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FINAL REPORT
FOR
CASPER ALCOVA IRRIGATION DISTRICT
COMPUTERIZED IRRIGATION SCHEDULING

Prepared For:

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002

Prepared By:

Anderson Consulting Engineers, Inc.
772 Whalers Way, Suite 200
Fort Collins, CO 80525

V-Notch Weir near Alcova Reservoir

Anderson Consulting Engineers, Inc.
Civil • Water Resources • Environmental
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(WYWDC16.1)

May 12, 2003
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Appendix A: Questionnaire and Comments
Appendix B: Internet-Based Water Ordering Program
I. INTRODUCTION

1.1 General

On March 16, 2000, Anderson Consulting Engineers, Inc. (ACE) entered into a contract with the Wyoming Water Development Commission (WWDC) to complete the Casper-Alcova Irrigation District (CAID) Rehabilitation Needs Analysis. ACE was instructed to conduct a rehabilitation needs analysis of the CAID's irrigation system, to identify areas of the canal system where excessive losses are occurring and to identify opportunities to conserve water. The work effort was conducted in two phases; Phase I included the inventory and evaluation of existing facilities along with the development and evaluation of alternatives while Phase II consisted of the development of conceptual design and cost estimate information associated with the selected alternatives. The results of the Phase I work effort were summarized in a report submitted to the WWDC and CAID on April 15, 2002. The work associated with Phase II is ongoing and will be complete prior to the Summer of 2003.

During the completion of the Phase I work, the WWDC issued an amendment to the original contract to: (a) extend the expiration date to June 30, 2003; and (b) add an additional phase (Phase III) to the work effort. The Phase III work consists of investigating the potential integration of a computerized irrigation scheduling system into the existing operation and management of the CAID. Specifically, utilization of a web-based operation and administration computer model, originally developed and modified for this feasibility study by University of Wyoming Professor Mohan Reddy, was investigated. This report documents the results of the work effort associated with Phase III.

1.2 History

The CAID is located along the north side of the North Platte River between Alcova Dam and the City of Casper, Wyoming. The District was formed with the development of the Kendrick Project (formerly Casper-Alcova) by the United States Bureau of Reclamation, Department of Interior (Reclamation). This project conserves waters of the North Platte River for irrigation and electric power generation. As indicated on Figure 1.1, the major features of the Kendrick Project are Seminoe Dam and Powerplant, Alcova Dam and Powerplant, the Casper Canal and laterals, and appurtenant drainage and power systems facilities.
Figure 1.1 Kendrick Project Location Map
The Casper-Alcova Project was conceived by Reclamation as early as 1904 as part of several irrigation projects planned for the North Platte River Valley under the Newlands or Reclamation Act of 1902. The Newlands Act authorized the federal government to conduct reclamation projects with money obtained from the disposal of public lands. Although Reclamation began planning the construction of the Casper Canal and application was made for a water permit in 1904, no further action was taken until 1927. At that time, Wyoming Governor Emerson and Congressman Winter pushed for initiation of the project. They argued that Natrona County had made large contributions to the reclamation fund in the form of oil royalties, especially from the Salt Creek Field. With the gradual reduction of the project life of that field, Natrona County was in need of the economic boost that such a project would provide. Following his election in 1928, Senator Kendrick continued to fight for the project over the next five years despite lack of encouragement from the Hoover Administration or Reclamation. Senator Kendrick was finally able to gain presidential approval for the project in 1933. However, the project was given a current water appropriation date rather than 1904, the date when the water permit was originally submitted, due to the objections of other North Platte River users downstream in Wyoming and Nebraska whose water rights would then be junior to this new project.

The project was authorized under the National Industrial Recovery Act of June 16, 1933, and as a result, the Public Works Administration provided initial construction funding to develop irrigation and hydroelectric power facilities. Construction began on Seminoe and Alcova Reservoirs on the North Platte River in 1933, and on the associated Casper Canal in 1934. The Casper-Alcova Project was renamed the Kendrick Project in 1937. The dams at Alcova and Seminoe Reservoirs were completed in 1938. The Casper Canal was finished in 1939, although World War II delayed completion of the lateral distribution system. The major laterals were completed by 1946, and the first irrigation water was diverted into the Casper Canal on June 14, 1946.

The original canal was designed to convey irrigation water necessary to irrigate two units totaling 66,000 acres. The first unit was constructed to deliver water to 35,000 acres, however, drainage related problems have resulted in only partial development of the first unit. Funding to advance the development of the second unit has not been realized (Reclamation, 1955). The total irrigated land in production during recent years is reported to be approximately 24,250 acres.

During its first year of operation in 1946, the Casper-Alcova Project irrigated only 600 acres on 14 farms. By 1976, there were 172 farms and 23,549 acres of irrigated land. Presently, 515 users divert water associated with the 24,250 acres of irrigated lands. The principal crops are alfalfa, irrigated pasture grass, and small grains. Presently, most of the water users within the CAID rely on flood irrigation systems to deliver water to their crops. In the last few years,
however, eight to nine center pivot sprinkler systems and six to seven side-roll irrigation systems have been installed.

1.3 Project Goals and Purpose

The purpose of this project is to assess the potential for integrating a web-based water administration and operation model into the daily management of the CAID. It is our understanding that the model, developed by Dr. Mohan Reddy of the University of Wyoming, is intended to promote:

- placement of daily orders by water users through the use of the Internet;
- identification of delivery requirements on each lateral and along the main canal through the evaluation of the daily requests for water by the users;
- integration of data associated with seepage losses and operational waste to more accurately identify the diversion requirement from Alcova Reservoir; and
- operational management of the diversions from Alcova Reservoir to minimize operational waste.
II. PROJECT MEETINGS

2.1 Project Scoping Meeting

The project scoping meeting was conducted on January 25, 2002 in the University of Wyoming Cooperative Extension Service Building in Mills, Wyoming. This meeting was conducted in conjunction with a presentation of the results of the Phase I effort. The Phase III scoping portion of the meeting focused on a discussion of several project issues specifically including the modeling study by Dr. Reddy, potential implementation issues of that model by CAID staff, and the integration of the Phase III work effort with the overall work by ACE for the WWDC and CAID.

Representatives from the WWDC, ACE and CAID that attended the scoping meeting are identified below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Representing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Brad Anderson</td>
<td>Anderson Consulting Engineers, Inc.</td>
</tr>
<tr>
<td>Mr. Jay Schug</td>
<td></td>
</tr>
<tr>
<td>Mr. Bruce Brinkman</td>
<td>Wyoming Water Development Commission</td>
</tr>
<tr>
<td>Mr. Dale Anderson</td>
<td></td>
</tr>
<tr>
<td>Mr. George Baker</td>
<td>Casper-Alcova Irrigation District</td>
</tr>
<tr>
<td>Mr. Herman Strand</td>
<td></td>
</tr>
<tr>
<td>Mr. Ron Richner</td>
<td></td>
</tr>
<tr>
<td>Mr. Bob Bressler</td>
<td></td>
</tr>
<tr>
<td>Mr. James Best</td>
<td></td>
</tr>
<tr>
<td>Mr. John Bentley</td>
<td></td>
</tr>
<tr>
<td>Dr. Mohan Reddy</td>
<td>University of Wyoming</td>
</tr>
</tbody>
</table>

Specific problem areas, study goals and procedures were discussed along with the schedule for completing the project. During the scoping meeting, the District members provided insight to the existing project operation and management, and potential advantages and disadvantages associated with a web-based administration and operation model. Specific comments generated by the CAID are summarized below.

- Not all CAID water users have, or are willing to use computers in their farming practices.
- Concern was expressed about the compatibility of the model with respect to the existing software utilized by the CAID to record water orders and issue assessment records.
• Re-regulation of water using telemetry-based systems represents a potentially large opportunity for the District to make better use of its water. The benefits and potential use of regulating reservoirs and possible use of additional in-canal storage merits further investigation. This item should be addressed during the Phase II work effort.

2.2 Coordination Meetings

During the completion of the Phase III work effort, several additional meetings were conducted to present preliminary results, discuss the status of the project, and coordinate the modeling and reporting efforts of Dr. Reddy. In general, these meetings were held in the Fort Collins office of ACE and included Mr. Bruce Brinkman, Jay Schug, Brad Anderson as well as Dr. Reddy. Coordination meetings were specifically scheduled and conducted on April 23, July 8, and August 27, 2002.
III. IRRIGATION SYSTEM COMPONENTS

3.1 The Irrigation System Plan

In general, agricultural projects are designed and constructed to increase the production of foodstuffs, to create jobs for the local population, and to foster economic growth in an area. Soil scientists and agricultural engineers undertake an initial assessment of the irrigation potential of the lands to determine the feasibility of growing crops and estimating the irrigable acreage. Field surveys are performed to design the carriage canals and structures necessary to deliver water to the lands. Hydrology studies are conducted to determine the average annual water supply available to the lands. Where feasible, reservoirs are identified, evaluated and designed to extend the water supply from wet years to dry years and/or store runoff during months when snowmelt or rains are plentiful for release during the irrigation season.

Typically, in arid areas where irrigation is required to supplement the natural rainfall in order to grow a crop, dry years will occur which will require the inclusion of reservoirs as part of the agricultural system. Usually the reservoirs are not designed and built with irrigation water supply as the only project purpose; hydropower, flood control, municipal water supply and other purposes are added to assist the economic and financial viability of the project and minimize the repayment obligation of the agricultural water users. Virtually all Reclamation projects in the Western United States are multiple-purpose projects wherein the agricultural water users are one sector of the project beneficiaries.

The development of an agricultural project starts with a determination of irrigable acreage and an estimate of the crop irrigation requirements. Typically a water budget analysis is completed, which will identify the diversion requirements at the main river/reservoir headgate to satisfy the on-farm delivery requirement. On a lateral-by-lateral basis, the analysis determines the water that must be diverted and conveyed in order to satisfy the irrigation demand. The diversion requirements identified during the analysis determine the size of the main carriage facilities (main delivery canal and laterals) as well as the need for irrigation structures such as lateral headgates and measurement structures, check structures, drop structures, and wasteway structures. Following the field survey of the lands required to identify the main delivery canal and laterals for the irrigation system, the on-farm water delivery requirements are evaluated to determine the placement and design of individual turnout and headgate structures.
3.2 Components of an Irrigation Project

3.2.1 Primary Conveyance Facilities

The irrigation system starts with the main diversion headgate from the river or reservoir. This headgate structure usually has a dual purpose: (a) to control the diversion of flow into the irrigation project; and (b) to measure the delivery to the project. Measurement at the main headgate typically requires a permanent and continuous recording device. The headgate structure is designed to divert a range of flows during the irrigation season including the maximum peak flow and minimum flows allowed by the administration of the irrigation water right. Furthermore, the structure's design should allow for the measurement of these deliveries over the full range of the diversions. The main delivery canal downstream of the headgate is sized to convey the maximum diversion requirement at a design velocity that prevents scour and damage to downstream structures, while maintaining sufficient velocities to minimize sediment deposition throughout the canal system. Spillways or wasteway structures are designed and constructed on the main canal and laterals to protect the conveyance facilities from damage associated with stormwater runoff or flow diversions in excess of demand requirements. Check structures are typically installed to promote the diversion of the irrigation deliveries by increasing the depth of flow at each structure. In general, check structures are located immediately downstream of headgates and wasteway structures within the main delivery canal and laterals.

Deliveries from the main canal to laterals are diverted through headgate structures, typically equipped with measurement devices. Similar to the main delivery canal, measurement at the lateral headgates often requires a permanent and continuous recording device. The design and configuration of these structures is based on the farm delivery requirements coupled with the potential losses to seepage, evaporation and operational waste, i.e., the efficiency of the lateral system. As stated previously, check structures are often designed and constructed to maintain pools to control the diversion of irrigation water into the lateral.

Gate structures (headgates, wasteways, etc.) on the main canal and laterals have historically been equipped with manual operators only, especially on smaller canals carrying 400 cfs or less. On larger canals, motorized gate operators are installed to ease the operation. The automation of these facilities promotes the operation and management of the water deliveries within the network of irrigation facilities. Remote operation of gates to control downstream water deliveries or to maintain upstream water levels requires automatic gate actuators and computerized logic to move the gate.

Other factors to consider in the design of canals and hydraulic structures are the sediment transport capabilities of the canals and structures and the foundation materials encountered
during construction. This information will be utilized to determine the need for potential sediment traps, lining of the canal to minimize potential seepage, or the need to install structures to sluice sediment accumulated within the delivery system. In addition, depending on the topographic conditions, specialty structures may be required to convey the water to the users. These structures may include siphons, tunnels, and drop structures.

3.2.2 On-Farm Structures

Farm turnout structures are provided at each delivery point within the irrigation delivery system. Typically, the farm turnout structures consist of concrete headwalls installed with canal slidegates to facilitate the diversion of the individual water deliveries. Measurement structures are typically required to record the actual delivery of water to the users. These structures vary but generally include either parshall flumes, cipoletti weirs or constant head orifice structures. The conveyance facilities and application of water to the irrigated lands is typically the responsibility of the individual landowner.
IV. FARM SYSTEM INVENTORY

During the Phase I study, ACE performed an inventory of the agricultural lands under the CAID system. Complete details of the inventory are included in the April 2002 Phase I final report. A synopsis of the inventory is included herein to facilitate the discussion related to the potential integration of a web-based administration and operation model.

As an integral part of this Phase III work effort, ACE conducted a survey of the 224 irrigators that currently order water from the CAID. The survey was intended to determine the computer resources and user knowledge of computers within the CAID. Additionally, the survey attempted to gauge the interest of the water users in adopting a web-based administration and operation model, particularly for the placement of daily water orders.

4.1 Irrigated Acreage Characterization

The determination of the irrigation demand relied heavily on the availability of irrigated acreage mapping. The WWDC provided the mapping in a GIS digital format for this purpose. The GIS mapping included delineation of:

- irrigated acreage;
- planimetric features such as roads, hydrologic features, etc.; and
- CAID boundary.

To characterize the irrigated acreage, ACE met with CAID ditch riders and staff on several occasions. With their assistance, additional information was added to the GIS mapping. Each irrigated parcel was described in terms of its cropping pattern, method of irrigation, and the lateral from which it receives water. Based upon the information provided by the CAID staff and data collected during subsequent field reconnaissance, Figure 4.1 was prepared. Figure 4.1 displays the irrigated acreage within the CAID according to the lateral from which it is irrigated. Table 4.1 provides a matrix that characterizes the irrigated acreage within the CAID in terms of its cropping pattern and method of irrigation. Alfalfa is by far the dominant crop within the CAID, followed by irrigated pasture, corn and spring grains. Of the total irrigated acres, roughly 91% consists of alfalfa. Of that portion, approximately 84% are irrigated using conventional furrow methods. This area constitutes over 76% of the irrigated acreage within the CAID.
This figure is intended to show the general location of parcels. Therefore, true boundaries between parcels may differ from those indicated.

NOTE: Delineation of irrigation methods is approximate and based upon areal information provided by CAID staff.

Figure 4.1. Casper-Alcova Irrigation District: Lateral Acreage
Table 4.1 CAID Irrigation Method – Cropping Pattern Matrix.

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Furrow (%)</th>
<th>Side Roll Sprinkler (%)</th>
<th>Center Pivot Sprinkler (%)</th>
<th>Home/Misc. Sprinklers (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>76.5</td>
<td>3.7</td>
<td>10.5</td>
<td>-</td>
<td>90.7</td>
</tr>
<tr>
<td>Corn</td>
<td>1.2</td>
<td>-</td>
<td>1.2</td>
<td>-</td>
<td>2.4</td>
</tr>
<tr>
<td>Pasture</td>
<td>4.5</td>
<td>0.1</td>
<td>-</td>
<td>-</td>
<td>4.6</td>
</tr>
<tr>
<td>Spring Grain</td>
<td>0.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>Lawns/Misc.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>82.9</td>
<td>3.8</td>
<td>11.7</td>
<td>1.6</td>
<td>100</td>
</tr>
</tbody>
</table>

It is understood that the overall cropping patterns may change each year as crops are rotated or irrigators otherwise decide to change cropping patterns. The numbers presented herein are intended to reflect the current cropping pattern within the CAID. Similarly, the irrigation methods summarized in Table 4.1 represent those methods presently utilized within the CAID.

4.2 District Water Requirements

4.2.1 Consumptive Irrigation Requirement

Given the cropping pattern previously described, an estimate of the Consumptive Irrigation Requirement (CIR) was computed. Table 4.2 tabulates the CIR required to sustain the existing crops within the District. These values represent the quantity of water that must be supplied to the crop. They do not account for irrigation method or conveyance losses. Based on this analysis, the baseline CIR for the District is estimated to be approximately 32,655 acre-feet.

Table 4.2 Summary of CAID Crop Irrigation Requirement: Baseline Conditions.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Furrow (ac-ft)</th>
<th>Side Roll (ac-ft)</th>
<th>Pivot (ac-ft)</th>
<th>Home/Misc. (ac-ft)</th>
<th>LEPA (ac-ft)</th>
<th>Surge (ac-ft)</th>
<th>Totals (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>24,756</td>
<td>1,194</td>
<td>3,394</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>29,344</td>
</tr>
<tr>
<td>Corn</td>
<td>293</td>
<td>--</td>
<td>278</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>571</td>
</tr>
<tr>
<td>Lawns</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,140</td>
<td>--</td>
<td>--</td>
<td>1,140</td>
</tr>
<tr>
<td>Spring Grains</td>
<td>127</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>127</td>
</tr>
<tr>
<td>Pasture</td>
<td>1,449</td>
<td>25</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,473</td>
</tr>
<tr>
<td>Total</td>
<td>26,624</td>
<td>1,219</td>
<td>3,672</td>
<td>1,140</td>
<td>--</td>
<td>--</td>
<td>32,655</td>
</tr>
</tbody>
</table>
4.2.2 On-Farm Delivery Requirements

The On-Farm Delivery Requirement (ODR) is defined as the amount of water that must be delivered in an average year to satisfy the CIR for the crop following efficiency losses associated with the irrigation practices in place. To estimate the ODR, the CIR for a given crop on a given parcel of irrigated land is divided by the efficiency associated with the irrigation method.

Irrigation methods/practices that are currently used within the CAID were identified with the assistance of CAID staff. As indicated in Table 4.1, the predominant irrigation method in the CAID is conventional furrow irrigation. A growing number of irrigators are using various forms of sprinkler systems, specifically, low-pressure center pivots or side roll sprinklers (linear move). According to the NRCS, high pressure sprinkler systems are no longer present within the CAID; all sprinklers have either been converted to low-pressure systems or were initially installed as low pressure. Based on conversations with the NRCS and the CAID staff, it is understood that no LEPA sprinkler or drip systems are currently utilized within the CAID.

Based upon the application efficiencies associated with each irrigation method, the water delivery necessary to satisfy the on-farm consumptive irrigation requirement was determined. This quantity of water is the amount needed to satisfy the CIR plus the amount needed to satisfy efficiency losses associated with the irrigation methods. Table 4.3 summarizes the On-Farm Delivery Requirement for the CAID.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Furrow (ac-ft)</th>
<th>Side Roll (ac-ft)</th>
<th>Pivot (ac-ft)</th>
<th>Home/Misc. (ac-ft)</th>
<th>LEPA (ac-ft)</th>
<th>Surge (ac-ft)</th>
<th>Totals (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>45,844</td>
<td>1,592</td>
<td>4,243</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>51,679</td>
</tr>
<tr>
<td>Corn</td>
<td>543</td>
<td>--</td>
<td>348</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>891</td>
</tr>
<tr>
<td>Lawns</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,425</td>
<td>--</td>
<td>--</td>
<td>1,425</td>
</tr>
<tr>
<td>Spring Grains</td>
<td>235</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>235</td>
</tr>
<tr>
<td>Pasture</td>
<td>2,683</td>
<td>33</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2,716</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49,305</strong></td>
<td><strong>1,625</strong></td>
<td><strong>4,591</strong></td>
<td><strong>1,425</strong></td>
<td><strong>--</strong></td>
<td><strong>--</strong></td>
<td><strong>56,946</strong></td>
</tr>
</tbody>
</table>

Within the CAID, an estimated 56,946 acre-feet of water must be delivered to the irrigated lands to satisfy the estimated CIR of 32,655 acre-feet. This implies that approximately 24,000 acre-feet of water are lost in a typical year due to losses associated with irrigation methods.
4.2.3 Alcova Reservoir Diversion Requirement

For the purposes of this project, the Alcova Reservoir Diversion Requirement (ADR) is defined as the water that must be diverted at Alcova Reservoir in an average year to meet the On-Farm Delivery Requirement. The results of a water budget analyses described in Chapter 5 of this report were utilized to estimate the diversion requirements at Alcova Reservoir. The water budget analyses accounts for reduction in the Alcova Reservoir diversions associated with seepage losses and operational waste.

Table 4.4 summarizes the results of this effort. By applying the estimated losses in the main canal and the estimated losses on each lateral, the mean annual diversion requirement from Alcova Reservoir was determined to be approximately 68,213 acre-feet.

**Table 4.4 Summary of CAID Diversion Requirement: Baseline Conditions.**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Furrow (ac-ft)</th>
<th>Side Roll (ac-ft)</th>
<th>Pivot (ac-ft)</th>
<th>Home/Misc. (ac-ft)</th>
<th>LEPA (ac-ft)</th>
<th>Surge (ac-ft)</th>
<th>Totals (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>55,921</td>
<td>1,794</td>
<td>4,810</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>61,525</td>
</tr>
<tr>
<td>Corn</td>
<td>646</td>
<td>--</td>
<td>369</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,015</td>
</tr>
<tr>
<td>Lawns</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1,598</td>
</tr>
<tr>
<td>Spring Grains</td>
<td>263</td>
<td>--</td>
<td>--</td>
<td>1,598</td>
<td>--</td>
<td>--</td>
<td>263</td>
</tr>
<tr>
<td>Pasture</td>
<td>3,775</td>
<td>37</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>3,812</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59,605</strong></td>
<td><strong>1,831</strong></td>
<td><strong>5,179</strong></td>
<td><strong>1,598</strong></td>
<td>--</td>
<td>--</td>
<td><strong>68,213</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Evaporation Factor</th>
<th>995</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Operational Waste</td>
<td>2,278</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total Diversion Requirement</strong></td>
<td>71,485</td>
<td></td>
</tr>
</tbody>
</table>

In summary, a total of 68,213 acre-feet of water must be diverted at Alcova Reservoir in an average year to meet the on-farm consumptive irrigation requirements within the CAID. This value accounts for irrigation efficiency, and canal/lateral losses identified in the water budget analyses. Operational waste is estimated to be approximately 4% of the on-farm requirement and evaporation losses were estimated to be approximately 995 acre-feet per year. Adding these factors to the estimated total diversion requirement brings the total to 71,485 acre-feet per year. This value compares very favorably to the long-term average diversion of 71,212 acre-feet at Alcova Reservoir computed from 20 years of recorded data (1979 to 1999).
4.3 Daily Administration and Computer Capabilities

4.3.1 Daily Administration

The administrative staff of the CAID utilizes personal computers to track the orders from individual water users. This information is collected to develop a continuous record of the water usage for each user and provides the basis for individual assessments for water delivery. Currently, the CAID receives water orders from its users on a daily basis and this information is input to the water allocation database. The administrative staff compiles these orders within the database and determines a daily diversion requirement from Alcova Reservoir into the Casper Canal. Actual diversion data is not recorded by the CAID although measurement structures exist at the turnout structures for each water user. Furthermore, although measurement structures are located at several of the lateral headgate structures, no daily measurements are recorded to track the water deliveries through the irrigation system. Based on the experience of the ditch riders and CAID manager, losses in the system are estimated and added to the daily water demands to develop an estimate of the diversion requirement from Alcova Reservoir. The estimate of the system losses has typically ranged from 25% to 35% of the total diversion from the reservoir.

4.3.2 Computer Capabilities

Questionnaires were mailed to 224 irrigators of the CAID on May 23, 2002 to determine the computer capabilities and computer knowledge of the individual water users. In addition, the interest of the water users in an Internet-based water ordering system was also queried. Results of the survey are presented in Figure 4.2. A review of the responses received from the water users is summarized below:

- Of the 100 water users that responded to the questionnaire, 70 owned a personal computer, one (1) stated interest in purchasing a computer in the near future and 29 expressed no interest in acquisition of a computer.

- Given the potential for placement of Internet-based water orders through a cable TV or satellite TV system, 95 water users (out of the 100 responses) owned a TV and of those that owned TVs, only 64 had either cable or satellite TV systems.

- The computer capability of those water users that responded to the questionnaire was determined to be above average based on a scale of 1 to 5 with the highest ability receiving a rating of 5.
Do you currently own a PC?

Yes: 70
No: 29
Will Buy: 1

Do you have internet access?

Yes: 61
Will Obtain: 4
No: 5

How would you rate your ability to use your computer?

No Computer Low High

Would you be willing to use an internet system to place water requests?

No: 58
Yes: 42

Do you currently own a TV?

Yes With Satellite Service: 43
Yes With Cable Service: 21
Yes With No Service: 31
No TV: 5

No 1 2 3 4 5
• Of those water users that owned a computer, 61 had access to the Internet with an additional four (4) planning on accessing the Internet in the near future.

• The number of water users willing to use an Internet-based system to place water orders was determined to be 42 of the 100 water users that responded to the questionnaire.

The majority of the respondents questioned the economic benefit of switching to an Internet-based system of placing water orders. In addition, some of the water users expressed concern that no benefits to water conservation would be realized through an Internet-based system. Appendix A presents an example of the survey questionnaire and a summary of the comments received from the water users that responded to the survey.
V. IRRIGATION SYSTEM INVENTORY

5.1 General

The CAID irrigation delivery system consists of the Casper Canal (59 miles long), 190 miles of laterals and sublaterals, and 41 miles of drains (Reclamation, 1982). Principal structures include the headgate located on Alcova Reservoir, six concrete-lined tunnels totaling approximately 3.4 miles in length, several siphons, highway and farm road bridges, and measurement and control structures. The original design and constructed capacity of the main canal was 1,200 cubic feet per second. Since construction of the canal, a V-notch weir has been installed which limits the flow into the Casper Canal to approximately 600 cubic feet per second and provides the principal measurement point for CAID water deliveries. Reclamation operates and maintains all power facilities, Seminoe Dam and Reservoir, and Alcova Dam and Reservoir. CAID operates and maintains all carriage, distribution, and drainage works (Reclamation, 1997). Figure 5.1 displays the Casper Canal and principal laterals.

In support of Phase I of the Casper-Alcova Irrigation District Rehabilitation Needs Analysis, a field investigation was conducted to: (a) inventory and document the condition of the existing facilities; (b) evaluate operational and management improvements; and (c) identify and evaluate areas of potential seepage loss. The field work provided the data necessary to promote the development of a water budget for the CAID and evaluation of the operational efficiency of the water delivery system. In addition, specific structures were earmarked where accurate flow measurement is needed to improve future management of the CAID.

The majority of the Phase I field inventory was conducted during the year 2000 and included measurements of existing structures, assessment of their condition, assessment of the hydraulic efficiency of the structures, photographic documentation of the structures and their condition, and location of the structures using GPS technology. The project workbook contains copies of all inventory forms completed during Phase I of the project. All structures inventoried during the completion of this project are also included in a layer/theme within the GIS database.

Several types of structures were identified during the inventory of existing facilities. These structures include the following categories: (a) main delivery canal; (b) siphons; (c) tunnels; (d) check structures; (e) wasteway structures; (f) crossings (roads, pipelines); (g) lateral headgates; (h) lateral canals; and (i) measurement devices. The field inventory included those structures along Casper Canal and Lateral 256 that convey over 30 percent of the diversions from Alcova Reservoir. Due to the relative magnitude of the diversions conveyed in the remaining laterals, the inventory of structures along these conveyance facilities was limited to the lateral headgates and associated measurement structures.
The results of the inventory work conducted in Phase I are summarized in this chapter. Aspects and results of the field inventory that are especially pertinent to the development of an Internet-based water ordering and management program are specifically earmarked.

5.2 Inventory of Existing Structures

The information collected during the field inventory of structures on the Casper Canal and Lateral 256 is summarized in Appendix B (Tables B.1 and B.2) of the Phase I Report (ACE, April 2002). These tables include descriptions of the structure and its function, its location, and assessment of its current condition.

Although many structures inventoried during the field investigation showed significant wear and varied degrees of deterioration, few appeared to be damaged to such extent that the integrity of the canal system is jeopardized. All headgates appeared to be in very good condition and, with the exception of possible sedimentation problems, should serve the CAID well into the future.

The Bureau of Reclamation completed a detailed inspection of several CAID structures in October 1999. These structures included the main canal; several siphons; Tunnels 3, 4 and 5; and the lateral headgates. Several problems associated with those structures were noted and specifically identified as “Category 2” repairs meaning “action is needed to prevent or reduce further damage, or preclude operational failure”.

Additional inventory work was conducted in 2002 in response to observations made by representatives of the CAID during routine inspections of the facilities. The additional inventory work identified the problems described below.

- The concrete box culvert attached to the headgate structure for Lateral 128 was severely cracked and displaced. Seepage of irrigation water along the box culvert resulted in noticeable sloughing of the canal bank during the irrigation season. Temporary repairs were made to prevent the loss of additional material along the canal bank. Immediate repair of the concrete box culvert and inspection of the structural integrity of the headgate structure is warranted.

- Seepage along the Johnson Siphon (Lateral 256) was noted during the 2002 irrigation season. A field inventory following the irrigation season noted several locations where potential seepage from the concrete conduit may be occurring. Rehabilitation of the siphon is warranted, specifically along the construction joints.
Those structures identified in the Casper Canal and Lateral 256 that require rehabilitation immediately, or in the near future, are presented in Table 5.1.

Table 5.1 Structures Requiring Rehabilitation.

<table>
<thead>
<tr>
<th>Location</th>
<th>Rehabilitation Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Canal</strong></td>
<td></td>
</tr>
<tr>
<td>Mile 13.04</td>
<td>Repair Tunnel No. 3 Transition Wall</td>
</tr>
<tr>
<td>Mile 14.51</td>
<td>Repair Tunnel No. 4 Transition Wall</td>
</tr>
<tr>
<td>Mile 20.91</td>
<td>Repair Willow Creek Siphon Transition Floor</td>
</tr>
<tr>
<td>Mile 22.41</td>
<td>Repair Poison Spider Siphon Transition Floor</td>
</tr>
<tr>
<td>Mile 33.76</td>
<td>Repair Tunnel No. 5 Transition Floor</td>
</tr>
<tr>
<td>Mile 61.52</td>
<td>Stabilize wasteway channel and spillway structure</td>
</tr>
<tr>
<td>Mile 24.66</td>
<td>Lateral 128 Headgate Structure Rehabilitation</td>
</tr>
<tr>
<td><strong>Lateral 256</strong></td>
<td></td>
</tr>
<tr>
<td>256-3</td>
<td>Replace concrete wall at turnout structure</td>
</tr>
<tr>
<td>256-4</td>
<td>Repair concrete walls and floor in drop structure</td>
</tr>
<tr>
<td>256-5</td>
<td>Repair concrete walls and floor in drop structure</td>
</tr>
<tr>
<td>256-6</td>
<td>This item recently repaired by CAID</td>
</tr>
<tr>
<td>256-7</td>
<td>Repair concrete in walls/apron of headgate structure</td>
</tr>
<tr>
<td>256-8</td>
<td>Repair concrete in Johnson Siphon</td>
</tr>
</tbody>
</table>

Due to the immediate need associated with the rehabilitation of the Lateral 128 headgate structure, the CAID is presently completing the repairs associated with this structure. Funding associated with the repairs to Tunnels 3 and 4 has been included in the Wyoming Water Development Commission Rehabilitation Program at Level III and recently approved by the Wyoming legislature. It is anticipated that construction related to Tunnels 3 and 4 will be completed following the 2003 irrigation season. Additional information related to the conceptual design and cost estimates of the rehabilitation associated with those structures identified in Table 5.1 will be included in the Phase II Final Report.

During the inventory of existing facilities, several lateral headgates were noted as being inactive. These headgates are presented in Table 5.2.
Table 5.2 Inactive Lateral Headgates.

<table>
<thead>
<tr>
<th>Casper Canal Milepost</th>
<th>Lateral Headgate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.71</td>
<td>Lateral 19</td>
</tr>
<tr>
<td>34.87</td>
<td>Lateral 183</td>
</tr>
<tr>
<td>45.15</td>
<td>Lateral 236</td>
</tr>
<tr>
<td>47.71</td>
<td>Lateral 250</td>
</tr>
<tr>
<td>50.19</td>
<td>Lateral 263</td>
</tr>
<tr>
<td>53.09</td>
<td>Lateral 278</td>
</tr>
<tr>
<td>57.57</td>
<td>Lateral 290</td>
</tr>
<tr>
<td>58.53</td>
<td>Lateral 309</td>
</tr>
<tr>
<td>58.98</td>
<td>Lateral 311</td>
</tr>
<tr>
<td>60.25</td>
<td>Lateral 318</td>
</tr>
<tr>
<td>61.13</td>
<td>Lateral 323</td>
</tr>
</tbody>
</table>

5.3 Measurement Structures

During the inventory of the existing facilities, several locations were noted where measurement structures should be installed or require replacement. Table 5.3 lists those locations where measurement structures are needed or improvements to existing measurement structures are necessary. It should be noted that measurement structures should be installed at all lateral and main canal wasteways to facilitate water management of the CAID. To the extent that an Internet-based water ordering and management program is developed, measurement structures will provide vital information to the operation and management of the irrigation diversions from Alcova Reservoir.

5.4 Water Budget Analysis

During the Phase I work effort, water budget models were developed for the Casper Canal and for each of the main laterals to further define and evaluate system-wide losses. As compared to the losses identified by the Phase I seepage studies at specific locations along the canal/laterals, the water budget models provide an indication of the average water losses over much longer reaches and on a much larger scale along the entire delivery system. This information provides valuable insight to the operation and management of the diversions from Alcova Reservoir and offers potentially valuable data that can be integrated into an Internet-based operation and management program.
### Table 5.3 Measurement Structure Rehabilitation Requirements.

<table>
<thead>
<tr>
<th>Canal/Lateral</th>
<th>Type</th>
<th>Device Type</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral 31</td>
<td>Earth-lined</td>
<td>Meter</td>
<td>Meter is not located near headgate.</td>
</tr>
<tr>
<td>Lateral 57</td>
<td>Concrete-lined</td>
<td>Control Section</td>
<td>Inaccurate readings.</td>
</tr>
<tr>
<td>Lateral 58</td>
<td>Pipeline</td>
<td>None</td>
<td>No measurement device exists.</td>
</tr>
<tr>
<td>Lateral 59</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Submergence of weir.</td>
</tr>
<tr>
<td>Lateral 125</td>
<td>Natural Drainageway</td>
<td>None</td>
<td>No measurement device exists.</td>
</tr>
<tr>
<td>Lateral 128</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Severe deterioration of weir plate.</td>
</tr>
<tr>
<td>Lateral 147</td>
<td>Pipeline/Concrete-lined</td>
<td>None</td>
<td>No measurement device exists near headgate.</td>
</tr>
<tr>
<td>Lateral 156</td>
<td>Earth-lined</td>
<td>None</td>
<td>No measurement device exists.</td>
</tr>
<tr>
<td>Lateral 160</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Need staff gage.</td>
</tr>
<tr>
<td>Lateral 174</td>
<td>Earth-lined</td>
<td>Parshall Flume</td>
<td>Poor flume location; replace flume with weir.</td>
</tr>
<tr>
<td>Lateral 256</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Weir not located near headgate.</td>
</tr>
<tr>
<td>Lateral 270</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Weir not located near headgate.</td>
</tr>
<tr>
<td>Lateral 314</td>
<td>Earth-lined</td>
<td>Weir</td>
<td>Sediment has rendered weir inoperable; replacement necessary.</td>
</tr>
<tr>
<td>Lateral 328-05</td>
<td>Earth-lined</td>
<td>None</td>
<td>No measurement device exists.</td>
</tr>
<tr>
<td>Main Canal (MP 0.6)</td>
<td>Earth-lined</td>
<td>V-Notch Weir</td>
<td>Instantaneous discharge not available</td>
</tr>
<tr>
<td>Main Canal (MP 48.9)</td>
<td>Earth-lined</td>
<td>None</td>
<td>No device to measure discharge downstream of Lateral 256.</td>
</tr>
</tbody>
</table>

The water budget models function by balancing the inflows to a canal or lateral against outflows. Ideally, inflow to a canal or lateral reach consists of canal discharge at the upstream end of the reach, surface runoff and direct precipitation. Outflow from a canal or lateral reach consists of the canal discharge at the end of the reach, diversions including operational waste, evaporation, and seepage losses. This concept is illustrated in Figure 5.2. Detailed information related to the development of the water budget models is presented in the Phase I Report. Pertinent information from the Phase I Report is summarized in this chapter to the extent that is can be utilized to promote the integration of an Internet-based water ordering and management model.
To facilitate the water budget analyses, a simplified diagram of the CAID canal system was developed and is illustrated in Figure 5.3. This diagram shows the relative locations of the main canal headgate at Alcova Reservoir, the V-notch weir, and the lateral headgates. The number of acres irrigated by each lateral is also presented. Lateral 256, also known as the Johnson Lateral, diverts the majority of the irrigation water from the Casper Canal and is used to irrigate approximately 9355 acres, or 39.5% of the total irrigated acreage. Other major diversions from the Casper Canal include Laterals 218, 128, and 147. As indicated previously, there are several lateral headgates located along the Casper Canal that have never been utilized. These headgates are not included in the diagram displayed in Figure 5.3.

5.4.1 Casper Canal Water Budget

A spreadsheet model was constructed which, using the water budget approach, estimated average losses and gains for the reaches bounded by control structures. The Casper Canal was divided into two study reaches based upon the location of adequate measurement structures. Reach 1 consists of the Casper Canal between the V-notch weir and the check structure at
Figure 5.3 Schematic Diagram of the Casper-Alcova Irrigation District.
Milepost 34.78. Reach 2 extends from the check structure at Milepost 34.78 to the 15-foot weir located on Lateral 256. In the vicinity of the Lateral 256 headgate, a check structure (Milepost 48.91) exists, however, no capability to measure flows has been incorporated at this location. This fact, combined with the fact that Lateral 256 diverts the majority of flow from the canal at this location, resulted in extending the downstream limit of Reach 2 to the Lateral 256 weir. In addition, downstream of Milepost 48.91, the lateral headgates (i.e., Laterals 270, 278 and 314) do not have measurement devices. Therefore, the Casper Canal and laterals downstream of Structure 48.91 were combined and treated as a single lateral.

Figure 5.4 presents the node diagram associated with the water budget model for the Casper Canal. At each node in the diagram, the average daily flow rate for the evaluation period is presented (July 4 to August 30). For Reach 1, the mean daily flow at the V-notch weir was 289.9 cfs, total diversions averaged 84.2 cfs, daily evaporation was estimated to be 1.8 cfs and precipitation/storm runoff was estimated to be 0.2 cfs. Given these water budget components, the reach outflow at Structure 34.78 was computed to be 204.1 cfs. This value is 7.9 cfs greater than the average measured flow rate (196.2 cfs) indicating that approximately 2.8% of the inflow may be lost to seepage. This value translates to a loss of approximately 0.08% per mile of canal.

The water budget for Reach 2 yielded similar results. The measured flow at Structure 34.78 was used as the canal inflow to the reach (196.2 cfs). Mean total diversions were determined to be 94.9 cfs; this value includes the average flow in the Casper Canal downstream of the Lateral 256 headgate (39.1 cfs). Evaporative losses averaged 0.9 cfs and precipitation input averaged 0.2 cfs. Given these water budget components, the reach outflow at the Lateral 256 weir was computed to be 100.6 cfs. Comparing this value to the average measured flow at the weir of 95.6 cfs, approximately 5.0 cfs can be assumed to be lost to seepage. This value represents approximately 2.5% of the reach inflow and translates to a loss of approximately 0.14% per mile of canal.

Figure 5.5 presents a pie chart of the combined water budget for Reach 1 and Reach 2. This figure indicates that on the average, about 95% of the water diverted from Alcova Reservoir reaches a lateral headgate and approximately 5% is lost to seepage within the Casper Canal between Alcova Reservoir and Mile 48.9. In a typical year, minimal operational waste occurs in the management of the main canal. To put the results of the water budget model in perspective, and assuming an average annual diversion of 71,000 acre-feet from Alcova Reservoir, over 3,200 acre-feet are potentially lost annually to seepage within the main canal from Alcova Reservoir to the Lateral 256 headgate.
Figure 5.4 Casper-Alcova Irrigation District Water Budget.
5.4.2 Lateral Water Budgets

A similar evaluation was conducted for each of the CAID laterals where data were available. The results of the individual water budget analysis are presented in Figure 5.6 for each lateral.

Figure 5.7 displays a pie chart showing the relative distribution of all irrigation water diverted by the CAID lateral headgates. As previously discussed, approximately 95% of the District’s diversions from Alcova Reservoir are delivered to lateral headgates. Following the diversion at the lateral headgates, approximately 12.7% is lost to seepage, 4.1% to operational waste, and 0.5% to evaporation, leaving almost 83% for delivery to the individual turnouts.

Based on the results of the water budget analyses, the relative distribution of the irrigation diversions from Alcova Reservoir was also evaluated. Figure 5.8 displays a pie chart,
Figure 5.6 Distribution of Flows Diverted from Casper Canal.
Figure 5.6  Distribution of Flows Diverted from Casper Canal (Continued).
Figure 5.6 Distribution of Flows Diverted from Casper Canal (Continued).
which represents the relative distribution of the irrigation diversions through the Casper Canal/lateral delivery system. All percentages in this figure relate to the total quantity of water diverted from Alcova Reservoir. As indicated in the figure, the diversions from Alcova Reservoir are reduced by 4.5% to Casper Canal seepage, 3.9% to lateral waste, 12.0% to lateral seepage, and 1.4% to evaporation from both the main canal and laterals. This leaves approximately 78% that ultimately is conveyed to the users’ turnout structure.

![Figure 5.8 Casper-Alcova Irrigation District: Distribution of 2000 Irrigation Diversions](image)

Assuming an average annual diversion of 71,000 acre-feet, the results of the water budget analysis reflects approximately 8,520 acre-feet lost to seepage from the laterals and another 3,195 acre-feet from the Casper Canal. Operational waste consists of approximately 2,769 acre-feet and water lost to evaporation is estimated to be 994 acre-feet.

While the results of the water budget analysis provide insight to the potential losses within the irrigation delivery system, several assumptions were made during the completion of the analysis. The most critical assumptions reflect the lack of accurate diversion records and measurement devices. To facilitate the management of water within the CAID as well as the tracking of potential water losses, diversions should be accurately measured and recorded on a daily basis at all measurement structures. In addition, accurate measurement structures/devices should be installed at all active lateral headgates, individual turnout structures, and locations where irrigation water is operationally spilled (operation waste). Once the measurement devices have been installed and daily diversions are recorded, the spreadsheet model developed as part of the water budget analysis can be utilized to track the delivery of water within the system and
improve the estimates of water lost to seepage and operational waste. Finally, the results of the spreadsheet model can provide valuable data to integrate into an Internet-based water ordering and management program.
VI. WATER RIGHTS

The water supplies for the CAID are stored under the water rights in Seminoe and Alcova Reservoirs held by Reclamation. The water rights associated with the CAID are presented in Table 6.1.

Table 6.1 Tabulation of Water Rights Associated with the Casper-Alcova Irrigation District.

<table>
<thead>
<tr>
<th>Permit</th>
<th>Facility</th>
<th>Priority Date</th>
<th>Use</th>
<th>Capacity (AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4552R</td>
<td>Seminoe Reservoir</td>
<td>12/1/1931</td>
<td>Irrigation, Power, Flood Control</td>
<td>1,026,360</td>
</tr>
<tr>
<td>4630R</td>
<td>Alcova Reservoir</td>
<td>4/25/1936</td>
<td>Irrigation, Power</td>
<td>184,295</td>
</tr>
</tbody>
</table>

The water stored in Seminoe and Alcova Reservoirs is allocated as a secondary supply under Permit Numbers 18682, 18683, and 18488 for irrigation within the CAID. Both storage rights are held by Reclamation. The CAID has contracted with Reclamation to provide storage water for irrigation of lands found within the boundaries of the CAID.

The irrigation season for the water users of the CAID begins in early May and ends in late September. The acreages served within the district range from 0.5 acres to more than 1,800 acres. Recent diversion records indicate an average annual diversion from the headgate at Alcova Reservoir ranging from 65,000 to 70,000 acre-feet. Figure 6.1 displays the annual diversions from Alcova Reservoir over the last twenty years in relation to the annual precipitation.
Figure 6.1 Summary of Annual CAID Diversions and Casper Precipitation.

Source:
Diversion Data: USBR Hydromet Website
Precipitation: High Plains Climate Center
VII. CURRENT IRRIGATION SYSTEM OPERATIONS

7.1 General

During the irrigation season, the day-to-day operations of a typical irrigation district start with the placement of water orders from the individual farmers under the ditch system. For the CAID, water orders are compiled by the office staff. Following an estimate of losses in the main canal and each lateral, the release from the headgate at Alcova Reservoir is determined. Communication and coordination for this request is accomplished on a daily basis between the CAID and Reclamation. Coordination is also carried out between Reclamation and officials from the Wyoming State Engineers Office to determine the administration and allocation of direct flow and storage water between the Reclamation’s projects on the North Platte River and other water right appropriators.

7.2 Water Accounting

The existing operation of the CAID canal and laterals involves simple operational rules and manual operation of the delivery system. Administratively, daily water orders are placed by the water users via the telephone to the CAID staff for delivery the following day. The office staff compiles the water orders for each lateral to determine the lateral headgate diversion. Lateral diversions are summed to estimate the main headgate delivery. The operational staff uses rule-of-thumb estimates to increase the individual water orders on laterals to account for net losses (attributable to seepage, evaporation and operational waste) and the CAID manager determines a daily request for diversion from Alcova Reservoir to the Casper Canal. Ditch riders within the CAID manually operate the gates and check structures on the main canal and laterals to ensure adequate delivery of the individual water orders.

The existing computer program used by the CAID to track water orders and issue bills is a proprietary software program, which maintains individual information on water orders and provides the assessment data for billing at the end of each year. Data is manually entered by CAID office staff from telephone orders made to the office during each workday for desired delivery the following day. The computer-based program keeps track of the cumulative orders for each water user to assist the water users in planning their total allotments and to forewarn office staff and water users of the status of their individual allocations for each year.
7.3 Delivery System Operations

The CAID manager coordinates and requests the diversion from Alcova Reservoir by Reclamation on a daily basis. Due to the length of time required to convey the diversions from Alcova Reservoir through the Casper Canal and lateral system, an averaging process is completed involving the previous day’s requests coupled with any occurrence of rainfall. The CAID manager also utilizes the excess capacity of the Casper Canal to provide a small buffer to ensure the demands placed by the water users are closely satisfied by the deliveries.

The operation of the delivery system of the CAID involves setting check structures, headgates and turnouts to deliver the water orders placed by the individual irrigators. The ditch riders are responsible for insuring the safe operation of the canal and all its structures, particularly during storm events. The CAID employs three ditch riders to handle the setting of lateral headgates, check structures and individual farmer’s turnout structures. Based on experience, the lateral headgate structures and farmer’s turnout structures are set to limit the operational waste within the system. Given the excess capacity of the Casper Canal, no wasteway/spillway structures are presently utilized along the main canal, either to promote the release of stormwater runoff captured by the main canal or to spill operational waste.

7.3.1 Discharge Measurement and Recording Procedures

As previously discussed, the CAID ditch riders typically divert additional quantities of water to ensure the irrigation demands are delivered following losses to evaporation and seepage. This occurs at the individual farmer’s turnouts as well as the headgates to the laterals. Currently, the water that is actually diverted at the lateral headgate or individual turnout structure is not recorded; however records of irrigation demand (water orders) are maintained by the CAID. Procedures should be instituted to record the total diversion at the headgates associated with each lateral, sublateral, and individual turnout on a daily basis. Operationally, this data will significantly improve the tracking and equitable delivery of water to all users and will promote the quantification of losses within the irrigation delivery system.

7.3.2 Canal and Lateral Management

The CAID manager and ditch riders rely on experience and judgment to manage the water supply following diversion into the Casper Canal. The staff maintains accounting sheets of the water orders on a daily basis to assist in the day-to-day operations. The farmer’s turnout
structures are typically equipped with a measuring structure (cipoletti weir, parshall flume, or pipe flow meter), although several structures are in need of rehabilitation to ensure accurate discharge measurements. Given the information on the individual demand at each turnout structure, the ditch riders typically ensure that the delivery meets or exceeds the demand by not less than 10%. As stated previously, no records of actual deliveries are maintained by the ditch riders.

Rainfall that falls on the CAID affects the operation of the canal system by introducing direct precipitation into the canal/lateral system as well as capturing stormwater runoff. Direct precipitation also reduces the required crop irrigation requirement, directly diminishing the demands at the farmer’s turnouts. This situation is handled by the ditch riders through: (a) delivery of the irrigation requirements into the individual farmer’s turnout structures and ultimately wasting the water into the field/drain system; or (b) utilizing the wasteway/spillway structures at the end of each lateral system to spill the operational waste into the existing drains. It should be noted that a reduction in the operational waste could be achieved through various measures including but not limited to the construction of re-regulation reservoirs together with automation of the existing headgate and check structures. Further benefits could be achieved through integration of the structures into a computerized management software system.

7.4 Summary

The operation of the CAID is very straightforward. Although the travel time from main headgate delivery to the end of the system complicates a static delivery system where demands and deliveries are met on a daily basis, there is sufficient capacity in the main canal to delicately balance much of the daily fluctuation. It should be noted, however, that recording the daily headgate diversions and deliveries to each turnout would assist the CAID manager with estimating losses and minimizing operational waste.
VIII. PROPOSED COMPUTERIZED IRRIGATION SYSTEM OPERATIONS

8.1 General

The intent of this study is to assess the present operation of the CAID and determine the construction activities and procurement of services and equipment necessary to computerize the operational management of the CAID. Historically, irrigation districts have managed the delivery of irrigation water through the manual operation of gates and conveyance facilities with the deliveries individually recorded through the use of various measurement structures. As water becomes more valuable because of increased competition for use, the implementation of improved measurement structures, improved tracking procedures and better management techniques will tend to minimize waste and potentially improve the yield of the water supplies.

With respect to this project, the first phase of system improvements involves replacement of the existing water ordering system with an Internet-based ordering program. To fully realize the benefits of a computerized management program, rehabilitation or installation of selected measurement and control structures will be required along with computer hardware and software to support their operation and provide a mechanism for remote data collection.

8.2 Automated Water Accounting and Billing

The primary objective of the Internet-based system of placing water orders is to allow the individual water users to remotely enter their water orders via computer from their home or office. This system would allow the users more flexibility in making their orders and largely alleviate telephone calls to the CAID office. The system could also be used to display cumulative water use for the irrigation season, both in tabular form or graphically. Furthermore, it is our understanding that the system will allow individual water users to view the water use on a district-wide basis during the irrigation season and for previous years. A final project report associated with the Internet-based program developed by Dr. J. Mohan Reddy of the University of Wyoming is included in Appendix B.

Based on our review of the documentation, the computer program is an Internet-based water ordering system that allows water users to input their orders on customized water order forms into a database. The intent of the program is to consolidate the orders, by lateral, for the entire CAID. Conceptually, each water user must access the computer program on CAID's computer system to place their order, regardless of time of day as long as it is before water orders are consolidated for distribution to the ditch riders for implementation. Prior to the
distribution to the ditch riders, water users could change their order at any time if climatic conditions change or farming practices are altered. Water users will be provided an individual set of forms for each turnout to enable individuals owning or operating multiple farms on different laterals to place orders accordingly. This feature is necessary to ensure that the water orders for each lateral are consolidated separately to determine an estimate for the diversion into each lateral from the Casper Canal.

Based on the results of the survey questionnaire, it is likely that complete participation in the automated ordering system will not be achieved. Consequently, manual data entry from telephone orders will continue to be necessary to incorporate all water orders into the system.

The existing computer program utilized by the CAID to track water orders and issue water assessments is a proprietary program. The proprietary nature of the program creates difficulty with respect to interfacing the data input and output with the program developed by Dr. Reddy. To avoid duplication of effort with respect to data input (e.g., placement of water orders), an interface between the two programs must be developed.

### 8.3 Extensions to Dr. Reddy’s Program

Based on a preliminary review of the information in Appendix B, several improvements to the proposed Internet-based water ordering and management program have been identified. These improvements, intended to increase the functional benefits associated with implementation of Dr. Reddy’s computer program for the CAID, are listed below.

- The program should be tailored to specifically reflect the Casper Canal, all laterals, and all CAID water users by lateral to promote consolidation of water orders.
- A minimum and maximum diversion threshold should be established for each water user.
- Develop a screen interface that illustrates the connectivity of the laterals and the Casper Canal.
- Integrate estimates of seepage loss, operational waste, and evaporation into the program to obtain the consolidated diversion estimate at each lateral headgate as well as the diversion from Alcova Reservoir.
- Develop an interface between the existing proprietary software for placement of water orders/accounting and the program provided by Dr. Reddy. Avoid duplication of effort with respect to data entry.
- Pending future automation of headgates and real-time data collection with respect to water measurement at the v-notch weir from Alcova Reservoir as well as laterals and
operational spills, integrate the capability to incorporate this data to promote management of the water supplies.

- Pending placement of automated weather stations within the CAID, incorporate the capability to access this data to obtain estimates of precipitation, crop evapotranspiration and promote irrigation scheduling.

### 8.4 System Integration

#### 8.4.1 Hardware and Software

The main computer in the CAID office may need to be replaced or upgraded to handle the increased data requirements associated with full implementation of Dr. Reddy's program. The potential installation and utilization of a more functional operational/management computer model, which includes the incorporation of the telemetered data from the field gaging stations to the central office, would necessitate an upgrade of computer resources.

Dr. Reddy's program necessitates a dedicated phone line, an Internet connection for the CAID main office and a personal computer capable of handling multiple tasks and multiple user access. The personal computers on the market today can handle these functions, although the PC would have to be a top of the line computer. Dr. Reddy's software would require Microsoft's Professional Office package for full implementation.

Integration of a more functional operations/management model would require software development with specific knowledge of irrigation system operations. The development should be completed utilizing standard programming languages and without proprietary control by the developers to allow for subsequent updates by CAID personnel or any individual with programming expertise.

#### 8.4.2 Maintenance and Training

The maintenance of the existing water ordering and accounting program is an on-going expense that may be avoided if a non-proprietary program is implemented. Dr. Reddy's program could be enhanced to replace that program, but with some additional costs in program development.

The individual water users will require minimal training in the use of Dr. Reddy's program. It is estimated that one training session (minimum of one-hour in duration) will be required to demonstrate the features of the program and the procedures to place water orders.
Given the number of water users within the CAID, several sessions may be required to provide this training. Many of the water users could be provided the training in conjunction with the annual meeting of the CAID. As a minimum, the office staff could provide the initial direction to individual water users regarding the procedures to place the water orders. This could be accomplished via the telephone during the initial utilization of the computer program by the individual water user.

Training CAID personnel in the use and maintenance of all new computer programs is necessary to insure success of the program. Training on the use of the water ordering program could be accomplished concurrently with the training of the individual water users. The utilization and maintenance of computerized operations software may require training lasting a minimum of one to two days.

8.5 Irrigation System Automation

Simply automating the water ordering system does not enhance the operational management of the canal and laterals. The ability to monitor and remotely control the irrigation flows in the Casper Canal and major laterals will require the design and construction of water level monitoring stations, flow measurement/gaging stations and an integrated telemetry system. Automation of the CAID system will also involve the development of an operational model that monitors the irrigation deliveries through the Casper Canal and lateral system.

8.5.1 Infrastructure

A preliminary assessment of the automation requirements for the CAID system was documented in the Phase I Final Report. In general, the sites recommended for automation fell into three categories as indicated below.

- Type A: Automated in-canal re-regulating storage sites
- Type B: Automated lateral headgate sites
- Type C: Automated discharge measurement sites

Automation sites recommended during the Phase I study are presented in Table 8.1.
Table 8.1 Recommended Automation Sites Within the Casper-Alcova Irrigation District.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Location</th>
<th>Description of Automation Site</th>
<th>Station Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-1</td>
<td>V-Notch Weir (Mile 0.61)</td>
<td>Monitor Main Canal level/discharge</td>
<td>C</td>
</tr>
<tr>
<td>Auto-2</td>
<td>Main Canal (Mile 12.5)</td>
<td>Automated re-regulating in-canal storage</td>
<td>A</td>
</tr>
<tr>
<td>Auto-3</td>
<td>Main Canal (Mile 34.5)</td>
<td>Automated re-regulating in-canal storage</td>
<td>A</td>
</tr>
<tr>
<td>Auto-4</td>
<td>Main Canal (Mile 48.5)</td>
<td>Automated re-regulating in-canal storage</td>
<td>A</td>
</tr>
<tr>
<td>Auto-5</td>
<td>Lateral 128 Headgate</td>
<td>Automate Gate/Monitor lateral discharge</td>
<td>B</td>
</tr>
<tr>
<td>Auto-6</td>
<td>Lateral 210 Headgate</td>
<td>Automate Gate/Monitor lateral discharge</td>
<td>B</td>
</tr>
<tr>
<td>Auto-7</td>
<td>Lateral 218 Headgate</td>
<td>Automate Gate/Monitor lateral discharge</td>
<td>B</td>
</tr>
<tr>
<td>Auto-8</td>
<td>Lateral 256 Headgate</td>
<td>Automate Gate/Monitor lateral discharge</td>
<td>B</td>
</tr>
<tr>
<td>Auto-9</td>
<td>Lateral 256 Spill Structure</td>
<td>Monitor lateral level/discharge</td>
<td>C</td>
</tr>
<tr>
<td>Auto-10</td>
<td>Lateral 328 Headgate</td>
<td>Monitor lateral level/discharge</td>
<td>C</td>
</tr>
<tr>
<td>Auto-11</td>
<td>Casper Canal (Mile 48.9)</td>
<td>Monitor lateral level/discharge</td>
<td>C</td>
</tr>
<tr>
<td>Auto-12</td>
<td>Casper Canal (Mile 61.52)</td>
<td>Monitor lateral level/discharge</td>
<td>C</td>
</tr>
<tr>
<td>Auto-13</td>
<td>Lateral 128 Spill Structure</td>
<td>Monitor lateral level/discharge</td>
<td>C</td>
</tr>
</tbody>
</table>

These sites are included in the improvements recommended as part of the Phase II rehabilitation plan for the CAID. To enhance the operational management capabilities of the CAID through the integration of an Internet-based water management program, additional sites should be automated. Those sites include all lateral headgates not included in Table 8.1. Including the automation and measurement of discharge at the remaining headgate structures will provide CAID with a capability to remotely control diversions into the laterals and monitor the discharge within the conveyance system. The headgates that have been identified for automation to enhance an Internet-based water management program are presented in Table 8.2.

Measurement of irrigation diversions typically requires an accurate control section, for example a weir or Parshall flume installed to force critical flow through a section of canal with measurable and stable cross-sectional area, and a recording device to measure water level stage in the control section. The Phase I Final Report (Table 3.2) identified those headgate locations where measurement structures are needed or improvements to existing structures are required. Improvements to the measurement structures are also included as part of the Phase II rehabilitation plan for CAID; consequently, these improvements are not included herein.
Table 8.2 Additional Automation Sites for Water Management Program.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Location</th>
<th>Description of Automation Site</th>
<th>Station Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-14</td>
<td>Lateral 41 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-15</td>
<td>Lateral 42 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-16</td>
<td>Lateral 57 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-17</td>
<td>Lateral 58 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-18</td>
<td>Lateral 59 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-19</td>
<td>Lateral 60 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-20</td>
<td>Lateral 125 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-21</td>
<td>Lateral 102 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-22</td>
<td>Lateral 147 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-23</td>
<td>Lateral 156 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-24</td>
<td>Lateral 160 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-25</td>
<td>Lateral 174 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-26</td>
<td>Lateral 202 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-27</td>
<td>Lateral 232 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-28</td>
<td>Lateral 239 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
<tr>
<td>Auto-29</td>
<td>Lateral 270 Headgate</td>
<td>Automate gate and/or monitor WSEL/ discharge</td>
<td>B or C</td>
</tr>
</tbody>
</table>

8.5.2 Operations Model

A computer program that simulates the operation of the CAID canal system, starting with the Casper Canal and progressing downstream to include the operation of all laterals, is required to provide management with information of the flows in the canal system. This program would be separate and distinct from Dr. Reddy’s program, the only interface being the water orders and delivery schedule. This operational model is necessary to manage waste flows under changing conditions in the CAID service territory due to rainfall or changes in the delivery requirements at individual turnout structures since the orders were initiated. The operational model would monitor flows in the canal at selected measurement stations and “deliver” water to each lateral in the quantities specified by water orders. The data collected by the computer program would provide insight into evaporation losses, seepage losses and operational waste within the delivery system. This data, coupled with records of individual water diversions, will assist the CAID in minimizing operational waste and fluctuations in the delivery system thereby optimizing the delivery of water to its users.
IX. IRRIGATION SYSTEM BENEFITS AND NON-BENEFITS

Through the implementation of an Internet-based water ordering and management program, several tangible and intangible benefits to the CAID can be realized. Benefits attributable to both the remote water ordering system as well as the water management program have been identified and are discussed in this chapter. The non-benefits of implementing this new technology have also been identified and are presented.

9.1 Internet-Based Water-Ordering System

Implementation of an Internet-based water ordering system will involve a transition from the present system of placing orders via the telephone to the office staff to the placement of water orders remotely via personal computers. The potential benefits of an Internet-based water ordering system are itemized below.

- Staff time may be reduced by the remote placement of water orders directly to the database. Given the number of water users and phone lines presently available at the CAID, water users will also be able to place their orders more timely.

- Both the water users and the CAID will have immediate access to historic water usage. As a minimum, the data base could provide the individual water users with previous water orders, total water ordered to date, and comparison of allotment to water deliveries. Data related to storage levels, total diversions from Alcova Reservoir, and deliveries to all water users could also be provided.

- Access to crop evapotranspiration data via meteorological stations within the CAID could assist the water users in the placement of water orders and provide for potential conservation of the individual allotments.

- Data input to the water ordering system can be stored and easily reviewed and utilized by the water users or office staff/management. Annually, the database can be archived to a CD to provide easy access to the historic water usage.

Several limitations have also been identified with the potential implementation of an Internet-based water-ordering program. The following information is presented with respect to these limitations.

- Based on the survey questionnaire, several water users either do not have computers or will not likely use an Internet-based water-ordering program. While the transition to a
new system may be lengthy, it is conceivable that remote placement of water orders will occur in the future. Until that time, however, some duplication of effort will take place.

- Presently, no interface exists between the Internet-based water ordering program and the existing program used by the CAID for placing orders and tracking the individual allotments. Until this interface is provided, duplication of effort will be required with respect to placement of individual water orders.

- Individual water users may incur additional costs associated with the purchase or replacement of computers necessary to utilize the Internet-based water-ordering program. Additional costs will also be incurred to access the Internet through a local Internet service provider (ISP).

- The CAID will incur additional costs associated with potential purchase or replacement of the computers as well as the acquisition of a dedicated phone line. Costs for software development will also be incurred. Virus protection requirements will be increased to ensure the integrity of the system and database.

- The service provided by the local ISP may not result in significant savings with respect to the time to place water orders. Information provided by the local water users and office staff has indicated that access to the Internet is very slow and often frustrating.

9.2 Irrigation System Operation and Management

As discussed previously, data pertinent to the operation and management of the irrigation deliveries within the CAID can also be integrated into the development of the computer program. Automation of existing facilities along with remote telemetry of headgates and measurement structures is assumed as part of the development of the computer program. The benefits of enhancing the computer program to provide this capability are discussed below.

- Tailoring the computer program to provide initial estimates of diversion requirements at the lateral headgates and at Alcova Reservoir will result in a reduction in staff time presently taken to estimate these requirements. The accuracy of the estimates may also be improved.

- Remote operation and measurement of lateral headgates will reduce the manpower requirements for each ditch rider thereby providing a cost savings for the CAID.

- The data collected remotely will promote a potential reduction in operational waste thereby enhancing the water supplies available to the CAID. Evaluation of the data may also identify locations where losses are presently occurring.
Based on improved diversion capability at the headgates within the system, the fluctuation in the water surface may be reduced thereby enhancing the efficiency of the delivery system.

The CAID will be provided more flexibility in managing the water in the canal and lateral system through an interpretation of the data. Integration of re-regulation reservoirs along with automated spillways will tend to minimize operational waste.

Similar to the Internet-based water-ordering program, there are limitations associated with implementation of an operational and management model that is based on system-wide automation. The following information addresses these limitations.

Full implementation of the system-wide automation of lateral headgates and measurement structures will be costly. An implementation plan to prioritize those structures that provide the most benefits should be developed.

Operation and management of the irrigation diversions associated with an automated system is directly tied to the reliability of the system. An increased risk is assumed if lateral headgates do not function properly, power supplies fail, or computer system become inoperable. As a minimum, ditch riders can be utilized to operate much of the automated systems should problems occur; however, plans should be developed to increase the reliability and reduce the risk of failures within the system.
X. IRRIGATION SYSTEM CONSTRUCTION

This chapter presents the conceptual design details associated with the installation of components associated with an Internet-based water ordering and operational management program. Information related to the components necessary to support the water-ordering program are provided initially. Pertinent information related to the components associated with implementation of the operation and management program is also presented.

10.1 Internet-based Water Ordering Program

Installation of an Internet-based water-ordering program within the CAID office in Mills, Wyoming will require:

- A dedicated, high speed, Internet access service line;
- A dedicated IBM compatible personal computer; and
- Additional software development to tailor the proposed water ordering program to the CAID.

The CAID office is presently utilizing McLeod USA as its local telephone service provider. A high speed, Internet access service line (DSL) will be required to provide dedicated service and timely access to the water-ordering program.

An IBM compatible personal computer should be acquired and dedicated for installation of the water ordering program and storage of all data files. The personal computer should, as a minimum, meet the following specifications:

- Pentium IV PC
- 2.0 GHz processor
- 40 Gb hard drive
- 512 Mb RAM
- CD-RW
- Tape backup
- 15” monitor

Acquisition of an IBM compatible personal computer is presently included in the automation requirements for the Phase II project improvements. It is envisioned that this computer could
function to host both the automation needs identified in the Phase II study as well as those needs identified to support the water ordering program and/or the water operation and management program. Consequently, acquisition of additional computers is not included in the Phase III improvements.

Software development is necessary to tailor the water-ordering program (documented in Appendix B) to the administrative operations of the CAID. Water users will need to be categorized by lateral to promote the consolidation of irrigations diversions at each lateral headgate. Minimum and maximum delivery information must be determined and tailored for each individual turnout structure. Furthermore, the software should be compatible with the existing software utilized by the CAID to compile existing water orders for individual allotments/assessments. Since the existing administrative software is proprietary, the proposed water ordering program may need to duplicate the software necessary to provide for administratively tabulating each water order, cumulating the individual water orders, and assessing the water users.

The capability to integrate data from meteorological stations and determine evapotranspiration estimates should be included in the software development. This information should be displayed for each water user to assist in the determination of daily water requirements.

As stated previously, the software developed for this program should utilize standard programming language to promote future revisions or modifications of the program. Furthermore, proprietary control for development of the software should reside with the CAID.

10.2 Water Operation and Management Program

The water operation and management program should be developed in modular form to integrate specifically into the module developed for the web-based water-ordering program. Depending on the needs or desires of the CAID, three levels of implementation should be considered.

10.2.1 Level I Implementation

From an operational standpoint, Level I implementation will support the estimation of diversion requirements at each lateral headgate as well as Alcova Reservoir. Installation of a Level I water operation and management program within the CAID office will require development of software to support the estimation of lateral diversion data as well as the
diversion from Alcova Reservoir. Initially, an operational schematic should be developed to illustrate the connectivity between Alcova Reservoir, the Casper Canal and all laterals within the CAID. Estimates of seepage loss, operational waste and evaporation for each lateral should be determined from measured diversion data and utilized along with the daily water orders to develop an estimate of the diversion requirements at each lateral headgate. Similarly, these losses should be determined on a reach-by-reach basis for the Casper Canal and utilized with the diversion requirements for each lateral to develop an estimate of the diversion requirement at Alcova Reservoir. As necessary, estimates of the losses in the laterals and Casper Canal should be modified by the program administrator to reflect seasonal changes.

10.2.2 Level II Implementation

Level II implementation involves the integration of real-time measurement data at each lateral headgate and the v-notch weir near Alcova Reservoir. Implementation at this level will provide instantaneous data of the diversions at each location as well as any daily fluctuation in the diversion.

The collection of real-time measurement data will require the installation of a radio-telemetry system within the CAID. Furthermore, measurement structures will be required at all locations identified for real-time data acquisition. Improvements to all measurement structures have been identified in the Phase I study and presented in Table 5.3 of this report. These improvements are included in the Phase II conceptual design. Furthermore, automation of selected sites was recommended as part of the Phase I study and is presently being addressed as part of the Phase II work effort. The automation recommended as part of the Phase II study includes the items described below.

- Establishing a network of radio antennae to support the automation of facilities within the CAID. This also includes the cost to obtain a license through the Federal Communication Commission.

- Installation of a base station to collect and compile the data and host the software to support the system automation. The station would consist of an IBM compatible personal computer equipped with a radio telemetry receiver capable of supporting all of the individual components of the automated system with a single radio frequency.

- Development of software to support the automation of the initial sites. The base station and associated software will be configured to monitor water levels, control gates, monitor weather data, and compute crop irrigation requirements. Software on the base station would allow the CAID to monitor water levels and remotely control diversions at the automated stations as well as to control storage in the re-regulation reservoirs. Additional
software will be necessary to record the weather data and compute the daily crop irrigation requirement based upon computed evapotranspiration values. A dedicated phone line will be required to allow irrigators to call the CAID for recorded crop water requirements for the previous five days. Based upon this data, the irrigator could then schedule irrigation of his crop.

- Development of spreadsheet software to assist CAID in tracking the actual diversions made at each headgate and turnout. A spreadsheet program will automatically obtain average daily diversion data generated by the automated stations. For all other locations, the actual diversions recorded by the ditch riders would be entered. Collection of this data would promote the tracking of losses and operational efficiency of the irrigation delivery system.

- Automation of 13 sites including those listed below. These sites include a combination of automation sites that monitor the main canal level/discharge, monitor the lateral level/discharge and monitor proposed re-regulation reservoirs within the Casper Canal.

1. V-notch weir (Mile 0.61)
2. Lateral 128 Headgate
3. Lateral 210 Headgate
4. Lateral 218 Headgate
5. Lateral 256 Headgate
6. Lateral 256 Spill Structure
7. Lateral 328 Headgate
8. Lateral 128 Spill Structure
9. Casper Canal (Mile 48.9)
10. Casper Canal (Mile 61.52)
11. In-canal re-regulating storage (Mile 12.5)
12. In-canal re-regulating storage (Mile 34.5)
13. In-canal re-regulating storage (Mile 48.5)

Given the automation of headgates recommended with the Phase II study, those additional headgates recommended for automation (real-time acquisition of measurement data) as part of this Phase III study are listed in Table 10.1.
Table 10.1 Additional Automation Sites for Water Management Program.

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Location</th>
<th>Description of Automation Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-14</td>
<td>Lateral 41</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-15</td>
<td>Lateral 42</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-16</td>
<td>Lateral 57</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-17</td>
<td>Lateral 58</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-18</td>
<td>Lateral 59</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-19</td>
<td>Lateral 60</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-20</td>
<td>Lateral 125</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-21</td>
<td>Lateral 102</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-22</td>
<td>Lateral 147</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-23</td>
<td>Lateral 156</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-24</td>
<td>Lateral 160</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-25</td>
<td>Lateral 174</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-26</td>
<td>Lateral 202</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-27</td>
<td>Lateral 232</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-28</td>
<td>Lateral 239</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
<tr>
<td>Auto-29</td>
<td>Lateral 270</td>
<td>Headgate Automate gate and/or monitor WSEL/ discharge</td>
</tr>
</tbody>
</table>

All monitoring locations will consist of a gauge house, stilling well, water level sensor, programmable data logger/radio transmitter, directional radio antenna, solar panels, lightning protection, and tipping bucket rain gauge. A gauge house will be used to enclose all the monitoring and radio electronics as well as the stilling well. The dimensions of the gauge house will be 6 feet wide, 6 feet deep, and 8 feet high. A bolt-action lock or similar device will be required in order to lock the gauge house to prevent unwanted entry.

All water level monitoring in the main canal as well as the laterals will be accomplished using a stilling well. A stilling well is desirable because of its ability to attenuate water level fluctuations in the canal or lateral thus providing a reading that exhibits stability over time. A stilling well also affords more protection to the water level sensor because the sensor is not located in the direct flow field. The stilling wells will be constructed using 24-inch corrugated metal pipe and will be hydraulically connected to the canal or lateral using 2-inch galvanized rigid conduit.

Electronic water level sensors will be used to monitor the water level in each of the stilling wells. Three options exist for monitoring water level including a shaft encoder, pressure transducer, and a sonic sensor. Based on research of the reliability and accuracy of these devices, either a pressure transducer or sonic sensor is the most acceptable instrument for measuring water levels.
Each site will require a programmable data logger/radio transmitter. It is recommended that the Campbell Scientific model 10X data recorder with radio transmitter (or approved equal) be utilized. Each site will require a directional radio antenna mounted to a mast. In order to ensure adequate functionality, a recommendation is made to use a Yagi (DB-235) directional antenna. The antenna mast should consist of a 2-inch galvanized rigid conduit (or equivalent) mounted securely to the gauge house. The height of the antenna off the ground will be approximately 25 feet or as stipulated by the radio license issued to the CAID.

All sites will require at least one solar panel. In order to ensure adequate functionality, a recommendation is made to use Solarex model MSX64 panels or equivalent. All sites will require lighting protection consisting of a 4-foot ground rod, polyphaser, 3-foot lightning rod and associated cables and hardware.

A general recommendation is made that all new sites include a tipping bucket rain gauge. Information regarding rainfall accumulation is very important to the CAID and the addition of a tipping bucket to each of the new sites can be provided at a small incremental cost. The tipping bucket rain gauges should have a minimum diameter of 8 inches and should be mounted on a mast so the tipping bucket is between 3 and 4 feet above the top of the gauge house. It is desirable to mount the tipping bucket up off the gauge house in an attempt to eliminate collection errors associated with the aerodynamics of the gauge house.

In addition to the hardware described above, all sites will require items of miscellaneous hardware consisting of, but not limited to, 10-Amp battery charger, deep cycle 12-Volt marine battery, enclosure to mount electronics in the gauge house, and ancillary mounting hardware.

Finally, the software developed as part of the Phase II study will need to be expanded to include the additional headgate locations. Ideally, the system automation software should be interfaced with the operations and management model to promote the tracking of individual diversion requirements versus actual measurements.

### 10.2.3 Level III Implementation

Level III implementation involves the integration of real-time measurement data at each lateral headgate and also includes the automation of slidegates to remotely control the diversions at these locations. Implementation at this level will: (a) provide instantaneous data of the diversions at each location as well as any daily fluctuation in the diversion; (b) ensure the delivery continuously meets the demand requirements through remote adjustment of the slidegate; and (c) provide for control of the slidegates to ensure the integrity of the existing facilities (i.e., during a thunderstorm event, control the diversions to ensure the stormwater is conveyed to facilities with sufficient capacity to safely spill the excess).
Similar to the Level II requirements, implementation of Level III improvements will require the installation of a radio-telemetry system within the CAID. The automation of the sites recommended in the Phase II study is assumed and specifically includes the automation of headgates at Laterals 128, 210, 218, 256 and 328. Level III requirements pertain to those sites listed in Table 10.1 and involves: (a) monitoring the water level in the main canal and lateral, (b) measurement of the diversion into the lateral, and (c) automation of the slidegate(s).

In addition to the improvements required at each location to support the Level II implementation plan, each site will provide automated gate control from the base station. Each site will require an actuator, electric motor, controller, and floor stand. At these locations, additional solar panels will be required.

Similar to the Level II implementation plan, the software developed as part of the Phase II study will need to be expanded to include remote control of the slidegates at each location. The system automation software should be interfaced with the operations and management model to promote the tracking and control of individual diversion requirements versus actual measurements.
XI. IRRIGATION SYSTEM IMPLEMENTATION

The implementation of computerized operations and automation of CAID facilities at the various levels described in this report will require purchases of new equipment and computer hardware and software. Training of CAID personnel in the use and maintenance of the new system will be required. Additionally, the individual farmers of the CAID will need training on the Internet-based water ordering system.

11.1 Additional Knowledge and Training Requirements

Training of personnel is an important aspect of insuring the installed system functions and produces information that fulfills the objectives of the program. CAID office staff should be trained first in the use of the Internet and the Internet-based water-ordering program of Dr. Reddy. It is estimated that this training could be accomplished in two days, concurrently with the training sessions for all CAID water users. The continued use or replacement of the existing water ordering and billing program will require some software development and training to maintain its compatibility with the new system. Alternatively, programming of Dr. Reddy's software to encompass the billing function will require training of CAID office staff in its use.

The automation of district facilities will require training in the hardware and software used to control the structures. This should be accomplished during and following construction and implementation of the remote telemetry/automation system. Training over a two or three day period during the installation process should be adequate to give the CAID operators an understanding of operational procedures. On-going training of new operations and maintenance staff will be required.

An application to the Federal Communications Commission for a license to operate radios in the very high frequency (VHF) range (assuming this will be the preferred communications protocol) must be accomplished. This application will require a schematic diagram of the location of radios and repeaters and the desired frequency for transmission and reception. Training of CAID personnel in the operations and maintenance of the radio telemetry system is required. This should be accomplished during installation of the equipment and could be done in two to three days concurrently with construction.
11.2 Maintenance Requirements

The development of a long-term maintenance program to insure the reliability and serviceability of the equipment is necessary for the sustainability of this program. Equipment must be maintained and computer hardware and software must be updated and replaced at reasonable intervals according to the manufacturer's guidelines. As operating systems change, modifications to the software may be required.

The purchase and stockpiling of replacement items should be considered as part of the maintenance program. For the level of automation suggested in this report, the purchase of one additional water level sensor (pressure transducer/sonic sensor) and radio is recommended. Due to the time to order and replace a data logger, purchase of an additional data logger should be considered.
XII. COST ESTIMATES AND ECONOMIC FEASIBILITY

Based on the conceptual design details provided in Chapter 10, detailed cost estimates were prepared for the phased implementation of two major components: (a) Internet-based water ordering program; and (b) water operation and management program. With respect to the implementation of the water operation and management program, costs are provided assuming the three levels of implementation discussed in Chapter 10. Finally, an economic analysis was completed to determine the impact of implementing the project components on the current annual assessment of the water users.

12.1 Internet-based Water Ordering Program

As indicated in Chapter 10, the installation of an Internet-based water ordering program will require the following items:

- Installation of a dedicated, high speed Digital Subscriber Line (DSL);
- Installation of a dedicated IBM compatible personal computer; and
- Development of software tailored to the CAID.

The IBM compatible personal computer will be included in the Phase II recommendations for the base station that supports irrigation system monitoring and automation. The estimated costs for the remaining items are included in the Phase III components associated with the Internet-based water ordering program and are presented in Table 12.1.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Installation / Development Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Digital Subscriber Line (DSL)</td>
<td>$ 150</td>
</tr>
<tr>
<td>2. Software Development</td>
<td>$ 20,000</td>
</tr>
<tr>
<td><strong>TOTAL INSTALLATION COST</strong></td>
<td><strong>$ 20,150</strong></td>
</tr>
</tbody>
</table>

The existing telephone line for the CAID must have certain characteristics to be able to carry the DSL signal. Assuming the telephone line qualifies, an order can be placed to convert the regular telephone line to a DSL circuit. In addition to the installation cost for the DSL noted
above, a monthly service fee will be charged depending on the speed of the connection (fees range from $22 to $88 per month) and for the DSL modem ($5 per month).

In addition to these costs, the water users will be required to purchase computer hardware to place the water orders. Based on the survey questionnaire, 30% of the water users did not own a computer. To facilitate the placement of the water orders, users will require the purchase of a computer with the minimum requirements listed below:

- Pentium IV PC
- 1.3 GHz processor
- 20Gb hard drive
- 128 Mb RAM
- 15” Monitor
- Modem

The cost for this hardware is estimated to be $1,000. Placement of the water orders will also require access to the Internet through an ISP. The monthly charge for Internet access is estimated to be $20/month for each water user.

12.2 Water Operation and Management Program

Three levels of implementation were identified for the development and utilization of a Water Operation and Management Program. Cost estimates for each level of implementation are presented in the following sections.

12.2.1 Level I Implementation

Level I implementation involves the development of software to support the integration of losses within the system along with water orders to obtain estimates of diversions at each lateral headgate as well as the headgate at Alcova Reservoir. No additional hardware or equipment requirements are necessary. The cost associated with Level I improvements are related to engineering and software development and are estimated to be $20,000.
12.2.2 Level II Implementation

Level II implementation integrates the utilization of real-time measurement data at each lateral headgate and the headgate at Alcova Reservoir. Accurate measurement structures will be required at all lateral headgates and a radio-telemetry system will be necessary to transmit the data. As discussed previously, improvements to the measurement structures and installation of a radio-telemetry system are included in the recommended improvements associated with system automation in the Phase II study. However, the recommended improvements for the Phase II study did not include the real-time collection of measurement data for all laterals within the CAID. Table 10.1 presents those remaining lateral headgates identified for the collection and transmission of measurement data. Sixteen (16) additional sites were identified specifically for real-time data collection. Each site will monitor the water level in the Casper Canal and lateral, remotely record the measurement data, and transmit the measurement data to a base station at the CAID office. Typical costs associated with the instrumentation and equipment requirements at each headgate are presented in Table 12.2.

Table 12.2 Costs for Typical Monitoring and Measurement Site

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water level sensors (2)/rain gage sensing devices; including desiccant box and 50 feet of cable, rain gage top section.</td>
<td>3,000</td>
</tr>
<tr>
<td>VHF dual-frequency radio meeting FCC requirements; including antenna, antenna mast and cable</td>
<td>1,000</td>
</tr>
<tr>
<td>12 VDC Battery/Charger/Solar Panel 80 mA (includes regulator)</td>
<td>600</td>
</tr>
<tr>
<td>Data Collection Platform (Campbell Scientific CR10X or equivalent), NEMA-4 enclosure and mounting rack</td>
<td>2,500</td>
</tr>
<tr>
<td>Gage house, stilling well and intake lines</td>
<td>2,000</td>
</tr>
<tr>
<td>Miscellaneous equipment/hardware/supplies</td>
<td>1,000</td>
</tr>
<tr>
<td>Labor (Gage house and stilling well installation)</td>
<td>1,500</td>
</tr>
<tr>
<td>Labor (mechanical engineering, RTU programming, sensor installation, solar power system, antenna)</td>
<td>4,000</td>
</tr>
<tr>
<td><strong>TOTAL INSTALLATION COST</strong></td>
<td><strong>15,600</strong></td>
</tr>
</tbody>
</table>

Assuming 16 additional headgates are installed with a radio-telemetry system, the total cost becomes $249,600.
12.2.3 Level III Implementation

Level III implementation includes the automation of one slide gate at each headgate structure to remotely control the diversions from the Casper Canal. This level of implementation assumes the integration of the real-time measurement data at each headgate as indicated for the implementation of Level II improvements. Similar to Level II, sixteen (16) sites were identified specifically for automation and control of the diversions from the Casper Canal. Each site will monitor the water level in the Casper Canal and lateral, remotely record the measurement data, transmit the measurement data to a base station at the CAID office, and provide for remote operation of the slide gate. Typical costs associated with the instrumentation and equipment requirements at each headgate are presented in Table 12.3.

Table 12.3 Costs for Typical Monitoring/Measurement/Automation Site

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water level sensors (2)/rain gage sensing devices; including desiccant box and 50 feet of cable, rain gage top section.</td>
<td>3,000</td>
</tr>
<tr>
<td>VHF dual-frequency radio meeting FCC requirements; including antenna, antenna mast and cable</td>
<td>1,000</td>
</tr>
<tr>
<td>12 VDC Battery/Charger/Solar Panel 80 mA (includes regulator)</td>
<td>600</td>
</tr>
<tr>
<td>Data Collection Platform (Campbell Scientific CR10X or equivalent), NEMA-4 enclosure and mounting rack</td>
<td>2,500</td>
</tr>
<tr>
<td>Gage house, stilling well and intake lines</td>
<td>2,000</td>
</tr>
<tr>
<td>Remote power system for slide gate</td>
<td>8,500</td>
</tr>
<tr>
<td>Gate Operator and stand</td>
<td>6,000</td>
</tr>
<tr>
<td>Miscellaneous equipment/hardware/supplies</td>
<td>1,000</td>
</tr>
<tr>
<td>Labor (gage house and stilling well installation)</td>
<td>1,500</td>
</tr>
<tr>
<td>Labor (mechanical engineering, RTU programming, sensor installation, solar power system, antenna)</td>
<td>4,000</td>
</tr>
<tr>
<td>Labor (remote power system, gate installation and control programming)</td>
<td>5,000</td>
</tr>
<tr>
<td><strong>TOTAL INSTALLATION COST</strong></td>
<td><strong>35,100</strong></td>
</tr>
</tbody>
</table>

Assuming 16 headgate structures are installed with a system to monitor water levels, obtain measurement data and remotely operate one slide gate, the total cost becomes $561,600.
12.3 Summary of Total Project Costs

The total project costs associated with installation the water ordering program and the water operation and management program have been estimated and are presented in Table 12.4. This estimate includes costs associated with construction contingency, engineering, and preparation of final plans and specifications. Table 12.4 also presents the final repayment plan for each implementation alternative. As indicated, the repayment plan assumes a 50% loan/50% grant from the WWDC with a term of 20 years and an interest rate of 6.0% on the loan.

Table 12.4 Automation and Measurement Structure Cost Estimates

<table>
<thead>
<tr>
<th>Item</th>
<th>Water Ordering Program</th>
<th>Water Operation &amp; Management Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level I</td>
<td>Level II</td>
</tr>
<tr>
<td>Cost of Project Components / Installation</td>
<td>$20,150</td>
<td>$20,000</td>
</tr>
<tr>
<td>Engineering (included in Project Components)</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$20,150</td>
<td>$20,000</td>
</tr>
<tr>
<td>Contingency (15%)</td>
<td>3,000</td>
<td>$3,000</td>
</tr>
<tr>
<td>Total Installation Cost</td>
<td>$23,150</td>
<td>$23,000</td>
</tr>
<tr>
<td>Final Plans / Specs</td>
<td>$2,350</td>
<td>$0</td>
</tr>
<tr>
<td>Permitting and Mitigation</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Legal Fees</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Access and Right-of-Way</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>TOTAL PROJECT COST</td>
<td>$25,500</td>
<td>$23,000</td>
</tr>
<tr>
<td>50% Loan</td>
<td>$12,750</td>
<td>$11,500</td>
</tr>
<tr>
<td>Repayment Factor (20 years)</td>
<td>0.0872</td>
<td>0.0872</td>
</tr>
<tr>
<td>Annual Payment</td>
<td>$1,112</td>
<td>$1,003</td>
</tr>
</tbody>
</table>

12.4 Impact on the Current Annual Assessment

The current annual assessment for the CAID is $250 for each water user for the first irrigated acre, and $12.50 per additional irrigated acre which is based on the average delivery of 2 acre-feet per acre to the on-farm turnout structure. Assuming a total irrigated acreage of 24,250 acres, the annual assessment increase was determined and is presented in Table 12.5 for each implementation alternative.
Table 12.5 Annual Assessment Increase.

<table>
<thead>
<tr>
<th>Payment Plan</th>
<th>Annual Payment</th>
<th>Annual Assessment Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation of Internet-based Water Ordering System</td>
<td>$1,112</td>
<td>$0.04</td>
</tr>
<tr>
<td>Water Operation and Management Program-Level I</td>
<td>$1,003</td>
<td>$0.04</td>
</tr>
<tr>
<td>Water Operation and Management Program-Level II</td>
<td>$13,603</td>
<td>$0.56</td>
</tr>
<tr>
<td>Water Operation and Management Program-Level III</td>
<td>$29,910</td>
<td>$1.23</td>
</tr>
</tbody>
</table>
XIII. SUMMARY AND CONCLUSIONS

The purpose of this Phase III study is to assess the potential for integrating an Internet-based water administration and operation model into the daily management of the CAID. A proto-type of the model, prepared by Dr. Mohan Reddy of the University of Wyoming, was modified to reflect the irrigation and delivery system maintained by the CAID. The model is intended to promote:

- placement of daily orders by water users through the use of the Internet;
- identification of delivery requirements on each lateral and along the Casper Canal through the evaluation of daily requests for water by the users;
- integration of data associated with seepage losses and operational waste to more accurately identify the diversion requirement from Alcova Reservoir; and
- operational management of the diversion from Alcova Reservoir to minimize the operational waste within the delivery system.

Based on the information presented in the previous chapters, the conclusions and recommendations described below are provided.

1. Presently, the administrative staff of the CAID utilizes a personal computer to track the orders from individual water users. A continuous record of water usage for each user is developed and provides the basis for individual assessments for water delivery. Daily water orders are placed via telephone from the water users and compiled to estimate a daily diversion requirement from Alcova Reservoir and each lateral headgate. Records of actual diversions from Alcova Reservoir, lateral headgates or farm turnout structures are not maintained.

2. The existing computer program used by the CAID administrative staff to track water orders and issue bills is a proprietary software program that maintains individual information on water orders and provides the assessment data for billing at the end of each year.

3. The administrative staff along with the CAID manager use rule-of-thumb estimates to increase the individual water orders on laterals to account for net losses (attributable to seepage, evaporation and operational waste) and ultimately develops a daily request for diversion from Alcova Reservoir to the Casper Canal. Ditch riders within the CAID manually operate the gates and check structures on the main canal and laterals to ensure adequate delivery of the individual water orders.
4. The CAID does not presently record the diversions at the lateral headgates or farm turnout structures. Procedures should be instituted, and a diligent effort provided, to record the total diversion at the headgates associated with each lateral, sublateral, and individual farm turnout structure on a daily basis. Implementation of these procedures will significantly improve the tracking and equitable delivery of water to all users and will promote the quantification of losses within the irrigation delivery system.

5. A questionnaire mailed to the CAID water users provided the following information:

- Less than 50% of the water users responded to the questionnaire.
- Of those that responded, 70% presently own a personal computer.
- Approximately 87% of those that owned a personal computer maintained access to the Internet.
- Only 42% of those that responded indicated a willingness to use an Internet-based system for placement of water orders.

6. A review of the Internet-based water ordering program developed by Dr. Reddy resulted in the following recommendations:

- The program should be tailored to specifically reflect the Casper Canal, all laterals, and all CAID water users by lateral to promote consolidation of water orders.
- A minimum and maximum diversion threshold should be established for each water user.
- A screen interface should be developed that illustrates the connectivity of the laterals and the Casper Canal.
- Estimates of seepage loss, operational waste, and evaporation should be developed and integrated into the program to obtain the consolidated diversion estimate at each lateral headgate as well as the diversion from Alcova Reservoir.
- An interface between the existing proprietary software for placement of water orders/accounting and the program provided by Dr. Reddy should be developed to avoid duplication of effort and cost with respect to data entry.
- Pending future automation of head gates and real-time data collection with respect to water measurement at the v-notch weir from Alcova Reservoir as well as laterals and operational spills, the capability to incorporate this data to promote management of the water supplies should be integrated into the program.
- Pending placement of automated weather stations within the CAID, the capability to access this data to obtain estimates of crop evapotranspiration and promote irrigation scheduling should be integrated into the program.

7. Improvements to the water ordering program were identified and include:

- A dedicated, high speed, Internet access service line;
- A dedicated IBM compatible personal computer; and
• Additional software development to tailor the proposed water ordering program to the CAID.

The total project cost to implement these improvements was estimated to be $25,500. Assuming a 50% grant/50% loan from the WWDC, the annual payment for this improvement becomes $1,112 and results in an increase in the annual assessment of $0.04 per irrigated acre.

8. Three levels of implementation were identified for the development and utilization of a water operation and management program. For all levels, it is assumed that the water orders reflect the actual deliveries at each turnout structure. If this is not a valid assumption, then actual delivery records should be input into the model and utilized.

Level I Implementation involved development of software to support the integration of losses within the system along with water orders to obtain estimates of diversions at each lateral headgate as well as the headgate at Alcova Reservoir. The total project cost to implement the Level I improvements was estimated to be $23,000. Assuming a 50% grant/50% loan from the WWDC, the annual payment for this improvement becomes $1,003 and results in an increase in the annual assessment of $0.04 per irrigated acre.

Level II Implementation integrates the utilization of real-time measurement data at each lateral headgate and the headgate at Alcova Reservoir. In addition to the system automation improvements identified in the Phase II study, sixteen (16) sites were identified specifically for real-time data collection. Each site will monitor the water level in the Casper Canal and lateral, remotely record the measurement data, and transmit the data to a base station at the CAID office. The total project cost to implement the Level II improvements was estimated to be $312,000. Assuming a 50% grant/50% loan from the WWDC, the annual payment for this improvement becomes $13,603 and results in an increase in the annual assessment of $0.56 per irrigated acre.

Level III Implementation includes the automation of one slide gate at each headgate structure to remotely control the diversion from the Casper Canal. This level assumes the integration of the real-time measurement data at each headgate as indicated for the implementation of Level II improvements. Each site will monitor the water level in the Casper Canal and lateral, remotely record the measurement data, and transmit the data to a base station at the CAID office, and provide for remote operation of the slide gate. The total project cost to implement the Level III improvements was estimated to be $686,000. Assuming a 50% grant/50% loan from the WWDC, the annual payment for this improvement becomes $29,910 and results in an increase in the annual assessment of $1.23 per irrigated acre.

The benefits derived from installation of an Internet-based water administrative and operation program depend on utilization by the water users as well as the administrative staff of the CAID. The survey questionnaire attempted to gauge the interest of the water users for a new
system of placing water orders. Based on the limited response to the questionnaire, one may conclude that limited interest exists to change the present system. Furthermore, many water users will need to acquire computers and incur a monthly charge to access the Internet to place the orders.

Discussions with the administrative staff of the CAID have indicated a reluctance to change from the current system unless it can be demonstrated that data only needs to be input one time and the same capability is provided in the new program. Consequently, it will be essential to interface the existing assessment program to the Internet-based system or simply develop software to replicate the existing assessment program.

The issues identified above must be addressed more fully before this program will be acceptable to the CAID. Based on this information, additional effort by the developers of the program is warranted to address these issues as well as the need to provide software development to tailor the existing program to reflect the CAID irrigation system. It is recommended that this effort be completed prior to potential funding of project improvements identified in this report.
APPENDIX A

QUESTIONNAIRE
and
COMMENTS
Casper-Alcova Irrigation District
Questionnaire

Dear Sir/Madam,

In view of our current drought and potential shortages in the future, the CAID is working with the Wyoming Water Development Commission on ways of improving its operation and efficiency. One of the options we are looking at is using the Internet as a way of placing requests for irrigation water. Dr. Mohan Reddy, from the University of Wyoming, has developed software that would allow water users to access a webpage over the Internet, enter your own personal access information, and place requests for water delivery while online. The system would also allow water users to view water use throughout the CAID. Under the system, you would still be able to call in your requests if you don’t own a computer, or would just rather talk to someone in person. The objective behind the system would be to allow the CAID to improve water management, reduce operational waste, and become more efficient on the whole.

In order to determine the feasibility and practicality of the system, we are asking for your input. Please take a few moments to complete the following brief questionnaire and return it to the CAID office as soon as possible. Feel free to add your name and comments if you like, or if you prefer, please respond anonymously.

1. Do you currently own a personal computer? yes / no
   If yes, what type of computer is it? IBM / MAC / Don’t know

2. If you do not own a computer, do you plan on purchasing one in the next year? yes / no

3. Do you own a TV? yes / no
   If yes, is it cable connected or using a satellite dish? satellite / cable / none

If you answered “No” to all of the above, you do not need to answer the following.

4. On a scale of 1 to 5, how would you rate your ability to use your computer?
   1 2 3 4 5
   Low High

5. Do you currently have access to the Internet from your computer? yes / no
   If No, do you plan on getting access in the next year? yes / no

6. Would you be willing to use an Internet – based system to place your water requests? yes / no

Comments:

________________________________________________________________________

________________________________________________________________________

Thanks very much for your time. Please drop this letter in the mail using the enclosed envelope or drop it by the CAID office by July 1st. Thanks again.
Casper-Alcova Irrigation District Questionnaire Comments (July 2002):

1. Would like to leave water requests and etc off the computer.

2. Computers don’t save water, good water delivery systems save water.

3. Computers take more time to log on, make a water request, and then wonder when the water will be turned on.

4. A direct call to Kelly, by phone, is the most efficient way to carry out business. Often times, an irrigator needs to have a two (2) way conversation.

5. Communication is the best way, with a human being, not another machine.

6. Not everybody has, or wants, a computer, they are expensive and they often times create another set of problems.

7. Farmers and ranchers currently have a more efficient water delivery system – “side rolls” – “pivots” – “gated pipe” – than CAID has with earthen ditches.

8. Money needs to be spent upgrading “wears” and water measuring devices so “ditch-riders” are able to deliver water more efficiently.

9. Ditches need to be upgraded to reduce seepage.

10. Spend money on CAID water delivery systems and not on computers.

11. Farmers and ranchers waste far less water than CAID, because we meter our water. We have pipe delivery systems – side rolls – pivots – gated pipe.

12. In some situations, CAID ditch riders have to turn in (5 or 6) acre feet of water just to get (2) acre feet of water to a ranchers “turn-out” because of seepage or poor or no existent wear systems or control points.

13. I use computers at work and fail to see where they save time, or make life easier, improve management, or become more efficient.

14. I don’t have a computer.

15. At some point in time, we’ll either connect to internet by WEB TV or get a PC and hook up to some online provider.

16. It would not save time or water. Just another overhead costs. No thanks.
17. Computers are only as smart as those who operate them and I think they have become an excuse for not doing the work properly and another way for some outfit to make money by selling a new program.

18. Don't know if I am computer literate enough to do so, we just got this one on a bill trade and it is old. I can do email well on it. Or I still have a telephone and a cell phone.


20. John and Tom Leman irrigate for me and are authorized to make calls for my allotment.

21. This would greatly modernize this process and allow orders placed even after CAID office hours and holidays.

22. If a person orders water via the internet after 2pm, will water adjustment or water shutoff/turnon be done the next day or will be the day after?

23. Water request by way of the internet would be fine, but telephone contacts are a must for problems that need immediate responses.

24. Thanks for everything! I think Dan would still like calling Kelly!

25. Let's do it!!

26. Ben Clark orders the water and doesn't have a computer in his shop.

27. I question if there would be a cost saving.

28. The internet is much too slow. My guess is the internet would take at least 15 minutes and sometimes much longer. Now I can frequently place an order in a minute. Right now, I can place an order from the field but with the internet I would have to drive home. I would use an internet system, but not for most of my orders. Right now, I do use email for some orders, but that is convenient only on occasion.

29. Water Conservation starts at our Alcova inlet. Tell me how this program will improve conservation?

30. Would this change lead time for turn ons and cut offs?

31. I have filled this out, but since we are moving to Lander, June 29th, I doubt it will be much help. Please contact the new owners for their input.

32. The problem isn't with the ordering process. It happens after the order is placed with getting the right amount of water in the ditch. The person we talk to when ordering is always friendly and accommodating!
33. What's wrong with phoning the office?
34. I'll miss talking to Kelly. She's always so pleasant and helpful.
35. Don't mind calling for turnon and turnoff. Internet accounts can be broken into by other computer users.
36. I would have to see how accessible the web site is before committing to using it.
37. Keep it simple for us. Technology-impaired people and yes, I would use it.
38. I would rather talk to someone directly.
39. Love the idea of being able to see where the water is going!
40. Sounds like a great way to disseminate information!
41. When are you going to update your computer with my correct mailing address? Should be 5408 South Shinn Road, Casper 82604.
APPENDIX B

INTERNET-BASED WATER ORDERING PROGRAM
WEB-Based Administration and Operation of Casper-Alcova Irrigation District, Casper, Wyoming

FINAL PROJECT REPORT

Submitted by

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University of Wyoming
Laramie, WY 82071

October 31, 2002
1. **Background**

A Memorandum of Understanding was signed between the University of Wyoming (UW) and the Wyoming Water Development Commission (WWDC) during the month of January, 2002, to study the feasibility of implementing a "Web-based Administration and Operation of Irrigation Districts" software for the Casper-Alcova Irrigation District, in Casper, Wyoming. As part of this feasibility study, the following activities were expected to be undertaken:

1. Develop a Demo-version of a Web-based software for Administration and Operation of Irrigation Districts.
2. Demonstrate the working of the Demo software to the Board Members of the Irrigation District as well as to the Officials of the Wyoming Water Development Commission.
3. In Association with Anderson Consulting Engineers, Inc., Fort Collins, conduct a survey on the use of computers by water users in the Irrigation District.

The duration of the project was for one year, with a total budget of $10,000 provided to the University of Wyoming for implementing the above project. The University of Wyoming project number is 5-39450.

2. **Development of a Demo Software**

Per agreement, a demo-version of the software was developed over a period of 3-months, by modifying an existing demo software package that was developed for an irrigation project in India. The software package used the state-of-the-art technology such as the Java Enterprise Edition with java beans, java server pages and servlets, relational database, and a web-server program.

Java Enterprise Edition: Java is an object-oriented programming language designed for use on the internet. The Enterprise Edition is specially designed for "heavy-duty" enterprise applications. Even though the demo version of the software is not very large, we wanted to start with a commercial application in mind. Once the Irrigation District makes a decision to implement the software on the project, the demo-version needs to be expanded to a commercial scale. Therefore, instead of using a standard java package for the demo and then migrating to a commercial package (Java Enterprise Edition) once it has been decided to implement it on a project, we decided to start with the enterprise edition even for the demo-version of the software.
Web-based administration

JavaBeans: This is Java's reusable software component model. JavaBeans allow developers to reap benefits of rapid application development in Java by assembling predefined software components to create powerful applications and applets. JavaBeans allow for development of more robust functionality.

Java Servlets: These are java-language based programs that reside on the Web-server and respond to clients' requests, thus extending the functionality of a web-server. Typically these servlets are functions written to accomplish a particular computation of interest.

Java Server Pages(jsp): Java Server Pages look like standard XHTML or XML documents. In fact, JSPs normally include XHTML or XML markup. They act like communication channels between the client and the server, and simplify the delivery of dynamic web-content, as opposed static web-content.

Relational Databases: A relational-database model is a logical representation of data that allows the relationships between the data to be examined without consideration of the physical structure of the data. A relational database is composed of tables (a set of rows and columns). Each row of the table is called a record, and one of the columns in the table is selected as the primary key for referencing data in the table. A primary key is a field in a table that contains unique data that cannot be duplicated in other records. This guarantees that each record can be identified by a unique value. Several tables were developed to represent the project data in an inter-linked fashion using the relational database concept. For the purpose of the demo-version, the Microsoft Access database was used. Java programs communicate with databases and manipulate their data using the Java Database Connectivity (JDBC) API. A JDBC driver implements the interface to a particular database, in this case the Microsoft Access database.

All the above elements were implemented into the demo-version of the software. The different web-pages that were designed for this project are discussed next. The software was developed in association with a private software consultant in Longmont, Colorado. For convenience, the software is currently located on a personal computer/server at the following address: http://129.82.224.46:8181/WaterWeb/index.jsp

There is a slight possibility that the IP address will change shortly. If it does, the new address will be informed to the WWDC.

Figure 1 shows the main page of the website, which provides an option for either the project administrator or the water user to log into the system. Since the responsibilities
and duties of the administrator are entirely different from the water user, two entirely different web pages were designed for their use.

Welcome to Wyoming State Water management!

Wyoming State is pioneering a web based system for irrigation management, by offering the water users the capability to communicate their water needs on a real time basis.

Water Administrators: You get unprecedented control over your water resources, and you can use state-of-the-art optimization and scheduling tools. This is your one stop shop for all your water management needs. (see benefits)

Water Users: You can request water real time, and view your water usage online. You can analyze your water needs based on your crop pattern. (see benefits)

Click here to login

Figure 1. Main page of the web-site
Figure 2 shows the login web-page for either the admin personnel or the water user.

Figure 2. Water User/Administrator Login page
Once the administrator logs into the system, he will have at a glance all the information regarding the project (Figure 3). Of course, this information needs to be entered first on other web pages.

Figure 3. Administrator's Home Page with several options
The administrator needs to setup the accounts, including passwords for all the water users, as shown in Figure 4. This is done only once for each water user in the irrigation district.

Figure 4. Water User Setup page
Figure 5 shows the page for setting up the geometry of the canal network. This information will be used to calculate the seepage losses through the laterals and the main, once a farmer places an order for water. This information will also be used to check the canal capacities to minimize spillage.

![Figure 5. Page for Setting up the Geometry of the Canal Network](image-url)
Figure 6 shows the page where the administrator enters the information on the starting and ending date of water deliveries during a given season. This information will be entered only once at the beginning of the season, but, if necessary, it can be changed by the administrator. All the water users will have access to this information on their home pages.
Figure 7 displays the web-page for the administrator to look at the amount of water requested by farmers on different laterals. The time horizon can be one week or 2 weeks in to the future.

![Web-based administration](image)

**Figure 7. Summary of Water Requests for the Next One Week**
Figure 8 shows the page that provides a summary of water used by all the farmers so far in the season, and the remaining volume of water in storage in the reservoir. He can also view the volume of water used by the District during the past irrigation seasons.
Figure 9 displays graphically the water requests as a function of time, over a period of one week. A similar graph can be displayed for a period of two weeks also.
Once a water user logs in, using the password setup by the administrator, he will see his home page, as shown in Figure 10. This home page provides a summary of his irrigation related information. Of course, this information needs to be entered on other web pages first.

![Figure 10. Water User Home Page](image-url)
Figure 11 shows the web page where a water user can plan his cropping pattern so that his crop water requirements do not exceed his available water supply for the season.
Figure 12 shows the web page for requesting water on-line. The farmer specifies the starting date, the ending date, the flow rate required and the location where water is to be delivered.

Figure 12. Water Request Form
Figure 13 shows the page where the water user has the option to view the water usage during the season, how much water is still available for use during the given season, how much water he used during the past irrigation season, etc.
2. **Demonstration of the Software Developed**

The developed software was demonstrated to the Board Members of the Casper-Alcova Irrigation District in the month of May, 2002, for their review and feedback. Four different accounts were setup (including username and password) on the names of four selected Board Members. The consultant demonstrated the software using a PowerPoint presentation, and at the end of the presentation, the Board Members whose accounts were created earlier were asked to log into the software, which was loaded onto a Laptop, and use the software for requesting water on-line, selecting appropriate cropping pattern, viewing the amount of water used by them so far in the season, viewing the starting date of water releases and the proposed ending date of irrigation releases, etc. Three Board Members worked with the software without any difficulty, and they were impressed by the user-friendliness of the software and its utility in their district. They also offered the following suggestions:

1. Currently, the software assumes that the entire landholding of a water user is at one location in the project area, which is not true. Therefore, they asked us to modify the program so that a water user would be able to request for water delivery at multiple locations, i.e. at different turnouts located on different lateral canals, in the project area.

2. The limits placed on the capacities of lateral canals were arbitrary, and were unrealistically very large. They wanted us to modify those and put project specific values for the laterals.

These were the only two comments that were received from the Board Members. These modifications will be taken care of in the near future. In addition to the above comments, they did agree that the software would be of immense help to the farmers if implemented, but their main concerns were the following:

3. How many farmers use computers?
4. How many farmers have access to an internet?

The Board Members said that if at least 20% of the farmers in the Irrigation District have access to internet connection, they would be willing to implement the software on their system. So it was decided to undertake a survey of computer usage by water users. In addition, it was agreed that after making the recommended changes to the software, the software would be installed on a web-server somewhere in Fort Collins, or on the Casper-Alcova Irrigation District's computer, so that interested water users can already start using the software and provide additional feedback for improvement. The software was eventually installed on a computer at Colorado State University. However, the suggested changes were time-consuming and did not finish making all the recommended changes during the summer months of 2002. We are still working on implementing the recommended changes to the software. Hence, the software will be ready for installation, after making the necessary changes to the program, on the Irrigation District's computer sometime during the spring of 2003. During the last two months, we have incorporated the project map onto the web page, as shown in Figure 14.
Welcome to Casper Alcova Irrigation District!

Casper-Alcova in Wyoming State is pioneering a web based system for irrigation management, by offering the water users the capability to communicate their water needs on a real time basis.

**Water Administrators:** You get unprecedented control over your water resources, and you can use state-of-the-art optimization and scheduling tools. This is your one stop shop for all your water management needs. (see benefits)

**Water Users:** You can request water real time, and view your

Figure 14.   New Main Page of the Casper-Alcova Irrigation Project
4. **Survey of Computer Usage by Water Users in the District**

Per the recommendations of the Board Members as well as the Wyoming Water Development Commission, a Survey Form was designed by the Anderson Consulting Engineers, Inc., Fort Collins, to solicit information on the level of computer usage and the level of interest in using a software package for water requesting, etc. The survey form was sent to the water users in the month of June, and most of the survey forms were received by the Anderson Consulting company in Fort Collins by the end of July, 2002. Based upon the information received by the end of July, there is extensive use of computers by farmers in the project area, and definitely more than 20% of the farmers have internet connections. Professor Reddy will obtain detailed results of the Survey from Anderson Consulting Engineers in the near future.

5. **Future Plans**

Since the suggested changes to the program required lot of time commitment from the Consultant, these changes were not completed during the summer months 2002. The consultant is still working on the software. It is our hope that the suggested changes to the software would be complete by end of April, 2003, and the software would be ready for implementation on the Casper-Alcova project for use during the 2003 irrigation season. This action will be initiated again with the help of the Wyoming Water Development Commission.