height 91). This amount is larger than the legal capacity of the Reservoir, but was chosen for the hydrologic model as it represents the most recent physical conditions on site. The Reservoir has additional temporary storage capacity, above the spillway crest, to attenuate flood inflows.

The District provided CDM the most current stage-storage curve (Figure 7-4), which was used in the hydrologic models.

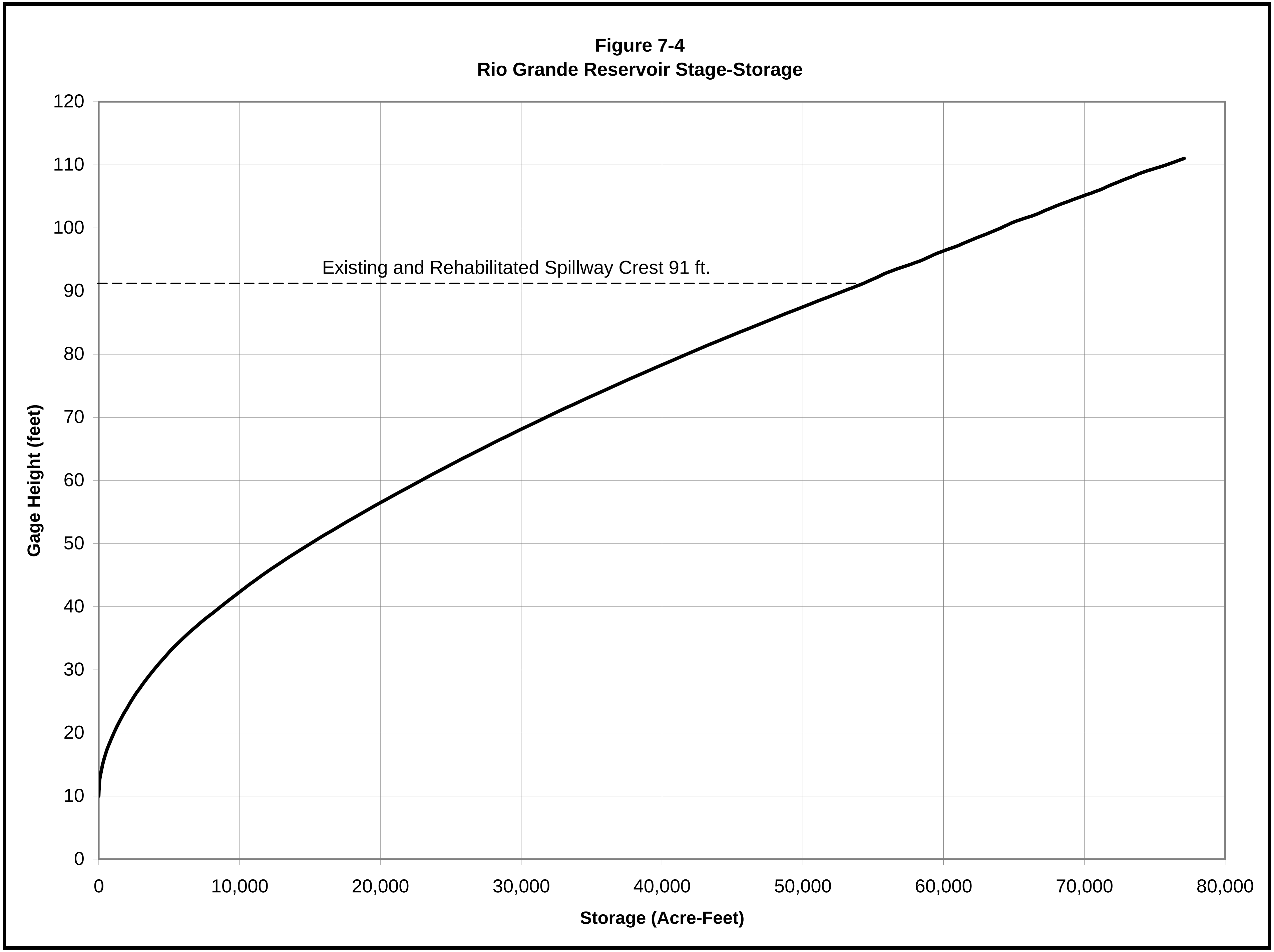


Figure 7-4
Rio Grande Reservoir Stage-Storage
Existing and Rehabilitated Spillway Crest 91 ft.
Gage Height (feet)
Storage (Acre-Feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000

Spillway Capacity

The existing spillway structure consists of an uncontrolled side channel spillway, trough, downstream control weir, and trapezoidal channel chute. The side channel spillway consists of an "L-shaped" ogee weir approximately 120 feet long, with a crest elevation at gage height 91 feet. An ogee weir of the same general cross-sectional shape is used in the trough to control flow into the spillway chute and provide proper hydraulic conditions in the side channel portion. The control weir is 32 feet long with a crest elevation of gage height 85 feet. The spillway chute, downstream of the control weir, consists of a trapezoidal channel approximately 32 feet wide and 475 feet long, narrowing to approximately 20 feet near the terminus.

The presence of the two weirs creates a unique discharge situation. Each weir has a different rating curve and, therefore, each weir controls the flow from the Reservoir at different reservoir stages. At lower flows, the flow rate is controlled by the upper "L-shaped" weir. As the flow rate increases, the downstream weir in the trough controls the flow rate as the upper weir becomes partly submerged. Following the USBR guidelines (USBR, 1987), a spillway rating curve was developed for each weir (Figure 7-5). Based on this information, a combination rating curve was calculated and is shown in Figure 7-6. Detailed explanation and calculations for the spillway rating curve can be found in Appendix E.

Enlarged Reservoir

At this level of preliminary design, the enlarged Reservoir will also include 20 feet of freeboard, which would provide surcharge storage during flood events, and an emergency side channel spillway (See section 5.3 for description of design and Appendix B for drawings of proposed design).

Reservoir Capacity

The storage capacity for an enlarged Reservoir is shown on Figure 7-7. The curve is the same as the existing reservoir curve from gage height 0 to 91 since the surcharge storage capacity is the same capacity as the existing Reservoir. A new surcharge storage capacity was determined from gage height 111 to 121 based on the proposed dam crest elevation of gage height 121 and site topography. A detailed survey to verify the estimated stage-storage relationship should be performed prior to final design.

Spillway Capacity

The enlarged Reservoir spillway structure will consist of a new uncontrolled gravity spillway that incorporates the existing uncontrolled side channel spillway, trough, control weir, and trapezoidal channel chute. The flow conditions inside the side channel trough would be similar to existing conditions.

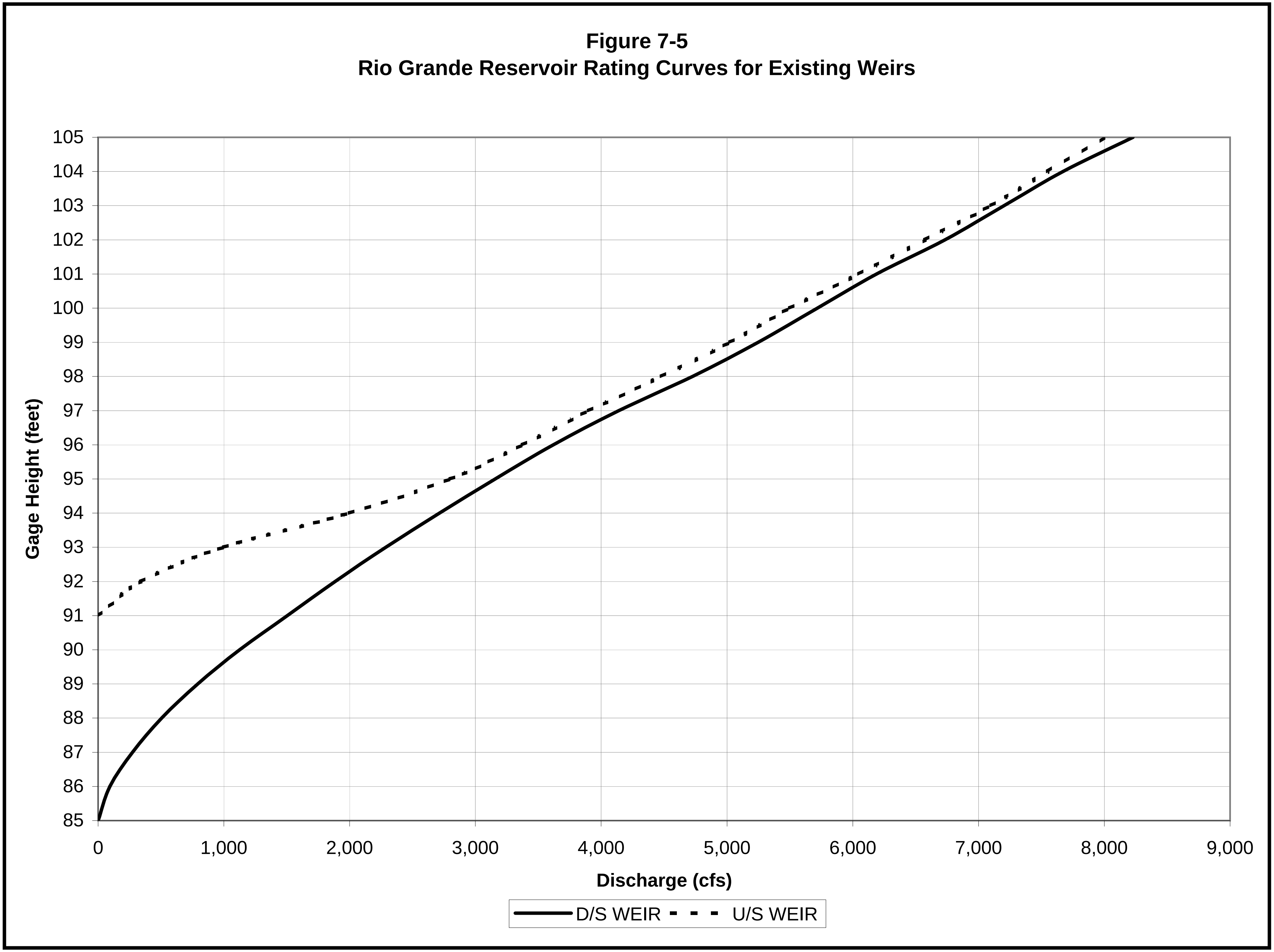


Figure 7-5
Rio Grande Reservoir Rating Curves for Existing Weirs
Gage Height (feet)
105
104
103
102
101
100
99
98
97
96
95
94
93
92
91
90
89
88
87
86
85
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
Discharge (cfs)
D/S WEIR
U/S WEIR

Figure 7-6
Rio Grande Reservoir Existing Spillway Rating Curve

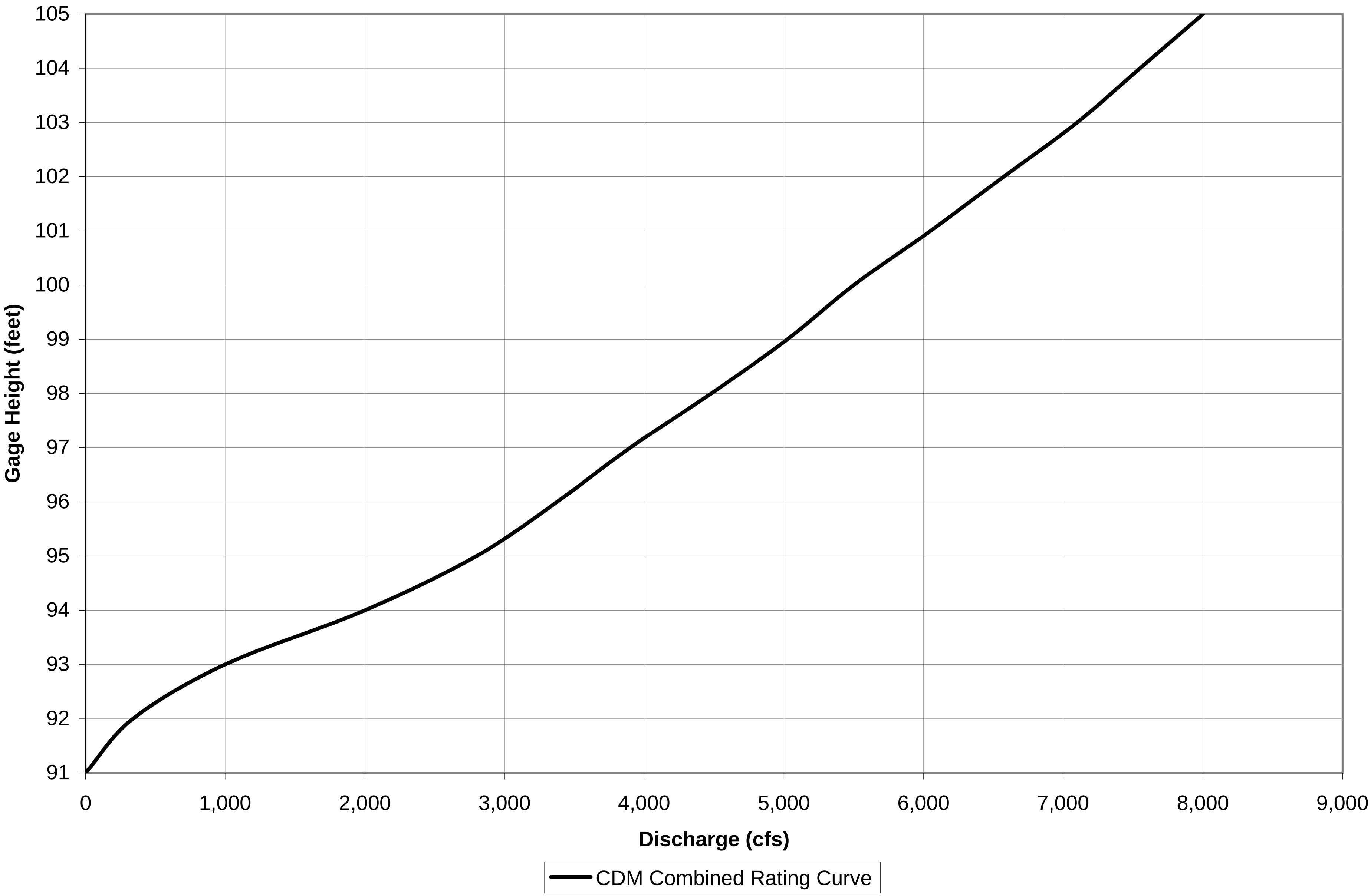
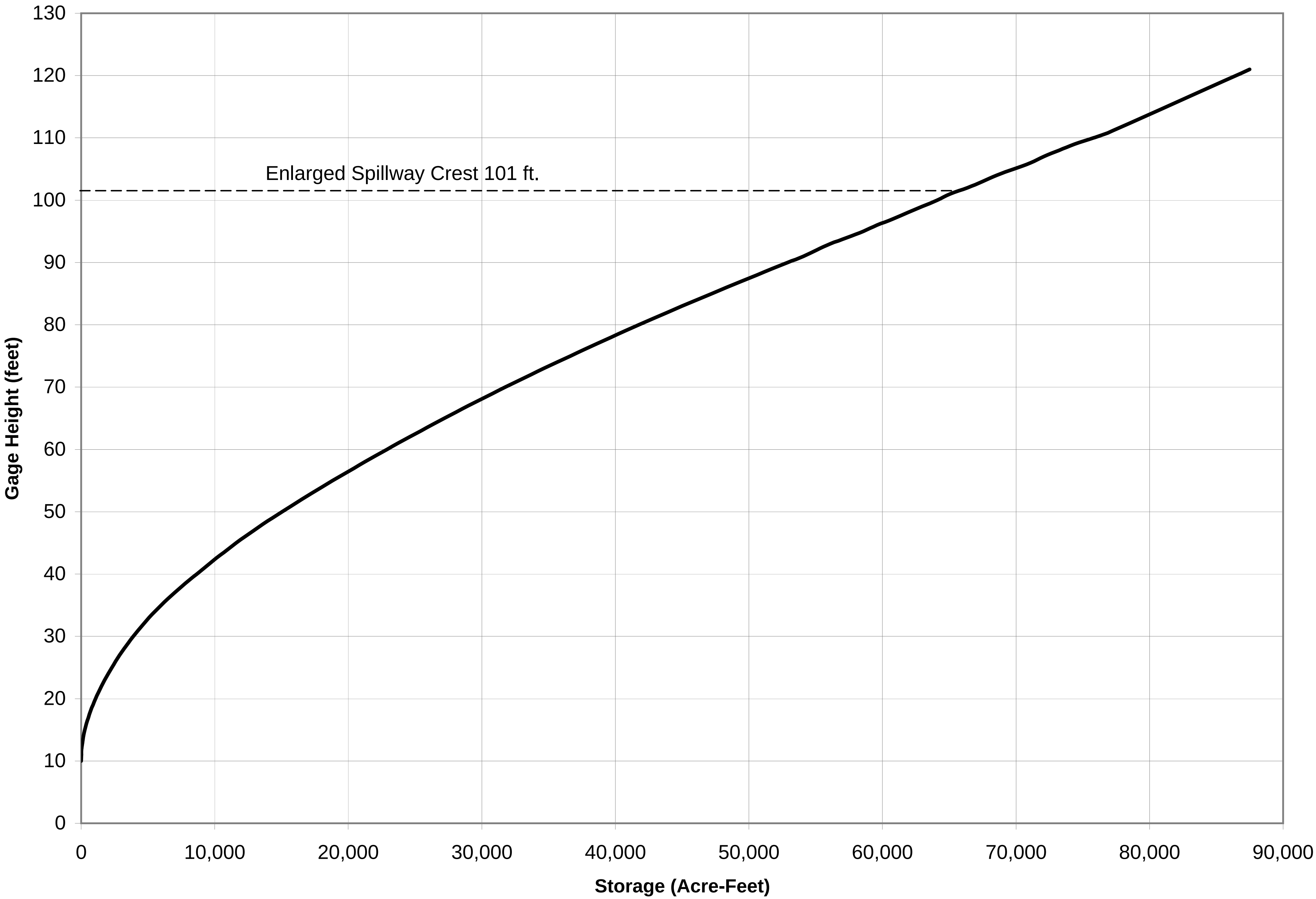


Figure 7-7
Enlarged Rio Grande Reservoir Stage-Storage



The presence of the new weir eliminates the unique discharge situation described for the existing Reservoir. Although each weir has a different rating curve, the new weir at gage height 101 will control the flow from the Reservoir for all reservoir stages. A spillway rating curve was developed for the new weir (Figure 7-8). Detailed explanation and calculations for the spillway rating curve can be found in Appendix E.

7.3.4 Hydrologic Model

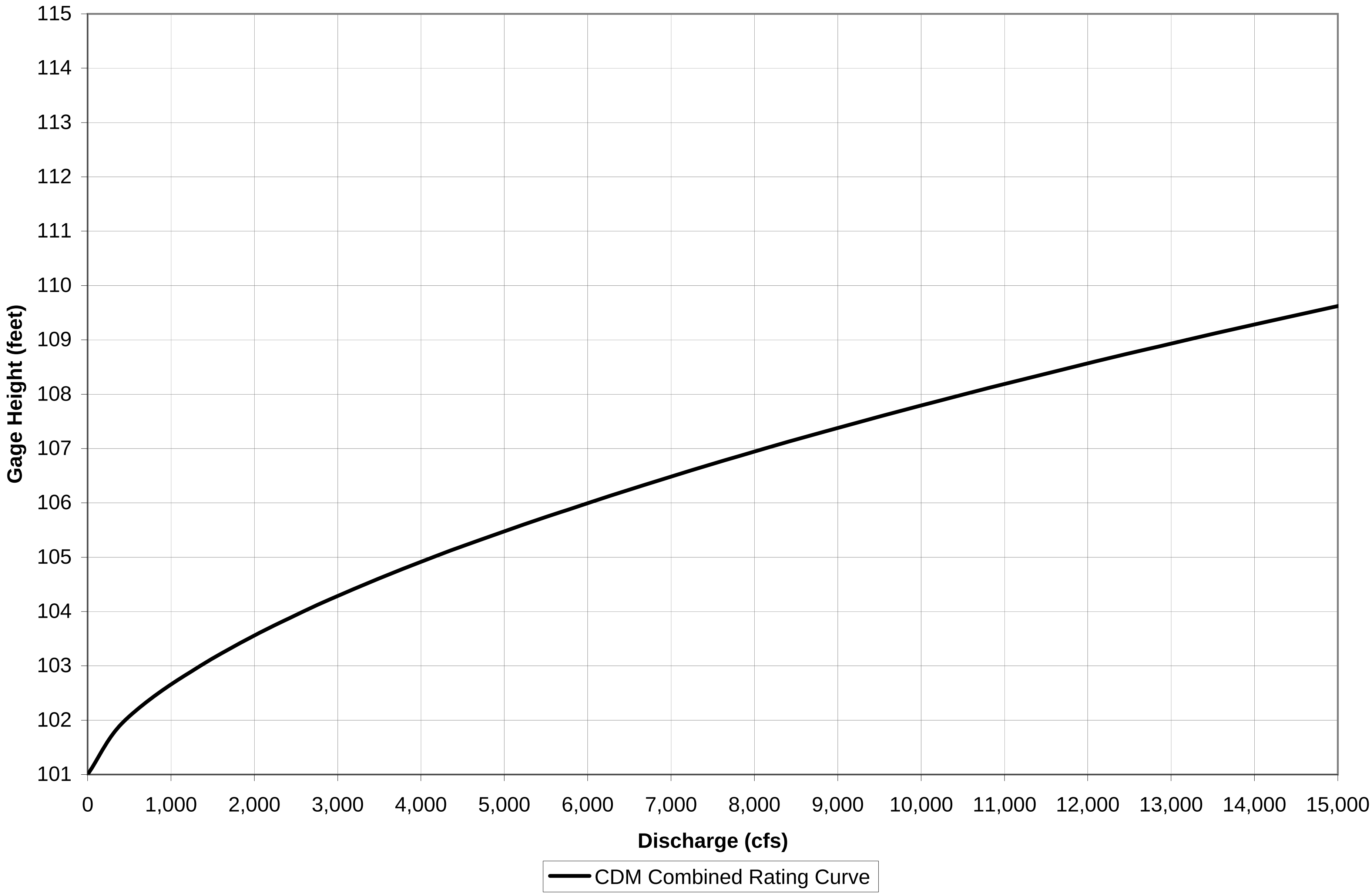
The U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS) software (version 3.1.0, 2006) was used to simulate the rainfall-runoff process and estimate the peak runoff and volume for both the existing and enlargement options. HEC-HMS modeling determined the IDF reservoir inflow and outflow hydrographs for the general storm (Figure 7-9) and local storm (see Appendix D). More detailed HEC-HMS information can be found in Appendix D

The results of the analysis indicated that a general storm is more critical than the local storm in determining flood routing through the Reservoir for both options. The general storm produces 6.22 inches of rainfall and 4.50 inches of runoff in 84 hours. The ESP produced a peak inflow of 13,300 cfs and a runoff volume of 38,100 acre feet. The hydrologic results for existing and enlarged Reservoir options are summarized below. More detailed HEC-HMS information can be found in Appendix D.

Existing Reservoir

The existing Reservoir has an estimated peak spillway discharge of 6,600 cfs and peak storage volume of 12,400 AF. The maximum water surface elevation is gage height 102.10 (11.10 feet above spillway crest, 8.90 feet remaining freeboard). The spillway overtops under these conditions. Severe erosion around the spillway structure and the right abutment of the dam would occur. The IDF and spillway discharge curve for the general storm ESP are shown in Figure 7-9. The reservoir elevation curve for the IDF routing is shown in Figure 7-10. The IDF and spillway discharge curve and reservoir elevation curve for the local ESP are shown in Appendix D.

Figure 7-8
Enlarged Rio Grande Reservoir - Spillway Rating Curve



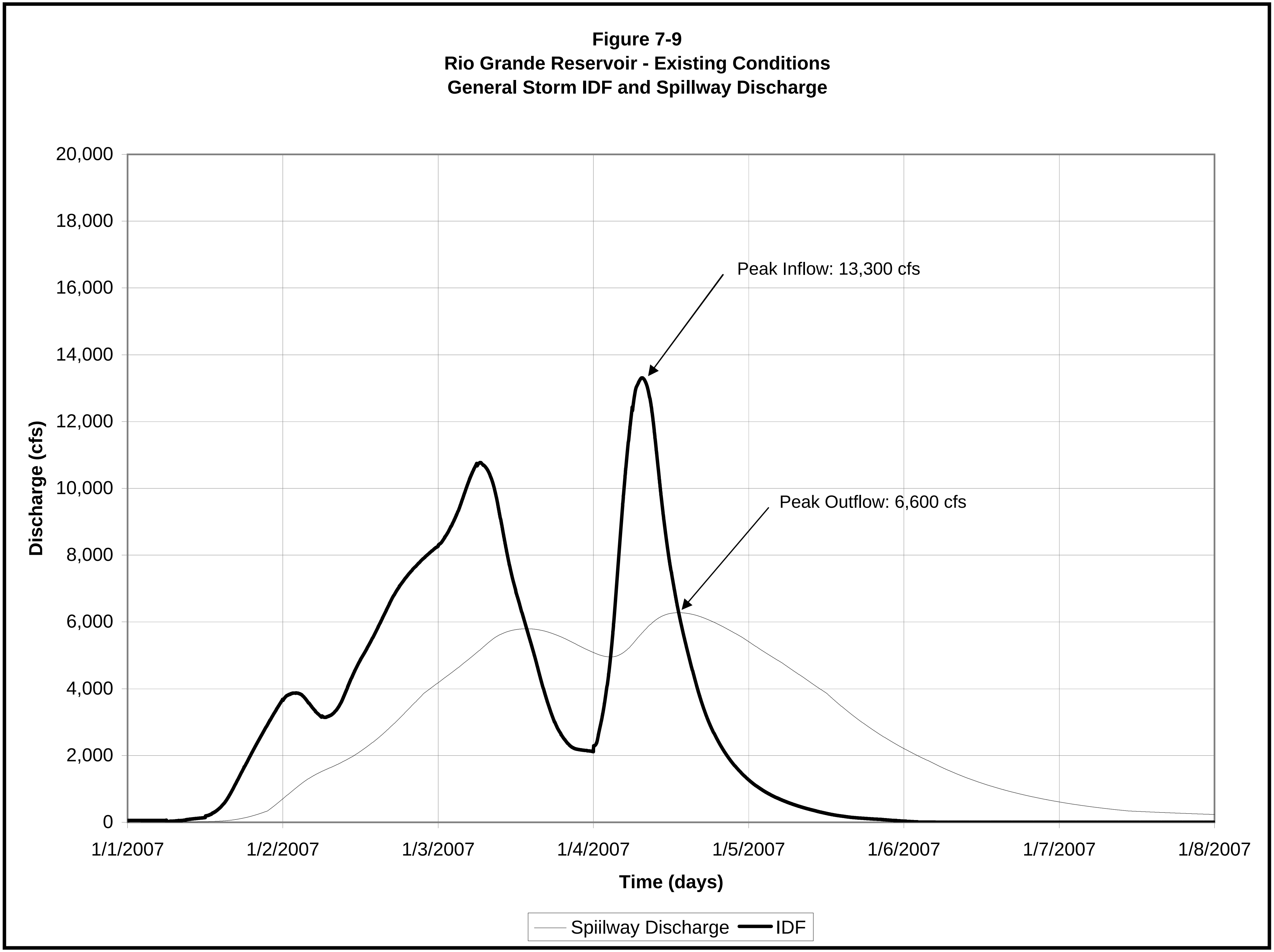
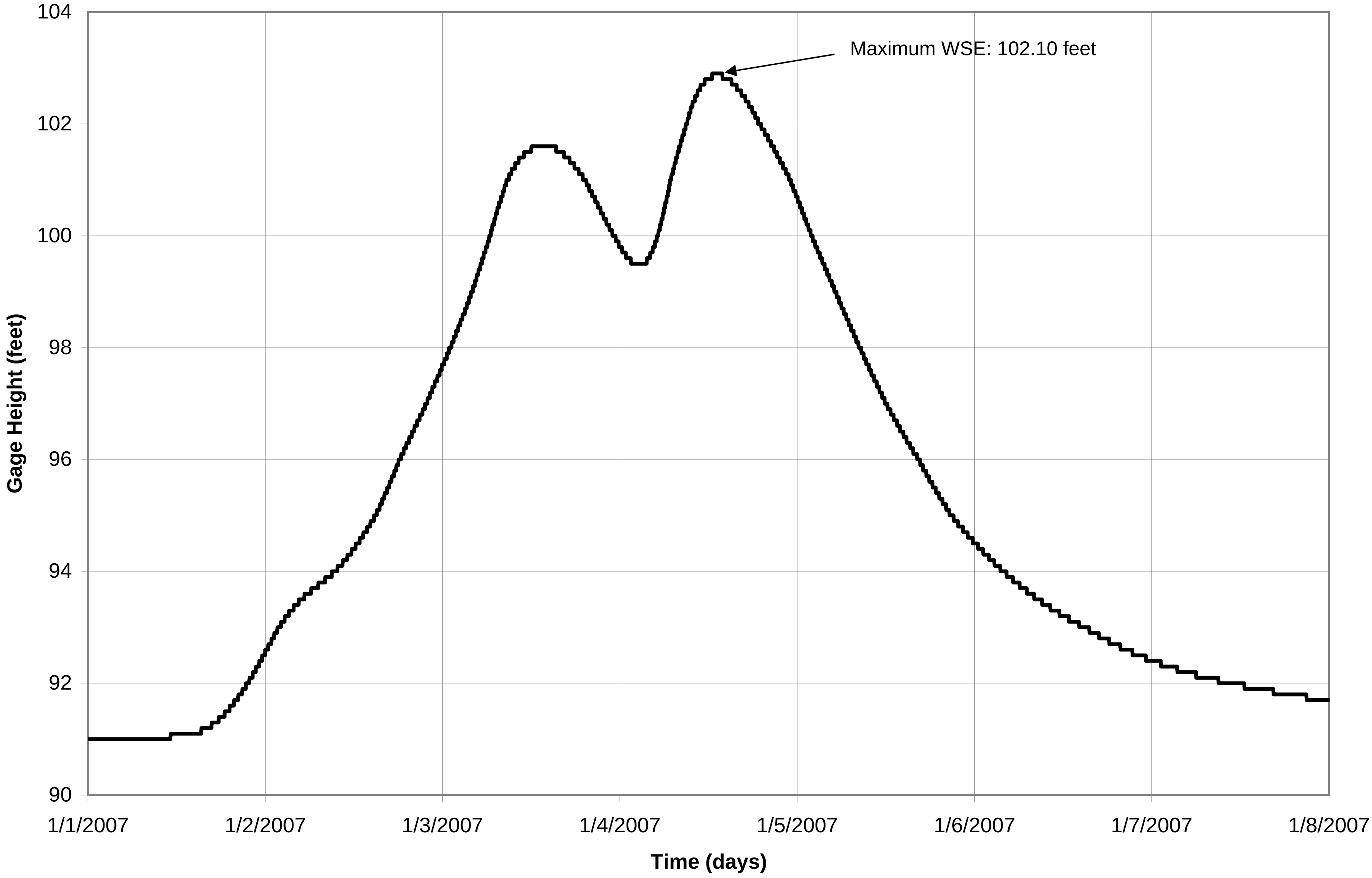


Figure 7-9
Rio Grande Reservoir - Existing Conditions
General Storm IDF and Spillway Discharge
Peak Inflow: 13,300 cfs
Peak Outflow: 6,600 cfs
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Discharge (cfs)
1/1/2007
1/2/2007
1/3/2007
1/4/2007
1/5/2007
1/6/2007
1/7/2007
1/8/2007
Time (days)
Spiilway Discharge
IDF

Figure 7-10
Rio Grande Reservoir - Existing Reservoir
General Storm Reservoir Stage



Enlarged Reservoir

The enlarged Reservoir has an estimated peak spillway discharge of 9,050 cfs and peak storage volume of 7,500 AF. The maximum water surface elevation is gage height 107.40 feet (6.40 feet above spillway crest, 13.60 feet of remaining freeboard). The IDF and spillway discharge curve for the general ESP are shown in Figure 7-11. The reservoir elevation curve for the IDF routing is shown in Figure 7-12. Since the general storm is the critical ESP for the enlarged Reservoir option, the IDF and spillway discharge curve and reservoir elevation curve for the local ESP are shown in Appendix D.

7.4 Hydraulic Analysis

Hydraulic analysis using the USACE HEC-RAS model (version 3.1.3) was performed to check the adequacy of the current and proposed spillway chute to pass the IDF.

The work performed for this analysis included:

1. Development of HEC-RAS model to evaluate the adequacy of the existing spillway chute to pass the IDF (existing conditions model) for both the rehabilitation and enlargement options.

2. Assuming that the current spillway is insufficient to pass the IDF, develop a proposed conditions HEC-RAS model based on modified spillway design including increasing the spillway chute walls.

The existing conditions HEC-RAS model was developed from the as-built drawings (1972 spillway replacement plan and 1962 spillway reconstruction drawings). Due to the elevation difference between 1962 and 1972 drawings, the elevations of 1972 drawings were lowered by 10.51 feet to match the 1962 drawing after comparing channel invert elevations at the same location.

Concrete spalling and cracking in the spillway chute

The modeling reach begins at the downstream end of the upstream "L-shaped" weir and ends 600 feet downstream of the downstream weir (control weir). The downstream weir is located 22 feet downstream of upstream boundary of the model. The cross-sections used for existing conditions model are presented in Appendix F.

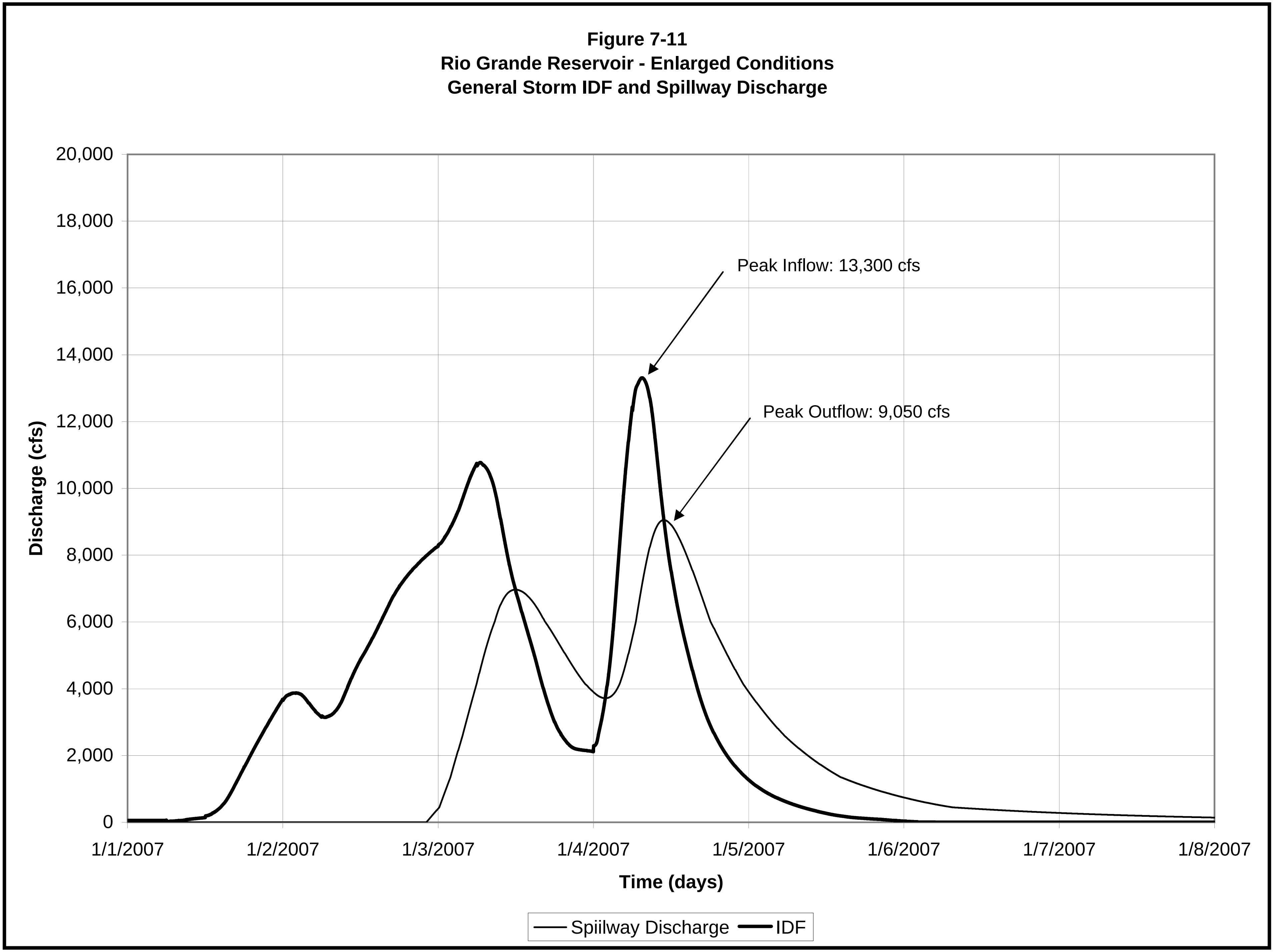
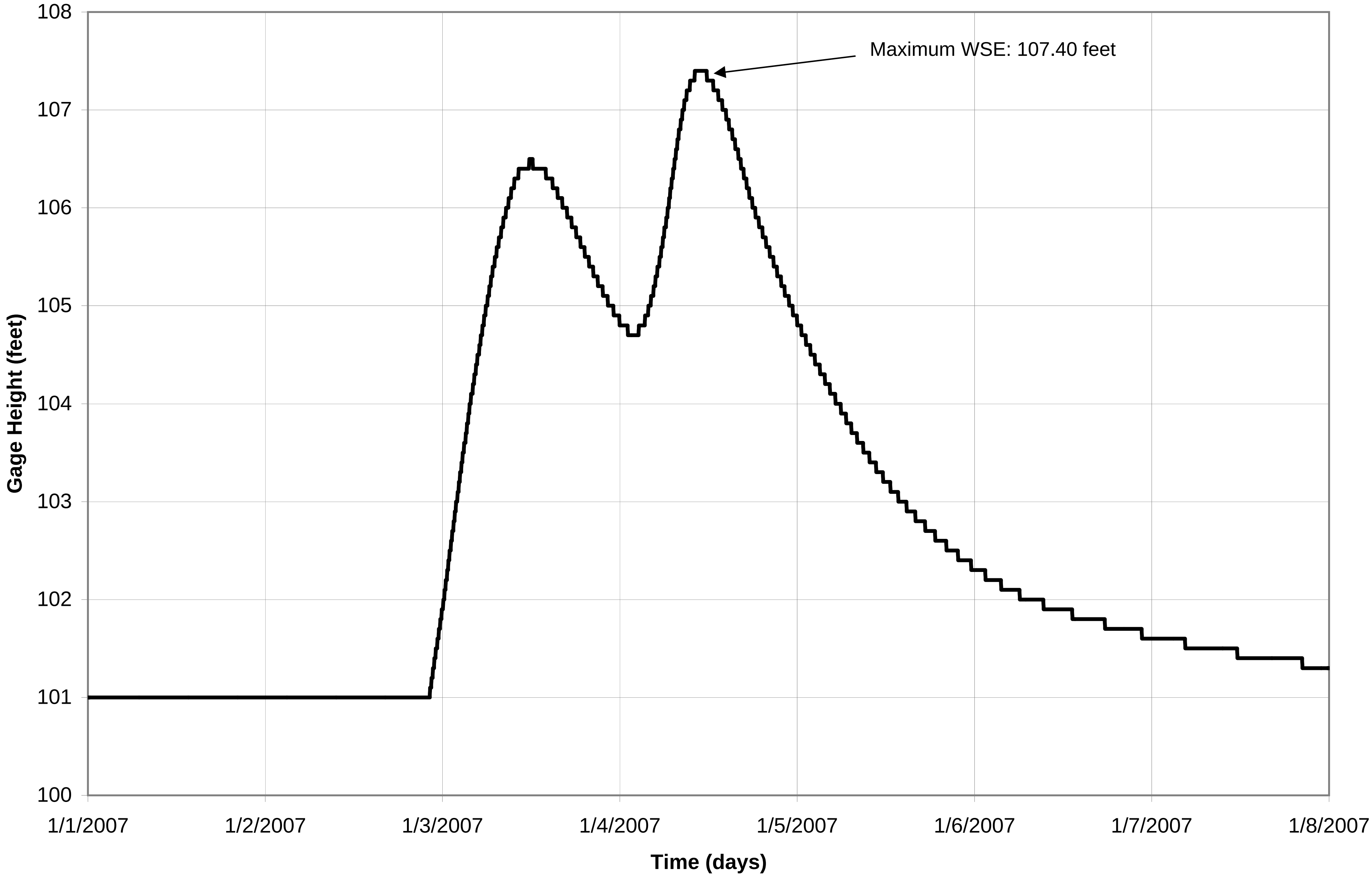


Figure 7-11
Rio Grande Reservoir - Enlarged Conditions
General Storm IDF and Spillway Discharge
Peak Inflow: 13,300 cfs
Peak Outflow: 9,050 cfs
Discharge (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1/1/2007
1/2/2007
1/3/2007
1/4/2007
1/5/2007
1/6/2007
1/7/2007
1/8/2007
Time (days)
Spiilway Discharge
IDF

Figure 7-12
Rio Grande Reservoir - Enlarged Reservoir
General Storm Reservoir Stage



The model was run for the IDF of the spillway (6,600 cfs). It was also run for flows of 1,000, 2,000, 3,000, 4,000, 5,000, and 6,000 cfs to check the flowing capacity of the spillway chute. The hydraulic analysis shows that 3,000 cfs is the maximum discharge that can be currently contained within the spillway chute without overtopping. However, the chute is not overtopped its entire length or at a constant depth and should be evaluated further once a survey of the chute has been completed.

The hydraulic analysis indicates that extending the spillway chute walls an additional 4 feet will completely contain the IDF for the existing reservoir spillway peak discharge (6,600 cfs). The spillway chute walls will need to be extended 6 feet to completely contain the IDF for the enlarged reservoir spillway peak discharge (9,050 cfs). Both extensions include 1 foot of freeboard. While a constant wall extension height is recommended for constructability reasons, further engineering and construction analysis of the chute wall extension heights is recommended during the final design process once a survey of the chute has been completed.

7.5 Conclusions and Recommendations

The purpose of the analysis was to develop the inflow design flood and required routing capacity for the rehabilitation only and enlargement options. Additionally, a hydraulic analysis of the spillway chute determined its capacity to pass the IDF. The results of the analyses follow:

Analysis of the IDF hydrology at the Reservoir indicates that the existing facility is inadequate to safely route the IDF as required for a high hazard dam. Under IDF conditions, the water surface elevation will overtop the existing bridge piers adjacent to the spillway and the spillway chute. Overtopping the existing bridge piers will result in erosion of the dam embankment and could lead to dam failure. Overtopping of the spillway chute may undercut the spillway chute, causing erosion around the chute, leading to cracking and shifting. Recommendations for rehabilitation of the existing spillway structure are presented in Section 5.2. Once implemented, the design recommendations for the rehabilitation only will safely pass the IDF of 6,600 cfs through the spillway. Construction costs for this work are estimated at $950,000.

The IDF for an enlarged Reservoir was calculated based on the proposed design presented in Section 5.3. Under IDF conditions, the maximum spillway discharge will is 9,050 cfs. Construction costs for this work are estimated at $1,700,000.

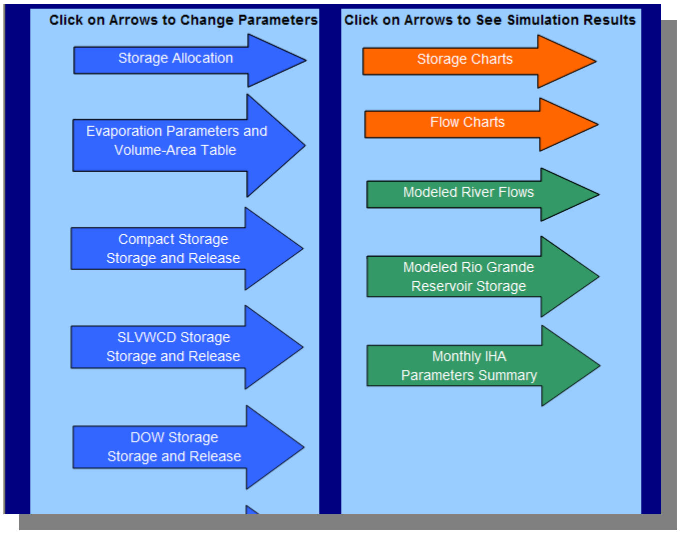
Section 8
Reservoir Storage Modeling

A water use and storage model was developed to investigate changes to Reservoir storage levels and stream flows that would occur by operating the Reservoir with increased storage capability and capacity associated with the rehabilitated and enlargement options. Multiple entities are modeled and their available flows for storage, release demands and quantity and type of storage (e.g., firm or space-available storage) can be specified. Differing storage and release patterns can be specified for dry, average, and wet years. The model calculates the volume of water each entity has in storage, how much water was spilled, and how the differing storage and release patterns change streamflow downstream of the dam.

8.1 Summary

Entities that have expressed interest in acquiring storage in the Reservoir were modeled. The entities are the Division of Water Resources (DNR), the San Luis Valley Water Conservancy District (SLVWCD), the Division of Wildlife (DOW), Direct Flow Storage by non-SLVID irrigators (DFS), and Other Entities, which include parties who have agreements with the District to store small amounts of water at the Reservoir. Those entities interested in storing water at the Reservoir may have to change their water right to allow for storage at the Reservoir, if not already decreed for such storage.

The model is a spreadsheet-based model that allows for instantaneous results when changes are made to any of the several model parameters, including pool sizes, storage and release patterns, and evaporation and loss charges. The model uses historical flows and storage patterns from 1980 to 2005 on a monthly time step as its input basis. This timeframe was selected because daily curtailment data was obtained from the Division 3 Engineer's Office for this period of record. Modeled storage and releases are superimposed over the historical regime and changes in flow patterns are calculated. Firm storage (non-spillable) and space-available storage capacity can be specified for each entity, and the demands for each entity can be specified as either a set volumetric demand, or as a percentage of the current pool. Storable flows for each entity were developed and are explained in further detail below.



User-friendly interface – model main menu shown

Modeled storage shows end of month contents at the Reservoir for each entity and for the Reservoir as a whole. Changes in stream flows as a result of the modeled storage patterns at the Reservoir are calculated at the Thirty Mile, Del Norte, Monte Vista, Alamosa and Lobatos gages.

8.2 Previous Modeling Efforts

During Phase I of the study, it was envisioned that output from the Rio Grande Decision Support System (RGDSS) water allocation model (StateMod) would be used as a part of this modeling effort. CDM reviewed the model results and worked with Division of Natural Resources staff and their consultants to determine the usefulness of the data to the current effort. As of spring of 2008, the baseline RGDSS surface water model is not calibrated to a sufficient degree to be useful for this project. There are several RGDSS model run types: historical, naturalized and baseline flows. Historical flows are calculated to calibrate the model to observed conditions. Naturalized flows represent what the flows in the river would have been without the influence of man, and were used in calculation of some of the indicators of hydrologic alteration parameters (IHA – see Section 8.7). Baseline flows operate the river system using the historical hydrology but under current operating conditions. The model run that would have been useful for the current effort is the baseline scenario, as it provides the ability to answer the 'what-if' type questions. However, review of these flows and contact with DNR's consultant showed that calibration on this model run is incomplete.

Historical storage levels at the Reservoir are an input to the RGDSS, and in the absence of a direct source, this model input was used in the model.

Helton and Williamson performed a water rights yield analysis of the Rio Grande Basin (Helton and Williamson 2003) and concluded that there is no un-appropriated native water in the upper Rio Grande Basin that would increase the District's yield at Rio Grande Reservoir. However, the report concluded that storage of Compact water at the Reservoir could prove beneficial to reducing losses during the peak runoff.

In light of the previous modeling efforts, only water that could be stored under existing water rights or other processes (e.g., Compact water, trans-basin imports) was modeled. Historical gage and Reservoir storage data was used to develop the primary inputs.

8.3 Input Development

There are several inputs to the model, including historical flow and storage data and user specified inputs. Historical gage data for the Thirty Mile, Del Norte, Monte Vista, Alamosa and Lobatos gages was downloaded from the DWR website and summarized in units of acre-feet per month. Historical Reservoir storage levels were taken from multiple sources. RGDSS model input was used for 1980 through September 1994, data provided by the District in the form of Reservoir Storage and Release books and monthly Superintendant reports were used for October 1994 through Dec 2005. Where the Res Storage and Release books or Superintendant reports were available, that value superseded RGDSS input as the District data is considered an original source. Where values were not available from the District provided data, RGDSS values were used. To avoid divide-by-zero errors in the model calculations, months where contents = 0 were replaced with contents of 0.1 AF.

The model user can specify the amount and type of storage for each entity in the model. There are two types of storage: firm and space-available. Firm storage is storage that is guaranteed to not spill and is higher priority water than any water the District has in storage. Space available storage is allocated only if there is remaining capacity after the District has stored its water and all firm storage pools have been quantified. If an entity has both firm and space available storage, water is stored first in firm storage, then in the space available pool. Water is released first from the space available pool, then from firm storage. The entire Reservoir capacity of approximately 54,000 AF is used in the model, but the District is limited to its decreed amount of 51,113 AF. Approximately 3,000 AF of carryover water would be required to avoid legal issues with the USFS reserved rights decree (see Section 10).

Storable flows were developed for each entity based on each entity's existing or projected water supplies. The portion of the storable flow to store could then be specified by either a percentage of the storable flow or as a volumetric demand. For example, SLVWCD was modeled as owning 50 percent of the Pine River Weminuche ditch that brings trans-basin water into the Reservoir and 121 AF of the Anaconda Ditch. The source of the storable flows are the historical flows of the ditch, but the Conservancy District's storable flows are specified as 50 percent of the Pine River Weminuche ditch flows + the 121 AF of the Anaconda ditch. The source of storable flows for each entity is summarized in Table 8-1.

Table 8-1 Source of Storable Flows

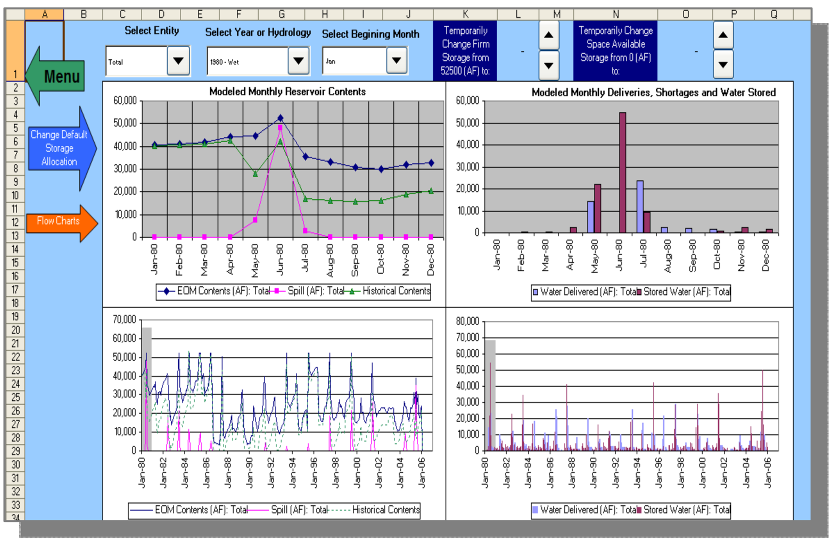
Entity	Source of Storable Flows
Compact Water	Historical curtailment water at the Del Norte gage, limited by physical availability of inflows at the Reservoir
SLVWCD	Pine River Weminuche Ditch and 121 AF of the Anaconda ditch (assumed to yield 60AF in May, 40AF in June and 21AF in July, and assumed exchanged to the Reservoir)
DOW	Tabor Ditch. Stored water assumed exchanged to the Reservoir
DFS	The minimum of Big 6 diversions without SLVID diversions, Flow at Del Norte less 2150cfs, or inflows to the Reservoir. DFS available flow is limited by the USFS instream flow decree.
Other Entities	Historical storage average based on wet, average and dry years

The model has storage and release pattern tables for each entity that can be modified by the user. These tables specify storable flow as either a percentage of the source of storable flows or as a volumetric storage demand. Different storage patterns can be specified for dry, average, and wet years. Volumetric storage demands are always supply-limited by the source of storable flows (e.g., if there is a specified storage demand of 100 AF, and only 80 AF is physically available, only 80 AF goes into storage). Release patterns are also specified for each entity in the tables. Releases can be specified as either a percentage of the current pool or a volumetric release, which is supply limited.

8.4 Rehabilitation Option Model

The rehabilitation option model was developed by using the existing capacity of the Reservoir (54,000 AF). Pool capacities for the various entities are shown in Table 8-2. Storage and release patterns for each entity were specified as shown in Tables 8-3 and 8-4.

Modeled and historical total storage in the Reservoir and modeled spills over the 1980 to 2005 timeframe are presented in Figure 8-1. The model allows for the storage patterns for each entity to be plotted in a similar manner. District water was spilled only in above average wet years in the model.



View of interactive storage charts

Modeled change in streamflow at the 30-Mile gage over the entire period of record is shown in Figure 8-2. Even at the 30-Mile gage, which is directly below the Reservoir, differences in flows are not large when looking at the entire period of record. Flows are not modified significantly relative to the total flows through a gage, but the difference provides tangible benefits. Figure 8-3, for example, shows the change in flow from historical to modeled at the 30-Mile gage during dry years. This figure shows that late season and winter flows – historically zero or only seepage through the dam – are increased by late season releases of water that was stored during the peak runoff. These increased flows during this time of year benefit the riparian habitat, and keep the river channel wet which will reduces losses during the subsequent runoff. Storage and release patterns used for this model run could be modified to yield higher late-season and winter releases.

Figure 8-1: Storage and Spills at Rehabilitated Rio Grande Reservoir
Rehabilitation Option

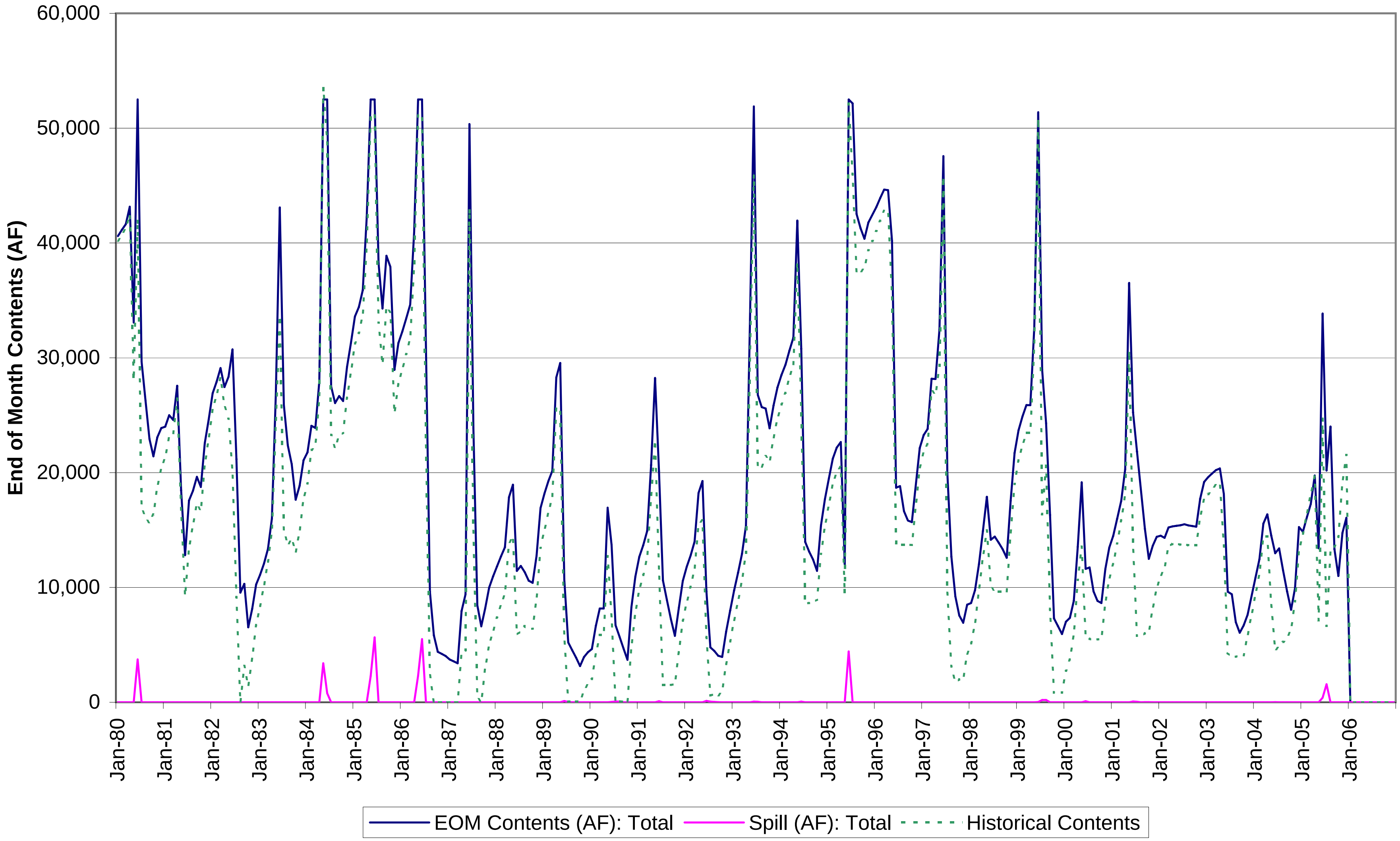


Figure 8-2: Historical and Modeled Flows at 30-Mile Gage
Rehabilitation Option

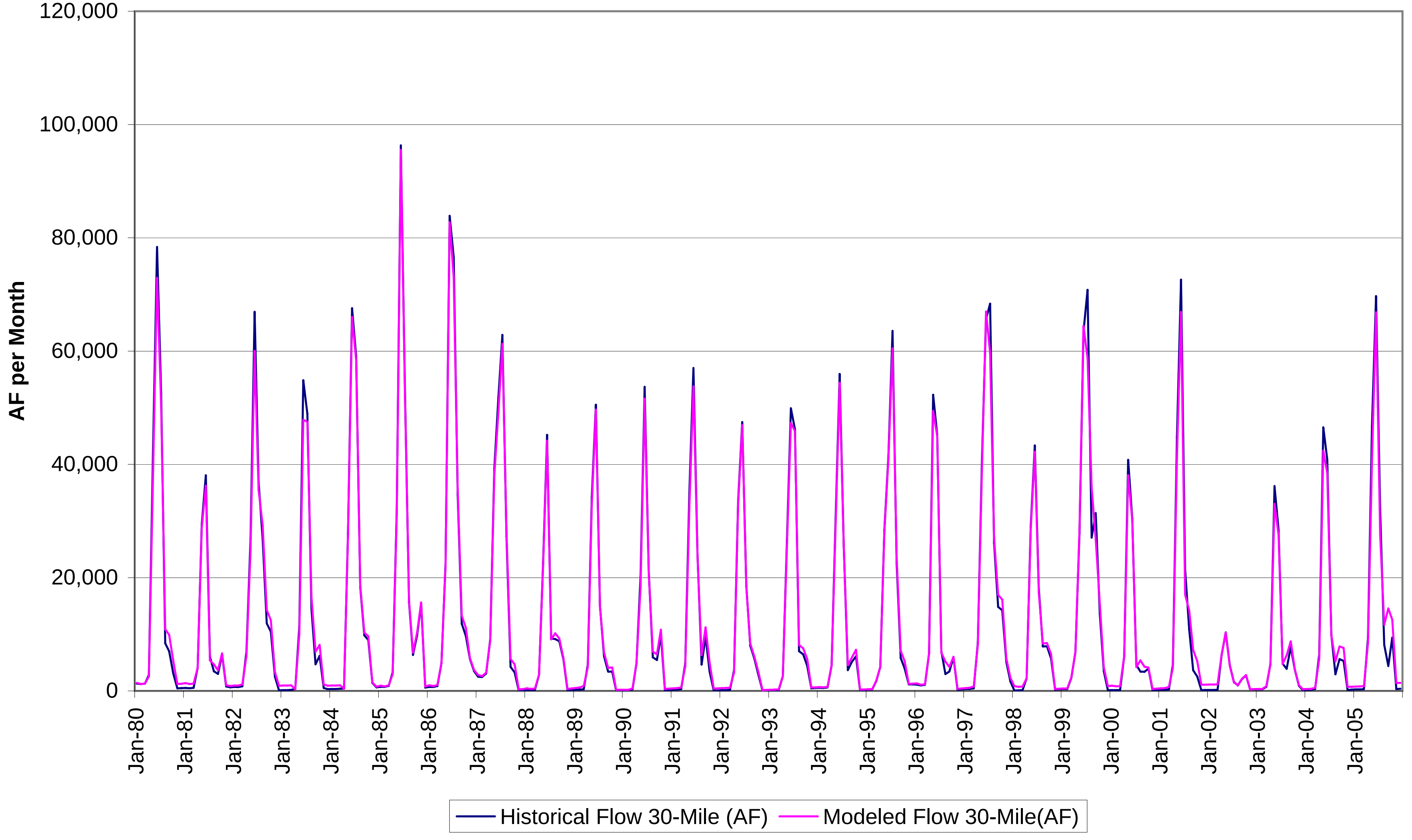
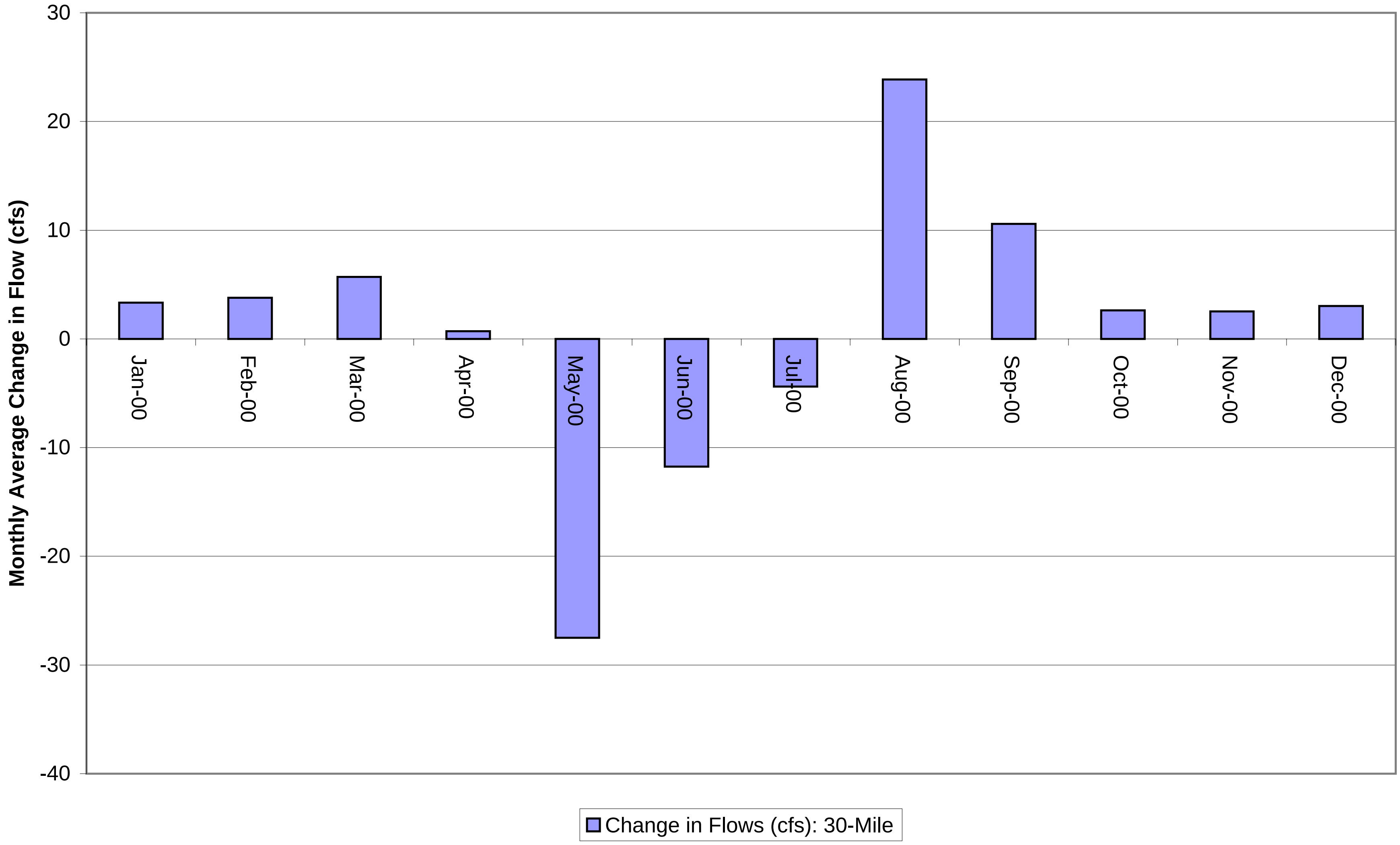


Figure 8-3: Dry Year Average Change in Flow at 30-Mile Rehabilitation Option



8.5 Enlargement Option Model

The enlargement option model was developed by using the proposed capacity of the Reservoir (65,000 AF). Pool capacities and storage and release patterns from the rehabilitation option model were used. Since spills are relatively infrequent in the rehabilitation model, the enlargement model results do not differ significantly from the rehabilitation only option model. In the enlargement option, no entity in the Reservoir spills, and maximum storage is just over 59,000 AF. Late-season and winter flow increases are similar to the rehabilitation only model. With an enlarged Reservoir, user-specified parameters could be modified such that more water is put into storage, thereby allowing for increased flexibility in operations. Further input from each entity would help define these storage and release targets.

8.6 Hydropower

Both the rehabilitation and enlargement option total Reservoir capacity values over the modeled POR were evaluated for hydropower potential. Modeled Reservoir capacity was converted to reservoir head through the use of the Reservoir storage-stage curve provided by the District. Modeled hydropower generated was calculated using the average monthly modeled reservoir head and releases and compared to potential electricity generation under historical Reservoir operations. The results of the hydropower analysis is presented by hydrology type is presented in Table 8-5. Number of people served was calculated by assuming 3,000 KWh per person per year.

Table 8-5 Potential Hydropower Generation

Hydrology Type	Historical Potential Generated (KWh)	Modeled Potential Generated (KWh)	Number of People Served under Historical Operations	Number of People Served Under Modeled Operations
Dry	492,909	548,484	164	183
Average	668,460	865,597	223	289
Wet	1,570,849	1,768,222	524	589
Average of All Years	940,314	1,104,864	313	368
Maximum Average Monthly Power Output (KW)	1,961	1,812		

Using high flow conditions of 2,500 cfs and a full reservoir head of 91 feet, the maximum instantaneous potential hydropower production is 15.6 megawatts (MW). Given that these extreme flows and full reservoir head conditions are very infrequent, the cost of the full hydropower capacity are not justified.

8.7 Environmental Flows

One of the benefits the rehabilitated or enlarged Reservoir provides is the ability to make late season releases that are beneficial for riparian habitat. Late season releases can come from any of the entities who need or want to release water later in the season (see Figure 8-3). For example, the DWR may choose to release Compact water after the peak runoff to reduce losses that occur at the peak of the hydrograph. DWR staff have also mentioned the potential benefit of maintaining even a small streamflow throughout the year so the river channel remains wet and losses are reduced during the subsequent runoff. The DOW may also wish to make late season releases to their wildlife refuges in the San Luis Valley through the autumn and winter, which would provide streamflow to reaches that historically have gone dry.

The volume of flow that could be stored at the Reservoir is a relatively small percentage of flow during peak runoff as compared to late season. The average monthly flow at the Del Norte gage in June of wet years is approximately 4,640 cfs (276,000 AF). If the Reservoir were to store 10,000 AF of Compact water in June of wet years, flow would be reduced to 4,470 cfs (266,000 AF), a 3.6 percent decrease in monthly average flow. Flushing and scouring flows that are important for channel maintenance could still occur with the average monthly flow of 4,470 AF at Del Norte. As discussed in Section 8.8, this relatively minor reduction can prevent significant property damage through certain downstream reaches. When the 10,000 AF is released later in October of the same year, the 10,000 AF represents an approximately 25 percent increase of the flow. Under new Compact operations, that water could be carried over until a dry year, in which case the effects would be even more dramatic (while also paying a lower Compact obligation). Peak flows would not be largely reduced, while lower late-season flows could be significantly augmented.

The Nature Conservancy has developed a statistical tool called the Indicators of Hydraulic Alteration (IGA) (reference, 1997). While the method is best applied to daily flow data, several of the monthly IHA parameters were calculated for this modeling effort. The IHA calculates statistics on naturalized (or pre-impact) flows and compares those flows with the modeled (or post-impact) flows. Naturalized flows from the RGDSS model were used to calculate monthly mean flows, annual mean maximum and minimum, month of annual maximum and minimum, and an annual three-month maximum and minimum. The standard deviation for these flows was calculated as well. Historical and modeled flows were then compared with the IHA statistics calculated on the naturalized flows. If the historical or modeled flow was within a standard deviation of the average naturalized flow parameter, it was considered a successful event. Flows outside of one standard deviation from the average naturalized flow were considered failures. A percent attainment was calculated for each of the parameters for the historical and modeled flows by dividing the number of successes by the total possible.

High attainment percentages mean that the flow regime (whether historical or modeled) is closer to the naturalized system, and is therefore more representative of the type of flow regime that supported riparian ecology before the impacts of man. Many of the attainment levels – particularly those having to do with minimum flows - increased when comparing the historical and modeled percent attainments. However, the increases are not always large due to the fact that the magnitude of water used in the basin (e.g. for irrigation) is very large compared to the relative difference in flows as produced by re-regulation of the Reservoir. Table 8-6 shows the IHA percent attainment levels for the rehabilitation option.

8.8 Flood Protection

The Reservoir is useful for flood protection for downstream residents and businesses particularly those in South Fork, Del Norte, Monte Vista, and Alamosa. Daily sheets were obtained for a period of high flows from May 12, 2005, through June 5, 2005, showing reservoir content and flows at the Del Norte gage. Flows at Del Norte are daily average flows as reported by the USGS. Actual daily peak flows are even higher than the daily average flows presented. Flows out of the Reservoir are the USGS Thirty-Mile daily average gage data. The flow at Del Norte, had the Reservoir not stored any water, was predicted by adding the change in storage at the Reservoir to the flow at Del Norte with a one-day travel time lag. Figure 8-4 presents the results of this analysis. The highest flow at Del Norte would have been more than 1,300 cfs greater had the Reservoir not stored water. In a discussion with the Division 3 Engineer's Office, it was noted that, "two more drops in the river would have flooded people out." More than 1,000 cfs was stored in the Reservoir to keep flows around 7,000 cfs at Del Norte. The Division 3 Engineer intimated that, had the flows in the River reached over 8,000 cfs, there could have been serious damage to persons and property as a result of flooding. Additionally, the Division Engineer noted that there are numerous houses in the reach between South Fork and Del Norte that are situated very close to the River shore in the floodplain on elevated pads. These homeowners have built elevated driveways to provide access at flood stage, and concern was expressed that these elevated roads will create dams in the floodplain at higher flows (personal communication, phone conversation with Division 3 staff, April 25, 2007).

8.9 Potential Model Enhancements

The storage and flow model presented in this report shows a single scenario of how the Reservoir could be operated. Increasing the amount of flow that any entity could be stored in the Reservoir would lead to different flow changes than shown in this report. Further input and review of the model by each entity would help refine the amounts of storage as well as the desired release patterns to best suit their needs.

There are limitations in the current version of the model that could be enhanced in future efforts. For example, the model shows no water available for Compact storage through the wet years of the mid 1980s. This is because the river was run with a 0 percent curtailment. Currently, the model uses curtailment at Del Norte as the source of storable flows for Compact storage. Under differing operations, curtailment perhaps would not be set a 0 percent during a similar hydrologic year, and water could be stored at the Reservoir during very wet years. Additionally, the District may choose to operate differently as well. The current model uses the District's historical operations as a basis for storage in the Reservoir.

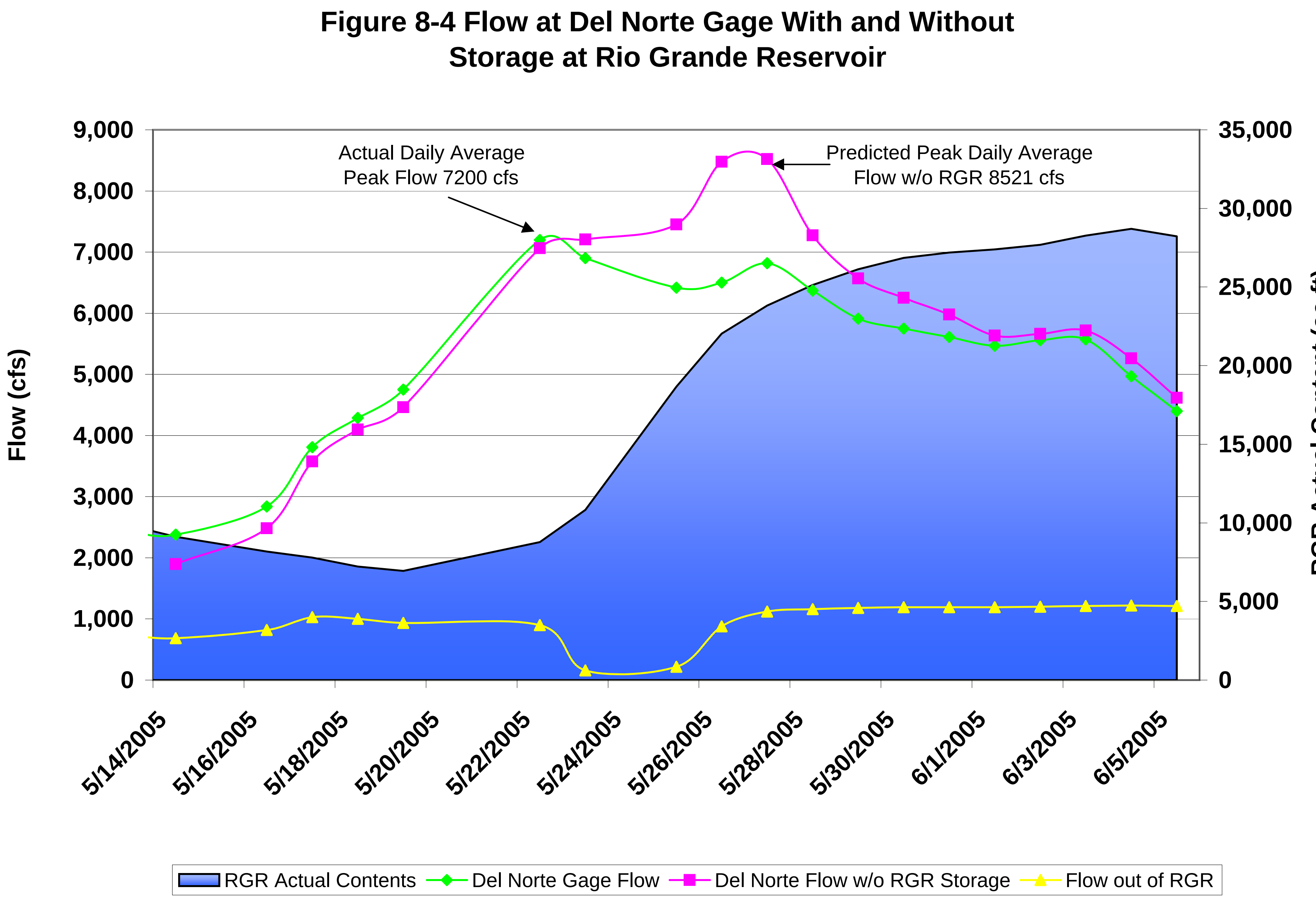


Figure 8-4 Flow at Del Norte Gage With and Without
Storage at Rio Grande Reservoir
Actual Daily Average
Peak Flow 7200 cfs
Predicted Peak Daily Average
Flow w/o RGR 8521 cfs
Flow (cfs)
RGR Actual Content (ac-ft)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
5/14/2005
5/16/2005
5/18/2005
5/20/2005
5/22/2005
5/24/2005
5/26/2005
5/28/2005
5/30/2005
6/1/2005
6/3/2005
6/5/2005
RGR Actual Contents
Del Norte Gage Flow
Del Norte Flow w/o RGR Storage
Flow out of RGR

Another enhancement that could make the model more useful is converting to a daily time step. Currently, the historical daily data is not easily accessible and calculating flows on a daily time step requires stream flow routing. Obtaining accurate and complete daily data for Reservoir levels and other inflows (e.g., transmountain diversions) is not a trivial task, but would show more detailed operation scenarios. Additionally, daily data would allow for the calculation of the complete suite of IHA parameters rather than relying on the subset of monthly parameters.

Section 9
Wetlands Investigation

This section presents the results of the wetlands, biological, and cultural resources investigations performed under this phase of the study. The wetlands and biological investigations were performed by Sugnet and Moore Environmental (SME) of Durango, Colorado, and the majority of their reports (SME 2008a, 2008b, 2008c) are presented in this section, omitting only general project information described in other sections of this report. The cultural resources investigation was performed by La Plata Archaeological Consultants and the conclusions of their report (LPAC 2008) are presented in Section 9.4.

Should the reservoir enlargement option be pursued at a later date, the results presented here become extremely important in the required permitting process (see also Section 10, Legal Issues). Phase I of this study recommended that a formal wetlands delineation be undertaken, a preliminary plan for wetlands mitigation be developed, a biological assessment performed, and a cultural resources survey conducted. These tasks were all performed as part of Phase II and the results are presented in the SME reports and lay the groundwork for completing an EIS should the District proceed with an enlargement of the Reservoir.

View looking northwest at tributary valley and braided stream at transition of the Reservoir to natural willow wetland area upstream of the reservoir. Most of the acreage that would be inundated by an enlargement is in this area.

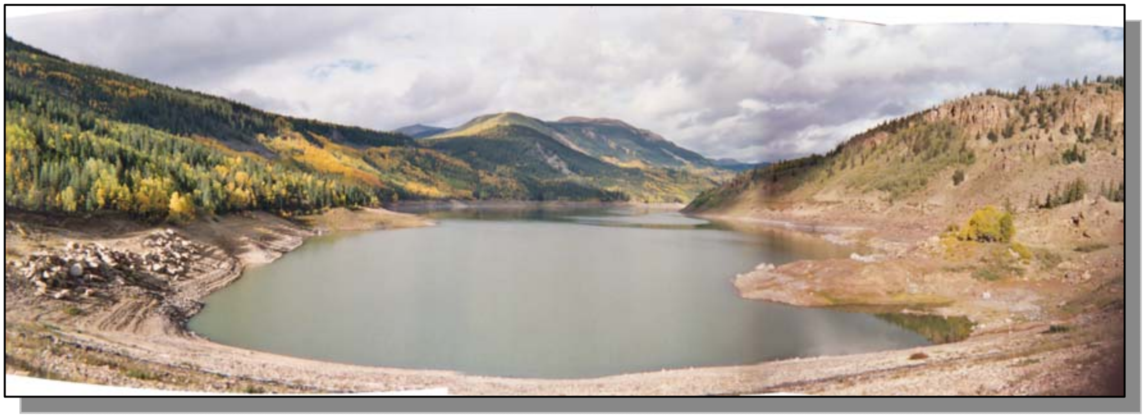
9.1 Wetlands Delineation

The purpose of the wetland delineation is to identify any jurisdictional waters of the United States that may be affected by raising the water level associated with increased reservoir capacity. The delineation report was prepared by SME staff wetland scientist, Patrick Hickey, and Environmental Specialist, Brian Magee, who conducted the field survey on August 8-10, 2007.

The project area elevations range from 9,280 feet (2,829 m) at the east end to 9,600 feet (2,926 m) at the west end, and is located in a middle phase volcanic formation in an entrenched glacial valley that cradles the south edge of the Lost Lake Caldera (Chronic 2002). Due to the steep valley walls, the north and south sides of the Reservoir maintain a distinct high water mark. The upstream end of the Reservoir is less defined as the fluctuations in reservoir levels are more subtle in the relatively flat floodplain. The focus area was defined by the area located between the current ordinary high water line (OHWL) of the Reservoir (gage height 91 feet) and the proposed OHWL (gage height 101 feet) that would result from the proposed 10-foot high-water elevation increase of the Reservoir spillway elevation. Additionally, SME looked at areas located above and below these elevation contours since the increased water elevation could also have an effect on the groundwater elevations of the surrounding areas.

9.1.1 Methodology

Wetlands and other waters of the U.S. (WOUS) in the study area were identified August 8-10, 2007 using the methodology defined in the routine wetland delineation procedure set forth in the USACE Wetlands Delineation Manual (USACE 1987). Wetland boundaries were defined based on the presence of hydrophytic vegetation, hydric soils, and hydrologic indicators that under normal conditions would indicate wetland conditions. Where wetland conditions did not occur adjacent to surface water, the jurisdictional boundary was identified based on evidence of the ordinary high water mark (OHWM) (USACE 2005). The upstream wetlands and those along the shore have been altered as a result of the regulated stream flows and prolonged periods of inundation. Therefore any areas located below the OHWM of the Reservoir were considered to be atypical areas, as defined by the 1987 manual. SME generally delineated the OHWM, in the field, based on the observed physical indications such as a lack of vegetation, water stains, rack lines, and historic aerial photos and mapping. SME did not delineate wetland areas below the OHWM of the Reservoir that was observed in the field. The primary areas of concern are those areas located above the existing OHWM and below the proposed OHWM, which were determined based on the topographic survey data provided by CDM (Wheeler 1981). The surveyed OHWM is based on the spillway elevation.



Panoramic photo looking west from the top of the dam; ordinary high water for the reservoir is marked by the vegetation line on the bank. The proposed enlargement would raise this level by 10 feet.

Sections of the wetland boundaries as well as point transects were survey-located using Trimble ProXR GPS (sub-meter accuracy) and are depicted on Figures 9-1 to 9-5. The sections and transects were overlaid and geo-referenced to aerial photographs of the site. The GPS boundaries and transects taken in the field were then extrapolated in the office utilizing AutoCAD to produce the map shown in Figure 9-1. Sample data transects and associated boring locations have been labeled as T1B1 (Transect one - Boring one) and T1B2 (Transect one - Boring two) etc.

9.1.2 Findings

Waters of the U.S.

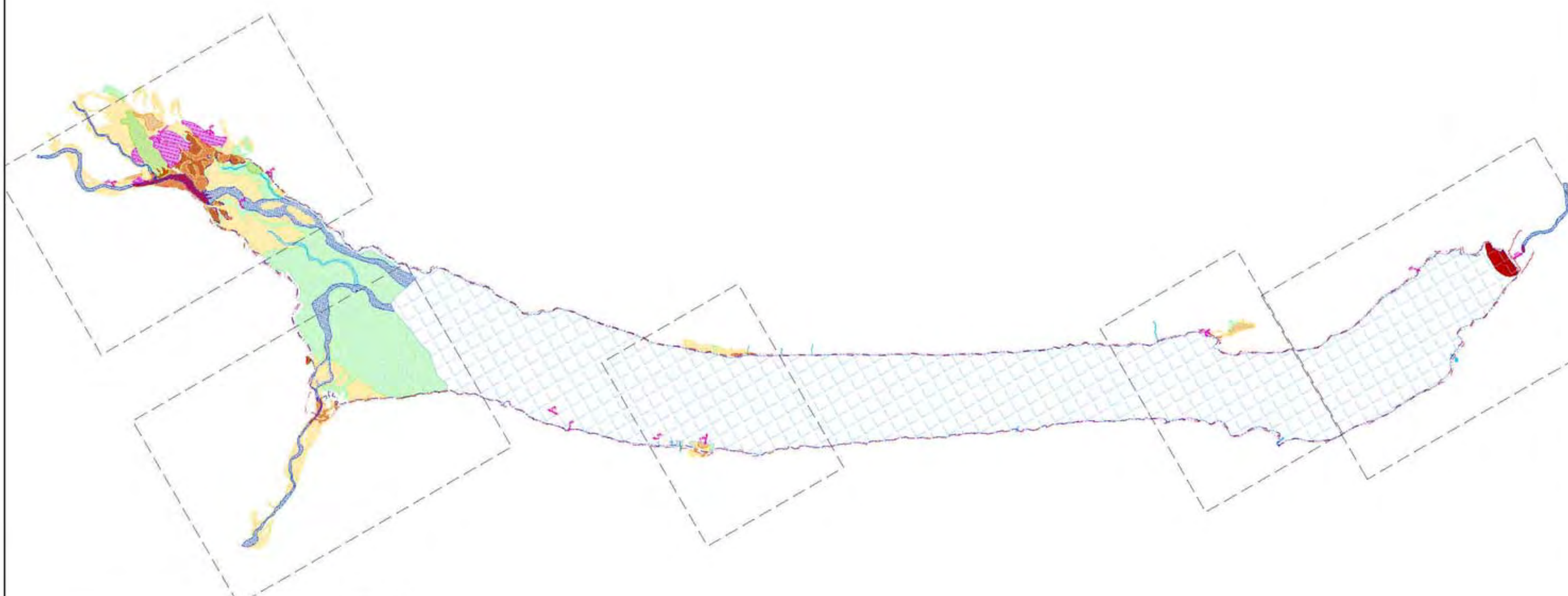
SME staff delineated 24.87 acres of wetlands and other WOUS within the area of concern. As noted above, the areas located below the current OHWL (gage height 91 feet) of the Reservoir are not considered to be new impacts since the current reservoir capacity includes these areas.

Table 9-1 lists the acreage and linear footage of waters of the U.S. within the area of concern, classified in accordance with the U.S. Fish and Wildlife Service (USFWS) classification system for wetlands and deepwater habitats (Cowardin et al. 1979). The delineated areas are also depicted graphically on Figures 9-1 to 9-5.

Table 9-1 Acreage and Linear Footage of Jurisdictional Waters of the U.S. that May Be Impacted by the Rio Grande Reservoir Multi-use Enlargement Project

Waters of the U.S.	Area (acres)*	Linear Feet*
Palustrine Scrub-Shrub (PSS) Wetlands	13.03 ac.	--
Palustrine Emergent (PEM) Wetlands	7.46 ac.	--
Upper Perennial Streambed (R3SB)	4.15 ac.	2,414 LF
Intermittent Streambed (R4SB)	0.23ac.	347 LF
Total:	**24.87 ac.**	**2,761 LF**

* The acreages provided in Tables 9-1 and 9-2 are conservative estimates based on the theoretical worst-case scenario of the Reservoir filling completely and remaining at a full stage for an extended period of time. The impact estimates include several assumptions about the frequency and duration of inundation including climatic variation and reservoir management practices as further described below



MAP LEGEND / KEY

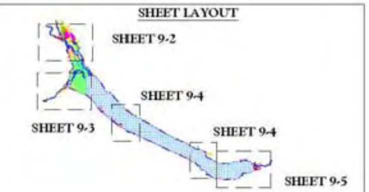
0 500' 1,000' 2,000'

Sugnet Photo Point Location	PP01	
Proposed Ordinary High Water Line 9499' (OHWL)		
Current Ordinary High Water Line 9449' (OHWL)		
Potential Wetland Creation Area		10.31 AC

JURISDICTIONAL WATERS OF THE US & POTENTIAL IMPACTS

	Existing Waters of the US	Potential Impacts		Potential Temporary Impacts	
Intermittent Streambed (R4SB)		0.23 AC	381 LF	0.00 AC	000 LF
Upper Perennial Streambed (R3SB)		4.15 AC	2,511 LF	0.00 AC	000 LF
Palustrine Scrub Shrub (PSS)		13.03 AC		0.00 AC	
Palustrine Emergent (PEM)		7.04 AC		0.00 AC	
Beaver Ponds		0.41 AC		0.00 AC	
Fens		0.00 AC		0.00 AC	
Open Waters		0.00 AC		4.58 AC	
TOTAL:		24.87 AC	2,891 LF	4.58 AC	000 LF

SHEET LAYOUT



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PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

WETLAND ASSESSMENT
RIO GRANDE RESERVOIR

Date: September 26, 2006
Drawn By: DJD
Reviewed By: SM
Job No.: 060051
File: Figure 9.dwg
Scale: As Shown

Revisions:
Revised: October 16, 2007

Figure
9-1

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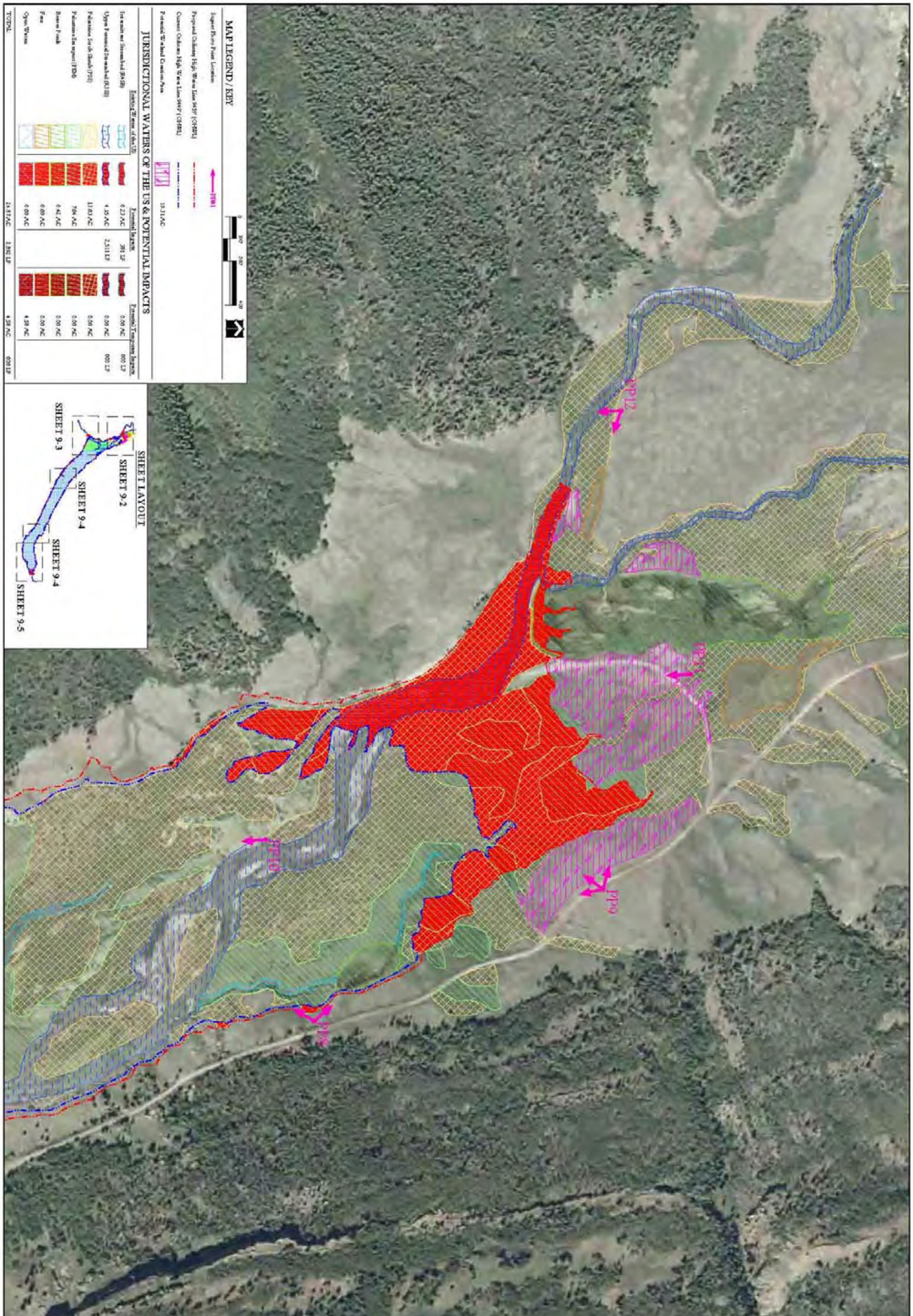

WETLAND DELINEATION
RIO GRANDE RESERVOIR

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Figure 9-2

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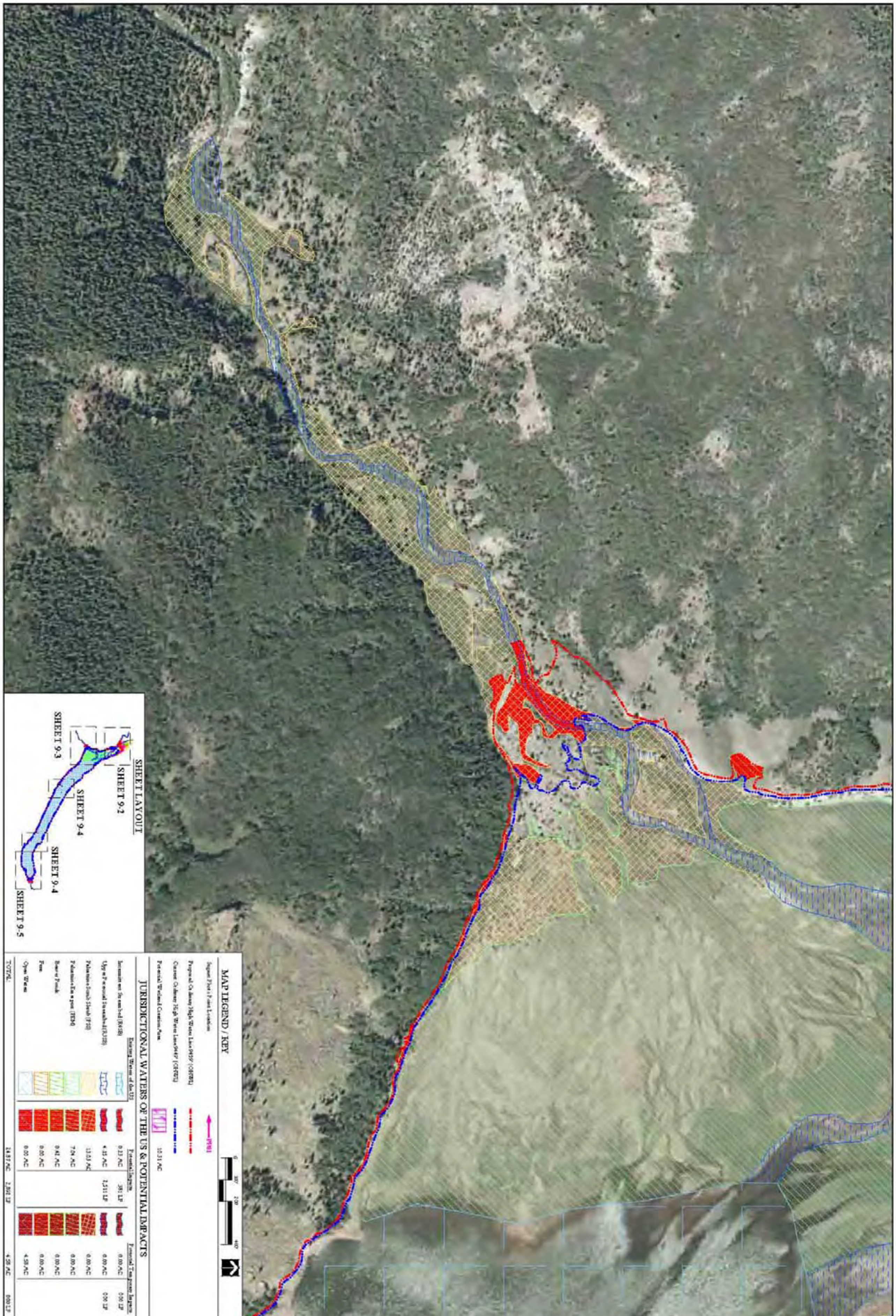

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WETLAND DELINEATION
RIO GRANDE RESERVOIR

Figure 9-3

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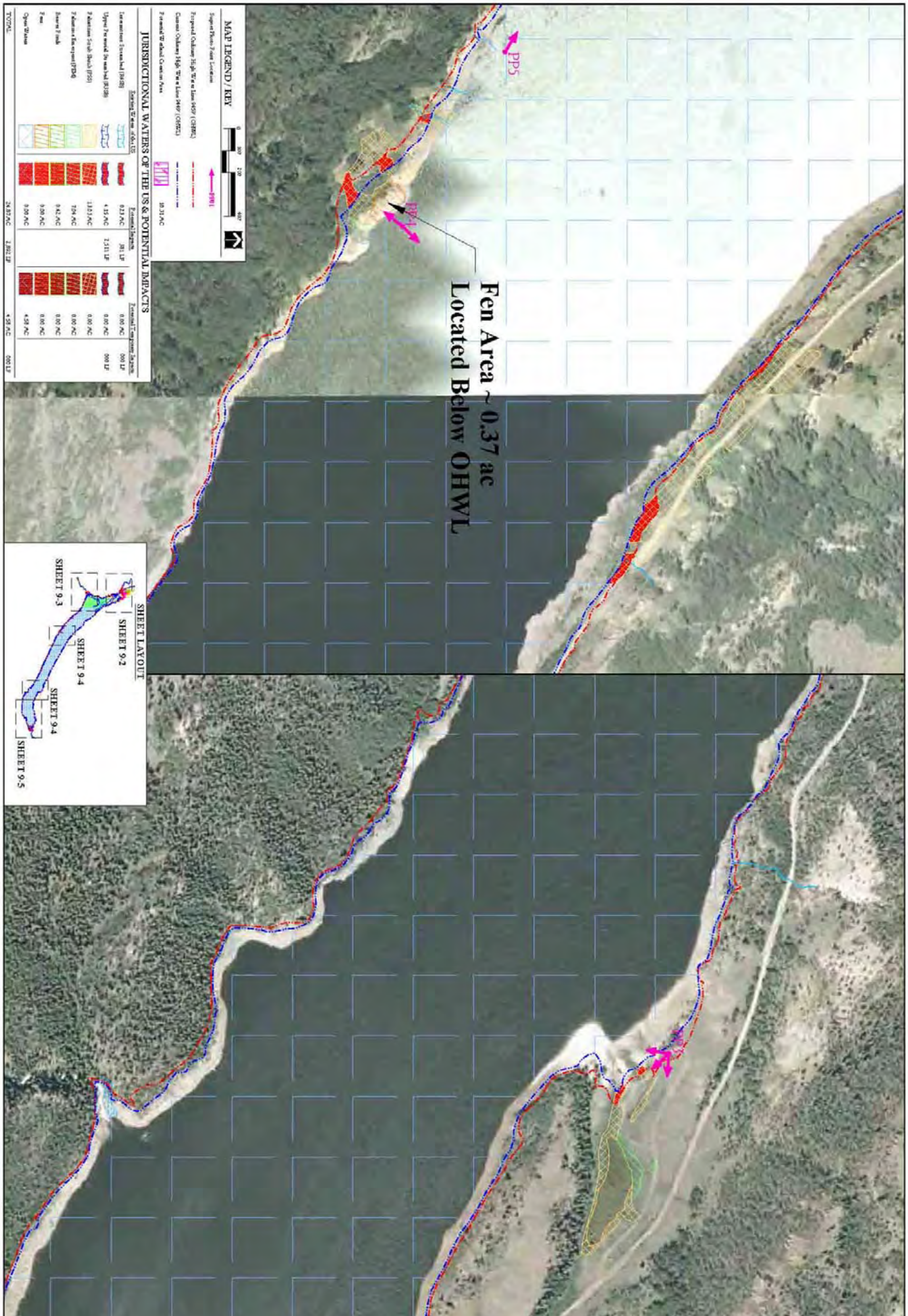

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WETLAND DELINEATION
RIO GRANDE RESERVOIR

Figure 9-4

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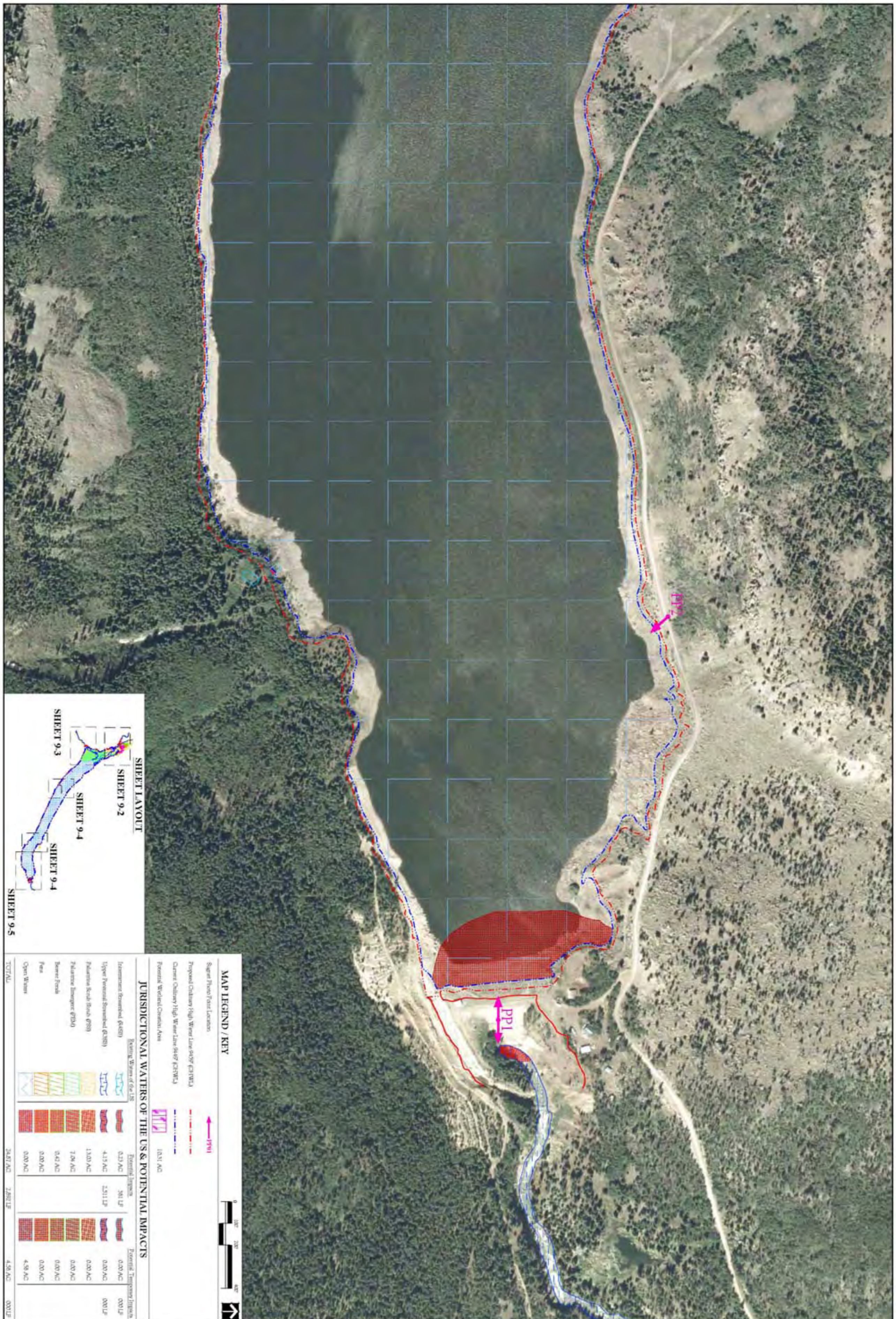

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Revisions:
Revised October 16, 2007

WETLAND DELINEATION
RIO GRANDE RESERVOIR

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

SUGNET & MOORE ENVIRONMENTAL, INC.

Figure 9-5

As a result of the increased water elevation, other areas located upstream that are not currently wetland areas will likely experience a higher frequency of saturation or inundation and therefore develop wetland characteristics. Based on SME's assessment it appears that approximately half of the lost wetland area will be mitigated by the incidental creation of new wetland area upslope. Furthermore, the increased water elevation would potentially create an additional 53.29 acres of open water habitat when the Reservoir is full. Table 9-2 lists the areas of expected wetland and open water creation as a result of the increased inundation.

Table 9-2 Acreage of Potential Wetland Creation Onsite Resulting from Proposed Rio Grande Expansion

Waters of the U.S.	Area (acres)	Linear Feet
Palustrine Wetlands (PSS/PEM)	10.31	--
Palustrine Open Water (OW)	53.29	--
Total:	**63.60**	**--**

Vegetation

At the time of inspection, the water level of the Reservoir appeared to be approximately 15 to 20 feet below the OHWL. Approximately one-third of the Reservoir basin was exposed. At the western end of the site, the exposed areas contained an herbaceous wet meadow that is characterized by shortawn foxtail (*Alopecurus aequalis*), beaked sedge (*Carex utriculata*), and Cinquefoil (*Potentilla sp*.). The upper transition of the Reservoir is dominated by a shrub wetland, which is characterized by the presence of mountain willow (*Salix monticola*) and Geyer willow (*Salix geyeriana*). The dry hillsides of the valley above the Reservoir are dominated by aspen (*Populous tremuloides*), spruce (*Picea spp*.), and fir (*Abies spp*.). Table 9-3 lists dominant and characteristic species observed onsite.

Table 9-3 Floral Species Observed in the Vicinity of the Rio Grande Reservoir Project Area

*Scientific Name**	Common Name	*Family*	Wetland Indicator Status**
TREES			
Abies arizonica	Corkbark fir	*Pinaceae*	FACU
Abies concolor	White fir	*Pinaceae*	NL
Alnus incana var. tenuifolia	thinleaf alder	*Betulaceae*	FACW
Betula fontinalis	river birch	*Betulaceae*	FACW
Picea engelmannii	Engelmann spruce	*Pinaceae*	FACU-*
Picea pungens	blue spruce	*Pinaceae*	FAC-
Populus tremuloides	quaking aspen	*Salicaceae*	NI
Pseudotsuga menziesii	Douglas-fir	*Pinaceae*	NL
Quercus gambelii	Gambel oak	*Fagaceae*	NL
SHRUBS			
Alnus incana var. tenuifolia	thinleaf alder	*Betulaceae*	FACW
Amelanchier alnifolia	serviceberry	*Rosaceae*	FACU-
Cornus sericea	red osier dogwood	*Cornaceae*	FACW
Crataegus erthyropoda	redhaw	*Rosaceae*	FAC
Lonicera involucrate	twinberry honeysuckle	*Caprifoliaceae*	FAC
Mahonia repens	creeping barberry	*Berberidaceae*	NL
Ribes aureum	golden current	*Grossulariaceae*	FACW
Ribes montigenum	mountain gooseberry	*Grossulariaceae*	NL
Rosa woodsii	Woods' rose	*Rosaceae*	FAC-

Table 9-3 Floral Species Observed in the Vicinity of the Rio Grande Reservoir Project Area

Scientific Name*	**Common Name**	***Family***	**Wetland Indicator Status****
Rubus idaeus	wild raspberry	*Rosaceae*	FACU
Pentaphylloides floribunda	shrubby cinquefoil	*Rosaceae*	FACW*
Salix geyeriana	Geyer willow	*Salicaceae*	FACW+
Salix monticola	mountain willow	*Salicaceae*	OBL
Symphoricarpos oreophilus	mountain snowberry	*Caprifoliaceae*	FACU
HERBS			
Forbs			
Achillea lanulosa	common yarrow	*Asteraceae*	FACU
Aconitum columbianum	monkshood	*Ranunculaceae*	FACW
Angelica grayi	Gray's angelica	*Apiaceae*	NL
Apocynum cannabinum	hemp dogbane	*Apocynaceae*	FAC
Argentina anserine	silverweed	*Rosaceae*	OBL
Cardamine cordifolia	heartleafed bittercress	*Brassicaceae*	FACW
Castilleja rhexiifolia	rosy paintbrush	*Scrophulariaceae*	FACU
Chrysanthemum leucanthemum	ox-eye daisy	*Asteraceae*	NL
Cirsium arvense	Canada thistle	*Asteraceae*	FACU
Cirsium parryi	Parry's thistle	*Asteraceae*	FACW
Cirsium scariosum	meadow thistle	*Asteraceae*	NI (OBL)
Clementsia rhodantha	rose crown	*Crassulaceae*	FACW+
Descurainia californica	sierra tansymustard	*Brassicaceae*	UPL
Epilobium hornemannii	willowherb	*Onagraceae*	FACW
Erigeron peregrinus	Subalpine fleabane	*Asteraceae*	FACW
Fragaria virginiana	wild strawberry	*Rosaceae*	FACU
Gentianopsis thermalis	fringed gentian	*Polemoniaceae*	OBL
Heracleum lanatum	cow parsnip	*Apiaceae*	FAC
Hippochaete hyemalis	scouring rush	*Equisetaceae*	FACW
Iris missouriensis	Rocky Mt. iris	*Iridaceae*	OBL*
Ligusticum porteri	Porter's lovage	*Apiaceae*	FACU-
Machaerantha spp.	Purple aster	*Asteraceae*	
Mentha arvensis	field mint	*Lamiaceae*	FACW
Mertensia ciliate	bluebells	*Boraginaceae*	OBL
Medicago lupulina	Black medick	*Fabacece*	FAC
Micranthes odontoloma	brook saxifrage	*Saxifragaceae*	FACW+
Oxypolis fendleri	Fendler's cowbane	*Apiaceae*	OBL
Packera crocata	saffron ragwort	*Asteraceae*	FACW
Pedicularis groenlandica	elephantella	*Scrophulariaceae*	OBL
Physalis hederifolia	ivyleaf groundcherry	*Solanaceae*	NL
Myosurus minimus	tiny mousetail	*Ranunculaceae*	OBL
Nasturtium officinale	watercress	*Brassicaceae*	OBL
Plantago lanceolata	lanceleaf plantain	*Plantaginaceae*	FACU
Plantago major	broadleaf plantain	*Plantaginaceae*	FAC
Polygonum amphibium	water smartweed	*Polygonaceae*	OBL
Potentilla sp.	Cinquefoil	*Rosaceae*	-----
Prunella vulgaris	common selfheal	*Lamiaceae*	FACU
Pseudocymopterus montanus	Mountain parsley	*Apiaceae*	NI
Rudbeckia laciniata	cutleaf coneflower	*Asteraceae*	FAC+
Rumex crispus	curly dock	*Polygonaceae*	FACW
Senecio amplectens	showy alpine ragwort	*Asteraceae*	FACW
Senecio triangularis	triangleleafed senecio	*Asteraceae*	OBL
Taraxacum officinale	dandelion	*Asteraceae*	FACU
Thalictrum fendleri	Fendler's meadow rue	*Coptaceae*	UPL
Trifolium pratense L.	red clover	*Fabaceae*	FACU
Veratrum tenuipetalum	false hellebore	*Liliaceae*	FACW*
Verbascum Thapsus	common mullein	*Scrophulariaceae*	NL

Table 9-3 Floral Species Observed in the Vicinity of the Rio Grande Reservoir Project Area

*Scientific Name**	Common Name	*Family*	Wetland Indicator Status**
Graminoids			
Agrostis idahoensis	Idaho redtop	*Poaceae*	FAC
Agrostis stolonifera	creeping bentgrass	*Poaceae*	FACW
Alopecurus aequalis	shortawn foxtail	*Poaceae*	OBL
Alopecurus pratensis	meadow foxtail	*Poaceae*	NI (FACW)
Bromus inermis subsp. Pumellianus	smooth brome	*Poaceae*	NL
Calamagrostis Canadensis	bluejoint	*Poaceae*	OBL
Calamagrostis stricta	northern reedgrass	*Poaceae*	FACW
Carex aquatilis	water sedge	*Cyperaceae*	OBL
Carex praegracillis	Clustered field sedge	*Cyperaceae*	FACW
Carex utriculata	beaked sedge	*Cyperaceae*	OBL
Dactylis glomerata	orchard grass	*Poaceae*	FACU
Deschampsia caespitosa	tufted hairgrass	*Poaceae*	FACW
Eleocharis macrostachya	common spiked rush	*Cyperaceae*	OBL
Elymus bakeri	Baker's wheatgrass	*Poaceae*	NL
Elymus smithii	western wheatgrass	*Poaceae*	FACU
Festuca idahoensis	Idaho fescue	*Poaceae*	NI
Festuca thurberi	Thurber fescue	*Poaceae*	NL
Juncus arcticus	wire rush	*Juncaceae*	FACW
Juncus mertensianus	Merten's rush	*Juncaceae*	OBL
Juncus parryi	Parry's rush	*Juncaceae*	FAC*
Muhlenbergia Montana	mountain muhly	*Poaceae*	
Pascopyrum smithii	Western wheat	*Poaceae*	FACU
Phleum alpinum	alpine timothy	*Poaceae*	FAC
Phleum pretense	timothy	*Poaceae*	FACU
Poa leptocoma	marsh bluegrass	*Poaceae*	FACW
Poa sp.	bluegrass	*Poaceae*	-----
FERN/ FERN ALLIES/ BRYOPHYTES			
Moss 1 (unidentified)			
Liverwort 1 (unidentified)			
Sphagnum spp.			

OBL	Obligate Wetland	99% probability of occurrence in wetlands
FACW	Facultative Wetland	67%-99% probability of occurrence in wetlands
FAC	Facultative	34%-66% probability of occurrence in wetlands
FACU	Facultative Upland	1%-33% probability of occurrence in wetlands
UPL	Obligate Upland	>99% non-wetlands in this region
NI	No Indicator	Insufficient information available
NL	Not Listed	Generally indicates upland species

* Scientific names according to USDA NRCS National PLANTA Database (1999)
** Wetland Indicator Status follows Reed 1988 for Region 8: Intermountain (CO wester, UT, NV)

Soils

No soil maps have been published by the Natural Resources Conservation Service (NRCS) for the subject area; however, the site investigation included periodic soil pits to examine the soil profiles. The wetland soils located within the Rio Grande floodway (both above and below the Reservoir) tend to be problematic (based on USACE Delineation Manual) due to their dynamic nature and coarse textures, which have the effect of masking potential hydric indicators. However, the soil profiles examined in the floodway (upstream of the Reservoir) did contain some faint redoximorphic features, which were used during the delineation process to indicate prolonged periods of saturation or inundation.

Upland soils located outside of the floodplain generally consisted of loam to sandy loam with gravel, cobble, and shallow bedrock. The wetland soils located in the fen areas, which are located outside of the proposed inundation area, contained 8 to 24+ inches of organic (histic) soil, which was the primary determinant for the fen classification. The fens are described in below.

Hydrology

The study area is located in a riparian valley that has been hydrologically altered by the presence of the subject dam. Upstream of the dam, the valley is flooded for water storage. The resulting Reservoir has fluctuated in depth and proportionate cross-sectional area of inundation. This artificial hydrologic regime has had a substantial impact on the plant communities on the steep banks of the Reservoir, which are largely unvegetated. Additionally, there are three primary tributaries that enter the Reservoir study area; the Rio Grande and Lost Trail Creek from the west and Ute Creek which flows into the Reservoir from the southwest. Several other small, unnamed intermittent and ephemeral streams enter the study area, most of which are located on the south side of the Reservoir. Stream flow, shallow groundwater, and reservoir (lacustrine) water are the primary source of hydrology for the delineated wetlands. Direct precipitation and surface runoff are secondary sources of hydrology. According to data produced at the National Resource Conservation Service (NRCS) Snotel Site, the average annual water equivalent in this area is approximately 45 inches per year of snow, not including rain in the summer and fall which would likely bring the total annual precipitation to at least 60 inches per year. The other indicators of hydrology observed onsite included drainage patterns, drift lines, and matted vegetation. During the delineation process, attention was given to distinguishing between the affects of the artificial hydrology created by the dam and natural hydrology, which would persist in the absence of reservoir inundation.

Fens

SME identified and roughly delineated 3.68 acres of fen wetland area located immediately adjacent to the project area. The fen wetland areas are all outside of the proposed reservoir expansion elevation range (gage height 91 feet to 101 feet), except for fen area on the south edge of the Reservoir (see description below of fen 2). Fen 2 is located below the current high water mark of the Reservoir, and therefore, does not constitute a *new* impact. Fen areas 3 and 4 may be impacted by backwater effects of the proposed expansion. Conservative estimates of the fen boundaries are depicted in Figure 9-1 to 9-5. The fen areas are generally described below:

Potential fen on south side of Reservoir

Fen 1 (north bank): The fen area located on the north bank (closer to the east end of the Reservoir) measures approximately 1.11 acres. The vegetative community of the fen on the north bank is a monoculture of beaked sedge with some willows and Canada reedgrass on the periphery. Organic soil material (peat) is 10-24+ inches over a depleted mineral soil. This fen area is located approximately 20 feet above the existing high water mark and therefore, would not be affected by the proposed 10 foot increase in water elevation.

Fen 2 (south bank): The fen area located on the south side of the Reservoir measures approximately 0.37 acres. It is located on a flat bench several feet below the current high water level, (defined by the gage height 91 feet elevation mark). The dominant vegetation in the fen South bank fen includes water sedge (*Carex aquatilis*), Canada reedgrass (*Calamagrostis canadensis*), and mountain and Geyer willow (*Salix monticola* and *S. geyeriana*). This area has denser willow canopy than the other fen areas. Organic soil material (peat and mucky peat) is 10-18+ inches over a depleted mineral soil and bedrock. The presence of this fen wetland below the current OHWL suggests that periodic inundation may not significantly affect the community. Due to the fact that fen area 2 is located below the current OHWL, no new impacts will occur as a result of the proposed project.

Fen 3 (Rio Grande): The smallest fen area is located at the west end of the Reservoir in the floodway of the Rio Grande and measures approximately 0.31 acres. This fen, which is located in an odd landscape position, is primarily characterized by the presence of histosols (A1) and histic epipedons (A2) that included 8-24+ inches of peat or mucky-peat material over a depleted mineral soil. The characteristic vegetation consisted of water sedge (*Carex aquatilis*), beaked sedge (*Carex utriculata*), Canada reedgrass (*Calamagrostis canadensis*), and Sphagnum mosses (*Sphagnum spp.*). The fen area is surrounded by willows, which generally define the boundaries of the fen. Scattered individual willow shrubs (*Salix monticola* and *S. geyeriana*) are found within the fen boundaries. This fen area is located outside of the proposed new high water mark, but the area may experience a slight backwater affect in the rare occasion that the Reservoir is filled to capacity. The area would not be inundated, but the through-flow of groundwater may temporarily be reduced due to the artificially raised local water table which creates a lower hydraulic gradient.

<u>Fen 4 (Lost Trail Creek):</u> The largest fen area is also located at the west end of the Reservoir but is in the wide floodway of Lost Trail Creek. This fen measures approximately 1.89 acres. Fen 4 is also located in an odd landscape position and is characterized by the same soil morphology and vegetative community as Fen 3. The proposed project might also have the same potential effect from raised water table on Fen 4 as it does for Fen 3.

Limitations

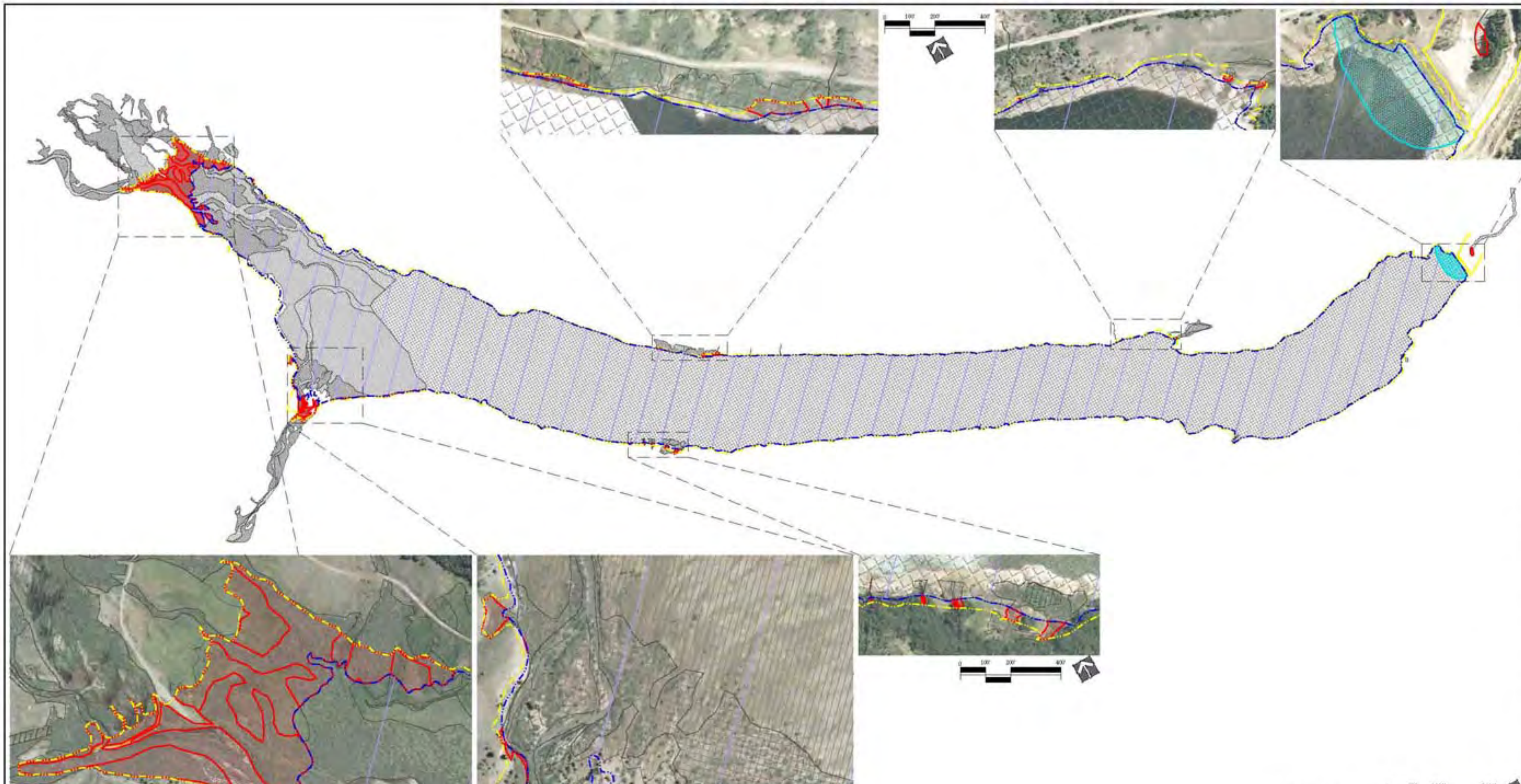
Field indicators can change with variations in hydrology and other factors. This report conservatively estimates the potential for wetlands at the site at the time of our review and does not address conditions at a given time in the future. Furthermore, the impact estimates provided in this report include several assumptions about the factors influencing the frequency and duration of inundation, including climatic variation and reservoir management practices.

Information with regards to the potential for impacts is theoretical in nature. Due to the uncertain nature of future climatic conditions and the associated reservoir operations the *actual* and *theoretical* impacts will vary. If, theoretically, the enlarged Reservoir was filled to capacity each season, then the indirect impacts would be significant. However, historically the Reservoir has only been filled to capacity in above average runoff years. Consequently, there is a substantial wetland area located below the current spillway elevation (including fen area 2) that has persisted despite the periodic inundation. Clearly, there is a limit to the frequency and period of inundation that the natural wetland areas can tolerate, but further research would be need to better define this threshold.

This wetland delineation is currently under review by the USACE and is subject to review by the U.S. Environmental Protection Agency (USEPA). Once the review and verification process is completed, this will constitute a Jurisdictional Determination of Water of the United States.

9.2 Wetlands Mitigation

A raised water line associated with a reservoir enlargement could inundate wetland areas including perennial and intermittent streambeds. This section provides a brief assessment of potential mitigation options to compensate for the direct and indirect impacts associated with the project. The assessment is preliminary in nature; further in-depth analysis would be required to locate feasible offsite mitigation options. The increased area of inundation would be approximately 53 acres, including 20.49 acres of wetlands and 4.38 acres of streambed (see Figure 9-6).



MAP LEGEND / KEY

Proposed Ordinary High Water Line 9459' (OHWL)

Current Ordinary High Water Line 9449' (OHWL)

Current Inundated Area Below OHWL 9449'

JURISDICTIONAL WATERS OF THE US & POTENTIAL IMPACTS

	Existing Waters of the US	Potential Impacts		Potential Temporary Impacts	
Intermittent Streambed (R4SB)		0.23 AC	381 LF	0.00 AC	000 LF
Upper Perennial Streambed (R3SB)		4.15 AC	2,511 LF	0.00 AC	000 LF
Palustrine Scrub Shrub (PSS)		13.03 AC		0.00 AC	
Palustrine Emergent (PEM)		7.04 AC		0.00 AC	
Beaver Ponds		0.42 AC		0.00 AC	
Fens		0.00 AC		0.00 AC	
Open Waters		0.00 AC		4.58 AC	
TOTAL		24.87 AC	2,892 LF	4.58 AC	000 LF

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PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

WETLAND IMPACT MAP
WETLAND MITIGATION/ASSESSMENT
RIO GRANDE RESERVOIR

Date: September 26, 2006
Drawn By:
Reviewed By:
Job No.:
File:
Scale: As Shown

Revisions:
Revised: October 16, 2007

Figure 9-6

Federal review of the project under Section 404 of the Clean Water Act (CWA) and the National Environmental Policy Act (NEPA) necessitate a thorough understanding of the direct and secondary impacts associated with the project. Section 404 requires compensatory mitigation for any unavoidable impacts to waters of the US that occurs as a result of fill or dredging activities. Although the inundation of waters of the US is not in itself a regulated activity, the inundation is an indirect result of fill, and hence becomes subject to Section 404 authorization. These secondary effects are considered impacts for which mitigation is typically required.

The USACE and USEPA generally require mitigation at a 1:1.5 ratio (impact: mitigation) to offset direct impacts and temporal loss of wetland function associated with the reestablishment of the lost resource. However, due to the over appropriated nature of the Rio Grande watershed, it has generally been acceptable to provide wetland replacement at a 1:1 ratio and compensate for the impacts and temporal loss of wetland function by means other than wetland creation. The information provided in this report, with regards to mitigation requirements, is based on this general assumption. However, mitigation ratios are subject to negotiation with the USACE during the permitting process.

SME estimated the potential impacts to wetlands and linear feet (LF) of stream which would be affected by the dam improvement project (Section 9.1). SME used the standard 1.5:1 mitigation to impact ratio to calculate the amount of wetland mitigation (1:1 wetland replacement, plus an additional 0.5:1 out of kind mitigation) and a straight 1:1 mitigation ratio for impacts to stream length. Using these numbers SME looked for various alternatives for mitigation including creation, restoration, enhancement, preservation, and in-lieu possibilities for wetlands, streams, and riparian areas. We focused our mitigation search on the upper reaches of the Rio Grande Watershed (Upstream of Creede, Colorado), but also considered areas downstream of Creede to Del Norte, Colorado.

9.2.1 Anticipated Impacts

The enlargement project will likely result in quantifiable direct impacts associated with the actual dam construction, but will also involve less quantifiable secondary impacts associated with an increased area of inundation.

Direct Impacts

Direct impacts will consist of permanent fill impacts in the downstream side of the current dam location and temporary fill to open water areas on the upstream side of the dam. Based on current engineering plans, SME has determined that 150 linear feet (approximately 0.16 acres) of perennial streambed will be directly impacted by the dam improvements. Temporary impacts to approximately 4.58 acres or reservoir substrate will not result in a loss of aquatic function or area and therefore will not require mitigation.

Indirect Impacts

Indirect, or secondary, impacts associated with potential inundation are less definitive than the direct impacts due to the fact that there is no actual "fill" area. The Reservoir is located in a narrow river valley with steep hillsides that are generally at a 2:1 slope. Consequently, the area of potential new inundation along the north and south sides of the Reservoir is relatively narrow (generally 10 to 30 feet wide), but in the upper reaches (western upstream end) the potential for new inundation is significantly wider (up to 700 feet wide). The effects of inundation on the existing community will vary depending on the reservoir operations. If, theoretically, the Reservoir was filled to capacity each season, then the indirect impacts would be significant. However, historically the Reservoir has only been filled to capacity in above average runoff years. Consequently, there is a substantial wetland area located below the current spillway elevation (including fen area 2) that has persisted despite the occasional inundation. Clearly, there is a limit to the frequency and period of inundation that the natural wetland areas can tolerate, but further research would be need to better define this threshold.

Furthermore, as the area of inundated willows increase, the water table in upland locations will rise proportionately. Consequently, much of the willow area that may be affected by inundation will be offset by a proportional increase in wetland areas upslope. However, some of this upslope area already exists as a wetland. Therefore, the increase in created wetland area will not be a direct trade off. The net difference would need to be mitigated in another location.

Anticipated Mitigation Requirements

Based on a theoretical worst case scenario (annual maximization of reservoir capacity), the area of indirect impacts would be approximately 20.49 acres of wetlands and 2,898 linear feet of streambed (150 LF downstream of the dam and 2,748 LF at the west end of the Reservoir). Approximately half of this area (10.31 acres) would be offset by the development of wetland conditions upslope.

Using a standard 1.5:1 mitigation ratio, 30.74 acres (20.49 x 1.5) of indirect wetland impacts would need to be mitigated. As previously explained, wetland creation will likely be completed at a 1:1 ratio (20.49 acres) with the additional 0.5:1 ratio (10.25 acres) mitigated by other means. Also, 2,898 LF of stream impacts would need to be mitigated at a 1:1 ratio. Table 9-4 provides a summary of the impacts and anticipated mitigation requirements.

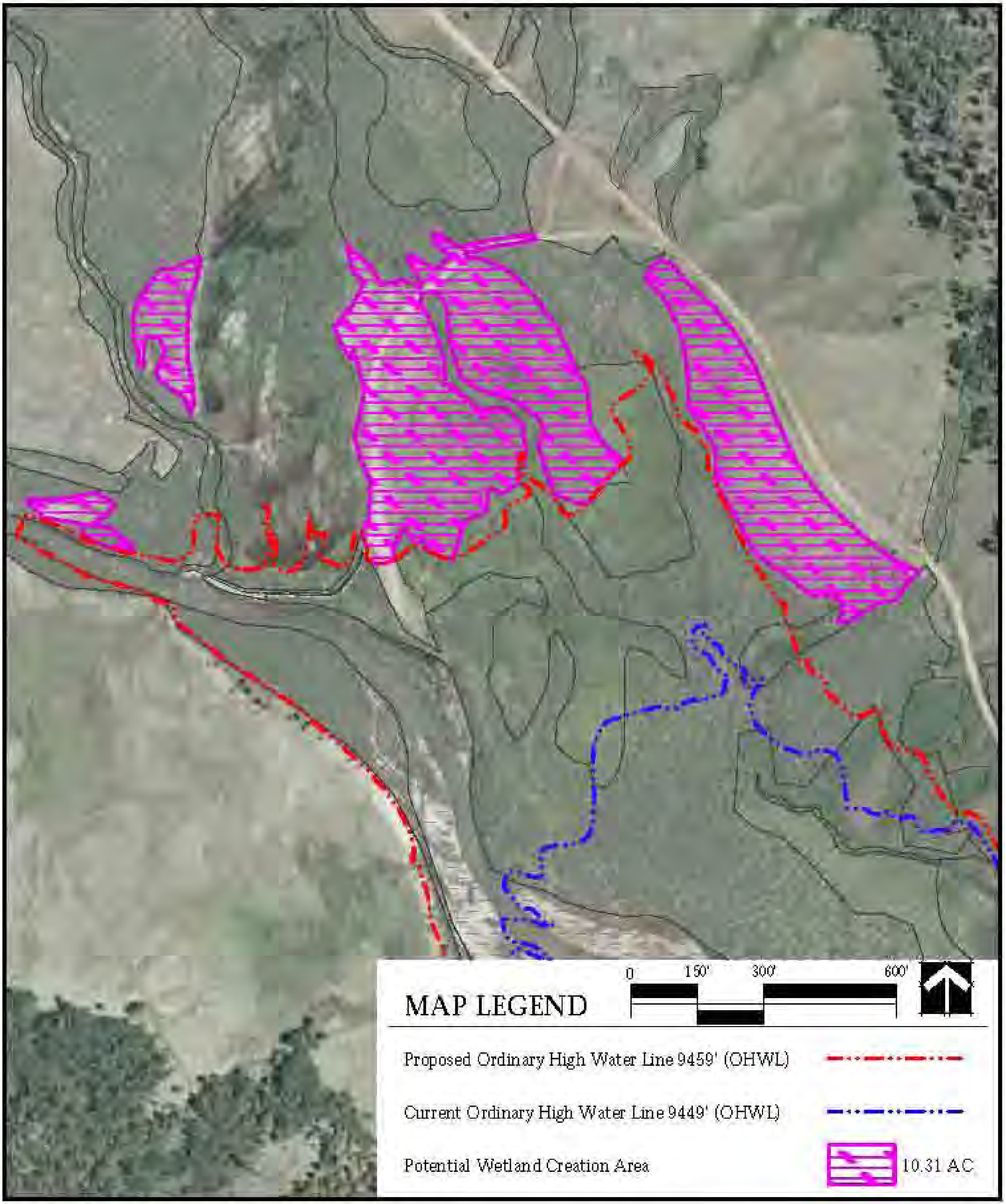
Table 9-4 Potential Impacts to Waters of the U.S. Resulting from the Proposed Enlargement of Rio Grande Reservoir

	Area (acres) Length (LF)	Mitigation Required	Comments
Permanent Impacts			
Direct (Dam Construction)			
Wetland (PEM/PSS)	0.00 ac.	---	---
Stream (R3SB/R4SB)	150 LF (0.16 ac)	150 LF	Best achieved through stream enhancement or restoration
Open Water (OW)	---	---	---
Indirect (Flooding)			
Wetland (PEM/PSS)	20.49 ac.	30.74 ac.	Best achieved through onsite and offsite wetland creation, enhancement, restoration In-lieu fee, and land preservation
Stream (R3SB/R4SB)	2,748 LF (4.22 ac.)	2,748 LF	Best achieved through stream enhancement or restoration
Open Water (OW)	--	---	---
Temporary Impacts			
Direct (Dam Construction)			
Wetland (PEM/PSS)	0.00 ac.	---	---
Stream (R3SB/R4SB)	0.00 ac.	---	---
Open Water (OW)	4.58 ac.	0.00 ac.	OW impacts from dam construction will be restored in-place and in-kind
Indirect (Flooding)			
Wetland (PEM/PSS)	0.00 ac.	---	---
Stream (R3SB/R4SB)	0.00 ac.	---	---
Open Water (OW)	0.00 ac.	---	---
TOTALS	**29.45 ac.**	**30.74 ac. of wetlands** **2,898 LF of stream**	

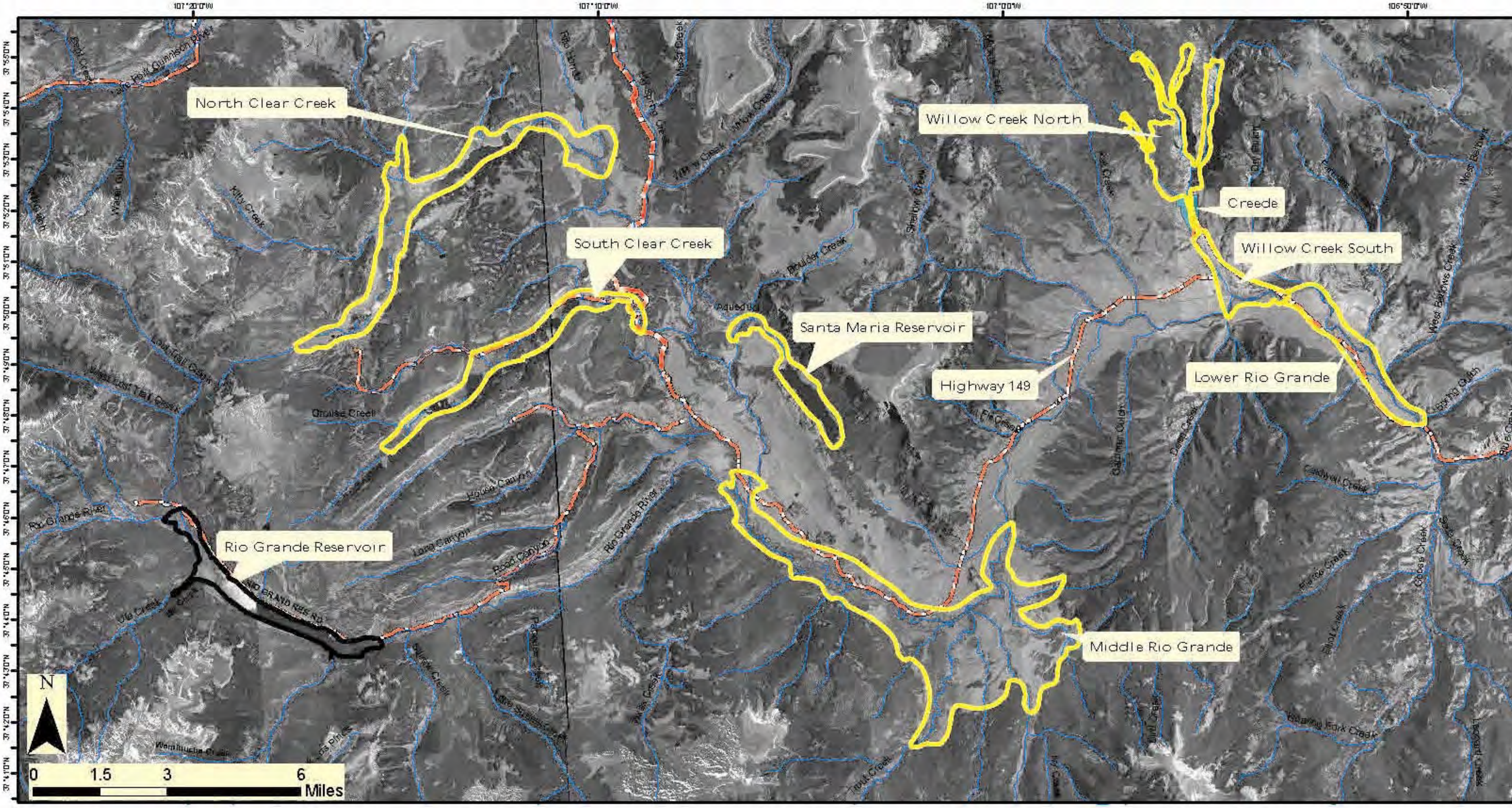
9.2.2 Possible Mitigation Options

The most practicable location to mitigate for wetland impacts is in the upland areas located just above the proposed high water mark. As previously explained, these areas would naturally evolve into wetlands without the need for any remedial action due to the artificial rise in the groundwater table associated with the project. These upland areas account for approximately 10.31 acres (Figure 9-7). Therefore, 10.18 (20.49 – 10.31) acres of wetlands would need to be created at an offsite location and 10.25 acres worth of compensation would be completed by means other than wetland creation (e.g. wetland enhancement, buffer preservation, riparian habitat enhancement, in-lieu fee, etc.). Finally, 2,898 linear feet of stream length impacts would be mitigated offsite (See Tables 9-4 and 9-5). SME has identified several locations within the upper Rio Grande Watershed that may offer opportunities to mitigate for the proposed enlargement project impacts.

A broad preliminary search was completed, utilizing aerial photography and anecdotal information from discussions with USFS and State Division of Minerals and Geology. This information was used to identify several potential offsite mitigation areas (Figure 9-8). The generalized nature of this search necessitates further site investigation to determine which of these areas are actually feasible and practicable for the purpose of mitigating the impacts from enlarging the Reservoir.



SUGNET & MOORE ENVIRONMENTAL, INC.	WETLAND CREATION MAP	FIGURE 9-7
	WETLAND MITIGATION/ASSESSMENT RIO GRANDE RESERVOIR	Source: *Aerial Photo Taken in 2005, by NAIP (National Agriculture Imagery Program).*



SUGNET & MOORE ENVIRONMENTAL, INC.	PRELIMINARY OFFSITE MITIGATION ASSESSMENT POTENTIAL AREAS OF MITIGATION	RIO GRANDE RESERVOIR HINSDALE COUNTY, CO	FIGURE 9-8	11/13/2007	Source: Aerial Photo Taken in 2006 by National Agriculture Imagery Program (USDA)

Table 9-5 Potential Mitigation Options to Compensate for Impacts Associated with the Enlargement of Rio Grande Reservoir

	Potential Locations	Area(s) (Acres)	Estimated Mitigation Credit (Impact To Mitigation Ratio)	Comments
Onsite Mitigation Options				
Wetland Creation (PEM/PSS)	Northwest end of existing Reservoir	10.31 ac.	10.31 ac. (1:1)	Wetland Creation may involve limited grading, followed by seeding and planting
Offsite Mitigation Options				
Wetland Creation/Restoration (PEM/PSS)	Disturbed areas located in the floodplain of the Rio Grande or its Tributaries	Unknown	(1:1)	A few opportunities exist downstream of the Reservoir on Forest Service and Private Lands. More in-depth analysis (outside of the scope of this assessment) is needed to locate the most feasible options. USFS has indicated that they may be able to identify potential wetland restoration areas located within the Rio Grande NF; further coordination is necessary.
Wetland Enhancement	Disturbed areas located in the floodplain of the Rio Grande or its Tributaries	Unknown	varies	A few opportunities exist downstream of the Reservoir on Forest Service and Private Lands. More in-depth analysis (outside of the scope of this assessment) is needed to locate the most feasible options. USFS has indicated that they may be able to identify potential wetland enhancement areas located within the Rio Grande NF; further coordination is necessary.
Stream Restoration (R3SB/R4SB)	• Stabilize problem areas and restore floodway of Rio Grande banks • Restore Willow Creek • Restore Kitty Creek • Decommission smaller reservoir(s)	Unknown	varies	A few opportunities exist downstream of the Reservoir on Forest Service and Private Lands. More in-depth analysis (outside of the scope of this assessment) is needed to locate the most feasible options. USFS has indicated that they may be able to identify potential wetland restoration areas located within the Rio Grande NF; further coordination is necessary.
Out-of-Kind or In-Lieu Fee	• Willow Creek Reclamation Committee, • Rio Grande National Forest • Acid Mine Drainage Treatments	Unknown	varies	The Upper Rio Grande watershed contains a few abandoned mining operations and other anthropogenic disturbances that have degraded the water quality in the Rio Grande and it tributaries. Therefore, opportunities exist for the restoration of waterways. This work could be done directly or accomplished via a monetary contribution to existing restoration efforts or organizations.
Land Preservation	• Unknown	Unknown	varies	The upper Rio Grande watershed is located within and adjacent to public lands. Therefore, private in-holdings could be purchased to serve as preserved buffers and reduce the potential for future floodplain development.

Two stream corridors have been identified as highly degraded and in need of restoration. The Willow Creek Drainage, which flows through the Town of Creede, has been severely degraded by past mining activities and Kitty Creek, located north of the project area suffers from erosion and entrenchment. These two tributaries require further investigation and coordination with existing restoration efforts already underway.

In summary, the proposed enlargement of Rio Grande Reservoir would have direct and indirect impacts. The direct permanent impacts would be limited to the filling of 150 linear feet of perennial streambed downstream of the dam, which will require mitigation. Direct temporary disturbance will occur to approximately 4.58 acres of reservoir substrate due to work on the front (upstream) side of the dam, which is not likely to require mitigation. Indirect impacts associated with flooding, would include approximately 20.49 acres of wetlands and 2,748 linear feet of jurisdictional streambed. The mitigation for indirect impacts is difficult to determine due to uncertainty about regulatory requirements and effects of reservoir operations on wetland communities surrounding the Reservoir.

Based on a standard 1.5:1 mitigation ratio, the project would require the creation of 30.74 acres of wetlands. However, due to the over-appropriated nature of the Rio Grande Watershed direct replacement of wetland area would likely be limited to a 1:1 mitigation to impact ratio with additional out-of-kind mitigation measures proposed to offset the remaining 20.43 acres of mitigation requirements. Consequently, mitigation for the project would likely include approximately 10.31 acres of onsite wetland creation,10.18 acres of offsite wetland creation, and 10.25 acres worth of out-of-kind mitigation, as well as 2,898 linear feet of offsite stream restoration or enhancement,. Onsite mitigation areas have been roughly identified, but offsite mitigation options will require further evaluation.

9.3 Biological Assessment

A Biological Assessment (BA) is required under federal consultation review by USACE for the Section 404 Permit process. However, this BA may be triggered by a different federal agency in the case where additional federal actions are involved, such as the NEPA process. Once further project details have been secured, the lead federal agency would be determined for the Endangered Species Act (ESA) consultation process.

The purpose of this BA is to review the proposed Rio Grande Reservoir project in sufficient detail to determine to what extent the proposed action may affect any of the threatened, endangered, proposed, or candidate sensitive species listed below. This BA is prepared in accordance with legal requirements set forth under Section 7 of the ESA (16 USC 1536 (c)).

The following fish species are endemic to the Colorado River system and do not exist on the east side of the continental divide; therefore, these species are not present in the project area and are excluded from further discussion in this BA.

- Colorado pikeminnow (*Ptychocheilus lucius*) (E)
- Razorback sucker (*Xyrauchen texanus*) (E)
- Bonytail (*Gila elegens*) (E)
- Humpback chub (*Gila cypha*) (E)

The bald eagle (*Haliaeetus leucocephalus*) was officially de-listed on August 8, 2007, in the lower 48 states under the ESA per Federal Register Volume 72, No. 130, Monday, July 9, 2007/Rules and Regulations. Thus, the bald eagle is not evaluated further in this BA under the ESA. Bald eagles are still protected under the Migratory Bird Treaty Act (MBTA) (916 USC 703-711) and the Eagle Protection Act of 1940 (16 USC I.S.C 668a-668b).

The species considered in this document for Hinsdale County, Colorado include. Threatened (T), Endangered (E), Proposed Threatened (PT), or Proposed Endangered (PE) Species:

- Southwestern willow flycatcher (*Empidonax traillii extimus*) (E)
- Canada lynx (*Lynx canadensis*) (T)
- Uncompahgre Fritillary butterfly (*Boloria acrocnema*) (E)

Candidate Species, Sensitive Species, and Species of Concern (C):

- Western yellow-billed cuckoo (*Coccyzus americanus*) (C)

9.3.1 Critical Habitat

There are currently no critical habitats located within the proposed project area.

9.3.2 Consultation to Date

The consultation with the US Fish and Wildlife Service (USFWS) concluded that the proposed project area was located on the Rio Grande River and there are no threatened or endangered fish species in the Rio Grande River in Hinsdale County, Colorado. Consequently, no further discussion is required in this BA for these fish species (T. Ireland, personal communication, 2007). Consultation with the USFWS regarding a regulatory elevation limit for Southwestern willow flycatchers (*Empidonax traillii extimus*) revealed that an elevation limit does not currently exist; therefore, the Southwestern willow flycatcher is addressed in this BA. Consultation with the USFWS on the status of American peregrine falcons (*Falco peregrinus anatum*), which is in the ESA post de-listing monitoring period, revealed territory occupancy, nest success, and productivity are generally increasing. Furthermore, established regulatory buffer zones were discussed around known nest sites. The list of threatened, endangered, proposed, and candidate species was accessed from a list posted at the USFWS Mountain-Prairie Region 6 website prior to the August 8, 2007 site visit (USFWS 2007).

9.3.3 Current Management Direction

There is no current management direction for this project.

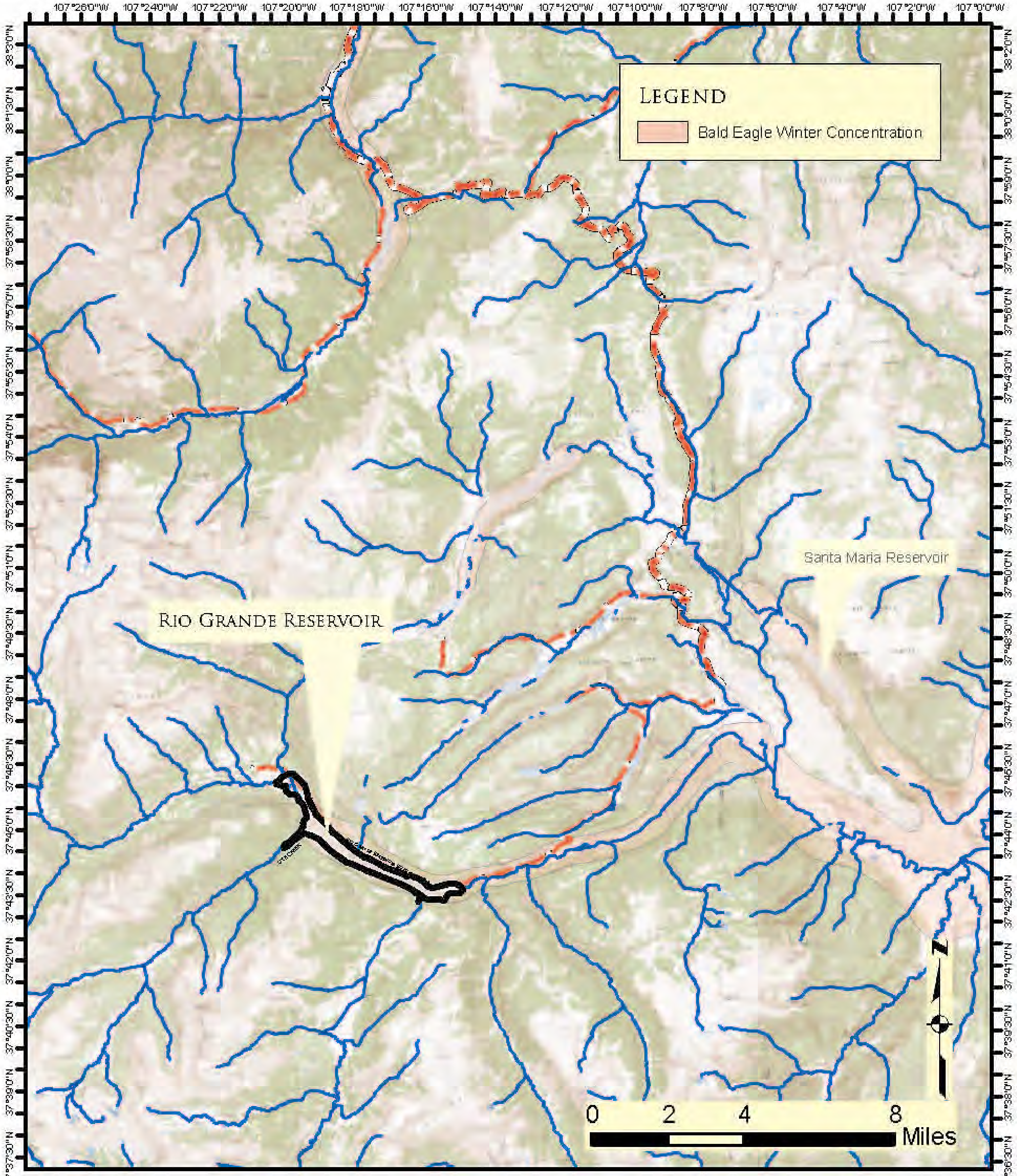
Migratory Bird Compliance

Executive Order 13186 addresses concerns over impacts to migratory birds and their habitats. The MBTA (916 USC 703-711) identifies numerous bird species in the southwestern US that are assigned a migratory status (most notably those included in the USFWS BCR 16 list). The intent is to minimize the "take" of migratory birds through consideration in land use decisions and in collaboration with the USFWS. The implications of this action have been assessed along with the site visit for evaluating potential impacts to protected species. Migratory birds common in the southwestern US are likely to be present in the project area.

Reasonable searches for the presence of migratory bird individuals with nesting potential have been instituted to prevent the inadvertent "take" of migratory birds. The proposed action will avoid the "take" of a listed migratory bird species that may nest in the proposed action area and any occupied nests, eggs, and/or fledglings thereof. The proposed Reservoir enlargement may impact several species of listed migratory birds passing through the area during project construction, but the effects are expected to be negligible.

Bald Eagle

Bald eagle winter range and winter concentration areas are located within the proposed project area (CNDIS 2007) (Figure 9-9). The nearest known bald eagle nesting site occurs at Santa Maria Reservoir, located approximately 11 miles northeast of the proposed project area. There is potential for bald eagles to pass through the area or utilize the trees for hunting perches. As a result, impacts to bald eagles would include avoiding the area during project construction, but the effects are expected to be negligible.



BIOLOGICAL ASSESSMENT	BALD EAGLE WINTER CONCENTRATION MAP	FIGURE 9-9	06/04/2008
SUGNET & MOORE ENVIRONMENTAL, INC.	RIO GRANDE RESERVOIR HINSDALE COUNTY, CO	*SOURCE: FINGER MESA AND WEEMINUCHE PASS COLORADO 7.5' USGS QUADRANGLES AND BLM BALD EAGLE DATA*	

American Peregrine Falcon

The Reservoir's riparian habitat and cliff bands above the Reservoir provide foraging and nesting for American peregrine falcons. American peregrine falcons may use the Reservoir for hunting amphibians and fish, the riparian areas for hunting waterfowl and shorebirds along the shoreline, and the surrounding forest provides a variety of trees that may be used for perches while hunting birds and small mammals (Wheeler 2003). The peregrine falcons mate for life, nest on cliffs and return to the same ledge or eyrie year after year (CDOW 2007). A documented American peregrine falcon eyrie is located directly north of the dam on a cliff band, approximately 0.25 miles. The eyrie has been occupied by a pair of falcons for the last three or four years (R. Ghormley, personal communication). The American peregrine falcon was de-listed from the ESA on August 25, 1999 (64 FR 46541 46558), but retains protection under the MBTA, and are in a post delisting monitoring period required under Section 4(g) of the ESA until 2015.

The USFWS has monitored the territory occupancy, nest success, and productivity of the American peregrine falcons in 2003 and 2006. The 2006 monitoring report is not complete at this time, but the 2003 monitoring report and 2006 data indicate a recovering population that is above the threshold that would trigger an "Agency Response" (Green et al 2006). Specifically, the population trends are not currently known in Hinsdale County, but populations in the Rocky Mountains/Great Plains, which includes Colorado regions, seem to be recovering.

Construction noise and activity during the nesting season may potentially disturb nesting and foraging American peregrine falcons. As a result, this species may avoid the area during construction or abandon the nesting site altogether. They may also lose potential foraging habitat from the proposed actions. The Colorado Division of Wildlife has recommended buffer zones and seasonal restrictions for the American peregrine falcon in Colorado, which are included in the next section.

Conservation/Minimization Measures

Prior to construction, installation of Best Management Practices (BMPs) should be implemented for erosion and sedimentation control at the Reservoir, streams, rivers, creeks, and associated channels and wetlands due to the proposed activities. Stormwater minimization measures such as the installation of straw wattles and silt fences should be employed pre and post construction.

Contractors should not conduct fueling or lubricating of construction equipment or other motor vehicles within 100 ft of the Reservoir, other open water sources, or other wetland areas. Major repairs to construction equipment should be performed offsite, where practicable.

Avoiding construction during the bald eagle winter roosting period from November 15 to March 15 would lessen the impacts to bald eagles. For a construction project planned during the bald eagle winter roosting period and within 0.25 miles of a riparian zone with a mature tree component, a pre-construction survey shall be initiated within 10 days prior to the start of construction to verify the presence or absence of bald eagle roosting activity. The surveys must be conducted by qualified biologist(s) according to protocol as set forth by the USFWS. Generally, the survey should be performed during dawn and dusk periods on two or more days immediately prior to the construction start date. The survey should be documented and results sent to the USFWS.

If one or no bald eagles are found to be roosting within 0.25 miles of the action area during the pre-construction survey, work may proceed with no time of day restrictions.

If two or more bald eagles are found to be roosting within 0.25 miles of the proposed construction site action area during the pre-construction survey, the operator will be restricted to working between 10:00AM and 2:00PM on a daily basis.

If bald eagles continue to occupy or enter the area within 0.25 miles of the construction site between the 10:00AM and 2:00PM time window, work will stop until the bald eagles leave the area. Under no circumstances shall bald eagles be harassed in order to disperse them from the area.

If a new bald eagle nest is established, no surface occupancy would be allowed (including human habitation, oil and gas wells, tanks, tracks, trails, etc.) beyond which historically occurred in the area within ½-mile of the nest site.

Avoiding construction within ½-mile of nest cliffs from March 15 to July 31 would lessen the impacts to nesting American peregrine falcons. Due to the birds moving nest sites along cliffs, it is appropriate to designate "nesting areas" that encompass the cliff system and place a ½-mile buffer around the cliff complex (Craig 2002). For a construction project planned during this season, surveys should be conducted prior to construction to determine the current status in the area, as disturbances that result in the abandonment of eggs or young can be construed as "take" under the MBTA.

9.3.4 Action Area

The action area consists of a 1/2-mile radius from the immediate project area. A survey of the action area was conducted for potential impacts to existing, potential, or suitable habitats from the proposed activities.

9.3.5 Species Accounts

Southwestern willow flycatcher (*Empidonax traillii extimus*) (E)

The southwestern willow flycatcher (SWWF) is a small bird, approximately 14 cm (5.75 in) in length, with a grayish-green back and wings, whitish throat, light grey-olive breast, and pale, yellowish body. The SWWF was listed as endangered in a 1995 final ruling by the USWFS. The breeding range includes southern California, Arizona, New Mexico, extreme southern portions of Nevada and Utah, southwest Colorado, and western Texas. SWWF typically arrive in May and depart in late August to early September (USFWS 2002).

The SWWF is a riparian obligate, neotropical migratory insectivore that breeds in summer along rivers, streams, and other wetlands where dense willow, cottonwood, salt cedar (*Tamarix* sp.), or other similarly structured riparian vegetation occurs (USFWS 2002). The SWWF is considered to be a partial cottonwood-willow obligate throughout southwestern riverine systems; however, individuals have also been observed in stands composed on willow only. Both even and uneven-aged sites are utilized by this subspecies for nesting habitat. Occupied habitat is generally associated with surface water and dominated by shrubs and trees 3 to 9 m (10 to 30 feet) tall that provide dense lower and mid-story vegetation, with small twigs and branches available for nesting material. Most SWWF nests are located in the fork of a shrub or tree branch from 1.2 m to 7.6 m (4 to 25 feet) above the ground (Unitt 1987, Tibbitts et al. 1994). Nesting habitat almost always contains or is adjacent to water or saturated soil (Muiznieks et al. 1994). Artificial water sources sustain 60 to 70 percent of the nesting habitat in the southwest including reservoir pools (D. Ahlers, personal communication).

There is no established elevation range of breeding for SWWF (T. Ireland, personal communication, 2007.) Recent discussions among involved parties in the Rio Grande basin suggest that the maximum elevation range may be 8500 feet or less. Minimum patch size dimensions that can support breeding SWWF have been determined by the USFWS. Willow patches measuring 9.1 m (30 feet) in width, 9.1 m (30 feet) in length, and 1.8 m (6 feet) in height are considered suitable habitat for the SWWF. However, linear patches wider than 4.5 m (15 feet) that cover at least 083.6 square meters (m^2) (900 sq ft) should also be considered potential SWWF habitat (T. Ireland, personal communication, 2000).

Canada lynx (*Lynx canadensis*) (T)

The lynx is a medium-sized cat, similar to the bobcat, but appears somewhat larger. It has longer hind legs and very large, well furred paws (USFWS 2003). It also has long tufts on the ears and a short, black-tipped tail. Adult males average 9.9 kilograms (kg) (22 lbs) in weight and 85.9 cm (33.5 in) in length with an average weight for females at 8.6 kg (19 lbs) and 81.2 cm (32 in) in length (USFWS 2004). The Canada lynx was listed by the USFWS as a federally threatened species in March of 2000 due to the inadequacy of existing regulatory mechanisms, specifically the lack of guidance to conserve lynx in National Forest and Bureau of Land Management Resource Plans (Ruediger 2000). The range of the Canada lynx in the contiguous United States includes the following states: Maine, New Hampshire, Vermont, New York, Michigan, Wisconsin, Minnesota, Washington, Oregon, Idaho, Montana, Wyoming, Utah, and Colorado (Ruediger 2000). Colorado is thought to be the southernmost range of the Canada lynx (Fitzgerald et al. 1994). In 1999, the Colorado Division of Wildlife (CDOW) began a lynx re-introduction program which entailed releasing lynx captured in Canada to the San Juan Mountains of Colorado (CDOW 2004).

Historically, lynx were relatively common in Colorado around 1900. Records indicate that they were found in the following counties: Conejos, Pitkin, Eagle, Lake, Clear Creek, Montezuma, Costilla, Summit, Larimer and possibly Park and Grand (ERO 2001).

Lynx habitat is generally described as climax boreal forest with a dense understory of thickets and windfalls (DeStefano 1987). In the Southern Rockies, primary lynx habitat is found in the subalpine and upper montane forests between 2,438 m and 3,657 m (8,000- 12,000 ft). Subalpine forest habitat is dominated by subalpine fir and Engelmann spruce while the upper montane forest supports lodgepole pine and aspen. Lower elevation montane forests of ponderosa pine, Douglas-fir, and riparian corridors provide connective habitat that may facilitate dispersal and movement between primary habitats provide additional foraging opportunities (Ruediger 2000).

Uncompahgre Fritillary butterfly (*Boloria acrocnema*) (E)

The Uncompahgre fritillary butterfly is in the Order Lepidoptera and Family Nymphalidae. It is small, with a 2-3 cm wingspan (1 in). Males have rusty brown wings crisscrossed with black bars; females' wings are somewhat lighter (Gall 1983). The species was listed as endangered on June 24, 1991 (56 FR 28712).

The butterfly has the smallest total range of any North American butterfly species. Its habitat is limited to two verified areas and possibly an additional two small colonies in the San Juan Mountains and southern Sawatch Range in Gunnison, Hinsdale, and Chaffee counties in southwestern Colorado (USFWS 1994). All known colonies are associated with patches of snow willow (*Salix nivalis*) above 3,810 m (12,500 feet). The species has been found only on northeast-facing slopes, which are the coolest and wettest microhabitat available in the San Juan Mountains (Scott 1982, Brussard and Britten 1989).

The butterfly was listed as endangered in 1991 due to the declines observed during the 1980's. The butterfly exhibits a two year life stage; the first year is spent in a larval stage and the second year as a reproductive adult. While there had been increased numbers in the even- and odd-year broods during the early 1990's, the status of the species is still difficult to determine because of gaps in survey information (USFWS 1994). Its sedentary nature, weak flying ability, and tendency to fly low to the ground make it easy to collect. Collection is considered the greatest human-caused threat to the species. Other actual or potential threats to the species include adverse climatic changes, small population size, and low genetic variability (USFWS 1994).

Western yellow-billed cuckoo (*Coccyzus americanus*) (C)

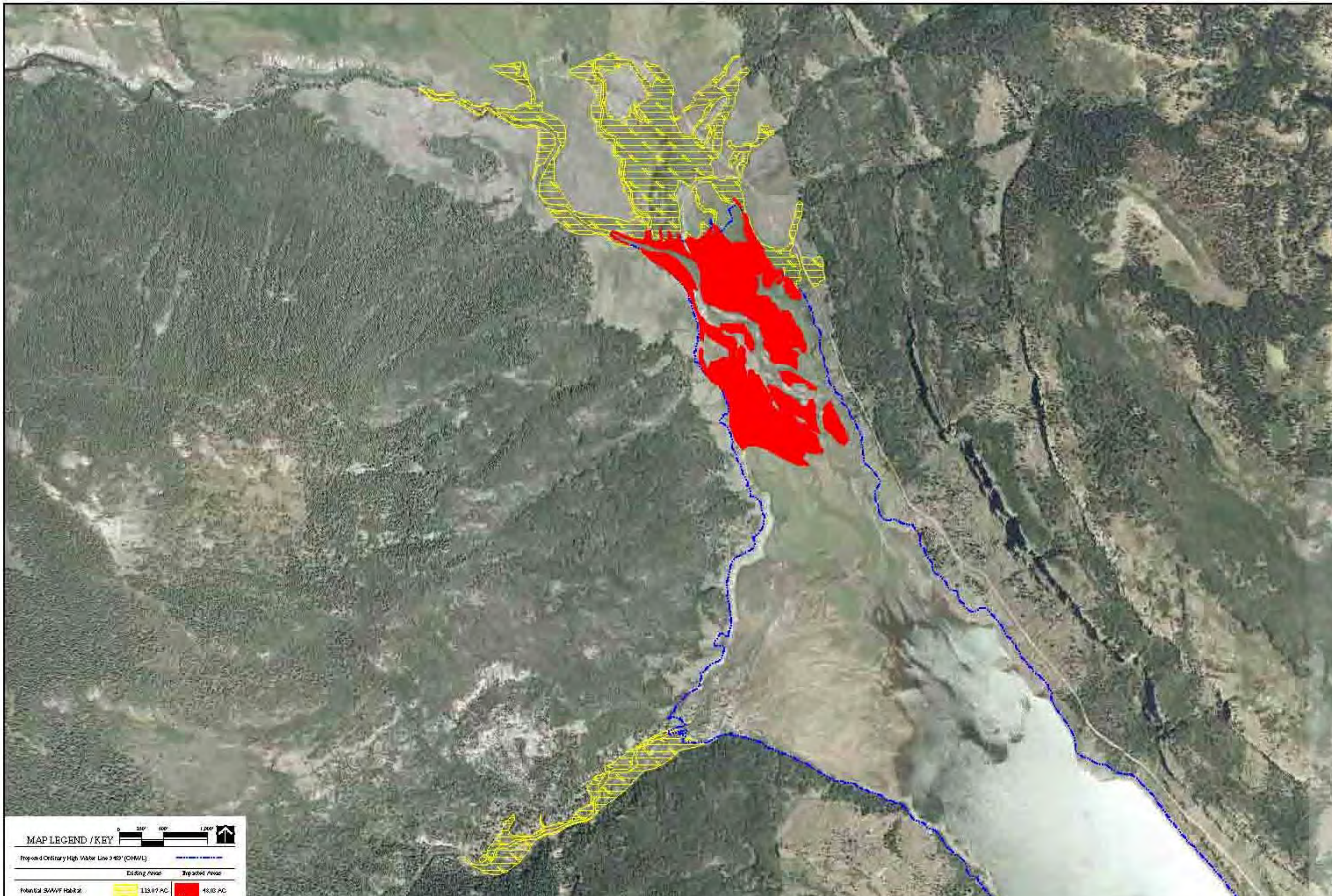
Historically, the western form of the yellow-billed cuckoo was a fairly common breeding species throughout the river bottoms of the western US and southern British Columbia (Gaines and Laymon 1984). Due to loss of riparian habitat, degradation, and fragmentation, the cuckoo has become an uncommon summer resident in scattered locations throughout its former range. The yellow-billed cuckoo winters in mature tropical forests, returning to the United States, northern Mexico and southern Canada for nesting (CBD 2000). In Colorado, yellow-billed cuckoos depend on old growth riparian woodlands with a dense understory (Kingery et al 1998). The yellow-billed cuckoos breed in low to mid-elevation (sea level -7,500 feet) and breeds in large blocks of riparian habitat with home ranges around 10 hectares (FR 66, 145). Nesting peaks around mid June through August. Insects are the most important food for cuckoos, and insecticide use in agriculture could be a contributing factor to the cuckoos decline.

Major threats to habitat loss for the yellow-billed cuckoo include reclamation through flood control and irrigation; habitat loss due to urbanization and agricultural activities, as well as continued invasion by exotic species such as Tamarisk (*Tamarix spp*.) and Russian olive (*Elaeagnus angustifolia*). Exposure to pesticides and other contaminants on wintering and breeding grounds, livestock grazing, and off road vehicle use within riparian habitats, also contribute to the species decline (Gains and Laymon 1984).

9.3.6 Status of the Species in the Action Area

Southwestern willow flycatcher (*Empidonax traillii extimus*) (E)

There is no suitable SWWF habitat at the dam area where construction activities would occur; however, suitable habitat exists on the west end of the Reservoir that may be impacted if the storage capacity of the Reservoir is increased. The west end of the Reservoir where Ute Creek and Rio Grande River inlet is located offers a substantial SWWF habitat mosaic of approximately 119 acres Based on a projected increase of the Ordinary High-Water Line (OHWL), as many as 48 acres of potential SWWF habitat may be inundated by the proposed project action (Figure 9-10). The USFS is conducting a survey of SWWF habitat in a potential habitat area of higher quality and elevation than the Reservoir site. If the SWWF is not found in this survey, the US Fish and Wildlife Department could conclude that there would be no impacts to SWWF habitat caused by this project. This would be consistent with other discussions in the Rio Grande basin that suggest that the maximum elevation may be 8500' or less.



POTENTIAL SOUTHWESTERN WILLOW FLYCATCHER HABITAT

BIOLOGICAL ASSESSMENT

RIO GRANDE RESERVOIR

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

SUGNET & MOORE ENVIRONMENTAL, INC

Figure 9-10

Generally, SWWF key into vertical stratification of riparian vegetation, but they have been known to utilize stands composed of willows alone. The dense willow habitat averages approximately 12 ft in height and occurs near open water and saturated soils. Therefore, potential SWWF habitat exists within the project area based on the habitat characteristics to support nesting SWWF. Furthermore, reservoir pools account for much of the breeding locations in the southwest and SWWF have been known to breed along the Rio Grande River in the San Luis Valley, (Valley floor elevation approximately 7,500 feet). As a result, impacts to these willow communities may disturb or interrupt nesting activities of SWWF in the area. SWWF surveys have been conducted upstream for the project area along the Rio Grande at Bruster Park Meadows by the US Forest Service (USFS). This area has been surveyed the past 2 years and has resulted in negative detections (R. Ghormley, 2007 personal communication) of SWWF.

Canada lynx (*Lynx canadensis*) (T)

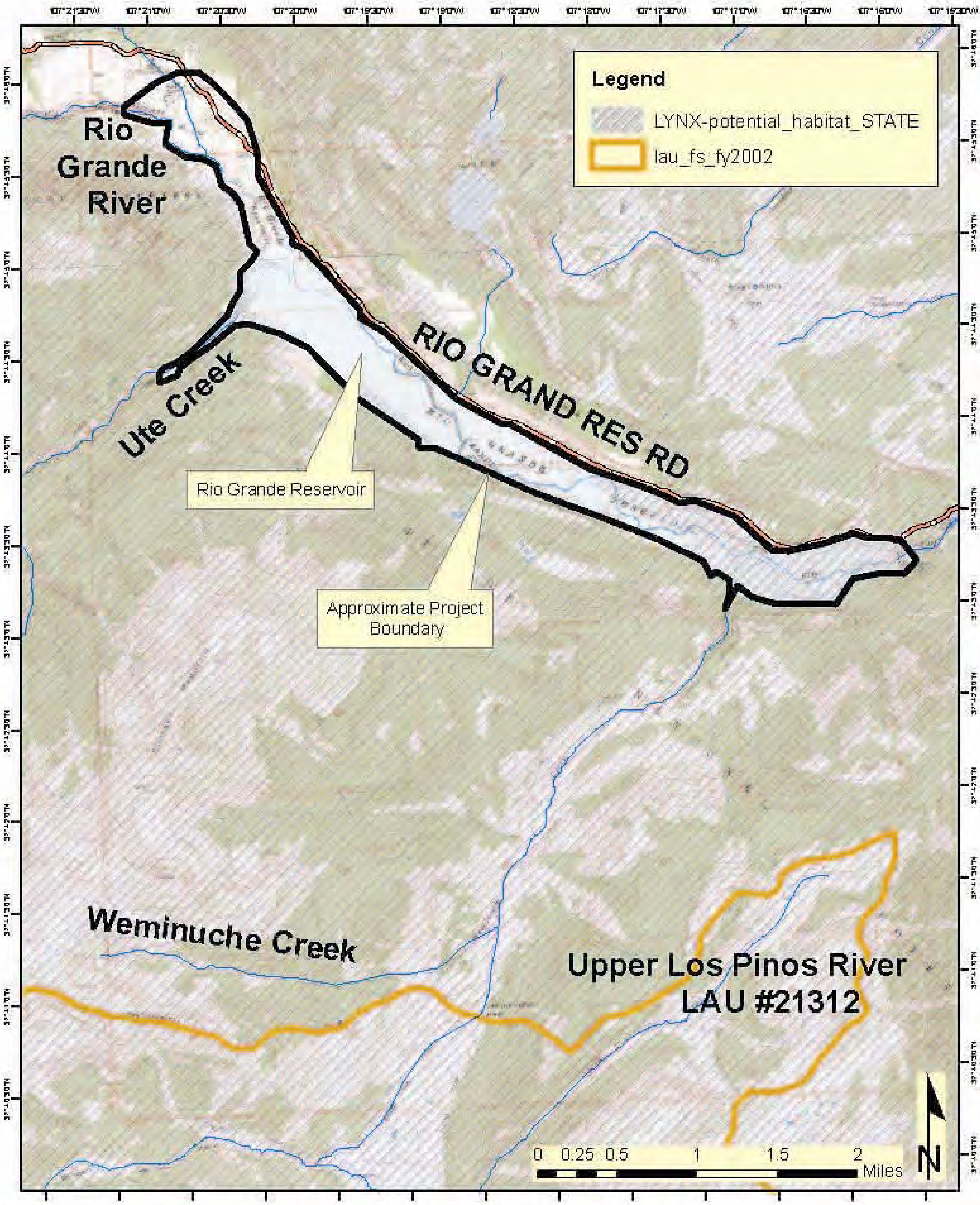
The area surrounding the Reservoir is mapped by the USFS as potential lynx habitat (USFS 2002) (Figure 9-11). The potential habitat includes any forested area surrounding the Reservoir. The nearest lynx analysis unit (LAU) is the Upper Los Piños River #21312, located approximately 1.6 miles south of the southern end of the Reservoir. The potential for lynx to be in the action area is extremely high because the Reservoir area meets several criteria for suitable lynx habitat. The forest type and elevations are correct for supporting lynx populations and are likely used as connective corridors.

The habitat quality and area would not be significantly altered based on a 10 ft water level increase. A concern would be an increase in construction traffic along Rio Grande Reservoir Road to the dam project area. Large trucks delivering materials and vehicles and transporting personnel would increase and may cause an increase in lynx mortalities. Construction at the dam would not impact additional habitat that has not already been disturbed by the existing dam.

Ute Creek and Rio Grande River may be a natural migration corridor through the rugged terrain of the surrounding area and the lynx may utilize the willow cover at the west end of the Reservoir to cross the valley in relative seclusion. However, lynx may already avoid the dam area of the Reservoir due to the disturbed open ground, a nearby residence, hikers or fisherman, and the dam maintenance and management operations that include regular human activity.

Uncompahgre Fritillary butterfly (*Boloria acrocnema*) (E)

There is no suitable habitat in or near the proposed project area. The butterfly exists at or above 12,500 feet in elevation, which is located well above the proposed project area elevation. This species is found with snow willows, which were not found during the site assessment.



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POTENTIAL CANADA LYNX HABITAT MAP

BIOLOGICAL ASSESSMENT
RIO GRANDE RESERVOIR
HINSDALE COUNTY, CO

FIGURE 9-11

Source: Finger Mesa and Weeminuche Pass Colorado 7.5' USGS Quadrangles and USFS Lynx Habitat Data 2002

Western yellow-billed cuckoo (Coccyzus americanus) (C)

There is no suitable habitat in or near the proposed project area due to a lack of dense understory and old growth riparian woodlands. Western yellow-billed cuckoos require large patches of mature riparian forests with a dense understory. The proposed site contains primarily a monoculture of willow species and offers no cottonwood (*Populus* sp.) forest. It is unlikely that yellow-billed cuckoos would utilize the area for nesting, foraging, or migrating. As a result, construction activities and an increase in Reservoir levels are not expected to disturb yellow-billed cuckoos. No surveys are known to have been conducted in or adjacent to the project area.

9.3.7 Effects

Southwestern willow flycatcher (*Empidonax traillii extimus*) (E)

The USFS is conducting a survey of SWWF habitat in a potential habitat area of higher quality and elevation than the Reservoir site. If the SWWF is not found in this survey, the US Fish and Wildlife Service could conclude that there would be no impacts to SWWF habitat caused by this project. The following effects are based on the assumption that the SWWF has been determined to have habitat above 9,400 feet elevation, while recent discussions in the Rio Grande basin suggest the maximum elevation may be 8,500 feet. The USFWS would ultimately be the authority for making such a determination.

SWWF may be disturbed by construction activities at the dam during migration up the Rio Grande River valley in search of suitable habitat. The effects are expected to be negligible as no suitable habitat exists at the dam, and therefore would not offer stop over habitat for migrating SWWF. SWWF would likely pass quickly through this area. However, suitable nesting habitat is located in the proposed project area, located west of the dam, and may be affected by an increase in Reservoir levels.

The loss of breeding habitat located along the west end of the Reservoir may have far greater impacts on SWWF than project construction noise. Changes in operational management and an overall increase of water levels in the Reservoir may lead to prolonged inundation of willow habitat, which may result in willow die-off. Based on the potential high water mark of the proposed enlarged Reservoir, theoretical impacts to existing willow habitat may be as high as 48 acres. If a SWWF population utilizes the suitable habitat area, then the local population may experience a decrease in fecundity and survival due to impacts associated with the proposed Reservoir expansion. However, frequent and short intervals of inundation may not have a substantial impact on the willow habitat and may, in fact, provide better SWWF habitat. Furthermore, as lower portions of the willow habitat are flooded out, an equivalent area of transitional upland meadow area may naturally succeed, or be converted into a willow dominated wetland due to an increase in the local water table. This impact may largely offset the potential loss of willow habitat due to increased inundation downstream. The lag-time associated with this willow succession may be decreased by planting willow stakes in the transitional meadows.

The extent of impacts to SWWF habitat is dependent on many variables, but is largely based on reservoir management practices after the proposed project is completed. Therefore, the 48 acres of impacts to SWWF habitat is based solely on the proposed OHWL if the Reservoir was filled to capacity at all times. It is unknown at this time what the actual impacts would be and it is possible that the changes in Reservoir management may result in an increase of willow habitat.

Canada lynx (*Lynx canadensis*) (T)

There is potential suitable habitat in the surrounding area in the Rio Grande National Forest. Canada lynx may use the project area around the Reservoir, but it appears that they avoid the dam area. As a result, construction noise may potentially disturb Canada lynx near the dam, but the effects are expected to be negligible as suitable habitat does not exist at the dam. The loss of habitat associated with an increase in Reservoir levels would have a negligible effect on the lynx as the impacts to suitable habitat are expected to be minimal. The majority of the water level increase would be a vertical increase up the steep sides of the Reservoir. However, impacts to the riparian vegetation on the west end of the Reservoir may affect winter foraging potential or potential as a connective corridor; however, this impact is expected to be negligible. The primary threat to the lynx associated with the Reservoir expansion is an increase in construction traffic. Construction vehicles carrying materials and personnel to and from the project area may increase the potential of lynx-vehicle collisions, thus increasing lynx mortality.

Uncompahgre Fritillary butterfly (*Boloria acrocnema*) (E)

There is no suitable habitat in or near the proposed project area.

Western yellow-billed cuckoo (*Coccyzus americanus*) (C)

There is no suitable nesting habitat in or near the proposed project area.

9.3.8 Cumulative Effects (State and Private Actions)

Southwestern willow flycatcher (*Empidonax traillii extimus*) (E)

Cumulative impacts for SWWF associated with the project may include a possible overall loss of breeding habitat or habitat fragmentation throughout its range. This may affect the fecundity rates of SWWF and lead to further population decline of the species. Results of a USFS survey may show that there is no SWWF habitat in the project area. However, the survey was not completed at the time of this report. Other ongoing studies may show that the maximum elevation is 8500'.

Canada lynx (*Lynx canadensis*) (T)

Cumulative effects for the lynx may include a population decrease due to vehicle mortality. Recreational activities may increase in the area including enhanced fishing opportunities with the expansion of the Reservoir. An increase in forest and Reservoir use may increase the overall disturbance of the surrounding area, which may result in an increase in vehicle mortality, dispersion/displacement of lynx, and poaching.

Uncompahgre Fritillary butterfly (*Boloria acrocnema*) (E)

No cumulative impacts are expected to occur to the Uncompahgre fritillary butterfly.

Western yellow-billed cuckoo (*Coccyzus americanus*) (C)

No cumulative impacts are expected to occur to the western yellow-billed cuckoo.

9.3.9 Conclusion and Determination

SME has determined that the proposed project will have a "**no effect**" on the following species:

- Western yellow-billed cuckoo
- Uncompahgre fritillary butterfly

The "no effect" determination for the species mentioned above is due to a lack of suitable habitat in or near the proposed project area. Overall, the effects of the proposed activities are expected to be negligible on these species.

SME has determined that the propose project will have a "**may affect, not likely to adversely affect**" on the following species:

- Canada lynx

The "may affect, not likely to adversely affect" determination resulted from limited amount of habitat impacts for this species, but a potential increase in vehicle mortality due to an increase of construction traffic to and from the site.

SME has determined that the propose project will have a "**may affect, likely to adversely affect**" on the following species:

- Southwestern willow flycatcher

The "may affect, likely to adversely affect" determination resulted from the potential loss of nesting habitat at the west end of the Reservoir. Significant habitat is approximately 48 acres and may be impacted due to an increase in Reservoir capacity. However, habitat impacts may be offset by fluctuations in reservoir water levels which may result in establishment of willows in other locations not currently dominated by willows. Results of the USFS survey of the SWWF will help determine the presence/absence and extent of use by SWWF within the project area. Results of this survey should be taken into account prior to commencing reservoir enlargement construction activities.

9.4 Cultural Resources Survey

The cultural resources survey for enlargement of Rio Grande Reservoir (LPAC, 2008) was conducted by personnel of La Plata Archaeological Consultants between October 25 and November 10, 2007. The field work was conducted by Steven Fuller. Conclusions of that report are presented in this section.

The cultural resources survey was required by the Rio Grande National Forest in response to a possible proposal by the San Luis Valley Irrigation District to raise the level of Rio Grande Reservoir by 10 ft. The area of potential effect (APE) is the area to be newly flooded by the enlargement (53.3 acres) plus an additional 6 acres (approximately) around the dam site, totaling approximately 59.3 acres. The survey was conducted as required by various legislation, including Section 106 of the National Historic Preservation Act. Based on extreme topography around much of the Reservoir, open slopes over 40 percent and heavily timbered, north-facing slopes over 30 percent were not surveyed (as approved by former Rio Grande Forest Archaeologist, Vincent Spero). New survey was conducted on the remainder of the APE and is estimated to cover 39 acres, including 35 acres on the Rio Grande National Forest and 4 acres on privately owned land.

During the survey of the Reservoir enlargement, two historic archaeological sites were encountered and recorded. The two archaeological sites include a segment of the newly defined Stony Pass Route (5HN1127.1) and an historic artifact scatter/camp (5HN1126). The Stony Pass Route, a transportation corridor up the Rio Grande and across Stony Pass into the Silverton area, though only evaluated in a short segment within this project area, is recommended to be eligible for nomination to the National Register under Criterion "a." However, the portion of the route within this APE (5HN1127.1) is recommended as being *non-supporting* of this overall eligibility. Site 5HN1126, an early 20th Century artifact scatter associated with an outdoor hearth, is recommended as being ineligible for National Register nomination. No further protection is recommended for either site should this reservoir enlargement project be approved.

Section 10
Legal Issues

During Phase 2, the District continued to evaluate the legal issues identified in Section 8 of the Phase 1 Report. Each of those issues is discussed below as they relate both to rehabilitation and enlargement or a rehabilitation only of the Reservoir. During the course of the Phase 2 study, the District's Board of Directors decided to pursue the rehabilitation only project. Therefore, it will not be necessary for the District to address several of the legal issues identified below. However, providing storage space from a rehabilitated Reservoir for multi-use purposes raises other legal issues that the District may be required to address. Those issues are discussed in more detail below.

10.1 National Environmental Policy Act (NEPA), 42 U.S.C. §§ 4321 et seq. Environmental Review

An enlargement of the dam would create an additional 11,000 acre-feet of storage space. While the dam itself is located on lands owned by the District, an enlargement would affect Forest Service lands not previously affected by operation of the Reservoir. When full, the additional water stored in the Reservoir would inundate Forest Service lands located around the Reservoir above its current high water mark. The majority of the Forest Service lands that would be inundated are located at the far western end of the Reservoir. Also, an enlargement would require the extension of the downstream toe of the dam, which may encumber Forest Service land not included in the District's patent. The inundation of new Forest Service lands and the enlargement of the dam toe would require a review of the environmental impacts discussed in Section 9 of this report. Those impacts likely would be significant resulting in a major federal action that would require preparation of an Environmental Impact Statement under NEPA. We believe the Forest Service would be the lead agency in any NEPA review process.

The District's decision to pursue only a rehabilitation of the dam, outlet works, and spillway should not require NEPA review. As noted above, the land beneath the dam, as well as the areas immediately upstream, to the north and south, and downstream along the River approximately one-quarter mile were conveyed to the District under Patent No. 1009165, Pueblo 050622, on November 8, 1927. A copy of the Patent and Official Plat of the Survey are included in Appendix H. The construction required for the rehabilitation of the dam will occur on the District's land, although there may be the need to move some equipment up the River-bed from the Thirty Mile Campground to the downstream face of the dam. That equipment may need to remain in the River-bed at the base of the dam for some period of time. The impacts would be temporary and not significant. An environmental review by the Forest Service may be required but would result, we believe, in a Finding of No Significant Impact (FONSI).

During the final design phase, the location of the new outlet tunnel will be determined more precisely. The downstream end of that tunnel may encroach slightly on Forest Service land. If so, an environmental review under NEPA will be required to determine whether the impact is or is not significant and the need for an environmental assessment or environmental impact statement.

Finally, while numerous funding sources have been researched during this phase of the study, there has not been any final determination of how rehabilitation will be funded. If federal funds are requested and authorized, a review of the environmental impacts will likely be required under NEPA.

10.2 Clean Water Act Section 404 Permitting

As discussed above, an enlargement of the dam will result in the inundation of new lands primarily at the far western end of the Reservoir. As discussed in Section 9, the Wetlands Delineation undertaken during this phase of the study identified 24.87 acres of wetlands, Jurisdictional Waters of the U.S., which may be impacted by an enlargement of the Reservoir. That impact will have to be mitigated. The range of mitigation requirements is discussed in detail in Section 9.2.

The rehabilitation only option, with the improvement of the outlet works and spillway, will not require a Section 404 permit. There will not be any inundation of new lands and no loss of wetlands. The rehabilitation only will not involve modifications that change "the character, scope, or size of the original design fill" which would be subject to regulation under Section 404. Maintenance and repair work previously undertaken on the outlet works and spillway was determined to be "maintenance, including emergency reconstruction of recently damaged parts, of currently serviceable structures such as dams . . .," 33 C.F.R. § 323.4(a)(2), which is not subject to regulation under Section 404, and falls within Nationwide Permit No. 2, for maintenance activities related to the "repair, rehabilitation, or replacement of any previously authorized, currently serviceable, structure or fill . . .."

As design plans are finalized the need for construction equipment on the downstream side of the dam will be determined. The most practical access for that equipment may be up the stream channel from the Thirty Mile Campground approximately one-quarter mile below the dam face. It will be determined at that time whether accessing and utilizing the stream channel requires a permit from the Corps of Engineers.

10.3 The Reservoir's 1891 Act Right of Way

As discussed above, the District received a patent for 146.81 acres of land beneath and surrounding the dam. The remainder of the lands inundated by the existing Reservoir are held by the District pursuant to a right-of-way granted under the Act of March 3, 1891, 43 U.S.C. §§ 946-949, which provided in part:

> The right of way through the public lands and reservations of the United States is hereby granted to any canal ditch company, irrigation or drainage district formed for the purpose of irrigation or drainage, and duly organized under the laws of any State or Territory, . . . to the extent of the ground occupied by the water of any reservoir and of any canals or laterals, and fifty feet on each side of the marginal limits thereof,

The 1891 Act was amended in 1898 to include other uses of water in the right of way grant:

> Rights of way for ditches, canals, or reservoir heretofore or hereafter approved under the provisions of sections 946-949 of this title may be used for purposes of a public nature; and said rights of way may be used for purposes of water transportation, for domestic purposes, for the development of power, as subsidiary to the main purpose of irrigation or drainage.[1]

43 U.S.C. § 951.

An enlargement of the Reservoir would inundate new Forest Service lands above the current high-water mark and the far western end of the Reservoir. Those areas are not included within the Reservoir's existing right-of-way. Therefore, an enlargement of the Reservoir and the inundation of new Forest Service land would require the District to apply with the Forest Service for a Special Use Permit for the enlarged portion of the Reservoir. See 43 U.S.C. § 1761(a)(1); § 1770. The rehabilitation only option will not result in new lands being inundated or the use of additional Forest Service lands for a dam enlargement. Therefore, the District will not be required to obtain any additional right-of-way or special use permit from the Forest Service if it proceeds with the rehabilitation only option.

Consistent with the terms of the 1891 Act, Rio Grande Reservoir was originally constructed to store water for irrigation. In recent years, small amounts of water have been stored for other public purposes. An enlarged or rehabilitated only reservoir will store some additional water for other public purposes. The use of the Reservoir to store water for these purposes is included within the 1891 Act right-of-way as amended in 1898. The Reservoir's primary purpose remains and will remain irrigation with some subsidiary use of purposes directly related to irrigation and other public purposes.

As discussed throughout this Report, a rehabilitated Reservoir will meet multi-use purposes and the District will provide existing storage space for use by others

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[1] [1] The 1891 Right-of-Way Act as amended in 1898 was repealed in the 1976 Federal Land Policy Management Act (FLPMA), 43 U.S.C. § 1701 *et seq.*, for the purposes of granting new rights-of way, 43 U.S.C. § 1701 note. However, all rights vested under prior rights-of-way acts remain in effect, 43 U.S.C. § 1769(a).

including: (1) the Division of Water Resources for the storage of water for delivery under the Rio Grande Compact; (2) the Division of Wildlife for the storage of transmountain water for irrigation, fish and wildlife uses throughout the Basin; (3) the San Luis Valley Water Conservancy District for the augmentation of domestic and commercial development in the Basin; (4) the operation of direct flow storage for later delivery for irrigation; (5) possible use by the Sub-District No. 1 to augment agricultural depletions from the operation of wells in the Closed Basin; and (6) other small domestic water users. Each of these uses is or will be approved in accordance with State law.

The most controversial issue surrounding the use of an 1891 Act right-of-way is the status of that right-of-way if it is no longer used for the primary purpose of irrigation. However, the majority of the storage space and water stored in the Reservoir will remain for the use by the District's landowners for irrigation. Moreover, the storage of Compact water assures that Colorado receives and can utilize its full entitlement under the Compact thereby assuring additional water for irrigation. And the storage of water to augment well depletions in Sub-District No. 1 is directly related to irrigation. Water stored for "purposes of a public nature," see 43 U.S.C. § 951, include the Division of Wildlife's transmountain water and its use for fish, wildlife, and riparian habitat, including irrigation, throughout the San Luis Valley, and the Conservancy District's use of stored transmountain water to augment domestic and related commercial uses. It would also include the re-regulation of deliveries from the Reservoir to further support the River habitat and fishery.

10.4 Minimum Stream Flows

10.4.1 Federal Reserved Water Rights Decree for Instream Flows in the National Forest

The Forest Service, Division 3 Water Users, and the State of Colorado reached a settlement of the Forest Service's reserved water rights claims for the Rio Grande National Forest. The Decree incorporating that settlement was issued on March 30, 2000, by the District Court for Water Division No. 3 (the "Decree"). The Decree specifically addressed Rio Grande Reservoir at pages 88-90 and establishes the parameters under which the Reservoir can store and operate without impact to the Forest Service's instream flow water rights.

First, the exercise of the District's water storage rights are senior to and cannot legally be curtailed by the instream flow water rights.

Second, the following practices can continue without regard to their impact on the instream flow:

(a) direct flow storage under the decrees in Case Nos. W-3979 (Rio Grande Canal), W-3980 (Irrigation District), and 95CW18 (Empire Canal);

(b) exchanges into and between Rio Grande, Santa Maria, and Continental Reservoirs decreed in Case No. 90CW42 (Reservoir Owner Exchange), 90CW45 (Closed Basin Water Exchange), and 97CW10 (Fun Valley Exchange);

(c) storage of compact water;

(d) the Reservoir may store up to 51,113 acre-feet each year without regard to carry-over storage from a previous year. This includes water stored under the decrees and practices listed in a-c above; and,

(e) future direct flow storage as long as:

    (1) annual storage is no more than 51, 113 acre-feet, not including any carry-over water;

    (2) the flow at Del Norte remains greater than 2,150 cfs or more;

    (3) direct flow storage can occur at rates greater than 1,972 cfs only so long as 225 cfs remains in the Rio Grande at the Thirty Mile Gage; and,

    (4) existing water rights changed to direct flow storage are not subject to the limitations in paragraph 20 of the Decree, so long as conditions 1-3 are met.

Third, significantly the final Decree omitted language included in earlier drafts regarding leakage from the Reservoir. Those early drafts "recognized" that leakage through the Reservoir's gates created "favorable conditions of flow" downstream. That language was removed from the final version of the Decree. This assures that the District can rehabilitate the outlet works and, to the extent feasible, reduce any seepage from the Reservoir regardless of its impacts on flows.

Finally, the District will store transmountain water in a rehabilitated Reservoir for the San Luis Valley Water Conservancy District and the Colorado Division of Wildlife. Paragraph 26 of the Decree provides that the United States has no interest in that non-native water:

> The United States does not claim and is not entitled to call for or require any water from any reservoir, or any transmountain, imported, foreign, or nontributary water source in Colorado Water Division No. 3 to be used to quantify or satisfy instream flow for National Forest purposes.

This language excludes transmountain water stored in the Reservoir from any claim or call by the United States for its instream flow, or a claim that it counts against the Reservoir's annual 51,113 acre-foot storage limitation.

An enlargement including rehabilitation, or just a rehabilitation of the Reservoir's outlet works and spillway can be accomplished within the terms of the Decree. The

District's analysis indicates that, except in the very highest flow years (when the Forest Service's flow requirements would be exceeded) there is no unappropriated native water available for storage in the Reservoir. It is, therefore, unlikely that the District will store more than 51,113 acre-feet during a water year even in an enlarged Reservoir. The additional 11,000 acre-feet of storage space in an enlarged reservoir or the space provided by the District to other uses in a rehabilitated only reservoir will be available for the storage and re-regulation of flows through compact storage, direct flow storage, and exchange. It will also be utilized to provide the Colorado Division of Wildlife with a fish and recreation pool filled with transmountain water, and to provide the San Luis Valley Water Conservancy District with space to store transmountain water which will be released to the Rio Grande when needed to replace out-of-priority depletions caused by domestic and related commercial uses.

10.4.1.1 Compact Storage

The Decree provides that Reservoir operations consistent with the "Compact Storage Agreement" have no material adverse impact on the reserved instream flow water rights for the National Forest. There are two agreements, both dated February 3, 1987, relating to the storage of Compact Water. The first is an "Operating Agreement" between the San Luis Valley Irrigation District and the State Engineer. The second is an "Agreement" between the Rio Grande Water User Association, the Santa Maria Reservoir Company, and the San Luis Valley Irrigation District, which was approved by the State Engineer. Generally, the two Agreements allow the State Engineer to store water in Rio Grande, Santa Maria, and Continental Reservoirs that would otherwise be delivered during the irrigation season to the State-line to fulfill Colorado's water delivery obligations under the Rio Grande Compact. There is no limitation on the timing or amount of Compact Water the State Engineer can store. If the State Engineer determines that the stored water is needed to meet obligations under the Compact, he decides when and at what flow the water will be delivered from storage to the State line. If the State Engineer does not call for the Compact Water in the year in which was stored, it is divided, one-half to the Reservoir Owners (which is then divided one-half to the San Luis Valley Irrigation District and one-half to the Santa Maria Reservoir Company), and one-half to the direct flow irrigation water rights on the Rio Grande. The Water Users can then call for their share of the unused Compact Water during the following irrigation season in three separate releases:

1. When the time the River reaches its annual peak, to benefit junior direct flow water rights;

2. When the time the River is at mid-stage in the declining hydrograph, to benefit middle-ranking direct flow diverters; and,

3. When the time the River is at a low flow stage on the declining hydrograph, to benefit senior direct flow rights.

Any Compact Water available to the direct flow rights that is not released during the irrigation season following its storage passes to the reservoir owners.

As part of the Reservoir rehabilitation, the allocation and timing of deliveries of stored Compact Water will be revised, subject to the agreement of the Water Users, Reservoir Owners, and State Engineer. A draft agreement between the State Engineer, included in Section 11, provides for the re-regulation of deliveries of stored Compact Water. While the State Engineer maintains the right to deliver water when he or she determines it to be in the State's best interest, the State Engineer will use his or her best efforts to make those deliveries when they will better meet the River's riparian and fish flow needs—late in summer and during the winter when flows are low. Additionally, stored Compact Water that is not needed for compact purposes during the year in which it is stored will remain available to the State Engineer for Compact deliveries in subsequent years rather than being distributed to the Reservoir owners and Water Users for use during the irrigation season. The draft agreement anticipates that the Division Engineer will use his or her best efforts to deliver that water to the State-line when it better meets fish and riparian needs—perhaps making early deliveries prior to the beginning of the irrigation season. As can be demonstrated with the water allocation model prepared as part of the Phase II Study (see Section 8), the re-regulation of stored Compact Water and, possibly other transmountain water stored by the Division of Wildlife and the Conservancy District, can be timed to better coincide with low-flows during late and non-irrigation season periods thereby better increasing the instream flows during those times when most needed to meet the needs in the Rio Grande National Forest. This would be consistent with the purposes of the Decree and may, in fact, enhance the Forest Service's instream flows through the Forest during historically low flow periods.

10.4.1.2 Direct Flow Storage

Direct flow storage only occurs under specific flow parameters set forth in the direct flow decrees identified above. Any new direct flow storage is subject to the Decree's limitations summarized in sub-paragraph (e) above. As the Decree recognizes, the effect of direct flow storage "dampens or redistributes peak flows, but typically extend, the duration of seasonal high flows by reservoir releases." Generally direct flow water is stored at times of high flow and then released from the Reservoir for downstream delivery after the peak flow, thereby adding to the flow on the falling limb of the hydrograph. Neither enlargement nor rehabilitation of the Reservoir will affect the operation of direct flow storage as contemplated in the Decree.

10.4.2 Inundation of CWCB Instream Flow Reaches

The Colorado Water Conservation Board holds instream flow water rights on Ute Creek and Weminuche Creek, both of which discharge into the Reservoir. Those rights extend upstream from the Creeks' confluence with the high water mark of the Reservoir. An enlargement will raise the high water level and, when the Reservoir is full, temporarily inundate a small portion of the lowest reach of the two Creeks.

The instream flow for Ute Creek was decreed in Case No. 84CW167 with a priority date of August 16, 1982. Between May 1st and September 30th the rate of flow is 25 cfs. Between October 1st and April 30th, the rate of flow is 12 cfs.

The instream flow for Weminuche Creek was decreed in Case No. 84CW168 with a priority date of August 16, 1982. Between May 1st and September 30th the rate of flow is 4.0 cfs. Between October 1st and April 30th, the rate of flow is ______.

The rules governing the CWCB's instream flow program require the staff to evaluate how an inundation will impact the existing instream flow right. The District may seek permission to inundate these small sections of stream pursuant to Rules 7c – 7m of the Rules Concerning Colorado Instream Flow and Natural Lake Level Program ("ISF Rules"). In evaluating such a request, the staff must consider whether "the proposed inundation interferes with an ISF right." (See ISF Rule 7f). An inundation of a tributary stream caused by the enlargement and raising the level of an existing reservoir does not appear to fit perfectly with the evaluation required in ISF Rule 7, Inundation of ISF Rights. However, the proposal to raise the dam 10 feet may fall within the terms of Rule 7a, which provides staff with the discretion not to file Statements of Opposition to "small inundations," including those that result from dam heights 10 feet or less. While the 10-foot raise of an existing dam that is not on the stream subject to the ISF does not fit precisely within the Rule, it may provide staff guidance in evaluating a request from the District.

The rehabilitation only option, which the District has decided to pursue, will not raise the water level of the Reservoir and will not result in the inundation of any instream flow reaches.

10.5 Federal Energy Regulatory Commission

During this study phase, the District analyzed the potential for hydro-power development through the rehabilitated outlet works. If the District were to proceed with hydro-power development, it would be required to obtain a license from the Federal Energy Regulatory Commission (FERC). If the decision was made to develop hydro-power from a rehabilitated reservoir, the Study's conclusions indicate (see Sections 8.6 and 12) that the District may be able to obtain an exemption from licensing for small hydroelectric projects of 5 megawatts or less. See 18 CFR 4.31(c)(2). Such an exemption is not subject to the comprehensive development standard of the Federal Power Act (FPA), including but not limited to section 10(a); the mandatory conditions under the FPA sections 4(e) and 18; the eminent domain authority under the FPA section 21. See 16 U.S.C. §§ 823A; 2705; 2708. See also FERC Handbook at Section 6.0 "Exemptions for Licensing."

10.6 Transferring Storage Capacity in the Reservoir to Other Water Users

The draft storage agreements provide the various parties with two types of storage—non-spillable storage, which remains in storage if the Reservoir fills and spills, and spillable storage, which is spilled before the District's water is spilled. While the amount of storage allocated has not been finally agreed upon, the Division of Water Resources, Division of Wildlife, and San Luis Valley Water Conservancy District have all indicated a need for some non-spillable storage and some spillable storage. The term of the storage agreements also has not been finally agreed to and remains subject to negotiation, with the possibility of long-term leases (30–99 years), or permanent storage.

Spillable storage does not implicate the sale or transfer of District assets. If the Reservoir fills, spillable water is released from the Reservoir to make space for water stored by the District. In this case, there is no transfer of District assets or property. It is simply an allocation of storage space if and when it is available.

The Irrigation District Law of 1905, under which the District was organized, does not prohibit the lease or sale of District assets such as non-spillable storage space. The Board of Directors is authorized to lease District water rights, see C.R.S. § 37-41-113 (7), and there is no prohibition on its authority to lease or sell other District assets. Under the 1905 Act, therefore, the Board can approve a long-term lease of non-spillable storage space. However, under the Irrigation Districts of 1905 and 1921 Act, which established additional procedures and requirements for Irrigation Districts, the approval of two-thirds of the District's qualified electors is required for the sale of District real property[2]. See C.R.S. § 37-43-124. Therefore, the permanent transfer of storage space to another party, if agreed to, may require approval in accordance with the terms of that statute.

10.7 Loan Approval

Throughout the Phase 2 Study, the District has investigated a variety of funding sources. They include grants, loans, federal appropriations, state appropriations, and purchase or lease payments. No final decision has been made as to how the rehabilitation project will be funded and that determination will require additional discussion, negotiation, and application to available funding sources. If, as part of its funding package, the District enters a contract that requires it to expend funds in excess of $250,000.00, as part of a loan repayment, it may be required to seek approval of the landowners in accordance with the terms of C.R.S. § 37-41-113(4).

[2] The Board is authorized to sell the District's personal property without any required approval. See C.R.S. § 37-43-130.

Section 11
Storage Agreements

To fund the rehabilitation project, the District has discussed potential storage contracts with three entities: the Division of Water Resources (DWR) for Compact storage, the Division of Wildlife (DOW) for storage of its transmountain water to be used for a conservation pool at the Reservoir and other fish and wildlife needs, and the San Luis Valley Water Conservancy District (Conservancy District) for storage of water for use in its Augmentation Program. During the second phase of this study, the District prepared and reviewed preliminary drafts of potential storage agreements with these three entities. Copies of the three draft storage agreements are included in this section. Each agreement is subject to further discussion and negotiation.

Each entity indicated the need for some non-spillable storage and some storage that could be spilled (space available storage). Preliminarily, the DWR indicated that it would need between 8,000 to 10,000 acre-feet of storage capacity for Compact water but did not differentiate between non-spillable and space available storage. The DOW indicated the need for 3,000 acre-feet of non-spillable storage and 5,000 acre-feet of space available storage. The Conservancy District indicated the need for 500 acre-feet of non-spillable storage and 1,000 acre-feet of space available storage. The water storage and delivery model created during this Phase of study will allow further analysis of the needs and demands of each entity providing for refinement of these numbers.

The cost and payment for storage space also was preliminarily discussed with each entity. The DNR and DOW both indicated that they would prefer to make a one time payment for permanent storage capacity that would include operation and maintenance costs for a specific period of time, perhaps 30 years, and then be annually assessed. The Conservancy District indicated that it would prefer to amortize its purchase of space over a period of 30 years. No costs were established, but a cost analysis model has been developed by CDM and will be utilized in future negotiations.

Further discussions with each entity are planned and the District anticipates that agreements will be reached during the final design phase as funding for the rehabilitation is determined.

11.1 Storage Agreement: Division of Water Resources

STORAGE AGREEMENT
BETWEEN THE SAN LUIS VALLEY IRRIGATION DISTRICT
AND
THE COLORADO DEPARTMENT OF NATURAL RESOURCE
FOR THE USE AND BENEFIT OF THE DIVISION OF WATER RESOURCES

THIS AGREEMENT, entered into on this __ day of ____________, 20___, between the STATE OF COLORADO acting by and through the DEPARTMENT OF NATURAL RESOURCES for the use and benefit of the DIVISION OF WATER RESOURCES, hereinafter referred to as the "Division" or "DWR" whose address is 1515 Sherman, Denver, Colorado 802_, and the SAN LUIS VALLEY IRRIGATION DISTRICT, whose address is P.O. Box 637, Center, Colorado 81125, hereinafter referred to as the "Irrigation District" or "District."

RECITALS

The Irrigation District is a Colorado Irrigation District organized and existing under and pursuant to the Irrigation District Law of 1905, Article 41 of Title 37 C.R.S.

The DWR is a division of the Colorado Department of Natural Resources organized and existing under and pursuant to Article 1 of Title 33 C.R.S.

The DWR administers the Colorado River for, in part, the purpose of meeting the State of Colorado's commitments under the Rio Grande Compact.

The Irrigation District is the owner of Rio Grande Reservoir located on the headwaters of the Rio Grande River in Hinsdale County, Colorado, and of water right priorities to store water therein.

Rio Grande Reservoir has been utilized for the purpose of aiding the State of Colorado in meeting its commitments under the Rio Grande Compact pursuant to the terms and conditions of an Operating Agreement dated February 3, 1987, between the Irrigation District and the State of Colorado.

Without the use of Rio Grande Reservoir for Compact regulation, the State of Colorado and its citizens would have and will suffer losses of water allocated to Colorado under the Compact.

It is the policy of the State of Colorado to conserve for the beneficial uses in Colorado the maximum amount of water that is available under interstate apportionments for use by the citizens of Colorado.

ADD A REFERENCE TO SWSI AND ITS PURPOSE RE: REHABILITATION AND ENLARGEMENT OF EXISTING RESERVOIRS, FULL UTILIZATION OF STATE'S COMPACT ALLOCATION

The Irrigation District is rehabilitating the dam, outlet works, and spillway at Rio Grande Reservoir and requires funding from the State of Colorado to undertake the "Rehabilitation Project." That Project is described in detail in the ___________________ Report, prepared by ______________, dated ____________.

The Rehabilitation Project is required to allow the Irrigation District continued use of the Reservoir to meet its irrigation demands, to continue the use of the Reservoir for the purpose of avoiding interstate over-deliveries, and to assure that the maximum amount of water is available to Colorado appropriators from the Rio Grande.

The Rehabilitation Project will not result in any additional storage space in the Reservoir. The District is willing to provide the DWR with an easement for a portion of the existing capacity and to make it available to DWR for the storage of Compact Water following the completion of the Rehabilitation Project.

The use of Rio Grande Reservoir for Compact purposes as contemplated in this Agreement is predicated on a continuation of Compact administration that imposes on the Rio Grande mainstem responsibility for satisfying the schedule of deliveries set out in the second table of Article III of the Rio Grande Compact.

Storage capacity in the Reservoir for the Compact Water will facilitate and assist the DWR in assuring the full utilization of Compact Water for the benefit of the citizens of the State of Colorado, and may provide environmental and wildlife benefits under certain administrative scenarios.

This Agreement will benefit the DWR by facilitating its administration of the Rio Grande, meeting is commitments under the Rio Grande Compact, and affording the maximum amount of water to Colorado appropriators from the Rio Grande, and will benefit the Irrigation District by providing funds to complete the Rehabilitation Project thereby providing a safe and fully functioning dam and outlet works.

DEFINITION OF TERMS

"Allocation of spill"

- Water stored by permission of DWR and District for which there is no decree
- Unused space of another party being used by DOW
- Direct flow storage water
- Water stored pursuant to exchange decrees
- "as available" space – pro-rata with other parties' "as available" space
- District stored water

"Rehabilitation Project" –description with final plans as attachment

"Extraordinary expenses" –

OTHERS AS NEEDED

AGREEMENT

NOW THEREFORE, for and in consideration of the premises, and the following covenants, terms and conditions, and if full consideration of other conditions as hereinafter set forth, it is hereby agreed by and between the DWR and the Irrigation District as follows:

1. Upon completion of the Rehabilitation Project, the Irrigation District agrees to provide the DWR with the following storage capacity in Rio Grande Reservoir for storage of the Compact Water:

a. A permanent easement for ________ acre-feet of storage capacity. Water stored in Rio Grande Reservoir which shall not be subject to spill except in extraordinary circumstances. **[Landowner approval may be required]**

b. A permanent easement for ______________ acre-feet of storage capacity on an "as available" basis. Water stored in this pool shall be subject to spill as allocated in this Agreement.

c. The DWR shall be entitled to use the unused storage space of other parties storing water in Rio Grande Reservoir, including the Irrigation District, on an equal share "as available" basis. Water stored in the unused storage space of other parties shall be the second water spilled from the Reservoir pursuant to the allocation of spill. Initial use of unused storage space shall not preclude the opportunity of others to later also share equally in the use of such space.

2. The Irrigation District shall be compensated for the storage capacity provided to the DWR in paragraph 1 as follows:

a. For the ____________ acre-feet of non-spillable storage capacity as provided for in paragraph 1.a. above, $_________, based upon the payment of $______ per acre-foot of capacity, paid by the State under the ________________________ ______.

b. For the ____________acre-feet of spillable storage capacity as provided for in paragraph 1.b. above, $___________, based upon the lease payment of $__ ____________ per year for a period of thirty (30) years, paid by the State under the _____ __________________.

c. The payments required under paragraphs 1.a. and 1.b. above will be made to the Irrigation District pursuant to a contract with the **__[Colorado Water Conservation Board?]______** and shall be utilized solely for the Rehabilitation Project as set forth in that contract.

d. The payments required under paragraphs 1.a. and 1.b. above, shall, for a period of 30 years from the date of the Rehabilitation Project is complete, include all normal operation and maintenance expenses necessary to maintain Rio Grande Reservoir so that it can capably and safely store fifty-one thousand one-hundred and thirteen (51,113) acre-feet of water. Thereafter, the DWR shall be responsible for its pro-rata share (___/51,113) of the normal operation and maintenance expenses to maintain and operate Rio Grande Reservoir. At that time, the parties shall negotiate an Operation and Management Agreement.

3. The Irrigation District will continue to be responsible for and furnish all personnel necessary for all normal operation and maintenance requirements at Rio Grande Reservoir, including but not limited to, reading and operating gauges, valves, and gates, maintenance of District property including the caretaker's house, and normal preventative maintenance.

4. The Irrigation District will continue to be responsible for the operation of Rio Grande Reservoir but will attempt to store and release water stored by the DWR in accordance with the direction of the Division, provided, however, that storage, release, and spill of the Compact Water is subject to the terms and conditions of this Agreement and the direction of the Division Engineer. The Irrigation District assumes no responsibility to assure that releases of the Compact Water or storage of the Compact Water can be accomplished at the rates of flow requested. The right of the Irrigation District to use the capacity of the Reservoir's outlet works and inflow capacity shall have first priority of use. The District may set a minimum and/or maximum rate of release or rate of storage of the Compact Water stored in Rio Grande Reservoir.

The Irrigation District maintains and reserves the right to operate the Reservoir, store, release, or spill water therefrom at such times and in such manner as is required, in the District's sole discretion, by sound reservoir management practices. In no event shall the Irrigation District be prevented from undertaking any action deemed necessary by the District to prevent or correct any emergency matter arising in the operation of Rio Grande Reservoir and all such amounts reasonably expended by the Irrigation District to correct any emergency matter shall be repaid on a pro-rata basis (__/51,113) by the DWR within _ days from the date of receipt of a statement of costs from the Irrigation District.

5. The DWR shall pay its pro-rate share (_____/51,113) of any extraordinary expense incurred by the Irrigation District, beyond normal operation and maintenance costs, that are required to ensure that Rio Grande Reservoir remains capable of safely operating and storing 51,113 acre-feet. To the extent reasonably possible, the Irrigation District shall submit its plan to the DWR for a project for which it will incur extraordinary expenses. **[Need to develop a review process and payment schedule]**

If a restriction of the storage capacity of Rio Grande Reservoir to less than 51,113 acre-feet is implemented by a lawful storage hold order, the DWR's storage capacity provided for in paragraphs 1.a. and 1.b. above shall be proportionately reduced. To implement an extraordinary expenditure to restore the storage capacity at Rio Grande Reservoir, and reduce any storage or hold order up to the current full storage capacity of 51,113 acre-feet, the Irrigation District shall submit a plan or program for the elimination or reduction of the storage hold order to the DWR. The Division shall have the option of participating in the plan or program, paying its pro-rata share of the extraordinary expense, and, upon completion of the plan or program, obtaining restoration of its full ___ ______ acre-feet of storage capacity. If the DWR determines not to participate in the plan or program to eliminate or reduce a storage hold order, it will not be entitled to any restoration of its storage capacity above that pro-rata amount it was entitled to under the storage hold order.

6. If Rio Grande Reservoir is enlarged and its current storage capacity of 51,113 acre-feet is increased, the DWR's pro-rata interest used to calculate its share of Reservoir expenses shall be recalculated. The Division shall have an option to obtain additional storage capacity in an enlargement subject to agreement with the Irrigation District.

7. The DWR agrees to allocate its proportionate share of water for seepage and evaporation of water held in Rio Grande Reservoir. Evaporation loses shall be assessed as determined by the Division Engineer if such evaporation losses are assessed to Rio Grande Reservoir.

8. The right to use storage capacity in Rio Grande Reservoir as provided for in this Agreement shall not be separately assigned or sublet by the DWR to any other person, firm, or organization unless agreed to in writing by the District and the DWR.

9. The Irrigation District and the DWR shall implement and utilize such reservoir accounting procedures to effectuate this Agreement as may reasonably be required by the Division Engineer.

10. By entering this Agreement and storing the Compact Water, the District does not and does not intend to abandon, relinquish, or forfeit any amount of water associated with the water rights decreed for Rio Grande Reservoir.

11. The DWR shall take delivery any Compact Water released from Rio Grande Reservoir at the Reservoir's outlet works.

12. The Irrigation District shall have no obligation or responsibility for delivery of any Compact Water stored in Rio Grande Reservoir downstream of the Reservoir's outlet works.

13. The DWR agrees that during the first three (3) Water Years following completion of the Rehabilitation Project it will provide up to _________________ acre-feet of its Compact Water stored in its spillable space, described in paragraph 1.b. above, for release from Rio Grande Reservoir in a consistent amount beginning November 1st or that date the Reservoir goes into storage following completion of the irrigation season, whichever is later. Such a release shall continue until such water is fully released or March 15th of the following year, whichever occurs first. Said water shall be utilized to meet the State's remaining Compact delivery obligations for that year, to provide initial Compact deliveries for the following year, to provide supplemental wintertime fish flows, and to meet other riparian needs in the Rio Grande mainstem below the Reservoir to the Colorado-New Mexico state line. At the conclusion of three (3) years the Irrigation District, DWR, and Division Engineer shall meet and determine whether and on what terms and conditions to continue the wintertime release program.

14. The Division waives any loss or claim of loss against the Irrigation District, its employees and agents, for its operation of Rio Grande Reservoir.

15. To the extent authorized by law, the Irrigation District shall indemnify, save and hold harmless the DWR, its employees and agents, against any and all claims, damages (including, but not limited to state owned natural resources), liability and court awards including costs, expenses, and attorney fees incurred as a result of any act or omission by the Irrigation District, or its employees, agents, subcontractors, or assignees in the operation of Rio Grande Reservoir pursuant to the terms of this Agreement.

16. Notwithstanding any other provision of this Agreement to the contrary, no terms or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of the limitations on the Irrigation District's potential liability that may arise from use of its property by members of the public for public recreational purposes under the provisions of Article 41 of Title 33, C.R.S., as amended or as it may be amended.

17. Notwithstanding any other provision of this Agreement to the contrary, no term or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of any of the immunities, rights, benefits, or protections provided to the DWR of the Irrigation District under the Colorado Governmental Immunities Act, 24-10-101, et seq. C.R.S., as amended or as it may be amended (including, without limitation, any amendments to such statute, or under any similar statute which is subsequently enacted).

18. The parties hereto understand and agree that liability for claims for injuries to persons or property arising out of the negligence of the State of Colorado, its departments, institutions, agencies, boards, officials, and employees is controlled and limited by the provisions of 24-10-101, et seq., C.R.S. as amended or as it may be amended, and 24-30-1501, C.R.S., as amended or as it may be amended. Any provision of this Agreement, whether or not incorporated herein by reference, shall be controlled,

limited, and otherwise modified so as to limit any liability of the DWR to the above-cited laws.

19. Nothing in this Agreement shall preclude the parties from instituting legal proceedings to compel performance hereunder. The venue for any such legal disputes shall be in the District Court in and for the County of Rio Grande, Colorado.

20. If at any time, the Irrigation District is unable to provide storage or release of water at Rio Grande Reservoir pursuant to this Agreement, by reason of an act of God or other forces beyond the District's control, state law, rule or order, then this Agreement shall terminate and be of no further force or effect.

21. If the Compact Water or some portion thereof stored in Rio Grande Reservoir are going to be spilled, released pursuant to a storage hold over, or pursuant to the conditions set forth in paragraph 21 above, the Irrigation District will, if possible, seek to exchange such water to Santa Maria or Continental Reservoir pursuant to a separate right of exchange, or, if possible, to provide the Division up to 90 days to remove the Compact Water from Rio Grande Reservoir.

22. This Agreement may be modified as necessary by mutual consent of both parties as set forth in a signed and dated written amendment. Each party assumes all risks, liabilities, and consequences of performing work outside the specified scope of this Agreement without a prior approved amendment.

23. All previous agreements and/or contracts between the parties hereto regarding Rio Grande Reservoir, if any, are hereby declared cancelled, null and void.

ADD PROVISIONS RELATING TO COMPLIANCE WITH THE LAWS, WHERE NOTICES WILL BE DELIVERED, AND RECORDING.

11.2 Storage Agreement: Division of Wildlife

STORAGE AGREEMENT
BETWEEN THE SAN LUIS VALLEY IRRIGATION DISTRICT
AND
THE COLORADO DEPARTMENT OF NATURAL RESOURCE
FOR THE USE AND BENEFIT OF THE WILDLIFE COMMISSION
AND THE DIVISION OF WILDLIFE

THIS AGREEMENT, entered into on this __ day of ____________, 20___, between the STATE OF COLORADO acting by and through the DEPARTMENT OF NATURAL RESOURCES for the use and benefit of the WILDLIFE COMMISSION and the DIVISION OF WILDLIFE, hereinafter referred to as the “Division of Wildlife” or “Division” whose address is 6060 Broadway, Denver, Colorado 80216, and the SAN LUIS VALLEY IRRIGATION DISTRICT, whose address is P.O. Box 637, Center, Colorado 81125, hereinafter referred to as the “Irrigation District” or “District.”

RECITALS

The Irrigation District is a Colorado Irrigation District organized and existing under and pursuant to the Irrigation District Law of 1905, Article 41 of Title 37 C.R.S.

The Division of Wildlife is a division of the Colorado Department of Natural Resources organized and existing under and pursuant to Article 1 of Title 33 C.R.S.

The Division of Wildlife owns, manages, and maintains numerous decreed water rights in the San Luis Valley, including transmountain water rights and native Rio Grande water rights. These water rights have varying decreed uses and are collectively referred to in this Agreement as the “Subject Water Rights.”

The Irrigation District is the owner of Rio Grande Reservoir located on the headwaters of the Rio Grande River in Hinsdale County, Colorado, and of water right priorities to store water therein.

The Irrigation District is rehabilitating the dam, outlet works, and spillway at Rio Grande Reservoir and requires funding from the State of Colorado to rehabilitate the Reservoir. The “Rehabilitation Project” is described in detail in the _____________________ Report, prepared by ______________, dated ____________.

The Rehabilitation Project will not result in any additional storage space in the Reservoir and the District is willing to provide the Division of Wildlife with an easement for a portion of the storage capacity in the Reservoir and to make it available to the Division of Wildlife following the completion of the Rehabilitation Project.

The Division of Wildlife requires storage capacity in the Reservoir for the Subject Water Rights to facilitate and assist in its full utilization of the Subject Water Rights for the benefit of wildlife and the people of the State of Colorado.

This Agreement will benefit both the Division of Wildlife, by facilitating its beneficial use of the Subject Water Rights for the benefit of the wildlife and people of the State of Colorado, and the Irrigation District by providing funds to complete the Rehabilitation Project thereby providing a safe and fully functioning dam and outlet works.

DEFINITION OF TERMS

"Allocation of spill"

- Water stored by permission of DWR and District for which there is no decree
- Unused space of another party being used by DOW
- Direct flow storage water
- Water stored pursuant to exchange decrees
- "as available" space – pro-rata with other parties' "as available" space
- District stored water

"Rehabilitation Project" –description with final plans as attachment

"Extraordinary expenses" –

OTHERS AS NEEDED

AGREEMENT

NOW THEREFORE, for and in consideration of the premises, and the following covenants, terms and conditions, and if full consideration of other conditions as hereinafter set forth, it is hereby agreed by and between the Division of Wildlife and the Irrigation District as follows:

1. Upon completion of the Rehabilitation Project, the Irrigation District agrees to provide the Division of Wildlife with the following storage capacity in Rio Grande Reservoir for storage of the Subject Water Rights:

a. A permanent easement for three-thousand (3,000) acre-feet of storage capacity. Water stored in this pool shall be the bottom three-thousand (3,000) acre-feet of capacity in the Reservoir and shall not be subject to spill except in extraordinary circumstances. The Division shall use this space to store the Subject Water Rights for a permanent recreational and fishery pool. **[Landowner approval may be required]**

b. A permanent easement for five-thousand (5,000) acre-feet of storage capacity on an "as available" basis. Water stored in this pool shall be subject to spill as allocated in this Agreement. The Division may use this storage capacity to store the Subject Water Rights for any decreed purpose or purpose approved by the Division Engineer.

c. The Division of Wildlife shall be entitled to use the unused storage space of other parties storing water in Rio Grande Reservoir, including the Irrigation District, on an equal share "as available" basis. Water stored in the unused storage space of other parties shall be the first water spilled from the Reservoir pursuant to the allocation of spill. Initial use of unused storage space shall not preclude the opportunity of others to later also share equally in the use of such space.

2. The Irrigation District shall be compensated for the storage capacity provided to the Division of Wildlife in paragraph 1 as follows:

a. For the three-thousand (3,000) acre-feet of non-spillable storage capacity as provided for in paragraph 1.a. above, $________, based upon the payment of $_____ per acre-foot of capacity, paid by the State under the ________________________ ______.

b. For the five-thousand (5,000) acre-feet of spillable storage capacity as provided for in paragraph 1.b. above, $_________, based upon the lease payment of $_ _____________ per year for a period of thirty (30) years, paid by the State under the _____ ___________________.

c. The payments required under paragraphs 1.a. and 1.b. above will be made to the Irrigation District pursuant to a contract with the **__[Colorado Water Conservation Board?]_____** and shall be utilized solely for the Rehabilitation Project as set forth in that contract.

d. The payments required under paragraphs 1.a. and 1.b. above, shall, for a period of 30 years from the date of the Rehabilitation Project is complete, include all normal operation and maintenance expenses necessary to maintain Rio Grande Reservoir so that it can capably and safely store fifty-one thousand one-hundred and thirteen (51,113) acre-feet of water. Thereafter, the Division of Wildlife shall be responsible for its pro-rata share (8,000/51,113) of the normal operation and maintenance expenses to maintain and operate Rio Grande Reservoir. At that time, the parties shall negotiate an Operation and Management Agreement.

3. The Irrigation District will continue to be responsible for and furnish all personnel necessary for all normal operation and maintenance requirements at Rio Grande Reservoir, including but not limited to, reading and operating gauges, valves, and gates, maintenance of District property including the caretaker's house, and normal preventative maintenance.

4. The Irrigation District will continue to be responsible for the operation of Rio Grande Reservoir but will attempt to store and release water stored by the Division of Wildlife in accordance with the direction of the Division, provided, however, that storage, release, and spill of the Subject Water Rights is subject to the terms and conditions of this Agreement and the direction of the Division Engineer. The Irrigation District assumes no responsibility to assure that releases of the Subject Water Rights or storage of the Subject Water Rights can be accomplished at the rates of flow requested. The right of the Irrigation District to use the capacity of the Reservoir's outlet works and inflow capacity shall have first priority of use. The District may set a minimum and/or maximum rate of release or rate of storage of the Subject Water Rights stored in Rio Grande Reservoir.

The Irrigation District maintains and reserves the right to operate the Reservoir, store, release, or spill water therefrom at such times and in such manner as is required, in the District's sole discretion, by sound reservoir management practices. In no event shall the Irrigation District be prevented from undertaking any action deemed necessary by the District to prevent or correct any emergency matter arising in the operation of Rio Grande Reservoir and all such amounts reasonably expended by the Irrigation District to correct any emergency matter shall be repaid on a pro-rata basis (8,000/51,113) by the Division of Wildlife within ___ days from the date of receipt of a statement of costs from the Irrigation District.

5. The Division of Wildlife shall pay its pro-rate share (8,000/51,113) of any extraordinary expense incurred by the Irrigation District, beyond normal operation and maintenance costs, that are required to ensure that Rio Grande Reservoir remains capable of safely operating and storing 51,113 acre-feet. To the extent reasonably possible, the Irrigation District shall submit its plan to the Division of Wildlife for a project for which it will incur extraordinary expenses. **[Need to develop a review process and payment schedule]**

If a restriction of the storage capacity of Rio Grande Reservoir to less than 51,113 acre-feet is implemented by a lawful storage hold order, the Division of Wildlife's storage capacity provided for in paragraphs 1.a. and 1.b. above shall be proportionately reduced. To implement an extraordinary expenditure to restore the storage capacity at Rio Grande Reservoir, and reduce any storage or hold order up to the current full storage capacity of 51,113 acre-feet, the Irrigation District shall submit a plan or program for the elimination or reduction of the storage hold order to the Division of Wildlife. The Division shall have the option of participating in the plan or program, paying its pro-rata share of the extraordinary expense, and, upon completion of the plan or program, obtaining restoration of its full 8,000 acre-feet of storage capacity. If the Division of Wildlife determines not to participate in the plan or program to eliminate or reduce a storage hold order, it will not be entitled to any restoration of its storage capacity above that pro-rata amount it was entitled to under the storage hold order.

6. If Rio Grande Reservoir is enlarged and its current storage capacity of 51,113 acre-feet is increased, the Division of Wildlife's pro-rata interest used to calculate

its share of Reservoir expenses shall be recalculated. The Division shall have an option to obtain additional storage capacity in an enlargement subject to agreement with the Irrigation District.

7. The Division of Wildlife agrees to allocate its proportionate share of water for seepage and evaporation of water held in Rio Grande Reservoir. Evaporation loses shall be assessed as determined by the Division Engineer if such evaporation losses are assessed to Rio Grande Reservoir.

8. The right to use storage capacity in Rio Grande Reservoir as provided for in this Agreement shall not be separately assigned or sublet by the Division of Wildlife to any other person, firm, or organization unless agreed to in writing by the District and the Division of Wildlife.

9. The Irrigation District and the Division of Wildlife shall implement and utilize such reservoir accounting procedures to effectuate this Agreement as may reasonably be required by the Division Engineer.

10. By entering this Agreement and storing the Subject Water Rights, the District does not and does not intend to abandon, relinquish, or forfeit any amount of water associated with the water rights decreed for Rio Grande Reservoir.

11. The Division of Wildlife is solely responsible for assuring that the Subject Water Rights may be legally stored in Rio Grande Reservoir and can be used for the purposes designated by the Division upon release from the Reservoir.

12. The Division of Wildlife shall take delivery any Subject Water Rights released from Rio Grande Reservoir at the Reservoir's outlet works.

13. The Irrigation District shall have no obligation or responsibility for delivery of any Subject Water Rights stored in Rio Grande Reservoir downstream of the Reservoir's outlet works.

14. The Division of Wildlife agrees that during the first three (3) Water Years following completion of the Rehabilitation Project it will provide up to ___acre-feet its Subject Water Rights stored in its spillable space, described in paragraph 1.b. above, for release from Rio Grande Reservoir in a consistent amount beginning November 1st or that date the Reservoir goes into storage following completion of the irrigation season, whichever is later. Such a release shall continue until such water is fully released or March 15th of the following year, whichever occurs first. Said water shall be utilized to provide supplemental wintertime fish flows and to meet other riparian needs in the Rio Grande mainstem below the Reservoir. The Division of Wildlife may withdraw the water so released at _____________ for use at ________________. At the conclusion of three (3) years the Irrigation District, Division of Wildlife, and Division Engineer shall meet and determine whether and on what terms and conditions to continue the wintertime release program.

15. The Division waives any loss or claim of loss against the Irrigation District, its employees and agents, for its operation of Rio Grande Reservoir.

16. To the extent authorized by law, the Irrigation District shall indemnify, save and hold harmless the Division of Wildlife, its employees and agents, against any and all claims, damages (including, but not limited to state owned natural resources), liability and court awards including costs, expenses, and attorney fees incurred as a result of any act or omission by the Irrigation District, or its employees, agents, subcontractors, or assignees in the operation of Rio Grande Reservoir pursuant to the terms of this Agreement.

17. Notwithstanding any other provision of this Agreement to the contrary, no terms or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of the limitations on the Irrigation District's potential liability that may arise from use of its property by members of the public for public recreational purposes under the provisions of Article 41 of Title 33, C.R.S., as amended or as it may be amended.

18. Notwithstanding any other provision of this Agreement to the contrary, no term or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of any of the immunities, rights, benefits, or protections provided to the Division of Wildlife of the Irrigation District under the Colorado Governmental Immunities Act, 24-10-101, et seq. C.R.S., as amended or as it may be amended (including, without limitation, any amendments to such statute, or under any similar statute which is subsequently enacted).

19. The parties hereto understand and agree that liability for claims for injuries to persons or property arising out of the negligence of the State of Colorado, its departments, institutions, agencies, boards, officials, and employees is controlled and limited by the provisions of 24-10-101, et seq., C.R.S. as amended or as it may be amended, and 24-30-1501, C.R.S., as amended or as it may be amended. Any provision of this Agreement, whether or not incorporated herein by reference, shall be controlled, limited, and otherwise modified so as to limit any liability of the Division of Wildlife to the above-cited laws.

20. Nothing in this Agreement shall preclude the parties from instituting legal proceedings to compel performance hereunder. The venue for any such legal disputes shall be in the District Court in and for the County of Rio Grande, Colorado.

21. If at any time, the Irrigation District is unable to provide storage or release of water at Rio Grande Reservoir pursuant to this Agreement, by reason of an act of God or other forces beyond the District's control, state law, rule or order, then this Agreement shall terminate and be of no further force or effect.

22. If the Subject Water Rights or some portion thereof stored in Rio Grande Reservoir are going to be spilled, released pursuant to a storage hold over, or pursuant to the conditions set forth in paragraph 21 above, the Irrigation District will, if possible, seek to exchange such water to Santa Maria or Continental Reservoir pursuant to a separate right of exchange, or, if possible, to provide the Division up to 90 days to remove the Subject Water Rights from Rio Grande Reservoir.

23. This Agreement may be modified as necessary by mutual consent of both parties as set forth in a signed and dated written amendment. Each party assumes all risks, liabilities, and consequences of performing work outside the specified scope of this Agreement without a prior approved amendment.

24. All previous agreements and/or contracts between the parties hereto regarding Rio Grande Reservoir, if any, are hereby declared cancelled, null and void.

ADD PROVISIONS RELATING TO COMPLIANCE WITH THE LAWS, WHERE NOTICES WILL BE DELIVERED, AND RECORDING.

11.3 Storage Agreement: San Luis Valley Water Conservancy District

STORAGE AGREEMENT
BETWEEN THE SAN LUIS VALLEY IRRIGATION DISTRICT
AND
THE SAN LUIS VALLEY WATER CONSERVANCY DISTRICT

THIS AGREEMENT, entered into on this __ day of ____________, 20___, between the SAN LUIS VALLEY WATER CONSERVANCY DISTRICT, ereinafter referred to as the "Conservancy District" whose address is 415 San Juan Ave., Alamosa, Colorado ______, and the SAN LUIS VALLEY IRRIGATION DISTRICT, whose address is P.O. Box 637, Center, Colorado 81125, hereinafter referred to as the "Irrigation District."

RECITALS

A. The Irrigation District is a Colorado Irrigation District organized and existing under and pursuant to the Irrigation District Law of 1905, Article 41 of Title 37 C.R.S.

B. The Conservancy District is a Colorado Water Conservancy District organized and existing under and pursuant to the Water Conservancy Act, C.R.S. 2007 §§ 27-45-101, *et seq.*

C. The Conservancy District has developed an Augmentation Program to provide augmentation water to program participants within the boundaries of the Conservancy District.

D. In order to provide augmentation water, the Conservancy District has acquired decreed rights to use the following water rights in its Augmentation Program: (1) transmountain water decreed in Case Nos. 84CW16 and 94CW62, District Court, Water Division No. 3, which water is delivered directly into Rio Grande Reservoir through the Pine River Weminuche Ditch; (2) consumptive use credit water decreed in Case Nos. 03CW41, 05CW13, and 07CW63, all in District Court, Water Division No. 3, which also provides for exchange into Rio Grande Reservoir; and, (4) the Conservancy District may acquire additional sources of water suitable for use in its Augmentation Program (all of which are referred to in this Agreement as the "Subject Water Rights"). The Subject Water Rights are either transmountain water rights diverted from the San Juan River Basin into the Rio Grande Basin or native Rio Grande Basin water rights decreed for fully consumptive uses by the Conservancy District in its Augmentation Program.

E. The parties wish to facilitate implementation of the Conservancy District's Augmentation Program by providing storage space in Rio Grande Reservoir for the Subject Water Rights. The parties acknowledge that some of the Subject Water Rights can be stored in Rio Grande Reservoir only by exchange.

F. The Irrigation District owns Rio Grande Reservoir located on the headwaters of the Rio Grande in Hinsdale County, Colorado, and owns water right priorities to store water therein.

G. The Irrigation District is rehabilitating the dam, outlet works, and spillway at Rio Grande Reservoir which requires that the various parties storing water in the Reservoir pay for that storage in an amount commensurate with the storage benefits received. Such payments will assist the Irrigation District in the payment for the rehabilitation work and the re-payment of loans necessary to complete that work. The "Rehabilitation Project" is described in detail in the __________________ Report, prepared by ______________, dated ____________.

H. The Rehabilitation Project will not result in any additional storage space in the Reservoir and the Irrigation District is willing to provide the Conservancy District with a long-term lease for a portion of the storage capacity in the Reservoir and to make it available to the Conservancy District following the completion of the Rehabilitation Project.

I. This Agreement benefits the Conservancy District by providing both firm and as available storage space to facilitate operation of its Augmentation Program, and the Irrigation District by providing funds to complete the Rehabilitation Project thereby providing a safe and fully functioning dam and outlet works.

J. This Agreement is authorized by C.R.S. § 37-41-156 and C.R.S. § 37-45-118 **[Need to check these citations]**.

DEFINITION OF TERMS

"Allocation of spill" – water spilled from Rio Grande Reservoir will be spilled in the following order:

- Water stored by permission of DWR and District for which there is no decree
- Unused space of another party being used by the Conservancy District will be spilled pro-rata with other parties storing water in unused space of others
- Direct flow storage water
- Water stored pursuant to exchange decrees unless it is stored in non-spillable or "firm" storage space
- "as available" space will be spilled pro-rata with other parties' water stored in "as available" space
- Irrigation District's stored water

"Rehabilitation Project" –description with final plans as attachment

"Extraordinary expenses" –

OTHERS AS NEEDED

AGREEMENT

NOW THEREFORE, for and in consideration of the premises, and the following covenants, terms and conditions, and in full consideration of other conditions as hereinafter set forth, it is hereby agreed by and between the Conservancy District and the Irrigation District as follows:

1. Upon completion of the Rehabilitation Project, the Irrigation District agrees to lease to the Conservancy District the following storage capacity in Rio Grande Reservoir for storage of the Subject Water Rights:

a. One-thousand (1,000) acre-feet of storage capacity in which the water stored is not subject to spill (firm storage) except in extraordinary circumstances as defined in this Agreement. The Conservancy District may use this storage space to store the Subject Water Rights for any decreed purpose or as approved by the Division Engineer. **[Landowner approval may be required if a permanent least = a sale, 37-42-___]**

b. Five-hundred (500) acre-feet of storage capacity on an "as available" basis in which water stored is subject to spill as allocated in this Agreement. The Conservancy District may use this storage capacity to store the Subject Water Rights for any decreed purpose or as approved by the Division Engineer.

c. The Conservancy District shall be entitled to use the unused storage space of other parties storing water in Rio Grande Reservoir, including the Irrigation District, on an equal share "as available" basis. Water stored in the unused storage space of other parties shall be spilled from the Reservoir as allocated in this Agreement. Initial use of unused storage space shall not preclude the opportunity of others to later also share equally in the use of such space. **[Do we establish a charge for this space]**

2. The Irrigation District shall be compensated for the storage space leased to the Conservancy District in paragraph 1 as follows:

a. For the one-thousand (1,000) acre-feet of non-spillable "firm" storage space, $_________________ per acre-foot. The Conservancy District shall pay this amount pro-rated on an annual lease basis over a period of thirty (30) years. For that period, the annual lease payment shall be $_____ per acre-foot of storage space avaialbe to the Conservancy District, or a total of $_________ annually.

b. For the five-hundred (500) acre-feet of spillable storage space, $_________, per acre-foot. The Conservancy District shall pay this amount pro-rated on an annual lease basis over a period of thirty (30) years. For that period, the annual lease payment shall be $_____ pre acre-foot of storage space available to the Conservancy District, or a total of $__________ annually.

c. The total annual payment made by the Conservancy District to the Irrigation District on or before March 1st of each year will be $__________, which payment shall, for a period of 30 years from the date of the Rehabilitation Project is complete, include all normal operation and maintenance expenses necessary to maintain Rio Grande Reservoir so that it can capably and safely store fifty-one thousand one-hundred and thirteen (51,113) acre-feet of water. At the end of the 30 year period the Conservancy District shall pay to the Irrigation District _________________________________ and also shall be responsible for its pro-rata share (1,500/51,113) of the normal operation and maintenance expenses to maintain and operate Rio Grande Reservoir. At that time, the parties shall negotiate an Operation and Maintenance Agreement.

3. The Irrigation District will continue to be responsible for and furnish all personnel necessary for normal operation and maintenance requirements at Rio Grande Reservoir, including but not limited to, reading and operating gauges, valves, and gates, maintenance of District property including the caretaker's house, and normal preventative maintenance.

4. The Irrigation District will continue to be responsible for the operation of Rio Grande Reservoir but will attempt to store and release the Conservancy District's stored water as directed by that District, provided however, that storage, release, and spill of the Subject Water Rights is subject to the terms and conditions of this Agreement and the direction of the Division Engineer. The Irrigation District assumes no responsibility to assure that storage or releases of the Subject Water Rights can be accomplished at the rates of flow requested. The right of the Irrigation District to use the capacity of the Reservoir's outlet works and inflow capacity shall have first priority of use. The Irrigation District may set a minimum and/or maximum rate of release or rate of storage of the Subject Water Rights stored in Rio Grande Reservoir. The Irrigation District maintains and reserves the right to operate the Reservoir, store, release, or spill water therefrom at such times and in such manner as is required, in its sole discretion, by sound reservoir management practices.

5. The Irrigation District may undertake any action deemed necessary by the District to prevent or correct any emergency matter arising in the operation of Rio Grande Reservoir. All funds reasonably expended by the Irrigation District to correct any emergency matter shall be repaid on a pro-rata basis (1,500/51,113) by the Conservancy District within ______ days from the date of receipt of a statement of costs from the Irrigation District.

6. The Conservancy District shall pay its pro-rate share (1,500/51,113) of any extraordinary expense incurred by the Irrigation District, beyond normal operation

and maintenance costs, or emergencies that are required to ensure that Rio Grande Reservoir remains capable of safely operating and storing 51,113 acre-feet. To the extent reasonably possible, the Irrigation District shall submit its plan to the Conservancy District for a project for which it will incur extraordinary expenses. **[Need to develop a review process and payment schedule]**

If Rio Grande Reservoirs storage capacity is subject to a lawful hold order and is restricted to less than 51,113 acre-feet, the Conservancy District's storage capacity provided for in paragraphs 1.a. and 1.b. above shall be proportionately reduced. Prior to undertaking an extraordinary expenditure to restore the Reservoir's storage capacity and reduce any hold order up to the current full storage capacity of 51,113 acre-feet, the Irrigation District shall submit a plan or program for the elimination or reduction of the storage hold order to the Conservancy District. The Conservancy District shall have the option of participating in the plan or program, paying its pro-rata share of the extraordinary expense, and, when the plan or program is complete, obtaining restoration of its full 1,500 acre-feet of storage capacity. If the Conservancy District decides it will not participate in the plan or program to eliminate or reduce a storage hold order, it will not be entitled to the restoration of its storage capacity above that pro-rata amount it was entitled to under the storage hold order. **[Does this work? We need them to make full payment every year and if we reduce their storage space their payment will drop accordingly]**

7. If Rio Grande Reservoir is enlarged and its current storage capacity of 51,113 acre-feet is increased, the Conservancy District's pro-rata interest used to calculate its share of Reservoir expenses shall be recalculated. It also shall have the option to obtain additional storage capacity in an enlargement subject to agreement with the Irrigation District.

8. The Conservancy District agrees to a proportionate allocation of the loss of water for the seepage and evaporation of water held in Rio Grande Reservoir. Evaporation loses shall be assessed as determined by the Division Engineer if such evaporation losses are assessed to Rio Grande Reservoir. If the seepage can be measured, subject to the agreement of the Division Engineer, the Conservancy District may account for the seepage to meet its augmentation requirements and the amount of seepage accounted for in this manner will be deducted from the Conservancy District's stored water.

9. The right to use storage capacity in Rio Grande Reservoir as provided for in this Agreement shall not be separately assigned or sublet by the Conservancy District to any other person, firm, or organization unless agreed to in writing by the Irrigation District and the Conservancy District.

10. The Irrigation District and the Conservancy District shall implement and utilize such reservoir accounting procedures to effectuate this Agreement as may reasonably be required by the Division Engineer.

11. By entering this Agreement and storing the Subject Water Rights, the District does not and does not intend to abandon, relinquish, or forfeit any amount of water associated with the water rights decreed for Rio Grande Reservoir.

12. The Conservancy District is solely responsible for assuring that the Subject Water Rights may be legally stored in Rio Grande Reservoir and can be used for the purposes designated by the Conservancy District upon release from the Reservoir.

13. The Conservancy District shall take delivery of any Subject Water Rights released from Rio Grande Reservoir at the Reservoir's outlet works.

14. The Irrigation District shall have no obligation or responsibility for delivery of the Subject Water Rights stored in Rio Grande Reservoir downstream of the Reservoir's outlet works.

15. The Conservancy District waives any loss or claim of loss against the Irrigation District, its employees and agents, for the Irrigation District's operation of Rio Grande Reservoir.

16. To the extent authorized by law, the Irrigation District shall indemnify, save, and hold harmless the Conservancy District, its employees and agents, against any and all claims, damages (including, but not limited to state owned natural resources), liability and court awards including costs, expenses, and attorney fees incurred as a result of any act or omission by the Irrigation District, or its employees, agents, subcontractors, or assignees in the operation of Rio Grande Reservoir pursuant to the terms of this Agreement.

17. Notwithstanding any other provision of this Agreement to the contrary, no terms or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of the limitations on the Irrigation District's potential liability that may arise from use of its property by members of the public for public recreational purposes under the provisions of Article 41 of Title 33, C.R.S., as amended or as it may be amended.

18. Notwithstanding any other provision of this Agreement to the contrary, no term or condition of this Agreement shall be construed or interpreted as a waiver, either expressed or implied, of any of the immunities, rights, benefits, or protections provided to the Conservancy District or the Irrigation District under the Colorado Governmental Immunities Act, 24-10-101, et seq. C.R.S., as amended or as it may be amended (including, without limitation, any amendments to such statute, or under any similar statute which is subsequently enacted).

19. Nothing in this Agreement shall preclude the parties from instituting legal proceedings to compel performance hereunder. The venue for any such legal disputes shall be in the District Court in and for the County of Rio Grande, Colorado.

20. If at any time, the Irrigation District is unable to provide storage or release of water at Rio Grande Reservoir pursuant to this Agreement, by reason of an act of God or other forces beyond the District's control, state law, rule or order, then for the period of time storage cannot be provided, this Agreement shall be held in abeyance and be of no force or effect.

21. If the Subject Water Rights or some portion thereof stored in Rio Grande Reservoir are going to be spilled, released pursuant to a storage hold over, or pursuant to the conditions set forth in paragraph 19 above, the Irrigation District will, if possible, seek to exchange such water to Santa Maria or Continental Reservoir pursuant to a separate right of exchange, or, if possible, to provide the Division up to 90 days to remove the Subject Water Rights from Rio Grande Reservoir.

22. This Agreement may be modified as necessary by mutual consent of both parties as set forth in a signed and dated written amendment. Each party assumes all risks, liabilities, and consequences of performing work outside the specified scope of this Agreement without a prior approved amendment.

23. The prior Storage Lease Agreement, dated ______________ between the Irrigation District and the Conservancy District shall remain in full force and effect until the Rehabilitation Project is declared to be complete. Upon that declaration, this Agreement shall take full force and effect and the prior Storage Lease Agreement and any other agreements and/or contracts between the parties hereto regarding Rio Grande Reservoir, if any, will be deemed cancelled, null, and void.

ADD PROVISIONS RELATING TO COMPLIANCE WITH THE LAWS, WHERE NOTICES WILL BE DELIVERED, AND RECORDING.

Section 12
Conclusions and Recommendations

The purpose of Phase II of this study was to address several of the issues raised during Phase I; the initial feasibility study. Key aspects of this report include a preliminary design of dam rehabilitation and enlargement options; further geologic and geotechnical analysis; spillway sizing and preliminary design of spillway structure improvements; development of a water use model to show benefits of rehabilitating the dam and possibly enlarging the Reservoir; wetlands, biological, and cultural resources investigation; further legal analysis of issues raised during the feasibility study; and draft storage agreements with various entities that need or may want storage space in a rehabilitated or enlarged Reservoir. Conclusions and recommendations from each of these investigations are summarized here. Further details can be found in the respective sections.

During the course of the Phase II study, the District's Board of Director decided to pursue the rehabilitation only project due to concerns over the significant additional costs of an enlargement and the legal and regulatory issues involved in pursing the enlargement. This decision does not preclude the possibility of enlarging the Reservoir in the future.

12.1 Conclusions

12.1.1 Preliminary Design

Seepage at the dam will be reduced by a grouting program that includes traditional foundation grouting as well as jet grouting on the left abutment. Reducing seepage will reduce the piping potential and enhance dam safety.

The outlet works will be completely rehabilitated by boring a new outlet tunnel and constructing a new outlet structure near the exiting spillway chute terminus. The new outlet tunnel will meet with the existing inlet tunnel above the existing gate chamber. The new tunnel will be lined with steel pipe and pressurized. Flow will be controlled by cone valves in the outlet structure, allowing for controlled releases of low flows and at high flow rates that currently cause unsafe conditions in the dam.

The spillway structure will be modified by raising the existing bridge piers and adding a training wall that will direct flow over the current spillway without overtopping during an inflow design storm event.

The enlargement option includes rehabilitation as described above plus a 10 foot downstream dam raise creating 11,000 acre-feet of additional storage capacity. A synthetic liner would be installed over the dam face to further reduce seepage, and a secondary intake tunnel will provide for greater release flexibility related to temperature and water quality. The spillway in the enlargement option is raised 10 feet by adding a second L-shaped weir along the perimeter of the existing spillway.

12.1.2 Geology and Geotechnical Investigation

There are several slow moving landslides in the Reservoir area. The most threatening landslide is the lateral block spread on the north shore, just west of the dam. A catastrophic fast-moving landslide, similar to the landslide in the Upper Lost Trail Creek drainage, is unlikely near the Reservoir due to differing geologic conditions. However, a strong earthquake could cause failure of the block spread, which could lead to a catastrophic landslide into the Reservoir.

Currently, total seepage is greater than 2,500 gallons per minute (gpm) when Reservoir storage is at high levels. Seepage begins to increase significantly when Reservoir storage reaches gage height 60 feet. Long-term seepage modeling shows that seepage correlates very closely to Reservoir stage.

Seepage modeling demonstrates that lengthening the current 225-foot seepage path to 450 feet reduces seepage by more than 7 percent. The proposed grout curtain would increase the seepage path to over 700 feet providing an even greater reduction in seepage through the left abutment. More importantly, the hydraulic gradient is significantly flattened, reducing the potential for soil piping of the rock slide mass along the dams left abutment.

Dam stability analysis shows that both the existing dam and proposed enlarged dam meet all minimum dam stability safety requirements.

Stability analysis of the Reservoir rim, specifically the lateral block spread identified in the geologic investigation, shows that an enlarged Reservoir would not significantly alter the stability of the lateral block spread using assumed parameters. Until field testing can be performed to better quantify various geotechnical parameters, the dam and reservoir safety factors should not be considered absolute firm values.

12.1.2.1 Hydrology and Hydraulic Modeling

The State of Colorado's Extreme Precipitation Analysis Tool (EPAT) was used to develop the probable maximum precipitation event.

HEC-HMS modeling (U.S. Army Corps of Engineers Hydraulic Engineering Center – Hydraulic Modeling Systems) routed the probable maximum precipitation runoff to the Reservoir (the "inflow design flood" or "IDF"). The general (regional) type storm was determined to be the critical storm (as opposed to a thunderstorm event). The maximum Reservoir inflow rate is 13,300 cfs.

Given the proposed spillway designs for the rehabilitation and enlargement options, the maximum spillway discharge under IDF conditions is 6,600 cfs and 9,050 cfs, respectively. Maximum reservoir stage is gage height 102 and 107, respectively.

Under IDF conditions, the existing spillway chute will overtop. Spillway chute extension walls are proposed to contain the maximum flow.

12.1.2.2 Water Use Model

Potential storage patterns and accounts, and resulting flows were modeled for the rehabilitation and enlargement scenario. The model provides a tool that allows those with storage pools to adjust the amount of firm or space-available storage they utilize and the timing and rates at which their available water is stored and released.

The model shows that available storage for Compact water can provide a buffer and additional flexibility in regulating the Compact, and that storage of water for other entities can provide indirect environmental benefits.

Under the rehabilitation only option with current District storage sold to other entities as specified in Section 8, the District spills water only in certain above average years.

Hydropower potential was revised using the modeled Reservoir water elevation, given the storage and release patterns specified in the model. The monthly-averaged maximum output for modeled storage conditions is approximately 1.9 megawatts (MW). However, under extreme flow conditions (2,500 cfs) and full Reservoir head, instantaneous potential power generation is 15.6 MW. Given that these extreme flows and full reservoir head conditions are very infrequent, the cost of the full hydropower capacity is not justified.

12.1.3 Wetlands, Biological, and Cultural Resources Investigation

The rehabilitation only project will not impact wetlands, biological, or cultural resources.

The enlargement option would potentially impact approximately 25 acres of wetlands. Four fens wetland areas were delineated near the Reservoir. Fens areas would not be inundated, but the change in hydrologic regime associated with an enlargement could potentially impact the fens areas. A fens area was discovered below the existing ordinary high water line (OHWL) of the existing Reservoir, which indicates that fens can survive periodic inundation.

If the Reservoir was enlarged, wetlands mitigation could be partially fulfilled by the creation of new wetlands on the western end of the Reservoir. Several other areas in the region were identified where other wetlands could be constructed; including Willow Creek, Clear Creek, and the Middle Rio Grande.

The biological assessment concluded that the project will have no effect on the Western yellow-billed cuckoo and the Uncompahgre fritillary butterfly. The project may affect, but is not likely to adversely affect the Canada Lynx. An enlargement may adversely affect the Southwestern willow flycatcher. However, the habitat elevation range for the Southwestern willow flycatcher is undergoing further review and its habitat may not extend to the Reservoir's elevation.

Avoiding construction from March 15 to July 31 would lessen the impacts to nesting American peregrine falcons. Avoiding construction during the bald eagle winter roosting period from November 15 to March 15 would lessen the impacts to bald eagles. The presence of either type of bird would need to be verified by biologists. Bald eagles are not known to roost in the Reservoir area at this time.

No cultural resources were discovered in the Reservoir area that would support a designation under the National Historic Preservation Act.

12.1.4 Legal

Rehabilitating the dam will not results in NEPA review, as all work will be performed on private land owned by the District. The enlargement option would result in NEPA review. The use of the Reservoir to store water for non-irrigation purposes is included within the 1891 Act right-of-way as amended in 1898, provided the primary use of the water stored at the Reservoir remains for irrigation.

An enlargement including rehabilitation, or just a rehabilitation of the Reservoir's outlet works and spillway can be accomplished within the terms of the USFS instream flows Decree.

An enlargement will raise the high water level and, when the Reservoir is full, temporarily inundate a small portion of the lowest reach of the two Creeks where the CWCB has instream flow rights. The District would need to seek permission from the Colorado Water Conservation Board to inundate these small sections of stream pursuant to Rules 7c – 7m of the Rules Concerning Colorado Instream Flow and Natural Lake Level Program.

Hydro-power development would require a license from the Federal Energy Regulatory Commission (FERC). The District may be able to obtain an exemption from licensing provided for small hydroelectric projects of 5 megawatts (MW) or less. The majority of the time, the potential electrical generation at the Reservoir would not exceed the 5 MW, and does not justify constructing hydropower capacity exceeding 5 MW.

The District's Board can approve a long-term lease of non-spillable storage space. The permanent transfer of storage space to another party may require approval of the District's landowners.

12.2 Recommendations

The District's Board of Directors has recommended that the District proceed with only the rehabilitation of the dam and Reservoir at this time.

12.2.1 Preliminary Design

Final design of all proposed enhancements will require a land and structure survey of the site. Plans from previous repairs conflict in several areas and do not necessarily represent as-built conditions.

A field program including test grouting, testing of onsite embankment liner materials, other geotechnical borings, and spillway concrete evaluation will be required before grout program, liner and spillway structure bracing can proceed to final design.

Outlet tunnel alignment and a downstream dam raise should be evaluated based on property rights evaluation and funding availability.

Results of the land and structure survey can be used to refine the HEC-RAS model and potentially reduce costs of chute wall extensions if maximum flow is reduced by shortening the proposed weir length.

12.2.2 Geologic and Geotechnical Investigation

A full geologic and geotechnical analysis of the lateral block spread is recommended. This would include subsurface drilling installation of inclinometers or benchmarks, and a testing program to more accurately assess the actual conditions. The results of this analysis will refine and affect the safety factors calculated for the Reservoir rim stability analysis and better quantify the risks to the Reservoir from the lateral block spread.

The modern movement rate of the landslide on the left abutment should be quantified to assess deformation risk to the dam. Deformation of the dam could occur if the movement of the landslide generates forces strong enough to act on and move the existing dam. The process of quantifying the movement rate can be aided by using ageing techniques on the rocks and rubble in the existing slide area.

Landslides surrounding the Reservoir should be periodically inspected for tension cracks, swallow holes, and other signs of imminent failure.

A dynamic analysis evaluating liquefaction potential of the hydraulic puddled fill of the dam embankment should be conducted for final design.

12.2.3 Hydrologic and Hydraulic Modeling

A land and structure survey, including an updated stage-storage-surface area relationship, should be completed to refine the modeling.

The design and the ability to construct the spillway chute wall extensions should be evaluated once concrete strength testing has been performed and the HEC-RAS model cross-sections updated based on the survey.

12.2.4 Water Use Model

Provide the model and support to the various stakeholders to assist them in developing storage and operational scenarios that achieves optimum multi-party benefits.

Incorporate a simplified water rights analysis to the model to allow the impact of modified storage and release patterns and changes in curtailment on certain water rights to be modeled.

Modify the available flows – in particular for Compact storage – to more accurately illustrate potential for different reoperations scenarios. Historically, in above average years, there was a zero curtailment and no flow is available to store in the model. The model could be enhanced to allow for storage of compact water even when there was no historical curtailment.

A detailed stream gain/loss study on the Rio Grande from the Reservoir to the state line would increase the reliability and accuracy of modeled stream flow predictions.

The water use model could be upgraded to include daily modeling. This would require a high level of record retrieval and future record keeping of curtailment, reservoir inflows and releases, water rights served etc.

Hydropower laws, regulations, and rules should be investigated in detail along with existing electrical infrastructure, emerging small-scale hydropower technology and funding opportunities to determine the feasibility of incorporating a hydropower plant at the dam.

12.2.5 Wetlands, Biological, and Cultural Resources Investigation

Results of a study on Southwestern Willow Flycatcher habitat elevation range would allow a determination of whether areas that would be inundated at the western edge of the Reservoir if it was enlarged, provide viable habitat.

Prior to construction, best management practices with regard to erosion and sedimentation should be implemented. Fueling and equipment maintenance should be performed at least 100 feet from open water.

Qualified biologists should be used to determine the presence of bald eagles and peregrine falcons prior to construction to avoid a "take" of the birds.

12.2.6 Legal

Legal issues should be finally addressed in coordination with the governing land or water use management agency. Perhaps the only significant legal issue to determine for the rehabilitation only project will be the use of the river bed during construction.

12.2.7 Storage Agreements

Storage agreements should be further refined and are finalized to determine how the Reservoir will be used and to assist in funding the rehabilitation.

Section 13
References

Ahlers, Darrell. 2007. Personal communication. Biologist. US Bureau of Reclamation. Denver, Colorado.

Atwood, W.W., 1918, "*Relation of Landslides and Glacial Deposits to Reservoir Sites in the San Juan Mountains, Colorado*," Department of the Interior, United States Geological Survey, Bulletin 685.

Brussard, P.F., and H. Britten. 1989. The status of the Uncompahgre fritillary (Boloria acrocnema). Final report prepared for the Forest Service, Bureau of Land Management, and Fish and Wildlife Service. Montana State University.

Center for Biological Diversity (CBD). 2000. Western Yellow Billed cuckoo information. Accessed from http://www.sw-center.org/swcbd.

CDM (Camp Dresser & McKee Inc.). 2007. Rio Grande Reservoir Multi-Use Enlargement Study. July.

Colorado Water Conservation Board (CWCB). 2004. Statewide Water Supply Initiative Report. November.

Chen and Associates, 1983, "*Geotechnical Investigation & Evaluation, Rehabilitation of Rio Grande Dam, Phase 2, Hindsdale County, Colorado*."

Chronic, H. and Williams, F. 2002. Roadside geology of Colorado, second edition. Mountain Press Publishing Company. Missoula, Montana.

Colorado Division of Wildlife. 2007. Colorado Department of Natural Resources. American peregrine falcon species of special concern. Available at http://wildlife.state.co.us/WildlifeSpecies/Profiles/Birds/PeregrineFalcon.htm.

Correspondence from Mr. James T. Passage to Mr. Hal Simpson dated September 21, 1998.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classifications of wetlands and deepwater habitats of the United States. (FWS/OBS-79/31) U.S. Fish and Wildlife Service. Washington D.C.

Craig, Gerald R. 2002. Colorado Division of Wildlife Recommended Buffer Zones and Seasonal Restrictions For Colorado Raptors.

Deere & Ault Consultants, Inc. 2006. Geotechnical Evaluation of the Rehabilitation and Enlargement of the Rio Grande Dam. October.

Deere & Ault Consulting, Inc. 2008. Preliminary Design Report: Rio Grande Reservoir Rehabilitation and Enlargement. April.

Destafano, S. 1987. The lynx. Pp.411-412 In: DiSilvestro, R.L., W.L. Chandler K. Barton, and Labate eds. 1987 Audubon Society wildlife report. The National Audubon Society, New York, Academic Press, New York.

Engineering Record, November 9, 1912, "Rio Grande Dam, Composite Riprapped Earth and Rock-Fill Dam Constructed by the Basin-and-Embankment Method near Creede, Colorado." Vol. 66, Number 19. November.

Fitzgerald, J.P, C.A. Meaney, and D.M. Armstrong. 1994. Mammals of Colorado. Denver Museum of Natural History and University Press of Colorado. 467 pp.

Gaines, D., and S. Laymon. 1984. Decline, status and preservation of the yellow-billed cuckoo in California. Western Birds 15: 49-80.

Gall, L.F. 1983. Uncompahgre fritillary butterfly. Pages 477-479 in the IUCN in the red data book. S.M. Wells, R.M. Pyle, N.M. Collins, eds. International Union for Conservation of Nature and Natural Resources, Gland, Switzerland. 632pp.

Ghromley, Randy. August 23, 2007. Personal communication. USFS Rio Grande National Forest Biologist. Monte Vista, Colorado.

Green, M.G., T. Swem, M. Moria, R. Mesta, R. Hazlewood, P. Delphey, R. Currie, and M. Amaral. 2006. Monitoring American Peregrine Falcons since removal from the list of Endangered and Threatened Species. USFWS Poster Presentation.

Harza Engineering Company, Western Division, September 21, 1998 letter re: Rio Grande Reservoir, Your Letter dated August 7, 1998.

Harza Northwest, Inc., September 7, 1993 letter re: "*Rio Grande Dam, Construction Observation, Left Abutment Slope Rehabilitation*."

Harza Northwest, Inc., November 17, 1993 letter re: "*Rio Grande Dam, Slope Stabilization and Field Work Activities*."

Hatton, Christopher N., and Johnson, Daniel L., 1997, "*Worster Dam: A Case History in Dam Rehabilitation Using a Flexible Membrane Liner*," Seventeenth Annual USCOLD Lecture Series, San Diego, CA, April 7-11, 1997.

Helton and Williamsen. 2003. ___________________________

Ireland, Terry. 2000 and 2007. Personal communication. US Fish and Wildlife Service. Grand Junction, Colorado.

Johnson, Daniel L., Jackson, Garrett O., and Birch, Daniel, 1997, "*Fish Creek Dam Geomembrane*," Seventeenth Annual USCOLD Lecture Series, San Diego, CA, April 7-11, 1997.

Kingery et al.1998. Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership. Denver, Colorado.

Kirkland, Robert M. for Deere and Ault Consultants, Inc., 2007. Geologic Investigation of Landslides, Rio Grande Reservoir, Hinsdale County, Colorado. November.
Koerner, Robert M., and Hsuan, Y. Grace, 2003, "*Lifetime Prediction of Polymeric Geomembranes Used in New Dam Construction and Dam Rehabilitation*," Proceedings Association of Dam Safety Officials Conference, Lake Harmony, PA, June 4-6, 2003.

La Plata Archaeological Consultants, 2008. A Cultural Resources Survey for Enlargement of Rio Grande Reservoir. June.

Miller, Dennis. 2003. Memorandum of Inspection: Rio Grande Reservoir. Inspection date Nov. 23, 2003.

Passage, January 2008, personal communication with Don Deere and Mark Severin.

Reed, P.B. 1988. National list of plant species that occur in wetlands: Intermountain Region (Region 8). U.S. Fish and Wildlife Service Biological Report 88 (24).

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Nancy, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, F. Wahl, N. Warren, D. Wenger, and A. Williamson. 2000. Canada lynx conservation assessment and strategy. USDA Forest Service. USDI Fish and Wildlife Service, USDI Bureau of Land Management, and USDI National Park Service. Missoula, Montana.

Scott, J.A. 1982. The life history and ecology of an alpine relict, Boloria improba acrocnema (Lepidoptera: Nymphalidae), illustrating a new mathematical population cenus method. Papilio 2:1-12.

State of Colorado, Department of Natural Resources, Division of Water Resources, Office of the State Engineer. 2007. Rules and Regulations for Dam Safety and Dam Construction. January 1.

Sugnet and Moore Environmental, Inc., 2008. Wetland Delineation Report, Rio Grande Reservoir, Proposed Reservoir Expansion Project. February.

Sugnet and Moore Environmental, Inc., 2008. Rio Grande Reservoir Expansion Project, Biological Assessment.. February.

Sugnet and Moore Environmental, Inc., 2008. Rio Grande Reservoir, Proposed Expansion Project, Preliminary Wetland Impact and Mitigation Assessment. February.

Tibbitts, T.J., M.K. Sogge and S.J. Sferra. 1994. A survey protocol for the Southwestern willow flycatcher (*Empidonax traillii extimus*). Technical Report NPS/NAUCPRS/NRTR-94/04, 15 pp.Unitt, P. 1987. *Empidonax traillii extimus*: An endangered subspecies. Western Birds 18(3): 137-162.

U.S. Army Corps of Engineers (USACE). 1987. Corps of Engineers wetlands delineation manual. Technical Report Y-87-1, Environmental Laboratory, U.S. Army Corps of Engineer Waterways Experiment Station. Vicksburg, MS.

U.S. Army Corp of Engineers. December 2002. *Regulatory Guidance Letter No. 02-2 Guidance On Compensatory Mitigation Projects For Aquatic Resource Impacts Under The Corps Regulatory Program Pursuant To Section 404 Of The Clean Water Act And Section 10 Of The Rivers And Harbors Act Of 1899*.

U.S. Army Corp of Engineers, 2004 Albuquerque District Mitigation And Monitoring Guidelines(*http://www.spa.usace.army.mil/reg/2003007881/Final%20Guidelines%20combied.pdf*)

U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center. 2005. River Analysis System, version 3.1.0.

U.S. Army Corp of Engineers (USACE). December 2005. Regulatory Guidance Letter No. 05-05. Guidance on Ordinary High Water Mark Identification.

U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center. 2006. Hydrologic Modeling System, version 3.1.0.

USBR (United States Bureau of Reclamation). 1987. Design of Small Dams. 3rd Edition.

U.S. Environmental Protection Agency and Department of Army. February 1990. *Memorandum of Agreement between the Environmental Protection Agency and Department of Army Concerning the Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines*.

U.S. Environmental Protection Agency and Department of Army. June 5, 2007: *Clean Water Act Jurisdiction Following the U.S. Supreme Court's Decision in Rapanos v. United States & Carabell v. United States (http://www.usace.army.mil/cw/cecwo/reg/cwa_guide/rapanos_guide_memo.pdf)*

US Fish and Wildlife Service. 2002. Southwestern Willow Flycatcher Recovery Plan. Albuquerque, New Mexico. i-ix, 210 pp. Appendices A-O.

Appendix A
Dam Embankment and Outlet Works Preliminary Design

US Fish and Wildlife Service. 1994. Uncompahgre Fritillary Butterfly Recovery Plan. Denver, Colorado. 20 pp.

US Fish and Wildlife Service. 2007. Endangered species lists. Mountain-Prairie Region Endangered Species. Colorado. Available at http://mountain prairie.fws.gov/endspp/CountyLists/COLORADO.htm.

US Forest Service (USFS). 2002. Canada lynx potential habitat in Colorado. GIS database information.

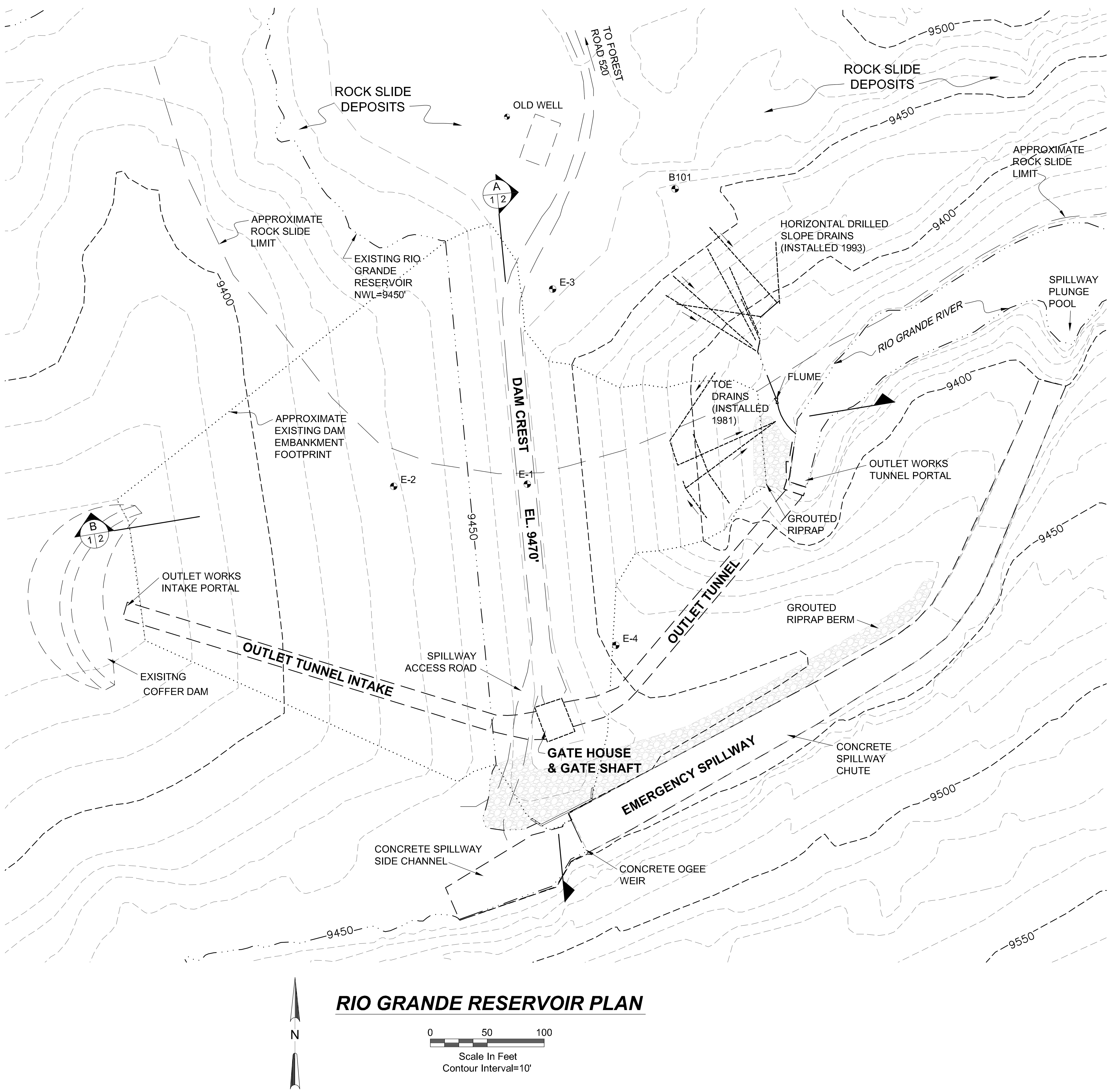
U.S. Natural Resource Conservation Service, Upper Rio Grande Snotel Station Data; http://www.wcc.nrcs.usda.gov/snotel/snotel.pl?sitenum=839&state=co, Site accessed on October 12, 2006

U.S. Soil Conservation Service. 1980. *Soil Survey of Rio Grande County Area, Colorado.* U.S. Department of Agriculture. Washington D.C.

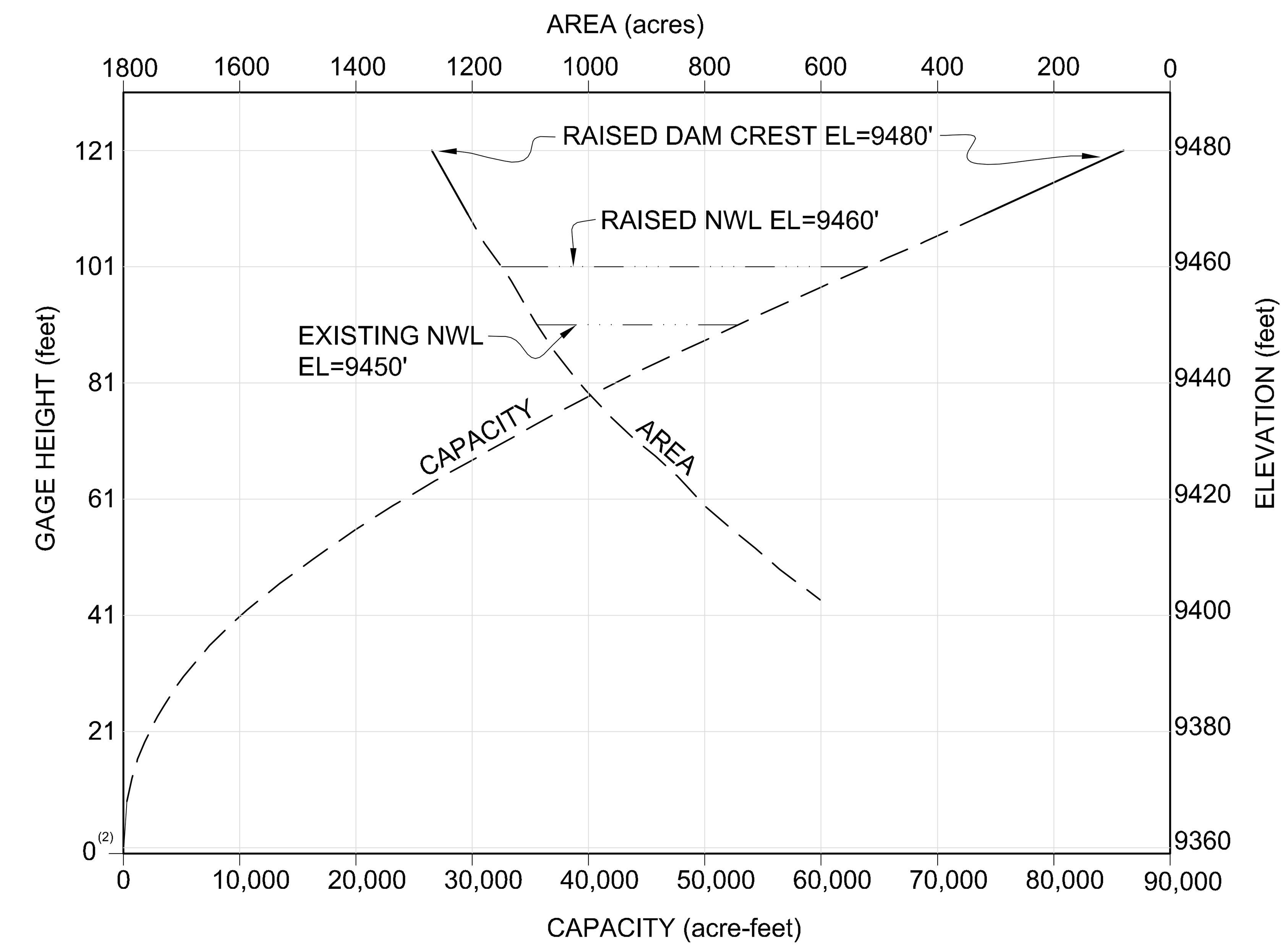
Wheeler 1981. Rio Grande Topographical Survey Report. Data provided by CDM Inc.

Wheeler, B.K. 2003. Raptors of Western North America. Princeton University Press, Princeton, NJ.

W.W. Wheeler and Associates, Inc. 1981. Appendices to Rio Grande Dam Rehabilitation Feasibility Report. November.



RIO GRANDE RESERVOIR PLAN



AREA-CAPACITY CURVE

AREA-CAPACITY NOTES:

1. AREA - CAPACITY CURVE TAKEN FROM WHEELER & ASSOCIATES, 1983. CURVES ARE REPORTEDLY BASED ON 1981 SURVEY.
2. GAGE HEIGHT 0 = ELEVATION 9359.0'.

GENERAL NOTES:

1. EXISTING CONTOURS AND FEATURES ARE APPROXIMATE AND BASED ON WW WHEELER & ASSOCIATES DECEMBER 1982 AS-BUILTS & THE SEPTEMBER 7, 1993 HORIZONTAL DRAIN REPORT AS PROVIDED BY HARZA NORTHWEST, INC.
2. OUTLET WORKS TUNNEL ALIGNMENT IS APPROXIMATE AND BASED OFF WW WHEELER & ASSOCIATES AS-BUILTS DATED DECEMBER 1982.
3. TESTHOLE E-1, E-2, E-3, E-4 DRILLED BY CHEN & ASSOCIATES IN 1981.
4. TESTHOLE B-101 DRILLED BY HARZA IN 1993.

SEO FILE NO

REVISIONS

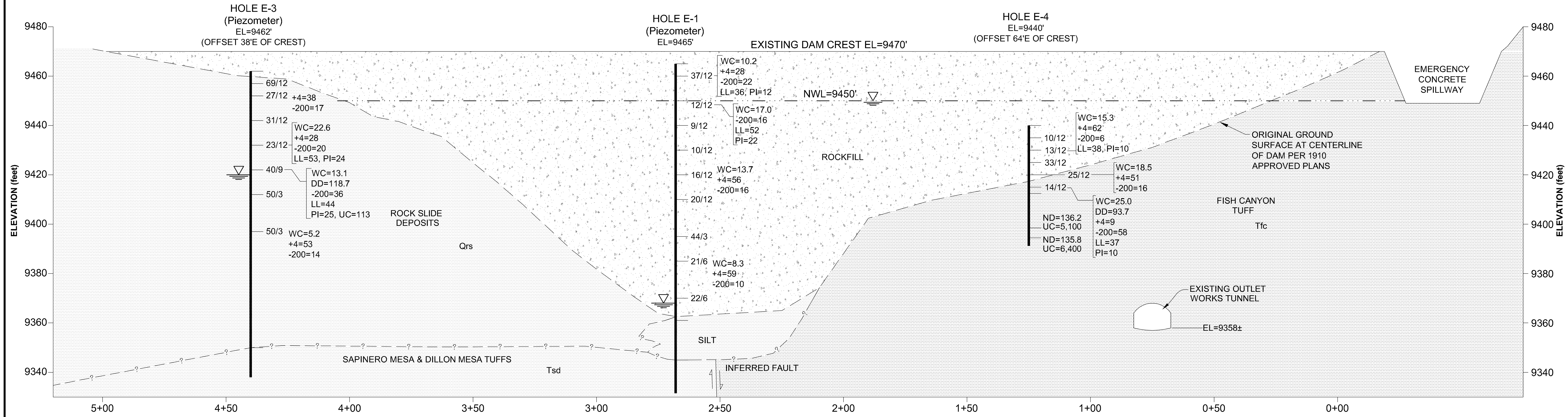
NO.	DESCRIPTION	DATE	BY

RIO GRANDE RESERVOIR

EXISTING DAM CONDITIONS
& AREA-CAPACITY CURVES

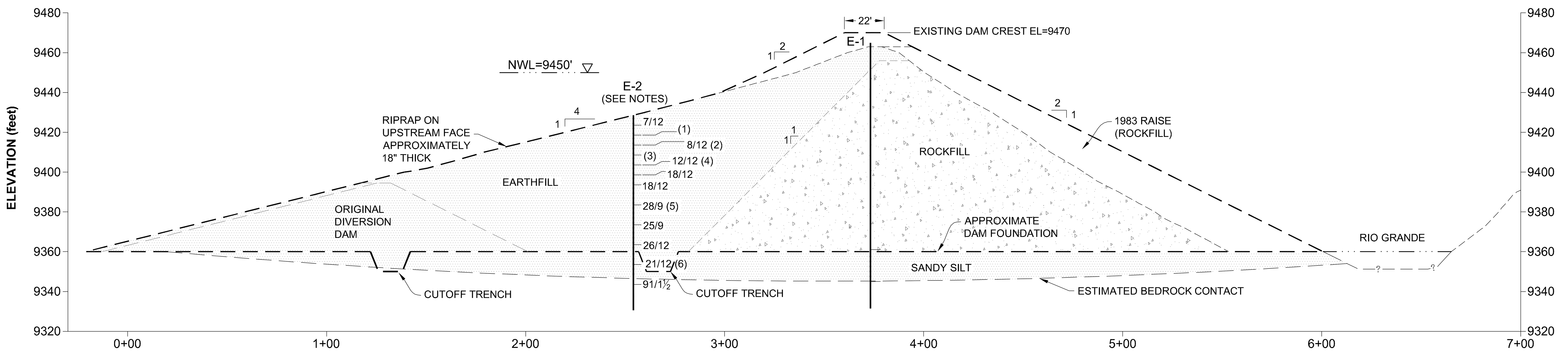
DEERE & AULT CONSULTANTS, INC.
600 S. AIRPORT RD., BLDG. A, SUITE 205
LONGMONT, CO 80503
TEL 303.651.1468 FAX 303.651.1469

DESIGNED BY: DWD/DF	APPROVED BY: DWD	JOB NO.	SHEET:
DRAWN BY: IR	DATE: 1-18-08	0246.001.51	1 of 6
CHECKED BY: GGC	SCALE: AS NOTED		



EXISTING DAM EMBANKMENT GEOLOGIC PROFILE (A 1|2)

Scale In Feet: 0 20 40



EXISTING DAM EMBANKMENT SECTION (B 1|2)

Scale In Feet: 0 30 60

NOTES

LAB DATA FOR BORING E-2:

(1)	(2)	(3)	(4)	(5)	(6)
WC=19.9	WC=23.9	WC=17.3	WC=21.0	WC=13.1	WC=34.7
DD=106.6	DD=98.2	DD=112.1	DD=102.5	DD=114.8	-200=72
-200=55	-200=25	+4=22	-200=31	-200=26	LL=40
LL=39	LL=38	-200=33	LL=32	LL=37	PI=7
PI=9	PI=15	LL=34	PI=8	PI=14	
G=2.58		PI=13			

LEGEND:

E-1	BORINGS BY CHEN & ASSOCIATES DRILLED IN 1981 & 1982
16/12	PENETRATION RESISTANCE OF DRIVE SAMPLER, HAMMER BLOWS OVER INCHES OF PENETRATION
WC=13.7	WATER CONTENT IN PERCENT
+4=56	PERCENT LARGER THAN SAND SIZE
-200=16	PERCENT SMALLER THAN SAND SIZE
LL=	LIQUID LIMIT
PI=	PLASTICITY INDEX
ND=	NATURAL DENSITY IN LBS/FT
UC=	UNCONFINED COMPRESSIVE STRENGTH IN PSI
▽	HISTORICALLY MEASURED WATER LEVEL WITH RESERVOIR AT NORMAL WATER LINE

SEO FILE NO

REVISIONS

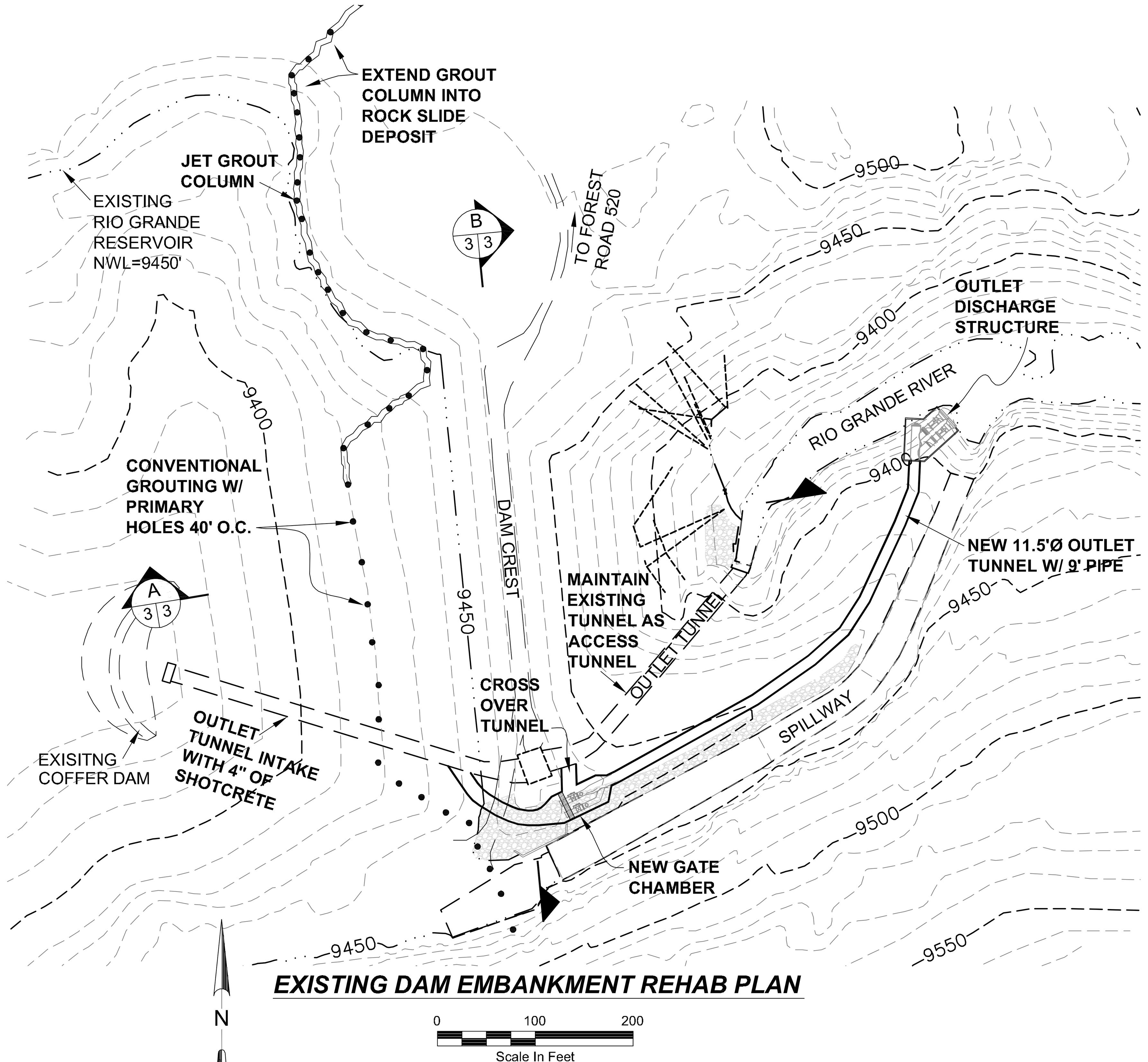
NO.	DESCRIPTION	DATE	BY

RIO GRANDE RESERVOIR

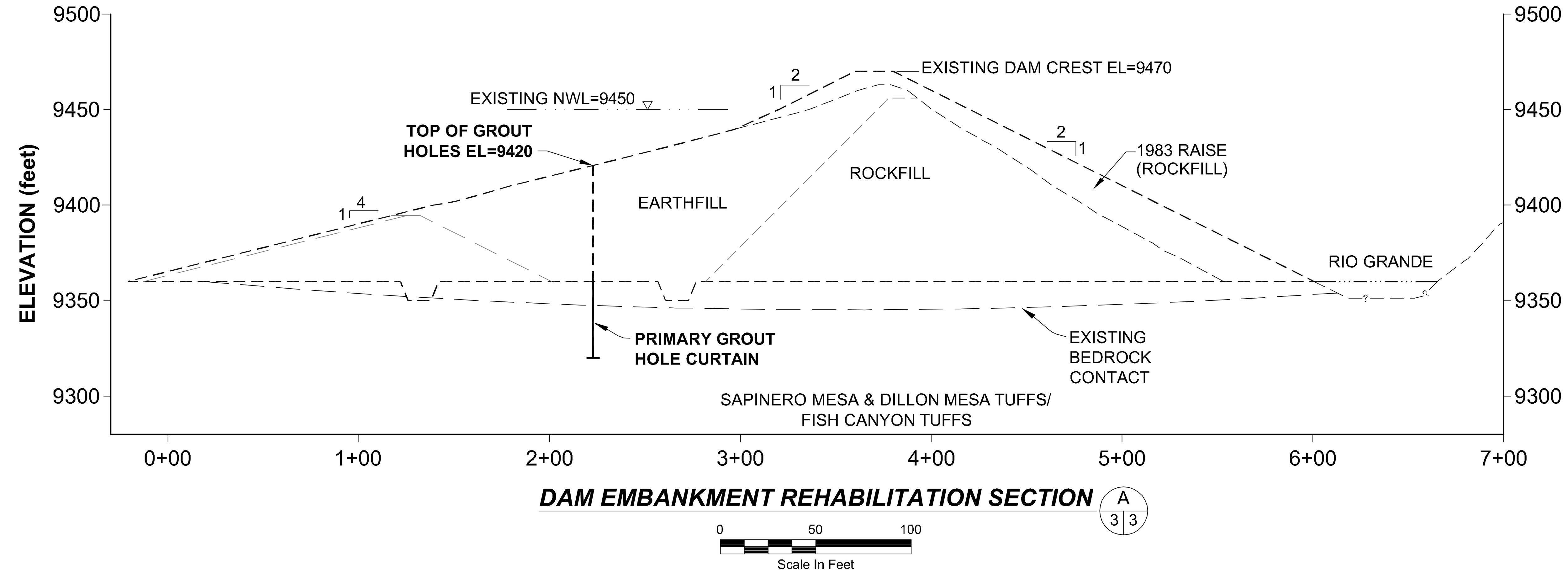
EXISTING DAM EMBANKMENT PROFILE & CROSS SECTION

DEERE & AULT CONSULTANTS, INC.
600 S. AIRPORT RD., BLDG. A, SUITE 205
LONGMONT, CO 80503
TEL 303.651.1468 FAX 303.651.1469

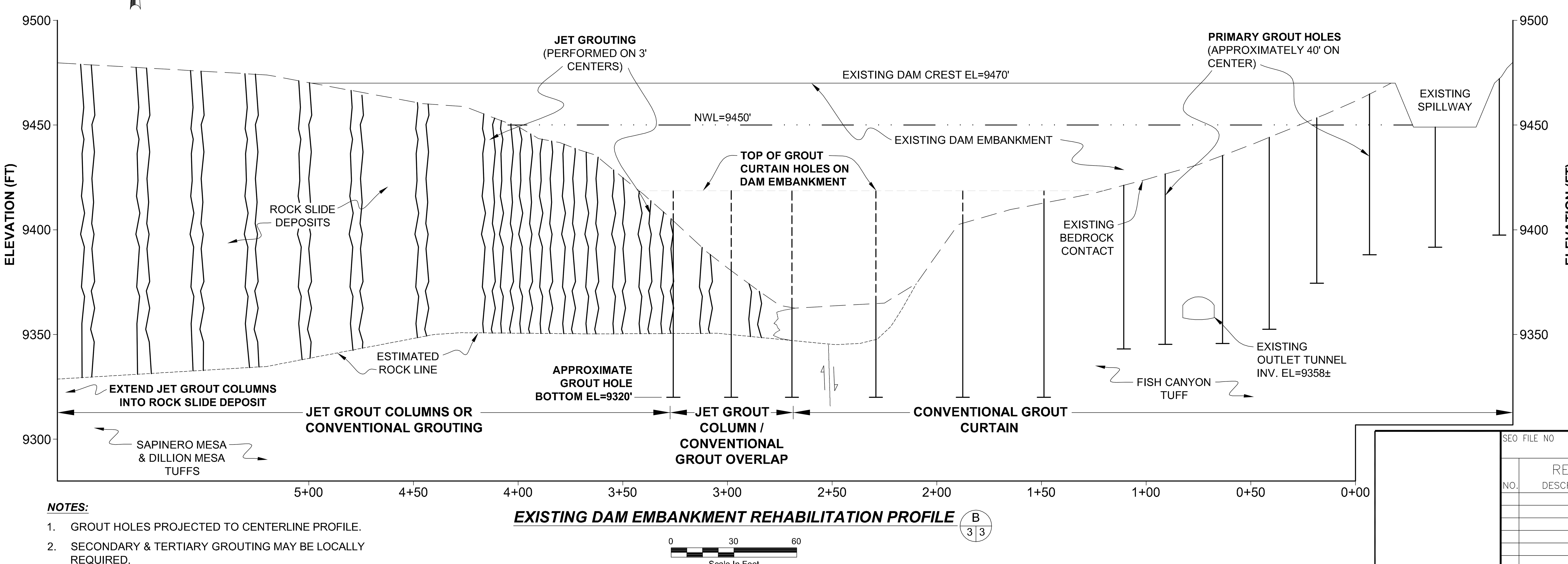
DESIGNED BY: DWD/DF APPROVED BY: DWD
DRAWN BY: IR DATE: 1-18-08
CHECKED BY: GGC SCALE: AS NOTED
JOB NO. 0246.001.51 SHEET: 2 of 6



EXISTING DAM EMBANKMENT REHAB PLAN



DAM EMBANKMENT REHABILITATION SECTION (A 3/3)



EXISTING DAM EMBANKMENT REHABILITATION PROFILE (B 3/3)

NOTES:

1. GROUT HOLES PROJECTED TO CENTERLINE PROFILE.
2. SECONDARY & TERTIARY GROUTING MAY BE LOCALLY REQUIRED.

SEO FILE NO

REVISIONS			
NO.	DESCRIPTION	DATE	BY

RIO GRANDE RESERVOIR

EXISTING DAM EMBANKMENT REHABILITATION

DEERE & AULT CONSULTANTS, INC.
600 S. AIRPORT RD., BLDG. A, SUITE 205 LONGMONT, CO 80503 TEL 303.651.1468 FAX 303.651.1469

DESIGNED BY: DWD/DF	APPROVED BY: DWD	JOB NO.	SHEET:
DRAWN BY: IR	DATE: 1-18-08	0246.001.51	3 of 6
CHECKED BY: GGC	SCALE: AS NOTED		

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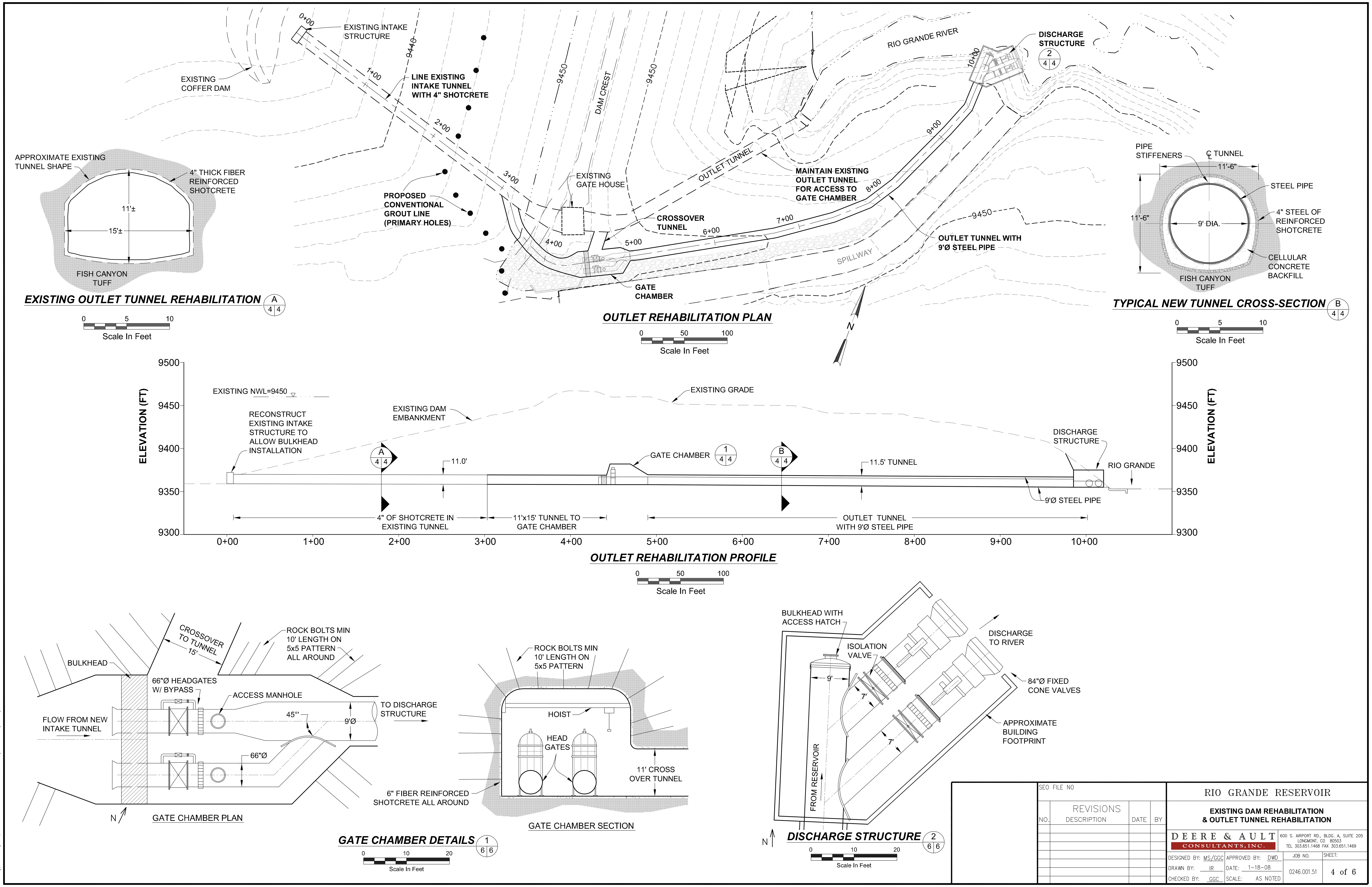
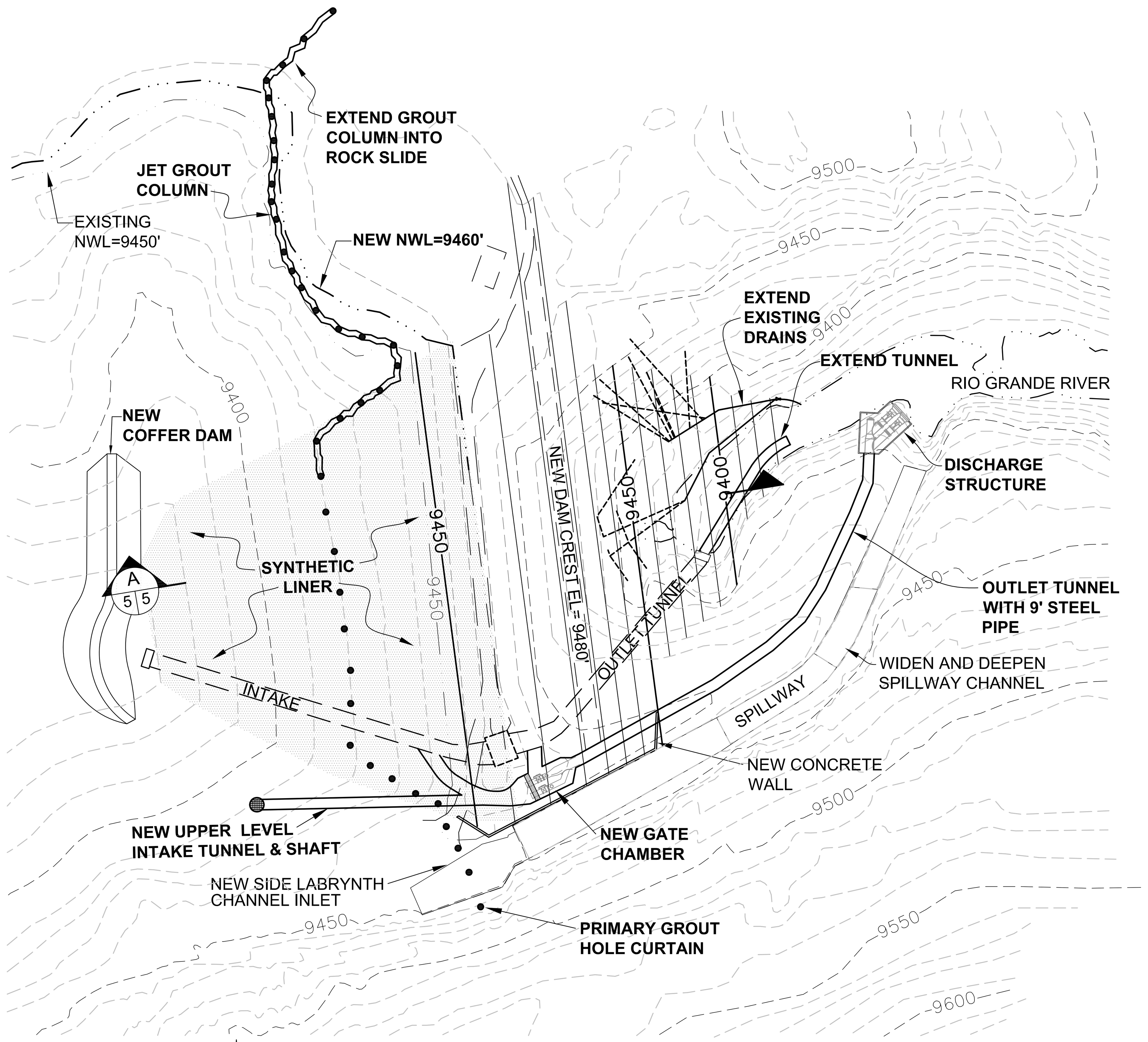




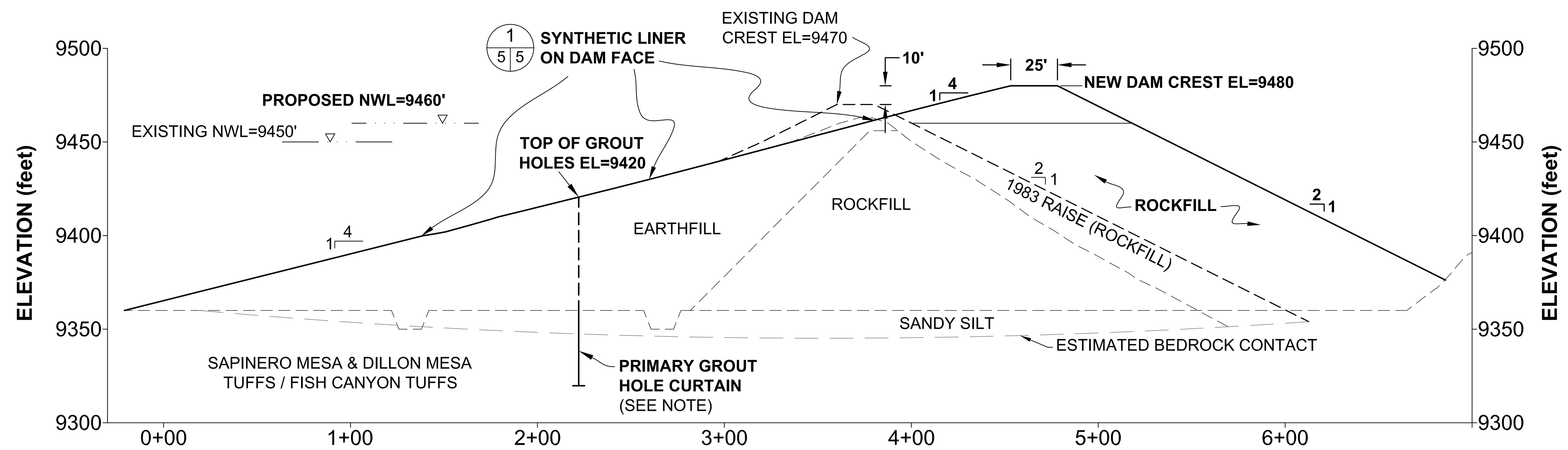
DAM EMBANKMENT RAISE AND RESERVOIR ENLARGEMENT PLAN

Existing Contour Interval=10'
Proposed Contour Interval=10'

0 100 200
Scale In Feet

NOTES:

1. NEW DAM CREST ELEVATION 9480=GAGE HEIGHT 121'.

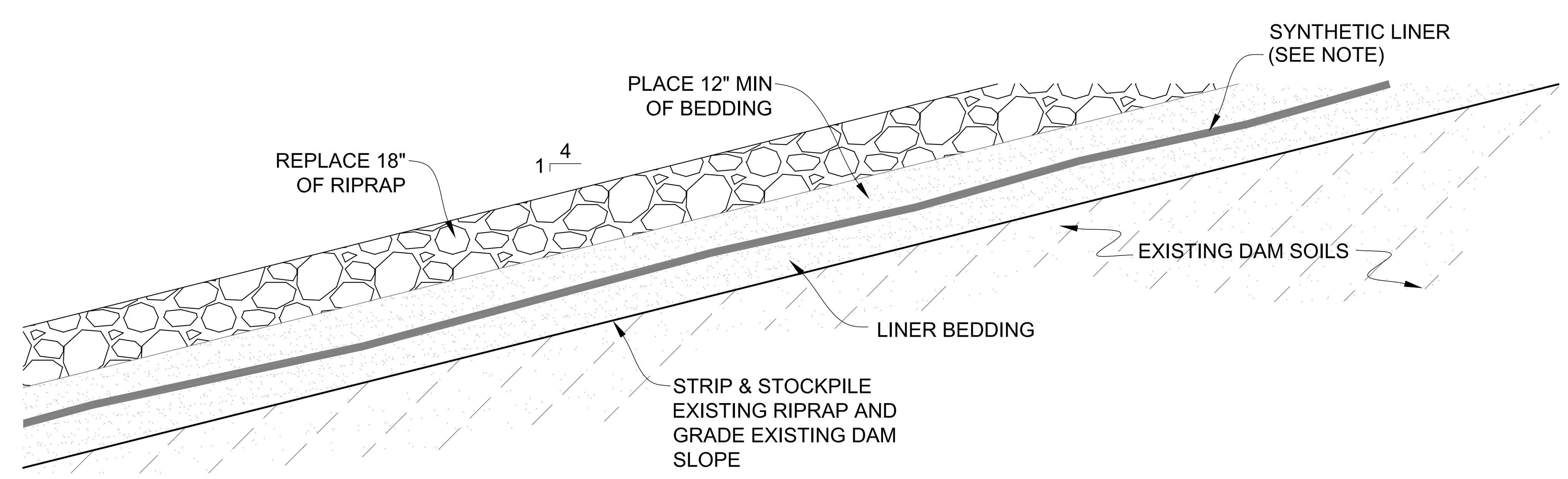


NOTE:

FOR APPROXIMATE GROUTING PROFILE SEE SHEET 3.

DAM EMBANKMENT RAISE CROSS SECTION (A 5/5)

0 50 100
Scale In Feet



SYNTHETIC LINER DETAIL (1 5/5)

NOTE:

EXTEND LINER TO ELEVATION 9465

0 3 6
Scale In Feet

SEO FILE NO				RIO GRANDE RESERVOIR		
REVISIONS				DAM ENLARGEMENT PLAN		
NO.	DESCRIPTION	DATE	BY	DEERE & AULT CONSULTANTS, INC.	600 S. AIRPORT RD., BLDG. A, SUITE 205 LONGMONT, CO 80503 TEL 303.651.1468 FAX 303.651.1469	
				DESIGNED BY: DF/DWD	APPROVED BY: DWD	JOB NO. 0246.001.51
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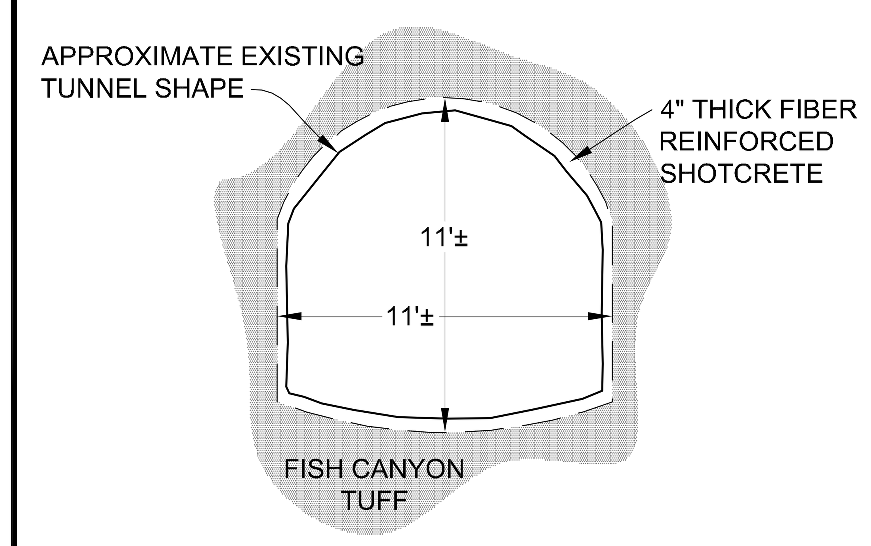
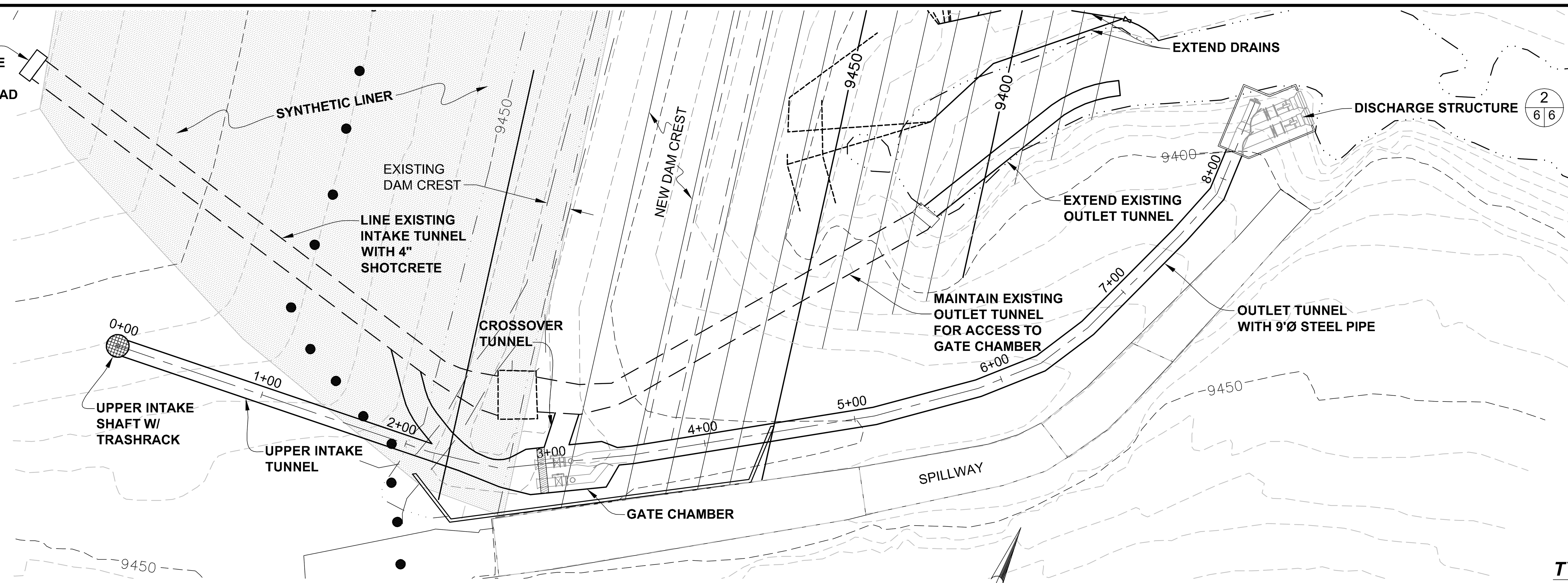


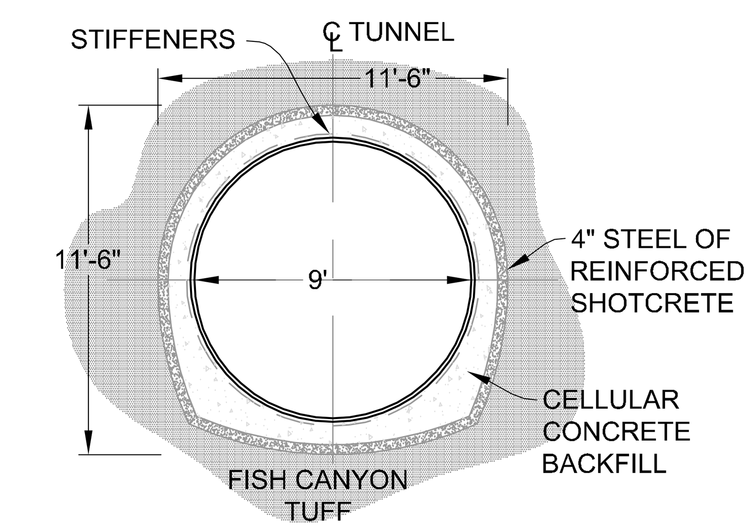
UPPER INTAKE TUNNEL (A 6/6)

0 5 10
Scale In Feet



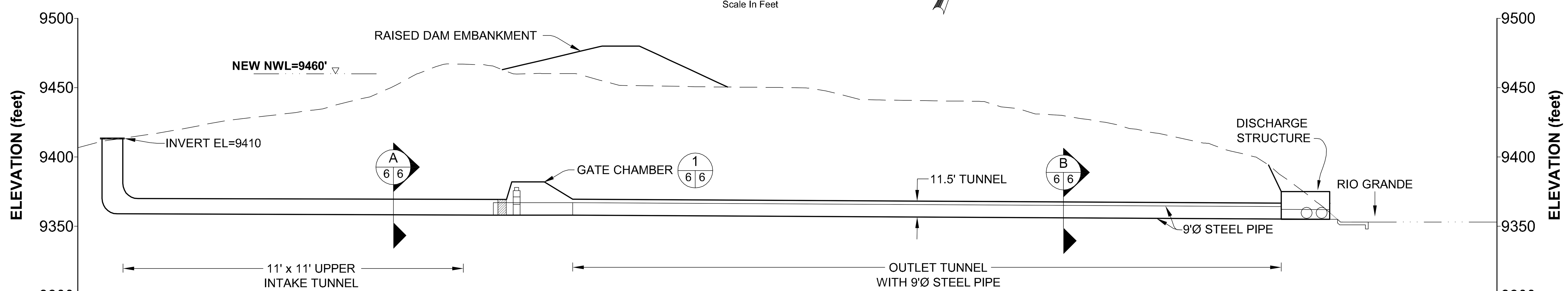
OUTLET TUNNEL PLAN FOR DAM RAISE

0 50 100
Scale In Feet



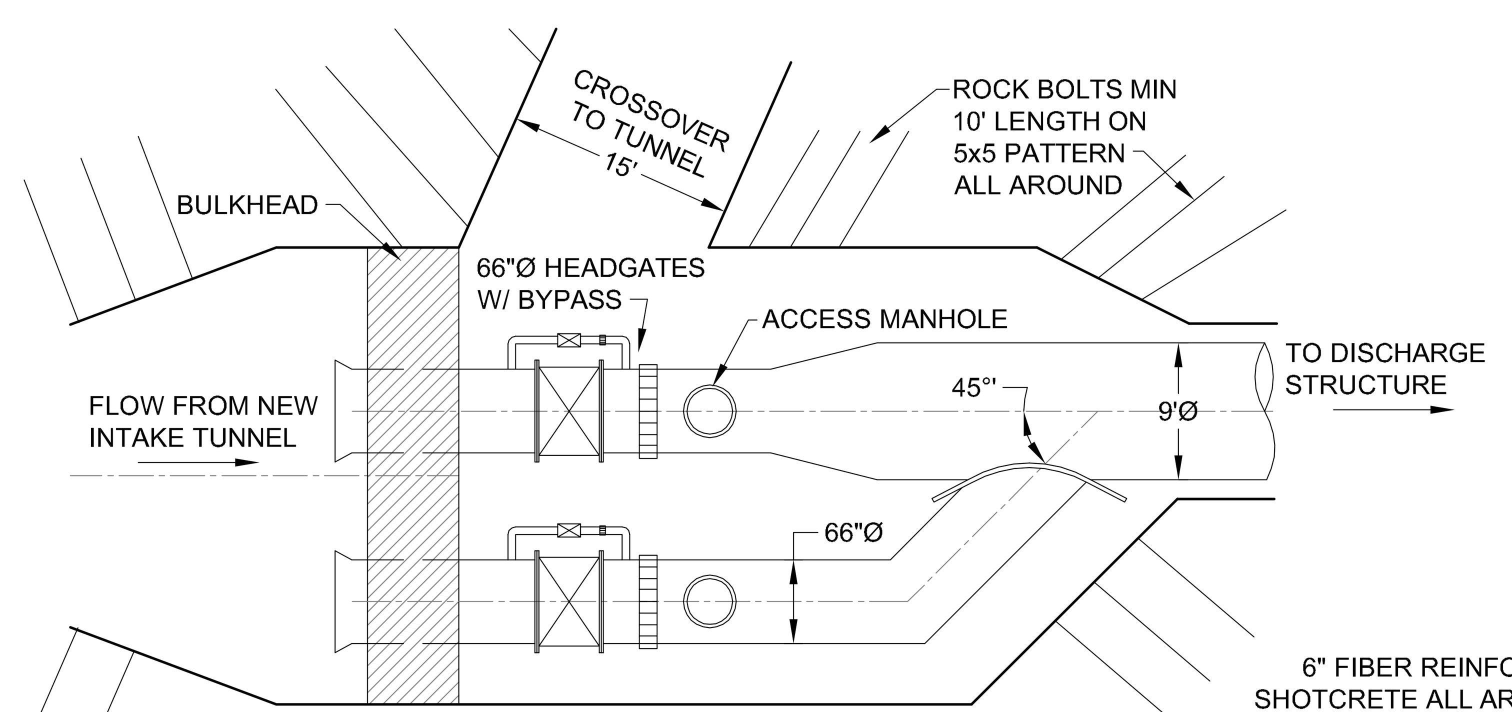
TYPICAL NEW TUNNEL CROSS-SECTION (B 6/6)

0 5 10
Scale In Feet

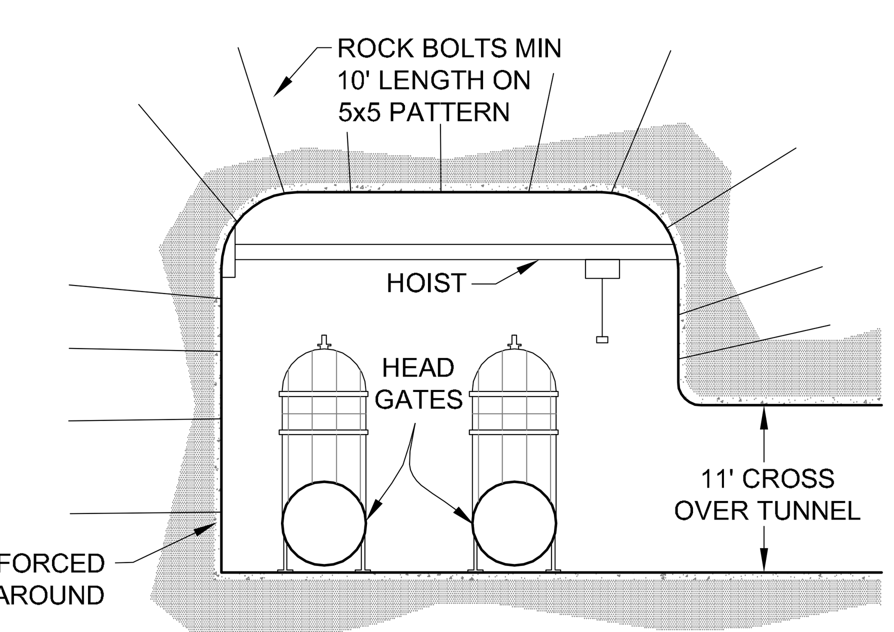


OUTLET TUNNEL PROFILE FOR DAM RAISE

0 50 100
Scale In Feet



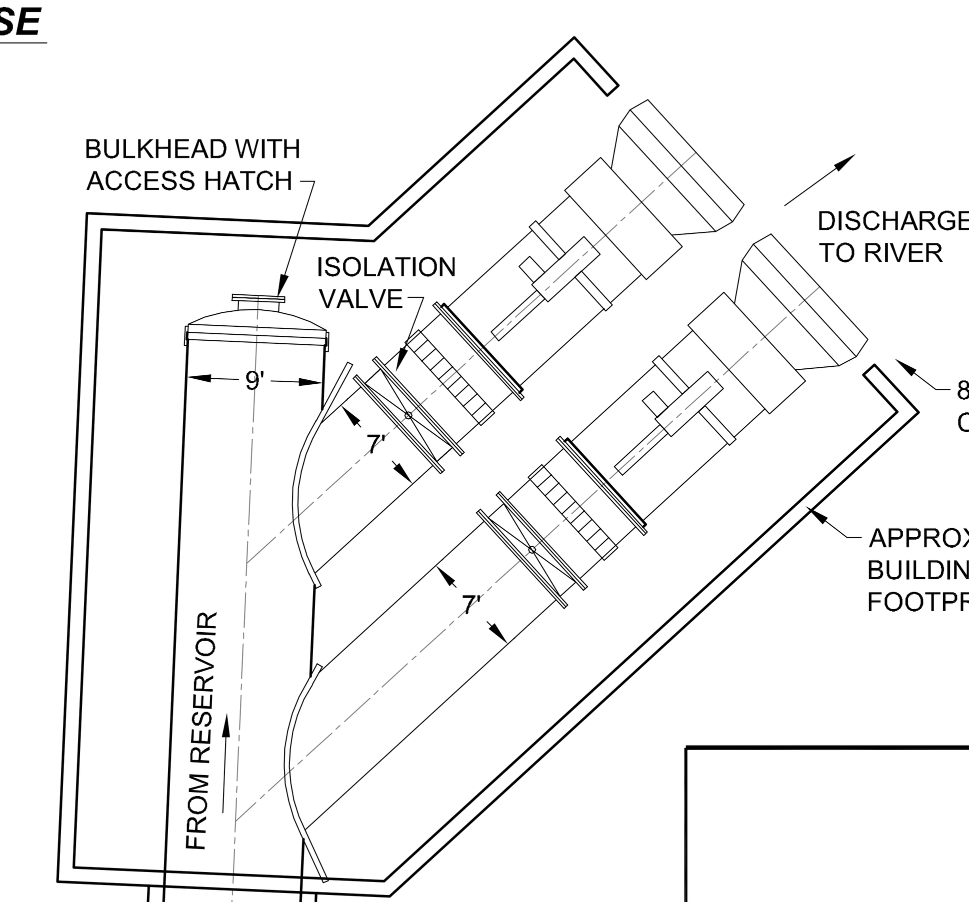
GATE CHAMBER PLAN



GATE CHAMBER SECTION

GATE CHAMBER DETAILS (1 6/6)

0 10 20
Scale In Feet



DISCHARGE STRUCTURE (2 6/6)

0 10 20
Scale In Feet

SEO FILE NO			
REVISIONS			
NO.	DESCRIPTION	DATE	BY

RIO GRANDE RESERVOIR

OUTLET TUNNEL WITH DAM RAISE

DEERE & AULT CONSULTANTS, INC.
600 S. AIRPORT RD., BLDG. A, SUITE 205 LONGMONT, CO 80503 TEL 303.651.1468 FAX 303.651.1469

DESIGNED BY: MS/GGC	APPROVED BY: DWD	JOB NO.	SHEET:
DRAWN BY: IR	DATE: 1-18-08	0246.001.51	6 of 6
CHECKED BY: GGC	SCALE: AS NOTED		

Appendix B
Spillway Improvements Preliminary Design

WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO

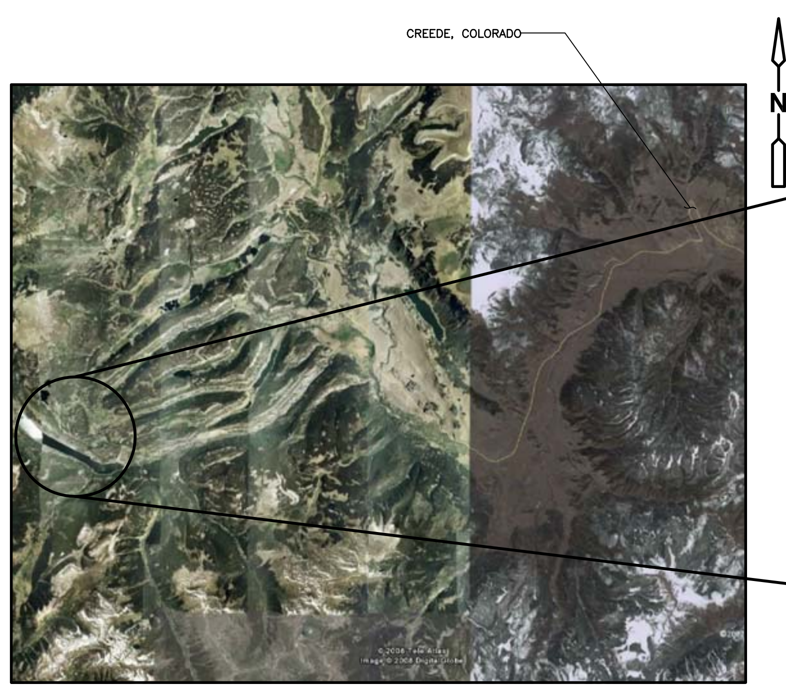
RIO GRANDE RESERVOIR SPILLWAY IMPROVEMENTS

MARCH 2008

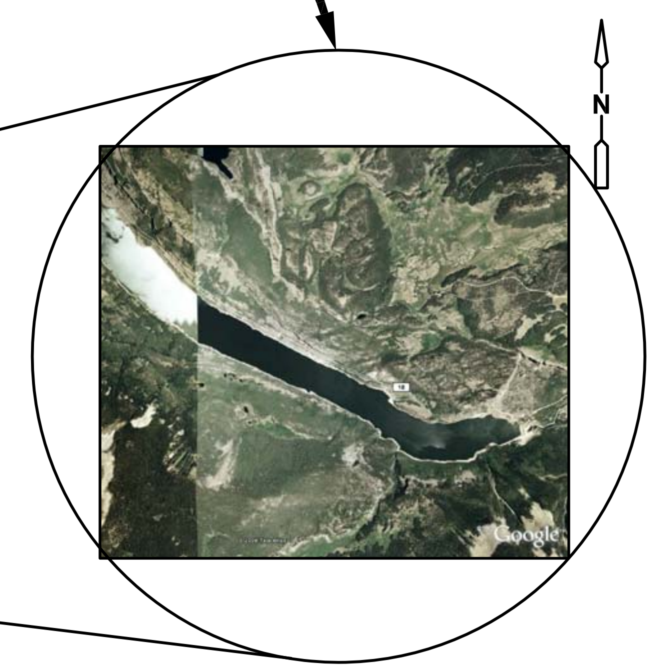
PROJECT LOCATION

CLIENT
SAN LUIS VALLEY IRRIGATION DISTRICT
296 MILES STREET
CENTER, CO 81125
TEL: (719) 754-2254
CONTACT: TRAVIS SMITH

ENGINEER
CDM, Inc.
555 17th STREET, SUITE 1100
DENVER, CO 80202
TEL: (303) 383-2300
CONTACT: BRIAN MURPHY, P.E.



VICINITY MAP



LOCATION MAP
(NTS)

DRAWING INDEX:

GENERAL:

G-1	TITLE SHEET
G-2	LEGEND AND ABBREV.

CIVIL:

C-1	EXISTING SPILLWAY CONDITIONS & RATING CURVE
C-2	EXISTING SPILLWAY REHABILITATION PLAN
C-3	NEW SPILLWAY PLAN FOR ENLARGED DAM
CD-1	EXISTING SPILLWAY REHABILITATION DETAILS
CD-2	NEW SPILLWAY DETAILS
CD-3	SPILLWAY CHUTE WALL DETAILS

NOTE:
1. ALL ELEVATIONS ARE IN GAGE HEIGHT UNLESS OTHERWISE NOTED.
2. GAGE HEIGHT 91 FEET = ELEVATION 9450 FEET.

CAMP DRESSER & McKEE INC.
DENVER, COLORAD0
PRELIMINARY DESIGN - NOT FOR CONSTRUCTION

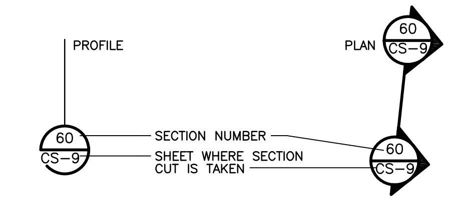
G-1

S:\43844\60541\GEN\ GCSGN001 04/03/08 14:03 morenoma

CIVIL LEGEND

EXISTING / NEW	
	AC PAVEMENT
	GRAVEL SURFACE
	CONCRETE WALK AND PAVEMENT
	PLAIN RIPRAP
	PLANTED RIPRAP
	CONCRETE
	WETLAND AREA
	CHANNEL CENTERLINE
× 1000.0 / ⊗1000.0	SPOT ELEVATION
1000 / 1000	CONTOUR
1000	DEPRESSION CONTOUR (HATCH MARKS POINT TO BOTTOM OF DEPRESSION)
	WETLAND BOUNDARY
	RIVER / CREEK
	STACKED BOULDER WALL
12"SAN	SANITARY SEWER (WITH PIPE SIZE)
8"W	WATER MAIN (WITH PIPE SIZE)
20"GAS	GAS MAIN (WITH PIPE SIZE)
OHE	OVERHEAD ELECTRIC
OHET	OVERHEAD ELECTRIC AND TELEPHONE
CON 2"	CONDUIT
24"STM / 24"STM	STORM DRAIN (WITH PIPE SIZE)
	CHAIN LINK FENCE
	UTILITY POLE
	LIGHT POLE
	SANITARY SEWER MANHOLE
	DROP INLET
	STORM SEWER MANHOLE
	GEOTECHNICAL BORING
8"dia	TREE
	CONTROL POINT
	SECTION CORNER
	INFORMATION SIGN
S	STOP SIGN
	SLOPE MARKER
	BOLLARD AND CABLE
	CENTER LINE
	MATCH OR SECTION LINE
	EXISTING STRUCTURE
P/L	PROPERTY LINE/RIGHT OF WAY
	ROAD
	GUARD RAIL
	CONSTRUCTION FENCE
	SILT FENCE
	SPLIT RAIL FENCE

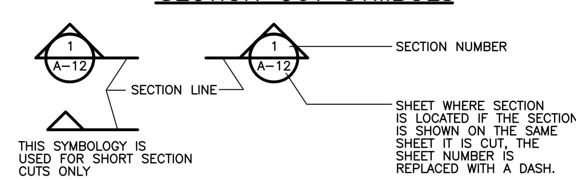
PLAN & PROFILE SYMBOLS



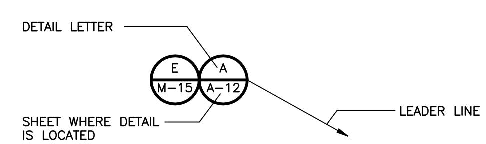
— · · — · · —	CHANNEL EXTENTS
— — —	CHANNEL CENTERLINE (EXISTING & PROPOSED)
———	PROPOSED CONDITIONS (PROFILE)
- - - - -	EXISTING CONDITIONS (PROFILE)
———	PROPOSED THALWEG (PROFILE)
- - - - -	EXISTING THALWEG (PROFILE)
— ESMT —	EASEMENT BOUNDARY
— P\L —	PROPERTY LINE BOUNDARY
━━━	CONSTRUCTION STAGING AREA BOUNDARY

NOTE: HATCHING SCALE MAY VARY DEPENDING ON ROCK TYPE

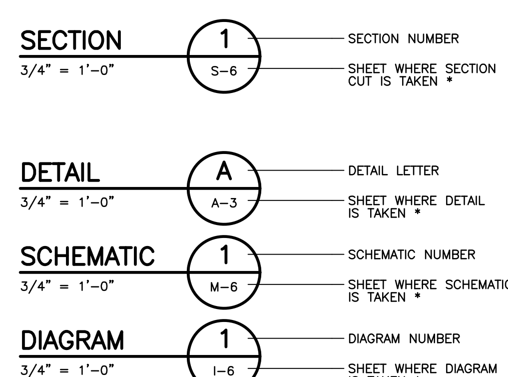
SECTION CUT SYMBOLS



DETAIL CALL OUT SYMBOLS



DRAWING, SECTION AND DETAIL TITLES



* IF SECTION, DETAIL, SCHEMATIC OR DIAGRAM IS DRAWN ON THE SAME SHEET THAT IT IS TAKEN FROM, THE SHEET NUMBER IS REPLACED WITH A HYPHEN. IF THE SECTION IS REFERENCED ON MULTIPLE SHEETS, THE SHEET NUMBER SHOWN INDICATES THE FIRST SHEET THE SECTION IS TAKEN FROM.

△	PANEL POINT
⊚	SURVEY POINT
⊕	GEOTECHNICAL BORING
▲	BENCH MARK

NOTES:

1. IN GENERAL, EXISTING STRUCTURES AND FACILITIES ARE SHOWN IN LIGHT LINE WEIGHTS, OR ARE SHOWN AS SCREENED BACKGROUND. NEW STRUCTURES ARE SHOWN IN SOLID LINE WEIGHTS. SCREENING OR LIGHT LINE WEIGHTS ARE ALSO USED TO CLARIFY DRAWINGS. FOR EXAMPLE, NEW AND EXISTING STRUCTURES ARE SCREENED ON MECHANICAL DRAWINGS TO HIGHLIGHT NEW PIPING AND EQUIPMENT.
2. THIS IS A STANDARD SHEET; NOT ALL ITEMS MAY BE REQUIRED IN THIS PROJECT.
3. SEE ALSO INDIVIDUAL DRAWINGS AND SPECIFICATIONS FOR ADDITIONAL INFORMATION.
4. INDICATES FACILITIES, EQUIPMENT, OR PIPING TO BE DEMOLISHED UNLESS OTHERWISE NOTED.
5. CONSTRUCTION STAGING AREA
6. PRESERVATION AREA
7. LIMITS OF CONSTRUCTION/PROJECT BOUNDARY

ABBREVIATIONS

&	AND
Ø	DIAMETER
⌃	PERPENDICULAR
#	NUMBER
@	AT
AC	ASPHALTIC CONCRETE, ASBESTOS CEMENT,
ACI	AMERICAN CONCRETE INSTITUTE
ANSI	AMERICAN NATIONAL STANDARDS UNITS
AP	ACCESS PANEL
APA	AMERICAN PLYWOOD ASSOCIATION
APPROX	APPROXIMATE (LY)
ARCH	ARCHITECTURAL
ARND	AROUND
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AVG	AVERAGE
BC	BEGIN CURVE
BEL	BELOW
BLDG	BUILDING
BLK	BLOCK(ING)
BM	BEAM, BENCHMARK
BRG	BEARING
BTWN	BETWEEN
BVCE	BEGINNING OF VERTICAL CURVE ELEVATION
BVCS	BEGINNING OF VERTICAL CURVE STATION
C TO C	CENTER TO CENTER
CB	CATCH BASIN, CIRCUIT BREAKER
CHAN	CHANNEL
C/L	CHAIN LINK
CL	CENTER LINE
CONC	CONCRETE
CONN	CONNECT(ION)
CONSTR	CONSTRUCTION
CONT	CONTINUOUS, CONTINUATION, CONTINUED
CONTR	CONTRACT(OR)
CORP	CORPORATION
CTJ	CONTROL JOINT
CTR	CENTER, CENTERED
CTRL	CONTROL
CW	CLOCK WISE
CY	CUBIC YARD
D	DRAIN, DEEP, DEPTH
d	PENNY
DBL	DOUBLE
DEG	DEGREE
DEMO	DEMOLITION, DEMOLISH
DET	DETAIL
DIA	DIAMETER
DIAG	DIAGRAM, DIAGONAL
DIM	DIMENSION
DI	DROP INLET
DN	DOWN
DWG	DRAWING
DWL	DOWEL
E	EASTING, EAST
(E)	EXISTING
EA	EACH
EC	END CURVE
ECC	ECCENTRIC
EF	EACH FACE
EL, ELEV	ELEVATION
ENGR	ENGINEER
EVCE	END OF VERTICAL CURVE ELEVATION
EVCS	END OF VERTICAL CURVE STATION
EQ	EQUAL(LY)
EX, EXIST	EXISTING
FG	FINISH GRADE
FT	FOOT
GC	GENERAL CONTRACTOR
GEN	GENERATOR, GENERAL
GRTG	GRATING
GND	GROUND
GR	GRADE, GUARDRAIL
HGL	HYDRAULIC GRADE LINE
HOR	HORIZONTAL
IE	INVERT ELEVATION
IN	INCH, INLET
INV	INVERT
JUNCT	JUNCTION
K	KIP(S), KEY, CURVE COEFFICIENT
L	LENGTH, STRUCTURAL ANGLE
LOC	LOCATION
LONG	LONGITUDINAL
LF	LINEAR FEET
LT	LEFT, LIGHT
LWS	LOW WATER SURFACE
M	METER
MAN	MANUAL
MATL	MATERIAL
MAX	MAXIMUM
MFR	MANUFACTURER
MIN	MINIMUM, MINUTE
MISC	MISCELLANEOUS
M/L	MATCH LINE
N	NORTH, NORMAL, NEUTRAL, NORTHING
NA	NOT APPLICABLE
NIC	NOT IN CONTRACT
NOM	NOMINAL
NS	NEAR SIDE
N/S	NORTH/SOUTH
NTS	NOT TO SCALE
OC	ON CENTER
OD	OUTSIDE DIAMETER
O/E	OR EQUAL
OF	OUTSIDE FACE
OH	OVERHEAD
OPER	OPERATOR, OPERATE
OPNG	OPENING
OPP	OPPOSITE
OPT	OPTIONAL
PC	POINT OF CURVATURE
PI	POINT OF INTERSECTION
P/L	PROPERTY LINE
PP	POWER POLE
PR	PAIR
PREFAB	PREFABRICATED
PT	POINT, POINT OF TANGENCY
PVI	POINT OF VERTICAL INTERSECTION
PVMT	PAVEMENT
PWR	POWER
R	RISER, RADIUS
RAD	RADIUS
RD	ROOF DRAIN, ROAD
RECT	RECTANGULAR
RED	REDUCE(R)
REF	REFERENCE
REINF	REINFORCE (D) (ING) (MENT)
REQD	REQUIRED
RET	RETURN, RETAINING
RT	RIGHT
R/W	RIGHT OF WAY
SCH	SCHEDULE
SD	STORM DRAIN
SECT	SECTION
SED	SEDIMENTATION
SF	SQUARE FEET
SHT	SHEET
SIM	SIMILAR
SL	SLOPE, SLOW
SPEC	SPECIFICATION(S), SPECIFIED
SQ	SQUARE
SS	SANITARY SEWER, START – STOP
STA	STATION
STD	STANDARD
STRUCT	STRUCTURE (AL)
SUPP	SUPPORT
S/W	SIDEWALK
SYM	SYMMETRICAL
SYS	SYSTEM
T	TOP
T&B	TOP AND BOTTOM
TC	TOP OF CURB, TOP OF CONCRETE
TEMP	TEMPORARY
THK	THICK(NESS)
T.O.	TOP OF
TOC	TOP OF CONCRETE
TOP	TOP OF PAVEMENT
TW	TOP OF WALL
TYP	TYPICAL
UBC	UNIFORM BUILDING CODE
UNO	UNLESS NOTED OTHERWISE
V_{100}	100–YEAR EVENT DISCHARGE VELOCITY
VAR	VARIES
VC	VERTICAL CURVE
VERT	VERTICAL
VIF	VERIFY IN FIELD
VPI	VERTICAL POINT OF INTERSECTION
W	WATER, WIDE, WASTE
W/	WITH
WL	WATER LEVEL
W/O	WITHOUT
WSE_{10}	10–YEAR EVENT WATER SURFACE ELEVATION
WSE_{100}	100–YEAR EVENT WATER SURFACE ELEVATION

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: CDM
DRAWN BY: K. SIMPSON
SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

CDM
Camp Dresser & McKee
555 17th Street, Suite 1100
Denver, CO 80202
Tel: (303) 383-2300
consulting • engineering • construction • operations

VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE

WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

GENERAL NOTES, LEGEND, & ABBREVIATIONS

PROJECT NO. 43844–60541
FILE NAME: CSYGN001
SHEET NO.
G-2

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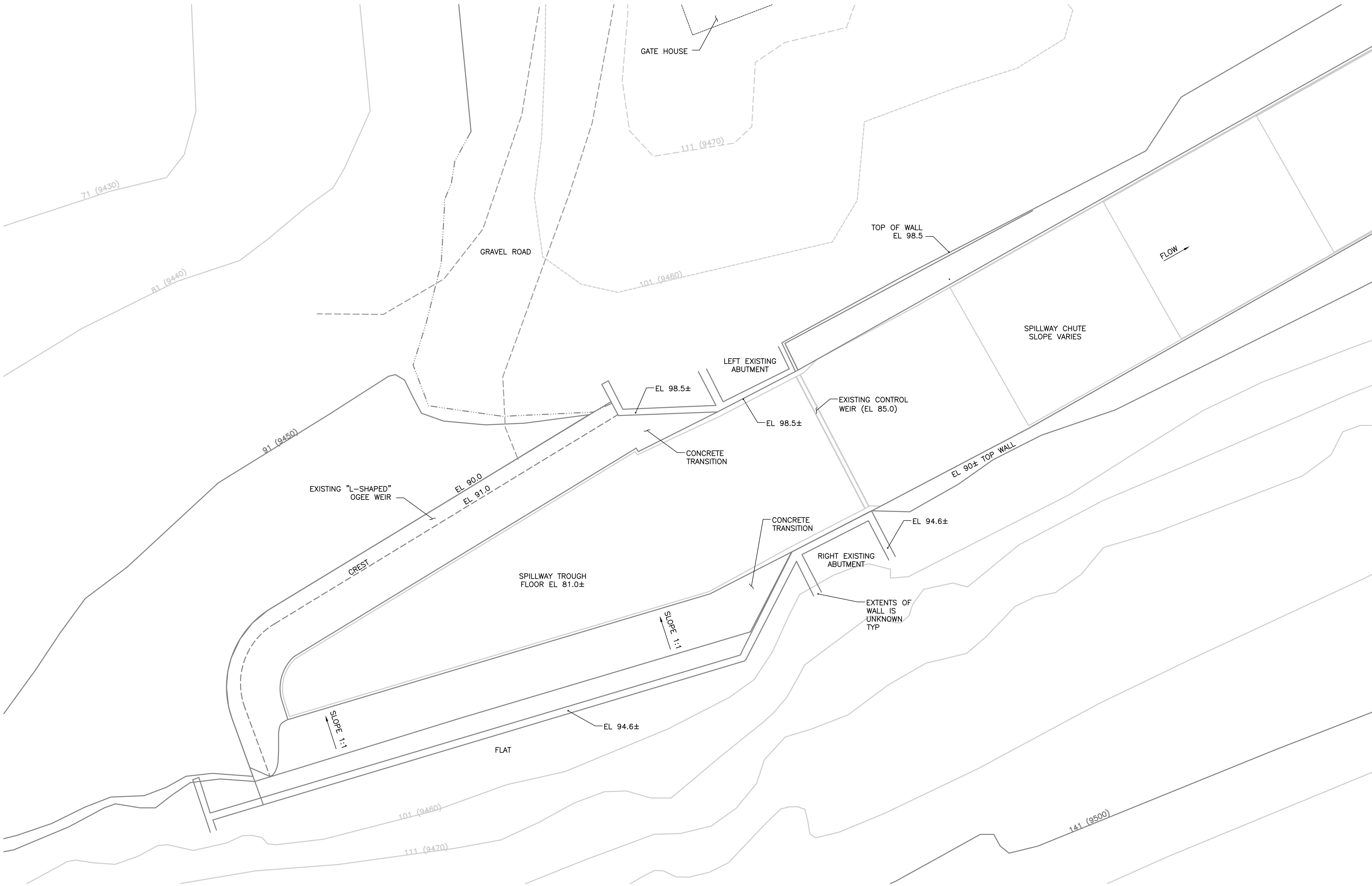

EXISTING PLAN

PRELIMINARY DESIGN NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: S. GAITAN
DRAWN BY: K. SIMPSON
SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

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HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

EXISTING SPILLWAY PLAN

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO. C-1

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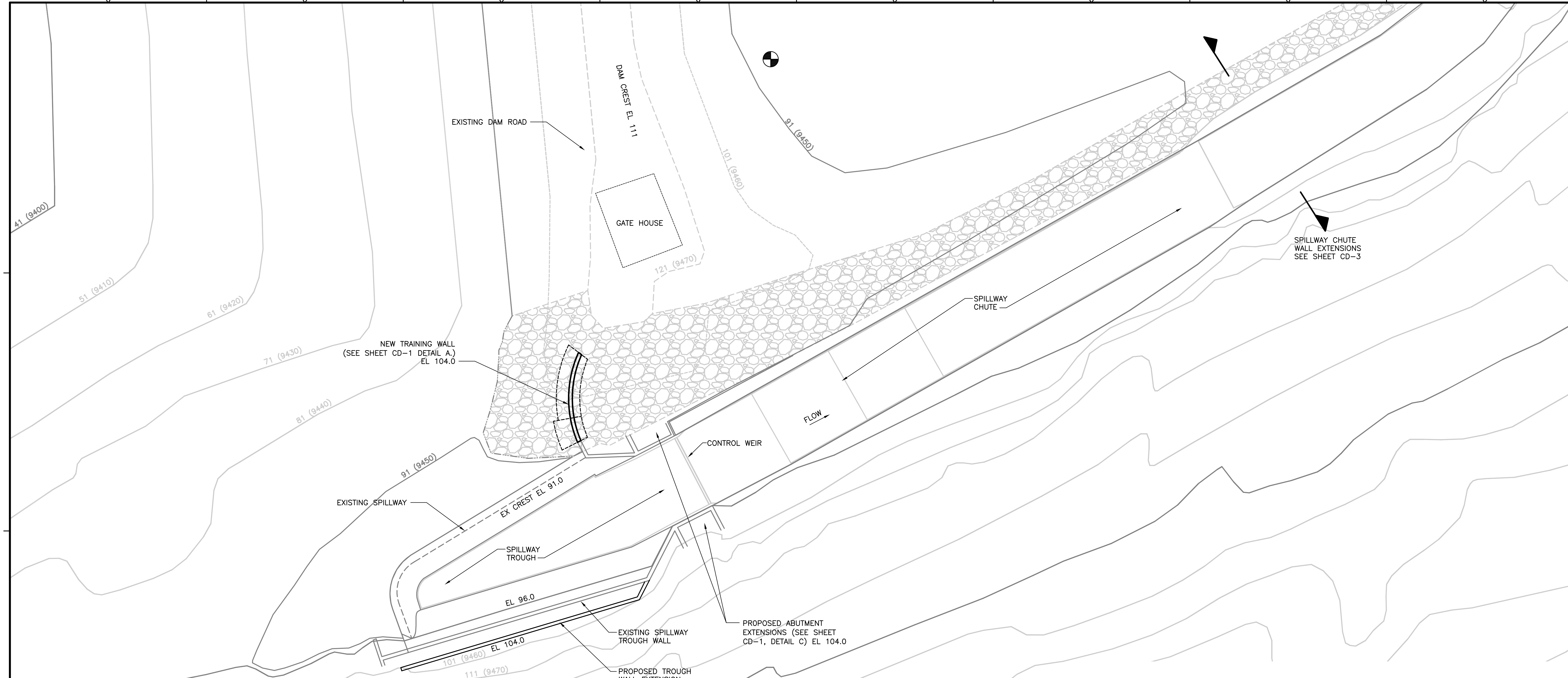

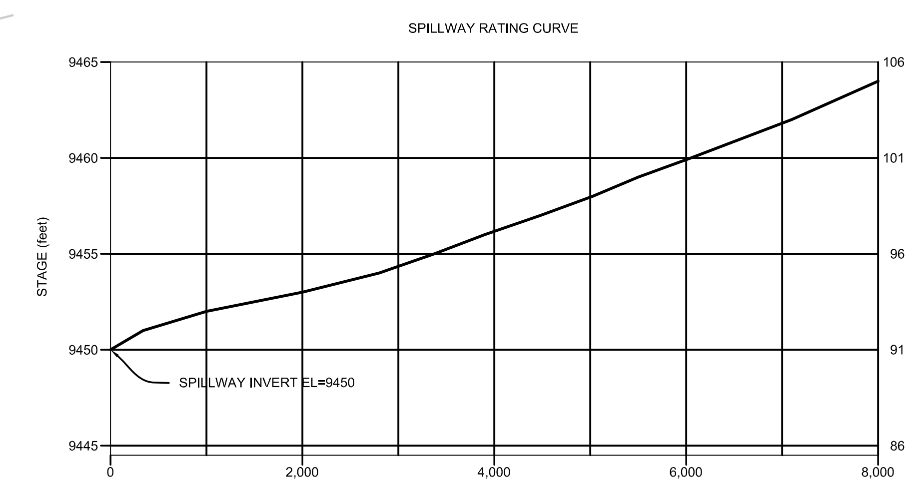

REHABILITATED SPILLWAY

PLAN

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: S. GAITAN
DRAWN BY: K. SIMPSON
SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

CDM
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555 17th Street, Suite 1100
Denver, CO 80202
Tel: (303) 383-2300
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WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

SPILLWAY REHABILITATION PER PLAN FOR EXISTING DAM

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO.
C-2

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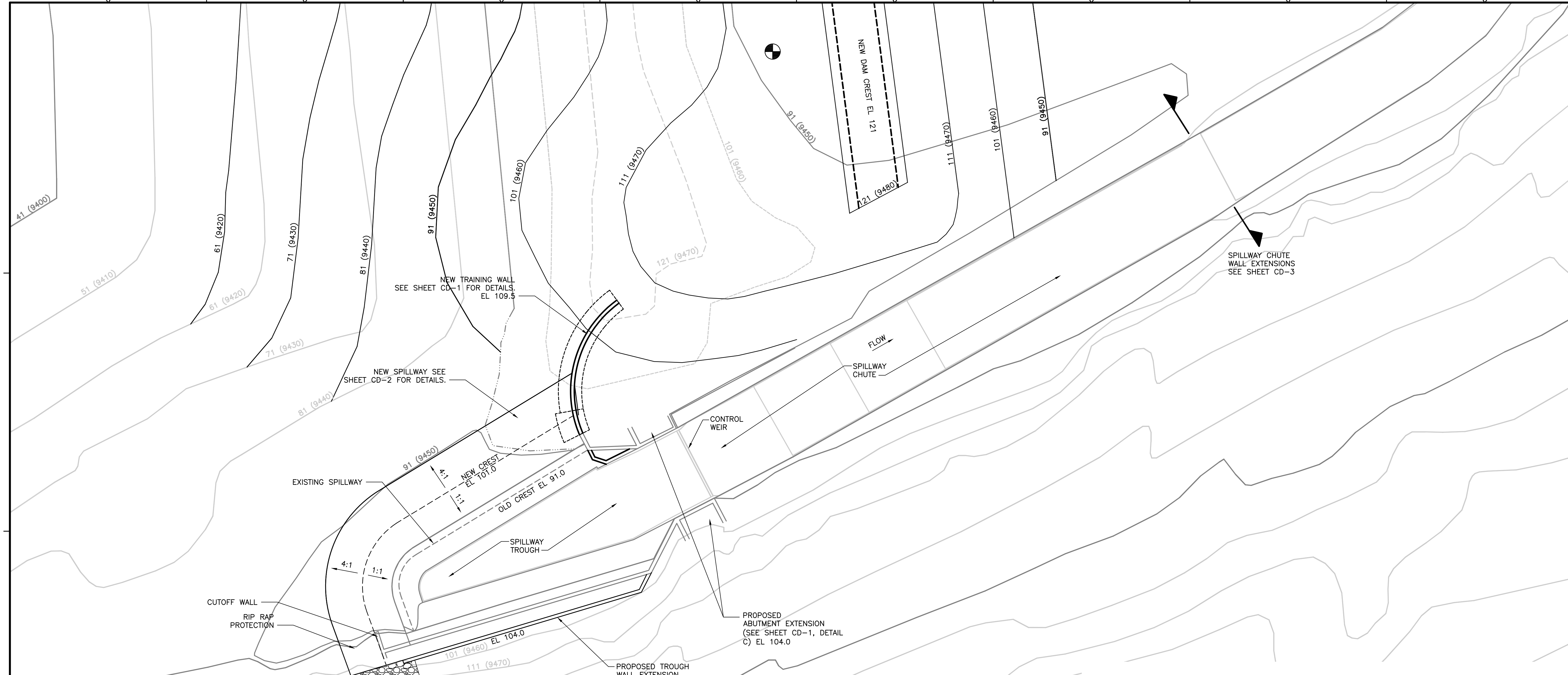
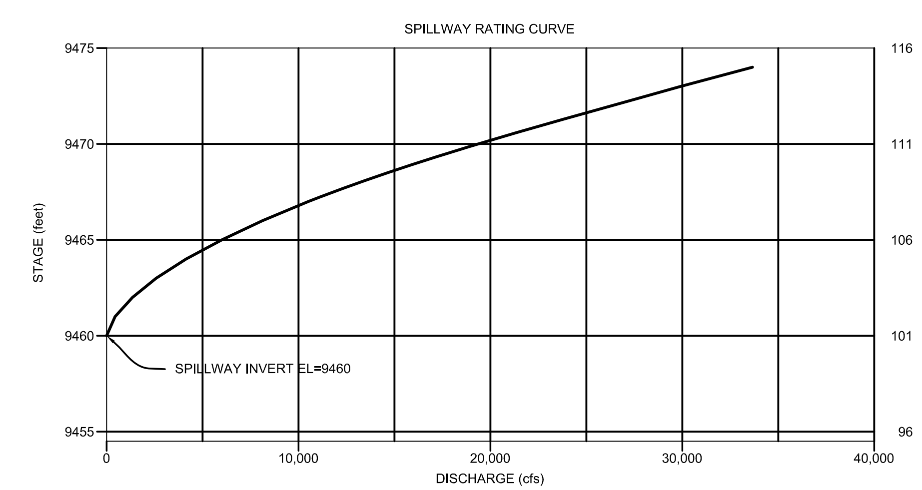


PROPOSED SPILLWAY PLAN



PRELIMINARY DESIGN NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: S. GAITAN
DRAWN BY: K. SIMPSON
SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

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Camp Dresser & McKee
555 17th Street, Suite 1100
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HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

SPILLWAY PLAN FOR ENLARGED DAM

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO. C-3

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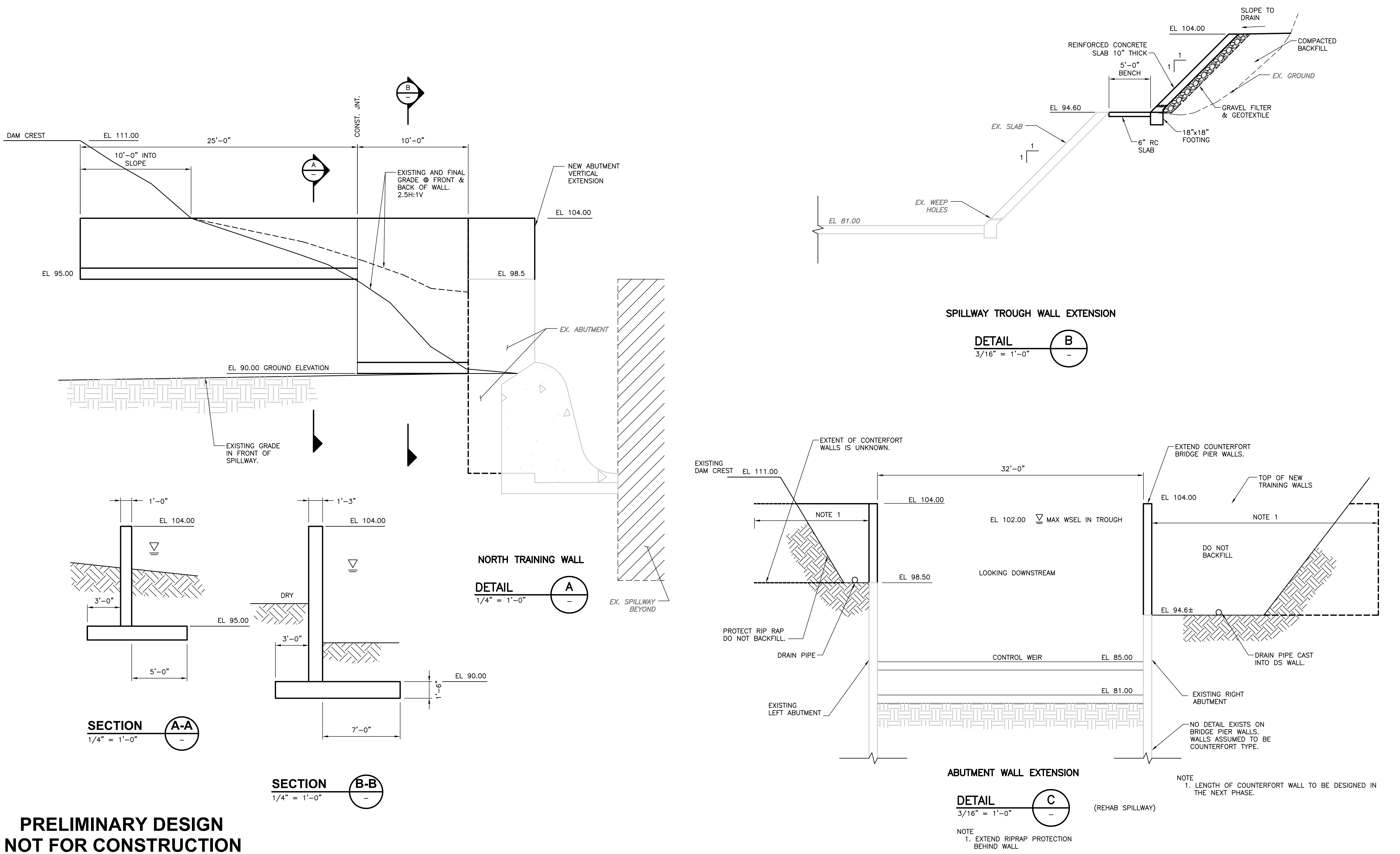

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: S. GAITAN
DRAWN BY: K. SIMPSON
SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

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555 17th Street, Suite 1100
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WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

EXISTING SPILLWAY REHABILITATION DETAILS

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO.
CD-1

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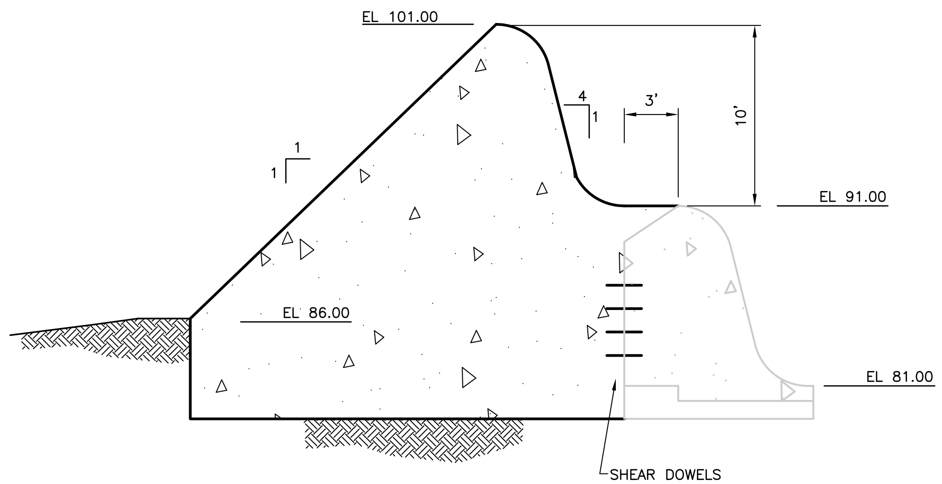
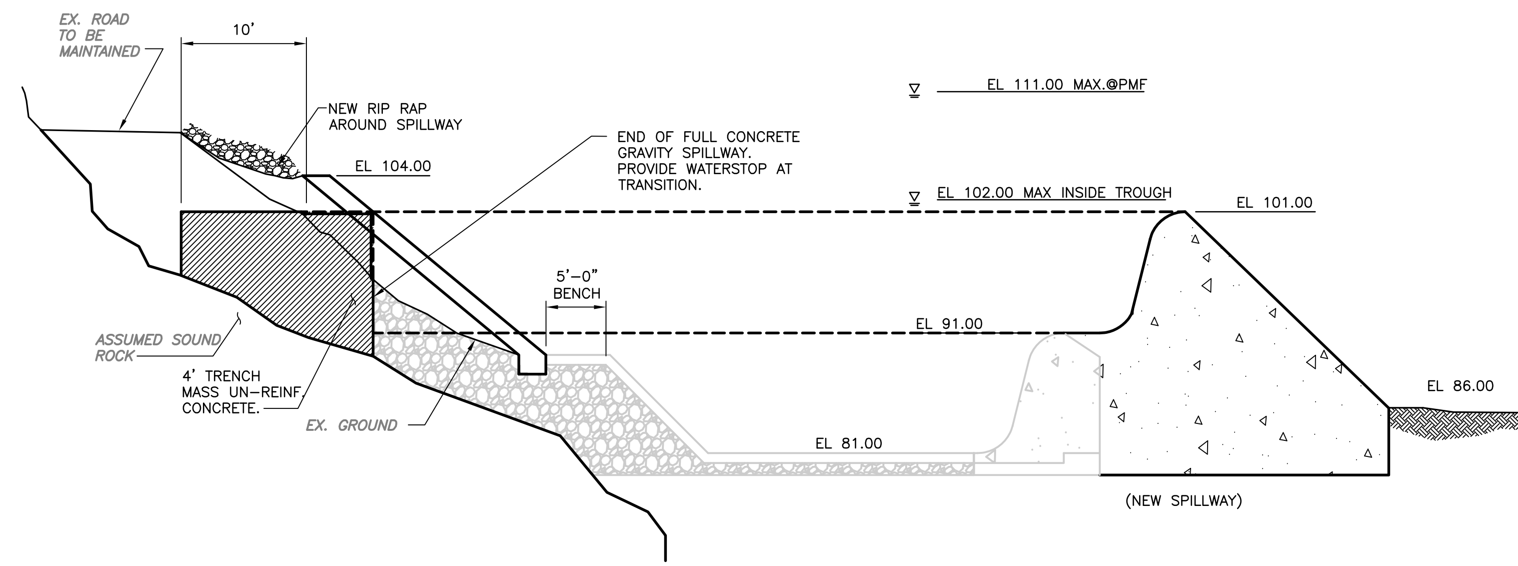
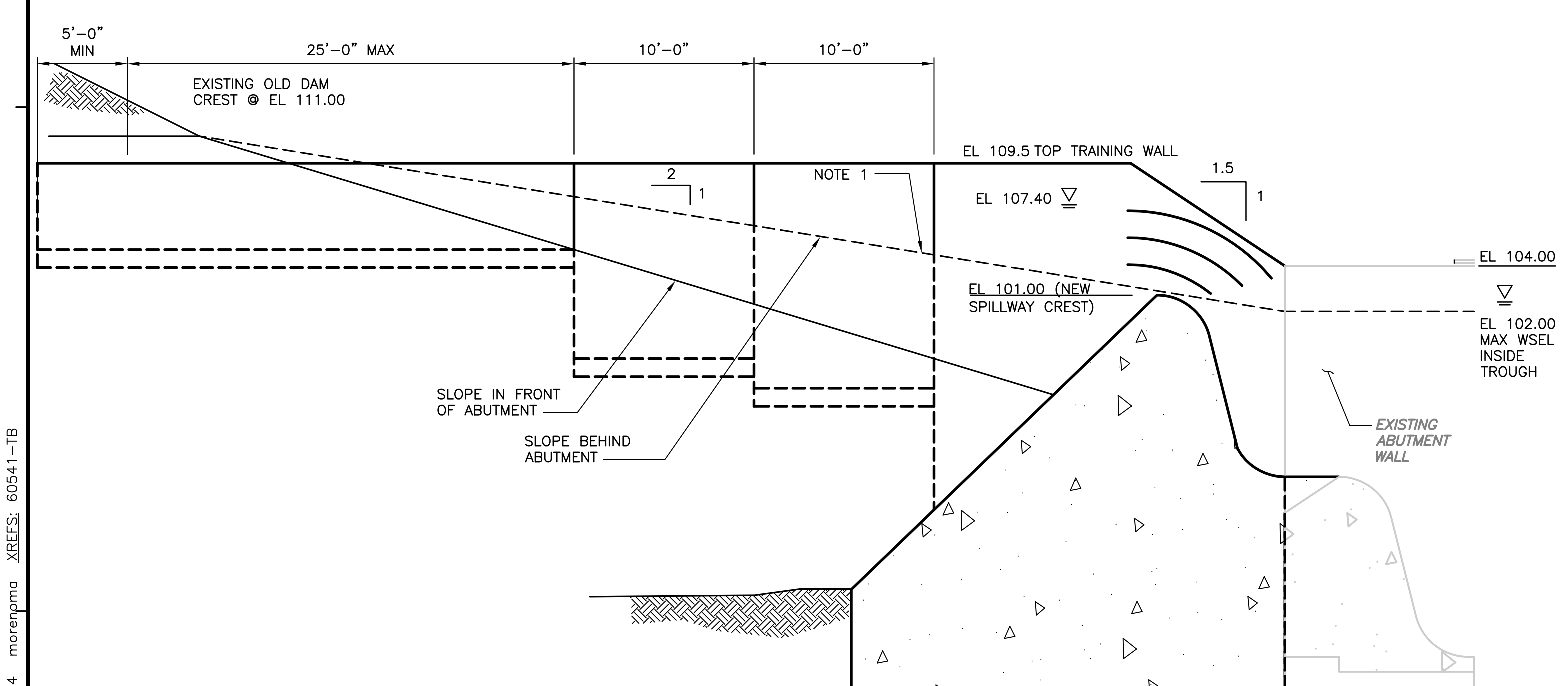


NEW SPILLWAY
DETAIL A
3/16" = 1'-0"



ABUTMENT TIE-IN (LOOKING WEST)
DETAIL C
1/8" = 1'-0"



LEFT ABUTMENT TRAINING WALL
DETAIL B
3/16" = 1'-0"

NOTE
1. LENGTH OF COUNTERFORT WALL TO BE DESIGNED IN THE NEXT PHASE.

PRELIMINARY DESIGN NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: S. GAITAN
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SHEET CHK'D BY: B. MURPHY
CROSS CHK'D BY: M. BLISS
APPROVED BY:
DATE: MARCH 2008

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WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

SPILLWAY DETAILS FOR ENLARGED DAM

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO.
CD-2

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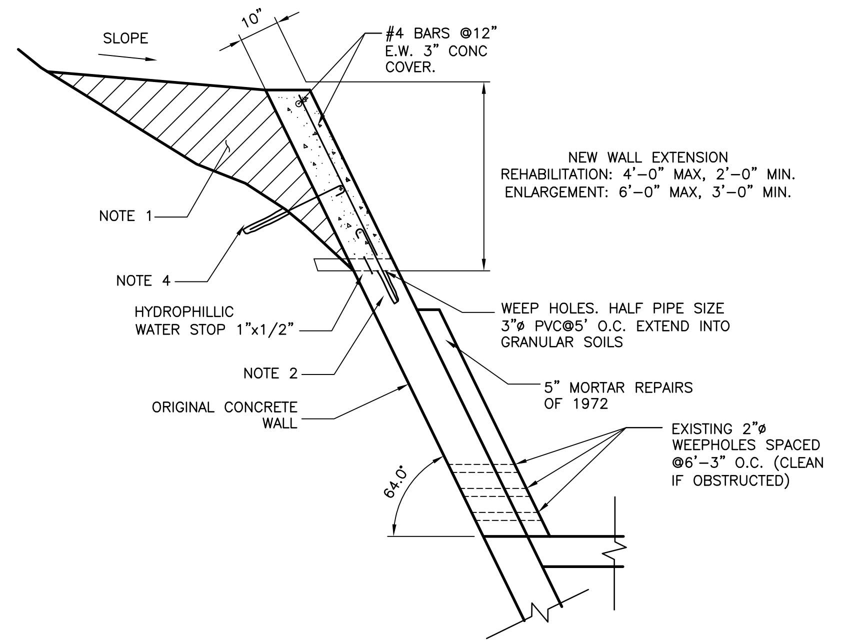
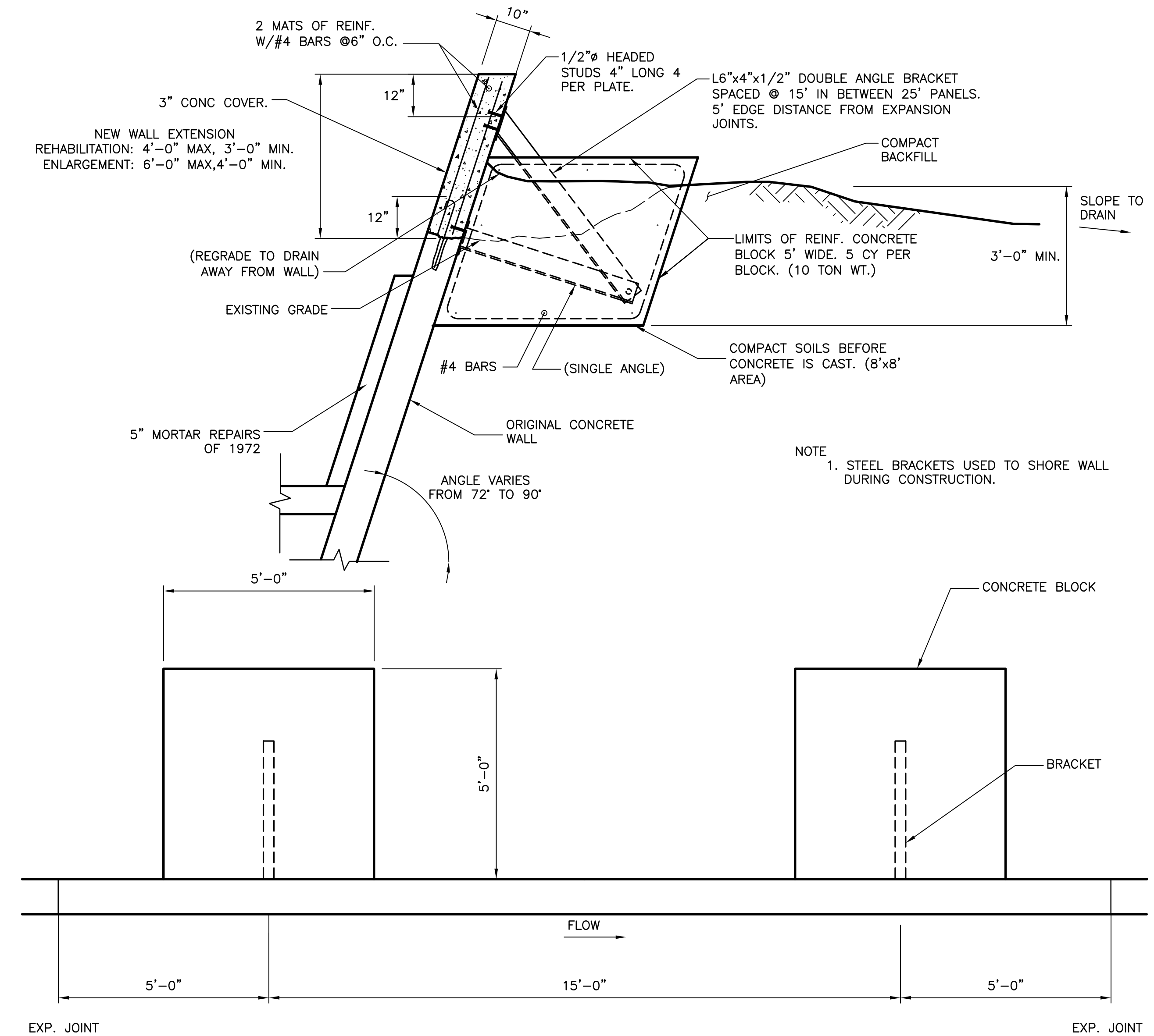


NOTES:
1. REMOVE ALL LOSE FRAGMENTS OF SOIL, ROCK & DEBRIS TO SOUND SURFACE. APPLY MORTAR NON-SHRINK GROUT AS SHOWN.
2. DRILL AND GROUT ONE 1/2"ø DEFORMED BAR 8" INTO SOUND CONCRETE. 5' SPACING
3. USE 4000 PSI CONCRETE WITH 1/2" MAX. COARSE AGGREGATE.
4. IF SOUND ROCK IS NOT FOUND, SOIL ANCHORS MAY BE USED AT 12' SPACING. 2 ANCHORS PER BLOCK MIN.

FULLY SUPPORTED WALLS
DETAIL (A / –)
NTS



FULLY UNSUPPORTED WALL EXTENSION
PLAN (B / –)
1/2"=1'

PRELIMINARY DESIGN. NOT FOR CONSTRUCTION.

STANDARD DETAILS SHOWN ON THIS DRAWING SHALL BE USED AT ALL APPLICABLE LOCATIONS UNLESS NOTED OTHERWISE OR SPECIFIC DETAILS ARE INDICATED FOR SPECIFIC LOCATIONS

DETAILS SHOWN ARE INTENDED TO COVER A WIDE RANGE OF SITUATIONS ON THIS PROJECT – ALL MAY NOT BE REQUIRED

PRELIMINARY DESIGN
NOT FOR CONSTRUCTION

REV. NO.	DATE	DRWN	CHKD	REMARKS

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WATER DIVISION NO.3 - WATER DISTRICT NO. 20
HINSDALE COUNTY, COLORADO
RIO GRANDE RESERVOIR
SPILLWAY IMPROVEMENTS

SPILLWAY CHUTE WALL EXTENSIONS

PROJECT NO. 43844-60541
FILE NAME: CSDDT001
SHEET NO.
CD-3

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