GAM run 03-03

By **Richard M. Smith**
Texas Water Development Board
Groundwater Availability Modeling Section
512- 936-0877
May 15, 2003

REQUESTOR:

Mr. Will Evans, D.V.M., Greater Gardendale Water Supply Corporation

DESCRIPTION OF REQUEST:

What is the effect of increasing production from 6 million gallons per month to 12 million gallons per month in a western Midland County well field and furthermore, would it be possible to produce 16 million gallons per month from the well field?

DATA:

- Rough diagram of the well field and an approximate location relative to two major roads
- Depths of six of the thirteen wells in the field and the saturated thickness for each
- Tested production rates for nine of the thirteen wells
- Anecdotal drawdown level associated with 10 million gallons per month pumping
- Proposed increase in pumping

METHODOLOGY:

- Application of an analytical model to determine the possible result of increased pumping.

PARAMETERS AND ASSUMPTIONS:

- Mr. Evans supplied a map of the well field with locations of the thirteen wells relative to one another, but not actual latitude-longitude locations. The well field is located approximately two miles west of Hwy 1788 and four miles north of Hwy 191 on the Midland County boundary. Based on the approximate location and well depths, we believe the well field under investigation probably derives its water from the Antlers Formation which is the lowest unit of the Edwards-Trinity Plateau aquifer and not the Ogallala aquifer. The Ogallala aquifer is in direct hydraulic connection with the Edwards-Trinity Plateau aquifer, but is very thin, probably less than 30-40 feet. We assigned a relative location to Well 13 located in the southwest corner of the well field and assigned the wells in the well field latitude-longitude values
- Mr. Evans supplied well depths and static water levels for wells PW8-PW13 (Note: all potential pumping wells in the field have been given the prefix PW). With known latitude-longitude, we assigned the surface elevations for each well and generated a

water surface map. We assigned locations to observation wells (O1-O9) to assess the effect of extended pumping outside the boundaries of the well field.

- Mr. Evans supplied us with information indicating the saturated thickness of the well field is on average 63 feet. No pumping tests with measured drawdown versus time were available. The only information about well performance was anecdotal evidence which suggests 30 feet of drawdown while pumping wells 1, 3, and 4 at 77 gallons per minute (gpm) during a 24-hour period. This pump rate converts to approximately 10 million gallons per month. The owner of the acreage is said to use 50 million gallons in a five month period each year for agricultural purposes.
- We used the time-drawdown information provided by Mr. Evans to calculate an estimate of 3,696 gallons per day per foot (gpd/ft) for the transmissivity. This estimate is a result of plotting a time-drawdown curve on six-cycle semilogarithmic paper starting with a static water level of 63 feet at initial time zero and ending with thirty feet of drawdown after 1440 minutes. Transmissivity is then calculated using a modified nonequilibrium equation T=(264*Q)/ delta *s* ; where delta *s* is the change in head from 10 minutes to 100 minutes after the pumping started. The value for delta *s* is 5.5 feet and Q = 77 gpm (See Graph 1). Starting with transmissivity equal 3,696 gpd/ft and using 0.01 for the initial value of the storage coefficient, which is consistent with a semi-confined aquifer, the model was run to check drawdown during the first 24 hour period. The drawdown generated by the model was slightly more than 27 feet. Based on these results, the storage coefficient was reduced to 0.004, which is still in keeping with a semi-confined aquifer. The next run indicated drawdown of 29.87 feet in 24 hours from each of the pumping wells. This is in agreement with reported results. Therefore, with the transmissivity at 3696 gpd/ft and the storage coefficient equal to 0.004, various model runs were conducted to ascertain the possible water-level declines of the well field with different pumping scenarios. Based on the analytical model, the maximum drawdown after five months was about 58 feet in pumping well 3, which may have enough saturated thickness to support continued pumping since no depth is given for this well. This result does give credence to the original owner's claim that 50 million gallons is capable of being pumped during a five month period (See Table 1 and Figures 1, 2, and 3).

RESULTS

- Table 2 and Figures 4, 5, and 6 illustrate the results of pumping from each of nine wells (3, 4, 6, 8, 9, 10, 11, 12, and 13) at a rate of about 15 gpm (gallons per minute) for a monthly total of approximately six million gallons. Maximum drawdown is less than 25 feet in well 8 at the end of ten months.
- Table 3 and Figures 7, 8, and 9 show the maximum drawdown at the end of two years is less than 57 feet in well 8, leaving a saturated thickness of more than 6 feet. This indicates the well field may be capable of producing 12 million gallons per month for an extended period. However, the development of the groundwater at this rate should be initiated only after a thorough assessment by qualified engineers and hydrogeologists.

- Table 4 gives the results of pumping at a monthly rate of 16 million gallons. This translates into about 41 gpm from each of the nine wells. Figures 10, 11, and 12 show the results in a graphical format. The blank area in the middle of Figure 12 represents where the aquifer has gone dry at that time. Sixteen million gallons per month does not appear to be sustainable for an extended period without an expansion of the well field and an increase in the total number of wells.

DISCUSSION:

- Based on the results, it may be possible that the well field can be pumped at 12 million gallons per month if the production is spread out among at least nine of the existing wells. However, this analysis is based on very limited information. We recommend a more detailed study that includes pumping tests and an assessment of the hydrogeology in the area.

Table1

TEXAS WATER DEVELOPMENT BOARD COMPUTER PROGRAM RS

WATER LEVEL DRAWDOWN IN A HOMOGENEOUS LEAKY AQUIFER

040403-01 RMS 042003 GROUNDWATER EVALUATION - 10 MYGALS/MONTH MIDLAND,TEXAS

= DATA = =

START OF PUMPING = 05 03

TOTAL NUMBER OF PUMPING PERIODS = 12

TRANSMISSIVITY (GPD/FT) = 3772.3

STORAGE COEFFICIENT - 0.004000

VERTICAL LEAKAGE FACTOR, P/M, (GPD/CU.FT.) = 0.0000000

TOTAL NUMBER OF PUMPING WELLS = 3

COORDINATE UNITS (FT/UNIT) = 1.

PUMPING WELLS --- AVERAGE PUMPING RATE (GPM)

WELL COORDINATES ELAPSED TIME (HOURS)---

NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.
PW03	4825.	3860.	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16
PW04	4195.	3485.	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16
PW01	6220.	3845.	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16	77.16

Drawdown in all wells- PW - Potential pumping wells and O - Observation wells

NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.
PW08	4390.	2720.	0.00	0.06	0.38	4.99	12.62	17.02	19.70	21.64	23.16	24.41	26.39	27.93
PW09	5890.	2255.	0.00	0.00	0.00	1.62	7.80	11.91	14.50	16.39	17.88	19.11	21.06	22.59
PW10	5395.	2030.	0.00	0.00	0.00	1.41	7.42	11.50	14.08	15.96	17.45	18.67	20.62	22.15

PW11	4120.	2105.	0.00	0.00	0.01	1.80	7.67	11.67	14.21	16.07	17.55	18.76	20.71	22.23
PW05	6205.	3185.	0.00	0.17	0.65	5.15	12.67	17.05	19.73	21.67	23.18	24.43	26.41	27.95
O1	6505.	1430.	0.00	0.00	0.00	0.29	3.80	7.14	9.43	11.16	12.56	13.72	15.59	17.07
O2	5005.	1430.	0.00	0.00	0.00	0.56	5.04	8.70	11.12	12.92	14.36	15.55	17.46	18.96
O3	3805.	1430.	0.00	0.00	0.00	0.49	4.39	7.82	10.14	11.89	13.29	14.46	16.34	17.83
O4	6505.	2930.	0.00	0.01	0.15	3.06	9.61	13.77	16.37	18.27	19.76	20.99	22.95	24.48
O5	5305.	2930.	0.00	0.01	0.14	4.97	13.26	17.81	20.56	22.52	24.06	25.32	27.32	28.87
O6	3805.	2930.	0.00	0.15	0.61	5.06	12.19	16.45	19.08	21.00	22.50	23.73	25.70	27.23
O7	6505.	4130.	0.00	0.98	2.00	6.87	13.98	18.24	20.88	22.79	24.30	25.54	27.50	29.04
O8	5005.	4130.	0.00	1.59	2.91	10.55	19.53	24.20	26.98	28.97	30.52	31.79	33.79	35.35
O9	3805.	4130.	0.00	0.09	0.50	5.51	13.04	17.39	20.06	21.99	23.50	24.74	26.72	28.26
PW01	6220.	3845.	21.98	27.80	29.44	35.53	43.39	47.82	50.52	52.47	53.99	55.24	57.23	58.77
PW02	5515.	3845.	0.00	0.25	1.10	8.44	17.38	22.04	24.82	26.81	28.36	29.62	31.63	33.19
PW03	4825.	3860.	21.98	27.90	29.90	38.57	47.70	52.38	55.17	57.16	58.71	59.98	61.99	63.55
PW04	4195.	3485.	21.98	27.90	29.89	37.76	46.20	50.73	53.47	55.43	56.96	58.22	60.21	61.77
PW06	4810.	3200.	0.00	0.32	1.25	8.46	17.25	21.88	24.65	26.63	28.18	29.44	31.44	33.00
PW07	6205.	2705.	0.00	0.00	0.05	2.68	9.42	13.64	16.26	18.17	19.67	20.91	22.87	24.41
PW12	4810.	1865.	0.00	0.00	0.00	1.26	6.92	10.90	13.44	15.30	16.78	17.99	19.93	21.45

PW13	6265.	1715.	0.00	0.00	0.00	0.56	4.96	8.60	11.01	12.80	14.23	15.42
17.33	18.83											

Table 2
TEXAS WATER DEVELOPMENT BOARD COMPUTER PROGRAM RS
WATER LEVEL DRAWDOWN IN A HOMOGENEOUS LEAKY AQUIFER

040403-01 RMS 042003 GROUNDWATER EVALUATION - 6 MYGALS/MONTH MIDLAND,TEXAS

= DATA = =
START OF PUMPING = 05 03
TOTAL NUMBER OF PUMPING PERIODS = 12
TRANSMISSIVITY (GPD/FT) = 3696.0
STORAGE COEFFICIENT - 0.004000
VERTICAL LEAKAGE FACTOR, P/M, (GPD/CU.FT.) = 0.0000000
TOTAL NUMBER OF PUMPING WELLS = 9
COORDINATE UNITS (FT/UNIT) = 1.

PUMPING WELLS --- AVERAGE PUMPING RATE (GPM)

WELL NO	COORDINATES X	Y	ELAPSED TIME (HOURS)--- 1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.
PW03	4825.	3860.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW04	4195.	3485.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW06	4810.	3200.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW08	4390.	2720.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW09	5890.	2255.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW10	5395.	2030.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW11	4120.	2105.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW12	4810.	1865.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43
PW13	6265.	1715.	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43	15.43

WELL	COORDINATES		ELAPSED TIME (HOURS)---											
NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.
O1	6505.	1430.	0.00	0.24	0.48	2.23	5.75	8.11	9.62	10.73	11.61	12.34	13.50	14.41
O2	5005.	1430.	0.00	0.14	0.42	3.15	7.68	10.30	11.91	13.07	13.98	14.73	15.91	16.84
O3	3805.	1430.	0.00	0.02	0.10	1.67	5.47	7.94	9.49	10.62	11.51	12.25	13.42	14.33
O4	6505.	2930.	0.00	0.00	0.05	1.49	5.33	7.82	9.37	10.51	11.40	12.14	13.31	14.23
O5	5305.	2930.	0.00	0.08	0.35	3.88	9.01	11.77	13.42	14.61	15.53	16.29	17.49	18.42
O6	3805.	2930.	0.00	0.08	0.34	3.15	7.65	10.27	11.87	13.03	13.93	14.68	15.87	16.79
O7	6505.	4130.	0.00	0.00	0.00	0.49	3.35	5.58	7.04	8.13	9.00	9.71	10.86	11.76
O8	5005.	4130.	0.00	0.32	0.61	2.74	6.73	9.23	10.79	11.93	12.82	13.56	14.73	15.65
O9	3805.	4130.	0.00	0.02	0.10	1.65	5.18	7.54	9.05	10.16	11.04	11.77	12.93	13.84
PW01	6220.	3845.	0.00	0.00	0.00	0.92	4.41	6.81	8.34	9.46	10.35	11.08	12.24	13.16
PW02	5515.	3845.	0.00	0.03	0.15	2.07	6.22	8.77	10.35	11.50	12.40	13.15	14.33	15.25
PW03	4825.	3860.	4.39	5.61	6.11	8.96	13.33	15.92	17.51	18.67	19.57	20.32	21.50	22.42
PW04	4195.	3485.	4.39	5.62	6.17	9.41	13.96	16.58	18.19	19.35	20.26	21.00	22.19	23.11
PW05	6205.	3185.	0.00	0.00	0.03	1.64	5.75	8.30	9.88	11.03	11.93	12.67	13.85	14.77
PW06	4810.	3200.	4.39	5.66	6.29	10.20	15.27	18.01	19.65	20.83	21.76	22.51	23.71	24.64
PW07	6205.	2705.	0.00	0.08	0.26	2.50	6.84	9.44	11.03	12.19	13.10	13.84	15.03	15.95
PW08	4390.	2720.	4.39	5.65	6.27	10.31	15.43	18.17	19.82	21.00	21.93	22.68	23.88	24.81

PW09	5890.	2255.	4.39	5.67	6.25	9.53	14.25	16.92	18.54	19.71	20.63	21.38	22.57	23.50
PW10	5395.	2030.	4.39	5.69	6.32	10.13	15.14	17.87	19.51	20.69	21.61	22.37	23.56	24.50
PW11	4120.	2105.	4.39	5.61	6.11	9.32	14.05	16.72	18.34	19.51	20.43	21.18	22.37	23.30
PW12	4810.	1865.	4.39	5.63	6.19	9.83	14.81	17.52	19.17	20.34	21.26	22.02	23.21	24.14
PW13	6265.	1715.	4.39	5.60	6.05	8.52	12.54	15.04	16.60	17.74	18.64	19.37	20.55	21.47

Table 3
TEXAS WATER DEVELOPMENT BOARD COMPUTER PROGRAM RS
WATER LEVEL DRAWDOWN IN A HOMOGENEOUS LEAKY AQUIFER

040403-01 RMS 042003 GROUNDWATER EVALUATION - 12 MYGALS/MONTH MIDLAND,TEXAS

= DATA = =
START OF PUMPING = 05 03
TOTAL NUMBER OF PUMPING PERIODS = 13
TRANSMISSIVITY (GPD/FT) = 3696.0
STORAGE COEFFICIENT - 0.004000
VERTICAL LEAKAGE FACTOR, P/M, (GPD/CU.FT.) = 0.0000000
TOTAL NUMBER OF PUMPING WELLS = 9
COORDINATE UNITS (FT/UNIT) = 1.

PUMPING WELLS --- AVERAGE PUMPING RATE (GPM)

WELL	COORDINATES		ELAPSED TIME (HOURS)---												
NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.	17280.
PW03	4825.	3860.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW04	4195.	3485.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW06	4810.	3200.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW08	4390.	2720.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW09	5890.	2255.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW10	5395.	2030.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW11	4120.	2105.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW12	4810.	1865.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86
PW13	6265.	1715.	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86	30.86

WELL	COORDINATES		ELAPSED TIME (HOURS)---												
NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.	17280.
O1	6505.	1430.	0.00	0.47	0.96	4.47	11.49	16.22	19.25	21.47	23.23	24.68	27.00	28.82	36.05
O2	5005.	1430.	0.00	0.29	0.84	6.30	15.36	20.61	23.82	26.14	27.96	29.46	31.83	33.68	40.99
O3	3805.	1430.	0.00	0.04	0.21	3.35	10.95	15.88	18.98	21.24	23.02	24.49	26.84	28.67	35.94
O4	6505.	2930.	0.00	0.01	0.09	2.97	10.67	15.63	18.75	21.02	22.81	24.28	26.63	28.46	35.74
O5	5305.	2930.	0.00	0.16	0.70	7.77	18.03	23.54	26.84	29.21	31.06	32.58	34.97	36.84	44.19
O6	3805.	2930.	0.00	0.16	0.68	6.31	15.31	20.53	23.74	26.05	27.87	29.36	31.73	33.58	40.89
O7	6505.	4130.	0.00	0.00	0.00	0.98	6.69	11.16	14.09	16.26	17.99	19.43	21.72	23.53	30.73
O8	5005.	4130.	0.00	0.64	1.21	5.48	13.45	18.45	21.58	23.85	25.64	27.12	29.47	31.30	38.58
O9	3805.	4130.	0.00	0.03	0.21	3.31	10.35	15.08	18.10	20.32	22.08	23.53	25.85	27.67	34.91
PW01	6220.	3845.	0.00	0.00	0.01	1.84	8.81	13.62	16.68	18.92	20.69	22.15	24.48	26.31	33.56
PW02	5515.	3845.	0.00	0.06	0.29	4.14	12.44	17.54	20.71	23.00	24.81	26.29	28.65	30.50	37.79
PW03	4825.	3860.	8.79	11.22	12.23	17.91	26.66	31.84	35.03	37.33	39.14	40.63	43.00	44.85	52.15
PW04	4195.	3485.	8.79	11.24	12.34	18.81	27.93	33.17	36.37	38.69	40.51	42.01	44.38	46.23	53.53
PW05	6205.	3185.	0.00	0.00	0.06	3.27	11.49	16.59	19.76	22.05	23.86	25.34	27.70	29.54	36.84
PW06	4810.	3200.	8.79	11.32	12.58	20.40	30.54	36.01	39.31	41.67	43.51	45.02	47.42	49.28	56.62
PW07	6205.	2705.	0.00	0.16	0.51	5.00	13.69	18.87	22.07	24.38	26.19	27.68	30.05	31.90	39.20
PW08	4390.	2720.	8.79	11.29	12.53	20.62	30.85	36.34	39.64	42.00	43.85	45.36	47.76	49.62	56.96

PW09	5890.	2255.	8.79	11.34	12.49	19.06	28.51	33.84	37.09	39.42	41.25	42.76	45.14	46.99	54.31
PW10	5395.	2030.	8.79	11.38	12.64	20.26	30.29	35.74	39.03	41.38	43.23	44.74	47.13	48.99	56.33
PW11	4120.	2105.	8.79	11.22	12.22	18.64	28.10	33.44	36.68	39.02	40.85	42.35	44.73	46.59	53.91
PW12	4810.	1865.	8.79	11.26	12.37	19.66	29.61	35.05	38.33	40.69	42.53	44.04	46.43	48.29	55.62
PW13	6265.	1715.	8.79	11.19	12.10	17.04	25.09	30.09	33.21	35.48	37.27	38.75	41.10	42.93	50.21

Table 4
TEXAS WATER DEVELOPMENT BOARD COMPUTER PROGRAM RS
WATER LEVEL DRAWDOWN IN A HOMOGENEOUS LEAKY AQUIFER

040403-01 RMS 042003 GROUNDWATER EVALUATION - 16 MYGALS/MONTH MIDLAND,TEXAS

= DATA = =
START OF PUMPING = 05 03
TOTAL NUMBER OF PUMPING PERIODS = 13
TRANSMISSIVITY (GPD/FT) = 3696.0
STORAGE COEFFICIENT - 0.004000
VERTICAL LEAKAGE FACTOR, P/M, (GPD/CU.FT.) = 0.0000000
TOTAL NUMBER OF PUMPING WELLS = 9
COORDINATE UNITS (FT/UNIT) = 1.

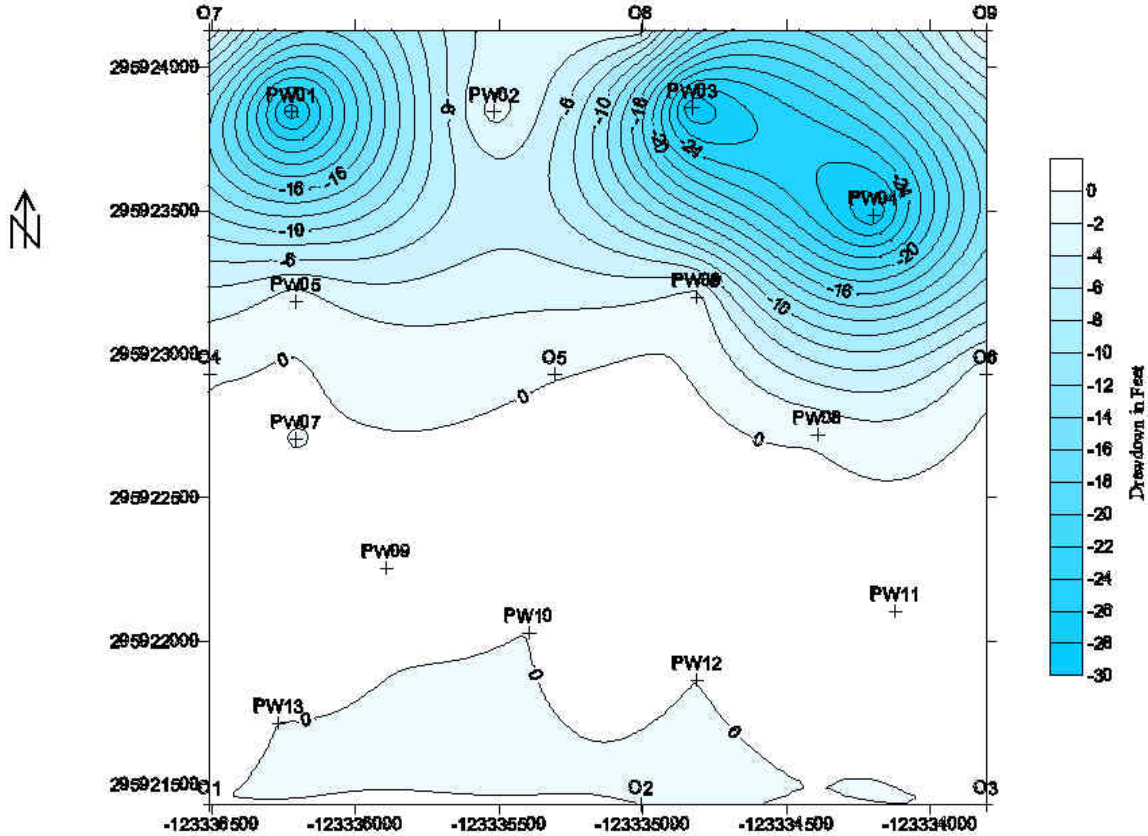
PUMPING WELLS --- AVERAGE PUMPING RATE (GPM)

WELL	COORDINATES		ELAPSED TIME (HOURS)---												
NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.	17280.
PW03	4825.	3860.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW04	4195.	3485.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW06	4810.	3200.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW08	4390.	2720.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW09	5890.	2255.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW10	5395.	2030.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW11	4120.	2105.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW12	4810.	1865.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15
PW13	6265.	1715.	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15	41.15

WELL	COORDINATES		ELAPSED TIME (HOURS)---												
NO	X	Y	1.	12.	24.	168.	720.	1440.	2160.	2880.	3600.	4320.	5760.	7200.	17280.
O1	6505.	1430.	0.00	0.63	1.28	5.95	15.32	21.63	25.66	28.63	30.97	32.91	36.00	38.43	48.08
O2	5005.	1430.	0.00	0.39	1.12	8.40	20.48	27.48	31.76	34.86	37.28	39.28	42.44	44.91	54.66
O3	3805.	1430.	0.00	0.05	0.27	4.47	14.60	21.17	25.30	28.32	30.70	32.66	35.79	38.23	47.92
O4	6505.	2930.	0.00	0.01	0.12	3.97	14.22	20.85	25.00	28.03	30.41	32.38	35.51	37.95	47.65
O5	5305.	2930.	0.00	0.22	0.93	10.36	24.04	31.39	35.79	38.95	41.42	43.44	46.64	49.12	58.92
O6	3805.	2930.	0.00	0.22	0.91	8.41	20.41	27.38	31.65	34.74	37.16	39.15	42.31	44.78	54.52
O7	6505.	4130.	0.00	0.00	0.00	1.31	8.93	14.88	18.79	21.69	23.99	25.90	28.97	31.37	40.98
O8	5005.	4130.	0.00	0.85	1.62	7.30	17.94	24.61	28.77	31.81	34.19	36.16	39.29	41.74	51.45
O9	3805.	4130.	0.00	0.05	0.28	4.41	13.81	20.11	24.14	27.10	29.44	31.38	34.47	36.90	46.54
PW01	6220.	3845.	0.00	0.00	0.01	2.45	11.75	18.16	22.24	25.23	27.59	29.54	32.65	35.08	44.75
PW02	5515.	3845.	0.00	0.08	0.39	5.51	16.59	23.39	27.61	30.67	33.08	35.06	38.21	40.66	50.39
PW03	4825.	3860.	11.72	14.97	16.30	23.89	35.56	42.46	46.70	49.78	52.20	54.18	57.34	59.80	69.53
PW04	4195.	3485.	11.72	14.99	16.45	25.09	37.24	44.23	48.50	51.60	54.02	56.01	59.17	61.64	71.38
PW05	6205.	3185.	0.00	0.01	0.09	4.36	15.33	22.13	26.35	29.41	31.81	33.79	36.94	39.40	49.12
PW06	4810.	3200.	11.72	15.10	16.77	27.21	40.72	48.02	52.41	55.56	58.02	60.04	63.23	65.71	75.50
PW07	6205.	2705.	0.00	0.21	0.69	6.66	18.25	25.17	29.42	32.51	34.92	36.91	40.07	42.53	52.27
PW08	4390.	2720.	11.72	15.06	16.71	27.50	41.14	48.46	52.86	56.01	58.47	60.49	63.68	66.17	75.96

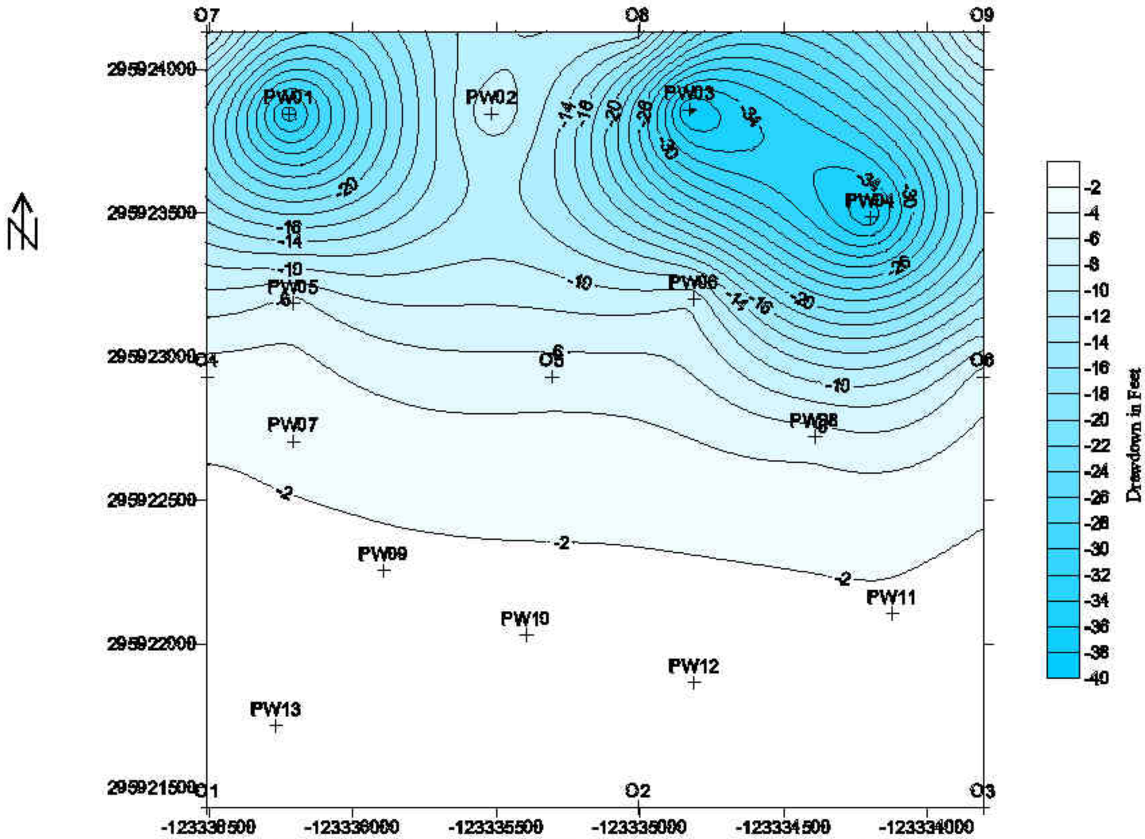
PW09	5890.	2255.	11.72	15.13	16.66	25.42	38.01	45.13	49.45	52.57	55.01	57.01	60.19	62.66	72.43
PW10	5395.	2030.	11.72	15.18	16.85	27.02	40.39	47.66	52.04	55.18	57.64	59.65	62.84	65.33	75.11
PW11	4120.	2105.	11.72	14.96	16.30	24.85	37.47	44.59	48.91	52.03	54.47	56.47	59.65	62.13	71.89
PW12	4810.	1865.	11.72	15.02	16.50	26.22	39.48	46.74	51.11	54.25	56.71	58.72	61.91	64.39	74.17
PW13	6265.	1715.	11.72	14.93	16.14	22.72	33.45	40.12	44.28	47.31	49.70	51.67	54.80	57.25	66.95

Figure 1: Western Midland County, Texas -- Well field covers about 160 acres



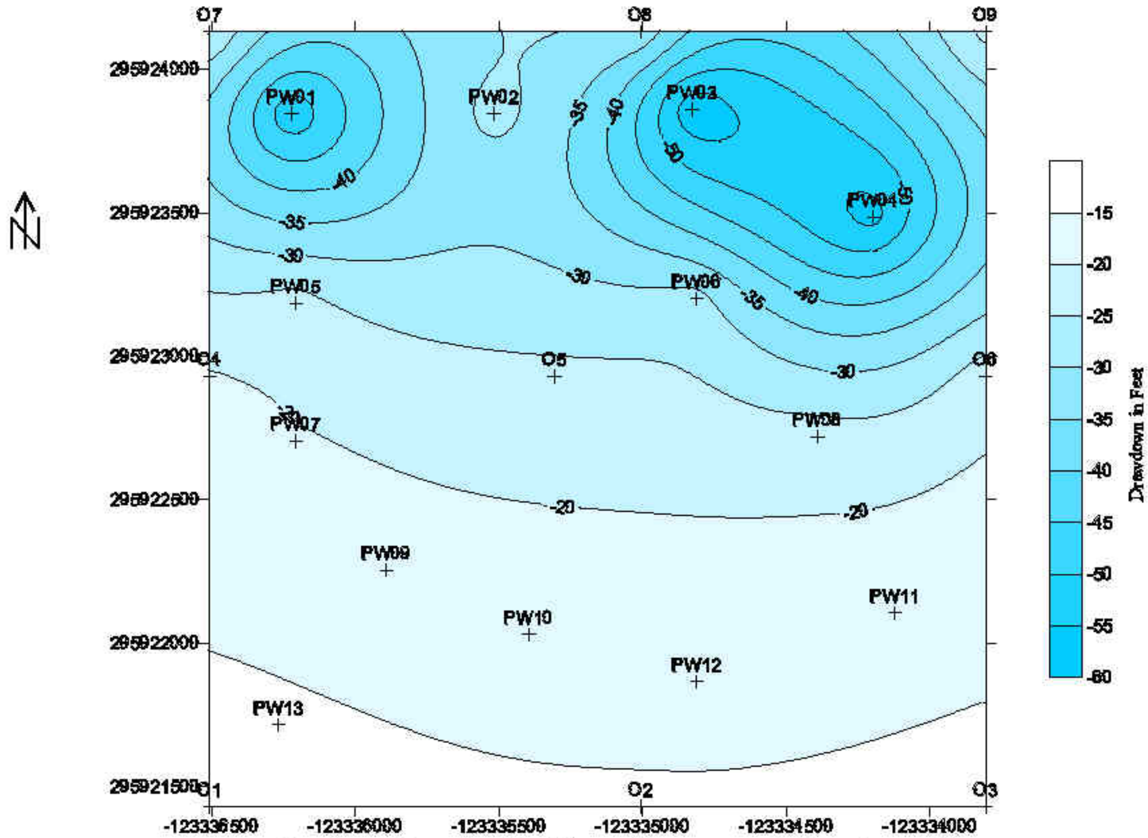
Baseline Case -- Pumping 10 million gallons per month from three wells
Pump rate 77.16 gpm
Time after 24 hours -- drawdown about -30 feet

Figure 2: Western Midland County, Texas -- Well field covers about 160 acres



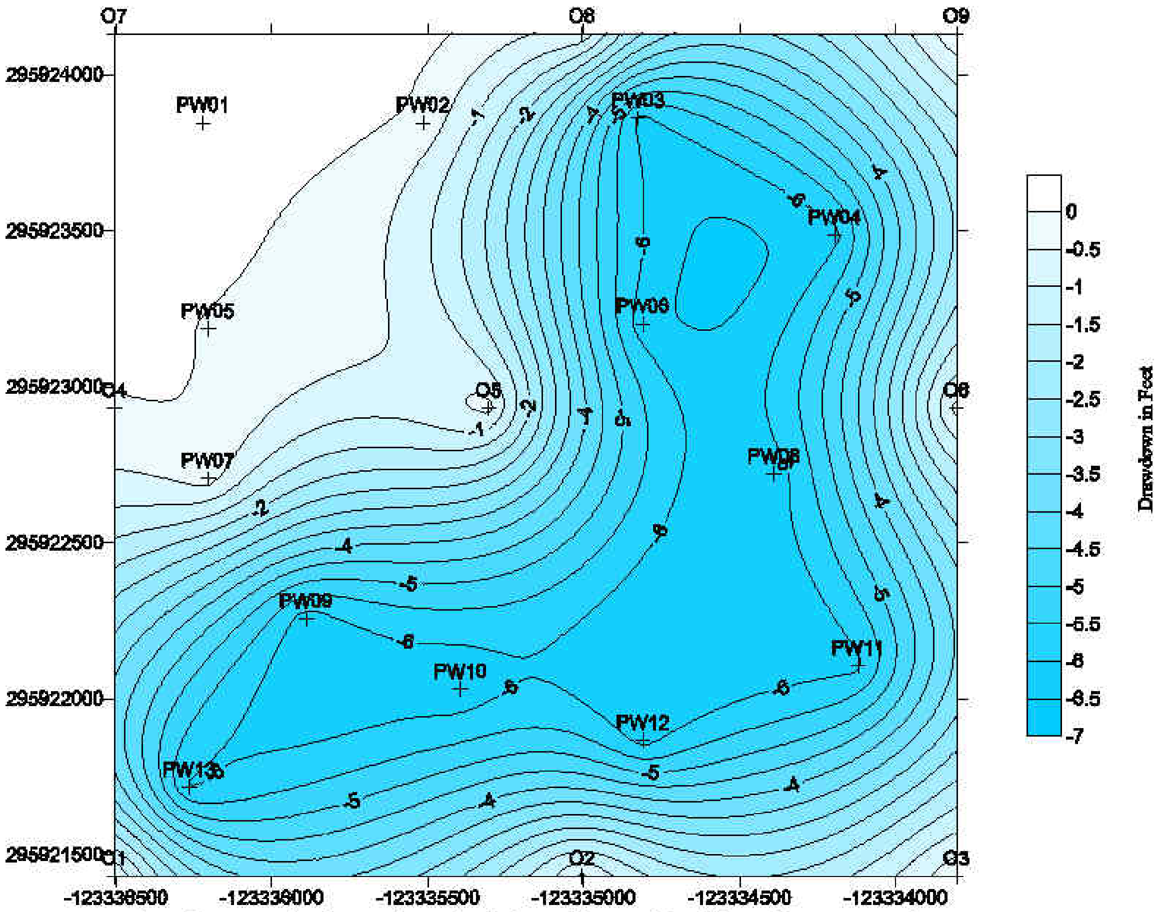
Baseline Case -- Pumping 10 million gallons per month from three wells
Pump rate 77.16 gpm
Time at one week -- drawdown between 38-40 ft max

Figure 3: Western Midland County, Texas -- Well field covers about 160 acres



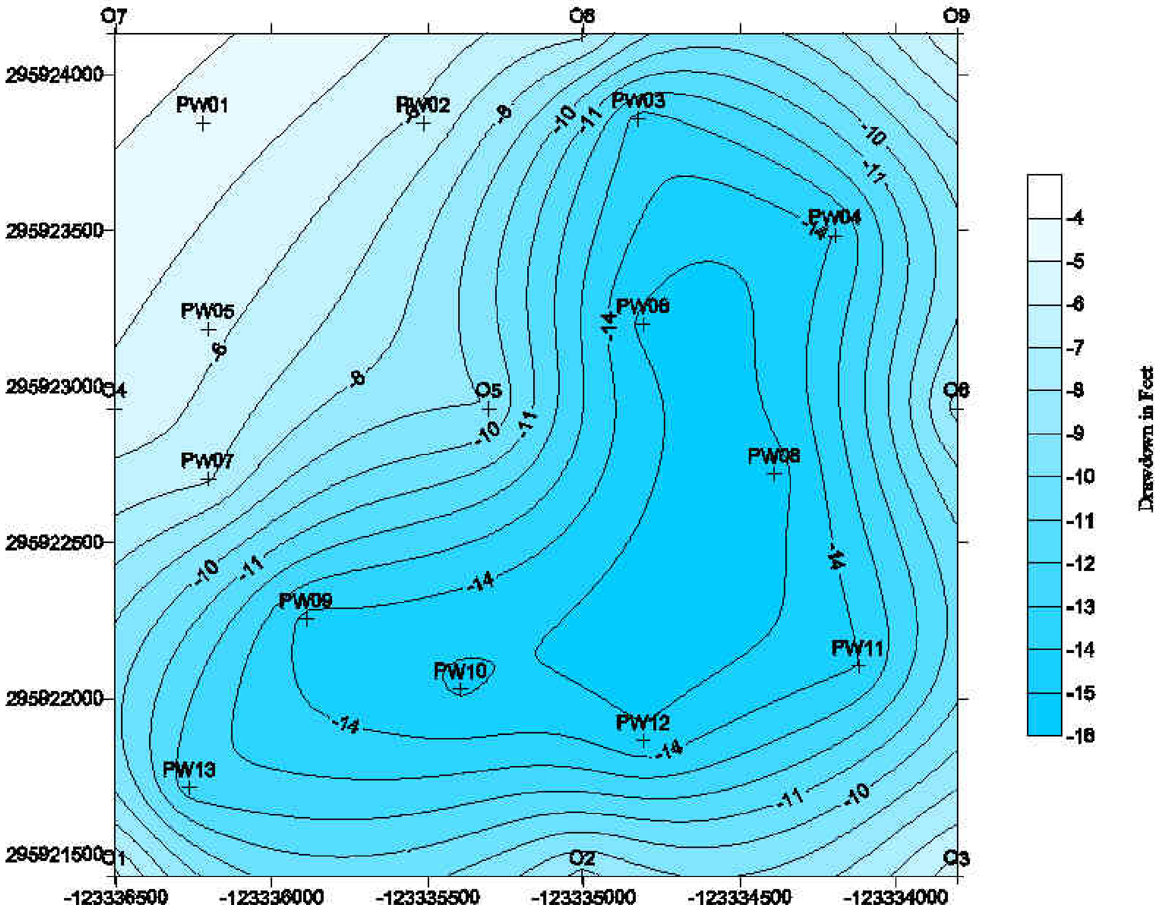
Baseline Case – Pumping 10 million gallons per month from three wells
Pump rate 77.16 gpm
Time 5 months -- drawdown arround -60 feet

Figure 4: Western Midland County, Texas -- Well Field Covers 160 acres



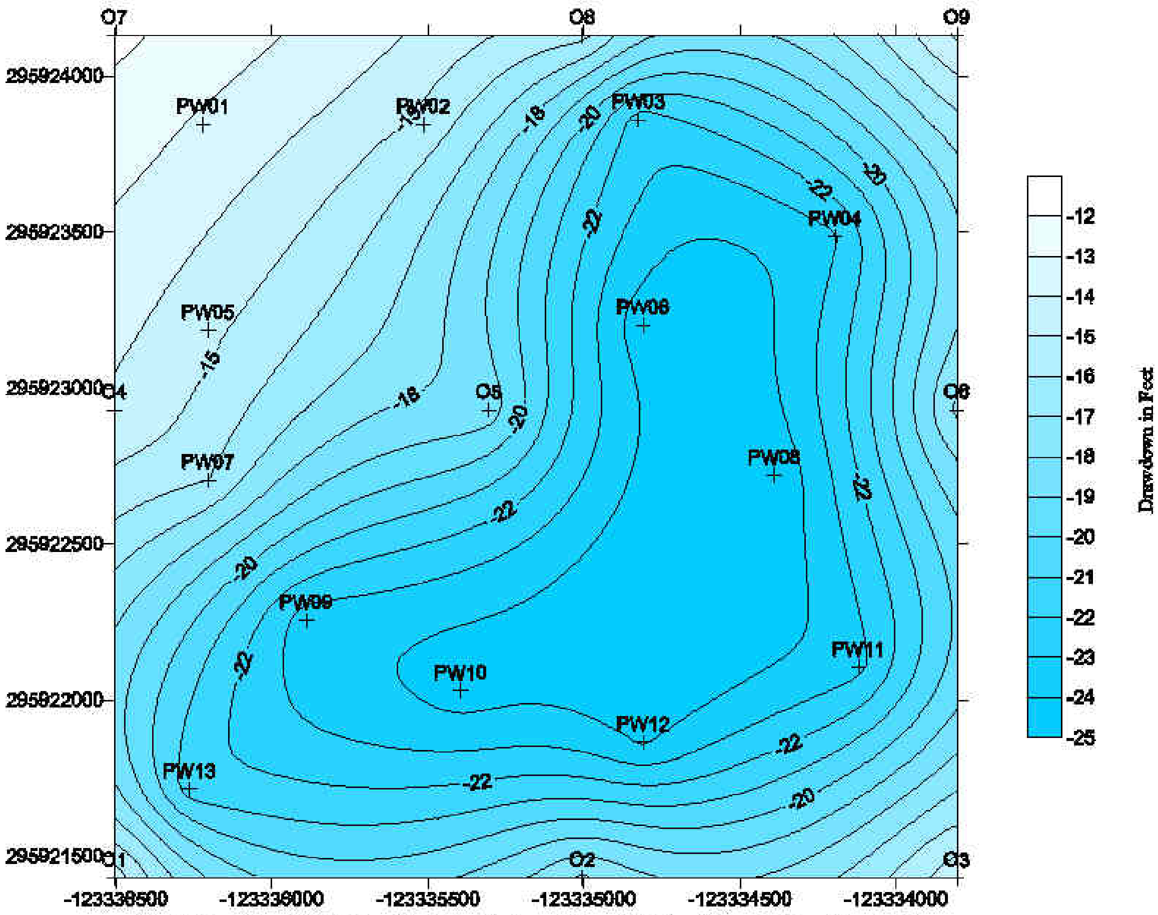
Pumping rate = 15.43 gpm for each of nine wells - total 6 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping -- 24 hours

Figure 5: Western Midland County, Texas – Well Field Covers 160 acres



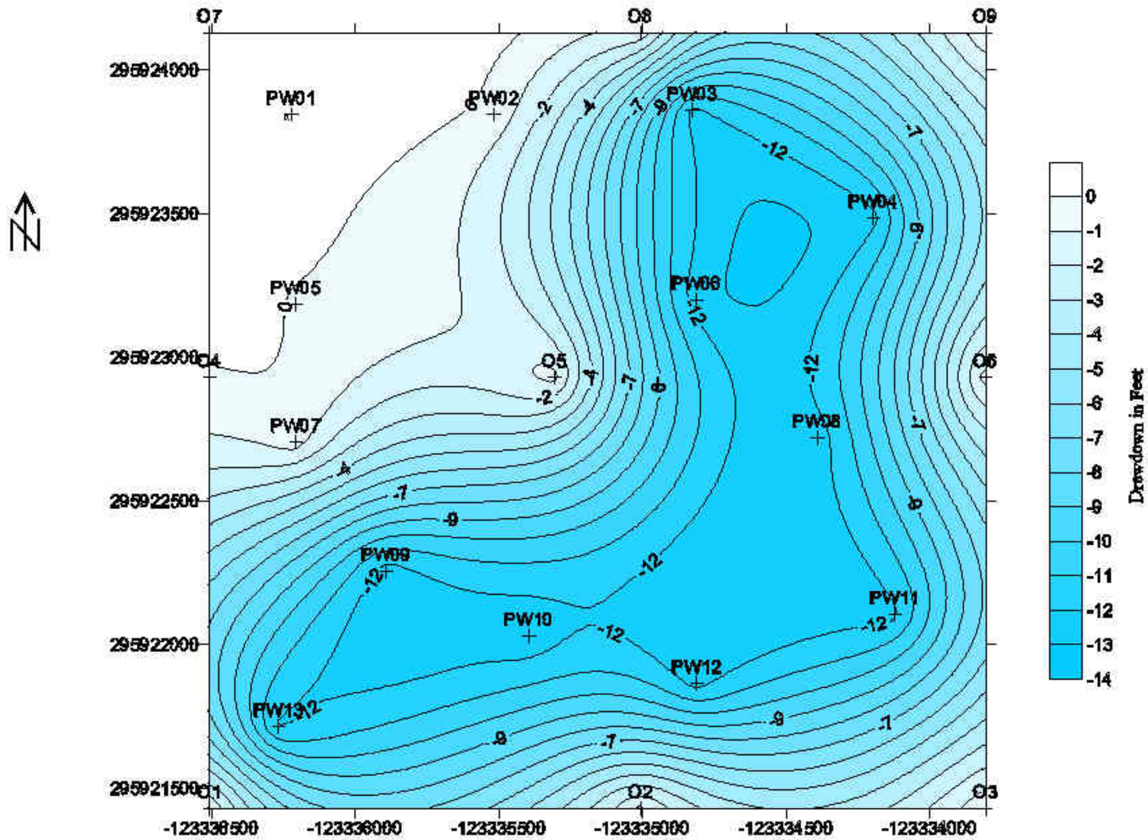
Pumping rate = 15.43 gpm for each of nine wells - total 6 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping -- 1 month

Figure 6: Western Midland County, Texas -- Well Field Covers 160 acres



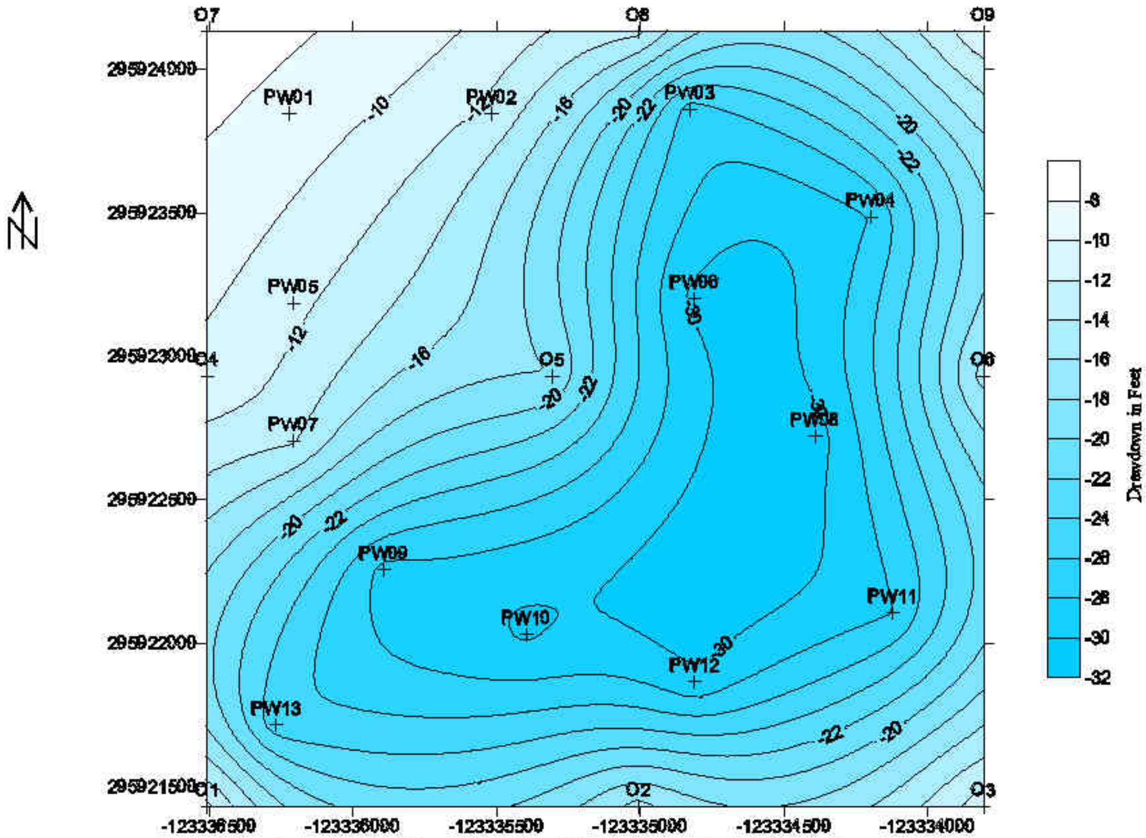
Pumping rate = 15.43 gpm for each of nine wells - total 6 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping -- 10 month

Figure 7: Western Midland County, Texas – Well field covers about 160 acres



Pumping rate = 30.86 gpm for each of nine wells - total 12 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping – 24 hours

Figure 8: Western Midland County, Texas – Well field covers about 160 acres

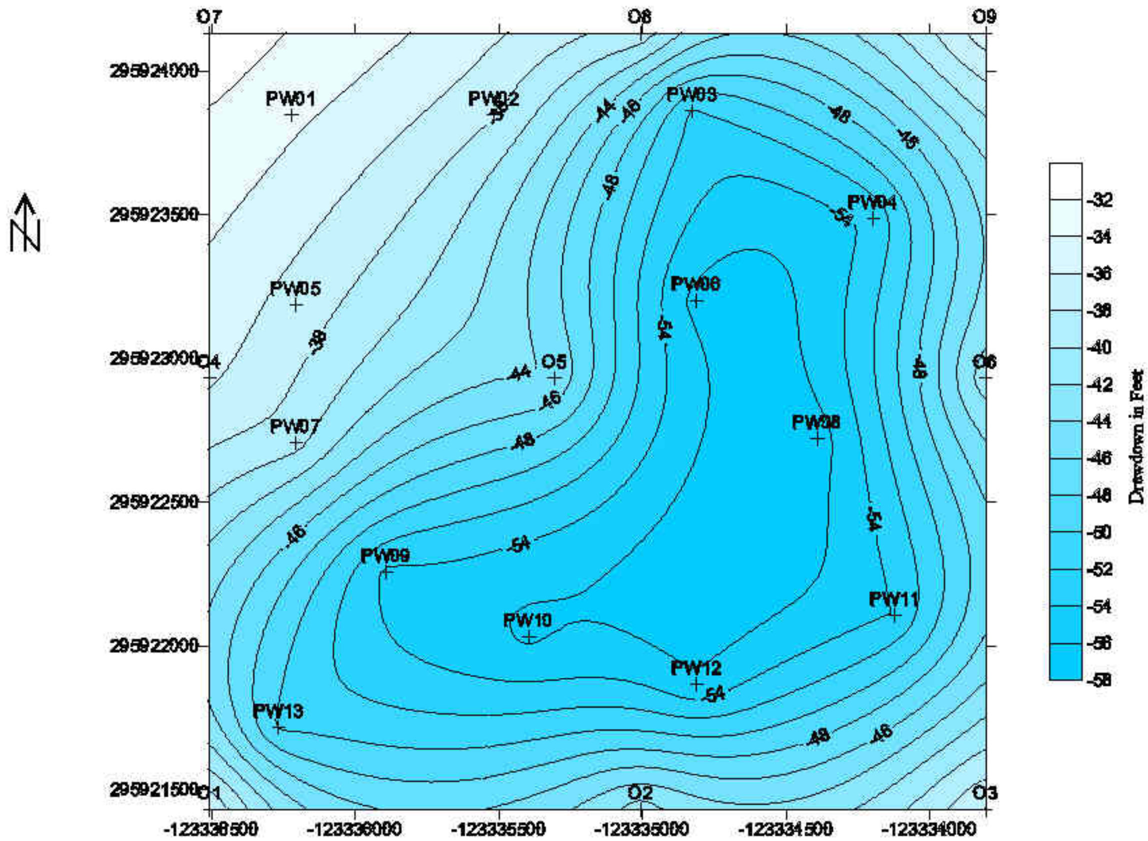


Pumping rate = 30.86 gpm for each of nine wells - total 12 million gallons per month

Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13

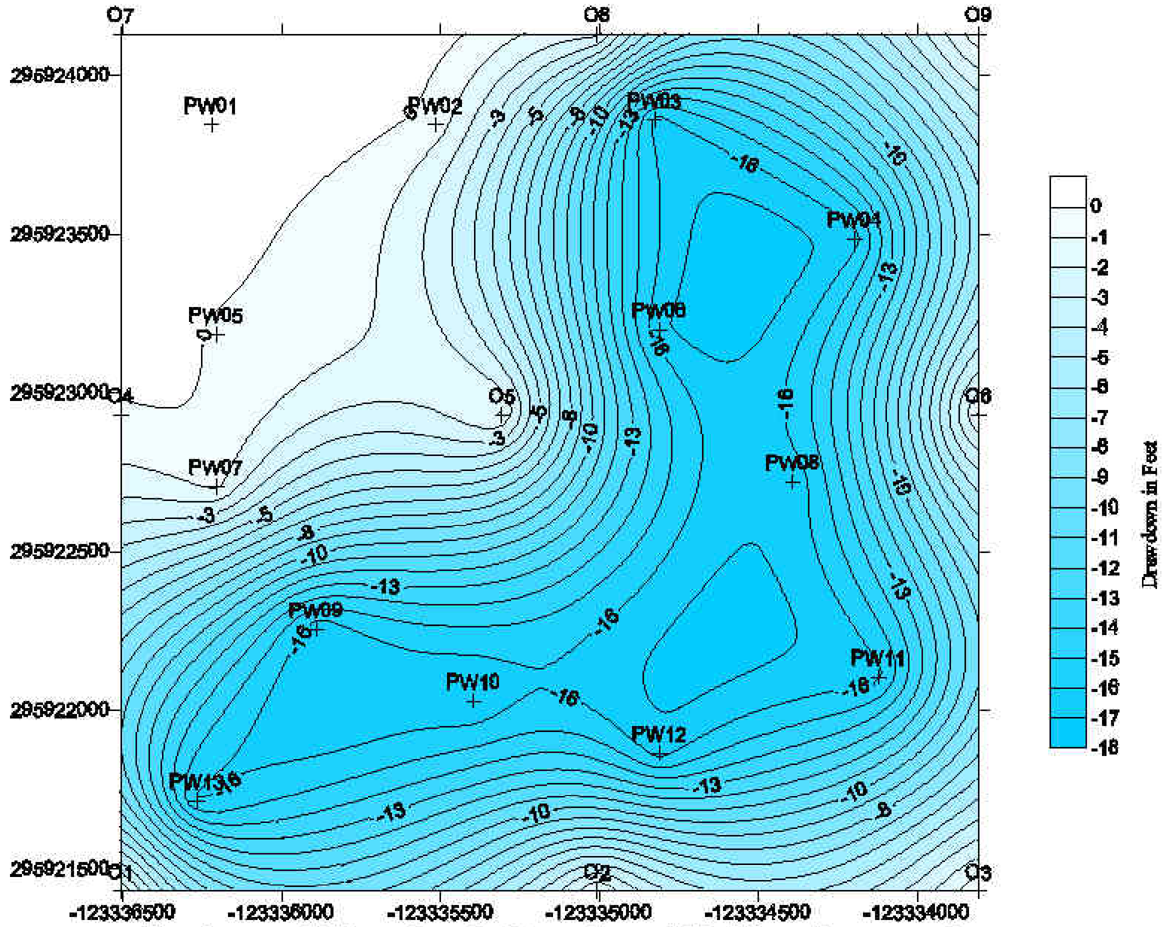
Time from start of pumping = 1 month

Figure 9: Western Midland County, Texas -- Well field covers about 160 acres



Pumping rate = 30.86 gpm for each of nine wells - total 12 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping -- 2 years

Figure 10: Western Midland County, Texas -- Well Field Covers 160 acres

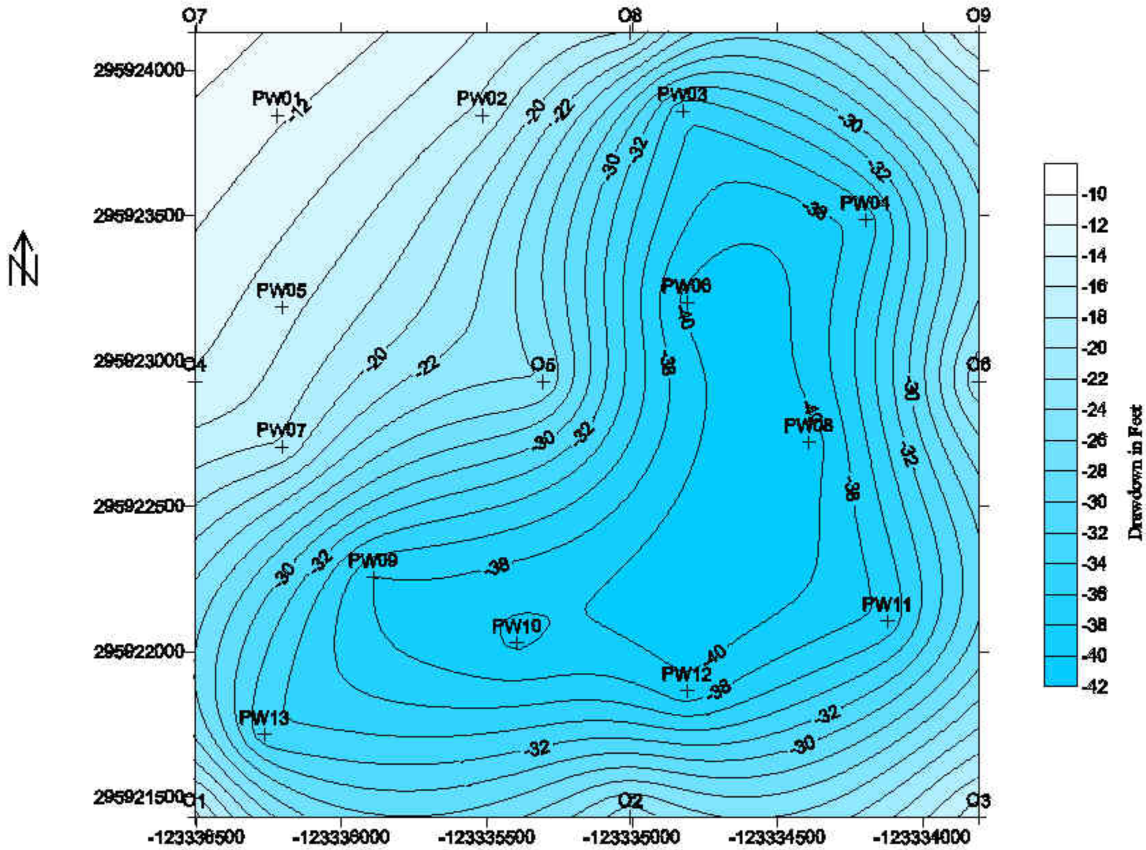


Pumping rate = 41.15 gpm for each of nine wells - total 16 million gallons per month

Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13

Time from start of pumping -- 24 hours

Figure 11: Western Midland County, Texas -- Well Field Covers 160 acres

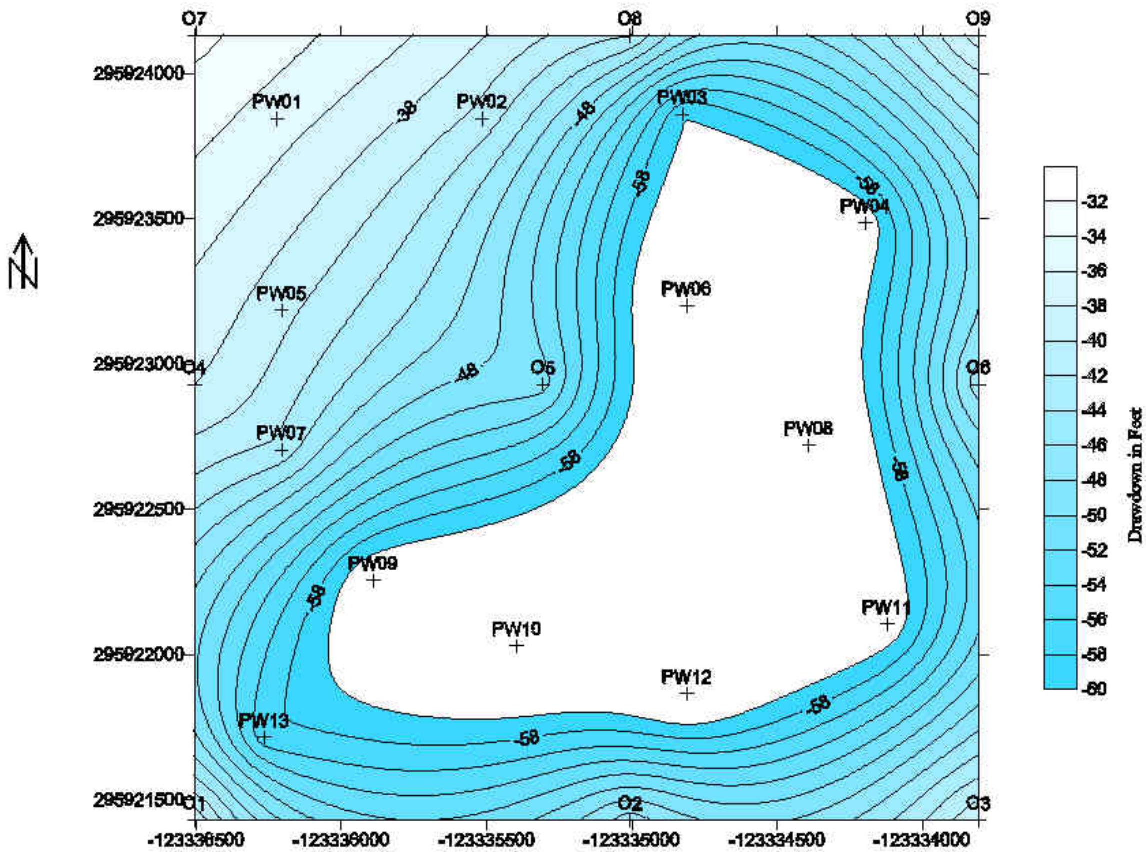


Pumping rate = 41.15 gpm for each of nine wells - total 16 million gallons per month

Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13

Time from start of pumping -- One month

Figure 12: Western Midland County, Texas -- Well Field Covers 160 acres



Pumping rate = 41.15 gpm for each of nine wells - total 16 million gallons per month
Pumping wells are PW03, PW04, PW06, PW08, PW09, PW10, PW11, PW12, PW13
Time from start of pumping -- Ten months