WILLWOOD DAM
REHABILITATION PROJECT

FINAL REPORT
EXECUTIVE SUMMARY

SUBCONSULTANTS

BANNER ASSOCIATES, INC.

CHEN-NORTHERN, INC.
WILLWOOD DAM
REHABILITATION PROJECT

FINAL REPORT - EXECUTIVE SUMMARY

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DATE: NOVEMBER 1, 1989
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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Willwood Dam Rehabilitation Project involves the identification of necessary repairs and improvements to the Willwood Irrigation District Diversion Dam and the conceptual design and preparation of cost estimates for the repairs and improvements.

1.2 WILLWOOD DAM DESCRIPTION

The Willwood Diversion Dam, shown in Figure 1, consists of a concrete gravity ogee weir with embankment wings, located on the Shoshone River 8 miles downstream from Corbett Dam and 13 miles northeast of Cody, Wyoming. The dam has a structural height of 70 feet, a hydraulic height of 41 feet, a weir crest length of 271 feet, and a total crest length of 476 feet. The weir crest is at elevation 4499.5.

The canal outlet works consists of a rectangular conduit through the right end of the dam and embankment wing to the Willwood Canal controlled by two, 5.6 x 7.0 foot diversion gates. Three sluiceways are controlled by 3.6 x 5.5 foot cast iron gates located on the upstream face of the dam. An outlet was provided through the dam near the right abutment for future construction of a powerplant.

The dam was designed by and built under the supervision of the Bureau of Reclamation. Construction was completed in 1924. The dam diverts water from the Shoshone River into the Willwood Canal and is used for irrigation.

1.3 WILLWOOD DAM OPERATIONS

Since January, 1982, operations of Willwood Dam have been subject to an agreement executed by Bureau of Reclamation, Wyoming Department of Environmental Quality, and the Willwood Irrigation District.

A significant control imposed by the operating agreement is a limitation on the allowable turbidity increase of 10 NTU in the Shoshone River from the upstream to the downstream side of the dam. The agreement also stipulated that records be kept of the upstream turbidity, downstream turbidity, upstream water surface elevation, and gate openings during the time sluice gates are in operation. Information derived from these records is summarized below.

Period of Record: Non-irrigation season from December 16, 1982 through April 10, 1989.

Range of upstream turbidity: 2.2 to 1,056 NTU

Range of downstream turbidity: 4.2 to 936 NTU

Range of change in turbidity from upstream to downstream of Willwood Dam: -120 NTU to +60.0 NTU
Percent of time turbidity increase exceeded 10 NTU: 25.0%
Percent of time turbidity increase exceeded 20 NTU: 4.2%
Range of flows through sluice gates: 877 cfs to 88 cfs
Range of upstream water surface elevation: 4499.7 to 4491.1

1.4 SHOSHONE PROJECT OPERATIONS

The Willwood Irrigation District is a division of the Shoshone Project and is impacted by Shoshone Project operations. The Bureau of Reclamation prepares annual operating plans for the Shoshone project. The non-irrigation season releases from Buffalo Bill Reservoir will definitely impact construction done at Willwood Dam as any construction will have to be completed during the non-irrigation season. Criteria for non-irrigation season releases, from the 1987 annual operating plan, is summarized below:

<table>
<thead>
<tr>
<th></th>
<th>Flow In Shoshone River below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release from Buffalo Bill Dam</td>
<td>Flow In Shoshone River below</td>
</tr>
<tr>
<td>Normal Years with Adequate Water Supply</td>
<td>100 cfs</td>
</tr>
<tr>
<td>Very Dry Year</td>
<td>50 cfs</td>
</tr>
</tbody>
</table>

2.0 INSPECTIONS

2.1 SPILLWAY APRON

In 1982 the Bureau of Reclamation determined the elevation of the concrete along a series of cross-section lines spaced at ten feet intervals starting from the downstream end of the apron and progressing towards the face of the dam. The apron was not dewatered so a visual inspection was not made. The results of the Bureau's survey indicated a significant loss of concrete downstream of the north sluice gate. There were also areas where the concrete elevations could not be determined because of silt deposits on the apron.

On September 27, 1988, Engineering Associates conducted a survey to determine the elevation of the top of the concrete on the spillway apron along approximately the same sections used by the Bureau of Reclamation in their 1982 work. The water surface elevation in the downstream pool was 4457.4. The design elevation of the top of concrete varies between 4454 and 4449.
Due to the fact that the sluice gates had been closed since the start of the irrigation season in April, and water had been flowing over the crest of the dam, the apron was free of silt. This survey confirmed the severe concrete damage downstream from the north sluice gate and indicated possible loss of concrete elsewhere. At one location, solid material could not be found by probing with the rod. The rod was able to penetrate the material encountered down to an elevation of 4445 +/−, which is approximately 5 feet below the calculated top of concrete elevation at that point. This could indicate that the concrete has been eroded through, exposing the underlying strata. Results of the survey are shown graphically in Figure 2.

2.2 CANAL GATES AND CONCRETE

On January 26, 1989, representatives of Engineering Associates, Banner Associates, Inc., and Chen-Northern, along with Wilber Higgins, Willwood Irrigation District Manager inspected the downstream side of the canal gates. The water surface elevation of the upstream pool was 4495.4 which prevented an examination of the upstream side of the gates. Seepage was occurring around both gates and some loss of concrete behind the gate frames was observed. Chen-Northern also conducted a visual inspection of the tunnel behind the gates, the dam, and the retaining walls.

3.0 TURBIDITY CONSIDERATIONS

The agreement discussed in Section 1.3 limits the increase in turbidity from the upstream side to the downstream side of Willwood Dam to 10 NTU. The Shoshone River below Willwood Dam is a brown trout fishery and the Wyoming Game and Fish Department initiated the process that lead to this agreement in order to protect the fishery. Prior to the operational changes imposed by the agreement, the Game and Fish Department had been observing fish kills downstream from Willwood Dam that appeared to be related to the sluicing operations.

An analysis of the turbidity and flow data referenced in Section 1.3 yields the information summarized below:

1. With the water surface elevation of the upstream pool at elevation 4493 or lower, turbidity increases greater than 10 NTU occur 46.9% of the time.

2. As the discharge through the sluice gates decreases, the frequency of turbidity increases greater than 10 NTU also decreases.
4.0 DEWATERING AND RIVER CONTROL

Completion of many of the repairs or replacements identified in the Rehabilitation Plan will require dewatering and river control at Willwood Dam. Figure 3 shows a conceptual design for facilities to reduce turbidity downstream from Willwood Dam during construction. Figure 4, which is a typical cross-section of the Dam, shows the elevation of various facilities which may require repair or replacement and gives an indication of the extent of dewatering required to accomplish the necessary work.

4.1 CANAL GATES

Work on the canal gates would require lowering the water surface on the upstream side of Willwood Dam below elevation 4487. The flow in the Shoshone River would have to be either pumped around the dam or passed through a sluice gate. Pumping appears to be prohibitively costly therefore, use of the sluice gates appears to be the only viable option. The calculated capacity of one sluice gate, wide open, with the upstream water surface at elevation 4485 is in the range of 480 cfs. Reference to Section 3.0 indicates that at water surface elevations below 4493, turbidity increases would exceed 10 NTU a significant percentage of the time, necessitating downstream turbidity control facilities.

4.2 SLUICE GATES

The method initially developed to dewater the upstream pool to allow repair or replacement of the sluice gates consisted of the following steps:

1. Install turbidity control facilities downstream of Willwood Dam.

2. Install a temporary pipe from the downstream end of the power outlet past the end of the spillway apron.

3. Install a sheet pile cofferdam upstream of the dam.

4. Install temporary pumping facilities to pump the river flows from the upstream side of the cofferdam to the downstream side of Willwood Dam.

5. Dewater the pool between the cofferdam and Willwood Dam.

6. Install a temporary pipe through the cofferdam and into the upstream end of the power outlet.

7. Divert the river through the temporary pipe.

This plan which would have a capacity up to approximately 500 cfs is estimated to cost $487,500.

An alternative to the method described above requires limiting the flows in the river above the dam to 100 - 150 cfs and lowering the upstream pool by discharging through a sluice gate. The alternate plan is estimated to cost $162,500.
4.3 SHOSHONE RIVER FLOWS

The average monthly gain in the flow in the Shoshone River between USGS gage 06282000 and Willwood Dam was analyzed. The period studied was the non-irrigating season from 1979 to 1988. The gain in the river ranged between 41 cfs and 446 cfs. For the period studied, the gain was less than 150 cfs 80% of the time. Gage 06282000 is located approximately one mile west of Cody.

150 cfs is probably the maximum flow which can be accommodated while working on the sluice gates if the less expensive alternate method of dewatering, discussed in Section 4.2 is used. Therefore, if the alternate method were used, any flows released from Buffalo Bill Reservoir or the associated power plants would have to be diverted around the Willwood Dam site.

The Garland Canal which diverts from the Shoshone River at Corbett Dam, approximately 8 miles above Willwood Dam, has a capacity of approximately 1,200 cfs, with a wasteway located on Eagle Nest Creek which flows into the Shoshone River approximately 1.8 miles downstream from Willwood Dam. The use of this canal during the non-irrigation season would enable the diversion of a significant amount of Shoshone River flow around the Willwood Dam site. However, the amount of flow diverted might be limited by the capacity of Eagle Nest Creek to carry the return flow and the canal could be subject to icing during extreme cold weather.

5.0 REPAIRS AND REPLACEMENTS

5.1 REHABILITATION PLAN

The Rehabilitation Plan identified the repair and replacement items listed below:

- Spillway Apron
- Canal Outlet Works
- Sluice Gates
- Right Abutment Contact
- Erosion at Right Wing Wall
- Abutment Grouting
- Cracks on Downstream Face of Dam
- Miscellaneous Concrete Repair

5.2 WILLWOOD IRRIGATION DISTRICT PRIORITIES

After review of the Draft Rehabilitation Plan, Willwood Irrigation District identified their priorities in a letter to the Wyoming Water Development Commission, dated August 24, 1989. Further discussions with the manager of the Willwood Irrigation District have provided additional information about the items on their priority list.

The Willwood Irrigation District feels that their irrigators are presently being assessed close to the maximum amount which they can afford. Therefore, their priority list only addresses the items which they feel may be critical and emphasizes repair rather than replacement of many facilities.
Because there is a possibility that much of the major work could be funded under the Pick-Sloan Missouri Basin Program, at essentially no cost to the irrigators, the District wants to minimize the amount of debt incurred at this time. The Pick-Sloan Program is discussed further in Section 7.1.2. The items on the Irrigation District's priority list are tabulated below.

- Spillway Apron Repair
- Canal Gate Repair - Replace Seat
- Right Abutment Repair
- Repair Sluice Gate Stems
- Repair Cracks on Downstream Face of Dam
- Miscellaneous Concrete Repair

6.0 COST ESTIMATES

The cost estimates associated with the recommended rehabilitation work are presented below and reflect 1990 prices. The estimates provided are a budget-level estimate and include a 15% contingency and 10% for design engineering.

6.1 RIVER CONTROL AND DEWATERING

6.1.1 River Control for Sluice Gate Replacement $ 487,000
6.1.2 River Control for Sluice Gate Replacement - Alternate $ 162,500
6.1.3 Turbidity Control Downstream $ 62,500
6.1.4 Cofferdam Intallation for Spillway Apron Repair $ 87,500

6.2 SPILLWAY APRON

River Control-6.1.3 and 6.1.4 $150,000

6.3 CANAL OUTLET WORKS

Replace Frames Only $ 60,000

River Control-6.1.3 $ 62,500

Replace Complete Gate Assemblies $ 150,000

River Control-6.1.3 $ 62,500

6.4 SLUICE GATES

Replace Stems Only $ 74,400

Replace 2 Gate Assemblies - Abandon South Gate $ 132,000

River Control-6.1.1 and 6.1.3 $550,000

If the alternate method of river control discussed in Section 4.2 can be used, the estimated cost for river control would be $225,000.
Replace 3 Gate Assemblies $ 165,000

River Control: $550,000

If the alternate method of river control discussed in Section 4.2 can be used, the estimated cost for river control would be $225,000.

6.5 RIGHT ABUTMENT CONTACT $ 62,500
6.6 REPAIRS CRACKS ON DOWNSTREAM FACE OF DAM $ 15,000
6.7 MISCELLANEOUS CONCRETE REPAIR $ 25,000
6.8 TOTAL PROJECT COST

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Control-6.1.1, 6.1.3, &amp; 6.1.4</td>
<td>$ 637,500</td>
</tr>
<tr>
<td>Spillway Apron</td>
<td>$ 345,000</td>
</tr>
<tr>
<td>Canal Gates - Replace Complete Gate Assemblies</td>
<td>$ 150,000</td>
</tr>
<tr>
<td>Sluice Gates - Replace 3 Gate Assemblies</td>
<td>$ 165,000</td>
</tr>
<tr>
<td>Right Abutment Contact</td>
<td>$ 62,500</td>
</tr>
<tr>
<td>Cracks on Downstream Face of Dam</td>
<td>$ 15,000</td>
</tr>
<tr>
<td>Miscellaneous Concrete Repair</td>
<td>$ 25,000</td>
</tr>
</tbody>
</table>

TOTAL $1,400,000

River control amounts to 46% of the total cost.

TOTAL PROJECT COST - RIVER CONTROL ALTERNATE

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Control-6.1.2, 6.1.3, &amp; 6.1.4</td>
<td>$ 312,500</td>
</tr>
<tr>
<td>Spillway Apron</td>
<td>$ 345,000</td>
</tr>
<tr>
<td>Canal Gates - Replace Complete Gate Assemblies</td>
<td>$ 150,000</td>
</tr>
<tr>
<td>Sluice Gates - Replace 3 Gate Assemblies</td>
<td>$ 165,000</td>
</tr>
<tr>
<td>Right Abutment Contact</td>
<td>$ 62,500</td>
</tr>
<tr>
<td>Cracks on Downstream Face of Dam</td>
<td>$ 15,000</td>
</tr>
<tr>
<td>Miscellaneous Concrete Repair</td>
<td>$ 25,000</td>
</tr>
</tbody>
</table>

TOTAL $1,075,000

River control amounts to 29% of the total cost.

6.9 PROJECT COST - WILLWOOD PRIORITY LIST

Because of their concern about the magnitude of additional assessments to their irrigators, the Willwood Irrigation District is considering repairs rather than replacement of many of the items.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Control-6.1.3 &amp; 6.1.4</td>
<td>$ 150,000</td>
</tr>
<tr>
<td>Spillway Apron</td>
<td>$ 345,000</td>
</tr>
<tr>
<td>Canal Gates - Replace Frames Only</td>
<td>$ 60,000</td>
</tr>
<tr>
<td>Sluice Gates - Replace Stems Only</td>
<td>$ 74,400</td>
</tr>
<tr>
<td>Cracks on Downstream Face of Dam</td>
<td>$ 15,000</td>
</tr>
<tr>
<td>Miscellaneous Concrete Repair</td>
<td>$ 25,000</td>
</tr>
</tbody>
</table>

TOTAL $ 669,400

River control amounts to 22% of the total cost.
7.0 ECONOMIC ANALYSIS

7.1 ABILITY TO PAY

7.1.1 Current District Assessments

Summarized below are the 1989 assessments paid by landowners in three irrigation districts, including Willwood, which are part of the Shoshone Project. The assessments are in dollars per acre.

<table>
<thead>
<tr>
<th>District</th>
<th>$ PER ACRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WILLWOOD</td>
<td></td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>11.50</td>
</tr>
<tr>
<td>R &amp; B Project-Repayment Complete 2005</td>
<td>4.50</td>
</tr>
<tr>
<td>Construction Loan-Repayment Complete 2006</td>
<td>0.74 - 3.01</td>
</tr>
<tr>
<td>Total</td>
<td>16.74 - 19.04</td>
</tr>
<tr>
<td>Average</td>
<td>17.88</td>
</tr>
<tr>
<td>GARLAND</td>
<td></td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>11.10</td>
</tr>
<tr>
<td>R &amp; B Project</td>
<td>3.00</td>
</tr>
<tr>
<td>Corbett Tunnel</td>
<td>1.00</td>
</tr>
<tr>
<td>Total</td>
<td>15.10</td>
</tr>
<tr>
<td>HEART MOUNTAIN</td>
<td></td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>9.00</td>
</tr>
<tr>
<td>R &amp; B Project</td>
<td>5.25</td>
</tr>
<tr>
<td>Construction (Average)</td>
<td>2.25</td>
</tr>
<tr>
<td>Total</td>
<td>16.50</td>
</tr>
</tbody>
</table>

7.1.2 Federal Funding Sources

The Bureau of Reclamation is currently conducting a Rehabilitation and Betterment (R & B) study for the entire Shoshone Project. The Bureau of Reclamation is funding 50% of this study and the irrigation districts are funding the other 50% with funds provided by the Wyoming Water Development Commission.

R & B projects are funded by zero interest loans with a maximum term of forty years, with the term of the loan being set by the Bureau of Reclamation. The loans cover the design and construction costs of the projects.

Another Federal funding source is the Pick-Sloan Missouri Basin Program. Funds for the Pick-Sloan Program are derived from power revenues from generating facilities associated with irrigation projects. There are no direct costs to the irrigation districts for projects funded under the Pick-Sloan Program. However, under Pick-Sloan, the projects require congressional legislation for funding. Given the current situation with the Federal budget, funds under Pick-Sloan could be difficult to obtain and might require several years before they became available.
7.1.3 Alternative Funding Plans

Tables 4, 5, and 6 present an annual cost per acre for the three projects summarized in Section 6, under various combinations of funding. The costs are calculated based on 11,422 acres of assessable land in Willwood Irrigation District. In our opinion, repair projects would probably be subject to a shorter repayment period than projects in which the existing facilities are replaced with new construction.

### TABLE 4 - TOTAL PROJECT

<table>
<thead>
<tr>
<th>Loan Repayment Period</th>
<th>10 YR</th>
<th>20 YR</th>
<th>30 YR</th>
<th>40 YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PROJECT COST</td>
<td>$1,400,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWDC Grant Funding 50%</td>
<td>$700,000</td>
<td>$7.56</td>
<td>$4.51</td>
<td>$3.54</td>
</tr>
<tr>
<td>WWDC Loan 4% Interest</td>
<td>$700,000</td>
<td>$4.99</td>
<td>$2.98</td>
<td>$2.34</td>
</tr>
<tr>
<td>WWDC Grant Funding 67%</td>
<td>$938,000</td>
<td>$6.13</td>
<td>$3.06</td>
<td>$2.04</td>
</tr>
<tr>
<td>USBR R &amp; B Loan 0% Int.</td>
<td>$1,400,000</td>
<td>$12.26</td>
<td>$6.13</td>
<td>$4.09</td>
</tr>
</tbody>
</table>

### TABLE 5 - TOTAL PROJECT WITH RIVER CONTROL ALTERNATE

<table>
<thead>
<tr>
<th>Loan Repayment Period</th>
<th>10 YR</th>
<th>20 YR</th>
<th>30 YR</th>
<th>40 YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL PROJECT COST</td>
<td>$1,075,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWDC Grant Funding 50%</td>
<td>$537,500</td>
<td>$5.80</td>
<td>$3.46</td>
<td>$2.72</td>
</tr>
<tr>
<td>WWDC Loan 4% Interest</td>
<td>$537,500</td>
<td>$3.83</td>
<td>$2.29</td>
<td>$1.80</td>
</tr>
<tr>
<td>WWDC Grant Funding 67%</td>
<td>$720,250</td>
<td>$9.41</td>
<td>$4.71</td>
<td>$3.14</td>
</tr>
<tr>
<td>USBR R &amp; B Loan 0% Int.</td>
<td>$1,075,000</td>
<td>$4.71</td>
<td>$2.35</td>
<td>$1.57</td>
</tr>
<tr>
<td>WWDC Grant Funding 67%</td>
<td>$720,250</td>
<td>$3.11</td>
<td>$1.55</td>
<td>$1.04</td>
</tr>
</tbody>
</table>
### TABLE 6 - WILLWOOD'S PRIORITY LIST

<table>
<thead>
<tr>
<th>Loan Repayment Period</th>
<th>Total Project Cost</th>
<th>10 YR</th>
<th>20 YR</th>
<th>30 YR</th>
<th>40 YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWDC Grant Funding 50%</td>
<td>$334,700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWDC Loan 4% Interest</td>
<td>$334,700</td>
<td>$3.61</td>
<td>$2.16</td>
<td>$1.69</td>
<td>$1.48</td>
</tr>
<tr>
<td>WWDC Grant Funding 67%</td>
<td>$448,498</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWDC Loan 4% Interest</td>
<td>$220,902</td>
<td>$2.38</td>
<td>$1.42</td>
<td>$1.12</td>
<td>$0.98</td>
</tr>
<tr>
<td>USBR R &amp; B Loan 0% Int.</td>
<td>$669,400</td>
<td>$5.86</td>
<td>$2.93</td>
<td>$1.95</td>
<td>$1.47</td>
</tr>
<tr>
<td>WWDC Grant Funding 50%</td>
<td>$334,700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USBR R &amp; B Loan 0% Int.</td>
<td>$334,700</td>
<td>$2.93</td>
<td>$1.47</td>
<td>$0.98</td>
<td>$0.73</td>
</tr>
<tr>
<td>WWDC Grant Funding 67%</td>
<td>$448,498</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USBR R &amp; B Loan 0% Int.</td>
<td>$220,902</td>
<td>$1.93</td>
<td>$0.97</td>
<td>$0.64</td>
<td>$0.48</td>
</tr>
</tbody>
</table>

#### 7.2 BENEFIT COST ANALYSIS

The problems with Willwood Dam which are the subject of this report are such that very little can be done from a maintenance standpoint on an annual basis to correct them. Therefore, there would be no significant reduction in annual maintenance costs due to the correction of any of these problems. However, if failing to correct some of the problems ultimately created a situation that prevented delivery of all or part of the water to the lands under the Willwood Canal, there would be significant adverse economic impacts on the farmers in the district as well as on the surrounding area. Some examples of such impacts are:

A. Farmers forced into bankruptcy due to inability to service their debt.

B. Willwood Irrigation District defaulting on loans due to farmers being unable to pay their assessments.

C. Loss of property and sales tax revenues.

D. Loss of business in the surrounding communities.

#### 8.0 PERMITS, EASEMENTS, AND AGREEMENTS

Several permits, easements and agreements are required for the construction necessary to rehabilitate Willwood Dam. These permits constitute a significant effort in time and money. Permits, easements, and agreements which may be required are listed below.
PERMITS

Dredge and Fill Permits (404 and Nationwide).
Section 401 Certification
Archaeology and SHPO Clearance
State Engineer's Office
Department of Environmental Quality (DEQ) Permits

EASEMENTS

Temporary easements for construction operations

AGREEMENTS

Shoshone River operations during construction
Diversion at Corbett Dam

APPROVALS

Approval by Bureau of Reclamation of repairs and/or replacements.
LIST OF FIGURES

FIGURE 1 - WILLWOOD DIVERSION DAM

FIGURE 2 - SPILLWAY APRON

FIGURE 3 - DOWNSTREAM TURBIDITY CONTROL FACILITIES

FIGURE 4 - CROSS SECTION OF WILLWOOD DAM
SUGGESTED LIMITS OF CONCRETE REMOVAL AND REPLACEMENT

TOP OF EXISTING CONCRETE SURFACE DETERMINED BY SURVEY SEPT. 27, 1988
(TYPICAL)

4450.70
0+50

4449.00
0+40

4450.20
0+30

4451.50
0+20

4452.80
0+10

4454.00 = COMPUTED TOP OF ORIGINAL CONCRETE SURFACE (TYPICAL)
0+00

VERTICAL SCALE: 1" = 10'
HORIZONTAL SCALE: 1" = 20'

REVISED 8/7/89
FIGURE 2
RANGE OF WATER SURFACE ELEVATIONS DURING NON-IRRIGATION SEASON
DEC 1982 - APR 1989  4499.7 - 4491.1

LOCATION OF SECTIONS TAKEN DURING SURVEY OF APRON SEPT. 27, 1988

CROSS SECTION OF WILLWOOD DAM

FIGURE 4