

# Water Efficiency and Verification Program

## Irrigation Meter Audits and Data Integrity

by

Steve Shumate  
C.E. Williams

Wade Oliver, P.G.  
Mitchell Tufford

**Panhandle Groundwater Conservation District**  
PO Box 637  
White Deer, TX 79097



2011 JUN 20 AM 6:09

10.24.2011 10:07:10 AM

# **Water Efficiency and Verification Program**

## **Irrigation Meter Audits and Data Integrity**

**by**

Steve Shumate  
C.E. Williams

Wade Oliver, P.G.  
Mitchell Tufford

**Panhandle Groundwater Conservation District**  
PO Box 637  
White Deer, TX 79097



*This page intentionally left blank.*

# **Water Efficiency and Verification Program**

## **Irrigation Meter Audits and Data Integrity**

**by**

Steve Shumate  
C.E. Williams  
Panhandle Groundwater Conservation District

Wade Oliver, P.G.  
Mitchell Tufford  
INTERA Incorporated



June 2017

This project was funded in part by a grant from the Texas Water Development Board, contract #1003581101.

## Table of Contents

Water Efficiency and Verification Program .....	- 1 -
Irrigation Meter Audits and Data Integrity .....	- 1 -
1 Executive Summary .....	2
1.1 Task 1 – Purchase Equipment / Evaluate Meter Data.....	2
1.2 Task 2 - Development of Meter Data Collection Protocols.....	3
1.3 Task 3 - Develop Functionality.....	3
1.4 Task 4 - Develop Application.....	3
1.5 Conclusions and recommendations.....	3
Appendix A.....	5
Evaluation of Meter Reading Data .....	5
Appendix B .....	28
Meter Data Collection Protocols.....	28
Appendix C.....	34
Functional Requirements for Meter Data Collection Application.....	34
Appendix D.....	40
Meter Data Collection Application User Guide.....	40
Appendix E.....	60
Example Water Use Report.....	60

## List of Figures

Figure A-1. Average Daily Water Use for example meter.....	11
Figure A-2. Evaluation of Readings for example, monthly trends.....	12
Figure A-3. Evaluation of Readings for example meter, system-wide monthly trends.....	13
Figure A-4. Identified roll-overs for example meter.....	15
Figure A-5. Historic Meter Readings for example meter.....	16
Figure C-1. Application Flowchart.....	41

## List of Tables

Table 1. List of Unique Meter ID.....	16
Table 2. List of Meters and Their Water Use Category.....	21

# **Water Efficiency and Verification Program**

## **Irrigation Meter Audits and Data Integrity**

### **Texas Water Development Board Contract No. 1003581101 – Final Report**

#### **1 Executive Summary**

The purpose of the Water Efficiency and Verification Program was to increase the level of staff resources dedicated to systematic verification, calibration, and re-calibration the accuracy of flow meters currently installed throughout Panhandle Groundwater Conservation District (District). The effort to acquire better quality information from the meters will continue after this contract is fulfilled.

During one quarter of the verification part of the contract, statistics were calculated with the following results: data samples indicate there are deviations ranging from -47% to +50%. The average deviation was 6.8% with the median being 6.7%. There were 37 verifications within -5% and +5%. It was decided the adoption of an application enforcing data checking and consistency would help the integrity and usefulness of the data.

As technology evolved the opportunity arose of attaining better quality meter data. The contract was changed in scope by way of amendments and as a result this report is a mixture of methods for the same objective. INTERA, a geoscience and engineering firm was subcontracted for the latter segments of this contract. Deliverables are included in the appendix. The project was broken down into the following tasks:

##### **1.1 Task 1 – Purchase Equipment / Evaluate Meter Data**

The District purchased three new state of the art Fuji Sonic Flow Meter kits upon approval of the contract with the Texas Water Development Board (TWDB). Field personnel attended a training session conducted by the technical representative from Great Plains Meters.

During the course of data collection a problem with meter registers rolling over was recognized. High production wells with small capacity meter registers make it difficult to determine when or if the register has rolled-over. To greatly increase the detection of roll-overs the District purchased 100 high capacity registers to replace existing registers. There will be greater confidence in the accuracy of volumetric estimates in the long term. With this confidence,

the replacement registers will allow additional methods of meter verification to be explored such as with sprinkler nozzle packages and telemetry data.

In addition to purchasing equipment, the District tasked its subcontractor with evaluating meter data previously collected by the district to identify any recurring data quality issues. This is documented in the technical memorandum included as Appendix A.

## **1.2 Task 2 - Development of Meter Data Collection Protocols**

Based on the meter data evaluation performed in Task 1, protocols were developed to improve the reliability and usability of the collected data. A migration from a Microsoft Access database to a Microsoft SQL Server database was completed by District staff. This will help protect the integrity of the data and will provide a long term path of growth for the District. The meter data collection protocols are included as Appendix B.

## **1.3 Task 3 - Develop Functionality**

The District through its Subcontractor INTERA developed functional requirements for an application for improving the process of collecting meter data. These functional requirements build on the issues and processes identified in tasks 1 and 2 and guided the development of the application in Task 4 below. These functional requirements are included as Appendix C.

## **1.4 Task 4 - Develop Application**

Task 4 involved the development of the application for improving meter data collection and interpretation processes described in Task 3. This work has been completed. Data collection will continue beyond the expiration date of this contract. Concerning this contract, District efforts focused on providing the subcontractor with oversight and any necessary data to complete this remaining task. Future verification efforts will be provided upon request and the general manager's direction. Documentation of the application developed as part of this task is included in Appendix D.

## **1.5 Conclusions and recommendations**

The initial phase of this contract was for meter verification and calculations are available upon request. The remainder of the contract involved working with the subcontractor who developed a web-based application for improving the quality and reliability of collected meter readings. The application has proven to be valuable. It is easy to use and helps avoid mistakes while also providing near real-time data recording for review by District office staff. In the course of using the application the technician takes a picture of the meter register. District staff can then verify the reading by using the picture. The picture also includes the date and GPS coordinates embedded within.



The application has a framework that is conducive toward expansion to other types of field data. The District has done this by requesting a well level function of the application. Though not part of this contract it is expected to be used by the next round of winter well level measurements.

# Appendix A

## **Evaluation of Meter Reading Data**

## **DRAFT MEMORANDUM**

**To:** C.E. Williams, General Manager, Panhandle GCD

**From:** Wade Oliver, PG, INTERA Inc.  
Gloria Teague, EIT, INTERA Inc.  
Meng Jia, INTERA Inc.

**Date:** May 21, 2015

**Re:** Contract 1003581101 – Evaluate Current Meter Data

---

## **INTRODUCTION**

The Panhandle Groundwater Conservation District (District) started its metering program in 1999 and since then the program has expanded to include meters on new wells with column pipe of 4 inch diameter or more. Over time, the District has encountered issues that may compromise the quality and usefulness of the data collected. In order to address these issues, INTERA has evaluated the existing data to identify and characterize recurring data-quality issues to develop quality control protocols for collecting metered data in the future. These protocols will help ensure all necessary data is transcribed correctly and completely and that the meter reading is reasonable compared to previous readings. These efforts were undertaken to determine key issues that can be addressed if the District decides to develop a mobile application for collecting meter data.

## **METHODOLOGY**

### **Step 1 - Data Review & Compilation**

The District provided meter data which included all recorded meter readings (20,392 entries) and each meter's water use category (e.g. industrial, irrigation). The meter readings were evaluated to remove all where the reading field was left blank (i.e. no reading was recorded) or the reading was entered as being negative. There were 2,550 meter reading entries where the reading field was left blank and two meter reading entries where the reading was entered as negative. This step resulted in 17,840 usable meter readings, indicating that 13% of the meter reading entries were not transcribed or were transcribed incorrectly.

## **Step 2 – Creation of Unique Meter List**

The usable meter readings each have an ID called “meter\_no.” These IDs are intended to be unique, however occasionally these IDs were transcribed incorrectly creating multiple IDs for one well. For example, the well with the meter\_no “SEAmet-1” also has data under the meter\_no “SEAMET-1” and “Seamet-1”. To eliminate these errors a new field was created “meter\_no\_ID” which assigned a new ID to those wells identified as having multiple “meter\_no” IDs. For example, “SEAmet-1”, “SEAMETt-1”, and “Seamet-1” were all assigned the “meter\_no\_ID” or “SEAmet-1”. For those wells where there were no duplicate “meter\_no” the original “meter\_no” was assigned to the “meter\_no\_ID”. This step resulting 978 unique meter IDs. This unique meter ID list may still contain duplicate meters, however these can be identified in the future through their geographic locations or other techniques.

## **Step 3 – Identify Meters for Analysis**

The usable meter readings were evaluated for the 978 unique meter IDs to identify and remove those meters with only one reading as these meters do not have historical readings they cannot be analyzed for trends. This step reduced the list of meters to be analyzed to 747, indicating that 231 meters had only one reading. This may be due to transcription errors or abandoned or newly installed meters. Transcription errors could have occurred during the recording of meter data. Currently, meter readings are recorded by hand in the field and then entered in the District database in the office. **Table 1** lists all 978 meters.

## **Step 4 – Assign Water Use to Meters**

In order to determine trends in water use and identify readings which fall outside the range of what is expected, each meter was evaluated according to its water use category. As irrigation water use is limited to the growing season and industrial water use may occur throughout the year, this distinction creates a more realistic range of expected values for meters in each category.

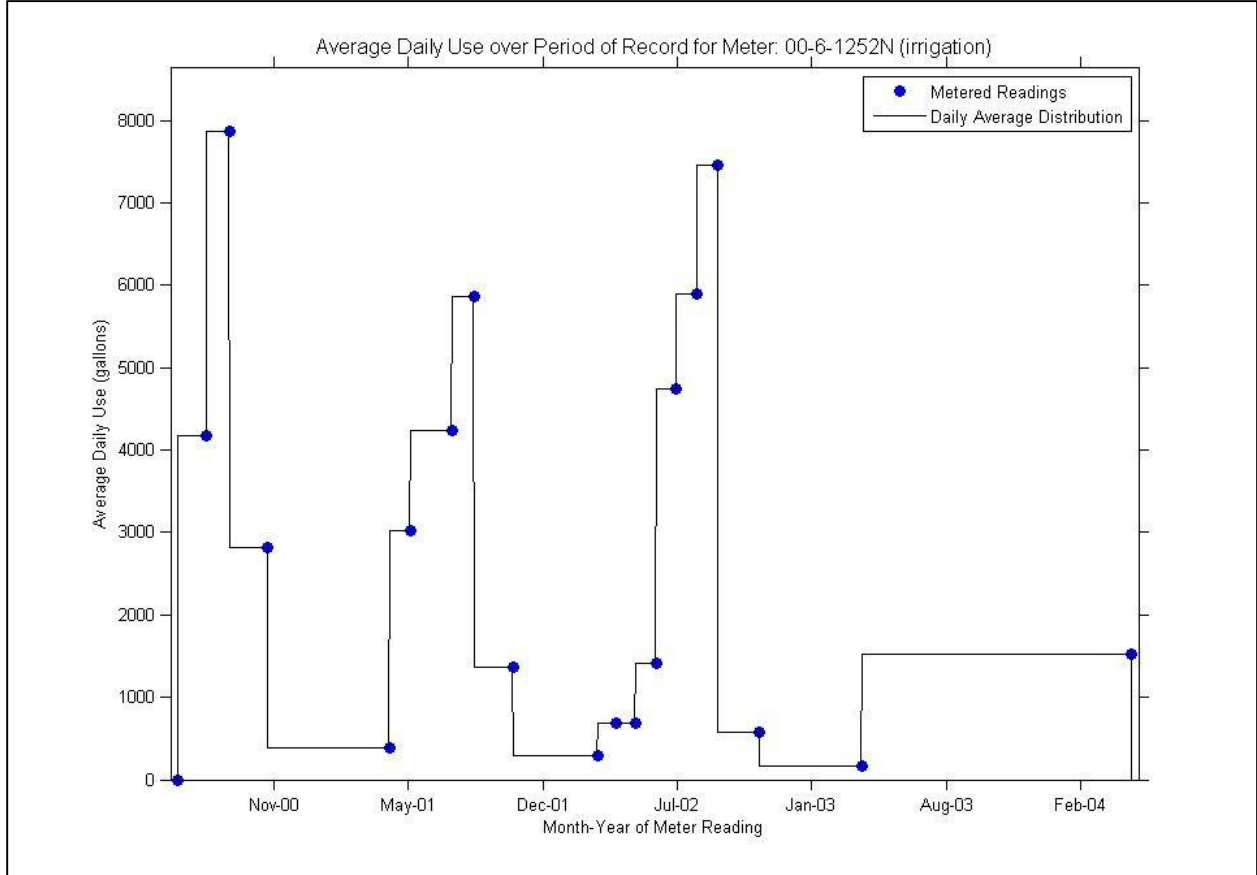
The district provided a well inventory which linked the water use category for the well to a District “ID” which links to the “meter\_no” and therefore “meter\_no\_ID”. Using these connections the 747 meters were evaluated to see if the water use category had been defined. Of these, 565 had defined water use categories. The most common water use category was stock (45%), followed by irrigation (17%). The remaining 182 meters were assumed to have a water use category of irrigation for our analysis as this is the most likely water use based on communication with the District. **Table 2** lists all 747 meters and their water use.

## **Step 5 – Analysis of Trends**

### **Calculation of Average Daily Use**

The average daily use for each of the 747 meters was calculated for the time period in which the meter was active. The average daily use was calculated by dividing the meter reading by the number of days since the last meter reading, assuming uniform water use between readings.

**Figure 1** illustrates the average daily use for a meter. In the figure the line shows the average daily water use between meter readings and the blue dots reflect the dates of the meter readings.

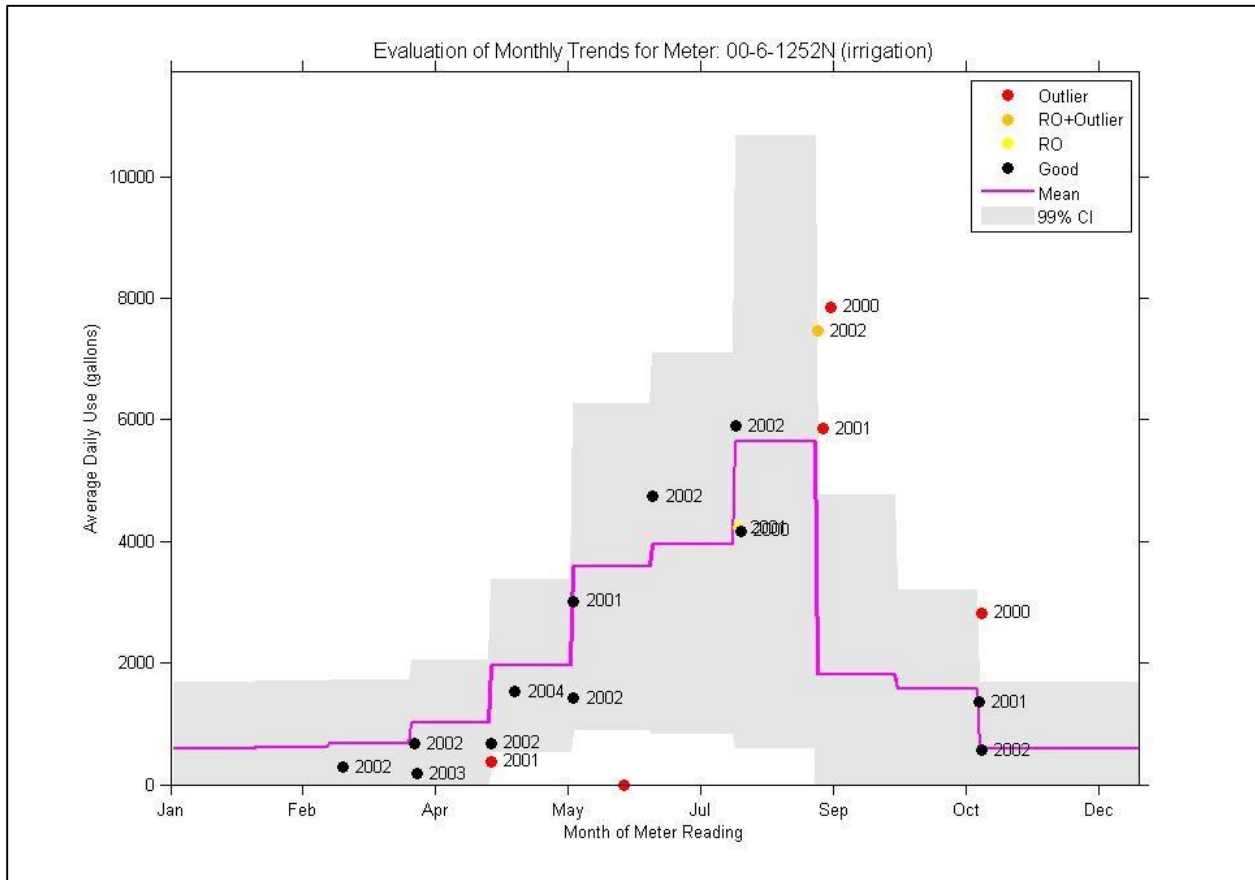


**Figure 1. Average Daily Water Use for meter\_no\_ID: 00-6-1252N**

**Evaluation of Meter Trends**

Each meter’s readings were evaluated to identify those readings taken after the meter rolled over and readings not reflective of the meter’s typical water use. Rollovers were identified as those readings lower than previous readings. This determination does not account for potential transcription errors.

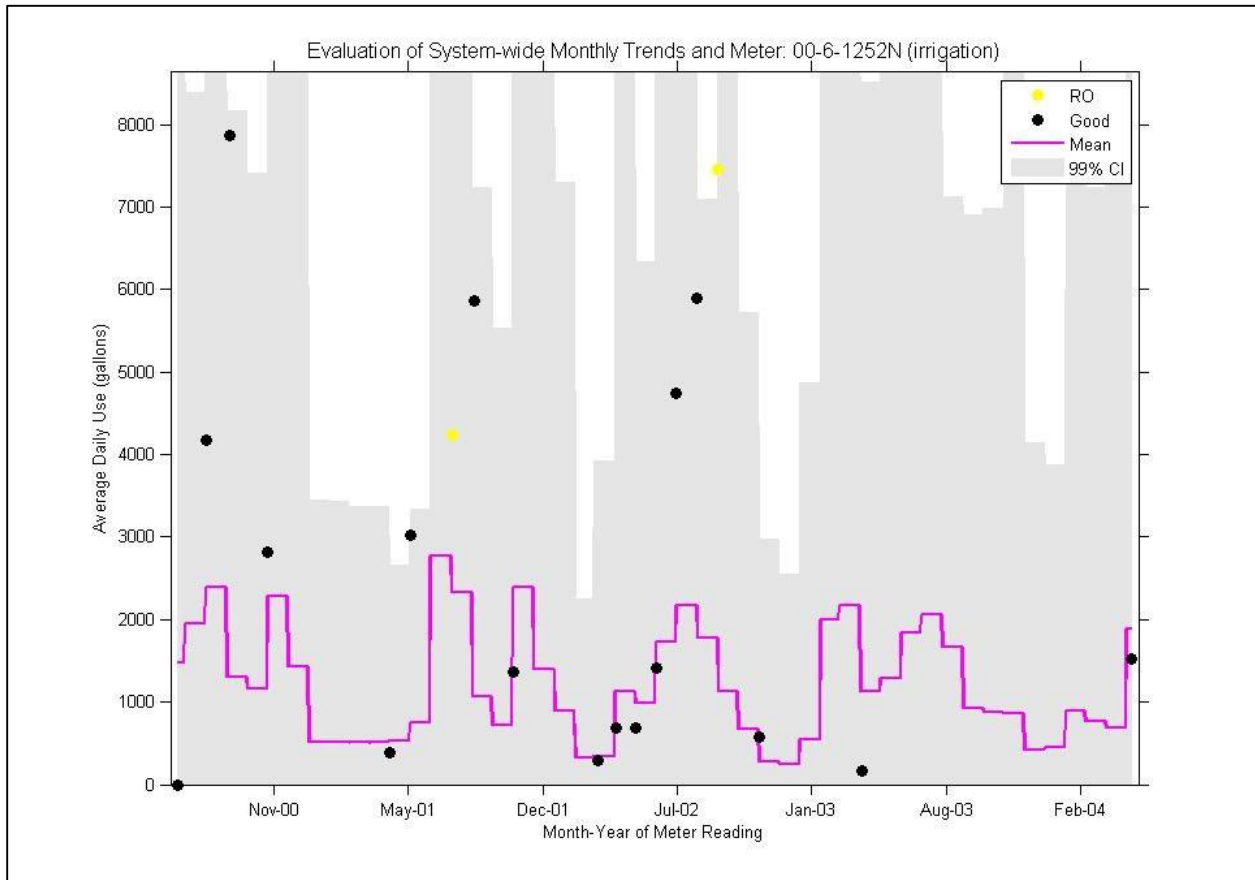
To identify readings falling outside of the meter’s expected water usage, a statistical analysis was performed to determine the 99% Confidence Interval (CI) for each month. Readings falling outside of the CI were identified as outliers. **Figure 2** illustrates this monthly analysis for a meter, showing the seasonal average (magenta line), the 99% CI (gray shading) and the month and day of each meter reading (colored dots). The year of the meter reading is annotated next to each dot.



**Figure 2. Evaluation of readings for meter\_no\_ID: 00-6-1252N as compared to the meter’s monthly trends**

**Evaluation of System-wide Trends**

All meter readings were evaluated to determine the 99% CI based on month, year, and water use. This system-wide analysis served to identify those readings which exceed the system-wide CI. This analysis takes into account water use distribution which varies by water use category as well as accounting for climatic effects such as months/years of above average precipitation and thus decreased water usage. Readings falling outside of the CI were identified as outliers and those readings taken after the meter rolled over were identified as rollovers. **Figure 3** illustrates this system-wide evaluation for a meter, showing the monthly average (magenta line), the 99% CI (gray shading) and the date of each meter readings (colored dots). However, due to the range of water uses for each water use type depending on the industry, irrigated acreage, crop, etc., this method of identifying outliers cannot confidently predict errors.



**Figure 3. Evaluation of readings for meter\_no\_ID: 00-6-1252N as compared to system-wide monthly trends**

## CONCLUSION

We characterized the District’s metered readings to identify quality-control issues, particularly those that could be addressed in the development of the mobile application. The following are the quality control issues identified and the protocol that could be used to resolve them:

**Issue #1: Transcription errors in meter ID**

**Example #1:** Meter\_no “Spearman Jr 1” and “Spearman Jr, 1” represent the same meter however one has a comma in the spelling causing them to be identified as different meters

**Proposed Resolution #1:** The application will have a drop-down list with all known meter IDs. For new meters the District will update the master list of meter IDs in their database so that the new meter will be in the mobile app’s list when staff goes into the field to make a reading.

**Issue #2: Missing GPS leading to potential for duplicate meter IDs**

**Example #2:** Several meters including meter\_no\_ID “00-6-1477N”, “04-8-2117”, and “06-83531V” have insufficient GPS information (i.e. lat/long with only 2 decimal places) to verify that these are unique meters

**Proposed Resolution #2:** The District will update GPS information when visiting meters to provide a more complete list of georeferenced meter IDs in the database.

**Issue #3:** Meter ID not reflective of user’s GPS position

**Example #3:** N/A – this is a QC measure to prevent errors

**Proposed Resolution #3:** If the meter ID selected is not in the approximate location of the user they will be prompted to confirm the meter ID and if it remains selected the reading will be flagged to indicate that the location of the data entry did not match that of the meter. This can then be followed-up by District staff.

**Issue #4:** Transcription errors in meter reading

**Example #4:** The meter\_no\_ID “99-8-1475N” has a reading of “-45” entered on May 4, 1999.

**Proposed Resolution #4:** User will be prompted to verify meter reading entry if field is left blank, entry is negative, or entry differs significantly from the expected value based on previous measurements.

**Issue #5:** Missing water use category

**Example #5:** Several meters including meter\_no\_ID “00-6-1252N” and “00-8-1847N” do not have an assigned water use category in the District’s database.

**Proposed Resolution #5:** The District will update their database to reflect the current water use category for all meters. If a well’s water use changes the water use category will be updated in the database accordingly.

**Issue #6:** Outliers

**Example #6:** Figure 2 indicates that the September 2000 meter reading is an outlier for this meter, lying outside of the 99% CI for this meter’s historic water use for September. **Proposed Resolution #6:** User will be prompted if the meter reading is an outlier for that particular meter or a system-wide outlier. The user will be asked whether the meter reading value entered is correctly. If it is confirmed as correct by the user, the average daily water use based on the current reading will be displayed and the user will be asked whether the water use is expected over this period for this water use and meter (e.g. is the water use reflective of irrigation practices or current climatic influences). If the reading is confirmed then it is flagged as an outlier for follow-up by the District and to aid later analyses of meter data.



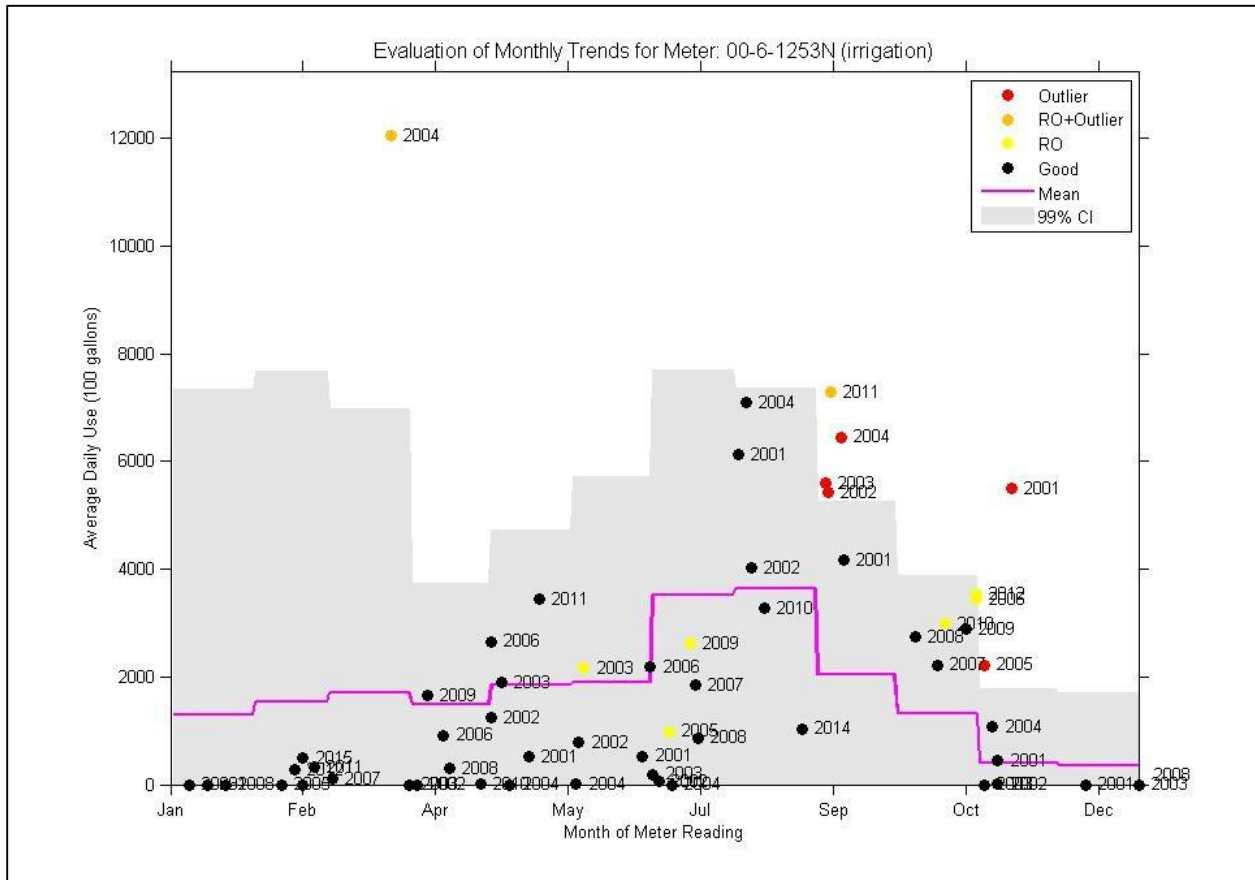
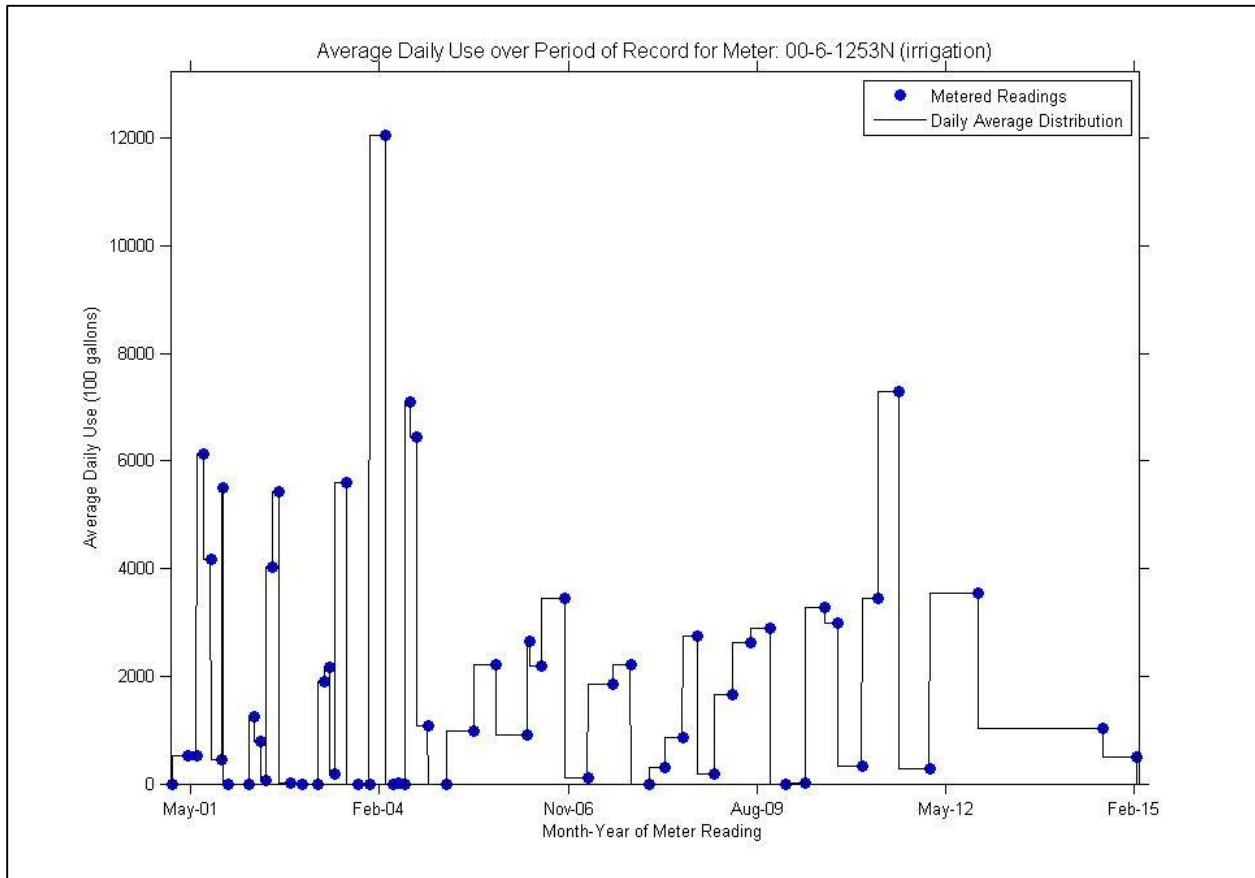


Figure 4. Identified rollovers for meter\_no\_ID "00-6-1253N"

**Issue #7:** Identification of rollovers

**Example #7:** Several rollovers were identified for meter\_no\_ID "00-6-1253N" using the assumption that a meter reading lower than the previous reading indicates a rollover (see **Figure 4**).

**Proposed Resolution #7:** If the current meter reading is lower than the previous and a rollover is identified, the user will be shown the previous meter reading and be prompted to confirm the meter reading as a rollover, eliminating the uncertainty of whether the meter has rolled over or if there has been a transcription error.



**Figure 5. Historic meter readings for meter\_no\_ID "00-6-1253N"**

**Issue #8:** Insufficient frequency of meter readings

**Example #8:** **Figure 5** illustrates the date of historical meter readings for meter\_no\_ID “00-61253N”. There was a 22-month gap between meter readings from October 2012 to August 2014. During this time there could have been one or more rollovers indicating higher water consumption. Insufficient frequency of meter readings could lead to systematic underreporting of water use.

**Proposed Resolution #8:** Identify necessary meter reading frequency for each well based on the yield of the well or its estimated water use rates from previous readings. This will protect against underestimation of water use in cases of multiple rollovers. If meter readings are taken less frequently than this cutoff, then the water use over the preceding period will be flagged for follow-up by District staff to confirm/deny that a rollover occurred.

## TABLE 1: LIST OF UNIQUE METER ID

All 978 meters are listed below, highlighted are those 747 meters which had sufficient readings to be further analyzed.

Table key:

Sufficient readings	Meter number with green highlighted background
---------------------	--

meter_no_ID					
00-6-1252N	04-8-2894	07-8-2818	09-8-1694	99-8-1572N	GP10-1102
00-6-1253N	04-8-3066	07-8-2819	09-8-1695	99-8-1576N	GP10-1103
00-6-1254N	04-8-3067	07-8-2820	09-8-1696	99-8-1759N	GP10-1104
00-6-1255N	04-8-3068	07-8-2821	09-8-1697	99-8-1765N	GP10-1105
00-6-1256N	04-8-3467	07-8-2822	09-8-1698	99-8-1776N	GP10-1106
00-6-1257N	04-8-3589	07-8-2823	09-8-1699	99-8-1792N	GP10-1107
00-6-1291N	04-8-3590	07-8-2825	09-8-1700	99-8-1793N	GP10-1248
00-6-1477N	04-8-3591	07-8-2826	09-8-1701	99-8-1794N	GP10-1986
00-6-2157N	04-8-3592	07-8-2827	09-8-1830	99-8-1795N	GP10-3375
00-8-1252N	04-8-3593	07-8-2829	09-8-3727	99-8-1796N	Gp10-3375
00-8-1522N	04-8-3594	07-8-2830	09-9-1085	99-8-1797N	GP10-3376
00-8-1657N	04-8-3596	07-8-2831	13-13347	99-8-1798N	GP10-3377
00-8-1753N	04-8-3597	07-8-2832	13-13348	99-8-1799N	GP10-3377-6
00-8-1847N	04-8-3597N	07-8-2834	13-13351	99-8-1800N	GP10-3378
00-8-1849N	04-8-3598	07-8-3832	14-03534	99-8-1801N	GP10-3379
00-8-1900	04-8-3599	07-8-4232	14-09558	99-8-1833	GP10-3380
00-8-1957N	04-8-3600	08-01655	14-09559	99-8-1882N	GP10-3381
00-8-1958N	04-8-3601	08-05127-06	14-09571	99-8-1883N	GP10-3382
00-8-2574N	04-8-3602	08-06-1255N	14-09574	99-8-1884N	GP10-3383
00-8-2576N	04-8-3603	08-09099-06	14-09586	99-8-1885N	GP10-3384
00-8-2586N	04-8-3604	08-10-1170	14-17043V	99-8-1886N	GP10-3385
00-8-2587N	04-8-3606	08-10-1170V	14-17070	99-8-1887N	GP10-3386
00-8-2588N	04-8-3607	08-10-1171	14-17085	99-8-1888N	GP10-3389
00-8-2590N	04-8-3607N	08-10-1171V	14-17086	99-8-1888n	GP10-3391V
00-8-3574N	04-8-3608	08-10-1481V	14-17087	99-8-1889N	GP10-3392V
01-05-1016N	04-8-3609	08-10-1555V	14-17088	99-8-1890N	GP10-3395
01-05-1018N	04-8-3610	08-10-1556V	6-10-1026	99-8-1891N	GP10-3396
01-05-1405N	04-8-3612	08-10-1557V	638922	99-8-1892N	GP10-3397
01-06-1401N	04-8-3613	08-10-1576	649-6-M1	99-8-1893N	GP10-3398
01-06-1403N	04-8-3614	08-10-1577	66-6-053	99-8-1894N	GP10-3399
01-06-1404N	04-8-3615	08-10-1578	66-6-05S	99-8-1895N	GP11-1562
01-06-1405N	04-8-3616	08-10-1579	6916878	99-8-1896N	GP11-1889
01-06-1406N	04-8-3617	08-10-1580	77-8-2032N	99-8-1897N	GP11-2209V

01-06-1450N	04-8-3618	08-10-1581V	78-8-1240N	99-8-1898N	GP11-2210V
01-06-1451N	04-8-3694	08-10-1582	78-8-867	99-8-1899N	GP11-2211V
01-06-1452N	04-8-601	08-4-1118	79-8-835	99-8-1900N	GP11-2213
01-06-1459N	05-06-1834	08-4-1119	80-8-178	99-8-1901N	GP11-2214

01-06-1476N	05-08-2960	08-4-4106V	80-8-181	99-8-1902N	GP11-2215
01-06-1477N	05-10-1309	08-4-4110	8-8-4119	99-8-1903N	GP11-2216
01-06-1478N	05-10-1310	08-6-1300	92-4-473	99-8-1904N	GP11-2217
01-06-1479N	05-10-1524	08-6-1306	94-8-1801N	99-8-1905N	GP11-2218
01-06-1480N	05-10-1524V	08-6-1307	9-6-1251N	99-8-2005N	GP11-2530
01-06-1482	0512911	08-6-1308	9-6-1619N	99-8-2010N	GP11-3811
01-06-1482N	05-4-1081	08-6-1309	97-8-2655N	99-8-2015N	GP11-3811-4
01-06-1483N	05-4-1106	08-6-1310	98-7-2655N	99-8-2016N	GP11-4641
01-06-1484N	05-5-1005	08-6-1311	98-8-109R	99-8-2017N	GP11-4642
01-06-1485N	05-6-1540	08-6-1312	98-8-110R	99-8-2018N	GP11-4643
01-06-1486N	05-6-1590	08-6-1313	98-8-1237N	99-8-2019N	GP11-4645
01-06-1489N	05-6-1707	08-6-1821	98-8-1240N	99-8-2020N	GP11-4647
01-08-1879N	05-6-1834	08-6-1822	98-8-1564N	99-8-2021N	GP11-4649
01-08-1891N	058	08-6-1823	98-8-1729N	99-8-2022N	GP11-4650
01-08-1892N	05-8-1297	08-6-1824	98-8-1759N	99-8-2023N	GP11-4651V
01-08-1896N	05-8-2262	08-6-1825	98-8-178	99-8-2024N	GP11-4653
01-08-1897N	05-8-2264	08-6-1826	98-8-2108N	99-8-2025N	GP11-4653V
01-08-1902N	05-8-2265	08-6-1827	98-8-4132	99-8-2026N	GP11-4654
01-08-1903N	05-8-2266	08-6-1897V	98-9159-8	99-8-2027N	GP11-4655
01-08-1904N	05-8-2266V	08-6-4118	98-9160-8	99-8-2028N	GP11-4656
01-08-1909N	05-8-2267	08-6-4119	98-9259-8	99-8-2029N	GP11-4656-8
01-08-2006N	05-8-2267V	08-8-1387	99-10-1019N	99-8-2030N	GP11-4657
01-08-2007N	05-8-2269	08-8-1408V	99-10-1193N	99-8-2031N	GP11-4657-8
01-08-2008N	05-8-2591	08-8-1697V	99-10-1194N	99-8-2032N	GP11-4658
01-08-2009N	05-8-2750	08-8-2061	99-10-1195N	99-8-2033N	GP11-4659
01-08-2010N	05-8-2862	08-8-2062	99-10-1196N	99-8-2034N	GP11-4660
01-08-2011N	05-8-2894	08-8-2063	99-10-1197N	99-8-2037N	GP11-4661
01-08-2093N	05-8-2942	08-8-2064	99-10-1238N	99-8-2070N	GP11-4663
01-08-2094N	05-8-2943	08-8-2065	99-10-1240N	99-8-2105N	GP11-4664
01-08-2095N	05-8-2944	08-8-2066	99-10-1241N	99-8-2106N	GP11-4665
01-08-2101N	05-8-2945	08-8-2067	99-10-1242N	99-8-2107N	GP11-5656
01-08-2102N	05-8-2946	08-8-2068	99-10-1243N	99-8-2108N	GP11-5656-4
01-08-2111N	05-8-2947	08-8-2069V	99-10-1244N	99-8-2109N	GP11-6750V
01-08-2147	05-8-2948	08-8-2070V	99-10-1245N	99-8-2110N	GP12-0817
01-08-2147N	05-8-2949	08-8-2071V	99-10-1246N	99-8-2111N	GP12-1847
01-08-2228N	05-8-2950	08-8-2072V	99-10-1294N	99-8-2112N	GP12-1849
01-08-2251N	05-8-2951	08-8-2073V	99-10-1295N	99-8-2113N	GP12-1850

01-08-2252	05-8-2952V	08-8-2074V	99-10-1296N	99-8-2115N	GP12-1852
01-08-2252N	05-8-2953V	08-8-2075V	99-10-1333N	99-8-2141N	GP12-1853
01-08-2253N	05-8-2953v	08-8-2076V	99-10-1334N	99-8-2375N	GP12-1854
01-08-2254N	05-8-2954V	08-8-2077V	99-10-1335N	99-8-2436N	GP12-1856
01-08-2255N	05-8-2955V	08-8-2078V	99-10-1336N	99-8-2487N	GP12-1857
01-08-2255n	05-8-2955v	08-8-2453	99-3-1387N	99-8-2559N	GP12-1858

01-08-2399N	05-8-2956V	08-8-2454V	99-6-1247N	99-8-2655N	GP12-1860
01-08-2400N	05-8-2957	08-8-4095	99-6-1251N	99-8-3700N	GP12-1862
01-08-2401N	05-8-2958	08-8-4095V	99-6-1252N	99-9-1462N	GP12-1863
01-08-2402N	05-8-2959	08-8-4096	99-6-1253M	99-9-1463N	GP12-1864
01-08-2403N	05-8-2960	08-8-4096V	99-6-1253N	99-9-1569N	GP12-1865
01-08-2415N	05-8-2961	08-8-4097V	99-6-1254	Babcock-1	GP12-1866
01-08-2416N	05-8-2962	08-8-4098V	99-6-1254N	Babcock-2	GP12-41
01-08-2417N	05-8-3098V	08-8-4099V	99-6-1255N	BOWERS-1	GP12-4228
01-08-2418N	05-8-3099	08-8-4100V	99-6-1341N	Crawford-1	GP12-4230
01-08-2419N	05-8-3100	08-8-4101V	99-6-1342N	DETTEN-1	GP12-4231
0108-2501N	05-8-3599	08-8-4102V	99-6-1343N	DETTEN-2	GP12-4232
01-08-2501N	06-10-1026	08-8-4103V	99-6-1344N	DETTEN-3	GP12-4233
01-08-2818	06-10-1117	08-8-4104V	99-6-1345N	Finsterwald-1	GP12-4234
01-08-2829	06-10-1118	08-8-4105	99-6-1346N	Gee-1	GP12-4235
01-10-1276N	06-10-1119	08-8-4105V	99-6-1347N	GP09-0985	GP12-4236
01-10-1277N	06-10-1120	08-8-4106V	99-6-1348N	GP09-1848	GP12-4237
01-6-1404N	06-4-1073	08-8-4107V	99-6-1386N	GP09-1849	GP12-4238
01-6-1459N	06-4-1098	08-8-4108V	99-6-1387N	GP09-1849-6	GP12-4239
01-6-1476N	06-4-1100	08-8-4109V	99-6-1432N	GP09-1850	GP12-4240
01-6-1477N	06-4-1102	08-8-4110	99-6-1443N	GP09-1852	GP12-4241
01-6-1478M	06-4-1103	08-8-4111	99-6-1444N	GP09-1853	GP12-4242
01-6-1481N	06-4-1104	08-8-4112	99-6-1482N	GP09-1854	GP12-4243
01-6-1909N	06-4-1105	08-8-4113	99-6-1560N	GP09-1855	GP12-4244
01-8-1754N	06-4-1110	08-8-4114	99-6-1561N	GP09-1856	GP12-4245
01-8-1892N	06-4-1112	08-8-4115	99-6-1566N	GP09-1857	GP12-4246
01-8-1896N	06-6-1307	08-8-4116	99-6-1568N	GP09-1860	GP12-4247
01-8-1902N	06-6-1344	08-8-4117	99-6-1585N	GP09-1861	GP12-4248
01-8-2006N	06-6-1345	08-8-4118	99-6-1619N	GP09-1862	GP12-4249
01-8-2008N	06-6-1346	08-8-4119	99-8-109R	GP09-1863	GP12-4250
01-8-2011N	06-6-1347	08-8-4120	99-8-110R	GP09-1864	GP12-4251
01-8-2094	06-6-1348	08-8-4121	99-8-1237N	GP09-1865	GP12-4252
01-8-2399N	06-6-1349	08-8-4122	99-8-1240N	GP09-1866	GP12-4322
01-8-2501	06-6-1350	08-8-4123	99-8-1342N	GP09-1867	GP12-5038
01-8-2587N	06-6-1351	08-8-4124	99-8-1387N	GP09-1868	GP13-0557

02-6-1403	06-6-1352	08-8-4125	99-8-1410N	GP09-1870	GP13-0558
02-6-1535	06-6-1353	08-8-4126	99-8-1437N	GP09-1871	GP13-0559
02-6-2535	06-6-1354	08-8-4127	99-8-1447N	GP09-1872	GP13-0560
02-8-1892N	06-6-1697	08-8-4128	99-8-1460N	GP09-1878	GP13-0561
02-8-2967	06-6-1789	08-8-4129	99-8-1461N	GP09-1879	GP13-0562
030-10-1142N	06-6-1790	08-8-4130	99-8-1462N	GP09-1966V	GP13-0563
03-06-1649N	06-6-1792	08-8-4131	99-8-1463N	GP09-1967V	GP13-0564
03-10-1141N	06-6-1793	08-8-4132	99-8-1464N	GP09-1968V	GP13-0566
03-10-1142N	06-6-1796	08-8-4133	99-8-1465N	GP09-1969V	GP13-0567
03-6-1606	06-6-1797	08-8-4134	99-8-1466N	GP09-1970V	GP13-0568
03-6-1649	06-6-1798	09-6-1083	99-8-1467N	GP09-1971V	GP13-0569
03-6-1650	06-8-1353	09-6-1084	99-8-1468N	GP09-1972V	GP13-0571
03-6-1795	06-8-1860	09-6-1085	99-8-1469N	GP09-1973V	GP13-0572
03-8-1516	06-8-1861	09-6-1086	99-8-1470N	GP09-1974V	GP13-0573
03-8-1520	06-8-1862	09-6-1087	99-8-1471N	GP09-1975V	GP13-0574-8
03-8-1753N	06-8-1863	09-6-1088	99-8-1472N	GP09-1976V	GP13-0576
03-8-1754N	06-8-1864	09-8-1370	99-8-1473N	GP09-1977V	GP13-0577
03-8-3568	06-8-1865V	09-8-1371	99-8-1474N	GP09-1978	GP13-0578
03-8-3612	06-8-1866	09-8-1372	99-8-1475N	GP09-1978V	GP13-0579
03-8-3726	06-8-2505	09-8-1373	99-8-1476N	GP09-1979	GP13-0580
03-8-3727	06-8-2505V	09-8-1374	99-8-1477N	GP09-1979V	GP13-0581
03-8-4122	06-8-2506V	09-8-1375	99-8-1478N	GP09-1980V	GP13-1522
04-08-3616	06-8-2507V	09-8-1376	99-8-1479N	GP09-1981	GP13-4248
04-6-1480	06-8-2508V	09-8-1377	99-8-1480N	GP09-1982	GP13-4275
04-6-1481	06-8-3031	09-8-1378	99-8-1481N	GP09-1983	GP13-4277
04-6-1599	06-8-3034	09-8-1379	99-8-1482N	GP09-1985	GP13-4278
04-6-1631	06-8-3521	09-8-1380	99-8-1483N	GP09-1986	GP13-4279
04-6-1632	06-8-3522	09-8-1381	99-8-1484N	GP09-1987	GP13-4280
04-6-1634	06-8-3523	09-8-1382	99-8-1486N	GP09-1988	GP13-4281
04-6-1635	06-8-3525	09-8-1383	99-8-1487N	GP09-1989	GP13-4285
04-6-1636	06-8-3526V	09-8-1384	99-8-1497N	GP10-1084	GP13-4286
04-6-1637	06-8-3527	09-8-1385	99-8-1498N	GP10-1085	GP13-4287
04-6-1638	06-8-3528V	09-8-1386	99-8-1546N	GP10-1087	GP13-4290
04-6-1639	06-8-3529	09-8-1387	99-8-1554N	GP10-1088	GP13-4751
04-6-1640	06-8-3529V	09-8-1478N	99-8-1556N	GP10-1089	GP13-4760-8
04-6-1642	06-8-3530V	09-8-1637	99-8-1558N	GP10-1090	GP-9-1860
04-8-2091	06-8-3531	09-8-1682	99-8-1559N	GP10-1091	H10-2949
04-8-2092	06-8-3533V	09-8-1683	99-8-1560N	GP10-1092	Hinton-1
04-8-2094	06-8-3534V	09-8-1683inv	99-8-1561N	GP10-1093	Hinton-2
04-8-2154	06-8-3535V	09-8-1684	99-8-1562N	GP10-1094	Hunt-1
04-8-2401	07-4952-8	09-8-1685	99-8-1563N	GP10-1095V	Jacobs-1

04-8-2411	07-8-2810	09-8-1686	99-8-1564N	GP10-1096V	SEAmet-1
04-8-2508	07-8-2811	09-8-1687	99-8-1565N	GP10-1097	Senniger
04-8-2509	07-8-2812	09-8-1688	99-8-1566N	Gp10-1097	SmithfieldGeneitics
04-8-2592	07-8-2813	09-8-1689	99-8-1567N	GP10-1098	SP10-3394V
04-8-2600	07-8-2814	09-8-1690	99-8-1568N	GP10-1099	SP11-4664
04-8-2816	07-8-2815	09-8-1691	99-8-1569N	GP10-1099-8	Spearman-1
04-8-2817	07-8-2816	09-8-1692	99-8-1570N	GP10-1100	SpearmanJr-1
04-8-2818	07-8-2817	09-8-1693	99-8-1571N	GP10-1101	WRITTER-1

## TABLE 2: LIST OF METERS AND THEIR WATER USE CATEGORY

All 747 meters are listed below, those highlighted indicate those whose water use category was defined by the District. For meters not having an assigned water use, irrigation was assumed based on communication with the District.

Table key:

Category defined by District	Meter number with yellow highlighted background
------------------------------	---

meter_no_ID	Water Use	meter_no_ID	Water Use
00-6-1252 N	irrigation	09-8- 1377	stock
00-6-1253N	irrigation	09-8-1378	domestic
00-6-1254N	irrigation	09-8-1379	unused
00-6-1255N	irrigation	09-8-1380	stock
00-6-1256N	irrigation	09-8-1381	stock
00-6-1257N	irrigation	09-8-1382	stock
00-6-1291N	irrigation	09-8-1383	unused
00-6-1477N	unused	09-8-1384	industrial
00-8-1522N	irrigation	09-8-1385	unused
00-8-1847N	irrigation	09-8-1386	stock
00-8-1957N	irrigation	09-8-1387	irrigation
00-8-1958N	irrigation	09-8-1682	irrigation
00-8-2574N	stock	09-8-1683	stock
00-8-2576N	stock	09-8-1684	stock
00-8-2586N	stock	09-8-1685	irrigation
00-8-2587N	industrial	09-8-1686	stock
00-8-2588N	irrigation	09-8-1687	irrigation
00-8-2590N	unused	09-8-1688	unused
01-05-1016N	stock	09-8-1689	domestic

01-05-1018N	stock	09-8-1690	domestic
01-06-1401N	stock	09-8-1691	irrigation
01-06-1403N	stock	09-8-1692	irrigation
01-06-1404N	stock	09-8-1693	irrigation
01-06-1405N	irrigation	09-8-1694	stock
01-06-1450N	domestic	09-8-1695	stock
01-06-1451N	industrial	09-8-1696	stock
01-06-1452N	stock	09-8-1697	domestic
01-06-1459N	unused	09-8-1698	irrigation
01-06-1476N	stock	09-8-1699	irrigation
01-06-1477N	unused	09-8-1700	stock
01-06-1478N	irrigation	09-8-1701	irrigation
01-06-1479N	stock	13-13347	public supply
01-06-1480N	stock	13-13351	irrigation
01-06-1482N	stock	14-09558	domestic
01-06-1483N	stock	6-10-1026	unused
01-06-1484N	irrigation	66-6-05S	stock

01-06-1485N	irrigation	77-8-2032N	irrigation
01-06-1486N	industrial (cooling)	78-8-867	stock
01-08-1891N	stock	79-8-835	stock
01-08-1892N	stock	80-8-178	stock
01-08-1896N	unused	80-8-181	irrigation
01-08-1897N	stock	92-4-473	irrigation
01-08-1902N	unused	94-8-1801N	irrigation
01-08-1903N	industrial (cooling)	97-8-2655N	domestic
01-08-1904N	stock	98-8-109R	stock
01-08-1909N	irrigation	98-8-110R	public supply
01-08-2006N	stock	98-8-1237N	domestic
01-08-2007N	unused	98-8-1240N	irrigation
01-08-2008N	stock	98-8-1759N	unused
01-08-2009N	stock	98-8-178	unused
01-08-2010N	stock	98-9159-8	stock
01-08-2011N	unused	98-9160-8	stock
01-08-2093N	stock	99-10-1019N	irrigation
01-08-2094N	stock	99-10-1193N	irrigation
01-08-2095N	irrigation	99-10-1194N	stock
01-08-2101N	industrial	99-10-1195N	domestic
01-08-2102N	unused	99-10-1196N	stock
01-08-2147N	unused	99-10-1197N	stock
01-08-2251N	public supply	99-10-1238N	unused



01-08-2252N	stock	99-10-1240N	irrigation
01-08-2253N	stock	99-10-1241N	irrigation
01-08-2254N	test hole	99-10-1242N	irrigation
01-08-2255N	irrigation	99-10-1243N	stock
01-08-2255n	irrigation	99-10-1244N	irrigation
01-08-2399N	industrial	99-10-1245N	irrigation
01-08-2400N	irrigation	99-10-1246N	irrigation
01-08-2401N	unused	99-10-1294N	irrigation
01-08-2402N	stock	99-10-1295N	irrigation
01-08-2403N	irrigation	99-10-1333N	irrigation
01-08-2415N	stock	99-10-1334N	irrigation
01-08-2416N	stock	99-10-1335N	irrigation
01-08-2417N	industrial	99-10-1336N	irrigation
01-08-2418N	stock	99-6-1251N	irrigation
01-08-2419N	domestic	99-6-1252N	irrigation
01-08-2501N	stock	99-6-1253N	irrigation
01-08-2818	stock	99-6-1254N	irrigation
01-10-1276N	unused	99-6-1255N	irrigation
01-10-1277N	unused	99-6-1341N	irrigation
01-6-1477N	irrigation	99-6-1342N	irrigation

01-6-1481N	irrigation	99-6-1343N	unused
01-8-2008N	irrigation	99-6-1344N	irrigation
01-8-2011N	irrigation	99-6-1345N	irrigation
01-8-2501	irrigation	99-6-1346N	irrigation
02-6-1403	irrigation	99-6-1347N	irrigation
02-6-1535	irrigation	99-6-1348N	irrigation
02-8-1892N	irrigation	99-6-1386N	irrigation
03-10-1141N	industrial (cooling)	99-6-1387N	irrigation
03-10-1142N	industrial	99-6-1443N	irrigation
03-6-1606	stock	99-6-1444N	irrigation
03-6-1649	unused	99-6-1560N	irrigation
03-6-1650	irrigation	99-6-1585N	unused
03-8-1516	stock	99-6-1619N	irrigation
03-8-1520	irrigation	99-8-109R	irrigation
03-8-1753N	unused	99-8-1342N	irrigation
03-8-1754N	stock	99-8-1460N	irrigation
03-8-3568	stock	99-8-1461N	stock
03-8-3726	stock	99-8-1462N	unused
03-8-3727	stock	99-8-1463N	irrigation
03-8-4122	stock	99-8-1464N	irrigation

04-6-1480	irrigation	99-8-1465N	irrigation
04-6-1481	domestic	99-8-1466N	irrigation
04-6-1599	stock	99-8-1467N	stock
04-6-1631	stock	99-8-1468N	stock
04-6-1632	stock	99-8-1469N	irrigation
04-6-1634	domestic	99-8-1470N	irrigation
04-6-1635	unused	99-8-1471N	irrigation
04-6-1636	domestic	99-8-1472N	irrigation
04-6-1637	domestic	99-8-1473N	irrigation
04-6-1638	stock	99-8-1474N	irrigation
04-6-1639	domestic	99-8-1475N	industrial
04-6-1640	stock	99-8-1476N	irrigation
04-6-1642	stock	99-8-1477N	irrigation
04-8-2091	test hole	99-8-1478N	unused
04-8-2092	stock	99-8-1479N	irrigation
04-8-2154	stock	99-8-1480N	irrigation
04-8-2401	domestic	99-8-1481N	irrigation
04-8-2411	irrigation	99-8-1482N	irrigation
04-8-2508	stock	99-8-1483N	stock
04-8-2509	irrigation	99-8-1484N	irrigation
04-8-2816	irrigation	99-8-1486N	irrigation
04-8-2817	stock	99-8-1558N	irrigation
04-8-2818	stock	99-8-1559N	irrigation

04-8-2894	stock	99-8-1560N	domestic
04-8-3066	irrigation	99-8-1561N	domestic
04-8-3467	irrigation	99-8-1562N	irrigation
04-8-3589	stock	99-8-1563N	irrigation
04-8-3590	domestic	99-8-1564N	irrigation
04-8-3591	stock	99-8-1565N	stock
04-8-3592	stock	99-8-1566N	domestic
04-8-3593	unused	99-8-1567N	irrigation
04-8-3594	stock	99-8-1568N	irrigation
04-8-3596	irrigation	99-8-1569N	irrigation
04-8-3597	stock	99-8-1570N	domestic
04-8-3598	stock	99-8-1571N	irrigation
04-8-3599	stock	99-8-1572N	irrigation
04-8-3600	stock	99-8-1793N	irrigation
04-8-3601	stock	99-8-1794N	irrigation
04-8-3602	unused	99-8-1795N	unused
04-8-3603	unused	99-8-1796N	irrigation
04-8-3604	stock	99-8-1797N	domestic

04-8-3606	stock	99-8-1798N	irrigation
04-8-3607	irrigation	99-8-1799N	test hole
04-8-3608	irrigation	99-8-1800N	irrigation
04-8-3609	irrigation	99-8-1801N	industrial
04-8-3610	irrigation	99-8-1883N	irrigation
04-8-3612	domestic	99-8-1884N	stock
04-8-3613	irrigation	99-8-1885N	irrigation
04-8-3614	stock	99-8-1886N	test hole
04-8-3615	industrial	99-8-1887N	irrigation
04-8-3616	stock	99-8-1888N	irrigation
04-8-3617	stock	99-8-1888n	irrigation
04-8-3618	stock	99-8-1889N	irrigation
05-10-1309	stock	99-8-1890N	irrigation
05-10-1310	domestic	99-8-1891N	irrigation
05-10-1524	domestic	99-8-1892N	irrigation
05-10-1524V	irrigation	99-8-1893N	industrial (cooling)
05-4-1081	stock	99-8-1894N	irrigation
05-4-1106	stock	99-8-1895N	stock
05-5-1005	stock	99-8-1896N	stock
05-6-1540	industrial	99-8-1897N	stock
05-6-1707	unused	99-8-1898N	domestic
05-6-1834	irrigation	99-8-1899N	unused
05-8-2264	stock	99-8-1900N	irrigation
05-8-2265	stock	99-8-1901N	irrigation
05-8-2266	stock	99-8-1902N	irrigation

05-8-2266V	irrigation	99-8-1903N	stock
05-8-2267	irrigation	99-8-1905N	industrial (cooling)
05-8-2267V	stock	99-8-2015N	irrigation
05-8-2942	unused	99-8-2016N	irrigation
05-8-2943	domestic	99-8-2017N	irrigation
05-8-2944	stock	99-8-2018N	irrigation
05-8-2945	stock	99-8-2019N	irrigation
05-8-2946	industrial (cooling)	99-8-2020N	irrigation
05-8-2947	irrigation	99-8-2022N	irrigation
05-8-2948	stock	99-8-2023N	irrigation
05-8-2949	stock	99-8-2024N	irrigation
05-8-2950	unused	99-8-2025N	irrigation
05-8-2951	irrigation	99-8-2026N	irrigation
05-8-2952V	irrigation	99-8-2027N	irrigation

05-8-2953V	irrigation	99-8-2028N	irrigation
05-8-2953v	irrigation	99-8-2029N	irrigation
05-8-2954V	domestic	99-8-2030N	irrigation
05-8-2955V	irrigation	99-8-2031N	irrigation
05-8-2955v	irrigation	99-8-2032N	irrigation
05-8-2956V	unused	99-8-2033N	irrigation
05-8-2957	irrigation	99-8-2034N	irrigation
05-8-2958	irrigation	99-8-2105N	irrigation
05-8-2959	stock	99-8-2106N	irrigation
05-8-2960	unused	99-8-2107N	irrigation
05-8-2961	stock	99-8-2108N	irrigation
05-8-2962	stock	99-8-2109N	irrigation
05-8-3098V	stock	99-8-2110N	irrigation
05-8-3099	unused	99-8-2111N	irrigation
05-8-3100	stock	99-8-2112N	irrigation
06-10-1026	irrigation	99-8-2113N	irrigation
06-10-1117	irrigation	99-8-2115N	irrigation
06-10-1118	unused	99-8-2375N	irrigation
06-10-1120	unused	99-8-2436N	irrigation
06-4-1073	domestic	99-8-2487N	public supply
06-4-1102	stock	Babcock-1	irrigation
06-4-1103	irrigation	Babcock-2	public supply
06-4-1104	irrigation	GP09-1848	domestic
06-4-1105	irrigation	GP09-1849	unused
06-4-1110	irrigation	GP09-1850	industrial
06-4-1112	unused	GP09-1852	unused
06-6-1344	stock	GP09-1853	unused
06-6-1346	domestic	GP09-1854	unused
06-6-1347	domestic	GP09-1855	stock

06-6-1348	unused	GP09-1856	irrigation
06-6-1350	stock	GP09-1857	domestic
06-6-1351	stock	GP09-1860	stock
06-6-1352	domestic	GP09-1861	stock
06-6-1353	irrigation	GP09-1863	stock
06-6-1354	irrigation	GP09-1864	stock
06-6-1789	domestic	GP09-1866	stock
06-6-1790	unused	GP09-1868	stock
06-6-1792	stock	GP09-1870	irrigation
06-6-1793	industrial	GP09-1871	unused
06-6-1796	unused	GP09-1872	stock
06-6-1797	industrial	GP09-1878	unused

06-6-1798	unused	GP09-1879	stock
06-8-1860	stock	GP09-1966V	unused
06-8-1861	industrial (cooling)	GP09-1967V	irrigation
06-8-1862	public supply	GP09-1968V	irrigation
06-8-1863	stock	GP09-1969V	public supply
06-8-1864	domestic	GP09-1970V	public supply
06-8-1865V	stock	GP09-1971V	public supply
06-8-1866	stock	GP09-1972V	irrigation
06-8-2505	irrigation	GP09-1973V	irrigation
06-8-2505V	stock	GP09-1974V	irrigation
06-8-2506V	stock	GP09-1975V	irrigation
06-8-2507V	domestic	GP09-1976V	public supply
06-8-2508V	irrigation	GP09-1977V	irrigation
06-8-3034	irrigation	GP09-1978V	domestic
06-8-3521	irrigation	GP09-1979V	irrigation
06-8-3522	industrial	GP09-1980V	stock
06-8-3523	stock	GP09-1981	public supply
06-8-3525	stock	GP09-1982	irrigation
06-8-3526V	stock	GP09-1983	irrigation
06-8-3527	unused	GP09-1985	stock
06-8-3528V	stock	GP09-1986	unused
06-8-3529V	stock	GP09-1987	stock
06-8-3530V	stock	GP09-1988	stock
06-8-3531	irrigation	GP09-1989	irrigation
06-8-3533V	stock	GP10-1085	domestic
06-8-3534V	irrigation	GP10-1087	irrigation
06-8-3535V	stock	GP10-1088	stock
07-4952-8	stock	GP10-1089	stock
07-8-2810	stock	GP10-1090	stock
07-8-2811	stock	GP10-1091	stock
07-8-2812	stock	GP10-1093	stock

07-8-2813	stock	GP10-1094	stock
07-8-2814	stock	GP10-1095V	stock
07-8-2815	irrigation	GP10-1097	unused
07-8-2816	stock	Gp10-1097	unused
07-8-2817	domestic	GP10-1098	domestic
07-8-2818	stock	GP10-1099	stock
07-8-2819	stock	GP10-1100	domestic
07-8-2820	domestic	GP10-1101	stock
07-8-2821	stock	GP10-1102	stock
07-8-2822	stock	GP10-1103	stock

07-8-2823	stock	GP10-1104	irrigation
07-8-2825	stock	GP10-1105	stock
07-8-2826	irrigation	GP10-1106	stock
07-8-2827	irrigation	GP10-1107	stock
07-8-2829	stock	GP10-1248	stock
07-8-2830	stock	GP10-1986	stock
07-8-2831	stock	GP10-3375	domestic
07-8-2832	industrial	Gp10-3375	domestic
07-8-2834	domestic	GP10-3377	industrial
07-8-4232	stock	GP10-3378	irrigation
08-01655	stock	GP10-3379	stock
08-05127-06	stock	GP10-3380	irrigation
08-09099-06	stock	GP10-3381	industrial (cooling)
08-10-1170V	irrigation	GP10-3382	stock
08-10-1171V	irrigation	GP10-3383	industrial (cooling)
08-10-1555V	industrial	GP10-3384	industrial (cooling)
08-10-1557V	stock	GP10-3385	domestic
08-10-1576	public supply	GP10-3386	industrial (cooling)
08-10-1577	public supply	GP10-3389	industrial
08-10-1578	stock	GP10-3391V	irrigation
08-10-1579	irrigation	GP10-3392V	stock
08-10-1580	irrigation	GP10-3395	irrigation
08-10-1581V	irrigation	GP10-3396	irrigation
08-10-1582	unused	GP10-3397	domestic
08-4-1118	irrigation	GP10-3398	irrigation
08-4-1119	irrigation	GP10-3399	irrigation
08-6-1306	stock	GP11-1562	stock
08-6-1307	stock	GP11-2209V	stock
08-6-1308	stock	GP11-2210V	irrigation
08-6-1309	stock	GP11-2211V	stock
08-6-1310	stock	GP11-2213	stock
08-6-1311	irrigation	GP11-2214	stock
08-6-1312	irrigation	GP11-2215	unused

08-6-1313	stock	GP11-2216	unused
08-6-1821	domestic	GP11-2217	unused
08-6-1822	stock	GP11-2218	domestic
08-6-1823	industrial	GP11-2530	stock
08-6-1824	irrigation	GP11-3811-4	irrigation
08-6-1825	irrigation	GP11-4641	stock

08-6-1826	irrigation	GP11-4642	stock
08-6-1827	stock	GP11-4643	stock
08-6-1897V	public supply	GP11-4645	stock
08-8-2061	unused	GP11-4649	irrigation
08-8-2062	domestic	GP11-4650	domestic
08-8-2063	unused	GP11-4651V	monitoring
08-8-2064	stock	GP11-4653V	irrigation
08-8-2065	stock	GP11-4655	public supply
08-8-2066	stock	GP11-4656	irrigation
08-8-2067	irrigation	GP11-4657	irrigation
08-8-2068	irrigation	GP11-4658	stock
08-8-2069V	irrigation	GP11-4659	stock
08-8-2070V	public supply	GP11-4660	stock
08-8-2071V	irrigation	GP11-4661	stock
08-8-2072V	stock	GP11-4663	domestic
08-8-2073V	public supply	GP11-4664	unused
08-8-2074V	public supply	GP11-4665	domestic
08-8-2075V	irrigation	GP11-5656	monitoring
08-8-2076V	public supply	GP12-1847	irrigation
08-8-2077V	domestic	GP12-1850	irrigation
08-8-2078V	irrigation	GP12-1852	public supply
08-8-2453	irrigation	GP12-1853	irrigation
08-8-2454V	irrigation	GP12-1854	stock
08-8-4095V	stock	GP12-1856	stock
08-8-4096V	stock	GP12-1858	stock
08-8-4097V	stock	GP12-1860	stock
08-8-4098V	unused	GP12-1862	industrial
08-8-4099V	stock	GP12-1863	industrial
08-8-4100V	unused	GP12-1864	irrigation
08-8-4101V	stock	GP12-1865	irrigation
08-8-4102V	stock	GP12-1866	irrigation
08-8-4103V	irrigation	GP12-4230	stock
08-8-4104V	stock	GP12-4231	stock
08-8-4105	irrigation	GP12-4233	domestic
08-8-4105V	stock	GP12-4234	stock
08-8-4106V	unused	GP12-4235	stock
08-8-4107V	irrigation	GP12-4236	stock
08-8-4108V	unused	GP12-4237	stock
08-8-4109V	unused	GP12-4238	irrigation
08-8-4110	unused	GP12-4239	industrial
08-8-4111	unused	GP12-4240	industrial
08-8-4112	unused	GP12-4241	irrigation

08-8-4113	unused	GP12-4243	stock
08-8-4114	stock	GP12-4245	domestic
08-8-4115	domestic	GP12-4246	stock
08-8-4116	irrigation	GP12-4247	public supply
08-8-4117	domestic	GP12-4248	public supply
08-8-4118	stock	GP12-4249	irrigation
08-8-4119	stock	GP12-4250	irrigation
08-8-4120	irrigation	GP12-4251	irrigation
08-8-4121	unused	GP12-4252	irrigation
08-8-4122	unused	GP12-5038	domestic
08-8-4123	irrigation	GP13-0557	stock
08-8-4124	unused	GP13-0558	stock
08-8-4125	irrigation	GP13-0560	stock
08-8-4126	domestic	GP13-0561	irrigation
08-8-4127	domestic	GP13-0562	irrigation
08-8-4128	stock	GP13-0563	irrigation
08-8-4129	stock	GP13-0564	irrigation
08-8-4130	irrigation	GP13-0566	stock
08-8-4131	stock	GP13-0567	test hole
08-8-4132	stock	GP13-0568	unused
08-8-4133	stock	GP13-0569	industrial (cooling)
08-8-4134	stock	GP13-0572	unused
09-6-1083	stock	GP13-0573	industrial
09-6-1084	stock	GP13-0576	domestic
09-6-1085	stock	GP13-0577	irrigation
09-6-1086	stock	GP13-0579	industrial
09-6-1087	monitoring	GP13-0580	stock
09-6-1088	stock	GP13-1522	irrigation
09-8-1370	industrial (cooling)	GP13-4287	public supply
09-8-1371	stock	GP13-4290	public supply
09-8-1372	irrigation	GP13-4751	irrigation
09-8-1373	industrial	Hinton-1	stock
09-8-1374	domestic	SEAmet-1	irrigation
09-8-1375	stock	SpearmanJr-1	irrigation
09-8-1376	irrigation		



# **Appendix B**

## **Meter Data Collection Protocols**

### **Panhandle GCD Meter Reading Data Collection Protocol**

**(1) Definitions.** As used in the meter reading data collection protocol, unless the context clearly states otherwise, the following words and phrases shall have the meanings ascribed to them in this section.

(a) “Meter reading record” means one complete meter reading record stored permanently in the database. The completed record should have at least the meter ID and the reading location.

(b) “Meter reading table” means a data table in the database that contains all the meter reading records. This table will be the main table the meter reading collection application interacts with.

(c) “Meter record” means one complete meter record stored permanently in the database. The completed record should have at least the meter ID and the meter location.

(d) “Meter table” means a master table in the database that contains all the meter records. It is assumed that the district will have a comprehensive and reliable meter table in the database before starting to use the meter reading collection application.

(e) “Meter ID” is the unique identifier of the meter records. A meter should only have one meter ID, and a meter ID can only be assigned to one single meter. Once a meter ID is set for a meter, it cannot be changed. The meter ID will be used in both the meter table and the meter reading table

(f) “Reading number” means the recorded meter reading number in the field, often copied from the totalizer. All reading numbers should be non-negative integers. A meter reading record must have the reading number unless otherwise explained in the notes

(g) “Multiplier” means the number after or before the multiply sign “X” on the meter face. Usually the multiplier is located below the meter reading digits. For a meter, both the meter reading records and the meter record itself will have the multiplier as an attribute.

(h) “Reading sample time” means the date and time on which a meter reading record was collected in the field. A meter reading record must have the reading sample time. When stored in the meter reading table, the reading sample time should follow the “DD/MM/YYYY HH:MM:SS” format.

(i) “Crop” means the irrigated crop on which the meter’s monitored water is being applied. In a meter reading record, specifying the crop is optional.

(j) “GPM” means pumping rate in gallons per minute during the recorded meter reading. This is the instantaneous rate, not the average since the last meter reading. In a meter reading record, specifying the pumping rate is optional.

(k) “Notes” means additional explanations on the meter reading record. It is required for a meter reading record without a reading number.

- (l) “Rollover occurred” means whether a rollover has occurred in the meter reading record. When the previous reading number is larger than the current reading number, it is assumed to be a rollover occurrence. The field collectors don’t have to include a value, however, the value will be populated during the data synchronization process if no value is recorded in the field.
- (m) “Water use” means water use type of the meter. Initially this value is stored with each meter in the meter table and is a fixed value with the meter. During the meter reading data collection phase, the water use value will be carried over to the meter reading records.
- (n) “Reading location” means the location (in the format of longitude/latitude) of a meter reading record. It will be recorded in the data collection application using the mobile device’s own GPS. A meter reading record must have a reading location.
- (o) “Reading status” means whether a meter reading record is approved, pending or rejected. The value will be populated during the data synchronization process.
- (p) “Reason for rejection” means the reason for a meter reading record being rejected by the data synchronization manager.
- (q) “Meter location” means the location (in the format of longitude/latitude) of a meter record. It will be pre-defined in the meter table with at least 3 digits after the decimal point. Each meter must have a meter location.
- (r) “Temporary storage” means the physical space to store the field-collected meter reading records data. It can be either the mobile devices or a temporary server’s storage on the Internet.
- (s) “Outlier” means the meter reading record’s reading number is abnormal based on the analysis of the meter’s activity history. If a reading number is considered as an outlier, the meter reading record will be flagged.

**(2) Meter record specifications.** Each finalized meter record in the database, when consumed by the meter reading collection application, shall meet the following minimum requirements:

- A. Must have a meter ID (e) of its own. The meter ID can be numerical (eg. 899) or a combination of letters, numbers and special characters (eg. GP12-0757). If a meter is replaced by a new meter, the new meter will be recorded as a meter with a different meter ID in the database.
- B. Must have a meter location (q), in the format of longitude and latitude. There must be at least three digits after the decimal point of any longitude/latitude, making the precision 360 feet.
- C. Must have a non-negative multiplier value (g). If the meter has no multiplier value indicated, the default value “1” will be applied to it.

- D. Must have a non-negative rollover value. The rollover value will be the maximum possible number a meter can show on its totalizer (multiplier not included).
- E. Must be assigned with a specific water use (m) (agricultural, municipal, industrial, etc.). This value can be changed by the database administrator.
- F. Must have a unit of measurement value. The default value will be “gallons”.

**(3) Meter reading record specification.** Each meter reading record, after data synchronization and validation, shall meet the following minimum quality assurance requirements:

- A. Must have a valid meter ID (e). Each meter reading record should be tied to a unique meter ID that can be found in the meter table.
- B. Must have a reading location (n). The reading location is collected in the field by using the mobile device’s own GPS. During the synchronization process, the reading location will be used to judge the nearby meters so as to provide the sync manager a list of potential correct meter IDs.
- C. Must have a reading sample time (h), regardless of whether there is an actual reading number (f) or not. The format of reading sample date is “DD/MM/YYYY HH:MM:SS”.
- D. Must have a non-negative reading number (f), unless an explicit reason for no reading number is provided in the notes (k). The reading number will be the raw number shown on the meter totalizer, without being multiplied by the multiplier (g).
- E. Must have a note (k) for the meter reading record if the reading number (f) is not provided (eg. meter not installed, meter out of function). Otherwise the note is optional.
- F. Must be assigned with a specific water use (m). This value will be copied over from the meter table (2)E.
- G. Must have a reading status (o) indicating whether the meter reading record is “Approved”, “Pending”, “Manager Overwrite”, or “Rejected”.
- H. Can have a crop (k) specified for the meter reading. The crop attribute will reflect the crop being irrigated at the time of the reading.
- I. Can have a GPM (j) value indicating the instantaneous pumping rate in gallons per minute J. Can have a value indicating whether a rollover (l) has occurred since last meter reading record. Depending on the 1) time gap between the previous reading and the current reading, 2) yield of the well and 3) the rollover value, the value of rollover occurred can be “Yes”, “No” or “Unknown”.
- K. If a meter reading record is rejected, must provide a reason for rejection (p).
- L. Has an attribute “Is Outlier”. If a meter reading record’s reading number is considered as an outlier, the field value will be “Yes”, otherwise will be “No”.

**(4) Meter reading record field collection specifications.** For the process of field meter reading, the mobile application will provide the functions to support the collection of the following attributes:

- A. Meter ID (3)A. The mobile app will provide a free input box (without auto-completion) for the field worker to input the meter ID he is reading. Before sending a data collector to the field, the district should provide the collector a list of meter IDs and address
- B. Reading location (3)B. The value of this attribute will be collected using the mobile device's native GPS.
- C. Reading sample time (3)C. The value will be the time when the record is created in the field.
- D. Reading number (3)D. The input method will be a numerical input box.
- E. Note (3)E. This attribute will be shown when the reading number is left blank. The input method will be a free input box. The application will not proceed if neither the reading number nor note is filled.
- F. Crop (3)H. The attribute will be optional. The input will be a drop-down list of possible crops in the field.
- G. GPM (3)I. The input will be a numerical box.

**(5) Meter reading record synchronization specifications.** The field-collected data will be either stored on the mobile device or on a temporary server on the Internet. To push the data into the district's database, a synchronization process will be needed to 1) pull the collected data from the temporary storage (r), 2) validate/correct data integrity by comparing the field-collected data with the meter table and meter reading table in the database and 3) push the validated meter reading data into the database. An automated data synchronization program (PC-based) will be created to fulfill the following tasks for each meter reading record collected:

- A. Confirm meter ID
- B. Populate water use
- C. Determine rollover status
- D. Assign reading status
- E. Assign reason for rejection (if rejected)
- F. Determine outlier status G. Temporary storage cleaning

*Confirm meter ID:* the purpose of the task is to ensure the correct meter ID is specified for the correct meter reading record. It is likely for errors to occur when typing the meter ID into the mobile device during the field collection process, so the confirm meter ID step enforces the correction of meter ID typos by using the following logic:

1. Get the reading location (4)B from the meter reading record.

2. Query and retrieve all the meter records (c) that are within a buffered distance (for example, 500 feet) of the reading location.
3. Compare the meter reading record's meter ID with each of the meter IDs from the queried meter records.
4. If there is an exact match, then the field-collected meter ID (user input meter ID) will be considered as valid.
5. If there is not a match, then a selection window with all the queried meter IDs will be presented to the sync manager. The sync manager will have to choose the correct meter ID in order to proceed.

It is assumed that the meter table (c) is up-to-date and all the meter locations are corrected with at least three digits after the decimal point (360 feet precision). Since the data integrity completely relies on the meter ID and meter location, it is strongly recommended that the districts validates their meter table before starting to use the mobile data collection application. In the above meter ID confirmation process, if the sync manager cannot find a correct meter ID in the list, he can choose to 1) manually input the correct meter ID or 2) reject the meter reading record. Action 1 will make the reading status (o) "Manager Overwrite" while action 2 makes the reading status "Rejected".

*Populate water use:* once the correct meter ID has been confirmed or overwritten, the synchronization program will retrieve the water use value from the meter record and fill it into the meter reading record.

It is assumed that the meter table (c) already has the water use populated for every meter record. It is allowed for the district manager to change the water use for a meter, which will result in new meter reading records having the changed water use while keeping the old water use as history in the meter reading table.

*Determine rollover status:* the process will update the "Rollover occurred" attribute (l) of the meter reading record based on the previous reading records.

Whether a rollover has occurred between the current reading time and the last reading time is determined by the following rules:

1. If the current reading number (4)C is blank, then the rollover occurred status will be set as "Unknown".
2. If the current reading number (4)C is less than the preceding reading, then the rollover will be set as "Yes".
3. If step 2) is not met and if the time gap between current reading sample time (h) and the closest previous reading sample time is long, then the rollover status will be set as "Unknown". To determine if the time gap between two reading records is long enough to pose a rollover risk, two items will be used:
  - a. The yield of the well
  - b. The meter rollover value

*Assign reading status:* the process will set the reading status (3)G using the following steps:

1. Initially, all reading status 3(G) will be set as “Pending”.
2. After the meter ID confirmation process, the reading status could become “Pending”, “Manager Overwrite” or “Rejected”.
3. For all the “Pending” records, the sync manager will be asked to confirm the approval. Once approved, the meter reading records will be “Approved”. If the sync manager chooses not to approve it at the moment, the reading record remains “Pending” and will participate in the next batch of synchronization.
4. All the “Manager Overwrite” meter reading records will remain “Manager Overwrite”.
5. All the “Rejected” meter reading records will remain “Rejected”.

*Assign reason for rejection:* if a meter reading record is rejected by the sync manager, he will choose a reason for the rejection:

- Meter ID mismatch.
- Incorrect or suspect reading number.
- Extreme reading value (outlier).
- Other (requires description in notes)

*Determine outlier status:* this process will use the historical meter reading records to assess whether a meter reading number is an outlier. If a reading number is deemed by the synchronization program as an outlier, the sync manager will be prompted to ask if this reading number is accurate. If the reading number is confirmed as accurate, then the “Is outlier” 3(L) will be set as “No”, otherwise “Is outlier” will be set as “Yes”.

*Temporary storage cleaning:* once the validation process is done, the “Approved”, “Manager Overwrite” and “Rejected” meter reading records will be transferred into the meter reading table (b) and removed from the temporary storage. The “Pending” records will remain in the temporary storage for the next round of validation and will not be imported into the database.

## **Appendix C**

# Functional Requirements for Meter Data Collection Application



# MeterMaid

A Database-backed Web Application for Publishing Water Meter Data from Mobile

Devices January 26, 2016

## Introduction

The Panhandle Groundwater Conservation District (District) has encountered issues that may compromise the quality and usefulness of the data collected as part of its metering program. INTERA was tasked with determining a set of functional requirements for a software application that would improve the quality and reliability of meter data. Those findings, detailed in previous memoranda [1, 2], are summarized as:

- Consolidate meter data into a normalized database with meters assigned unique identification codes.
- Assign water use and geospatial coordinates to specific meters.
- Leverage existing data to flag outliers and identify rollover events when registering new meter records.
- The application must run on mobile devices and enforce consistency of new records.
- The application must be developed within a budget of \$39,402. This number includes labor, hardware, and deployment costs; maintenance costs are to be kept at the minimum that ensures reliability and quality of service.

This product proposal describes MeterMaid, a database-backed web application that addresses these concerns by providing a means to view and record District meter data.

Seen from the user's perspective, MeterMaid is a series of web pages; users can log in from a desktop computer or any mobile device connected to the internet and view both aggregate information and data relating to specific meters. Users may also post new readings to the database with a form that enforces the requirements described in [1, 2]. This web-based deployment strategy was favored over software running on specific devices to minimize both development time and maintenance costs.

## Product Description

### Overview

MeterMaid (shown in Figure 1) has the following four components:

- A database, containing meter information, field notes, user names, and geospatial (location) data. This will either be the District's existing water meter database, or a copy that is extended to include additional data structures critical for MeterMaid's operation.
- A physical server connected to the internet, deployed by INTERA, but located at and maintained by the District. The server holds the database and related software, described below.
- A series of web pages:
  - A login page (**Login**)

- An administrative site (**Admin**), where a subset of users may assign privileges and view or modify records. Administrators may also use this site to create new meters. These pages are not visible to general users.
- A District summary page (**Summary**), where users may view aggregate information such as:
  - A map displaying meter locations and the user's location. Users may zoom the map and view individual meter information.
  - Summary statistics, such as water consumption by user over time, etc.
- A collection of meter pages (**Meter**), where users may view information relating to a specific meter. These pages will also allow users to post new meter readings and field notes. MeterMaid automatically creates Meter pages; there will be one page for every meter in the database.
- A collection of programs that connect to the database, enforce data consistency, provide feedback content to the user (including reports, charts, data entry errors, and meter statistics), and generates the HTML (web pages) viewed by the user.

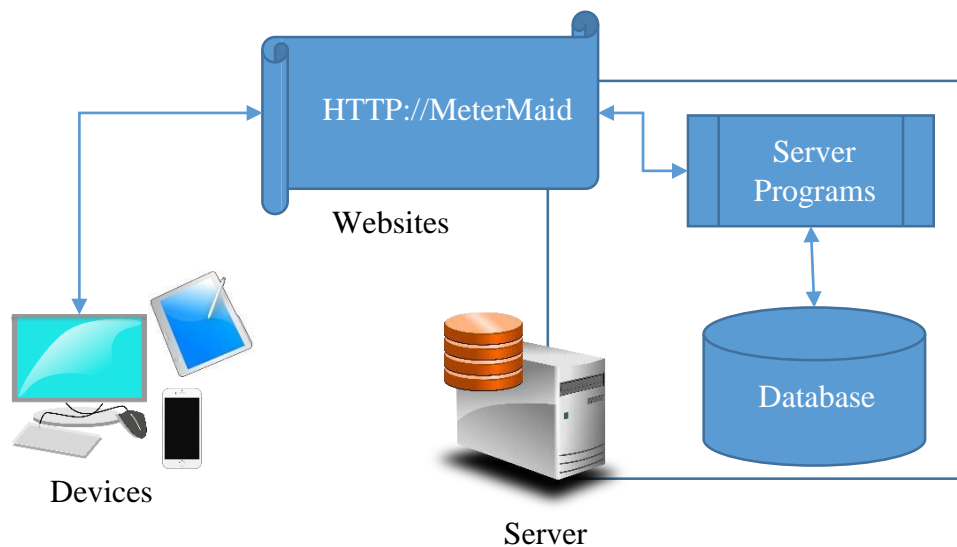


Figure 1: MeterMaid is a database-backed web application for recording and viewing District meter data. The product consists of a server (blue hollow box) containing a database and programs that generate web pages for input provided by the user. MeterMaid tailors content to the screen size of the user's device, which may be any device connected to the internet, including phones, tablets, or desktop computers. Users access MeterMaid with their favorite web browser (Internet Explorer, Chrome, Firefox and Safari are the most common).

### Intended Use

MeterMaid is designed to be viewed from both desktop computers and mobile devices. Best viewed from a desktop computer, the Admin and Summary pages provide easy access to detailed information relevant to headquarters but not particularly useful in the field; here administrators can add or update meter information and add new users. The administration site adds a layer of security and reliability to MeterMaid by leveraging a set of forms that enforce data integrity. The

Meter pages (one page for each meter) is intended for use in the field; here users update specific meter information and log new meter readings. Meter pages are automatically generated when new meters are added to the system via the administration site.

MeterMaid's value is apparent when it is viewed from the field, as it relies upon server scripts to enforce data consistency and provide geospatial feedback while the user is recording a measurement. For example, when a user logs in, MeterMaid obtains GPS coordinates from the user's device to auto-detect which meter is being measured and it makes recommendations based on historical trends for that specific meter. When the technician posts a new meter reading, MeterMaid will warn him/her if the reading is outside historical trends. MeterMaid will also log the user's ID and provide a timestamp.

## Technical Design Description

This section provides a technical description of each of MeterMaid's components:

### Database

INTERA will evaluate whether to integrate MeterMaid into the District's current database or deploy a separate database containing a copy of the District's meter records. If a separate database is chosen, PostgreSQL will be used as the relational database backend because it is free, has native support for geospatial datatypes, and schemas for controlling user access. When developing the database, INTERA will copy the structure and data from the District's existing data store; this operation is a trivial but may be necessary to integrate existing data with MeterMaid.

### Server

INTERA will procure and deploy a server; pending successful completion of testing, the District will be responsible for hosting and maintaining the server in the long run. Since traffic is expected to be relatively modest, a server will be selected based on performance and price; hardware costs will not exceed \$5000 and are included within the budget for this task.

### Scripts

INTERA will develop a number of scripts or programs that act as the "middlemen" between the user and the database. For example, when the server receives a "GET" request, it will connect to the database, retrieve the needed records, and post the results to the user in the form of a webpage. INTERA will develop server scripts in Python using the Django framework, which is a set of technologies commonly used in the industry for database-backed web applications. This framework was selected for its cost (it is free) and reliability; it was originally developed to host newspaper sites and assist reporters with posting new content.

### Web Pages

Web pages are automatically generated by MeterMaid's server; however, they will follow basic templates defined by the Django framework. When a user requests a specific URL (<http://thedistrictdomain/metermaid/meter#1234> for example), the server will fetch the appropriate template (the meter template in this case) and "fill in" HTML containing data pulled from the database (meter 1234 in this case). A typical web page consists of several components:

- CSS – defines the appearance of the web page (font sizes, page width, etc.)

- HTML – defines the web page’s static content (text, chart data, etc.)
- JavaScript – defines dynamic content; this includes the code necessary to generate charts and maps tailored to the specific context.

## Development Timeline

Pending the District’s approval to develop MeterMaid, INTERA will adhere to the following development schedule:

### 1. Prototype

INTERA will develop a basic prototype that provides the District with a concrete “view” of what the final product will look like. The prototype will include the core components of the finished application: a. Basic Admin site

- b. Basic overview page
- c. Basic data entry page
- d. The prototype will use “toy” data

### 2. Design Approval

After incorporating the District’s feedback of the Prototype in the form of a formal approval, INTERA will then proceed with “fleshing out” the remaining components of the application.

### 3. Implementation of Production code:

- a. Server scripts
- b. Administration pages
- c. Data summary page(s)
- d. Data entry page
- e. Help pages

### 4. Application Testing

### 5. Documentation

- a. Users’ manual, detail
- b. Code manual

## A Platform for Growth

MeterMaid’s modular design makes it easy to add functionality, should the District decide to do so later. Since software is not deployed to individual devices, updates are automatically “pushed out” to clients; users do not need to maintain an app store account, maintain licenses, or download updates. Examples of extensions which could add value to the District are:

**Analytics utilities:** Scripts could be deployed determining how water is used, by which entity, by season, etc. Report pages showing the results of specific queries could be added to the general website and could be made available to clients or stakeholders on a case-by-case basis.

**Additional Data:** MeterMaid could be extended to include other information of interest to the District, which might include well logs, maintenance and rehabilitation data, pumping records, local lithology, etc.

**Maintenance schedules:** users could be assigned specific meters and MeterMaid could automatically generate maintenance/measurement schedules and even print out directions and calculate routes to meters.

**Self-reporting hardware:** the recent decrease in the price of processor chips has created a market for small, portable computers that can act as sensor stations. Some examples include Arduino and Raspberry Pi, both which can cost under \$50. These devices could be deployed to the field as sensors to automatically register data at a much higher frequency. The devices could either post results to MeterMaid directly (if a nearby Wi-Fi connection is available), or technicians could download data in bulk during site visits.

**Self-reporting:** The District may elect to allow users to self-report water use data. This could be managed under public-facing accounts, managed as schemas in the MeterMaid's PostgreSQL database. Using this schema convention, the District can control which meters are visible or available to specific users (presumably this is a subset of all meter data corresponding to the user's *own* meters). Summary and statistics pages could likewise be tailored for specific users.

## References

INTERA memorandum to C. E. Williams, General Manager, Panhandle GCD, January 12, 2016 re: Contract 1003581101 – Task1: Evaluate Current Meter Data.

**Panhandle GCD Meter Reading Data Collection Protocol**, INTERA memorandum to C. E. Williams, General Manager, Panhandle GCD, August 5, 2015.

# **Appendix D**

## Meter Data Collection Application User Guide

# MeterMaid User Guide

8/17/2016



Version 1.0  
DRAFT  
Mitchell Tufford  
INTERA INC.

## Table of Contents

Overview .....	1
Mobile Application .....	1
Device and Browser Compatibility .....	1
Logging In .....	1
Viewing the Currently Logged in User .....	2
Meter Selection .....	2
Selecting a meter with the dropdown .....	2
Selecting a meter with the map .....	3
Map Tool .....	5
Current Location .....	5
Meter Clustering .....	5
Shapefile Rendering .....	6
Charting Tool .....	7
Timeline .....	8
Legend .....	8
Saving Charts .....	9
Meter Readings .....	9
Meter Reading Fields .....	10
Verifying Meter Location .....	12
Verifying and Submitting a Meter Reading .....	14
Administrative Site .....	15
Overview .....	15
Device and Browser Compatibility .....	15
Authentication and Authorization .....	15
Managing Groups .....	15
Managing Users .....	16
Meters .....	16
Meter Readings .....	16
Water Meters .....	18
Ensuring that edits are saved .....	20
Exporting Data .....	20
Viewing Meters Without Readings .....	21
Support .....	22



## 2 Overview

MeterMaid makes use of a client-server architecture to send and receive data from a database of water meters and water meter readings. It consists of a mobile application for gathering meter data, an administrative panel for viewing, editing, and verifying data submitted by users of the mobile application; and a backend relational database for storing water meter and meter reading information.

## 3 Mobile Application

The MeterMaid mobile application is used for submitting meter reading data, as well as viewing charts of historic data and mapping meter locations. It is optimized for mobile device screens, and permanently set to portrait mode on desktop and laptop browsers.

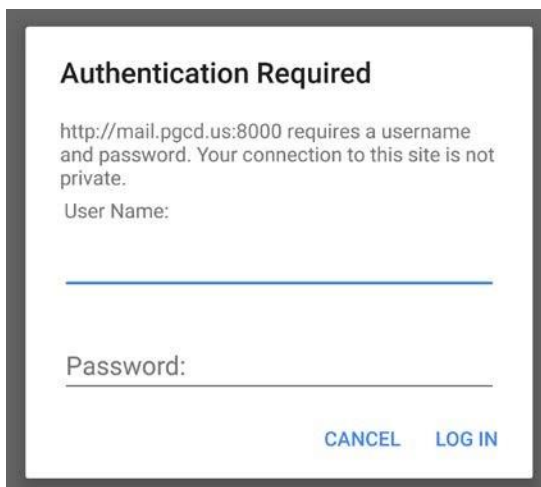
### 3.1 Device and Browser Compatibility

The MeterMaid mobile application is compatible with most smartphones and tablets. The preferred browser for each mobile operating system is detailed below. Android: Google Chrome iOS: Apple Safari

The MeterMaid mobile application can also be used on desktop or laptop computers. Use either Google Chrome or Mozilla Firefox for the best experience.

### 3.2 Logging In

Upon accessing the MeterMaid site, the user is greeted with the login form below. Here the user must log in with the account created for them via the MeterMaid Administrative panel.

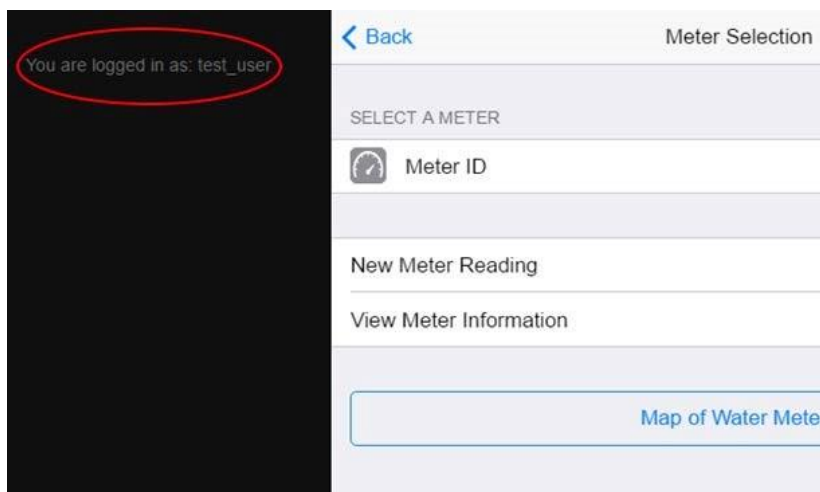
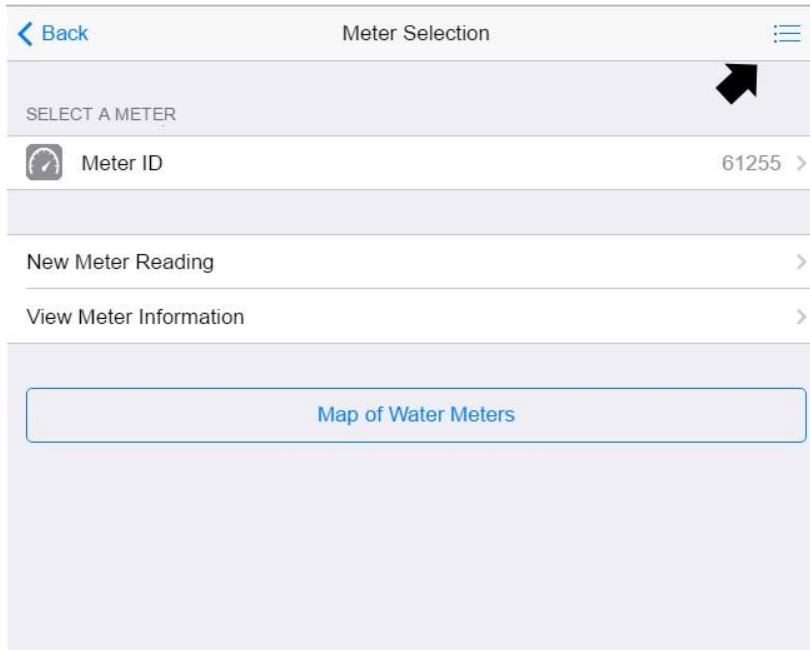


The screenshot shows a login form with the following elements:

- Title:** Authentication Required
- Message:** http://mail.pgcd.us:8000 requires a username and password. Your connection to this site is not private.
- User Name:** A text input field with a blue underline.
- Password:** A text input field with a blue underline.
- Buttons:** CANCEL and LOG IN buttons at the bottom right.

### 3.2.1 Viewing the Currently Logged in User

Tapping the details button in the upper right-hand corner of the app will open a sidebar showing the currently logged in user.

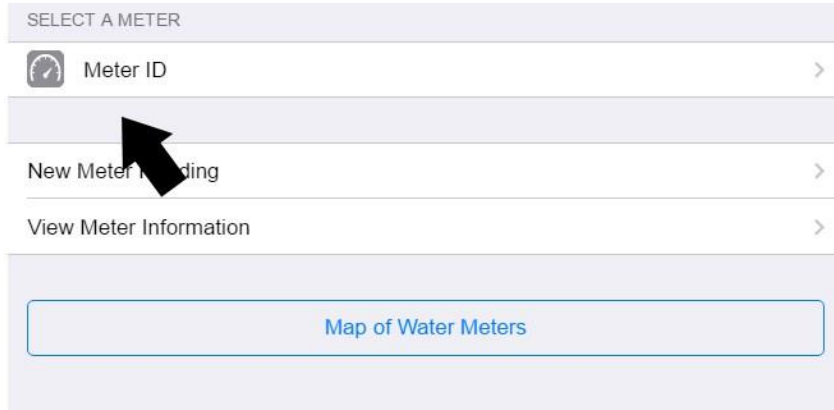


## 3.3 Meter Selection

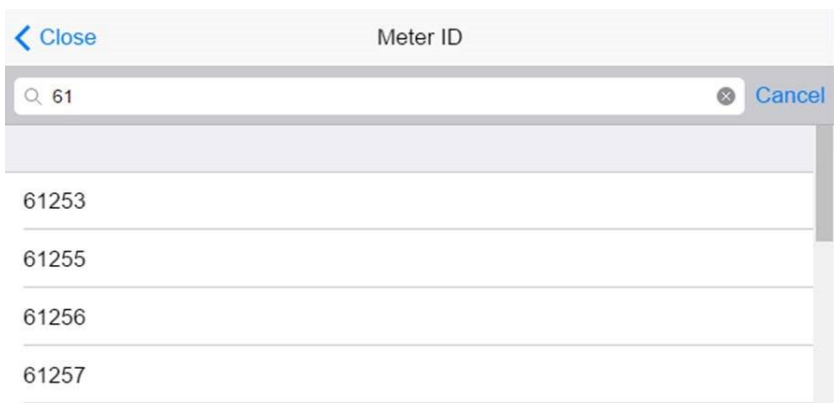
Meters can be selected via the meter map, or a dropdown with autocomplete. The user must select a meter before they are able to view historic water usage charts or submit a new reading.

### 3.3.1 Selecting a meter with the dropdown

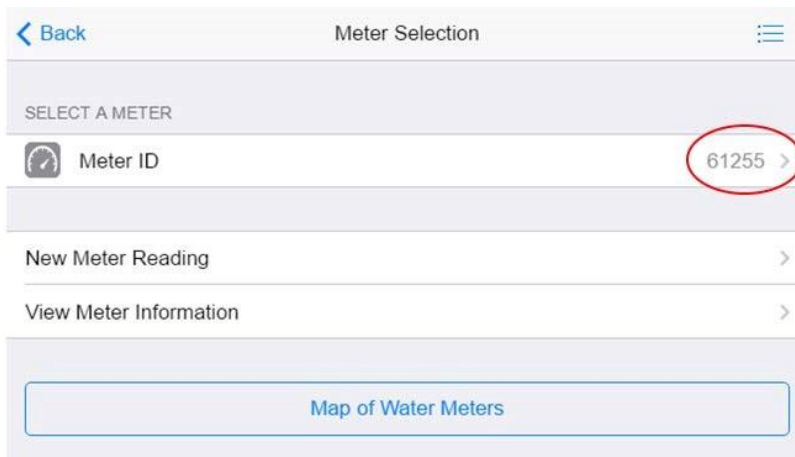
To open the dropdown, tap the "Meter ID" field.



Typing in the text field will search the database for meters beginning with or containing the typed text.

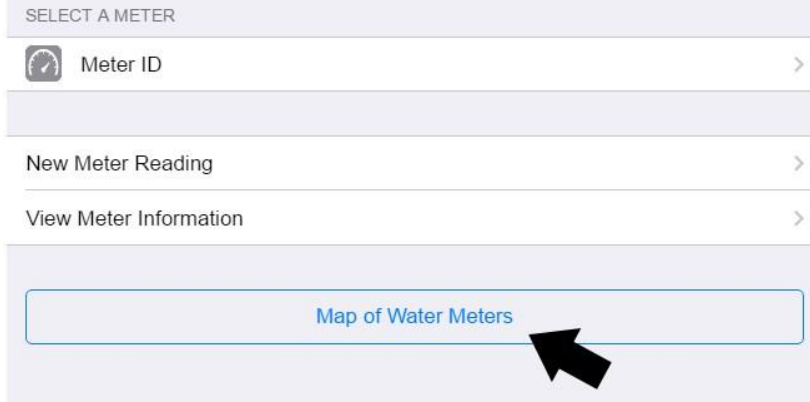


Tapping on a listed meter will close the dropdown and fill in the "Meter ID" field with the selected meter ID.

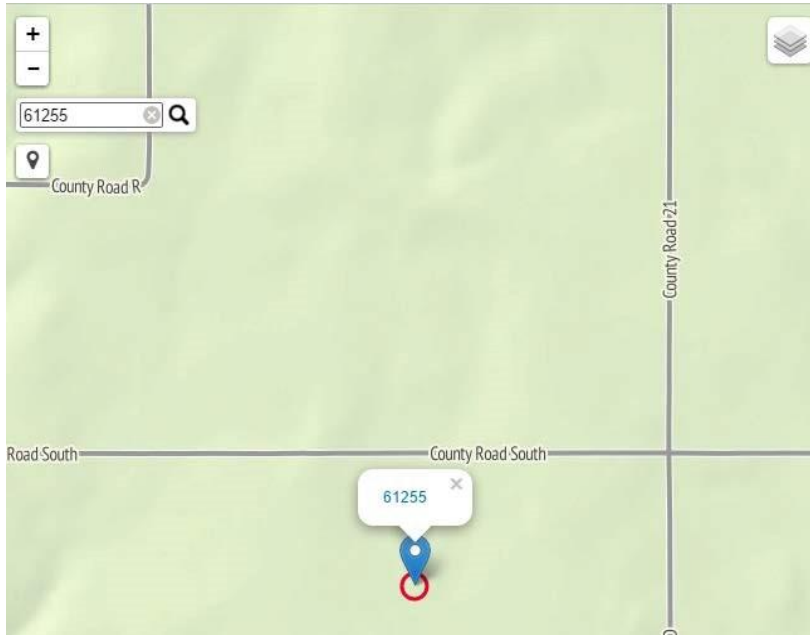


### 3.3.2 *Selecting a meter with the map*

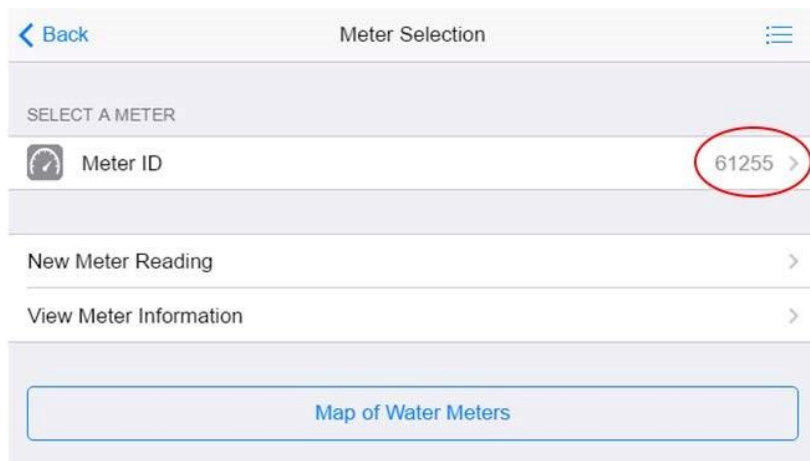
To open the map, tap the "Map of Water Meters" button on the bottom of the meter selection page.



Meters can be quickly found on the map by using the search feature ( ). Selecting a meter from the search dropdown will cause the map to zoom in on and highlight the selected meter.



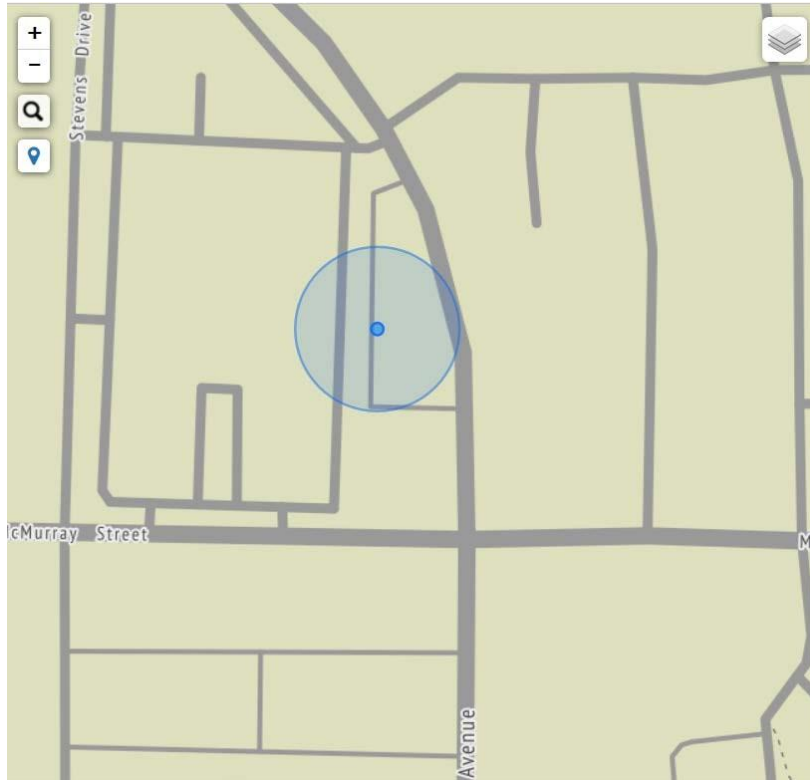
Tapping on the meter marker will cause a popup with the meter name to appear. Tapping on a popup will redirect the user back to the meter selection page and automatically fill the "Meter ID" field with the selected meter.



## 3.4 Map Tool

### 3.4.1 Current Location

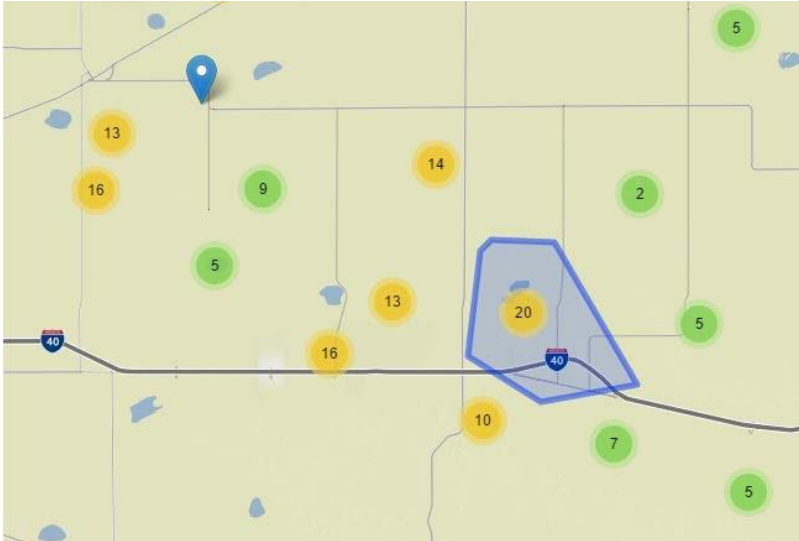
The user's current location can be displayed on the map by tapping the location button (📍). The map will then zoom to the user's location, signified by a blue dot surrounded by an accuracy circle.



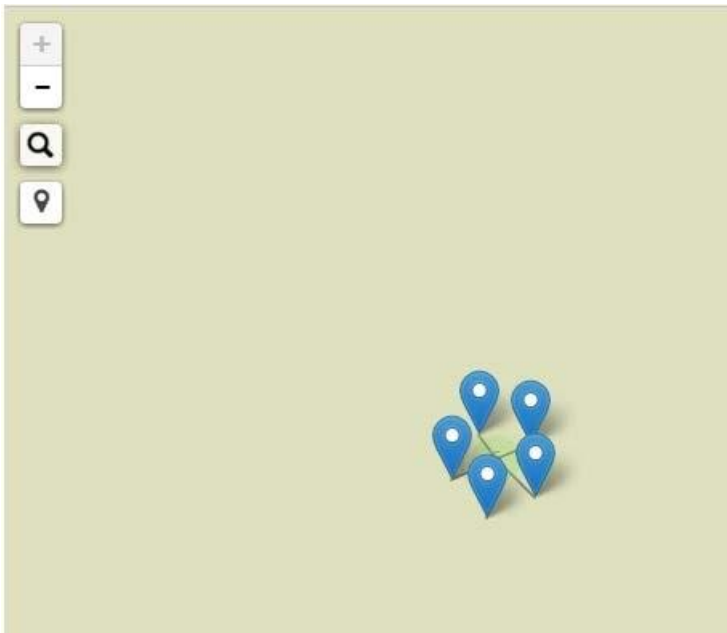
### 3.4.2 Meter Clustering

To make rendering densely packed meters more efficient, the meter map uses clustering. Tapping on these clusters or zooming in will cause them to break apart into smaller clusters or individual meter markers, depending on the density of the markers and the zoom level.

Hovering over a meter cluster will show the bounds of the meters included in the cluster.

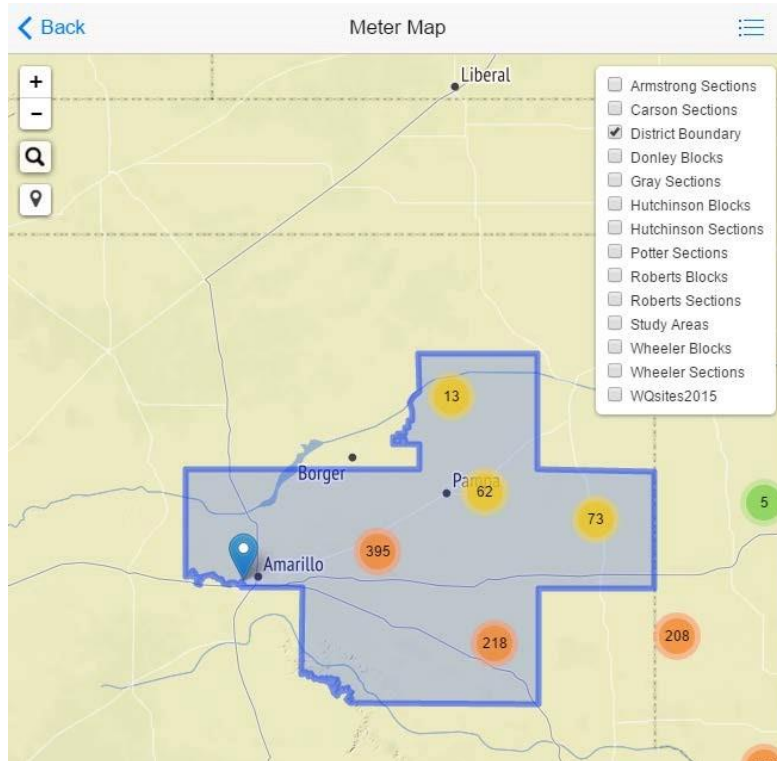


If multiple meters share the same location, they will not automatically separate when the zoom increases. Instead the user must tap on the cluster icon to view the separate meter markers.



### 3.4.3 *Shapefile Rendering*

The meter map is capable of displaying ESRI shapefiles, which can be toggled via the layer control.



Tapping on sections of these shapefiles will display information about that section of the shapefile in a popup.



### 3.5 Charting Tool

Historical Water usage charts can be viewed from the "View Meter Information" link on the Meter Selection page.

### 3.5.1 Timeline

The chart's timeline can be adjusted with the slider, the "From – To" fields, or by selecting a predefined timeline (6mo, 1y, 2y, 5y, YTD, All).



### 3.5.2 Legend

Tapping on a legend item will remove it from the chart, allowing Water Usage and Meter Readings to be viewed individually.





### 3.5.3 Saving Charts

Charts can be printed or saved in various formats by tapping the details button in the upper right corner of the chart. Charts can also be viewed full-screen, which is useful for viewing charts in landscape mode on an iPad.



## 3.6 Meter Readings

To take a meter reading, first select a meter, then tap the "New Meter Reading" button on the Meter Selection page.

Back Meter Selection

SELECT A METER

Meter ID 82574 >

New Meter Reading >

View Meter Information >

Map of Water Meters

The Meter reading form automatically fills the Meter field with the selected meter, and the Time/Date field with the current date. If the application was able to retrieve a GPS location from the device, the Location field will automatically update to show the current location.

Back Meter Reading

METER INFORMATION

Meter 82574

Time/Date 08/09/2016

Location Current GPS Data

GPM Current GPM

Reading Meter Reading

Crop(s) Select a Crop

Photo Choose File No file chosen

Needs Maintenance

Notes

Submit

### 3.7 Meter Reading Fields

#### Meter

Auto-filled field with the meter selected on the meter selection page, cannot be modified from the meter reading form

## Time/Date

Auto-filled field with the current date from the mobile device's clock. When manually overridden, opens a date picker for date selection.

The screenshot shows a form with several fields. The 'Time/Date' field is highlighted with a date picker. The date '08/09/2016' is displayed. The date picker shows a calendar for August 2016. The 9th is highlighted. The calendar shows the following dates:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	1	2	3

## Location

Latitude/Longitude field that is auto-filled by either the mobile device's GPS, or by a photo uploaded to the server in the Photo field. Can be manually overridden, but will only accept input in "Latitude, Longitude" pairs.

## GPM

Accepts a maximum value of 3000. The user will be warned if the input exceeds this number, and the field will automatically adjust to 3000.

## Reading

Accepts the number of characters defined by a meter's "DigitCount" property in the MeterMaid database. By default, this value is six characters. If the character limit is exceeded, the user will be warned and the input adjusted accordingly. This field or the Notes field is required to be filled when submitting a meter reading.

## Crop(s)


A multi-select field allowing the user to select multiple crops/land use categories and percentages for each.

Tapping this field will cause a scrollable selector to open containing a predefined list of crops and percentages.

The screenshot shows a form with a 'Crop(s)' field set to 'Corn 50%'. Below it is a 'Photo' field with a 'Choose File' button and 'No file chosen' text. A scrollable selector is open, showing a list of crops and their percentages:

Crop	Percentage
Bermuda	25%
Bluestem	33%
<b>Corn</b>	<b>50%</b>
Cotton	66%
Feedlot	75%

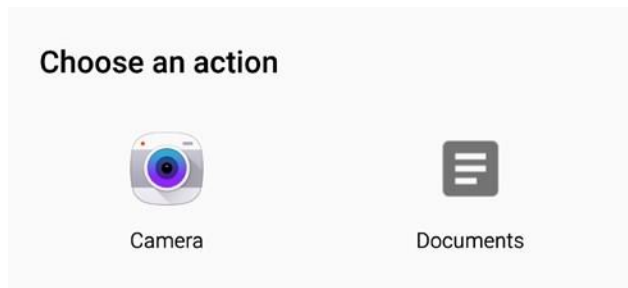
The Crop(s) field will continue to accept crops until the combined percentages reach 100% (or 99% in the case of 33%-66% splits).

	Crop(s)	Corn 50%
		Alfalfa 25%
		Peas 25%

### Photo






Tapping the "Choose File" button on the photo field allows the user to take a photo of a meter, or upload one from their device's storage.

When taking a photo, ensure that the mobile device is held in Landscape orientation and location is turned on for best results.



Pictures are stored on the MeterMaid server, and used by the mobile application to retrieve GPS information, assuming GPS was turned on when the picture was taken. If no GPS information is contained in the uploaded image, the user is notified.

If an image contains GPS information, it will be extracted from the image and used to automatically update the Location field.

	Location	-119.282 46.302
	GPM	Current GPM
	Reading	Meter Reading
	Crop(s)	Select a Crop
	Photo	<input type="button" value="Choose File"/> 20160324_130806.jpg

### Needs Maintenance

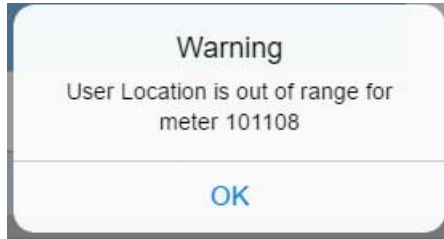
Tapping on the toggle button will mark this meter as needing maintenance when the reading is submitted.

### Notes

This field will accept theoretically unlimited text for notes. It is not required to be filled in unless the meter reading field is left blank.

#### 3.7.1 *Verifying Meter Location*

MeterMaid compares the current location of the user with the location of the meter a reading is being submitted for. If they do not match, the user will receive a warning, but the meter reading can still be submitted after closing the alert by tapping "OK".



### 3.7.2 Verifying and Submitting a Meter Reading

After filling out the meter reading fields and clicking the “Submit” button, the user is directed to the reading verification page where they can review the reading information they have submitted, including a graph how this new reading compares to previous readings.



Tapping the “Cancel” button will delete the meter reading information and return the user to the Meter Selection page. If edits need to be made to reading information, tapping the “Back” button in the top left corner will take the user back to the meter reading page without erasing any data. Tapping the “Submit” button will submit the meter reading to the database, and a “Submitting...” popup will display until all the recorded information has been uploaded.

## 4 Administrative Site

### 4.1 Overview

The administrative panel allows the viewing, editing, verifying, and exporting of meter readings. The administrative panel also manages user accounts for the MeterMaid mobile app.

The screenshot displays the 'MeterMaid Administration' interface. It is divided into two main sections: 'Site administration' and 'Recent Actions'.

**Site administration**

**AUTHENTICATION AND AUTHORIZATION**

- Groups: + Add, Change
- Users: + Add, Change

**METER**

- Meter readings: + Add, Change
- Water meters: + Add, Change

**Recent Actions**

**My Actions**

- test\_user (User)
- phgcd (User)
- 61255, 2016-05-26 (Meter reading)
- 61255, 2016-05-26 (Meter reading)
- 61257, 2016-05-26 (Meter reading)
- 1061483 (Water meter)
- 65007, 2016-05-26 (Meter reading)
- 65003, 2016-05-25 (Meter reading)
- phgcd (User)
- Meter-1 (Water meter)

### 4.2 Device and Browser Compatibility

For the best experience, the Administrative Site should be accessed on a Laptop or Desktop system through any of the major internet browsers (Google Chrome, Mozilla Firefox, Microsoft Internet Explorer).

### 4.3 Authentication and Authorization

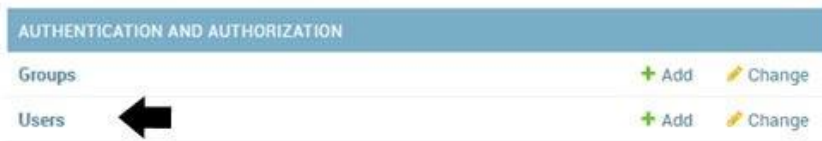
The "Authentication and Authorization" section contains User and Group information. When creating users, all MeterMaid mobile application users should be created under the "General Authorized User" group.

#### 4.3.1 Managing Groups

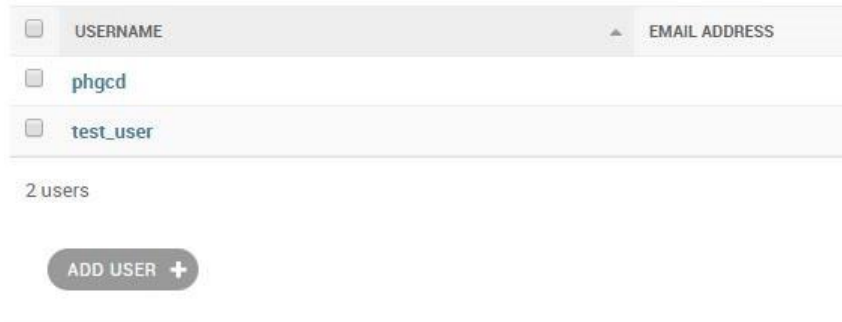
It is not necessary to create or modify groups, MeterMaid functions only take into account the "General Authorized Users" group.

### 4.3.2 Managing Users

Clicking the “Users” link will take you to a page where all User accounts can be viewed, and new ones added

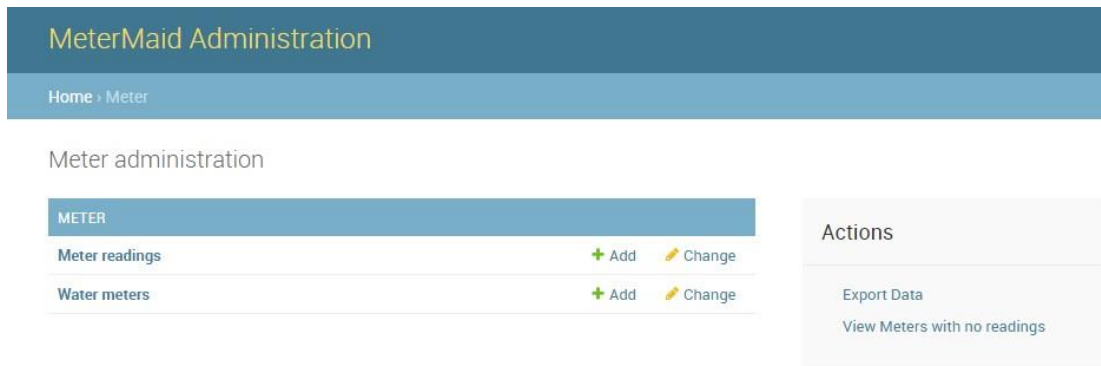


Click on a username to change information about that user, or add new users with the “Add User” button in the upper right corner.



## 4.4 Meters

The “Meter” section contains information on Meters, Meter readings, and allows data to be exported from the MeterMaid database to a .CSV file. “Meter readings” is a list of all the meter readings that have been taken via the MeterMaid mobile application. “Water Meters” contains a list of all the meters in the district’s database, as well as the location and digit count of each.



## 4.5 Meter Readings

From the meter readings page, the administrator can view the details of each individual meter reading by clicking on it. For meter readings to be exportable, they must be verified by the administrator.



Select meter reading to change

ADD METER READING +

Q  Search

Action:  0 of 100 selected

NAME	READINGDATE	USERID	CPM	READINGVALUE	USAGE	VERIFIED	MAINTENANCE	ADDED	UPDATED
682506	Aug 12, 2016		334	23423	44444			Aug 11, 2016, 10:57 p.m.	Aug 12, 2016, 10:31 a.m.
884123	Aug 12, 2016		444	345345	5555			Aug 11, 2016, 11:26 p.m.	Aug 12, 2016, 1:22 a.m.
1603241	Aug 12, 2016	admin	554	55555	3455333			Aug 12, 2016, 12:46 a.m.	Aug 12, 2016, 12:46 a.m.
91855	Aug 12, 2016	test_user	444	3444	965267			Aug 11, 2016, 11:44 p.m.	Aug 12, 2016, 12:10 a.m.
9981795	Aug 12, 2016		334	34	4443			Aug 11, 2016, 11:28 p.m.	Aug 11, 2016, 11:31 p.m.
9981795	Aug 12, 2016		34	4	44			Aug 11, 2016, 11:01 p.m.	Aug 11, 2016, 11:31 p.m.
121860	Aug 12, 2016		777	7777	667			Aug 11, 2016, 11:29 p.m.	Aug 11, 2016, 11:31 p.m.
882862	Aug 12, 2016		333	444	-			Aug 11, 2016, 11:25 p.m.	Aug 11, 2016, 11:25 p.m.
103398	Aug 11, 2016	test_user	0	23444	510680			Aug 11, 2016, 9:38 p.m.	Aug 12, 2016, 1:24 a.m.
582950	Aug 11, 2016	admin	-	-	-			Aug 11, 2016, 11:36 p.m.	Aug 11, 2016, 11:36 p.m.
1603239	Aug 11, 2016		0	0	-			July 20, 2016, 12:54 p.m.	July 21, 2016, 7:52 p.m.
9981795	July 26, 2016	pw	600	1922179	602850			July 26, 2016, 3:27 p.m.	Aug 12, 2016, 7:23 a.m.
101093	July 26, 2016	carcbobald	510	999999	997191			July 26, 2016, 9:02 p.m.	Aug 12, 2016, 1:24 a.m.
483602	July 26, 2016	pw	300	167081	18823			July 26, 2016, 4:06 p.m.	Aug 12, 2016, 1:24 a.m.
134084	July 26, 2016	test_user	3000	55545	669462			July 14, 2016, 4:50 p.m.	Aug 12, 2016, 1:24 a.m.
1082254	July 26, 2016	pw	500	290054	31667			July 26, 2016, 8:24 a.m.	Aug 12, 2016, 1:24 a.m.
641100	July 26, 2016	carcbobald	240	99042	535617			July 26, 2016, 8:59 p.m.	Aug 12, 2016, 1:24 a.m.
121864	July 26, 2016	pw	800	11	521221			July 26, 2016, 9:35 p.m.	Aug 12, 2016, 1:24 a.m.

**FILTER**

By verified






- All
- Yes
- No

By userid

- All
- admin
- carcbobald
- phodgen
- pw
- test\_user
-

When viewing the details of a reading, the administrator can see all of the reading information that was submitted, the location the reading was taken at, and what user account the reading was taken by.

### Change meter reading

Name:	782816  
Readingdate:	2016-07-07  Today 
Note: You are 7 hours behind server time.	
Readinglocation:	 <p>© OpenStreetMap contributors Scale = 1 : 27K -11229221.84444, 4235469.48441</p> <p>Delete all Features</p>
Latitude:	<input type="text" value="35.529"/>
Longitude:	<input type="text" value="-100.883"/>
Gpm:	<input type="text" value="800"/>
Readingvalue:	<input type="text" value="618629"/>
Usage:	<input type="text" value="618629"/>
Crops:	<input type="text" value="Corn, 100%"/>

## 4.6 Water Meters

The "Water Meters" page contains all of the Meters in the PGCD database, and is used by the map, autocomplete, and location verification functions of the MeterMaid mobile app.

Any new meters need to be added here or they will not show up in the mobile app.

MeterMaid Administration
WELCOME, PHGCD. [VIEW SITE](#) / [CHANGE PASSWORD](#) / [LOG OUT](#)

Home » Meter » Water meters

Select water meter to change ADD WATER METER +

Action: -----  0 of 100 selected

<input type="checkbox"/>	NAME	LATITUDE	LONGITUDE	ADDED	UPDATED
<input type="checkbox"/>	99101335	35.39277778	-101.1766667	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101245	35.4075	-101.1408333	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101244	35.36277778	-101.3016667	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101243	35.5	-99.5	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101242	35.36333333	-101.2663889	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101241	35.37638889	-101.3375	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101240	35.61472222	-100.5544444	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101238	35.39083333	-101.3905556	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.
<input type="checkbox"/>	99101197	35.40666667	-101.2659722	May 25, 2016, 10:08 p.m.	May 25, 2016, 10:08 p.m.

Clicking a meter name will take you to the edit page for that meter, which shows all the information imported from the PGCD database.

**MeterMaid Administration**

Home > Meter > Water meters > 99101241

Change water meter

Name:

---

Latitude:

---

Longitude:

---

Description:

---

DigitCount:

---

Oldmeterno:

---

Curr site no:

---

Cleanup:

---

Inentorycheck:

---

Field map:

---

Stwl no:

---

Meter inst dt:

## 4.7 Ensuring that edits are saved

If an edit needs to be made to a Water Meter or Meter Reading entry, ensure that the reading is saved by scrolling to the bottom of the edit page and clicking one of the save buttons.

Save and add another   Save and continue editing   SAVE

## 4.8 Exporting Data

Verified meter readings can be exported to a .CSV from the "Export Data" link

**MeterMaid Administration**


Home » Meter

Meter administration

METER	
Meter readings	<a href="#">+ Add</a> <a href="#">✎ Change</a>
Water meters	<a href="#">+ Add</a> <a href="#">✎ Change</a>

**Actions**

- [Export Data](#)
- [View Meters with no readings](#)



Simply select a start date, and click the button to download a .CSV

A .CSV with all the verified meter readings from the specified date to the current data will be generated and downloaded.

## MeterMaid Data Export

This will export all meter readings that have been verified as a .csv file, starting with the date below:

Date:

Please enter a date as 'YYYY-MM-DD'.



### 4.9 Viewing Meters Without Readings

The "View Meters with no readings" view allows the user to select a time period and view all meters that did not have a reading during that time period and the last recorded time that meter was read.

MeterMaid Administration

Home > Meter

Meter administration

METER	
Meter readings	+ Add Change
Water meters	+ Add Change

Actions

- Export Data
- View Meters with no readings

This view only takes the most recent reading of a meter into consideration. If the time period 2010-08-08 – 2011-08-09 is selected, any meters that had a last reading date prior to 2010-08-08 will be shown. However, if a reading was not taken for a meter between 2010-08-08 – 2011-08-09, but a reading was taken on 2011-08-10, the meter will not show up in the list. From the list of meters, the user can click on a meter and be redirected to a page where information about that meter can be edited.

## MeterMaid No Reading Filter

This will find all Meters that do not have any readings during the date range below:

Date start:  Date end:

Please enter dates as 'YYYY-MM-DD'.

Meters with no readings between 2000-08-05 and 2016-08-05

- [81958](#): last read May 17, 2000
- [988110](#): last read May 4, 2000
- [9961253](#): last read March 23, 1999
- [9961341](#): last read April 12, 1999
- [9961344](#): last read April 16, 1999
- [9961347](#): last read April 13, 1999
- [9961387](#): last read April 16, 1999
- [9961619](#): last read Aug. 24, 1999
- [9981462](#): last read March 16, 1999
- [9981465](#): last read March 4, 1999
- [9981468](#): last read March 31, 1999
- [9981471](#): last read March 17, 1999
- [483609](#): last read April 15, 2000
- [9961251](#): last read March 8, 1999
- [9961254](#): last read March 11, 1999
- [9961342](#): last read June 2, 1999
- [9961345](#): last read April 7, 1999
- [9961348](#): last read April 12, 1999
- [9961443](#): last read May 12, 1999
- [9981460](#): last read March 17, 1999
- [9981463](#): last read March 17, 1999
- [9981466](#): last read March 4, 1999
- [9981469](#): last read March 8, 1999
- [9981472](#): last read April 6, 1999

## 5 Support

Support for the MeterMaid application can be obtained by emailing Mitchell Tufford at [mtufford@intera.com](mailto:mtufford@intera.com) or Wade Oliver at [woliver@intera.com](mailto:woliver@intera.com).

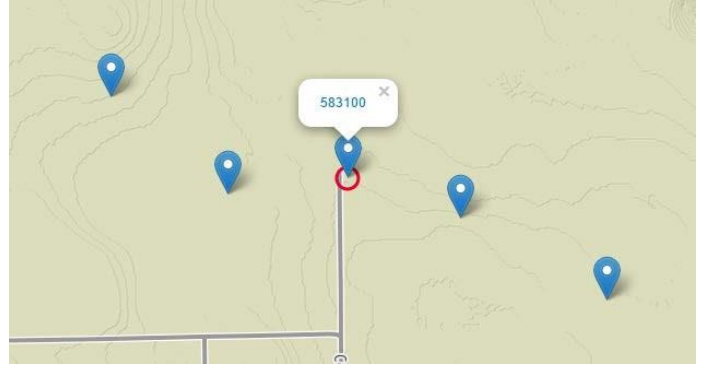
# **Appendix E**

## **Example Water Use Report**

# Water Usage Report

Meter 583100 –  
Armstrong County

November 29, 2016



**Meter Location**

## Owner and Operator Information

Panhandle Groundwater  
Conservation District 201 W. 3<sup>rd</sup> Street  
White Deer, TX 79097 [www.pgcd.us](http://www.pgcd.us)

Owner First Name John  
 Owner Last Name Doe Operator First Name John  
 Operator Last Name Doe  
 Operator Address 2xxx US Hwy 287  
 Operator city Anywhere  
 Operator Zip 79xxx  
 Phone Number 806-xxx-xxxx

## Most Recent Reading and Calculating Water Usage Photo of Most Recent Reading

Reading Date: 2016-09-27  
 Current Reading Value (CRV): 161693  
 Previous Reading Value (PRV): 159627  
 Rollover Value 1000000  
 Meter Multiplier (MM): 1000  
 Meter Correction Factor (MCF): 1.011  
 Water Usage Calculation:  
 $(CRV - PRV) * MM * MCF / 325851 = 6.4$  acre-feet



## Recent Readings and Water Usage

Date	Days Since Last Reading	Usage (acre-feet)	Usage (million gallons)	Average Use Rate (gallons per minute)
2011-09-06	111	102.1	33	208
2012-02-24	171	12.6	4	17
2012-06-20	117	22.7	7	44
2012-08-17	58	54.1	18	211
2012-10-10	54	26.6	9	111
2014-03-14	520	89.7	29	39



2015-02-17	340	73.71	24	49
2015-10-26	251	61.8	20	56
2016-08-09	288	26.7	9	21
2016-09-27	49	6.4	2	30
<b>Total</b>	<b>1959</b>	<b>476.4</b>	<b>155</b>	<b>55</b>
<b>Annual Average</b>	<b>365</b>	<b>88.9</b>	<b>30</b>	<b>55</b>

Individual staff members' comments on the draft final report  
Agricultural water conservation contract #1003581101

Contractor's responses in **blue font**.

1. Please revise the task descriptions in the executive summary to match the final version of the scope of work, rather than referencing both the original task names and the revised task names from Amendment 4.
  - a. Include tasks 1–3, as defined in Amendment 3; and,
  - b. Task 4, as defined in Amendment 4.
  - c. *Task 5 was removed from the scope of work by Amendment 4. No need to mention this task.*

**This was accommodated.**

2. Include in the executive summary, an estimate of water savings (or improvements in water use efficiency) as a result of the activities funded through this project.

**This was done.**

3. Consider also reorganizing the body of the report into sections that match the final task descriptions.
  - a. Suggest moving the information presented in Appendix A into the main body of the report.

**This was considered but the decision was to leave the sub-contractor reports separate.**

- b. Note that Appendix A currently includes two appendices of its own, resulting in duplicate sections in the report titled as "Appendix A" and "Appendix B".

**This was re-labeled.**

- c. Update the table of contents to match any such changes, and consider including a list of figures.

**This was done.**

- d. The TWDB formatting guidelines and author's report formatting template are available online, as an example, at [http://www.twdb.texas.gov/about/contract\\_admin/index.asp](http://www.twdb.texas.gov/about/contract_admin/index.asp).

4. Remove the task numbers from the names in the appendices.

**This was done.**

5. In Appendix A, Figures 1 and 5, consider including a table and/or a secondary y-axis to graph the actual value of the meter readings, along with the daily average distribution lines. The basis for these lines is unclear without those values.

**In conversation with a TWDB staff member it was understood the stair-stepping was the issue. The stair-stepping is necessary to reflect the average water use either 1) between two readings (e.g. figures 1 and 5) or 2) by month for a set of readings (e.g. figures 2-4). Connecting the pairs of data with a curve as is commonly done on line charts was discussed, but that approach can mislead the reader into interpreting that water use is**

steadily increasing or decreasing over a particular time period. In our view, the choppiness of the lines better communicates the density of data used to develop the charts.

6. Please provide further clarification on the outliers in Figures 2 and 4 in Appendix A.  
Outliers can result from physical meter issues such as an incorrect propeller or a malfunction of the register. Transcription errors do happen as well. The application will help mitigate these issues.
7. In the Appendix A appendices (Appendix A: List of Unique Meter IDs and Appendix B: List of Meters and their Water Use Category), consider moving the introductory statement about the highlighted records into a key to explain the significance of the shading and why irrigation was the assumed use for records without a defined water use category.  
A key to the tables was inserted in the report. The sub-contractor talked with the PGCD staff on this subject. After consideration of location and volume of water produced, the PGCD decided a water use of irrigation was prudent.
8. The contract requires delivery of an electronic copy of any computer programs and user manuals developed through this project.
  - a. Please coordinate with TWDB staff to determine a satisfactory means of delivering the MeterMaid application. This is considered joint property of the TWDB, the Contractor, and the Subcontractor, according to the terms of the contract. TWDB staff will need to review the actual web application to confirm consistency with the information presented in the report. Consider developing a login profile for TWDB staff to access a sample demonstration of the application.  
A TWDB staff member advised a USB flash drive and one is provided along with the hard copies of the report.  
A demonstration website exists with the URL of <https://metermaid.intera.com/>  
The username is TWDB and password is twdbpassword1
  - b. Please consider acknowledging TWDB in the MeterMaid User Guide; and, provide a revised electronic copy of the document.  
This was done.
9. Please remove any personal identification information of individual agricultural producers in the report, for example, the landowner's name, address, and phone number in Appendix E.  
This was done.