UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Institute of Natural Resource Sustainability
Illinois State Water Survey

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

January 30, 2009

Mr. Morris Bell
Chairman
Imperial Valley Water Authority
3278 CR 1030E
Chandlerville, IL 62627

Dear Chairman Bell:

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 16 which covers the time period from September 1, 2007 through August 31, 2008.

The groundwater observation well network consists of thirteen wells, MTOW-01 through MTOW-13. MTOW-01, located near Snicarte, 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. 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 Year 15, a new well was drilled to replace MTOW-1. This new well, named Snicarte #2, will eventually take the place of the original well (MTOW-01 or Snicarte #1) within the monitoring well network. The two wells are still being observed jointly so that their water level data can be correlated. The new well is equipped with the same type of Stevens recorder as the original well, but once the well to well comparison is complete, the well will be converted to digital data collection. It is unknown at this time how long this procedure will take as Snicarte #1 has been intermittently dry.

A gridded, 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.

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-01 is

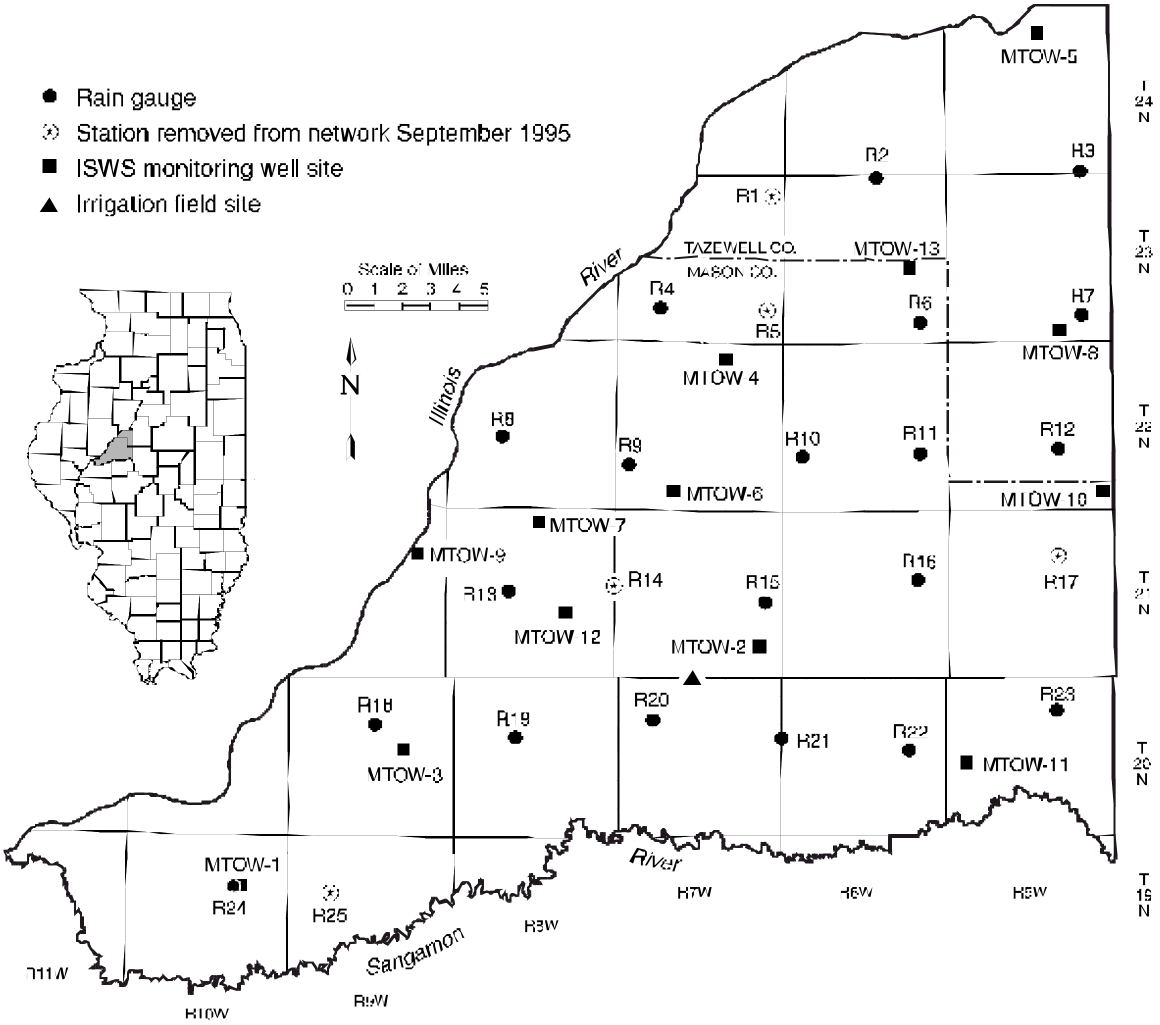


Figure 1. Configuration of the 13-site observation well and 25-site rain gauge networks, and location of the irrigation field site, Imperial Valley, 2007-2008.

visited monthly because of its inclusion in the Shallow Groundwater Well Network of the ISWS Water and Atmospheric Resources Monitoring (WARM) Program. 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 Sixteen of network operation are similar to those performed during the previous fifteen. Hourly rainfall amounts are totaled from 10-minute digital data and are placed into an array of monthly 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.

Groundwater levels for each well for the period of record (September 1, 2007-August 31, 2008) are presented in Appendix A. For MTOW-1, -5, and -9 their entire period of record is shown because they do not have digital recorders. 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. For observation wells located relatively near the Illinois River (MTOW-1, -5, and -9), the stage of the river at the nearest U.S. Army Corps of Engineers (USACE) gauging station also is shown. The groundwater level data in these wells are presented as depth-to-water from land surface. Mean monthly stage data were downloaded for the Beardstown, Havana, and Kingston Mines stations from the USACE Internet site (http://water.mvr.usace.army.mil).

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 serve 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.

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 Sixteen 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.

The Year Sixteen network precipitation of 35.02 inches was above average, 1.31 inches above the previous 15-year's average of 33.71 inches. It was the sixth wettest year in the 16 years of network operation. The spring and summer seasons in Year Sixteen were above average in seasonal total precipitation. Table 1 gives the monthly precipitation totals for each rain gauge within the network during Year 16.

Figure 2 presents the 16-year network average, excluding sites 16, 19, 21 during the period 1997-2002, and Figure 3 presents the annual precipitation pattern for Year Sixteen. During Year Sixteen, annual gauge totals varied from 27.75 inches at site 16 to 38.16 inches at site number 2 (Figure 3). Eight inch gradients 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.

Table 1. Monthly Precipitation Amounts (inches), September 2007-August 2008

	Month												
Station	*Sep*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Total*
2	0.3	1.39	1.16	3.44	2.71	2.59	1.38	1.78	1.52	3.89	4.69	1.38	26.23
3	0.32	2.01	1.24	4.17	2.84	3.12	1.57	2.32	1.86	4.13	5.58	1.63	30.79
4	0.75	2.32	1.34	4.07	2.73	3.79	2.05	2.25	2.01	4.58	4.66	2.46	33.01
6	0.65	2.49	1.86	4.2	3.04	3.19	1.3	2.16	1.68	3.67	3.86	1.92	30.02
7	1.5	3.31	1.73	4.07	2.97	2.96	1.37	2.57	2.48	4.24	4.42	2.2	33.82
8	0.99	2.1	1.4	4.23	2.82	3.63	1.6	2.95	2.12	4.46	3.84	4.75	34.89
9	0.37	2.98	1.53	4.25	2.8	3.48	1.37	2.37	2.71	4.21	4.45	4.19	34.71
10	0.46	2.35	1.65	4.21	2.82	3.12	1.5	2.42	2.42	4.62	3.76	2.78	32.11
11	0.84	2.02	1.49	3.85	2.57	3.07	1.31	2.75	2.48	4.63	3.6	1.72	30.33
12	0.79	2.69	1.93	4.48	2.75	3.78	1.33	2.76	2.62	5.01	3.4	2.28	33.82
13	0.42	1.64	1.39	4.06	2.19	3.21	1.36	2.97	2.38	4.42	3.69	3.32	31.05
15	0.76	2.09	1.83	4.35	2.22	3.85	1.42	2.46	2.77	3.37	5.63	3.	33.75
16	0.81	1.69	1.3	3.48	2.33	2.73	1.3	2.56	2.44	4.81	4.4	1.75	29.6
18	0.76	2.45	1.88	4.54	2.41	4.32	1.6	4.35	4.76	8.24	8.58	2.07	45.96
19	0.90	2.49	2.38	4.41	2.31	4.36	1.61	3.36	4.57	6.17	8.86	1.76	43.18
20	0.95	2.17	1.68	3.84	2.32	3.58	1.72	2.75	3.6	5.12	8.61	2.31	38.65
21	1.06	2.11	1.54	3.91	2.63	3.47	1.74	2.64	4.54	5.81	7.78	1.49	38.72
22	1.06	2.6	1.54	3.56	2.97	3.3	1.89	2.93	3.96	6.38	7.19	1.01	38.39
23	1.45	2.69	1.85	3.79	3.46	3.43	1.99	3.44	4.63	5.93	6.35	1.28	40.29
24	0.76	2.41	1.74	4.53	2.18	3.87	1.79	3.35	4.44	6.38	7.07	2.01	40.53
Avg	0.80	2.30	1.62	4.07	2.65	3.44	1.56	2.76	3.00	5.02	5.52	2.27	35.02

December of 2007 and January, February, June and July of 2008 were the wettest months of the year. All other months of the year received below average precipitation (Figures 4-9). These five months account for 20.71 inches of precipitation or 61 % of the 15-year average annual precipitation. The network received 20.53 inches less precipitation than in the wettest year (1992-1993) and 9.32 inches more than in the driest year (1995-1996).

Storm Events

The number of network precipitation periods was determined for the 16-year period. Mean monthly, seasonal, and annual number of these precipitation events are presented for 2007-2008 (Table 2). The monthly, seasonal, and annual number of precipitation events averaged over the 1992-2007 period also is presented (Table 2). A network storm period was defined as a precipitation event separated from proceeding and succeeding events at all network stations by at least three hours.

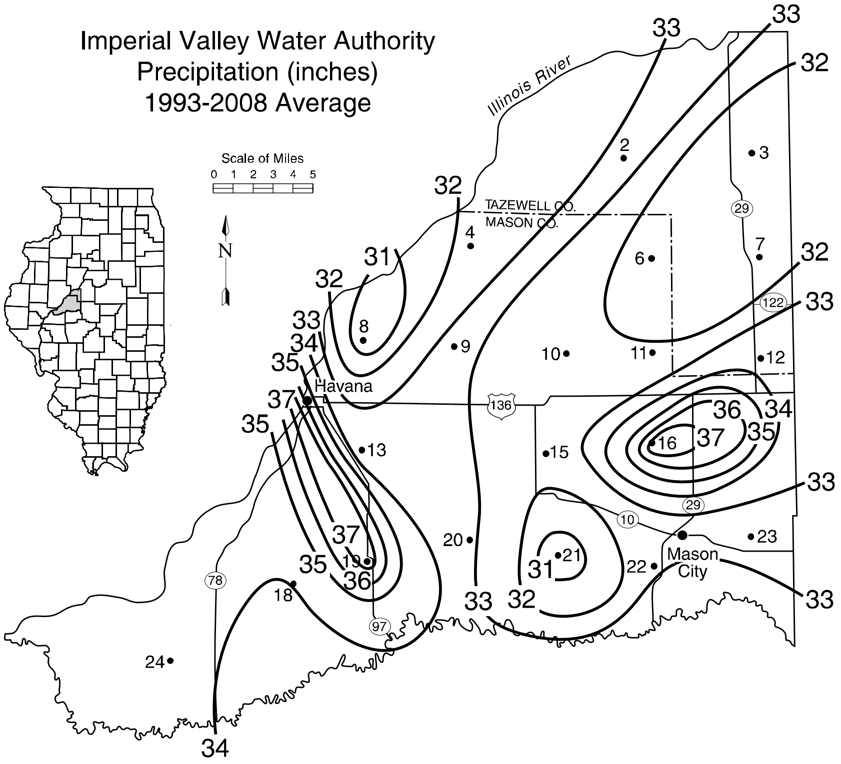


Figure 2. Network average annual precipitation (inches) for September 1992 - August 2008

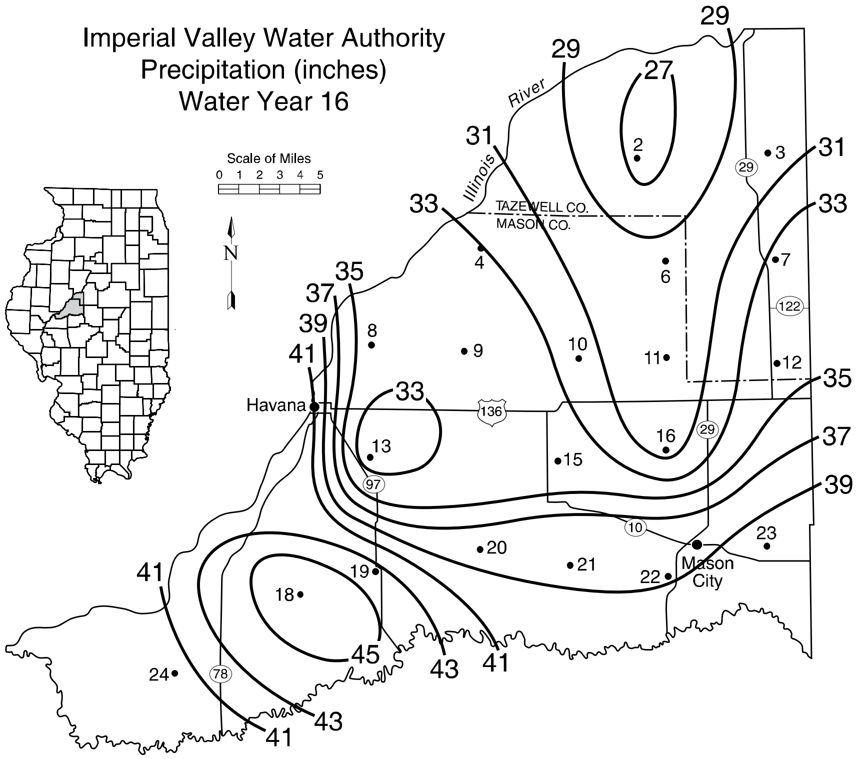
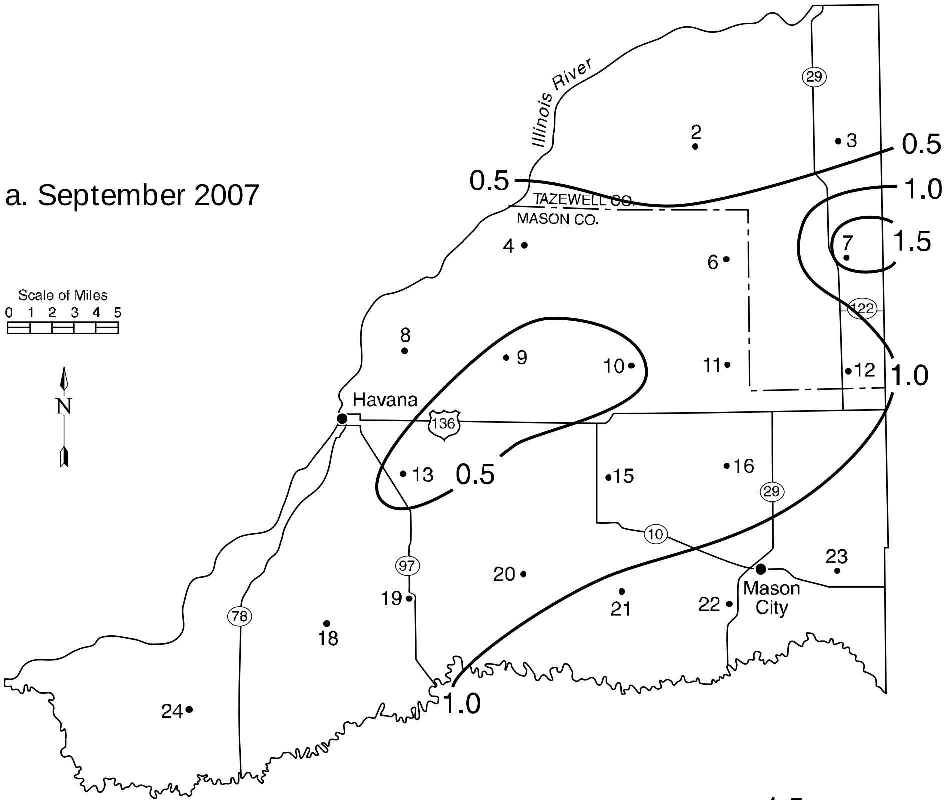


Figure 3. Total precipitation (inches) for September 2007- August 2008

a. September 2007



b. October 2007

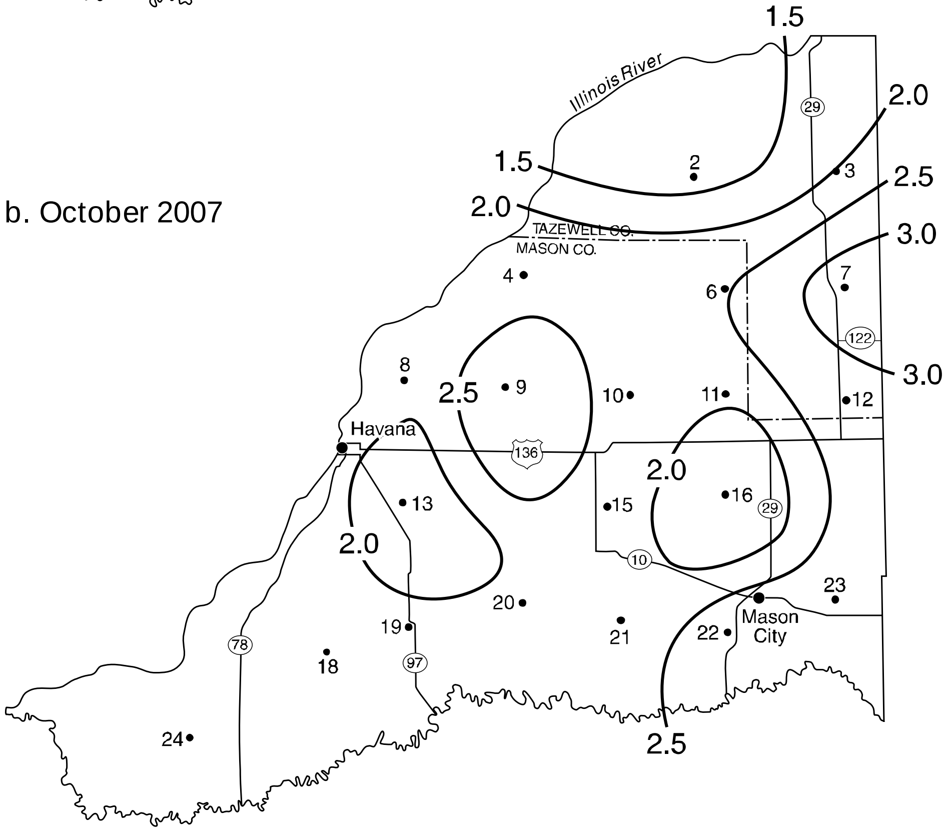


Figure 4. Precipitation (inches) for September 2007 and October 2007

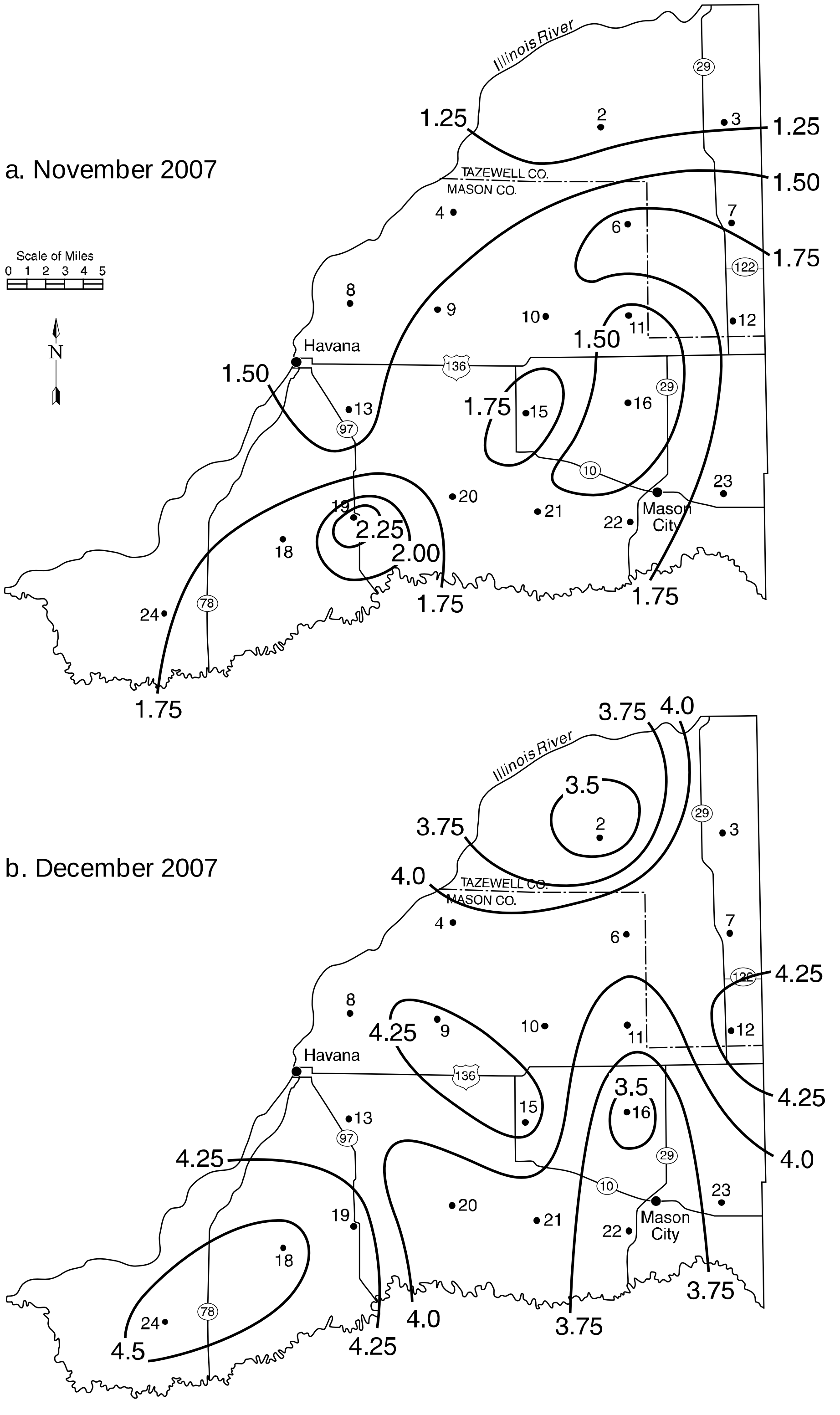
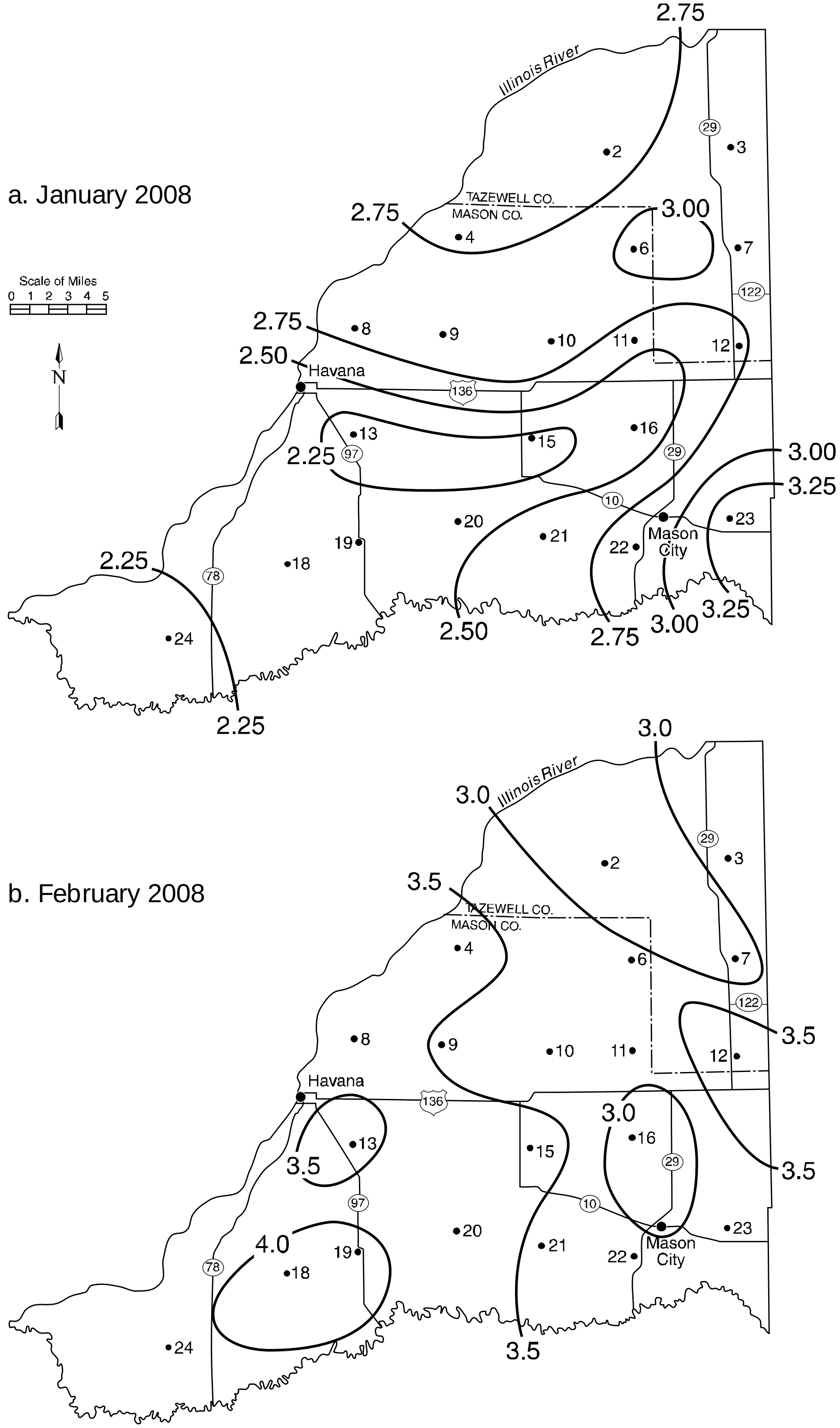


Figure 5. Precipitation (inches) for November 2007 and December 2007


a. January 2008

b. February 2008

Figure 6. Precipitation (inches) for January 2008 and February 2008

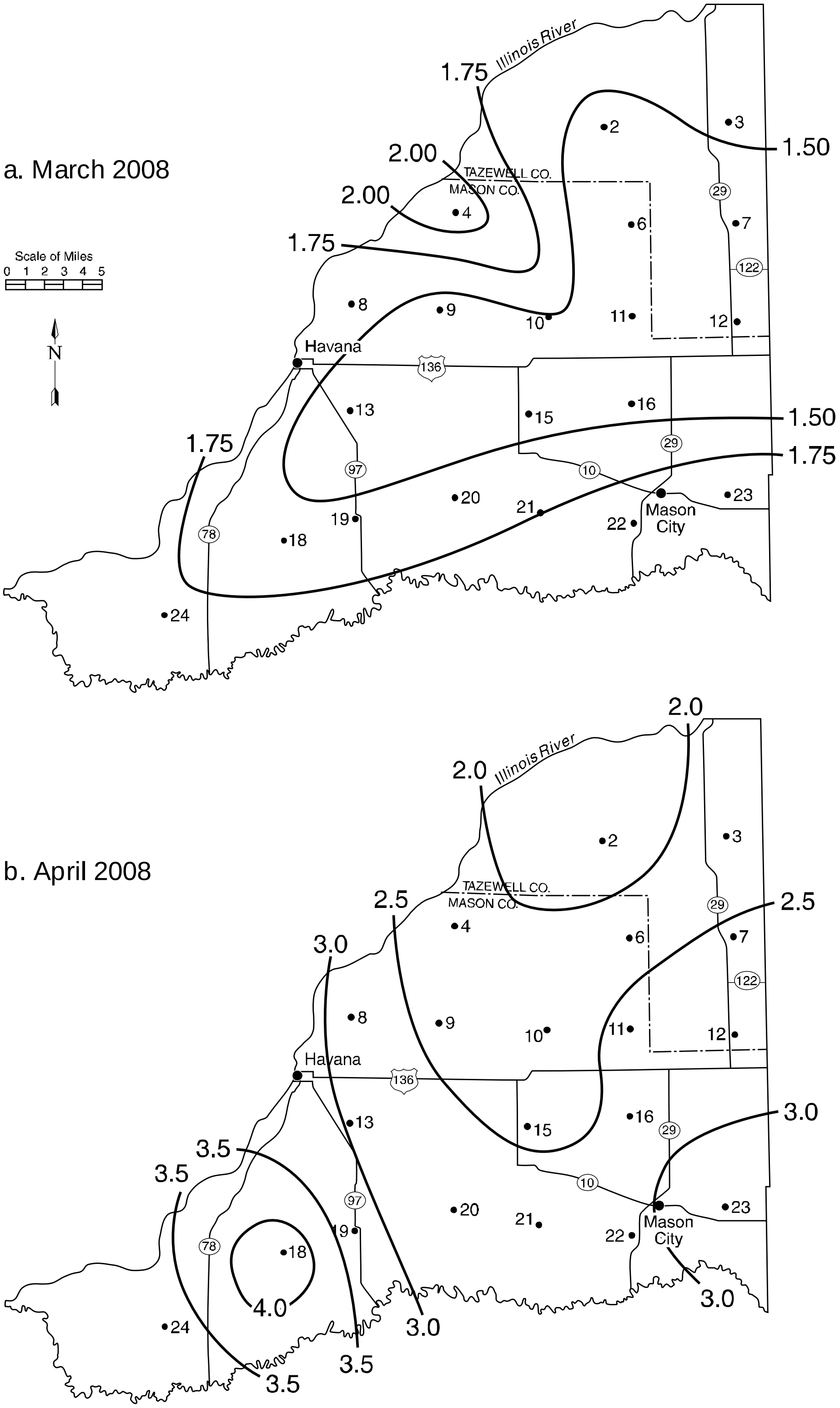
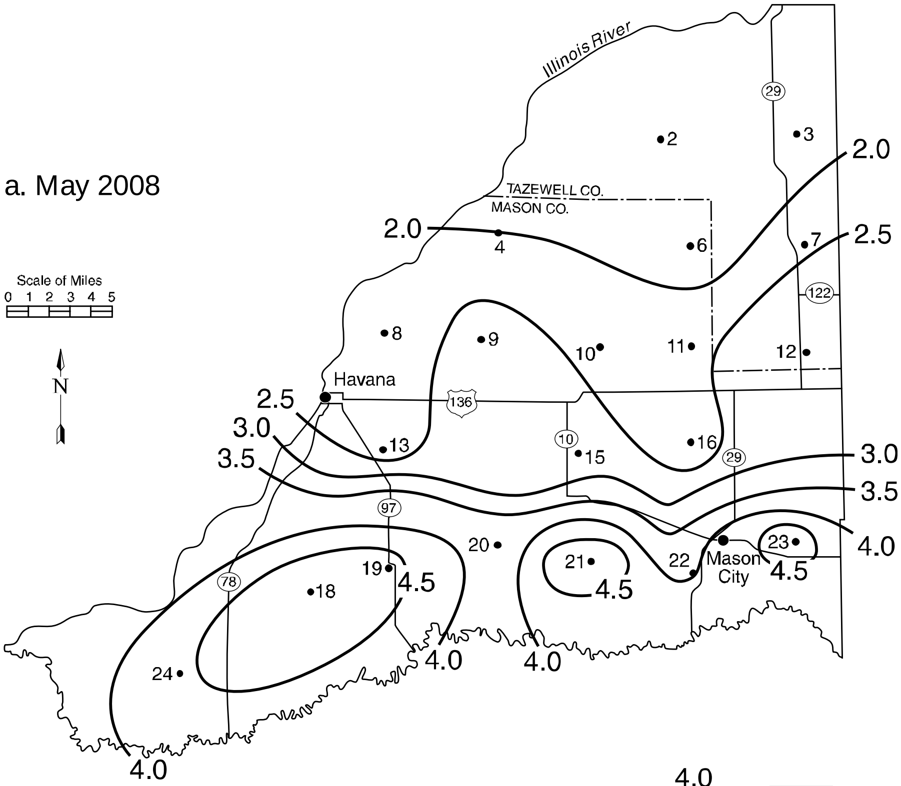


Figure 7. Precipitation (inches) for March 2008 and April 2008

a. May 2008



b. June 2008

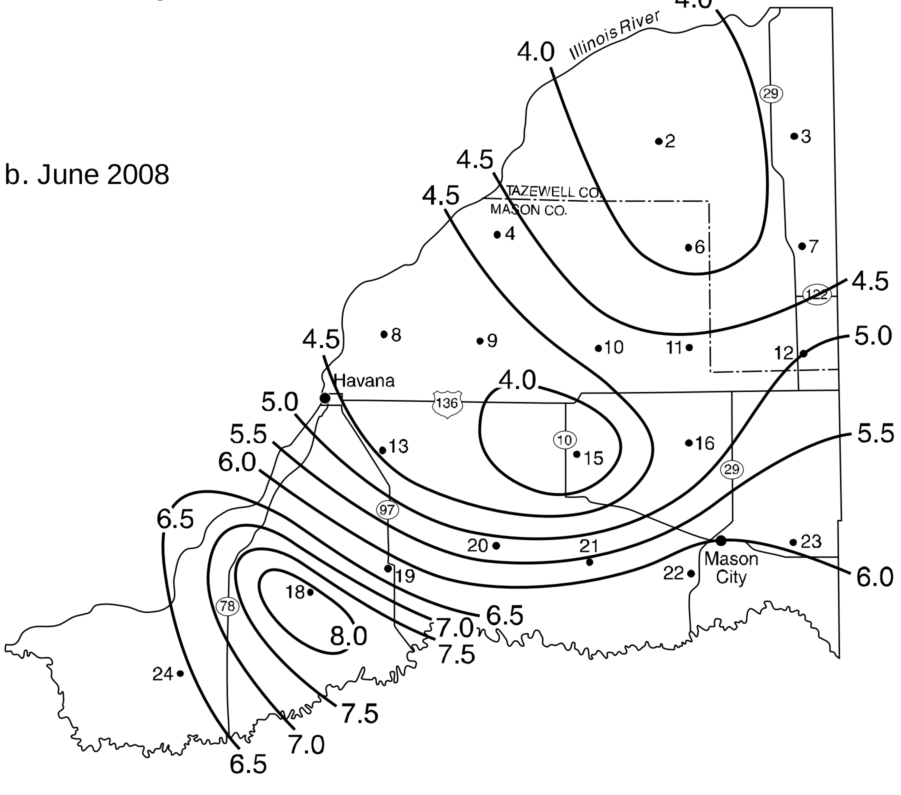
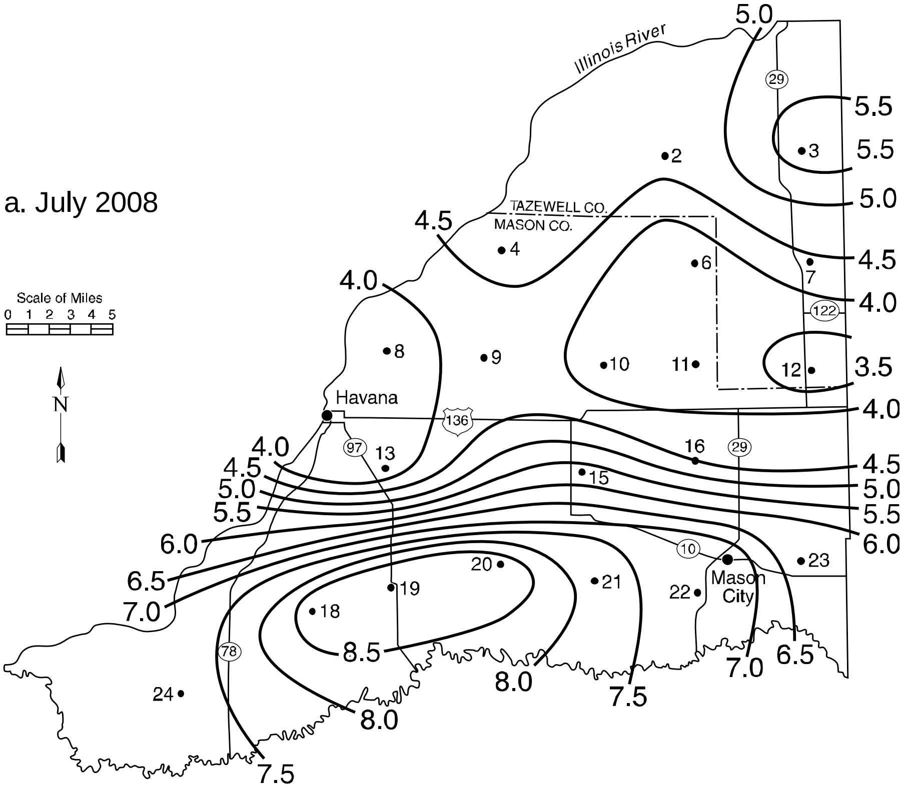
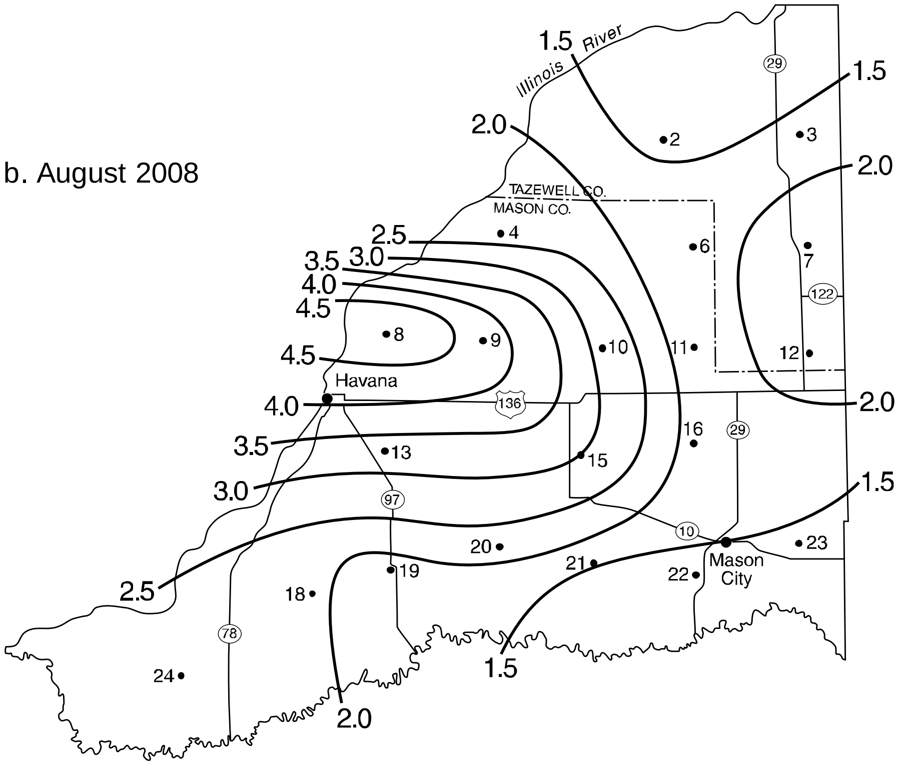


Figure 8. Precipitation (inches) for May 2008 and June 2008



a. July 2008



b. August 2008

Figure 9. Precipitation (inches) for July 2008 and August 2008

Table 2. Comparison of Total Precipitation (inches), Number of Precipitation Events, and Average Precipitation per Event for Each Month and Season, 1992-2007 and 2007-2008.

	1992-2007 15-yr average			*2007-2008 average*		
Period	*Precipitation*	*Events*	*Inches/event*	*Precipitation*	*Events*	*Inches/event*
Sep	2.60	7.1	0.37	0.80	11	0.07
Oct	2.42	9.0	0.27	2.30	5	0.46
Nov	2.82	9.6	0.29	1.62	6	0.27
Dec	1.46	8.3	0.18	4.08	19	0.21
Jan	2.21	9.7	0.23	2.65	8	0.33
Feb	1.57	7.7	0.20	3.44	8	0.43
Mar	2.22	8.7	0.25	1.56	8	0.20
Apr	3.39	10.8	0.31	2.76	12	0.23
May	4.17	14.1	0.30	3.00	11	0.27
Jun	3.75	11.7	0.32	5.02	16	0.31
Jul	3.71	10.7	0.35	5.52	13	0.42
Aug	3.40	12.9	0.26	2.27	8	0.28
Fall	7.84	25.7	0.31	4.72	22	0.21
Winter	5.23	25.7	0.20	10.17	35	0.29
Spring	9.79	33.6	0.29	7.32	31	0.24
Summer	10.86	35.3	0.31	12.81	37	0.35
Annual	33.71	120.2	0.28	35.02	125	0.28

During Year 16, there were 125 precipitation events. Fewer events than average occurred in October and November of 2007 and January, March, May and August of 2008. A greater number of events than average occurred in September and December of 2007 and February, April, June and July of 2008.

The plot of the network average monthly precipitation time series (Figure 10) shows the monthly variation of precipitation. From February 2005 through August 2007, a very dry period of record, only six months had precipitation of greater than 3.0 inches. During 2007-08, five months received 3.00 inches of precipitation or greater.

A total of 1928 storm periods occurred during the 16-year observation period, with 125 in 2007-08, resulting in an average of 120.5 storm events per year.

The network average precipitation is the arithmetic mean of the precipitation received at all network stations, while the storm average is the arithmetic mean of the precipitation received at stations reporting precipitation during the storm period. 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 based upon the total storm duration for the area.

In the first 15-years of network operation, 68 of the 1803 storm events produced maximum precipitation at one or more gages with a recurrence frequency greater than one year: 50-yr (1 storm), 10-year (4 storms), 5 year (8 storms), 2 year (34 storms), and greater than 1-year but less than 2-year (21 storms). The 50-year storm occurred on 13 September 1995, and the 10-year storms on 16 May 1995, 8 May 1996, 19 July 1997, and 30 March 2007. In Year 16, three of the 125 network storm periods exceeded the one-year or greater recurrence frequency. One event exceeded the 5-year recurrence frequency and occurred from 2-4 June 2008.

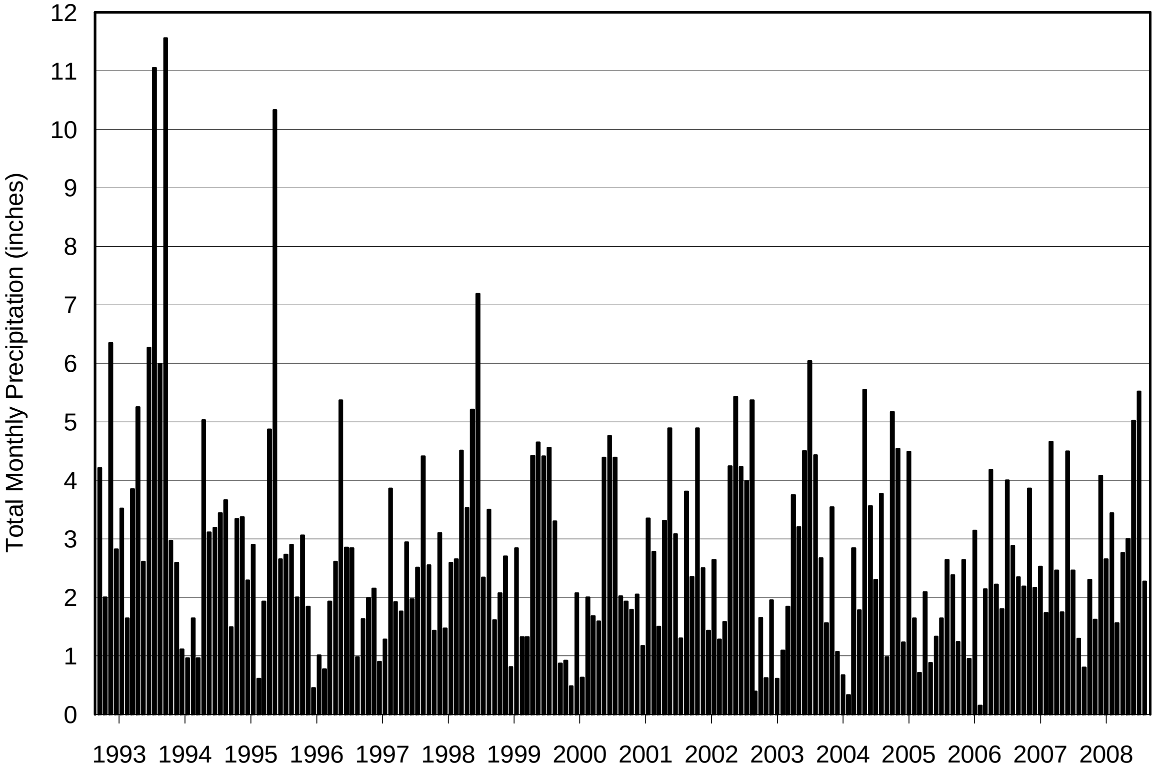


Figure 10. Network average monthly precipitation (inches), September 1992 - August 2008

Groundwater Levels

The long-term hydrograph at MTOW-1 (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 49-year record, both the record low and high have been observed within the last 15 years.

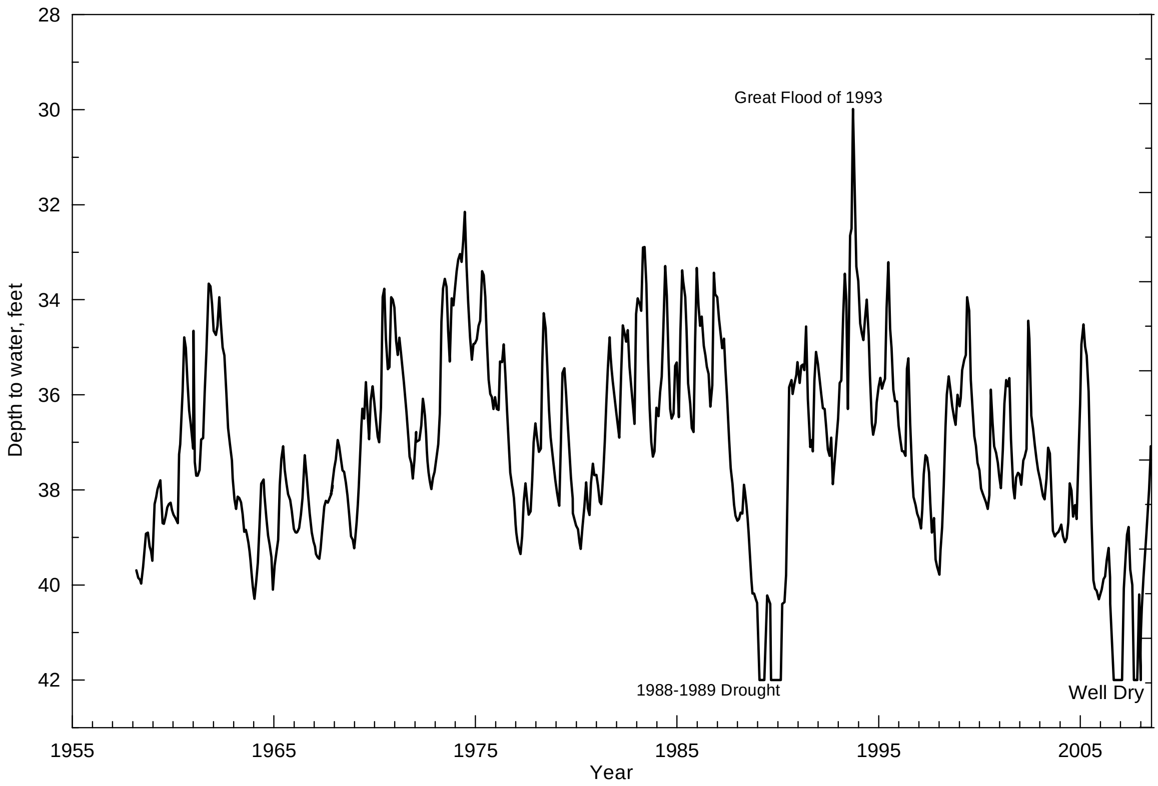


Figure 11. Groundwater levels at the Snicarte well, MTOW-01, 1958-2008.

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. During the 1993 flood, groundwater levels rose almost 10 feet and peaked at approximately 30 feet in September 1993.

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, 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 temps were so high in 1988. Similarly, the irrigation amounts in 2005 (72 billion gallons) were 164 percent of average since 1995 and we see similar dramatic declines in water levels. Again in 2005, temps were high and summer precip was low. It is likely that local summer precip in future years will cause similar declines in aquifer levels.

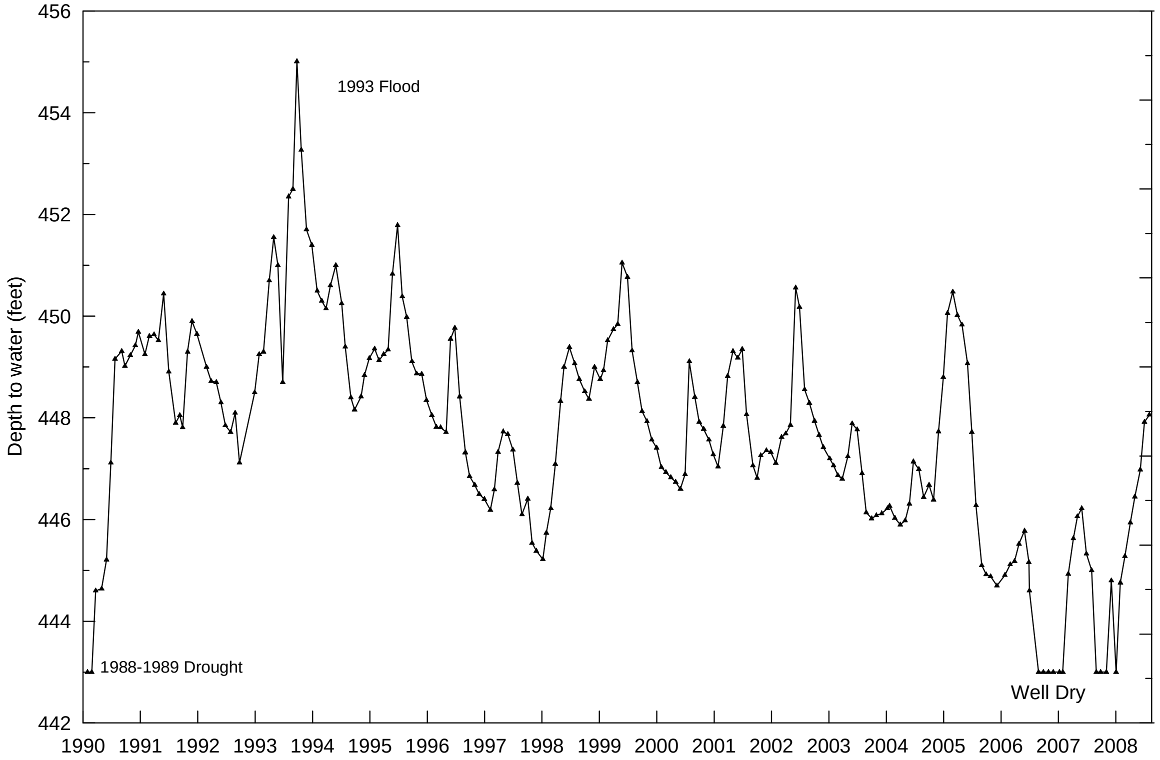


Figure 12. Groundwater levels at the Snicarte well, MTOW-01, 1990-2008.

Groundwater levels in observation wells MTOW-5 and MTOW-9, 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.

Over the course of the last few years, the study area has received below average rainfall. These below average precipitation totals in combination with irrigation withdrawals have affected the groundwater elevations in the study area. This began in March 2005, when rainfall amounts fell below average and have continued overall since that time until this year. Year Sixteen seems to have offered some relief as groundwater elevations are approaching the March 2005 levels.

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 Sixteen, several rainfall events at the Easton Well (MTOW-2) are very evident as recharge as shown in Figures 13 - 15. The two separate rainfall events during early February on Figure 14 produced nearly two feet of recharge within approximately ten days. Other recharge events throughout this project year produce similar results. Recharge was not expected to be as pronounced during the irrigation season, when water use is high. The rainfall events of June 2008 show this was not always the case. In Figure 15, the nearly 2-inch rainfall event on June 3, 2008, produced close to 3 feet of recharge. Two similar rainfall events in June of 2007 (Figure 16), each about 2 inches of rainfall and only 5 days apart, produced about a foot of rise in the aquifer. It is likely the end of May rainfall in 2008 contributed to higher soil moisture for the June 3, 2008 event, resulting in more recharge and less water lost in the vadose zone. The June 2007 events came after nearly three weeks of dry weather, so the vadose zone was able to hold much more precip, limiting recharge.

Along with Easton, hydrographs showing continuous water levels and daily rain gauge data are available for the remaining monitoring wells in Appendix A. And while the hydrographs showing the recharge following precipitation for these wells are not as dramatic as at Easton, in general, the information they provide is just as vital. The recent addition of continuous measurement of water levels has already led to increased understanding of the relationship between rainfall, irrigation, water levels, and recharge.

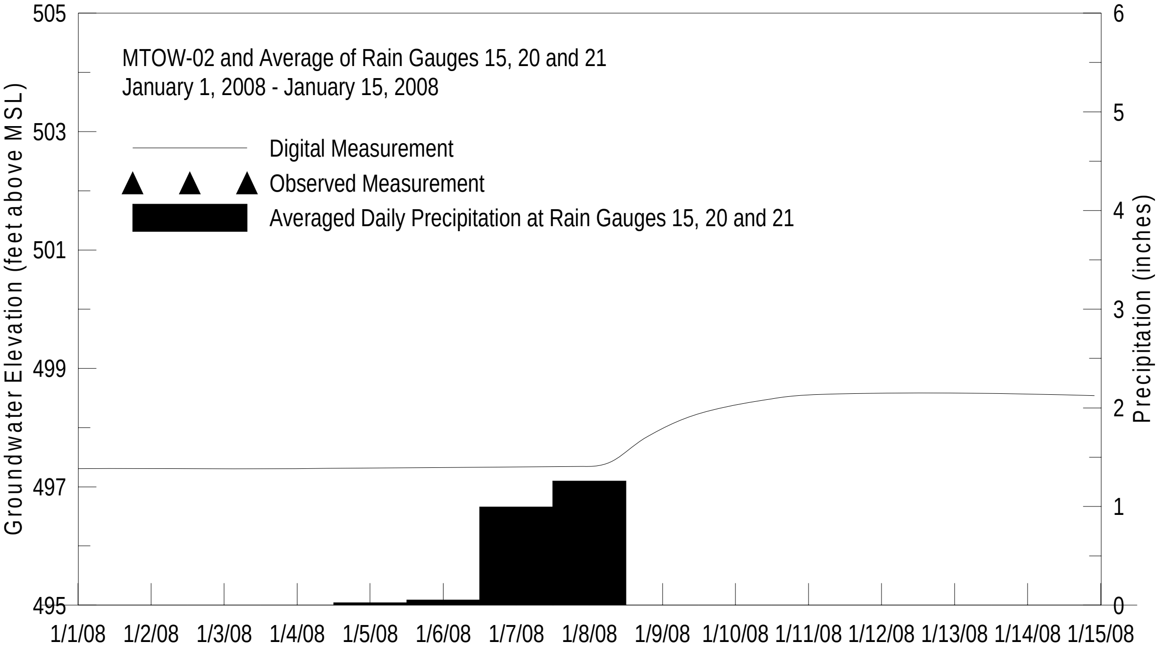


Figure 13. Groundwater elevations at the Easton well, MTOW-02,
January 1, 2008-January 15, 2008.

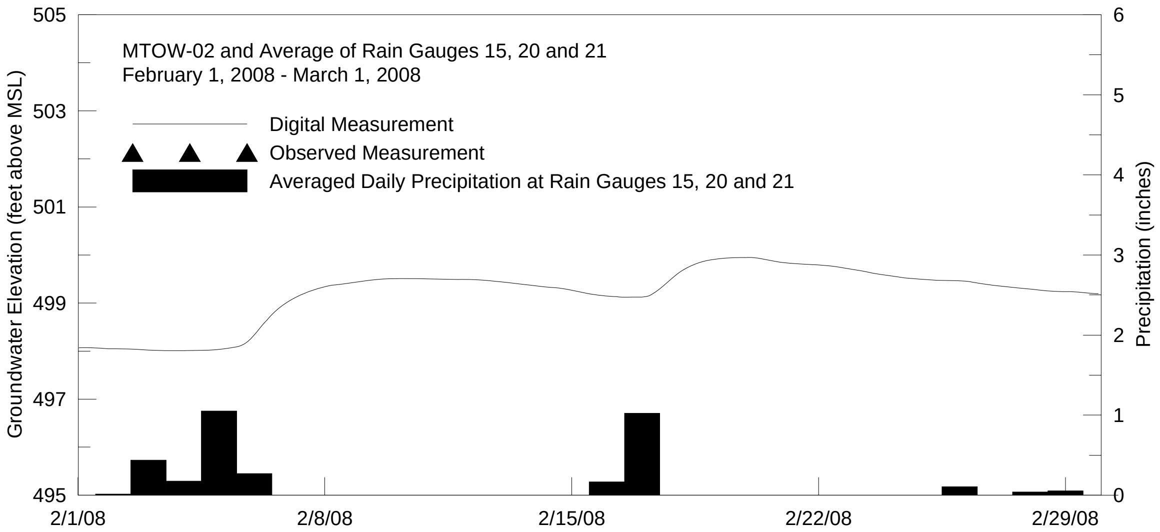


Figure 14. Groundwater elevations at the Easton well, MTOW-02, February 1, 2008-March 1, 2008.

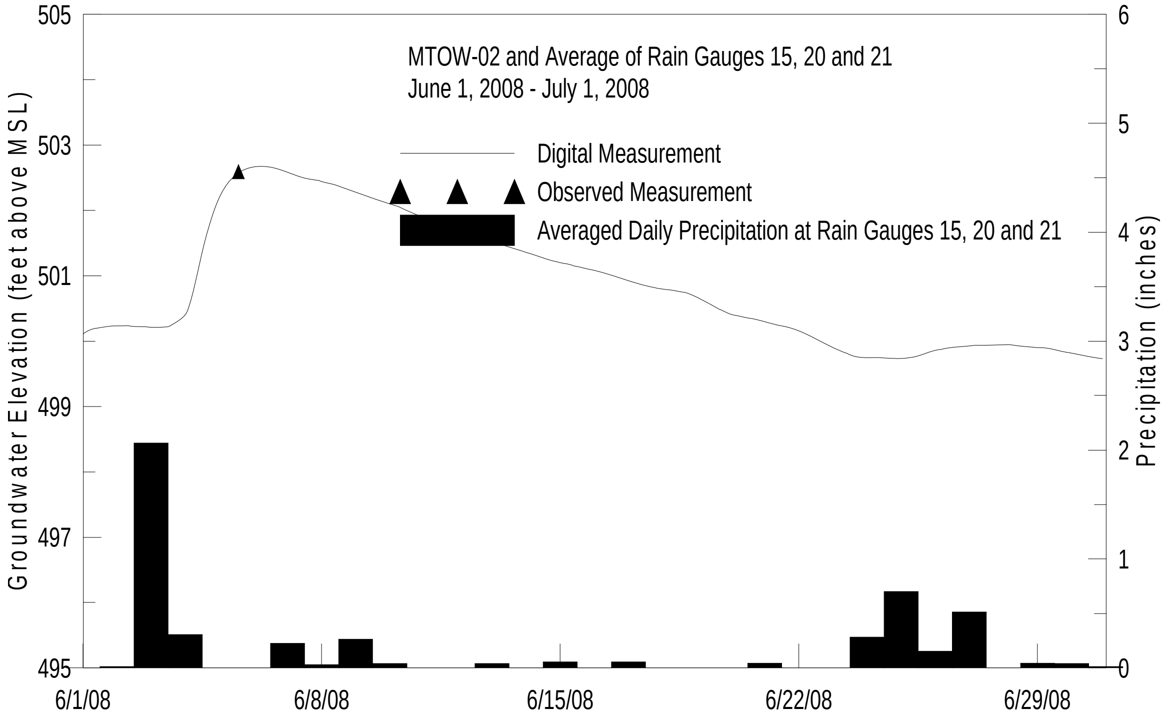


Figure 15. Groundwater elevations at the Easton well, MTOW-02, June 1, 2008-July 1, 2008.

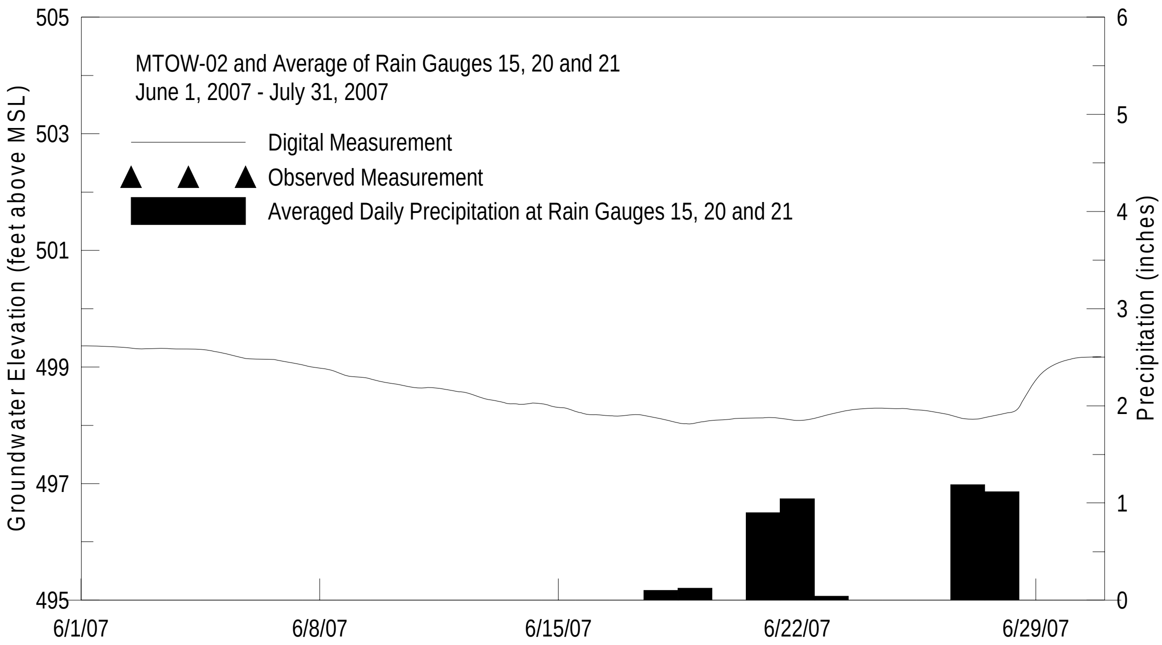


Figure 16. Groundwater elevations at the Easton well, MTOW-02,
June 1, 2007- July 1, 2007.

Irrigation Water Use

For Year Sixteen, the higher than normal precipitation early in the summer of 2008 affected irrigation practices significantly. Irrigation in June was the lowest June for the length of the study and July was the third lowest on record. The total irrigation pumpage in 2008 was approximately 33 billion gallons (bg), which is the third lowest irrigation amount, ahead only of the approximately 30 bg pumped in 1998 and 2000, when there were several hundred fewer irrigation systems in use.

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; and 1998 and 2000 (equal). 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.

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. Similarily, Year Fifteen (summer 2007) was the ninth driest of network operation, but ranked no. 2 for irrigation pumpage.

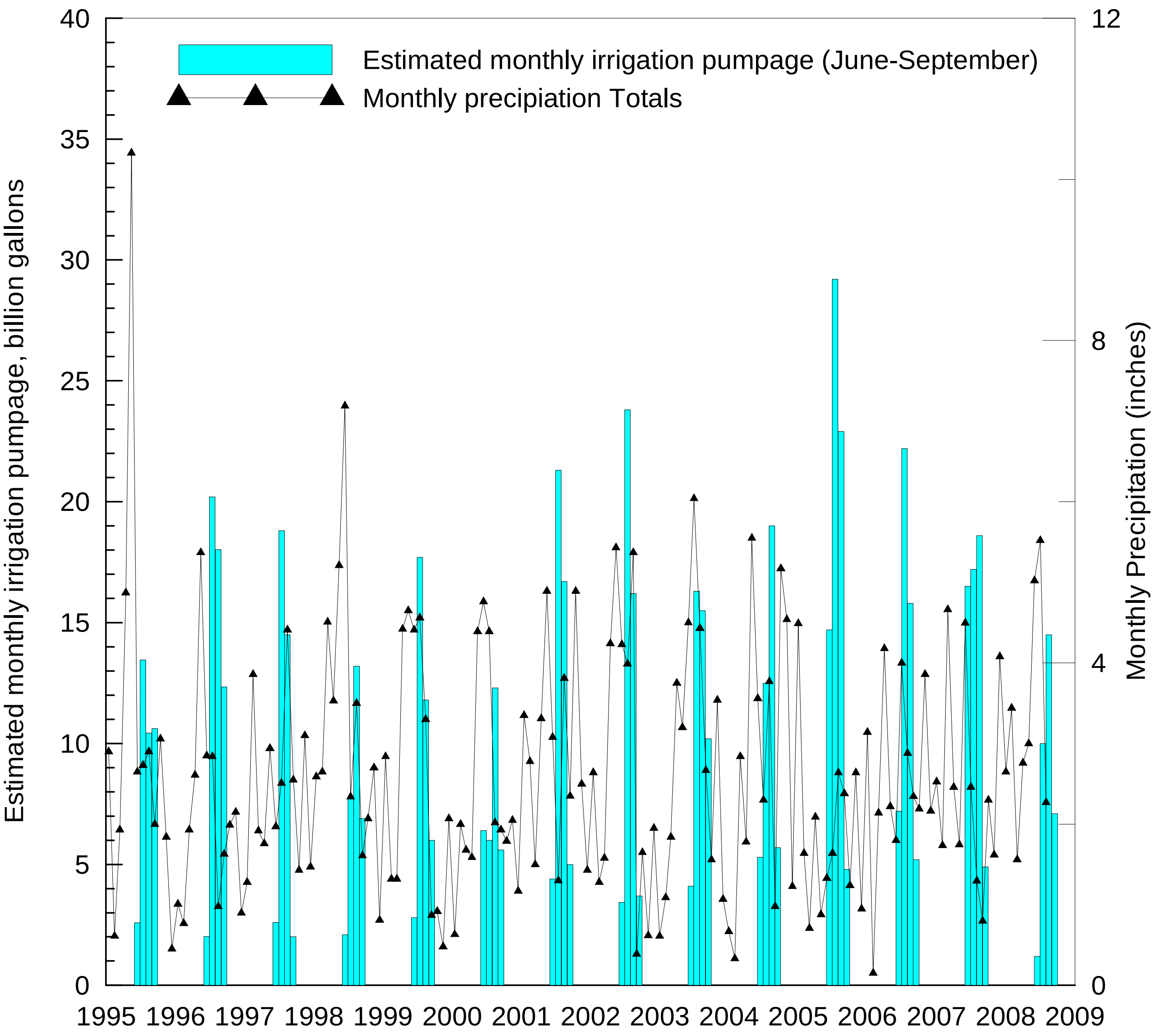


Figure 17. Estimated irrigation pumpage and average monthly precipitation, Imperial Valley

Note: Rain gauge 16 was excluded from network average precipitation computations from 1996-1997 through 2001-2002.

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

Year	*June*	*July*	*August*	*September*	*Total*	*# Systems*	*BG/system*	*Rank*
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
Average	5.4	16.8	15.6	6.4	44			

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.

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

September-August period	*Network average precipitation (in.)*	*Annual surplus (in.)*	*Running surplus (in.)*	*Rank*	
				Precip.	*Irrigation*
1992 - 1993	55.55	+18.79	+18.79	1	-
1993 - 1994	40.21	+3.45	+22.24	2	-
1994 - 1995	39.42	+2.66	+24.90	5	10
1995 - 1996	25.70	-11.06	+13.84	16	3
1996 - 1997	27.31	-9.45	+4.39	14	10
1997 - 1998	40.06	+3.30	+7.69	3	13
1998 - 1999	34.02	-2.74	+4.95	7	9
1999 - 2000	25.81	-10.95	-6.00	15	13
2000 - 2001	30.97	-5.79	-11.79	9	5
2001 - 2002	39.91	+3.15	-8.64	4	5
2002 - 2003	30.06	-6.70	-15.34	10	7
2003 - 2004	29.64	-7.12	-22.46	11	8
2004 - 2005	27.34	-9.42	-31.88	13	1
2005 - 2006	27.74	-9.02	-40.90	12	4
2006 - 2007	31.94	-4.82	-45.72	8	2
2007 - 2008	35.02	-1.74	-47.46	6	12
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.

The influence of the reduced rainfall is evident in both the increased amount of water withdrawn for irrigation and in lower groundwater levels throughout the study area. Table 4 also shows that for the last 6 years and for 11 of the last 13 years, rainfall has been below the 30-year (1971-2000) historical average of 36.76 inches (average of Havana and Mason City). But, because the timing of rainfall during the growing season has the most impact on the amount of irrigation withdrawals, Year 16 was the 3rd lowest irrigation withdrawal.

In summary, for Year Sixteen of the rain gauge network operation (September 2007-August 2008), the network received an average of 35.02 inches of precipitation, 1.31 inches more than the network previous 15-year average precipitation of 33.77 inches. This was 1.74 inches less than the 30-year average for the study area, however.

The timing of rainfall was such that the need for irrigation in the summer of 2008 was greatly reduced. This lower pumpage in the aquifer for irrigation, along with only slightly below long-term normal precipitation, provided an opportunity to recharge the aquifer system significantly. In fact, the ISWS carried out two synoptic measurements of water levels in 2008, once in the spring before irrigation started, and once again in the fall after irrigation had ended. Instead of seeing a decline in water levels, as would be expected after a summer of irrigation, water levels in the fall were actually higher than they had been in the spring. This likely occurred because of significant summer rainfall coupled with reduced withdrawal for irrigation.

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 or Steve Wilson if you have any questions or comments.

Sincerely,

Kevin L. Rennels	***Steven D. Wilson***
Kevin L. Rennels	Steven D. Wilson
Associate Supportive Scientist	Groundwater Hydrologist
Illinois State Water Survey	Illinois State Water Survey
krennels@uiuc.edu	sdwilson@uiuc.edu
Phone: (217) 333-8466	Phone: (217) 333-0956

c: Dorland Smith
Wayne Deppert
Don Osborn, Jr.

Appendix A. Hydrographs, Imperial Valley Observation Well Network

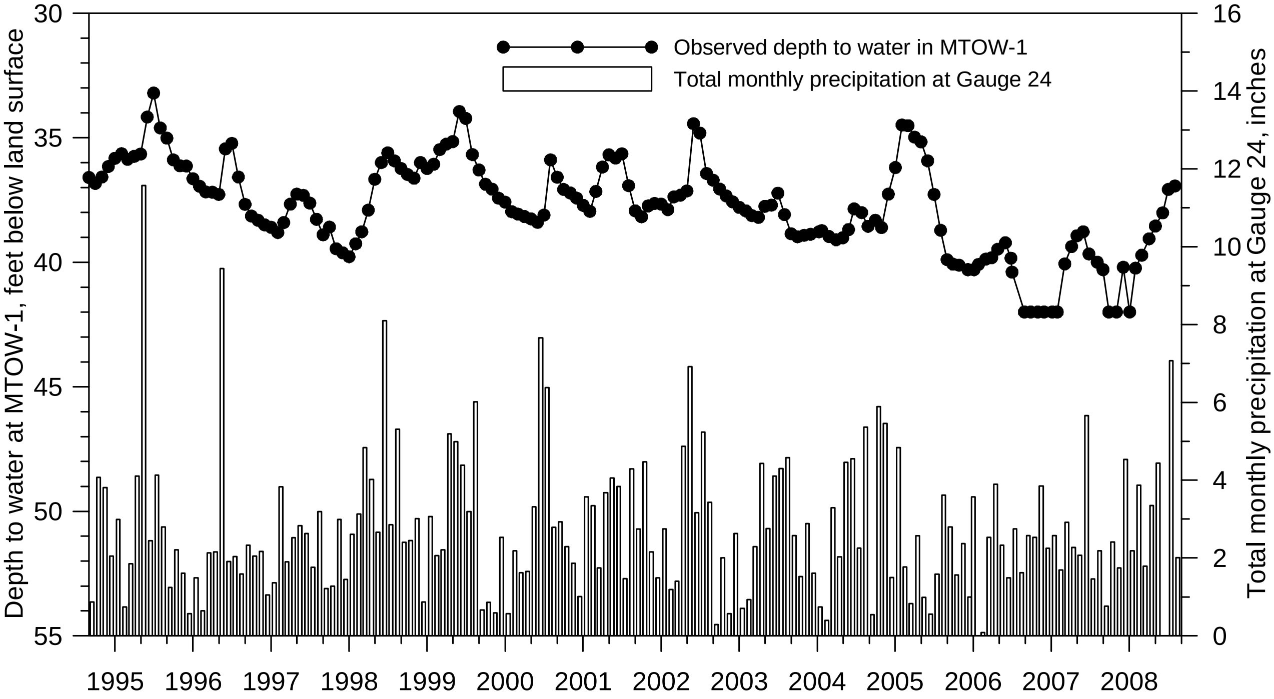


Figure A-1. Groundwater depth and precipitation for MTOW-01

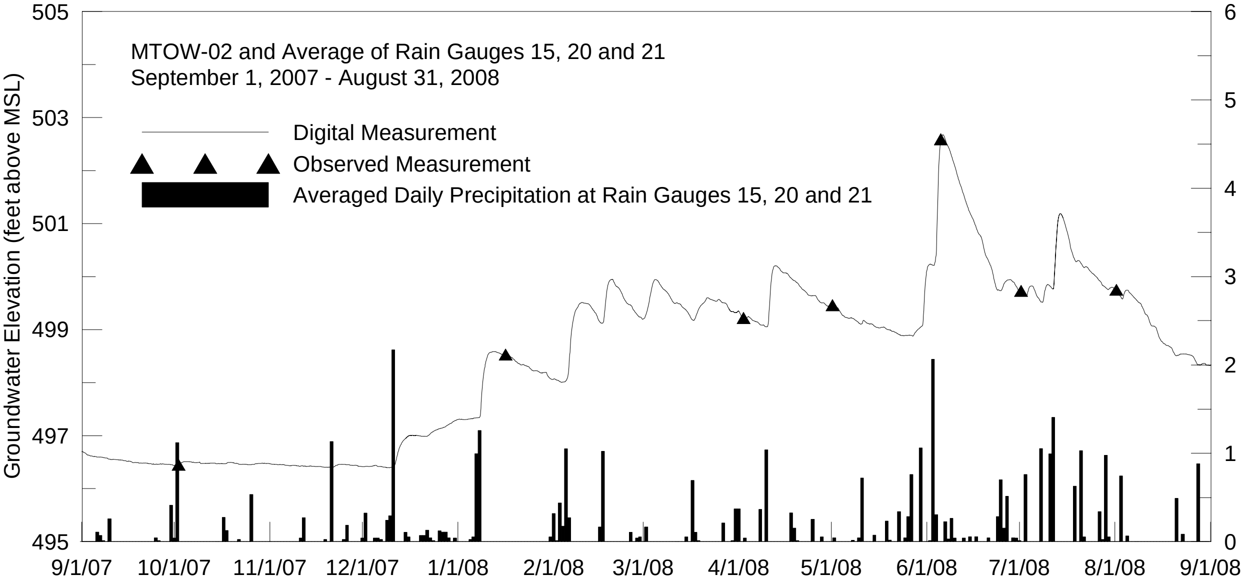


Figure A-2. Groundwater depth and precipitation for MTOW-02

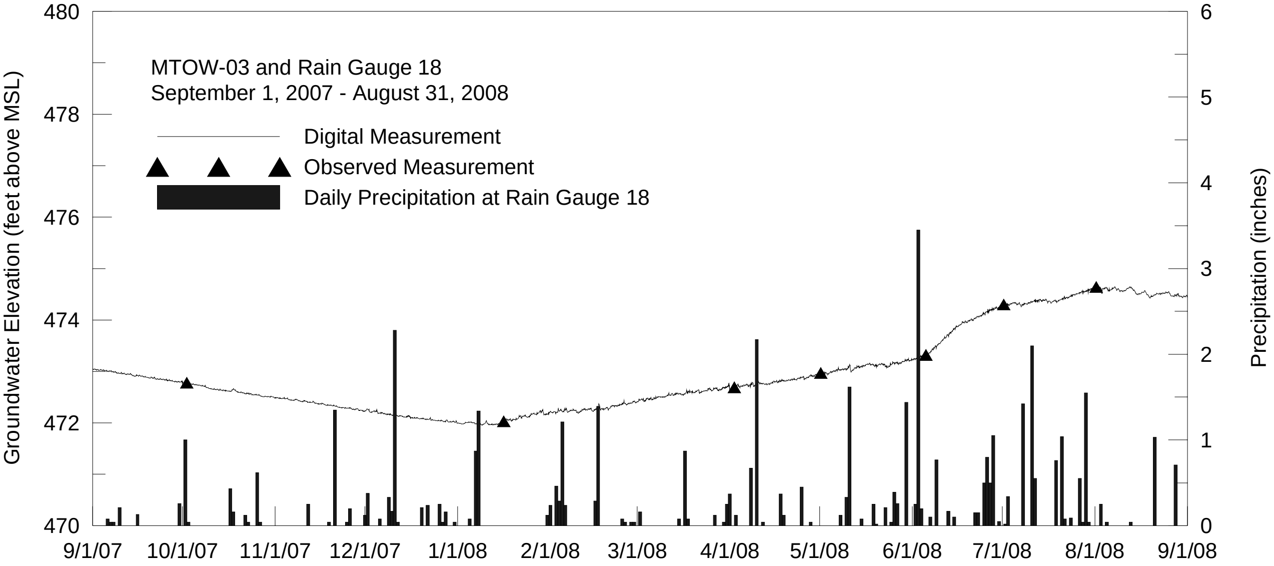


Figure A-3. Groundwater depth and precipitation for MTOW-03

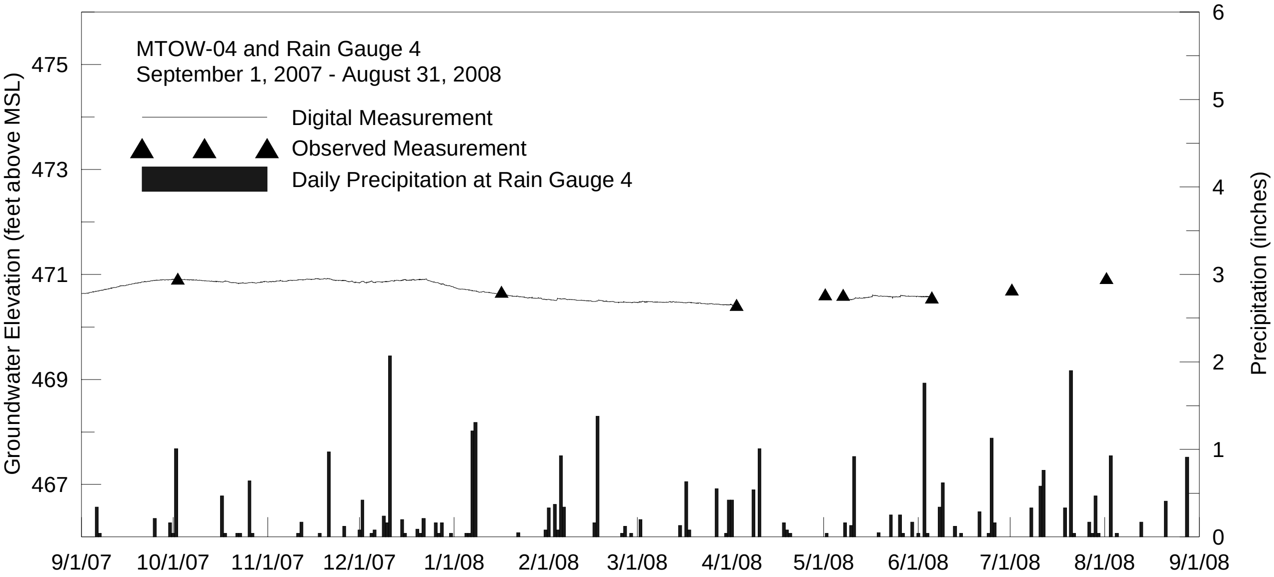


Figure A-4. Groundwater elevation and precipitation for MTOW-04

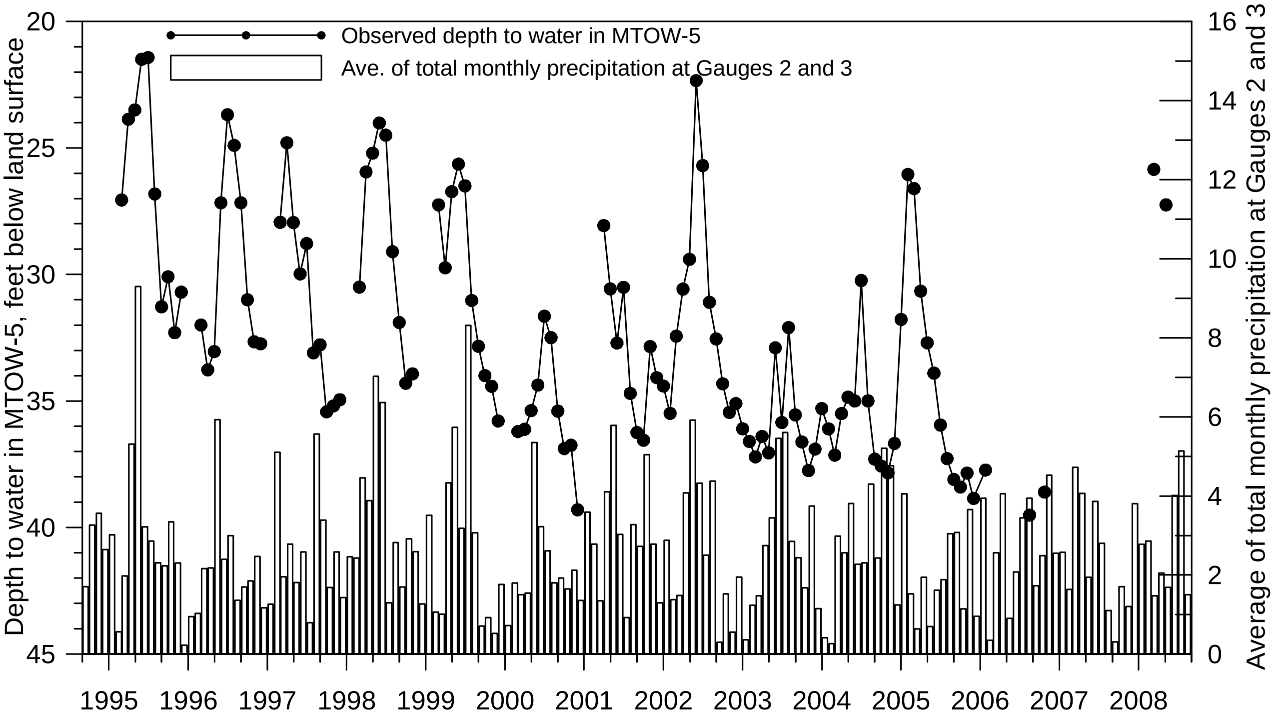


Figure A-5. Groundwater depth and precipitation for MTOW-05

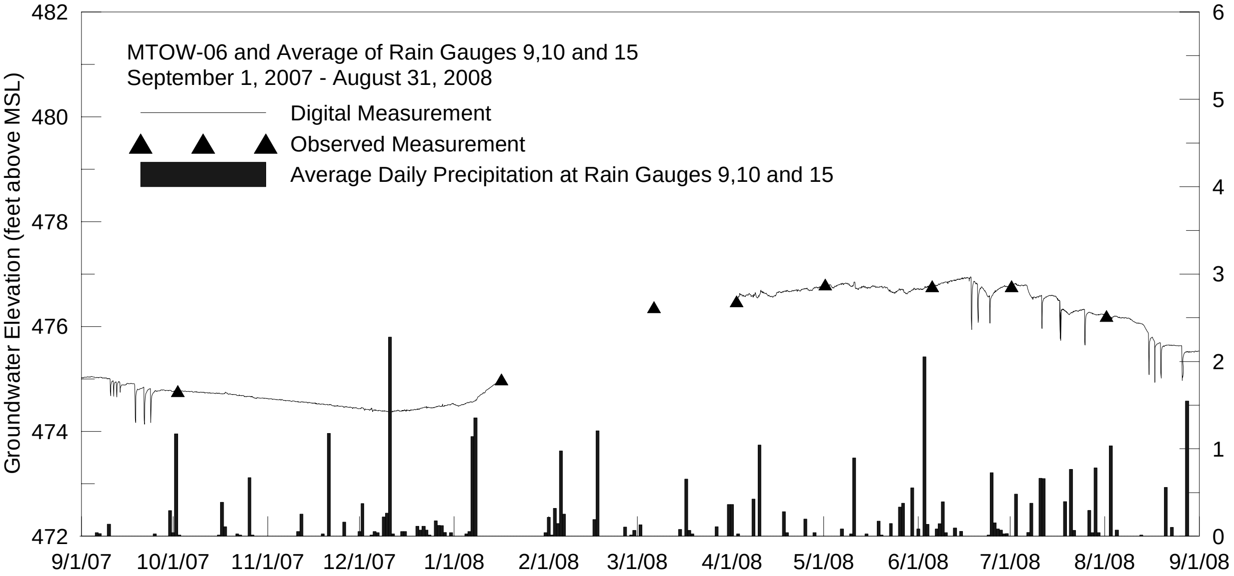


Figure A-6. Groundwater elevation and precipitation for MTOW-06

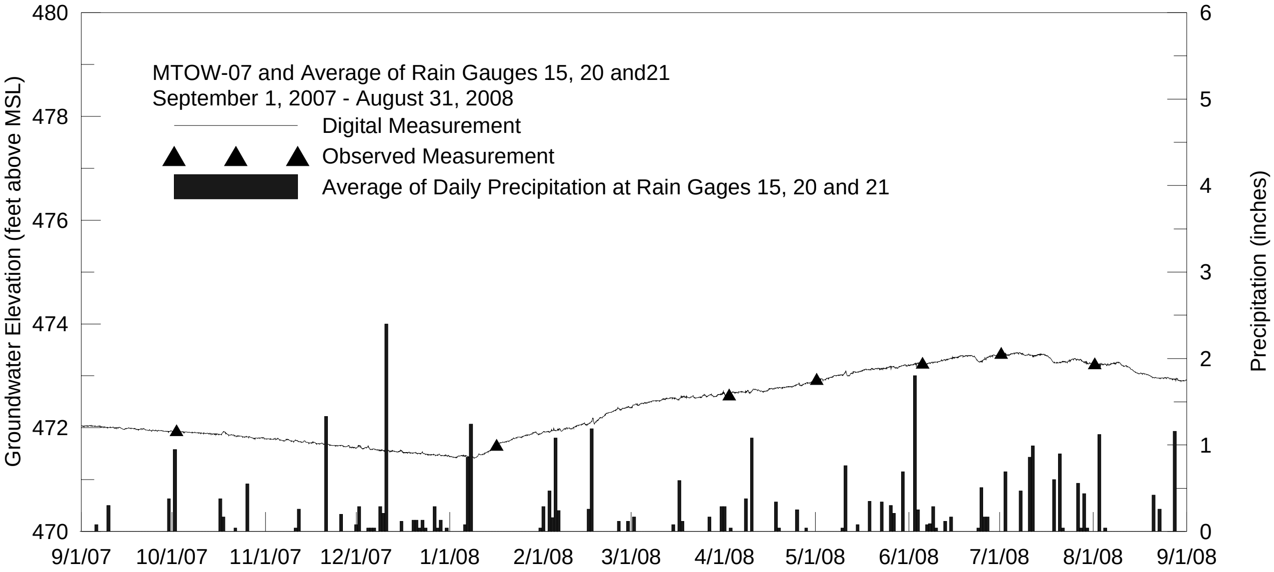


Figure A-7. Groundwater elevation and precipitation for MTOW-07

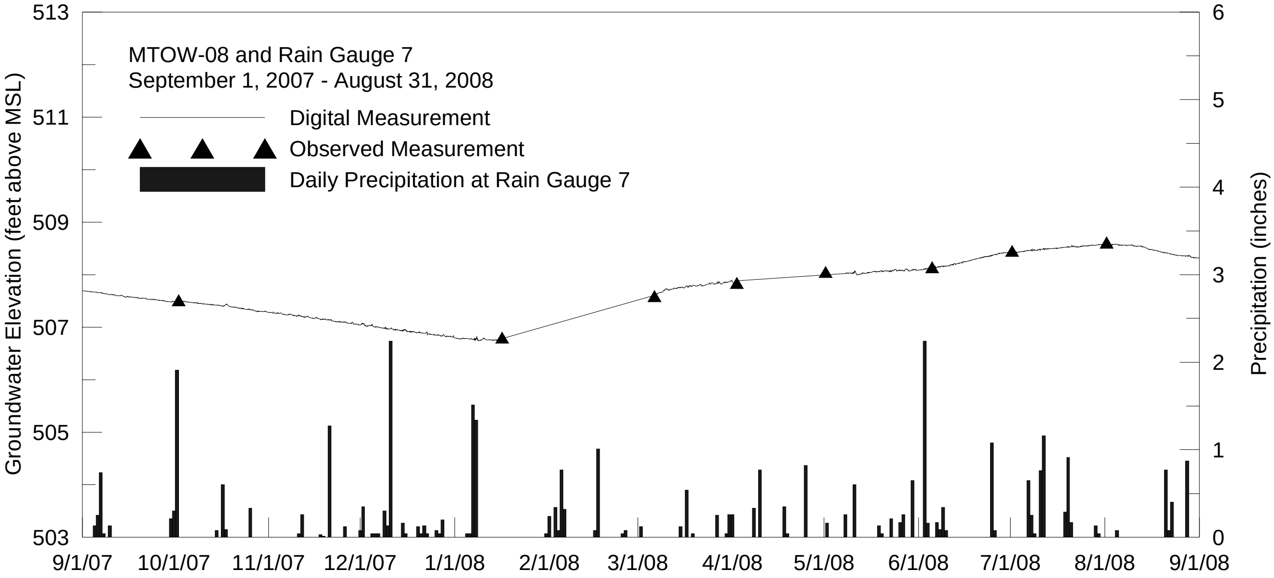


Figure A-8. Groundwater elevation and precipitation for MTOW-08

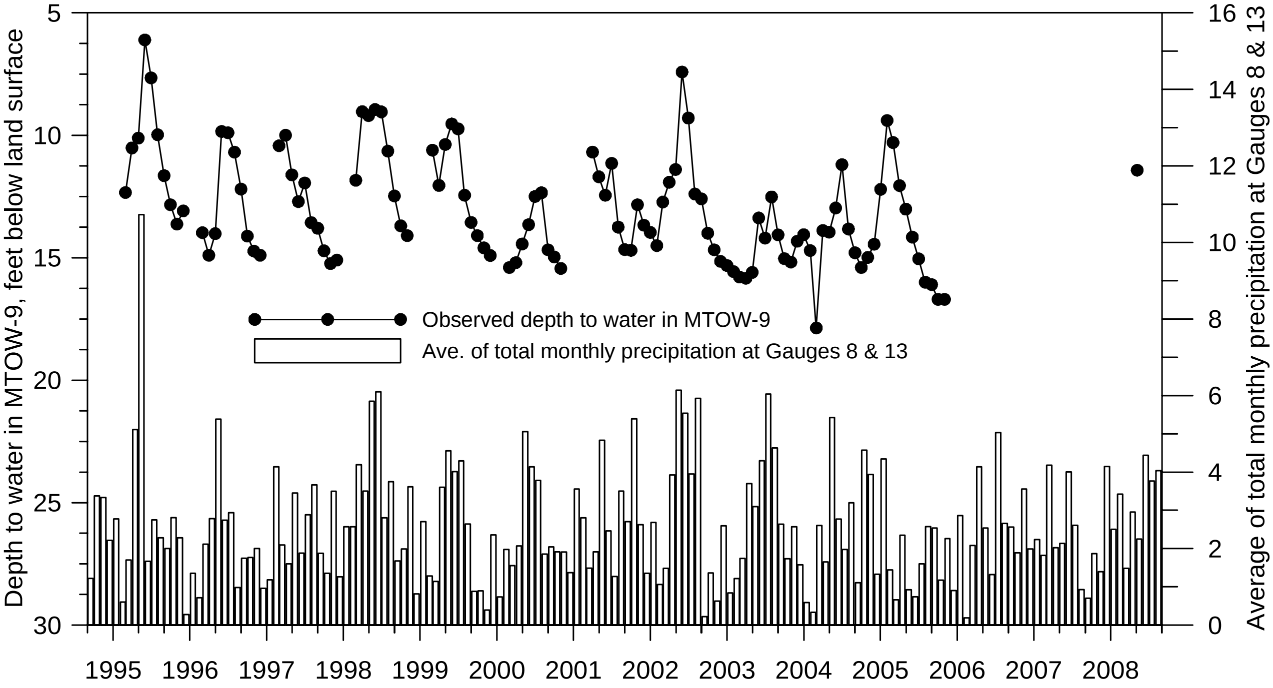


Figure A-9. Groundwater depth and precipitation for MTOW-09

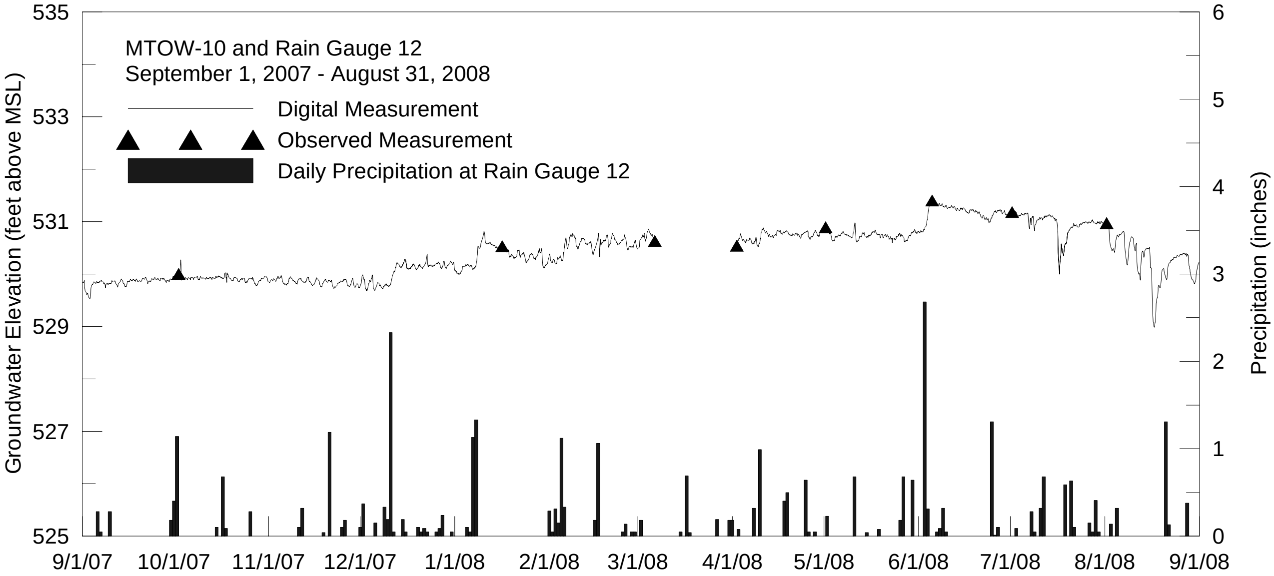


Figure A-10. Groundwater depth and precipitation for MTOW-10

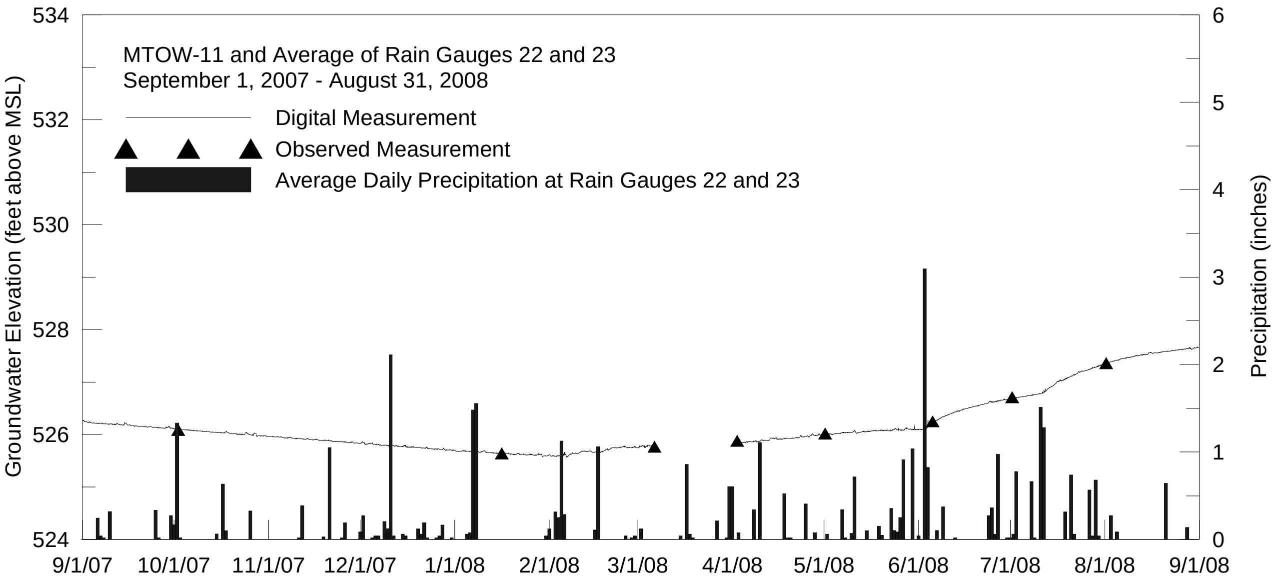


Figure A-11. Groundwater elevation and precipitation for MTOW-11

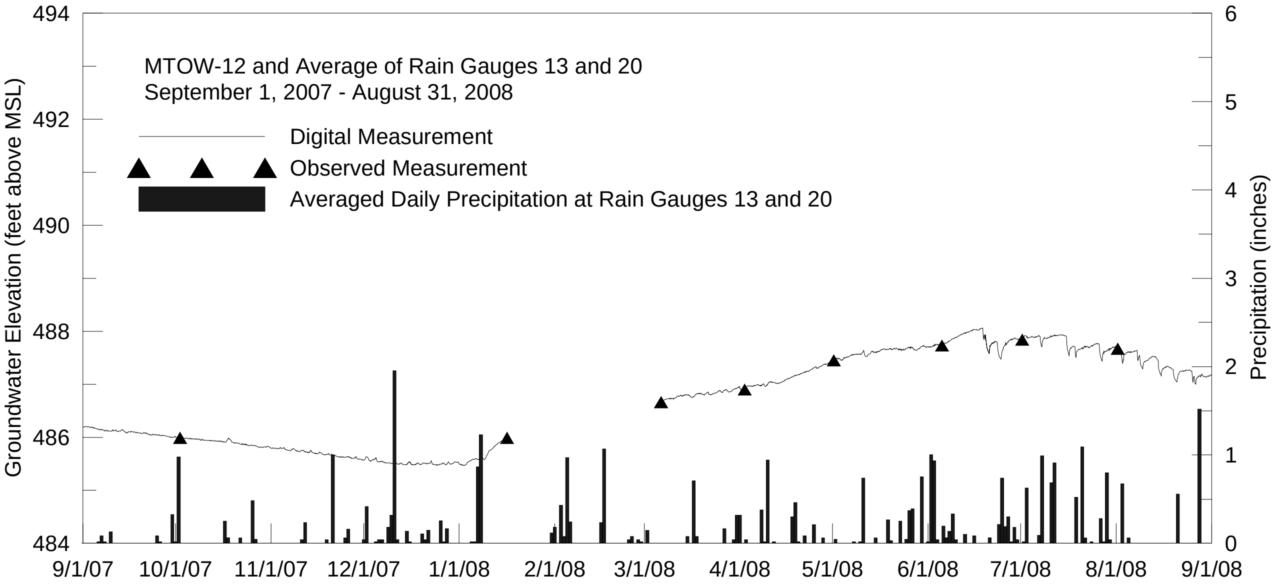


Figure A-12. Groundwater elevation and precipitation for MTOW-12

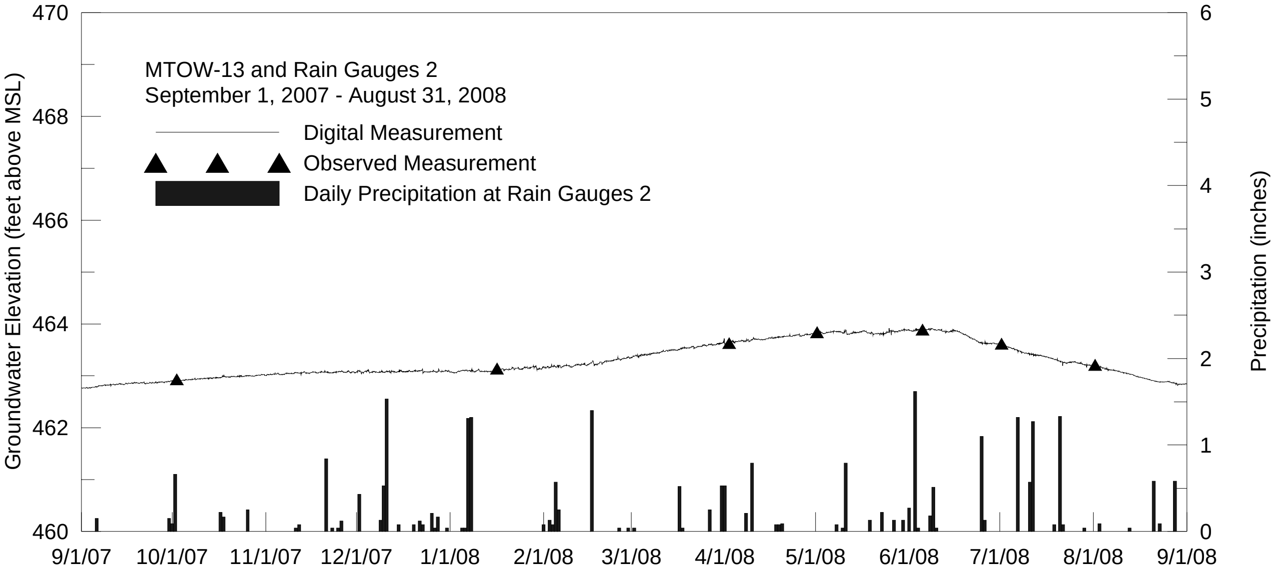


Figure A-13. Groundwater depth and precipitation for MTOW-13