Rio Tinto

Kennecott Utah Copper | Environmental Restoration Group

South Facilities Groundwater

2008 Remedial Progress Report

April 2009

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1. Introduction

Kennecott Utah Copper Corporation (KUC) is conducting groundwater remediation at its South Facilities as selected by the U.S. Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (DEQ) in a Record of Decision (ROD; EPA 2000) dated December 13, 2000 for the Kennecott South Zone, Operable Unit 2. In response to the ROD, KUC submitted a Final Design for Remedial Action (RDRA; KUC 2002) for the groundwater remediation in December 2002. EPA and DEQ approved the RDRA and issued an Explanation of Significant Differences (ESD) in June 2003 (EPA 2003). A second ESD (EPA 2007) was issued in June 2007 modifying and clarifying certain aspects of the remedy.

KUC has completed construction of remedy components and now operates under an Operations, Maintenance, and Replacement (OM&R) Plan for South Facilities Groundwater (Version 2, approved April 2009). This plan will be updated from time to time as needed. A work aspect of the OM&R Plan is preparation and submittal of annual reports on remedial activities and remedial progress. This report describes remedial activities and results for calendar year 2008 along with comparative changes from previous years.

Groundwater contamination at the South Facilities, referred to as the Zone A Plume, is located immediately down gradient of the old Bingham Reservoir and Bingham Canyon Mine waste rock piles. It consists of an acidic core area with low pH and elevated metals surrounded by a partially to fully neutralized zone of elevated sulfate groundwater.

The technical components of the selected South Facilities groundwater remedy include:

- Maintaining source control measures,
- Containing the sulfate plume in Zone A through extraction from barrier wells at the leading edge of the contamination,
- Remediation of the Zone A plume through extraction of heavily contaminated waters from the acidic core of the plume,
- Treatment of extracted water by reverse osmosis (RO) technology for barrier well water, and by neutralization of acid well water in the tailings pipeline, and
- Monitoring and reporting progress.

2. Remedial Operations

2.1 Groundwater Remediation System

KUC has completed construction of groundwater extraction and treatment systems necessary to implement the remedy. Components of this system are:

- Barrier well extraction system consisting of three wells, B2G1193, BFG1200, and LTG1147, and conveyance lines to deliver water to an RO treatment plant.

- A reverse osmosis treatment plant capable of producing 3,500 acre feet of drinking water per year using feed water from the barrier wells.

- Acid well extraction system comprised of three wells, ECG1146, BSG1201 and BSG2784, and conveyance to the beginning of the tailings pipeline at the Copperton Concentrator.

- Acid plume water treatment system which relies on operating KUC milling facilities, specifically a) the tailings pipeline, which serves as a 17-mile plug-type treatment reactor; b) the Copperton Concentrator lime plant, which has ability to add hydrated lime directly to the tailings line as needed, and c) the North Tailings Impoundment, which provides a repository for non-hazardous solid treatment residuals.

2.2 Extraction and Treatment

Annual calendar-year extractions for 2004 through 2008 from the remedial wells in Zone A are reported in Table 2-1. The 2008 average daily pumping rates for each of the barrier and acid wells are plotted on Figure 2-1 and Figure 2-2, respectively.

Table 2-1 Annual Zone A Groundwater Extraction 2004-2008 (ac-ft)

	2004	**2005**	**2006**	**2007**	**2008**
Barrier Well Extraction					
B2G1193	1936	2093	2188	2225	2464
BFG1200	2390	1080	2244	2353	2464
LTG1147	1106	292	374	307	30
Total	*5432*	*3465*	*4806*	*4885*	*4958*
Acid Well Extraction					
ECG1146	1115	1527	*1495*	1419	947
BSG1201	1282	1292	1300	869	927
BSG2784	0	0	0	1	706
Total	*2397*	*2819*	*2795*	*2289*	*2580*

Total extraction from barrier wells B2G1193 and BFG1200 was higher in 2008 than in 2007, while production from LTG1147 was notably lower. KUC did not utilize LTG1147 water as feed to the RO Plant in 2008, relying entirely on production from B2G1193 and BFG1200 for feed water. Both of these wells operated more than 95% of the year (Figure 2-1a and b). Well LTG1147 operated intermittently (Figure 2-1c) during 2008 to supply water for KUC operations.

Acidic water extraction well ECG1146 operated approximately 50% of 2008 (Figure 2-2a). This well did not operate during the first five months of the year due to equipment modifications at the wellhead and operational constraints limiting the flow rate of acidic water that could be treated in the tailings system. Additional wellhead modifications resulted in down time in fall 2008.

BSG1201 operated about 95% of 2008 (Figure 2-2b). The new acidic water extraction well BSG2784 was placed in service in late May 2008 and operated about 50% of 2008 (Figure 2-2c).

Both ECG1146 and BSG2784 were not operated during the last two weeks of December in order not to exceed the annual volume of the water rights assigned to these wells. In January 2009, the Division of Water Resources approved a permanent water rights change assigning additional water rights to the acidic extraction wells.

All groundwater extracted from the acidic water extraction wells was conveyed to the KUC tailings line at Box NP-5 where it was treated in the tailings line.

KUC's groundwater extractions removed 57,925 tons of sulfate in 2008. Since 1997, KUC has removed over 569,865 tons of sulfate from the principal alluvial aquifer in the South West Jordan Valley.

Barrier Well water from B2G1193 and BFG1200 was routed to the RO Plant during 2008 and the drinking water produced was delivered to the Jordan Valley Water Conservancy District. LTG1147 was routed to operations when it was pumped in 2008. The by-product water from the plant was routed to the KUC tailings pipeline at Box NP-5. Feed water volumes are indicated in Table 2-2.

Table 2-2 Annual RO Plant Feed Water Volumes (ac-ft)

	2004	2005	2006	2007	2008
RO Treatment	817	1549	4806	4762	4928

Figure 2-1 Average Daily Pumping Rates for Barrier Wells

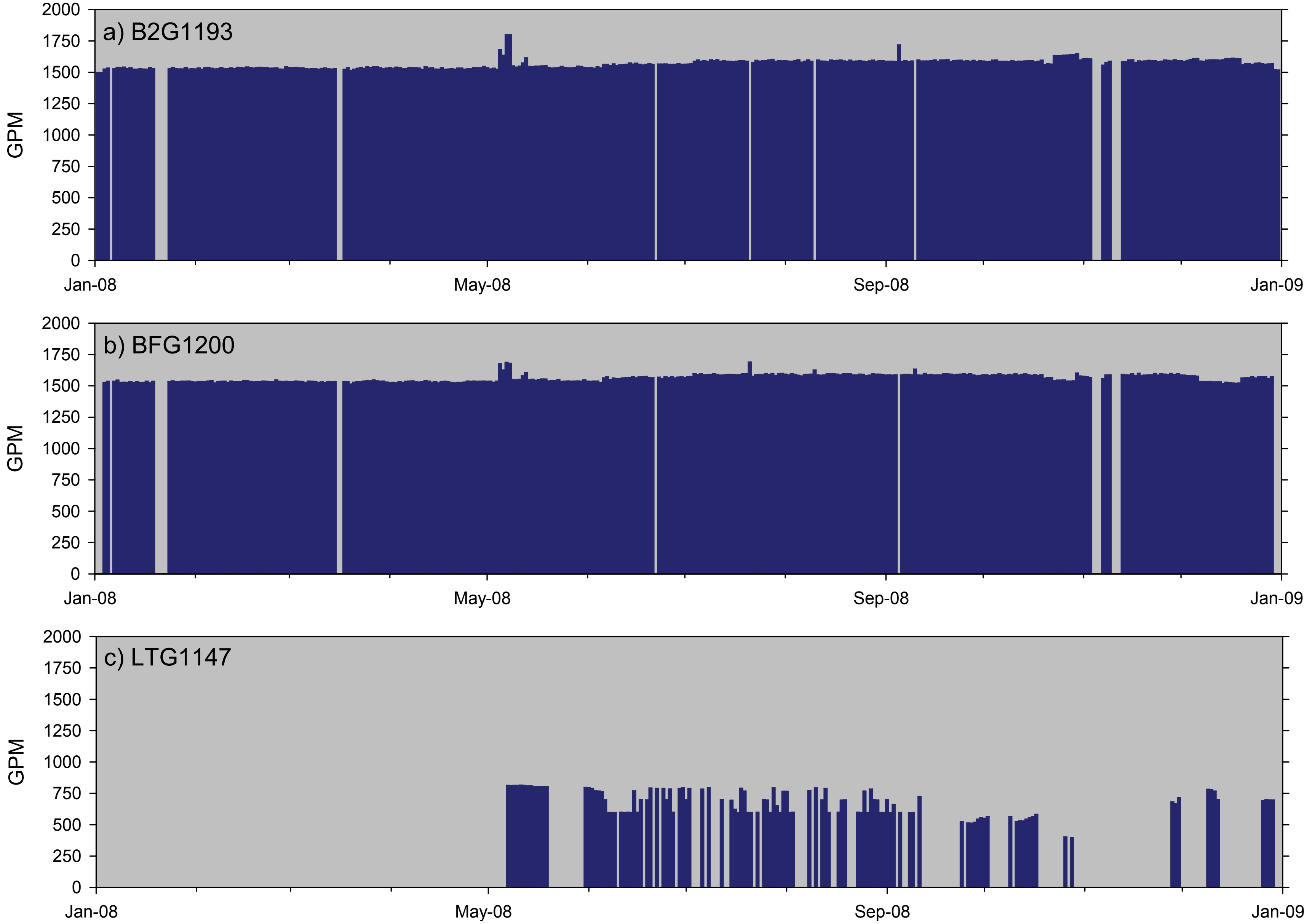
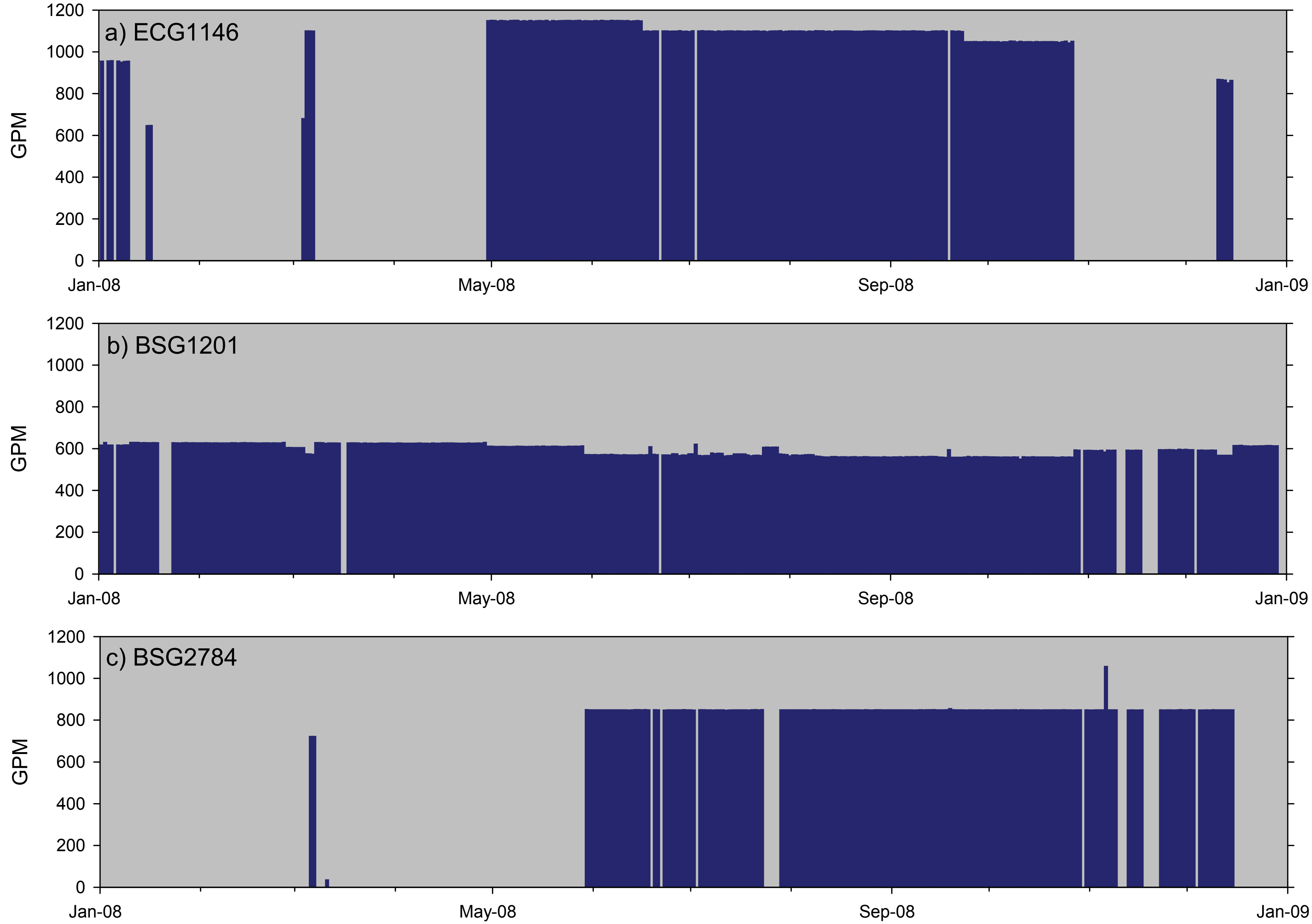


Figure 2-2 Average Daily Pumping Rates for Acid Wells



3. Compliance with Performance Standards and Monitoring Requirements

3.1 Performance Standards

Performance standards for operation and maintenance of the remedy are described in the 2007 ESD and include:

- Extract a minimum of 1,200 acre-feet per year from the core of the acid plume, on a five-year rolling average.

- Maintain groundwater sulfate concentration in a network of compliance wells, listed in the OM&R Plan, at or below 1,500 mg/l.

The OM&R Plan specifies required monitoring including sampling frequency, timing, and parameters for compliance and extraction wells.

Performance in 2008 toward these performance standards and requirements is discussed below. KUC reports separately to the State Trustee for Natural Resources on operations at the RO Plant in compliance with the Natural Resource Damage settlement and implementing project agreements.

3.2 Extraction Rate

Average acid water extraction for the 5-year period 2004 to 2008 was 2,576 acre feet (Table 3-1). Thus, KUC complied with the minimum annual extraction performance standard of 1,200 acre-feet of acid plume water on a 5-year rolling average.

Table 3-1 Five-year average extraction from the core of the acid plume (acre-feet)

	2004	2005	2006	2007	2008	5-Year Average
Extraction	2397	2819	2795	2289	2580	2576

KUC does not anticipate any operating constraints in 2009 that would impede continuing compliance with this performance standard.

3.3 Required Monitoring

The OM&R Plan specifies required monitoring frequency and timing for compliance wells, which is dependant on sulfate concentration as shown in Table 3-2. Extraction wells are to be sampled semi-annually in the first and third quarters. Required monitoring parameters are indicated in Table 3-3.

Table 3-2 Compliance Well Sampling Frequency and Timing

Sulfate (mg/l)	Frequency	Timing*
<1,000	Annually	3rd Quarter
1,000-1,250	Semi-annually	1st and 3rd Quarters
>1,250	Quarterly	Each Quarter

*calendar-year quarters

Table 3-3 Compliance and Extraction Well Monitoring Parameters

pH
Arsenic (D)
Barium (D)
Cadmium (D)
Copper (D)
Fluoride
Lead (D)
Selenium (D)
Nickel (D)
Sulfate

*(D) means dissolved

All compliance monitoring wells had sulfate concentrations less 1,000 mg/l and all were sampled in 2008 within the third quarter, at a minimum. Extraction wells were monitored during first and third quarter 2008, at a minimum.

Required monitoring parameters were gathered for compliance and extraction well sampling in 2008 except for fluoride in the replacement compliance wells. Fluoride will be monitored in these wells in 2009 and subsequent years.

3.4 Plume Containment

The compliance well network for 2008 is indicated on Figure 3-1. Two (BSG1135A and HMG1126A) of the ten compliance monitoring wells went dry in late 2007 or early 2008 and two additional monitoring wells (WJG1154A and WJG1169A) are anticipated to go dry in 2009 or 2010. Each of the compliance wells that is or soon will be dry is part of a nested site, and KUC had revised the OM&R Plan to designate the next completion below each dry well as the compliance well. EPA and UDEQ approved the revised OM&R Plan in April 2009. Sulfate concentrations in the third quarter of 2008 are listed in Table 3-4; for comparison, third-quarter measurements from 2007 are also listed.

No compliance wells or replacement compliance wells exceeded 1,500 mg/l in 2008. Other than two compliance wells discussed below, there does not appear to be any increase in sulfate concentrations in compliance wells that would suggest the potential for future non-compliance with the performance standard.

Table 3-4 Compliance Monitoring Well Sulfate (mg/l) Measurements during Third Quarter

Well ID	Type	2007	2008
COG1178A	Compliance	275	284
WJG1169A	Compliance	433	488
WJG1169B	Replacement Compliance	499	455
WJG1154A	Compliance	405	352
WJG1154B	Replacement Compliance	Not sampled	329
W189	Compliance	100	105
P192B	Compliance	36	136
P194B	Compliance	38	41
EPG1165A	Compliance	157	157
BSG1135A	Compliance	320	dry
BSG1135B	Replacement Compliance	66	75
HMG1123A	Compliance	658	663
HMG1126A	Compliance	525	dry
HMG1126B	Replacement Compliance	Not sampled	386

One notable change occurred in a compliance wells between 2007 and 2008. In P192B, located near the former South Jordan Evaporation Pond area where surface soils contain relatively high concentrations of gypsum, the third-quarter sulfate increased from 36 mg/l in 2007 to 136 mg/l in 2008. At this site, site grading activities conducted for land development included raising the ground surface approximately 12 feet. The well was not extended until site grading was completed leaving the well within a depression. A large rain event filled approximately six feet of the depression with storm runoff water. Rainwater that had been in contact with high-sulfate soil was able to enter the well casing beneath the non-water tight cap. P192B was sampled twice in 2008 after the storm water event and after the well casing was extended. In early January 2008, the well had a sulfate concentration of 410 mg/l, and by late July 2008, the sulfate concentration had decreased to 136 mg/l. It is anticipated that the sulfate in future samples will continue to show decreases.

4. Remedial Progress

Analysis of 2008 groundwater monitoring data, especially as shown on the time-series plots included in this report, indicates that the remedial extraction program is continuing to achieve reduction in contaminant levels within the plume as well as containment of the plume.

All water chemistry data collected during 2008 is reported in Appendix A; results from 2007 are also included in Appendix A. Samples were analyzed at Kennecott Environmental Laboratory, a State of Utah certified analytical laboratory.

KUC's Groundwater Monitoring and Characterization Plan (GCMP; KUC 2005a) and associated Standard Operating Procedures (SOPs; KUC 2005b) are followed for all sampling. The GCMP annual report is submitted by KUC to the Utah Division of Water Quality on an annual basis. Quality-control procedures, as documented in KUC's Quality Assurance Project Plan (QAPP; KUC 2005c) for the GCMP program, are followed for all data collected. KUC submits quarterly Quality Assurance Reports to the Division of Water Quality. These reports discuss quality assurance for the data utilized below to assess remedial progress.

4.1 Sulfate

The distribution of sulfate in 2008 in Zone A is represented on Figure 4-1 as contoured sulfate concentrations. Changes in contoured sulfate concentrations from 2007 to 2008 are highlighted on Figure 4-2. In monitoring wells with multiple completions, the sampling event during 2008 (or the most recent analyses within the past five years if no 2008 data were available) with the highest sulfate concentration was used to generate contours. Time-series plots of sulfate concentration for selected monitoring wells are also presented and discussed below.

4.1.1 Plume Interior

The plume interior includes areas with groundwater sulfate concentrations greater than 5,000 mg/l.

Zone A Source Area

Comparison of the isoconcentration contours from 2008 with those from 2007 indicates complete contraction of the 20,000 mg/l contour in the western acid plume area at monitoring well site SRG946 near the Small Bingham Reservoir. As indicated on Figure 4-3 the concentration of sulfate at this well decreased notably from 23,000 mg/l in 2007 to 16,800 mg/l in 2008, following several years of increasing sulfate concentrations. Due to the potential for remobilization of precipitated gypsum in the Zone A source area, KUC is cautious to ascribe any certain meaning to this recent decrease, but does view the trend as encouraging.

Monitoring wells ECG1115 A, B, and C are located 1,500 feet upgradient from extraction well ECG1146 along the apparent migration pathway of the Zone A plume. In 2008, sulfate concentrations in ECG1115 A and B decreased slightly (Figure 4-4), while sulfate in ECG1115C increased slightly from 36,000 mg/l in 2007 to 36,900 mg/l. Sulfate concentrations in ECG1115A have been greater than 30,000 mg/l since at least 1996 and, while showing increases and decreases, have not had an overall downward trend (Figure 4-4). Sulfate concentrations in ECG1115 B and C have shown marked increases since initiation of pumping at ECG1146. These responses are attributed to induction of horizontal contaminant migration from the western portion of the Zone A source area, slow release of contaminants from lower-permeability horizons, and/or possible induction of vertical migration between horizons .

Acid Extraction Well ECG1146 Area

There was a discernable aquifer response, both in terms of sulfate concentration and water level, to partial year pumping at extraction well ECG1146 (Section 2.2). Examination of the time series concentration plots (Figure 4-5 to Figure 4-9) indicates that sulfate concentrations at most wells within the ECG1146 area either decreased at a slower rate than previous years or increased slightly.

Sulfate concentrations in ECG1146 averaged 19,900 mg/l in 2007 and 19,350 mg/L in 2008 (Figure 4-5). However, the concentrations increased to 21,300 in the December 2008 sampling, causing expansion of the 20,000 mg/l sulfate contour (Figure 4-2).

Sulfate concentrations in ECG1124B (Figure 4-5), located adjacent to extraction well ECG1146, decreased from an average of 1,720 mg/l in 2007 to an average of 1,480 mg/l in 2008. However, the rate of decrease was lower than during the previous three years, likely as a result of partial-year pumping at ECG1146.

In ECG1145A, located just south of well ECG1146, sulfate increased from 7,700 mg/L in 2007 to 9,180 mg/L in 2008 (Figure 4-6). Partial-year pumping appears to have allowed high sulfate concentration water located upgradient of ECG1146, to move southeast instead of being induced towards ECG1146.

In ECG1144A (Figure 4-7), located approximately 500 feet northeast of ECG1146, sulfate concentrations decreased from 7,300 mg/l in 2007 to 7,120 mg/l in 2008, which is a lower rate of decrease compared to previous years. During the same period, ECG1144B increased from 4,950 mg/l to 5,490 mg/l. The changes from previous trends, especially the increase in sulfate in ECG1144B, are also attributed due to partial-year pumping at extraction well ECG1146.

The sulfate concentration in monitoring well ECG1128A (Figure 4-8) decreased from 7,950 mg/l in 2007 to 5,210 mg/l in 2008, also at a lower rate than observed in previous years. The decreasing sulfate concentration in this well is reflected in contraction of the 5,000 and 10,000 mg/l contours on the southwest sector of the low pH plume.

In ECG1118A, located approximately 1,800 feet east-northeast of ECG1146, sulfate concentration decreased from 9,950 mg/l in 2007 to 9,750 mg/l in 2008 (Figure 4-9). The rate of decrease was less than previous years, which was likely due to partial-year extraction at ECG1146; however, because the concentration has been below 10,000 mg/l for two consecutive years, the 2008 10,000 mg/l isocontour has changed to reflect the remedial progress in this area (Figure 4-2).

Acid Extraction Well BSG1201Area

Acid extraction well BSG1201 operated for the full year in 2008. Sulfate in BSG1201 did not change notably from the previous year (Figure 4-10). At the adjacent monitoring wells, BSG1177A and B (Figure 4-10), the sulfate concentration decreased slightly in 2008.

Sulfate concentrations in BSG1119B (Figure 4-11), located at the leading edge of the low pH plume decreased from 7,030 mg/l in 2007 to 6,450 mg/l in 2008.

Acid Extraction Well BSG2784 Area

At acid extraction well BSG2784, sulfate increased (Figure 4-12) from 10,800 mg/l when the well was placed in service at mid year to 14,700 mg/l by year end. Contrasting responses to extraction at BSG2784 are notable at monitoring wells BSG2782A, B and C (Figure 4-12), located 150 feet west and upgradient of extraction well BSG2784. Sulfate in BSG2782A dropped markedly from 25,700 mg/l at startup to 19,700 by year end. In the less contaminated and lower permeability horizon monitored by BSG2782B, sulfate did not show a response to pumping in 2008. In BSG2782C, sulfate increased from 26,700 mg/l to 30,900 mg/l between startup of BSG2784 and year end.

The contrasting responses of these three monitoring wells likely reflects the induction of groundwater flow to BSG2784 from cleaner areas through the horizon monitored by BSG2782A, while induced flow in the hydrostratigraphic horizon monitored by BSG2782C is from higher contaminated areas. In the BSG2782B hydrostratigraphic horizon, lower permeability results in lower flux through the horizon and little change in quality.

Sulfate concentrations in monitoring wells BSG1179 A and B and P241B, located approximately 1400 feet west of BSG2784, decreased in 2008 (Figure 4-13). Importantly, the decrease observed in BSG1179A and P241B follow about five years of steadily increasing concentrations. These decreases are not attributed to initiation of pumping at BSG2784 because the wells were sampled less than 30 days after start up of the well, but are likely due to pumping at BSG1201. The highest concentration of sulfate at this location occurs in BSG1179C which did not change notably in 2008 (Figure 4-13); pumping at BSG2784 is expected to influence this hydrostratigraphic horizon with time.

At monitoring well BSG2777A, located 1,200 feet east and downgradient of extraction well BSG2784, there was no change in sulfate concentration (Figure 4-14) following initiation of pumping at BSG2784. However, there was a water level response indicating that extraction at BSG2784 will have an influence on the leading edge of the low pH plume in this sector. Overall sulfate decreased from an average of 21,650 mg/l in 2007 to 18,600 mg/l in 2008. This relatively large change moved the 20,000 mg/l sulfate contour west (Figure 4-2).

Approximately 1,700 feet southeast of acid extraction well BSG2784 sulfate concentrations in BSG2783B decreased from an average of 17,300 mg/l in 2007 to an average of 16,800 mg/l in 2008 (Figure 4-15). There was a slight decrease in sulfate concentration following the initiation of pumping at BSG2784 as well as a water level response suggesting that operation of BSG2784 will have a remedial influence on this sector of the leading edge of the low pH plume. Concentrations of sulfate in monitoring well BSG2783A increased from an average of 526 mg/l in 2007 to an average of 718 mg/l in 2008 and BSG2783C decreased from an average of 620 mg/l in 2007 to an average of 406 mg/l in 2008.

4.1.2 KUC Deep Well Field

The KUC deep well field area includes barrier extraction wells B2G1193 and BFG1200 and the monitoring wells located on the northeast margin of the plume. Sulfate concentrations in the extraction wells held essentially steady during 2008. Sulfate concentrations in monitoring wells located close to extraction well B2G1193 were also essentially steady in 2008, while other monitoring wells in the well field generally held steady or decreased.

Deep Well B2G1193 Area

B2G1157A, B, and C are located immediately adjacent to barrier extraction well B2G1193. Sulfate in B2G1157A decreased slightly from an average of 2,115 mg/l in 2007 to an average of 2,013 mg/l in 2008 and went dry in mid-2008. Sulfate in ECG1157B increased from 6,530 mg/l at the end of 2007 to 6,620 mg/l at the end of 2008 (Figure 4-16). Sulfate concentration in water extracted from B2G1193 slightly decreased from an average of 1,958 mg/l in 2007 to an average of 1,920 mg/l in 2008. The changes in B2G1157A and B reflect the consequences of pumping at B2G1193, which is drawing water from the interior of the plume as well as the margin. That the sulfate concentration in extraction well B2G1193 has only slightly increased despite increasing sulfate in B2G1157B suggests that the horizon monitored by B2G1157B does not contribute significantly to the overall production from B2G1193. Sulfate concentrations in B2G1157C decreased from an average of 534 mg/l in 2007 to 424 mg/l in 2008.

Monitoring wells BFG1156B, C, and D are located half the distance between extraction wells BFG1200 and B2G1193 and are located at the northern leading edge of the 1,500 mg/l sulfate contour. Sulfate concentrations in BFG1156B increased slightly from 1,620 mg/l in 2007 to 1,690 mg/l in 2008. Sulfate concentrations in BFG1156C decreased slightly from 1,170 mg/l in 2007 to 1,060 mg/l in 2008 (Figure 4-17). Pumping from B2G1193 and BFG1200 has likely caused cleaner water from the approximate upper 300 feet of saturation to be pulled laterally from the north and east. However, in BFG1156D the sulfate concentration increased, which is likely due to lateral movement of higher sulfate water from the south and west and from vertical movement of higher sulfate water.

Deep Well BFG1200 Area

Sulfate concentrations over time for extraction well BFG1200 are shown on Figure 4-18 along with monitoring well BFG1155A, B, C, D, E, and F. There are seasonal fluctuations in sulfate concentrations in this extraction well. The sulfate concentration in BFG1200 decreased slightly from an average sulfate concentration of 805 mg/l in 2007 to 788 mg/l in 2008.

In well BFG1195A (Figure 4-19), the sulfate concentration increased from 1,550 mg/l in 2007 to 1,660 mg/l in 2008. BFG1195B increased from 1,430 mg/l in 2007 to 1,580 mg/l in 2008. It is likely that the extraction from barrier wells BFG1200 and B2G1193 is causing contaminated water to move vertically and/or laterally to the monitoring wells.

Time-series plots for other monitoring wells in the deep well field area where sulfate concentrations were measured in 2008 are presented here. In these wells, sulfate concentrations increased slightly in P277 (Figure 4-20), B2G1194A (Figure 4-21), and B3G1197 A and B (Figure 4-22). A slight decrease was measured in B2G1194B (Figure 4-21).

4.1.3 Southeast Margin

Increasing sulfate concentrations in some wells on the southeast margin of the Zone A plume triggered the installation of additional monitoring wells and eventually acid extraction well BSG2784. Sampling in 2008 indicates an overall continued increase in sulfate in P241C (Figure 4-23) and BSG1148A (Figure 4-24). There were no notable changes at BSG1133A or B (Figure 4-25) or BSG1132A (Figure 4-26). Responses to pumping at extraction well BSG2784 are expected in these areas with time.

4.1.4 West Jordan Well Field

KUC monitors water quality and water levels in and adjacent to the West Jordan municipal well field, which includes wells W363 and W387, shown on Figure 4-1, and W420, not shown. A fourth well, W361, was abandoned by West Jordan in the early 2000s due to land development activities. Heavy extraction from these four wells in the 1990s caused migration of elevated-sulfate groundwater toward this area and well W363 saw increasing sulfate throughout the 1990s (Figure 4-27).

Sulfate concentrations at W363 have declined since 1999 and correspond to reduced annual extraction by West Jordan and increased extraction by KUC. During 1999, W363 had its highest sulfate concentration of 188 mg/l, and in 2008, the average concentration increased slightly from 121 mg/l in 2007 to 125 mg/l. Well W363 is located approximately 6,700 feet northeast of KUC's barrier well BFG1200. Well W387, located 2,700 feet west of W363, had 48 mg/l sulfate in 2008 and has had a steady sulfate concentration since the late 1990s. The northern-most West Jordan well (W420) has not been regularly sampled by KUC and is well north of the sulfate plume pathway.

Monitoring wells located between the leading edge of the sulfate plume and the West Jordan Well field showed generally steady to increasing sulfate concentrations in 2008. WJG1154A, located 3,400 feet southeast of W363, also saw elevated concentrations through the late 1990s and has shown fairly consistent sulfate concentrations since. The average concentration for WJG1154A in 2008 decreased from 407 mg/l in 2007 to 349 mg/l with seasonal highs and lows (Figure 4-28). Sulfate concentrations in well WJG1154B have increased to 329 mg/l in 2008 from a high of 216 mg/l in 2007. The increase in sulfate at WJG1154B is likely due to vertical movement of water with higher sulfate concentration in the WJG1154A horizon moving downward which corresponds to the declining water table.

Monitoring well WJG1170A was dry when depth to water was measured in 2008. Sulfate concentrations in well WJG1170B decreased to 260 mg/l in 2008 compared with 302 mg/l in 2007 (Figure 4-29). The water has continued to decline in this general area and it appears that the poorer quality water in the upper portion of the aquifer is moving downward from the WJG1170A horizon into the WJG1170B horizon. WJG1171A has an increasing sulfate trend with a maximum of 166 mg/l in 2007 and a maximum of 177 mg/l in 2008 (Figure 4-30).

4.2 Aluminum

In general, aluminum concentrations continued to decrease in 2008. This constituent is the primary contributor to mineral acidity and influences treatment strategies for acid plume water.

The distribution of aluminum in groundwater in 2008 is shown on Figure 4-31. The aluminum concentration contours for 2008 on this figure was drawn in a similar manner as the sulfate contour map (Section 4.1; Figure 4-1). Changes in aluminum from 2007 to 2008 are highlighted on Figure 4-32. Decreases in aluminum concentration in the Zone A plume generally mimic the decreases in sulfate concentrations. As with sulfate, the decrease is attributed primarily to mass removal due to groundwater extraction.

Zone A Source Area

In the western-most portion of the low pH plume, adjacent to the Small Bingham Reservoir, SRG946 aluminum concentration remained below 1,000 mg/l for a second consecutive year (Figure 4-33). This is reflected as a complete contraction of the 1,000 mg/l aluminum isocontour in this area (Figure 4-32). As noted above in the discussion of sulfate in SRG946 (Section 4.1.1), due to the potential remobilization of precipitated minerals in the immediate Zone A source area, it is likely that aluminum concentrations will continue to be elevated over time in this area and may increase in the future.

Acid Extraction Well ECG1146 Area

In 2008, the main area of aluminum concentrations greater than 1,500 mg/l continues to center in the core of the low pH plume at monitoring well ECG1115A, northwest and up gradient of extraction well ECG1146. With continued pumping from acid extraction well ECG1146, the area containing greater than 1,500 mg/l aluminum continues to decrease slightly in size. ECG1115A, which contained 2,200 mg/l in 2007 decreased to 1,910 mg/l in 2008 (Figure 4-34). However, during the same period, ECG1115C increased from 1,390 mg/l to 1,440 mg/l and ECG1115B increased from 204 mg/l to 263 mg/l. Aluminum concentrations in ECG1115 B and C have shown marked increases since initiation of pumping at ECG1146. These responses are attributed to induction of horizontal contaminant migration from the western portion of the Zone A source area, slow release of contaminants from lower-permeability horizons, and/or possible induction of vertical migration from shallower to deeper horizons.

Aluminum concentrations in ECG1146 remained relatively steady with an average concentration of 992 mg/l in 2007 and 986 mg/l in 2008 (Figure 4-35).

ECG1128A aluminum decreased from 215 mg/l in 2007 to 131 mg/l in 2008 (Figure 4-36). The rate of decrease from 2007 to 2008 was lower than in previous years, possibly reflecting partial-year extraction at acid extraction well ECG1146.

ECG1118A aluminum increased from 369 mg/l in 2007 to 503 mg/l in 2008 (Figure 4-37). The increase changes the 500 mg/l isocontour as shown on Figure 4-32. Partial-year extraction at ECG1146 appears to have also influenced the aluminum concentration for this area.

Acid Extraction Wells BSG1201and BSG2784 Area

In 2008, aluminum concentrations in the BSG1201 and BSG2784 area decreased and the 1,500 mg/l isocontour contracted notably from 2007. Average aluminum concentrations decreased at acid extraction well BSG1201 from 418 mg/l in 2007 to 371 mg/l in 2008 (Figure 4-38) and at acid extraction well BSG2784, decreased from an average of 500 mg/l in 2007 to 438 mg/l in 2008 (Figure 4-39). Continued pumping at both wells appears to be decreasing the aluminum concentration for this eastern portion of the low pH plume area.

Aluminum concentrations at monitoring well BSG2782A, located 150 feet west of acid extraction well BSG2784, responded similarly to sulfate concentrations to the initiation of pumping at acid extraction well BSG2784, sulfate increased when the well was placed in service at mid year. Aluminum in BSG2782A dropped markedly from 1,440 mg/l at startup to 820 mg/l by year end (Figure 4-39). In the less contaminated and lower permeability horizon monitored by BSG2782B, aluminum did not show a notable response to pumping in 2008. In BSG2782C, aluminum increased from 418 mg/l to 741 mg/l between startup of BSG2784 and year end.

On the leading edge of the low pH plume, aluminum in well BSG1119B increased to 53 mg/l in 2008 from 49 mg/l in 2007 (Figure 4-40). BSG2777A decreased from an average of 132 mg/l in 2007 to 116 mg/l in 2008 (Figure 4-41).

4.3 Arsenic, Copper, and Cadmium

In general, the concentrations of arsenic, copper, and cadmium have been declining in the acid plume due to pumping. These metalloids and metals are prevalent where groundwater has a pH less than or equal to 4.5. Changes are also monitored closely at the leading edge of the 4.5 pH plume. Extraction and monitoring wells located in neutral pH water generally have less than or near detection limit concentrations of arsenic, cadmium, and copper.

Comparisons of arsenic, cadmium, and copper for 2008 and 2007 are included in Table 4-1 for each of the three acid extraction wells. Most of the changes are relatively small, which is comparable with the aluminum and sulfate concentrations changes noted in 2008.

Table 4-1 Arsenic, Copper, and Cadmium (mg/l) in Acid Wells

	ECG1146		BSG1201		BSG2784	
	2007	2008	2007	2008	2007	2008
Arsenic	0.036	0.038	0.019	0.019	0.028	0.026
Cadmium	0.786	0.771	0.677	0.643	0.870	0.822
Copper	69.82	66.03	20.89	17.42	13.80	12.69

At the leading edge of the low pH plume, monitoring wells BSG1119B and BSG2777A show changes (Table 4-2) that would be typical for the reaction boundary of low pH water where the aluminum, arsenic and copper concentrations are relatively low compared to the core of the low pH plume. BSG1119B shows very minor changes for arsenic, cadmium, and copper, while BSG2777A shows slightly decreasing arsenic but increasing cadmium and copper. The influences of pumping at BSG1201 and BSG2784 should cause the metal and metalloid concentrations to hold relative steady and possibly decrease. BSG1119B and BSG2777A are located approximately 2000 ft and 1200 ft down gradient respectively of extraction wells BSG1201 and BSG2784 and some of the water at the leading edge may move eastward farther into the basin.

Table 4-2 Arsenic, Copper, and Cadmium (mg/l) in Leading Edge Wells

	BSG1119B		BSG2777A	
	2007	2008	2007	2008
Arsenic	0.010	0.010	0.042	0.031
Cadmium	0.760	0.780	1.435	1.730
Copper	0.073	0.072	0.113	0.151

4.4 pH

Groundwater pH value isocontours for 2008 are shown on Figure 4-42. Figure 3-43 displays pH contours based on the most recent 2008 sample. Figure 4-43 indicates changes in contoured pH values from 2007 to 2008. Specific portions of the pH plume are discussed below.

4.4.1 Plume Core

The 2008 data depict three separate areas containing groundwater with an approximate pH of 3.5 or less. The areas include Bingham Creek Reservoir and adjacent area which contains residual low pH water; the area surrounding extraction well ECG1146; and the area adjacent to extraction wells BSG1201 and BSG2784.

Monitoring wells in the Bingham Creek Reservoir area containing a pH of around 3.5 or less include LRG912, which had a pH of 3.5 in 2007 and 3.8 in 2008. B1G951 had a pH of 3.6 in 2007 and 3.3 in 2008 and SRG946 with a pH of 3.6 in 2007 and 3.4 in 2008. Because all three sites are within or adjacent to the footprint of the Large Bingham Reservoir, residual sediments, especially iron hydroxides with sorbed hydrogen ions, will likely continue to cause the pH of groundwater to remain low for many years.

In the area of extraction well ECG1146, certain wells including ECG1121A and ECG1144A, both of which had a pH slightly greater than 3.5 for 2007 were slightly less than 3.5 in 2008. Monitoring well B1G1120A had pH measurement slightly greater than 3.5. Other wells including ECG1146, ECG1115A, and ECG1117A have similar or declining pH measurements of 3.5 or less from 2007 through 2008. Monitoring well ECG1124B, located adjacent to extraction well ECG1146 and screened at and below the ECG1146 screen interval, shows a pronounced increase in pH during the past several years with a 2006 measurement of 4.0, 5.4 in 2007 and 5.8 in 2008. This increase in pH is likely due to cleaner water located near the base of principal alluvial aquifer rising upward into the base of the low pH plume core.

In the area of extraction wells BSG1201 and BSG2784, four wells had pH measurements of 3.5 or less and include BSG1201, BSG2784, BSG1179C and P241B.

4.4.2 Leading Edge of Plume

In prior years, BSG1119B was typically the indicator well where groundwater transitioned from low pH (< 5.5) to neutral pH. Monitoring site BSG2777A was drilled and completed in 2006 and is located one-quarter mile south of BSG1119 and also at the leading edge of the low pH plume. The average pH in well BSG1119B in 2007 was 4.6 and increased to 4.7 in 2008. In BSG2777A, the pH decreased from an average of 4.4 in 2007 to 4.3 in 2008. Monitoring wells located east of BSG1119B and BSG2777A have neutral or near neutral pH values with no significant changes from 2007 to 2008. The nearest monitoring wells located down gradient of BSG1119B is BSG2779A, B and C. Measurements of pH in all of the wells remained relatively steady from 2007 to 2008. BSG1133A, B, and C are the nearest down gradient wells to BSG2777A and are located approximately 1700 feet east. The pH of BSG1133B was measured at 6.8 in 2007 and 6.9 in 2008.

Changes in pH from 2007 to 2008 were not observed at the barrier wells. Average pH measurements were 7.1 at LTG1147, 6.7 at B2G1193, and 7.1 at BFG1200.

Along the north side of the plume area, 2008 pH measurements in monitoring well WJG1169A was 7.1 and did not change from 2007. At well WJG1169B pH decreased from 7.2 in 2007 to 7.0 in 2008.

Monitoring wells between barrier well BFG1200 and West Jordan's municipal wells, including WJG1154A and B, WJG1170A and B and WJG1171A and B show steady pH measurements above a pH of 7.0.

Figure 4-3 Time-Series Plot of Sulfate in SRG946

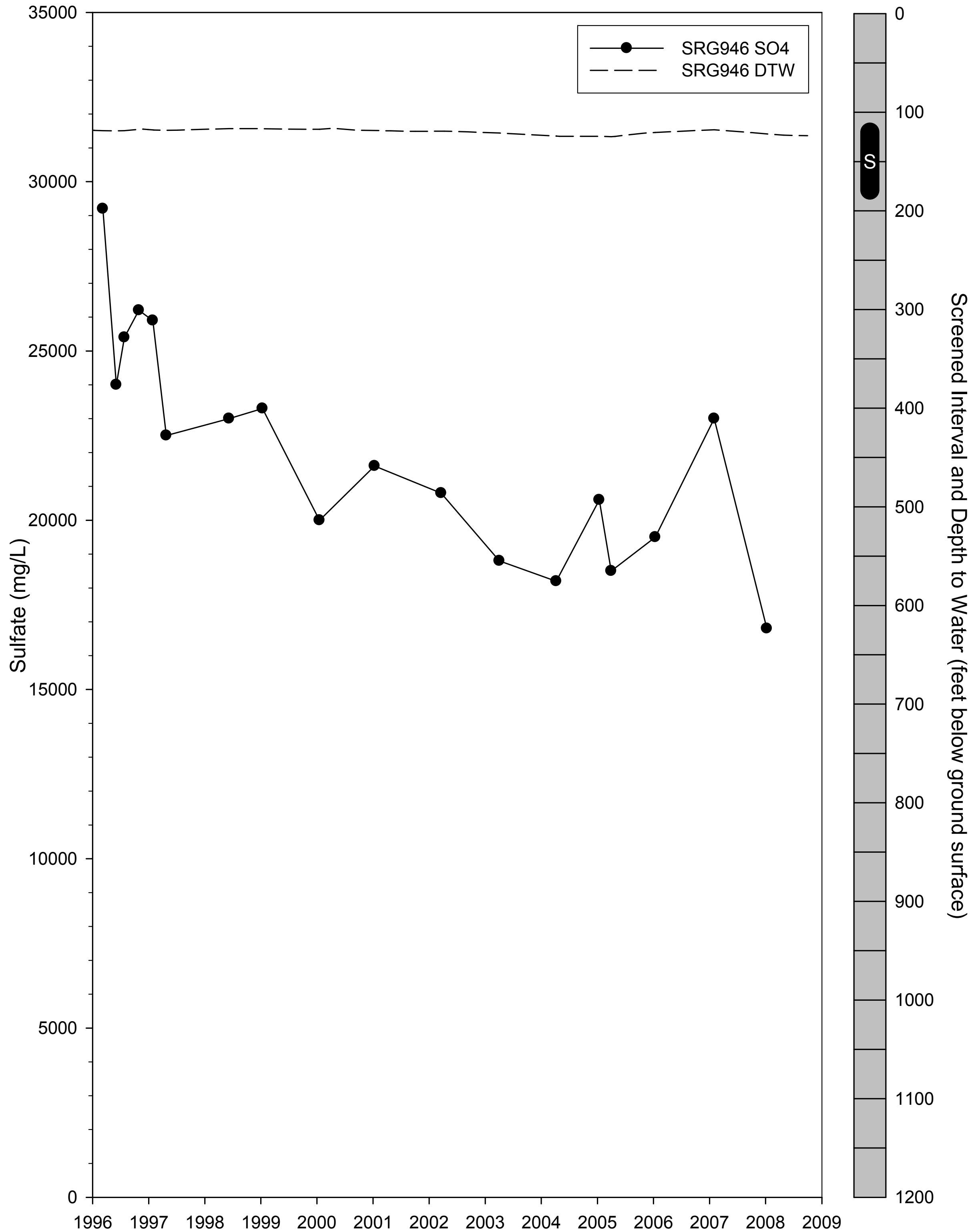


Figure 4-4 Time-Series Plot of Sulfate in ECG1115A, B, and C

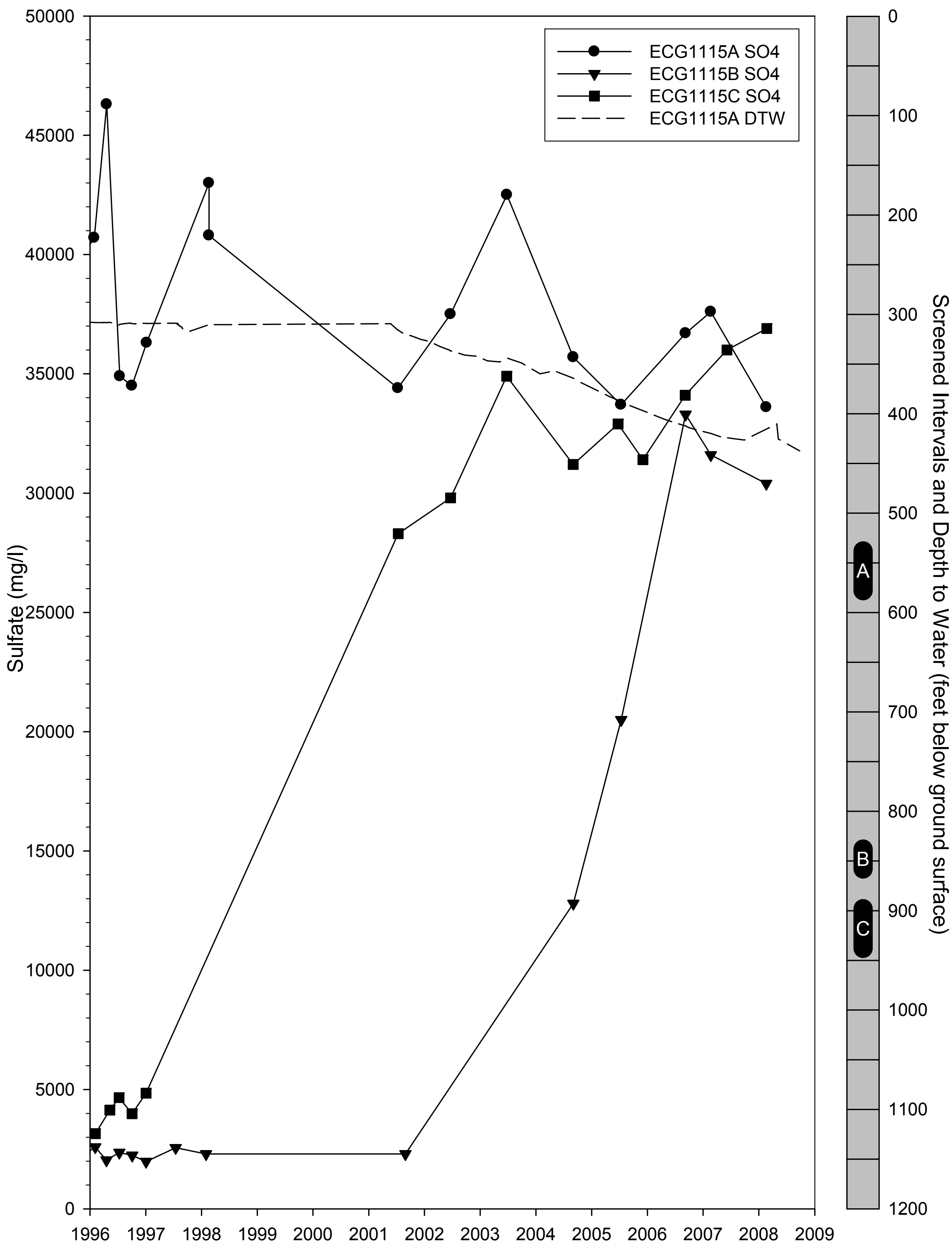


Figure 4-5 Time-Series Plot of Sulfate in ECG1124A, B, and C and ECG1146

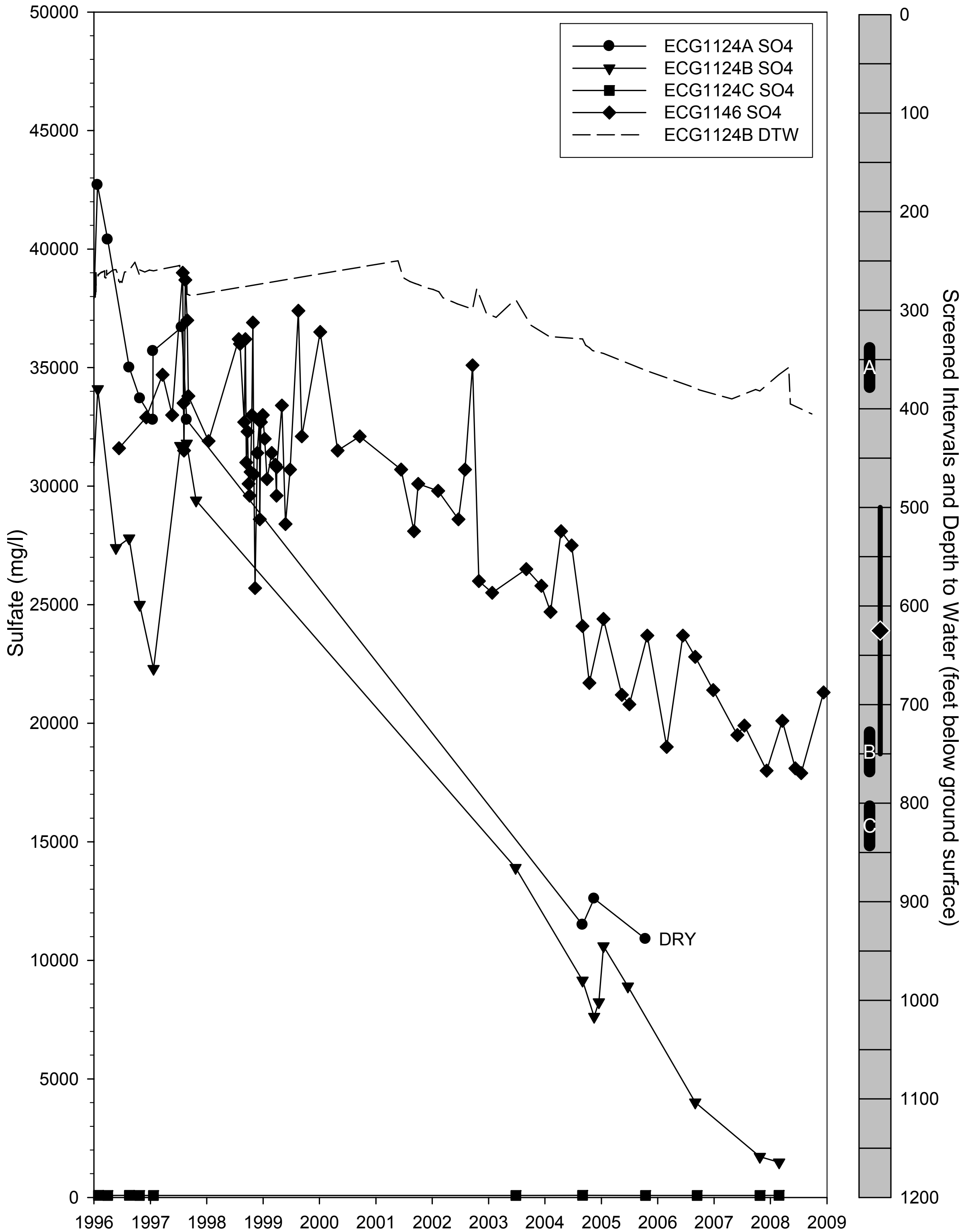


Figure 4-6 Time-Series Plot of Sulfate in ECG1145A, B, and C

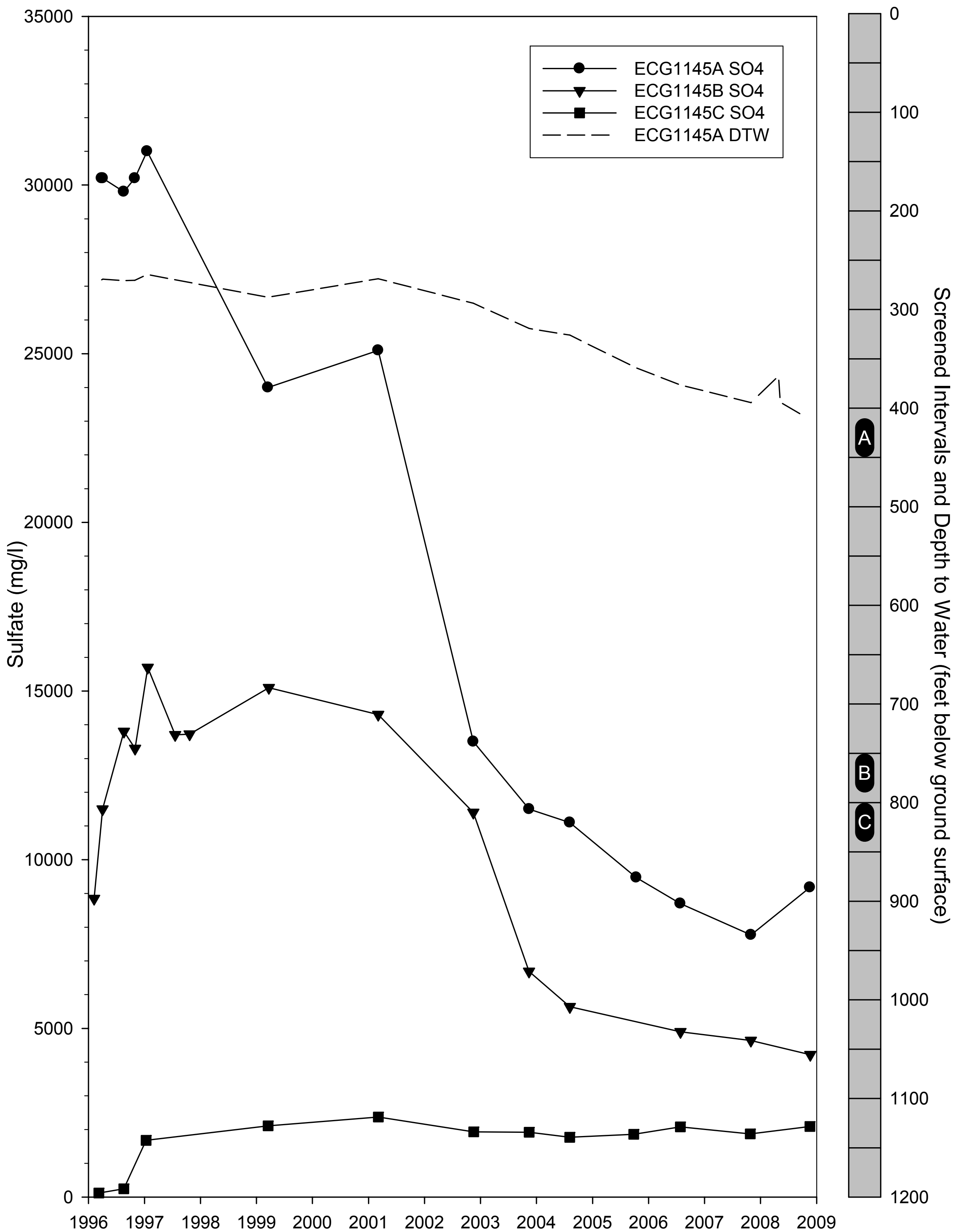


Figure 4-7 Time-Series Plot of Sulfate in ECG1144A, B, and C

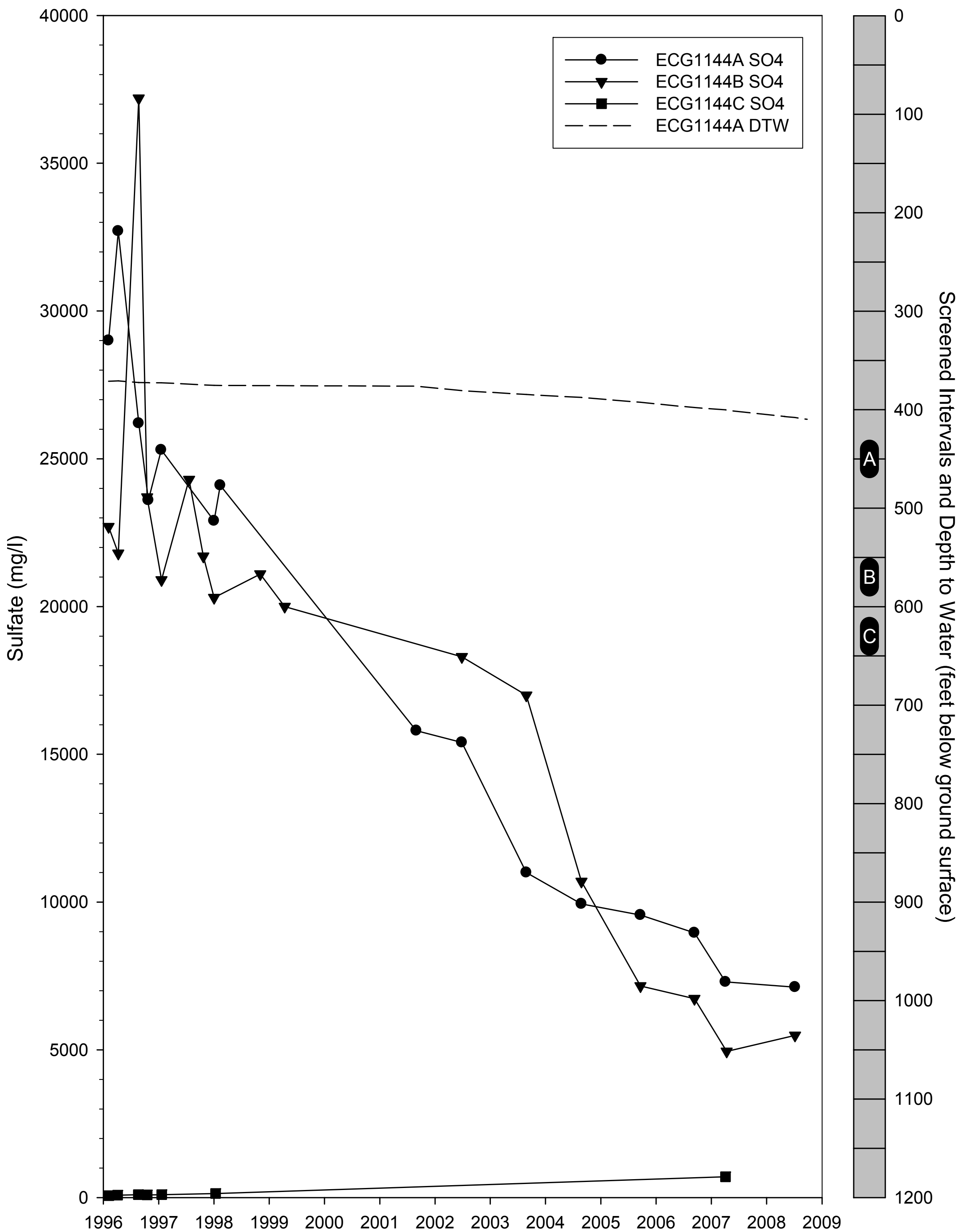


Figure 4-8 Time-Series Plot of Sulfate in ECG1128A, B, and C

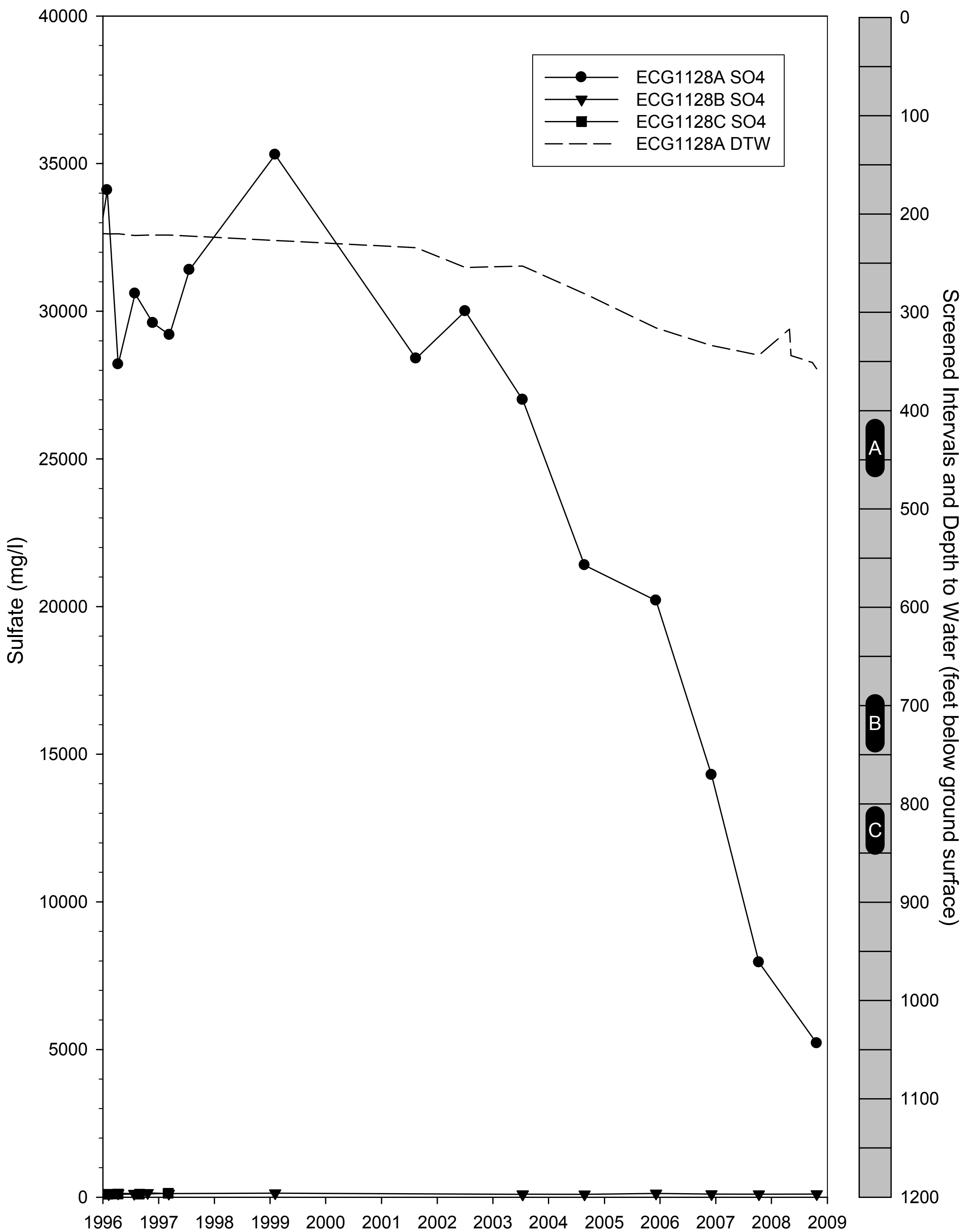


Figure 4-9 Time-Series Plot of Sulfate in ECG1118A, B, and C

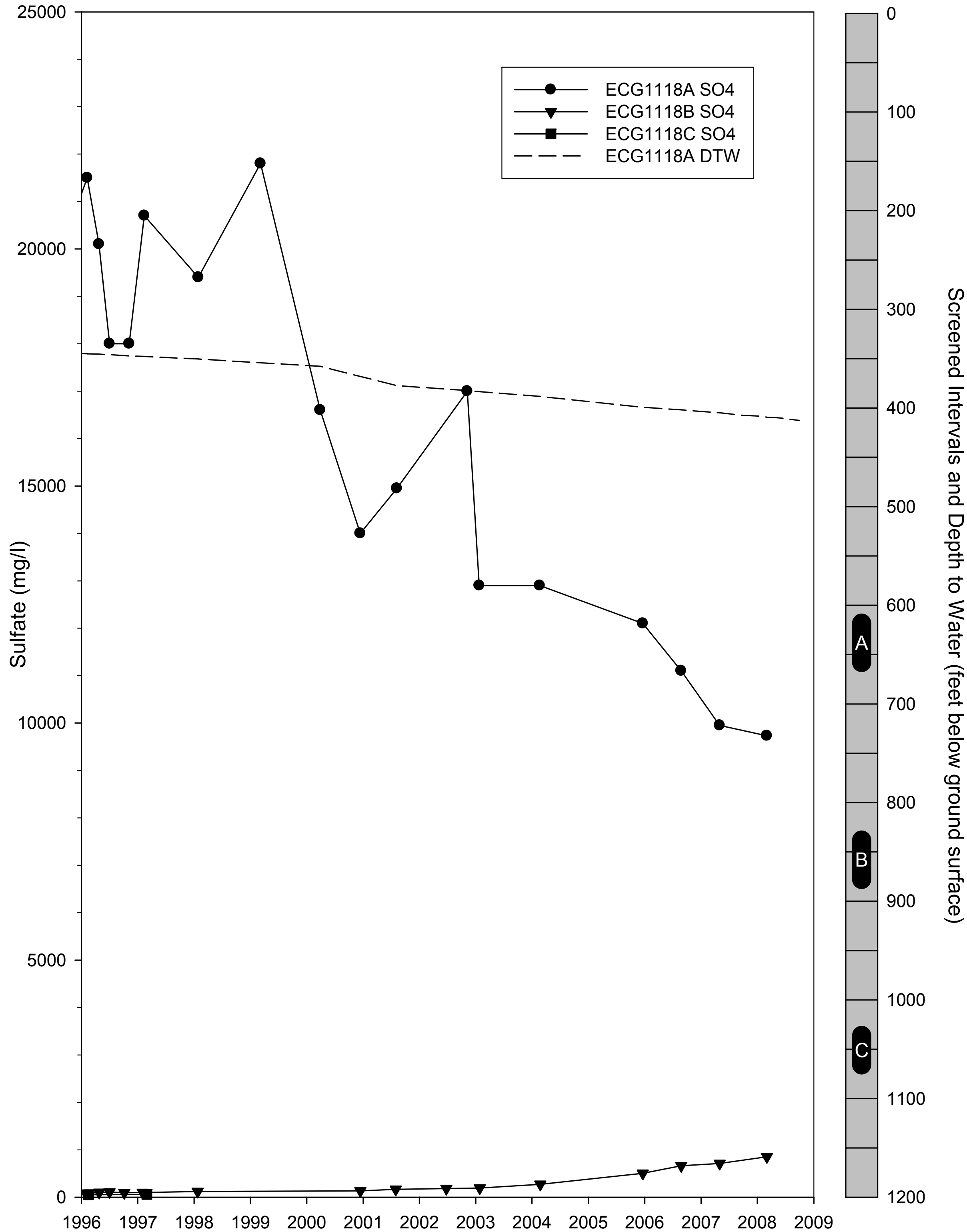


Figure 4-10 Time-Series Plot of Sulfate in BSG1177A, B, and C and BSG1201

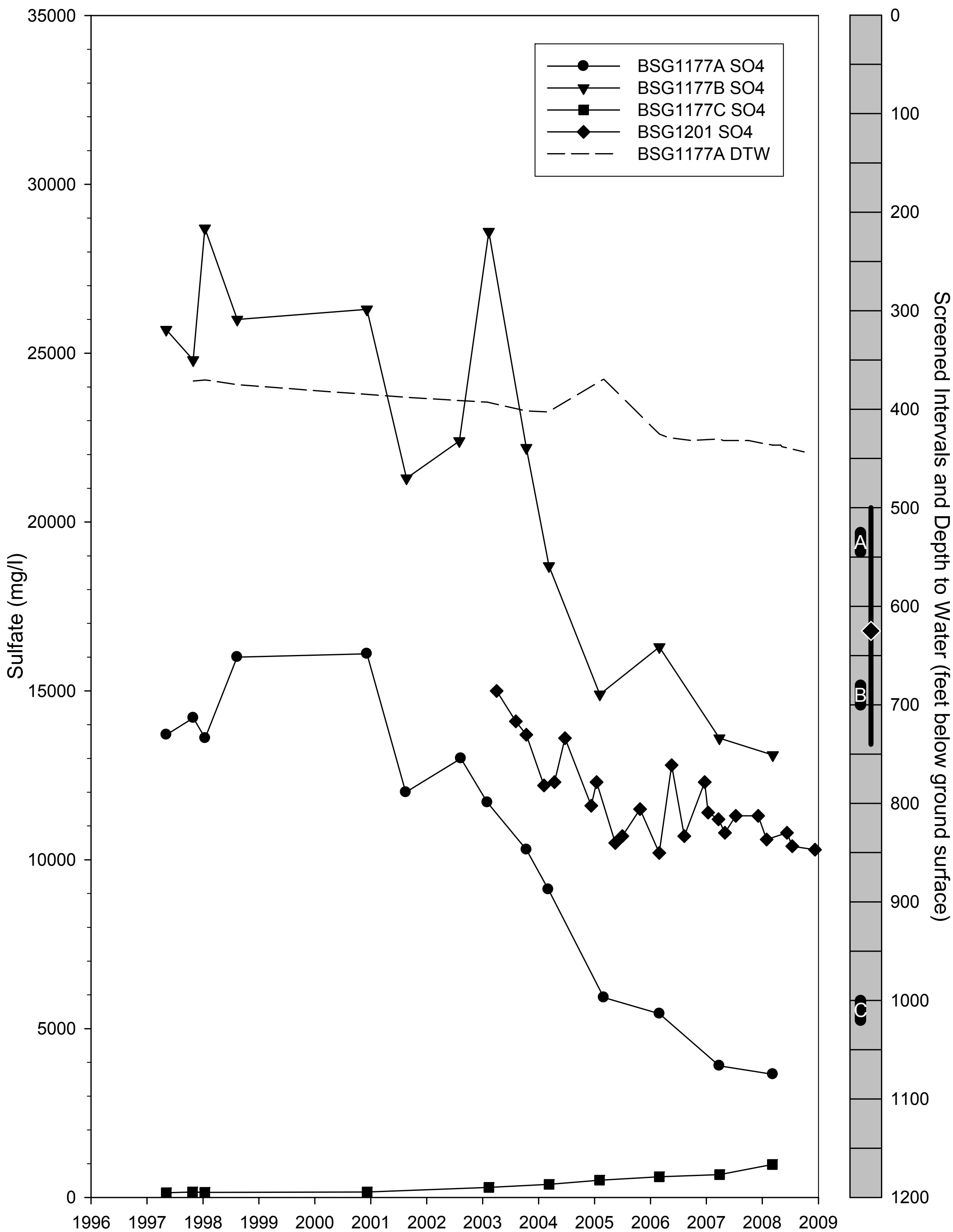


Figure 4-11 Time-Series Plot of Sulfate in BSG1119A, B, and C

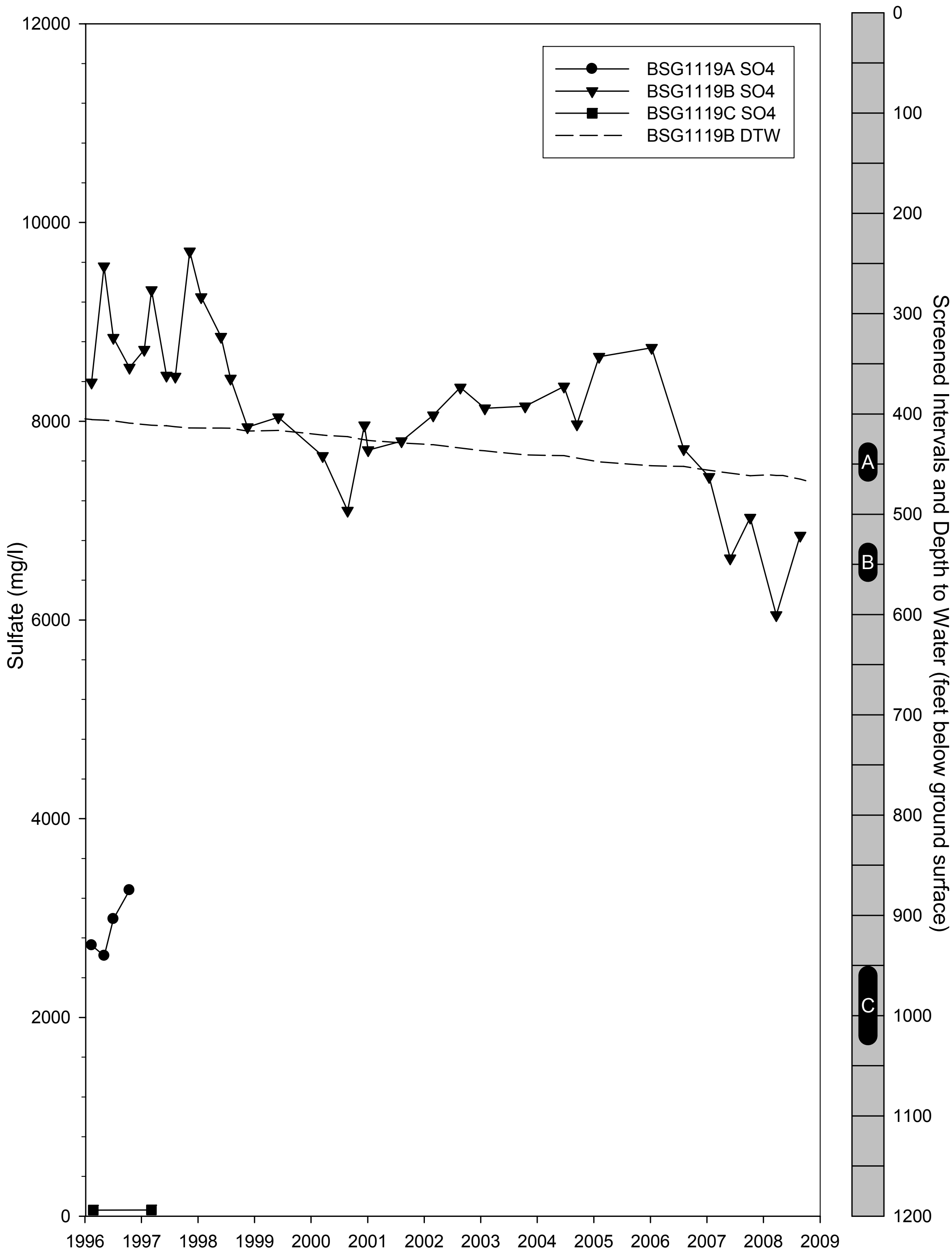


Figure 4-12 Time-Series Plot of Sulfate in BSG2782A, B, and C and BSG2784

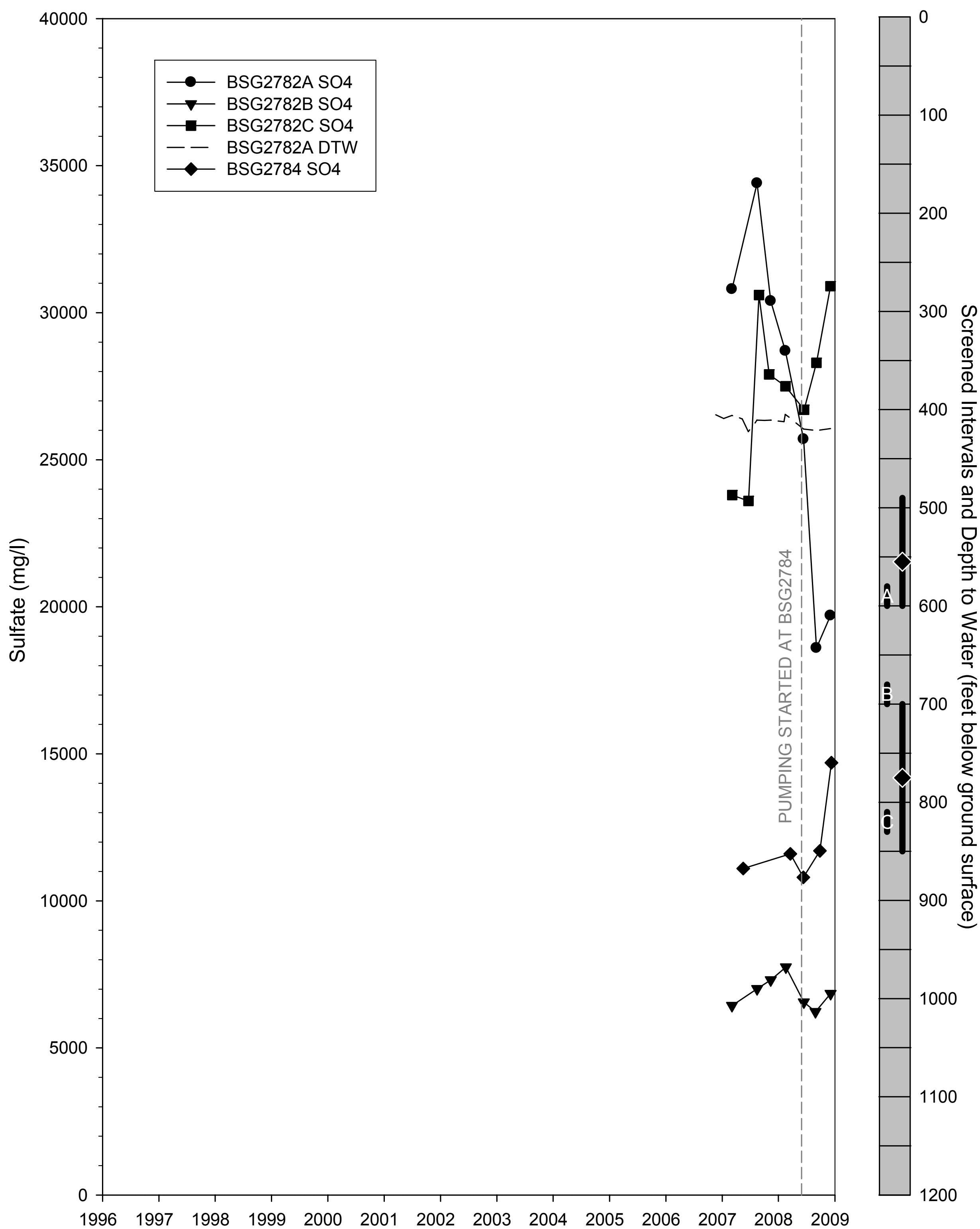


Figure 4-13 Time-Series Plot of Sulfate in BSG1179A, B, and C and P241B

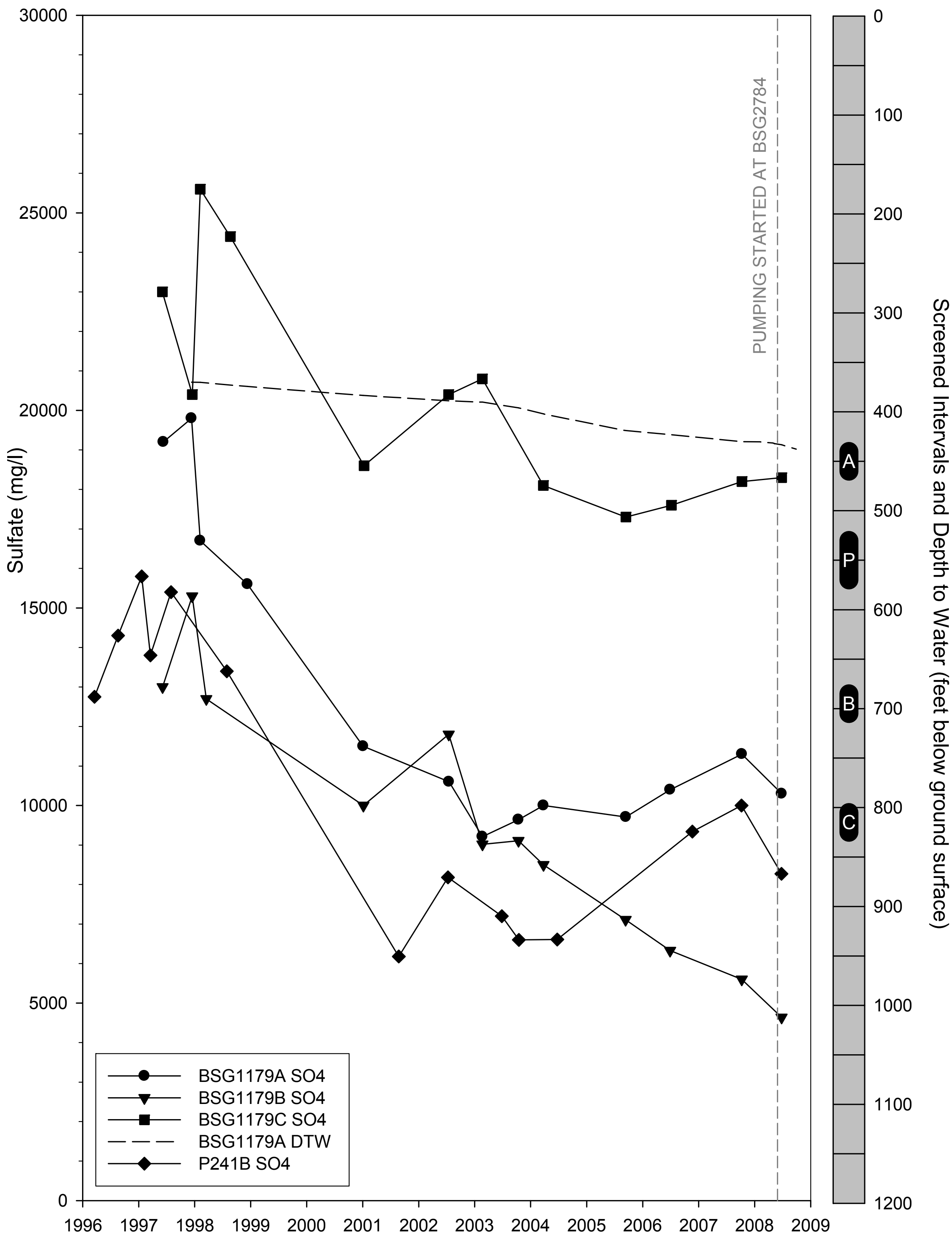


Figure 4-14 Time-Series Plot of Sulfate in BSG2777A, B, and C

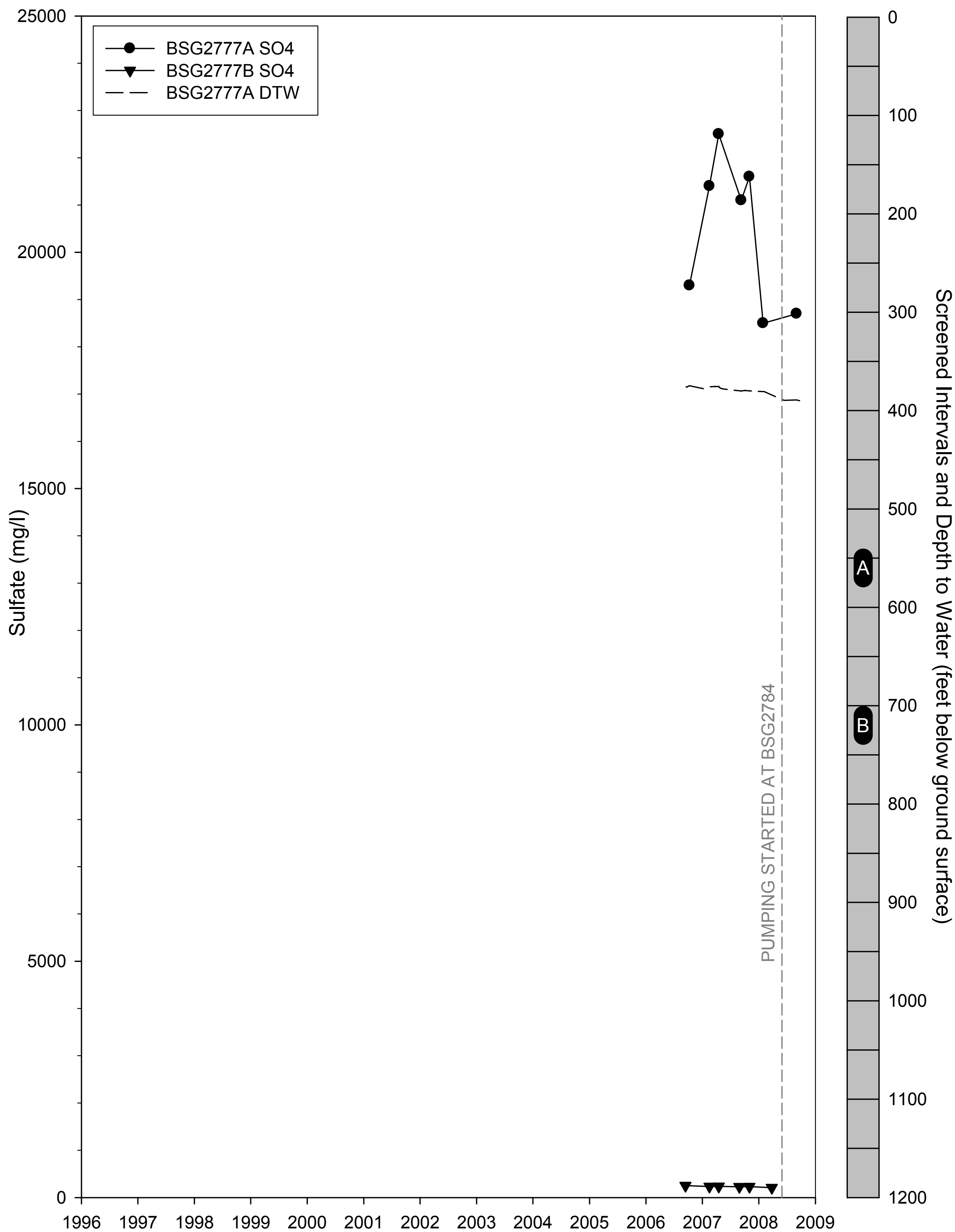


Figure 4-15 Time-Series Plot of Sulfate in BSG2783A, B, and C

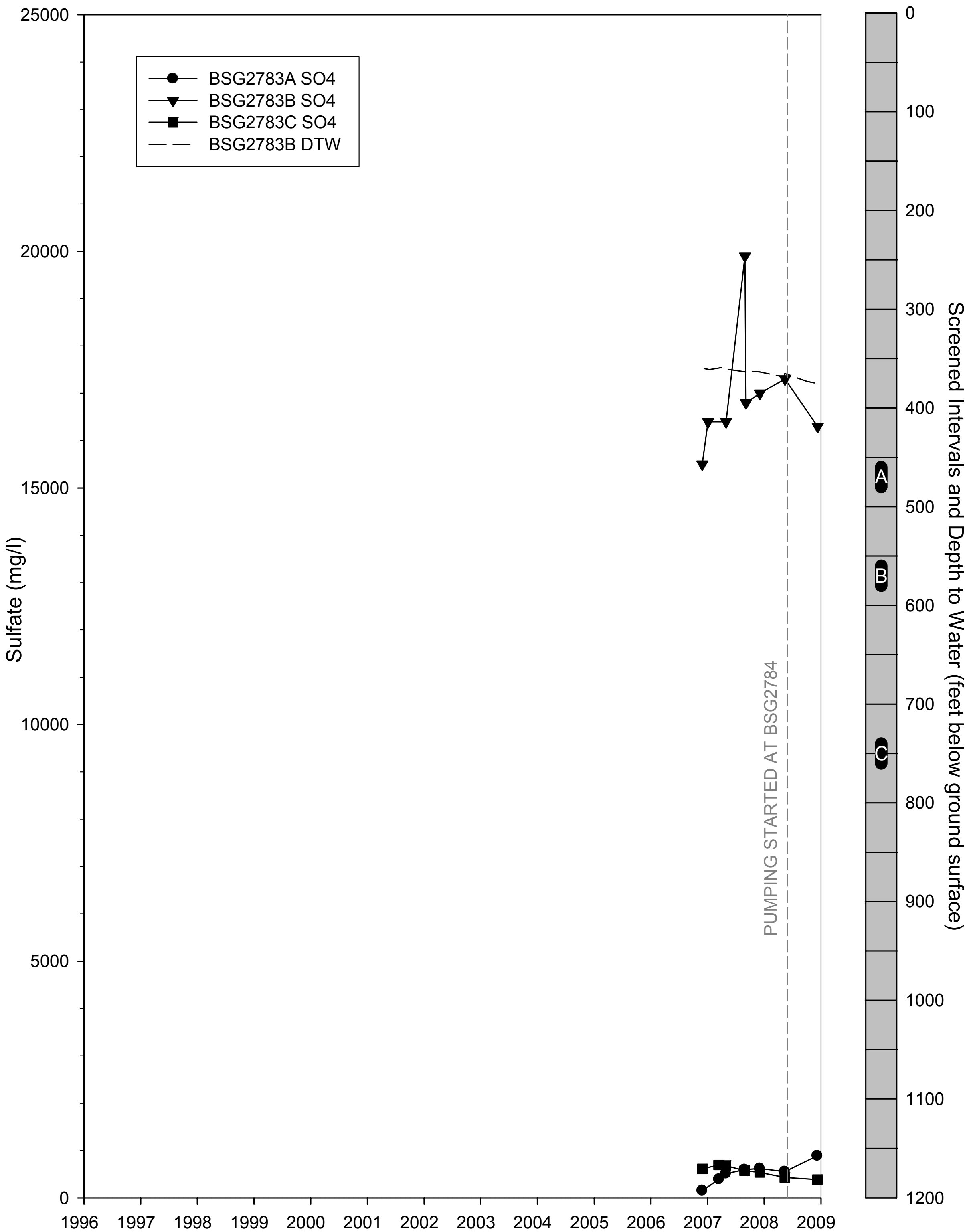


Figure 4-16 Time-Series Plot of Sulfate in B2G1157A, B, and C and B2G1193

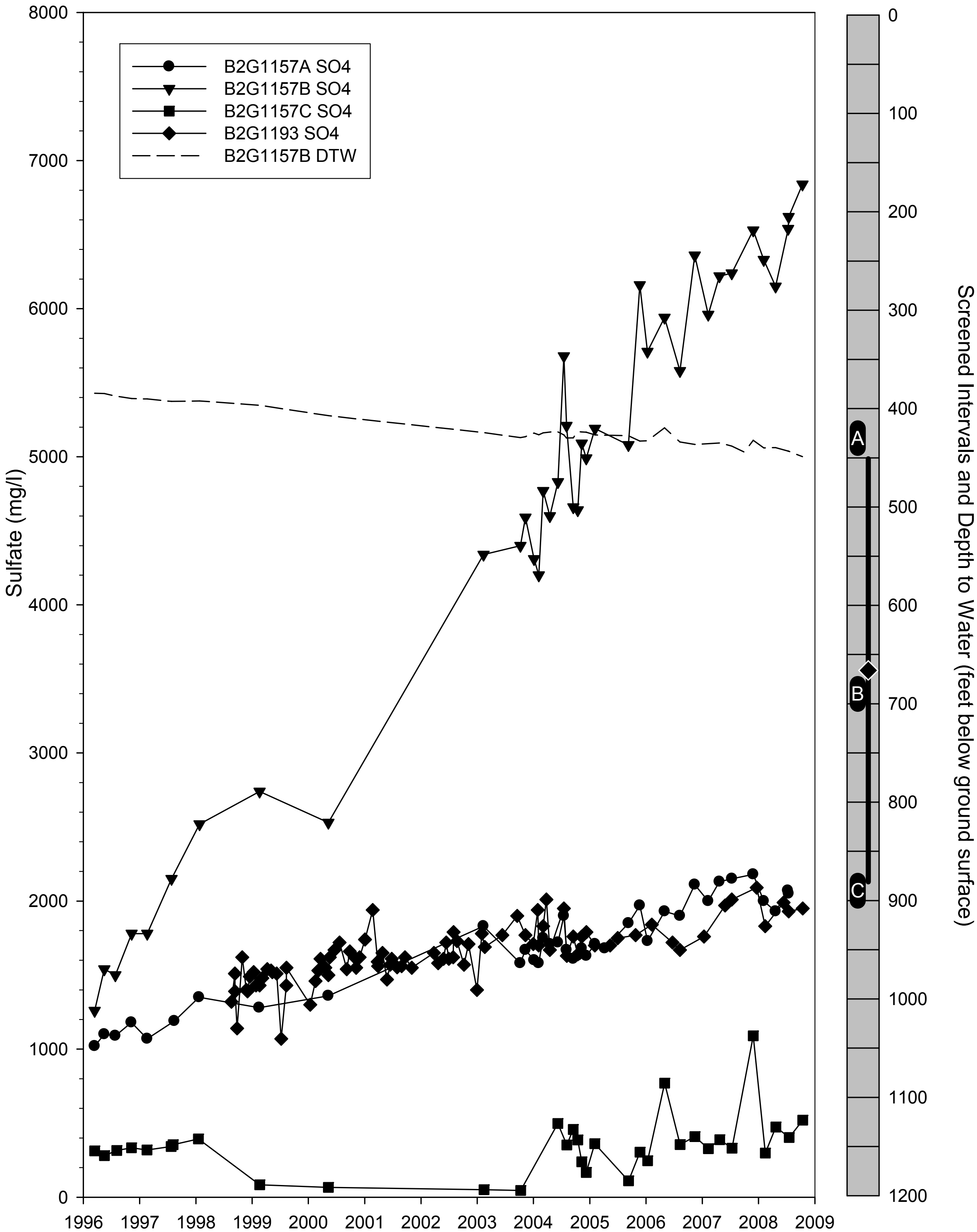


Figure 4-17 Time-Series Plot of Sulfate in BFG1156A through F

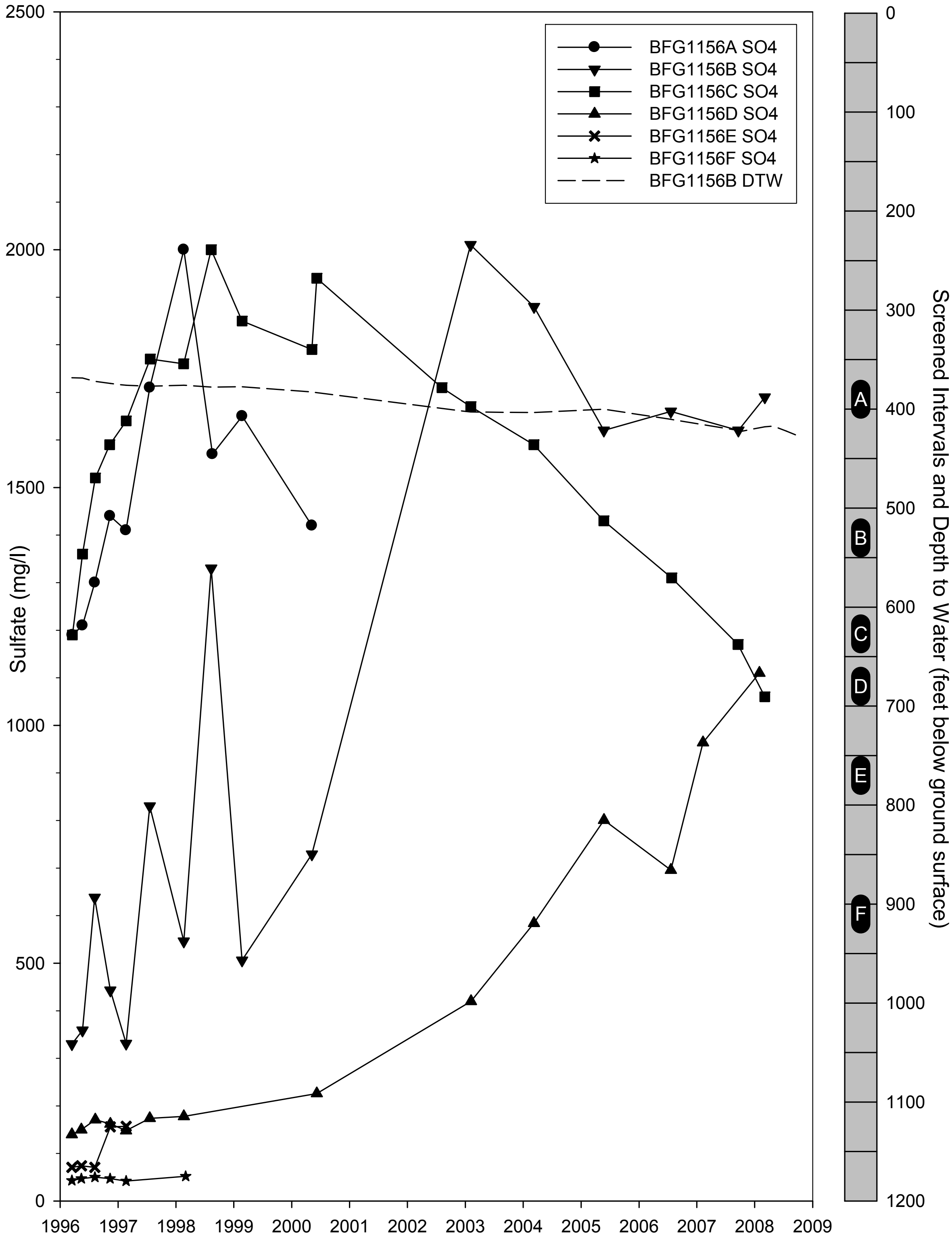


Figure 4-18 Time-Series Plot of Sulfate in BFG1155A through F and B2G1200

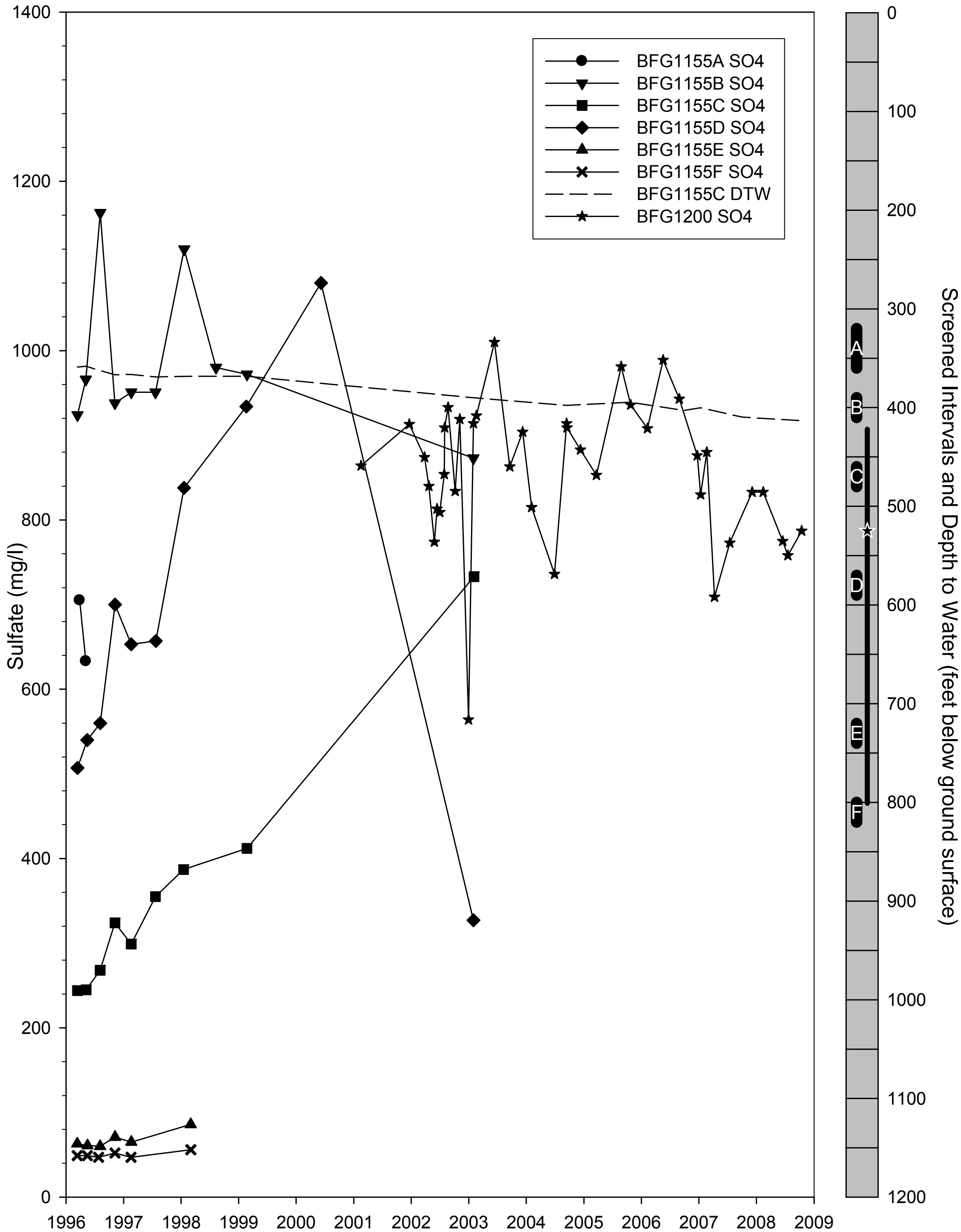


Figure 4-19 Time-Series Plot of Sulfate in BFG1195A and B

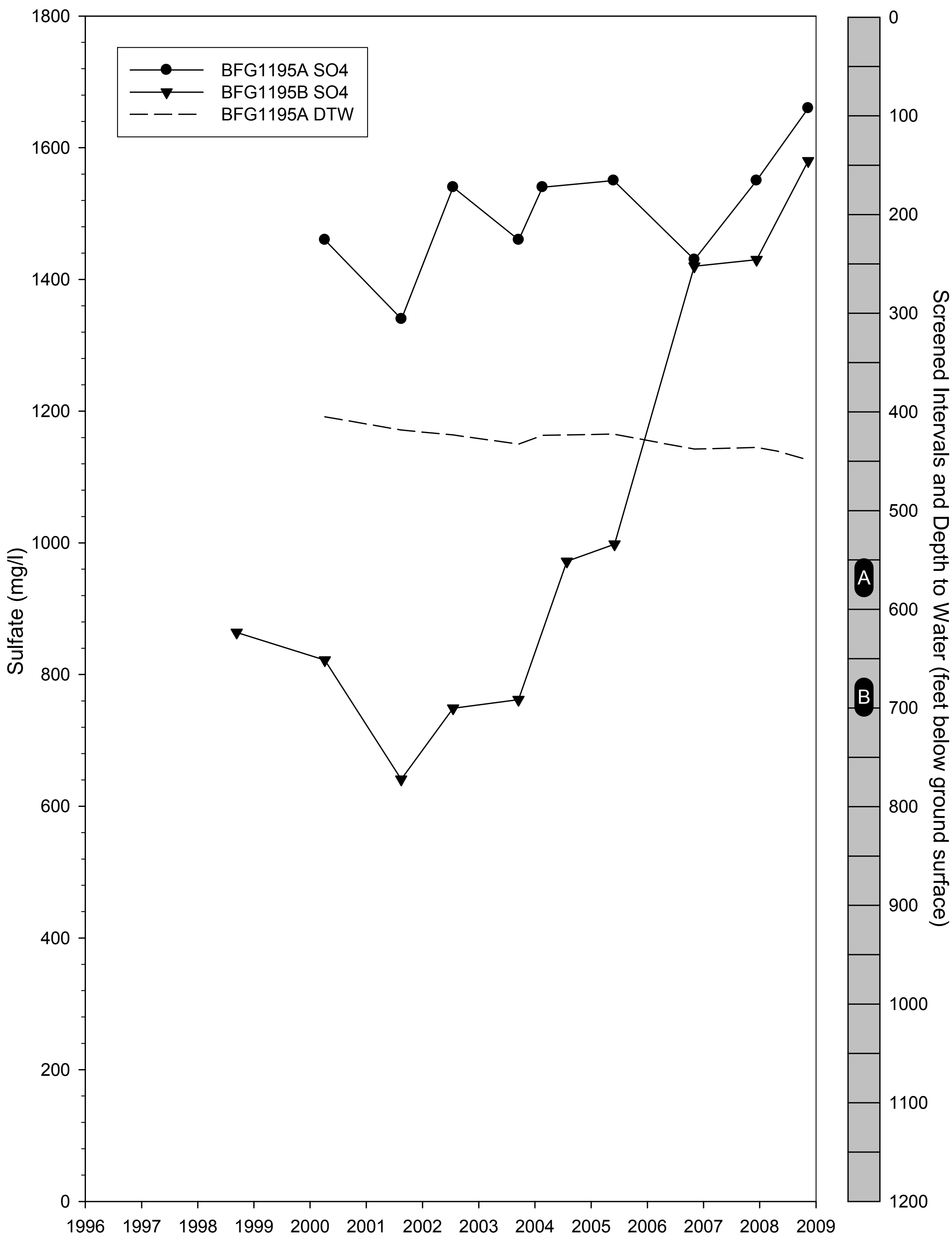


Figure 4-20 Time-Series Plot of Sulfate in P277

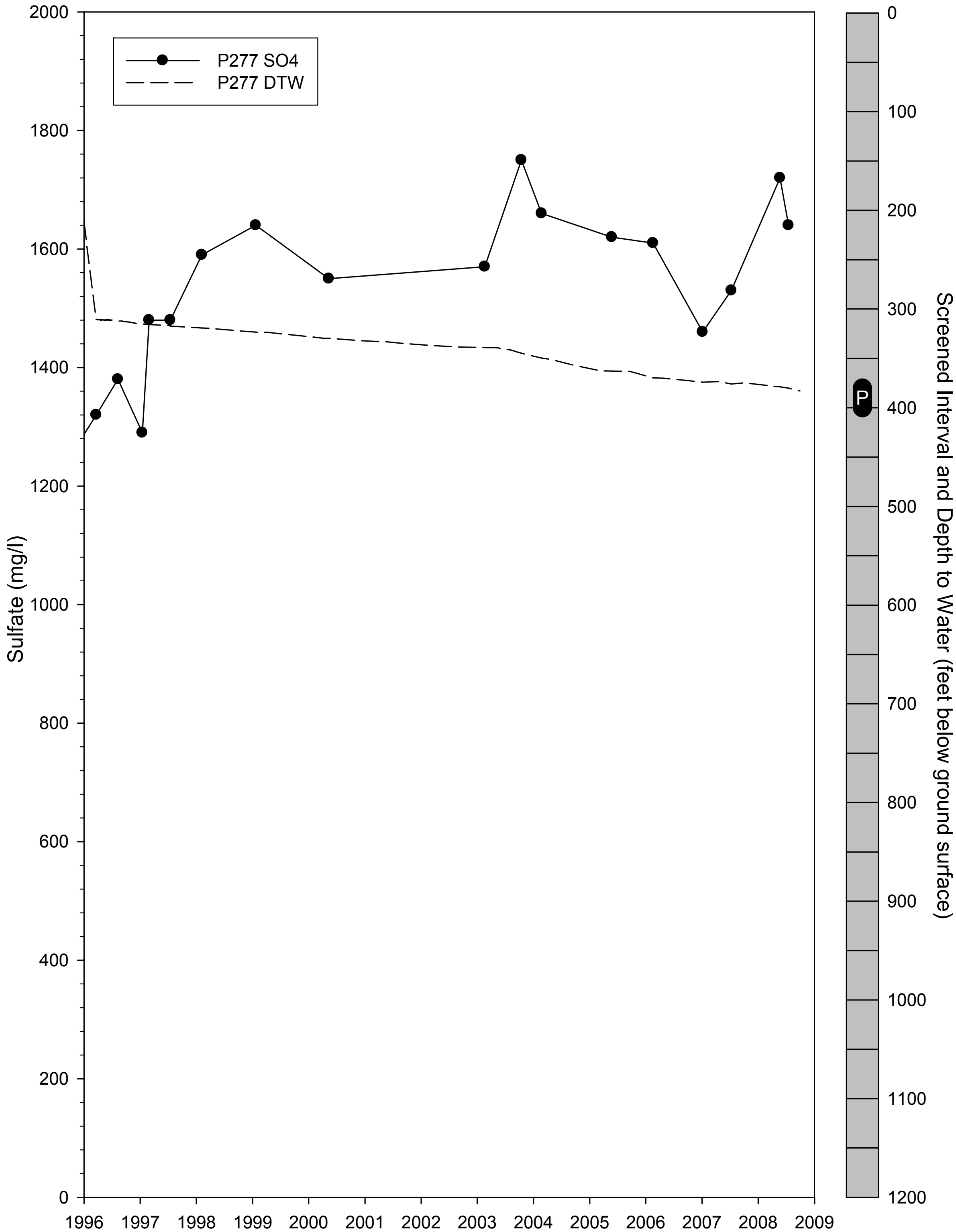


Figure 4-21 Time-Series Plot of Sulfate in B2G1194A and B

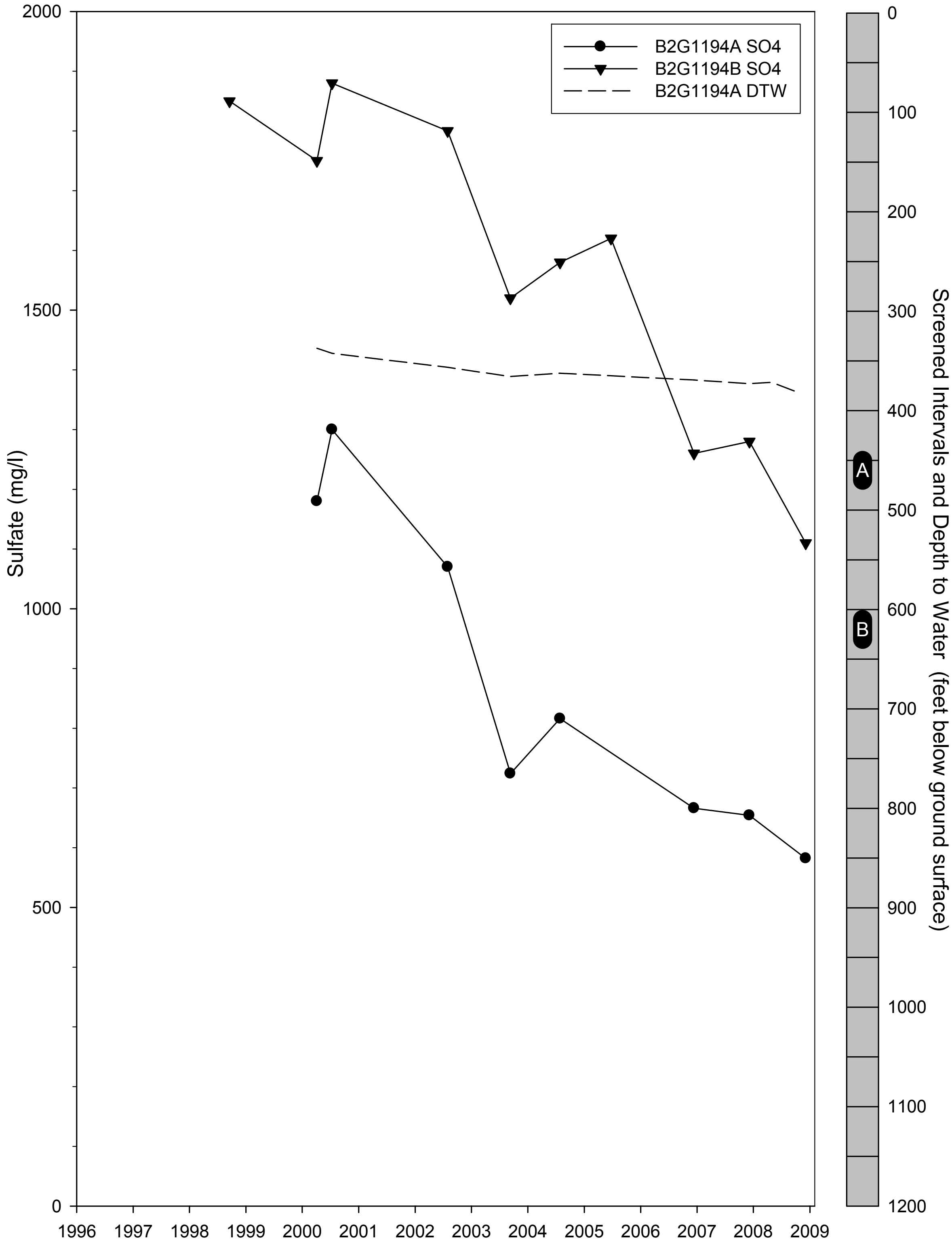


Figure 4-22 Time-Series Plot of Sulfate in B3G1197A, B, and C

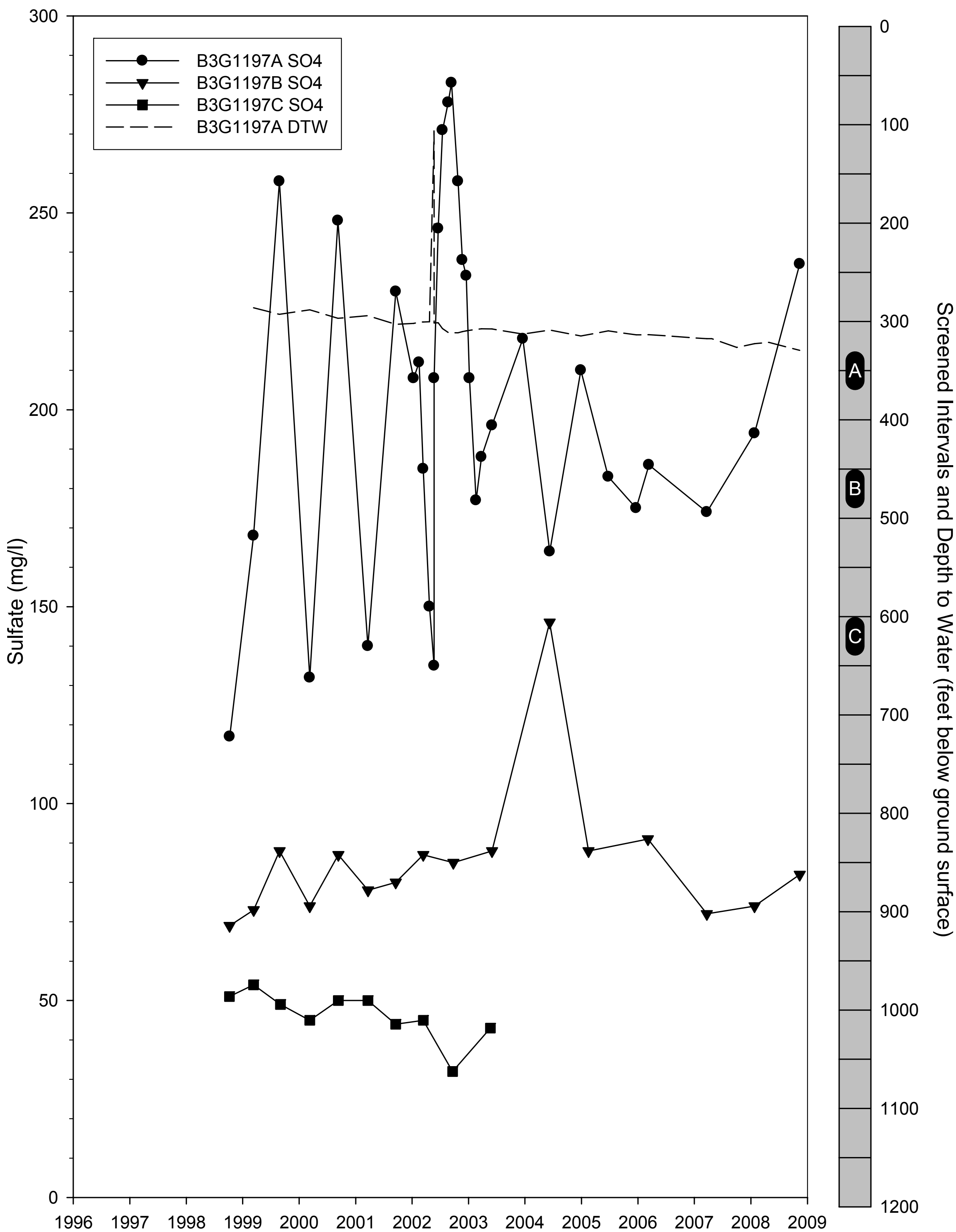


Figure 4-23 Time-Series Plot of Sulfate in P241C

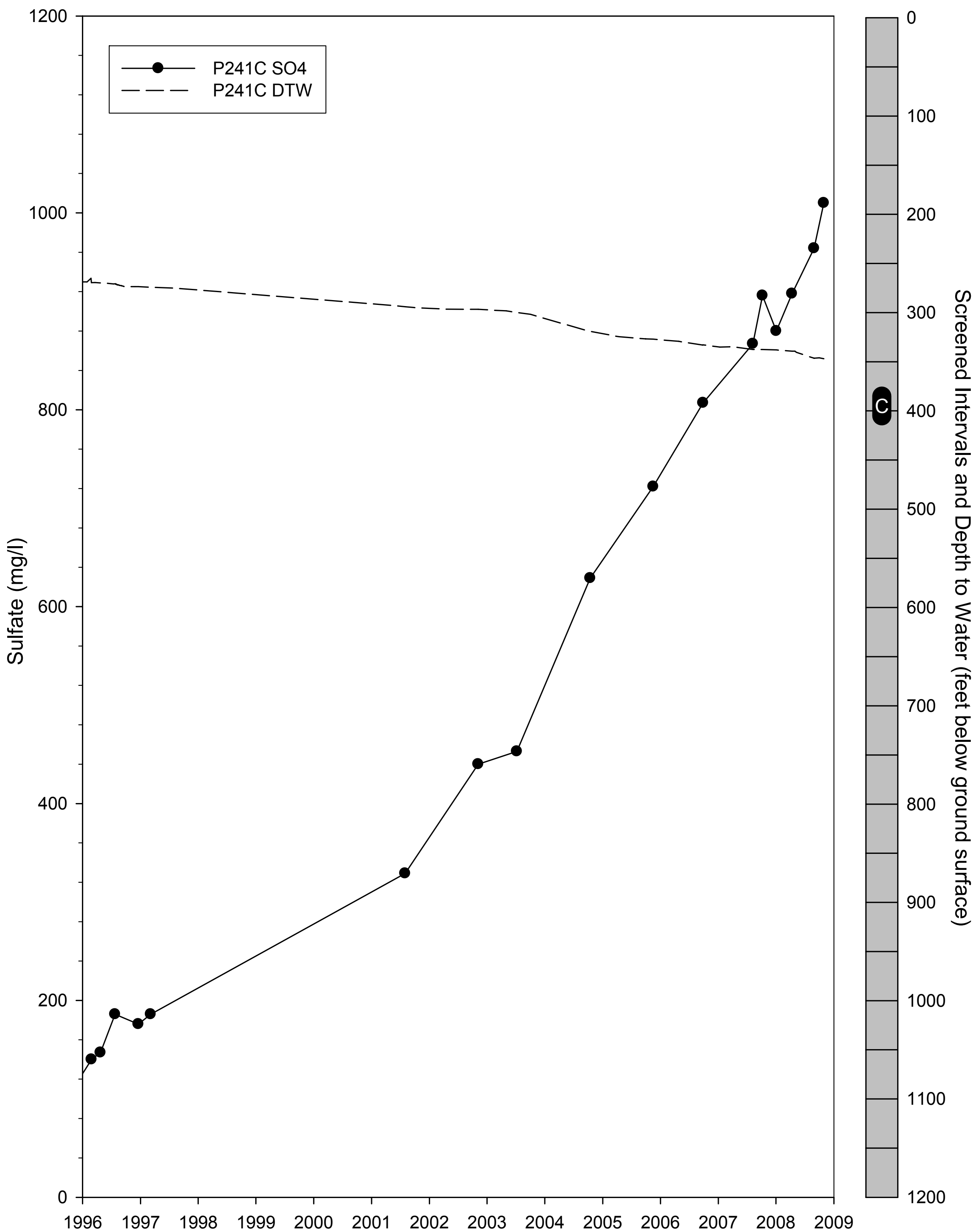


Figure 4-24 Time-Series Plot of Sulfate in BSG1148A, B, and C

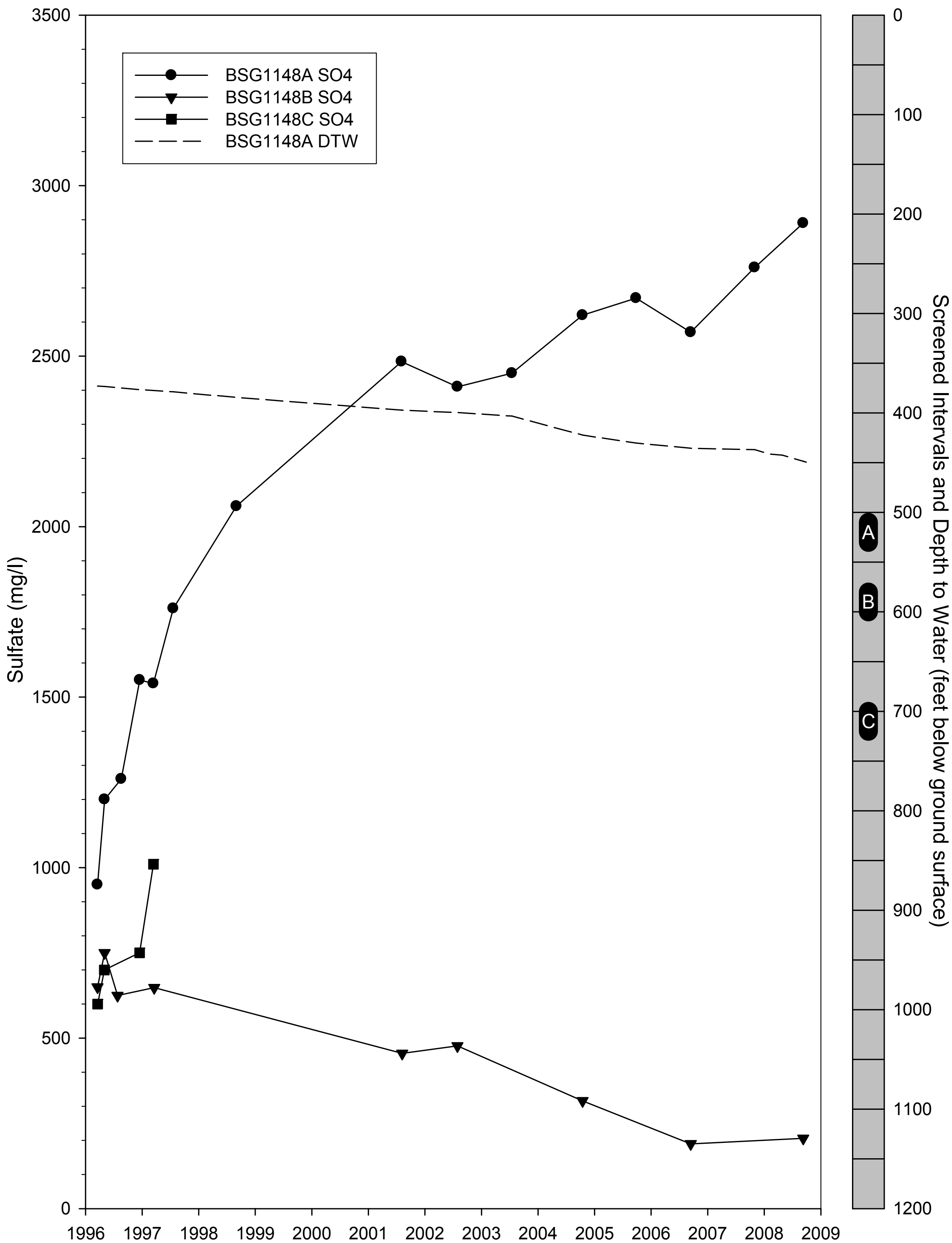


Figure 4-25 Time-Series Plot of Sulfate in BSG1133A, B, and C

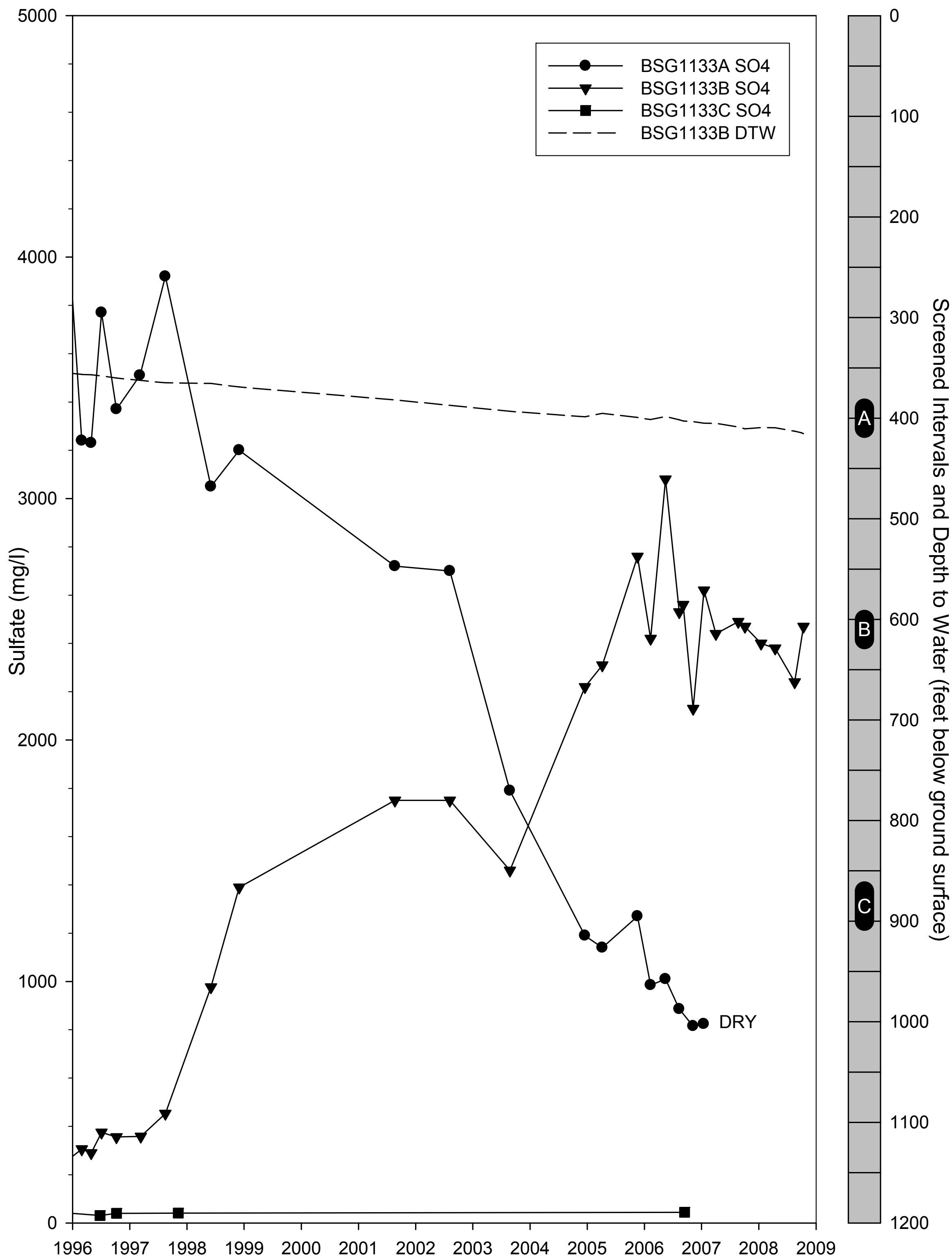


Figure 4-26 Time-Series Plot of Sulfate in BSG1132A, B, and C

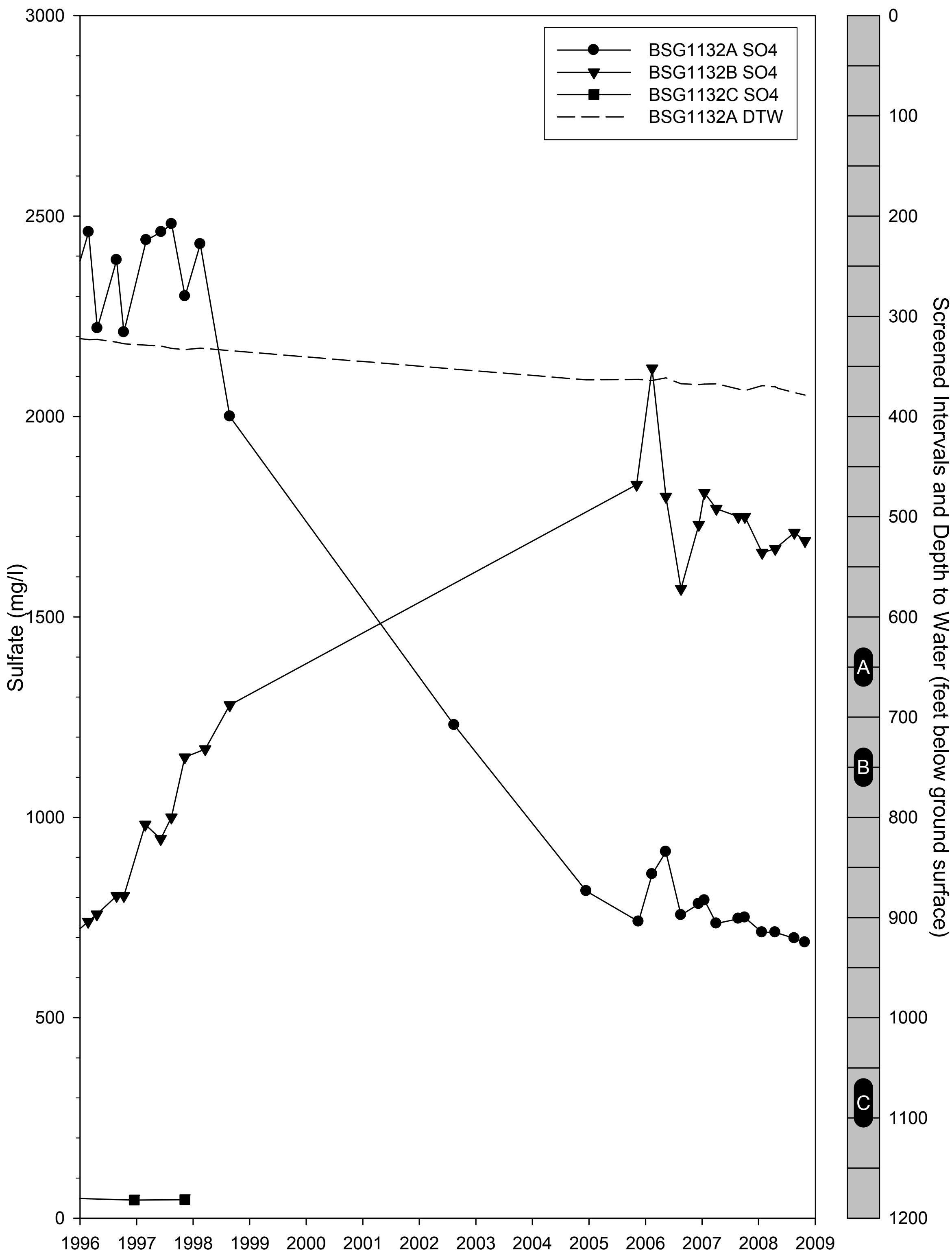


Figure 4-27 Time-Series Plot of Sulfate in W363

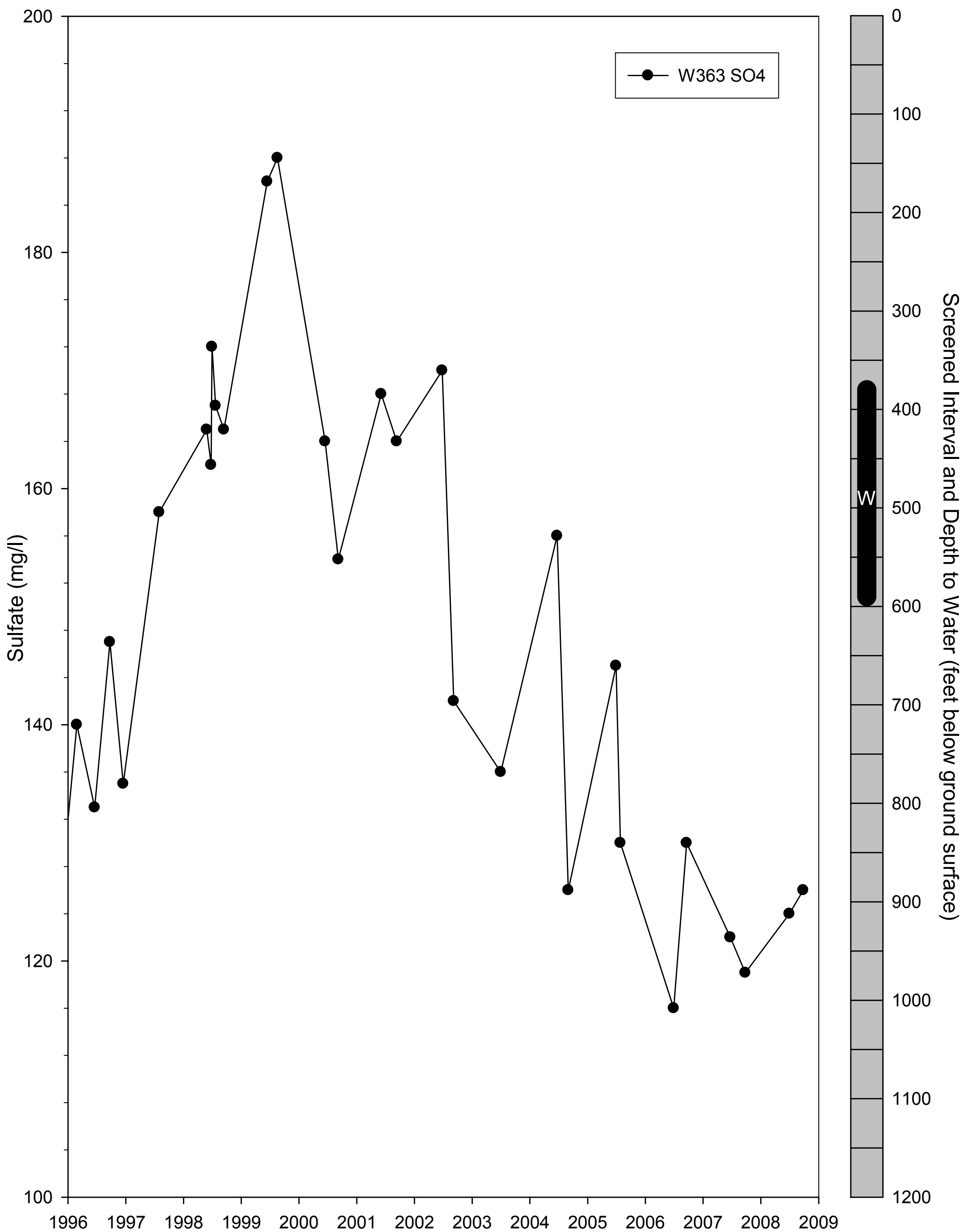


Figure 4-28 Time-Series Plot of Sulfate WJG1154A, B, and C

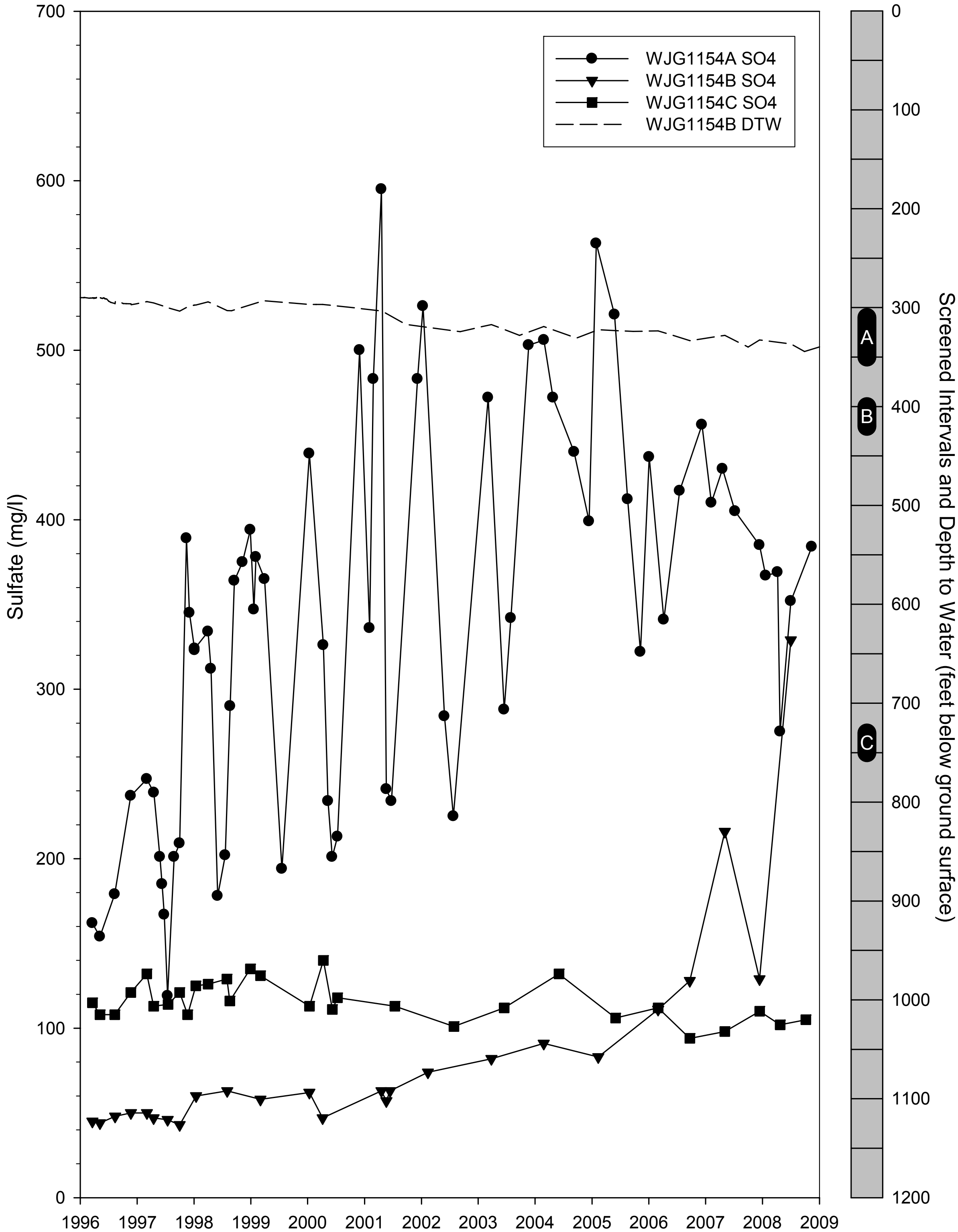


Figure 4-29 Time-Series Plot of Sulfate in WJG1170A, B, and C

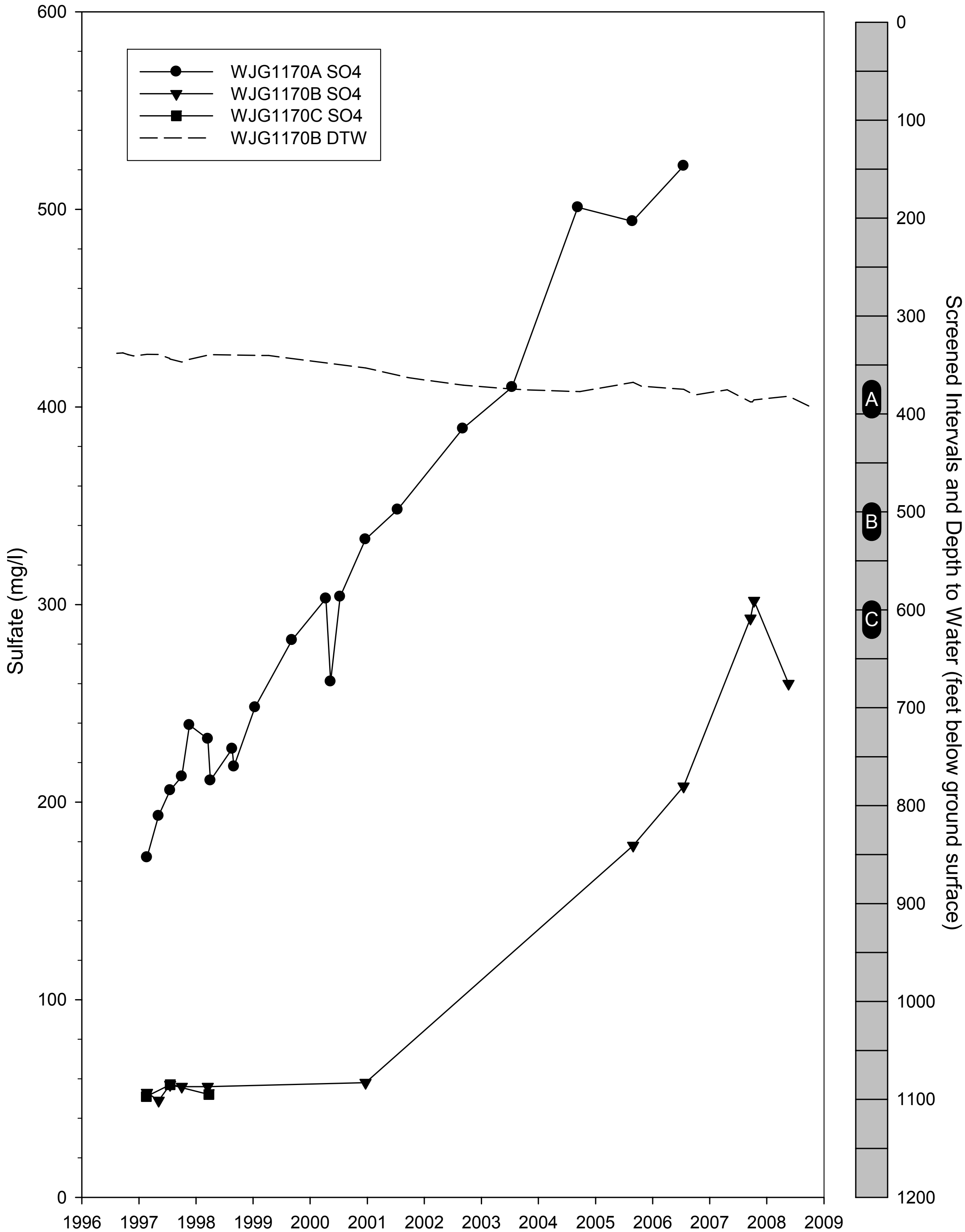


Figure 4-30 Time-Series Plot of Sulfate in WJG1171A, B, and C

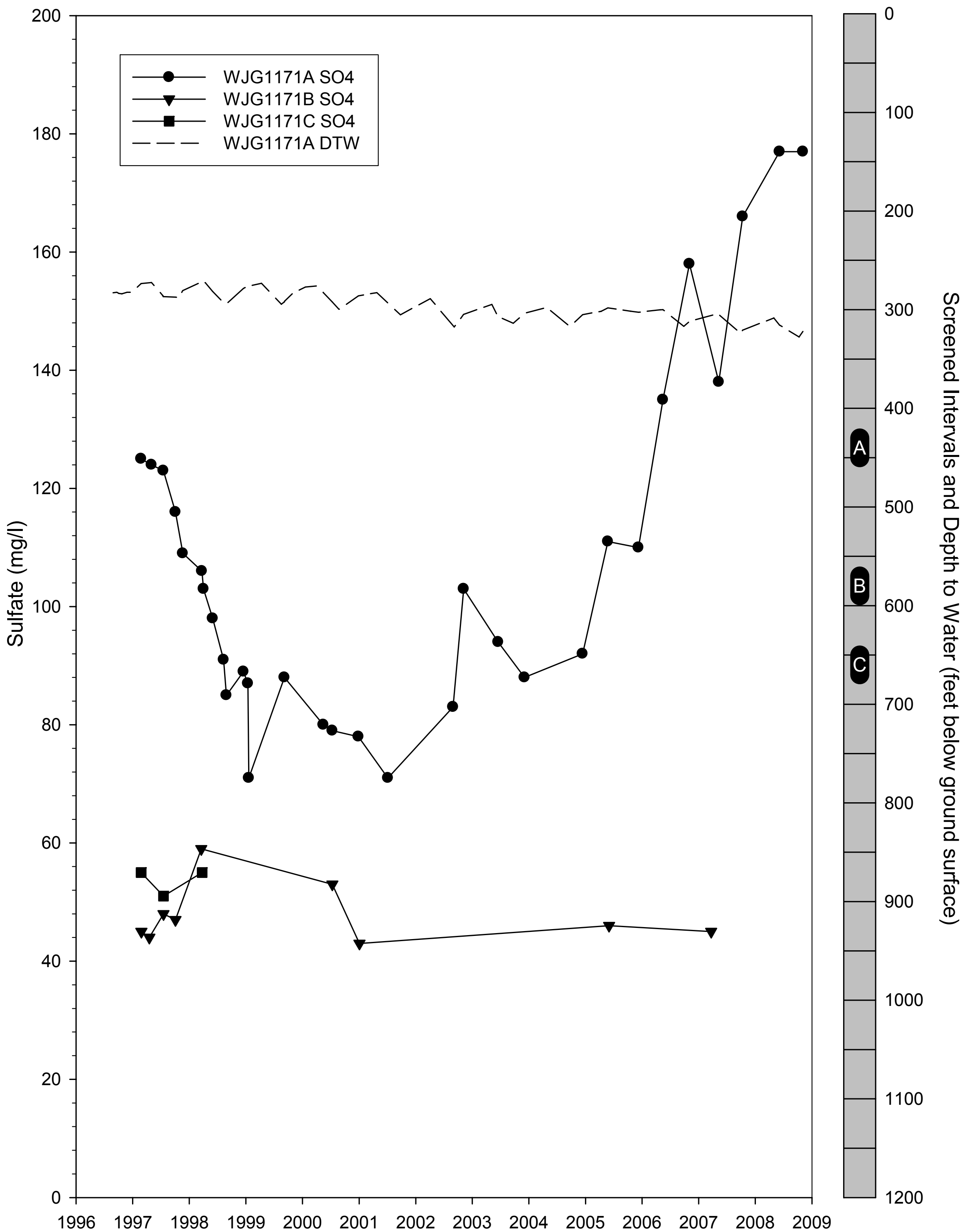


Figure 4-33 Time-Series Plot of Aluminum in SRG946

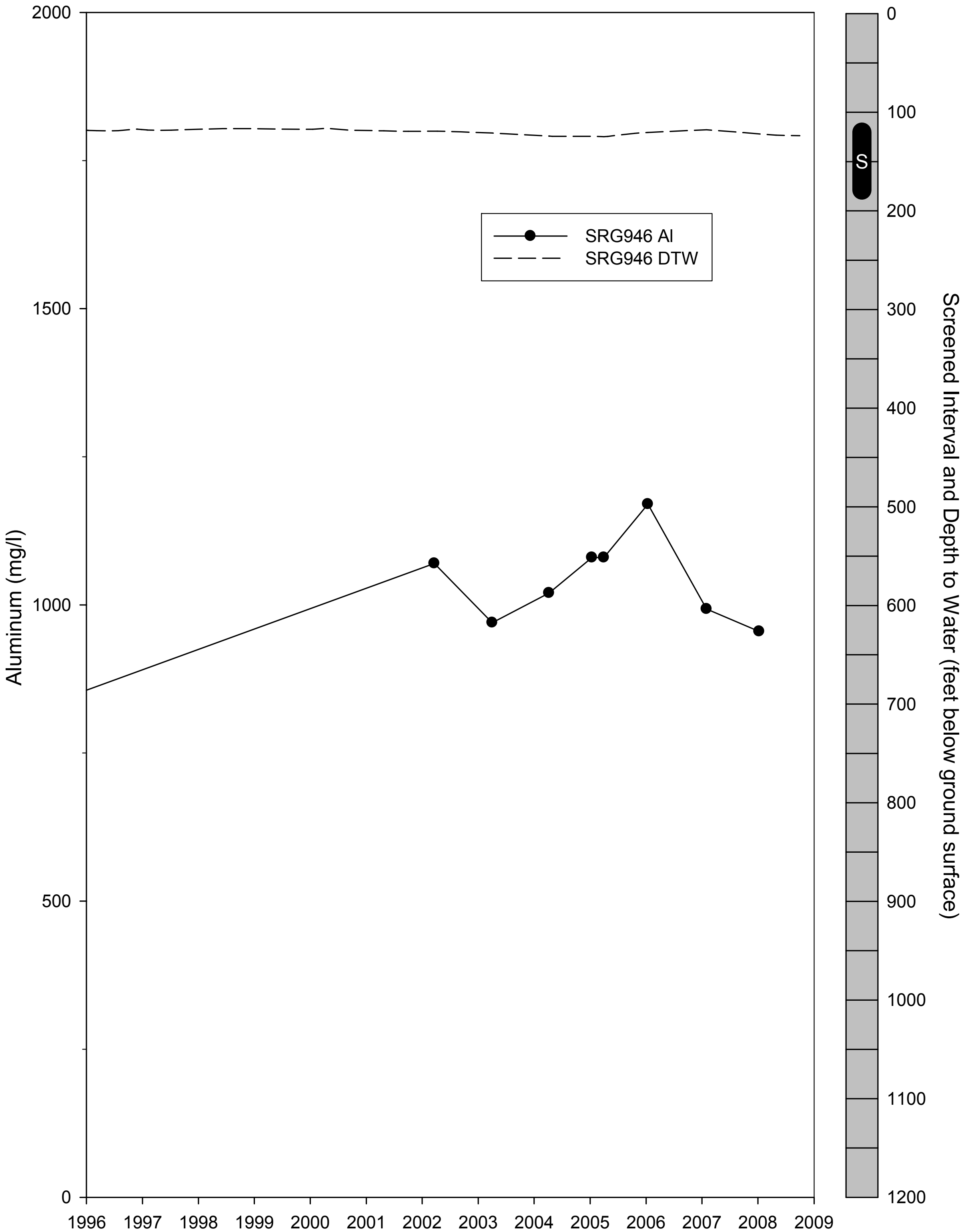


Figure 4-34 Time-Series Plot of Aluminum in ECG1115A, B, and C

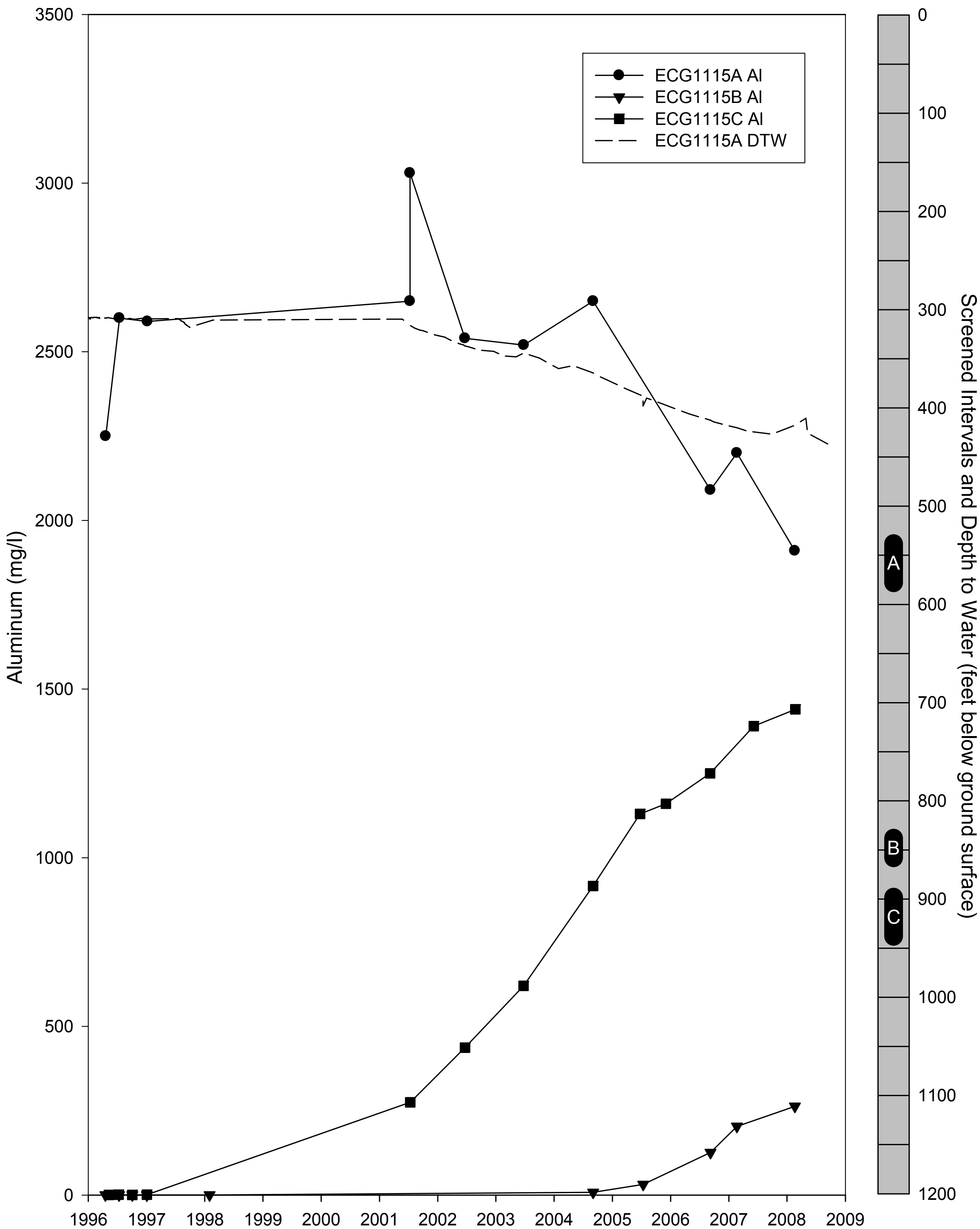


Figure 4-35 Time-Series Plot of Aluminum in ECG1146 and ECG1124A, B, and C

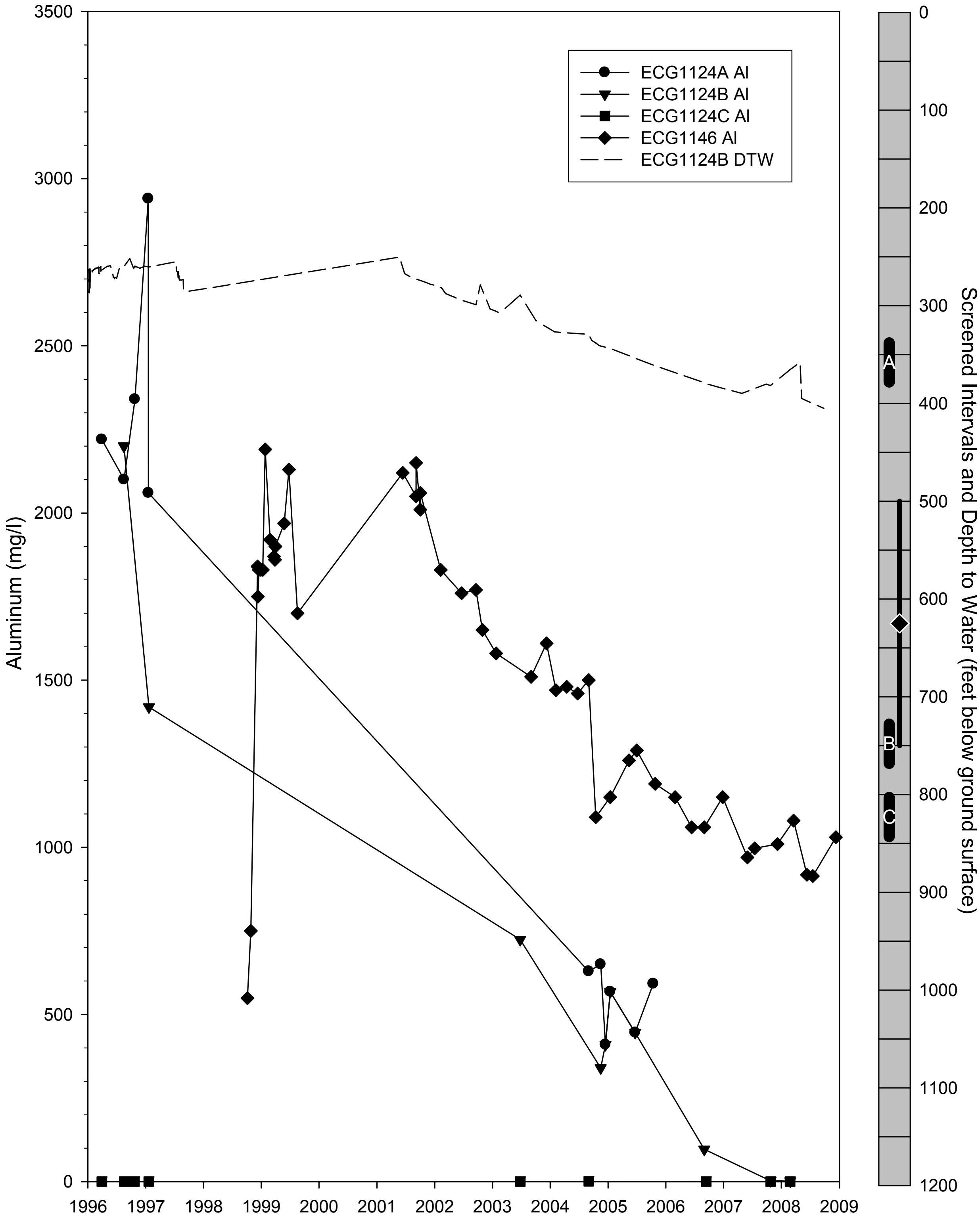


Figure 4-36 Time-Series Plot of Aluminum in ECG1128A

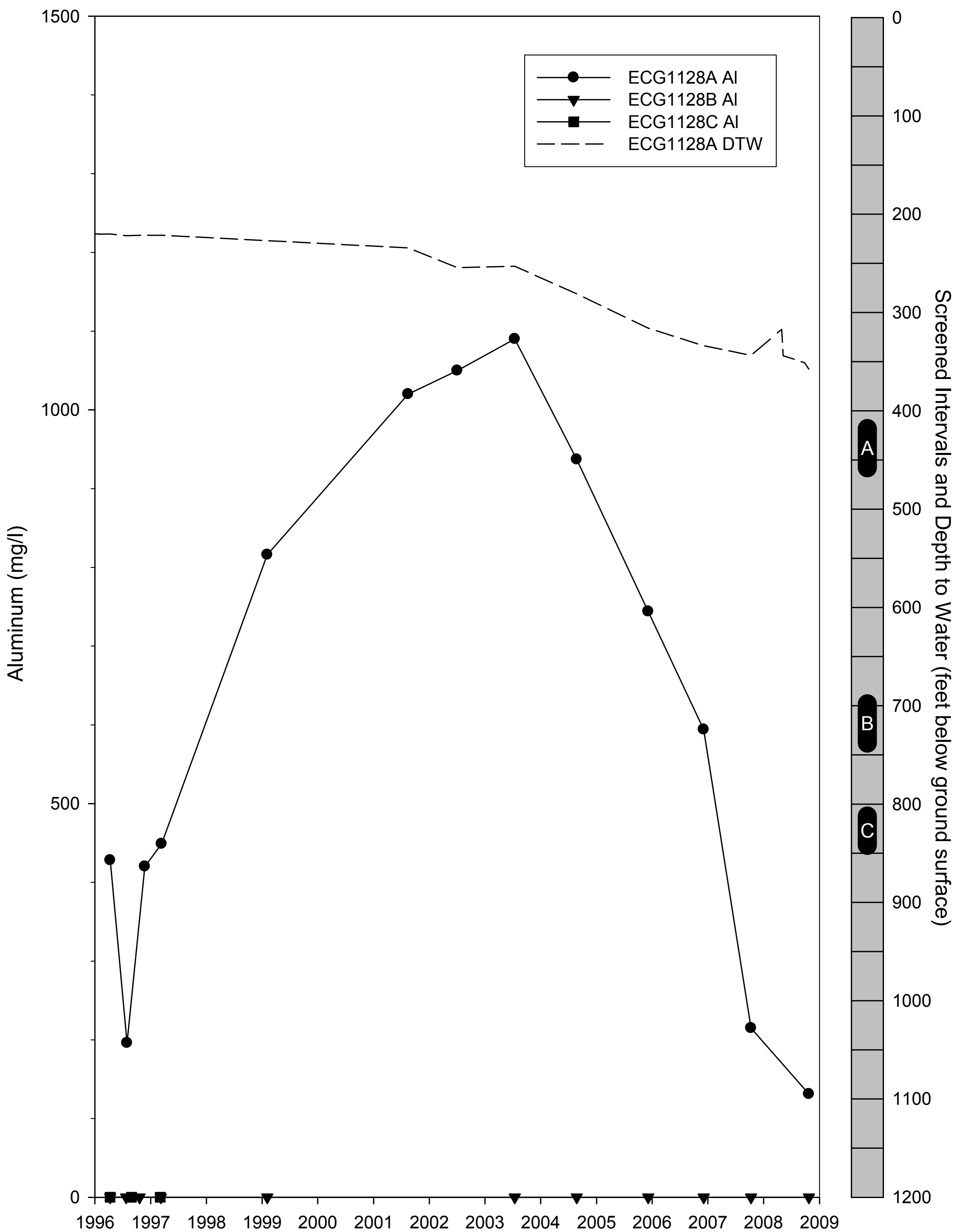


Figure 4-37 Time-Series Plot of Aluminum in ECG1118A, B, and C

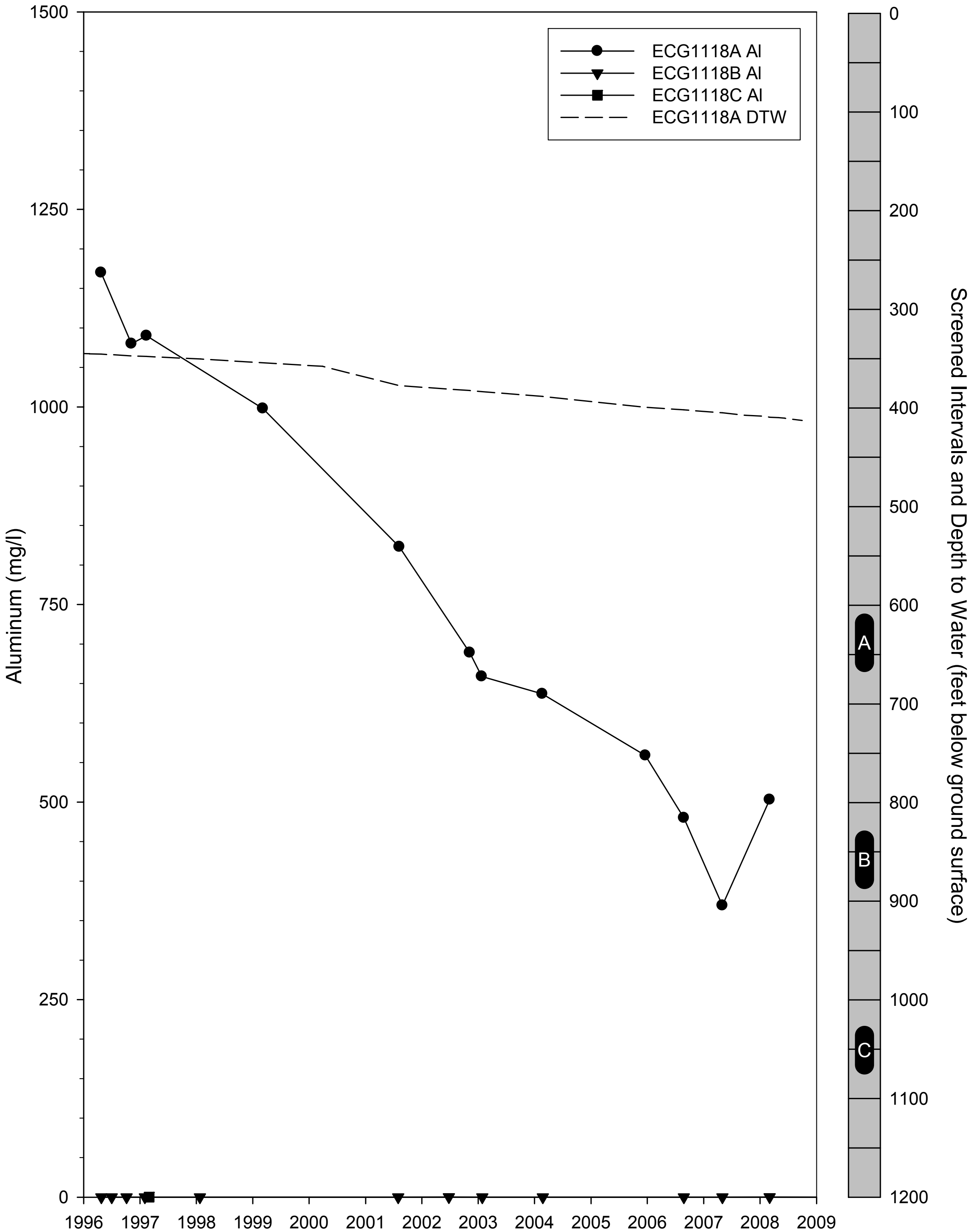


Figure 4-38 Time-Series Plot of Aluminum in BSG1201

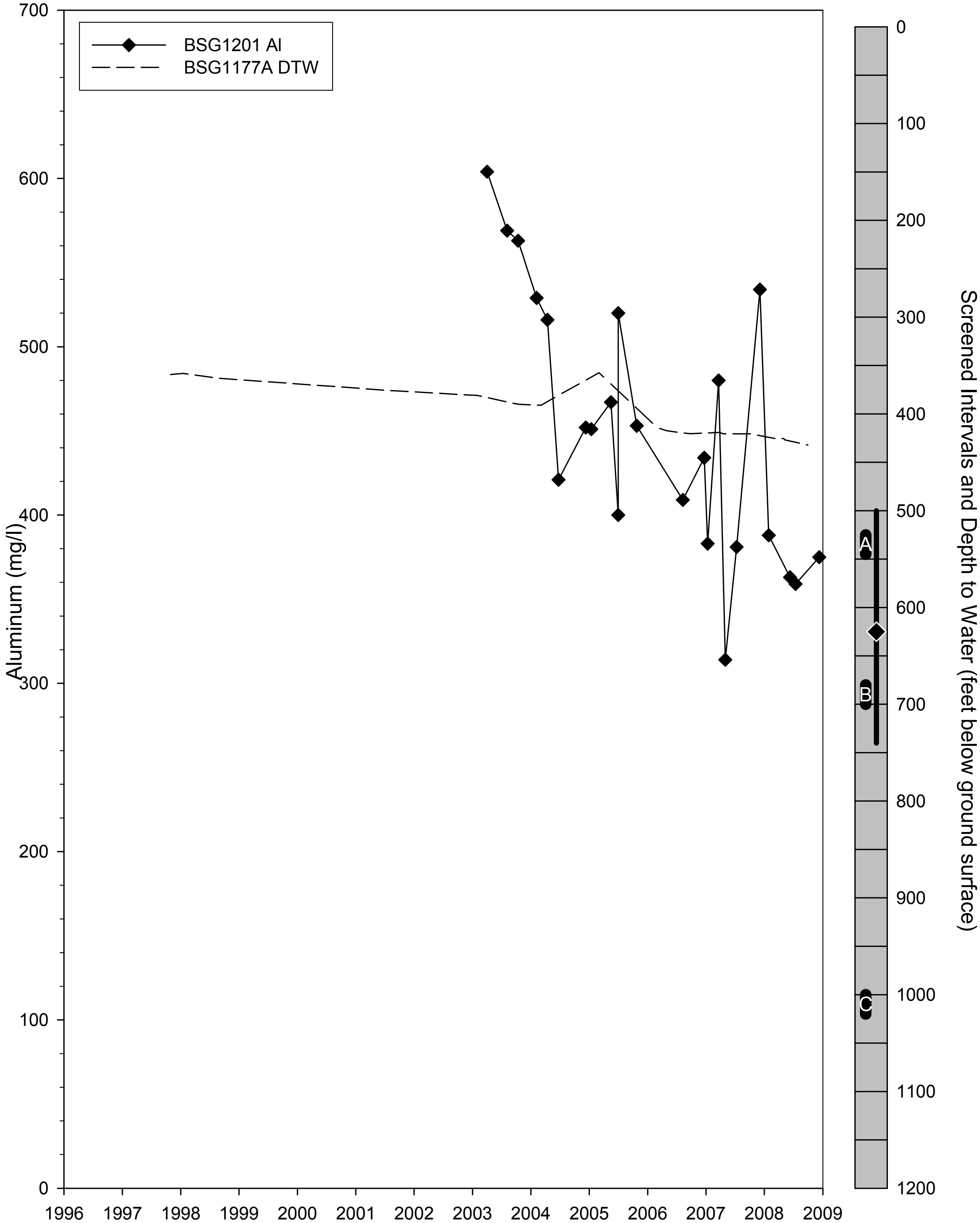


Figure 4-39 Time-Series Plot of Aluminum in BSG2782A, B, and C and BSG2784

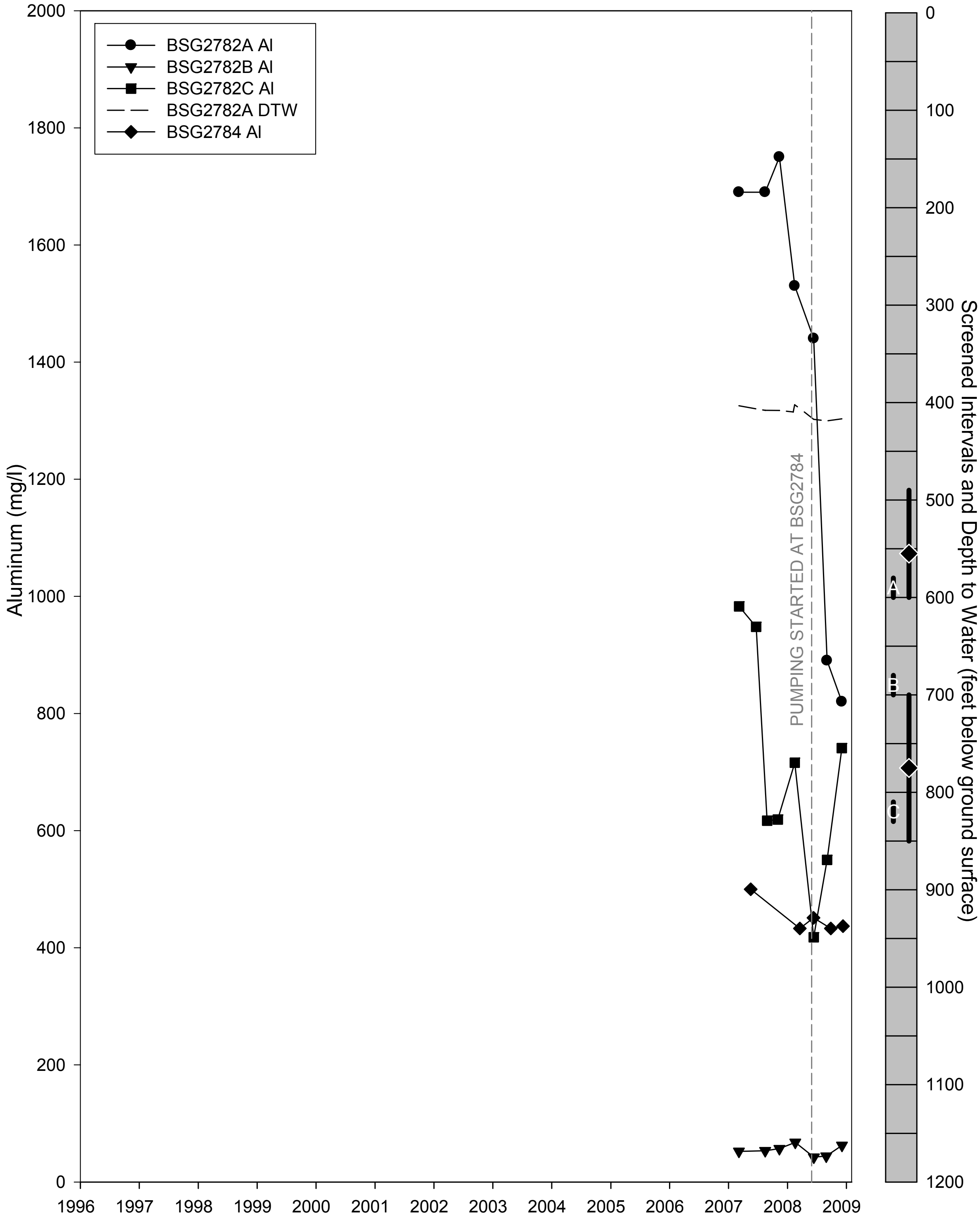


Figure 4-40 Time-Series Plot of Aluminum in BSG1119B

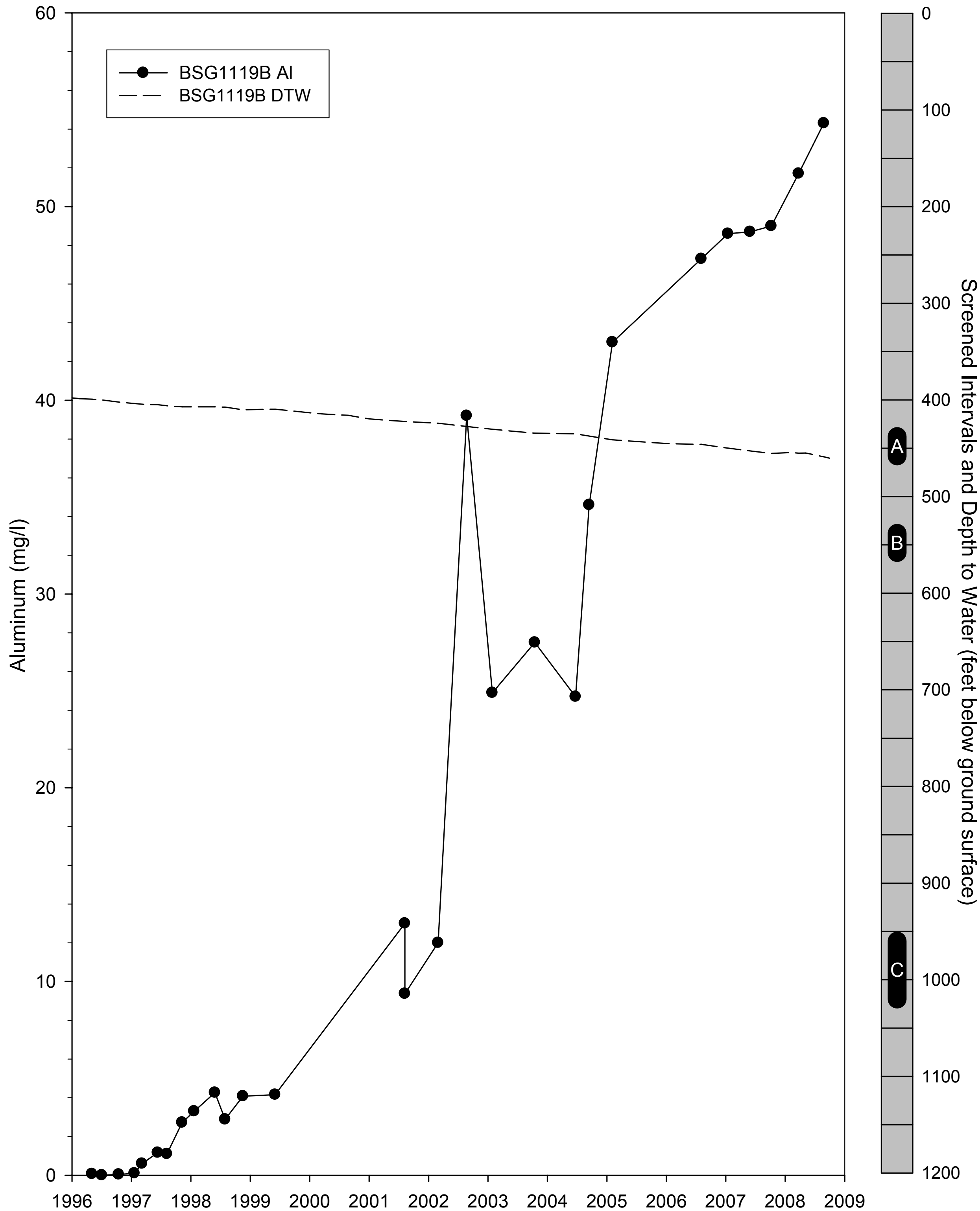
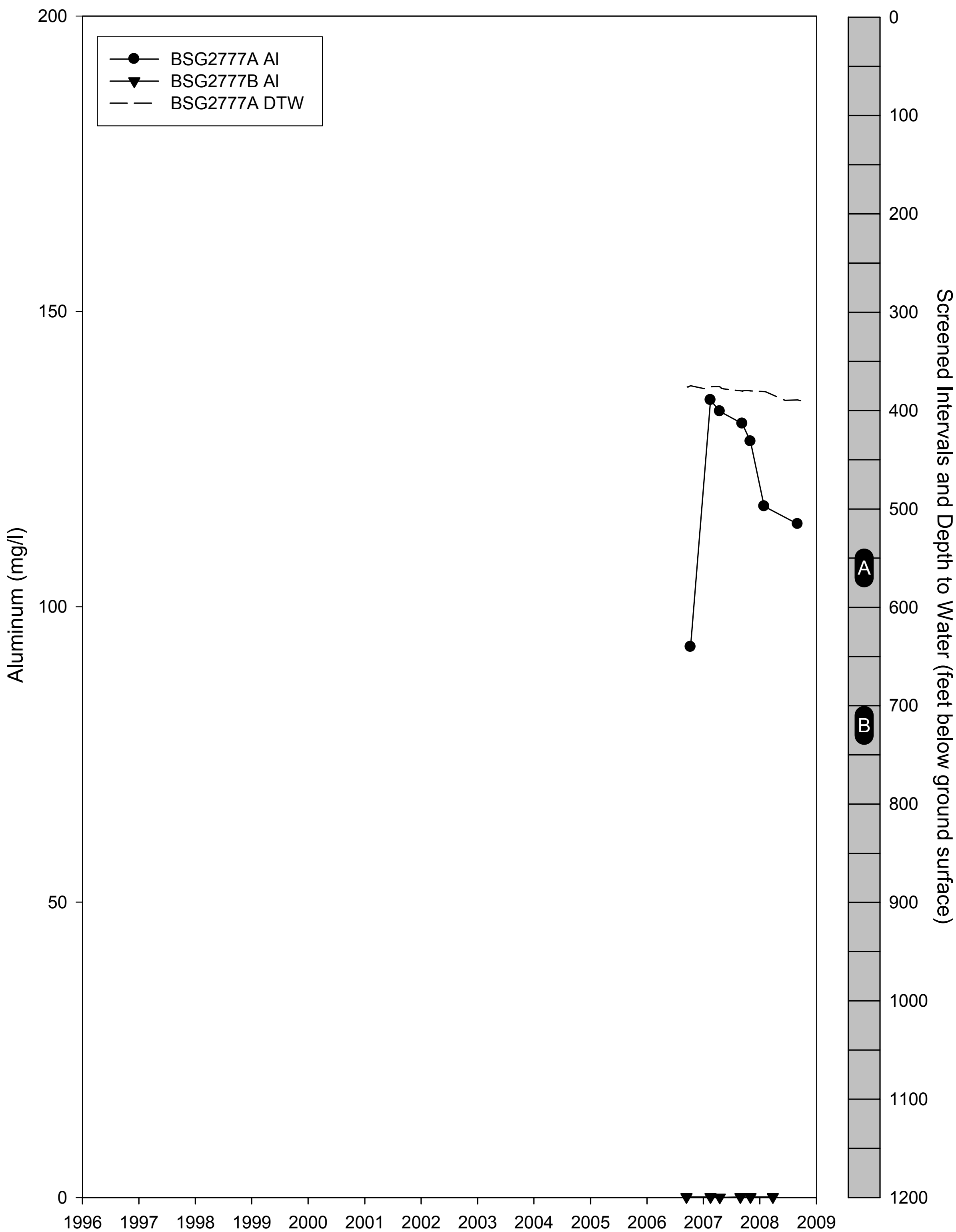


Figure 4-41 Time-Series Plot of Aluminum in BSG2777A and B



5. Groundwater Elevation

Water level measurements in wells in the Kennecott South Area are routinely performed by KUC at about 195 wells. The water level data collected is used to monitor the response of the alluvial groundwater system to ongoing aquifer remediation activities and nearby municipal groundwater extraction. These data also provide insight into the relationship between groundwater recharge, storage, and discharge in the principal alluvial aquifer system.

The results of the water level measurements for 2008 are presented in Appendix B. These water level measurements were corrected for fluid density effects on potentiometric head. Groundwater with elevated total dissolved solid concentrations have a higher specific gravity than do fresh waters. Consequently, corrections to measured water levels was performed to convert the measured hydraulic heads to equivalent fresh-water hydraulic heads. In most portions of the aquifer, where TDS concentrations are moderate, the density corrections applied to water levels are small, generally less than one foot. In areas where groundwater TDS concentrations are elevated appreciably, such as within the plume core, the density corrections may be on the order of several feet.

5.1 Groundwater Gradients

A contour map of water level elevations in the upper portion of the alluvial aquifer in the Zone A plume area for September 2008 is presented on Figure 5-1. Data from pumping wells were omitted from the contouring dataset unless the well had not been pumped for a sufficient amount of time for the water level to recover from localized pumping effects. Some wells along the western margin of the alluvial aquifer that are screened in shallow bedrock were also used in the creation of the water level contour maps. The contour lines shown in Figure 5-1 were generated using the computer program Surfer 8 by Golden Software, Inc.

As shown on Figure 5-1, the hydraulic gradient in the upper portion of the alluvial aquifer is from upland recharge areas in the west toward lower elevation regions to the east, nearer the center of the southwestern Jordan Valley. The hydraulic gradient in the alluvial aquifer is steep (approximately 0.056 or 300 feet per mile) from the east side mine waste-rock dumps eastwardly to approximately 2,000 feet east of Highway 111. The groundwater gradient then flattens considerably for a distance of approximately 4,000 feet eastward before again becoming appreciably steeper to the west of KUC's barrier wells (B2G1193 and BFG1200). The gradient is again flatter from the production wells east to eastern margin of Zone A plume area with a gradient of about 0.005 (40 feet per mile). The variability in the hydraulic gradient may be due in part to lateral heterogeneity in hydraulic conductivity of the alluvial sediments in the basin, as was observed during KUC well drilling activities in the area.

The influence of groundwater pumping from KUC's production wells is apparent in deflections of the contour lines near the KUC production wells. Variations in the water due to the pumping of production wells are apparent in several areas. The water shows a general deflection for a relatively large area at and upgradient of acid extraction well ECG1146, in the western portion of the acid plume, indicating that water is being captured at ECG1146.

The other area showing relative large deflections of the water contours is centered near extraction wells BFG1200 and B2G1193. Both wells were pumped relatively steady in 2008. This area along with the West Jordan Well Field depicts a large area of capture. West Jordan regularly pumps their three wells during the months of May through September, depending on water needs. This same area has experienced heavy pumping for a number of years.

Extraction wells LTG1147 and LTG1139, both located along 11800 South, were pumped occasionally 2008. Slight deflections in the water are apparent at both sites, which is largely due to the time of pumping as to when the water level measurements were taken.

Large vertical hydraulic gradients were generally not observed in the Zone A plume area (away from pumping wells) during 2008. Moderate vertical gradients were observed in some localized areas. The lack of appreciable vertical hydraulic gradients is consistent with the generally unconfined condition in the alluvial aquifer system in the project area.

5.2 One-Year Water-Level Elevation Changes

A map showing the contoured change in water levels in the upper portion of the alluvial aquifer system in the Kennecott South Facilities area between September 2007 and September 2008 is presented on Figure 5-2. For zones of increasing and decreasing water levels, changes were contoured on one-foot intervals from 0 to 10 feet of change and 5 feet intervals for changes of more than 10 feet.

Water levels as measured from September 2007 to September 2008 along the Eastside Collection and Butterfield Canyon have generally declined 0 to 3 feet. More pronounced decreases of 4 to 6 feet occurred at BRG287, BRG288, BRG289 which are all in Bluewater 1 drainage, ECG905, P220, P225 and P245 in Bluewater 2 and 3 drainages and ECG923 and ECG928 located just north of Lark. These water level drops are likely attributed to very limited recharge, drought conditions and possibly from pumping east and down-gradient from these areas. Only seven wells showed a rising water with the largest increase at ECG1184, located in the mouth of Butterfield and it increased by 1.9 feet. Comparison of spring water levels with fall water levels in individual wells indicates notable seasonal variability in areas along the western margin of the alluvial aquifer, demonstrating the influence of the annual recharge event to water levels in the alluvial aquifer. Appreciable seasonal fluctuations in water levels in wells further eastward are generally not apparent.

Water levels in the Bingham reservoirs area did not significantly change from September 2007 to September 2008. Monitoring wells located immediately upgradient of the reservoirs all increased less than one foot, which include P248A, B and C along with LRG911 while the remaining monitoring wells (4 total) decreased less than one foot. Water levels in the monitoring wells located immediately east and north of the reservoir system decreased one to four feet from September 2007 to September 2008.

Between September 2007 and September 2008, water levels in the western portion of the acid plume in the vicinity of acid extraction well ECG1146 declined with the exception of ECG1116B which increased by 1 foot. ECG1124B, the monitoring well closest to the extraction well declined by 25 feet and wells more distal like ECG1117A declined by 10 feet and K120 declined 4 feet. Water levels in monitoring wells completed below the highly contaminated portions of the aquifer in the ECG1146 area declined from 0.1 feet to 7 feet.

Water levels continued to decline in the eastern portion of the acid plume area in the vicinity of acid extraction wells BSG1201 and BSG2784 from September 2007 to September 2008. Pumping was continuous for BSG1201 in 2007-08 and BSG2784 was pumped for about six months in latter 2008. Monitoring wells within one-quarter mile of the two extraction acid extractions wells and within the principal alluvial aquifer showed the water declining between 3 to 16 feet. Effects of pumping both acid wells for this area appears to have caused a fairly consistent water decline within a quarter mile upgradient and adjacent to the extraction wells. These monitoring wells including BSG1148A and B, BSG1177A, B and C, BSG1179A, B and C, BSG1180B and C, BSG1196B and C, BSG2777A and B, BSG2782A, B and C and BSG2783A B and C all show a decline of 8 to 16 feet. Certain monitoring wells, including WJG1169A, COG1175A and B2G1176A, all located more than half a mile and up to one mile northerly from BSG1201, show water levels declines of 5 to 7.6 feet. Monitoring wells P273 and BSG1153A and B, located about three quarter mile southwest of extraction well BSG1201 showed declines of 4 to 6 feet. BSG1119A and B, located on the leading edge of the acid plume showed declines of 3 to 5 feet.

For the barrier well areas, water levels in the immediate vicinity of extraction wells B2G1193 and BFG1200 decreased generally 3 to 6 feet from September 2007 to September 2008. These changes are attributed to the continuous extraction from the two KUC wells and continued seasonal extraction by West Jordan. Monitoring well P277, located approximately 1,200 feet west of extraction well B2G1193 had the largest water level decline for this area at 8.1 feet which was only level for this area that declined by more than 6 feet. At locations further north from B2G1193 and BFG1200, including the West Jordan well field area, water levels declined from 3.0 to 4.6 feet between September 2007 and September 2008. Water levels at barrier well LTG1147 declined 3 to 11 feet. Monitoring wells immediately adjacent to LTG1147 declined by 11 feet and sites located one-half mile radius from LTG1147 declined by 3.5 to 9 feet.

Water levels in the BSG1139 clean water extraction well area responded from September 2007 to September 2008 to the periodic pumping with wells upgradient rebounding from one to two feet and wells downgradient declining two to seven feet.

Water level changes in the Herriman area from September 2007 to September 2008 are derived from four sites. All four sites showed a declining water table. LTG1167A, located approximately one mile northwest of Herriman, declined 7.3 ft; P267B and HMG1856, located on the northwest edge of Herriman, declined 1.9 ft and 1.8 feet respectively; and W403, located one-quarter mile south of Herriman declined 0.4 ft.

KUC also measures more than 12 monitoring wells in the western portion of Zone B including the Daybreak area and extending to about 2200 West. From September 2007 to September 2008, water levels for this area changed by plus or minus several feet. The largest decrease in the water was at well EPG2781A, located immediately east of south Oquirrh Lake, at 2.2 feet.

5.3 Water Level Changes from 1996 to 2008

Figure 5-3 shows changes in water levels in the upper portion of the alluvial aquifer system from 1996 to 2008. Data from 1996 used to create this map are reported in Appendix B. The year 1996 represents the initiation of remedial pumping at extraction well ECG1146, and Figure 5-3 shows, in part, the long-term effects of remedial pumping on the alluvial aquifer system. However, multiple hydrodynamic stressors influence water level changes during this time including the discontinuation of artificial recharge from the Bingham Reservoir System which occurred from 1965 to 1990, pumping by KUC at wells K60 and K109 prior to 1996, municipal extractions in West Jordan and Herriman, and variations in precipitation and natural recharge.

Most of the water level responses indicated on Figure 5-3 and equivalent to those apparent in the change from September 2007 to September 2008 (Figure 5-2), but, expectedly, larger in magnitude. The largest water table decline area is centered immediately west and upgradient of acidic extraction well ECG1146. Monitoring well ECG1124B, located 150 feet north of ECG1146, has declined more than 160 feet from September 1996 to September 2008. The area of influence from pumping at ECG1146 is elongated from north to south and the minus 100-foot contour encompasses approximately 150 acres. Transmissivity for this area is relatively low as compared to the pumping areas east near the eastern acidic extraction wells and in the sulfate extraction area encompassing B2G1193 and BFG1200.

In the eastern portion of the low pH plume where acidic extraction wells BSG1201 and BSG2784 are located, the maximum water table decline is centered over approximately a one-quarter mile area including monitoring well BSG1177A, located 150 feet east of BSG1201 and monitoring well P241B, located approximately one-quarter mile southwest of BSG1201. The decline for this area is greater than 75 feet from September 1996 through September 2008. The majority of decline for this area occurred after 2003 when pumping was initiated at BSG1201. The area of influence is elongated in a north-south direction that stretches almost two miles and more than one-half mile in an east-west direction. The southern portion of this area of influence also includes sulfate extraction well LTG1147. LTG1147 extraction appears to extend the area of pumping influence south for approximately one-half mile.

For the area that includes sulfate extraction wells B2G1193 and BFG1200, the water level decline from September 1996 through September 2008 is as much as 60 feet. For this area, there is less of a pronounced centered area or sink at the pumping wells, which reflects the higher transmissivity for this area.

The combined affect of pumping from the sulfate and acidic extraction wells as shown on Figure 5.3 influences a large area. The 50-foot water level decline contour interval encompasses approximately 5,200 acres. This large area of decline is also influenced from ground water extraction from private and municipal wells in the West Jordan and Herriman areas.

6. Subsidence

KUC measures ground surface elevation in Zone A to assess possible ground subsidence caused by groundwater extraction from the plume area. KUC monitored ground elevation at eight survey sites in June 2008.

The specific well sites selected for survey control are shown on Figure 6-1 and located as follows: western edge of the acid plume area (K105 and ECG1116); in the acid plume and adjacent to the west-most acid extraction well (ECG1124); 1,000 feet east of the eastern acid extraction well (BSG1180); and three wells (BSG1137, BFG1156a and WJG1170) within a 4,500 foot radius of the two sulfate extraction wells (B2G1193 and BFG1200) located north of Bingham Creek. The monitoring well sites (survey locations) located near the acid and sulfate extraction wells also coincides with the greatest observed decrease in water elevation. Each well has a cement pad that surrounds the steel surface casing and each pad has a steel bolt cemented into it. The steel bolt was the survey point for six of the wells. The seventh well (K105) was surveyed on top of the steel surface casing. The land survey monument measured in 2008 and in previous years is called 1973 West, located near the northwest corner of Section 15, in Township 3 South, Range 2 West which is on the northern edge of the plume.

The sites were surveyed using a global positioning system (GPS) unit (Leica System 530). The degree of accuracy of this GPS unit is approximately 0.25 centimeters (0.098 inches or 0.008 feet). The survey is in NAD83 (North American Datum of 1983) and NAVD88 (North American Vertical Datum of 1988).

Ground elevation measurements over time are reported in Table 6-1 and shown on Figure 6-2. Small variations in elevation measurements are attributed to variability inherent in measurement systems. There are no ground elevations changes that KUC attributes to groundwater-extraction induced subsidence.

Table 6-1 Subsidence Survey Data (Elevation Feet AMSL)

Survey Site	12/19/02 Survey	3/11/04 Survey	4/5/05 Survey	5/16/06 Survey	7/18/07 Survey	6/12/08 Survey	2007-08 Difference
ECG1116	5318.519	5318.518	5318.593	5318.562	5318.5819	5318.5839	0.0020
ECG1124	5250.985	5250.969	5251.076	5251.024	5251.0136	5251.0286	0.0150
BSG1137	4941.591	4941.549	4941.624	4941.591	4941.5989	4941.5732	-0.0257
BFG1156A	4997.262	4997.275	4997.344	4997.327	4997.3012	4997.3032	0.0020
WJG1170	4968.166	4968.016	4968.119	4968.123	4968.1194	4968.1324	0.0130
BSG1180	5078.004	5078.010	5078.032	5078.008	5078.0463	5078.0463	0.0000
K105	5341.950	5341.996	5342.09	5342.088	5342.0747	5342.0648	-0.0099
1973 West	---	5205.333	5205.428	5205.389	5205.4231	5205.3796	-0.0435

Figure 6-2 Time-Series Plots of Ground Elevation Measurements

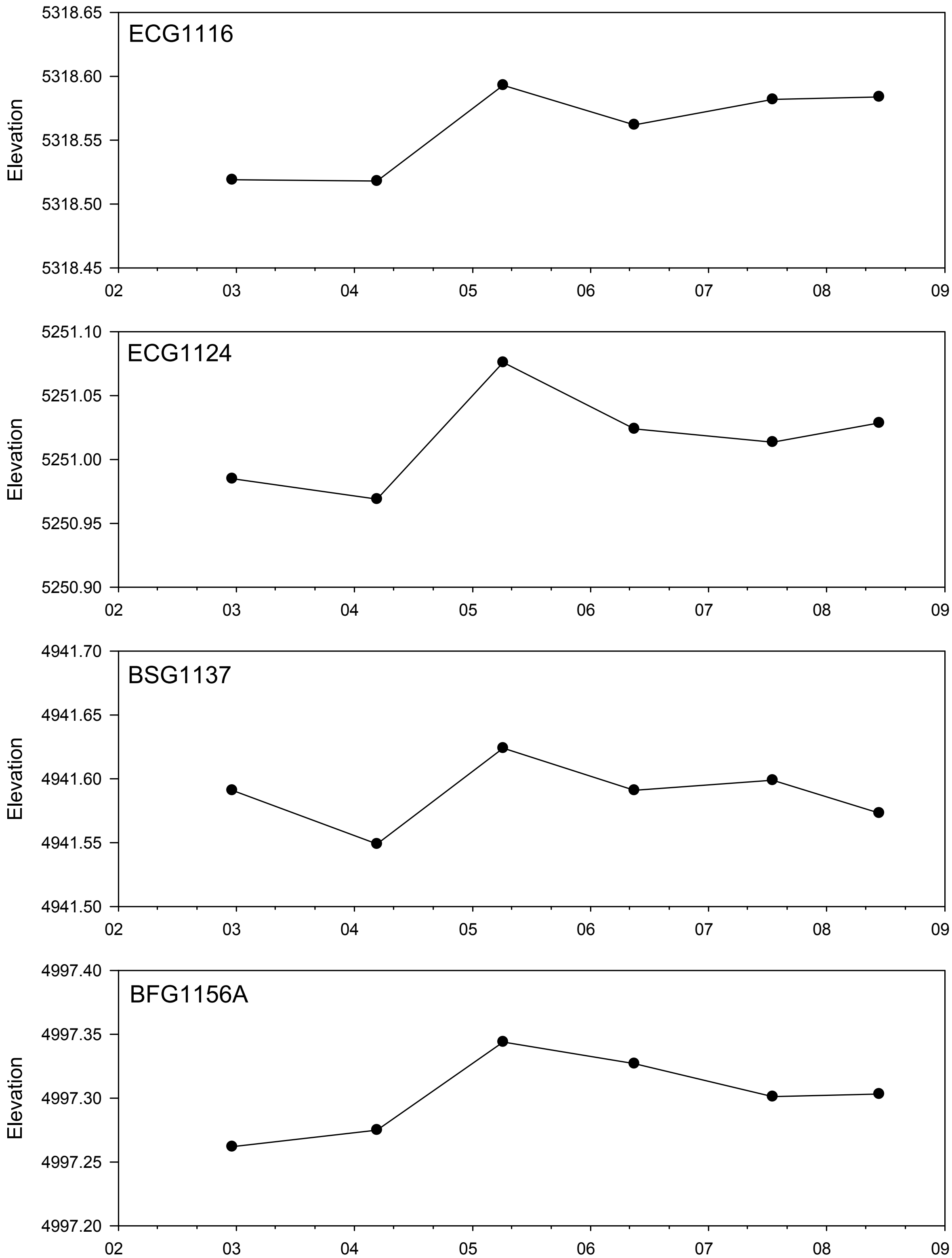
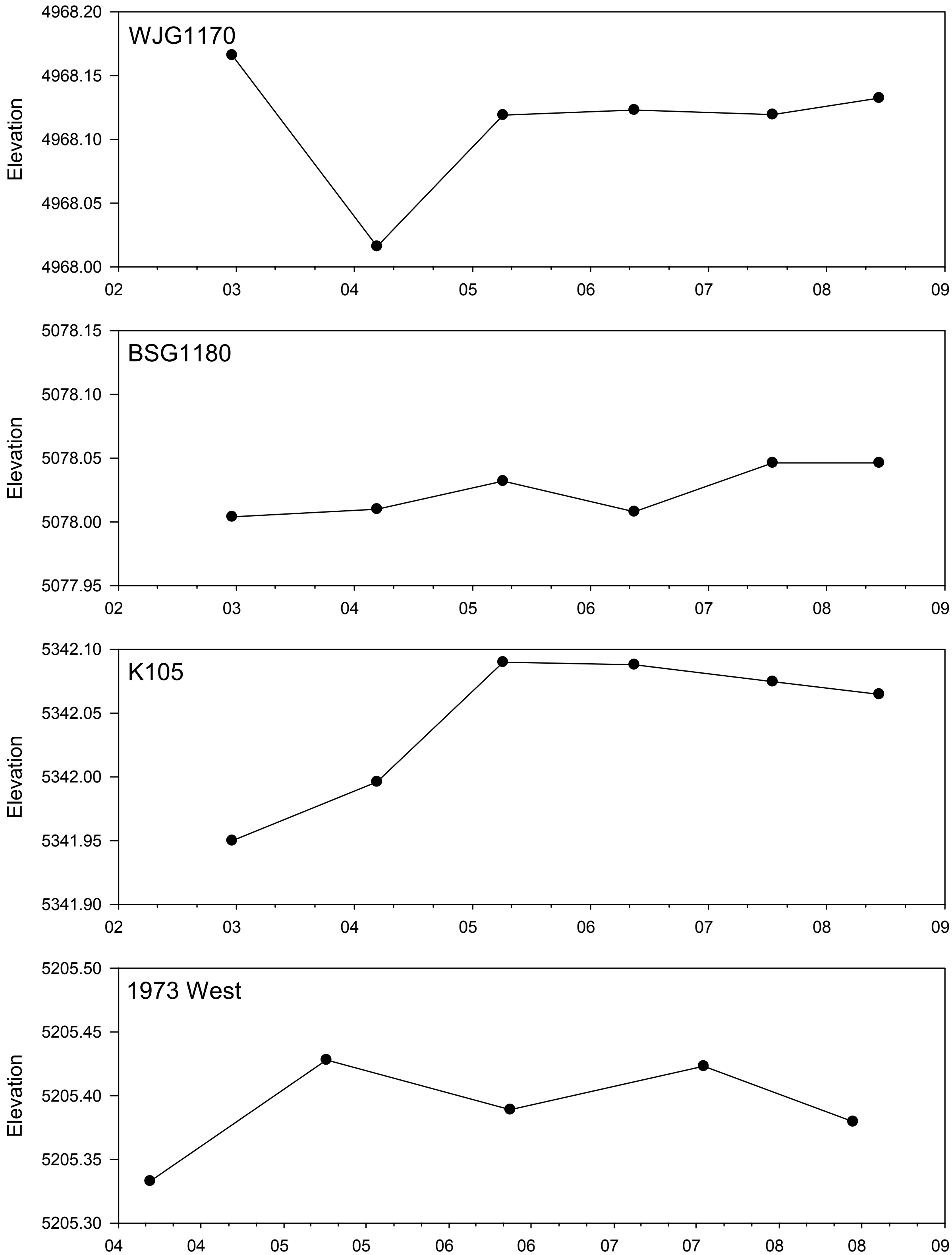


Figure 6-2 Continued



7. Tailings Chemistry

KUC manages groundwater extracted from the acid plume and other mining-affected waters in the tailings pipeline and the North Tailings Impoundment. Other waters managed in this circuit include meteoric drainage from the Eastside Collection System, RO concentrate from treatment of the Zone A sulfate plume, and water from dewatering of the mine pit. Acid plume water, meteoric leach water, and RO concentrate are commingled in and pumped through the Wastewater Disposal Pump Station (WWDPS) to the beginning of the tailings pipeline. The mine dewatering flows are pumped directly to the process circuit.

KUC monitors the chemistry of the tailings system to assure that acidic plume waters and other mining-affected waters do not adversely impact the process water system or the long-term acid-generating potential of the tailings.

7.1 Flow and Tailings pH

KUC continuously monitors pH at the North Splitter Box (NSB) and flow through the WWDPS. Daily data for 2008 is reported in Appendix C. These data are plotted on Figure 7-1 using a 7-day rolling average. Also plotted is ore throughput through the Copperton Concentrator, which directly correlates to tailings production reporting to the tailings line. The correlations between WWDPS flow, mill throughput, and tailings pH are readily apparent in these plots.

The monitoring data show that the tailings process circuit maintained the pH at North Splitter Box above pH 6.7 for every day in 2008 for which data are available. (Due to pH probe malfunction, data were not collected for 26 days during 2008) KUC met the management criterion listed in Appendix A of the OM&R Plan which specifies that pH at the North Splitter Box be greater than or equal to 6.7 for 90% of the time over a calendar year.

7.2 Tailings Chemistry

As specified by the monitoring program described in Appendix A of the OM&R Plan, KUC collects aqueous metals concentrations in tailings at NSB to confirm that the geochemical processes identified during the Remedial Design investigations are maintained.

There are no numeric criteria for the specific chemical conditions – other than pH, alkalinity, and neutralization potential (NP) – within the process circuit. Inspection of the data presented in Appendix C shows that the pH-driven solubility controls on dissolved metals identified in laboratory and field-scale pilot testing continue to operate.

7.3 UPDES Permit Compliance

KUC maintained compliance with UPDES discharge limits for metals concentrations during 2008.

7.4 Tailings Neutralization Potential

KUC monitors NP monthly in general mill tailings (GMT), which provides tailings neutralization characteristics prior to introduction of acid water flows, and NP and aqueous alkalinity at the North Splitter Box (NSB), which shows the characteristics of reacted tailings and the availability of aqueous neutralization potential. These data are used to measure operation against management criteria and assess the impact of acid water neutralization on the long-term acid rock drainage potential of the tailings.

Monthly and 6-month rolling average NP and alkalinity data are presented in Table 7-1 and. The data indicate that there are some months in which the NP value at NSB is greater than that at GMT and other months in which GMT is greater. However, in all cases the NP is greater than 5 tons $CaCO_3$ eq/kt. Monthly aqueous alkalinity at NSB usually was greater than 10 mg $CaCO_3$ eq/l in 2008.

KUC met the management criteria listed in Appendix A of the OM&R Plan.

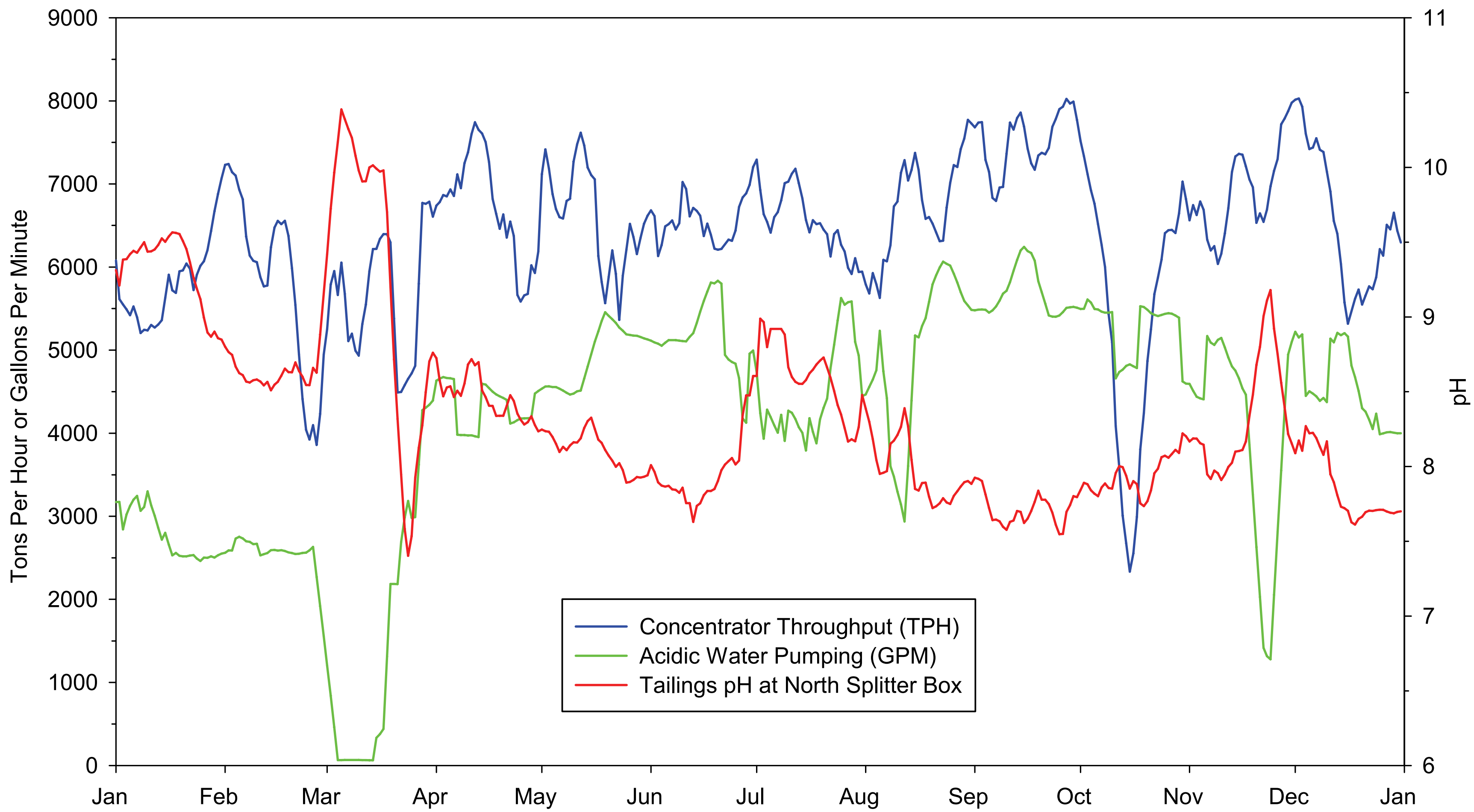
Table 7-1 2008 Tailing NP (t $CaCO_3$/kt)

	Monthly		6-Month Average	
Date	GMT	NSB	GMT	NSB
Jan-08	15	14	25	23
Feb-08	151	147	46	41
Mar-08	31	22	47	40
Apr-08	11	15	44	38
May-08	21	24	46	40
Jun-08	23	21	42	41
Jul-08	149	153	64	64
Aug-08	20	14	43	42
Sep-08	26	30	42	43
Oct-08	104	107	57	58
Nov-08	21	24	57	58
Dec-08	11	15	55	57

Table 7-2 2008 Aqueous Alkalinity (mg CaCO3/l)

	Monthly		6-Month Average	
Date	**GMT**	**NSB**	**GMT**	**NSB**
Jan-08	23	47	34	57
Feb-08	17	11	30	45
Mar-08	175	103	54	50
Apr-08	51	34	55	43
May-08	59	98	60	59
Jun-08	29	27	59	53
Jul-08	11	<5	57	55
Aug-08	57	82	64	69
Sep-08	26	84	39	65
Oct-08	27	36	35	65
Nov-08	22	15	29	49
Dec-08	20	76	27	59

Figure 7-1 2008 Tailings Circuit Monitoring Data (7-Day Average)



8. References

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Appendix A

Groundwater Chemistry Data

Appendix B

Groundwater Level Monitoring Data

Appendix C

Tailings Monitoring Data