IRRIGATION TRAINING & RESEARCH CENTER

Flathead Indian Irrigation Project

Modernization of Pablo Feeder Canal and Polson-Area Canals

U.S. Bureau of Indian Affairs
Branch of Irrigation & Power

April 2016

TABLE OF CONTENTS

Pablo Feeder Canal Modernization near Polson 1
Modernization Plan 1
Improvements at Flathead River Pumps 3
Existing Problems 6
Improvements Needed 6
Pablo Feeder Canal Pumpback System 7
Pumpback System Design 10
Canal Lining 11
Hydraulic Simulations 12
Individual Pump Stations 14
Polson Pipelines 30
Proposed Polson Pipeline System 31
Improved Flow Measurement at Head of Pablo A Canal 33
Improvements to Mud Creek and Ronan B Canal 35
Improved Flow Measurement at Mud Creek Diversion 36
Improved Control at Ronan B Canal Diversion on Mud Creek 38
Flow Restriction in the Ronan B Canal 40

LIST OF FIGURES

Figure 1. General overview of modernization changes made to the canal system near Polson....2
Figure 2. Aerial view of the Flathead River Pump House and its discharge into the Pump Canal....3
Figure 3. Pump house intakes on the Flathead River....3
Figure 4. The three individual Flathead River Pump motors....4
Figure 5. Single stage vertical centrifugal pump (left). Old impeller with pitting that needs to be repaired (right)....4
Figure 6. Existing SCADA system for the river pumps....5
Figure 7. Pump discharge pipelines....5
Figure 8. Discharge into the Pump Canal....5
Figure 9. General area that suffers from lack of water in the Pablo Canal Feeder during the late irrigation season....7
Figure 10. Overview of the Pablo Feeder Canal Pumpback System....8
Figure 11. Pablo Feeder Pumpback Design – Conceptual....10
Figure 12. Simulated water level profile of the Pablo Feeder Canal for reverse grade pumping at steady state....12
Figure 13. Simulated water level profile of the Pablo Feeder Canal for steady state gravity flow. Both low (40 CFS) and high flows (400 CFS) were simulated....13
Figure 14. Existing conditions at the Pablo Drop....14
Figure 15. Existing GOES gauging station upstream of the Pablo Drop....15
Figure 16. Downstream of the Pablo Drop....15
Figure 17. Upstream (left) and downstream (right) views of the existing check structure located downstream of the Pablo Drop....16
Figure 18. New control components at the Pablo Drop for Pump Station #1....16
Figure 19. Conceptual plan view of LCW structure at Pump Station #1 (not to scale)....17
Figure 20. Conceptual plan view of new LCW structure in the Pablo Feeder Canal downstream of the Pablo Drop (not to scale)....19
Figure 21. Approximate location for new Pump Station #2 on the Pablo Feeder Canal....19
Figure 22. Small check in the Pablo Feeder Canal upstream of Caffrey Rd....20
Figure 23. New components for the new Pump Station #2 on the Pablo Feeder Canal....20
Figure 24. Conceptual plan view of Pump Station #2 (not to scale)....21
Figure 25. Location for Pump Station #3 on the Pablo Feeder Canal approximately 0.6 miles upstream of Skyline Drive....22
Figure 26. Existing conditions in the Pablo Feeder Canal at Highway 93....23
Figure 27. Existing manual check gate at head of the chute drop in the Pablo Feeder Canal upstream of Highway 93....24
Figure 28. Chute drop on the Pablo Feeder Canal upstream of Highway 93....24
Figure 29. Modernization changes in the Pablo Feeder Canal at Highway 93 to incorporate Pump Station #4....25
Figure 30. Location of Pump Station #5 on the Pablo Feeder Canal located approximately 2.25 miles upstream of Highway 93....26
Figure 31. Existing Pablo Feeder Canal downstream of Dubay Road....27
Figure 32. Existing check structure in the Pablo Feeder Canal located downstream of Dubay Road....27
Figure 33. Location of Pump Station #6 on the Pablo Feeder Canal approximately 0.7 miles downstream of Dubay Road....28
Figure 34. Location of Pump Station #7 on the Pablo Feeder Canal downstream of Minesigner Trail Road....29
Figure 35. Existing Polson Canal System....30
Figure 36. Proposed limited-demand pipeline network near Polson....31
Figure 37. Existing conditions at the discharge of the Pablo Reservoir into the Pablo A Canal....33
Figure 38. Modernization changes at the discharge of the Pablo Reservoir into the Pablo A Canal....34
Figure 39. Examples of flow conditioner walls. Note the photo on the bottom has the flow conditioner constructed on the wrong side of the canal. The conditioner must be constructed on the outside of a canal bend....34
Figure 40. Existing alignment of Mud Creek and the Ronan B Canal west of the Pablo Feeder Canal....35

Figure 41. Mud Creek headgate on the Pablo Feeder Canal. Photo from HKM 2008 report (HW-25).....................36
Figure 42. Downstream of the Mud Creek Diversion headgate on the Pablo Feeder Canal. Photos from HKM 2008 report (HW-25). 36
Figure 43. Flow measurement improvements at Mud Creek headgate.....37
Figure 44. Ronan B Canal diversion on Mud Creek.....38
Figure 45. Existing check structure in Mud Creek just downstream of the Ronan B Canal headgates. Photo from HKM 2008 report (CH-466). 38
Figure 46. Gauging station on the Ronan B Canal just downstream of the canal headgates. Photo from HKM 2008 report (HW-21). 39
Figure 47. Modernization changes made near the head of the Ronan B Canal at Mud Creek.....39
Figure 48. Conceptual plan view of new LCW structure to be constructed in Mud Creek at the head of the Ronan B Canal (not to scale). 40
Figure 49. Approximate location of an apparent flow restriction on the Ronan B Canal.....41
Figure 50. Existing portion of the Ronan B Canal where there is an apparent flow restriction.....41

LIST OF TABLES

Table 1. Pump station characteristics for the Pablo Feeder Canal Pumpback System. Rough estimates for planning purposes. 11
Table 2. Approximate dimensions of canal sections (pools) 11

PABLO FEEDER CANAL MODERNIZATION NEAR POLSON

Modernization Plan

Figure 1 shows the general modernization plan for the canal system near Polson. The modernization plan includes:

1. Improvements will be made at the Flathead River Pumps to reduce/eliminate current cavitation problems as well as update existing components.
2. Using discharge from the Flathead River Pumps, a new pumpback system will be created in the Pablo Feeder Canal to supply water to areas upstream in the canal system that normally cannot be provided with water during the late portion of the irrigation season.
    a. The new pumpback system will consist of the Pablo Canal Feeder from the Pablo Drop to the Mud Creek diversion (approximately 9.75 miles).
    b. A total of seven automated pump lift stations will be constructed to pump water reverse grade all the way to Mud Creek.
    c. Each lift station will have a long-crested weir (LCW) and gate combination to provide upstream water level control during normal gravity flow operation.
    d. The section of the Pablo Feeder Canal used for the pumpback system will be lined using a shotcrete and geomembrane combination for:
        i. Improved hydraulic characteristics for the pumpback system
        ii. Reduced canal seepage
3. The existing Polson Canals will be replaced with multiple limited-demand pipelines.
4. Flow measurement will be improved at:
    a. The discharge from the Pablo Reservoir into the Pablo A Canal
    b. Discharge into Mud Creek from the Pablo Feeder Canal
5. The existing control at the Ronan B Canal diversion on Mud Creek will be improved to provide better control and measurement of the flow into the Ronan B Canal.
6. The flow measurement at the discharge of the Pablo Reservoir will be improved to include SCADA.

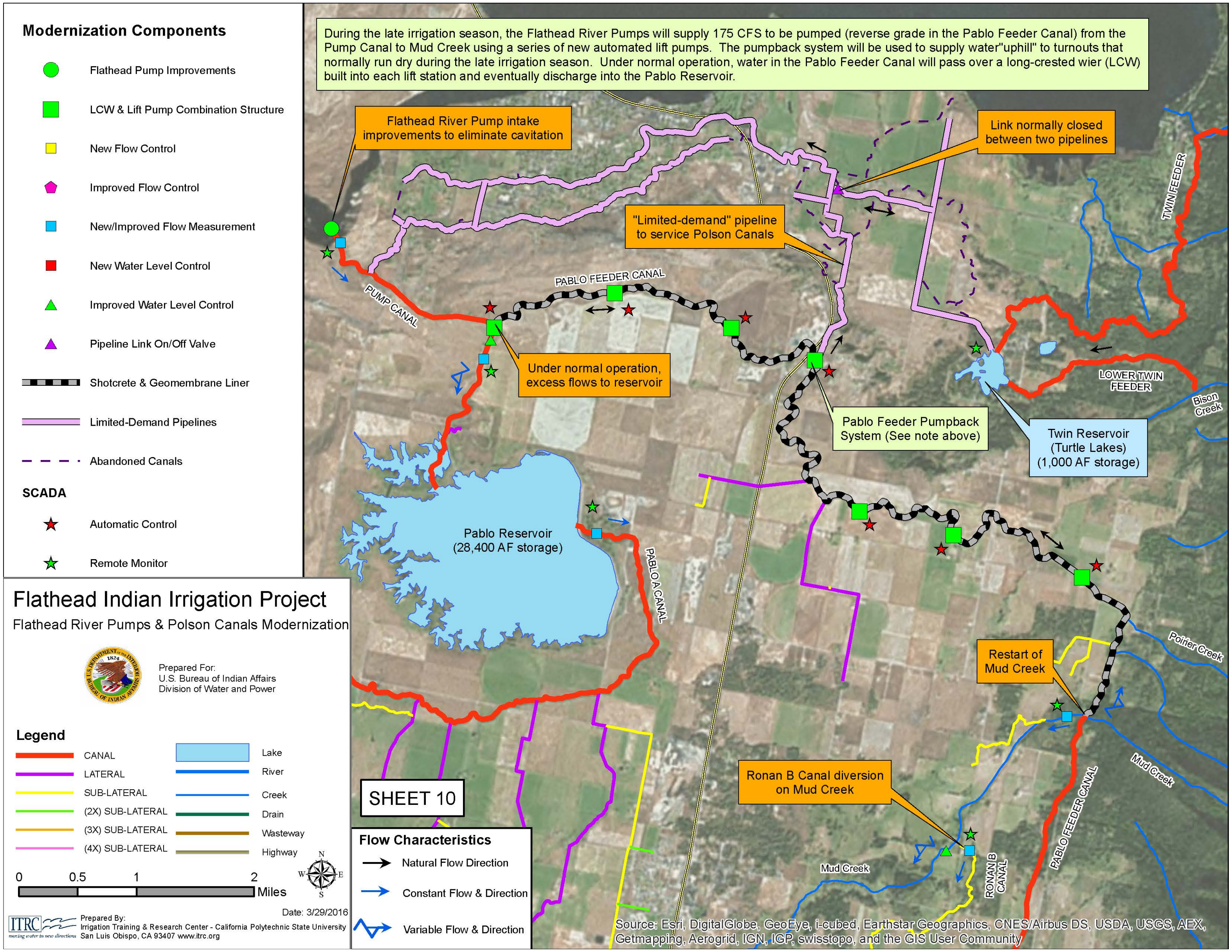

Figure 1. General overview of modernization changes made to the canal system near Polson

Improvements at Flathead River Pumps

Figure 2 shows an aerial view of the Flathead River Pump House and Pump Canal. The pumping plant was completed in 1940 and still has many of the original components.

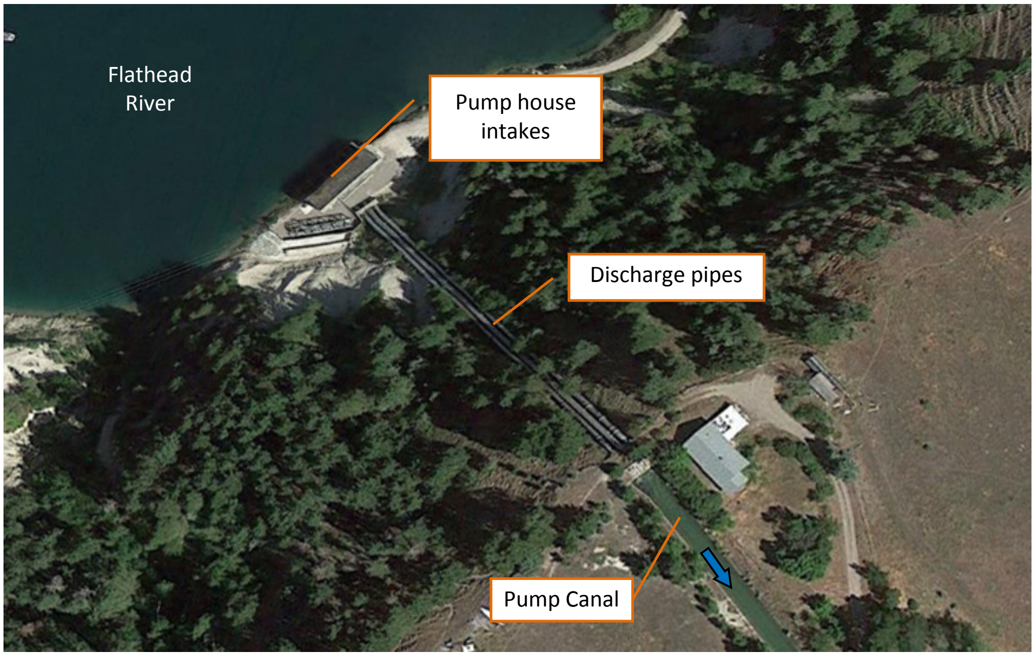

Figure 2. Aerial view of the Flathead River Pump House and its discharge into the Pump Canal

Figure 3 shows the pump house intakes on the Flathead River. Each river intake has a near vertical trash rack. A large floating board was installed in each intake opening structure to catch large debris prior to reaching the trash rack.

Figure 3. Pump house intakes on the Flathead River

Figure 4 shows the three individual motors and Figure 5 shows an example of one of the single stage vertical centrifugal pumps. The right photo in Figure 5 shows an old impeller that has pitting and which was replaced with the only spare impeller. All impellers are the originals.

Figure 4. The three individual Flathead River Pump motors

Figure 5. Single stage vertical centrifugal pump (left). Old impeller with pitting that needs to be repaired (right).

The river pump station has the following characteristics:

- Three individual vertical centrifugal, single stage pumps
- Each pump has:
    - A flow rate of 67 CFS. A mercury manometer with a venturi or orifice plate is used to measure the flow rate from each pump.
    - Motor speed of 900 RPM
    - Motor horsepower of 3,000 HP
- The pumping heads are as follows:
    - Normal static lift = 331.1 ft.
    - Normal dynamic lift = 335 ft.
    - Maximum dynamic lift = 341 ft.
    - Minimum dynamic lift = 322 ft.

Figure 6 shows the existing SCADA system for monitoring various operating characteristics of the three pumps. An alarm system is built into the SCADA system to alert the main FIIP office and operators of problems at the pumping plant.

Figure 6. Existing SCADA system for the river pumps

Figure 7 shows the three individual discharge pipelines from the Flathead River to the Pump Canal. Figure 8 shows the actual discharge point into the Pump Canal.

Figure 7. Pump discharge pipelines

Figure 8. Discharge into the Pump Canal

Existing Problems

The existing problems at the Flathead River Pumps include the following:

- Based on the current trash rack design, it is difficult and even hazardous for operators to try to remove log debris. The angle of the trash rack is too steep; the rack does not support most of the weight of the debris when being removed.
- The pumps often experience cavitation when on.
    - The cavitation occurs at any river stage elevation in the Flathead River.
    - Small valves were installed downstream of the impellers to somehow help with cavitation.
    - Vibratory sensors installed in the pumping plant will shut downs the pumps if the vibration exceeds an allowable level.
    - There are no check valves on any of the pumps so the pumps and motors spin in reverse when shut down, allowing the water in the discharge pipes to flow back into the river. When the pumps are started up again, there usually are no more cavitation problems.
    - It is unclear what causes the cavitation. Possible causes are:
        1. A buildup of debris on the trash racks could be causing a significant loss of pressure at the pump inlets.
        2. Air entrainment evidently occurs during low river levels, because vortexing has been observed upstream of the inlets.
- The impellers were supplied during the original construction, and have experienced wear. Repairs have been made using an abrasive coating produced by the Thortex Group.
- Many components are the originals and either do not work or often need to be repaired. For example, there are no working pressure gauges upstream or downstream of the pumps.
- The SCADA system uses outdated computer software.
- There is erosion occurring from leaking water somewhere along the hillside that supports the three discharge pipelines. The leaking water appears to be coming from near an abandoned operator house at the top of the hill near the pump discharge.

Improvements Needed

The Flathead River Pumps were identified as part of the Tribes Compact to be replaced/modernized to current standards. Focusing only on the existing pumping plant, the following improvements are needed at the Flathead River Pumps:

1. New automated trash screens should be installed at each inlet opening. The trash screens would continuously clean the pump inlets to help reduce cavitation and vortexing. They would also ease maintenance requirements, and provide safety for operators.
2. New stainless-steel impellers can be installed to replace the worn original impellers. The new impellers should be polished, balanced, and have all new wear rings.
3. New electrical oil-circuit breakers (OCB) should be installed to replace the original electrical components that are often in need of repair.
4. A new computer system with updated SCADA components should be installed, to be compatible with a new FIIP SCADA system.

Pablo Feeder Canal Pumpback System

During the normal part of the irrigation season, the Pablo Feeder Canal supplies many direct canal turnouts and can supply Pablo Reservoir with a maximum of 400 CFS. During the late irrigation season, when there is limited or no flow in the very northern portion of the Pablo Feeder Canal, approximately 18,000 acres have reduced access to irrigation water (see Figure 9). Some of the fields with pivots do have well pumps to continue irrigation in the later season.

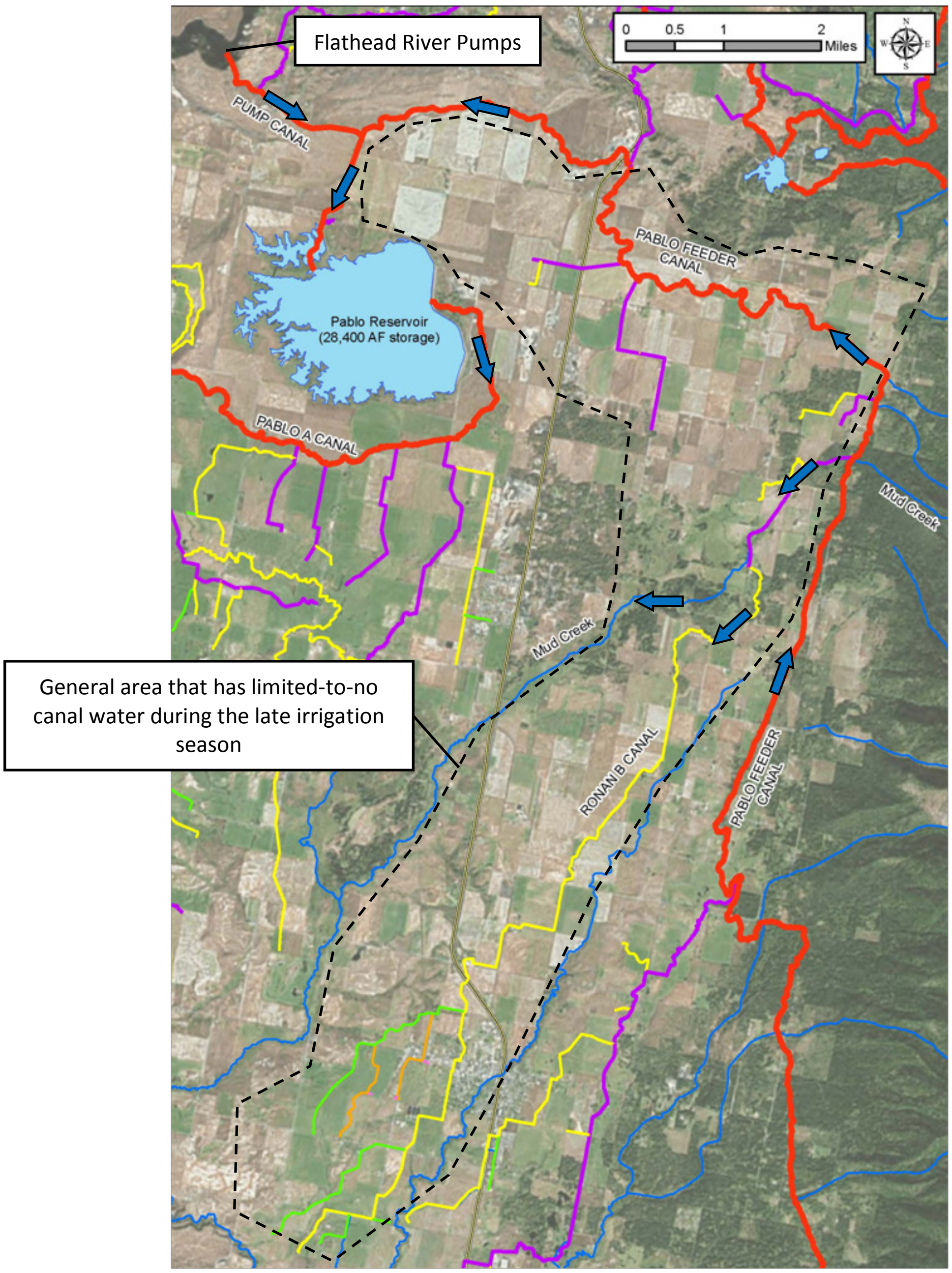

Figure 9. General area that suffers from lack of water in the Pablo Canal Feeder during the late irrigation season

The overall efficiency improvements in the Mission Area should help provide more flow during the late summer, but an additional opportunity exists – that of using water from the Flathead River Pumps.

This would be an expensive option because it would require lining canals, using up to 2100 kW of power, and installing new pumps and control structures between Mud Creek and the Pablo Drop. The option is presented here for consideration. One might compare the 2100 kW for this option against the approximately 7500 kW capacity of the river pumping plant; the additional 1/3 power might be considered reasonable, given the acreage served. The hours of operation would likely be much less than the river pumping hours.

Many irrigation projects have canals that convey water downhill part of the irrigation season, and then use a pumped system to move water uphill during other parts of the irrigation season. The Pablo Feeder Canal, between Mud Creek and the Pump Canal/Pablo Feeder Canal intersection, could be configured to operate in this manner. This system is referred to in this report as the "Pablo Feeder Canal Pumpback System".

Figure 10 shows the general overview of the Pablo Feeder Canal Pumpback System.

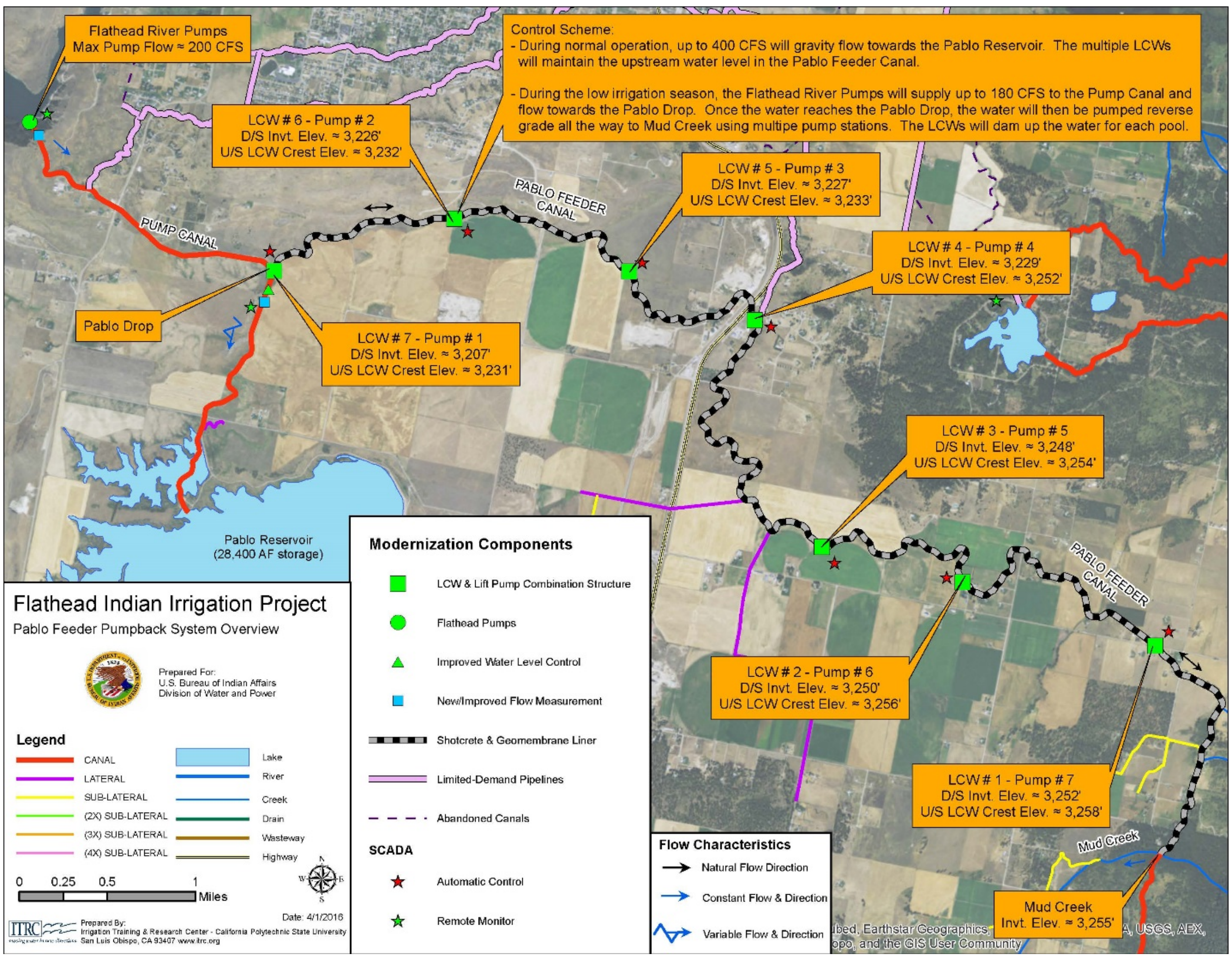

Figure 10. Overview of the Pablo Feeder Canal Pumpback System

The general overview of the control components includes:

1. A total of seven combination structures, each consisting of both a long-crested weir (LCW) and lift pumps, will be constructed along a 10-mile section of the Pablo Feeder Canal between Mud Creek and the Pablo Drop located upstream of the Pablo Reservoir. Water will have the ability to move both directions in the canal to service turnouts throughout the irrigation season.
2. The Pablo Feeder Canal will be re-shaped and re-configured.
3. The Pablo Feeder Canal will be lined for 10 miles with a shotcrete and geomembrane combination to:
    a. Improve hydraulics conditions when water is being pumped reverse grade.
    b. Significantly reduce canal seepage.
4. The automation of the VFD-equipped pumps should be of specialized, proven PIF logic. The pumps will operate with a general control scheme known as "downstream control" and will automatically respond to water shortages beginning at Mud Creek and extending to the Pablo Drop. The pumps will be locally and automatically controlled, with SCADA monitoring.

The general operation control scheme will be as follows:

- During the normal operation (when there is adequate flow available in the Pablo Feeder Canal from the upstream portion of the project):
    - Up to 400 CFS will gravity flow down the Pablo Feeder Canal towards Pablo Reservoir.
    - The new LCWs will provide upstream water level control for direct turnout deliveries on the canal.
    - A manually operated canal gate(s) installed at the tail end of the LCW will be adjusted so that the head over the crest is approximately 0.6 ft. With a head of 0.6 ft., the LCW will pass approximately 220 CFS.
    - The remaining flow rate (approximately 180 CFS, maximum) will pass through the manually operated canal gates.
    - Depending upon whether the primary problem is sediment or floating trash, the manually operated canal gates will be underflow or overflow.
- During lows flows in the Pablo Feeder Canal at the latter portion of the irrigation season:
    - The manually operated canal gates in each LCW structure will be completely closed.
    - The Flathead River Pumps will be turned on to supply up to 175 CFS at the Pablo Drop, for use uphill in the Pablo Feeder Canal.
    - A special control scheme will automatically pump enough water over the long-crested weirs (LCWs) as far uphill as Mud Creek, to supplement whatever demands are not met by flows supplied by the Pablo Feeder source.
- During low flows the control of the new Pablo Feeder Canal pumps, between Mud Creek and the Pablo Drop, will be what is known as *downstream control*. This can be illustrated as follows:
    - If there is insufficient flow coming down the Pablo Feeder Canal, the water level just upstream of the LCW at the new Pump Station #1 will drop below the LCW crest. Redundant water level sensors upstream of the LCW will detect this, and VFD-equipped pumps at Pump Station #1 will start operating. The pumps will maintain the canal pool so that the water level will stay just below the crest of the LCW.
    - If the water shortage supplied by the Pablo Feeder Canal is greater than what is needed upstream of Pump Station # 1, the water level just upstream of the LCW at the new Pump

Station #2 will drop below its LCW crest. The pumps at Pump Station #2 will start operating, and will automatically maintain the water level upstream of the LCW. The pumps at Pump Station #1 will also automatically increase their flow, to supply the water needed for Pump Station #2.

- This sequence will move uphill until all the pools can satisfy their deliveries. If more water becomes available from the Pablo Feeder Canal, the pumps will shut down one station at a time, beginning with the most uphill pumps.
- Up to 175 CFS will be pumped uphill at Pump Station #1 (at the Pablo Drop) to fill the upstream pools.
- The design should allow water to be pumped reverse grade into each pool until up to 100 CFS is pumped into the last pool that will supply Mud Creek.
- Direct turnouts and laterals along the Pablo Feeder Canal will be able to take water at any time since the VFD pumps will automatically maintain the pool levels when there is a change in flow.

Pumpback System Design

Figure 11 shows the design characteristics for the Pablo Feeder Canal Pumpback System. A total of seven individual lift pump/LCW stations will provide upstream water level control in the Pablo Feeder Canal during either gravity flow or reverse grade pumping operation.

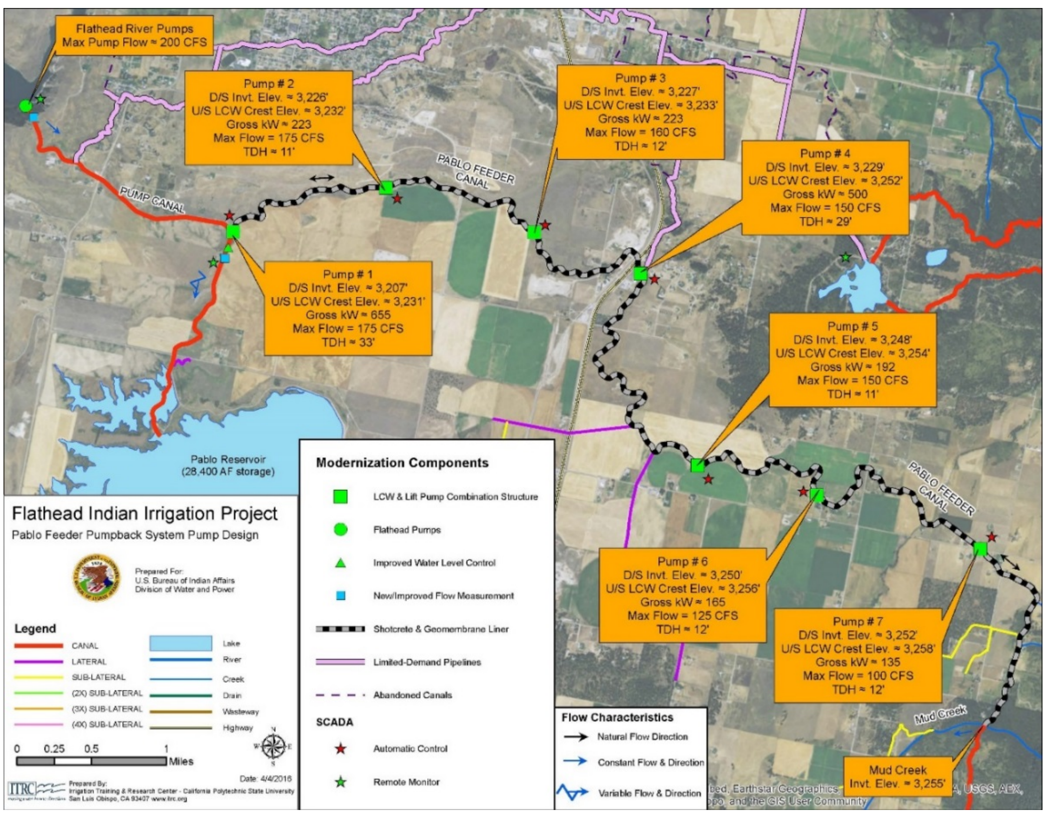

Figure 11. Pablo Feeder Pumpback Design – Conceptual

Table 1 summarizes the individual pumping stations characteristics for the Pablo Feeder Canal Pumpback System.

Table 1. Pump station characteristics for the Pablo Feeder Canal Pumpback System. Rough estimates for planning purposes.

	Distance U/S from Pablo Drop	Invert Elevation	Pool Invert Elevation Rise	Gross Electric Requirement	Max Flow	Total-Dynamic Head (TDH)
Point Description	Mile	ft.	ft.	KW	CFS	ft.
Pablo Drop, Pump Station #1	0.00	3,224.8	24.0	655	175	33
Pump Station #2	1.18	3,225.8	1.6	223	175	11
Pump Station #3	2.35	3,227.4	1.9	223	160	12
Pump Station #4	3.53	3,229.3	18.4	500	150	29
Pump Station #5	5.08	3,247.7	2.1	192	125	11
Pump Station #6	6.63	3,249.8	2.5	165	125	12
Pump Station #7	8.18	3,252.3	2.5	135	100	12
Mud Creek	9.74	3,254.8	n/a		n/a	

All long-crested weirs (LCWs) will have a 160 ft. crest length, with a concrete crest height of 5.5' plus an additional 0.5' of board on top – providing a total crest height of 6.0'. The LCWs will:

- Maintain the upstream water level during normal gravity flow operation scheme.
- Act as a dam for the upstream pool to allow water to be pumped reserve grade to the next upstream pool.

The maximum flow rate in the Pablo Feeder Canal during normal gravity flow operation is 400 CFS. The 160' LCW will pass approximately 220 CFS with a head of 0.6', and 480 CFS with a head of 1.0'. However, the recommended operation would be to maintain the head over the LCW at 0.6', and pass the remainder of the flow through manually operated gates.

<u>Canal Lining</u>

Several design configurations and options were considered. Given the slopes and flow rates, it appears that the complete canal between Mud Creek and the Pablo Drop will need lining. Some sections are already lined.

It is highly recommended that all future lining consist of a high quality membrane covered by shotcrete. Studies of canal lining consistently show that this combination of a membrane (to minimize seepage) and concrete (to provide physical protection from animals and cleaning) is most cost effective for the most years. One popular membrane, made especially for this purpose, is the Huesker Canal[3] 8028 product.

Table 2. Approximate dimensions of canal sections (pools)

			New Canal Dimensions		
	Pool Length	Existing Lining Length	Bottom Width	Side Slope	Total Depth
Pool Uphill of	Mile	Mile	ft.		ft.
PS #1	1.18	0	20	1.5:1	8
PS #2	1.17	0	20	1.5:1	8
PS #3	1.18	0	20	1.5:1	8
PS #4	1.55	0	20	1.5:1	8
PS #5	1.55	0	20	1.5:1	7.5
PS #6	1.55	0	20	1.5:1	7.5
PS #7	1.56	0	20	1.5:1	7.5

Hydraulic Simulations

The ITRC's proprietary unsteady flow/control simulation program was used to simulate both steady state gravity flow and reverse grade pumping schemes to determine the approximate locations of the lift pump/LCW stations along the Pablo Feeder Canal. The simulation results are presented in the next two sections. Unsteady flows were not modeled, nor was a control algorithm tuned. A variety of physical configurations were examined; the results below provided the best results.

Reverse Grade Pumping at Steady State

Figure 12 shows the water surface profile in the Pablo Feeder Canal for the reverse grade pumping at steady state simulation. Figure 12 contains the water level depths at the start and end of each canal pool from the Pablo Drop to Mud Creek. The water level surface will be maintained approximately 0.1 ft. below the crest of the LCW. The uphill end of each pool will have a water depth of approximately 3-5 ft. during reverse flow.

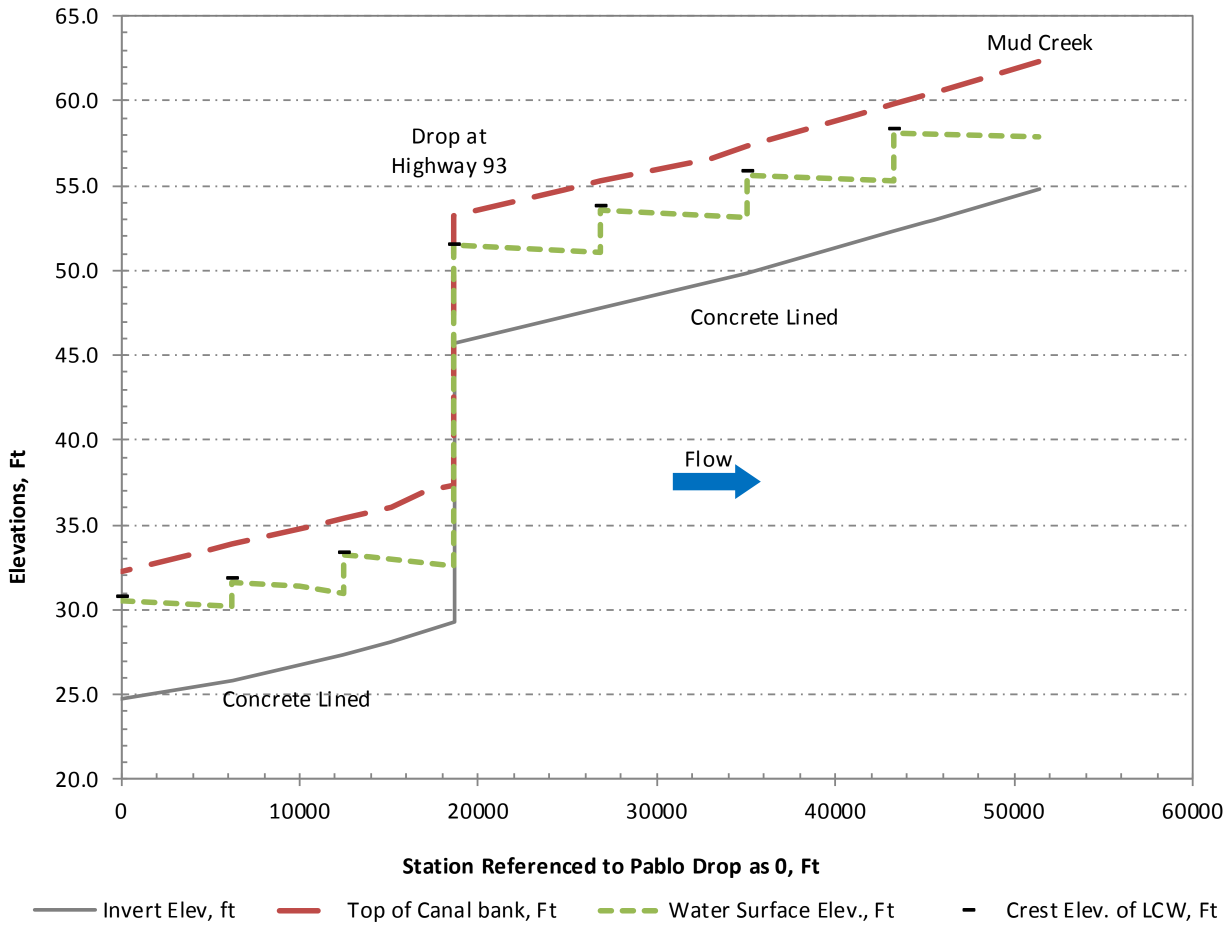

Figure 12. Simulated water level profile of the Pablo Feeder Canal for reverse grade pumping at steady state

Gravity Flow at Steady State

Figure 13 shows the simulated water surface profile in the Pablo Feeder Canal for steady state gravity flow. Figure 13 contains the water level depths at the start and end of each canal pool from Mud Creek to the Pablo Drop. All of the high (400 CFS) and low (40 CFS) flows were simulated to pass over the LCWs to check the available freeboard. Under normal operation, a large portion of the flow will path through a gate(s) installed in the center of the LCW.

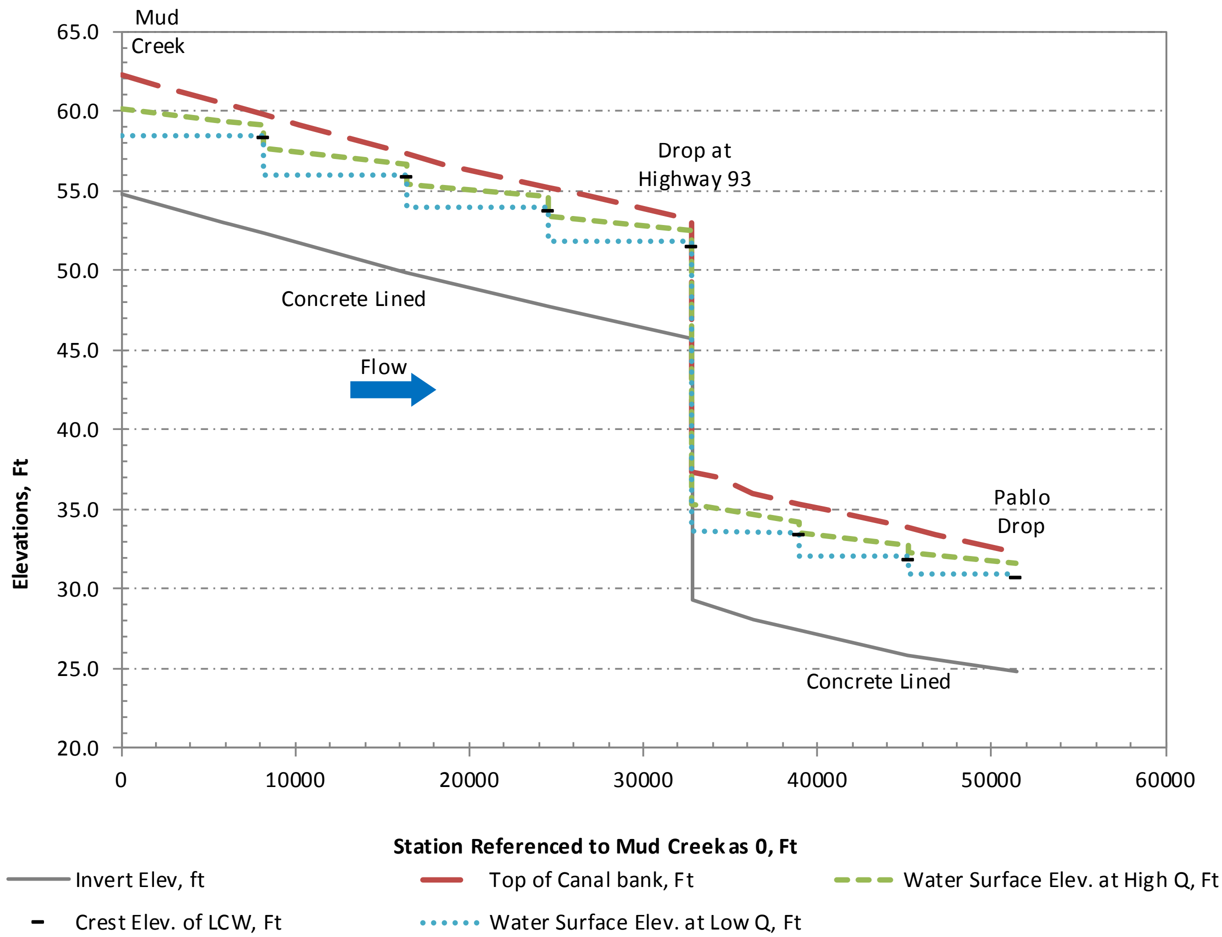

Figure 13. Simulated water level profile of the Pablo Feeder Canal for steady state gravity flow. Both low (40 CFS) and high flows (400 CFS) were simulated.

Individual Pump Stations

The following report sections provide further information for each individual lift pump/LCW station of the Pablo Feeder Canal Pumpback System.

Pump Station #1 (Pablo Drop)

Figure 14 shows the existing canal control at the Pablo Drop.

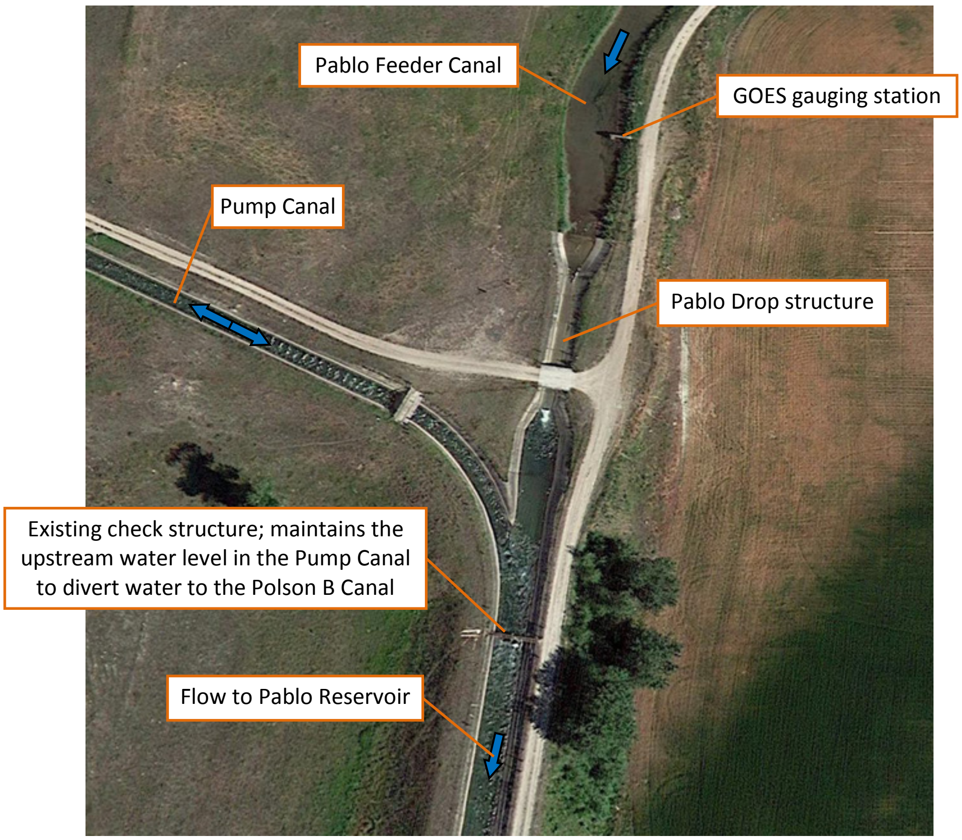

Figure 14. Existing conditions at the Pablo Drop

The flow rate in the Pablo Feeder Canal is measured by a GOES gauging station (see Figure 15) located approximately 100 ft. upstream of the Pablo Drop.

Figure 15. Existing GOES gauging station upstream of the Pablo Drop

Immediately downstream of the Pablo Drop, the Pablo Feeder Canal joins with the Pump Canal (see Figure 16).

Figure 16. Downstream of the Pablo Drop

An existing check structure downstream of the Pablo Drop (see Figure 17) maintains the upstream water level so that water can be backed up in the Pump Canal in order to make a delivery to the Polson B Canal.

Figure 17. Upstream (left) and downstream (right) views of the existing check structure located downstream of the Pablo Drop

Figure 18 shows the new control components at the Pablo Drop for Pump Station #1. Figure 19 shows the conceptual plan view of the new LCW structure to be constructed just upstream of the Pablo Drop.

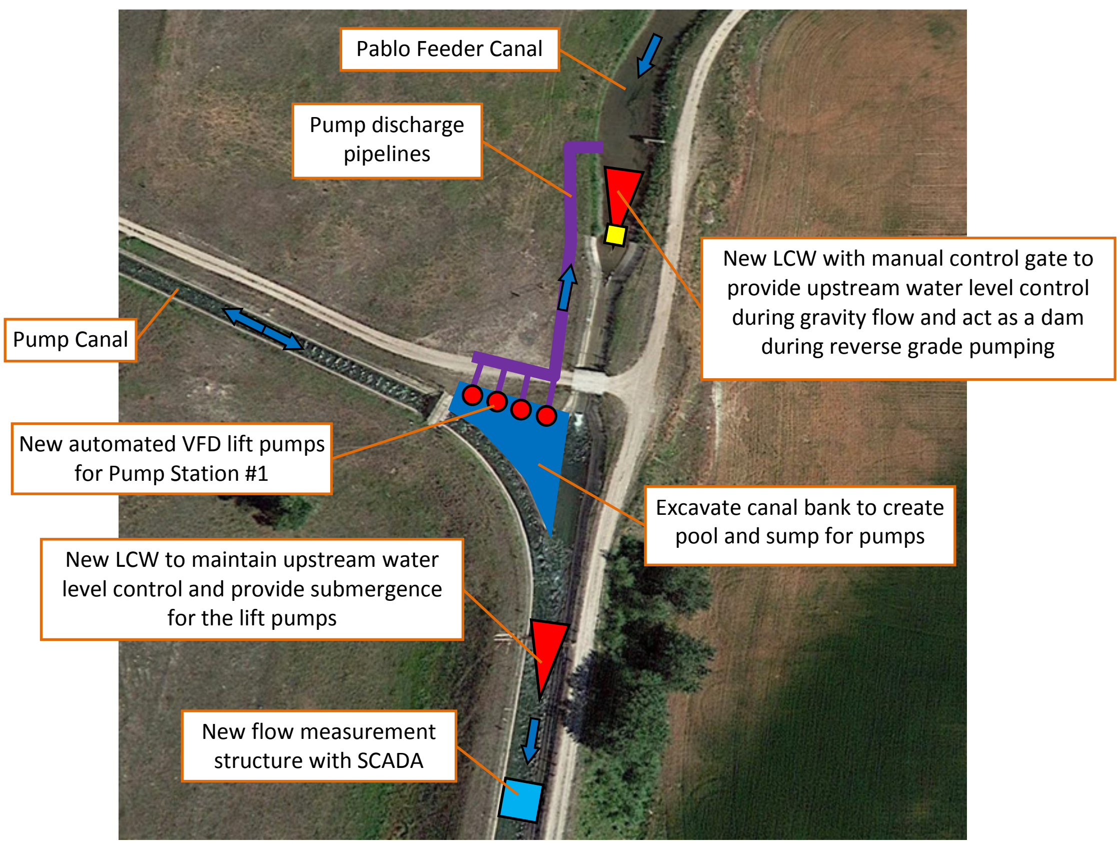

Figure 18. New control components at the Pablo Drop for Pump Station #1

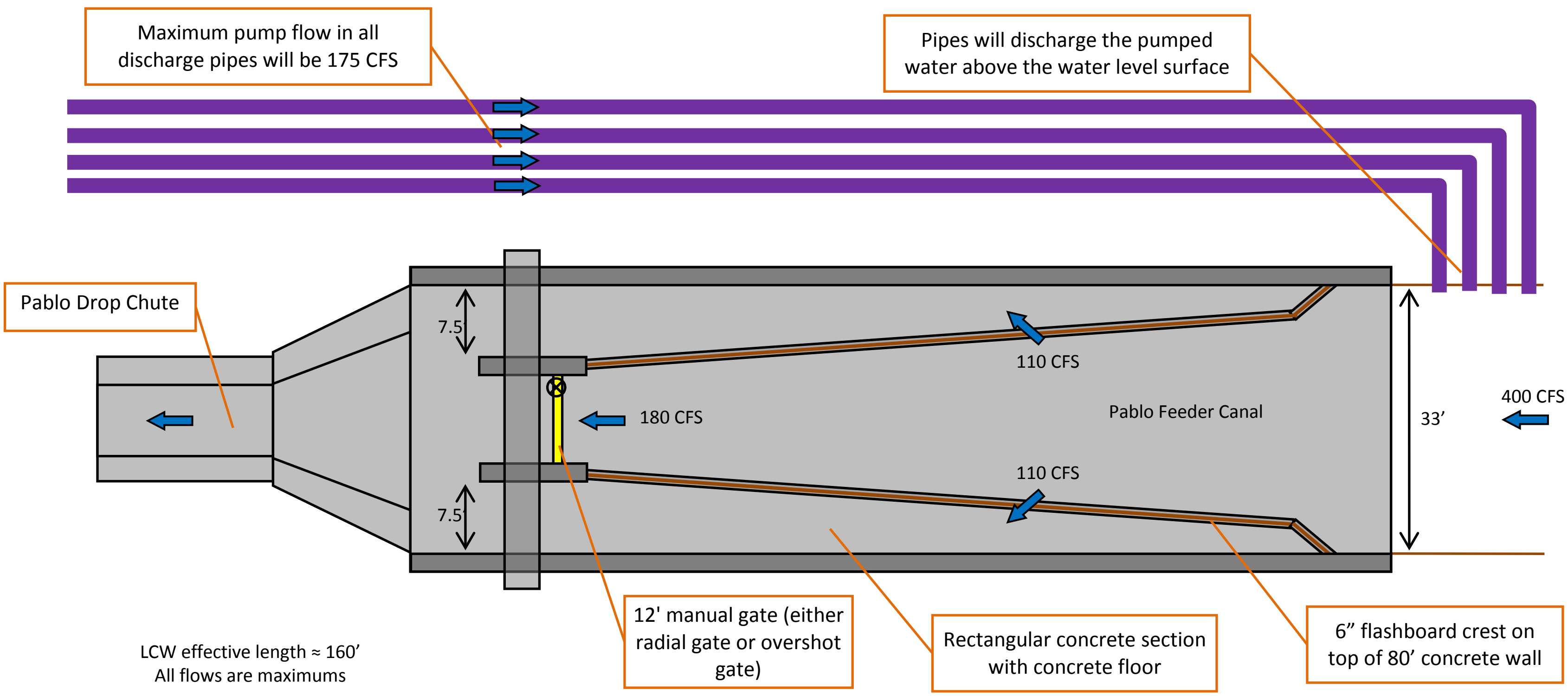

Figure 19. Conceptual plan view of LCW structure at Pump Station #1 (not to scale)

The new control components include the following:

1. A new downstream-facing LCW structure will be constructed immediately upstream of the Pablo Drop.
    a. The LCW will have an effective length of approximately 160 ft. Up to 220 CFS will pass over the LCW with a head of 0.6 ft.
    b. A manually operated 10 ft. gate (either a radial gate or overshot gate) installed at the center of the LCW will pass approximately 180 CFS. The operation of the gate will be as follows:
        i. During normal gravity flow, the gate will be adjusted so there is typically 0.6 ft. of head over the crest of the LCW.
        ii. During the reverse grade pumping operation, the gate will be completely closed to create a dam for the upstream pool.
2. Automated VFD-equipped pumps will be installed in the pool downstream of the Pablo Drop. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
    a. The pump station characteristics will be approximately 655 kW, 175 CFS, and 33' TDH.
    b. The existing canal bank between the Pablo Feeder Canal chute and the Pump Canal will be excavated to create a pool and sump for the new pumps.
    c. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
    d. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.
3. The existing check structure downstream of the Pablo Drop will be replaced with a similar downstream-tapering LCW. Because the water level control does not need to be as precise as in the Pablo Feeder Canal (with the control), the total weir length can be reduced to 100', yet still pass a total of 220 CFS over the weir walls. Surveying will be required to determine exact dimensions that will function appropriately here.
4. A new flow measurement structure will be constructed in the Pablo Feeder Canal downstream of the new upstream-facing LCW to measure the flow rate to the Pablo Reservoir during normal gravity flow operation.
    a. The type of flow measurement structure will depend on the available head across the new LCW structure.
    b. The flow rate will be remotely monitored via SCADA.

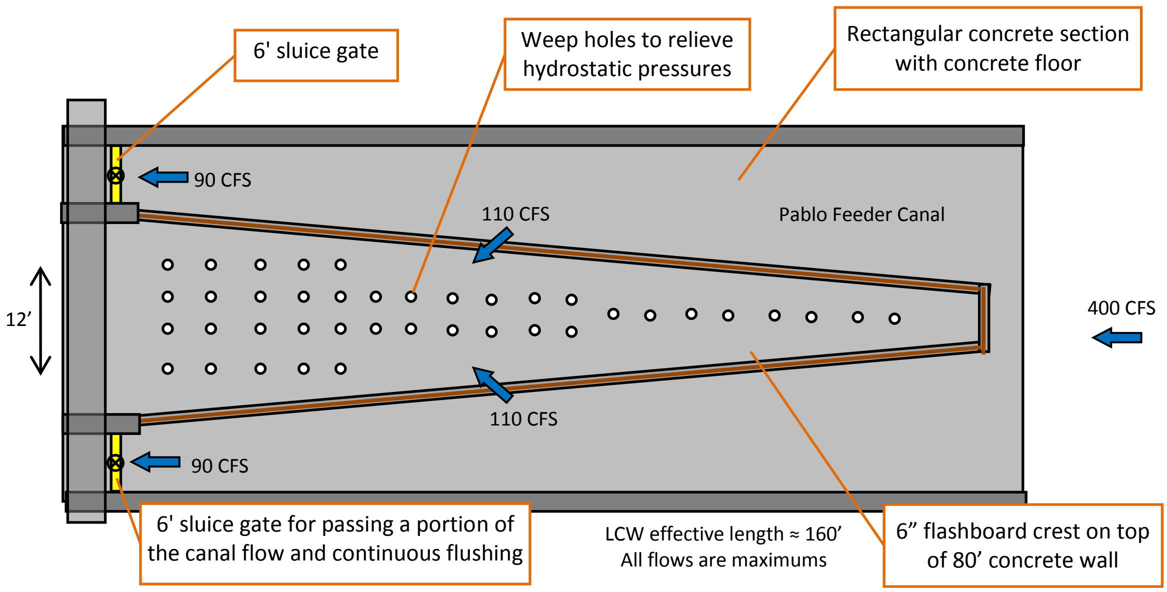

Figure 20. Conceptual plan view of new LCW structure in the Pablo Feeder Canal downstream of the Pablo Drop (not to scale)

Pump Station #2

Figure 21 shows the location for the Pump Station #2 found approximately 0.6 miles upstream of Caffrey Road.

Figure 21. Approximate location for new Pump Station #2 on the Pablo Feeder Canal

Currently there is a small check flashboard check (see Figure 22) most likely used during the late irrigation season to raise the upstream water level enough for a farmer's pump turnout.

Figure 22. Small check in the Pablo Feeder Canal upstream of Caffrey Rd.

Figure 23 and Figure 24 show the conceptual components for Pump Station #2.

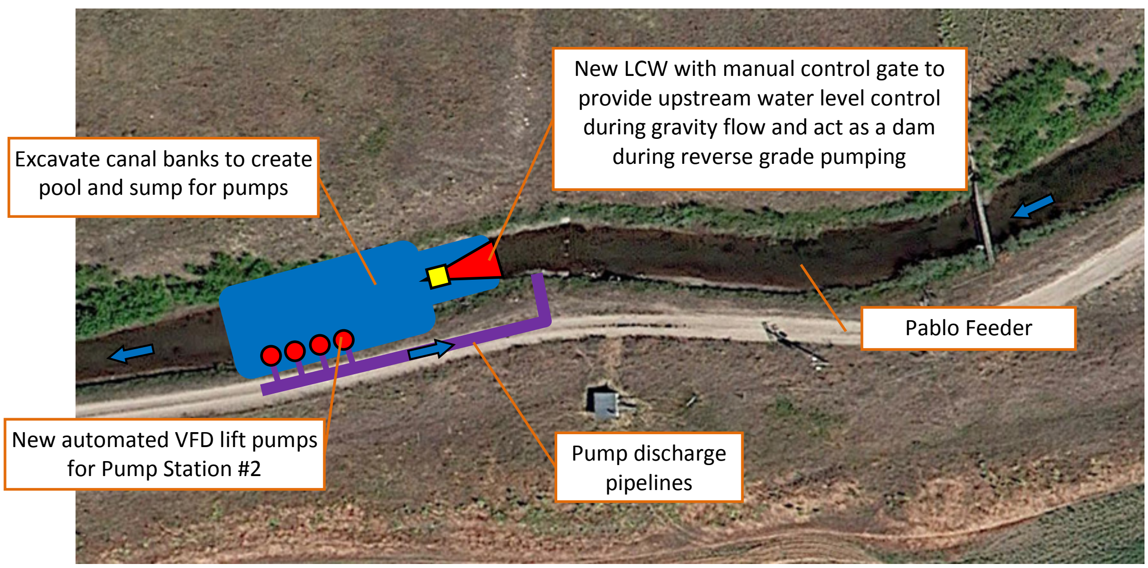

Figure 23. New components for the new Pump Station #2 on the Pablo Feeder Canal

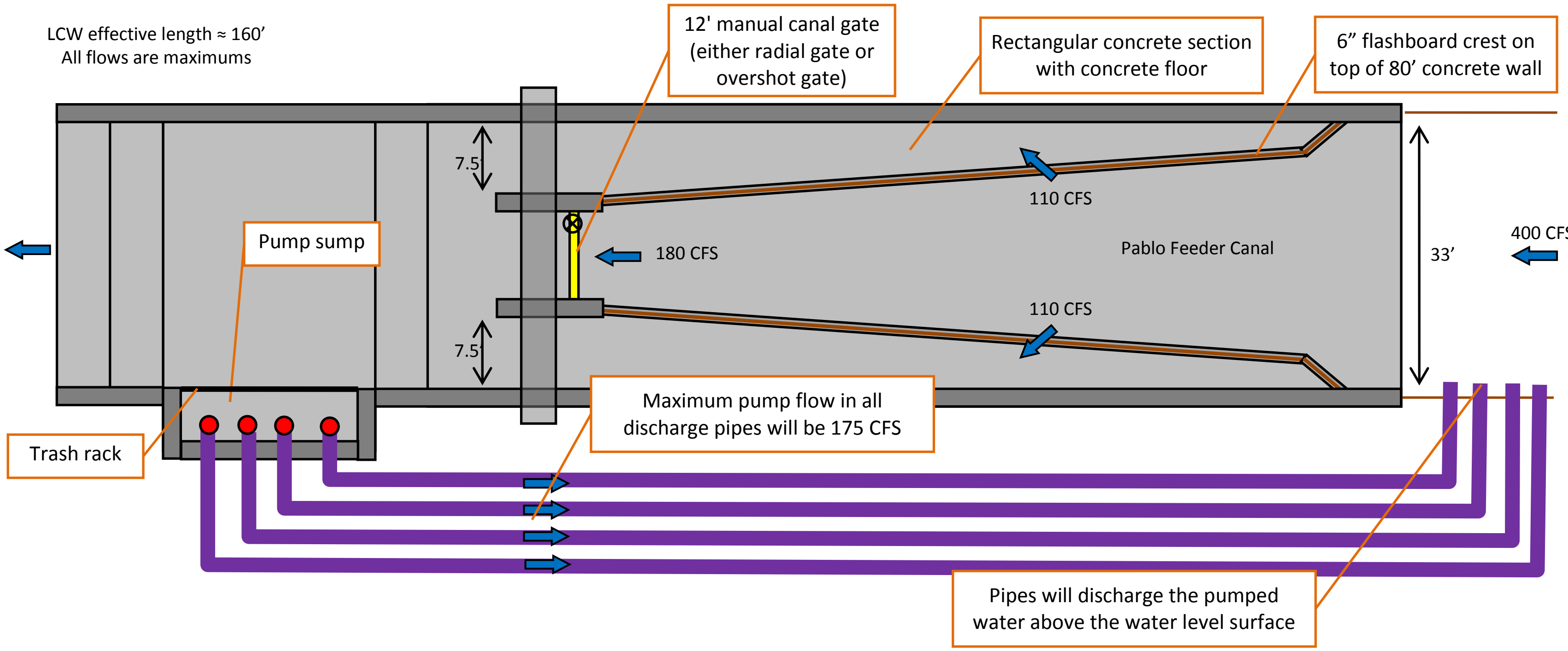

Figure 24. Conceptual plan view of Pump Station #2 (not to scale)

The components of Pump Station #2 will include:

1. A new 160 ft. LCW structure will be constructed to control the upstream water level during normal gravity flow operation and act as a dam during reverse pumping operation. The 12 ft. manually operated gate will be adjusted according to either the gravity flow or reverse grade pumping scenario.
    a. During the gravity flow scenario, the manual gate will be adjusted so that there is approximately 220 CFS flowing over the LCW wall (at a head of 0.6 ft. over the crest). Approximately 180 CFS will pass through the gate.
    b. During the reverse pumping scheme, the manual gate will be completely closed to create a dam for the upstream pool.
2. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
    a. The pump station characteristics will be approximately 223 kW, 175 CFS, and 11' TDH.
    b. The existing canal bank will be excavated to create a pool and sump for the new pumps.
    c. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
    d. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.

Pump Station #3

Figure 25 shows the location for Pump Station #3 on the Pablo Feeder Canal, approximately 0.6 miles upstream of Skyline Drive.

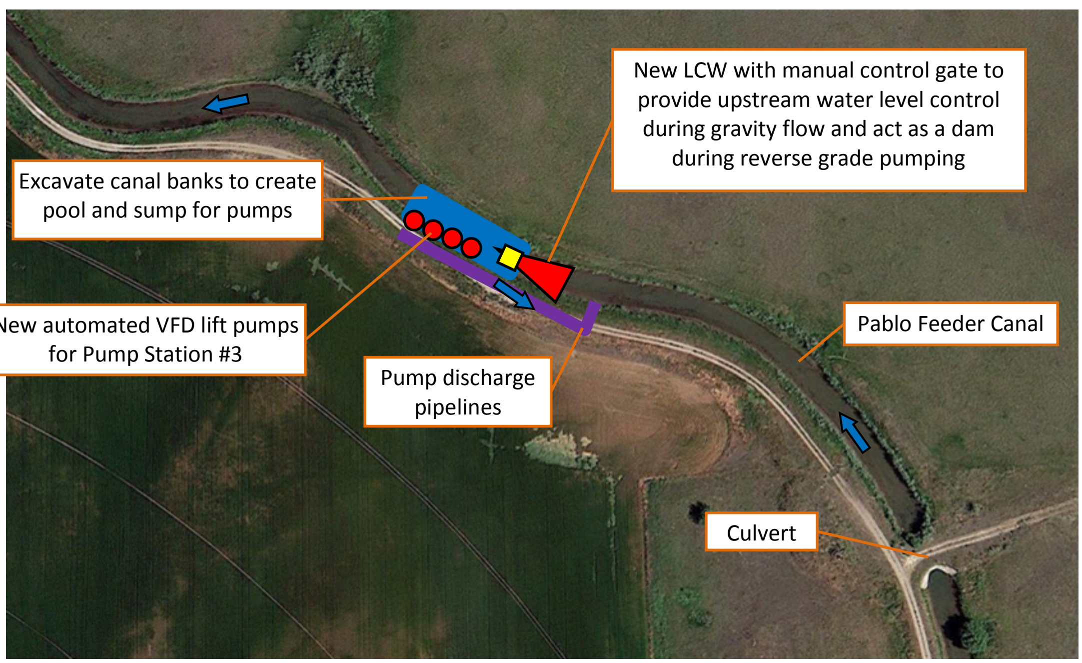

Figure 25. Location for Pump Station #3 on the Pablo Feeder Canal approximately 0.6 miles upstream of Skyline Drive

Pump Station #3 will be designed similarly to the structures presented in Figure 24. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.

1. The pump station characteristics will be approximately 223 kW, 160 CFS, and 12’ TDH.
2. The existing canal bank will be excavated to create a pool and sump for the new pumps.
3. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
4. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.

The existing culvert upstream of the pumping station will need to be investigated to determine the friction loss. There should be less than 0.05’ of head loss across the culvert at 160 CFS; otherwise it will need to be replaced.

Pump Station #4

Figure 26 shows the existing canal structures in the Pablo Feeder Canal at the Highway 93 Crossing.

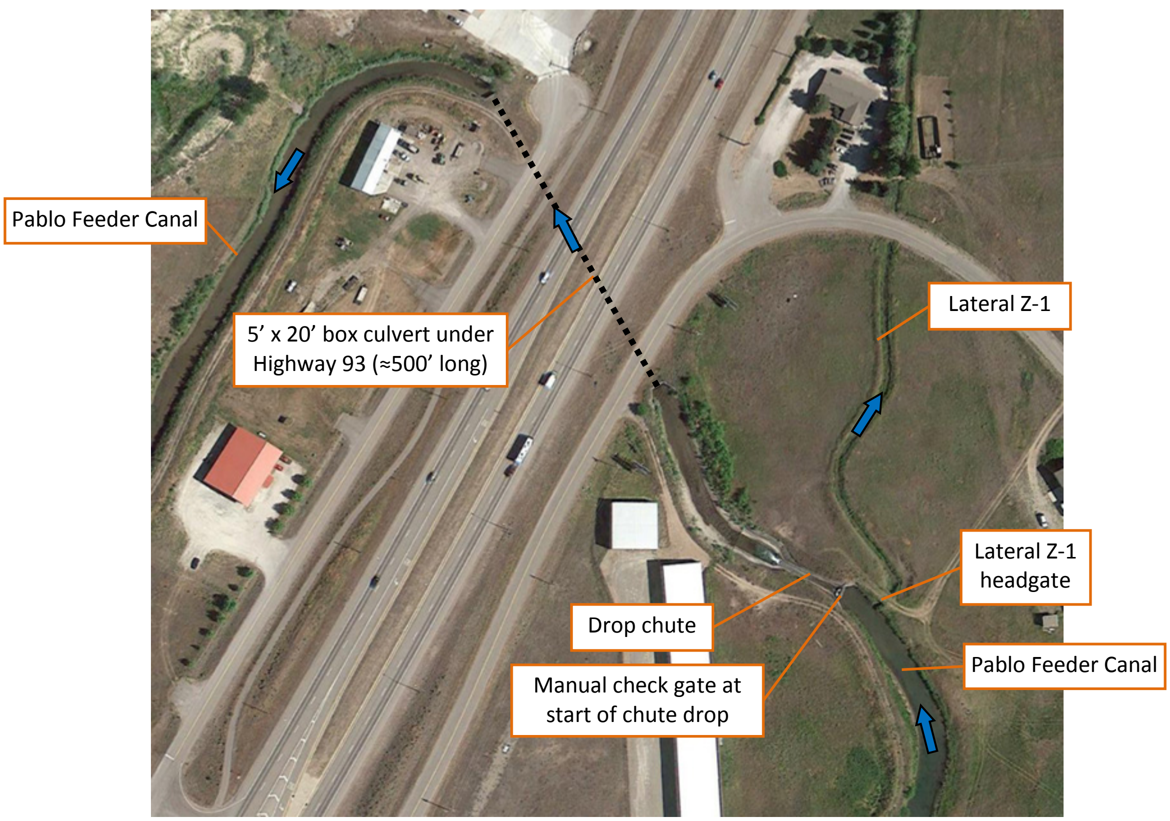

Figure 26. Existing conditions in the Pablo Feeder Canal at Highway 93

A manual check gate installed at the top of the concrete chute (see Figure 27) raises the upstream water level in the Pablo Feeder Canal enough to make a 10-15 CFS delivery to Lateral Z-1.

Figure 27. Existing manual check gate at head of the chute drop in the Pablo Feeder Canal upstream of Highway 93

The excess flow travels down a concrete chute as shown in Figure 28. Approximately 300 ft. downstream of the chute discharge is a 5 ft. tall by 20 ft. wide by 500 ft. long box culvert that crosses under Highway 93.

Figure 28. Chute drop on the Pablo Feeder Canal upstream of Highway 93

Figure 29 shows the modernization components for the new Pump Station #4 at Highway 93.

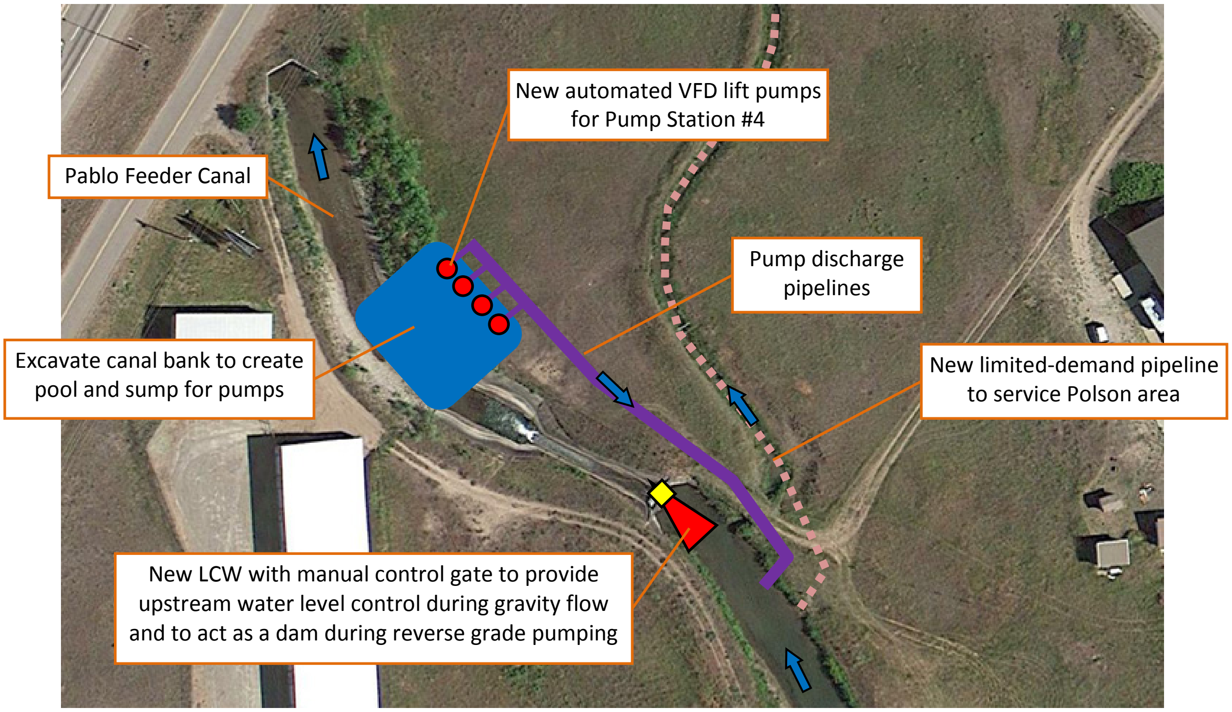

Figure 29. Modernization changes in the Pablo Feeder Canal at Highway 93 to incorporate Pump Station #4

Pump Station #4 will be designed similarly to the structures presented in Figure 24.

1. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
2. The pump station characteristics will be approximately 500 kW, 150 CFS, and 29' TDH.
3. The canal bank will be excavated to create a pool and sump for the new pumps.
4. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
5. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.
6. Lateral Z-1 will be replaced with a new limited-demand pipeline (to be explained later in the report).

Pump Station #5

Figure 30 shows the location for Pump Station #5 on the Pablo Feeder Canal located approximately 2.25 miles upstream from Highway 93.

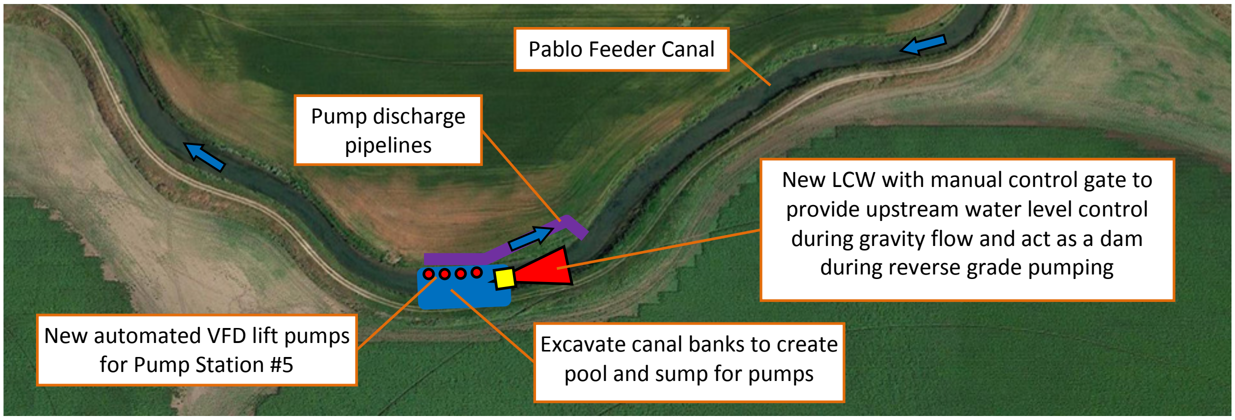

Figure 30. Location of Pump Station #5 on the Pablo Feeder Canal located approximately 2.25 miles upstream of Highway 93

Pump Station #5 will be designed similarly to the structures presented in Figure 24.

1. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
2. The pump station characteristics will be approximately 192 kW, 125 CFS, and 11’ TDH.
3. The canal bank will be excavated to create a pool and sump for the new pumps.
4. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
5. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.

Pump Station #6

Figure 31 shows the existing conditions of the Pablo Feeder Canal just downstream of Dubay Road.

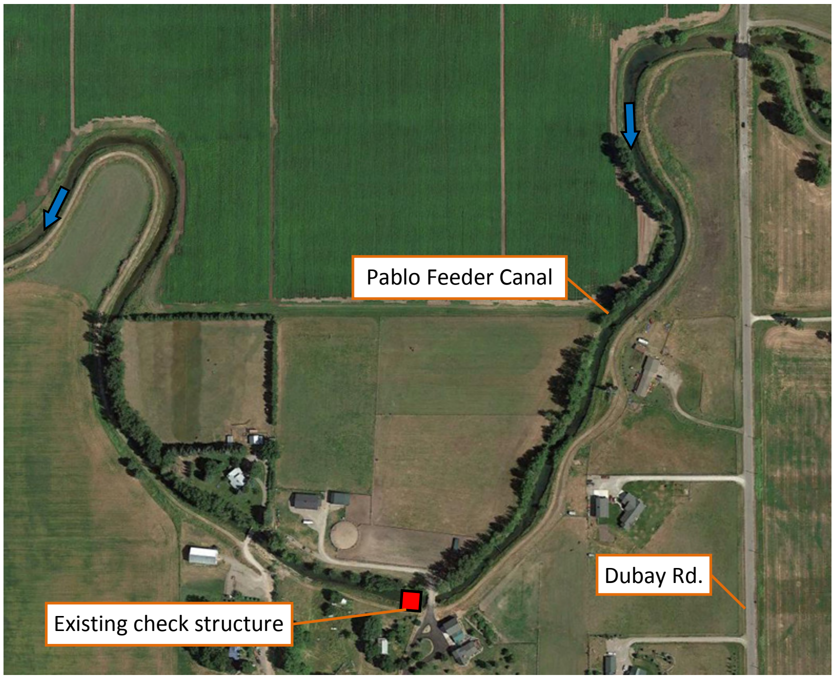

Figure 31. Existing Pablo Feeder Canal downstream of Dubay Road

An existing check structure immediately downstream of a road culvert crossing (see Figure 32) maintains the upstream water level for several turnouts.

Figure 32. Existing check structure in the Pablo Feeder Canal located downstream of Dubay Road

Figure 33 shows the location of Pump Station #6 on the Pablo Feeder Canal located approximately 0.7 miles downstream of Dubay Road.

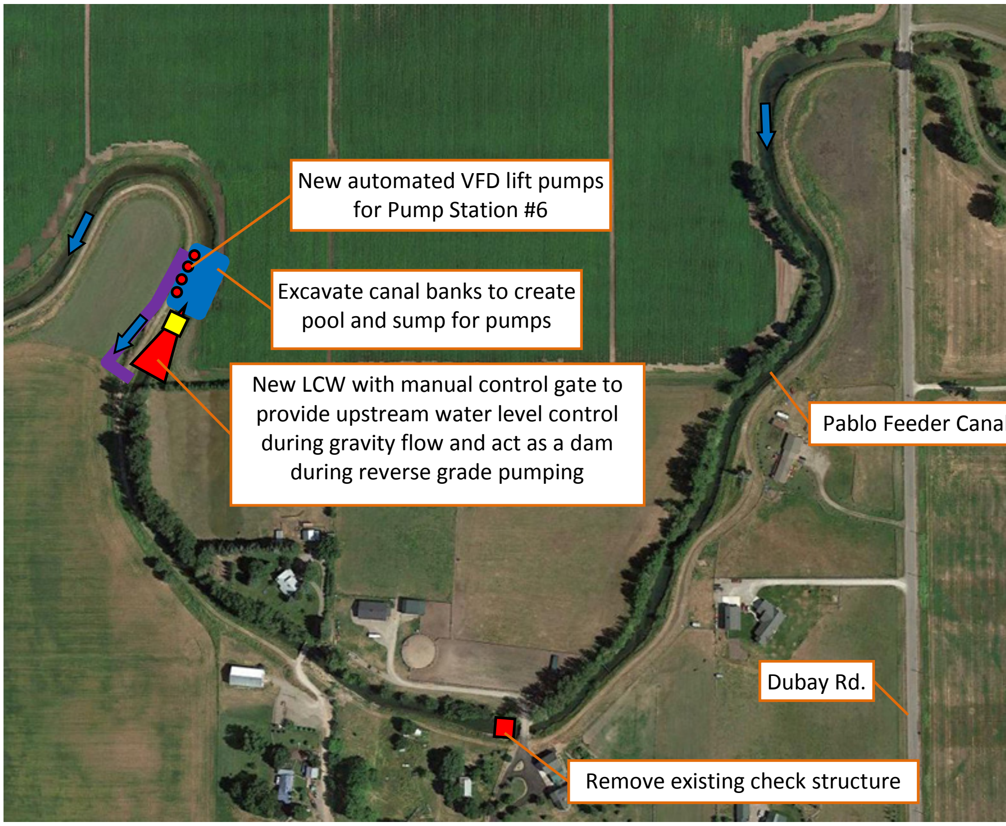

Figure 33. Location of Pump Station #6 on the Pablo Feeder Canal approximately 0.7 miles downstream of Dubay Road

The existing check structure at the road culvert will be removed. The pump and LCW structure will be constructed further downstream from the existing check structure to move away from the houses.

Pump Station #6 will be designed similarly to the structures presented in Figure 24.

1. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
2. The pump station characteristics will be approximately 165 kW, 125 CFS, and 12' TDH.
3. The canal bank will be excavated to create a pool and sump for the new pumps.
4. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
5. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.

Pump Station #7

Figure 34 shows the approximate location for Pump Station #7 on the Pablo Feeder Canal located downstream of Minesinger Trail Road.

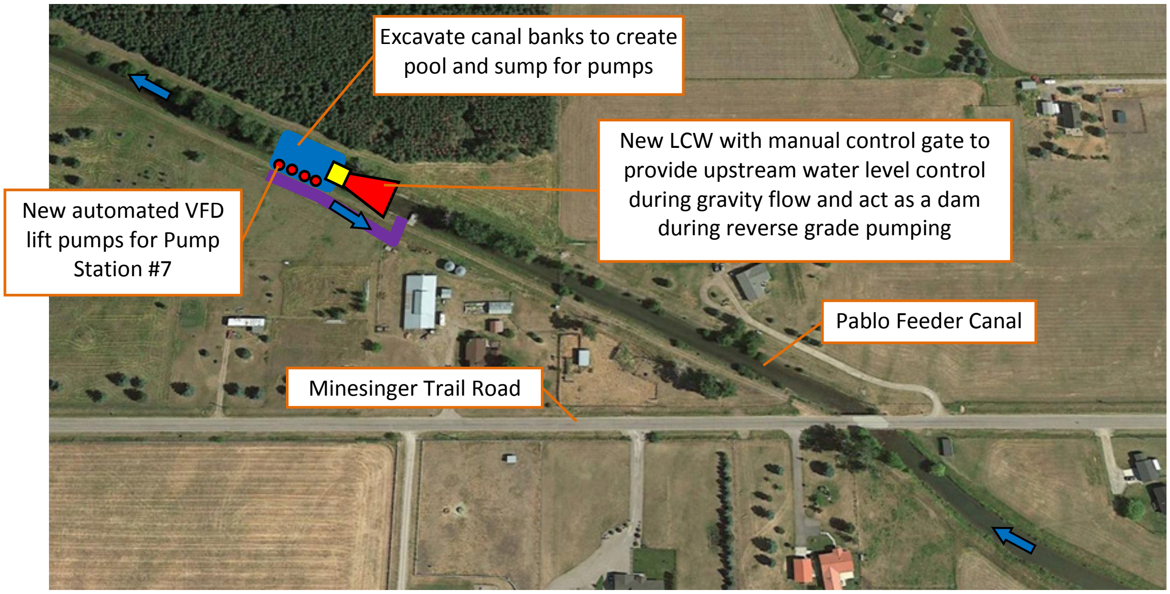

Figure 34. Location of Pump Station #7 on the Pablo Feeder Canal downstream of Minesigner Trail Road

Pump Station #7 will be designed similarly to the structures presented in Figure 24.

1. Automated VFD-equipped pumps will be installed in the pool downstream of the LCW. When turned on, the pumps will discharge water into the upper pool to maintain a target water level elevation approximately 0.1 ft. below the crest of the LCW.
2. The pump station characteristics will be approximately 135 kW, 100 CFS, and 12' TDH.
3. The existing canal bank will be excavated to create a pool and sump for the new pumps.
4. The pumped water will discharge into the air above the maximum water level surface upstream of the LCW. This eliminates the need for a check valve on each pump discharge pipeline.
5. SCADA will accompany the pump automation to remotely monitor the operating characteristics of the lift pumps (individual pump flows, speeds, etc.), although the control of each pump station will be local and independent.

Polson Pipelines

Figure 35 shows the existing Polson Canal System. Roughly 2,200 acres are irrigated by the multiple Polson Canals.

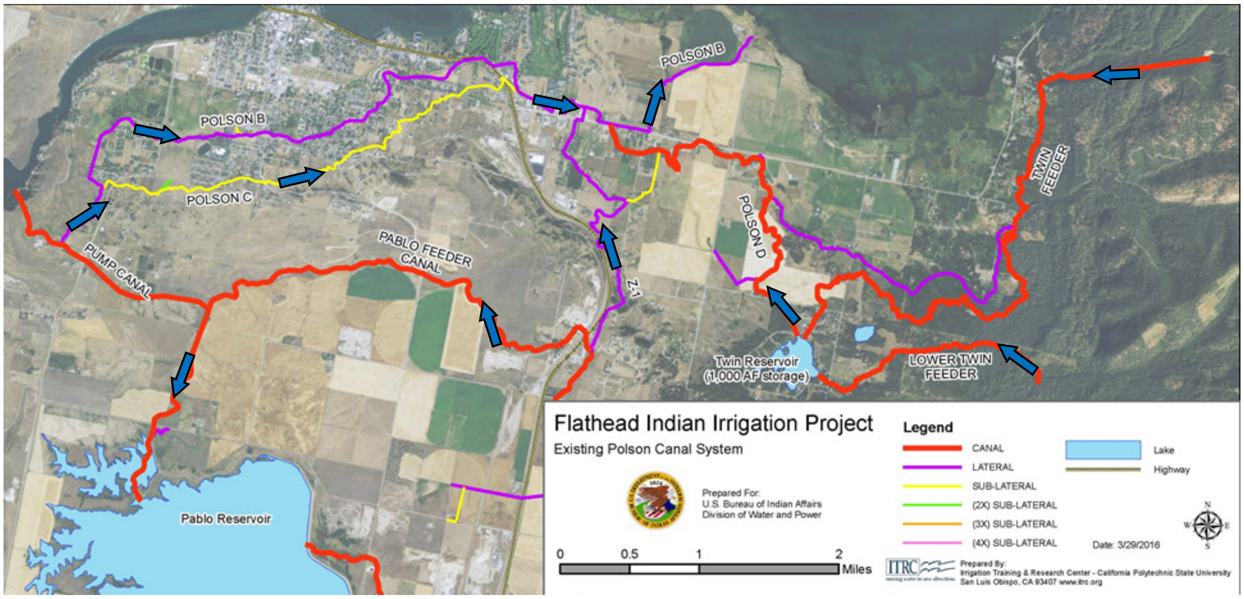

Figure 35. Existing Polson Canal System

The existing operation of the Polson Canal System is as follows:

- The Polson B Canal diverts water from the Pump Canal which is supplied either with water from the Pablo Feeder Canal or the Flathead River Pumps during the late irrigation season.
  - The Polson B Canal meanders through mostly residential areas. There are multiple portions of the canal that are piped.
  - Through the town, residents place small pumps in the canal to water their lawns. FIIP has started charging households to take water.
  - The Polson B Canal crosses under Highway 93 to supply several fields near Flathead Lake.
- The Polson C Canal diverts water from the Polson B Canal to service fields in the southern portion of the City of Polson.
  - Most of the Polson C Canal is an open channel except for the last portion of the canal, which is piped.
  - Excess flows in the Polson C Canal spill back to the Polson B Canal near Highway 93.
- Lateral Z-1 diverts water from the Pablo Feeder Canal upstream of Highway 93 to service several fields. The excess flows in Lateral Z-1 spill into the Polson B Canal.
- Twin Reservoir (1,000 AF of storage) is supplied from the twin feeder canals.
  - The Twin Feeder Canal is supplied by water from Hell Roaring Reservoir on Hell Roaring Creek.
  - The Lower Twin Feeder Canal diverts water from Bisson Creek.
- Discharge from Twin Reservoir is released into the Polson D Canal.
- The Polson D Canal supplies multiple fields prior to spilling into the Polson B Canal.

The Polson Canal System appears to be difficult to manage for operators because:

- Most of the service area has been urbanized.
- There is a large number of small and large turnouts.
- The canals are long and very winding.
- There is limited access.
- Excess flows from four different canals are concentrated at a single point.

Previous studies have examined the Polson B and C Canal sections that pass through urban areas.

Proposed Polson Pipeline System

Figure 36 shows the proposed modernization changes made to the Polson Canal System. Key elevations are included in the figure.

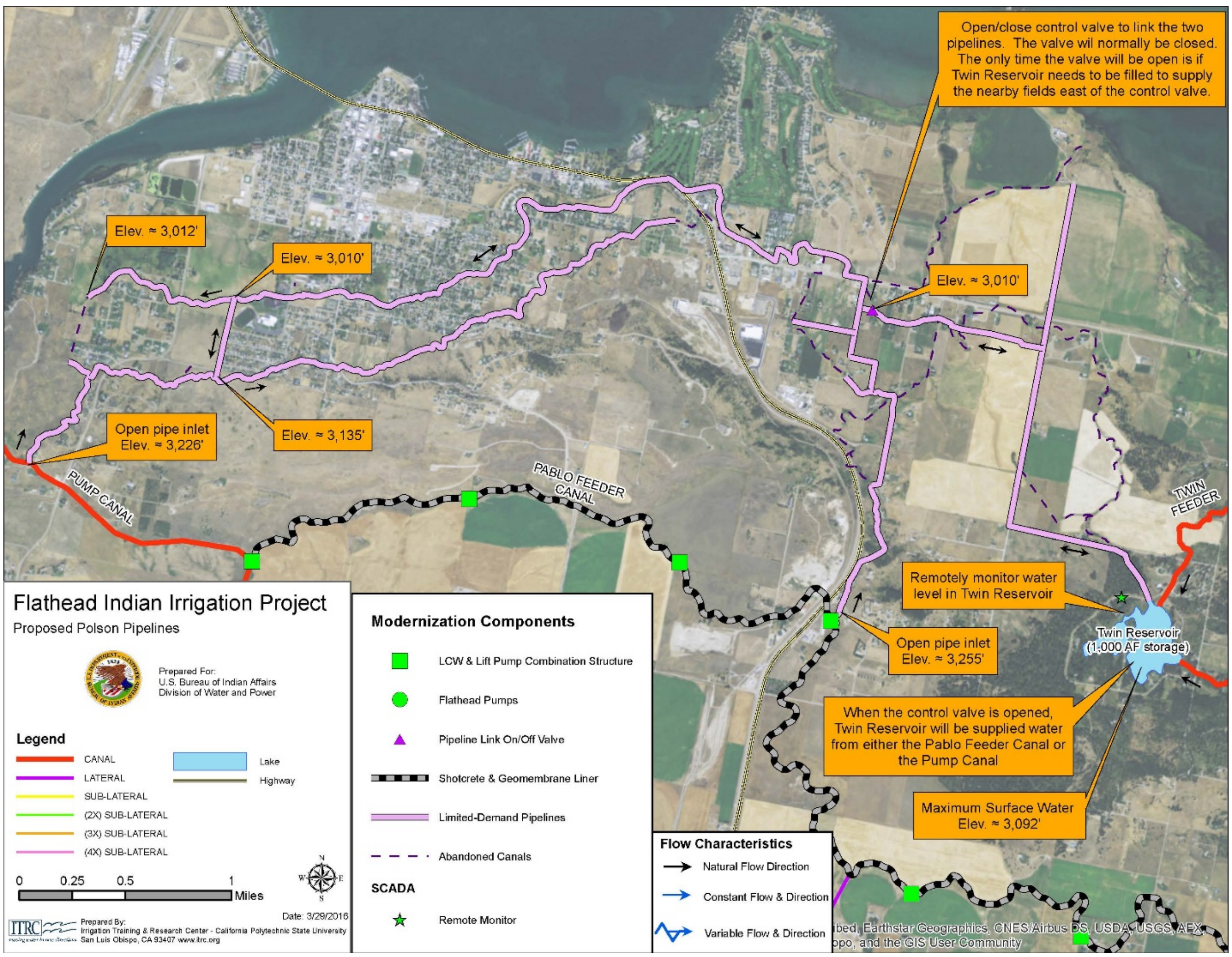

Figure 36. Proposed limited-demand pipeline network near Polson

In short, it is very difficult to effectively manage meandering canal systems in urban areas. Almost all modernization plans recommend pipelines in urbanized areas. The key decisions are related to flexibility, rules of operation, and allowable flow rates.

The changes suggested in this plan include:

1. The Polson B, C, and D Canals as well as Lateral Z-1 will be converted to limited-rate demand pipelines that are linked to service water users throughout the Polson area. Most of the new pipelines will have to follow the existing alignment of the canals since there is limited access for new pipeline alignments.
2. Lateral Z-1 and the Polson B Canal pipes will be linked to form a large loop.
    a. Both pipe ends will be open to allow water to freely move in and out.
    b. Water will move in both directions for a majority of the loop pipeline.
    c. The Polson C Canal Pipeline will be supplied by water from either end of the loop pipeline.
3. A manual open/close valve will be installed to link the pipeline from the Pablo Feeder Canal and the pipeline from the Twin Reservoir.
    a. The valve will normally remain closed to keep the flow in both pipelines separate.
    b. The valve will only be opened if the storage level in Twin Reservoir is low and needs to be filled in order to service the water users to the very east of Polson.

A design analysis was not performed to determine the hydraulic conditions and pipeline sizes.

Improved Flow Measurement at Head of Pablo A Canal

Figure 37 shows the existing conditions at the discharge of Pablo Reservoir into the Pablo A Canal.

Figure 37. Existing conditions at the discharge of the Pablo Reservoir into the Pablo A Canal

Up to 400 CFS is diverted from the reservoir into the canal to service roughly 45,000 acres in the Pablo Canal Unit. The flow diverted into the Pablo A Canal is continuously measured at a GOES gauging station located immediately upstream of Skyline Drive.

With the proposed modernization changes to be made in the Pablo Canal Unit (the Round Butte Road Interceptor Pipeline, West Pablo Interceptor Pipeline, Horte Reservoir Pumpback System), water that would normally leave the Pablo Canal Unit due to operational spill will be recirculated. Based on the future recirculation of the water and the storage level in Horte Reservoir, flow rate releases from Pablo Reservoir into the Pablo A Canal will be made more frequently. Therefore it will be helpful for FIIP to have excellent flow measurement at the discharge of the Pablo Reservoir to effectively manage the water in the Pablo Canal Unit.

The modernization changes include:

1. A new Replogle flume will be constructed approximately 800 ft. downstream from the Pablo Reservoir discharge to provide more accurate flow measurement. The flow rate will be remotely monitored via SCADA.
2. The Pablo A Canal will be straightened for several hundred feet upstream of the new Replogle flume.
3. A new concrete flow conditioner wall (see Figure 39) will be constructed on the new right canal bank at the large bend upstream of the Replogle flume.
4. A buried conduit housing electrical signal wires will be run from the new Replogle flume to the reservoir discharge gate house to relay the instantaneous flow rate measurement in the canal. Operators will be able to then set the target flow rate based on the reading.

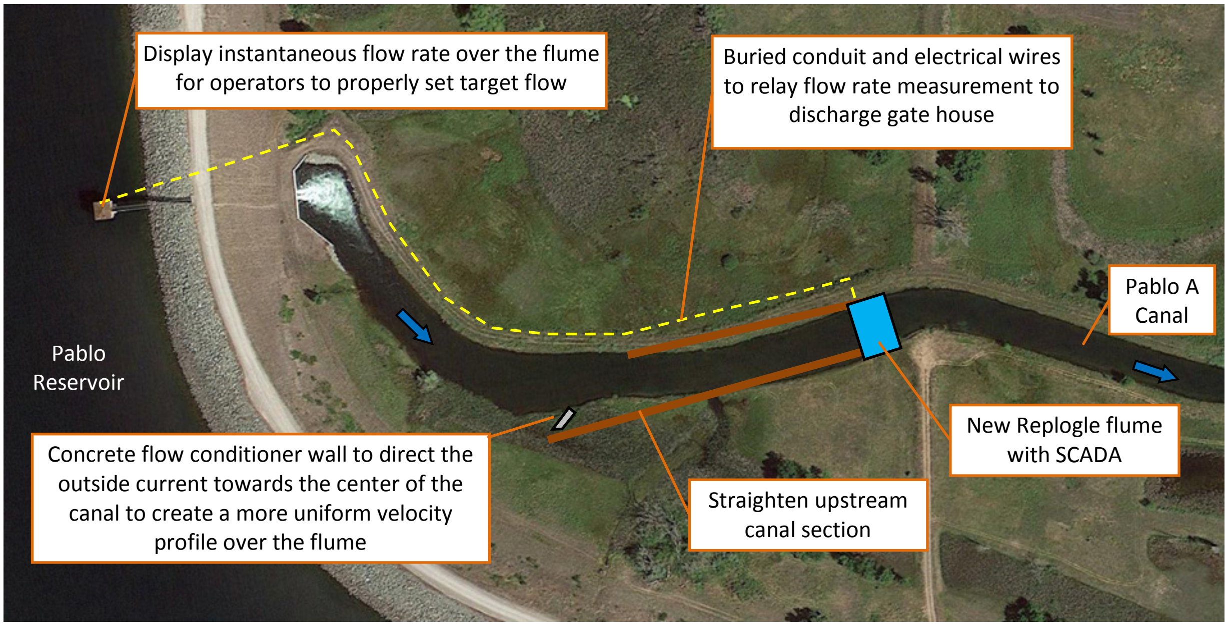

Figure 38. Modernization changes at the discharge of the Pablo Reservoir into the Pablo A Canal

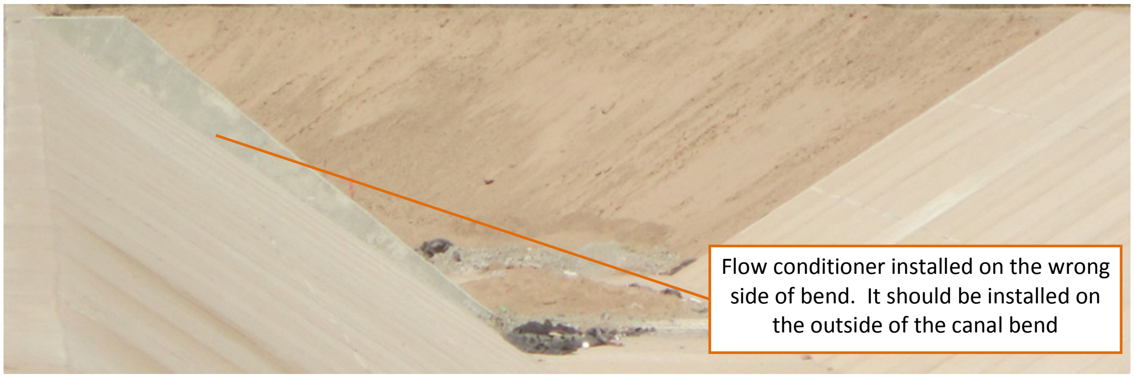

Figure 39. Examples of flow conditioner walls. Note the photo on the bottom has the flow conditioner constructed on the wrong side of the canal. The conditioner must be constructed on the outside of a canal bend.

Improvements to Mud Creek and Ronan B Canal

Figure 40 shows the existing alignments of Mud Creek and the Ronan B Canal west of the Pablo Feeder Canal.

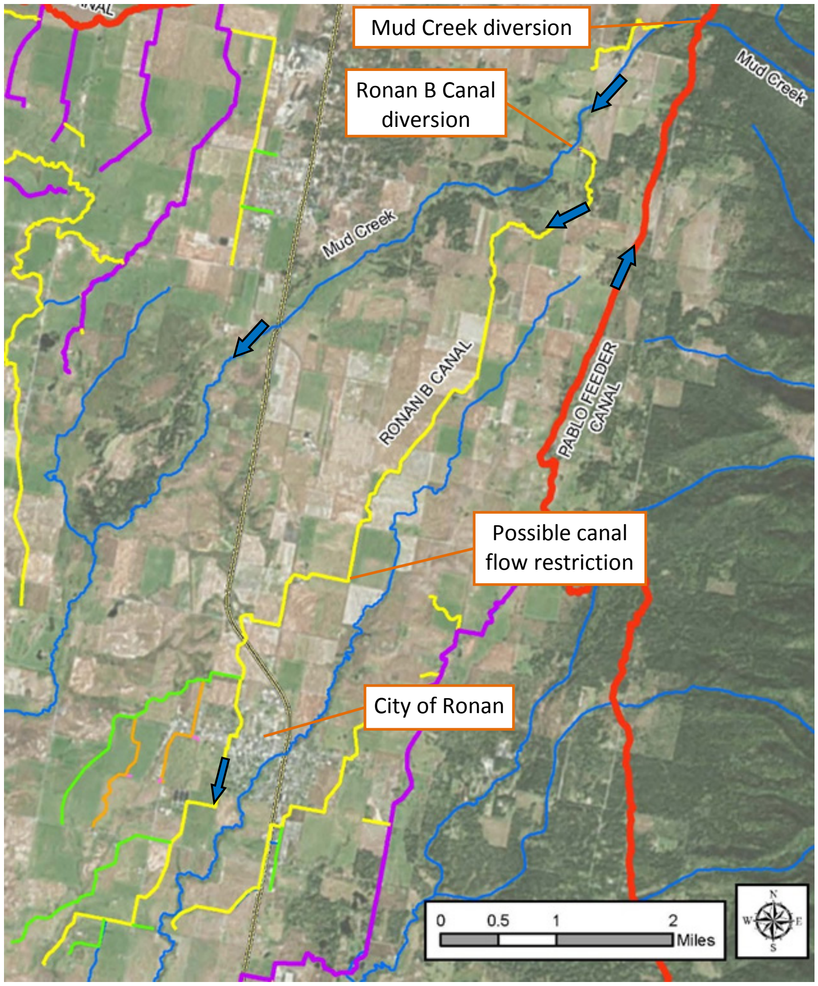

Figure 40. Existing alignment of Mud Creek and the Ronan B Canal west of the Pablo Feeder Canal

The improvements to Mud Creek will focus on the following two items:

- Improving flow measurement at the Mud Creek diversion on the Pablo Feeder Canal
- Improving the control at the Ronan B Canal diversion on Mud Creek
- Eliminating a possible flow restriction in the Ronan B Canal upstream of the city of Ronan

An explanation of the three key improvements are provided in the following sections.

Improved Flow Measurement at Mud Creek Diversion

From tribal records it appears a maximum of 50 CFS has historically been diverted into Mud Creek from the Pablo Feeder Canal to meet in-stream demand and supply the Ronan B Canal. Figure 41 shows the existing Mud Creek headgate on the Pablo Feeder Canal. There is a check structure in the Pablo Feeder Canal to provide water level control at the Mud Creek headgate.

Figure 41. Mud Creek headgate on the Pablo Feeder Canal. Photo from HKM 2008 report (HW-25).

Figure 42 shows the existing conditions in Mud Creek immediately downstream of the headgate. The existing concrete side walls of the structure are approximately 15 ft. apart. A ways downstream from the headgate is a gauging station that continuously records the flow rate diverted into Mud Creek. The condition of the gauging station is currently unknown.

Figure 42. Downstream of the Mud Creek Diversion headgate on the Pablo Feeder Canal. Photos from HKM 2008 report (HW-25).

During the late part of the irrigation season, the flow rate diverted to Mud Creek can be limited based on available flow in the Pablo Feeder Canal. This then affects the service to the farmers that are supplied water via the Ronan B Canal.

Flow Measurement Improvement

With the construction of the Pablo Feeder Canal Pumpback System, water should always be available to be diverted into Mud Creek throughout the irrigation season. For improved management of the flows in Mud Creek, the flow measurement at the creek diversion will be improved (see Figure 43).

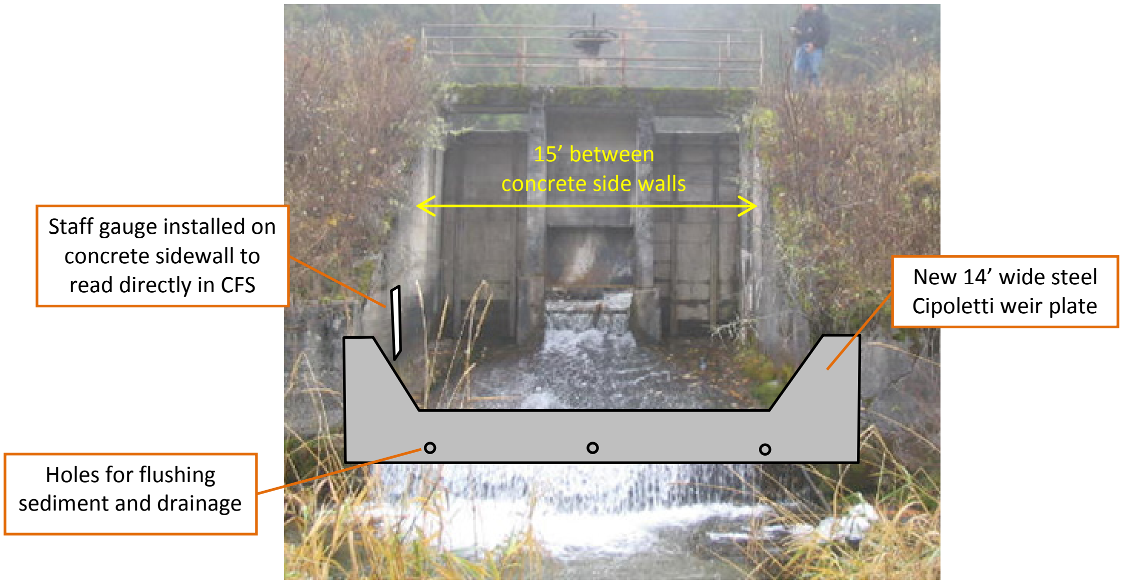

Figure 43. Flow measurement improvements at Mud Creek headgate

The improvements will include the following:

1. A new steel Cipoletti weir plate (with an effective length of 14 ft.) will be installed at the very end of the concrete structure downstream of the Mud Creek headgate. The Cipolleti weir will pass approximately 50 CFS with a head of about 1 ft. over the crest.
2. Multiple holes along the bottom of the steel Cipoletti weir plate will be cut out for continuous flushing of sediment as well as for drainage.
3. A staff gauge that reads directly in CFS will be installed on one of the concrete side walls upstream of the Cipoletti weir. Eventually the flow rate could be remotely monitored via SCADA but this would be a low priority compared to other sites.

Improved Control at Ronan B Canal Diversion on Mud Creek

Figure 44 shows the existing control at the Ronan B Canal diversion on Mud Creek.

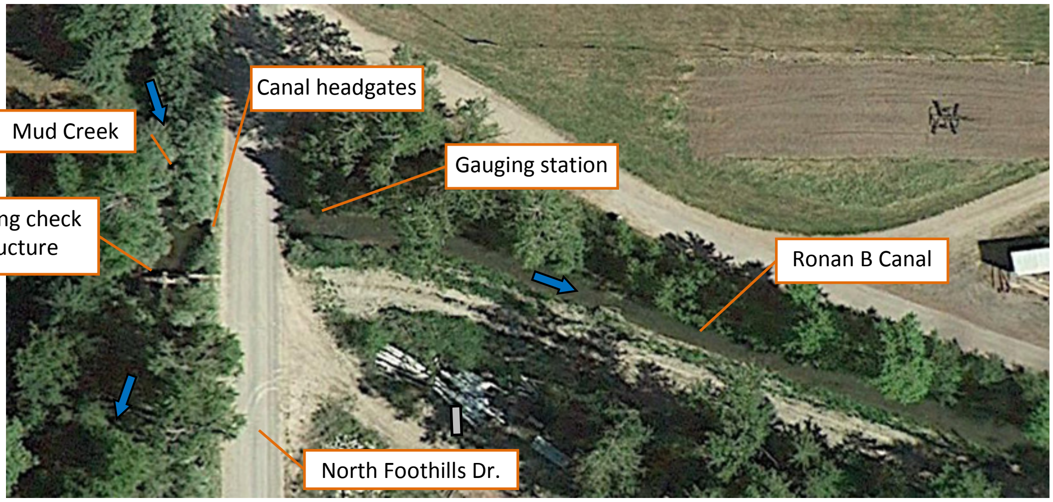

Figure 44. Ronan B Canal diversion on Mud Creek

The existing check structure shown in Figure 45 controls the upstream water level for the Ronan B Canal diversion.

Figure 45. Existing check structure in Mud Creek just downstream of the Ronan B Canal headgates. Photo from HKM 2008 report (CH-466).

According to tribal flow records, a maximum of 35 CFS is diverted into the Ronan B Canal from Mud Creek. A gauging station (see Figure 46) continuously measures the flow rate diverted into the Ronan B Canal.

Figure 46. Gauging station on the Ronan B Canal just downstream of the canal headgates. Photo from HKM 2008 report (HW-21).

Improved Control

By improving water level control and flow measurement at the head of the Ronan B Canal, easier management for operators and better service will be provided to farmers along the canal. Figure 47 shows the modernization changes made near the head of the Ronan B Canal.

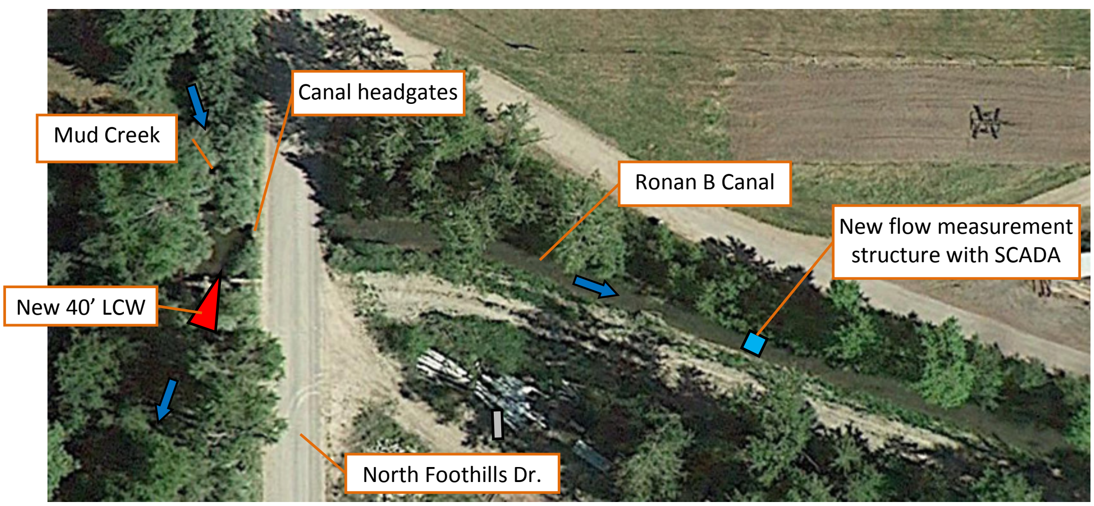

Figure 47. Modernization changes made near the head of the Ronan B Canal at Mud Creek

The modernization changes will include:

1. A new 40' LCW (see Figure 48) will be constructed to replace the existing check structure in Mud Creek. The new LCW will provide better water level control for the Ronan B Canal headgates and therefore provide a more constant turnout flow.

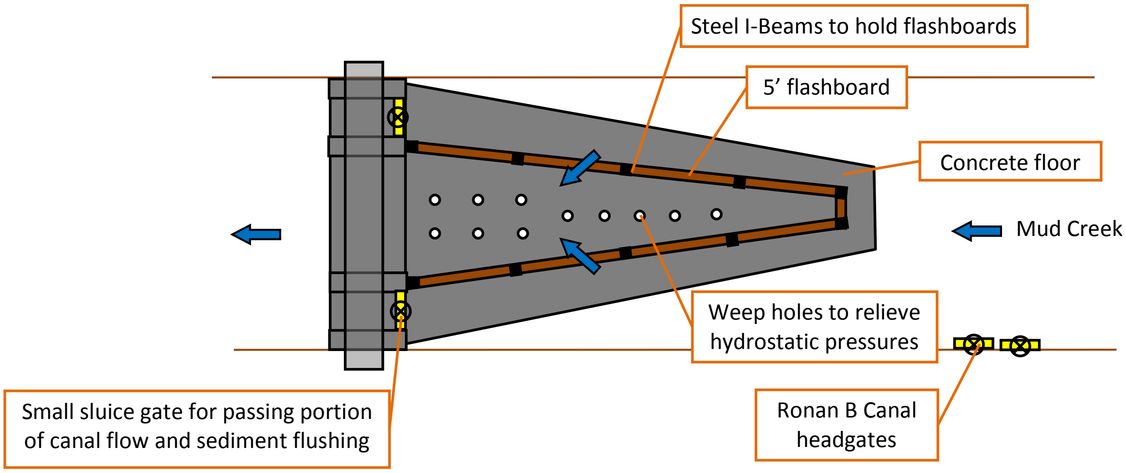

Figure 48. Conceptual plan view of new LCW structure to be constructed in Mud Creek at the head of the Ronan B Canal (not to scale).

2. A new flow measurement structure will be constructed in the Ronan B Canal approximately 250 ft. downstream from the canal headgates.
    a. The available headloss will need to be investigated to determine the type of new structure for accurate flow measurement.
    b. SCADA would be used to remotely monitor the canal flow rate, but this would be considered low priority compared to other SCADA locations.

Flow Restriction in the Ronan B Canal

According to an FIIP operator, there is a flow restriction in the Ronan B Canal upstream of the city of Ronan. The operator stated that not enough flow is capable of moving past a sharp canal bend to service all the downstream water users on the Ronan B Canal System. Not enough time was allowed for ITRC to investigate the cause of the flow restriction.

Some initial ideas for what could be causing the flow restriction are:

- The canal cross section at the sharp bend may be too small and would need to be excavated.
- There are two road crossings downstream of the sharp bend. The two culverts may be undersized and causing a large amount of friction loss that would then restrict the flow.
- There is a 400 ft. section of piped canal that crosses under a farm. There could also be a significant amount of headloss across the pipe causing the restriction.

A further field evaluation will need to be conducted to determine the actual cause of the flow restriction. Once the restriction is eliminated, better service and improved flexibility will be provided to the downstream water turnouts.

Figure 49 and Figure 50 show the approximate location and existing conditions near the apparent flow restriction.

Figure 49. Approximate location of an apparent flow restriction on the Ronan B Canal

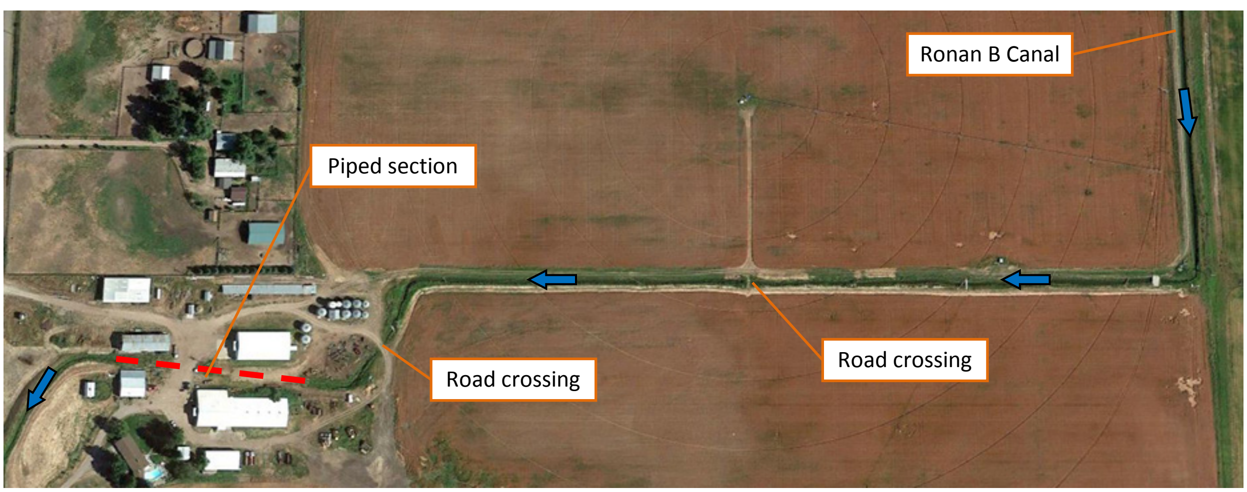

Figure 50. Existing portion of the Ronan B Canal where there is an apparent flow restriction