ANNUAL MONITORING REPORT
2014

MARANA HIGH PLAINS EFFLUENT RECHARGE PROJECT

Underground Storage Facility Permit No. 71-563876.0007 (PCRFCD)
Water Storage Permit No. 73-563876.0200 (PCRWRD)

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TABLE OF CONTENTS

1.0 INTRODUCTION

The Marana High Plains Effluent Recharge Project (MHPERP) is a constructed recharge project developed by the Pima County Regional Flood Control District (PCRFCD) in cooperation with the Bureau of Reclamation (BOR), Arizona Water Protection Fund (AWPF), Pima County Regional Water Reclamation Department (PCRWRD), and the Town of Marana. The project is located in Section 33 of Township 11 South, Range 11 East in the Avra Valley sub-basin of the Tucson Active Management Area (**Figure 1**). It is one component of a regional water resource, flood control, environmental protection and enhancement, and recreation program (the Northwest TAMA Replenishment Program) that is sponsored by more than a dozen local, state, and federal entities.

MHPERP is designed to recharge treated effluent into the local groundwater aquifer, while simultaneously creating wildlife habitat and public recreation opportunities associated with recharge facilities. The overall objectives for the project include the following:

- To recharge up to 600 acre-feet of water per year while maximizing infiltration rates in basins having side slopes vegetated with emergent plants and riparian trees;

- To provide trails, descriptive literature, and interpretive signs describing the project operations. Trails at the project site may eventually be linked to a longer river trail network that is scheduled to be built along the Santa Cruz River;

- To re-vegetate the area outside the recharge basins with plants that will improve wildlife habitat value and, once established, could survive if the recharge activities cease;

- To maintain wildlife, aquatic macroinvertebrates, and vegetative resources associated with an important effluent-dominated stream; and

- To monitor the biological effects that may result from establishing other habitat types that are now rare to the area (e.g., marsh, grassland), and increase the aerial extent of riparian vegetation.

The MHPERP facility is comprised of one settling basin (equalization basin) and four spreading basins (recharge cells), totaling 4.5 acres of recharge area (**Figure 2**). A comprehensive description of the MHPERP and the related monitoring plan was provided to the Arizona Department of Water Resources (ADWR) in support of the Constructed Underground Storage Facility (USF) Permit Application for the project filed in June 2007. In addition to the USF Permit (No. 71-563876.0007), the facility has an Aquifer Protection Permit (No. P-103195) from the Arizona Department of Environmental Quality (ADEQ) that authorizes the discharge of treated effluent into the aquifer.

The facility has been operating since February 2003, first as a pilot project and then as a constructed recharge project. In accordance with Sections 2 and 3 of the USF Permit (all versions), this is the twelfth annual report for the MHPERP. This report includes all of the data that was collected during the 2014 Calendar Year.

2.0 PROJECT OPERATIONS

A modified USF Permit was approved and signed by the ADWR Assistant Director, Ms. Sandra Fabritz-Whitney, on November 24, 2008. This permit authorizes PCRFCD to store effluent at MHPERP over a twenty-year term (through November 24, 2028) or until the Operation Prohibition Limits are met. Maximum annual storage at the facility is based on three constructed phases as follows:

Phase 1: 350 acre-feet per annum recharged within the equalization basin and the four recharge cells, as constructed in 2002;

Phase 2: 450 acre-feet per annum after construction of recharge enhancement trenches within Recharge Cells 1, 3 and 4, as constructed in 2009.

Phase 3: 600 acre-feet per annum after re-excavation of Recharge Cell 2, as constructed in 2010.

The facility was operated per Phase 3 of the permit throughout the 2014 Calendar Year. Contingency plans are in place within the current USF Permit to allow the District to perform enhancement functions as needed to maximize recharge at the facility.

2.1 Water Delivery

Water is delivered to the MHPERP via the "oxbow" channel, a remnant channel of the Santa Cruz River from when the riverbed was less incised and the channel meandered back and forth across the floodplain. A berm consisting of streambed materials is used to divert some of the effluent flowing down the main channel of the Santa Cruz River into the oxbow channel. Sources of the effluent discharges are the Roger Road Wastewater Treatment Plant and the Ina Road Wastewater Treatment Plant, which are approximately 15 miles and 10 miles upstream of the diversion structure, respectively. The effluent flows down the oxbow channel for about one mile before reaching MHPERP.

A constructed wet well collects the oxbow channel flows and two non-clogging, submersible pumps convey the effluent through an 8-inch line into an equalization basin. The equalization basin is used to provide a more constant source of available effluent for recharge and to help serve as a settling basin for removing particulate materials that could clog the recharge cells. A level sensor is installed in this basin to automatically turn the pumps on and off based on levels within the oxbow channel and the equalization basin. From the equalization basin, the effluent passes through a 16-inch isolation valve into the main distribution line, which feeds into each of the four recharge cells through motorized butterfly valves. A level sensor is installed at each cell to automatically open and close the valves based on pre-set water levels. The valves are closed, either using an electronic switch or manually cranking the turn valve, by the daily operator when the cells are scheduled for a drying cycle.

Deliveries to MHPERP are based on the daily cycle of discharges from the treatment plants to the Santa Cruz River. Peaks in water levels at this site normally occur in the late morning and early evening hours. Deliveries to the facility are impacted by storm water events in the Santa Cruz River that demolish the earthen structure used to divert flows into the oxbow channel. Malfunctioning pumps, faulty valve controls, and basin maintenance can also disrupt deliveries to the recharge cells. Details of all the delivery interruptions for Calendar Year 2014 are provided in Section 6.0 (Facility Inspections and Maintenance) of this report.

2.2 Inflow Volumes

Water deliveries into the MHPERP facility are measured using a Magnetflow® Mag Meter installed within the main line that runs from the pumps to the equalization basin (FMeq). The daily totals are read on-site by the facility operator, who compiles the data onto a daily log sheet. The daily log sheets are transmitted to PCRFCD staff on a weekly basis.

Appendix A contains the daily flow meter readings and volumes for Calendar Year 2014. Monthly, quarterly and annual volumes are provided at the bottom of the worksheets in both gallons and acre-feet. The total water volume delivered to MHPERP for Calendar Year 2014 was 612.7 acre-feet (AF). Water volumes delivered for recharge by month are as follows: January – 70.0 AF, February – 71.6 AF, March – 78.6 AF, April – 76.2 AF, May – 85.4 AF, June – 74.9 AF, July – 16.6 AF, August – 0.0 AF, September – 23.6 AF, October – 69.4 AF, November – 41.8 AF, and December – 4.7 AF. A total amount of 606.2 AF (after subtracting evaporation/evapotranspiration) was stored at the facility during the Calendar Year. This means that the maximum permitted amount of 600 AF was stored for the Pima County Regional Wastewater Reclamation Department (formerly Pima County Wastewater Management), who has a Water Storage Permit (No. 73-563876.0200) for the facility.

2.3 Evaporation/Evapotranspiration

Appendix B displays the calculated monthly, quarterly and annual evaporation volumes for the recharge facility. These calculations are based on the Cooley Method (1970) using the “Maximum Curve”, as approved by ADWR (also in **Appendix B**). Evaporation for each recharge cell was based on the percentage of open surface water that is not covered by vegetation. Daily and monthly wetted areas are provided in **Appendix C**.

Daily and monthly evapotranspiration volumes for the vegetated basins are provided in **Appendix D**. Evapotranspiration for each recharge cell was based on the percentage of vegetation within each basin, which was determined on a monthly basis during routine site inspections. The evapotranspiration volumes are calculated using the daily reference evapotranspiration values determined by the Arizona Meteorological Network (AZMET) at their Tucson weather station (**Figure 3**).[1] AZMET determines reference evapotranspiration (ETo) using a modification to the Penman Equation developed for the California Irrigation Management Information System (CIMIS). An explanation of the procedures used in this computation is also provided in **Appendix D**. No multiplication factor was used in the calculation of reference evapotranspiration (ETo) for the MHPERP because there are no available crop coefficients for the native vegetation in this region.[2]

[1] The Marana weather station has been out of service since December 14, 2011 so reference evapotranspiration values were collected from the Tucson weather station for Calendar Year 2014.

[2] The reference evapotranspiration (ET) values are determined for tall (8-15”), cool season grasses. Much of the vegetation in Recharge Cells 3 and 4 consists mostly of shrubs and grasses that are approximately 8-15” in height. Since no information is available for the species at MHPERP, it is assumed that ET losses at this facility are the same as those calculated at the AZMET station.

2.4 Recharge Volumes

The water quantity reporting summary is provided at the end of **Appendix A**. This summary includes the monthly net recharge volumes for the facility, which are the sum of the monthly volumes delivered to the recharge cells less the monthly evaporation and evapotranspiration losses. Quarterly sums and the annual sum are also provided on this worksheet. The net recharge (effluent stored) for the facility during the 2014 Calendar Year is 606.2 AF.

3.0 HYDROLOGIC MONITORING

Hydrologic monitoring of the facility includes measurement of on-site and off-site groundwater levels and direct observation of basin water levels. The on-site monitoring network consists of one monitor well and one piezometer, both measured monthly using a depth sounder (**Figure 4**). Off-site monitoring consists of quarterly water level measurements for one monitor well, SC-10.

3.1 Basin Water Levels

Water levels within the equalization basin are expected to fluctuate from one to five feet above the bottom elevation of 1,984 feet above mean sea level. Water depths in Recharge Cells 1 and 3 can fluctuate from 4 to 5 feet during the wet cycle, while water depths in Recharge Cell 2 can fluctuate from about 5 to 6 feet during the wet cycle.[3] Water depths in Recharge Cell 4 are expected to fluctuate from six to twenty inches during the wet cycles.[4] Water level sensors within the basins are programmed to automatically open and close the motorized butterfly valves to maintain these ranges if needed. However, due to malfunctioning electrical systems over the last year, the daily operator has been in charge of maintaining water levels in each of the recharge cells. Valves are operated on a manual basis by the daily operator, based on basin level conditions observed, until the automated systems can be repaired.

3.2 Regional Groundwater Levels

In 2014, groundwater levels were measured for two monitoring wells, one on-site (HP-1) and one off-site (SC-10). Both wells were measured by PCRFCD personnel using either an electric sounder or contact meter. HP-1 was measured on a monthly basis and SC-10 was measured on a quarterly basis.

Appendix E contains the water level data and hydrographs for the on-site and off-site monitor wells. All of the monitor wells have alert levels of 30 feet below land surface (bls) and operation prohibition limits of 20 feet bls. Alert levels for the monitoring wells were not exceeded during the 2014 Calendar Year. Water levels in the on-site deep well (HP-1) fluctuated from 189.2 feet below land surface (bls) in January 2014 to 199.8 feet bls in July 2014, and back up to 191 feet bls in December 2014. The off-site monitor well (SC-10 ranged from 191.2 feet bls in December 2014 to 198.5 feet bls in June 2014.

[3] Water depths have been significantly increased in these three basins due to enhancement activities, but the level sensors are still at the original elevation of 1982 feet.

[4] Water depths are measured from a base elevation of 1982 feet above mean sea level. The bottom of the basin has been lowered approximately 8-10 inches by regular maintenance activities to remove vegetation and clogging soil layers.

3.3 Perched Groundwater Occurrence

Appendix E also contains the monitoring data and hydrograph for the one piezometer (HP-2) used to assess perched water conditions at the facility. This well was dry at its total depth of 80 feet bls during the entire 2014 Calendar Year. The alert level and operation prohibition limit for this well are set at 30 feet bls and 20 feet bls respectively.

4.0 INFILTRATION RATE ASSESSMENT

The average monthly, quarterly and annual infiltration rates for the entire facility during the 2014 Calendar Year are displayed in **Appendix F**. Infiltration rates were estimated using the "volumetric" method, which is simply the total daily inflow divided by the wetted acreage. Total wetted acreage for the facility is a summation of the wetted acreages for the individual recharge cells, which is described below.

Average monthly, quarterly and annual infiltration rates for each of the recharge cells are also displayed in **Appendix F**. The total wetted acreage used to calculate the infiltration rate within each recharge cell is determined using observations made by the daily operator combined with known topography of the recharge cell bottom. Rating curves, calculated using topography of the site, are used to estimate the percentage of wetted area in each recharge cell. The percent wetted area is then multiplied by the total basin acreage to calculate the wetted acreage.

Water levels within the equalization basin are determined visually by the facility operator using a staff gauge. The data is recorded onto daily logs and provided to PCRFCD on a monthly basis. Infiltration rates are then calculated using the same methods as for the recharge cells described above.

In 2014, monthly infiltration rates for the project ranged from 0.00 feet per day (August-no water delivered) to 3.61 feet per day (December). The average infiltration rate for the year was 1.86 feet/day, which is 1.3 feet/day higher than last year's average and is the highest annual infiltration rate ever recorded at this facility. Except for August, when no recharge occurred, monthly infiltration rates never dipped below 1.44 feet/day for the facility. Significant increases in infiltration were observed after May 2014, which is most likely due to excavation work performed in Recharge Cell 3 to remove three to four feet of fine grained soil materials, thus allowing for greater drying cycles within the other basins.

Infiltration was the highest in Recharge Cell 1 (7.23 feet/day annual average), which was over-excavated in September 2013 to remove fine grained materials and expose coarser sands and gravels. Recharge Cell 2 also had a high rate (3.57 feet/day), due to continued exposure of sands and gravels since it was over-excavated in April 2010. Recharge Cell 3 was over-excavated in May 2014 to remove fine-grained materials and expose coarse sands and gravels located approximately three to four feet below the previous bottom surface; this resulted in a much higher annual infiltration rate (2.52 feet/day) than in any previous year of operation. Recharge Cell 4 still has the greatest depth to coarse sands and gravels, approximately 7.5 to 8 feet, which accounts for its continued low annual average infiltration rate (0.60 feet/day in 2014). The equalization basin had the lowest annual average infiltration rate (0.07 feet/day), but this is primarily due to its function as a settling basin for fine deposits from effluent deliveries into the facility.

5.0 WATER QUALITY MONITORING

5.1 Water Quality Sampling Activities

The Aquifer Protection Permit (APP) requires water quality samples to be collected and analyzed on a monthly basis for nutrients (Nitrogen constituents) and total coliform (presence/absence); on a quarterly basin for total metals, fluoride and cyanide; and on a semiannual basis for Volatile Organic Compounds (VOCs). Samples are collected from the source water inflow and from monitor well HP-1. Nitrogen forms are monitored more frequently because of the high nitrogen content in effluent water, and the potential for recharge to increase the nitrogen content in the local aquifer through leaching of nearby agricultural soils. Water quality sampling at the MHPERP also serves as a tool for studying nitrogen transformations in riparian and aquatic ecosystems, to determine if nitrogen levels can be reduced through the wetland recharge process.

5.2 Chemical Analyses Results

Table 1 summarizes the results from samples taken during the 2014 Calendar Year. Samples were taken at the oxbow channel (Source Water) and at the compliance well (HP-1). There were no disruptions for sampling the Source Water or HP-1.

There were no exceedances of the aquifer quality limits in 2014 for both the Source Water and HP-1. Therefore, there was no violation of the Aquifer Protection Permit (APP) during Calendar Year 2014.

6.0 FACILITY INSPECTIONS

Inspections of the facility equipment and functions were required by the APP on a weekly basis through June 2014. The facility operator at MHPERP performs inspections on a daily basis while collecting data for PCRFCD, transmitting any problems or required maintenance through the daily logs delivered on a weekly basis to PCRFCD. PCRFCD staff is contacted immediately for any alarms or serious problems concerning the facility equipment. PCRFCD performs weekly investigations of the facility to insure quality of the data collected and note any general maintenance needs.

Table 2 lists the problems that occurred during the 2014 Calendar Year and the actions performed to resolve them. The main disruption of effluent deliveries to the facility was due to storm water runoff events along the Santa Cruz River during the summer monsoon period, which is typical for every year. The two month period from July through August was used to allow the recharge cells to dry and for maintenance activities such as the excavation and removal of vegetation and fine grained soil materials from the cell bottoms. A few small storm water runoff events occurred during the rest of the year causing washout of the berm, but it was easily repaired and caused only temporary disruptions in effluent delivery (total of 22 days). Effluent deliveries to Recharge Cell 1 were halted for about one month in March to repair erosion damage around the inlet spill pad. Effluent deliveries to Recharge Cell 3 were halted from mid-April to late May for maintenance crews to over-excavate soil materials from the bottom to help improve infiltration rates.

7.0 CONCLUSIONS

The calculated volume of water stored at MHPERP for Calendar Year 2014 was 606.2 AF. This is over 100 AF more than last year's total of 500.3 AF, and is the first time that the facility has reached its permitted maximum of 600 AF since facility operations began in 2003. The facility operated under Phase 3 of the modified USF Permit No. 71-563876.0007 for the entire Calendar Year, which allowed the District to store a maximum of 600 AF per year.

Monitoring of operations has shown no exceedences of water quality standards at the project site. On-site and off-site monitoring showed no negative impacts to surrounding operations from a water level perspective.

Recharge Cell 2 continues to perform at a high level, having contributed 45% of the total amount of effluent stored at the facility over Calendar Year 2014. However, this amount is about 11% less than last year's contribution, which can be attributed to the improvements made to Recharge Cells 1 and 3 over the last two years. Recharge Cell 1 was over-excavated in September 2013, contributing about 26 % of the total amount of effluent stored at the facility in 2014 (up 11% from the 2013 Calendar Year). Recharge Cell 3 contributed about 20% of the total amount of effluent, up 6% from last year; and was over-excavated in May 2014 to expose coarser sands and gravels. Recharge Cell 4, which only had a few inches of clogging soil materials removed during regular maintenance, contributed 7% to the total recharge amount. The equalization basin, which had some maintenance performed during regular maintenance, provided less than 2% to the total volume.

Infiltration rates for the facility gradually increased during the Calendar Year, especially after maintenance activities were performed on each of the basins in late August and from effluent with lower turbidity and nutrients resulting from upgradient treatment facility improvements in March 2014. The average annual infiltration rate for the entire facility in 2014 was 1.86 feet/day, which is 1.1 feet/day greater than the previous annual high of 0.76 feet/day that was recorded in 2008. Recharge Cell 1 had the highest annual infiltration rate in 2014 (7.23 feet/day), while Recharge Cell 4 had the lowest (0.60 feet/day).[5] Excavation within Recharge Cells 1 and 3, and thus exposure of coarse sands and gravels, over the last two years has significantly helped the overall infiltration rate for this facility, especially when coupled with the continued high rates within Recharge Cell 2 (3.57 feet/day in 2014).

A total of 120 days (about 4 months) resulted in no effluent deliveries to the project. However, 40 days were due to the facility reaching its permitted amount of 600 AF by November 19th. Much of the remaining down time (80 days) was due to washout of the diversion berm by storm water flows during the months of January, July, August and September. Some of the down time in the summer, approximately 14 days, can be attributed to maintenance activities within the recharge cells, which continues to have a significant effect on infiltration rates by frequently breaking up the clogging layers that form in the basin bottoms. Additional excavation within Recharge Cell 3 in May 2014 has greatly increased infiltration by exposing more coarse sands and gravels in this basin. Three of the five basins have been excavated down to coarse sands and gravels, thus making the facility much more efficient and making 600 AF of recharge per annum more attainable.

[5] The equalization basin actually had the lowest infiltration rate recorded (0.07 feet/day), but this basin is primarily used for purposes other than recharge to the aquifer so it is not included in the comparison of infiltration rates.

FIGURES

FIGURE 1
Location Map

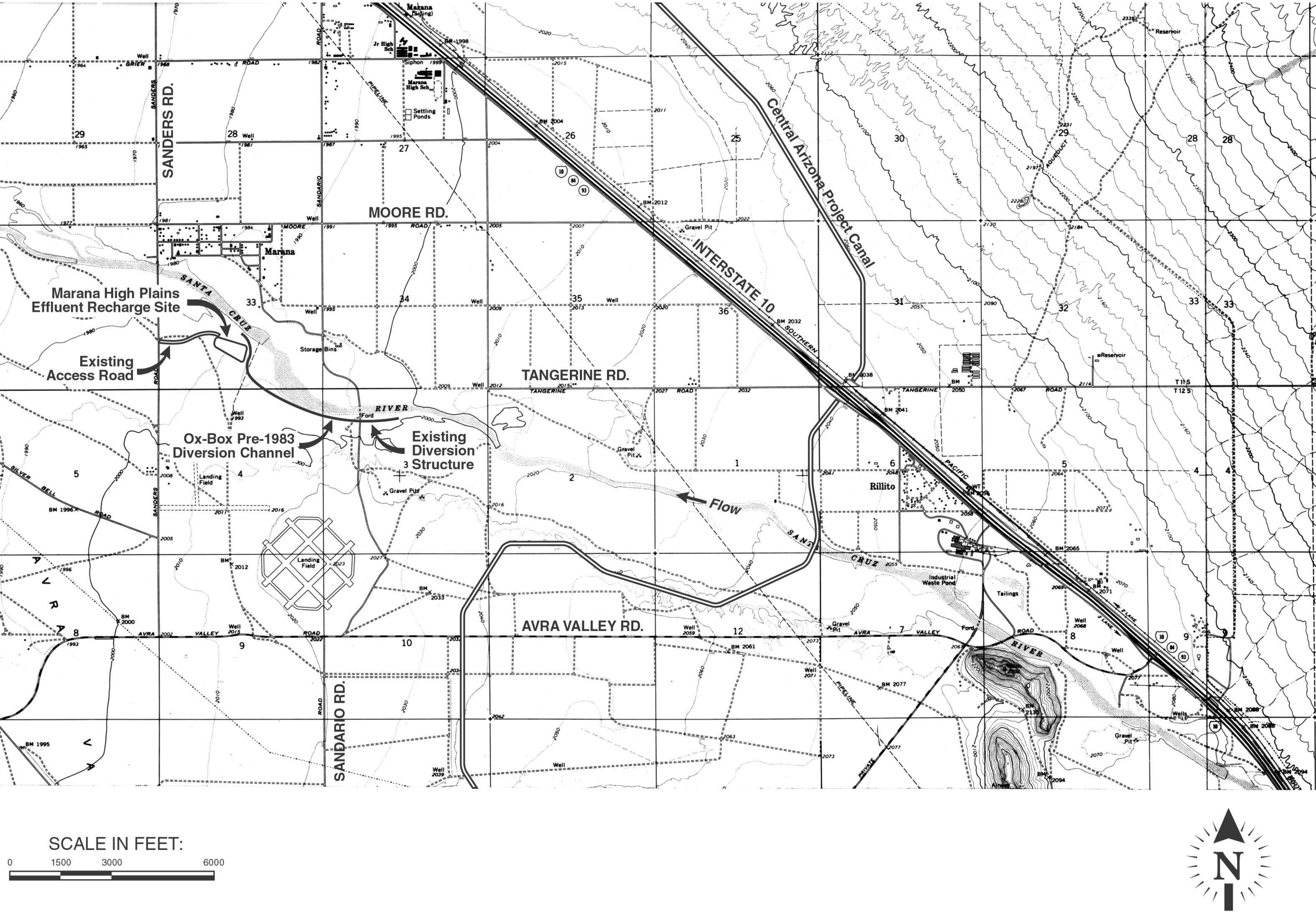
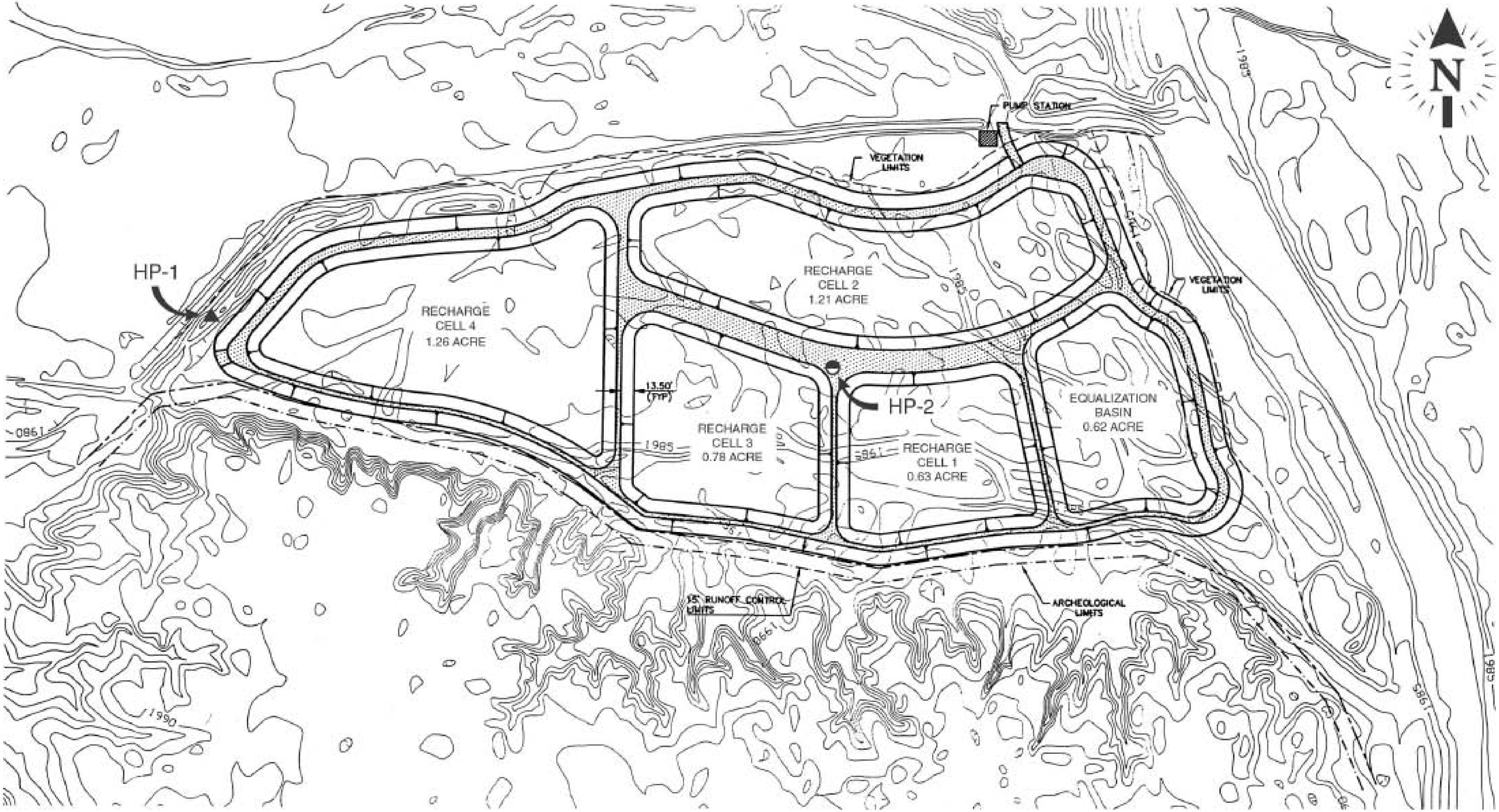


FIGURE 2
Facility Map



SCALE IN FEET:

TOTAL RECHARGE AREA = 4.50 ACRES
ESTIMATED RECHARGE VOLUME = 600 ACRE-FT/YR

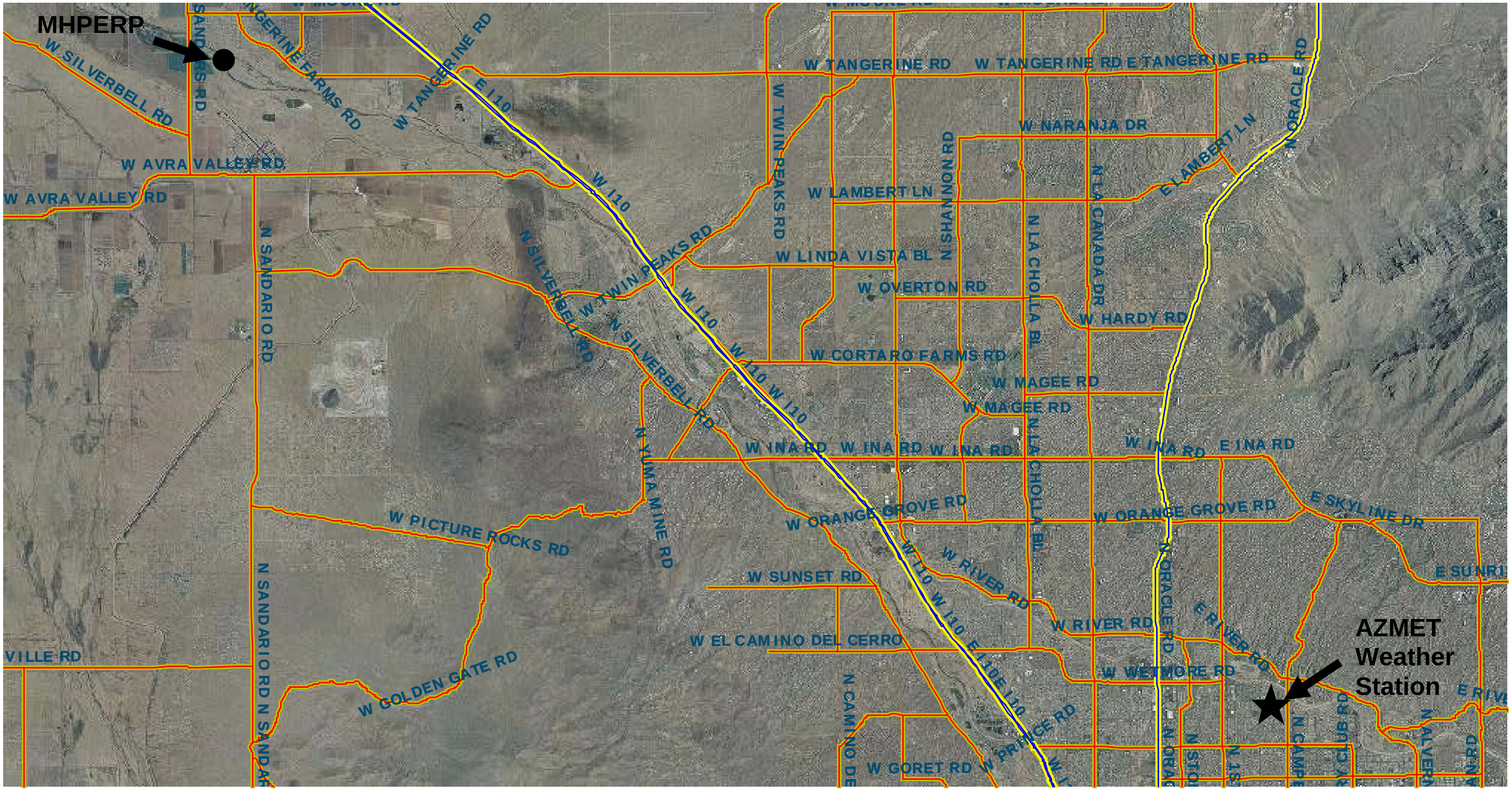
LEGEND

▲ MONITOR WELL

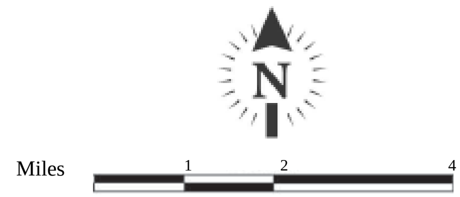
PIEZOMETER

Pima County Graphic Services ds3483 7/02

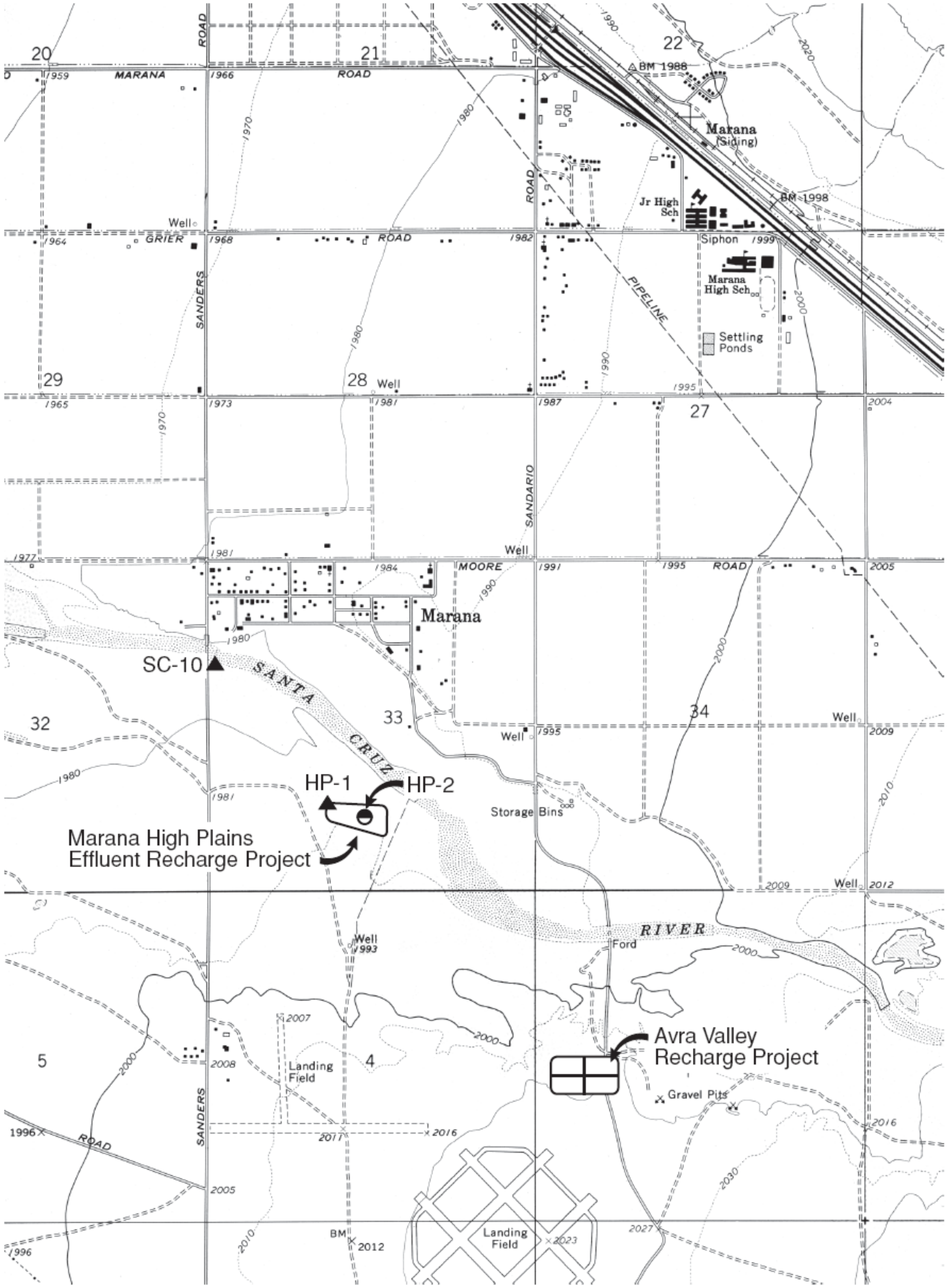
FIGURE 3
Tucson AZMET Weather Station
Location Map



Date on line: Jan 1 1987 (Day of Year = 1)
Location: 1 km (p.6 miles) northwest of Intersection of Campbell Ave. & Roger Rd.
Elevation: 713 meters (2339 ft)
Coordinates: Latitude = 32º 16' 49" N; Longitude = 110º 56' 45" W
Cooperator: Campus Agricultural Center (CAC), College of Agri., Univ. of Arizona



LEGEND
★ Weather Station



LEGEND

▲ MONITOR WELL

⊖ PIEZOMETER

N

Miles .5 1 2

SCALE:

FIGURE 4
Marana High Plains
Effluent Recharge Project
Monitor Wells Location Map

TABLES

TABLE 1A
MARANA HIGH PLAINS EFFLUENT RECHARGE PROJECT
WATER QUALITY SUMMARY - SOURCE WATER DIVERSION
CALENDAR YEAR 2013

Constituent	Unit	Discharge Limit	Sample Date & Results											
			Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
Nutrients														
Total Nitrogen[1]	mg/l	N/A	6.0	6.9	9.2	9.36	7.74	5.99	6.1	3.5	4.0	2.83	2.23	3.1
Nitrate-Nitrite as N	mg/l	N/A	4.5	6.9	7.9	9.0	7.0	5.2	5.1	1.5	2.9	1.9	1.3	2.1
Total Kjeldahl Nitrogen (TKN)	mg/l	N/A	1.5	< 1.0	1.3	0.36	0.74	0.79	1.0	2.0	1.1	0.93	0.93	1.0
Metals (Total)														
Free Cyanide	mg/l	0.2	< 0.05	No Event	No Event	No Event	< 0.05	No Event	No Event	No Event	< 0.005	No Event	< 0.05	No Event
Total Fluoride	mg/l	4	0.48	No Event	No Event	No Event	0.47	No Event	No Event	No Event	0.50	No Event	< 0.50	No Event
Arsenic	mg/l	0.05	< 0.003	No Event	No Event	No Event	0.0034	No Event	No Event	No Event	0.005	No Event	0.0031	No Event
Barium	mg/l	2	0.045	No Event	No Event	No Event	0.039	No Event	No Event	No Event	0.092	No Event	0.058	No Event
Beryllium	mg/l	0.004	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Cadmium	mg/l	0.005	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Chromium	mg/l	0.1	< 0.002	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	< 0.002	No Event	< 0.002	No Event
Lead	mg/l	0.05	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	0.001	No Event	< 0.001	No Event
Thallium	mg/l	0.002	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Nickel	mg/l	0.1	0.0048	No Event	No Event	No Event	0.0037	No Event	No Event	No Event	0.0044	No Event	0.0032	No Event
Antimony	mg/l	0.006	< 0.003	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	< 0.003	No Event	< 0.003	No Event
Selenium	mg/l	0.05	< 0.002	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	< 0.002	No Event	< 0.002	No Event
Mercury	mg/l	0.002	< 0.0002	No Event	No Event	No Event	< 0.0002	No Event	No Event	No Event	< 0.0002	No Event	< 0.0002	No Event
Volatile Organic Compounds (VOCs)														
para-Dichlorobenzene	mg/l	0.075	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Dichloromethane	mg/l	0.005	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	No Event	No Event	< 0.003	No Event	No Event
o-Dichlorobenzene	mg/l	0.6	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Carbon tetrachloride	mg/l	0.005	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	No Event	No Event	< 0.003	No Event	No Event
Toluene	mg/l	1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Benzene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Monochlorobenzene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Ethylbenzene	mg/l	0.7	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Tetrachloroethylene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,1-Dichloroethylene	mg/l	0.007	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event
1,1,1-Trichloroethane	mg/l	0.2	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,1,2-Trichloroethane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2-Dichloroethane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2-Dichloropropane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2,4-Trichlorobenzene	mg/l	0.07	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event
Vinyl Chloride	mg/l	0.002	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	No Event	No Event	< 0.001	No Event	No Event
Trichloroethylene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Hexachlorobenzene	mg/l	0.001	No Event	No Event	No Event	< 0.0008	No Event	No Event	No Event	No Event	No Event	< 0.0008	No Event	No Event
cis--1,2-Dichloroethylene	mg/l	0.07	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Styrene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Xylenes (Total)	mg/l	10	No Event	No Event	No Event	< 0.010	No Event	No Event	No Event	No Event	No Event	< 0.010	No Event	No Event
Trihalomethane (TTHM)	mg/l	0.1	No Event	No Event	No Event	< 0.004	No Event	No Event	No Event	No Event	No Event	< 0.004	No Event	No Event
trans-1,2-Dichloroethylene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Hexachlorocyclopentadiene	mg/l	0.05	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event

No Event = No sample taken (No flow, HP-1 pump not operating, or no testing required)
No Set Alert Levels per APP #103195
[1] Total Nitrogen = Nitrate-Nitrite as N + TKN (APP #103195)

TABLE 1B
MARANA HIGH PLAINS EFFLUENT RECHARGE PROJECT
WATER QUALITY SUMMARY - COMPLIANCE WELL HP-1
CALENDAR YEAR 2013

Constituent	Unit	Aquifer Quality Limit	Sample Date & Results											
			Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
Nutrients														
Total Nitrogen[1]	mg/l	10	< 2.0	< 2.0	1.8	1.7	1.5	1.6	1.3	1.93	1.5	1.4	1.4	1.6
Nitrate-Nitrite as N	mg/l	10	< 2.0	< 2.0	1.8	1.7	1.5	1.6	1.3	0.83	1.5	1.4	1.4	1.6
Total Kjeldahl Nitrogen (TKN)	mg/l	N/A	< 1.0	< 1.0	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	1.1	< 0.25	< 0.50	< 0.50	< 0.50
Total Coliform (P-Present, A-Absent)	P/A	A	A	A	A	A	A	A	A	A	A	A	A	A
Metals (Total)														
Free Cyanide	mg/l	0.2	< 0.05	No Event	No Event	No Event	< 0.05	No Event	No Event	No Event	< 0.05	No Event	< 0.050	No Event
Total Fluoride	mg/l	4	< 0.40	No Event	No Event	No Event	< 0.40	No Event	No Event	No Event	< 0.40	No Event	< 0.50	No Event
Arsenic	mg/l	0.05	< 0.003	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	< 0.003	No Event	< 0.003	No Event
Barium	mg/l	2	0.11	No Event	No Event	No Event	0.1	No Event	No Event	No Event	0.1	No Event	0.095	No Event
Beryllium	mg/l	0.004	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Cadmium	mg/l	0.005	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Chromium	mg/l	0.1	< 0.002	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	< 0.002	No Event	0.0063	No Event
Lead	mg/l	0.05	0.033	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Thallium	mg/l	0.002	< 0.001	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	< 0.001	No Event	< 0.001	No Event
Nickel	mg/l	0.1	0.0079	No Event	No Event	No Event	0.004	No Event	No Event	No Event	0.0039	No Event	0.0069	No Event
Antimony	mg/l	0.006	< 0.003	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	< 0.003	No Event	< 0.003	No Event
Selenium	mg/l	0.05	< 0.002	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	< 0.002	No Event	< 0.002	No Event
Mercury	mg/l	0.002	< 0.0002	No Event	No Event	No Event	< 0.0002	No Event	No Event	No Event	< 0.0002	No Event	< 0.0002	No Event
Volatile Organic Compounds (VOCs)														
para-Dichlorobenzene	mg/l	0.075	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Dichloromethane	mg/l	0.005	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	No Event	No Event	< 0.003	No Event	No Event
o-Dichlorobenzene	mg/l	0.6	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Carbon tetrachloride	mg/l	0.005	No Event	No Event	No Event	< 0.003	No Event	No Event	No Event	No Event	No Event	< 0.003	No Event	No Event
Toluene	mg/l	1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Benzene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Monochlorobenzene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Ethylbenzene	mg/l	0.7	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Tetrachloroethylene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,1-Dichloroethylene	mg/l	0.007	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event
1,1,1-Trichloroethane	mg/l	0.2	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,1,2-Trichloroethane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2-Dichloroethane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2-Dichloropropane	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
1,2,4-Trichlorobenzene	mg/l	0.07	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event
Vinyl Chloride	mg/l	0.002	No Event	No Event	No Event	< 0.001	No Event	No Event	No Event	No Event	No Event	< 0.001	No Event	No Event
Trichloroethylene	mg/l	0.005	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Hexachlorobenzene	mg/l	0.001	No Event	No Event	No Event	< 0.0008	No Event	No Event	No Event	No Event	No Event	< 0.0008	No Event	No Event
cis--1,2-Dichloroethylene	mg/l	0.07	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Styrene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Xylenes (Total)	mg/l	10	No Event	No Event	No Event	< 0.010	No Event	No Event	No Event	No Event	No Event	< 0.010	No Event	No Event
Trihalomethane (TTHM)	mg/l	0.1	No Event	No Event	No Event	< 0.004	No Event	No Event	No Event	No Event	No Event	< 0.004	No Event	No Event
trans-1,2-Dichloroethylene	mg/l	0.1	No Event	No Event	No Event	< 0.002	No Event	No Event	No Event	No Event	No Event	< 0.002	No Event	No Event
Hexachlorocyclopentadiene	mg/l	0.05	No Event	No Event	No Event	< 0.005	No Event	No Event	No Event	No Event	No Event	< 0.005	No Event	No Event

No Event = No sample taken (No flow, HP-1 pump not operating, or no test required)
1 Total Nitrogen = Nitrate-Nitrite as N + TKN (APP #103195)

TABLE 2
MARANA HIGH PLAINS EFFLUENT RECHARGE PROJECT
FACILITY INSPECTIONS: PROBLEMS AND RELATED SOLUTIONS
CALENDAR YEAR 2014

Date	Problem	Solution
January 1, 2014	No electricity to Recharge Cells 1, 3 and 4	Electrician was contacted to investigate the problem and come up with solutions to restore electric power to the recharge cells; the valves were operated manually by the daily operator based on water level conditions in the recharge cells
January 1, 2014	Compliance well HP-1 pump is not functioning	Hired contractor replaced the well pump and two leaky discharge pipes to restore water production for the well in order to collect water quality samples.
January 12, 2014	Oxbow channel was breached upstream of the pump station, allowing no flow to reach the pumps, thus no deliveries to the facility	Oxbow channel berm was repaired and effluent deliveries were restarted on January 15th.
February 26, 2014	Spill pad is breaking away from inlet structure in Recharge Cell 1 causing severe erosion damage at the inlet	Effluent deliveries to the cell were halted; once the basin was dry, the spill pad was reset and anchored with large rocks; cement grout was used to fill in the space between the spill pad and the inlet structure; effluent deliveries to the cell were restarted on March 31st.
April 14, 2014	Infiltration rate in Cell 3 is low (< 0.5 feet/day)	Approximately four feet of materials were excavated and removed from the bottom of the cell to expose coarse sands and gravels; the cell bottom was cross-ripped with a 1.5-foot ripper connected to a tractor; recharge deliveries recommenced on May 23rd.
April 21, 2014	Vegetation is overgrown, reducing the footprint of the maintenance roads around the recharge cells	A landscape maintenance crew was utilized for two days in May to clear vegetation from roadways and around the facility equipment
July 8, 2014	Water in the oxbow channel is very turbid, with high sediment load, due to storm water runoff along the Santa Cruz River	Effluent delivery pumps were shut off to keep storm water out of the facility; effluent deliveries were halted for the remainder of the summer monsoon season to allow the recharge cells to dry out for maintenance activities in the Fall.
August 21, 2014	Diversion berm has been washed out due to storm water runoff along the Santa Cruz River	The diversion berm was repaired to restore water flows into the oxbow channel and to the facility
August 21, 2014	Recharge cells are clogged with weedy vegetation	Maintenance activities were performed during early September to clear vegetation and remove clogging soil materials from the recharge cell bottoms; the cell bottoms were cross-ripped to improve infiltration rates; recharge deliveries were restarted on September 4th.
September 7, 2014	Diversion berm has been washed out due to storm water runoff along the Santa Cruz River	The diversion berm was repaired and effluent deliveries to the facility recommenced on September 23rd.
October 8, 2014	Diversion berm has been washed out due to storm water runoff along the Santa Cruz River	The diversion berm was repaired and effluent deliveries to the facility recommenced on October 14th.
December 18, 2014	Diversion berm has been washed out due to storm water runoff along the Santa Cruz River	The diversion berm was repaired on December 24th; effluent was not being delivered at this time because the maximum recharge amount for the facility (600AF) had been reached by November 19th.

APPENDIX A

Daily Flow Volumes &
Water Quantity Summary

USF DAILY FLOWMETER READINGS AND VOLUMES

Marana High Plains Recharge Facility

USF Permit No. 71-563876.0007

Meter ID: Fm-eq

Year: 2014

	January		February		March		April		May		June	
	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons
	72066967		94870240		118216869		143819868		288427		28107166	
Day 1	72902296	835329	95688040	817800	119052469	835600	144638044	818176	1146829	858402	28899948	792782
2	73715028	812732	96527940	839900	119875011	822542	145470088	832044	1973719	826890	29811228	911280
3	74543518	828490	97363346	835406	120691692	816681	146306296	836208	2808349	834630	30794210	982982
4	75406878	863360	98197904	834558	121531076	839384	147128504	822208	3667581	859232	31754706	960496
5	76234298	827420	99030836	832932	122374926	843850	147958744	830240	4563404	895823	32783772	1029066
6	77051260	816962	99871949	841113	123200376	825450	148797614	838870	5458208	894804	33736184	952412
7	77891128	839868	100701214	829265	124039244	838868	149619032	821418	6371609	913401	34676614	940430
8	78742846	851718	101545454	844240	124869244	830000	150462984	843952	7340645	969036	35610073	933459
9	79572768	829922	102373790	828336	125700376	831132	151283812	820828	8327959	987314	36654024	1043951
10	80379578	806810	103214704	840914	126536880	836504	152124897	841085	9205719	877760	37693744	1039720
11	81203520	823942	104052244	837540	127381846	844966	152958444	833547	10118209	912490	38729363	1035619
12	81303520	100000	104876086	823842	128203634	821788	153783133	824689	11083255	965046	39752496	1023133
13	81303520	0	105708180	832094	129032920	829286	154583533	800400	12046455	963200	40633348	880852
14	81303520	0	106509863	801683	129866848	833928	155435066	851533	12965634	919179	41356548	723200
15	81513721	210201	107371223	861360	130708448	841600	156261680	826614	13860589	894955	42005092	648544
16	82360350	846629	108234676	863453	131531272	822824	157101180	839500	14768306	907717	42709414	704322
17	83178520	818170	109046782	812106	132368916	837644	157924476	823296	15617266	848960	43428416	719002
18	84040440	861920	109881272	834490	133164856	795940	158773340	848864	16454022	836756	44175008	746592
19	84841520	801080	110703648	822376	133777700	612844	159575180	801840	17355636	901614	44910364	735356
20	85674560	833040	111546376	842728	134621172	843472	160375130	799950	18292974	937338	45666472	756108
21	86518664	844104	112374476	828100	135477564	856392	161200336	825206	19212046	919072	46349652	683180
22	87355600	836936	113217116	842640	136296096	818532	162042218	841882	20152766	940720	47040528	690876
23	88184720	829120	114065356	848240	137134564	838468	162865178	822960	21069292	916526	47740740	700212
24	89038383	853663	114875176	809820	137971596	837032	163686842	821664	21973492	904200	48437472	696732
25	89870063	831680	115706464	831288	138780696	809100	164514986	828144	22869772	896280	49119968	682496
26	90682865	812802	116534928	828464	139642624	861928	165336362	821376	23728660	858888	49809732	689764
27	91541774	858909	117376828	841900	140470824	828200	166165411	829049	24643884	915224	50498142	688410
28	92370108	828334	118216869	840041	141301231	830407	166985779	820368	25587253	943369	51149592	651450
29	93196380	826272			142138511	837280	167813923	828144	26451602	864349	51787116	637524
30	94031174	834794			142970024	831513	168636883	822960	27289886	838284	52501024	713908
31	94870240	839066			143819868	849844			28107166	817280		
	Total (gal)	**22803273**	**Total (gal)**	**23346629**	**Total (gal)**	**25602999**	**Total (gal)**	**24817015**	**Total (gal)**	**27818739**	**Total (gal)**	**24393858**
	Total (ac-ft)	**69.98**	**Total (ac-ft)**	**71.65**	**Total (ac-ft)**	**78.57**	**Total (ac-ft)**	**76.16**	**Total (ac-ft)**	**85.37**	**Total (ac-ft)**	**74.86**

1st Qtr Total (gal) =	**71752901**
1st Qtr Total (ac-ft) =	**220.20**
2nd Qtr Total (gal) =	**77029612**
2nd Qtr Total (ac-ft) =	**236.40**

USF DAILY FLOWMETER READINGS AND VOLUMES

Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Meter ID: Fm-eq
Year: 2014

	July		August		September		October		November		December	
	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons	Totalizer Reading	Gallons
	52501024		57914364		11795637		19495692		42117269		55724368	
Day 1	53180260	679236	57914364	0	11795637	0	20112314	616622	42795029	677760	55724368	0
2	53873628	693368	57914364	0	11795637	0	21158160	1045846	43419352	624323	55724368	0
3	54606596	732968	57914364	0	11795637	0	22199144	1040984	44246872	827520	55724368	0
4	55307788	701192	57914364	0	11795637	0	23199944	1000800	45093590	846718	55724368	0
5	55987754	679966	57914364	0	12445177	649540	24291116	1091172	45862512	768922	55724368	0
6	56793884	806130	57914364	0	12978662	533485	25332830	1041714	46650242	787730	55724368	0
7	57636129	842245	57914364	0	13216712	238050	26379416	1046586	47455204	804962	55724368	0
8	57914364	278235	57914364	0	13216712	0	27142322	762906	48171304	716100	55724368	0
9	57914364	0	57914364	0	13216712	0	27142322	0	48850190	678886	55724368	0
10	57914364	0	57914364	0	13216712	0	27142322	0	49613036	762846	55724368	0
11	57914364	0	57914364	0	13216712	0	27142322	0	50346469	733433	55724368	0
12	57914364	0	57914364	0	13216712	0	27142322	0	51082572	736103	55724368	0
13	57914364	0	57914364	0	13216712	0	27142322	0	51815010	732438	55724368	0
14	57914364	0	57914364	0	13216712	0	27784350	642028	52504152	689142	55724368	0
15	57914364	0	57914364	0	13216712	0	28545414	761064	53158152	654000	55724368	0
16	57914364	0	57914364	0	13216712	0	29327221	781807	53787496	629344	55724368	0
17	57914364	0	57914364	0	13216712	0	30181468	854247	54623056	835560	55724368	0
18	57914364	0	57914364	0	13216712	0	31035068	853600	55447878	824822	55724368	0
19	57914364	0	57914364	0	13216712	0	31887380	852312	55724368	276490	55724368	0
20	57914364	0	57914364	0	13216712	0	32901040	1013660	55724368	0	55724368	0
21	57914364	0	57914364	0	13216712	0	33893287	992247	55724368	0	55724368	0
22	57914364	0	57914364	0	13216712	0	34820494	927207	55724368	0	55724368	0
23	57914364	0	57914364	0	13532117	315405	35688816	868322	55724368	0	55724368	0
24	57914364	0	57914364	0	14449055	916938	36532972	844156	55724368	0	55724368	0
25	57914364	0	57914364	0	15349967	900912	37306312	773340	55724368	0	55724368	0
26	57914364	0	57914364	0	16196912	846945	38045616	739304	55724368	0	55724368	0
27	57914364	0	57914364	0	16947066	750154	38979656	934040	55724368	0	55724368	0
28	57914364	0	57914364	0	17722767	775701	39871724	892068	55724368	0	55724368	0
29	57914364	0	57914364	0	18680431	957664	40643652	771928	55724368	0	55724368	0
30	57914364	0	57914364	0	19495692	815261	41371160	727508	55724368	0	56287276	562908
31	57914364	0	57914364	0			42117269	746109			57254024	966748
	Total (gal)	**5413340**	**Total (gal)**	**0**	**Total (gal)**	**7700055**	**Total (gal)**	**22621577**	**Total (gal)**	**13607099**	**Total (gal)**	**1529656**
	Total (ac-ft)	**16.61**	**Total (ac-ft)**	**0.00**	**Total (ac-ft)**	**23.63**	**Total (ac-ft)**	**69.42**	**Total (ac-ft)**	**41.76**	**Total (ac-ft)**	**4.69**

3rd Qtr Total (gal) =	**13113395**
3rd Qtr Total (ac-ft) =	**40.24**

4th Qtr Total (gal) =	**37758332**
4th Qtr Total (ac-ft) =	**115.88**
Annual Total Del. Vol for FM-eq (ac-ft) =	**612.72**

USF WATER QUANTITY REPORTING SUMMARY
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	FM-eq Delivered Volumes (ac-ft)	**Evaporation Losses** (ac-ft)	**Evapotranspiration Losses** (ac-ft)	**Net Recharge Volumes** (ac-ft)	**Quarterly Net Recharge Totals** (ac-ft)
January	70.0	0.4	0.1	69.5	
February	71.6	0.6	0.0	71.0	
March	78.6	0.9	0.0	77.7	218.2
April	76.2	1.1	0.1	74.9	
May	85.4	1.1	0.1	84.2	
June	74.9	0.9	0.0	74.0	233.1
July	16.6	0.3	0.0	16.3	
August	0.0	0.0	0.0	0.0	
September	23.6	0.2	0.0	23.5	39.8
October	69.4	0.4	0.0	69.1	
November	41.8	0.3	0.0	41.5	
December	4.7	0.0	0.0	4.7	115.2

Annual Totals =	**612.7**	**6.1**	**0.4**	**606.2**

APPENDIX B

Evaporation Calculations &
Cooley Method Description

USF EVAPORATION CALCULATIONS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

Basin ID	January Wetted Acres	Evap (AF)	February Wetted Acres	Evap (AF)	March Wetted Acres	Evap (AF)	April Wetted Acres	Evap (AF)	May Wetted Acres	Evap (AF)	June Wetted Acres	Evap (AF)
Equal. Basin	15	0.1	14	0.2	16	0.3	12	0.3	13	0.4	11	0.3
Cell 1	5	0.0	1	0.0	0	0.0	4	0.1	1	0.0	4	0.1
Cell 2	9	0.1	14	0.2	15	0.3	11	0.2	20	0.5	5	0.1
Cell 3	8	0.1	3	0.0	6	0.1	11	0.2	1	0.0	8	0.2
Cell 4	9	0.1	18	0.2	15	0.3	12	0.3	5	0.1	0	0.0
	46	**0.4**	**49**	**0.6**	**53**	**0.9**	**50**	**1.1**	**39**	**1.1**	**28**	**0.9**

1st Quarter Total Evap (AF) **=**	**1.9**
2nd Quarter Total Evap (AF) **=**	**3.1**

Cooley Adj. Fac	**0.95**

USF EVAPORATION CALCULATIONS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

Basin ID	July Wetted Acres	Evap (AF)	August Wetted Acres	Evap (AF)	September Wetted Acres	Evap (AF)	October Wetted Acres	Evap (AF)	November Wetted Acres	Evap (AF)	December Wetted Acres	Evap (AF)
Equal. Basin	6	0.2	0	0.0	4	0.1	10	0.2	9	0.1	1	0.0
Cell 1	2	0.0	0	0.0	1	0.0	4	0.1	1	0.0	0	0.0
Cell 2	2	0.1	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0
Cell 3	1	0.0	0	0.0	1	0.0	6	0.1	1	0.0	0	0.0
Cell 4	0	0.0	0	0.0	0	0.0	0	0.0	9	0.1	0	0.0
	11	**0.3**	**0**	**0.0**	**7**	**0.2**	**20**	**0.4**	**21**	**0.3**	**1**	**0.0**

3rd Quarter Total Evap (AF) **=**	**0.5**

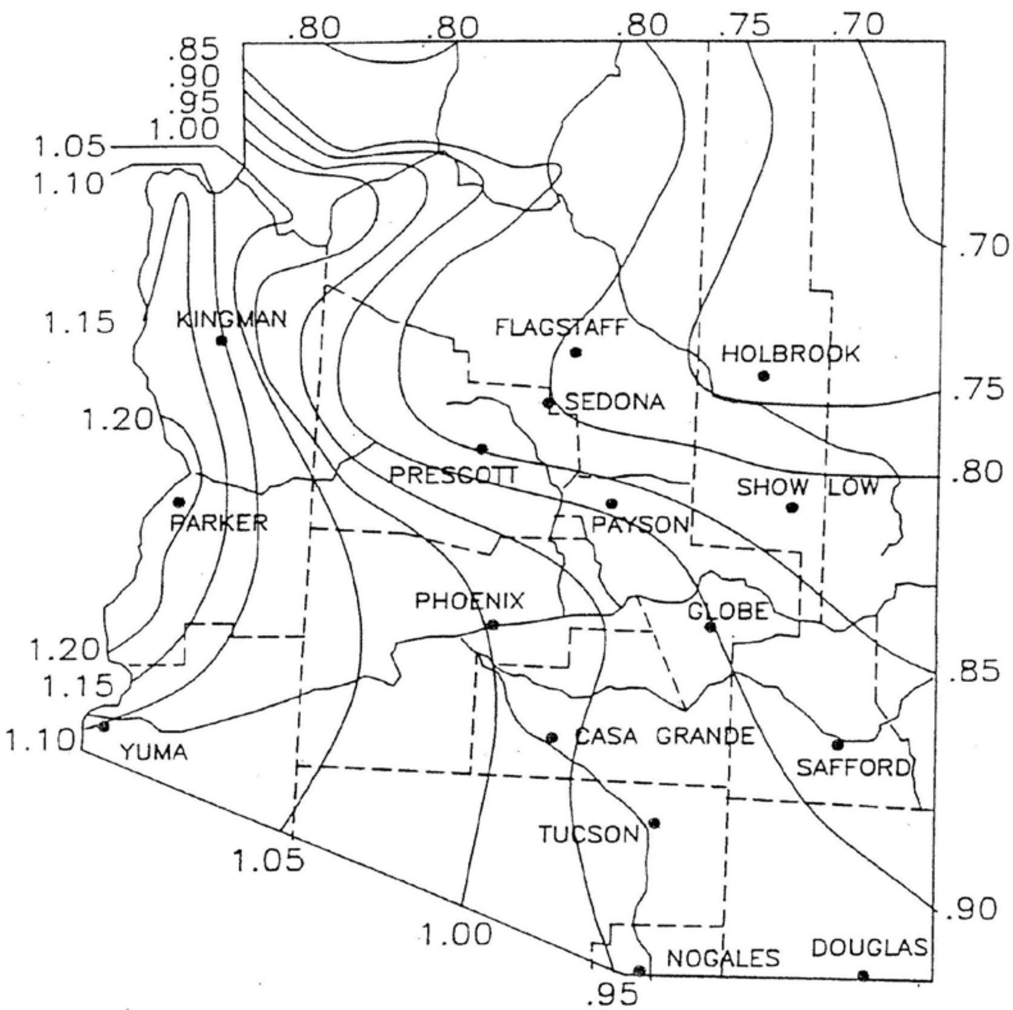
4th Quarter Total Evap (AF) **=**	**0.6**
Annual Total Evap (AF) **=**	**6.1**

COOLEY EVAPORATION INFORMATION

Cooley Monthly Maximum Evaporation Rates
from Cooley, 1970

Month	Maximum Evap Rate (inches)	Maximum Evap Rate (feet/day)	
January	3.6	0.009677	0.3
February	4.5	0.013393	0.375
March	6.5	0.017473	0.541667
April	8.4	0.023333	0.7
May	10.9	0.029301	0.908333
June	11.4	0.031667	0.95
July	11.8	0.031720	0.983333
August	10.5	0.028226	0.875
September	8.7	0.024167	0.725
October	7.0	0.018817	0.583333
November	4.8	0.013333	0.4
December	3.1	0.008333	0.258333

Cooley Evaporation Adjustment Factors for Arizona
from Cooley, 1970



ARIZONA DEPARTMENT OF WATER RESOURCES
HYDROLOGY DIVISION

TECHNICAL BULLETIN

Justification for using the Cooley Method Maximum Curve as the standard method for calculating evaporation losses at open-air underground storage facilities.

The Hydrology Division recommends using the Cooley Method with the Maximum Curve when calculating evaporative losses for spreading basins. This recommendation was derived for the following reasons:

- The Cooley Method is very consistent, in that, the daily evaporation rates and adjustment factors are fixed and do not change over time. This allows for a very simplified calculation method that is identical from year to year.
- The Cooley method is easy to use and can be adopted by a wide range of permittees and facilities. Especially as it relates to the collecting, reporting, and reviewing of the data and calculations. This has proven to be a benefit for new facility operators and changes in personnel at the Department. This is an important factor to consider when taking into account a duration of twenty years or longer for some facilities.
- The consistency of the Cooley Method makes it easy for the Department to review and verify calculation parameters when reviewing a new application and/or determining long term storage credits.
- The Cooley Method can be used without the Department demanding extraneous monitoring cost. The information required such as, wet/dry status of the basin(s) and the volume of water discharged are currently required in the USF permit for credit calculations and infiltration calculations.
- The Cooley Method unlike other empirical methods was designed specifically for Arizona.
- Other methods of determining evaporation can be very accurate, however, they are relatively expensive, requiring intensive measurements and calculation efforts to obtain evaporation values. In Hydrology's experience the difference between these methods and Cooley is negligible. This is especially true given the relatively small ratio of evaporation to the total amount of water recharged.
- The daily evaporation rates and adjustment factors, determined by Cooley, are used by the Arizona Department of Environmental Quality (ADEQ Engineering Bulletin No. 12). Thus having consistency between state agencies.

Justification for Using the Maximum Curve of the Cooley Method

- Using the maximum evaporation rate calculates evaporative loss less than the Class A pan evaporation data and greater than the normal evaporation curve. This produces a value that assures that all losses have been accounted for when calculating annual storage credits but is not over conservative.

- Class A pan data was one of the three sources used in preparing the Cooley Method. The corrections used in Class A pan calculations were calibrated to open water surfaces, considerably deeper than the average spreading basin. These deep open water bodies contain cooler water upwelling toward the surface causing a decrease in the evaporation rate. The spreading basins used in current recharge operations typically contain very shallow water (2 to 3 feet) that heats up fairly rapidly, thus increasing evaporative losses. Therefore, using the evaporation values calibrated for open water conditions would underestimate the evaporative losses in a spreading basin. The maximum evaporation rate more accurately estimates the evaporative losses for the conditions present at shallow recharge basins.

- Evaporation caused by the "wicking effect" may continue during dry cycles even when the basin does not contain standing water. The "wicking effect" process consists of water moving upward toward the surface due to the drying and heating of the ground above. This factor is not taken into account when using the normal values of evaporation, but is compensated for when using the maximum evaporation rate in calculations.

Attachments:

Evaporation from Open Water Surfaces in Arizona, K.R. Cooley, 1970

EVAPORATION FROM OPEN WATER SURFACES IN ARIZONA

Keith R. Cooley
Research Hydrologist
U. S. Water Convservation Laboratory, Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture.

Most people know that a considerable amount of water is lost by evaporation from open water surfaces in Arizona. However, they are amazed that, from a stock tank containing water 7 feet deep, the loss to evaporation in a year's time could be as much as 6 feet, leaving only one foot for livestock. On the other hand, declines in water level of 3 or 4 inches per day from fish ponds and swimming pools cannot be due entirely to evaporation.

Using the method outlined in this folder, the home owner, farmer, rancher, contractor, or consultant can estimate the amount of evaporation expected from an open, unfrozen water surface during any part of the year and for any location in Arizona. Results will generally be within 10 percent of actual evaporation on an annual basis.

How to Estimate Evaporation

Estimation of evaporation consists of three steps.

1. Select the average daily or average monthly evaporation for the period in question from Figure 1. For daily evaporation, choose one of the three curves, depending on whether you want maximum, normal, or minimum expected evaporation.

Values of average normal evaporation are shown in the bar graph as inches per month.

Use the curve representing normal evaporation for an estimate of expected evaporation under average conditions. However, for extremely hot windy periods, or cool cloudy periods, the curves representing maximum and minimum evaporation, respectively, will give a better estimate. The curves of maximum and minimum evaporation may also be of value when considering the possible range of seepage losses from water storage facilities.

2. Determine an adjustment factor from Figure 2 for the location in question. Read from the map the factor nearest the location in which you are interested.

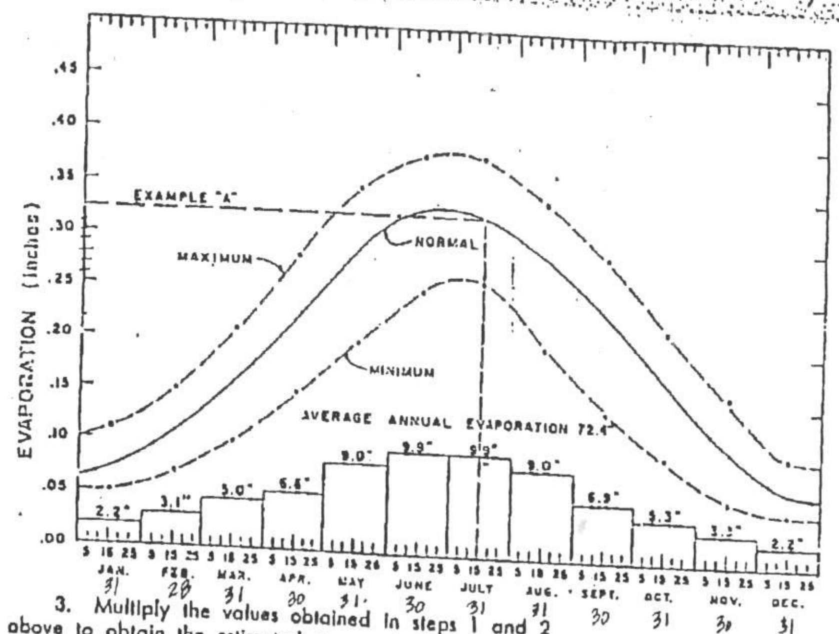


FIGURE 1. Maximum, Normal, and Minimum Daily Evaporation and Average Monthly Evaporation From Open Water Surfaces (Adjustment Factor = 1.00).

3. Multiply the values obtained in steps 1 and 2 above to obtain the estimated evaporation for the time and location in question.

For facilities with exposed walls, such as above-ground stock tanks and exposed-wall swimming pools, multiply the value obtained in step 3 above by 1.25, which is an average coefficient for the entire state for all types of exposed-wall structures.

Examples:

A. Wanted: Average daily normal evaporation from from a swimming pool in Tucson during July.
- Step 1. From Figure 1, average evaporation for July = 0.32 inches/day.
- Step 2. From Figure 2, adjustment factor = 0.95.
- Step 3. Multiply values obtained in steps 1 and 2 above: 0.32 x 0.95 = 0.3 inches/day = average daily evaporation during July in Tucson.

B. Wanted: Average normal evaporation from a fish pond in Phoenix during May and June.
- Step 1. From Figure 1, average evaporation for May and June = 9.0 and 9.9 inches, respectively.
- Step 2. Adjustment factor from Figure 2 for Phoenix = 1.0.

(See over)

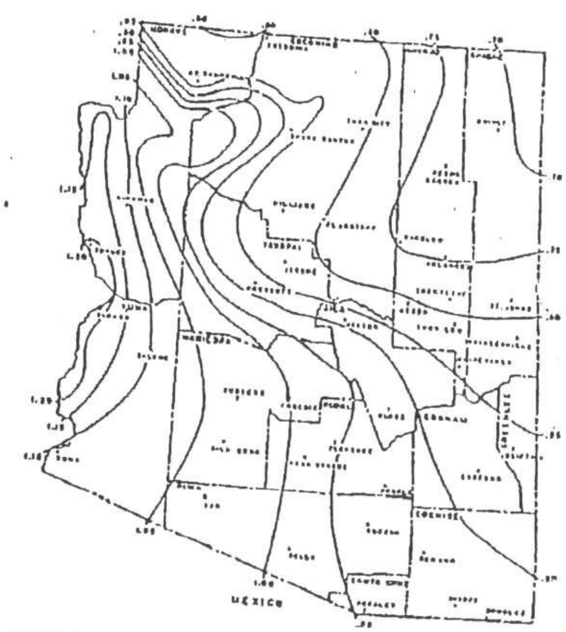


FIGURE 2. Evaporation Adjustment Factors for Arizona

Step 3. Multiply values obtained in steps 1 and 2 above: (9.0 x 1.0) + (9.9 x 1.0) = 18.9 or approximately 19 inches = total average evaporation for May and June.

C. Wanted: Maximum evaporation to be expected from a stock pond near Snowflake during May, June, and July.

Step 1. From the curve of maximum values in Figure 1, values for May, June, and July are: 0.35, 0.38, and 0.38 inches/day, respectively.

Step 2. From Figure 2, adjustment factor for Snowflake = 0.80.

Step 3. Multiply values obtained in steps 1 and 2 above times the number of days in each month:

May:	0.35 x 31 x 0.8 = 8.7
June:	0.38 x 30 x 0.8 = 9.1
July:	0.38 x 31 x 0.8 = 9.4
Total:	27.2 Inches

Maximum evaporation expected from a stock pond near Snowflake during May, June, and July is approximately 27 inches.

D. Wanted: Average normal evaporation from an exposed-wall swimming pool near Yuma during June.

Step 1. From Figure 1, average evaporation for June is 9.9 inches.

Step 2. From Figure 2, adjustment factor for Yuma = 1.10.

Step 3. Multiply values obtained in steps 1 and 2 above:
9.9 x 1.10 = 10.9 inches.

Step 4. Multiply by the coefficient for exposed-wall storage facilities, 1.25:
10.9 x 1.25 = 13.6 inches = average evaporation from an exposed-wall swimming pool at Yuma during June.

Acknowledgement

Data used in preparing this paper were obtained from three sources: (1) records of evaporation from sunken insulated evaporation pans at the U. S. Water Conservation Laboratory near Phoenix, Arizona, for the years 1966-1968, (2) records of evaporation from a Class A evaporation pan at the University of Arizona Mesa Experiment Farm for the years 1917-1967, and (3) evaporation maps of the United States based on 1946-1955 data.

Special acknowledgement is made to Mr. Paul C. Kangieser, U. S. Weather Bureau Climatologist, for supplying records of evaporation recorded at the Mesa Experiment Farm.

This publication is issued by the Cooperative Extension Service and the Agricultural Experiment Station of The University of Arizona. See your local County Extension Agent for additional information.

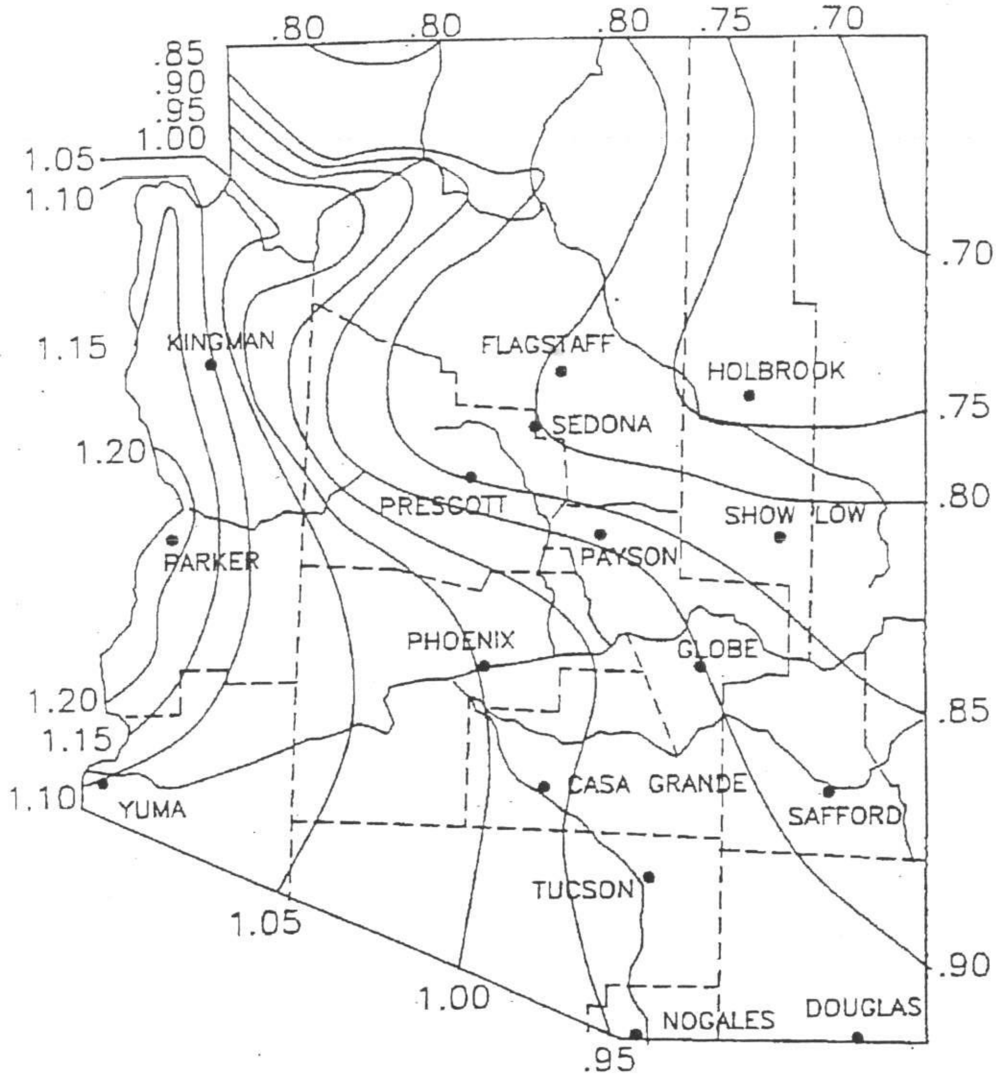
EVAPORATION FROM OPEN WATER SURFACES IN ARIZONA

FOLDER 159

Agricultural Experiment Station
And
Cooperative Extension Service
The University of Arizona

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture. George E. Hull, Director of Extension Service, The University of Arizona College of Agriculture, Tucson,

FIGURE 10. EVAPORATION ADJUSTMENT FACTORS FOR ARIZONA



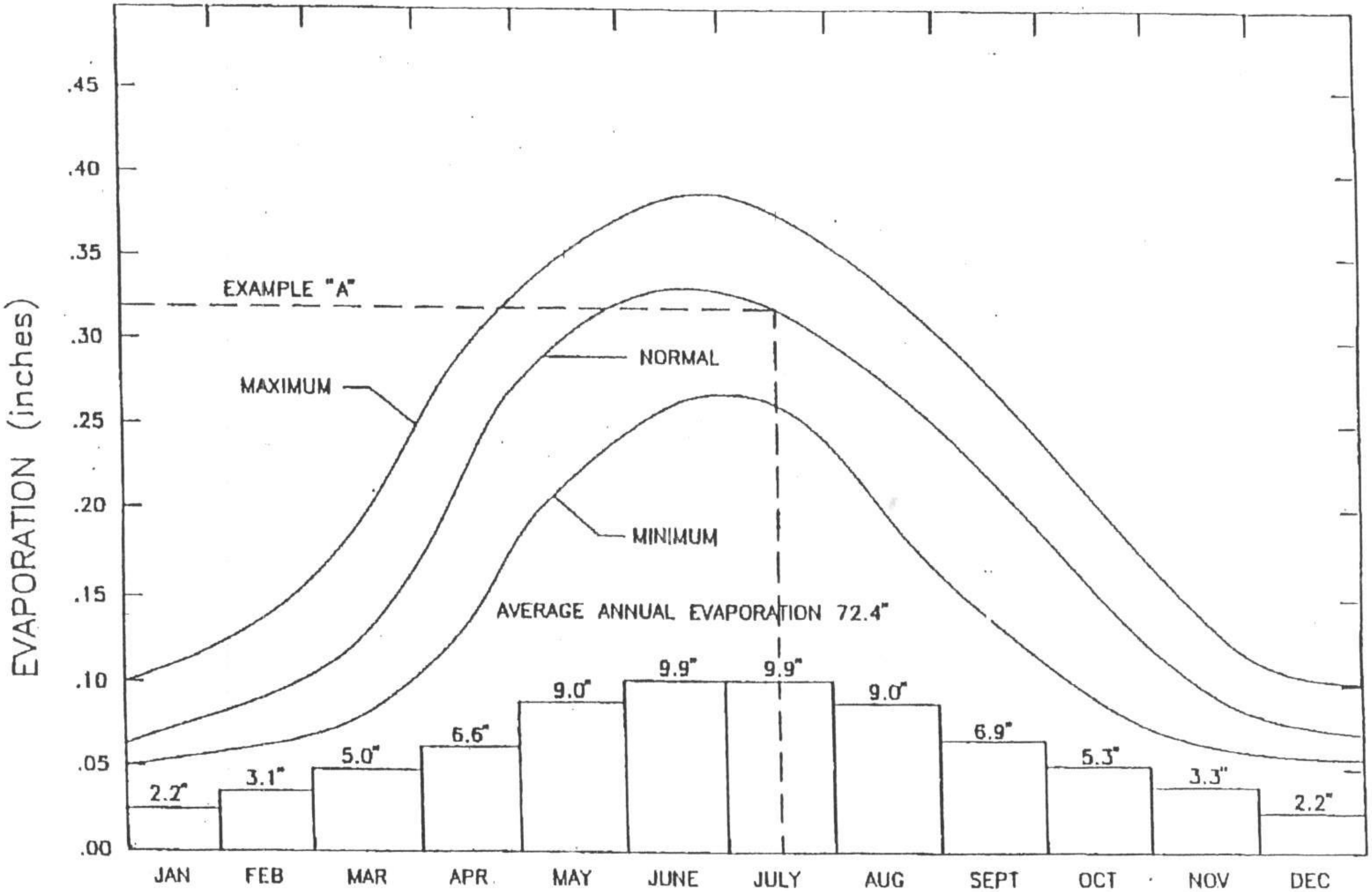


FIGURE 9. MAXIMUM, NORMAL AND MINIMUM DAILY EVAPORATION AND AVERAGE MONTHLY EVAPORATION FROM OPEN WATER SURFACES (Adjustment Factor = 1.00)

TABLE 3.2 MONTHLY MAXIMUM, NORMAL, AND MINIMUM OPEN WATER EVAPORATION AMOUNTS FOR ARIZONA (UNADJUSTED).

	EVAPORATION (IN)		
MONTH	MAXIMUM	NORMAL	MINIMUM
Jan (31 days)	3.6	2.2	1.6
Feb (28)	4.5	3.1	2.3
Mar (31)	6.5	5.0	3.1
April (30)	8.4	6.6	4.5
May (31)	10.9	9.0	6.2
June (30)	11.4	9.9	7.5
July (31)	11.8	9.9	8.1
August (31)	10.5	9.0	6.0
Sept (30)	8.7	6.9	4.1
Oct (31)	7.0	5.3	2.8
Nov (30)	4.8	3.3	1.8
Dec (31)	3.1	2.2	1.6
TOTAL	91.2 (7.6 ft.)	72.4 (6.0 ft.)	49.6 (4.1 ft.)

From: Cooley, 1970

APPENDIX C

Daily Wetted Acreages

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

January

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.5208	0.0000	0.5808	0.0000	0.0000
2	0.5208	0.0000	0.5929	0.0000	0.0000
3	0.5208	0.0000	0.6050	0.0000	0.0000
4	0.5208	0.0000	0.6050	0.0000	0.0000
5	0.5208	0.0000	0.6413	0.0000	0.0000
6	0.5208	0.0000	0.6776	0.0000	0.0000
7	0.5208	0.0000	0.6897	0.0000	0.0000
8	0.5208	0.0000	0.7260	0.0000	0.0000
9	0.5208	0.0000	0.7260	0.0000	0.0000
10	0.5208	0.0945	0.7260	0.3120	0.0000
11	0.4030	0.1890	0.3630	0.3900	0.0000
12	0.3720	0.1418	0.2420	0.3705	0.0000
13	0.3410	0.0945	0.1210	0.3510	0.0000
14	0.3410	0.0630	0.0968	0.3120	0.0000
15	0.3410	0.0504	0.0242	0.2946	0.0000
16	0.5208	0.0063	0.0121	0.2730	0.0000
17	0.5208	0.1575	0.0000	0.0780	0.0000
18	0.5208	0.2835	0.0000	0.3900	0.0000
19	0.5208	0.3780	0.0000	0.6630	0.0000
20	0.5208	0.3150	0.0000	0.6864	0.0000
21	0.5208	0.2835	0.0000	0.6864	0.0000
22	0.5208	0.3024	0.0000	0.6864	0.1890
23	0.5208	0.3465	0.0000	0.6864	0.3780
24	0.5208	0.3780	0.0000	0.6630	1.0458
25	0.5208	0.3780	0.0000	0.3900	1.0458
26	0.5208	0.3780	0.0000	0.2730	1.0458
27	0.5208	0.3780	0.1815	0.1560	1.0458
28	0.5208	0.1890	0.3630	0.1170	1.0458
29	0.5208	0.1260	0.4840	0.0390	1.0458
30	0.5208	0.0945	0.4235	0.0000	1.0458
31	0.5208	0.0315	0.4356	0.0000	1.0458
Total Wetted Acres	**15.3388**	**4.6589**	**9.317**	**7.8177**	**8.9334**

February

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.5208	0.0063	0.3872	0.0000	0.9450
2	0.5208	0.0000	0.3751	0.0000	0.9450
3	0.5208	0.0000	0.3630	0.0000	0.9450
4	0.5208	0.0000	0.4598	0.0000	0.8820
5	0.5208	0.0000	0.4719	0.0000	0.7560
6	0.5208	0.0000	0.4719	0.0000	0.7560
7	0.5208	0.0000	0.4840	0.0000	0.6930
8	0.5208	0.0000	0.5445	0.0000	0.6300
9	0.5208	0.0000	0.5929	0.0000	0.4095
10	0.5208	0.0000	0.6050	0.0000	0.1890
11	0.5208	0.0000	0.6050	0.0000	0.1512
12	0.5208	0.0000	0.6050	0.0000	0.1260
13	0.5208	0.0000	0.6050	0.0000	0.1134
14	0.5208	0.0000	0.6050	0.0000	0.1008
15	0.5208	0.0000	0.6050	0.0000	0.0756
16	0.5208	0.0000	0.6050	0.0000	0.0252
17	0.5208	0.0000	0.6050	0.0000	0.0000
18	0.5208	0.0000	0.6050	0.0000	0.0000
19	0.5208	0.0315	0.6050	0.0000	0.5040
20	0.5208	0.0945	0.4235	0.0000	1.0458
21	0.5208	0.0315	0.5808	0.0000	1.0458
22	0.5208	0.0630	0.5445	0.0000	1.0458
23	0.5208	0.0315	0.4235	0.0000	1.0458
24	0.5208	0.0063	0.3025	0.3900	1.0458
25	0.5208	0.0000	0.1452	0.6864	1.0458
26	0.5208	0.1260	0.1210	0.6864	1.0458
27	0.4340	0.0756	0.3932	0.6630	1.0458
28	0.5208	0.0504	0.4235	0.6240	1.0458
29					
Total Wetted Acres	**14.4956**	**0.5166**	**13.558**	**3.0498**	**17.6589**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

March

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.5208	0.0504	0.4538	0.5850	1.0080
2	0.5208	0.0284	0.4598	0.4680	0.9702
3	0.4836	0.0063	0.4840	0.3900	0.9324
4	0.4030	0.0063	0.4901	0.2340	0.8820
5	0.5208	0.0063	0.4961	0.0780	0.7560
6	0.5208	0.0000	0.5022	0.0000	0.6300
7	0.5208	0.0000	0.5203	0.0000	0.6048
8	0.5208	0.0000	0.5324	0.0000	0.5922
9	0.5208	0.0000	0.5445	0.0000	0.5481
10	0.5208	0.0000	0.5445	0.0000	0.5040
11	0.5208	0.0000	0.5445	0.0000	0.4788
12	0.5208	0.0000	0.5445	0.0000	0.4410
13	0.5208	0.0000	0.5445	0.0000	0.2520
14	0.5208	0.0000	0.5445	0.0000	0.2520
15	0.5208	0.0000	0.5445	0.0000	0.2268
16	0.5208	0.0000	0.5445	0.0000	0.1260
17	0.5208	0.0000	0.5445	0.0000	0.0630
18	0.5208	0.0000	0.5445	0.0000	0.0126
19	0.5208	0.0000	0.5566	0.0000	0.0063
20	0.4340	0.0000	0.5566	0.0000	0.0000
21	0.5208	0.0000	0.5566	0.0000	0.0000
22	0.5208	0.0000	0.5566	0.0000	0.0000
23	0.5208	0.0000	0.5566	0.0000	0.0000
24	0.5208	0.0000	0.5566	0.0000	0.0000
25	0.5208	0.0000	0.5566	0.3120	0.5040
26	0.4836	0.0000	0.4356	0.6630	0.6300
27	0.5208	0.0000	0.4235	0.6630	0.6300
28	0.5208	0.0000	0.3751	0.6864	1.0458
29	0.5208	0.0000	0.2541	0.6864	1.0458
30	0.5208	0.0000	0.2480	0.6864	1.0458
31	0.5208	0.0630	0.2420	0.6864	1.0458
Total Wetted Acres	**15.8658**	**0.1607**	**15.25805**	**6.1386**	**15.2334**

April

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.4092	0.1575	0.3630	0.6864	1.0458
2	0.4092	0.1890	0.3025	0.6864	1.0458
3	0.4092	0.2835	0.2783	0.6864	1.0458
4	0.4092	0.3150	0.2420	0.6864	1.0458
5	0.4092	0.3150	0.2178	0.6864	1.0458
6	0.4092	0.3150	0.1815	0.6864	1.0458
7	0.4092	0.3150	0.1815	0.6864	0.8190
8	0.4092	0.3150	0.1815	0.6864	0.7560
9	0.4092	0.3150	0.1815	0.6864	0.7560
10	0.4092	0.3150	0.1694	0.6864	0.6300
11	0.4092	0.3150	0.1573	0.6864	0.6300
12	0.4092	0.3150	0.1452	0.6864	0.6048
13	0.4092	0.3150	0.1331	0.6864	0.5040
14	0.4340	0.3150	0.1210	0.6864	0.3780
15	0.4092	0.1260	0.1815	0.6864	0.2520
16	0.4092	0.0630	0.3630	0.3900	0.2520
17	0.4092	0.0315	0.3630	0.1170	0.1260
18	0.4092	0.0000	0.4235	0.0780	0.0630
19	0.4092	0.0000	0.4598	0.0780	0.0630
20	0.4092	0.0000	0.4598	0.0000	0.0378
21	0.4092	0.0000	0.4840	0.0000	0.0126
22	0.4092	0.0000	0.4961	0.0000	0.0126
23	0.4092	0.0000	0.5445	0.0000	0.0126
24	0.4092	0.0000	0.5445	0.0000	0.0126
25	0.4092	0.0000	0.5687	0.0000	0.0000
26	0.4092	0.0000	0.5687	0.0000	0.0000
27	0.4092	0.0000	0.5808	0.0000	0.0000
28	0.4092	0.0000	0.6050	0.0000	0.0000
29	0.4092	0.0000	0.6050	0.0000	0.0000
30	0.4092	0.0000	0.6050	0.0000	0.0000
Total Wetted Acres	**12.3008**	**4.3155**	**10.7085**	**10.959**	**12.1968**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

May

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.4092	0.0000	0.6050	0.0000	0.0000
2	0.4092	0.0000	0.6050	0.0000	0.0000
3	0.4092	0.0000	0.6050	0.0000	0.0000
4	0.4092	0.0000	0.6050	0.0000	0.0000
5	0.4092	0.0000	0.6050	0.0000	0.0000
6	0.4092	0.0000	0.6050	0.0000	0.0000
7	0.4092	0.0000	0.6050	0.0000	0.0000
8	0.4092	0.0000	0.6050	0.0000	0.0000
9	0.4092	0.0000	0.6050	0.0000	0.0000
10	0.4092	0.0000	0.6655	0.0000	0.0000
11	0.4092	0.0000	0.6474	0.0000	0.0000
12	0.4340	0.0000	0.6292	0.0000	0.0000
13	0.4092	0.0000	0.6413	0.0000	0.0000
14	0.4092	0.0000	0.6655	0.0000	0.0000
15	0.4092	0.0000	0.7018	0.0000	0.0000
16	0.4092	0.0000	0.7260	0.0000	0.0000
17	0.4092	0.0000	0.7260	0.0000	0.0000
18	0.4092	0.0000	0.7260	0.0000	0.0000
19	0.4092	0.0000	0.7260	0.0000	0.0000
20	0.4092	0.0000	0.7865	0.0000	0.0000
21	0.4092	0.0630	0.7865	0.0000	0.1260
22	0.3720	0.0945	0.7744	0.0000	0.2520
23	0.3720	0.0945	0.7260	0.0390	0.6300
24	0.4340	0.0945	0.6776	0.0546	0.6300
25	0.4340	0.0945	0.6413	0.0780	0.5040
26	0.4340	0.0945	0.6050	0.0780	0.5040
27	0.4340	0.0945	0.6050	0.0780	0.5040
28	0.4340	0.0945	0.4840	0.1170	0.5040
29	0.4340	0.0945	0.4840	0.1170	0.5040
30	0.4340	0.0945	0.4235	0.1170	0.3780
31	0.4092	0.1071	0.4114	0.1170	0.3150
Total Wetted Acres	**12.8092**	**1.0206**	**19.7049**	**0.7956**	**4.851**

June

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.4092	0.1134	0.3993	0.1134	0.2142
2	0.4092	0.1134	0.3872	0.1134	0.1260
3	0.3720	0.1197	0.3630	0.1560	0.0630
4	0.3720	0.1260	0.3388	0.1716	0.0630
5	0.3720	0.1260	0.2420	0.1950	0.0126
6	0.3720	0.1512	0.2420	0.1716	0.0000
7	0.3720	0.1512	0.2299	0.1872	0.0000
8	0.3720	0.1512	0.2299	0.1872	0.0000
9	0.3720	0.1449	0.2299	0.1794	0.0000
10	0.3720	0.1449	0.2178	0.1872	0.0000
11	0.3720	0.1449	0.2178	0.1872	0.0000
12	0.3720	0.1512	0.1936	0.1950	0.0000
13	0.3720	0.1575	0.1452	0.2340	0.0000
14	0.3720	0.1575	0.1210	0.2730	0.0000
15	0.3720	0.1575	0.1210	0.3120	0.0000
16	0.3720	0.1575	0.1210	0.3198	0.0000
17	0.3720	0.1575	0.1210	0.3120	0.0000
18	0.3720	0.1449	0.1089	0.3120	0.0000
19	0.3720	0.1449	0.1089	0.3120	0.0000
20	0.3720	0.1449	0.0968	0.3120	0.0000
21	0.3720	0.1449	0.0605	0.3510	0.0000
22	0.3720	0.1260	0.0605	0.3120	0.0000
23	0.3720	0.1260	0.0605	0.3120	0.0000
24	0.3720	0.1260	0.0605	0.3354	0.0000
25	0.3720	0.1260	0.0605	0.3354	0.0000
26	0.3720	0.1260	0.0605	0.3354	0.0000
27	0.3720	0.1260	0.0484	0.3354	0.0000
28	0.3720	0.1260	0.0484	0.3354	0.0000
29	0.3720	0.1386	0.0484	0.3237	0.0000
30	0.3720	0.1449	0.0484	0.3120	0.0000
Total Wetted Acres	**11.2344**	**4.1706**	**4.7916**	**7.7187**	**0.4788**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

July

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.3720	0.1512	0.0242	0.3120	0.0000
2	0.3720	0.1764	0.1210	0.2340	0.0000
3	0.3720	0.1764	0.1815	0.1560	0.0000
4	0.3720	0.1827	0.1815	0.0078	0.0000
5	0.3720	0.1890	0.2178	0.0000	0.0000
6	0.4340	0.1890	0.2299	0.0000	0.0000
7	0.3720	0.1764	0.2178	0.0000	0.0000
8	0.3410	0.1701	0.2057	0.0000	0.0000
9	0.3100	0.1575	0.1815	0.0000	0.0000
10	0.3100	0.0630	0.1210	0.0000	0.0000
11	0.2914	0.0126	0.0605	0.0000	0.0000
12	0.2790	0.0063	0.0605	0.0000	0.0000
13	0.2604	0.0000	0.0605	0.0000	0.0000
14	0.2480	0.0000	0.0605	0.0000	0.0000
15	0.2046	0.0000	0.0484	0.0000	0.0000
16	0.1860	0.0000	0.0363	0.0000	0.0000
17	0.1674	0.0000	0.0242	0.0000	0.0000
18	0.1550	0.0000	0.0121	0.0000	0.0000
19	0.1364	0.0000	0.0000	0.0000	0.0000
20	0.1240	0.0000	0.0000	0.0000	0.0000
21	0.1147	0.0000	0.0000	0.0000	0.0000
22	0.1054	0.0000	0.0000	0.0000	0.0000
23	0.0992	0.0000	0.0000	0.0000	0.0000
24	0.0930	0.0000	0.0000	0.0000	0.0000
25	0.0620	0.0000	0.0000	0.0000	0.0000
26	0.0310	0.0000	0.0000	0.0000	0.0000
27	0.0124	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000	0.0000
Total Wetted Acres	**6.1969**	**1.6506**	**2.0449**	**0.7098**	**0**

August

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000	0.0000
Total Wetted Acres	**0**	**0**	**0**	**0**	**0**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

September

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.3410	0.0000	0.0000	0.0000	0.0000
5	0.3410	0.0032	0.0000	0.0039	0.0000
6	0.3410	0.0032	0.0000	0.0039	0.0000
7	0.3410	0.0063	0.0000	0.0078	0.0000
8	0.1550	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.3410	0.0032	0.0000	0.0039	0.0000
24	0.3410	0.0063	0.0000	0.0078	0.0000
25	0.3720	0.1575	0.0000	0.2340	0.0000
26	0.3720	0.1575	0.0000	0.2340	0.0000
27	0.3720	0.1575	0.0000	0.2340	0.0000
28	0.3720	0.1575	0.0000	0.2340	0.0000
29	0.3720	0.1575	0.0000	0.2340	0.0000
30	0.3720	0.1575	0.0000	0.2340	0.0000
Total Wetted Acres	**4.433**	**0.9671**	**0**	**1.4313**	**0**

October

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.3410	0.1575	0.0000	0.2340	0.0000
2	0.3565	0.1575	0.0000	0.2340	0.0000
3	0.3720	0.1575	0.0000	0.2340	0.0000
4	0.3720	0.1575	0.0000	0.2340	0.0000
5	0.3720	0.1575	0.0000	0.2340	0.0000
6	0.3720	0.1575	0.0000	0.2730	0.0000
7	0.3720	0.1575	0.0000	0.3120	0.0000
8	0.3720	0.1890	0.0000	0.3510	0.0000
9	0.0000	0.0945	0.0000	0.1560	0.0000
10	0.0000	0.0000	0.0000	0.0780	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.3225	0.0126	0.0000	0.0156	0.0000
15	0.3720	0.0315	0.0000	0.0390	0.0000
16	0.3720	0.0945	0.0000	0.0780	0.0000
17	0.3720	0.0945	0.0000	0.0780	0.0000
18	0.3720	0.1260	0.0000	0.1560	0.0000
19	0.3720	0.1260	0.0000	0.1560	0.0000
20	0.3720	0.1260	0.0000	0.1560	0.0000
21	0.4340	0.1418	0.0000	0.1950	0.0000
22	0.4340	0.1418	0.0000	0.1950	0.0000
23	0.4340	0.1418	0.0000	0.2340	0.0000
24	0.4340	0.1575	0.0000	0.2340	0.0000
25	0.4340	0.1575	0.0000	0.2925	0.0000
26	0.4340	0.1575	0.0000	0.2925	0.0000
27	0.4340	0.1890	0.0000	0.3120	0.0000
28	0.4340	0.1890	0.0000	0.3120	0.0000
29	0.4092	0.1890	0.0000	0.3315	0.0000
30	0.4092	0.2205	0.0000	0.3315	0.0000
31	0.3720	0.2205	0.0000	0.3510	0.0000
Total Wetted Acres	**10.1464**	**3.903**	**0**	**6.0996**	**0**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

USF DAILY WETTED ACREAGES
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

November

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.3720	0.2205	0.0000	0.3510	0.0000
2	0.3720	0.2205	0.0000	0.3510	0.0000
3	0.3720	0.2205	0.0121	0.3510	0.0315
4	0.3410	0.0630	0.0242	0.1560	0.0630
5	0.3720	0.0063	0.0242	0.0624	0.2520
6	0.3720	0.0032	0.0242	0.0390	0.3150
7	0.3720	0.0000	0.0363	0.0078	0.6300
8	0.3720	0.0000	0.0363	0.0000	0.8190
9	0.3720	0.0000	0.0484	0.0000	0.6300
10	0.3720	0.0000	0.0605	0.0000	0.5040
11	0.3720	0.0000	0.0605	0.0000	0.6300
12	0.3720	0.0000	0.0605	0.0000	0.6300
13	0.3720	0.0000	0.0605	0.0000	0.6300
14	0.3720	0.0000	0.0605	0.0000	0.5670
15	0.3720	0.0000	0.0605	0.0000	0.5670
16	0.3720	0.0000	0.0605	0.0000	0.5292
17	0.3720	0.0000	0.0605	0.0000	0.5292
18	0.3720	0.0000	0.0726	0.0000	0.5292
19	0.3720	0.0000	0.0726	0.0000	0.5292
20	0.3410	0.0000	0.0121	0.0000	0.2520
21	0.3410	0.0000	0.0000	0.0000	0.0000
22	0.3410	0.0000	0.0000	0.0000	0.0000
23	0.3410	0.0000	0.0000	0.0000	0.0000
24	0.1550	0.0000	0.0000	0.0000	0.0000
25	0.1550	0.0000	0.0000	0.0000	0.0000
26	0.1240	0.0000	0.0000	0.0000	0.0000
27	0.0930	0.0000	0.0000	0.0000	0.0000
28	0.0620	0.0000	0.0000	0.0000	0.0000
29	0.0310	0.0000	0.0000	0.0000	0.0000
30	0.0124	0.0000	0.0000	0.0000	0.0000
Total Wetted Acres	**9.0334**	**0.73395**	**0.847**	**1.3182**	**8.6373**

December

Date	Equal. Basin Wetted Area (acres)*	Recharge Cell 1 Wetted Area (acres)*	Recharge Cell 2 Wetted Area (acres)*	Recharge Cell 3 Wetted Area (acres)*	Recharge Cell 4 Wetted Area (acres)*
1	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.3410	0.0000	0.0242	0.0000	0.1260
31	0.3720	0.0000	0.1210	0.0000	0.3150
Total Wetted Acres	**0.713**	**0**	**0.1452**	**0**	**0.441**

* Only include wetted non-vegetated area. All vegetated area must be inputted on the evapotranspiration calculation sheet.

APPENDIX D

Evapotranspiration Calculations & AZMET Method Description

Evapotranspiration Calculations
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	January			February			March		
Date	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)
1	0.0620	0.09	0.000465	0.0620	0.08	0.000413333	0.0620	0.04	0.000206667
2	0.0434	0.11	0.000397833	0.0620	0.11	0.000568333	0.0620	0.14	0.000723333
3	0.0434	0.11	0.000397833	0.0620	0.09	0.000465	0.0062	0.17	8.78333E-05
4	0.0124	0.05	5.16667E-05	0.0620	0.1	0.000516667	0.0000	0.14	0
5	0.5208	0.09	0.003906	0.0620	0.1	0.000516667	0.0062	0.19	9.81667E-05
6	0.5208	0.1	0.00434	0.0620	0.03	0.000155	0.0124	0.18	0.000186
7	0.5208	0.11	0.004774	0.0620	0.12	0.00062	0.0124	0.21	0.000217
8	0.5208	0.11	0.004774	0.0620	0.13	0.000671667	0.0124	0.22	0.000227333
9	0.5208	0.07	0.003038	0.0620	0.15	0.000775	0.0124	0.3	0.00031
10	0.5208	0.11	0.004774	0.0620	0.17	0.000878333	0.0124	0.21	0.000217
11	0.0000	0.1	0	0.0620	0.16	0.000826667	0.0124	0.21	0.000217
12	0.0000	0.12	0	0.0310	0.17	0.000439167	0.0124	0.22	0.000227333
13	0.0000	0.13	0	0.0310	0.17	0.000439167	0.0124	0.2	0.000206667
14	0.0000	0.11	0	0.0310	0.18	0.000465	0.0124	0.16	0.000165333
15	0.0000	0.12	0	0.0310	0.19	0.000490833	0.0124	0.27	0.000279
16	0.5208	0.13	0.005642	0.0620	0.18	0.00093	0.0124	0.25	0.000258333
17	0.0930	0.11	0.0008525	0.0620	0.18	0.00093	0.0124	0.26	0.000268667
18	0.0310	0.12	0.00031	0.0620	0.18	0.00093	0.0124	0.25	0.000258333
19	0.5208	0.11	0.004774	0.0620	0.12	0.00062	0.0124	0.23	0.000237667
20	0.5520	0.13	0.00598	0.0562	0.19	0.000889833	0.0000	0.21	0
21	0.1556	0.13	0.001685667	0.2384	0.16	0.003178667	0.0124	0.24	0.000248
22	0.1088	0.11	0.000997333	0.2510	0.18	0.003765	0.0124	0.24	0.000248
23	0.0776	0.11	0.000711333	0.2762	0.11	0.002531833	0.0310	0.24	0.00062
24	0.0872	0.11	0.000799333	0.2762	0.12	0.002762	0.0620	0.24	0.00124
25	0.2762	0.13	0.002992167	0.2978	0.1	0.002481667	0.0620	0.2	0.001033333
26	0.2762	0.13	0.002992167	0.3320	0.17	0.004703333	0.0062	0.24	0.000124
27	0.2762	0.12	0.002762	0.0252	0.19	0.000399	0.0124	0.23	0.000237667
28	0.2510	0.13	0.002719167	0.0872	0.19	0.001380667	0.1184	0.24	0.002368
29	0.2510	0.13	0.002719167			0	0.1718	0.24	0.003436
30	0.1754	0.14	0.002046333				0.3212	0.18	0.004818
31	0.0872	0.14	0.001017333				0.3464	0.22	0.006350667
Monthly Evapo-transpiration			**0.065918833**			**0.033742833**			**0.025115333**

Evapotranspiration Calculations
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	April			May			June		
Date	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)
1	0.4190	0.27	0.0094275	0.1736	0.35	0.005063333	0.1054	0.35	0.003074167
2	0.4376	0.24	0.008752	0.1550	0.31	0.004004167	0.1054	0.36	0.003162
3	0.4562	0.22	0.008363667	0.1054	0.31	0.002722833	0.0310	0.37	0.000955833
4	0.4202	0.22	0.007703667	0.1054	0.33	0.0028985	0.0310	0.39	0.0010075
5	0.2930	0.19	0.004639167	0.1054	0.34	0.002986333	0.0310	0.38	0.000981667
6	0.2242	0.25	0.004670833	0.1054	0.35	0.003074167	0.0310	0.37	0.000955833
7	0.1990	0.26	0.004311667	0.0930	0.3	0.002325	0.0310	0.37	0.000955833
8	0.1990	0.26	0.004311667	0.0930	0.27	0.0020925	0.0310	0.35	0.000904167
9	0.1990	0.25	0.004145833	0.0930	0.29	0.0022475	0.0310	0.36	0.00093
10	0.1990	0.26	0.004311667	0.0930	0.34	0.002635	0.0310	0.36	0.00093
11	0.1990	0.23	0.003814167	0.0744	0.38	0.002356	0.0310	0.37	0.000955833
12	0.1990	0.24	0.00398	0.0434	0.33	0.0011935	0.0310	0.33	0.0008525
13	0.1866	0.29	0.0045095	0.1054	0.31	0.002722833	0.0310	0.38	0.000981667
14	0.1026	0.26	0.002223	0.1736	0.45	0.00651	0.0310	0.4	0.001033333
15	0.1366	0.27	0.0030735	0.1550	0.37	0.004779167	0.0310	0.36	0.00093
16	0.1736	0.28	0.004050667	0.1364	0.35	0.003978333	0.0310	0.4	0.001033333
17	0.1736	0.26	0.003761333	0.1054	0.35	0.003074167	0.0310	0.34	0.000878333
18	0.1054	0.09	0.0007905	0.0930	0.31	0.0024025	0.0310	0.32	0.000826667
19	0.1054	0.2	0.001756667	0.0930	0.35	0.0027125	0.0310	0.34	0.000878333
20	0.0930	0.25	0.0019375	0.0930	0.34	0.002635	0.0310	0.36	0.00093
21	0.0930	0.25	0.0019375	0.0930	0.37	0.0028675	0.0310	0.4	0.001033333
22	0.0930	0.28	0.00217	0.0310	0.36	0.00093	0.0310	0.37	0.000955833
23	0.1364	0.31	0.003523667	0.0310	0.32	0.000826667	0.0310	0.36	0.00093
24	0.1736	0.28	0.004050667	0.0434	0.29	0.001048833	0.0310	0.35	0.000904167
25	0.1736	0.3	0.00434	0.0558	0.33	0.0015345	0.0310	0.37	0.000955833
26	0.1736	0.14	0.002025333	0.0558	0.35	0.0016275	0.0310	0.37	0.000955833
27	0.1736	0.23	0.003327333	0.0558	0.34	0.001581	0.0310	0.38	0.000981667
28	0.1736	0.28	0.004050667	0.0558	0.29	0.0013485	0.0310	0.34	0.000878333
29	0.1736	0.32	0.004629333	0.0558	0.19	0.0008835	0.0310	0.35	0.000904167
30	0.1736	0.28	0.004050667	0.0558	0.33	0.0015345	0.0310	0.37	0.000955833
31				0.1054	0.36	0.003162			
Monthly Evapo-transpiration			**0.124639667**			**0.079757833**			**0.032612**

Evapotranspiration Calculations
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	July			August			September		
Date	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)
1	0.0310	0.38	0.000981667	0.0000	0.17	0	0.0000	0.26	0
2	0.0310	0.38	0.000981667	0.0000	0.1	0	0.0000	0.26	0
3	0.0310	0.26	0.000671667	0.0000	0.24	0	0.0000	0.2	0
4	0.0310	0.25	0.000645833	0.0000	0.24	0	0.0000	0.26	0
5	0.0310	0.24	0.00062	0.0000	0.3	0	0.0000	0.23	0
6	0.0434	0.27	0.0009765	0.0000	0.29	0	0.0000	0.1	0
7	0.0310	0.18	0.000465	0.0000	0.26	0	0.0000	0.23	0
8	0.0124	0.26	0.000268667	0.0000	0.3	0	0.0000	0.04	0
9	0.0000	0.26	0	0.0000	0.31	0	0.0000	0.15	0
10	0.0000	0.24	0	0.0000	0.23	0	0.0000	0.2	0
11	0.0000	0.28	0	0.0000	0.23	0	0.0000	0.22	0
12	0.0000	0.16	0	0.0000	0.11	0	0.0000	0.24	0
13	0.0000	0.22	0	0.0000	0.25	0	0.0000	0.3	0
14	0.0000	0.21	0	0.0000	0.12	0	0.0000	0.26	0
15	0.0000	0.11	0	0.0000	0.2	0	0.0000	0.21	0
16	0.0000	0.29	0	0.0000	0.26	0	0.0000	0.07	0
17	0.0000	0.26	0	0.0000	0.25	0	0.0000	0.07	0
18	0.0000	0.27	0	0.0000	0.23	0	0.0000	0.09	0
19	0.0000	0.3	0	0.0000	0.13	0	0.0000	0.12	0
20	0.0000	0.3	0	0.0000	0.23	0	0.0000	0.15	0
21	0.0000	0.35	0	0.0000	0.07	0	0.0000	0.19	0
22	0.0000	0.26	0	0.0000	0.19	0	0.0000	0.22	0
23	0.0000	0.3	0	0.0000	0.23	0	0.0000	0.22	0
24	0.0000	0.33	0	0.0000	0.24	0	0.0000	0.2	0
25	0.0000	0.21	0	0.0000	0.16	0	0.0000	0.22	0
26	0.0000	0.32	0	0.0000	0.13	0	0.0000	0.11	0
27	0.0000	0.31	0	0.0000	0.22	0	0.0000	0.19	0
28	0.0000	0.18	0	0.0000	0.26	0	0.0000	0.19	0
29	0.0000	0.29	0	0.0000	0.26	0	0.0000	0.19	0
30	0.0000	0.27	0	0.0000	0.27	0	0.0000	0.2	0
31	0.0000	0.24	0	0.0000	0.28	0			
Monthly Evapo-transpiration			**0.005611**			**0**			**0**

Evapotranspiration Calculations
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	October			November			December		
Date	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)	Wetted Vegetated Area (acres)	Daily AZMET ETo (inches)	Daily Evapo-Transpiration (acre-feet)
1	0.0000	0.21	0	0.0000	0.13	0	0.0000	0.07	0
2	0.0000	0.2	0	0.0000	0.1	0	0.0000	0.04	0
3	0.0000	0.2	0	0.0000	0.14	0	0.0000	0.07	0
4	0.0000	0.22	0	0.0000	0.12	0	0.0000	0.02	0
5	0.0000	0.2	0	0.0000	0.2	0	0.0000	0.06	0
6	0.0000	0.16	0	0.0000	0.21	0	0.0000	0.01	0
7	0.0000	0.17	0	0.1890	0.15	0.0023625	0.0000	0.08	0
8	0.0000	0.03	0	0.2142	0.16	0.002856	0.0000	0.05	0
9	0.0000	0.07	0	0.1890	0.15	0.0023625	0.0000	0.06	0
10	0.0000	0.15	0	0.0000	0.15	0	0.0000	0.09	0
11	0.0000	0.17	0	0.1890	0.13	0.0020475	0.0000	0.09	0
12	0.0000	0.18	0	0.1890	0.12	0.00189	0.0000	0.1	0
13	0.0000	0.16	0	0.1890	0.11	0.0017325	0.0000	0	0
14	0.0000	0.17	0	0.0000	0.11	0	0.0000	0.07	0
15	0.0000	0.17	0	0.0000	0.11	0	0.0000	0.06	0
16	0.0000	0.17	0	0.0000	0.13	0	0.0000	0.04	0
17	0.0000	0.1	0	0.0000	0.1	0	0.0000	0.02	0
18	0.0000	0.17	0	0.0000	0.11	0	0.0000	0.04	0
19	0.0000	0.13	0	0.0000	0.11	0	0.0000	0.06	0
20	0.0000	0.15	0	0.0000	0.11	0	0.0000	0.06	0
21	0.0062	0.14	7.23333E-05	0.0000	0.07	0	0.0000	0.06	0
22	0.0062	0.15	0.0000775	0.0000	0.1	0	0.0000	0.07	0
23	0.0062	0.14	7.23333E-05	0.0000	0.13	0	0.0000	0.11	0
24	0.0062	0.15	0.0000775	0.0000	0.13	0	0.0000	0.09	0
25	0.0062	0.15	0.0000775	0.0000	0.13	0	0.0000	0.1	0
26	0.0062	0.13	6.71667E-05	0.0000	0.11	0	0.0000	0.09	0
27	0.0062	0.13	6.71667E-05	0.0000	0.13	0	0.0000	0.07	0
28	0.0062	0.14	7.23333E-05	0.0000	0.12	0	0.0000	0.07	0
29	0.0310	0.15	0.0003875	0.0000	0.13	0	0.0000	0.07	0
30	0.0310	0.13	0.000335833	0.0000	0.12	0	0.0000	0.12	0
31	0.0000	0.14	0				0.0000	0.02	0
Monthly Evapo-transpiration			**0.001307167**			**0.013251**			**0**

THE UNIVERSITY OF ARIZONA®

Cooperative Extension

STANDARDIZED REFERENCE EVAPOTRANSPIRATION

A NEW PROCEDURE FOR ESTIMATING REFERENCE EVAPOTRANSPIRATION IN ARIZONA

Introduction

The Arizona Meteorological Network (AZMET) has provided daily values of reference evapotranspiration (ETo) for a number of southern Arizona locations for more than 15 years. ETo is a computed meteorological parameter that provides an estimate of environmental evaporative demand and serves as a critical input variable for most scientifically based irrigation scheduling systems. ETo is also used to estimate evaporation from water bodies and evapotranspiration (ET) from rain-fed ecosystems.

While there is general agreement among agronomists, irrigation engineers and meteorologists that ETo is a useful environmental parameter, there has been less agreement on how to compute ETo. And all too often the computational procedure for ETo varies from region to region and sometimes within a region. Use of multiple ETo computation procedures within a region can generate biases in ETo that result from the computation process, not any true differences in environmental evaporative demand. Figure 1 provides graphic evidence of this computational bias by presenting the total ETo for Tucson in 1996 as computed using the published ETo procedures for the public weather networks operating in Arizona (Brown, 1998), California (Snyder and Pruitt, 1985), and New Mexico (Sammis, 1996). It is important to note that the same meteorological data were used to generate the ETo data in Figure 1; only the computational procedures differed. These results provide clear evidence that lack of a standardized computational procedure for ETo can lead to confusion and perhaps serious mistakes when one is involved in activities such as irrigation scheduling, estimating consumptive use of vegetation, water rights litigation (especially across state lines), and development of crop coefficients (adjustment factors that convert ETo to crop ET).

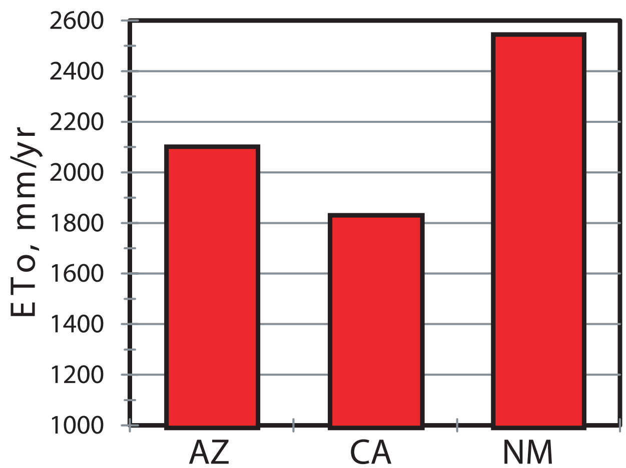


Figure 1. Reference ET (ETo) for Tucson for calendar year 1996 as computed using the published procedures for the public weather networks in Arizona, California, and New Mexico.

Over the past decade, scientists have recognized the problems and frustrations associated with non-standardized ETo computation and have formed national and international committees to address this issue. The American Society of Civil Engineers (ASCE) developed

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This information has been reviewed by university faculty.

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a special Task Committee (TC) in 1999 to develop a standardized procedure for computing ETo. The ASCE TC has issued its recommendations (Walter et al., 2004) which are to be published in 2005. AZMET participated in the ASCE TC and began generating ETo values using this ASCE Standardized ETo procedure in 2003. The purpose of this report is to first review the computation procedure recommended by the ASCE TC; second, provide specifics on the computation procedure AZMET will employ; and third, summarize how the new standardized ETo procedure and the original AZMET ETo (EToa) procedure compare across months and locations.

Standardized Reference Evapotranspiration Definition

The ASCE TC defined reference evapotranspiration as "the ET rate from a uniform surface of dense actively growing vegetation having specified height and surface resistance (to transfer of water vapor), not short of soil water, and representing an expanse of at least 100 m of the same or similar vegetation." This definition leaves open the option of having more than one reference surface (differing height and surface resistance) and reflects the view of the TC that standardized computation procedures were necessary for two reference surfaces: 1) a short crop similar to clipped grass and 2) a tall crop similar to full-cover alfalfa. The recommended abbreviations for ETo computed for the short and tall crops using the standardized procedures are ETos and ETrs, respectively (see Table 1 for list of ET abbreviations used in this report).

The need to have procedures for two reference surfaces reflects the history of ET research in the U.S. Two crops — cool-season grass and alfalfa — have been used as reference surfaces for ET estimation for several decades. The TC recommendations allow users with a strong preference for one reference surface or another to continue using their preferred surface. An important reason for recommending two surfaces pertains to crop coefficients (Kcs) — the adjustment factors used to convert ETo to estimates of ET for a specific type of vegetation. Kcs will differ for the two reference surfaces since alfalfa typically uses more water than grass when both are grown under reference conditions. Over the past 30+ years, Kcs have been developed for use with ETo computed for both grass and alfalfa reference surfaces. The TC recommendation to allow for two reference surfaces allows local users to continue using the Kcs and reference surface they are most comfortable with.

ABBREVIATION	EXPLANATION
ET	Evapotranspiration
ETc	Evapotranspiration of a particular crop or vegetation type
ETo	Reference Evapotranspiration in general
ETos	Standardized Reference Evapotranspiration for Short Reference Crop
ETrs	Standardized Reference Evapotranspiration for Tall Reference Crop
ETsz	Standardized Reference Evapotranspiration in general
ETοa	Reference Evapotranspiration as computed by AZMET in past years

Table 1. Abbreviations related to evapotranspiration that are contained in this report.

Standardized Reference ET Equation

Generalized Form of Standardized Equation

The ASCE TC standardized procedure for computing reference evapotranspiration is based on the Penman-Monteith Equation and more specifically on simplifying the version of the Penman Monteith Equation recommended by ASCE (Jensen et al., 1990). The recommended general computation procedure is provided below:

$$ETsz = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{C_n}{T+273} u_2(e_s - e_a)}{\Delta + \gamma(1 + C_d u_2)} \quad (1)$$

Where:

ETsz = standardized reference crop evapotranspiration (mm d^{-1} or mm h^{-1})

Δ = slope of the saturation vapor pressure-temperature curve (kPa $^oC^{-1}$)

R_n = Calculated net radiation at the crop surface (MJ m^{-2} d^{-1} or MJ m^{-2} h^{-1})

G = Soil heat flux density at the soil surface (MJ m^{-2} d^{-1} or MJ m^{-2} h^{-1})

γ = psychrometer constant (kPa $^oC^{-1}$)

C_n = numerator constant that changes with reference type and calculation time step

T = mean daily air temperature measured at 1.5 to 2.5 m above ground level (^oC)

U_2 = mean daily wind speed wind speed measured at 2 m above ground level (m s^{-1})

e_s = saturation vapor pressure measured at 1.5 to 2.5 m above ground level (kPa)

e_a = mean actual vapor pressure measured at 1.5 to 2.5 m above ground level (kPa)

C_d = denominator constant that changes with reference type and calculation time step

Equation 1 represents a generalized equation that can, with appropriate use of constants, handle different reference surfaces; different computational time steps; and slight variation in the measurement height of certain meteorological measurements. Note that standardized reference ET when described in this generalized form is given the abbreviation ETsz.

Standardized Equation To Be Used By AZMET

AZMET will utilize the standardized procedure for a short reference crop computed using a daily computational time step. The appropriate equation for this version of the standardized procedure is provided below:

$$ETos = \frac{0.408\Delta R_n + \gamma \dfrac{900}{T+273} u_2(e_s - e_a)}{\Delta + \gamma\,(1 + 0.34u_2)} \qquad (2)$$

Where:

ETos = standardized reference crop evapotranspiration for a short crop in mm d^{-1}

Δ = slope of the saturation vapor pressure-temperature curve (kPa $^oC^{-1}$)

R_n = Calculated net radiation at the crop surface in MJ m^{-2} d^{-1}

γ = psychrometer constant (kPa $^oC^{-1}$)

T = mean daily air temperature measured at 1.5 m above ground level (^oC)

u_2 = mean daily wind speed measured at 2 m above ground level (m s^{-1})

e_s = saturation vapor pressure measured at 1.5 m above ground level (kPa)

e_a = mean actual vapor pressure measured at 1.5 m above ground level (kPa)

A comparison of Eqs. 1 and 2 reveal some significant differences. One notable difference is the change in abbreviation for reference ET. The ASCE task force recommended using the abbreviation ETos for short crop standardized reference ET. Another important difference among the two equations is that the numerator and denominator constants in Eq. 1 are set equal to 900 and 0.34, respectively which represent the appropriate constants for the short reference crop and daily computational time step. Finally, one will notice that Eq. 2 no longer contains the soil heat flux variable (G in Eq. 1). Soil heat flux is typically very small over a period of 24 hours (heat that flows into soil in day is lost back to the surface at night) and thus is set equal to zero in the standardized equation when the daily computation time step is used.

The reason AZMET chose to use reference ET computed for a short reference crop is to provide continuity with past AZMET ETo data. AZMET has used a 0.08-0.15 m tall cool season grass as its ET reference surface since the inception of the network in 1987.

The time step for ETsz computation was another factor addressed by the ASCE TC. Time step refers to the time interval over which the ETsz computation is made. The TC recommended standardized procedures for two computational time steps — hourly and daily. The daily computational time step has been used for many decades, in part because most older meteorological data sets consisted of daily summaries. The advent of automated weather stations in the late 1970s led to an increase in the number of hourly data sets that could be used to compute ETo. Past research suggests the ETo computation is more accurate when the computation time step is hourly as opposed to daily or longer (Tanner and Pelton, 1960, Van Bavel, 1966), particularly in regions where meteorological conditions vary in an asymmetric manner each day (e.g., coastal locations with fog or sea breeze; certain mountain areas subject to sudden changes in wind or cloudiness each day). One of the objectives of the TC was to recommend a standardized procedure where the computational time step did not greatly impact the resulting ETsz value. The TC did conduct an evaluation of the impact of time step on the resulting ETsz value (Itenfisu et al., 2000). The evaluation found that ETsz computed using the hourly and daily time step was generally within 2% across a large number of locations (including Arizona).

AZMET chose to use the daily time step computation model for the following reasons: 1) meteorological conditions in Arizona do not generally exhibit serious asymmetric tendencies over the course of a day; 2) daily

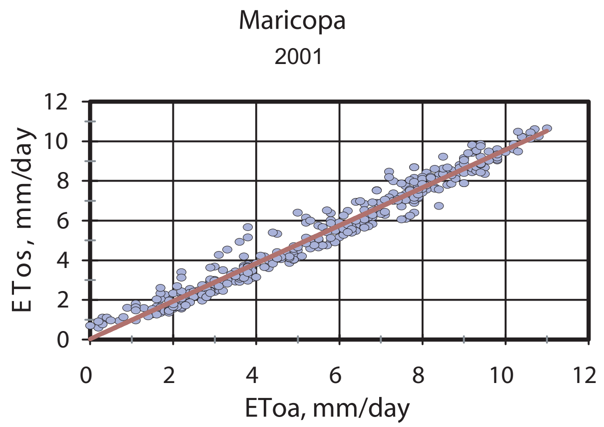

Figure 2. Reference evapotranspiration as computed using the ASCE standardized procedure (ETos) versus reference evapotranspiration computed using procedure employed by AZMET. The line represents the least squares regression line (ETos = 0.03 + 0.95 x ETоa; $r^2 = 0.96$).

meteorological data are easier to estimate than hourly data when data are missing due to instrument failure or station maintenance; and 3) AZMET questions the accuracy of nighttime net radiation (R_n)estimates required to estimate ETos on an hourly timescale.

Data Required To Compute ETos

Both meteorological and non-meteorological data are required for the computation of ETos. The required meteorological data include: 1) daily solar radiation (MJ m^{-2} d^{-1}), 2) mean daily vapor pressure (kPa), 3) mean daily wind speed (m s^{-1}), and 4) maximum and minimum air temperature for the day (^oC). All of the required meteorological data are collected by AZMET weather stations. Required non-meteorological data consist of elevation above sea level and latitude for the locations providing the meteorological data (AZMET weather station locations).

The meteorological data required for computation of ETos must be converted into the specific variables required in Eq. 2. Multiple procedures are available for making these required conversions. The ASCE TC reviewed many of the recommended conversion procedures and made recommendations on the best procedures to use based on the kind and quality of available meteorological data. The specific procedures and/or equations employed by AZMET to generate these required variables are presented in the Appendix to this report

Comparison of Standardized Reference ET with Original AZMET ETo

A logical question for users of ETo data would be how does the new standardized procedure (ETos) compare with the original AZMET ETo (ETоa) data. To answer this question, AZMET computed daily ETos for the period 1 January 1998 through 31 December 2001 (4 years), then compared the monthly, seasonal, and annual totals of ETos against similar totals of ETоa for locations presently served by AZMET weather stations.

ETos and ETоa were highly correlated across all locations served by AZMET. The data presented in Figure 2 are representative of the general relationship between ETos and ETоa. While ETos and ETоa are highly correlated, values of ETos generally run lower than ETоa. This lower bias of ETos is clearly evident in Tables 2 and 3 that present monthly, seasonal, and annual totals of ETos and ETоa for all locations presently served by AZMET weather stations. Also included in Tables 2 and 3 are ratios of ETos to ETоa for the various time scales.

Annual totals of ETos were 3-17% lower than similar totals of ETоa depending on location (Table 3). The lowest ratios of ETos to ETоa occur where wind flow is generally low (e.g., Waddell, Phoenix Encanto, and Phoenix Greenway). The highest ratios occur at locations exhibiting fairly high wind speeds (e.g., Marana, Parker).

The monthly and seasonal ratios presented in Tables 2 and 3 reveal that the lower bias of ETos (relative to ETоa) is not constant over time. Higher ratios typically occur during windy months and months with higher dew point temperatures (e.g., summer monsoon months). Lower ratios commonly occur when dew point and wind flow are low.

Converting Past ETоa to ETos

Long time users of AZMET data may have databases and spreadsheets that contain values of ETоa generated in past years. Users interested in converting ETоa data into reliable estimates of ETos may use the ratios presented in Tables 2 & 3. The simple conversion process uses the following equation:

$$\text{ETos} = \text{Ratio} * \text{EToa} \quad (3)$$

Table 2. Mean monthly values of reference evapotranspiration for all AZMET station sites for the period 1998-2001 computed using the ASCE standardized (ETos) and original AZMET (EToa) computation procedures. Monthly ratios of ETos to EToa are provided in columns labeled "Ratio."

LOCATION	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio
Aguila	72.6	80.5	0.90	77.8	90.1	0.86	125.4	147.2	0.85	171.1	198.5	0.86	241.6	273.0	0.89	261.4	289.3	0.90
Buckeye	74.3	83.8	0.89	84.7	96.1	0.88	134.0	151.7	0.88	180.2	207.0	0.87	240.5	270.0	0.89	251.0	276.2	0.91
Bonita	69.8	79.0	0.88	82.8	94.2	0.88	126.3	146.6	0.86	167.5	197.2	0.85	222.8	256.6	0.87	228.1	247.6	0.92
Coolidge	73.5	78.4	0.94	82.2	90.4	0.91	124.6	140.4	0.89	174.5	197.5	0.88	247.4	269.4	0.92	253.7	271.7	0.93
Eloy	69.4	77.1	0.90	81.1	91.3	0.89	125.7	146.0	0.86	173.5	204.2	0.85	241.6	274.7	0.88	254.0	277.5	0.92
Harquahala	65.7	76.6	0.86	73.9	87.7	0.84	124.5	148.0	0.84	166.8	198.2	0.84	220.9	253.1	0.87	246.7	272.4	0.91
Litchfield Pk.	66.8	75.7	0.88	77.5	88.4	0.88	126.1	144.3	0.87	173.5	202.5	0.86	238.7	270.1	0.88	263.1	287.7	0.91
Maricopa	63.3	72.5	0.87	80.0	89.7	0.89	126.0	143.6	0.88	175.0	199.1	0.88	244.0	267.5	0.91	261.3	280.4	0.93
Marana	90.2	89.5	1.01	98.9	102.2	0.97	144.9	157.5	0.92	184.2	206.2	0.89	251.8	274.1	0.92	264.6	277.3	0.95
Mohave Val.	80.7	87.0	0.93	87.3	94.6	0.92	145.8	164.6	0.89	191.8	214.9	0.89	257.8	278.6	0.93	257.4	275.2	0.94
Paloma	72.9	79.6	0.92	84.8	94.9	0.89	131.1	149.5	0.88	173.5	200.0	0.87	234.4	259.8	0.90	255.8	276.2	0.93
Parker	72.5	78.4	0.93	80.9	90.1	0.90	134.7	153.2	0.88	192.1	211.4	0.91	263.8	280.9	0.94	281.5	288.9	0.97
Phoenix Encanto	54.5	65.6	0.83	67.5	80.7	0.84	111.8	133.6	0.84	153.6	185.3	0.83	209.9	247.0	0.85	228.2	262.3	0.87
Phoenix Greenway	51.1	69.8	0.73	65.4	83.5	0.78	108.6	134.3	0.81	149.7	182.8	0.82	205.3	245.3	0.84	226.0	261.4	0.86
Queen Ck.	61.7	66.0	0.93	74.8	81.9	0.91	117.9	131.0	0.90	159.9	182.3	0.88	214.9	240.3	0.89	227.0	249.1	0.91
Roll	64.5	80.5	0.80	76.9	92.4	0.83	128.4	153.6	0.84	174.8	204.8	0.85	222.5	251.6	0.88	234.2	258.4	0.91
Safford	74.8	80.8	0.93	92.4	100.8	0.92	139.4	156.8	0.89	187.0	211.8	0.88	250.8	274.1	0.92	252.7	264.5	0.96
Tucson	68.6	80.8	0.85	82.4	94.6	0.87	128.0	151.2	0.85	166.3	196.0	0.85	224.3	258.1	0.87	235.4	258.3	0.91
Waddell	54.0	76.2	0.71	67.3	86.2	0.78	111.4	136.8	0.81	156.1	192.3	0.81	217.8	262.6	0.83	236.4	276.2	0.86
Yuma Mesa	69.7	85.2	0.82	80.2	95.8	0.84	129.4	155.0	0.83	168.7	199.6	0.85	217.6	247.7	0.88	238.8	261.8	0.91
Yuma N. Gila	71.6	84.2	0.85	80.2	94.3	0.85	127.5	151.3	0.84	170.2	199.0	0.86	211.8	239.7	0.88	229.0	251.2	0.91
Yuma Valley	83.9	94.5	0.89	90.5	103.3	0.88	135.1	158.7	0.85	181.3	207.9	0.87	230.5	254.1	0.91	259.3	278.5	0.93

Table 2 continued. Mean monthly values of reference evapotranspiration for all AZMET station sites for the period 1998-2001 computed using the ASCE standardized (ETos) and original AZMET (EToa) computation procedures. Monthly ratios of ETos to EToa are provided in columns labeled "Ratio."

LOCATION	JULY			AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			DECEMBER		
	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio
Aguila	249.1	259.6	0.96	218.3	222.3	0.98	184.0	199.0	0.92	138.3	153.7	0.90	90.5	100.6	0.90	75.5	82.3	0.92
Buckeye	236.8	245.5	0.96	225.3	226.9	0.99	188.6	200.6	0.94	137.9	153.6	0.90	86.3	97.8	0.88	70.9	79.3	0.89
Bonita	192.3	194.1	0.99	179.3	185.2	0.97	166.7	180.4	0.92	125.9	140.8	0.89	82.3	94.2	0.87	66.3	77.1	0.86
Coolidge	217.7	219.4	0.99	198.3	200.8	0.99	166.0	172.9	0.96	128.0	138.5	0.92	83.5	89.2	0.94	71.9	75.4	0.95
Eloy	236.1	237.6	0.99	219.0	221.7	0.99	177.3	192.1	0.92	130.3	147.1	0.89	78.5	93.6	0.84	65.3	73.0	0.89
Harquahala	249.6	260.8	0.96	231.2	234.9	0.98	182.7	199.1	0.92	127.6	148.5	0.86	77.7	93.4	0.83	68.6	78.6	0.87
Litchfield Pk.	246.8	257.5	0.96	219.2	228.3	0.96	172.5	192.0	0.90	121.4	138.1	0.88	74.7	86.8	0.86	60.9	69.0	0.88
Maricopa	247.6	249.7	0.99	223.6	225.1	0.99	182.8	192.9	0.95	128.1	141.9	0.90	73.6	84.4	0.87	58.9	66.1	0.89
Marana	220.2	216.1	1.02	209.6	204.4	1.03	193.4	194.1	1.00	152.9	155.2	0.99	107.9	107.5	1.00	82.6	83.7	0.99
Mohave Val.	233.5	244.3	0.96	211.0	217.2	0.97	169.0	184.8	0.91	131.0	144.1	0.91	89.0	97.6	0.91	91.8	99.8	0.92
Paloma	241.4	247.8	0.97	213.4	213.9	1.00	174.4	183.4	0.95	129.5	142.7	0.91	81.4	90.8	0.90	69.4	72.9	0.95
Parker	276.1	275.7	1.00	224.0	224.4	1.00	194.2	202.2	0.96	144.8	156.7	0.92	88.4	97.7	0.90	75.3	82.2	0.92
Phoenix Encato	223.8	243.3	0.92	207.0	222.7	0.93	161.3	185.7	0.87	108.7	131.2	0.83	63.3	79.8	0.79	49.9	61.7	0.81
Phoenix Greenway	221.2	240.3	0.92	206.2	222.1	0.93	158.1	185.7	0.85	106.8	137.0	0.78	60.3	85.6	0.70	47.0	66.4	0.71
Queen Ck.	219.7	222.5	0.99	205.8	207.9	0.99	169.2	179.5	0.94	117.9	131.1	0.90	72.5	82.2	0.88	57.3	63.2	0.91
Roll	234.1	246.0	0.95	222.2	230.5	0.96	180.8	193.5	0.93	129.9	143.3	0.91	74.8	84.3	0.89	63.8	77.5	0.82
Safford	205.5	203.4	1.01	178.2	177.7	1.00	161.8	170.0	0.95	125.7	136.0	0.92	80.3	88.5	0.91	68.9	72.4	0.95
Tucson	201.1	205.2	0.98	192.1	197.9	0.97	168.8	183.8	0.92	123.6	143.1	0.86	77.6	92.0	0.84	64.1	77.3	0.83
Waddell	225.6	250.7	0.90	199.0	220.2	0.90	156.2	188.8	0.83	107.5	140.2	0.77	61.9	88.8	0.70	48.8	71.0	0.69
Yuma Mesa	241.0	252.4	0.95	217.6	224.6	0.97	174.9	191.3	0.91	129.3	150.2	0.86	83.4	98.5	0.85	75.1	90.5	0.83
Yuma N. Gila	249.3	254.1	0.98	233.6	233.6	1.00	182.9	193.5	0.95	133.6	148.3	0.90	82.7	92.8	0.89	74.6	85.5	0.87
Yuma Valley	266.8	276.3	0.97	240.2	241.8	0.99	203.7	212.8	0.96	148.8	162.9	0.91	96.1	104.1	0.92	89.0	97.9	0.91

Table 3. Seasonal and annual means of reference evapotranspiration for all active AZMET monitoring sites for the period 1998-2001 as computed using the ASCE standardized (ETos) and original AZMET (EToa) procedures. Ratios of ETos to EToa are provided in columns labeled "Ratio."

LOCATION	WINTER (Dec. - Feb.)			SPRING (Mar. - May)			SUMMER (Jun. - Aug.)			FALL (Sep. - Nov.)			ANNUAL		
	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio	ETos (mm)	EToa (mm)	Ratio
Aguila	225.9	252.9	0.89	538.1	618.7	0.87	728.8	771.2	0.94	412.8	453.3	0.91	1905.7	2095.9	0.91
Buckeye	229.9	259.2	0.89	554.7	628.7	0.88	713.1	748.6	0.95	412.8	452.0	0.91	1910.5	2088.2	0.91
Bonita	218.9	250.3	0.87	516.6	600.4	0.86	599.7	626.9	0.96	374.9	415.4	0.90	1710.2	1892.9	0.90
Coolidge	227.6	244.2	0.93	546.5	607.3	0.90	669.7	691.9	0.97	377.5	400.6	0.94	1821.3	1944.0	0.94
Eloy	215.8	241.4	0.89	540.8	626.4	0.86	709.1	735.3	0.96	386.1	432.8	0.89	1851.9	2035.7	0.91
Harquahala	208.2	242.9	0.86	512.2	599.3	0.85	727.5	768.1	0.95	388.0	441.0	0.88	1835.9	2051.2	0.90
Litchfield Pk.	205.2	233.1	0.88	538.3	616.9	0.87	729.1	773.5	0.94	368.6	416.9	0.88	1841.3	2040.4	0.90
Maricopa	202.2	228.3	0.89	545.0	610.2	0.89	732.5	755.2	0.97	384.5	419.2	0.92	1864.2	2012.8	0.93
Marana	271.7	275.4	0.99	580.9	637.8	0.91	694.4	697.8	1.00	454.2	456.8	0.99	2001.2	2067.6	0.97
Mohave Val.	259.8	281.4	0.92	595.4	658.1	0.90	701.9	736.7	0.95	389.0	426.5	0.91	1946.2	2102.4	0.93
Paloma	227.1	247.4	0.92	539.0	609.3	0.88	710.6	737.9	0.96	385.3	416.9	0.92	1862.0	2011.3	0.93
Parker	228.7	250.7	0.91	590.6	645.5	0.91	781.6	789.0	0.99	427.4	456.6	0.94	2028.4	2141.6	0.95
Phoenix Encanto	171.9	208.0	0.83	475.3	565.9	0.84	659.0	728.3	0.90	333.3	396.7	0.84	1639.6	1898.7	0.86
Phoenix Greenway	163.5	219.7	0.74	463.6	562.4	0.82	653.4	723.8	0.90	325.2	408.3	0.80	1605.6	1914.1	0.84
Queen Ck.	193.8	211.1	0.92	492.7	553.6	0.89	652.5	679.5	0.96	359.6	392.8	0.92	1698.5	1836.7	0.92
Roll	205.2	250.4	0.82	525.7	610.0	0.86	690.5	734.9	0.94	385.5	421.1	0.92	1806.9	2016.3	0.90
Safford	236.1	254.0	0.93	577.2	642.7	0.90	636.4	645.6	0.99	367.8	394.5	0.93	1817.6	1936.6	0.94
Tucson	215.1	252.7	0.85	518.6	605.3	0.86	628.6	661.4	0.95	370.0	418.9	0.88	1732.2	1938.2	0.89
Waddell	170.1	233.4	0.73	485.3	591.7	0.82	661.0	747.1	0.88	325.6	417.8	0.78	1642.0	1989.7	0.83
Yuma Mesa	225.0	271.5	0.83	515.7	602.3	0.86	697.4	738.8	0.94	387.6	440.0	0.88	1825.7	2052.4	0.89
Yuma N. Gila	226.4	264.0	0.86	509.5	590.0	0.86	711.9	738.9	0.96	399.2	434.6	0.92	1847.0	2027.4	0.91
Yuma Valley	263.4	295.7	0.89	546.9	620.7	0.88	766.3	796.6	0.96	448.6	479.8	0.93	2025.2	2192.5	0.92

where **Ratio** represents the appropriate annual, seasonal or monthly ratio from Tables 2 and 3. Annual ratios should be used only to adjust annual totals of ETOa. Monthly ratios provide the best means of converting short term data sets (e.g., daily, weekly or monthly totals of ETOa). *Users wishing to obtain actual computed values of ETos for past years should contact AZMET. As part of the move to adopt ETos, AZMET will generate ETos for its entire database which extends back to 1987 at some locations.*

Crop Coefficients and ETos

Crop coefficients (Kcs) are used to convert ETo data into estimates of crop evapotranspiration (ETc). The simple conversion procedure is as follows:

$$ETc = Kc * ETo \qquad (4)$$

It is important to note that Kcs need to be matched to the ETo procedure in order to obtain reliable estimates of ETc from Eq. 4. To help clarify this point, suppose one has a turf Kc of 0.75 that is appropriate for use with AZMET ETo (ETOa). To obtain an estimate of turf water use in Tucson for May one would multiply the Kc (0.75) times the May ETOa value for Tucson (258.1 mm from Table 2):

$$ETc = Kc * EToa$$

$$ETc = 0.75 * 258.1 \text{ mm}$$

$$ETc = 193.6 \text{ mm } (7.62'')$$

If, however, this same Kc is erroneously applied to values of ETos, the same May turf water use estimate in Tucson would be:

$$ETc = Kc * ETos$$

$$ETc = 0.75 * 224.3 \text{ mm}$$

$$ETc = 168.2 \text{ mm } (6.62'')$$

or 25.4 mm (1.0") less than the correct value. It is clear from this example that failure to match Kcs with ETo procedure can lead to significant errors when estimating water use from vegetation.

Very few Kcs have been validated for use with ETos in Arizona with the notable exception of turfgrass (Brown and Kopec, 2000). While a number of research studies are presently underway (University of Arizona and USDA-ARS) that should provide validated Kcs for a number of Arizona crops in the near future, individuals interested in applying Kcs to ETos must either use published Kcs developed in another location, or adjust existing AZMET Kcs. A good place to locate Kcs for use with ETos is the publication entitled *Crop Evapotranspiration: Guidelines for computing crop water requirements* which is listed in the Reference section of this report.

Adjusting AZMET Kcs is a simple process that requires the use of the ratio data in Tables 2 and 3:

$$Kc_{os} = Kc_{az} \,/\, Ratio \qquad (5)$$

where Kc_{os} and Kc_{az} are the crop coefficient values appropriate for use with ETos and ETOa, respectively; and **Ratio** is the ratio of ETos to ETOa provided in Tables 2 and 3. In the previous example pertaining to turfgrass water use for Tucson in May, one would correct the Kc_{az} value of 0.75 by dividing by the May ratio presented in Table 2 (0.87):

$$Kc_{os} = 0.75 \,/\, 0.87 = 0.86$$

Seasonal ratios of ETos to ETOa are provided in Table 3 to assist with adjusting Kc_{az} for row crops. For example, AZMET has recommended using a Kc of 1.12 for full cover cotton when using ETOa. The process of adjusting this Kc for use with ETos at Maricopa would proceed as follows:

$$Kc_{os} = 1.12 \,/\, 0.97 = 1.15$$

The value of 0.97 is the summer ratio for Maricopa (see Table 3).

On a practical note it is important to recognize that existing Kc_{az} values will require only minor adjustments (if any) when used during the summer months. Larger adjustments will be required in winter where the ratios of ETos to ETOa are generally much less than 1.0.

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Appendix

The procedures and equations used to compute the variables presented in Equation 2 are described in this Appendix. The variables are presented in the order they are encountered in Eq. 2.

Δ: Slope of Saturation Vapor Pressure vs. Temperature Relationship

The slope of the saturation vapor pressure versus temperature relationship, Δ (kPa $^{o}C^{-1}$), is computed using:

$$\Delta = 2503 \exp((17.27T)/(T + 237.3))/(T + 237.3)^2 \quad \text{(A1)}$$

where T is the mean temperature for the day (^{o}C).

Rn: Net Radiation

Net radiation is the net amount of radiant energy available at the surface for evaporating water. Rn includes both short and long wave radiation and is computed using:

$$Rn = Rns - Rnl \qquad \text{(A2)}$$

where Rns = net shortwave radiation (MJ m^{-2} d^{-1}) defined as positive in the downward direction (toward earth) and Rnl = net longwave radiation (MJ m^{-2} d^{-1}) defined as positive in the upward direction (toward sky).

Net shortwave radiation (Rns) is computed as the difference between incoming and reflected shortwave radiation:

$$Rns = Rs - \alpha Rs = (1 - \alpha)Rs \qquad \text{(A3)}$$

where α = albedo or canopy reflection coefficient which is fixed at 0.23 and Rs = incoming solar radiation (MJ m^{-2} d^{-1}).

Net longwave radiation (Rnl) is the difference between upward longwave radiation (Rlu) and downward longwave radiation from the sky (Rld):

$$Rnl = Rlu - Rld \qquad \text{(A4)}$$

The daily value of Rnl is computed using:

$$Rnl=\sigma[(T_K^4max+T_K^4min)/2]*(0.34-0.14\sqrt{ea})[1.35(Rs/Rso) - 0.35] \qquad \text{(A5)}$$

where Rnl is net long-wave radiation in MJ m^{-2} d^{-1}, σ is the Stefan-Boltzman constant [= 4.901 x 10^{-9} MJ K^{-4} m^{-2} d^{-1}], T_K^4max is the maximum absolute temperature for the day (K), T_K^4min is the minimum absolute temperatures for the day (K), ea is the actual vapor pressure (kPa), Rs is solar radiation (MJ m^{-2} d^{-1}), and Rso is calculated clear-sky solar radiation (MJ m^{-2} d^{-1}). The ratio Rs/Rso indicates the relative level of cloudiness must be limited to 0.3 < Rs/Rso < 1.0. Rs/Rso values <0.30 are set = 0.30; Rs/Rso values > 1.0 are set = 1.0.

Clear sky solar radiation (Rso) is computed using:

$$Rso = (0.75 + 2 * 10^{-5} z)Ra \qquad (A6)$$

where z is the elevation above sea level (m) and Ra is extraterrestrial radiation (MJ m^{-2} d^{-1}).

Extraterrestrial radiation is computed from earth-sun geometry using:

$$Ra = (24/\pi)Gsc\ dr * [\omega s \sin(\varphi) \sin(\delta) + \cos(\varphi) \cos(\delta) \sin(\omega s)] \qquad (A7)$$

where Gsc is the solar constant [= 4.92 MJ m^{-2} h^{-1}], dr is relative distance factor (between the earth and sun), ωs is sunset hour angle (radians), φ is the latitude (radians), and δ solar declination (radians).

The relative distance factor is computed using:

$$dr = 1 + 0.033\cos(2\pi J/365) \qquad (A8)$$

where J is the day of the year (1 = 1 January; 365 = 31 December).

The solar declination angle is computed using:

$$\delta = 0.409\sin((2\pi J/365) - 1.39) \qquad (A9)$$

The sunset angle is computed using:

$$\omega s = \arccos[-\tan(\varphi) \tan(\delta)] \qquad (A10)$$

γ: Psychrometer Constant

The psychrometer constant, γ (kPa $^{o}C^{-1}$), is computed using:

$$\gamma = 0.000665\ P \qquad (A11)$$

where P is the atmospheric pressure at the weather station site. Atmospheric pressure (kPa) is computed from the elevation of the weather station site:

$$P = 101.3\ ((293 - 0.0065\ z)\ /\ 293)^{5.26} \qquad (A12)$$

where z is the elevation of the weather station above mean sea level (m).

T: Mean Air Temperature

Mean air temperature (^{o}C) is calculated as the mean of the daily maximum and daily minimum air temperature:

$$T = (Tmax + Tmin)/2 \qquad (A13)$$

where Tmax and Tmin are the maximum and minimum air temperatures (^oC) as obtained from the weather station data logger.

U_2:Wind Speed

The standardized equation requires the mean daily wind speed measured at 2 m above ground level (agl). Because AZMET measures wind speed at 3 m agl, wind speed is adjusted to an equivalent value at 2 m agl using the following:

$$u_2 = u_3 (4.87/\ln(67.8\ zw - 5.42) \qquad (A14)$$

where u_3 is the wind speed measured at 3 m agl and zw is the height of the wind speed measurement (3 m).

e_s: Saturation Vapor Pressure

Saturation vapor pressure is computed using:

$$es = (es(Tmax) + es(Tmin)) / 2 \qquad (A15)$$

where es(Tmax) and es(Tmin) are the saturation vapor pressures (kPa) computed using the maximum and minimum air temperatures, respectively. Saturation vapor pressure is computed using the following:

$$es = 0.6108 \exp((17.27Tex) / (Tex + 237.3)) \qquad (A16)$$

where Tex is either Tmax or Tmin (^oC) .

ea: Actual Vapor Pressure

The mean actual vapor pressure for the day is computed by the weather station datalogger using simultaneous measurements of relative humidity (RH; %) and air temperature (Ta; ^oC) using:

$$ea = (RH/100) [0.6108 \exp((17.27Ta)/(Ta + 237.3))] \qquad (A17)$$

Values of ea are computed by the datalogger every 10 s and averaged for the day.

APPENDIX E

Water Level Measurements

USF WATER LEVEL MEASUREMENTS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

Monitor Point ID	**HP-1**			
ADWR Registration Number	55-574110			
Cadastral Location	D(11-11)33cad			
Measuring Point Elevation (feet amsl)	1985.17			
Measuring Point Description	top of port			
Measuring Point Height (ft)				
Land Surface Elevation at Wellhead (feet amsl)	1985.17			
Permit Alert Level (feet bls)	30			
Permit OPL (feet bls)	20			
Measurement Date	**DTW (feet below MP)**	**DTW (feet bls)**	**Elevation (feet amsl)**	**Exceedance Status**
1/21/2014	189.2	189.2	1796.0	
2/9/2014	191.1	191.1	1794.1	
3/11/2014	191.6	191.6	1793.6	
4/17/2014	197.6	197.6	1787.6	
5/12/2014	197.4	197.4	1787.8	
6/5/2014	198.0	198.0	1787.2	
7/28/2014	199.8	199.8	1785.4	
8/20/2014	199.2	199.2	1786.0	
9/22/2014	194.2	194.2	1791.0	
10/27/2014	192.1	192.1	1793.1	
11/18/2014	192.3	192.3	1792.9	
12/10/2014	191.2	191.2	1794.0	

* If well is dry, type the word **dry** in the DTW (feet below MP) column.

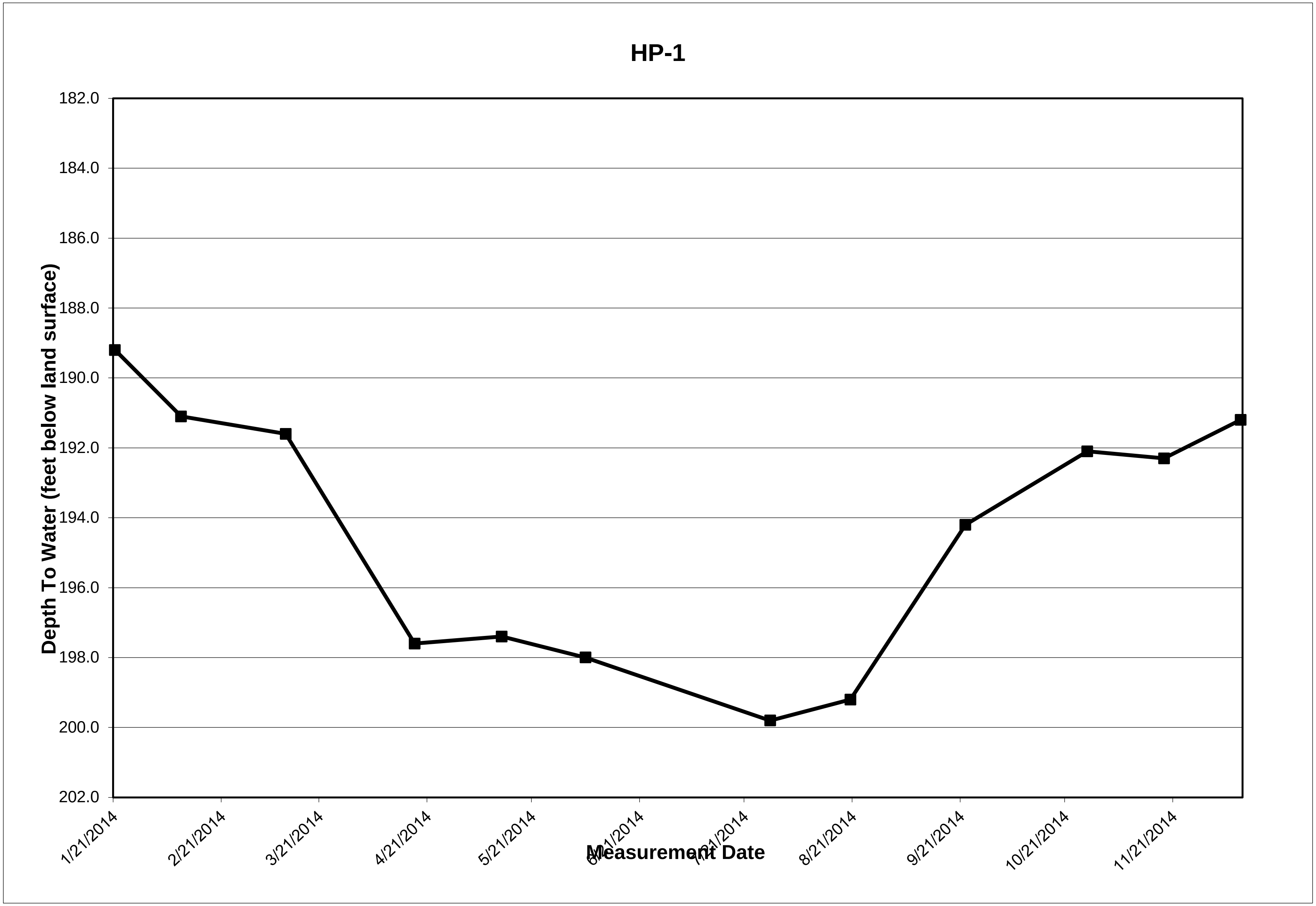
amsl - above mean sea level; DTW - depth to water; bls - below land surface; MP - measuring point

USF WATER LEVEL MEASUREMENTS

Marana High Plains Recharge Facility

USF Permit No. 71-563876.0007

Year: 2014



USF WATER LEVEL MEASUREMENTS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

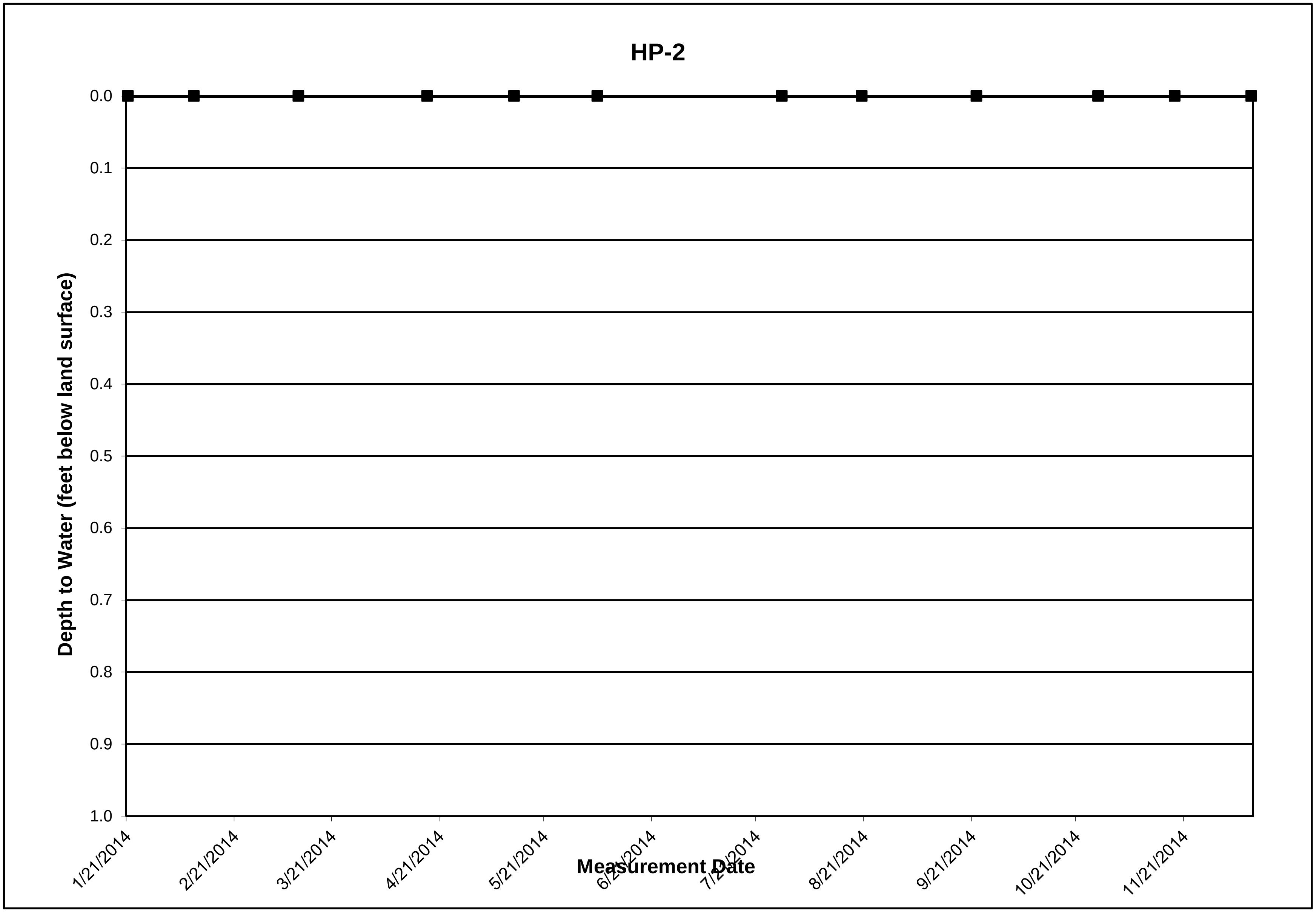
Monitor Point ID	HP-2
ADWR Registration Number	55-593607
Cadastral Location	D(11-11)33cad
Measuring Point Elevation (feet amsl)	1986.75
Measuring Point Description	top of port
Measuring Point Height (ft)	
Land Surface Elevation at Wellhead (feet amsl)	1986.75
Permit Alert Level (feet bls)	30
Permit OPL (feet bls)	20

Measurement Date	DTW (feet below MP)	DTW (feet bls)	Elevation (feet amsl)	Exceedance Status
1/21/2014	dry			
2/9/2014	dry			
3/11/2014	dry			
4/17/2014	dry			
5/12/2014	dry			
6/5/2014	dry			
7/28/2014	dry			
8/20/2014	dry			
9/22/2014	dry			
10/27/2014	dry			
11/18/2014	dry			
12/10/2014	dry			

* If well is dry, type the word **dry** in the DTW (feet below MP) column.

amsl - above mean sea level; DTW - depth to water; bls - below land surface; MP - measuring point

USF WATER LEVEL MEASUREMENTS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014



USF WATER LEVEL MEASUREMENTS

Marana High Plains Recharge Facility

USF Permit No. 71-563876.0007

Year: 2014

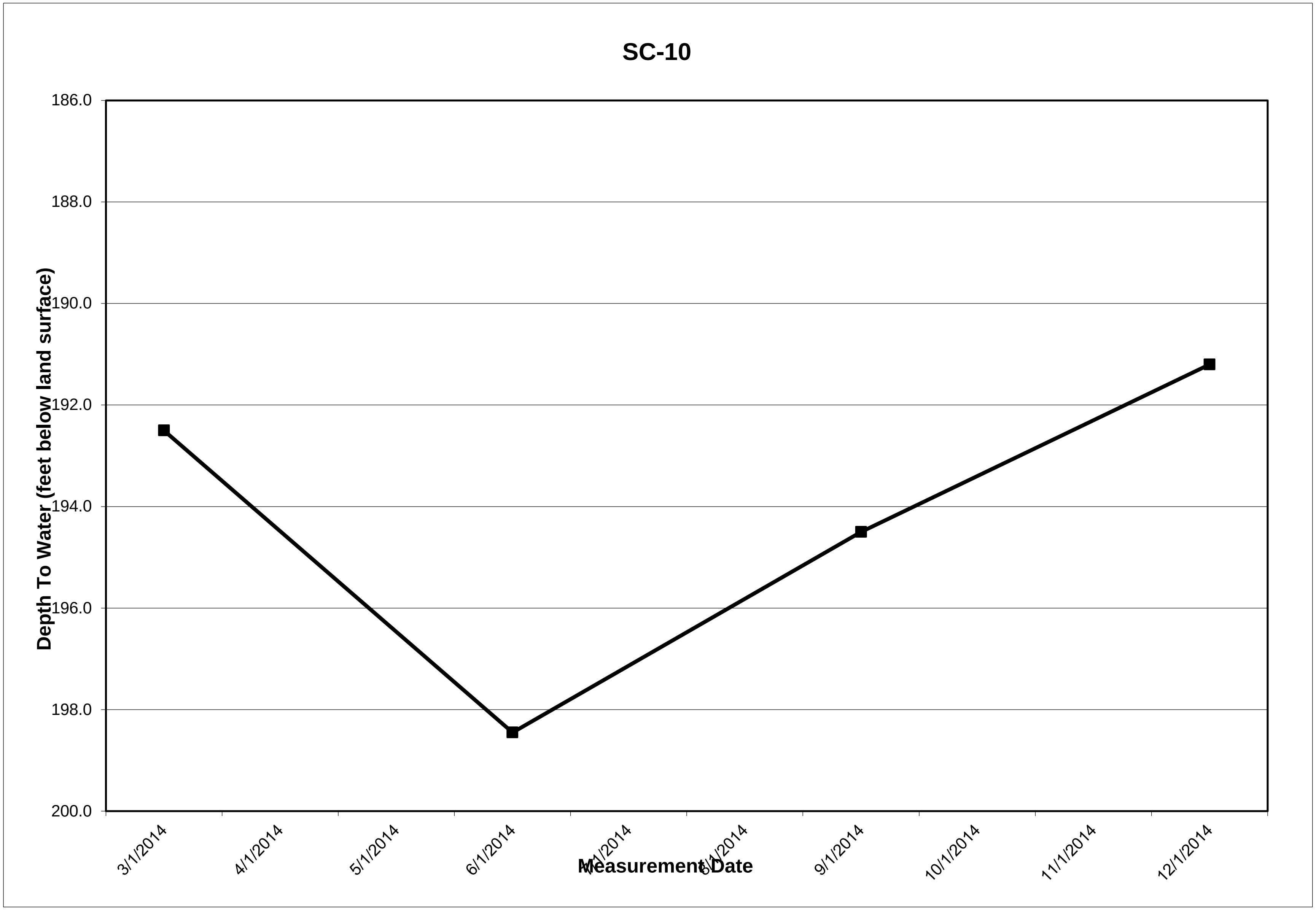
Monitor Point ID	SC-10
ADWR Registration Number	55-520129
Cadastral Location	D(11-11)33bcb
Measuring Point Elevation (feet amsl)	1978.36
Measuring Point Description	top of port
Measuring Point Height (ft)	
Land Surface Elevation at Wellhead (feet amsl)	1978.36
Permit Alert Level (feet bls)	30
Permit OPL (feet bls)	20

Measurement Date	DTW (feet below MP)	DTW (feet bls)	Elevation (feet amsl)	Exceedance Status
3/11/2014	192.5	192.5	1792.7	
6/5/2014	198.5	198.5	1786.7	
9/22/2014	194.5	194.5	1790.7	
12/10/2014	191.2	191.2	1794.0	

* If well is dry, type the word **dry** in the DTW (feet below MP) column.

amsl - above mean sea level; DTW - depth to water; bls - below land surface; MP - measuring point

USF WATER LEVEL MEASUREMENTS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014



APPENDIX F

Infiltration Rate Data & Calculations

INFILTRATION RATE DATA AND CALCULATIONS
Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	Net Recharge Volumes (ac-ft)	**Total Wetted Acreages** (ac-days)	**Infiltration Rate** (ft/day)	**Quarterly Average Infiltration Rate** (ft/day)
January	69.5	46.1	1.51	
February	71.0	49.3	1.44	
March	77.7	52.7	1.48	1.47
April	74.9	50.5	1.48	
May	84.2	39.2	2.15	
June	74.0	28.4	2.61	1.97
July	16.3	10.6	1.54	
August	0.0	0.0		
September	23.5	6.8	3.44	2.28
October	69.1	20.1	3.43	
November	41.5	20.6	2.02	
December	4.7	1.3	3.61	2.74

Totals	**606.2**	**325.5**	**1.86**

CELL 1: INFILTRATION RATE DATA AND CALCULATIONS

Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	Net Recharge Volumes (ac-ft)	Total Wetted Acreages (ac-days)	Infiltration Rate (ft/day)	Quarterly Average Infiltration Rate (ft/day)
January	16.5	4.7	3.53	
February	4.4	0.5	8.54	
March	1.8	0.2	11.06	4.25
April	31.0	4.3	7.19	
May	14.2	1.0	13.88	
June	37.3	4.2	8.95	8.68
July	7.7	1.7	4.69	
August	0.0	0.0		
September	10.5	1.0	10.78	6.95
October	33.7	3.9	8.63	
November	2.7	0.7	3.64	
December	0.0	0.0		7.85
Totals	**159.7**	**22.1**	**7.23**	

CELL 2: INFILTRATION RATE DATA AND CALCULATIONS

Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	Net Recharge Volumes (ac-ft)	Total Wetted Acreages (ac-days)	Infiltration Rate (ft/day)	Quarterly Average Infiltration Rate (ft/day)
January	36.1	9.3	3.87	
February	52.3	13.6	3.86	
March	60.4	15.3	3.96	3.90
April	41.3	10.7	3.85	
May	56.5	19.7	2.87	
June	0.0	4.8		2.78
July	8.0	2.0	3.91	
August	0.0	0.0		
September	0.0	0.0		3.91
October	0.0	0.0		
November	18.0	0.9	21.22	
December	0.0	0.2		18.04
Totals	**272.6**	**76.4**	**3.57**	

CELL 3: INFILTRATION RATE DATA AND CALCULATIONS

Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	Net Recharge Volumes (ac-ft)	Total Wetted Acreages (ac-days)	Infiltration Rate (ft/day)	Quarterly Average Infiltration Rate (ft/day)
January	8.2	8.0	1.02	
February	5.9	3.2	1.86	
March	7.7	6.4	1.20	1.24
April	3.5	12.2	0.28	
May	10.8	0.8	13.49	
June	37.2	7.7	4.82	2.49
July	0.6	0.7	0.83	
August	0.0	0.0		
September	10.5	1.4	7.31	5.16
October	33.6	6.1	5.51	
November	2.7	1.3	2.01	
December	0.0	0.0		4.89
Totals	**120.6**	**47.8**	**2.52**	

CELL 4: INFILTRATION RATE DATA AND CALCULATIONS

Marana High Plains Recharge Facility
USF Permit No. 71-563876.0007
Year: 2014

	Net Recharge Volumes (ac-ft)	Total Wetted Acreages (ac-days)	Infiltration Rate (ft/day)	Quarterly Average Infiltration Rate (ft/day)
January	7.0	10.1	0.69	
February	7.9	18.9	0.42	
March	7.5	15.7	0.48	0.50
April	0.0	13.1		
May	3.2	4.9	0.67	
June	0.0	0.5		0.18
July	0.0	0.0		
August	0.0	0.0		
September	0.0	0.0		
October	0.0	0.0		
November	18.0	9.8	1.84	
December	0.0	0.0		1.84
Totals	**43.7**	**72.9**	**0.60**	

EQUALIZATION BASIN: INFILTRATION RATE DATA AND CALCULATIONS

Marana High Plains Recharge Facility

USF Permit No. 71-563876.0007

Year: 2014

	Net Recharge Volumes (ac-ft)	Total Wetted Acreages (ac-days)	Infiltration Rate (ft/day)	Quarterly Average Infiltration Rate (ft/day)
January	1.7	21.0	0.08	
February	0.4	16.0	0.02	
March	0.4	16.6	0.02	0.05
April	0.0	16.3		
May	0.0	15.6		
June	0.0	12.3		
July	0.0	6.4		
August	0.0	0.0		
September	2.6	4.4	0.58	0.24
October	1.8	10.3	0.17	
November	0.1	9.0	0.02	
December	2.7	0.7	3.79	0.23
Totals	**9.6**	**128.7**	**0.07**	