

UNIVERSITY OF ILLINOIS  
AT URBANA-CHAMPAIGN

Institute of Natural Resource Sustainability  
Illinois State Water Survey

2204 Griffith Drive, MC-674  
Champaign, Illinois 61820-7463

March 31, 2011



Mr. Jeff Smith, Chairman  
Imperial Valley Water Authority  
25865 E. County Road 1000 N  
Easton, IL 62633

Dear Chairman Smith:

The Illinois State Water Survey (ISWS), under contract to the Imperial Valley Water Authority (IVWA), has operated a network of rain gauges in Mason and Tazewell Counties since August 1992 and a network of groundwater observation wells since 1994. The purpose of the rain gauge and groundwater observation well networks is to collect long-term data to determine the impact of groundwater withdrawals during dry periods and during the growing season, and the rate at which the aquifer recharges. This letter serves as the year end report for Year 18 which covers the time period from September 1, 2009 through August 31, 2010.

The groundwater observation well network consists of thirteen wells, MTOW-01 through MTOW-13. MTOW-01, located near Snicarte, Illinois, is an inactive, large diameter, hand-dug domestic well that has been monitored by the ISWS since 1958. This well is equipped with a Stevens, Type F water-level recorder that produces a continuous record of the groundwater level on a 32-day paper chart. In Year 15, a deeper well was drilled to replace MTOW-01 which we found would go dry during dry weather. This new well, named Snicarte #2 or MTOW-01a, has taken the place of the original well (MTOW-01 or Snicarte #1) within the monitoring well network. The two wells were being observed jointly so that their water level data can be correlated. The new well was first equipped with the same type of Stevens recorder as the original well, but has since been converted to digital data collection. This digital data collection system is outfitted with telemetry which allows access to the data at the ISWS office via a cell phone modem. The final correlation between data from the two Snicarte wells occurred during Year 18. A separate letter report will be presented in the future to address the Snicarte well correlation to the IVWA. The remaining observation wells are drilled wells between 2 and 6 inches in diameter. With the exception of MTOW-05 and MTOW-09, these wells are equipped with pressure transducers that electronically log the groundwater level data.

In accordance with our agreement, each well, with the exception of MTOW-05 and MTOW-09, is visited by ISWS personnel during the first few days of the month during irrigation season and approximately bi-monthly during the non-irrigated portion of the year. MTOW-05 is measured by a local well watcher approximately monthly, while MTOW-09 is measured 3 or 4 times per year by an ISWS staff member.

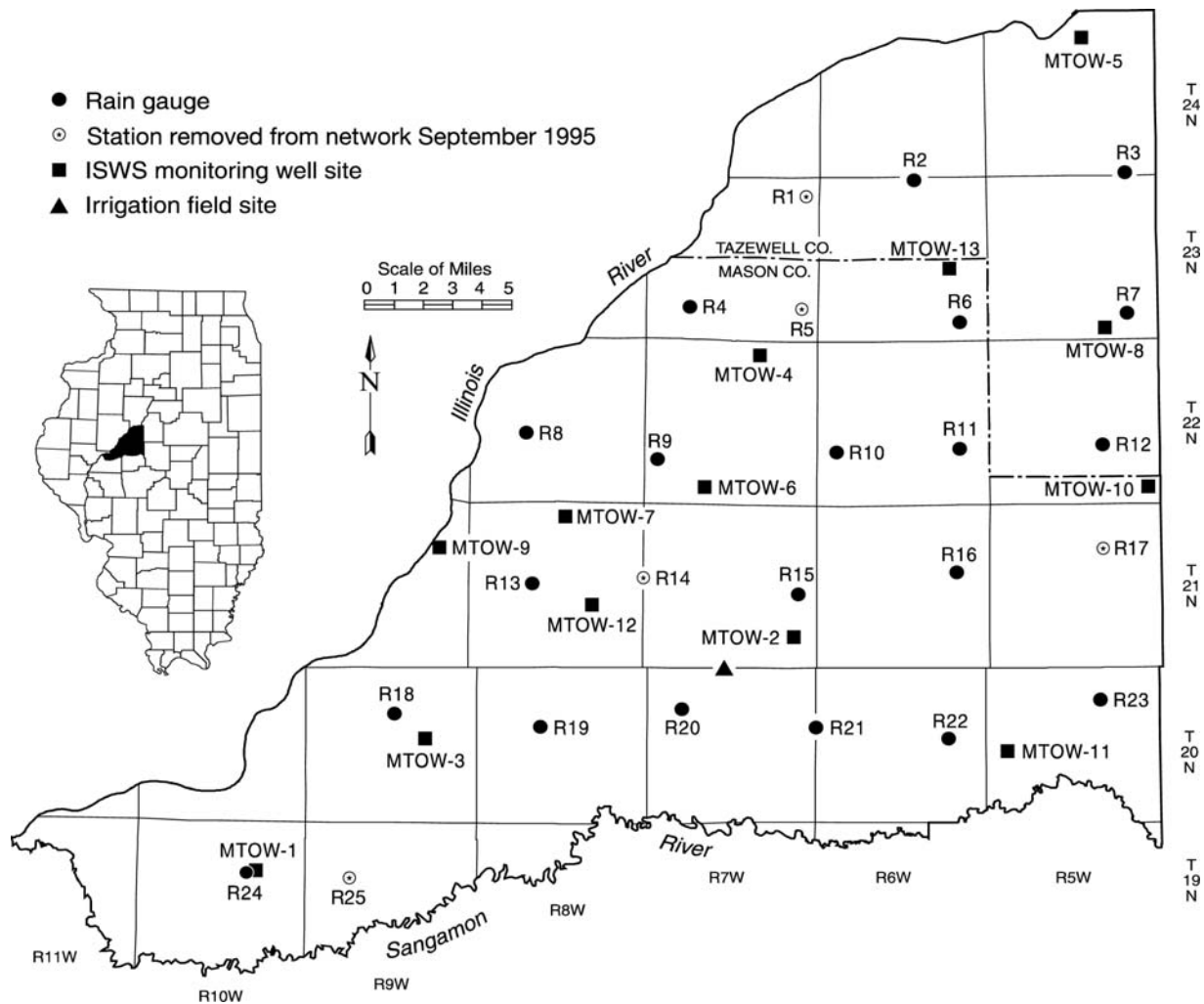


Figure 1. Configuration of the 13-site observation well and 25-site rain gauge networks, and location of the irrigation field site, Imperial Valley, 2009-2010.

Groundwater levels for each well for the period of record (September 1, 2009-August 31, 2010) are presented in Appendix A. For MTOW-05, and -09 their entire period of record is shown because they do not have digital recorders. MTOW-01 follows the yearly format as the well is now equipped with a digital recorder which allows for daily data collection. Each hydrograph also contains the daily precipitation for the nearest rain gauge. For observation wells located between several rain gauges, an average of the surrounding rain gauge data is presented. Groundwater level data are presented as groundwater elevation above mean sea level.

A 25-site rain gauge network (Figure 1) with approximately 5 miles between gauges was established in late August 1992. The network was reduced to 20 sites in September 1996. The rain gauge network is maintained by a Mason County resident hired to visit each site monthly. During these visits the charts are changed, data downloaded and other routine services performed. Champaign-based ISWS personnel visit the rain gauge network to perform major maintenance and repairs as needed.

Data reduction activities during Year Eighteen of network operation are similar to those performed during the previous seventeen years. Each month, hourly rainfall amounts are totaled from 10-minute digital data and are placed into an array of values for the 20 gauges. This data array is used to check for spatial and temporal consistency between gauges, and to divide the data into storm periods. If the digital data are missing, hourly rainfall amounts from the analog (paper) charts are used. In the rare event that data from both a data logger and the corresponding chart are missing, the hourly amounts are estimated based on an interpolation of values from the nearest surrounding gauges.

Since 1995, the IVWA has estimated irrigation pumpage from wells in the Imperial Valley based on electric power consumption. Menard Electric Cooperative provides the IVWA with electric power consumption data for the irrigation services they provide during the growing season (June-September). The pumpage estimate assumed that application rates for the irrigation wells with electric pumps in Menard Electric Cooperative also are representative of other utilities and other energy sources. Past estimates were based on the assumption that 33 percent of the irrigation wells were in Menard Electric Cooperative in 1995-1997, 40 percent in 1998-2001. Since 2002, the percentage of wells in Menard Electric Cooperative is extrapolated from known values and not assumed.

In 2002, the U.S. Geological Survey (USGS) updated the formula used to calculate pumpage by closely measuring the pumping rate at 77 irrigation systems serviced by Menard Electric. The updated formula provides estimates that are appreciably lower than the previous formula, by approximately 20 percent. Therefore, irrigation withdrawals for the years 1997 to the present were recalculated using the new formula, replacing earlier published estimates (reports through Year 11 use the original formula).

The Year Eighteen dataset was used to produce summaries for all storm data for each station and the network; monthly, seasonal, and annual rainfall totals; analysis of the rainfall and river stages and groundwater level fluctuations; the data obtained from the long-term monitoring well network; the database showing the individual storms in the Imperial Valley region; and an updated version of the irrigation pumpage data.

### **Precipitation Analysis**

The Year Eighteen network precipitation of 47.91 inches was above average, 13.20 inches above the previous 17-year's average of 34.71 inches. It was the third wettest year in the 18 years of network operation. All seasons in Year Eighteen were above average in seasonal total precipitation. Table 1 gives the monthly precipitation totals for each rain gauge within the network during Year 18.

**Table 1. Monthly Precipitation Amounts (inches), September 2009-August 2010**

<i>Station</i>	<i>Month</i>												<i>Total</i>
	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>	
2	2.97	9.27	3.2	4.25	1.73	1.8	3.4	3.15	7.79	8.71	5.74	2.63	54.64
3	1.61	8.11	3.14	2.6	1.55	1.37	2.59	3.32	4.52	8.18	3.48	2.84	43.31
4	2.79	7.85	3.78	3.65	1.35	1.51	2.71	2.92	7.77	8.81	6.91	2.04	52.09
6	1.9	7.06	2.72	2.05	1.2	1.31	2.41	2.99	6.08	8.48	3.81	2.04	42.05
7	1.75	7.41	3.06	2.91	1.21	1.27	2.39	3.28	5.26	8.67	2.77	1.94	41.92
8	2.88	7.81	3.9	3.97	1.62	1.4	2.2	2.94	7.45	8.24	5.39	3.03	50.83
9	2.63	8.56	3.58	3.38	1.57	1.35	2.29	2.07	6.3	7.99	4.98	3.07	47.77
10	2.09	8.31	3.77	3.14	1.49	1.33	2.18	2.7	6.65	8.77	7.08	3.41	50.92
11	2.11	7.5	3.18	3.09	1.26	1.37	2.1	2.76	6.2	7.75	3.85	2.78	43.95
12	2.55	7.74	3.34	3.28	1.24	1.41	2.45	3.84	5.99	7.02	2.44	2.6	43.9
13	3.15	6.98	3.66	3.14	1.35	1.75	2.12	2.73	5.69	6.63	7.18	3.43	47.81
15	3.01	7.81	3.77	3.37	1.36	1.45	2.1	2.52	7.41	5.34	4.68	2.58	45.4
16	3.02	7.78	3.42	2.69	1.17	1.42	1.77	2.39	6.24	5.75	3.31	2.72	41.68
18	3.2	9.33	3.3	4.24	1.2	1.49	2.15	2.61	6.86	6.02	8.46	3.43	52.29
19	3.93	9.7	3.48	3.87	1.29	1.9	2.32	2.84	6.61	6.07	7.91	4.16	54.08
20	2.83	8.28	3.5	3.48	1.2	1.54	2.11	2.63	6.39	6.55	8.29	3.98	50.78
21	2.24	7.78	3.27	2.68	1.19	1.32	2.21	2.42	6.36	6.73	6.76	4.17	47.13
22	2.14	8.22	3.94	3.38	1.04	1.39	2.18	2.6	7.39	7.11	5.13	3.52	48.04
23	2.12	7	3.26	2.94	0.98	1.28	2.45	3.17	5.82	7.31	4.4	2.86	43.59
24	4.16	9.06	3.19	3.98	1.38	1.55	2.02	2.91	6.49	7.87	10.3	3.19	56.1
Avg	2.65	8.08	3.42	3.3	1.32	1.46	2.31	2.84	6.46	7.4	5.64	3.02	47.91

Figure 2 presents the 18-year network average, excluding sites 16, 19, 21 during the period 1997-2002, and Figure 3 presents the annual precipitation pattern for Year Eighteen. During Year Eighteen, annual gauge totals varied from 41.68 inches at site 16 to 56.10 inches at site number 24 (Figure 3). Eleven inch gradients between gauges in annual precipitation are not unusual during any given year, as long as they are not replicated at the same gauges year after year, and are somewhat supported by surrounding gauges.

October, November, and December of 2009 and May, June, and July of 2010 all received above average precipitation with October 2009 being the wettest month of the year. All other months of the year received average or below average precipitation (Figures 4-9). October 2009 accounted for 8.08 inches of precipitation or 337 percent of the 17-year average October precipitation, and 17 percent of Year Eighteen total network precipitation. The network received 7.64 inches less precipitation than in the wettest year (1992-1993) and 22.21 inches more than in the driest year (1995-1996).

The number of network precipitation periods was determined for the 18-year period. Mean monthly, seasonal, and annual number of these precipitation events are presented for 2009-2010 (Table 2). The monthly, seasonal, and annual number of precipitation events averaged over the 1993-2009 period also are presented (Table 2). A network storm period is defined as a precipitation event separated from preceding and succeeding events at all network stations by at least three hours.

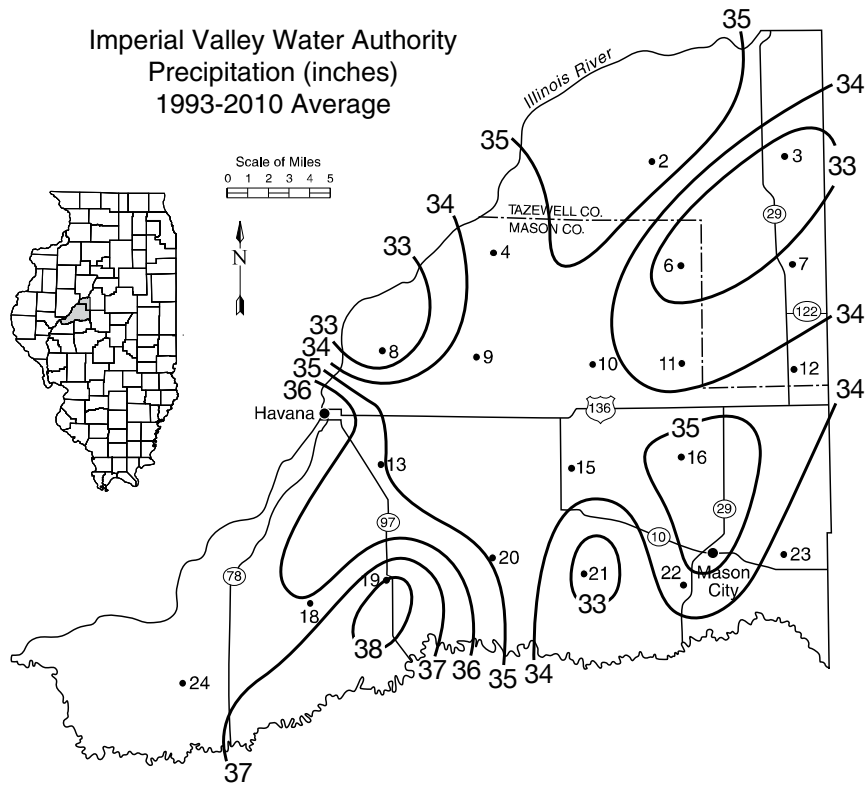


Figure 2. Network average annual precipitation (inches) for September 1993 - August 2010

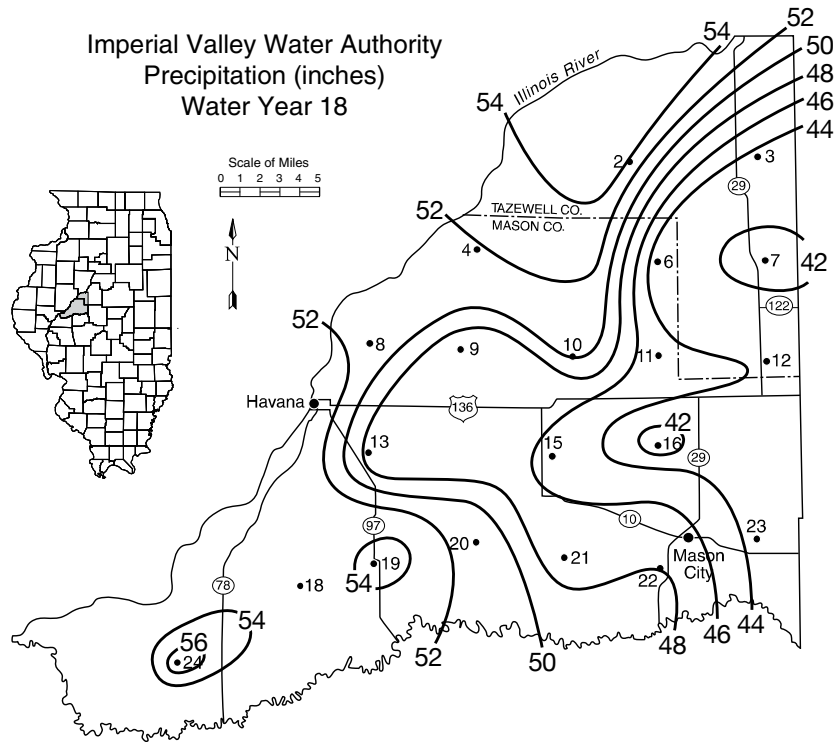


Figure 3. Total precipitation (inches) for September 2009 - August 2010

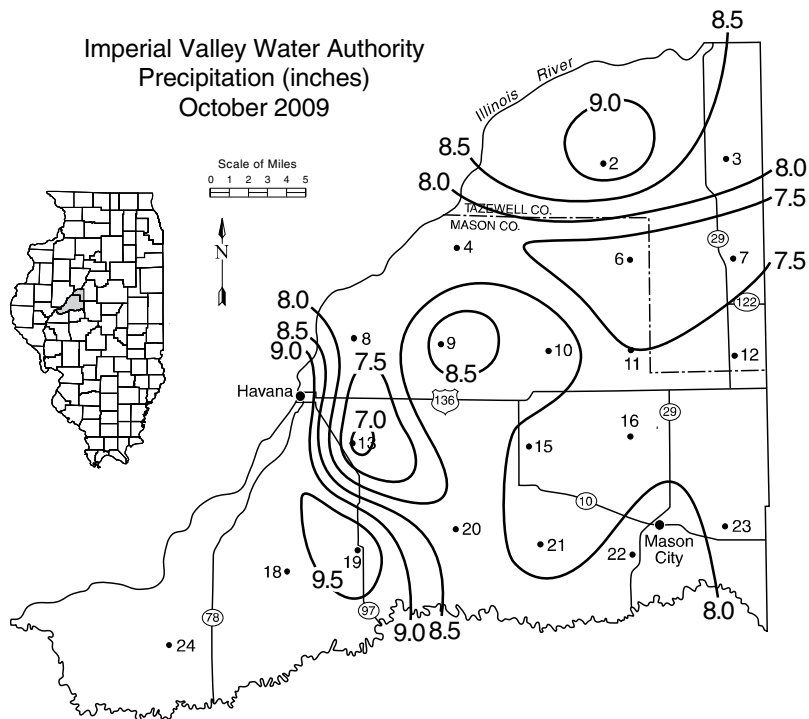
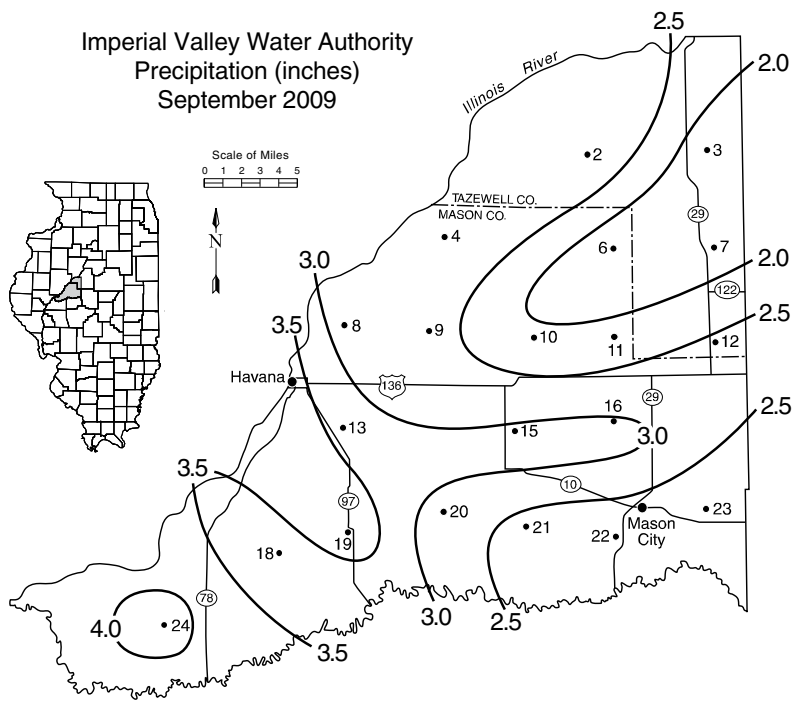


Figure 4. Precipitation (inches) for September 2009 and October 2009

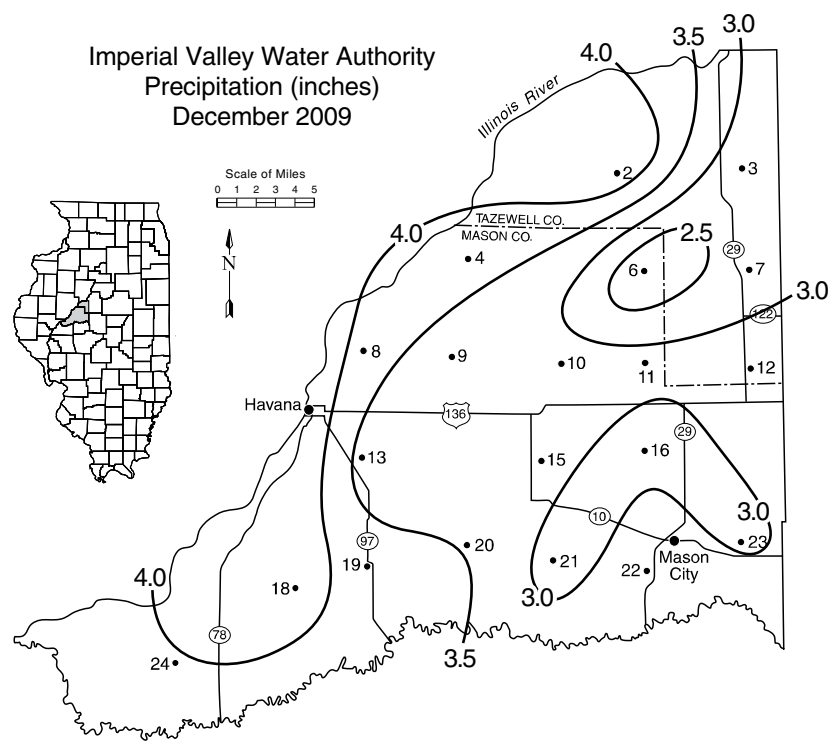
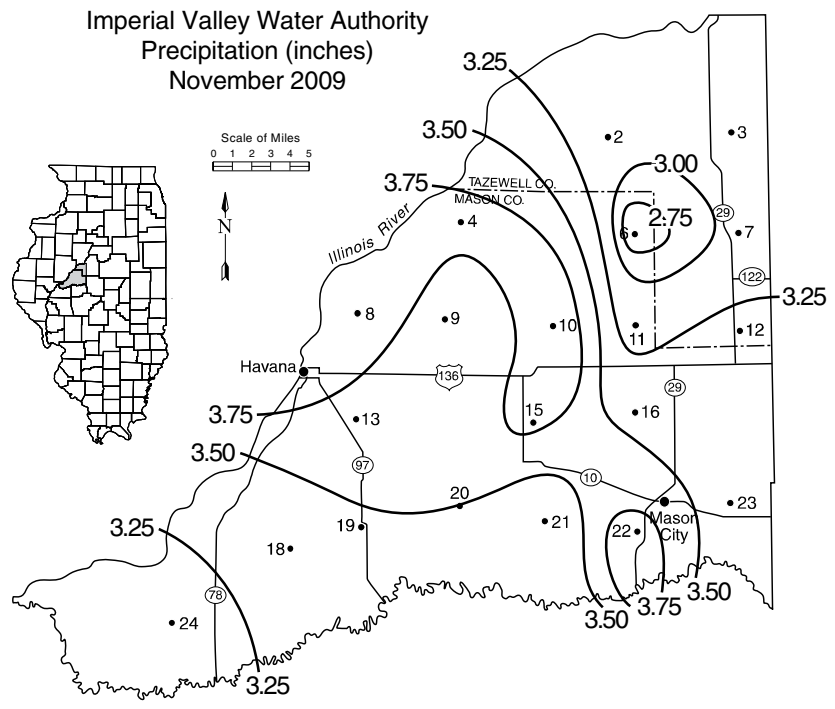


Figure 5. Precipitation (inches) for November 2009 and December 2009

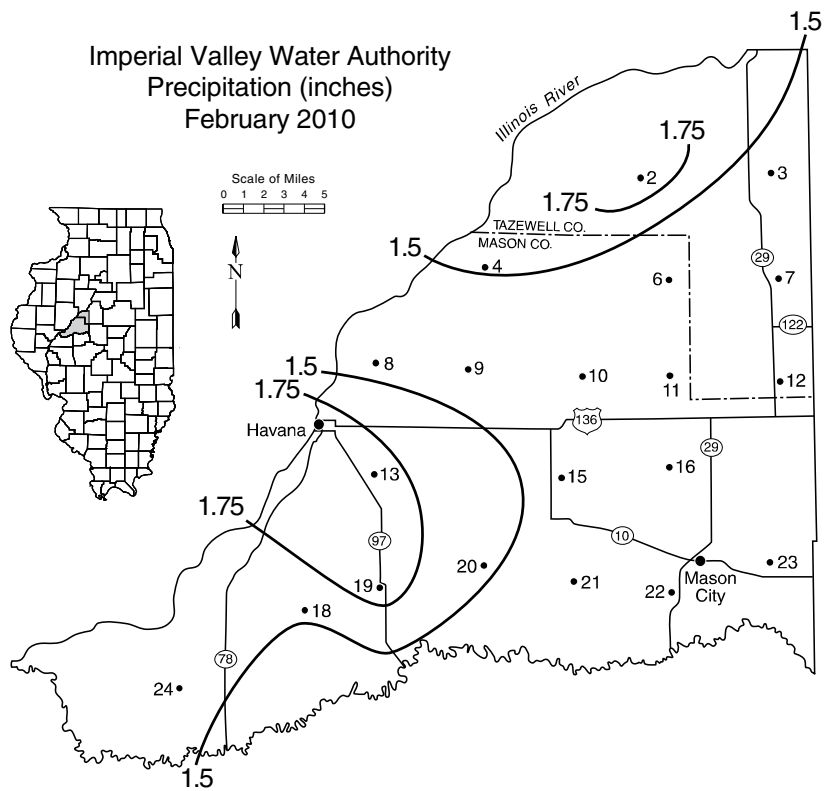
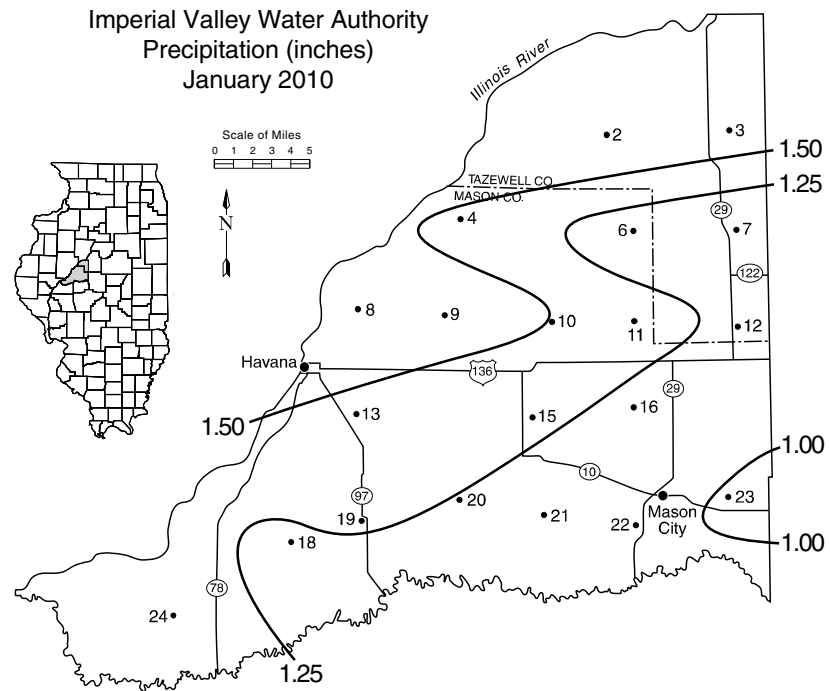


Figure 6. Precipitation (inches) for January 2010 and February 2010



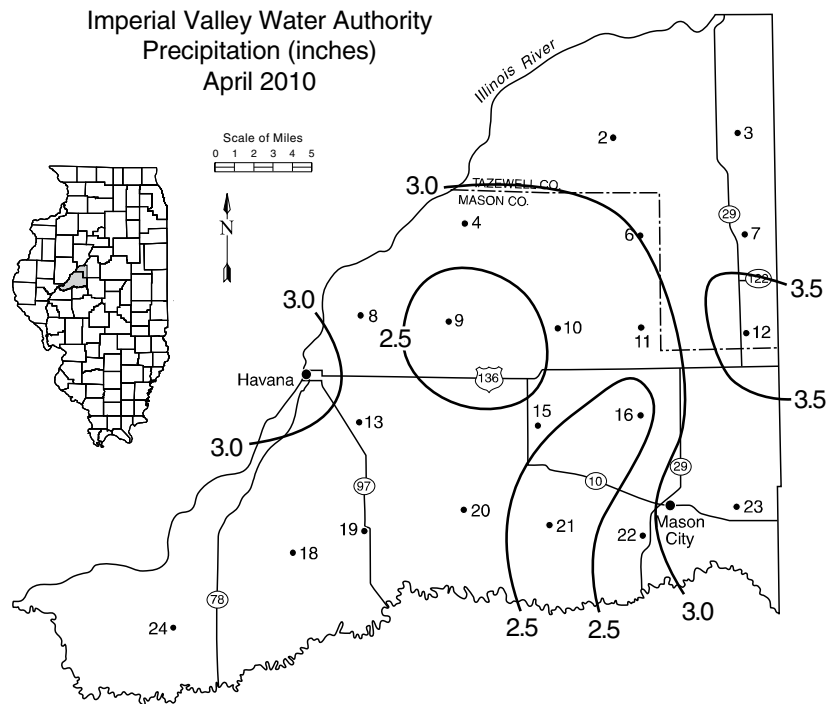
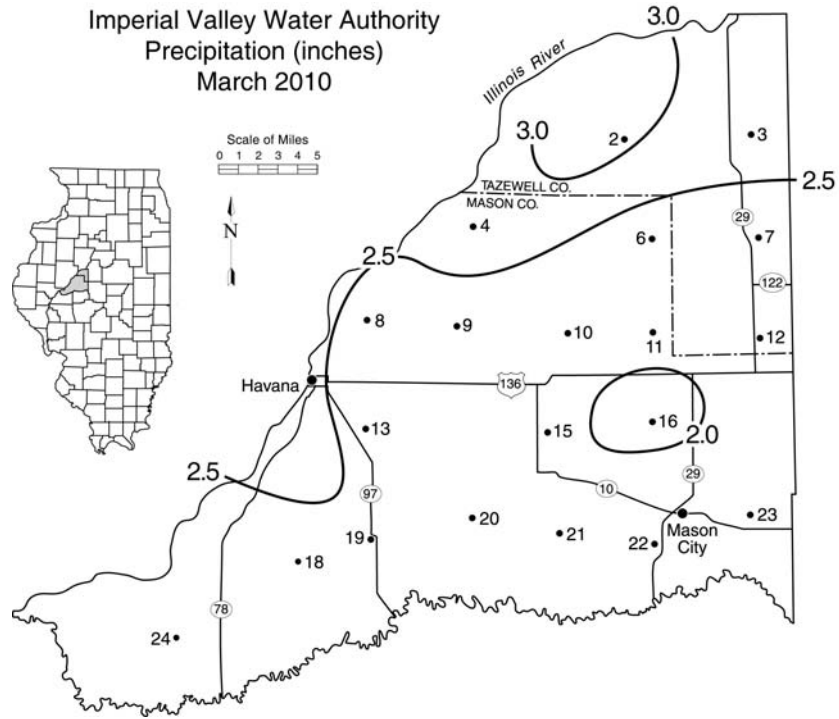


Figure 7. Precipitation (inches) for March 2010 and April 2010

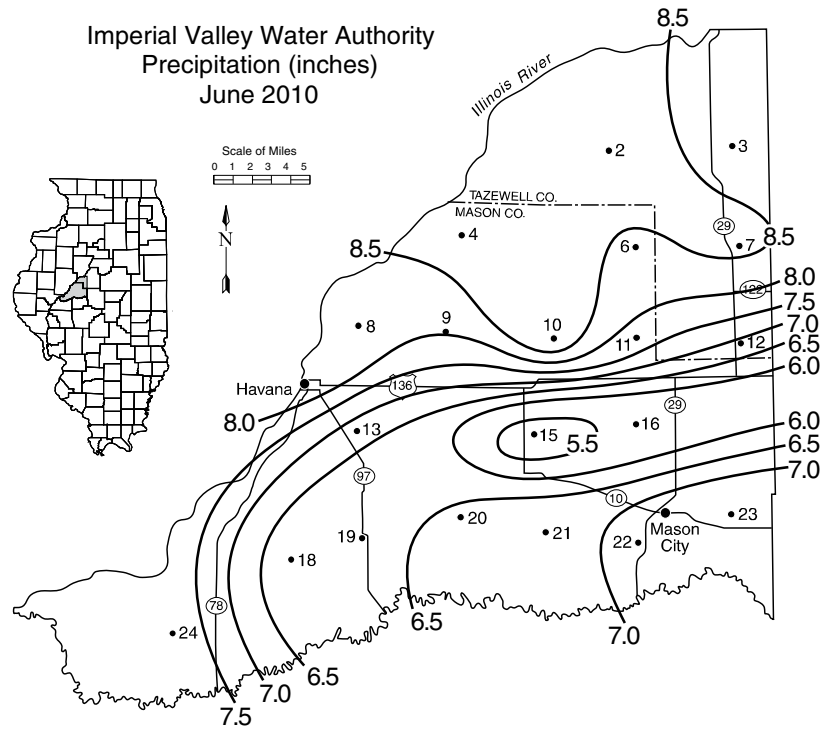
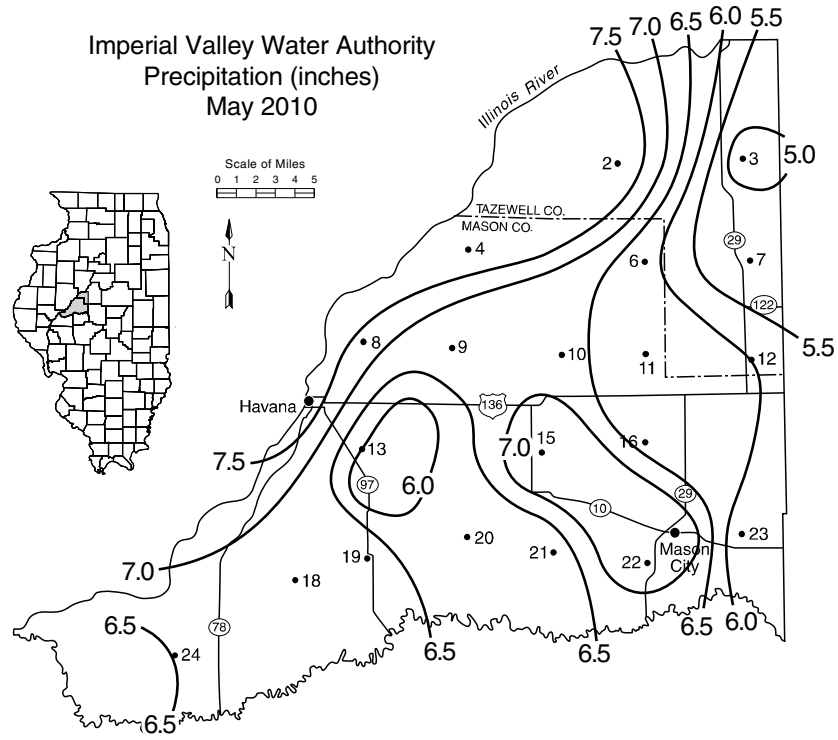


Figure 8. Precipitation (inches) for May 2010 and June 2010

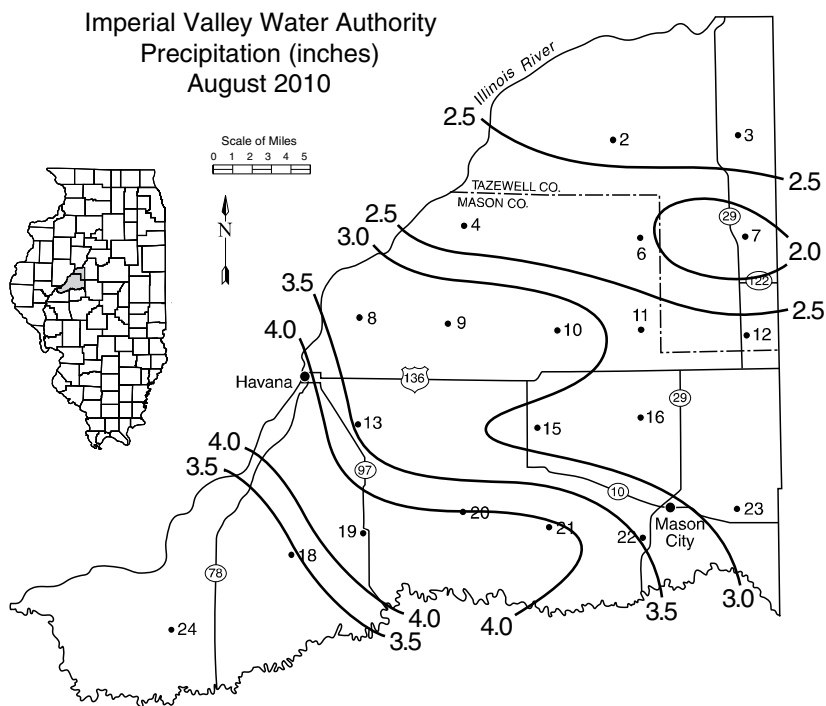
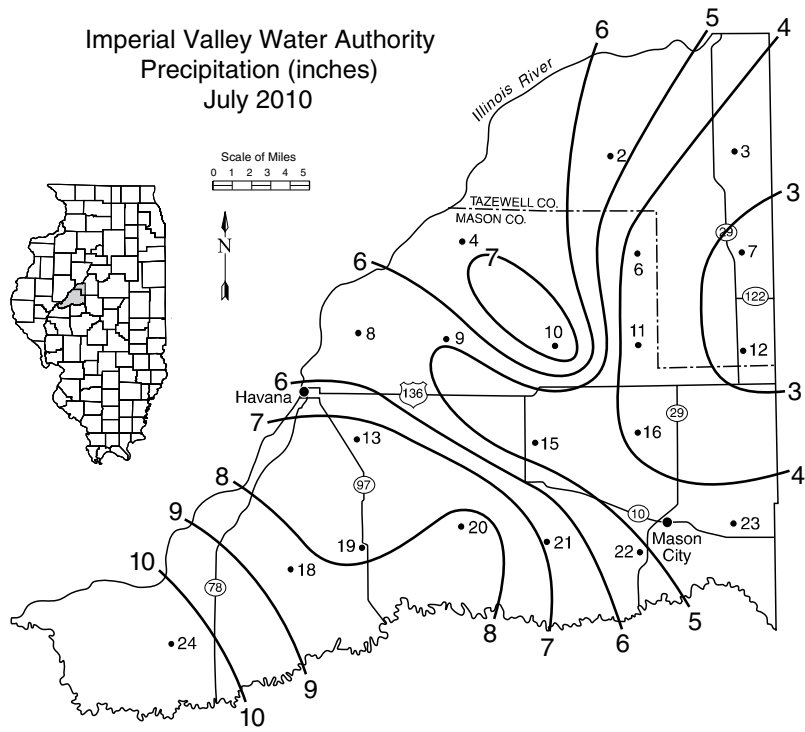


Figure 9. Precipitation (inches) for July 2010 and August 2010

Table 2. Comparison of Total Precipitation (inches), Number of Precipitation Events, and Average Precipitation per Event for Each Month and Season, 1992-2009 and 2009-2010

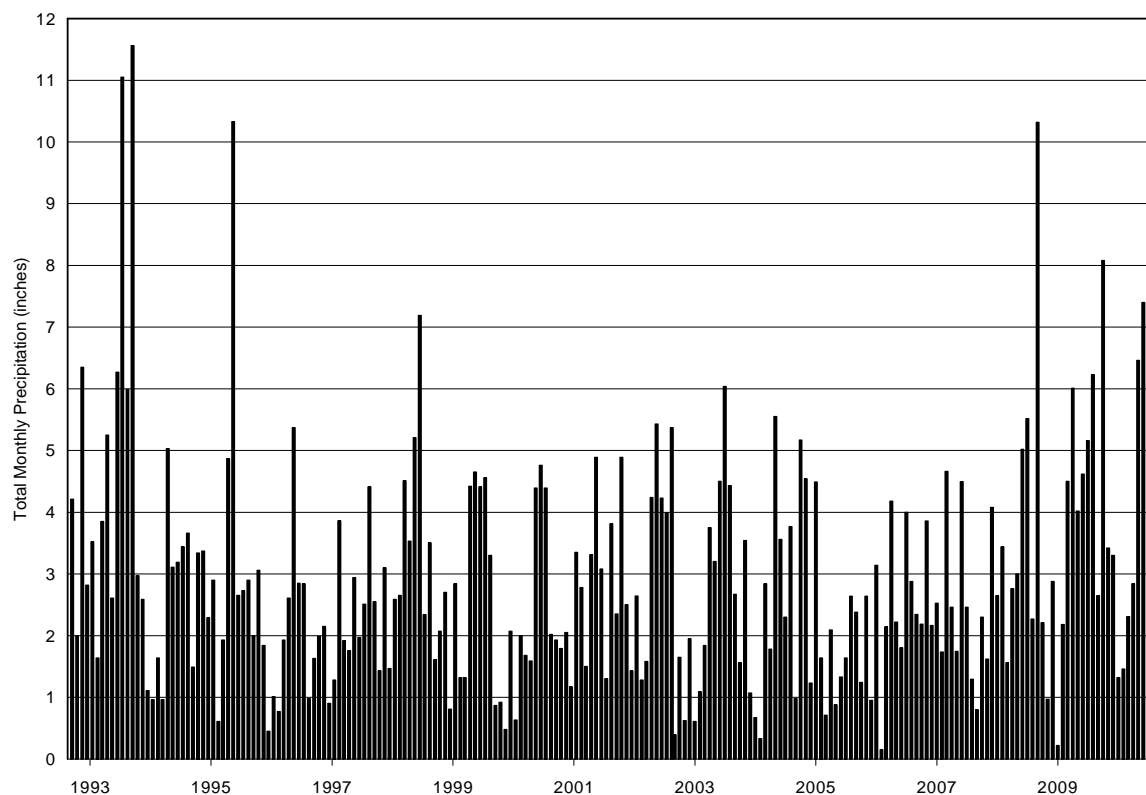
<i>Period</i>	<i>1992-2009 17-yr average</i>			<i>2009-2010 average</i>		
	<i>Precipitation</i>	<i>Events</i>	<i>Inches/event</i>	<i>Precipitation</i>	<i>Events</i>	<i>Inches/event</i>
Sep	2.95	7.4	0.40	2.65	7	0.38
Oct	2.40	8.6	0.28	8.08	11	0.73
Nov	2.64	9.5	0.28	3.42	7	0.49
Dec	1.70	9.1	0.19	3.31	13	0.25
Jan	2.12	9.4	0.23	1.32	5	0.26
Feb	1.71	7.6	0.22	1.46	8	0.18
Mar	2.32	8.7	0.27	2.31	8	0.29
Apr	3.51	11.1	0.32	2.84	13	0.22
May	4.09	13.9	0.29	6.46	16	0.40
Jun	3.88	12.1	0.32	7.40	17	0.44
Jul	3.90	10.8	0.36	5.64	16	0.35
Aug	3.50	12.5	0.28	3.02	6	0.50
Fall	7.99	25.5	0.31	14.15	25	0.57
Winter	5.53	26.1	0.21	6.09	26	0.23
Spring	9.92	33.7	0.29	11.61	37	0.31
Summer	11.27	35.4	0.32	16.06	39	0.41
Annual	34.71	120.7	0.29	47.91	127	0.38

A total of 2179 storm periods occurred during the 18-year observation period, resulting in an average of 121 storm events per year. During Year 18, there were 127 precipitation events. Fewer events than average occurred in November 2009, January 2010, March 2010 and August 2010. A greater number of events than average occurred in December 2009 and April through July of 2010. The spring and summer had a larger number of events than average. All seasons during the year received more precipitation than average and the events during these seasons were more intense than average.

The plot of the network average monthly precipitation time series (Figure 10) shows the monthly variation of precipitation. From February 2005 through August 2008, a very dry period of record, only six months had precipitation of greater than 3.0 inches. During 2009-10, four months received 4 inches of precipitation or greater.

The storm recurrence frequency is the statistical probability of the recurrence of a storm with the reported precipitation (i.e., a 10-year storm would be expected to occur on average only once every 10 years at a given station, or have a 10 percent chance of occurring in any given year). The recurrence frequencies computed here are for each gage and are based upon the gage total storm precipitation and the total storm duration for the gages with precipitation.

In the first 17-years of network operation, 80 of 2052 storm events produced maximum precipitation at one or more gages with a recurrence frequency greater than one year: 50-yr (1 storm), 10-year (5 storms), 5-year (10 storms), 2-year (37 storms), and 1-year events (27 storms).



**Figure 10. Network average monthly precipitation (inches), September 1992 - August 2009**

The 50-year storm occurred on 13 September 1993, and the 10-year storms on 16 May 1995, 8 May 1996, 19 July 1997, and 30-31 March 2007, 11-14 September 2008. An average of 121 rain events and 5 heavy rain events occurred per year.

In Year 18, three of the 127 network storm periods exceeded the one-year or greater recurrence frequency. Year 18 had an above average number of storm periods and a below average number of heavy rainfall events. One event exceeded the 10-year recurrence frequency and occurred from 19 to 20 July 2010. The 1-year events occurred on 20 September 2009 and 29-30 October 2009.

### **Groundwater Levels**

The long-term hydrograph at MTOW-01 (Snicarte) in Figure 11 provides a reference for comparison with the shorter records of the other network wells. The ISWS has recorded water levels in this well since 1958. Annual fluctuations from less than a foot to more than 6 feet have been observed. Based on the data we have available, these annual fluctuations often appear to be superimposed on longer term trends, perhaps 10 years or more. For the 52-year record, both the record low and high have been observed within the last 20 years.

A detailed look at water levels since 1990 is shown in Figure 12. During and shortly after the drought years of 1988 and 1989, the water level fell to 40.5 feet below land surface from September 1989 until April 1990, the only time in its 45-year history that the well went dry, until it did so again in 2006 and 2007. During the 1993 flood, groundwater levels rose almost 10 feet and peaked at approximately 30 feet in September 1993.

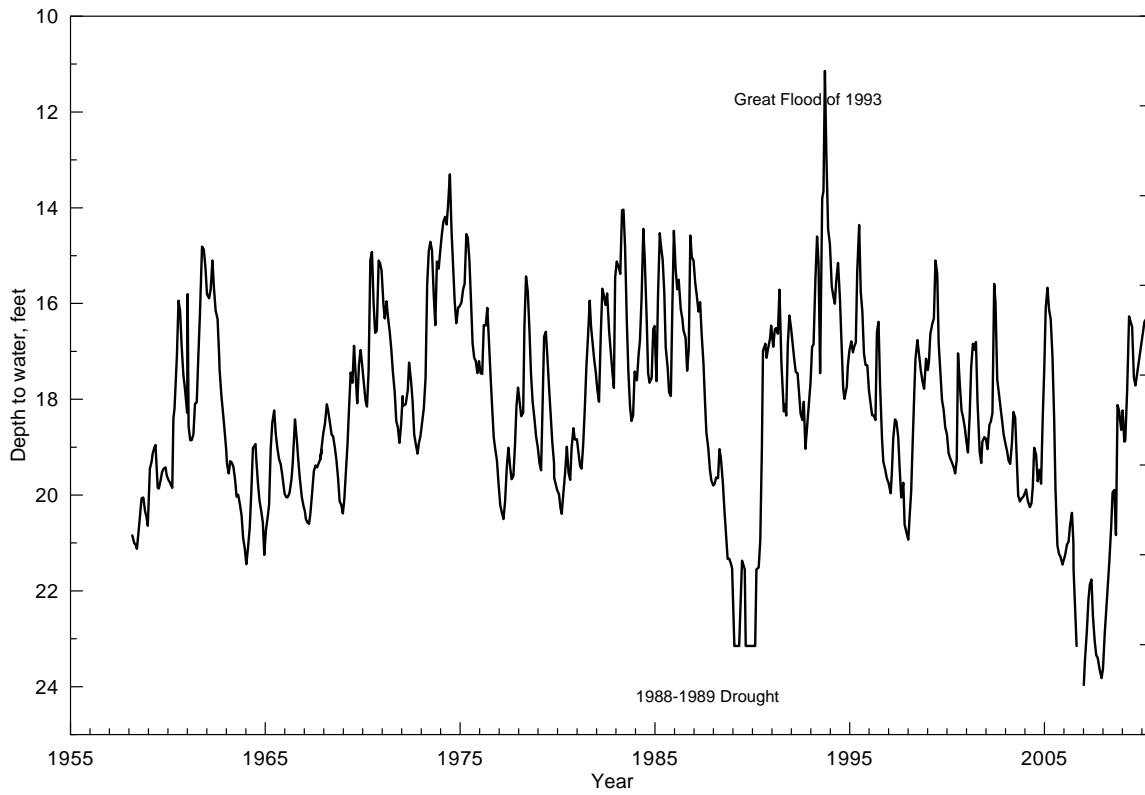


Figure 11. Groundwater levels at the Snicarte wells, 1958-2010

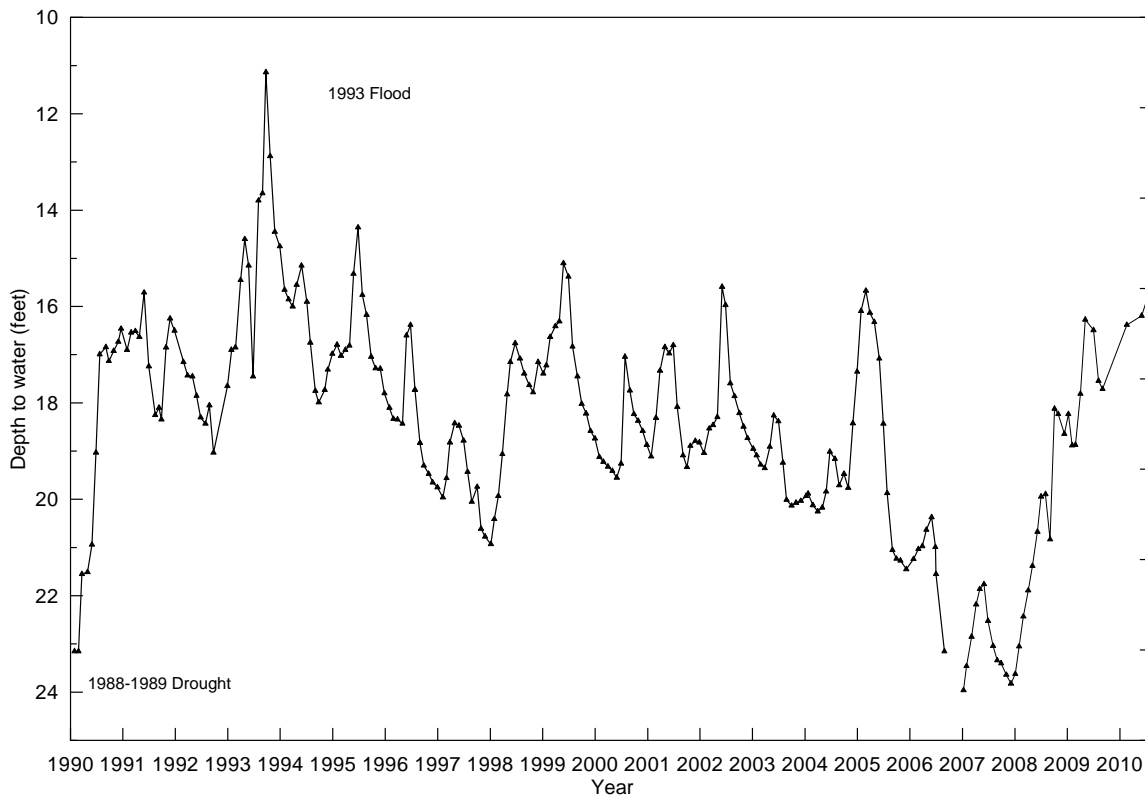


Figure 12. Groundwater levels at the Snicarte wells, 1990-2010

The dramatic drop in 1988-89 shows how significantly a major drought can impact the aquifer. Though we don't have irrigation data for 1988, based on data from the other parts of the state (Cravens, et al., 1989) it is likely that irrigation in 1988 was one of the highest amounts of any year. This is because summer precipitation was so low and summer temperatures were so high in 1988. Similarly, the irrigation amounts in 2005 (72 billion gallons) were 164 percent of average since 1995 and we saw similar dramatic declines in water levels. In Year 14, temperatures were high and summer precipitation was low. Conversely, Year 17 and Year 18 were relatively wet years with low irrigation withdrawals and water levels rose. It is likely that local summer precipitation in future years will cause similar fluctuations in aquifer levels.

From late 2002 until 2008 the study area received below average rainfall. These below average precipitation totals in combination with irrigation withdrawals affected the groundwater elevations in the study area. Above average precipitation in Year 17 elevated groundwater levels to the point of near record highs since the observation well network was established in 1995. A second year of higher than average precipitation in Year Eighteen elevated groundwater levels to record highs in several of the network wells.

Previous reports have shown hydrographs indicating recharge events in the aquifer occurring within a few days after a rainfall event. In other words, recharge occurs on a scale of days after a precipitation event, and so historical monthly measurements missed many such events. Based on these results, the IVWA purchased ten In-Situ data loggers that were installed in wells between December 30, 2004 and August 2005. The hydrographs for these ten loggers can be seen in Appendix A.

In Year Eighteen, a rainfall event during July at the Easton Well (MTOW-02) is very evident as recharge as shown in Figure 13. Other regions of the aquifer show a similar but less pronounced response. Figures 14, 15 and 16 show the same precipitation event at the Hahn Farm (MTOW-12), Rest Area (MTOW-07), and Wildlife Refuge wells (MTOW-03) producing over 1 foot of recharge within seven days. And while the hydrographs showing the recharge following precipitation for the Hahn Farm, Rest Area, and Wildlife Refuge wells are not as dramatic as at Easton, in general, the information they provide are just as vital. The recent addition of continuous water level measurements has already led to an increased understanding of the relationship between rainfall, irrigation, water levels, and recharge. Along with Easton, Hahn Farm, Rest Area, and Wildlife Refuge, the hydrographs showing continuous water levels and daily rain gauge data for Year 18 are available for the remaining monitoring wells in Appendix A.

Groundwater levels in the Pekin (MTOW-05) and Havana-IDOT (MTOW-09) wells, because of their proximity to the Illinois River, have been found to fluctuate largely in response to river stage. Since these two monitoring wells are so strongly influenced by the Illinois River, the wells are not outfitted with pressure transducers and in the future will be measured infrequently. The hydrographs for these two wells (MTOW-05 and MTOW-09) are located in Appendix A.

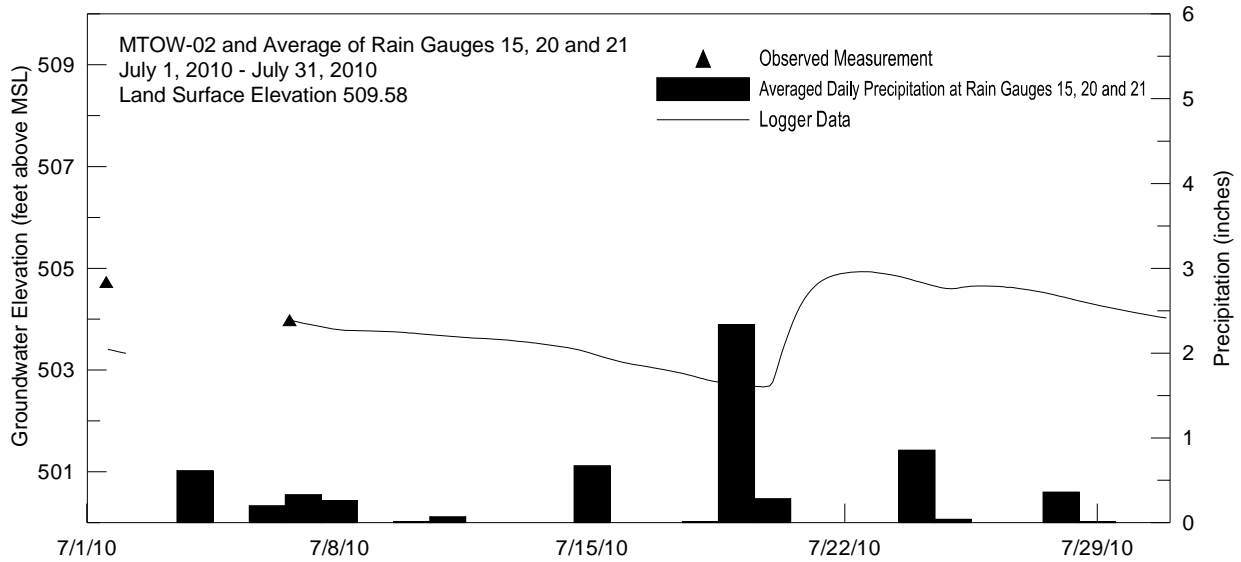


Figure 13. Groundwater elevations at the Easton well, MTOW-02, July 1, 2010-July 31, 2010

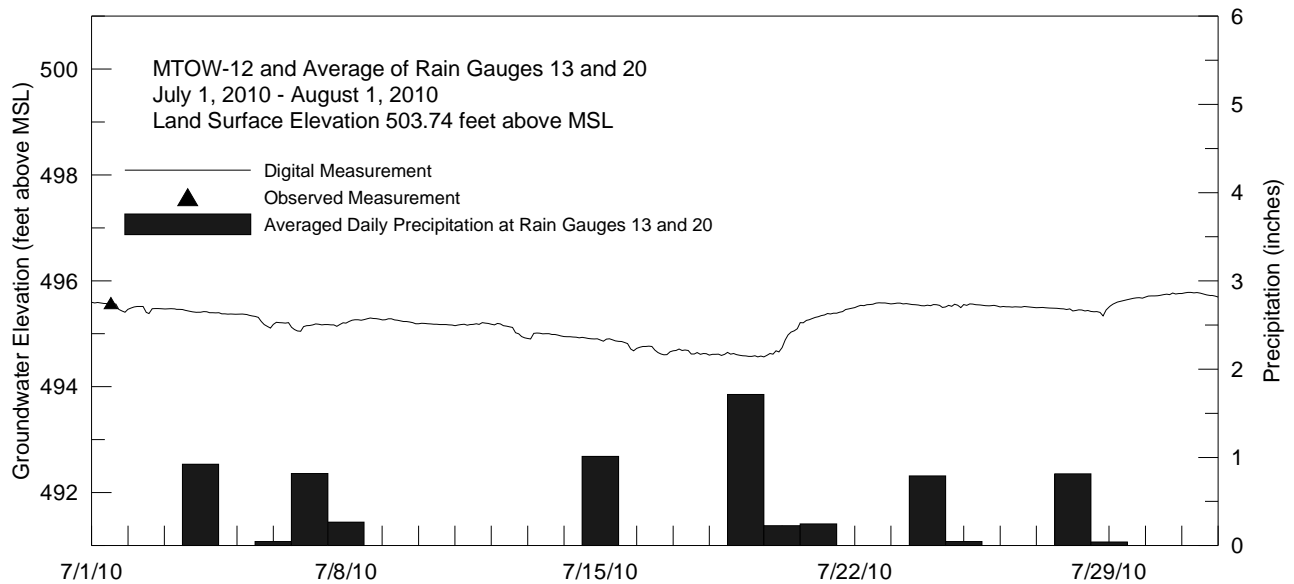


Figure 14. Groundwater elevations at the Hahn Farm, MTOW-12, July 1, 2010-August 1, 2010



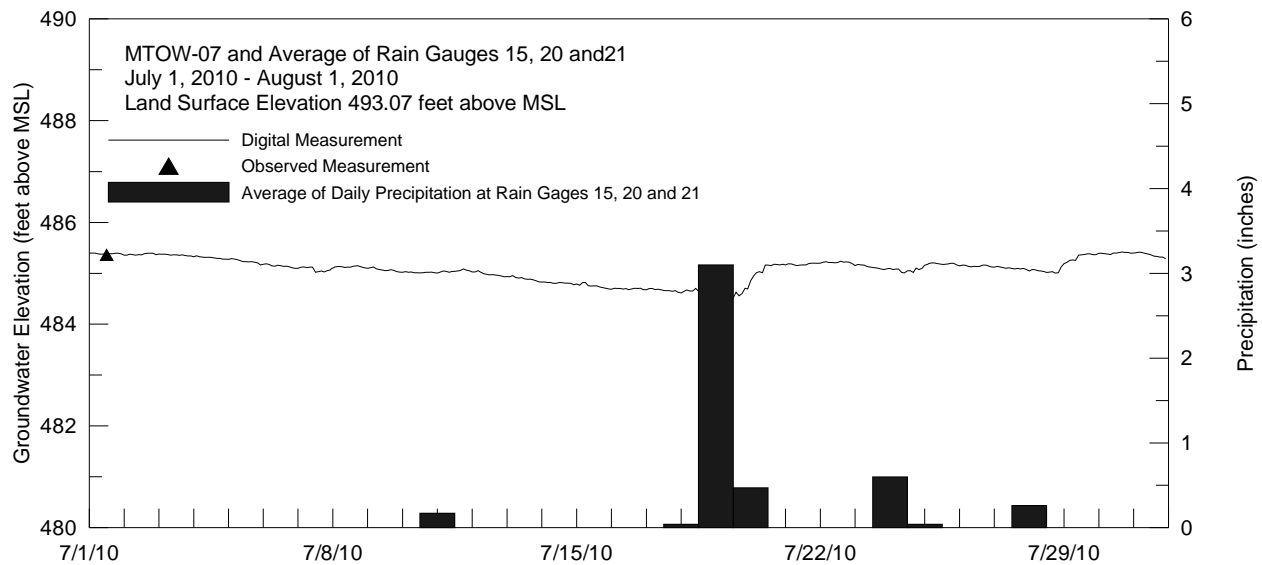


Figure 15. Groundwater elevations at the Rest Area wells, MTOW-10, July 1, 2010-August 1, 2010

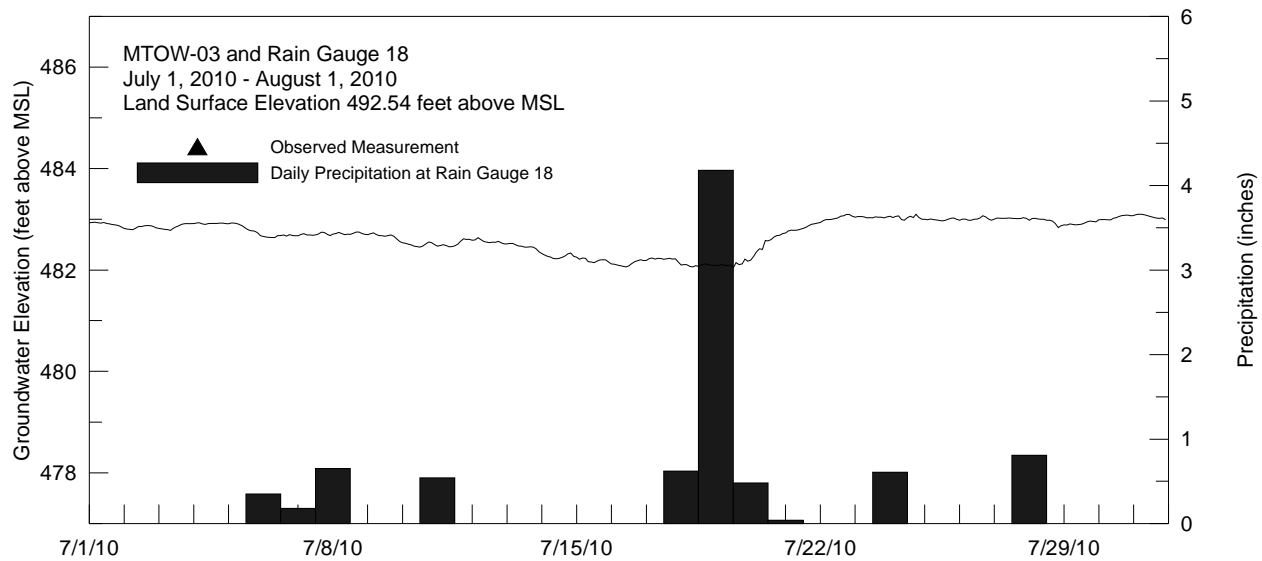


Figure 16. Groundwater elevations at the Wildlife Refuge wells, MTOW-03, July 1, 2010-August 1, 2010

## Irrigation Water Use

For Year Eighteen, the higher than normal precipitation in the spring and early summer of 2010 affected irrigation practices significantly. Irrigation in June was the third lowest June for the length of the study, July the third lowest, August the second lowest while September the third highest on record. The total irrigation pumpage in 2010 was approximately 27 billion gallons (bg), which is the second lowest irrigation amount for the observation period, below the approximately 30 bg pumped in 1998 and 2000 (when there were several hundred fewer irrigation systems in use) and above only the 26 bg pumped in 2009. The hot and dry September clearly affected pumpage as 40% of the total pumpage was during this period.

The monthly and seasonal estimates of irrigation withdrawals are shown in Table 3. These data were calculated for the Imperial Valley by previously described methods. Total annual irrigation withdrawals, from highest to lowest, are as follows: 2005, 2007, 1996, 2006; 2001 and 2002 (equal); 2003; 2004; 1999; 1997 and 1995 (equal); 2008; 1998 and 2000 (equal); 2010 and 2009. Typically, irrigation withdrawals are greatest in July and August, with September and June withdrawals being much less. Though more irrigation systems are added each year, suggesting that irrigation pumpage should keep increasing, it is clearly apparent that the timing and amount of rainfall received during the irrigation season (rather than throughout the whole year) are primary factors affecting the amount of irrigation.

**Table 3. Estimated Monthly Irrigation Withdrawals (billion gallons), Number of Irrigation Systems, Withdrawal per System and Withdrawal Rank**

<i>Year</i>	<i>June</i>	<i>July</i>	<i>August</i>	<i>September</i>	<i>Total</i>	<i># Systems</i>	<i>BG/system</i>	<i>Rank</i>
1995	2.6	14	10	11	38			10
1996	2.0	20	18	12	52			3
1997	2.6	19	14	2.0	38			10
1998	2.1	7.8	13	6.9	30	1622	.018	13
1999	2.8	18	12	6.0	39	1771	.022	9
2000	6.4	6.0	12	5.6	30	1799	.017	13
2001	4.4	21	17	5.0	47	1818	.026	5
2002	3.4	24	16	3.7	47	1839	.026	5
2003	4.1	16	15	10	46	1867	.025	7
2004	5.3	12	19	5.7	42	1889	.022	8
2005	15	29	23	4.8	72	1909	.038	1
2006	7.2	22	16	5.2	50	1940	.026	4
2007	16	17	19	4.9	57	1971	.029	2
2008	1.2	10	14.5	7.1	33	2014	.016	12
2009	1.6	9.3	12.1	2.9	26	2054	.013	16
2010	1.8	2.4	11.7	10.6	27	2077	.013	15
Average	4.9	15.5	15.1	6.5	42			

**Note:**

Total annual withdrawal may differ from sum of monthly withdrawals due to rounding error. Also, data regarding the number of systems in 1995-1997 are unavailable. Also, the BG/system was rounded incorrectly for 2009 and should be .013.

The estimated monthly irrigation pumpage is displayed graphically in Figure 17 along with average monthly network precipitation. These pumpage values show a tendency for lower irrigation amounts during times of increasing precipitation and vice versa, but also show that irrigation is dependent on the timing of precipitation. For example, only 30 bg were pumped in 2000 (Year Eight), even though Year Eight showed a deficit of 9.5 inches (Table 4). This was because significant precipitation fell during the summer of 2000, reducing the need for irrigation. Similarly, Year Fifteen (summer 2007) was the ninth driest of network operation, but ranked number 2 for irrigation pumpage.

The influence of the abundant rainfall during Year 18, 11.15 inches of precipitation above average, is evident in both the decreased amount of water withdrawn for irrigation and in higher groundwater levels throughout the study area. Table 4 also shows that for 6 of the last 8 years and for 11 of the last 15 years, rainfall has been below the 30-year (1971-2000) historical average of 36.76 inches (average of Havana and Mason City). The influence of the heavy rainfall, coupled with a second straight year of low irrigation has resulted in record high groundwater levels within much of the Imperial Valley.

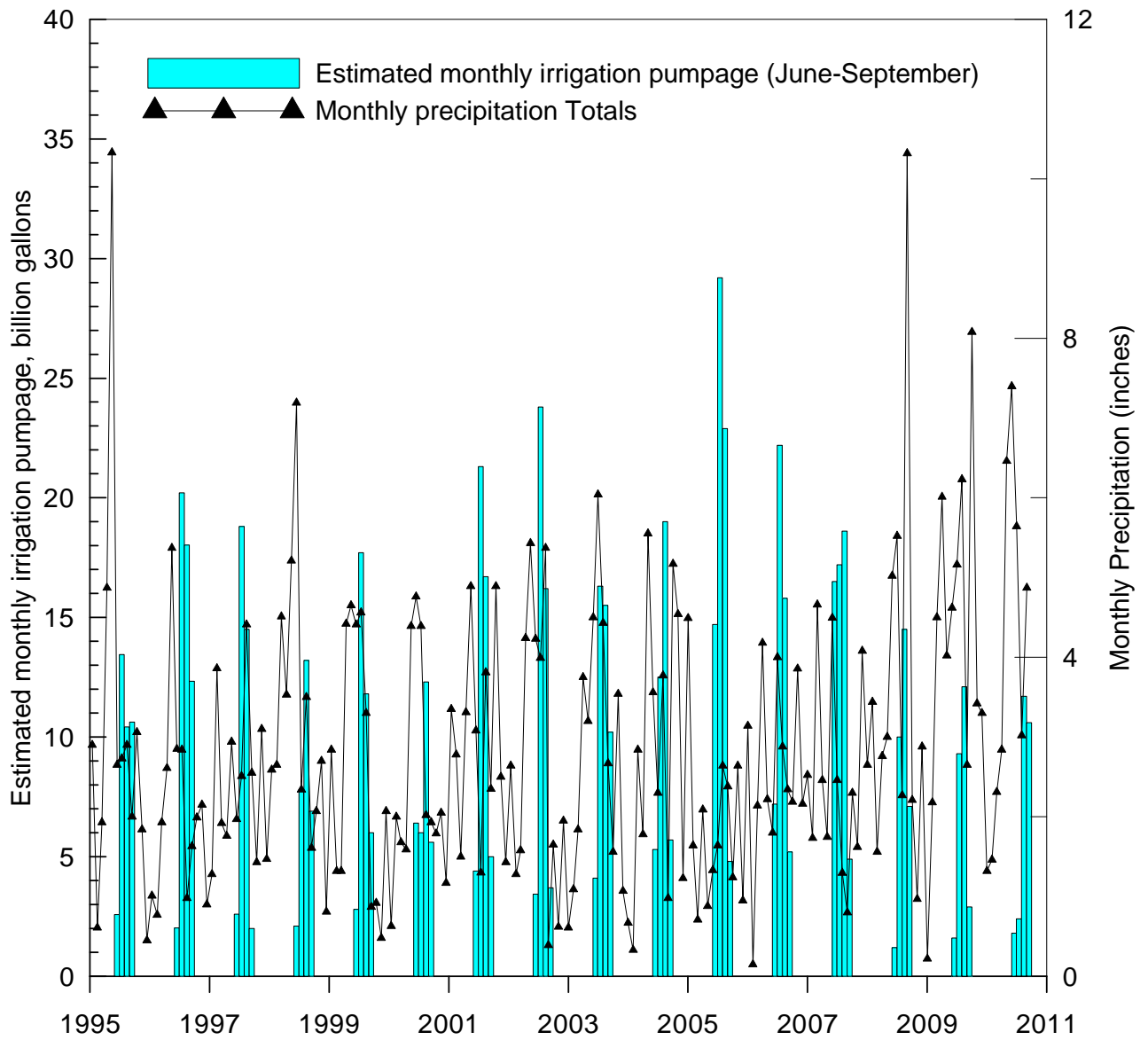


Figure 17. Estimated irrigation pumpage and average monthly precipitation, Imperial Valley

**Table 4. Average Annual Precipitation, Annual Precipitation Surplus, Running Surplus, and Ranked Annual Precipitation and Irrigation, Imperial Valley Network**

<i>September-August period</i>	<i>Network average precipitation (in.)</i>	<i>Annual surplus (in.)</i>	<i>Running surplus (in.)</i>	<i>Rank Precip.</i>	<i>Rank Irrigation</i>
1992 - 1993	55.55	+18.79	+18.79	1	-
1993 - 1994	40.21	+3.45	+22.24	4	-
1994 - 1995	39.42	+2.66	+24.90	7	10
1995 - 1996	25.70	-11.06	+13.84	18	3
1996 - 1997	27.31	-9.45	+4.39	16	10
1997 - 1998	40.06	+3.30	+7.69	5	13
1998 - 1999	34.02	-2.74	+4.95	9	9
1999 - 2000	25.81	-10.95	-6.00	17	13
2000 - 2001	30.97	-5.79	-11.79	11	5
2001 - 2002	39.91	+3.15	-8.64	6	5
2002 - 2003	30.06	-6.70	-15.34	12	7
2003 - 2004	29.64	-7.12	-22.46	13	8
2004 - 2005	27.34	-9.42	-31.88	15	1
2005 - 2006	27.74	-9.02	-40.90	14	4
2006 - 2007	31.94	-4.82	-45.72	10	2
2007 - 2008	35.02	-1.74	-47.46	8	12
2008 - 2009	49.34	+12.58	-34.88	2	16
2009 - 2010	47.91	+11.15	-23.73	3	15
1971 - 2000 30-yr average	37.82 (Havana)				
1971 - 2000 30-yr average	35.70 (Mason City)				
1971 - 2000 30-yr average	36.76 (average of Mason City and Havana used to determine surplus)				

**Note:** Site 16 was excluded from network average computations from 1996-1997 through 2001-2002.

### Summary

In summary, for Year Eighteen of the rain gauge network operation (September 2009-August 2010), the network received an average of 47.91 inches of precipitation, 13.20 inches more than the network’s previous 17-year average precipitation of 34.71 inches, and 11.15 inches more than the 30-year average for the study area. Year-Seventeen was the second wettest year since the deployment of the precipitation network, and Year-Eighteen the third wettest year.

The timing and amount of rainfall was such that the need for irrigation in the summer of 2010 was greatly reduced, the exception being September when 10.0 bg was pumped for irrigation from the aquifer. This reduced pumping of the aquifer for irrigation, along with above average precipitation, provided an opportunity to recharge the aquifer system significantly. In fact, groundwater levels within the aquifer achieved record highs during Year 18 within many of the network observation wells. This likely occurred because of significant spring and summer rainfall coupled with reduced withdrawal for irrigation and high precipitation from the previous year.

Ten pressure transducers installed at study wells indicate that the amount of rainfall, depth to water, and distance to a nearby stream all influence how quickly and to what extent water levels rise in the aquifer after a precipitation event. We expect to have more supporting data to analyze as more storm events of greater magnitude occur in the future.

Please contact either Kevin Rennels, Steve Wilson or Nancy Westcott if you have any questions or comments.

Sincerely,

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## Appendix A. Hydrographs, Imperial Valley Observation Well Network

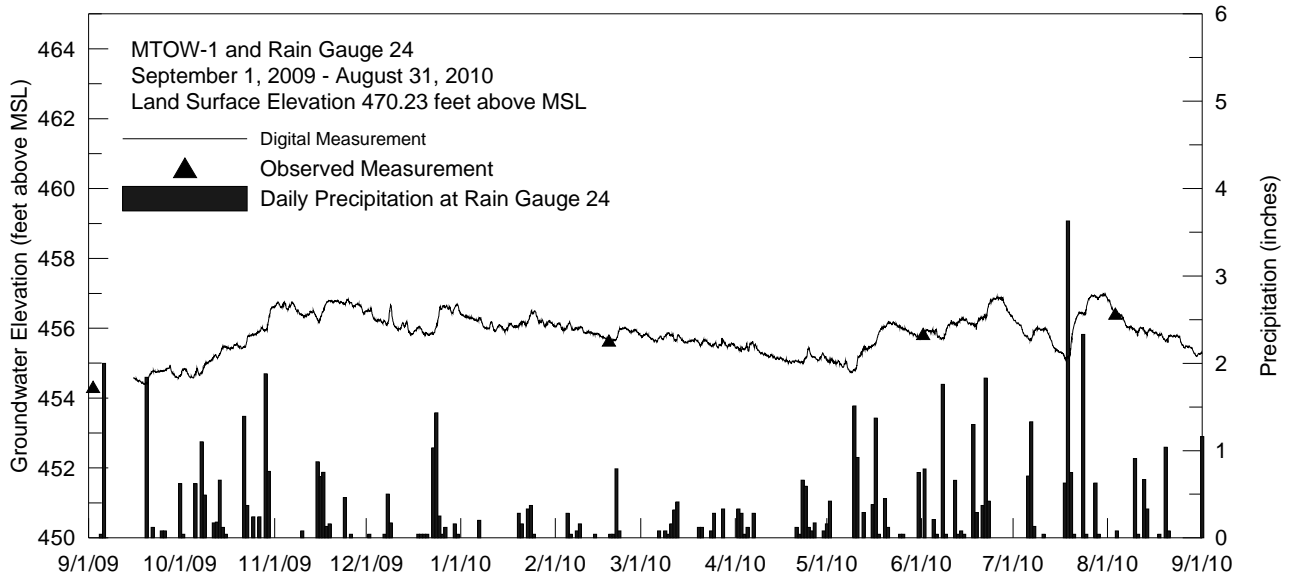


Figure A-1. Year 18 Groundwater depth and precipitation for MTOW-01

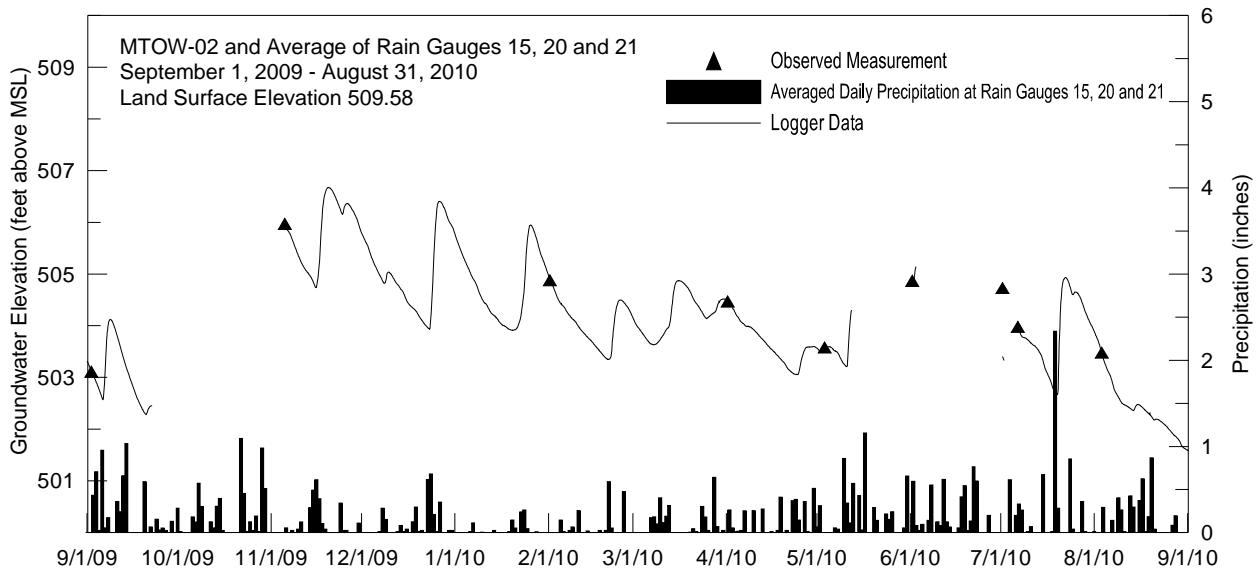


Figure A-2. Year 18 Groundwater depth and precipitation for MTOW-02

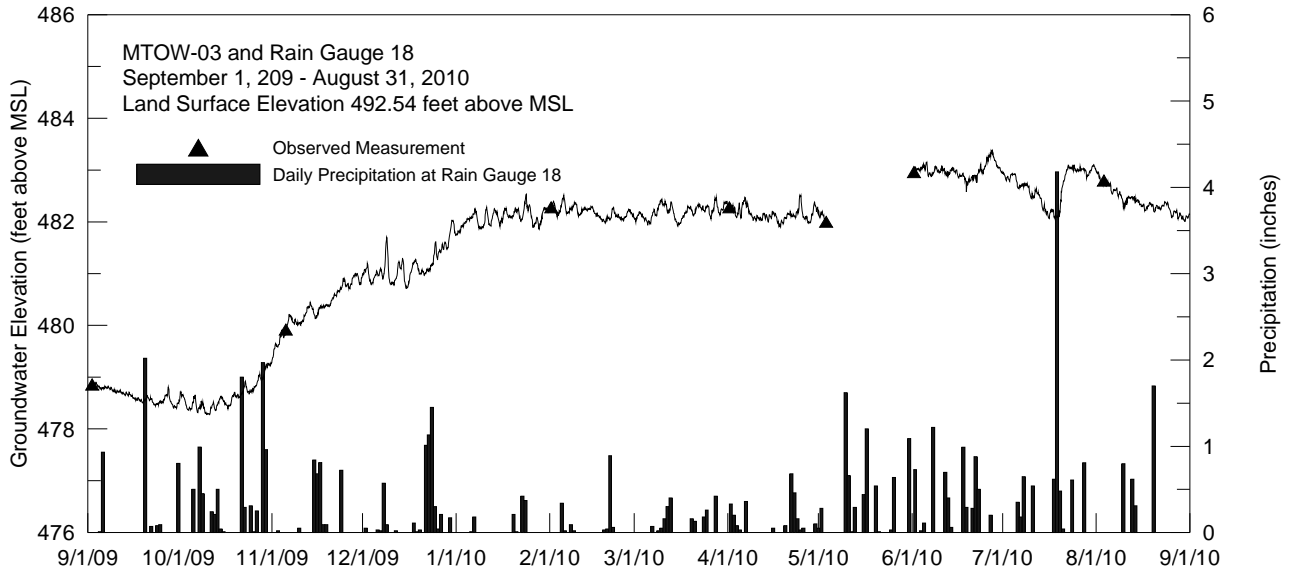


Figure A-3. Year 18 Groundwater depth and precipitation for MTOW-03

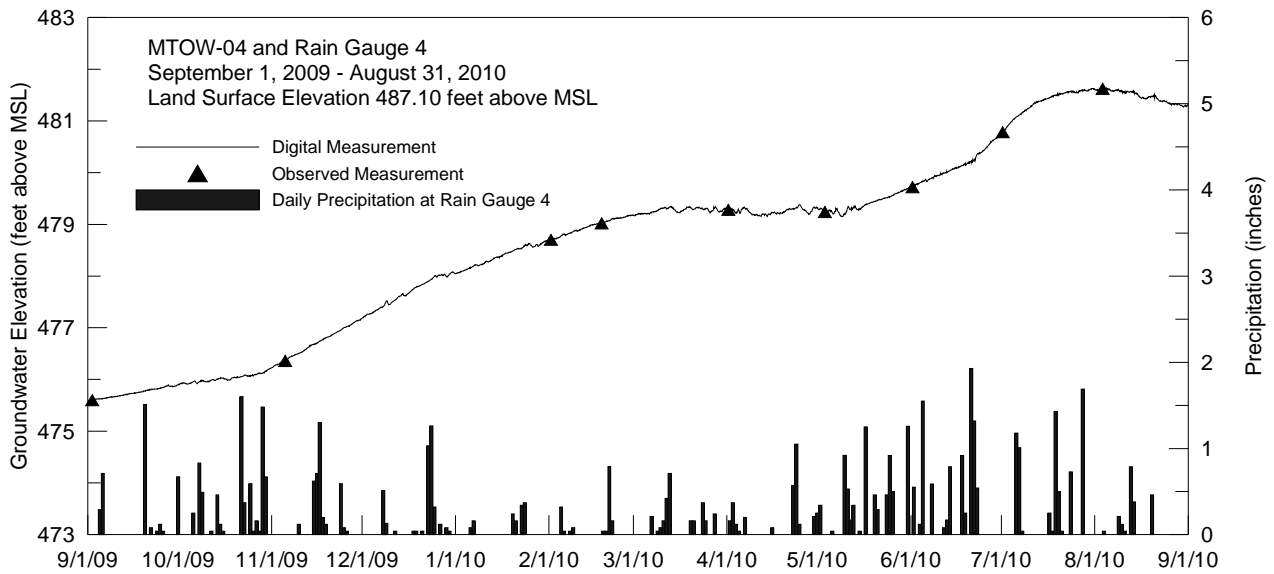


Figure A-4. Year 18 Groundwater elevation and precipitation for MTOW-04



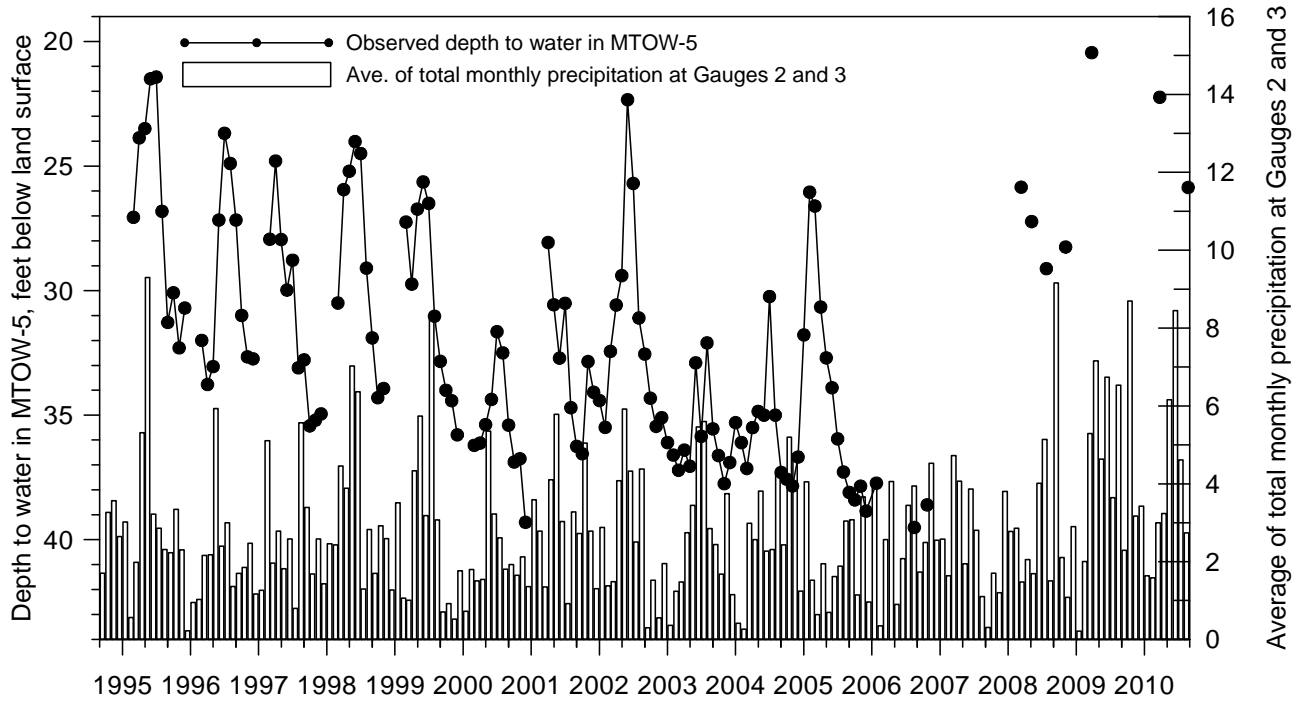


Figure A-5. Year 18 Groundwater depth and precipitation for MTOW-05 (not continuous recorder)

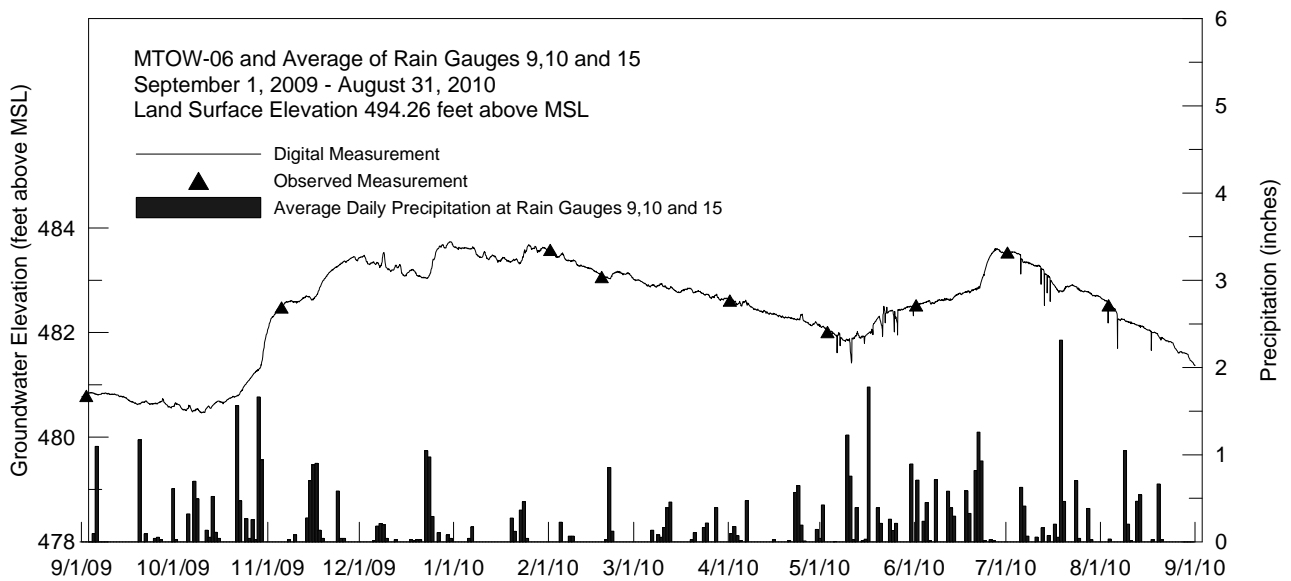


Figure A-6. Year 18 Groundwater elevation and precipitation for MTOW-06

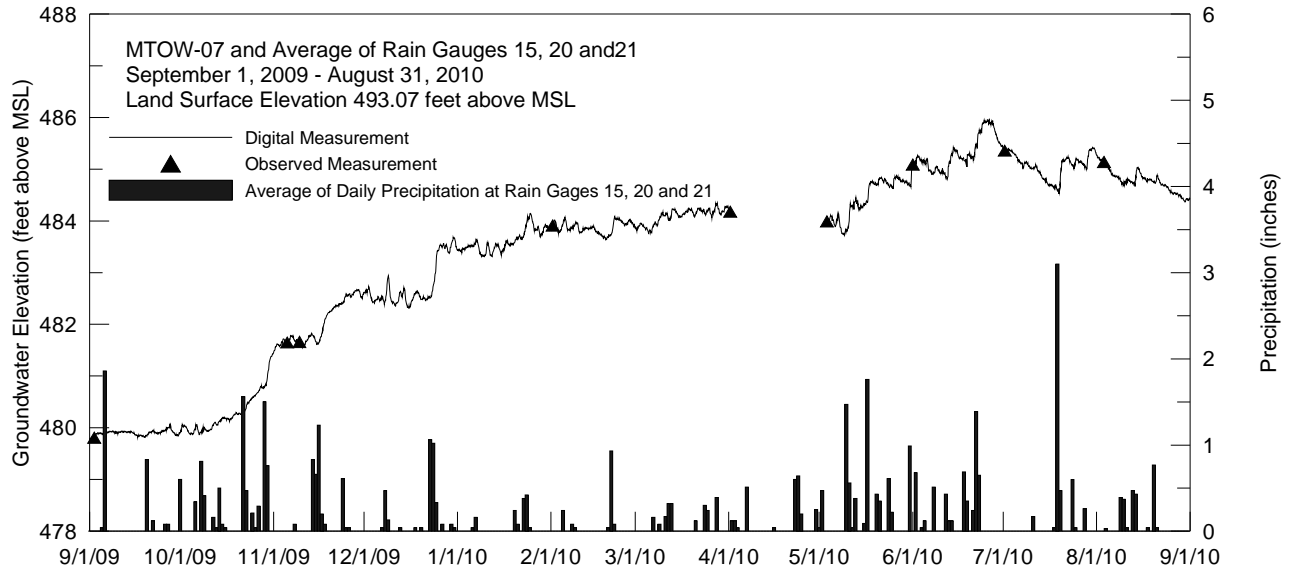


Figure A-7. Year 18 Groundwater elevation and precipitation for MTOW-07

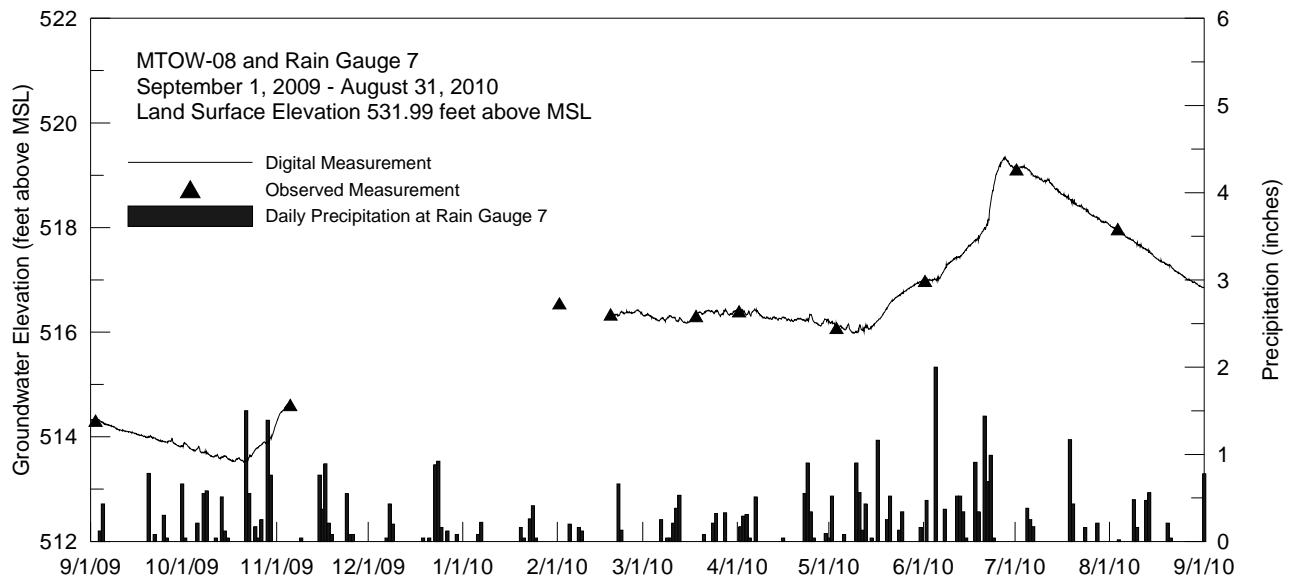


Figure A-8. Year 18 Groundwater elevation and precipitation for MTOW-08

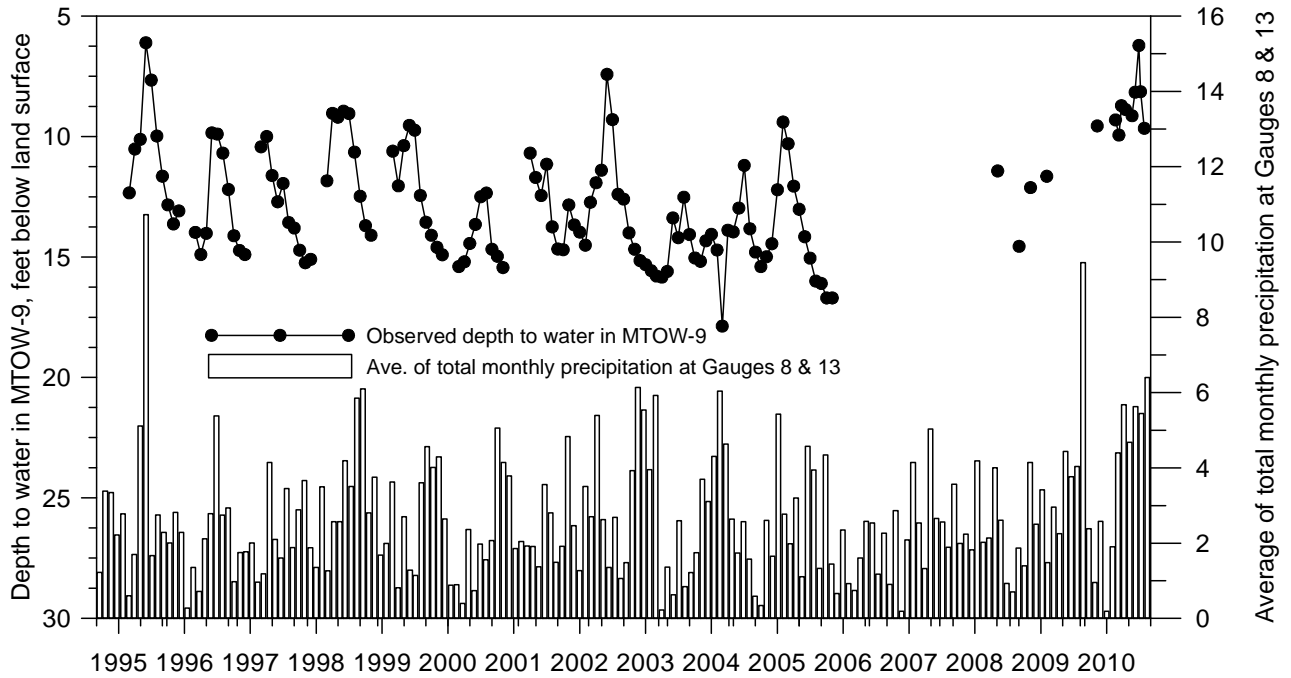


Figure A-9. Year 18 Groundwater depth and precipitation for MTOW-09 (not continuous recorder)

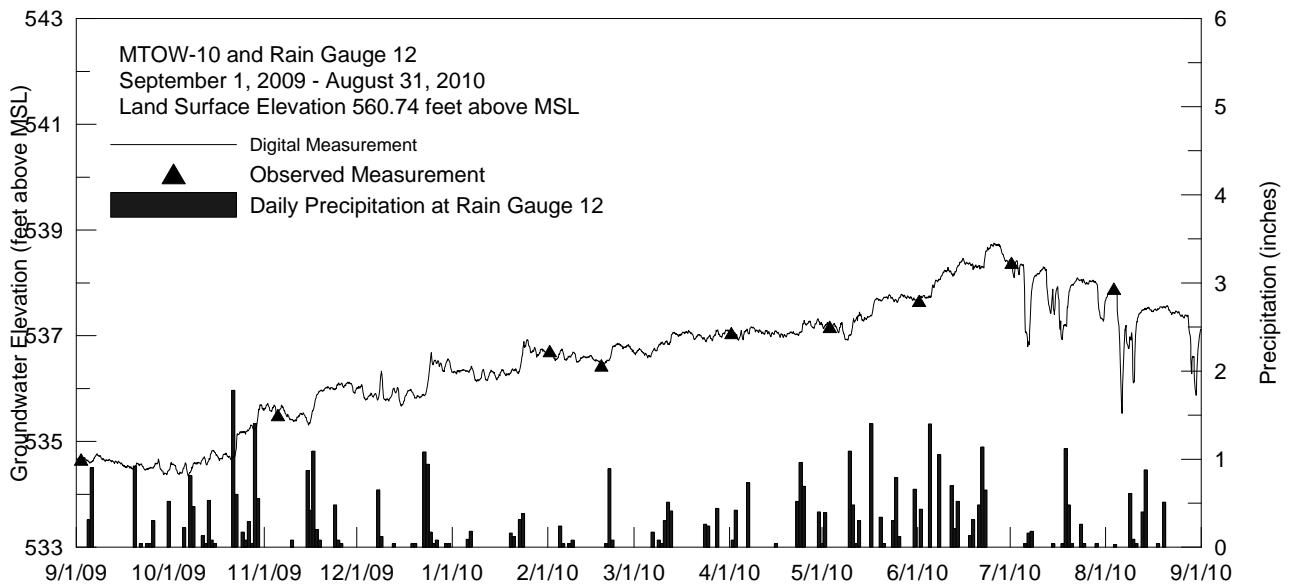


Figure A-10. Year 18 Groundwater depth and precipitation for MTOW-10

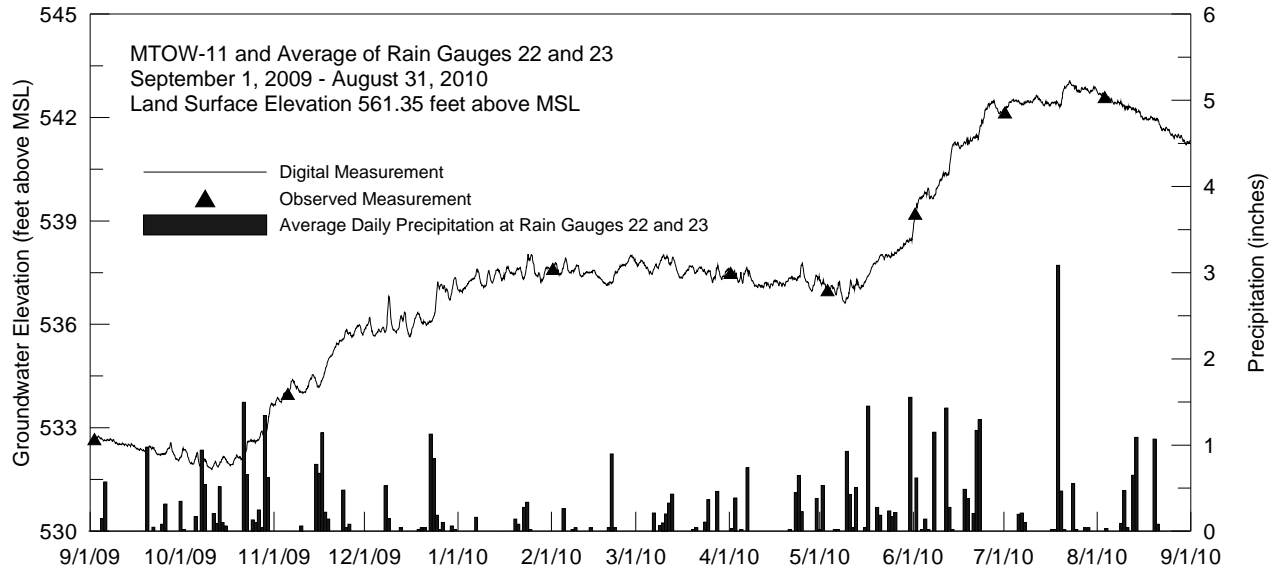


Figure A-11. Year 18 Groundwater elevation and precipitation for MTOW-11

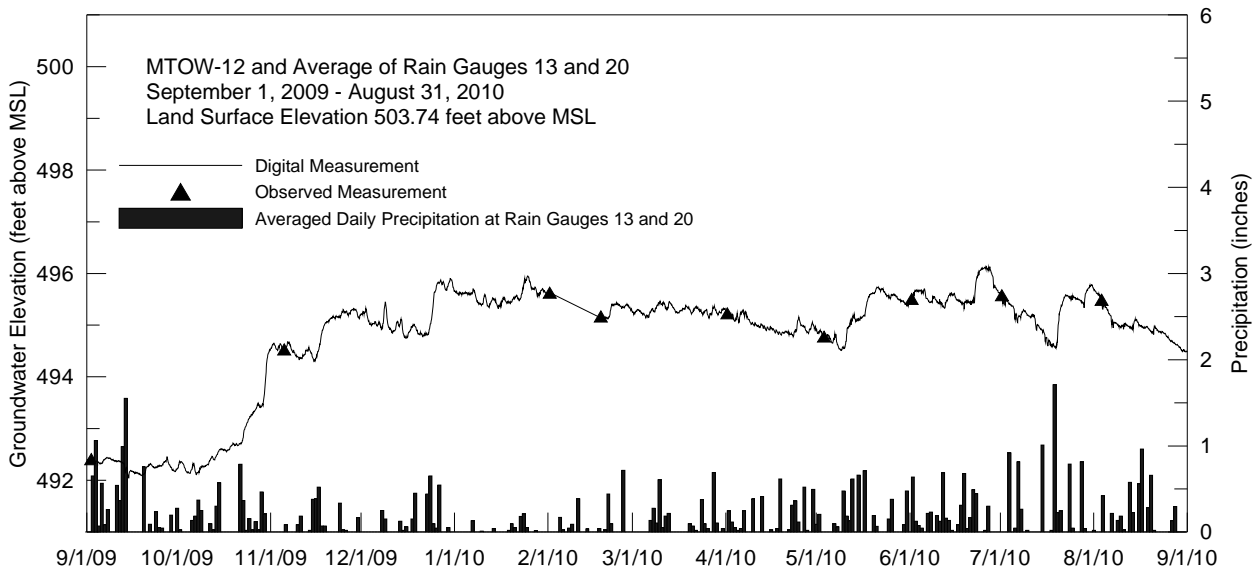


Figure A-12. Year 18 Groundwater elevation and precipitation for MTOW-12

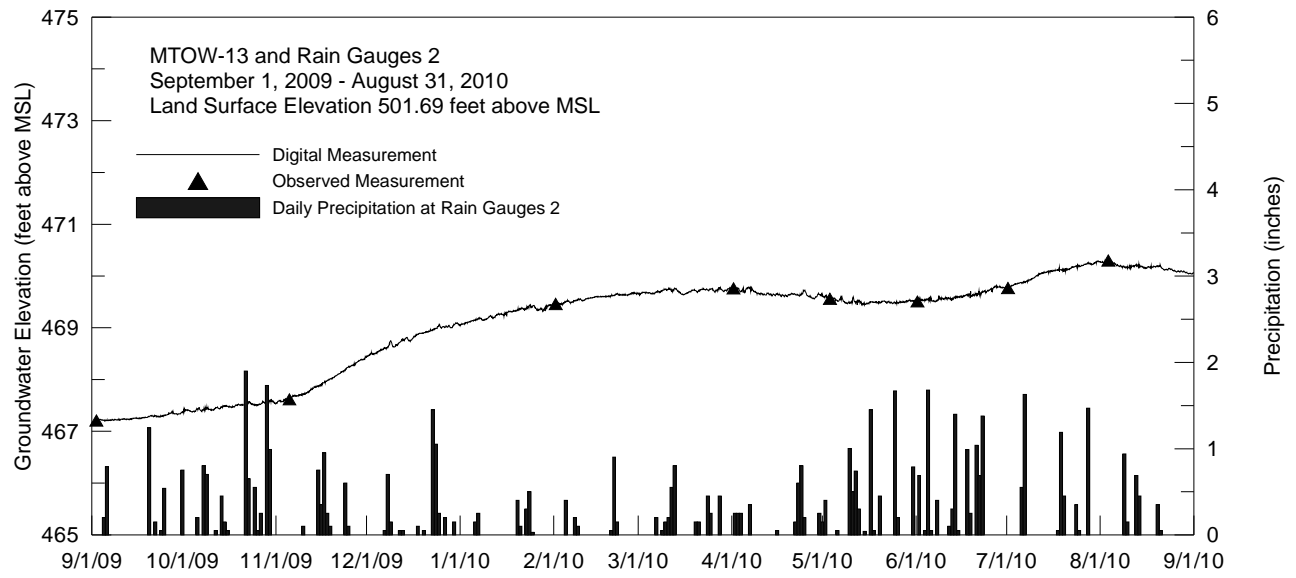


Figure A-13. Year 18 Groundwater depth and precipitation for MTOW-13