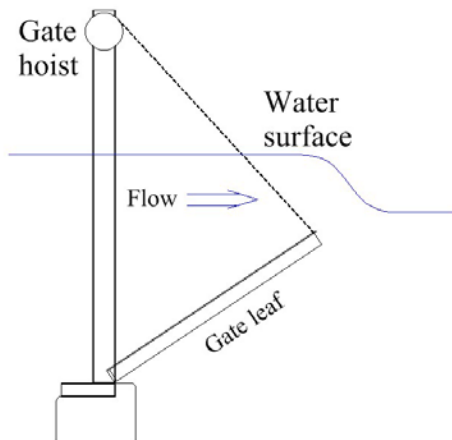


## Modernizing Canal Check Structures with BI-Fold Overshot Gates

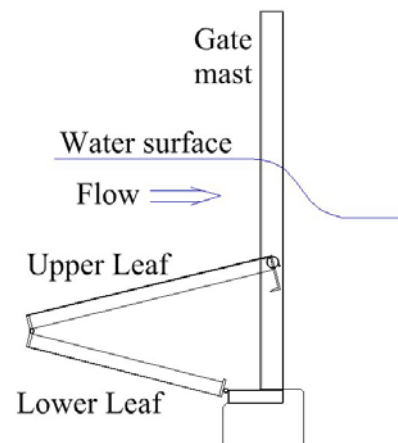
Ram Dhan Khalsa

<sup>1</sup>The Government Highline Canal is part of the Bureau of Reclamation's Grand Valley Project, located in Grand Junction, Colorado. The canal construction was started in 1913 and completed during the Great Depression. The canal extends 52-miles from the diversion dam on the Colorado River flowing westward through the Grand Valley. Two Federal environmental programs spanning a 25-year period have had a dramatic impact on the modernization of the Highline Canal. This paper discusses the use of bi-fold overshot gates in modernizing four existing canal structures and an application in a new pumping plant.



The classical canal overshot gate has a gate-leaf horizontally hinged near the bottom of the canal, with the gate-leaf extending downstream. Water flows over the gate-leaf, which acts as a horizontal weir. The gate actuator is a hoist mechanism that moves the downstream end of the leaf up and down, or in some designs an air bladder under the leaf is used to move the leaf.

The bi-fold overshot gate has a double leaf, horizontally hinged on the bottom and between the lower and upper leaf. The lower leaf extends upstream and is hinged to the upper leaf that folds over the top and is extending downstream. The hinged gate leaves form a horizontal upstream wedge, with the bottom hinge and the top of the leaf crest nearly in a vertical line. Because the gate-leaf and hoist mechanism are upstream of the mounting hardware, the gate can be mounted on the vertical upstream face of an existing canal structure, or in a rectangular concrete canal section.



The bi-fold gates used on the Government Highline Canal were invented by Peter Langemann. The Langemann Gate and controller were developed as a cooperative effort between the St. Mary River Irrigation District in Alberta, Canada and Peter Langemann. The patented design is recognized and accepted for its simplicity, overshot technology, control capabilities, and low power requirements.

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Before embracing the technology for other applications within the irrigation project, the decision was made to install and test one Langemann Gate in an existing three bay stop-log structure, six miles from the river diversion. The stop-log structure had three 7-foot wide bays that create a fore-bay pool for a hydraulic pump turnout. Significant flow changes in the canal required adding or removing stop-logs in an attempt maintain a stable water surface level in the fore-bay. This type of control was difficult. The original check structure was made by forming four massive vertical concrete gussets that create the three 7-foot wide bays. To help install the stop-logs, the stop-log slots and gussets were sloped.

To provide a vertical surface to mount the Langemann gate, the center two gussets were cut to create two vertical columns. A short concrete stem-wall was doweled into the base of the concrete structure.



The base beam sets on a stepped stem-wall and the hoist channels are supported by vertical steel angle sections bolted to the inside of the outside concrete gussets. The assembled gate was placed into the modified structure using a crane.

The gate functions as a vertically adjustable weir. The long horizontal gate-leaf slices through the canal current like a wing. The forces are somewhat balanced; the lower-leaf has an up lifting force that is countered by the downward force on the upper-leaf. With this “balanced” load it is possible to operate the gate hoist with a fractional-horsepower DC motor, which is powered by batteries. The batteries can be charged either by solar panels or an AC/DC battery charger.

Gate automation is accomplished with a Programmable Logic Controller (PLC), with open architecture, that can be easily programmed to run custom control algorithms. Standard control options for a Langemann Gates are upstream water level control and flow control, although the manufacturer will customize the control to the user’s need. In addition, this gate was supplied with an optical encoder to determine gate position, rather than the typical potentiometer indicator.

The purpose of this installation was to maintain a constant upstream water surface level in the pump fore-bay. The completed installation has a 25-foot wide automated bi-fold overshot gate, mounted in a modified 90-year old three bay concrete stop-log structure. The gate performs well, running on the manufactures automation software, and the decision to install four additional gates on the irrigation project was implemented.

The second site is six miles downstream from the first gate. This structure contained a Waterman D-450 Amil gate and six stop-log bays, three on each side. The purpose of this canal check was to change and maintain the upstream water surface in the canal to prevent upstream freeboard encroachment at high canal flows, and to allow upstream turnout deliveries to be made during low canal flows. Although the structure was built in the 1990's, it was poorly designed and did not work. The Amil gate performed as expected but it was not the correct device for this application.



Amil gates have a trapezoidal gate-leaf and massive concrete buttresses. A large concrete saw was used to cut the buttresses from the floor of the structure. The Amil gate, the concrete buttresses, and one stop-log bay on each side of the of the buttresses were removed. A short concrete stem-wall was doweled into the floor of the check structure.



A 28-foot Langemann gate was installed in the open span. There is a small difference in water surface elevation across the gate-leaf, so that the hydrostatic pressures are nearly equal. Of the



remaining stop-log bays, the two adjacent to the Langemann gate were fitted with manually operated electric sluices gates. These gates are open during high canal flows and closed during low flows. The outer most stop-log bays are only half the depth of the canal and the stop-logs are permanently in place. The automation at this canal check is accomplished by the Langemann gate, similar to the previous pump fore-bay Langemann gate.

The third gate was placed at the entrance of an 800 CFS siphon crossing the Colorado River. The purpose of this installation was to maintain automated flow control and flow measurement into the siphon.

Over 1600 CFS is diverted into the Highline Canal at high demand. A bifurcation five miles downstream in the canal splits the flow approximately in half. Originally the bifurcation was controlled using two radial gates, with hand-crank gate hoists. One radial gate controls the Highline Canal and the other controls the siphon. The gate on the Highline Canal had been rebuilt recently, and as part of the canal modernization, it was upgraded with an automated electric hoist. This radial gate controls the upstream water level in the bifurcation.

The Langemann gate, in the entrance to the siphon, is used to control flow. The installation was similar to the previous Langemann gates, but flow conditions were different. The entrance water velocity is over 6-feet/second and the water freefalls over the gate-leaf into the throat of the siphon. Even though the bi-fold leaf balances the approach velocity head on the gate, the hydrostatic difference across the leaf causes the gate to want to float.



To counteract this lift force, the bottom beam of the gate was securely anchored to the concrete stem-wall and the upstream side plates were bolted to the concrete side walls. The greater hydrostat force across the gate-leaf required high inrush current to the motor to start the gate moving. Because of increased the inrush current through the motor, the DC motor solenoids were

replaced with a solid-state soft-start device. DC motor soft starters were installed on all five of the project gates, and are now standard equipment on Langemann gates.

One unexpected site improvement was a great reduction in the trapped air belching back from the siphon inlet. The high velocity discharge under the old radial gate pulled air into the siphon. The water velocity over the Langemann gate-leaf is reduced and the energy is dissipated in the siphon intake. The gate at this site is presently operated in local hand mode. When it is tied into the SCADA radio network, it will be locally automated and remotely operated.

The forth gate was placed downstream of an emergency siphon on a side-channel spillway from the canal. The purpose of this installation is to maintain an automated constant upstream water surface in the canal, and to measure the canal water administratively spilled into Highline Lake. Historically the siphon would be started by a high water level in the canal and then break suction when the canal water level was drawn down ½-foot. With the Langemann gate installed in the spillway, the three sluice gates in the bottom of the canal are opened and the siphon is inoperative.



This Langemann gate has the same hydraulic control challenges as the gate at the bifurcation siphon inlet. The lake spill is 44-miles from the canal diversion point, and there are a series of 14 canal check structures upstream from the spill. The canal checks are operated in upstream control mode, and the miss matches between canal diversion and irrigation deliveries are accumulated downstream at the Highline Lake spill. This gate is 13-feet wide and the spill flow ranges from 0 to 200 CFS. The gate must respond quickly to maintain the canal water surface level. The PLC algorithm control time step was shortened to make the gate move aggressively.





The fifth gate was placed at the entrance of the Highline Lake pump back station. The pump station is operated to supplement canal supply during short-term increases irrigation demand. The purpose of this gate installation is to prevent debris from building up on the pump screens when the pumps are not running. A trash rake cleans the screens when the pumps are operation. A low water level in the canal will cause the Langemann gate in the spillway to rise and stop the spill. If the canal water level falls below the pump target level, the pump PLC will lower the pump station Langemann gate in front of the screens prior to starting the pump. When the pumps stop, the gate is raised to block debris from entering the screens.

Conclusion: Canal modernization, with bi-fold overshot gates was very successful on the Highline Canal. The gates performance well in a variety of water control applications. These gates are custom engineered for each site and designed with the water control feature desired by the user. The low power requirement and the minimal concrete work needed for installations, makes the Langemann gate a versatile and economic tool for modernizing old canals or constructing new canals.

References: Personal contact with Gerald Robinson, R.E.T., Aqua Systems 2000 Inc.