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EXECUTIVE SUMMARY

LOVELL ID HYDROPOWER
STUDY LEVEL II

MAY 1, 2003

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISION
CHEYENNE, WYOMING

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INTRODUCTION

The Lovell ID Hydropower Study Levell II was prepared for the Lovell Irrigation District (District) and funded by the Wyoming Water Development Commission (WWDC). The purpose of the study is two-fold: (1) evaluate system improvements that could be made to provide better irrigation service and reduce water shortages within the district, and (2) evaluate the feasibility for development of hydroelectric generating facilities within the district. This study was prepared by A&H Consulting of Lovell, Wyoming and their subconsultant, Sunrise Engineering of Afton, Wyoming. Recommendations were made involving both construction and non-construction irrigation system improvements. Several hydropower development options were evaluated for the Pumpkin Center and Brown Cascade drop structure sites southwest of Lovell, Wyoming. A potential hydropower site east of Lovell along the May Highline Ditch was also evaluated. Please refer to the study report for maps, drawings, and more detailed information.

The study concluded that none of the proposed hydropower facilities were economically feasible under current power market conditions.

SEEPAGE LOSS EVALUATION

The Elk-Lovell Canal was built in the early 1900's and consists mostly of earth channel. The western part of the canal provides irrigation to the Elk Water Users Association which irrigates about 3,800 acres. The eastern part of the canal serves the Lovell Irrigation District which irrigates about 11,200 acres. The total acreage served by the Elk-Lovell Canal is about 15,000 acres. The Lovell Irrigation District requested that some specific locations in their District be evaluated for seepage losses and the potential to install pipe. Some irrigators in the District have suffered from shortages in irrigation water, and it was believed that high seepage losses were a major contributing factor in the water shortages. The District requested evaluation of seepage losses in the Moncur Lateral, Bench Lateral, and the main canal from the May Highline check structure east to the end of the canal.

A number of flow measurements were made on the main canal and the Moncur and Bench Laterals. A loss of 2 cubic feet per second (cfs) was measured in the first 7,000 feet of Moncur Lateral. The first 6,000 feet of Bench Lateral east of WY Highway 32 had a measured loss of 5.5 cfs. The next approximately half mile of Bench Lateral had no measured loss. The next approximately 6,000 feet of lateral from near Road 11-1/2 east and north to Lane 12 had a measured loss of 3.4 cfs. The main canal had a measured loss of 3.6 cfs in the first 4.9 miles downstream of the May Highline check. The last approximately 4 miles of main canal had a measured loss of 3.9 cfs.

Most of the measurements were made in August or September. The measurements were estimated to have an accuracy of $\pm$5% of the measured flow, so the actual losses could be about 2 cfs higher or lower than the measured loss. Discussions with the local District Conservationist with the Natural Resources Conservation Service and others familiar with the system indicated that the Elk-Lovell irrigation water contains a lot of sediment. During the irrigation season some of the sediment settles in the canal and tends to create a "seal" in the canal and reduce seepage.

Much of the land under the Bench Lateral has a few feet of topsoil overlying a layer of gravel. In the areas where the gravel layer is exposed, the seepage losses are higher.

Location	Upstream Flow (cfs)	Measured Loss (cfs)	Distance (ft)	Loss (cfs/mile)
Start of Moncur Lateral	40	2	7,000	1.5
Bench Lat. east of WY Hwy 32	48	5.5	6,000	4.8
Bench Lat. Rd 11 to Rd 11-1/2	31	0	3,000	0
Bench Lat. Rd 11-1/2 to Lane 12	31	3.4	6,000	3.0
Main Canal east of May High.	58	3.6	26,000	0.7
End of Main Canal	42	3.9	21,000	1.0

Seepage Loss Measurement Results

IRRIGATION SYSTEM RECOMMENDATIONS

The State Board of Control keeps records of the Elk-Lovell Canal diversions from the Shoshone River, but the District does not have records of water deliveries within the District. Since there were no District records, there was no way to evaluate or verify reports of shortages within the District. Several people experienced with the operation of the District indicated that water shortages tend to occur at the ends of the Bench Lateral and at the end of the main canal. Although seepage losses contribute to shortages of water, the relatively small amounts of measured seepage did not appear to substantiate the idea that installing pipe would alleviate irrigation shortages in the District.

Flow measurements made at various locations during mid- summer indicated that there were other factors contributing to water shortages in the District. Flow measurements in the main canal and the laterals showed a disparity in how much water was being delivered to different parts of the District. The table below shows a comparison of flows and acres served. Although the measurements were made on different days, it was apparent that the main canal below the May Highline diversion had a disproportionately low share of the water.

PLACE	Flow (cfs)	Acres served	CFS per 70 acres	Date
Elk-Lovell parshall at river diversion	320	15,000	1.5	End of July 2002
Moncur Lateral	40	900	3.1	August 9, 2002
Bench Lateral	74	2,200	2.4	August 14, 2002
Main canal below Bench Lat. diversion	107	3,478	2.2	August 14, 2002
May Highline ditch	7.4	220	2.4	July 29, 2002
Main canal below May High. diversion	55	2,900	1.3	July 29, 2002

Comparison of Flows and Acres Served

Recommendation 1 – Modify Management Practices

Based on comparisons with upstream districts, the District was under-staffed to operate 40 miles of main canal, many miles of laterals, and provide water to 15,000 acres. The District operating practice allowed farmers to call for water then adjust their own headgates and take what they

wanted out of the canal and laterals. The result was that the water users at the end of the system had to make do with whatever was left in the canal. The study recommends adding at least one additional ditch rider. The ditch riders should actively manage the water and attempt to provide an equal amount of water to everyone in the District rather than just "react" when the users on the end of the system run short. Record keeping and accountability within the District should be initiated.

Recommendation 2 – Flow Measurement

Knowing how much water is in different parts of the system is a critically important element of water management. The District has four flow measurement structures in the Lovell area, and only one was found to be accurate. A study done for the District about 20 years ago recommended flow measurement structures at every farm turnout on the main canal. This has not yet been done, but should be done. In recent years the Shoshone Irrigation District upstream in Powell, WY has installed a number of broad crested weirs ("ramp flumes") within their system. A free program available from the US Bureau of Reclamation on the internet is used by the Shoshone ID to design these flumes for various locations within their district (for the program and documentation see http://www.usbr.gov/wrrl/winflume/). Using the program, these flumes are relatively simple to design, less complex to install, less expensive, and require less maintenance than prefabricated parshall flumes. Within just a few years, an ongoing program of installing additional measurement structures each year would greatly improve the ability to manage water within the district and improve accountability for water diverted without a large additional debt repayment obligation for the water users.

The first new flow measurement structures that should be installed should be in the main canal, in each main lateral, and in large distribution ditches diverting from the canal and laterals. These "primary" measurement structures should be located in areas that will best assist the ditch riders in the management of the District's water. After those primary canal, lateral, and ditch measurement structures have been installed, installation of flow measurement at farm turnouts should be implemented. The District should begin a program for installation of measuring structures within the District in the main canal, laterals, and farm turnouts. It is important that the program for flow measurement get started, even if only with several new structures each year. The District should not wait for a big loan or grant or wait another 20 years before taking action.

Recommendation 3 – Construct Check For Pump Diversion In Sand Draw

Sand Draw is a natural drainage that flows all year as a result of drainage from the Lovell Irrigation District. The District has a pump installation for pumping water from Sand Draw to supplement irrigation flows to the eastern 2,900 acres of the District. However, the pump facility was inoperable in 2002 and did not have any kind of check structure to divert flows from Sand Draw to the pump station. It is recommended that a new irrigation diversion be constructed in Sand Draw. The diversion installation would include a check in Sand Draw, a diversion pipe to a sediment pond, and a check at the downstream end of the sediment pond allowing the pond to be drained in the fall. The existing pump and motor could be used, but the pump building needs to be rehabilitated. This installation would provide an estimated 4.5 to 5.5 cfs with the one existing pump and could be used on an "as-needed" basis to alleviate water shortages at the end of the canal.

Recommendation 4 – Install Pipes In Laterals
The recommended pipe installations in order of preference are as follows: (1) 4,000 ft of 42 inch diameter pipe in the Bench Lateral starting at Rd 11 and going west, (2) 6,000 ft of 36 inch diameter pipe in the Bench Lateral starting at Lane 12 and going north and west, and (3) 5,300 ft of 42 inch pipe in the Moncur Lateral starting at its diversion from the canal. These installations should reduce seepage and future maintenance in these parts of the laterals. There was not enough measured seepage loss to justify pipe installation for seepage reduction in the main canal east of Sand Draw.

ESTIMATED IRRIGATION SYSTEM IMPROVEMENT COSTS

The table below shows costs for implementation of the recommended system improvements. Monthly payments for priorities 2-4 were based on assumed 20 year loans at 6% annual interest.

COST SUMMARY TABLE

ACTVITY	Estimated Total Cost (2004 Dollars)	Estimated WWDC Grant (2004 Dollars)	Estimated District Cost (2004 Dollars)	District's Estimated Annual Cost ($/YR)	Annual Cost/acre (11200 ac) ($/acre)	Estimated Water To Reduce Shortages (acre-ft/YR)	Est. Cost of Water To Reduce Shortages ($/acre-ft)
Priority 1 -- Improved management	* $0	$0	$0	* $12,000	$0.80	see below	see below
Priority 2 -- Flow measurement	$117,500	$0	$117,500	$10,244	$0.91	see below	see below
Priorities 1 & 2 combined	$117,500	$0	$117,500	$22,244	$1.71	3570	$6.23
Priority 3 -- Sand Draw diversion	$30,303	$13,886	$16,417	$6,357	$0.57	536	$11.86
Priority 4 -- phase I Bench pipe	$258,350	$129,175	$129,175	$11,261	$1.01	1428	$7.88
Priority 4 -- phase II Bench pipe	$286,180	$143,090	$143,090	$12,475	$1.11	1071	$11.64
Priority 4 -- phase III Moncur pipe	$330,303	$165,151	$165,152	$14,398	$1.29	714	$20.17
TOTAL ESTIMATED COSTS	$1,022,636	$451,302	$571,334	$66,735	$5.69		

* Priority 1 (first year $15,000) $12,000 average annual cost -- this should be cost-shared with Elk Water Users Assoc. so the $/acre cost is based on 15,000 acres served by Elk-Lovell Canal

PROPOSED HYDROPOWER SITES

Pumpkin Center
The Pumpkin Center Drop is an existing pipe drop on the Lovell Canal southwest of Lovell. The level of the canal drops about 47 feet in the 550 ft long drop structure. This site was evaluated for a hyropower plant near the bottom of the existing drop utilizing existing flows at the site.

Brown Cascade
The Brown Cascade Drop is an existing pipe drop on the Lovell Canal about ¾ mile downstream of the Pumpkin Center Drop. The canal level drops about 34 feet in the 280 ft length of the drop structure. This site was evaluated for a hydropower plant on the south side of the existing drop. Several options were evaluated for this site as described below.

Brown Cascade (Combined Elevations)
Construction of a penstock from the top of the Pumpkin Center Drop down to a powerhouse near the bottom of the Brown Cascade Drop was evaluated for feasibility. The proposed hydropower plant would utilize the combined elevations of the two drops. Three penstock routes were

evaluated combined with two flow options. "Option 1" utilized the flow which would normally be at the Brown Cascade (Pumpkin Center flows minus estimated diversions into the Bench Lateral and farm turnouts between Pumpkin Center and Brown Cascade). "Option 2" reroutes most of the Bench Lateral flows through the penstock and hydropower plant – a new pipeline would need to be constructed below the powerplant to convey the Bench Lateral flows north to the existing Bench Lateral channel.

May Highline

The May Highline Ditch diverts from the main canal east of Sand Draw. The May Highline has a flatter slope than the main canal, and at the proposed hydropower site the May Highline is about 31 feet above and 175 feet away from the main canal. There are no existing drop structures at the site. The proposal for this site is to enlarge the May Highline to convey most of the main canal flows to the hydropower site. At the site, the canal flow would be diverted into a penstock, through a hydropower plant, and back to the existing main canal channel. May Highline flows would continue down the May Highline Ditch to irrigate the lands currently served by the ditch.

CONCEPTUAL HYDROPOWER DESIGN

Historic and estimated flow data was used to develop flow duration curves for the proposed hydropower sites. Normal irrigation operation of the canal extends from mid-April to about mid-October. The study assumes that canal operation for hydropower generation could be extended from March 1 to about mid-November without serious ice or operational problems. The extended flow period was used in the study to estimate annual power generation and project feasibility. Penstocks, turbines, and generators were sized to balance annual power production with facility cost. In other words, the recommended generators are not necessarily the largest possible, but rather the smallest that still produces power volumes similar to that of the largest generator. The conceptual design of the power transmission facilities utilizes existing three phase distribution lines in the area of the proposed hydropower sites. Connection to existing facilities will require interconnect studies for each site, safety equipment to protect personnel and facilities, and agreements with Big Horn Rural Electric Company, the owner/operator of the existing distribution system.

POWER AND COST ESTIMATES

Facility costs were estimated to represent 2004 dollars and include equipment, construction, permitting, environmental, right of way, interconnection study, design, inspection, and a 15% construction contingency. Annual power estimates are based on the extended March through mid-November canal operation. The table below shows the proposed unit sizes, estimated annual power produced, estimated cost in 2004 dollars, and estimated cost in dollars per installed kWh.

ESTIMATED INSTALLATION COSTS

8-Jan-03

Site	Alternative	Unit Size KW*	Estimated Annual Power Prod. Kwh	Estimated Cost	Cost ($) Per Installed Kwh
Pumkin Center	Option 2	460	2,296,000	$ 1,328,000	0.58
Brown Cascade	Option 1	190	935,000	$ 1,149,000	1.23
Pumpkin Ctr./Brown Cascade	Option 1 - Route 1	480	2,365,000	$ 2,750,000	1.16
	Option 1 - Route 2	480	2,357,000	$ 2,406,000	1.02
	Option 1 - Route 3	460	2,315,000	$ 2,459,500	1.06
	Option 2 - Route 1	690	3,613,000	$ 3,093,000	0.86
	Option 2 - Route 2	680	3,595,000	$ 2,463,000	0.69
	Option 2 - Route 3	660	3,504,000	$ 2,527,000	0.72
May-Highline		120	553,000	$ 942,000	1.70

Option 1 is to use only flows currently passing through the Pumpkin Center/Brown Cascade
Option 2 is to reroute the flows from the Bench Lateral through the Pumpkin Center/Brown Cascade penstock then return the flows to the Bench Lateral below the station.

BENEFIT / COST ANALYSIS

Benefit / cost analysis were performed for each site based on 20 and 30 year loan periods, 4% energy price escalation rate, 3% inflation rate, and the interest rates shown. The benefit / cost analysis used the Tri States Generation and Transmission (Tri States) rate schedule along with estimated operation, maintenance, and equipment replacement costs. The 30 year analysis produced results similar to the 20 analysis. The tables below show the results for the 20 year analysis using 6% and 4% interest rates for a 20 year loan. For the projects to be feasible, they must have a benefit / cost ratio greater than 1.0 for the given energy rate.

The tables below demonstrate the most attractive alternative is the Pumpkin Center site followed by the Pumpkin Center/Brown Cascade Alternative 2 using penstock Routes 2 or 3. These sites are most feasible if the canal operation is extended from March 1st to November 15th. None of the proposed sites are feasible at the current power purchase prices of about 1.5¢/kWh to 1.6¢/kWh indicated by Tri-State and PacifiCorp. The rate will need to be in the 5.0¢/kWh range for the most promising sites to cash flow with a 20 year 6% loan.

BENEFIT COST RATIO FOR VARYING ELECTRICITY RATES
ELK-LOVELL HYDRO FEASIBILITY STUDY
20 YR LOAN PERIOD @ 6.0%

Operation From March 1 to November 15.		**ENERGY RATE $/kwh**									
LOCATION/ALTERNATIVE		0.01	0.015	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Pumkin Center	Option 2	0.334	0.446	0.557	0.781	1.005	**1.229**	1.452	1.676	1.900	2.124
Brown Cascade	Option 1	0.161	0.215	0.269	0.377	0.485	0.593	0.701	0.809	0.917	**1.025**
Pumpkin Ctr./Brown Cascade	Option 1 - Route 1	0.138	0.184	0.230	0.323	0.415	0.507	0.600	0.692	0.784	0.877
	Option 1 - Route 2	0.221	0.295	0.369	0.517	0.665	0.813	0.961	**1.109**	1.257	1.405
	Option 1 - Route 3	0.223	0.298	0.373	0.523	0.673	0.823	0.973	**1.123**	1.273	1.423
	Option 2 - Route 1	0.178	0.239	0.299	0.421	0.542	0.663	0.785	0.906	**1.027**	1.149
	Option 2 - Route 2	0.283	0.380	0.477	0.671	0.864	**1.058**	1.252	1.446	1.640	1.833
	Option 2 - Route 3	0.285	0.383	0.480	0.676	0.871	**1.067**	1.262	1.457	1.653	1.848
May-Highline		0.103	0.137	0.171	0.239	0.307	0.375	0.443	0.511	0.579	0.647

Benefit/Cost Ratio @ 6.0%

BENEFIT COST RATIO FOR VARYING ELECTRICITY RATES
ELK-LOVELL HYDRO FEASIBILITY STUDY
20 YR LOAN PERIOD @ 4.0%

Operation From March 1 to November 15.		**ENERGY RATE $/kwh**									
LOCATION/ALTERNATIVE		0.01	0.015	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Pumkin Center	Option 2	0.382	0.510	0.637	0.894	**1.150**	1.405	1.661	1.917	2.173	2.429
Brown Cascade	Option 1	0.183	0.244	0.306	0.428	0.551	0.673	0.796	0.918	**1.041**	1.163
Pumpkin Ctr./Brown Cascade	Option 1 - Route 1	0.162	0.216	0.271	0.379	0.488	0.596	0.705	0.813	0.922	**1.030**
	Option 1 - Route 2	0.257	0.343	0.429	0.601	0.773	0.945	**1.117**	1.289	1.461	1.632
	Option 1 - Route 3	0.259	0.346	0.433	0.607	0.781	0.956	**1.130**	1.304	1.479	1.653
	Option 2 - Route 1	0.209	0.281	0.353	0.495	0.638	0.781	0.924	1.067	1.210	1.353
	Option 2 - Route 2	0.330	0.444	0.557	0.783	1.009	**1.235**	1.461	1.687	1.913	2.140
	Option 2 - Route 3	0.332	0.446	0.560	0.788	1.016	**1.244**	1.471	1.699	1.927	2.155
May-Highline		0.117	0.155	0.194	0.271	0.348	0.425	0.502	0.579	0.655	0.732

Benefit/Cost Ratio @ 4.0%

PERMITTING AND OTHER CRITICAL ISSUES

The Federal Energy Regulatory Commission (FERC) has authority to regulate all non-federal hydropower projects on navigable waters, federal land, and under other certain circumstances. Permits will be necessary from FERC. The licensing process with FERC will involve environmental review of the proposed projects. This review will involve US Fish & Wildlife Service and the WY Game & Fish. Environmental requirements can have a significant impact on project feasibility for all of the sites. Permits will also be necessary from the WY State Engineer's Office and the WY Department of Environmental Quality.

The market for the power is a critical issue and must be determined prior to development of the projects. Due to limitations on the power transmission grid, it does not appear currently feasible to market power outside of Wyoming. Pacific Power and Tri States Generating and Transmission are potential local markets for the power, but agreements and power marketing

contracts will be necessary. In addition, agreements will be necessary with the owners/operators of the local power distribution system prior to making any interconnections of power facilities.

SUMMARY

Irrigation System Improvements

Several priorities were outlined for improving the irrigation system and reducing shortages of irrigation water within the Lovell Irrigation District. The first priority is to modify the management of the water within the system and begin record keeping and accountability for the water. The second priority is to begin a program of constructing flow measurement structures within the District. The third priority is the construction of a new check structure at the Sand Draw pump site – this will provide additional flow to the irrigators in the east end of the District on an as-needed basis. For the last priority, sections of the Bench Lateral and Moncur Lateral were identified for potential installation of pipe to reduce seepage and to reduce future maintenance.

Hydropower Development

The sites and alternatives reviewed in this study do contain significant potential for the development of hydropower resources. The combined Pumpkin Center/ Brown Cascade site has the greatest generation potential, but its feasibility is adversely impacted by lengthy penstocks, long transmission lines, and the need to reroute the Bench Lateral flows to reestablish deliveries. The Pumpkin Center site benefits from close proximity to overhead power lines and a relatively short penstock.

However, at current published rates none of the projects will produce a cash flow for the District after construction repayment, operation and maintenance, and future equipment replacement expenses are considered. The difference between the existing electric rates and the required rates to cash flow is great, and probably cannot be negotiated. The transmission of power out of the State will be difficult to negotiate and may add a half cent or more per kWh to the cost of the power. Limitations on existing transmission capacity reduces the possibility of marketing power at higher prices in out of state markets.