Evaluation of Wyckoff Groundwater Level Data, January 2011 – March 2011

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DATE: August 1, 2011

The purpose of this memorandum is to summarize the Wyckoff groundwater level results for the 90-day monitoring period of January 1 through March 31, 2011.

Summary/Recommendations

- Hydraulic containment was maintained in 7 of the 10 well pairs over the full 90- day monitoring period: MW18/02CDMW01, PO03/99CDMW02A, CW03/CW02, VG-2U/VG-2L, VG-3U/VG-3L, VG-5U/VG-5L, and PO13/VG-1L.
- Two of the well pairs (MW14/CW05 and CW13/VG4L) had only 56 days of record because of a logger failure and lost data.
    - The MW14/CW05 well pair data could not be fully analyzed due to the failed lower aquifer logger in CW05. The logger in CW05 was replaced during the February 3 download and there are only 56 days of data for CW05 for this monitoring period. However, hydraulic containment was maintained over the shortened monitoring period.
    - The CW13/VG4L well pair data could not be fully analyzed because the data downloaded from the CW13 logger (from January 1 –February 3, 2011) were accidentally lost sometime after the February 3, 2011download and there are only 56 days of data for CW13 for this monitoring period. However, hydraulic containment was <u>not</u> maintained over the shortened monitoring period.
- Hydraulic containment was <u>not</u> maintained in well pair CW08/P4L during this 90-day monitoring period. Water levels in the upper aquifer well, CW08, were on

average greater than water levels in the lower aquifer well, P4L, thus not meeting the definition of hydraulic containment

- The Leveloggers should be downloaded again in August 2011 to maintain a quarterly schedule consistent with the definition of hydraulic containment.

Water Level Data Collection

Solinst Leveloggers are installed in 11 upper aquifer wells and 18 lower aquifer wells. The loggers were downloaded on May 12, 2011. For this memorandum, the data set was truncated at March 31, 2011 and analyzed with the January 1 to February 3, 2011 data collected during the previous download on February 3, 2011. The remaining data from this May 12, 2011 download (April 1, 2011 to May 12, 2011) will be included in the next memorandum with the next set of downloaded data. The locations of the wells are shown in Figure 1 and wells with loggers are listed in Table 1. All data in e-format are available upon request.

Table 1 – Wells with Data Loggers, February 3, 2011 – May 12, 2011

Upper Aquifer		Lower Aquifer		
CW03	PO13	02CDMW01	PZ09[1]	P-1L
CW08	VG-2U	99CDMW02A	PZ11	P-2L
CW13	VG-3U	CW01	VG-1L	P-3L
MW14	VG-5U	CW02	VG-2L	P-4L
MW18		CW05[1]	VG-3L	P-5L
MW21		CW09[3]	VG-4L	P-6L
PO03		PZ03	VG-5L	SE-2[2]

1 –The logger in well CW05 failed on May 7, 2010 and was replaced on February 3, 2011 with the logger located in piezometer PZ-09.

2 – The logger in well SE-2 failed prior to the May 12, 2011 download and was unable to be downloaded. The logger was removed from SE-2 on May 12, 2011 and was not replaced.

3 – The logger in well CW-09 failed on October 22, 2010, when it began recording incorrect water level values. This logger was removed after downloading on May 12, 2011 and was not replaced.

Hydraulic Containment / Isolation Discussion

The hydraulic containment/isolation performance at the Wyckoff site has been evaluated based on water level data from 10 upper and lower aquifer well pairs: MW14/CW05, MW18/02CDMW01, PO03/99CDMW02A, CW03/CW02, VG-2U/VG-2L, VG-3U/VG-3L, VG-5U/VG-5L, PO13/VG-1L, CW13/VG-4L, and CW08/P-4L. The hydraulic containment at each well pair is evaluated in two steps. First, the average groundwater elevations of the upper and lower aquifers are calculated by averaging the water level data (converted to elevations) recorded every 15 minutes during the monitoring period. Second, the average groundwater elevations are compared. If the average lower aquifer groundwater elevation is greater than that of the upper aquifer, indicating an overall net upward movement of groundwater, then hydraulic containment is demonstrated. If a well pair meets the definition of hydraulic containment, then the ratio of the average lower aquifer water

elevation to the average upper aquifer water elevation for that well pair will be greater than 1.

Data collected from the Leveloggers indicate that some of the logger timers drifted over the data collection period (from the February 3, 2011 download to the recent download on May 12, 2011). In cases where the logger timer did "drift", the logger time was always ahead of the actual clock time. In most of the drift cases, the logger timer drift was small (less than 15 minutes). The average timer drift was calculated to be 6 minutes for the May 12, 2011 download. The loggers in two wells (02CDMW01 and MW14), however experienced significant drift over the data collection period. The logger and actual clock times varied by 52 minutes in 02CDMW01 and 50 minutes in MW14. However, because hydraulic containment is defined by the average lower and upper aquifer water level elevations over the monitoring period, errors in the recorded logger time have no effect on the hydraulic containment results presented in this memorandum. Because the loggers in wells 02CDMW01 and MW14 have consistently shown significant time drift over multiple downloading events, the loggers were swapped on May 12, 2011 with loggers from wells that are not part of a well pair and which have not experience significant time drift in the past. The logger in well 02CDMW01 was swapped with the logger in P-6L and the logger in well MW14 was swapped with the logger in P-3L.

Hydrographs from the 10 well pairs are shown in Figures 2 through 11 for the monitoring period.

Well Pair MW14/CW05

90-Day Monitoring Period (January 1 through March 31, 2011)

The logger in CW05 had previously failed and was replaced on February 3, 2011. For this monitoring period, there are 56 days of data for CW05, from February 3 through March 31, 2011. Because there are less than 90 days of data for CW05, the data for well pair MW14/CW05 could not be analyzed for this monitoring period. The hydrograph for well pair MW14/CW05 (Figure 2) shows the data available for the well pair during this time period. During the 56 days for which data are available for both wells, hydraulic containment by was maintained based on the shortened period of record. Water levels in the lower aquifer well, CW05, were always greater than water levels in the upper aquifer well, MW14.

Well Pair MW18/02CDMW01

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair MW18/02CDMW01 (Figure 3) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.89 feet MLLW in the lower aquifer (Well 02CDMW01) and 5.09 feet MLLW in the upper aquifer (Well MW18). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair MW18/02CDMW01 was calculated to be 1.94, thus demonstrating hydraulic containment.

Over the 90-day monitoring period, 11 periods of downward flow potential occurred for well pair MW18/02CDMW01. The sum of all downward gradient periods over the monitoring period was 72 hours and 45 minutes (approximately 3 days). The average duration of a downward gradient period was 6 hours and 36 minutes. The maximum duration of a downward gradient period was 11 hours and 30 minutes. The average downward flow potential was calculated to be – 1.05 feet. The maximum downward flow potential was calculated to be – 1.96 feet and occurred on March 15, 2011 at 03:15 and 03:30, and on March 16, 2011 at 02:15, 02:30, 22:15, and 22:30.

Well Pair PO03/99CDMW02

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair PO03/99CDMW02 (Figure 4) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 14.46 feet MLLW in the lower aquifer (Well 99CDMW02) and 8.32 feet MLLW in the upper aquifer (Well PO03). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair PO03/99CDMW02 was calculated to be 1.74, thus demonstrating hydraulic containment.

Over the 90-day period, 20 periods of downward flow potential occurred for well pair PO03/99CDMW02. The sum of all downward gradient periods over the monitoring period was 106 hours and 30 minutes (approximately 45 days). The average duration of a downward gradient period was 5 hours and 19 minutes. The maximum duration of a downward gradient period was 7 hours and 15 minutes. The average downward flow potential was calculated to be – 1.00 foot. The maximum downward flow potential was calculated to be – 2.28 feet and occurred on January 4, 2011 at 00:30.

Well Pair CW03/CW02

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair CW03/CW02 (Figure 5) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 8.62 feet MLLW in the lower aquifer (Well CW02) and 7.89 feet MLLW in the upper aquifer (Well CW03). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair CW03/CW02 was calculated to be 1.09, thus demonstrating hydraulic containment.

Over the 90-day period, 93 periods of downward flow potential occurred for well pair CW03/CW02. The sum of all downward gradient periods over the entire monitoring period was 559 hours and 15 minutes (approximately 23 days). The average duration of a downward gradient period was approximately 6 hours. The maximum duration of a downward gradient period was 18 hours and 30 minutes. The average downward flow potential was calculated to be – 0.86 feet. The maximum downward flow potential was

calculated to be -3.01 feet and occurred on January 2, 2011 at 23:30 and on January 4, 2011 at 00:30.

Well Pair VG-2U/VG-2L

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair VG-2U/VG-2L (Figure 6) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.09 feet MLLW in the lower aquifer (Well VG-2L) and 8.12 feet MLLW in the upper aquifer (Well VG-2U). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair VG-2U/VG-2L was calculated to be 1.12, thus demonstrating hydraulic containment.

Over the 90-day period, 19 periods of downward flow potential occurred for well pair VG-2U/VG-2L. The sum of all downward gradient periods over the entire monitoring period was 70 hours and 30 minutes. The average duration of a downward gradient period was approximately 3 hours and 42 minutes. The maximum duration of a downward gradient period was 6 hours and 15 minutes. The average downward flow potential was calculated to be -0.10 feet. The maximum downward flow potential was calculated to be – 0.24 feet and occurred on January 4, 2011 at 05:15.

Well Pair VG-3U/VG-3L

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair VG-3U/VG-3L (Figure 7) shows that water levels in the lower aquifer were always greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 11.34 feet MLLW in the lower aquifer (Well VG-3L) and 7.76 feet MLLW in the upper aquifer (Well VG-3U). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair VG-3U/VG-3L was calculated to be 1.46, thus demonstrating hydraulic containment.

Over the 90-day period, there were no occurrences of downward flow potential for well pair VG-3U/VG-3L.

Well Pair VG-5U/VG-5L

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair VG-5U/VG-5L (Figure 8) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 11.48 feet MLLW in the lower aquifer (Well VG-5L) and 11.24 feet MLLW in the upper aquifer (Well VG-5U). The ratio of the average lower aquifer water elevation to the average upper

aquifer water elevation for well pair VG-5U/VG-5L was calculated to be 1.02, thus demonstrating hydraulic containment.

Over the 90-day monitoring period, 83 periods of downward flow potential occurred for well pair VG-5U/VG-5L. The sum of all downward gradient periods over the monitoring period was 925 hours and 30 minutes (approximately 38 and 1/2 days). The average duration of a downward gradient period was approximately 11 hours and 9 minutes. The maximum duration of a downward gradient period was 138 hours. The average downward flow potential was calculated to be – 1.26 feet. The maximum downward flow potential was calculated to be – 4.10 feet and occurred on January 1, 2011 at 22:30 and 22:45.

Well Pair PO13/VG-1L

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair PO13/VG-1L (Figure 9) shows that water levels in the lower aquifer were on average greater than the water levels in the upper aquifer, thus meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.71 feet MLLW in the lower aquifer (Well VG-1L) and 8.89 feet MLLW in the upper aquifer (Well PO13). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair PO13/VG-1L was calculated to be 1.09 thus demonstrating hydraulic containment.

Over the 90-day monitoring period, 116 periods of downward flow potential occurred for well pair PO13/VG-1L. The sum of all downward gradient periods over the monitoring period was 656 hours and 30 minutes (approximately 27 days). The average duration of a downward gradient period was approximately 5 hours and 39 minutes. The maximum duration of a downward gradient period was 15 hours and 30 minutes. The average downward flow potential was calculated to be – 1.39 feet. The maximum downward flow potential was calculated to be – 4.22 feet and occurred on January 20, 2011 at 00:45.

Well Pair CW13/VG-4L

90-Day Monitoring Period (January 1 through March 31, 2011)

The data for well pair CW13/VG-4L could not be analyzed for this monitoring period because the data downloaded from the CW13 logger, from January 1 to February 3, 2011, were accidentally lost sometime after download on February 3, 2011. For this monitoring period, there are 56 days of data for CW13, from February 3 through March 31, 2011. Because there are less than 90 days of data for CW13, the data for well pair CW13/VG-4L could not be analyzed for this monitoring period. The hydrograph for well pair CW13/VG-4L (Figure 10) shows the data available for the well pair during this monitoring period. During the 56 days for which data are available for both wells, hydraulic containment by definition was not maintained. Water levels in the lower aquifer well, VG4L, were, on average, less than water levels in the upper aquifer well, CW13.

Well Pair CW08/P-4L

90-Day Monitoring Period (January 1 through March 31, 2011)

The hydrograph for well pair CW08/P-4L (Figure 11) shows that water levels in the lower aquifer were on average lower than the water levels in the upper aquifer, thus not meeting the definition of hydraulic containment.

During the monitoring period, the average groundwater elevation was calculated to be 9.93 feet MLLW in the lower aquifer (Well P-4L) and 10.59 feet MLLW in the upper aquifer (Well CW08). The ratio of the average lower aquifer water elevation to the average upper aquifer water elevation for well pair CW08/P-4L was calculated to be 0.94, thus not demonstrating hydraulic containment.

Over the 90-day monitoring period, 140 periods of downward flow potential occurred for well pair CW08/P-4L. The sum of all downward gradient periods over the monitoring period was 1,275 hours (approximately 53 days). The average duration of a downward gradient period was approximately 9 hours and 6 minutes. The maximum duration of a downward gradient period was 39 hours and 15 minutes. The average downward flow potential was calculated to be – 1.90 feet. The maximum downward flow potential was calculated to be -6.16 feet and occurred on January 20, 2011 at 00:45.

Treatment Plant Operations and Precipitation Effects on Vertical Gradients

During the January 1, 2011 through March 31, 2011 monitoring period, Former Process Area (FPA) groundwater extraction well pumps periodically had to be shut down. The majority of the shut downs during this monitoring period were due to freezing weather or well maintenance. Shutdowns of the extraction well pumps that occurred for periods of one day or longer (as noted in CH2M HILL operation records) are shown in Table 2. These periods are graphically overlaid with the precipitation records and are shown in Figure 12.

The treatment plant and extraction well systems were operated 24 hours per day and 7 days per week, with the exception of the dates listed in Table 2, when the treatment plant was shut down due to freezing weather or well maintenance. The total volume of water pumped was 6,603,892 gallons during the 90-day monitoring period which equates to about 51 gpm over the entire period including all down time regardless of cause. [Note, when fully operating, the system can pump about 57 to 60 gpm.]

During the January 1, 2011 through March 31, 2011 monitoring period, negative vertical groundwater gradients were associated with precipitation events and treatment plant and extraction well systems shutdowns.

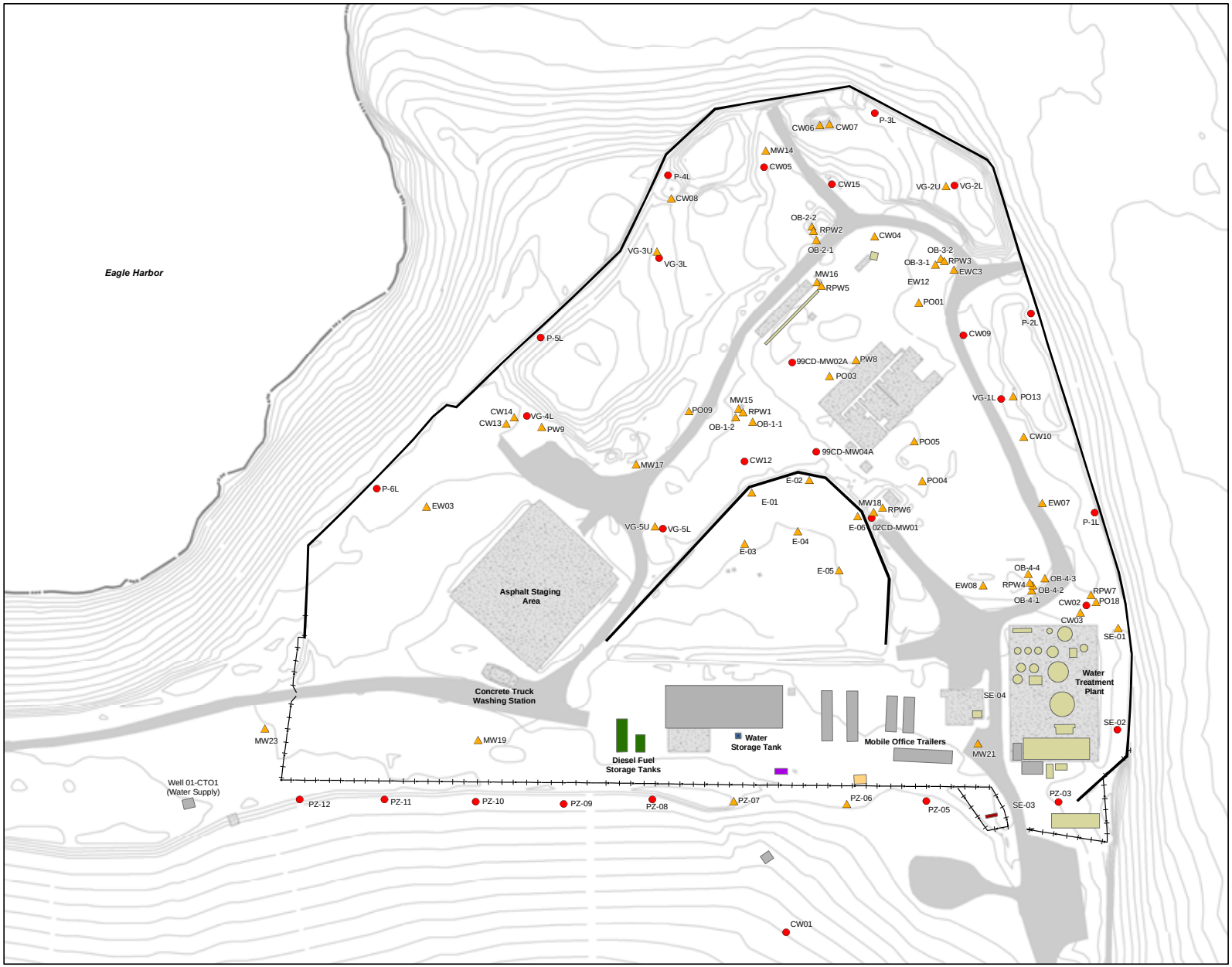
Figure 12 shows the cumulative precipitation of 15.91 inches at the site for the monitoring period, with the heaviest precipitation occurring in March. Negative gradients were observed in 7 of the monitored well pairs during the monitoring period. The maximum negative gradient observed for well pairs VG5U/VG5L, CW03/CW02, PO03/99CDMW02, and VG2U/VG2L occurred on January 1 through 4, 2011, during a freezing weather condition well field shutdown and approximately five to eight days after a daily

precipitation amount greater than 1-inch (not shown in Figure 12). The maximum negative gradient observed for well pairs PO13/VG1L and CW08/P4L occurred on January 20, 2011, following a period of increased rainfall. The maximum negative gradient observed in the remaining monitored well pair, MW18/02CDMW01, occurred on March 15 and 16, 2011, immediately following a greater than 2.6-inch single-day precipitation event, the highest of the monitoring period, and during the March 16 - 18, 2011 well field shutdown.. Well pair VG3U/VG3L did not experience any periods of negative downward gradients during the monitoring period.

Many of the upper aquifer hydrographs show a rapid groundwater rise following the major March 14 – 16, 2011 rainfall event. Although the extraction and treatment system was operating 24/7, most of the water levels in the upper aquifer wells could not be drawn back down to early December levels by the end of the month. This clearly demonstrates that total precipitation can easily exceed pumping capacity and thus supports the need to maintain the extraction operations at full capacity before and during the wet season.

Table 2 – Former Process Area (FPA) Extraction Well Pump Shutdown Periods Greater than 1 Day

Date	Wells Shut Down	Reason
November 15, 2010 – January 12, 2011	PW-9	Well maintenance
December 29, 2010 – January 6, 2011	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, EW-2, EW-6	Plant shutdown due to freezing weather
January 10 – January 12, 2011	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, EW-2, EW-6	Plant shutdown due to freezing weather
February 23 – February 28, 2011	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, PW-9, EW-2, EW-6	Plant shutdown due to freezing weather
March 16 – March 18, 2011	PW-1, PW-2, PW-4, PW-5, PW-6, PW-8, PW-9, EW-2, EW-6	Well maintenance
March 29 – March 30, 2011	PW-1, PW-9	Well maintenance



Lower Aquifer Well
Upper Aquifer Well
Fence
Sheetpile Wall
Roads
Buildings
Concrete Slab
Structures

N

0 50 100 200 Feet

FIGURE 1

Former Process Area Well Locations

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

File Path: \\bianca\proj\URSGreiner\180776\GIS\Layouts\Former_Process_Area_Well_Locations_v2.mxd, Date: February 12, 2009

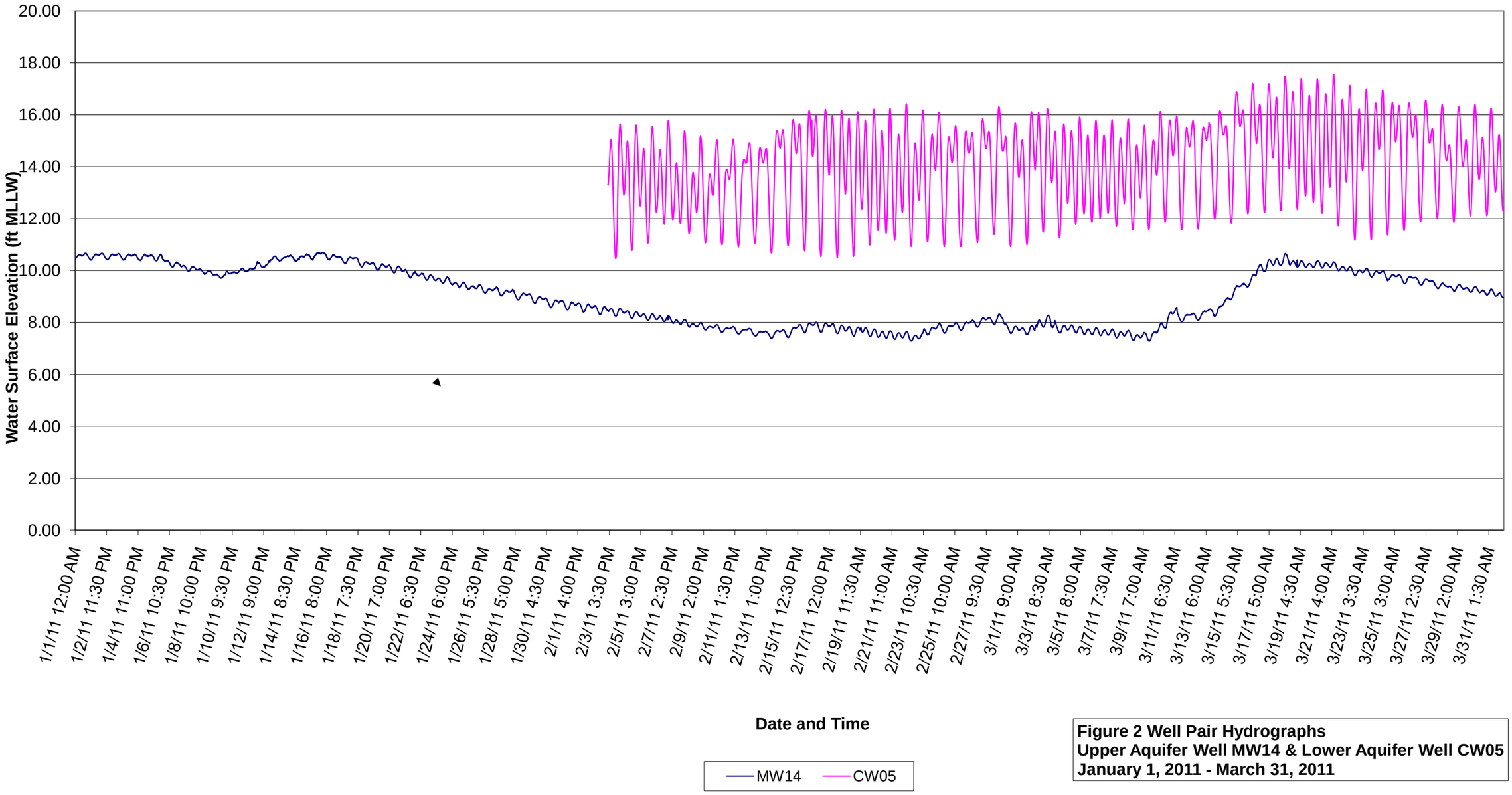


Figure 2 Well Pair Hydrographs
Upper Aquifer Well MW14 & Lower Aquifer Well CW05
January 1, 2011 - March 31, 2011

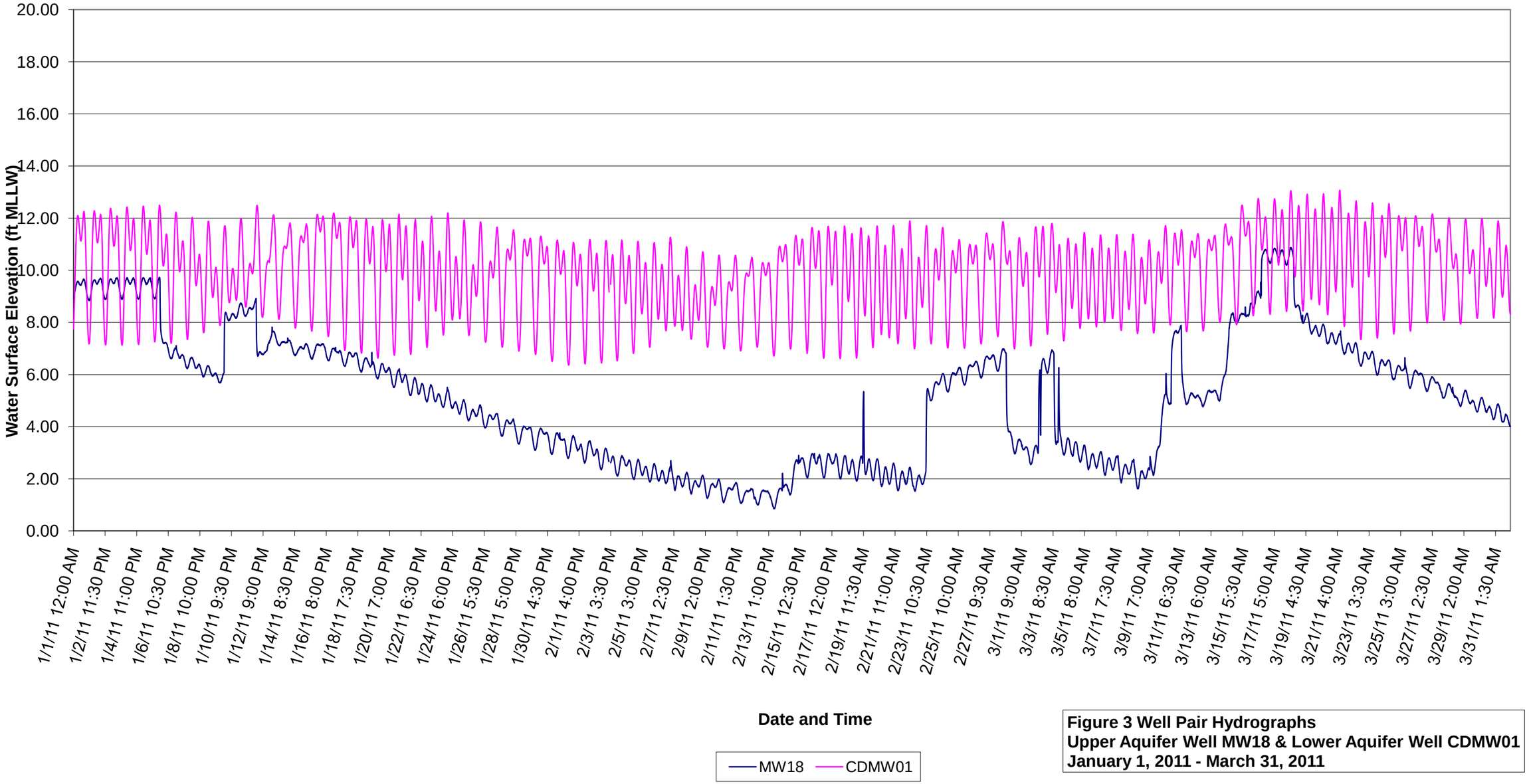


Figure 3 Well Pair Hydrographs
Upper Aquifer Well MW18 & Lower Aquifer Well CDMW01
January 1, 2011 - March 31, 2011

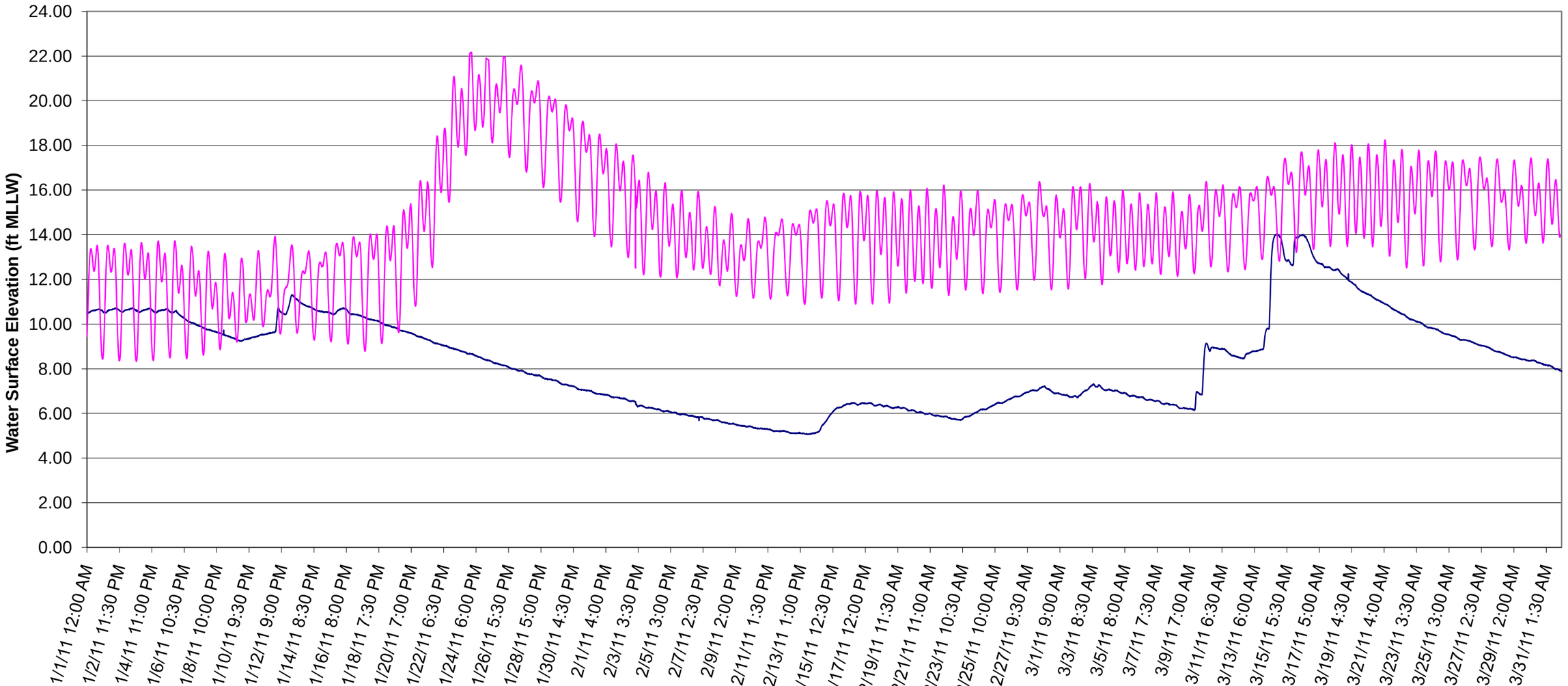


Figure 4 Well Pair Hydrographs
Upper Aquifer Well PO03 & Lower Aquifer Well CDMW02
January 1, 2011 - March 31, 2011

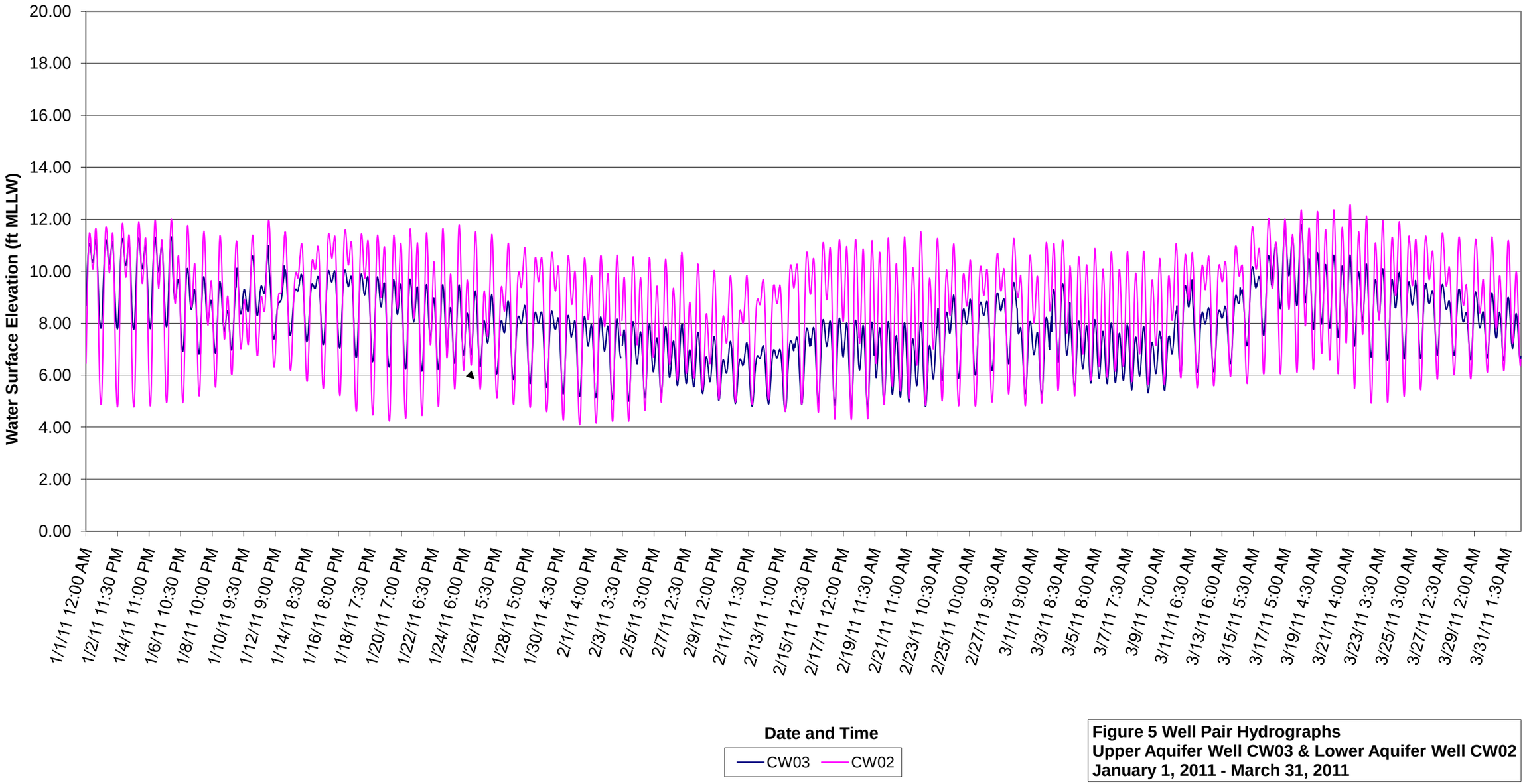


Figure 5 Well Pair Hydrographs
Upper Aquifer Well CW03 & Lower Aquifer Well CW02
January 1, 2011 - March 31, 2011

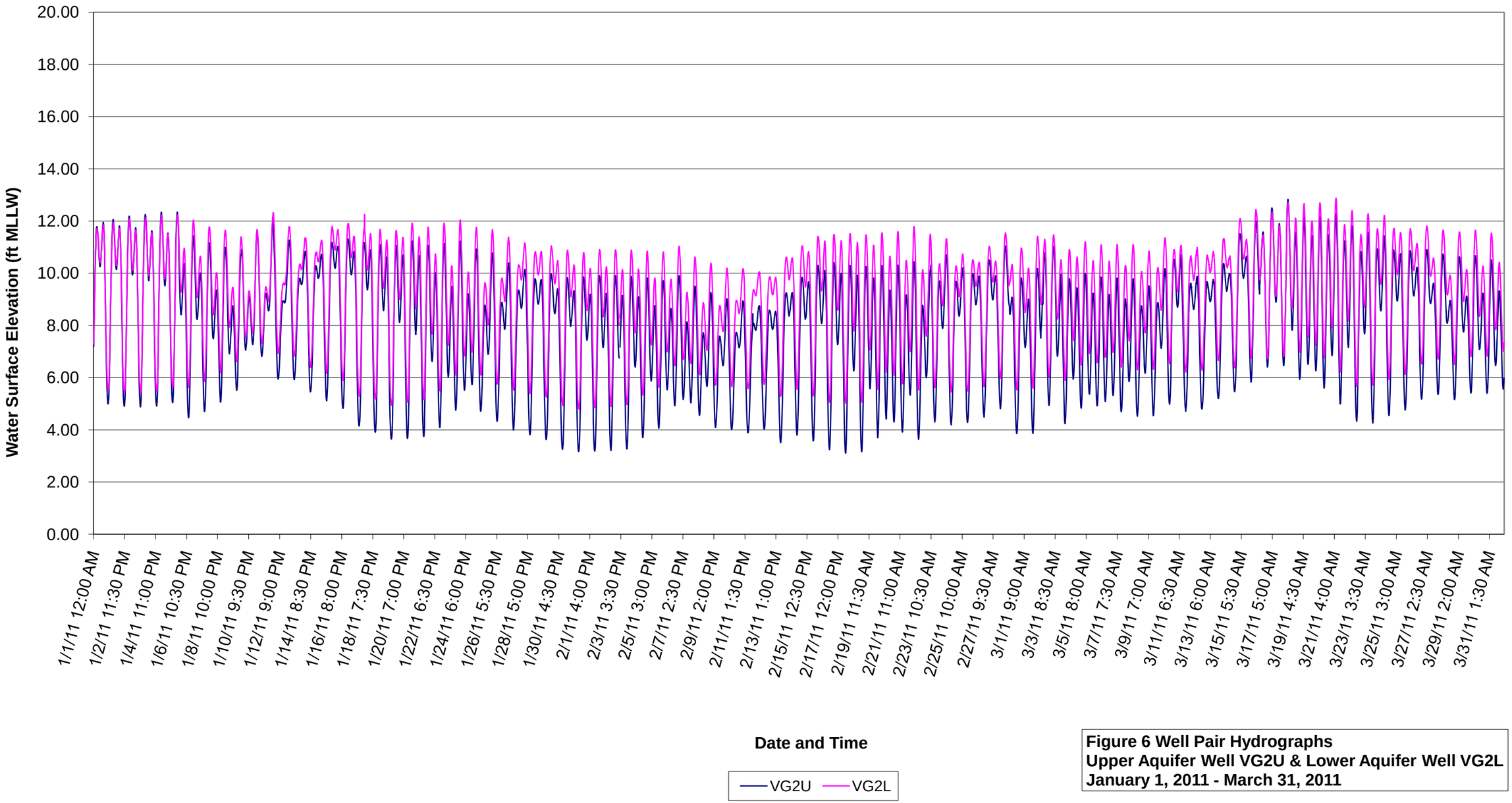


Figure 6 Well Pair Hydrographs
Upper Aquifer Well VG2U & Lower Aquifer Well VG2L
January 1, 2011 - March 31, 2011

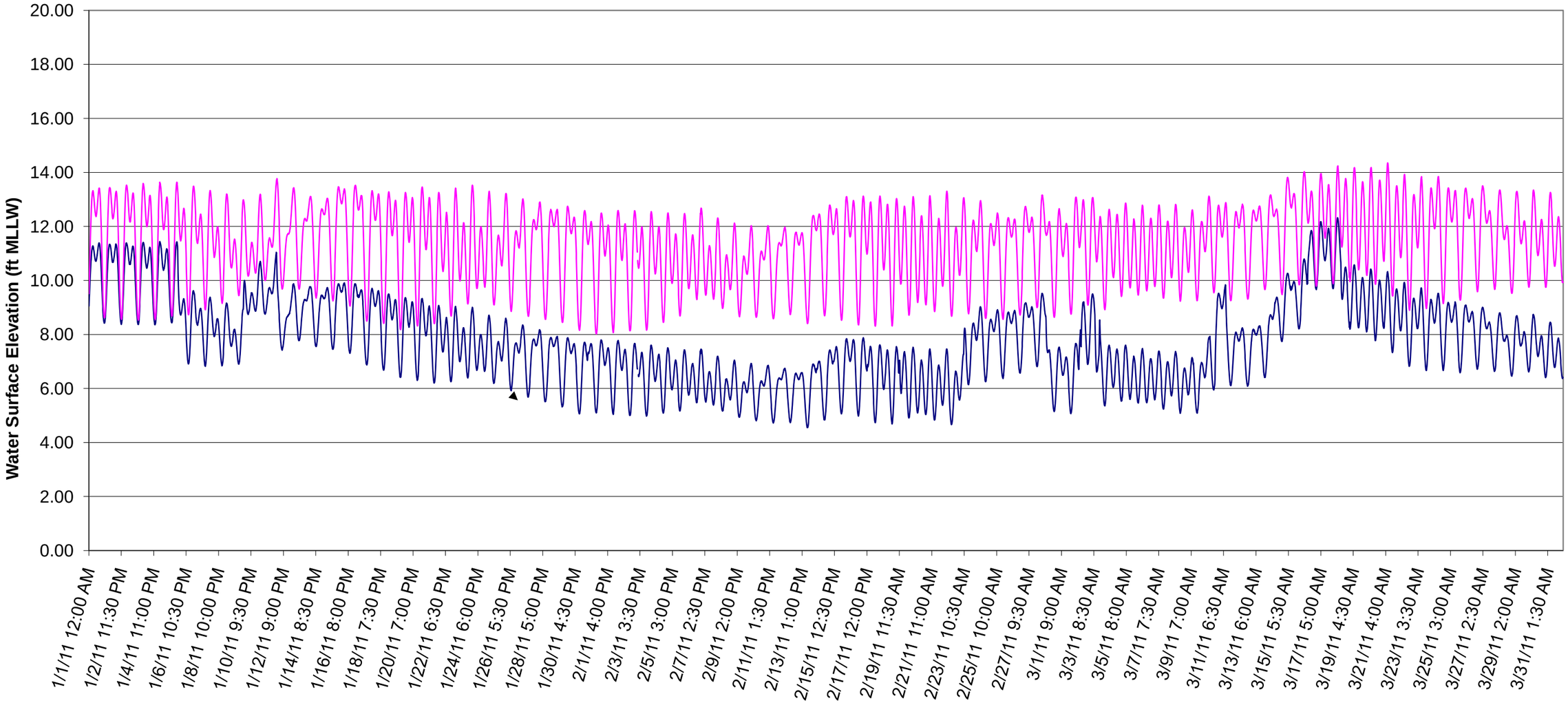


Figure 7 Well Pair Hydrographs
Upper Aquifer Well VG3U & Lower Aquifer Well VG3L
January 1, 2011 - March 31, 2011

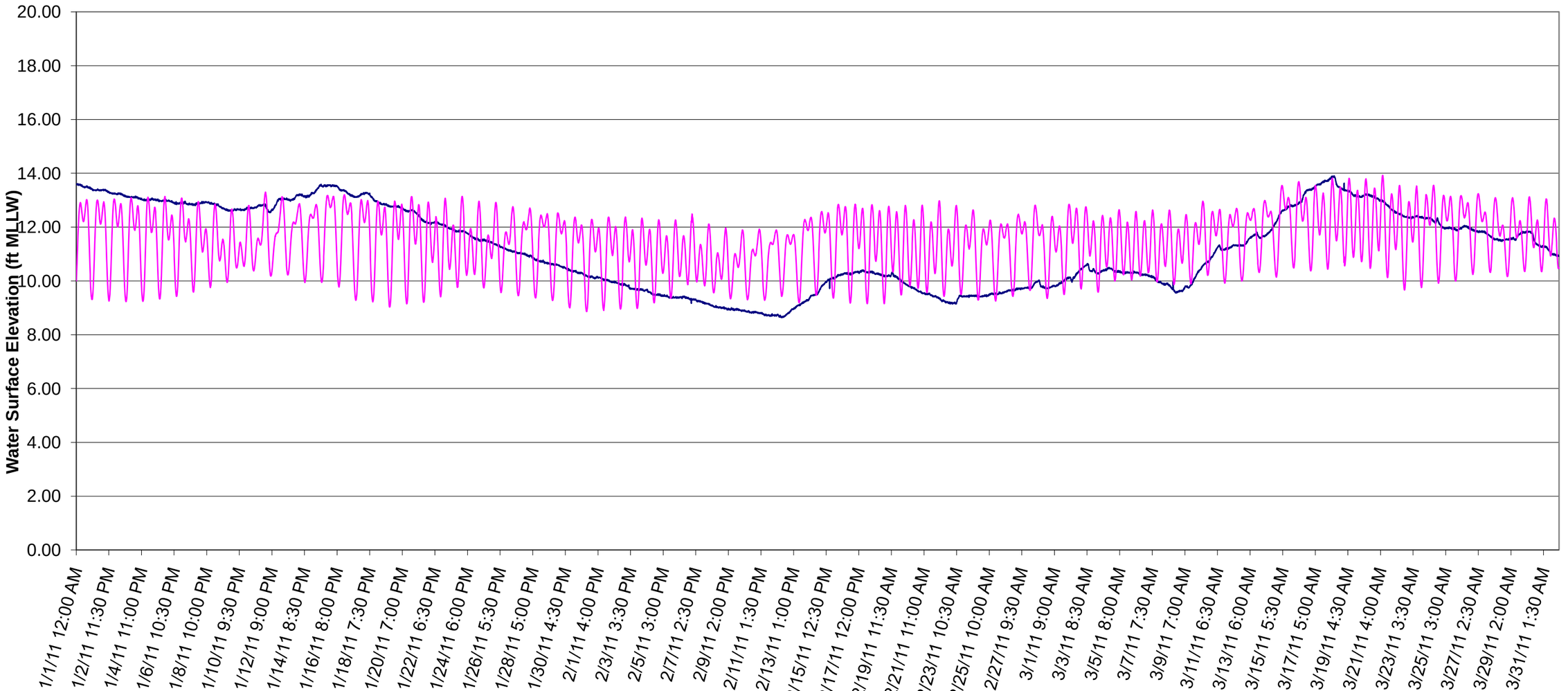


Figure 8 Well Pair Hydrographs
Upper Aquifer Well VG5U & Lower Aquifer Well VG5L
January 1, 2011 - March 31, 2011

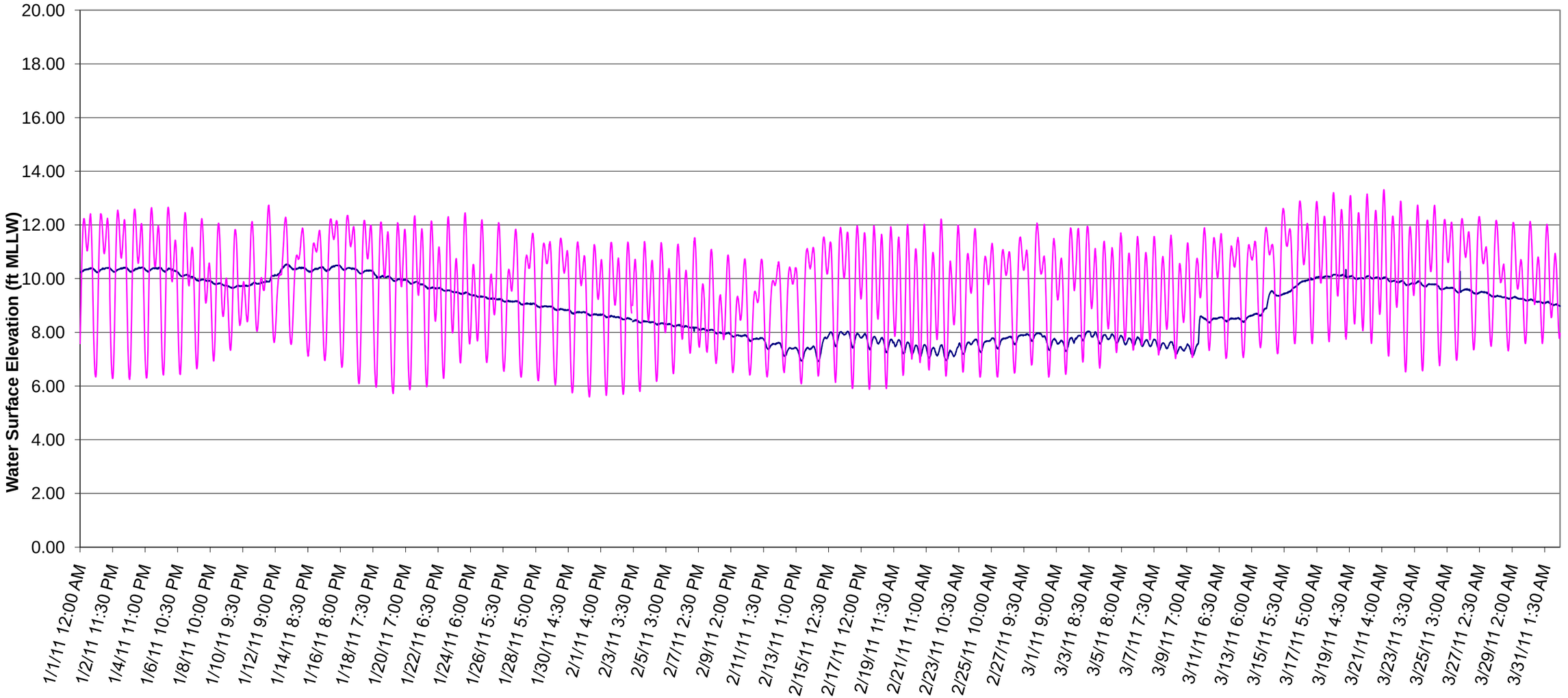


Figure 9 Well Pair Hydrographs
Upper Aquifer Well PO13 & Lower Aquifer Well VG1L
January 1, 2011 - March 31, 2011

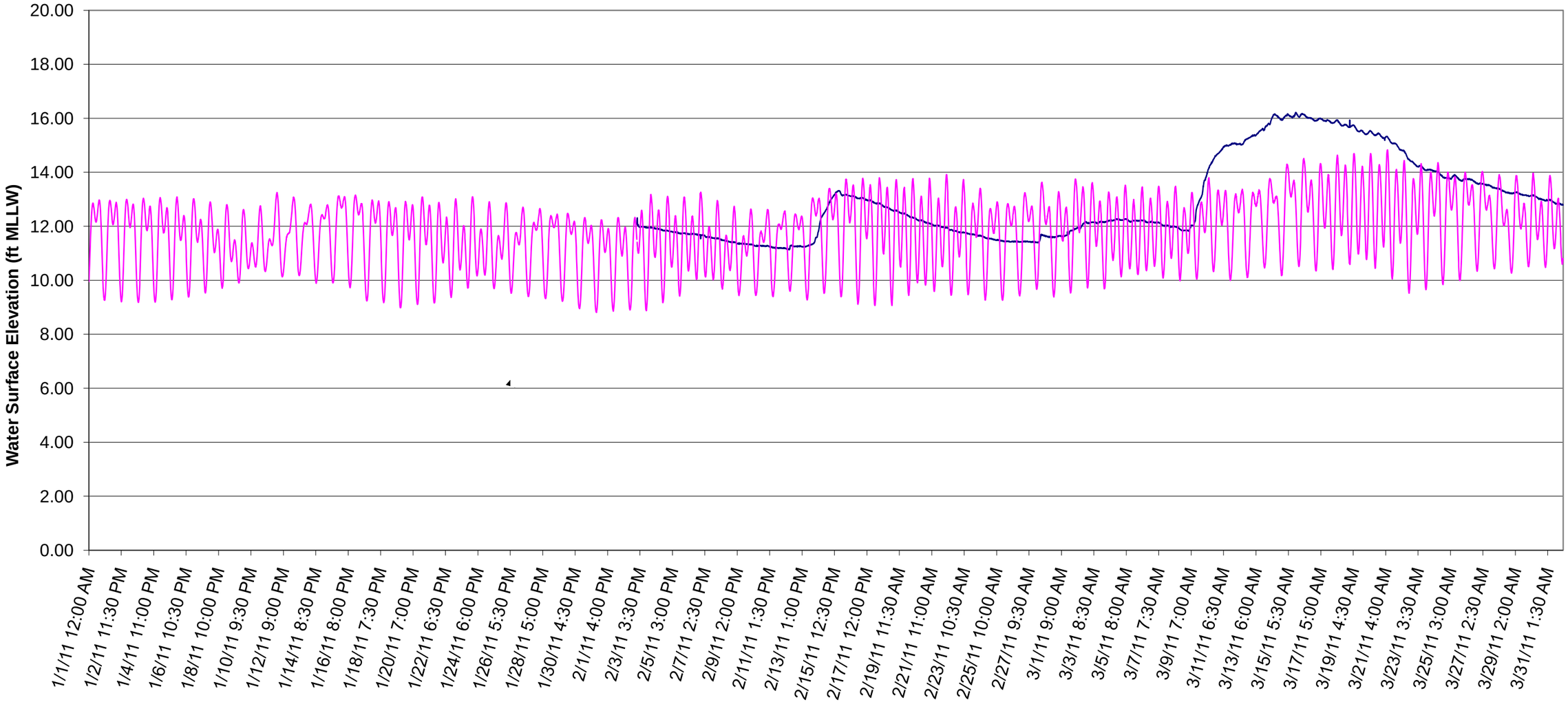


Figure 10 Well Pair Hydrographs
Upper Aquifer Well CW13 & Lower Aquifer Well VG4L
January 1, 2011 - March 31, 2011

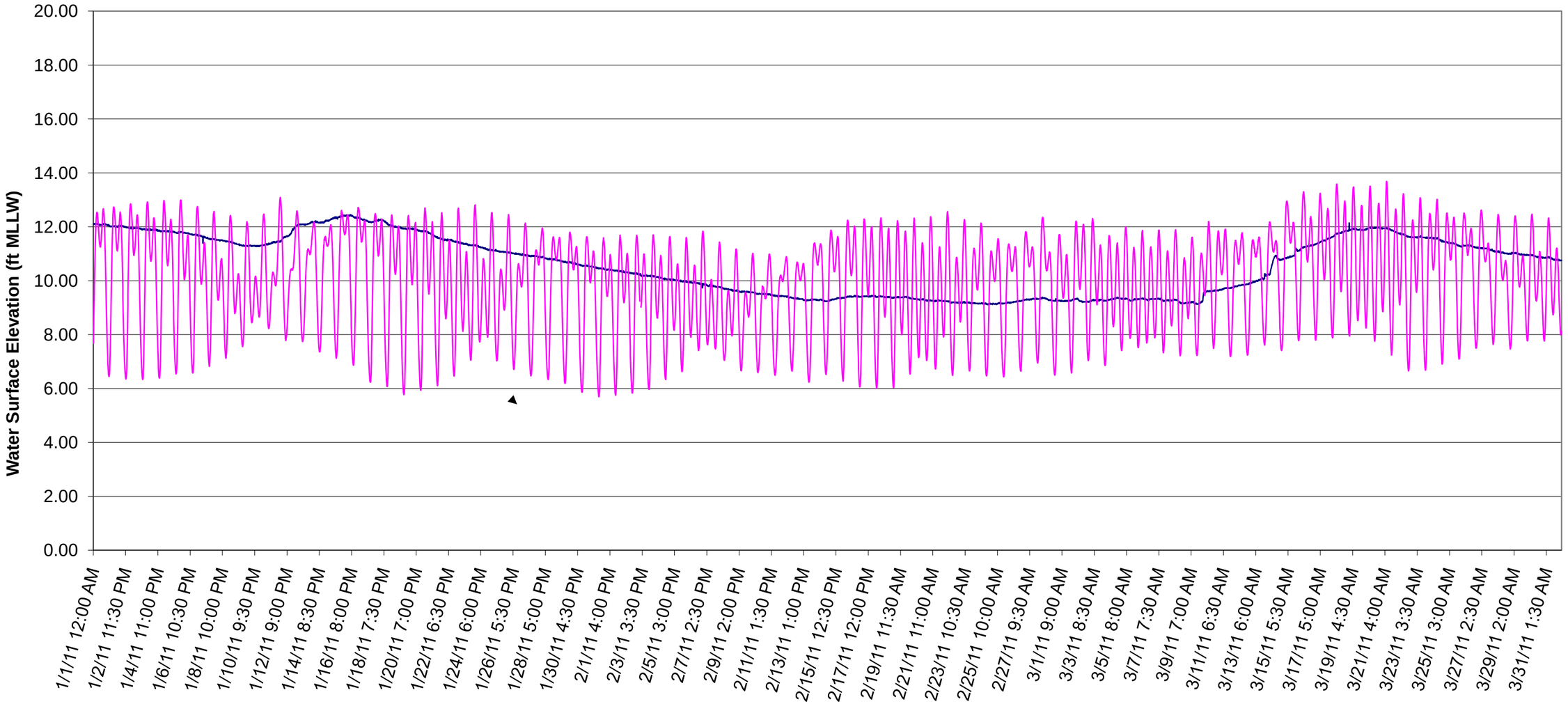


Figure 11 Well Pair Hydrographs
Upper Aquifer Well CW08 & Lower Aquifer Well P4L
January 1, 2011 - March 31, 2011

Maximum Negative Vertical Gradient

MW14/CW05	N/A (logger failure)
MW18/02CDMW01	3/15/2011, 3/16/2011
PO03/99CDMW02	1/4/2011
CW03/CW02	1/2/2011, 1/4/2011
VG2U/VG2L	1/4/2011
VG3U/VG3L	none
VG5U/VG5L	1/1/2011
PO13/VG1L	1/20/2011
CW13/VG4L	N/A (lost data)
CW08/P4L	1/20/2011

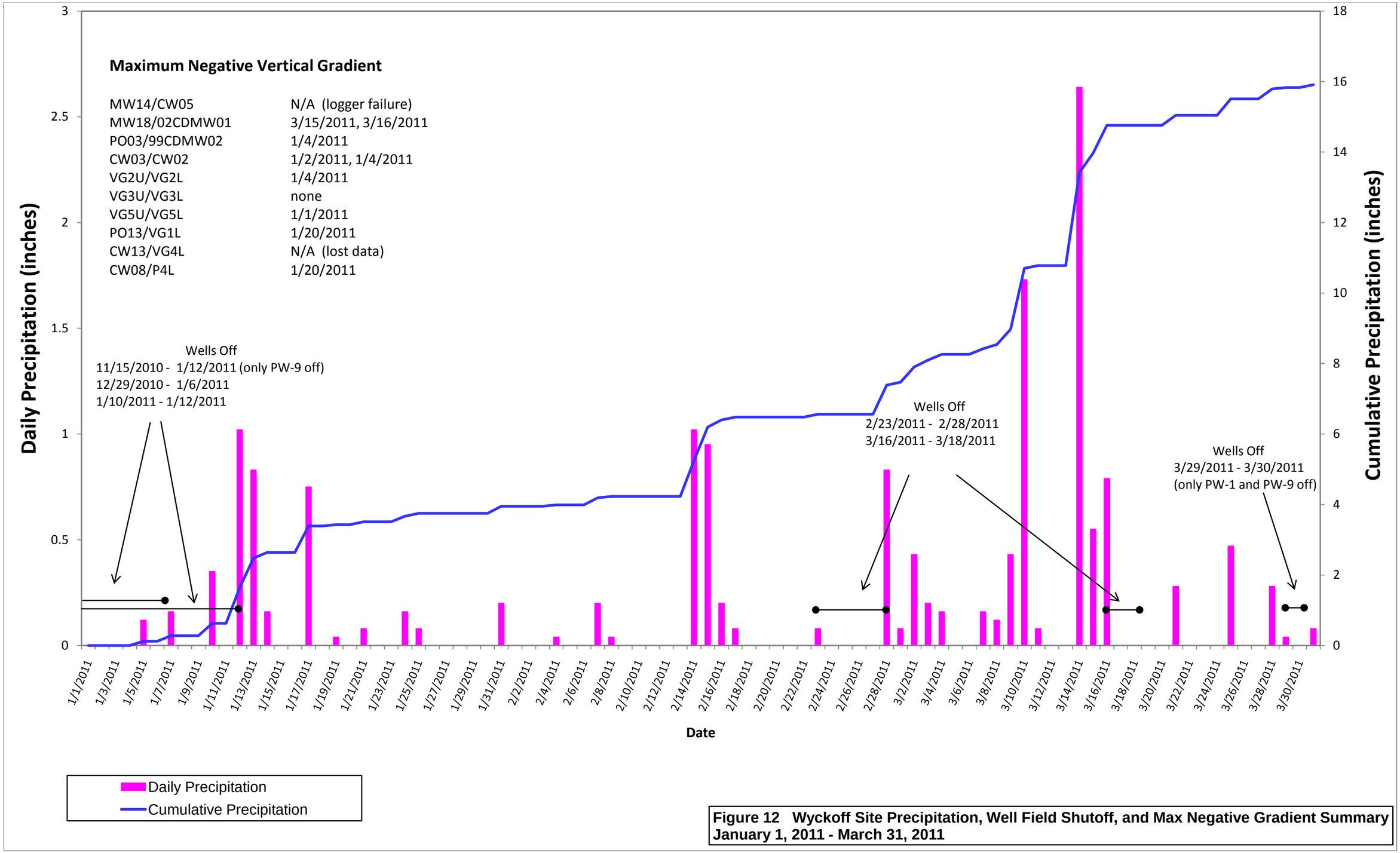


Figure 12 Wyckoff Site Precipitation, Well Field Shutoff, and Max Negative Gradient Summary January 1, 2011 - March 31, 2011