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EXECUTIVE SUMMARY

GOOSEBERRY CREEK
LEVEL I STUDY

Prepared for:

Wyoming Water Development Commission
Cheyenne, Wyoming

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February 2007
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1.0 INTRODUCTION

The Wyoming Water Development Commission (WWDC) and the Project Sponsor, Gooseberry Irrigation District (District) retained Lidstone and Associates, Inc. (LA) to complete a Level II Study of the Gooseberry Creek watershed. The watershed is located in the Big Horn Basin with portions in Park, Hot Springs, and Washakie counties. Gooseberry Creek generally flows in an easterly direction, beginning with its headwaters in the Absaroka Range to its confluence with the Big Horn River south of Worland. Gooseberry Creek’s flow characteristics are typical of snowmelt driven systems with a high spring runoff peaking in mid-May to mid-June followed by a sharp drop in flow during the summer.

Historically, there has been a shortage of water to meet the mid to late season irrigation demand. This shortage of water has resulted in annual yields of approximately 1.5 tons per acre alfalfa/grass hay. Beginning with the Wyoming State Planning Board in the 1930s, a series of studies have been conducted to remedy this shortage. Results from these prior studies indicated that, on average, the watershed yield is sufficient to meet irrigation demands if it could be re-regulated. The prior Level I study completed by LA concurred with the findings of earlier studies, however, from an economic perspective it became apparent that the District could not financially support reservoir construction. Due to cost, several other alternatives to increase the water available during the irrigation season were also eliminated.

Based on the results of the Level I investigation, three options were open to further evaluation: (1) Irrigation System Upgrades, (2) Grass Creek Oil Field, and (3) Alluvial Ground Water. During the course of the Level II investigation other options were also evaluated. These included: (1) Increasing production from the Little Buffalo Basin Oil Field, (2) Deep abandoned oil well located near the upper District boundary, (3) Shallow aquifers, and (4) On-farm practices. This Level II study’s goals were to evaluate each of these options in order to increase the volume of available water within the Gooseberry drainage basin, in order to provide District members additional water for irrigation.

The District has indicated they are willing to pay a maximum of $25 per acre to fund projects to meet the goals set forth. If 80% of this assessment goes to debt payments, the maximum project cost the District can afford is $3.416 million dollars. This assumes that the WWDC provides a 67% grant to the District to help with the project as shown below in Table 1.

Table 1, Gooseberry Reservoir Site Economic Information

<table>
<thead>
<tr>
<th>Total Irrigated Acres</th>
<th>3200 Acres enrolled as of Sept. 7, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>80% Irrigated Acres Billed</td>
<td>2560 Equates to approximately 100 acres/member</td>
</tr>
<tr>
<td>Cost Per Acre</td>
<td>$25.00</td>
</tr>
<tr>
<td>Annual Income (100%)</td>
<td>$80,000.00 100% of Irrigated Acres Included</td>
</tr>
<tr>
<td>Annual Income (80%)</td>
<td>$64,000.00 80% of Irrigated Acres Included</td>
</tr>
<tr>
<td>Assumed Annual O&amp;M</td>
<td>20% of Annual Income</td>
</tr>
<tr>
<td>Annual O&amp;M (100%)</td>
<td>$16,000.00</td>
</tr>
<tr>
<td>Annual O&amp;M (80%)</td>
<td>$12,800.00</td>
</tr>
<tr>
<td>Funding Source (Loan %)</td>
<td>33%</td>
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<tr>
<td>Funding Source (Grant %)</td>
<td>67%</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>4.00%</td>
</tr>
<tr>
<td>Loan Maturity</td>
<td>30 Years</td>
</tr>
<tr>
<td>Maximum Loan Amount</td>
<td>$1,127,440.57 100% of Irrigated Acres Included</td>
</tr>
<tr>
<td>Maximum Project</td>
<td>$3,416,486.58</td>
</tr>
</tbody>
</table>
2.0 GROUND WATER

Five ground water options were analyzed as part of the Level II investigation. These options include: (1) Develop an abandoned oil well located at the head of the District, known as Red Ridge 2-1, (2) Acquire water the from the Grass Creek Oil Field, (3) Request Citation Oil Company increase production from the Little Buffalo Basin Oil Field, (4) Develop a well field in the Gooseberry Creek Alluvial Aquifer, and (5) Develop a well field in the Tertiary aquifer system. Each option is described below.

Red Ridge 2-1

Red Ridge 2-1 is an abandoned oil well that never produced and is located just east of the Meeteetse Highway. Completion records for the well were obtained from the Wyoming Oil and Gas Commission Database and indicate that drilling was stopped approximately 14,000 feet below ground surface. Based on the driller’s log, the top 4,800 feet of the well were cased with the remaining portion being an open hole completion, running from the top of the Cody Formation to the Amsden. Within this column, only the Tensleep Formation has been documented as a major water producer. Due to the depth at which the Tensleep was encountered, it is anticipated that overall yield would be low. Water quality sampling results were obtained from the Bureau of Land Management’s Worland Field Office and indicated that the well produced water of marginal irrigation quality due to elevated sulfate levels and a moderate Sodium Absorption Ratio. Due to the lack of production data and marginal water quality, Red Ridge 2-1 was discounted as being a viable substantial source of supply.

Grass Creek Oil Field

The Level I study (LA, 2005) identified the discharge water associated with production from the Grass Creek Oil Field as a potential source of supply. LA contacted Marathon Oil and was informed that of the 170,000 barrels being produced per day 150,000 barrels were being re-injected to assist with production. This activity left only 20,000 barrels or approximately 580 gpm (1.3 cfs) available for diversion. The reduced supply of readily available water did not make the option as attractive as originally thought under the Level I study. LA also obtained water quality sampling results for the discharge water and determined that due to high sodium, sulfate, and total dissolved solids levels that this water was not acceptable for irrigation purposes.

Little Buffalo Basin Oil Field

During a meeting with the District in June 2006, several members requested LA to evaluate the potential for requesting Citation Oil Company to increase their discharges to Buffalo Creek. LA obtained water quality sampling results from four production wells in the Little Buffalo Basin Oilfield and determined that while the water quality generally does not appear to be as poor as that measured in the Grass Creek Field, the quality of the produced water is far from the best to be applied for irrigation water. Field observations during the week of June 28, 2006 indicated that there was approximately four cubic feet per second (cfs) in Buffalo Creek at the point where it crosses under Wyoming Highway 120; there was no flow at the first diversion point downstream of the confluence of Gooseberry and Buffalo Creeks. This observation indicated that even if production were increased, seepage and evaporative losses would eliminate its potential for irrigation use. Based on poor quality and lack of availability, this ground water option was eliminated from consideration.
Gooseberry Creek Alluvial Aquifer

Data compiled for alluvial wells in the Bighorn Basin indicated that specific capacities ranged from 0.5 to 25 gpm/ft and have an average yield of 33 gpm. Although this pumping rate is relatively low for irrigation purposes, LA thought that it could be sufficient to irrigate small land areas or if a battery of alluvial wells could be developed, run a small sprinkler system. To evaluate this alternative, two alluvial wells were completed; one upstream and one downstream of the Gooseberry and Buffalo Creek confluence. The purpose of the investigation was to evaluate expected pumping volumes and the second was to investigate the potential influence of Little Buffalo Basin oil field discharges on water quality. Aquifer testing results indicated that production was probably limited to a maximum of five gpm at the upstream location and declined significantly proceeding downstream. Water quality was found to be generally acceptable for irrigation at the upstream well, but did not meet livestock standards at the downstream location. Quantity and quality were reasons for removing this option from future consideration as a supply source.

Tertiary Aquifer System

The majority of domestic wells within the District appeared to be completed in the Tertiary Aquifer system consisting of the Willwood and Fort Union formations. Because this aquifer system serves as a domestic supply source with no treatment, water quality was assumed to be acceptable for agricultural use. LA completed an abbreviated aquifer test of a domestic well in the Willwood Formation and estimated a specific capacity of 0.17 gpm/ft, which was close to the mean value of 0.4 gpm/ft reported in the literature. Aside from limited production rates when considering an irrigation use, the other significant problem with the Tertiary formations as an irrigation water source is the discontinuity of the sandstone lenses, which are the primary water bearing units within these formations. Due to this condition, there is a distinct probability that a Tertiary completion may not even produce 30 to 40 gpm, a flow rate capable of running a small big gun sprinkler.

3.0 SYSTEM IMPROVEMENT

The Level I (2005) and II (2006) site investigations identified several problems with the existing delivery system, ranging from the poor condition of several diversion structures to substantial seepage losses. Sedimentation is also a significant issue, especially at the lower end of the District, and results in substantial maintenance problems. Much of the sedimentation problem is directly correlated to the orientation of the diversion dam/check structure to the headgate. The diversion dam endpoint is generally tied to the immediate downstream edge of the diversion and is angled to direct creek flow into the headgate. To address all of these issues a variety of options were investigated.

LA recommended that the diversion dams be relocated to a point approximately 30 feet downstream of the diversion. The suggested configuration of the diversion dam would resemble a compound weir. By moving the diversion dam downstream, water flowing into the diversion does so through backwater and the area between the headgate and diversion dam serves as a settling basin. Utilizing a compound weir as a diversion structure will allow the deposited sediment to be sluiced downstream on a frequent basis. This type of system should reduce the current maintenance levels significantly.

In addition to rehabilitation of diversion structures and headgates, LA investigated several options to limit seepage losses and improve overall system efficiency. These options included:
(1) Pipelines, (2) Concrete liners, (3) Buried geosynthetic clay liners, (4) Polymer application, (5) Exposed geomembrane liners, and (6) Combining headgates to reduce ditch length.

Pipelines are close to 100% efficient in conveying flows, have a relatively long life, and are reasonably cost effective. As described previously, sedimentation is a significant issue with the system and reconfiguration of the diversion system should substantially eliminate loading. However, given the relatively shallow slope of the pipeline routes and some uncertainties regarding sediment loading, the pipelines could become plugged with sediment and therefore eliminated from future consideration.

Concrete lining of ditches was eliminated from consideration due to the high cost and the reduced efficiency with time because of cracking. Geosynthetic clay liners were eliminated because of the often short periods of time when flow is occurring. These liner systems function by being hydrated and causing the bentonitic clays to swell and therefore seal. Swelling is not an action that occurs instantaneously, which in the Gooseberry Creek delivery system could result in continued significant seepage losses for an extended period of time. For these reasons, this system was eliminated from further consideration.

Polymer application has been used in several irrigation districts to reduce seepage losses. The polymer acts as a flocculent, causing the suspended sediment to settle, and thereby sealing the ditch. While the product is fairly inexpensive, it must be applied annually and as a result is not a permanent solution to the seepage loss problem. For these reasons, polymers were eliminated from further consideration as a District-wide solution. There are a variety of geomembranes available on the market, such as PVC, HDPE, and EPDM. From these three liner systems, EPDM is the easiest to install because seaming does not require specialized equipment and it is the most flexible of the three, reducing the potential for puncture.

A previous study prepared in 1984 by the Natural Resource Conservation Service suggested that system efficiency could be improve by reducing the number of diversions and overall ditch length, which in turn would reduce seepage losses as well as lessen impacts to channel morphology. Much of the work completed under this study is still applicable today and LA recommended combining a number of ditches and reducing the number of diversion points from 20 to 9. This effort would eliminate approximately seven miles of ditch thereby reducing seepage losses. Additional water savings could also be gained by the need to divert less water initially and reducing the seepage loss associated with the Creek. Maintenance costs would also be reduced because of the reduction in the number of diversion points.

4.0 ALTERNATE CROPS

Since 2000, the District has been experiencing the affects of continued drought and the limited availability of irrigation water. LA discussions with several area residents and observations of old farm equipment indicated that crops other than alfalfa had been raised in the District in past years. Many of these crops require less irrigation water than alfalfa. LA also investigated some alternative seed mixtures to convert a portion of the currently irrigated lands to dryland pasture that could be irrigated at times when water supplies are not limited. While conversion of irrigated hayland to dryland pasture does not increase water supply, it has the potential to increase the overall production of a District member’s operation.

5.0 RECOMMENDATIONS

Analyses performed through the Level II investigation indicated that there was no single source available to increase the overall supply of irrigation water. From a District perspective, the best
opportunity to increase supply is by decreasing the losses in the system. LA recommended that this be accomplished by combining and lining ditches. The following outlines the basic of the proposed plan;

- **Star Ditch:** Replace diversion dam and headgate, line one mile of ditch
- **Quartz Ditch:** Line one mile of ditch and rebuild overflow
- **Quartz Enlargement:** Replace headgate and wasteway, line 1.25 miles of ditch
- **Combine Morton, Murphy, Perkins, and Steele ditches using the Murphy diversion**
  - Rebuild and enlarge Murphy headgate and rebuild the diversion dam
  - Construct an inverted siphon to connect the Murphy to the Morton
  - Enlarge 5.8 miles of ditch to add required capacity
  - Line 2.5 miles of ditch
  - Install required measuring and flow diversion (splitter) structures
- **Combine Homestead, Holder, Holly-Nichols, and Holland ditches using the Homestead diversion**
  - Rebuild and enlarge Homestead headgate and rebuild the diversion dam
  - Enlarge 7.2 miles of ditch to add required capacity
  - Line 1.0 miles of ditch
  - Install required measuring and flow diversion (splitter) structures
- **Combine North Sunnyside, Toyne and Blake-Denton ditches using the North Sunnyside diversion**
  - Rebuild and enlarge North Sunnyside headgate and rebuild the diversion dam
  - Enlarge 4.5 miles of ditch to add required capacity
  - Line 2.5 miles of ditch
  - Install required measuring and flow diversion (splitter) structures
- **Combine the South Sunnyside and Warren Ditches using the South Sunnyside diversion**
  - Rebuild and enlarge South Sunnyside headgate and rebuild the diversion dam
  - Enlarge 1.0 miles of ditch to add required capacity
  - Line 2.5 miles of ditch
  - Install required measuring and flow diversion (splitter) structures

The total estimated cost for the proposed project is **$2,511,000.00**. The project cost is substantially less than what was deemed affordable by the economic analysis. Based on the current WWDC grant – loan split of 67% and 33%, respectively, the District would need to borrow $828,630.00. Assuming a 30-year loan at four percent, each of the 25 members would be responsible for an annual payment to the District of approximately $1,917.00. This payment does not include any monies for basic District Operations and Maintenance (O&M) costs. To address this issue, it is suggested that the annual District payment be raised to $2,400.00. The payment allocation would be approximately 80% toward debt retirement and 20% to O&M costs. Excluding lands irrigated by the Mahan Ditch and using the irrigated lands mapping from the Wind-Bighorn River Basin Master Plan, there are approximately 2,934 acres under irrigation.
Assuming the entire project is built as presented and the entire District participates, this equates to an annual assessment of $20.40 per acre, which is slightly less than the initial maximum of $25.00 per acre established by the District in 2005.

6.0 CONCLUSIONS

Success of the proposed project is entirely dependent on complete cooperation within the District. Obviously, the members that are located at the upper end of the District and with the most senior water rights could potentially receive greater benefit than those at the lower end of the system. Thus, the success of increasing efficiency is dependent on complete cooperation amongst the District members to ensure each has a reasonable chance of obtaining water every year. There will be instances such as this summer (2006) when creek flows are low and members with the more junior rights may not receive water. This situation may not be acceptable to some District members since they will still be responsible for their portion of the annual assessment.

It is possible for some District members to proceed forward with a WWDC funded project and others to not, provided a reasonable project can be developed. The project would still be subject to the same funding split of 67% grant and 33% loan (match). The match portion can consist of a WWDC loan, cash match from the District, or funding from another outside source, such as the NRCS. If a WWDC loan is used for the match portion of the project funding, the District could choose to only assess those members that opted to proceed with a project. However, from the WWDC perspective the entire District is still responsible for the loan.

As stated above, implementing a project to improve system efficiency does not provide any guarantee that water will be available every year for every District member. Because of this and other liability reasons cited above, the District may not decide to proceed forward with a project. Nevertheless, there are still several upgrades that individuals could implement to increase the overall productivity of their property. Some of these measures could be eligible for funding through the NRCS’s EQIP program. These upgrades include:

- Converting some irrigated hay meadow into dryland pasture;
- Drilling a well and irrigating a small area (e.g., 20 to 40 acres) using a big gun sprinkler;
- Lining sections of ditch to decrease seepage losses; and,
- Applying PAM or HydroGel to seal the ditch bottoms and reduce seepage losses.

While the recommended project will result in more water being available to the District, it does not address the shortage of late season water or afford any extended protection to the District during drought. For these reasons, it is recommended that the District convert some of its existing irrigated hayland to dryland pasture/hay meadow. Converting some irrigated land to dryland, which can be irrigated if “excess” water is available, should increase overall production. The conversion allows for the focus of available water on parcels that are identified to be the most productive. By having a mixture of irrigated and dryland, the overall production on each District members property should increase over the existing condition.