PAP-731

Control Recommendations for Geranium Lateral 6.1, North Loup Division, Pick-Sloan Missouri Basin Program, Nebraska

by

David C. Rogers

May 1996

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D-8560
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MAY 23 1996

MEMORANDUM

To: Manager, Grand Island NE
Attention: NK-MDK (Kube)

From: David C. Rogers
Hydraulic Engineer

Subject: Control Recommendations for Geranium Lateral 6.1, North Loup Division, Pick-Sloan Missouri Basin Program, Nebraska

The attached report contains recommendations and cost estimates for a local automatic downstream water level control scheme to upgrade the operation of Geranium Lateral 6.1, as requested in your work request dated May 2, 1996.

David C. Rogers

Attachment

cc: Manager, Billings MT, Attention: GP-2200 (Armer)
(w/att)

bc: D-8140 (Glickman)
D-8560 (Rogers, Ehler, PAP file)
(w/att to each)

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GERANIUM LATERAL 6.1 CONTROL RECOMMENDATIONS

1.0 INTRODUCTION

Geranium Lateral 6.1 is an open lateral canal approximately 3/4 mile long that begins at a gated turnout from Geranium Canal and ends with two gated deliveries to pipe laterals serving sprinkler irrigation systems. Gates at the inlet and outlet structures are manually controlled by ditchrider, but outflow at the lateral's downstream end is really determined by valves in the pipe laterals (outlet control). Because it is nearly impossible to match the lateral inflow and outflow exactly, water level in the lateral either drops or rises over time. Low water levels cause sprinklers to shut off and high water levels cause bank overtopping.

The most technically and economically feasible solution to these operating problems appears to be an automatic control system that will adjust the Lateral 6.1 head gate to maintain a target water level at the downstream end of the lateral. This report contains recommended methods and equipment, plus cost estimates, for such a system.

2.0 CONTROL METHOD

A *local automatic control* scheme is proposed. The head gate to Lateral 6.1 (Lateral G-6.1 turnout gate) can be automatically controlled to maintain a downstream target water level. In this case, the location of the water level target should be near the downstream end of the lateral, because that level is important to serve the pipe laterals and sprinkler systems downstream. The target water depth should be set to the normal, full-flow depth (2.5 ft). A controller at the lateral head gate will automatically adjust the head gate position to keep the downstream water level near this target depth. (This is called *feedback control*, because the actual water level is constantly fed back into the controller and compared with the target level. When actual water level is below the target, the head gate will be raised; when actual water level is above the target, the head gate will be lowered.)

Water level at the lateral's upstream end will need to vary with flow rate--deeper at high flows and shallower at low flows--while level at the lateral's downstream end remains fairly constant. Because of the distance between the head gate and the water level sensor, a lag time will exist between each corrective action (gate adjustment) and the water level correction at the sensor. For Lateral 6.1, this lag time will be about 10 to 15 minutes, depending on the magnitude of the change required. (Larger changes will take longer because the canal storage volume must change as the upstream end of the canal fills or drains a little.)

The automatic gate controller will contain an algorithm--a set of logical instructions--to compute appropriate gate adjustments based on present water level. A PID (Proportional-Integral-Derivative) control algorithm with an electronic water level filter is recommended. Coefficients in the algorithm will be calibrated to keep lateral water levels near the target level, to account for lag time between the gate and the water level sensor, and to minimize the number of gate movements. Controller performance should be quite good for the type of minor flow adjustments that are anticipated. Gate movements should be infrequent and lateral water level should remain near the target. However, any sudden, large flow changes from the downstream pipe systems will cause greater water level fluctuation in the lateral canal.

Telemetry and monitoring of this site from the master station is recommended. As a minimum, alarms should be provided to alert canal operators of abnormal conditions. Examples of these are high water level, low water level, lost water level signal, and equipment failure. Additional monitoring could include actual water level, head gate position, and flow at the ramp flume (from flume water level).

3.0 EQUIPMENT

3.1 Water level measurement - A sensor is required to measure canal water level at the target location. Many types of water level sensors are available, but probably the best type for this application is either a submerged pressure transducer or a bubbler water level recorder. The bubbler has advantages because the pressure sensor is above water and less susceptible to damage from freezing. Either device could use a pipe extending below the water surface. This pipe could be attached to either the siphon outlet structure or the turnout structure at the canal's tail end (see photo 1). These options would eliminate the need to construct a stilling well along side the canal.

The water level measurement point could be located anywhere between the siphon outlet and the tail end of Lateral 6.1 (photo 2). At full flow, the water surface drops only about 0.16 ft (2 inches) from the siphon outlet to the tail end. Typical depth variations during operation will exceed this amount, so, for operating purposes, this short canal segment can be thought of as a pond. Locating the water level sensor at the upstream end of this "pond" will reduce the telemetry distance and provide a better line of sight for telemetry to the head gate.

3.2 Remote terminal units (RTU's) - Two canalside RTU's are required: one located near the water level sensor and another at the lateral head gate. RTU #1 will process the water level sensor output and telemeter this information to the lateral head gate. RTU equipment should include a microprocessor, radio, RF modem, lightning protection, software, and an enclosure. Additional on-site equipment, which may or may not be included as part of the RTU, should include a power supply, antenna, and mast. Although a power line runs past the site, solar power has the advantages of low hook-up cost, no monthly power costs, and stand-alone operation. RTU #1 will have very low power requirements. Solar power supply--including solar panel, battery, and charger--is recommended.

RTU #2 will receive the water level data transmitted from RTU #1, control head gate adjustments, and communicate with the master station. RTU #2 will need similar capabilities to RTU #1, plus additional software and interface equipment for gate motor control. RTU #2 could be mounted at the turnout structure (photo 3) or it could be placed inside the existing corrugated metal shed at the ramp flume (photo 4). Metallic cable will connect the RTU with the head gate actuator.

3.3 Head gate actuator - The 24-inch slide gate at the turnout to Lateral 6.1 will require retrofit motorization. (See photo 3.) The motor actuator should include an electric motor, raise and lower limit switches, a torque switch, control relays, local manual controls, an enclosure, thrust base, mounting hardware, and gate position indicator (potentiometer). Motorized gate actuators for applications such as this are commercially available. An example is shown on figure 1.

The gate motor will draw much more power than the RTU, but solar power is still a good alternative for this site. Additional feasibility evaluation is recommended before selecting the power supply method for this site.

3.4 Master station - Master station equipment was described in the report on *Mirdan Canal Operation, Control and Wasteway Recommendations* dated April 26, 1996. Telemetry between Geranium Lateral 6.1 and the master station should not require additional master station equipment, but it will require some minor software modifications to accommodate one additional site. Additional field evaluation is needed to determine whether or not a radio repeater is required for communication between Lateral 6.1 and the master station.

4.0 COST

Estimated costs for the Geranium Lateral 6.1 automatic control system are shown in the table below. Costs will vary depending on equipment supplier, installation, infrastructure requirements, and communication system requirements, but the table shows costs that are realistic for a good quality system in today's market.

ITEM	ESTIMATED COST
Water level measurement (near tail end):	
Water level sensor and associated hardware	$ 600
RTU #1	$ 1500
Solar power supply	$ 500
Antenna and mast	$ 350
Gate control:	
Gate actuator (motor, limit switches, torque switch, relays, pushbutton station, enclosure, thrust base, mounting hardware)	$ 3900
Gate position potentiometer	$ 400
RTU #2	$ 2300
Power supply	$ 1000
Antenna and mast	$ 350
Master station:	
Software for additional site	$ 500
Installation	$ 3000
TOTAL COST	$ 14,400

5.0 CONCLUSIONS

A local automatic controller is recommended for the Geranium Lateral 6.1 head gate. Using a water level sensor near the lateral's downstream end, the controller is a technically and economically feasible method to prevent undesirable depth fluctuations in the lateral. Telemetry between the automatic controller and the master station should be provided so that any problems at the lateral will create an alarm at the master station.

Recommendations in this report are concepts, not final designs. Variations or modifications of these concepts should be considered as details become finalized. For example, another option to the two-RTU configuration proposed in this report is a single RTU at the head gate with buried cable to the water level sensor. This one-RTU option may be competitive if district personnel provide installation labor, but the two-RTU configuration still appears advantageous.

Several different companies now make RTU equipment that is satisfactory for canal control applications. Control equipment chosen for Geranium Lateral 6.1 should be compatible with the other control equipment for Mirdan Canal.

{Report prepared by D.C.Rogers, D-8560, 5/23/96}

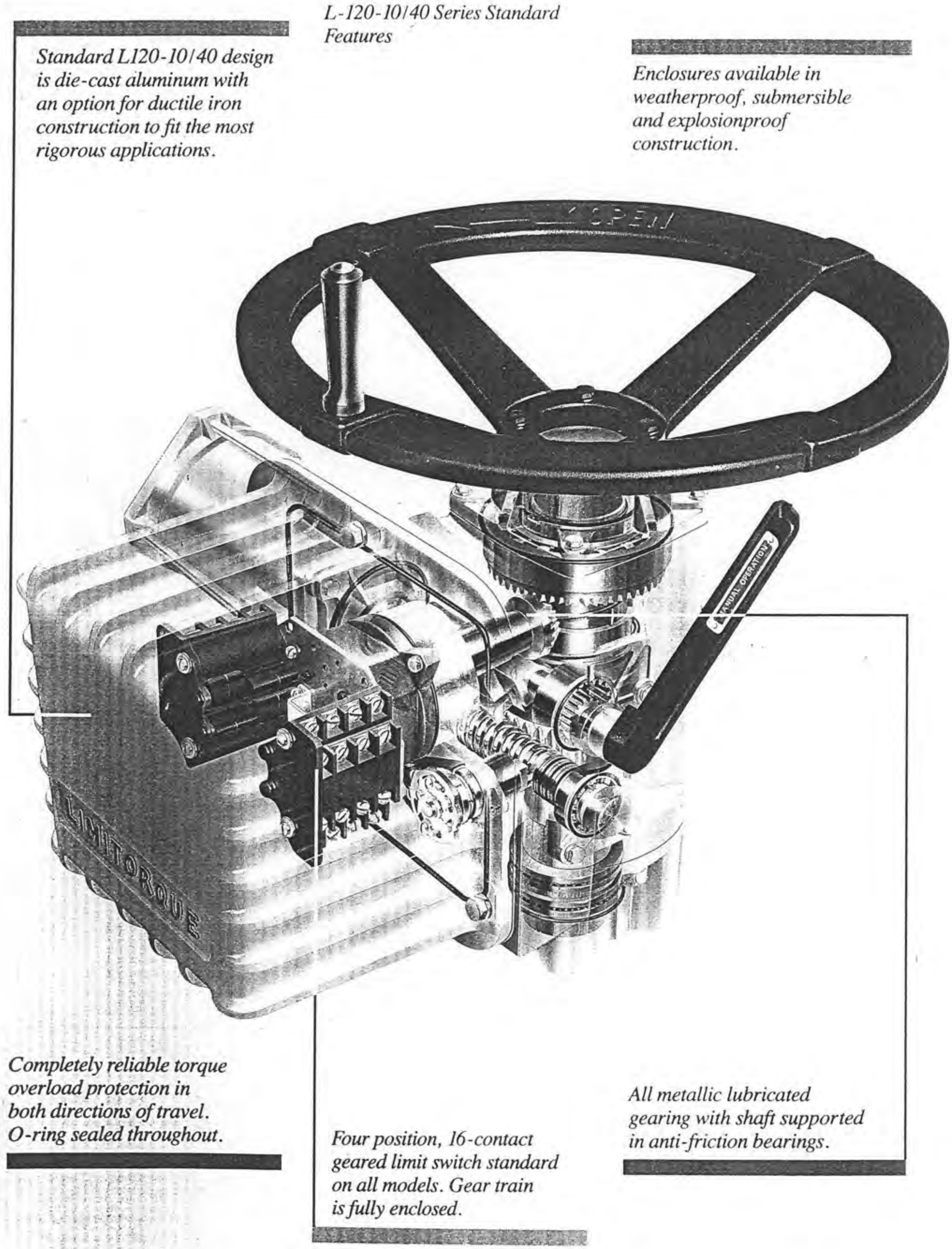

Figure 1 - Example gate actuator for motorized slide gate operation.

Photo 1 - Pipe lateral turnouts at tail end of Geranium Lateral 6.1

Photo 2 - Downstream segment of Lateral 6.1, from siphon outlet to tail end

Photo 3 - Lateral 6.1 turnout gate (head gate) with handwheel operator

Photo 4 - Upstream segment of Lateral 6.1, with ramp flume and stilling well shelter