BMO Revision - Example
August 2015--DRAFT

What is in the packet?
Two examples of the proposed process will be discussed today. Each example will have a packet. Below is a list included in each packet.

Page 1:
- Map of the BMO area
- Map of the dedicated monitoring well location with construction details for each zone
- Well depth distribution graph
- Sacramento Valley Water Year Type Index 1971-2014

Page 2:
- Hydrograph for all zones within the dedicated monitoring well for the period of record available for that well

Page 3:
- Annual and cumulative groundwater level change graph for the dedicated monitoring well zone being analyzed

Page 4:
- Condensed analysis spreadsheet

Dedicated Monitoring Well Groundwater Level BMO Process
The term “process” or "methodology" is used to indicate this is an attempt to apply science-based information and develop a method to help make informed decisions about basin management objectives (BMOs). The process will be presented as a foundational step providing for a range of possibilities for BMOs that would ultimately be decided by policy makers. The concept of a slide rule or some other type of calculator has been used as a way to think about the process that will be presented. This process does not advocate for any particular BMO levels but seeks to provide sound methods of applying groundwater level and well information to frame the possibilities.

The sub-committee’s goal was to develop a methodology that would frame potential BMO options that used a process that could be consistently applied and repeated across all sub-basins and over time. The process utilizes Glenn County's dedicated groundwater monitoring network as much as possible. It also takes into account current well infrastructure, groundwater levels, and seasonal fluctuations. The process is aimed at balancing both the protection of the current wells and allowing reasonable and responsible potential growth in Glenn County. The process attempts to be sensitive to balancing groundwater use with recharge. It also tries to be sensitive to widely varying groundwater conditions. The process also seeks to provide insight to determine a timeline for sustainability in different areas.

Once an acceptable process for discussing possible BMO's is established by the TAC, stage alert levels can be combined with management actions that will help provide for sustainability. Development of stage alert levels and management actions will be taken up by the TAC in later meetings after a process for establishing BMO's is in place.

This method will use measurements from dedicated monitoring wells for analysis to guide management. If a data gap exists it may become necessary to utilize information from other types of wells. Many of the monitoring wells that will be used have a period of record over the last 10+ years, many of which have been dry years. As a result, this analysis will provide information on dry periods in particular, which tend to be the most challenging to manage. Many groundwater levels are hitting all-time lows.

The well infrastructure has been plotted into a frequency distribution graph that shows the number of wells by depth constructed between 1970 and approximately June 2014. A frequency distribution graph is developed for constructed wells within 9 square miles (sections) of each dedicated monitoring well. Domestic, irrigation, industrial, municipal, public, other, stock, and unknown well types are included. Monitoring, test holes, destroyed, injection, soil, and vapor are not included in this analysis. Depth ranges are indicated in 10 foot intervals from 0 to 1000+ feet. For example: A depth range of 120 feet means that the wells within this range may be 111 and 120 feet deep. The depth of the dedicated monitoring well zones is indicated by arrows at the bottom of the page.

Groundwater level data was analyzed independently for each monitoring well to identify the annual high and low groundwater levels collected from the Department of Water Resources using data loggers recording daily measurements or hand measurements taken periodically throughout the period of record . The annual low measurements did not occur during the same months for all monitoring wells. Considering that the principle concern is low groundwater levels and risk of wells being dewatered, the annual low groundwater levels are used in this proposed process. Using the lowest groundwater level from each year, the annual change was calculated for the period of record of that well. From this, the average annual change and the standard deviation of the average annual change were determined for the period of record. From these calculations, the number of years to reach potential BMO levels will be projected for current observed conditions over the period of record for that well. Projections will be developed based upon the average annual change in groundwater levels (rate of change) and also for one and two standard deviations from the average.

The standard deviation measures the spread of data points around the average. It helps describe the variation in the rate of change of groundwater levels measured in key wells throughout Glenn County over time. By linking the average annual rate of change in groundwater levels with the standard deviation, it distinguishes annual changes in groundwater levels that are within a familiar operating range from those that are approaching or are outside of the normally observed operation range. During drought, when one standard deviation is added to the average annual decline in groundwater levels, this annual rate of decline represents the 67 percentile, meaning this rate of decline in groundwater levels is equal to or greater than 67 percent of all measurements for the key well. Adding two standard deviations to the average annual decline in groundwater levels accounts for 95% of the measurements, indicating this rate of decline is greater than 95 percent of all measurements for the key well. If a measurement of average annual decline in groundwater levels falls outside of the average plus two standard deviations, the measurement is approaching a rate of decline rarely, if ever, recorded for that well. During normal and wet years, coupling the average annual change in groundwater levels with the standard deviation is useful to evaluate the rate that groundwater levels are increasing and how quickly groundwater levels are recovering.

A spreadsheet indicating percent of wells at risk, meaning wells whose depths are shallower than the groundwater level, at certain groundwater levels (potential BMO levels) is created. The categories are listed at 2 ½ % intervals from 0%-50%. Using the well infrastructure information, the percentage of wells is calculated based on the total number of wells within the 9 square mile area. Depth ranges are listed for each of the percentage intervals. The number of wells at that depth range is then corrected to reflect the true number of wells at that range, and the true percentage of "at risk" wells at each depth range that is calculated. For example:

There are 86 wells indicated in the 9 square miles surrounding a dedicated monitoring well. 10% of 86 is 8.6. 8.6 rounded to the nearest whole number equals 9 wells. The ninth shallowest well is at depth range 110. There are actually 12 wells within the depth range 110. Re-calculating the true number of wells at risk, 12 wells out of 86 wells, is 14% of the wells are at risk at depth range 110.

This analysis spreadsheet is the "slide rule" concept mentioned earlier, which includes the analysis indicated above.

A policy maker would be able to use this to effectively make an informed judgment concerning the balance between protection of current well infrastructure and changes to groundwater use. In one page, policy makers would have access to a summary of the well infrastructure, current rate of change, how many wells are affected at each step or depth range, and a projected timetable of different levels of risk to the groundwater resources and current infrastructure. If the trend for rate of change stabilizes, it indicates "sustainability" or a balanced use and recharge have been reached in that area. If the trend for rate of change increases, then recharge is likely occurring. If the trend in rate of change continues to decline and the rate of change persists outside the average plus two standard deviations it indicates an unsustainable condition.

More Thoughts and Considerations

- Is the process sensitive to balancing use with recharge? Yes. If use and recharge are equal, the annual change will remain stable. If use becomes greater than recharge, the annual change will reflect that by having a negative change number (ex. -2.4 ft per year) and rate of decline will be outside of familiar levels. If recharge is greater than use, the fall annual change will also reflect that with a positive change number (ex. 2.4 feet per year).
- Is the process sensitive to widely varying groundwater conditions? Yes, this process effectively distinguishes groundwater sub-basins with relatively small fluctuations in groundwater levels from those with larger fluctuations.
- Potential options for setting BMO levels:
  - One BMO level for each zone of a monitoring well
  - Choose a zone that is most closely representative of the wells in the area, and set a BMO for that zone (this is the current set of information)
  - Use "Sustainability timeframe" 50 years to determine BMO levels
    - If below X% risk to infrastructure
  - Use an aggregate approach for each BMO area. Would aggregate data need to be depth specific? If not aggregate approach, how will BMO actions apply to the area?
- What do we do with areas in which no dedicated well is very representative of the well infrastructure? In those cases, spreadsheets have been developed for the 2 zones closest to the well infrastructure. Is that sufficient?
- Perhaps a BMO narrative process could be developed to determine which parts apply and under what situations/conditions. A bit like a flow chart or a key.
- More thought will be needed on where the levels are set and what actions are triggered with each level (examples: outreach/education, voluntary actions, additional permit conditions, etc.)

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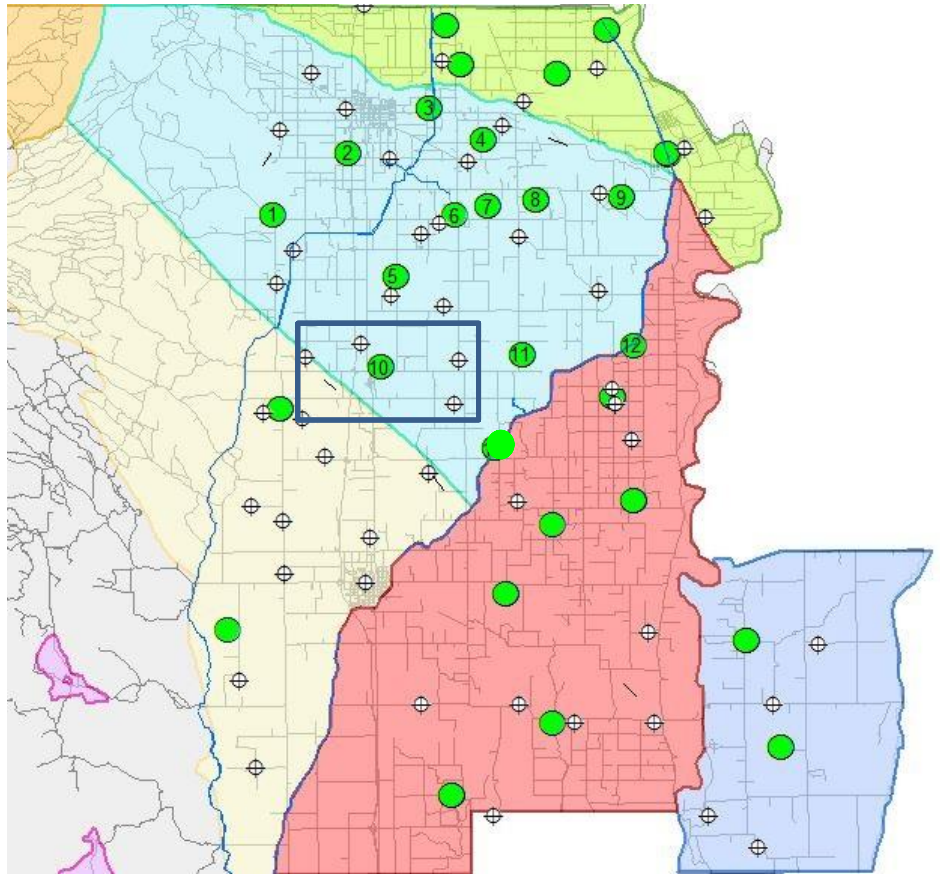
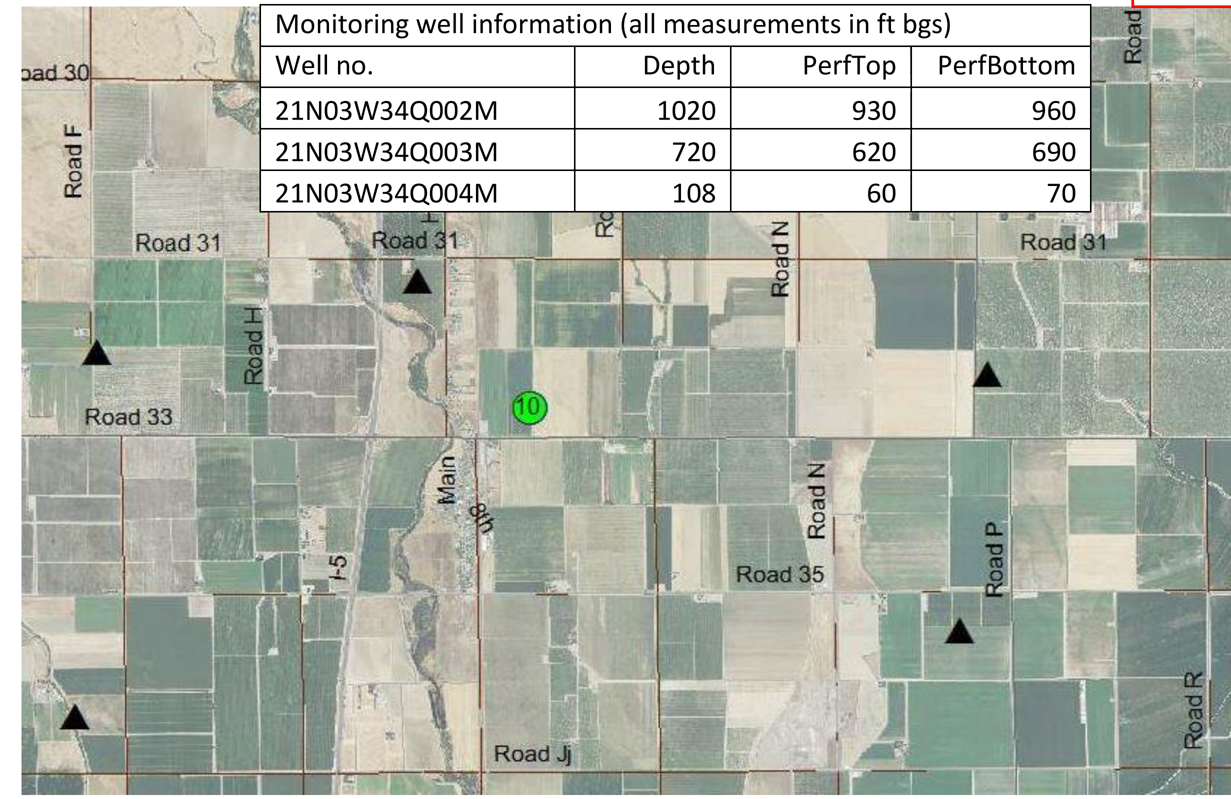
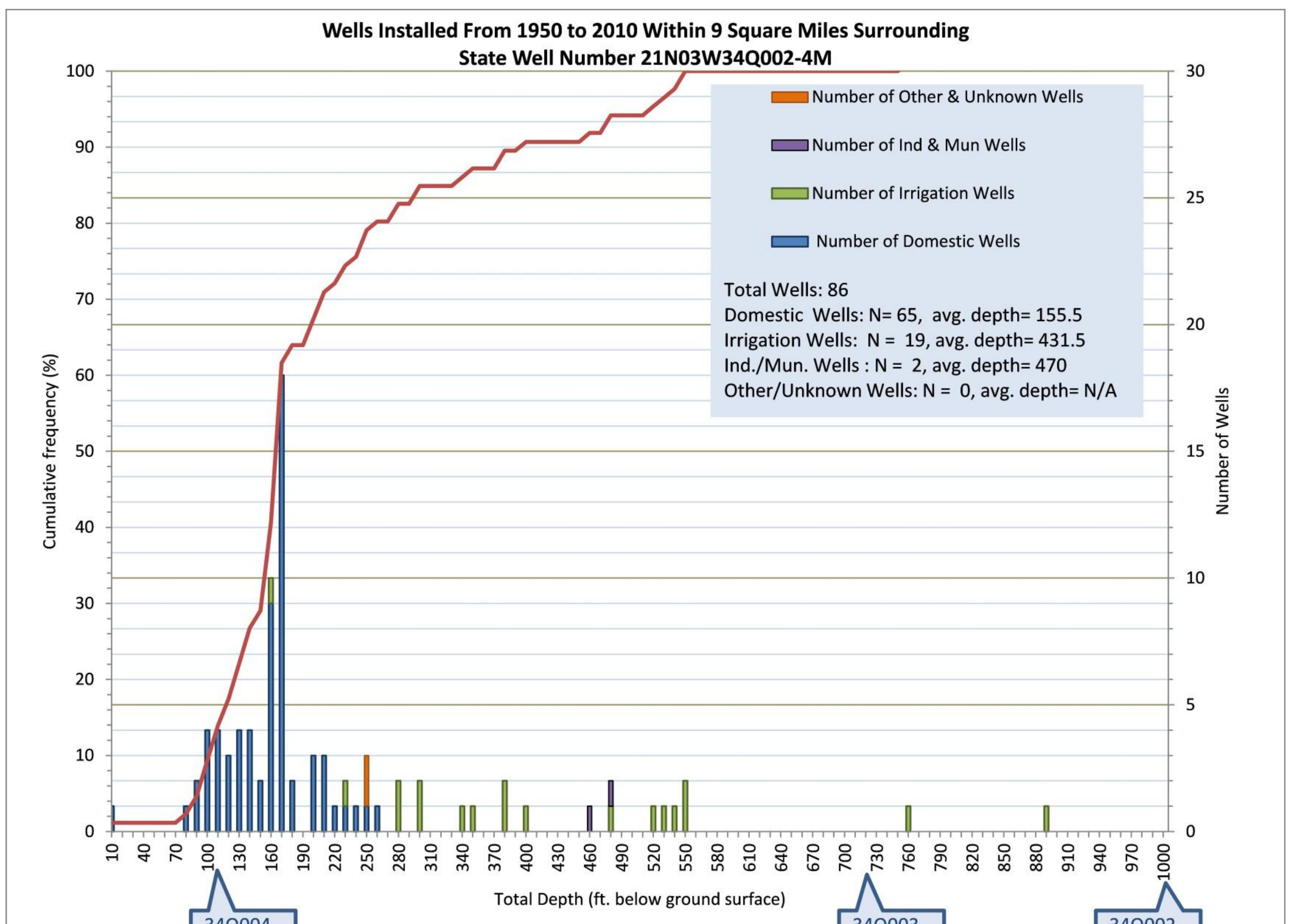
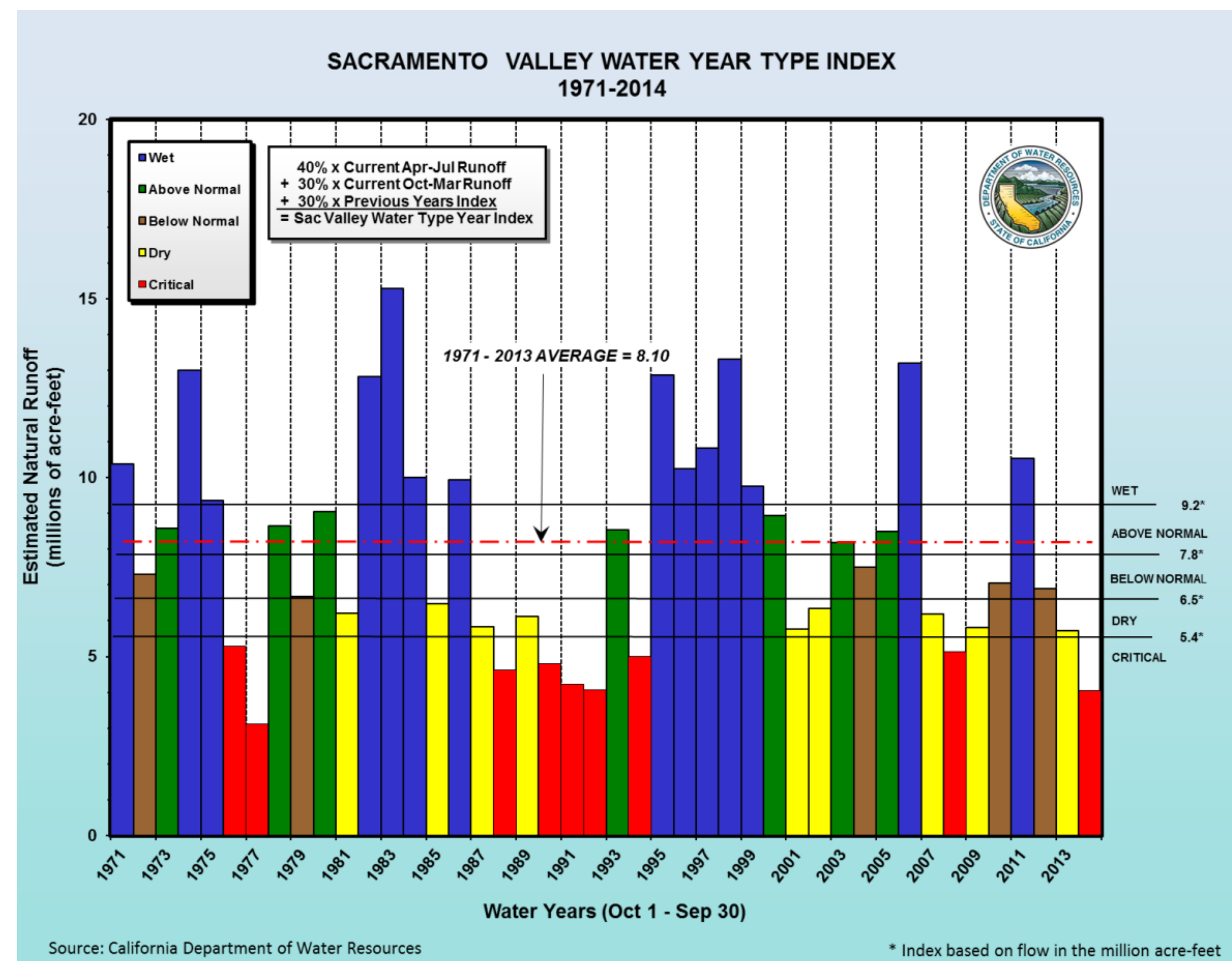


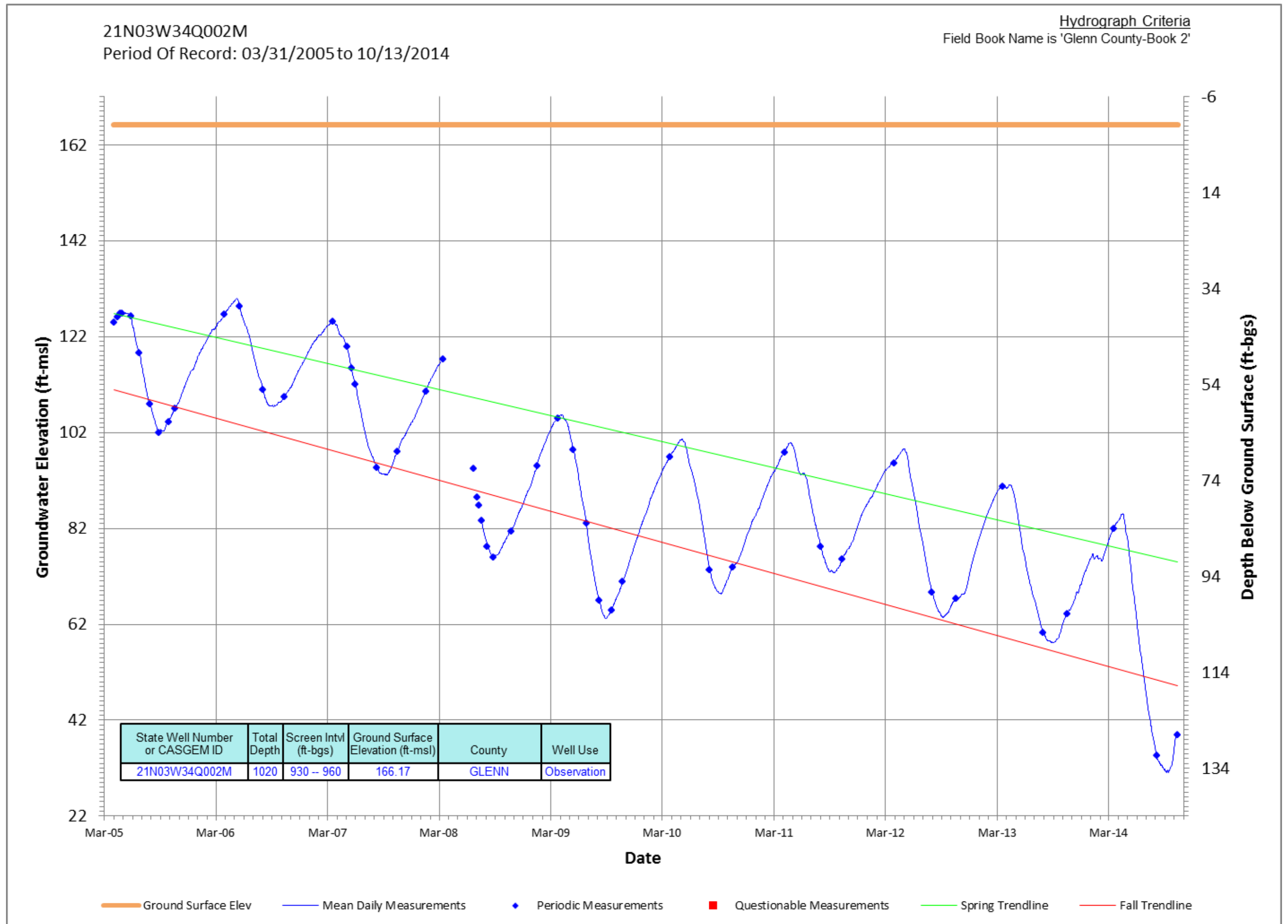
Map #	State Well #
1	21N04W12A002M
2	22N03W28P001M
3	22N03W24E001M
4	22N02W30H002M
5	21N03W23D001M
6	21N03W01R002M
7	21N02W05M001M
8	21N02W04G002M
9	21N02W01F001M
10	21N03W34Q002M
11	21N02W33M001M
12	21N02W36A002M

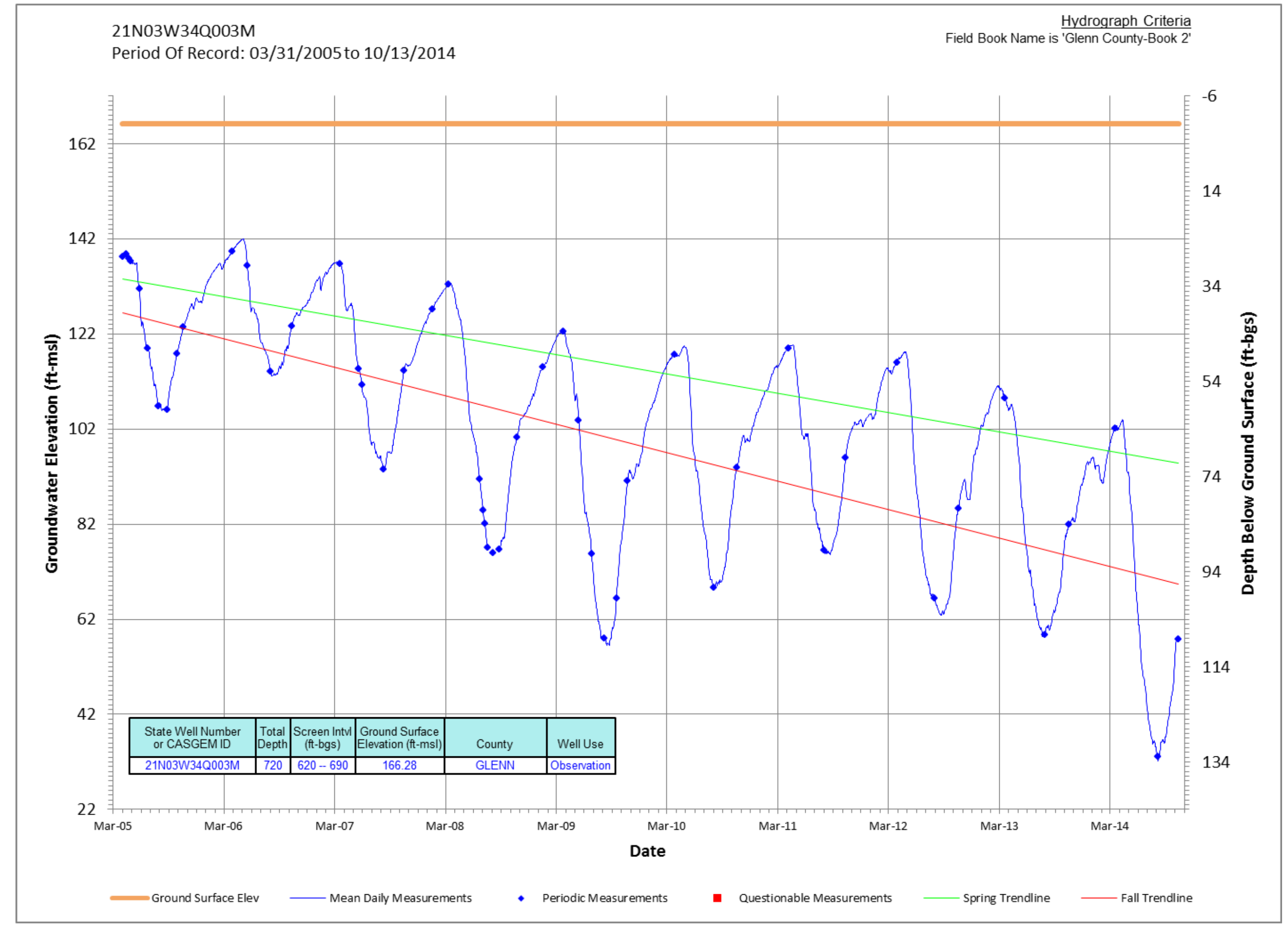
Monitoring well information (all measurements in ft bgs)			
Well no.	Depth	PerfTop	PerfBottom
21N03W34Q002M	1020	930	960
21N03W34Q003M	720	620	690
21N03W34Q004M	108	60	70

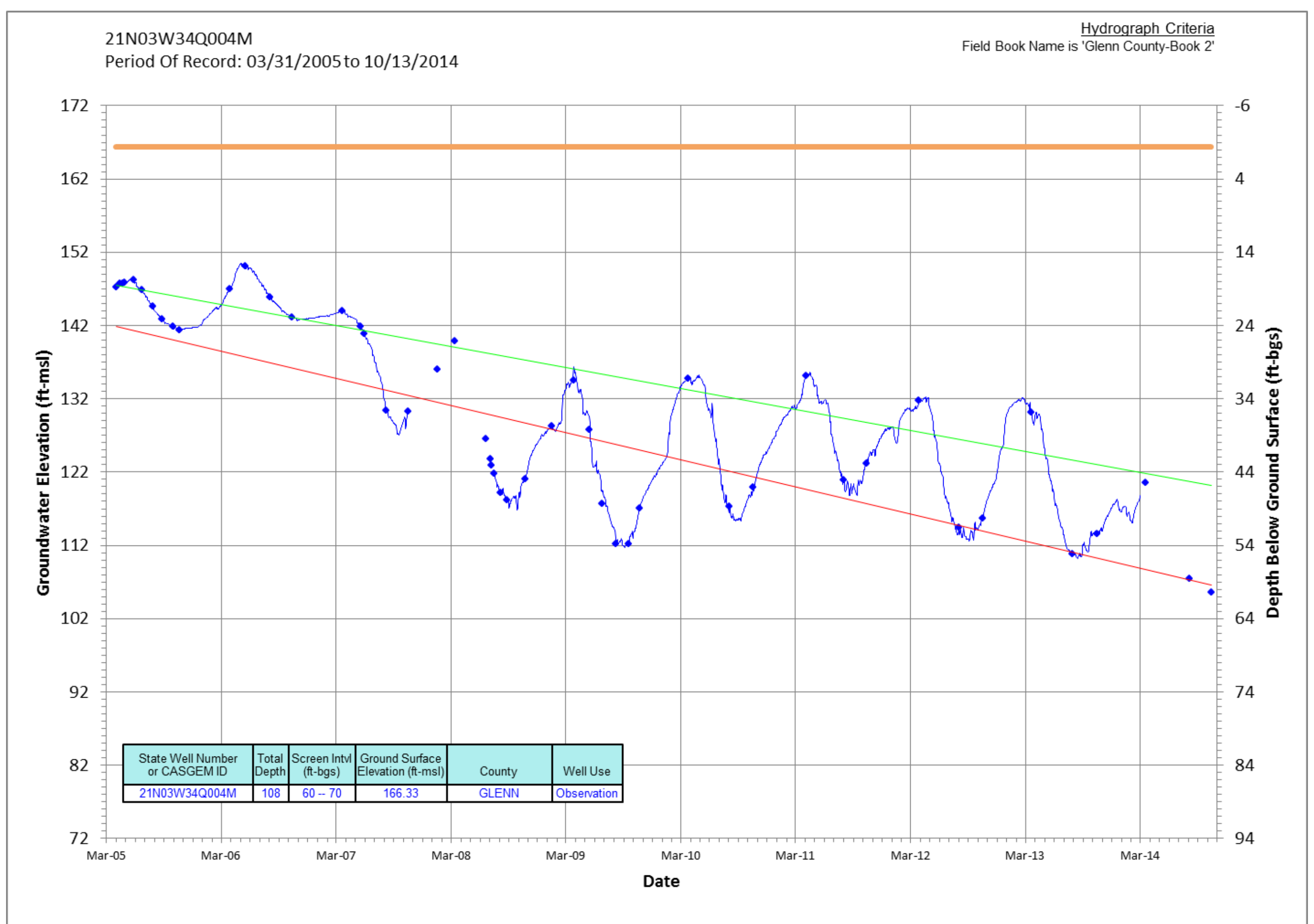












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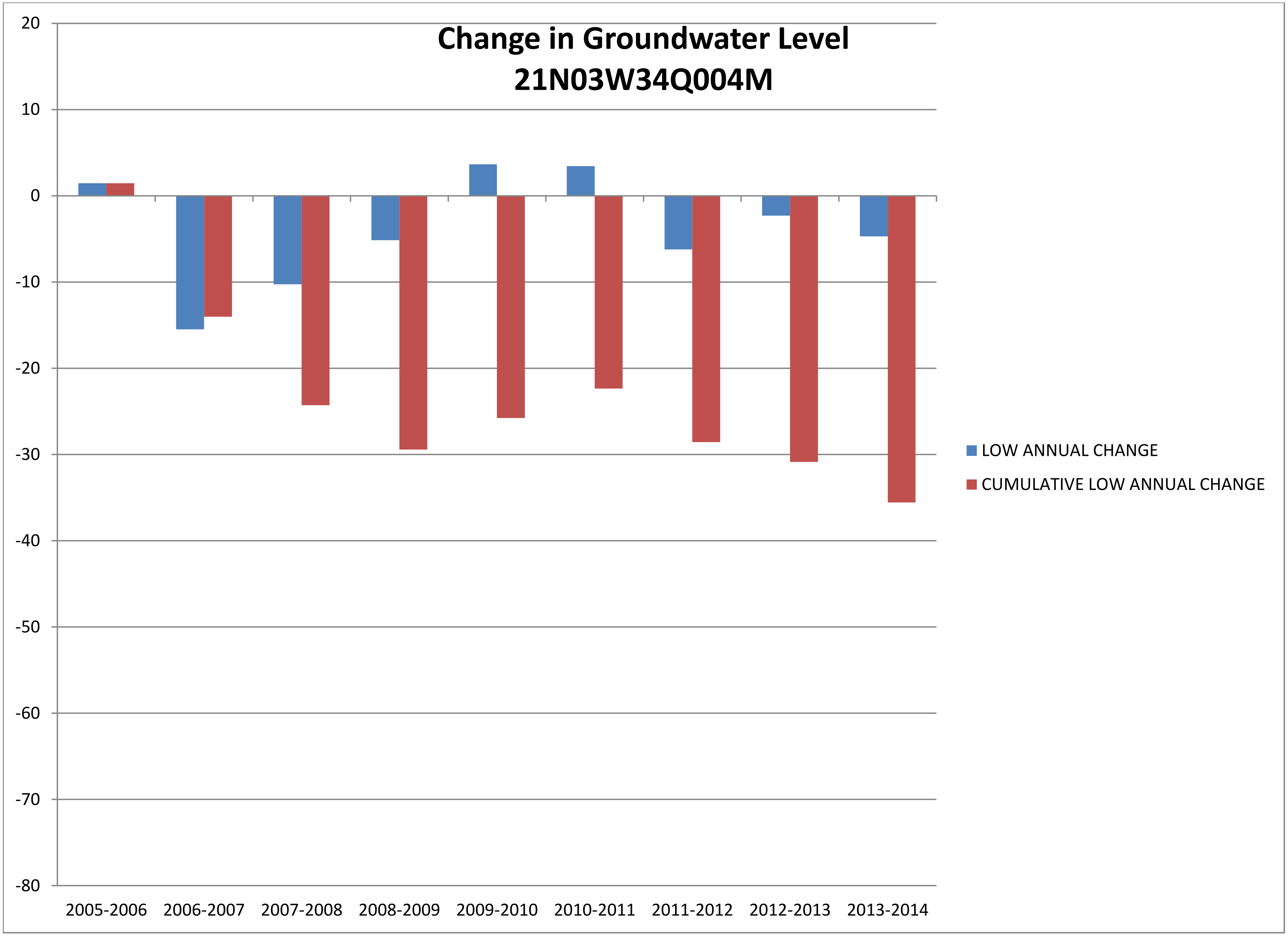

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WELL NUMBER	TOTAL WELLS IN 9 SQUARE MILE AREA	GSE	LOW 2014 WSE	LOW 2014 LEVEL (DEPTH)	AVERAGE LOW ANNUAL CHANGE=CHANGE/YEAR IN FT/YR	1 STD IN FT	FLUCTUATION AT 1 STD IN FT	FLUCTUATION AT 2 STD IN FT
21N03W34Q004M	86	166.33	105.55	60.78	-4	6.4	2.4 TO -10.3	8.8 TO -16.7
PERIOD OF RECORD	2005-2014							

MATHEMATICAL % WELLS AT RISK	WELL DEPTH DISTRIBUTION CUMULATIVE FREQUENCY % TRUE % OF WELLS AT RISK	DEPTH	DIFFERENCE POSSIBLE BMO LEVEL AND 2014 LEVEL (WATER COLUMN)	NUMBER OF WELLS SHALLOWER	INDICATOR OF NUMBER OF YEARS AT AVERAGE LOW ANNUAL CHANGE	1 STD FROM AVERAGE LOW ANNUAL CHANGE	2 STD FROM AVERAGE LOW ANNUAL CHANGE
0.0%	1.2%	0	-60.78	1	NA	NA	NA
2.5%	2.3%	80	19.22	2	4.8	1.8	1.1
5.0%	4.7%	90	29.22	4	7.3	2.8	1.7
7.5%	9.3%	100	39.22	8	9.8	3.8	2.3
10.0%	14.0%	110	49.22	12	12.3	4.7	2.9
12.5%	14.0%	110	49.22	12	12.3	4.7	2.9
15.0%	17.4%	120	59.22	15	14.8	5.7	3.5
17.5%	17.4%	120	59.22	15	14.8	5.7	3.5
20.0%	22.1%	130	69.22	19	17.3	6.7	4.1
22.5%	22.1%	130	69.22	19	17.3	6.7	4.1
25.0%	26.7%	140	79.22	23	19.8	7.6	4.7
27.5%	29.1%	150	89.22	25	22.3	8.6	5.3
30.0%	40.7%	160	99.22	35	24.8	9.5	5.9
32.5%	40.7%	160	99.22	35	24.8	9.5	5.9
35.0%	40.7%	160	99.22	35	24.8	9.5	5.9
37.5%	40.7%	160	99.22	35	24.8	9.5	5.9
40.0%	40.7%	160	99.22	35	24.8	9.5	5.9
42.5%	61.6%	170	109.22	53	27.3	10.5	6.5
45.0%	61.6%	170	109.22	53	27.3	10.5	6.5
47.5%	61.6%	170	109.22	53	27.3	10.5	6.5
50.0%	61.6%	170	109.22	53	27.3	10.5	6.5

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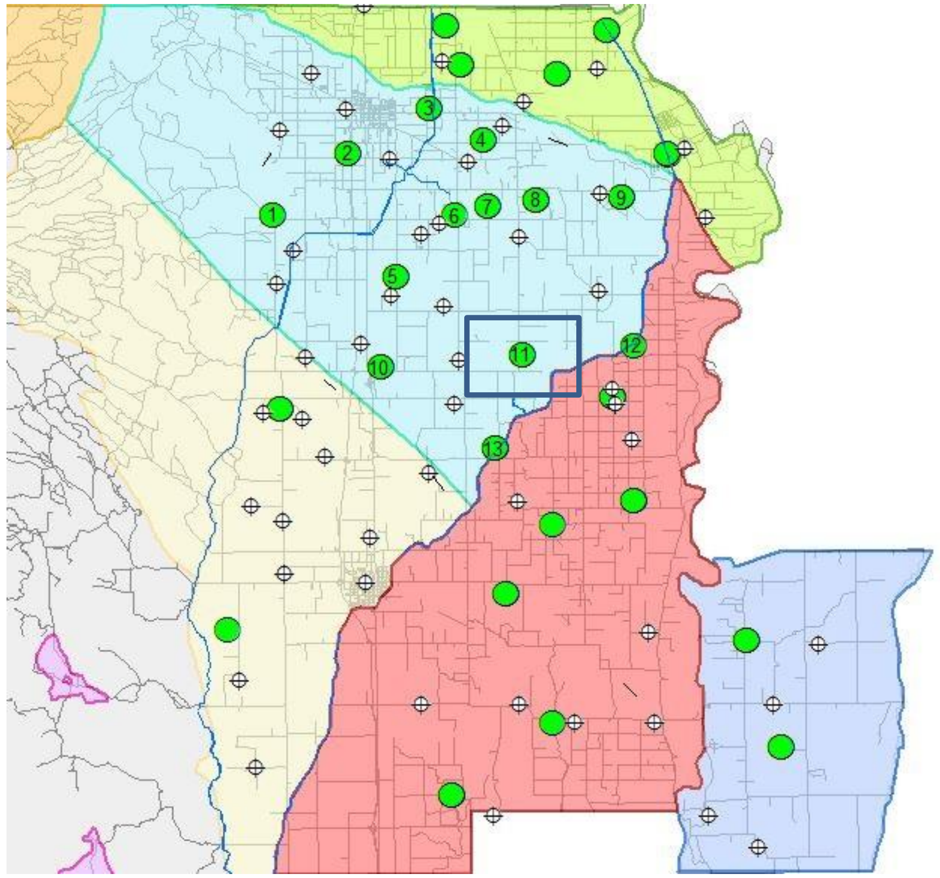

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5	21N03W23D001M
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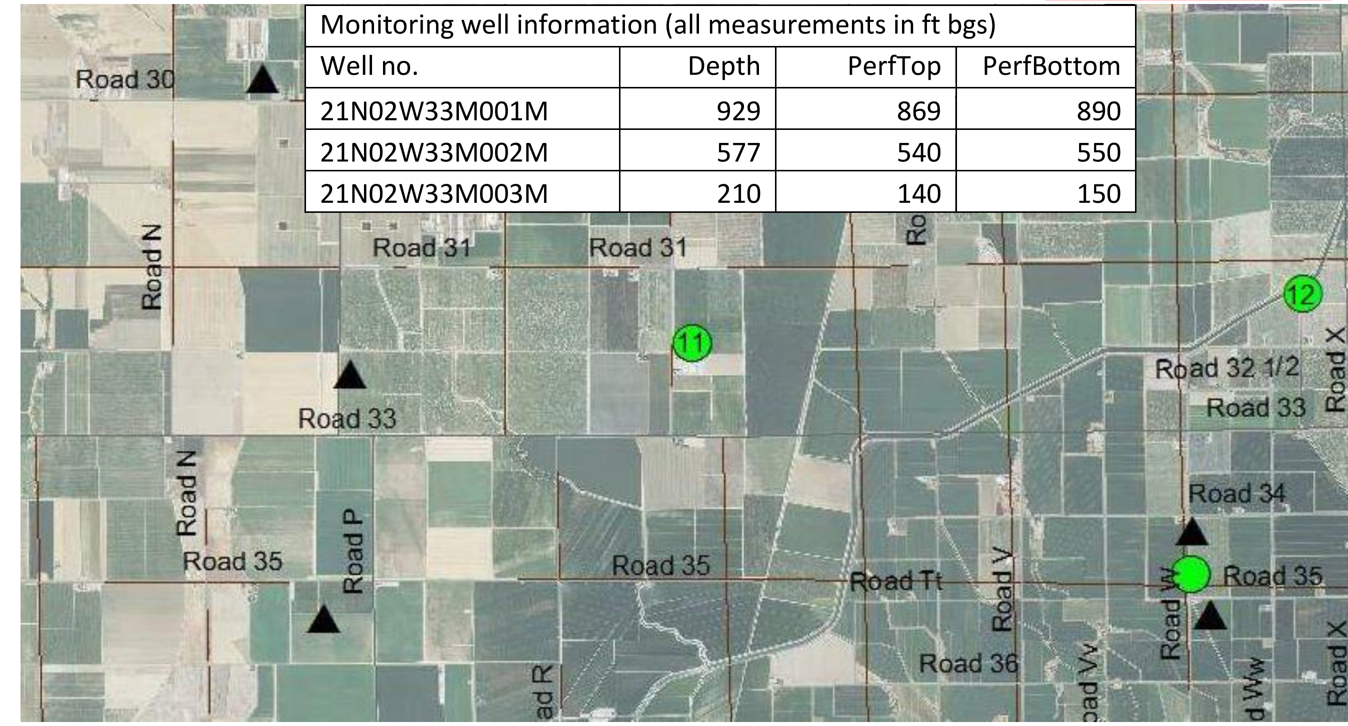
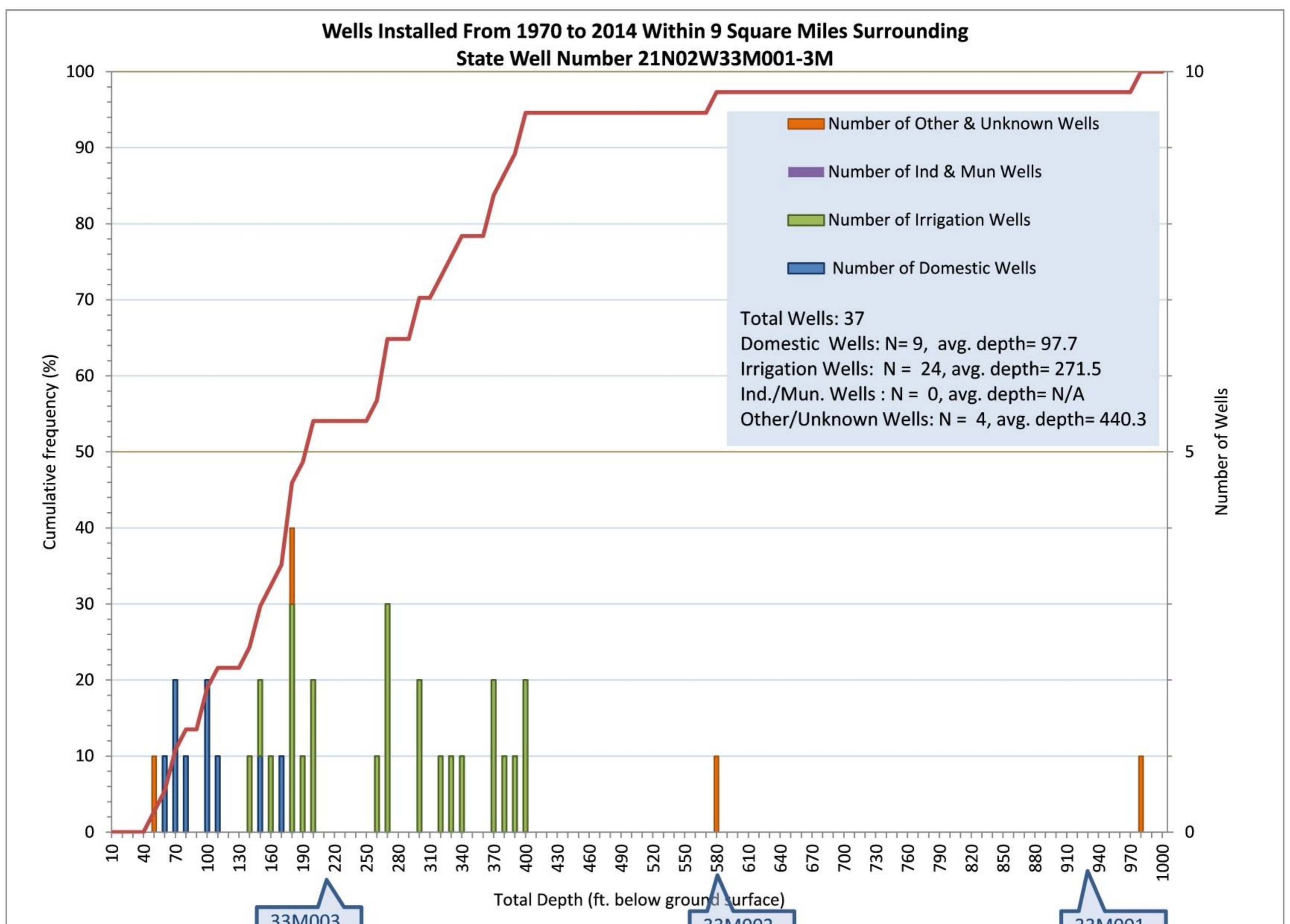
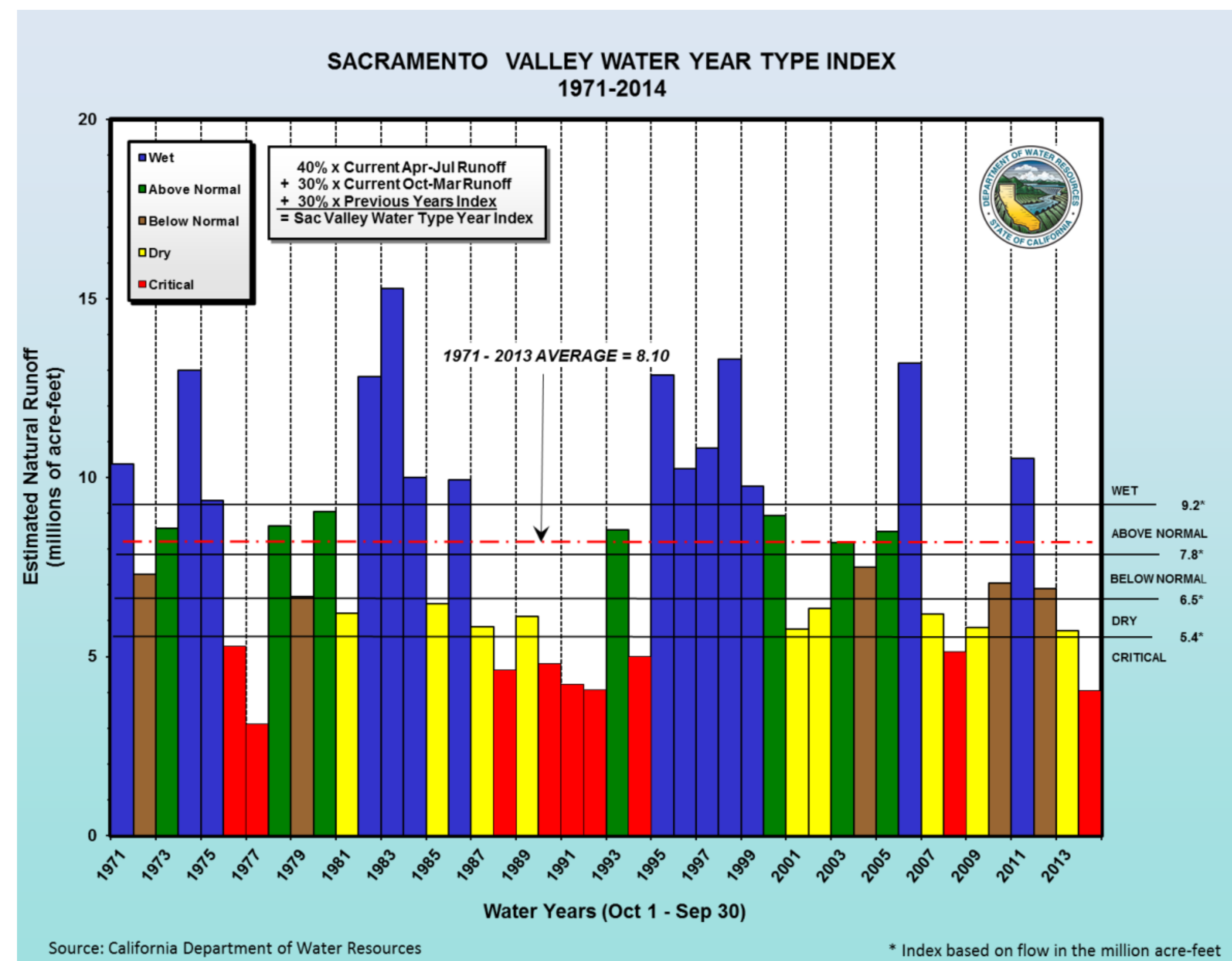
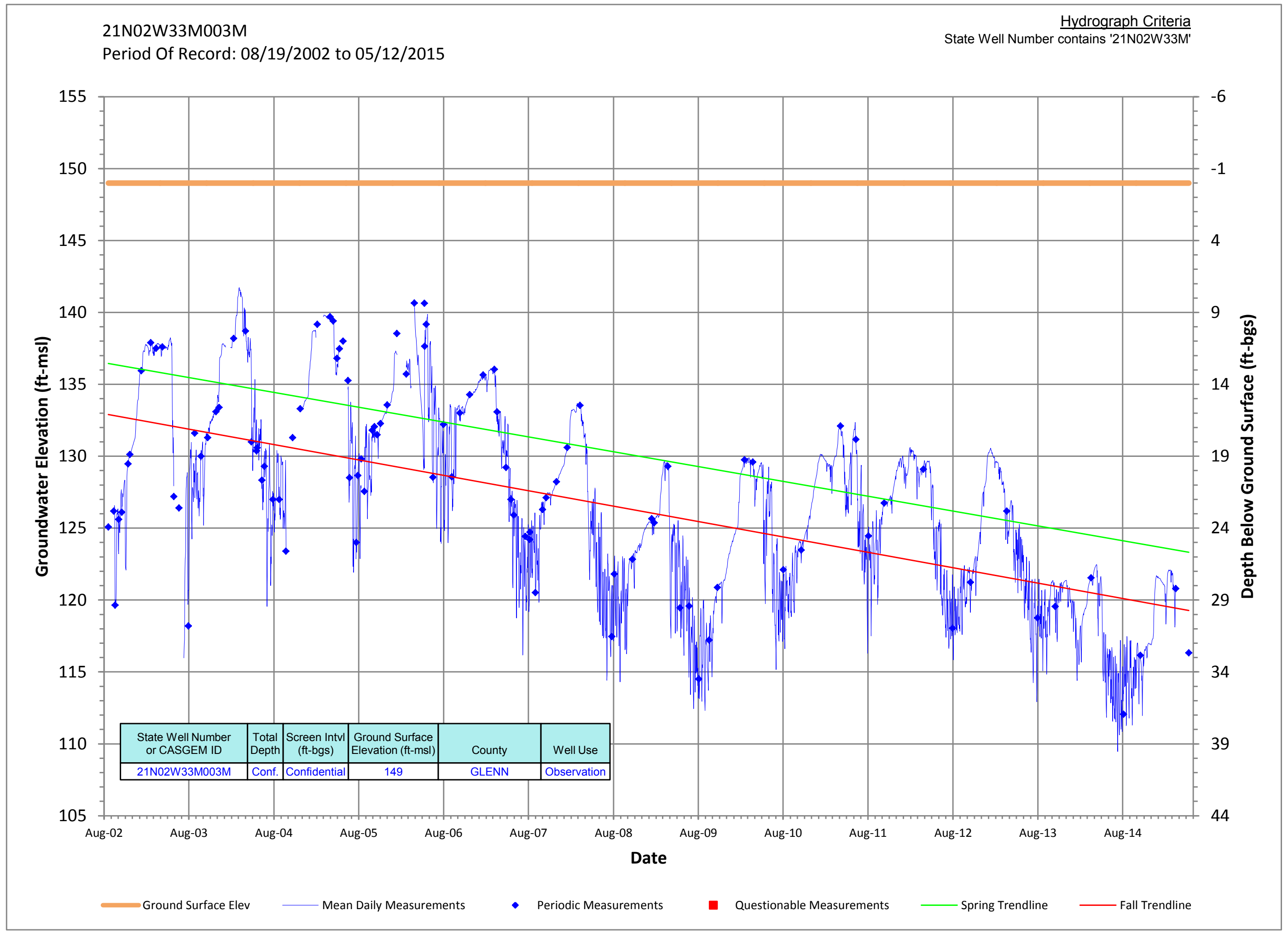
7	21N02W05M001M
8	21N02W04G002M
9	21N02W01F001M
10	21N03W34Q002M
11	21N02W33M001M
12	21N02W36A002M

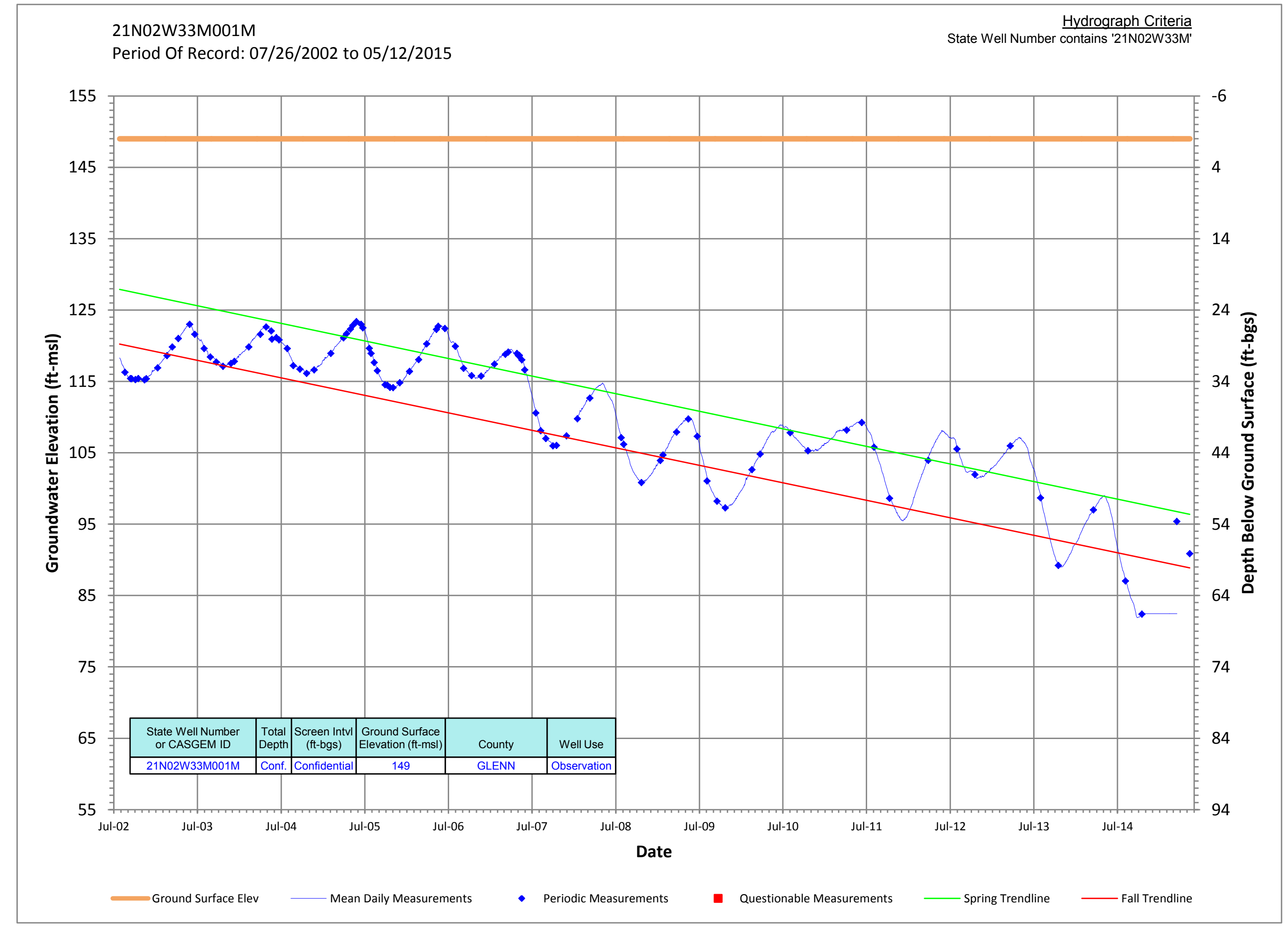


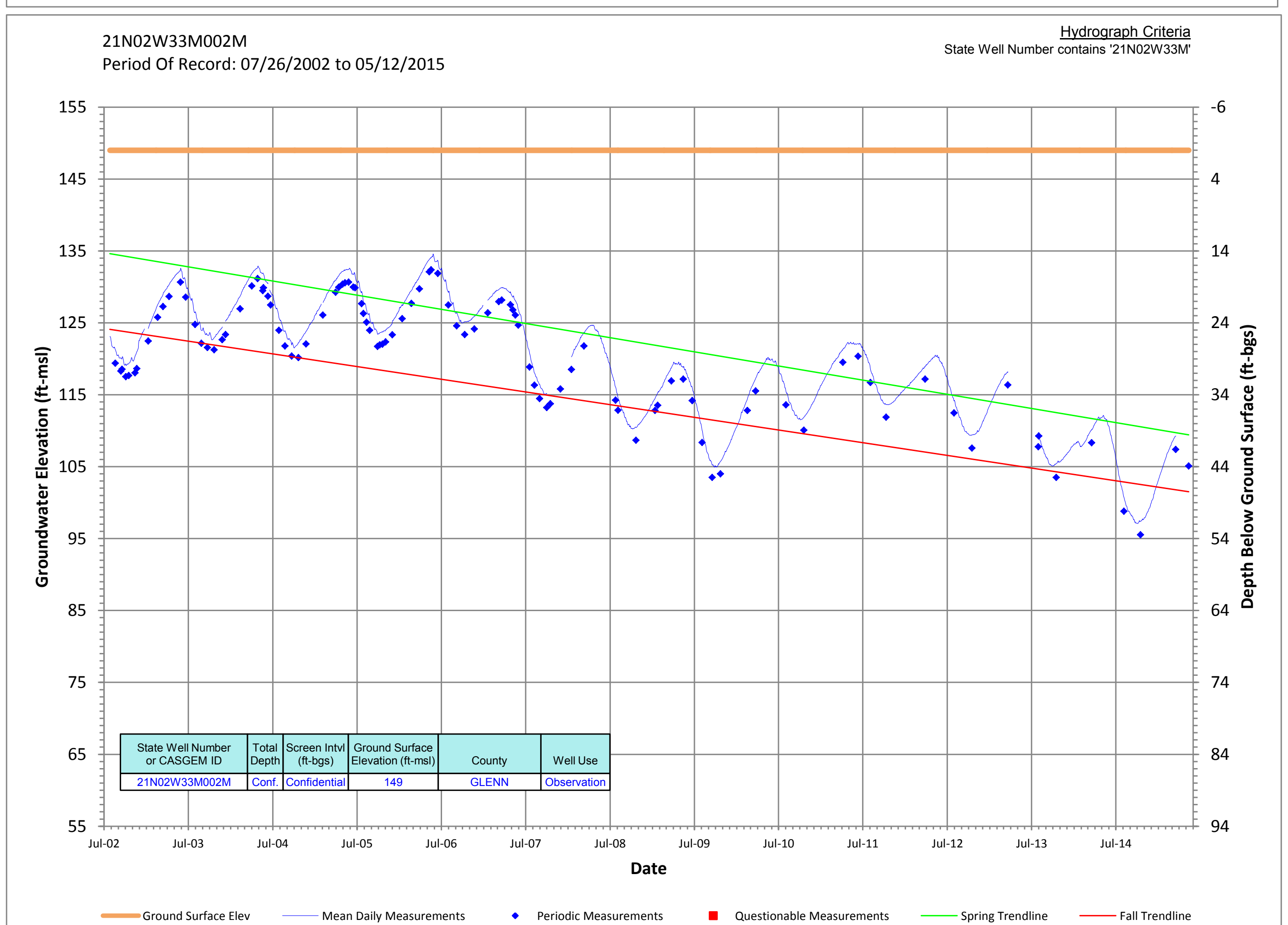
Monitoring well information (all measurements in ft bgs)			
Well no.	Depth	PerfTop	PerfBottom
21N02W33M001M	929	869	890
21N02W33M002M	577	540	550
21N02W33M003M	210	140	150











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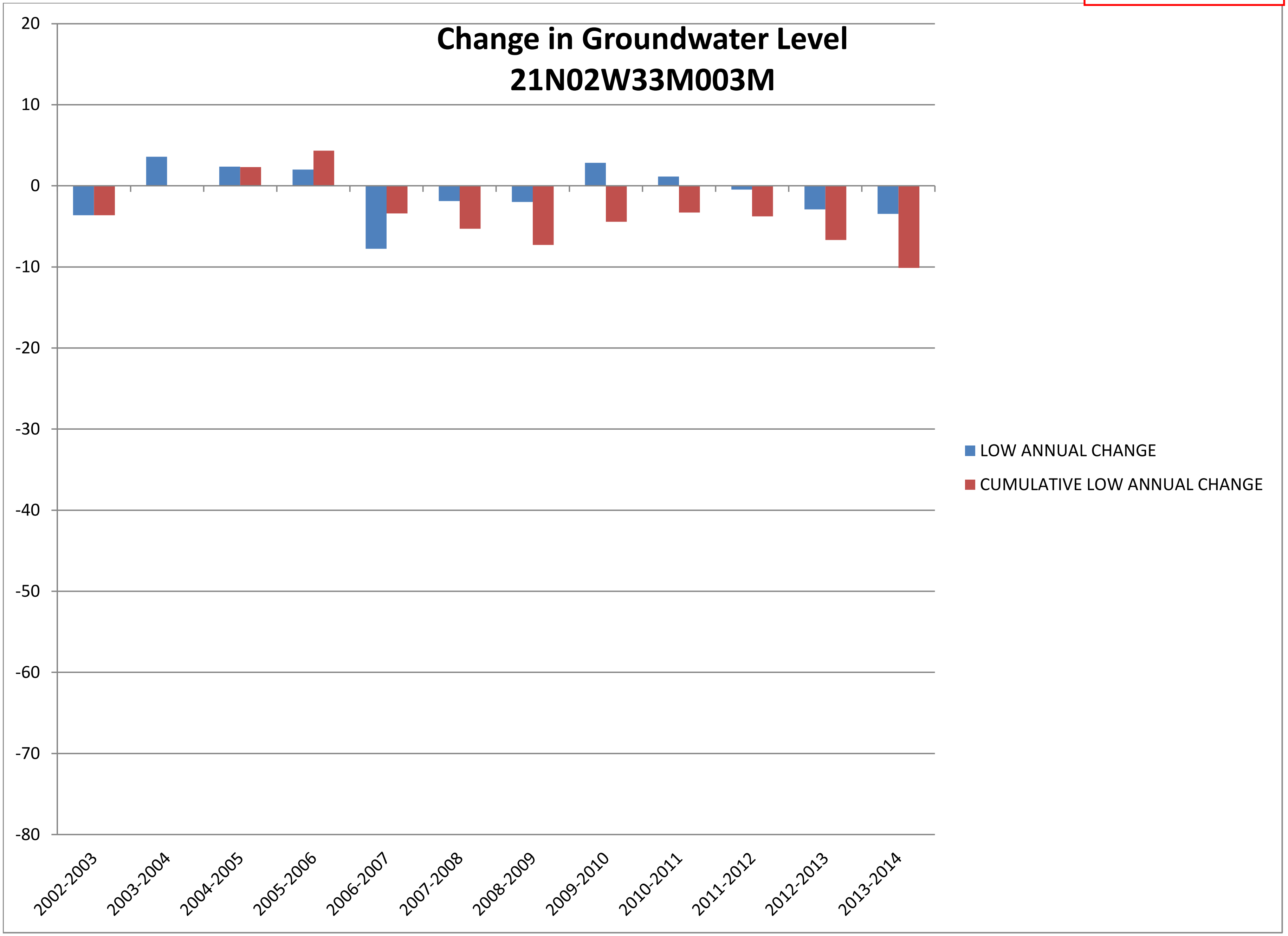

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21N02W33M003M	37	149	109.47	39.53	-0.8	3.4	2.5 TO -4.2	5.9 TO -7.6
PERIOD OF RECORD	2002-2014							

MATHEMATICAL % WELLS AT RISK	WELL DEPTH DISTRIBUTION CUMULATIVE FREQUENCY % TRUE % OF WELLS AT RISK	DEPTH	DIFFERENCE POSSIBLE BMO LEVEL AND 2014 LEVEL (WATER COLUMN)	NUMBER OF WELLS SHALLOWER	INDICATOR OF NUMBER OF YEARS AT AVERAGE LOW ANNUAL CHANGE	1 STD FROM AVERAGE LOW ANNUAL CHANGE	2 STD FROM AVERAGE LOW ANNUAL CHANGE
0.0%	0.0%	0	-39.53	0	NA	NA	NA
2.5%	2.7%	50	10.47	1	13.1	2.5	1.4
5.0%	5.4%	60	20.47	2	25.6	4.9	2.7
7.5%	10.8%	70	30.47	4	38.1	7.3	4.0
10.0%	10.8%	70	30.47	4	38.1	7.3	4.0
12.5%	13.5%	80	40.47	5	50.6	9.6	5.3
15.0%	18.9%	100	60.47	7	75.6	14.4	8.0
17.5%	18.9%	100	60.47	7	75.6	14.4	8.0
20.0%	18.9%	100	60.47	7	75.6	14.4	8.0
22.5%	21.6%	110	70.47	8	88.1	16.8	9.3
25.0%	24.3%	140	100.47	9	125.6	23.9	13.2
27.5%	29.7%	150	110.47	11	138.1	26.3	14.5
30.0%	29.7%	150	110.47	11	138.1	26.3	14.5
32.5%	32.4%	160	120.47	12	150.6	28.7	15.9
35.0%	35.1%	170	130.47	13	163.1	31.1	17.2
37.5%	45.9%	180	140.47	17	175.6	33.4	18.5
40.0%	45.9%	180	140.47	17	175.6	33.4	18.5
42.5%	45.9%	180	140.47	17	175.6	33.4	18.5
45.0%	45.9%	180	140.47	17	175.6	33.4	18.5
47.5%	48.6%	190	150.47	18	188.1	35.8	19.8
50.0%	54.1%	200	160.47	20	200.6	38.2	21.1

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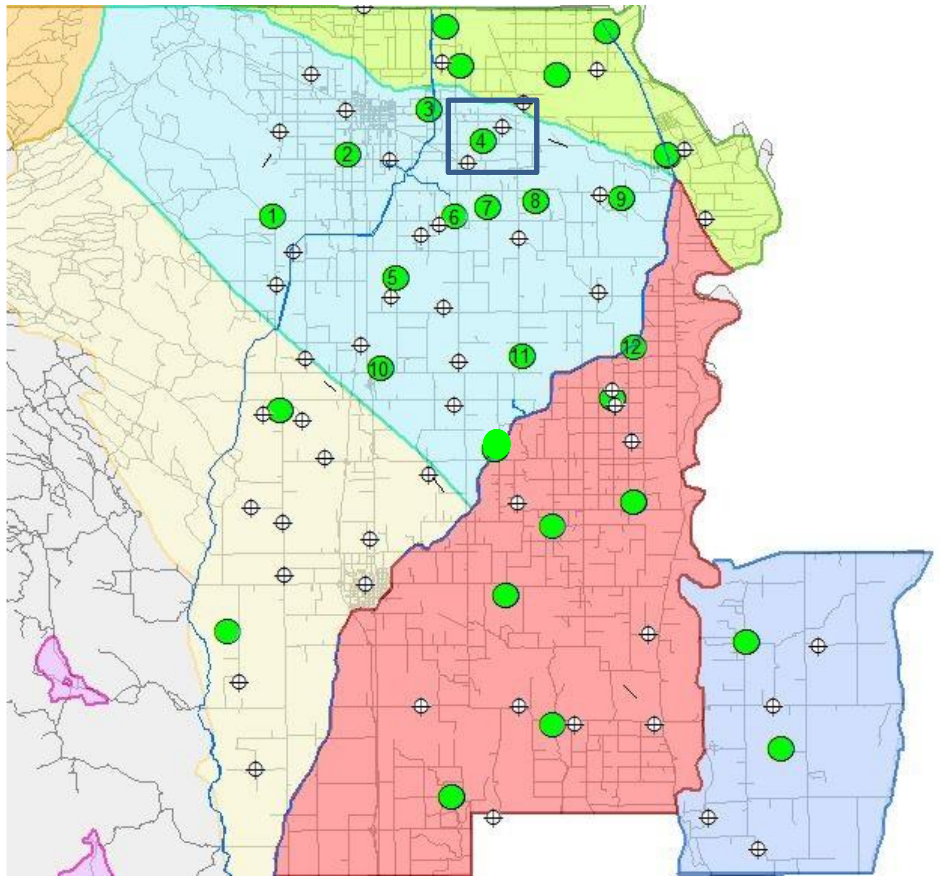

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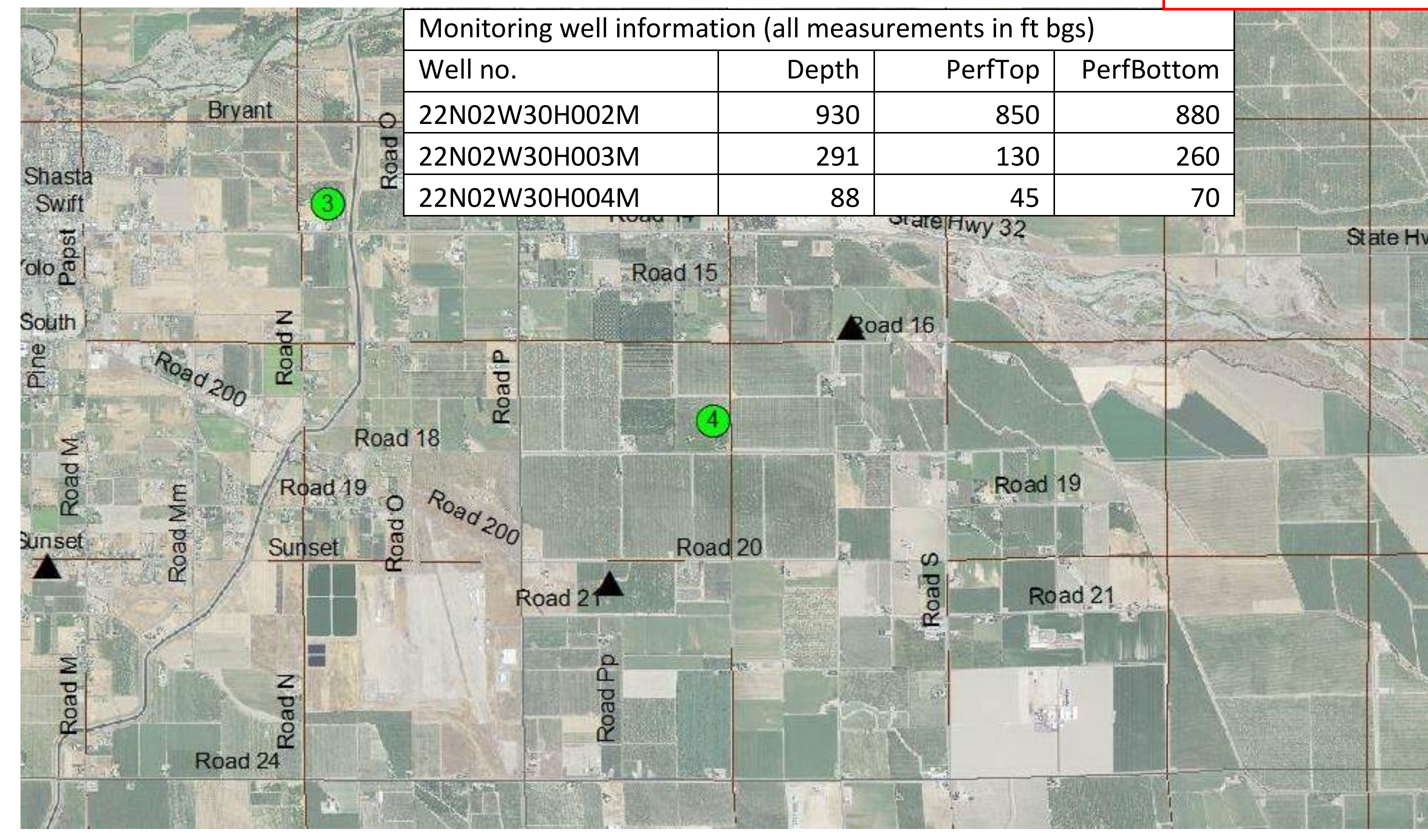
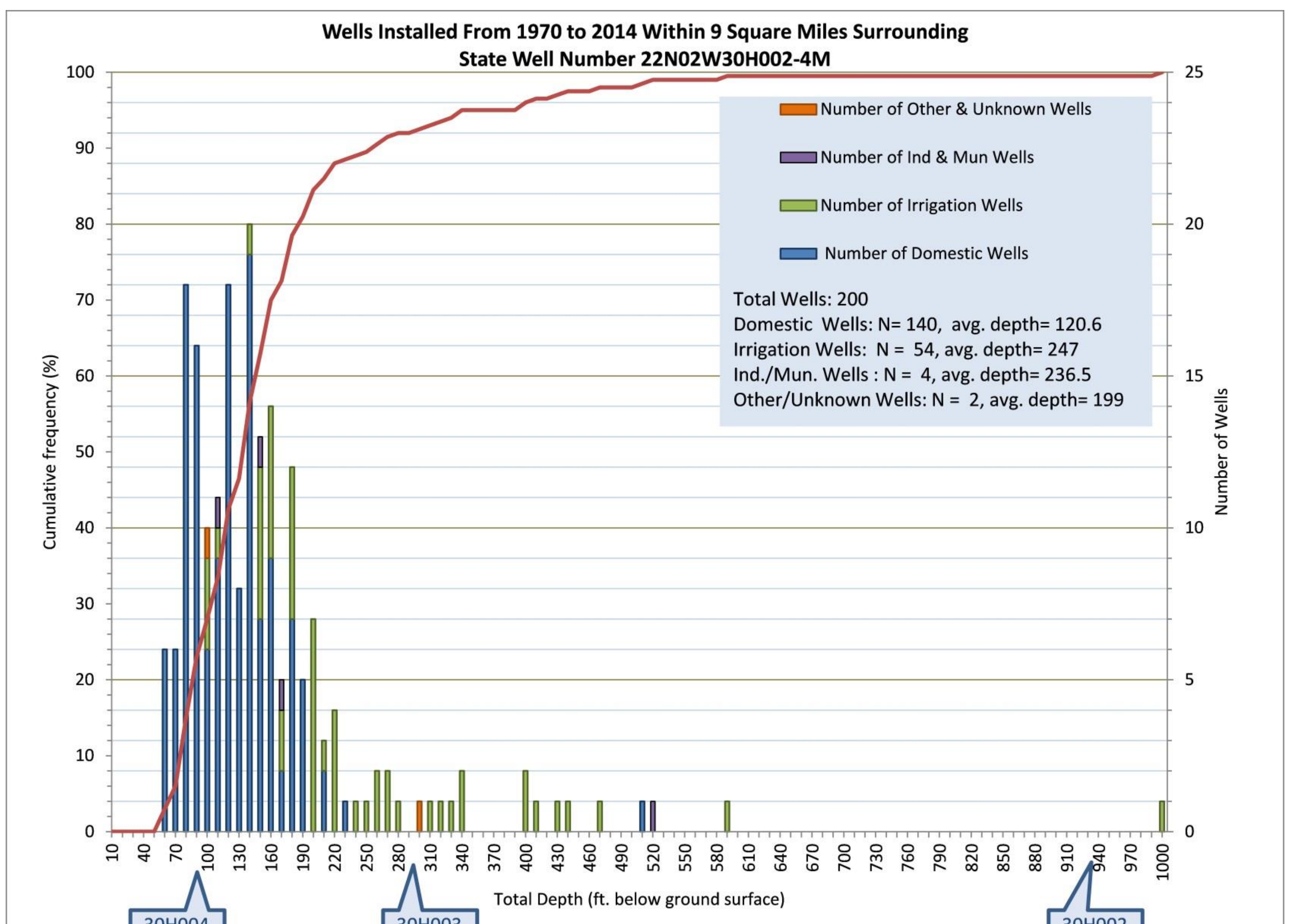
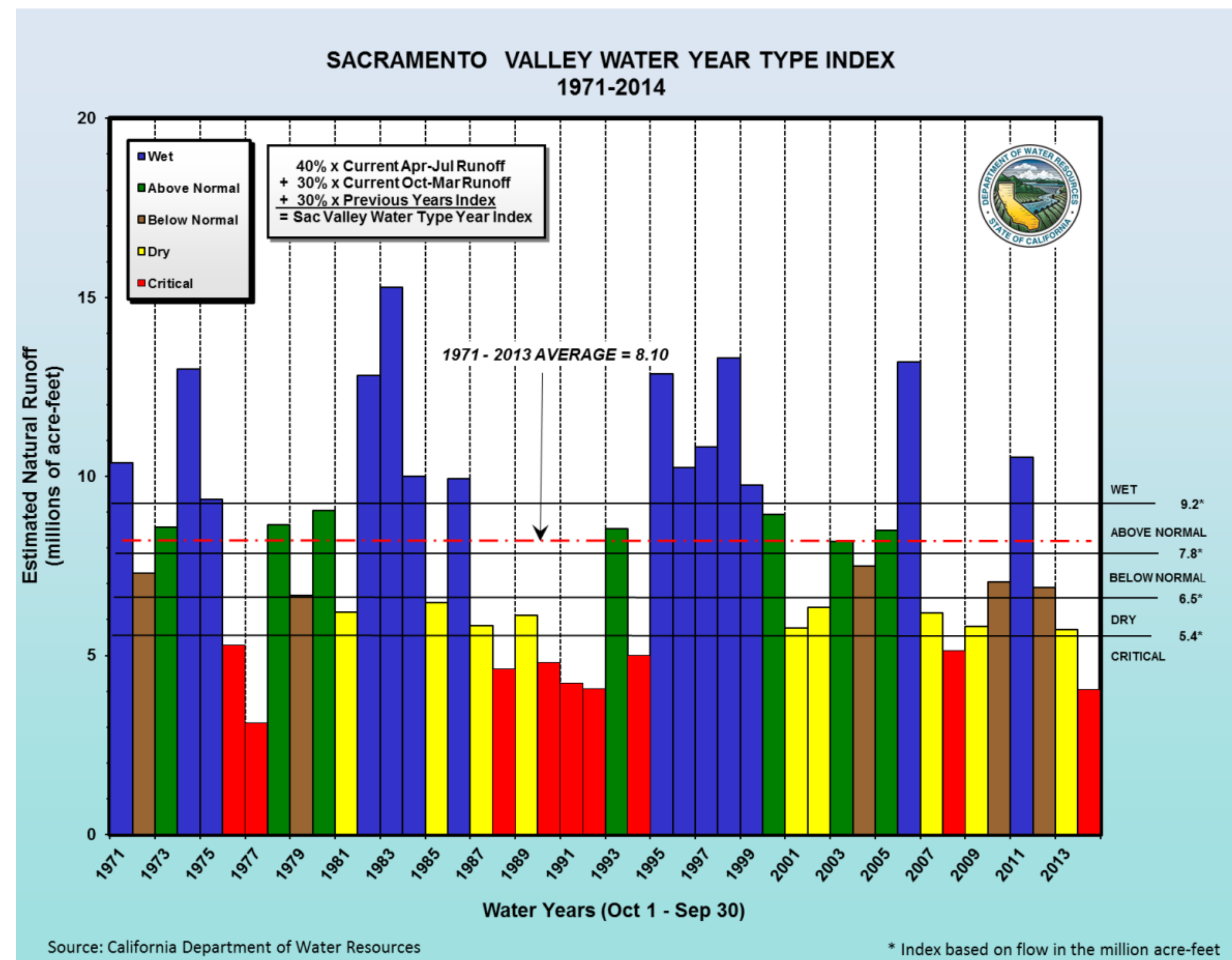
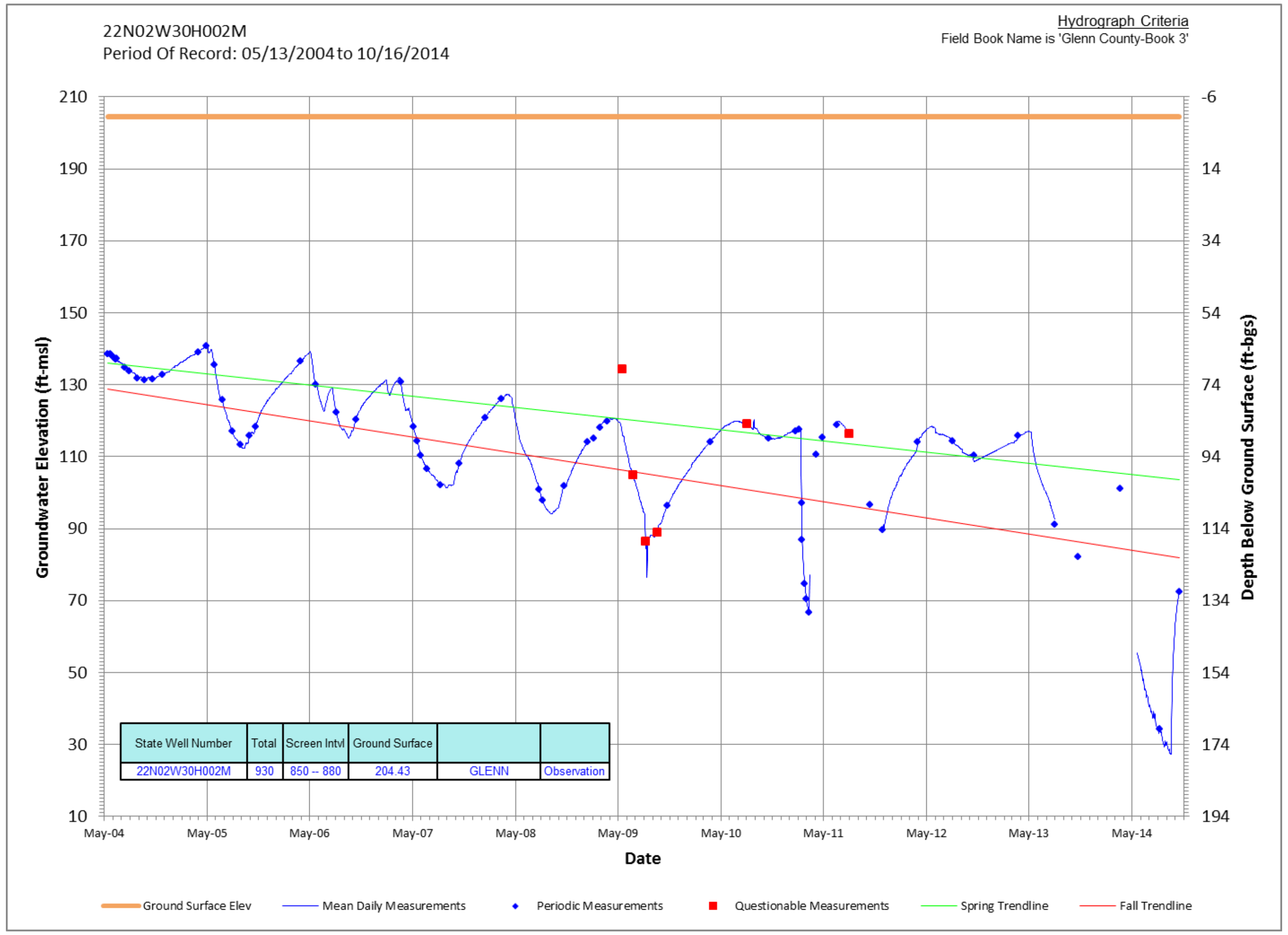
6	21N03W01R002M
7	21N02W05M001M
8	21N02W04G002M
9	21N02W01F001M
10	21N03W34Q002M
11	21N02W33M001M
12	21N02W36A002M

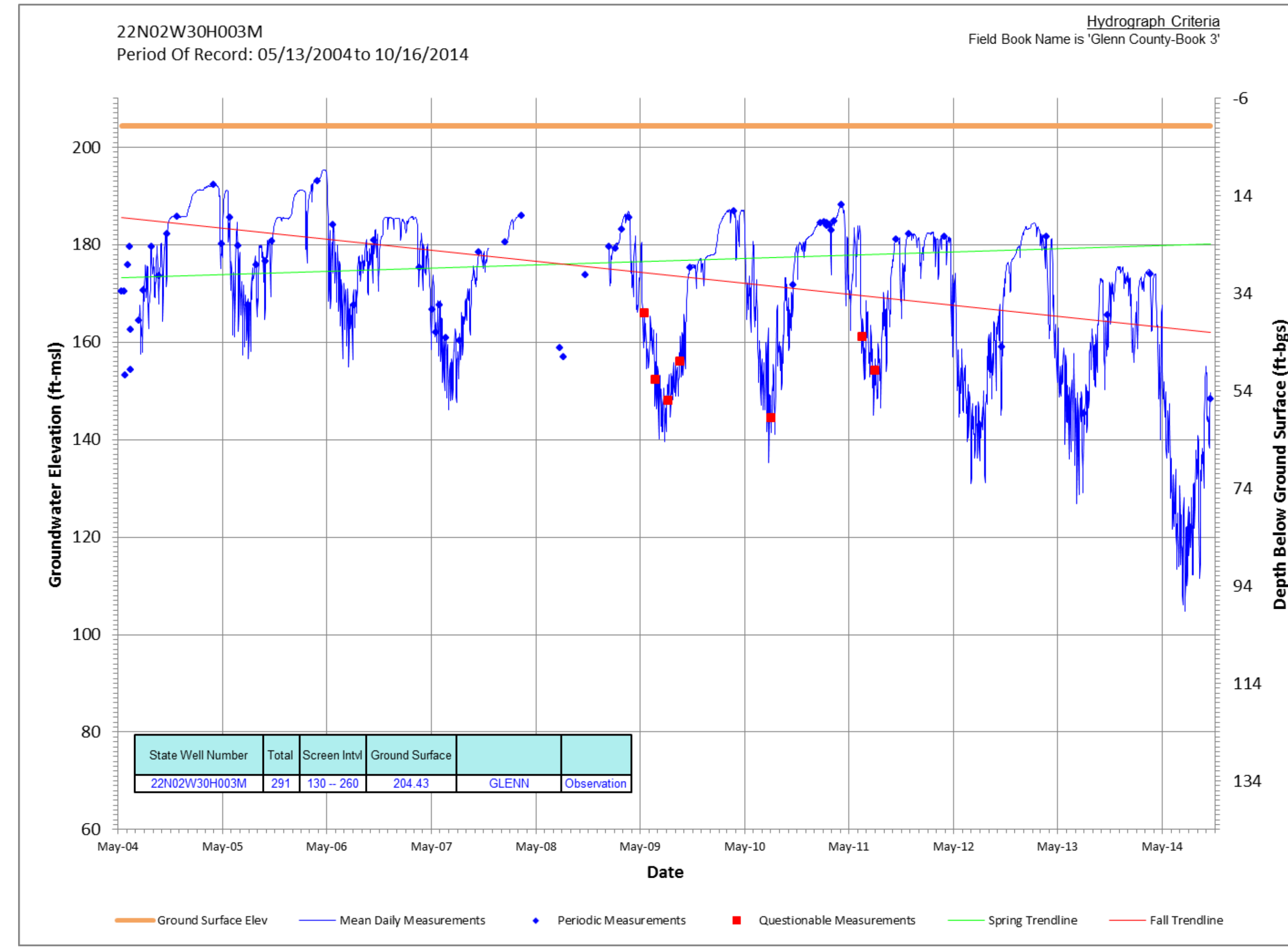


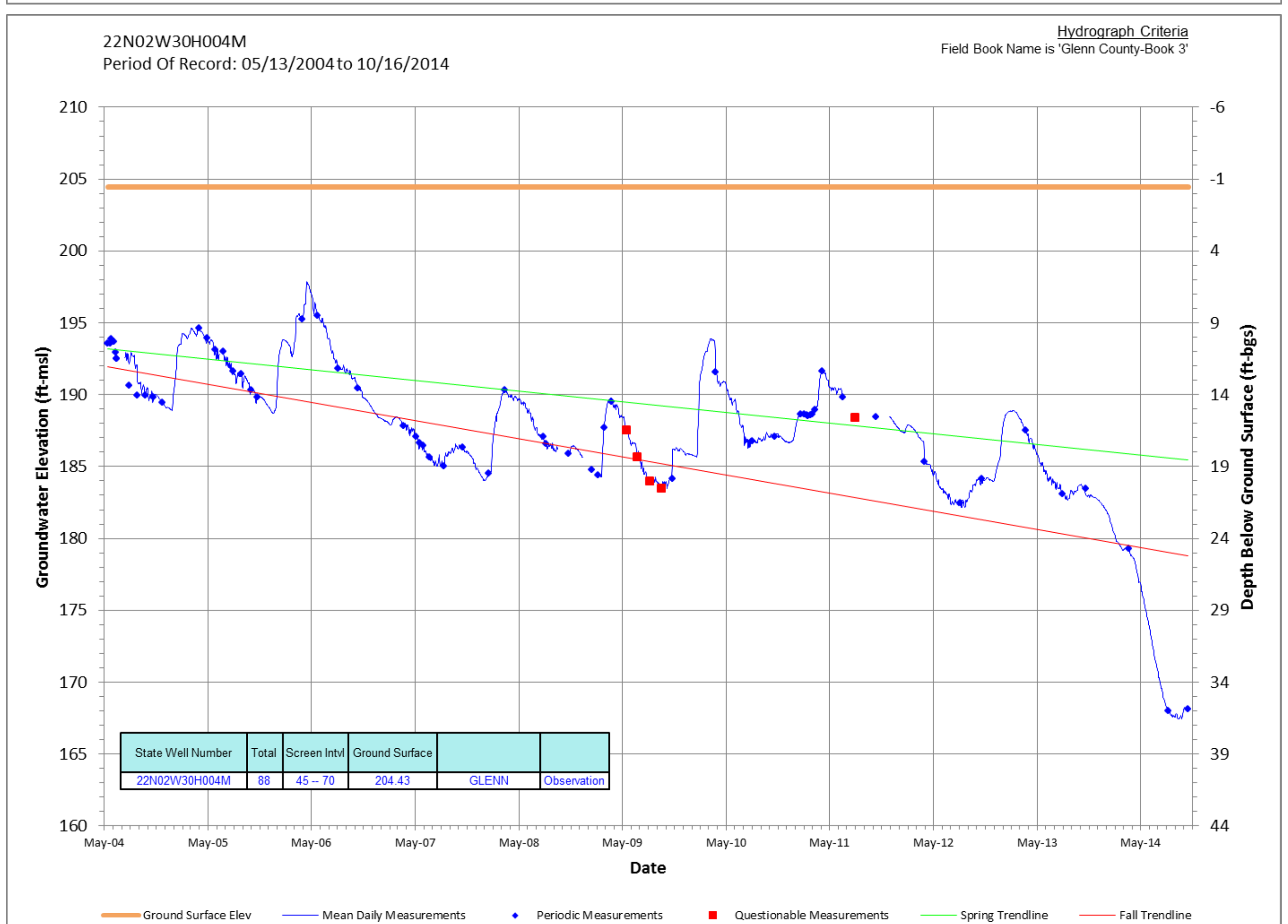
Monitoring well information (all measurements in ft bgs)			
Well no.	Depth	PerfTop	PerfBottom
22N02W30H002M	930	850	880
22N02W30H003M	291	130	260
22N02W30H004M	88	45	70











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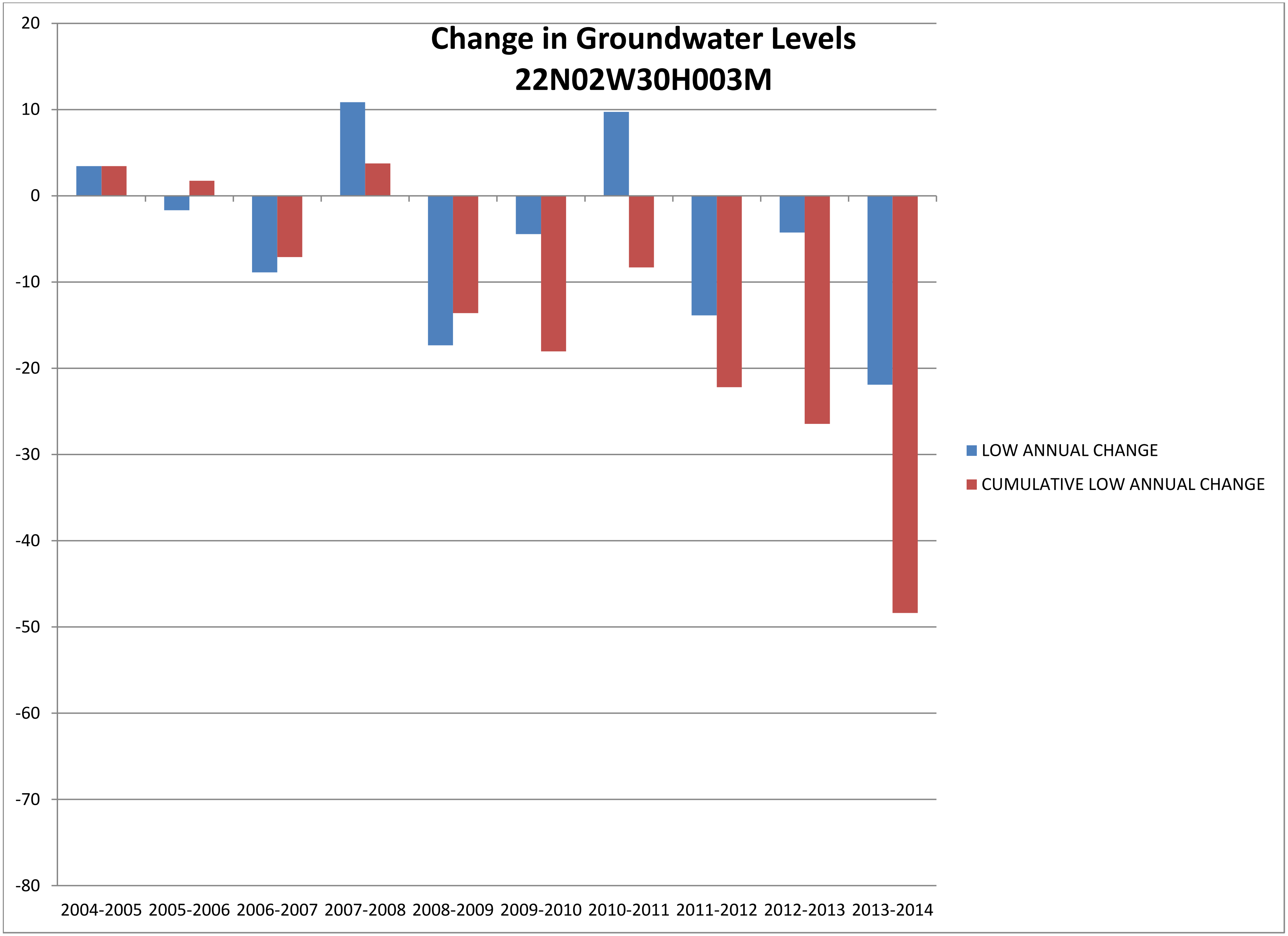

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22N02W30H003M	200	204.43	104.86	99.57	-4.8	11	6.1 TO -15.8	17.1 TO -26.8
PERIOD OF RECORD	2004-2014							

MATHEMATICAL % WELLS AT RISK	WELL DEPTH DISTRIBUTION CUMULATIVE FREQUENCY % TRUE % OF WELLS AT RISK	DEPTH	DIFFERENCE POSSIBLE BMO LEVEL AND 2014 LEVEL (WATER COLUMN)	NUMBER OF WELLS SHALLOWER	INDICATOR OF NUMBER OF YEARS AT AVERAGE LOW ANNUAL CHANGE	1 STD FROM AVERAGE LOW ANNUAL CHANGE	2 STD FROM AVERAGE LOW ANNUAL CHANGE
0.0%	0.0%	0	-99.57	0	NA	NA	NA
2.5%	3.0%	60	-39.57	6	NA	NA	NA
5.0%	6.0%	70	-29.57	12	NA	NA	NA
7.5%	15.0%	80	-19.57	30	NA	NA	NA
10.0%	15.0%	80	-19.57	30	NA	NA	NA
12.5%	15.0%	80	-19.57	30	NA	NA	NA
15.0%	15.0%	80	-19.57	30	NA	NA	NA
17.5%	23.0%	90	-9.57	46	NA	NA	NA
20.0%	23.0%	90	-9.57	46	NA	NA	NA
22.5%	23.0%	90	-9.57	46	NA	NA	NA
25.0%	28.0%	100	0.43	56	0.1	0.0	0.0
27.5%	28.0%	100	0.43	56	0.1	0.0	0.0
30.0%	33.5%	110	10.43	67	2.2	0.7	0.4
32.5%	33.5%	110	10.43	67	2.2	0.7	0.4
35.0%	42.5%	120	20.43	85	4.3	1.3	0.8
37.5%	42.5%	120	20.43	85	4.3	1.3	0.8
40.0%	42.5%	120	20.43	85	4.3	1.3	0.8
42.5%	42.5%	120	20.43	85	4.3	1.3	0.8
45.0%	46.5%	130	30.43	93	6.3	1.9	1.1
47.5%	56.5%	140	40.43	113	8.4	2.6	1.5
50.0%	56.5%	140	40.43	113	8.4	2.6	1.5

Proposed Sub-area: North-West Colusa Basin

Well Number	Wells within 9 square miles	GSE	LOW 2014 GWE	LOW 2014 Depth to GW	Average Annual Change (LOW)	STD of Annual Change (LOW)	ANNUAL GROUNDWATER FLUCTUATION DURING MORE FAMILIAR OPERATION AND CONDITIONS (66%=1STD)	ANNUAL GROUNDWATER FLUCTUATION DURING MORE EXTREME OPERATION AND CONDITIONS (95%=2STD)	PROJECTED NO. YEARS AT 2.5% RISK AT CURRENT RATE OF CHANGE	PROJECTED NO. YEARS AT 50% RISK AT CURRENT RATE OF CHANGE	PROJECTED NO. YEARS AT 50% RISK AT 2 STANDARD DEVIATIONS FROM ANNUAL CHANGE
21N04W12A002M	32	247.88	72.2	175.7	-7.7	8.5	0.9 TO -16.2	9.4 TO -24.7	N/A	49.9	15.6
21N04W12A004M	32	247.5	-2.21	249.71	-7.3	5.3	-2.0 TO -12.6	3.4 TO -17.9	N/A	42.5	17.3
22N03W28P002M	421	258.22	164.1	94.12	-2	6.2	4.1 TO -8.2	10.3 TO -14.4	N/A	12.9	1.8
22N03W28P003M	421	258.22	221.7	36.52	-1.2	4.3	3.1 TO -5.4	7.3 TO -9.7	27.9	69.6	8.5
22N03W24E002M	263	230.53	142.57	87.96	-3.3	6.1	2.9 TO -9.4	9.0 TO -15.6	N/A	12.7	2.7
22N03W24E003M	263	230.51	199.91	30.6	-1.1	2.1	1.0 TO -3.2	3.1 TO -5.3	26.7	90.4	18.8
22N02W30H003M	200	204.43	104.86	99.57	-4.8	11	6.1 TO -15.8	17.1 TO -26.8	N/A	8.4	1.5
21N03W23D002M	61	204.76	125.07	79.69	-3.4	7.3	3.9 TO -10.7	11.2 TO -18.0	3	29.5	5.6
21N03W01R002M	65	203.32	93.77	109.55	-6	17.1	11.2 TO -23.1	28.3 TO -40.2	N/A	16.7	2.5
21N02W05M001M	105	188.93	90.04	98.89	-4.3	13.8	9.5 TO -18.1	23.3 TO -31.8	N/A	18.9	2.5
21N02W05M002M	105	188.93	120.43	68.5	-2.5	9.8	7.3 TO -12.3	17.1 TO -22.1	4.6	44.6	5
21N02W04G004M	55	178.41	86.59	91.82	-1.9	11	9.1 TO -13.0	20.2 TO -24.0	N/A	67.5	5.4
21N02W01F002M	42	160.83	88.04	72.79	-1.5	6.7	5.2 to -8.2	11.9 to -14.8	11.5	71.5	7.2
21N03W34Q003M	86	166.28	32.11	134.17	-8.2	14.1	5.9 TO -22.3	20.0 TO -36.4	N/A	4.4	1
21N03W34Q004M	86	166.33	105.55	60.78	-4	6.4	2.4 TO -10.3	8.8 TO -16.7	4.8	27.3	6.5
21N02W33M003M	37	149	109.47	39.53	-0.8	3.4	2.5 TO -4.2	5.9 TO -7.6	13.1	200.6	21.1
21N02W36A002M	47	135.39	96.61	38.78	-0.5	4	3.5 TO -4.5	7.5 TO -8.5	42.4	222.4	13.1

DRAFT August 11, 2015

Report of Abnormal Groundwater Level

Name: ______________________________ Email: ______________

Address: ______________________________ Phone number: ______________

Well Information

Location: ______________

Age of well: ______________

Depth: ______________

Screen Depth: ______________

Pump Depth: ______________

Depth to Water: ______________

Measurement Date: ______________ Static Measurement: Yes/No

Gallons per Minute: ______________

Percent Change/Describe change ______________

Additional Information: ______________

____

Brief Description of the problem: ______________

____

____

______________________________ (Continue on additional paper if necessary.)

Do you have a well driller log? Yes/No If yes, please attach (optional).

Do you have pump maintenance records? Yes/No

Do you have well maintenance records? Yes/No

Do you have groundwater level records? Yes/No

Have you contacted a pump repair person? Yes/No

Have you contacted a well driller? Yes/No

____

Sign Print Name Date

For Office Use Only

Received

Acknowledgement sent

Forward to Committees

Follow-up necessary?

Follow-up sent

Revised: May 8, 2015

GSA Formation Notifications Received by DWR

From DWR website August 11, 2015

Show 10 entries

Search:

Name of Local Agency	Basin/Subbasin Name	Basin/Subbasin Number	County(s) the Basin is Located	Date of GSA Notification Posting
Provident ID and Princeton-Codora-Glenn ID	Colusa	5-21.52	Colusa	04/16/2015
Reclamation District No. 1004	West Butte	5-21.58	Glenn	08/07/2015
County of Glenn	Corning	5-21.51	Glenn	07/09/2015
County of Glenn	Colusa	5-21.52	Glenn	07/09/2015
County of Glenn	West Butte	5-21.58	Glenn	07/09/2015
Orland-Artois Water District	Colusa	5-21.52	Glenn	07/02/2015
City of Orland	Colusa	5-21.52	Glenn	07/02/2015
Glide Water District	Colusa	5-21.52	Glenn	05/05/2015
Kanawha Water District	Colusa	5-21.52	Glenn	05/05/2015
Provident ID and Princeton-Codora-Glenn ID	Colusa	5-21.52	Glenn	04/16/2015