FINAL TECHNICAL MEMORANDUM

Crooked River - Diversion Gaging Memo

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1.0 INTRODUCTION

1.1 Introduction

The purpose of this Technical Memorandum (TM) is to provide an overview of the potential benefits of installing additional gaging on diversions located below Prineville Reservoir on the Crooked River. This TM was funded under the direction of the Upper Deschutes Basin Study Team and will address the following topics:

- Overview of Crooked River System
- Potential Benefits of Additional Diversion Gaging
- Prioritization of Additional Diversion Gaging
- Overview of Implementation Process
- Future Actions

1.2 Stakeholders

This TM was developed with collaboration from the following stakeholders:

- Ochoco Irrigation District (OID)
- Bureau of Reclamation (Reclamation)
- Oregon Water Resources Department (OWRD)
- Upper Deschutes Basin Study Team

2.0 OVERVIEW OF CROOKED RIVER SYSTEM

The following section provides an overview of the Crooked River system and existing surface water diversions below Prineville Reservoir. The description of the Crooked River system will focus on the river reach located between Prineville Reservoir and approximately four miles downstream of the City of Prineville, Oregon. An overview map of the Crooked River system can be found in Attachment A.

2.1 Crooked River Description

The Crooked River is a regulated system controlled by the Arthur R. Bowman Dam. The dam impounds stream flow from the Crooked River and a small tributary (Bear Creek) to create

Prineville Reservoir. The dam serves many purposes including providing Section 7 flood control, water supply (Irrigation and Municipal & Industrial (M&I)), fish and wildlife benefits, and recreational opportunities. During the non-irrigation season, water is primarily released for fish and wildlife purposes (excluding flood control releases) while outside of this season additional releases are made to meet irrigation and M&I demand.

Immediately downstream of Arthur R. Bowman Dam, the Crooked River travels for approximately eight miles through a deep canyon that is used heavily by recreationists and is regarded as one of the finest trout fisheries in the State of Oregon. After this initial canyon section, the river travels through a small valley, herein referred to as the "Small Upper Valley", where the first surface water points of diversion are located (Attachment A). These small diversions include four river pumps owned by Quail Valley, LLC. The river pumps generally divert approximately 1 to 2 cubic feet per second (cfs) each. Downstream of the Small Upper Valley, the river travels through a short canyon section before entering a larger valley, herein referred to as the "Larger Lower Valley". The head of the Larger Lower Valley is approximately 14 miles downstream from the dam and approximately six miles upstream from the City of Prineville. Immediately after the Crooked River enters the Larger Lower Valley, several small river pumps as well as two canals divert water from the river. The smaller upstream canal diversion (Rice Baldwin Diversion) is located on the left bank while the larger downstream diversion (Feed Canal Diversion) is located on the right bank. The Rice Baldwin Diversion has an approximate diversion rate of 16 cfs while the Feed Canal Diversion has a typical diversion rate between 140 to 160 cfs.

Downstream of the Feed Canal Diversion, the Crooked River continues through the Larger Lower Valley with numerous agricultural fields being located on both sides of the river. Five additional small pumps divert from the river in this section including four river pumps owned by Quail Valley, LLC (diverting an average of 1 to 2.3 cfs, each) and one owned by Ulupalakua (diverting an average of 5.5 cfs). At approximately 22 miles downstream from the Arthur R. Bowman Dam, another canal diversion (Peoples Irrigation Diversion) is located on the left bank of the river. The Peoples Irrigation Diversion has an approximate diversion rate of 18 to 24 cfs and delivers water through an earthen canal along the south side of the valley. An additional river pump (River Stepps), owned by Ulupalakua, diverts approximately 2 to 3 cfs near the Peoples Diversion.

Downstream of the Peoples Diversion, the Crooked River enters the Prineville Valley and travels along the southern side of the City of Prineville until crossing under Highway 126 (location of Crooked River at Prineville (CAPO) streamflow gage) and continuing downstream in a northwesterly direction. Between the Peoples Diversion and the CAPO stream gage, an additional six river pumps are present that are owned by:

- Crook County Parks and Recreation, Les Schwab Park (1 pump),
- Robert Gray/OID, Direct #14 (1 pump),

- Crook County Parks and Recreation, Middle Park (1 pump),
- City of Prineville, Meadow Lakes Golf Course (1 pump),
- Margaret Gervais, Private Lawn and Garden (1 pump), and
- Crook County Parks and Recreation, Library Park (1 pump).

At approximately 28 miles downstream from the Arthur R. Bowman Dam, the Crooked River Central Diversion is located on the left bank. The Crooked River Central Diversion has an approximate diversion rate of 12 cfs. Between the CAPO stream gage and the Crooked River Central Diversion, additional water enters the Crooked River from a combination of Ochoco Creek, McKay Creek and various irrigation drains. Due to this additional inflow downstream of the CAPO gage, the CAPO stream gage is regarded as a point of lowest flow in the system. Streamflow measurements at the CAPO gage are utilized to account for water being released from the dam for the benefit of fish and wildlife.

Table 1 provided below summarizes the surface water diversions from the Crooked River between Prineville Reservoir to approximately four miles downstream of the City of Prineville.

Table 1. Crooked River Surface Water Diversions between Prineville Reservoir and four miles downstream of the City of Prineville

Diversion Name	Diversion Type	Approximate Diversion Rate (cfs)	Approximate River Mile[3]	Owner
Arthur R. Bowman Dam[1]	n/a	n/a	72	Bureau of Reclamation
Quail Valley Diversions[2]	River Pumps	4-17 (total)	64-55	Quail Valley, LLC
Rice Baldwin Diversion	Canal	16	56.8	Rice Baldwin
Feed Canal Diversion	Canal	140-160	56.6	Ochoco Irrigation District
Ulupalakua	River Pump	5.5	53.7	Ulupalakua
Peoples Diversion	Canal	18-24	50.23	Peoples Irrigation
River Steppes	River Pump	2-3	50.22	Ulupalakua
Les Schwab Park	River Pump	0.75	49.3	Les Schwab
Direct #14	River Pump	0.25	49.29	Robert Gray/OID
Middle Park	River Pump	0.5	49.08	Crook County Parks and Recreation
Meadow Lakes Golf Course	River Pump	0.75	48.3	City of Prineville
Private Lawn and Garden	River Pump	0.1	48.11	Margaret Gervais
Library Park	River Pump	1.0	47.91	Crook County Parks and Recreation
Crooked River Central Diversion	Canal	12	44.5	Crooked River Central Ditch Company

1. Arthur R. Bowman Dam was included in the table to provide a river mile reference.
2. Quail Valley Diversions consists of 8 river pumps with individual pump capacities ranging from 0.5-2.5 cfs.
3. Approximate River Mile was obtained from OWRD and is referenced as the miles upstream from the confluence with the Deschutes River.

2.2 Existing Stream and Diversion Gaging

Six stream gages and one diversion gage currently exist on the Crooked River for determination of flows in the system in near real-time. Ten river pump meters were installed in 2018 and include eight owned by Quail Valley and two owned by Ulupalakua. These river pumps were metered with battery operated Valley 3000 MagMeters and constitute over 90 percent of the pumped diversion above the Crooked River at Prineville, Oregon (CAPO) stream gage but at this time are not telemetered.

Six of the seven near real-time gages measure streamflow in the Crooked River while the other gage collects diversion data for the Crooked River Feed Canal near Prineville, Oregon (CRCO) which consists primarily of OID diversions. The six river gages include:

- Crooked River above Prineville Reservoir near Post, Oregon (CRPO) located approximately 22 miles upstream of the Arthur R. Bowman Dam. This gage is utilized to determine inflows into the reservoir.
- Crooked River near Prineville, Oregon (PRVO) located approximately 0.5 miles downstream of the Arthur R. Bowman Dam. This gage is utilized to determined outflows from the reservoir.
- Crooked River at Prineville, Oregon (CAPO) located at the Highway 126 Bridge near Prineville. This gage is utilized to meet minimum flow targets for the benefit of fish and wildlife during the irrigation season. The location of the CAPO gage is considered to be the low flow point in this system.
- Crooked River at Smith Rocks State Park near Terrebonne, Oregon (CRSO) located near the Smith Rock State Park. This gage is utilized to meet North Unit Irrigation District (NUID) minimum flow targets for their river pumps as well as account for water that was released from Prineville Reservoir for the benefit of fish and wildlife.
- Crooked River below Osborne Canyon near Opal City, OR (Sta. ID 14087380) located above Opal Springs and approximately 10 miles downstream from Smith Rocks State Park. This gage is available through the OWRD website but is not currently on the Reclamation Hydromet website.
- Crooked River below Opal Springs near Culver, Oregon (CROO) located below Opal Springs shortly before the Crooked River enters Lake Billy Chinook. This gage is utilized to meet 2005 Biological Opinion requirements for the Operation and Maintenance of Reclamation projects in the Deschutes River Basin.

In addition to the seven gages mentioned above, measurements of the water surface elevation and reservoir content of Prineville Reservoir (PRV) is also available. Table 2 provided below summarizes the near realtime gages that are currently available on the Crooked River. Current discharges at most of these gages can be obtained from Reclamation's Hydromet website: (http://www.usbr.gov/pn/hydromet/destea.html).

Table 2. System Gages on the Crooked River

Gage Name	CBTT Code	Measurement Unit*
Crooked River at Post, OR	CRPO	QD
Prineville Reservoir	PRV	AF, FB
Crooked River near Prineville	PRVO	QD, QU
Crooked River Feed Canal near Prineville, OR	CRCO	QJ
Crooked River at Prineville, OR	CAPO	QD
Crooked River at Smith Rocks	CRSO	QD
Crooked River below Osborne Canyon near Opal City, OR (Sta. ID 14087380)**	NA	QD
Crooked River below Opal Springs near Culver	CROO	QD

*QD=Mean Daily Discharge (cfs), QU=Mean Daily Unregulated Discharge (cfs), FB=Reservoir Forebay Elevation (ft), AF=Reservoir Storage (ac-ft), QJ= Mean Daily Canal Discharge (cfs)

**This gage is available through the OWRD website but is not currently available the Reclamation Hydromet website.

3.0 POTENTIAL BENEFITS OF INSTALLING ADDITIONAL DIVERSION GAGING

The gaging summary provided above shows that the majority of diversions from the Crooked River system are not currently telemetered and hinder the ability to accurately perform water accounting in near real-time. The following section provides a summary of the potential benefits of installing additional near real-time diversion gaging on the Crooked River.

3.1 Water Right Accounting

The passage of the "Crooked River Collaborative Water Security and Jobs Act of 2014" (CRCWA) resulted in, among other things, a modification to the use of water storage rights in the Prineville Reservoir including defining the method by which reservoir storage accounts would be filled and how unused water would be carried over from one water year to the next. The Prineville Reservoir has twenty-one contracted storage accounts which have a combined storage right of 86,113 acre-feet. The remaining 62,520 acre-feet of uncontracted active storage space in Prineville Reservoir is to be used for the benefit of fish and wildlife as described in the CRCWA. At present time, the only real-time gaged diversion in the system is the Feed Canal Diversion (CRCO), therefore requiring the other diversions to be estimated to complete a water right accounting for the system. Currently, the un-gaged and/or non-telemetered diversions upstream of the Highway 126 Bridge are estimated in near real-time by subtracting the measured Feed Canal Diversion and the water passing the CAPO gage from the amount released from the dam.

With additional measurement of the remaining diversions, a more accurate accounting of water deliveries could be completed. The diversion information plays a critical factor when calculating the end of the water year carryover storage for each space holder. Currently, due to being limited to only a single gaged stream diversion (Feed Canal Diversion), the carryover is calculated on a broader basis by lumping unmeasured diversions together rather than on an individual basis.

It is important to note that although additional gaging would allow for a more accurate calculation of water accounting, errors inherent in water measurement will always be present. Typical standard errors of water measurement in canals similar to what is proposed on the Crooked River are approximately +/-10%. In addition to the errors inherent in water measurement, additional gages may identify reach gains or losses that would also need to be addressed when completing the water accounting.

3.2 Operational Efficiency

The release of water from Arthur R. Bowman Dam during the irrigation season is completed through correspondence with water users. Although typical seasonal water deliveries are known, in-season adjustments to deliveries are not always known before the change occurs at the diversion. If additional, near real-time diversion data was available, changes in diversion demand would be available immediately for water managers to consider when making adjustments to releases from the dam. During most seasons, operational losses occur based on this lack of diversion change information (typically occurring during times of crop harvest or changing weather conditions) and additional gaging would allow an opportunity to help minimize this loss.

3.3 Water Savings

A potential for water savings may exist if water users and managers utilize the information gained from additional diversion gaging to modify existing water use practices. Through a better understanding of current in-season water usage as well as current storage water balances, water use may be reduced during periods when diverted water is not fully utilized. Modification of water usage may provide opportunity to carryover additional storage into the next water year to increase the likelihood of reservoir refill.

4.0 PRIORITIZATION OF ADDITIONAL DIVERSION GAGING

The following section provides a prioritized list of diversions needing gaging that are based on the amount of water believed to be diverted (larger diversions were given higher priority over smaller diversions), ability of new gaging to incentivize water conservation, and the ability to increase the accuracy of the water right accounting.

4.1 Priority 1 – Peoples Irrigation Diversion

The Priority 1 location was determined to be the Peoples Irrigation Diversion due to the size of the diversion and the fact that a measurement flume (Figure 1) already exists at this location. This ungaged diversion is located between the CRCO and CAPO gages. The diversion head gate, ramp flume (weir control section now since removed), equipment platform and staff plate were installed by OWRD in 2010. Additional supplies needed to develop a near real-time gaging station at this site are to install a weir control section, a gage shelter, stage recorder equipment and telemetry equipment. The preliminary cost estimate for this equipment is approximately $11,000 to $14,000. Operation of this diversion gage will require flow measurements throughout each season to confirm the stage-discharge rating curve.

In addition to the equipment list above, permitting may be required including but not limited to State Historic Preservation Office (SHPO) requirements as well as securing an Access Agreement to the site.

Figure 1. Peoples Irrigation Diversion Canal Measurement Flume (Photo provided by OWRD).

4.2 Priority 2 – Rice Baldwin Diversion

The Priority 2 location was determined to be the Rice Baldwin Diversion due to the amount of surface water being diverted by the canal each season (typically 16 cfs, or approximately 30 acre-feet per day). This un-gaged diversion is located just upstream of the Crooked River Feed Canal. Currently, the only infrastructure present at this location is an existing head gate (Figure 2) in the river that appears to be functioning but may need to be updated in the future. It should be noted that fish passage at the Rice Baldwin Diversion was completed in 2018. The

measurement location for the diversion has been identified by OWRD. The supplies needed for this location include a ramp flume, 4 ft x 4 ft concrete pad, gage shelter, stage recorder equipment and telemetry equipment. The preliminary cost estimate for this equipment is approximately $12,000 to $15,000. Operation of this diversion gage will require flow measurements throughout each season to confirm the stage-discharge rating curve.

In addition to the equipment list above, permitting may be required including but not limited to SHPO requirements as well as securing an Access Agreement to the site.

Figure 2. Picture of Rice Baldwin Diversion Canal Head Gate Structure (Photo provided by OWRD).

4.3 Priority 3 – Crooked River Central Diversion

The third priority location for additional gaging was determined to be the Crooked River Central Diversion (Figure 3). This site has a newly constructed diversion structure from the river. An optimal measurement site for the canal has not been identified yet by OWRD. This un-gaged diversion is located between the CAPO and CRSO gages. The supplies needed for this location would most likely include a ramp flume, 4 ft x 4 ft concrete pad, gage shelter, stage recorder equipment and telemetry equipment. The preliminary cost estimate for this equipment is approximately $12,000 to $15,000. Operation of this diversion gage will require flow measurements throughout each season to confirm the stage-discharge rating curve.

In addition to the equipment list above, permitting may be required including but not limited to SHPO requirements as well as securing an Access Agreement to the site.

Figure 3. Picture of Crooked River Central Diversion Head Gate Structure (Photo provided by OWRD).

4.4 Priority 4 – Ulupalakua Pump

The Ulupalakua Pump (Figure 4) was determined to be the fourth priority measurement location on the Crooked River. The river pump has an approximate capacity of 5.5 cfs and is located at river mile 53.77 that is between the CRCO and PRVO gages. This river pump was metered with a battery-operated Valley 3000 MagMeters in 2018 but installation of telemetry is still recommended to provide near real-time diversion data at this location. The preliminary cost estimate for purchasing and installing telemetry for this site is approximately $3,500 or $5,000 depending on if the transmitter is a cell modem or GOES.

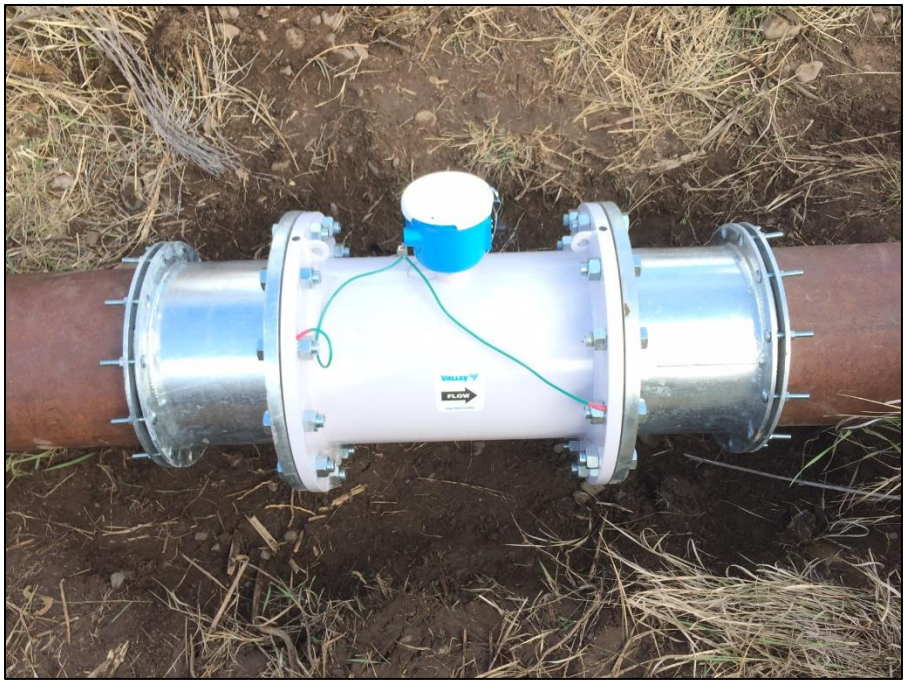


Figure 4. Picture of the Ulupalakua Pump meter (Photo provided by OWRD).

4.5 Priority 5 – River Steppes Pump

The River Steppes Pump (Figure 5) was determined to be the fifth priority measurement location on the Crooked River. The river pump has an approximate capacity of 2 to 3 cfs and is located at river mile 50.22 that is between the CRCO and PRVO gages. This river pump was metered with a battery-operated Valley 3000 MagMeters in 2018 but installation of telemetry is still recommended to provide near real-time diversion data at this location. The preliminary cost estimate for purchasing and installing telemetry for this site is approximately $3,500 or $5,000 depending on if the transmitter is a cell modem or GOES.

Figure 5. Picture of River Steeps Pump meter (Photo provided by OWRD).

5.0 OVERVIEW OF IMPLEMENTATION PROCESS

5.1 Permitting

The Peoples Diversion, Rice Baldwin Diversion and Crooked River Central Diversion location will need Access Agreements and may require some form of permitting. The level of permitting will depend on the exact location of the measurement section but may require SHPO and NEPA analysis. Permitting and legal constraints posed by land ownership should be part of the site selection process and may cause the most optimal measurement location to be infeasible. The final location selected should ensure that operation of the gage can continue indefinitely.

5.2 Installation Costs

Total cost of a particular site depends on the type of data collected, access to the site and permitting requirements. In some instances, cost share opportunities may be available through coordination with Federal, State, or local funding partners. The cost estimates in the following paragraph were provided by OWRD and are based on current equipment and installation costs.

The typical cost for a new gaging station that includes a ramp flume, 4 ft x 4 ft concrete pad, gage shelter, stage recorder equipment and telemetry equipment would be approximately $12,000 to $15,000.

The typical cost for a flow meter with telemetry capabilities for a 1.5 cfs (~675 gpm) pump is approximately $5,500 to $7,000 depending on if the transmitter is a cell modem or GOES. Telemetry for a river pump already metered ranges from $3,500 or $5,000 depending on if the transmitter is a cell modem or GOES.

5.3 Operation and Maintenance (O&M)

Typical annual O&M costs provided by OWRD for gaging a diversion with near real-time data collection is approximately $12,000. This includes the costs associated with maintaining and operating the station, management of real-time data, website data access, final records review, and equipment replacement costs. It is important to note that due to changes in channel conveyance caused from macrophyte growth, it should be anticipated that monthly measurements would be required to confirm the stage-discharge relationship throughout the season. If a cell modem transmitter is utilized at a gaging site there would be a monthly charge for the cell service as well.

6.0 FUTURE ACTIONS

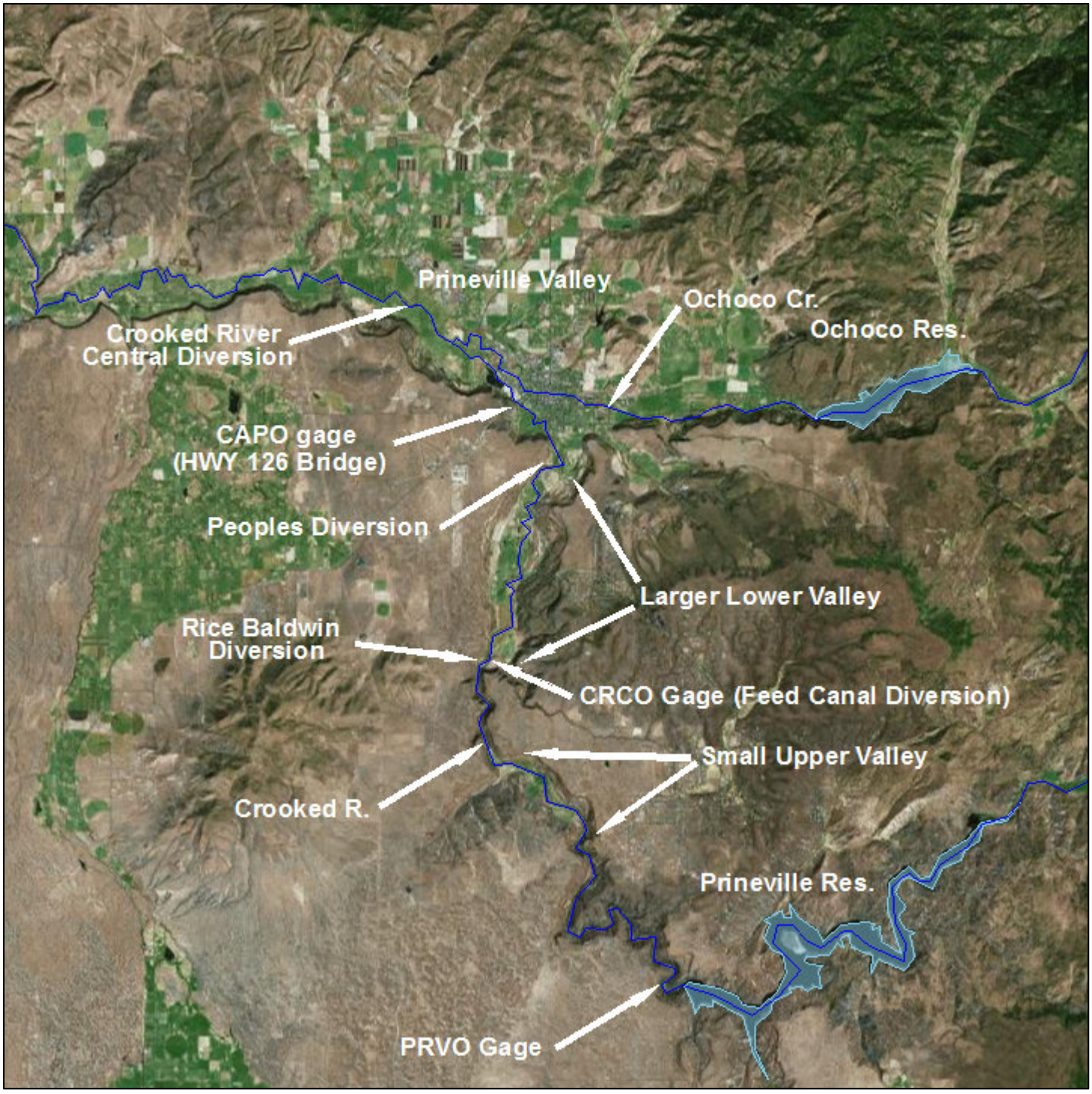
Based on the findings provided in this TM, the following is a list of future actions that may be warranted:

- Investigate funding mechanism for measuring equipment, telemetry, and O&M costs for the Peoples Irrigation Diversion. Complete any permitting requirements including but not limited to SHPO requirements as well as securing an Access Agreement to the site.
- Investigate funding mechanism for measuring equipment, telemetry, and O&M costs for the Rice Baldwin Diversion. Complete any permitting requirements including but not limited to SHPO requirements as well as securing an Access Agreement to the site.
- Investigate possible measurement locations for the Crooked River Central Diversion based on landownership and permitting constraints.
- Investigate funding mechanisms for measuring equipment, telemetry, and O&M costs for the Crooked River Central Diversion.
- Investigate funding mechanism and landowner agreements for the purchase of telemetry for the Ulupalakua Pump (R.M. 53.7) and River Steppes Pump (RM 50.22) flow meters.

Attachment A

Crooked River System Map

Crooked River System Map



RECLAMATION
Managing Water in the West