BUREAU OF RECLAMATION
Technical Service Center
Denver, Colorado

TRAVEL REPORT

Code: 86-68560 Date: November 28, 2006

To: Manager, Water Resources Research Laboratory

From: Tony L. Wahl

Subject: Travel to Tom Green County Water Control and Improvement District #1 near San Angelo, Texas

1. **Travel period:** August 28-30, 2006

2. **Places or offices visited:** Tom Green County Water Control and Improvement District #1, San Angelo, Texas

3. **Purpose of trip:** Review district infrastructure and operations and evaluate the potential for improvements to water measurement and canal control structures and operation and maintenance procedures

4. **Synopsis of trip:** I traveled by air to Dallas, Texas on August 28, where I rented a car and drove on to San Angelo, Texas. On Tuesday morning I met up with Brenton Johnson and Thomas Michalewicz from the Oklahoma-Texas Area Office in Austin, TX. We traveled together to the headquarters of the Tom Green County Water Control and Improvement District #1 at Veribest, Texas, just outside of San Angelo. We visited key sites in the district on Tuesday with Mr. Yantis Green, District Manager, and Mr. John Woiton, water master for the Concho River (Texas Commission on Environmental Quality—TCEQ). On Wednesday morning we met at the office again for a short time with Mr. Green and Mr. Lyn Hatley, one of the district's two ditchriders. We also spoke briefly with a representative of the City of San Angelo who works with the district to regulate releases from Lake Nasworthy into the district's main canal. We visited a few additional sites on Wednesday morning, and I drove to Dallas and flew back to Denver in the afternoon. An attached report summarizes our observations and recommendations for the district related to water measurement and canal control operations.

5. **Conclusions:** The district has successfully made numerous improvements in recent years and weathered a time of transition for management and operations personnel. An unresolved question about the accuracy of flow measurement at the head of the district's main canal seems to be the biggest issue facing the district at this time. There are some opportunities for additional flow measurement and check structure automation improvements. On the whole, the district

infrastructure is in good condition, although there are some isolated areas of damaged canal lining that the district is working to correct.

New personnel working for the district might benefit from attending the Modern Methods in Canal Operation and Control class that will be held in Reclamation's hydraulics laboratory in Denver during January 22-26, 2007.

6. **Action correspondence initiated or required:** None

Attachment

cc: TX-Michalewicz, TX-Johnson
(w/att to each)

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bc: 86-68560 files

WBR:TWahl:pab:11-28-06:303-445-2155
File:

Travelers: November 28, 2006

SIGNATURES AND SURNAMES FOR:

Travel to: San Angelo, Texas

Date or Dates of Travel: August 28-30, 2006

Names and Codes of Travelers: Tony Wahl (86-68560)

Traveler	**Date**

Noted and Dated by:

RECLAMATION

Managing Water in the West

Review of Water Measurement and Water Distribution Infrastructure and Operations

Tom Green County Water Control and Improvement District #1
San Angelo, Texas

by

Tony L. Wahl

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Water Resources Research Laboratory
Denver, Colorado

December 2006

Introduction

At the request of Reclamation's Oklahoma-Texas Area Office, the Water Resources Research Laboratory was asked to perform a site visit of the district to review project infrastructure and procedures relating to the operation and management of the water distribution system. This review considers recently completed and potential future improvements to water measurement structures and methods, canal check structures and turnouts, and canal operation procedures.

Background

The principal features of the San Angelo Project were placed into operation in 1963. The Tom Green County Water Control and Improvement District #1 was established to operate the irrigation water distribution system, which serves about 15,000 acres. In recent years, the district has operated from two different water sources: freshwater supplies from Lake Nasworthy (water initially stored in Twin Buttes Reservoir and diverted to Lake Nasworthy), and primary-treated effluent discharged from the San Angelo city sewage treatment system. When operating from effluent, the district must prevent any return flow back to the Concho River, so a tail-end reuse pond captures outflow at the tail end; this water can be pumped back upstream for redelivery. Due to drought conditions in recent years, the district has operated only with effluent water for at least the past 5 years, but during the summer of 2006 they had additional freshwater supply from Lake Nasworthy. This is also the first year of operation for the Concho River Watermaster program, which will oversee the operations of the district and other water users in the basin. The primary (almost exclusive) crop grown in the district is cotton, which can be irrigated with sewage effluent water since it is not a food crop.

Site Visit

The site visit took place on August 29-30, 2006 and primarily involved the following personnel:

- Mr. Tony Wahl, USBR, Water Resources Research Laboratory, Denver, CO
- Mr. Brenton Johnson, USBR, Oklahoma-Texas Area Office, Austin, TX
- Mr. Thomas Michalewicz, USBR, Oklahoma-Texas Area Office, Austin, TX
- Mr. Yantis Green, District Manager

Mr. John Woiton, water master for the Concho River (Texas Commission on Environmental Quality—TCEQ) also accompanied us on the first morning of the site visit, and we met briefly on the second morning with Mr. Lyn Hatley, one of the district's two ditchriders. We also spoke in the district offices on the second day with a representative of the City of San Angelo who works with the district to regulate releases from Lake Nasworthy into the district's main canal.

The San Angelo area had received 5 inches of rain in the two days preceding our visit, so the canal had been shut down and was either dewatered or filled with standing water at all sites we visited.

We began our tour of the district at the head of the main canal, where a slide gate controls releases from Lake Nasworthy. A rating table for the gate provides the release flow as a function of the lake elevation and the gate opening. The gate is operated by the city, which maintains and operates the dam, setting releases according to district needs. Flows released from Lake Nasworthy are also measured at a 10-ft Parshall flume located about 6 miles downstream in the main canal. The district has operated this year with water from Lake Nasworthy for the first time in several years, and has had a complete turnover of district personnel since lake water was last used, so there was initial uncertainty about procedures for the use of the gate rating table and the flume. Early in the season, releases from the lake were small (10-30 ft^3/s) and the measurements at the Parshall flume were in substantial agreement with the rating table for the head gate at the dam. Later in the season as flow rates increased, a difference between the gate rating and the flume measurements began to appear at flows above 60 ft^3/s. At one point the gate was opened fully, which should have produced a flow of 160 ft^3/s according to the gate rating table, but the district reported that the flow rate indicated at the flume never exceeded 85 ft^3/s, even though the flow depth at the head of the canal was reported to have increased when the change was made and water was near the top of the canal lining in photos taken by Yantis Green. The flow depth seen in these photos was slightly higher than the design condition (0.5 ft freeboard) for the flow rate of 165 ft^3/s in this section, which may be due to the growth of star grass (watermilfoil) in the canal.

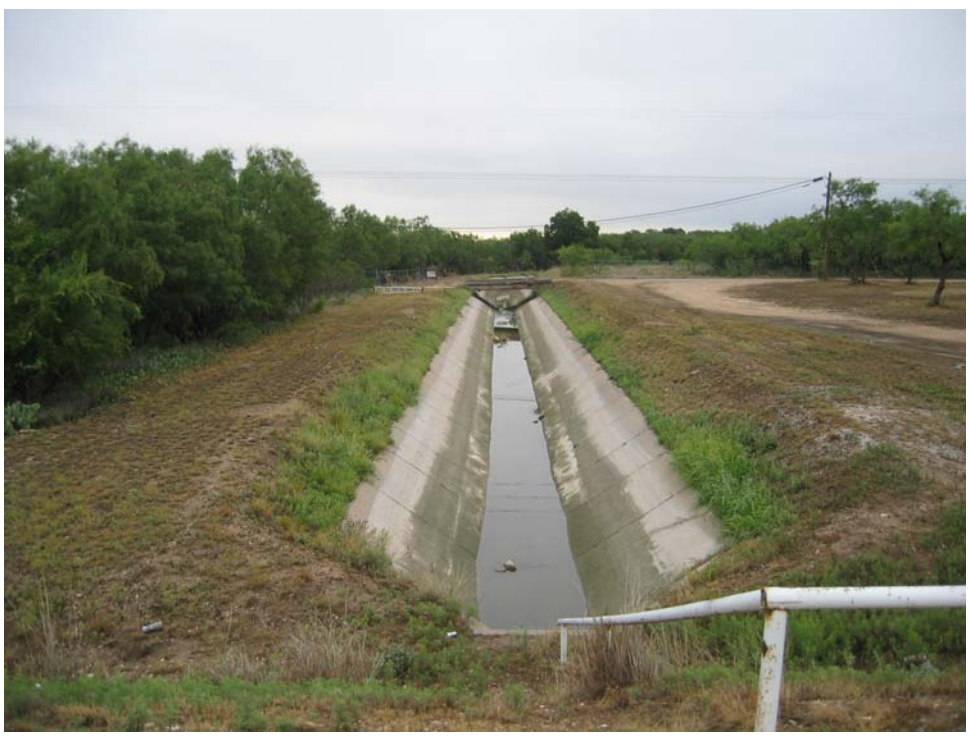

Figure 1. — Head of the main canal, looking downstream from the top of the dam at Lake Nasworthy.

This is a substantial and perplexing difference. We discussed possible sources of error in the use of the gate rating table and the flume. These included blockage of the fish screens around the dam outlet gate, errors in knowledge of the reservoir water surface, errors in gate position, additional tailwater caused by weed growth in the downstream canal, and leakage of flow out of the canal between the head gate and Parshall flume, Nothing we uncovered is able to explain such a large difference in flow. There were significant questions on the part of the district regarding how the reservoir water level is determined, but after our discussions on Thursday with the city representative, we were convinced that reservoir levels are known with sufficient accuracy to prevent this size of error.

Some minor improvements could be made to the flow measurement systems at the head of the main canal. At the dam, there is presently no staff gage inside of the trash rack and fish screen structure that surrounds the intake. When trash accumulates on the screens, it will reduce the effective head on the gate, which will reduce the flow rate. A gage on the interior of the screened area would allow for measurement of the net reservoir head acting on the gate. Unfortunately, there are few suitable locations where a staff gage could be added inside of the intake structure and still be visible. Another option would be to add a water level sensor that could be integrated into the district's SCADA system.

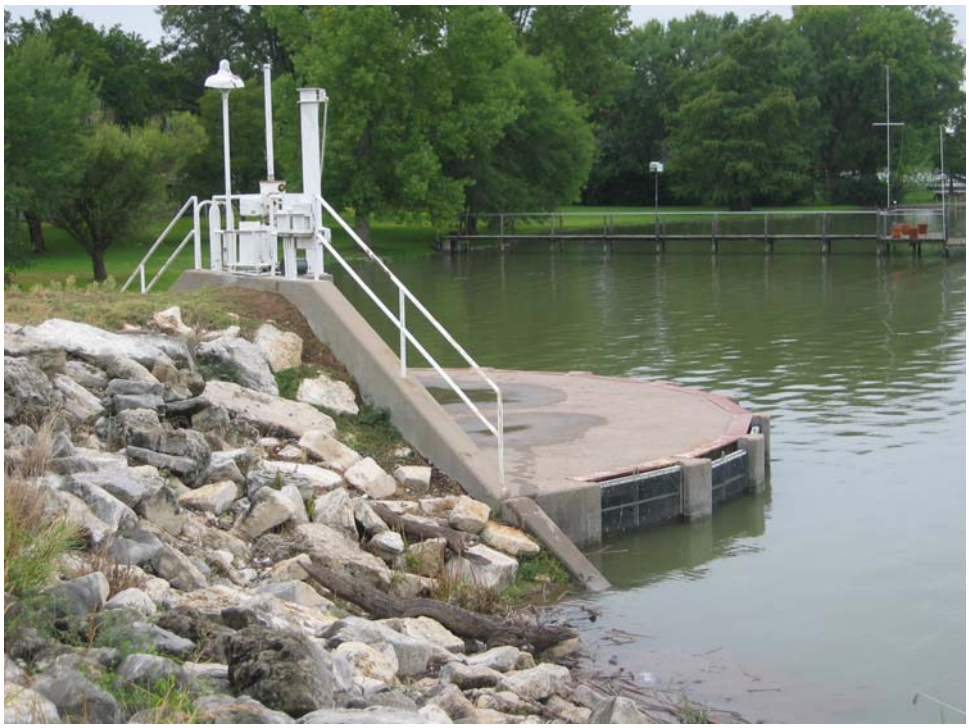

Figure 2. — Intake structure at Lake Nasworthy.

The 6 mile distance from the head of the canal to the Parshall flume is an operational issue. The district expressed interest in having an independent flow measurement device closer to the head of the canal to reduce the delay in obtaining a measurement after gate changes are made, and to solve the problem of the discrepancy between the gate rating and the Parshall flume. This is possible, but may require raising the canal lining upstream from the flume, since the design maximum flow already has only 0.5 ft of freeboard in the existing lining. Consideration would

also need to be given to the effect that a flume and increased water surface would have on the flow capacity of the head gate at the dam. Finally, this may not solve the flow discrepancy problem, since we were unable to find any significant problems with the Parshall flume and could not otherwise explain the source of the discrepancy. This issue probably needs to be investigated further at a time when the upstream reach of the canal is in operation. If a new flume were constructed, the best type of flume for this application would probably be a ramp flume, since it could be designed to have the lowest possible head loss. An acoustic meter, such as the SonTek Argonaut-SW might also be a good solution for this application, since it would introduce no additional head loss.

We walked the canal for several hundred yards downstream from the head gate. Overall, the canal is in good condition, but there are significant reaches in which mesquite growth prevents canal access. The district is working now to clear these areas and restore access. There are problems with mesquite trees growing near the top of the canal lining and occasionally there are short sections of canal lining that have bulged out. These seemed to often be associated with the presence of mesquite trees next to the lining, but could also be the result of rapid dewatering of the canal. **A typically specified acceptable drawdown rate for concrete-lined canals with 1.5:1 side slopes is no more than 0.5 ft in a 1-hour period, and not more than 1 ft in a 24-hr period.** (Canal Systems Automation Manual, pg. 48). Higher rates can be used in many cases, but should be considered with caution. In the lower part of the system there are some signs of canal lining damage caused by vehicle and farm implement traffic too close to the canals.

We proceeded downstream and stopped briefly at the bridge where Callison Rd. crosses the canal. This is a potential site for installation of a new flume. High water marks show the normal operating depth to be a few inches lower in this reach. Next, we traveled another short distance downstream to the country club siphon. The entrance to the siphon is equipped with an inclined trash rack. This site has required a lot of cleaning this year and the district is interested in automating weed removal with a motorized traveling screen device. Reclamation's Water Conveyance Group (Dave Edwards, Group Manager, phone 303-445-2750) can provide recommendations of appropriate devices and vendors.

The Parshall flume located 6 miles downstream from the head of the canal provides the first flow measurement in the canal. This is a 10-ft Parshall flume in good condition with a drop on the downstream side. A quick check of dimensions and the placement of stilling well inlet and staff gage showed the flume to have standard dimensions. There is every reason to believe that accurate measurements are being obtained with this flume. The district has equipped this site with an ultrasonic level sensor that will eventually be integrated into the SCADA system so that flows can be monitored from the district office. The sensor is positioned about 6 inches further upstream than the staff gage and stilling well inlet, but this is a minor issue. For best accuracy, the sensor should be located at the same cross section as the stilling well inlet. In a Parshall flume the water level is sensed in the converging section, so locating the level sensor upstream or downstream of the standard position produces a <u>slight</u> bias in the water level reading due to changing drawdown as the flow accelerates in the converging transition. In this case the error would be such that the automated measurement would be higher than the true flow, but the discrepancy is probably no more than 1% to 2% of the total flow.

Figure 3. — Parshall flume at mile 6 of the main canal.

Figure 4. — Ultrasonic level sensor in Parshall flume entrance. The sensor should be aligned with the stilling well inlet holes. In the current position, it appears to be about 6 inches upstream from the inlet holes.

After leaving the flume site, we visited several of the check structures that have been automated in recent years. Most are reported to be working well. They are equipped with upstream and downstream water level sensors and gate position sensors. Flow through the gates is estimated using an orifice equation. Flow over the side weirs could be estimated with a weir equation, but it is uncertain whether this computation is being made at the present time. Figure 5 shows a typical automated check. One common issue with these installations is turbulence downstream from the gate, which affects the ability to make an accurate downstream water level measurement. This is compounded by the fact that ultrasonic level sensors are used, which are

sensitive to disturbance of the water surface. A water level measurement well downstream from the gate would be preferable, but this arrangement has been satisfactory for most of the sites. The district is able to use the instrumentation at the automated checks to estimate flow rates and monitor flow changes as they occur.

One site that has been especially problematic is check #16, which we were unable to visit on this trip due to the muddy roads. Figure 6 shows a photo from a previous site visit by Brenton Johnson. The downstream side of the check is immediately upstream from a siphon entrance. The short distance and low tailwater produced by the siphon entrance leads to especially high turbulence and makes it difficult to obtain a good downstream water level reading. This site could probably be improved by moving the water level sensor to the downstream end of the siphon, and being sure to locate it far enough from the siphon exit to avoid any highly turbulent flow issuing from the siphon. Some adjustment of the flow rate estimation equations would be needed to account for the losses incurred through the siphon, but the end result would probably be a more stable and reliable output from the instrumentation. This approach will not work if the flow entering the siphon passes through critical depth, but this is not believed to be the case.

In the afternoon we visited several turnouts from the main canal into laterals and from laterals into individual farms. In general, flows into the laterals are measured with constant-head orifice (CHO) turnouts, while the farm turnouts utilize simple slide gates followed by a Sparling propeller meter.

Figure 5. — Typical automated check structure.

Figure 6. — Downstream side of check #16.

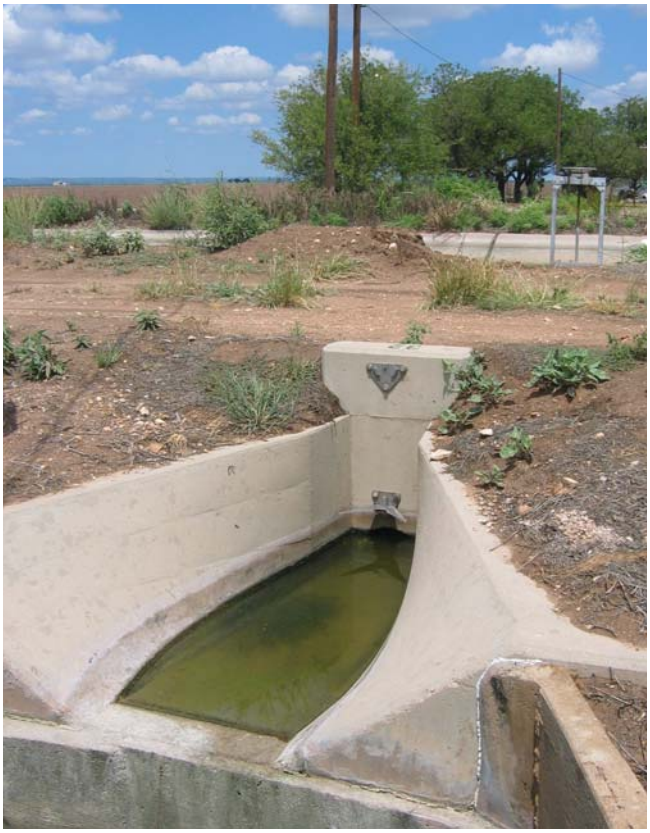

Figure 7. — Mounting bracket for a Sparling meter at a typical turnout.

The district seems comfortable operating either type of turnout. Originally, the project was equipped with a dedicated Sparling meter at each turnout, but the expense of maintaining so many meters was excessive. Today the district's two ditchriders each use one meter with a backup kept available. Newly reconditioned meters with stiffer bearings are reportedly unable to

measure flows less than 1 ft^3/s. Yantis Green reported many customer service difficulties dealing with the Sparling Instruments company, including meters that were delayed excessively and then shipped back to the district still in non-working condition. The district should consider utilizing a third-party provider for maintenance and recalibration of meters. Two of many possibilities are:

- Mid America Meter, Inc., http://www.midamericameter.com/
- Colorado Engineering Experiment Station Incorporated, http://www.ceesi.com/

Mid America Meter also advertises that they repurchase old meters and parts, which could be a valuable source of revenue for the district, given the large supply of meters they have mothballed.

In the downstream end of the system we visited the tail-end capture pond where excess flows are collected and then pumped back upstream for redelivery in the lower part of the system. While at the site, an audible alarm was going off, indicating that the water level in the pond had exceeded a threshold at which pumping should occur. This alarm was intended to be relayed to the district office and shown on the SCADA system, but this function was never fully implemented. Integrating this alarm into the SCADA system should be made a high priority. Another potential SCADA system improvement would the addition of water level trendline displays, which may help the district to better monitor and appreciate canal water level fluctuations over time.

The last lateral in the system (15.9N 6.5E) is reported to be a difficult portion of the system to manage. This is a typical issue with canals operated to maintain upstream water levels because flow mismatches (plus or minus) are passed downstream and accumulate at the tail end. We discussed several things that could improve this situation. First, an automated turnout system at the head of this lateral could stabilize flow rates into the lateral even when canal flows vary, although there would be limits to how much variation could be accommodated. The Hydraulics Laboratory in Denver has developed an "Automated Farm Turnout" device that provides this functionality. It combines a flow measurement device (typically a flume) in the lateral with a motorized turnout gate automated to regulate the flow through the flume. Second, the addition of an accurate flow measurement device at about the mid-point of the main canal could make it easier to accurately manage the lower half of the system. The reach below check #18, which we visited on Wednesday morning, is a potential site for such a flume installation. This would be a good location partly because it is an administrative boundary between the areas covered by the two ditchriders.

On Wednesday morning we visited check #18. A ramp flume could be constructed below the check to provide accurate flow measurement, or this check could be automated in a manner similar to the other automated checks, but this would provide less accurate flow measurement. One issue to consider related to the design of a ramp flume for this site is the operating water level in the canal downstream from check #18. At the next check downstream the canal is presently kept checked up, which creates a high tailwater that might submerge a flume. If a flume is desired, it may be necessary to lower the operating level at the next check. This could require that turnout gates in the vicinity of that check be opened farther than they presently are. These issues should be considered if the design of a flume is pursued.

General Observations

During our visit we discussed a number of operational issues and future plans the district is considering. One issue the district is facing is the need for alternative measurement devices for turnouts at which low flows are delivered to subsurface drip irrigation systems. Such systems are becoming widespread in the district and the previously mentioned problem with reconditioned Sparling meters is making it difficult to measure low flows. Turnout #2 was an example of this, where a Sparling meter is permanently installed to totalize flow, but the flow rate is so low that the meter is not working. Shifting to different metering technology, such as positive displacement municipal-type flow meters, may be a solution to this problem.

Yantis Green and Lyn Hatley both reported that the system is much easier to manage when operating solely from the municipal effluent supply. The stability of the effluent supply and the releases from Lake Nasworthy are probably similar, but the ability to accurately measure the releases from the lake is suspect due to the discrepancy between the Parshall flume measurements and the rating table for the head gate at the lake. We were unable to determine the source of the discrepancy during this visit. Additional investigation of this issue is needed, and the addition of an accurate flow measurement device near the mid-point of the main canal should be considered.

The district is considering improvements to laterals within the system, either lining to reduce seepage, or conversion to closed pipe. Putting laterals into pipe could make their operation more flexible, but might make it more difficult to manage the main canal, since the laterals would no longer have the ability to absorb volume changes. Ongoing efforts to repair damaged canal lining should be continued.

The district has been asked on occasion about the possibility of conveying non-Project water in the system to support water transfers and other management alternatives. We informed Yantis Green that such modifications of use may require reauthorization of the project. The OTAO will investigate this further.

Conclusions

The district has successfully made numerous improvements in recent years and weathered a time of transition for management and operations personnel. An unresolved question about the accuracy of flow measurement at the head of the district's main canal seems to be the biggest issue facing the district at this time. There are some opportunities for additional flow measurement and check structure automation improvements. Obtaining an accurate measurement near the middle of the system should be a high priority. On the whole, the district infrastructure is in good condition, although there are some isolated areas of damaged canal lining that the district is working to correct.

The establishment of a water master for the Concho River basin will make it increasingly important to eliminate tailwater spills out of the system when operating from the effluent water

supply. Reducing the volume of water that reaches the tail-end pond will also reduce pumping costs for the district, which are significant. The district did well this year operating with lake water for the first time in several years and with new staff. Lyn Hatley has quickly gotten a good feeling for operation of the system, and might now benefit from some structured training experience. The district should consider having their staff attend the Modern Methods in Canal Operation and Control class that will be held in Reclamation's hydraulics laboratory in Denver during January 22-26, 2007.

Recommendations

- Head of main canal – explore discrepancy between Lake Nasworthy releases and Parshall flume measurements of flow rate.
- Head of main canal – explore options for adding a flow measurement structure or instrument near the head of the main canal.
- Lake Nasworthy outlet into main canal – explore possibility of installing and using a reservoir water level sensor downstream from the intake structure fish screen panels.
- Integrate the water level sensor and alarm for the tail-end water reuse pond into the SCADA system.
- To avoid canal lining damage, limit canal drawdown rates. Ideally, drawdown should be no more than 0.5 ft in a 1-hour period, and not more than 1 ft in a 24-hr period, although such a slow rate may be impractical.
- The acoustic water level sensor at the Parshall flume should be located at the same cross section as the stilling well inlet.
- Consider utilizing a third-party provider for maintenance and recalibration of Sparling flow meters. Two possibilities are:
    - Mid America Meter, Inc., http://www.midamericameter.com/
    - Colorado Engineering Experiment Station Incorporated, http://www.ceesi.com/
- Check 16 – relocate water level sensor downstream from siphon exit.
- Check 18 – pursue construction of a ramp flume downstream from this check structure.
- Consider the addition of an Automated Farm Turnout at the last lateral in the system (15.9N 6.5E), or provide flow measurement at Check 18 as mentioned in the previous bullet; either improvement could help stabilize flows in the 15.9N 6.5E lateral.
- Investigate the use of positive displacement flow meters to measure deliveries to drip irrigated fields. If the drip systems themselves have an integral flow meter, the district should explore the possibility of tying such flow meters into their system.