Irrigation
Training &
Research
Center

Flathead Indian Irrigation Project

Camas Canal Unit Modernization

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

April 2016

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CAMAS CANAL UNIT MODERNIZATION

Modernization Plan

The Camas Canal Unit is an isolated service area in the northwest portion of the Flathead Irrigation Project that supplies water to approximately 13,000 irrigated acres.

The basic goals for the modernization plan in the Camas Canal Unit are:
- Maximize utilization of in-stream flows from Mill Creek to prolong storage in Hubbart Reservoir
- Simplify management of the canal unit for operators
- Provide more flexible and reliable water deliveries to farmers
- Re-circulate operational spills and farmer runoff near the southern-most part of the canal unit, to maximize the overall Unit efficiency and flexibility

Figure 1 and Figure 2 show the overall conceptual modernization improvements in the Camas Canal Unit. The key improvements include the following:
1. The Hubbart Reservoir satellite SCADA system will be modified, along with a PLC and gate actuators to remotely control the discharge gate(s). Flow measurement at the reservoir outlet will also be improved.
2. Flow limiting structures will be constructed near the head of the Camas A Canal at the main diversion on the Little Bitterroot River as well as at the inflow from Mill Creek. Variable flow will be diverted into the Camas A Canal, up to the maximum canal capacity. The current operation seeks a constant flow into the Camas A Canal. The new strategy will be to:
    a. Maintain in-stream flows on the Little Bitterroot River
    b. Maximize diversions into the Camas A Canal from stream inflows
    c. Minimize early season usage from the Upper and Lower Dry Fork reservoirs
3. The Camas B and D Canals will have new flow "restart" points near the Lower Dry Fork Reservoir.
4. A new 50 AF regulating reservoir will be constructed between the Camas B and C Canals near Kopp Road in order to:
    a. Buffer flows in the Camas C Canal by maintaining a constant water level in a new level pool in the canal.
    b. Capture excess flows in the Camas B Canal to then be used in the Camas C Canal.
    c. Capture return flows from Garden Creek and Dry Fork Creek. Creek flows will be captured using pumps with variable frequency drives (VFDs).
5. The Camas C Canal will have a new flow "restart" point near the new regulating reservoir.
6. Water level control will be improved along the main canals by constructing either long-crested weirs (LCW) or ITRC flap gates.
7. New or improved flow measurements sites will be constructed at key locations throughout the canal system to ease operation management.
8. Supervisory Control And Data Acquisition (SCADA) will be incorporated to help operators make effective decisions for managing the Camas Canal Unit.

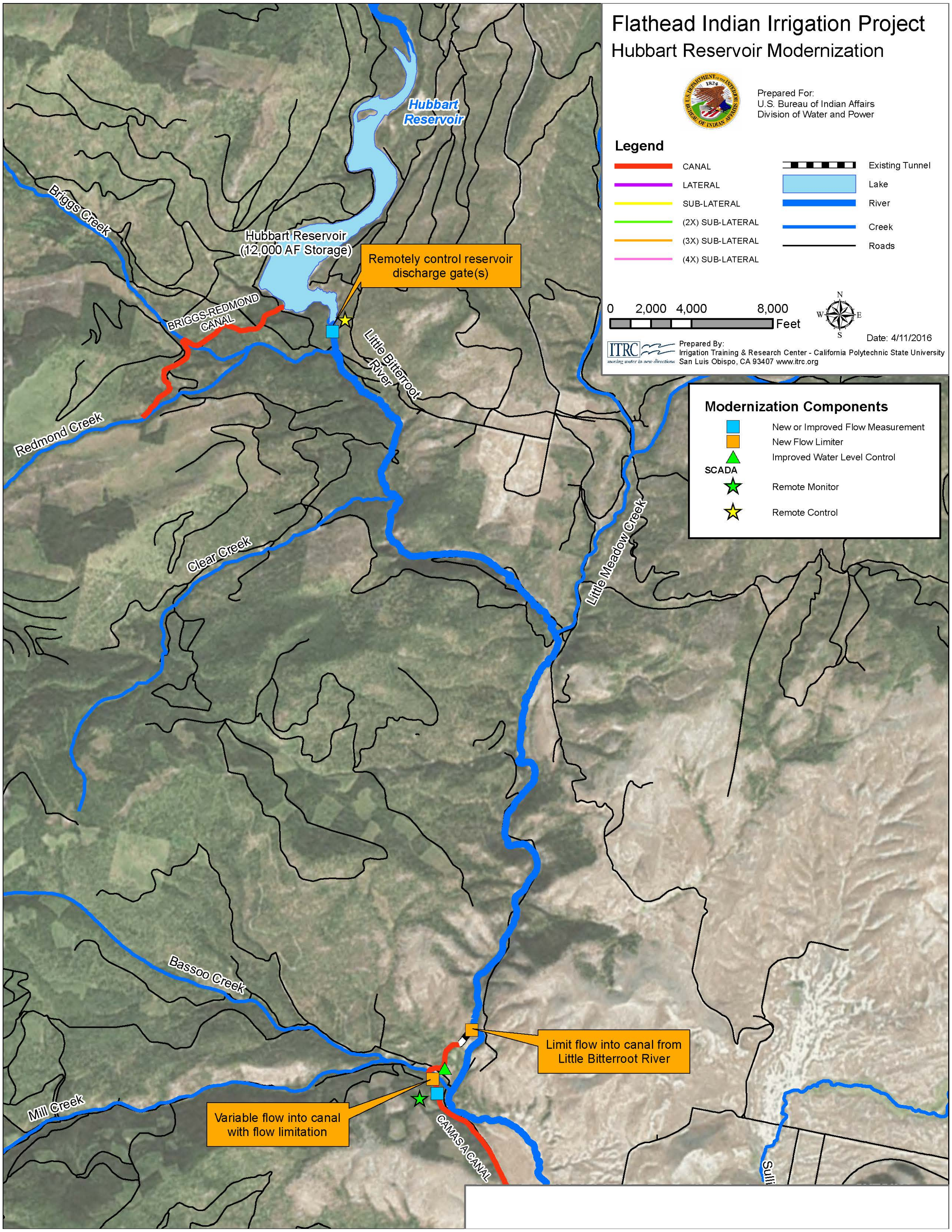

Figure 1. Modernization improvements to Hubbart Reservoir and at the head of the Camas A Canal

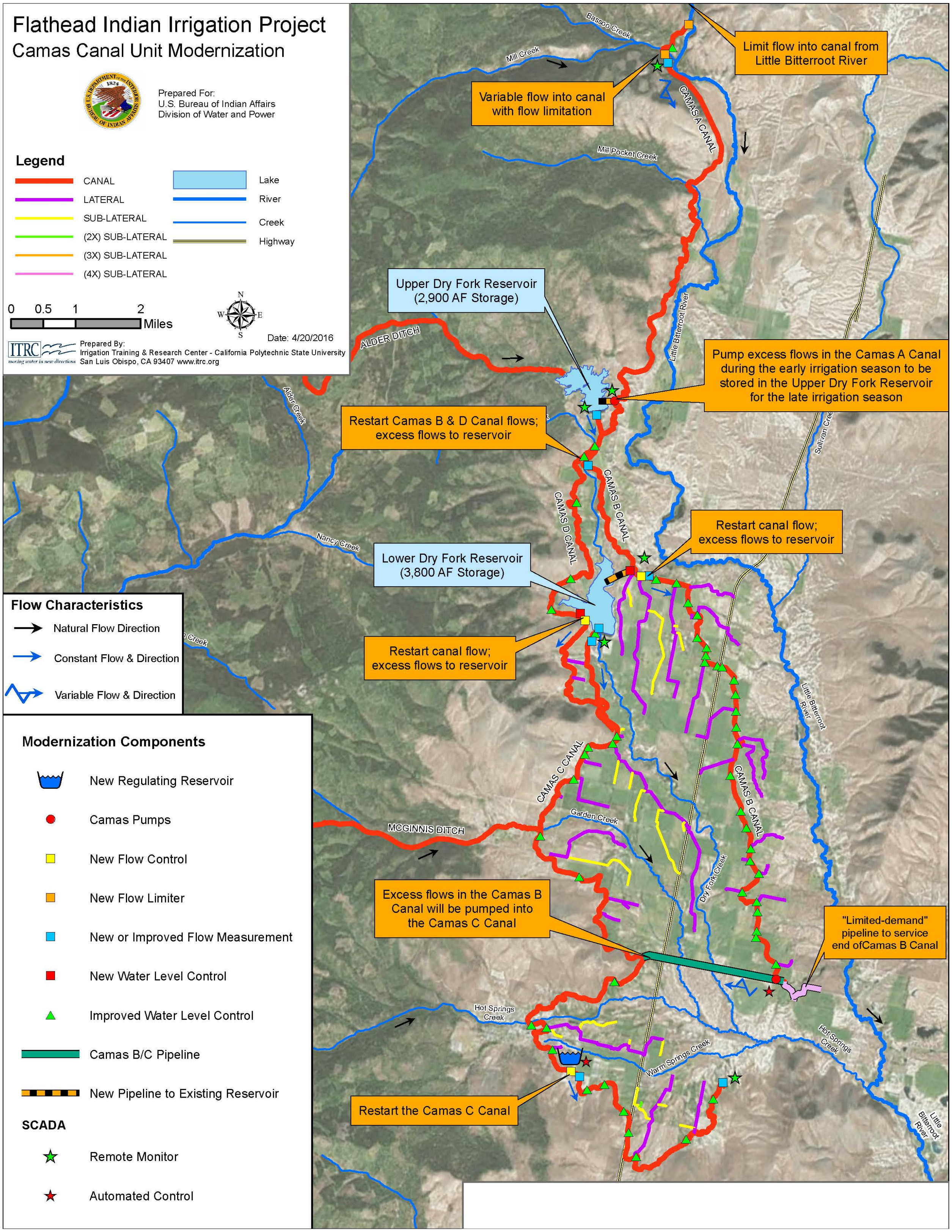

Figure 2. Overall modernization improvements to the Camas A, B, C, and D Canals

Overview of Water Control Strategies

With the proposed canal infrastructure improvements, new water control strategies will be developed to allow operators to more efficiently operate the Camas Canal system while simultaneously providing good flexibility to farmers. Most of the "art" of operating the canal system will be eliminated.

The control strategy proposed for the Camas Canal Unit is this:

- The discharge gate(s) at Hubbart Reservoir will be remotely controlled so more frequent flow changes can be made based on downstream flows at the head of the Camas A Canal. This will help to maximize the beneficial use of storage at Hubbart Reservoir.
- New canal infrastructure at the head of the Camas A Canal will require structural changes at the tunnel inlet from the Little Bitterroot River, and also at Mill Creek. They must function automatically to pass as much flow as possible into the Camas A Canal, while preventing the flow into the canal from exceeding some maximum safe flow rate.
- The long weir diversion structure on the Little Bitterroot River can be modified to effectively divert flows into the Camas A Canal while simultaneously maintaining in-stream flows.
  - The outlet to the Little Bitterroot River (for instream flows) will be modified so that flow is manually controlled with a valve at the downstream end of a discharge pipe.
  - A new gate will be installed at the head of the Camas A Canal tunnel and will be manually adjusted (described later) one time to limit the maximum flow rate into the tunnel. Any excess flow will pass over the diversion dam. This manual gate will not be adjusted to control the flow; the flow rate will be controlled at Hubbart Reservoir.
- The Camas A Canal and Mill Creek junction will be modified to allow as much flow as possible to enter the Camas A Canal, without exceeding some maximum target value. This will all be done automatically with hydraulic gates and proper mixes of hydraulics, rather than relying on computerized control. If the maximum canal flow rate is exceeded, the additional flow will automatically spill back to the river.
- When excess flow is available in the Camas A Canal, the water will be pumped into the Upper Dry Fork Reservoir to be stored and used later in the irrigation season.
- The existing Lower Dry Fork Reservoir will provide the necessary "buffer" for the new variable flow rate traveling down the Camas A Canal.
- The water stored in the Upper Dry Fork Reservoir will be maintained until it is needed for the later part of the irrigation season when in-stream flows decrease.
- Extra water will be diverted into the Camas B and D Canals to ensure there is excess flow (≈3-5 CFS each) at two new flow "restart" points in the canals near the Lower Dry Fork Reservoir. This will:
  - Allow faster flow rate changes to be made in the downstream canals
  - Provide improved flexibility to turnouts upstream of the "restart" points
  - Ensure that excess flow will automatically spill to the Lower Dry Fork Reservoir
- The water level in the main canals will be maintained fairly constant with the construction of long-crested weirs (LCW) or ITRC flap gates. The new water level control structures will:
  - Provide a fairly constant pressure on lateral and turnout headgates
  - Automatically pass all flow variations downstream without the manipulation of check structures by operators
  - Protect the canal from overflowing

- A new pipeline along Kopp Road will convey excess flows (up to 5 CFS) that will be pumped from the Camas B Canal and discharge directly into the Camas C Canal.
- A 30 AF regulating reservoir will be constructed on the Camas C Canal just southeast of Hot Springs.
    - The reservoir will buffer the variable flows in the Camas C Canal.
    - A reservoir pump will attempt to automatically maintain a target water level upstream of a new flow control restart gate in Camas C Canal.
    - The flow into the downstream reaches of the Camas C Canal will be manually re-adjusted to a target flow rate as needed.
- SCADA will be incorporated at key locations throughout the canal unit to help operators make effective management decisions for moving water around the entire Camas Canal system. The new SCADA system will include:
    - Remote monitoring of flow rates, water levels, and pump characteristics
    - Remote manual control of the discharge gate(s) at Hubbart Reservoir
    - Monitoring of the automatic control of the VFD-equipped pumps that will provide water level control in the Camas B Canal and in the new regulating reservoir.

Figure 3 depicts the proposed future control strategies for the Camas Canal Unit.

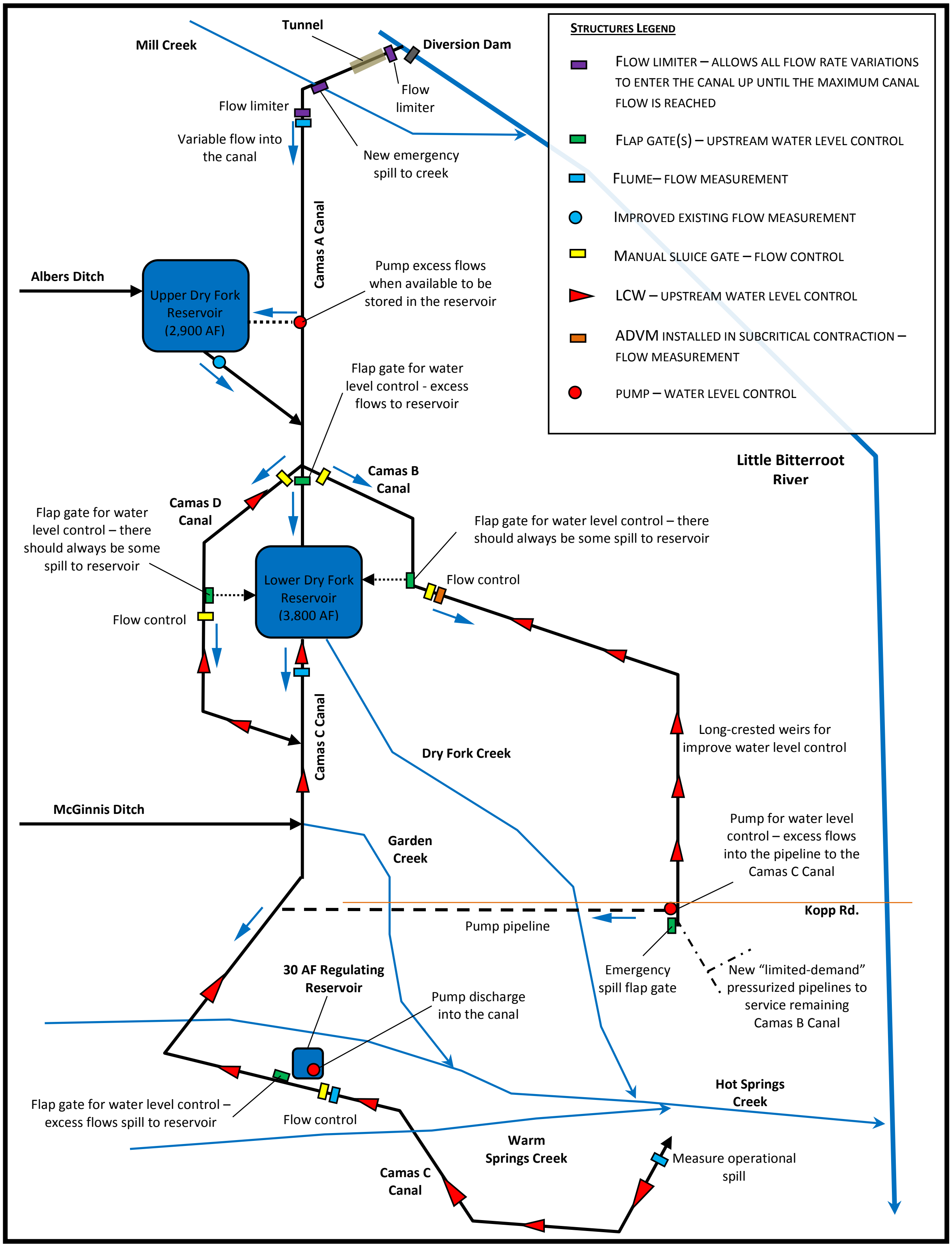

Figure 3. Proposed future control strategies for the Camas Canal Unit (not to scale)

Improvements at Hubbart Reservoir and Head of Camas A Canal

Hubbart Reservoir

Hubbart Reservoir is a 12,000 AF storage reservoir located on the Little Bitterroot River approximately 8 miles upstream from the Camas A Canal diversion. In-stream flows from two additional creeks are diverted into the reservoir via the Briggs-Redmond Canal (see Figure 4). Hubbart Reservoir is the main water supply for the entire Camas Canal Unit.

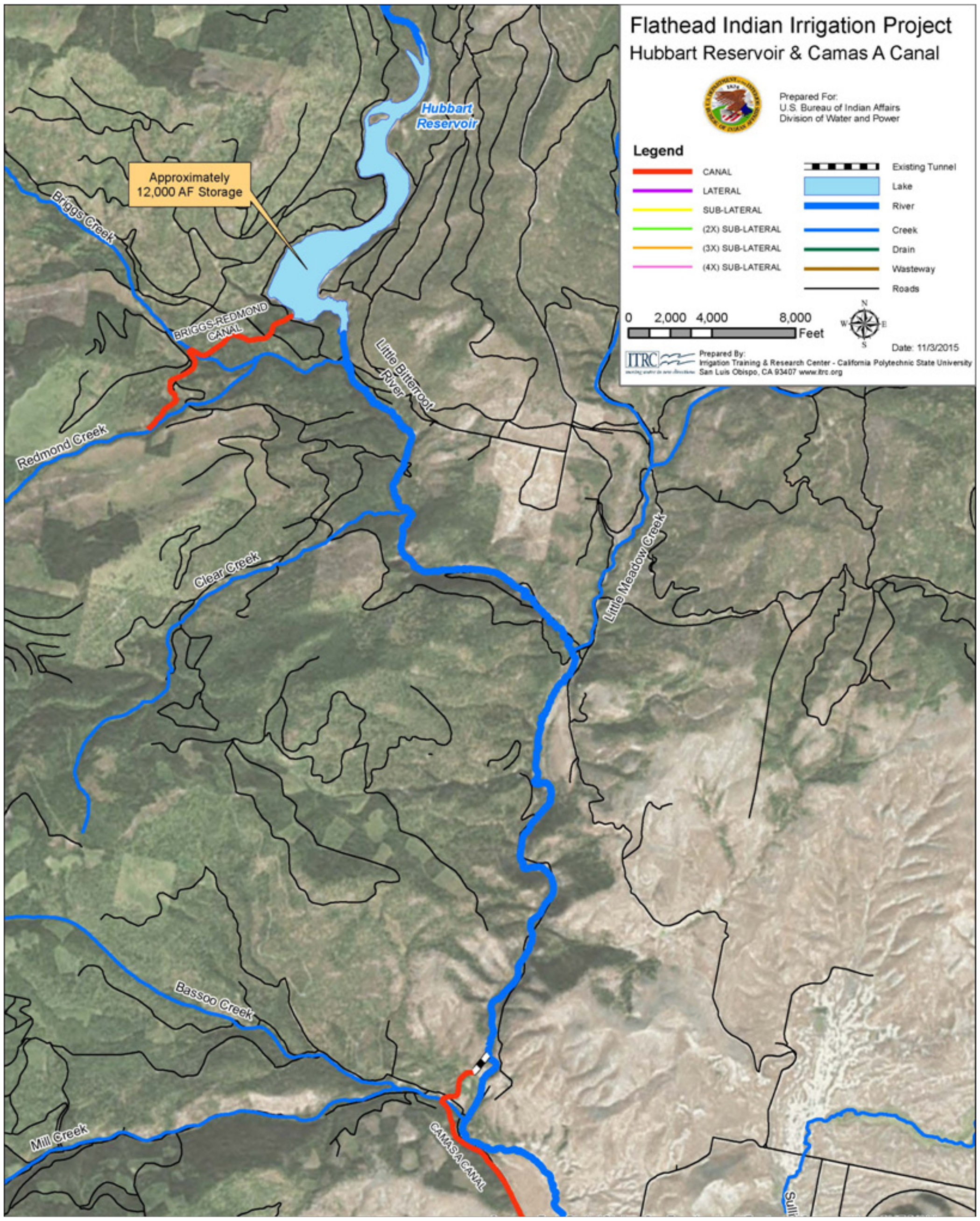

Figure 4. Hubbart Reservoir and Camas A Canal diversion

The Hubbart Reservoir was not visited by ITRC engineers, so some details are missing. It is understood that at least an hour is needed to make a round trip to the reservoir, and partly for that reason the reservoir discharge flows are not changed often.

For better operations management, the recommended general changes at Hubbart Reservoir include:

- There is currently a satellite SCADA connection to this site, which evidently has 2-way capabilities. This connection would be upgraded to connect to a PLC at the discharge gates, to provide additional capabilities.
- The reservoir discharge gate(s) will be equipped with electric actuators. The positions of those gates will be remotely set via SCADA, but could also be adjusted on-site.
- An electric power supply must be provided, with battery backup.
- The discharge gate(s) will be rated for flow measurement. Since the gate(s) appear to operate hydraulically under free flow conditions (refer to Figure 4), only the gate position(s) and upstream water level will be needed.
- The SCADA information would include data from redundant sensors of the following:
    - The reservoir water elevation
    - The positions of the shafts for the reservoir discharge gate(s)
- Other standard information such as battery voltage and gate setting (manual/auto) would also be obtained.

Head of the Camas A Canal Tunnel

Approximately 8 miles downstream of Hubbart Reservoir along the Little Bitterroot River, the masonry diversion dam at the Camas A Canal tunnel entrance is listed on the FIIP Rehabilitation Compact to be replaced. ITRC did not examine the dam for structural integrity. In terms of functionality (assuming it is structurally sound), it does not need replacement. Rather, some simple modifications will make it much more effective for control and operation.

Figure 5 shows the existing control at the Camas A Canal tunnel entrance and exit.

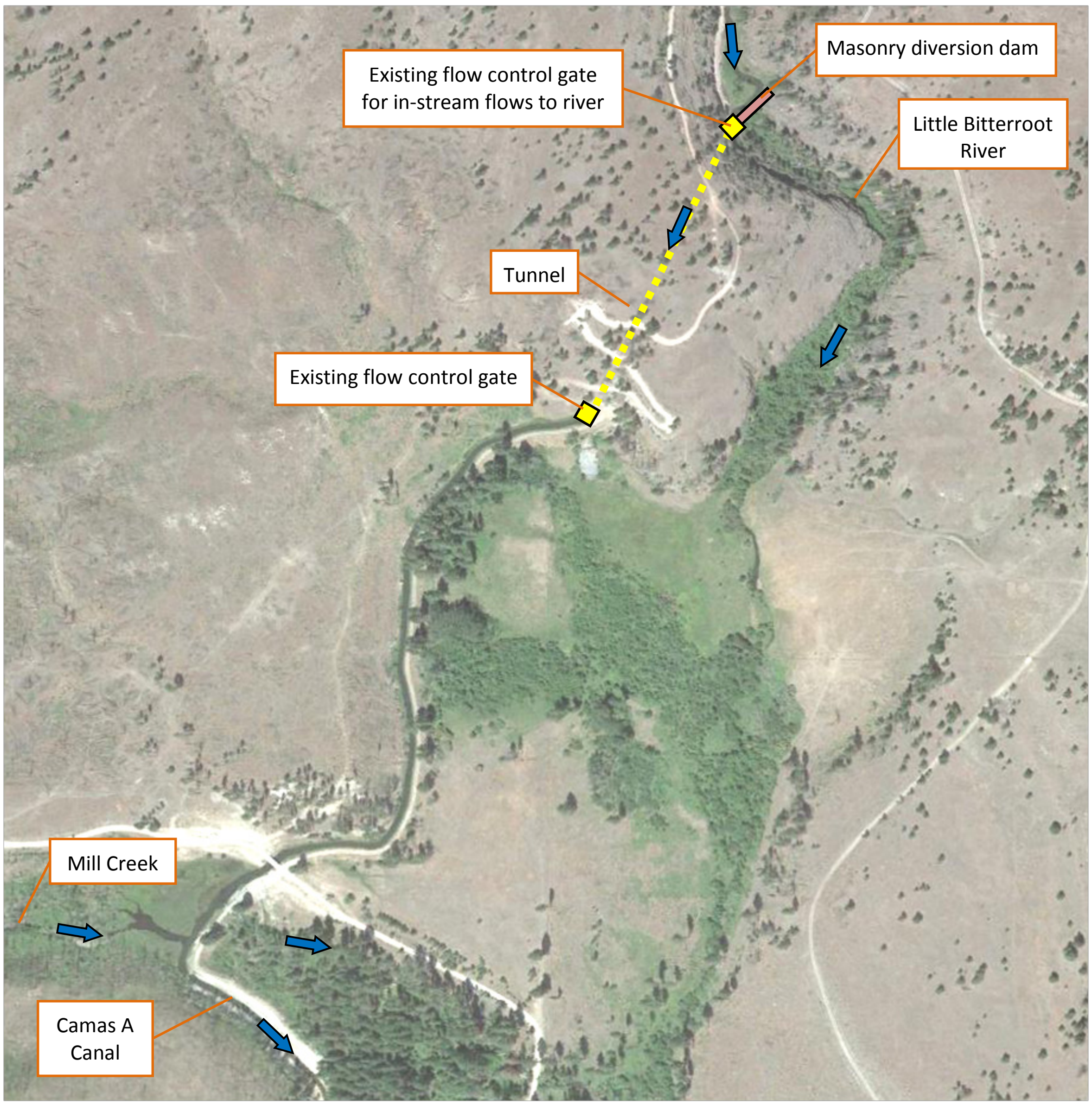

Figure 5. Existing control near Camas A Canal head diversion

The existing control at the diversion from the Little Bitterroot River to the Camas A Canal tunnel is as follows:

- An approximately 80 ft. long masonry diversion dam diverts water from the Little Bitterroot River into the Camas A Canal Tunnel.
    - Excess flows spill over the masonry dam and continue down the river.
    - A canal gate adjacent to the masonry dam (on the right-hand side, adjacent to the tunnel entrance) is used to maintain in-stream flows to the river.

Figure 6. Upstream side of the masonry diversion dam

Figure 7. Inlet to the Camas A tunnel. Masonry dam is on the left. Sluice gate controls flow into downstream section of Lower Bitterroot Creek.

- The tunnel is approximately 1,000 ft. long through a large hillside. Operators need several minutes to go from one end of the tunnel to the other because of poor dirt road conditions.
- A manual sluice gate located at the discharge of the tunnel controls the flow rate released to the lower portion of the canal.

Figure 8. Manual sluice gate at the tunnel discharge

The improvements shown in Figure 9 will include:

1. The manual sluice gate at the discharge of the tunnel will normally be fully open. It will not be used to control flows.
2. A new manual flow control gate will be installed in the existing board slots of the Bitterroot River masonry diversion dam (see Figure 9) to limit the flow rate into the canal. The operational procedure for the new “flow limiter” sluice gate will be explained in a later section. This does not need to be a fancy gate that is designed to be moved frequently. A simple sluice gate made of a plate of steel with a shaft and wheel (to move it up and down) would be sufficient.
3. The existing manual flow control gate in the masonry dam will be repaired or replaced. This gate will not be used for flow control of in-stream flows. Rather, it will be used for on/off only.
4. A new manual flow control gate will be installed at the downstream end of a pipe that flows from the old flow control gate, to a much lower elevation on the downstream side of the dam. This gate will be manually adjusted to provide the desired instream flow rate. This new position of the flow control gate will provide a hydraulic condition that will make the instream flow rate relatively insensitive to the water level upstream of the diversion dam.

Figure 9. New flow control gate to the tunnel, at the Little Bitterroot River diversion

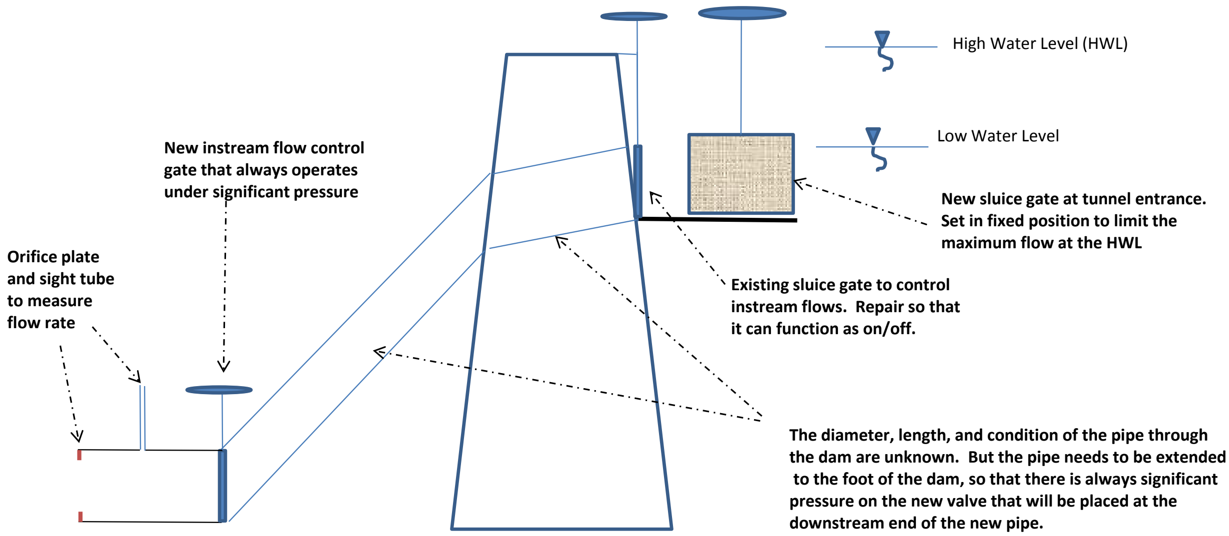

Figure 10. Side view of diversion dam with new control features (conceptual, not to scale). Orifice plate must discharge into the air.

Setting the Flow Limiting Gate at the Little Bitterroot River Diversion

The following section provides the basic procedures and an example of setting the new flow limiting gate at the Little Bitterroot River Diversion. The procedure is as follows:

1. Determine what the flow rate through the tunnel is. This can be determined by using the new flow measurement device downstream or using current meters in the canal.
2. Determine what the actual maximum flow rate could be. It should be somewhere around 80 CFS, which is assumed in this example.
3. Make sure that the flow control gate at the entrance to the tunnel is out of the water.
4. Measure the vertical distance between the water surface (upstream of the new gate) and the crest of the diversion dam. For example, assume the vertical distance is 5 ft.
5. Calculate the ratio of what the present flow rate is compared to the maximum flow rate. For example, assume the present flow rate is 40 CFS. Therefore, the present to maximum flow ratio (P/M) is approximately 0.50 (40 CFS/80 CFS = 0.50).

6. Use Table 1 to determine how much to close the flow control gate. The table indicates how much to raise the water level upstream of the flow control gate, by closing the flow control gate. The correct gate position (in terms of opening position) is not given in the table.

   The gate setting ratio is based on the following equation derived from the submerged orifice equation:

$$\frac{H_1}{H_2} = \left(\frac{Q_1}{Q_2}\right)^{2.2} = (P/M)^{2.2}$$

Table 1. Present to maximum flow ration versus water level rise for the flow limiting gate at the Little Bitterroot River Diversion

Flow Ratio (Present/Maximum), (P/M)	Water Level Rise (% rise/100)
0.1	0.01
0.15	0.02
0.2	0.03
0.25	0.05
0.3	0.07
0.35	0.10
0.4	0.13
0.45	0.17
0.5	*0.22*
0.55	0.27
0.6	0.33
0.65	0.39
0.7	0.46
0.75	0.53
0.8	0.61
0.85	0.70
0.9	0.79
0.95	0.89
1	1

The following is an example of the process for determining proper gate setting.

Given:

- Maximum flow rate (M) = 80 CFS
- Present flow rate (P) = 40 CFS
- Vertical distance between the water level and the dam crest with the gate out of the water = 5 ft.

Find:

When the gate is dropped into the water at the "present flow rate", how far below the crest should the water be?

Solution:

- The P/M ratio = 40 CFS/80 CFS = 0.50
- Table 1 shows the "Water level rise" = 0.22
- Drop the gate into the water until it rises by:

  Rise = 0.22 × 5' = 1.1'

In other words, at 40 CFS, the gate should be positioned in the flow to raise the water level to within the following vertical distance from the overflow crest:

Distance to crest = Original vertical distance - Rise
= 5' - 1.1'
= 3.9'

This will place the flow limiting gate in approximately the correct position. Ultimately, the position should be fine-tuned when the highest desirable flow rate is available. At that time (when the highest desired flow rate through the tunnel is available), the gate position should be adjusted so that the upstream water is just at the crest of the diversion dam, but not spilling over. Any extra flow will spill over the crest.

Control of Camas A Canal at Mill Creek

Approximately 2,500 ft. downstream of the tunnel discharge is the "official start" of the Camas A Canal, where two existing canal headgates (see Figure 12) regulate the downstream canal flow rate.

Figure 11. "Official start" of Camas A Canal at Mill Creek

Figure 12. Existing Camas A Canal headgates near Mill Creek

The existing control is as follows:

- The maximum demand flow for the Camas A Canal is approximately 70 CFS but the canal is designed to convey a maximum of 90 CFS.
- Flows from Mill Creek join flows from the Camas A Canal tunnel, forming a large pond upstream of the flow control structure seen in the photo above.
- An existing single bay waste structure located upstream of the canal headgates in the pond embankment is intended to discharge excess flows.
- A rated section stream gauging station is located approximately 1,700 ft. downstream of the Camas A Canal flow control gates in a lined section of canal. The gauging station is linked to the GOES system and is remotely monitored via a webpage.

Figure 13. Inlet to the spill structure from the pond. The bridge in the background crosses the Camas A Canal, d/s of the tunnel exit. Mill Creek enters from the left-hand side of the photo.

Figure 14. Downstream side of the spill structure from the pond

New Control Scheme at the Head of the Camas A Canal at Mill Creek

Recommended improvements near the head of the Camas A Canal at Mill Creek are shown in Figure 15. The reasons for improvement at the head of the Camas A Canal are as follows:

- Just as with Hubbart Reservoir, the Camas A Canal heading is remote and not easily accessible.
- The combination and configuration of the existing canal structures make it difficult to properly manage the highly variable and unpredictable inflows from Mill Creek and the tunnel.
- In-stream flows from Mill Creek can provide up to 2,000 AF of water for the Camas Canal System. Unused water from Mill Creek returns to the river and is lost to FIIP. It is desirable to capture as much of this water as is possible.
- New infrastructure is needed to handle storm flows to prevent future pond embankment breaks. Approximately 4 years ago a canal break (on the pond embankment) occurred that shut down operation of the Camas A Canal.

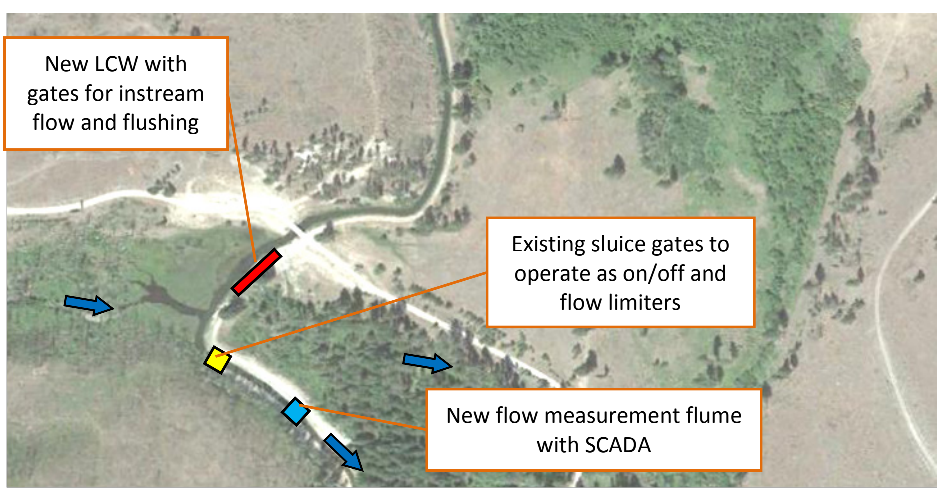

Figure 15. Control changes near the head of the Camas A Canal

The changes include:

1. Updates to the pond embankment wall:
    a. The existing pond embankment walls, which are also the left-hand side of the Camas A Canal, will be strengthened if needed.
    b. The existing narrow flashboard outlet will be replaced with a 100' long-crested weir. This will provide significantly better safety during periods of very high flow rates from Mill Creek.
    c. The elevation of the top of the board crest of the long-crested weir will have the same elevation as the high water mark on the existing Camas A Headgates
    d. The long-crested weir will be accompanied by two gates:
        i. One of the gates (12" diameter) will be used to control in-stream flows. It will be constructed in a manner similar to that on the diversion dam (with a flow control valve at the downstream end of a pipe – at an elevation lower than the bottom of the pond). During the winter, this gate will remain completely open so that it does not plug.
        ii. A second large gate (5'× 5' manual sluice gate) will be kept open during the winter to pass large flow rates, and to keep the pond clean.
        iii. The invert of the 5' manual sluice gate will be 5' below the board crest of the long-crested weir.
        iv. An inclined trash rack (manually cleaned) will be located upstream of the gates.

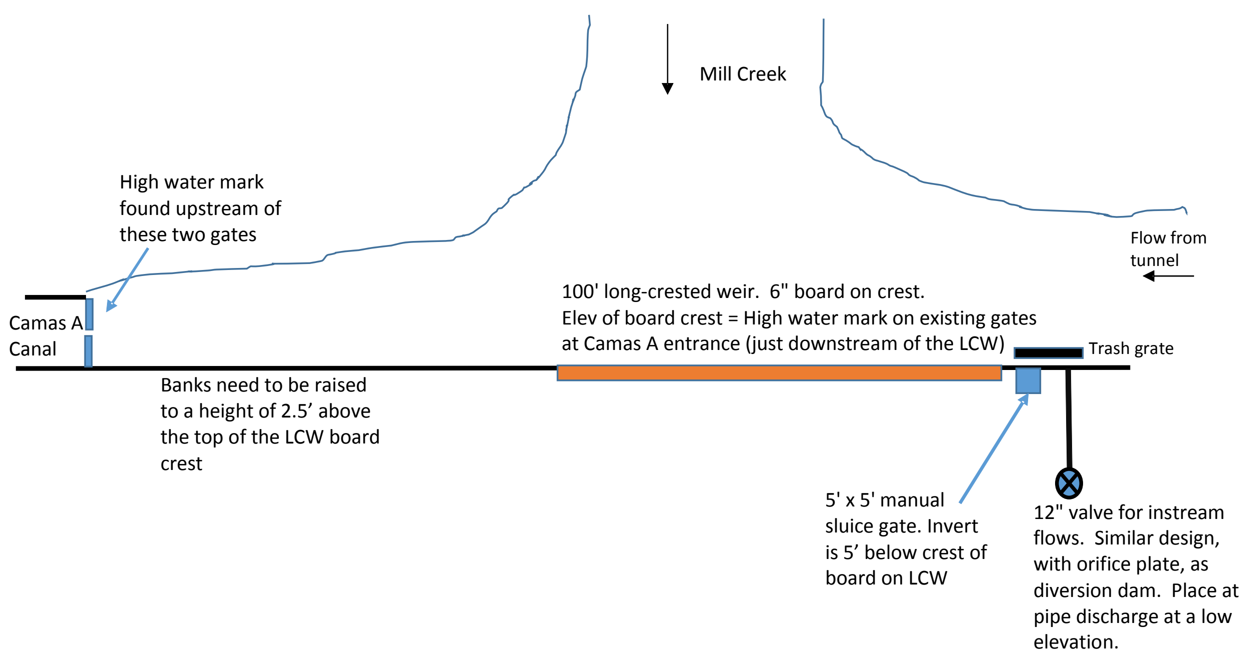

Figure 16. Conceptual plan view of long-crested weir layout (not to scale)

2. The existing two manual flow control gates at the head of the Camas A Canal will remain in place, but will be set to pass the maximum allowable flow rate into the Camas A Canal, with the upstream pond level just at the crest of the 100' long-crested weir.
    a. Whenever the flow rate approaching the Camas A Canal gates is less than the target flow, all that flow will pass into the canal.
    b. When the flow rate approaching the Camas A Canal equals the maximum safe allowable flow rate, water will begin to spill over the 100' long-crested weir. In other words, it will function in the same manner as the gate at the head of the tunnel.
3. During the winter the gates will be closed to isolate creek flows from the canal.
    a. A new flow measurement flume will be constructed in the Camas A Canal approximately 150 ft. downstream of the existing canal flow control gates.
    b. The flume will be constructed in a rectangular concrete section and will have a flat-bottom flow with vertical side-contracted walls. Therefore, sediment will freely pass through the flume.
    c. SCADA will be incorporated to remotely monitor the flow rate.

Pump To Augment Upper Dry Fork Reservoir from Camas A Canal

Evidently (the modernization study did not examine this in detail) at some times of the year it is possible to convey excess flows through the Camas A Canal. The Upper Dry Fork Reservoir is under-utilized. It would be possible to install a pump in the Camas A Canal, pump over a relatively low hill, and discharge excess flows into the Upper Dry Fork Reservoir.

This option is provided for consideration without knowing the details of available water supply. Figure 17 and Figure 18 shows what appears to be the best connection – with a minimum hill height over which to pump.

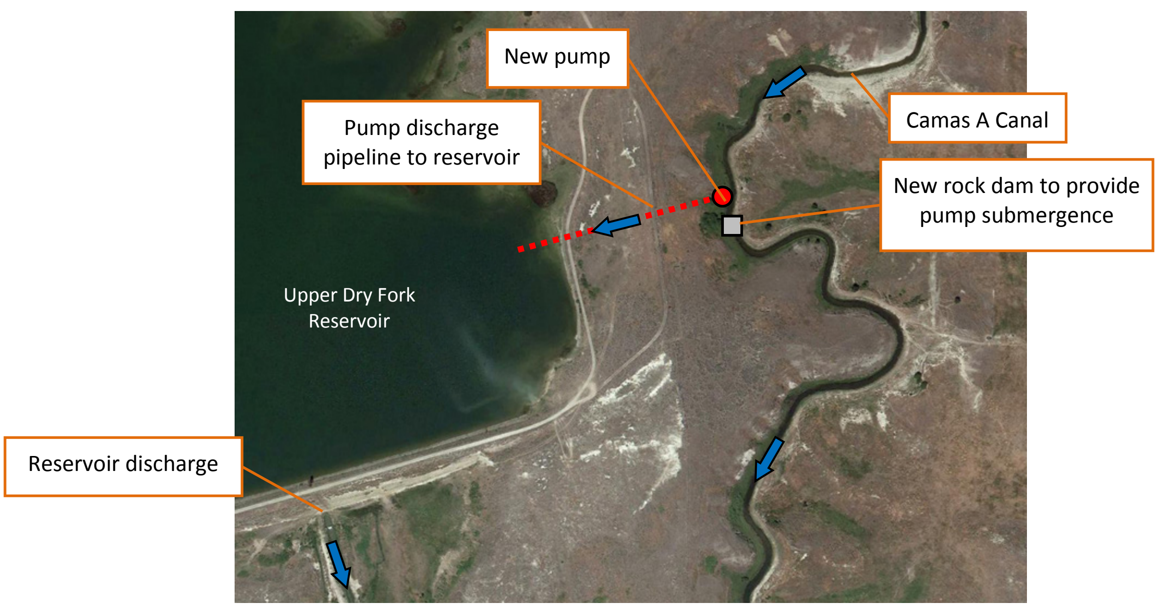

Figure 17. Plan view of possible pipeline to convey water from Camas A to Upper Dry Fork Reservoir

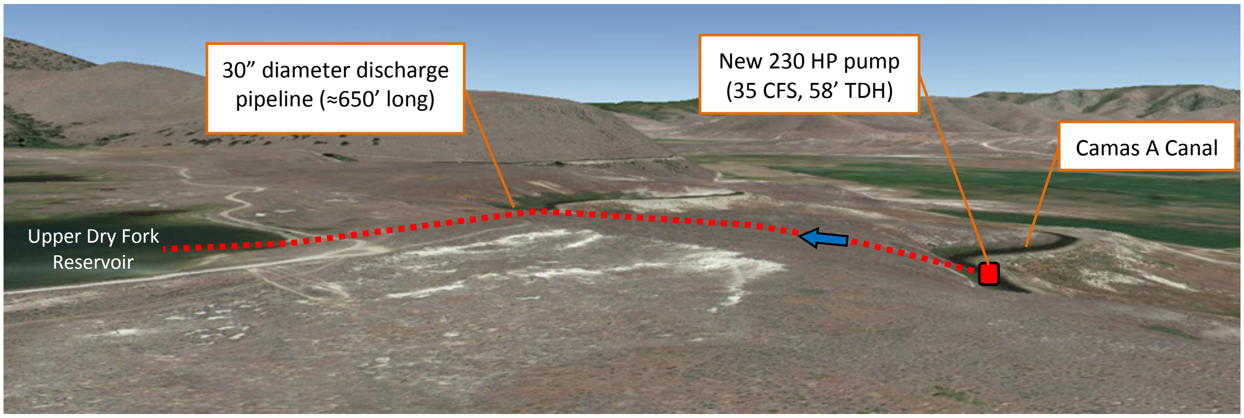

Figure 18. Side view of possible pump location to supplement Upper Dry Fork Creek Reservoir from Camas A Canal

Approximate characteristics of the pipeline and pump would include:

1. Pump flow rate = 35 CFS
2. Maximum elevation change = 38'
3. Pipe diameter = 30"
4. Total pipe length = 650'
5. Inlet HP to the pump motor = 230 HP
6. Slow start motor controls, but VFD is not necessary for special control.
7. 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.
8. The pipeline must have a manual drain valve just downstream of the pump check valves, below ground surface.

Operation near Upper Dry Fork Creek Reservoir

Figure 19 shows the existing layout of the Camas A, B, C, and D Canals near the two Dry Fork Creek Reservoirs.

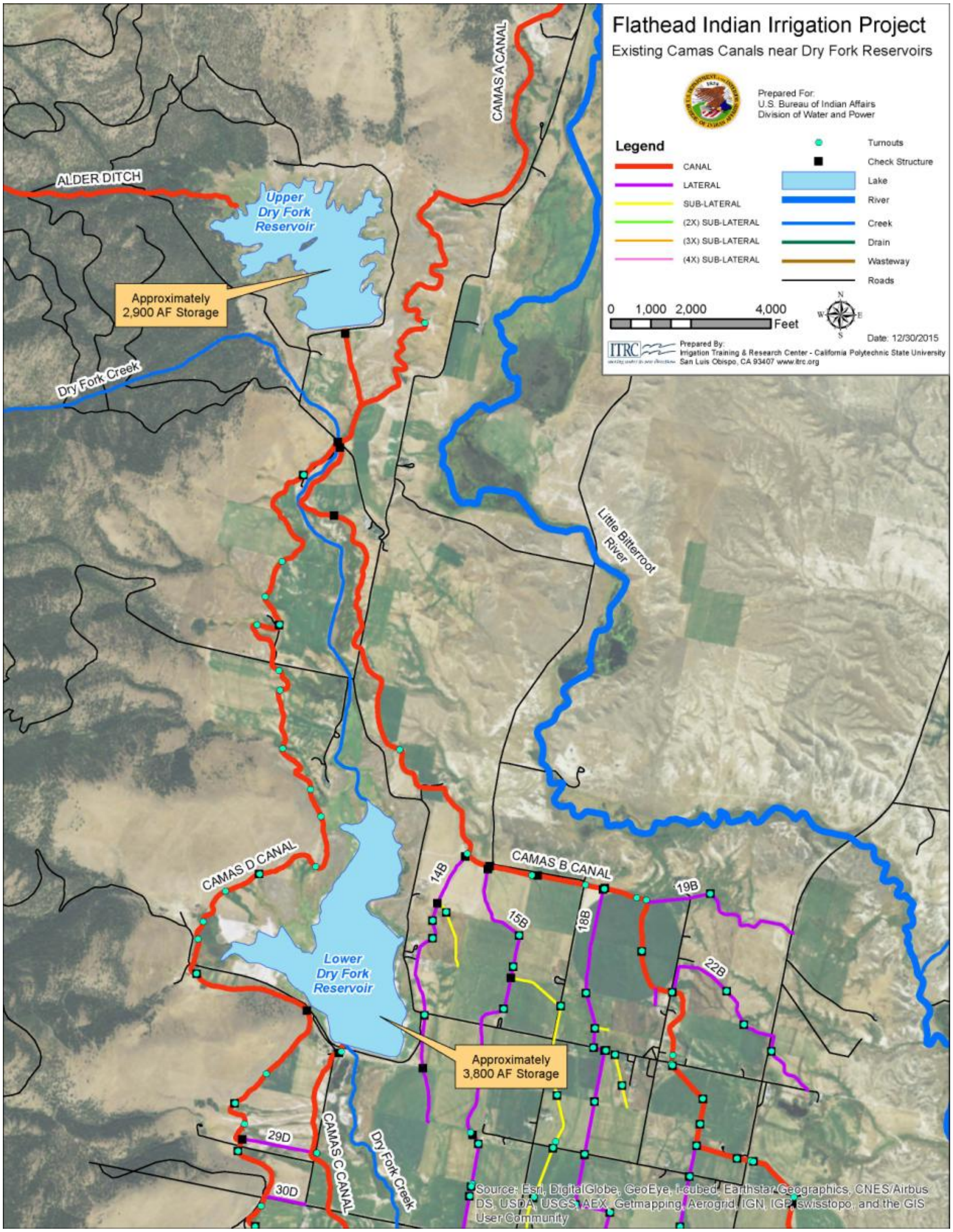

Figure 19. Existing layout of Upper and Lower Dry Creek Reservoirs as well as Camas B, C, and D Canals

Key points for the area around Upper Dry Fork Reservoir are:

- Water in the Camas A Canal flows for approximately 8 miles before it nears the Upper Dry Fork Reservoir. There are no turnouts located in that 8-mile stretch of the Camas A Canal.
- A maximum of 35 CFS is released from the Upper Dry Fork Reservoir to supplement flows in the Camas A Canal.
- The Camas A Canal continues south until it reaches a junction (approximately 3,000 ft. downstream of the Upper Dry Fork Reservoir) with three outlets:
    - Head of Camas B Canal
    - Head of D Canal
    - Spill to Dry Fork Creek
- Approximate maximum flows of 60 CFS and 10 CFS are diverted into the Camas B and D Canals, respectively.
- The remaining flow spills into Dry Fork Creek and reaches the Lower Dry Creek Reservoir.

The existing rectangular weir downstream of Upper Dry Fork Reservoir is shown in Figure 20. The crest is approximately 15' long. With a maximum flow rate of 35 CFS, the head on the weir is about .85'.

Figure 20. Existing approximately 15' rectangular weir downstream of Upper Dry Fork Reservoir outlet

The junction of Camas A, B, and D Canals and spill to Dry Fork Creek is shown in Figure 21.

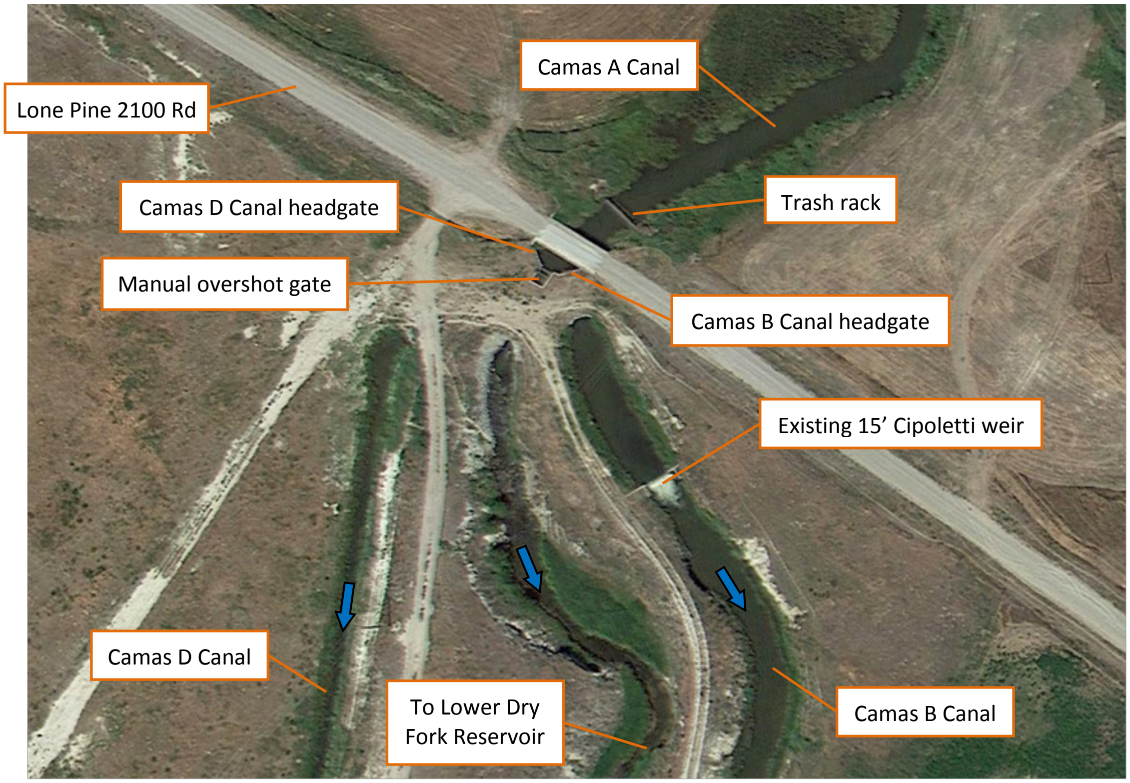

Figure 21. Existing conditions at the head of Camas B and D Canals

A trash rack is installed in the Camas A Canal approximately 60 ft. upstream of the three-way canal split. Figure 22 shows a large pile of aquatic debris on the canal bank. This suggests that operators must pay careful attention to this trash rack.

Figure 22. Existing trash rack upstream of Camas B and D Canal headgates

An 8-ft wide manual overshot gate is used to maintain a target upstream water level at both the Camas B and D Canal headgates. The upstream water level must be maintained high because there is very little head loss available across the Camas D Canal headgate. The configuration of overshot/undershot is correct, but the low head loss available across the Camas D headgate makes it difficult to control properly.

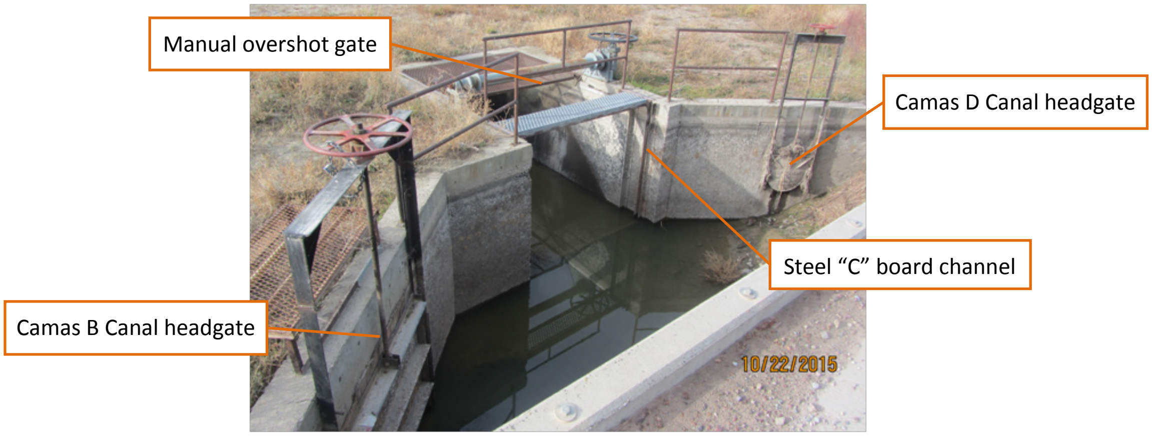

Figure 23. Existing overshot gate at Camas B and D Canal headgates

A 15-ft Cipoletti weir (see Figure 24) is located approximately 150 feet downstream of the Camas Canal B headgate. The crest is set fairly high, so that there is also very little head loss available for controllability of the headgate. However, the crest needs to be set high because even at that height it appears there is submergence on the downstream side.

Figure 24. View of upstream side of 15' Cipoletti weir (left photo) and high water mark on downstream side of the weir (right photo) at head of Camas B Canal

Figure 25 indicates the key changes near Upper Dry Fork Reservoir.

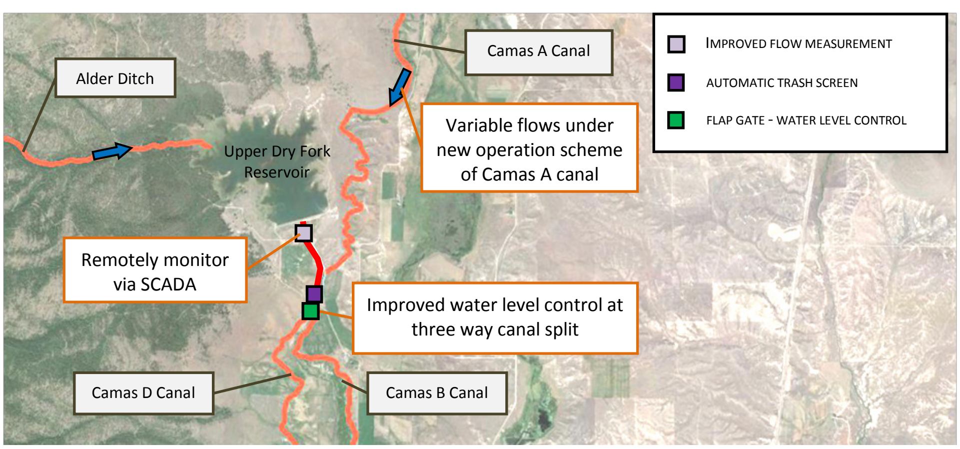

Figure 25. Changes to control near Upper Dry Fork Reservoir

The changes near Upper Dry Fork Reservoir will include:

1. The existing rectangular weir at the discharge of the Upper Dry Fork Reservoir will be slightly modified for improved flow measurement. That flow rate, as well as the water level in Upper Dry Fork Reservoir, will be remotely monitored via SCADA.
2. An automatic trash screen will replace the existing trash rack in the Camas A Canal just upstream of the Camas B and D Canal bifurcation.
3. A new flap gate will replace the existing overshot gate at the Camas B and D Canal headgates to:
   a. Maintain a fairly constant water level on the two canal headgates
   b. Automatically pass excess variable flow rates arriving from the Camas A Canal into the creek and subsequently into the Lower Dry Fork Reservoir

Improved Flow Measurement at Outlet of the Upper Dry Fork Reservoir

The improvement of the weir will not provide large benefits, but the improvement is inexpensive and simple to do. The improvement to the structure itself is to shorten the crest length to 8' (instead of the present 15') by replacing the existing steel plate. This will provide a head of 1.3' at 35 CFS. This greater head will provide better resolution of head measurement (and therefore, also for the flow rate measurement) across a range of flow rates.

The weir will also be equipped with an electronic water level sensor (bubblers with solar power work well in the cold climates). That electronic signal will be conveyed over wires in a PVC conduit to a small SCADA site on the reservoir bank. The water level in the reservoir will also be measured with another bubbler water level sensor. Both the flow rate and the reservoir water level data will be sent over the SCADA system for remote monitoring.

Control Improvements at Head of Camas B and D Canals

The control improvements include:

1. The existing trash rack will be replaced with a new inclined trash screen, such as those from Aqua Systems 2000, to automatically remove aquatic debris from the canal. The automatic trash unit can be solar powered or AC power is available approximately 0.25 miles away (see Appendix B for details).
2. The existing overshot gate will be removed and re-installed in a different part of the irrigation project.
3. The existing overshot gate will be replaced with an ITRC flap gate with dimensions of approximately 8 ft. wide by 2.5 ft. tall, capable of discharging a maximum flow of about 60 CFS. It will be of a frame construction; the frame can be dropped into the existing steel "C" board channels located at the beginning of the concrete structure.
   a. The flap gate will maintain a fairly constant head pressure on the two canal headgates and will automatically pass the Camas A Canal variations downstream to the Lower Dry Fork Reservoir.
   b. The flap gate will sit on top of several flashboards so that it can be set to achieve the target water level elevation.
   c. The water level upstream of the ITRC flap gate can be held at a higher water level than is presently managed. This higher water level will provide better controllability of the flows into Camas D and B Canals.

4. The existing Camas D Canal headgate will be converted to a metergate (with a stilling well downstream) to both control and measure the flow rate diverted into the canal.
5. The existing Cipoletti weir in the Camas B Canal will be removed and replaced by a flume. There are two reasons for doing this:
   a. A properly designed flume will require less head loss than does the existing weir. This will eliminate the existing submergence problems.
   b. This site is scheduled for a GOES flow monitoring station. A flume only requires one water level measurement to compute the flow rate. In other words, a calibrated sluice gate or metergate could be used as the headgate to both control and measure flows. However, measurement of the flows with those less expensive devices would require three measurements (upstream water level, downstream water level, and gate position).

Figure 26 shows the control improvement changes at the Camas B and D Canal headgates.

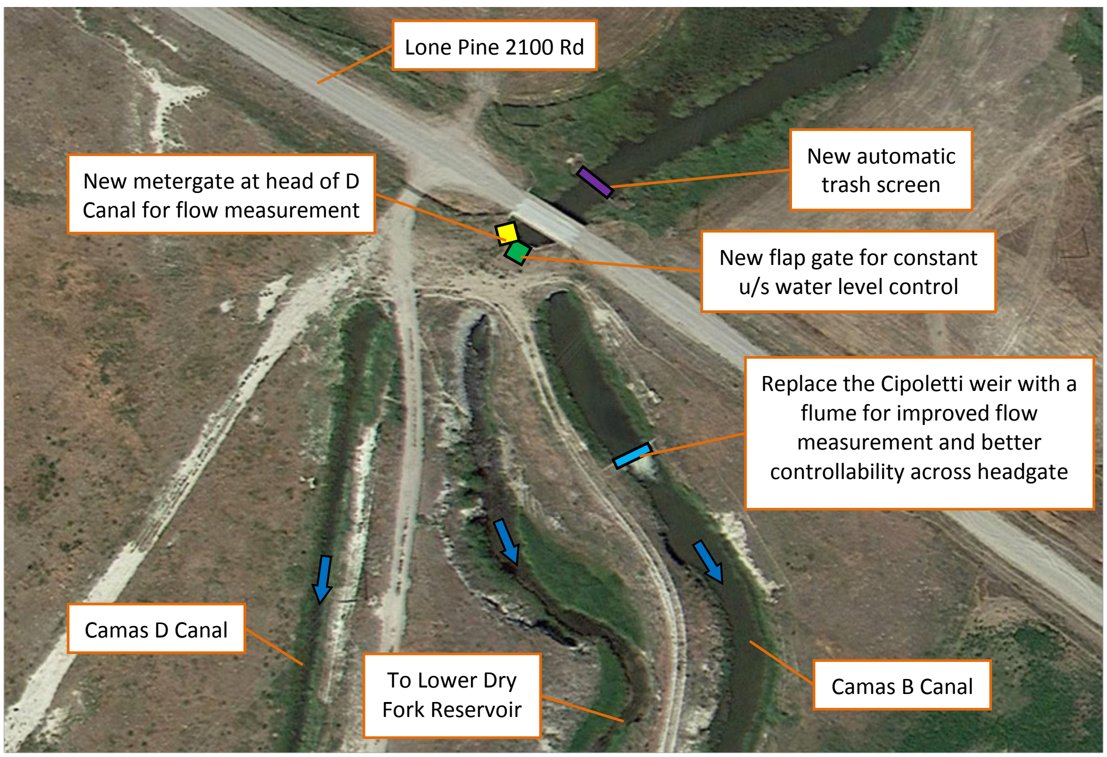

Figure 26. Improvement changes at the Camas B and D Canal headgates

Control near the Lower Dry Fork Reservoir

Existing Conditions – General

Figure 27 shows that Camas D and Camas B Canals have no simple re-regulation or re-start points downstream of their headgates at Lone Pine 2100 Rd.

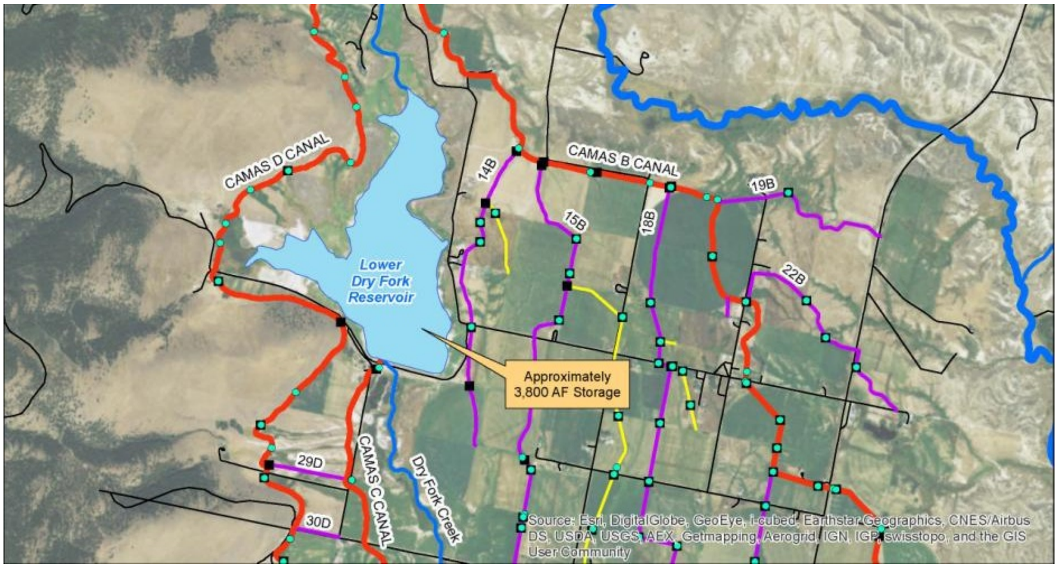

Figure 27. Existing conditions near the Lower Dry Fork Reservoir

General Control Changes near the Lower Dry Fork Reservoir

Figure 28 shows the overall conceptual control changes in the Camas Canal Unit near the Lower Dry Fork Reservoir, which will focus on obtaining excellent flow control and measurement for the Camas B, C, and D Canals.

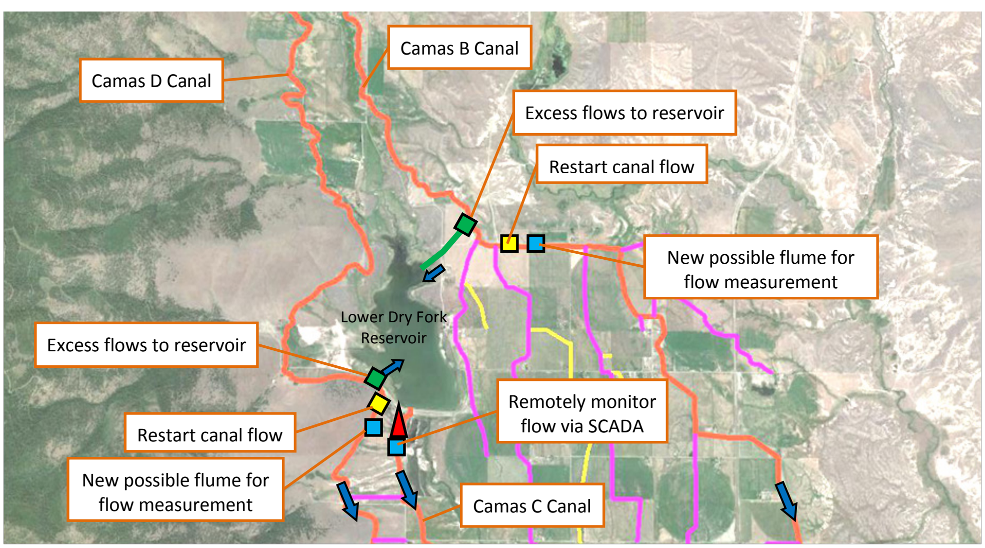

Figure 28. General conceptual control changes to the Camas Canal System near the Upper and Lower Dry Fork Reservoirs

Head of Camas C Canal

Existing Conditions

Figure 30 shows the existing control at the head of the Camas C Canal located at the outlet of the Lower Dry Fork Reservoir. A maximum of approximately 60 CFS is released into the canal from the reservoir.

Figure 29. Existing control at the head of the Camas C Canal and Lower Dry Fork Reservoir discharge

The existing control includes:

- Two individual turnout gates (see Figure 30) to service a nearby wetlands area as well as in-stream flows to Dry Fork Reservoir.
    - There approximately 10 farmer deliveries downstream on Dry Fork Creek.
    - The maximum flow rate diverted to Dry Fork Creek is approximately 15 CFS.
- A two bay check structure with overflow walls to maintain the upstream water level for the two individual turnouts.
- A rated section located just downstream of the existing check structure for flow measurement. Readings from the rated section are continuously monitored via a GOES system.

Figure 30. Existing control at the head of Camas C Canal at the outlet of Lower Dry Fork Reservoir

Control Improvements at Head of Camas C Canal and Lower Dry Fork Reservoir Discharge

Figure 31 shows the control improvements at the head of the Camas C Canal and Lower Dry Fork Reservoir discharge. The control improvements will include the following:

1. The existing reservoir discharge gate(s) will be remain as-is, but operators will be able to remotely monitor the flume flow rate from there.
2. The existing first check structure will be modified to include a new 30 ft. LCW as shown in Figure 32.
3. A new Replogle flume will be constructed in a straight section of canal approximately 800 ft. downstream from the reservoir outlet to accurately measure the flow rate to the Camas C Canal. There appears to be several feet of elevation drop in the canal to achieve the required head loss upstream as well as prevent submergence on the downstream side.
4. The GOES station will be re-located to the new flume.
5. A buried conduit pipe with sensor wires will be installed from the flume and flow meter(s) to the reservoir outlet gate house to display the two key flow rates to operators in order to properly set the discharge flow.
6. The existing turnouts to Dry Fork Creek and the wetlands will be upgraded to be metergates.

Figure 31. Control improvements at the head of Camas C Canal and Lower Dry Fork Reservoir discharge

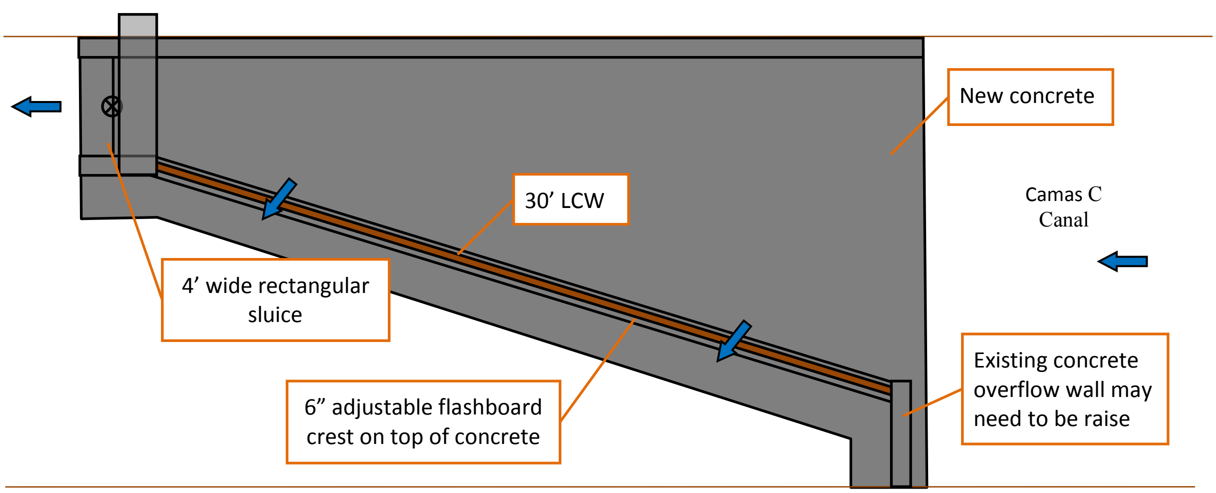

Figure 32. Conceptual plan view of LCW to be incorporated in to the 1st check structure on Camas C Canal (not to scale).

Camas B Canal near Lower Dry Fork Reservoir

Existing Conditions

Figure 33 shows the existing control of the Camas B and D Canals near Lower Dry Fork Reservoir. Water level control is provided to multiple lateral and farmer turnouts by the first check structure in the Camas B Canal (see Figure 34) located just downstream of the Lateral 15B headgate.

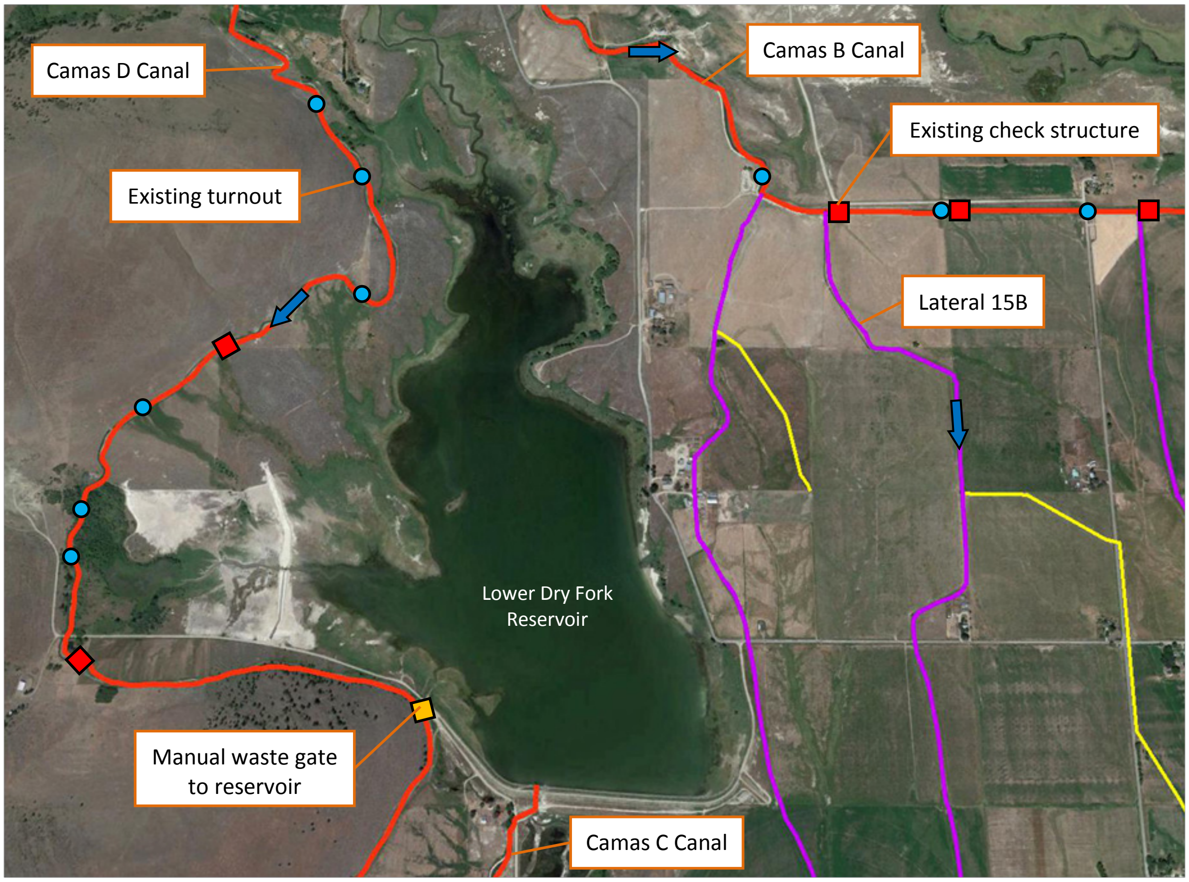

Figure 33. Existing control of Camas Canals near Lower Dry Fork Reservoir

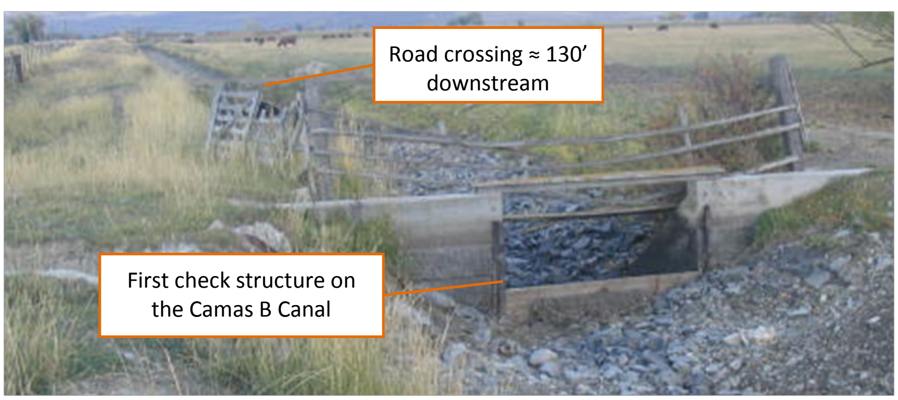

Figure 34. This existing check structure on the Camas B Canal is to be replaced with a new sluice gate structure for flow control. Photo from HKM 2008 report.

New Restart of Camas B Canal

Figure 35 shows the modernization changes at the new "restart" of the Camas B Canal near Lower Dry Fork Reservoir.

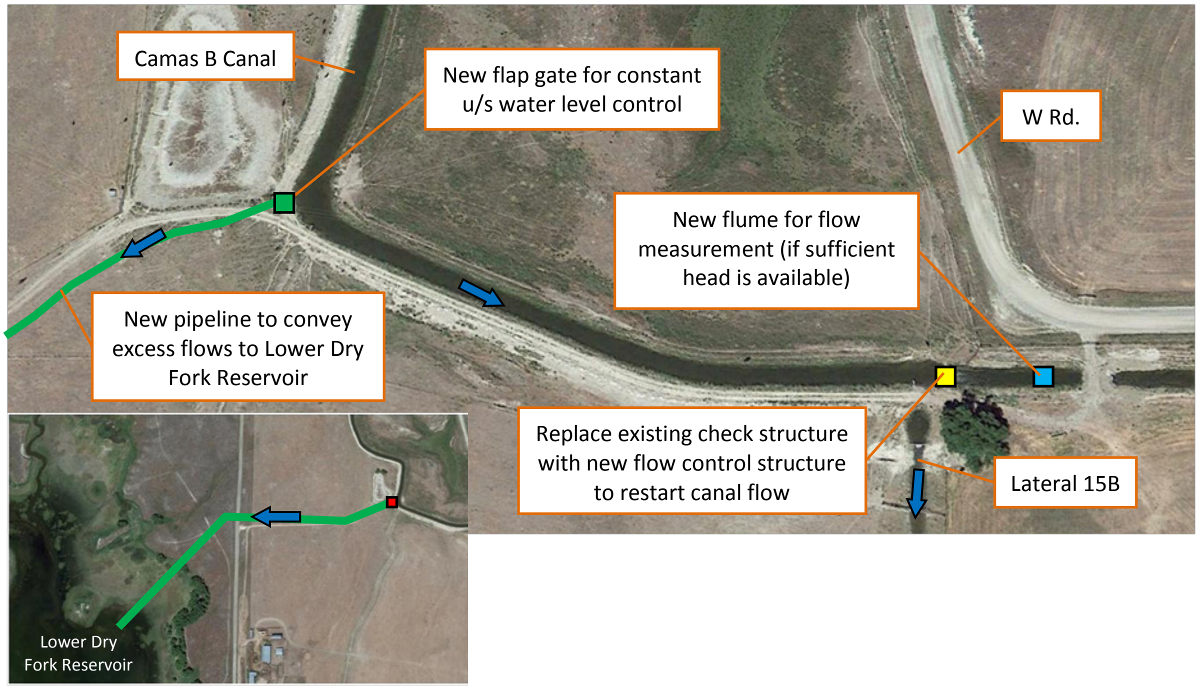

Figure 35. Modernization changes at the new restart of the Camas B Canal near Lower Dry Fork Reservoir

The modernization changes include:

1. The existing single bay flashboard check structure shown in Figure 34 will be replaced with a new flow control sluice gate structure to restart the flow rate in the Camas B Canal.
2. A new flap gate will be installed in the right canal bank approximately 650 ft. upstream of the new flow control structure.
    a. The flap gate will be 5 ft. long by 2 ft. tall and be designed to pass a maximum flow rate of 30 CFS.
    b. The flap gate will be installed in a 5 ft. wide precast "U" shaped concrete box similar to Figure 36.
    c. A 36" diameter pipe will be constructed from the new spill structure to the reservoir (approximately 2,000 ft. long).
3. A new flume would ideally be installed approximately 75 ft. downstream from the new flow control structure to measure the restart flow rate. The flow rate could be remotely monitored via SCADA. For this to work, the canal banks upstream of the flow control structure may need to be raised by about a foot. This would supply sufficient head for a flume to function accurately. No detailed survey/elevation data were available at the time of this report, but the flap gate will maintain a fairly constant water level, which requires very little freeboard. The higher canal bank, plus less freeboard, will likely provide enough head for the flume to function properly. If there is insufficient head available, the new flow control sluice gate could be used for both flow control and flow measurement.

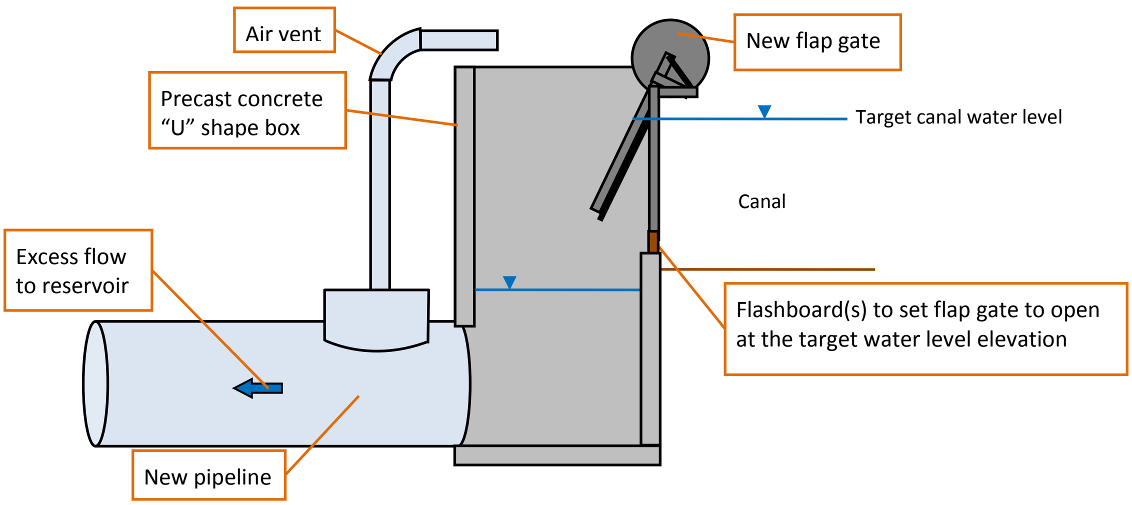

Figure 36. Conceptual side view of new flap gate spill structure (not to scale)

Camas D Canal near Lower Dry Fork Reservoir

Existing Conditions

This is almost identical to the Camas B Canal situation, which will be discussed later. A manual waste gate in the Camas D Canal is used when needed to spill water to the Lower Dry Fork Reservoir (Figure 37).

Figure 37. Existing Camas D Canal waste gate (left) and wash (right) to Lower Dry Fork Reservoir

New Camas D Canal Restart

A new flow "restart" point will be established in the Camas D Canal near the Lower Dry Fork Reservoir. Figure 38 shows the modernization changes in the Camas D Canal.

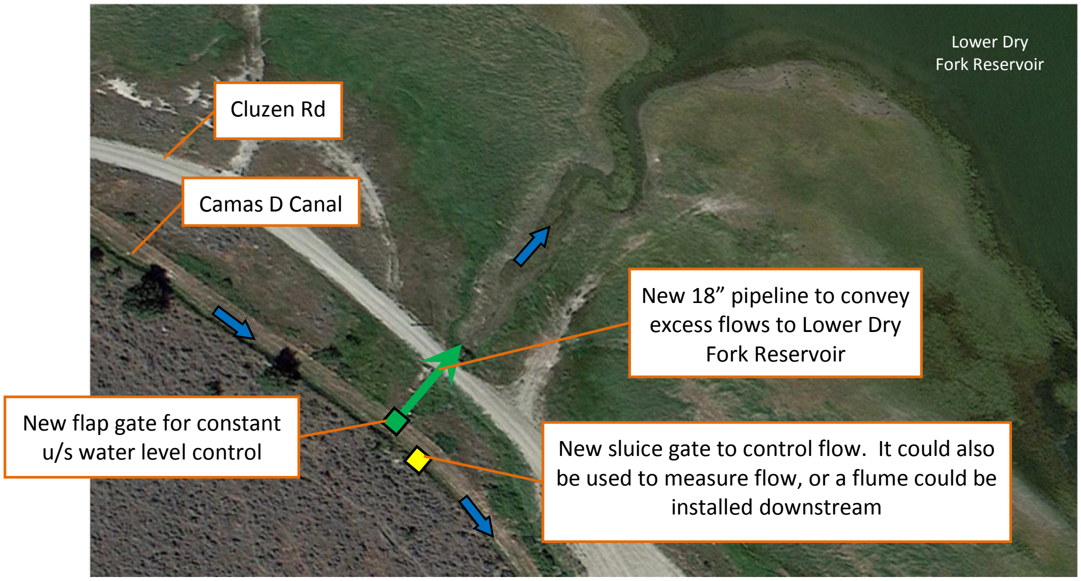

Figure 38. Modernization changes at the new restart of the Camas D Canal near Lower Dry Fork Reservoir

The modernization changes will be almost identical to the changes at the equivalent Camas B Canal site:

1. A new sluice gate will be constructed in the Camas D Canal to control and measure the flow rate to the downstream portion of canal. However, if there is sufficient head available, a flume would ideally be placed downstream of the sluice gate for flow measurement.
2. The existing manual waste gate will be removed and replaced with a new flap gate to maintain the upstream water level in the canal.
    a. The flap gate will be 36" long and 20" tall and will have the ability to pass a maximum of 10 CFS.
    b. The flap gate will be installed in a similar precast concrete box as shown in Figure 36.
3. A new 18" diameter pipeline (approximately 100 ft. long) will be installed from the flap gate structure, to the existing wash into the reservoir. The pipeline will replace the existing culvert pipe under the road.

Revised Operation/Management Scheme of the Lower Dry Fork Reservoir and Upstream

The new operation and management scheme of the Camas Canal System near the Upper and Lower Dry Fork Reservoirs will be:

- Controlled releases will be made more frequently from the Upper Dry Fork Reservoir depending on the variable flow from the Camas A Canal head at Mill Creek.
    - Operators will have the ability to remotely monitor the variable flow rate at the head of the Camas A Canal, to more effectively manage the releases from the Upper Dry Fork Reservoir.
    - Operators will be able to remotely monitor the discharge from the Upper Dry Fork Reservoir.
- An additional 3-5 CFS on top of the daily flow demand will be diverted into both the Camas B and D Canals just downstream of the Upper Dry Fork Reservoir. The extra flow will:
    - Provide improved flexibility to farmer turnouts located between the two reservoirs.
    - Ensure that there is always excess flow to show up at the new "restart" points on the two canals near the Lower Dry Fork Reservoir.
- Operators will "restart" the flow in both the Camas B and D Canals at the new flow control structures to meet the downstream demand of the two canals. The excess flow in both canals will automatically be diverted to the Lower Dry Fork Reservoir.
- Releases from the Lower Dry Fork Reservoir will be better controlled with the improvement in flow measurement downstream in the Camas C Canal.

Southern End of the Valley – Overview

<u>Existing Conditions - General</u>

Figure 39 shows the existing canal system near the town of Hot Springs. The southern portion of the Camas Canal service area near Hot Springs appears to have the following problems:

- The canals are relatively small, long, winding, and have numerous amount of turnouts and check structures. These factors likely make the canal system very difficult to manage.
- Turnout headgates are difficult to access.
- High seepage losses occur.
- Operational spills flow to the Little Bitterroot River and are lost to the project.

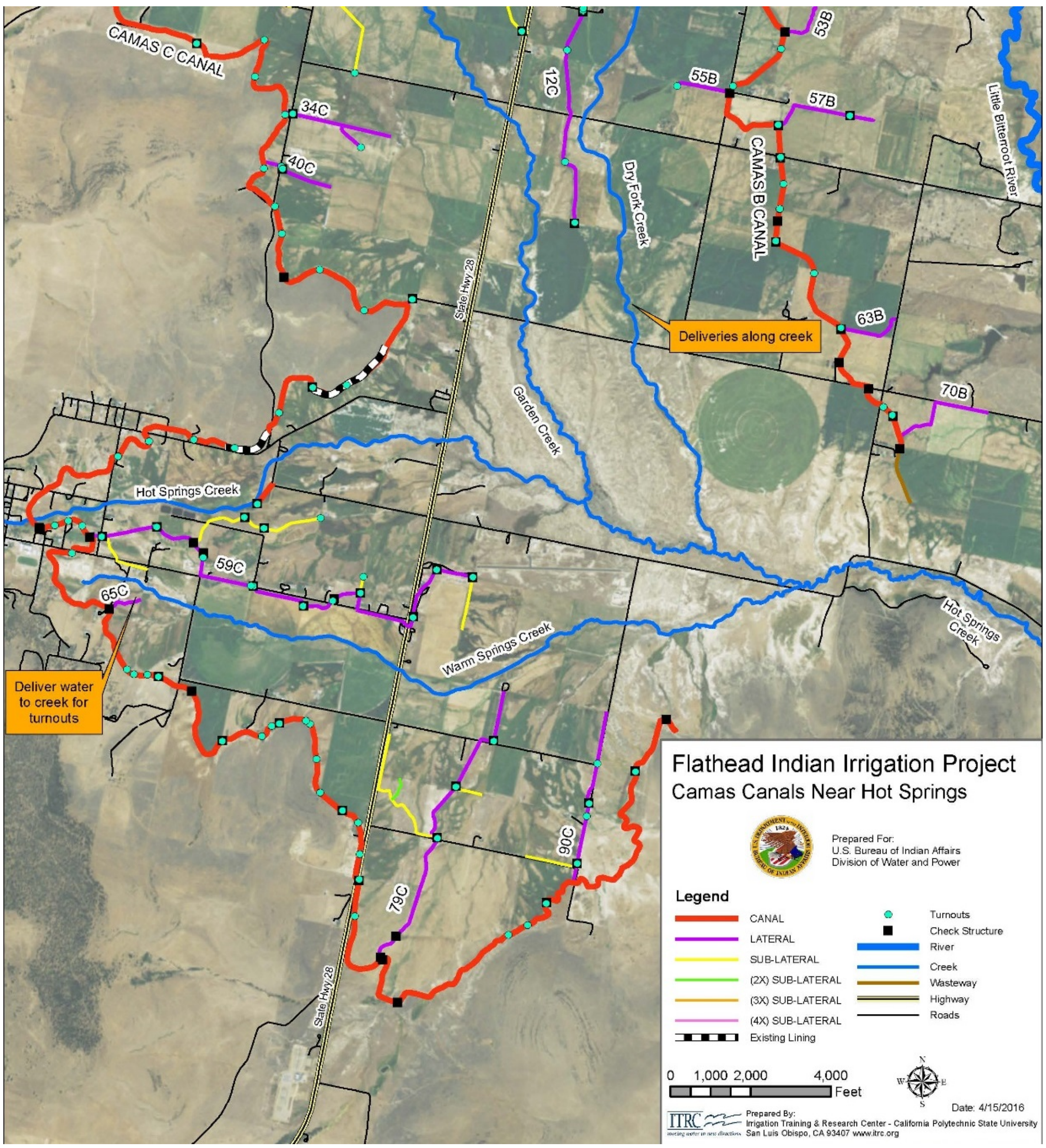

Figure 39. Existing conditions of the Camas Canal system near Hot Springs

Overview of the Modernization Changes in the Southern End of the Valley

Figure 40 shows the overview of the modernization changes for the southern end of the Camas Canal Unit.

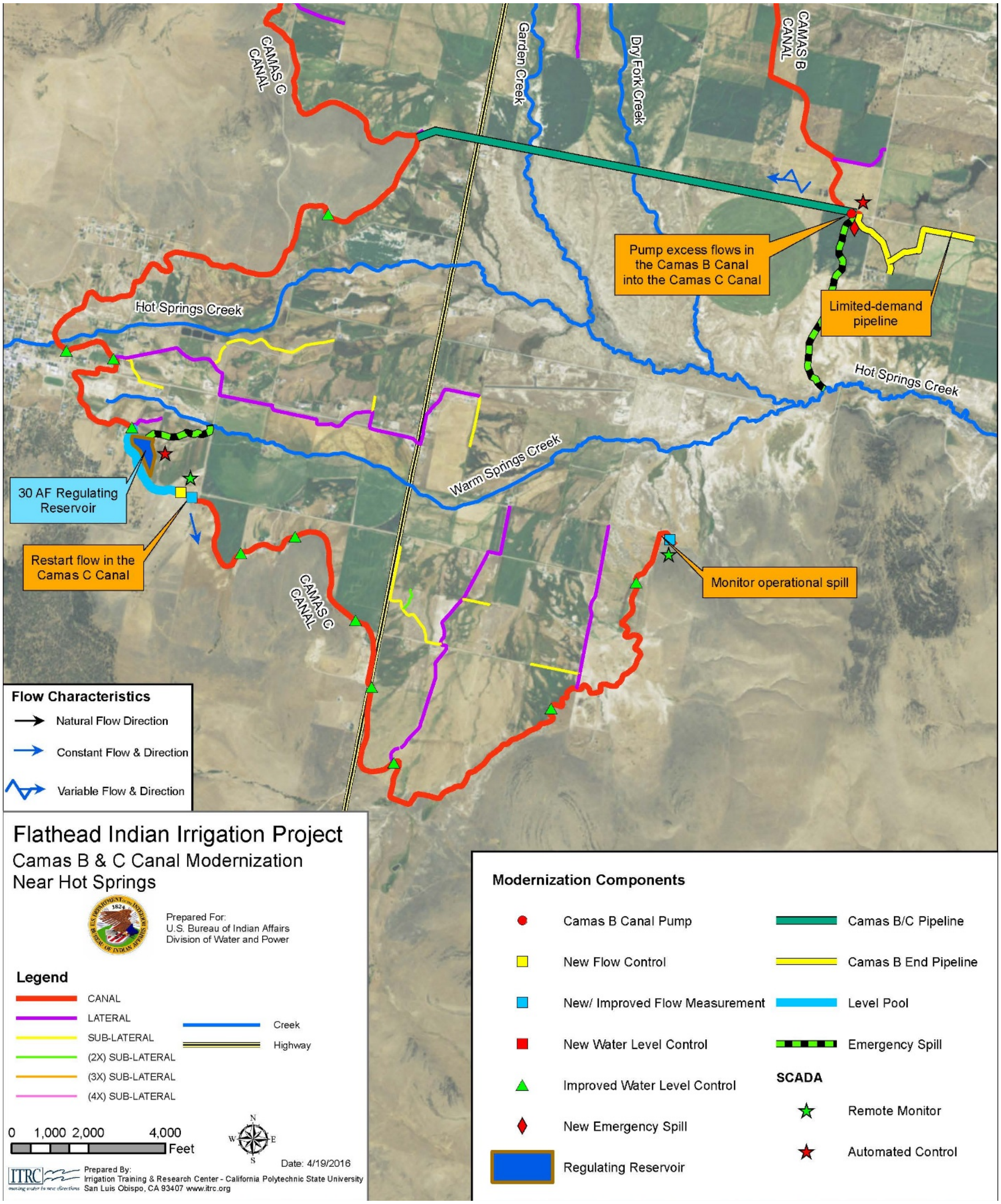

Figure 40. Overview of modernization changes is southern end of the valley

The modernization changes will include the following:

1. Near the end of the Camas B Canal:
    a. The last 1,850 ft. of the Camas B Canal will be piped to operate on "limited-demand".
    b. The open channel portion of Lateral 70B will be converted to a closed pipeline.
    c. Excess flows in the Camas B Canal will be pumped into the Camas C Canal via a new 15" diameter pipeline that runs along Kopp Road (approximately 2.2 miles long). See Figure 41 for the key elevations along Kopp Road.
    d. A new emergency spill will be constructed to automatically handle any emergency flow that may occur.
2. A new 30 AF regulating reservoir will be constructed on the Camas C Canals just southwest of Hot Springs. The new reservoir will:
    a. Provide increased flexibility to farmer turnouts upstream and downstream
    b. Capture and re-regulate excess flows in both the Camas B and C Canals
    c. Provide the required "buffer" for the flow control restart of the Camas C Canal
    d. Reduce operational spills
    e. Ease management for operators
3. Just downstream of the new regulating reservoir, a new flow control structure will be constructed to restart the flow rate in the last portion of the Camas C Canal.
4. Other modernization changes to the remaining portion of the Camas C Canal will include:
    a. Improving existing water level control structures for better service and easier management for operators.
    b. Remotely monitoring the amount of operational spill at the end of the Camas C Canal.

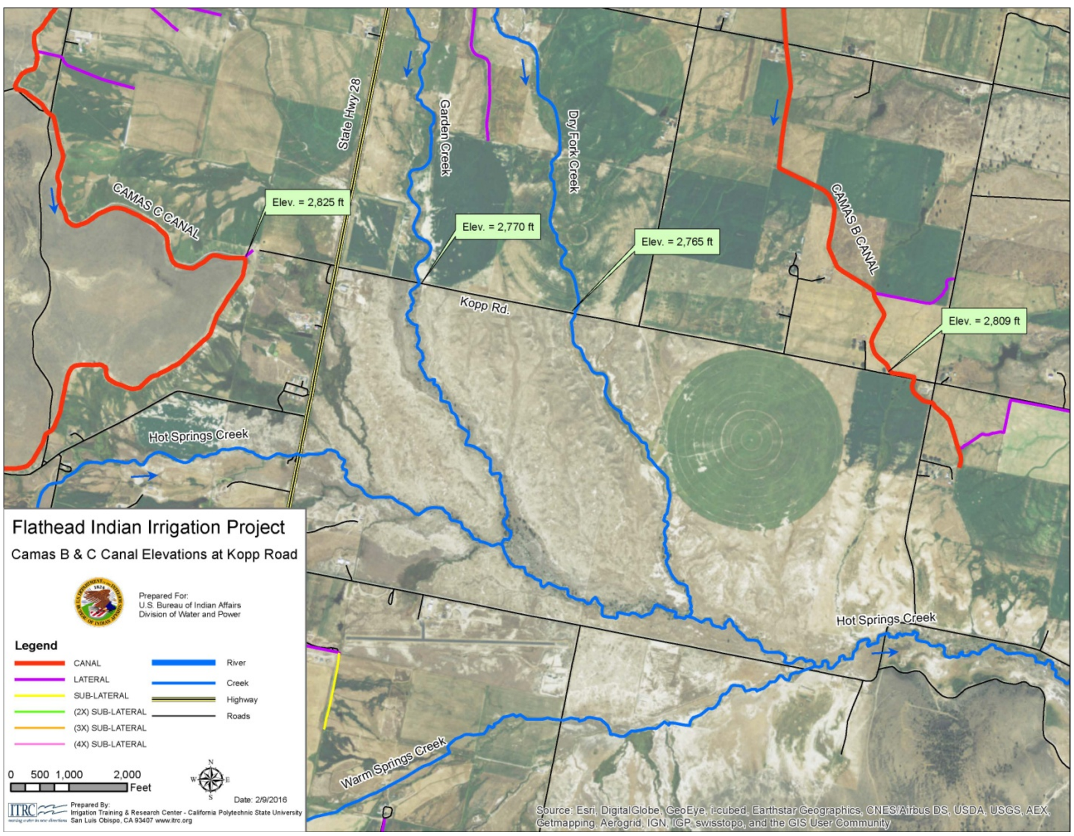

Figure 41. Approximate elevations along Kopp Road

New Operation Scheme for the Southern End of the Valley

The operation and management scheme of the Camas Canal system near the new regulating reservoir would be as follows:

- Operators will divert an extra 1-2 CFS more than is needed into the Camas B Canal at the new "restart" location near the Lower Dry Fork Reservoir.
  - This will ensure that there is always excess flow to spill at the head of the new Camas B End Pipeline.
  - The excess flow will be automatically pumped into the Camas C Canal via the 15" diameter pipeline that runs along Kopp Road.
- The flow rate released from the Lower Dry Fork Reservoir into the Camas C Canal will depend on the water level in the new Camas C Regulating Reservoir:
  - When the storage volume of regulating reservoir is low:
    - Operators will release an extra 10 CFS into the Camas C Canal from the Lower Dry Fork Reservoir.
    - The excess flow will be captured and begin filling the regulating reservoir.
  - When the regulating reservoir is near full:
    - Operators will cut the flow rate at the head of the Camas C Canal by 10-15 CFS.
    - Since the flow in the upper portion of the Camas C Canal will not be able to meet the demand for the downstream portion of the canal (downstream of the new canal restart), the reservoir will automatically make up the flow rate discrepancy.
    - This operation will continue until the storage volume in the reservoir approaches its low operating water level.
- SCADA will be incorporated to help make effective management decisions with the new control scheme by remotely monitoring key flow rates and water levels. Automatic control will be utilized for all pump control at the Camas C Canal Regulating Reservoir.

End of Camas B Canal

Existing Conditions

Figure 42 shows the existing control near the terminus of the Camas B Canal. The existing conditions are as follows:

- A check and waste structure (see Figure 43) located along Kopp Road spills water to a nearby drain that eventually leads to Hot Springs Creek.
- A portion of Lateral 70B has already been converted to pipeline.
- Any operational spill at the end of the Camas B Canal flows to Hot Springs Creek.

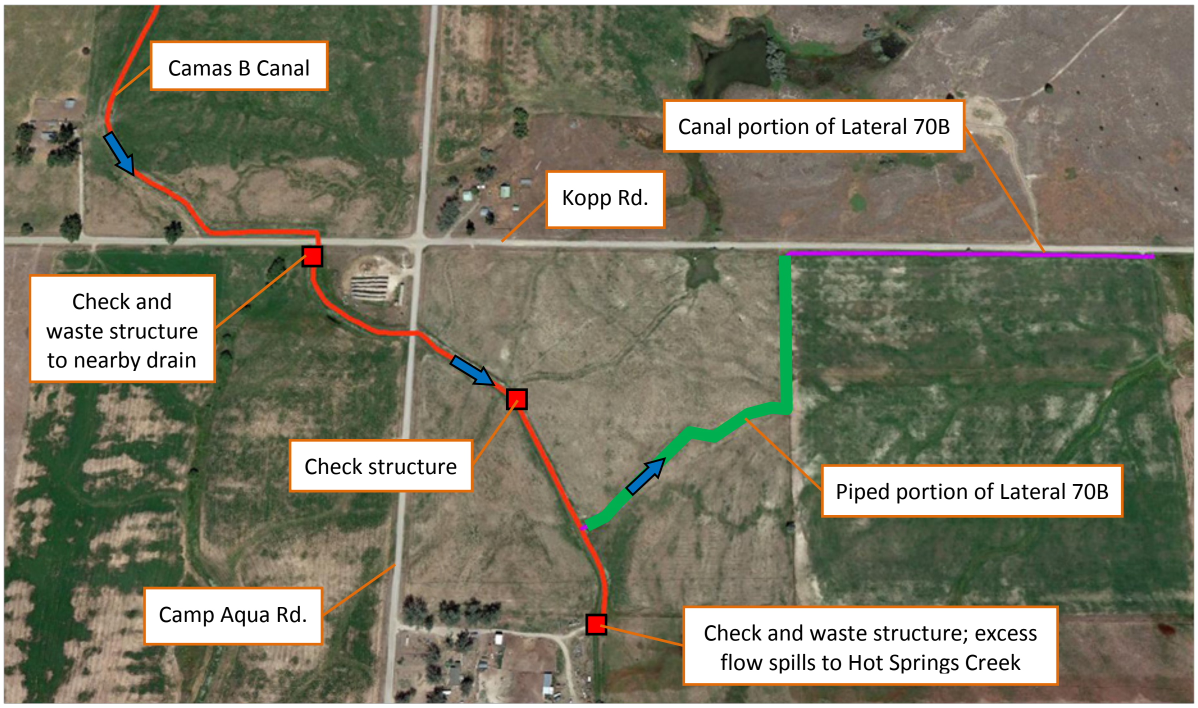

Figure 42. Existing conditions near the end of the Camas B Canal

Figure 43. Existing waste check in the Camas B Canal immediately downstream of Kopp Rd. Photo from HKM 2008 report.

Modernization Changes at the End of the Camas B Canal

The goals for the modernization changes at the end of the Camas B Canal will be to:

- Ease management for operators
- Provide excellent service to the few farmer turnouts
- Divert all excess canal flows towards the Camas C Canal to be reused

Figure 44 shows the modernization changes near the end of the Camas B Canal.

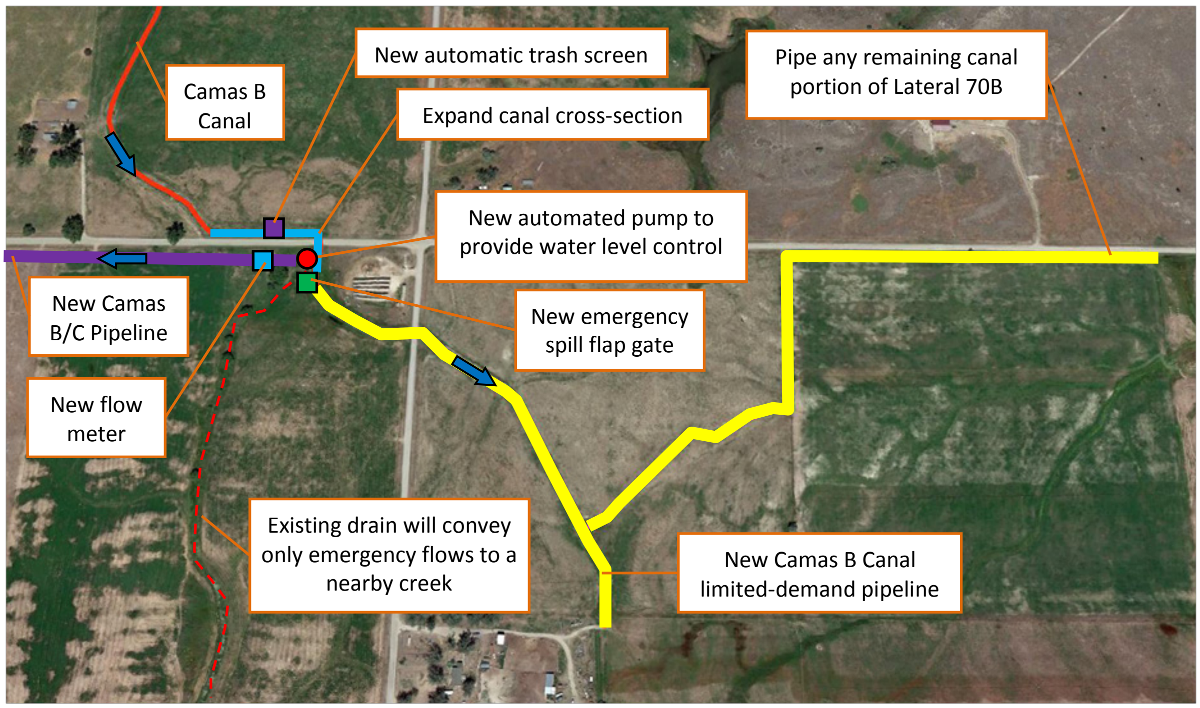

Figure 44. Improvements near the end of the Camas B Canal

The changes near the end of Camas B Canal include the following (see Figure 45):

1. An automatic trash screen will be installed in a straight section of the Camas B Canal upstream of Kopp Road to remove large trash or debris in the canal before it enters the downstream pipeline.
2. The remaining portion of the Camas B Canal (approximately 1,850 ft.) along with the remaining portion of Lateral 70B will be converted to a closed pipeline. The existing piped portion of the lateral will need to be investigated to see if the existing pipe can be pressurized.
3. The water level in Camas B Canal, between the trash screen and the Camas B Canal Limited-Demand Pipeline, will be kept constant by a new 42 HP VFD pump (5 CFS, 54 ft. TDH).
    a. The excess canal flow will be pumped into a new 15” diameter pipeline that runs along Kopp Road until it eventually discharges into the Camas C Canal approximately 2.2 miles to the west.
    b. A portion of the Camas B Canal upstream and downstream of Kopp Road will need to be expanded to increase the canal pool volume to reduce pump cycling.

c. A flow meter will be installed on the new 15" diameter pipeline to allow operators to remotely monitor the flow rate being pumped.

d. The control code for the pump will be programmed directly into the VFD controller.

4. A new 15 CFS emergency flap gate will replace the existing check waste structure in order to automatically pass any emergency flows into an existing drain that discharges to Hot Springs Creek. The flap gate will be set to open when the water level rises approximately 0.2 ft. above the target water level elevation in the canal.

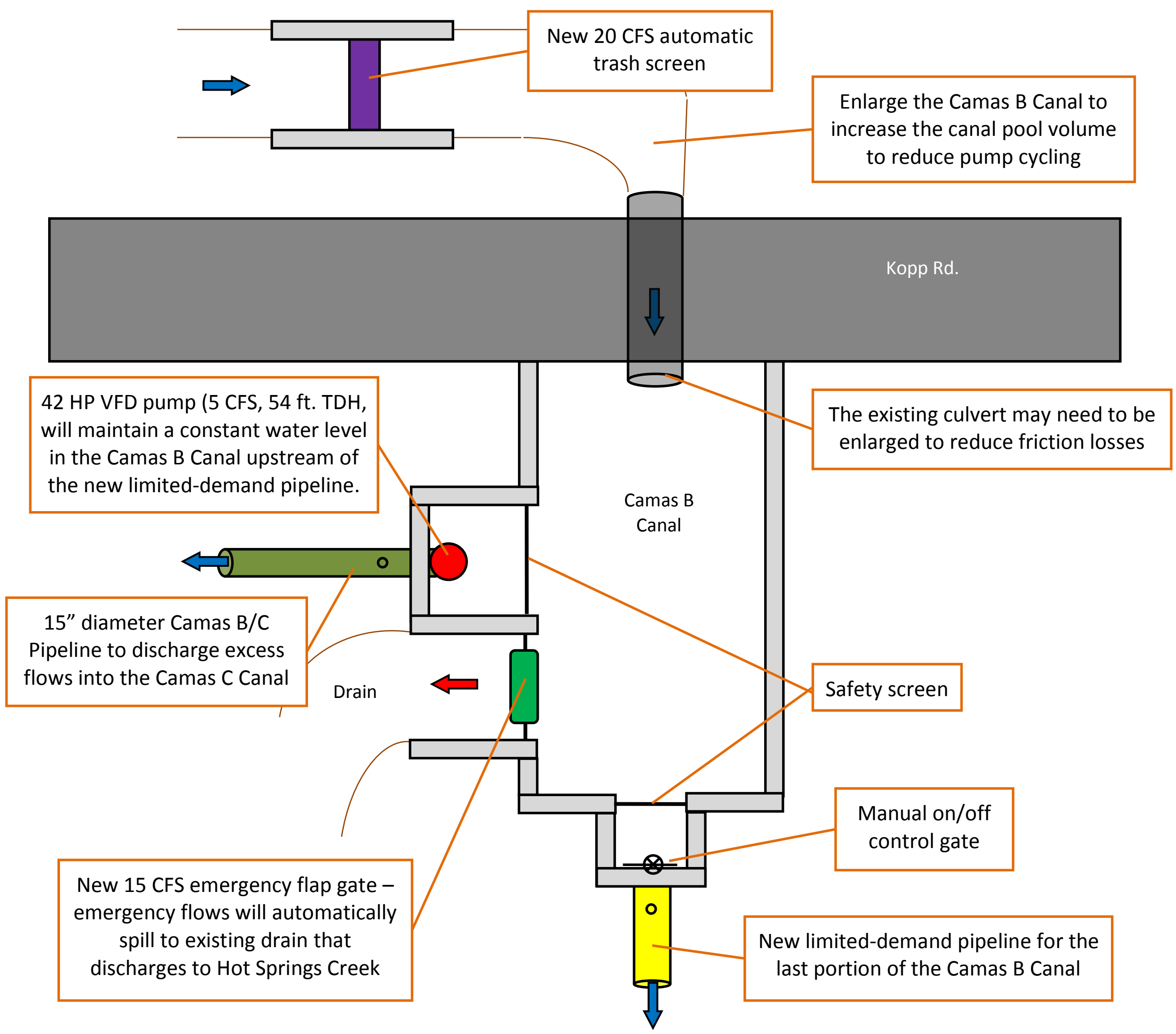

Figure 45. Conceptual plan view of new control components in the Camas B Canal at Kopp Road (not to scale)

Camas C Canal Regulating Reservoir

Figure 46 shows the approximate location for a new 30 AF regulating on the Camas C Canal just southeast of Hot Springs.

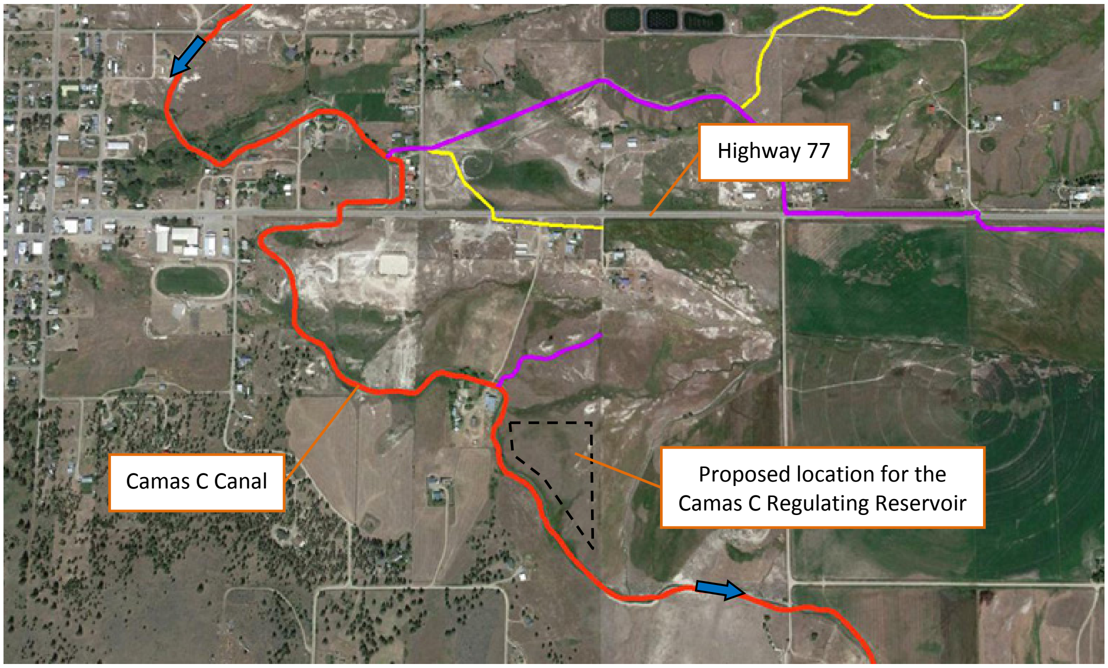

Figure 46. Approximate location for new Camas C Canal Regulating Reservoir southeast of Hot Springs

The operational and managements benefits of the new regulating are:

- Increase flexibility to farmer turnouts upstream and downstream in the canal system
- Provide the required "buffer" for the restart point in the Camas C Canal
- Reduce operational spills
- Ease management for operators

Figure 47 shows the existing check structure in the Camas C Canal located upstream of the proposed regulating reservoir site. Figure 48 shows an aerial view of the existing site.

Figure 47. Existing check structure on the Camas C Canal located upstream of the proposed regulating reservoir site. Photo from HKM 2008 report (CH-25).

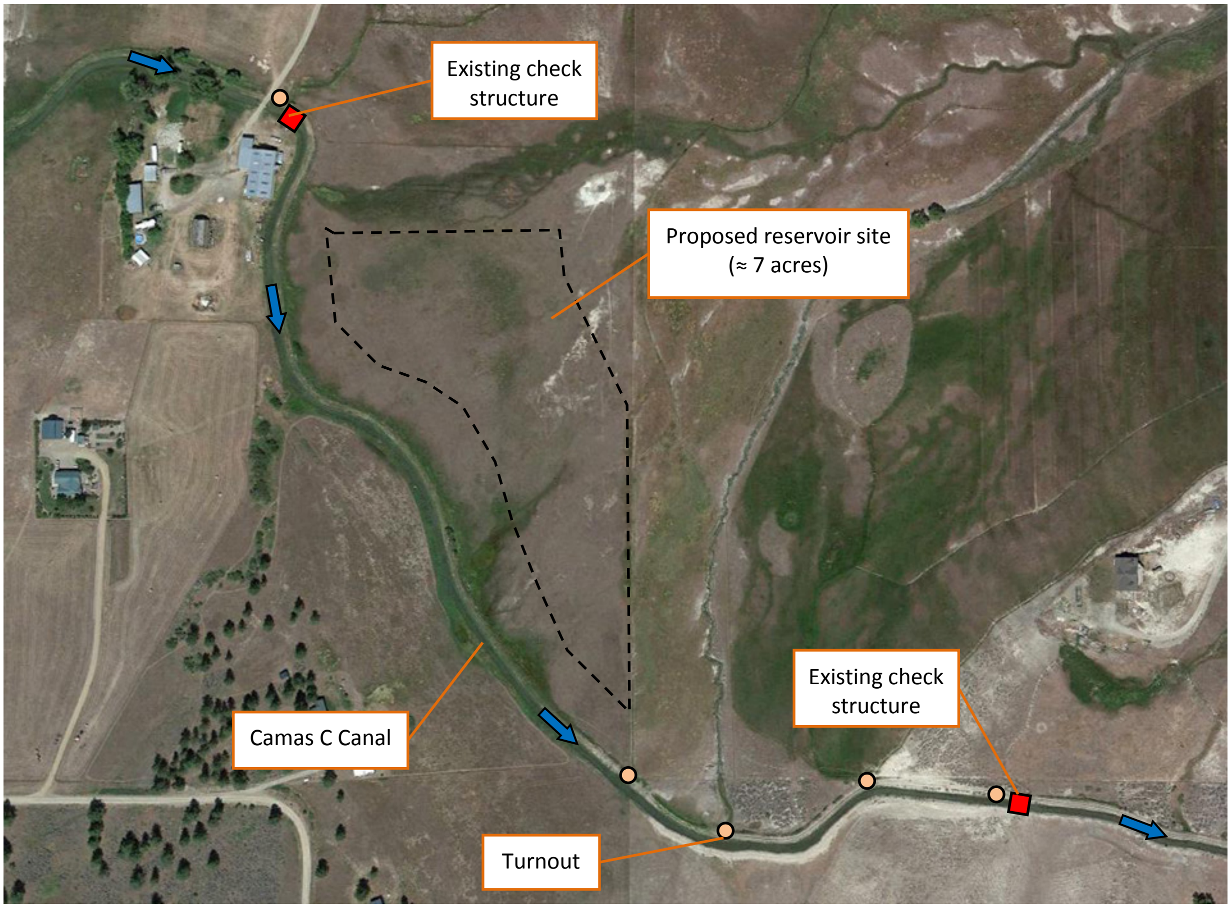

Figure 48. Existing canal control near the proposed Camas C Canal regulating reservoir site

Figure 49 shows the existing check structure in the Camas C Canal located downstream of the proposed reservoir site that is used to maintain the upstream water level for several individual turnouts.

Figure 49. Existing check structure on the Camas C Canal located downstream of the proposed regulating reservoir site. Photo from HKM 2008 report (CH-26).

Figure 50 shows estimated 5 ft. and 10 ft. elevation contours near the proposed regulating reservoir site. The elevation contours were developed from the National Elevation Dataset (NED) provided by the USGS. Based on the elevation contours, the reservoir will consist of one large single cell that will have gravity inflow and pumped outflow.

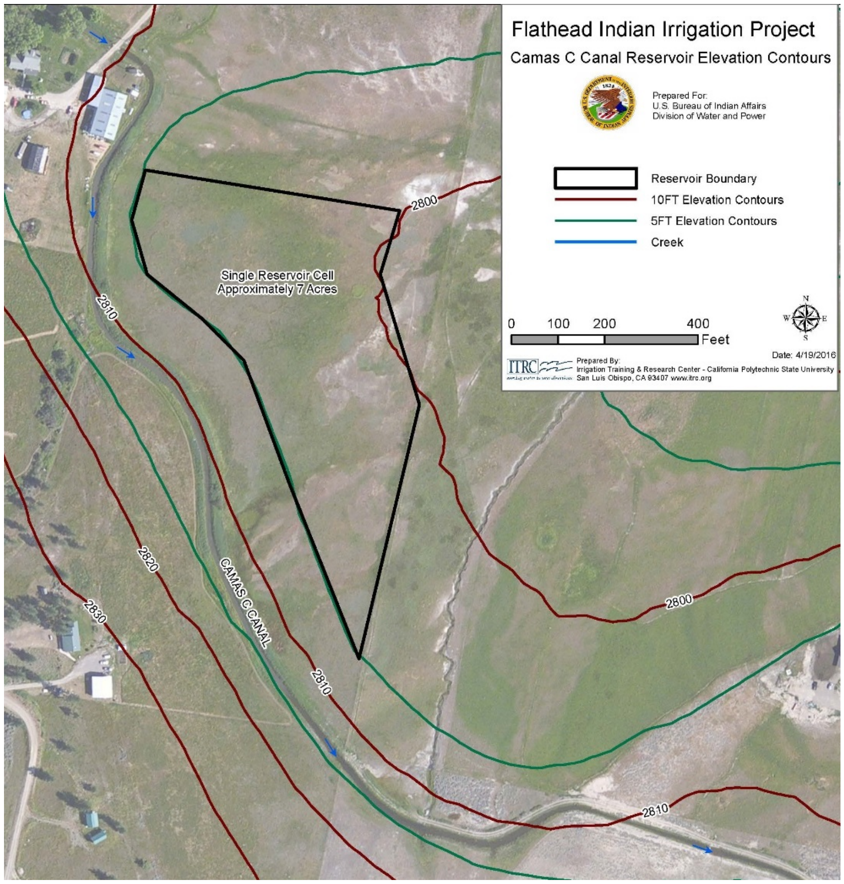

Figure 50. Estimated 5' and 10' elevation contours of the proposed Camas C Canal regulating reservoir site. Elevation contours were produced from the National Elevation Dataset (NED) provided by the USGS.

Regulating Reservoir Components

Figure 51 shows the new components of the new 30 AF regulating reservoir to be constructed on the Camas C Canal.

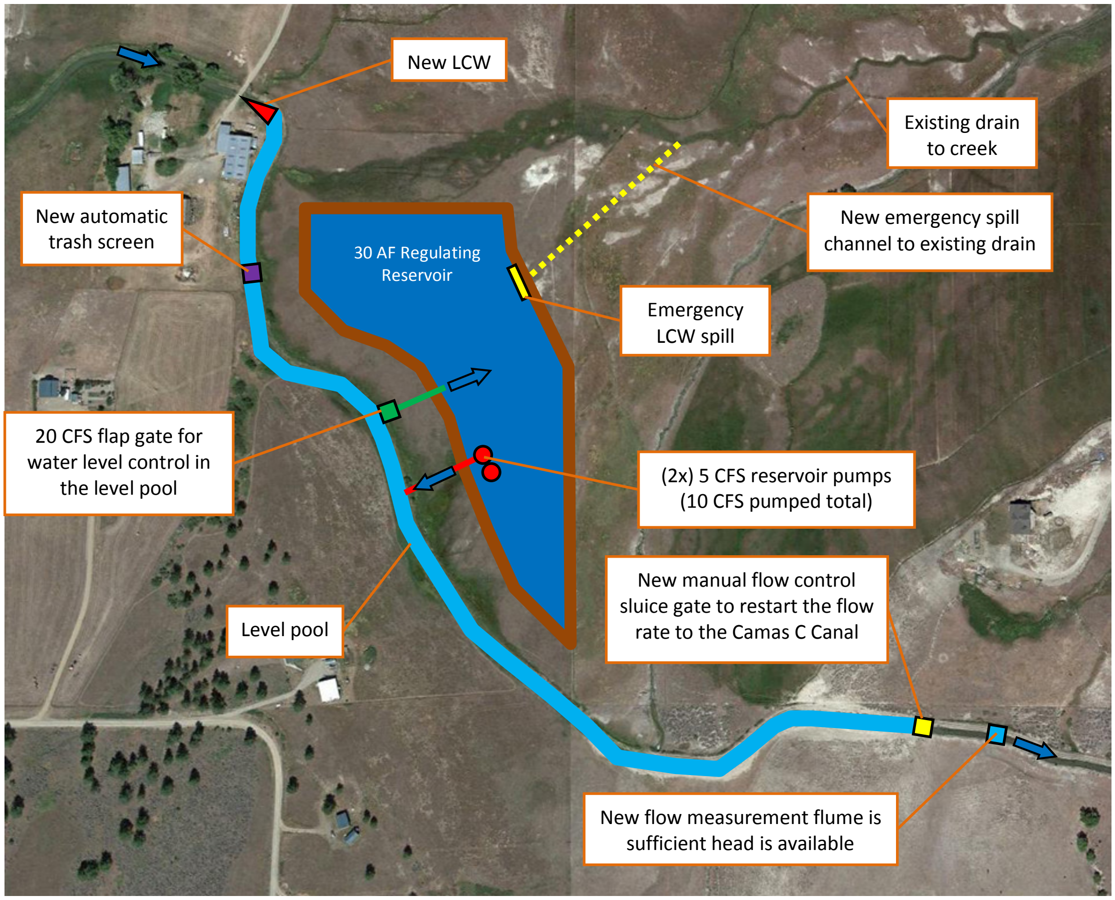

Figure 51. Modernization components of the new Camas C Canal regulating reservoir

The components of the new regulating reservoir are:

1. Water in the Camas C Canal will pass over a new LCW before entering a new level pool.
2. A new automatic trash screen will be installed near the start of the level pool to remove any debris in the canal.
3. A new 20 CFS flap gate will maintain the water level in the canal level pool by automatically passing all excess flows into the reservoir. The flap gate structure will be designed similarly to the conceptual drawing in Figure 36.
4. The reservoir discharge (10 CFS maximum) will be controlled by two identical pumps installed in the reservoir. The pumps will be activated if the canal water level drops below the target water level of the flap gate. 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 are:
    a. Two identical pumps
    b. 5 CFS each
    c. 35 ft. TDH

   d. 26 Input HP to motors
   e. Inverter duty premium motors
   f. Use VFD controllers for slow start option, even if not used for control
   g. 18" diameter common, single discharge pipe to the canal.
5. An emergency LCW will be constructed in the reservoir to automatically spill water to an existing nearby drain if the maximum water level in the reservoir is exceeded. The emergency flow will be conveyed via a new spill channel until it connects to the existing drain that leads to Hot Springs Creek.
6. A new manually operated sluice gate will be installed at the downstream end of the level pool to restart the flow rate to the remaining portion of the Camas C Canal.
7. Flow measurement at the new restart point of the Camas C Canal will depend on the available head loss:
   a. If very little head is available, the sluice gate will measure flow by measuring:
      i. To the water surface both upstream and downstream of the sluice gate to determine the change in head
      ii. The net gate opening height
   b. If sufficient head is available, a new flow measurement flume will be constructed downstream of the new flow control sluice gate. The flow rate through the flume will be remotely monitored via SCADA.
8. SCADA will be incorporated to remotely monitor the water level in the single reservoir cell.

<u>Camas C Canal Spill</u>

Figure 52 shows the existing conditions near the terminus of the Camas C Canal.

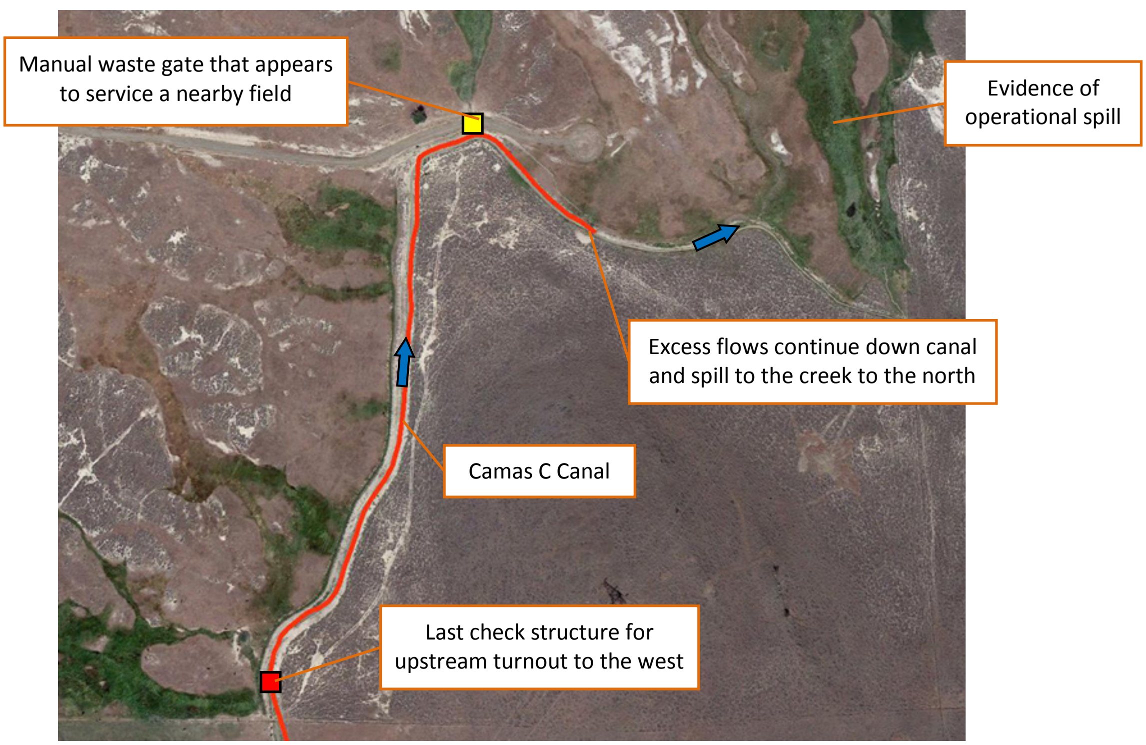

Figure 52. Existing conditions near the end of the Camas C Canal

The last check structure on the Camas C Canal (see Figure 53) is located approximately 2,000 ft. upstream from the terminus of the canal. The check structure maintains the water level for a single turnout as well as the Lateral 90C headgate located approximately 1 mile upstream.

Figure 53. Last check structure on the Camas C Canal. Photos from HKM 2008 report (CD-4).

Figure 54 shows a canal gate structure that was identified as a check waste structure in the HKM report but appears to be an actual turnout to a nearby field. The canal gate is located approximately 400 ft. upstream of the terminus of the Camas C Canal. There is no water level control structure located downstream of the canal gate.

Figure 54. Manual waste gate that appears to service a nearby field. Photo from HKM 2008 report (CW-8).

All excess flows in the canal eventually spill to a creek to the north. Figure 52 shows a large green area indicating that there must be a fair amount of spill at the end of the Camas C Canal. Any spill at the end of the canal is lost to the project.

Measuring Operational Spill at the End of the Camas C Canal

By introducing flow measurement at the end of the Camas C Canal, operators will be able to:

- Make effective management decisions for setting flow rate in the Camas C Canal at the new restart point further upstream.
- Help reduce operational spill that is lost to the project.

Figure 55 shows the location of a new Cipoletti weir near the terminus of the Camas C Canal.

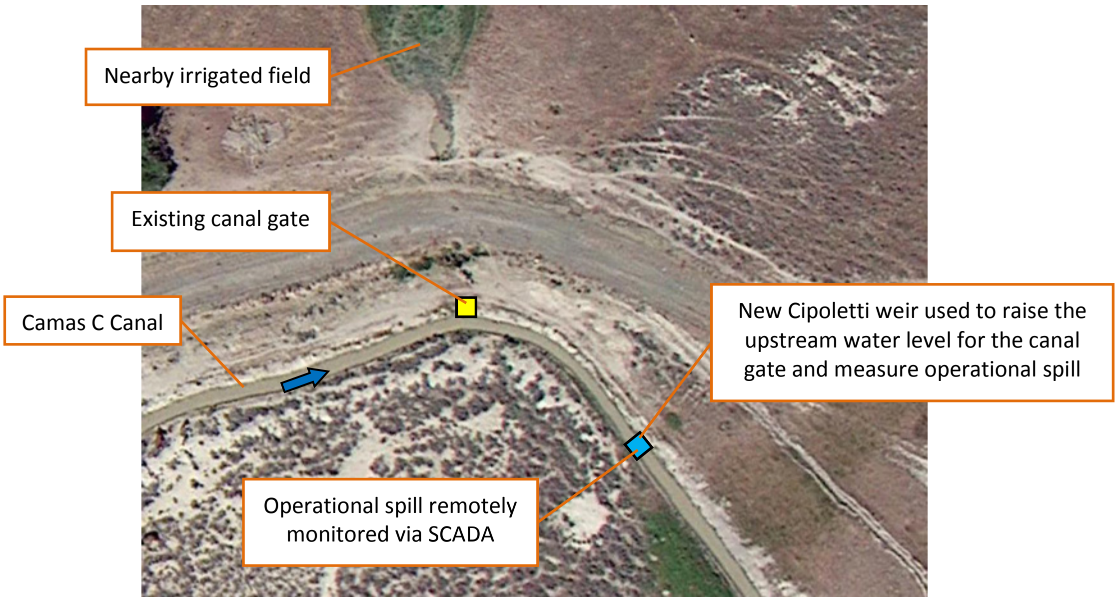

Figure 55. New Cipoletti weir at the end of the Camas C Canal

The new Cipoletti weir will provide the following functions:

1. Measurement of any operational spill at the end of the Camas C Canal. SCADA will be incorporated to remotely monitor the spill so that operators can make the necessary flow rate changes at the new restart point of the Camas C Canal near the level pool.
2. Upstream water level control for the existing canal gate.

Improved Water Level Control along the Camas Main Canals

The existing water level control structures in the Camas main canals are not capable of easily handling variable flow rates. This can have a significant impact on turnout deliveries since the check structures are not able to maintain a fairly constant upstream water level.

Figure 57 on the next page shows the locations for improved water level control structures along the Camas main canals. It is not financially feasible to improve each structure. Therefore, it will be up to FIIP to determine which structures should be improved when funding is available. The most likely candidates are the existing structures that are operationally difficult for FIIP staff to manage.

Either a flap gate or an LCW structure should be used to improve the existing water level control. The downside to a flap gate is that there must be about 2.5 ft. of elevation drop in order for it to work properly (the flap gate cannot be submerged on the downstream side). It has been observed that most the existing check structures have too little head loss to accommodate a flap gate.

The alternative to a flap gate is an LCW structure. Figure 56 shows a conceptual example of the new LCW structures to be utilized along the Camas Canal. 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 adjusted by adding or removing flashboards.

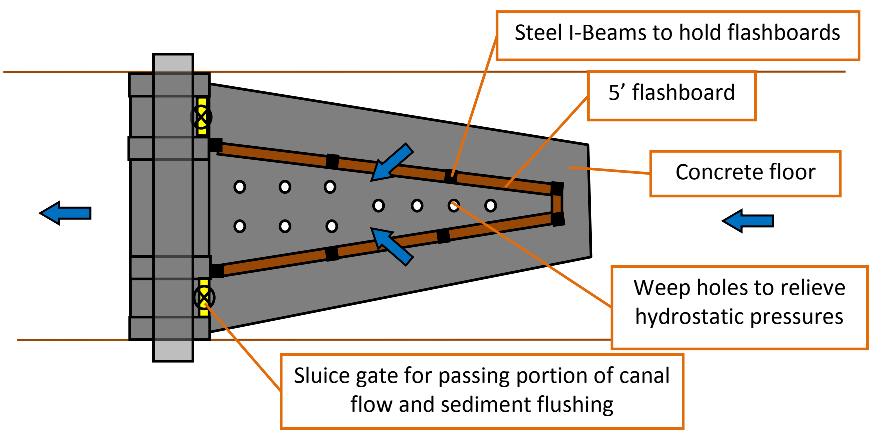

Figure 56. Example of a new LCW structure to be constructed along the MA Canal (not to scale)

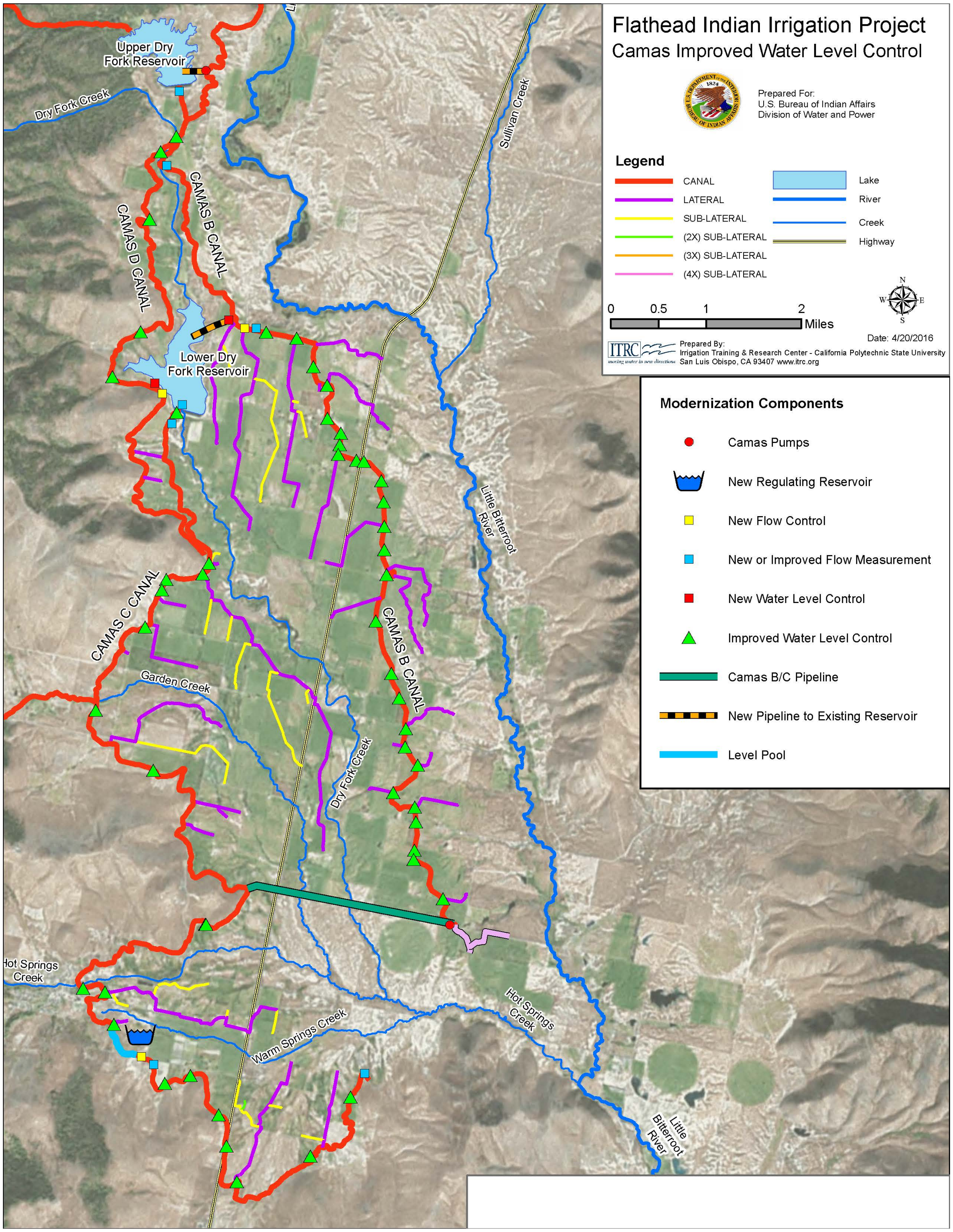

Figure 57. Locations of improved water level control structures along the Camas B, C, and D Canals

Figure 58 and Figure 59 show similar examples of existing LCW structures installed in two irrigation districts in California.

Figure 58. Somewhat similar LCW installed at Turlock ID

Figure 59. 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.

A good design rule of thumb for LCW is that for every lineal foot of weir crest, 1 CFS will be passed with a head of 0.5 ft. over the crest. For example, an LCW in a 30 CFS canal would have an effective crest length of 30 ft. For high flow canals, the outside sluice gates can be enlarged to pass more flow in order to reduce the length of the LCW. For example, a LCW structure in a 150 CFS canal could be designed to that 50 CFS passes through each outside sluice gate (for a total of 100 CFS) and the remaining 50 CFS would then pass over a 50 ft. LCW.