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Flathead Indian Irrigation Project

Post Canal Unit Modernization

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

April 2016

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POST CANAL UNIT MODERNIZATION

Modernization Plan

Figure 1 on the next page shows the overall modernization changes in the Post Canal Unit that are not described in the *Modernization Plan* section of this report that dealt with the flows into and out of Ninepipe and Kicking Horse Reservoirs.

The key modernization changes to the remaining areas of the Post Canal Unit include:

1. Modify the Post C and Lateral 25C Subsystems:
   a. Improve the spill site on the Post B Canal and its intertie to the Post C Canal.
   b. Improve the existing control at the Post C Canal and Lateral 25C bifurcation. All flow variations will enter Lateral 25C, while improved flow control and measurement is provided at the "restart" of the Post C Canal.
   c. Improve the existing water level control down the Post C Canal and Lateral 25C "superhighway" to maintain a constant upstream water level over a wide range of flows.
   d. Construct a regulating reservoir approximately halfway down Lateral 25C to capture and buffer flow rate fluctuations. Flows in the following laterals can then be re-started with target flows as needed:
      i. Lateral 25C
      ii. Lateral 22C
      iii. Sub-Lateral 25CA
2. Modify the Post F Canal Subsystem:
   a. Change the existing control at the head of the Post F Canal by diverting all flow rate variations from Post Creek and the Mission C Canal into the Post F Canal heading.
   b. Construct a new regulating reservoir near the head of the Post F Canal to:
      i. Capture the upstream flow rate variations in the canal and re-regulate the flow to the downstream canal section at any time.
      ii. Improve flexibility to turnouts from the canal both upstream and downstream of the reservoir.
      iii. Prevent over-topping of the Post F Canal during occasional periods of high flow rates.
      iv. Provide better control of the operational spill to Hillside Reservoir.
   c. Convert all of the existing open laterals supplied by the Post F Canal to limited-demand pipelines.
   d. Improve the water level control down the Post F Canal superhighway.
   e. Improve flow control at the head of Lateral 36F in Dublin Gulch, to limit the flow into Lateral 36F.
3. Improve the flow measurement into Hillside Reservoir.
4. Incorporate SCADA to remotely monitor flow rates and to monitor automatic control at key locations in the Post Canal System in order to effectively manage the movement of water.

Post C Canal and Lateral 25C Subsystem

Figure 2 on page 3 shows the general modernization changes along the Post C Canal and Lateral 25C.

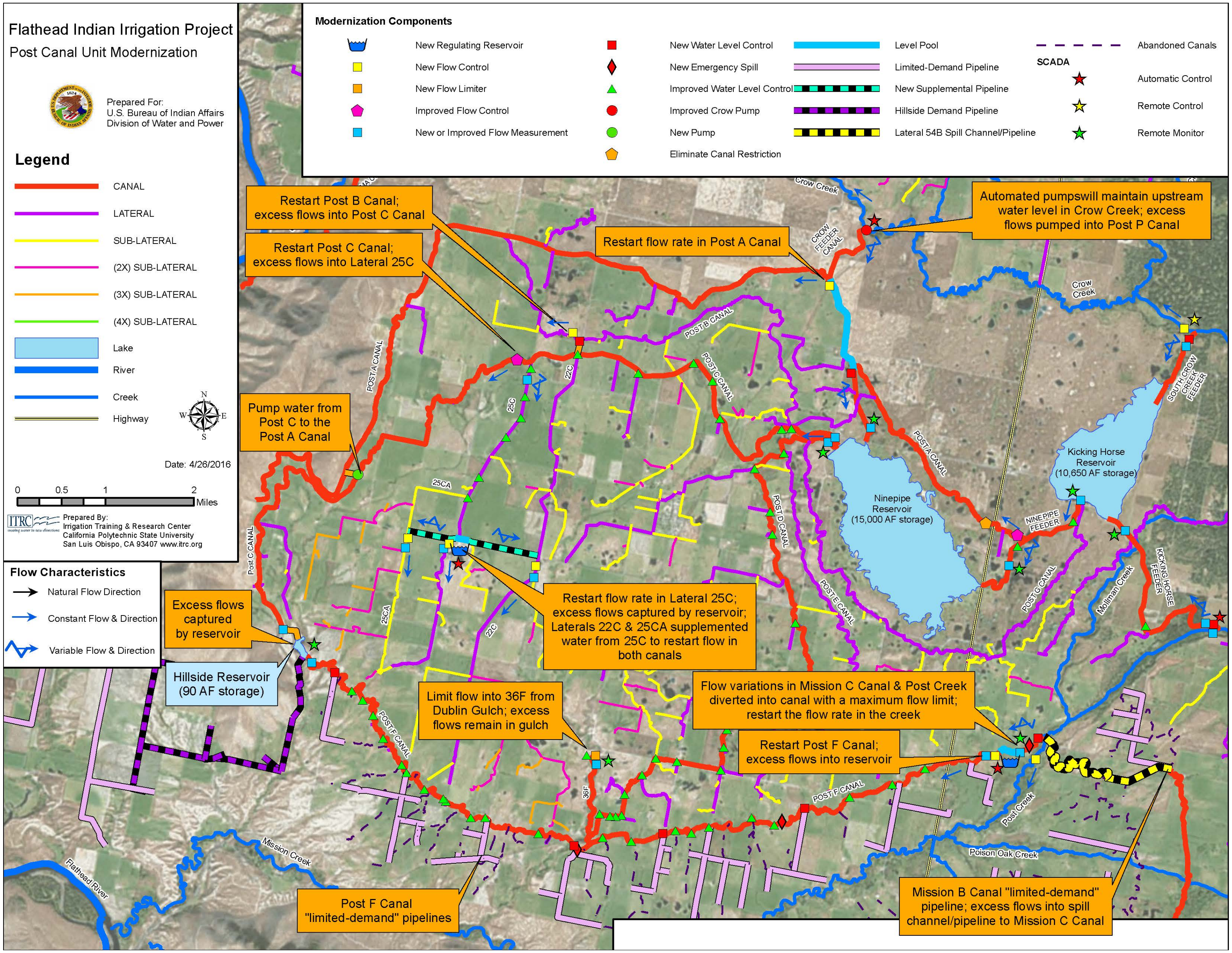

Figure 1. Overall Post Canal Unit modernization changes in this section of the report

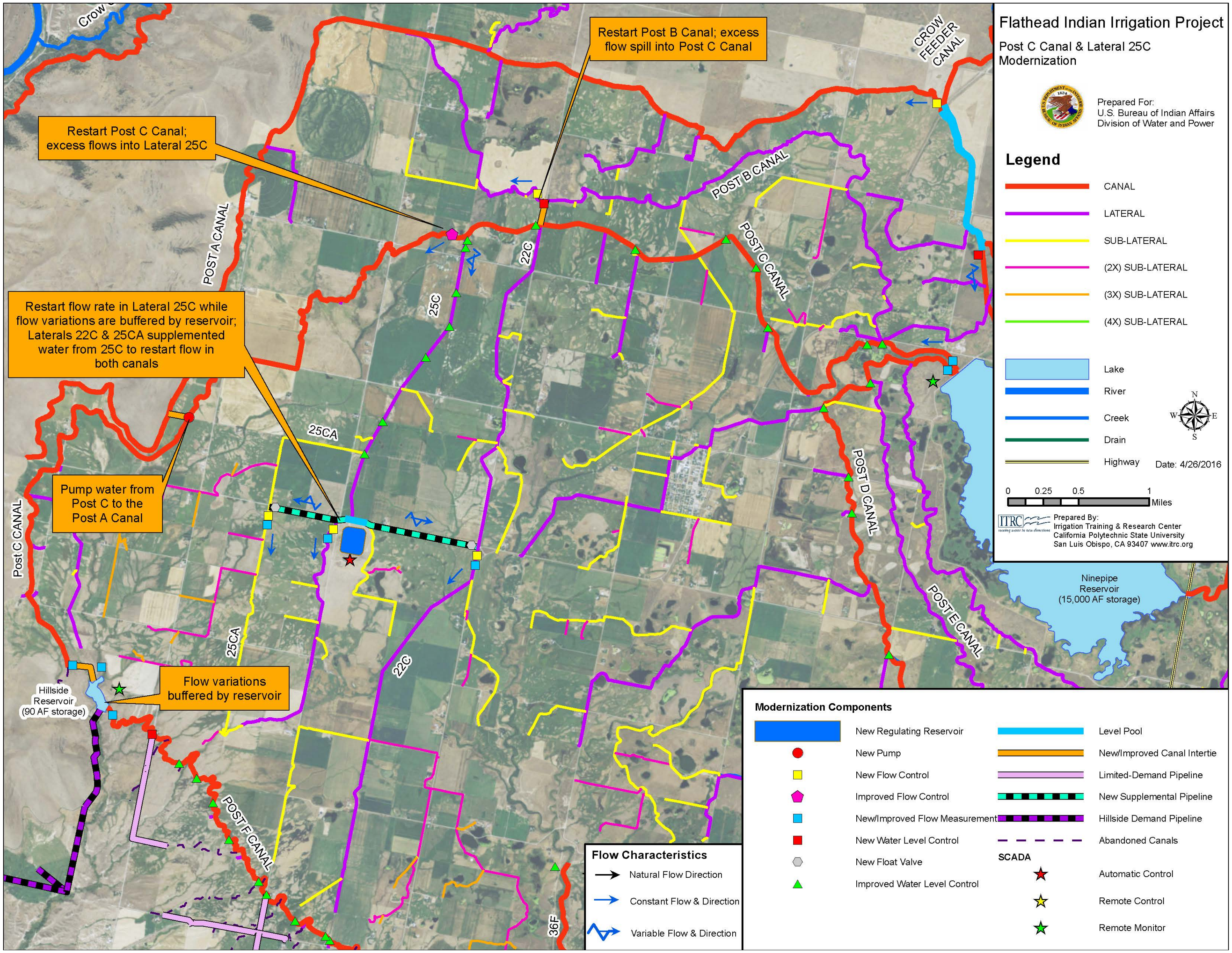

Figure 2. Overview of modernization changes along the Post C Canal and Lateral 25C

Improved Post B Spill Site and Intertie to the Post C Canal

The Post B Canal (see Figure 3) diverts water from the Post C Canal near Ninepipe Reservoir. Approximately 6 miles downstream, a spill structure on the Post B Canal allows operators to redirect excess flows back to the Post C Canal. Figure 4 shows the existing control in the Post B and C Canals near Hall Road.

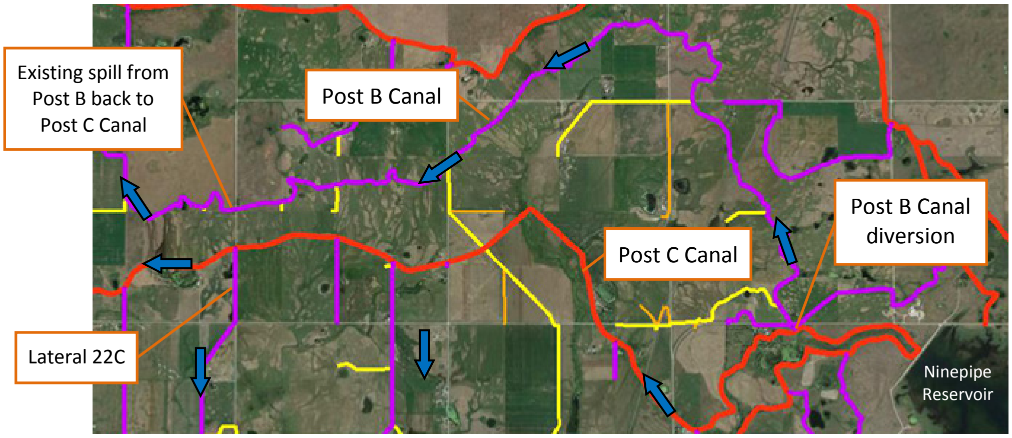

Figure 3. General alignment of the Post B Canal

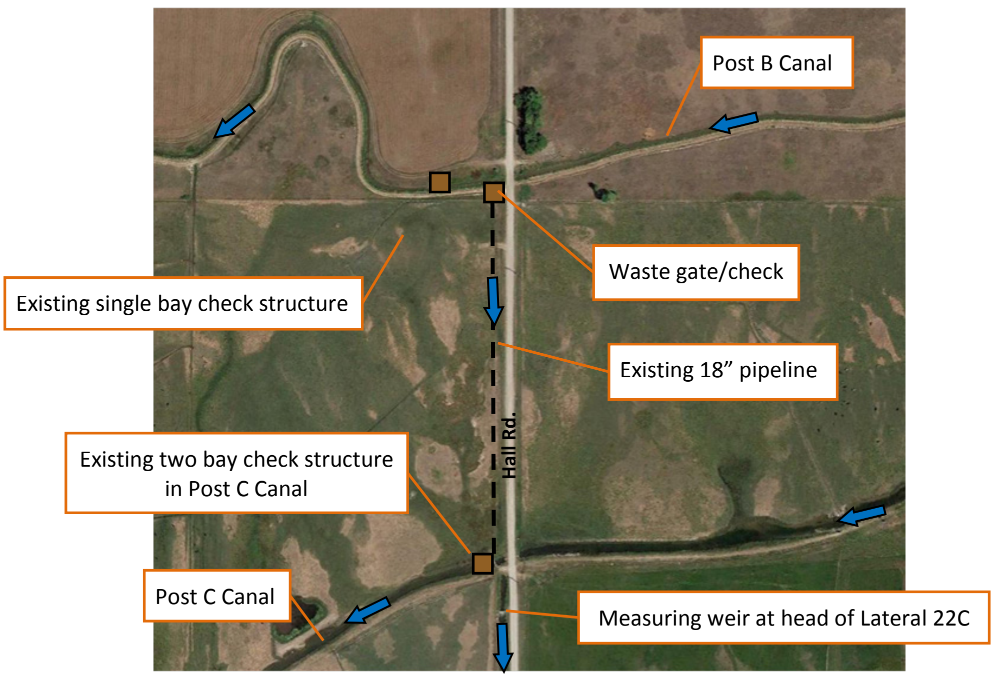

Figure 4. Existing control at the Post B Canal spill and intertie to the Post C Canal at Hall Rd.

An existing check structure and waste gate are located in the Post B Canal just downstream of the Hall Road crossing (refer to Figure 5). Flashboards in front of the spill gate act as an emergency weir in case the water level in the Post B Canal rises too high. An 18" pipe conveys the spill from the Post B Canal along Hall Road approximately 900 ft. until it discharges into the Post C Canal just upstream of a two bay check structure in Post C Canal, at the Lateral 22C headgate. The physical condition of the pipeline is unknown.

Figure 5. Existing Post B Canal check structure (left) and waste/spill structure gate (right) just west of Hall Road. Photos from HKM 2008 report.

Figure 6. Existing check in Post C Canal, with the Lateral 22C headgate on the left-hand side

Control Improvements to Post B Canal Spill to the Post C Canal

By making minor improvements to the Post B Canal spill to Post C Canal, the following benefits will be achieved:

- Flow control and measurement will be provided to the remaining portion of the Post B Canal.
- Excess flows in the Post B Canal will be automatically diverted into the Post C Canal to be used in the main agricultural area of the Post Canal Unit. Currently, excess flows in the Post B Canal pass through a small area of irrigation prior to spilling into the Hillside Reservoir.
- Operation of Post B Canal will be simpler for ISOs.

Figure 7 shows the conceptual control improvements to the Post B and C Canals near the existing intertie.

Figure 7. Conceptual control components of the new Post B and C Canal intertie

The existing waste structure has very short weir boards and therefore cannot maintain good water level control. The problem is compounded by the fact that the existing check structure is a weir design, so most flow fluctuations continue down the Post B Canal instead of returning to the Post C Canal.

The improved control components in the two canals include:

1. The existing single bay check structure in the Post B Canal should be replaced with a new flow control structure. A suppressed sluice gate can be used to both control and measure the target flow rate set for the downstream portion of the Post B Canal.
2. The spill structure can be removed and replaced with a new flap gate structure (see Figure 8 and Figure 9) or LCW.
    a. If there is sufficient drop, a flap gate would likely be less expensive than a LCW. The flap gate will maintain the upstream water level in the Post B Canal as well as automatically pass all flow variations into the existing spill pipeline to the Post C Canal.
    b. The flap gate will be installed in a precast concrete U-shape box structure.

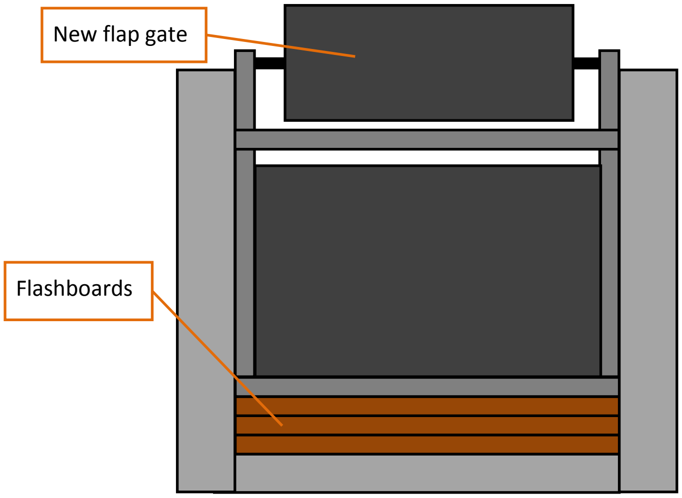

Figure 8. Conceptual front view of new flap gate structure in the Post B Canal (not to scale)

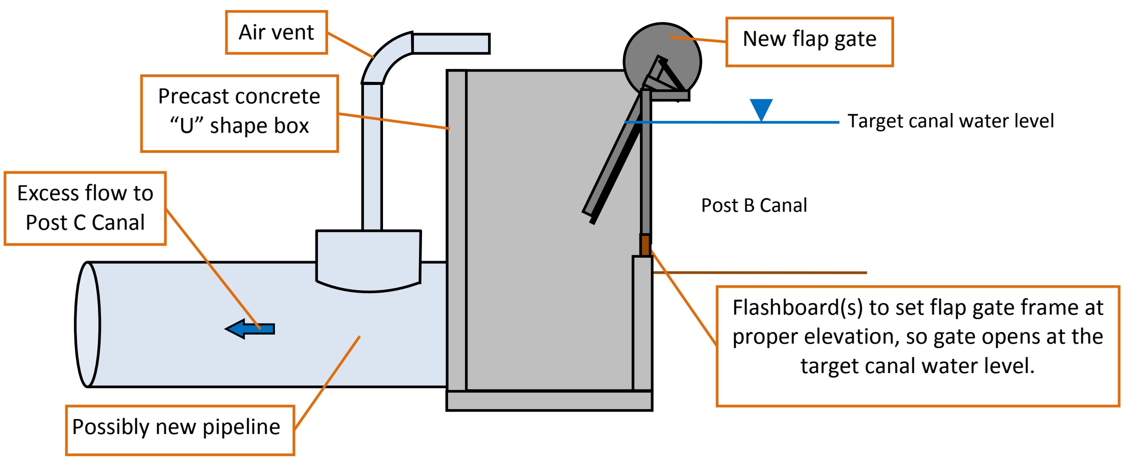

Figure 9. Conceptual side view of new flap gate structure in the Post B Canal (not to scale). Flap gates cannot be submerged on the downstream side, so there must be sufficient drop available for a flap gate to work properly.

3. An investigation should be conducted of the physical integrity of the existing spill pipeline.
   a. If the existing pipeline is found to be physically ok, then it will be used.
   b. If the pipeline is deficient, then the entire 900 ft. of pipeline will be replaced.
4. The existing check structure in the Post C Canal should be replaced with a new 80 ft. long downstream-facing LCW structure as shown in Figure 10 for upstream water level control.
5. SCADA could be incorporated to remotely monitor the flow rate over the existing measuring weir at the head of Lateral 22C.

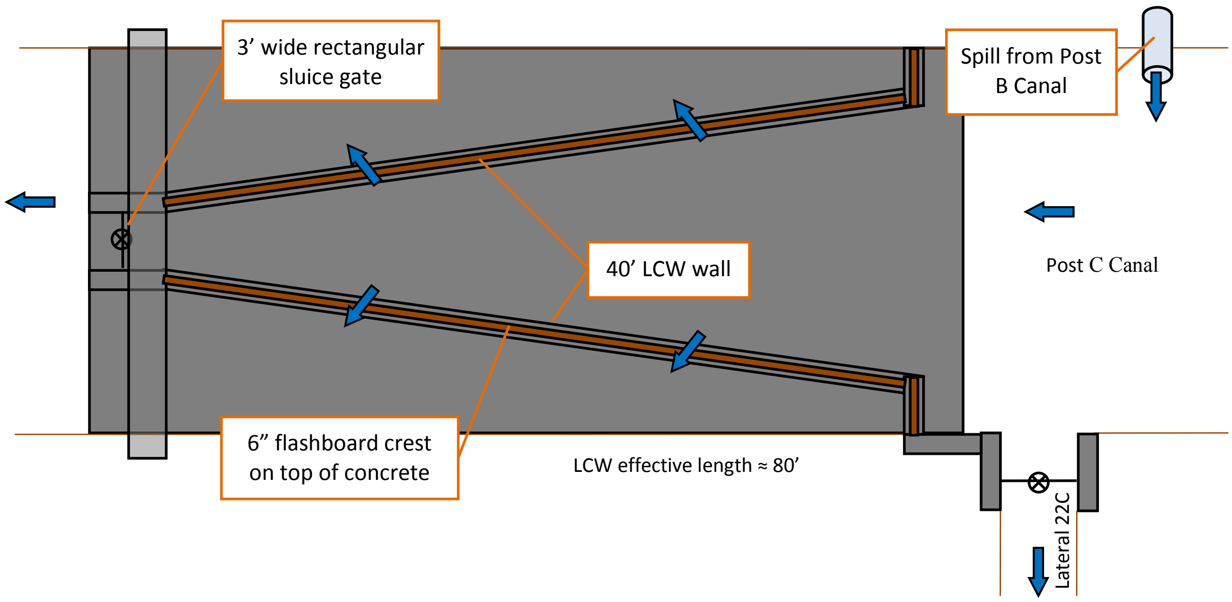

Figure 10. Conceptual plan view of new LCW structure in the Post C Canal at head of Lateral 22C (not to scale)

Control Improvements at Head of Lateral 25C

Figure 11 shows the existing control at the Post C Canal and Lateral 25C bifurcation.

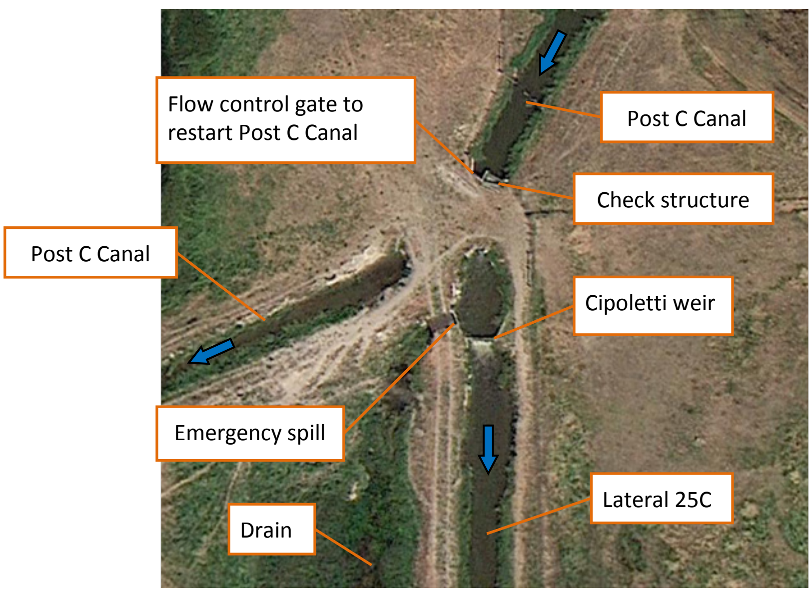

Figure 11. Aerial image showing existing control at the Post C Canal and Lateral 25C bifurcation

A 30" diameter canal gate is used to restart the flow rate down the Post C Canal at the Lateral 25C head. A single 9 ft. long flashboard bay (see Figure 12) is used to maintain the upstream water level in the Post C Canal while passing all the flow variations into Lateral 25C. The basic configuration of underflow/overflow should be retained. The Cipoletti weir will no longer be important.

Figure 12. Head of Lateral 25C on the Post C Canal

Approximately 75 ft. downstream from the Lateral 25C head is a Cipoletti weir and an emergency spill to a nearby drain (see Figure 13).

Figure 13. Existing Cipoletti weir and spill downstream of Lateral 25C head

Improvements at the Post C Canal and Lateral 25C Bifurcation

Figure 14 shows the improvements in control at the Post C Canal and Lateral 25C bifurcation.

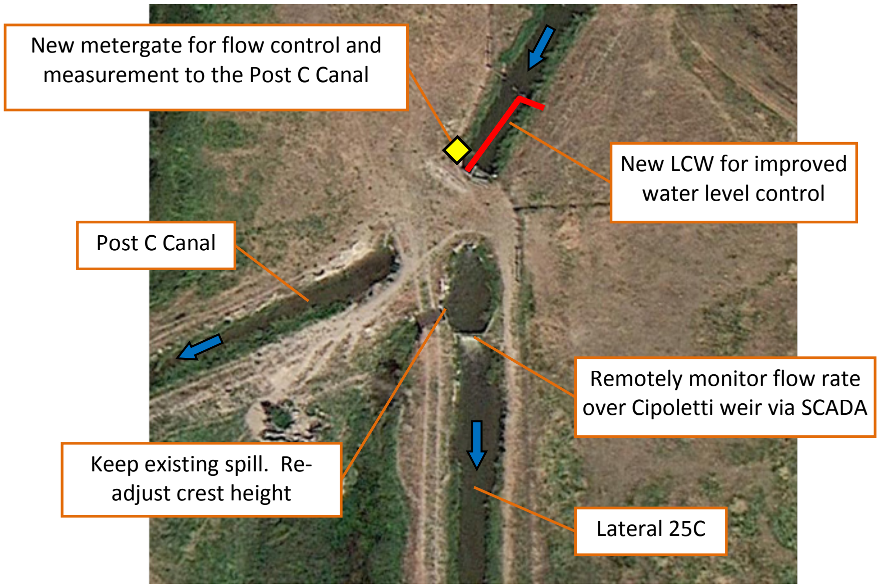

Figure 14. Control improvements at the Post C Canal and Lateral 25C bifurcation

To improve the existing control, the modifications will be as follows.

1. A new control structure shown in Figure 15 will be constructed that will contain the following control components:
   a. A 50 ft. upstream-facing LCW will maintain a fairly constant upstream water level in the Post C Canal and pass all excess flows into Lateral 25C.
   b. A new metergate will control and measure the flow rate being diverted to the downstream portion of the Post C Canal.
2. SCADA will be used to remotely monitor the flow rate over the existing Cipoletti weir. Also, a new staff gauge will be installed that reads directly in CFS.
3. The crest of the existing emergency spill structure in Lateral 25C will be raised so the top of the crest is approximately 0.1ft higher than the water level at the maximum lateral flow rate.

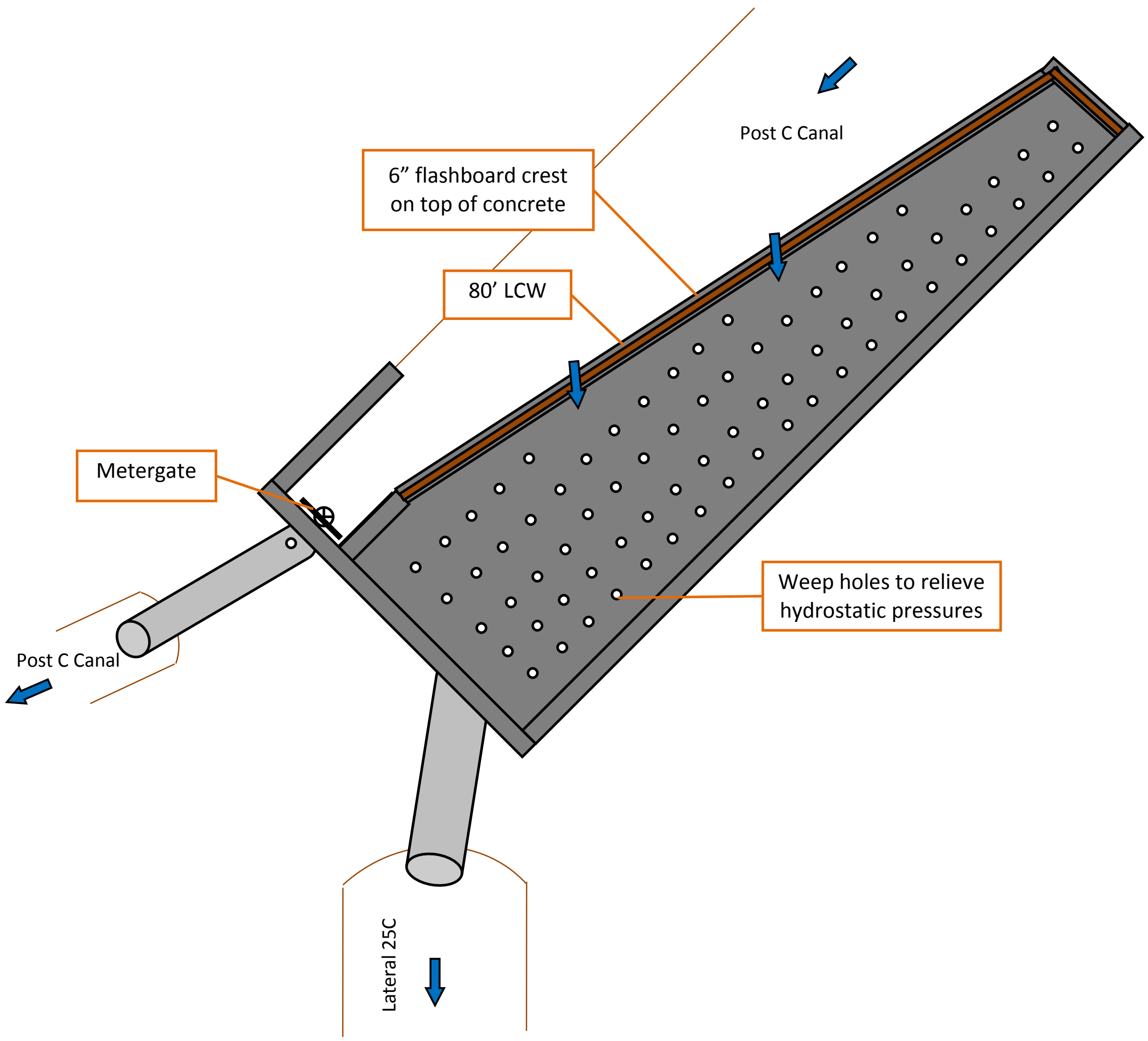

Figure 15. Conceptual plan view of new control structure at the Post C Canal and Lateral 25C bifurcation (not to scale)

Lateral 25C Regulating Reservoir

Figure 16 shows the approximate location of the proposed regulating reservoir to be constructed adjacent to Lateral 25C in the Post Canal System.

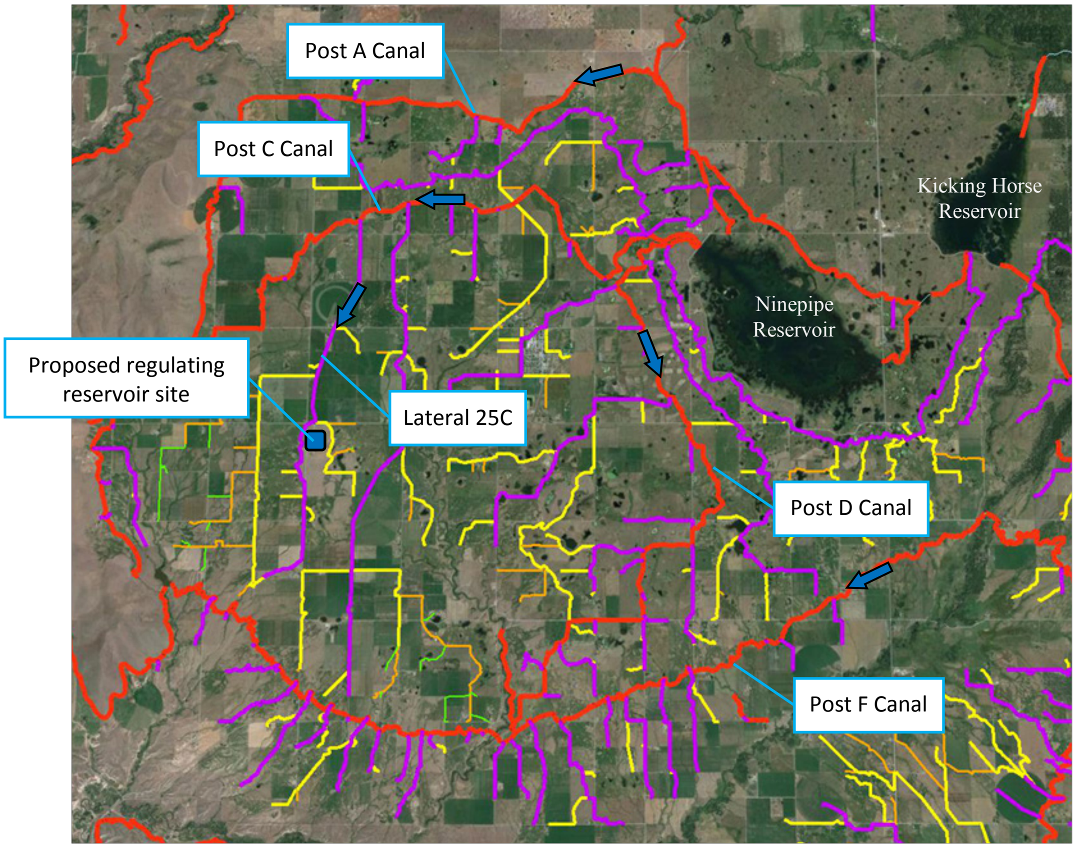

Figure 16. Approximate location of proposed Lateral 25C regulating reservoir site in the Post Canal System

Reservoir Site and Existing Control

A regulating reservoir is proposed to be constructed in a 30 acre field (refer to Figure 17) at the Lateral 25C and Sub-Lateral 25CB bifurcation in the Post Canal System. The existing control of the adjacent laterals is shown in Figure 17 as well. The proposed field is basically a large natural sump, which is ideal for a reservoir site since less excavating will be needed to form the basin. Water can flow into the reservoir by gravity; it will need to be removed with pump(s).

Figure 18 shows the proposed Lateral 25C regulating reservoir site looking northeast from Crow Dam Road.

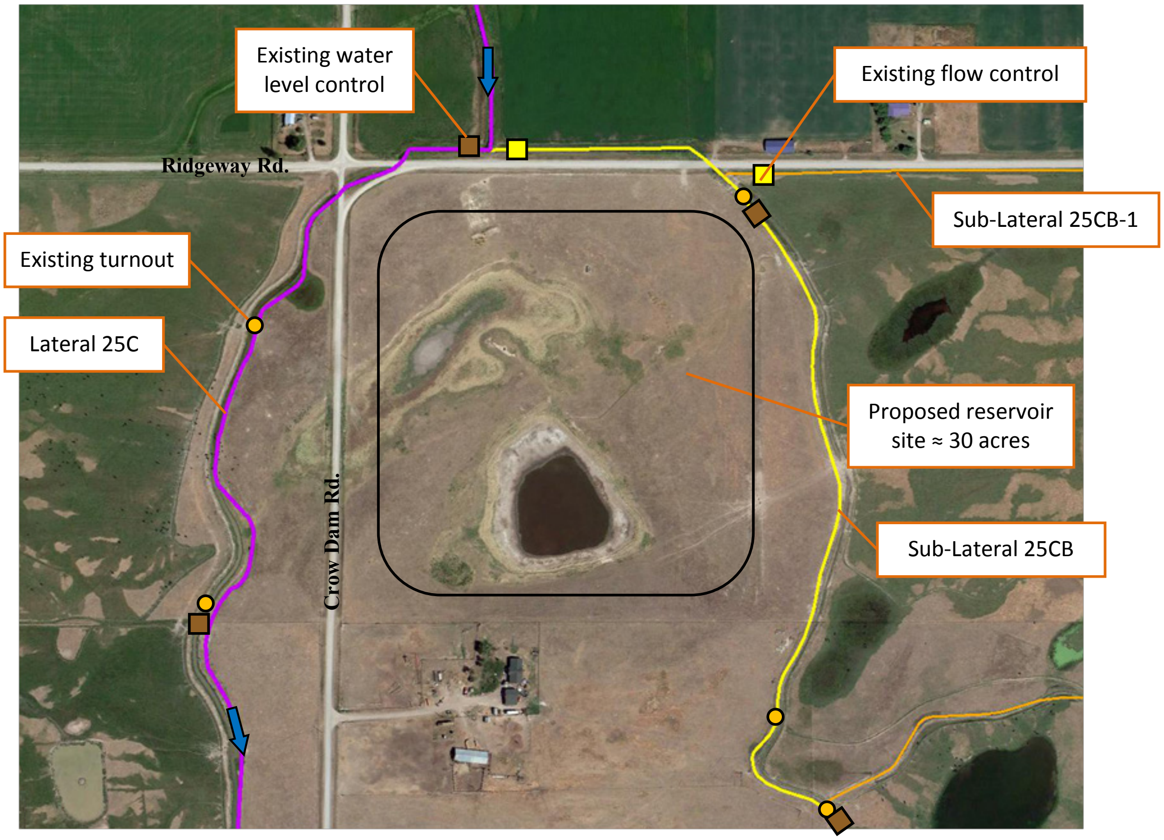

Figure 17. Aerial image of proposed Lateral 25C reservoir site as well as nearby existing canal control

Figure 18. Photo of proposed Lateral 25C regulating reservoir site looking northeast from Crow Dam Road

Figure 19 shows the approximate 10 ft. elevation contours near the proposed regulating reservoir site. The elevation contours were produced with a National Elevation Dataset (NED) provided by the USGS. Note that the elevation contours can be inaccurate by several feet in the vertical direction and are only used as a reference for a feasibility reservoir design.

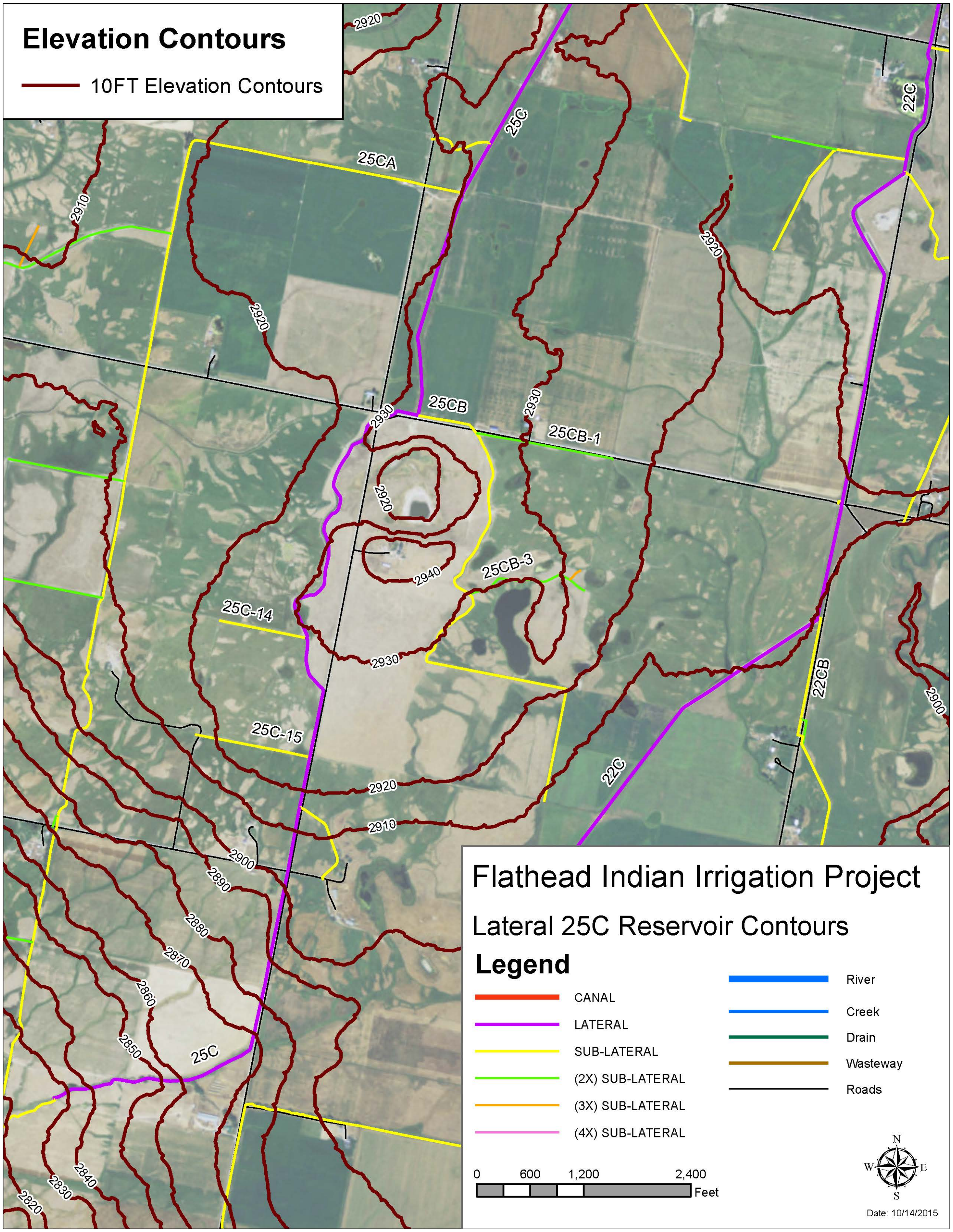

Figure 19. Approximate 10' elevation contours. Elevations were produced by National Elevation Dataset (NED) provided by the USGS.

Reservoir Control Overview

The new Lateral 25C regulating reservoir will provide the following benefits:

- The reservoir will allow for improved flexibility to turnouts along the Post C Canal and Lateral 25C.
- The downstream flow rate to Lateral 25C will have the ability to restart the demand flow rate at any time.
- Supplemental flow will be provided "on-demand" to the downstream portion of Lateral 22C as well as Sub-Lateral 25CA to ensure there is enough flow to meet the downstream irrigation demand.
- Operational spills at the tail ends of Lateral 25C will be reduced.

Figure 20 shows the general overview of the control scheme of the Lateral 25C regulating reservoir.

The general control scheme of the new Lateral 25C regulating reservoir includes the following:

1. Variable flows in the Post C Canal will be diverted into Lateral 25C and be buffered by the new 80 AF regulating reservoir. If the flows are insufficient to meet downstream demands, the reservoir will supply the deficit. If the flows are more than needed, the excess flows will be diverted into the reservoir.
2. A short section of canal, just to the north of the new reservoir, will serve as a "level pool". It will serve as the headworks for:
    a. Excess flows that must be passed into the reservoir
    b. Continuation of Lateral 25C
    c. Re-regulation of Lateral 22C
    d. Re-regulation of Sub-Lateral 25CA
3. A new 100' long LCW will control the maximum water elevation in the new level pool while automatically passing any excess flows into the reservoir. Most of the flow entering the new pool will not flow into the reservoir; only excess flows will go over the LCW. The length is selected for very good water level control.
4. Two automated pumps in the reservoir will turn on (one at a time) if the water level in the level pool drops below the crest of the LCW. Whether they can be single speed pumps or require smart VFD control (both options with a PLC) will depend upon the final dimensions of the new level pool.
5. The remainder of Lateral 25C, where it is attached to the level pool, will start with a rated suppressed sluice gate to control and measure flow rates.
6. The existing headworks for Sub-Lateral 25CA and Lateral 22C will be operated with a slight (15%) deficit so that the flows can be supplemented with the new pipelines (see next item).
7. Two separate pipelines will branch out from the level pool and will supplement flows to both Lateral 22C and Sub-Lateral 25CA. The discharge flow rate from the two supplemental pipelines will be automatically regulated by a float valve installed at the terminus of the pipeline to maintain the water elevation just upstream of new flow control structures in each lateral. It appears that these two pipelines can deliver flow to the laterals by gravity. Elevations must be checked. There are variety of possibilities to create a gravity flow condition. For example, the pipelines could be connected to Lateral 25C to the north of the level pool, where the elevation might be greater.

8. New flow measurement structures will be constructed downstream of each new flow control structure, if there is sufficient head available. If there is insufficient head, the flow control gates should be of a suppressed sluice gate design that can be used for both flow control and measurement.
9. Water entering pipelines should be cleaned by automatic screens.
10. The headgate at the restart of Lateral 25C should be equipped with a side LCW bypass (40' long). If the water level in the reservoir should get too high, the flow into the reservoir will be automatically stopped by the AVIO gate, the water level in the level pool will rise, and the water will overflow into Lateral 25C.

The next two sections explain the inlet and outlet control of the reservoir in more detail.

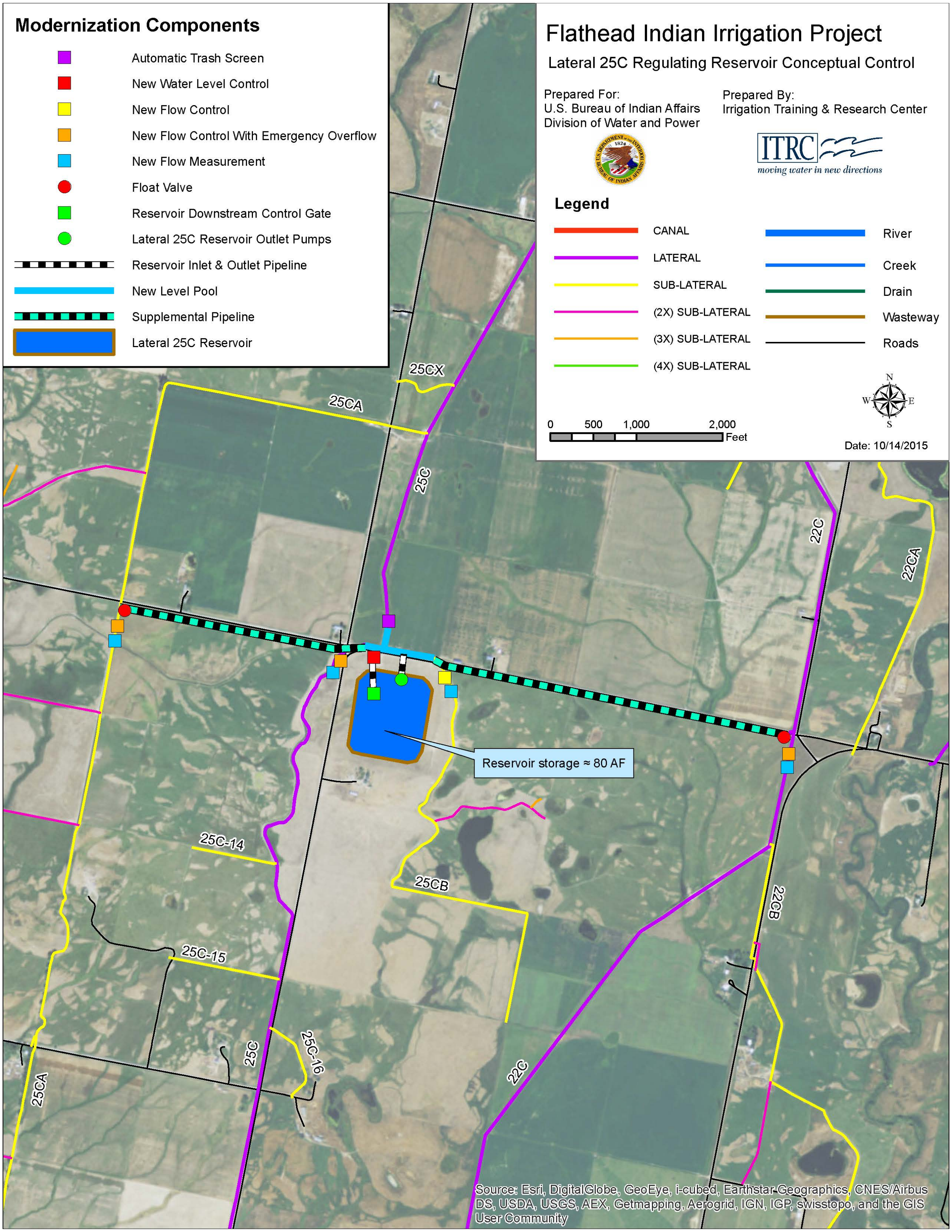

Figure 20. General overview of control scheme of new Lateral 25C regulating reservoir

Reservoir Inlet Control

Figure 21 shows the conceptual control at the inlet to the Lateral 25C regulating reservoir.

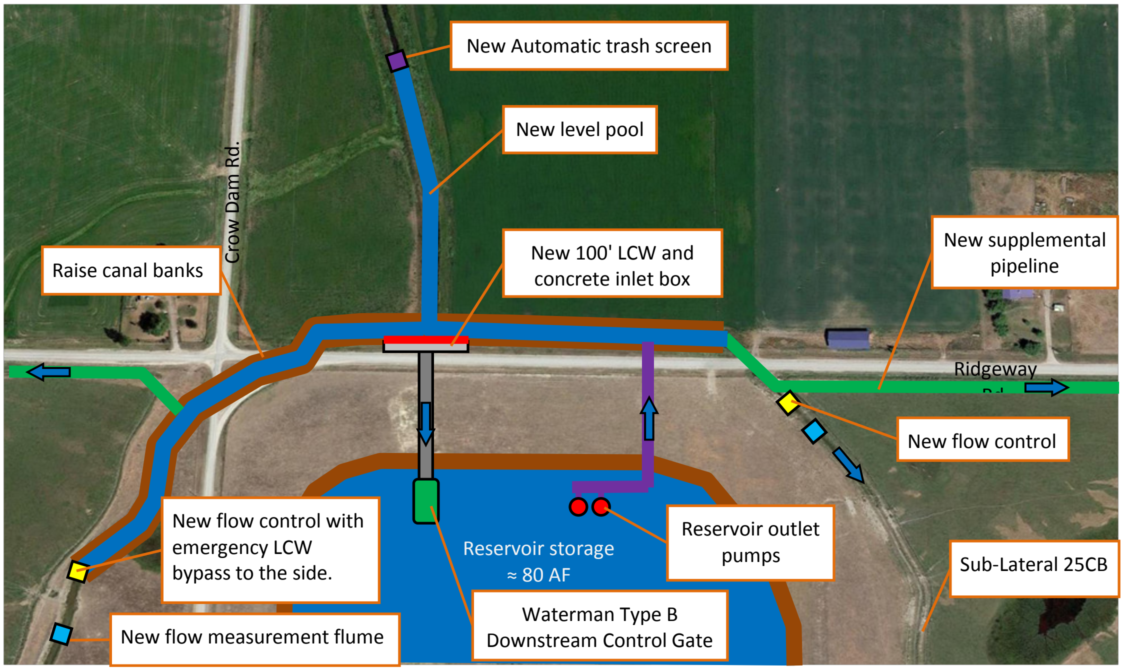

Figure 21. Conceptual control at the inlet of the Lateral 25C regulating reservoir

The control scheme at the inlet of the Lateral 25C regulating reservoir will be as follows:

1. An AquaSystems 2000 inclined trash screen (or equivalent) will be installed in Lateral 25C upstream of Ridgeway Road to remove debris and trash flowing down the lateral. Refer to Appendix B for details on the AquaSystems 2000.
2. A level pool will be constructed along Ridgeway Road, for a length of about 1000'. Its eastern boundary will be the location where Sub-Lateral 25CB moves to the south. Its western boundary will be near Crow Dam Road. Portions of the existing canal banks will most likely need to be raised.
3. A 100 ft. LCW will help maintain the water level in a new level pool by automatically passing all excess flows into the new Lateral 25C regulating reservoir.
    a. The LCW will be constructed into the side of the level pool.
    b. Any water that passes into the level pool will spill into a new concrete inlet box before entering the reservoir inlet pipeline under Ridgeway Road that connects to the new reservoir.
4. A Waterman Type B downstream control gate, sized for a maximum flow rate of 25 CFS, will be installed at the tail end of the new box culvert to operate as an automatic emergency shutoff if the reservoir was to reach its maximum operating water level. The operation of the Waterman Type B gate will be as follows:
    a. If the water level in the reservoir is below the maximum water level elevation, the Waterman gate will open to allow flow into the reservoir.
    b. As the water level in the reservoir begins to rise and is within about 0.2' of the maximum allowable water level elevation, the Waterman gate will begin to close down.

   c. Once the maximum water level elevation is reached, the Waterman gate will completely close, preventing any water from entering the reservoir; the box culvert will fill up until the water level in the box culvert equals the water level in the level pool. The water level in the level pool will rise, and spill over an emergency spill into Lateral 25C.
   d. It should be noted that Waterman gates do not completely seal. Therefore, the pump control logic must incorporate an action that pumps water from the reservoir if the water level in the reservoir exceeds some maximum elevation.
5. The reservoir discharge will be controlled by two identical pumps installed in the reservoir.
   a. The pumps will discharge back into the level pool when the water level in the pool drops below the crest of the LCW.
   b. The pumps will be controlled by redundant water level sensors installed in the level pool, which will connect to a PLC to sequence the order of turning pumps on/off. The general sequencing of the reservoir pumps will be as follows (assume there are two individual pumps):
      i. If the water elevation in the level pool falls below the target water level elevation, the first reservoir pump would automatically turn on.
      ii. If the water level in the level pool does not recover to the target elevation, the second reservoir pump will automatically turn on.
      iii. Once the water level in the level pool begins to rise, the pumps will automatically start turning off in the reverse order that they turned on.

      Note: There will only be one target water level because this will use PLC logic and water level sensors with 4-20 mA signals.
   c. The successful use of this simple sequencing logic depends upon the sizes of the pumps and the size of the level pool. Other, more complicated VFD logic can be used as a last resort.
   d. The pump characteristics will be approximately:
      i. Two identical pumps
      ii. 10 CFS each
      iii. 24 ft. TDH
      iv. 37 Input HP to motors
      v. Inverter duty premium motors
      vi. Use VFD controllers for slow start option, even if not used for control
      vii. 24” diameter common, single discharge pipe to the canal.
6. A new suppressed sluice gate or metergate will be installed at the new heading of Sub-Lateral 25CB, to control and measure flows into Sub-Lateral 25CF.
7. The head of the remainder of Lateral 25C needs a new flow control and measurement structure(s). If there is sufficient head available, a flume can be used downstream for flow measurement. In that case, the details of the flow control gate are not too important as long as it is an orifice design. If there is insufficient head available for a flume, the new flow control gate can also be effectively used for flow measurement if it is a suppressed sluice gate design.
8. The new flow control structure will have built-in emergency overflow walls (see Figure 22) to automatically pass all emergency flows downstream if the reservoir is at capacity. All emergency flows will pass down Lateral 25C until it eventually spills into the Post F Canal and is recaptured at Hillside Reservoir.

9. New Replogle flumes will be constructed downstream of the three new flow control points near the reservoir inlet (refer back to Figure 21) to provide flow measurement if sufficient head is available.

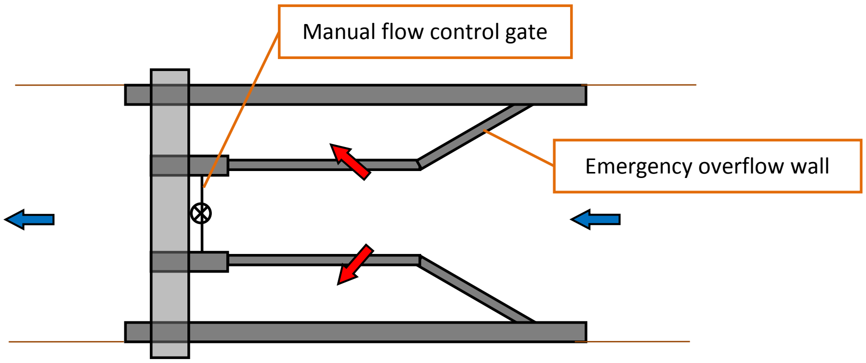

Figure 22. Conceptual plan view of the new Lateral 25C flow control structure and reservoir inlet (not to scale)

Control Improvements at Lateral 22C

Figure 23 shows the new conceptual control in Lateral 22C at the corner of Hall and Ridgway Road.

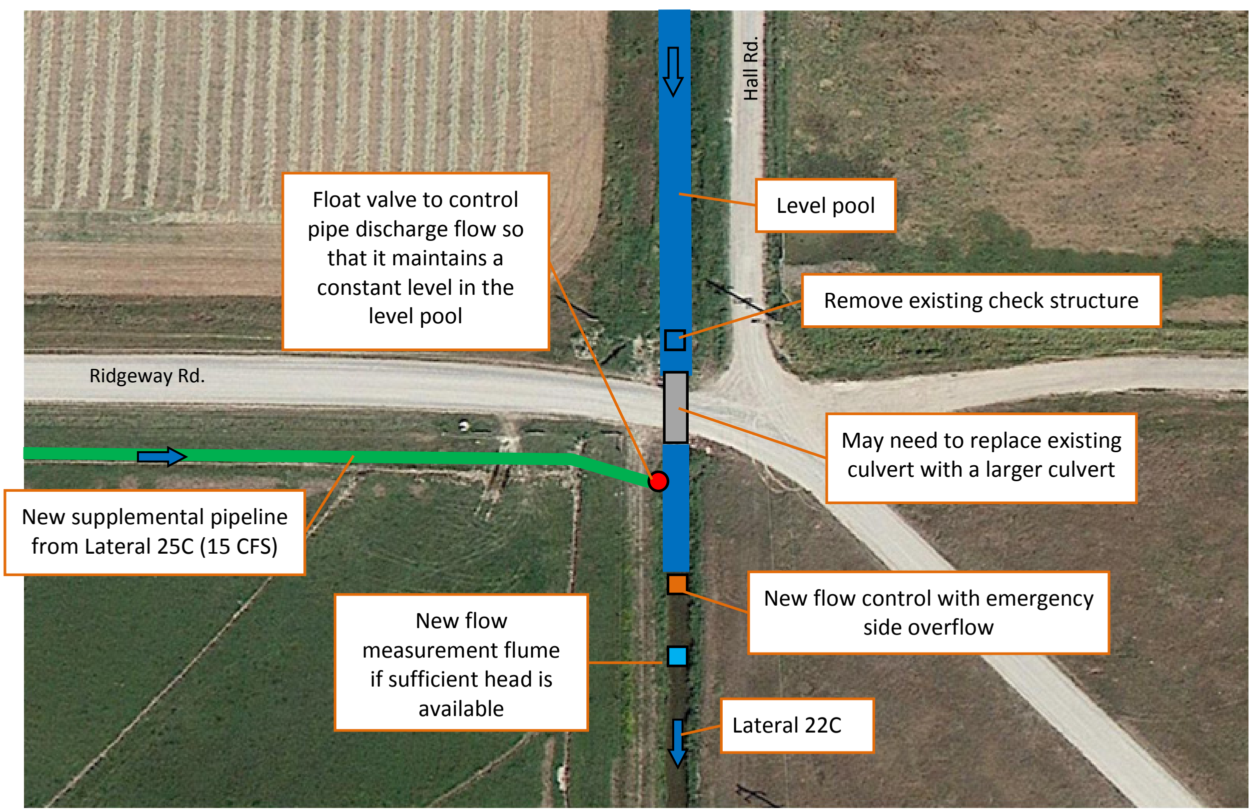

Figure 23. Aerial image showing the new flow control on Lateral 22C at Hall and Ridgway Road

The control in Figure 23 is as follows:

1. Operators will set the flow rate at the head of Lateral 22C to meet approximately 85-90% of the demand flow for the entire lateral.
    a. This will ensure that there is always a shortage in flow that shows up at the three-way lateral bifurcation from Lateral 22C.
    b. The reservoir will make up remaining flow to supply the approximately 1,500 acres downstream.
2. The existing check structure upstream of Ridgeway Road will be removed.
3. A new flow control structure will be constructed 100 ft. downstream of Ridgway Road to restart the downstream flow rate to Lateral 22C.
    a. A manual rectangular sluice gate will control the downstream flow rate to Lateral 22C and will have the ability to be changed at any time.
    b. Emergency overflow walls will be built into the new flow control structure to automatically pass any emergency flows down Lateral 22C.
    c. The canal section upstream of the new flow control structure will need to be expanded.
4. The new supplemental pipeline from Lateral 25C will automatically provide the remaining demand flow for Lateral 22C.
    a. The pipeline will have a total length of approximately 4,200 ft.
    b. A flow meter will measure the discharge flow rate from the supplemental pipeline.
    c. The outflow from the supplemental pipeline will be controlled by a float valve (see Figure 25) installed at the terminus of the pipeline to maintain a constant water level in a new level pool upstream of the new flow control structure. Because this is a very low pressure situation, the float valve must be fabricated locally using a free-moving butterfly valve and proper linkage. Commercial hydraulically actuated valves require a fairly high pressure to operate; PLC-controlled electrically actuated valves are too complex. Float valves, if properly designed, are very effective.
    d. The operation of the float valve will be as follows:
        i. If the water level in level pool was to fall below the target water level elevation, the float valve would automatically open, discharging water into the lateral.
        ii. As the water level would begin to rise, the float valve would start to close off, reducing the amount of water discharging from the pipe into the pool.
        iii. Once the target water level in the lateral was reached or exceeded, the float valve would completely close, preventing any discharge from the reservoir outlet pipeline.
    e. The exact dimensions will be determined by the design flow and available pressure.
        i. The total float travel should be such that the water level in the canal will remain within 0.2', from fully open to fully closed.
        ii. The float is typically constructed of urethane foam poured into a large diameter PVC pipe for protection.
        iii. Floats need a weight on top to force the float to open if the water level drops.
        iv. The float is located in a stilling well that gives a 0.4' of space (gap) between the stilling well walls and the float.

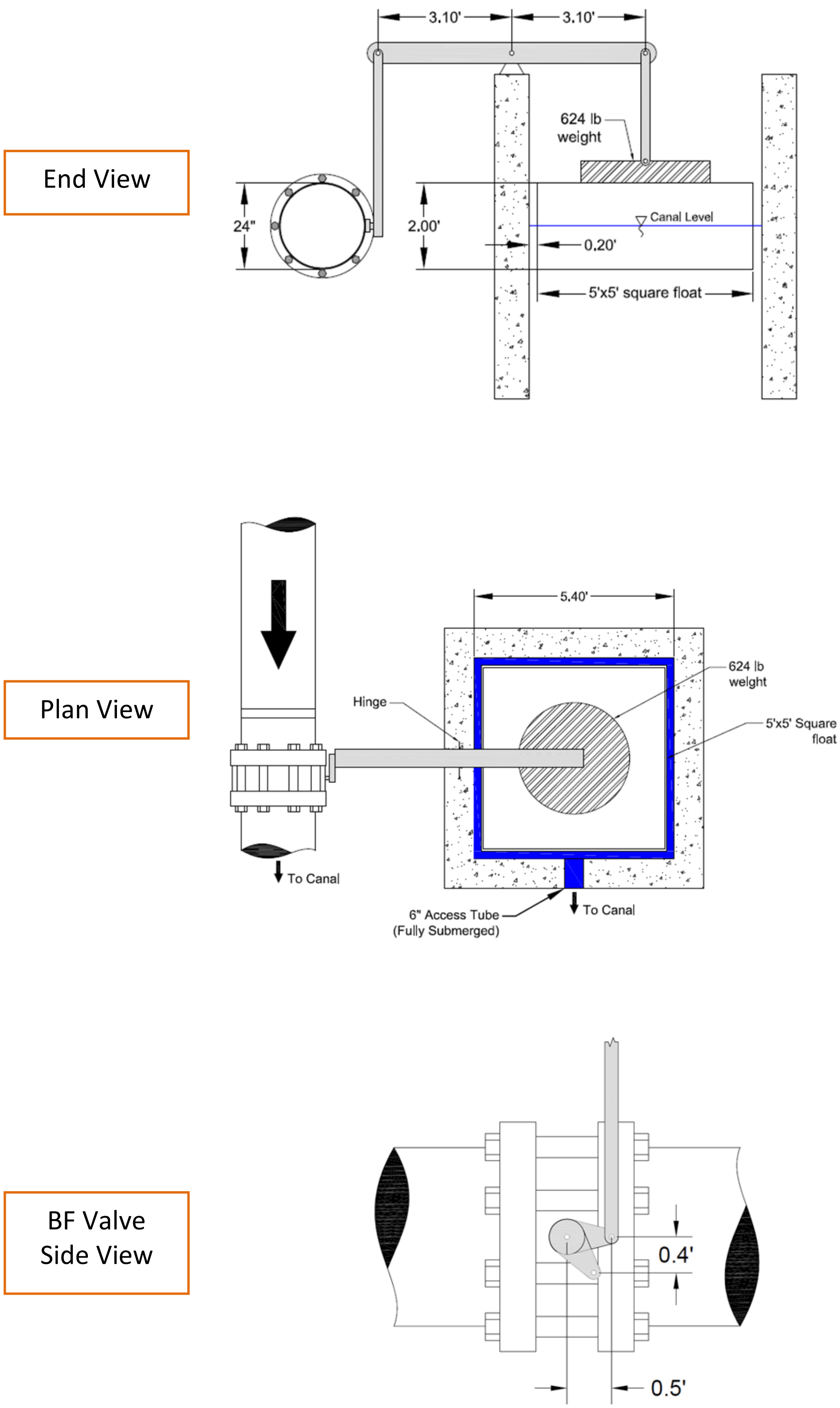

Figure 24. Likely float valve design

5. Replogle flumes will be constructed downstream of each of the three flow control structures to provide fairly accurate flow measurement to the downstream portion of the lateral, if sufficient head is available.
6. The existing culvert under Ridgeway Road may need to be improved if the downstream water level is raised.

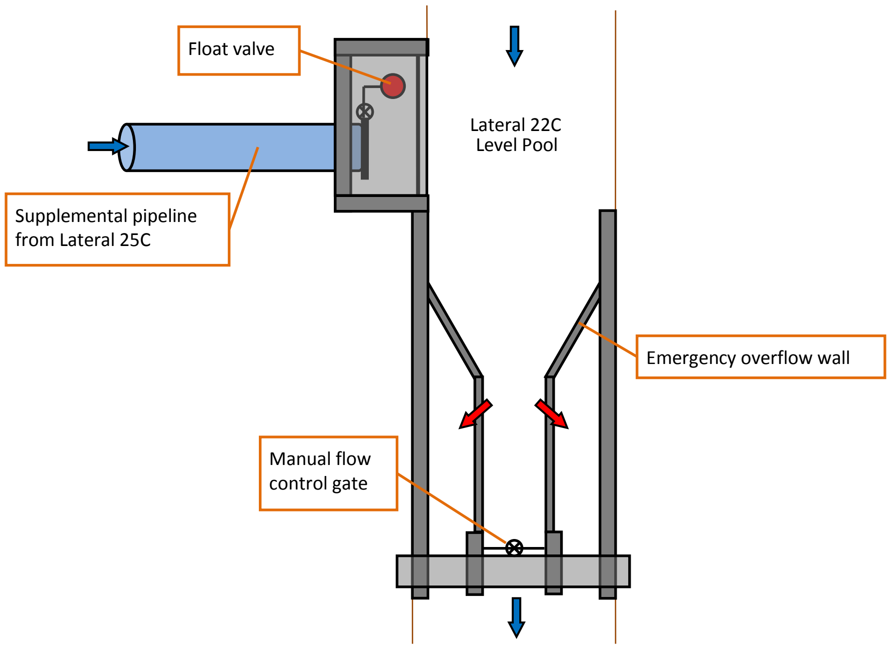

Figure 25. Conceptual plan view of new flow control in Lateral 22C at Ridgeway Road (not to scale)

Control Improvements at Sub-Lateral 25CA

Figure 26 shows the conceptual control improvements in Sub-Lateral 25CA at Ridgeway Road. The control will be similar as that listed in the section above. Of all the additions in this general area, <u>this has the lowest priority</u>.

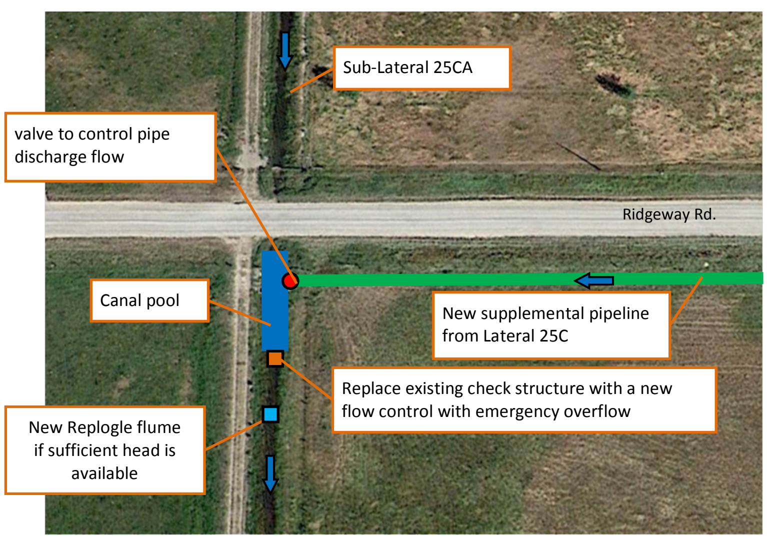

Figure 26. Conceptual control improvements at Sub-Lateral 25CA at Ridgeway Road

Improving Water Level Control along the Lateral 25C Superhighway

The existing water level control structures along the Post C Canal and Lateral 25C, between Ninepipe Reservoir and the new Lateral 25C Reservoir, will be improved to create a "superhighway". The idea of a canal superhighway is that operators can change flows into the canal, and to all turnouts, without having to move up and down the canal and make adjustments to any canal structures or other turnouts.

In other words, the key to creating a superhighway is to have excellent water level control at all cross regulators. The results are:

- A fairly constant upstream water level is maintained on all turnouts, resulting in an undisturbed turnout flow rate even if the canal flows are changed.
- The constant canal levels help to prevent over-topping of canals.
- The operators can focus on making flexible deliveries, rather than needing to make numerous gate and check structure changes during the day.
- If the new reservoir on Lateral 25C is too high or too low, it will be easy to make a change in the flow rate at Ninepipe Reservoir, and the flow change will arrive at Lateral 25C relatively quickly.

Figure 27 on the next page shows the locations of improved water level control structures along the Post C Canal and Lateral 25C superhighway. Table 1 contains a list all of the improved water level control locations. The sizes of the structures, and whether they will be ITRC Flap Gates or long-crested weirs, will depend upon the flows and the elevations at each structure.

Table 1. List of improved water level control structures along Post C Canal and Lateral 25C

No.	Longitude	Latitude
1	-114.1492	47.4567
2	-114.1514	47.4563
3	-114.1665	47.4561
4	-114.1699	47.4619
5	-114.1752	47.4642
6	-114.1883	47.4614
7	-114.2037	47.4619
8	-114.2133	47.4590
9	-114.2134	47.4583
10	-114.2135	47.4535
11	-114.2134	47.4500
12	-114.2161	47.4464
13	-114.2206	47.4390
14	-114.2224	47.4354

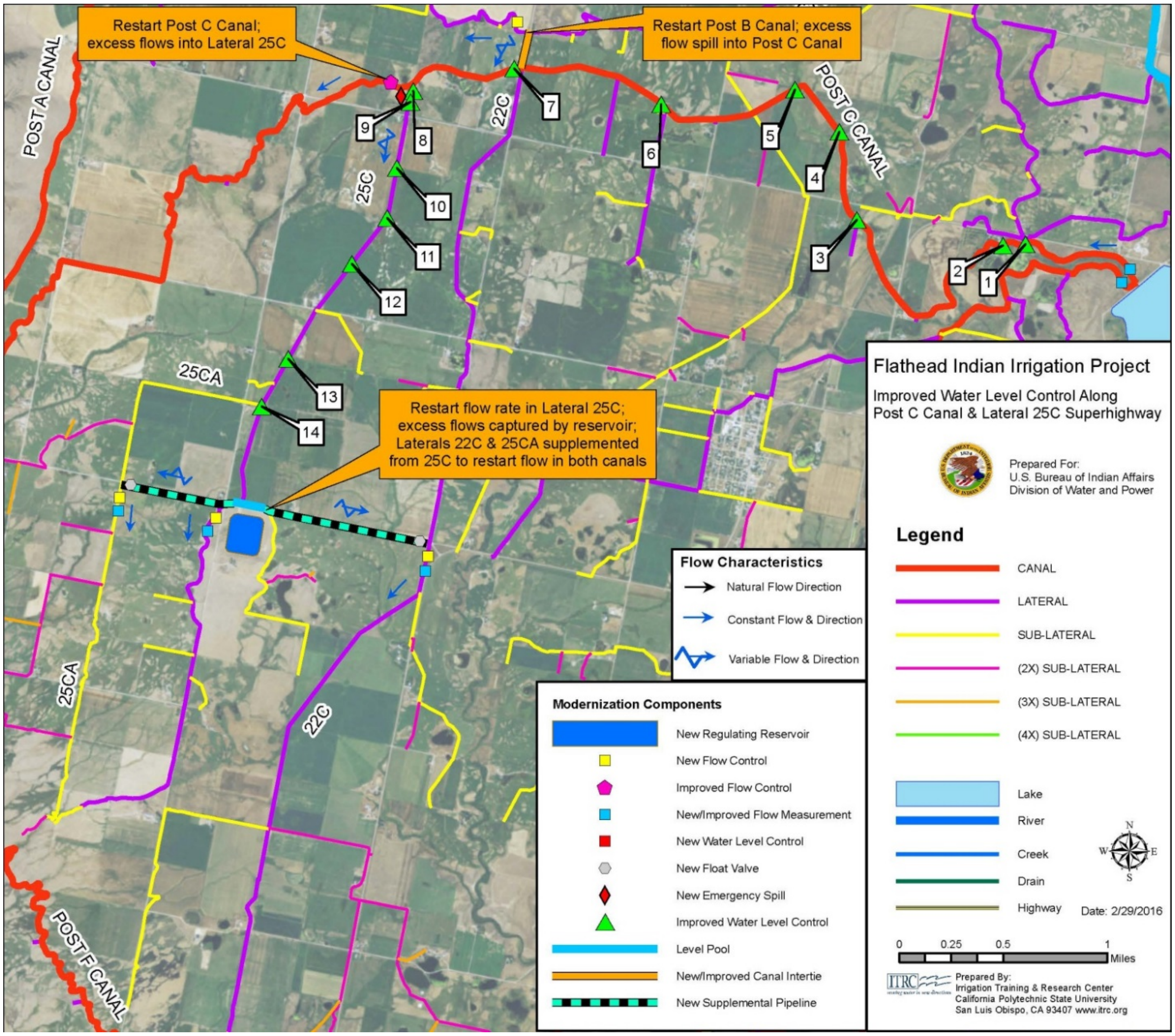

Figure 27. Improved water level control down Lateral 25C superhighway

Connection between Post A and Post C Canal

The end of the Post A Canal often experiences shortages of water. Farmers mentioned that at times, deliveries on the upstream portions of Post A Canal need to be stopped just to make deliveries to the downstream end of the Post A Canal. It is possible to install a pump and lift 5 CFS from Post C to Post A Canal. The location of a possible connection is shown below in Figure 28.

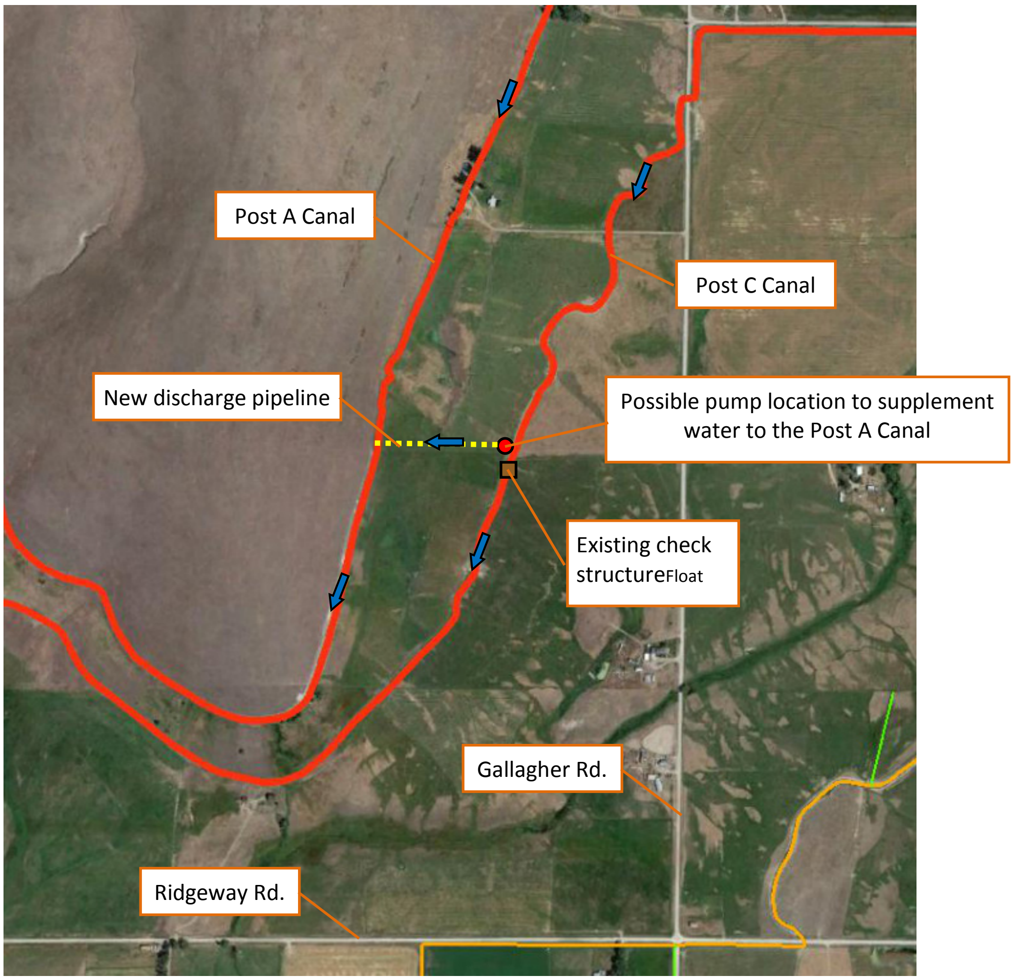

Figure 28. Proposed new pump and pipeline to supplement water in the Post A Canal

Approximate details of the pump and pipeline would be the following:

- Elevation lift between the canals = 53 ft.
- Flow rate = 5 CFS
- Pipe diameter: 12" (the velocity of about 6 feet/sec is not a problem because there is no valve on the end of the pipeline, and the hours of operation are low.
- Pipe length = 750 ft.
- Total dynamic head (TDH) = 64 ft.
- Input HP to the motor = 52 HP

Post F Canal Superhighway

The Post F Canal diverts anywhere between 30-50 CFS from Post Creek and has a total alignment length of approximately 10.5 miles. The canal captures operational spill and farmer tailwater runoff from the northern portion of the Post Canal Unit. Supplemental flow from Dublin Gulch via the 36F Canal discharges into the Post F Canal nearly halfway down the canal diversion on Post Creek. Variable flows at the end of the Post F Canal spill into Hillside Reservoir. The modernization goals are listed below, and the following sections explain the modernization changes made at individual sites along the Post F Canal.

The modernization goals for the Post F Canal will be:

- Divert variable Post Creek flows into the Post F Canal rather than leaving the variable flow in the creek where it can no longer be used for irrigation. However, a target in-stream flow will be maintained.
- Capture spill from the end of Mission C Canal.
- Buffer the variable flows entering the Post F Canal with a new regulating reservoir near the head of the Post F Canal.
- Provide flexibility to the new pipelines that will be supplied from the Post F Canal. Previously, when farmers to the south of Post F Canal shut off their flows, the flows continued down through drains to creeks. With the new pipelines, this water will remain in the Post F Canal, causing significantly more flow fluctuations in the Post F Canal than are seen now.
- Convert the Post F Canal into a superhighway between the new regulating reservoir and the Hillside Reservoir, to accomplish the objectives above while also minimizing the possibility of overtopping the canal.

Figure 29 shows the general modernization changes made to the Post F Canal, which include:

1. The control structure at the head of Post F Canal on Post Creek will be modified. Variable flows up to the canal maximum capacity will be diverted into the Post F Canal, while the flow rate to the downstream portion (instream flows) of the Post Creek will be carefully controlled.
2. The capacity of the Post F Canal will be increased to 100 CFS, between Post Creek and the new regulating reservoir.
3. A 100 AF regulating reservoir to be constructed near the head of the Post F Canal will:
    a. Capture and re-regulate variable flows from Post Creek and from the tail end of the Mission C Canal
    b. Provide flexibility to turnouts upstream and downstream
    c. Provide simpler management for operators
4. The main laterals to the south of the Post F Canal will be converted to limited-demand pipelines. This will:
    a. Improve service to farmers
    b. Ease management for operators since farmer turnouts will be re-located along roads for easy access
    c. Significantly reduce operational spills back to the Post and Mission Creeks where the water is no longer usable
5. Control improvements at the head of the 36F Canal will be made to maximize the inflows from Dublin Gulch.

6. Water level control all along the Post F Canal superhighway will be improved with long-crested weirs with sediment flushouts. It is important that all structures be converted, so that flow changes can be moved down the canal quickly without needing operator intervention. Without a doubt, new long-crested weirs will be needed just downstream of every new pipeline inlet; however, it may be possible to eliminate some of the existing check structures – good surveying will be required to make that determination. Because of the high sediment load in the Post F Canal, the sediment flushout sluice gates should be sized large enough to pass the full canal flow. With the exception of the long-crested weirs at pipeline turnouts, the other long-crested weirs that only service one or two turnouts may be adjusted if those turnouts are not receiving water – with the sluice gate wide open to drop the upstream water level, thereby increasing velocity, and decreasing sedimentation.
7. SCADA will be incorporated at key locations to help with managing the canal system.

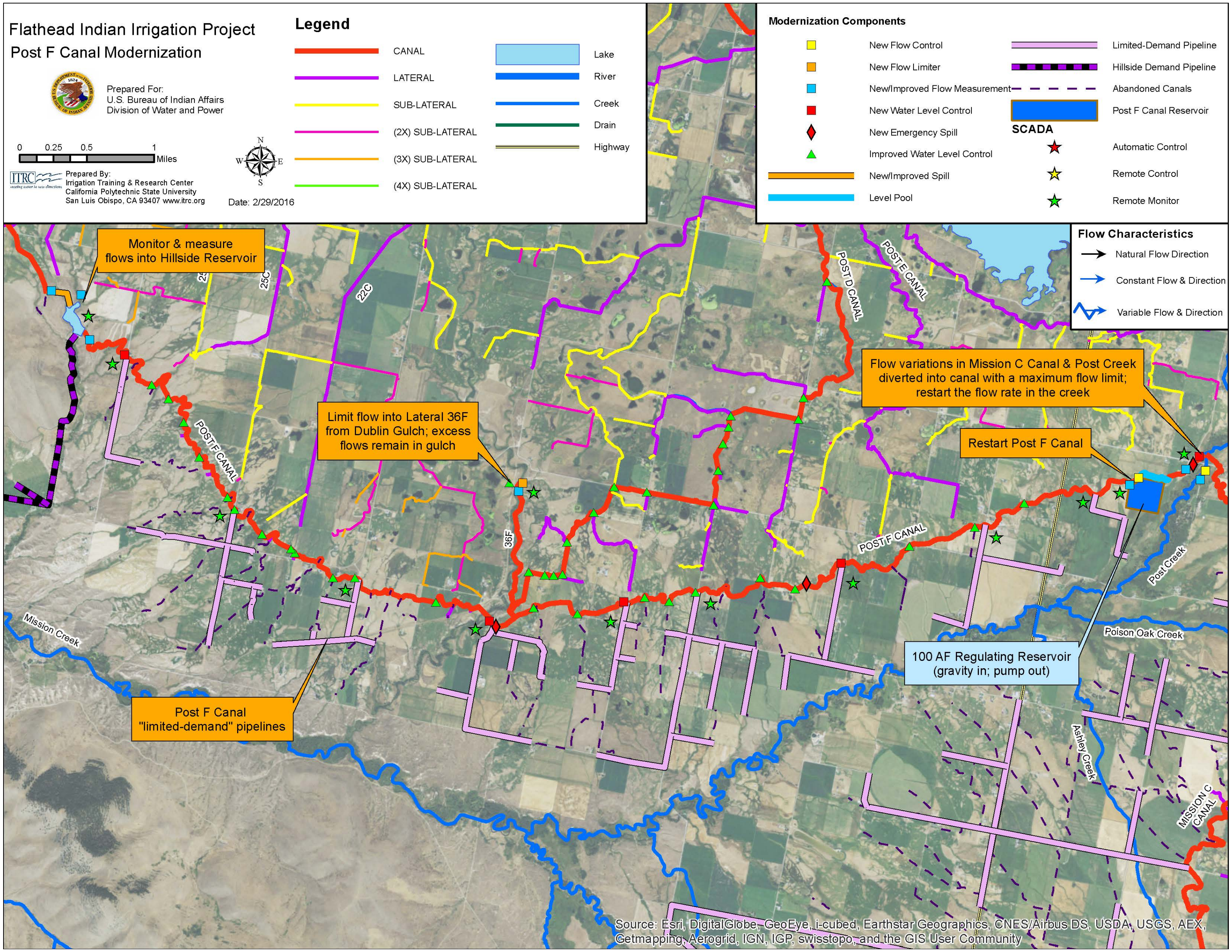

Figure 29. Modernization changes along the Post F Canal Superhighway

Change of Control at Post F Canal Diversion on Post Creek

Figure 30 shows the existing control at the Post F Canal diversion in Post Creek. The existing control is as follows:

- A multiple bay flashboard structure with a built-in fish ladder (see Figure 31) dams up the upstream water level in Post Creek to make a delivery to the Post F Canal.
- Two 36" circular canal gates control the flow rate into the Post F Canal. It is assumed that approximately 30-50 CFS is diverted into the canal.
- Operational spill from the Mission C Canal enters a 30" siphon under Post Creek and discharges into the Post F Canal downstream of the fish screen.
- If the spill in Mission C Canal exceeds the capacity of the 30" siphon, the excess flow rate passes over an emergency waste structure and spills into Post Creek just upstream of the diversion structure.
- A rated section in an earth lined section of the Post F Canal is used for flow measurement.
- FIP is obligated to maintain a certain flow downstream to Post Creek for fish life but very little acreage is serviced for irrigation purposes. Basically, any excess flows in Post Creek are lost and unusable to FIIP.

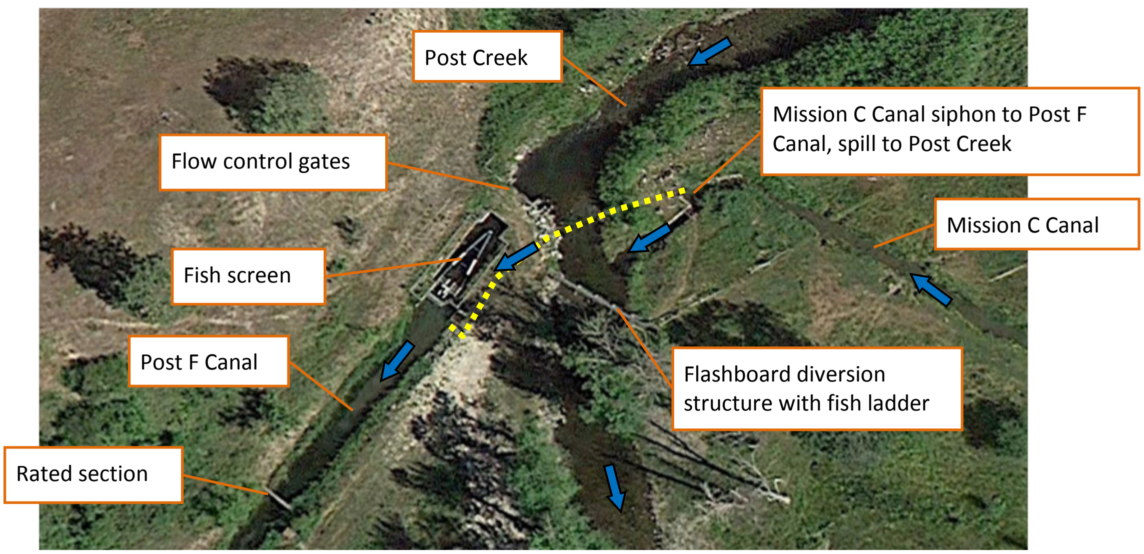

Figure 30. Existing control at the Post F Canal diversion on Post Creek

Figure 31. Post F Canal headgates (top left), Post F Canal fish screen (top right), Post Creek flashboard diversion (bottom left), Mission C Canal siphon entrance and waste (bottom right). Photos taken from HKM 2008 report.

Control Change at Head of Post F Canal

A change of control will be made at the Post F Canal and Post Creek bifurcation to keep as much water in the canal system as possible, while still meeting in-stream demands to Post Creek. The general control changes are shown in Figure 32.

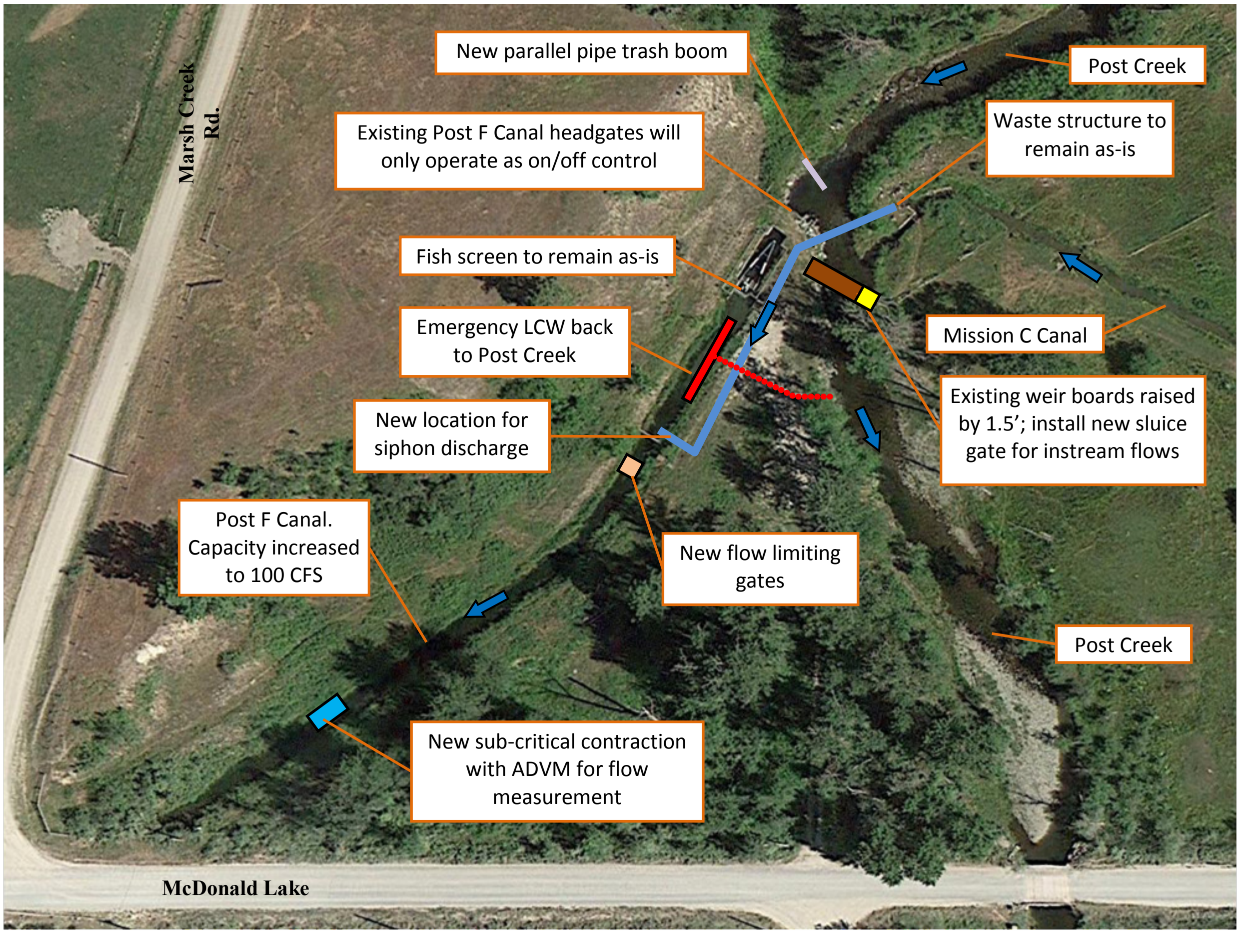

Figure 32. Control changes at Post F Canal diversion on Post Creek

The control changes include:

1. A new horizontal-pipe debris rack will be installed in Post Creek upstream of the control structures to deflect large floating trash away from the inlet to the Post F Canal.
2. The existing diversion dam in Post Creek will be slightly modified to raise the creek water level by about 1.5', plus a 2' sluice gate will be added at the side to deliver in-stream flows.
3. The existing Post F Canal headgates will operate only as on/off control most of the time, unless there is more flow than needed in the Post F Canal system. In other words, all the flow except for the instream flow will pass into the Post F Canal head.
4. An emergency long-crested weir (100' long) will be positioned on the left-hand bank of the Post F Canal, just downstream of the existing fish screen.
5. A flow limiting gate, usually at a constant position, will be located just downstream of an emergency overflow weir. The flow limiting gate should be set in a position such that when the flow rate downstream of it is close to the maximum allowable flow rate (100 CFS with enlarged canal), water will begin to spill over the new long-crested weir.

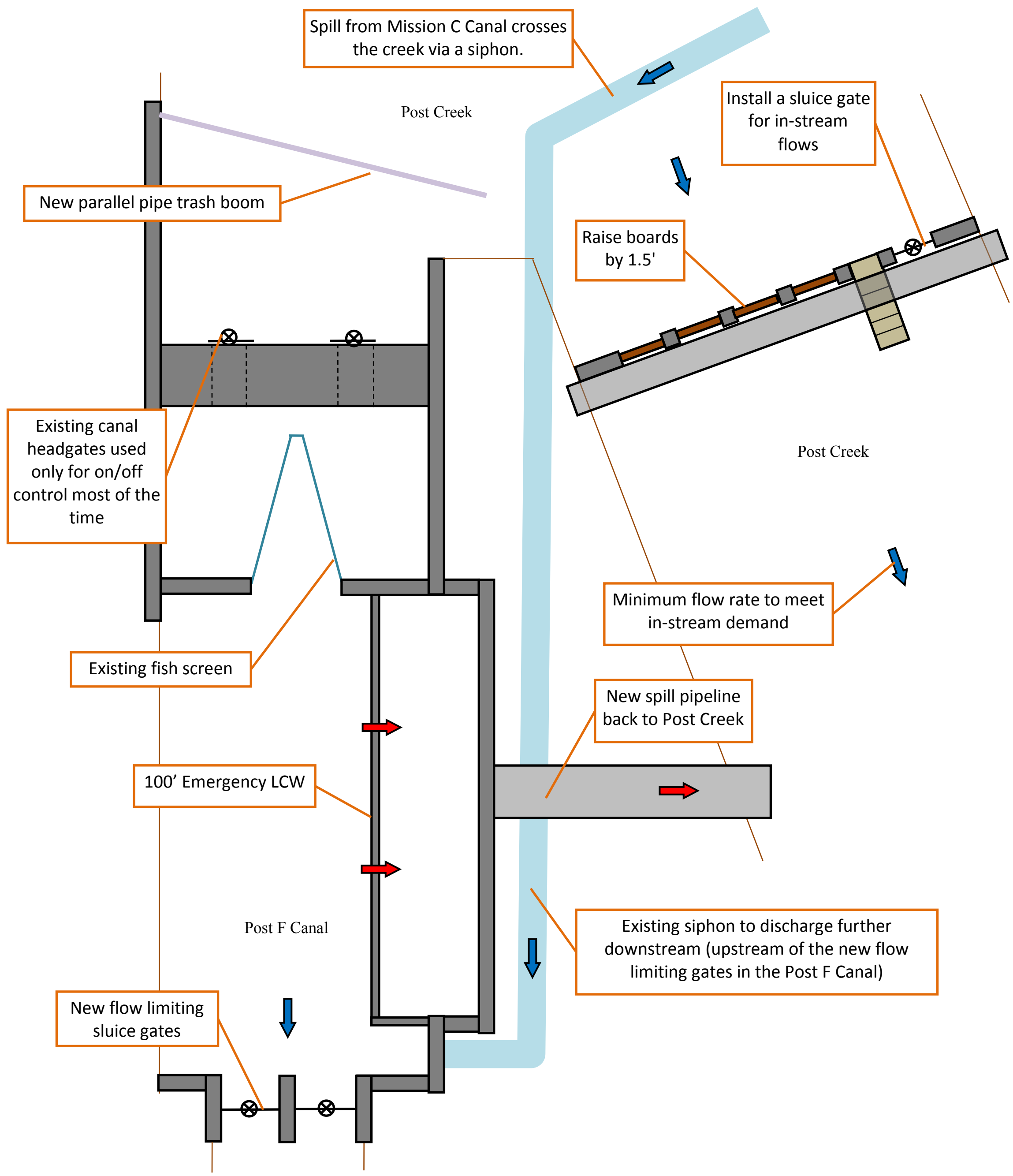

Figure 33. Conceptual plan view of new control structures at Post F Canal and Post Creek bifurcation (not to scale)

6. The existing diversion structure in Post Creek will be modified to provide flow control to the downstream portion of the creek.
    a. The new structure will consist of a combination of undershot sluice gates, flashboards, and a fish ladder.
    b. The manually controlled sluice gates will be set to divert a target flow rate to Post Creek. The two flow control gates will be calibrated for flow measurement where ISOs will use a rating table for each gate to set the required flow.

   c. The flashboards in the new flow control structure will serve as emergency overflows only.
      i. The flashboards will need to be raised.
      ii. The crest of the flashboard will need to be above the anticipated maximum head over the crest of the pleated LCW.
7. The existing fish screen in the Post F Canal will remain as-is.
8. A new 100 ft. emergency LCW will be installed in the left bank of the Post F Canal downstream of the fish screen.
   a. The emergency LCW will pass excess flow back to Post Creek if the maximum flow and target water level elevation in the Post F Canal are exceeded.
   b. Water over the emergency LCW will enter a concrete box and pass into a new spill pipeline that will connect to Post Creek.
9. The Mission C Canal waste structure at the siphon entrance will remain as-is. Any emergency spill from the Mission C Canal discharges into Post Creek upstream of the new flow control structure and can still be diverted into the Post F Canal.
10. The outlet of the existing 30" siphon will be extended and the discharge point will be moved downstream of the new emergency LCW on the Post F Canal.
    a. <u>The water quality in the Mission C Canal water is very poor compared to the Post Creek water quality and FIIP personnel do not want the poor-quality water to discharge into the creek if it can be helped.</u>
    b. <u>Any water passing over the emergency LCW will be clean water from Post Creek while the poor-quality water from the Mission C Canal will flow down the Post F Canal.</u>
11. A new subcritical contraction with a side-looking acoustic Doppler velocity meter (ADVM) will measure the flow rate in the Post F Canal.
    a. The subcritical contraction will be constructed approximately 100 ft. upstream of the Post F Canal crossing with McDonald Lake Road.
    b. SCADA will remotely monitor the flow rate through the subcritical contraction.

Increased Capacity between Post Creek and the Regulating Reservoir

The new reservoir will allow the project to capture higher runoff flows from the creek as well as increased spill from the new Mission B canal. It is recommended to increase the capacity of the canal, between the creek and the reservoir, to 100 CFS. All excess flows will spill into the new reservoir, allowing time for operators to make upstream source adjustments.

Post F Canal Regulating Reservoir

Under the proposed operation scheme of the Post F Canal system, variable flows will be diverted into the canal rather than attempting to maintain a constant flow into the head of Post F Canal. A new regulating reservoir will be needed on the Post F Canal approximately 0.3 miles downstream of the canal diversion on Post Creek. Figure 34 and Figure 35 show the approximate location for a new regulating reservoir. The new reservoir will provide the following management benefits:

- Capture and regulate variable flows entering the Post F Canal from Post Creek as well as the Mission C Canal
- Allow water to remain in the irrigation system rather than in Post Creek where it becomes essentially unusable to the project

- Allow the target flow rate to the downstream portion of the Post F Canal to be restarted at any time
- Provide improved flexibility to laterals and turnouts:
    - Upstream in the Mission B and C Canals
    - Downstream on the Post F Canal
- Improve operation management for ISOs

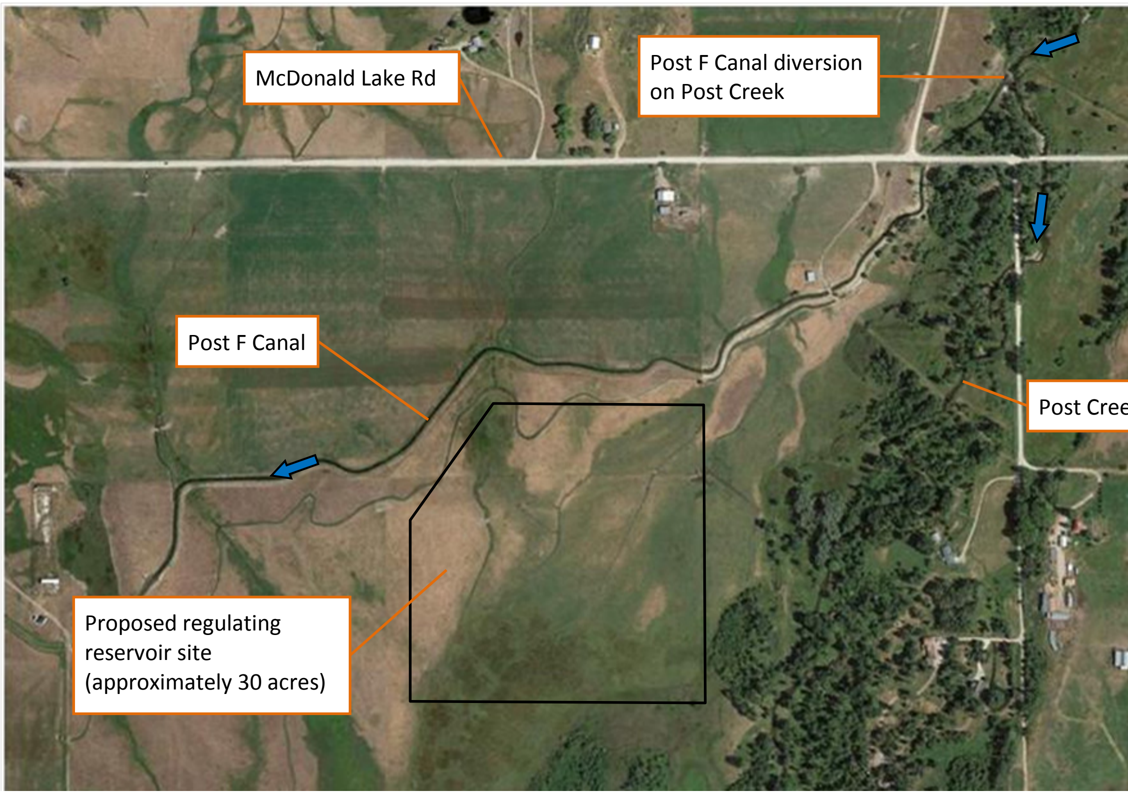

Figure 34. Approximate location for a regulating reservoir on the Post F Canal

Figure 35. Proposed reservoir site from the Post F Canal looking southwest

The approximate 5 ft. and 10 ft. elevation contours for the proposed regulating reservoir site are shown in Figure 36. Based on the existing contours, the reservoir will have the following control characteristics:

1. Control will be gravity in, and pump out.
2. The reservoir will be composed of two individual cells that will be hydraulically connected. This is to minimize the earthwork, and to keep the reservoir levees reasonably low.

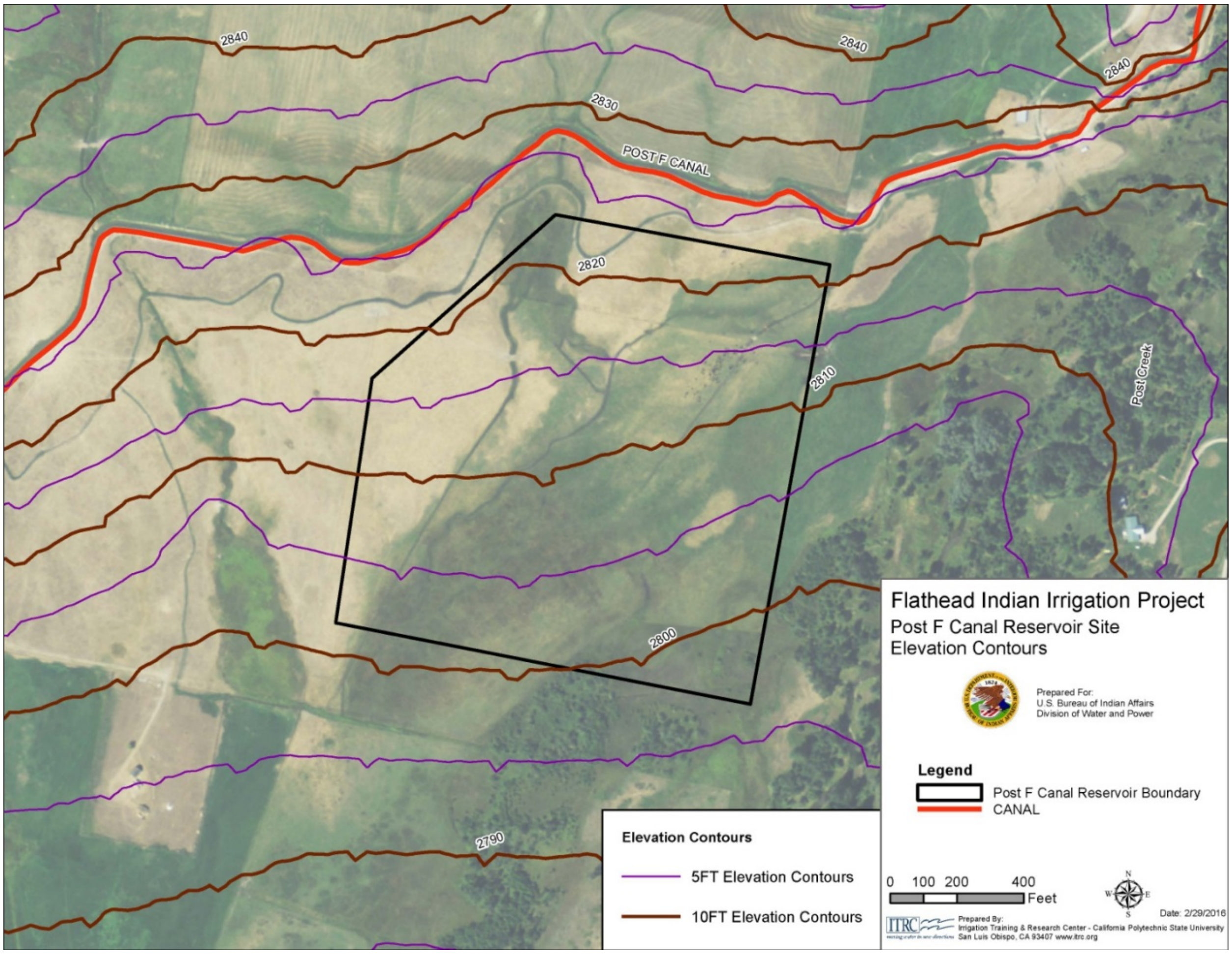

Figure 36. Approximate 5' and 10' elevation contours at the proposed Post F Canal Regulating Reservoir site. Elevations were produced by National Elevation Dataset (NED) provided by the USGS.

Overview of Post F Canal Regulating Reservoir Control

The new Post F Canal Regulating Reservoir will consist of two individual cells with a total minimum live storage of approximately 100 AF. Figure 37 shows an overview of the conceptual inlet and outlet control of the reservoir.

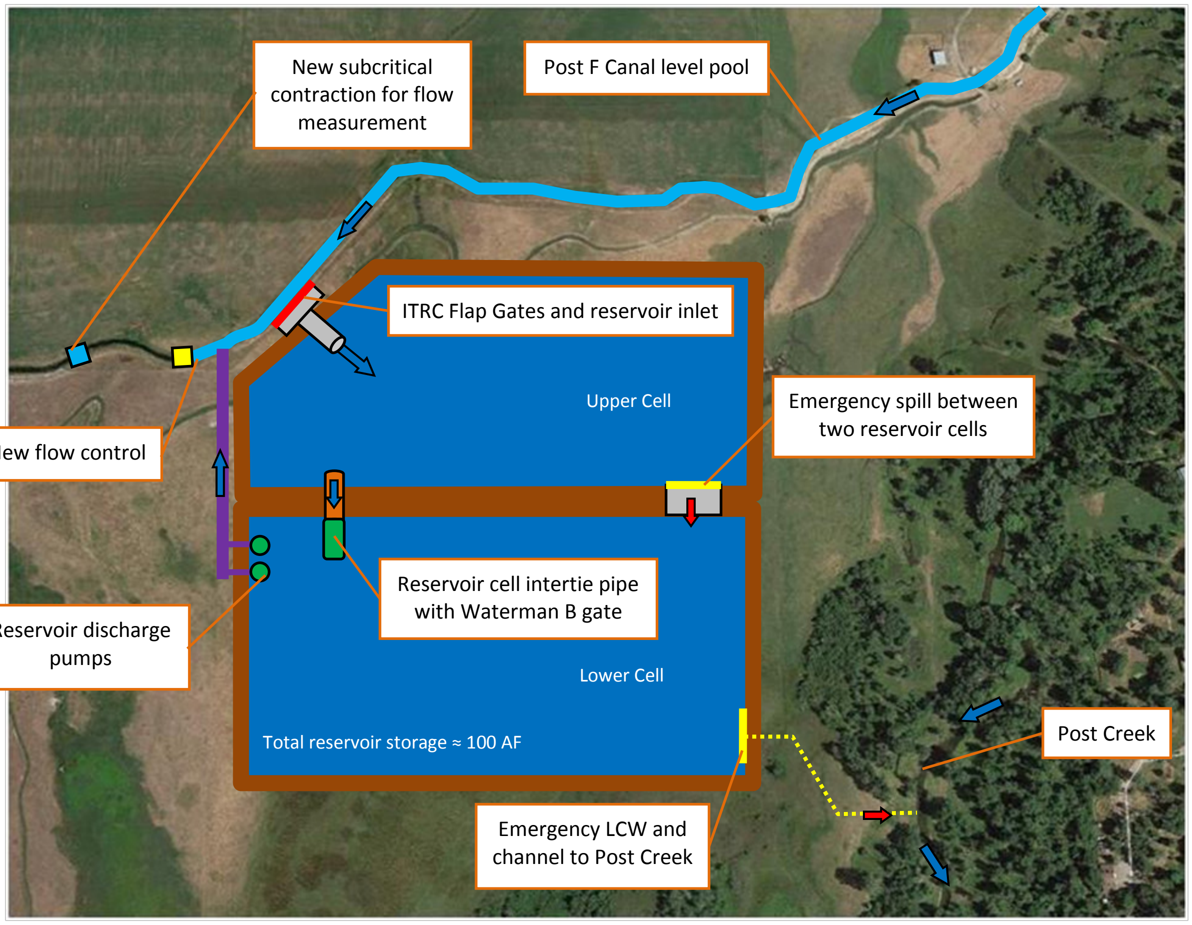

Figure 37. Conceptual control of the Post F Canal Regulating Reservoir

The overall control components of the reservoir will include:

1. Variable flows in the Post F Canal will enter a new level pool maintained by the new regulating reservoir.
2. Based on the existing topography of the site, the reservoir will have two individual cells, an upper and lower cell. The two reservoir cells will be interconnected by a pipeline with a Waterman B float gate installed in the lower cell, at the downstream end of the pipeline. The float valve acts as an automatic on/off valve between the two cells. The movement of water between the two cells will be as follows:
    a. Water will enter the reservoir from the canal and immediately flow into the lower cell.
    b. The lower cell will begin to fill first before the upper cell begins to fill.
    c. Once the water level in the lower cell reaches the maximum target water level elevation, the Waterman B gate will automatically close down, preventing any water (except for some leakage; these gates always leak) from entering the lower cell.
    d. Once the float gate is closed, the upper cell will begin to fill.

   e. Water will be pumped from the lower cell. As it is pumped, any water stored in the upper cell will continually refill the lower cell. The lower cell will fill first. Once it is full, the upper cell will begin to fill. Enroute to the lower cell, water will pass through the upper cell.
3. Emergency spills will be constructed in both cells to prevent the reservoir from overtopping. The two emergency spills will operate as follows:
   a. If the lower cell is already full and the water level in the upper cell exceeds the maximum target water level elevation, the excess flow in the upper cell will automatically spill over the first emergency LCW (located between both cells) and pass into the lower cell.
   b. As the emergency flow from the upper cell spills into the already full lower cell, the excess flow in the lower cell will automatically spill over the second emergency LCW out of the reservoir.
   c. Any emergency spill from the reservoir will be directed into Post Creek via a new emergency channel.
4. The inflow to the reservoir will be controlled by several parallel ITRC Flap Gates installed in the left bank of the Post F Canal.
   a. The ITRC Flap Gates will maintain the water level in the level pool while automatically passing all of the excess flows into the reservoir.
   b. The inflow capacity will be 75 CFS.
   c. All water that passes through the flap gates will enter a concrete inlet box and pass into the reservoir via a new inlet pipeline.
   d. The downstream end of the inlet pipeline will have a Waterman B float gate that will stop the flow rate into the reservoir if the upper cell fills.
5. The reservoir discharge will be controlled by two pumps installed in the lower cell of the reservoir. They will be activated if the canal water level drops below the target water level of the ITRC flap gates. The control logic for the pumps turning on/off, or varying speeds (if VFDs are used), will depend upon the availability of VFD technicians, discussions with USBIA, and the hydraulics of the canal pool. Likely pump characteristics will be:
   a. Two identical pumps
   b. Each will have a VFD control.
   c. Motors will be premium inverter duty.
   d. 20 CFS/pump, with a maximum TDH of 35’
   e. 30” discharge pipe
   f. Input HP to each motor will be about 105 HP
6. A new flow control structure with a manual rectangular sluice gate(s) will restart the flow rate to the downstream portion of the Post F Canal.
7. A subcritical contraction with an ADVM will be constructed approximately 200 ft. downstream of the new flow control structure to measure the flow rate to the downstream portion of the Post F Canal.
8. SCADA will be utilized to remotely monitor water levels, flow rates, and pump characteristics associated with the reservoir system.

Improvements at Head of 36F Canal

Dublin Gulch collects operational canal spill and farmer runoff from the northern portion of the Post Canal Unit. Water in the gulch is dammed up approximately one mile north of the Post F Canal by an existing flashboard structure (see Figure 38 and Figure 40). Two manual canal gates divert water in Dublin Gulch into the 36F Canal through two manual canal gates, and the water eventually spills into the Post F Canal just upstream of the Post F Canal siphon. Excess flows that remain in Dublin Gulch eventually spill into Mission Creek and, with the exception of the Mission H Canal diversion, become unusable by the irrigation project.

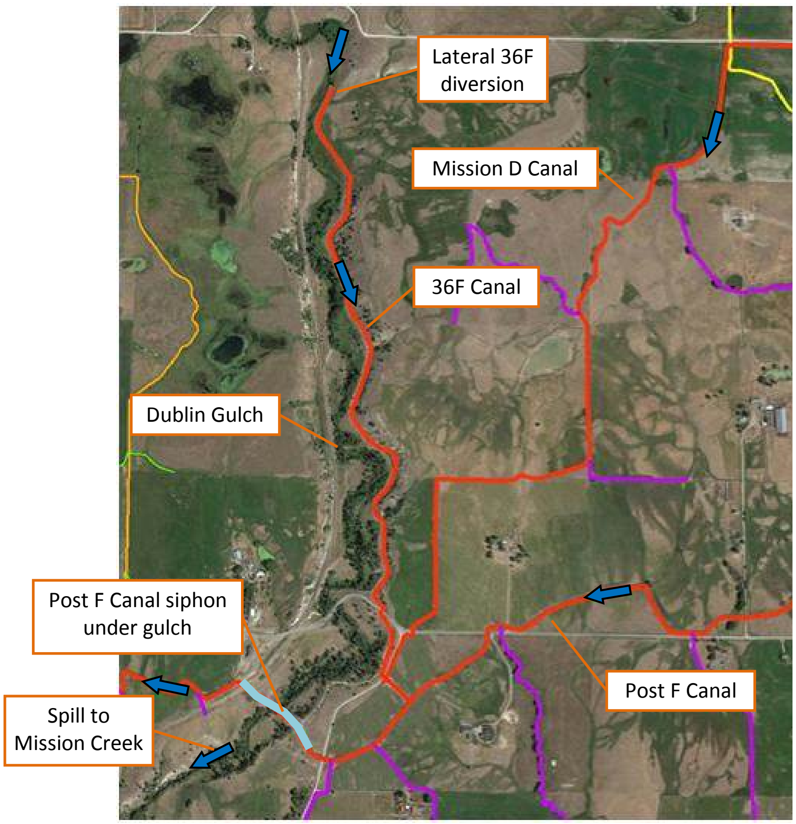

Figure 38. Existing alignment of the 36F Canal

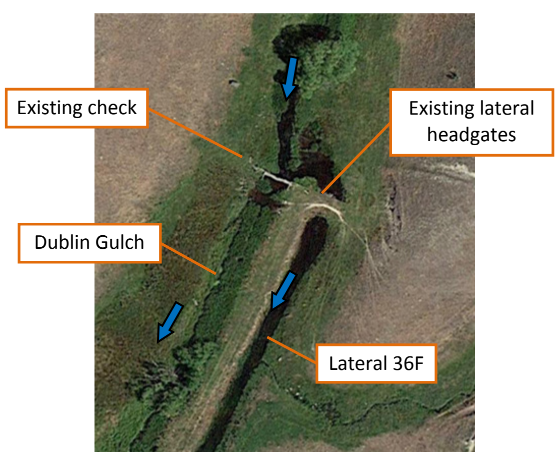

Figure 39. Lateral 36F diversion works

Figure 40. Existing 36F Canal headgates (left) and Dublin Gulch check structure (right)

Control Improvements

The control improvements to be made will be designed to function automatically during the irrigation season so that little to no time will be needed from operators. Figure 41 shows the improved control at the head of the 36F Canal on Dublin Gulch.

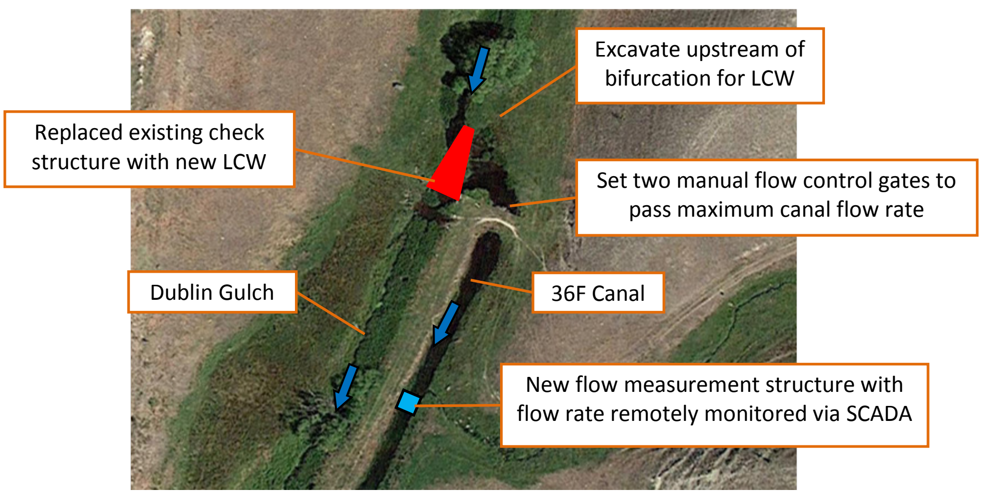

Figure 41. Improvements at head of 36F Canal on Dublin Gulch

The control improvements include the following:

1. The existing flashboard structure will be replaced with a new upstream-facing LCW structure (see Figure 42).
    a. The LCW will have an effective length of approximately 70 ft. to maintain a fairly tight water level upstream of the two flow control gates.
    b. The LCW structure will have a single manual sluice gate on each side of the LCW to:
        i. Pass anticipated large storm flows
        ii. Drain the upstream pool during the non-irrigation season
        iii. Be raised occasionally to flush any sediment buildup on either side of the LCW
    c. The gulch will need to be excavated approximately 100 ft. upstream to make room for the new LCW structure.

2. The two manual flow control gates will be set to pass the maximum flow rate into the 36F Canal with an upstream water level that is just beginning to overtop the LCW.
    a. The two gates will be set at the beginning of the irrigation season and left at that setting for the duration of the season.
    b. The flow rate into the Lateral 36F Canal will be variable, because much of the time, the creek water level will not overtop the LCW.
3. A new flow measurement flume will be constructed approximately 150 ft. downstream from the Lateral 36F Canal headgates to measure the flow entering the canal and eventually spilling into the Post F Canal.
    a. The flow rate through the new flow measurement structure will be remotely monitored by SCADA.
    b. Operators will be able to make proper flow adjustments up at the new Post F Canal Regulating Reservoir based on the amount of water in the 36F Canal spilling into the Post F Canal.

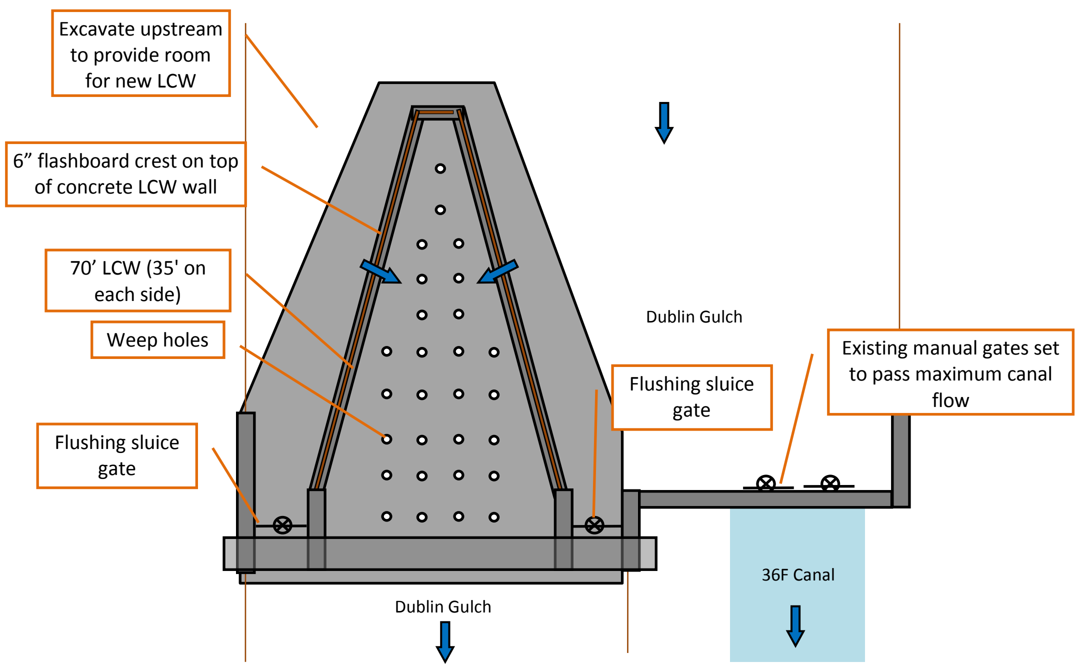

Figure 42. Conceptual plan view of new LCW structure in Dublin Gulch at head of 36F Canal (not to scale)

Post F Canal Limited-Demand Pipelines

The Post F Canal unit services approximately 4,550 acres. Approximately 1,430 acres have direct turnouts originating from the Post F Canal. Limited-demand pipelines were designed to improve delivery flexibility to the remaining 3,120 acres in the Post F Unit.

Assumptions and Pipeline Design

The pipeline design considered a variety of factors:

1. The flow rate requirement is very different from the volumetric allocation. For efficient irrigation with most irrigation systems, the flow rate that is needed is dependent upon the

irrigation system design. For example, a wheel line (side roll) sprinkler design will have a design flow rate requirement. The turnout must meet that flow rate requirement.
2. The volumetric limitation can be enforced if USBIA operators have easy access to accurate flow meters with totalizers. In other words, a high flow rate can be allowed, but not 24/7.
3. The design flow rate for each parcel was 8 GPM/acre. A check of various sprinkler designs in the area indicated that this was adequate.
4. Major pipelines are located adjacent to roads where possible for ease of access for flow and volume measurement by FIIP staff.
5. All turnout flow meters and emergency on/off valves are located adjacent to roads. The normal operating valves and final discharge flanges are located at the high point of each parcel.

Other considerations for the conceptual design include:
1. The maximum velocity in the large pipelines is limited to 5 feet/second. There should be no water hammer damage at these velocities, because the total flow rate cannot be stopped simultaneously.
2. Maximum pipeline pressures (which occur under static conditions in this case) must be less than 75% of the pressure rating of the pipes.
3. A minimum pressure rating of 80 psi is required for all pipes 6" and above. These minimum pressures are selected based on the properties needed for external soil loading and installation requirements.

Field Turnout Design

In the *Modernization Plan* for the Post F area, the high point of every parcel would be supplied by an individual meter and shutoff valve that is located along a road. Details of the field turnout designs for pumps are found in Appendix A.

Filtration at the Canal

Relatively clean water is important for pipeline applications such as this. For recommendations on filtration, refer to Appendix B.

Pipeline Layout

The pipeline design (Figure 43) includes nine separate pipelines along the Post F Canal. Each pipeline is relatively short in length and each serves 16 or fewer turnouts.

The benefits of this pipeline layout are:
- Increased flexibility for deliveries to farmers
- Ease of access to turnouts for FIIP staff
- The lower capacities in these relatively short few laterals makes these pipelines very easy to monitor and manage.

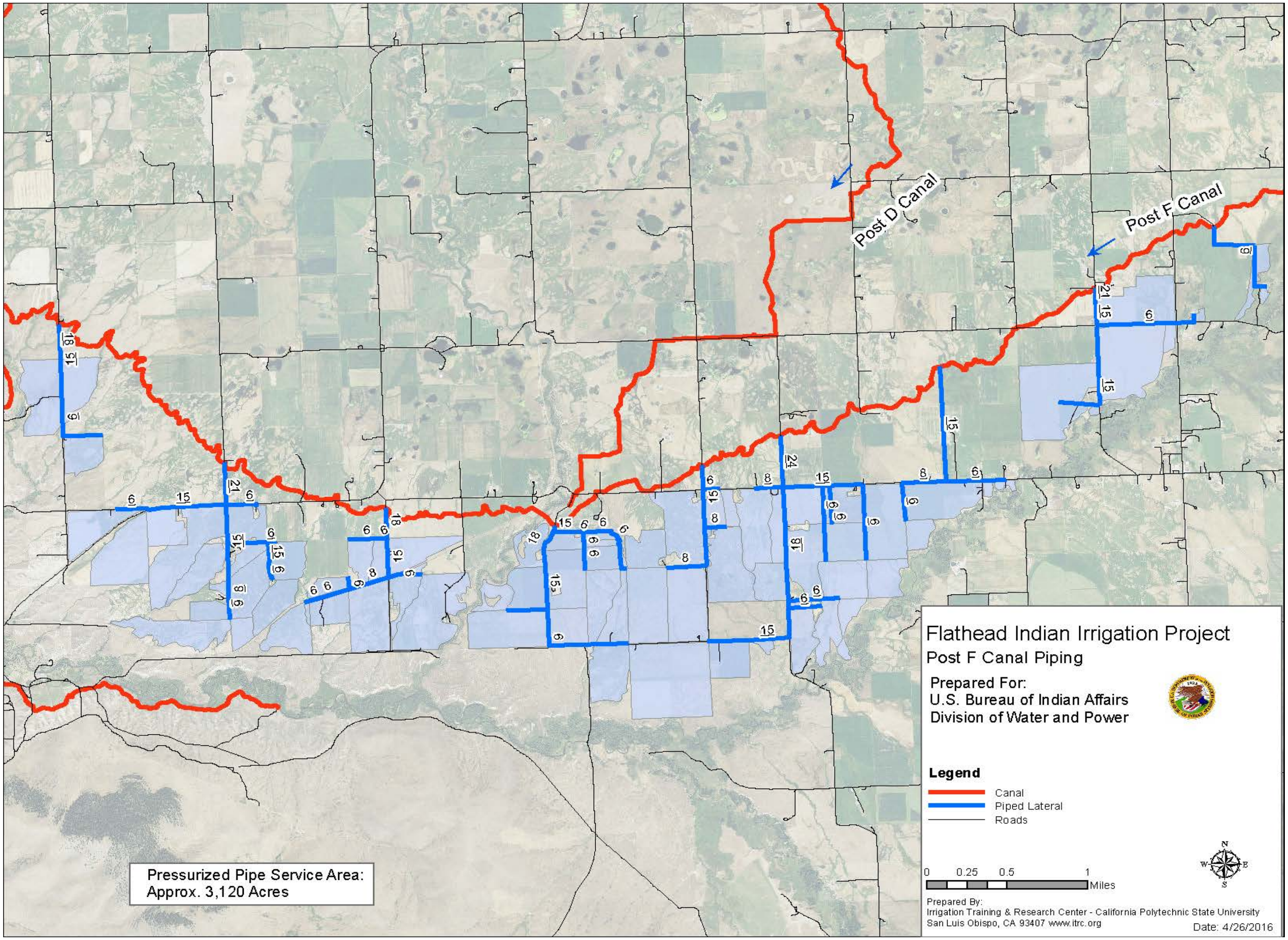

Figure 43. Layout of piped laterals in Post F Unit

Post F Pipeline Cost

The service area and cost for all nine pipelines is summarized in Table 2. This cost equates to approximately $1,800 per acre.

Table 2. Irrigated acreage and construction cost for Post F area pipelines

Pipeline	Service Area (Acres)	Cost
Post F	3,120	$5,627,200

Improved Water Level Control along Post F Canal

The water level control down the entire length of the Post F Canal will need to be significantly improved. There are two different aspects to this:

1. Vegetative and algae growth in the canal needs better management.
2. The water level control structures need to be re-designed.

The existing flashboard structures should be replaced with new LCW structures along the entire length of the Post F Canal, in order to accomplish the following:

- All of the existing laterals along the Post F Canal will be converted to limited-demand"pipelines, which will cause frequent flow rate variations in the main canal.
    - Farmers will have the ability to start/stop flows at their turnouts at any time.
    - When a farmer stops taking water, that flow will no longer enter the pipeline; rather, it will remain in the canal.
- More frequent flow rate changes will likely be made at the head of the Post F Canal. The new regulating reservoir will allow operators to fairly easily compensate for changing Post F Canal needs, and the water level in the Hillside Reservoir.
- The existing canal infrastructure is not capable of maintaining a constant upstream water level over a wide range of flow rate changes.
    - This would cause the direct farmer turnouts on the Post F Canal (which would not be piped) to have constantly varying turnout flow rates.
    - The LCW will maintain a fairly constant upstream water level while automatically handling all flow rate variations in the Post F Canal.
- Variable flows will be spilling into the Post F Canal from the 36F Canal, the Post D Canal, and runoff from fields north of the canal.

It will be important to clean out the canal, widen it several feet, and increase the flow capacity.

Figure 44 shows the approximate locations of either new or improved water level control structures. The map also shows the approximate locations of improved waste structures that will be necessary for emergency situations. Table 3 contains a summary of the improved water level control along the Post F Canal.

A good elevation and cross section survey of the entire Post F Canal should be done. It may be possible to change some canal cross sections (raise banks, widen the canal, etc.) and reduce the number of check structures that are needed.

Table 3. List of new or improved water level control structures along Post F Canal

No.	Longitude	Latitude	Status	Structure Type	Design Length (ft.)
1	-114.0918	47.4082	New Structure	LCW	50
2	-114.1021	47.4058	Improved Structure	LCW	50
3	-114.1091	47.4022	Improved Structure	LCW	50
4	-114.1187	47.3988	Improved Structure	LCW	50
5	-114.1287	47.3956	New Structure	LCW	50
6	-114.1334	47.3927	New Emergency Spill	Flap Gate	--
7	-114.1351	47.3919	Improved Structure	LCW	50
8	-114.1408	47.3924	Improved Structure	LCW	50
9	-114.1504	47.3896	Improved Structure	LCW	50
10	-114.1542	47.3880	Improved Structure	LCW	50
11	-114.1581	47.3880	Improved Structure	LCW	50
12	-114.1610	47.3871	New Structure	LCW	50
13	-114.1680	47.3848	Improved Structure	LCW	50
14	-114.1750	47.3845	Improved Structure	LCW	50
15	-114.1804	47.3818	New Emergency Spill	Flap Gate	--
16	-114.1813	47.3823	Improved Structure	LCW	50
17	-114.1903	47.3831	Improved Structure	LCW	45
18	-114.2007	47.3828	Improved Structure	LCW	45
19	-114.2035	47.3841	Improved Structure	LCW	45
20	-114.2070	47.3836	Improved Structure	LCW	45
21	-114.2136	47.3855	Improved Structure	LCW	45
22	-114.2143	47.3858	Improved Structure	LCW	45
23	-114.2193	47.3868	Improved Structure	LCW	45
24	-114.2242	47.3889	Improved Structure	LCW	45
25	-114.2257	47.3900	Improved Structure	LCW	45
26	-114.2313	47.3937	Improved Structure	LCW	40
27	-114.2347	47.3971	Improved Structure	LCW	40
28	-114.2378	47.3993	Improved Structure	LCW	40
29	-114.2408	47.4004	Improved Structure	LCW	40
30	-114.2456	47.4028	New Structure	LCW	40

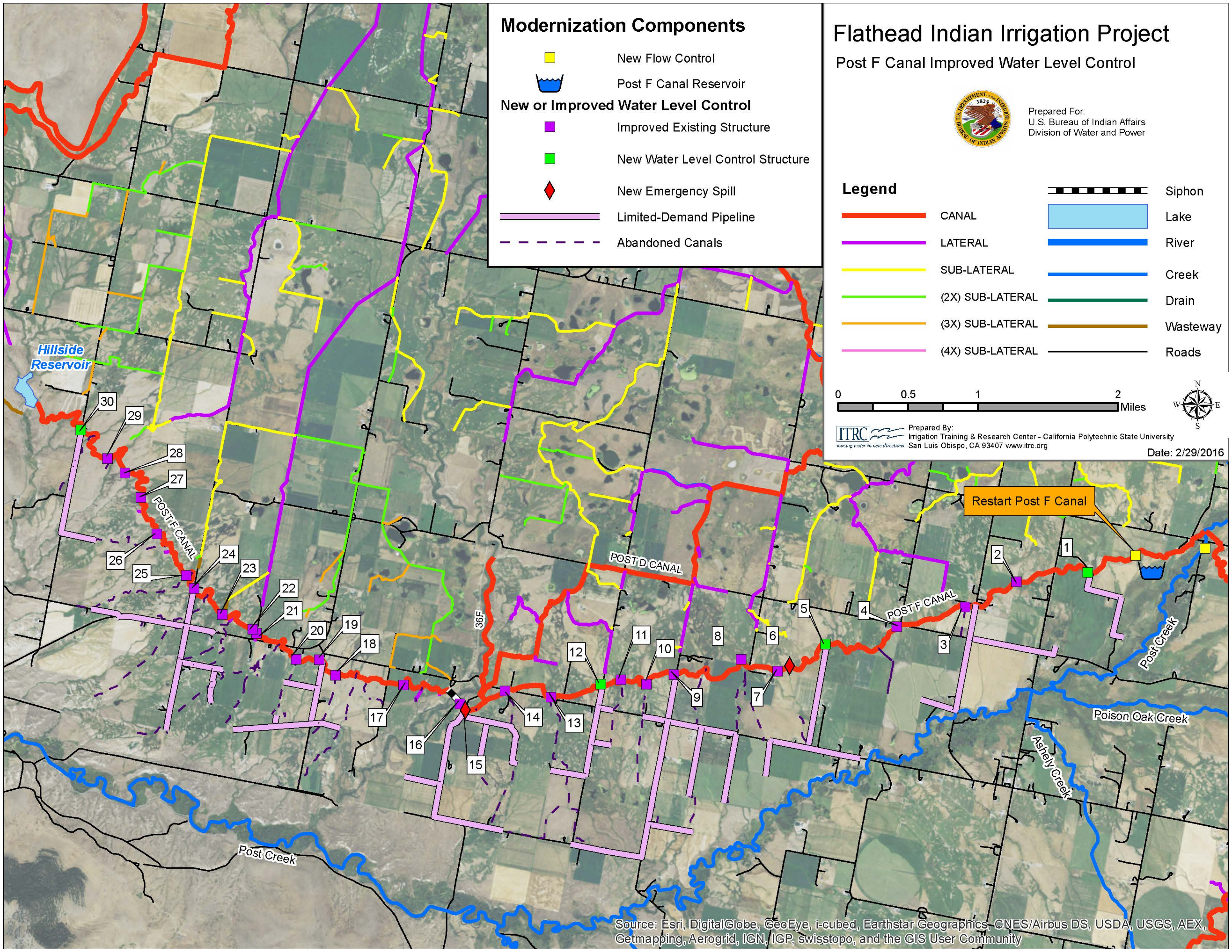

Figure 44. Location of new or improved water level control and waste structures along the Post F Canal

Figure 45 shows a conceptual example of the new LCW structures to be utilized along the Post F Canal superhighway. The advantages to the presented LCW design are:

- The construction is relatively simple, so the cost of the entire structure is relatively low.
- The structure does not need to be designed by a civil engineer.
- The crest height can easily be adjustable adding or removing flashboards.

Figure 46 and Figure 47 show similar examples of existing LCW structures installed in two irrigation districts in California.

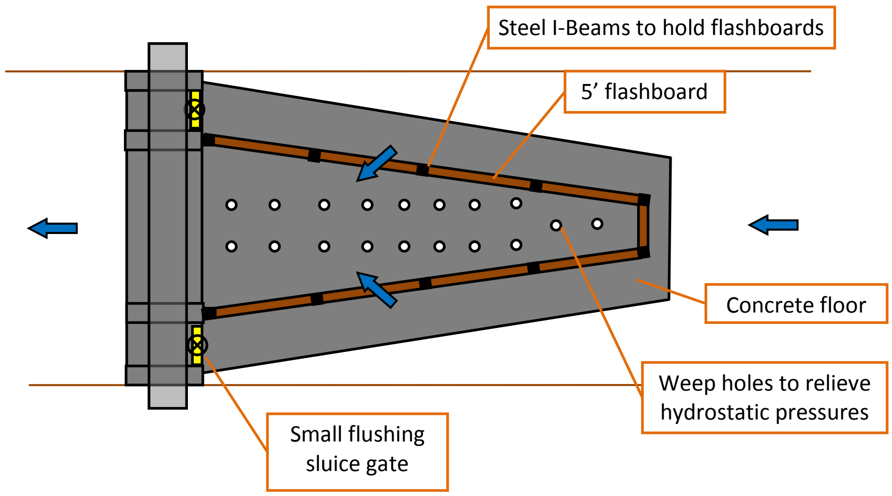

Figure 45. Example of new LCW structures to be constructed along the Post F Canal superhighway (not to scale)

Figure 46. Somewhat similar LCW installed at Turlock ID

Figure 47. Somewhat similar LCW in Fresno ID, but lacking the side sluice gates and the tapered configuration of the LCW itself (although the banks are tapered). This illustrates a construction technique for tying the walls together for strength, and providing access for operators to clean off the weir crest.

New Emergency Spill

Figure 48 shows the existing location of a manual waste gate (see Figure 49) installed in the left canal bank of the Post F Canal. Any water intentionally diverted through the waste gate spills to a small drain that crosses under Dublin Gulch Road and eventually spills to Post Creek.

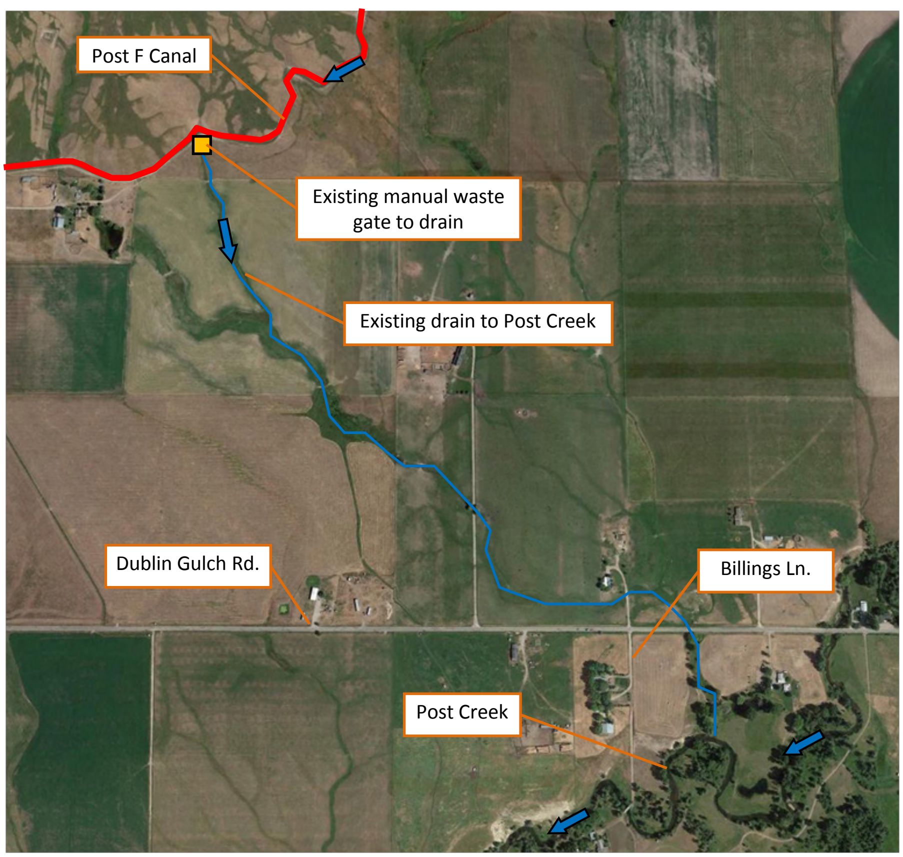

Figure 48. Existing manual waste gate location on the Post F Canal and drain to Post Creek

Figure 49. Existing manual waste gate on the Post F Canal. Photo from HKM 2008 report (CW-63).

The existing waste gate will be replaced with a new ITRC Flap Gate in order to automatically spill all emergency flows from the upstream canal portion if the maximum canal capacity is ever exceeded. With the construction of the new limited-demand pipelines, emergency flows will occur in the Post F Canal when the power goes out in the area due to the turnouts that operate pumps for their wheel lines and center pivots. The flap gate will provide automatic safety to the canal system.

Figure 50 shows a conceptual side view of an ITRC Flap Gate to be used for an emergency spill on the Post F Canal.

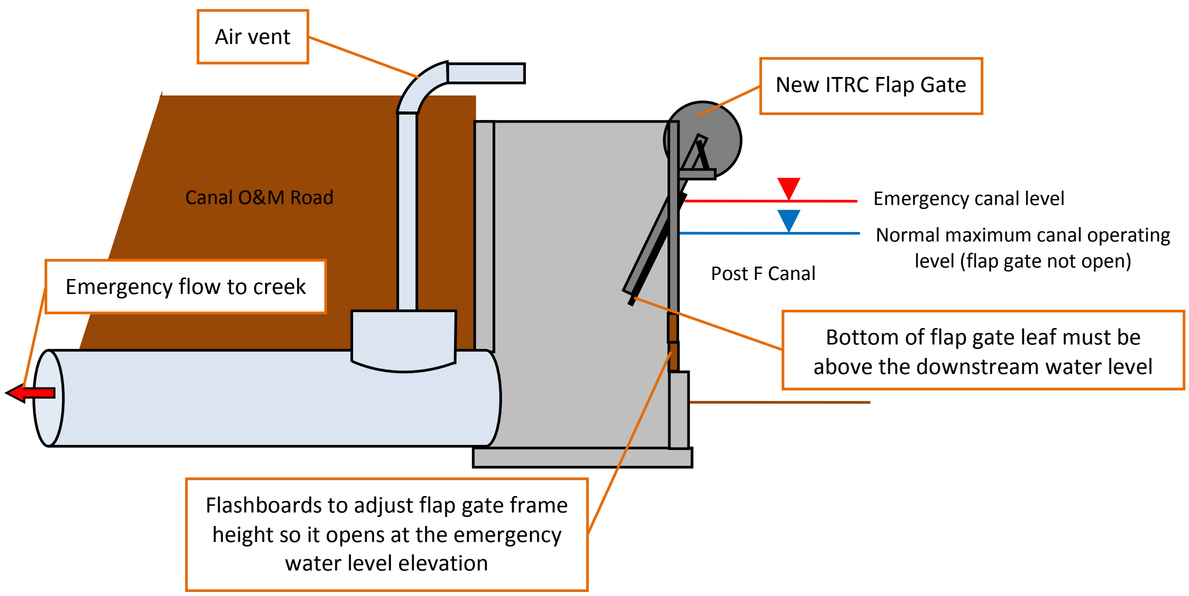

Figure 50. Conceptual side view of improved emergency spill structure for the Post F Canal (not to scale)

The existing drain to Post Creek will need to be evaluated to see if it can handle the anticipated emergency flow capacity. Portions of the existing drain may need to be excavated.

Improvements Upstream of Post F Canal Siphon

A 30" siphon (approximately 650 ft. long) shown in Figure 51 conveys water in the Post F Canal under Dublin Gulch. Approximately 100 ft. upstream of the siphon is a single farmer turnout that experiences constantly varying water levels since no check structure is present downstream to maintain the water level. Approximately 350 ft. upstream at Curlew Drive are the following:

- A single bay flashboard check structure used (see Figure 52) to maintain the upstream water level for Lateral 35F and several other turnouts.
- A manual canal waste gate to pass flow from the canal to Dublin Gulch. The existing wasteway passes under the road and through the downhill farmers' fields.

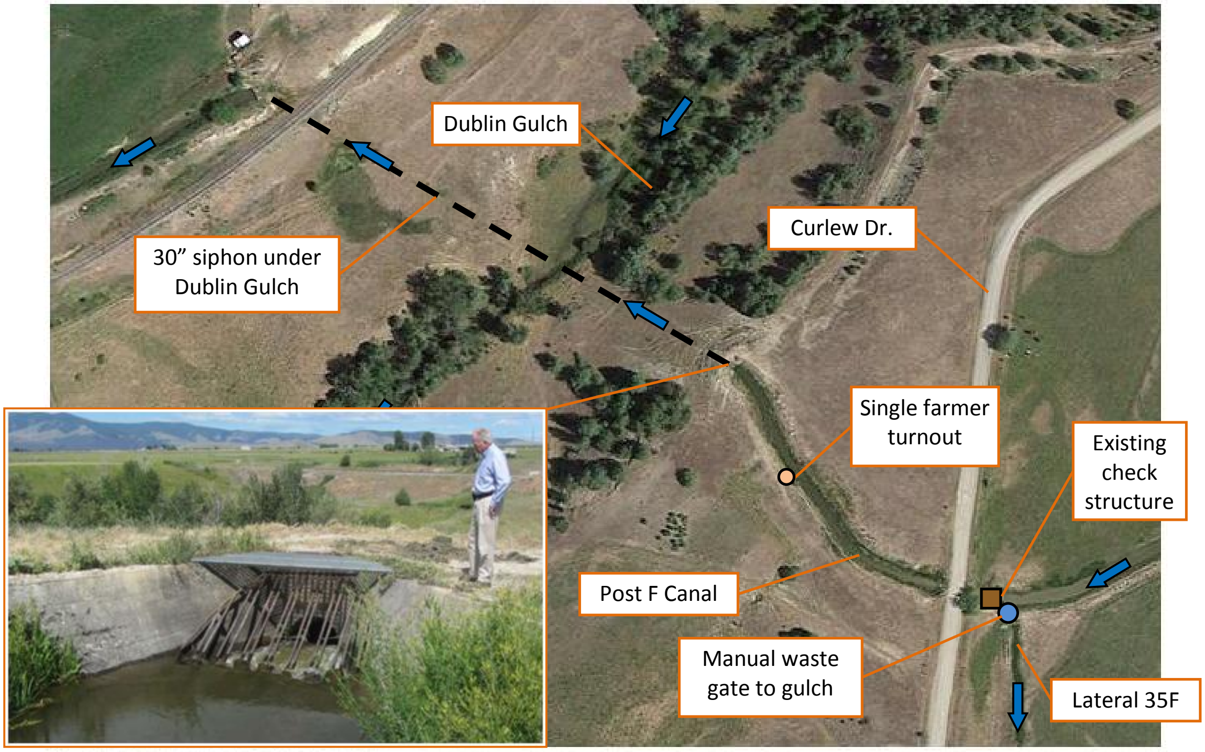

Figure 51. Post F Canal siphon under Dublin Gulch

Figure 52. Existing check structure and waste gate in the Post F Canal upstream of Curlew Dr.

At a minimum, the modifications shown in Figure 42 could be made to improve control, provide better service, and provide automatic safety of the canal system. The improved control includes:

1. Both the existing check structure and waste gate at Curlew Drive could be removed. A new LCW can be installed to replace the existing check structure.
2. A new emergency flap gate structure will be installed in the left canal bank upstream of the siphon.
    a. The flap gate will automatically open once the maximum target water level in the Post F Canal is exceeded.
    b. A new emergency wash will be constructed to avoid erosion.
3. A new automatic trash screen will be installed directly in front of the siphon entrance to prevent any debris or trash from potentially clogging the siphon.

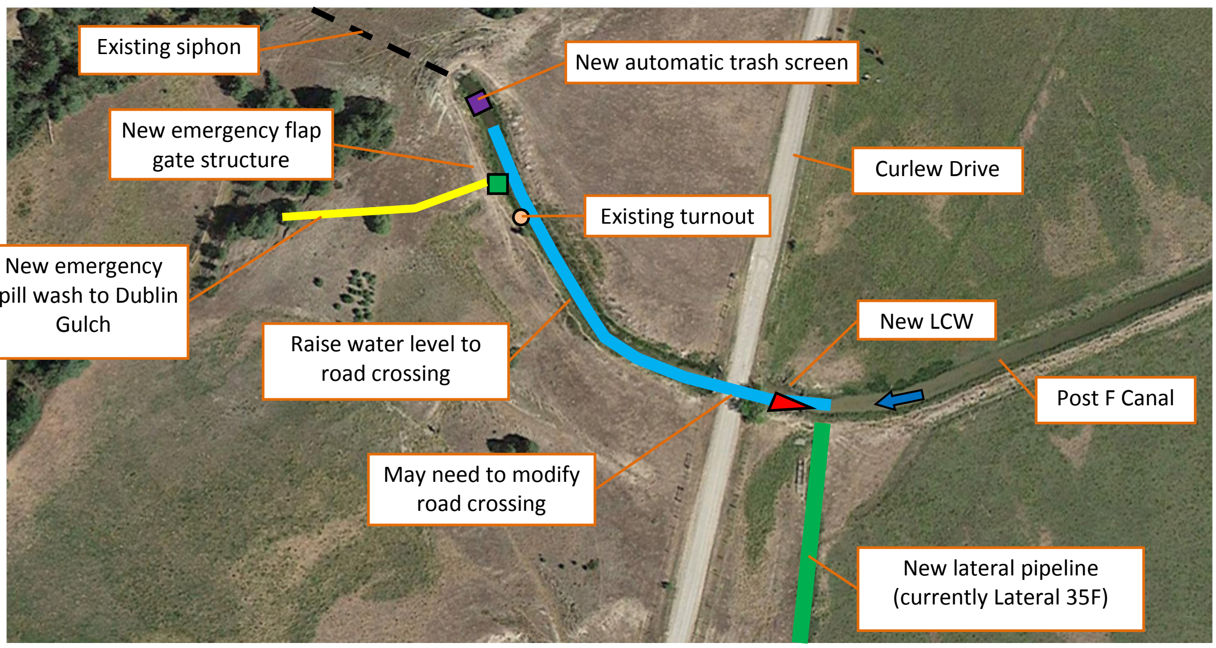

Figure 53. Conceptual improvements upstream of Post F Canal siphon

Siphon Replacement

The larger question is whether the existing 30" siphon is large enough to pass the increased flows that are likely to pass this point. Occasional larger flows are expected because of the increased flexibility upstream (with the new pipelines). Consistently larger flows may occur because of the increased capture of water from Dublin Gulch, and the future use of Hillside Reservoir to serve a large irrigated area.

The hydraulics of the siphon need to be examined. The difference in elevation of the canal surfaces upstream and downstream of the siphon, at a known flow rate, should be measured. Based on that, one can examine options such as increasing the flow by increasing the upstream water level, decreasing the downstream water level, or improving inlet conditions.

Improved Water Level Control along Post D Canal

The Post D Canal diverts an estimated 50 CFS from Ninepipe Reservoir to service numerous laterals and turnouts in the Post Canal Unit. The Post D Canal does not appear to be easily manageable for the following reasons:

- The canal covers a large agricultural area.
- There are 20 individual check structures that maintain the upstream water level for laterals and turnout headgates.
- The existing check structures are not capable of easily handling flow rate variations without affecting the canal water level. Fluctuating canal water levels result in continuously varying turnout flow rates.

The Post D Canal operates eventually as a flow-through system since operational spills from the main canal and laterals end up in the Post F Canal. By improving the existing water level control structures along the Post D Canal, the canal system would have the ability to essentially handle itself over a wide range of canal flows. Therefore, operators would spend less time managing the water levels down the Post D Canal, and be able to focus more time on the turnout deliveries or in other parts of the canal unit.

Figure 54 shows the improved existing water level control structures along the Post D Canal. Table 4 contains a list of the proposed improved existing water level control structures. Table 4 assumes all structures are LCWs designed similar to the configuration shown in Figure 45. Each structure should be evaluated to see if there is a sufficient elevation drop across the structure to accommodate an ITRC Flap Gate for improved water level control. If so, the flap gate should be used rather than the LCW, because:

- The flap gate is cheaper and faster to construct.
- It can possibly use the existing check structure (this assumes that it is structurally sound).
- The flap gate can hold a tighter target water level elevation.

Table 4. List of improved water level control structures along Post D Canal

No.	Longitude	Latitude	Structure Type	Design Length (ft.)
1	-114.1498	47.4525	LCW	40
2	-114.1560	47.4491	LCW	40
3	-114.1503	47.4426	LCW	30
4	-114.1488	47.4390	LCW	30
5	-114.1393	47.4254	LCW	30
6	-114.1395	47.4125	LCW	20
7	-114.1397	47.4101	LCW	20
8	-114.1502	47.4091	LCW	20
9	-114.1502	47.4078	LCW	20
10	-114.1502	47.3992	LCW	20
11	-114.1505	47.4030	LCW	15
12	-114.1609	47.3992	LCW	15
13	-114.1661	47.3991	LCW	15
14	-114.1686	47.3960	LCW	15
15	-114.1718	47.3922	LCW	15
16	-114.1715	47.3887	LCW	15
17	-114.1506	47.4059	LCW	15
18	-114.1729	47.3884	LCW	15
19	-114.1743	47.3883	LCW	15
20	-114.1768	47.3883	LCW	15

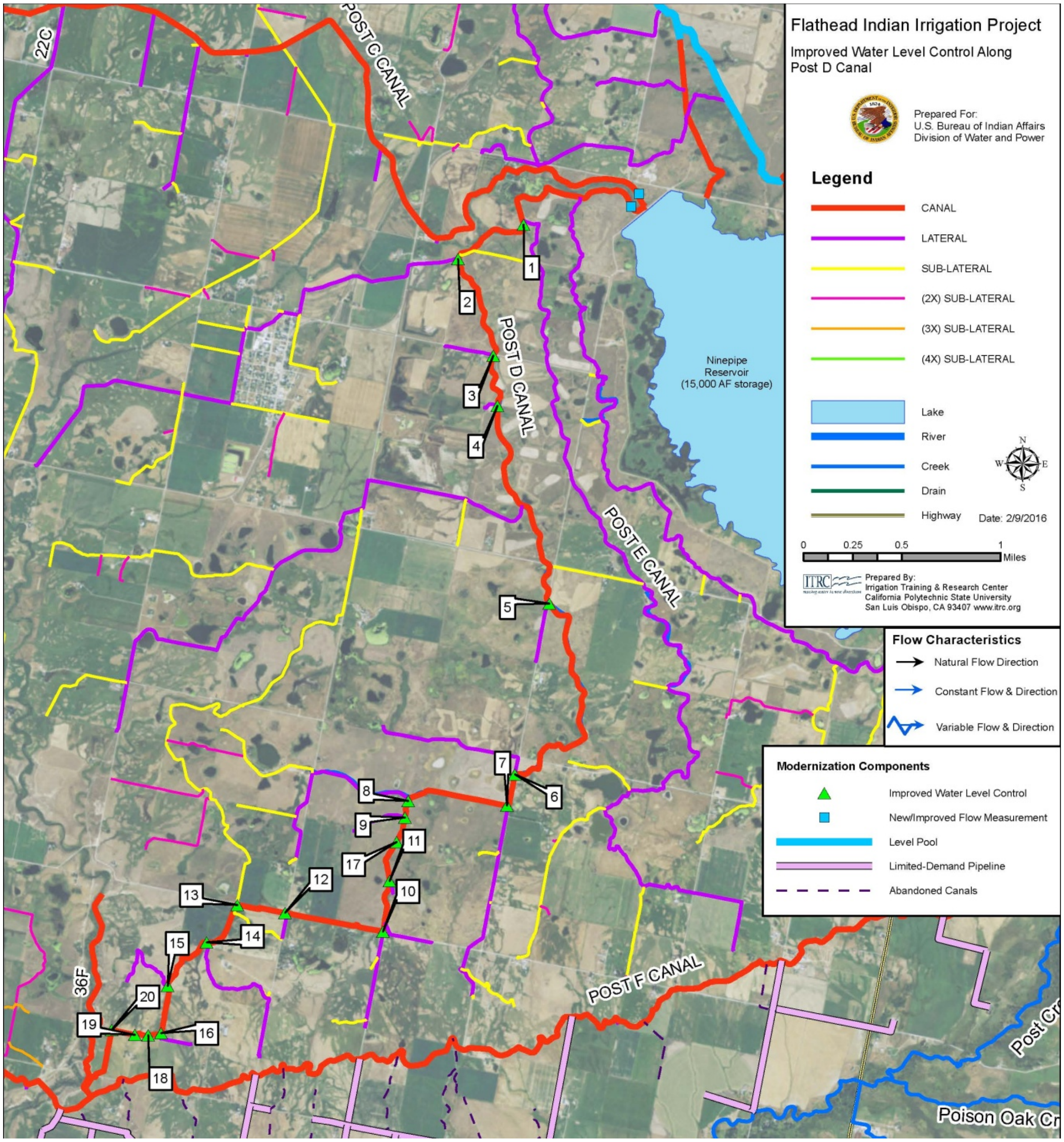

Figure 54. Improved water level control along the Post D Canal

Flow Measurement to Hillside Reservoir

Figure 55 shows an aerial image of the Hillside Reservoir, which has a total storage volume of approximately 90 AF. The reservoir is currently under-utilized due to the fact that the reservoir is almost always full because the Hillside Ditch has a very low flow capacity. This reservoir can serve an important function in buffering flows and supplying large irrigated areas downstream.

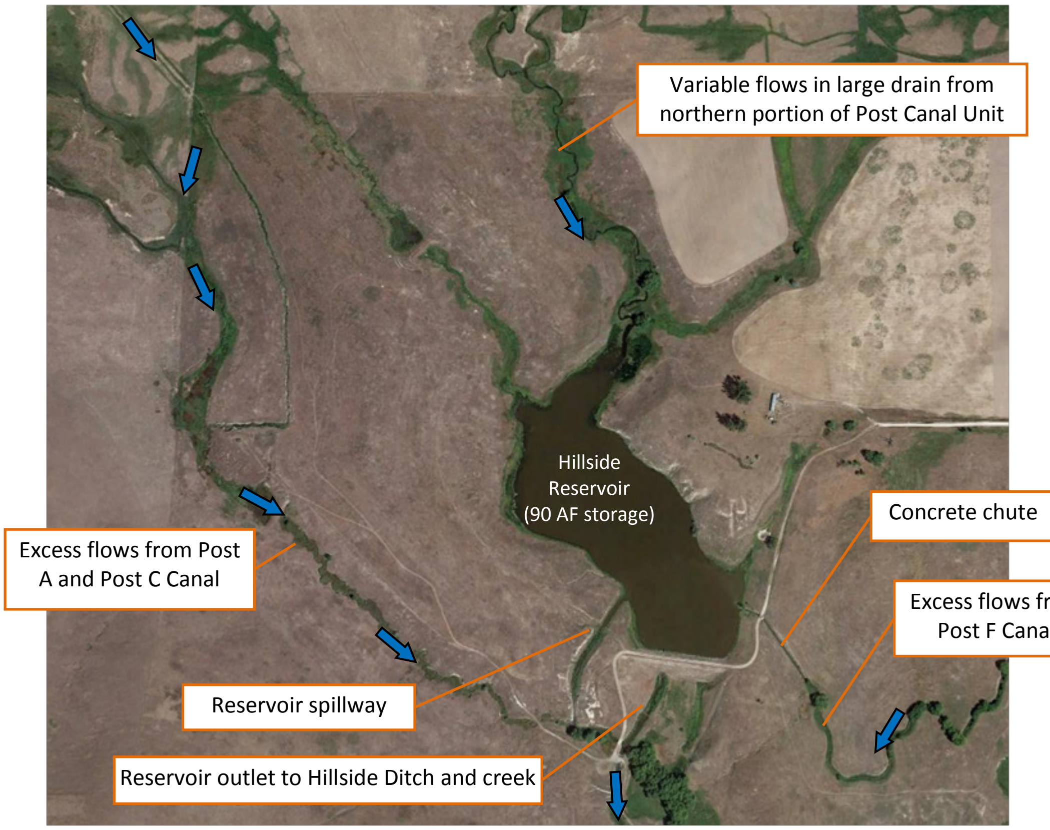

Figure 55. Aerial of Hillside Reservoir

Figure 56 shows the Post F Canal concrete chute drop into Hillside Reservoir. Figure 57 shows the existing control at the Hillside Reservoir discharge. A check and waste structure maintains the water level in a pool so that a delivery can be made to the Hillside Ditch.

Figure 56. Post F Canal chute into Hillside Reservoir

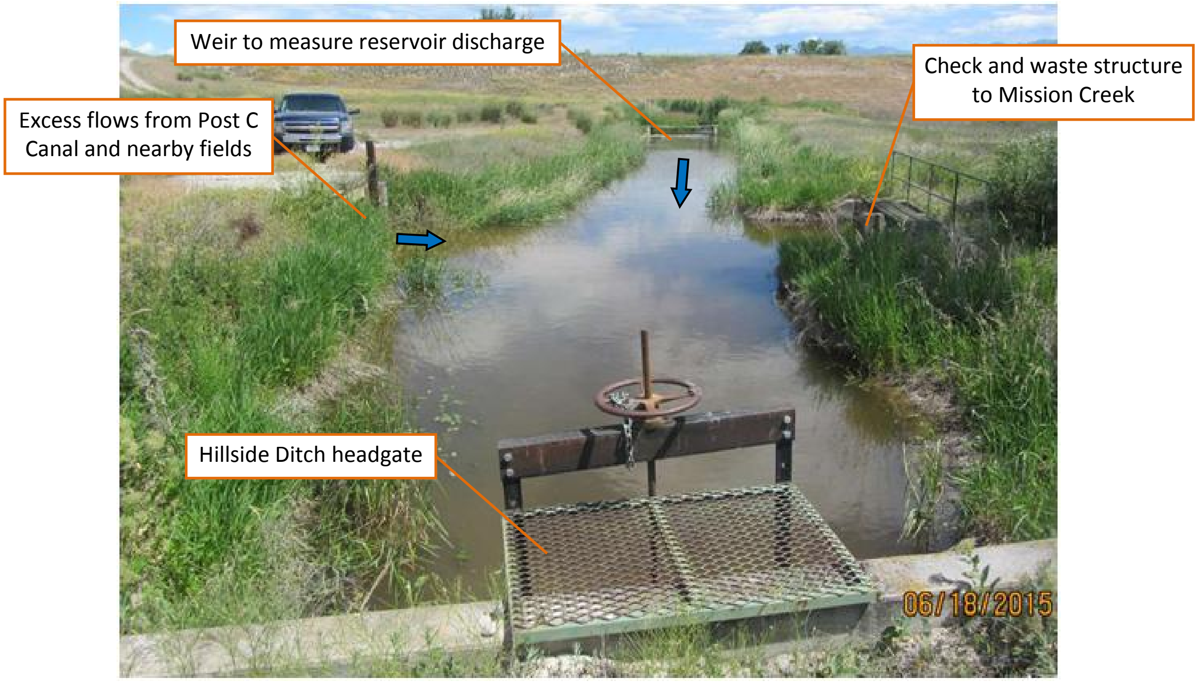

Figure 57. Existing control downstream of Hillside Reservoir

Modernization Changes at Hillside Reservoir

The modernization changes at the Hillside Reservoir are shown in Figure 58. They consist of:

1. Flows into the reservoir will be measured and possibly monitored via SCADA.
2. Drain flows from the Post C Canal, which would normally bypass the reservoir, will be redirected into the reservoir.
   a. A new 1,300 ft. drainage ditch will be constructed that will pick up field runoff and all operational spill from the Post C Canal that would normally bypass Hillside Reservoir.
   b. A new earth dam will be constructed in the existing wasteway so that all water is diverted into the new drainage ditch.
   c. A new Replogle flume will be constructed in the drainage ditch to measure the flow rate.
3. A new Hillside Pipeline will be directly connected to the reservoir discharge. The gate at the head of that pipeline will typically be wide open, to provide water "on demand" to downstream users.

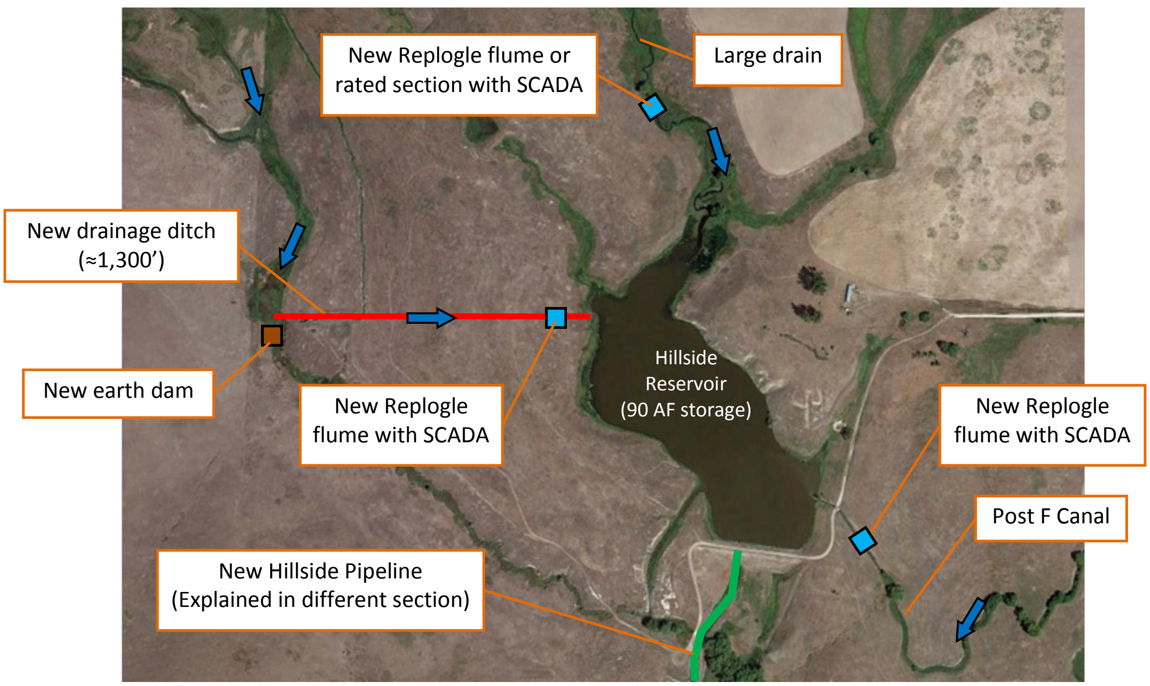

Figure 58. New flow measurement to Hillside Reservoir