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INTRODUCTION

The Government Highline Canal is part of U. S. Bureau of Reclamation (Reclamation) Grand Valley Project, Grand Junction, Colorado. The canal construction was started in 1910 and completed during the Great Depression. The canal diversion of 1620 CFS extends 55-miles from the Colorado River diversion and delivers water to four irrigation districts and a hydroelectric plant. Two Federal environmental programs spanning a 25-year period have had a dramatic impact in the modernization of the Highline Canal.

PROGRAM ONE

In the 1970's the Colorado River Salinity Control Program funded improvements to reduce canal and lateral seepage that was increasing the salt loading of the Colorado River. The cost effective portions of the canal were lined and most of the earth laterals were piped. These seepage reduction measures dramatically improved the delivery of irrigation water to the farmers.

General Description

The salinity control work was authorized for construction in 1974, amended in 1984. The purpose of the Reclamation's portion of the Grand Valley Salinity Project was to reduce the estimated 580,000 tons per year of salt added to the Colorado River as a result of irrigation conveyance system seepage. Salt loading to the Colorado River occurs when seepage from irrigation canals and laterals, irrigated fields, and irrigation return flows pass through highly saline underlying Mancos Shale Formation in the Grand Valley. By reducing the amount of groundwater percolating through these saline soils, salt loading to the Colorado River is decreased.

Reclamation's program in the Grand Valley primarily focuses on off-farm irrigation system improvements. Off-farm construction included lining portions of the main canal and piping the laterals that deliver water from the main canal to irrigated land. On-farm improvements were conducted by the Natural Resource Conservation Service, a.k.a. Soil Conservation Service, which includes upgrading irrigation systems through cost assistance and improving irrigation management to reduce deep percolation from farm operations. The improvements include installing underground pipelines, gated pipe, concrete-lined ditches, land leveling, drip irrigation systems, and a variety of other practices.

The Highline Canal is operated and maintained by the Grand Valley Water Users' Association (GVWUA). The Grand Valley Salinity Project was completed in two stages. Stage I was used as a test area to refine analysis and construction techniques used on the balance of the project (Stage II). Stage I construction began in October 1980. As part of the development, 6.8 miles of the Government Highline Canal was lined with un-reinforced slip-form concrete lining and four check structures were constructed in the canal. Thirty-four miles of unlined laterals were consolidated into 30 miles of close pipeline laterals. Construction of Stage One was essentially completed in April 1983. Beginning in November 1981, Stage Two investigations included re-evaluating various alternatives and analyzing salinity control measures other than concrete lining of the canals and laterals.

Stage Two improvements to the Highline Canal used a PVC membrane lining instead of concrete. Work in the canal included the construction of four check structures. Laterals in the Highline Canal systems were converted from open earth ditches to closed pipelines.

Construction

Improving the Highline Canal involved shaping the canal bottom and banks. After the canal was shaped, a 40-mil PVC membrane lining was pulled across the canal. A 15-inch-thick layer of gravel was placed over the membrane lining to protect it from the sun and canal maintenance. The laterals were a closed pipe design, with pipe sizes ranged from 6 to 48 inches in diameter. The individual deliveries have propeller type flow-meters and various valve schemes to deliver water to the on-farm irrigation system. Typically the user controls the delivery of water.

Benefits Salinity Control

The Grand Valley Salinity Project removes 115,700 tons of salt per year. The resulting annualized cost for the Salinity Project is $93 per ton of salt removed.

Consequential benefits for the GVWUA irrigators

The irrigation delivery system was changed from an open-flow supply-side system to a gravity pressured closed-pipeline demand-side system. The use of water orders went from water delivery accounting to canal monitoring. Water accounting is recorded with flow-meters, and the water orders are used to forecast the day-to-day demand on the canal. The increased flexibility in terms of rate and duration went from 24-hour blocks of water to whatever the irrigator desires. The down-side of increased flexibility at the deliveries is that the canal has the same limited capacity to deliver water to the laterals. The laterals no longer have tail-water spills. Changes in lateral demands are immediately reflected in the canal. Increased flexibility at the deliveries requires greater attention to the administrative spills or lack of spills to prevent the inadvertently de-watering and refilling of lateral pipelines.

PROGRAM TWO

In the 1990's The Recovery Implementation Program for the Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) identified a 15-Mile Reach of the Colorado River between Palisade, Colorado and the confluence of the Colorado and the Gunnison Rivers at Grand Junction, Colorado as an area needing additional water supplies to maintain habitat conditions for several identified endangered fish species. The Colorado Endangered Fish Recovery Program needed to increase late season in-stream flows in the Colorado River through the Grand Valley. A cost effective alternative for accomplishing increased flows in the river was by modernizing the Highline Canal to reduce the late season administrated spills.

Historically the Highline Canal delivers 650 CFS to the GVWUA project area. The minimum flow to maintain a water surface in the canal to make the turnout deliveries is around 400 CFS. The canal is operated by starting out with 400 CFS in the spring and ramping up to 650 CFS within a month. The canal carries 650 CFS through most of the summer. Then as demand drops off in August through October, The canal is ramped down to 400 CFS. Demand decreases substantially below the 400 cfs needed to run the canal. In the very late season, demand can approach 25 cfs. Any water in the canal in excess of demand is released through administrative spills. Canal administrative spills are returned to the Colorado River through natural drains with little environmental impact, other than reducing the flows in the upper 15-mile reach of the river.

To deliver real water to the Colorado River from canal modernization is a complex problem which requires careful analyses. The Government Highline Canal Modernization Study was proposed, and a team was formed. The following were the cooperators in the study: Colorado River Fish Recovery Program (Recovery Program), USBR - Grand Junction Area Office (USBR), Grand Valley Water Users Association (GVWUA), and Cal Poly - Irrigation Training and Research Center (ITRC).

The study provided an analysis of structural and operational options that will permit the reduction of operational spills, a series of alternate designs that could achieve this effect, and a computer model of the Government Highline Canal. The problems with reducing canal flow rate requirement during periods of low user demand, is that the water level is too low to deliver adequate water to the canal turnouts, and secondly it is difficult to match canal flows to the flexible delivery demand. In addition, any canal modernization must maintain the current level of "service" to the irrigators in the GVWUA. The current system is characterized as having a simple and efficient operation as created by the flexible closed pipeline lateral systems from the salinity program.

The Salinity Control Program incorporated 8 new canal check structures in the portions of the canal that received lining. The modernization study recommended 7 additional check structures in the unimproved sections of the canal to permit reduced river diversion. The 7 new check structures were constructed in 2001. With 15 check structures operating in some kind of localized automation, the canal can operate with 150 CFS in flow in late season. Since the completion of the canal checks, river diversions have been reduced 30,000 to 45,000 acre feet per year.

The second part of the puzzle was to more closely match canal flows to the flexible demand. To quickly adjust canal supply, a pumping plant was constructed at Highline Lake. The canal is operated in an up-stream control strategy and has a major administrative spill into the lake. With the canal operated in up-stream control from the river diversion to Highline Lake, all the mismatches between supply and demand are accumulated at the Highline Lake spill. A pump back station was constructed at the spill to supply lake water to the canal during times when demands exceed the supply in the canal. The operation of the pump-back station allows the canal water diversions to more closely match the user demands, without the fear of shortages in the last 6-miles of canal downstream of the Highline Lake spill. The pump station is capable of delivering up to 75 CFS to the canal. The maximum down stream demand is about 150 CFS, and this 6-mile portion of the canal will be operated in downstream control mode to further reduce the tail-end spills. The pump station will reduce the attention required to the administrative spills to prevent the inadvertently de-watering and refilling of lateral pipelines on the tail end of the canal, and further reduce the required diversion from the Colorado River.

CONCLUSION

Irrigation districts and association are very interested in maintaining their agricultural water rights. Most districts and association would like to increase the reliability and flexibility of their delivery systems, but it is unlikely the profit margins from the collective irrigated lands within the projects are capable of funding a massive modernization project as described in this paper. The key to project funding is finding non-project partners to fund the modernization for their own benefits and create a win-win situation.