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North Canal Master Plan
Level I

Executive Summary

November 1, 2003

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Executive Summary

North Canal
Master Plan
Level I

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November 1, 2003
Executive Summary

A Level I Master Plan Study was conducted for Wyoming Water Development Commission, with North Canal Irrigation Company as the sponsor, to investigate the existing North Canal system and make recommendations for immediate and future improvements. Field investigations, mapping, seepage loss field measurements, and meetings were used to gain information on physical and operational aspects of the system. This report details the findings and summarizes the recommended improvements. Preliminary cost estimates and concept designs are also presented.

North Canal Irrigation Company, a privately owned company with approximately 80 shareholders, holds a direct flow decree for 40.38 CFS from Swift Creek in Lincoln County, Wyoming. As allowed by the State of Wyoming, when sufficient water is available, the North Canal Irrigation Company may divert twice the decreed flow, or approximately 80 CFS. The canal system delivers irrigation water to a service area of approximately 2,800 acres. The entire canal system is approximately 13 miles in total length starting from the headworks on Swift Creek and ending at Salt River. The system includes the Main Canal (1.15 miles long), two sections referred to as the Upper Canal (4.75 miles long) and Lower Canal (4.75 miles long) that parallel one another in fairly close proximity, and the Tail End Canal (2.4 miles). Each shareholder opens and closes their individual headgate when notified by the Company's Water Master. The current water delivery allocation is 30 minutes per acre of land. Direct flow measurement is not currently a part of each headgate.

During the summer of 2003, an extensive investigation and inventory of the North Canal system was undertaken to include mapping and evaluation of structures and measurement of seepage losses in various reaches of the canal system. The Level 1 Master Plan was developed to provide the Company with a long term vision for improvements on the North Canal system that could be used for future direction and guidance. Specific project goals for the Level 1 Master Plan include:

- Meet with the public and shareholders to discuss concerns and potential solutions.
- Conduct seepage loss field tests and analysis to determine if physical improvements to the canal are required.
- Conduct a complete structure inventory to locate and map all existing canal structures and note operating conditions.
- Prepare a map and database (Geographic Information System, GIS format) to document the existing canal system and to serve as a tool for future planning.
- Develop a rehabilitation plan with prioritized improvements and per acre assessment costs.
- Create conceptual level designs, concept details, and cost estimates for recommended improvements.
- Prepare a final report summarizing the investigations and recommendations for this project.

Seepage Loss Analysis

Seepage loss was determined for the Main Canal, Upper Canal, and Lower Canal by utilizing a velocity meter and measuring the flow rate at an upstream and downstream...
location on several reaches of each canal section. The inflow/outflow method of calculating seepage loss was determined to have a +/-12% accuracy for the flow rate calculation for this study. Measurements indicate that seepage is not as extensive as was intuitively thought.

The Main Canal average flow measured over the course of the field tests was 74.0 CFS. The average seepage loss was determined to be approximately 7.5 CFS or 10.1%. Applying the accuracy parameter of +/-12%, the seepage loss ranged from 6.6 CFS to 8.4 CFS (8.9% to 11.4%). Approximately 8.1 CFS loss could be anticipated along the Main Canal when the diversion at the headworks is 80.8 CFS.

The Upper Canal average flow was found to be 20.5 CFS and the average seepage loss measured was 3.0 CFS, or 14.8%. Applying the accuracy parameter of +/-12%, the seepage loss ranged from 2.6 CFS to 3.4 CFS (12.9% to 16.4%). Because the flow rates and seepage loss measurements along the Lower Canal varied from reach to reach, the highest seepage case is reported rather than an average. On the downstream end of the Lower Canal, the upstream flow rate was measured to be 9.0 CFS. The seepage loss in this reach was 1.5 CFS or 16.7%. Applying the flow rate accuracy parameter of +/-12%, the seepage loss ranged from 1.3 CFS to 1.7 CFS (14.7% to 18.7%).

Other outflows / inflows to the canal system were quantified where possible. Based on average width and canal lengths, the evaporation from the surface of the water in the canal was estimated to be 35 acre-ft annually. Vegetation consumption along the banks of the canal system may account for approximately 3.9 acre-ft to 8.5 acre-ft annually. Leaking headgates were visible throughout the canal system and the average flow rate was estimated to be 0.5 CFS to 1.0 CFS. A total of 14 gates were leaking during the structure inventory, resulting in implied potential losses from the canal system of 7 CFS to 14 CFS. Ground water may penetrate the canal and enter the system as might subsurface drainage from basins located directly east of the canals contributing to a "gaining condition" in some reaches of the canal.

Combining the losses due to seepage and leaking headgates, real daily losses observed and measured during the field investigations were approximately 24.5 CFS over the entire length of the canal system from the headworks on Swift Creek to the point where Upper and Lower Canals reunite. This loss represents approximately 33% of the diversion (measured at 74.0 CFS during the field tests) and is typical of many similar irrigation canal systems.

**Structure Inventory**

The North Canal Irrigation Company canal system was physically inventoried by walking the canals to locate all structures. As applicable, each structure was mapped, photographed, sketched, and roughly dimensioned. Observations were noted about the structures as well. In general, eight types of structures were located and evaluated during the structure inventory. These included:

- Headgates
- Check structures
- Bank cuts (diversions without headgates)
- Pumps
• Half pipe lining and/or eroded bank areas
• Bridges
• Culverts
• Pipe crossings

Additionally, the main Swift Creek diversion structure and headgates and components at the bifurcation were evaluated.

The location of each structure was mapped using a handheld Global Positioning System (GPS) unit and results are shown on Map A. The label associated with each structure for reference within this study is shown on Map B. Additionally, the GIS based maps include data from aerial photographs, USGS topographic maps, NRCS soils maps, and Lincoln County parcel maps.

Two 6-ft wide rectangular wheeled headgates comprise the North Canal Irrigation Company's Swift Creek headworks. A staff gauge is located on the concrete structure downstream of the gates, but it is not calibrated for measurement. Approximately 140 feet downstream of the headworks is a check structure constructed in 1980 for flow measurement purposes but has never been utilized as such.

The bifurcation is the point in the canal system where the Main Canal divides into the Upper Canal and the Lower Canal. An old concrete diversion structure and abandoned half-pipe are no longer used. Some leakage from the Upper Canal passes the existing structure through the abandoned half-pipe. A new headwall, gate, and 48-inch corrugated metal pipe were constructed to divert water to the Lower Canal when the old half-pipe collapsed. The wheel on this canal gate does not properly operate the gate. Concrete walls below the diversion pipe help protect the banks of the Lower Canal from erosion due to the energy associated with freely dropping the water approximately 20 feet.

The majority of the individual headgates along the canal system that divert water to shareholders are slide gate style. Some are canal gates with wheels. At least 14 of the 59 gates observed were leaking (almost 25%). As previously noted, the estimated water loss from these 14 leaking gates is between 7 CFS and 14 CFS daily. When the diversion from Swift Creek is 80 CFS, the leaky gates account for 9% to 18% of the realized losses in the overall canal system.

Three locations along the canal system had the banks cut for diversion purposes. There were no gates associated with these diversion points and the quantity delivered is unknown. The cuts ranged from 1-ft to 2-ft wide. Four pumps were located along the canal system and typically had the suction pipes located directly in the canal.

Check structures downstream of individual headgates were found along the canal system to increase the flow to the particular farm lateral. These structures were of variable construction methods and conditions. Several erosion areas along the canal banks were observed. Loose soil had often been placed along the breached areas to temporarily fix the canal bank. Bridges (pedestrian and vehicular) and culverts were also located throughout the system.
Rehabilitation Plan

Structure improvements are recommended based on the inventory and assessment conducted. No immediate improvements are recommended at the main diversion from Swift Creek. Future recommended improvements include the installation of a flow measurement device. Both Langemann gates and long-throated flumes are discussed in the report.

Immediate recommendations at the bifurcation include removing the abandoned half-pipe for safety concerns and possible damage incurred to the Lower Canal if it falls from the bank. The existing structure should be sealed to prevent leakage out of the Main Canal. The wheel on the canal gate for the Lower Canal diversion should be repaired to allow for proper operation. Additional rip rap should be placed at the head of the Lower Canal to help dissipate the energy from the water dropping from the Main Canal. The installation of Langemann gates or long-throated flumes is recommended in the future to provide accurate flow measurement capabilities at this location.

A standardized individual headgate design should be determined by the North Canal Irrigation Company for all diversions. A wheeled canal gate is recommended for more control and locking ability. A numbering or naming scheme is suggested for keeping records and added ease of operation for the Company. The 14 leaking headgates should be repaired or replaced immediately. Improved accessibility to all headgates on the system is highly recommended as some were located in heavy vegetation at the end of a narrow footpath. Areas of the canal with bank cuts should be investigated to determine ownership and whether or not the diversions are allowed and appropriate. If they are associated with a shareholder, new canal gates should be installed to provide control over the diverted flow. If they are not associated with a shareholder, the banks should be repaired to prevent future diversions. A prioritized list is provided for repairing or replacing the individual headgates. For flow measurement capabilities, long-throated flumes are recommended downstream of each individual headgate. This provision will then allow the Company to divert water on a volumetric and time basis rather than only a time basis. This method of water allocation would eliminate the current distinction between shareholders on the head and tail of the canal system.

Check structures in the canals should be investigated to determine placement and effect on downstream shareholders. The North Canal Irrigation Company should consider standardizing these structures with a U.S. Bureau of Reclamation check structure design including concrete floors and walls with slots for stoplogs.

No immediate improvements are recommended for the culverts or bridges, as these were found to be in fair to excellent condition. Continued inspections and a naming scheme should be considered and incorporated into the Company’s maintenance program.

North Canal must clarify if the Company or individual shareholders are responsible for canal repairs after a breach occurs. Soil backfill and compaction are recommended in these areas to create lasting solutions.

Canal lining is not highly recommended based on the 10% to 17% measured seepage losses throughout the canal system. However, five lining options are presented in the report to provide the Company with adequate information should they pursue lining.
sections of the system. Those liners include: soil sealants, buried impermeable membranes, exposed impermeable membranes, concrete hard surface, and pipe or half-pipe. Of the methods presented, an exposed 45-mil polypropylene liner would be recommended for North Canal.

Additional topics briefly discussed in the rehabilitation plan include the installation of supervisory control and data acquisition (SCADA) systems and creation of off-ditch storage. An overview of SCADA components, monitoring and control capabilities, and solar power and radio technologies is presented. Off-ditch storage is broadly discussed for potential re-regulation (flow equalization) or late season supply.

As a result of the seepage loss studies and field structure inventory, several recommendations were presented to increase the efficiency and operations of North Canal. Following is a prioritized list of structure improvements that are recommended; listed in order, with the highest priority being number one.

1) Repair all broken and leaking individual headgates. It is estimated that 7 CFS to 14 CFS is lost to these leaks in the system on a regular basis. (Refer to Table 3.)
2) Eliminate bank cuts in the canal. Losses through these bank cuts were not quantified and are assumed to be quite variable. Water diverted through these potentially unauthorized cuts reduces the amount of water in the system available to shareholders.
3) Remove the abandoned half-pipe at the bifurcation for safety reasons and potential damage to the Lower Canal if it falls from the upper bank. Seal up the old diversion to prevent water from leaking into the old half-pipe.
4) Replace the Lower Canal diversion canal gate wheel at the canal bifurcation.
5) Place additional rip rap at the base of the Lower Canal diversion from the Main Canal to protect the area from continued erosion and damage due to the effects from the 20-ft water drop.
6) Complete bank repairs by compacting the fill soil and possibly adding concrete to prevent future erosion and breaches of the same areas. Failure to do so will result in potential loss of water to downstream shareholders.
7) Install Langemann gates or long-throated flumes in the Main Canal and at the bifurcation (in the Upper and Lower Canal) for flow measurement capabilities.
8) Determine standard check structure construction and acceptance in canal system. Construct new structures as deemed beneficial.
9) Consider lining the areas of the Lower Canal system, which have the highest seepage losses. As funding is available, additional reaches of the canal system can be lined.

Maintenance improvements include constructing a canal maintenance road to re-establish the Company’s easement and right-of-way. Fences crossing the canals should be removed or gates installed for access along the canals. Weeds and vegetation along the canal banks should be cleaned and controlled on a regular basis.

Organizational and operational improvements are also presented as part of the Level 1 Study. These recommendations include:

1) Work towards removal of the head / tail shareholder distinction by installing flow measuring devices and future delivery of water on a time and flow basis.
2) Strengthen policies for payment of annual assessments from shareholders.
3) Patrol or "ride" the canal system regularly to both clean and maintain the canal system and to set and adjust system gates and individual headgates.
4) Improve communications between the North Canal Irrigation Company and the shareholders with newsletter or mailings.
5) Hold regular Board of Director meetings.

**Concept Level Designs and Cost Estimates**

Based on the Rehabilitation Plan, conceptual level designs and cost estimates were prepared to assist the North Canal Irrigation Company in strategizing improvements for both the immediate and long term future. The conceptual designs presented in this report include Langemann gates, long-throated flumes, individual headgates, check structures, and canal lining. Cost estimate tables presented below include estimated material and installation costs as well as contingency costs. Annual cost per acre and total cost per acre are shown based on construction funding and assistance from the Wyoming Water Development Commission. Construction funding is available from WWDC as a 50/50 loan and grant split. WWDC will provide the new District with a grant of at least 50% for construction improvements of the existing canal system. This is a standard grant percentage; the District may request additional assistance however there are no guarantees that WWDC would provide more than 50% as a grant. The remaining 50% of the construction cost would be a loan from WWDC. Current terms for these loans are 20 years at an interest rate of 6%. Another way to look at the funding assistance from WWDC is as a 20-year loan at an interest rate of 3% for the entire construction cost.

Costs associated with immediate and future improvements recommended are shown in Table 1.

A broad conceptual improvement in the North Canal system would be to pipe the system and create pressure along the way. If the North Canal system did not currently exist, with modern materials and the present lay of the land, it would be quite logical to consider piping all or most of the canal system. Piping would eliminate seepage, eliminate evaporation, eliminate liabilities of the open channel, and allow for delivery of water under pressure. The preferred route for a single pipe might be similar to the route that Upper Canal presently takes in order to take advantage of the higher elevation to maintain a higher pressure at individual headgates. A full analysis of this option is beyond the defined scope of work but order of magnitude costs are presented. Assuming the funding described above, the annual cost of an extensive capital improvement project as is envisioned here, would vary from approximately $354,000 to $441,000. That equates to a financed cost of approximately $124.35 per acre to $155.08 per acre annually.
### Table 1 – Immediate and future improvements cost estimates

<table>
<thead>
<tr>
<th>Recommended Improvement</th>
<th>Location</th>
<th>Qty</th>
<th>Const. Cost per Qty</th>
<th>Const. Cost</th>
<th>Eng. Design Fees (6%)</th>
<th>Subtotal Const. Cost</th>
<th>Const. Eng. Fees (10%)</th>
<th>Subtotal</th>
<th>Contingency (15%)</th>
<th>Total Project Cost</th>
<th>Annual Loan Repayment</th>
<th>Annual Cost per Acre</th>
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<tr>
<td><strong>Individual Headgates (immediate)</strong></td>
<td>Headgate</td>
<td>14</td>
<td>$5,500</td>
<td>$77,000</td>
<td>$4,620</td>
<td>$81,620</td>
<td>$8,162</td>
<td>$89,782</td>
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<td>Flume</td>
<td>14</td>
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<td>$21,000</td>
<td>$1,260</td>
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<td><strong>Eliminate Bank Cuts</strong></td>
<td>Various</td>
<td>3</td>
<td>$250</td>
<td>$750</td>
<td>N/A</td>
<td>$750</td>
<td>$75</td>
<td>$825</td>
<td>$123.75</td>
<td>$948.75</td>
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<td><strong>Remove Lower Canal Half Pipe</strong></td>
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<td>$3,500</td>
<td>$3,500</td>
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<td>$3,500</td>
<td>$350</td>
<td>$3,850</td>
<td>$577.50</td>
<td>$4,427.50</td>
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<td><strong>Replace Wheel on canal gate</strong></td>
<td>Lower Canal</td>
<td>1</td>
<td>$150</td>
<td>$150</td>
<td>N/A</td>
<td>$150</td>
<td>$15</td>
<td>$165</td>
<td>$24.75</td>
<td>$189.75</td>
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<td><strong>Add Rip Rap at Lower Canal</strong></td>
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<td>$1,500</td>
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<td>N/A</td>
<td>$1,500</td>
<td>$150</td>
<td>$1,650</td>
<td>$247.50</td>
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<td><strong>Canal Bank Repairs</strong></td>
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<td><strong>Langemann Gates</strong></td>
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<td>$42,120</td>
<td>$2,527</td>
<td>$44,647</td>
<td>$4,465</td>
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<td>Upper Canal</td>
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<td>$27,108</td>
<td>$27,108</td>
<td>$1,262</td>
<td>$28,370</td>
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<td>$33,372</td>
<td>$2,002</td>
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<td>$3,537</td>
<td>$38,911</td>
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<td><strong>Long-throated Flumes</strong></td>
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<td>$7,500</td>
<td>$450</td>
<td>$7,950</td>
<td>$795</td>
<td>$8,745</td>
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<td>$10,056.75</td>
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<td>Upper Canal</td>
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<td>$5,000</td>
<td>$5,000</td>
<td>$300</td>
<td>$5,300</td>
<td>$530</td>
<td>$5,830</td>
<td>$874.50</td>
<td>$6,704.50</td>
<td>($450.65)</td>
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<td>$5,000</td>
<td>$300</td>
<td>$5,300</td>
<td>$530</td>
<td>$5,830</td>
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<td><strong>Check Structure</strong></td>
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<td>$229,444</td>
<td>$13,767</td>
<td>$243,211</td>
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<td>$953,040</td>
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