Executive Summary for the
Little Snake River Supplemental Storage Level II Study

Prepared for
Wyoming Water Development Commission

Prepared by
States West Water Resources Corporation, Cheyenne WY

In association with
RJH Consultants, Inc., Englewood CO
Leonard Rice Engineers, Inc., Denver CO
Western EcoSystems Technology, Inc., Cheyenne WY
Miller and Associates, Fort Collins CO
Lidstone and Associates, Fort Collins CO
Office of the Wyoming State Archaeologist, Laramie WY

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I. Introduction

In June, 2008, the Wyoming Water Development Commission contracted with the team led by States West Water Resources to perform the Little Snake River Supplemental Storage Project, Level II Study. The overall purpose of this study is two-fold. The first is to review and revise hydrological models of the basin to bring the models up to date and get an accurate measure of the shortage and supply conditions. The second purpose of this study is to identify practical locations within the Savery-Little Snake Conservancy District (“District”) for a maximum of two reservoirs to augment the irrigation water supply within the District. The recently completed High Savery reservoir has yielded a larger supply of water than had been predicted and, while this reservoir serves a large number of water users, its geographic location and size prevents service to a significant number of other irrigators. Additionally, High Savery does not meet all of the shortages downstream of the facility. The District would like to construct a reservoir, or a combination of two reservoirs, that would increase the benefits to these users and others.

While the Little Snake River basin is one of the most widely studied basins, previous studies focused on larger reservoirs such as High Savery. This study has focused on smaller reservoirs. These reservoirs were selected based on previous reports as well as conversations with the District and WWDO.

The major components of this study are: the basin hydrology study; site identification and initial screening; preliminary design and cost estimates for the most feasible site(s); and Haggarty Creek in-stream dissolved copper investigation and fisheries investigation.

II. Little Snake River Basin Hydrological Model

Leonard Rice Engineers, Inc. (LRE) developed a historical consumptive use analysis and surface water allocation model representation of the Little Snake River. The historical consumptive use analysis defined crop demands and provided estimates of crop shortages. The surface water allocation model identified available flow and provided information regarding “why” crop demands are shorted.

Surface Water Model Results

The initial model scenario was run to develop an estimate of baseline irrigation shortages and water availability based on current conditions. The Baseline Scenario utilizes the irrigation water requirement for current irrigated acreage divided by the monthly efficiency as irrigation demands, and uses current High Savery Reservoir operations with releases to downstream water users. The simulated water availability was then used to help determine favorable locations for future reservoir sites.

Future scenarios were run with proposed reservoirs operating to store water under junior permits, with storage water then released to meet irrigation demands not satisfied by their respective permits. The future scenarios were run with one reservoir operating at a time, and the irrigation shortages from the future
scenario runs were compared to the baseline shortages to identify the extent of shortage reduction from operations of the proposed reservoir.

**III. Site Identification and Screening**

**Site Identification**

The identification of reservoir sites to be analyzed in this study was compiled from previous studies, input from the Project Sponsor, and map and field reconnaissance. This study concentrated on smaller storage sites than previous studies and resulted in sites not previously considered. The potential storage sites analyzed for this study are shown in Figure III-1. Each of the potential storage sites is discussed in detail in the following sections.

**Screening**

The screening of potential storage sites was facilitated by the use of a matrix that incorporated the important factors for reservoir feasibility. These factors are weighted to reflect the relative importance of the factors. Each reservoir site is then relatively rated for each factor on a scale from zero to ten. When a factor presents a “fatal flaw” – a characteristic that would make the project completely impractical or impossible – that factor was assigned a score of zero. The totaling of the ratings and weights results in a total score that allows for comparison of the overall suitability of the potential reservoir sites. The factors considered and the weights for screening were ability to meet needs, access, multiple use potential, geotechnical feasibility, land ownership, cultural resources, environmental impacts, ability to permit, and cost.

**IV. Preliminary Designs and Cost Estimates**

**Introduction**

The result of the initial screening process was the determination of the West Fork Battle Creek at Haggarty Creek site as the preferred site. This site scored 80% of the maximum number of possible points in the scoring matrix, while the next highest site scored 55% of the maximum number. Therefore, it was determined that the West Fork Battle Creek site would be the only site to proceed to the preliminary design stage.

**Dam Embankment**

Detailed surface geological and geotechnical mapping was performed at the site. Due to the rugged terrain of the site, drilling would have required the use of helicopters for equipment delivery and was not performed. One of the results of the geotechnical work was the determination of the recommended dam cross-section. Another result of the geotechnical work was the recommendation of two dam alignments. The sites were determined to be appropriate for roller compacted concrete (RCC) dams. Preliminary designs and cost estimates were developed from the recommendations presented in the geotechnical report. Preliminary designs and cost estimates were developed for four reservoir sizes: 4,000AF; 6,500AF; 8,500AF; and 10,000AF at the two recommended alignments.
Executive Summary

FIGURE III-1
POTENTIAL RESERVOIR SITES LOCATION MAP

- Battle Lake
- Haggarty Creek near Copperton Sites A and B
- West Fork Battle Creek and Haggarty Creek
- Upper Cottonwood Creek
- Lower Cottonwood Creek
- Upper Little Sandstone
- Sage Grouse Core Population Area
- Lower Little Sandstone
- Roaring Fork
- West Fork Battle Creek
- Haggarty Creek Near Copperton Sites A and B
- Lower Little Sandstone
- Big Gulch

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LITTLE SNAKE SUPPLEMENTAL STORAGE LEVEL II STUDY
<table>
<thead>
<tr>
<th>Site</th>
<th>Ability to Meet Needs</th>
<th>Access</th>
<th>Multiple Use Potential</th>
<th>Geotechnical Feasibility</th>
<th>Land Ownership</th>
<th>Cultural Resources</th>
<th>Environmental Impacts</th>
<th>Ability to Permit</th>
<th>Cost</th>
<th>Total Site Score</th>
<th>% of Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Gulch</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>590</td>
<td>39.3%</td>
</tr>
<tr>
<td>Lower Little Sandstone</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>600</td>
<td>40.0%</td>
</tr>
<tr>
<td>Upper Little Sandstone</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>830</td>
<td>55.3%</td>
</tr>
<tr>
<td>W. Fork Battle Creek</td>
<td>7</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>1200</td>
<td>80.0%</td>
</tr>
<tr>
<td>Haggarty Creek Near Copperton</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>780</td>
<td>52.0%</td>
</tr>
<tr>
<td>Battle Lake</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>610</td>
<td>40.7%</td>
</tr>
<tr>
<td>Lower Cottonwood Creek</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>780</td>
<td>52.0%</td>
</tr>
<tr>
<td>Upper Cottonwood Creek</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>670</td>
<td>44.7%</td>
</tr>
<tr>
<td>Roaring Fork Little Snake River</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>580</td>
<td>38.7%</td>
</tr>
</tbody>
</table>

Note: Maximum Total Site Score Possible = 1500

Factor Weight as % of Total: 20.0% 6.7% 13.3% 6.7% 6.7% 6.7% 13.3% 13.3% 13.3%

Probable fatal flaw or very unfavorable characteristic
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Figure IV-1: West Fork Battle Creek at Haggarty Creek
Northern Alignment Site Plan
**Outlet Works**

The primary components of the outlet works would be a gated multi-level concrete intake tower, a 42-inch concrete-encased outlet pipe and access adit, a control building with valves to regulate the outflow of water, and an aeration/energy dissipation structure.

**Spillway**

The spillways would consist of a cast-in-place concrete Ogee crest, a stepped chute integral to the RCC dam steps, and a grouted riprap stilling basin.

**Cost Estimates**

Cost estimates for the alternative dam locations and reservoir sizes were developed and are as follows.

<table>
<thead>
<tr>
<th>Reservoir Size</th>
<th>Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North</td>
</tr>
<tr>
<td>4,000AF</td>
<td>52</td>
</tr>
<tr>
<td>6,500AF</td>
<td>66</td>
</tr>
<tr>
<td>8,500AF</td>
<td>74</td>
</tr>
<tr>
<td>10,000AF</td>
<td>120</td>
</tr>
</tbody>
</table>

*Table IV-1 - Estimated Cost (in Millions of Dollars) – West Fork Battle Creek Site*

**V. Fisheries Analysis**

**Introduction**

A fisheries analysis was conducted at the West Fork Battle Creek at Haggarty Creek dam site. Specific issues addressed in the study included an instream flow study, macroinvertebrate evaluation, and metals analysis.

**Instream Flow Study**

An instream flow study was conducted on Haggerty Creek, Lost Creek, West Battle Creek and Battle Creek in areas with potential impacts from the proposed reservoir. The Habitat Retention Method was used to assist with determining base flows from which mitigation flows could be established, Physical Habitat Simulation System (PHABSIM) was used to determine fish flows during runoff, and natural flows were recommended during winter months from October through March. The resulting recommended flow rates are listed below.

<table>
<thead>
<tr>
<th>Location</th>
<th>Monthly Flow Recommendation (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oct</td>
</tr>
<tr>
<td>West Fork Battle Creek (Downstream of Dam)</td>
<td>5.6</td>
</tr>
<tr>
<td>Battle Creek</td>
<td>20.8</td>
</tr>
</tbody>
</table>

*Table V-1 - Recommended Minimum Flow Rates*
VI. Water Quality and Copper Mitigation

The preferred West Fork Battle Creek at Haggarty Creek site would be located approximately 7 miles downstream of the inactive Ferris-Haggarty Mine. This mine has impacted the stream ecology for over 100 years by discharging copper laden water to Haggarty Creek.

An extensive investigation was completed by Lidstone and Associates on the water quantity, quality, and biological effects of the copper on invertebrates in the stream. As with previous studies, it was determined that the copper discharge negatively affects aquatic life, including Colorado Cutthroat Trout. Lidstone and Associates (LA) explored options that could be incorporated into the storage project that would improve the fishery in the area by improving water quality.

LA recommended utilizing passive treatment options that would lower the copper concentrations to the EPA species mean acute level (SMAL) and should allow recovery of cutthroat trout downstream of the mine.

The implementation of the recommendations should revitalize the fishery from near the Ferris-Haggarty mine to the Belvidere Ditch diversion, a stream length of approximately 3.3 miles.

VII. Site Specific Hydrology and Reservoir Sizing

Introduction

The hydrological model described in Chapter 2 of this report was utilized to develop estimated operation conditions for the West Fork at Haggarty Creek reservoir site. This information was developed for the baseline condition with no reservoir and reservoir active irrigation (not total) capacities of 3,000AF, 5,000AF, and 8,000AF.

Reservoir Sizing

The hydrological model results were utilized to determine the optimum storage and operation of the proposed reservoir. The reservoir pool was divided into a permanent recreation pool, an irrigation supplemental supply pool, and a stream fishery pool. The model was utilized to verify the optimum size of the pools.

Irrigation Supplementary Supply Pool

The optimum size of the supplementary irrigation pool was determined to be approximately 5,000 acre-feet. This size of pool would yield approximately 2,500 to 3,000 acre-feet of irrigation supply on average. The model operates such that all shortages are met with storage. This results in complete draining of the irrigation pool by mid-August in dry years. The operation of the reservoir under those circumstances would probably be modified to deliver the storage water for a longer portion of the irrigation season.

Stream Fishery Pool

The hydrological model was utilized to determine the ability of the fishery storage pool to meet the recommended minimum flows downstream of the dam.
and reservoir and to size the pool. The optimum size of the fishery pool was determined to be 1,500 acre-feet.

Permanent Recreation Pool

The permanent recreation pool is normally assumed to be optimum at 25% to 30% of the storage pools. Based upon the recommended 5,000AF irrigation pool and 1,500AF fishery pool, the optimum recreation pool would be approximately 2,000AF.

Recommended Reservoir Size

Based on a 5,000AF supplemental irrigation pool, a 1,500AF fishery pool, and a 2,000AF recreation pool, the recommended size of reservoir is 8,500AF.

VIII. Conclusions and Recommendations

Recommended Project

The recommended total project storage of 8,500AF would result in a reservoir with the following parameters:

- Total Storage = 8,500 Acre-Feet
- Maximum Reservoir Area = 110 Acres
- Maximum Reservoir Depth = 240 Feet
- Minimum Storage = 2,000 Acre-Feet
- Minimum Reservoir Area = 40 Acres
- Minimum Reservoir Depth = 145 Feet
- Dam Crest Length = 700 Feet

The estimated total 2012 project cost would be $64 Million for a unit storage cost of approximately $7,000 per acre-foot.

IX. Purpose and Need

Purpose and Need Statement

The purpose of the West Fork Battle Creek reservoir would be to develop 3,000 acre-feet per year of average yield to the Upper Little Snake River water users for supplemental irrigation water supplies. The project would recover and improve portions of Haggarty Creek, West Fork Battle Creek, Battle Creek, and the Little Snake River.