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SECTION I
EXECUTIVE SUMMARY

1. INTRODUCTION
The Big Sandy River Unit has been identified as a major contributor of salt to the Green River, which is a tributary of the Colorado River. As part of the Colorado River Basin Salinity Control Program, numerous farms in the Eden Irrigation & Drainage District (District) are converting to sprinkler irrigation with the assistance of the U.S. Soil Conservation Service. Consequently, better regulation of delivered water, with less sedimentation, has become more desirable.

The current District records indicate there are approximately 105 operators irrigating 17,010 acres. The water delivery system has essentially remained as designed and constructed through contract with the Bureau of Reclamation and was completed in 1959. There are currently about 50 sprinkler irrigation systems serving an estimated 5200 acres.

The salinity reduction program on the Big Sandy River Unit is estimated to result in the eventual reduction of 52,900 tons of salt annually entering the Big Sandy River. The implementation of this plan requires the voluntary conversion of irrigation methods to Low Pressure Sprinkler Irrigation Systems. As farms convert to sprinkler irrigation, the excessive sedimentation in the canals has the potential to become a significant problem as it decreases the life of the pumps and other components.

This study and Level II report was authorized in June 1992 by WWDC and the Eden Valley I&D District. The study
objective was to identify and evaluate potential sand/silt control facilities and regulating reservoirs on the canal systems.

2. DESIGN CRITERIA AND DESIGN CONSIDERATIONS
Criteria was established so that the capacity, quality or functional capability of each canal segment is integral to each design.

The general design considerations include:
• accepted civil engineering rules used in reservoir design
• accepted design criteria and project-specific findings relative to silt/sediment control
• earthwork and foundation investigations
• cultural constraints
• geotechnical considerations
• environmental constraints

3. PRELIMINARY DESIGN
Using the design criteria, five(5) reservoir sites were chosen. To design the reservoirs for specific sites, the following factors were considered:
• Reservoir Type: Preliminary design of two reservoir types were created for each location.
• Reservoir Capacity: Surge, Operating Demand and Emergency Reserve were the three general factors effecting the size of each reservoir. In total, they provided a volume that each reservoir was designed to accommodate.
• Water Surface Elevations: Water surface levels in the canal, above and below each site, dictate the usability of each location.

• Inlet/Outlet: The design was based on the capacity of the facilities (pipes, gates and other appurtenances) to move water into and out of the reservoir.

• Silt Traps: Reduce the flow of sediment in the canals. Silt traps were determined to be especially useful in the Eden Canal.

These criteria provided a uniform basis of comparing and evaluating each site.

4. COST ESTIMATES AND ECONOMIC ANALYSIS
An opinion of probable cost has been generated based upon the information available. These costs have been tabulated and appear on the following page.

5. EVALUATION
Silt was not found to be a serious problem on either the Westside or the Farson Lateral. The sedimentation of the Eden Canal was found to be a more significant problem. A minimum of two silt traps have been proposed on the Eden Canal where the most significant sand and silt buildup has occurred.

Reservoirs provide a more efficient management of water. There are many variables to be considered in the evaluation of reservoir sites. A logical basis of comparison has been established so that the characteristics of the reservoirs can be equated.
The District, WWDC and other reviewing agencies will need to consider their own methods to fully equate each of the alternatives.

6. CONCLUSIONS AND RECOMMENDATIONS

A questionnaire was prepared to determine the rehabilitation priorities of the irrigators and assess their willingness to pay for potential improvements. An example of the survey questionnaire is presented in Appendix D.

The public input that was received on this project was overwhelmingly negative. Those that completed the survey questionnaire, and spoke at the public hearings, did recognize some merit in the project. However, the irrigators did not feel that salinity or sedimentation of the Big Sandy System was a problem of such magnitude as to justify the costs to them and the State for the scheduled 'improvements'. The respondents generally did not view either of these problems as significant, and did not feel that the delivery time of irrigation water to their farms was as problematic as previously thought.

Consequently, it is the concensus of the District Board and the Wyoming Water Development Commission that further study of the Big Sandy Water Supply Project, Level II, be terminated.
SECTION II

2. **INTRODUCTION**

2.1 **Background**

The Big Sandy River heads in the Wind River Mountains of northwestern Wyoming and flows southerly to the Big Sandy Reservoir from which water is diverted to the Eden Irrigation Project. From Big Sandy Dam, the river flows southwesterly to the Green River several miles downstream from Eden, Wyoming. The Big Sandy River Unit has been identified as a major contributor of salt (up to 180,000 tons annually) to the Green River, a tributary of the Colorado River. As part of the Colorado River Basin Salinity Control program, numerous farms of the Eden Irrigation Project are converting to sprinkler irrigation for more efficient irrigation. Less return flow results from conversion to sprinklers and less salt loading to the Big Sandy River. As more farms convert to sprinkler systems, it becomes more desirable to better regulate water delivered to irrigators and reduce the sand/silt load in the delivered water.

2.2 **Authorization**

In June 1992, Nelson Engineering contracted with the Wyoming Water Development Commission to provide a Level II Feasibility and Conceptual Design Study for the Big Sandy Water Supply Project. Nelson Engineering performed an evaluation of the canal systems on the Big Sandy Project to determine the possibility of constructing regulating reservoirs on the West Side Lateral, Eden Canal, and Farson laterals. Nelson Engineering studied methods of sediment removal/control and developed conceptual designs and cost estimates for the most cost effective of the proposed facilities. This report is submitted as a result of that study.
2.3 Data Sources

Nelson Engineering is especially grateful to the following bureaus, agencies, commissions and districts for assistance and information as enumerated:

- Wyoming Water Development Commission, Cheyenne, Wyoming, especially Patrick Erger and Mike Carnevale, for suggestions, attendance at meetings and timely response to questions.
- U.S. Bureau of Reclamation, Provo, Utah, and specifically, Lynn Barnhard, for research, document retrieval and copying.
- U.S. Bureau of Reclamation, Salt Lake City, Utah, for library checkout of relevant documents.
- U.S. Soil Conservation Service, Farson, Wyoming, and specifically, Earl Cross, Larry Moody and Lynn Cornia for suggestions and assistance in describing the sprinkler irrigation program.
- Eden Valley Irrigation and Drainage District, Farson, Wyoming, especially Tom Taliaferro, Lee Harms, James Eaton, Ralph DeLambert, Gary Zakotnik, Dale Daubert and Jan Mines for suggestions, support, timely review and attendance at meetings.

A Scoping Meeting, to introduce the consultant to the project sponsor and to define the project objectives was held June 17, 1992, in Farson. Representatives of the Sponsor, WWDC, SCS, Nelson Engineering and Nelson Engineering subcontract consultants met to initiate the study. During the following two months, data gathering and

SECTION II-2
design formulation progressed. On August 24, 1992, a meeting was again held in Farson, a progress report was given and design considerations were discussed. At conclusion of the Draft Phase I Report, a third meeting was held in Farson to discuss the project on January 25, 1993. At that time, the Irrigation District Board decided to terminate the project. Minutes of these meetings are included in Appendix A.

2.4 Project Team

Nelson Engineering employed the following subcontract consultants on this project:

- Jon Howell, Inberg-Miller Engineers, Riverton, Wyoming, investigated geotechnical and foundation aspects of the project.
- Robert Dorn, Mountain West Environmental Services, Cheyenne, Wyoming, was responsible for biological aspects, including threatened and endangered species and revegetation of disturbed lands.
- Jim Welch, Frontier Archaeology, Inc., Worland, Wyoming, was responsible for cultural resource surveys.
- Dusty Zaunbrecher, Headwaters Ecology, Jackson, Wyoming, identified wetlands and assisted with wildlife habitat considerations.

Nelson Engineering completed extensive field data gathering which, coupled with the information collected by the sources listed above, has been utilized in development of this report.
2.5 Objective

The objective of the Level II study was to identify and evaluate the potential sand/silt control facilities and regulating reservoirs on the canal systems.

The evaluation considered alternative facilities and compared them based on size, environmental or cultural constraints, land ownership, licensing and permitting requirements, cost and benefits. This information may be used by the District and the Wyoming Water Development Commission to determine the feasibility of future infrastructure improvements to the water supply and delivery system.

At the inception of the study, SCS had tentatively proposed eight reservoir sites, all on Bureau of Reclamation land. The reservoir sites were numbered in the same order that they were visited during the preproposal site tour. Early in the investigation, the original Site 6 was dropped from further study because it provided little or no direct benefits to the irrigation district. Subsequently, an additional four potential sites were identified. All four sites were located on private land. One was near Site 7 and was given the reassigned number 6. New Sites 9, 10 and 11

SECTION II-4
round out the total of twelve sites investigated. New Site 6 was dropped because Site 11, very nearby, proved to be a better site. Sites 2, 3 and 8 were dropped when they did not meet the site selection or design criteria. The sites that survived to evaluation were: Site 1 serving the Farson Lateral, Sites 4 and 5 serving the Eden Lateral, Site 7 serving the Westside Lateral, Site 9 serving the Farson Lateral and Sites 10 and 11 serving the Westside Lateral.

At the coordinating meeting held on August 24, 1992, numerous considerations were presented for use in selecting reservoir sites. A general consensus was gained from the District Board and WWDC on these "considerations". Engineering and operating parameters were then assumed as criteria for reservoir design. These considerations and criteria directly influenced the size, operation, benefit and cost of the reservoirs.

In addition, several of the evaluation parameters, including cultural resource impacts, wildlife enhancement, threatened and endangered species impacts, access and wetland impacts were given equal weight in the evaluation of alternatives.
SECTION III

3. EXISTING FACILITIES

3.1 Historical Development

Irrigation was introduced in the valley in 1886 when settlers began to divert water from the Big Sandy River. Due to project actions beginning with the Eden Irrigation and Land Company in the early 1900's, the Rock Springs Land and Water Company and the Wyoming Land and Water Company in the 1930's, and the existing Eden Valley Irrigation and Drainage District, there has been an increase of irrigated land in Eden Valley to the present 15,700 acres of the 18,370 water-righted acres. During 1962-73, the Eden Valley irrigation project served an average of 84 farms, averaging 173 acres per farm. Total farm population is 279 people; 79 of the 84 operators currently are part-time farmers (USDA, 1988).

Work on the main canal was begun in 1907 by the Eden Irrigation and Land Company, organized by the John M. Farson and Sons Company who financed it and maintained a controlling interest. Work was completed in 1914. During the 1920's, the Mennonite Church became interested in the irrigation project and encouraged its members to move into the area and settle. Forty-five miles of canal and 110 miles of laterals irrigated the fields of about 30 farmers by 1926. In 1927, the project was sold to the Rock Springs Water Company, who resold it in 1932 to the Wyoming Land and Water Company. In 1940, the Civilian Conservation Corps, under the administration of the Bureau of Reclamation, began work on the Big Sandy Dam, a project that was interrupted by World War II and resumed in 1950.
The Bureau of Reclamation project in the 1950's included completion of Big Sandy dam and dikes, building the Means Canal, extending and rebuilding the Eden Canal, Farson Lateral, Westside Lateral and Eden Lateral System. The work took most of the 1950's with completion of most work by 1959. Figures 1 through 6 are Bureau of Reclamation maps showing the Means Canal, Eden Canal and Laterals, Farson Lateral and Westside Lateral.

Canal and lateral diversion capacities were based upon information contained in the Final Project Report, Bureau of Reclamation (1953).

Canal capacities were arrived at, based on the growing season during 1935, a year which had the highest accumulation of heat units during the growing season. The growing season during this year has a total of 6240 heat units for which the Johnson-Lowery curve gives a consumptive use of 1.81 acre-foot/acre.

A diversion requirement of 4.62 acre-foot/acre was determined as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Consumptive use (1935)</td>
<td>1.81</td>
</tr>
<tr>
<td>Less winter use</td>
<td>.18</td>
</tr>
<tr>
<td>Net irrigation requirement</td>
<td>1.63</td>
</tr>
<tr>
<td>Plus farm losses (42% of farm delivery)</td>
<td>1.81</td>
</tr>
<tr>
<td>Farm delivery</td>
<td>2.81</td>
</tr>
<tr>
<td>Conveyance losses</td>
<td>1.81</td>
</tr>
<tr>
<td>Diversion requirement</td>
<td>4.62 Acre-foot/acre</td>
</tr>
</tbody>
</table>

The District was created on April 18, 1950, and a Board of District Commissioners appointed. The District has continued to function since that date.
Current District records indicate approximately 105 operators irrigating 17,010 acres. The water delivery system remains essentially as designed and constructed through contract by the Bureau of Reclamation.

The Bureau developed farm units and applied for water rights for the lands to be irrigated. Figures 7 and 8 show current farm units and water rights in the District.

3.2 Salinity Reduction
The USDA Selected Plan - Big Sandy River Unit (1988), explains the reasons for taking actions to reduce salinity and explains the actions planned to be taken. The four-page SUMMARY of that study is included in Appendix B of this report.

The major provision of the salinity reduction program is to facilitate voluntary conversion of flood irrigated fields to Low Pressure Sprinkler Irrigation Systems. Voluntary participation in the program is implemented through longterm contracts administered by the ASCS. This conversion is estimated to result in eventual reduction of 52,900 tons of salt annually entering the Big Sandy River. Implementation of the USDA Selected Plan for the Big Sandy River Unit was estimated to increase production by an average yield of more than two tons/per acre annually.
According to the plan, increased water use efficiencies would leave water available for release from the reservoir on a schedule which would improve fisheries and wildlife habitat in the Big Sandy River.

It appears the salinity reduction program is working. There are currently about 50 sprinkler irrigation systems operating or planned to be in operation by the 1994 irrigation season. These will irrigate an estimated 5200 acres. Irrigators in the District acknowledge a saving of irrigation water. However, because of drought conditions the past several years, there has not been a surplus of water in the reservoirs. The farmers who have participated and converted lands to sprinkler irrigation have noted increased crop yields, and there has been a reduction of salt loading to the Big Sandy River. Figures 9 and 10 show lands that have been, or are being, converted to sprinkler irrigation. The figures also show proposed reservoir sites on Bureau of Reclamation land as well as proposed sites on private land. Some of the proposed sites on Bureau land proved to not be feasible, as will be described in a later section.

3.3 Water Delivery Management
The station where the Eden Lateral branches to serve its last deliveries is 1219+44. At an average velocity of 1.5 feet per second, water diverted at the Big Sandy Reservoir takes 22 1/2 hours to reach this point. An additional 20 hours are required for diverted water to reach the average farm turnout near the Town of Eden. District operators would like a storage reservoir in closer proximity to the points of delivery to reduce the time required to deliver water.

SECTION III-4
3.4 Sand/Silt
Sand/silt buildup in parts of the delivery system are excessive. Annual maintenance to clean sand and silt from laterals and on-farm ditches has been increasing. In addition, as more farms are converted to sprinkler irrigation, the wear on pumps and sprinkler components will be an increasing problem. District operators expressed a desire to reduce and control the sand/silt load carried by parts of the canal system.

3.5 Surge Routing/Wasting
Surge is defined as the volume of water that would be available for storage during an unexpected period of reduced need.

Interviews with Frank Brower, Bridger Valley Power, with Gene Smith, former Irrigation District operator, and with Irrigation District board members indicate that the type of massive power outage envisioned by the SCS in "USDA-SELECTED PLAN" is very rare and quite unlikely. Outages are usually specific to a more localized area and of relatively short duration. Interviews with Mr. Brower and Mr. Smith are included in Appendix C.

Our observation of the canals in operation during the season of 1992 indicated that surge routing and surge or flood wasting was not a serious problem for the operators and canal capacities were always very adequate. Indeed, given the alternative of a few regulating reservoirs throughout the system, the operators would have no difficulty managing surges and minor flood inflows.

SECTION III-5
As more farms are converted to the sprinkler systems, there will be less demand for larger flows in the canals, resulting in increasing canal capacity to accommodate unanticipated water surges and minor flood flows.

For these reasons, surge routing and flood control/wasting are not given further consideration.
4. DESIGN CONSIDERATIONS

4.1 General

The design considerations are presented as the general criteria for defining the facilities to be proposed and for selecting the location, capacity, operation and general features of each. The listing includes normal civil engineering rules used in reservoir design, criteria and findings relative to silt/sediment control, earthwork and foundation investigation and cultural and environmental constraints.

Eight reservoir sites were preselected by SCS engineers. These sites were visited and discussed during the scoping meeting. Nelson Engineering obtained topographic mapping of these sites and related the vertical scale to canal water elevations. This mapping is adequate only for preliminary design purposes. Each of our subconsultants has visited and analyzed the sites relative to their expertise. The eight sites are all on federal land under BuRec jurisdiction. In addition, Nelson Engineering has selected three additional sites on private land. These sites were selected to conform to most of the design considerations included in this section. Figures 9 and 10 in the preceding section show all the site locations.
4.2 Reservoir Type, Location, Capacity and Inlet/Outlet Design

The purpose of the regulating reservoirs is to provide options in controlling the distribution of irrigation water in the canals and their associated laterals. Options fall into three categories as follows:

1. The ability to store water already committed to the canals but subsequently unusable because of power outage or reduced demand after storms.

2. The ability to store water closer to the point of need so that response time in water delivery is reduced.

3. The ability to store water as an emergency reserve so that at least those users below the reservoir can be served during a short duration of loss at the main diversion.

Reservoir Types

Within the context of this study, two types of reservoirs are proposed:

1. Online reservoirs are in the line of flow of the canal. They accept all of the canal flow as input and regulate the output. Thus, regulation must be managed at the outlet. Inflow is uncontrolled. Therefore, inflow silts must be trapped or accepted. Outflow control benefits from topographic relief with the difference in inflow and outflow elevation governing reservoir effectiveness.

2. Offline reservoirs are on a side channel of the canal. Inflow and outflow are both regulated. Thus, regulation is achieved through operator control. Inflow silts should be trapped prior to entering the reservoir. The reservoir must have greater topographic relief than online type reservoirs because of the increased hydraulic requirements. They demand greater attention to operation and provide an alternative method of silt control. A major advantage of offline reservoirs is that they can be bypassed and the canal utilized in its historic pattern whenever desired.

The two types of reservoirs are illustrated in Figure 11.
Reservoir Location

Preliminary considerations in locating the reservoirs were:

1. Land ownership. Eight preselected sites were on Bureau of Reclamation land. Three additional sites were identified on private land. Cost of acquiring the sites will be a factor in final reservoir selection.

2. Topography. The reservoir site must have elevation difference enough to move water through the reservoir and provide required storage. Sites on or near existing check/drops or drop structures are preferred. The more elevation difference available, the more effective the proposed reservoir will be.

3. A reservoir at the identified location must be able to provide a definable benefit to the water delivery system. It should protect the canal, provide surge storage or provide reduced water delivery time.

4. The degree of impact on cultural and environmental resources. These impacts will affect the permitting and acquisition processes.

5. Accessibility by District personnel so that water delivery and water management are benefitted. Water delivery and management are dependent on how quickly ditchriders can respond to a change in water need.

6. Areas of high sediment load affect the reservoir and silt trap design. A reservoir and silt trap to protect the canal may be dictated by the extent of silt loading in the canal.

7. The location may be influenced by the extent of wasting in a given area. Reduction of wasting by routing water into storage will conserve water and reduce salt carried back into Big Sandy River.

8. Geotechnical Considerations. Soils and substrata dictate the extent of material and effort that must be expended in lining with clay. Location and availability of clay to use as liner greatly influence the cost of the individual reservoir.
Reservoir Capacity

Several factors effect the size of each potential reservoir. The following preliminary considerations for determining reservoir capacity were used to screen potential sites:

1. Site limitations. Topography and extent of land available govern how large the reservoir can be.

2. Surge considerations. Surge is defined as the volume of water that would be available for storage during an unexpected period of reduced need. This is contingent upon canal capacity and upon the time duration and nature of the period of reduced need.

3. Operating demand. Operating demand is defined as the volume of water needed during a period of unanticipated increased need. This is contingent upon the amount of land irrigated by the canal below the reservoir site.

4. Emergency reserve. Emergency reserve is a volume of water desired to be held for special emergency use only. This volume would be usable by irrigators downstream of the reservoir in any circumstance (such as washout or bank repair) when diversion would be shut down.

5. Board of Directors policy. Current policy required each irrigator to continue his diversion through a downtime and either store or waste his water. This would indicate numerous, small reservoirs on private property for the individual operators to divert into and store in.

6. Silt management. If part of the reservoir function is silt reduction in the canal, then part of its capacity will be required for silt storage.

Inlet/Outlet Design

The inlet works serves to include or divert flow into the reservoir. It must be designed to divert partial to complete capacity of the channel at its point on the channel. It can serve to regulate the rate of inflow to the reservoir or, for offline reservoirs, it can divert a portion of the flow while the balance goes down-channel.

SECTION IV-4
The outlet works serves to regulate the release of water impounded in the reservoir. It must be designed to release stored waters at rates dictated by downstream needs and the capacity of downstream channels. They can be classified and designed according to their purpose, physical arrangements and hydraulic operation. Following considerations are in outline format:

**Capacity**

Capacity is given as $Q = \text{Quantity of flow.}$

Minimum $Q$ must equal all downstream demands.

Operating $Q$ must equal demands plus 20%.

Maximum $Q$ must not exceed downstream canal capacity.

Capacity is related to Head $= H_r$.

$$H_r = K \frac{Q}{A} \quad \text{Where } K = \text{constant and } A = \text{area.}$$

$H_r$ is total water level difference across the reservoir and facilities.

Must assure operating $Q$ or Minimum $Q$ across all reservoir stages.

**Type**

Cut-and-cover for higher $H_r$. If cut-and-cover, gates and pipe losses will control $Q$.

Channel for lower $H_r$. If channel, gates only will control $Q$.

**Location**

Best suited to reservoir function.

Best suited to foundation material.

**Outlet Control**

Function - Operating gates

Regulating valves

Guard gates or valves
**Location** - Upstream toe of dam:
results in open flow pipe.
Upstream crest of dam:
partial pressure, partial
open.
Downstream toe of dam:
results in pressure pipe.

**NOTE:** Usually best at midsection or upstream
crest.

**Trash Racks**

**Type** - Submerged at toe of dam:
surface at beginning of channel.

**Entrance** - Vertical, inclined, horizontal.

**Maintenance** - If accessible, design for
entrance velocity up to
5 ft. per sec.

If inaccessible, design for
entrance velocity at or less
than 2 ft. per second.

**Energy Dissipators**
Must reduce velocity to exit at or below 2
ft. per sec.

### 4.3 Sand/Silt Trap Locations and Design

In support of the primary objective of this project,
Lidstone & Anderson, Inc. (LA) investigated alternatives to
reduce the silt and sand particles transported to the low-
head sprinkler systems. This investigation included the
identification of potential sediment sources, the
determination of the composition of the transported sediment
and the evaluation of the mode of transport. The field
reconnaissance and data collection program provided
information to identify the location of existing and
potential sediment problem areas in the canal.
Based on the information provided in the report prepared by LA (Appendix E), the following recommendations and conclusions were provided:

1) Limiting sediment inflow is especially important between the Highway 28 bridge and the Siphon on the Eden Canal.

2) Maintenance activities that remove sediment from the canal bed will reduce the sediment source contributing to the problems within the canal.

3) Sediment traps are recommended in the main delivery system.

4) Sediment traps should be located upstream of the E-7 lateral, the Hay lateral and between the E-19 and E-25 laterals.

5) To promote upstream sediment deposition, the location and impact of check-drop structures should be evaluated.

6) The rate of sedimentation in the main delivery system has not been determined.
4.4 Geotechnical Considerations

To accommodate the objectives of this project, Inberg-Miller Engineers (IME) reviewed previous research in the project area and performed field reconnaissance at the eight (8) proposed reservoir/wasteway sites and the eleven (11) borrow areas. Based on the observations and findings discussed in the report prepared by IME (Appendix G), the following conclusions and recommendations were made:

1) The soils in the project area have typically permeable characteristics (predominantly sands) and will likely require a reservoir lining.

2) A high quality riprap source is not readily available within the project area.

3) The soils in the project area tend to be sandy and with relatively low plasticity characteristics. The higher plasticity soils (more clay) would serve as a better quality liner material for the reservoirs.

The issues presented will impact the potential project costs and, therefore, would require a more detailed investigation if the project were to continue.
4.5 Cultural Resources Constraints

To accommodate the objectives of this project, Frontier Archaeology (FA) performed a Class I Resource Inventory of the Big Sandy Water Supply Project. FA researched previous cultural resource inventories in the study areas (1/2 acre of land contiguous to reservoir sites) and evaluated the field observations for each project site (reservoir parcel to have land disturbing activities). The report prepared by FA is included in an abbreviated form in Appendix F. The photographs and maps included in the complete report have been omitted from this text.

Based on this report, the following conclusions and recommendations have been made:

1) A database of information regarding the historic and prehistoric cultural resources in the Farson area is very limited.

2) The National Register of Historic Places is currently considering eligible for nomination four (4) historic roads and one historic canal in the Study Area.

3) Six (6) of the eight (8) proposed project areas are known to contain cultural resources.

4) It is recommended that prior to any ground-disturbing activities, a Class III Cultural Resource Inventory should be performed.
4.6 Environmental Constraints

To adequately accommodate the objectives of this project, Mountain West Environmental Services (MWES) and Headwaters Ecology (HE) investigated aspects of the environmental constraints.

The Report of Field Reconnaissance prepared by MWES has been included in Appendix H. Of the eight potential reservoir locations, environmental constraints were evaluated on the basis of the presence (or potential presence) of listed or candidate threatened or endangered species and migratory birds of high federal interest. Based on the information provided in the report, the following conclusions can be made:

1) No listed or candidate threatened or endangered species were observed on any of the sites.

2) No birds of high federal interest were observed on the sites.

3) Sites 2, 5 and 6 appeared to have the greatest potential for developing wildlife habitat.

The Wetlands Survey Reconnaissance Report prepared by HE has been included in Appendix H. This report assesses the dominance of wetlands vegetation and examined for evidence of hydric soils and wetlands hydrology. Based on the information provided in this report, the following conclusions have been made regarding the environmental constraints (existence of wetlands) at the potential reservoir sites:
1) Sites 2, 5, 6 and 8 support jurisdictional wetlands as defined by the U.S. Army Corp of Engineers Regulatory Program.

2) These sites may require the issuance of Nationwide Permits and/or an individual 404 Permit prior to construction.

3) No wetland indicators are present at Sites 1, 3, 4 and 7.
SECTION V

5. DESIGNS

5.1 Specific Criteria
In Section IV, general considerations for reservoir and silt trap evaluation were presented. In order to design the reservoirs to fit specific sites, more specific design criteria were developed.

Reservoir Type - To the extent practical, two reservoir types were designed for each of the three canals/laterals. This was done in order to provide a basis for cost comparison of the two types of storage. This design does not necessarily reflect which type would ultimately be most appropriate for the site. Reservoir selection and design for each site will need to be reanalyzed if construction is considered at a later date.

Reservoir Location - In addition to the preliminary design considerations listed in Section IV, a study of each site as it affects water delivery time (flow time) was conducted. The summary of this information, along with other site characteristics, has been listed on the drawings for each reservoir site referenced as Figures 12 through 22.

Reservoir Capacity - Three of the factors that effect reservoir size; Surge, Operating Demand and Emergency Reserve, have been assigned values. The appropriate amount for each is somewhat arbitrary and is subject to revision. However, in total they provide a volume that each reservoir is designed to accommodate. The volumes were determined using the following criteria:
Surge - It is assumed that the canal would be carrying 1 cfs per 70 acres of total land irrigated by the canal. It is assumed that, of that total flow, the ditch rider would be able to control or wish to divert one-third to relieve an overfull canal during a period of reduced demand. It is assumed that the period of reduced demand would be limited to flow time from diversion to reservoir site because the diversion could be reduced at the same time as surge diverted into the reservoir. On the drawings, this is designated as Potential Storage Capture.

Operating Demand - It is assumed that an unanticipated demand could result in one-third of the users below the reservoir site requesting a supply of 1 cfs per 70 acres. It is further assumed that the duration of this unusual demand would be equal to flow time from the diversion, because makeup water could be diverted from the Big Sandy Reservoir the same time as operating water was released at the regulating reservoir. Therefore, Operating Demand is equal to 1 cfs per 70 acres below the site, times one-third, times flow time from diversion to reservoir. On the drawings, this is noted as Potential Unanticipated Demand.

Emergency Reserve - It is assumed that the canal operators desire to supply 1 cfs per 70 acres to all the acres below the site for a period of 12 hours. Therefore, Emergency Reserve is equal to 1 cfs per 70 acres below the site times 12 hours. On the drawings, this is noted as Emergency Reserve Storage.
**Design Storage** - The sum of the three elements listed above is the total storage requirement. Each reservoir drawing refers to this storage requirement and reflects the site specific quantities.

**Evaporative Loss** - The water loss from the surface of each reservoir due to evaporation effects the volume of water available. For the Big Sandy region, the rate of loss due to evaporation is approximately 1 ac.ft./ac. Therefore, depending on the average surface area of each reservoir, the volume of water lost to evaporation can be determined. On the drawings of the eight reservoir sites that were selected, this is noted as the Evaporative Losses.

**Water Surface Elevations** - Canal water surface above and below a reservoir site are critical to the effective use of the site. If there are no checks or drops of significant elevation difference, the site becomes virtually unusable.

**Inlet/Outlet** - The capacity of structures, pipes, gates and other facilities to move water through the reservoir are based on canal design values and accumulated downstream needs. When dike height of the impoundment exceeds 8 feet above outlet flowline, a piped outlet is used.

**Silt Traps** - To limit the sediment within the canal, maintenance activities should be undertaken to prevent tributary inflow of sediment and water into the main delivery system. This is especially important between the
Highway 28 Bridge and the siphon on the Eden Canal. The rate of sediment supplied to the main delivery system is not presently known. However, it is likely that the sediment within the canal has accumulated over the course of several years. Maintenance activities that will remove sediment from the canal bed will minimize a source of sediment that is presently contributing to the problems in the canal.

The installation of sediment traps, in conjunction with annual maintenance, will reduce the buildup of sediment in the canal bed. Consequently, the frequency and volume of sediment removal during the maintenance operations may decrease after several years of operation.

From Subsection 4.3, it is recommended that sediment traps should be located on the Eden Lateral system above E-7 lateral and between E-19 and E-25 laterals. Further, if a reservoir is located at Site 4 or Site 5, it should be protected by a sediment trap. Sediment traps should be average width of 20 feet, average depth of 2 feet below bottom of existing canal and between 125 to 500 feet long. Three such traps were proposed at the locations indicated above.

For the purpose of preliminary reservoir design and analysis, these criteria have provided a uniform basis of comparison and evaluation of the sites.
5.2 Preliminary Design Drawings

Figures numbered 12 through 22 are included following this section. The figures illustrate seven sites preselected by SCS and four additional sites selected by Nelson Engineering. One site preselected by SCS was dropped because it did not produce a measurable benefit to the District. This site was initially designated Site 6 on the end of Eden Laterals. A substitute Site 6 was found on Westside Lateral, but since a better site was in close proximity, both the original and substitute sites were dropped. The design analyses resulted in seven sites (two on Eden Lateral, two on Farson lateral and three on Westside Lateral) that offer potential for construction. They are numbered as follows:

Eden Lateral - Site 4 and Site 5  
Farson Lateral - Site 1 and Site 9  
Westside Lateral - Site 7, Site 10 and Site 11

Figure 16 shows a typical silt trap.
SITE CHARACTERISTICS

Topography - Broken and cut up

Minimum water surface elevation difference

Flow time from site to average point of use at 1.5' sec.

Reduction of flow time for average use

RESERVOIR STORAGE COMPUTATION

Total acreage on Eden Canal = 9161.1 Acres

Acreage above site = 66.8 Acres

Acreage below site = 9094.3 Acres

Total water surface change at site: +0.0

Take out elevation = 87.4

Return elevation = 86.9

Elevation change = 0.5' (would require new check)

Potential Surplus Capture

Potential Unanticipated Peak Demand

Emergency Reserve Storage

Total Storage = 5,612,482 cu. ft.

To large of an area for storage gained.

NOTES:

* Not enough reduction in delivery time.

** Too much acreage is too far below site.

*** Too large of an area for storage gained.

ALL RELATIONSHIPS SHOW THIS IS NOT A SUITABLE SITE: THEREFORE DISCONTINUE DESIGN.
Site Characteristics:

Maximum water surface elevation difference: 11.0 ft.

Flow time from Big Sandy Reservoir at 1.3 sec. = 11.0 hrs.

Flow time is average point of use at 1.0 sec. = 1.4 hrs.

Reduction of flow time for average use = 11.0 hrs.

Reservoir Storage Computation:

Total acreage on Cenon Canal = 125.7 acres
Acreage above site = 92.7 acres
Acreage below site = 32.1 acres
Total water surface elevation change at site:

Rise = 11.0 ft.
Elevation change = 11.0 ft.

Potential Energy Change

Reservoir

Total Storage = 1,726,789 cu. ft.
Emergency Reserve Storage = 123.2 cu. ft.

NOTES:

- The reduction of flow time is not suitable for this site.
- Too much acreage is to far below site.
- Site would require excessive excavation.

Area shown = 27.5 acres; therefore, this site is not suitable. Therefore, discontinue design.
SITE CHARACTERISTICS

Topography - Quite flat.
Good water surface elevation difference.
Flow time from site to average point of use at 1.5'/sec. - 13.4 hrs
Reduction of flow time for average use - 13.4 hrs

RESERVOIR STORAGE COMPUTATION

Total acreage on Westside Canal - 9161.1 Acres
Acreage above site - 1951.3 Acres
Acreage below site - 7209.8 Acres
Total water surface change at site:
Take out elevation - 76.7
Return elevation - 66.7
Elevation difference - 10.0
Potential Storage Capacity at 13.4 hrs = 2,103,994 cu. ft.
Potential Unanticipated Demand:
7209.8/35x1.2 = 247 cfs at 13.4 hrs = 1,606,777 cu. ft.
Emergency Reserve Storage:
7209.8/70 - 103.0 cfs at 12 hrs = 4,449,477 cu. ft.
Total Storage - 8,159,496 cu. ft.
187.3 Acre-feet
Acreage at mid depth of trapezoidal volume 187.3/10.0 = 18.7 Acres

RESERVOIR DESIGN CONSIDERATIONS

Max water surface elevation = 76.7
Min usable water surface elevation = 66.7
Volume Computation:
Bottom area = 580x1270 - 1000 = 735,600 sq. ft.
Surface area = 660x1350 - 4828 = 886,171 sq. ft.
Average area = 810,885 sq. ft.
Top & Bottom Depth = 10.0 ft.
186.1 close to 187.3 O.K.

INLET DESIGN

Canal Design Capacity = 190 cfs
Inlet Design Capacity = 190 cfs
Rectangular Inclined Drop Capacity = 190 cfs

OUTLET DESIGN

Downstream Demand Q = 7209/35x1.2 = 247 cfs
Outlet Operating Design Q =
Dike Height = 15' - Use pipe outlet.

EVAPORATIVE LOSS

Rate of Evaporation = 1.0 ACF/AC
Average Surface Area = 810,885 sq. ft. = 18.82 AC
Evaporative Loss = 18.10 AC[0.345(AC/FT)] = 18.16 ACF
Storage Capacity = 186.1-10.16 ACF = 167.94 ACF

SCALE 1" = 200'
**SITE CHARACTERISTICS**

- Topography: Reasonably flat.
- Flow from Big Sandy Reservoir to site at 1.5 cfs = 14.8 hrs.
- Reduction of flow time for average use = 14.8 hrs.

**RESERVOIR STORAGE COMPUTATION**

- Same as site no. 3 except change in water elevation difference,
  - Total water surface change at site = 1.7'
  - Min. usable water surface elevation = 57.3
  - Return elevation = 57.3
  - Elevation difference = 7.4
  - Acreage at mid depth of reservoir volume = 167.37 = 26.7 acres

**RESERVOIR DESIGN CONSIDERATIONS**

- Min. usable water surface elevation = 64.8
- Min. usable water surface elevation = 57.5

**VOLUME COMPUTATION**

- Bottom area = 5061.800 sq. ft.
- Surface area = 4861.400 sq. ft.
- Average area = 4911.600 sq. ft.
- Volume = 5061.800 cu. ft.
- Volume = 167.37 acres

**INLET DESIGN**

- Canal design capacity = 180 cfs
- Inlet design capacity = 160 cfs
- Inclined drop capacity = 180 cfs

**OUTLET DESIGN**

- Downstream capacity = 247 cfs
- Outlet operating design Q = 247 cfs
- Pipe height = 12'- Use pipe outlet.
SITE CHARACTERISTICS
Topography: A borrow area will be used. This reduces excavation. Good water surface elevation difference. Flow time from Big Sandy Reservoir to site at 1.5"/sec. = 10.6 hrs
Flow time from site to average point of use at 1.5"/sec. = 2.8 hrs
Reduction of flow time for average use

RESERVOIR STORAGE COMPUTATION
Total acreage on Westside Canal = 3394.7 Acres
Acreage below site = 1803.0 Acres
Acreage below site = 1591.7 Acres
Total water surface change at site:
Take out elevation = 36.1
Return elevation = 29.6
Elevation difference = 6.5'
Potential Storage Capture:
3394.7/70 = 19.2 cfs at 10.6 hrs = 818.192 cu. ft.
Potential Unanticipated Demand:
1591.7/70 = 7.6 cfs at 2.8 hrs = 76.608 cu. ft.
Total Storage = 1,894,800 cu. ft.
Acreage at mid depth of reservoir: volume = 20.5/3 = 66.8 acres
No required size computations because of using existing depression.

RESERVOIR DESIGN CONSIDERATIONS
Max water surface elevation = 36.0
Min usable water surface elevation = 30.0
Volume computation:
Bottom area = 550x1400 = 770,000 sq. ft.
Surface area = 640x1700 = 1,088,000 sq. ft.
average area = 1,490,000 sq. ft.
average area/2 = 745,000 sq. ft.
at 3' depth = 2,787,000 cu. ft.
84.036.8 G.K.
INLET
Canal Design Capacity = 70 cfs
Diversion Design Capacity = 70 cfs
Outlet Operating Design Q = 55 cfs
OUTLET
Downstream Demand = 36.4 cfs
Outlet Operating Design Q = 54.4 cfs
Dike Height = 9' - Use check gate.

EVAPORATIVE LOSS
RATE OF EVAPORATION = 1 ACS/AC
AVERAGE SURFACE AREA = 1,490,000 SF
STORAGE CAPACITY = 64.0-21.33 ACS = 42.67 ACS

SCALE 1" = 200'
SITE CHARACTERISTICS

Topography - Existing depression caused by old borrow area.
Minimum water elevation change - -4'

RESERVOIR STORAGE COMPUTATION

Total acreage on Westside Lateral - 3394.7 Acres
Total acreage above site - 0
Total acreage below site - 3394.7 Acres

Total water surface change at site:
Take out elevation - 84.8
Return elevation - 84.3
Elevation change = 0.5' (would require new check)

Potential storage: 3.794 x 16.2 = 62,944 CU.ft.
1 - 59.3 Acre feet

NOTES:
- Not enough reduction in delivery time.
- Too much acreage is too far below site.
- Too large an area for storage gained.

ALL RELATIONSHIPS SHOW THIS IS NOT A SUITABLE SITE; THEREFORE DISCONTINUE DESIGN.
SITE CHARACTERISTICS

Topography: Mostly flat with a previous borrow which can be used to reduce excavation.

Flow from the borrow area is at 1.0 ft/sec. = 0.3 m/s.

Reduction of flow from normal level to 1.0 ft/sec. = 0.3 m/s.

RESERVOIR STORAGE COMPUTATION

Total storage on pond lateral: 3976.7 acres

Pond area at 92.0 ft = 1876.9 acres

Total pond area: 2299.8 acres

Minimum pond area: 139.0 ft = 42.4 m

Evaporation difference: 0.5

Potential storage at 139.0 ft = 3976.7 acres

Pond area at 92.0 ft = 3976.7 / 4.5 = 883.1 acres

Evaporation difference: 0.5

Total storage: 3976.7 / 4.5 = 883.1 acres

Note: This is less than the total storage area, but may be acceptable.

INLET

Canal Design Capacity: 50 c.f.s.

Outlet Diversion Design Capacity: 50 c.f.s.

OUTLET

Pond area at 92.0 ft = 1876.9 acres

Outlet Design Capacity: 50 c.f.s.

Evaporative Loss: 9.64 acres

STORAGE CAPACITY

49.2 / 5 = 9.84 ACF

49.2 / 5 = 39.36 ACF

Evaporative Loss: 9.64 ACF

STORAGE CAPACITY

Canal reservoir diversion

1 = 0.5 ft.

OUTLET PIPE CROSS-SECTION

SCALE 1" = 200'
SITE CHARACTERISTICS

Topography - Hillside to west makes this site narrow and possibly too small. Good water surface elevation difference.

Flow time from Big Sandy Reservoir to site at 1.5'/sec = 4.1 hrs.

Reduction of flow time for average use - 7.0 hrs.

RESERVOIR STORAGE COMPUTATION

Total acreage on Westside Lateral - 3394.7 acres
Total acreage above this site - 378.9 acres
Total acreage below this site - 3015.6 acres

Potential Surge Capture: 3394.7/3/70 = 16.2 CFS at 7.0 hrs - 408.240 cu. ft.
Potential Unanticipated Peak Demand: 3015.8/3/70 = 14.4 CFS at 7.0 hrs - 362.880 cu. ft.

Emergency Reserve Storage: 3015.8/70 = 43.1 CFS for 12 hrs - 1.861.179 cu. ft.

NOTE: This site limits and required storage not attainable.

RESERVOIR DESIGN CONSIDERATIONS

Max water surface - 82.7 ft
Min water surface - 73.7 ft

Volume Computation:
Bottom area = 100x200+175x700 = 602,500 sq. ft.
Top area = 172x286+247x738 = 320,884 sq. ft.

Area at 9' depth = 282,092 sq. ft.

Average at midpoint of reservoir volume = 60.4/9 = 6.7 acres average

Required acreage at surface for 9' depth: 6.7 acres average = 540'x540' or 150'x2000'

NOTE: This is less than the total desirable storage but may be acceptable

INLET DESIGN

Canal Design Capacity = 110 CFS
Inlet Design Capacity = 110 CFS

Rectangular Inclined Drop Capacity = 110 CFS

OUTLET DESIGN

Downstream Demand = 103 CFS
Outlet Operating Design = 103 CFS

Outlet pipe section

EVAPORATIVE LOSS

R A T E  O F  E V A P O R A T I O N  =  1.05 FT/AC

AVERAGE SURFACE AREA = 264.06 AC

EVAPORATIVE LOSS = 264.06 x 1.05 = 278.63 FT

STORAGE CAPACITY = 528,084 cu. ft = 54.6 acre feet
SITE CHARACTERISTICS

Topography:
- Generally flat with a gentle slope which can be utilized to reduce excavation.

Reservoir Surface Area:
- Evaporation rate surface area difference.
- Potential storage capacity.
- Real storage capacity.
- Storage capacity change.
- Average surface area at site.
- Average surface area.
- Storage capacity.
- Total storage capacity.
- Total storage capacity change.
- Potential storage capacity.
- Real storage capacity.
- Storage capacity change.

Reservoir Storage Computation

- Total storage on westside Canal = 43.0 AC ft
- Average storage at site = 43.0 AC ft
- Real storage capacity = 43.0 AC ft
- Potential storage capacity = 15.0 AC ft
- Real storage capacity change = 43.0 AC ft
- Average surface area at site = 5,600 SF
- Total storage = 43.0 AC ft
- Storage capacity change = 43.0 AC ft
- Average surface area at mid reservoir = 7,800 SF
- Total storage = 43.0 AC ft
- Storage capacity change = 43.0 AC ft

Reservoir Design Considerations

- Wet basis water surface elevation = 53.0
- Total storage on westside Canal = 9.8 AC ft
- Average surface area at site = 15,000 SF
- Average surface area = 15,000 SF
- Real storage capacity = 44.8 AC ft
- Potential storage capacity = 244.048 AC ft
- Real storage capacity change = 44.8 AC ft
- Average surface area = 244.048 AC ft
- Total storage = 44.8 AC ft
- Storage capacity change = 44.8 AC ft

Evaporative Loss

- Rate of evaporation = 5 AC ft/
- Storage capacity = 44.8 AC ft
- Storage capacity change = 44.8 AC ft
- Storage capacity = 44.8 AC ft
- Storage capacity change = 44.8 AC ft

Inlet

- Design flow capacity = 5 AC ft
- Storage capacity = 44.8 AC ft
- Storage capacity change = 44.8 AC ft

Outlet

- Design flow discharge = 3 AC ft
- Storage capacity = 44.8 AC ft
- Storage capacity change = 44.8 AC ft

FIGURE 22

CANAL RESERVOIR DIVERSION

OUTLET PIPE CROSS-SECTION

SCALE 1" = 200'
SECTION VI

6. COST ESTIMATES AND ECONOMIC ANALYSIS

6.1 Construction Costs

Unit prices and material quantities are used to determine an opinion of probable construction cost. Therefore, the accuracy of the opinion is based both on the preliminary design/quantity estimates and the assumed price of materials/construction effort expended. Unit prices used in the estimates are based upon recent Nelson Engineering experience with similar projects. The unit prices upon which the estimates are based were:

1. Mobilization - 10% of all other construction, rounded to nearest $100

2. Site Preparation - $150 per acre (clearing and grubbing)

3. Excavation-Reservoir - $1.25 per cubic yard
   -Stockpile - $1.50 per cubic yard (double move)

4. Canal Excavation - $2.00 per cubic yard
   - $3.00 per cubic yard (silt trap)

5. Clay-Liner - $5.00 per cubic yard
   *Haul - $0.20 per cubic yard per mile

6. Riprap - $60 per cubic yard

7. Concrete Work - $500 per cubic yard (includes rebar and excavation)

*dependent on the proximity of borrow pit and reservoir
8. Gates-Up to 3' - $4,000 in place
   -Up to 5' - $5,500 in place

9. Reinforced Concrete
   Pipe-Up to 30" - $35 per linear foot
   -36" to 42" - $50 per linear foot
   -48" to 56" - $65 per linear foot
   -60" - $85 per linear foot

10. Sluice Gate Valves
    -24" - $3,500 tall frame
     -36" - $4,500
     -48" - $5,500
     -60" - $6,500

11. Trash Racks - $30 per square foot

12. Misc. Metal - $750 per structure
    -Timber - $150 per 1000 board feet

13. Fine Grading and Seeding - $50 per acre

The mapping used during the Phase I designs were generated by the Bureau of Reclamation in the 1950's. All the site maps were given field review, were field-tied to existing canal datum and are considered adequate for preliminary design purposes. Material quantities were calculated from the preliminary plans developed in Section V. The designs, material quantities and resulting estimates are adequate to produce "order-of-magnitude" cost estimates. "Order-of-magnitude" cost estimating means that the estimator has produced the best opinion of probable cost that can be generated based upon the information available. More
detailed mapping, better geotechnical data and more complete conceptual designs may need to be developed at a later date. However, for the purpose of evaluating numerous alternatives, each against the others, the level of estimating accuracy described above is adequate and consistent across the various sites.

The construction cost of the reservoirs is presented in Table VI.1.
<table>
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<tr>
<th>ITEM</th>
<th>SITE #1 Farson Lateral</th>
<th>SITE #4 Eden Canal</th>
<th>SITE #5 Eden Canal</th>
<th>SITE #7 Westside Lateral</th>
<th>SITE #9 Farson Lateral</th>
<th>SITE #10 Westside Lateral</th>
<th>SITE #11 Westside Lateral</th>
<th>SILT TRAP STA 650 + 00 Eden Canal</th>
<th>SILT TRAP STA 750 + 00 Eden Canal</th>
<th>SILT TRAP STA 1020 + 00 Eden Canal</th>
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<td>N/A</td>
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<td>B. Construction Costs</td>
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<td>1. Mobilization</td>
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<td>311,250.00</td>
<td>298,125.00</td>
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<td>$14,887.00</td>
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6.2 Total Costs

The purpose of Phase 1 is to present the sites for evaluation. One (or more) site(s) may ultimately be selected but, at this stage, they must be considered individually. Therefore, the following summation presents total costs for the development of each site. However, if several were lumped together, some economies could be realized.

Site 1

<table>
<thead>
<tr>
<th>Description</th>
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<tr>
<td>Legal Fees</td>
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<tr>
<td>Acquisition of Access and Rights-of-Way</td>
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<td>Cost of Project Components (See Table VI.1)</td>
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<tr>
<td>Construction Cost Subtotal 1</td>
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Site 4

Preparation of Final Designs and Specifications $53,950.00
Permitting and Mitigation 2,500.00
Legal Fees 500.00
Acquisition of Access and Rights-of-Way 0.00

Cost of Project Components (See Table VI.1)
Construction Cost Subtotal 1 $605,580.00
Engineering Costs = CCS#1x10% 60,560.00
Subtotal 2 $666,140.00
Contingency = Subtotal 2x15% 99,920.00
Construction Cost Total $766,060.00
Project Cost Total $823,010.00

Site 5

Preparation of Final Designs and Specifications $64,830.00
Permitting and Mitigation 2,500.00
Legal Fees 500.00
Acquisition of Access and Rights-of-Way 0.00

Cost of Project Components (See Table VI.1)
Construction Cost Subtotal 1 $747,840.00
Engineering Costs = CCS#1x10% 74,780.00
Subtotal 2 $822,620.00
Contingency = Subtotal 2x15% 123,390.00
Construction Cost Total $946,010.00
Project Cost Total $1,013,840.00

SECTION VI-5
Site 7

Preparation of Final Designs and Specifications $37,460.00
Permitting and Mitigation 2,500.00
Legal Fees 1,500.00
Acquisition of Access and Rights-of-Way 6,000.00

Cost of Project Components (See Table VI.1)

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Project Cost Total $560,720.00

Site 9

Preparation of Final Designs and Specifications $29,760.00
Permitting and Mitigation 2,500.00
Legal Fees 1,500.00
Acquisition of Access and Rights-of-Way 8,000.00

Cost of Project Components (See Table VI.1)

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Project Cost Total $355,020.00

SECTION VI-6
Site 10

Preparation of Final Designs and Specifications $ 36,020.00
Permitting and Mitigation 2,500.00
Legal Fees 1,500.00
Acquisition of Access and Rights-of-Way 3,150.00
Cost of Project Components (See Table VI.1)
Construction Cost Subtotal 1 $310,200.00
Engineering Costs = CCS#1x10% 31,020.00
Subtotal 2 $341,220.00
Contingency = Subtotal 2x15% 51,180.00
Construction Cost Total $ 392,400.00
Project Cost Total $ 435,570.00

Site 11

Preparation of Final Designs and Specifications $ 22,300.00
Permitting and Mitigation 2,500.00
Legal Fees 1,500.00
Acquisition of Access and Rights-of-Way 5,000.00
Cost of Project Components (See Table VI.1)
Construction Cost Subtotal 1 $168,040.00
Engineering Costs = CCS#1x10% 16,800.00
Subtotal 2 $184,840.00
Contingency = Subtotal 2x15% 27,730.00
Construction Cost Total $ 212,570.00
Project Cost Total $ 243,870.00

SECTION VI-7
Silt Traps at E-7 and E-19

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Cost of Project Components  $14,890.00

\[ \text{Construction Cost Subtotal 1} = \text{Cost of Project Components} + \text{Engineering Costs} \]

\[ \text{Engineering Costs} = \text{CCS} \times 10\% = 2,920.00 \]

\[ \text{Subtotal 2} = \text{Construction Cost Subtotal 1} + \text{Contingency} \]

\[ \text{Contingency} = \text{Subtotal 2} \times 15\% = 4,810.00 \]

\[ \text{Construction Cost Total} = \text{Subtotal 2} + \text{Contingency} \]

\[ \text{Project Cost Total} = \text{Construction Cost Total} \]

\[ \text{Project Cost Total} = $36,890.00 + $4,810.00 = $43,260.00 \]

6.3 Economic Analysis

In order to quickly analyze how a reservoir or combination of reservoirs would effect the economics of Eden Valley Irrigation and Drainage District, three scenarios are presented:

1. Silt traps only, prior to E-7 lateral and below E-19.
2. A reservoir at Site 4 plus the two silt traps listed above.
3. A reservoir at Sites 1, 4 and 11. (The least expensive sites on each major lateral) plus the two silt traps listed above.
It is assumed that Federal (SCS) financing will provide seventy percent (70%) of all project costs and State (WWDC) funding will provide the balance on the basis of half grant and half loan. The loan is amortized over 30 years at 4% interest. The scenarios are as follow:

1. Cost $ 43,260.00
   Federal (SCS-grant) 30,282.00
   State Grant 6,489.00
   State Loan 6,489.00

   Loan at 30 years @4%
   Annual Payments 375.25
   Annual Cost Per Acre 0.04
   (Based on Eden Canal Acreage Only)

2. Cost $ 886,270.00
   Federal (SCS-grant) 606,390.00
   State Grant 129,940.00
   State Loan 129,940.00

   Loan at 30 years @4%
   Annual Payments 7,514.00
   Annual Cost Per Acre 0.82
   (Based on Eden Canal Acreage Only)

3. Cost $1,387,510.00
   Federal (SCS-grant) 971,258.00
   State Grant 208,126.00
   State Loan 208,126.00

   Loan at 30 years @4%
   Annual Payments 12,036.00
   Annual Cost Per Acre 0.71
   (Based on Total District Acreage)

A survey questionnaire was circulated to members of the District which contained questions whose answers were helpful in completing an economic analysis of the project.
Returns from the survey questionnaire were used by the Irrigation District Board and Wyoming Water Development Commission in evaluating options and selecting the extent of the project to carry forward.
SECTION VII

7. EVALUATION OF ALTERNATIVES

7.1 General
Silt was not found to be a serious problem on the Westside Lateral and was only of minor consequence on the Farson Lateral. Two silt traps have been proposed on the Eden Lateral at locations found to have serious silt problems. The cost of silt trap construction is small compared to that of reservoirs and the District may prefer to evaluate them separately from the reservoirs. Sediment traps should be included in the first phase of an Eden Canal improvement plan. Limiting the tributary inflow of sediment and water into the delivery system is especially important between Highway 28 Bridge and the siphon on the Eden Canal.

All of the proposed reservoirs would benefit the entire system by providing more efficient water management. Less wasting, overland flow and less leaching of salts into Big Sandy Creek would also result. The reservoirs will have some benefits to wildlife even though it is anticipated that only one (Site 7) would contain water on a year-round basis. The reservoirs were ranked on the basis of surface area. Reservoirs with greater surface area would have a greater benefit to wildlife. The reservoirs would benefit the whole District by providing an increment of additional storage which could be added to that contained in the Big Sandy Reservoir in years when the reservoir would spill. The sites are ranked only on the basis of that added storage.
There are many variables to be considered in evaluating the reservoir sites. They are not equal in the benefits they provide, their cultural or environmental impacts, their ability to economically store water or their estimated construction costs. A matrix is presented to allow a logical basis to compare the characteristics of the reservoirs. However, minor differences, such as relative loss to evaporation, transpiration and seepage, or such as relative benefits to wildlife are beyond the requirements of this effort. If the project is to be reconsidered or carried forward at a future time, the Eden Valley Irrigation and Drainage District, along with the Wyoming Water Development Commission, will need to develop additional methods of comparison between reservoir sites. The district, WWDC and agencies will find it necessary to weigh our comparisons differently and consider their own methods in order to fully equate the reservoirs and determine the best candidates for additional study.

7.2 Evaluation

Site 1 - The reservoir benefits the entire District by providing 39.0 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 211,200 sq.ft. The average reduction of water delivery time is 11.3 hours which benefits irrigators on 1079.2 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction.
No threatened or endangered species were found. No wetland indicators were found. The recommended reservoir costs $277,370 or $7,112.00 per acre-foot of water storage provided. It is easily accessed by county road and a short distance of travel on canal bank. The site provides opportunity for a much larger reservoir if design criteria were changed and more storage desired.

**Site 4** - The reservoir benefits the entire District by providing 186.1 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 886,171 sq.ft. The average reduction of water delivery time is 13.4 hours which benefits irrigators on 7209.8 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. No wetland indicators were found. The recommended reservoir costs $823,010 or $4,422.00 per acre-foot of water storage provided. It is easily accessed by county road and a short distance of travel on canal bank. The site provides opportunity for a much larger reservoir should design criteria be changed to require more storage.

**Site 5** - This reservoir benefits the entire District by providing 192.7 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 1,270,016 sq.ft. The average reduction of water delivery time is 14.8 hours which benefits irrigators on 7209.8 acres. There were
no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. Some wetland indicators were found and may require mitigation. The recommended reservoir costs $1,013,840 or $5,261.00 per acre-foot of water storage provided. It is easily accessed by county road and a short distance of travel on canal bank. The site provides opportunity for a much larger reservoir should design criteria be changed to require more storage.

**Site 7** - This site benefits the entire District by providing 64.0 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 1,088,000 sq.ft. In addition, it has unusable storage which would remain year-round. The average reduction of water delivery time is 10.6 hours which benefits irrigators on 1591.7 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. No wetland indicators were found. The recommended reservoir costs $560,720 or $8,761.00 per acre-foot of water storage provided. It is easily accessed by U.S. Highway 191 and a short distance of travel on canal bank. The site provides opportunity for a much larger reservoir should design criteria be changed to require more storage.
Site 9 - This site benefits the entire District by providing 49.2 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 457,600 sq.ft. The average reduction of water delivery time is 9.2 hours which benefits irrigators on 2299.8 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. Some wetland indicators were found. The recommended reservoir costs $355,020 or $7,216.00 per acre-foot of water storage provided. It is easily accessed by county road and a short distance of travel on canal bank. The site provides opportunity for a slightly larger reservoir should design criteria be changed to require more storage.

Site 10 - This site benefits the entire District by providing 54.6 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 325,584 sq.ft. The average reduction of water delivery time is 7.0 hours which benefits irrigators on 3015.8 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. No wetland indicators were found. The recommended reservoir costs $435,570 or $7,977.00 per acre-foot of water storage provided. It is easily accessed by county road and a short distance of travel on canal bank. The site does not provide opportunity for a larger reservoir.
Site 11 - This site benefits the entire District by providing 44.8 acre-feet of storage. It provides wildlife benefits in proportion to its surface area of 278,096 sq.ft. The average reduction of water delivery time is 9.2 hours which benefits irrigators of 1815.1 acres. There were no direct cultural resource impacts found, and indirect impacts would probably be minor. A Class III Cultural Resource Inventory would be recommended prior to construction. No threatened or endangered species were found. No wetland indicators were found. The recommended reservoir costs $243,870 or $5,444.00 per acre-foot of water storage provided. It is easily accessed by U.S. Highway 191 and a short distance of travel on canal bank. The site provides opportunity for a slightly larger reservoir should changing needs require more storage in the future.

7.3 Matrix Comparison
The matrix which follows is generated using the above information. The reservoir sites are compared to each other for each of the previously discussed variables and ranked from best to worst. For each variable, seven points are assigned to the best, down to 1 point to the worst. Wetland areas indicating or requiring mitigation and confined, storage limited sites, were given negative 3 points.
The above analysis indicates Site 4 as most beneficial overall. Assuming Site 4 were selected, the next most desirable on a different lateral would be Site 9 on Farson Lateral. Assuming Site 4 and 9 were selected, the next most desirable on a different lateral would be Site 7 or 11 on Westside Lateral.
8. **CONCLUSIONS AND RECOMMENDATIONS**

In an attempt to gain public input on this project, the WWDC and Eden Valley Irrigation & Drainage District mailed a survey questionnaire to the irrigators in the project's service area. The individual replies were collected and the results tabulated by Nelson Engineering, WWDC and the District. Nelson Engineering sent a result of tabulation of the Eden Valley I&D Questionnaire to the District and the WWDC on January 12, 1993 (Appendix D). Some additional questionnaires were received since the post date of correspondence, however, they do not significantly change the nature of the results.

The public input on the feasibility of constructing re-regulating reservoirs and sediment traps was overwhelmingly against any such project.

The irrigators that responded to the questionnaire, generally, did not feel the salinity nor the sedimentation problems that have been identified are a significant burden on the existing water delivery system. Many respondents had learned to accommodate for delayed delivery times through planning, and few of the respondents directly experienced a significant siltation/sedimentation problem.

Additionally, very few respondents supported any increases in per acre assessments to fund the construction of the recommended improvements.

Due to the overwhelming lack of public support, it has been decided by the District and WWDC to terminate any further development of the Level II, Big Sandy Water Supply Project.
SECTION IX

9. REFERENCES

1. USDA Selected Plan - The Big Sandy River Unit, 1988, Soil Conservation Service

2. Final Project Report, 1953, Bureau of Reclamation
APPENDIX A

MEETING MINUTES
BIG SANDY WATER SUPPLY PROJECT - LEVEL II

SCOPING MEETING
June 17, 1992 - 1:30 PM
Farson, WY

ATTENDANCE:

<table>
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<tr>
<td>Patrick Erger</td>
<td>WWDC</td>
</tr>
<tr>
<td>Boots Nelson</td>
<td>WWDC</td>
</tr>
<tr>
<td>Brad Anderson</td>
<td>WWDC</td>
</tr>
<tr>
<td>Jon Howell</td>
<td>WWDC</td>
</tr>
<tr>
<td>Lynn Cornia</td>
<td>WWDC</td>
</tr>
<tr>
<td>John Jackson</td>
<td>WWDC</td>
</tr>
<tr>
<td>George Zebre</td>
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<tr>
<td>Dale Gaubert</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>James Eaton</td>
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<td>Lee Harns</td>
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<td>John Batson</td>
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<tr>
<td>Michael Minear</td>
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</tr>
<tr>
<td>Tom Taliaferro</td>
<td>Eden Valley Irrigation Dist.</td>
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Pat Erger called the meeting to order; brief self-introduction all around; then Pat explained WWDC objectives and processes. He explained WWDC involvement; Eden Valley Irrigation District came to WWDC meeting in October in Casper to request a study of reregulating reservoirs. At first, only one reservoir was contemplated, but WWDC decided the system warranted more extensive study and possibly find other needs. Study will look at eight reservoir sites on all three laterals; will look for need for wasteways; will look at silt and sedimentation problems. By end of Phase I of Level II, all sites and other recommended facilities will be evaluated by District and WWDC to select most needed and cost-effective. In Phase II of Level II, those selected facilities are completed through conceptual design stage and estimated. Estimate is accurate and suitable to go to Legislature for Construction (Level III) funding.
Pat then turned meeting over to Boots Nelson for discussion of Nelson Engineering study methods and schedules. Boots first asked Tom Taliaferro to discuss District goals and desires.

Tom Taliaferro from the District point of view:

Most interested in reservoir on Eden Canal; mostly to speed up delivery on lower Eden. Not interested in one on Carlson Draw and would not want to participate in cost; cannot utilize water.

Advantage - reservoirs can supply same day delivery of water. Now takes two days.

Boots then asked for Soil Conservation Service comments:

Lynn Cornia - Possibility of 70% cost share, but must show wildlife mitigation. Reservoirs can be built to satisfy district, but will have secondary benefits to wildlife. All sites proposed are on BuRec land and District has approached BuRec for longterm leases so land cost is low. May be sites as good or better on private land, but were not proposed due to thoughts about land cost. Will have to show benefits to get cost share. One site doesn't help District and SCS agency would not have pushed that.

Other District Board Members were asked to comment:

Lee Harms - Favorable to one site, but questions District cost share on all others. Will be interested in study results.

James Eaton - Looking at several things that relative to wildlife situation make costs go up, generally opposed. Does District maintain water for these or are they seasonal. Generally favor only the one on Eden at E-7.

Boots described Nelson Engineering's procedure:

Prior to Scoping Meeting - On this system, we researched BuRec files. Found 165 documents. Five reports all relative to Eden Project. Documents will be useful to define canal system operation under original intent and how to change to meet new irrigation methods. Nelson Engineering objective will be to obtain answer for numerous questions about the District so we can design improvements. Questions such as:
• How often and extensive are power failures and how long do they last, on average?
• Where are silt loadings highest? From storm or erosion?

With answers to these and numerous other questions, we will then design solutions to delivery system problems. Phase I will take this summer; Phase II completed next October.

Brad talked about sediment - previously supplied info and directive need LA to find most economical alternative for silt/sand control. Reservoirs may not function well as sediment trap. Suggest enlarged canal section as better method of sediment removal. Need to find out where the most troublesome sediment problems are. Will be taking samples and collecting data, then with data, estimate what can be removed and what maintenance schedule is satisfactory.

Jon talked about objective of geotechnical - will review literature from BuRec and determine what feasibility of each site is from subsoil and geological point of view. Canals have been lined to prevent seepage loss, therefore reservoirs will need to be lined also. Where to find the material and how much needed and how much cost. Where to borrow for embankment and where to find riprap. After review of literature and mapping, we will do fieldwork necessary to determine materials for construction.

Dale Gaubert - Question: Will regulation reservoir have large structure with regulating gates?

Answer: Depends on topography. Where possible and we have drop into the canal, we can go "offline" then we would have gate and regulation structure at reservoir back to canal. Where we don't have fall, the reservoir will be "online", then it would only have gate (check) type structure at its outlet back to canal. "Online" would be dangerous in silty areas because it would silt up; hard to clean; may or may not have radial gates on either type reservoir.

Boots presented mapping to show where preliminary sites are located. Lynn indicated preliminary sites are selected on basis of land ownership. May also get cost share by salt load reduction.
Mike Minear indicated that canals are quite flat and on some preliminary reservoir sites, we may get water out of canal into reservoir, but no way to get it back into canal other than the "online" reservoir. Had some general discussion of sites relative to upstream and downstream water surface elevations.

Discussion about individual on-farm sprinkler system design. All but one system to date have been designed such that water is delivered onto the farm. If power is lost, farmer is responsible to either store or waste the water.

Advantages: District doesn't have to deal with fluctuation of flow due to power loss. District not responsible for waste or overflow water.

Disadvantages: Don't save or manage surplus water available during outage. Wastewater usually goes to drains and back to Sandy. Drains maintenance may be aggravated. Salt reductions may not be as good. Efficiency of system not as high. Eden area not drained very well and problems will be between farmers there.

No specific Board policy on how sprinkler systems diversion designed.

Lynn C. added - SCS original proposal included wasting into draws where water could be stored then picked up and reentered into the system.

Discussion on where silt loads are highest: Eden Canal at E-7 on down to E-25 and E-27; have silt trap at Hay lateral; some on Farson lateral.

Discussion on silt control and maintenance methods: Traps vs. reservoirs contingent on equipment available; track excavator vs. front-end loaders, etc.

Discussion of power outages: How serious, how often and how long do they last. Concensus was that outages were not real serious but rather an inconvenience. Have had quite a few (about 20) lately. Usually at night. They probably don't last long. District has some questions about Bridger Valley ability to serve the entire area at buildout. The system not designed to handle and maybe Bridger Valley won't want to expand and upgrade. Quite
a few operate on diesel now and at buildout will probably be a lot higher percentage. Therefore, power outage will be less detrimental. This will reduce water loss, reduce problems relative to power outage. Bridger Valley has no longrange plan to upgrade, but Bridger Valley engineers don't foresee a problem.

Balance of afternoon used in visit to preliminary reservoir sites and discussions relative to each site.
EDEN VALLEY IRRIGATION AND DRAINAGE DISTRICT

MEETING
August 24, 1992 - 8:00 PM
Farson, WY

ATTENDEES:

<table>
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<tbody>
<tr>
<td>Albert L. Nelson</td>
<td>Nelson Engineering</td>
</tr>
<tr>
<td>Jon Howell</td>
<td>Inberg-Miller Engineers</td>
</tr>
<tr>
<td>Dale Daubert</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>Patrick Erger</td>
<td>WWDC</td>
</tr>
<tr>
<td>Mike Carnavale</td>
<td>WWDC</td>
</tr>
<tr>
<td>Michael Minear</td>
<td>Nelson Engineering</td>
</tr>
<tr>
<td>Brad Anderson</td>
<td>Lidstone &amp; Anderson, Inc.</td>
</tr>
<tr>
<td>Tom Taliaferro</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>Ralph DeLambert</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>Gary Zakotnik</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>Lee Harns</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>James Eaton</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
<tr>
<td>Lynn Cornia</td>
<td>SCS</td>
</tr>
<tr>
<td>Jan Mines</td>
<td>Eden Valley Irrigation Dist.</td>
</tr>
</tbody>
</table>

Pat Erger opened the meeting and informed everyone he is leaving WWDC for a job with the Bureau of Reclamation in Montana. He thanked everyone for the cooperation they have extended him and expressed how much he has enjoyed working with each and everyone. He introduced Mike Carnevale as his replacement as WWDC project officer.

Had self-introductions all around and Boots Nelson gave the purpose of this coordinating meeting:

- To present findings to date.
- Gain concensus on "Considerations in reservoir site selection, size and type.
- Ask for board and agency input per directions the study should be taking.
Boots introduced Jon Howell who described the basic findings relative to geotechnical issues. Boots introduced Brad Anderson who discussed findings to date relative to sedimentation and silt loadings. Brad described the monitoring program and how sampling is done. Nearly all of the sand/silt load is in Eden Lateral below E-7 and at E-19 to E-25.

Boots described what had been submitted in the Threatened Endangered report by Bob Dorn. He then talked about Wetland issues and cultural resources work in progress.

Mr. Nelson then opened a discussion about land prices. Tentative agreement was that land would be about as follows:

- $500-$up per acre Cultivated land
- $200-$350 per acre Uncultivated sub-irrigated
- $150-$250 per acre Uncultivated brush pasture

Discussed that land cost, as discussed above, would add to reservoir costs. Board is interested in seeing all potential good reservoir sites even if they are on private land. Board members generally agree that reservoirs should be drainable and maintainable. Should provide for minimum of 1 cfs per 35 acres demand in lower Eden area. The Board agreed that one day of delivery need should be emergency reserve storage criteria.

Tom Taliaferro asked what sites Nelson Engineering feels are not viable at this time. Boots replied that 2, 3 and 8 were probably not practical because low water level differential across the sites made storage too large in acreage and shallow in depth. Site 6 dropped because it didn't provide any direct benefit to irrigators. Site 1 not best site on Farson lateral but will be studied. Site 7 not best on Westside but will be included in the study.

Mr. Nelson then discussed interview with Bridger Valley Power Manager, Mr. Brower. Discussion of power outages -- not many, according to Brower. Board members said fluctuation is problem. Several members and Tom has been off couple times. All agreed it is much better than used to be. Their biggest complaint is surges; spikes not real bad on sprinkler system.

Tom Taliaferro said outages for Bridger Valley better than Utah Power & Light in Salt Lake City.
Several issues of Board policy were discussed as follows:

Farm is delivered the water and must be used or wasted or stored on farm.

Boots asked if they wanted to re-examine that policy.

Board concurrence not to alter policy. Is really not a policy but will be continued. Sprinkler sets would not require the District to adjust gates because pump pond head would designed to just match canal when pumps are off. This would require different metering and chargeout for water. Didn't want Farmer Control of water delivery.

Mr. Nelson then talked about Criteria for Reservoir Locations:

- Geotech as set forth will require clay liners.
- Ownership - look at private land sites.
- Topography - need head loss across site; not interested in minimum pool type.
- Must benefit canal.
- Cultural and environmental permits.
- Accessibility - management and maintenance.
- High sediment areas - dictate need:
  Silt traps "on line"
  Should be protection for reservoir
- Extent of wasting - sprinkler system density over given area. Wasting also predicated by heavy rain resulting in decreased demand.
- Recovery reservoirs - end of field consensus; not favorable because of state policy about "on farm".
- Numerous small reservoirs on farm; same problem as above.
- Water rights question also a problem; water already delivered to farm.
Middle one-third of service area. Lands above contribute unused or non-demand water. Lands below site represent potential use for the water. Stored water close to points of non-use or potential use. Board in substantial concurrence. Also SCS.

Criteria for Capacity:

Topo - head difference and physical size.

Surplus water during reduced need - 1/2 day of upstream non-need; Excess demand during increasing demand periods; records can show past practice.

Rationing - (Jim Eaton) is really a cutback from peak demand because of canal capacity.

Have to order before 1:00 PM on previous day in order to get water into end of Eden service area by late the next day (24-48 hrs.).

Three classifications of water stored:

1. Emergency Reserve
2. Operating Storage
3. Surge Storage

Components for silt storage; separate silt management from storage.

Evaporative loss and other losses.

Other advice or input--

Pat Erger about ability to pay questionnaires.

SCS will want to look at and have input into designs to help the wildlife habitat issues.

SCS needs to keep EPA off their backs.

Probable funding -- SCS - 70%
    State - 15%
    District - 15%

Questionnaire needs to be based on three levels of cost per farmer for the facilities considered.
BIG SANDY PROJECT MEETING
MINUTES
SCS OFFICE, FARSON, WY
JANUARY 25, 1993

ATTENDANCE:

<table>
<thead>
<tr>
<th>NAME</th>
<th>REPRESENTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Jackson</td>
<td>WWDC</td>
</tr>
<tr>
<td>Mike Carnevale</td>
<td>WWDC</td>
</tr>
<tr>
<td>Dick Rintamaki</td>
<td>SCS - Casper</td>
</tr>
<tr>
<td>James Eaton</td>
<td>Eden Valley Irrigation District</td>
</tr>
<tr>
<td>Ralph Delambert</td>
<td></td>
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<tr>
<td>Gary Zakotnik</td>
<td></td>
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<tr>
<td>Neale Jones</td>
<td></td>
</tr>
<tr>
<td>Duane D. Klamm</td>
<td>SCS - Casper</td>
</tr>
<tr>
<td>Dale Daubert</td>
<td>SVI</td>
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<td>Lynn Cornia</td>
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<td>Michael Minear</td>
<td>Nelson Engineering</td>
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<td>Tom Taliaferro</td>
<td>Eden Valley Irrigation District</td>
</tr>
<tr>
<td>Boots Nelson</td>
<td>Nelson Engineering</td>
</tr>
</tbody>
</table>

Mike C. Funds and grants available now, but may not be in the future.

Duane K. Talked about regulating reservoir intent to maintain canal flows, but SCS would also take credit for any wetland mitigation it can.

Gary Z. System has to waste water at end to work.

Boots N. Water is saved up at front end, not on waste at end.

Gary Z. How does reservoir control salinity?

Duane K. Keep from wasting in fields which percolate deep picking up salinity.

Boots N. and Duane K. Salinity discussion.

Duane K. Efficiency will help salinity and water conservation.

EVID people financially cannot afford it.

Mike C. Would EVID go for 70% Fed and 30% State funding?

EVID people don't want duck ponds.
Mike C. Talked about response from irrigators being negatives. Asked Boots to go over report.

Boots Explained evaluation process, sizing criteria location, explained weighing matrix, talked about questionnaire, asked if anyone had questions.

Mike C. Explained that it’s up to District as to where we proceed from here.

Tom T. No irrigators interested in Wetland Mitigation.

James E. Not interested in next phase.

Boots Talked about not getting into prior agreements with BuRec; States, etc.

Mike C. Wetlands very important issue.

Neal Wetlands be damned.

Dick R. Talked about State program, said project has not really caused wetland problems; drought more of cause.

Duane K. Explained SCS plan for regulating reservoir; thought would help salinity and wetland mitigation with cost to landowner would be minimal.

Mike C. To EVID, decide at annual meeting. Write letter to State with what they want; thinks State will probably put project and funds on hold.
APPENDIX B

SALINITY PLAN SUMMARY
SUMMARY

The Selected Plan proposes the installation of the following structures on 15,700 acres of irrigated land in the Big Sandy River Unit to reduce salinity in the Colorado River Basin. (See Figure S-1, Location Map.)

- Distribution Pipeline and Risers
- Motor, Pumps, and Valves
- Low Pressure Sprinkler Irrigation Systems
- Semi-Automated and Automated Border Irrigation Systems
- Irrigation-Regulating Reservoirs and Wasteway System
- Voluntary Replacement of Fish and Wildlife Habitat Values

Economic and environmental analyses are based on the estimated 15,700 acres of participation. Actual acreage will vary depending on individual participation in the program. Participation will be voluntary and implemented through long-term contracts administered by the ASCS. Technical assistance for salinity control and conservation planning, implementation of planned practices, assistance to realize irrigation water management objectives, and installation of fish and wildlife practices will be provided by the SCS. An SCS project team will consist of soil conservationists, an irrigation water management specialist, engineers, a biologist, civil engineering technicians, and soil conservation technicians. Additional technical assistance will be provided by the CES.

Implementation of the Selected Plan will result in a reduction of an estimated 52,900 tons of salt annually entering the Big Sandy River. This will decrease salinity concentration in the Green River at the town of Green River, Wyoming, by 27 milligrams per liter and decrease salinity concentration by 5 milligrams per liter at Imperial Dam on the lower Colorado River.

The Selected Plan will also increase hay production by an average yield of more than 2 tons annually. Present average yields of hay vary from 1.6 tons/acre to more than 4 tons/acre. In addition to the increased yields, irrigators will be able to maintain pure stands of alfalfa or higher-value crops. These benefits will include: stands maturing earlier, remaining productive longer, and may produce an additional cutting yearly.

If 15,700 acres were converted to sprinkler and other improved irrigation systems, about 3,775 acres of irrigation water induced and supplemented wetlands (USFWS Circ. 39, Types 1, 2, 3, 4, 9, and 10) will be affected. See Glossary for definition of wetland types. Typical wetlands in the project area are shown in Figures 2-5 and 2-6 in Chapter 2. Reduced water supply will occur on about 1,010 acres of wetlands, and 2,765 acres of wetlands will be eliminated. The majority of the 3,775 acres of wetlands are Types 1, 2, and 9. To replace wildlife habitat values foregone, the habitat quality of about 860 acres of Types 3, 4, and 10 wetlands will be voluntarily preserved and enhanced by pond lining, livestock exclusion, seeding, and installation of nesting islands. Landowners, the Irrigation and Drainage District,
units of government, and private organizations will also install various conservation practices to create and enhance wildlife habitat (vegetation) around ponds, regulating reservoirs, wasteways, ditches, field edges, and odd areas. All wildlife habitat (wetland and vegetation) will be inventoried in the before and after individual salinity reduction plan condition in order to determine wildlife values needed to replace values foregone. The Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service (USFWS) will be used by the SCS salinity team biologist and other HEP certified SCS team members for these inventories. Interagency biologists will participate in the inventories as time and resources permit.

Water remaining in the reservoir or as a result of improved efficiencies could be released on a schedule that will replace and enhance fish habitat and reduce downstream flood damages. Potential release schedules have been developed by SCS with assistance from the WGFD. An annual release schedule will require concurrence from the Wyoming State Engineer and the Eden Valley Irrigation and Drainage District. Reduced annual reservoir drawdowns will improve fish habitat and related recreational activities.

Installation of the Selected Plan is not expected to have any adverse effects on endangered species that may occur in the project area. A Section 7 "no jeopardy opinion" was issued by the USFWS for this project on January 23, 1987.

If the entire project were placed under low-pressure sprinklers, it is estimated that the annual electricity requirements for low-pressure sprinkler irrigation pumping will be about 3.2 million kilowatt hours. Summary Table S-1 shows the costs, benefits, and impacts of the Selected Plan implementation.

The following is an economic display that further breaks down the annual benefits and costs for the Selected Plan implementation.
TABLE S-1  SUMMARY OF SELECTED PLAN FOR 15,700 ACRES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>SELECTED PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Costs</td>
<td>$18,403,000</td>
</tr>
<tr>
<td>Annual Installation Cost</td>
<td>1,494,700</td>
</tr>
<tr>
<td>Annual OM&amp;R Cost</td>
<td>675,900</td>
</tr>
<tr>
<td>Total Annual Cost</td>
<td>$2,170,600</td>
</tr>
<tr>
<td>Annual Salinity Reduction Benefits</td>
<td>3,323,100</td>
</tr>
<tr>
<td>Increased Agricultural Benefits</td>
<td>1,318,800</td>
</tr>
<tr>
<td>Total Annual Benefits</td>
<td>$4,641,900</td>
</tr>
<tr>
<td>Net Benefits</td>
<td>$2,471,300</td>
</tr>
<tr>
<td>Salt Load Reduction</td>
<td>52,900 tons/yr</td>
</tr>
<tr>
<td>Salinity Reduction at Imperial Dam</td>
<td>5.00 Mg/L</td>
</tr>
<tr>
<td>Salinity Reduction at Green River, Wyoming</td>
<td>26.67 Mg/L</td>
</tr>
<tr>
<td>Annual Cost per ton of Salt Reduction</td>
<td></td>
</tr>
<tr>
<td>-- Project</td>
<td>$41.86</td>
</tr>
<tr>
<td>-- Federal</td>
<td>$19.09</td>
</tr>
<tr>
<td>Streamflow Increase from Big Sandy Reservoir to Confluence of Big Sandy River and Little Sandy River</td>
<td>+20,470 ac ft</td>
</tr>
</tbody>
</table>

Price Index: 1986
APPENDIX C
INTERVIEWS
MEMO

I (Name) Boots

Talked With Frank Brower - Bridger Valley Power.

I Called Party Called

Time 4:30 p.m. Date 8/17/92

Job# 92-075-1

A- Asked Frank about particulars of feed to Fasson area:

A. Substation is at Fasson. Fasson area is 40 mi away. 
   42 has 3 levels of voltage protection - regulation -
   3-phase, not looped - is on end of a 
   radial feed. They lose a pole once in a while and have quite a few raptor 
   electrocutions but most outages are lightning.
   They have worked at these problems so now most of line is arrestor protected and has raptor protection.

Q How often and how long are outages
   A. Fasson is 100 mi from Ft. Bridges and so 
   response time has to be considered. Would say minimum outage in 24 hours.
   They try hard and usually get it back on pretty quick after arriving and finding cause. Real problem is difficulty of 
   trying to finance upgrades. Need a substation in Fasson area but it would 
   cost 1-2 million. Farmers and govt won't
Help Bridge Valley with a cost like that. Bridge Valley has 4,000 customers. Don't have financial base for major costly expansion. The system has very good record (2.2 to 2.5 customer outage hours per year). National specs say 3 is allowable. Customer Outage = No. of customers x hours out. Bridge Valley average is 2.2 to 2.5.

Q: If they have 30+ limits now and build out is 100+, can B.V. serve that many?
A: Probably not. Actually B.V. hasn't reached winter peak yet but also have to watch power factor and other variables. But, probably cannot serve full build out.

Q: Would build out increase demand justify capital outlay for upgrade.
A: It would help but real problem is need for a new substation in Glen Fason area that will cost $1-$2 million so where can we get that kind of capital.
I (Name) BUDTS
Talked With GENE SMITH 273-5746
____ I Called ___ Party Called X MEETING
Time 7:00AM Date JUNE 19, 1992
Job# 92-075-1

Asked Gene about power outages -
A - They have had 18 outages in last 2 months - Mostly at night.
Asked how much power costs are
A - 41/2 cent per KWH. Most operators figure operation of average sprinker
set @ $1.15 to $1.50 per hr.

Gene is prior manager of Eden Valley Irrigation Dist so asked him general
questions about Dist mgmt.
A - Eden canal gets some sand/silt from
rain, quite a bit from wind blown
drifting sand and quite a bit from
stock breaking down banks. Mostly
below E-7 and down by E-19 to E-25
• Bridge Valley power not too concerned
about bringing in more fuel. *(more power)
• Gene suggested two areas for good clay
  • By the airstrip.
  • By the rifle range.
APPENDIX D

SURVEY QUESTIONNAIRE
BIG SANDY WATER SUPPLY PROJECT

Background Information

The Wyoming Water Development Commission, in cooperation with your District, Eden Valley Irrigation and Drainage, is studying methods of improving water delivery to your farm. The first major improvement would be a reduction of delivery time --- (the time between when you request water and when water can arrive at your diversion to be delivered). The second major improvement would be reduction of sand and silt carried in the canals. A minor benefit every irrigator in the District will receive will be a small increase in the amount of stored water which can be set aside in the regulating reservoirs rather than spilled from the Big Sandy Reservoir. Contemplated structures that will result in the two improvements would be regulating reservoirs along the canals, that would make a volume of water more readily available to lower canal users, and sand/silt traps. The sand/silt traps would be either in conjunction with or independent from the reservoirs. The study is being funded by Wyoming Water Development Commission.

A majority, but probably not all, of the construction funding is anticipated to come from the Federal government through their Big Sandy Salinity Reduction Program. Some funding, again not all, of construction costs is anticipated to be available from Wyoming Water Development Commission. It is anticipated that a minor share of the construction cost will be paid by the Eden Valley Irrigation and Drainage District through a longterm, low interest rate loan from one or the other (federal or state) agencies involved. The loan would be paid through a slight increase of your annual water cost.

The following questions are asked to establish the degree of need for the improvements, and the extent of benefit the improvements may provide. Your individual reply to the questions will be greatly appreciated, and your reply will be held strictly confidential.
**QUESTIONNAIRE**

**Part I**

1. How many acres of land do you irrigate in a typical year? ______________ acres.

2. Are part of your acres sprinkler irrigated? ___ Yes ___ No.

   If Yes, how many acres are under sprinkler irrigation? ______________ acres.

3. Please describe your non-sprinkler irrigated acreages and yields in a typical year. **Non-sprinkler only:**

<table>
<thead>
<tr>
<th>Irrigated Crop</th>
<th>No. of Acres</th>
<th>Avg. Yield per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigated Pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oat Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Grain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (list)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


4. Please describe your sprinkler irrigated acreages and average yield for a typical year. **Sprinkler only:**

<table>
<thead>
<tr>
<th>Irrigated Crop</th>
<th>Sprinkler Acreage</th>
<th>Avg. Yield per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved Hay</td>
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<td></td>
</tr>
<tr>
<td>Alfalfa Hay</td>
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<tr>
<td>Irrigated Pasture</td>
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<tr>
<td>Oat Hay</td>
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<tr>
<td>Light Grain</td>
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<tr>
<td>Other (list)</td>
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</tr>
</tbody>
</table>

5. Do you intend to convert any of your non-sprinkler irrigated acreage to sprinkler irrigated acreage in the near future?  ____ Yes  ____ No

6. If yes, please indicate approximate year and acreage of conversion to sprinkler:

<table>
<thead>
<tr>
<th>Probable Year</th>
<th>Probable No. of Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>Acres</td>
</tr>
<tr>
<td>On or by 1995</td>
<td>Acres</td>
</tr>
<tr>
<td>On or by 1997</td>
<td>Acres</td>
</tr>
</tbody>
</table>
Part II

7. What is the average delay time between when your call for water and when water can be delivered to you? __________ hours.

8. What is your estimated yield reduction due to delay of water delivery?

<table>
<thead>
<tr>
<th>Irrigated Crop</th>
<th>No. of Acres</th>
<th>Est. Yield Reduction/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Hay</td>
<td>___________</td>
<td>_________________________</td>
</tr>
<tr>
<td>Improved Hay</td>
<td>___________</td>
<td>_________________________</td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td>___________</td>
<td>_________________________</td>
</tr>
<tr>
<td>Irrigated Pasture</td>
<td>___________</td>
<td>_________________________</td>
</tr>
<tr>
<td>Oat Hay</td>
<td>___________</td>
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<tr>
<td>Light Grain</td>
<td>___________</td>
<td>_________________________</td>
</tr>
<tr>
<td>Other (list)</td>
<td>___________</td>
<td>_________________________</td>
</tr>
</tbody>
</table>

9. Do you have sand/silt problems with the water delivered to you? ___ Yes ___ No

10. What is your estimated maintenance cost due to sand/silt problems? $_______________

11. Assume that the delay time you experience could be reduced to less than half, and you would receive the benefit of a slight increase in stored water available, would you accept an increase in your water charge of $0.50 per acre? ___ Yes ___ No
12. What if the price were $1.00 per acre?  
   __ Yes __ No

13. What if the price were $1.50 per acre?  
   __ Yes __ No

14. Assume that the sand/silt load you experience could be substantially eliminated. Would you accept an increase in your water charge of $0.50 per acre?  
   __ Yes __ No

15. What if the price were $1.00 per acre?  
   __ Yes __ No

16. What if the price were $1.50 per acre?  
   __ Yes __ No
Part III

Please use the space below for any comments you have on this survey. (You may attach extra sheets if you need more space).
APPENDIX E

SEDIMENTATION INVESTIGATION
LIDSTONE & ANDERSON, INC.
SEDIMENTATION INVESTIGATION
BIG SANDY WATER SUPPLY PROJECT
FARSON, WYOMING

SUBMITTED TO:
NELSON ENGINEERING
P.O. BOX 1599
JACKSON, WY 83001

SUBMITTED BY:
LIDSTONE & ANDERSON, INC.
736 WHALERS WAY, F-200
FORT COLLINS, CO 80525

September 24, 1992
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APPENDIX

Appendix A: Laboratory Analysis Results
I. INTRODUCTION

Return flows from the Eden Valley Irrigation District have been identified as a contributor to the salinity problem within the Colorado River. In an effort to reduce this problem, The SCS devised a plan of voluntary installation of modernized low-head sprinkler irrigation systems to replace the existing flood irrigation practices. To date, over 30 farms have been converted to low head sprinkler irrigation systems with several additional farms earmarked for future conversion. With the improvements to the on-farm irrigation practices, the main delivery system of the Eden Valley Irrigation District must also be improved to support these changes.

Consistent with the conversion of on-farm irrigation practices to low-head sprinkler systems, the major objective of the Big Sandy Water Supply Project is: (a) to investigate the regulatory features of the canals and laterals, and (b) identify improvements to the conveyance system to facilitate the delivery of water in a manner consistent with the needs of modern irrigation methods. Critical components of the sprinkler systems include pumps, pipes and sprinkler nozzles; consequently, the removal of silt and sand particles from the irrigation water becomes increasingly important. This material tends to increase the operation and maintenance costs of the low-head sprinkler systems by excessive abrasion to the pumps and clogging of the sprinkler nozzles.

In support of the primary objective for this project, Lidstone & Anderson, Inc. (LA) investigated alternatives to reduce the silt and sand particles transported to the low-head sprinkler systems. This investigation specifically included: (a) identification of the potential sediment sources, (b) determination of the composition of the transported sediment, and (c) evaluation of the mode of sediment transport. The approach to our work consisted of a field reconnaissance and data collection program, identification and evaluation of alternatives, and recommendations to remove or reduce the sediment transported to the sprinkler systems.
II. FIELD RECONNAISSANCE AND DATA COLLECTION PROGRAM

The field reconnaissance and data collection program was completed during three field trips to the Eden Valley Irrigation District. The first trip coincided with the Project Scoping Meeting on June 17, 1992. Two additional field trips were conducted during the months of July and August. The observations and data collected during these field trips provided insight into the location of the existing sedimentation problems, potential sources of the sediment within the canal, and mechanisms associated with sediment transport and deposition.

Location of Sediment Problems

During the field reconnaissance, sediment deposition problems were specifically identified along the Eden Canal and to a lesser extent along the Farson Lateral. Discussions with representatives of the Irrigation District indicated the West Side Lateral has historically experienced minimal deposition. Within the Eden Canal, the deposition problems are particularly severe in the vicinity of the E-7 Lateral, the Hay Lateral and between the E-19 and E-25 Laterals. For the Farson Lateral, sediment deposition has been identified along the canal reach between the F-2 and F-5 Laterals. Based on this information, the sediment sampling program was initiated within the Eden Canal near Station 681+70 (Site 1 - upstream of the E-7 Lateral), Station 857+60 (Site 2 - upstream of the Hay Lateral), Station 965+00 (Site 3 - upstream of the E-19 Lateral) and within the Farson Lateral at Station 89+00 (Site 4 - between the F-2 and F-5 Laterals).

Potential Sediment Sources

Within the main delivery system of the Irrigation District, the two factors that control the sediment deposition are: (a) the source and supply rate of sediment to the canal, and (b) the capacity of the water within the canal to transport the sediment load. Several potential sources of sediment have been identified and include the following:

1. material within the canal bed and banks,

2. wind blown deposits, and
3. tributary inflow.

Following a review of the soils and geology of the area, it is evident that portions of the canal have been constructed in materials largely composed of sands and gravels. This observation was specifically noted for several reaches within the Eden Canal. Although the canal is lined, contribution of sediment from the canal banks was specifically noted in the vicinity of the E-7 Lateral where livestock have encroached onto the canal banks and effectively "pushed" the sediment into the canal. With respect to the canal bed, the field reconnaissance noted that sand dunes are evident in many reaches of the main delivery system. The dunes are often in excess of 6-inches in height with several locations within the Eden Canal experiencing sediment deposition in excess of one foot; hence, the canal bed offers a significant source of sands/silts available for transport within the canal.

Although not specifically observed during the field reconnaissance, it is also likely that sand/silt material is transported into the canal system by wind. During the non-irrigation season, the canal offers a primary location for deposition of wind-blown deposits.

Along the Eden Canal, two locations were identified where tributary inflow of stormwater is occurring. These two locations were specifically noted between the Highway 28 bridge (Station 508+02) and the siphon (Station 626+63). Stormwater is likely to contain a high concentration of suspended sediments which will directly contribute to the deposition and transport of sand/silt material within the canal.

An additional source of sediment into the canal system is often provided at the headgate from the river. In this case, the water supplied to the main delivery system is controlled by upstream reservoirs (Big Sandy Reservoir and Eden Reservoir). These reservoirs serve to trap the sediment diverted from the river and release relatively sediment-free water to the downstream canals and laterals. Consequently, no additional sediment is likely to be supplied from this potential source.

Data Collection Program

At each of the four sampling sites previously discussed, canal discharge measurements were obtained and sediment samples collected. This data was collected during the months of June, July and August to obtain a representative sample of the transport conditions during the irrigation season. The data collection program consisted of the following items.

1. Survey data of the canal section was obtained to define the channel geometry.
2. Stream gaging measurements were obtained to estimate the discharge within the canal at each location. This was accomplished with a Pygmy Meter and a top-setting wading rod.

3. Bed samples were obtained to determine the nature and composition of the material in the canal.

4. Suspended sediment samples were collected with a DH-48 sampling device in accordance with the procedures in "Field Methods for Measurement of Fluvial Sediment" (USGS, 1970).

5. Bedload samples were collected with a Helley-Smith bedload sampler in accordance with the procedures in USGS Professional Paper 1139 (1980).

Following each data collection effort, the sediment samples were delivered to a laboratory for analysis. Copies of the results of the laboratory analysis are provided in Appendix A.

The results of the data collection efforts are summarized in Table 1. The following observation are provided based on these results along with the information in Appendix A.

- Suspended sediment concentrations are very small; bedload transport contributes the majority of the sediment moved within the canal.

- Sediment is transported in much greater quantities within the Eden Canal as compared to the Farson Lateral; no measurable quantities of bedload were collected on the Farson Lateral.

- The bedload transport within the Eden Canal appears to be greater in the vicinity of the Hay Lateral.

- Within the Eden Canal, the canal bed is largely composed of a mixture of medium to coarse sands. Material within the canal bed in the Farson Lateral predominantly consists of very fine sand to coarse silt.
Table 1. Results of Field Data Collection and Sampling

<table>
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<tr>
<th>Data</th>
<th>Location</th>
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<th>Site #2</th>
<th>Site #3</th>
<th>Site #4</th>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
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<td></td>
<td>92</td>
<td>73</td>
<td>49</td>
<td>13</td>
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<td>125 (*)</td>
<td>91</td>
<td>57</td>
<td>24</td>
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<tr>
<td>Suspended Sediment (mg/l)</td>
<td></td>
<td>534</td>
<td>425</td>
<td>539</td>
<td>392</td>
</tr>
<tr>
<td>July 21, 1992</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedload (lbs/day)</td>
<td></td>
<td>610</td>
<td>5505</td>
<td>400</td>
<td>**</td>
</tr>
<tr>
<td>July 21, 1992</td>
<td></td>
<td>1990</td>
<td>2530</td>
<td>1940</td>
<td>**</td>
</tr>
<tr>
<td>August 25, 1992</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

* measured at check-drop structure downstream of Site #1.
** no measurable sediment collected.
The material transported as bedload can be classified as a medium to coarse sand with particle sizes ranging from a very coarse gravel to a medium silt.

**Sediment Transport Mechanism**

The sediment within the canals and laterals is transported as either suspended load or bedload. The results of the initial sampling indicated that minimal sediment is transported as suspended load. This is reasonable since the velocity of the water within the canal is very low which will severely limit its capacity to transport suspended sediment. The majority of sediment within the canal is transported as bedload with the amount largely dependent on the canal slope and flow depth. Consequently, the locations where the slope and flow depth are the greatest usually coincide with an increase in sediment transport. Where check-drop structures are located, the backwater that is created tends to limit the sediment transport and promote sediment deposition.

An incipient motion analysis was also conducted as part of this investigation. The results of the analysis confirmed that the Eden Canal is able to transport the majority of the sand and silt particles found in the canal bed; an inspection of the representative sediment size distributions found on Figures 1 and 2 also support this observation. The analysis also confirmed that minimal bedload transport will occur within the Farson Lateral.

A review of the sediment movement through the canal system indicates that deposition is significant upstream of the check-drop structures. This is particularly evident along the Eden Canal. The check-drop structures create an environment of upstream deposition, prevent the downstream movement of sediment and essentially provide a source of sediment once the check-drop structures are lowered. As the check-drop structures are lowered, the sediment is transported downstream from reach to reach.
FIGURE 1. SIZE DISTRIBUTION OF BED MATERIAL SAMPLES
FIGURE 2. SIZE DISTRIBUTION OF BEDLOAD SAMPLES.
III. IDENTIFICATION AND EVALUATION OF ALTERNATIVES

Concurrent with improving the regulatory features of the canal system, this investigation specifically identified alternatives for reducing the sedimentation problems within the canals and laterals. Finding a solution to these problems not only improves the conveyance capacity of the existing canal; it also reduces the operation and maintenance costs associated with the low-head sprinkler systems. The alternatives identified during the course of this investigation included: (a) utilization of the proposed regulating reservoirs to trap the sediment, and (b) installation of sediment traps within the main delivery canals and laterals. Each alternative was evaluated with respect to the following criteria:

- feasibility of the alternative to provide a long-term solution to the sedimentation problem;
- trapping efficiency of the alternative (capability to remove sediment from the system); and
- relative operation and maintenance costs associated with removal of the sediment.

Feasibility to Provide a Long-Term Solution

The regulating reservoirs are intended to divert and store water on a temporary basis to control surges and prevent unnecessary wasting of irrigation water. To be effective in the removal of sediment, "on-line" regulating reservoirs are necessary. Reservoirs located "off-line" or adjacent to the main delivery canals or laterals will not receive the water on a continual basis; consequently, much of the sediment transported within the canals and laterals will not be trapped within the reservoir.

Sediment traps located within the main delivery system will receive the sediment-laden water throughout the irrigation season. Properly designed and maintained, this type of sediment trap will remove the majority of the sediment presently transported within the canal system.

From a feasibility standpoint, in-line sediment traps provide a better alternative for the removal of sediment from the main delivery system.
Trapping Efficiency

A comparison of the trapping efficiency associated with both types of sediment traps was completed. The following equation (Borland, "Proceedings of the Third International Symposium on River Sedimentation", 1971) was utilized to estimate the fraction of sediment deposited in a reservoir:

\[ TE = 1 - \exp \left[ -1.055 \frac{Lw}{Vd} \right] \]

in which TE is the fraction of sediment deposited in the reservoir; L is the total length of the reservoir; \( w \) is the fall velocity of the sediment; \( V \) is the mean velocity of the flow in the reservoir; and \( d \) is the flow depth.

The efficiency of a sediment trap located within a regulating reservoir is presented in Table 2. Table 3 presents the efficiency of a sediment trap located within a main canal or lateral. As indicated, the trapping efficiency within the reservoir is much greater and removal of the sediment transported within the canal will be extremely effective. A cursory review of Figure 2 indicates, however, that approximately 90% of the sediment transported within the main canal is greater than 0.2 mm. Using the information in Table 3, this means that approximately 94% of the material greater than 0.2 mm will be deposited within a sediment trap located within the canal; therefore, one can assume that approximately 85% of all the material will be deposited within a sediment trap installed within the main delivery system.

Operation and Maintenance Costs

The operation and maintenance costs associated with a sediment trap are directly related to the removal of the sediment. Within the reservoir, the sediment will be deposited initially at the inlet with a delta formed that will extend to the reservoir embankment. While it is possible to excavate a sediment trap within the reservoir, one must consider that the reservoirs will be lined to prevent seepage; removal of the sediment requires careful attention to prevent damage to the liner material. In addition, special equipment, not presently available within the Irrigation District, may be necessary to remove the sediment.
Table 2. Reservoir Trap: Sediment Deposition (As a Percentage of Total Sediment Load).

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>Texture Class</th>
<th>Width = 1,500 ft Length = 2,900 ft Velocity = 0.1 fps</th>
<th>Width = 1,000 ft Length = 4,400 ft Velocity = 0.15 fps</th>
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<tr>
<td>0.5</td>
<td>Coarse Sand</td>
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<td>100</td>
</tr>
<tr>
<td>0.2</td>
<td>Medium Sand</td>
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<td>100</td>
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<tr>
<td>0.1</td>
<td>Fine Sand</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0.05</td>
<td>Coarse Silt</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0.02</td>
<td>Medium Silt</td>
<td>100</td>
<td>100</td>
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</table>

Assumptions:

- Discharge = 300 cfs
- Flow Depth = 5 ft
- Bottom Width = 20 ft
- Sideslope = 1:1
Table 3. Canal Trap: Sediment Deposition (as a Percentage of Total Sediment Load)

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Texture Class</th>
<th>Length of Trap (L)</th>
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<td>0.5</td>
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<td>Medium Sand</td>
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<td>0.1</td>
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<td>0.05</td>
<td>Coarse Silt</td>
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<tr>
<td>0.02</td>
<td>Medium Silt</td>
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</table>

Assumptions:

- Discharge = 300 cfs
- Flow Depth = 5 ft
- Bottom Width = 20 ft
- Sideslope = 1:1
The sediment deposition associated with a sediment trap in the canal will be confined to the geometry of the trap. Operation and maintenance costs will largely depend on the width of the trap. Assuming a reasonable width (approximately 20 feet), a backhoe or similar type of equipment may be utilized to remove the sediment. Although it is recognized that the canal sediment trap will also be lined, the potential damage to the trap will be localized.

Based on the foregoing discussion, it appears that a sediment trap located within the main delivery system will be the most beneficial and cost effective. Assuming an average maximum sediment delivery of approximately 5500 lbs/day (this corresponds to a discharge of approximately 100 cfs), the total sediment delivery at a given location becomes 5000 cubic feet during the course of a five-month irrigation season. If the sediment trap is 20 wide and 2 feet deep, the length of the trap becomes 125 feet. As stated previously, a trap length of 500 feet may be necessary to promote the effective removal of sediment within the canal. Consequently, under the assumptions stated above, a typical trap that is 500 feet in length should have the capacity to contain sediment for four years of operation.
IV. CONCLUSIONS AND RECOMMENDATIONS

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

1. To limit the sediment within the canal, maintenance activities should be undertaken to prevent tributary inflow of sediment and water into the main delivery system. This is especially important between Highway 28 Bridge and the siphon on the Eden Canal.

2. Maintenance activities that will remove sediment from the canal bed will minimize a source of sediment that is presently contributing to the problems within the canal.

3. Sediment traps that are located within the main delivery system are recommended as opposed to traps located within the regulating reservoir. Where a regulating reservoir is proposed, it may be cost effective to identify a sediment trap within the canal and upstream of the reservoir.

4. A sediment trap(s) should be located upstream of the E-7 Lateral and Hay Lateral and between the E-19 and E-25 Laterals.

5. The length of the trap should be approximately 500 feet to promote the deposition of the majority of the sediment transported within the canal. A trap width of 20 feet may promote a reduction in operation and maintenance costs if equipment is readily available to remove the sediment.

6. The location and impact of check-drop structures should be evaluated. Check-drop structures will tend to promote upstream sediment deposition.

7. The rate of sediment supplied to the main delivery system is not presently known. It is likely, however, that the sediment within the canal has accumulated over the course of several years. The installation of the sediment traps and annual maintenance will tend to deplete the system of the sediment within the canal bed. Consequently, the frequency and amount of sediment removed during the maintenance operations may decrease after several years of operation.
APPENDIX A

LABORATORY ANALYSIS RESULTS
<table>
<thead>
<tr>
<th>Composite Sample Sites and Number</th>
<th>Weight of Bottle +Sediment (gm)</th>
<th>Weight of Bottle +Water (gm)</th>
<th>Weight of Clean Bottle (gm)</th>
<th>Weight of Sediment (gm)</th>
<th>Concentration (mg/l)</th>
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<td>2770.6</td>
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<td>2114.9</td>
<td>1095.1</td>
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<td>0.4</td>
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ANALYSIS OF AGGREGATES REPORT

Job No. 12921056
Date June 1992

Architect or
Engineer Lidstone and Anderson, Inc. Contractor ____________________________

Project Big Sandy Project Source Farson Canal ____________________________

REPORT OF TESTS OF Washed Sieve Analysis

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<th>% Retained</th>
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<th>Specifications</th>
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Remarks: Material Sampled and Delivered by Lidstone and Anderson, Inc. Personnel

Received at Laboratory 6/23/92

Quantity Represented ____________________________

Submitted by Lidstone and Anderson, Inc.

Sampled from Site 4

Identification Bed 4

Date Sampled Delivered

Intended Use ____________________________

Remarks:

Organic matter, colorimetric
Coal & Lignite
Clay Lumps
Chert
Soft Particles
Percent Absorption
Specific Gravity
Dry Rodded Weight
Weight Before Washing 451.4 Gms.
Weight After Washing 288.8 Gms.
(36.0% -200 Wash)
ANALYSIS OF AGGREGATES REPORT

Job No. 12921056
Date. June 1992

Architect or Engineer  Lidstone and Anderson, Inc.  Contractor  

Project  Big Sandy Project  Source  Eden Canal

REPORT OF TESTS OF Washed Sieve Analysis

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Fineness Modulus

Remarks: Material Sampled and Delivered by

Lidstone and Anderson, Inc. Personnel

Received at Laboratory 6/23/92
Quantity Represented  
Submitted by Lidstone and Anderson, Inc.
Sampled from Site 3
Identification Bed 3
Date Sampled Delivered
Intended Use  
Remarks:
- Organic matter, colorimetric
- Coal & Lignite
- Clay Lumps
- Chert
- Soft Particles
- Percent Absorption
- Specific Gravity
- Dry Rodded Weight
Weight Before Washing 321.9 Gms.
Weight After Washing 316.5 Gms.
(1.7% -200 Wash)
**ANALYSIS OF AGGREGATES REPORT**

**Job No.** 12921056

**Date** June 1992

**Architect or Engineer** Lidstone and Anderson, Inc.

**Contractor**

**Project** Big Sandy Project

**Source** Eden Canal (Sta. 875+60)

**REPORT OF TESTS OF** Washed Sieve Analysis

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**Remarks:**

- Material Sampled and Delivered by Lidstone and Anderson, Inc. Personnel

**Received at Laboratory** 6/23/92

**Quantity Represented**

**Submitted by** Lidstone and Anderson, Inc.

**Sampled from** Site 2

**Identification** Bed 2

**Date Sampled** Delivered

**Intended Use**

**Remarks:**

- Organic matter, colorimetric
- Coal & Lignite
- Clay Lumps
- Chert
- Soft Particles
- Percent Absorption
- Specific Gravity
- Dry Rodded Weight

**Weight Before Washing** 2328.9 Gms.

**Weight After Washing** 2085.7 Gms.

(10.4% -200 Wash)
ANALYSIS OF AGGREGATES REPORT

Job No. 12921056
Date: June 1992

Architect or Engineer: Lidstone and Anderson, Inc. Contractor: 

Project: Big Sandy Project Source: Eden Canal (Sta. 681+70)

REPORT OF TESTS OF Washed Sieve Analysis

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Remarks: Material Sampled and Delivered by Lidstone and Anderson, Inc. Personnel

Received at Laboratory: 6/23/92

Quantity Represented: 

Submitted by Lidstone and Anderson, Inc.

Sampled from: Site 1

Identification: Bed 1

Date Sampled: Delivered: 

Intended Use: 

Remarks:
Organic matter, colorimetric
Coal & Lignite
Clay Lumps
Chert
Soft Particles
Percent Absorption
Specific Gravity
Dry Rodded Weight
Weight Before Washing: 384.9 Gms.
Weight After Washing: 370.9 (3.6% -200 Wash)
**Analysis of Aggregates Report**

**Field Trip 7/21/92**

Job No. 12921027  
Date July 1992

Architect or Engineer  
Lidstone & Anderson  
Contractor

Project Eden Canal  
Source

**Report of Tests of Wash Sieve Analysis**

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Fineness Modulus

Received at Laboratory 7/27/92

Quantity Represented

Submitted by Lidstone & Anderson

Sampled from Eden Canal - Site No. 3

Identification Bed Load Sample

Date Sampled

Intended Use

Remarks:

- Organic matter, colorimetric
- Coal & Lignite
- Clay Lumps
- Chert
- Soft Particles
- Percent Absorption
- Specific Gravity
- Dry Rodded Weight
- Weight Before Washing 50.1 Grams
- Weight After Washing 49.4 Grams

Remarks:
ANALYSIS OF AGGREGATES REPORT

Job No. 12921027
Date July 1992

Architect or Engineer Lidstone & Anderson Contractor

Project Eden Canal Source

REPORT OF TESTS OF Wash Sieve Analysis

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Remarks:
Organic matter, colorimetric
Coal & Lignite
Clay Lumps
Chert
Soft Particles
Percent Absorption
Specific Gravity
Dry Rodded Weight

Weight Before Washing 520.7 Grams
Weight After Washing 507.3 Grams

Received at Laboratory 7/27/92
Quantity Represented
Submitted by Lidstone & Anderson
Sampled from Eden Canal - Site No. 2
Identification Bed Load Sample
Date Sampled
Intended Use

Remarks:
### ANALYSIS OF AGGREGATES REPORT

**Job No.** 12921027  
**Date** July 1992

**Architect or Engineer** Lidstone & Anderson  
**Contractor**

**Project** Eden Canal  
**Source**

### REPORT OF TESTS OF Wash Sieve Analysis

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### Remarks:

Organic matter, colorimetric  
Coal & Lignite  
Clay Lumps  
Chert  
Soft Particles  
Percent Absorption  
Specific Gravity  
Dry Rodded Weight  
Weight Before Washing 56.7 Grams  
Weight After Washing 55.4 Grams

### Received at Laboratory

July 27, 1992

### Quantity Represented

Submitted by Lidstone & Anderson

Sampled from Eden Canal - Site No. 1

Identification Bed Load Sample

Date Sampled

Intended Use

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APPENDIX F

GEOTECHNICAL REPORT
INBERG-MILLER ENGINEERS
August 6, 1992

Nelson Engineering  
P.O. Box 1599  
Jackson, Wyoming 83001  

ATTENTION:  MR. ALBERT L. NELSON, P.E. & L.S.  

RE: PHASE I REPORT  
BIG SANDY WATER SUPPLY PROJECT  

Gentlemen:  

The following is a report of the geotechnical reconnaissance level work performed under Phase I Task 1 of the scope of services for the above-referenced project. This portion of the work was authorized and performed according to our June 9, 1992 agreement with Nelson Engineering.  

PROJECT INFORMATION  

We understand that the purpose of the Big Sandy Water Supply Project, Level II is to evaluate the possibility of installing regulating reservoirs on the West Side, Eden, and Farson Laterals of the Big Sandy Project. These reservoirs will provide operational improvements and sediment control to the canal systems. With the installation of modernized sprinkler irrigation systems with individual pumping, the desired operational improvements include providing regulating reservoirs and/or wasteways which can control canal flow surges caused by extensive area power outages. In addition, it is desired that these facilities will also provide sediment control as well.  

In order to accomplish our objective as geotechnical subconsultants for Phase I of this project, we have performed background research of the project area and have reviewed researched information pertaining to the eight (8) proposed wasteway/reservoir sites and eleven (11) potential borrow areas. In addition, we have also performed field reconnaissance at the above-mentioned sites. Our observations and findings are discussed in the following sections of this report.
PROPOSED RESERVOIR SITES

We observed each of the eight (8) proposed reservoir sites in order to obtain preliminary information with respect to general geologic conditions. Our conclusions are based on both our visual observations of the sites as well as the research information we obtained from the U.S. Bureau of Reclamation (U.S.B.R.).

Reservoir Site No. 1 (E\SWw and W\SE\ Section 14, T.25 N., R.106 W.)

Topographically, the site slopes gently to the southwest with a change in elevation of approximately 10 to 15 feet. The Farson Lateral runs along the eastern boundary and near the southern boundary of the site. Vegetation consisted primarily of sagebrush and prairie grass. Our research indicates that the closest U.S.B.R. power auger borings (AP-65, AP-66, AP-67) were performed along the Farson Lateral alignment just south of the southern boundary of the site. Based on observations of drain ditch cutbanks and U.S.B.R. logs of shallow power auger borings, it appears that overburden soils near this site consist primarily of either silty or poorly-graded sands. These soil types typically drain moderately to rapidly with a coefficient of permeability expected to range from approximately $1 \times 10^{-3}$ to $1 \times 10^{-5}$ centimeters per second. At the time of the U.S.B.R. exploration, groundwater was reportedly measured in the power auger holes at depths ranging from 2.5 to 4.0 feet below existing ground surface on August 10, 1955. Currently, a drain ditch (approximately 7 to 9 feet deep) exists along the southern boundary of the site and likely has a significant effect on the groundwater elevation at the site. Based on the information available to us at the time of this report, the actual depth to bedrock at this site is unknown.

Reservoir Site No. 2 (E\SE\, Section 32 T.26 N., R.105 W.)

This site is located between the drainage of the Little Sandy Creek and some small hills which lie east of the Eden Lateral. The Eden Lateral runs through the southwest corner of the site. Site surface topography is relatively irregular but generally slopes to the southwest. Some areas
PROPOSED RESERVOIR SITES, continued

Reservoir Site No. 2 (E\$SE\$ Section 32, T.26 N., R.105 W.), continued

appeared to be poorly drained. Some ponds were noted west of the canal
adjacent to the site. Vegetation consisted primarily of sagebrush and
prairie grass. Logs of exploration performed along the Eden Lateral
alignment by the U.S.B.R. in 1951 (E-24, E-25, E-26 and E-27) indicate that
overburden soils consisted of silty sand, well-graded sand and silty clay.
There was no indication on the logs as to whether groundwater was
encountered within exploration depths. With the exception of the silty
clay overburden, the surficial sand soils are expected to possess
permeability characteristics as described for Site No. 1. Where silty clay
is present, coefficients of permeability may be on the order of $1 \times 10^{-5}$ to
$1 \times 10^{-7}$ centimeters per second. Overburden thicknesses appeared to be
variable, ranging from zero to greater than eleven feet. As expected,
overburden thicknesses were found to be greater in drainages and
nonexistent in several hill (bedrock outcropping) areas. Bedrock was
visually classified as shale on the U.S.B.R. logs and appeared in outcrops
to be thinly bedded with sandstone in some areas. Upon review of the
Geologic Map of Wyoming prepared by J.D. Love and Ann Coe Christiansen,
1985, it is likely that the shale bedrock in the project area is part of
the Laney member of the Green River Formation.

Reservoir Site No. 3 (SW\$ Section 15, T.25 N., R.105 W.)
The Eden Lateral runs through this site, entering near the northwest corner
and exiting near the southeast corner of the site. The site surface
generally slopes in a southwesterly direction. Very little relief exists
in the portion of the site which is southwest of the canal. The area
northeast of the canal is at the base of the hilly area, consequently, the
site surface in this area is more irregular. Surface vegetation consists
of primarily prairie grass and sagebrush. U.S.B.R. logs of exploration
performed along the Eden Lateral alignment (E-42 through E-46) indicate
that overburden soils generally consist of silty and clayey sand.
PROPOSED RESERVOIR SITES, continued

Reservoir Site No. 3 (SW1, Section 15, T.25 N., R.105 W.), continued
Consequently, permeabilities in the overburden soils are expected to be similar to those discussed on Site No. 1. Shale bedrock was encountered near the ground surface in E-43 and near the bottom of E-45 (approximately 16 feet deep). An existing shale borrow area is located near the northwest corner of the site. No indication of groundwater was noted on the logs of exploration. As has been discussed previously, it is likely that the shale is part of the Laney member of the Green River Formation.

Reservoir Site No. 4 (E1NW1 and NE1 Section 28, T.25 N., R.105 W.)
The Eden Lateral also runs through this site, entering north central and exiting near the southwestern corner of the site. The site surface is relatively level but slopes gently to the west with approximately 10 feet or less of elevation change over the entire site area. Vegetation consists primarily of sagebrush and prairie grass. U.S.B.R. logs of exploration performed along the Eden Lateral alignment (E-59 through E-66) indicate that overburden soils consisted primarily of silty, clayey, poorly-graded and well-graded sands. A clay layer (approximately 8 to 9 feet deep) was encountered in Boring E-59. No bedrock was encountered within exploration depths (approximately 12 to 15 feet below ground surface). In addition, there was no indication of groundwater on the logs of exploration.

Reservoir Site No. 5 (S1NNE1 and SE1 Section 32, T.25 N., R.105 W.)
This site is located approximately one mile southwest of Site No. 4. The Eden Lateral enters the site near the southeast corner and exits near the west central portion of the site. In terms of topography, vegetation and subsurface conditions, this site is very similar to Site No. 4. The U.S.B.R. logs of exploration performed on this site along the Eden Lateral alignment were E-76 through E-84.
PROPOSED RESERVOIR SITES, continued

Reservoir Site No. 6 (NE\SW Section 18, T.24 N., R.106 W.)
This site is located in Carlson Draw approximately one mile northwest of Eden, Wyoming and approximately one-half mile north of Eden Lateral. The change in elevation across the draw is approximately 10 feet. The draw drains in a southwesterly direction through the central portion of the site. Upon review of the U.S.B.R. information, we could not find any logs of exploration within the site area. However, we found logs of exploratory borings which had been performed as part of a feasibility geology report, Big Sandy return flow dam and pumping plant sites which was performed in November, 1967. Geologic logs of drill holes DH-8 and DH-9 (closest drill holes, approximately 400 to 800 feet north of the site) indicates that overburden soils consisting of sand and clay are relatively shallow (2.5 to 3.5 feet). Bedrock consisted of siltstone overlying sandstone. Based on the drill hole locations indicated in the report, it appears that these holes were performed near the bottom of the draw near the northeast corner of the site. According to the information on the logs, depth to groundwater was unknown.

Reservoir Site No. 7 (NW\SW Section 16, T.25 N., R.106 W.)
This site is located approximately an eighth to a tenth of a mile west of the West Side Lateral. The site surface is relatively flat with primarily sagebrush and prairie grass vegetation. No U.S.B.R. logs of exploration could be found on the site, however, a borrow area had been explored on the east side of and adjacent to the lateral. Borings WB-35 through WB-40 (approximately one to four feet deep) indicate that overburden soils consist primarily of sand with some gravel. Shale bedrock was encountered in one, possibly two borings within exploration depths. There was no indication on the logs that any groundwater had been encountered within exploration depths.
PROPOSED RESERVOIR SITES, continued

Reservoir Site No. 8 (S\NW\ and NW\SW\ Section 23, T.26 N., R.106 W.)

The West Side Lateral runs through this site, entering near the northeast corner and exiting near the southwest corner of the site. The ground surface is somewhat irregular, particularly due to the surface topography and partially due to excavation from several shale borrow areas located within the site northwest of the canal. Vegetation is slight or nonexistent in disturbed areas and consists primarily of prairie grass and sagebrush in other areas. U.S.B.R. logs of exploration (AP-31 through AP-41) performed along the lateral alignment indicate that overburden soils in this area area relatively thin to nonexistent. Shale bedrock was encountered at or near the surface in the majority of borings performed. In many cases, borings were terminated at relatively shallow depths due to apparent hard drilling conditions. There was no indication on the logs that any groundwater had been encountered within exploration depths.

POTENTIAL BORROW SITES

We observed a total of eleven (11) potential borrow area sites. These sites were selected as potential sites based on the following:

1. U.S.B.R. records of explored borrow areas.
2. Interviews of past and present District employees.

The purpose of the observations was to gather preliminary (reconnaissance level) information which would be useful in evaluating the potential of the sites as sources of clay liner material and/or riprap. As is typical for reconnaissance level studies, our observations were limited to visual examination of the exposed soils and limited excavation with a hand shovel in the upper 6 to 8 inches.
POTENTIAL BORROW SITES, continued

The following is a summary of our observations of potential borrow areas:

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.B.R.</td>
<td>SW1 Section 27,</td>
<td>No</td>
<td>Approximately 4 feet of soil has been removed in an area of approximately 40,000 square feet west of and adjacent to the West Side Lateral. No evidence of clay or bedrock on any exposed soils.</td>
</tr>
<tr>
<td>Borrow</td>
<td>T.26 N., R.106 W.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit No. 7</td>
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</table>

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.B.R.</td>
<td>NW1 Section 26,</td>
<td>No</td>
<td>Approximately 3-4 feet of soil has been removed in a small, low-lying area west of West Side Lateral. Exposed soils do not appear to have good potential as either a clay and/or riprap source.</td>
</tr>
<tr>
<td>Borrow</td>
<td>T.26 N., R.106 W.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit No. 6</td>
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<table>
<thead>
<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small ridge</td>
<td>NW1 Section 26,</td>
<td>Yes</td>
<td>Shale exposed at surface of ridge. Appears to be similar to shale already being used as riprap on the project.</td>
</tr>
<tr>
<td>south of</td>
<td>T.26 N., R.106 W.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.B.R.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit No. 6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.B.R.</td>
<td>W1 Section 23,</td>
<td>No</td>
<td>Soil types exposed are variable, primarily consisting of shale, silty clay and clayey fine sand. It appears that the site has had some significant use based on the size of the excavation. Observations in bottoms of excavations indicate that site was probably used as a shale source. Fragments of 1/2-inch to 3/4-inch thick by one to six inches are common.</td>
</tr>
<tr>
<td>Borrow</td>
<td>T.26 N., R.106 W.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit No. 5</td>
<td></td>
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<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.B.R.</td>
<td>NE1 Section 23,</td>
<td>No</td>
<td>Approximately 3 feet of soil has been removed in an area of approximately 240,000 square feet. Shale exposed in bottom of excavation may have potential as shale source, but probably not clay.</td>
</tr>
<tr>
<td>Borrow</td>
<td>T.26 N., R.106 W.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pit No. 4</td>
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POTENTIAL BORROW SITES, continued

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<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.B.R. Borrow Pit No. 1</td>
<td>SE1/4, Section 13, T.26 N., R.106 W.</td>
<td>No</td>
<td>A significant portion of site surface had been disturbed. Exposed soils predominantly consist of clayey sand and well-graded fine to coarse sand. Some excavations down to groundwater (approximately 7 to 8 feet deep).</td>
</tr>
<tr>
<td>East of NE1/4 Section 24, Means Canal T.26 N., R.106 W. (on hill) Approximately Station 160+00</td>
<td>Yes</td>
<td>This area was currently being used for borrow. Exposed soils consisted of clayey sand and sandy clay. A relatively massive rock layer (visually looked like quartzitic sandstone) outcrops within the pit area. Boulder-sized fragments are common.</td>
<td></td>
</tr>
<tr>
<td>Rifle Range Pit</td>
<td>NW1/4 Section 26, T.25 N., R.106 W.</td>
<td>No</td>
<td>A significant portion of the site surface has been disturbed. Exposed soils appeared to be predominantly sand. Occasional intermittent layers and/or pockets of sandy clay were observed.</td>
</tr>
<tr>
<td>Airport Pit</td>
<td>SW1/4 Section 34, T.25 N., R.106 W. and N1/4 Section 5, T.24 N., R.106 W.</td>
<td>Yes</td>
<td>A significant portion of site surface had been excavated. Exposed soils, particularly in cutbank, appear to be predominantly low to moderate plasticity clays. A relatively thin topsoil layer is clayey sand. If soils consistent horizontally, site has good potential as clay source.</td>
</tr>
</tbody>
</table>
### POTENTIAL BORROW SITES, continued

<table>
<thead>
<tr>
<th>Area Name</th>
<th>Approx. Location</th>
<th>Further Exploration Warranted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Creek</td>
<td>NE1/4 Section 21, T.25 N., R.105 W.</td>
<td>Yes</td>
<td>Site is undisturbed, exposed soils on creek bank are moderately plastic clays. Exposed creek bank soils grade to sandy gravel/gravelly sand to the east. Clay may continue further to the north and west.</td>
</tr>
<tr>
<td>Approx. 0.75 miles west of siphon (Eden Lateral)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Shale Pit Eden Lateral</td>
<td>SW1/4 Section 15, T.25 N., R.105 W.</td>
<td>No</td>
<td>A significant portion of the site surface has been disturbed. Several mounds of excavated shale are scattered over the site surface. The majority of exposed shale appeared to be thinly bedded and typically had broken down into one to two inch fragments.</td>
</tr>
</tbody>
</table>

Based on our preliminary observations of the potential borrow areas, we recommend further exploration of four of the sites as indicated in the above summary during Phase II, Task 1a. of this project. The purpose of these explorations will be to more closely define the vertical and horizontal extent of potential riprap and/or clay deposits. Also, samples can be obtained so that laboratory tests can be performed to evaluate the quality of the materials explored.

### CONCLUSIONS AND RECOMMENDATIONS

Based on what we have learned from our background research, review of researched materials and field reconnaissance, it is our opinion that several geotechnical issues may affect the construction and/or cost of regulating reservoirs and canal regulating structures in the Big Sandy/Eden Valley irrigation area. They are the following:
CONCLUSIONS AND RECOMMENDATIONS, continued

1. As expected, existing background subsurface information available from U.S.B.R. records indicates that lining of the reservoirs will likely be required due to the typically relatively permeable characteristics of the overburden soils (predominantly sands) logged in the project area.

2. High quality sources for riprap do not appear to be readily available within a reasonable proximity to the project area. The material within the area which appear to have the best potential as a source of riprap is the underlying sandstone/shale bedrock which is encountered at various depths throughout the project area. This bedrock is thinly bedded, and visually, appears to possess low to moderate durability characteristics. Based on the limited subsurface information available to us at this time and our visual observations, it appears generally, that better and more accessible sources of the sandstone/shale bedrock are more plentiful within the northern portion of the project area.

3. The majority of the clay overburden soils observed and researched appear to be sandy with relatively low plasticity characteristics. Clay deposits of higher plasticity and lower sand content were observed occasionally in localized areas. In our opinion, these higher plasticity clays would serve as a better quality liner material. Generally, it appears that the higher quality clay sources may be more plentiful in the southern portion of the project area.

In our opinion, the above-listed geotechnical issues will have an impact on potential project construction costs. Thus far, our conclusions are based on preliminary information. Consequently, we recommend a more detailed exploration of selected regulating reservoir and canal regulating structure sites and borrow
CONCLUSIONS AND RECOMMENDATIONS, continued

areas in order to confirm our preliminary conclusions. This information will allow us to more specifically define those site conditions which could impact the project construction costs. The more detailed exploration will be performed under Phase II of this project and will consist of test borings and backhoe test pits. Field and laboratory tests will be performed on selected soils samples obtained from the exploration. This information will help us to develop specific recommendations for facility construction, estimate quantities of available borrow materials and evaluate impact to project costs resulting from anticipated haul distances.

CLOSURE

This Phase I report has been prepared for the exclusive use of our client, Nelson Engineering, for preliminary geotechnical evaluation of the project area and planning purposes of the described project. It may contain insufficient information for applications other than as herein described.

We appreciate the opportunity to participate thus far in the project. If there are any questions regarding the enclosed information, please contact us.

Sincerely,

INBERG-MILLER ENGINEERS

Jon C. Howell, P.E.
Geotechnical Engineer

Reviewed By:

Steven F. Moldt, P.E.
Vice President

Professional Engineer (Civil)
Jon C. Howell
4936
Date 8-20-92
Wyoming
4.5 Cultural Resources Constraints

The report of Frontier Archaeological follows in an abbreviated form. Photographs and maps included in the complete report are omitted from this text.
FRONTIER ARCHAEOLOGY
CLASS I CULTURAL RESOURCE INVENTORY OF
NELSON ENGINEERING
BIG SANDY WATER SUPPLY PROJECT,
SWEETWATER COUNTY, WYOMING

by
Anton L. Hoffman

Project #FA92-37

August 1992

James M. Welch
Principal Investigator

FRONTIER ARCHAEOLOGY
P.O. Box 1326
811 Big Horn Avenue
Worland, Wyoming 82401
(307) 347-8848
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<td>Appendix</td>
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<td>Appendix</td>
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<td>Appendix</td>
</tr>
<tr>
<td>Table 6</td>
<td>Identified but Not Recorded Sites Within the Big Sandy Water Supply Project Study Areas</td>
<td>Appendix</td>
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</tbody>
</table>
ABSTRACT: A Class I cultural resource inventory was conducted for Nelson Engineering Big Sandy Water Project. There are eight proposed project areas with associated study areas. These study areas lie in all or parts of 38 sections in Sweetwater County. Only five previous Class III cultural resource inventories have been performed, and only 14 sites recorded, in or near any of these study areas; therefore, the data base for this Class I inventory is too small to allow any valid inferences to be drawn from the data. Among the recorded sites ten are historic, one is a prehistoric and historic multicomponent site, and three are prehistoric lithic scatters. Of the ten historic sites, six are roads, two are bridges, one is a canal, and one is a trash dump. Four of the roads and the canal are considered eligible for nomination to the National Register of Historic Places (NRHP). Two of the roads are of unknown eligibility. Neither of the bridges is considered eligible, nor is the trash dump. Only one of the sites with a prehistoric component is considered to be NRHP eligible. Other roads and ditches are known from the GLO plats, and unrecorded historic and prehistoric sites were seen during a pedestrian reconnaissance conducted in conjunction with this project. Because of the dearth of knowledge about prehistoric and historic cultural resources in the eight proposed project areas, it is recommended that a Class III cultural resource inventory be conducted before any ground disturbing activities take place.

CLIENT: Nelson Engineering

PROJECT: Big Sandy Water Supply Project

LOCATION: Bureau of Reclamation, Upper Colorado Region.
Legal Location—See Table 1
USGS 7.5' Eden Reservoir East (Photoinspected 1977), Eden Reservoir West (Photorevised 1980), Farson (Photorevised 1980), Fifteenmile Spring (1968), Wyoming Quadrangles
Land Ownership Status—See Table 3
Mineral Ownership Status—See Table 3
Sweetwater County, Wyoming

PROJECT DESCRIPTION: Eight sites in the vicinity of Farson, Wyoming are currently under consideration by the Wyoming Water Development Commission for the construction of regulating reservoirs to provide operational improvements and sediment control as part of the effort to control salinity in the Colorado River System. This project's purpose is to evaluate the possibility of installing the proposed regulating reservoirs and associated wasteways. For the purposes of this report a distinction will be made between the terms "project area" and "study area". A project area (also referred to as a "parcel") is the specific legal location under consideration for ground disturbing activities resulting from the proposed Big Sandy Water Supply Project. The project areas are named "Reservoir 1", "Reservoir 2", etc. A study area consists of a project area plus the contiguous lands extending one-half mile in all directions from the quarter sections (i.e. 160 acre quarters of a section) in which a project area is located. The study area boundaries were designed so as to include all areas of direct and indirect impact to result from the proposed project and to provide an acceptable "buffer zone" around the proposed ground disturbing activities. These study areas occur in all or parts of 38 sections near Farson. Thus, this report has been prepared as an aid in avoiding potential conflicts with known significant cultural resources and the results of the research are intended to offer insight as to
the probability of as yet unknown/unreported sites in the region.

ENVIRONMENTAL SETTING: The region in which the Big Sandy Water Supply Project is to occur lies in the Green River Basin. The area is generally flat with little topographic relief; however, prominent features such as Haystack Butte, Round Top, Buffalo Hump, and Fourmile Knoll may be seen near the project area. Elevations range from approximately 6,600 feet to approximately 6,700 feet above mean sea level. Geologically the project area lies in the Laney Member of the Green River Formation. The sediments consist of oil shales and marlstones laid down during the Eocene Epoch (Love and Christiansen 1985). Most of the drainages in the area are ephemeral, but the Little Sandy Creek and the Big Sandy Creek are perennial. Generally the area is arid, averaging 7-9 inches of rainfall per year. Agriculture is made possible by a system of canals, laterals, and ditches that bring irrigation water to the fields.

The soils tend to be tan sandy loams that vary in their sand contents. Sedimentary and metamorphic pebbles and gravels of cherts, chalcedonies, limestone, conglomerates, mudstones, and shales can be seen in the surface soils. The vegetation is sparse to moderate and may be characterized as consisting of low sagebrush, bunch grasses, rabbitbrush, saltbush, greasewood, prickly pear cactus, and low forbs. Where relatively more water is available, tall sagebrush and a denser grass cover may be found. The faunae are typical of the Wyoming High Plains context.

As mentioned above, the construction of irrigation works has allowed the planting of cash crops in this area. Other impacts to the region are roads, housing, and fencelines. A gas pipeline is currently being considered for construction through one parcel, Reservoir 1 (Altamont 1992a).

CULTURAL RESOURCE REVIEW: The purpose of this Class I cultural resource inventory is to synthesize data into a usable format to assist in the development of the project design for the Big Sandy Water Supply Project. Collection of this data involved a review of files search information dated May 27, 1992 (#8155) and July 27, 1992 (#8678) requested from the State Historic Preservation Office (SHPO) Cultural Records Office by Anton L. Hoffman, and a pedestrian reconnaissance of the proposed project areas by Anton L. Hoffman and David Day performed on June 16-17, 1992. The appropriate GLO Survey Plats for the eight parcels being considered for ground disturbing activities were also consulted. There is a dearth of extant data on historic and cultural resources in the Farson area due to a paucity of projects and recorded sites. In order to gain a better picture of the prehistoric resources in the region, four sites that are in fact not within any of the eight study areas, but which are within one-half mile of a study area boundary, have been included. Within the discussion of recorded sites, they are grouped by theme: transportation and agriculture, multicomponent and prehistoric sites.

Previous Class III Cultural Resource Inventories: Only three projects seem to have been done in the study areas defined for this report. Western Wyoming College performed a Class III cultural resource inventory for a road in SW/SW/NW, Section 24, T25N, R106W for a citizen who wanted to upgrade a road that passed through Bureau of Reclamation (BuRec) land in 1987 (SHPO accession #870081); they also seem to have conducted a project, for which no information is available from SHPO (Meyer 1992), in SE, Section 13, T24N, R107W; and Frontier Archaeology is currently conducting a Class III cultural resource inventory for a proposed pipeline that traverses the Reservoir 1 study area (#FA91-1LT) (Altamont Gas Transmission Company [Altamont] 1992a).

Two other Class III inventories have also been conducted within one-half mile
of a study area: the Bureau of Reclamation (BuRec) conducted an inventory for a borrow pit in W/NE, Section 15, T26N, R106W (#831023), and the Office of the Wyoming State Archeologist conducted an inventory for a borrow pit in E/SE/NW and SW/NE, Section 12, T24N, R107W (#840979). All of these projects seem to have been carried out after 1980, the year in which new performance standards for conducting Class III inventories and evaluating sites went into effect (Hough-Stilphen and Welch 1987).

Cultural Resources in the Big Sandy Water Supply Project Study Areas:
Site 48SW3869 - See Table 5 for location - The Bryan to South Pass City Stage Road is not specifically identifiable from the GLO Survey Plats or any maps of the project areas, previous projects, or site forms for recorded sites in the study areas. It was originally recorded by the Wyoming Recreation Commission Historic Division, whose site records are not available from the Cultural Records Office (Meyer 1992). Where it has been recorded, it is considered to be eligible for nomination to the NRHP. The site has only been recorded outside of the various study areas for this project and is not well known in this vicinity. Its route, according to the files search, goes through the Reservoir 1 and 6 study areas.

The route ran from Bryan to South Pass City, a distance of 95 miles. Daily runs by the Sweetwater Stage Company, founded by Alex Benham in 1869, carried passengers, the mail, and Wells Fargo cargo. The trip cost $20.00 and lasted 15 hours in a Concord coach drawn by a four horse team. Between the Green River and Pacific Springs the route followed an earlier stage route.

The town of Bryan was only prosperous for a few years. It was laid out in 1868 by the Union Pacific Railroad Company, whose management was engaged in a dispute with the citizens of Green River City over property rights along the railroad's right-of-way. The citizens agreed to the Union Pacific's demands provided that Green River City would become the railroad's winter terminus. The company's response was to build the station town of Bryan. Even so, by 1872 Bryan went into decline because the Union Pacific moved its shops to Green River and Evanston, and Green River City became a more popular point of departure. In 1870, Benham expanded his operation east to Point of Rocks to challenge another stage line that had been running out of that location since 1869. Neither prospered, and in 1871, Benham sold his company to C. Huntley who moved the stage line operation to Green River City (Altamont 1992a; Larson 1978).

Site 48SW3864 - See Table 5 for location - The historic, Green River to South Pass City Stage Road is not specifically identifiable from the GLO Survey Plats or any maps of the project areas, previous projects, or site forms for recorded sites in the study areas. According to the files search its overall NRHP eligibility is unknown, but it appears to be coincident with the Bryan to South Pass City Stage Road (48SW3869). The site has been recorded outside of the various study areas for this project, but in conjunction with other roads/trails. It is not well known in this vicinity. Its route, according to the files search, traverses the Reservoir 1 and 6 study areas.

The town of Bryan went into decline because of the Union Pacific Railroad Company's decision to move its shops to Evanston and Green River City, which became a more popular point of departure. The route from Green River to South Pass City had one advantage over the Bryan to South Pass City route: there was no need to cross the Green River. The route out of Green River met up with the route from Bryan about 10 miles north-northeast of the Green River. In 1870, Alex Benham expanded his operation east to Point of Rocks to challenge another stage line that had been running out of that location since 1869. Neither prospered, and in 1871, Benham sold his company
to C. Huntley, who moved it to Green River City. Huntley expanded the route across the Owl Creek Mountains into the Big Horn Basin. This route was used for stage and freight traffic until 1911 (Altamont 1992a).

Site 48SW4148 - Section 7, T24N, R106W - The historic Bryan Trail is not specifically identifiable from the GLO Survey Plats consulted for this project, but a road segment does appear in the designated section on the plats. The site is not recorded, however, for the adjoining section that this road segment goes into. It was recorded by the Wyoming Recreation Commission Historic Division, but no site records or site maps are available from the SHPO Cultural Records Office (Meyer 1992). The site's NRHP eligibility is unknown. Little is on record about this historic cultural resource and its location, but according to the files search, it traverses the Reservoir 6 study area.

Site 48SW4163 - See Table 5 for location - An alternate route of the Rock Springs to Lander Stage Road passes through the Reservoir 4 and 5 study areas. The road was originally recorded by the Wyoming Recreation Commission Historic Division and is considered NRHP eligible. It is not specifically identifiable from the GLO Survey Plats consulted for this project. No original site forms are available (Meyer 1992), nor is a map of the entire stage route; however, a short history of the Rock Springs to Lander Stageline (Gardner 1982), not associated with a project report, is available from the SHPO Cultural Records Office. The maps contained in this report do not show the segments of the site that are located in or near the proposed project areas, rather they portray the route that joins the Point of Rocks to South Pass Stage Road in Section 8, T23N, R101W. Hickman (1983:Figure 2) provides a map that shows the general location of the route in this vicinity, but this map lacks detail and can not be used to pinpoint the road's location within the Big Sandy Water Supply Project study areas. The route of concern to us here runs almost straight north from Rock Springs to meet the Bryan/Green River to South Pass City Stage Routes and traverses the Reservoir 3, 4, and 5 study areas.

The road and stage route were built in response to the perceived economic needs of the town of Rock Springs, which experienced a small mining boom in the 1890s. Local boosters raised capital by selling bonds to the citizenry, who enthusiastically supported the project.

Many benefits accrued to towns that had transportation lines serving them. Roads built for stage lines could also be used as freight corridors, encouraging the growth of warehouse businesses, and passengers awaiting the next stage coach spent money on food, lodging, and other services while in town, stimulating the growth of various service industries. The line opened for business in 1894, but soon went bankrupt when the manager proved unworthy of the townspeople's confidence. The next attempt to found a stage company serving the Rock Springs to Lander route was more successful because the Rock Springs investors were more careful to hire a trustworthy manager (Gardner 1982).

Site 48SW827 - See Table 5 for location - The Oregon/Emigrant Trail passes through the study areas for Reservoirs 1 and 2. Action by the United States Congress in November 1978 (Public Law 95-625) amending the National Trail System Act (Public Law 90-543) designated the Oregon Trail as a National Historic Trail (Bureau of Land Management [BLM] 1986:1). It is considered to be NRHP eligible. The site has recently been investigated in the vicinity of the proposed project areas, but not in those areas. It was thought that the proposed Altamont pipeline would pass within one-quarter mile of the site when it crosses Reservoir 1, but no trace of the trail was found (Altamont 1992a). According to the USGS 7.5' Eden Reservoir West, Wyoming Quadrangle
(Photorevised 1980), the trail passes approximately one-half mile north and west of the parcel, possibly accounting for its not being located during the Class III cultural resource inventory for the proposed pipeline (Altamont 1992a:1:245). The site's location on the topographic map approximates the location of a road found on the GLO Survey Plats.

From the 1840s to the 1870s, this trail was one of the major routes westward for emigrants to Oregon and California. Its importance as a transportation route was eclipsed by the development of the railroads after the 1860s. The entire portion of the Oregon Trail in Wyoming covers 489 miles, but only a small portion of the trail is of concern for this project. The study areas through which this segment of the trail passes seem to be located south of the Sublette Cutoff. Those emigrants who traveled southward from the Parting of the Ways had made the choice to travel farther, with access to water, rather than go a shorter distance, but traverse a 50 mile stretch of waterless desert. This route took the emigrants southwest to Fort Bridger before turning northward again (Altamont 1992a; BLM 1986:47).

Site 48SW1841 - See Table 5 for location - The Sublette Cutoff is one of a number of trek shortening routes that developed during the course of the Oregon Trail's history. The site was originally recorded by the Wyoming Recreation Commission Historic Division. The BLM also recorded the site in 1973. It is considered to be eligible for nomination to the NRHP.

There are problems with the information concerning the location of the Sublette Cutoff: 1) GLO Survey Plats that were consulted for this report show no roads or trails in one of the sections in which it is recorded, another GLO Survey Plat shows a road segment that might be confused with the site until it is matched to the roads on adjoining plats (which show that the road segment is short by 49 miles and a variant of the main trail), and that same plat shows another road or trail several miles northeast of the study area that approximates the location of the Sublette Cutoff as it is shown on the maps in secondary sources and site reports consulted for this report; 2) the Cultural Records Office does not have information from the Historic Division's recording of the site so that there is no information on how the site's location was determined; and 3) the BLM's recording of the site includes only portions of a Wyoming road map with the site indicated. Moreover, maps in a BLM (1986) publication on management of the Oregon/Mormon Trail and the USGS 7.5' Eden Reservoir West, Wyoming Quadrangle (Photorevised 1980) show the approximate location of the site to be about 1 mile north of the most northern study area for this project (Reservoir 8) and about 1 to 3.5 miles north of the study areas that the files search indicates it should pass through (Reservoirs 2 and 8).

This route contributed to the settlement of the West by shortening the journey to Oregon and California by 2.5 to 3 days, and 60 to 70 miles, but the trade-off was that the Sublette Cutoff traversed 50 miles of waterless desert. There is some dispute over who first found and used the route. Proponents of William Sublette as the route's discoverer claim that he found it in 1832 and rely on a vague depiction of it by David Burr on an 1840 map to support their argument. The other man credited with first use of the route is Caleb Greenwood who led the Stephens-Townsend-Murphy Party across the route in 1844, the Cutoff's first recorded use. The route's popularity was at its height during the California Gold Rush because it saved time on the trip west, but the development of other alternate routes, the decline of the California gold fields, and the coming of the railroads all contributed to a decline in its use. The last known covered wagon to cross the Sublette Cutoff was in 1912 (BLM 1986:34, 47).

Site 48SW6291 - C/E/SW, Section 15, T25N, R106W - This site is the
bridge over the Big Sandy River and was recorded as part of the Wyoming Truss Bridge Survey undertaken by the Wyoming Highway Department in 1981. It is considered to be not eligible for nomination to the NRHP. The bridge is described as a single-span, pin-connected steel Pratt through truss bridge with a span length of 120' 0" and a roadway width of 13' 6". It was judged to be a "typical early example of a truss configuration common for Wyoming" (Wyoming State Highway Department 1981). The bridge does not lie within a study area but is located in the one-half mile wide corridor between the Reservoir 1 and 7 study areas. It is included here because it contributes to a reasoned appraisal of the cultural potential of the area.

Site 48SW6292 - S/SE/SE, Section 13, T25N, R106W - This site is the timber trestle bridge over the Little Sandy Creek. It was recorded by the SHPO, who considers the site to be not eligible for nomination to the NRHP. The bridge is described as a simple span, timber bridge 117' 0" long and 29' 8" wide. It was constructed of treated timber and concrete and was deemed to be in good condition at the time of recording. The resource is not located within a study area, but it lies less than one-half mile east of Reservoir 1. It is included here because it contributes to a reasoned appraisal of the cultural potential of the area.

Site 48SW9110 - See Table 5 for location - The Eden Canal was recorded during the Class III inventory for the proposed Altamont pipeline (Altamont 1992a). It is considered to be an NRHP-eligible site, but it was not recorded within any of the study areas covered by this report. It is still maintained and in use, and it passes through four of the eight proposed project areas (Reservoir 2, 3, 4, and 5).

The canal was built to carry irrigation water from the Big Sandy River to the croplands in what is now the Farson area. This drew the attention of farmers, who began colonizing the Eden Valley in 1908, the year that the first crops were raised. Work on the main canal was begun in 1907 by the Eden Irrigation and Land Company, organized by John M. Farson, Sons, and Company who financed it and maintained a controlling interest. Work was completed in 1914. During the 1920s, the Mennonite Church became interested in the area and encouraged its members to move into the area and settle. Forty-five miles of canal and 110 miles of laterals irrigated the fields of some 30 farmers by 1926. In 1927, it was sold to the Rock Springs Water Company, who resold it in 1932 to the Wyoming Land and Water Company. In 1940, the Civilian Conservation Corps, under the administration of the Bureau of Reclamation, began work on the Big Sandy Dam, a project that was interrupted by World War II and resumed in 1950, the year that the Eden Valley Irrigation and Drainage District was also created.

Taken as a whole, the Eden Canal System has contributed to the agricultural and economic development of the region. It is not well known, though, having been documented only by the recent inventory for the proposed Altamont pipeline. A system of earthworks, currently abandoned, and seemingly associated trash was found in the southeast corner of Reservoir 2, approximately 1.5 miles from where the canal was documented.

Site 48SW6276 - W/SE, Section 13, T24N, R107W - Information provided by the Cultural Records Office files search indicates that this site is a historic trash dump that is considered to be not eligible for nomination to the NRHP. It is located within the Reservoir 6 study area. No other information could be obtained since the recorders did not provide the SHPO with copies of the project report or site forms (Meyer 1992).

Site 48SW9288 - N/SE/NE/SE and S/SE/NE/NE/SE, Section 13, T25N, R106W - This site is a multicomponent site consisting of flaked stone tools, cores, debitage, and fire-cracked rock along with fragments of various colored glass,
pieces of sanitary cans, tobacco tins, and other agriculture related debris. The site is considered to be not eligible for nomination to the NRHP (Altamont 1992b). This resource is located about one-half mile to the east of the Reservoir 1 study area but is included here because it contributes to a reasoned appraisal of the cultural potential of the area.

**Site 48SW06277 - SE/NW/SW/SE, Section 13, T24N, R107W** - Information provided by the Cultural Records Office files search indicates that this site is a prehistoric lithic scatter that is considered to be not eligible for nomination to the NRHP. It is located within the Reservoir 6 study area. No other information could be obtained since the recorders did not provide the SHPO with copies of the project report or site forms (Meyer 1992).

**Site 48SW09097 - SE/SE/NW/SW/SW, Section 21, T25N, R106W** - The site is a sparse lithic scatter comprising four flakes and one piece of fire-cracked rock found on the plain of the Eden Valley. It is not considered to be eligible for nomination to the NRHP. The site was found during the inventory conducted for the proposed Altamont pipeline (Altamont 1992a). It is located about one-half mile south of the Reservoir 7 study area but is included here because it contributes to a reasoned appraisal of the cultural potential of the area.

**Site 48SW06154** - See Table 5 for location - This site is a lithic scatter consisting of two Late Prehistoric projectile points, ground stone and debitage that was found on a ridge overlooking the Big Sandy River (Eckles 1984). The site is considered eligible for nomination to the NRHP. It is located less than one-quarter mile north of the Reservoir 6 study area but is included here because it contributes to a reasoned appraisal of the cultural potential of the area.

Besides the recorded sites discussed above, two isolated artifacts are known to occur in the vicinity of the proposed project. The first of these is a Late Prehistoric projectile point found in SE/SW/NW/SW/NW, Section 21, T25N, R106W. It was recorded by Western Wyoming College, but its recording is not associated with a project. This location is in the Reservoir 7 study area. The second isolated artifact is a cowbell that was found during the inventory for the Altamont pipeline. It was found in SW/NW/SW/SW/SE, Section 14, T25N, R106W and recorded by Mariah Associates, Inc. (Altamont 1992b). The location is in Reservoir 1.

**Unrecorded Cultural Resources:** Four roads/trails are shown by the GLO Survey Plats to occur in the eight study areas; only one is named: the Fort Washakie to Green River City Road, which seems also to be the Oregon/Emigrant Trail (Hickman 1983:Figure 18). In addition, two ditches are also shown on the GLO plats as man made features in the various study areas. Identification and recording of these features should be a consideration during planning for the Big Sandy Water Supply Project. Other unrecorded cultural resources, both historic and prehistoric, were found during the pedestrian reconnaissance.

**FIELDWORK:** A pedestrian reconnaissance of the proposed project areas was conducted by Anton L. Hoffman and David Day on June 16-17, 1992 in support of this Class I inventory. Its purpose was to gain firsthand knowledge of the environmental setting and the potential for locating sites on the specific parcels under consideration for ground disturbing activities. Each parcel was visited and will be described separately. The pedestrian reconnaissance was not conducted as a systematic parallel or zigzag transect inventory of the area, nor was any subsurface testing conducted, as would be done for a Class III inventory. Rather, it was an informal walk-over of the proposed project areas only and was conducted for the purpose of gaining firsthand knowledge of the topography, soils, flora, and features present on each parcel. Historic
and prehistoric artifacts and features were noted when encountered, but formal recording was beyond the purview of this project.

Each of the proposed project areas is discussed in terms of the data collected from the files search for its specific study area and the pedestrian reconnaissance of the parcel to provide a basis for predicting the potential for cultural resources occurring within it. The generated data may be grouped into general categories for purposes of the following discussion: 1) environmental description; 2) known Class III cultural resource inventories performed within the defined study area; 3) recorded and unrecorded cultural resources within the study area; 4) site types within the study area; and 5) a discussion and synthesis of the above data into a generalized model for locating as yet unreported sites and archaeologically/historically sensitive locales, and for generating recommendations for further work.

Reservoir 1 - W/SE and E/SW, Section 14, T25N, R106W - This is an area of flat topography with grasses, low sagebrush, greasewood, and prickly pear cactus. The soil is a tan, medium to coarse sand loam with subdued pebbles of quartz, quartzite, mudstone/shale, and occasional rounded cobbles of chert. The Oregon/Emigrant Trail, which may also be the Green River to Fort Washakie Stage Road, passes within one-half mile of the north and west sides of the parcel. There seem to have been irrigated fields in the southeastern part of the parcel. A canal, the Farson Lateral, runs along the south edge, another canal runs along the eastern edge, and small gullies that may be abandoned ditches can be seen within the proposed project area. The centerline of the proposed Altamont pipeline also runs through this parcel. Therefore it is recommended that before any ground disturbing activities commence, a Class III cultural resources inventory should be conducted for this project area.

Reservoir 2 - E/SE, Section 32, T26N, R105W - This proposed project area lies in an area in which tall dunes rise above a flat to rolling plain. The soil is a tan, sandy loam with mudstone/shale tabular pebbles, gravel, and cobbles. Fist-sized rounded chert and chalcedony cobbles were also noted. The vegetation consists of low sagebrush, forbs, bunch grasses, greasewood, and prickly pear cactus. The area seems to have been used by human populations since aboriginal times. Prehistoric lithic artifacts of quartzite, chert, and a green silicified siltstone were seen on the plain and the dunes. Historic earthworks and ditches, which may be related to the Eden Canal system, and historic trash (hole-in-top cans, green glass, purple glass, brown glass, metal) could be seen throughout the area. One of the dunes has a swale in its west edge that may be a road cut. No projects are recorded as having been conducted in this section and only two sites, the Oregon/Emigrant Trail and the Sublette Cutoff, are recorded as occurring in the section. Because of the lack of Class III inventories done in the area and the fact that cultural materials and historic features were found during the pedestrian reconnaissance it is recommended that a Class III inventory be conducted before the commencement of any ground disturbing activities in this proposed project area.

Reservoir 3 - SW, Section 15, T25N, R105W - This proposed project area is in an area of general flatness, but there is approximately 20 feet of abrupt rise at the north of the parcel. The soil is a tan sandy loam with tabular mudstone/shale pebbles and occasional rounded chert pebbles. There are small dunes in the southwest corner of the parcel. The vegetation consists of low sagebrush, greasewood, bunch grasses, forbs, and prickly pear cactus. No projects are recorded as having been done in this proposed project area, but three sites have been recorded in the study area. The historic Eden
Canal (48SW9110), considered to be an NRHP eligible site, passes northwest to southeast through the proposed area of effect. Besides the canal, the Green River to South Pass City Stage Road (48SW3864) and Bryan to South Pass City Stage Road (48SW3869) are recorded as traversing the study area. Their locations are not known, though. Southwest of the canal is a swath of parallel scars about 100 meters wide trending northwest to southeast. There is a periodicity to the spacing of the scars, about 1.5 m-4 m-1.5 m, but their function/cause is unknown, and it is assumed that they are modern features. Other features occur northeast of the canal. At the base of the levee is a small, overgrown, abandoned ditch. Two parallel two-track swales were also found. Swale A is approximately 30 meters east of the canal, four meters wide, 20-25 centimeters deep, and trends 345°-165°. Swale B is approximately 60 meters east of the canal, three meters wide, 20-25 centimeters deep, and trends 340°-160°. A modern borrow pit represents other disturbance in the area. No prehistoric artifacts or features were noted. Because of the lack of Class III inventories done in the area and the fact that cultural materials and historic features were found during the pedestrian reconnaissance it is recommended that a Class III inventory be conducted before the commencement of any ground disturbing activities in this proposed project area.

Reservoir 4 - NE and E/NW, Section 28, T25N, R105W - The proposed project area is divided into two parts by the historic Eden Canal (48SW9110), which passes northeast to southwest through the parcel. The area is a flat to rolling plain with enough of a drop in elevation at the southern end of the parcel that there is an elevation drop of approximately six feet engineered into the canal. The soil is a tan, sandy loam with tabular pebbles of mudstone/shale and occasional subrounded to subangular pebbles of chert. The vegetation consists of low sagebrush, grasses, prickly pear cactus, and forbs. No previous projects are recorded, and only the Rock Springs to Lander Road (48SW4163) is recorded in the study area. The land on the west side of the canal is currently in use for horse pasture and materials storage, and ground visibility was severely limited by a thick carpet of hay and horse feces; however, where ground visibility was possible, no historic or prehistoric cultural materials or features were seen. No trace of 48SW4163 could be located with certainty anywhere during the pedestrian reconnaissance. An unused, rather deep ditch/lateral running generally north-south was found just west of the parcel. To the east of the canal are two two-track trails. One of these is the currently used maintenance access road for the east side of the canal, the other is unused and overgrown with grasses. No prehistoric artifacts or features were noted during the pedestrian reconnaissance. Because of the lack of Class III inventories performed in the study area and the fact that the Eden Canal flows through but is not recorded in the proposed project area, it is recommended that a Class III cultural resources inventory be performed before the beginning of any ground disturbing activities in the parcel.

Reservoir 5 - S/NE and SE, Section 32, T25N, R105W - This project area is located in an area of varied topography on both sides of the Eden Canal (48SW9110), which runs northeast-southwest through the project area. To the north of the canal the land is rather flat, rising slightly to the west, while to the south of the canal the land is somewhat hummocky and has been disturbed by the excavation of borrow pits. The soil is generally a tan, sand loam with tabular pebbles of mudstone/shale and subrounded chert pebbles. The vegetation consists of low sagebrush, greasewood, bunch grasses, forbs, and prickly pear cactus. The southernmost part of the parcel contains dunal sand deposits. No projects are recorded as having been performed and only the Rock Springs to Lander Road (48SW4163) is recorded in the study area. A two-
track swale was found during the pedestrian reconnaissance south of the canal. This swale parallels the canal, is approximately four meters wide and 20-25 centimeters deep, and trends 60°-240°. Small unused ditches were also found. Besides these historic and modern constructed features a grey silicified mudstone flake was found on the levee of the canal. North of the canal two overgrown two-track trails were seen. Because of the lack of previous Class III inventories, the presence of unrecorded prehistoric materials, and the possibility of locating 48SW4163 on the ground, it is recommended that a Class III inventory be conducted before the start of ground disturbing activities in the proposed project area.

Reservoir 6 - N 1/4, Section 18, T24N, R106W - This parcel lies in an area of low relief covered by low sagebrush, bunch grasses, forbs, and prickly pear cactus. It is deeply cut by two arms of Carlson Draw, an ephemeral drainage that had approximately 75 centimeters of standing water at the time of the pedestrian reconnaissance. Sod grasses grow at the bottom of the draw, which is about two meters below the sage covered flats. The soil is a tan, sandy loam with subangular and tabular gravels, pebbles and cobbles of chert, chalcedony, silicified mudstone, and similar materials. Several two-track trails were seen within the parcel and new road construction carried out in conjunction with the building of a housing development has produced recent changes on the landscape in the eastern part of the study area. Two Class III cultural resource inventories have been conducted near the study area in Section 12, T24N, R107W, and another one that resulted in the recording of two sites in the study area (48SW6276 and 48SW6277) was done in Section 13, T24N, R107W. Site 48SW6276 is a historic trash dump and site 48SW6277 is a lithic scatter. Neither is considered eligible for nomination to the NRHP. No other information is available from the Cultural Records Office concerning these sites. The Green River to South Pass City Stage Road (48SW3864) and Bryan to South Pass City Stage Road (48SW3869) traverse the study area, and one NRHP eligible prehistoric site, 48SW6154, lies just outside. Because few Class III inventories have been performed in the study area and there is a lack of information concerning those sites that have been recorded, it is recommended that a Class III cultural resource inventory be done before ground disturbing activity commences.

Reservoir 7 - NW/SE, Section 16, T25N, R106W - The proposed project area is located on a flat plain covered with low sagebrush, bunch grasses, forbs, and prickly pear cactus. The soil is a tan, coarse sandy loam with tabular, subangular and subrounded chert, chalcedony, limestone, and conglomerate pebbles and cobbles. No projects or sites are recorded in the study area. The study area has been affected, however, by the excavation of borrow pits, housing and ranch construction, a gravel road, two-track trails, and the construction of the West Side Lateral of the Eden Canal system. Within the parcel, the only impacts are from the excavation of a borrow pit and construction of a fenceline. Historic and modern trash was found occasionally during the pedestrian reconnaissance, and a small (three flakes) concentration of lithic debris was noted. Because of the lack of Class III inventories conducted in the study area and the presence of both historic and prehistoric debris, it is recommended that a Class III inventory be performed prior to the initiation of ground disturbing activities.

Reservoir 8 - S/NW and NW/SW, Section 23, T26N, R106W - This proposed project area lies in an area of flat plains. The soil is a tan, sandy clay with tabular shale pebbles and cobbles and tabular, subangular, and subrounded pebbles of various cherts, chalcedonies, and conglomerate. The vegetation consists of low sagebrush, greasewood, grasses, and forbs. The majority of the project area lies on the northwest side of the West Side...
Lateral, which runs northeast to southwest through the parcel. There are two borrow pits within the proposed project area and one other in the study area. Faint two-track trails can also be seen in the project area. No projects are recorded as occurring in the study area, but the historic Sublette Cutoff is recorded as passing through it. This segment of the road/trail is not shown on the GLO plats; however, a ditch is recorded on the plats. No prehistoric cultural material or features were seen during the pedestrian reconnaissance. Because no previous inventories have been conducted and there is a dearth of information concerning the historic and archaeological resources in the area, it is recommended that a Class III cultural resources inventory be conducted before the commencement of ground disturbing activities for the proposed project.

RESULTS: Cultural Resources in the Big Sandy Water Supply Project Study Areas: The purpose of this Class I cultural resource inventory is to synthesize data into a usable format to assist in the development of the project design for the Big Sandy Water Supply Project.

There are nine recorded sites that occur in the study areas and five within one-half mile of various study areas. Of these six are historic roads or trails, two are bridges, one is a historic canal, one is a historic trash dump, one is a multicomponent site, consisting of a historic trash dump and a prehistoric lithic scatter, and three are lithic scatters. There are other, unrecorded sites within the project study areas, too. The GLO Survey Plats show four roads and two ditches, and during the pedestrian reconnaissance of the study areas, various historic and prehistoric cultural materials and features were noted.

National Register of Historic Places Eligible Sites: This information is important because NRHP listing, eligibility, or noneligibility affects the decision making process concerning each individual identified resource. Sites eligible for nomination or actually listed on the NRHP are afforded some measure of protection and consideration against adverse effects from ground disturbing projects.

A site may be mitigated in a variety of ways. The preferred way to mitigate a site is avoidance, and avoidance is considered to be one mitigation option. Avoiding the site affords the greatest level of protection for the resource by eliminating all impact to the site; therefore, avoidance is the generally preferred option. When avoidance is not feasible or possible, though, mitigation of the adverse effects must occur. The other options available include small- to large-scale testing/excavation, detailed mapping and photographic recording, and monitoring of the construction or reclamation by a qualified archaeologist. These are not the only options available but only a sample to be considered in devising a mitigation or data recovery plan.

Each mitigation plan must be site specific and thus unique since the objective of mitigation is to preserve the scientific data that the site may provide for understanding the history and/or prehistory of the region. Any plan for a site must be developed in conjunction with the federal agency having jurisdiction over the land on which the site is located as well as the SHPO and Advisory Council on Historic Preservation (Hough-Stilphen and Welch 1987:22).

The recorded sites, i.e. those sites that have been assigned Smithsonian trinomial designations, have been listed in Table 5. This table gives site number, legal location from north to south and east to west, a synoptic site description derived from the recording forms, National Register of Historic Places (NRHP) status, and reference to the projects with which the recording of the sites is associated.
Four of the recorded roads/trails are NRHP eligible, and two are of unknown eligibility. None of them was identified as a result of a Class III inventory, but three have been re-recorded elsewhere as a result of other projects. The canal is also considered to be eligible while the trash dump and the prehistoric lithic scatter are not. Of the five sites recorded outside, but within one-half mile, of the study areas, only one, a lithic scatter (48SW6154), is considered to be NRHP eligible.

Historic resources known from information on the General Land Office survey plats have been treated as "Identified but not Recorded Sites" and are considered to be of unknown NRHP eligibility. Four roads/trails, only one of which is specifically named, and two ditches fit in this category. Their approximate locations are plotted on the topographic maps that accompany this report and they are listed in Table 6. The named road is the Green River to Fort Washakie Road, which is not a recorded site according to the files search. It is possible that this road was known by (an)other name(s) and has in fact been recorded. (Hickman [1983:Figure 18] identifies this road as the Oregon/Emigrant Trail [48SW827].) It is similarly possible that the unnamed roads on the plats have been recorded as named sites.

Based on what is known about human activities in the Big Sandy Water Supply Project study areas, it is not possible to predict where unknown historic or prehistoric sites will be found. The paucity of available data precludes prediction of site locations. Because the preponderance of known sites comprises historic features it is tempting to speculate that most of the unknown sites in the area will also be historic sites. Including the Green River to Fort Washakie Road there are seven named roads that traverse the various study areas, three roads whose names are not known, two bridges, one historic canal, and two unnamed ditches. These represent the development of transportation and agriculture in the region, and they probably had economic impacts in various towns and cities of Wyoming. Unfortunately, the data base is so scanty that such speculation is meaningless. The prehistory of the Farson vicinity is so poorly known that it is not yet possible to make a reasoned estimation of the cultural potential of the study areas. Prehistoric materials were identified, but not recorded, during the pedestrian reconnaissance conducted for this project. None of these artifacts was associated with a known site. Thus, the lack of information argues for the necessity of performing a Class III inventory before engaging in ground disturbing activities in association with this project.

CONCLUSIONS: A comparison of historic eligible sites, prehistoric eligible sites, and multicomponent eligible sites was not done for this study because the data base is so small that no meaningful results would be possible. The most that can be said about NRHP eligible sites is that four historic roads and one historic canal found in the study areas are currently considered eligible for nomination. Of the three sites outside, but within one-half mile, of a study area only one, a lithic scatter, is considered NRHP eligible.

There is a lack of information concerning the historical and archaeological cultural resources in the Big Sandy Water Supply Project study area. Six of the eight proposed project areas are known to contain cultural resources, either as a result of the files search or the pedestrian reconnaissance. The known sites in the study area are predominately historic roads, some of which seem to be coincident, and prehistoric cultural remains are not well known at all. With such a small data base there is little use speculating on what kinds of sites will be associated with what topographic features, what percentage of sites will fall into what categories, or even whether the majority of unknown sites will be prehistoric or historic. In
short, much more work needs to be done before any meaningful conclusions can be drawn concerning cultural resources in the Farson area as a whole.

RECOMMENDATIONS: There is a lack of knowledge about the historic and prehistoric cultural resources in the Farson area. Therefore, it is recommended that before any ground disturbing activities are initiated in any of the proposed project areas, a Class III cultural resource inventory should be conducted.
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APPENDIX H

ENVIRONMENTAL CONSTRAINTS
Report of Field Reconnaissance for Environmental Constraints,
Big Sandy Water Supply Project, Sweetwater County, Wyoming

Prepared for Nelson Engineering
by
Mountain West Environmental Services
Cheyenne, Wyoming

Field Investigator: Robert D. Dorn

June 1992
A field reconnaissance of the eight potential reservoir sites for the Big Sandy Water Supply Project was conducted on June 19, 1992, for potential environmental constraints. Specific constraints would be the presence or potential presence of listed or candidate threatened or endangered species and migratory birds of high federal interest.

**Site Characteristics**

**Site 1 (T25N R106W Sec 14)**
Dominated by big sagebrush (*Artemisia tridentata*) and rubber rabbitbrush (*Chrysothamnus nauseosus*) with some greasewood (*Sarcobatus vermiculatus*), introduced crested wheatgrass (*Agropyron cristatum*) and Russian wild rye (*Elymus junceus*) common, highly disturbed in past

**Site 2 (T26N R105W Sec 32)**
Dominated by greasewood and big sagebrush, some Gardner saltbush (*Atriplex gardneri*) and American Kochia (*Kochia americana*), rubber rabbitbrush in places with the sagebrush, some needle and thread (*Stipa comata*) with the sagebrush, highly disturbed in past

**Site 3 (T25N R105W Sec 15)**
Dominated by big sagebrush and rubber rabbitbrush, some Gardner saltbush

**Site 4 (T25N R105W Sec 28)**
Dominated by big sagebrush and rubber rabbitbrush, relatively undisturbed

**Site 5 (T25N R105W Sec 32)**
Dominated by big sagebrush and rubber rabbitbrush, elongate pond on east side of Eden Canal

**Site 6 (T24N R106W Sec 18)**
Dominated by big sagebrush, Sandberg bluegrass (*Poa secunda*), and needle and thread, two ponds toward southwest corner

**Site 7 (T25N R106W Sec 16)**
Dominated by big sagebrush, rubber rabbitbrush, and needle and thread

**Site 8 (T26N R106W Sec 23)**
Dominated by big sagebrush, rubber rabbitbrush, needle and thread, and Douglas rabbitbrush (*Chrysothamnus viscidiflorus*)

**Threatened and Endangered Species**
No listed or candidate threatened or endangered species were observed on any of the sites. Potential for any to occur on the sites is near zero. The only species of significance noted was a small annual plant (*Eriastrum wilcoxii*) which is somewhat rare in Wyoming but more common to the west. This was found on Sites 4 and 7.

**Migratory Birds**
The following birds were observed on the sites. Site numbers where observed are indicated after each species. None of these are birds of high federal interest.
The following bird species were observed on or around the pond just outside the southwest corner of Site 2: Mallard, Gadwall, American Wigeon, Killdeer, Spotted Sandpiper, Wilson's Phalarope.

Other Major Wildlife
A Mule Deer was observed on Site 1 and Pronghorns were observed on Sites 6 and 7.

Wildlife Habitat Potential
The potential for wildlife habitat as a part of the project construction would be very minimal for Sites 1, 3, 4, 7, and 8. Potential for Site 2 is greater because of the clay soils at the south end, and the presence of a pond just outside the southwest corner which is already frequented by water birds. Site 5 already has a small pond with wildlife use indicating some potential here. Site 6 has perhaps the greatest potential in the areas of the two drainageways and the two ponds already present. In general, the sandy sites would be less productive of cover and be less prone to hold water for an extended period than the clay sites.

Summary
There are no environmental constraints regarding threatened or endangered species or migratory birds of high federal interest on any of the eight sites. Sites 2, 5, and 6 appear to have the greatest potential for developing wildlife habitat.
The purpose of this report is to summarize work done by this firm on the referenced project through July 31, 1992. Two days, June 19-20 were spent in the project area on Phase I tasks. The Project Manager was met at the Farson offices of the Department of Agriculture to review job requirements and scope of work. Field reconnaissance was done on potential reservoir sites 1, 2, 7, and 8 to gain a basic knowledge of the ecology of the landscape and to identify wetland issues and constraints. Manpower resources expended were 9 hours for field investigations and 6 hours of travel time for a total of $600 in manpower costs. Reimbursable expenses were $90.90 for 303 miles of vehicle use at $.30/mile. A cab-over camper was used for travel and lodging and no per diem expenses accrued. The remaining 4 sites will be investigated during August, 1992 to obtain the appropriate Phase I information.

Field investigations at the four potential reservoir sites included ocular estimates of vegetation by cover type to assess dominance of wetland vegetation. Bore holes were dug and examined for evidence of hydric soils and wetland hydrology. The vegetation, soils, and hydrologic evidence was recorded in a voice recorder for later transcription to data sheets to document the occurrence of jurisdictional wetlands. Color photographs were taken of the sites for the project record and final report. Potential reservoir sites #8 and #2 (Little Sandy River Site) were observed to support wetland vegetation, soils, and hydrology. Sites #1 and #7 were lacking in any indicators of wetlands.

**Issues and Constraints**

The Final Environmental Impact Statement (EIS) prepared by the US Soil Conservation Service was read for information on any potential wetland
issues or constraints which might affect the project. In the comments on the EIS submitted by the US Environmental Protection Agency (EPA) and the Wyoming Game and Fish Department it is disclosed that Section 404 Clean Water Act permits may be required by the US Army Corps of Engineers (COE) for actual construction at reservoir sites that will involve the discharge of dredged or fill material into water of the US. This issue will require clarification through consultation with the COE, EPA, and the Wyoming Game and Fish Department.

If permits will be required, the category of permit(s) will also have to be decided. Different regulatory requirements exist for activities which are Congressionally approved, for activities on major tributaries (defined as >5 CFS) such as the Little Sandy site, and for activities in "isolated" wetlands 10 acres or less in size and not adjacent to major tributaries.

Initial consultations with EPA (phone call to Vern Helbig, Regional Wetlands Coordinator, Denver, CO) indicate they are "on-board" the project and therefore unlikely to oppose issuance of any permits which might be required. The necessity of obtaining Section 404 permits for construction of reservoirs should be determined once the site selection process is completed.
HEADWATERS ECOLOGY
September 25, 1992

Wetlands Survey Reconnaissance Report
Environmental Constraints
Big Sandy Water Supply Project
Project No. 92-075-1
Part II of Phase I

Prepared for Nelson Engineering by Headwaters Ecology
Field Investigator: Dusty Zaunbrecher

This Report of Field Reconnaissance covers potential reservoir sites numbers 3, 4, 5, and 6. Sites 1, 6, 7, and 8, were described in Part I of this report dated July 31, 1992. Wetland constraints for all 8 sites are summarized at the end of this report.

Field investigations at the four potential reservoir sites included ocular estimates of vegetation by cover type to assess dominance of wetland vegetation. Bore holes were dug and examined for evidence of hydric soils and wetland hydrology. In accordance with the Federal Manual for the Delineation of Jurisdictional Wetlands, vegetation, soils, and hydrologic data was recorded on the appropriate data sheets to document the occurrence of jurisdictional wetlands. Data sheets for all potential reservoir sites are attached. Of the 4 sites examined in this part of the report, potential reservoir sites #5 and #6 were observed to support wetland vegetation, soils, and hydrology. Sites #3 and #4 were lacking in any indicators of wetlands.

Issues and Constraints

Authority from the Corps of Engineers exists to fill up to one acre of isolated wetlands which are not adjacent to major tributaries (> 5 cubic feet per second flow) under the so-called "Nation-wide permit (NWP)" program published in the Federal Register in November, 1991. Existing wetlands at potential reservoir sites #5, #6, and #8 fall into the "isolated wetlands"...
category and therefore, technically may be filled or altered for reservoir development purposes under NWP number 26. If the proposed development activity results in the loss or alteration of more than one acre of isolated wetlands, Federal regulations require that the Corps of Engineers be notified. Notification should take place once development plans have been completed. The Corps also has discretionary authority to require an individual permit if it is determined that the cumulative impacts of NWP authorized projects are significant.

The regulations implementing the NWP program state that users of the Nationwide permits may request verification that proposed activities are authorized by the program even though notification is not required for fills of less than one acre in isolated wetlands and bridge crossings that do not involve filling wetlands or special aquatic sites. Project proponents may request such verification once development plans are completed.

Only the wetlands at site #2 (Little Sandy River) meet the Corps's regulatory criteria for an individual Section 404 permit because the wetlands are adjacent to a > 5 cubic feet per second stream. The Little Sandy River is on the Corps' list of major tributary streams of Wyoming (Personal communication with Ed Gooley, COE Regulatory Office, Riverton). If an individual Section 404 permit will be required for filling or altering wetlands at site #2, the State Office of Historic Preservation will probably require an archaeological survey be conducted, the US Fish and Wildlife Service will review the project for conflicts with Endangered or Threatened Species Habitat, and the State Department of Environmental Quality will review the project for Section 401 Water Quality Certification purposes.

Summary: Sites #2, #5, #6, and #8 (#8 to only an extremely limited extent) support jurisdictional wetlands as defined by the US Army Corps of Engineers Regulatory Program. Nationwide permits have been authorized for construction activities in so-called "isolated" wetlands such as exist at sites #5, #6, and #8. An individual permit may be required if the Corps determines the cumulative impact of construction at individual reservoir sites are significant. Construction activities at site #2 may require an individual 404 permit because it is adjacent to a major tributary of US waters.
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #1

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator</th>
<th>Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agropyron cristatum</td>
<td>Crested Wheatgrass</td>
<td>FACU</td>
<td>Herb</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Artemisia tridentata</td>
<td>Big Sagebrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Atriplex gardneri</td>
<td>Gardner Saltbush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chrysothamnus nauseosus</td>
<td>Rabbitbrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Elymus junceous</td>
<td>Russian Wildrye</td>
<td>FACU</td>
<td>Herb</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Sarcobatus vermiculatus</td>
<td>Greasewood</td>
<td>FACU+</td>
<td>Shrub</td>
<td></td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 0

Is the hydrophytic vegetation criterion met?  Yes  No  X
Rationale: No wetland vegetation present

Soils

Series/phase: Ferson-Vanason-Means
Is the soil on the hydric soils list?  Yes  No  X  Undetermined
Is the soil a Histosol?  Yes  No  X  Histic epipedon present?  Yes  No  X
Is the soil mottled?  Yes  No  X  Gleyed?  Yes  No  X
Matrix color: N/A  Mottle Colors: None
Other hydric Soil Indicators: None
Is the hydric soil criterion met?  Yes  No  X
Rationale: No hydric soils indicators present

Hydrology

Is the ground surface inundated?  Yes  No  X  Surface water depth:
Is the soil saturated?  Yes  No  X
Depth to free standing water in a bore hole: >36 inches
List other evidence of inundation or saturation.
Is the wetland hydrology criterion met?  Yes  No  X
Rationale: No wetland hydrology indicators present

Jurisdictional Determination and Rationale

Is the plant community a wetland?  Yes  No  X
Rationale: No indicators present
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site State: Wyoming County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #2

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator</th>
<th>Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carex (spp.)</td>
<td>Sedge</td>
<td>FACW-OBL</td>
<td>Herb</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Typha latifolia</td>
<td>Cattail</td>
<td>OBL</td>
<td>Herb</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Elodea</td>
<td>Water weed</td>
<td>OBL</td>
<td>Herb</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Juncus</td>
<td>Rush</td>
<td>FACW-OBL</td>
<td>Herb</td>
<td></td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 75%

Is the hydrophytic vegetation criterion met? Yes X No
Rationale: Dominance of wetland vegetation

Soils

Series/phase: Saprist
Is the soil on the hydric soils list? Yes X No Undetermined
Is the soil a Histosol? Yes X No Histic epipedon present? Yes No X
Is the soil mottled? Yes No X Gleyed? Yes X No
Matrix color: 10 YR 4/1 Mottle Colors: None
Other hydric Soil Indicators: None
Is the hydric soil criterion met? Yes X No
Rationale: Mucky surface layer, low matrix chroma, gleyization

Hydrology
Is the ground surface inundated? Yes X No Surface water depth:
Is the soil saturated? Yes X No
Depth to free standing water in a bore hole: at surface
List other evidence of inundation or saturation.
Is the wetland hydrology criterion met? Yes X No
Rational: Wetland hydrology criteria met: standing water-saturation

Jurisdictional Determination and Rationale
Is the plant community a wetland? Yes X No
Rationale: All three wetland indicators present
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #3

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator</th>
<th>Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artemisia tridentata</td>
<td>Big Sagebrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Atriplex gardneri</td>
<td>Gardner Saltbush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chrysothamnus nauseosus</td>
<td>Rabbitbrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 0
Is the hydrophytic vegetation criterion met?  Yes  No  X
Rationale: No wetland vegetation present

Soils

Series/phase: Farson-Vanason-Means
Is the soil on the hydric soils list? Yes  No  X  Undertermined
Is the soil a Histosol?  Yes  No  X  Histosol epipedon present? Yes  No  X
Is the soil mottled?  Yes  No  X  Gleyed? Yes  No  X
Matrix color: N/A  Mottle Colors: None
Other hydric Soil Indicators: None
Is the hydric soil criterion met? Yes  No  X
Rationale: No hydric soils indicators present

Hydrology
Is the ground surface inundated? Yes  No  X  Surface water depth:
Is the soil saturated?  Yes  No  X
Depth to free standing water in a bore hole: >36 inches
List other evidence of inundation or saturation.
Is the wetland hydrology criterion met? Yes  No  X
Rationale: No wetland hydrology indicators present

Jurisdictional Determination and Rationale
Is the plant community a wetland? Yes  No  X
Rationale: No wetland indicators present
Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater  
Transect (T) and Test Site (S): Potential Reservoir site #4

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator</th>
<th>Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artemisia tridentata</td>
<td>Big Sagebrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Chrysanthemus nauseosus</td>
<td>Rabbitbrush</td>
<td>U</td>
<td>Shrub</td>
<td></td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 0
Is the hydrophytic vegetation criterion met? **Yes** **No** **X**  
Rationale: **No wetland vegetation present**

Soils

Series/phase: **Farson-Vanason-Means**  
Is the soil on the hydric soils list? **Yes** **No** **X**  Undertermined  
Is the soil a Histosol? **Yes** **No** **X**  Histic epipedon present? **Yes** **No** **X**  
Is the soil mottled? **Yes** **No** **X**  Gleyed? **Yes** **No** **X**  
Matrix color: N/A  Mottle Colors: None  
Other hydric Soil Indicators: **None**  
Is the hydric soil criterion met? **Yes** **No** **X**  
Rationale: **No hydric soils indicators present**

Hydrology

Is the ground surface inundated? **Yes** **No** **X**  Surface water depth:  
Is the soil saturated? **Yes** **No** **X**  
Depth to free standing water in a bore hole: **>36 inches**  
List other evidence of inundation or saturation.  
Is the wetland hydrology criterion met? **Yes** **No** **X**  
Rational: **No wetland hydrology indicators present**

Jurisdictional Determination and Rationale

Is the plant community a wetland? **Yes** **No** **X**  
Rationale: **No wetland indicators present**
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #5 and #6

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carex (spp.)</td>
<td>Sedge</td>
<td>FACW-OBL</td>
<td>Herb</td>
</tr>
<tr>
<td>1</td>
<td>Typha latifolia</td>
<td>Cattail</td>
<td>OBL</td>
<td>Herb</td>
</tr>
<tr>
<td>1</td>
<td>Elodea</td>
<td>Water weed</td>
<td>OBL</td>
<td>Herb</td>
</tr>
<tr>
<td></td>
<td>Juncus</td>
<td>Rush</td>
<td>FACW-OBL</td>
<td>Herb</td>
</tr>
<tr>
<td></td>
<td>Potomgeton</td>
<td>Pondweed</td>
<td>OBL</td>
<td>Herb</td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 75%
Is the hydrophytic vegetation criterion met?  Yes X No
Rationale: **dominance of wetland vegetation**

Soils

Series/phase: **Sapristis**
Is the soil on the hydric soils list? Yes X No  Undertermined
Is the soil a Histosol?  Yes X No  Histic epipedon present?  Yes X No
Is the soil mottled?  Yes X No  Gleyed?  Yes X No
Matrix color: **10 YR 4/1**  Mottle Colors: None
Other hydric Soil Indicators: None
Is the hydric soil criterion met?  Yes X No
Rationale: **Mucky surface layer, low-matrix chroma, gleization**

Hydrology

Is the ground surface inundated?  Yes X No  Surface water depth:
Is the soil saturated?  Yes X No
Depth to free standing water in a bore hole:  **at surface**
List other evidence of inundation or saturation.
Is the wetland hydrology criterion met?  Yes X No
Rationale: **Wetland hydrology criteria met; standing water-saturation**

Jurisdictional Determination and Rationale

Is the plant community a wetland?  Yes X No
Rationale: **All three wetland indicators present**
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #7

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artemisia tridentata</td>
<td>Big Sagebrush</td>
<td>U</td>
<td>Shrub</td>
</tr>
<tr>
<td>1</td>
<td>Chrysothamnus nauseosus</td>
<td>Rabbitbrush</td>
<td>U</td>
<td>Shrub</td>
</tr>
<tr>
<td>1</td>
<td>Stipa Cornata</td>
<td>Needlegrass</td>
<td>U</td>
<td>Herb</td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 0

Is the hydrophytic vegetation criterion met?  Yes  No X
Rationale: **No wetland vegetation present**

Soils

Series/phase: Farson-Vanerson-Means

Is the soil on the hydric soils list?  Yes  No X  Undetermined

Is the soil a Histosol?  Yes  No X  Histic epipedon present?  Yes  No X

Is the soil mottled?  Yes  No X  Gleyed?  Yes  No X

Matrix color: N/A  Mottle Colors: None

Other hydric Soil Indicators: None

Is the hydric soil criterion met?  Yes  No X
Rationale: **No hydric soils indicators present**

Hydrology

Is the ground surface inundated?  Yes  No X  Surface water depth:

Is the soil saturated?  Yes  No X

Depth to free standing water in a bore hole: >36 inches

List other evidence of inundation or saturation.

Is the wetland hydrology criterion met?  Yes  No X
Rationale: **No wetland hydrology indicators present**

Jurisdictional Determination and Rationale

Is the plant community a wetland?  Yes  No X

Rationale: **No wetland indicators present**
Data Form
Routine Onsite Determination Method

Project/Site: Big Sandy Project Site  State: Wyoming  County: Sweetwater
Transect (T) and Test Site (S): Potential Reservoir site #8

Vegetation

<table>
<thead>
<tr>
<th>Number</th>
<th>Dominant Species</th>
<th>Common Name</th>
<th>Indicator Status</th>
<th>Stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Carex (spp.)</td>
<td>Sedge</td>
<td>FACW-OBL</td>
<td>Herb</td>
</tr>
<tr>
<td></td>
<td>Juncus</td>
<td>Rush</td>
<td>FACW-OBL</td>
<td>Herb</td>
</tr>
</tbody>
</table>

Percent dominant species that are OBL, FACW, and/or FAC: 65%
Is the hydrophytic vegetation criterion met? Yes X No
Rationale: Dominance of wetland vegetation

Soils

Series/phase: Excavated Farson-Vanason-Means
Is the soil on the hydric soils list? Yes _ No X Undetermined
Is the soil a Histosol? Yes _ No X Histic epipedon present? Yes _ No X
Is the soil mottled? Yes _ No X Gleyed? Yes _ No X
Matrix color: 10 YR 4/1 Mottle Colors: None
Other hydric Soil Indicators: None
Is the hydric soil criterion met? Yes X No
Rationale: Low matrix chroma

Hydrology

Is the ground surface inundated? Yes X No: Surface water depth:
Is the soil saturated? Yes X No:
Depth to free standing water in a bore hole: NA
List other evidence of inundation or saturation:
Is the wetland hydrology criterion met? Yes X No
Rationale: Wetland hydrology criteria met only for short period during growing season

Jurisdictional Determination and Rationale

Is the plant community a wetland? Yes X No
Rationale: All three wetland indicators present only in small area at bottom of slope