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CONSULTING ENGINEERS

GROUNDWATER RESOURCES
HYDROLOGY · DEVELOPMENT · MANAGEMENT

Technical Memorandum

DATE: November 30, 2016 PROJECT: 16-1-013

TO: Mr. Dan Reiff, CEMEX

FROM: Liese Schadt, Till Angermann

SUBJECT: **ESTIMATION OF AVERAGE HIGH GROUNDWATER LEVELS CEMEX MADISON PLANT, YOLO COUNTY**

The Yolo County Off-Channel Surface Mining Reclamation Ordinance, Sec. 10-5.516, requires a minimum separation of five feet between the areal average high groundwater levels (AHG) and the surface of any reclaimed below-grade agricultural lands. To address this requirement, Luhdorff and Scalmanini Consulting Engineers (LSCE) completed two tasks. First, LSCE developed a methodology for estimating areal AHG that incorporates the variations in climatic, hydrologic, and water supply conditions in the area. Secondly, the methodology was utilized to derive areal AHG at the CEMEX Madison plant area (Figure 1), specifically for Phases III, IV, and VI (Figure 2).

This Technical Memorandum provides herein a summary description of the areal AHG estimation methodology and the results of the AHG estimation for the CEMEX Phases.

METHODOLOGY

Establishing areal AHG for the CEMEX Madison plant phases consisted of a three-step process:

1. Selection of a hydrologic base period, a historical period of time that represents average hydrologic conditions in the area;
2. Computation of well-specific AHG for the base period; and
3. Identification of historically observed groundwater level condition that most closely compares to the computed well-specific AHG.

Step 1 Selection of a Hydrologic Base Period

For over 20 years, groundwater levels at the CEMEX Madison plant have been documented to fluctuate in response to historical variations in area precipitation and Cache Creek stream discharge. Therefore, the estimation of areal AHG was based on determination of a hydrologic base period during which historical area precipitation and creek discharge are considered average and not biased toward overly wet or dry conditions. Several criteria must be met in selecting any base period, primarily that, during the base period, the cumulative departure from historical mean precipitation and stream discharge is near zero, and there are numerous and equal numbers of wet and dry shorter time periods. Additionally, it is desirable for the base period to be recent and with a comprehensive set of hydrologic

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data. Accordingly, base period selection for the CEMEX phases involved the analysis of cumulative departure of annual precipitation and annual creek discharge from their respective historical mean values.

Step 2 Computation of Well-Specific AHG for the Selected Base Period

Groundwater levels in the vicinity of the CEMEX Madison plant fluctuate on a seasonal and long-term basis, with levels typically highest each year during the early spring months. Thus, the estimation of areal AHG was based on the identification of the spring high groundwater level observed each year of the selected base period in each well surrounding the CEMEX phases. Then, on a well-by-well basis, the average of the identified spring high groundwater levels was computed. For this analysis, the computed well-specific AHG were computed for six wells surrounding CEMEX Phases III, IV, and VI, specifically monitoring wells OW-3, OW-4, OW-8d, OW-9, and OW-10, and shallow water supply well 10N/01W-36B02.

Step 3 Identification of Historically Observed Groundwater Level Condition (Areal AHG) Comparative to Computed Well-Specific AHG

The areal AHG for CEMEX Phases III, IV, and VI are best illustrated by a map of groundwater level contours across the phases, specifically contours constructed from observed groundwater levels that most closely compare to the computed well-specific AHG. Therefore, comparison was made between the computed well-specific AHG and the observed spring high groundwater levels in each well from each year of the hydrologic base period. The month/year when the differences between the well-specific AHG and observed groundwater levels were minimized and most evenly distributed (i.e., exhibiting both positive and negative differences) was selected as the time period representing areal AHG conditions. Accordingly, the map of AHG contours was constructed from the observed groundwater levels from that selected time period.

It is important to note that the well-specific AHG computed in Step 2 were not utilized to construct the areal AHG contour map because they are not observed values. Further, it cannot be assumed that a hydrologic condition has or ever would exist where groundwater levels in all six wells would exhibit their respective well-specific AHG at the same time.

RESULTS

The cumulative departure from mean precipitation exhibits average conditions over the period from 1995 to 2014 (Figure 3)[1]. Similarly, the cumulative departure from Cache Creek's mean annual discharge (as measured at the Rumsey Bridge Station) exhibits essentially average conditions over the same period (Figure 4). During this time, precipitation and stream discharge alternated between an equal number of above average and below average conditions. Therefore, the period of 20 water years from 1995 to 2014 was selected as the hydrologic base period[2].

For the computation of well-specific AHG, the historical groundwater level data for area wells (Figure 5) were utilized, specifically the groundwater level data observed each spring during the 1995-2014 base period in each of the wells closest to Phases III, IV, and VI. The wells included CEMEX monitoring wells OW-3, OW-4, OW-8d, OW-9, and OW-10, as well as nearby shallow water supply well 10N/01W-36B2 monitored by the Yolo County Flood Control & Water Conservation District (WRID, 2016)[3]. The monthly water level record (1990-2000) shows that the highest groundwater levels each year typically occur in February or March. During the quarterly measurement schedule implemented since then, February or March measurements are not always available. In those cases, high water levels were estimated based on the strong and consistent correlation of groundwater levels between nearby wells.

The AHG for each well were computed by averaging the observed (or estimated, as necessary) spring high groundwater level from each of the base period years 1995 through 2014 on a well by well basis. Each well's computed AHG elevation was then compared to each year's observed spring elevation in order to identify a specific year when the difference (computed average vs. observed) for each well was the smallest (Figure 6). This comparison indicated that the groundwater elevations observed in each well during spring 2000 were closest to their respective computed AHG and, as such, the map of groundwater elevation contours for spring 2000 represents the areal AHG for CEMEX Phases III, IV, and VI (Figure 7). Separate water level contour maps need not be generated for each of these three mining phases because this map comprehensively aggregates information specific to each of the mining phases. From west to east, AHG ranges from approximately 113 to 105 feet (NGVD29).

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[1] Precipitation records from the Woodland station were also reviewed but were found to have substantial periods of missing data. Periods where data from both stations are available indicate similarity between the two stations' records. For consistency, the Davis station was favored for this analysis.
[2] By design, the entirety of the record used for a cumulative departure curve reflects average conditions (i.e., the starting and ending point match the long-term average. However, average precipitation and discharge conditions overlap during the 1995-2014 period.
[3] This well is 115 feet deep, which is similar to monitoring well depths on the CEMEX Madison plant area.

The AHG condition established herein is not applicable to the mining phases west of Phase III (Phases I, II, and VII) because the analysis did not include groundwater level data from this area. Similarly, the AHG condition established herein is not applicable to Phase V due to the absence of a downgradient groundwater level record.

CONTEXT

Since the average is an estimator of central tendency, it should be expected that spring groundwater levels will periodically rise above the AHG established herein. Review of the historical groundwater elevation data from the CEMEX monitoring wells indicates that spring groundwater levels have risen above the areal AHG several times during the approximate 25 years comprising the period of record (fall 1990 through present). Such conditions were most pronounced in the spring time of the four consecutive years from 1995 to 1998. A map of contours of equal groundwater elevation for March 1998 illustrates the highest groundwater levels observed during the period of record (Figure 8). The groundwater levels observed in March 1998 exceed the areal AHG conditions by two (in the vicinity of OW-4) to eight feet (in the southwest corner of Phase VI). This suggests that periodic inundation of a lowered surface reclaimed to agriculture in compliance with the Yolo County Off-Channel Surface Mining Reclamation Ordinance (Sec. 10-5.516) is a possibility in years of high precipitation and/or stream discharge.

Last, variations in agricultural irrigation practices (and associated percolation of irrigation water) on adjacent lands have likely affected groundwater levels beneath the CEMEX parcels over time. Following reclamation, if conducted by the backfilling of fine materials, additional effects on groundwater levels may be expected due to the reduced or delayed percolation of irrigation water and incident precipitation, as well as the impedance of groundwater flow through the finer materials.

REFERENCES CITED

California Department of Water Resources, California Data Exchange Center (CDEC), 2016; Hourly Mean Stream Discharge Data, "Cache Creek at Rumsey" gauge, Water Years 1994-2016.

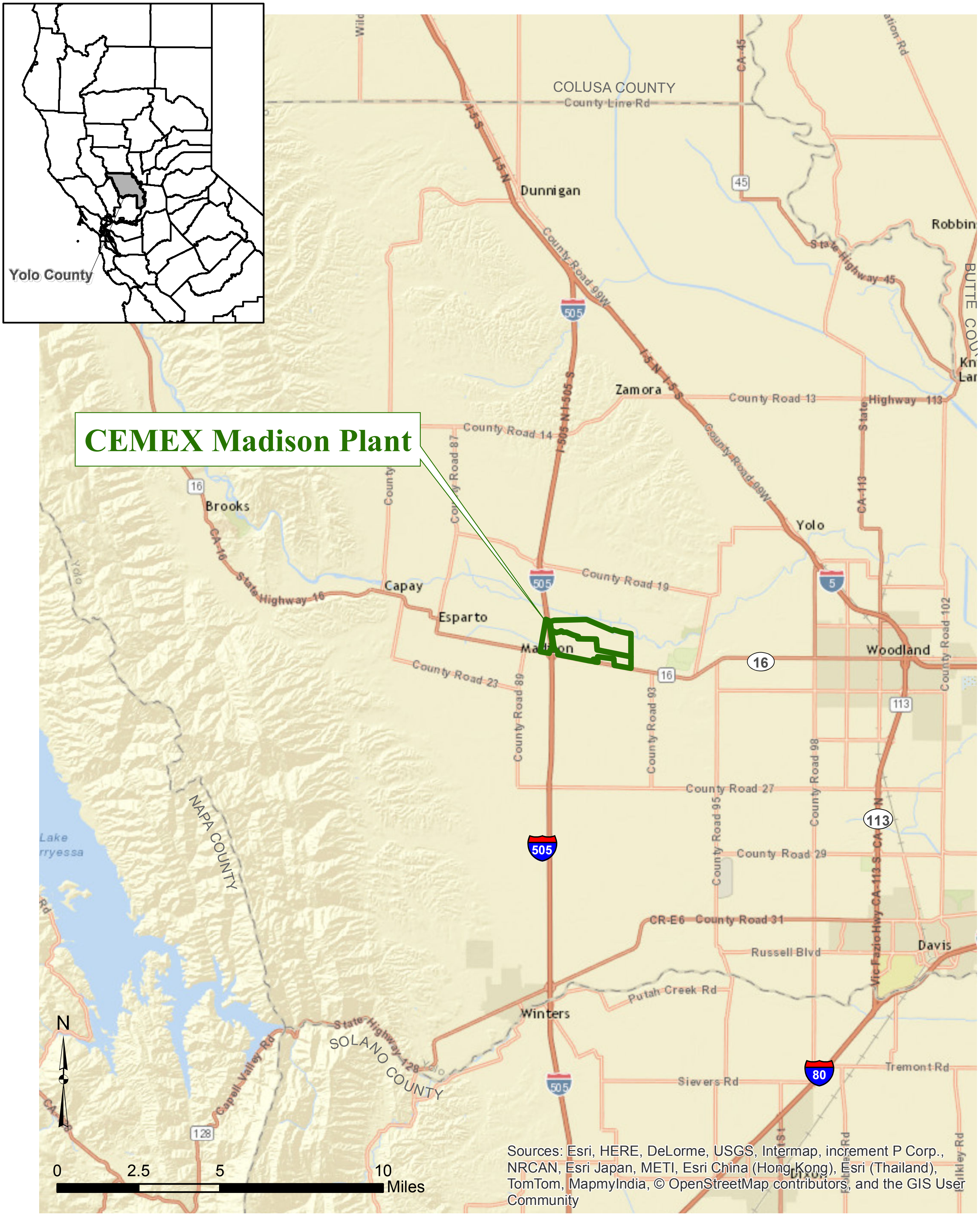
Western Regional Climate Center, 2016; Monthly Precipitation Data, "Davis 2 Experimental Farm" and "Woodland" gauges, Water Years 1950-2016.

Yolo County Water Resources Information Database (WRID), 2016; Semi-annual Groundwater Level Data and Summary Well Information.

Enclosures

Attachments

FIGURES



File: C:\Users\Dell\Desktop\GIS for Desktop\CEMEX\Figure 1 Location Map.mxd

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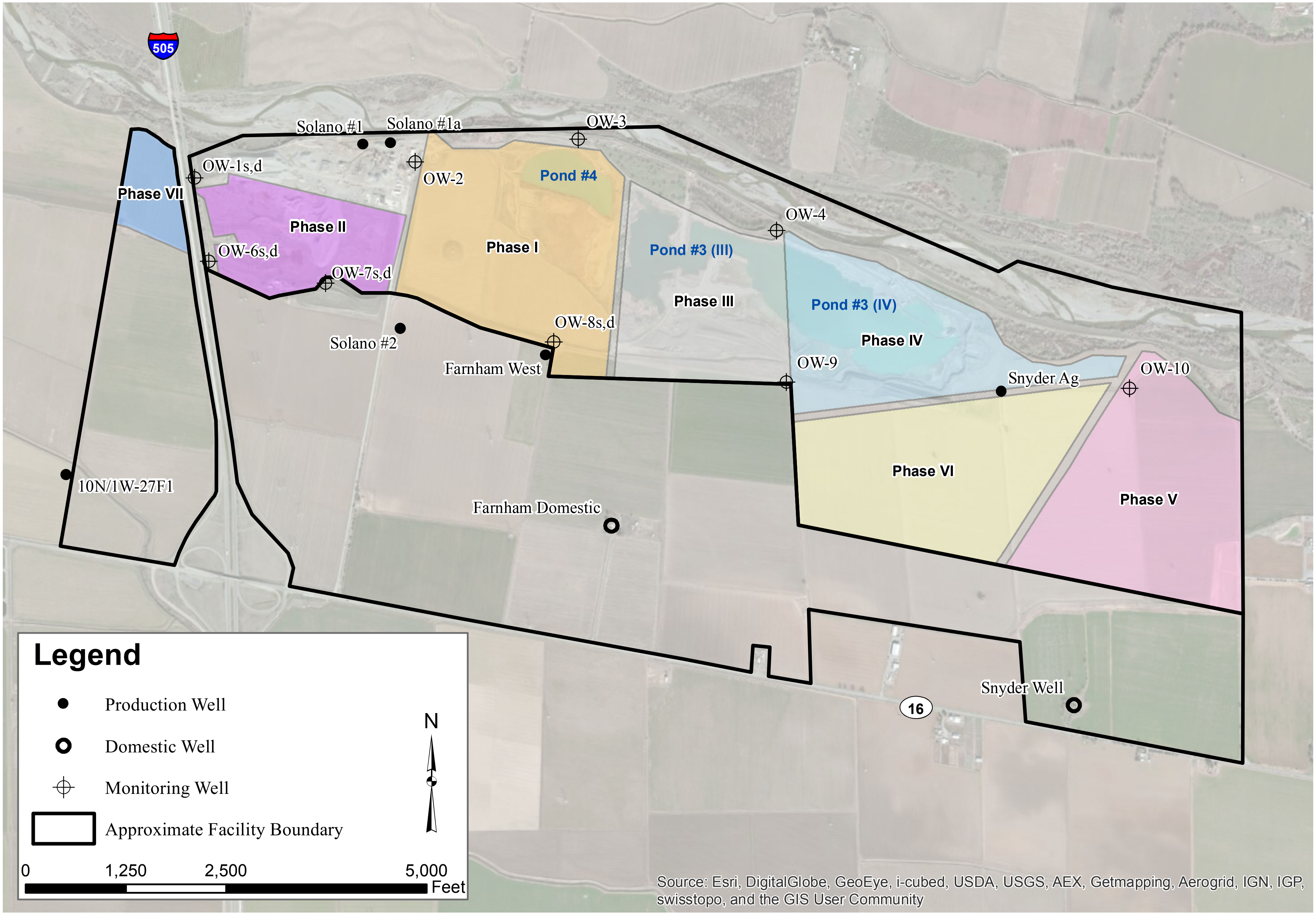
Figure 1
Location Map
CEMEX - Madison Plant



File: C:\Users\Dell\Desktop\GIS for Desktop\CEMEX\Figure 2 Mining Phases and Well Locations

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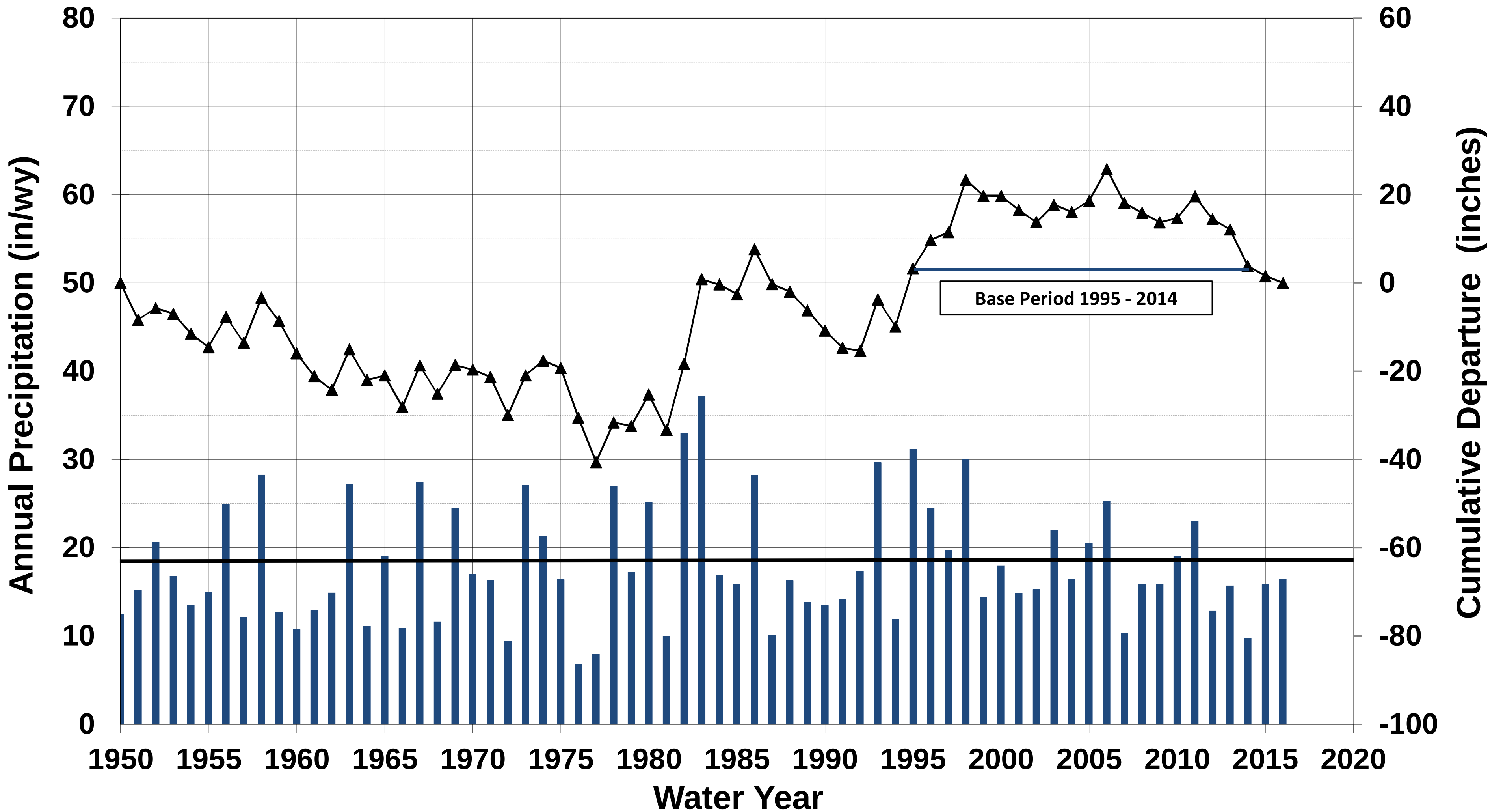
Figure 2
Mining Phases and Well Locations
CEMEX - Madison Plant Site



Historical Data from Davis 2 Experimental Farm Station #2294 (NCDC), #042294 (WRCC)

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Figure 3
Area Historical Precipitation
CEMEX - Madison Plant Site

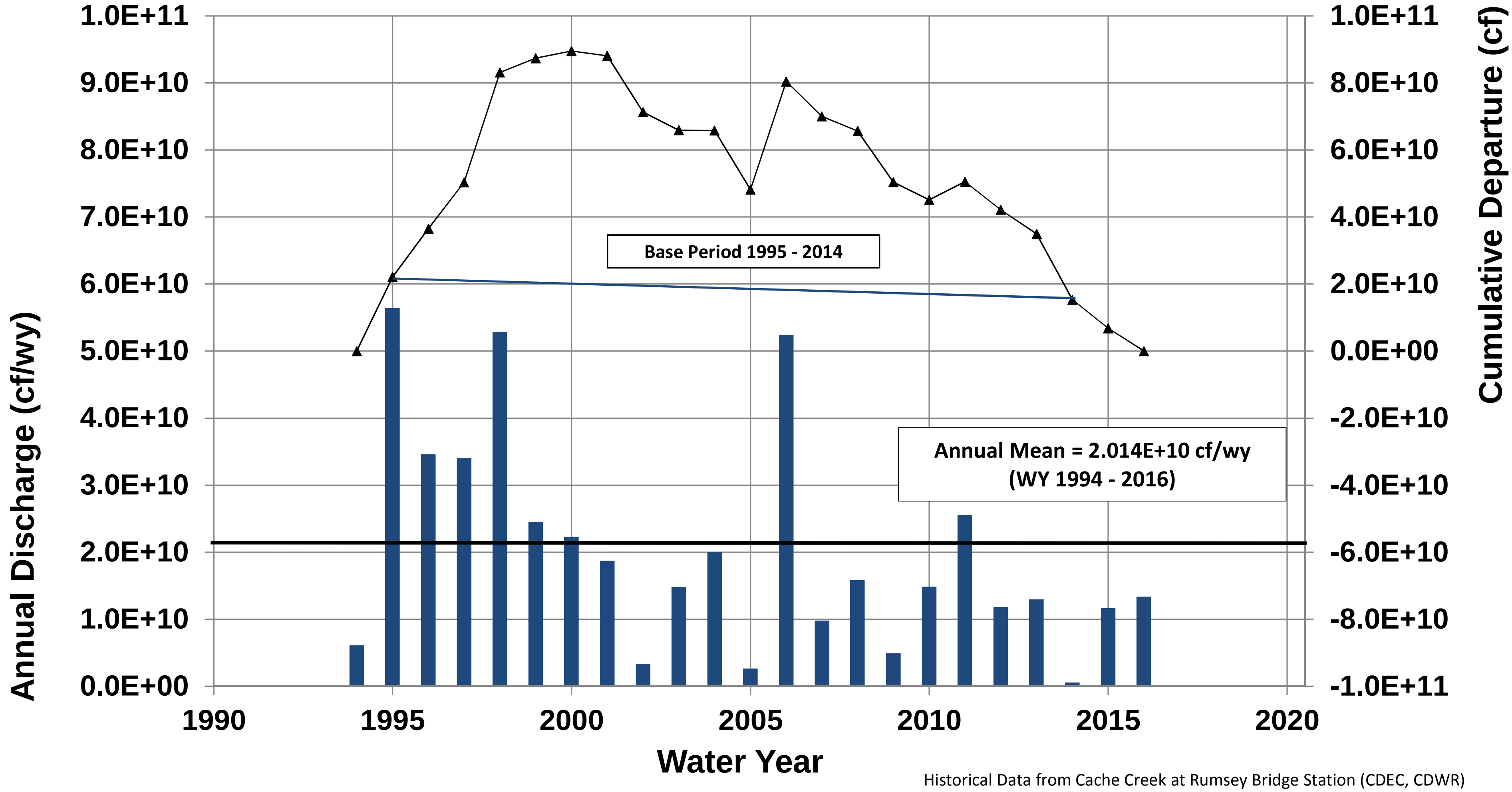

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Figure 4
Historical Stream Discharge, Cache Creek at Rumsey Bridge
CEMEX-Madison Plant Site

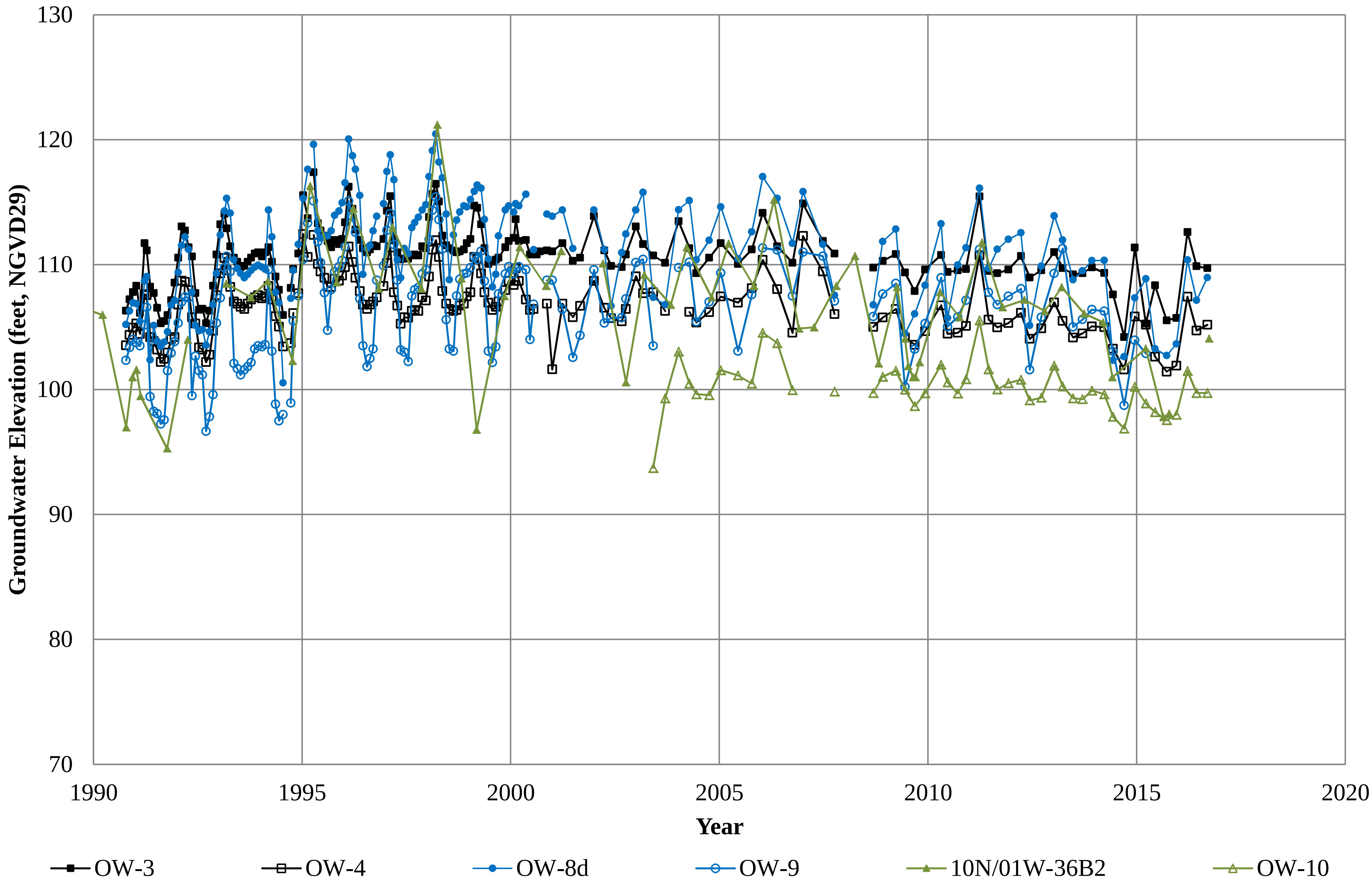

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Figure 5
Historical Groundwater Elevations, Phases III, IV, and VI
CEMEX - Madison Plant Site

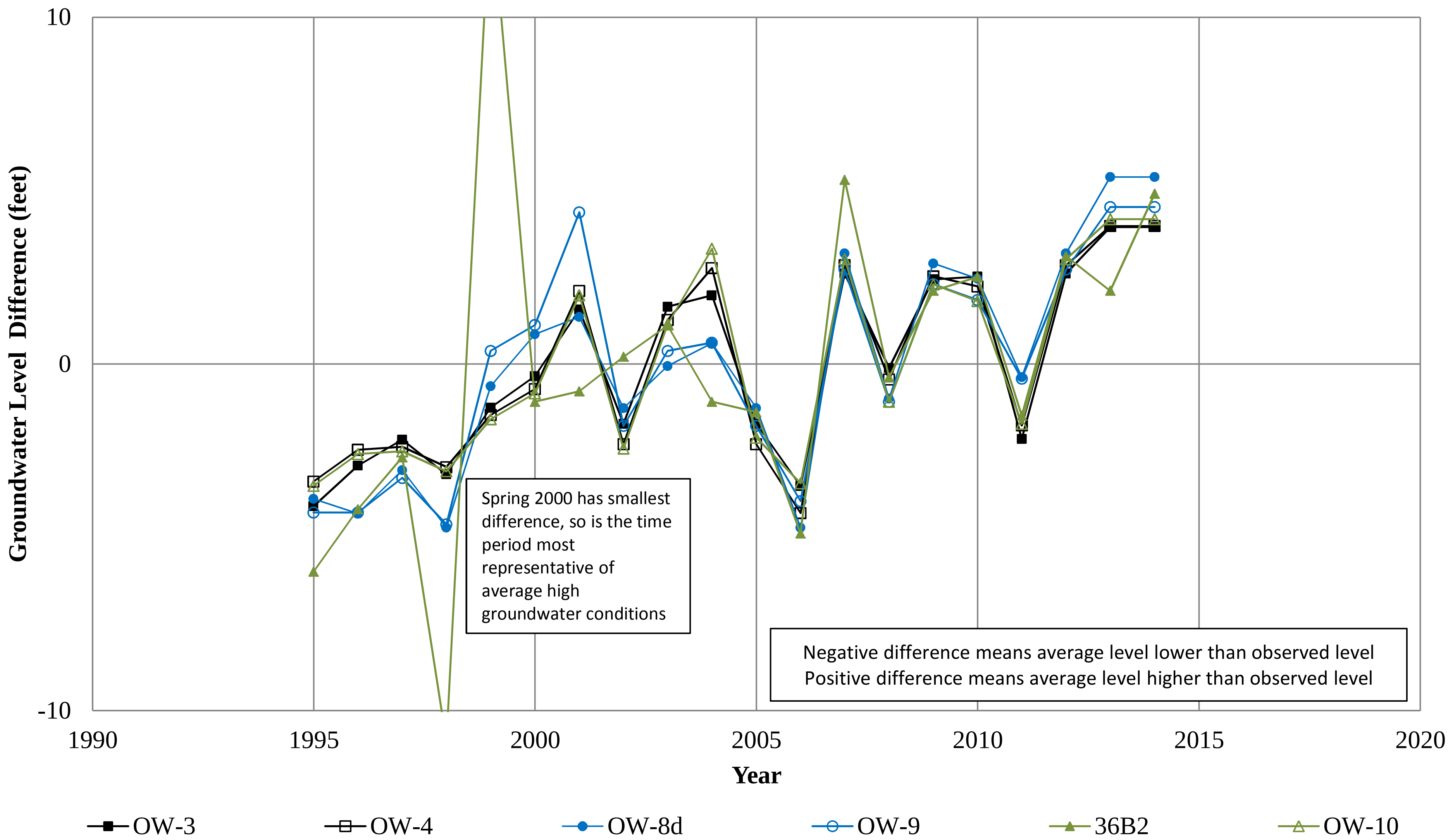

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Figure 6
Difference Between Calculated Average High and Observed Groundwater Levels
CEMEX - Madison Plant Site

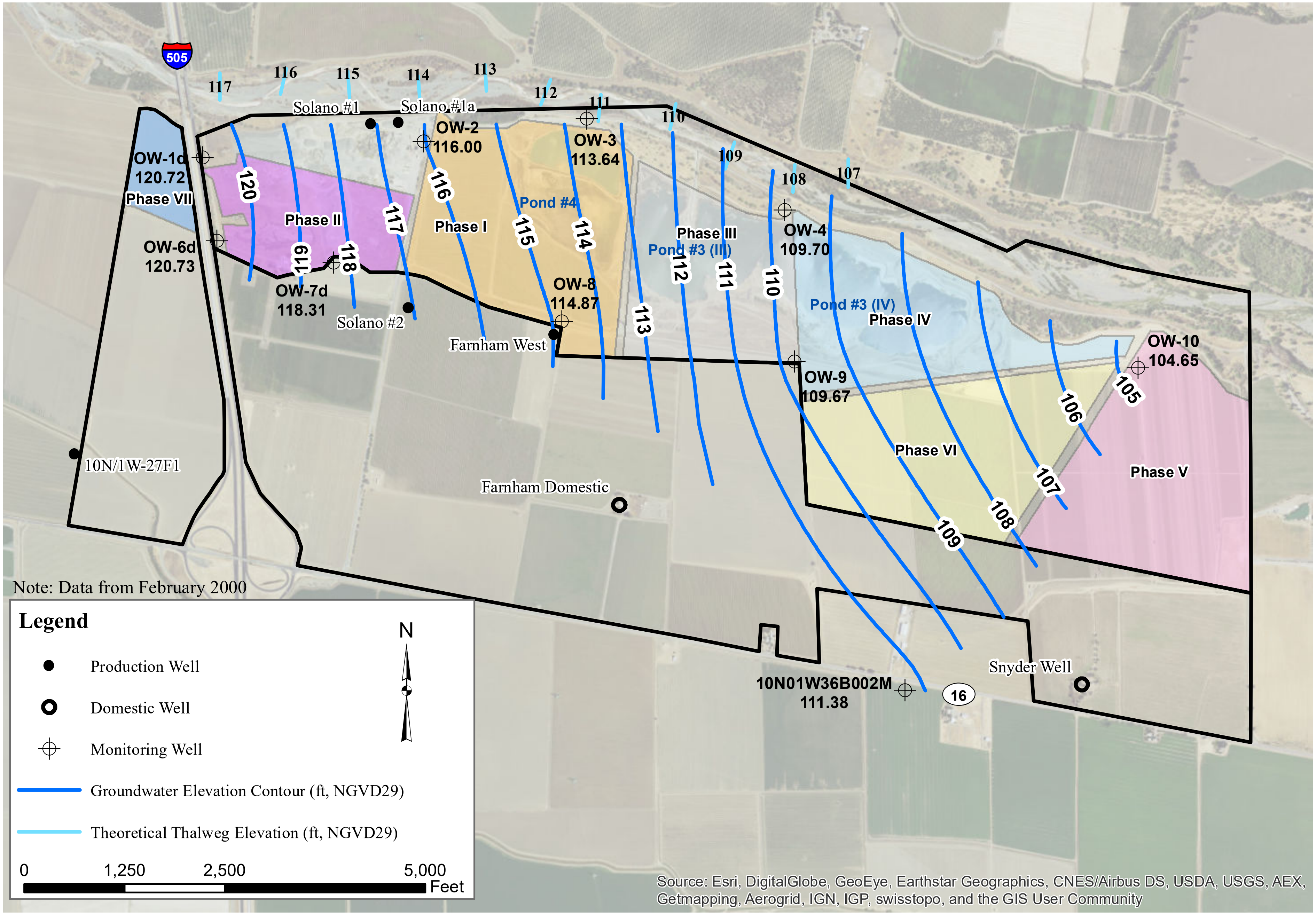

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Figure 7
Contours of Equal Groundwater Elevation, Average High Groundwater Conditions
CEMEX - Madison Plant Site

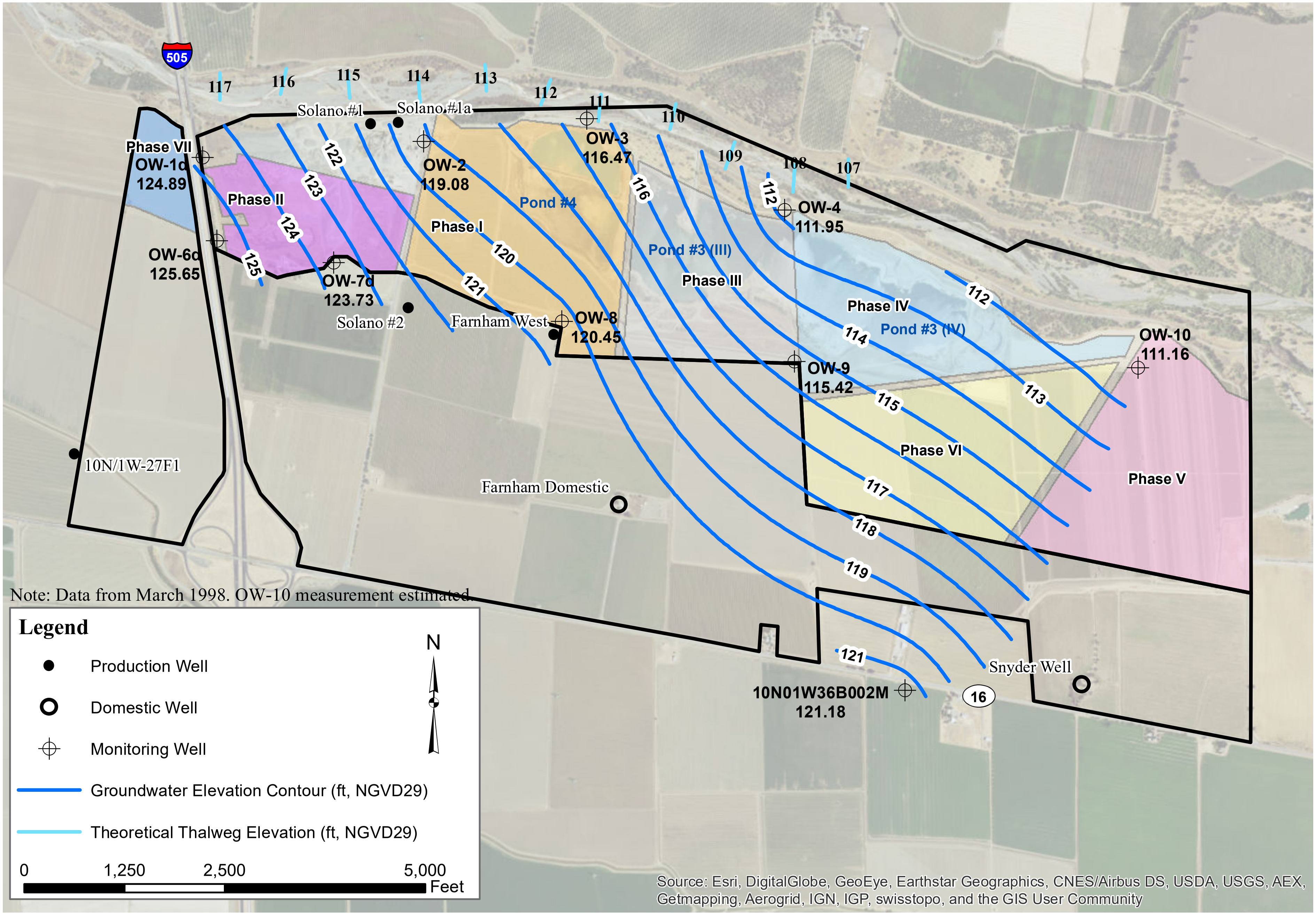

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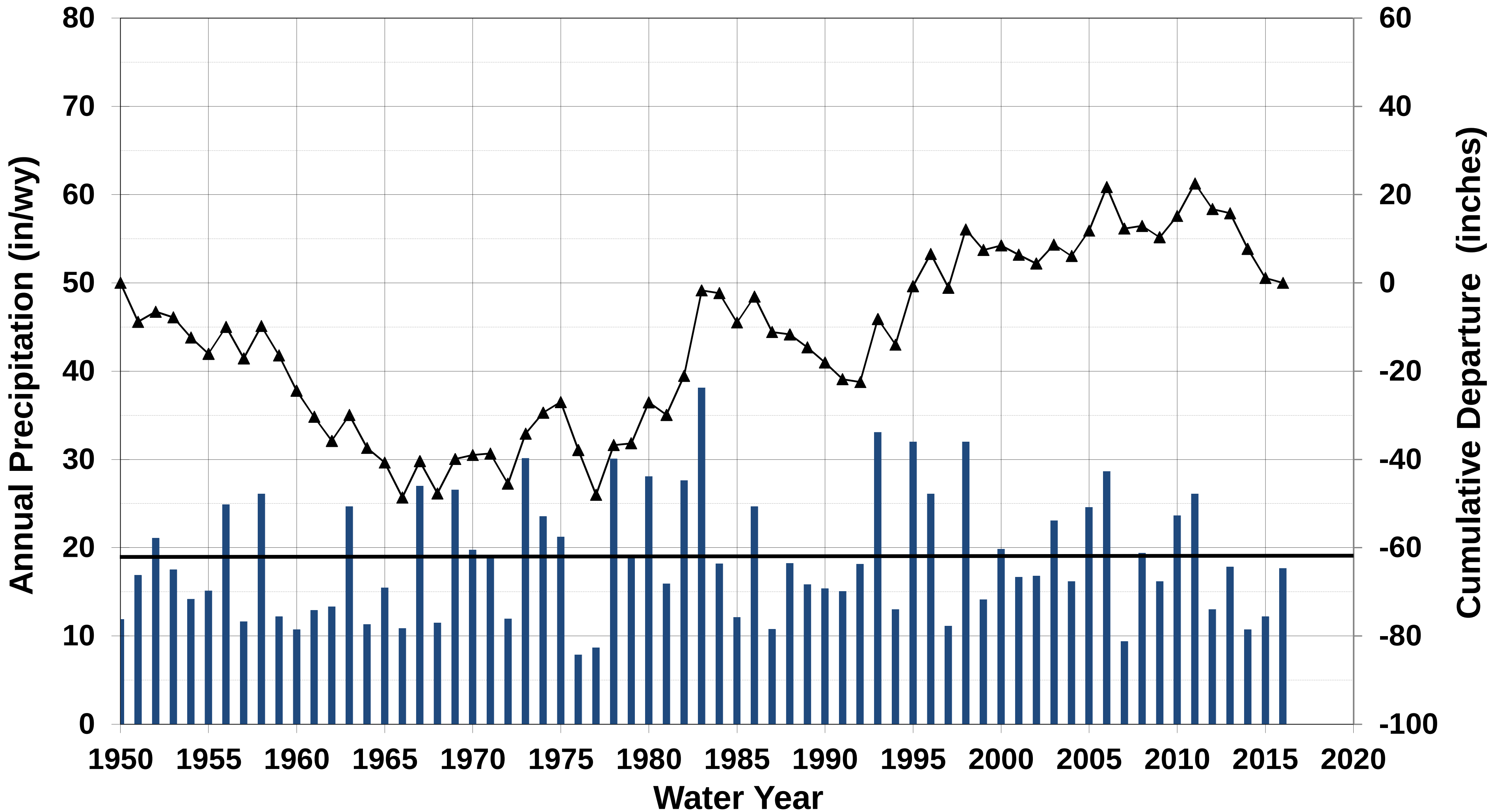
Figure 8
Contours of Equal Groundwater Elevation, Highest Observed
CEMEX - Madison Plant Site

ATTACHMENTS



Historical Data from Woodland 1 WNW Station #049781 (WRCC) (Multiple flagged years)

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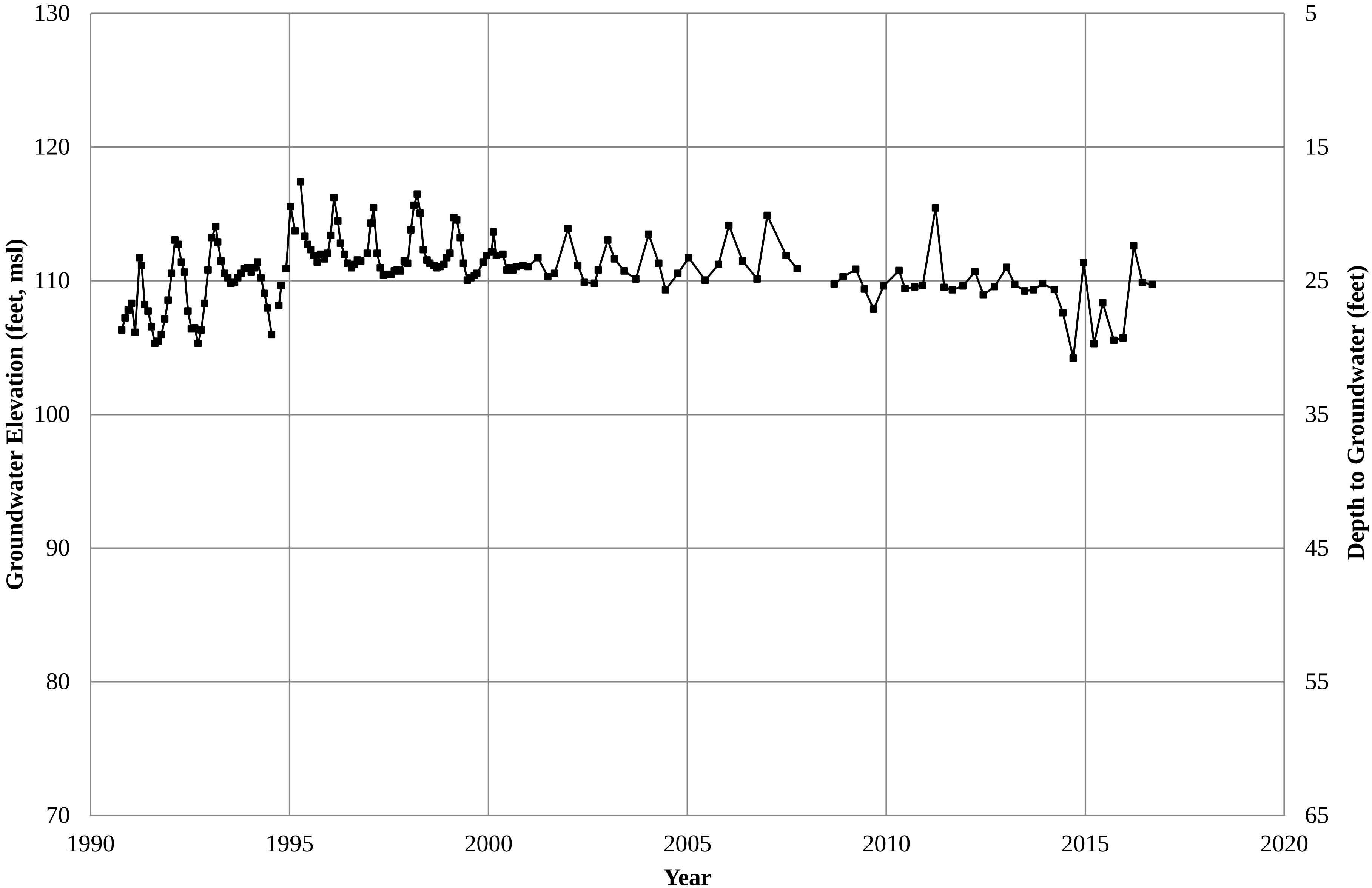
Area (Woodland) Historical Precipitation
CEMEX - Madison Plant Site



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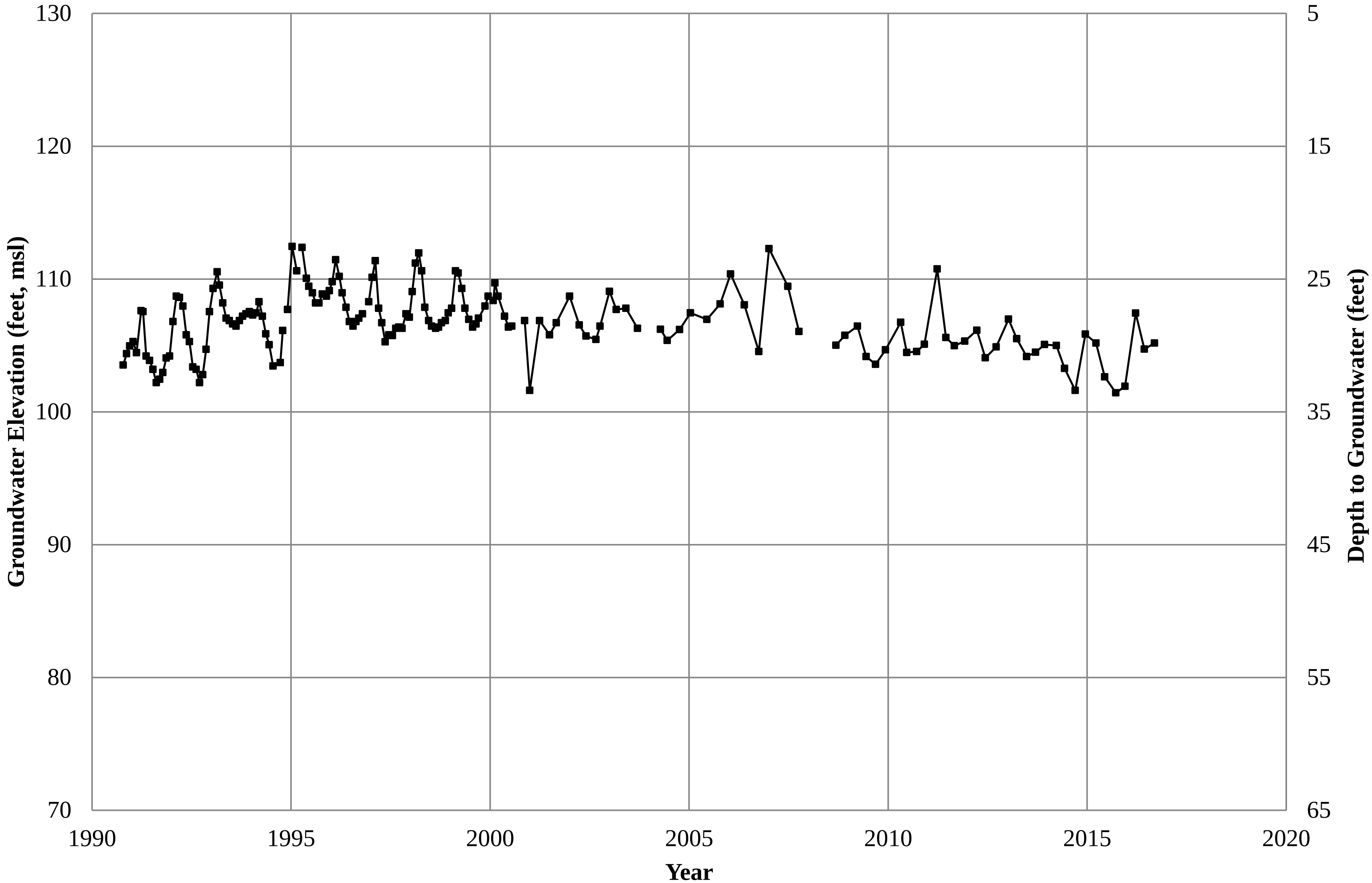
CEMEX - Madison, Yolo County, CA
Observation Well OW-3



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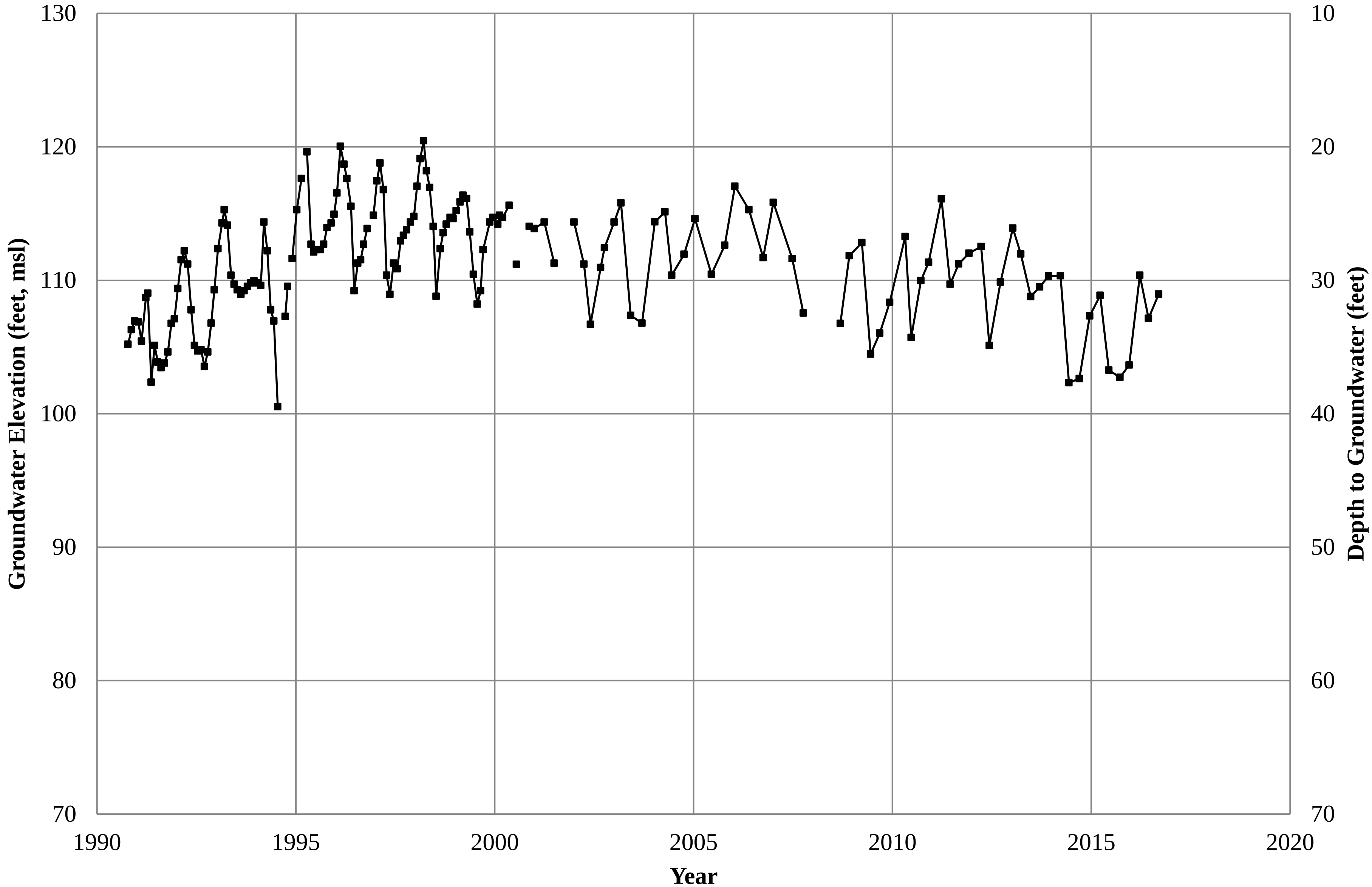
CEMEX - Madison, Yolo County, CA
Observation Well OW-4



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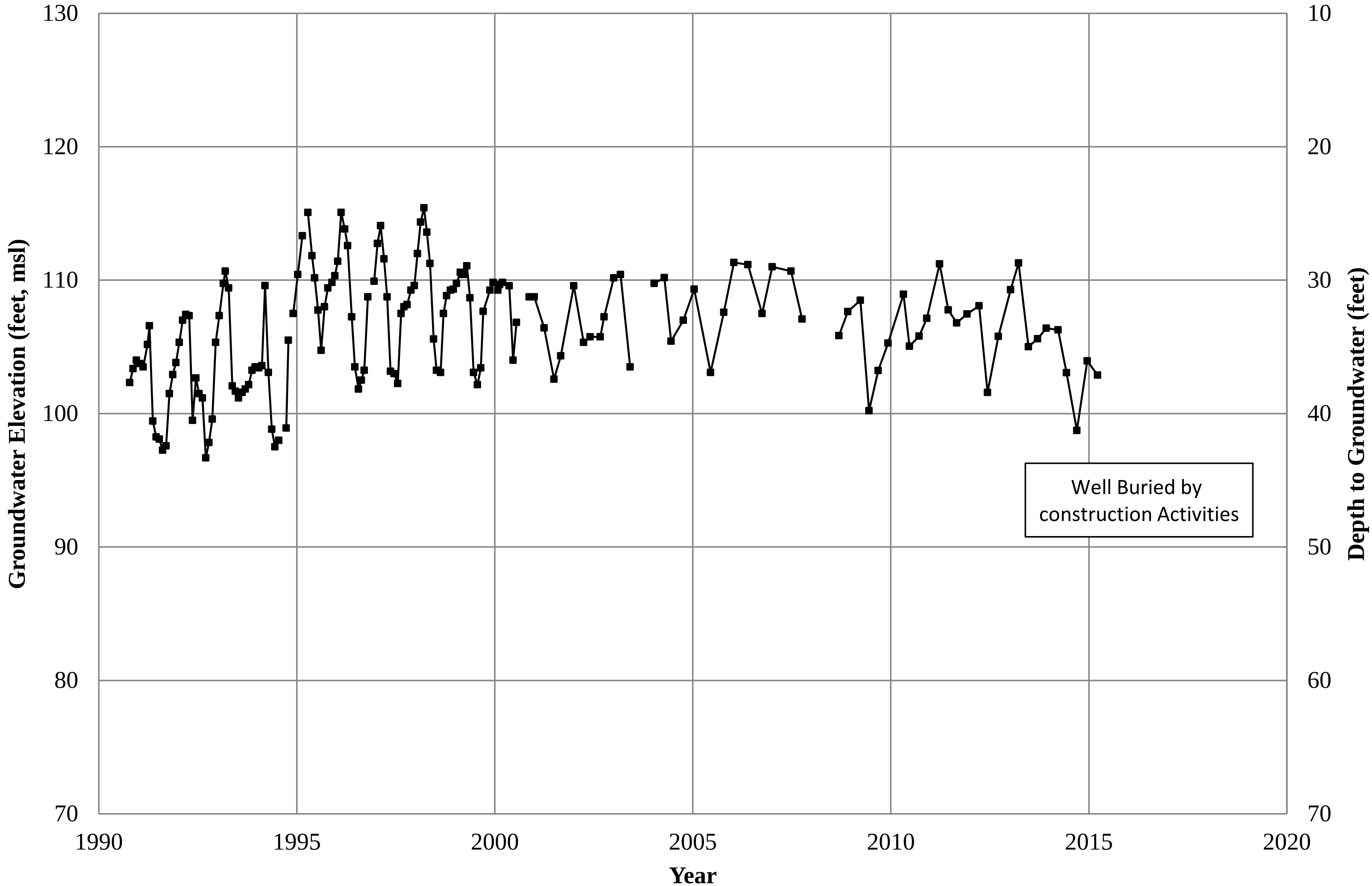
CEMEX - Madison, Yolo County, CA
Observation Well OW-8d



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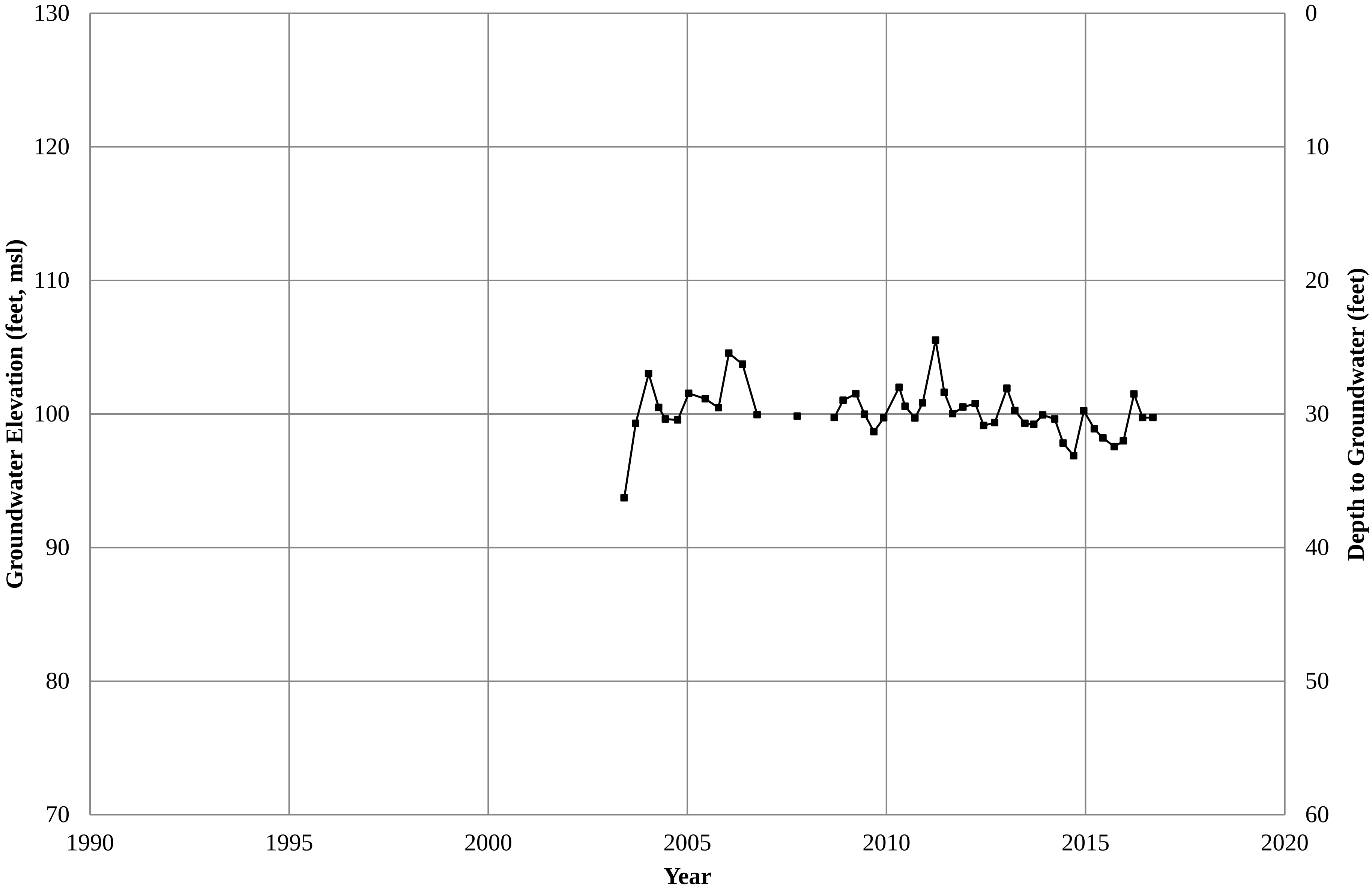
CEMEX - Madison, Yolo County, CA
Observation Well OW-9



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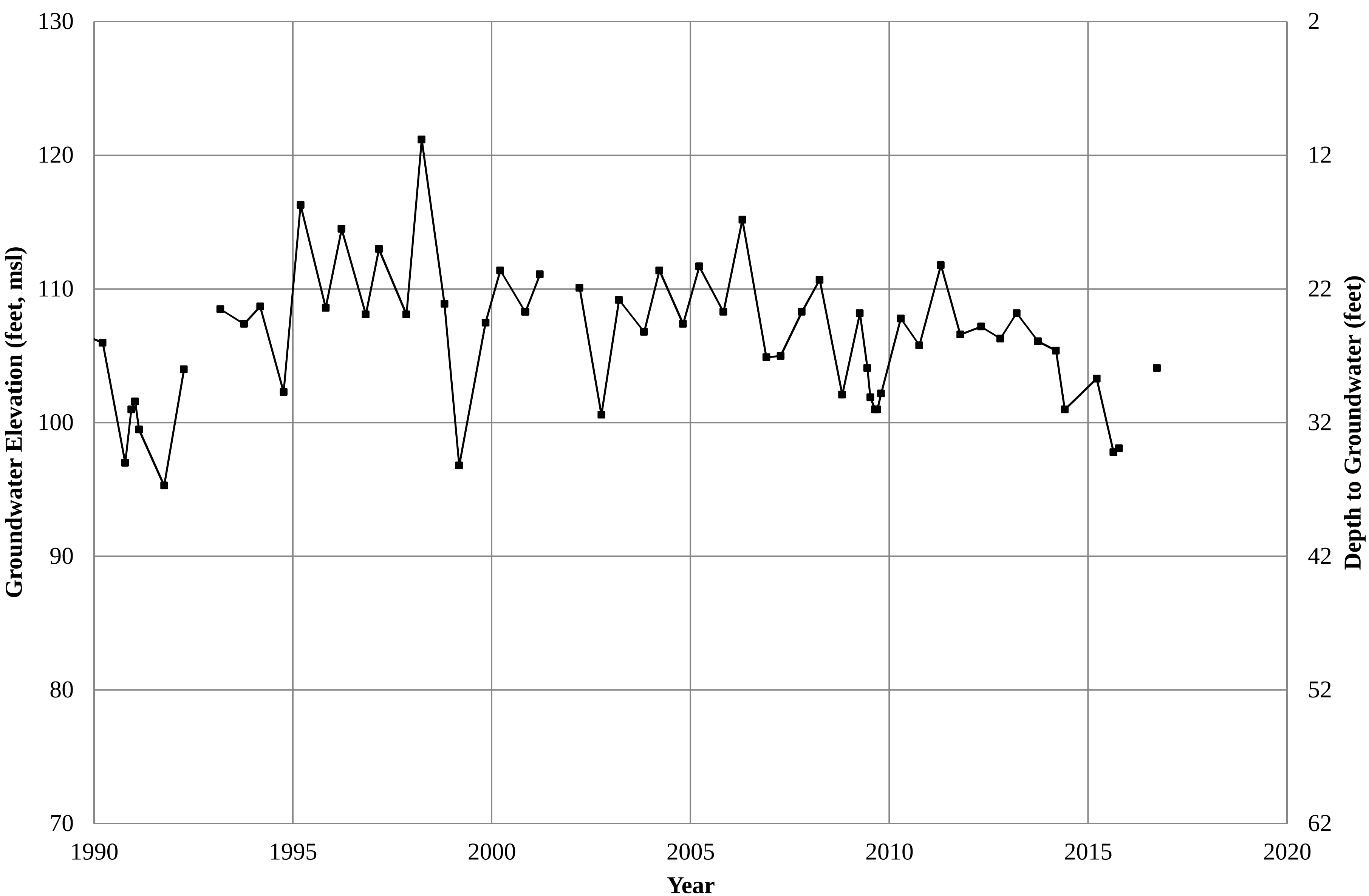
CEMEX - Madison, Yolo County, CA
Observation Well OW-10



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CEMEX - Madison, Yolo County, CA
Water Supply Well SWN 10N/01W-36B2