RAY LAKE ENLARGEMENT, LEVEL II
Executive Summary

SUBMITTED BY
Gannett Fleming

IN ASSOCIATION WITH
States West Water Resources Corporation

July 2005
Executive Summary

RAY LAKE ENLARGEMENT
LEVEL II STUDY

Prepared for:
Wyoming Water Development Commission
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1. Introduction and Project Background

The Little Wind River basin experiences chronic irrigation water shortages. Enlargement of Ray Lake on the Wind River Reservation near Lander, Wyoming (Figure 1.1), has been under consideration for several years to help alleviate these shortages. The existing 28 feet high embankment dam impounds a reservoir with a capacity of 6980 acre-feet. The off-stream reservoir is supplied by canals and diversions from the South Fork and the North Fork of the Little Wind River.

Ray Lake Dam was built between 1924 and 1925. The dam has a history of dam safety issues including excessive foundation and embankment seepage, embankment cracking, cracking and leakage of the primary outlet structure, poor condition of the upstream slope protection, and inadequate emergency spillway capacity. These deficiencies were documented between 1983 and 1992 by U.S. Bureau of Reclamation (USBR) inspections and studies associated with their Safety Evaluation of Existing Dams (SEED) program. Due to the structural deficiencies identified by the SEED reports, the reservoir has been operating under a restricted pool elevation since about 1991.

In 1993, the Tribal Water Engineer for the Eastern Shoshone and Northern Arapahoe Tribes hired GEI Consultants Inc. (GEI) to develop conceptual designs for dam safety modifications to the existing dam (GEI, 1993a). At the time, GEI also conducted a feasibility study for enlarging the dam and reservoir (GEI, 1993b). Safety of Dams (SOD) and Enlargement Project alternatives and designs were carried forward in tandem studies by Western Water Consultants (now doing business as WWC Engineering) between 1994 and 1996 (WWC 1994, 1995a, 1995b, 1995c, and 1996). WWC advanced the designs, and in 1996 near-final (95%) construction plans and specifications for both the SOD and Enlargement Projects were completed and submitted to USBR for review.

Funding was provided to the tribes for the SOD modifications by the Bureau of Indian Affairs (BIA). However, the SOD work was delayed, evidently in the hope that the Enlargement Project could be approved and advanced, with the SOD funds applied to the enlargement construction costs. The Enlargement Project was not constructed at that time due to lack of funding and unresolved project technical issues, primarily concerns expressed by USBR about the inadequacy of the geotechnical information to support the enlargement design. The SOD improvements have not been completed as of the date of this report (July 2005).

The 95% final design (WWC, 1996) sized the reservoir at 35,000 acre-feet, with approximately 10,000 acre-feet of inactive storage/recreational pool. This size was based on achieving the desired active storage volume, while still having enough driving head near the bottom of the active pool level to be able to deliver water to new service areas via proposed new outlet canals. The current design has approximately 25,000 acre-feet of active storage, and is based on anticipated average annual need of 16,500 acre-feet.
The final design that is shown on the 1996 “95% Plans and Specifications” is for a project with the following features:

- 35,000 acre-feet reservoir with normal high water line elevation of 5565 feet;
- removal of the old dam;
- a new, approximately 70-feet high embankment dam with a crest elevation of 5571 ft;
- 3 distinct embankment components: North Embankment, South Embankment, and Lateral 37C Dike;
- new emergency spillway cut in native materials on the south side of the reservoir;
- two new outlet works with appurtenant structures on the south and north sides of the reservoir;
- work associated with Highway 287 realignment and rebuilding along a portion of the crest of the new dam (North Embankment), and a causeway across a low spot on the north side of the reservoir;
- realignment, rehabilitation, and enlargement of Lateral 37C between Ray Canal and Ray Lake on the north side of the reservoir; and
- construction of a new canal pipeline to serve Lateral 67C-19 on the south side of the reservoir.

Conceptual designs and cost estimates were also prepared at the time (WWC, 1995b) for two new canals to deliver water from an enlarged Ray Lake to areas not previously served by the existing reservoir, as follows:

- a new south outlet canal would expand the service capacity under Lateral 65C and would have a peak capacity of 60 cfs; and
- a new north outlet canal would be cut through the ridge north of the reservoir that separates the Mill and Trout Creek drainages, and would deliver water to the Coolidge Canal with a maximum capacity of 270 cfs.

The locations of these new canals are shown on Figure 1.1. The outlet canal designs were sized based on recommendations in the systems analysis report (NRCE, 1995).

2. Project Purpose, Authorization, and Scope

The Joint Business Council of the Eastern Shoshone and Northern Arapaho Indian Tribes (Sponsor) applied for funding of this Level II study to review the existing (95%) design for the Enlargement Project, and to identify outstanding issues that would have to be coordinated between various stakeholders in order to advance the project.

This study has been carried out under the direction and funding of the Wyoming Water Development Commission (WWDC) by Gannett Fleming, Inc. (Gannett Fleming), in association
The scope of services that are documented in the Level II study report, included the following activities:

- compilation and review of previous reports and studies relevant to the project;
- engineering review of previous enlargement designs and construction cost estimates;
- evaluation of supplemental geotechnical investigation requirements and costs;
- analyses of hydrology, water availability, and reservoir size;
- review of the Little Wind River irrigation system, and assessment of how the Ray Lake Enlargement project would operate within the system;
- identification of potential permitting requirements; and
- facilitation of meetings and discussions between potential stakeholders.

3. Study Conclusions and Recommendations

Key findings resulting from this study are summarized as follows:

- The Ray Lake Enlargement Project has already passed several rounds of screening in previous water planning studies, and was recommended for advancement through both the Upper Wind River Storage Project, Level I Study (SEH, 2001) and the Wind/Bighorn Basin Plan (BRS, 2003). This Level II study confirms that the project is justified and viable in terms of both identified needs and water availability.

- Needs analysis by previous studies (NRCE, 1995 and SEH, 2001), as summarized in Section 3.1 of the Level II report, indicate that there are identified needs of at least 16,500 acre-feet per year. Identified needs may be as much 33,000 acre-feet per year, based solely on existing un-met and future potential irrigation demands in the Little Wind River basin that could be serviced by an enlarged Ray Lake. Additional irrigation needs have also been identified downstream from the confluence of the Little Wind and Big Wind Rivers that potentially could be supplemented from Ray Lake storage. Other beneficial uses for an enlarged storage facility also are identified, including, improving in-stream flows on the Wind River below its confluence with the Little Wind River (including in-stream flow enhancement for fisheries, wildlife, pollution control, aesthetics and cultural purposes), recreational benefits, potential downstream municipal uses, agricultural uses, hydropower, industrial uses, marketing and transfer, and cultural and religious uses.

- Previous system analysis studies (NRCE, 1995), and the current model study presented in Section 3.2 of the report, indicate that a Ray Lake enlargement size of at least 35,000 acre-feet (25,000 acre-feet active storage and 10,000 acre-feet recreation pool for proper system operation) is viable based on water supply and conservative (present-day) water rights assumptions.

- To adequately supply the enlarged Ray Lake Reservoir, the North Fork Diversion Canal would need to be upgraded to carry an additional 50 cfs of water for storage, and the Ray Canal and Lateral 37C upgraded to carry 200 cfs of water for storage. These capacities
would be in addition to canal capacity required for simultaneous delivery of direct flow irrigation water.

- This combination of reservoir size and supply canal size could deliver an average supplemental water demand of 16,500 acre-feet in 9 out of 10 years. Increasing the active storage capacity above 25,000 acre-feet would improve the ability of the project to meet the supplemental water demands.
- The existing dam has significant dam safety issues, and will require rehabilitation work, whether or not the enlargement project moves forward. The safety of dams (SOD) design is substantially complete and approved by USBR subject to minor design change recommendations (USBR, 2003), and it has been funded by the BIA.
  - This Level II study concluded that it was neither economically or technically feasible to incorporate the SOD work components into a future enlargement design, and the team recommends constructing the SOD improvements as soon as possible.
- Although significant engineering design has already been completed for a 35,000 acre-feet reservoir, one important issue that must be resolved is the inadequate geotechnical and geologic information at the site to support the final design of the embankment dam. A proposed detailed plan for supplemental geotechnical work to address this issue is outlined in the report.
- The design review under this Level II study identified several recommended changes to the 1995 design to facilitate construction, and to simplify long-term operation and maintenance of the project, without substantially impacting the construction cost estimates. The primary recommended changes include:
  - Separate the highway realignment from the dam. The 1995 design shows the Highway 287 embankment realigned and joined with the north portion of the raised embankment dam. The current study team recommends separating these projects for a variety of reasons, including the administrative advantage of having separate construction packages and schedules for the different types of construction, elimination of a costly temporary detour, separation of highway and dam maintenance and operations, and other considerations, as described in Section 4.1 of the report. Two preliminary feasible alternative alignments for the highway are identified.
  - Shift the enlarged embankment alignment downstream along the segment adjacent to the existing dam. The 1995 design shows the upstream toe of the raised dam coincident with the upstream toe of the existing dam. Shifting the raised dam downstream will allow the reservoir to remain in operation during the anticipated two-year construction period, and will allow the existing dam to provide a protective cofferdam retaining unstable reservoir sediments and storm water runoff during construction.
  - Modify the embankment sections to incorporate a wider crest width across higher sections of the dam, and to reduce the crest width where the embankment no longer has to carry the highway over its crest. Additional recommendations are made regarding blanket filter configuration, and possible foundation treatment requirements, but these are preliminary and require additional geotechnical site investigations before final recommendations can be made.
o **Use a different type of pipe for the outlet works.** The 1995 design shows a steel pipe encased in concrete. Considering the compressible nature of the foundation and embankment materials, Gannett Fleming recommends using specially fabricated reinforced concrete cylinder pipe (embedded steel cylinder) with articulated joints. This type of pipe would provide better performance at a lower cost.

o **Recommendations for final design analysis.** Additional recommendations regarding final design analysis and details for the sluice gate operating system and spillway design are also provided in the report.

The following additional analyses are recommended for a follow-on Phase II, Level II study if the project is advanced by the Sponsors:

1. **Additional System Modeling.** Additional detailed system modeling is recommended to provide more accurate analysis of reservoir yield by tying releases from Ray Lake directly to actual water needs in the basin. Existing water shortages and future water supply needs are demonstrated in the project service area. Existing annual un-met irrigation demand is estimated to be at least 16,500 acre-feet (NRCE, 1995 estimate), up to 18,500 acre-feet (SEH, 2001 estimate). Future potential irrigation demand in the Little Wind River basin is estimated to be on the order of about 14,500 acre-feet (Type 7, Type 8 and Futures Awards). Since one of the primary inhibiting factors of the amount of yield derived from an enlarged Ray Lake Reservoir is the storage in Boysen Reservoir, the model may need to address the entire basin associated with the inflows and demands upon Boysen Reservoir.

2. **Supplemental Geotechnical Investigations and Analysis.** Additional geotechnical information is required to support final design of the enlargement project. A detailed program is outlined in Section 3.5 of the report, including estimated costs for labor, drilling and test pits, and laboratory testing. In addition to the costs associated with the field work and geotechnical report, additional budget should be provided for pre-final engineering analysis and design of modifications (as needed) to the embankment section and foundation treatment requirements based on the findings of the supplemental geotechnical investigation.

3. **Supplemental Analysis and Design Verification for Emergency Spillway.** The design review identified some potential problems with the spillway routing model regarding input assumptions. The spillway hydraulics should be reviewed, and appropriate methods and routing assumptions applied to develop the rating curve. Also, additional analysis are recommended, once the geotechnical information is available, to evaluate the spillway erodibility and potential for scour at the toe of the embankment adjacent to the spillway, using the SITES model developed by the Natural Resources Conservation Service (NRCS).

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1 The Eastern Shoshone and Northern Arapahoe Tribes were awarded Federal reserved water rights, of which approximately 209,000 acre-feet/yr are referred to as Futures Awards. Type 7 and 8 Awards are federally reserved Tribal water rights tied either to lands that have been irrigated in the past but are not currently irrigated (Type 7), or lands that have been identified as potentially irrigable but have never been irrigated (Type 8) (SEH, 2001).
4. **Pre-Final Design of Ray Lake Inlet and Outlet Canals, and Improvements to Existing Ray Canal System.** In 1995 and 1996, WWC prepared conceptual designs for alternatives to provide a new inlet to an enlarged Ray Lake, and for new outlet canals to deliver water to areas northeast and southeast of Ray Lake (WWC 1995b, 1996b). Following additional system analysis to confirm the optimum size of the enlarged reservoir (see recommendation 1), these designs could be advanced to a preliminary level in a follow-on Level II, Phase II study. Also, to adequately supply the enlarged Ray Lake Reservoir, the North Fork Diversion Canal should be upgraded to carry at least an additional 50 cfs of water for storage, and the Ray Canal and Lateral 37C upgraded to carry 200 cfs of water for storage. These capacities would be in addition to canal capacity required for simultaneous delivery of direct flow irrigation water. Designs and cost estimates for these canal enlargements should also be advanced in further studies.

5. **Evaluation of Lateral 37C Realignment at North End of Dam.** The current (1995) embankment design plans show Lateral 37C passing through the dam above the North Outlet Works pipe. To avoid this penetration, it is recommended that the next phase of design evaluate alternative alignments of the lateral around the north end of the dam.

6. **Preliminary Selection and Design of Alternative Highway Relocation.** A key recommendation that originated from this study is to separate the highway and dam construction projects. Two very preliminary possible alignments have been identified, and feasibility-level cost estimates presented for these options. If this recommendation is to be advanced, supplemental studies will be required to evaluate optimum alignment options and provide a more detailed design basis for cost estimating.

7. **Additional Cultural Resources and Wetland Impact Studies.** This study developed a preliminary wetland inventory based on National Wetlands Inventory Mapping prepared in the mid 1990’s and do not likely represent actual areas at this time. Also, cultural resource surveys conducted in the mid-1990’s were developed for smaller reservoir alternatives, and did not include areas potentially impacted by a larger reservoir inundation area, as well as new canal and road construction disturbance areas. Field mapping for wetlands and cultural resources surveys specific to the final project features should be completed to support the permitting and identify mitigation requirements.

8. **Economic Analysis and Project Financing.** This Level II study did not include detailed economic analysis and identification of project financing opportunities. These tasks also should be included in a Level II, Phase II study.
4. Issues Coordination

A crucial aspect of the study was to define issues that must be coordinated among the state, tribes and federal agencies that are involved. Two Issues Coordination meetings were held during the course of the project. Issues that were identified include the following:

- Irrigation and other water needs in the project area
- Water availability and optimum reservoir size
- Canal system upgrade requirements
- Consideration of SOD and enlargement project timelines
- Adequacy of geotechnical information to support final design of enlargement project
- Enlargement design review and recommended modifications
- Anticipated NEPA and permitting requirements
- Costs

Technical issues listed above have been preliminarily addressed by this study, and recommendations for future studies that will be needed to advance the project on these issues are summarized. In addition to the previously identified issues, there are two additional outstanding issues that will require further coordination and consideration if the project is to be advanced. These issues are described as follows:

State of Wyoming Permitting of an Enlarged Reservoir

The existing Ray Lake has no storage permit from the State of Wyoming. The normal State of Wyoming procedures for the permitting of an enlarged Ray Lake would be to issue a present day priority date. One of the purposes of the optimum reservoir sizing presented in the report was to determine if the reservoir priority date was critical to the enlargement project feasibility.

Based upon the results of additional system modeling performed for this Level II study, the reservoir priority date would not affect the ability to expand the storage and canal delivery capacities for diverting the available early season stream flows, in addition to those presently stored in Ray Lake. These diversions for storage in the enlarged reservoir could continue to be accounted for as a part of the existing 1868 priority diversion volume as decreed.

Water saved as a result of conservation activities through reduction of seepage losses could also be stored in an enlarged Ray Lake. This water would also be accounted for in the existing diversion right.

Additional irrigated acreage as allowed for in the decree and identified as Type 7, Type 8, or future project lands could be served water from the storage provided in an enlarged Ray Lake. Portions of these decreed water rights could also be stored in an enlarged Ray Lake.

Even greater amounts of water stored under a present day storage water rights would be available in larger water years. Consequently, expanded canal conveyance capacities and carry-over
storage capacity would be needed to efficiently utilize the available water under these high streamflow conditions.

In summary, a present day priority storage water right for Ray Lake would not affect the feasibility of the enlargement project. However, water rights issues will undoubtedly remain a key issue in future discussions among project stakeholders.

**State of Wyoming Permitting of Rehabilitated Reservoir**

The potential rehabilitation of Ray Lake at its present capacity is a likely scenario regardless of whether the reservoir is enlarged in the future. Based on discussions with representatives of the SEO during the course of this study, the rehabilitation project may not be granted a construction permit from the SEO without a reservoir storage permit. The SEO procedures, as previously discussed, would be to issue a present day priority date for the reservoir. As discussed in the previous section, this priority date would not affect the ability to store early water as is presently done.

**5. Anticipated NEPA Requirements**

An Environmental Impact Study (EIS) would likely be required for the enlargement project due to potential impacts to existing cultural sites and wetlands. Individual property owners and tribal properties both could be impacted. The BIA would be the lead agency, with the Tribes as cooperating agencies. The U.S. Army Corps of Engineers (COE) also would be involved due to wetlands issues that need to be addressed. Key issues that need to be considered include:

- Cultural Resources
- Wetland Impacts
- Land Ownership and Acquisition

**6. Updated Cost Estimates for Project Construction**

The Ray Lake Enlargement project can only be achieved if all major project components are considered, including costs for dam, outlet and spillway, and Lateral 37C relocation construction; Highway 287 relocation; new canal construction; final design engineering; and permitting and mitigation costs. Base construction costs for all elements of the project were updated, considering three scenarios: 2006 escalated cost estimates for the 1995 design (unmodified design), and 2006 escalated cost estimates for the modified design (separate highway and dam projects) for two different highway re-alignment options (Alternative 1 and Alternative 2). For dam elements, escalated unit costs were derived from the Engineering News Record (ENR) construction cost index ratio (CCIR) between December 1995 to April 1995 (CCIR = 1.344), plus 4% inflation to estimate April 2006 unit costs (inflation factor – 1.04). Highway costs were escalated based the WYDOT data base (BIDTABLES) program for unit prices.
Table 1 summarizes the estimated total project costs for the combined project components, including costs for the new dam and appurtenant facilities; Lateral 37C relocation construction; Highway 287 relocation; new north and south outlet canal construction; final design engineering; and estimated permitting and mitigation costs.
### Table 1 Total Project Costs (2006 Dollars)

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References


