ITRC
moving water in new directions

IRRIGATION TRAINING & RESEARCH CENTER

Flathead Indian Irrigation Project

Modernization near Horte Reservoir

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

April 2016

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

MODERNIZATION NEAR HORTE RESERVOIR

Modernization Plan

The key goals for the overall modernization changes near Horte Reservoir are to:

- Capture and re-regulate excess flows from Mud Creek and multiple surface drainageways that cross Round Butte Road.
- Improve the utilization of the Horte Reservoir as a regulating reservoir for the Pablo A Canal System.
- Improve ease of operation and flexibility of water deliveries to fields.
- Significantly reduce possible operational spills in the laterals west of Horte Reservoir that are lost to FIIP. This will be accomplished by:
    - Piping the downstream portions of the laterals
    - Capturing and re-regulating the excess flows, which can be used in other parts of the canal system

The recommended overall modernization changes near Horte Reservoir are shown in Figure 1. The modernization changes include:

1. New automated pumps will be installed in Mud Creek and multiple drainageways near Round Butte Road to capture excess flows. Extractions from the creek and drains would be limited to maintain any required in-stream, downstream flow rates in the creek and drains.
2. A new interceptor pipeline constructed near Round Butte Road will convey the excess flows to Lateral 70A.
3. The lower portion of Lateral 70A (downstream of Round Butte Road) will be restarted.
4. The new Horte Reservoir Recirculation Pipeline will connect Horte Reservoir to the new level pool in Lateral 70A. Excess flows from the level pool will spill into the recirculation pipeline to either:
    a. Supply a portion of the Lateral 71A
    b. Supply a portion of the turnouts and pipelines on the West Pablo Interceptor Pipeline
    c. Be stored in Horte Reservoir
5. The West Pablo Interceptor Pipeline will connect several laterals west of Horte Reservoir to the new Horte Reservoir Recirculation Pipeline.
    a. The pipeline will automatically buffer the flow in two separate laterals directly upstream of two new limited pipelines.
    b. Excess flows in the laterals will be pumped to either:
        i. Supply direct turnouts along the interceptor pipeline
        ii. Supply a portion of Lateral 71A
        iii. Be stored in Horte Reservoir
6. New pumps and a pumpback pipeline will be constructed in Horte Reservoir to help maintain the target water level in a level pool at the existing “restart” points for the Lower Pablo A Canal and Lateral 73A.
7. SCADA will be incorporated to help with making effective operation and management decisions for the movement of water in the nearby canal systems.

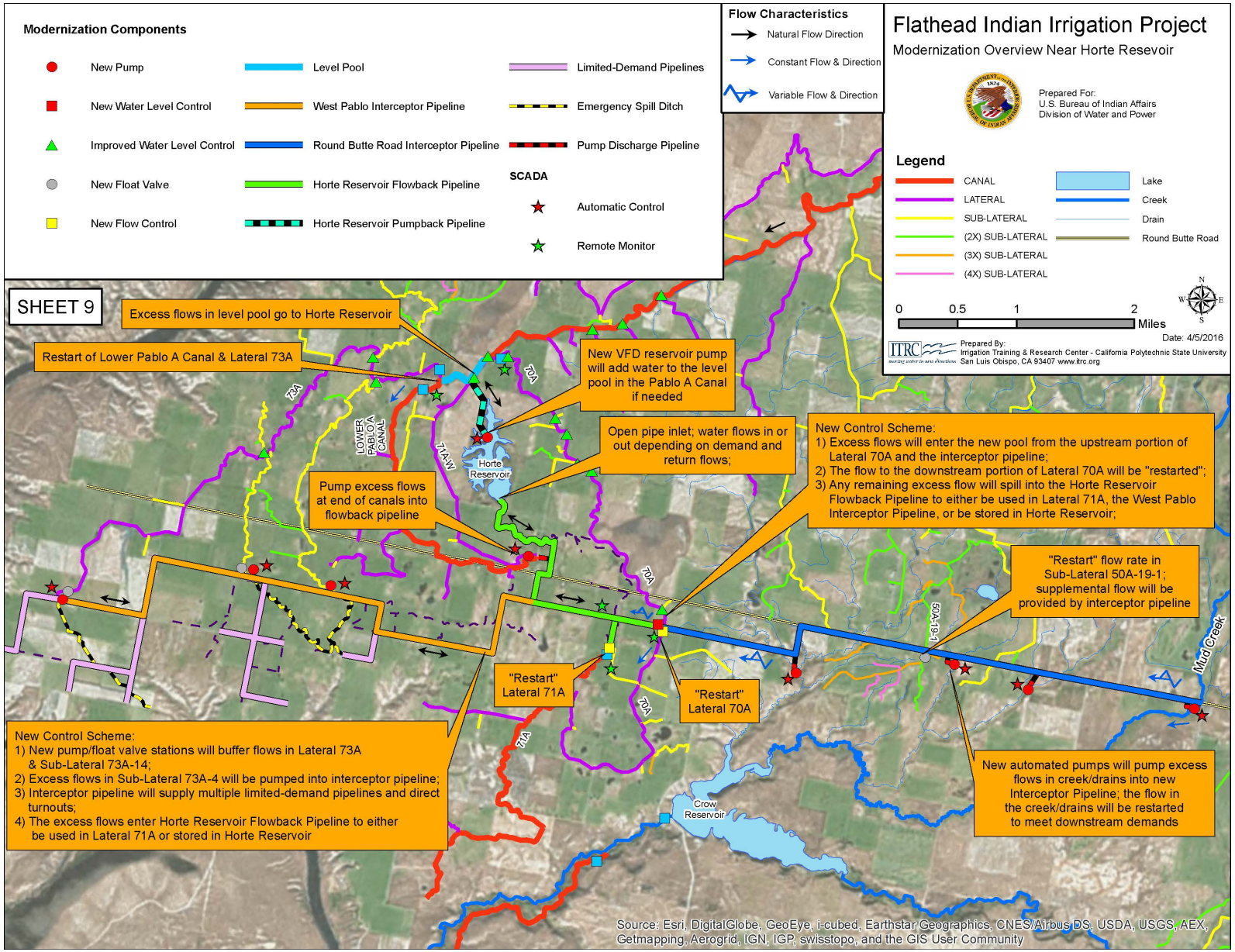

Figure 1. Overall modernization changes made near Horte Reservoir

Pablo A Canal and Horte Reservoir Pumpback System

Existing Conditions

Figure 2 and Figure 3 shows the existing control in the Pablo A Canal near the discharge to Horte Reservoir.

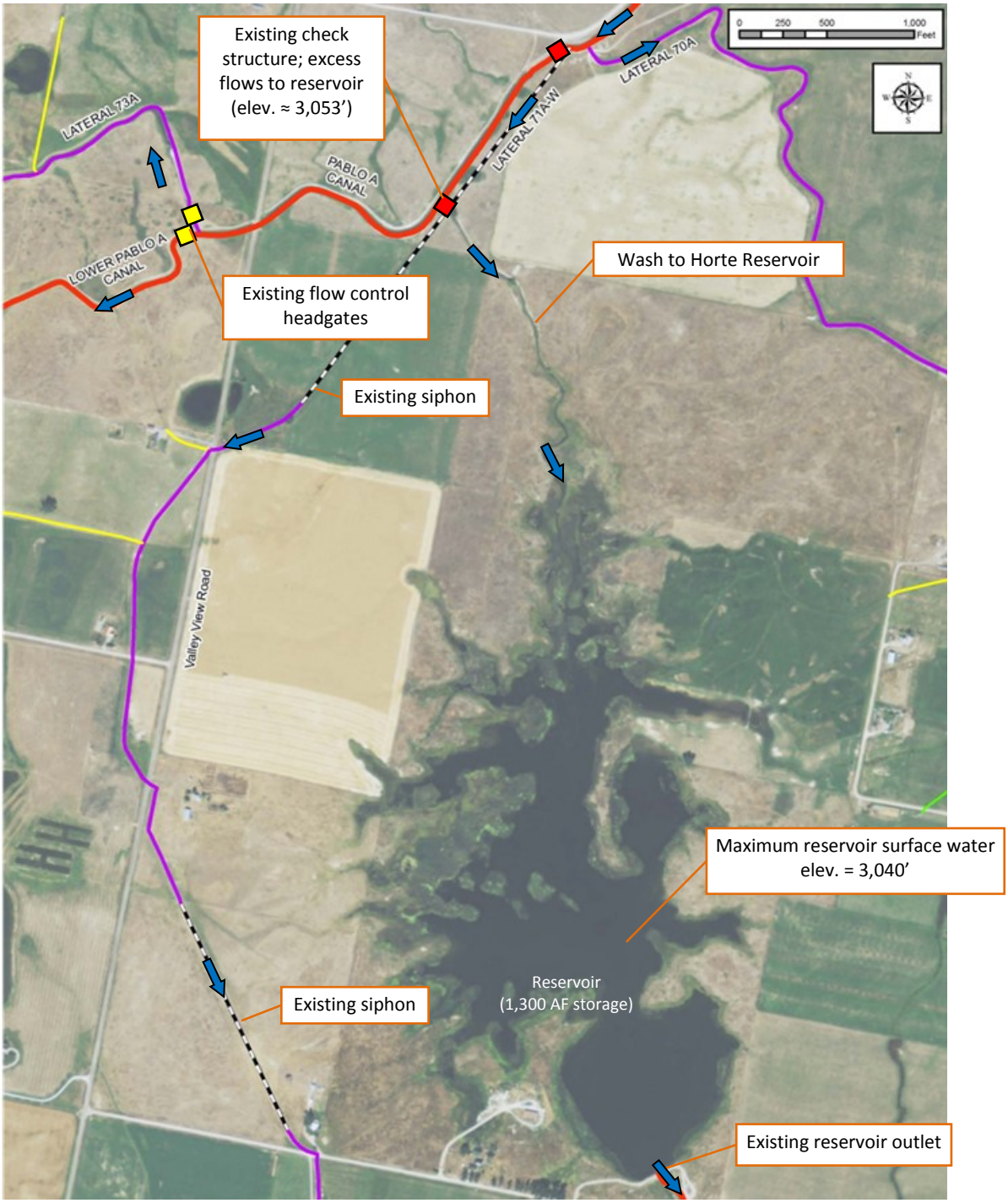

Figure 2. Overview of existing control in the area of the Pablo A Canal and Horte Reservoir

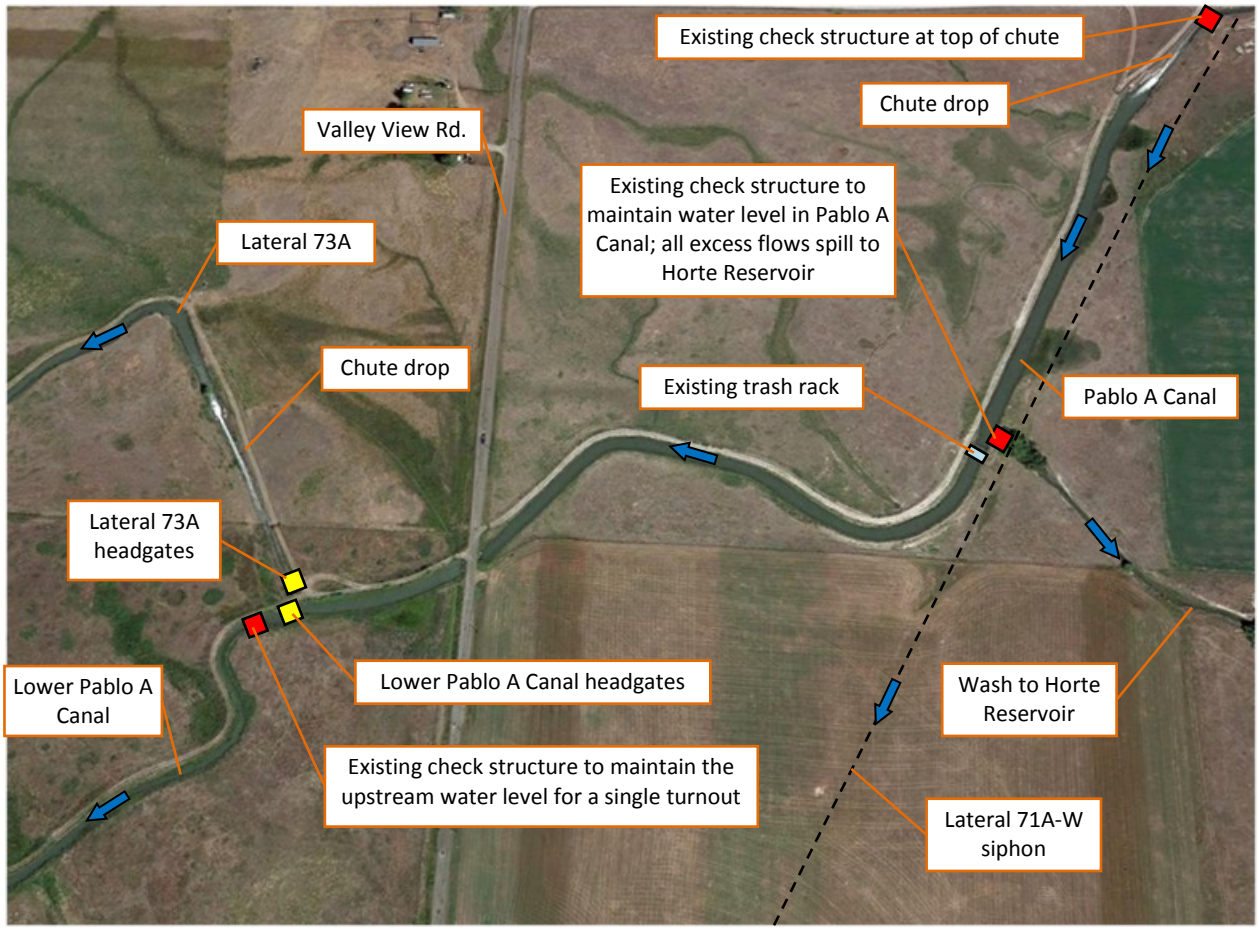

Figure 3. Existing control in the Pablo A Canal near Horte Reservoir

The existing control is as follows:

- A flashboard check structure at the entrance to a large concrete chute drop in the Pablo A Canal (see Figure 4) maintains the upstream water level for Laterals 70A and 71A-W. The first 2,400 ft. of the Lateral 71A-W is a siphon pipe.

Figure 4. Existing check structure at entrance to chute drop on the Pablo A Canal several hundred feet upstream of inlet to Horte Reservoir. Photo from HKM 2008 report (CHT-11).

- Water flows down the concrete chute (see Figure 5) and discharges into a 2,500 ft. canal pool.

Figure 5. Existing chute drop on the Pablo A Canal several hundred feet upstream of inlet to Horte Reservoir. Photo from HKM 2008 report (CHT-11).

- An existing 9 ft. wide flashboard spill structure installed in the left canal bank of the Pablo A Canal (see Figure 6) provides the following functions:
  - Maintains the water level in the 2,500 ft. canal pool of the Pablo A Canal
  - Passes excess flows into a wash that leads to Horte Reservoir

Figure 6. Existing spill structure to maintain water level in the Pablo A Canal and pass all excess flows to Horte Reservoir

- A trash rack installed in the canal just downstream of the existing check structure captures aquatic debris in the canal. Figure 7 shows large debris piles, indicating that:
  - Aquatic debris is constantly flowing down from the upper portion of the canal system.
  - Operators spend a considerable amount of time cleaning the debris from the canal.

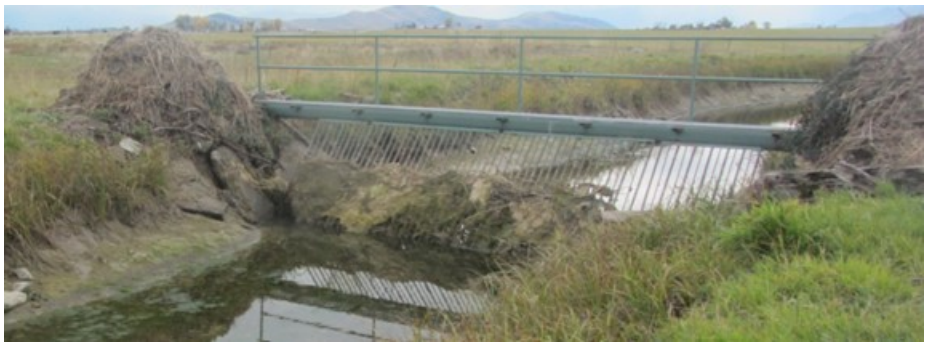

Figure 7. Existing trash rack in the Pablo A Canal just downstream of the inlet to Horte Reservoir. Notice the large piles of aquatic debris on the canal banks and on the screen itself.

- Approximately 1,600 ft. downstream of the existing check structure are the headgates for Lateral 73A as well as the Lower Pablo A Canal (see Figure 8).

Figure 8. Existing Lower Pablo A Canal and Lateral 73A headgates

- An existing check structure installed in the Lower Pablo A Canal approximately 75 ft. downstream of the canal headgates (see Figure 9) is used to maintain the upstream water level for a single farmer turnout. The existing check structure may have previously been used for a Cipoletti weir for flow measurement.

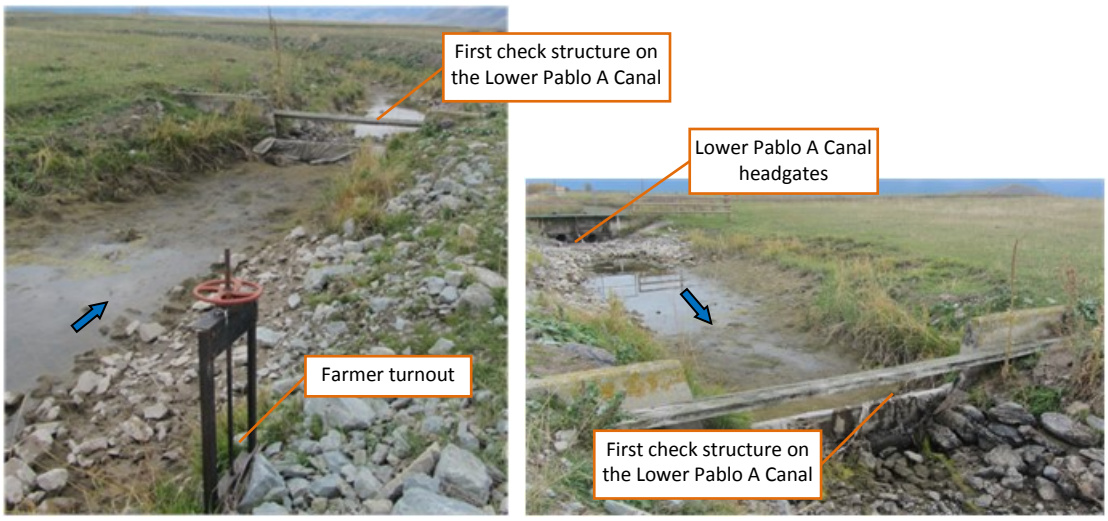

Figure 9. First turnout and check structure in the Lower Pablo A Canal

- Immediately downstream of the Lateral 73A headgates is a large concrete chute drop (see Figure 10).

Figure 10. Upstream view (left) and downstream view (right) of chute drop immediately downstream of the Lateral 73A headgates

Overview of Modernization Changes to the Pablo A Canal and Horte Reservoir System

The modernization changes to be made in the Pablo A Canal near Horte Reservoir will focus on:

- Providing better water level control at lateral and turnout headgates in order to provide better controllability of flow rates.
- Providing better flow measurement at multiple locations to better manage water deliveries.
- Easing management for operators.
- Discharging water back into the Pablo A Canal from the Horte Reservoir, to supplement water to the Lower Pablo A Canal and Lateral 73A when Pablo A Canal flow deficits occur.

Figure 11 shows the modernization changes to the Pablo A Canal and Horte Reservoir.

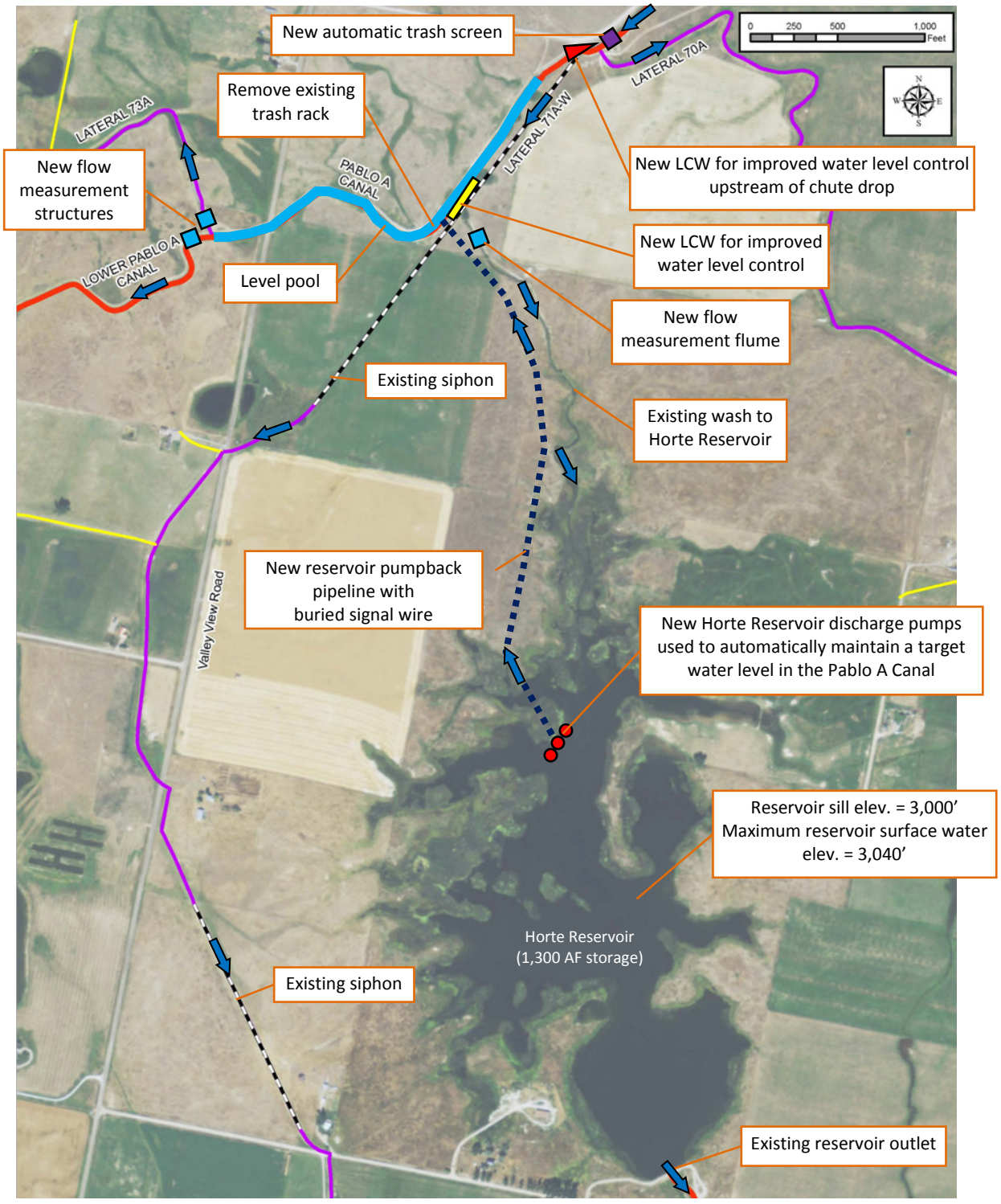

Figure 11. Overall modernization changes to be made near the Pablo A Canal and the connection to Horte Reservoir

Improvements near the Pablo A Chute

The objectives of changes near the Pablo A Chute will be to:

1. Maintain good, simple water level control at the headgates to Lateral 70A and Lateral 71A-W
2. Remove floating trash from the canal water in a manner that does not require frequent operator effort. Trash removal is important to avoid interference with flow measurement at downstream delivery points. The new trash screen will replace the existing trash screen that is presently located downstream.

The major changes will include:

1. A new automatic trash screen manufactured by Aqua Systems 2000 (or similar; see Appendix B for details) will be installed in the Pablo Canal, upstream of Lateral 70A:
    a. The automatic trash screen will run off the available power grid.
    b. Batteries will provide backup power in the event the power grid goes down.
2. A 50 ft. oblique long-crested weir (LCW) will be installed in the Pablo A Canal just upstream of the entrance to the chute drop to improve the water level control upstream at the Lateral 70A and 71A-W headgates.
    a. Figure 12 shows the conceptual plan view of the new LCW structure.
    b. The water level over the crest of the LCW will only vary approximately 0.7 ft. between the estimated high and low flows (200 CFS and 50 CFS respectively).
    c. At high flow, approximately half of the canal flow will pass through a 5 ft. manual sluice gate. The remaining flow will pass over the LCW.
    d. At low flow, nearly all the flow will pass over the LCW. The 5 ft. sluice gate will only be slightly open for continuous sediment flushing.
    e. The LCW will maintain a high downstream water level on the automatic trash screen to provide a large water surface area through the screen. This will reduce the friction loss through the trash screen.

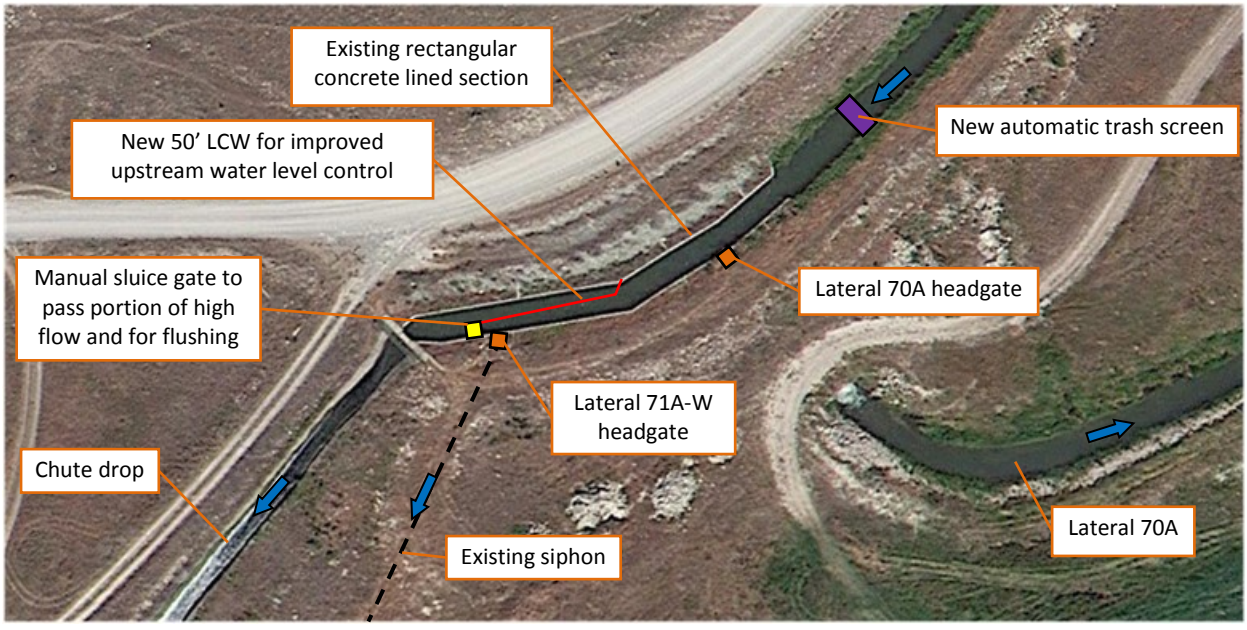

Figure 12. Modernization changes at the Lateral 70A and 71A-W headgates on the Pablo A Canal

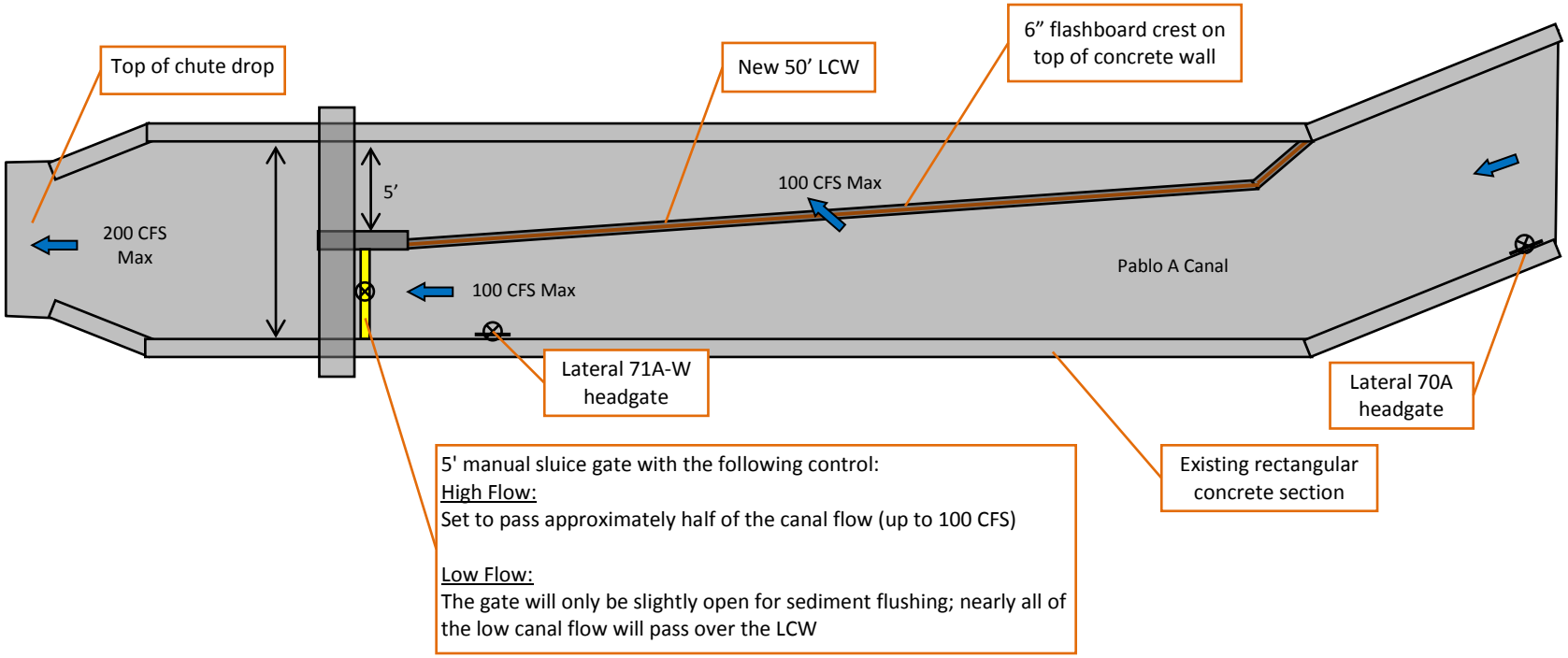

Figure 13. Conceptual plan view of new LCW in the Pablo A Canal at the Lateral 70A and 71A-W headgates (not to scale)

Improvements at the Connection between Horte Reservoir and Pablo A Canal

The objective of the modernization changes in this area of the Pablo A Canal is to maintain a fairly constant water level in the Pablo A Canal, regardless of flow rates.

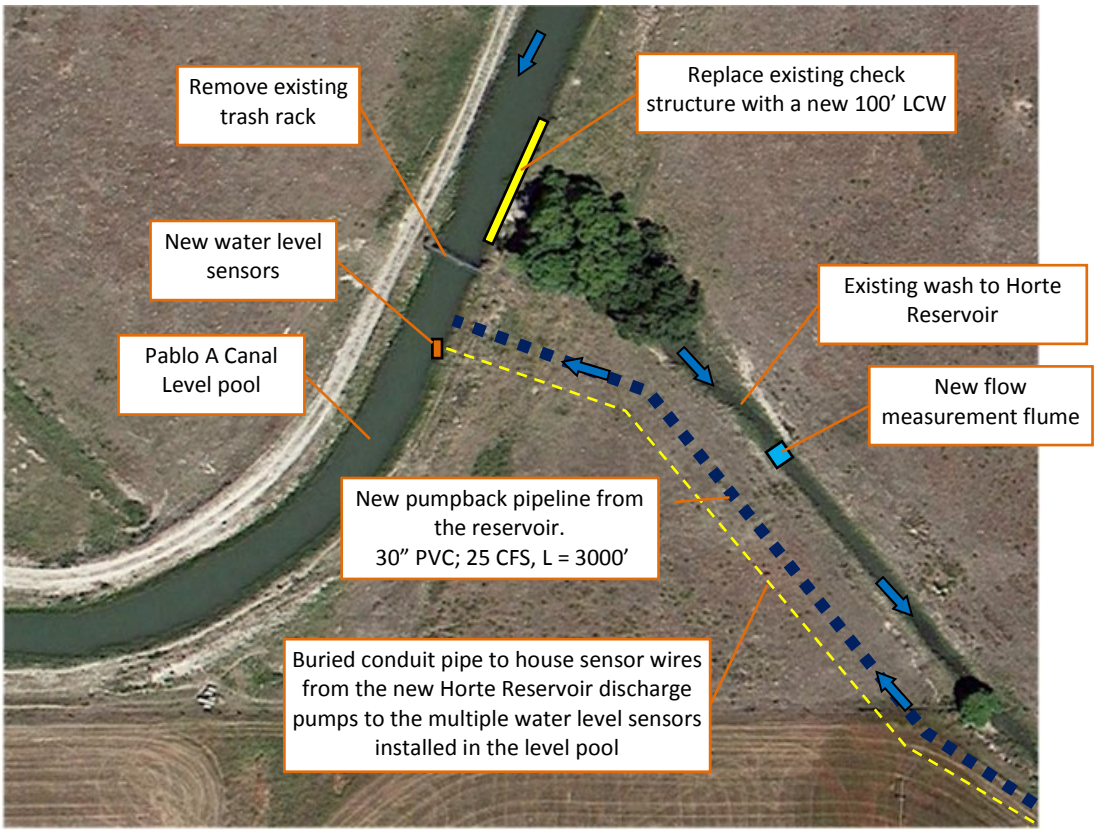

Figure 14. Modernization changes at discharge to Horte Reservoir

1. The existing check structure in the Pablo A Canal will be replaced with a new 100 ft. LCW to:
    a. Maintain a fairly constant water level in the new level pool.
    b. Automatically pass all excess flows from the Pablo A Canal into Horte Reservoir.
2. A new flow measurement flume or weir will be installed in the existing wash to Horte Reservoir to measure the excess flow entering the reservoir. The flow rate spilling to Horte Reservoir will be remotely monitored via SCADA.
3. Two pumps installed in Horte Reservoir will discharge water back into the new Pablo A Canal to maintain a target water level when there is a deficit in canal flow.
    a. The new 30" diameter PVC pumpback pipeline will have an approximate length of 3,000 ft.
    b. The reservoir pumps will be controlled with special logic in a Programmable Logic Controller (PLC), using data from redundant water level sensors installed in the level pool.
    c. A buried conduit pipe with sensor wires will be installed from the level pool to the reservoir pumps. While wireless communication would be less expensive, it is more problematic. Reliability is very important for this project.

d. The general sequencing of the two reservoir pumps will be:
    i. If the water elevation in the level pool falls below the elevation of the crest of the long-crested weir, the first reservoir pump will automatically turn on. The speed of the pump will automatically change, in an attempt to maintain the pool water surface just below the crest of the long crested weir.
    ii. If the water level in the level pool does not recover to the target elevation, the second reservoir pump will automatically turn on, also. While the first pump will remain at 100% speed, the second pump will adjust its speed to maintain the target water level just below the LCW crest
    iii. This sequence will be repeated in reverse, as the deficit in the level pool is reduced.
e. Approximate pump characteristics will be:
    i. 2 pumps
    ii. Maximum flow/pump = 12.5 CFS
    iii. Maximum TDH = 26'
    iv. Input HP to motor of each pump = 50
    v. Each pump will be equipped with a VFD controller and inverter duty motor.
    vi. Each pump will have a check valve on its discharge. Therefore, the pipe will be full when a pump starts. The VFD can assure a soft start to avoid water hammer.
    vii. The pipeline must have a manual drain valve just downstream of the pump check valves, below ground surface.

Improvements near the Heads of Lateral 73A and Lower Pablo A Canals

The new control into and out of Pablo A Canal, with Horte Reservoir, will be designed to maintain a fairly constant water level in the canal pool that supplies Lateral 73A and Lower Pablo A Canals. This will allow the operators to change the flow into these two canals at will. To accomplish this, the following changes will be made.

1. The existing canal gates at the head of the Lower Pablo A Canal will be replaced with new sluice gates.
2. The existing check structure in the Lower Pablo A Canal will be replaced with a new flow measurement flume. The flow rate through the flume will be remotely monitored via SCADA.
3. The existing farmer turnout just downstream of the Lower Pablo A Canal headgates will be moved from its current location to just next to the canal headgates in the new level pool.
4. A new flow measurement flume or weir will be constructed in the existing concrete chute drop just downstream of the Lateral 73A headgates. The flow rate will be remotely monitored.

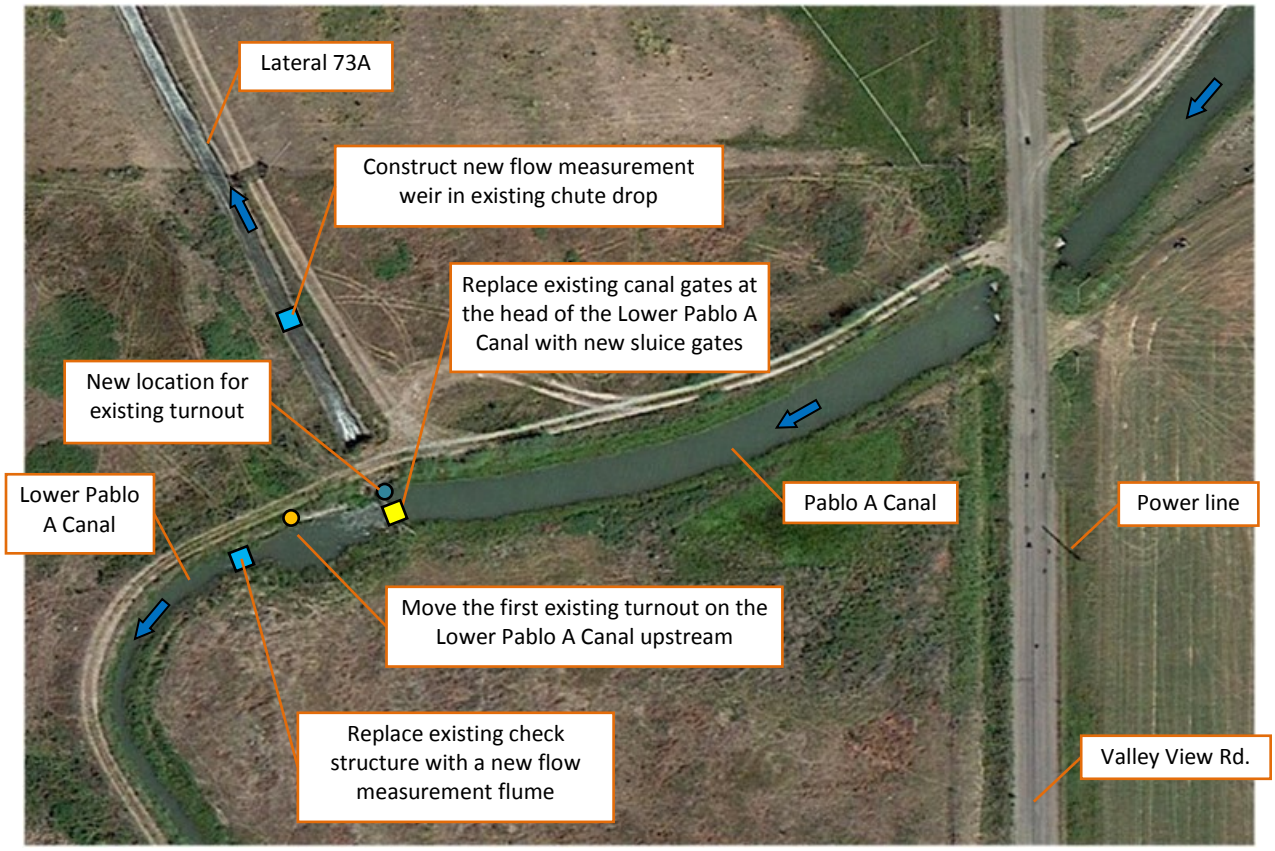

Figure 15. Modernization changes near at the heads of Lateral 73A and the Lower Pablo A Canal

Round Butte Road Interceptor and Horte Reservoir Flowback Pipeline System

Figure 16 shows the existing watershed north of Round Butte Road that is confined between Mud Creek and the Pablo A Canal.

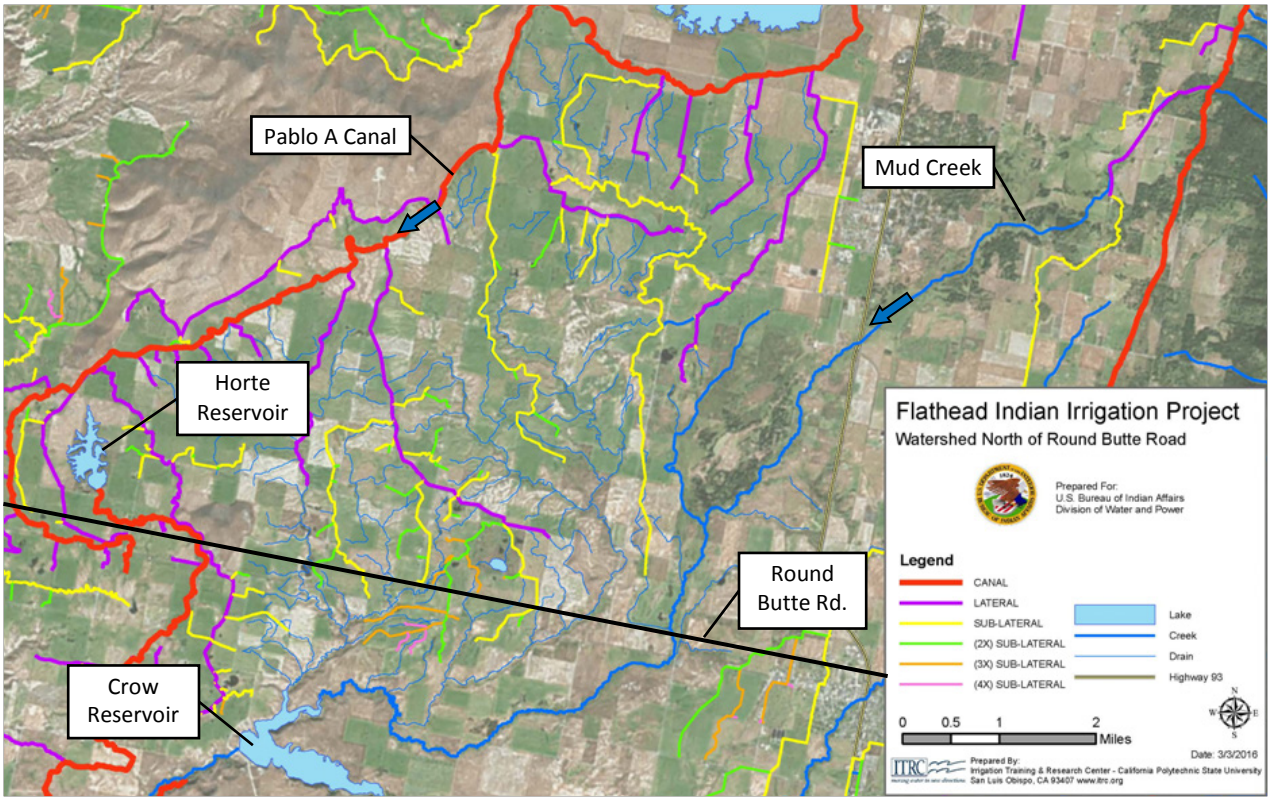

Figure 16. Existing watershed north of Round Butte Road between Mud Creek and the Pablo A Canal

Mud Creek and multiple drains capture canal operational spill and farmer runoff. These drainage ways cross under Round Butte Road prior to discharging into Crow Reservoir. There is potential to recapture most of the excess flows in Mud Creek and the individual drains prior to reaching Crow Reservoir. Crow Reservoir is only able to provide water to the Moiese Canal Unit and with the new operation scheme of Hillside Reservoir, less water will be needed from Crow Reservoir. Therefore, this recovery scheme is intended to re-use drainage flows that will otherwise be lost to the project.

With the construction of multiple pumps and an Interceptor Pipeline, the re-captured flow could be utilized to supply turnouts west and south of Horte Reservoir. This would then prolong the storage of Pablo Reservoir as well as other upstream reservoirs used to supply water to the southwest portion of the Pablo Canal Unit.

Figure 17 shows the general overview of the new Round Butte Road Interceptor Pipeline as well as the Horte Reservoir Flowback Pipeline systems. Figure 18 shows the approximate elevations of key locations for the pipeline system.

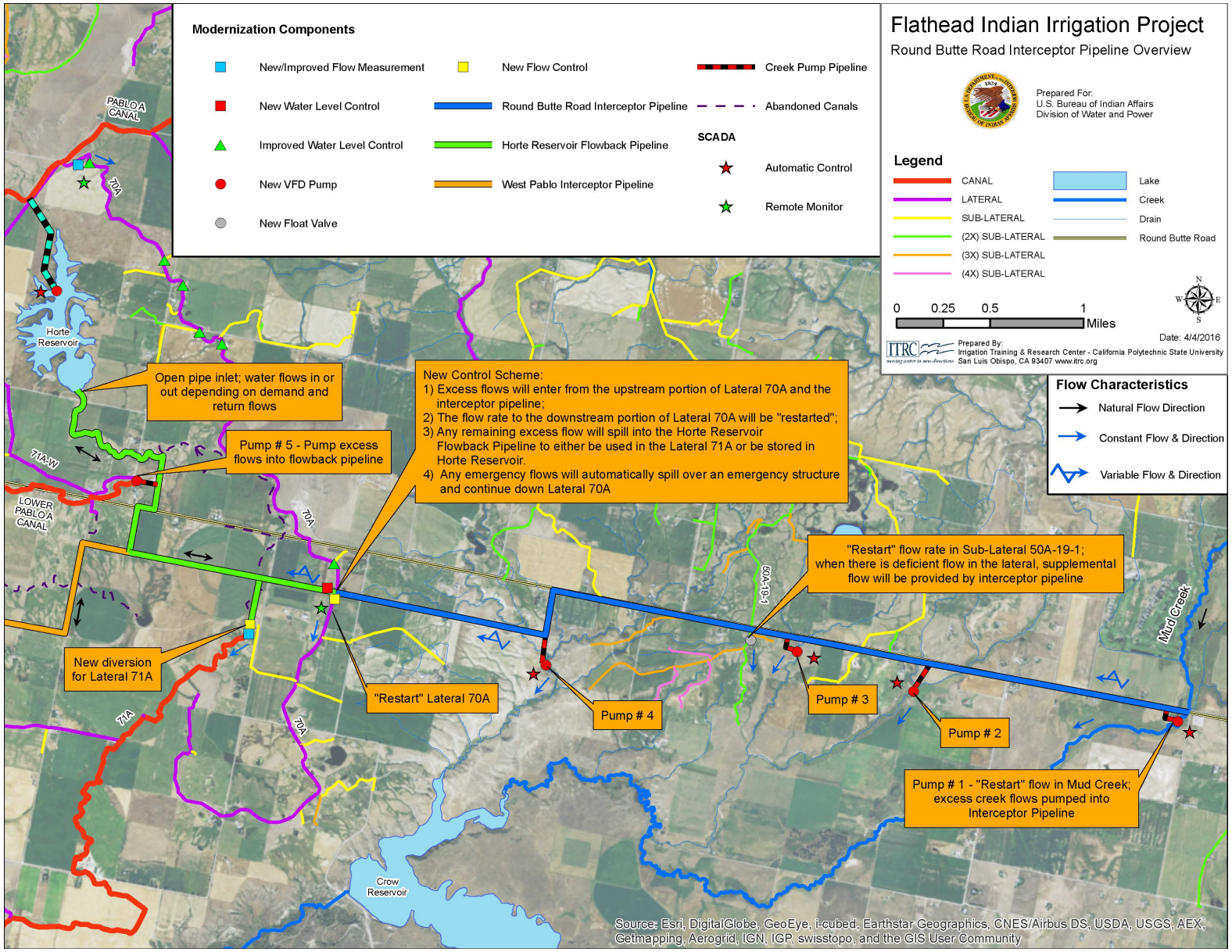

Figure 17. Overview of new Round Butte Road Interceptor Pipeline and Horte Reservoir Flowback Pipeline systems

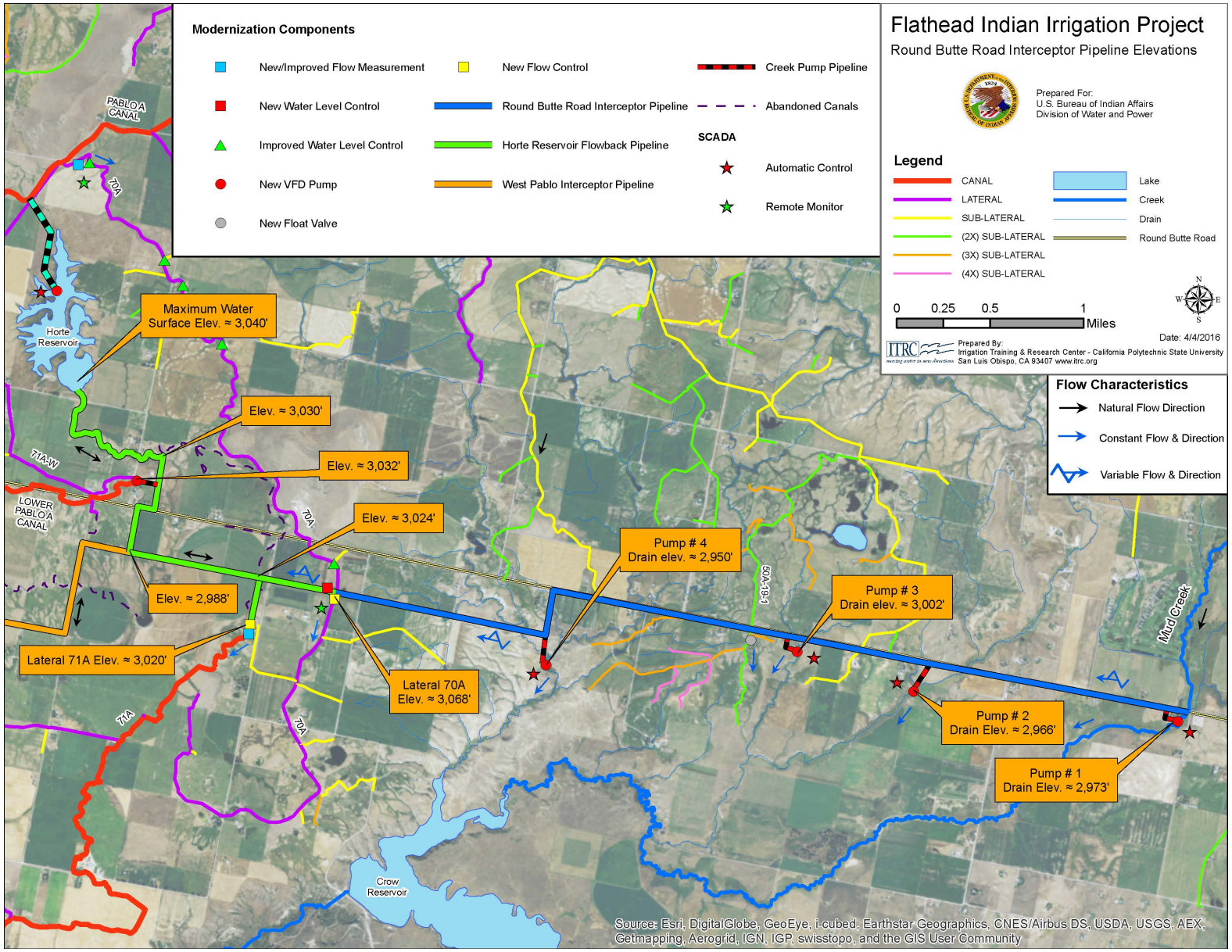

Figure 18. Key elevations for the Round Butte Road Interceptor Pipeline System

The components shown in Figure 17 include the following:

1. A new interceptor pipeline will follow the alignment of Round Butte Road from Mud Creek to Lateral 70A (approximately 4.75 miles).
    a. Automated VFD-equipped pumps will be installed in the Mud Creek and three individual drains (four pumps total) to pump excess drain flows into the new interceptor pipeline.
    b. Water will be supplemented to Sub-Lateral 50A-19-1 from the interceptor pipeline when there is deficient flow in the sub-lateral. The discharge flow rate from the interceptor pipeline will be controlled by a float valve to maintain a target water level in the sub-lateral.
    c. The excess flow interceptor pipeline will discharge into a new level pool in Lateral 70A located downstream of Round Butte Road.
2. A new pipeline will be constructed from Horte Reservoir to the new level pool in Lateral 70A. The pipeline will supply water to the new diversion to Lateral 71A from either:
    a. Horte Reservoir
    b. The Lateral 70A level pool
    c. The West Pablo Interceptor Pipeline (explained later in different section)
3. A new level canal pool will be created in Lateral 70A just south of Round Butte Road. The control scheme of the level pool will be as follows:
    a. Flows will enter the new level pool from both the upstream portion of Lateral 70A and the interceptor pipeline.
    b. A new flow control structure will "restart" the flow rate to the downstream portion of Lateral 70A.
    c. Any remaining excess flow not utilized in the remaining portion of Lateral 70A will automatically spill into the Horte Reservoir Flowback Pipeline to either be (by gravity):
        i. Used in the new Lateral 71A
        ii. Used in the West Pablo Interceptor Pipeline
        iii. Stored in Horte Reservoir
4. SCADA will be incorporated at various locations to help remotely monitor water levels and flow rates as well as accompany the automation of the creek/drain pumps.

The following report sections provide a further explanation of the new control components at individual locations.

Interceptor Pipeline Design

Figure 19 shows the design characteristics for the new Round Butte Road Interceptor Pipeline. The interceptor pipeline will consist of a single pipeline of various diameters and flows that runs from Mud Creek to a new level pool in Lateral 70A (total pipeline length approximately 4.8 miles). Four individual pumps stations will pump excess flows into the interceptor pipeline from Mud Creek and three drains. The interceptor pipeline will discharge into the air above the water surface in the Lateral 70A Level Pool.

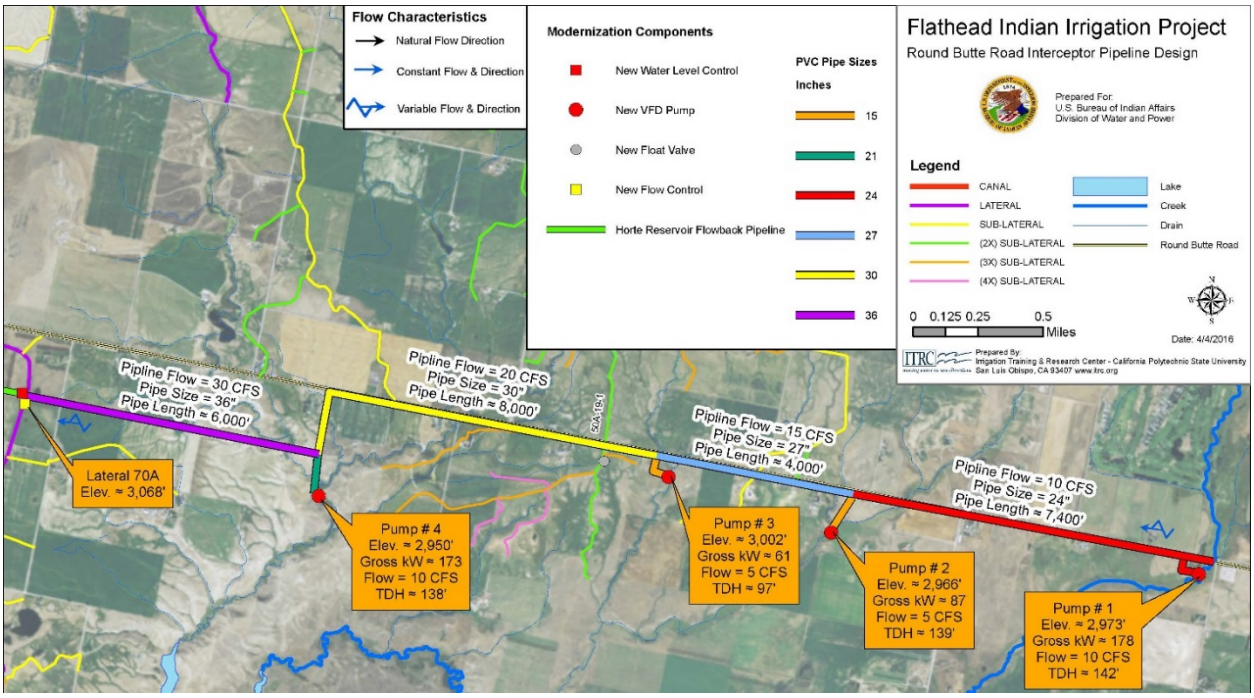

Figure 19. Design characteristics for the Round Butte Road Interceptor Pipeline

Table 1 and Table 2 show approximate pump and pipe characteristics for the Round Butte Road Interceptor Pipeline design. The energy use will be about 200 KWH per Acre-foot pumped, compared to about 420 KWH per Acre-foot pumped at the FIIP pump station.

Table 1. Approximate pump characteristics for the Round Butte Road Interceptor Pipeline System

Pump No.	Elevation[1] (ft.)	Gross Electric KW	Max Flow (CFS)	Total-Dynamic Head (TDH in ft.)
1	2,973	178	10	142
2	2,966	87	5	139
3	3,002	61	5	97
4	2,950	173	10	138

[1] Lateral 70A Level Pool elevation ≈ 3,068'

Table 2. Pipe characteristics for Round Butte Road Interceptor Pipeline

Pipe Segment	Pipe Flow (CFS)	PVC Pipe Size[1] (in)	Approx. Pipe Length (ft.)
Pump 1 – Pump 2	10	24	7,400
Pump 2 – Pump 3	15	27	4,000
Pump 3 – Pump 4	20	30	8,000
Pump 4 – Level Pool	30	36	6,000

[1] 27" and below are PIP; 30" and above are C905. All pipe has pressure rating of 100 psi.

The following sections describe the control components to be incorporated into Mud Creek, Sub-Lateral 50A-19-1, and the three individual drains.

Mud Creek Pump

Figure 20 and Figure 21 show the Mud Creek crossing at Round Butte Road.

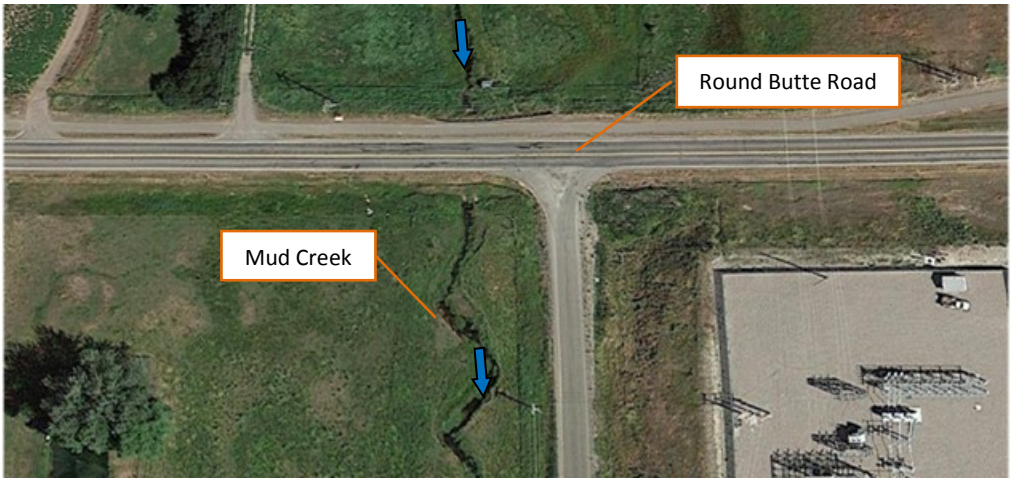

Figure 20. Aerial of Mud Creek at Round Butte Road

Figure 21. Mud Creek downstream of the Round Butte Road crossing. Photo was taken looking west.

Figure 22 shows a conceptual example of the control components in Mud Creek. The new control components in Mud Creek would include:

1. A Cipoletti weir constructed in the creek to:
    a. Measure in-stream flows that will continue downstream
    b. Check up the water for the VFD pump installed upstream
2. A single 178 KW (gross input) VFD pump (10 CFS, 142 ft. TDH) will be installed in the creek to automatically limit pumping to maintain a target water level over the new Cipoletti weir. The target water level will result in a target downstream creek flow rate. The pipeline will not provide additional water to supplement the Mud Creek flow if it drops below the target downstream creek flow rate.
3. An automatic trash/debris removal screen is needed at the inlet to the pump.
4. The excess creek flow will be pumped directly into the new Round Butte Road Interceptor Pipeline via a 24" PIP discharge pipeline (approximately 100 ft. long).
5. Inexpensive slide gates will be installed on both sides of the Cipoletti weir to drain and flush the upstream portion of the creek.

Ideally, SCADA will be incorporated to remotely monitor the pump status and the flow rate to the downstream portion of Mud Creek. If Horte Reservoir should become too full, the pump could be de-activated remotely.

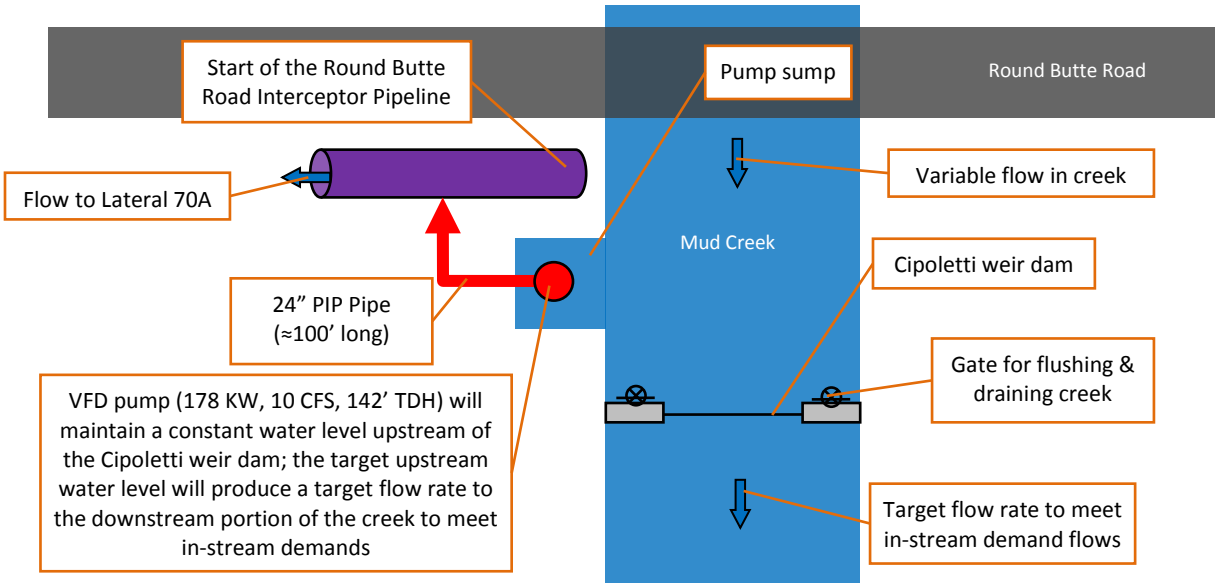

Figure 22. Conceptual example of control components in Mud Creek (not to scale)

Pump #2

Figure 23 shows the approximate location of Pump #2 in an existing drain downstream of Round Butte Road and approximately 2,500 ft. west of Hughes Road.

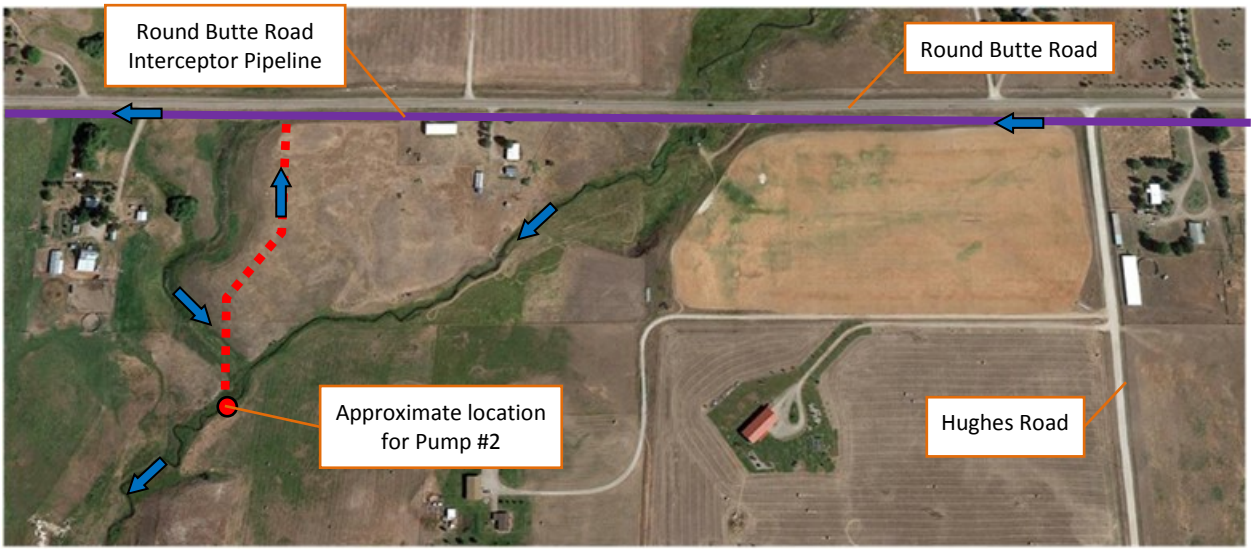

Figure 23. Approximate location of Pump #2 in an existing drain downstream of Round Butte Road and approximately 2,500' west of Hughes Road

Figure 24 shows part of the drain immediately downstream of Round Butte Road located approximately 1,100 ft. west of Hughes Road.

Figure 24. Existing drain downstream of Round Butte Road approximately 1,100' west of Hughes Road

Figure 25 shows the control components for Pump #2. The components include:

1. A rock dam will be constructed downstream of the confluence of the two drains into one (approximately 1,000 ft. due south of Round Butte Road). The rock dam will raise the upstream water level in the drain to provide the necessary submergence for the new pump.
2. A single 87 KW VFD pump (5 CFS, 139 ft. TDH) will be installed in the creek to automatically maintain a target water level upstream of the new rock dam.
3. An automatic trash/debris removal screen will be installed at the inlet to the pump.
4. The excess drain flow up to 5 CFS will be pumped directly into the new Round Butte Road Interceptor Pipeline via a 15" PIP pipe.
    a. Excess flows that exceed 5 CFS will automatically spill over the rock dam and continue down the drain and will eventually be captured at Crow Reservoir.
    b. It is assumed that there are no in-stream flow requirements in the drain.
5. SCADA will be incorporated to remotely monitor the pump status.

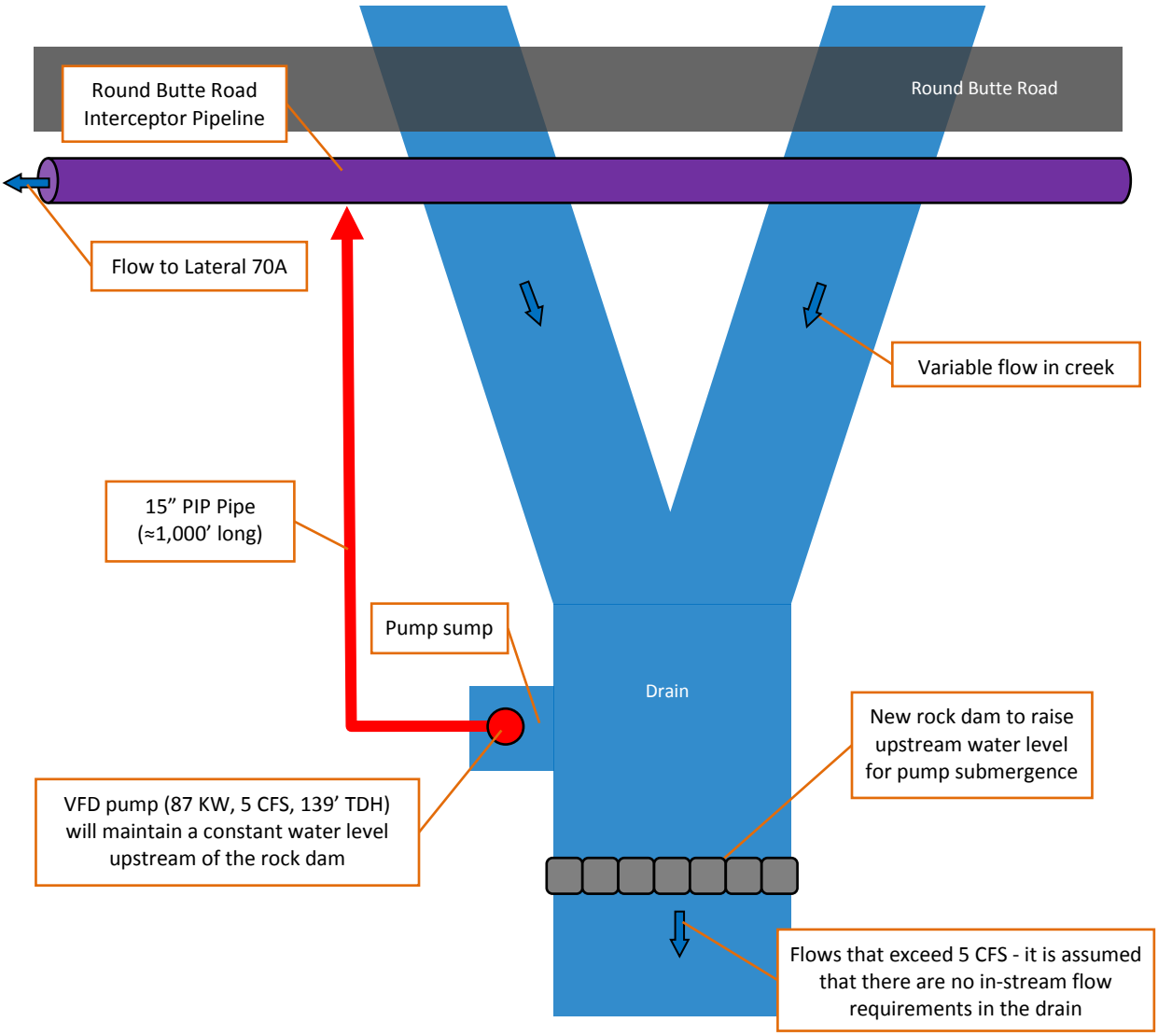

Figure 25. Conceptual example of control components for Pump #2 (not to scale)

Supplement to Sub-Lateral 50A-19-1

Approximately 350 acres are serviced from Sub-Lateral 50A-19-1 downstream of Round Butte Road as shown in Figure 26. Figure 27 shows the existing control in Sub-Lateral 50A-19-1 immediately downstream of Round Butte Road.

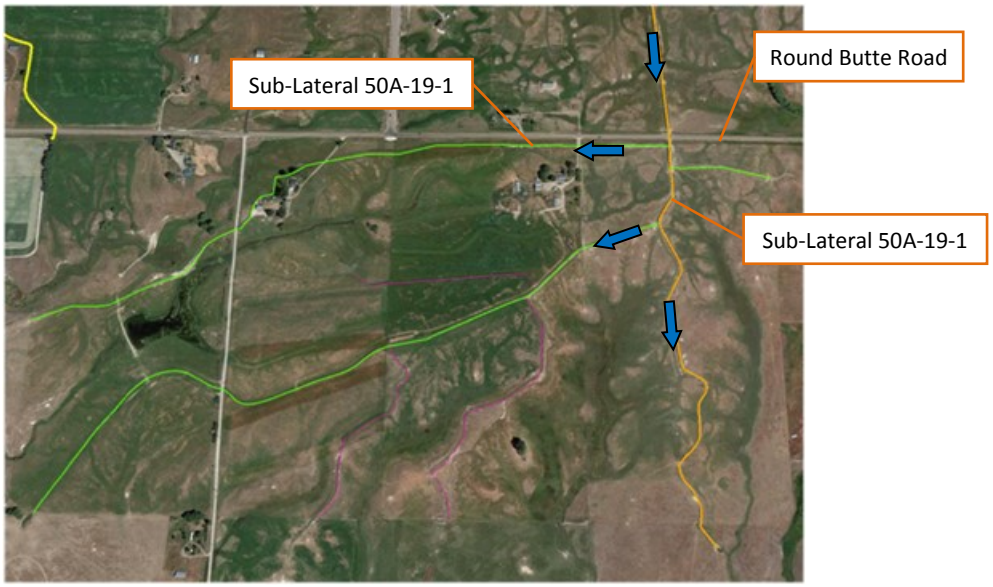

Figure 26. Sub-Lateral 50A-19-1 service area downstream of Round Butte Road

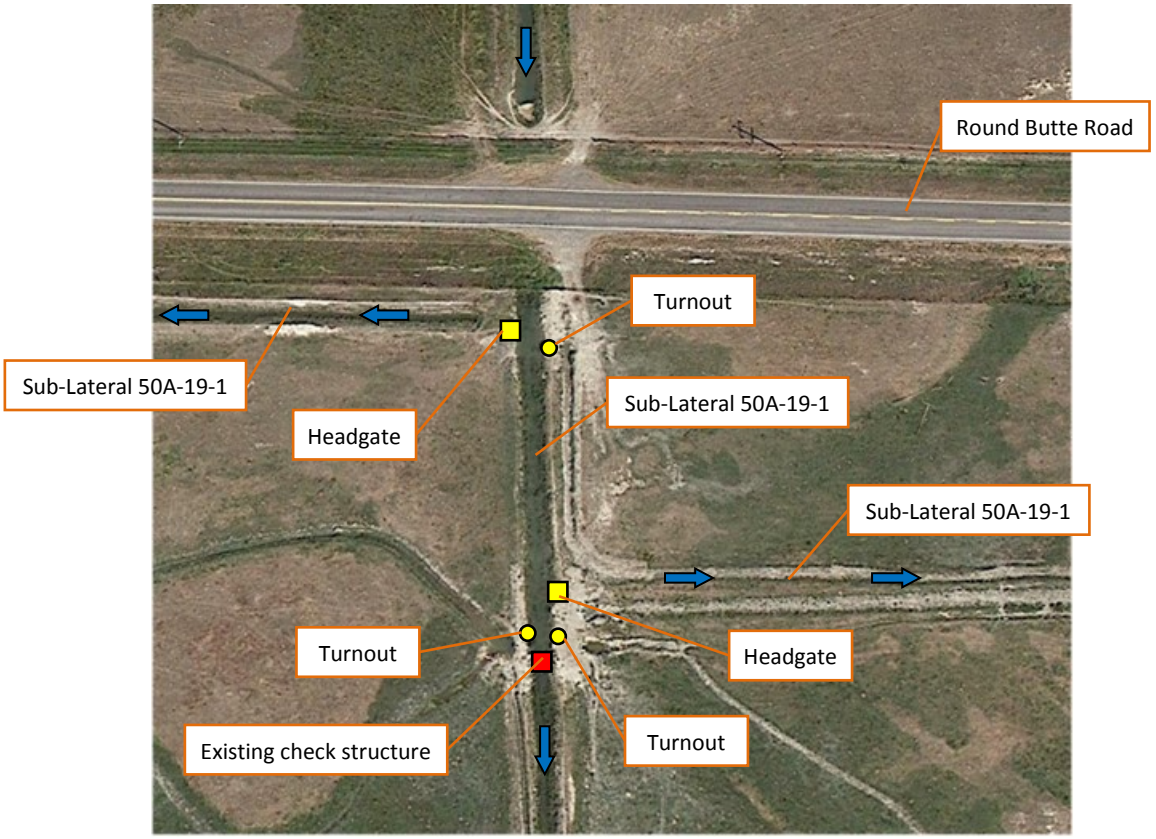

Figure 27. Existing control in Sub-Lateral 50A-19-1 at Round Butte Road

A single check structure installed in Sub-Lateral 50A-19-1 (see Figure 28) maintains the upstream water level for two sub-lateral headgates as well as three individual farmer turnouts.

Figure 28. Upstream view (top) and downstream view (bottom) of the existing check structure in Sub-Lateral 50A-19-1 at Round Butte Road. Photos from HKM 2008 report.

With the sub-lateral at the very tail end of the canal system, the water delivery service can most likely be characterized as a "feast or famine" scenario. There is either more flow than is needed or there is too little flow for all the turnouts in the area. The modernization changes below will focus on providing better service to help reduce or possibly eliminate the "famine" scenario.

The modernization changes to Sub-Lateral 50A-19-1 at Round Butte Road are shown in Figure 29.

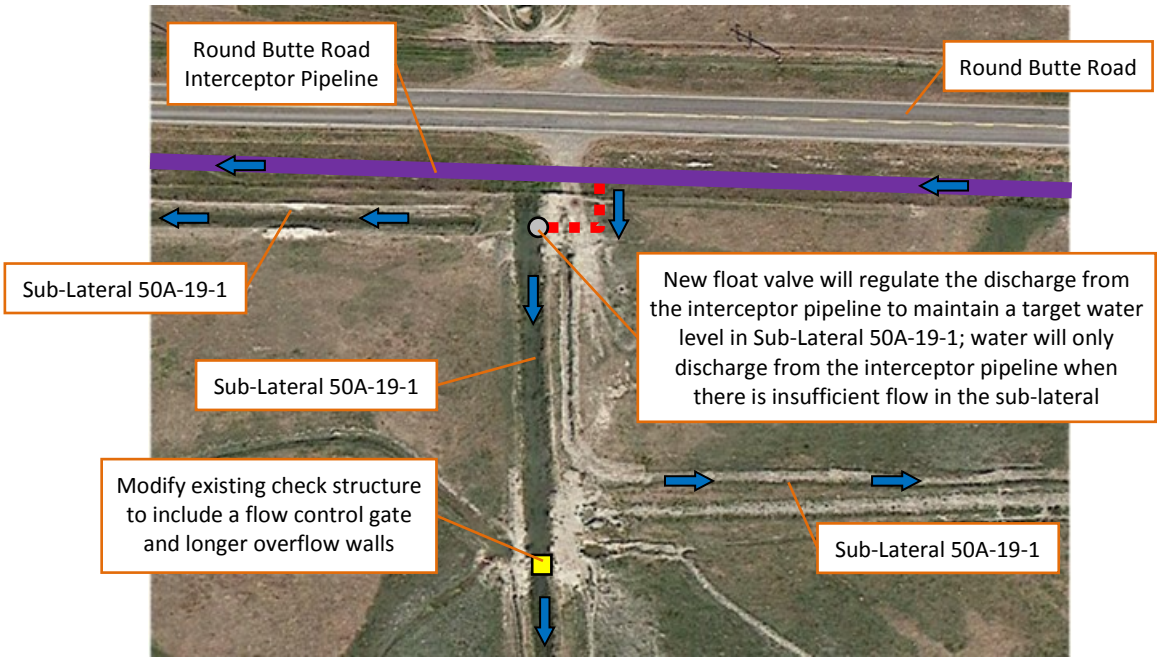

Figure 29. Modernization changes to Sub-Lateral 50A-19-1 at Round Butte Road

The modernization changes include:

1. A supplemental pipeline off the Round Butte Road Interceptor Pipeline will provide water to Sub-Lateral 50A-19-1 when there is insufficient flow in the sub-lateral to meet downstream demands.
    a. The supplemental discharge flow from the interceptor pipeline will be regulated by a float valve installed at the end of the supplemental pipeline.
    b. The float valve will maintain a target water level in the Sub-Lateral 50A-19-1 downstream of Round Butte Road.
    c. The flow valve will operate as follows:
        i. If the water level in the sub-lateral drops below the target water level, the valve will open, allowing water from the interceptor pipeline to discharge into the canal pool.
        ii. If the water level in the sub-lateral is at or above the target water level, the valve will close to prevent any discharge flow from the interceptor pipeline.
2. The existing check structure in Sub-Lateral 50A-19-1 will be modified as shown in Figure 30. The modifications will include:
    a. The existing overflow walls will be extended upstream to:
        i. Automatically spill excess flows in the sub-lateral downstream.
        ii. Provide better control of the upstream water level during emergency situations.
    b. A new 3 ft. sluice gate installed at the upstream end of the weir walls will provide flow control during normal operation to the downstream portion of Sub-Lateral 50A-19-1.

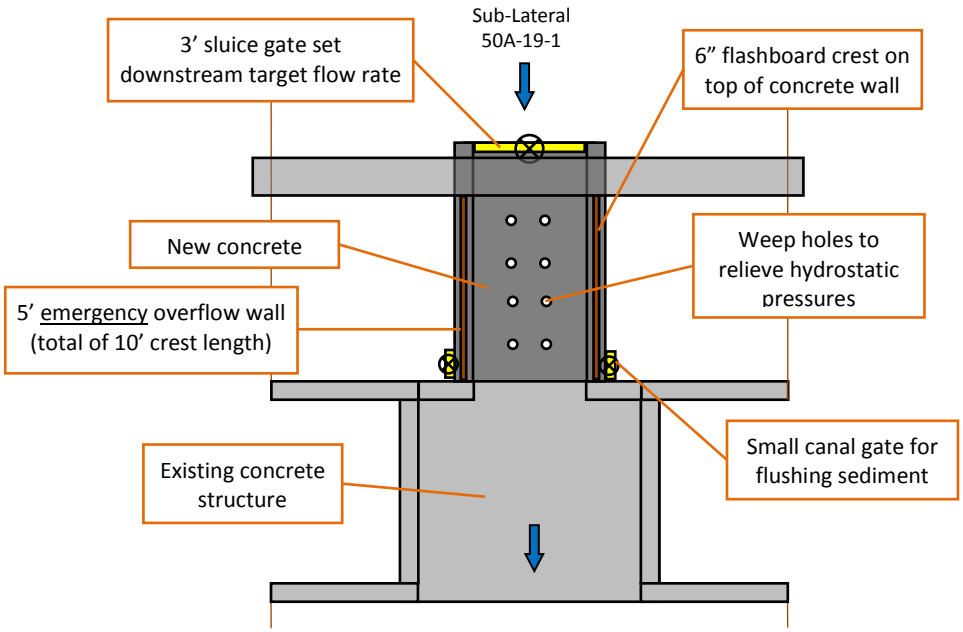

Figure 30. Conceptual plan view of modifications made to the existing check structure in Sub-Lateral 50A-19-1 to provide flow control with emergency overflow (not to scale)

Pump #3

Figure 31 shows the approximate location of Pump #3 in an existing drain approximately 1,400 ft. east of Sub-Lateral 50A-19-1.

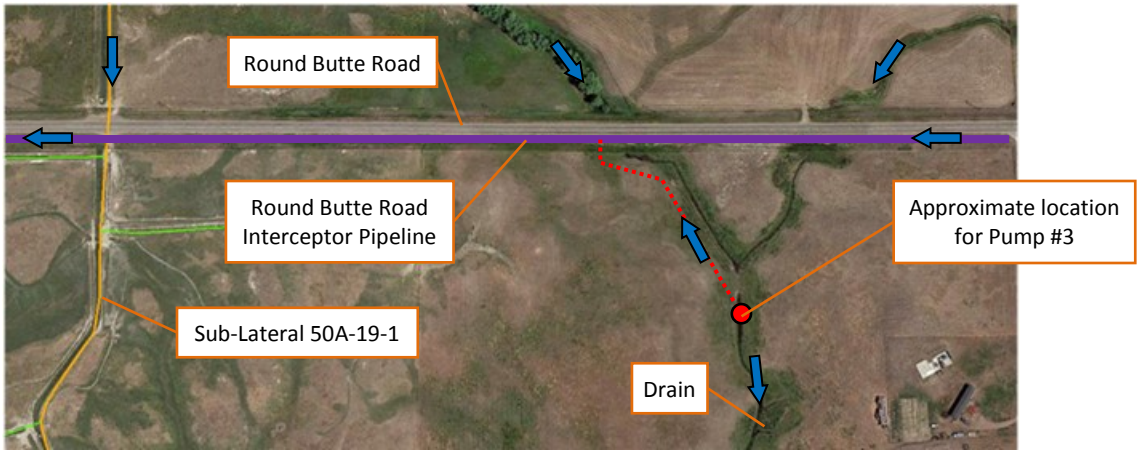

Figure 31. Approximate location of Pump #3 in an existing drain at Round Butte Road approximately 1,400' east of Sub-Lateral 50A-19-1

The control components for Pump #3 will be the same as that shown in Figure 25 for Pump #2. Pump #3 will consist of:

- A 61 KW VFD pump (5 CFS, 97 ft. TDH).
- An automatic trash/debris screen in front of the pump sump.
- 15" PIP discharge pipeline (approximately 400 ft. long) connected directly to the new Round Butte Road Interceptor Pipeline.

Pump #4

Figure 32 shows the approximate location for Pump #4 installed in a drain between Ryan and Guenzler Lanes. Figure 33 shows part of the drain immediately downstream of Round Butte Road located approximately 300 ft. east of Ryan Lane.

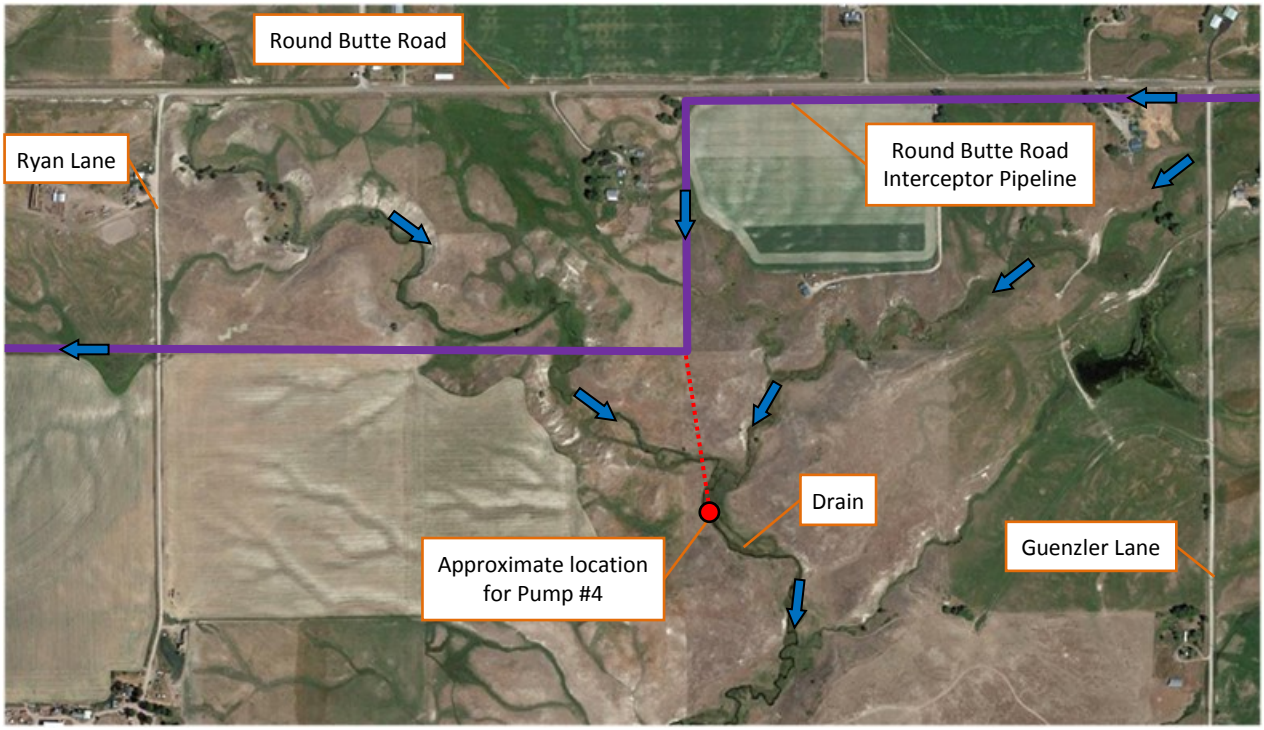

Figure 32. Approximate location for Pump #4 in an existing drain between Ryan Lane and Guenzler Lane

Figure 33. Existing drain downstream of Round Butte Road approximately 300' east of Ryan Lane

The control components for Pump #4 will be the same as that shown in Figure 25 for Pump #2. Pump #4 will consist of:

- A 173 KW VFD pump (10 CFS, 138 ft. TDH).
- An automatic trash/debris screen.
- 21" PIP discharge pipeline (approximately 800 ft. long) connected directly to the new Round Butte Road Interceptor Pipeline.

Lateral 70A Pool

Figure 34 shows the existing control in Lateral 70A downstream of Round Butte Road. An existing check structure (see Figure 35) installed in Lateral 70A maintains the upstream water level for the Sub-Lateral 70A-19 headgate.

Figure 34. Existing conditions of Lateral 70A downstream of Round Butte Road

Figure 35. Existing check structure in Lateral 70A immediately downstream of the Sub-Lateral 70A-19 headgate. Photo from HKM 2008 report (CH-368). The side roll sprinkler lateral appears to be lost.

Control at Lateral 70A

A target flow rate into the downstream portion of Lateral 70A will reestablish where the Round Butte Interceptor Pipeline will cross Lateral 70A. The new basic control scheme will be as follows:

- The flow rate into the remainder of Lateral 70A will be readjusted with a new control gate that will also have an emergency overflow side weir built into it.
- Operators will open a valve from the Round Butte Road Interceptor Pipeline to provide about 5-10 CFS extra flow into Lateral 70A, to eliminate any chance of deficit flows.
- The remainder of the Round Butte Road Interceptor Pipeline flows will discharge into the new Horte Reservoir Flowback Pipeline.
- Excess flow that comes into Lateral 70A, upstream of the new flow control gate, will exit Lateral 70A via an ITRC Flap Gate that is sized for 20 CFS. The flap gate will discharge into the new Horte Reservoir Flowback Pipeline.
- A new automatic trash screen will be installed in the structure that contains the ITRC Flap Gate.

Figure 36 and Figure 37 show the conceptual control components in the Lateral 70A Pool.

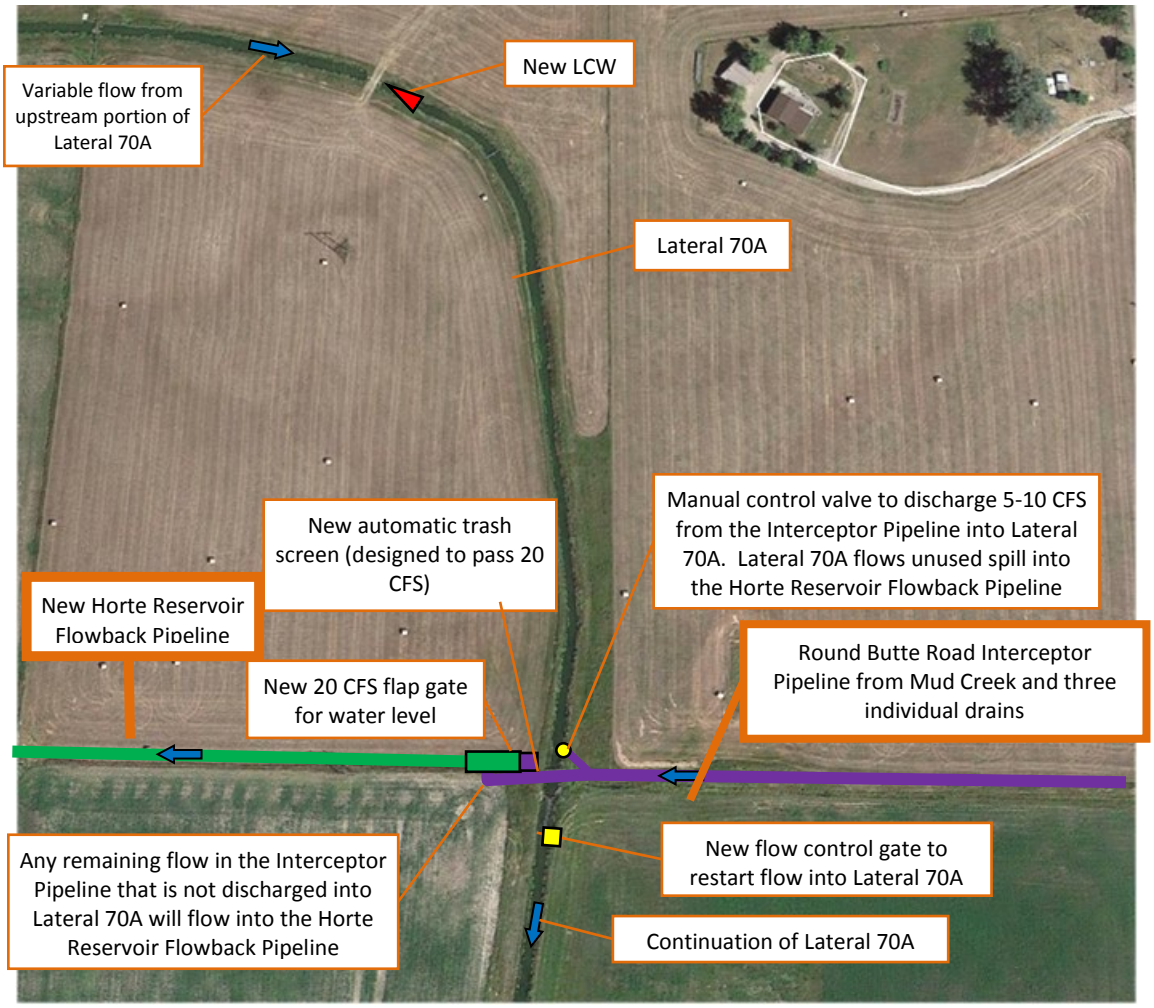

Figure 36. Modernization components of the Lateral 70A Pool

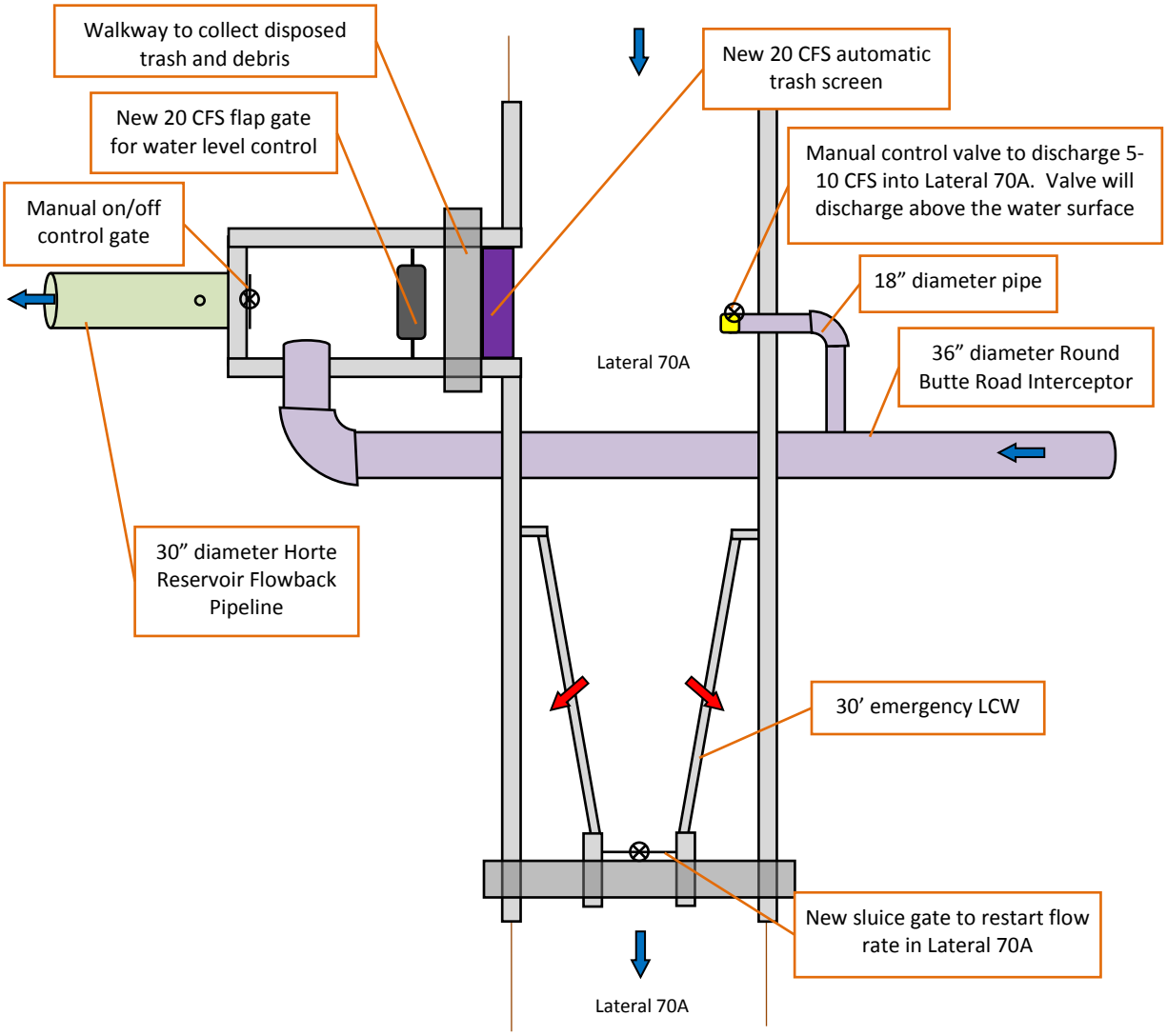

Figure 37. Conceptual plan view of control components in the Lateral 70A Pool (not to scale nor with all angles shown.)

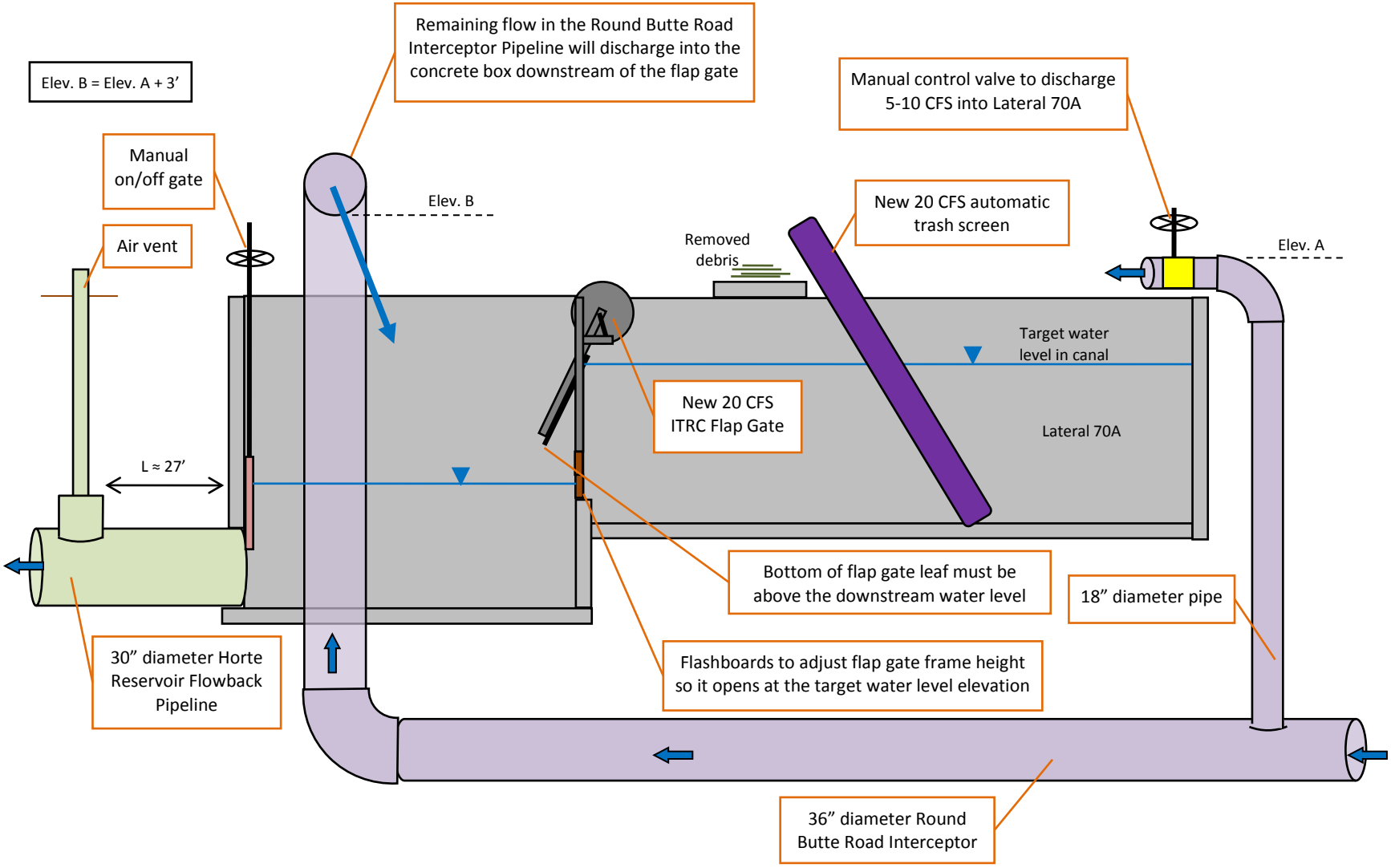

Figure 38. Conceptual side view of ITRC Flap Gate installed in the Lateral 70A Pool (not to scale)

Horte Reservoir Flowback Pipeline

The Horte Reservoir Flowback Pipeline will connect the new Lateral 70A Pool and Horte Reservoir (see Figure 39), with a number of discharge points in between. The components of the Flowback Pipeline will consist of:

- A main pipeline (see Table 3 for summary of pipe characteristics) that varies in pipe size and flow. The pipeline will re-circulate water between:
  - Lateral 70A Level Pool
  - Lateral 71A
  - The West Pablo Interceptor Pipeline
  - Horte Reservoir
- A 30" PIP pipe with a length of 1,300 ft. will convey up to 25 CFS from the main Flowback Pipeline to Lateral 71A.
- A VFD-equipped pump (19KW, 5 CFS, 31 ft. TDH) will pump excess flows from Lateral 71A-W and the Lower Pablo A Canal directly into the Horte Reservoir Flowback Pipeline.

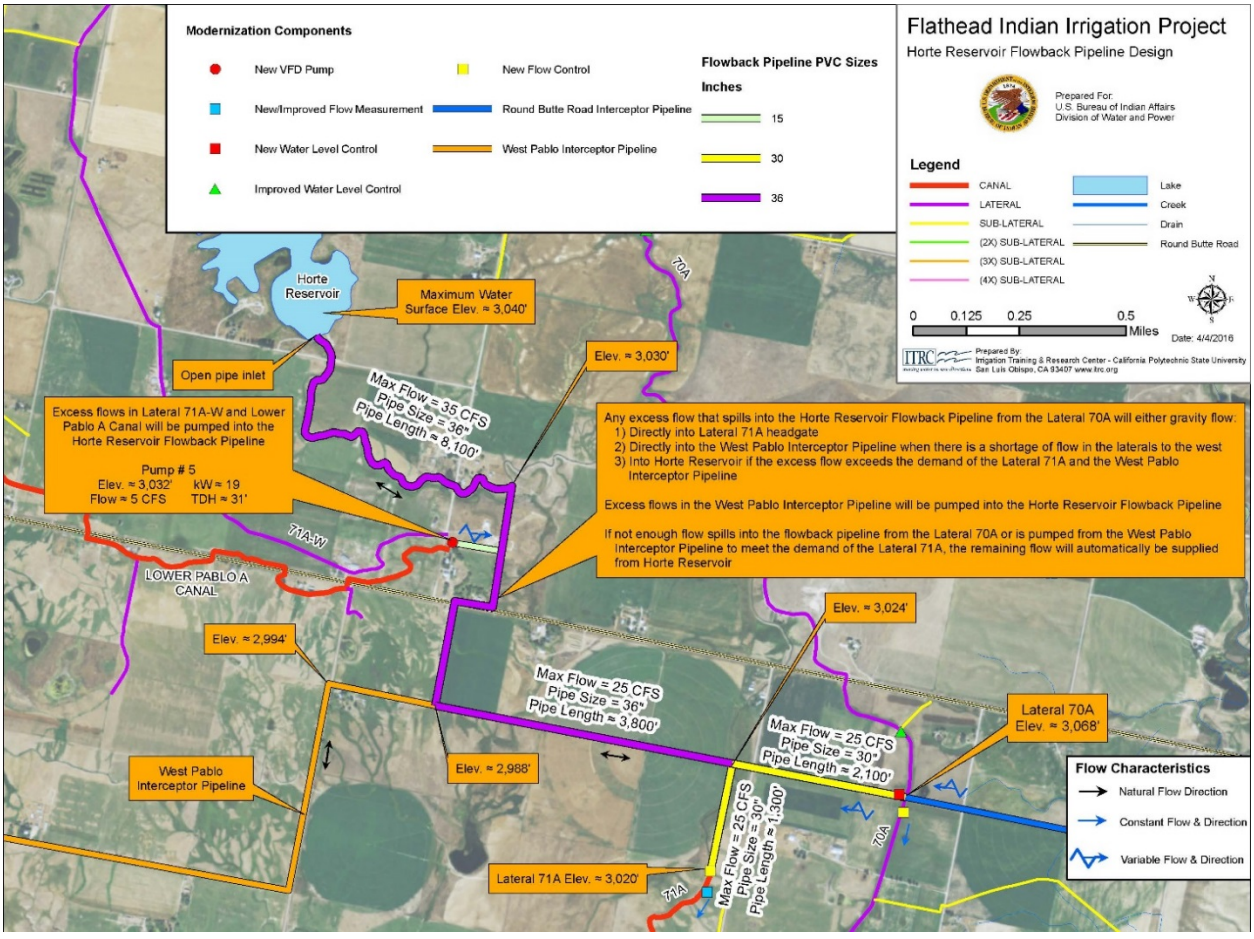

Figure 39. Horte Reservoir Flowback Pipeline design

Table 3. Pipe characteristics for the main portion of the Horte Reservoir Flowback Pipeline

Pipe Segment	Max Flow (CFS)	PVC Pipe Size[1] (in)	Approx. Pipe Length (ft.)
70A Pool –to– Start of 71A Feeder Pipeline	25	30	2,100
Start of 71A Feeder Pipeline –to– West Pablo Interceptor Pipeline	25	36	3,800
West Pablo Interceptor Pipeline –to– Horte Reservoir	35	36	8,100

[1] 27" and below are PIP; 30" and above are C905. All pipe has pressure rating of 100 psi.

The operation of the Horte Reservoir Flowback Pipeline will be as follows:

- Any excess flow that enters the Horte Reservoir Flowback Pipeline from the eastern end will go to one of three locations:
    - Directly to the Lateral 70A headgate.
    - Directly into the West Pablo Interceptor Pipeline when there is a shortage of flow in the laterals to the west (not shown in Figure 39).
    - Into Horte Reservoir if the excess flow exceeds the demand of Lateral 71A and the West Pablo Interceptor Pipeline.
- Excess flows in the West Pablo Interceptor Pipeline will be pumped into the Horte Reservoir Flowback Pipeline. The excess flow will either be used in Lateral 71A or stored in Horte Reservoir.
- If not enough flow spills into the Horte Reservoir Flowback Pipeline from the Lateral 70A Level Pool or is pumped from the West Pablo Interceptor Pipeline to meet the demand of Lateral 71A, the remaining flow will automatically be supplied from Horte Reservoir. The flow rate capacity of the pipeline increases as the demand from Lateral 71A increases.
- Horte Reservoir will also supplement water to the West Pablo Interceptor Pipeline when needed.
- Excess flows at the ends of Lateral 71A-W and the Lower Pablo A Canal will be pumped into the Horte Reservoir Flowback Pipeline.

New Diversion for Lateral 71A

Figure 40 shows the existing Lateral 71A downstream of Round Butte Road. After passing under Corrigan Road, Lateral 71A meanders through a large center pivot field before continuing south.

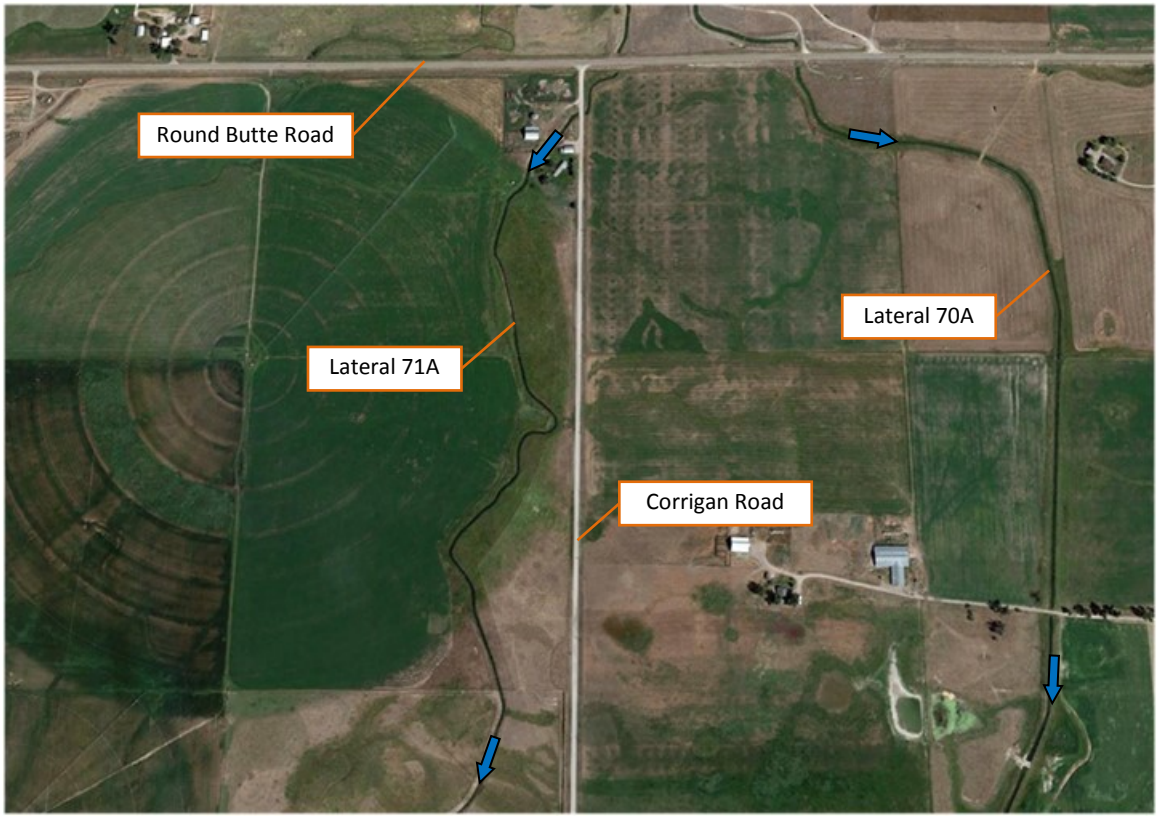

Figure 40. Lateral 71A currently downstream of Round Butte Road

Under the proposed modernization plan for the area, the existing portion of Lateral 71A between the SE boundary of the pivot (in the figure above) and Horte Reservoir will be abandoned. Lateral 71A will have a new start south of Round Butte Road, to be supplied from the new Horte Reservoir Flowback Pipeline.

The water supplied to Lateral 71A will be composed of a mix of three sources, depending upon the demands of any particular day:

- Excess flows from the Lateral 70A Pool and Round Butte Road Interceptor Pipeline
- Excess flows in the West Pablo Interceptor Pipeline that are pumped from multiple laterals located to the west
- Stored water from Horte Reservoir

Control Components for New Lateral 71A Diversion

Figure 41 shows the modernization components for the new Lateral 71A diversion.

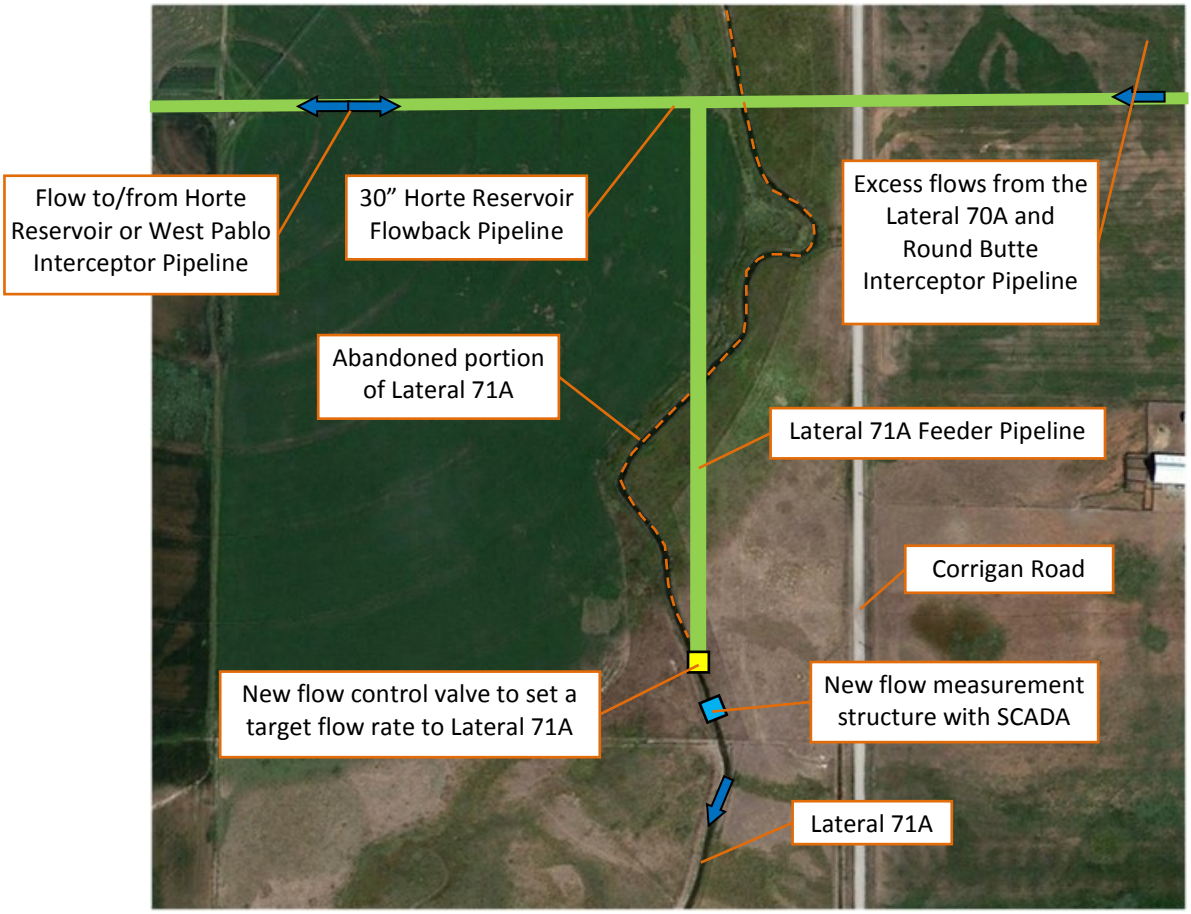

Figure 41. Location of new diversion point for Lateral 71A

The new control components for the new Lateral 71A diversion will include:

1. A 30" PIP Feeder Pipe (approximately 1,300 ft.) will be constructed due south from the main alignment of the Horte Reservoir Flowback Pipeline. This will move the new diversion point for Lateral 71A away from the existing center pivot field.
2. A flow control valve will be installed at the end of the 30" Lateral 71A Feeder Pipeline to set the target flow rate into the downstream canal portion of Lateral 71A.
3. Either a new flow measurement flume or Cipoletti weir will be installed downstream of the new flow control valve to help operators set the target flow rate to Lateral 71A. The flow rate measured will be remotely monitored via SCADA.
4. The existing portion of Lateral 71A from Horte Reservoir to the new diversion point will be abandoned and filled in. The existing center pivot will no longer have an open ditch running through it.

Lower Pablo A Canal and Lateral 71A-W Pump

Figure 42 shows the existing control scheme of the Lower Pablo A Canal and Lateral 71A-W near Turnquist and Round Butte Roads.

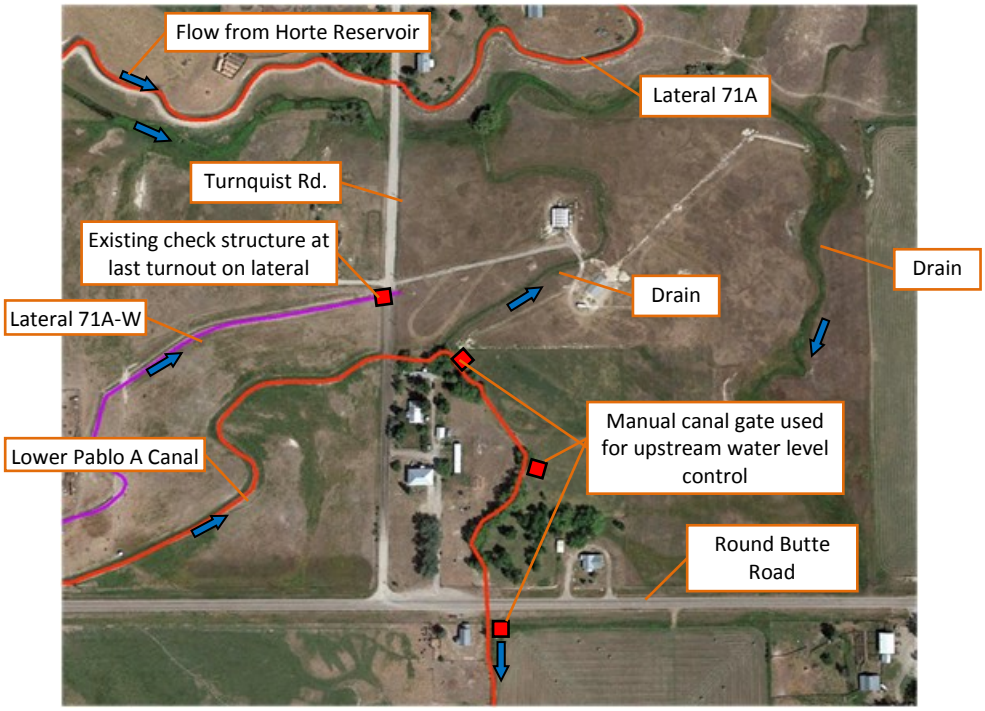

Figure 42. Existing control scheme of the Lower Pablo A Canal and Lateral 71A-W near Turnquist and Round Butte Roads

The existing control is as follows:

- A check structure is located at the terminus of Lateral 71A-W for the last farmer turnout.
- Down the hill from Lateral 71A-W is the Lower Pablo A Canal.
- Three cross regulating structures are used for upstream water level control along the Lower Pablo A Canal. A manual canal gate is used as the cross regulator to maintain the water level control for a single turnout (see Figure 43). The canal gate is the wrong type of structure to solely provide water level control.
- Multiple drains meander through the area and appear to cross under Round Butte Road.

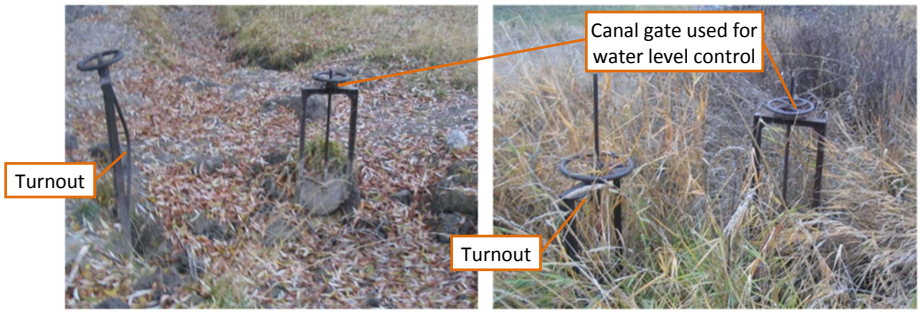

Figure 43. Example of the existing manual canal gates installed in the Lower Pablo A Canal both upstream and downstream of Round Butte Road used for upstream water level control. Photos from HKM 2008 report (left image CC-31, right image CC-52)

Modernization Changes

Figure 44 and Figure 45 show the new modernization components and control of Lateral 71A-W and the Lower Pablo A Canal near Turnquist Road.

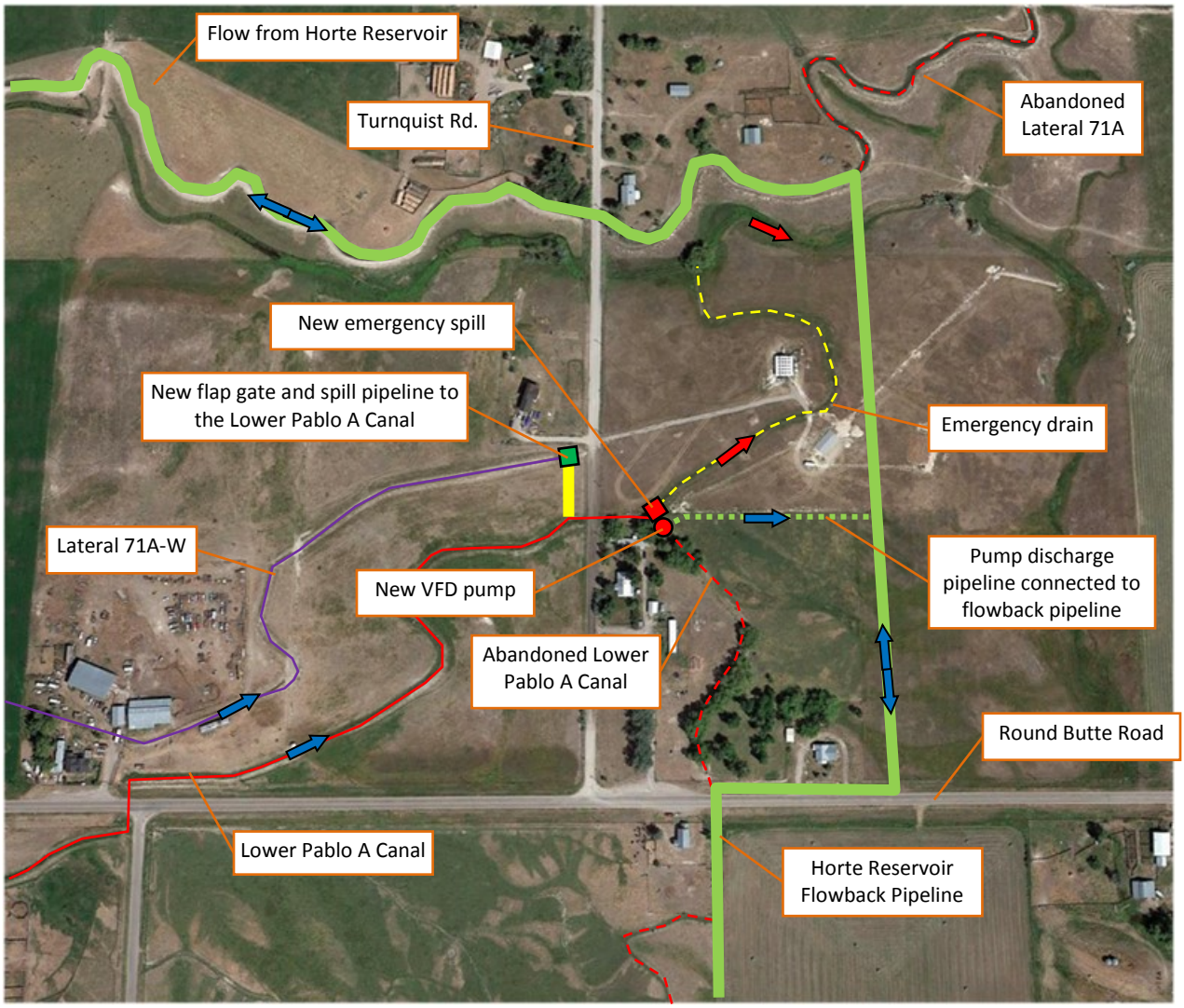

Figure 44. Modernization changes to Lower Pablo A Canal and Lateral 71A-W near Turnquist and Round Butte Roads

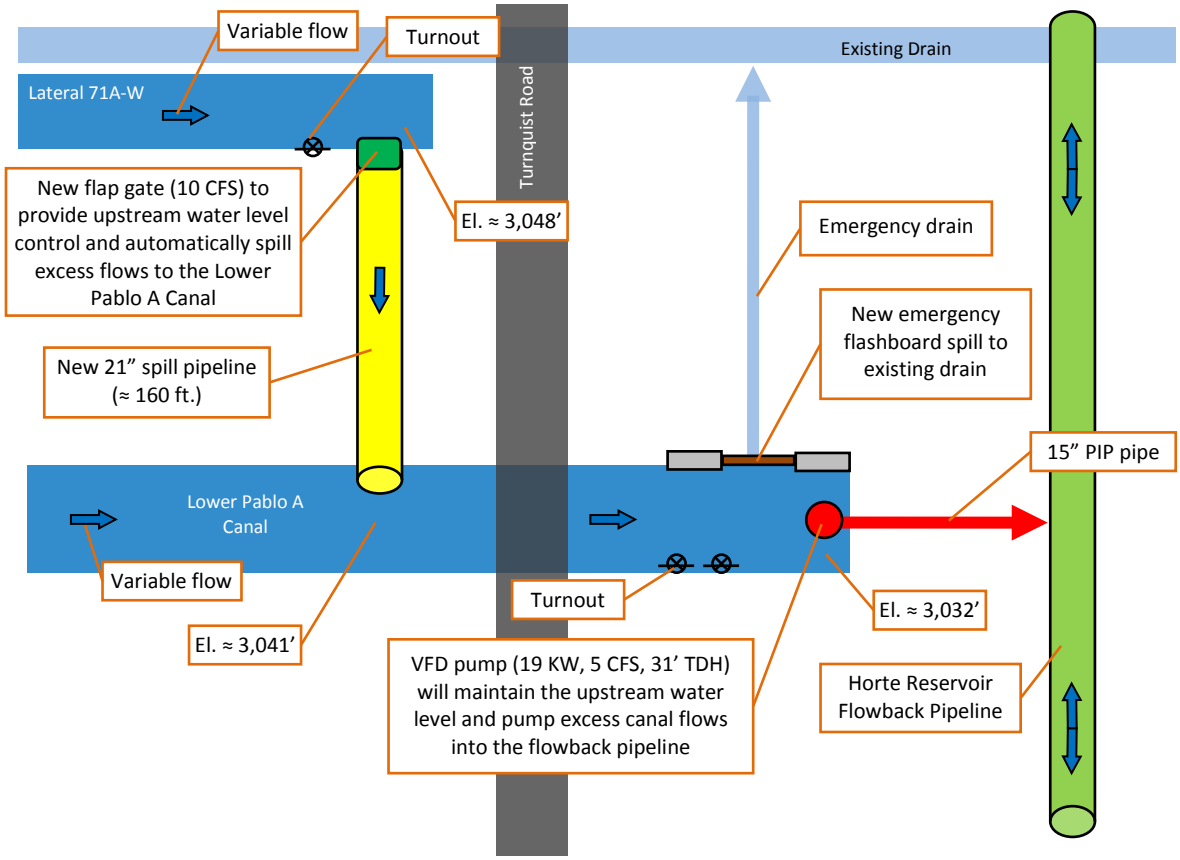

Figure 45. Conceptual control spill and pump for Lateral 71A-W and the Lower Pablo A Canal (not to scale)

The modernization components and control are as follows:

1. A 10 CFS flap gate will be installed at the terminus of the Lateral 71A-W. The flap gate structure will look similar to the conceptual design shown earlier in Figure 38. Note that the manual on/off gate at the start of the pipeline will not be needed. The flap gate will:
    a. Maintain the upstream water level for an individual farmer turnout.
    b. Automatically spill excess flows into a new spill pipeline.
2. A new 21" PIP pipe (approximately 160 ft. long) will convey excess flows from Lateral 71A-W to the Lower Pablo A Canal.
3. A new automated VFD-equipped pump installed in the Lower Pablo A Canal downstream of Turnquist Road will:
    a. Maintain a constant upstream water level for individual turnouts to nearby fields.
    b. Automatically pump up to 5 CFS of excess flows into the Horte Reservoir Flowback Pipeline.
4. A new emergency flashboard spill will be constructed in the Lower Pablo A Canal near the new VFD pump.
    a. Excess flows in the Lower Pablo A Canal that exceed 5 CFS will automatically spill over the flashboards and into an emergency spill drain.
    b. The crest of the flashboards will be set several tenths of a foot above the target water level elevation in the Lower Pablo A Canal.
5. An existing small drain will be used as an emergency spill drain that will convey emergency flows from the Lower Pablo A Canal to a larger existing drain.

Improvements to Upper Portion of Lateral 70A

With the modernization changes to be made to the lower portion of Lateral 70A near Round Butte Road, the control scheme for the upper portion of the lateral will also have to change. The improvements to the upper portion of Lateral 70A will focus on two objectives:

- Improve the flow measurement at the head of the Lateral 70A.
- Improve the existing water level control down the lateral to Round Butte Road.

The two improvements are explained further in the following report sections.

Improved Flow Measurement at Head of Lateral 70A on the Pablo Canal

Figure 46 shows the existing conditions near the head of Lateral 70A on the Pablo A Canal.

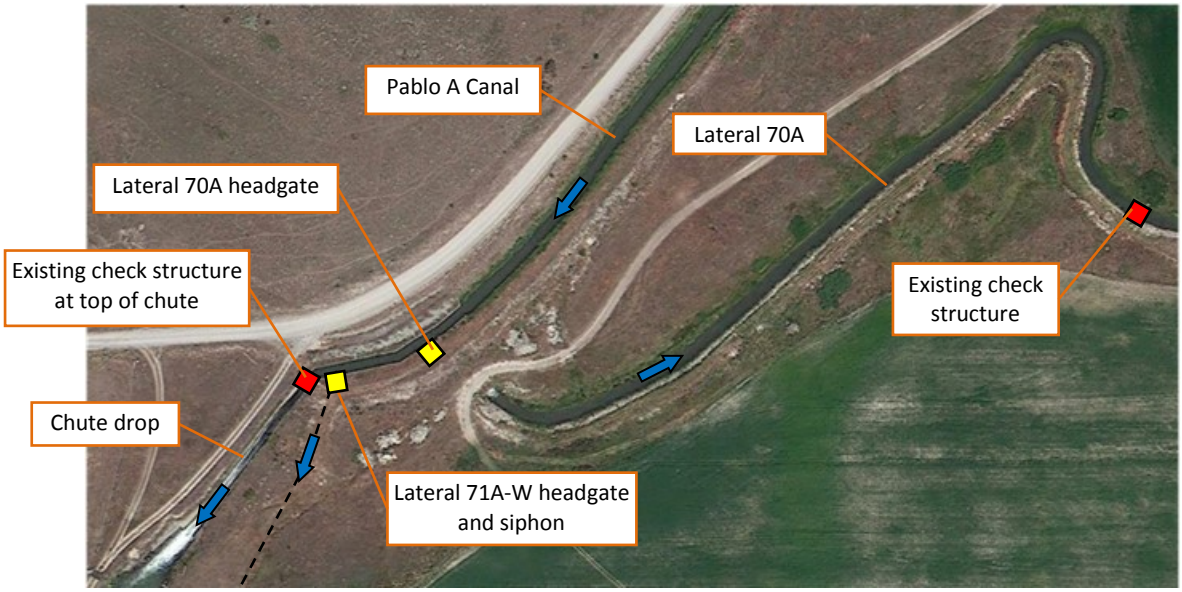

Figure 46. Existing conditions at head of Lateral 70A on the Pablo A Canal

An existing check structure at the top of a concrete chute drop in the Pablo A Canal provides upstream water level control for both the Lateral 70A and 71A-W headgates (see Figure 47). There is a large elevation drop across the Lateral 70A headgate as shown in Figure 48. The first check structure (see Figure 49) on Lateral 70A is located approximately 1,100 ft. downstream from the lateral headgate.

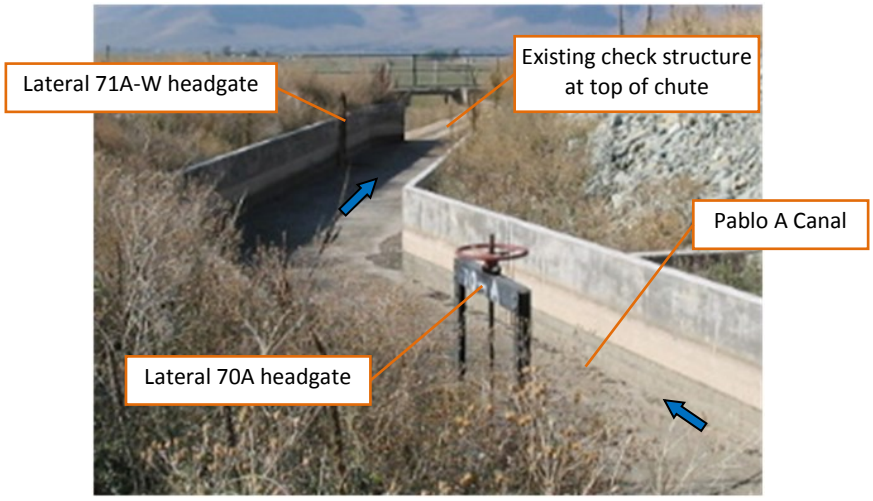

Figure 47. Lateral 70A headgate on the Pablo A Canal. Photo from HKM 2008 report (CHT-11)

Figure 48. Lateral 70A headgate discharge. There appears to be large elevation drop across the headgate. Photo from HKM 2008 report (CHT-11).

Figure 49. First existing check structure on Lateral 70A. Photo from HKM 2008 report (CH-351)

Modernization Changes at Head of Lateral 70A

Operators will want to make sure that there is always some small amount of spill occurring in the new Lateral 70A Level Pool. Therefore, accurate flow measurement is required at the head of the Lateral 70A to ensure enough flow is always diverted from the Pablo A Canal.

Figure 50 shows the modernization changes made near the head of Lateral 70A.

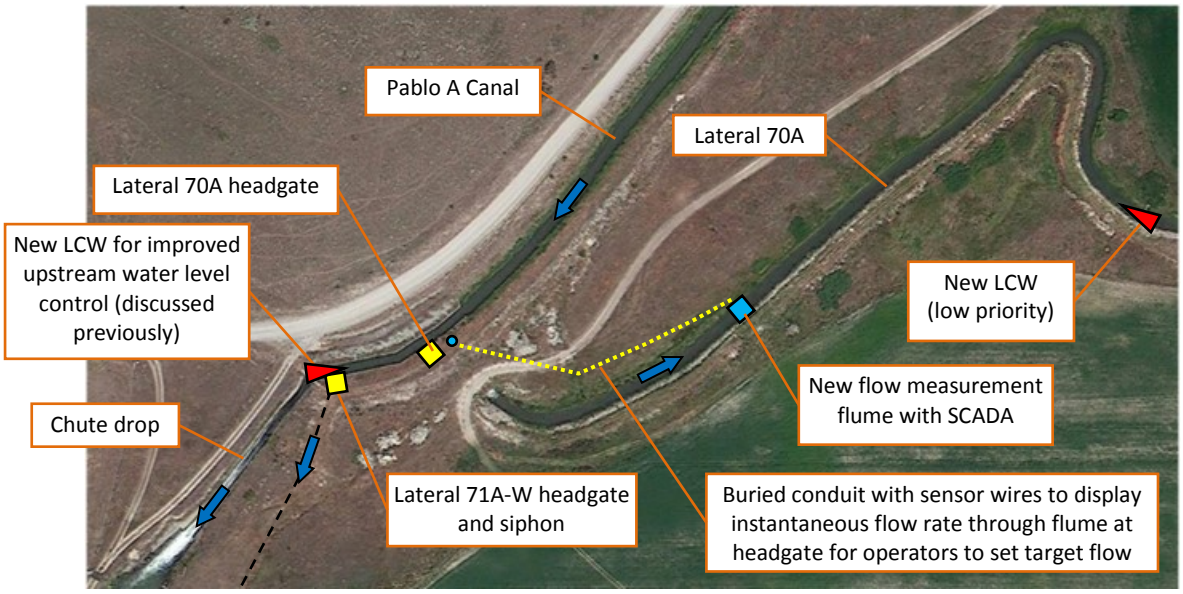

Figure 50. Modernization changes at head of Lateral 70A on the Pablo A Canal

The improvements include:

1. A new flow measurement flume will be constructed in Lateral 70A approximately 400 ft. downstream from the lateral head. The flow rate through the flume will be remotely monitored via SCADA.
2. Buried conduit housing sensor wires will be installed from the new flume to the Lateral 70A headgate to display the instantaneous flow rate through the flume for operators to properly set the target downstream flow rate.
3. The first existing check structure will be replaced with a new LCW for improved water level control. This improvement is a very low priority.

Improved Water Level Control along Upper Portion of Lateral 70A

Figure 51 shows the location for improved water level control for six existing check structures along the upper portion of Lateral 70A. This is relatively low priority.

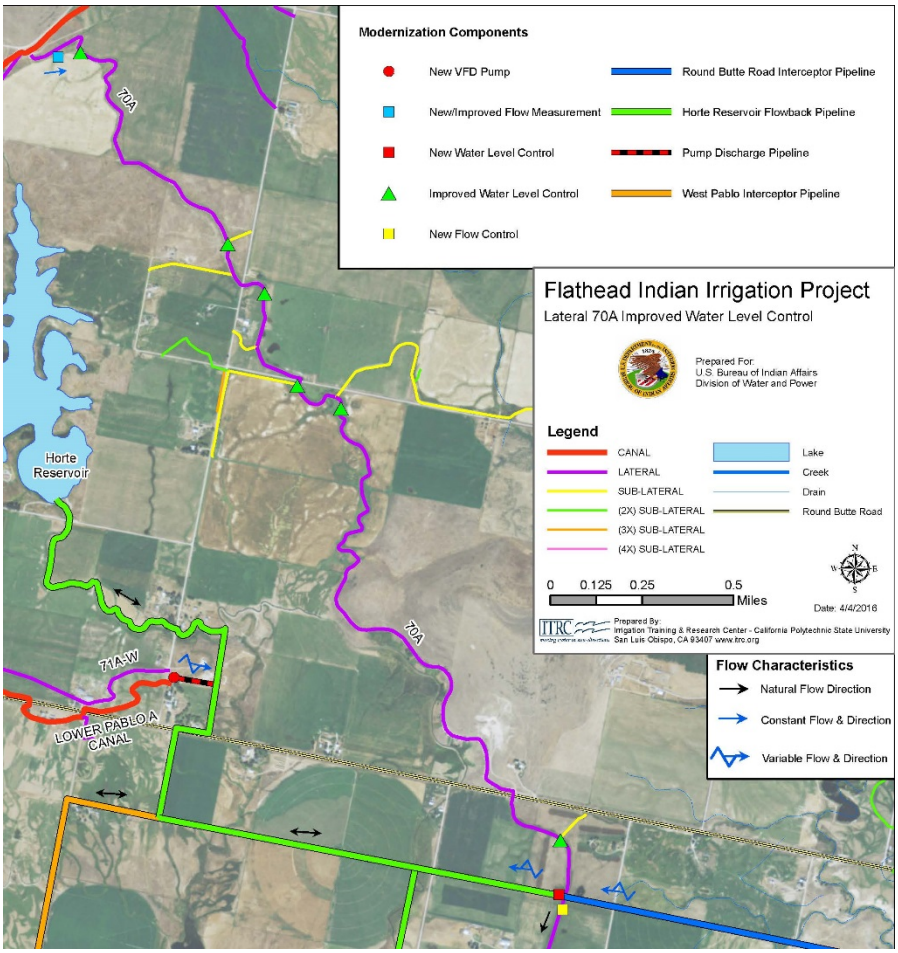

Figure 51. Improved water level control locations along the upper portion of Lateral 70A

Even though this is considered a low priority, improving the water level control along Lateral 70A would provide the following benefits:

- The 3.5-mile section of Lateral 70A from the head to the Round Butte Interceptor would be very easy to operate.
- Flow rate changes made at the head of Lateral 70A would reach the Round Butte Interceptor more quickly.
- Delivery flexibility would be increased to farmer turnouts.

West Pablo Interceptor Pipeline

Figure 52 shows the existing Pablo Canal Unit west of Horte Reservoir that services approximately 8,500 acres. A majority of the acreage is serviced by Lateral 73A.

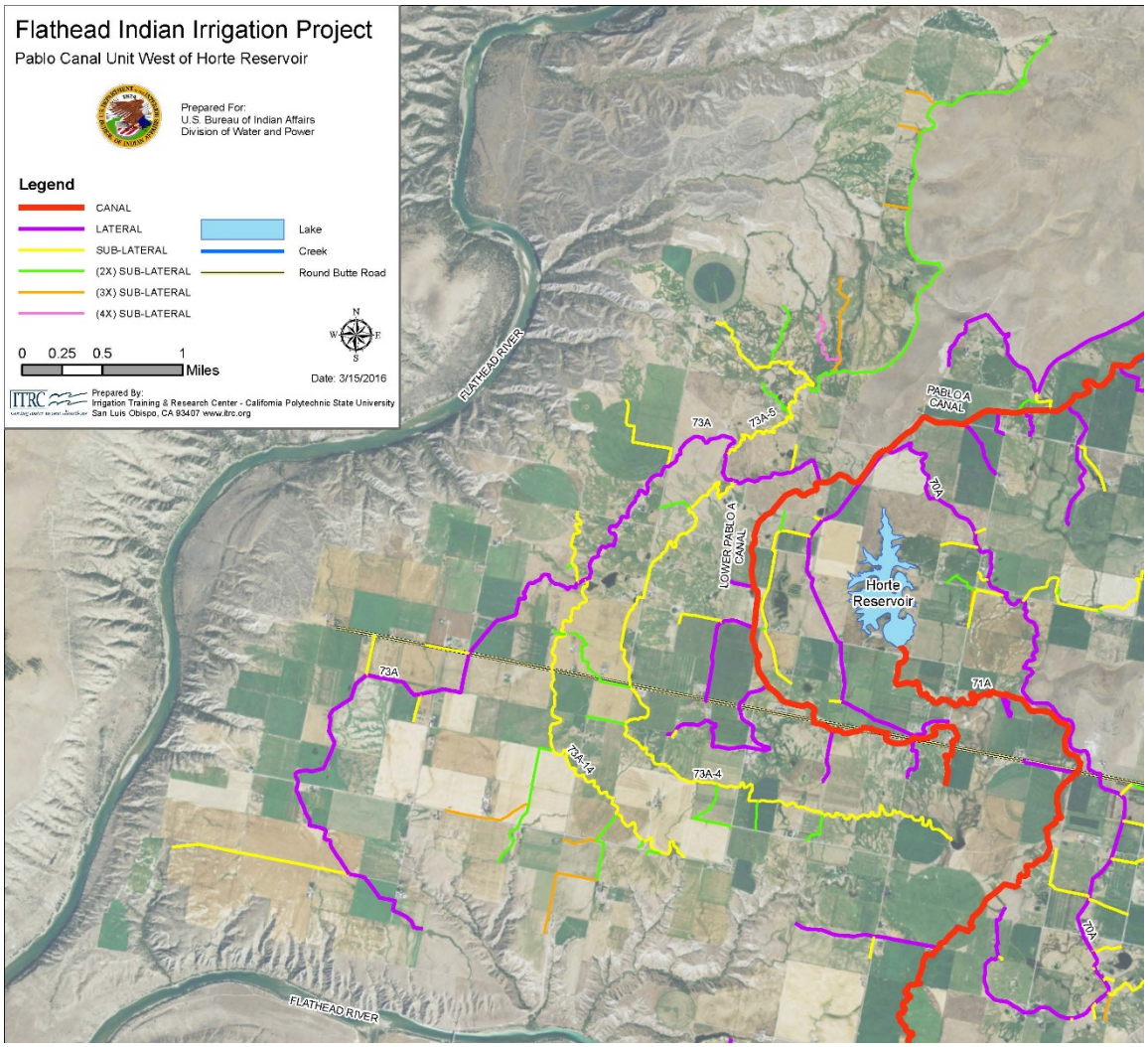

Figure 52. Existing Pablo Canal Unit west of Horte Reservoir

In Figure 52 it is clear that any operational spill from multiple laterals or field runoff flows into draws that lead to the Flathead River. Once the water spills to the river, it is lost to FIIP.

With the construction of multiple pumps and pipelines, a new re-circulation system would significantly reduce operational spill by diverting the excess flows normally lost to Lateral 71A or restored to Horte Reservoir. Likewise, the laterals in the very southwest part of the canal unit could also be supplemented from the same pipelines when experiencing a deficiency in flow. This would then prolong the storage of Pablo Reservoir as well as other upstream reservoirs used to supply water to the southwest portion of the Pablo Canal Unit.

Figure 53 shows the general overview of the new West Pablo Interceptor Pipeline system. Figure 54 shows the approximate elevations of key locations for the pipeline system.

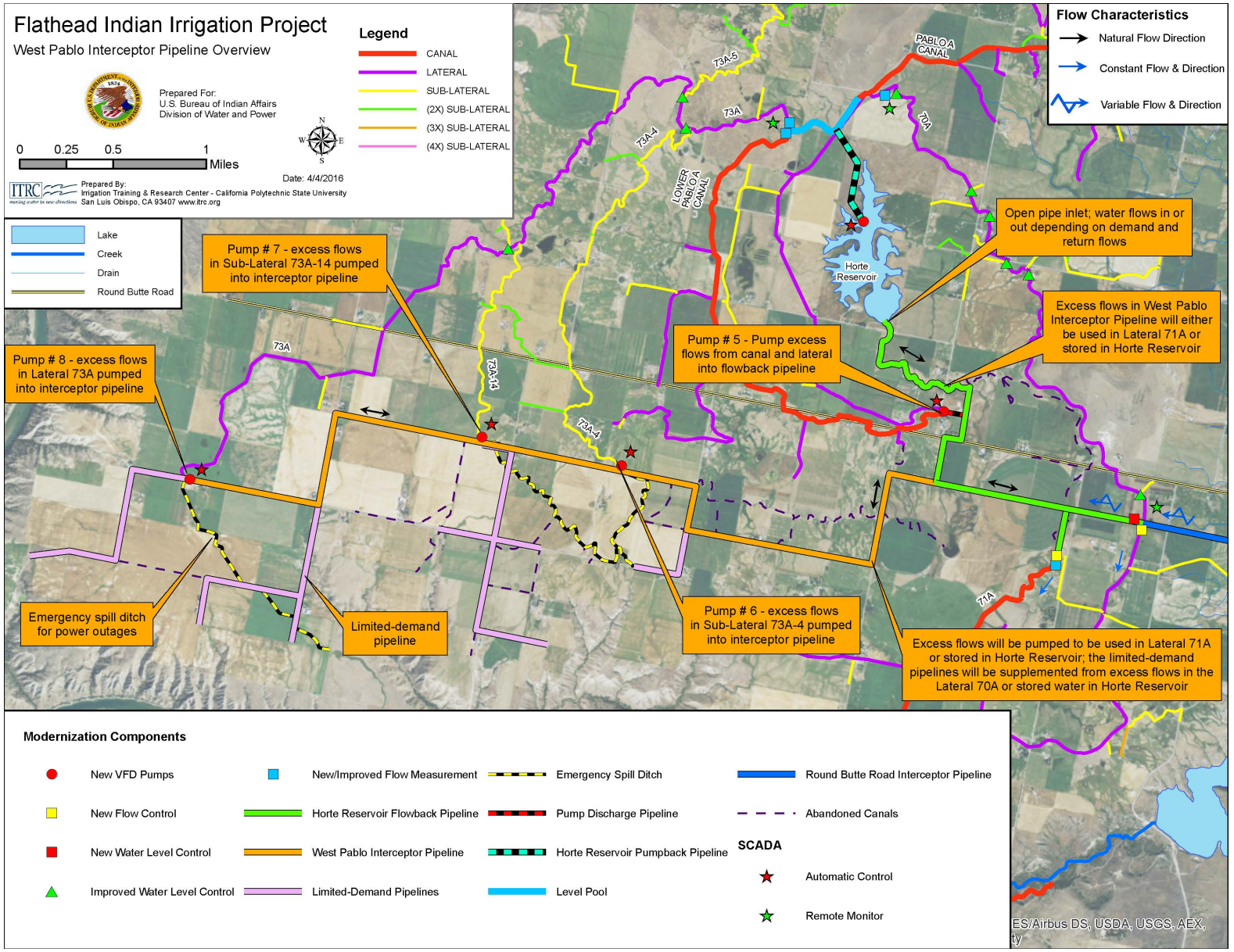

Figure 53. Overview of new West Pablo Interceptor Pipeline system

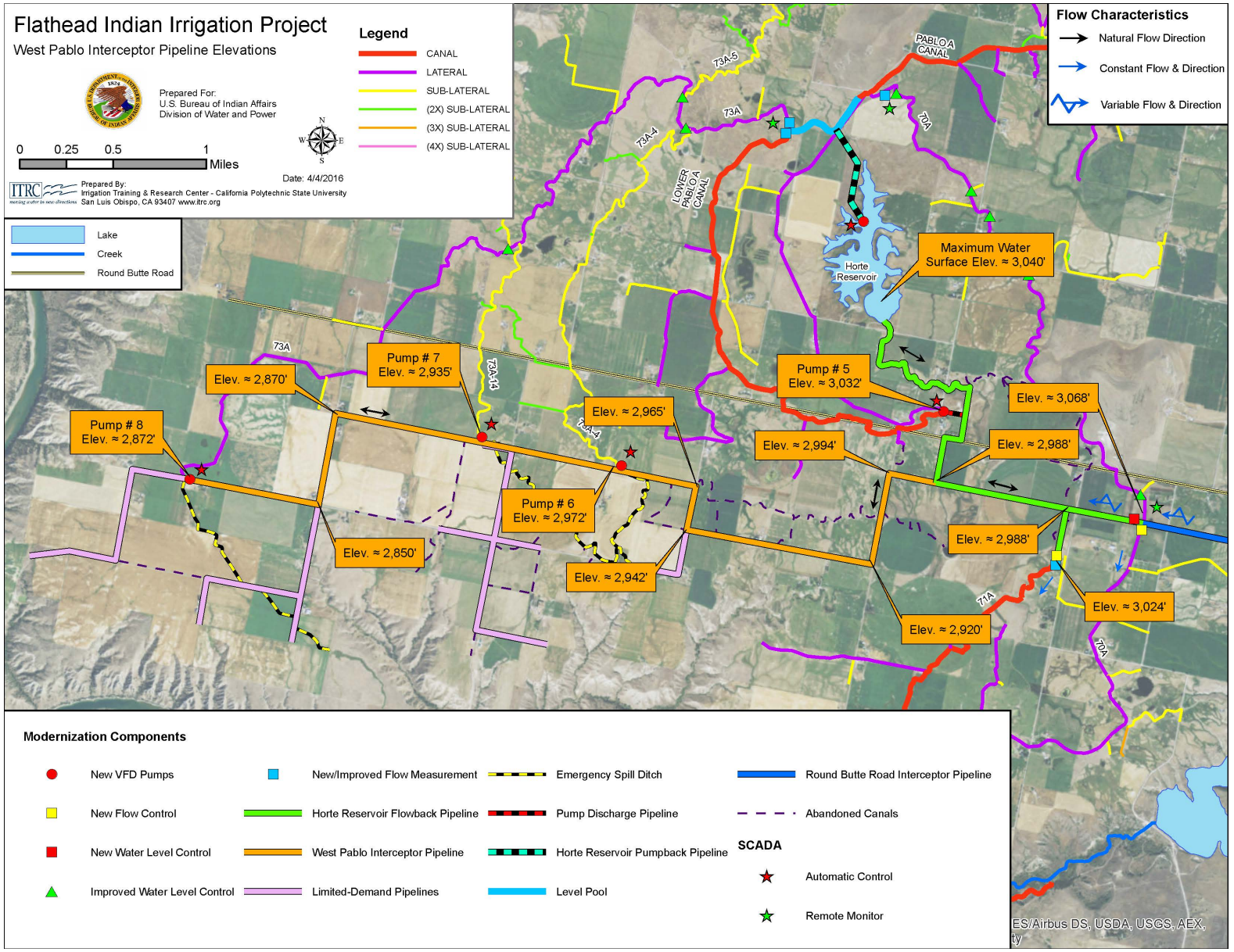

Figure 54. Approximate key elevations for the West Pablo Interceptor Pipeline

The general overview components shown in Figure 53 include the following:

1. A new interceptor pipeline would be constructed to connect Lateral 73A with the new Horte Reservoir Flowback Pipeline (approximately 5 miles long).
    a. A total of three individual automated VFD-equipped pumps would be installed in three separate laterals (73A, 73A-14, and 73A-4) to pump excess canal flows into the new interceptor pipeline.
    b. The interceptor pipeline would directly supply water to individual fields as well as several new limited-demand pipelines that would replace the existing laterals south of the interceptor pipeline.
    c. The flow in the interceptor pipeline would be bidirectional.
        i. When little to no water is being pumped into the interceptor pipeline, the new limited-demand pipelines and direct turnouts would either be supplied from:
            1. Excess flows from the Lateral 70A Level Pool.
            2. Stored water in Horte Reservoir.
        ii. Any excess flows in the interceptor pipeline would discharge into the Horte Reservoir Flowback Pipeline to either be:
            1. Used in Lateral 71A
            2. Stored in Horte Reservoir.
    d. Emergency spill ditches would follow the existing alignment of laterals and drains to discharge emergency flows in the laterals during power outages.
2. SCADA would be incorporated at the four pump locations to accompany the automation of the lateral pumps.

The following report sections provide a further explanation of the new control components at individual locations.

West Pablo Interceptor Pipeline Design

Figure 55 shows the design characteristics for the new West Pablo Interceptor Pipeline. The interceptor pipeline would consist of a single pipeline of various sizes and flow that would connect Lateral 73A directly to the Horte Reservoir Flowback Pipeline (total pipeline length approximately 5.2 miles). Other components include:

- Two individual pump/valve stations would buffer the flow rate in Lateral 73A and Sub-Lateral 73A-14 immediately upstream of two new limited-demand pipelines.
- A third pump station would pump excess flows in Sub-Lateral 73A-4 into the interceptor pipeline.
- The interceptor pipeline would supply many direct turnouts to individual fields as well as other limited-demand pipelines.

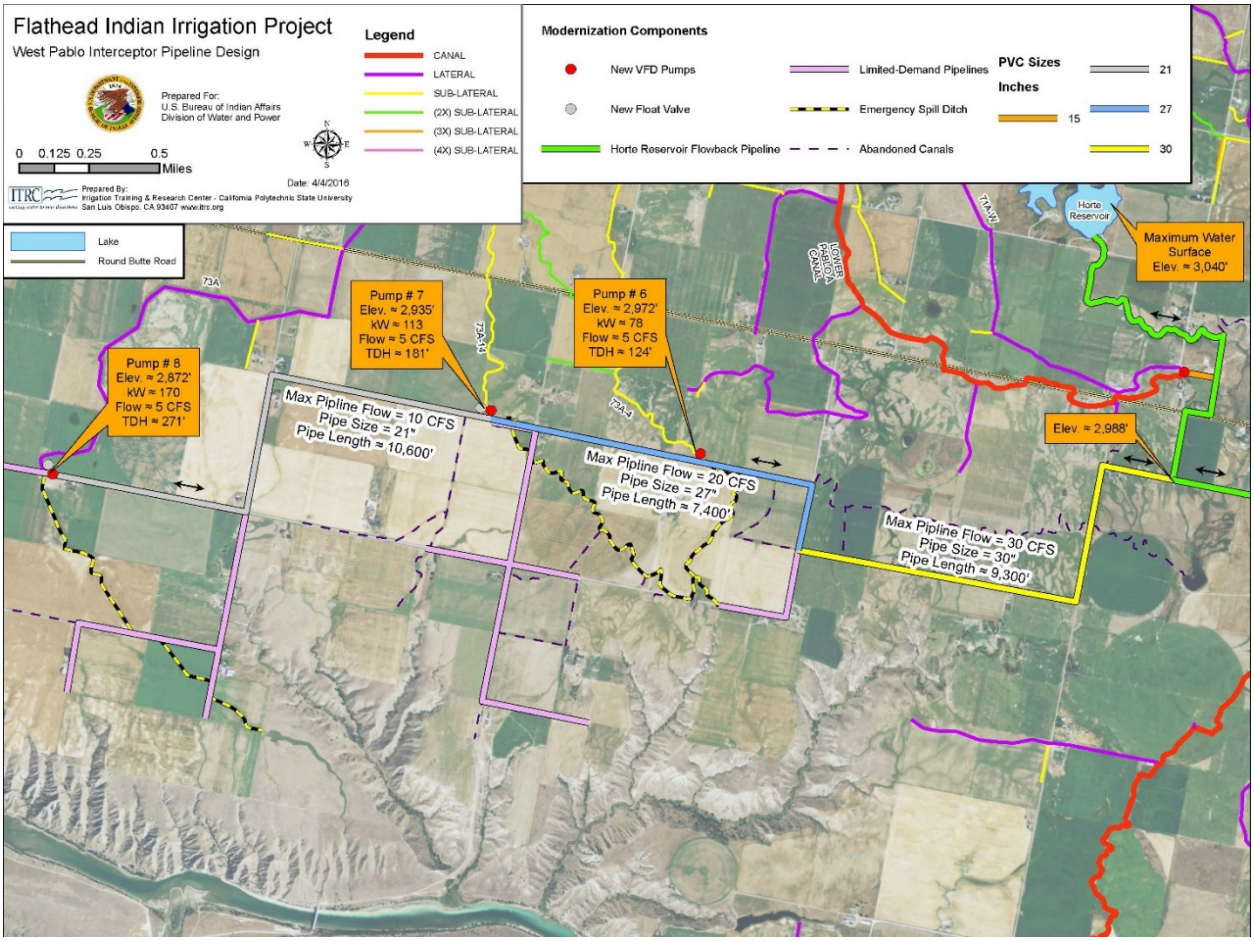

Figure 55. Design characteristics for the West Pablo Interceptor Pipeline

Table 4 and Table 5 show approximate pump and pipe characteristics for the West Pablo Interceptor Pipeline design. The energy use will be about 145 KWH per Acre-foot pumped, compared to about 420 KWH per Acre-foot pumped at the FIIP pump station.

Table 4. Approximate pump characteristics for the Round Butte Road Interceptor Pipeline System

Pump No.	Elevation[1] (ft.)	Gross Electric KW	Max Flow (CFS)	Total-Dynamic Head (TDH in ft.)
6	2,972	78	5	124
7	2,935	113	5	181
8	2,872	170	5	271

[1] Horte Reservoir Maximum Water Surface Elevation ≈ 3,040'

Table 5. Pipe characteristics for West Pablo Interceptor Pipeline

Pipe Segment	Pipe Flow (CFS)	PVC Pipe Size[1] (in)	Approx. Pipe Length (ft.)
Pump 8 – Pump 7[2]	10	21	10,600
Pump 7 – Pump 6	20	27	7,400
Pump 6 – Flowback Pipeline	30	30	9,300

[1] 27" and below are PIP; 30" and above are C905. All pipe has pressure rating of 100 psi otherwise indicated.
[2] Pipe segment from Pump 7 to Pump 8 has pressure rating of 165 psi

The following sections describe the control components to be incorporated into Lateral 73A as well as Sub-Laterals 73A-14 and 73A-4.

Lateral 73A Pump

Figure 56 shows the existing conditions in Lateral 73A at Beaver Drive. An existing check structure located approximately 100 ft. downstream of Beaver Drive (see Figure 57) maintains the upstream water level for multiple turnouts.

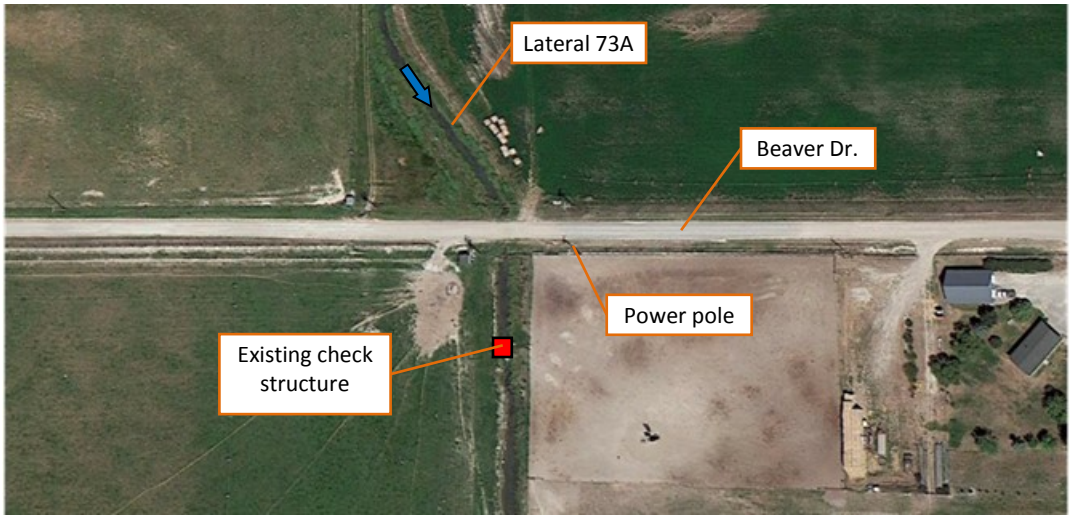

Figure 56. Existing Lateral 73A at Beaver Drive

Figure 57. Upstream view (top) and downstream view (bottom) of the existing check structure in Lateral 73A downstream of Beaver Drive. Photos from HKM 2008 report (CD-71).

Figure 58 shows the new modernization components in Lateral 73A at Beaver Drive.

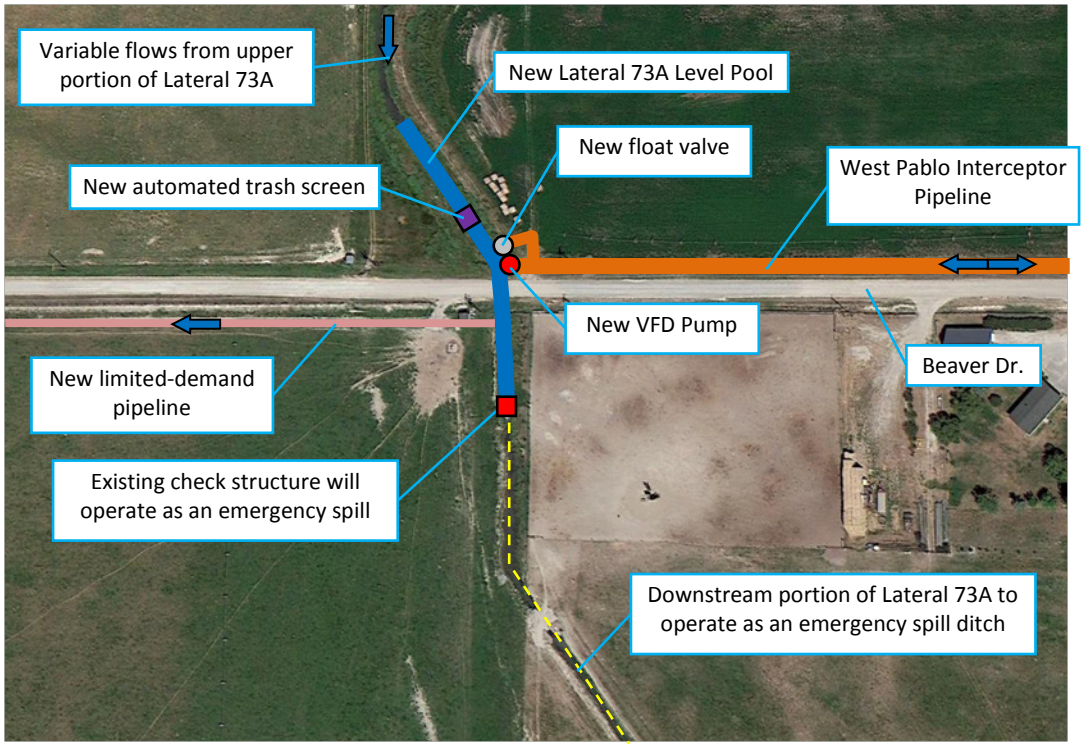

Figure 58. Modernization changes to Lateral 73A at Beaver Drive

The new modernization components include:

1. Variable flow from the upstream portion of Lateral 73A will flow directly into a new level pool section of canal.
2. A new automated trash screen will be installed in Lateral 73A Level Pool approximately 50 ft. upstream of Beaver Drive to remove any trash or debris that may be in the canal.
3. A new limited-demand pipeline will divert water from the level pool towards the west to service approximately 525 acres normally serviced by Lateral 73A.
4. The West Pablo Interceptor Pipeline will connect directly to the Lateral 73A Level Pool and will "buffer" the flow in the lateral based on the downstream demand.
5. A new automated VFD-equipped pump and float valve (both connected to the West Pablo Interceptor Pipeline) will provide water level control in the Lateral 73A Level Pool. The control scheme of the pump and valve will be as follows:
    a. Both the VFD pump and float valve will maintain a target water level in the Lateral 73A Level Pool.
    b. If the water level in the level pool rises above the target water level elevation, the VFD pump will automatically start to pump the excess flow into the interceptor pipeline.
    c. If the water level in the level pool falls below the target water level elevation, the float valve would automatically open to discharge water from the interceptor pipeline into the level pool.

6. The existing check structure in Lateral 73A downstream of Beaver Driver will physically remain as-is but only be operated as an emergency spill.
    a. An emergency spill is needed when:
        i. The power goes out and the flow rate from the upper portion of Lateral 73A exceeds the flow requirement of the limited-demand pipeline.
        ii. If the flow rate from the upper portion of Lateral 73A exceeds the flow requirement of the limited-demand pipeline and the pump capacity.
    b. The check structure will be boarded up until the crest of the flashboards is approximately several tenths of a foot above the target water level elevation in the Lateral 73A Level Pool.
    c. The check structure will provide the necessary submergence for the pump.
7. The existing downstream portion of Lateral 73A will operate as an emergency spill ditch. Any emergency flows will eventually spill to the Flathead River.

Sub-Lateral 73A-14 Pump

Figure 59 shows the existing control at the bifurcation of Sub-Laterals 73A-14 and 73A-14-7 located west of Sloan Road.

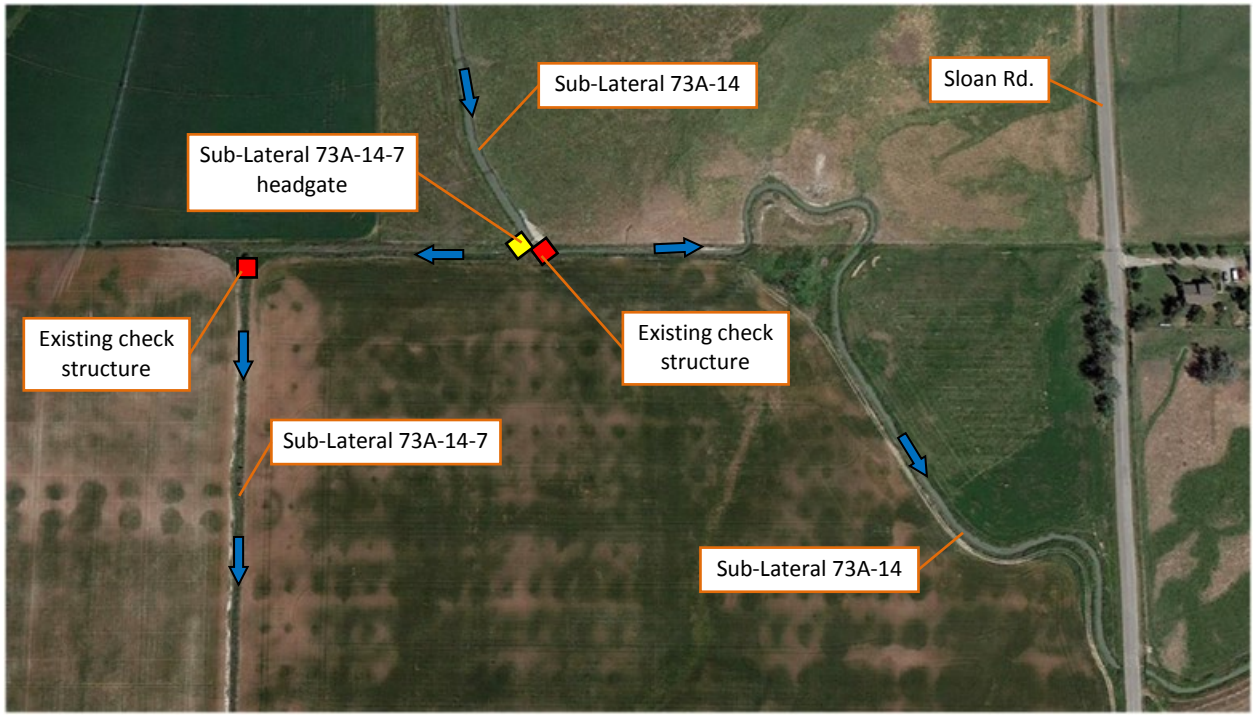

Figure 59. Sub-Laterals 73A-14 and 73A-14-7 bifurcation west of Sloan Road

An existing check structure maintains the upstream water level in Sub-Lateral 73A-14 for the Sub-Lateral 73A-14-7 headgate. Sub-Lateral 73A-14 continues on for approximately one mile before eventually spilling into a wash that leads to the Flathead River.

Figure 60 and Figure 61 show the modernization changes to be made near the bifurcation of Sub-Laterals 73A-14 and 73A-14-7.

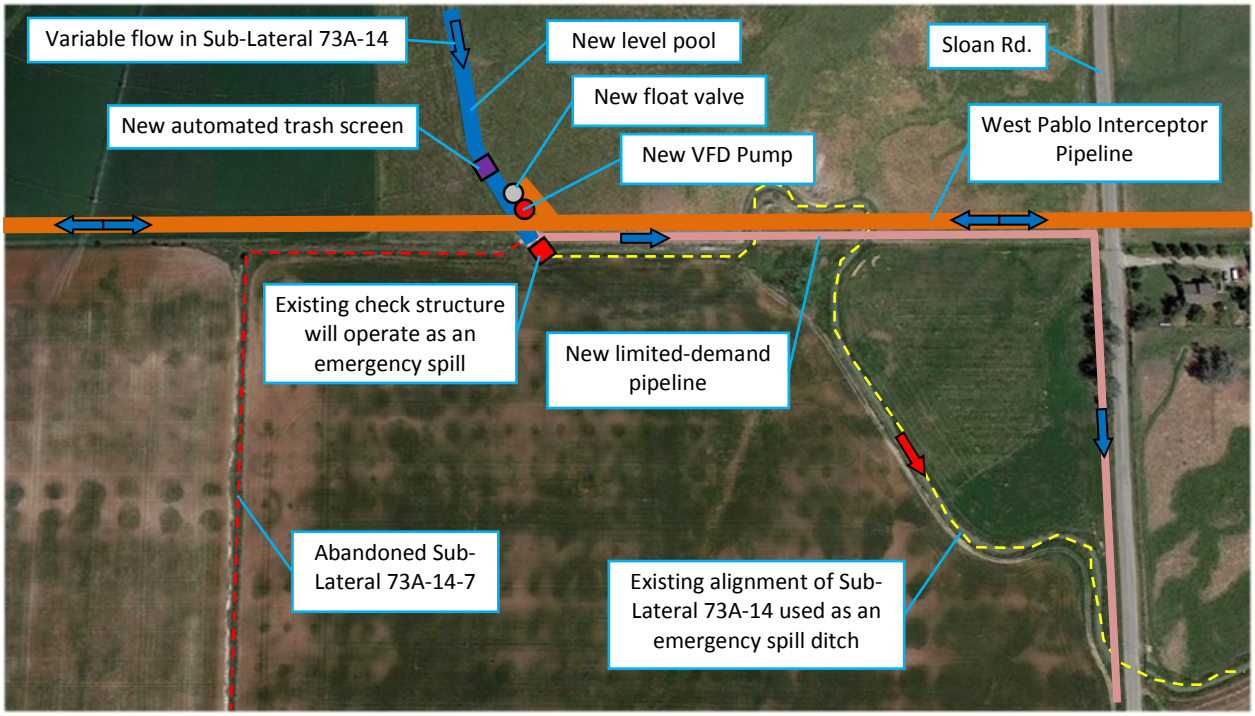

Figure 60. Modernization changes at the Sub-Laterals 73A-14 and 73A-14-7 bifurcation

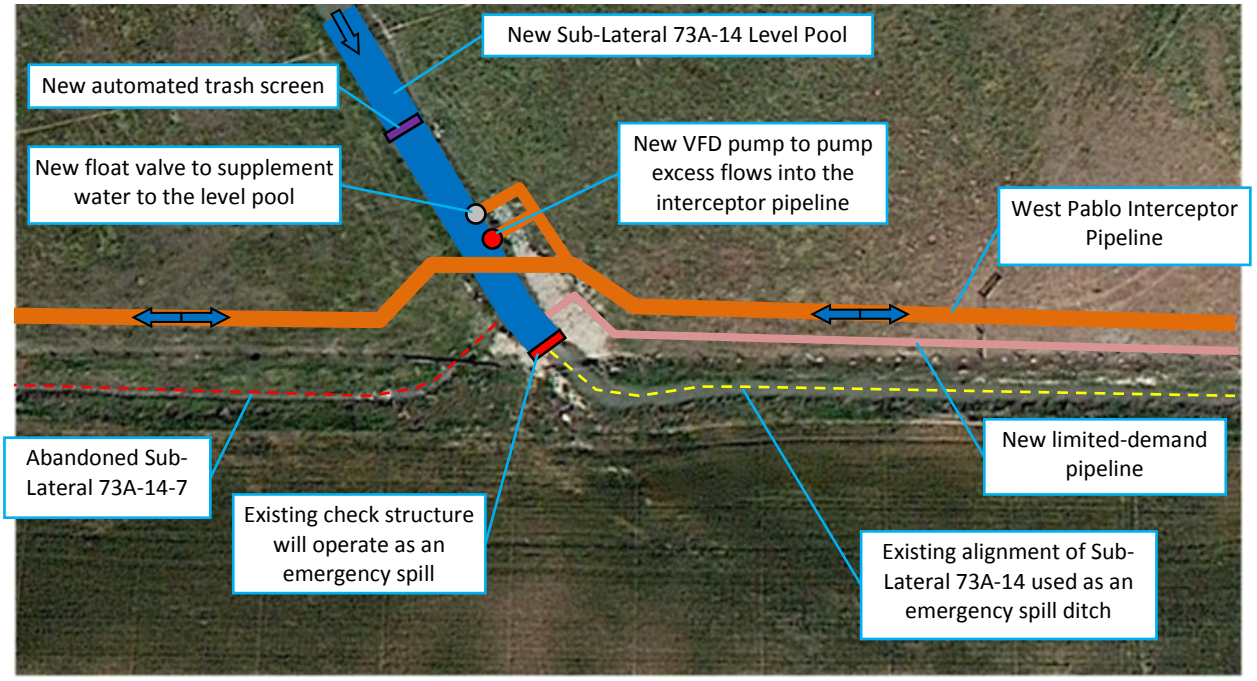

Figure 61. New control components in Sub-Lateral 73A-14

The modernization changes will include:

1. Variable flow from the upstream portion of Sub-Lateral 73A-14 will flow directly into a new level pool.
2. A new automated trash screen will be installed in the Lateral 73A Level Pool approximately 75 ft. upstream of the existing check structure.
3. A new limited-demand pipeline will divert water from the level pool directly upstream of the existing check structure to service approximately 700 acres.
4. The West Pablo Interceptor Pipeline will connect directly to the Sub-Lateral 73A-14 Level Pool and will "buffer" the flow in the lateral based on the downstream demand.
5. A new automated VFD-equipped pump and float valve connected to the West Pablo Interceptor Pipeline will provide water level control in the Sub-Lateral 73A-14 Level Pool. The control scheme of the pump and valve will be as follows:
    a. Both the VFD pump and float valve will maintain a target water level in the Sub-Lateral 73A-14 Level Pool.
    b. If the water level in the level pool rises above the target water level elevation, the VFD pump will automatically start to pump the excess flow into the interceptor pipeline.
    c. If the water level in the level pool falls below the target water level elevation, the float valve would automatically open to discharge water from the interceptor pipeline into the level pool.
6. The existing check structure in Sub-Lateral 73A-14 will physically remain as-is but only be operated as an emergency spill.
7. The existing downstream portion of Sub-Lateral 73A-14 will operate as an emergency spill ditch. Any emergency flows will eventually spill to the Flathead River.

Sub-Lateral 73A-4 Pump

Figure 62 shows the existing control in Sub-Lateral 73A-4 near Orchard Hill Road.

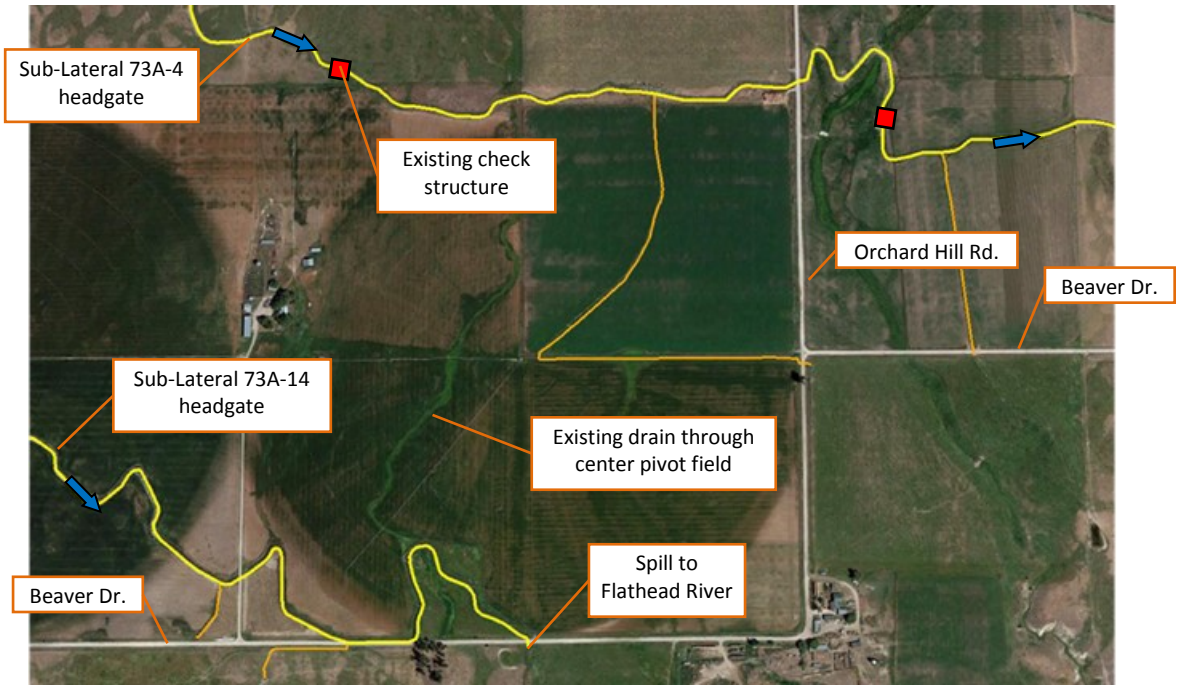

Figure 62. Existing conditions in Sub-Lateral 73A-4 near Orchard Hill Road

Figure 63 and Figure 64 show the modernization changes to Sub-Lateral 73A-4 near Orchard Hill Road.

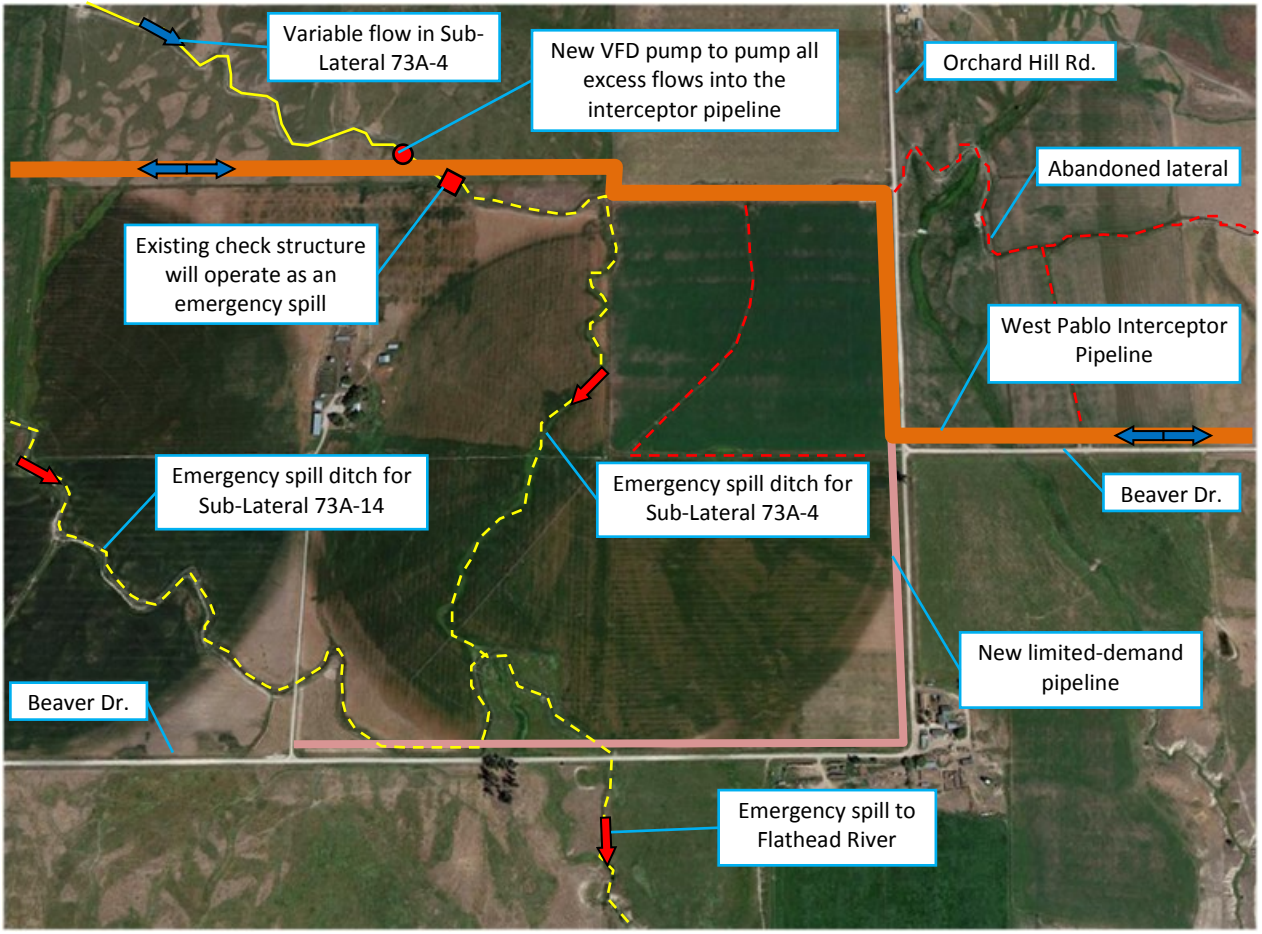

Figure 63. Modernization changes made to Sub-Lateral 73A-4 near Orchard Hill Rd.

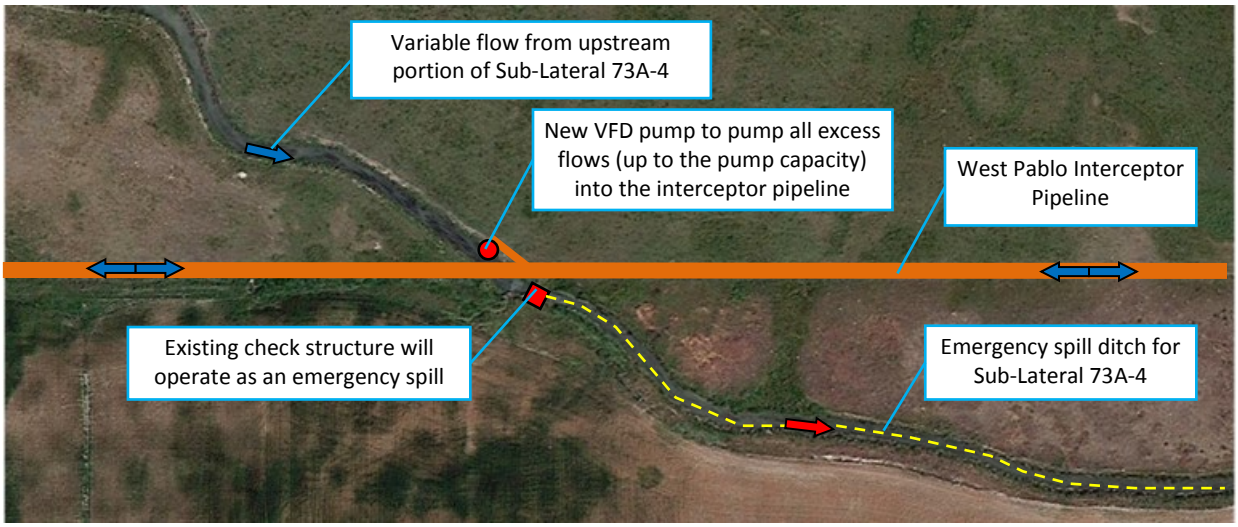

Figure 64. Close up of new control in Sub-Lateral 73A-4

The modernization changes include:

1. A new VFD-equipped pump will be installed in Sub-Lateral 73A-4 upstream of the existing check structure. Excess flow in the sub-lateral (up to the pump flow rate capacity) will be pumped into the West Pablo Interceptor Pipeline.
2. The existing check structure in Sub-Lateral 73A-4 will physically remain as-is but only be operated as an emergency spill.
3. An emergency spill ditch will be formed from an existing portion of Sub-Lateral 73A-4 and an existing drain that meanders through a center pivot field. The emergency spill drain for Sub-Lateral 73A-4 will connect to the emergency spill ditch for Sub-Lateral 73A-14. Any flow in the two emergency spill ditches will eventually spill to Flathead River.
4. A new limited-demand pipeline will divert water directly from the West Pablo Interceptor Pipeline near the corner of Orchard Hill Road and Beaver Drive to service approximately 120 acres.
5. Irrigated fields normally serviced from the last portion of Sub-Lateral 73A-4 will be provided with water directly from the West Pablo Interceptor Pipeline.

Improved Water Level Control along Lateral 73A

Figure 65 shows the main three sub-lateral diversions (73A-4, 73A-5, and 73A-14) on Lateral 73A.

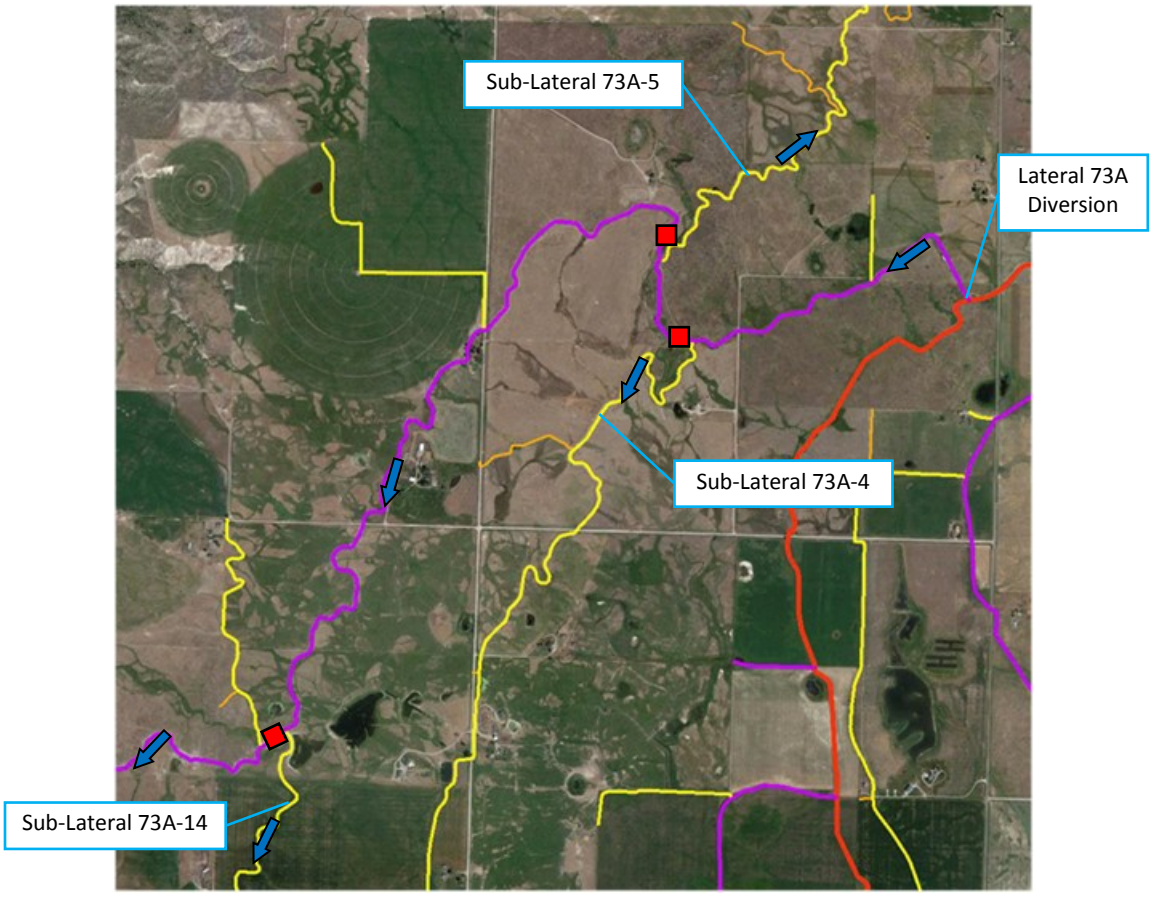

Figure 65. The main sub-lateral diversion on Lateral 73A

Figure 66, Figure 67, and Figure 68 show the existing check structures in Lateral 73A at the heads of Sub-Laterals 73A-4, 73A-5, and 73A-14 respectively.

Figure 66. Existing check drop at the head of Sub-Lateral 73A-4. Photo from HKM 2008 report (CD-82).

Figure 67. Existing check structure at the head of Sub-Lateral 73A-5. Photo from HKM 2008 report (CH-387).

Figure 68. Downstream view of existing check drop at the head of Sub-Lateral 73A-4. Photo from HKM 2008 report (CD-79).

The water level control will be improved at the three existing check structures by:

- Maintaining a fairly constant upstream water level so that the pressure on the sub-lateral headgates remains constant. Therefore, the flow rate diverted into the laterals will remain fairly constant, which will result in better service for farmers.
- Easing management of Lateral 73A for operators.
- Allowing flow rate changes made at the head of Lateral 73A to move faster down the canal system.

Figure 69 shows the location and type of improved water level control structures along Lateral 73A.

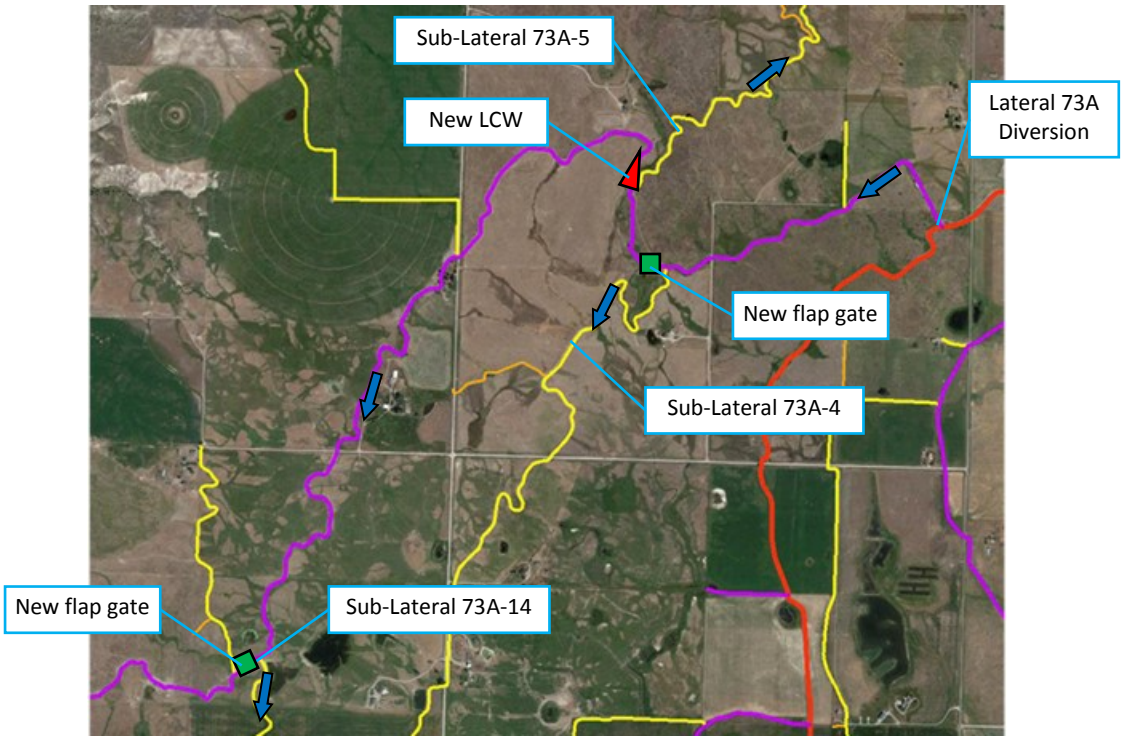

Figure 69. Improved water level control on Lateral 73A

The improved water level control will include:

- A new ITRC Flap Gate will be installed in each of the existing check structures at the heads of Sub-Laterals 73A-4 and 73A-14. The flow rate in Lateral 73A is unknown and therefore will need to be verified for the proper sizing of the two individual flap gates.
- A new LCW structure similar to the one shown in Figure 70 will be constructed just downstream of the Sub-Lateral 73A-5 headgate.

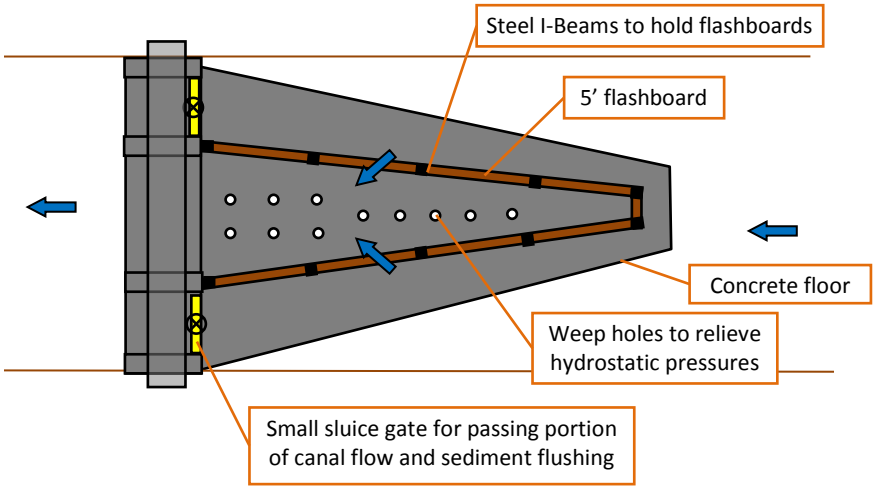

Figure 70. Conceptual plan view of new LCW structure to be constructed in Lateral 73A at the head of Sub-Lateral 73A-5 for improved water level control (not to scale).