Memorandum: Water Bank Phase 2B

To: Water Bank Technical Subcommittee
From: Shaden Musleh and John Craven, Hydros Consulting, Inc.
Subject: Qualitative Assessment of Water Banking
Date: October 19, 2015

Overview

The purpose of this memorandum is to provide a qualitative assessment and summary of conclusions for water banking for the three ditch systems described in Hydros' technical memoranda attached as Appendices A-C.

Systems Reviewed

The following memorandum includes an assessment of the following ditch systems: the Grand Valley Project (Grand Valley Water Users' Association), the Uncompahgre Valley Water Users' Association, and the Doctor Morrison ditch system. Table 1 below presents an overview summary of these three ditches related to water banking.

Table 1: System Overview Summary

System	Grand Valley	Doc. Morrison	Uncompahgre
Owner of Water Rights	US Bureau of Reclamation	US Government /Bureau of Indian Affairs (BIA)	US Bureau of Reclamation
Operator	Grand Valley Water Users' Association	Bureau of Indian Affairs (BIA)	Uncompahgre Valley Water Users' Association
Water Division/District	Div. 5 / Dist. 72	Div. 7 / Dist. 31	Div. 4 / Dist. 41
Primary Water Source	Colorado River	Pine River	Uncompahgre River, Gunnison River
Structure(s) Serving Project	Grand Valley Project (ID: 646)	Dr. Morrison Canal (ID: 1044)	Multiple canals, see Appendix B.
Total Irrigated Acreage (2010 CDSS)	20,229	2,158	74,954
Pre-Compact Total Direct Flow Rights [cfs]	730 cfs for irrigation/ 230 cfs limited to non-irrigation season (domestic/stock watering)	64.83 cfs	1,225.64 cfs (Uncompahgre)/ 1,300.0 cfs (Gunnison Tunnel & South Canal)
Storage Rights [acre-feet]	-	-	106,230 acre-feet(Taylor Park Res, own a second fill storage right) / 11,200 acre-feet (Ridgway Reservoir, annual lease)
Non-project Water Rights Carried by System?	Yes, taken at river headgate diverted from canal prior to Gravity Division	Yes	Yes, carriage contracts exist
Any Colorado Senior Rights that Divert Downstream of the Ditch?	Two Senior downstream rights	No, most senior right on Pine River	Several downstream senior rights exist
Downstream Reliance on Return Flows	Yes, potentially from natural washes	Yes, but limited	Limited. Water reused multiple times within system
Proximity/Timing of Return Flows	Parcels are set back from the CO river, return flows accrue to drains/natural washes within the ditch system then travel thorough Grand Valley Irrigation District, limited lagging to drains/natural washes	Parcels are close to river, limited lagging	Return flows utilized within ditch system, limited lagging
Need for Replacement of Return Flows	Yes, may be high (according to system representatives, ditch is no obligated to replace return flows from irrigation)	Yes	Yes, low
Water Allocation	4 ft/acre (users can buy additional water)	1.0 cfs/80 acres	Based on soil type. Adobe (clay) soils: 4 ft/acre, Mesa (sandy) soils: 5 ft/acre, Additional water can be requested with a fee
Cropping Pattern (2010 CDSS)	~75% Alfalfa/Grass Pasture (mixed), 12% Corn Grain, 10% Small Grains, 3% Others	99% Pasture Grass, 1% others	16.7% Alfalfa, 26.2% Corn Grain, 43.0% Grass Pasture, 14.1% Small Grains/Other
Irrigation Method (2010 CDSS)	91.5% Furrow/ 5.5% Sprinkler/ 3% Other	>96.5 % Flood	82.4% Furrow/ 17.6% "Unknown/Other"
Crop Mix Recorded Annually	Yes, on a farm level	No	Yes, only on entire system level
Availability of Nearby Quality Meteorological Data (for assessment of consumptive use)	Adequate. One nearby CoAgMet station exists in addition to various stations.	Adequate. Nearby EPA Air Quality met station in addition to various other stations	High. Several CoAgMet stations exist within/near project.
Current State of System Control (Check Structures, SCADA system, etc.)	SCADA system installed 2002, high level of system control	Minimal; only river headgate diversions are recorded	Medium. Water can be moved throughout the system via canal laterals in a relatively efficient manner.
Potential for Additional System improvements for water savings (i.e. lining of canals/switching to sprinkler irrigation, etc.)	Low. Majority of the system has been lined/piped as of 2002.	High. Approximately over 90% of the system is unlined/not piped.	Moderate/High. Approximately 75% of the system is unlined/not piped.

System	Grand Valley	Doc. Morrison	Uncompahgre
Current state of system measurement (i.e. farm headgate measurement/recording, return flows, drain flow, bypass structures, etc.)	Delivery to individual farm headgates measured/recorded, no measurement of drain flows, some end of canal measurement structures exist.	No farm headgate measurement, no measurement of drain flows, no record of lateral deliveries.	Combined delivery to one or more farms measured/ recorded, some end-of-canal measurement devices in place
Storage Availability in Existing Storage Structures	Highline Reservoir, Limited in space and time in	Vallecitio Reservoir (upstream of div. point)	Taylor Park Reservoir/Ridgway Reservoir
Approximate Travel Distance to Stateline [miles] (from bottom of system)	10 Miles (Colorado-Utah Stateline)	13 miles (Colorado-New Mexico Stateline)	75 miles (Colorado-Utah Stateline)
Salinity and Water Quality Issues	1974 Salinity Control Project - Grand Valley Unit	No known salinity or other water quality issues	Salinity and selenium issues exist
Potential Involvement of Parties Required for Water Banking	USBR/ GVWUA and associated users/Land owners	USBR/BIA/Land owners	USBR/UVWUA/Land owners

1. Grand Valley Project

The Grand Valley Project is a federal US Bureau of Reclamation project that consists of two divisions: the Gravity Division and the Orchard Mesa Division. The Grand Valley Water Users' Association (GVWUA) is responsible for operating the Gravity Division of the project comprised of the Grand Valley Diversion Dam and Government Highline Canal. The GVWUA currently serves between 20,000 – 25,000 irrigable lands under the Government Highline Canal with an average annual diversion of approximately 300,000 acre-feet.

The GVWUA envisions two approaches to forbearance: individual forbearance, or collective Association-wide forbearance. Given the potential economic benefits, water users would probably be interested in participating in a water bank. The most feasible methods to supply a water bank would be rotational fallowing and deficit irrigation. Additional system improvements may also provide a means by which to make limited amounts of water "available" for a water bank under certain circumstances.

The following sections qualitatively outline various system features as they apply to the concept of Water Banking. For a full description of the system overview please refer to Appendix A.

1.1. Conservation Potential, System Control, and Measurement

Based upon system-wide most recent CDSS records, approximately 75% of the Grand Valley Project lands are used to grow alfalfa and/or pasture grass. These cropping patterns present potential for deficit irrigation or rotational fallowing. Furrow irrigation is the primary (>90%) method of irrigation, which typically can be switched to a more efficient irrigation system, such as sprinkler irrigation, to provide savings in water use. However, as indicated by the GVWUA manager the irregular shape and size of many parcels may make on-farm efficiency improvements cost-prohibitive. Thus, we concluded that the potential for water savings by switching to a more efficient irrigation system would probably not be feasible on a system-wide level.

In 2002 a SCADA (supervisory control and data acquisition) system, as well as a series of canal check dams were installed allowing for the automated control of the system and improved delivery management. In addition to the automation and enhanced control of the main canal, over 90 percent of the system's laterals have been piped/lined to allow for an efficient delivery of water to individual farm headgates. Deliveries made to individual farm headgates are measured and recorded. Additionally, a gaging structure exists at the end of the canal. The current improved level of system wide measurement would facilitate the ability for quantifying and administering foregone consumptive use under a water bank scenario.

1.1.1. Potential Water Bank Benefits:

Given the current cropping pattern trend of alfalfa and pasture grass, potential exists for deficit irrigation or rotational fallowing (i.e. fewer

cuttings of alfalfa). This poses a potential opportunity to capture foregone consumptive use created through reduced application.

Because the system is highly controlled, measured, and adequate water delivery records are maintained this may be beneficial to a scenario where foregone consumptive use is either left in the river or passed through the system. As monthly water delivery records are maintained at the farm headgate level, the quantification of foregone consumptive use credit may be possible without additional measurement. Additionally, the current automation and control of the main canal may be beneficial in the case of reduced canal flow and reduced head (due to the removal of foregone consumptive use) allowing for delivery of water to non-participating parcels without impact.

1.1.2. Potential Water Bank Challenges:

Due to the irregular and generally smaller individual parcel size, on-farm efficiency improvements (i.e. switch to sprinkler irrigation) would probably be difficult from a cost standpoint.

Increased conservation through system improvements may be limited due to the already highly controlled state of the system (i.e. >90% lined/piped with SCADA system automation).

1.2. Administrative Considerations

Although the Grand Valley system is highly controlled and measured, return flows from irrigation to the various drains or natural washes (which subsequently deliver water through Grand Valley irrigation Company land and ultimately to the Colorado River), are not measured. The water in these drains and natural washes can be diverted and used by Grand Valley irrigation Company's users. Administrative spills made at the end of the Government Highline canal are measured. Because of these current conditions, a feasible administrative scenario would be to either measure and release consumptive use savings at the river headgate (an additional measurement station is probably needed for that) or consumptive use savings are passed through to the end of the system where measurement devices are in place. Another potential alternative would be to measure foregone consumptive use through reduced farm headgate deliveries, which are actively measured and recorded by the GVWUA.

As mentioned previously, parcels served by the GVWUA generate return flows that are captured by the drains or natural washes running through the system. The majority of these return flows are captured by the drains and natural washes in the form of surface water without lag. According to the GVWUA representatives, GVWUA is not obligated to maintain historical return flows from irrigation. The extent and magnitude of reliance of downstream users on these return flows has not been investigated. However, replacement of these return flows may be needed. Should replacement of such return flows deemed necessary, additional administrative consideration may be necessary to account for travel time of these return flows.

A preliminary review of existing storage both within and near the project, indicated that the Highline Reservoir, located near the end of the Government Highline Canal, may be a potential site to temporarily impound foregone consumptive use for later delivery to the Stateline. However, the Association currently does not have a storage right to store water for longer than 72 hours. This reservoir is also relatively small (3,400 acre-feet) and therefore may be a limiting factor when considering its potential use. A junior water right can be adjudicated to allow for additional storage in the Highline Reservoir, which then can be used to store significant amount of banked water for later use.

Participation in a water bank scenario would involve coordination between the US Bureau of Reclamation (USBR), GVWUA, and individual land owners served by the GVWUA. We should note that GVWUA manager stated that careful consideration of any intentionally created surplus and their relationship to the Grand Valley Power Plant, the related water rights put to beneficial use by the Association and the Orchard Mesa Irrigation District, the impacts on the operating partners, and other concerns must be included in discussion of water banking in the Grand Valley and on the Grand Valley Project system.

1.2.1. Potential Water Bank Benefits:

As mentioned above, the project is highly controlled and measured. Because of this several administrative alternatives (mentioned above) may be feasible to measure and administer foregone consumptive use.

Given the proximity (~10 miles) of the project's location to the Colorado-Utah Stateline foregone consumptive use could be efficiently delivered to the Stateline. Additionally, due to the limited number of downstream water users shepherding water to the Stateline may be possible with minimal mitigation efforts.

1.2.2. Potential Water Bank Challenges:

No substantial storage reservoir exists in the immediate upstream or downstream vicinity of the project, therefore an additional investigation into potential storage reservoirs (existing or for future construction) is needed. Although the project would be able to efficiently delivery water to the Stateline in the event of a compact call, the current lack of storage would limit the projects ability to control the timing to some extent.

Mitigation of return flow obligations (if deemed necessary) in the case of rotational fallowing may require administrative attention with regards to timing and measurement.

As stated above, consideration of multiple stakeholders would be necessary for the successful implementation of a water banking scheme.

2. Uncompahgre Valley Water Users' Association

The Uncompahgre Project consists of multiple diversions and structures comprised of seven diversion dams, over 128 miles of main canals, 438 miles of laterals, and 216 miles of drains located throughout the Uncompahgre Valley, District 41, Water Division 4. It is owned by the USBR and is operated and maintained by the Uncompahgre Valley Water Users' Association (UVWUA). The Project, which first delivered irrigation water in 1912, currently irrigates approximately 79,000 acres of agricultural land extending 34 miles along the Uncompahgre River and provides water supply to approximately 40,000 people including mostly irrigators and some residential customers.

The following sections qualitatively outline various system features as they apply to the concept of Water Banking. For a full description of the system please refer to Appendix B.

2.1. Conservation Potential, System Control, and Measurement

In 2010 approximately 60% of crops grown within the UVWUA boundary consisted of alfalfa and grass pasture (approx. 17 and 43%, respectively), highlighting the potential opportunity for deficit irrigation and/or rotational fallowing. Nearly 80% of all lands within the boundary are currently irrigated using furrows. On-farm efficiency improvements, such as the installation of sprinklers may be possible; however the feasibility requires further investigation.

As of 2015 approximately 25% of the canal system has been lined/piped. According to UVWUA Manager, Steve Fletcher, he anticipates that it may take an additional 10 years before the entire system is fully lined/piped. Given the large size (128 miles of main canals and 438 miles of lateral) of the UVWUA system, delivery system improvements may yield significant savings that may be banked under a water banking scheme.

The UVWUA utilizes multiple headgates along the Uncompahgre River to divert its water rights. In addition to this system of multiple headgates, drains and laterals allow water to be moved relatively easily throughout the system.

River and farm headgate deliveries are both measured and recorded by the UVWUA. Several measurement structures exist near the end of the system, in addition to several USGS stream flow gages which are located on the Uncompahgre River.

2.1.1. Potential Water Bank Benefits:

Conservation potential exists due to the relatively low percentage of the system which has been lined/piped. Savings based on future system efficiency improvements may be beneficial with regards to a water banking scenario as water may be made "available" through increased efficiency. Currently a high percentage of parcels are irrigated using furrows. Whether converting to sprinklers for increased on-farm efficiency would be economically/operationally feasible needs to be evaluated.

The current practice of rotational cropping presents an opportunity for rotational fallowing and/or deficit irrigation. Additionally, local hay crops are generally sold as a commodity allowing for greater operational flexibility as herd reductions may not be necessary.

The projects' use of multiple river headgates (on the Uncompahgre) may allow for rotational fallowing to take place without disruption of service in other parts of the system. This system may allow for multiple water delivery scenarios to be developed. For example parcels near the bottom of the system may still be able to receive water through an alternative headgate in the case of fallowing of upstream parcels.

The projects' use of multiple sources including direct flow Uncompahgre River water rights, Taylor Park Reservoir storage rights, and Ridgway Reservoir water may allow for flexible operations to be developed to accommodate a water banking scenario.

2.1.2. Potential Water Bank Challenges:

The historical operation of the UVWUA has been based on the reuse tailwater and return flows multiple times throughout the system, from upstream to downstream. This may present an issue in the event of rotational fallowing where downstream users within the system relied on return flows delivered through the end of an upstream canal. Mitigation efforts may be necessary to ensure water is able to be delivered via an alternative headgate.

Although it may be possible to deliver water throughout the system via multiple headgates, adequate flow would need to be maintained in order to maintain a head within the canal that would allow delivery to all users.

2.2. Administrative Considerations

Participation in a water banking scenario would require coordination among the UVWUA, USBR, and individual land owners. As discovered during the development of the attached system memo, approximately one-third of water users within the UVWUA boundary own five shares or less (1 share equals 1 irrigated acre). The large number of individual shareholders may present administrative challenges.

A preliminary review of existing structures showed that the UVWUA currently utilizes water from both Taylor Park Reservoir and Ridgway Reservoir. Further investigation is required to determine the feasibility of potentially using these structures for the storage of foregone consumptive use.

The UVWUA boundary is located approximately 75 river miles upstream of the Colorado-Utah Stateline. A preliminary review of downstream water rights indicated that multiple senior rights exist. Given this distance, shepherding water

to the Stateline may be administratively difficult. Additionally deliveries to the Stateline may experience significant transit loss reducing the efficiency.

As previously stated, UVWUA users rely heavily on return flows from upstream parcels also within the system. Mitigation efforts may be necessary to ensure non-participating parcels are not negatively impacted.

2.2.1. Potential Water Bank Benefits:

The project has historically and currently used water from multiple nearby reservoirs. These reservoirs may be useful with regards to storage of foregone consumptive use. However, at the time of this memo further investigation into the feasibility of their use is needed.

2.2.2. Potential Water Bank Challenges:

Given the projects location and as mentioned earlier, shepherding water to the Colorado-Utah Stateline would require passing water approximately 75 miles downstream (from the bottom of the UVWUA boundary). This may result in significant transit losses and be administratively difficult.

As mentioned above approximately one-third of the water users in the UVWUA service area own five shares or less. This may pose a challenge as it may create a fragmented system in terms of participation in addition to increasing potential administrative requirements to monitor.

3. Doctor Morrison Ditch System

The Dr. Morrison Canal/Ditch (DMC) is a partially unlined canal that diverts from the Pine River (aka Los Pinos River) in District 31 of Water Division 7, approximately 1 river mile below Bayfield, Colorado. The DMC is approximately 14 miles in length and receives water from direct-flow rights and water from the Pine River Indian Irrigation Project (PRIIP) stored in Vallecito Reservoir. The ditch is operated by the Bureau of Indian Affairs (BIA). Based upon an assessment by the BIA, the ditch has a service area of approximately 4,200 serviceable acres (a serviceable acre was determined by the BIA as lands arable under gravity-fed irrigation). Based upon the most recent CDSS assessment of irrigated lands in 2010, the DMC irrigates approximately 2,000 acres.

The following sections qualitatively outline various system features as they apply to the concept of Water Banking. For a full description of the system please refer to Appendix C.

3.1. Conservation Potential, System Control, and Measurement

Based upon the most recent data provided by the BIA, approximately 11% of the main canal has been lined or piped. Review of the system has indicated that limited work has been done to improve efficiency.

Historically the DMC has been used to grow grass pasture used for grazing (>99% of cropping). Although the arable lands under the canal total

approximately 4,200 acres, CDSS records have indicated that typically only around half of the total arable lands are actively irrigated.

Water diverted at the main river headgate is measured and recorded. Water is turned out to laterals at a rate equal to approximately 1.0 cfs per 80-acres served. Measurement and recording of individual lateral and farm deliveries are not maintained.

3.1.1. Potential Water Bank Benefits:

As indicated previously, only a small percentage of the entire canal has been lined/piped and generally no laterals are lined/piped. This presents a significant opportunity for system improvements and therefore conservation.

In addition to system improvements such as lining or piping of the main canal or laterals, the DMC system has the potential for improved measurement and control of water deliveries to main/farm laterals. Improved control and measurement of these laterals may allow for additional conservation creating surplus water.

The historical cropping pattern and level of irrigation (as compared to total arable land) presents the potential for rotational fallowing and/or deficit irrigation. Given the historical of irrigation under the DMC, the level of participation in a water bank by the land owners may be significant. However, a significant player in this would be the BIA.

3.1.2. Potential Water Bank Challenges:

Although the current level of control and measurement may be viewed as a potential benefit for future savings through conservation, it also poses a challenge. Given the current state of control and measurement, significant improvements with regards to measurement and recording of deliveries may be necessary before administration of a water banking scenario would be possible.

A detailed historical consumptive use assessment of parcels interested in participating in a water banking scheme may be necessary to determine the actual savings as some parcels have only been intermittently irrigated.

It is may be necessary, for political and social reasons, to start irrigating the lands that haven't been recently irrigated, before such lands participate in a water bank.

3.2. Administrative Considerations

The DMC system is unique from the other systems reviewed in that the water rights for this system cannot be forfeited in the case of non-use

and therefore full supply can be assumed for determination of consumptive use credit (according to DMC representatives).

The Indian water rights diverted by the DMC system hold the most senior priority on the Pine River. However, several other non-Indian water rights are delivered via the DMC which may result in the need to mitigate potential carriage issues (i.e. a given amount of water may need to remain in the canal so that adequate head exists to make delivery to all non-participating parcels).

The BIA currently has a storage account in the nearby upstream Vallecito Reservoir (owned by the USBR). This storage account possesses potential to act as the storage reservoir of foregone consumptive use, however further investigation into the feasibility of this potential is needed.

The DMC system is near to the Colorado-New Mexico Stateline (approx. 13 miles from the end of the system) with very few downstream water users between the end of the system and Stateline. Additionally, as mentioned above the DMC is the most senior right on the Pine River, this eliminates the possibility of a downstream call being placed on the system.

Due to the spatial location of most parcels it is expected that a large portion of return flows from irrigation would accrue to the river rather quickly.

3.2.1. Potential Water Bank Benefits:

Given their senior priority, the system's water rights would not be subject to being called out by other users on the Pine River. Also as stated previously, only a few water rights divert (most of which with very small diversion rates) from the Pine River downstream of the DMC system. This would make shepherding water to the Colorado-New Mexico Stateline efficient.

Given the proximity of upstream Vallecito Reservoir, consumptive use savings can be easily exchanged and stored in Vallecito Reservoir. At this time further investigation is needed to determine the space that would be potentially available in Vallecito Reservoir and the associated administrative challenges associated with its use.

3.2.2. Potential Water Bank Challenges:

There is no existing downstream storage between the systems lower boundary and the Stateline. Therefore consumptive use savings would either need to be passed directly to the Stateline, upstream storage would need to be found, or storage facility would need to be built on DMC land.

As mentioned above, installation of additional measurement and control structures may be necessary to quantify and administer foregone consumptive use.

Appendices

Appendix A: Grand Valley Project System Overview Memo
Appendix B: Uncompahgre System Overview Memo
Appendix C: Doctor Morrison System Overview Memo

Appendix A: Grand Valley Project System Overview Memo

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Memorandum: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems Grand Valley Project

To: Water Bank Technical Subcommittee
From: Shaden Musleh, John Craven, Hydros Consulting, Inc.
Subject: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems Grand Valley Project
Date: October 16, 2015

Overview

The Grand Valley Project (Project) is a US Bureau of Reclamation (USBR) project. Its features include the Grand Valley Project Diversion Dam and Government Highline Canal that diverts from the Colorado River approximately eight miles northeast of Palisade, CO. The project includes two divisions: the Gravity Division and the Orchard Mesa Division. The Grand Valley Water Users' Association (GVWUA, or the Association) is responsible for operating the Gravity division of the Project. The Project is served by the Government Highline Canal, which is approximately 55 miles long, with a capacity of 1,675 cfs, and has historically served a full and supplemental supply of irrigation water to approximately 25,000 acres. In addition to the main canal, the system consists of approximately 150 miles of laterals, of which over 90 percent have been piped creating a pressurized delivery system. As part of the USBR Grand Valley Unit 1974 salinity control project, canals and ditches within the Association boundaries began to be lined. Totalizing meters have been installed at each farm turnout; however no records are maintained of how water is distributed among fields below a farm turnout.

Operation and Management

The Association operates the Gravity Division of the Project, which first delivered a full supply of irrigation water in 1917, and currently delivers a full supply of water to approximately 25,000 acres of agricultural and residential lands on the north side of the Colorado River. The value of crops grown with irrigation water from the Project is approximately $20 million per year. From 1970 to 2013, the Association (Gravity Division) diverted an average of 300,000 acre-feet/year from the Colorado River for use within its boundaries. Water is diverted from the Colorado River at the Grand Valley Project Diversion Dam into the Government Highline Canal, which runs approximately 16 miles to the boundary of the Association lands. The Government Highline Canal provides water to the Palisade and Mesa County Irrigation Districts through turnouts on the Government Highline Canal and direct diversions into their respective systems for further conveyance to individual users, pursuant carriage contracts with these two districts. The Orchard Mesa Power Canal diverts 860 cfs (460 cfs irrigation and pumping, and 400 cfs for power generation at the Grand Valley Plant, owned jointly with GVWUA) into the Orchard Mesa Power Canal for power purposes and irrigation of the lands in the Orchard mesa Division of the Project pursuant contracts with the Association and USBR.

As part of the Grand Valley Unit salinity control project, a significant portion of system canals were lined and most of the delivery laterals have been converted to pressurized

pipe. Totalizing meters have been installed at each farm turnout. As a result of these improvements, GVWUA can maintain excellent control and measurement of water deliveries to its beneficiary lands. In most cases the Association has no records of water distribution among fields below a farm turnout.

In 2002 additional canal checks and a SCADA (supervisory control and data acquisition) system were installed along the main canal, which allow for improved supply/demand management in the canal system. The canal checks enable the water within the canal to be raised, allowing delivery of water during periods of lower demand throughout the system. Installation of the SCADA system, canal checks, and the lining of much of the system is believed to have substantially increased the overall system efficiency.

Growth of urban and suburban areas within its boundaries means that the Association also supplies increasing amounts of water for use in landscape irrigation in high-density residential developments. These deliveries are made through a system of pressurized pipes, and are controlled and delivered at a “development level”, i.e. one turnout and meter for each development, with the Association sending a single bill to the homeowners’ association for the development.

Additionally, the Project uses the Highline Reservoir (located near the end of the system) to temporarily hold and manage water within the system. Based on conversation with GVWUA Manager, Mark Harris, Mr. Harris stated that although the Project does not have storage rights in this reservoir, they do have an agreement to temporarily store water in the reservoir for up to 72 hours per the State Engineer’s regulations.

The Project’s water rights are held by the United States of America and put to beneficial user by the owners of the properties to which the water is appurtenant. The Association is the contracting entity with Reclamation with responsibility for water delivery and operation and maintenance of the system. The Association has managed the maintenance and operation of the system since 1949. In practice, the Association treats the facilities and water as if it owned them; a description of the water rights is presented below.

The Project diverts water for use on Association lands from the Colorado River through the Grand Valley Project Diversion Dam using the following water rights: 730 cfswater right for irrigation use and a 220 cfs water right for domestic uses. In addition, natural runoff from up-gradient Bureau of Land Management (BLM) lands is intercepted by the Project canals.

Table 1: Grand Valley Project Water Rights, Division 5 District 72, Structure 646

Water Right Name	Water Source	Adj. Date	Appr. Date	Rate Amount (CFS)	Absolute	AP/EX[3]	Use	Project Division[4]
Water Rights used by the Association								
Grand Valley Project	Colorado River	7/22/1912	2/27/1908	730.0	A		Irrigation	GD
Grand Valley Project	Colorado River	7/25/1941	2/27/1908	220.0[1]	A		Domestic	GD
Other Project Water Rights Diverted at Grand Valley Project Dam Headgate								
Grand Valley Project	Colorado River	7/25/1941	2/27/1908	800.0[2]	A		Commercial	Power Plant
Grand Valley Project	Colorado River	7/22/1912	10/1/1900	10.2	A		Irrigation	OMID
Grand Valley Project	Colorado River	7/22/1912	10/25/1907	450	A		Irrigation	OMID
Grand Valley Project	Colorado River	7/22/1912	10/1/1889	80.0	A		Irrigation	PID
Grand Valley Project	Colorado River	7/25/1941	6/1/1918	23.5	A		Irrigation	PID
Grand Valley Project	Colorado River	7/22/1912	7/6/1903	40.0[3]		40.0	Irrigation	MCID

1) Limited to non-irrigation season (for domestic use, including livestock purposes)
2) Project power plant non-consumptive right, limited to 400 cfs during irrigation season and 800 cfs during the non-irrigation season.
3) Alternate Point/Exchange Point
4) **GD**: Gravity Division (i.e. GVWUA water), **MCID**: Mesa County Irrigation District, **OMID**: Orchard Mesa Irrigation District, **PID**: Palisade Irrigation District

Water Allocation and Land Classification

USBR land classifications determine the water allotments associated with individual parcels within the Project's boundaries. Since 1953 arable lands are classified as Class 1 and non-arable lands as Class 6. Only Class 1 lands have an irrigation water allotment, Class 6 do not receive any Project water. The water rights for the Project are tied to lands assessed as arable (Class 1). The base allotment to Class 1 Association lands is 4 acre-feet/acre, measured at the farm headgate. Should additional water be available it can be delivered to Class 1 lands and paid for at the "Excess Rate". Salinity control considerations restrict deliveries to Class 6 lands. It is common, for example, to see the application of 6 acre-feet/acre to corn grown under furrow irrigation and higher rates for alfalfa. The Project's water cannot be applied to lands outside the Project area. Water is provided to Project's lands from approximately April 1 through October 31 of each year.

Historical Diversion Records

River headgate diversions are readily available on CDSS, however during a phone conversation on 5/18/2015 with Division 5 Engineer, Alan Martellaro, he stated that there are known errors associated with diversion records kept for the Grand Valley Project Structure ID 646. Mr. Martellaro stated that the known errors affect records from 2004 – present. He also stated that the Division 5 office was actively working on correcting the errors. Because diversion records through the structure are known to contain errors, they are not included as a part of this memorandum. River headgate diversions, deliveries to major laterals and deliveries to main farm turnouts gaged. Irrigation return flows to the natural washes and drains are currently not measured.

Irrigated Lands and Cropping Records

Irrigated lands in Division 5 served by the Grand Valley Project (Structure ID 646) were assessed by the State of Colorado in 1993, 2005, and most recently in 2010 and are summarized in Table 2. The Project's lands are located at lower elevations and therefore have higher consumptive use and can typical yield multiple cuttings.

Table 2: Grand Valley Project, Structure 646, CDSS Estimated Acreage

Year	Total Acreage	Irrigation Method
1993	25,095	84.2% Furrow/ 7.3% Sprinkler/ 2.2% Flood/ 6.3% Other
2005	21,160	91.0% Furrow/ 5.7% Sprinkler/ 0.9% Flood/2.4% Other
2010	20,229	91.5% Furrow/ 5.5% Sprinkler/ 1.2% Flood/1.8% Other

As can be seen in Table 2 there is a noticeable drop in total acreage served by Structure ID 646 between 1993 and 2010. Reviewing the available CDSS irrigated acreage GIS coverage indicates a majority of the reduction is most likely attributable to urbanization of formerly irrigated lands. Additionally it appears that potential data quality issues between the 1993 and 2010 coverage may exist (e.g. 1993 coverage tends to incorporate roadways between parcels into the irrigated acreage, whereas the 2010 coverage excludes these areas which are not irrigated).

Table 3 below presents the cropping pattern for years where data was available on CDSS. As shown, the primary crops irrigated within the Project boundary include alfalfa, corn grain, grass pasture and small grains. The "others" category in Table 3 includes dry beans, orchards, vegetables, grapes, and grass and sod farms. Much of the hay crops and row crops are sold as commodities rather than used directly for animal feed.

Table 3: Grand Valley Project, Structure 646, Cropping Pattern [%]

Crop/Year	1993	2005	2010
Alfalfa	28.6	41.4	63.6[1]
Corn Grain	25.8	14.3	12.9
Grass Pasture	24.9	29.6	10.4
Small Grains	15.4	12.8	11.5
Others	5.3	1.9	1.6

1) Based on feedback from Mr. Mark Harris, it appears that the estimated 2010 acreage for Alfalfa includes Alfalfa and Alfalfa/Grass Pasture mix

It should be noted that the data presented in Table 3 above is based on CDSS irrigated acreage GIS coverage. As previously stated, between 1993 and 2010 the noticeable difference in total acreage is believed to be a result of urbanization within the Project. Based on recent conversation with GVWUA Manager, Mr. Harris stated that changing economics have also had an impact on the crops being grown on Project lands. With urbanization, farm lands became smaller over time. Users with smaller farms tend to grow Alfalfa or grass crops as it requires less labor than Corn, or other row crops with Grass Pasture and Alfalfa becoming more economically feasible.

Return Flows

A large proportion of the return flows from irrigation of the Association lands are collected by man-made drains (see Figure 1), which were developed as part of the Grand Valley Unit salinity control project. Class 1 lands are drained through a network of approximately 150 miles of drainage canals. Drainage canals that collect return flows discharge to the natural washes that intersect the Project lands and subsequently terminate in the Colorado River. Figure 1 below shows the location of the drainage throughout the GVWUA boundary as well as some of the more prominent natural washes.

Water collected by drains is not measured. Return flows from some Association lands accrue to natural drainages running south. Some return flows are intercepted by the Grand Valley Irrigation Company canals. Once water in drains and natural washes flows outside the Project boundary the GVWUA has no control of such water. CDSS shows a large number of diversions from the natural washes have been filed (Figure 1). Through discussion with Mr. Harris and review of CDSS diversion data, it was determined that users outside of the Project may divert from these natural washes, which means that the return flows from the Project is relied upon by other users located south of the Project boundary before these return flows reach the Colorado River. It is therefore necessary to consider whether impacts from changes in the Project's return flows arising from forbearance should be mitigated. However according to the Association the Project is under no obligation to assure a continued supply of irrigation return flow that is used downstream, regardless of whether filed upon or not. Administrative spills from the canal are discharged to the natural washes and are measured. Additionally a review of the Highline Reservoir (Structure ID 3957), located near the end of the Government Highline Canal, indicates that water from the Government Highline Canal has been used to fill the Highline Reservoir.

Groundwater

Groundwater throughout the Project is variable with evidence of locally high groundwater as indicated by the need for drainage. A review of CDSS well records indicated that only one decreed well exists within the Project boundary. During conversation with the GVWUA Manager, Mr. Harris stated that due to recent system improvements, including canal linings and drainage network improvements that started in the early 1980's; there has been a noticeable decrease in the influence of the groundwater table.

Salinity and Water Quality Issues

The Project lands are underlain by Mancos shales, which are a source of salinity and selenium problems in the Colorado River basin. Salinity levels vary within the project area. USBR's Colorado River Basin Salinity Control Project-Grand Valley Unit was authorized in 1974 and focuses on reducing seepage from conveyance systems in the Grand Valley. As mentioned, Class 1 lands are drained through drainage ditches.

Measurement, Control, and Data

Control and measurement of deliveries is excellent and has been described above. As stated, canal checks as well as a SCADA system have been installed. Irrigation return flows to nearby natural washes and drains are not measured; however Administrative spills made at the end of the canal are measured. Based on discussion with Mr. Harris, water quality discharge permits are not needed within the Project boundary for discharges of agricultural return flows.

The Colorado Agricultural Meteorological Network (CoAgMet) maintains several stations that provide daily estimates of consumptive use by crop type. In addition several other weather stations are maintained in the surrounding area and are summarized below in Table 4.

Table 4: Summary of nearby meteorological stations

Station Name	Agency	Approximate Distance from GVWUA Service Area [miles]	Comments
Palisade	NOAA	24.0	-
Grand Junction Walker Field	NOAA	14.0	-
Grand Junction, 3 Mi NW Grand Junction	CoAgMet	8.25	Record ends in 2009
CSU Fruita Expt Station	CoAgMet	4.75	-
Orchard Mesa	CoAgMet	20.50	Record begins in 2006
Fruita 1W	NOAA	5.25	Record ends in 2012

Potential for Water Banking and Potential Challenges

Due to the administrative and operational structure of the Project, any involvement in the Water Bank would require the participation of the GVWUA, USBR, and various land owners served by the Project. Operational potential exists for both fallowing and deficit irrigation on parcels where grass pasture or alfalfa is grown (approximately 74% of the total acreage in 2010) where several cuttings per season take place. Annual row crops could also forbear on a year-to-year basis.

Hydraulic considerations may limit the degree to which deliveries can be reduced, since a certain level of flow is required to maintain head in the canal sufficient to make deliveries to farm headgates. However, with the recent upgrades including the SCADA system and canal checks, flow may be able to be reduced while maintaining adequate head to ensure delivery to non-participants.

In addition to being able to maintain adequate head in the main canal, the recent system upgrades including the increased farm headgate delivery measurement may serve as a way to measure foregone consumptive use. The system improvements may also allow the system to move water from the main canal through the drainage system to the Colorado River and subsequently to the Colorado-Utah Stateline. The Project's location would allow for efficient shepherding of foregone consumptive use to the Stateline. Review of CDSS diversion records indicate that only two senior downstream water rights exist. However, based on the review of the 2002-2003 period (one of the worst dry periods on record), the Project's water rights were not called out by these two senior downstream rights. Careful consideration of any Intentionally Created Surplus (ICS) and their relationship to the Grand Valley Power Plant, the related water rights put to beneficial use by the Association and the Orchard Mesa Irrigation District, the impacts on the operating partners, and other concerns must be included in discussion of Water Banking in the Grand Valley and on the GVP system.

Located near the end of the Government Highline Canal is the Highline Reservoir, which is owned by the State. The Highline Reservoir, which has an appropriation date of 4/27/1966 and adjudication date of 12/31/1978, captures wastewater from the Government Highline Canal for recreation and piscatorial uses with a decreed volume of 3,400 acre-feet. The Association currently has an agreement with the State that allows the Association to store water in the top 2 feet of the reservoir for up to 72 hours. It might be feasible for the Association to expand the reservoir capacity to allow for a permanent storage under a new filing. This would allow the Association to store banked water as well as unappropriated water available during free river conditions. Under existing conditions, the Highline Reservoir could potentially be used to store foregone consumptive use or system savings temporarily for delivery to the Stateline. Due to the reservoir's location near the end of the system, water may be delivered near the end of the Government Highline Canal in order to maintain adequate head within the main canal. The water then could be delivered to the Highline Reservoir and be subsequently released to the Colorado River via the Mack Wash which delivers water to the Colorado River approximately 10 miles upstream of the Stateline. It should be noted that there is a measuring structure at the terminus of the Government Highline Canal which is used to spill excess water to Badger Wash. This structure could also potentially be used to deliver water through the system to the Colorado Stateline.

The Association envisions two approaches to forbearance: individual forbearance, or collective Association-wide forbearance. During conversation with Mr. Harris, he stated that he believes water users may be interested in participating in a water bank due to the potential economic benefits. Mr. Harris indicated that the two most feasible methods to supply a water bank would be rotational fallowing and deficit irrigation. System improvements may also provide a means by which to make limited amounts of water "available" for other purposes under certain circumstances. Under a water bank scheme, the Association will continue to make sure that its water rights and current uses are fully protected.

Savings through system improvements such as using shorter runs for furrow irrigation systems to reduce on-farm losses and additional lining of canal may also be feasible. Savings through using higher efficiency irrigation systems such as sprinkler systems may not be feasible in most cases given current agronomic regimes. This is because of the current size, and irregular shape of the irrigated parcels and lower value crops that are typically grown within the Project which makes the switch to a sprinkler system economically infeasible. Although the system has recently undergone major improvements including lining of significant portions of the main canal, piping of many laterals, installation of check structures and installation of a SCADA control system, participation in a water bank scheme may still be complicated due to carriage water requirements.

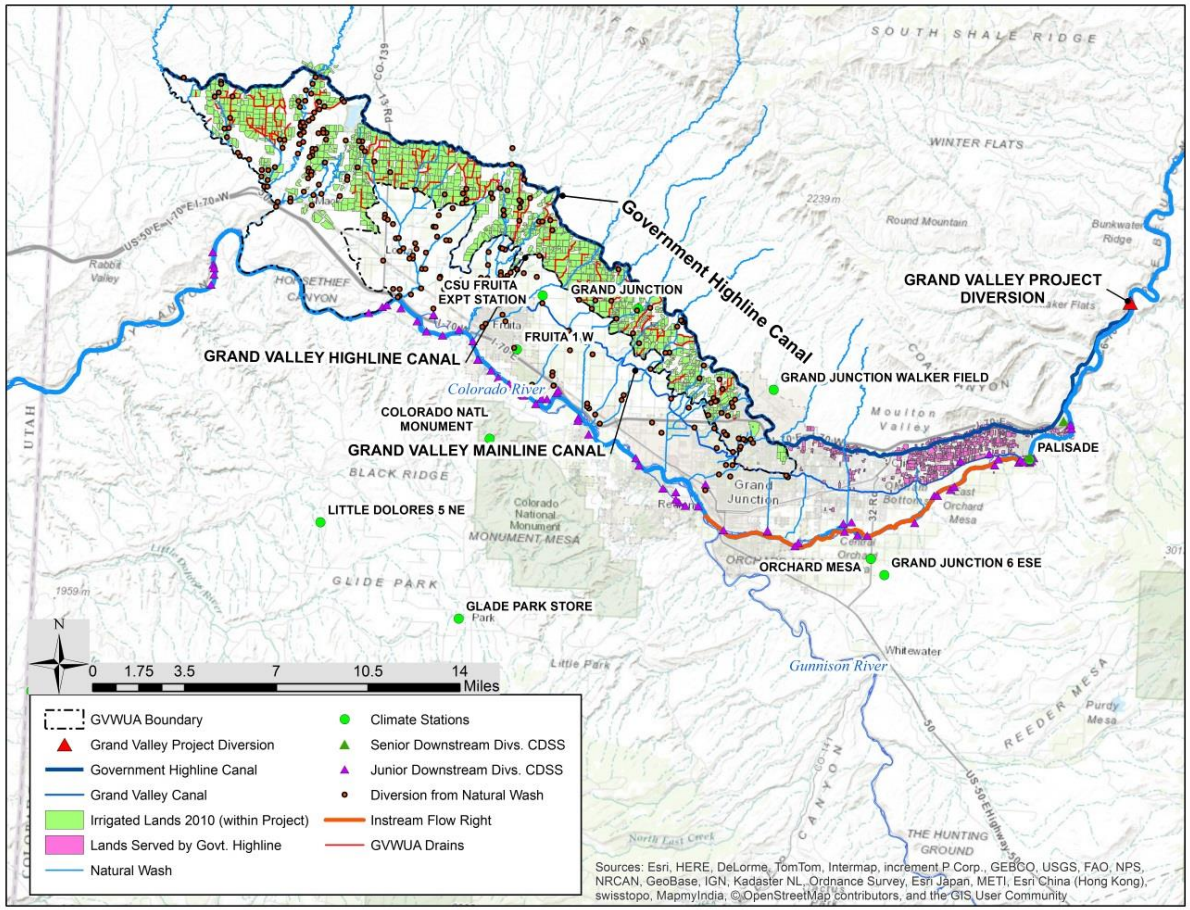

Figure 1: Irrigated Lands in 2010 and Water Rights between Palisade and Stateline

Hydros Consulting Inc.
1628 Walnut Street
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Appendix B: Uncompahgre Valley Water Users' Association System Overview Memo

Hydros Consulting Inc.
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Memorandum: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems
Uncompahgre Valley Water Users' Association

To: Water Bank Technical Subcommittee
From: Shaden Musleh, John Craven, Hydros Consulting, Inc.
Subject: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems
Uncompahgre Valley Water Users' Association
Date: June 24, 2015

Overview

The Uncompahgre Project (the Project) consists of multiple diversions and structures comprised of seven diversion dams, over 128 miles of main canals, 438 miles of laterals, and 216 miles of drains located throughout the Uncompahgre Valley, District 41, Water Division 4. It is owned by the Bureau of Reclamation (USBR) and is operated and maintained by the Uncompahgre Valley Water Users' Association (UVWUA). The Project, which first delivered irrigation water in 1912, currently irrigates approximately 79,000 acres of agricultural land extending 34 miles along the Uncompahgre River and provides water supply to approximately 40,000 people including mostly irrigators and some residential customers. The value of crops irrigated by the Project ranges from approximately $25 to $40[1] million per year.

Operation and Management

The USBR owns the Project, and holds the water rights. The UVWUA operates and maintains the Project.

The UVWUA Board sets the annual allocation of water based on predicted runoff. During times when the forecast results in a less than 100% allocation, all shareholder allocations are reduced on a pro-rata basis. Project water originates from direct-flow water rights on the Uncompahgre River, and from a transbasin diversion from the Gunnison River that relies on direct-flow water rights and storage in Taylor Park Reservoir (see Table 1). The USBR determines releases from Taylor Park Reservoir for Project water. The USBR has a second-fill right in Taylor Park Reservoir in the amount of 106,230 acre-feet based upon an exchange agreement for Taylor Park Reservoir and the Aspinall Unit. The second fill rights are for users in the Upper Gunnison River Basin (UGRB). Because of this second-fill right, the USBR moves water from Taylor Park Reservoir to Blue Mesa Reservoir as soon as possible in order to be able to store water in Taylor Park under its second-fill right. In addition to using the water rights owned by the UVWUA, the Project also obtains approximately 11,200 acre-feet of water annually from Ridgway Reservoir (Appropriation Date=11/16/1956, Administration Number= 39036.00000) on the Uncompahgre River. The UVWUA can exchange up to 15,000 acre-feet per year of water that can be diverted through the Gunnison Tunnel under the UVWUA decrees for an equal amount of water released from Ridgway Reservoir.

[1] USBR Uncompahgre Project : Project Data overview

The Project maintains 128 miles of main canals, 438 miles of laterals, and 216 miles of drains. Since 1998 the UVWUA has been in the process of lining system canals and lining and/or piping laterals. According to Steve Fletcher, the UVWUA manager, as of 2015 approximately 25% of the canal system has been lined/piped. Mr. Fletcher also indicated that it may take an additional 10 years before the entire system has been fully lined/piped.

Water Rights, Hydrology, and Water Supply

As indicated previously, the Project diverts water for use on the Project lands from the Uncompahgre River using direct flow rights and from the Gunnison River through the Gunnison Tunnel using direct flow rights and a storage right at Taylor Park Reservoir. Additionally, the Project utilizes leased Ridgway Reservoir as a supplemental supply. A basic summary of Project water rights are shown in Table 1; Table 2 presents a detailed summary of all Project water rights.

Table 1: Uncompahgre Project water rights

Water Right	Water Source	Adjudication Date	Amount
Gunnison Tunnel and South Canal	Gunnison River	5/8/1913	1,300 cfs
Uncompahgre River Direct Flow Diversions	Uncompahgre River	6/30/1890	1,225.64 cfs
Taylor Park Reservoir	Taylor River	4/29/1941	106,230 acre-feet

Gunnison River Delivery System

Water diverted from the Gunnison River is delivered to the Project through the following structures (Figure 1)

- **Gunnison Tunnel:** the Gunnison Tunnel which brings water from the Gunnison River to the UVWUA was originally decreed a 1,300 cfs absolute flow right, however after subsequent water court cases the tunnel currently has an absolute water right of 1,175 cfs and a conditional water right of 125 cfs. The tunnel diverts from the Gunnison River below Blue Mesa Reservoir and enters the UVWUA system in the Southeast. The tunnel is approximately 5.8 miles long.

- **South Canal:** the South Canal brings water diverted through the Gunnison Tunnel into the Uncompahgre system. The canal can be used to deliver water to either the West Canal or directly to the Uncompahgre River for use by downstream canals. Tailwater from the South Canal is picked up by the Loutzenhizer canal system. Additionally, the canal brings water to approximately 13,600 acres and has a carrying capacity of 1,300 cfs.

- **West Canal:** constructed as an extension of the South Canal. The West Canal receives water that is diverted through the Gunnison Tunnel through a flume that

crosses the Uncompahgre River. Additionally, the canal has a headgate on the Uncompahgre for diversion of water released from Ridgway Reservoir or for the diversion of supplemental water under free river conditions. The canal is used to irrigate approximately 7,200 acres on the west side of the Uncompahgre River and has a carrying capacity of 160 cfs. Tailwater from the canal is utilized by the Montrose and Delta Canal.

Uncompahgre River Delivery System

The UVWUA operates a series of canals that stretch from the upstream to downstream extents of the UVWUA's service boundary. The canals/ditches are described below and shown on Figure 1:

- **Montrose and Delta Canal (M&D Canal)**: the Montrose and Delta Canal diverts water from the Uncompahgre River and is used to irrigate approximately 33,600 acres on the west side of the Uncompahgre River. The canal has a carrying capacity of 650 cfs.

- **Loutzenhizer Canal**: the Loutzenhizer Canal diverts from the east side of the Uncompahgre River near Montrose and is used to irrigate approximately 11,200 acres. The canal is approximately 20 miles long and has a carrying capacity of 200 cfs. As previously stated, the Loutzenhizer Canal has the ability to capture and reuse tailwater from the South Canal.

- **Ironstone Canal (aka California Mesa System)**: the Ironstone Canal diverts water from the Uncompahgre River south of Olathe and is used to irrigate approximately 26,000 acres on the west side of the Uncompahgre River. The carrying capacity of the canal is 400 cfs.

- **Selig Canal**: the Selig Canal diverts water from the northeast side of the Uncompahgre River and is used to irrigate approximately 22,400 acres. The canal has a carrying capacity of 300 cfs. In addition to the water diverted from the Uncompahgre River the canal picks up tail water from the Loutzenhizer Canal.

- **East Canal (aka Colorow Ditch)**: the East Canal diverts water from the eastside of the Uncompahgre River near Olathe. The canal is used to irrigate approximately 22,000 acres between Olathe and Delta. The canal has a carrying capacity of 325 cfs and joins the end of the old Loutzenhizer Ditch.

- **Garnet Ditch**: the Garnet Ditch irrigates lands on the east side of the Uncompahgre River in and around Delta. The ditch diverts from the Uncompahgre River near Delta and irrigates approximately 4,000 acres. The ditch has a capacity of approximately 100 cfs.

Mr. Fletcher mentioned that the system utilizes the extensive network of canals (described above), laterals, and various creeks to effectively move water through the system for use by UVWUA members.

Uncompahgre River Storage Contracts

The UVWUA currently has an agreement for the annual purchase of 11,200 acre-feet of water in the storage pool of Ridgway Reservoir that typically has been used as supplemental source for irrigation within the Project area. The UVWUA also uses Ridgway Reservoir water to operate an exchange that allows water to be diverted at the Gunnison Tunnel under the UVWUA decrees and delivered to the Project 7 Water Treatment Plant in exchange for an equal amount of water released from Ridgway Reservoir. This exchange has been operated since 1991. The purpose of this exchange is to utilize the higher quality Gunnison River water for irrigation. As indicated above, the maximum amount of water stored in Ridgway Reservoir under this exchange is limited to 15,000 acre-feet annually. Water stored under this agreement cannot be carried over from year to year.

Taylor Park Dam and Reservoir

The Taylor Park reservoir, constructed between 1935 and 1937, is an on-channel reservoir on the Taylor River which is located in Gunnison County. The water right for Taylor Park Reservoir was adjudicated on April 26, 1941 with an appropriation date of August 8, 1904 for irrigation use associated with the Gunnison Tunnel.

Taylor Park Reservoir is currently operated under an exchange agreement known as the Taylor Park Reservoir Operation and Storage Exchange Agreement (aka: Four Parties Agreement) that was signed in 1975 by the UVWUA, USBR, Upper Gunnison Water Conservation District (UGWCD), and the Colorado River Water Conservation District (CRWCD). The agreement allows for all releases from Taylor Park reservoir above 20 cfs to be exchanged for the same amount of stored water in the downstream Blue Mesa Reservoir. Water can then be released from Blue Mesa Reservoir and delivered to the Project. The purpose of this exchange is to minimize transit losses associated with moving water from Taylor Park reservoir to the Project.

Table 2: Detailed Summary of UVWUA Water Rights

Water Right Name	Water Source	Adj. Date(s)	Appr. Date(s)	Rate Amount (cfs)	Absolute	Conditional	AP/EX[1]
Uncompahgre Direct Flow Water Rights for Irrigation Use							
East Canal	Uncompahgre River	1890-06-30	1885-07-31	24.64	A	-	-
		1890-06-30	1883-08-25	25	A	-	-
		1890-06-30	1888-11-14	21.88	A	-	-
		1890-06-30	1882-05-01	5.5	A	-	-
		1890-06-30	1888-11-14	4.94	A	-	-
		1890-06-30	1882-05-10	3.12	A	-	-
Garnet Ditch	Uncompahgre River	1890-06-30	1883-06-18	45	A	-	-
		1890-06-30	1888-11-14	48.33	A	-	-
Ironstone Canal	Uncompahgre River	1890-06-30	1882-06-30	37.5	A	-	-
		1890-06-30	1884-03-31	76	A	-	-
		1890-06-30	1888-11-14	37.5	A	-	-
		1890-06-30	1882-01-05	4.64	A	-	-
		1890-06-30	1882-01-01	0.26	A	-	-
		1890-06-30	1882-10-01	2.5	A	-	-
		1890-06-30	1882-11-21	1.83	A	-	-
		1890-06-30	1884-08-24	21	A	-	-
		1890-06-30	1888-11-14	21.5	A	-	-
Loutsenhizer Canal	Uncompahgre River	1890-06-30	1882-02-23	18	A	-	-
		1890-06-30	1882-02-23	30	A	-	-
		1890-06-30	1888-11-14	13	A	-	-
		1890-06-30	1888-11-14	20.6	A	-	-
		1890-06-30	1881-11-01	0.54	A	-	-
		1890-06-30	1883-11-30	7	A	-	-
		1890-06-30	1886-07-12	33.3	A	-	-
		1890-06-30	1888-11-14	5.5	A	-	-
Montrose & Delta Canal	Uncompahgre River	1890-06-30	1883-04-07	100	A	-	-
		1890-06-30	1884-04-07	100	A	-	-
		1890-06-30	1885-03-31	50	A	-	-
		1890-06-30	1888-11-14	231	A	-	-
		1890-06-30	1881-11-01	5	A	-	-
		1890-06-30	1881-12-08	12.61	A	-	-
		1890-06-30	1882-01-05	6.05	A	-	-
		1890-06-30	1882-01-27	0.65	A	-	-
		1890-06-30	1882-02-11	4	A	-	-
		1890-06-30	1884-01-24	17.37	A	-	-
		1890-06-30	1888-11-14	17.37	A	-	-
		1890-06-30	1885-04-01	25	A	-	-
		1890-06-30	1888-11-14	58.4	A	-	-
Selig Canal	Uncompahgre River	1890-06-30	1883-10-29	14.5	A	-	-
		1890-06-30	1888-02-07	58.1	A	-	-
		1890-06-30	1888-11-14	12	A	-	-
		1890-06-30	1882-01-27	1.41	A	-	-
		1890-06-30	1888-11-14	2	A	-	-
		1890-06-30	1882-04-30	1.1	A	-	-
	Total Uncompahgre Direct Flow (cfs)			**1,225.64**		-	-

Water Right Name	Water Source	Adj. Date(s)	Appr. Date(s)	Rate Amount (cfs)	Absolute	Conditional	AP/ EX[1]
Gunnison Tunnel Direct Flow Water Rights for Irrigation/Municipal/Stock Use							
Gunnison Tunnel & South Canal	Gunnison River	1913-05-08	1901-06-01	1,300.00	1,175.00	125.00	50.0
Total Gunnison Tunnel & South Canal (Irrigation/Municipal/Stock)				**1,300.00**	1,175.00	125.00	50.0
Gunnison Tunnel Direct Flow Water Rights for Hydropower Generation							
Gunnison Tunnel & South Canal	Gunnison River	1982-12-31	1981-02-16	**900.00**	-	900.00	-
		1982-12-31	1984-10-31	**235.00**	-	235.00	-
Total Gunnison Tunnel & South Canal (Irrigation/Municipal/Stock)				**1,135.00**	-	1,135.00	-
Taylor River Storage Water Rights for Irrigation Use (values in acre-feet)							
Taylor Park Reservoir	Taylor River	4/29/1941	8/3/1904	106,230	A	-	-
Total Taylor River Storage Water Rights				**106,230**	106,230		
Ridgway Reservoir Annual Leased Water for Irrigation Use (values in acre-feet)							
Ridgway Reservoir	Uncompahgre River	4/14/1956		**11,200**	A	-	-
Total Ridgway Reservoir				**11,200**	-	-	-

1) Alternate Point/Exchange Point

Water Allocation and Land Classification

USBR land classification determines water allocation, with arable lands classified as Class 1-3, special use lands as Class 4, and non-arable lands at Class 5-6. Arable lands have the ability to receive project water, however water rotation between parcels and onto non-arable (Class 5-6) lands is permissible. Soils differ substantially on either side of the Uncompahgre River; on the west side are “Mesa” (sandy) soils, while on the east side soils are primarily “Adobe” (clay) soils. Shareholders are allocated water on the basis of soil type, with Adobe soils receiving 4 acre-feet/acre and Mesa soils receiving 5 acre-feet/acre. Shareholders can request additional water above their allotment in exchange for an additional fee. Currently there are approximately 76,000 outstanding shares (1 share equals 1 irrigated acre) in the project, consisting of nearly 3,000 account holders. Approximately one-third of the water users in the Project own five shares or less.

During the construction of the Project several ditch owners within the UVWUA boundary chose not to sell their water rights to the Project but instead entered into carriage contracts with the UVWUA. These carriage contracts are still in effect today and assessed according to the contract agreement. The UVWUA manages the carriage and delivery of water to these non-participants within the Project boundary.

Historical Operations

The project utilizes several headgates (described above and shown on Figure 1) along the Uncompahgre River where the canals located in the lower part of the system rely on tailwater and return flows from the canals and irrigated lands located in the upper part of

the system. The Project water rights allow for water to be diverted at various canal headgates from the Uncompahgre River. If one canal is not available, water can be diverted from the river at other canal headgates.

The irrigation season typically begins mid-March to early April. Direct flow rights from the Uncompahgre River are used first until a call is placed on the Uncompahgre River, which typically occurs by July 1. When a call is placed on the Uncompahgre River water from the exchange pool of Ridgway reservoir is released to supplement declining flows in the Uncompahgre River. When the exchange pool is exhausted, water from the storage pool of the Ridgway Reservoir is then released. When Gunnison River flows decrease to the point where only 90% of the Gunnison Tunnel water right can be diverted, a call is placed on the Gunnison River by the UVWUA. At this time water is released from the Taylor Park account in Blue Mesa Reservoir to supplement diversions by the Gunnison Tunnel.

Review of Water Rights and Call Records

The water rights downstream of the UVWUA diversion points on the Gunnison, Uncompahgre and Colorado Rivers were plotted and reviewed. Figure 2 shows all the water rights between UVWUA's most upstream diversion and the State Line that are senior to UVWUA.

There are seven water rights, senior to UVWUA that divert from the Gunnison River downstream of the Gunnison Tunnel. There are 23 water rights, senior to UVWUA that divert from the Uncompahgre River between the most upstream diversion point for the UVWUA and the confluence of the Gunnison and the Uncompahgre Rivers. There are no water rights, senior to UVWUA irrigation rights that divert form the Colorado River between its confluence with the Gunnison River and the Colorado-Utah Stateline. It should be noted that although the water rights on Figure 2 were identified as senior to UVWUA, many of these water rights are only senior to a portion of the UVWUA irrigation rights. It should also be mentioned that most of the senior water rights that divert from the Uncompahgre River within the Project boundary are delivered by the UVWUA canals to their users.

Administrative call records for the period of 2000-2014, which includes the 2002-2003 dry period, were reviewed to determine the calls that may potentially impact the UVWUA water rights under a water bank scenario. This review focused on the calls that were placed by water users on the Gunnison, Uncompahgre and Colorado Rivers that divert between the UVWUA's most upstream water right and the Colorado-Utah Stateline. On the main stem of the Uncompahgre River, the only call by other senior water users was placed by the Ouray Hydro Project in 2012. However, this call was placed outside of the irrigation season and therefore is not of any significance. On the main stem of the Gunnison River, the only call placed downstream of the Gunnison Tunnel occurred between April 22nd and May 31st, 2002 which was placed by the Redlands Power Canal. However, this call was only senior to UVWUA's hydropower right and therefore not of any significance. The UVWUA senior irrigation rights have not been historically curtailed by other senior water users even during dry times such as the 2002-2003 period.

In recent history, the Gunnison Tunnel has placed a call on the river twice in the past 38 years, namely in 2002 and 2003. In 2002, the Gunnison Tunnel placed a call on the

Gunnison River from April 18th through September 30th, and the water delivered to the project irrigators was at 50% of the normal deliveries from July through September 30 of the year. In 2003, the Gunnison Tunnel placed a call from July 10 to September 9 and delivered water was at 80% of the normal deliveries from July through October 15 of 2003.

In the case of the Uncompahgre River, UVWUA has typically placed a call on the Uncompahgre River six out of every ten years. During a UVWUA call, all available river water must be at the East Canal (near the town of Olathe, approximately in the middle of the system). Return flows during the call must remain under 120 cfs at the Uncompahgre gage in Delta. In 2002, the UVWUA placed a call on the Uncompahgre River between May 2nd and September 27th, and delivered water at 70% throughout the season.

Irrigated Lands and Cropping Records

Approximately 79,000 acres are served within the UVWUA boundary. A summary of the irrigated acreage as assessed by the State of Colorado in 1993, 2005, and most recently in 2010 is shown below in Table 3.

Table 3: Uncompahgre, Acreage within UVWUA Boundary, CDSS Estimated Acreage

Year	Reported Acreage	Irrigation Method
1993	79,144	87.1% Furrow/ 12.9% "Unknown/Other"
2005	80,203	83.8% Furrow/ 16.2% "Unknown/Other"
2010	74,954	82.4% Furrow/ 17.6% "Unknown/Other"

As shown above in Table 3, over 80% of the system is irrigated via Furrow irrigation. During recent conversation with Mr. Fletcher, he indicated that there are approximately 10 sprinkler systems currently being used within the Project boundary.

The main crop types grown within the UVWUA boundary are Alfalfa, Grass Pasture, and Corn.

Table **4** presents the typical cropping pattern within the UVWUA boundary as determined in the CDSS records. The UVWUA maintains yearly cropping reports for the entire project area. However, crop mix on a farm level is not recorded

Table 4: Crop Mix within the Project Boundary as Reported in CDSS [% of total acreage]

Crop/Year	1993	2005	2010
Alfalfa	21.0	12.5	16.7
Corn Grain	26.0	18.5	26.2
Grass Pasture	32.8	49.8	43.0
Small Grains	4.8	11.6	5.1
Others	15.4	7.6	9.0

Location of Return Flows

Due to the nature of the water rights associated with the Project, which according to Mr. Fletcher can be used to extinction, return flows are recaptured and utilized by downstream irrigators. Excess water from the Project is discharged at various locations near the bottom of the system to various arroyos and washes before returning to the Gunnison River. During a conversation with Mr. Fletcher in June of 2015, Mr. Fletcher indicated that there are two existing gaging stations at the bottom of the system that allow for measurement of the excess /unused water released to arroyos and natural washes before it travels back to the Gunnison River. A third measurement station is expected to be installed in the near future that would also allow for measurement of unused/excess water released to the Gunnison River. These stations have been constructed or funded by Trout Unlimited and the Nature Conservancy. The approximate locations of these stations are depicted on Figure 1 below. In addition to the gaging stations mentioned above, several other gaging stations have been installed (see Figure 1) at the terminus of several canals.

Groundwater

Subirrigation by high groundwater is not believed to be an important source of water in the project area.

Salinity and Water Quality Issues

The Project has both salinity and selenium issues. This issue is more extensive on irrigated lands located at the downstream end of the Project area. Both the USBR and the Natural Resources Conservation Service are conducting multiple salinity reduction efforts within the Uncompahgre Valley. These efforts include both on-farm (increased application efficiency) and off-farm (canal linings) improvements. Water that is saved as a result of the salinity control efforts is still used within the project area by downstream irrigators. During a conversation with the UVWUA manager, Mr. Fletcher indicated that return flows from irrigated lands affected by high salinity and selenium levels are treated in the same manner as those from lands with no salinity and selenium issues. The lands that are impacted by the high levels of salinity and selenium are typically located on the east side of the Uncompahgre River.

Historical Diversion Records, Measurement and Data

Canal headgates on the Uncompahgre River have recorders, but there are no recorders elsewhere on the system canals. Deliveries to farms are measured at headgates, each of which may serve one or more farm. Farm deliveries made from pipes are equipped with totalizing flow meters. Historical deliveries recorded at the canal headgates are available in paper format. However, the UVWUA has recently started to store canal diversions and farm deliveries in an electronic database. Ditch riders have recently started to record farm deliveries using handheld electronic devices.

Deliveries to farms are made on an order basis. In most years the Project "goes on restrictions" and irrigators receive a fraction of a full share. These restrictions are usually made before the irrigation season based on estimates of snowpack. In 2013, the Project delivered only 60% of a full share, so many irrigators did not plant their full acreage. In general, the number of irrigated acres does not vary much from year to year.

As indicated previously, several streamflow gaging stations exist within the Project (see Figure 1) as well as directly upstream and downstream of the confluence of the Uncompahgre River and the Gunnison River. The existing streamflow gaging stations and the gaging stations located the terminus of canals provide potential locations for measuring foregone consumptive use and associated return flows that can be sent to the Colorado-Utah Stateline under a water bank scenario.

There is a weather station at the Montrose County Airport. Colorado State University may install another weather station to support the work of the No Chico Bush Project, funded by the Walton Foundation to look at ways to conserve water. Several additional weather stations, including three Colorado Agricultural Meteorological stations (which provide daily estimates of evapotranspiration for various crop types) exist within the UVWUA boundary. A summary of these stations is presented in Table 5.

Table 5: Summary of nearby meteorological stations

Station Name	Agency	Comments
Delta 3 Mi W Delta	CoAgMet	1995 – present
Delta	NOAA	1893 – 1999
Delta 3E	NOAA	2000 – present
Olathe 3 Mi NE	CoAgMet	1992 – present
Olathe 2 4 Mi W	CoAgMet	2010 – present
Olathe 4 SSW	NOAA	1983 – 1985
Montrose 1	NOAA	1905 – 1982
Montrose 2	NOAA	1898 – present
Montrose Regional Airport	NOAA	1996 - present

Potential for Water Banking and Challenges

Because many parcels within the UVWUA boundary have rotating cropping practices, potential exists for both fallowing and/or deficit irrigating. Additionally, because most hay and grain crops are being sold as a commodity, rather than being used within the Project, this allows for greater flexibility for participation in water banking as herd reduction is not a major concern.

Participation in a water bank scenario would require coordination among the UVWUA, USBR, and individual land owners. Due to the typical practice of reusing drain flows and return flows multiple times, this will require close coordination with the UVWUA to ensure that the foregone consumptive use and the associated return flows are released to the River and measured at the closest gaging station.

Foregone consumptive use as a result of deficit and/or temporary fallowing of lands within the project has the opportunity to be transported to the Colorado-Utah Stateline via the Gunnison River and then via the Colorado River. In order for the banked Project water to reach the Colorado-Utah Stateline during a Colorado Compact call without being diverted by other downstream users, by-pass and measurement structures may need to be constructed at various locations on the river to prevent banked water from being diverted by other pre-compact water rights that concurrently divert from the river downstream of the Project. This will require the involvement of the State Engineer.

There is a need to maintain adequate head in each of the canals for carriage purposes. To maintain adequate head within the system, foregone consumptive use (and associated return flows that can be used for a water bank) may need to be diverted and carried as normal through structures so that non-participants' water may be delivered. Given the above requirement for head maintenance in the canal system, it is unlikely that the forgone consumptive use (and associated return flows) can be by-passed and measured at the River headgate. Based on a recent discussion with Mr. Fletcher and the current operation of the Project, the most likely scenario is that the forgone consumptive use (and associated return flows) would need to be calculated and then measured and released to the River at the closest gaging station to the fallowed land. Currently the three gaging stations located at the bottom of the system (shown in pink on Figure 1) are suitable candidates for measurement of releases attributable to a water bank. Additional stations may be needed to be installed at other locations at the bottom of the system.

In addition to the challenges identified above and as described previously, the project typically reuses all of its water rights to extinction by using downstream canals/ditches within the UVWUA system to capture tailwater. Although this presents a unique opportunity alleviating return flow concerns to downstream water users, this would require coordination with the UVWUA and the individual shareholders of the Project to ensure that foregone consumptive use (and associated return flows) is transported to the end of the system and not diverted by downstream canals within the Project.

Another concern may arise from the fact that the UVWUA has relied on leased water of up to 11,200 acre-feet annually from Ridgway Reservoir and on an exchange of up to 15,000 acre-feet per year of Gunnison Tunnel water for water released from Ridgway Reservoir. Even though the water from Ridgway Reservoir has been typically used by

UVWUA as a supplemental supply, it should be noted that this supplemental supply has a post-compact water right and therefore in the event of a Colorado River Compact call this water may be curtailed thus limiting some flexibility of the UVWUA system.

As indicated above, several downstream water rights on the Gunnison River are senior to the Gunnison Tunnel water right. Although these water rights did not place any calls during the 2002-2003 dry period, the Gunnison Tunnel may still be called out by these downstream water rights during worse periods.

Given the long travel distance (approximately 75 miles) between the Project and the Colorado-Utah Stateline, the transit loss of the banked Project water could be significant.

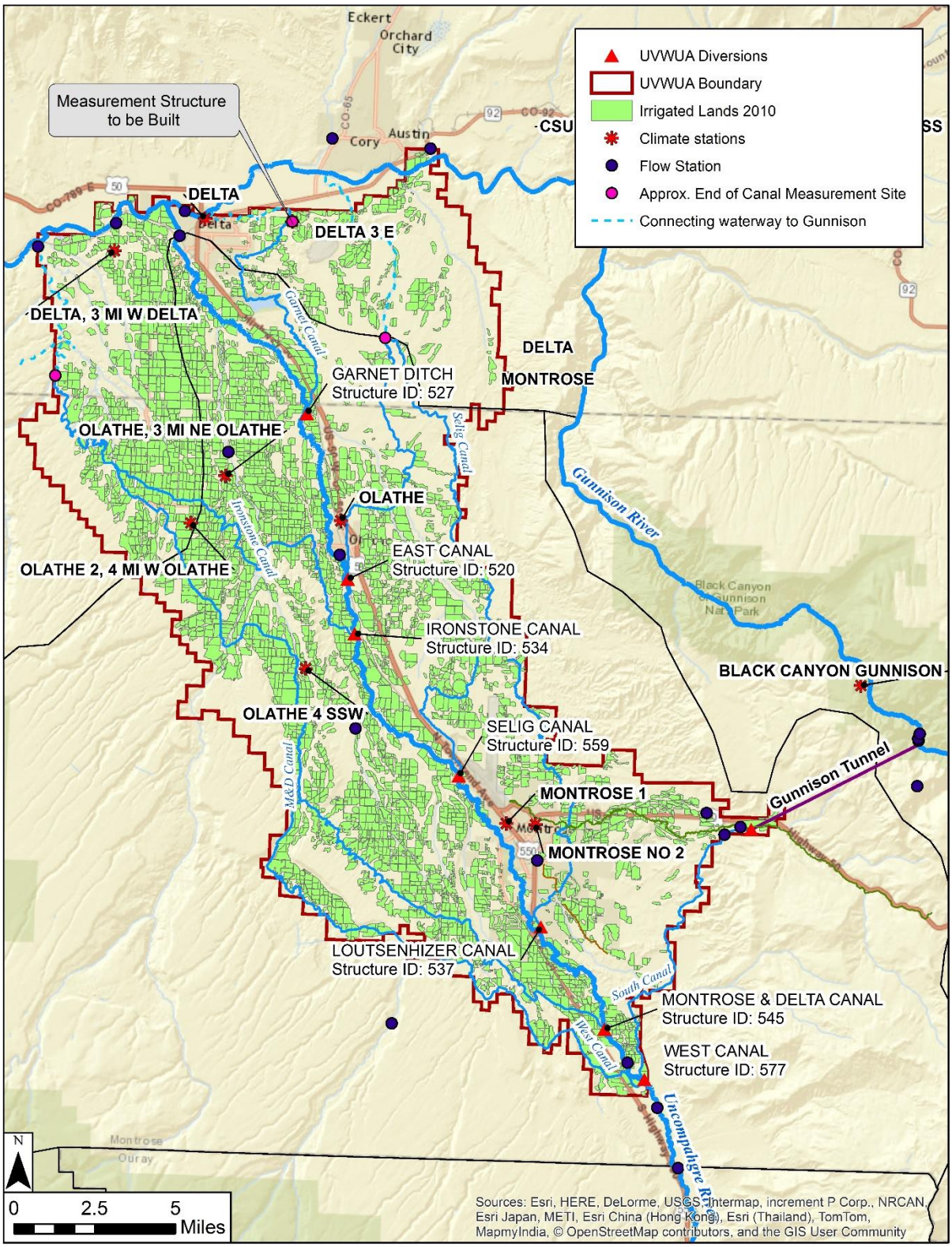

Figure 1

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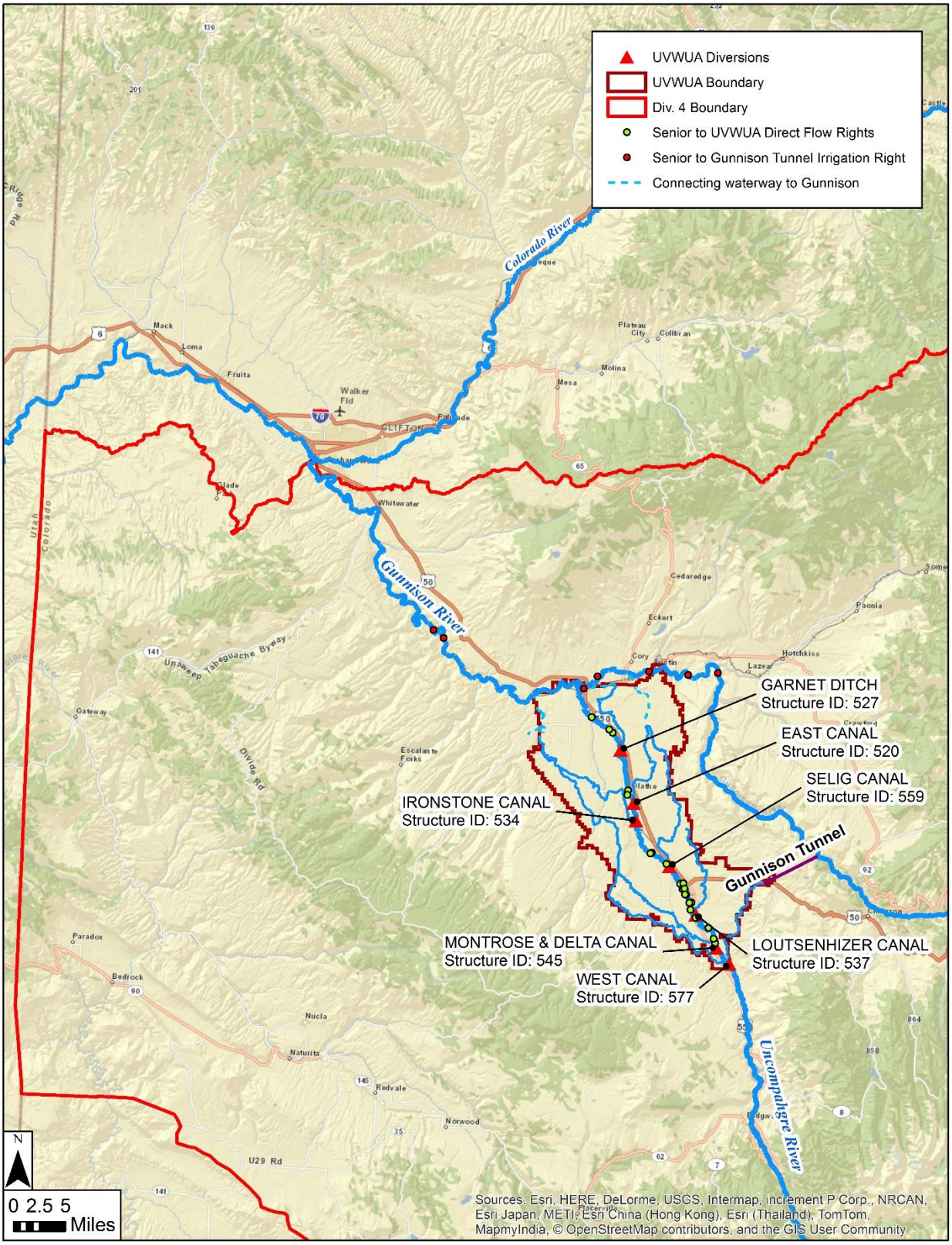
UVWUA Diversions
UVWUA Boundary
Div. 4 Boundary
Senior to UVWUA Direct Flow Rights
Senior to Gunnison Tunnel Irrigation Right
Connecting waterway to Gunnison
Colorado River
Gunnison River
GARNET DITCH
Structure ID: 527
EAST CANAL
Structure ID: 520
SELIG CANAL
Structure ID: 559
IRONSTONE CANAL
Structure ID: 534
Gunnison Tunnel
MONTROSE & DELTA CANAL
Structure ID: 545
LOUTSENHIZER CANAL
Structure ID: 537
WEST CANAL
Structure ID: 577
Uncompahgre River
Unaweep Tabeguache Byway
Divide Rd
U29 Rd
Mack
Loma
Fruita
Walker Fld
CLIFTON
Whitewater
Gateway
Paradox
Bedrock
Nucla
Naturita
Redvale
Norwood
Mesa
Molina
Plateau City
Collbran
Cedaredge
Eckert
Paonia
Hotchkiss
Lazear
Cory
Austin
Escalante Forks
Olathe
N
0 2.5 5
Miles
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 2

Appendix C: Doctor Morrison Canal System Overview Memo

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Memorandum: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems, Dr. Morrison Canal

To: Water Bank Technical Subcommittee
From: Shaden Musleh, John Craven, Hydros Consulting, Inc
Subject: Water Bank Phase 2B, Task 1, Test Case Irrigation Systems Dr. Morrison
Date: September 21, 2015

Overview

The Dr. Morrison Canal/Ditch (DMC) is a partially unlined canal that diverts from the Pine River (aka Los Pinos River) through Structure ID 1044 (prior to 2011 DMC diversions were tracked under Structure IDs 505 and 664 for administrative purposes) in District 31 of Water Division 7, approximately 1 river mile below Bayfield, Colorado. The DMC is approximately 14 miles in length and receives water from direct-flow rights (see Table 1) and water from the Pine River Indian Irrigation Project (PRIIP) stored in Vallecito Reservoir. Water delivered to the canal is measured through an 8-foot Parshall flume and recorded daily. Figure 1 shows the lands irrigated by DMC in 2010 as reported on the Colorado Decision Support System (CDSS) website and the location of the river headgate diversion structure as well as the main canal and laterals.

The ditch is operated by the Bureau of Indian Affairs (BIA). Based upon an assessment by the BIA, the ditch has a service area of approximately 4,200 serviceable acres (a serviceable acre was determined by the BIA as lands arable under gravity-fed irrigation). Based upon the most recent CDSS assessment of irrigated lands in 2010, the DMC irrigates approximately 2,158[1] acres that are primarily grass pasture in the drainages of the Pine River and its tributaries, Dry Creek and Rock Creek. Water is applied to most lands via flood irrigation. Due to a recent trend of moving away from farming and ranching, substantial areas under the DMC have not been irrigated recently. The lands that have not been irrigated are sometimes used as range grazing for livestock.

Operation and Management

As mentioned previously the BIA operates the DMC system. Diversions to the DMC are measured at the river headgate by an 8-foot Parshall flume. Real-time flow measurements are available at the Headquarters of the Southern Ute Indian Tribe's Water Resources Division (WRD) by telemetry; however there is no remote control of the headgate. The major laterals (Frost and Westside laterals) off the DMC extend approximately 12.6 miles and are gaged by Parshall flumes. An additional 8.3 miles (approximate) of sub-laterals are used to deliver water to individual parcels. Acreage served by the DMC is comprised of a combination of allotments, fee lands, and Tribal assignments. The duty of water under the DMC system is 1.0 cfs per 80 acres, which according to WRD staff is used to determine the approximate flow rate to be made available at canal laterals. Data are managed by the BIA, but may not be archived. The

[1] This is based on irrigated acreage as reported in CDSS for 2010. In 1993, CDSS shows a total of 2,869 acres irrigated by DMC.

WRD assists the BIA with maintenance and construction of canals and facilities. This includes installation and maintenance of water measuring devices within the ditch system, implementation of soil and water conservation projects, acquisition and protection of water rights and development of water resources.

Water Rights, Hydrology, and Water Supply

In 1930, water rights for the Tribe, including the direct-flow rights for the DMC, were adjudicated in Federal Court with a priority of July 25, 1868, and are therefore pre-compact rights. The DMC operates under the water rights[2] shown in Table 1.

Table 1: Dr. Morrison Ditch Water Rights, Division 7, District 31, Structure 1044

Water Right Name	Water Source	Adj. Date	Appr. Date	Rate Amount (cfs)	Absolute	Conditional
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	0.50	A	-
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	24.75	A	
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	38.58	A	
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	1.00	A	
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	6.42	-	C
Dr. Morrison Ditch	Pine River	10/25/1930	7/25/1868	7.50	-	C
Dr. Morrison Ditch	Pine River	6/12/1934	10/1/1900	7.80	A	-
Total (cfs)				***86.55***	***72.63***	***13.92***

Some of the water rights shown in Table 1 were transferred from other ditches to the DMC. The 0.5 cfs, 24.75 cfs, 38.58 cfs, and 1.0 cfs shown above are absolute water rights with No.1 priority. These water rights are held in Trust for the Tribe by the United States and are used to supply Tribal lands. Although these combined rights (totaling 64.83 cfs) are rights held in Trust for the Tribe, a portion of these rights have been used on allottee lands. The 6.42 cfs and 7.5 cfs water rights, conditional water rights with No1. priority, are held in Trust by the United States for the owner of former tribal allotments. The 7.80 cfs water right is privately owned but diverted and used for irrigation under the DMC system.

As part of a settlement with the State, the water rights for the DMC were granted a presumption of "full-supply" when quantifying historical consumptive use. So, even though a large portion of the land under the ditch has not been irrigated, this will not compromise historical water use estimates. Additionally, the water rights for the DMC system are not subject to forfeiture if not used.

Following adjudication of the Southern Ute Tribe water rights, some shortages occurred to non-Indian water rights on the Los Pinos River. This motivated the construction of Vallecito Reservoir, completed in 1941 as part of the Pine River Project. One-sixth of the water stored in the reservoir is held by the BIA in trust primarily for the Southern Ute Indian Tribe under the PRIIP. CDSS records show that the Vallecito Indian account is 21,612.45 acre-feet at full supply. Vallecito Reservoir is operated by the Pine River

[2] Source: CDSS website

Irrigation District, which releases water to its own shareholders and to the PRIIP, DMC and its associated diversions off the Pine River.

Between its direct-flow rights and its allocation of storage in Vallecito Reservoir, the DMC has not experienced a water supply shortage since the construction of the Vallecito Reservoir.

Historical Diversion Records

Historical diversion records are readily available on CDSS. Although river headgate diversions as well as deliveries to major laterals are gaged, deliveries to individual farms and surface water returns are not directly measured. Due to the lack of direct measurement of farm headgate deliveries and return flows, foregone consumptive use and return flows would need to be estimated. Figure 2 shows the CDSS diversion records for DMC, including total diversions (includes direct flow right and reservoir water) and diversions for irrigation (only includes direct flow rights).

As shown below in Figure 2, there have been instances where water diverted by the DMC was not coded under their direct flow rights, but rather as from "Multiple" sources. During conversation with Division 7, District 31 Water Commissioner, David Hofmann, Mr. Hofman stated that during years where Vallecito Reservoir is full, the Vallecito Superintendent has typically begun making releases (to hit a fall target pool elevation) earlier in the season. When this has occurred, Mr. Hofmann stated that a letter indicating this operation would be sent to the Water Commissioner. Because excess water is being made available to downstream users, Mr. Hofmann stated that the source of all diversions during these events is coded as "Multiple".

Irrigated Lands and Cropping Records

Irrigated lands in Division 7 were assessed by the State of Colorado in 1993, 2005, and most recently in 2010 and are summarized in Table 2.

Table 2: Dr. Morrison Ditch, CDSS Reported Acreage

Year	Reported Acreage	Irrigation Method
1993	2,869.21	>99% Flood Irrigated
2005	2,107.21	>96.5% Flood Irrigated
2010	2,158.42	>96.5% Flood Irrigated

As previously stated, the DMC is primarily used for the irrigation of grass pasture for hay production. Table 3 below presents the cropping pattern for years where data was available on CDSS. Crop yields vary between parcels and may be as high as 4 tons/acre; however yields typically average between 1.5-2 tons/acre (as stated by WRD staff). Typically, hay fields served by the DMC yield two cuttings per year but occasionally yield three cuttings per year. Yield varies based upon the operator's level of commitment to irrigating his land. Hay is typically fed to cattle owned by the land owner or nearby cattle herds although some hay is sold out of the area.

Table 3: Dr. Morrison Ditch, Cropping Pattern

Crop/Year	1993	2005	2010
Alfalfa	12.74	71.26	0
Grass Pasture	2,856.47	2,035.95	2,158.42

Review of Administrative Call Records

Administrative call records on the Pine River were reviewed for the period of 2002 through 2014. Given that the DMC is the No. 1 priority on the Pine River, calls from downstream water rights on the Pine River that were placed during the above time period had no impact on DMC.

Return Flows

The DMC diverts water from the Pine River above Ignacio to irrigate lands on the west side of the River. Some of the irrigated lands are in the drainages of Dry Creek and Rock Creek, which are tributary to the Pine River, respectively just above and just below Ignacio. Accordingly, return flows from the lands under the DMC accrue to the Pine River directly or to Dry or Rock Creek and subsequently to the Pine River.

Figure 1 also shows Non-Tribal water rights that divert from the mainstem of the Pine River between the DMC river headgate and the Stateline. These water rights were extracted from CDSS, and updated based upon feedback from WRD to remove those that are Tribal water rights. There are 12 water rights that divert from the river reach described above. Of the 12 water rights, the Spring Ditch which diverts approximately 2 miles below the DMC is the only water right with a significant decreed diversion rate. According to CDSS records, two of the 12 structures are “historical”, which is defined in CDSS documentation as “Historical structure only - no longer exists or has records, but has historical data”. Most of the other 11 water rights are either pump stations or alternate points of diversion and generally have a significantly lower diversion rate compared to the Spring Ditch or DMC.

During conversation with WRD staff, WRD stated that return flows attributable to Vallecito Reservoir water may be reused to extinction within Tribal lands. However, as CDSS records show Vallecito Reservoir water is post-compact and has been used sparingly on lands served by the DMC system.

Return flows generally return to the Pine River downstream of the irrigated lands, and accrue within the PRIIP area. As mentioned above the only significant diversion that has historically received return flows from the DMC is the Spring Creek Ditch which diverts above most of lands irrigated by the DMC.

Groundwater

The WRD maintains water level sensors on some wells located within the DMC service area. A groundwater study has been conducted but the spatial scope of that study is not known at this time. When more information about this study becomes available, if any, this technical memorandum will be updated to reflect that. It appears that lands located

near the Pine River may be sub irrigated. However, generally lands directly adjacent to the Pine River are mostly served by the Nannice Ditch (also a Tribal water right) that runs between the DMC system and the Pine River.

Salinity and Water Quality Issues

There are no known salinity issues affecting lands served by the DMC. Some areas in the western portion of the service area have minor selenium issues but it doesn't appear to be a significant issue.

Measurement, Control, and Data

The U.S. Geological Survey maintains river gages at La Boca (1/1/1950 to present) and at Ignacio (10/1/1999 to present). The latter gage is located a short distance below the DMC headgate and below a large portion of lands currently served by the DMC.

As stated, water delivered to the ditch is measured via an 8-foot Parshall flume. The DMC system is mapped in GIS, including the location of measuring devices on both surface water and groundwater diversion structures.

During conversation with WRD staff, it was stated that several sections of the DMC system were piped/lined in recent years to mitigate high seepage loss. Review of GIS coverage of the DMC system (provided by the BIA) indicated that approximately 11% (or 1.6 miles) of the main canal has been either piped or lined. Additionally, WRD staff stated that there have been several issues with the piped sections of the main canal specifically that several of the piped sections appear to be limiting the flow causing delivery issues.

Several meteorological stations are actively maintained in the area surrounding the ditch service area. Table 4 summarizes several stations that can provide the meteorological data necessary for determining crop water irrigation requirements. There is an EPA air-quality meteorological station at WRD Headquarters at Ignacio. The WRD recently provided hourly temperature and precipitation data from the air-quality monitoring station for the historical use analysis.

It should be noted that the Bureau of Reclamation and the Ten Tribes Partnership are jointly pursuing a Colorado River-Basin-wide study of tribal water use and long-term needs.

Table 4: Summary of nearby meteorological stations

Station Name	Agency	Approximate Distance from DMC Headgate [miles]	Comments
Bayfield 0.6 WSW	NOAA	0.75	Only precipitation is measured, starting in November of 2004
Durango LaPlata CO Airport	NOAA	10.25	-
Ignacio 8E	NOAA	9.85	Data available starting 2001, some missing data
EPA Air Quality Monitoring Station	EPA	5.0	Data available starting 2002, some missing data

Potential for Water Banking

Due to the administrative and operational structure of the DMC any involvement in the Water Bank would require the participation of the Southern Ute Tribe, BIA, USBR (owner of Vallecito Reservoir), and the various land owners served by the ditch (classified as fee lots, allotments, and Tribal assessments). However, as the lands served by the DMC are typically deficit-irrigated potential for operational fallowing exists.

The Doctor Morrison system has unique potential for participation in a water banking scheme for several reasons, one being that the rights are not subject to forfeiture in the case of non-use and another due to the fluctuating interest level in irrigating by a portion of individuals served by the system. Because some operator's served by the DMC system irrigate their lands only intermittently there may be interest amongst users to forego irrigation.

Additionally, due to the proximity to the Stateline (Colorado to New Mexico, <10 miles) and limited downstream water use, the DMC system would be able to efficiently move water to the Stateline with little concern of the water being mistakenly diverted by downstream water users. A potential downstream measurement point to determine the amount of foregone consumptive use delivered to the State Line may be the downstream USGS La Boca gage which is approximately ½ mile above the Stateline.

Potential Challenges and Recommendations

During conversations with WRD staff, several concerns were raised regarding the concept of water bank participation. The concerns generally involved coordination of participation, specifically regarding the private rights carried by the DMC system as well as water held in Trust by the US for non-Tribal allotments. As stated by WRD staff, participation in a water bank by the South Ute Tribe would ultimately be decided upon by the Tribe and therefore coordination with individuals served by the Tribe's direct flow water rights would be necessary. Because some water carried by the DMC system is diverted under private water rights (described above) as well as water held in Trust for non-Indian allotments served by the DMC, coordination would be required to ensure that an adequate head would be maintained in the canals for carriage purposes (in the event

of non-participation by the non-Indian allotments and/or the private water rights carried by the DMC system).

As stated above, the water rights of the Tribe cannot be forfeited in the case of non-use and therefore full supply can be assumed for determination of consumptive use. Although this presents a unique opportunity for water bank participation, it may also complicate participation. Because a large portion of the lands under the DMC are either inadequately or are only intermittently irrigated (from year to year), it is possible that lands which have not historically requested water from the DMC, yet are entitled to water, may choose to participate. If the majority of the water bank participants are such, the river flow below the DMC under a water bank scenario (under same hydrology) will generally remain similar to the historical river flow and hence no significant increase in river flow will be physically felt. For water users that never or rarely used their water, it may be recommended as a protective measure that these users use their water for irrigation first before they participate in a water bank. Under this case, any river releases due to savings in consumptive use would be physically felt at downstream locations and at the Colorado-New Mexico Stateline.

Review of DMC operations indicated that hay grown on lands served by the DMC system is typically used for cattle owned by the land owner or sold locally. Because the hay is being used by the land owner, this may present a challenge as herd sizes may need to be reduced in order for a land owner to participate.

Under a water bank operational scenario that would bypass consumptive use savings at the river headgate and in order to keep the head in the DMC canal system high enough to allow for water to be delivered to the users at the end of the system, check structures may need to be installed within the ditch system. Additional measurement devices may be required in order to ensure that releases of consumptive use savings to the river are quantified.

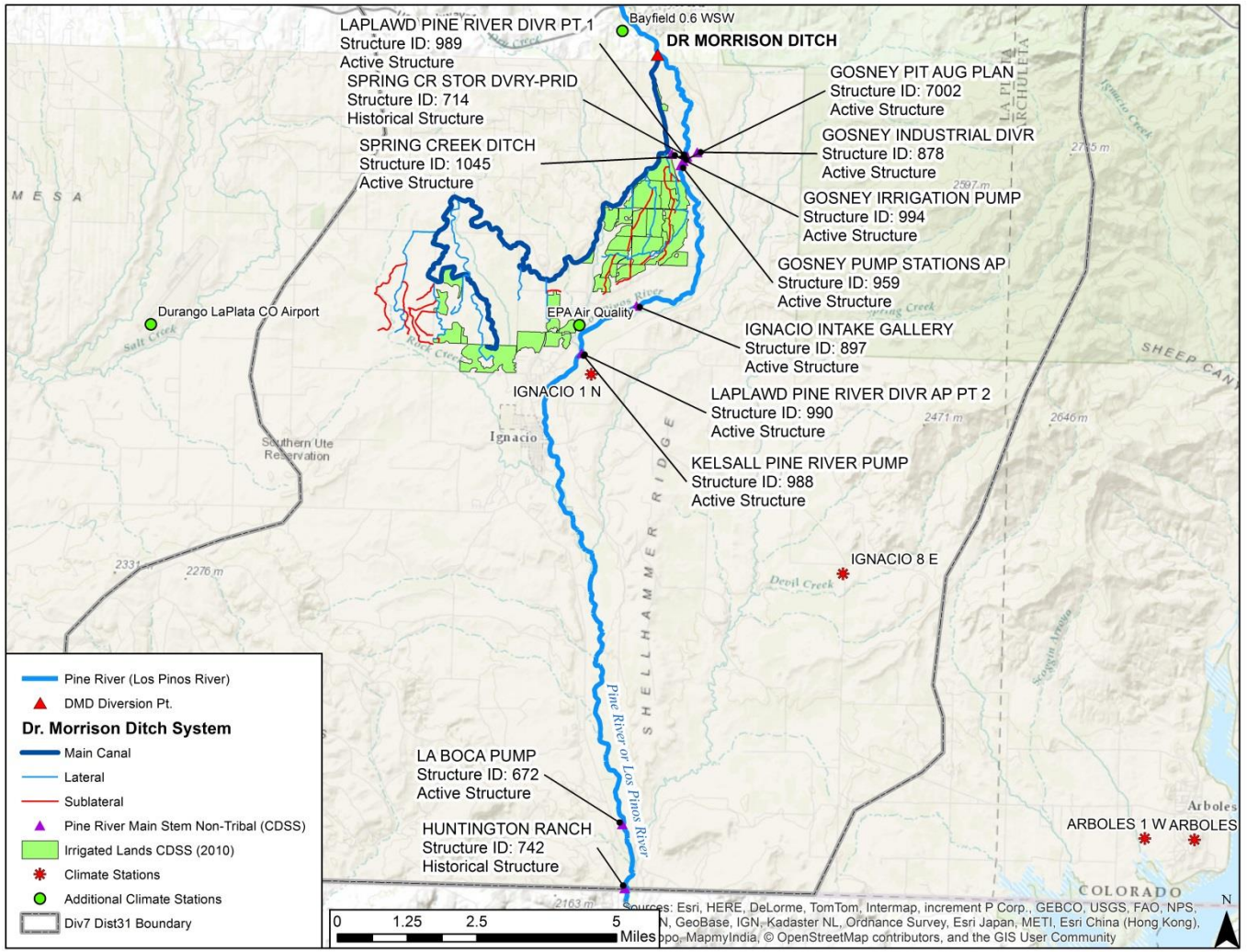

Figure 1: Irrigated Lands in 2010 by DMC and Non-Tribal Water Rights*

***All downstream diversion shown are junior to the Doctor Morrison Ditch (Spring Creek Ditch has water rights under the same priority)**

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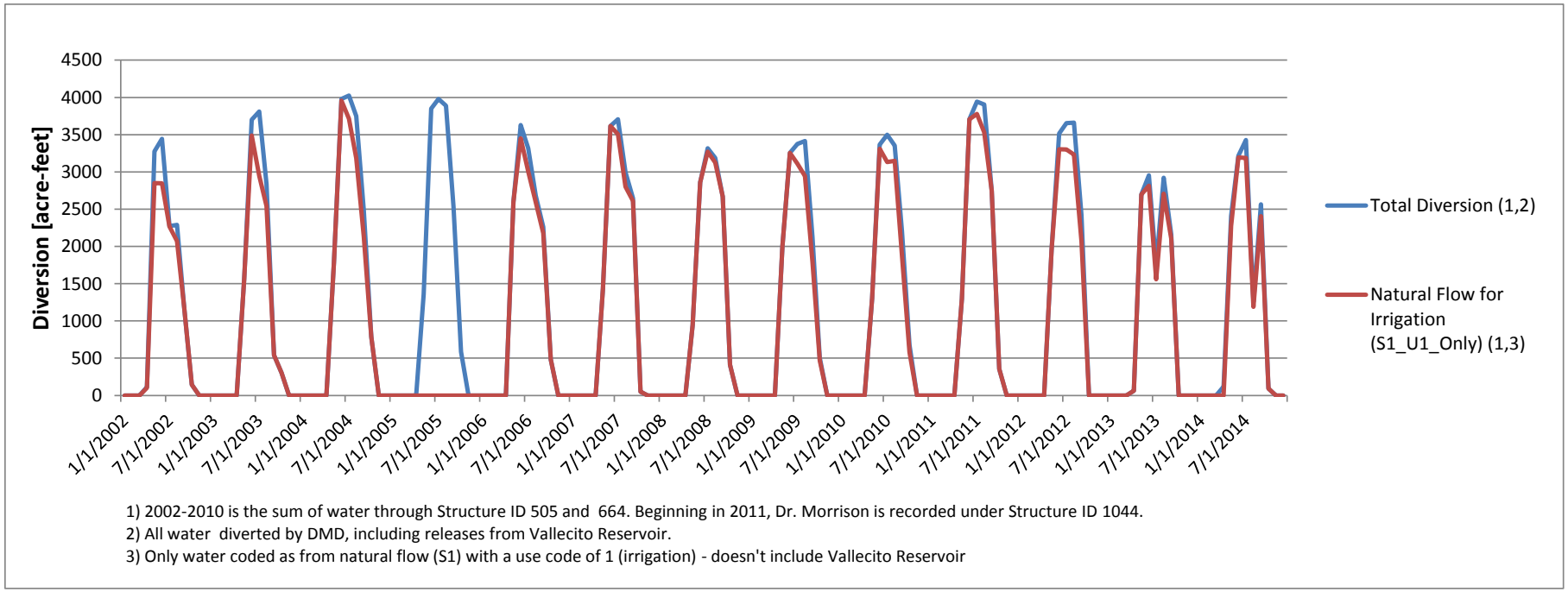

Figure 2. Total Diversions through Structure vs. Natural Flow Diversions for Irrigation - Dr. Morrison Ditch*

***2005 Diversions by the DMC coded as S9-Multiple Sources. Division 7 District 31 Water Commissioner, David Hofmann, stated (5/20/15 phone call) that water from Vallecito Reservoir was made available to all Pine River water users and therefore the State did not track differences between reservoir water and natural flow.

Table 5: Diversions coded as S1U1 (from natural flow for irrigation, red line Figure 2)

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	103	2,850	2,848	2,266	2,070	1,166	144	-	-	11,448
2003	-	-	-	-	1,561	3,490	2,949	2,541	541	304	-	-	11,386
2004	-	-	-	-	1,784	3,956	3,714	3,183	2,136	785	-	-	15,559
2005	-	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	2,597	3,450	3,007	2,595	2,177	482	-	-	14,309
2007	-	-	-	-	1,431	3,617	3,505	2,803	2,609	51	-	-	14,016
2008	-	-	-	-	948	2,860	3,272	3,127	2,670	411	-	-	13,287
2009	-	-	-	-	1,996	3,256	3,110	2,944	1,793	469	-	-	13,567
2010	-	-	-	-	1,307	3,310	3,134	3,149	1,877	579	-	-	13,355
2011	-	-	-	-	1,296	3,706	3,778	3,532	2,745	355	-	-	15,413
2012	-	-	-	-	1,963	3,306	3,302	3,232	2,072	-	-	-	13,876
2013	-	-	-	62	2,697	2,816	1,558	2,708	2,106	-	-	-	11,948
2014	-	-	-	-	2,276	3,193	3,189	1,188	2,407	93	-	-	12,346
Min	-	-	-	165	22,705	39,808	36,783	33,073	24,300	3,674	-	-	11,386
Max	-	-	-	103	2,850	3,956	3,778	3,532	2,745	785	-	-	15,559
Average	-	-	-	83	1,892	3,317	3,065	2,756	2,025	306	-	-	12,347

Table 6: Total Vallecito Reservoir Water*

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	11	425	595	6	218	-	-	-	-	1,255
2003	-	-	-	-	-	209	860	295	-	1	-	-	1,364
2004	-	-	-	-	-	23	310	565	349	-	-	-	1,248
2005*	-	-	-	-	1,359	3,850	3,978	3,887	2,534	587	-	-	16,195
2006	-	-	-	-	-	178	309	85	84	-	-	-	656
2007	-	-	-	-	-	-	202	192	37	-	-	-	430
2008	-	-	-	-	-	-	45	60	-	-	-	-	106
2009	-	-	-	-	-	-	266	470	329	35	-	-	1,100
2010	-	-	-	-	-	56	366	205	325	97	-	-	1,050
2011	-	-	-	-	-	-	166	372	-	-	-	-	539
2012	-	-	-	-	-	208	352	429	345	-	-	-	1,334
2013	-	-	-	-	-	137	179	215	57	-	-	-	588
2014	-	-	-	119	132	22	239	71	159	-	-	-	742
Min	-	-	-	11	132	22	6	60	37	1	-	-	106
Max	-	-	-	119	1,359	3,850	3,978	3,887	2,534	587	-	-	16,195
Average	-	-	-	10	147	406	560	543	325	55	-	-	2,047

*As noted above, all water in 2005 is coded as S9 (source: Multiple). All water was coded from multiple sources due to operations at Vallecito.

Table 7: Total through Structure (blue line Figure 2, Table 5 + Table 6)

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	114	3,276	3,443	2,272	2,288	1,166	144	-	-	12,703
2003	-	-	-	-	1,561	3,699	3,809	2,836	541	305	-	-	12,750
2004	-	-	-	-	1,784	3,979	4,024	3,748	2,486	785	-	-	16,806
2005	-	-	-	-	1,359	3,850	3,978	3,887	2,534	587	-	-	16,195
2006	-	-	-	-	2,597	3,628	3,316	2,680	2,261	482	-	-	14,965
2007	-	-	-	-	1,431	3,617	3,707	2,995	2,646	51	-	-	14,446
2008	-	-	-	-	948	2,860	3,317	3,187	2,670	411	-	-	13,392
2009	-	-	-	-	1,996	3,256	3,375	3,413	2,122	504	-	-	14,667
2010	-	-	-	-	1,307	3,366	3,500	3,354	2,202	677	-	-	14,406
2011	-	-	-	-	1,296	3,706	3,944	3,905	2,745	355	-	-	15,951
2012	-	-	-	-	1,963	3,514	3,654	3,662	2,417	-	-	-	15,209
2013	-	-	-	62	2,697	2,953	1,737	2,923	2,163	-	-	-	12,536
2014	-	-	-	119	2,408	3,215	3,428	1,258	2,566	93	-	-	13,088
Min	-	-	-	-	948	2,860	1,737	1,258	541	-	-	-	12,536
Max	-	-	-	119	3,276	3,979	4,024	3,905	2,745	785	-	-	16,806
Average	-	-	-	23	1,894	3,468	3,389	3,087	2,194	338	-	-	14,393