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Evaluation of Groundwater-Flow Models for Estimating Drawdown from Proposed Groundwater Development in Tule Desert, Nevada

Open-File Report 2019–1091

U.S. Department of the Interior
U.S. Geological Survey

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By Keith Halford

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2019

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow rate	
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm^3/yr)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Transmissivity	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83), Universal Transverse Mercator Projection, Zone 11.

Evaluation of Groundwater-Flow Models for Estimating Drawdown from Proposed Groundwater Development in Tule Desert, Nevada

By Keith Halford

Introduction

At the request of the Bureau of Land Management (BLM), the U.S. Geological Survey (USGS) is releasing with this open-file report (OFR) a previously unpublished review and comparison of two numerical models for Tule Desert, Nevada. The original review was performed in spring 2013, and only minor editorial revisions were made in the current (2019) OFR for clarity and to reformat the original interagency correspondence to the USGS OFR template. No revisions have been made to the technical content of the original review for this OFR release. Report content presented in the purpose and scope statement, and all subsequent sections of the OFR, are original content submitted to BLM in May 2013. Model review and comparisons described in the following paragraphs are based on, in part, results of a long-term (more than 2 years) aquifer test mandated by Nevada State Engineer Order 1169. Additional information on Order 1169 and associated aquifer test results can be found at the State of Nevada Division of Water Resources website (State of Nevada, 2019).

Purpose and Scope

The purpose of this report is to evaluate the relative appropriateness of two existing groundwater-flow models for estimating drawdowns from proposed groundwater development in Tule Desert, Nevada. Mock (2008) and Tetra Tech (2012) developed the two existing groundwater models that will be referred to by the names of the developers, herein. Agreement between estimates from aquifer-test results and simulated transmissivities in Tule Desert and fidelity to conceptual models of groundwater flow in the study area (fig. 1) defined relative model appropriateness for estimating drawdowns from pumping four wells in Tule Desert. The scope of this review was limited to assessing relative appropriateness between two models and did not exhaustively review either model. A third regional groundwater-flow model, the Central Carbonate-Rock Province model (Southern Nevada Water Authority, 2009), was not compared because this model does not simulate flow in Tule Desert.

Measured and simulated transmissivity were compared because the spatial distribution of hydraulic diffusivity largely controls drawdown (Halford and Plume, 2011). This is especially true where groundwater pumping is distant from discharge areas. Hydraulic diffusivity is the ratio of transmissivity divided by storage coefficient. Characterizing pumping responses with hydraulic diffusivity implies that an aquifer system is two-dimensional and vertical differences in drawdown are minor. This simplification is reasonable when analyzing drawdowns and groundwater capture that occur during decades of groundwater development. Agreement between numerical and conceptual models of groundwater flow in the study area also was considered because flaws in conceptualization affect hydraulic property estimates.

Storage coefficients were not compared because assigned values are similar in both models. Storage coefficients ranged between 0.02 and 0.19 and averaged 0.09 near Tule Desert hydrographic area in the Mock model. Storage coefficients ranged between 0.04 and 0.17 and averaged 0.12 near Tule Desert hydrographic area in the Tetra Tech model. These differences are slight relative to differences in transmissivity distributions in the two models.

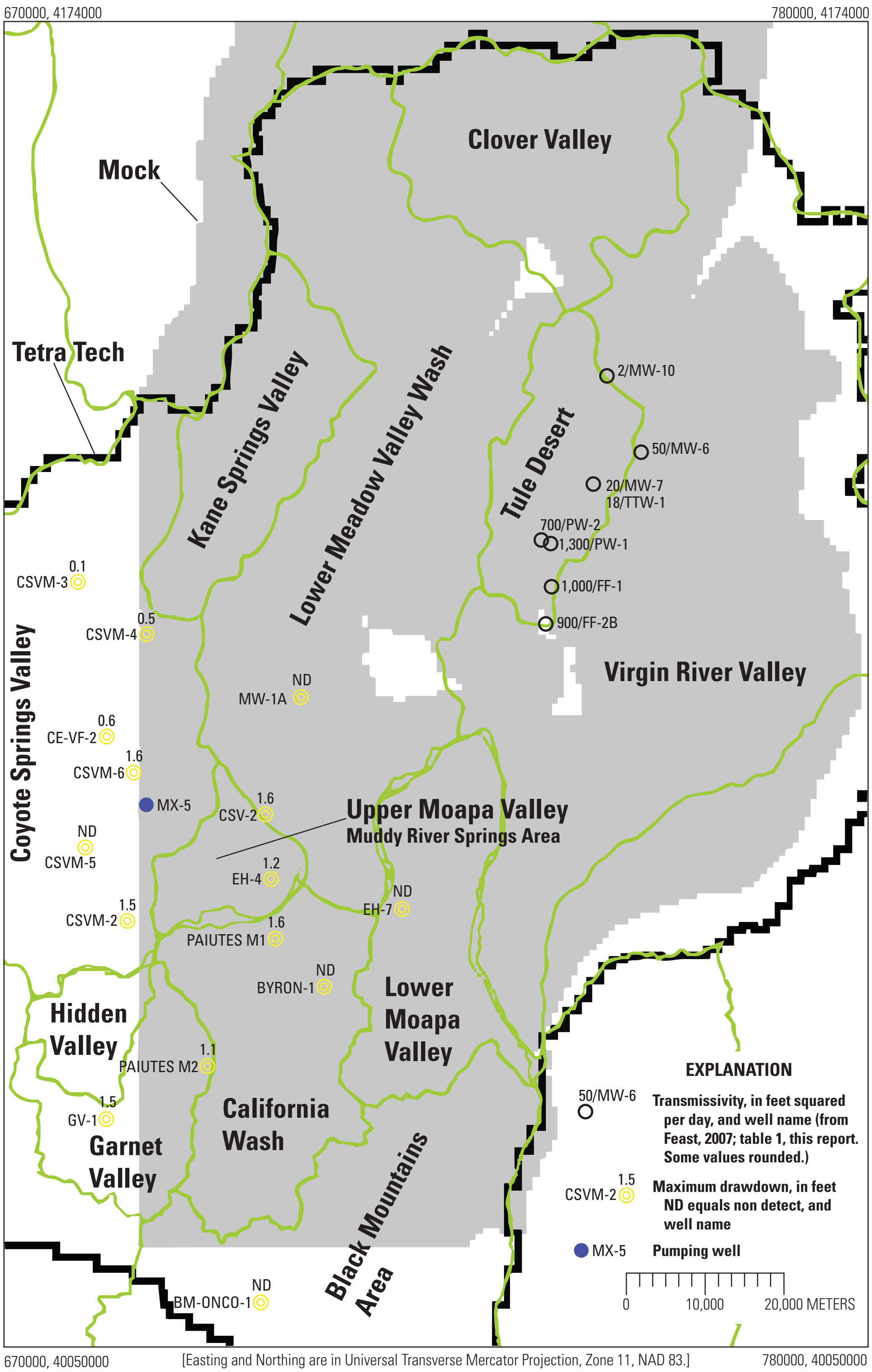

Figure 1. Extents of Mock and Tetra Tech models in study area, aquifer-test sites in Tule Desert, Nevada, and maximum drawdown from pumping well MX-5 for Order 1169.

Aquifer-Test Results and Transmissivity Distributions

Transmissivity estimates from eight aquifer tests in Tule Desert ranged between 2 and 1,300 square feet per day (ft^2/d; table 1; Feast, 2007). Transmissivity generally decreased from south to north, where the lowest transmissivity was encountered in the northernmost well, MW-10 (fig. 1). Transmissivity estimates from wells PW-1 and PW-2 were integrated across greater areas because more than 30 acre-feet (acre-ft) were produced from each well (Feast, 2007). Cumulative production from wells MW-6, MW-7, and MW-10 was less than 0.1 acre-ft per well, and all transmissivity estimates were less than 50 ft^2/d (table 1).

Simulated transmissivity distributions were computed from each model, but approaches differed. Hydraulic properties were distributed with the layer-property flow (LPF) package in the Mock model and with the hydrogeologic-unit flow (HUF) and horizontal flow barrier (HFB) packages in the Tetra Tech model. Simulated transmissivity at a row and column of the Mock model was the summation of saturated thickness multiplied by the hydraulic conductivity in all layers (fig. 2). Saturation was defined by the predevelopment water table. Simulated transmissivity at a row and column of the Tetra Tech model was the geometric mean of inter-cell transmissivities that were computed from row and column conductances (fig. 3). Row and column conductances were used so that sampled transmissivities were affected by averaging hydrologic units and depth decay in the HUF package and conductance modification in the HFB package.

Simulated transmissivities from the Mock model exceeded estimates from aquifer-test results by a factor of 200 (fig. 4) and did not follow the trend of decreasing transmissivities in northern Tule Desert (fig. 2). Simulated transmissivities from the Mock model all exceeded 10,000 ft^2/d, except near well FF-2b. Simulated transmissivity was less because well FF-2b coincided with an area in the Mock model where values of 0 ft^2/d were sampled (fig. 2).

Simulated transmissivities from the Tetra Tech model exceeded estimates from aquifer-test results by a factor of 10 (fig. 4) but approximated the trend of decreasing transmissivities in northern Tule Desert (fig. 3). Simulated transmissivities from the Tetra Tech model ranged between about 200 and 8,000 ft^2/d near the aquifer-test sites (table 1). Simulated transmissivities from the Tetra Tech model ranged between 60 and 14,000 ft^2/d by cell in Tule Desert (fig. 3).

Table 1. Wells with transmissivity estimates from aquifer tests in Tule Desert, Nevada, and simulated transmissivities that were sampled from the Mock and Tetra Tech models.

[ft^2/day, square foot per day; gpm/ft, gallon per minute per foot; SC, specific capacity in gpm/ft]

Well	Maximum discharge, gpm	Duration, days	Transmissivity, ft^2/d		
			Aquifer test (Feast, 2007)	Tetra Tech	Mock
PW-1	**1,400**	**9.0**	**1,300**	**4,000**	**49,000**
PW-2	1,000	7.0	680	6,600	51,000
MW-6	20	0.3	47	8,400	14,000
MW-7	25	0.4	24	270	53,000
[1]MW-10	30	0.1	2	210	23,000
TTW-1	35	1.1	18	270	47,000
FF-1	70	0.8	960	400	21,000
FF-2B	150	1.0	940	2,800	690

[1]Transmissivity in well MW-10 reported as “very low” and SC = 0.01 gpm/ft.

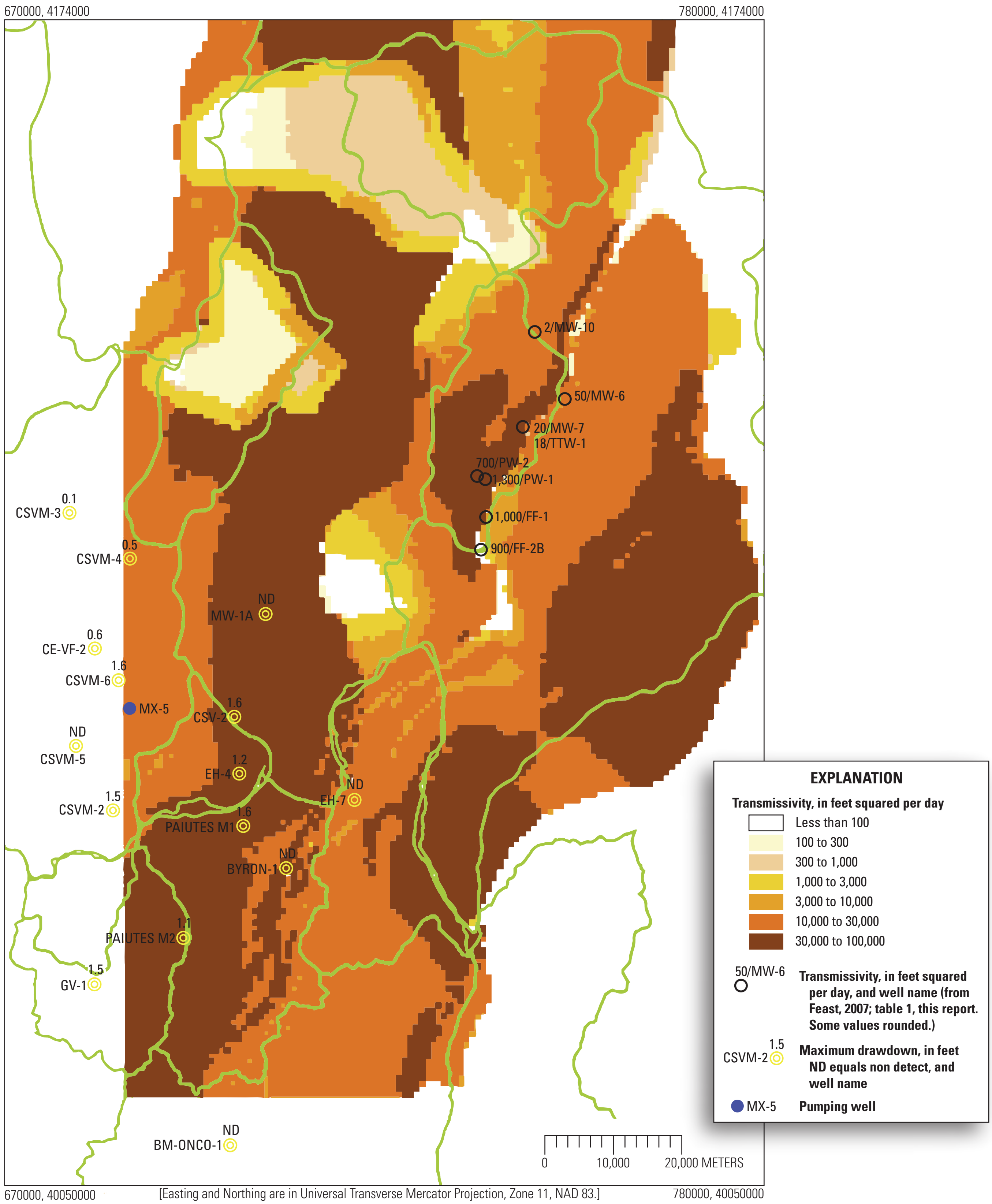

Figure 2. Transmissivity distribution from Mock model in study area, aquifer-test sites in Tule Desert, Nevada, and maximum drawdown from pumping well MX-5 for Order 1169.

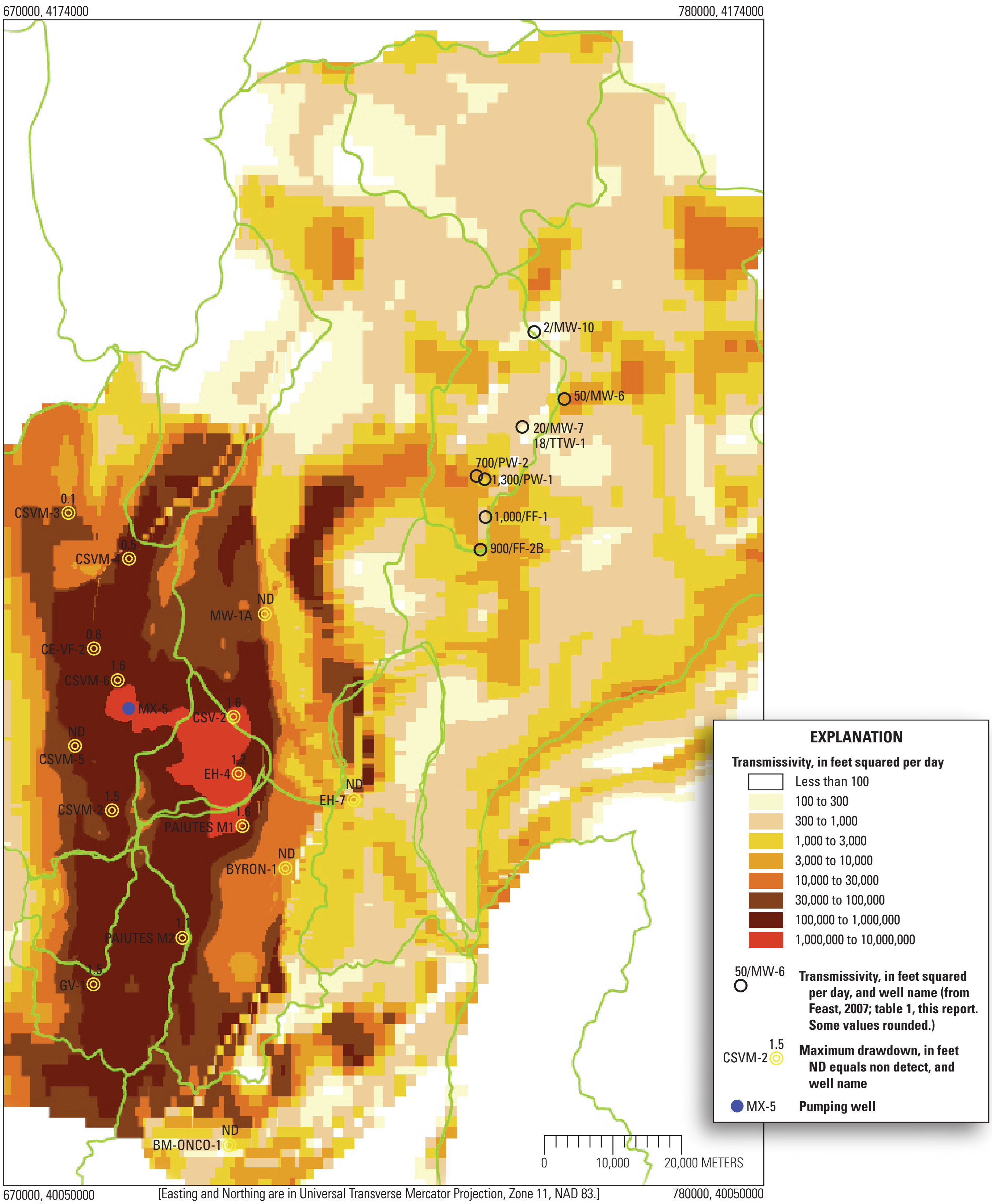

Figure 3. Transmissivity distribution from Tetra Tech model in study area, aquifer-test sites in Tule Desert, Nevada, and maximum drawdown from pumping well MX-5 for Order 1169.

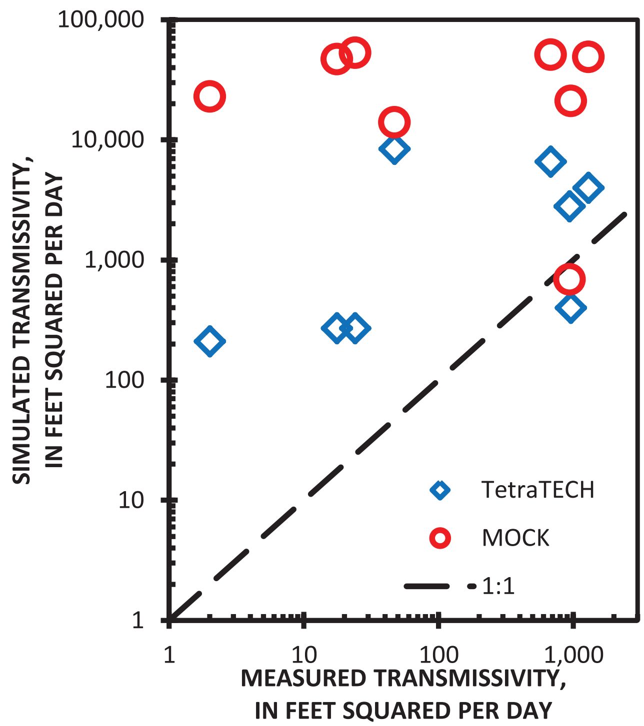

Figure 4. Comparison between transmissivity estimates from aquifer tests (Feast, 2007) and simulated transmissivities that were sampled from the Mock and Tetra Tech models.

Conceptual Model of Muddy River Springs and Responses to Pumping Well MX-5

The Muddy River Springs have been conceptualized as the southern terminus of the White River regional groundwater-flow system that extends more than 200 miles north to Long Valley (Eakin, 1966). Groundwater flows through carbonate rocks beneath Coyote Springs Valley to Upper Moapa Valley where it discharges to the Muddy River Springs. This interpretation is supported by geologic controls, groundwater levels, water quality, and stability of discharge from Muddy River Springs (Eakin, 1966; Dettinger and others, 1995). Groundwater flow from Upper Moapa Valley to Lower Meadow Valley Wash is negligible because carbonate rocks pinch out against geologic barriers east and south of Muddy River Springs (Dettinger and others, 1995, p. 57).

Simulated predevelopment flow in the Mock model is inconsistent with Muddy River Springs being the southern terminus of the White River regional groundwater-flow system. Simulated, three-dimensional potentiometric surfaces show all water moves from Lower Meadow Valley Wash to Muddy River Springs (figs. 1 and 5). Additional simulated flow moves from Lower Meadow Valley Wash and discharges to specified heads in the center of Coyote Springs Valley. The potentiometric surfaces in Coyote Springs Valley extend beneath lower potentiometric surfaces to the western edge of the Mock model (figs. 1 and 5). This unusual feature exists because heads were specified differently in layers 12 and 13 on the western edge, where the maximum vertical difference in specified heads exceeded 1,600 ft. The Mock model also is inconsistent with Muddy River Springs being the southern terminus because a continuous corridor of transmissivity greater than 30,000 ft²/d extends from south of Muddy River Springs to the Clover Mountains along the northeastern border of Lower Meadow Valley Wash (figs. 1 and 2).

The Tetra Tech model simulates predevelopment flow that agrees with Muddy River Springs being the southern terminus of the White River regional groundwater-flow system. The simulated water table compares well with measured water levels (Tetra Tech, 2012, figs. 6.2-1 and 6.2-2) and published potentiometic surfaces (Dettinger and others, 1995, plate 2). The Tetra Tech model also is consistent with Muddy River Springs being the southern terminus because simulated transmissivity decreases orders of magnitude east of Muddy River Springs (fig. 3).

Hydraulic connections beneath Coyote Springs, Muddy Springs, Garnet Valley, and Hidden Valley hydrographic areas have been further characterized by pumping of well MX-5 in response to Order 1169 from the Nevada State Engineer (State of Nevada, 2013). Large-scale hydraulic testing was mandated by the State Engineer in response to known uncertainty about the distribution and extent of the carbonate-rock aquifer in these hydrographic areas. Pumping of well MX-5 was for staged groundwater development as stated on pages 3 and 4 of Order 1169,

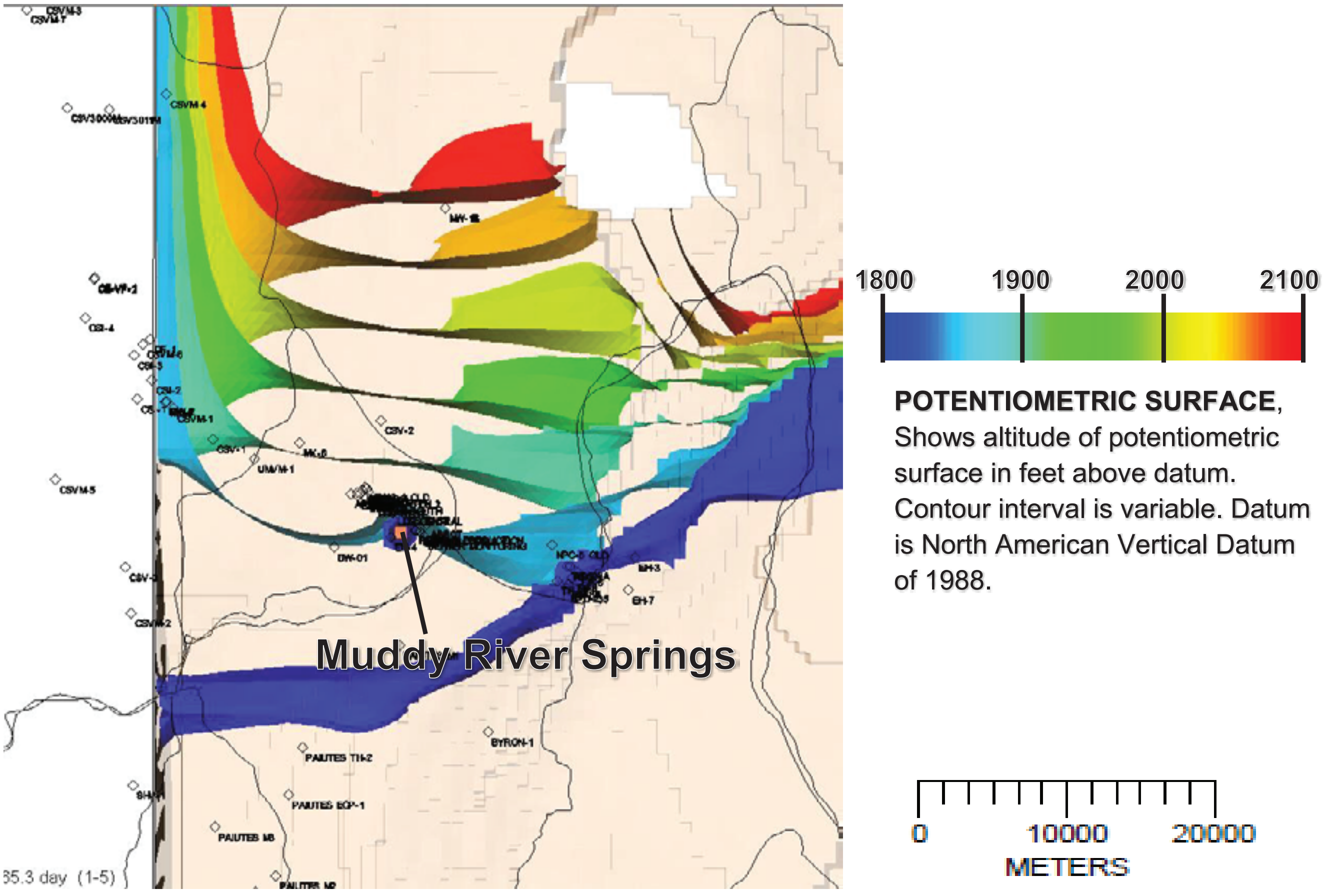

Figure 5. Simulated, three-dimensional potentiometric surfaces from Mock model near Muddy River Springs.

> "WHEREAS, because assurances that the adverse effects of development will not overshadow the benefits cannot be made with a high degree of confidence, development of the carbonate-rock aquifer system must be undertaken in gradual stages together with adequate monitoring in order to predict, through the use of a calibrated model, the effects of continued or increased development with a higher degree of confidence."

Well MX-5 was pumped during the period between September 2010 and December 2012, but regional drawdowns from pumping well MX-5 were obscured. This was because 31 other wells pump from the carbonate aquifer in Coyote Springs, Muddy Springs, Garnet Valley, and Hidden Valley hydrographic areas. These 31 wells are indentified in table 2 and have been grouped into three pumping centers: Q_CSI, Q_EAST, and Q_SOUTH (table 3; fig. 6). Average annual pumping rates from all wells in the study area ranged between 5,900 and 8,700 gallons per minute (gpm; fig. 7). Monthly pumping from all centers vary seasonally and typically fluctuate between 2,000 and 12,000 gpm. Q_EAST is the primary pumping center, which is 10 miles east-southeast of well MX-5 (fig. 6) and seasonally pumps between about 3,000 to over 8,000 gpm (fig. 7). Monthly pumping from well MX-5 averaged 2,400 gpm and ranged between 0 and 3,600 gpm during the aquifer test.

Regional drawdowns from well MX-5 were differentiated in 15 observation wells by modeling water levels. Drawdowns from all 32 wells that pumped from the carbonate aquifer were simulated analytically with Theis transforms, where step-wise pumping records of discharge are transformed into water-level changes using multiple superimposed Theis solutions. The analytical solutions were solved and fitted to measured water levels with SeriesSEE (Halford and others, 2012). Theis transforms can approximate drawdowns as well as the measurement resolution of transducers even in complex hydrogeologic systems (Garcia and others, 2013). Water-level fluctuations from environmental stresses such as barometric changes, Earth tides, and regional trends were not simulated. Estimated drawdowns, regional pumping rates, and pumping rates from the 15 observation wells are summarized in appendix 1.

Table 2. Location of selected wells in Tule Desert and surrounding hydrographic areas.

[HA, hydrographic area (Harrill and others, 1988); LAT, latitude; LONG, longitude; UTM_X, Universal Transvers Mercator projection, horizontal coordinate in east-west (X) direction; UTM_Y, Universal Transverse Mercator projection, horizontal coordinate in north-south (Y) direction]

Well name	HA name	LAT	LONG	UTM_X	UTM_Y
ARROW CANYON 1	Muddy River Springs Area	36.7339	–114.7477	701,104	4,067,755
ARROW CANYON 2	Muddy River Springs Area	36.7339	–114.7475	701,103	4,067,768
BM-ONCO-1	Black Mountains Area	36.2204	–114.7454	702,650	4,010,748
BYRON-1	California Wash	36.5837	–114.6416	710,749	4,051,002
CE-VF-2	Coyote Spring Valley	36.8743	–114.9467	683,007	4,082,892
CSI-1	Coyote Spring Valley	36.7977	–114.9152	686,043	4,074,459
CSI-2	Coyote Spring Valley	36.8094	–114.9027	687,083	4,075,781
CSI-3	Coyote Spring Valley	36.8254	–114.9165	685,813	4,077,531
CSI-4	Coyote Spring Valley	36.8500	–114.9545	682,366	4,080,185
CSV-2	Muddy River Springs Area	36.7807	–114.7227	703,217	4,072,967
CSVM-2	Coyote Spring Valley	36.6618	–114.9231	685,625	4,059,370
CSVM-3	Coyote Spring Valley	37.0525	–114.9834	679,319	4,102,600
CSVM-4	Coyote Spring Valley	36.9911	–114.8865	688,086	4,095,971
CSVM-5	Coyote Spring Valley	36.7476	–114.9804	680,295	4,068,774
CSVM-6	Coyote Spring Valley	36.8325	–114.9092	686,453	4,078,333
EH-4	Muddy River Springs Area	36.7064	–114.7170	703,929	4,064,736
EH-7	Lower Moapa Valley	36.6706	–114.5320	720,660	4,060,990
GV-1	Garnet Valley	36.4351	–114.9586	682,983	4,034,143
GV-DUKE-WS1	Garnet Valley	36.3890	–114.9230	686,286	4,029,104
GV-Duke-WS2	Garnet Valley	36.3890	–114.9239	686,199	4,029,097
GV-MIRANT1	Garnet Valley	36.4186	–114.9576	683,115	4,032,318
GV-PW-WS1	Garnet Valley	36.4110	–114.9629	682,654	4,031,460
LDS Central	Muddy River Springs Area	36.7227	–114.7144	704,114	4,066,544
LDS East	Muddy River Springs Area	36.7231	–114.7103	704,479	4,066,594
LDS West	Muddy River Springs Area	36.7278	–114.7296	702,746	4,067,083
Lewis 2	Muddy River Springs Area	36.7355	–114.7339	702,339	4,067,921
MW-1A	Lower Meadow Valley Wash	36.9147	–114.6677	707,764	4,087,945
MX-5	Coyote Spring Valley	36.7951	–114.8919	688,084	4,074,219
MX-6	Muddy River Springs Area	36.7676	–114.7873	697,482	4,071,381
PAIUTES M1	California Wash	36.6376	–114.7124	704,517	4,057,109
PAIUTES M2	California Wash	36.4932	–114.8136	695,836	4,040,876
Perkins Production	Muddy River Springs Area	36.7103	–114.6972	705,693	4,065,206
REPUBLIC WELL #1	Muddy River Springs Area	36.7111	–114.6953	705,950	4,065,126
CHEM LIME NEW	Garnet Valley	36.3634	–114.8986	687,757	4,026,573
CHEM LIME OLD	Garnet Valley	36.3884	–114.8964	687,950	4,029,343
REPUBLIC WELL #2	Garnet Valley	36.3754	–114.8659	690,680	4,027,900
REPUBLIC WELL #5	Garnet Valley	36.3910	–114.8617	691,059	4,029,635
REPUBLIC WELL #6	Garnet Valley	36.3612	–114.8673	690,559	4,026,328
BEHMER	Muddy River Springs Area	36.7107	–114.6944	706,025	4,065,079
GV-RW-1	Garnet Valley	36.4543	–114.8407	692,932	4,036,653

Table 2. Location of selected wells in Tule Desert and surrounding hydrographic areas.—Continued

[HA, hydrographic area (Harrill and others, 1988); LAT, latitude; LONG, longitude; UTM_X, Universal Transvers Mercator projection, horizontal coordinate in east-west (X) direction; UTM_Y, Universal Transverse Mercator projection, horizontal coordinate in north-south (Y) direction]

Well name	HA name	LAT	LONG	UTM_X	UTM_Y
LEWIS 1	Muddy River Springs Area	36.7383	–114.7368	702,237	4,068,143
LEWIS 3	Muddy River Springs Area	36.7372	–114.7399	701,954	4,068,019
LEWIS 4	Muddy River Springs Area	36.7336	–114.7391	702,025	4,067,618
LEWIS 5	Muddy River Springs Area	36.7323	–114.7372	702,194	4,067,484
NV COGEN EBM-4	Black Mountains Area	36.2936	–114.8758	689,791	4,018,839
NV COGEN EBP-2	Black Mountains Area	36.2916	–114.8776	689,635	4,018,612
NV COGEN EGV-3	Black Mountains Area	36.2952	–114.8750	689,865	4,019,012
PW-1	Tule Desert	37.0748	–114.3029	739,559	4,107,457
PW-2	Tule Desert	37.0791	–114.3164	738,353	4,107,930
FF-1	Tule Desert	37.0250	–114.3016	739,676	4,101,938
FF-2b	Tule Desert	36.9824	–114.3098	738,944	4,097,209
MW-7	Tule Desert	37.1435	–114.2418	745,029	4,115,076
MW-6	Tule Desert	37.1796	–114.1736	751,130	4,119,075
MW-10	Tule Desert	37.2675	–114.2226	746,742	4,128,822
TWS-B	Tule Desert	37.0522	–114.3290	737,225	4,104,952
TWS-A	Tule Desert	37.0403	–114.3204	737,997	4,103,628
TWS-D	Tule Desert	37.1202	–114.3007	739,761	4,112,496
TTW-1[a]	Tule Desert	37.1435	–114.2418	745,029	4,115,076

[a]Coordinates of nearby well MW-7 used for location of well TTW-1.

Table 3. Well name and associated pumping center.

[Pumping Center, arbitrary grouping of production wells completed in the carbonate aquifer and pumped concurrently with MX-5 during Order 1169 aquifer test]

Well Name	Pumping Center
MX-5	MX-5
CSI-1	Q_CSI-ALL
CSI-2	Q_CSI-ALL
CSI-3	Q_CSI-ALL
CSI-4	Q_CSI-ALL
ARROW CANYON 1	Q_East
ARROW CANYON 2	Q_East
BEHMER	Q_East
PERKINS PRODUCTION	Q_East
LDS CENTRAL	Q_East
LDS EAST	Q_East
LDS WEST	Q_East
LEWIS 1	Q_East
LEWIS 2	Q_East
LEWIS 3	Q_East
LEWIS 4	Q_East
LEWIS 5	Q_East
MX-6	Q_East
CHEM LIME NEW	Q_South
CHEM LIME OLD	Q_South
GV-MIRANT1	Q_South
GV-PW-WS-1	Q_South
GV-DUKE-WS-1	Q_South
GV-DUKE-WS-2	Q_South
GV-RW-1	Q_South
NV COGEN EBM-4	Q_South
NV COGEN EBP-2	Q_South
NV COGEN EGV-3	Q_South
REPUBLIC WELL #1	Q_South
REPUBLIC WELL #2	Q_South
REPUBLIC WELL #5	Q_South
REPUBLIC WELL #6	Q_South

Maximum drawdowns from well MX-5 approximately delineate where the carbonate aquifer is relatively transmissive (fig. 1). Drawdowns of more than 1 foot (ft) were detected 25 miles south and 9 miles east of well MX-5 in wells GV-1 and CSV-2, respectively. Drawdown was not detected 15 miles northeast of well MX-5 in well MW-1A, which is consistent with less transmissive rocks between wells CSV-2 and MW-1A. The delineated area of more transmissive rocks generally agrees with the transmissivity distribution in the Tetra Tech model (fig. 3) and contradicts the transmissivity distribution in the Mock model (fig. 2).

The Tetra Tech model better approximates the hydraulic diffusivity in Tule Desert and surrounding hydrographic areas than the Mock model and is more appropriate for estimating drawdowns from proposed groundwater development. This is because transmissivity estimates from aquifer tests in Tule Desert are more comparable to simulated transmissivities in the Tetra Tech model. The Tetra Tech model also honors a well-substantiated conceptual model of groundwater flow in the study area (Eakin, 1966; Dettinger and others, 1995), whereas the Mock model does not.

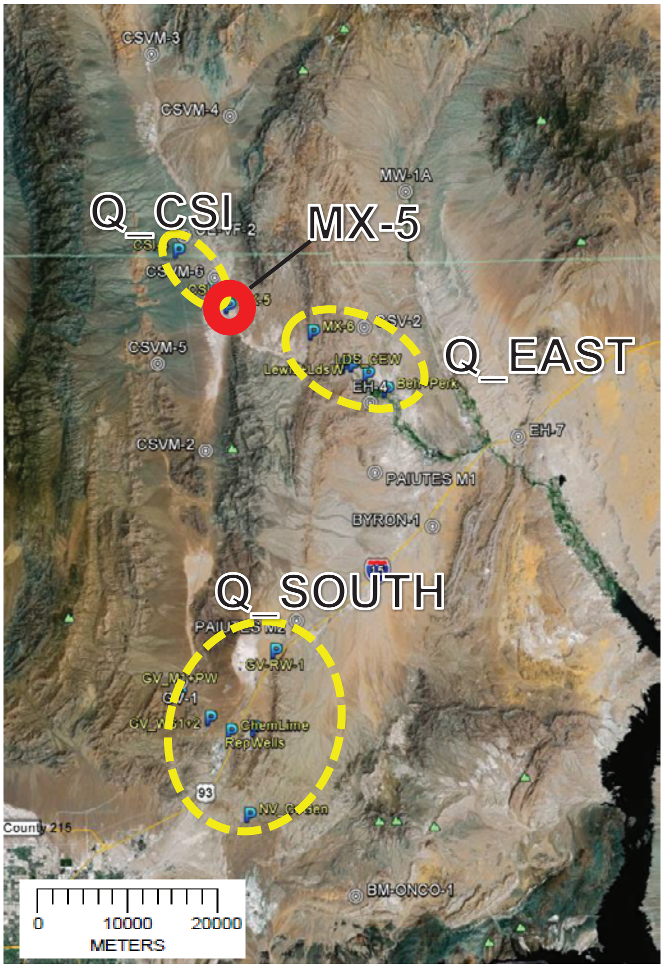

Figure 6. Pumping centers around the MX-5 well.

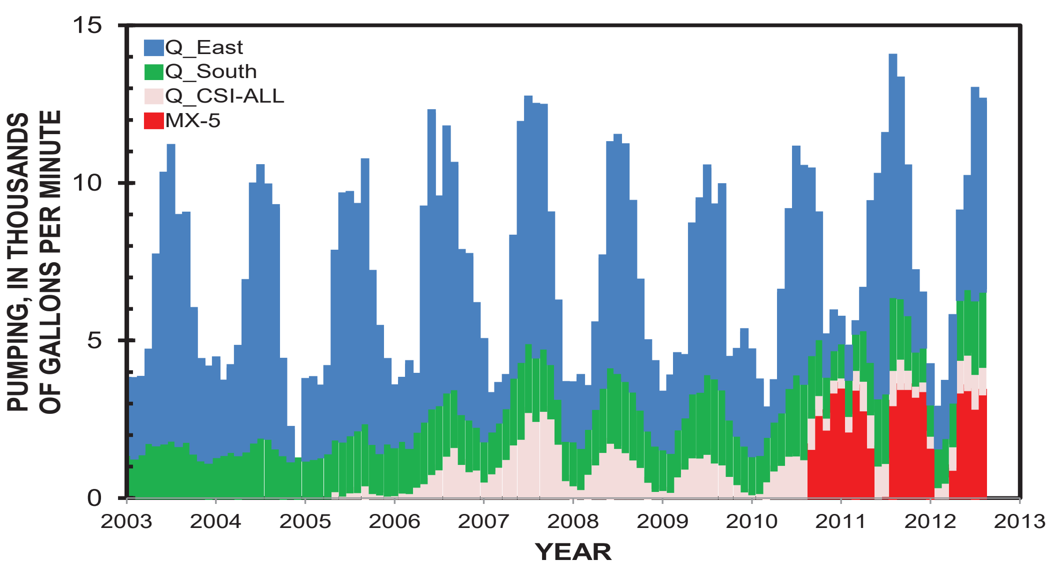

Figure 7. Monthly pumpage from Q_East, Q_South, Q_CSI, and well MX-5 between January 2003 and August 2012.

Simulated Drawdowns in Tule Desert

Drawdowns from pumping 6,000 acre-feet per year (acre-ft/yr) from Tule Desert during a 100-year period were simulated with the Tetra Tech model. Water was pumped from four wells that were mapped in a draft environmental assessment, DOI-BLM-NV-L030-2013-0006-EA (Bureau of Land Management, 2013). Well PW-2 exists, and the other three wells are proposed (table 4). Pumping was distributed equally between the four wells and was pumped from layers 6, 7, and 8 with the multi-node well (MNW) package (Halford and Hanson, 2002).

The maximum extent of simulated drawdowns greater than 10 ft was about 10 miles south and west of the pumping wells (fig. 8). Simulated drawdowns greater than 10 ft propagated less than 4 miles north and east of pumping well TWS-D because of decreases in transmissivity. Drawdowns greater than 100 ft were simulated beneath all of Tule Desert south of well TWS-D after pumping 600,000 acre-ft during the 100-year stress period.

Table 4. Points of diversion, locations, pumped intervals, and pumping rates for existing (PW-2) and proposed (TWS-B, -A, and -D) wells used in the Tetra Tech model to simulate drawdown over a 100-year period.

[acre-ft/yr, acre-foot per year; UTM_X, Universal Transvers Mercator projection, horizontal coordinate in east-west (X) direction; UTM_Y, Universal Transverse Mercator projection, horizontal coordinate in north-south (Y) direction; Q, equals production well discharge]

Well name	UTM_X	UTM_Y	Column	Row	Layer	Q, acre-ft/yr
PW-2	738,353	4,107,930	177	45	6 to 8	1,500
TWS-B	737,225	4,104,952	177	47	6 to 8	1,500
TWS-A	737,997	4,103,628	177	47	6 to 8	1,500
TWS-D	739,761	4,112,496	178	41	6 to 8	1,500

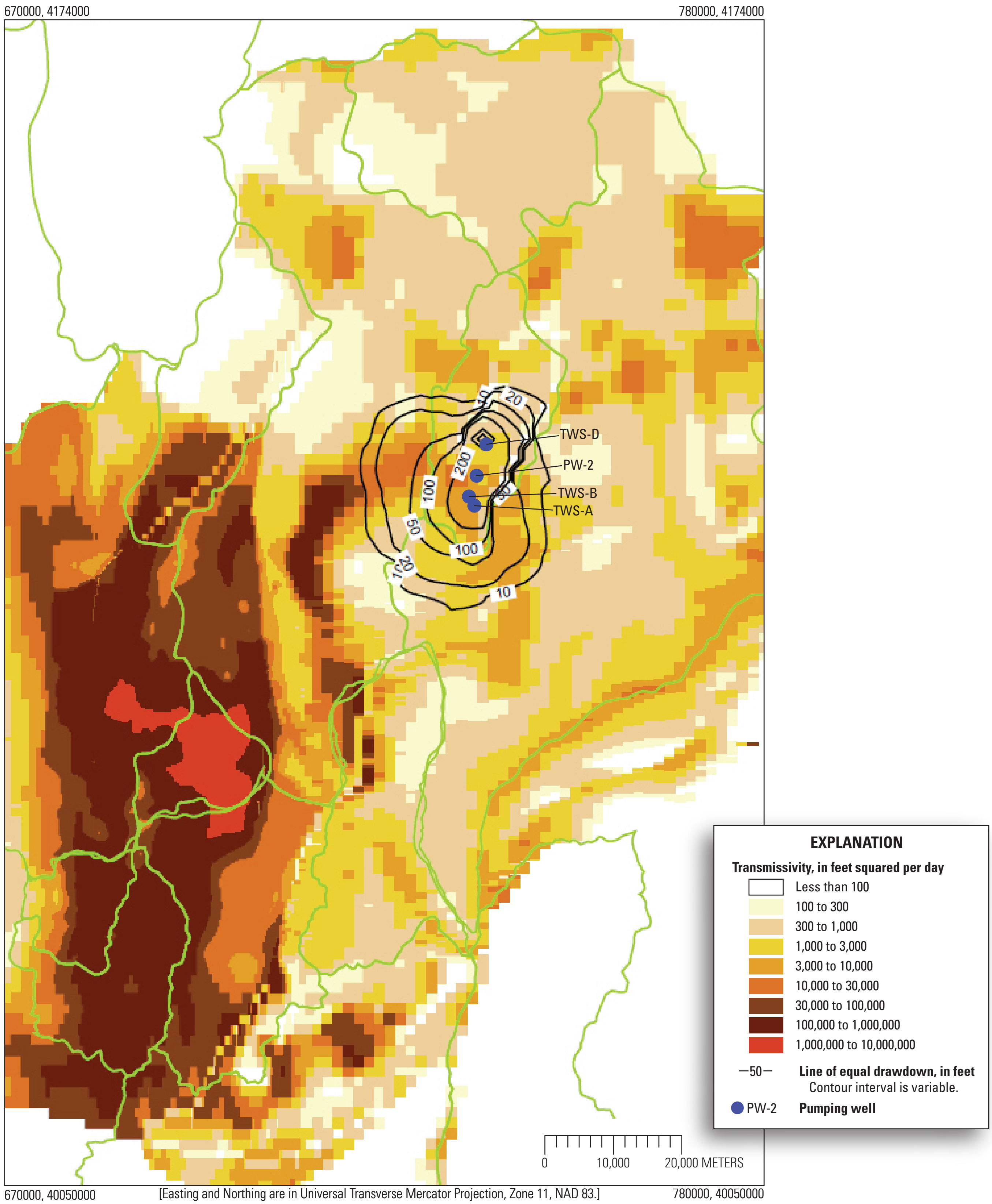

Figure 8. Simulated drawdown in layer 8 after 100 years of pumping four wells at 1,500 acre-ft/yr and transmissivity distribution from Tetra Tech model in Tule Desert, Nevada, study area.

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Appendix 1. Estimated Drawdowns, Regional Pumping Rates, and Pumping Rates From the 15 Observation Wells

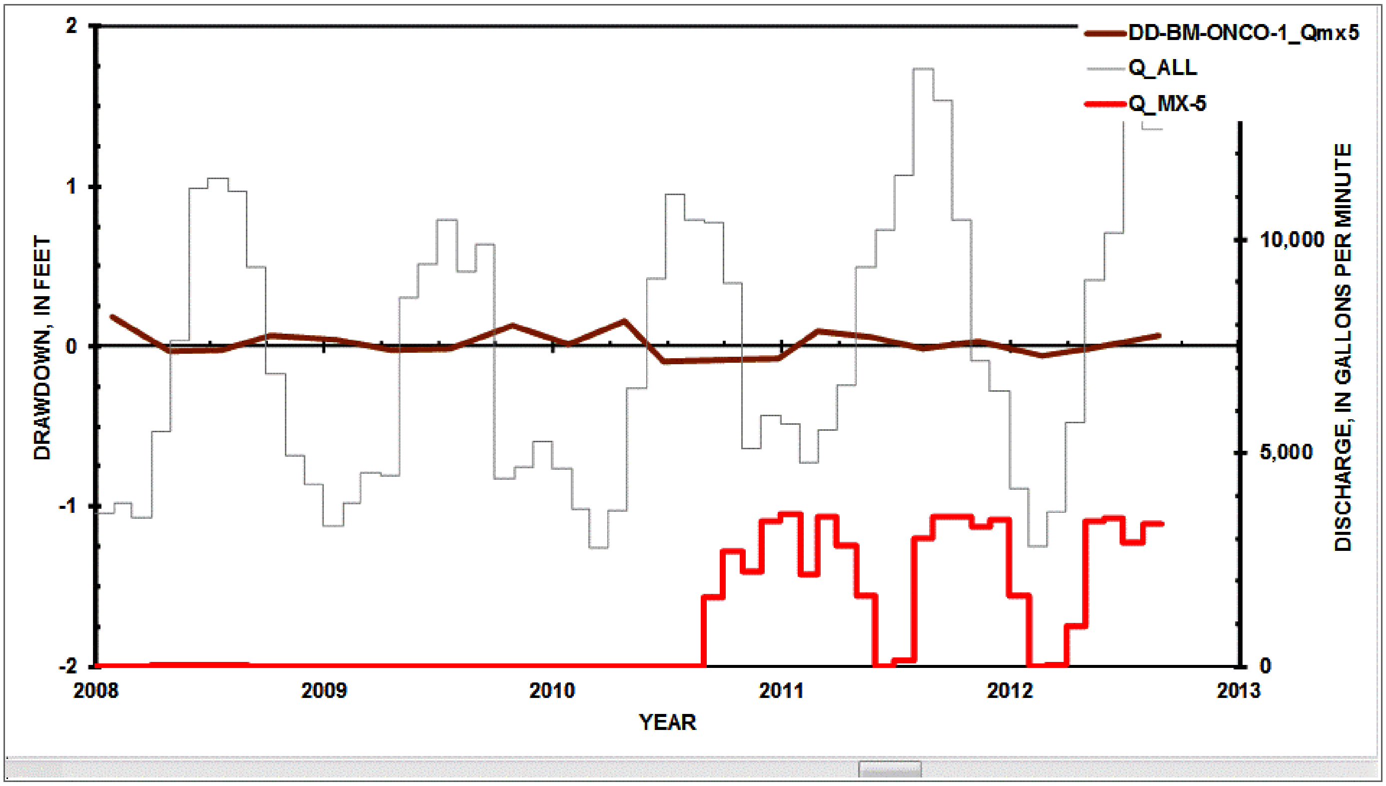

Figure 1–1. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well BM-ONCO-1 (DD-BM-ONCO-1_Qmx5).

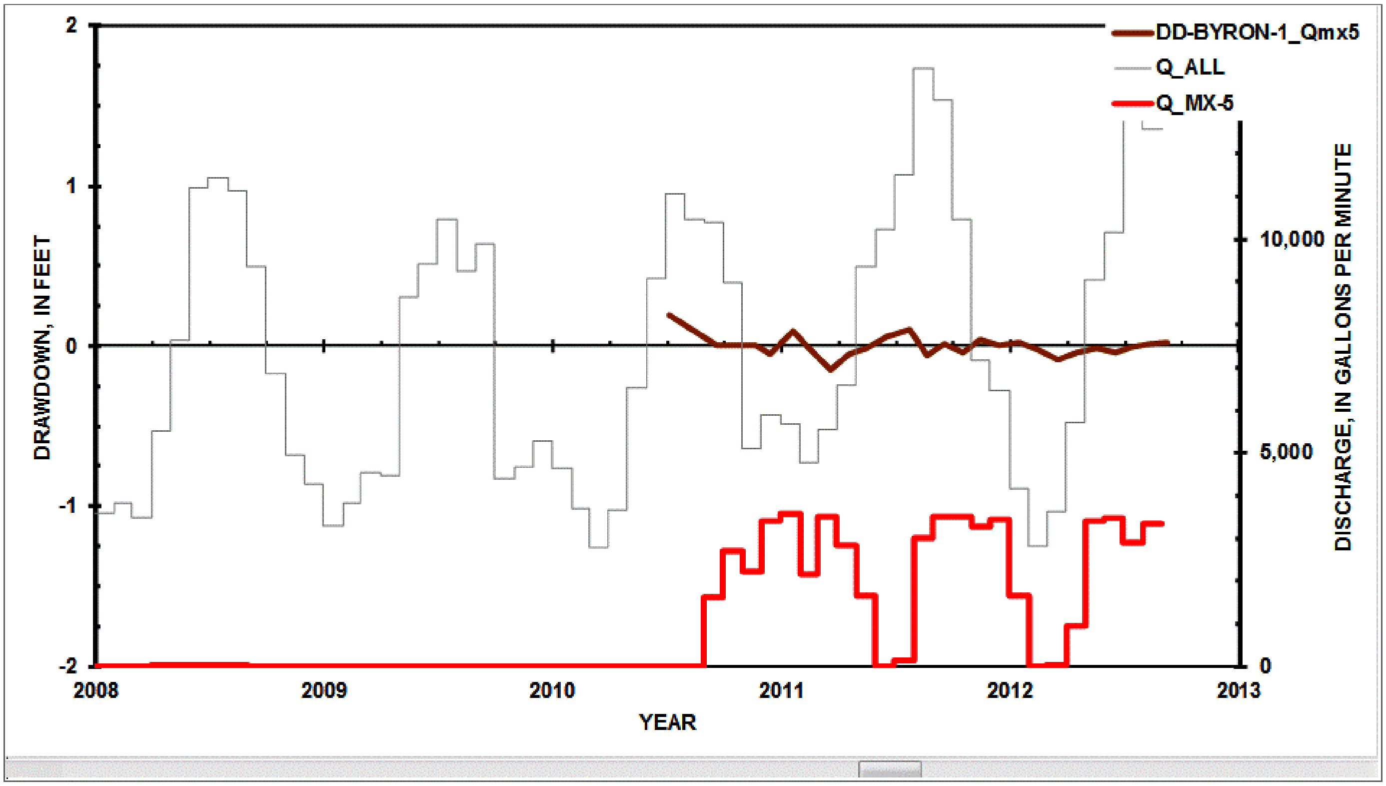

Figure 1–2. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well BYRON-1 (DD-BYRON-1_Qmx5).

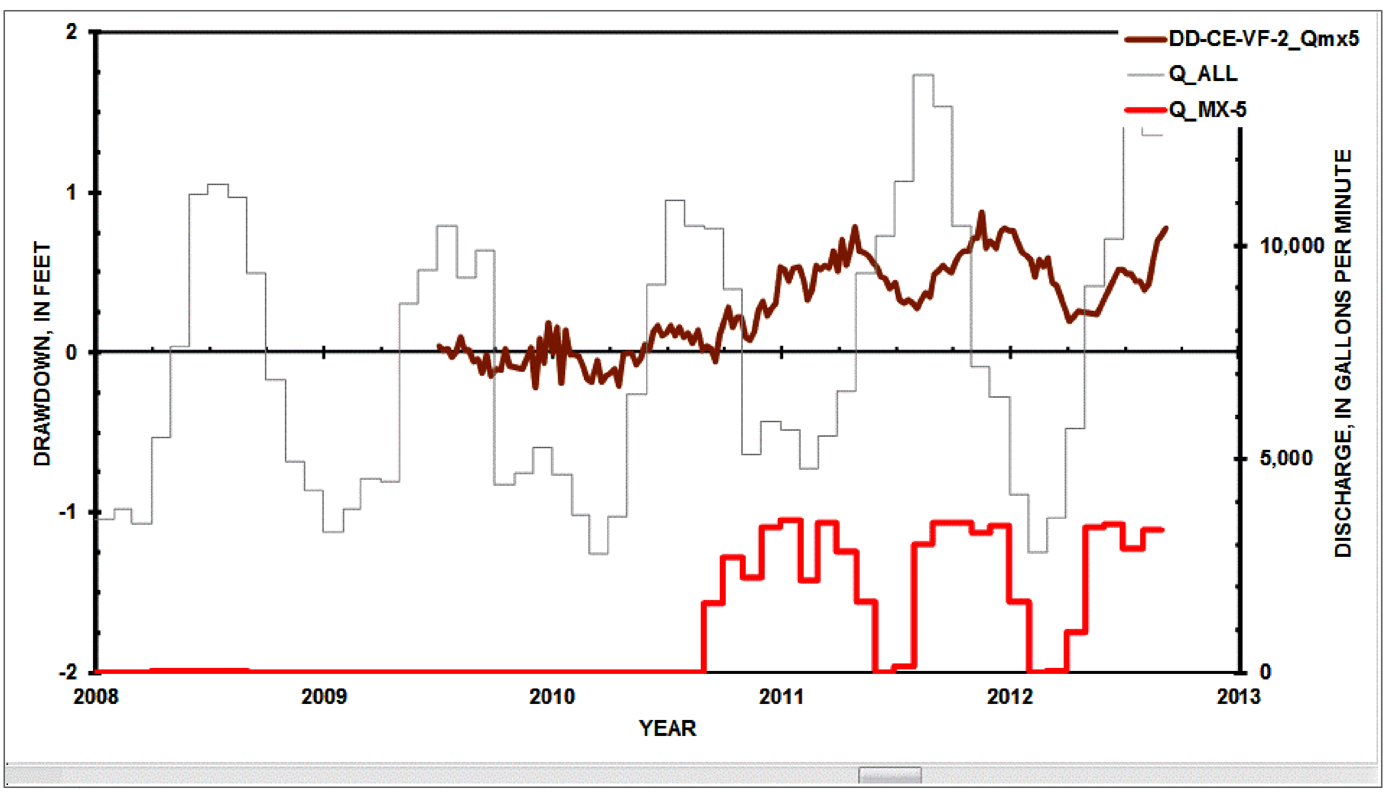

Figure 1–3. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CE-VF-2 (DD-CE-VF-2_Qmx5).

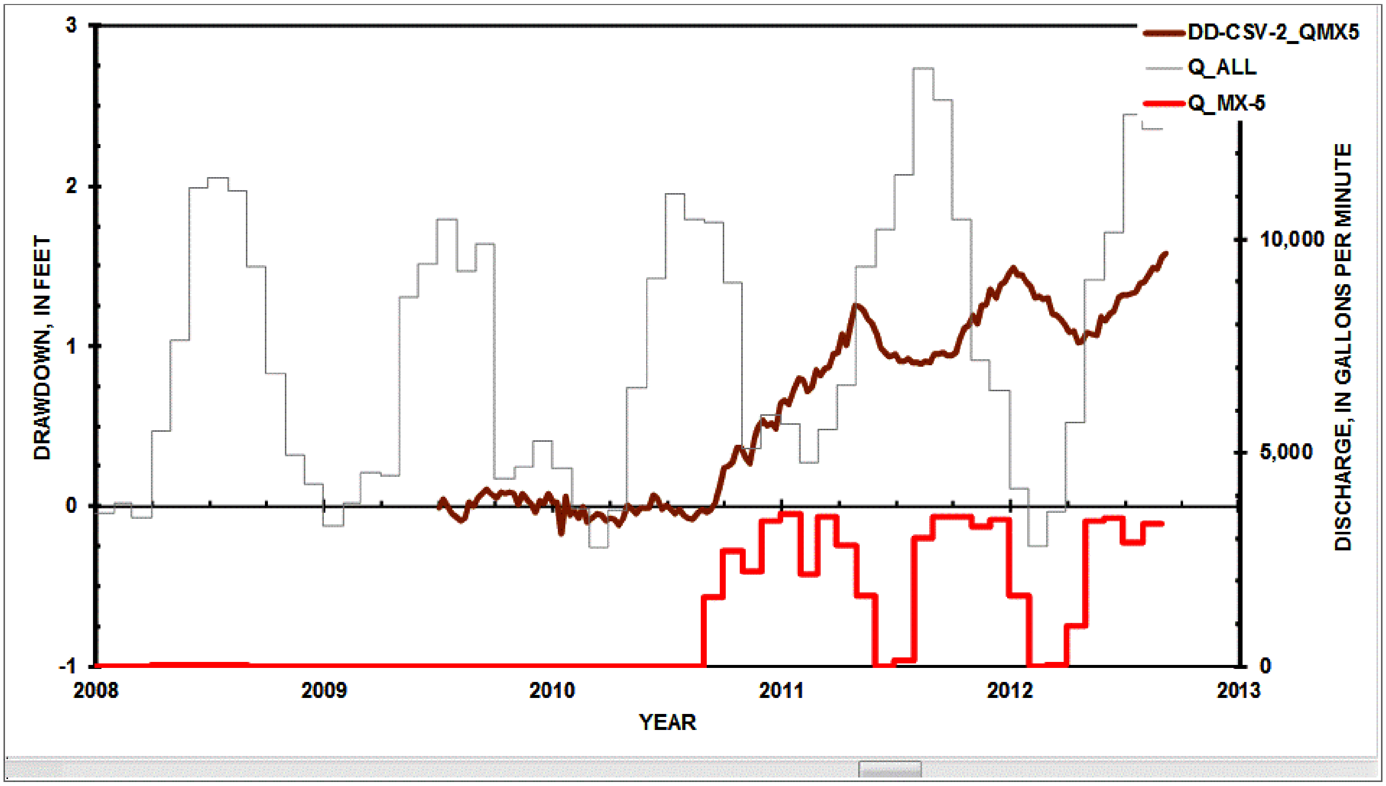

Figure 1–4. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSV-2 (DD-CSV-2_QMX5).

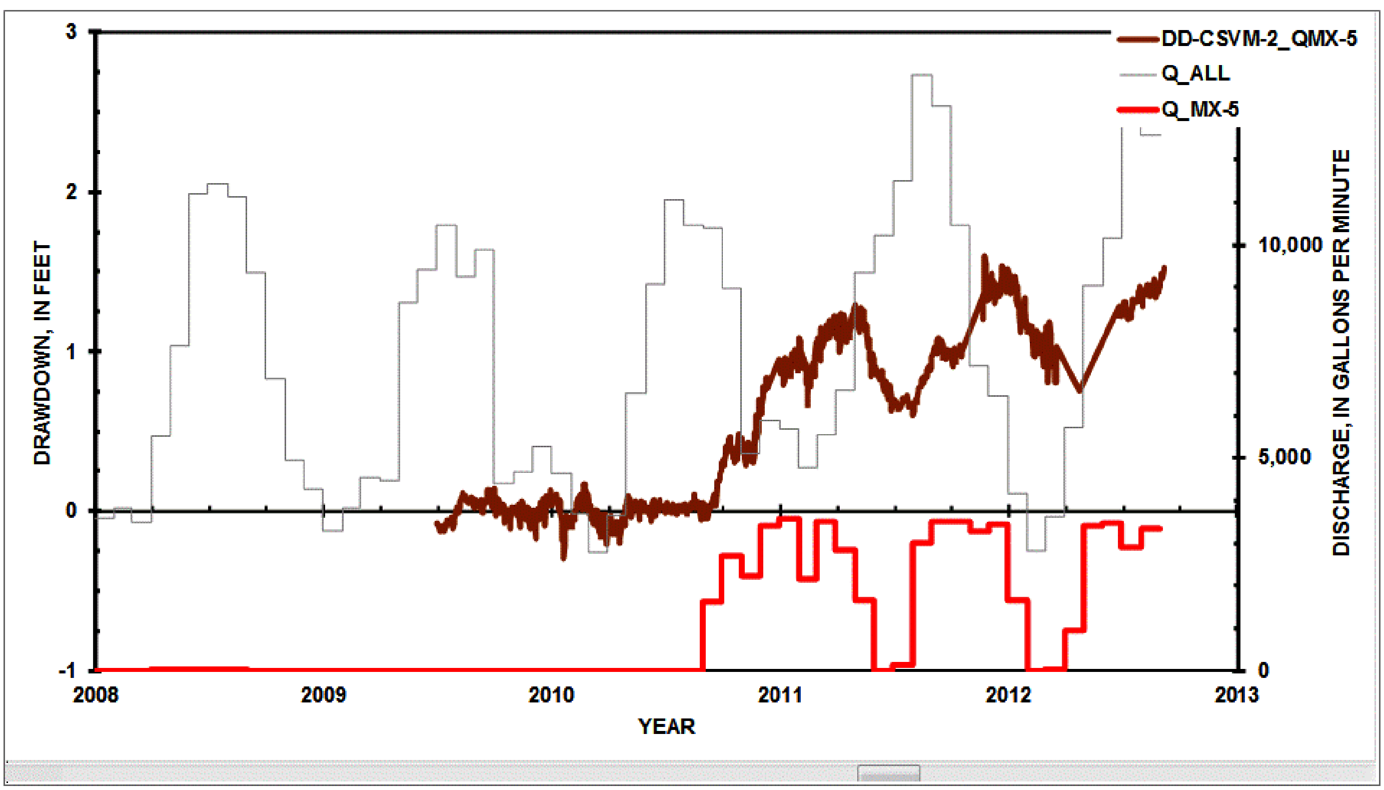

Figure 1–5. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSVM-2 (DD-CSVM-2_QMX-5).

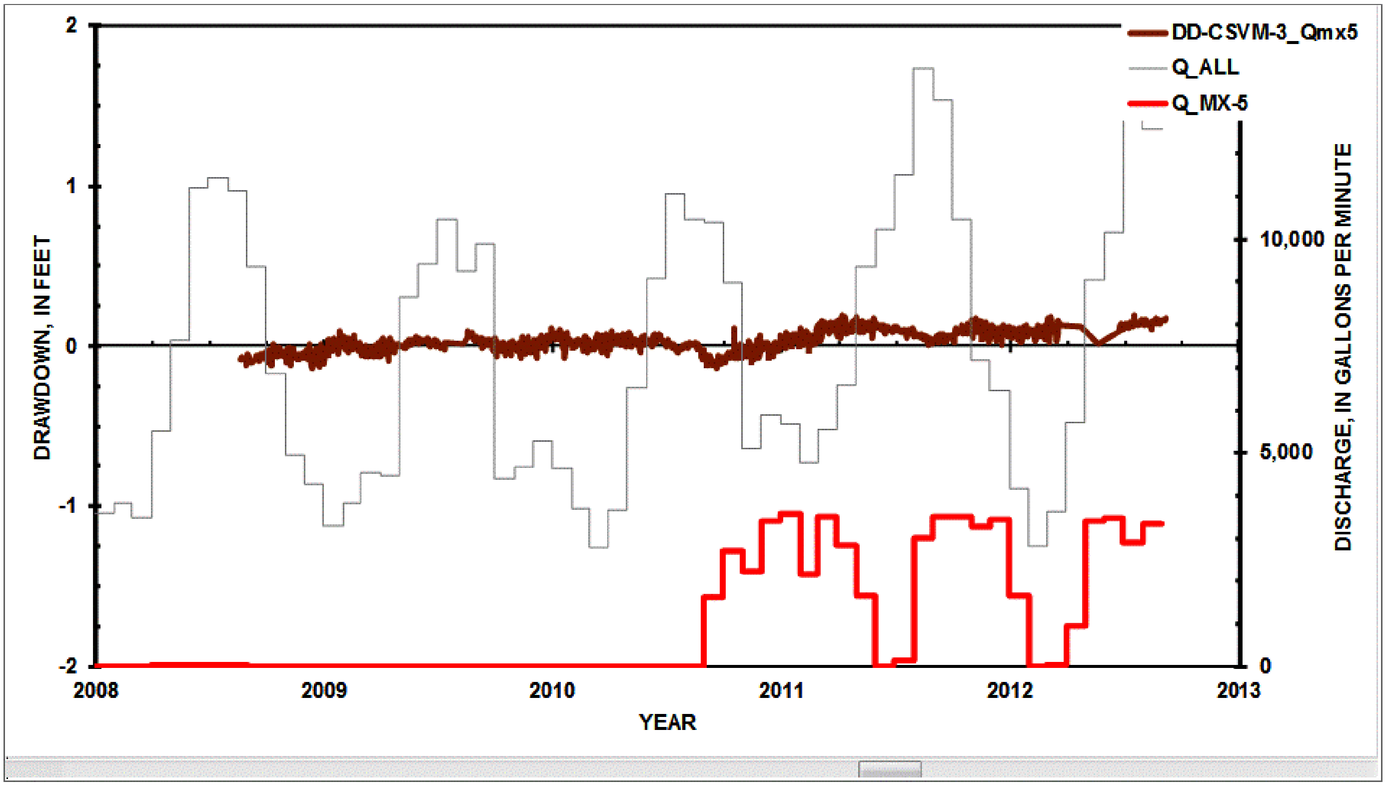

Figure 1–6. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSVM-3 (DD-CSVM-3_Qmx5).

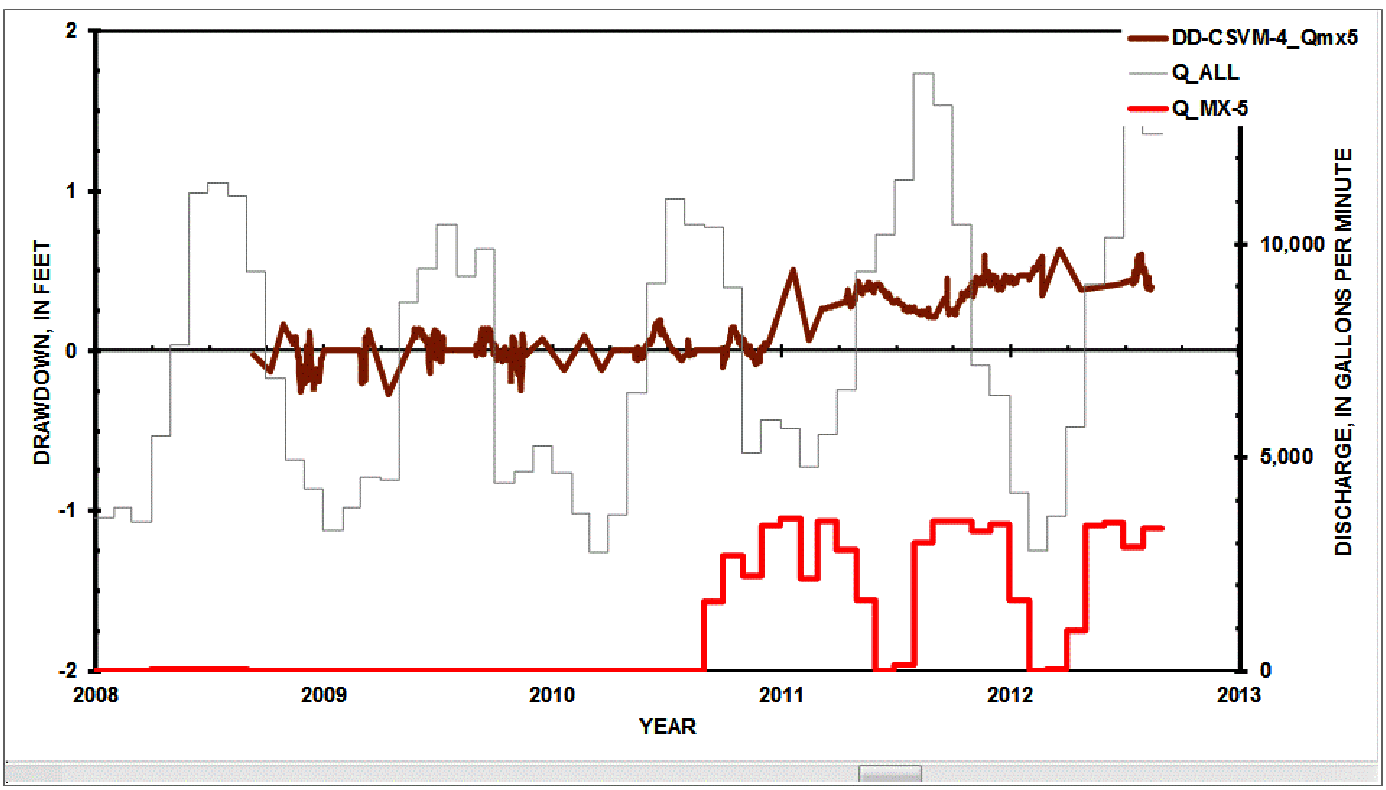

Figure 1–7. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSVM-4 (DD-CSVM-4_Qmx5).

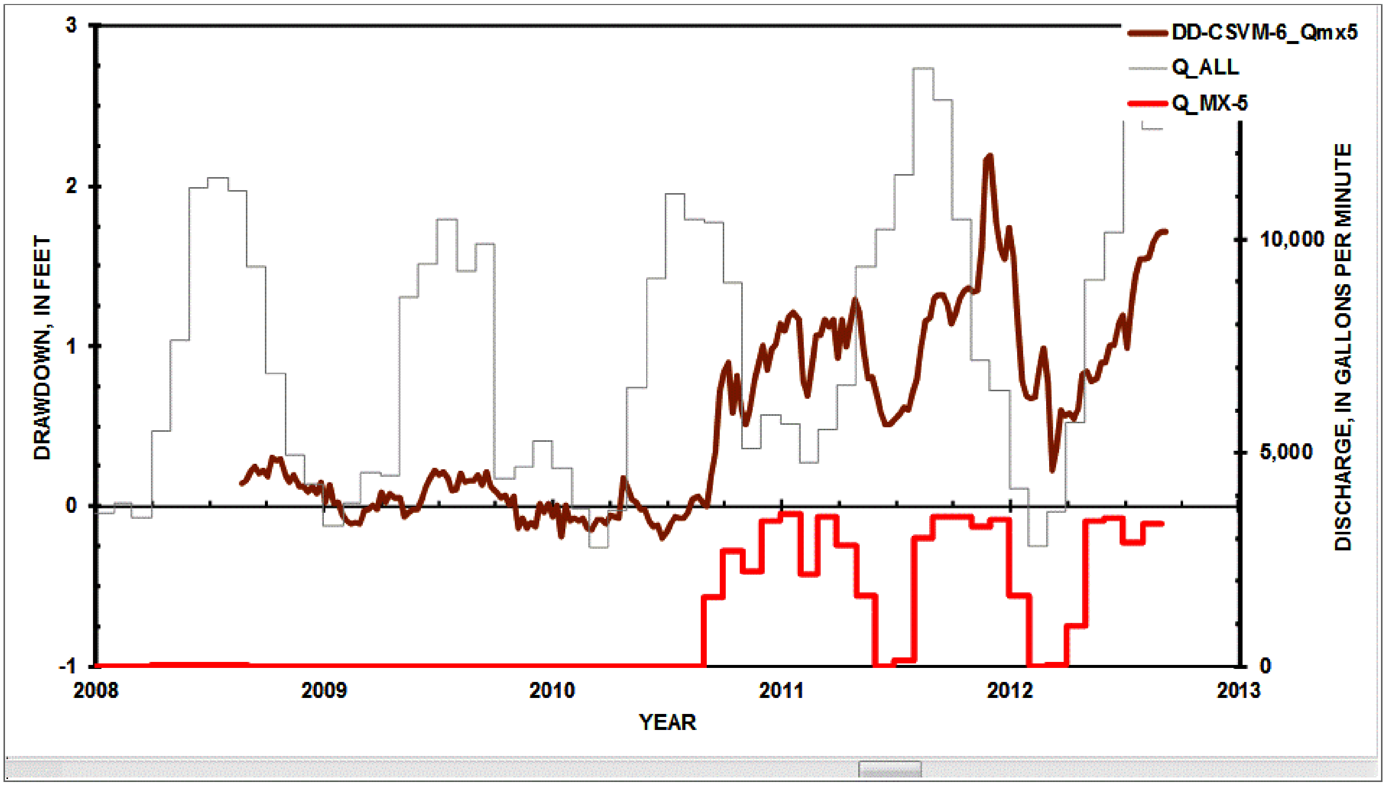

Figure 1–8. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSVM-6 (DD-CSVM-6_Qmx5).

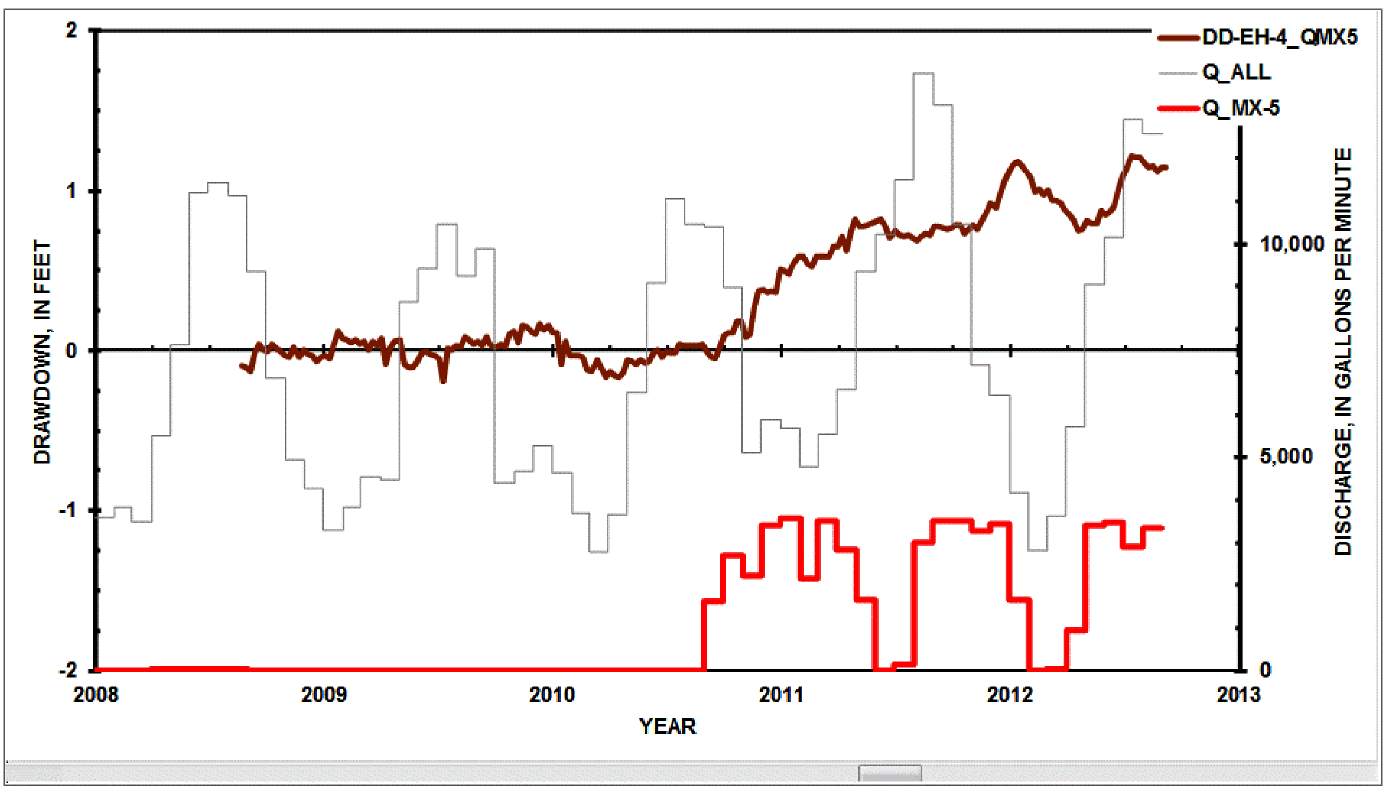

Figure 1–9. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well EH-4 (DD-EH-4_QMX5).

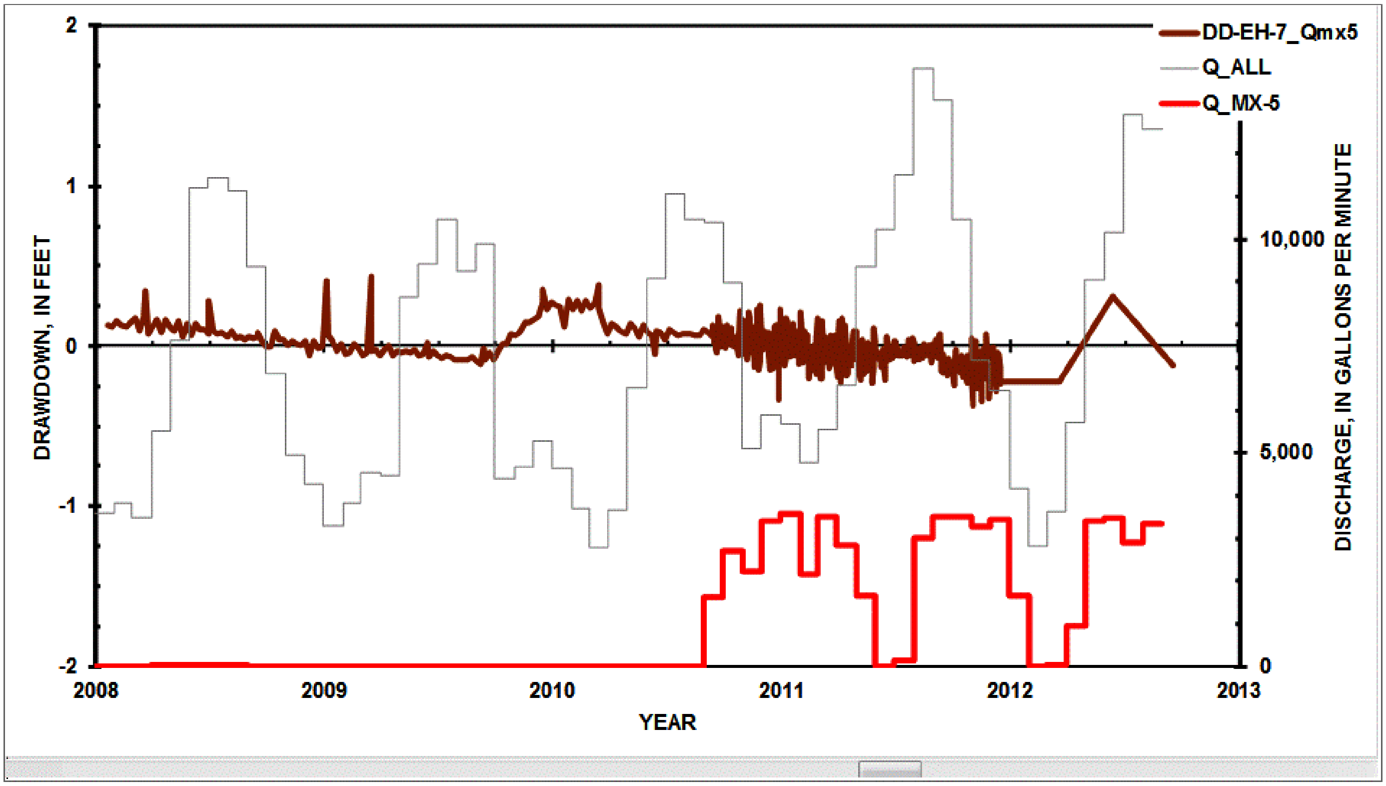

Figure 1–10. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well EH-7 (DD-EH-7_Qmx5).

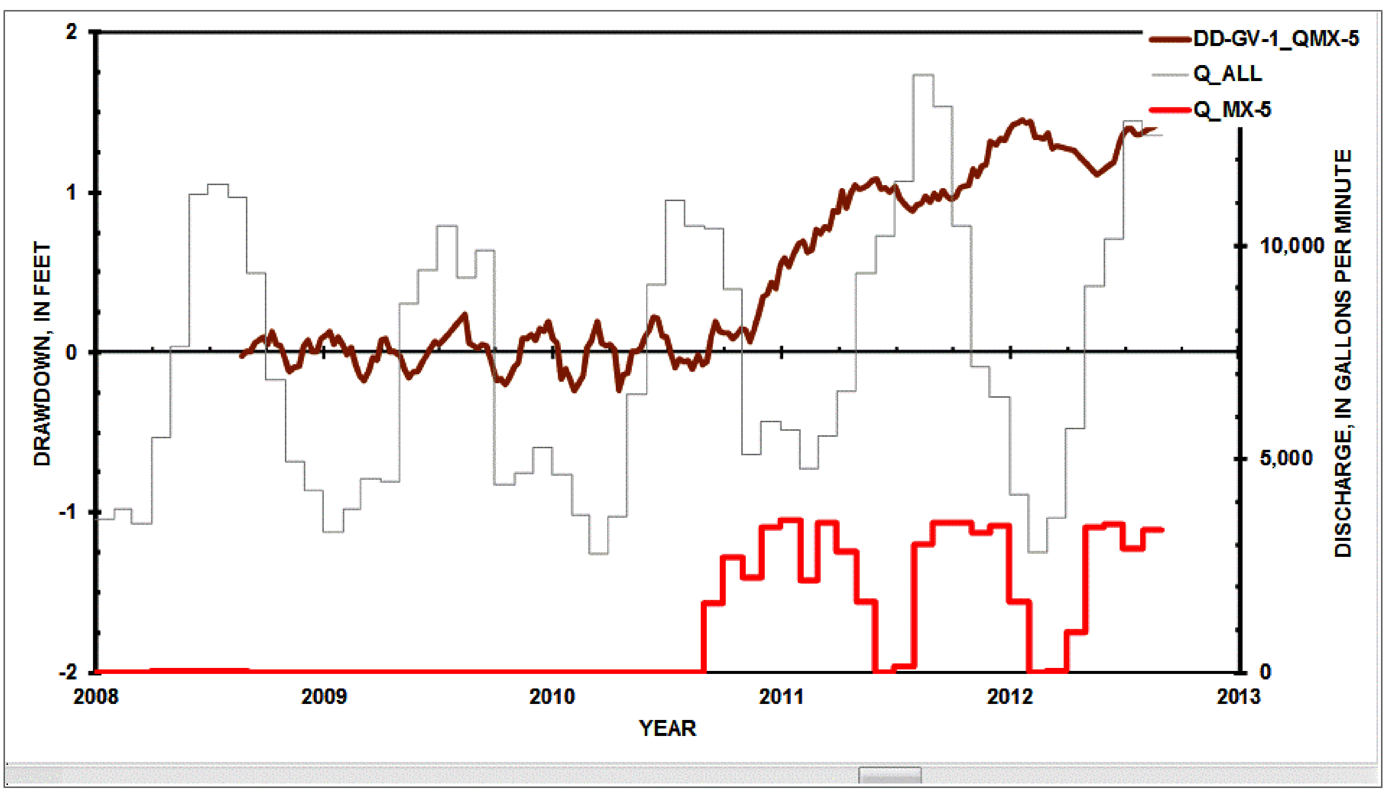

Figure 1–11. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well GV-1 (DD-GV-1_QMX5).

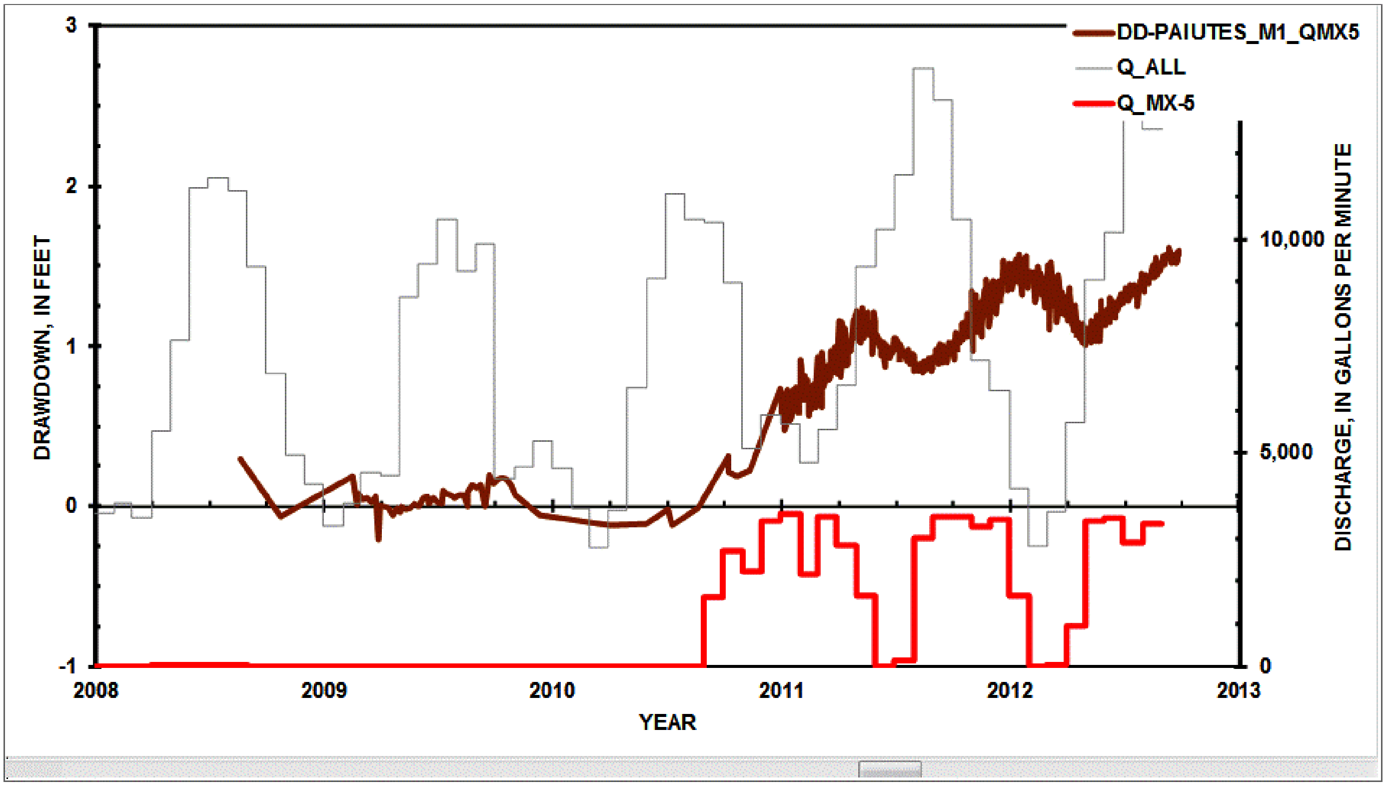

Figure 1–12. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well PAIUTES_M1 (DD-PAIUTES_M1_QMX5).

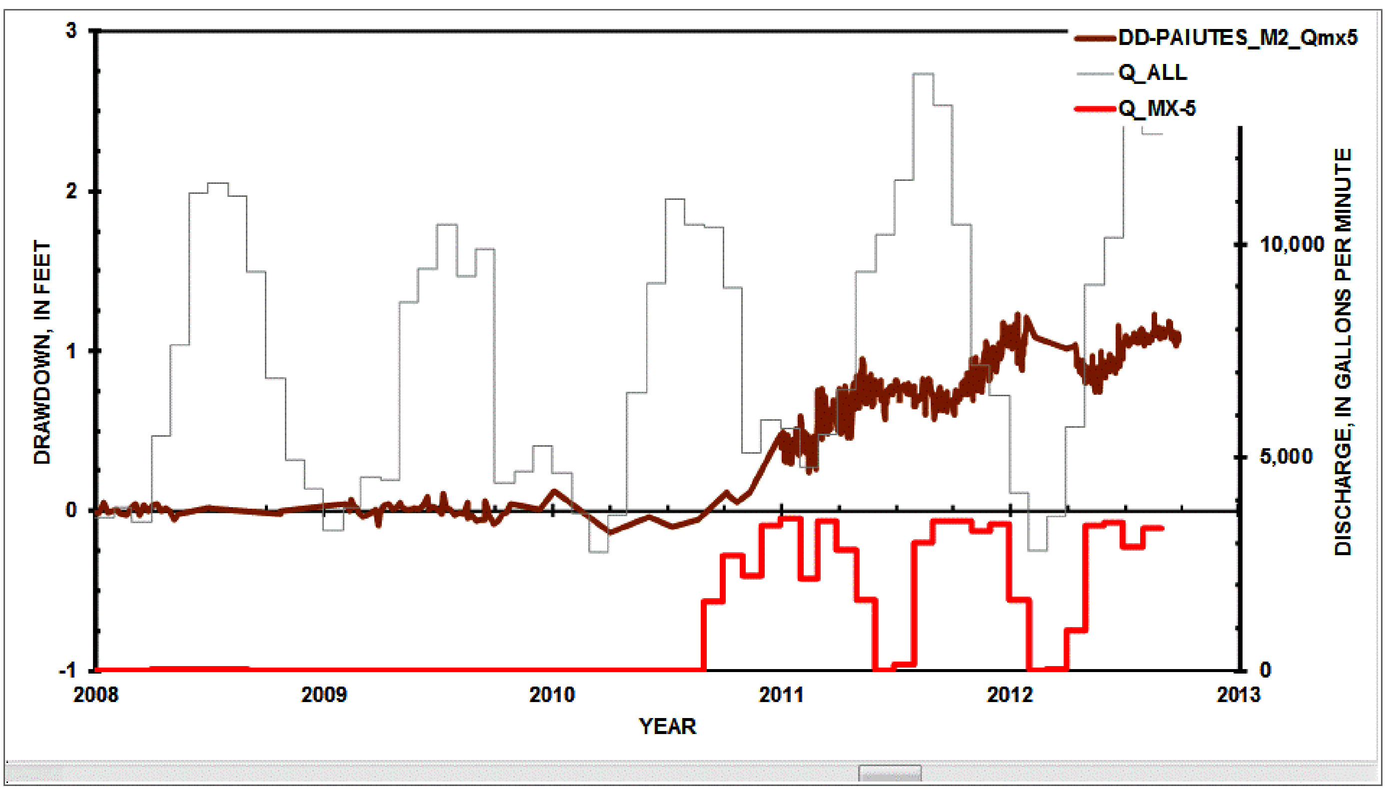

Figure 1–13. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well PAIUTES_M2 (DD-PAIUTES_M2_Qmx5).

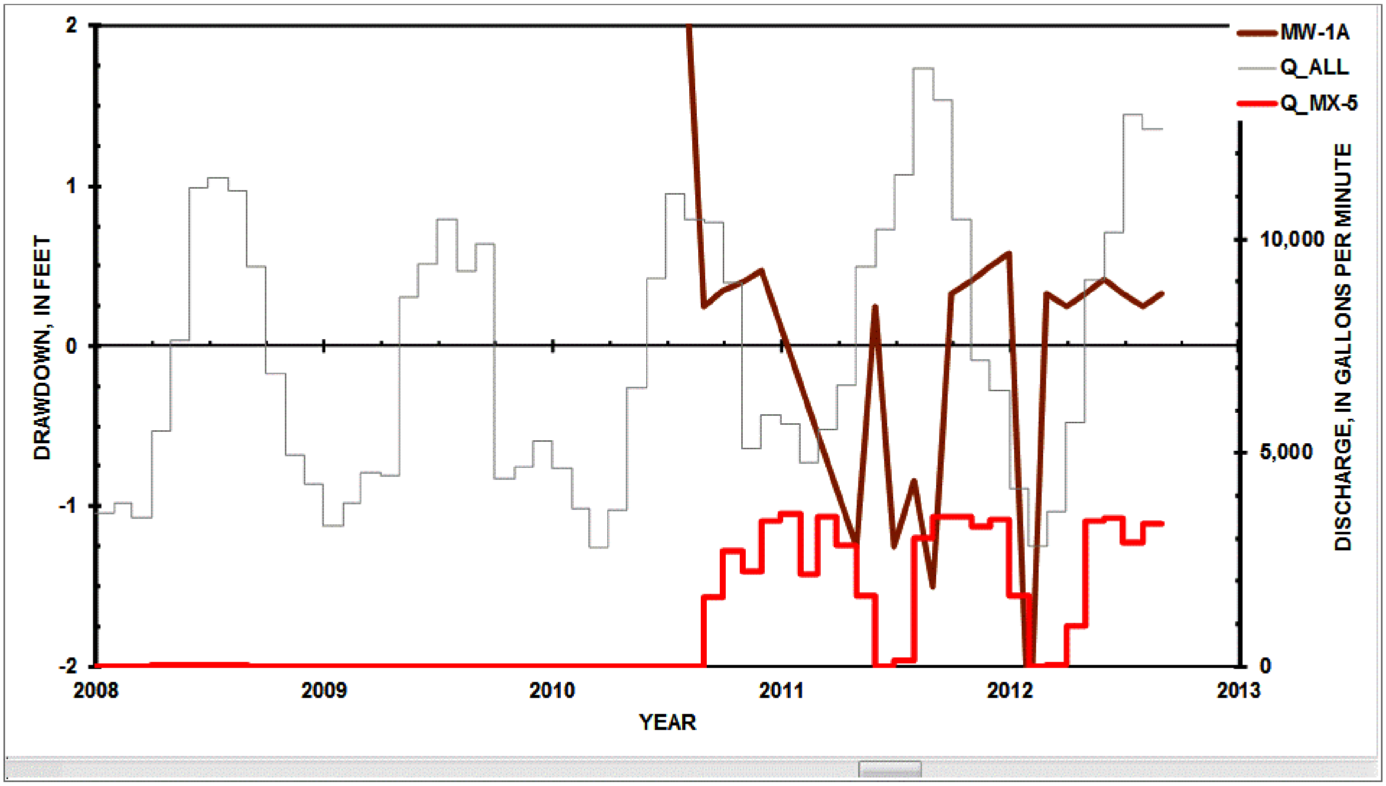

Figure 1–14. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well MW-1A.

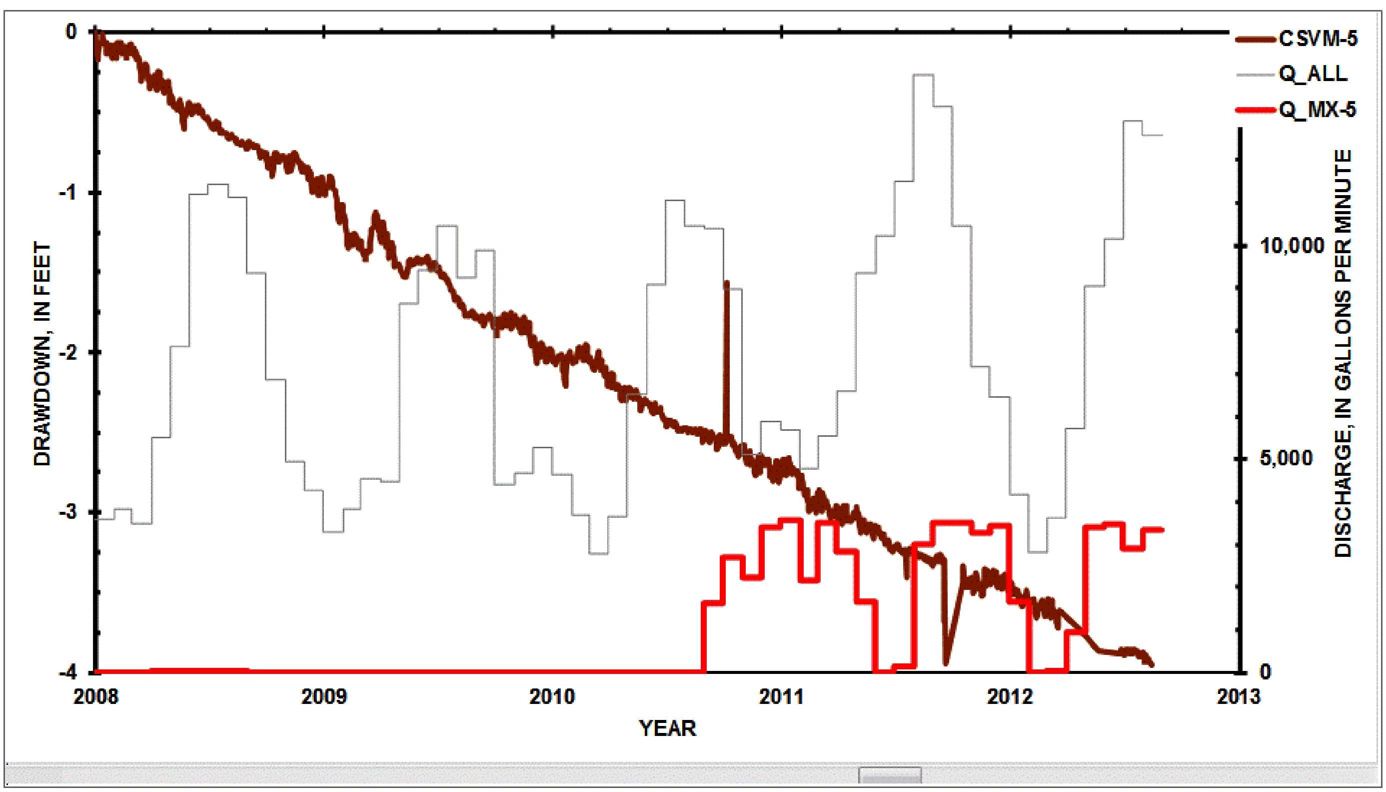

Figure 1–15. Estimated discharge from well MX-5 (Q_MX-5) and all pumping centers (Q_ALL), and simulated drawdown for well CSVM-5.

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