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GOSHEN IRRIGATION DISTRICT
LEVEL II REHABILITATION PROJECT
SIPHONS, TUNNELS, AND CANAL EVALUATION
FINAL REPORT

EXECUTIVE SUMMARY
GOSHEN IRRIGATION DISTRICT
LEVEL II REHABILITATION PROJECT
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FINAL REPORT

EXECUTIVE SUMMARY

PREPARED FOR:

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and

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October 30, 1992
EXECUTIVE SUMMARY

Authorization and Purpose

In the Fall of 1990, the Wyoming Water Development Commission (WWDC) received an application to fund a feasibility study to identify deficiencies in facilities owned and operated by the Goshen Irrigation District (GID). Specifically, these facilities included a pumping station, two tunnels and four siphons. On June 5, 1991 Lidstone & Anderson, Inc. (LA) entered into a contract with the WWDC to provide professional services related to the Level II-Goshen Irrigation District Rehabilitation Project. As stated in the contract, the purpose of the Level II project is threefold: (1) inventory and evaluate the potential bottlenecks in the main irrigation delivery system, specifically consisting of the two tunnels and four siphons; (2) evaluate and design an efficient pumping station on the Laramie River; and (3) identify and describe those rehabilitation measures necessary to increase capacity and ensure a more efficient operation of the water supply system. This contract was later amended to include a detailed evaluation of the capacity of the main delivery canal. The scope of services for the project consists of two separate tasks: Task A which involves the evaluation of the Laramie River Pump Station, and Task B which entails the evaluation of the siphons, tunnels and main delivery canal. On December 1, 1991, LA submitted the final report associated with the completion of Task A. This report documents the results of the work associated with the completion of Task B.

History of the Existing System and Summary of Existing Problems

The Goshen Irrigation District (GID) is located in Goshen County, Wyoming and was formed in November 1926 following the construction of the project by the U.S. Bureau of Reclamation (USBR). Approximately 52,500 acres of land in Wyoming and an additional 54,850 acres of land in Nebraska are served by the water conveyed in the Canal. The primary source of irrigation water is obtained from the North Platte River via the Fort Laramie Canal. In addition to the water diverted from the North Platte River, a supplemental supply (100 cfs) from the Laramie River has been earmarked for the GID and is presently diverted by a pump station located 4 miles west of Fort Laramie. The general location map for the project is presented on Figure 1.1.

In recent years, the GID has been unable to provide the full irrigation requirements of its users. Several factors have contributed to the inadequacy of the irrigation water supply. First, crop water requirements have increased since the construction of the main
Figure 1.1. Location Map for the Fort Laramie Canal.
delivery canal and associated facilities. In 1945, sugar beets, beans, alfalfa and small grains dominated the crop mix; these crops have been replaced by increased acreages of corn with a corresponding increase in water requirements. Furthermore, the increase in water requirements occurs during July and August which coincides with the peak irrigation demand for the majority of all other crops grown within the GID. Second, 40% of the water diverted for irrigation is lost to canal and lateral seepage and evaporative losses before delivery to the farms. Although an adjudicated allocation of 1 cfs per 70 acres is permitted in accordance with the administration of water rights through the State Engineers Office (SEO), the GID consistently delivers approximately 1 cfs per 100 acres to the farmers headgates. Finally, the existing conveyance facilities lack the capacity to divert sufficient water to supply 1 cfs per 70 acres at the headgates of the individual farmer. Assuming 40% loss within the conveyance facilities, an additional 500 cfs would need to be diverted at Whalen Dam to provide the GID with an on-farm delivery of 1 cfs per 70 acres. It should be noted, however, that these limitations assume that an adequate water supply is available for diversion at Whalen Dam. The GID has no intention of appropriating more water to meet the increased irrigation requirements; improving the existing conveyance facilities will allow the GID to divert the water available from their existing direct flow and storage rights to meet the increased demand in July and August.

At various times since the construction of the Fort Laramie Canal, the GID has attempted to divert flows in excess of 1,600 cfs. Problems which have surfaced in relation to the conveyance of these higher flows include the overtopping of the canal banks at selected locations, potential backwater conditions at the Parshall Flume near Whalen Dam, and increased seepage losses in the main delivery canal and laterals.

Overview of the Level II Investigation

This Level II investigation focused on the evaluation of the existing conveyance structures and Canal, as an interconnected system, and the development of alternatives to increase the Canal and structure capacity by a maximum of 20 percent, from 1,500 to 1,800 cfs. Assuming water is available for diversion, the capability to divert an additional 300 cfs will partially offset the shortfall in the water requirements created by an increase in crop consumptive use and the steadily recurring losses in the canal delivery system.

To increase the capacity of the main delivery canal, several rehabilitation alternatives were developed and evaluated. A recommended alternative was selected and both conceptual design information and cost estimates were prepared. Permits necessary for construction of the recommended alternative were also identified. Finally, an economic analysis was completed to assist the State of Wyoming in the development of a fair and
analysis was completed to assist the State of Wyoming in the development of a fair and equitable financing plan for the project improvements.

**Inventory and Evaluation of Existing Structures**

The inventory and evaluation of existing structures included the two tunnels, four siphons, six wasteway structures, the Parshall Flume near the headgate at Whalen Dam and the Canal from Whalen Dam to the Horse Creek Siphon. The results of the evaluation are summarized as follows.

**Tunnels and Siphons**

- Since construction of the tunnels and siphons, limited maintenance has been required to remedy either structural or hydraulic deficiencies.

- No serious structural deficiencies were noted in the structures that were inventoried. Some distress was noted but did not indicate serious subgrade movement or a high potential for structural failure.

- Some noticeable deterioration has occurred in several inlet and outlet transitions to the tunnels and siphons. Spalling and pitting of the concrete was observed along with exposed reinforcing bars and moderate cracking. Evidence of maintenance activities to repair historic spalling, pitting and cracking was noted.

- Hydraulically, the tunnels and siphons are very efficient which is a direct result of the extremely smooth nature of the concrete linings. The siphons create limited backwater within the Canal compared to the tunnels; the backwater created by the tunnels is largely due to their lengths which range from 2,000 to 2,700 feet. Although these structures are very efficient, the results of the evaluation indicate that they create a bottleneck in the canal thereby limiting the capacity of the canal to carry additional flow. This is especially true for the two tunnels.

**Fort Laramie Canal**

- Annual maintenance is performed on the Canal to repair sloughing and erosive banks. Maintenance activities also include the removal of vegetation that has encroached into the Canal.

- Compared to the original design drawings, the canal configuration has changed. In several locations, the canal has widened and sideslopes have increased. The canal bed is experiencing localized erosion and deposition at several locations along the study reach.
• The freeboard throughout the study reach is typically less than that indicated on the original design drawings. At several locations, the available freeboard during a diversion of 1,500 cfs is approximately 1 foot.

• The Canal is hydraulically efficient given the flat gradient (average slope less than 0.0001 ft/ft). The roughness of the canal bed and banks is relatively low and typical of an earth-lined channel. The velocity within the Canal is generally less than 2 fps with depths of flow ranging from 7.5 to 12 feet during a diversion of 1,500 cfs.

• A hydraulic analysis was conducted to determine the water surface profiles in the Canal with and without the presence of the tunnels and siphons. The results of the hydraulic analysis confirmed that the water levels in the Canal would be significantly lower, thereby creating additional capacity, if the tunnels and siphons were removed, bypassed or enlarged.

Wasteways and Parshall Flume

• The wasteway structures were found to be in good structural condition. Minor spalling and cracks were evident but did not indicate a serious structural deficiency.

• The majority of the wasteway structures are hydraulically ineffective. Only one structure will operate as originally designed. Three of the structures will not begin to release water until after overtopping of the canal banks becomes imminent. Structural modification along with increases in available freeboard will increase the capability of the wasteway structures to remove excess flows from the Canal.

• The Parshall Flume will operate effectively for diversions of 1,500 cfs. Significant backwater may be experienced during diversions ranging from 1,650 to 1,800 cfs; the backwater created by these diversion rates may render the Parshall Flume useless as a flow measuring device.

Summary of Alternative Evaluation

The development of alternatives fell into two broad categories: (a) those alternatives that increased the capacity of the canal system to divert water from 1,500 cfs to either 1,650 or 1,800 cfs, and (b) alternatives to improve or automate the existing wasteway structures. The alternatives evaluated during this project included the following:

Rehabilitation of the Siphons, Tunnels and Canal

1. No action,
2. Raising the canal banks,
3. Reducing the roughness of the siphon and tunnel linings,
4. Improving the inlets and outlets to the siphons and tunnels,
5. Increasing the cross sectional area of the siphons and tunnels, and
6. Pumping the increased diversion to bypass Tunnel Nos. 1 and 2.

**Rehabilitation of the Wasteway Structures**

1. No action, and
2. Modifying the existing siphon spillway or construction of a weir wall.

Based on the inventory and initial evaluation of the existing structures, a more
detailed hydraulic and economic investigation of each rehabilitation alternative was
conducted. Following the detailed analyses, several criteria were utilized to compare and
evaluate the alternatives. These criteria included: (a) feasibility of meeting the
rehabilitation objectives, (b) capital construction costs, (c) operation and maintenance costs,
and (d) permits, easements and environmental issues.

The initial screening of alternatives was based on the feasibility of the alternative to
meet the rehabilitation objectives. Two of the alternatives offered limited capability for
increasing the conveyance capacity. Due to the hydraulic efficiency of the existing
structures, both Alternatives #3 and #4 offered minimal benefits. Neither alternative,
whether implemented individually or combined, substantially increased the conveyance
capacity of the main delivery system; consequently, Alternatives #3 and #4 did not warrant
further consideration. In addition, the "no action" alternatives represent the existing
condition and were utilized solely as a means of comparison with the recommended
alternative.

The results of the initial screening identified Alternatives #2, #5 and #6 as feasible
alternatives to increase the conveyance of the main delivery system and Alternative #2 for
improving the existing wasteway structures. For the improvements to the wasteways,
no additional evaluation is warranted and Alternative #2 is recommended for conceptual
design and preparation of detailed cost estimates.

For rehabilitation of the main delivery system, Alternatives #2, #5 and #6 were
further evaluated on the basis of capital construction costs. These costs are listed below.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Q = 1,650 cfs</th>
<th>Q = 1,800 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative #2</td>
<td>$ 226,000</td>
<td>$ 570,000</td>
</tr>
<tr>
<td>Alternative #5</td>
<td>$ 2,109,000</td>
<td>$ 2,284,000</td>
</tr>
<tr>
<td>Alternative #6</td>
<td>$ 918,000</td>
<td>$ 1,522,000</td>
</tr>
</tbody>
</table>

6
The capital construction costs for Alternative #6 only include the costs associated with the pumps and drivers; costs for the associated pipelines were not specifically evaluated due to uncertainties in pipeline alignment. If construction costs for the pipelines are included, it is reasonable to assume that the costs indicated above for Alternative #6 would increase significantly.

As a means of confirming the selection of the recommended alternative, operation and maintenance costs; and permitting, easements and environmental issues were evaluated in a cursory manner for each remaining alternative. With construction of the pumping system for Alternative #6, operation and maintenance costs must be considered and will significantly increase the costs associated with this alternative. In addition, permitting, easements and environmental issues for Alternative #6 will require more effort considering the construction of the associated pipeline. Both Alternatives #2 and #5 compare favorably during the evaluation with these criteria.

Given the results of the alternative evaluation, especially the comparison of capital construction costs, preparation of both a conceptual design and detailed cost estimate is recommended for Alternative #2 for the rehabilitation of the siphons, tunnels and Canal.

In view of the minimum freeboard allowance of 3 feet in the USBR original design drawings, a cost estimate was also prepared for raising the canal banks to provide a 3-foot freeboard with the existing diversion of 1,500 cfs. The estimated capital construction costs associated with increasing the available freeboard to 3 feet are approximately $1,475,000 including construction and mobilization.

Conceptual Design and Cost Estimates

The conceptual design of improvements associated with the selected alternative consisted of four major components: (1) raising the canal banks to safely convey either 1,650 cfs or 1,800 cfs; (2) construction and calibration of a control section downstream of the existing Parshall Flume; (3) modifying five of the existing wasteway structures to automate the evacuation of excess flows from the Canal; and (4) improving the concrete aprons at the inlets and outlets to the tunnels and siphons.

Table 1.1 presents the total cost of the project components and the final cost estimate assuming the GID benefits solely from implementation of the selected alternative. Assuming a strict interpretation of the existing contract with the USBR, however, the GID may benefit from only 49% of the increased diversions. Consequently, Table 1 also presents the final cost estimate under this scenario.
Table 1.1 Cost of Project Components and Final Cost Estimate.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Cost for (Q = 1,650 cfs)</th>
<th>Cost for (Q = 1,800 cfs)</th>
<th>Cost for (Q = 1,650 cfs)</th>
<th>Cost for (Q = 1,800 cfs)</th>
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</thead>
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<tr>
<td>Raise Canal Banks</td>
<td>$ 200,250</td>
<td>$ 543,900</td>
<td>$ 200,250</td>
<td>$ 543,900</td>
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<tr>
<td>Control Section</td>
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<td>$ 25,950</td>
<td>$ 25,950</td>
<td>$ 25,950</td>
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<tr>
<td>Wasteways</td>
<td>$ 22,380</td>
<td>$ 29,900</td>
<td>$ 22,380</td>
<td>$ 29,900</td>
</tr>
<tr>
<td>Inlet and Outlet Improvements</td>
<td>$ 26,400</td>
<td>$ 26,400</td>
<td>$ 26,400</td>
<td>$ 26,400</td>
</tr>
<tr>
<td>Cost of Project Components</td>
<td>$ 274,980</td>
<td>$ 626,150</td>
<td>$ 274,980</td>
<td>$ 626,150</td>
</tr>
<tr>
<td>Engineering Costs (10%)</td>
<td>$ 27,500</td>
<td>$ 62,600</td>
<td>$ 27,500</td>
<td>$ 62,600</td>
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<tr>
<td>Subtotal</td>
<td>$ 302,480</td>
<td>$ 688,750</td>
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<tr>
<td>Contingency (15%)</td>
<td>$ 45,400</td>
<td>$ 103,300</td>
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<td>$ 103,300</td>
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<td>TOTAL CONSTRUCTION</td>
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<td>Final Plans and Specs</td>
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<td>$ 79,200</td>
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<td>Permitting and Mitigation</td>
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<td>$ 10,000</td>
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<tr>
<td>Access and Right-of-Way</td>
<td>$ 3,000</td>
<td>$ 3,000</td>
<td>$ 3,000</td>
<td>$ 3,000</td>
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<tr>
<td>TOTAL PROJECT COST</td>
<td>$ 396,680</td>
<td>$ 885,250</td>
<td>$ 396,680</td>
<td>$ 885,250</td>
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<td>Amount Eligible for WWDC Funding</td>
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<td>50% Loan</td>
<td>$ 198,340</td>
<td>$ 442,625</td>
<td>$ 97,190</td>
<td>$ 216,895</td>
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<td>Repayment Factor (25 yrs @ 4%)</td>
<td>0.06401</td>
<td>0.06401</td>
<td>0.06401</td>
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<td>ANNUAL PAYMENT</td>
<td>$ 12,700</td>
<td>$ 28,330</td>
<td>$ 6,221</td>
<td>$ 13,885</td>
</tr>
</tbody>
</table>
Conclusions and Recommendations

Based on the information provided in the previous chapters, the following conclusions and recommendations are provided.

1. If an increased diversion capability is desired or warranted, the rehabilitation improvements should consist of:
   - raising the canal banks to increase the conveyance capacity of the main delivery system from 1,500 cfs to either 1,650 or 1,800 cfs; the improvements extend from the Parshall Flume to the Horse Creek Siphon; and
   - replacement of the Parshall Flume with a control section to gage the increased flows of 1,650 or 1,800 cfs.

2. To reduce long-term operation and maintenance costs, rehabilitation of the wasteway structures (Wasteways 13.5, 25.5, 39.9, 52.4, and 77.3) should be completed to ensure the removal of water in excess of the capacity of the main delivery canal.

3. Deterioration of the inlet and outlet floors to several siphons and the two tunnels has been noted during this study. Selective improvements to the apron floors associated with the siphon and tunnel inlets and outlets are recommended.

4. Based on the increased diversion potential attributed to raising the canal banks, the GID will have the capability to divert an additional 16,365 acre-feet and 32,730 acre-feet, respectively for diversions of 1,650 and 1,800 cfs.

   The annual cost to divert an additional 150 or 300 cfs is estimated to be $12,700 and $28,330, respectively. This results in a cost per acre-foot of $0.78 for a diversion of 1,650 cfs at Whalen Dam or $0.87 for a diversion of 1,800 cfs. Costs associated with construction of the recommended improvements are estimated to increase the annual assessment from $18.76 per acre to either $19.00 or $19.30 per acre.

5. If the GID benefits from only 49 percent of the increased diversion capability, the GID will have the potential to divert an additional 8,020 acre-feet and 16,040 acre-feet, respectively for diversions of 1,650 and 1,800 cfs.

   The annual cost to increase the diversion capability is estimated to be $6,221 and $13,885, respectively for increased diversions of 150 or 300 cfs. The cost per acre-foot remains unchanged. Costs associated with construction of the recommended improvements are estimated to increase the annual assessment from $18.76 to either $18.88 or $19.02 per acre.
The remaining costs to complete the construction of the proposed improvements must be subsidized by the GFLID or funding sources/agencies within the State of Nebraska.

6. In view of the federal ownership status and the original design drawings for the Fort Laramie Canal, serious consideration should be given to increasing the existing freeboard (for a diversion of 1,500 cfs) at selected locations along the Canal. The capital construction costs to raise the canal banks to ensure a minimum freeboard of 1 foot is estimated to be $42,900. Raising the canal banks to ensure a minimum freeboard of 3 feet results in an estimated capital construction cost of $1,475,000.

7. Prior to proceeding to Level III, cost sharing with the water users in the State of Nebraska should be investigated. Improvements to the main delivery system have been limited to the study reach which ends at the Horse Creek Siphon with the increased diversion potential specifically earmarked solely for the water users within the GID. Additional improvements to the Horse Creek Siphon and the downstream canal will be required to convey additional water to the Nebraska water users. Furthermore, should a portion of the increased diversions be conveyed to Nebraska, additional improvements to the canal banks upstream of Horse Creek Siphon will also be required. It should be noted, however, that the delivery of additional water to Nebraska would require that the improvements recommended by this study be implemented. Alternate sources of funding must be obtained to assist the GFLID with payment obligations for the remaining 51% of the total project costs.

8. Direct coordination is required with the USBR to facilitate their approval of the recommended rehabilitation improvements. The following items should be addressed in future negotiations with the USBR.

- Transfer of ownership of the main irrigation delivery system from the USBR (Secretary of the Interior) to the GID.
- If ownership of the main irrigation delivery system remains with the USBR, a written request should be submitted to the USBR to obtain consent for all improvements that will increase the conveyance capacity.
- Modifying the existing contract with the USBR to include: (a) the capability of the GID to solely benefit from an increased diversion potential if the additional water is solely owned by the GID (i.e. not split the additional diversion on the basis of 49% to the GID and 51% to the GFLID); and (b) increasing the diversion potential, on a seasonal basis, from 1 cfs per 70 acres at Whalen Dam to a value that will provide the additional diversions necessary to meet the increased irrigation demands during July and August.