TREND AND DATA ANALYSIS
GREATER WATTENBERG AREA
WATER QUALITY ANALYSIS PROJECT
NORTHEASTERN COLORADO

Submitted to:

Colorado Oil and Gas Conservation Commission

Denver, Colorado

Submitted by:

Amec Foster Wheeler Environment & Infrastructure, Inc.

Denver, Colorado

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Project No. 32820037

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TREND AND DATA ANALYSIS

Greater Wattenberg Area Water Quality Analysis Project
Northeastern Colorado

1.0 INTRODUCTION

The producing formations of the Denver-Julesburg Basin are currently being economically recovered in the Greater Wattenberg Area (GWA) of north-central Colorado for gas and oil condensate. Production has occurred mainly in southwestern Weld County, with minor production also occurring in adjoining sections of Larimer, Boulder and Adams counties. The data analyzed in this study is from wells in Townships 2 South to 7 North and Ranges 61 to 69 West.

In 2005 the Colorado Oil & Gas Conservation Commission (COGCC) began to require, per Rule 318A.e(4), pre-drilling (baseline) water quality sampling of the closest Laramie/Fox Hills aquifer well within a quarter section of infill wells within the GWA. This requirement was expanded in 2011 to include all wells within the GWA. In January 2013, COGCC approved Rule 318A.f (Rule), which requires both baseline and post-drill (subsequent) sampling events. For oil, gas, multi-use or dedicated injection wells with permit applications submitted on or after May 1, 2013, collection of an initial baseline and subsequent monitoring sample are required. Baseline sampling must occur within the 12 months prior to commencement of drilling, and one subsequent sampling event shall be conducted between six and 12 months following completion. Wells that are drilled and abandoned without producing hydrocarbons are exempt from the Rule. Additionally, voluntary baseline water quality sampling by area operators has been overseen by the Colorado Oil & Gas Association (COGA) since 2011.

The analytical requirements for water well samples per Rule 318A.f are summarized as follows:

Monitoring Period	Analytical Requirements
Baseline (pre-drilling)	Major cations (Ca^{2+}, Fe^{2+}, Mg^{2+}, Mn^{2+}, K^{+}, Na^{+}), major anions (Br^{-}, Cl^{-}, F^{-}, SO_4^{2-}, nitrate + nitrite as N, PO_4^{3-}), other elements (Ba, B, Se, Sr), total dissolved solids (TDS), dissolved gases (methane, ethane, propane), pH, presence of bacteria, specific conductance, alkalinity (total CO_3^{2-} and HCO_3^{-} as $CaCO_3$), total petroleum hydrocarbons (TPH), BTEX compounds (benzene, toluene, ethylbenzene, and xylenes). Free gas or methane ≥ 1.0 milligrams per liter (mg/L) triggers gas compositional analysis and stable isotope analysis (δD and $\delta^{13}C$) of the methane to determine the gas type.
Subsequent (six to 12 months post well completion)	TDS, dissolved gases (methane, ethane, propane), major cations (Ca^{2+},Mg^{2+}, K^{+}, Na^{+}), major anions (Br^{-}, Cl^{-}, F^{-}, SO_4^{2-}), alkalinity (total CO_3^{2-} and HCO_3^{-} as $CaCO_3$), TPH and BTEX compounds. Free gas or methane ≥ 1.0 mg/L triggers gas compositional analysis and stable isotope analysis (δD and $\delta^{13}C$) of the methane to determine the gas type.

It is important to note that the 2005 and 2011 Rules listed a methane concentration ≥ 2.0 mg/L as the trigger for stable isotope analysis. Therefore, not all methane concentrations ≥ 1.0 mg/L have associated stable isotope data, which did not become a requirement until 2013.

Area operators have been submitting data required by COGCC per rule 318.A since 2005 and from COGA voluntary sampling since 2011. Additional data has been obtained through sampling events in response to complaint investigations. The data is maintained in a SQL database in the Denver COGCC offices; the database currently includes records for 1,121 wells, a total of 2,369 samples and over 56,000 analytical results for the GWA.

The objective of the Greater Wattenberg Area Water Quality Analysis (GWAWQA) Project is to assess potential long-term trends in general groundwater quality in the GWA based on data available in the COGCC database and to evaluate any identified trends for relevance to area drilling and production.

The remaining sections of this report describe the data and trend analysis.

2.0 TREND AND DATA ANALYSIS

Data and trend analysis were performed to assess the distribution and long-term changes in the groundwater quality in the GWA. It is important to note that the water quality database contains more than 56,000 records for 301 different water quality parameter names. The intent of the analysis was to identify any short or long-term trends that might indicate that oil and gas drilling and production activities are impacting domestic water wells in the GWA. Therefore, emphasis was placed on a subset of constituents that could indicate potential impacts from drilling and production activities.

Water quality data and trend analysis were performed by geographic mapping, plotting data on time-concentration plots, performing Mann-Kendall trend analysis, and evaluating the results of compositional analysis of methane.

Most common statistical methods of analysis require at least four data points for the results of the statistical analysis to be considered reliable. Therefore, time-concentration plots and Mann-Kendall trend analysis were limited to data sets that included four or more results. For example, trend analysis was performed for each water well and for each target parameter that had four or more results in the water quality database. Non-detect results with no recorded detection limit were not included in the Mann-Kendall analysis and time-concentration plots as no value could be assigned to the result. The isotope data (δD and $\delta^{13}C$ of methane) were also excluded from the trend analysis.

Using this approach, a total of 105 data sets for 12 parameters in 16 wells were evaluated using time-concentration plots and Mann-Kendall trend analysis. Note that there were not enough data to perform trend analysis reliably for all 12 parameters in all 16 wells (the total number of possible analyses for all 12 parameters in all 16 wells is 192).

2.1 TARGET PARAMETERS

The scope of the data and trend analysis was limited to 14 target parameters that are considered to be indicators of possible impacts from drilling and production activities. The 14 target parameters are as follows:

Methane	Alkalinity
Total Dissolved Solids (TDS)	pH
Calcium	Carbonate
Magnesium	Bicarbonate
Potassium	Chloride
Sodium	Sulfate
δD (methane)	$\delta^{13}C$ (methane)

Cations, anions, alkalinity, TDS, and pH are considered to be reliable indicators of general water quality. As further described in Section 2.2, concentrations of methane and compositional analysis of methane isotopes trigger prescribed actions under the Rule.

2.2 MONITORING TRIGGERS

The Rule describes specific monitoring requirements and regulatory actions, or triggers. As specified in the Rule, if free gas or methane at a concentration greater than 1 mg/L is detected in a water quality testing well then compositional and isotopic analysis of the methane is required to determine the gas type. The operator must notify the COGCC Director and the owner of the water well immediately if:

- The isotope analysis indicates that the gas is thermogenic or a mixture of thermogenic and biogenic (i.e., bacterial);
- Methane concentrations increase by more than 5 mg/L between sampling periods; or
- Methane is detected at or above 10 mg/L.

These triggers provide the rationale for the data and trend analysis that are described in Sections 2.3 through 2.6.

2.3 GEOGRAPHIC MAPPING

The geographic distribution of methane in water wells in the GWA is shown in Figures 1 through 3. Analytical and field data for methane in groundwater are available for 964 water wells in the water quality database (Figure 1). There are 360 water wells that had methane concentrations greater than 1 mg/L (Figure 2) and there are 235 water wells that had methane concentrations equal to or greater than 10 mg/L (Figure 3). Because the solubility of methane in water is

between 28 and 30 ppm (USGS, 2006), analytical results that are greater than 30 ppm may indicate free gas in the sample.

2.4 TIME-CONCENTRATION PLOTS

Time-concentration plots were prepared for 105 data sets in 16 water wells. Wells are identified by FacilityID numbers that are stored in the water quality database. Detected results are shown on the plots as closed circles at the measured concentration. The time-concentration plots are presented as Appendix A. The time-concentration plots are provided in Excel format so that individual data points can be reviewed. The plots are also compiled into a PDF document.

Initially, the time-concentration plots were reviewed visually to evaluate changes in the long-term concentrations qualitatively. Note that qualitative interpretation of the long-term trends by visual methods is subject to some bias. The vertical axis on each time-concentration plot is scaled to show the full range of concentrations for the selected parameter on each plot. Long-term changes in the concentration of a parameter in different wells may appear to be similar, however, the magnitude of the concentration on the vertical axis must be considered. For example, the methane concentrations in FacilityID 704700 range from 0.005 to 0.077 mg/L whereas the methane concentrations in FacilityID 752520 range from 0.0002 to 36 mg/L.

2.5 MANN-KENDALL TREND ANALYSIS

Mann-Kendall trend analysis was used to evaluate changes in the long-term concentrations using a quantitative approach. Mann-Kendall trend analysis is a non-parametric statistical technique that is routinely used to assess trends in groundwater. Non-parametric statistical methods do not assume any underlying distribution in the data whereas parametric statistical methods assume that a certain underlying distribution is present, such as normal or log-normal distribution. Mann-Kendall was selected for the GWAWQA Project for the following reasons:

- Mann-Kendall is particularly well-suited for small data sets that do not have enough data to establish the underlying distribution as required for most parametric statistical techniques. The individual data sets in this evaluation included between four and 22 data points;

- Mann-Kendall is insensitive to missing data because the missing values are ignored and do not influence the results; and

- Mann-Kendall is able to handle non-detects because the non-detect values are replaced with a common value that is less than the smallest detected concentrations. However, if a non-detect result did not have a detection limit, the result was excluded from the analysis as it could not be assumed that the non-detection occurred at a value less than the smallest detected concentrations.

Mann-Kendall trend analysis is used to determine the presence or absence of a *statistically significant* trend in the data over time. Statistical significance is determined by comparing the S-statistic (***S***) for the number of data points (**n**) in the sample population to the table of null

probability values (**α**) at the specified significance level. For this analysis, the statistical significance of the trend was evaluated at the 95 percent confidence level (**α** = 0.95) as follows:

(1- **α**) < 0.05	True (trend is significant)
(1- **α**) > 0.05	False (trend is not significant)

Mann-Kendall is also a test for zero slope of time-ordered data that is based on a nonparametric analog of linear regression. The slope of the data is determined using the S-statistic as follows:

S > 0	Increasing trend
S = 0	No trend
S < 0	Decreasing trend

Results of the Mann-Kendall trend analyses are summarized in Table 1 and the complete results are presented in Appendix B. Wells with datasets for which Mann-Kendall analysis was performed are shown in Figure 4.

2.6 COMPOSITIONAL AND ISOTOPIC ANALYSIS OF METHANE

As described in Section 2.2, compositional and isotopic analysis of methane is required when free gas is detected in a well or when methane is detected at a concentration greater than 1 mg/L. Isotope data are typically reported in the standard δ-notation expressed in per mil (‰). Isotopic analysis of methane includes the carbon isotope ratio $\delta^{13}C$ ($\delta^{13}C = [(^{13}C/^{12}C)_{sample}/(^{13}C/^{12}C)_{standard} -1] *1000$) and hydrogen isotope ratio δD ($\delta D = [(^{2}H/^{1}H)_{sample}/(^{2}H/^{1}H)_{standard} -1] *1000$). Analytical results for both of these isotope ratios are available for 369 water samples that were collected in 277 wells in the GWA where methane was detected at a concentration greater than 1 mg/L.

Whiticar (1999) presented ranges of $\delta^{13}C$ and δD isotope ratios for various natural and artificial sources of methane (Figure 5). Thermogenic methane has a range of $\delta^{13}C$ values from -50 to -20 ‰ and a range of δD values from -275 to -100 ‰. Biogenic methane has a range of $\delta^{13}C$ values from -110 to -50 ‰ and a range of δD values from -400 to -150 ‰. The ratios of the $\delta^{13}C$ and δD isotopes from methane in the GWA are compared to the ranges presented by Whiticar (1999) for various sources of methane in Figure 6. The geographic distribution of isotopic results for the water samples is shown on Figure 7.

3.0 RESULTS

Results of the data and trend analysis are summarized as follows:

- The database contains data for 1,121 wells in the GWA; 16 wells had four or more sampling events in the database and were eligible for Mann-Kendall analysis.

- Analytical results for methane in groundwater are available for 964 water wells throughout the GWA (Figure 1).

- Methane was detected in 360 water wells at a wide range of concentrations that are greater than 1 mg/L generally in the south-central portion of the GWA (Figures 2 and 3).

- Mann-Kendall trend analysis was performed for 105 data sets including 12 water quality parameters and 16 wells (Table 1 and Figure 4).

- Based on the results of Mann-Kendall trend analysis, six data sets in two wells have increasing trends that are statistically significant, five data sets in four wells have decreasing trends that are statistically significant, and 24 data sets in 10 wells have no trend. Wells and analytes with statistically significant increasing or decreasing trends are presented in Table 2 with minimum and maximum concentrations from the analyzed datasets for consideration of magnitude. Statistically significant trends are summarized as follows:

    - Analytes with statistically significant increasing trends are Ca, K, Methane, Mg, SO_4, and TDS. Cations, anions and TDS are considered reliable indicators of general water quality. An increase in SO_4 may indicate communication with the Laramie-Fox Hills formation.

    - Analytes with statistically significant decreasing trends are Ca, Cl, and Methane.

- Mann-Kendall analysis of methane data was completed for 14 wells:

    - One well (FacilityID 704700) had a statistically significant increasing methane trend, but had no methane results greater than 1 mg/L and therefore had no $\delta^{13}C$ and δD results for methane;

    - Two wells had statistically significant decreasing methane trends, and both of these wells had methane concentrations greater than 10 mg/L. One well (FacilityID 703279) had a biogenic methane isotope signature while the other (FacilityID 704130) had a thermogenic methane isotope signature;

    - Mann-Kendall results for methane in the remaining 11 wells were either not statistically significant or had no trend.

- Results of methane isotope analysis for $\delta^{13}C$ and δD for 343 samples in 266 wells were interpreted to have biogenic sources and results for 27 samples in 15 wells were interpreted to have thermogenic sources (Figure 6). The geographic distribution of isotopic results for the water samples is shown on Figure 7.

4.0 RECOMMENDATIONS

Fifty wells in the GWA have data for three distinct sampling events in the database. Collection of a fourth sample would results in an additional 409 datasets eligible for Mann-Kendall analysis. A list of these wells and analytes with three distinct sampling events is provided as Appendix C.

5.0 REFERENCES

US Geological Survey, 2006, Methane in West Virginia Groundwater, Fact Sheet 2006-3001, 2006.

Whiticar, M.J, 1999, Carbon and Hydrogen Isotope Systematics of Bacterial Formation and Oxidation of Methane, Chemical Geology, Vol. 161, p. 291-314, 1999.

TABLES

TABLE 1
MANN-KENDALL RESULTS SUMMARY
Greater Wattenberg Area Water Quality Analysis Project

Parameter	Increasing Trend		Decreasing Trend		No Trend	No. Wells / Analysis
	Statistically Significant	Not Statistically Significant	Statistically Significant	Not Statistically Significant		
Alkalinity	0	3	0	2	2	7
Ca	1	2	2	2	2	9
Cl	0	3	1	2	3	9
CO3	0	2	0	2	2	6
HCO3	0	2	0	4	2	8
K	1	5	0	2	1	9
Methane	1	4	2	3	4	14
Mg	1	3	0	3	2	9
Na	0	4	0	3	3	10
pH	0	1	0	3	1	5
SO4	1	5	0	3	0	9
TDS	1	2	0	5	2	10
No. Analyses	6	36	5	34	24	105
No. Wells	2	12	4	10	10	

TABLE 2
STATISTICALLY SIGNIFICANT TRENDS
Greater Wattenberg Area Water Quality Analysis Project

Increasing Trends

FacilityID	Analyte	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
704700	Ca	9.9	14
	Methane	0.005	0.077
	Mg	0.9	1.4
	SO_4	350	500
	TDS	740	870
752226	K	6.3	24.8

Decreasing Trends

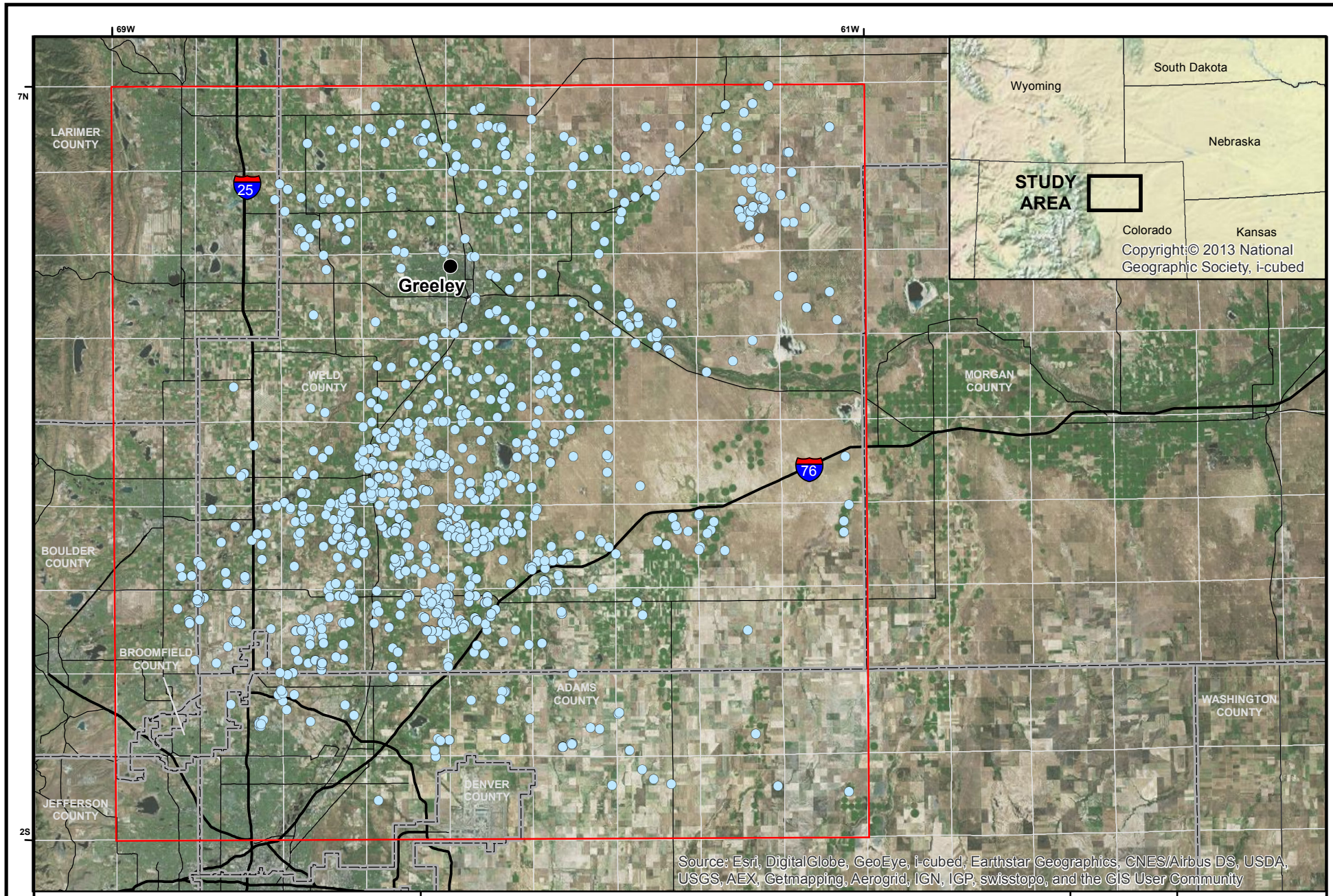
FacilityID	Analyte	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
703279	Methane	10	22
704130	Methane	7.5	15
705446	Ca	1.9	2.61
705779	Ca	1.87	2.2
	Cl	87	110

Notes

Statisical significance and trend direction determined by Mann-Kendall analysis of four or more data points from unique sampling events.

mg/L - milligrams per liter

FIGURES



LOCATIONS OF METHANE RESULTS
Greater Wattenberg Area
Water Quality Analysis Project
Northeastern Colorado

N

0 5 10 Miles

LEGEND

- Methane Results (964 wells)
- Greater Wattenberg Area Boundary
- County Boundary

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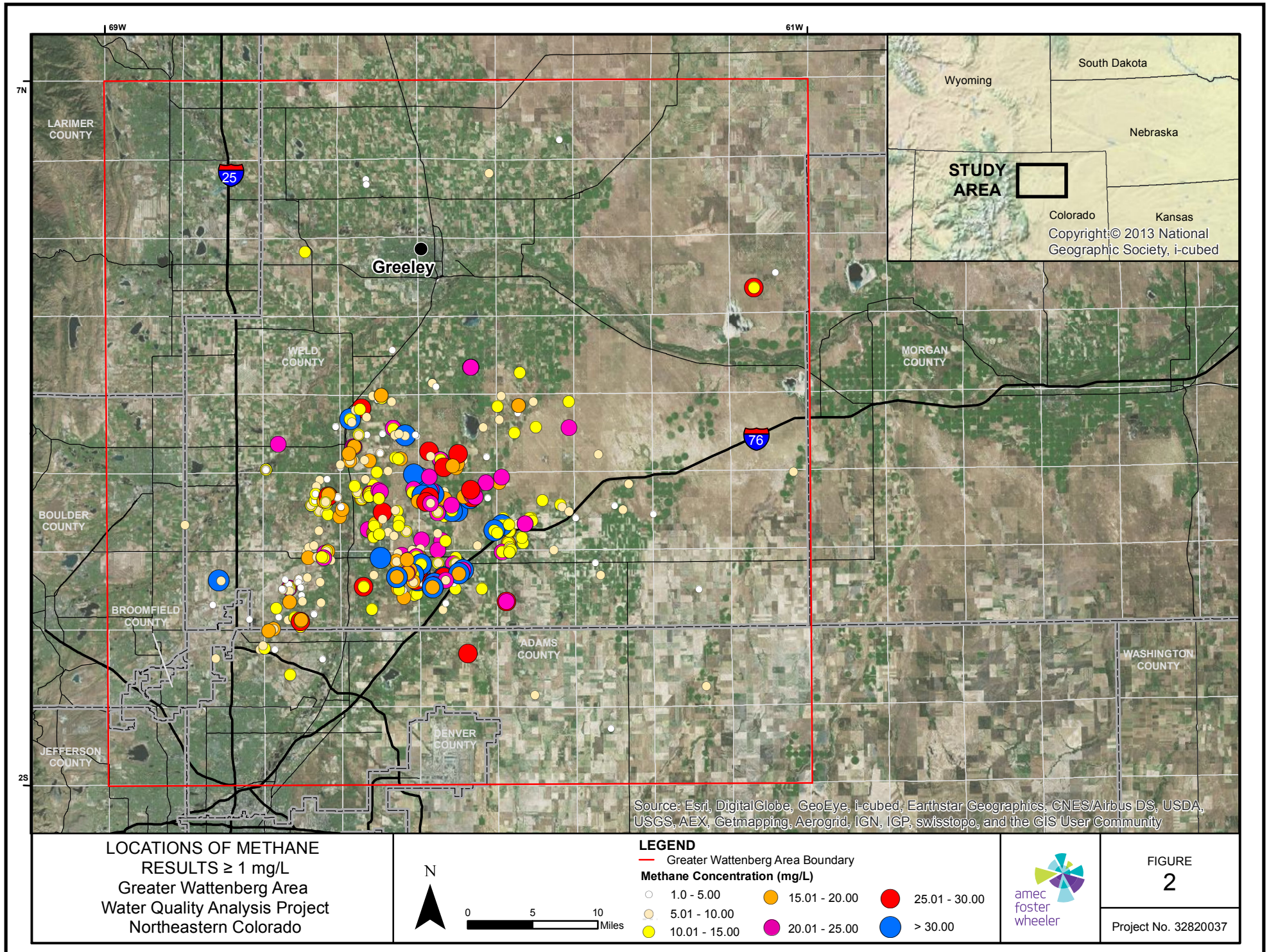
FIGURE
1

Project No. 32820037



LOCATIONS OF METHANE RESULTS ≥ 1 mg/L
Greater Wattenberg Area
Water Quality Analysis Project
Northeastern Colorado

N

0 5 10 Miles

LEGEND

Greater Wattenberg Area Boundary

Methane Concentration (mg/L)

- 1.0 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00
- 15.01 - 20.00
- 20.01 - 25.00
- 25.01 - 30.00
- > 30.00

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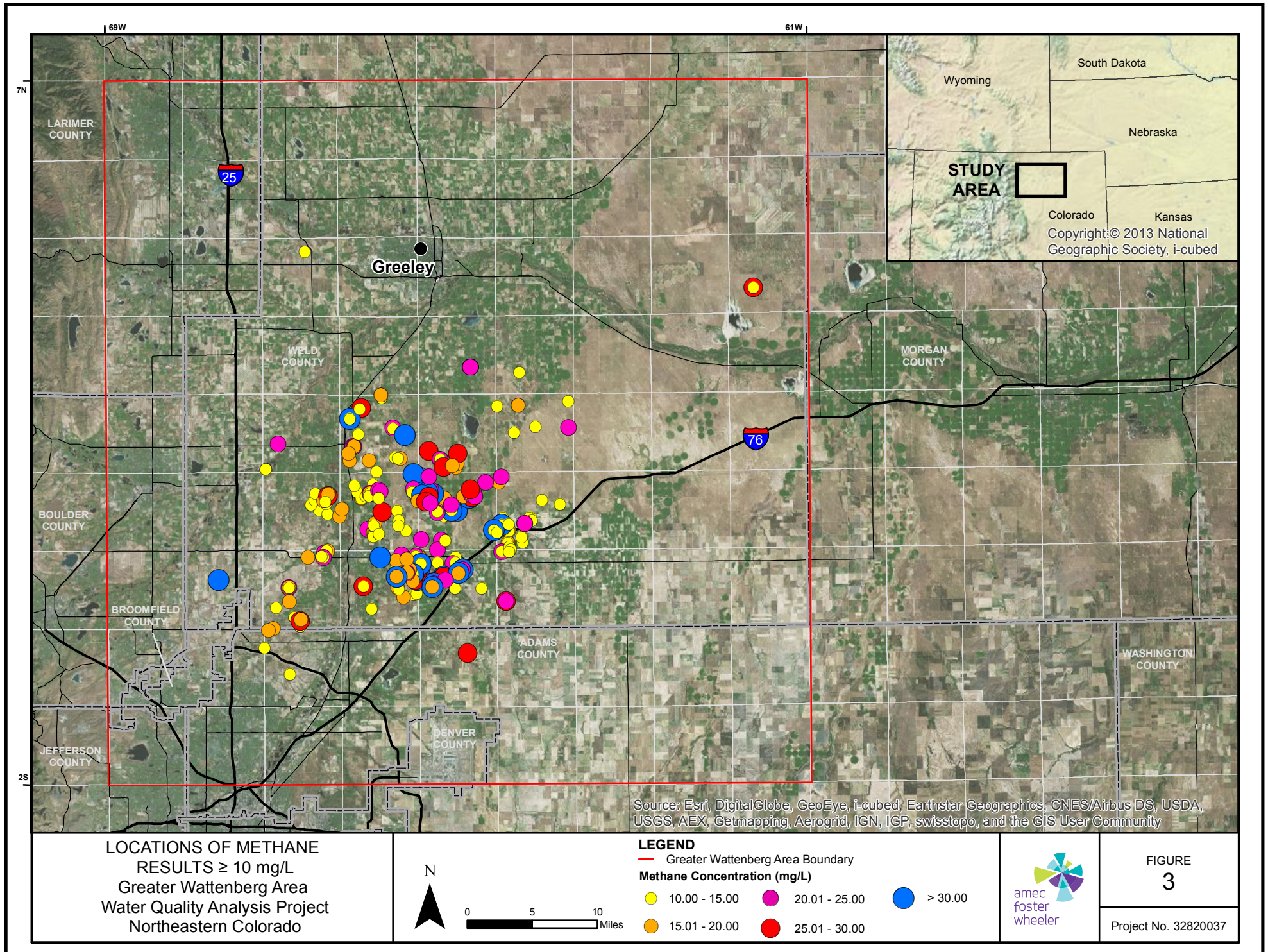
FIGURE
2

Project No. 32820037



LOCATIONS OF METHANE RESULTS ≥ 10 mg/L
Greater Wattenberg Area
Water Quality Analysis Project
Northeastern Colorado

N

0 5 10 Miles

LEGEND

Greater Wattenberg Area Boundary

Methane Concentration (mg/L)

- 10.00 - 15.00
- 15.01 - 20.00
- 20.01 - 25.00
- 25.01 - 30.00
- > 30.00

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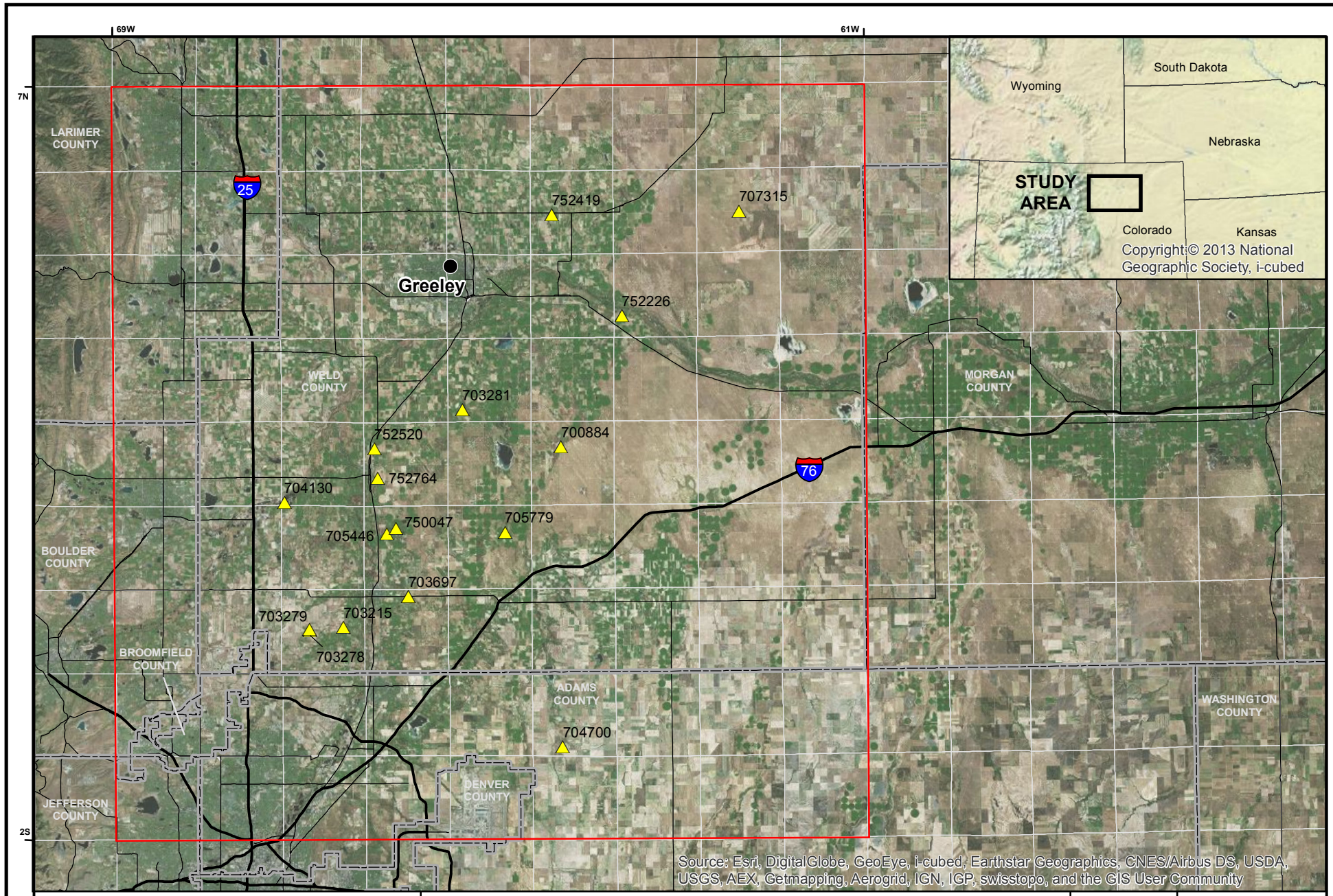
FIGURE 3

Project No. 32820037



LOCATIONS OF MANN-KENDALL RESULTS
Greater Wattenberg Area
Water Quality Analysis Project
Northeastern CO

N

0 5 10 Miles

LEGEND

- Mann-Kendall Analysis Performed (16 wells)
- Greater Wattenberg Area Boundary
- County Boundary

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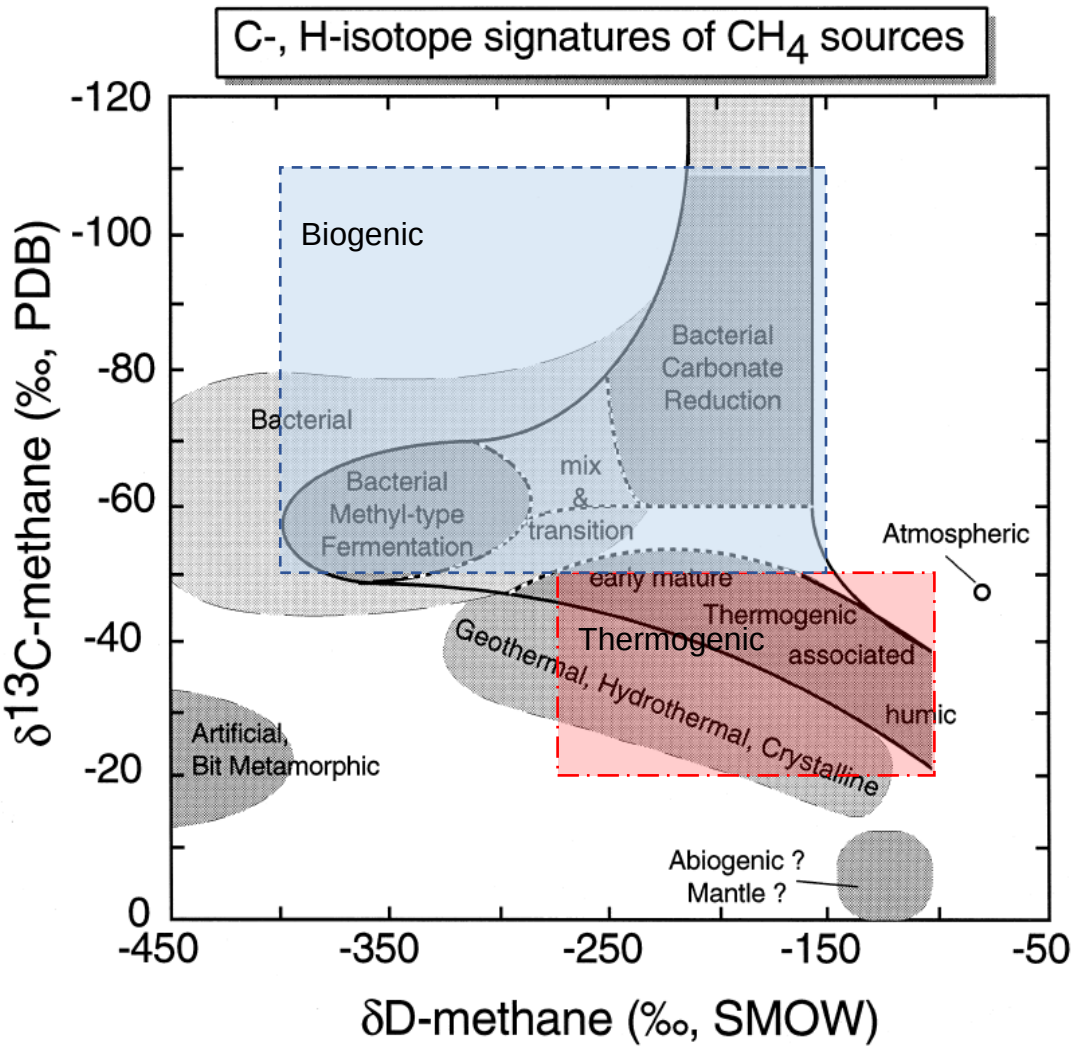
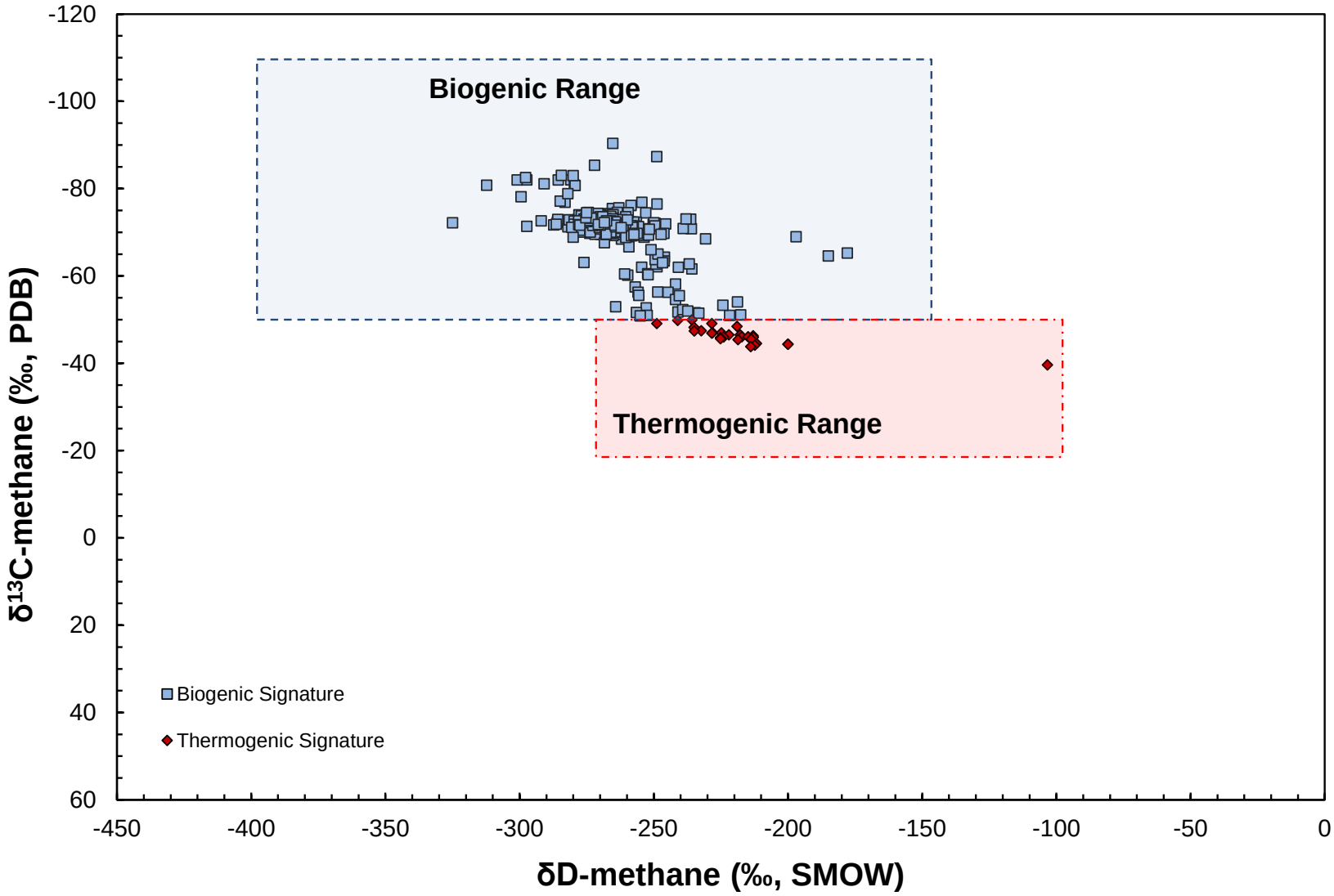
FIGURE
4

Project No. 32820037



From Whiticar, M.J. (1999)

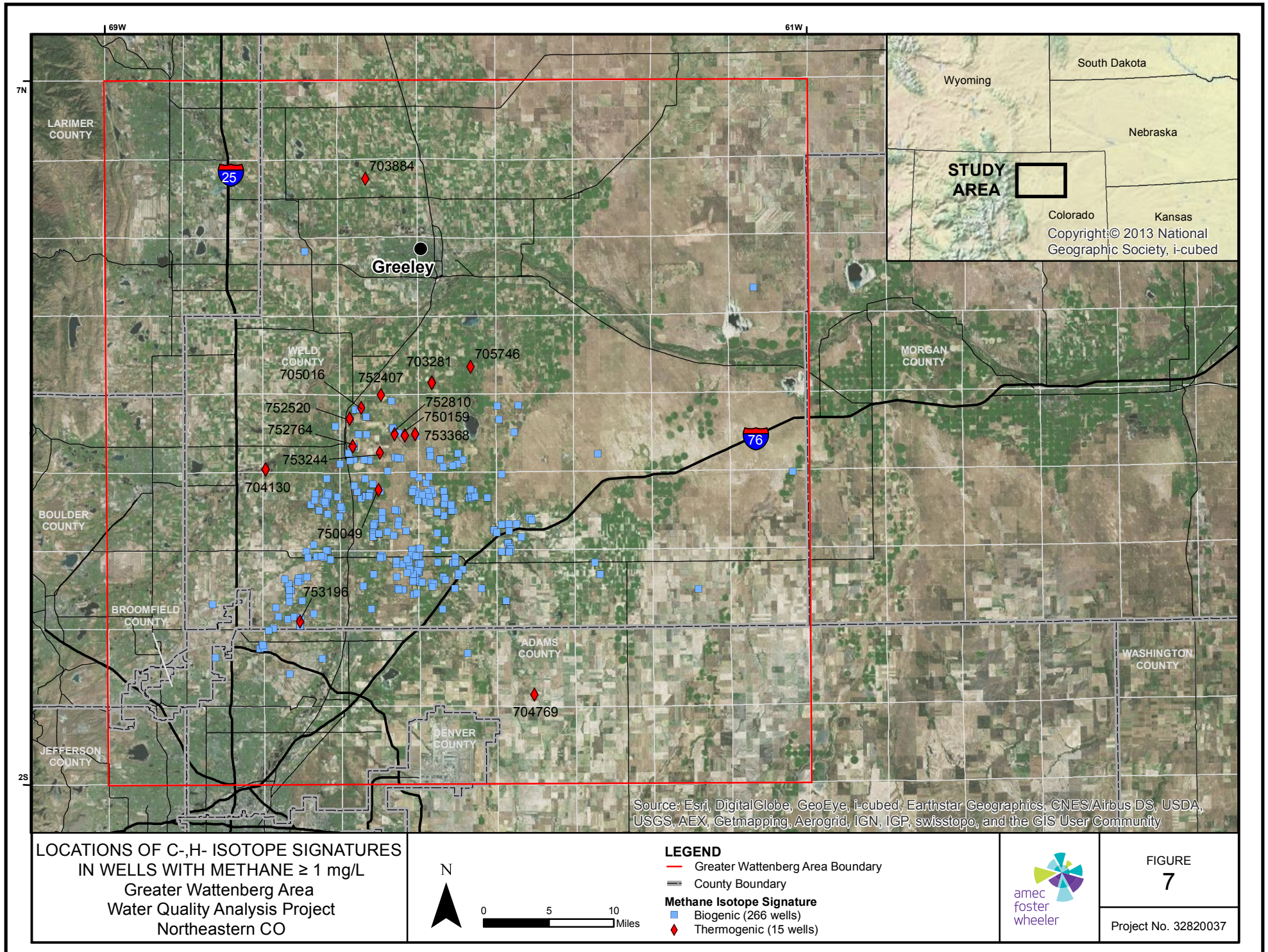
C-, H- ISOTOPE SIGNATURES OF METHANE SOURCES Greater Wattenberg Area Water Quality Analysis Project Northeastern Colorado	
amec foster wheeler	Project No. 32820037
	Figure **5**



C, H - ISOTOPE SIGNATURES IN WELLS WITH METHANE ≥ 1 mg/L
Greater Wattenberg Area Water Quality Analysis Project
Northeastern Colorado

Project No. 32820037

Figure **6**



LOCATIONS OF C-,H- ISOTOPE SIGNATURES
IN WELLS WITH METHANE ≥ 1 mg/L
Greater Wattenberg Area
Water Quality Analysis Project
Northeastern CO

N

0 5 10 Miles

LEGEND

Greater Wattenberg Area Boundary

County Boundary

Methane Isotope Signature

Biogenic (266 wells)

Thermogenic (15 wells)

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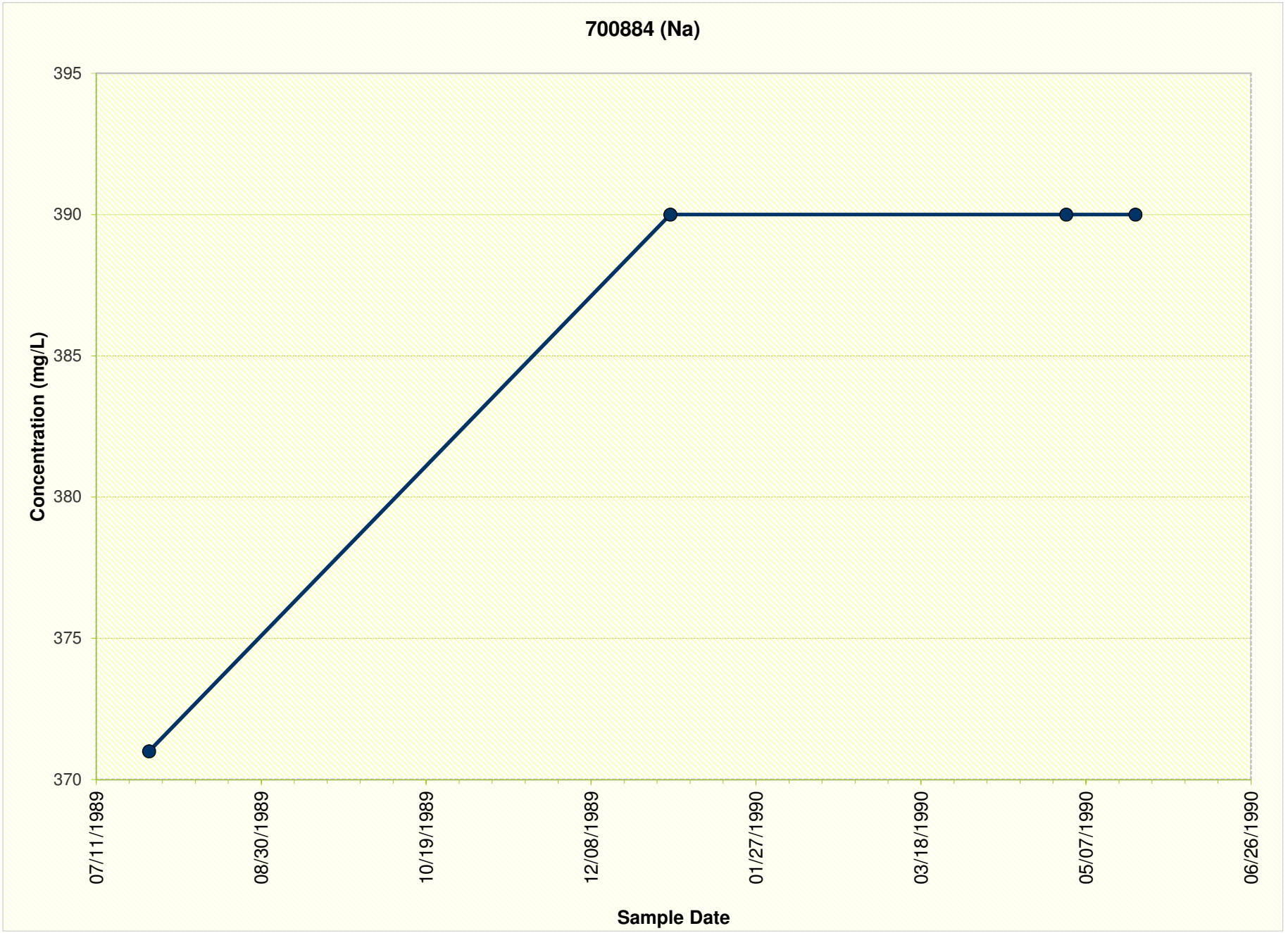
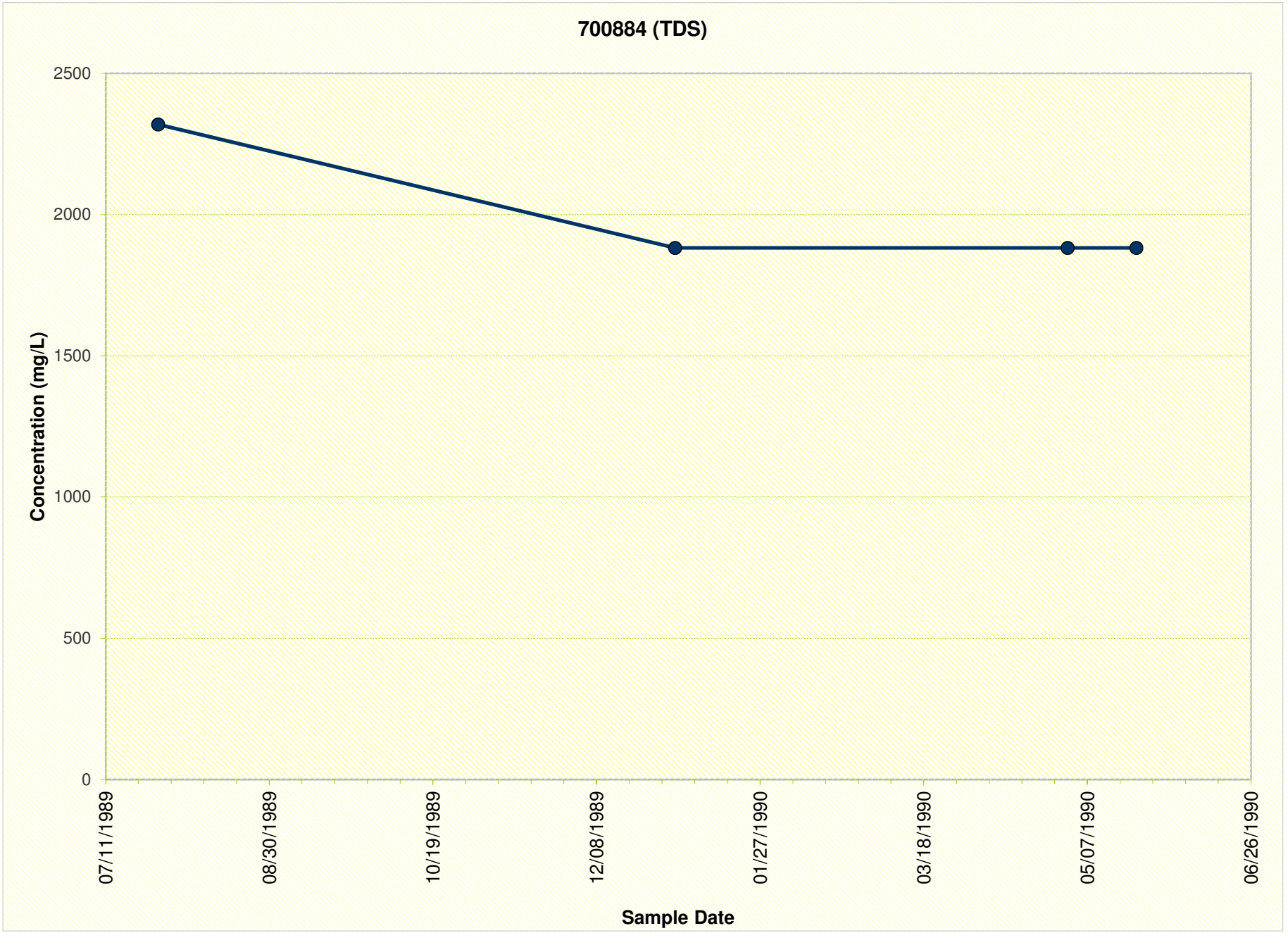
FIGURE
7

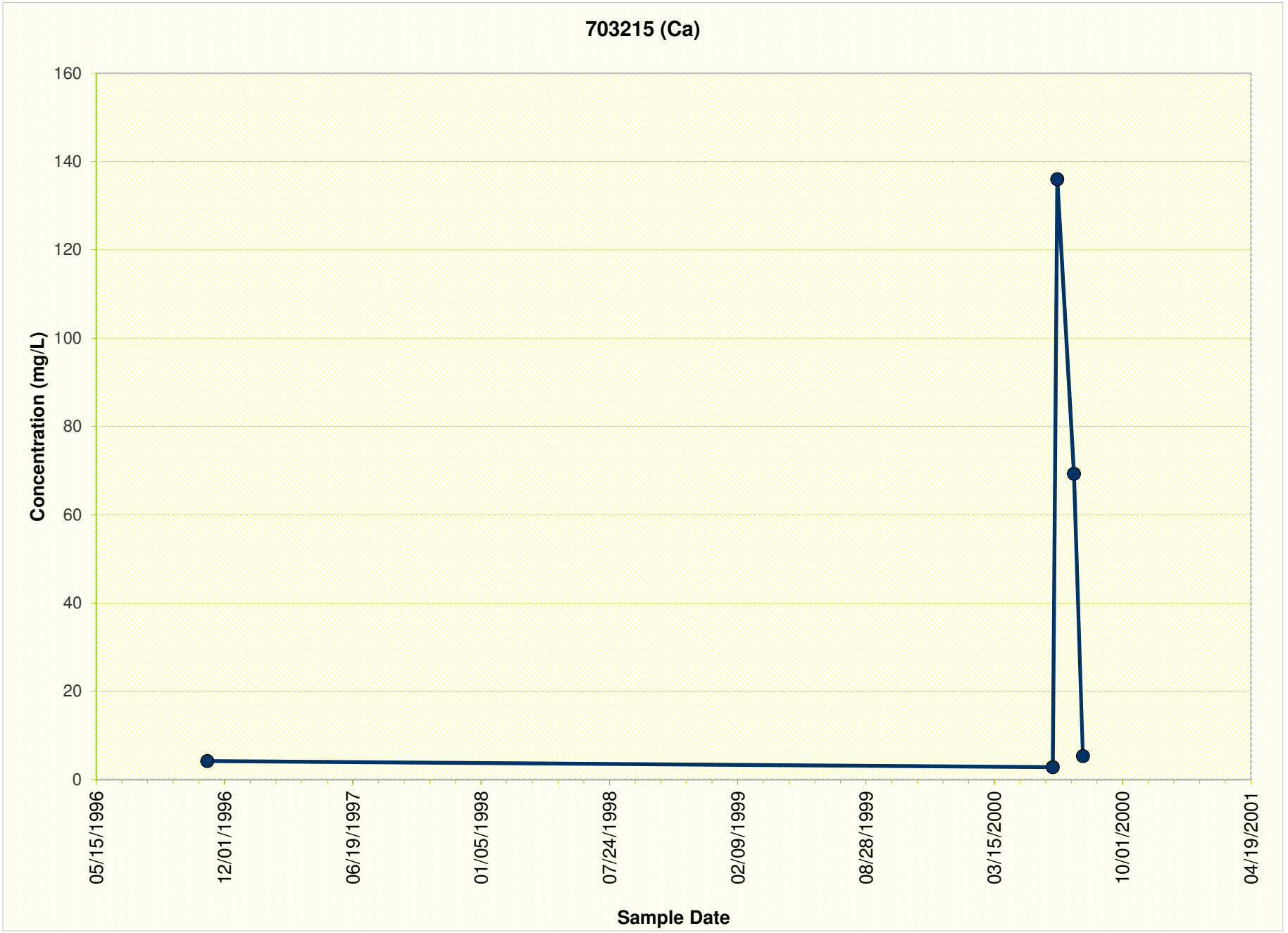
Project No. 32820037

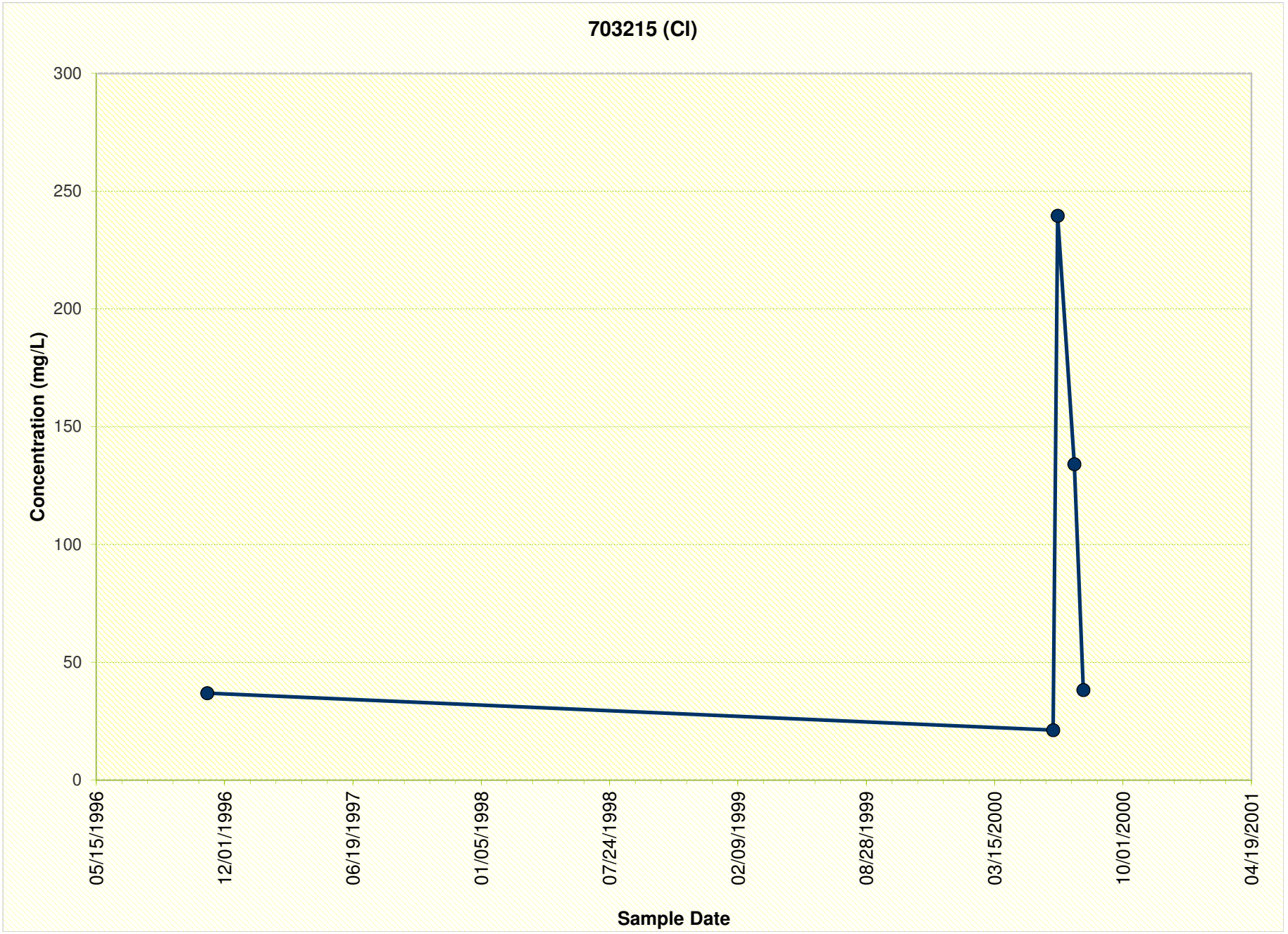
APPENDIX A

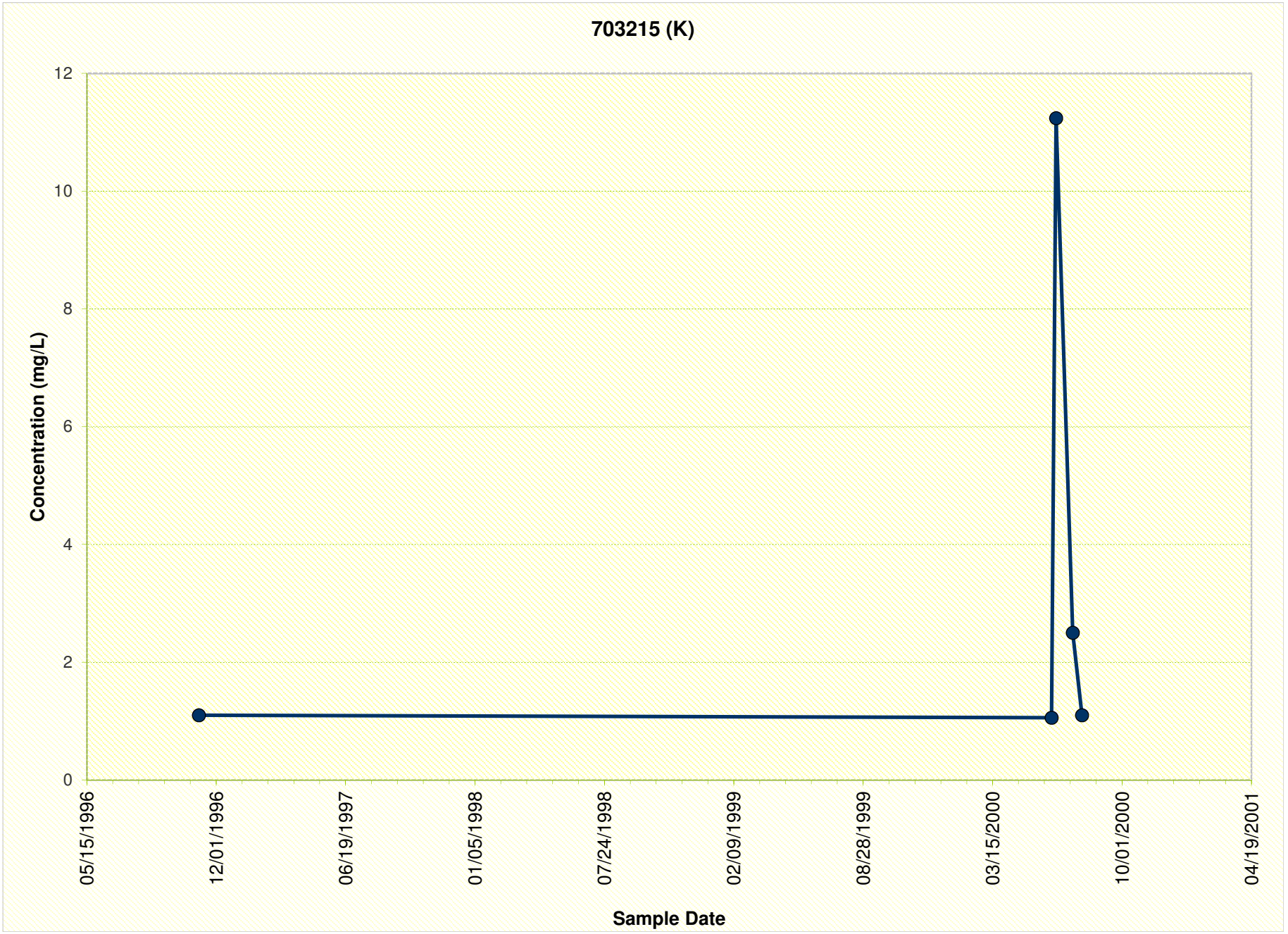
Time-Concentration Plots

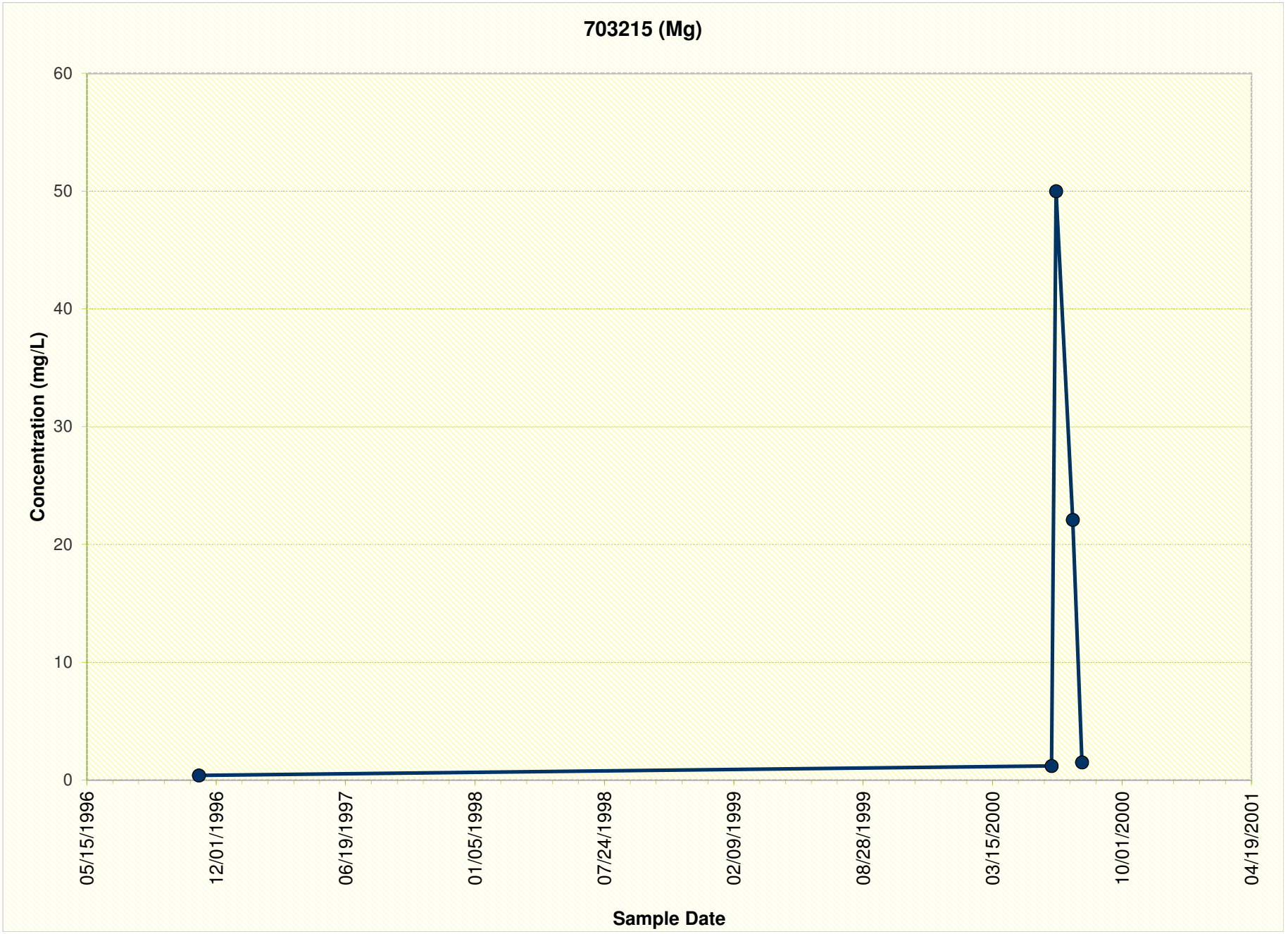

700884 (Na)
395
390
385
380
375
370
Concentration (mg/L)
07/11/1989
08/30/1989
10/19/1989
12/08/1989
01/27/1990
03/18/1990
05/07/1990
06/26/1990
Sample Date


700884 (TDS)
2500
2000
1500
1000
500
0
Concentration (mg/L)
07/11/1989
08/30/1989
10/19/1989
12/08/1989
01/27/1990
03/18/1990
05/07/1990
06/26/1990
Sample Date


703215 (Ca)
160
140
120
100
80
60
40
20
0
Concentration (mg/L)
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date


703215 (Cl)
300
250
200
150
100
50
0
Concentration (mg/L)
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date


703215 (K)
Concentration (mg/L)
0
2
4
6
8
10
12
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date


703215 (Mg)
Concentration (mg/L)
60
50
40
30
20
10
0
05/15/1996
12/01/1996
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07/24/1998
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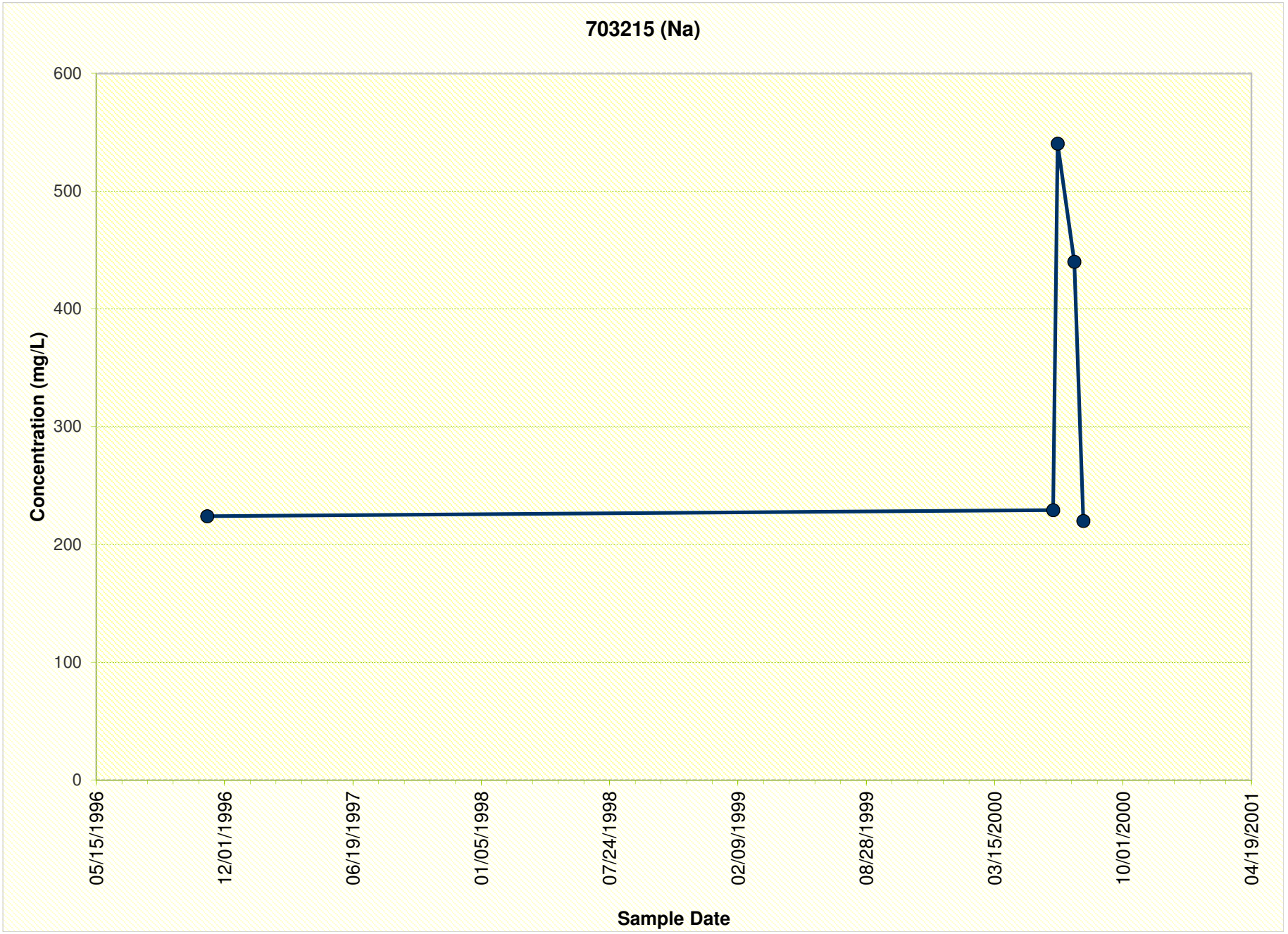
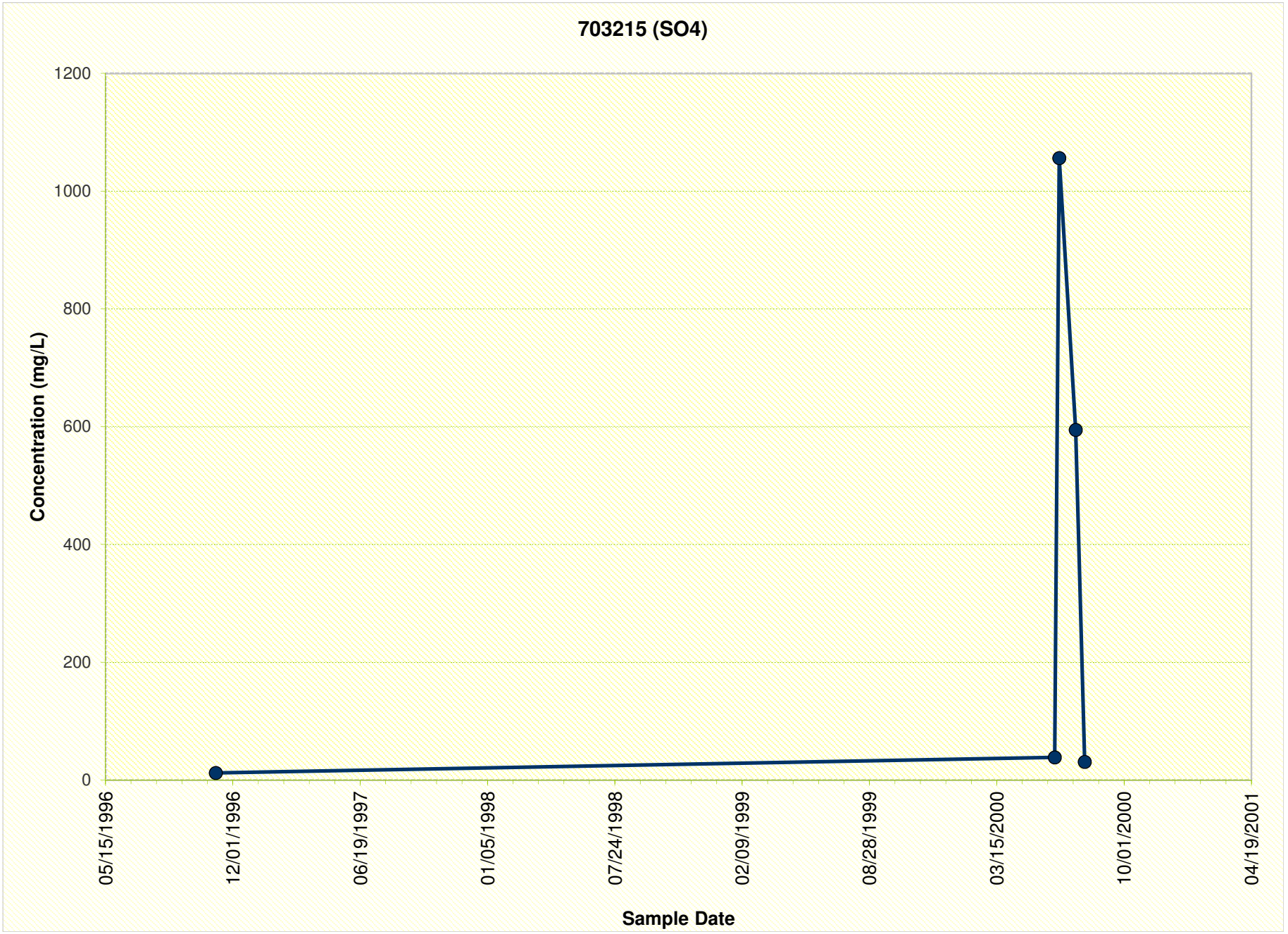
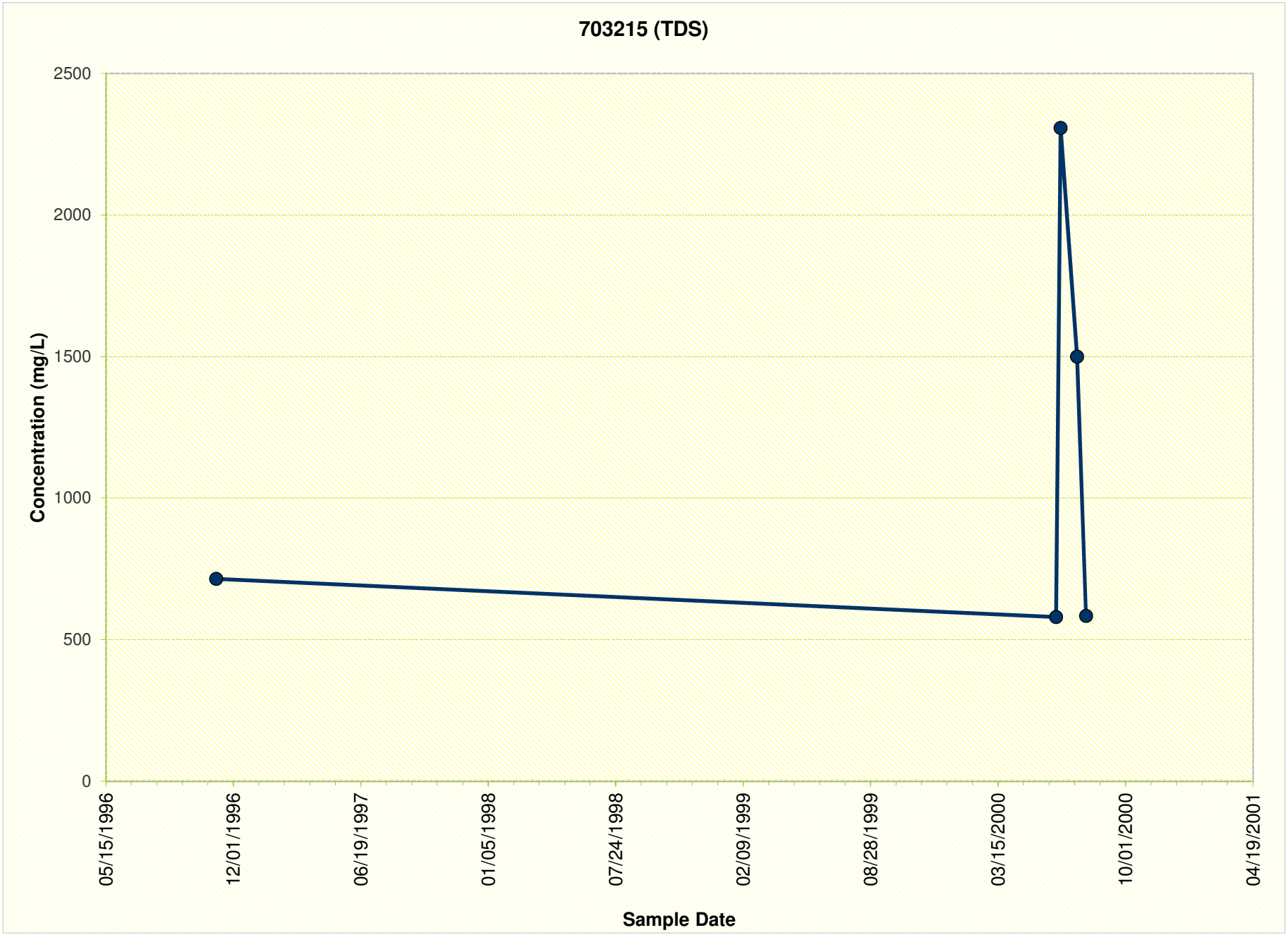
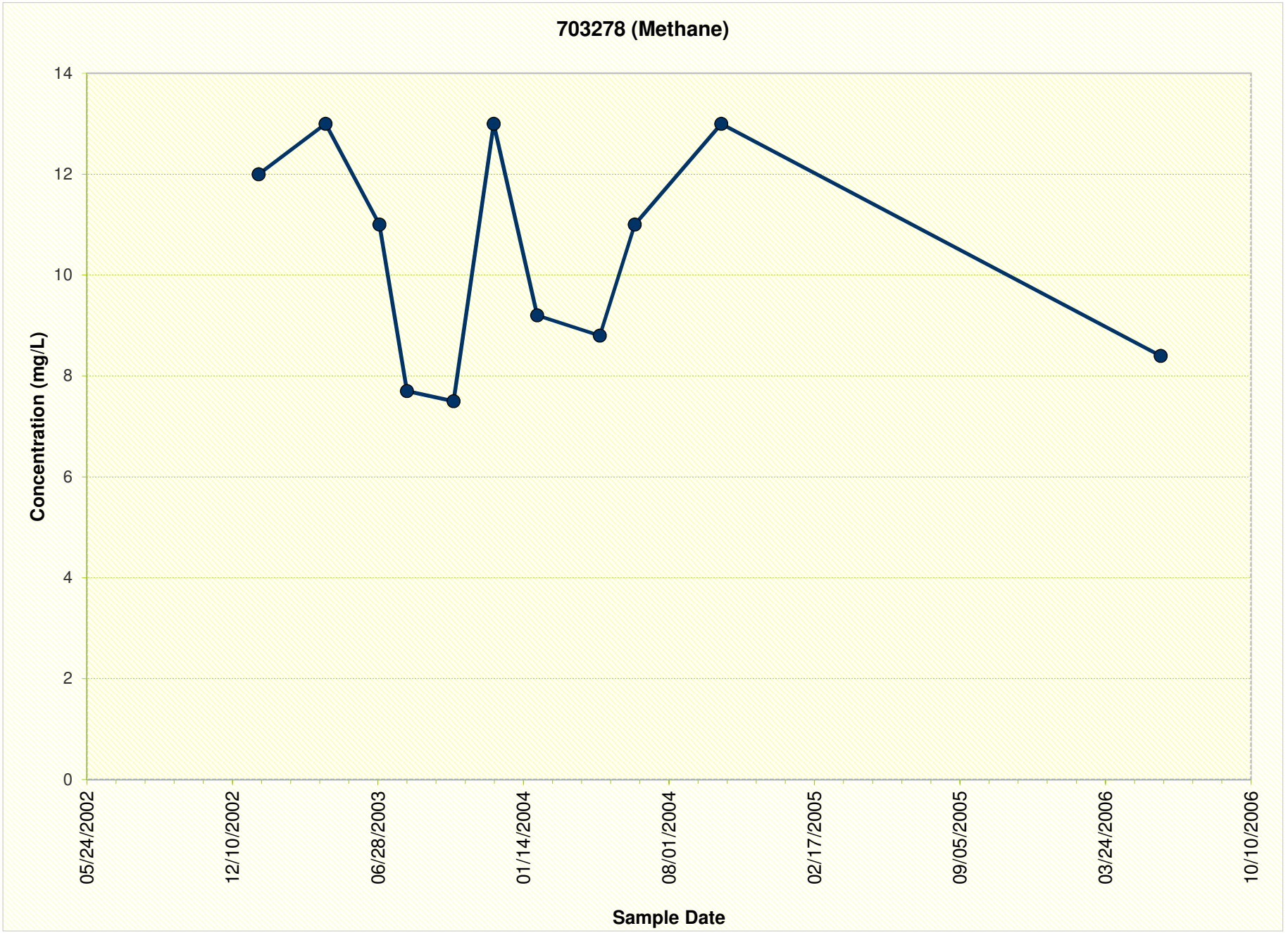
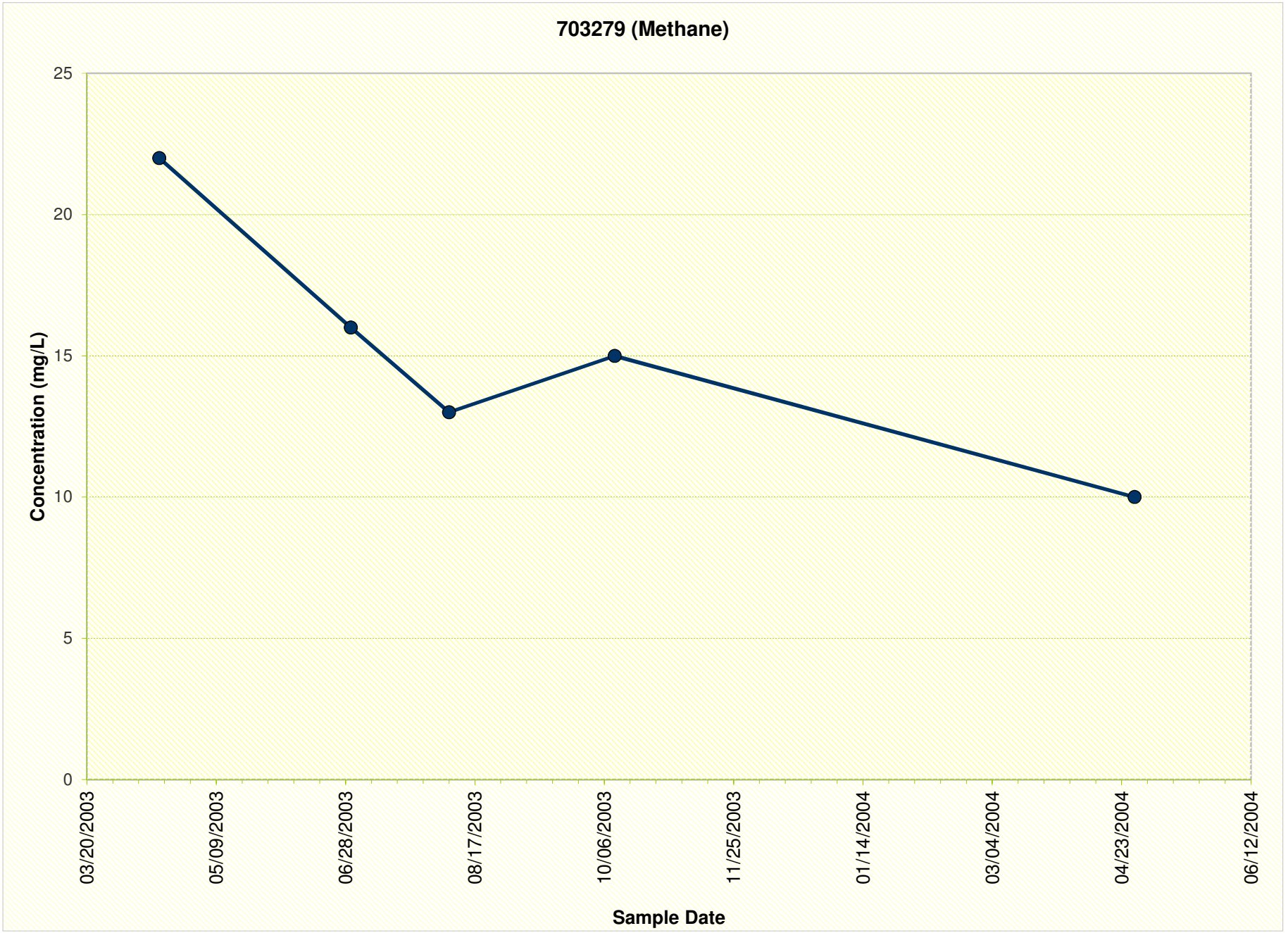
03/15/2000
10/01/2000
04/19/2001
Sample Date

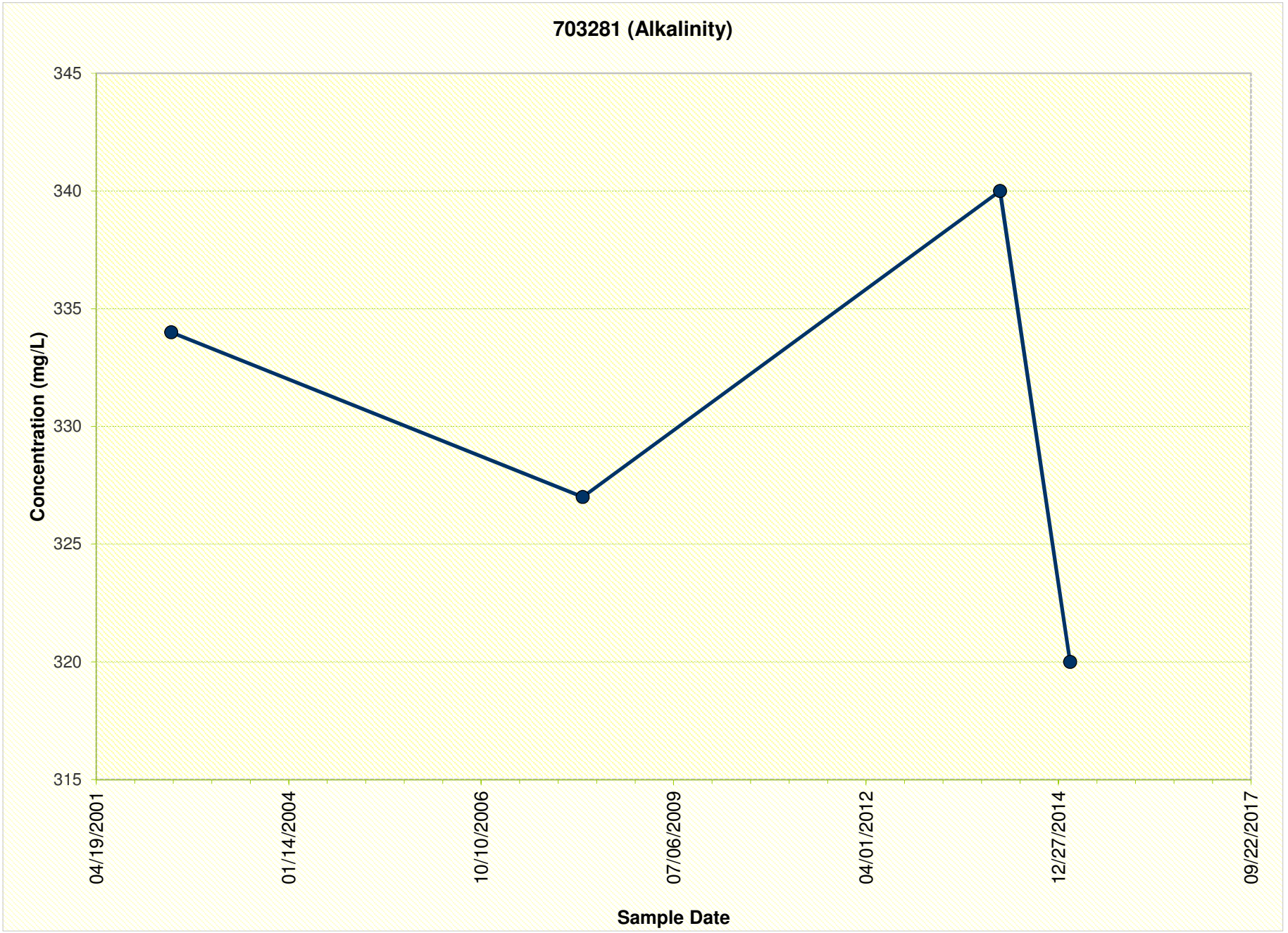

703215 (Na)
600
500
400
300
200
100
0
Concentration (mg/L)
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date

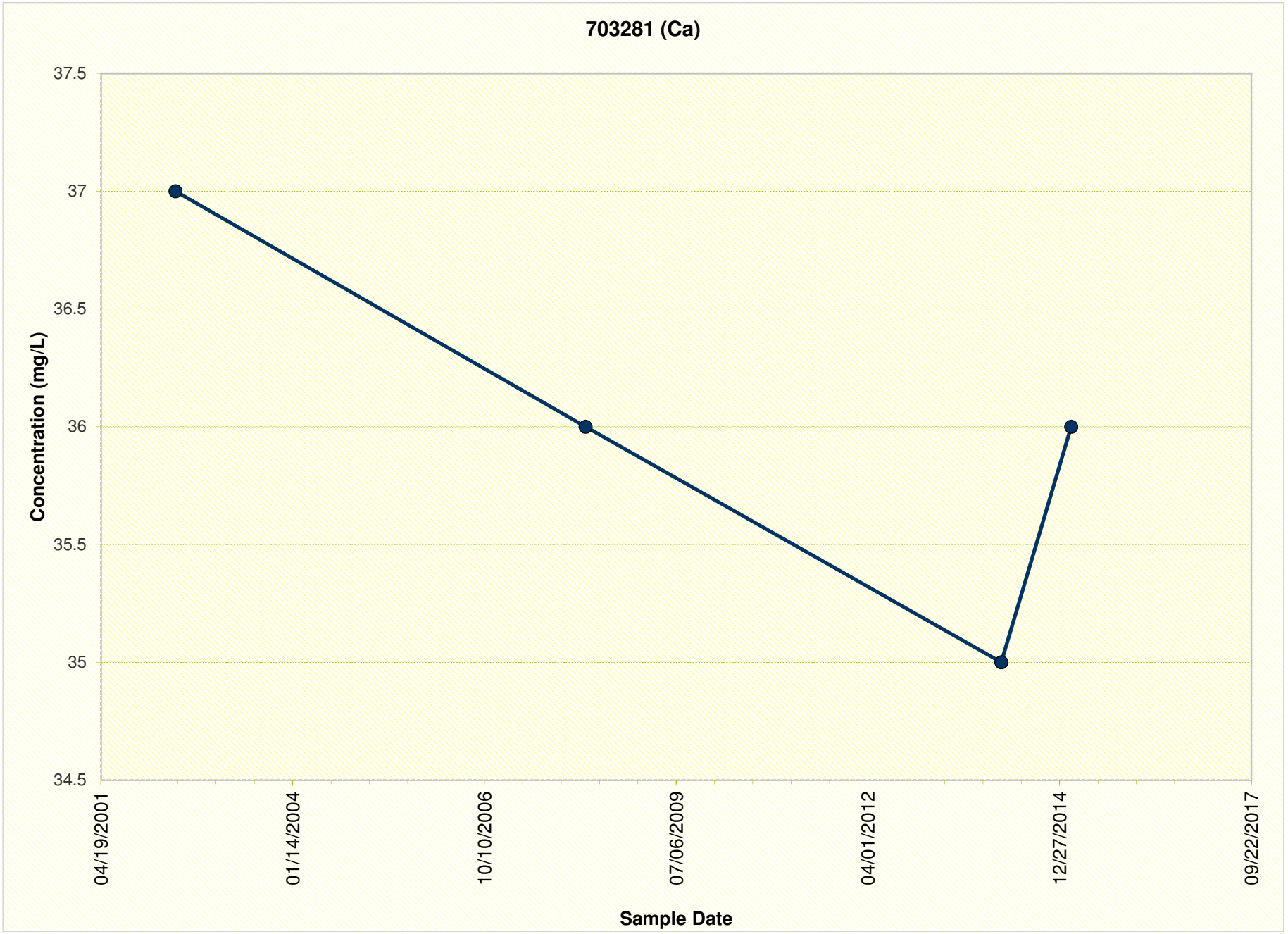

703215 (SO4)
1200
1000
800
600
400
200
0
Concentration (mg/L)
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date

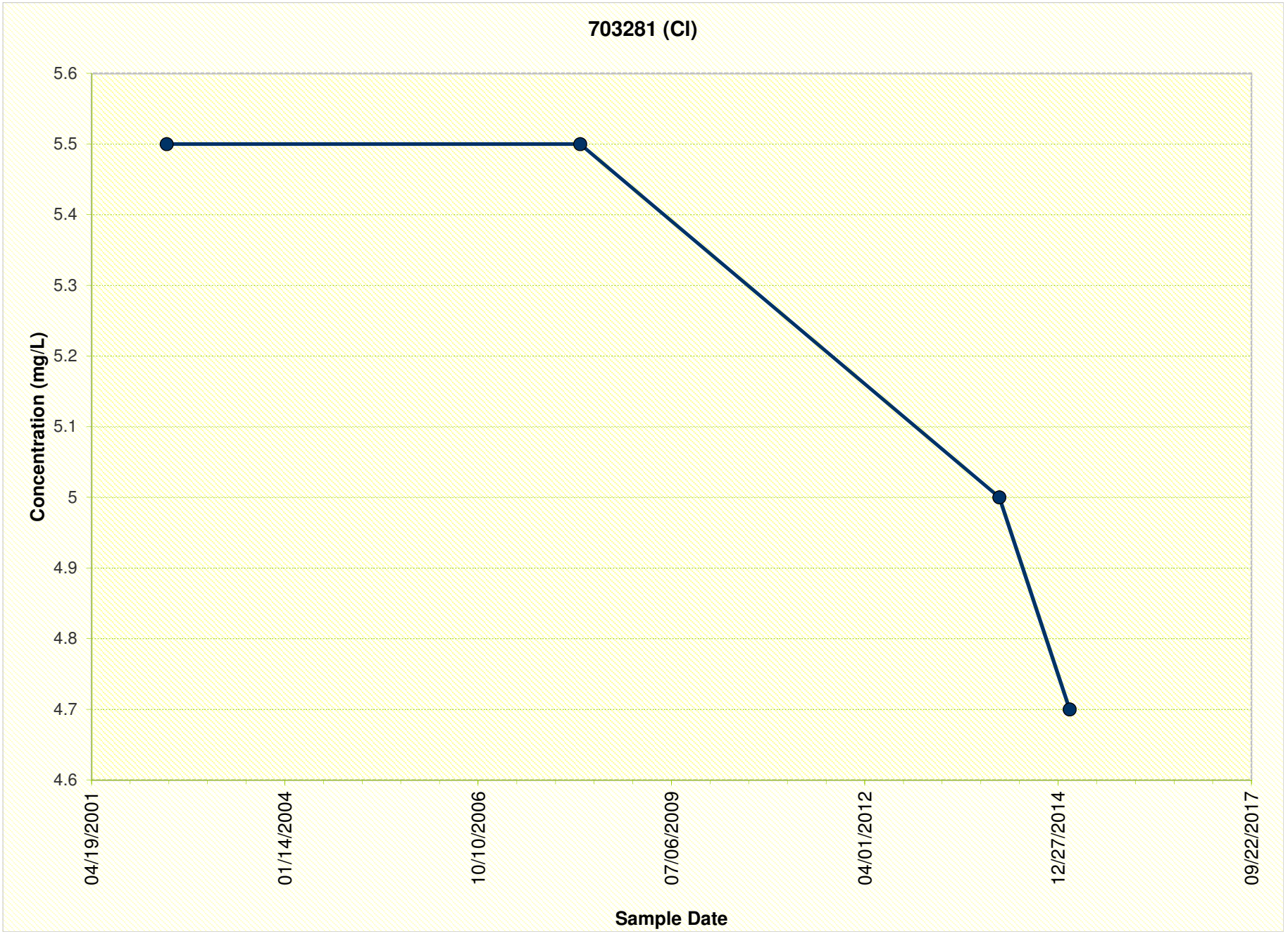

703215 (TDS)
Concentration (mg/L)
2500
2000
1500
1000
500
0
05/15/1996
12/01/1996
06/19/1997
01/05/1998
07/24/1998
02/09/1999
08/28/1999
03/15/2000
10/01/2000
04/19/2001
Sample Date

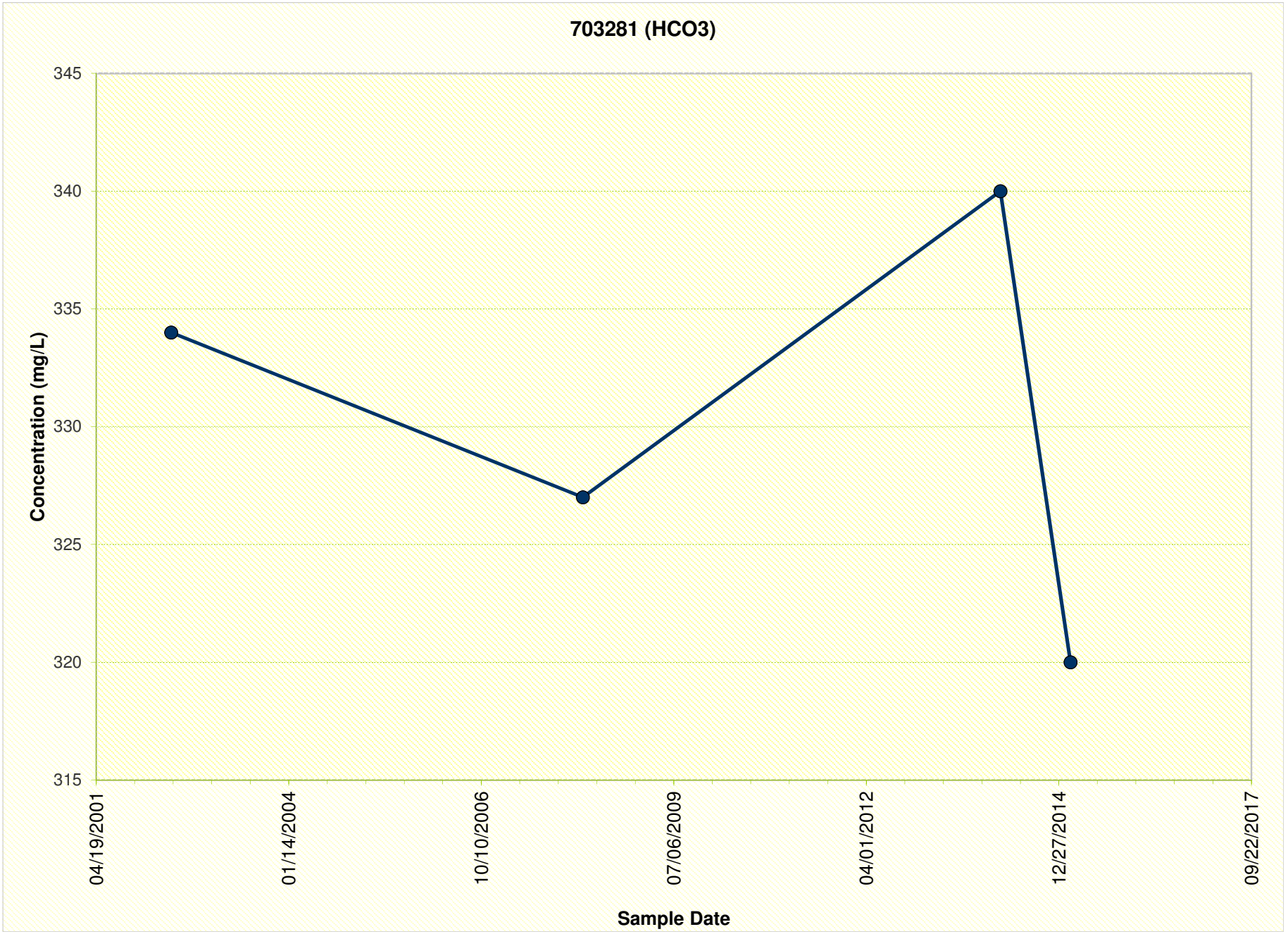

703278 (Methane)
Concentration (mg/L)
0
2
4
6
8
10
12
14
05/24/2002
12/10/2002
06/28/2003
01/14/2004
08/01/2004
02/17/2005
09/05/2005
03/24/2006
10/10/2006
Sample Date

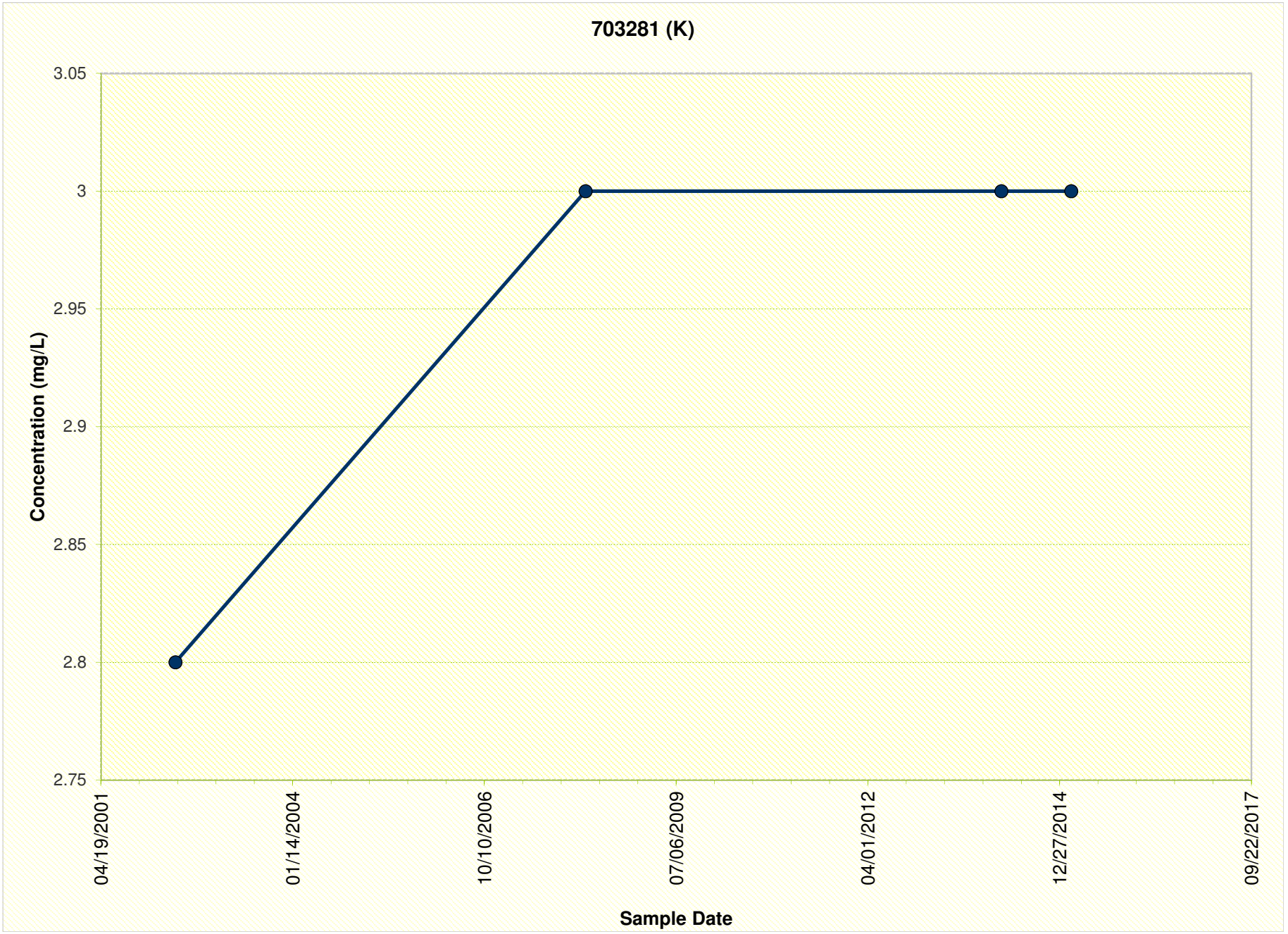

703279 (Methane)
Concentration (mg/L)
25
20
15
10
5
0
03/20/2003
05/09/2003
06/28/2003
08/17/2003
10/06/2003
11/25/2003
01/14/2004
03/04/2004
04/23/2004
06/12/2004
Sample Date

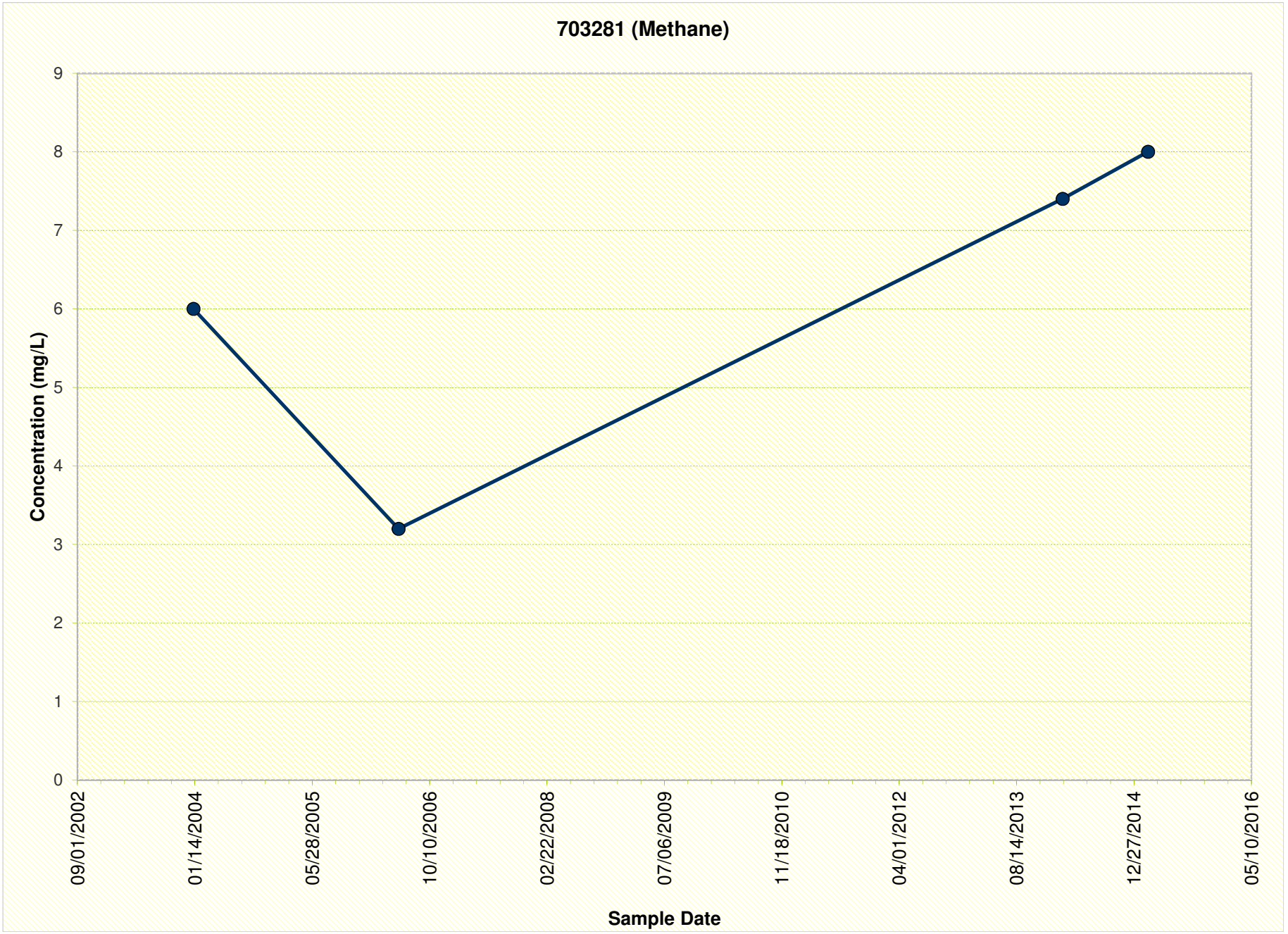

703281 (Alkalinity)
345
340
335
330
325
320
315
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

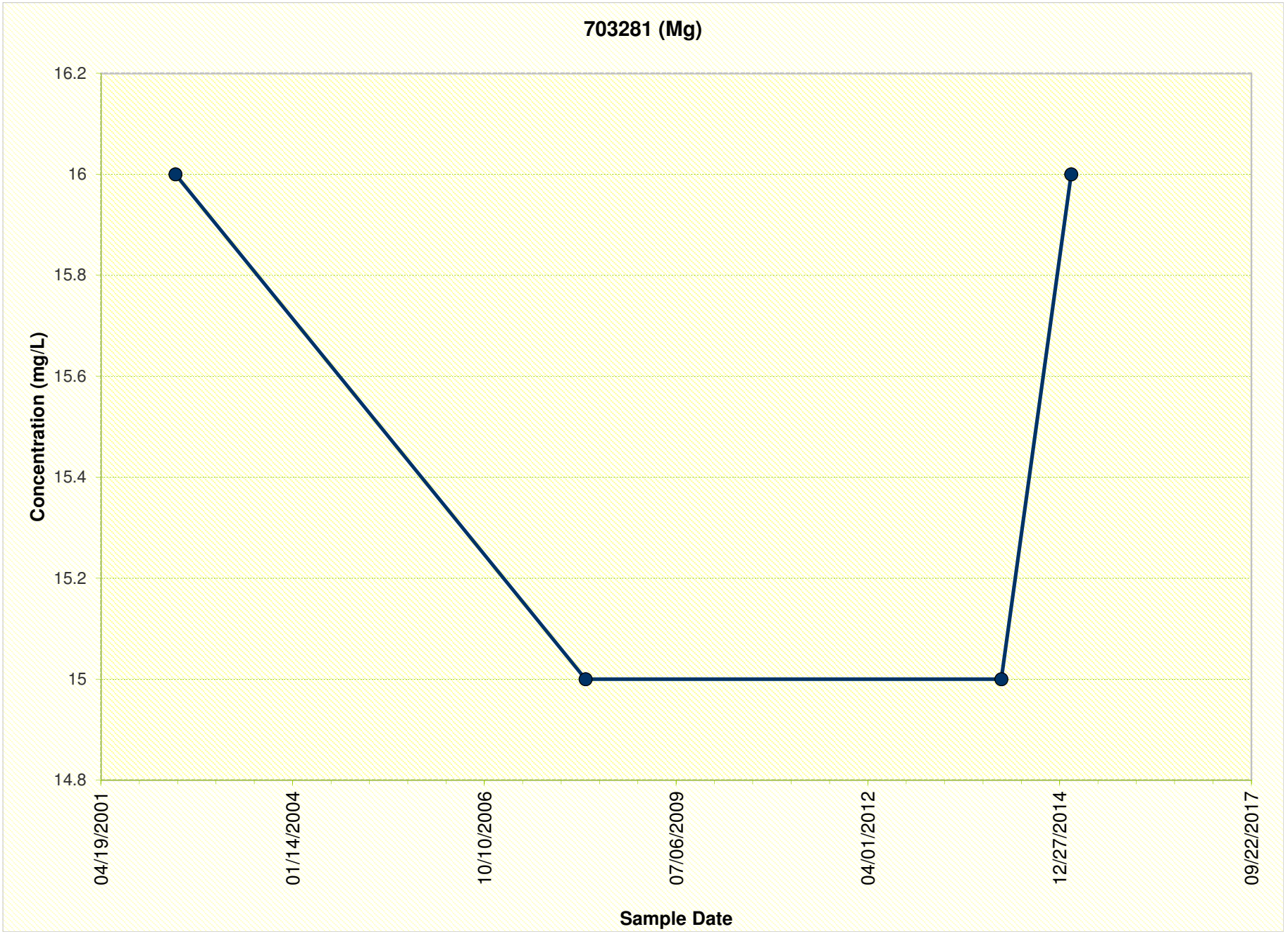

703281 (Ca)
37.5
37
36.5
36
35.5
35
34.5
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

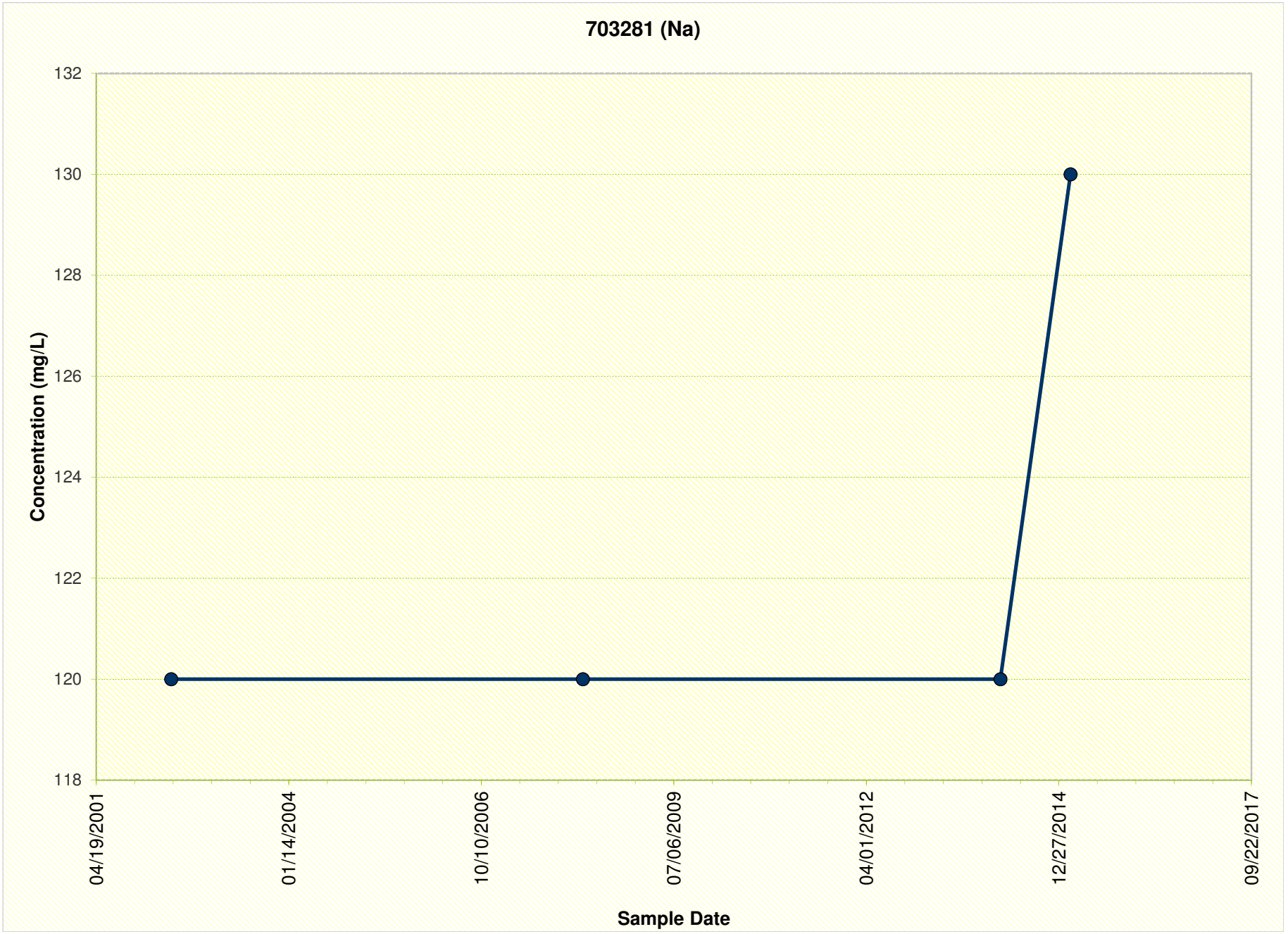

703281 (Cl)
Concentration (mg/L)
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

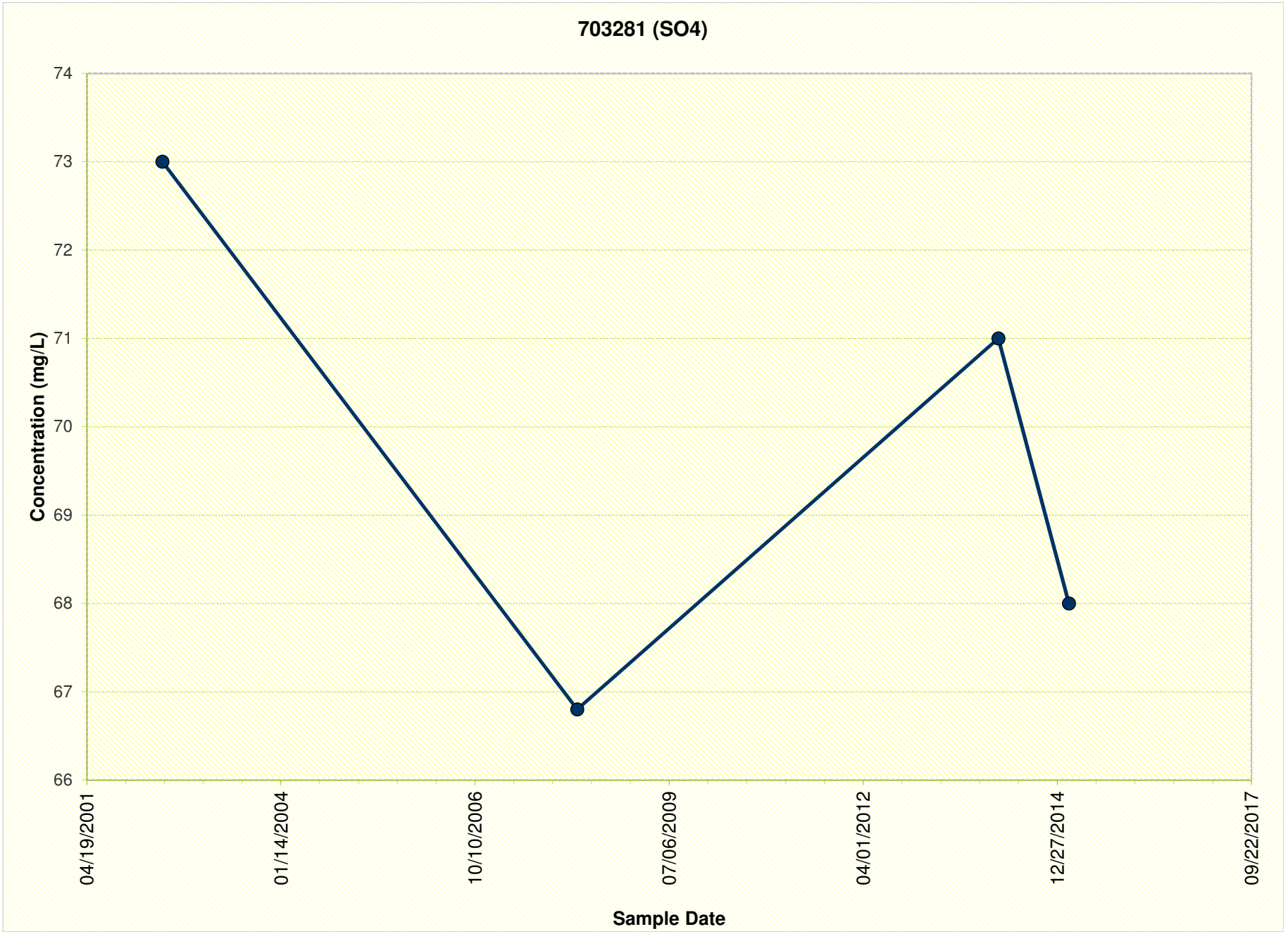

703281 (HCO3)
345
340
335
330
325
320
315
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

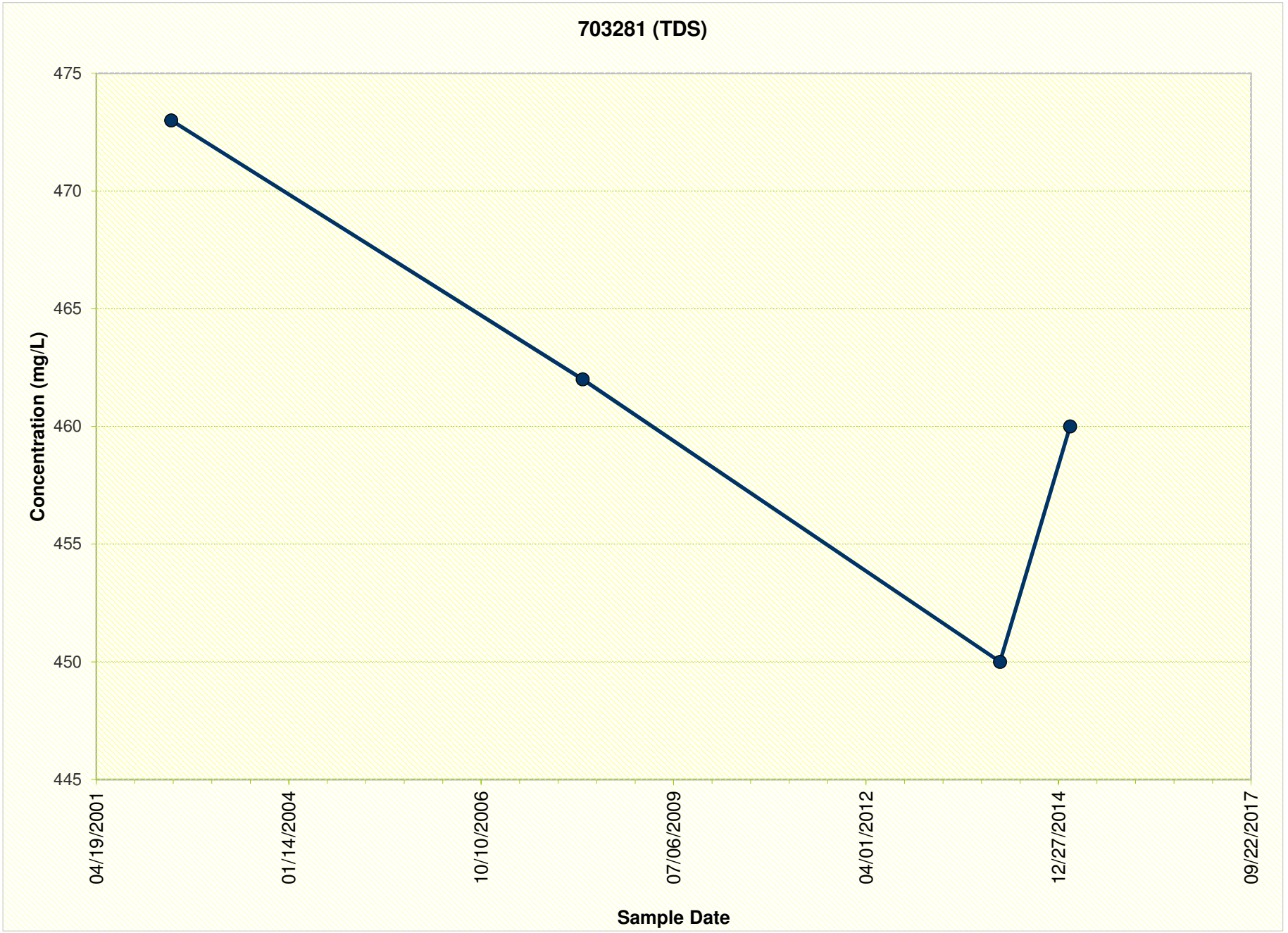

703281 (K)
3.05
3
2.95
2.9
2.85
2.8
2.75
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

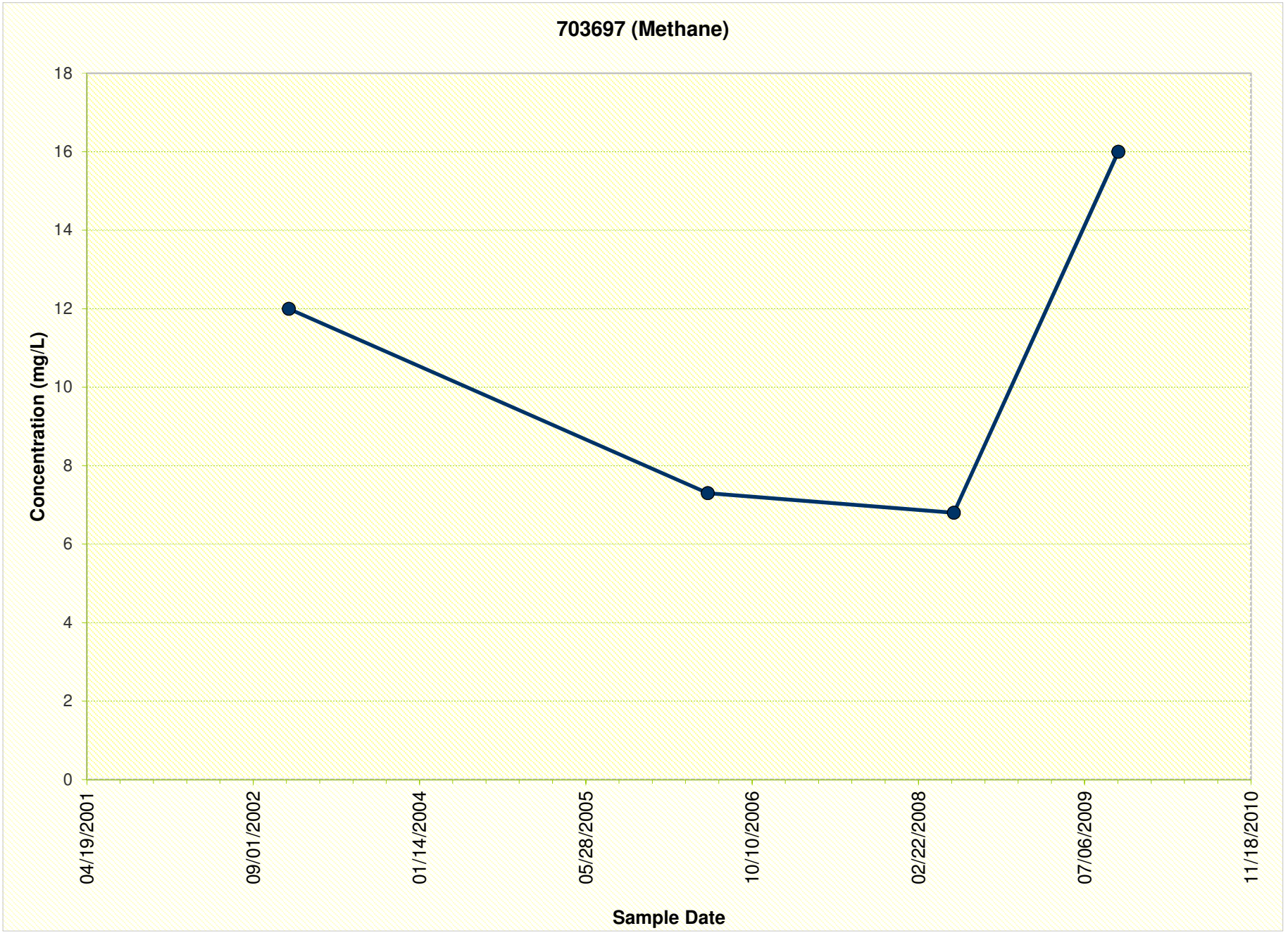

703281 (Methane)
Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
09/01/2002
01/14/2004
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

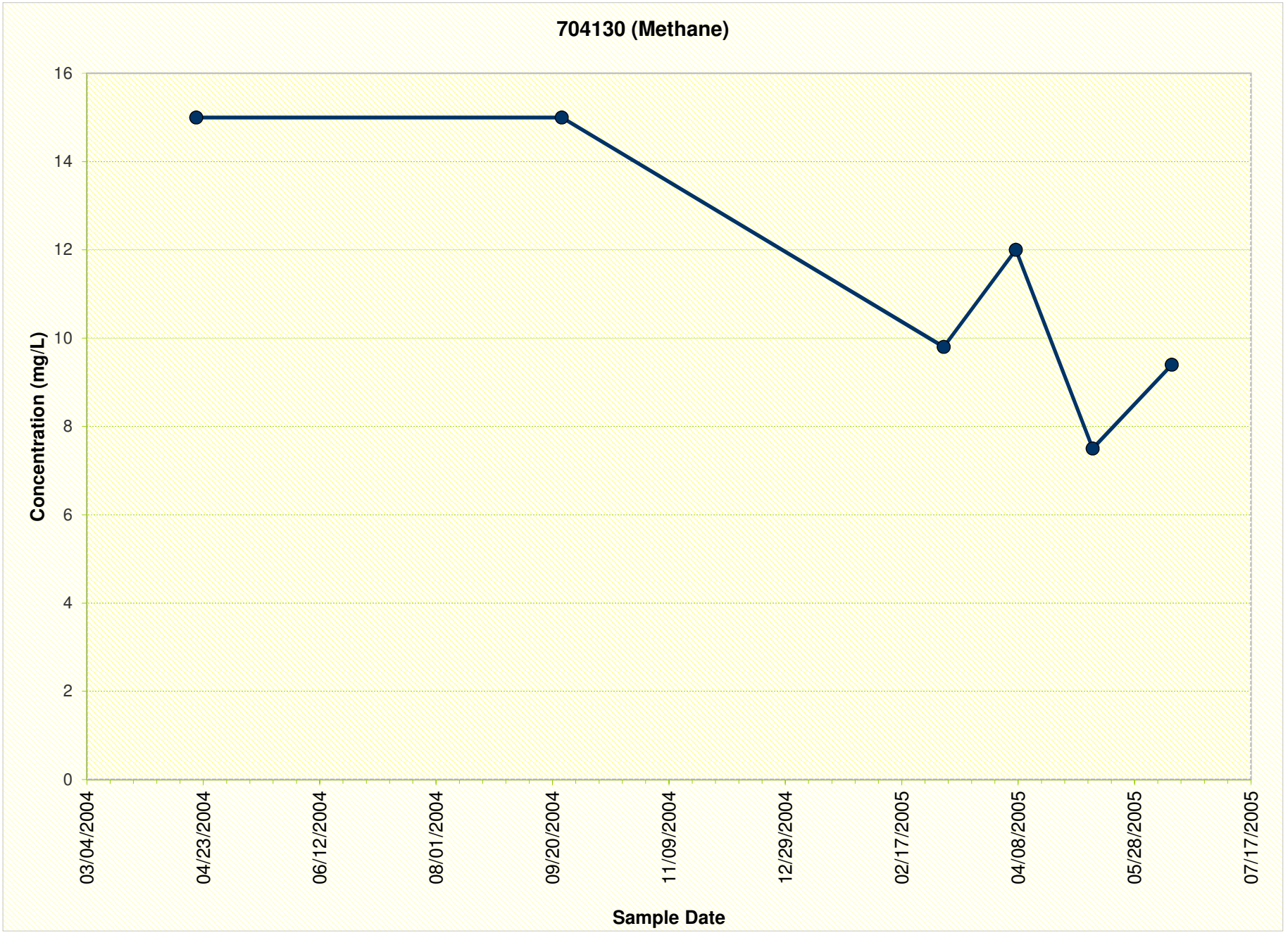

703281 (Mg)
16.2
16
15.8
15.6
15.4
15.2
15
14.8
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

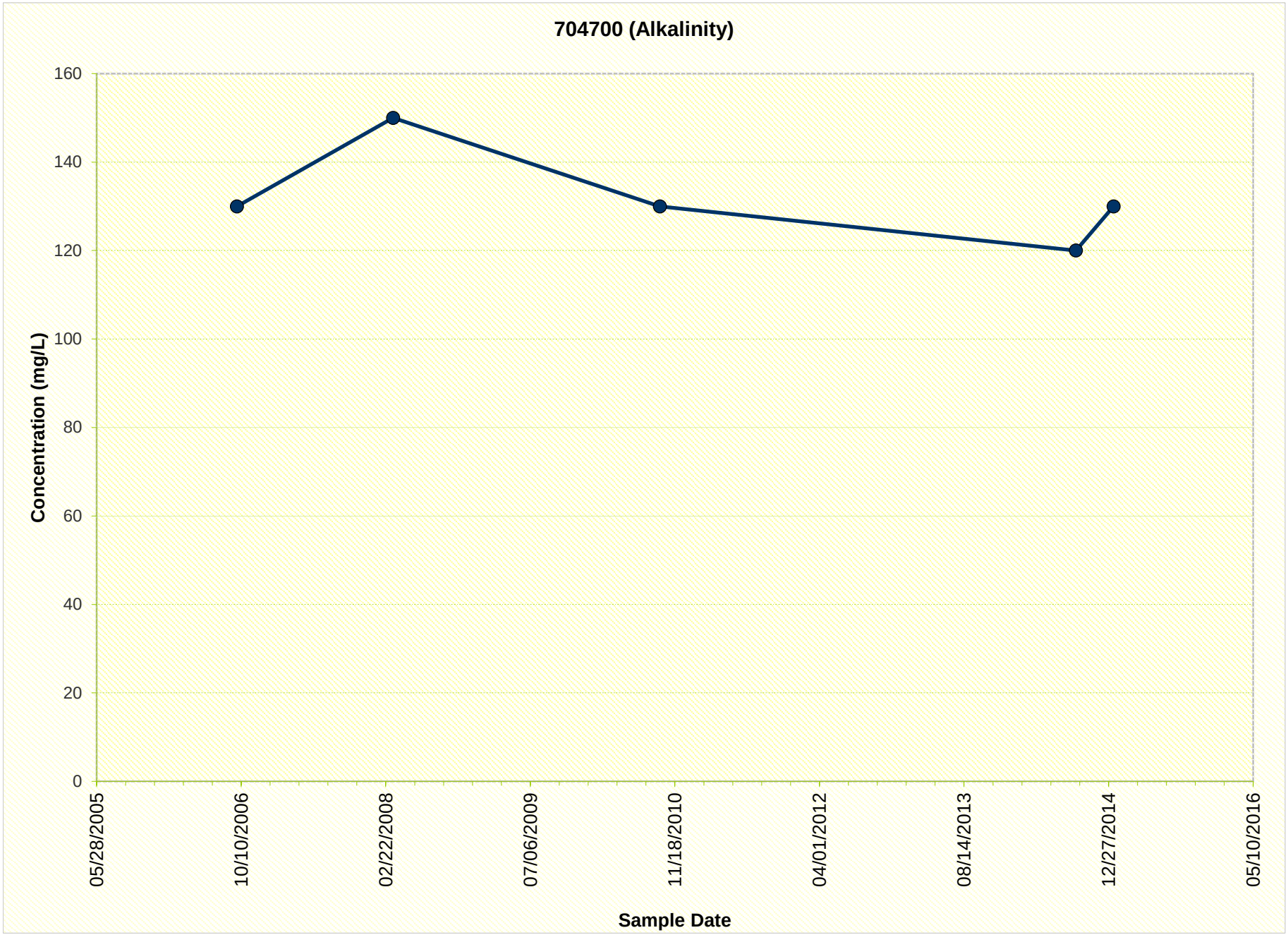

703281 (Na)
132
130
128
126
124
122
120
118
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

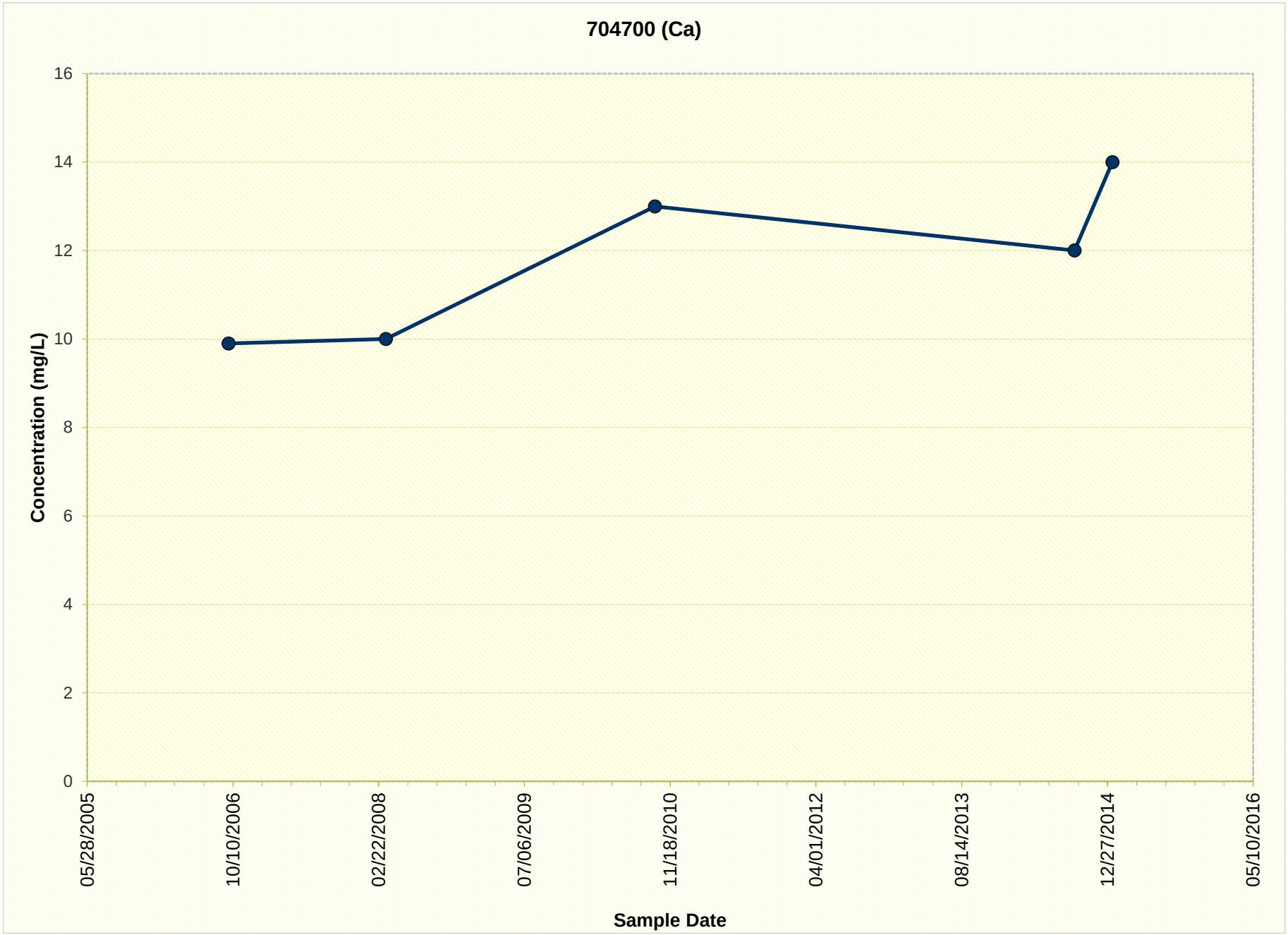

703281 (SO4)
74
73
72
71
70
69
68
67
66
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

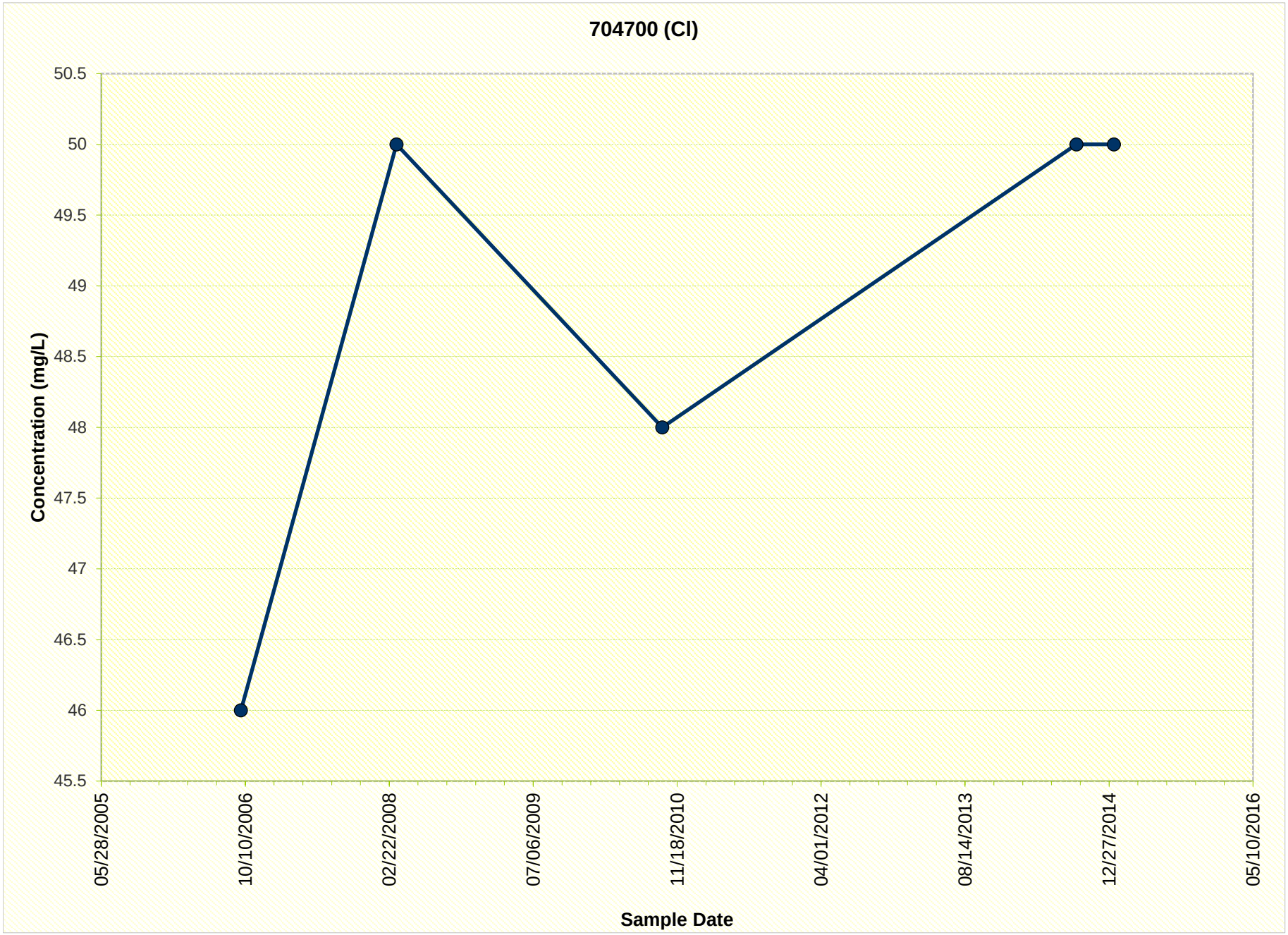

703281 (TDS)
475
470
465
460
455
450
445
Concentration (mg/L)
04/19/2001
01/14/2004
10/10/2006
07/06/2009
04/01/2012
12/27/2014
09/22/2017
Sample Date

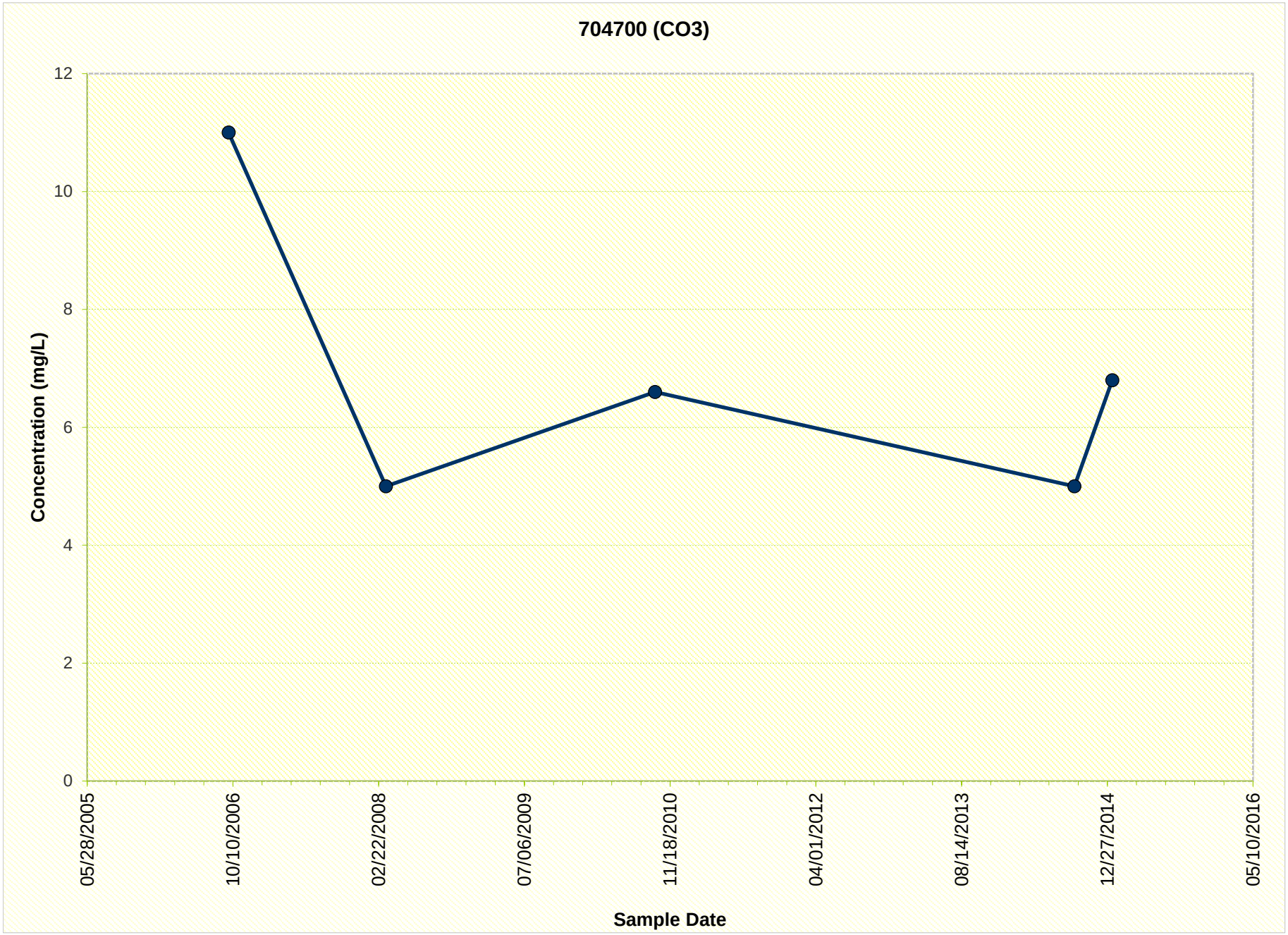

703697 (Methane)
Concentration (mg/L)
18
16
14
12
10
8
6
4
2
0
04/19/2001
09/01/2002
01/14/2004
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
Sample Date

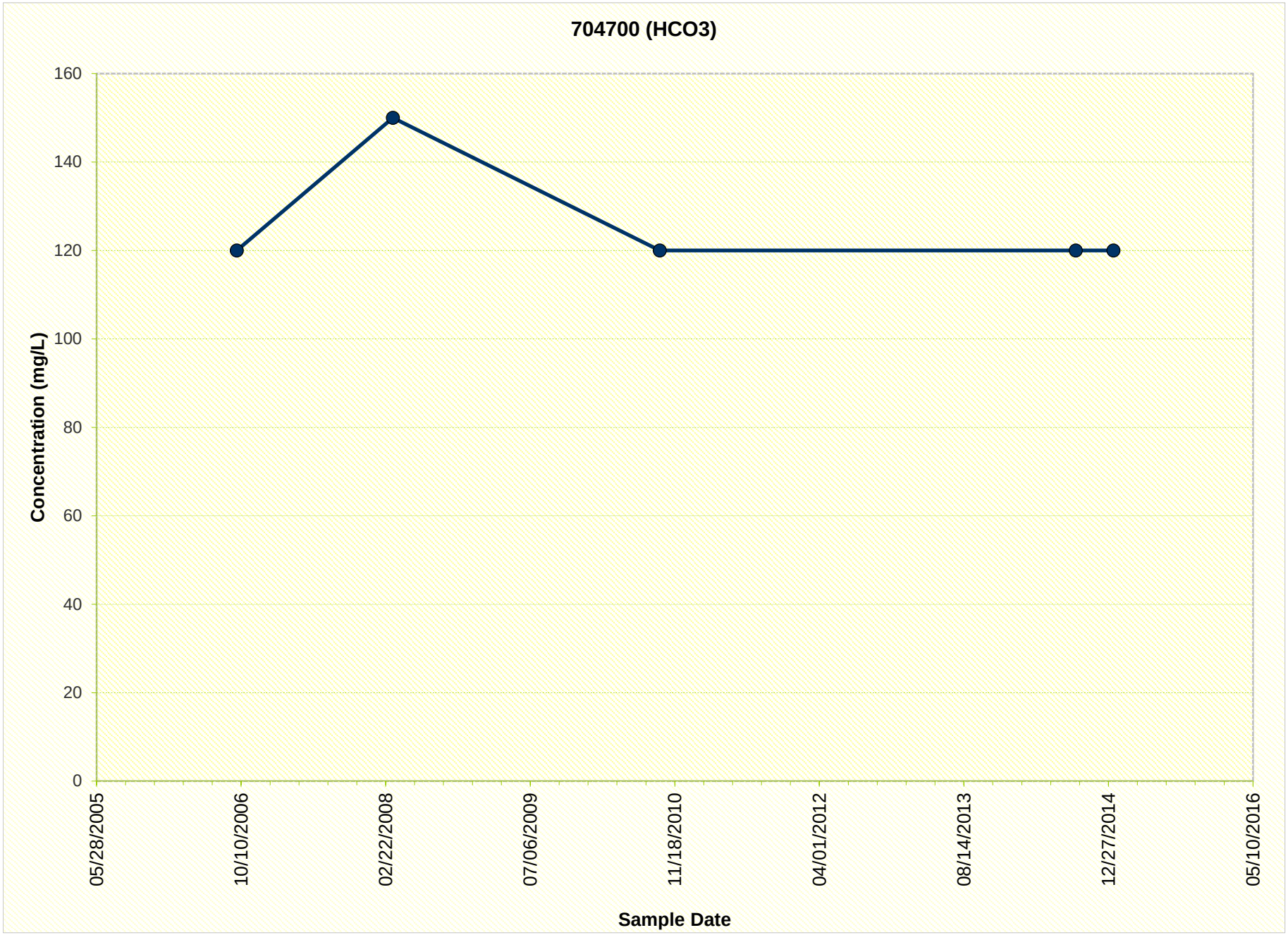

704130 (Methane)
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
03/04/2004
04/23/2004
06/12/2004
08/01/2004
09/20/2004
11/09/2004
12/29/2004
02/17/2005
04/08/2005
05/28/2005
07/17/2005
Sample Date

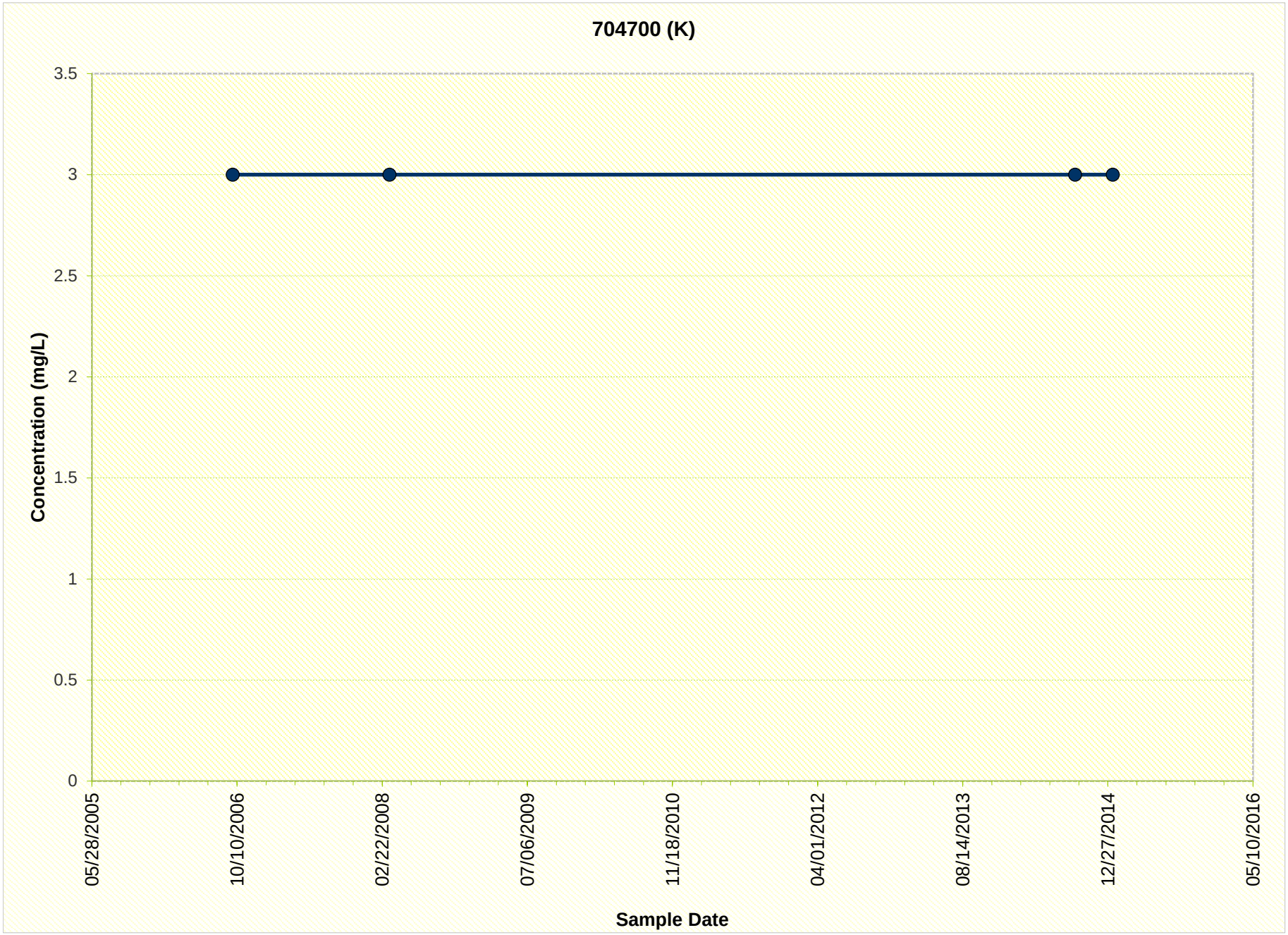

704700 (Alkalinity)
160
140
120
100
80
60
40
20
0
Concentration (mg/L)
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

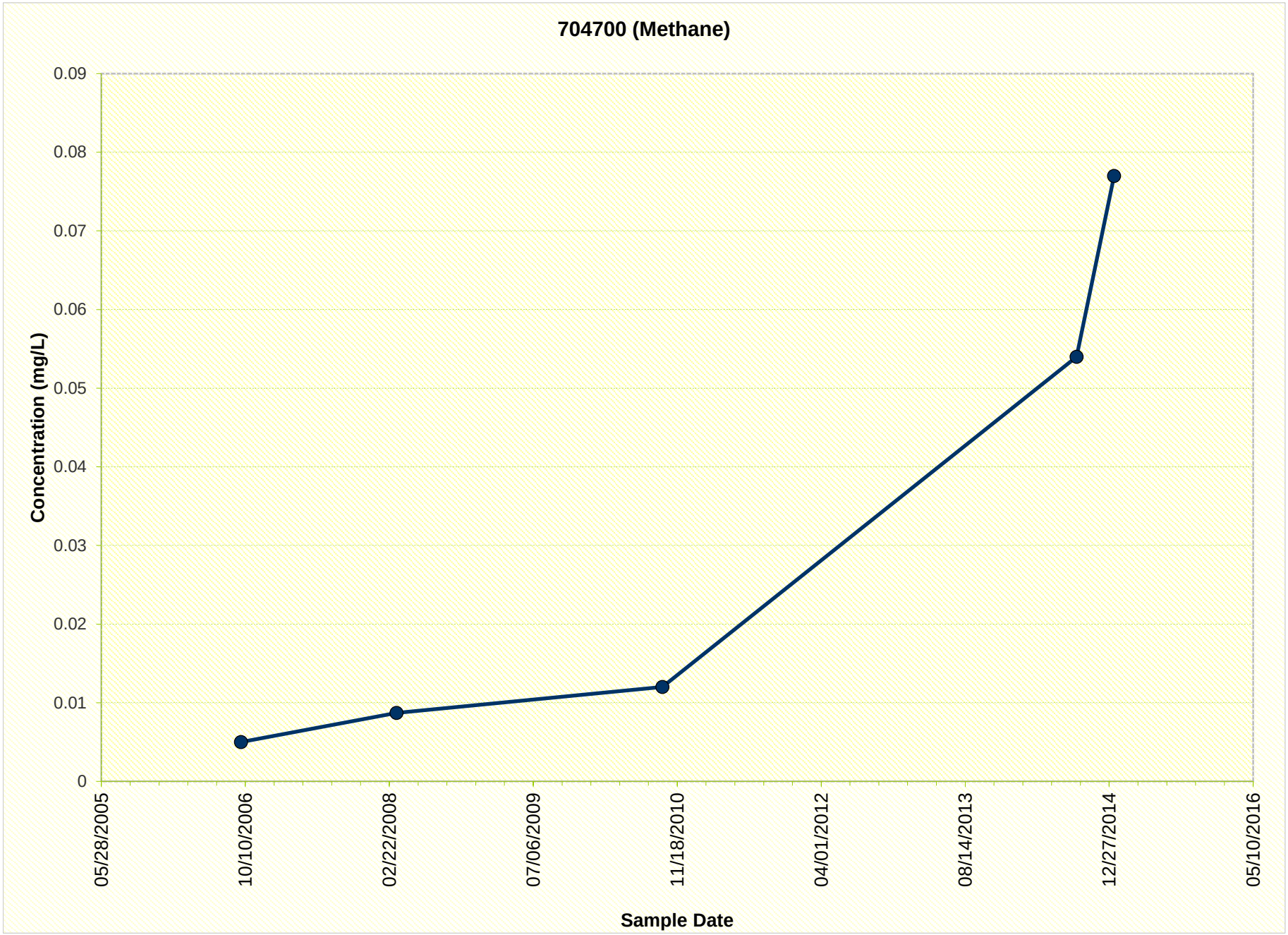

704700 (Ca)
Concentration (mg/L)
16
14
12
10
8
6
4
2
0
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

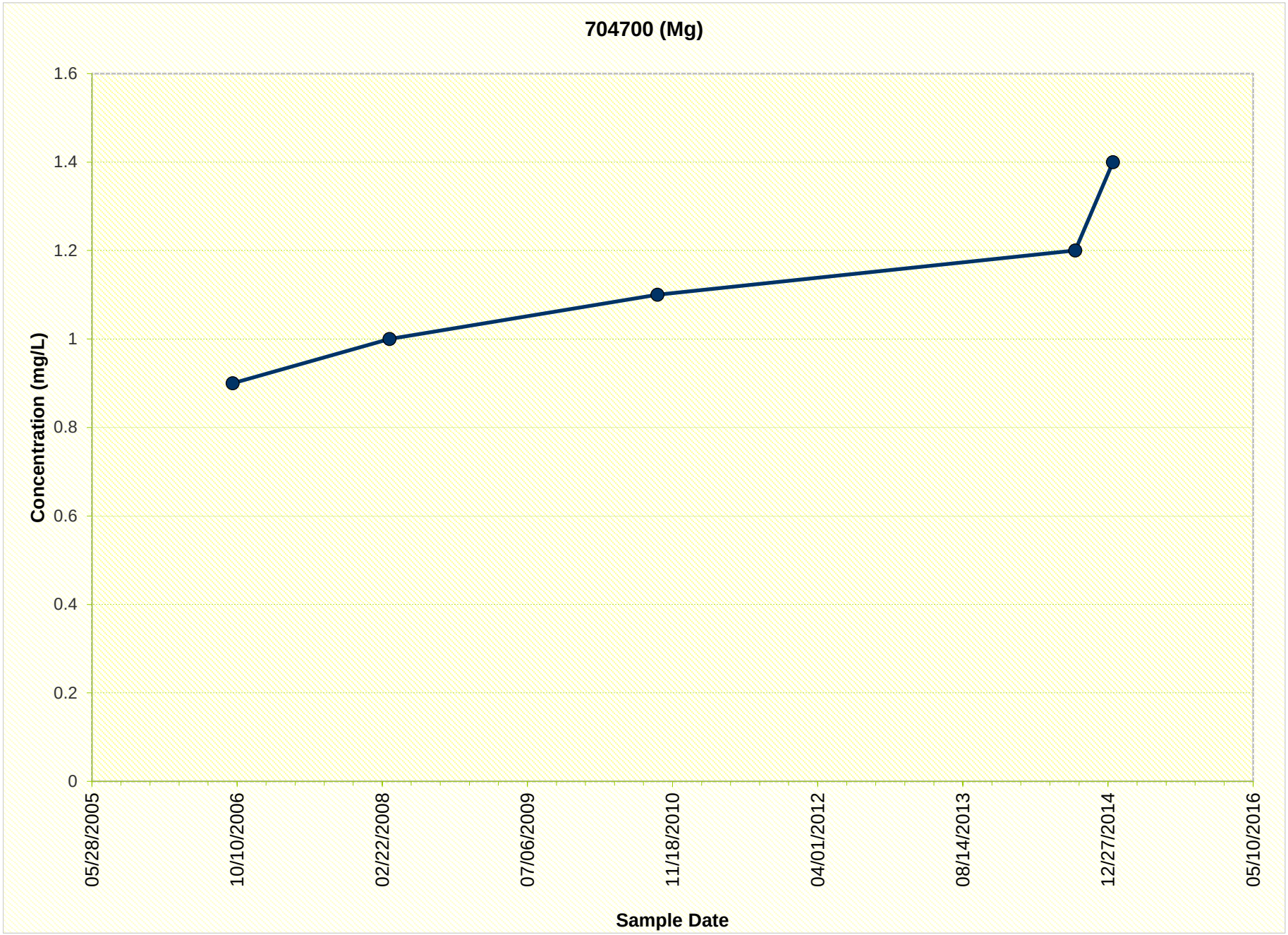

704700 (Cl)
Concentration (mg/L)
50.5
50
49.5
49
48.5
48
47.5
47
46.5
46
45.5
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

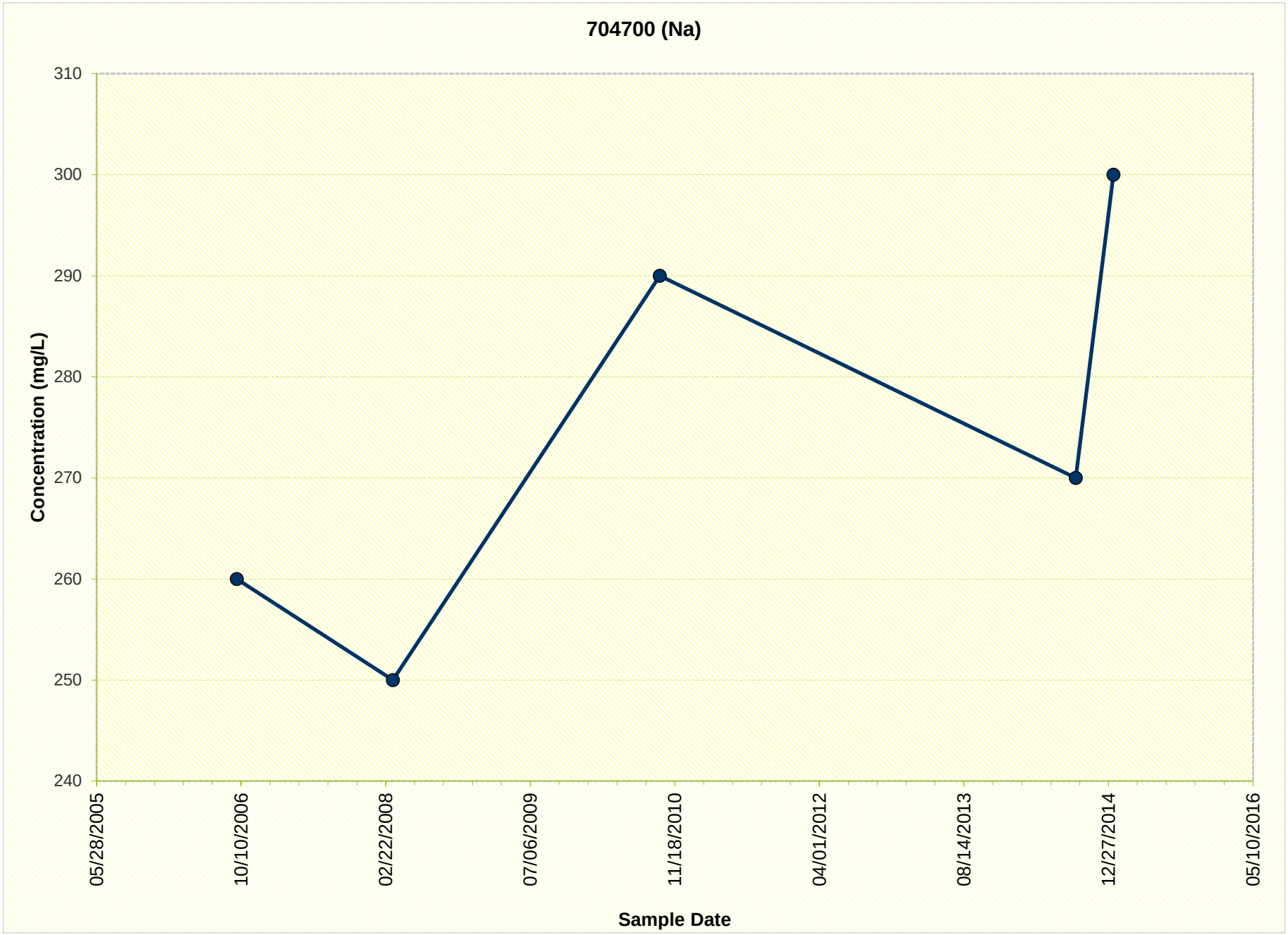

704700 (CO3)
Concentration (mg/L)
12
10
8
6
4
2
0
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

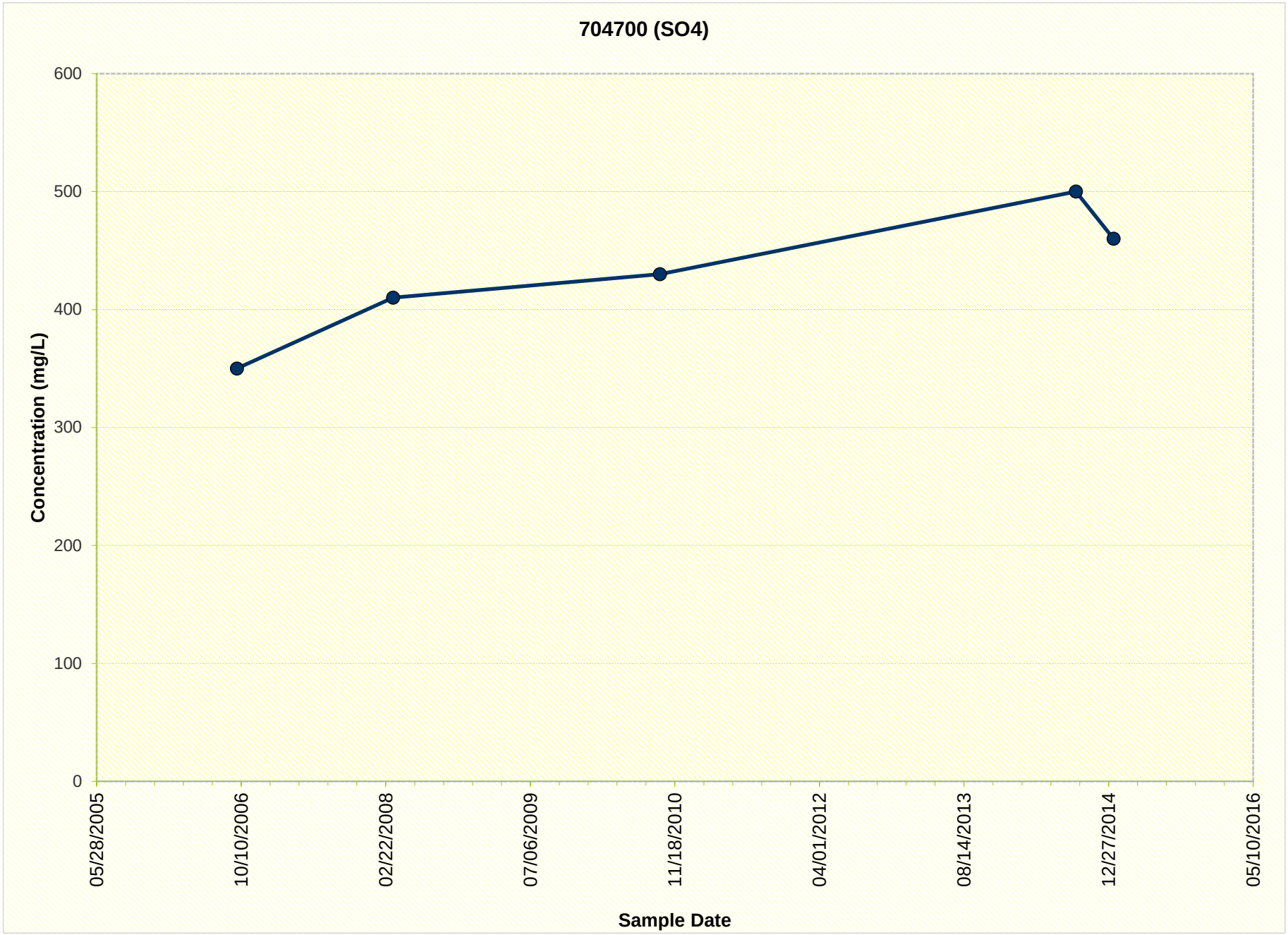

704700 (HCO3)
160
140
120
100
80
60
40
20
0
Concentration (mg/L)
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

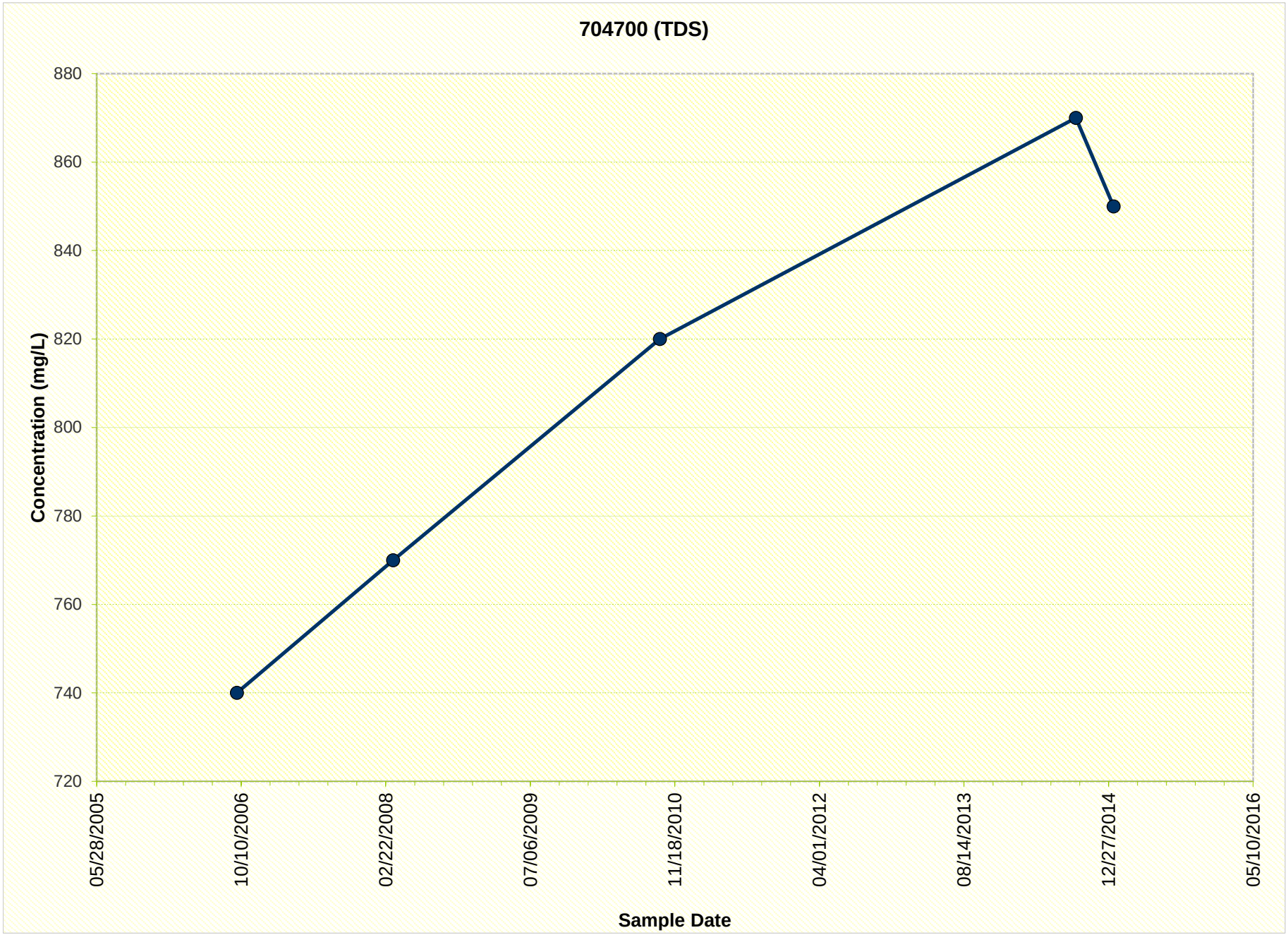

704700 (K)
Concentration (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

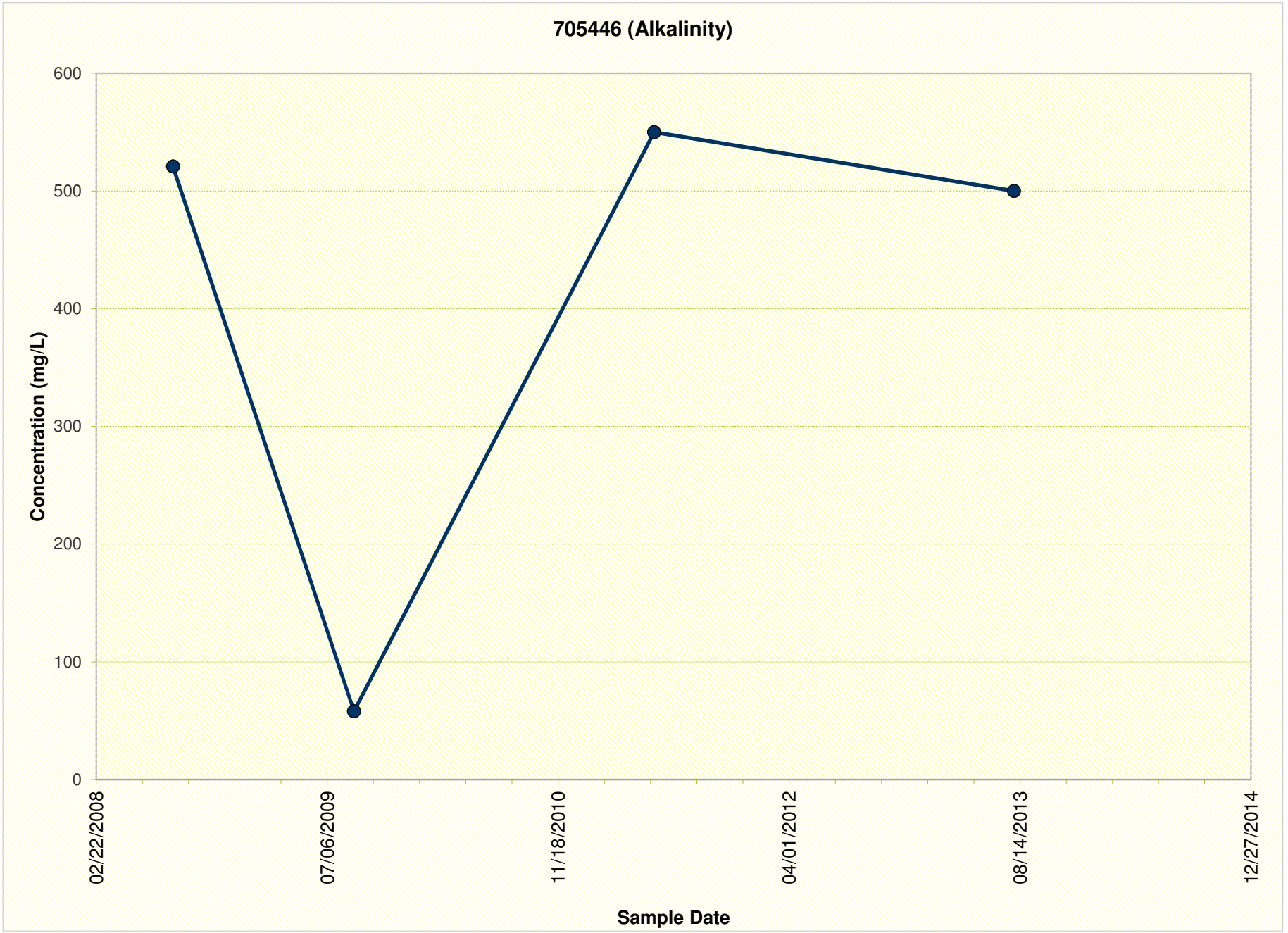

704700 (Methane)
Concentration (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

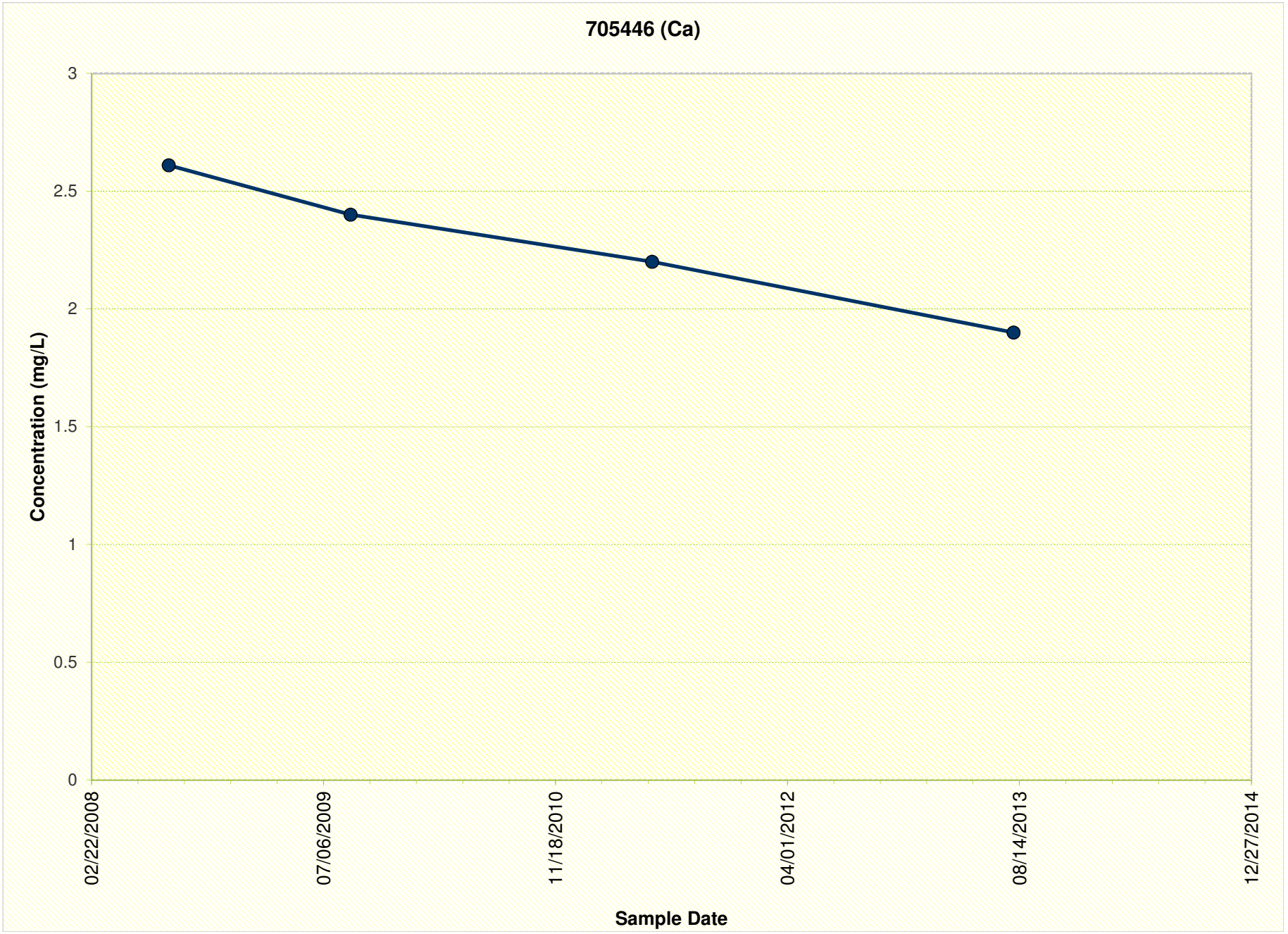

704700 (Mg)
Concentration (mg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

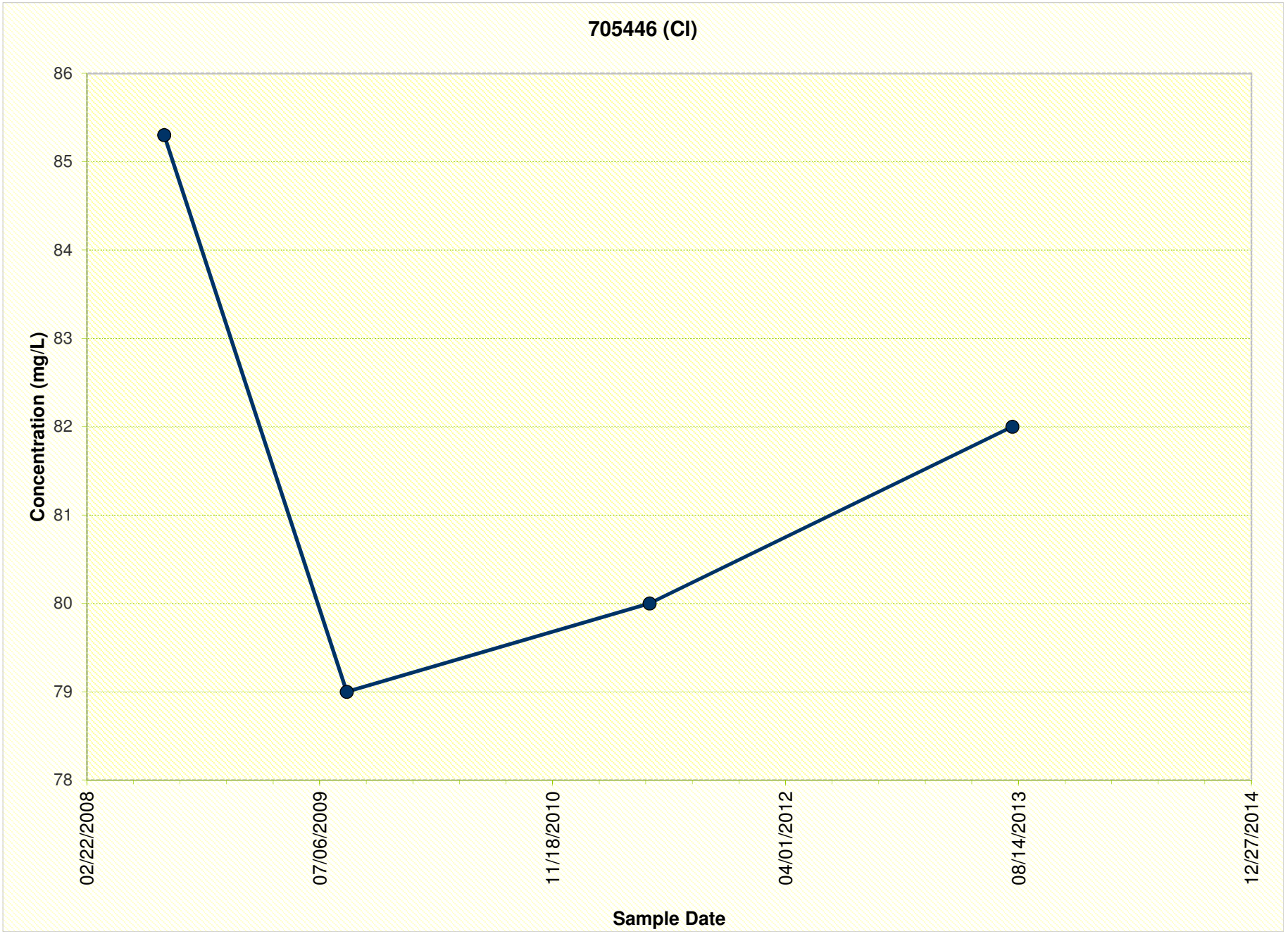

704700 (Na)
Concentration (mg/L)
310
300
290
280
270
260
250
240
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

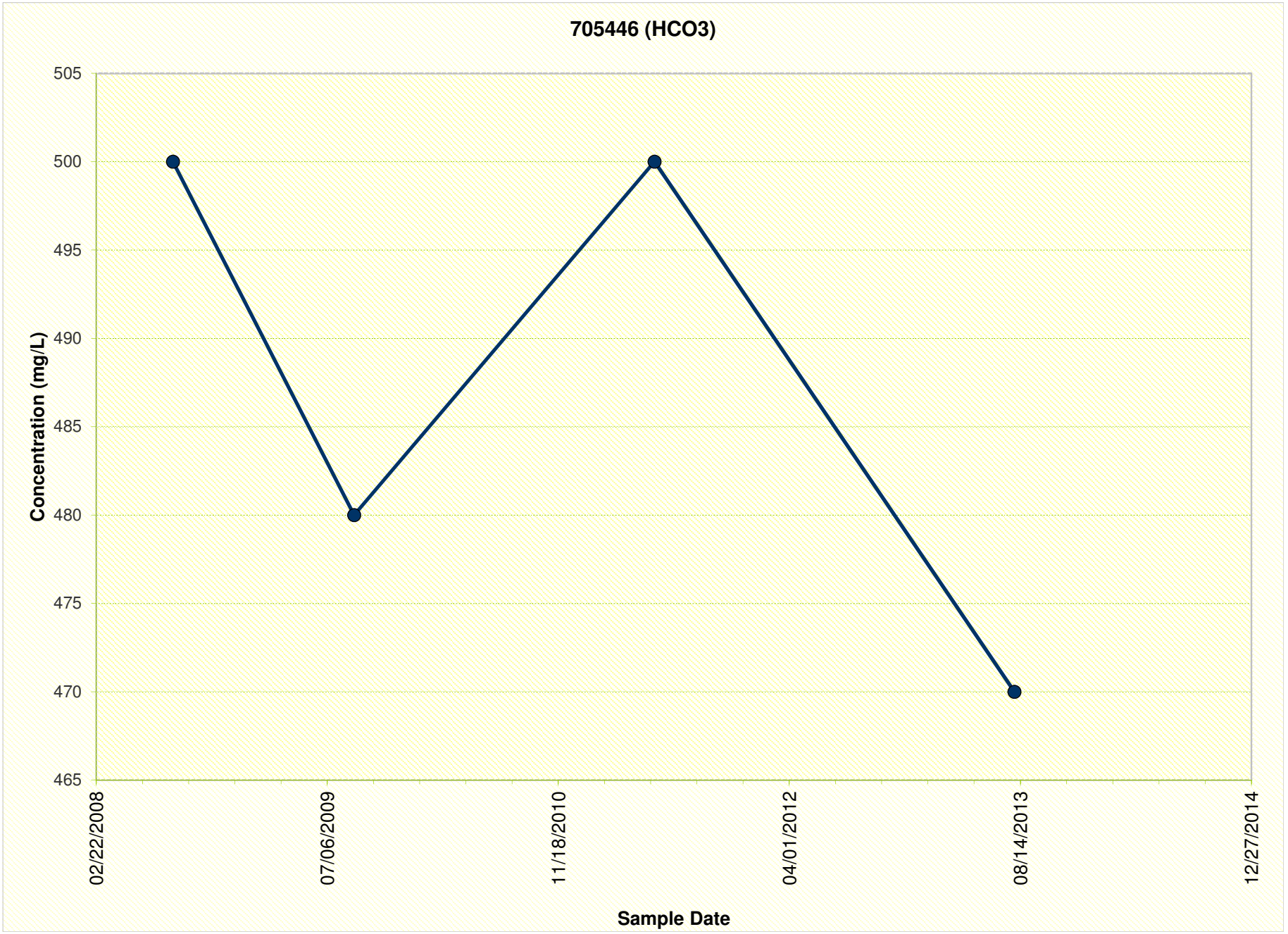

704700 (SO4)
600
500
400
300
200
100
0
Concentration (mg/L)
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

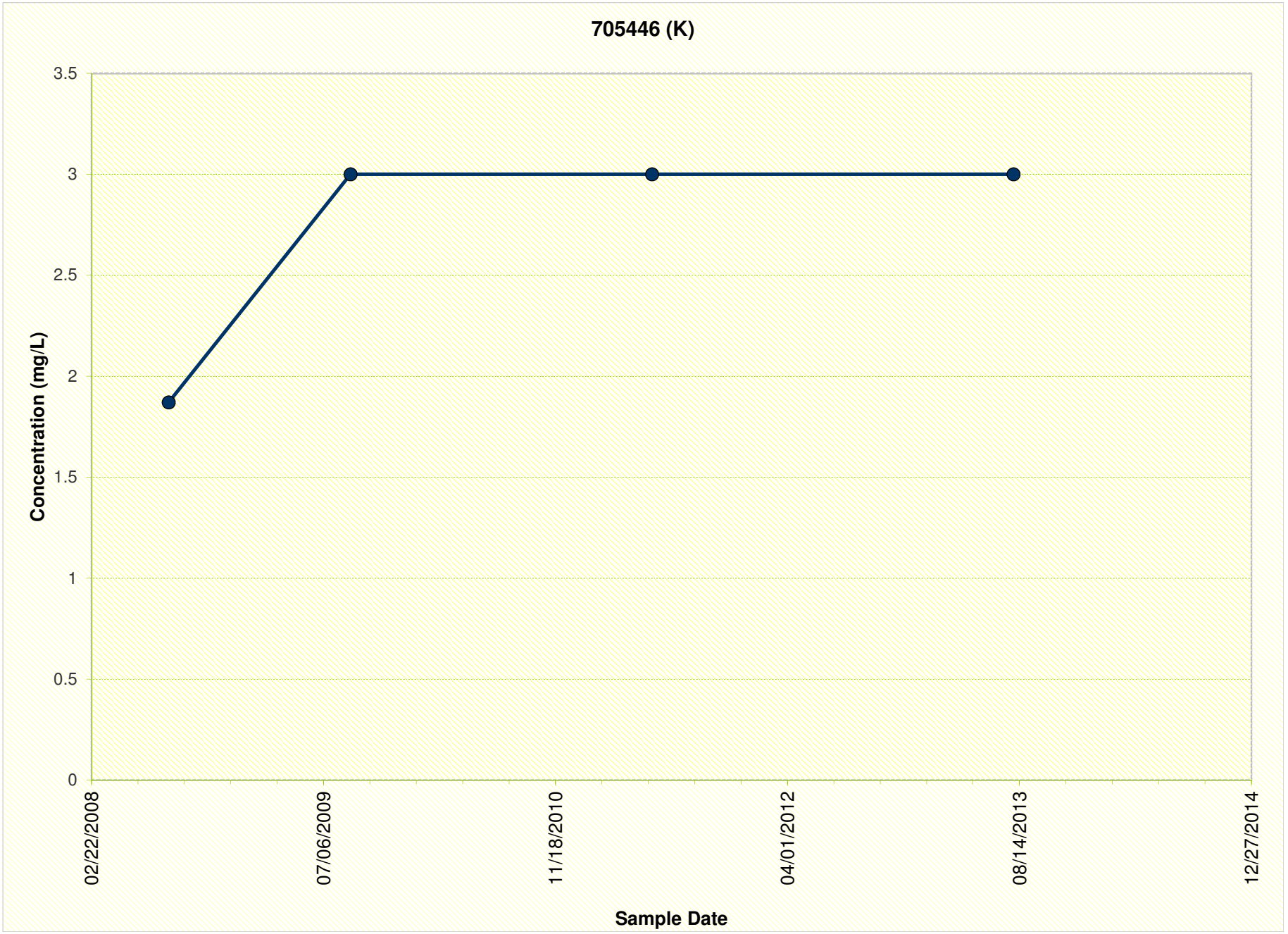

704700 (TDS)
880
860
840
820
800
780
760
740
720
Concentration (mg/L)
05/28/2005
10/10/2006
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

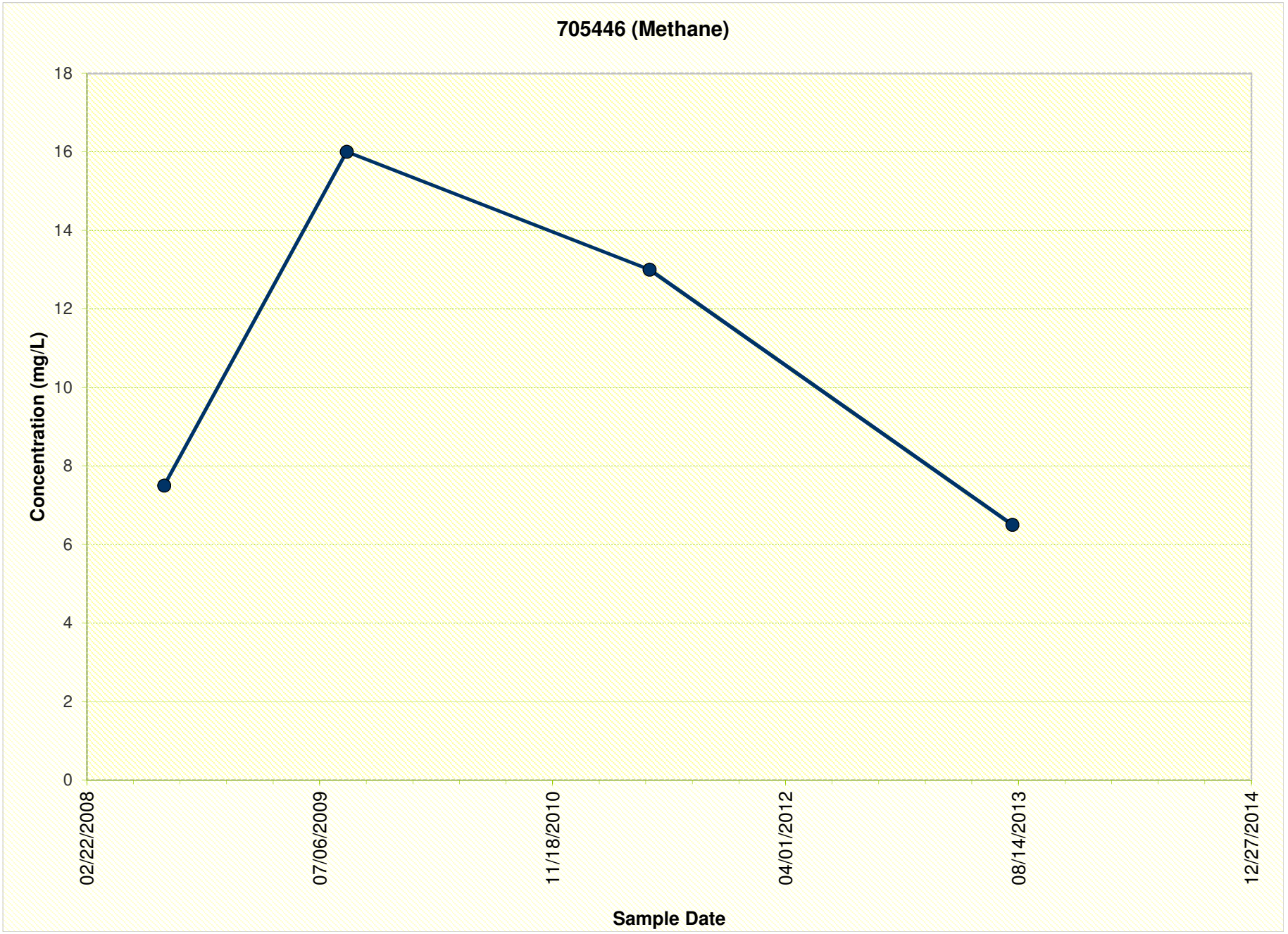

705446 (Alkalinity)
600
500
400
300
200
100
0
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

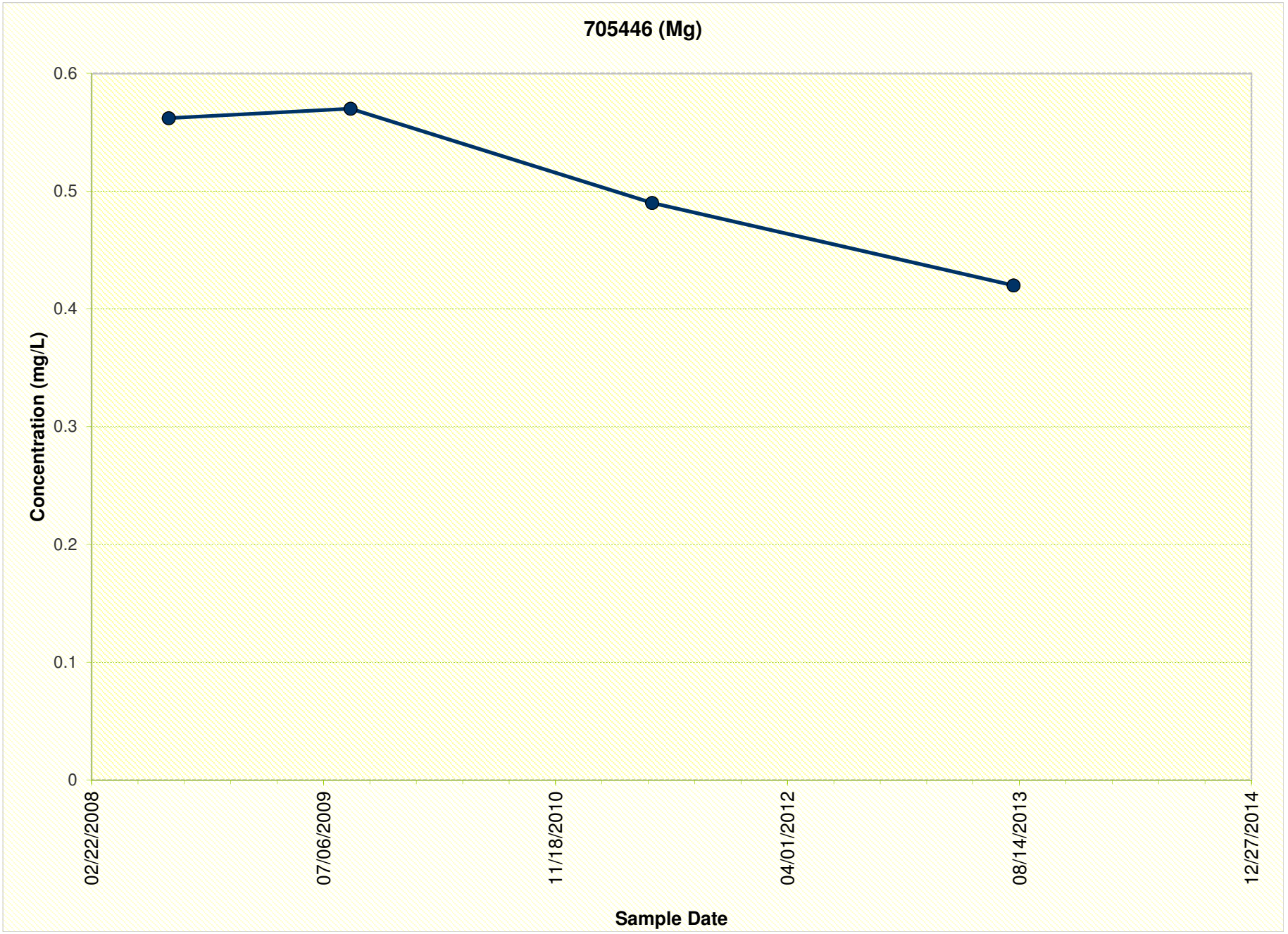

705446 (Ca)
Concentration (mg/L)
3
2.5
2
1.5
1
0.5
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

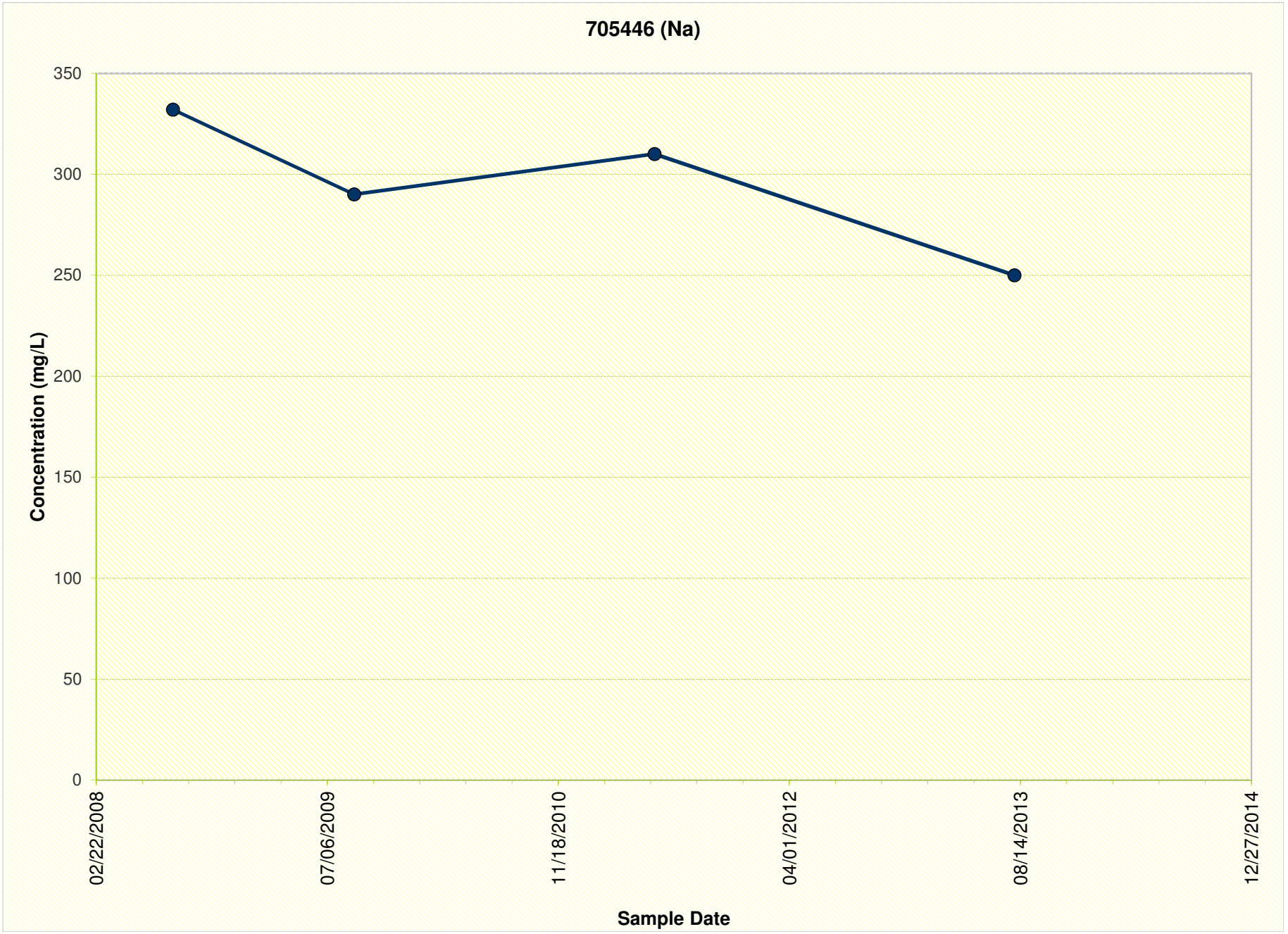

705446 (Cl)
86
85
84
83
82
81
80
79
78
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

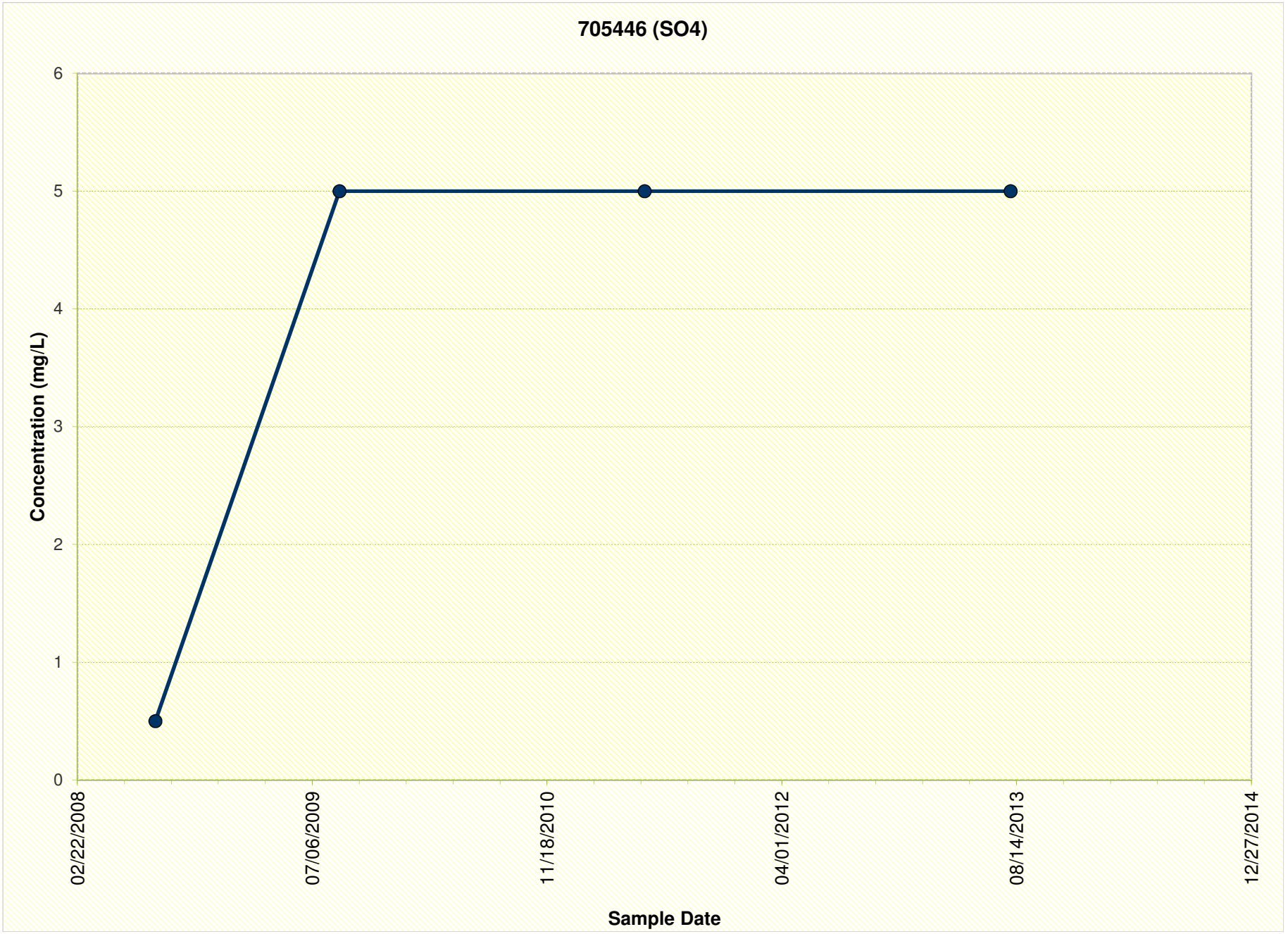

705446 (HCO3)
505
500
495
490
485
480
475
470
465
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

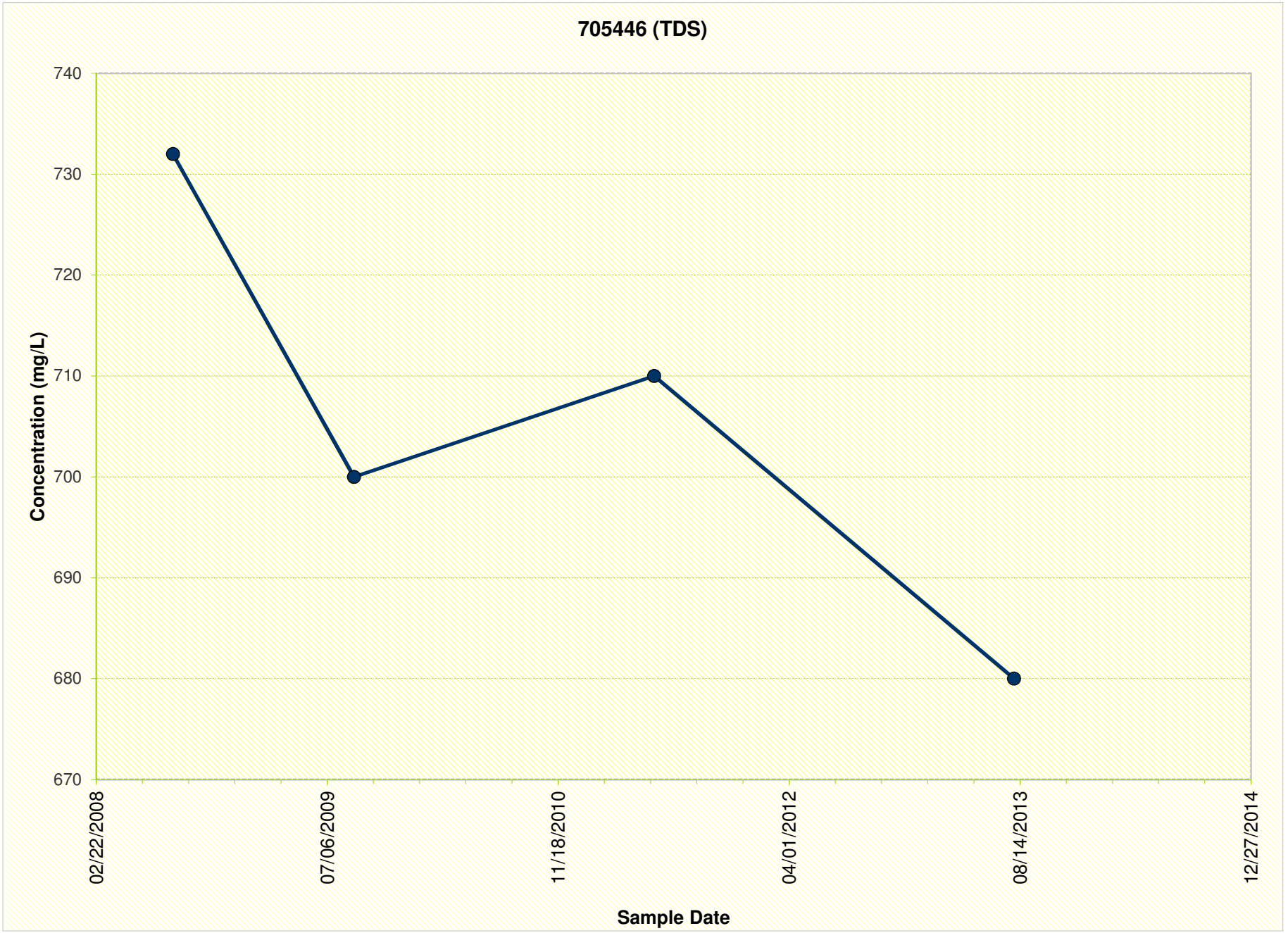

705446 (K)
3.5
3
2.5
2
1.5
1
0.5
0
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

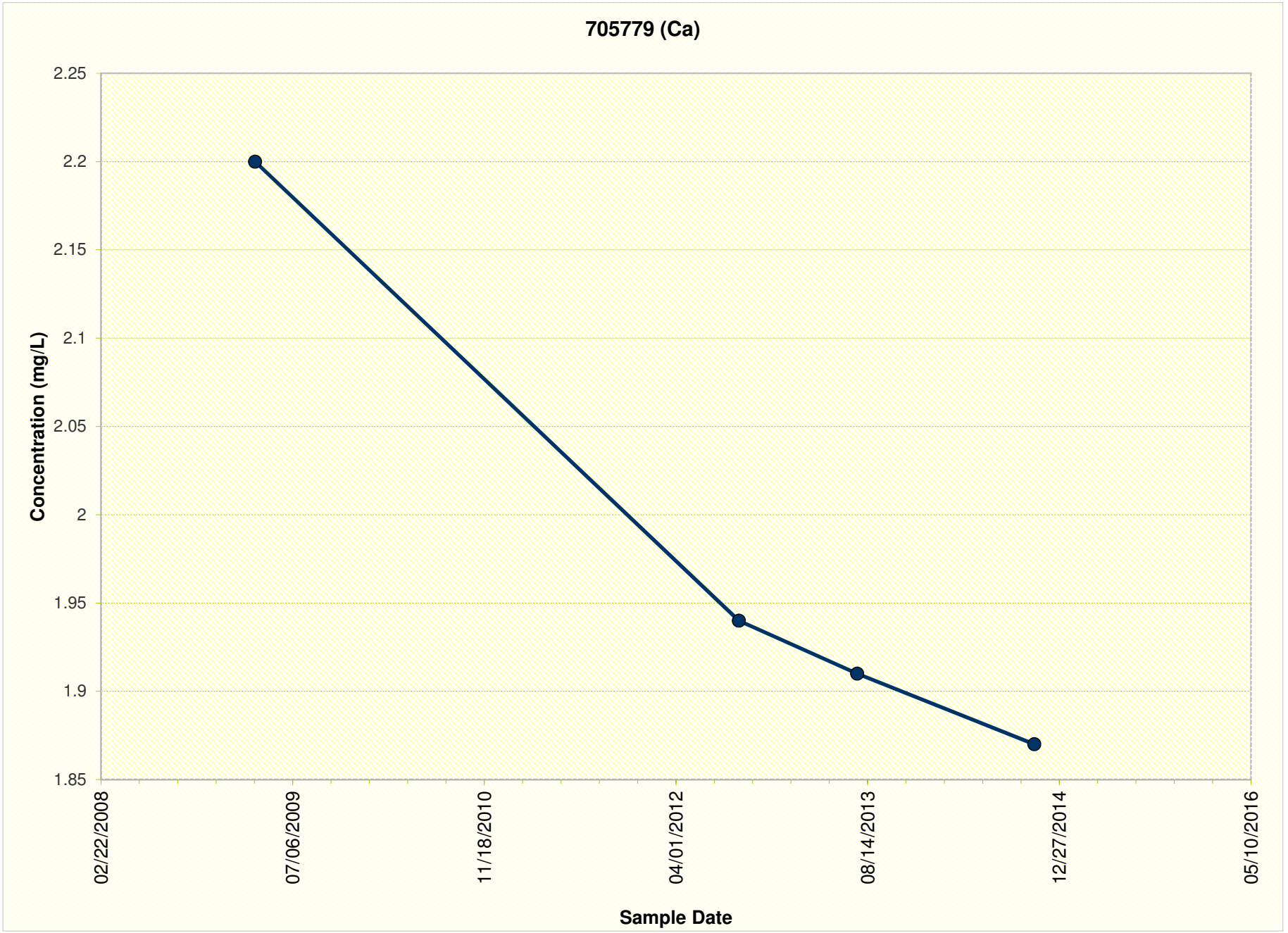

705446 (Methane)
Concentration (mg/L)
18
16
14
12
10
8
6
4
2
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

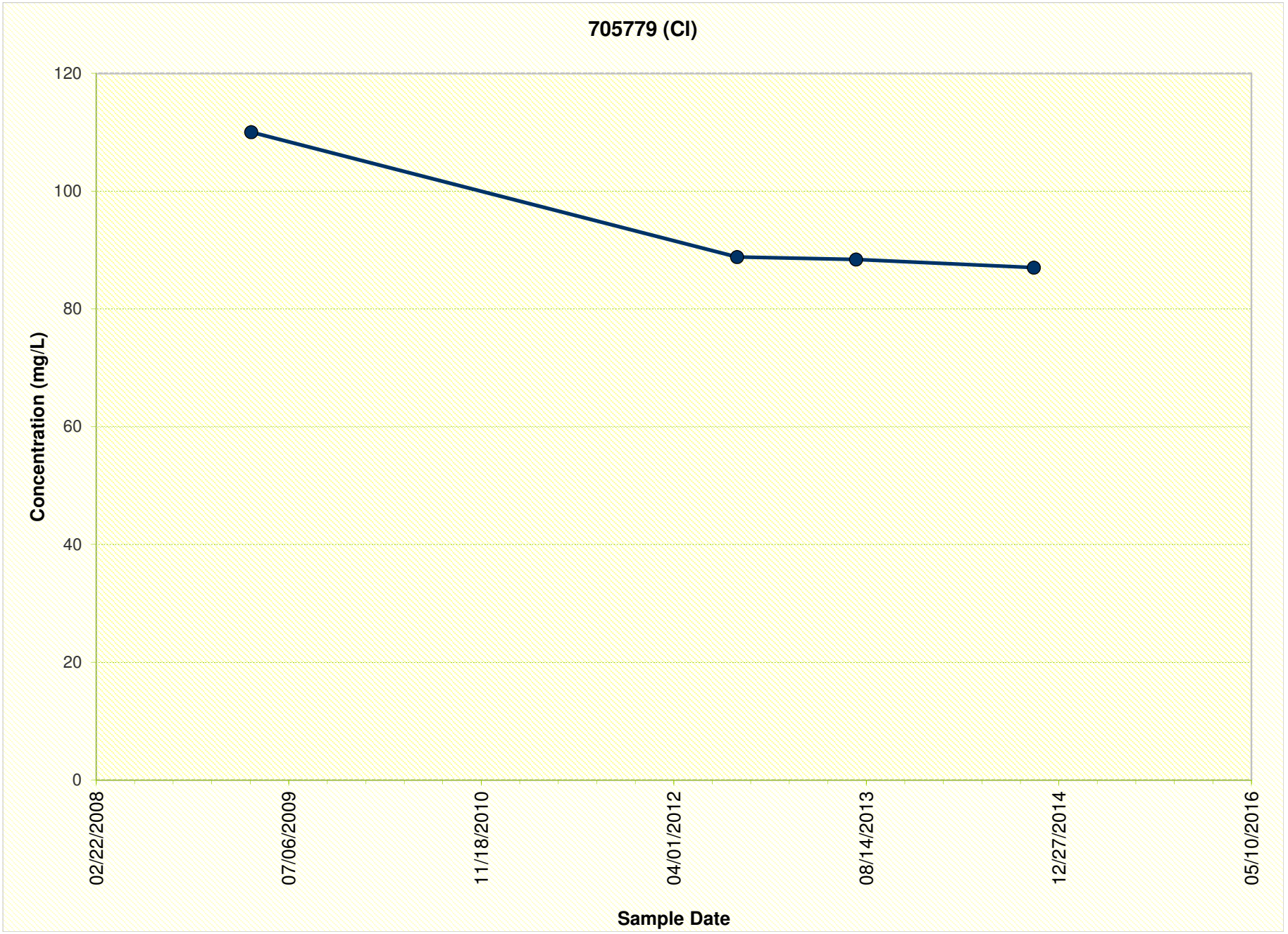

705446 (Mg)
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

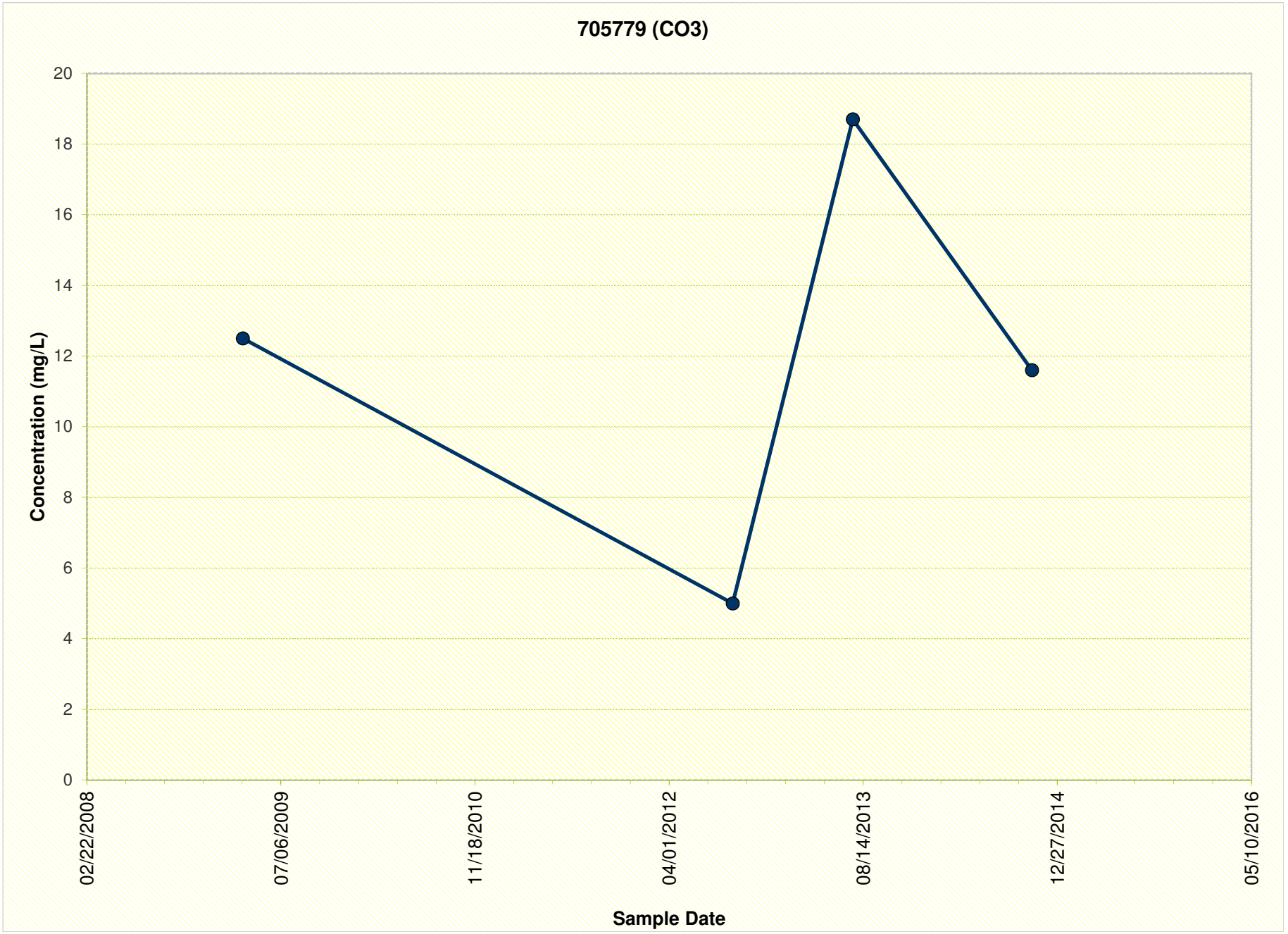

705446 (Na)
Concentration (mg/L)
350
300
250
200
150
100
50
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

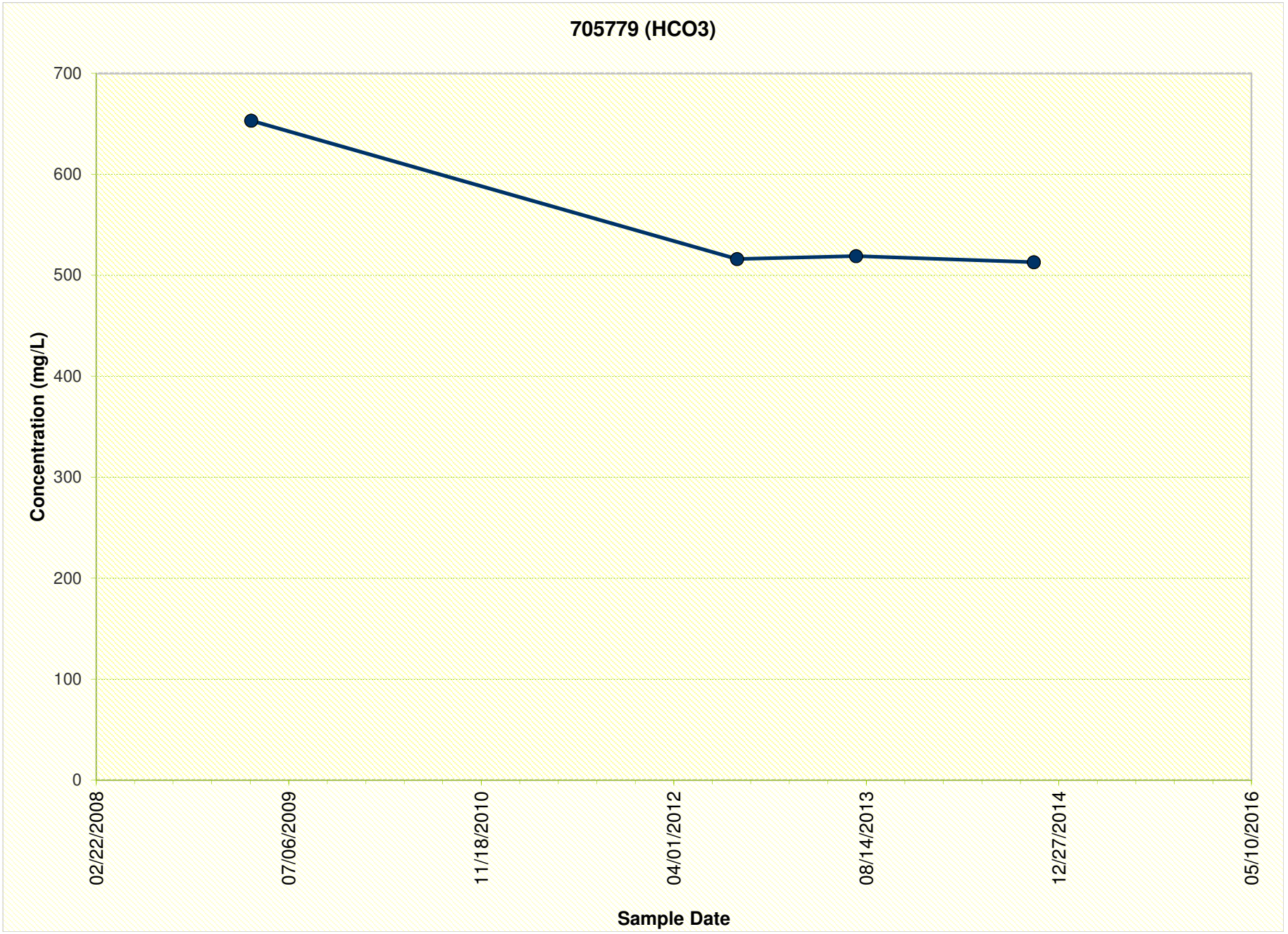

705446 (SO4)
Concentration (mg/L)
0
1
2
3
4
5
6
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

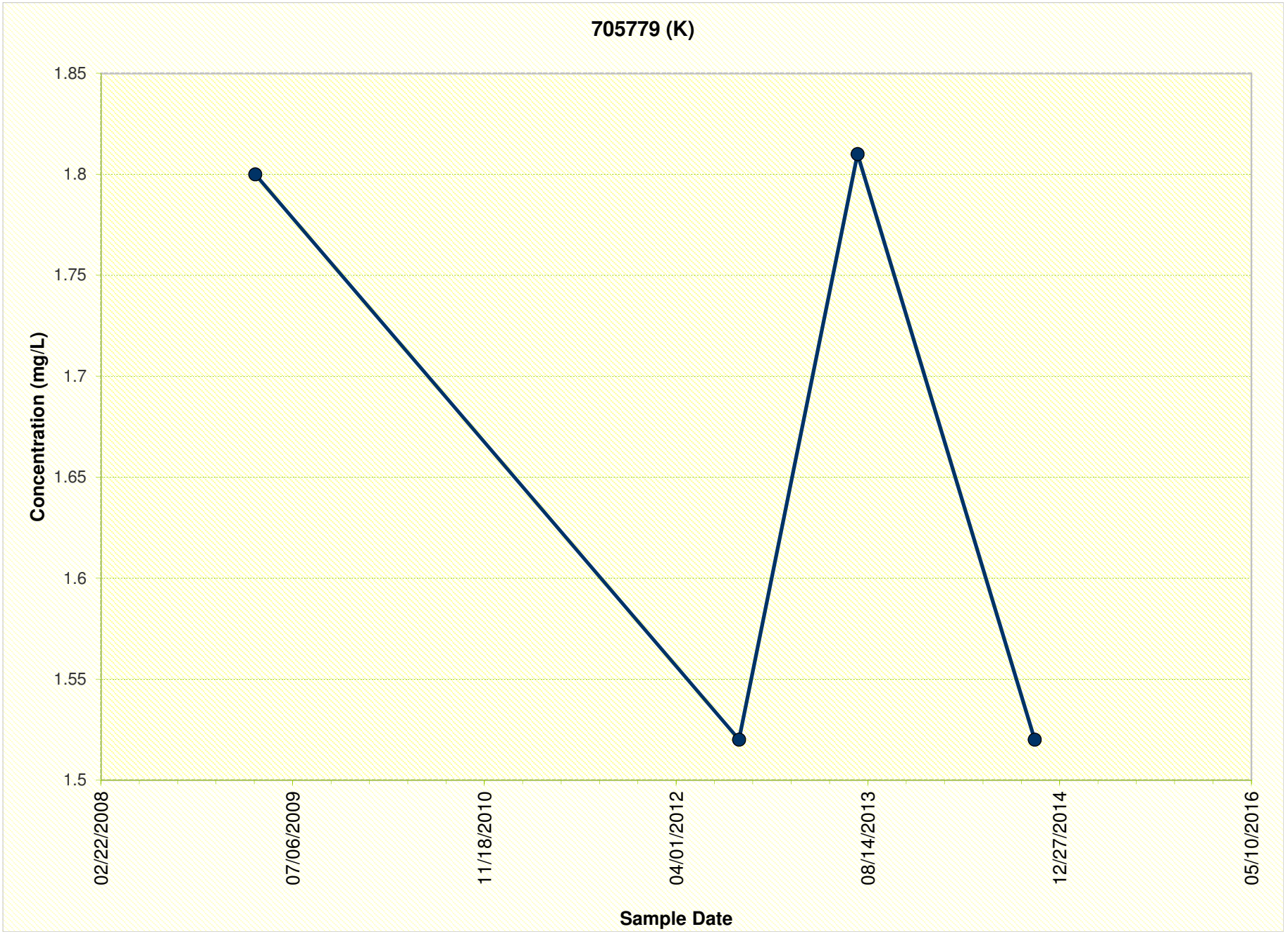

705446 (TDS)
740
730
720
710
700
690
680
670
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
Sample Date

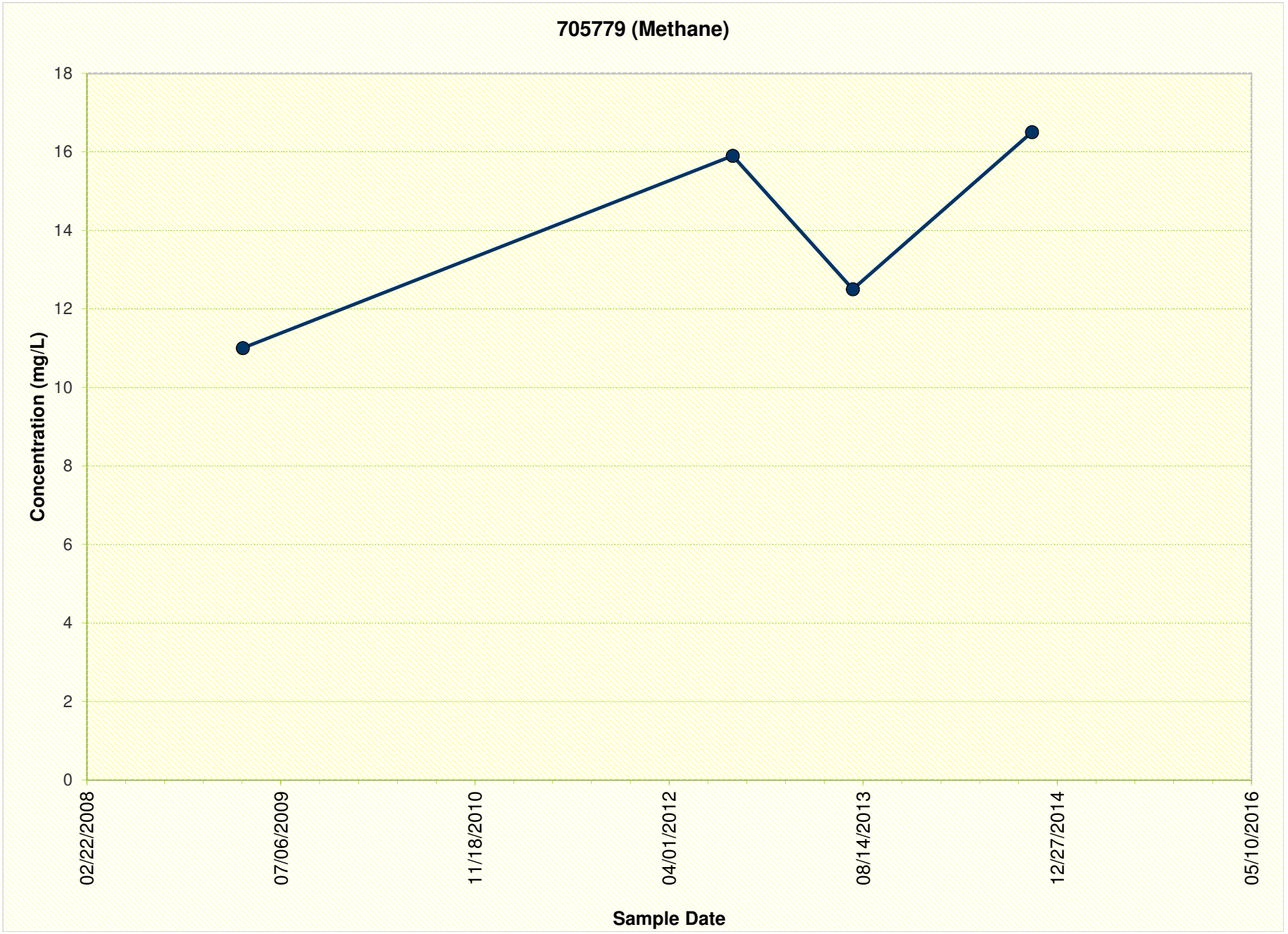

705779 (Ca)
Concentration (mg/L)
2.25
2.2
2.15
2.1
2.05
2
1.95
1.9
1.85
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

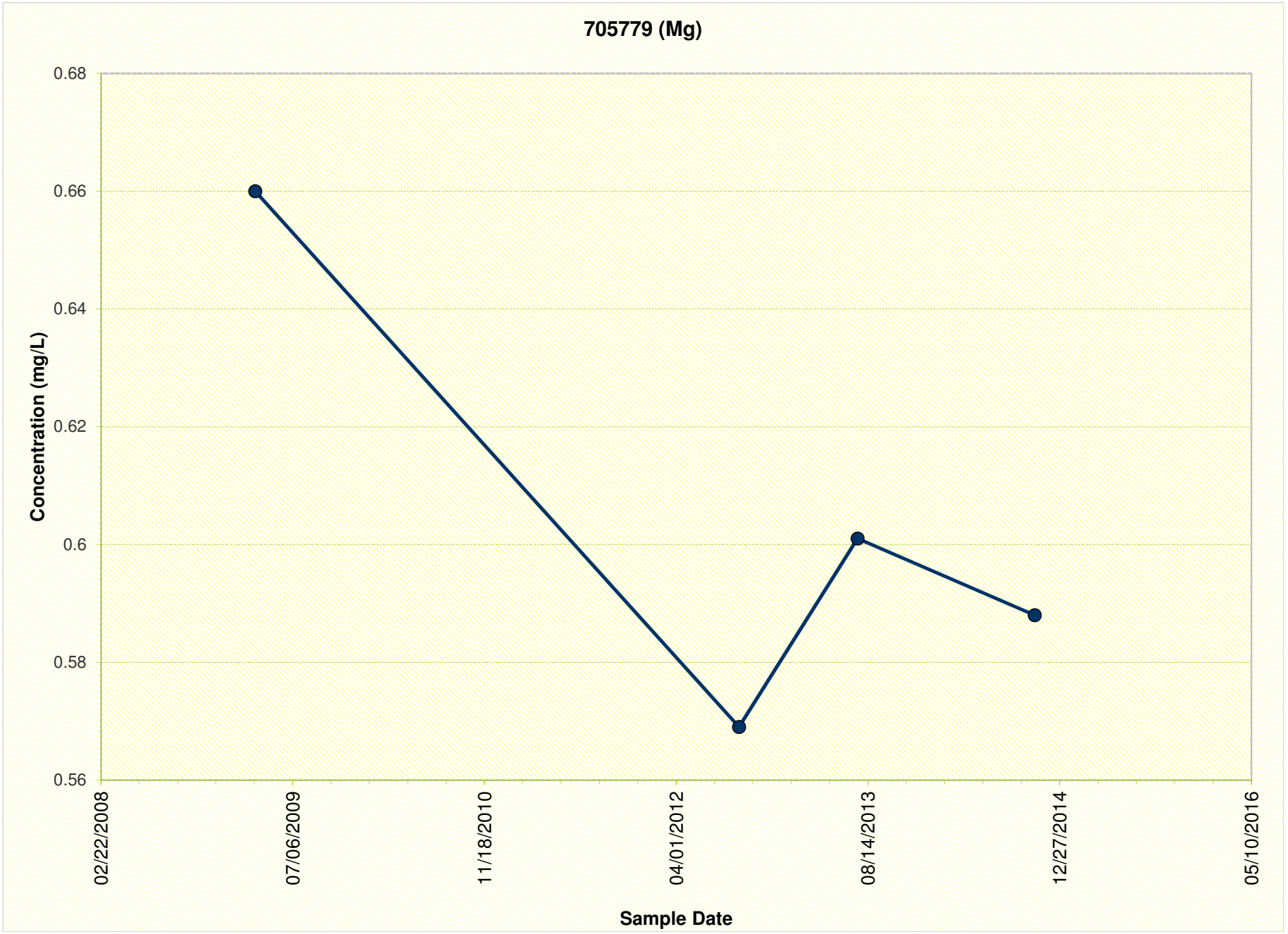

705779 (Cl)
120
100
80
60
40
20
0
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

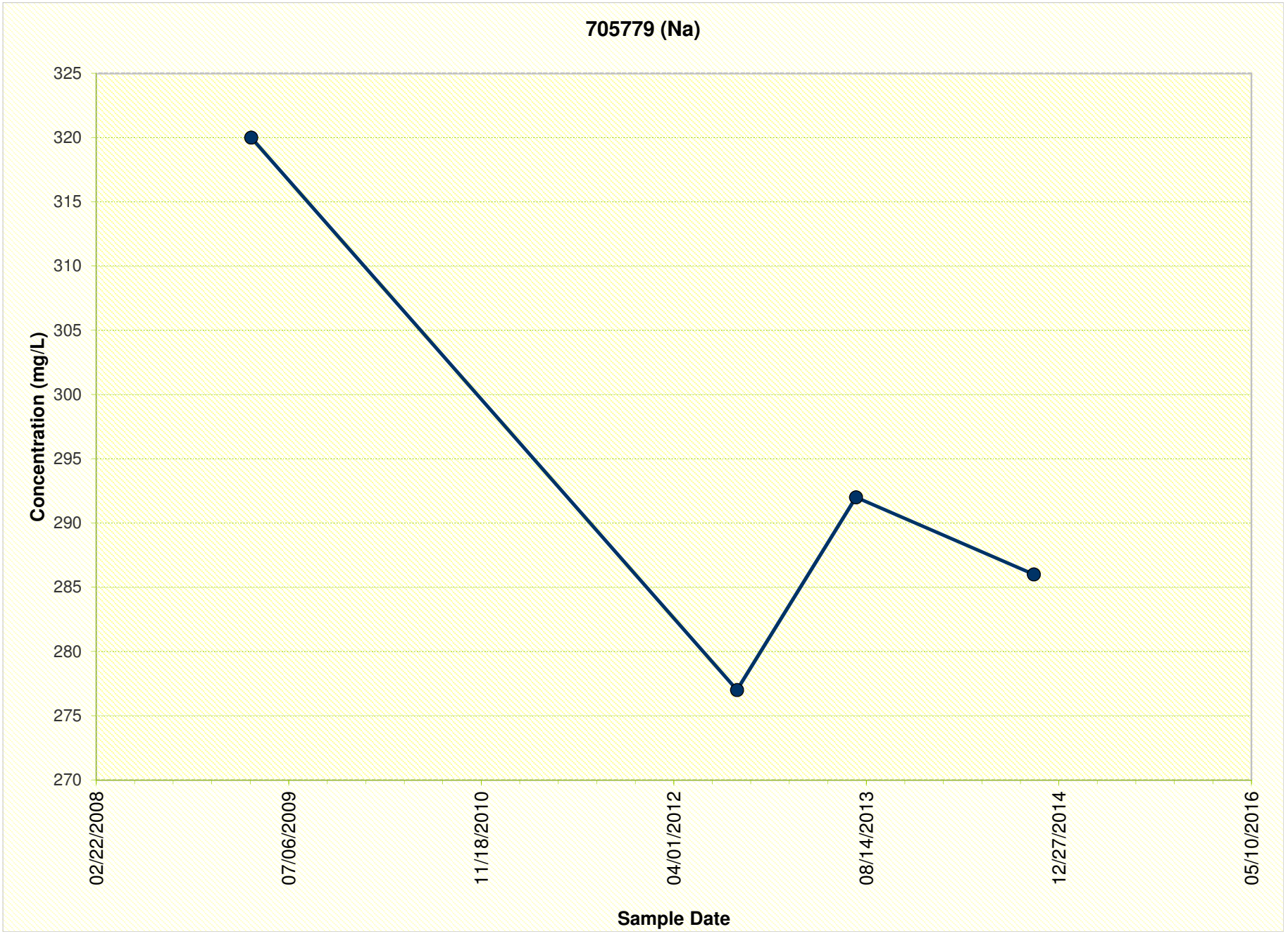

705779 (CO3)
Concentration (mg/L)
20
18
16
14
12
10
8
6
4
2
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

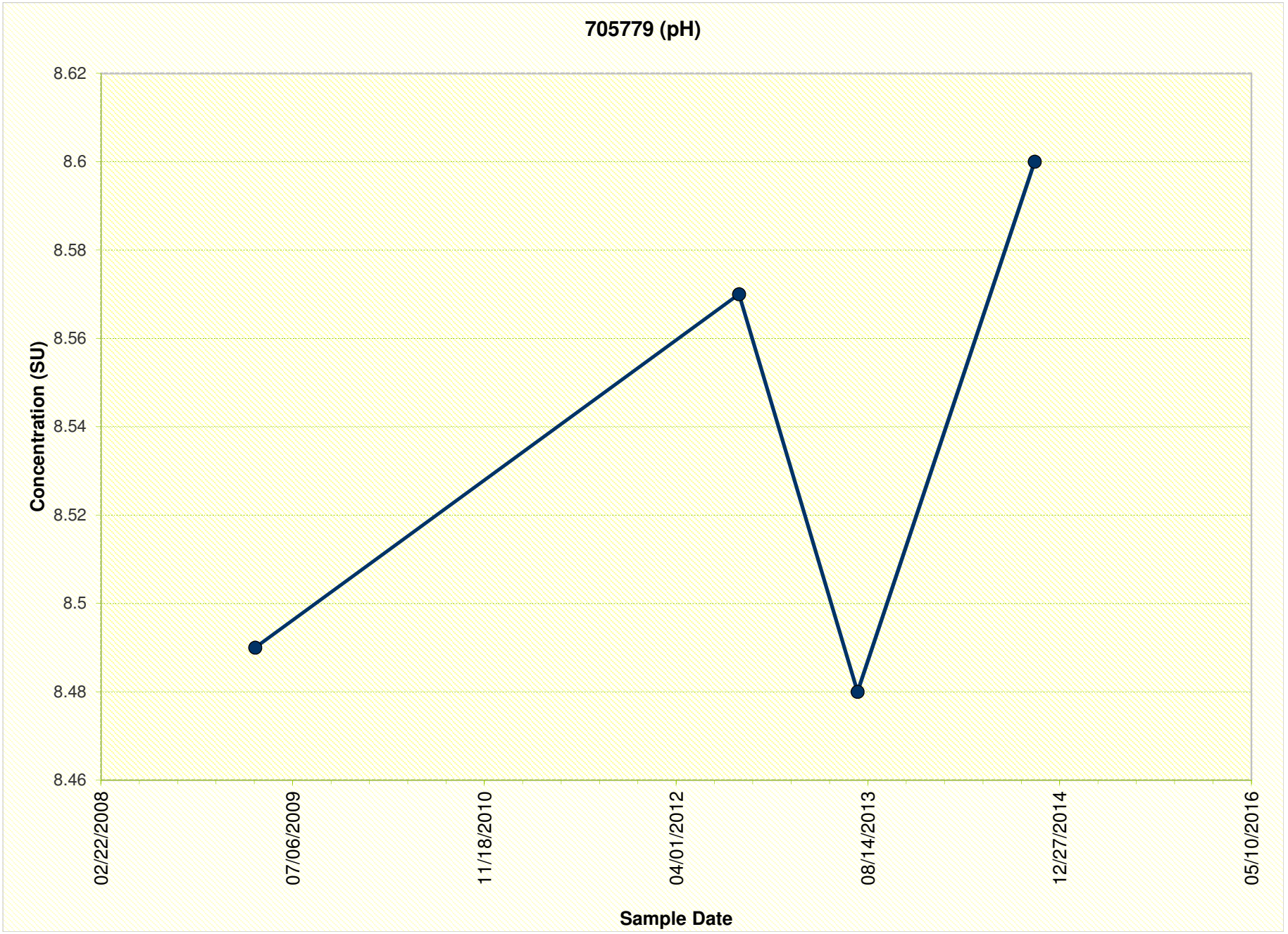

705779 (HCO3)
700
600
500
400
300
200
100
0
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

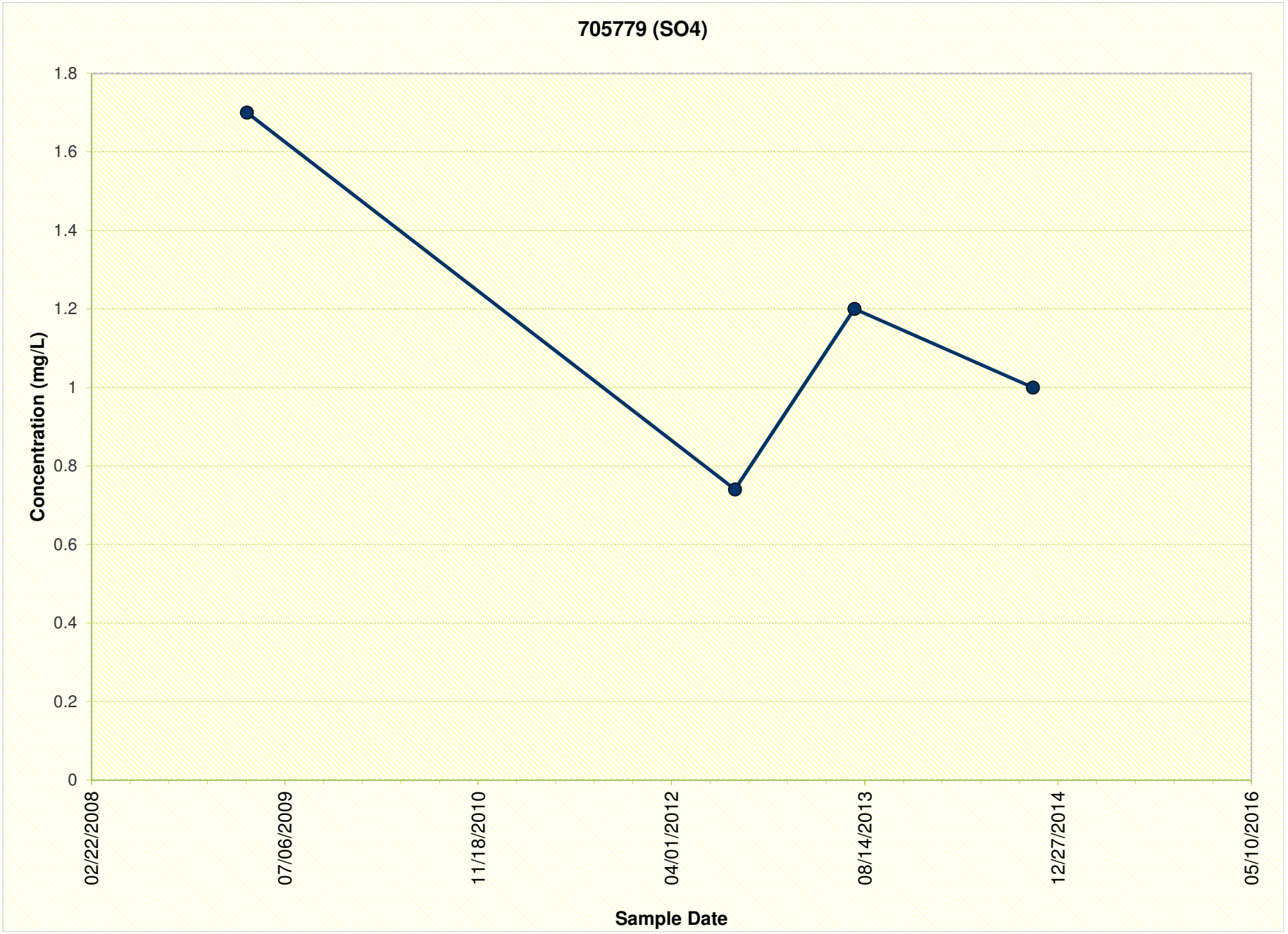

705779 (K)
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

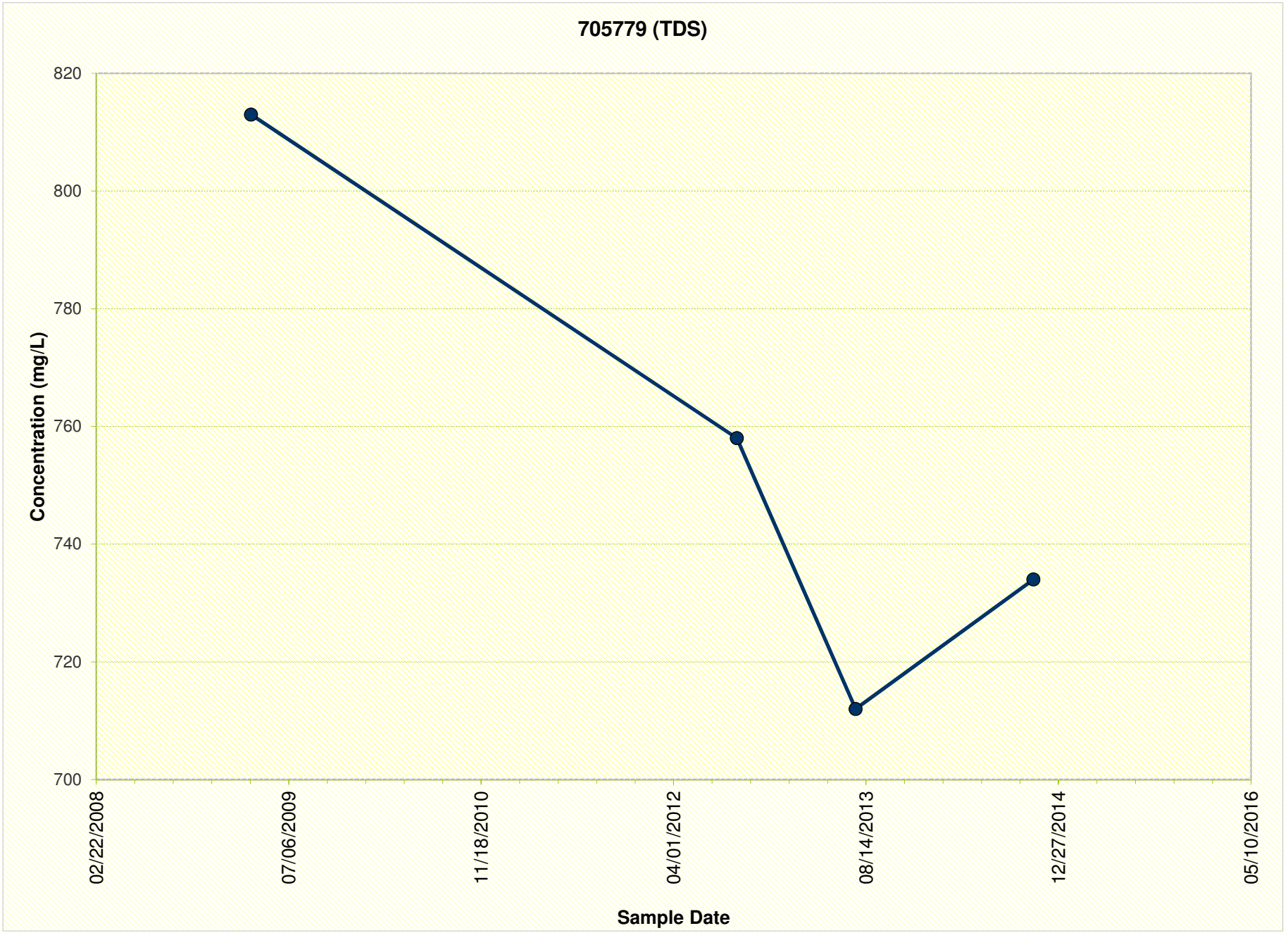

705779 (Methane)
Concentration (mg/L)
18
16
14
12
10
8
6
4
2
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

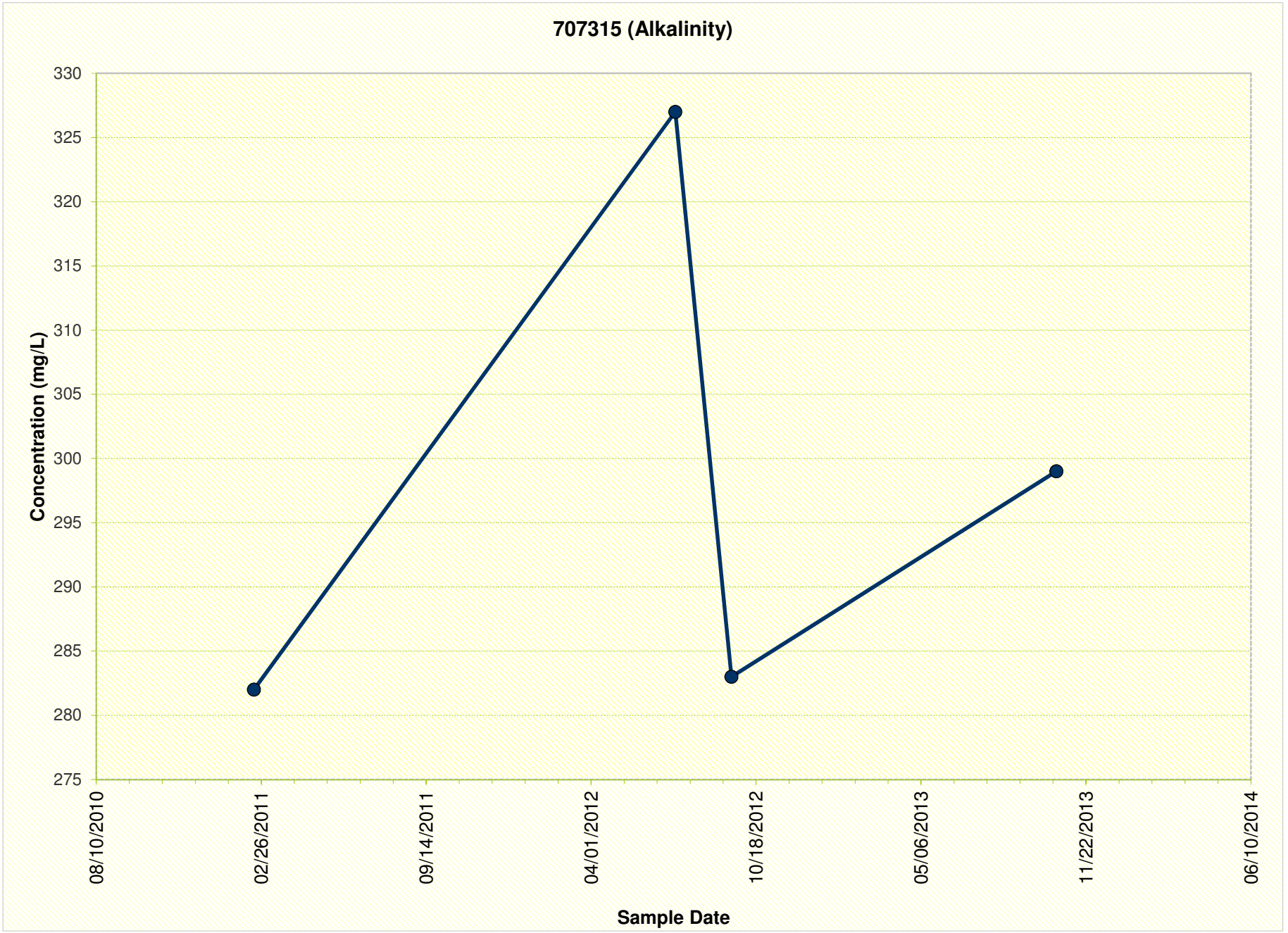

705779 (Mg)
0.68
0.66
0.64
0.62
0.6
0.58
0.56
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

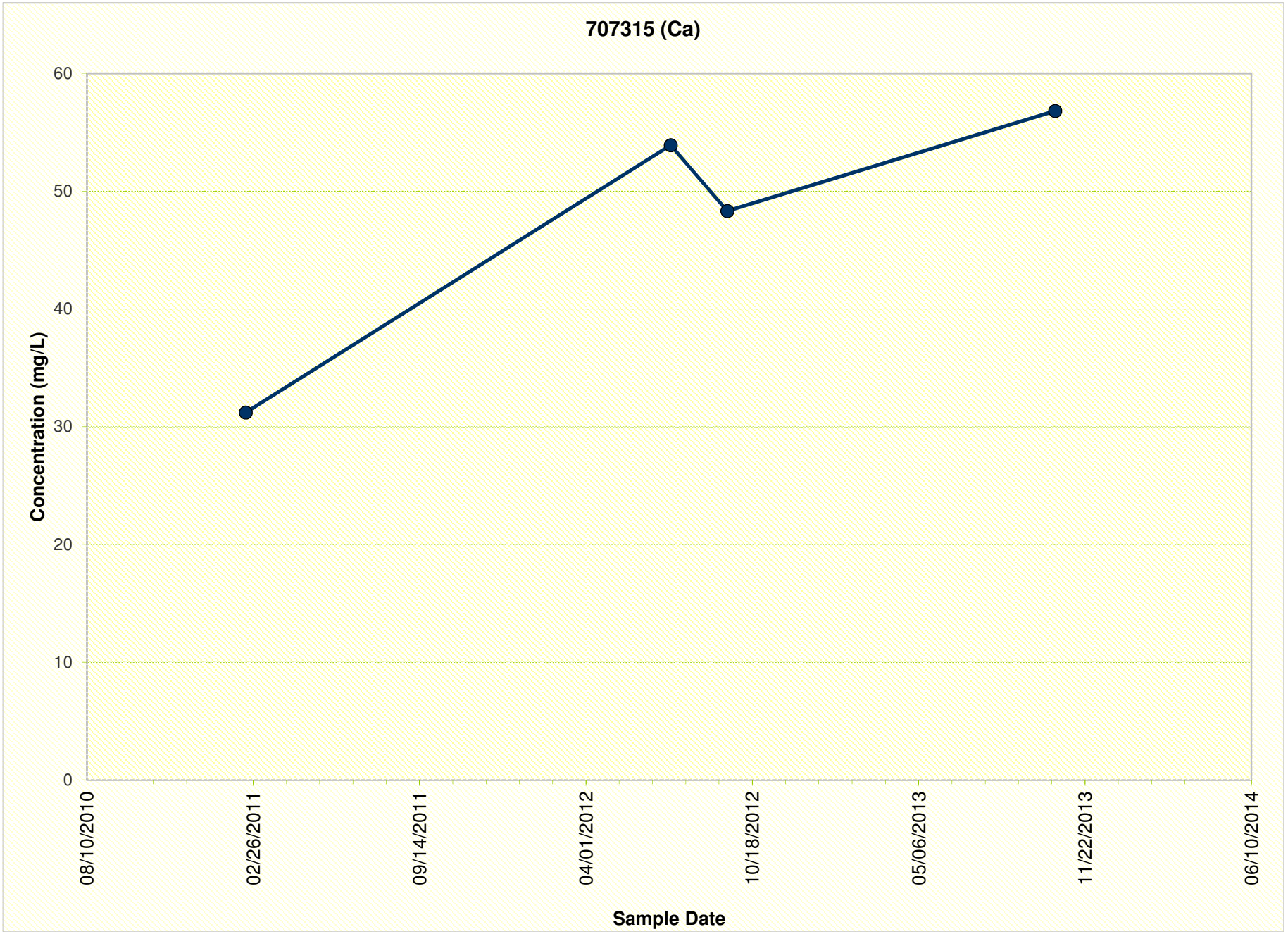

705779 (Na)
Concentration (mg/L)
325
320
315
310
305
300
295
290
285
280
275
270
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

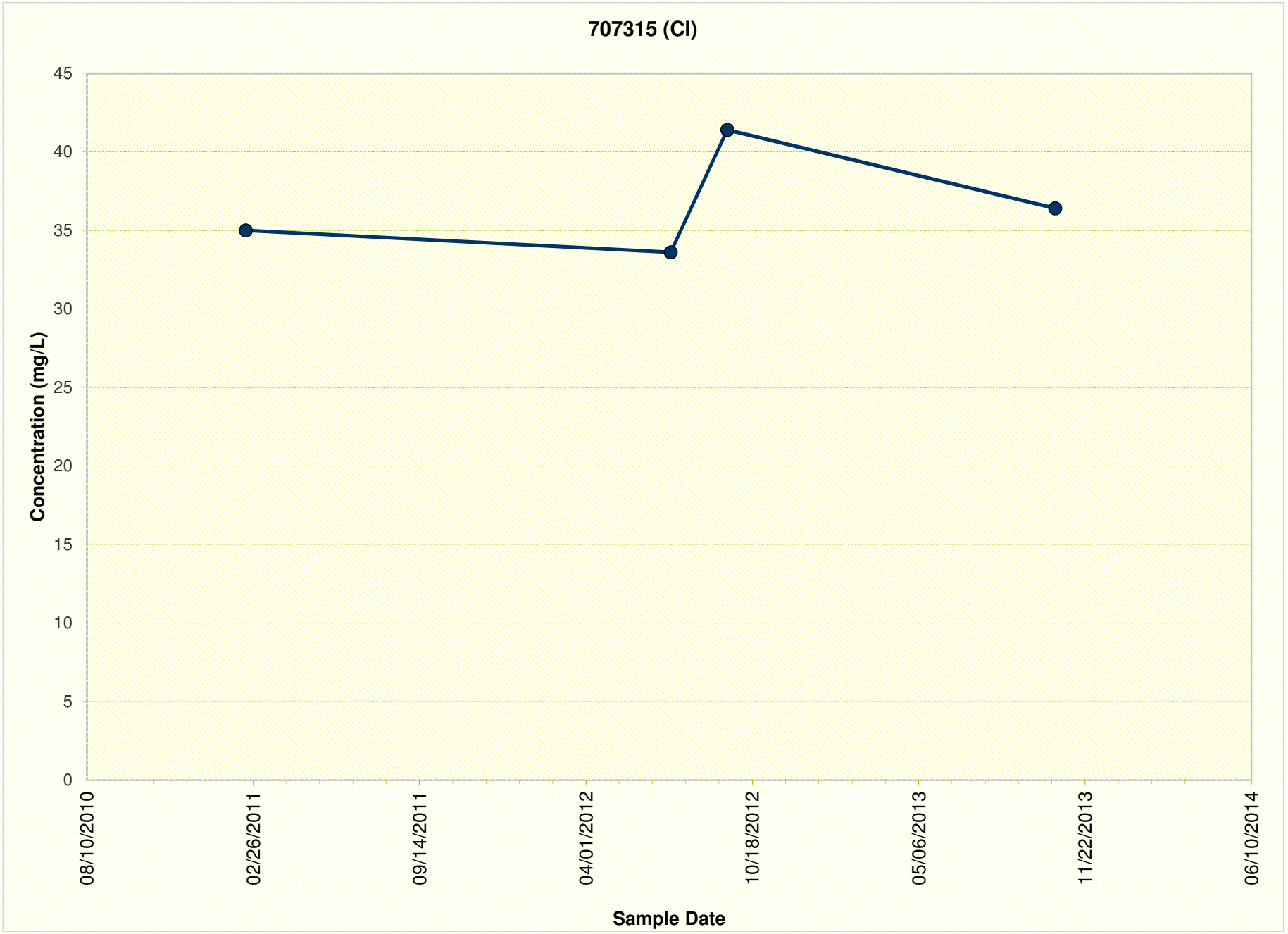

705779 (pH)
8.62
8.6
8.58
8.56
8.54
8.52
8.5
8.48
8.46
Concentration (SU)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

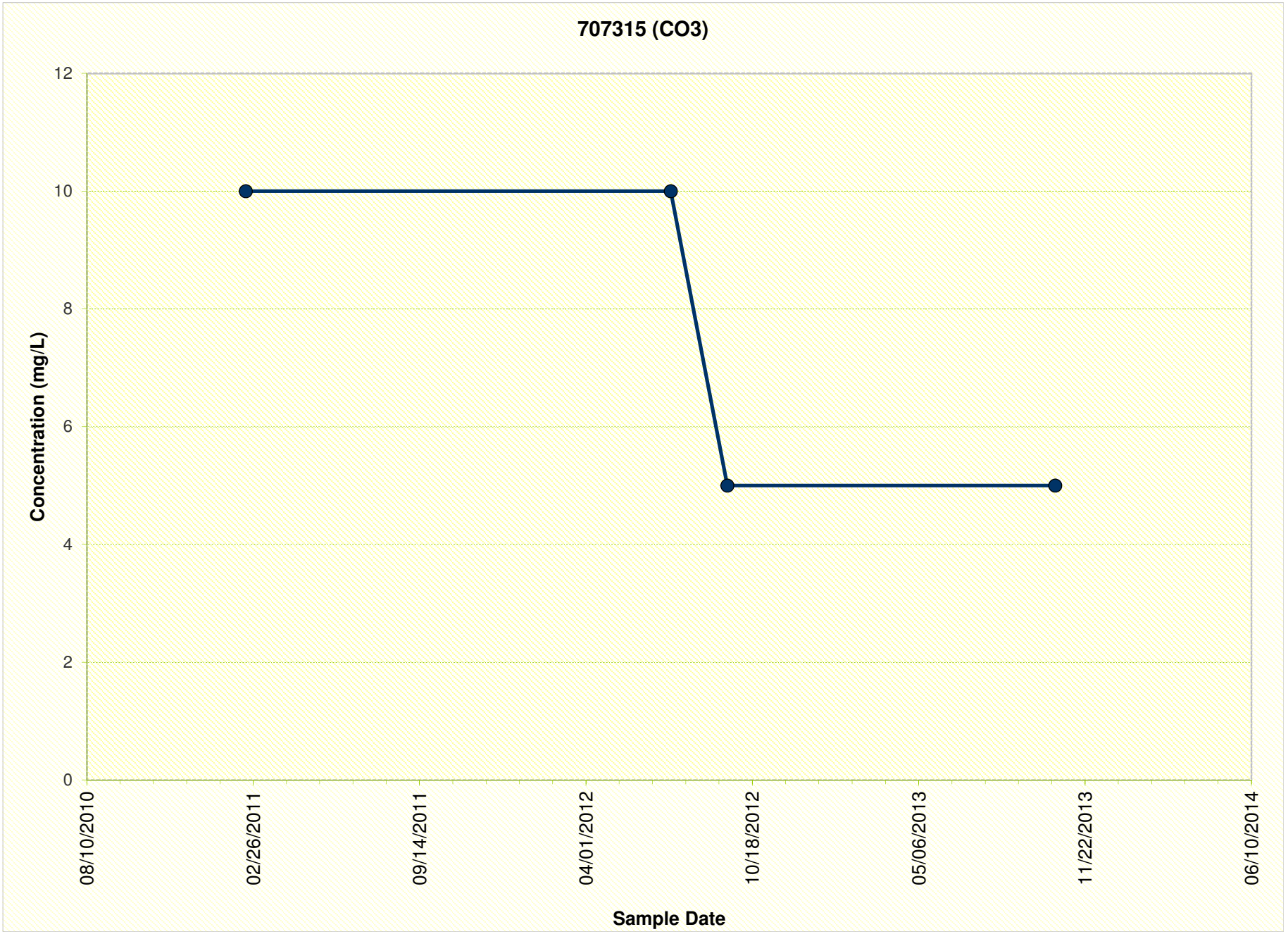

705779 (SO4)
Concentration (mg/L)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

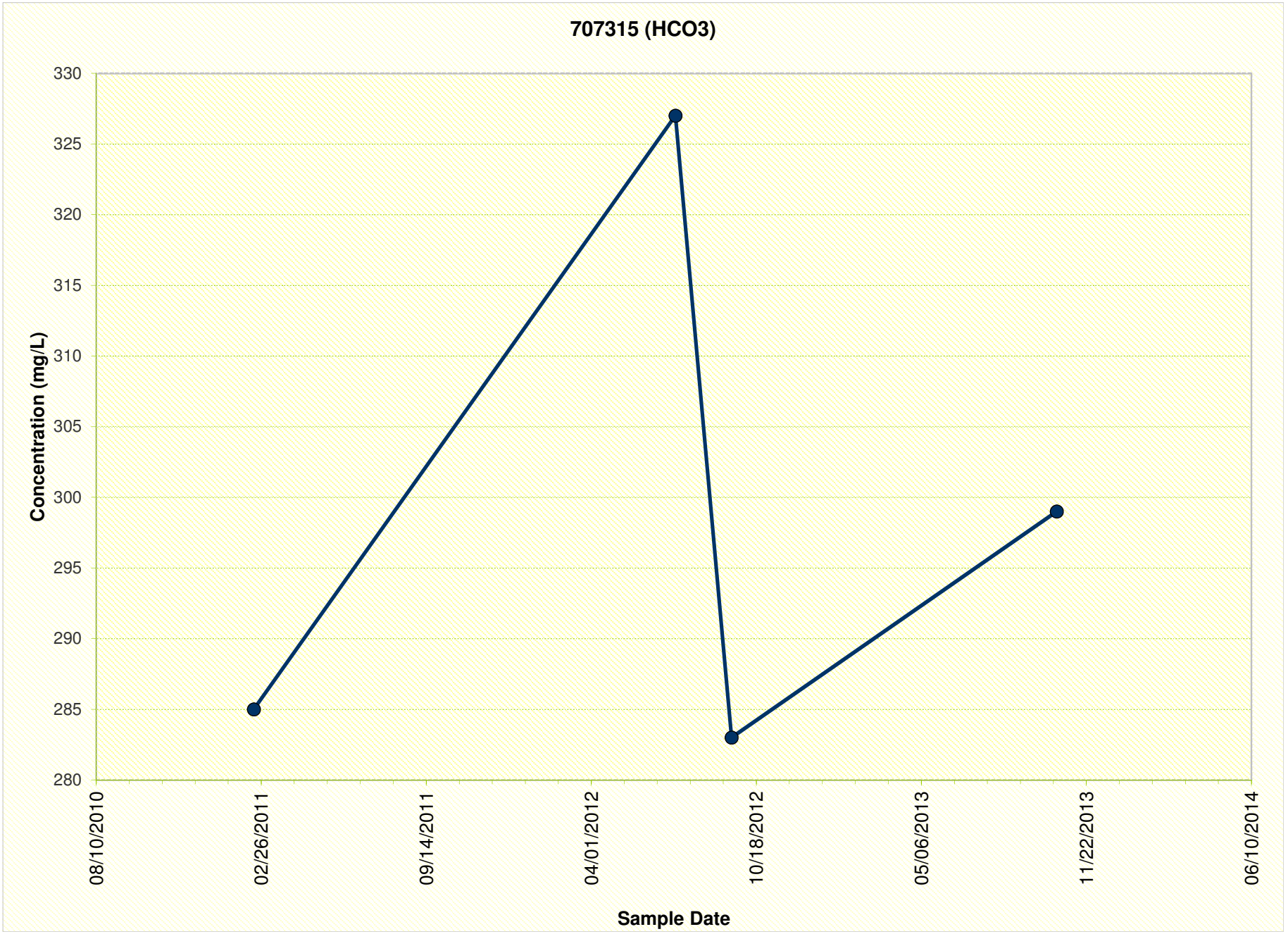

705779 (TDS)
820
800
780
760
740
720
700
Concentration (mg/L)
02/22/2008
07/06/2009
11/18/2010
04/01/2012
08/14/2013
12/27/2014
05/10/2016
Sample Date

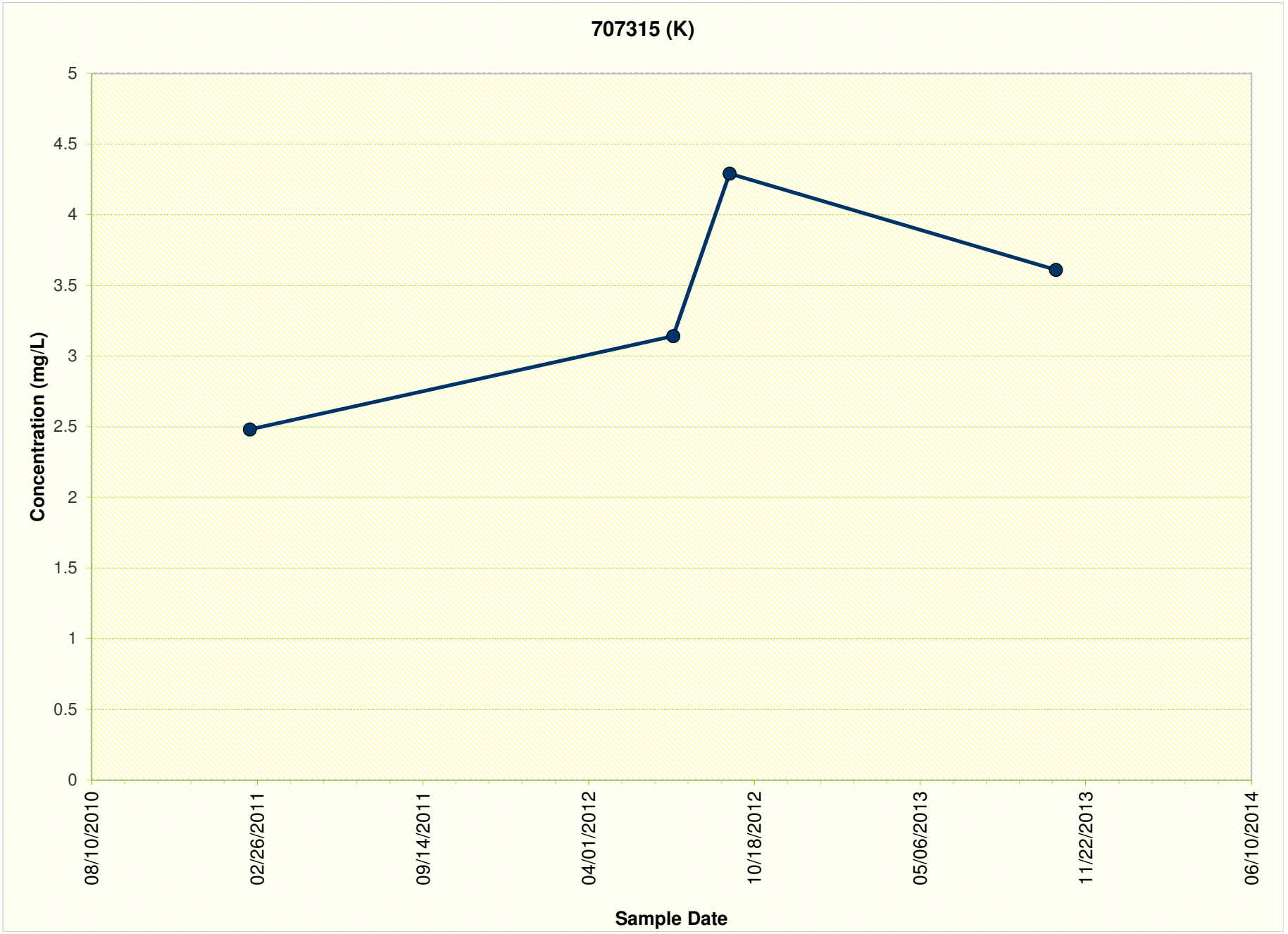

707315 (Alkalinity)
330
325
320
315
310
305
300
295
290
285
280
275
Concentration (mg/L)
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

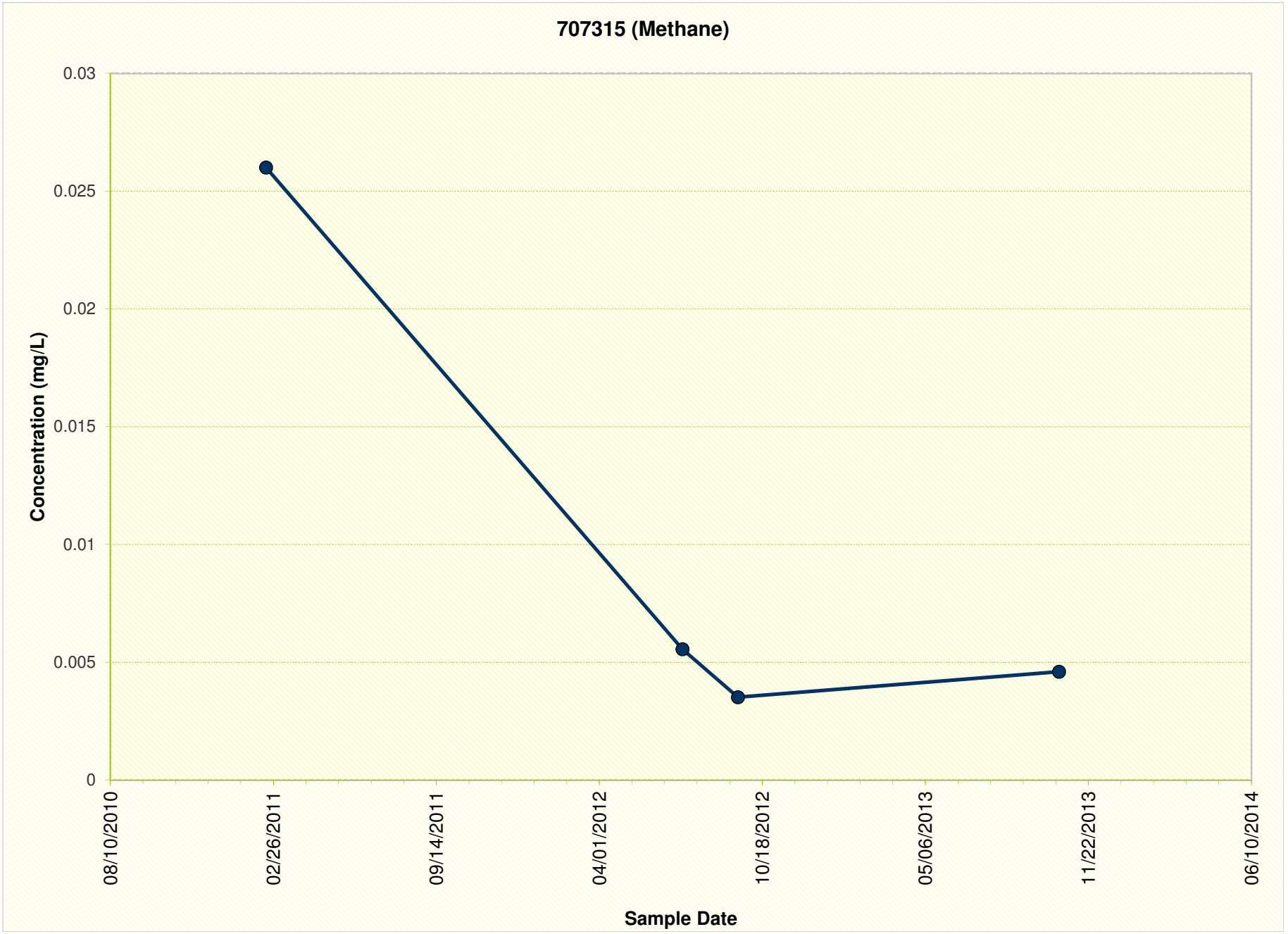

707315 (Ca)
Concentration (mg/L)
60
50
40
30
20
10
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

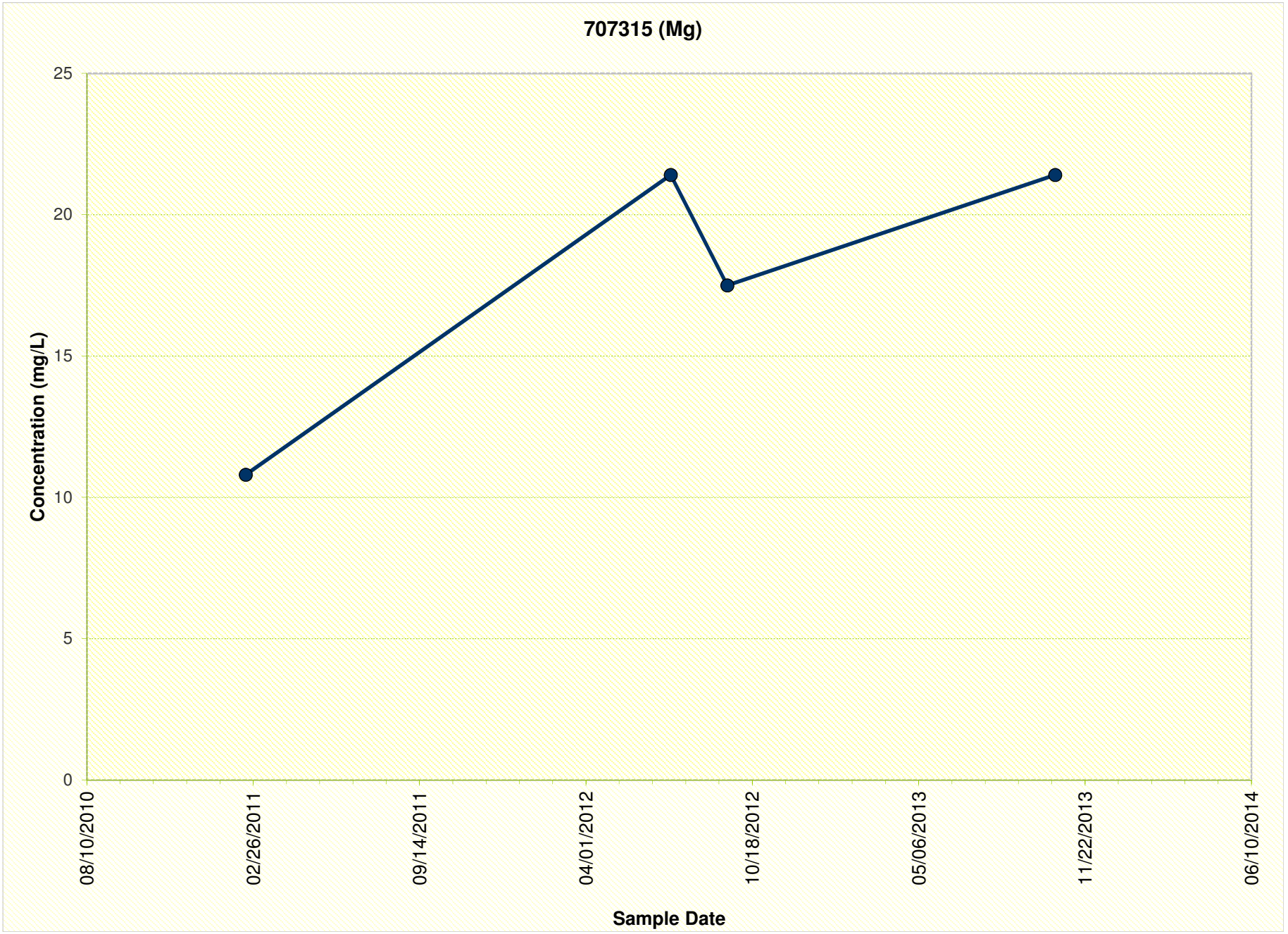

707315 (Cl)
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

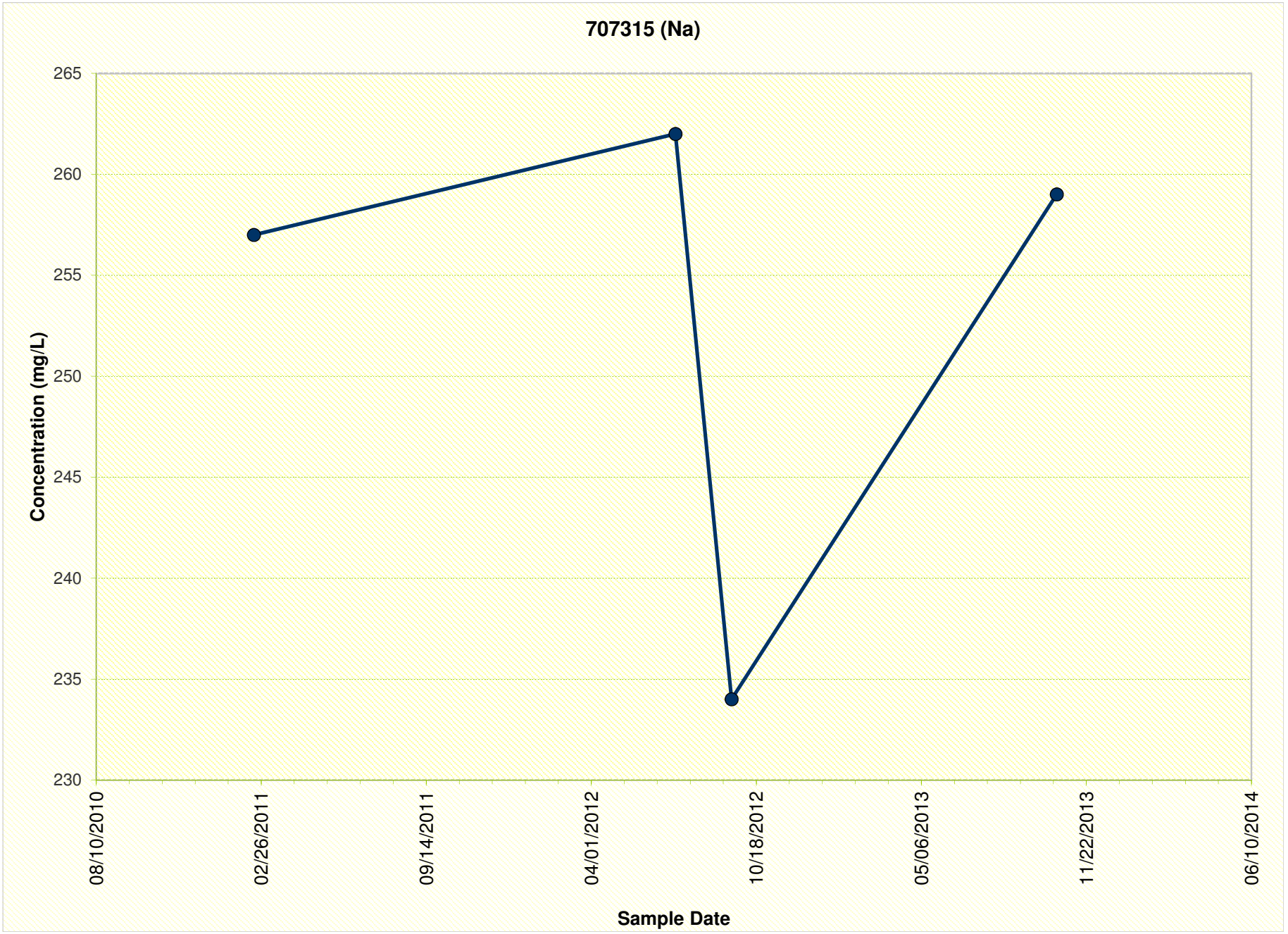

707315 (CO3)
Concentration (mg/L)
12
10
8
6
4
2
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

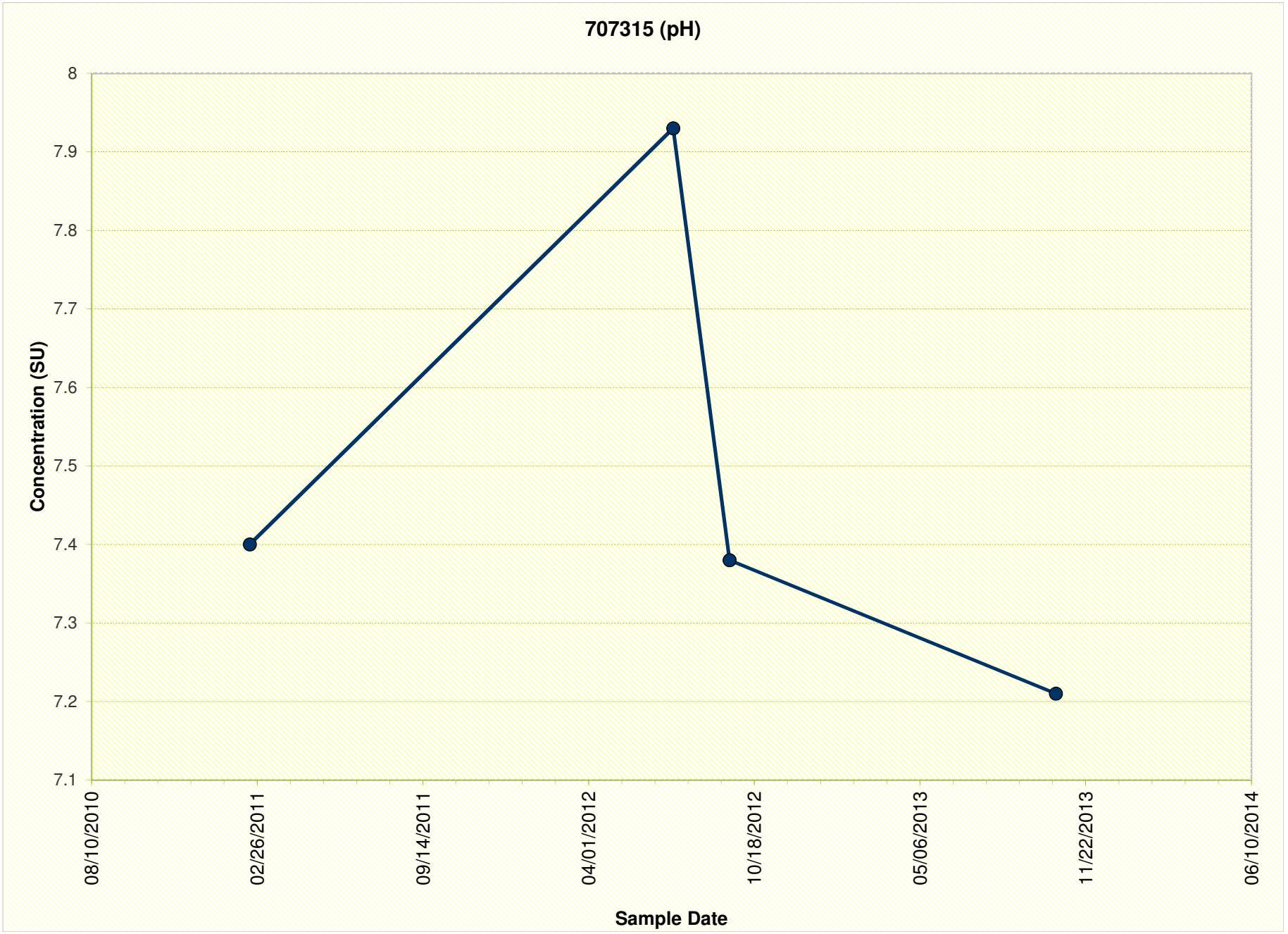

707315 (HCO3)
330
325
320
315
310
305
300
295
290
285
280
Concentration (mg/L)
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

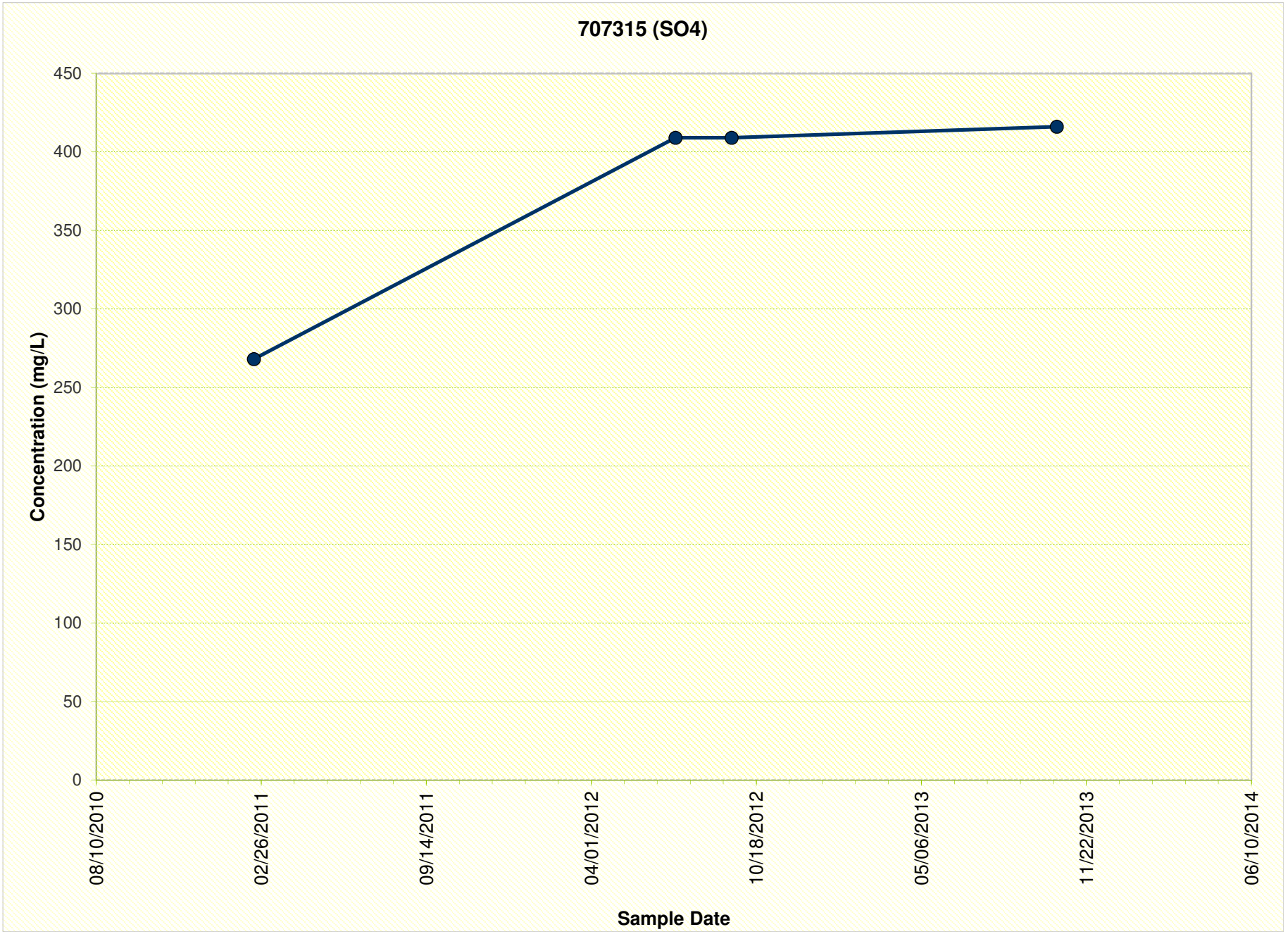

707315 (K)
Concentration (mg/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

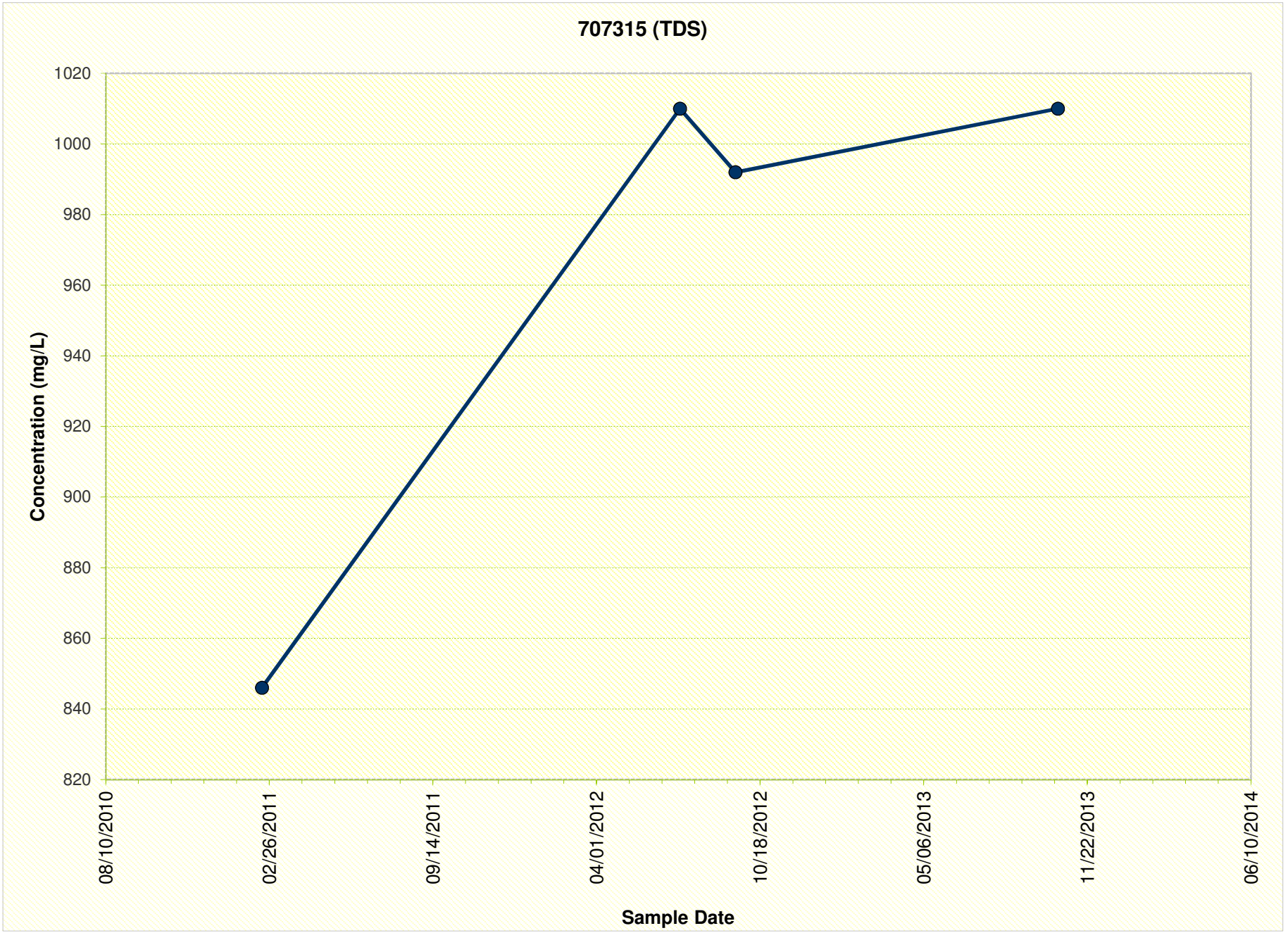

707315 (Methane)
0.03
0.025
0.02
0.015
0.01
0.005
0
Concentration (mg/L)
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

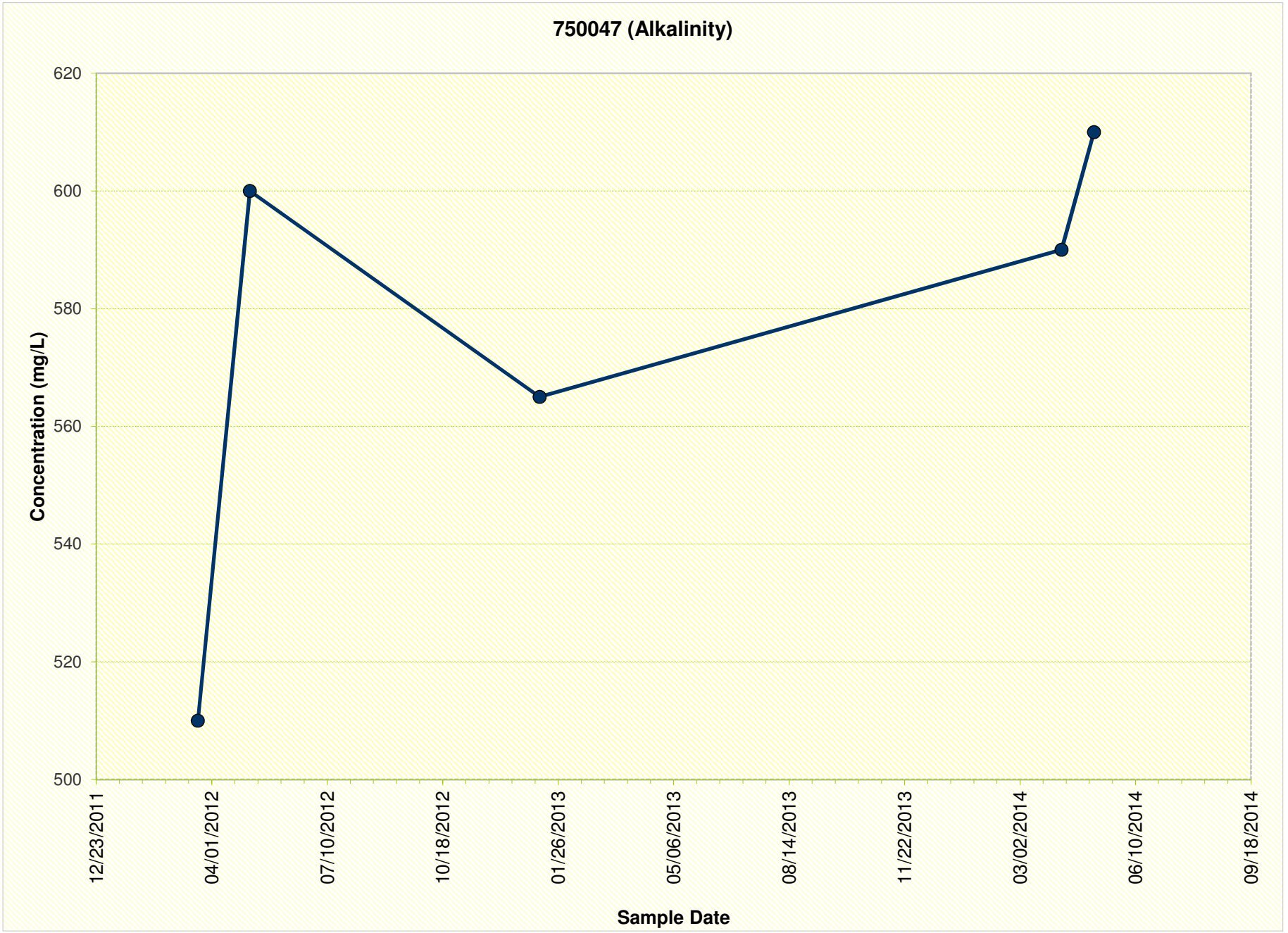

707315 (Mg)
Concentration (mg/L)
25
20
15
10
5
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

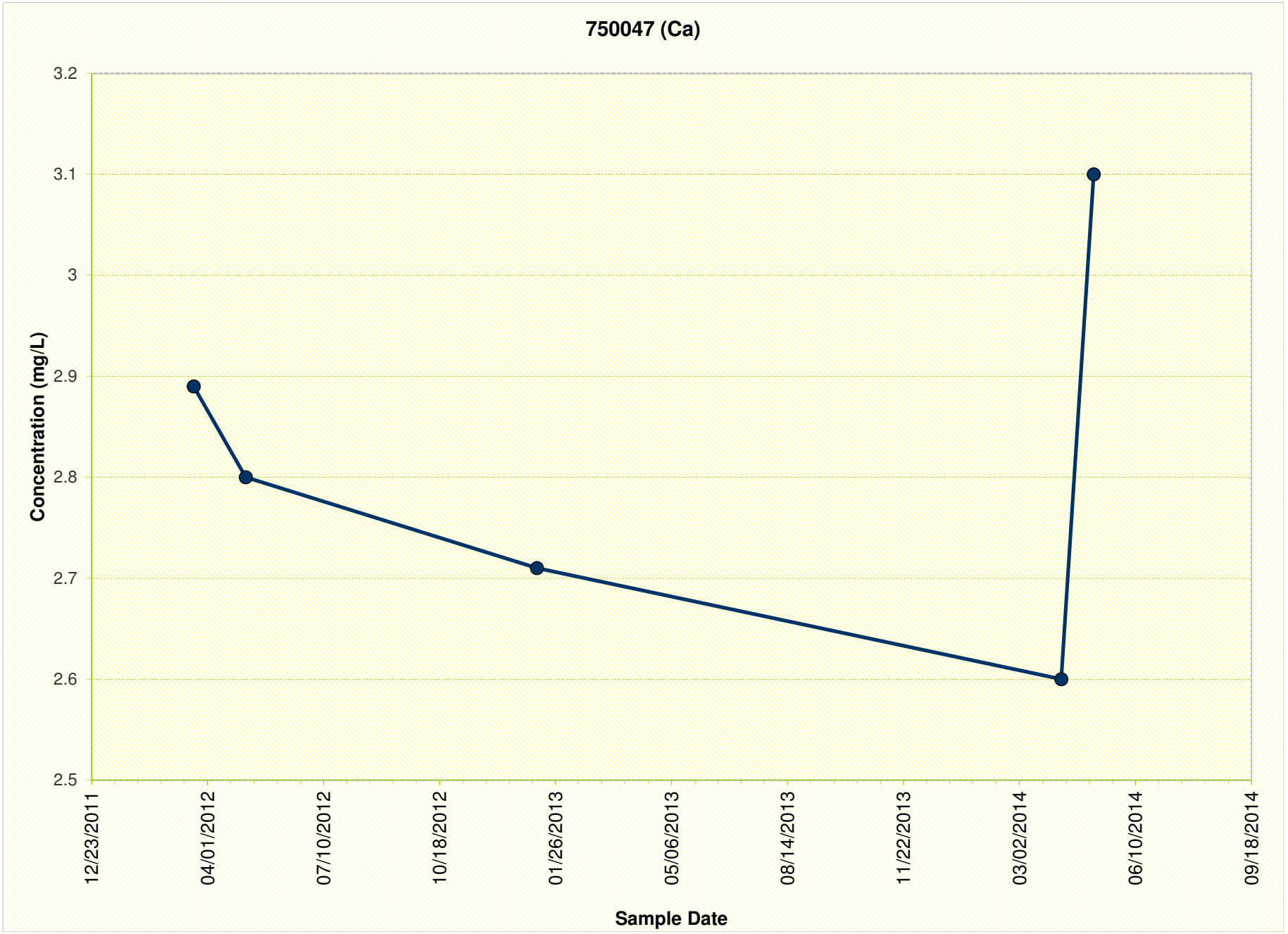

707315 (Na)
265
260
255
250
245
240
235
230
Concentration (mg/L)
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

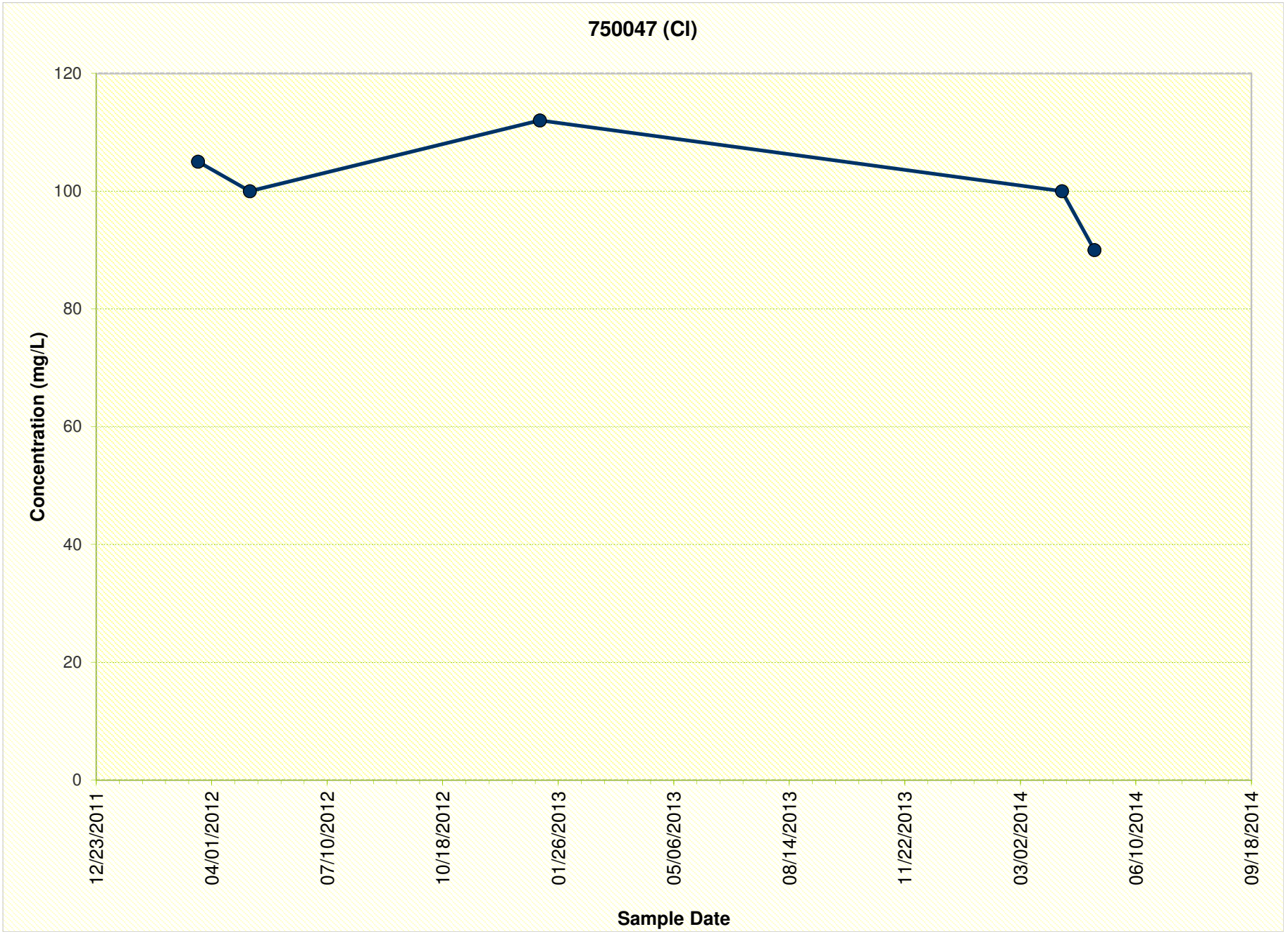

707315 (pH)
Concentration (SU)
8
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

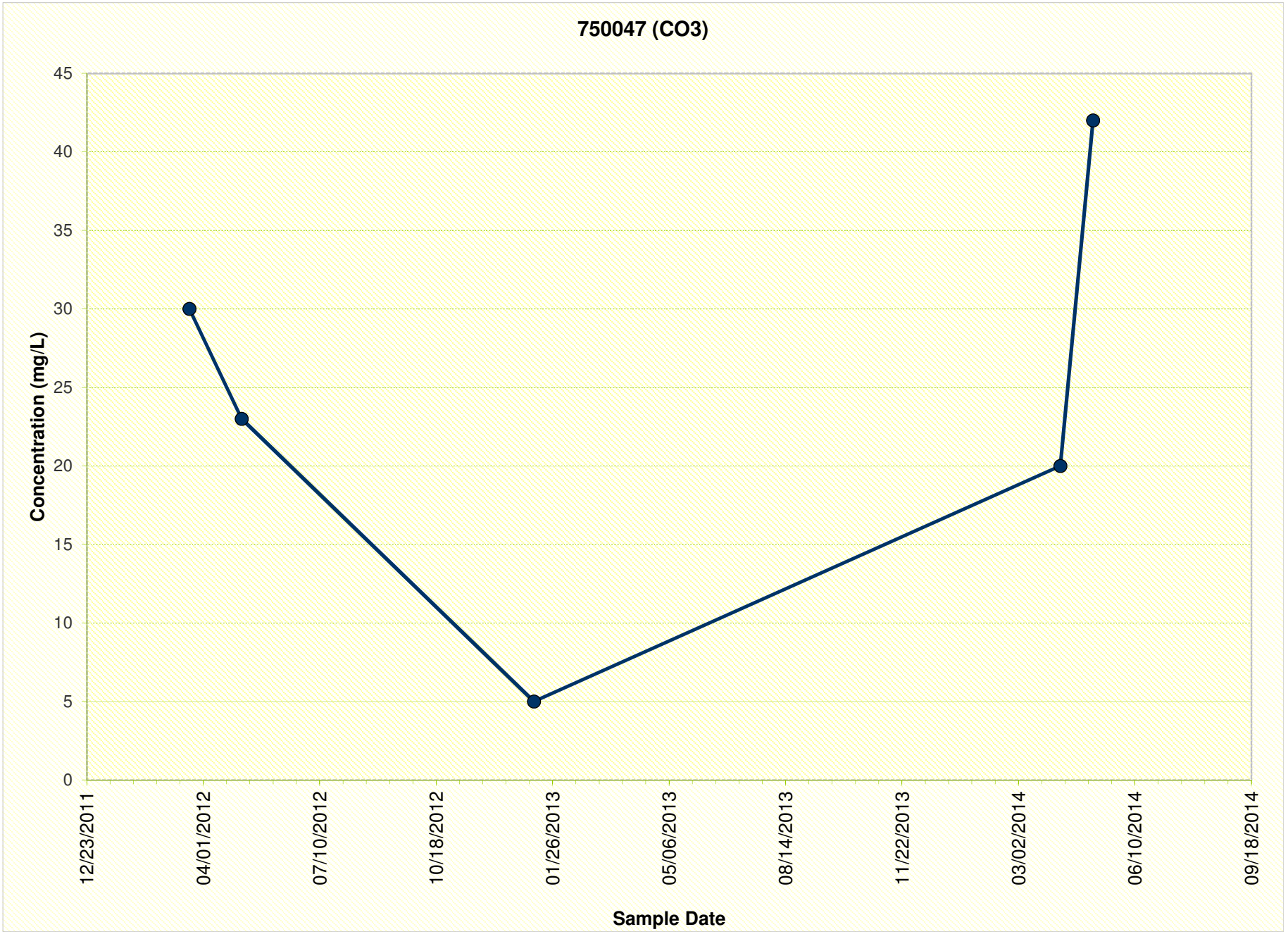

707315 (SO4)
Concentration (mg/L)
450
400
350
300
250
200
150
100
50
0
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

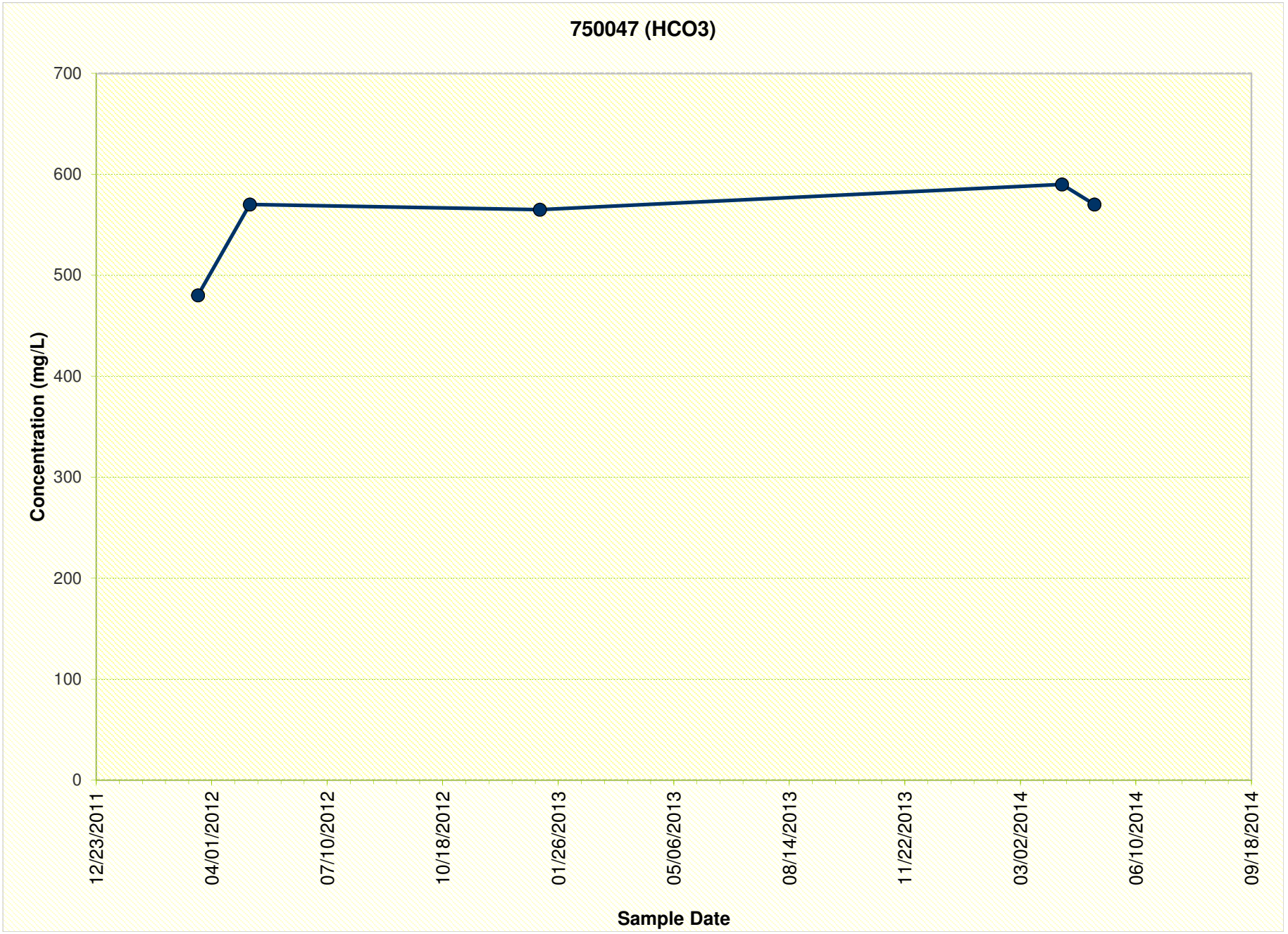

707315 (TDS)
1020
1000
980
960
940
920
900
880
860
840
820
Concentration (mg/L)
08/10/2010
02/26/2011
09/14/2011
04/01/2012
10/18/2012
05/06/2013
11/22/2013
06/10/2014
Sample Date

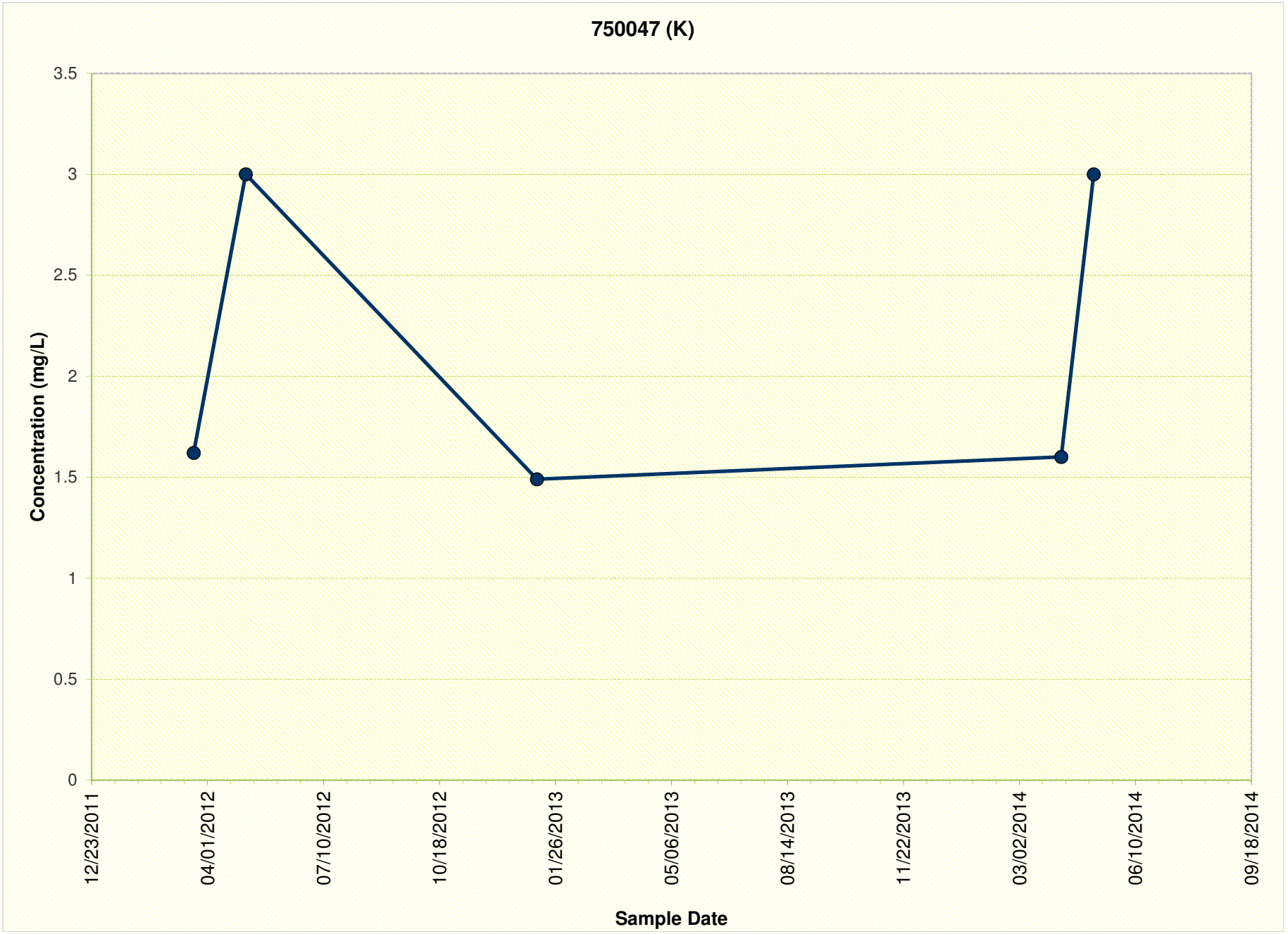

750047 (Alkalinity)
620
600
580
560
540
520
500
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

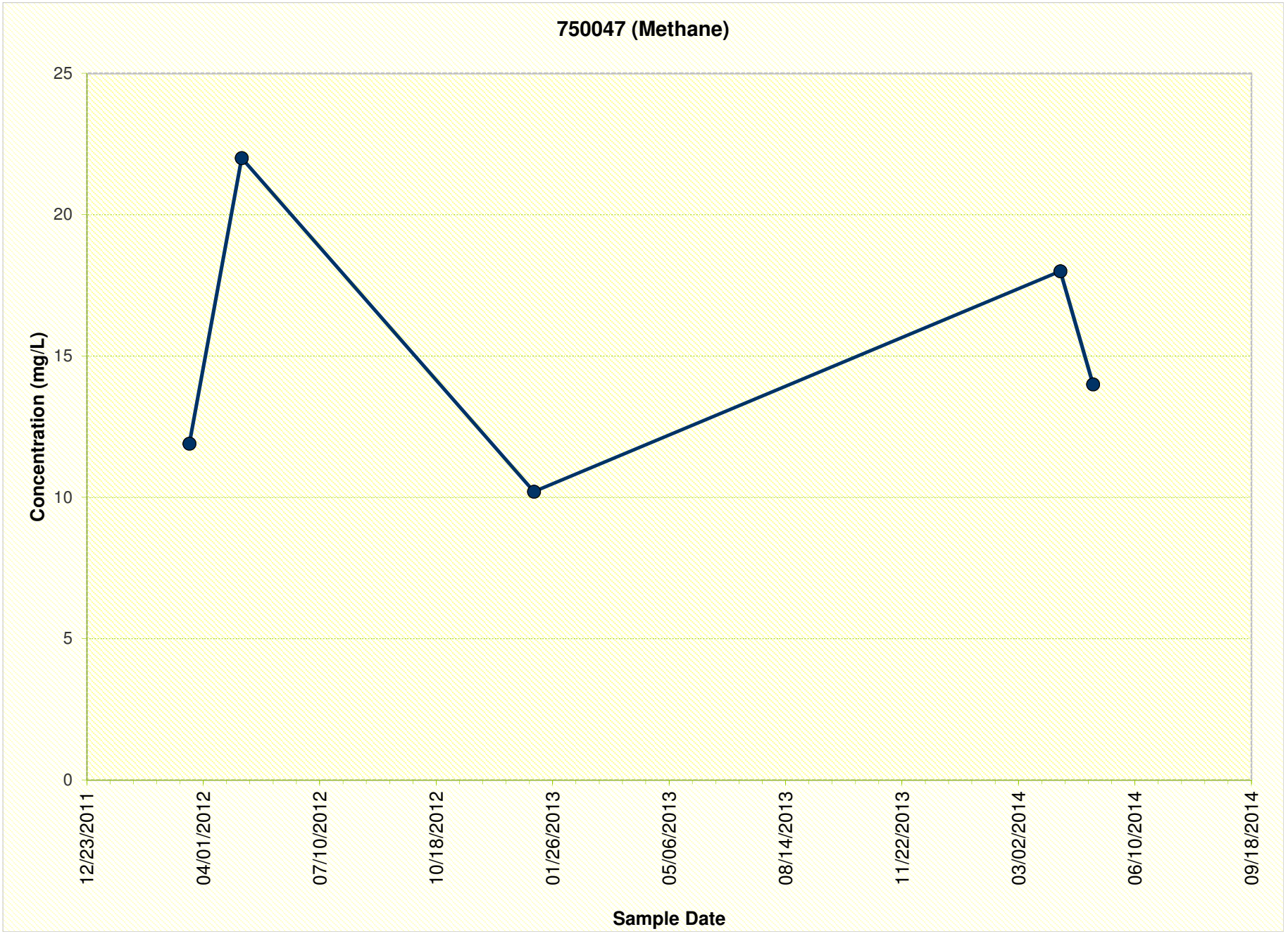

750047 (Ca)
Concentration (mg/L)
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

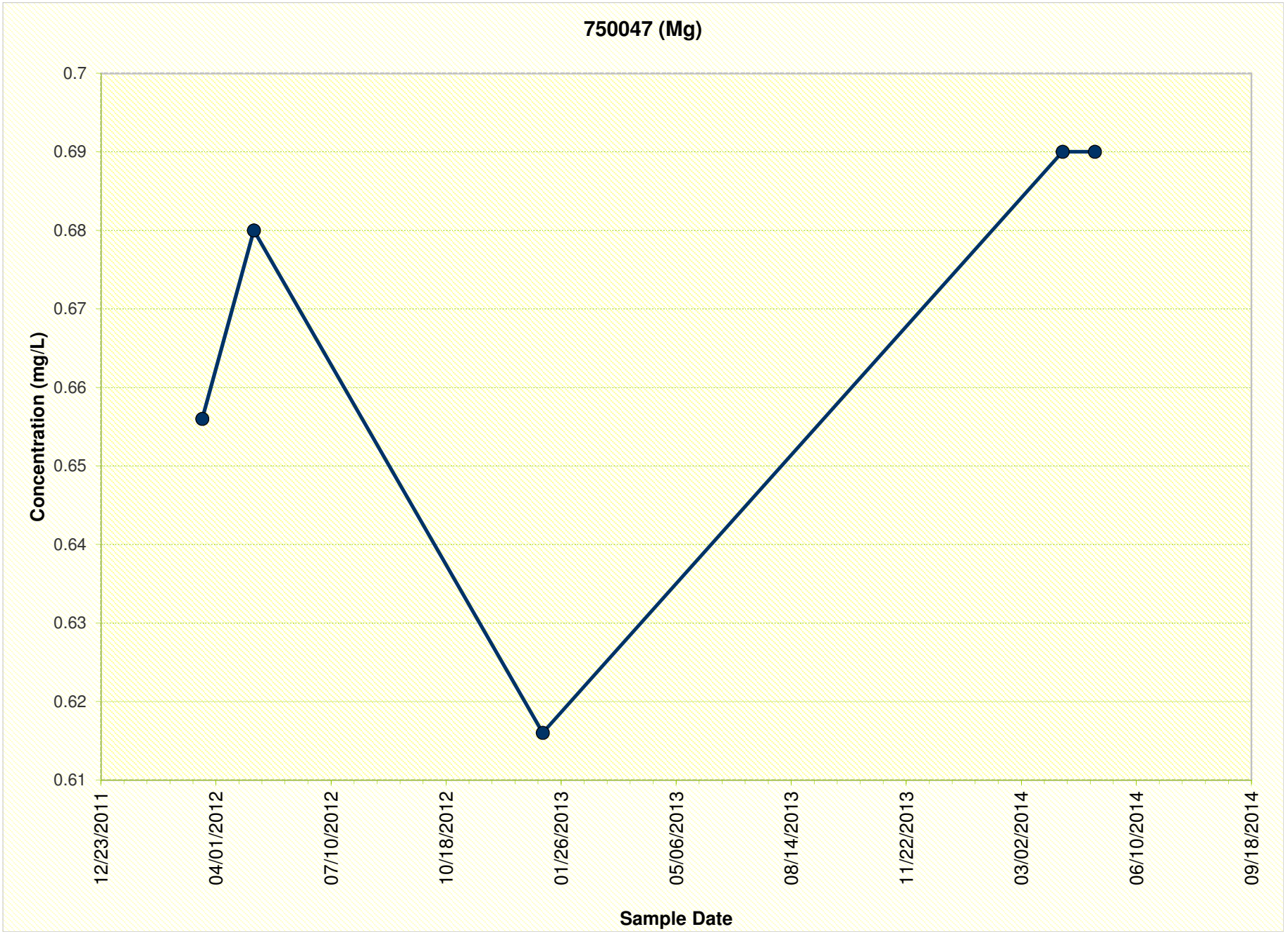

750047 (Cl)
120
100
80
60
40
20
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

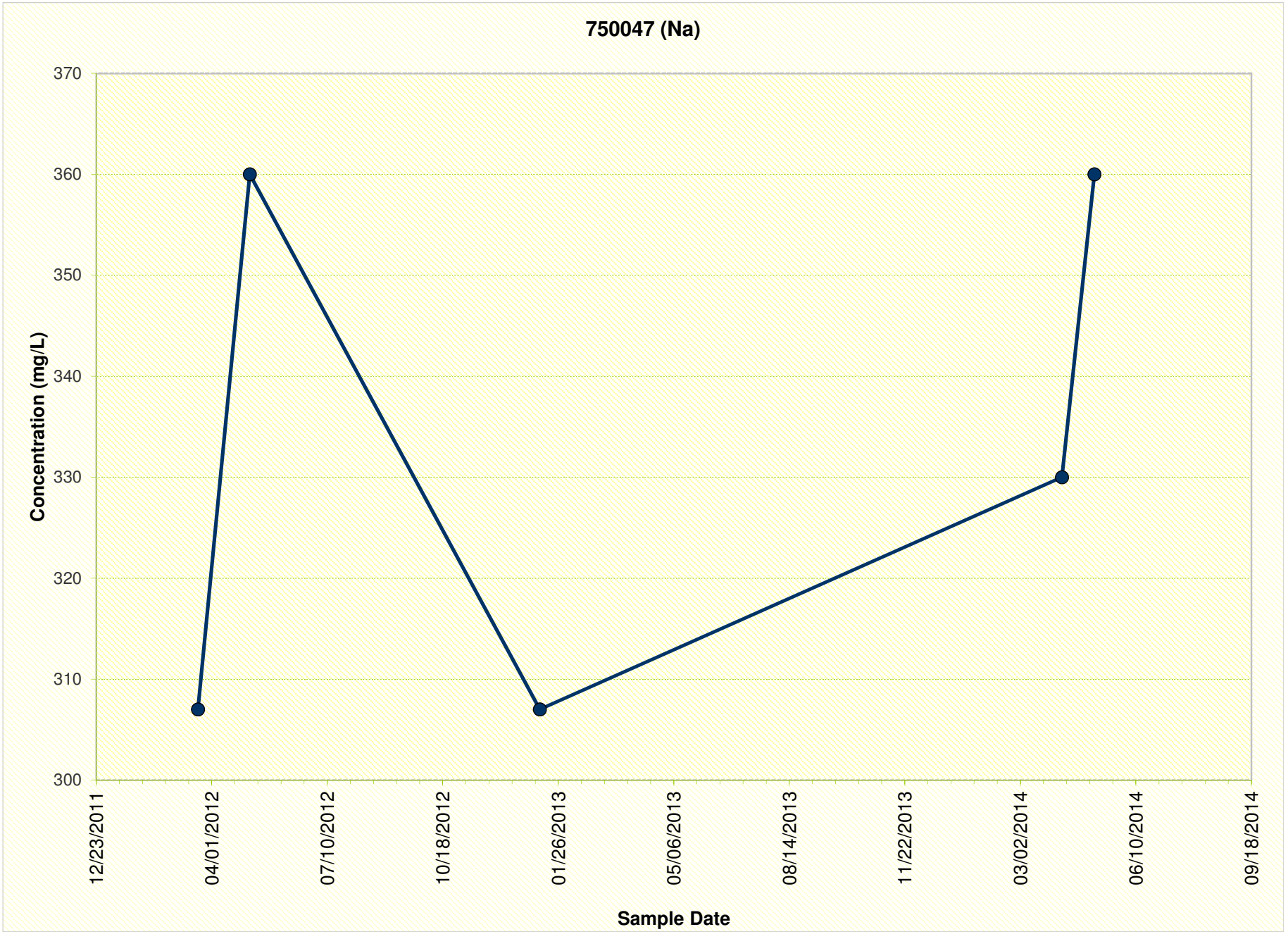

750047 (CO3)
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

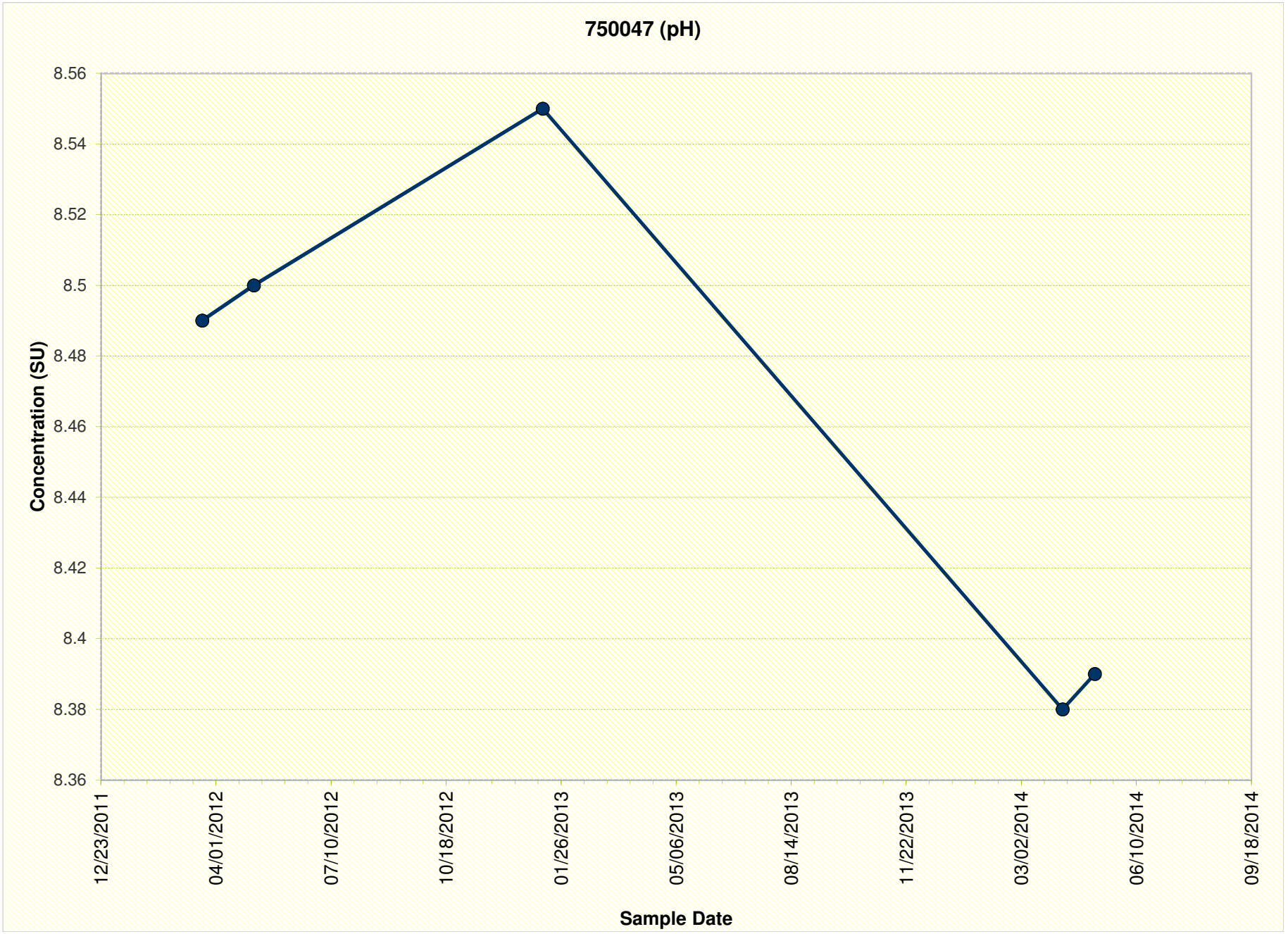

750047 (HCO3)
700
600
500
400
300
200
100
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

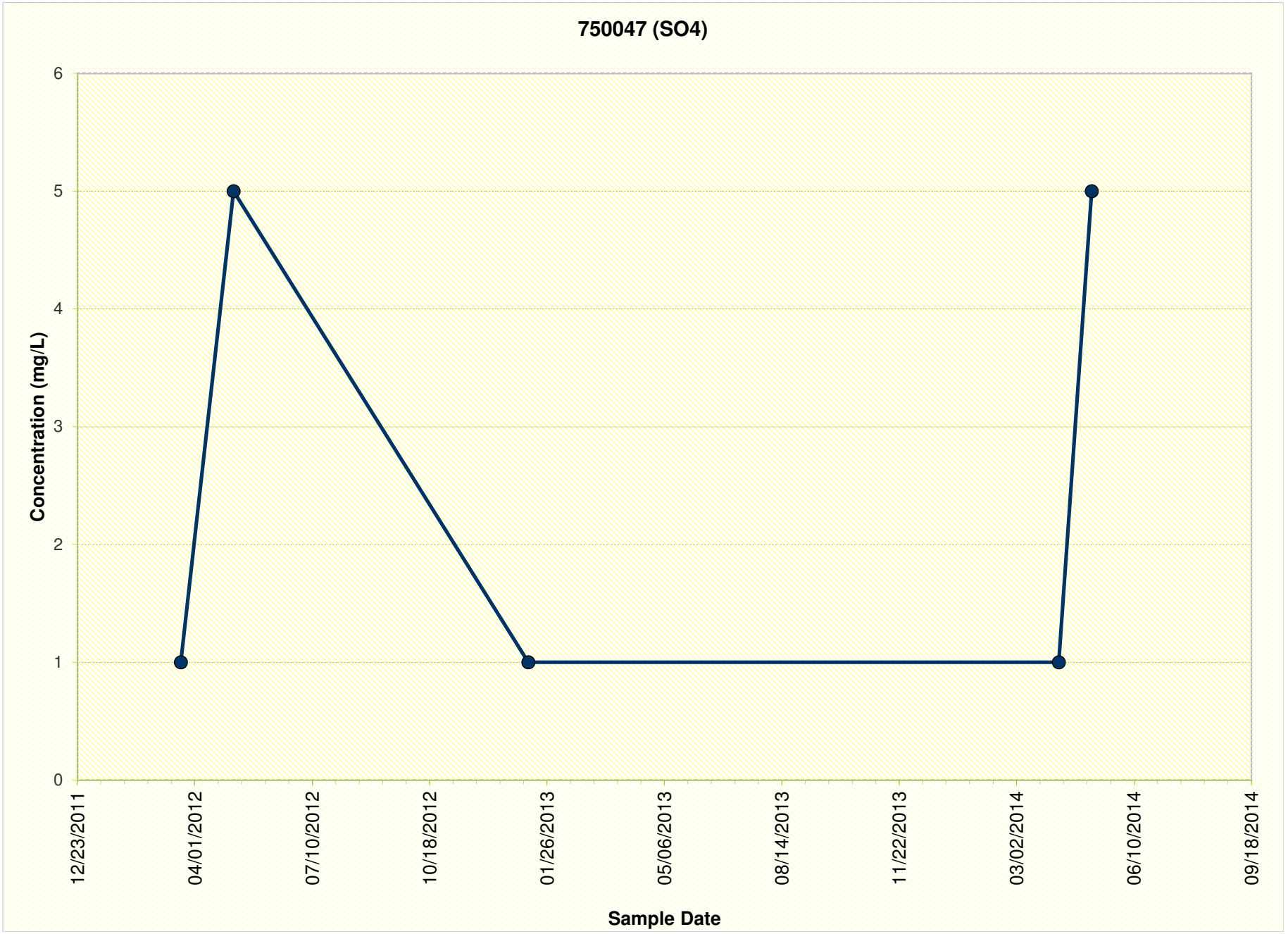

750047 (K)
Concentration (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

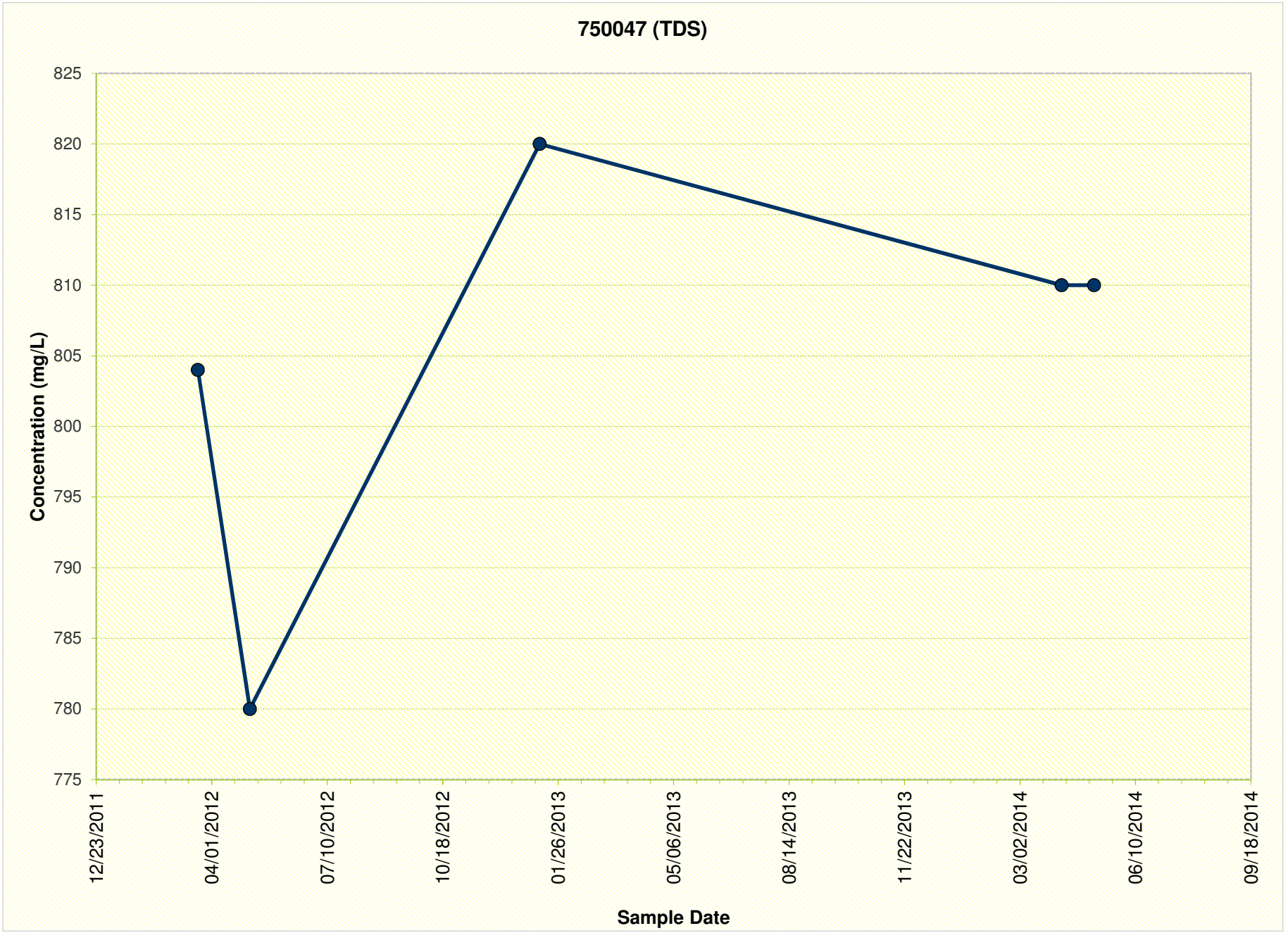

750047 (Methane)
Concentration (mg/L)
25
20
15
10
5
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

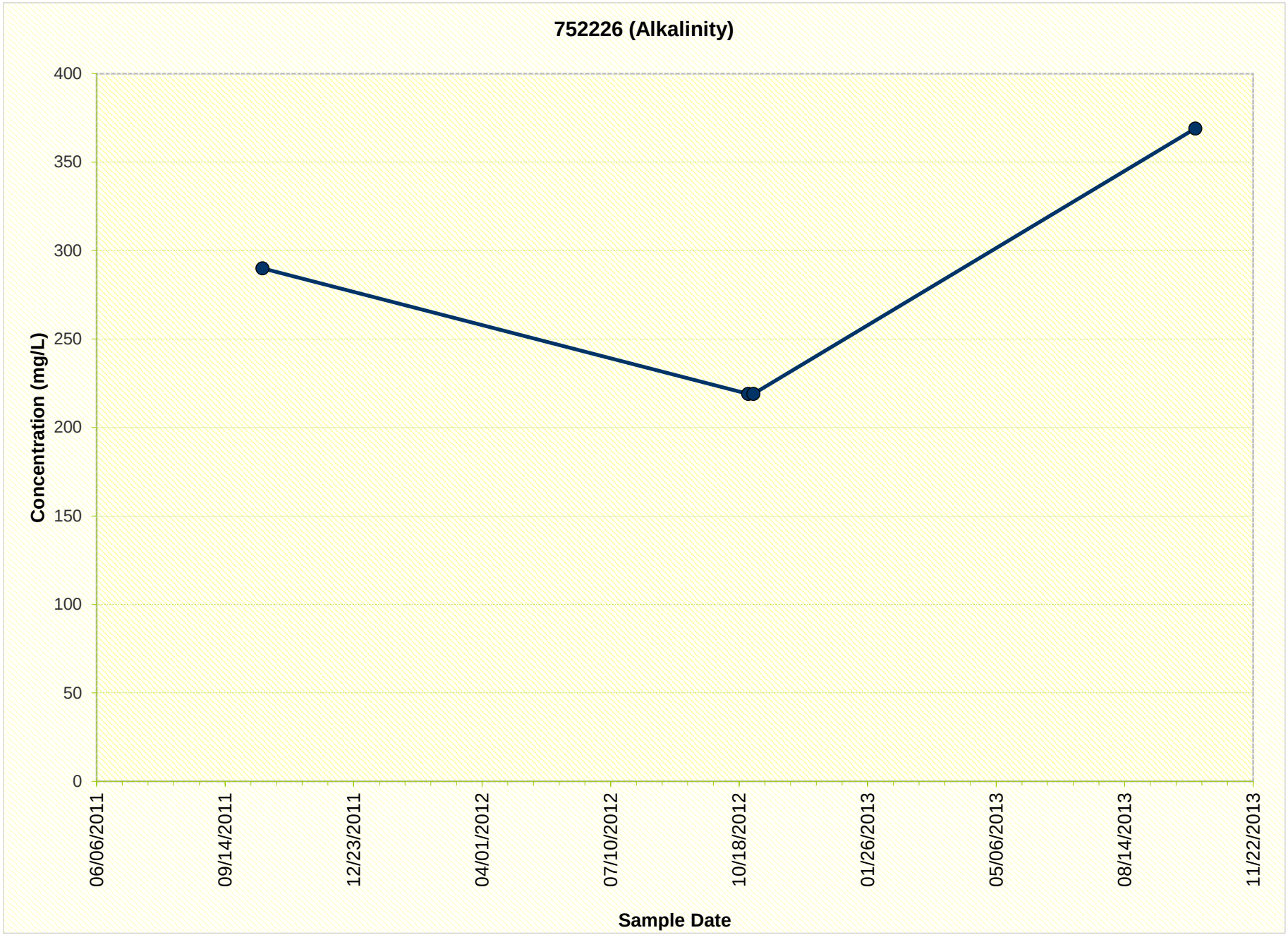

750047 (Mg)
0.7
0.69
0.68
0.67
0.66
0.65
0.64
0.63
0.62
0.61
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

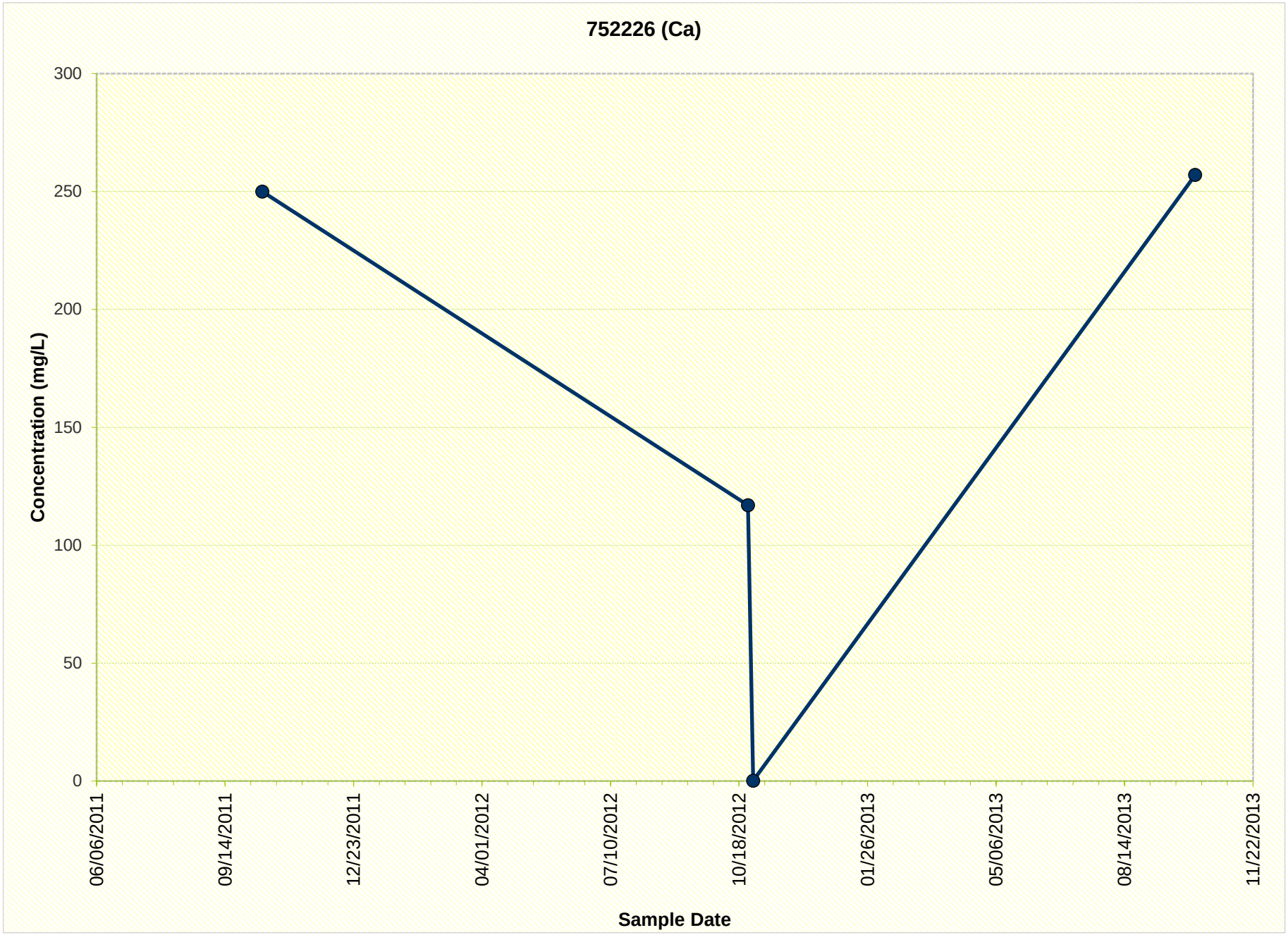

750047 (Na)
370
360
350
340
330
320
310
300
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

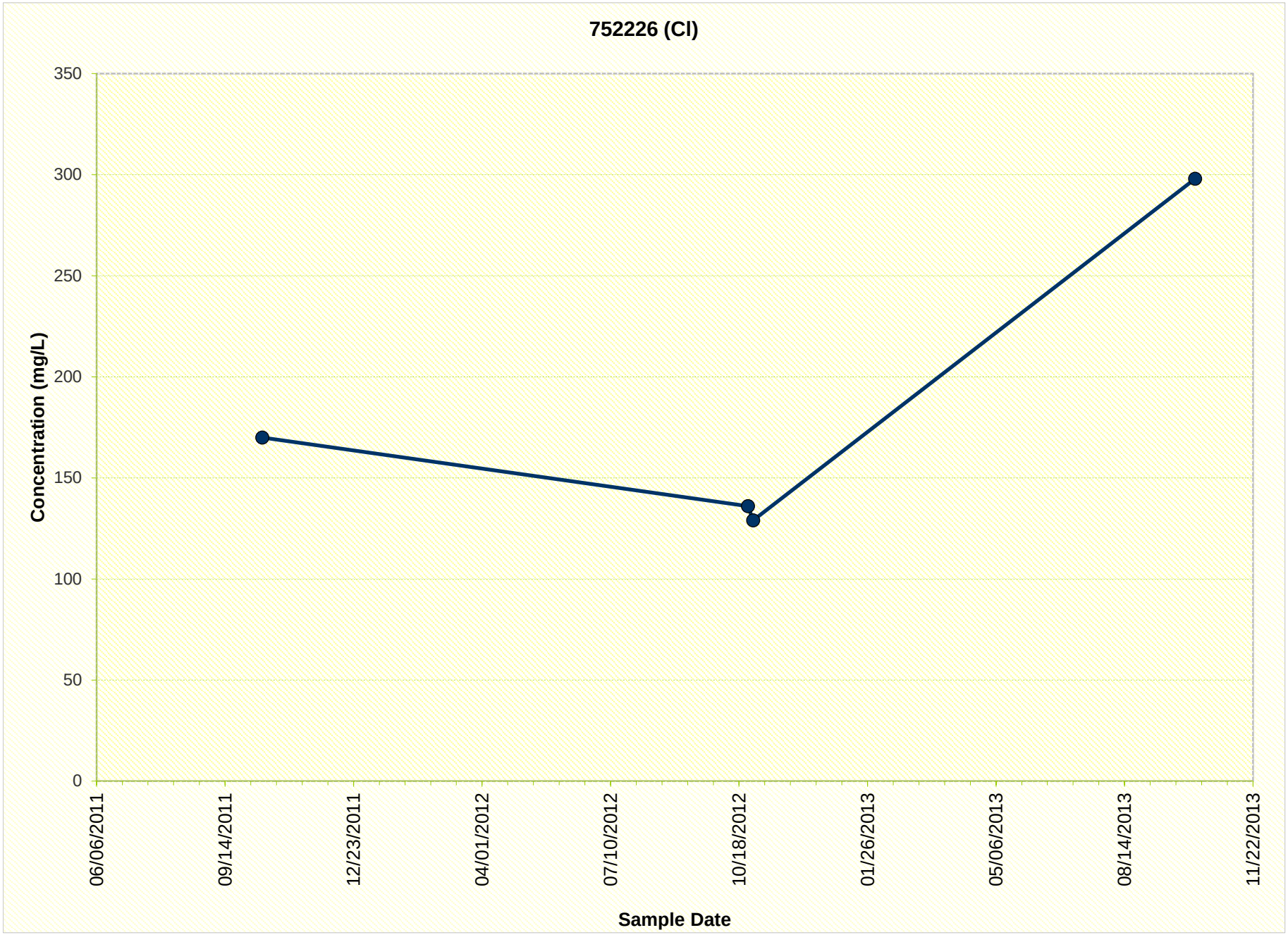

750047 (pH)
Concentration (SU)
8.56
8.54
8.52
8.5
8.48
8.46
8.44
8.42
8.4
8.38
8.36
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

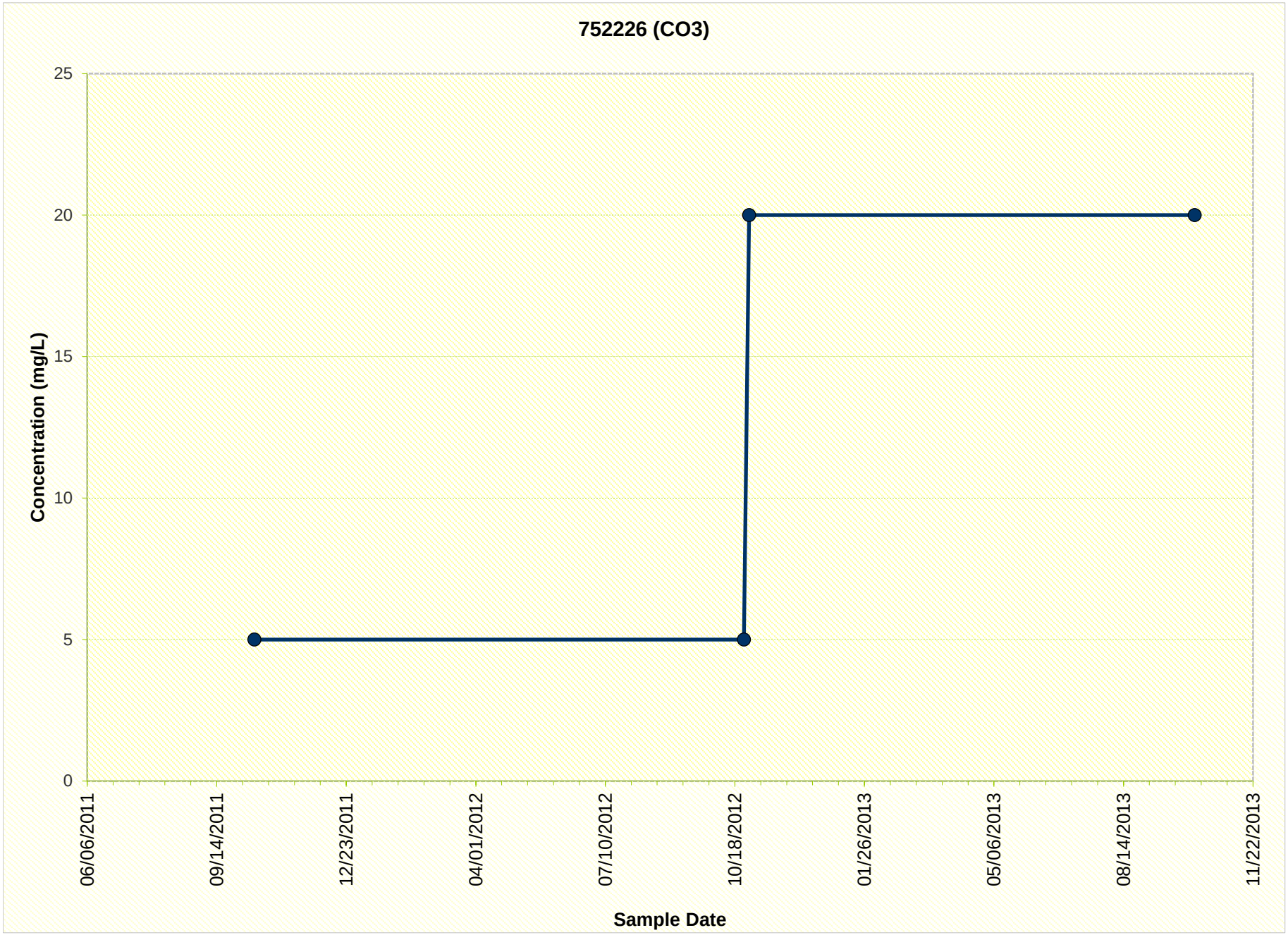

750047 (SO4)
Concentration (mg/L)
0
1
2
3
4
5
6
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

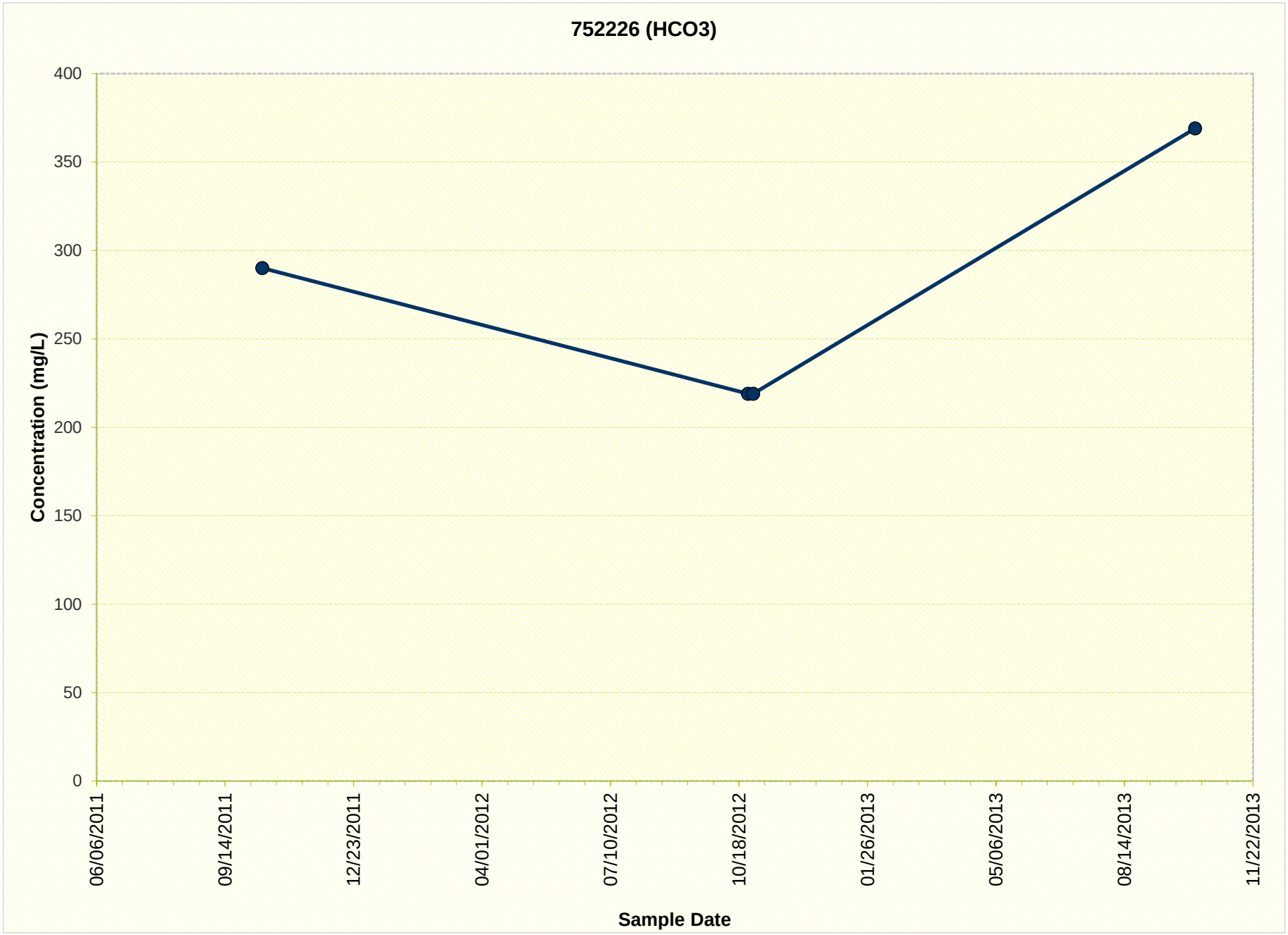

750047 (TDS)
825
820
815
810
805
800
795
790
785
780
775
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
Sample Date

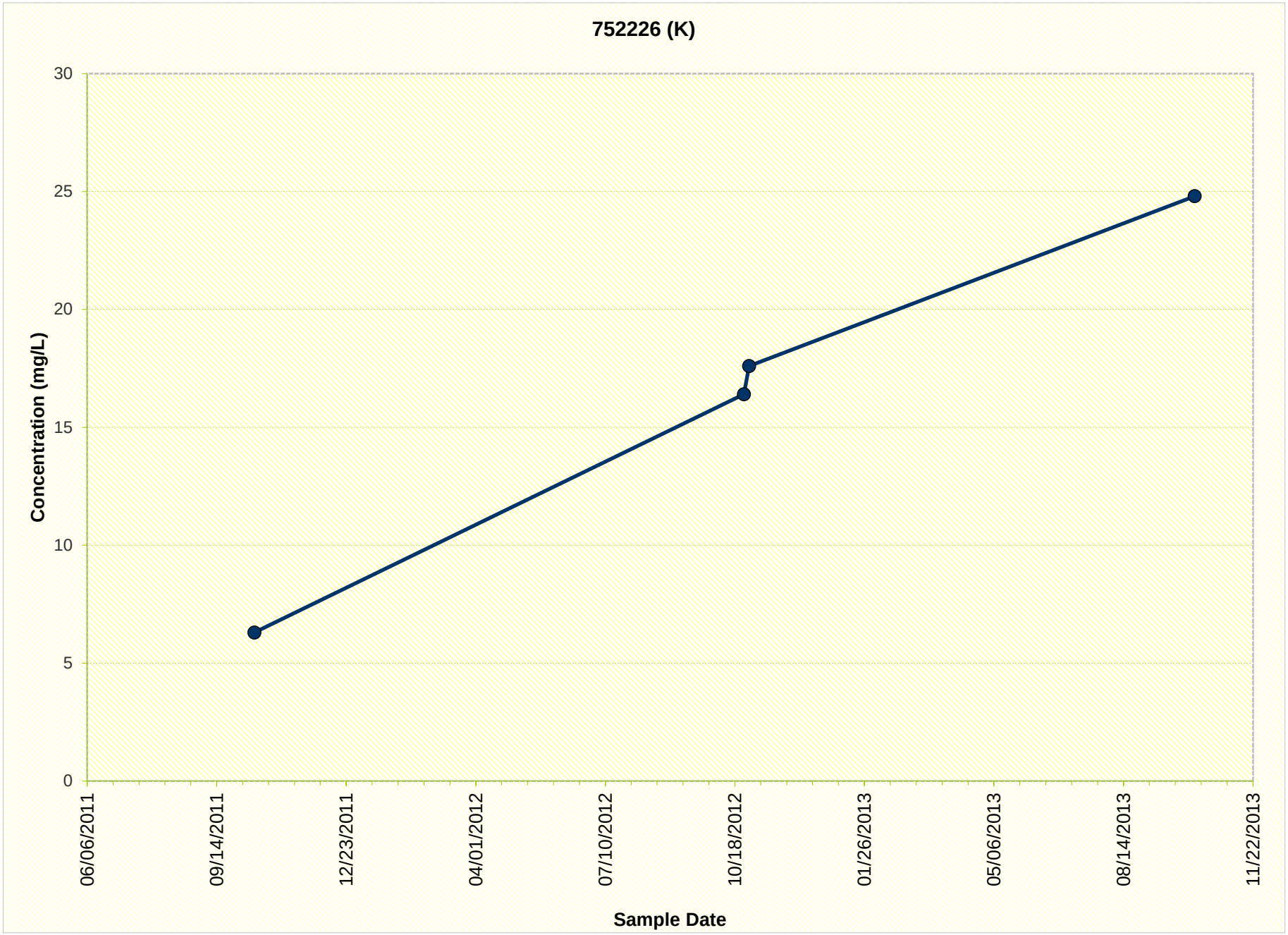

752226 (Alkalinity)
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

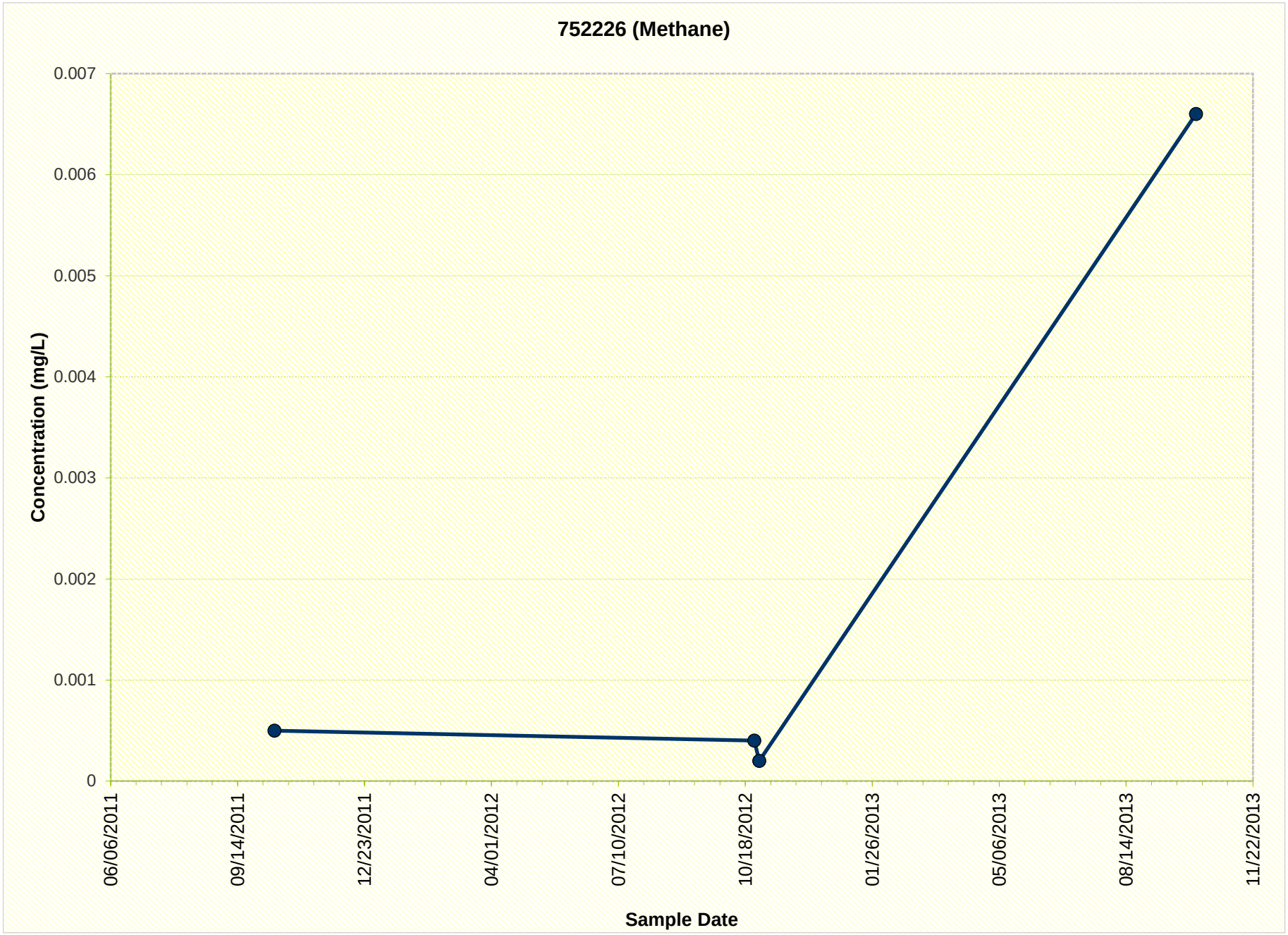

752226 (Ca)
300
250
200
150
100
50
0
Concentration (mg/L)
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

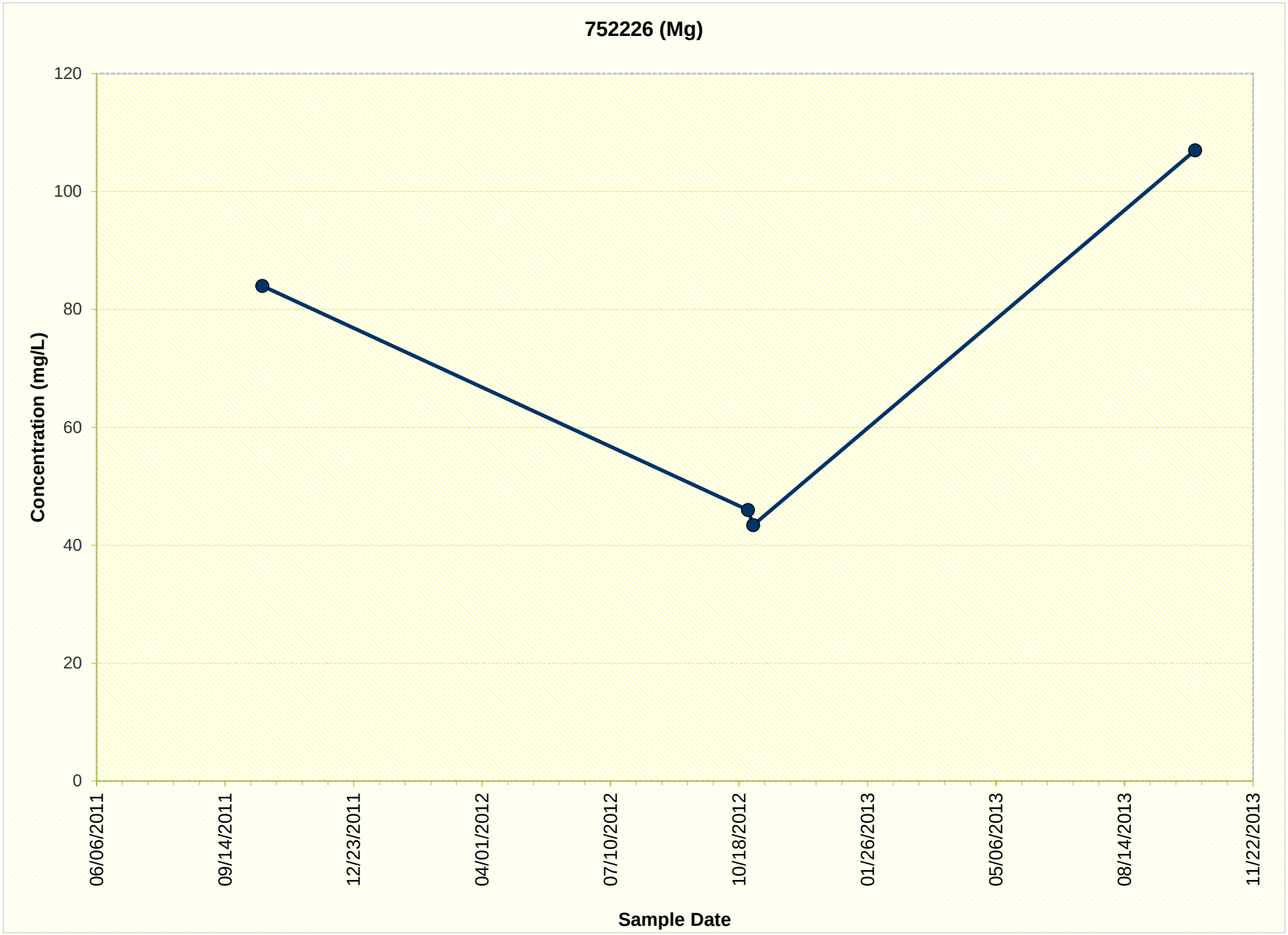

752226 (Cl)
Concentration (mg/L)
350
300
250
200
150
100
50
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

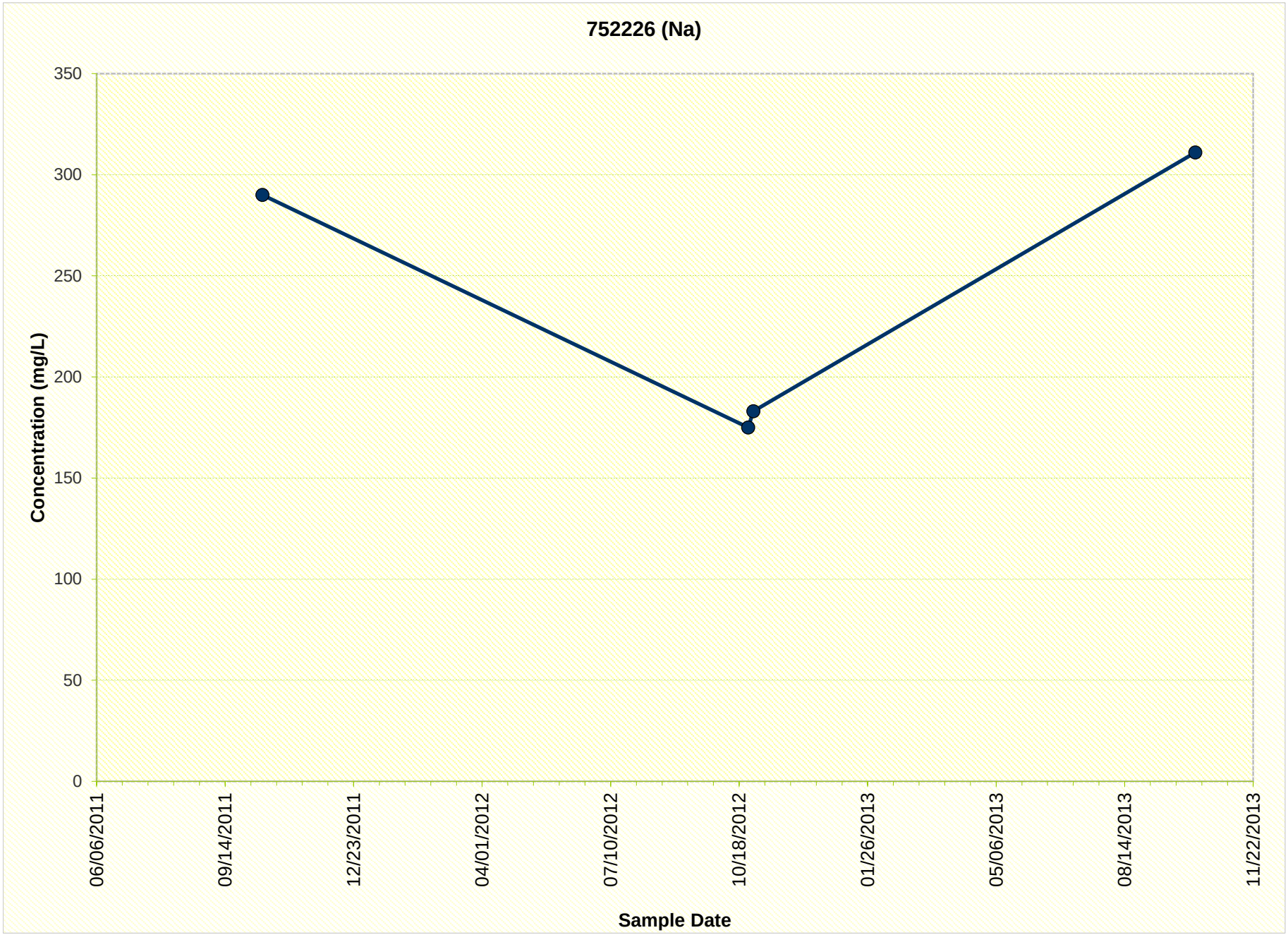

752226 (CO3)
Concentration (mg/L)
25
20
15
10
5
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

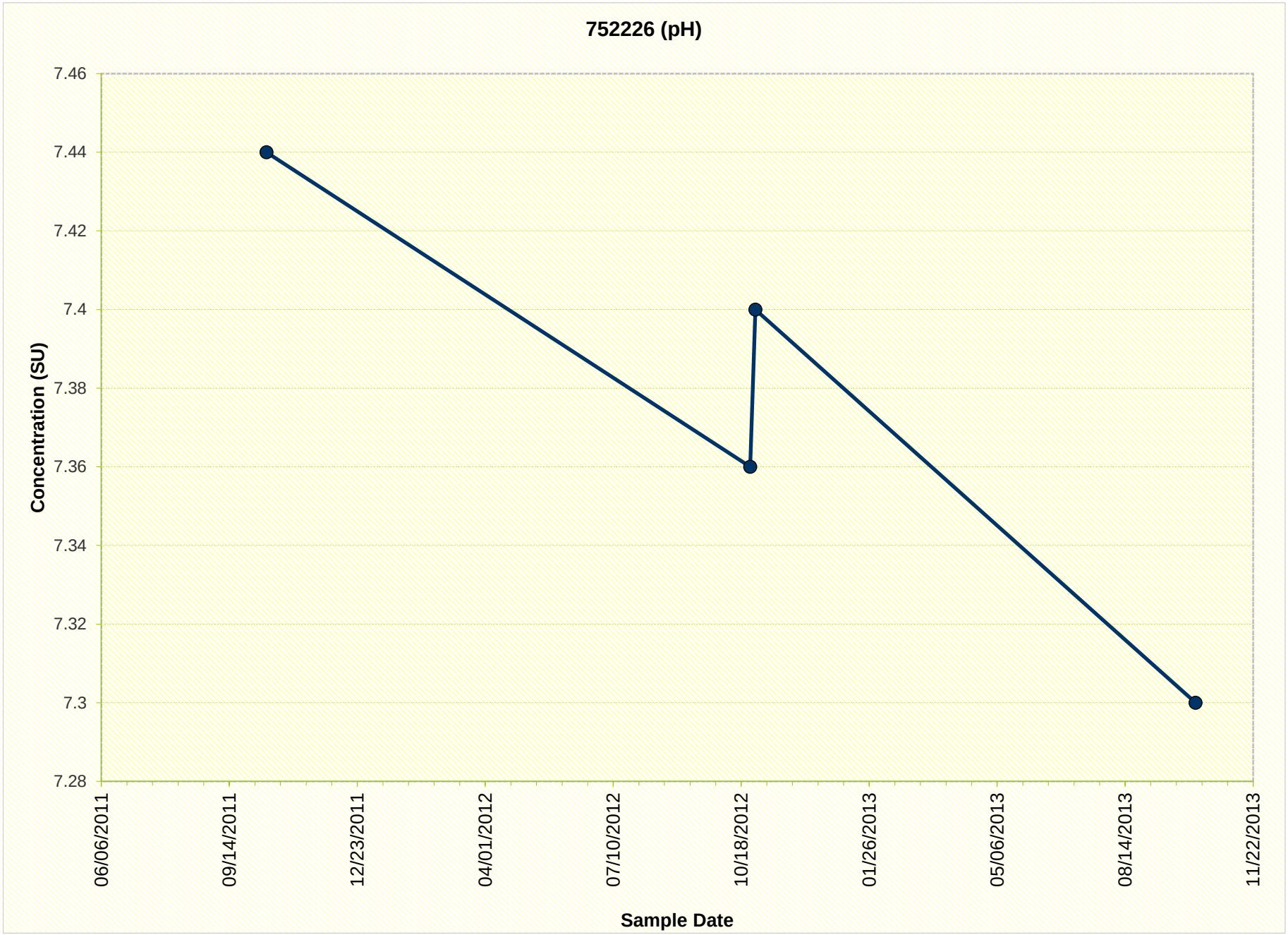

752226 (HCO3)
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

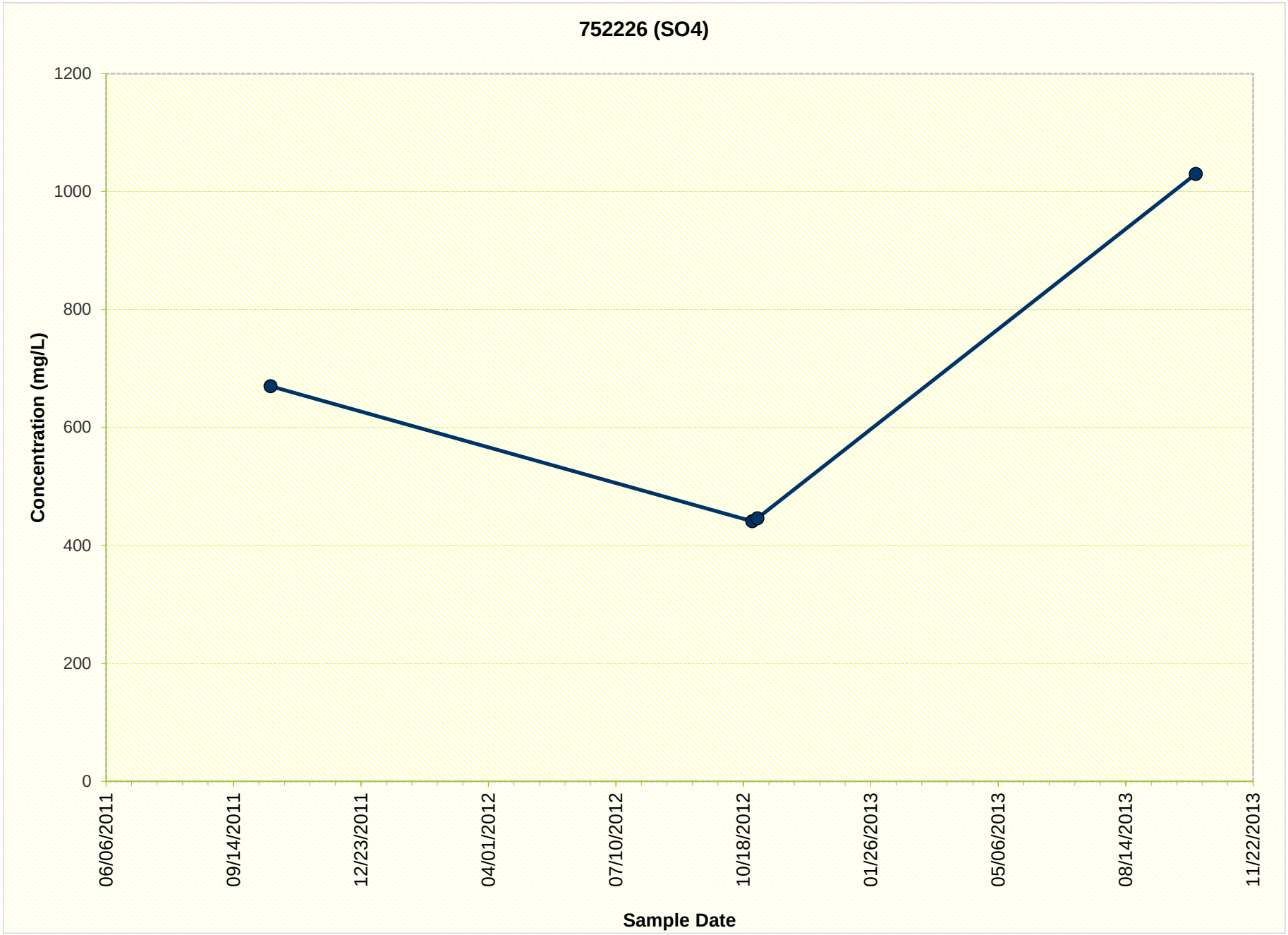

752226 (K)
Concentration (mg/L)
30
25
20
15
10
5
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

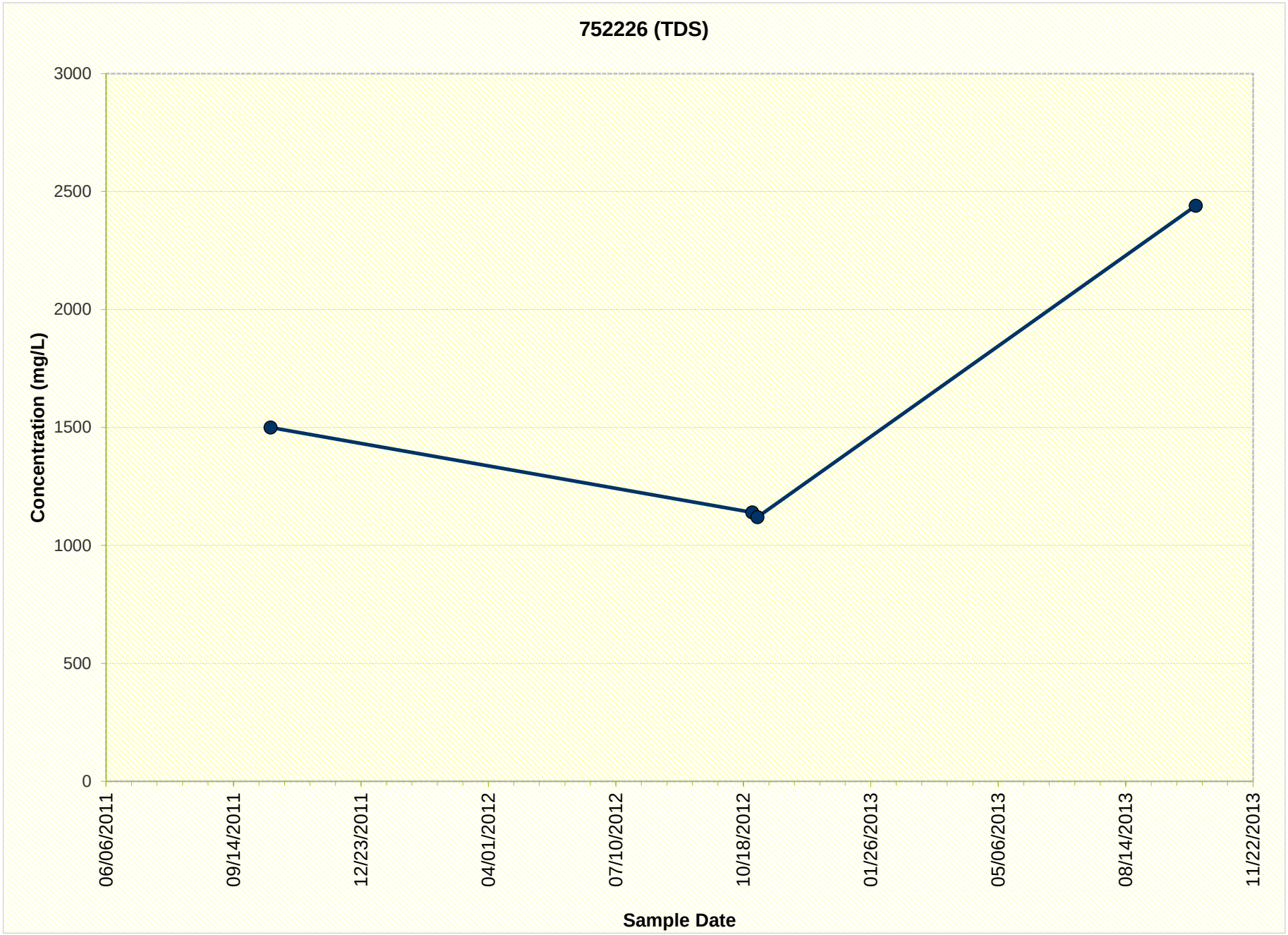

752226 (Methane)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Concentration (mg/L)
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

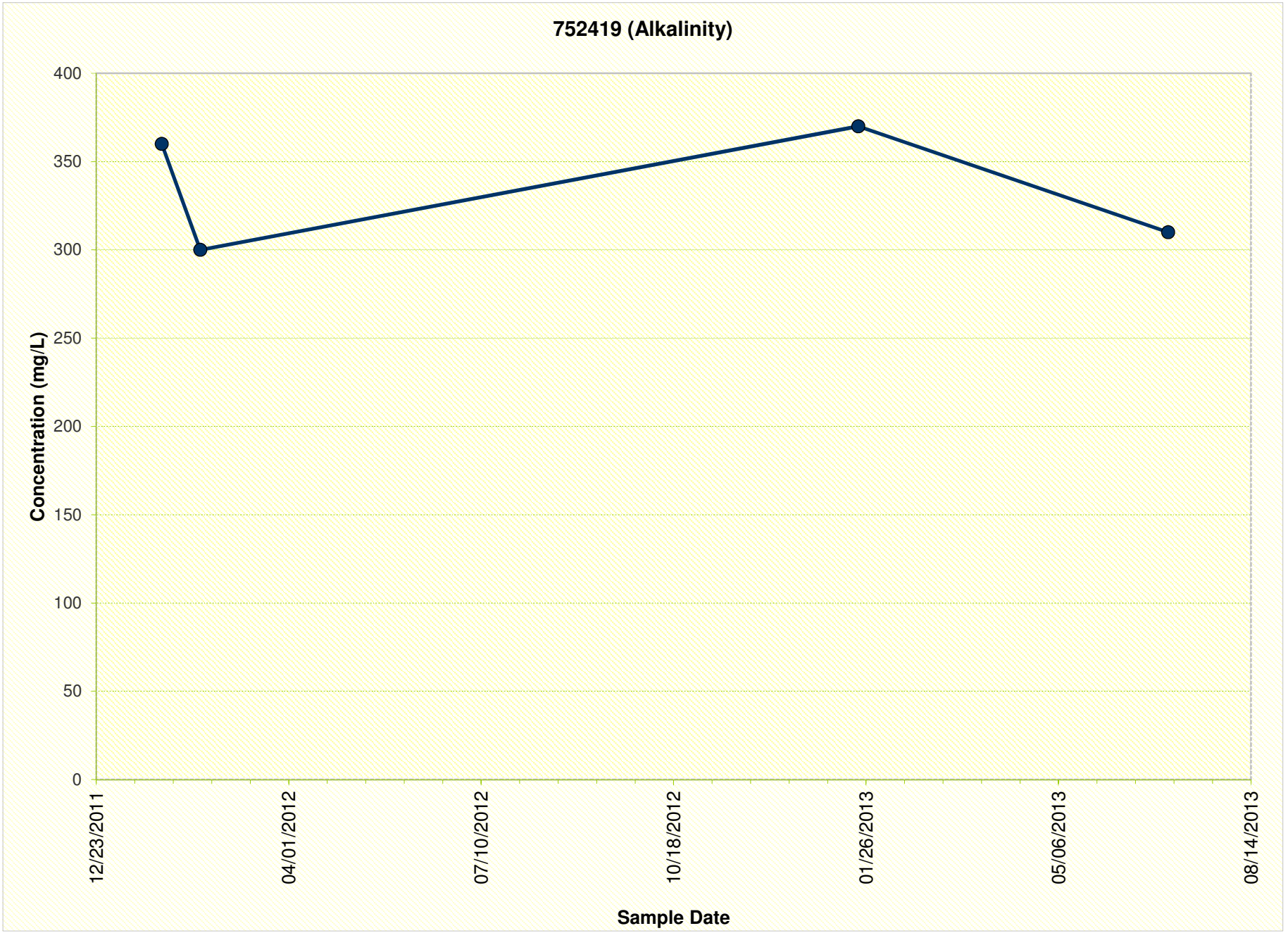

752226 (Mg)
120
100
80
60
40
20
0
Concentration (mg/L)
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

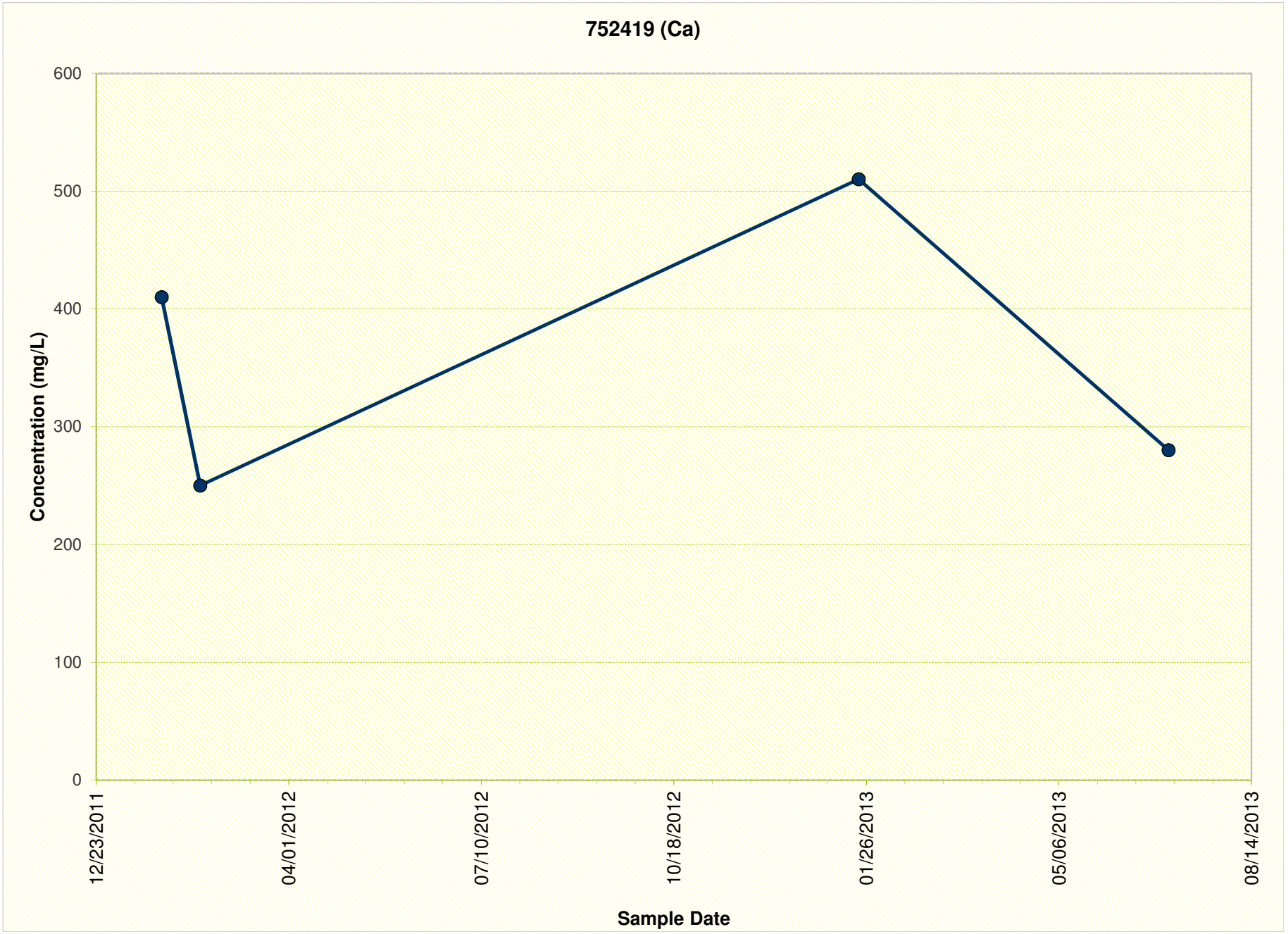

752226 (Na)
Concentration (mg/L)
350
300
250
200
150
100
50
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

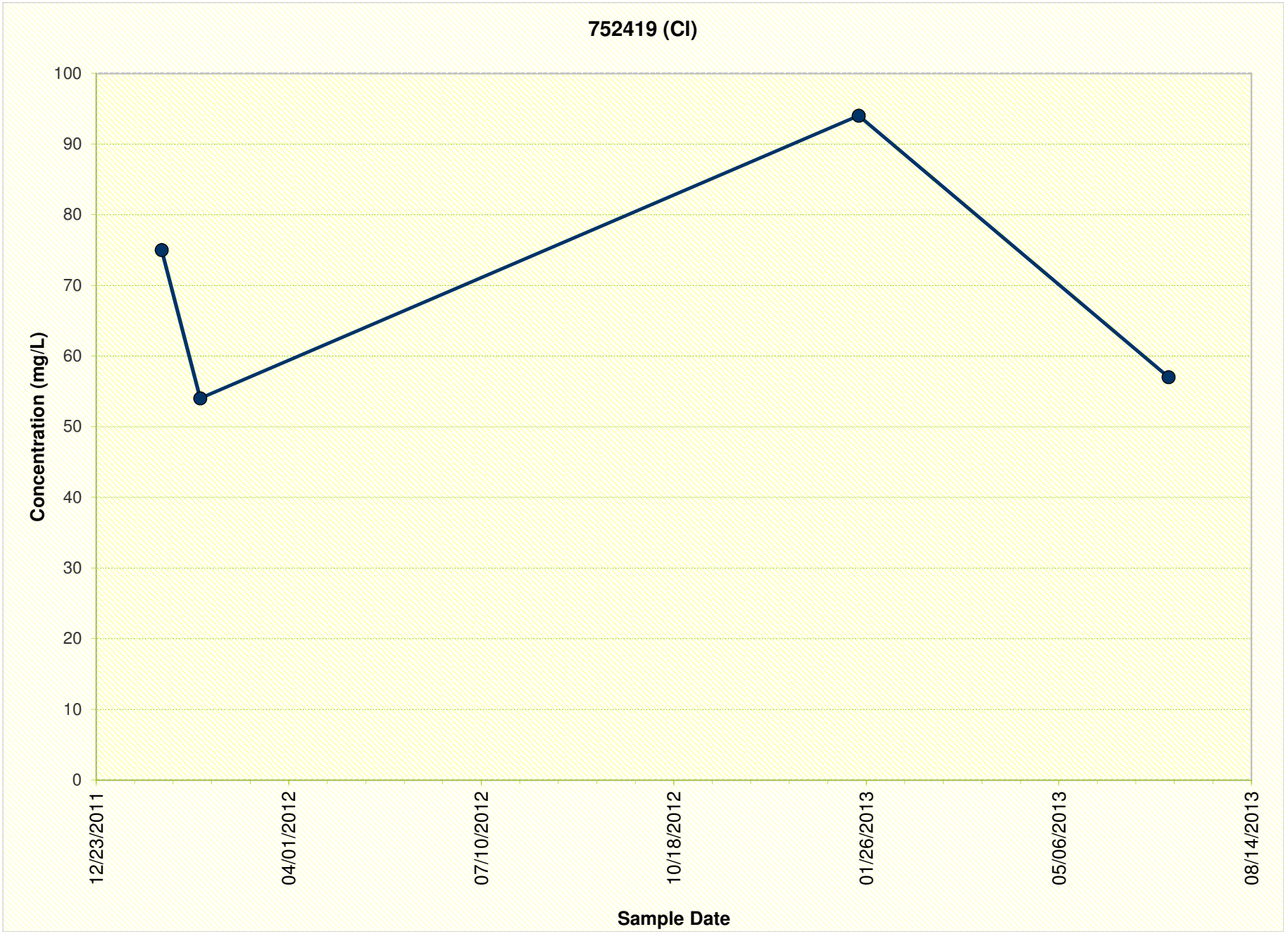

752226 (pH)
Concentration (SU)
7.46
7.44
7.42
7.4
7.38
7.36
7.34
7.32
7.3
7.28
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

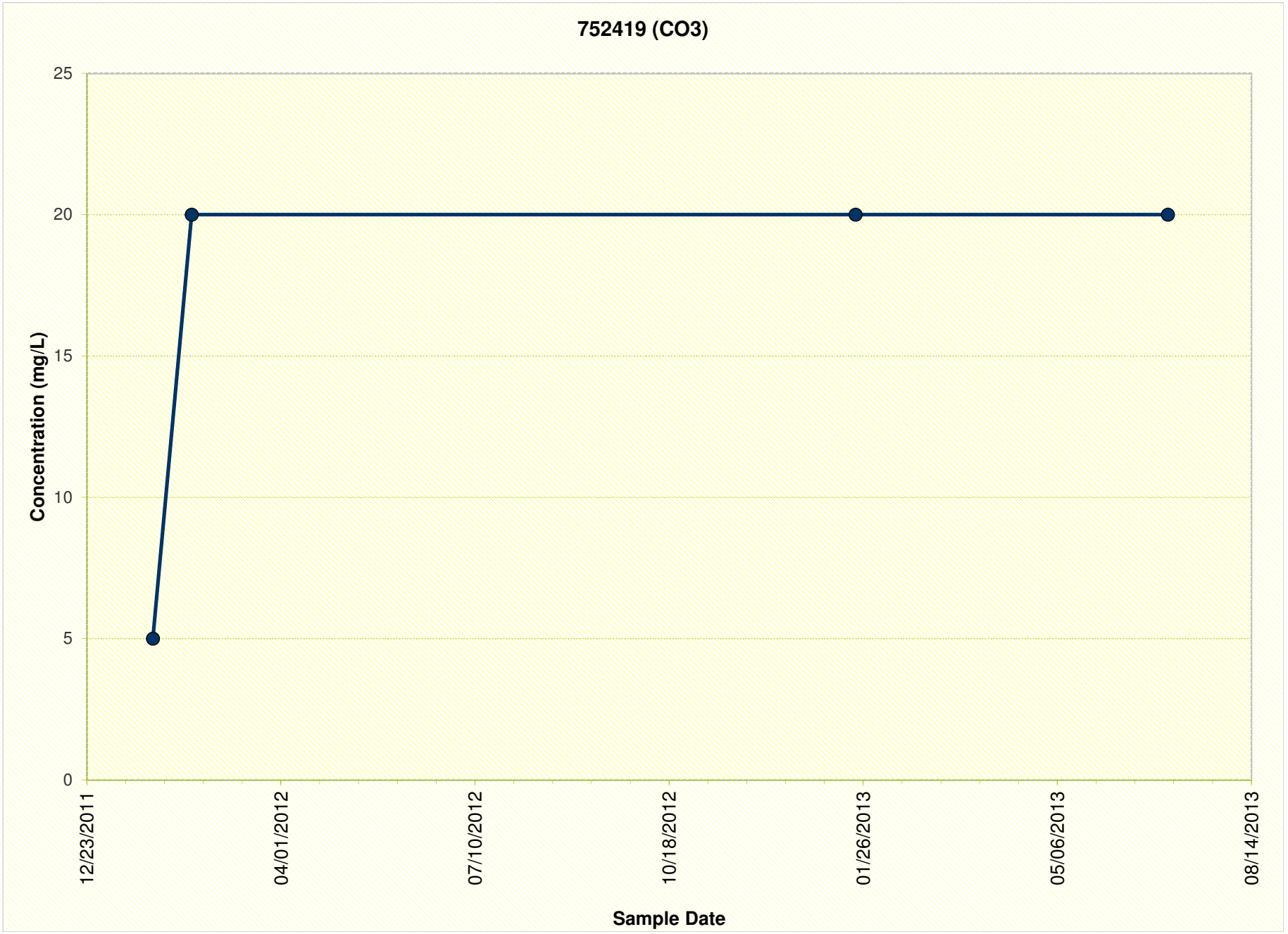

752226 (SO4)
1200
1000
800
600
400
200
0
Concentration (mg/L)
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

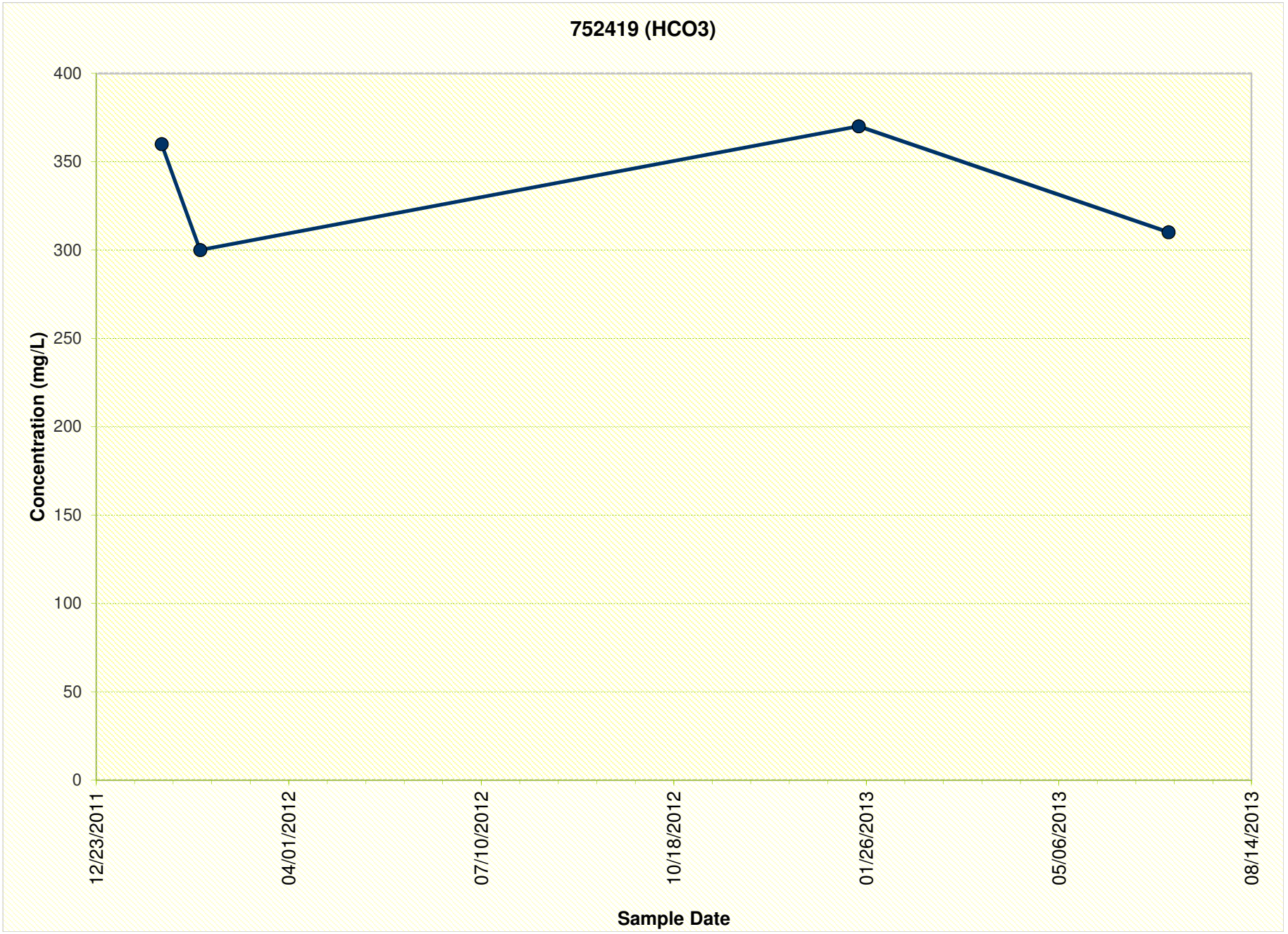

752226 (TDS)
Concentration (mg/L)
3000
2500
2000
1500
1000
500
0
06/06/2011
09/14/2011
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

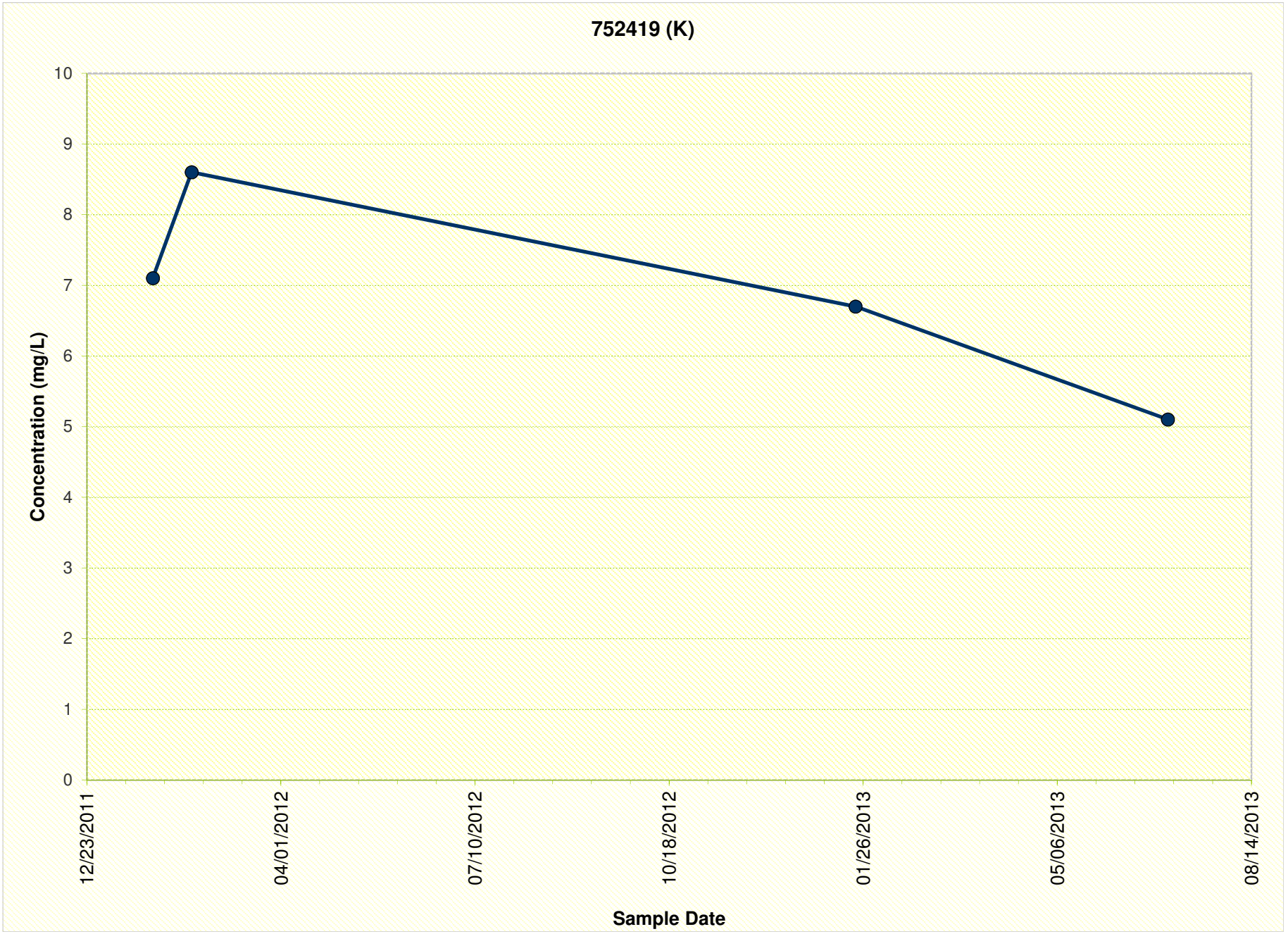

752419 (Alkalinity)
400
350
300
250
200
150
100
50
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

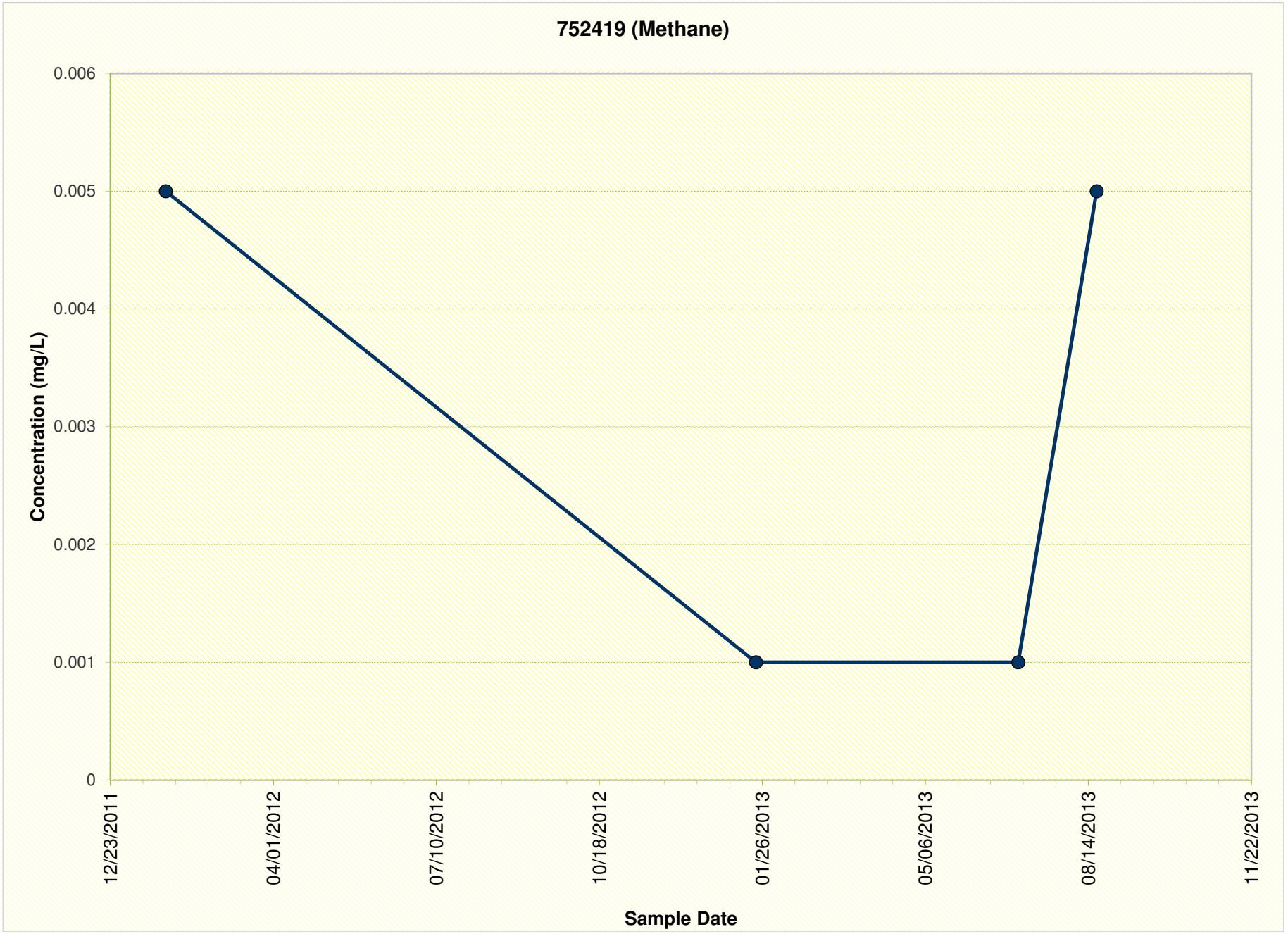

752419 (Ca)
600
500
400
300
200
100
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

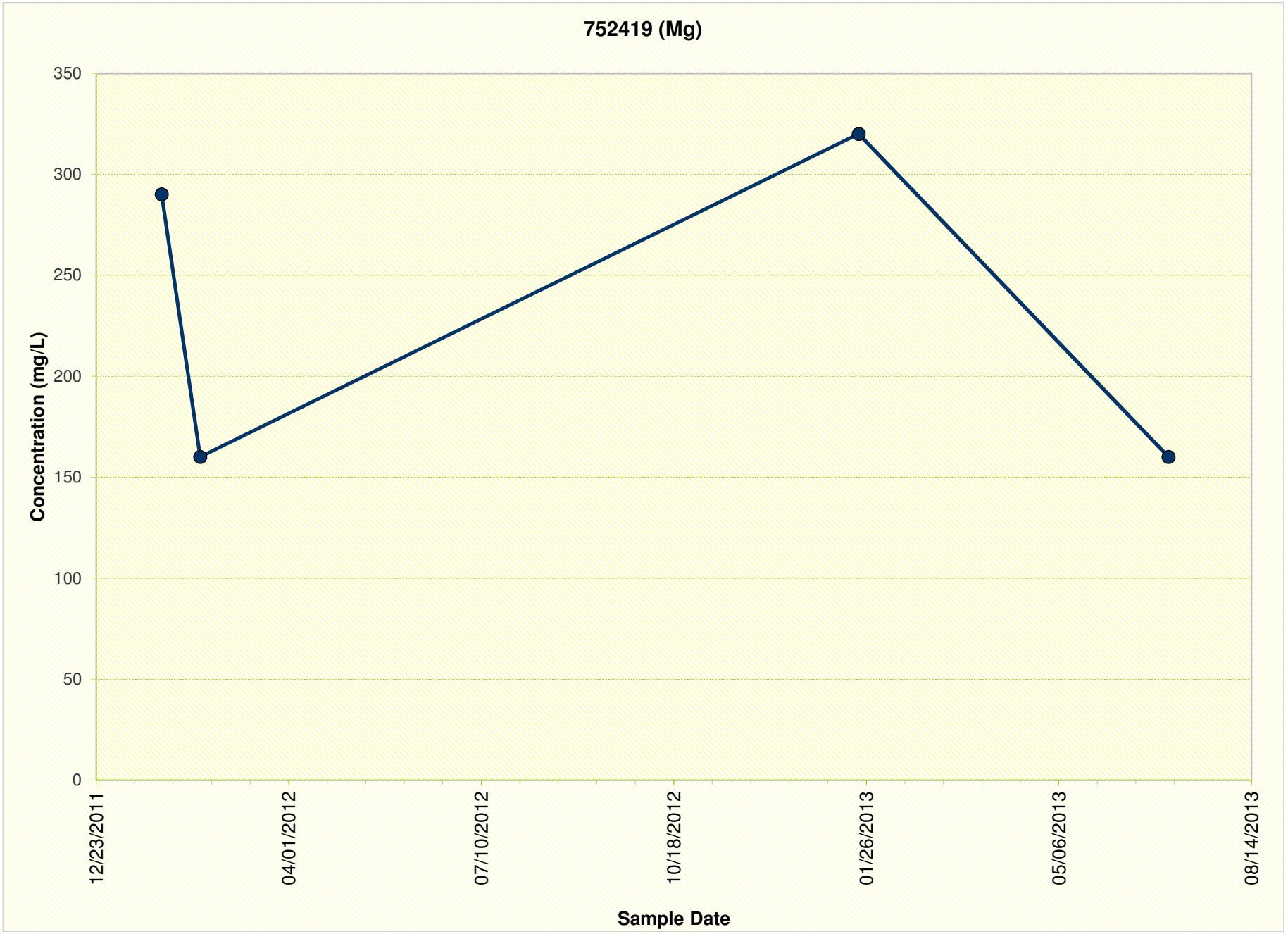

752419 (Cl)
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

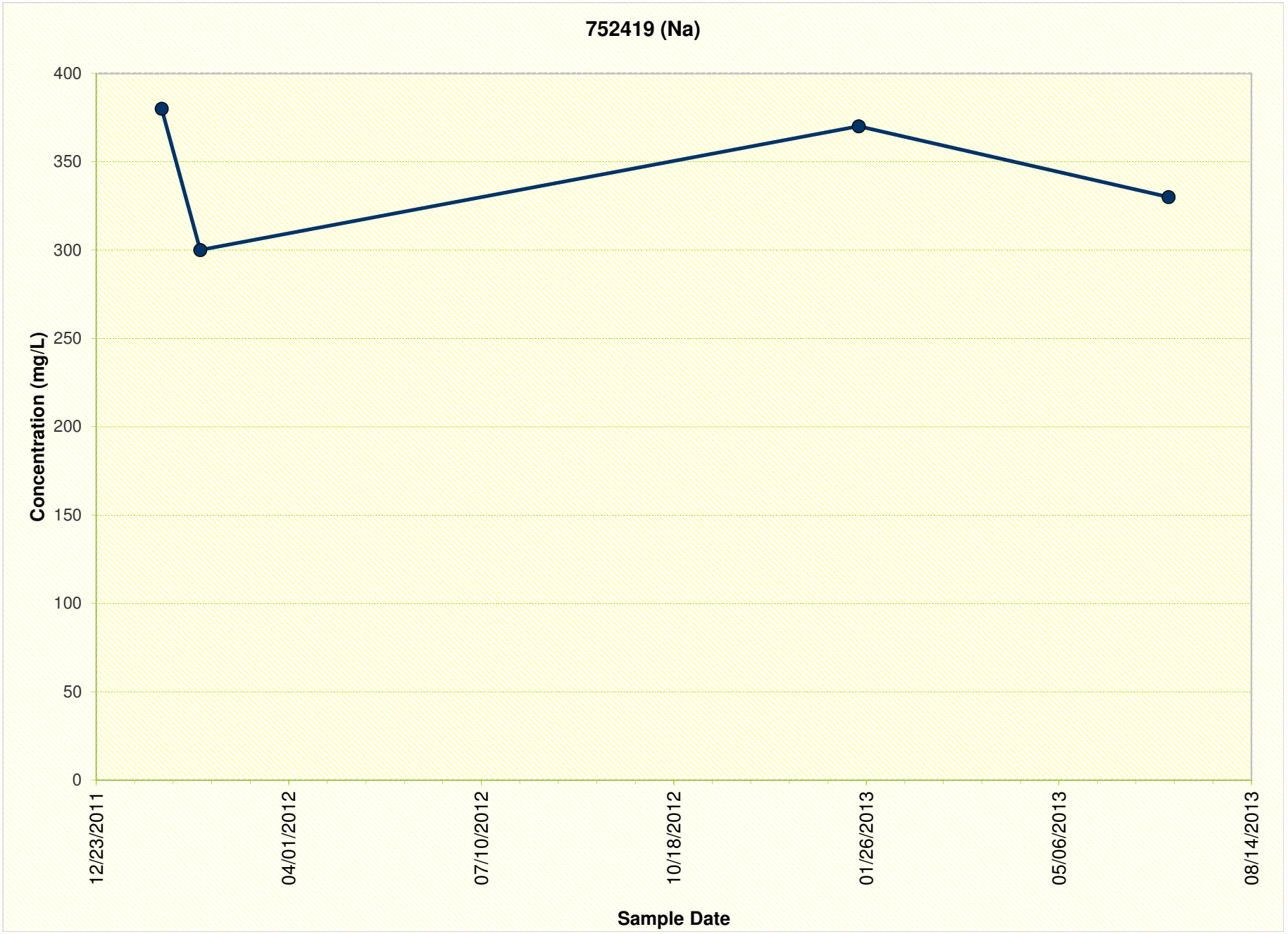

752419 (CO3)
25
20
15
10
5
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

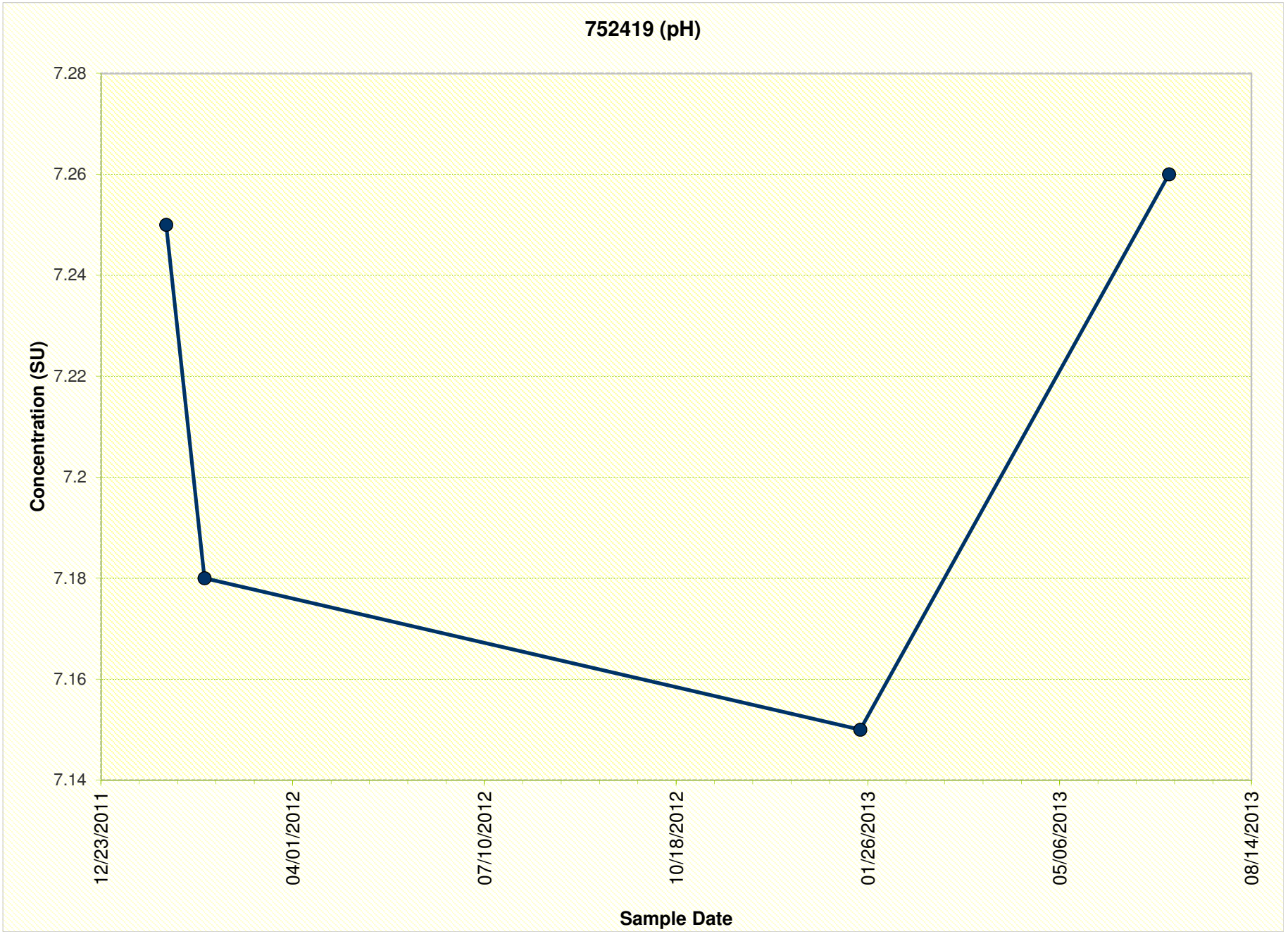

752419 (HCO3)
400
350
300
250
200
150
100
50
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

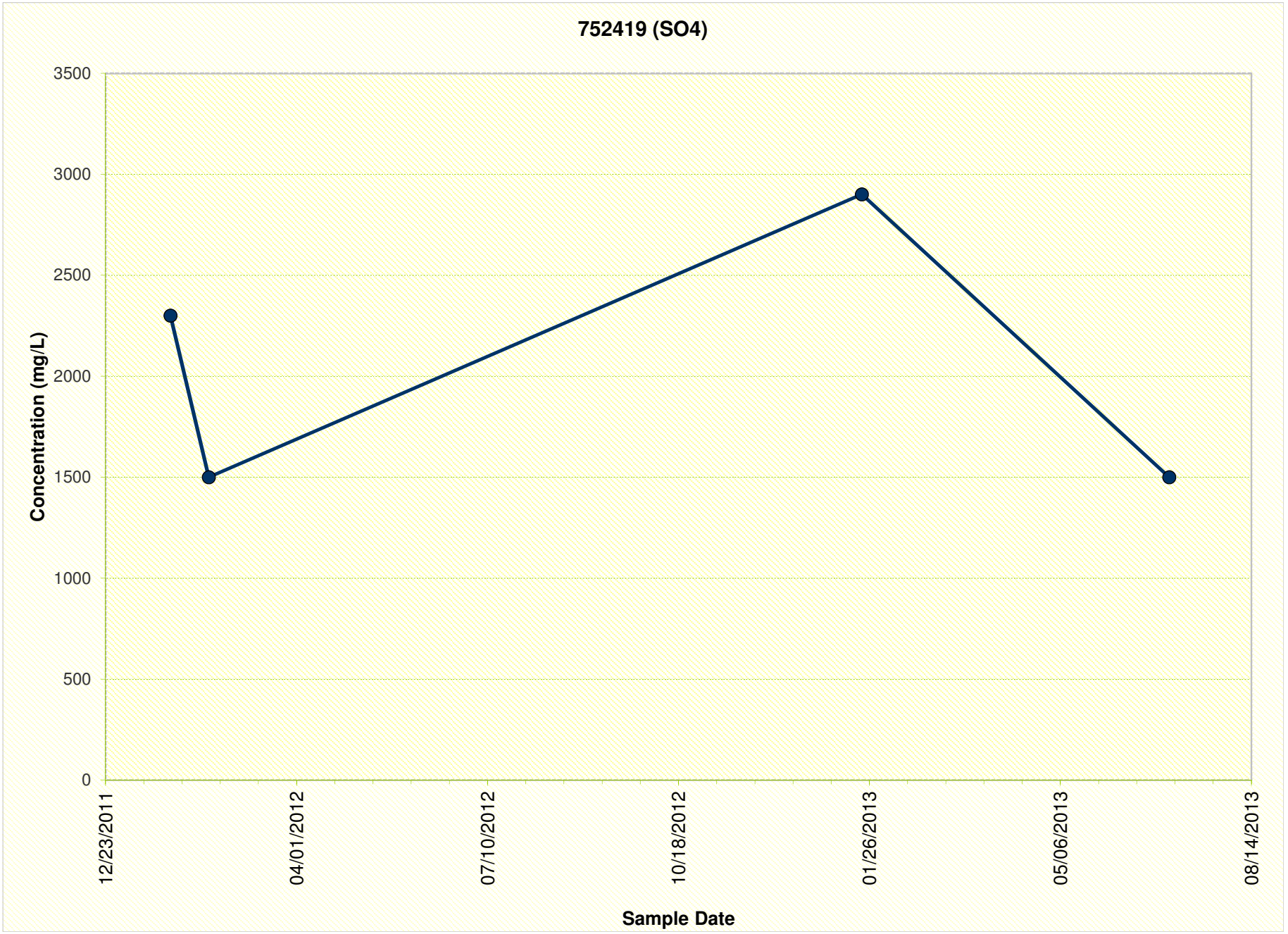

752419 (K)
Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

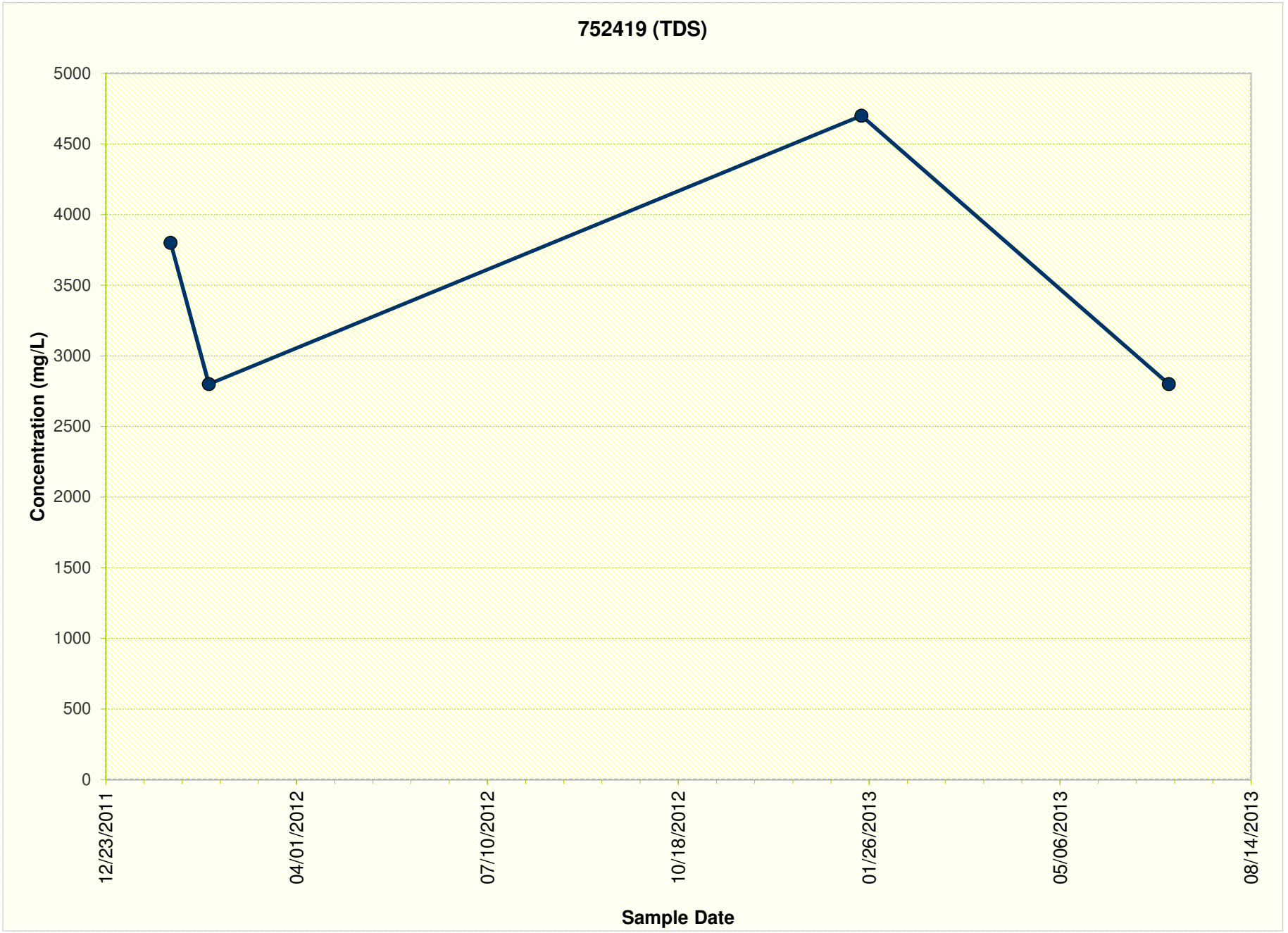

752419 (Methane)
0.006
0.005
0.004
0.003
0.002
0.001
0
Concentration (mg/L)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
11/22/2013
Sample Date

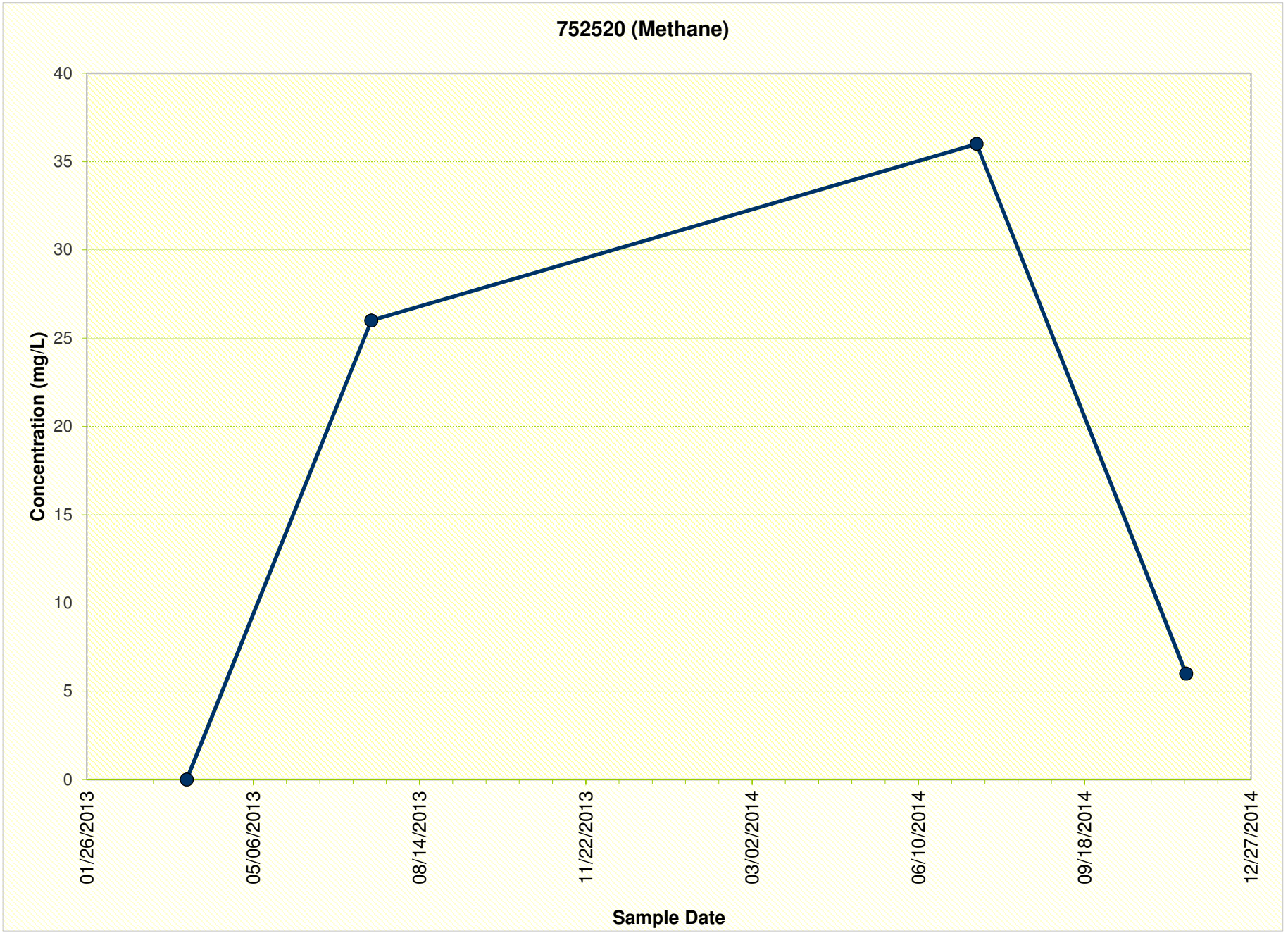

752419 (Mg)
Concentration (mg/L)
350
300
250
200
150
100
50
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date

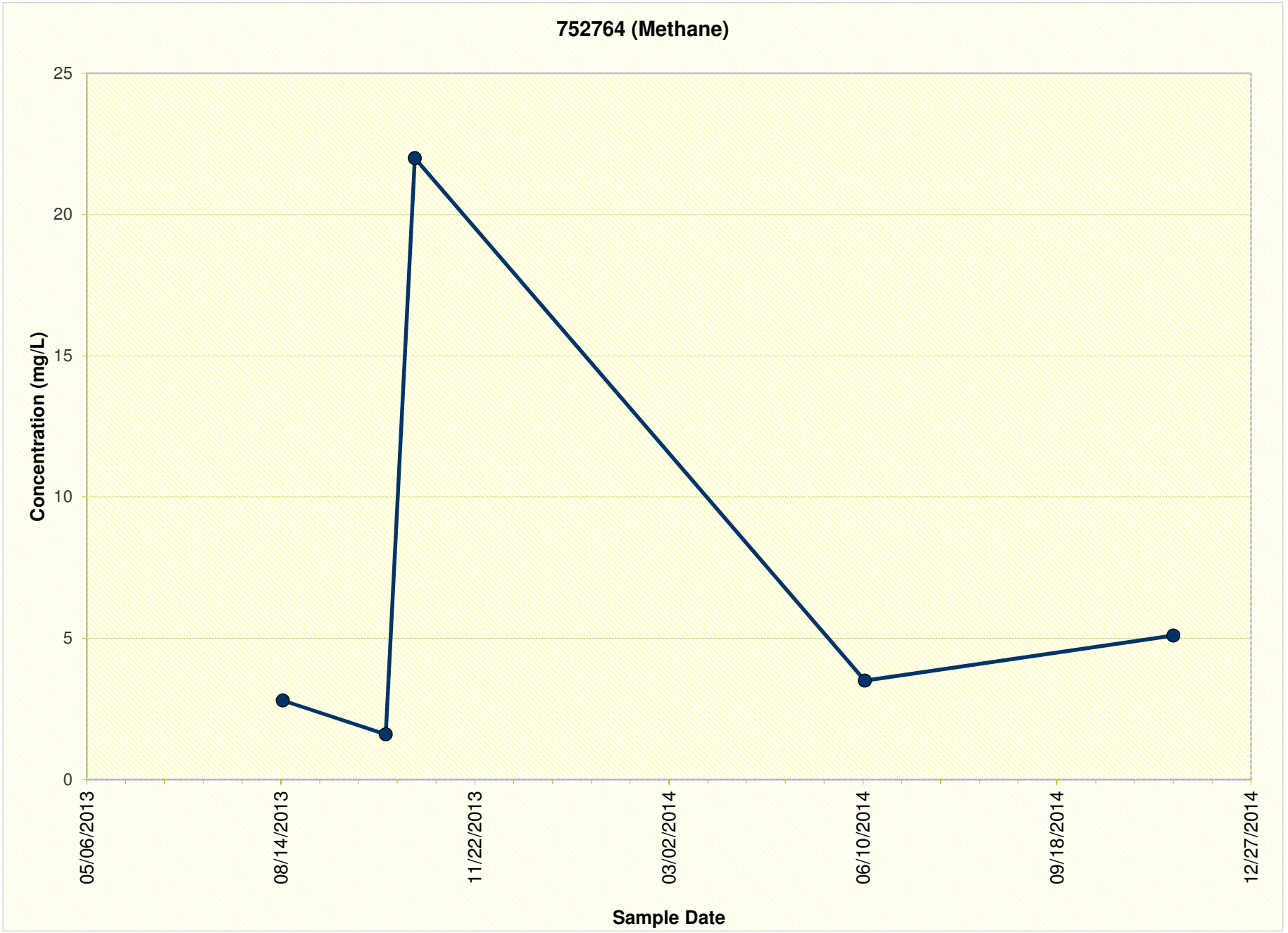

752419 (Na)
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date


752419 (pH)
7.28
7.26
7.24
7.22
7.2
7.18
7.16
7.14
Concentration (SU)
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date


752419 (SO4)
Concentration (mg/L)
3500
3000
2500
2000
1500
1000
500
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date


752419 (TDS)
Concentration (mg/L)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
12/23/2011
04/01/2012
07/10/2012
10/18/2012
01/26/2013
05/06/2013
08/14/2013
Sample Date


752520 (Methane)
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
01/26/2013
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
12/27/2014
Sample Date


752764 (Methane)
Concentration (mg/L)
25
20
15
10
5
0
05/06/2013
08/14/2013
11/22/2013
03/02/2014
06/10/2014
09/18/2014
12/27/2014
Sample Date

APPENDIX B

Mann-Kendall Results

APPENDIX B
MANN-KENDALL RESULTS
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte	S	N	Probability	Trend	Significance
700884	Na	3	4	0.271	Increasing	FALSE
700884	TDS	-3	4	0.271	Decreasing	FALSE
703215	Ca	2	5	0.408	Increasing	FALSE
703215	Cl	2	5	0.408	Increasing	FALSE
703215	K	1	5	0.5	Increasing	FALSE
703215	Mg	4	5	0.242	Increasing	FALSE
703215	Na	0	5	0.592	No Trend	FALSE
703215	SO4	2	5	0.408	Increasing	FALSE
703215	TDS	0	5	0.592	No Trend	FALSE
703278	Methane	-7	11	0.324	Decreasing	FALSE
703279	Methane	-8	5	0.042	Decreasing	TRUE
703281	Alkalinity	-2	4	0.375	Decreasing	FALSE
703281	Ca	-3	4	0.271	Decreasing	FALSE
703281	Cl	-5	4	0.105	Decreasing	FALSE
703281	HCO3	-2	4	0.375	Decreasing	FALSE
703281	K	3	4	0.271	Increasing	FALSE
703281	Methane	4	4	0.167	Increasing	FALSE
703281	Mg	0	4	0.625	No Trend	FALSE
703281	Na	3	4	0.271	Increasing	FALSE
703281	SO4	-2	4	0.375	Decreasing	FALSE
703281	TDS	-4	4	0.167	Decreasing	FALSE
703697	Methane	0	4	0.625	No Trend	FALSE
704130	Methane	-10	6	0.048	Decreasing	TRUE
704700	Alkalinity	-3	5	0.325	Decreasing	FALSE
704700	Ca	8	5	0.042	Increasing	TRUE
704700	Cl	7	6	0.136	Increasing	FALSE
704700	CO3	-1	5	0.5	Decreasing	FALSE
704700	HCO3	-2	5	0.408	Decreasing	FALSE
704700	K	0	4	0.625	No Trend	FALSE
704700	Methane	10	5	0.008	Increasing	TRUE
704700	Mg	10	5	0.008	Increasing	TRUE
704700	Na	6	5	0.117	Increasing	FALSE
704700	SO4	10	6	0.048	Increasing	TRUE
704700	TDS	8	5	0.042	Increasing	TRUE
705446	Alkalinity	0	4	0.625	No Trend	FALSE
705446	Ca	-6	4	0.042	Decreasing	TRUE
705446	Cl	0	4	0.625	No Trend	FALSE
705446	HCO3	-3	4	0.271	Decreasing	FALSE
705446	K	3	4	0.271	Increasing	FALSE
705446	Methane	-2	4	0.375	Decreasing	FALSE
705446	Mg	-4	4	0.167	Decreasing	FALSE
705446	Na	-4	4	0.167	Decreasing	FALSE
705446	SO4	3	4	0.271	Increasing	FALSE
705446	TDS	-4	4	0.167	Decreasing	FALSE

APPENDIX B
MANN-KENDALL RESULTS
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte	S	N	Probability	Trend	Significance
705779	Ca	-6	4	0.042	Decreasing	TRUE
705779	Cl	-6	4	0.042	Decreasing	TRUE
705779	CO3	0	4	0.625	No Trend	FALSE
705779	HCO3	-4	4	0.167	Decreasing	FALSE
705779	K	-1	4	0.5	Decreasing	FALSE
705779	Methane	4	4	0.167	Increasing	FALSE
705779	Mg	-2	4	0.375	Decreasing	FALSE
705779	Na	-2	4	0.375	Decreasing	FALSE
705779	pH	2	4	0.375	Increasing	FALSE
705779	SO4	-2	4	0.375	Decreasing	FALSE
705779	TDS	-4	4	0.167	Decreasing	FALSE
707315	Alkalinity	2	4	0.375	Increasing	FALSE
707315	Ca	4	4	0.167	Increasing	FALSE
707315	Cl	2	4	0.375	Increasing	FALSE
707315	CO3	-4	4	0.167	Decreasing	FALSE
707315	HCO3	0	4	0.625	No Trend	FALSE
707315	K	4	4	0.167	Increasing	FALSE
707315	Methane	-4	4	0.167	Decreasing	FALSE
707315	Mg	3	4	0.271	Increasing	FALSE
707315	Na	0	4	0.625	No Trend	FALSE
707315	pH	-4	4	0.167	Decreasing	FALSE
707315	SO4	5	4	0.105	Increasing	FALSE
707315	TDS	3	4	0.271	Increasing	FALSE
750047	Alkalinity	6	5	0.117	Increasing	FALSE
750047	Ca	-2	5	0.408	Decreasing	FALSE
750047	Cl	-5	5	0.18	Decreasing	FALSE
750047	CO3	0	5	0.592	No Trend	FALSE
750047	HCO3	5	5	0.18	Increasing	FALSE
750047	K	1	5	0.5	Increasing	FALSE
750047	Methane	0	5	0.592	No Trend	FALSE
750047	Mg	5	5	0.18	Increasing	FALSE
750047	Na	4	5	0.242	Increasing	FALSE
750047	pH	-2	5	0.408	Decreasing	FALSE
750047	SO4	2	5	0.408	Increasing	FALSE
750047	TDS	3	5	0.325	Increasing	FALSE
752226	Alkalinity	1	4	0.5	Increasing	FALSE
752226	Ca	0	4	0.625	No Trend	FALSE
752226	Cl	0	4	0.625	No Trend	FALSE
752226	CO3	4	4	0.167	Increasing	FALSE
752226	HCO3	1	4	0.5	Increasing	FALSE
752226	K	6	4	0.042	Increasing	TRUE
752226	Methane	0	4	0.625	No Trend	FALSE
752226	Mg	0	4	0.625	No Trend	FALSE
752226	Na	0	5	0.592	No Trend	FALSE

APPENDIX B
MANN-KENDALL RESULTS
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte	S	N	Probability	Trend	Significance
752226	pH	-4	4	0.167	Decreasing	FALSE
752226	SO4	2	4	0.375	Increasing	FALSE
752226	TDS	0	4	0.625	No Trend	FALSE
752419	Alkalinity	0	4	0.625	No Trend	FALSE
752419	Ca	0	4	0.625	No Trend	FALSE
752419	Cl	0	4	0.625	No Trend	FALSE
752419	CO3	3	4	0.271	Increasing	FALSE
752419	HCO3	0	4	0.625	No Trend	FALSE
752419	K	-4	4	0.167	Decreasing	FALSE
752419	Methane	0	4	0.625	No Trend	FALSE
752419	Mg	-1	4	0.5	Decreasing	FALSE
752419	Na	-2	4	0.375	Decreasing	FALSE
752419	pH	0	4	0.625	No Trend	FALSE
752419	SO4	-1	4	0.5	Decreasing	FALSE
752419	TDS	-1	4	0.5	Decreasing	FALSE
752520	Methane	2	4	0.375	Increasing	FALSE
752764	Methane	4	5	0.242	Increasing	FALSE

APPENDIX C

Datasets with Three Samples

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
700019	Alkalinity
700019	Ca
700019	Cl
700019	K
700019	Methane
700019	Mg
700019	Na
700019	SO4
700019	TDS
700039	Alkalinity
700039	Ca
700039	Cl
700039	K
700039	Methane
700039	Mg
700039	SO4
700039	TDS
702121	Ca
702121	Cl
702121	CO3
702121	HCO3
702121	K
702121	Methane
702121	Mg
702121	Na
702121	SO4
703215	HCO3
703247	pH
703278	Cl
703278	SO4
703278	TDS
703874	Ca
703874	Mg
703874	Na
703874	pH
703874	SO4
703884	Methane
704604	Alkalinity
704604	Ca
704604	Mg
704604	Na
704604	pH
704604	TDS
704628	Alkalinity

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
704628	Mg
704628	Na
704628	pH
704628	TDS
704769	Alkalinity
704769	Ca
704769	Cl
704769	K
704769	Methane
704769	Mg
704769	Na
704769	SO4
704769	TDS
704999	Alkalinity
704999	Ca
704999	Cl
704999	K
704999	Methane
704999	Mg
704999	Na
704999	pH
704999	TDS
705016	Alkalinity
705016	Ca
705016	Cl
705016	CO3
705016	HCO3
705016	K
705016	Methane
705016	Mg
705016	Na
705016	SO4
705016	TDS
705064	Ca
705064	Cl
705064	K
705064	Methane
705064	Mg
705064	Na
705064	SO4
705064	TDS
705327	Alkalinity
705327	Cl
705327	CO3

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
705327	HCO3
705327	K
705327	Methane
705327	Mg
705327	Na
705327	SO4
705327	TDS
705353	Alkalinity
705353	Ca
705353	Cl
705353	CO3
705353	HCO3
705353	K
705353	Methane
705353	Mg
705353	Na
705353	SO4
705353	TDS
705355	Alkalinity
705355	Ca
705355	Cl
705355	CO3
705355	HCO3
705355	K
705355	Methane
705355	Mg
705355	Na
705355	SO4
705355	TDS
705446	pH
705499	Alkalinity
705499	Ca
705499	Cl
705499	CO3
705499	HCO3
705499	K
705499	Methane
705499	Mg
705499	Na
705499	SO4
705499	TDS
705543	Alkalinity
705543	Ca
705543	Cl

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
705543	CO3
705543	HCO3
705543	K
705543	Methane
705543	Mg
705543	Na
705543	SO4
705543	TDS
705544	Methane
705552	TDS
705592	Ca
705592	Cl
705592	K
705592	Methane
705592	Mg
705592	Na
705592	SO4
705592	TDS
705593	Ca
705593	Cl
705593	CO3
705593	HCO3
705593	K
705593	Methane
705593	Mg
705593	Na
705593	SO4
705593	TDS
705757	Alkalinity
705757	Ca
705757	Cl
705757	CO3
705757	HCO3
705757	K
705757	Methane
705757	Mg
705757	Na
705757	SO4
705757	TDS
705776	Ca
705776	Cl
705776	CO3
705776	HCO3
705776	K

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
705776	Methane
705776	Mg
705776	Na
705776	pH
705776	SO4
705776	TDS
705779	Alkalinity
705801	Ca
705801	Cl
705801	HCO3
705801	K
705801	Methane
705801	Mg
705801	Na
705801	SO4
705801	TDS
707312	Alkalinity
707312	Ca
707312	Cl
707312	CO3
707312	HCO3
707312	K
707312	Methane
707312	Mg
707312	Na
707312	pH
707312	SO4
708165	Cl
708165	K
708165	Methane
708165	Na
708165	pH
708165	SO4
708165	TDS
750054	Alkalinity
750054	Ca
750054	Cl
750054	CO3
750054	HCO3
750054	K
750054	Methane
750054	Mg
750054	Na
750054	pH

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
750054	SO4
750054	TDS
750059	Alkalinity
750059	Ca
750059	Cl
750059	CO3
750059	HCO3
750059	K
750059	Methane
750059	Mg
750059	Na
750059	pH
750059	SO4
750059	TDS
750066	Alkalinity
750066	Ca
750066	Cl
750066	CO3
750066	HCO3
750066	K
750066	Methane
750066	Mg
750066	Na
750066	pH
750066	SO4
750066	TDS
750159	Alkalinity
750159	Ca
750159	Cl
750159	CO3
750159	HCO3
750159	K
750159	Methane
750159	Mg
750159	Na
750159	pH
750159	SO4
750159	TDS
752129	Alkalinity
752129	Ca
752129	Cl
752129	CO3
752129	HCO3
752129	K

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
752129	Methane
752129	Mg
752129	Na
752129	SO4
752129	TDS
752132	Alkalinity
752132	Ca
752132	Cl
752132	CO3
752132	HCO3
752132	K
752132	Methane
752132	Mg
752132	Na
752132	pH
752132	SO4
752132	TDS
752186	Ca
752186	Cl
752186	K
752186	Methane
752186	Mg
752186	Na
752186	pH
752186	SO4
752186	TDS
752280	Alkalinity
752280	Ca
752280	Cl
752280	CO3
752280	HCO3
752280	K
752280	Methane
752280	Mg
752280	Na
752280	pH
752280	SO4
752280	TDS
752315	Alkalinity
752315	Ca
752315	Cl
752315	CO3
752315	HCO3
752315	K

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
752315	Methane
752315	Mg
752315	Na
752315	SO4
752315	TDS
752342	Ca
752407	Methane
752520	Alkalinity
752520	Ca
752520	Cl
752520	CO3
752520	HCO3
752520	K
752520	Mg
752520	Na
752520	pH
752520	SO4
752520	TDS
752524	Methane
752599	Alkalinity
752599	Ca
752599	Cl
752599	CO3
752599	HCO3
752599	K
752599	Methane
752599	Mg
752599	Na
752599	SO4
752599	TDS
752665	Alkalinity
752665	Ca
752665	Cl
752665	CO3
752665	HCO3
752665	K
752665	Methane
752665	Mg
752665	Na
752665	pH
752665	SO4
752665	TDS
752764	Alkalinity
752764	Ca

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
752764	Cl
752764	CO3
752764	HCO3
752764	K
752764	Mg
752764	Na
752764	pH
752764	SO4
752764	TDS
752794	Alkalinity
752794	Ca
752794	Cl
752794	CO3
752794	HCO3
752794	K
752794	Methane
752794	Mg
752794	Na
752794	pH
752794	SO4
752794	TDS
752844	Alkalinity
752844	Ca
752844	Cl
752844	CO3
752844	HCO3
752844	K
752844	Methane
752844	Mg
752844	Na
752844	pH
752844	SO4
752844	TDS
753196	Alkalinity
753196	Ca
753196	Cl
753196	CO3
753196	HCO3
753196	K
753196	Methane
753196	Mg
753196	Na
753196	pH
753196	SO4

APPENDIX C
DATASETS WITH THREE SAMPLES
Greater Wattenberg Area Water Quality Analysis Project

FacilityID	Analyte
753196	TDS
753591	Alkalinity
753591	Ca
753591	Cl
753591	CO3
753591	HCO3
753591	K
753591	Methane
753591	Mg
753591	Na
753591	pH
753591	SO4
753591	TDS