PHASE I REPORT

I. Introduction

The Green River Supply Canal (GRSC) diverts from Pooles Slough, a branch of and probable former meander, of the Green River. Within the GRSC district there are 7,286.1 acres and the land is described as relatively arid and high in elevation. The primary use of irrigated land within the district is production of forage for livestock. The most prominent crop is grass hay, with some alfalfa hay.

On June 18, 2002, Nelson Engineering received notice to proceed on work under contract with the Wyoming Water Development Commission (WWDC) relative to the GRSC. The main objectives of the work were to study land ownership and mapping, water supply versus water uses and demands, seepage loss and conveyance problems, operational issues, such as water management and measurement, diversion structure and structures inventory, erosion concerns, and irrigator problems and issues related to water delivery. Phase 1 report presents the findings of the study conducted from June 2002 to November 2003.

II. Water Needs and Land Ownership

Under Wyoming water law, which is administered by the Wyoming State Engineer, the GRSC district should be able to deliver 1 CFS per 70 acres of direct or supplemental flow. For the 7,286.1 acres of water rights within the district, this flow would be 104.1 CFS. Wyoming also allows for double appropriation under flood flow conditions, which would be 208.2 CFS. The GRSC is currently able to transport about 150 CFS.

In order for the GRSC to supply any new irrigated land within the district, enlargement of the canal would be necessary. This would exacerbate seepage loss and be costly relative to the gain of lands.

There are lands that are currently irrigated by the GRSC waters and are not listed as being within the district. A boundary change and proper legal work should be done to include these lands.

Water needs include water lost to seepage, evaporation and transpiration. Cumulative loss of GRSC is high, probably 50%. Because of this, a good management plan is required to adequately divide the available water among district irrigators.

III. Inventory

Nelson Engineering began field inventory on July 1, 2002. It began at the diversion of the canal from Pooles Slough. Each structure was given a worksheet/waypoint number, and the longitude and latitude for each was recorded so that they would all be included in the GIS map and database of the system. Each structure was then inspected for sufficiency, remaining life, condition of different elements, condition of the canal before and after the structure, and safety. Also inventoried were all lateral and farm turnouts, previously identified and marked seepage areas, areas of low bank, bank failure and excessive vegetation and all major laterals for the canal.

IV. Flow Measurement, Seepage Losses

Flow Measurement

Methods

Nelson Engineering measured and monitored flows in waterways pertinent to the operation of the GRSC during the 2002 and 2003 irrigation seasons. Flow measurements were taken in Pooles Slough, the GRSC, the Cottonwood Creeks, and the laterals diverting from the GRSC. The purpose of gauging and recording of the GRSC system are to understand the overall disbursement of water and to attempt to identify seepage areas and quantify seepage losses. Two methods were used, flow gauging and flow monitoring.
Flow gauging is conducted using a current meter to measure canal flow at a given point. Using this methodology and assuming that a reach of the canal has conditions reasonably close to uniform flow, an accuracy of plus or minus 5% can be achieved. When flow measurements are taken at the same location at a range of flows, a relationship or rating curve can be created.

There were eight flow-monitoring stations set up along the canal prior to the 2003 irrigation season, each of which consisted of Stevens chart recorder and staff gauges. Nelson Engineering personnel provided maintenance of the stations and recorded staff gauge readings on a periodic basis.

Data Analysis

In order to analyze the data recorded at each station, rating curves were constructed using the flow gauging measurements. The rating curves used linear, logarithmic, and exponential best-fit curves. Due to the unpredictability of the canal, it was difficult to obtain the highest and lowest range of flows. Therefore, extrapolation was used to come up with these. The average estimated error associated with the curves is ±5% within the range of flows gauged at each station. Data collection had some errors, including mechanical problems with Station #4 and placement of Station #3.

Findings

The analysis of the flow monitoring and flow gauging is discussed with respect to three different reaches.

Reach #1: Upper Canal

There were four flow monitoring stations in this reach. The highest flows recorded in this reach occurred downstream at Stations #2 and #3 from late May through late July. Since there is no source of inflow between stations #2 and #3, this indicates that 70 to 80 CFS of inflow is occurring in between stations #1 and #2. Other sources of inflow from late May to late July, in this reach, are ditches that divert from Pooles Slough, including Danielson, Woods, Sutton #1, and Slate ditches. After Mid-July, it was apparent that there was almost no inflow, which indicates that they are shut down for haying in late July.

The first major diversion in the canal (Andrikopoulos Lateral) is located just downstream of Station #3. The staff gauge readings taken over the irrigation season during site visits indicate that flows in this lateral were maintained in the range from 19 to 26 CFS from May until mid September, with most readings indication flows of about 21 CFS.

In May and June, total irrigation usage and seepage losses between Station #2 and Station #4 was at approximately 90 CFS. Both decrease after mid-July, which is most likely due to the Glen Millards property being shut off.

Reach #2: Cottonwood Creeks Transit

Just as in Reach #1, there were four flow monitoring stations in this reach. Flow data was collected on three occasions for the channels of concern within this reach. The data collected at the four stations indicates that there is a net gain of water into the GRSC across the Cottonwood Transit during high water on the Cottonwood Creeks. This period occurred from mid-May through late June in 2003. From late June through mid-August, a small net gain was indicated across the Cottonwood Transit. Overall, it is reasonable to conclude that a significant amount of recharge to the GRSC occurs in this reach. However, since the source of inflow is water from the upgradient irrigation ditches, if these are shut off, there is little gain or loss in the GRSC across this reach.

Reach #3: Lower Canal

There were two flow-monitoring stations in this reach. At the second station within this reach (Point of Diversion of Earl Wright’s Lateral), flows were relatively constant, which indicates that the irrigators in this reach used less water as less water became available. Overall, the usage and losses between the two stations ranged from 30 to 40 CFS in June, gradually decreased to 25 CFS in mid July and by early August, decreased to 10 CFS.

During the 2003 season, GRSC flows reached the end of the canal until about mid-July. Some water was conveyed to the lower reaches of the canal throughout most of the irrigation season.
Seepage

General
There was two phases to the assessment of seepage losses from the GRSC. The first phase was to use aerial photos, information from landowners and irrigators, and visual evidence from a field inspection of the canal. This identified where seepage loss was significant. The second phase consisted of monitoring and measuring flows in sections of the canal identified in the first phase of the study.

Methods
Phase 1: Field Observations and Landowner Information
NE and a geological engineer from a sub-consultant conducted a geological field inspection of the canal during the first week of July 2002. This inspection indicated the severity of seepage loss in the various parts of the canal.
Visual evidence of seepage noted included standing water, sub-irrigated vegetation, running water in draws down slope from the canal, boils or seeps, and alkaline deposits. Aerial photography, and information provided by landowners and irrigators also provided invaluable information on areas of significant seepage.
Excessive seepage has damaged the lower dike in several locations and will cause failure in these locations if not repaired. Two additional areas are also exhibiting extensive tension cracks accompanied by seepage and also need to be repaired.

Phase 2: Flow Gauging and Flow Monitoring
Flow gauging was conducted in the reaches of the canal that were suspected of high seepage loss. Although some of the loss observed during flow gauging is due to evaportranspiration and evaporation, the percentage of loss is believed to be small in comparison to seepage.

Analysis
Seepage was analyzed at four locations: Canal above Andrikopoulos Lateral, Soap Hole Basin, Cottonwood Transit, and the Lower Canal. The overall conclusions of this analysis, was that the GRSC suffers from significant loss due to seepage, especially in the Soap Hole Basin. In dry years, and/or when upgradient ditches located in the Green River and Cottonwood Creek valleys do not supply the canal with significant inflows, seepage losses become critical. When water is scarce, seepage losses are likely large enough to impact the ability of the canal to supply allocated water to all users, in particular users farthest down canal.

V. Point of Diversion
Point of Diversion for GRSC is from Pooles Slough, however, Pooles Slough gets water from the Green River proper at a point in Seven Mile River Ranch. Regulation of the ranch is accomplished by stop logs in a double culvert made of two old boiler sections and is very difficult to operate. The length of flow in Pooles Slough is approximately three miles.
The land at the diversion from Green River to Pooles Slough was once a historic cattle ranch and the owners have cooperated with the GRSC in providing the desired flow into Pooles Slough. However, the ranch has been sold and subdivided to wealthy individuals as a “fisherman’s paradise.” Although the current ranch management says they will continue to operate in the harmony with the GRSC, the possibility of conflict between ideal fishing flow and flow needed for irrigation is obvious.
There are three alternatives to this problem:
1. Obtain a written agreement from the ranch allowing for participation in the management of the flow of Pooles Slough. This agreement would define the flow requirements of the GRSC and acknowledge rights of access and management of GRSC personnel.
2. Petition the Wyoming State Engineers Office for a change of point of diversion and means of conveyance. The point of diversion would change to the diversion from Green River to
Pooles Slough and the means of conveyance change would name Pooles Slough as a conveyance.

3. Petition for and construct a change of point of diversion and means of conveyance to a point on the Green River below the mouth of Pooles Slough. GRSC and Soaphole Ditch would then no longer be responsible for the management of Pooles Slough, but it would require the cooperative management of the GRSC and Soaphole Ditch. Requirements of this alternative, which is the most desirable, but also the most expensive, would be obtaining land rights from the owners, construction of a diversion structure on the Green River, construction of a mile or more of canal and construction of a bifurcation structure for turning part of the flow into Soaphole Ditch.

VI. Water Storage

Due to irrigators along Cottonwood Creek often experiencing shortages of water in the latter part of irrigation seasons, water storage was researched. The two studies reviewed were the “Green River Basin Plan” and the “Green River Groundwater Recharge and Alternate Storage, Level 1 Project.” Of the reservoir sites listed in the two reports, only sixteen were applicable to GRSC irrigators.

Of all of the sites indicated as applicable, all but the Cottonwood sites would require that the Green River be a means of conveyance. Since the Green River does not suffer potential irrigation shortages at GRSC point of diversion, these sites become unnecessary unless the GRSC is anticipated to become significantly larger.

In the “Recharge and Alternate Storage Level 1” report, the unit cost per acre-feet (a.f) for seven reservoirs was considered and the average cost was $3,850/a.f. At that rate, the South Cottonwood Reservoir, which is 6,000 acre-feet, would cost $23,104,285.00, which is prohibitive without substantial assistance from the WWDC.

VII. Proposed Rehabilitation Work and Cost Estimation

Safety Problems

Two structures, at Andikopoulos lateral and at Diversion from South Cottonwood, the access walkways are unsafe. These two walkways would cost approximately $6,340 to repair. At South Cottonwood, a gate wheel and minor steel repair work is needed, which would cost approximately $400. Total Cost of all Safety Problems is approximately $6,740.

Obligations/Necessities

GRSC’s obligation is to replace failed underdrains that are necessary to maintain irrigation patterns in existence before the canal was built. Also, the GRSC must replace failed underdrains that do not function and/or provide points of leakage loss. There are approximately six underdrains that need to be replaced with a total estimated cost at $51,510.

Potential Washouts

Low dike areas, seepage boils and tension fractures represent potential washout and loss of irrigation time for all down-canal users. The estimated cost of potential washouts with the cost of a barrow of dirt at $8.00/yard^3 would be $29,971.26.

Seepage Loss/Lining

Seepage losses occur over the full length of the GRSC, but some areas are higher than others. Therefore, due to the high cost of lining when using bentonite or ERDM membrane, only the high seepage areas have been proposed as lined.

There are approximately three miles, or 16,000 feet of high seepage areas on the canal in the Soap Hole. Lining these areas would greatly increase the efficiency of the canal and allow down canal users to receive water in times of shortage. The cost of various types of lining per linear foot was obtained from the Bureau of Reclamation demonstration project published in 2001. These costs are as follows:

- Geomembranes, PVC, HDPE, Hypalon, VDPE = $25-$35/LF which would be $480,000± for 16,000 LF
• Roller Compacted Concrete/Shotcrete = $50-$60/LF, which would be $880,000± for 16,000 LF
• Geocomposite Clay Liner (Bentomat) = $20-$30/LF, which would be $400,000± for 16,000 LF

Main Diversion
The main diversion structure, no matter where placed, is an expensive structure. The cost of the diversion is based on Nelson Engineering’s experience in construction of a similar structure from Shoshone River to Hunt Canal. This price is $263,000.

Other Expenses
• Engineering = $75,000
• Contingencies: Legal & Administrative = $165,250

Total Rehabilitation Work Cost = $991,500
• Approximate WWDC Grant = $495,750
• Approximate WWDC Loan (Low Interest) = $495,750

VIII. Operation and Maintenance Recommendations

Proportion Water Quantities
During the irrigation season of 2003, there was sufficient water in the upper canal until around August 16th, after which there was not a full 1 cfs per 70 acres of the district. The water at the beginning of the season is provided by direct diversion from Pooles Slough and return flow from irrigation above the canal. The shortage after August 16th would be even greater in a year of less runoff. Similar activity occurs below Cottonwood Creek, in which adequate water is provided from direct diversion and return flow from Jigger Ditch and El Rancho Ditch until August, followed by a shortage, which could again be more severe in other years.

Another problem is that all lands in the portion of the district referred to as Wright Lateral are at a shortage because only at one point during the season did the needed amount of water reach this point.

The table located on page VIII-2 of the Phase I report summarizes a way in which to more equitably proportion the water, both during periods of surplus and shortage. The table presents a ratio by which the volume of water should be proportioned at each of eight nodes along the system.

Phraetiphite Loss, Willows, and Trees
Studies, made in the 1980’s, by Bob Burman, a professor of Agriculture/Engineering at the University of Wyoming indicate that the average cottonwood tree releases, through transpiration, over 250 gallons of water per day into the atmosphere and an average willow, half that amount. These trees, although aesthetically pleasing, are competing for the district’s water and in all future maintenance and cleaning operations, sections of the canal with heavy tree and willow growth should be given precedence and all willows and trees removed. If an owner wants or needs tree and willow growth, the growth should happen on his share of water.

SEEPAGE STUDY REPORT

I. Background

Prior Study
As was discussed in the Phase I report, major seepage occurred in the Soap Hole Basin. The seepage occurred in three major areas, which are referred to in this study as reaches 1,2, and 3.

Nelson Engineering Learns of Polyacrylamides
In the spring of 2003, Frank Grimes, vice president of Nelson Engineering, attended a meeting in Nebraska in which he learned of the use of polyacrylamides (polymer) as a means of reducing seepage from canals. In theory, the polyacrylamide causes a tightly bonded film of flocculent to form on the canal bottom and thus reduces water penetration through the bottom.

After discussing this new found idea and doing further research on it, it became apparent that it had very limited trial in Wyoming, but was by far less expensive than any other method of reducing seepage. In the fall
of 2003, the GRSC and Nelson Engineering applied for WWDC funding for a test project on the Green River Supply Canal.

Study Plan

A section of the GRSC would be used to test the efficacy of anionic polyacrylamides as a canal sealant. Testing protocols would differ by utilizing more than one polymer compound, utilizing higher and lower application rates, and in the method of polymer application.

The test reaches are those that were identified in the Phase I report as reaches with high seepage loss. Differing test protocols would be used in each seepage reach, with polymer applications being surficial in reaches #2 and #3 and infused into the canal flow in reach #1.

Reach #1

The canal was not cleaned in this section and the effectiveness of sealing in the section would be done using CIBA and Exacto products. The point of insertion would be immediately upstream of the control structure below the Lateral #1 diversion and the product would be in the form of pellets or block that dissolve at a predetermined rate or liquid dripped into the flow. Turbidity testing would be conducted as the polymer was inserted into this section and jar testing (consists of measuring the flocculating abilities of polymer at differing concentrations using turbid water) was considered, but found to not be necessary.

Reach #2 & 3

Testing Protocol was the same for both of these reaches. The difference was that Reach #3 would be cleaned and Reach #2 would not be. Initially, field-testing would consist of applying polymer to the canal bed and sides with a hydromulcher in concentrations determined by hydraulic conductivity testing and manufacturers recommendations. Exacto product would be used in Reach #2 and Ciba in Reach #3. If visible seepage occurred in these reaches during the irrigation season, additional polymer applications would be conducted, however, in season, the polymer applications would be conducted using the same method that was used in Reach #1.

II. Preparation and Polymer Application

Permeability Testing Procedures

Several lab tests were performed to determine the optimal amount and the effectiveness of the two different polymers used in Reach #2 and #3. Modified Falling Head Hydraulic Conductivity tests were performed on undisturbed soil samples from the canal bottom. The test specimens were sections of four-inch diameter pipe driven into the canal bottom or bank approximately ten inches. Ten samples were collected at various locations of the three reaches and the soil type varied from sand to a silty clay.

The soils were subjected to a standard falling hydraulic conductivity test. Tests were first conducted on untreated soil and then tested once they had been treated with two polymers, either “Exacto” or “CIBA.” Six of the samples were determined to have low baseline permeability due to the presence of low permeability clay in them. From the remaining four samples, the polymer provided by “Exacto” was easier to use and a better seal on porous soil. The “CIBA” polymer did not provide a homogeneous layer of polymer across the entire surface area, resulting in “drain holes” where water could escape. The tests also indicated that the primary avenue of seepage is lateral, through the down land canal bank, not vertical.

Proposed Lab Test Improvements

The most apparent problem was trying to replicate several acres of canal surface with a four-inch diameter circle. The solution to this is to use a five-gallon bucket with the bottom cut out for free drainage.

Proper draining of the sample tubes was another problem. To allow unrestricted flow, several methods were attempted including geo-textiles and cheesecloth wrapped around the tube bottom and seating the sample in a bed of coarse sand. A combination of geo-textiles and bedding sands was found to work best.

A third problem was found to be applying polymers to the surface uniformly through a long tube. The optimum height of the sample tubes was found to be about 10 inches from the soil. However, on six of the samples, a layer of low permeability clays was 8 inches from the surface and the polymer did not decrease
An important note is that with the existence of low permeability clays, canal seepage is likely through the down gradient bank, not the bottom.

**Canal Cleaning**

In order to clean reach #3, a caterpillar track hoe was utilized and cleaning resulted in approximately 3:1 side slopes on each bank. Vegetation was removed and the bottom brought to a fairly uniform grade. This process noticeably improved the operating characteristics of the reach.

**Chemical Application**

**Hydromulching**

The Exacto Chemical Company product that was applied to reach #2 was done so using a hydromulch applicator that had a 400 gallon tank. The product from this company was in a liquid form with a syrup-like viscosity and required extensive mixing to dilute. Once the product was mixed completely in the tank, it was sprayed onto the canal using a relatively small nozzle in order to ensure consistent coverage. One tank load covers 300 to 350 feet of 20-foot wide canal and takes 20 to 30 minutes. The application process takes four people to do. Overall, the application process went smoothly, but took much longer than anticipated.

Using the same equipment, the Ciba Chemical Company’s Product was applied to Reach #3. The product was furnished in a pellet form and mixed by the hydromulch agitator, which took even longer than the mixing of the “Exacto” product. The product also appeared to build up in the mix tank, which required a full flush of the tank to prevent it from becoming jammed. Overall, the product was much more difficult and time consuming to work with than the similar “Exacto” product. However, due to the cleaning of reach #3, it was much easier to uniformly cover the bank with the solution as well as keep the hose free of obstacles.

Both products, if the hydromulch machine, crew and water truck are on an hourly basis, can add significantly to the cost.

**Infusion of Polymer**

**Flow Induced Polymer Introduction**

Two forms of polymer were introduced into the canal once the flow was turned on. The purpose of this is to settle any sediment suspended in the flow of the canal. Both forms of polymer were manufactured by Ciba, one of which was in the liquid form and the other an egg shaped “biscuit.”

On June 15th, the liquid polymer was dripped into canal in several locations through the use of a stopcock valve. The consistency of the material caused the valve to become plugged after 40 to 120 minutes. When an attempt was made to dilute the liquid polymer in order to add it at a lower concentration, it was determined that this was extremely difficult, as it turned to a “goo” like consistency.

The “biscuit” polymer was not received until July, which resulted in a minimal amount of flocculation due to the fact that spring run off had ended and there was little sediment in the canal. The biscuits were placed in a mesh bag and two mesh bags were put at each location. These bags were filled at least two times a week. It was difficult to tell if any flocculation occurred due to the low dosage rate and lack of turbidity in the water, however, the injection of polymer was effective in reducing seepage in all three reaches.

**III. Data Collection & Analysis**

In order to determine the effect of the polyacrylamide application on the seepage from the canal, Nelson Engineering collected flow, turbidity, and groundwater elevation data in the test reaches during the spring and summer of 2004.

**Flow Measurements and Seepage Loss Measurements**

The two methods used for measuring flow were flow gauging and flow monitoring. The flow recorder data was used to provide an overall picture of the flow regime and the flow gauging data was used to determine seepage in the test reaches and thus to determine the efficiency of the polyacrylamide in the test reaches.

The flow monitoring stations were installed to record a continuous record of flows at the upper and lower ends of the seepage study areas.
Rating curves were constructed using the flow gauging measurements at each station, however due to the unpredictability of the day to day canal operations and inflows during snowmelt, neither the highest nor lowest range of flows was measured. Therefore, engineering judgment was used to extrapolate this data.

**Monitoring Well Data Collection and Analysis**

Monitoring wells were installed down-gradient of the canal, at the beginning and end of each reach of the test area, resulting in a total of six locations. The monitoring wells consisted of 4” diameter perforated PVC pipes wrapped in geotextile to prevent sediment deposition in the well.

From the monitoring well data, it was concluded that the seepage flow rate from the canal to down gradient areas was large enough to raise the local groundwater elevation to the ground surface for most of the irrigation system. Therefore, neither a qualitative nor a quantitative determination of seepage reduction due to polyacrylamide application could be made using this data.

**Turbidity Measurements**

Turbidity of the surface water was very low throughout the season. It was measured in various locations throughout the canal. In reach #1, it was measured every 300 feet downstream of the insertion point and in reaches #2 and #3, turbidity testing was performed on a weekly basis at four evenly spaced intervals.

It was noted that turbidity increased through the three reaches. With this finding, it was concluded that turbidity reduction could not be utilized as a measure of polymer effectiveness, on GRSC.

**IV. Results, Cost, and Benefits**

From the data collected, the average reduction of seepage across the three reaches was 9.5 cfs when comparing summer of 2004 with the prior year. The average value per reach is as follows: Reach #1 = 3.7 cfs per 0.85 mile, Reach #2 = 0.3 cfs per 0.88 mile, and Reach #3 = 5.5 cfs per 1.45 mile.

In order to determine if this reduction was worth the cost a cost/benefit analysis was done. The cost per reach is as follows: Cost/LF of Reach #1 = $0.22/LF, Cost/LF of Reach #2 = $0.73/LF, Cost/LF of Reach #3 = $1.93/LF and the Combined Cost of all three reaches = $1.14/LF.

The benefit of a cfs of irrigation water is the dollar value irrigators are willing to pay for it. At an assessment of $5.00/acre, and appropriation of 1 cfs/70 acres, the benefit equals $5.00 x 70 acres = $350.00. Therefore, the Cost/Benefit Ratio for each reach is as follows (it should be noted that a ratio of more than 1 is good and less than one is not good): Reach #1 = 1.288, Reach #2 = 0.130, Reach #3 = 0.130 and the combined cost/benefit ratio = 0.164.

If canal cleaning is considered a maintenance item, and not associated directly with seepage reduction, then with a life expectancy of 10 years, the cost of reach #3 lowers the benefit/cost ratio increases to 0.326.

**Conclusions**

**Effectiveness**

Polymer was proven successful in reduction of seepage in the GRSC, however, the degree of success is dependent on many factors, including polymer application process and whether or not the canal has been cleaned.

**Cost Effectiveness**

The major unknown in developing cost effectiveness figures is longevity. The results discussed previously were based on a one-year life of the treatment. If the benefits last longer than this, the ratios would change dramatically.

**Other Techniques**

Other techniques suggested are inducing turbidity in the flow by stirring the canal bottom with a backhoe while injecting the polymer. Low and clean spring runoff hampered the ability to provide better data concerning turbidity control.

**Soils & Permeability Investigations**

Future studies should include a comprehensive soil sampling and permeability investigation.
Injection of Polymer

Mechanical methods, rather than manual, of injecting polymer into the canal should be used. Metering pumps for liquid polymer or “bird feeder” devices to meter in dry polymer would be more desirable than the methods used in this study.

Measurements

Better, more accurate, methods of flow measurement should be used, and would subsequently result in more quantitative differences of flow and therefore more justifiable results.

PHASE II STUDY

I. Background

Prior Study

In the Phase I report, a menu list of items needing attention is presented, along with the complete background on the local geology, canal operation, and environmental and legal parameters within which the canal functions. The Seepage Study concludes that seepage loss prevention was not viable for the GRSC.

Economic Considerations

Dr. James Jacobs, a Professor of Agricultural Economics at the University of Wyoming was retained to study the economic variables of the GRSC problem. The result was an indicated “Ability to Pay” of $4.50 to $6.00, in which the higher number is above the district assessment at the present time.

Conceptual Design

The district has asked that the construction of the “Level II” project be divided into two increments. Increment One is defined in this study and is to be constructed in the Fall of 2005, and Increment Two, in which a diversion structure is to be addressed, is to be constructed in the 2006-2007.

II. Economic Considerations

The economic analysis of the GRSC Level II study was to provide an estimate of the producers “ability to pay” for improvements to the water delivery system. These improvements will enhance water delivery and improve water conveyance resulting in better efficiency of water use. This should greatly benefit existing irrigators.

Using various sources, three crop budgets were developed for the GRSC economic analysis. These three crop budgets were for 1) Existing irrigated hay meadows, 2) Establishment of an improved mixed hay meadow hay, and 3) Improved mixed meadow hay. Based on the crop budgets, the three types of existing acres of land with water rights, and the proportion of the acreage that would benefit from the first phase of the GRSC improvements, an “ability to pay” estimate was established. Again the “ability to pay” ranges from $4.50 to $6.00.

III. Other Considerations

Permits & Easements

In order for the Green River Supply Canal to establish legal access and right to control water at Pooles Slough, which is subdivided as “7 Mile River Ranch,” a fisherman’s style club ownership, the Green River Irrigation District should do one of two things:

1) Negotiate these rights into written agreement with “7 Mile River Ranch” and improve the diversion structure, or
2) Apply to the State Engineer for a change of point of diversion and means of conveyance for their water.

Environmental Analysis
The only environmental concern was identified to be potential loss of wetland if seepage from the canal was reduced. Since it was determined that at this point, seepage reduction is not a viable project effort, this is not a problem. Phase II has no identifiable environmental impact.

**Benefit/Cost Analysis**

Safety problems are identified as access walkways on two main diversion headgates. Since these safety problems could potentially cause serious bodily injury or even death, the proposed estimated repair cost of $7,000.00 is a very real benefit.

There are two classifications of underdrains. The first is those that carry irrigation water from upland to the lowland side. Since these have now failed, the Green River Irrigation District has a legal and moral obligation to repair them. This benefit outweighs the cost of underdrain replacement. The second classification is those carrying upland storm water runoff to the lowland side. These failed underdrains have the potential to cause canal failure during periods of heavy rainfall. The cost of this would include both the cost of loss of irrigation as well as the cost of canal repair. The benefits of avoiding expensive canal repair outweigh the cost of the underdrain structures.

In order to avoid washout of the bank and canal failure, it is important to build any low banks that may become overtopped with canal water during any time in the season. Bank failure would result in loss of irrigation and cost of repair. Therefore, adequately building the banks outweighs the cost of improvement.

Numerous turnouts from the canal are worn out to the point of being inoperative or are a style that quickly jams to the point of non-closure, causing the turnouts to be inoperable. This results in not enough water or too much water for the lands in question. The benefit of control over the water diverted outweighs the cost of turnout replacement.

Canal reshaping involves bringing the canal bottom to a consistent grade and bringing the sides to a consistent slope. This produces a more uniform flow velocity, which results in less scour and deposition of salts, as well as better control of individual turnouts. These benefits outweigh the cost of canal reshaping.

The diversion structure discussed earlier, to be replaced in Increment Two of construction, has benefits that far outweigh the cost of reconstruction. First of all, it is definitely unsafe and its operation could easily result in bodily injury or death. Secondly, its operation ultimately dictates how much water is available to the Green River Irrigation District.

**IV. Outline of Specifications**

An outline of contract documents and Technical Specifications that will be written to produce a contractor bid, a contract for work, and assurance of the work quality for the items of construction is provided in this section.

**V. Conceptual Design Drawings**

**VI. Cost Estimates**

The total cost Increment I, including the design and construction of rehabilitation of all the problems discussed earlier, is $198,425 or rounded to $200,000.

The total cost of Increment II, including design and construction is $263,000.

All improvements are to be designed for construction such that they can be built and funded within the districts “Ability to Pay” economic concept.