Appendix A

Well specifications and supplemental groundwater level, drawdown, and production hydrographs

Table A.1 Specifications for Wells Utilized in Groundwater Analyses, Section 1.

Basin_name	Well	Well Type	Agency	UTM E 11N NAD83 (m)	UTM N 11N NAD83 (m)	MP Elev NAVD88 (ft)	Completion Unit *1	Perforations (ft bgs)	Frequency WL Monitoring	Record
Lower Meadow Valley Wash	MVWD MW-1	Monitoring	MVWD	707,906	4,087,860	1992.16	F	144 - 200	Monthly	Monthly: Aug-10 - Dec-12
Coyote Spring V	CE-VF-2	Monitoring	SNWA	683,007	4,082,892	2468.35	C	---	Continuous	Intermittent: 8/13/98 - 10/1/04 Daily: 8/13/03 - 12/11/12
Coyote Spring V	CSVM-1	Monitoring	SNWA	688,602	4,073,793	2160.6	F	320 - 1020	Continuous	Intermittent: 3/20/03 - 5/28/03 Daily: 7/10/03 - 12/13/12
Coyote Spring V	CSVM-2	Monitoring	SNWA	685,625	4,059,370	2572.74	C	720 - 1380	Continuous	Intermittent: 3/5/03 - 7/23/03 Daily: 10/14/04 - 12/11/12
Coyote Spring V	CSVM-3	Monitoring	SNWA	679,319	4,102,600	2650.68	C	380 - 1180	Continuous	Intermittent: 7/15/03 - 7/23/03 Daily: 8/14/03 - 12/11/12
Coyote Spring V	CSVM-4	Monitoring	SNWA	688,086	4,095,971	2842.38	C	800 - 1580	Continuous	Intermittent: 7/10/03 Daily: 8/13/03 - 12/11/12
Coyote Spring V	CSVM-5	Monitoring	SNWA	680,295	4,068,774	3130.70	C	1020 - 1760	Continuous	Intermittent: 2/18/03 - 7/10/03 Daily: 8/13/03 - 12/11/12
Coyote Spring V	CSVM-6	Monitoring	SNWA	686,453	4,078,333	2251.66	C	420 - 1160	Continuous	Intermittent: 3/28/03 - 7/15/03 Daily: 7/23/03 - 12/13/12
Coyote Spring V	MX-4	Monitoring	SNWA/USGS	688,003	4,074,277	2174.98 (NWIS); 2177.02 (SNWA)	C	50 - 669	Continuous	Intermittent: 10/16/98 - 12/10/12
Coyote Spring V	CSI-1	Production	CSI (reported by SNWA)	686,043	4,074,459	2278.05	C	520 - 880	Continuous	Monthly: Jan-05 - Dec12 Daily: 1/1/10 - 12/31/12
Coyote Spring V	CSI-2	Production	CSI (reported by SNWA)	687,083	4,075,781	2208.95	C	525 - 1006	Continuous	Monthly: Jan-05 - Dec12 Daily: 1/1/10 - 12/31/12
Coyote Spring V	CSI-3	Production	CSI (reported by SNWA)	685,813	4,077,531	2334.51	C	571 - 1132	Monthly/Cont.	Monthly: Jan-06 - Dec12 Daily: 1/1/10 - 12/31/12
Coyote Spring V	CSI-4	Production	CSI (reported by SNWA)	682,366	4,080,185	2511.40	C	844 - 1373	Monthly/Cont.	Monthly: Jan-06 - Dec12 Daily: 1/1/10 - 12/31/12
Coyote Spring V	RW2	Production	NV Energy	687,862	4,074,082	2200.06	C	460 - 700	Continuous	Monthly: Jan-10 - Dec12 Daily: 8/1/10 - 12/31/12
Coyote Spring V	MX-5	Production	SNWA	688,084	4,074,219	2176.13	C	121 - 628	Continuous	Monthly: Apr-08 - Dec12 Daily: 1/1/10 - 12/31/12
Black Mountains Area	BM-ONCO-1	Monitoring	SNWA	702,650	4,010,748	2055.83	Clastic	440 - 1280	Quarterly	Intermittent: 5/21/02 - 11/19/12
Black Mountains Area	EBP-2	Production	NV Cogen.	689,628	4,018,599		C	755 - 1241	Monthly	Monthly: Jan-00 - Dec-12
Black Mountains Area	EGV-3	Production	NV Cogen.	689,858	4,018,999		C	702 - 955	Monthly	Monthly: Jan-00 - Dec-12
Black Mountains Area	EBM-4	Production	NV Cogen.	689,784	4,018,826		C	608 - 1129	Monthly	Monthly: Jan-00 - Dec-12

Garnet V	GV-1	Monitoring	SNWA	682,983	4,034,143	2691.14	C	1040 - 1380	Continuous	Intermittent: 6/18/02 - 11/07/02 Daily: 12/14/02 - 12/13/12
Garnet V	GV-DUKE-WS1	Production	NV Energy	686,197	4,029,178	2243.50	C	537 - 685	Monthly	Monthly: Jan-02 - Dec-12 Daily: 8/1/10 - 12/31/12
Garnet V	GV-DUKE-WS2	Production	NV Energy	686,185	4,029,177	2246.72	C	877 - 1944	Monthly	Monthly: Jan-02 - Dec-12 Daily: 8/1/10 - 12/31/12
Garnet V	GV-MIRANT1	Production	NV Energy	683,115	4,032,318	2567.87	C	1197 - 1979	Monthly	Monthly: May-2 - Dec-12 Daily: 1/1/10 - 12/31/12
Garnet V	GV-PW-WS1	Production	NV Energy	682,654	4,031,460	2532.29	C	1240 - 1980	Monthly	Monthly: Jan-02 - Dec-12
Garnet V	GV-RW1	Production	NV Energy	692,928	4,036,645	2069.20	C	553 - 833	Quarterly	Monthly: Jan-01 - Dec-12 Daily: 8/1/10 - 12/31/12
Garnet V	Chem Lime Old	Production	Chemical Lime Co.	687,941	4,029,333	---	F	350 - 500	Monthly	Monthly: Jan-01 - Dec-12
Garnet V	Chem Lime New	Production	Chemical Lime Co.	687,748	4,026,563	---	C	540 - 840	Monthly	Monthly: Jan-01 - Dec-12
Garnet V	GV-2	Production	Dry Lake Water Co.	686,226	4,025,690	2424	C	852 - 1232	Monthly	Monthly: Jan-08 - Dec-12
Garnet V	Republic Well #1	Production	Republic Env. Tech.	---	---	---	C	---	Monthly	Quarterly: Mar-07 - Mar-10; Monthly Apr-10 - Dec-12
Garnet V	Republic Well #2	Production	Republic Env. Tech.	690,674	4,027,890	---	C	883 - 963	Monthly	Quarterly: Mar-07 - Mar-10; Monthly Apr-10 - Dec-12
Garnet V	Republic Well #5	Production	Republic Env. Tech.	691,053	4,029,626	---	C	460 - 700	Monthly	Quarterly: Mar-07 - Mar-10; Monthly Apr-10 - Dec-12
Garnet V	Republic Well #6	Production	Republic Env. Tech.	690,552	4,026,318	---	C	900 - 1150	Monthly	Quarterly: Mar-07 - Mar-10; Monthly Apr-10 - Dec-12
Garnet V	M-3	Monitoring	MBPI	691,536	4,044,302	2235	C	630 - 670	Continuous	Intermittent: 12/6/00 - 11/13/10 Daily: 1/1/11 - 12/31/12
Hidden V	SHV-1	Monitoring	SNWA/USGS	685,751	4,047,256	2650.32	C	45 - 920	Continuous	Intermittent: 5/29/98 - 12/11/12
California Wash	ECP-1	Production	MBPI	696,729	4,046,590	2230.05	C	600 - 1125	Continuous	Monthly: Jan-09 - Dec-12
California Wash	ECP-2	Production	MBPI	696,723	4,046,742	---	C	55 - 1228	Quarterly	Monthly: Jan-09 - Dec-12
California Wash	ECP-3	Production	MBPI	696,714	4,046,984	---	C	74 - 1500	Quarterly	Monthly: Jan-09 - Dec-12
California Wash	M-1	Monitoring	MBPI	704,517	4,057,109	1895.69	C	360 - 400	Continuous	Intermittent: 12/6/00 - 11/13/10 Daily: 1/1/11 - 12/31/12
California Wash	M-2	Monitoring	MBPI	695,836	4,040,876	2108.5	C	640 - 680	Continuous	Intermittent: 12/6/00 - 11/13/10 Daily: 1/1/11 - 12/31/12
California Wash	TH-2	Monitoring	MBPI	697,684	4,049,916	2338.09	C	TD 1198	Continuous	Intermittent: 12/6/00 - 11/13/10 Daily: 1/1/11 - 12/31/12

California Wash	TH-1	Production	MBPI	697,233	4,044,981	2205.95	C	TD 1100	Daily	Monthly: Jan-09 - Dec-12
California Wash	BYRON	Monitoring	SNWA	710,994	4,051,282	1903.06	C	780 - 1095	Monthly	Intermittent: 7/5/10 - 12/13/12
MRSA	CSV-2	Monitoring	SNWA/USGS	703,217	4,072,967	2188.68	C	---	Continuous	(NWIS) Daily: 2/6/91 - 4/24/13
MRSA	EH-4	Monitoring	NV Energy	703,929	4,064,736	1933.93	C	TD 285	Continuous	Intermittent: 1/23/87 - 9/8/10 Daily: 9/15/10 - 12/17/12
MRSA	EH-5B	Monitoring	NV Energy	701,569	4,067,619	1844.80	C	TD 264	Continuous	Intermittent: 1/23/87 - 9/8/10 Daily: 9/15/10 - 12/17/12
MRSA	UMVM-1	Monitoring	SNWA	694,305	4,070,248	2061.88	C	960 - 1760	Continuous	Intermittent: 7/15/03 Daily: 7/23/03 - 12/13/12
MRSA	ARROW CANYON1	Production	MVWD	701,104	4,067,755	1861.45	C	205 - 565	Continuous	Monthly: Jan-00 - Dec-12 Daily: 8/1/10 - 12/31/12
MRSA	ARROW CANYON 2	Production	MVWD	701,103	4,067,768	1863.29	C	480 - 742	Continuous	Monthly: Jan-05 - Dec-12 Daily: 8/1/10 - 12/31/12
MRSA	MX-6	Production	MVWD	697,482	4,071,381	2278.11	C	325 - 937	Monthly	Monthly: Jan-00 - Dec-12 Daily: 8/1/10 - 12/31/12
MRSA	LDS Central	Production	NV Energy	704,114	4,066,544	1762.78	F	25 - 50	Monthly	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	LDS East	Production	NV Energy	704,479	4,066,594	1753.13	F	17 - 77	Monthly	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	LDS West	Production	NV Energy	702,746	4,067,083	1807.80	F	---	Monthly	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Lewis 1	Production	NV Energy	702,182	4,068,043	1828.71	F	---	4 months (production only)	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Lewis 2	Production	NV Energy	702,339	4,067,921	1826.04	F	---	Continuous	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Lewis 3	Production	NV Energy	701,956	4,068,021	---	F	---	4 months (production only)	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Lewis 4	Production	NV Energy	702,028	4,067,620	---	F	---	4 months (production only)	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Lewis 5	Production	NV Energy	702,196	4,067,485	---	F	---	4 months (production only)	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	Behmer	Production	NV Energy	706,031	4,065,080	---	F	0 - 115	4 months (production only)	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
MRSA	PERKINS PRODUCTION	Production	NV Energy	705,693	4,065,206	2274.60	F	25 - 125	Monthly	Monthly: Jan-00 - Dec-12 Daily: 1/1/11 - 12/31/12
Lower Moapa V	EH-7	Monitoring	NV Energy	720,660	4,060,990	---	C	---	Continuous	Intermittent: 1/23/87 - 1/4/13

Appendix A.2 – Additional groundwater level and production hydrographs as a function of time

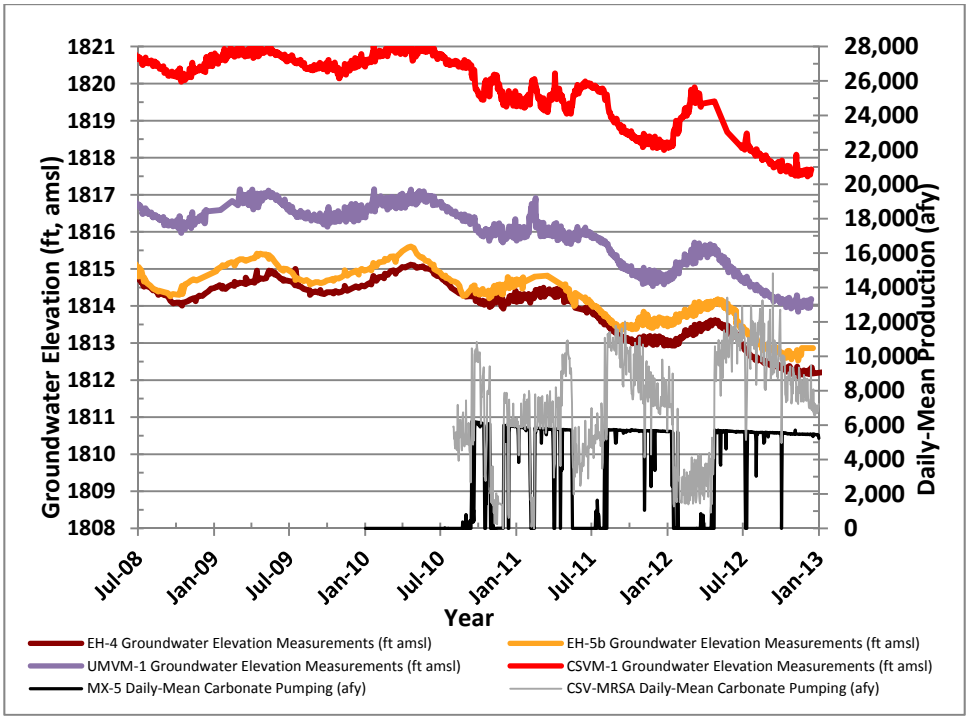


Figure A.2-1. Groundwater elevations in carbonate monitoring wells CSVM-1 in CSV and UMVM-1, EH-5b, and EH-4 in the MRSA EH-4, July 2008 to December 2012, and daily-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from August 2010 to December 2012.

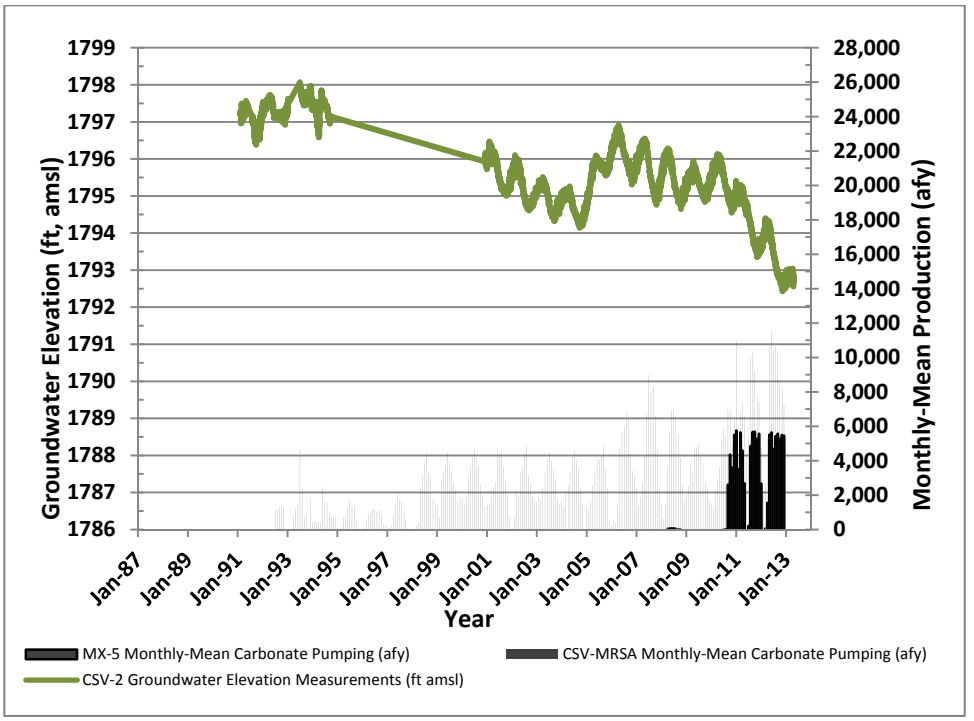


Figure A.2-2. Groundwater elevation in carbonate monitoring well CSV-2 in the MRSA and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

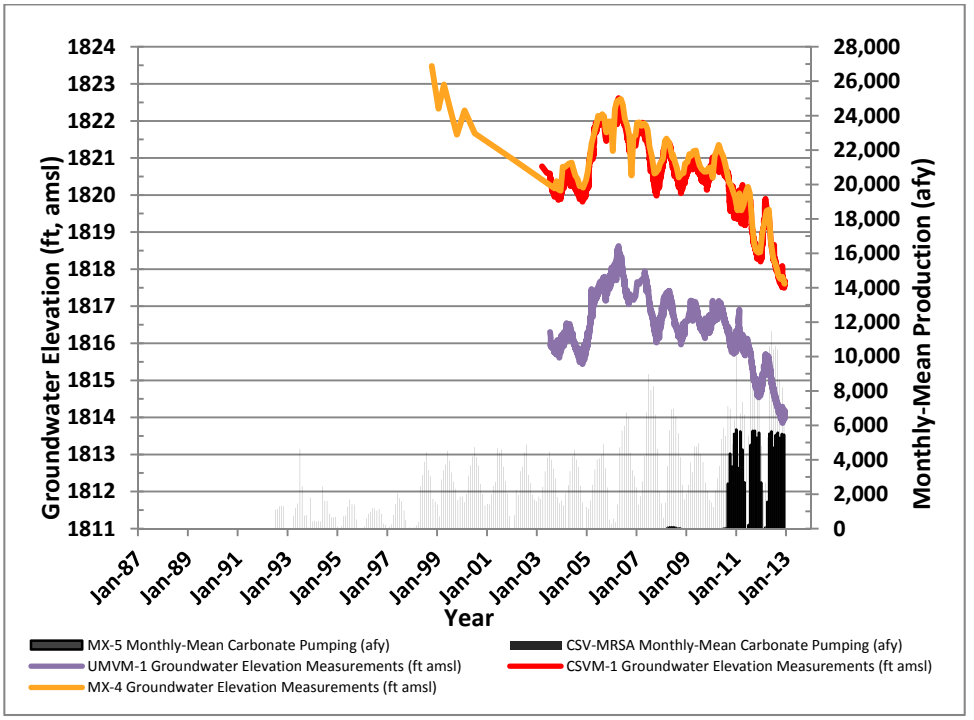


Figure A.2-3. Groundwater elevations in carbonate monitoring well UMVM-1 in the MRSA and CSVM-1 and MX-4 in the CSV and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

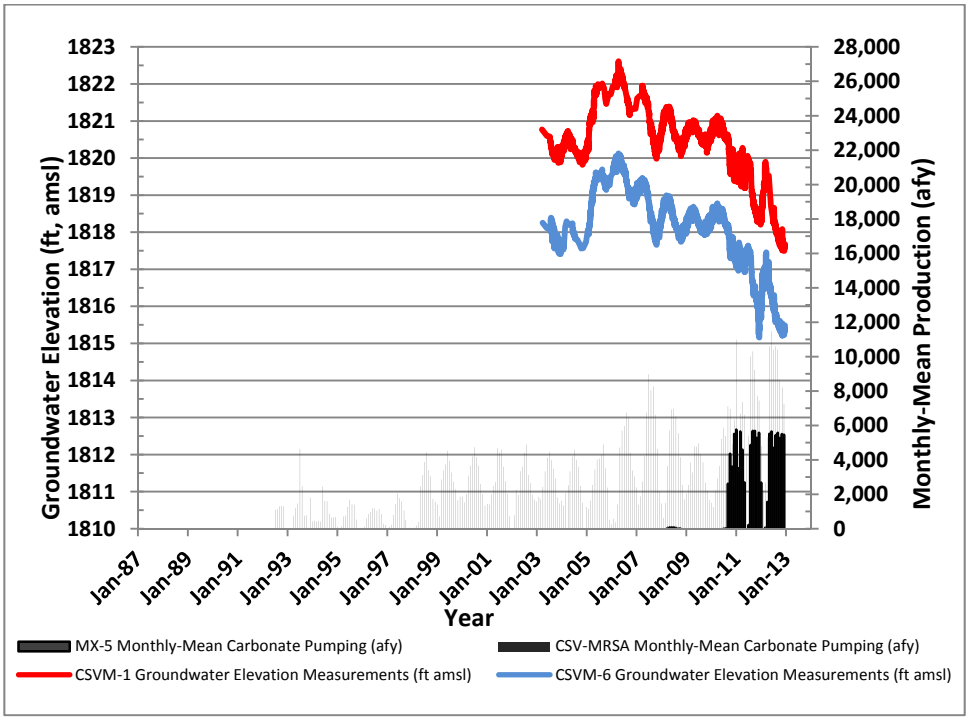


Figure A.2-4. Groundwater elevations in carbonate monitoring well CSVM-1 and CSVM-6 in the CSV and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

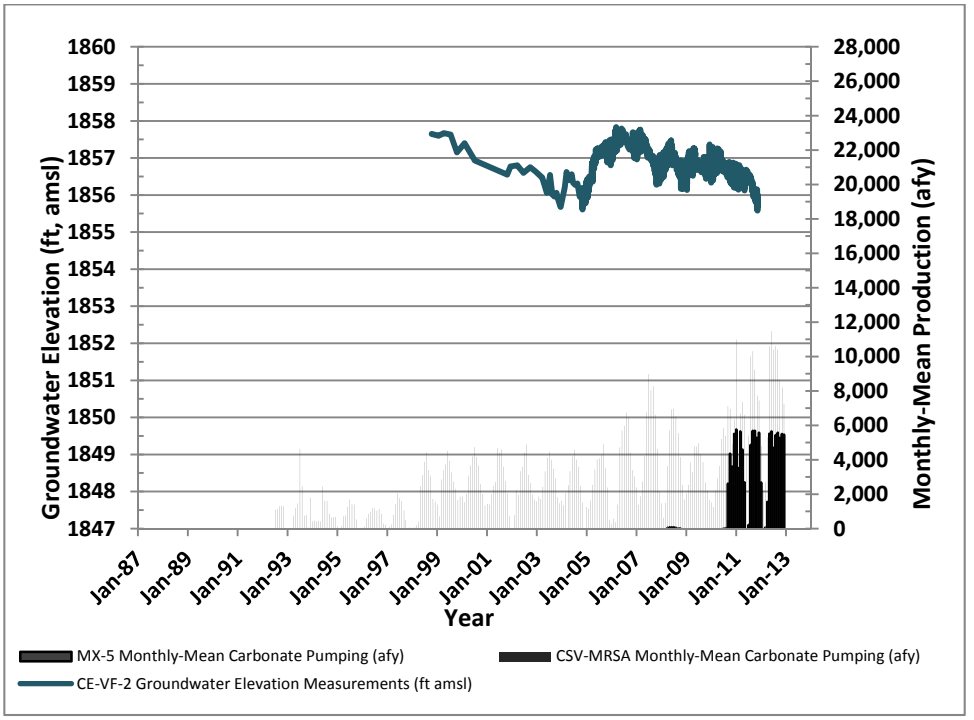


Figure A.2-5. Groundwater elevations in carbonate monitoring well CE-VF-2 in the CSV and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

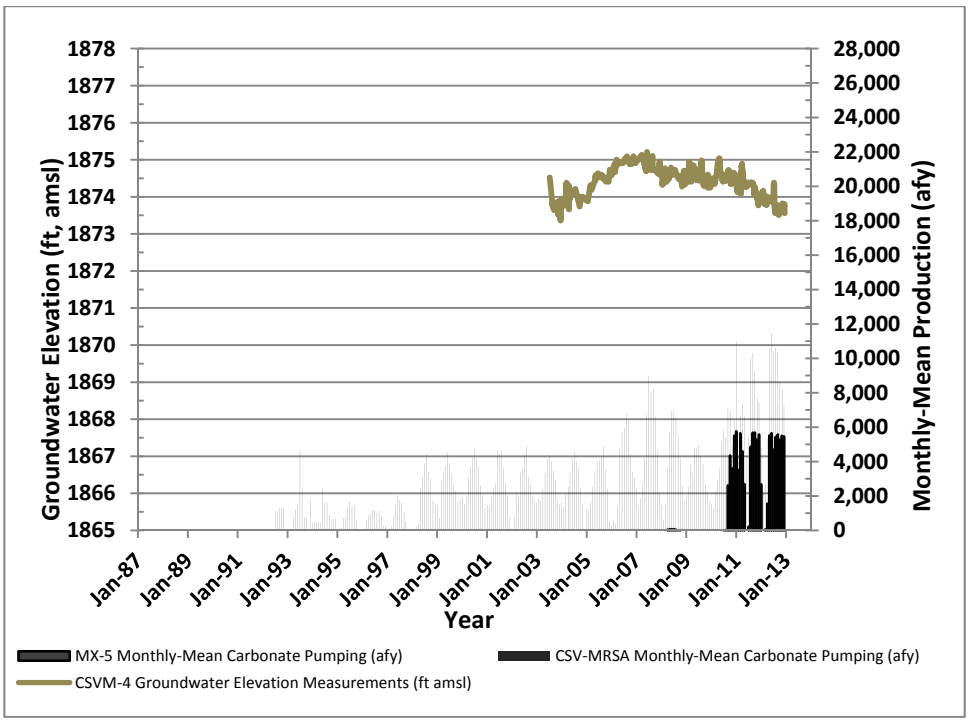


Figure A.2-6. Groundwater elevations in carbonate monitoring well CSVM-4 in the CSV and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

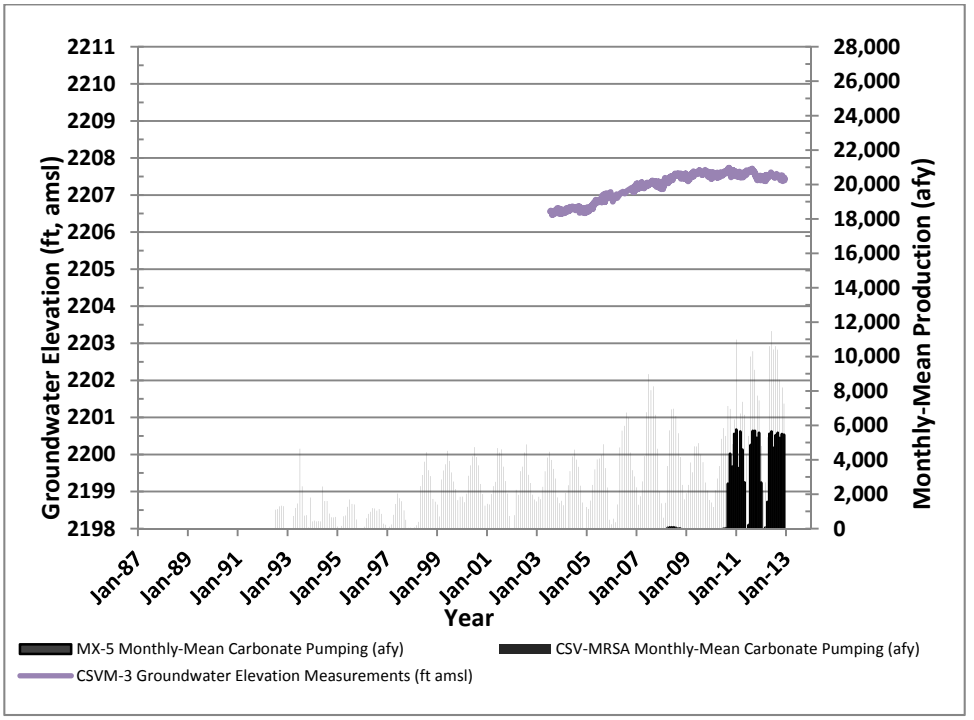


Figure A.2-7. Groundwater elevations in carbonate monitoring well CSVM-4 in the CSV and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

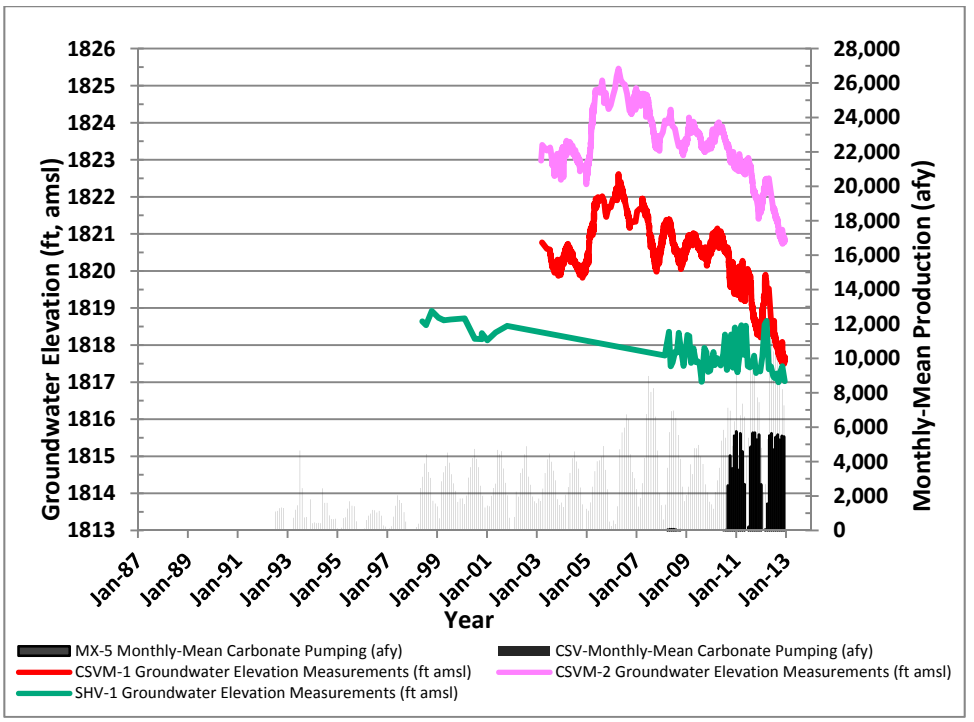


Figure A.2-8. Groundwater elevations in carbonate monitoring well CSVM-1 and CSVM-2 in the CSV and SHV-2 in Hidden Valley and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

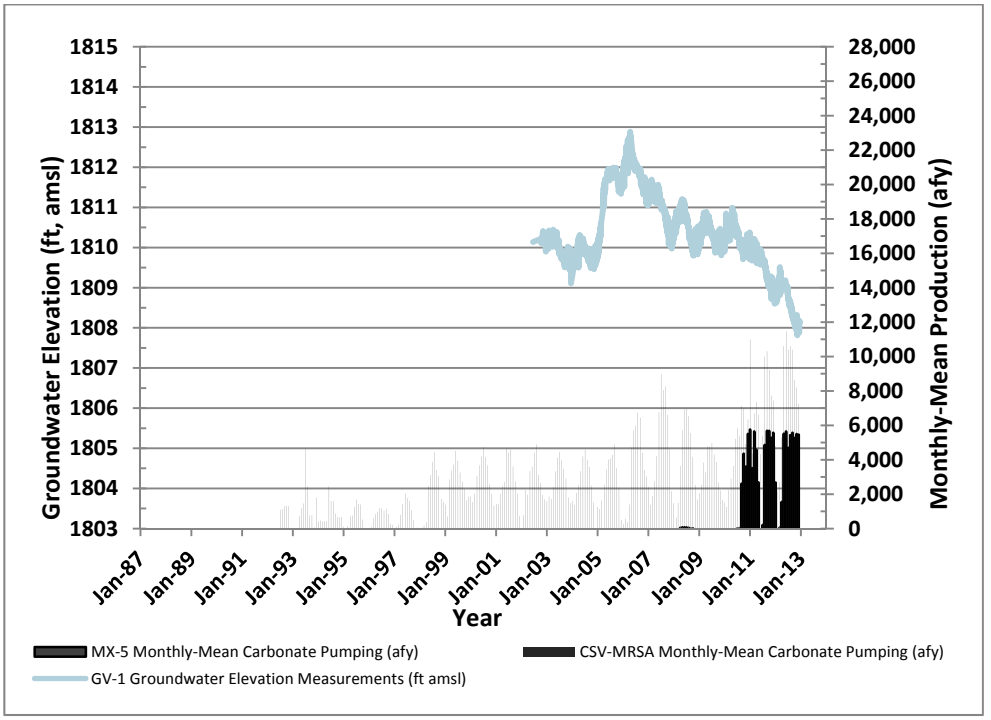


Figure A.2-9. Groundwater elevations in carbonate monitoring well GV-1 in Garnet Valley and monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area from 1987 to 2012.

Appendix A.3 – Additional drawdown and production hydrographs as a function of time

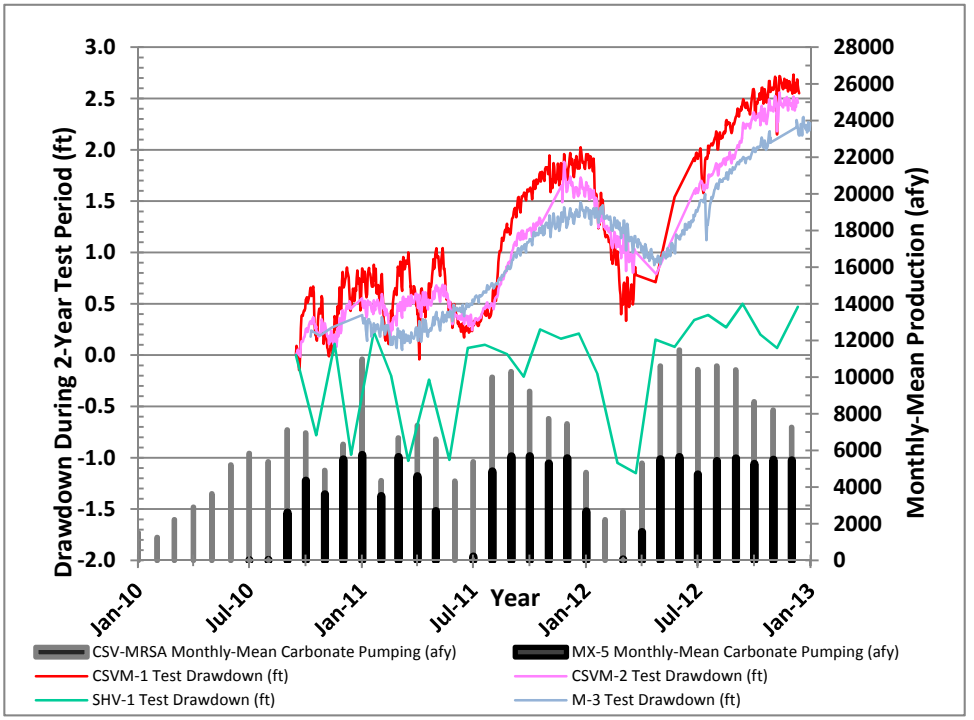


Figure A.3-1. Estimated drawdown in carbonate monitoring wells CSVM-1 and CSVM-2 in CSV, SHV-1 in Hidden Valley, and M-3 in Garnet Valley versus monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area, from September 15, 2010, to December 31, 2012, i.e., during the 2-year pumping test.

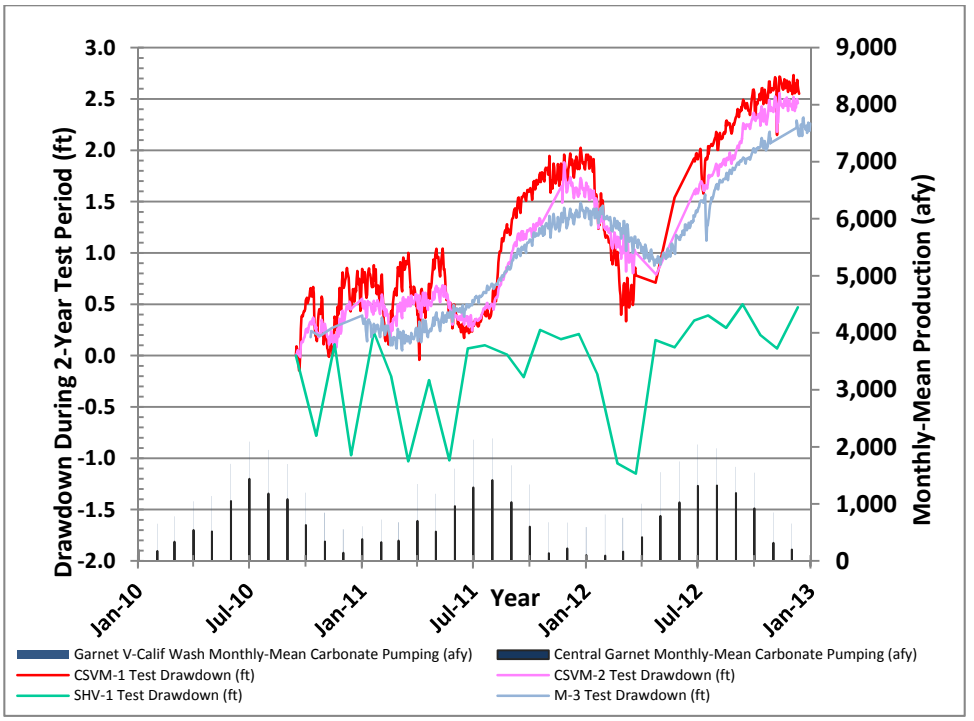


Figure A.3-2. Estimated drawdown in carbonate monitoring wells CSVM-1 and CSVM-2 in CSV, SHV-1 in Hidden Valley, and M-3 in Garnet Valley versus monthly-mean production rates in the carbonate-rock aquifer in central Garnet Valley and Garnet Valley and California Wash as a whole from 1987 to 2012.

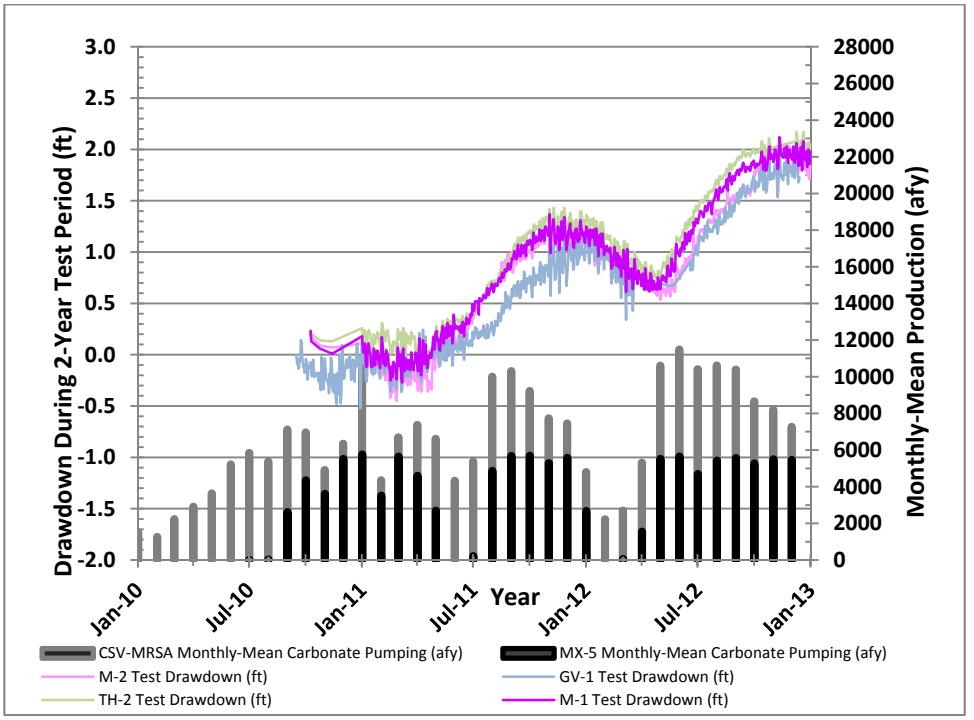


Figure A.3-3. Estimated drawdown in carbonate monitoring wells M-3, M-2, and GV-1 in Garnet Valley, and TH-2 and M-1 in California Wash versus monthly-mean production rates in the carbonate-rock aquifer at production well MX-5 and in the combined CSV and MRSA area, from September 15, 2010, to December 31, 2012, i.e., during the 2-year pumping test.

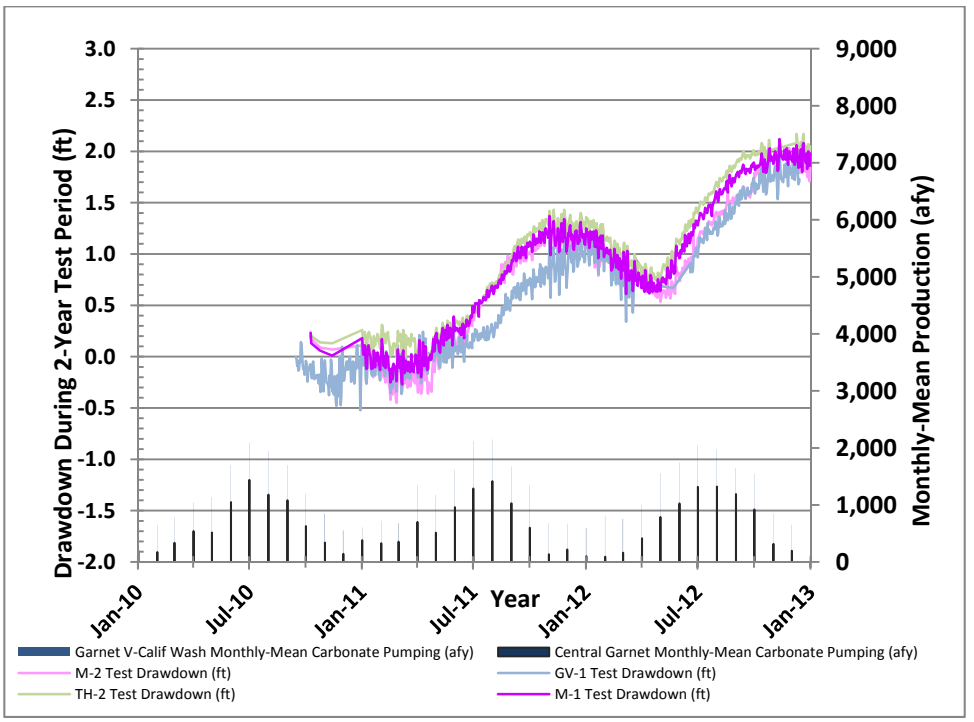


Figure A.3-4. Estimated drawdown in carbonate monitoring wells M-3, M-2, and GV-1 in Garnet Valley, and TH-2 and M-1 in California Wash versus monthly-mean production rates in the carbonate-rock aquifer in central Garnet Valley and Garnet Valley and California Wash as a whole from 1987 to 2012.

Appendix A.4 Results of SeriesSEE Evaluation of Drawdown, Order 1169 Pumping of MX-5

SeriesSEE (Halford and others, 2012) is a software package that uses multiple-regression techniques to remove "noise" caused by barometric pressure changes, earth tides, and pumping of other wells from a set of water-level measurements to facilitate interpretation. Because of the length of time for the Order 1169 test, and the much shorter wavelength and lower magnitude of barometric and earth-tide induced changes, no corrections for barometric and earth-tide changes were needed. The SeriesSEE approach uses Theis transforms to calculate the drawdown caused at a well of interest from pumping from another well or pumping center. These transforms are based on the standard Theis assumptions. In particular, each Theis transform used to calculate the drawdown assumes that the aquifer is homogeneous (using transmissivity and storage parameters specific to each pumping well/observation well pair), and infinite in extent. Superposition is used to incorporate the effects of monthly temporal changes in flow rates and the combined effects of multiple pumping wells.

A multiple-regression technique is used to estimate the transmissivity and storage parameters for each production well/observation well, minimizing the sum of squared differences between the measured and modeled drawdowns at the well of interest. The quality of the results from the multiple regression is determined by the available data, the applicability of the modeling equation (superposed Theis solutions), and the independence of the dependent variables, in this case the monthly pumping rates. If the pumping rates are highly correlated (i.e, the shapes of the rate versus time curves are very similar), the regression technique will not be successful in separating out the effects of pumping of the different wells. In other words, if all pumping schedules have similar seasonal variability, and do not vary year to year, the technique will be unable to differentiate the drawdown caused by different wells. There will be a tendency to "zero out" the effect of some wells and increase the effects caused by other wells. However, if the pumping schedules are not similar, the technique will be much more effective in differentiating the effects of the different wells. For example, if one well was pumped for a few months one year, and another well was pumped for a few months a different year, the technique would be very successful in differentiating the wells' effects. In an area where there is existing groundwater production for different wells, the situation is more complicated than this example.

The area in which the Order 1169 test was performed is one in which there is existing seasonal pumping, and more constant pumping, from many wells. Fortunately, the Order 1169 test was conducted with collection of water-level data from many wells for a period of several years before the pumping of MX-5, followed by data collection during a more than two-year period of MX-5 pumping. Although there were some breaks in the pumping of MX-5, these breaks were short and not at the same time as the periods of low seasonal pumping of other wells. The pumping schedule for MX-5 was different from the schedules for other wells (thus, poorly correlated with other wells). It was therefore likely that the effects of MX-5 pumping could be differentiated.

Three examples of the SeriesSEE-evaluated drawdowns are provided in **Figures A.4-1, A.4-2, and A4-3**. **Figure A.4-1** shows the modeled drawdowns for observation well EH-4, located near many of the springs of concern. This figure includes several different plots. At the top is a plot of the measured and SeriesSEE-modeled drawdowns at EH-4. The modeled drawdown is the sum of the drawdowns calculated at the different pumping wells or groups of wells (some of which are not shown in these

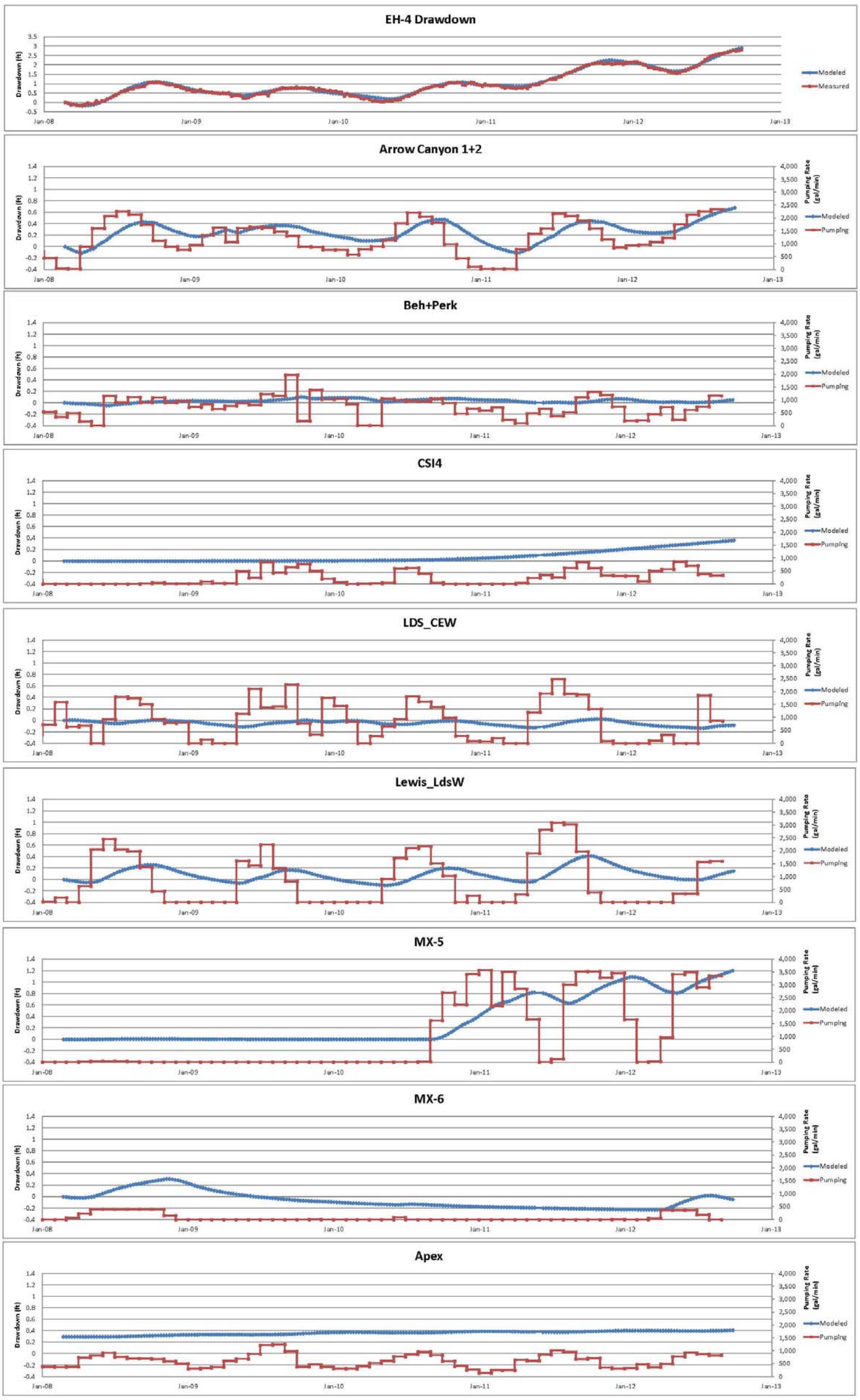


Figure A.4-1. SeriesSEE-estimated drawdown at EH-4, caused by pumping at selected wells.

figures). The other plots show monthly production (expressed in gpm) for selected different production wells or groups of pumping wells, and the modeled drawdown caused by that pumping. For example, the second plot from the top shows the measured monthly pumping and the model-simulated drawdown (at EH-4) for the Arrow Canyon wells. There is a seasonal variation in the pumping rate, and in the resultant model-simulated drawdown. There is also a several-month lag between the pumping and the simulated drawdown. The annual cycle has an amplitude of approximately 0.4 feet, and the total simulated drawdown of approximately 0.6 feet. Similar seasonal effects were simulated for the pumping labeled LDS_CEW (LDS Central and Eastern wells) and for Lewis_LDSW (Lewis wells and LDS West well). There were two short periods of pumping (in 2008 and 2012) from MX-6 and the simulated drawdown at EH-4 is apparent for each period. For pumping from some of the wells (e.g., CSI-4 and Beh+Perk (Behmer and Perkins)), the simulated drawdown is limited and smooth, a result of the transmissivity and storage parameters estimated for these wells for this particular analysis (drawdown at EH-4). The drawdown at MX-5 is notable on this figure, a result of the magnitude of the pumping, and its timing. As noted above, pumping did not occur during the early part of the analysis period (before October 2008), and there are two subsequent periods where pumping was stopped. The difference between the temporal pattern for MX-5 and the patterns for other wells allows SeriesSEE to successfully separate the effects of MX-5 pumping from other pumping.

The next figure (**Figure A.4-2**) shows the SeriesSEE results for well M2 on the Paiute Reservation in California Wash. The plot at the top shows that the regression was able to match the measured drawdown well. The results indicate that there are signals from the Arrow Canyon wells, Lewis_LdsW, MX-5, MX-6, and the Apex wells. Note that, although the rates and timing of production from LDS_CEW and Lewis_LdsW are similar, the regression model determined that the effects of the pumping from these wells were considerably different. This illustrates an important factor of this type of analysis, mentioned above. When two of the independent variables are similar (correlated), the regression approach may not be able to differentiate their contributions, and may cancel out effects of one of the variable (in this case, the effects of pumping from LDS_CEW). Note, however, that the timing and magnitude of pumping from MX-5 provided sufficient information to the regression process that the technique was able to differentiate the effects of this pumping.

The analysis of drawdown measured at CSVM-6 (**Figure A.4-3**) is an example of a SeriesSEE evaluation where there are some results that are hydrologically inconsistent, but where the approach was successful in differentiating the effects of MX-5 pumping. CSVM-6 is located northwest of MX-5, near CSI-3. The regression analysis indicated little drawdown from Arrow Canyon pumping, or pumping from the valley-fill wells in the Muddy River Springs area. It did indicate drawdown from CSI-4, which is nearby. The SeriesSEE model considers earlier pumping (pre-2008) and calculated that cessation of earlier pumping of CSI-3 caused recovery of water levels in CSVM-6 (not shown) during the period 2008 through 2012. To offset this drawdown, the model simulated over 2 feet of drawdown from pumping of MX-6, even the pumping from this well was limited. The estimated drawdown from many of these wells does not appear to be reasonable. In spite of these unrealistic results, the regression procedure was able to differentiate the effects of MX-5 pumping, and estimated a drawdown pattern from MX-5 pumping that is very similar to the other MX-5 patterns shown.

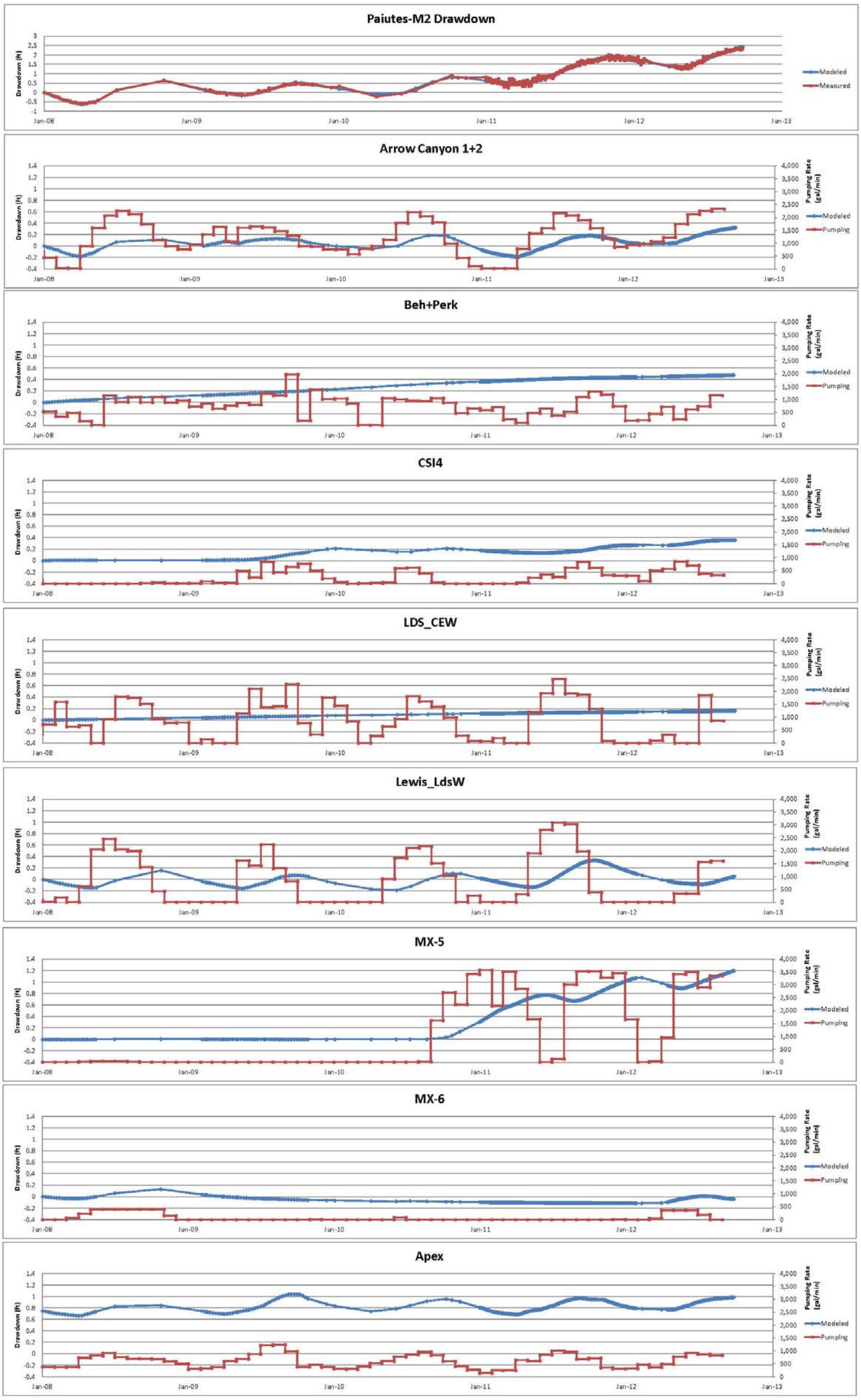


Figure A.4-2. SeriesSEE-estimated drawdown at Paiutes-M2, caused by pumping at selected wells.

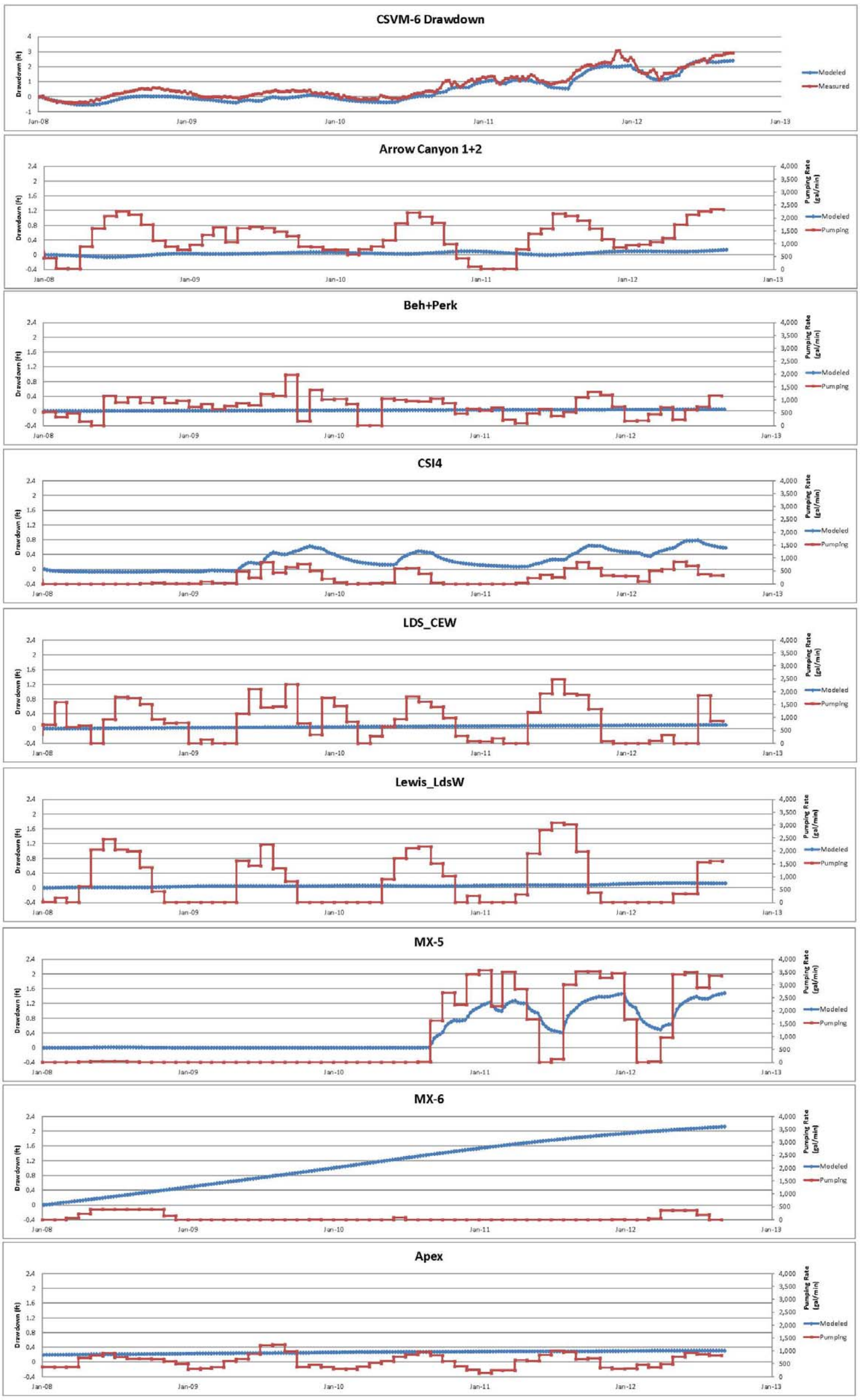
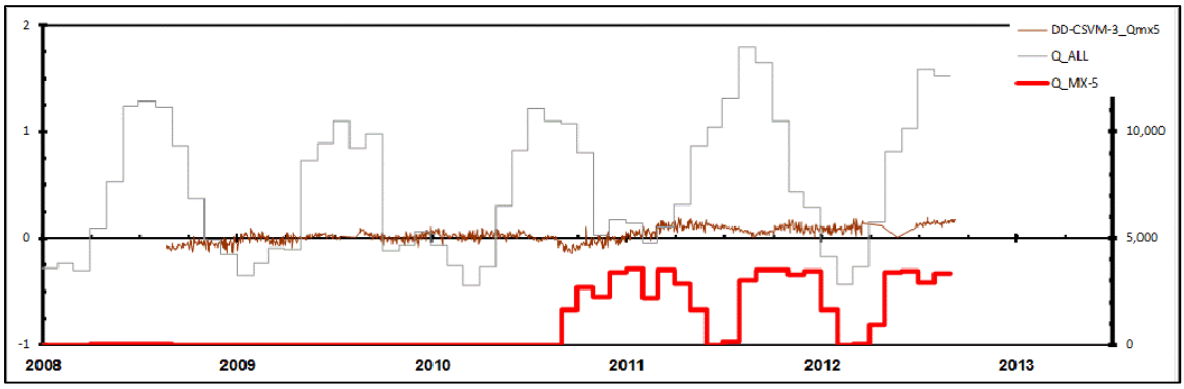


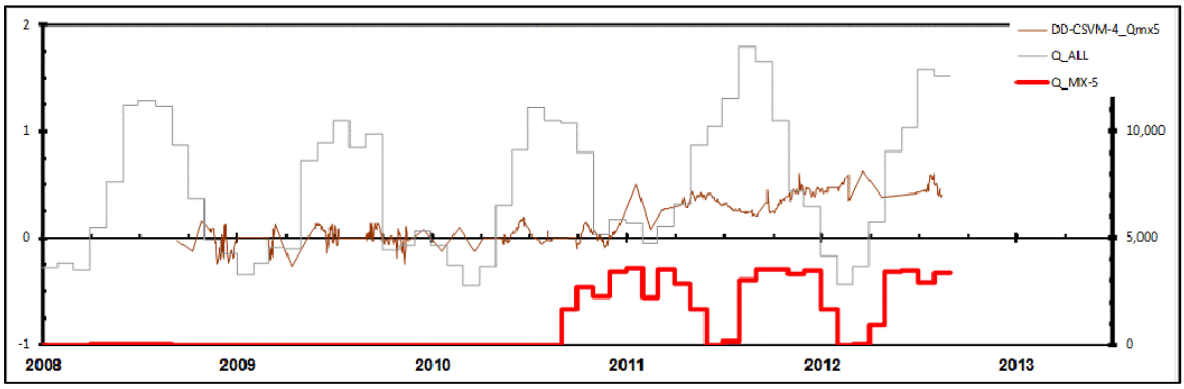
Figure A.4-3. SeriesSEE-estimated drawdown at CSVM-6, caused by pumping at selected wells.

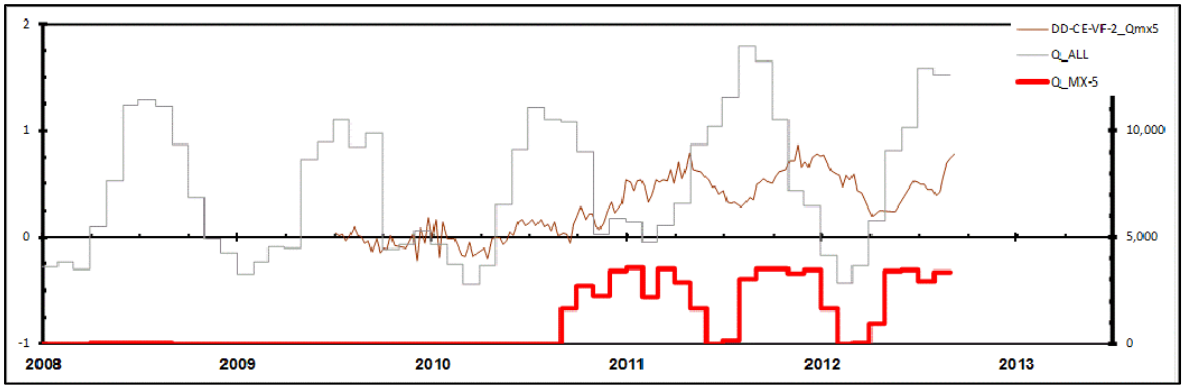
Evaluation of the results from other observation wells that were evaluated confirm these patterns. While the available data may not allow SeriesSEE to consistently identify the sources of the drawdown observed in the observations well (largely because of temporal correlation of pumping rates), SeriesSEE consistently identified drawdown caused by pumping of MX-5. The MX-5-caused drawdown patterns were similar in magnitude and shape. The ability of SeriesSEE to determine the drawdown caused by MX-5 is the result of the large magnitude and different temporal pattern of the MX-5 pumping.

The remainder of this Appendix provides SeriesSEE-determined drawdown caused by pumping of MX-5, added to the residuals of the regression (the differences between the measured and simulated drawdowns). This provides a visual comparison of the estimated drawdown with the residuals, and allows the viewer to decide whether the remaining noise (residuals) obscures the drawdown.

Appendix A.4-4 – Hydrographs of MX-5 pumping-induced drawdown estimated in monitoring wells within and outside of the Study Area, based on preliminary SeriesSEE analyses versus MX-5 pumping and total pumping within the Study Area, January 1, 2008 to December 13, 2012.



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5,000
0
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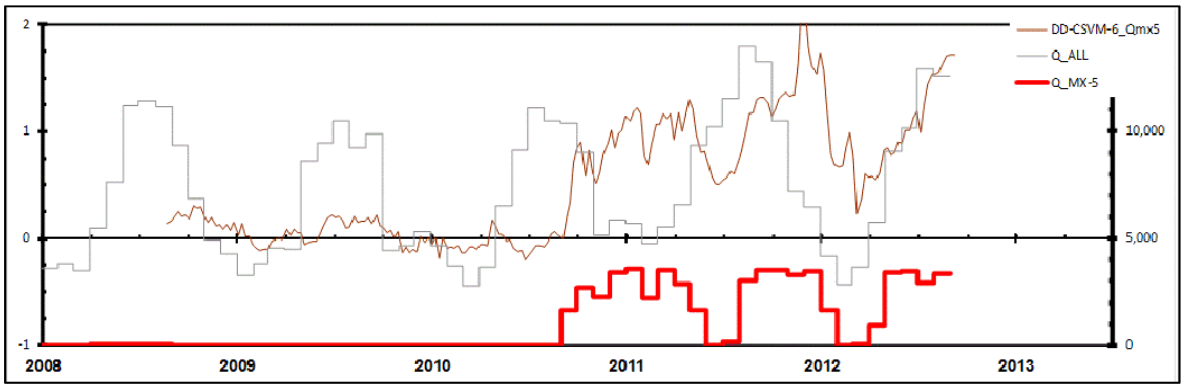
2009
2010
2011
2012
2013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2009
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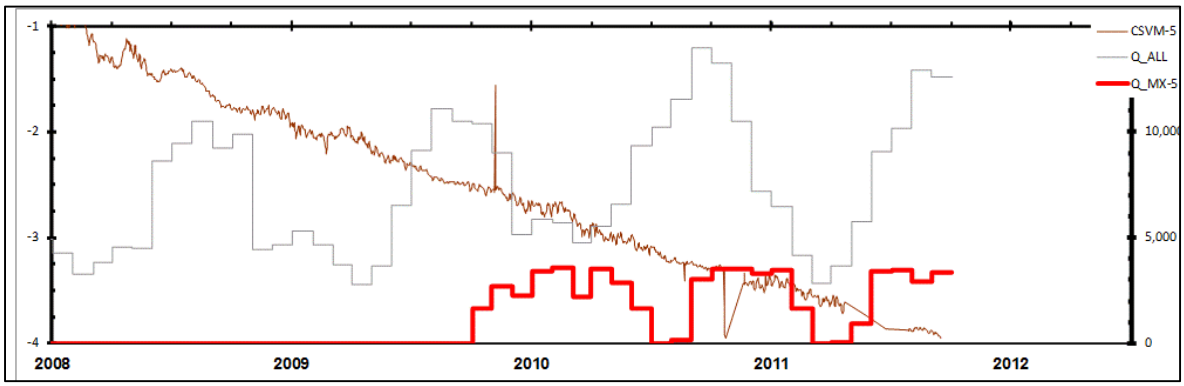
2011
2012
2013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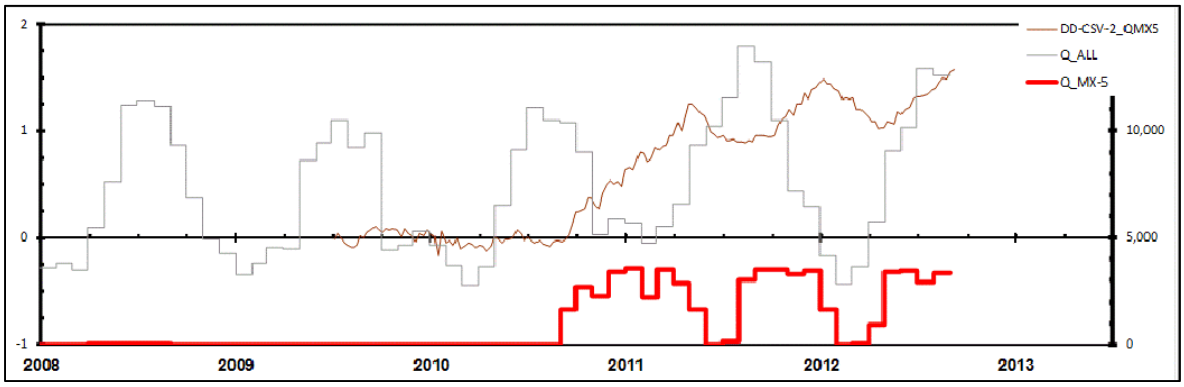
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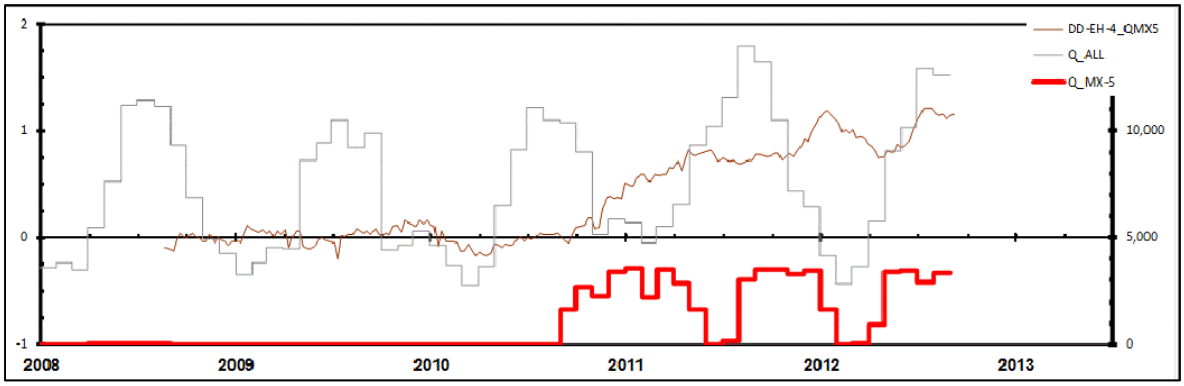
2011
2012
2013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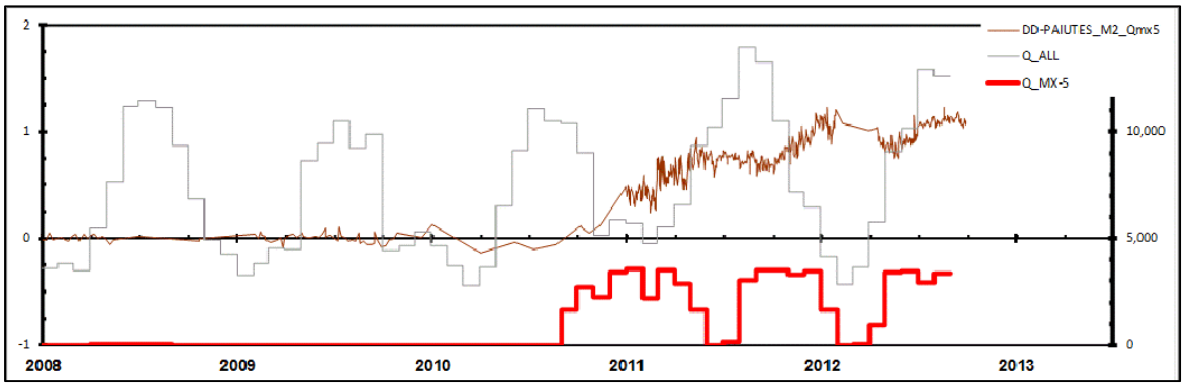
2012
2013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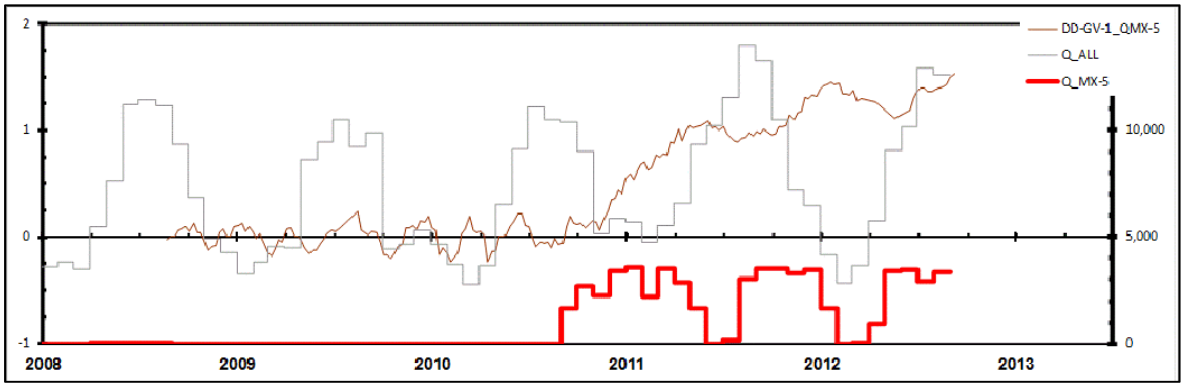
2011
2012
2013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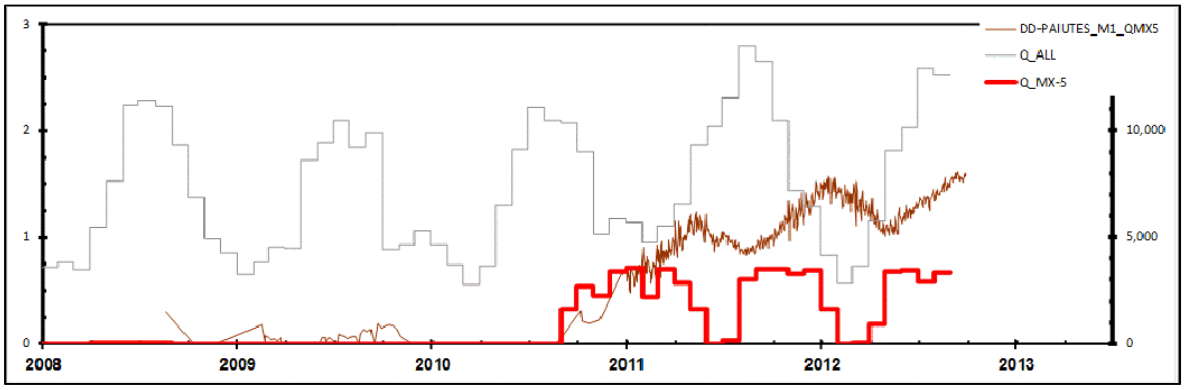
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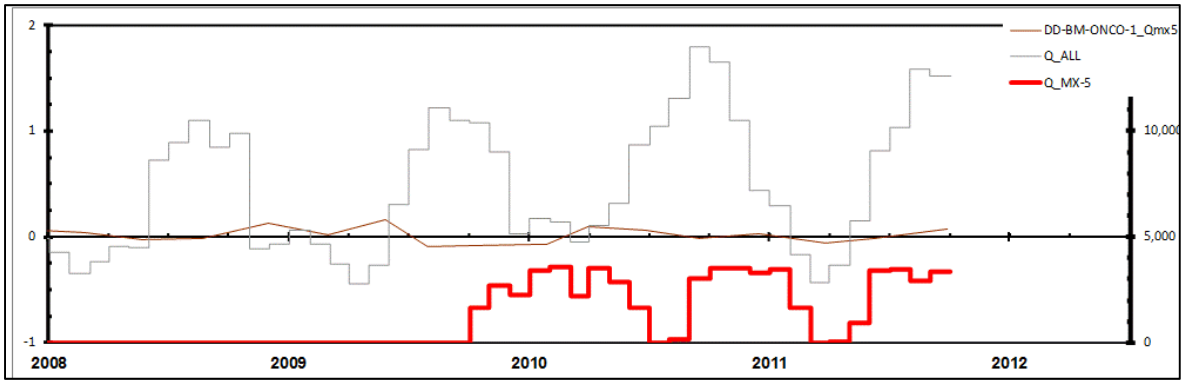
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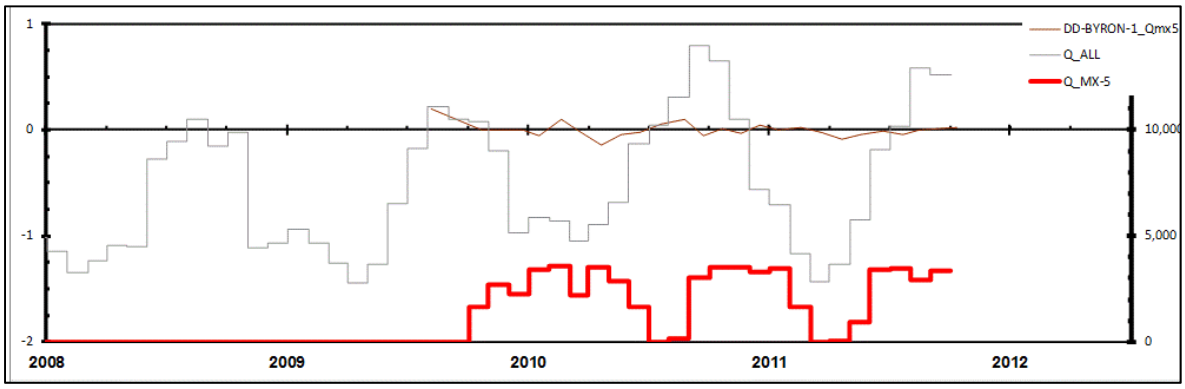
2012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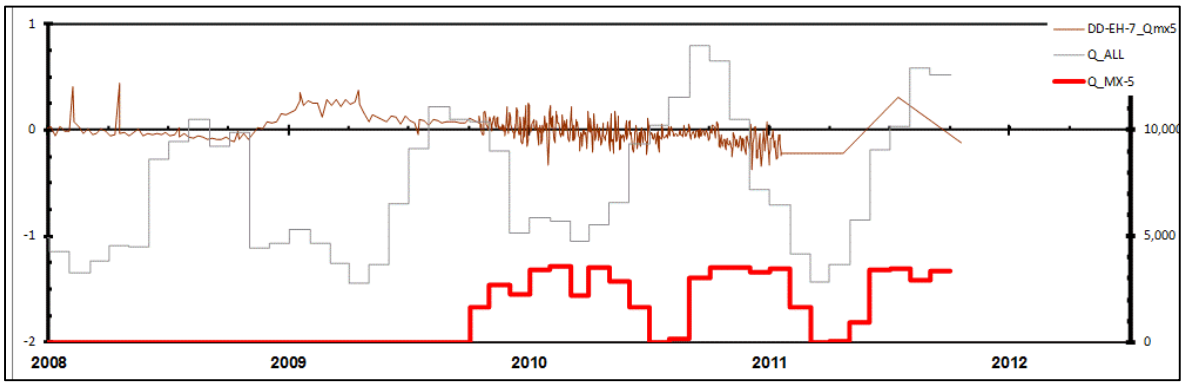
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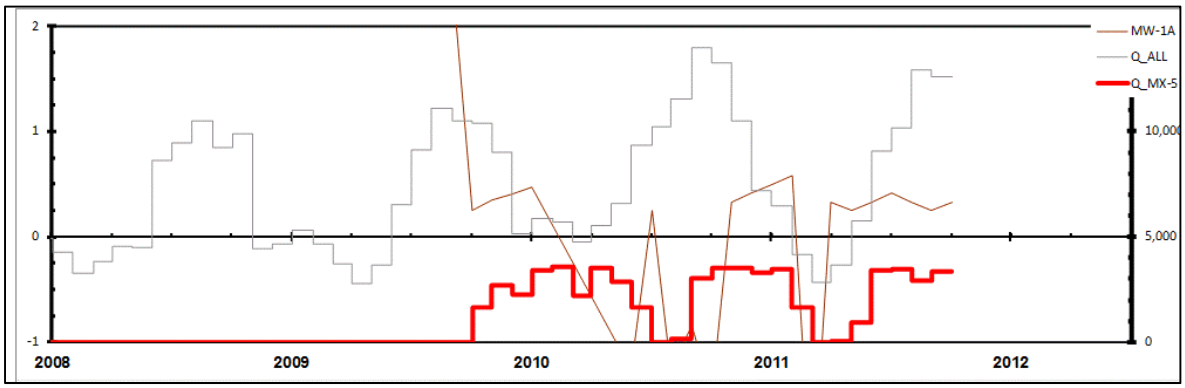
2012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