TAILINGS AND PRODUCTION ROCK SITE
2011 ANNUAL REPORT

Hecla Green Creek Mining Company

April 15, 2012

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(Data Graphs see Appendix 3; Photographs see Appendix 4)

APPENDICES

1.0 Executive Summary

This annual report has been prepared by Greens Creek Mining Company in accordance with Alaska Waste Disposal Permit 0211-BA001 and the mine's General Plan of Operations Appendices 3 and 11. The following itemized list summarizes key information and indicates where in this report the information outlined in Section 6.2 of Permit 0211-BA001 is presented:

Permit Section		Report Section
6.2.1	Closure plan summary	2.8
	Precipitation	2.4, 3.4
	Mill Site 65.94" Tailings 38.75"	
	Summary of internal monitoring and fresh water monitoring plans	2.5, 3.5
	FWMP annual report separate for water year 2011 as per the ADEC request for full data presentation.	
	Internal monitoring water compositions at both sites dominated by Ca, Mg, SO_4, neutral pH, high alkalinity, high zinc, low to moderate concentrations of other metals. Data are consistent with sulfide oxidation and carbonate mineral buffering. Sulfate reduction and/or thiosulfate reduction/disproportionation in saturated zone of tailings pile yields low concentrations of all metals. Seasonal compositional fluctuations continue evident in most wells/drains.	
	Stability	2.3, 3.3
	Stability monitoring at the Tailings Facility and Site 23 indicate that piles meet design specifications. Foundation heads are consistently low at both sites except for short-lived spikes in one piezometer (north end of West Buttress).	
	Cover performance	3.8
	>85% saturation maintained, barrier layer not subject to freeze/thaw cycles. Oregon State University studies are ongoing to help better understand cover water characteristics. Lateral flows are being analyzed within cover.	
	Pond D flow and composition	3.4, 3.5
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6.2.5	Location and volume of materials	2.2, 3.2
	Northwest Tailings area 359,374 total tons in 2011 (tailings 318,377 tons and other materials 40,997 tons)	
	Site 23 4,181 total tons placed in 2011	

	Compaction	2.3, 3.3
	Target compaction densities achieved.	
	Acid Base Accounting	2.5, 3.5
	Potentially acid generating Class 3 production rock	
	Neutralization potential values continue to demonstrate long lag time (buffering capacity)	
	Class 1 production rock is significantly acid neutralizing (about 36% carbonate)	
	Possible water releases	2.5
	No new signs of possible releases were identified in 2011	
6.2.4	Information regarding validity, variations and trends	various
	Full FWMP data assessment in separate report	
	Internal Monitoring Plan variations are seasonal, no deleterious trends identified	

The report is separated such that all aspects of the Tailings Facility are discussed first in Section 2 followed by discussion of Site 23/D in Section 3. Information that is pertinent to both sections is generally not repeated but is discussed in the most relevant section and identified by reference in the other section.

2.0 Tailings Area

2.1 Introduction

Hecla Greens Creek Mining Company (HGCMC) has prepared this section of the Annual Report in accordance with the mine's General Plan of Operations (Appendix 3) and Alaska Waste Management Permit 0211-BA001. Permit 0211-BA001 expired in November of 2008 and is in the process of renewal. HGCMC is operating under a permit extension from ADEC (letter dated October 6, 2008) until a new permit is finalized. This report provides a summary of all operational and monitoring activities performed in 2011. Refer to GPO Appendix 3 and permit 0211-BA001 for a detailed description of the Tailings Facility and associated monitoring requirements.

HGCMC operated its Tailings Facility continuously in 2011. Primary placement of tailings was in the Northwest Excavation area (see Tailings Facility as-built in Appendix 1). HGCMC added 198,363 cubic yards of material to the Tailings Facility in 2011, bringing the total facility volume to approximately 3,499,383 cubic yards. These yardages convert to approximately 318,377 tons of tailings placed at the Tailings Facility with placement of all materials at the Tailings Facility totaling approximately 359,374 tons during this report period as calculated from HGCMC surveyed volumes and material densities.

2.2 Placement Records

Table 2.1 contains the monthly placement records for tailings, production rock and other materials at the Tailings Facility for 2011. Surveyed volumes (cubic yards) were converted to tons using a tonnage factor of 1.8 tons per cubic yard (134.2 pcf for tailings). Production rock from Site 23 used for road access and erosion control contributed approximately 7,665 tons to the facility. An additional 33,332 tons of other material (including production rock from Site E) were also placed at the facility in 2011. The calculated tonnage of tailings was derived by subtracting the tons of production rock and other material from the surveyed total. The full pile currently contains approximately 6.3 million tons of material. Based on the survey data presented in Table 2.1 there is a remaining capacity of approximately 3.3 million tons of the 9.6 million tons permitted for placement at the facility. Estimates of other miscellaneous materials disposed in the facility are shown in Table 2.2. It is difficult to determine the amount of time remaining before permitted space at the Tailings Facility is consumed, but a range of 3 – 4 years has been estimated. An EIS is currently in progress for a proposed expansion of the Tailings Facility.

Table 2.1 Tailings Placement Area Data

2011	All Materials Monthly Total by Survey (CY)	All Materials Cumulative by Survey (CY)	All Materials Monthly Total Tonnage (Calculated tons)	All Materials Cumulative Total Tonnage (Calculated tons)	Prod Rock from Site 23 by truck count (tons)	All Other Materials (Ditch Seds and Construction) by truck count (tons)	Tailings Tonnage (Calculated tons)
1/31/2011	18,154	3,319,174	32,890	6,013,348	140	2,418	30,332
2/28/2011	No survey	3,319,174	No survey	6,013,348	No survey	No survey	No survey
3/31/2011	32,647	3,351,821	59,147	6,072,494	950	1,605	57,192
4/30/2011	16,287	3,368,108	29,507	6,102,001	0	5,307	24,200
5/31/2011	17,182	3,385,290	31,129	6,133,130	70	9,949	21,110
6/30/2011	17,923	3,403,213	32,471	6,165,601	563	1,702	30,206
7/30/2011	20,514	3,423,727	37,165	6,202,766	1,323	3,434	32,408
8/31/2011	16,848	3,440,575	30,542	6,233,290	0	5,011	25,513
9/30/2011	18,133	3,458,708	32,852	6,266,141	2,213	2,063	28,576
10/30/2011	17,151	3,475,859	31,072	6,297,214	386	124	30,562
11/30/2011	14,584	3,490,443	26,422	6,323,636	798	1,137	24,487
12/31/2011	8,940	3,499,383	16,197	6,339,832	1,222	582	14,393
Totals	**198,363**	**3,499,383**	**359,374**	**6,339,832**	**7,665**	**33,332**	**318,377**
Tons calculated at 134.2 pounds per cubic foot for tailings							

Table 2.2 Miscellaneous 2011 Materials Disposal Estimates

Surface Tailings	**CY**
Pressed Sewage Sludge	50
Pressed Water Treatment Plant Sludge	500
Incinerator Ash	16
Site E	8,000
Underground	**CY**
Tires	550 ea
Sump Sediments	3640
Shop Refuse	730
Mill Refuse	310
Electrical Refuse	120

2.3 Stability

Tailings placement compaction is tested to monitor the performance goal of achieving 90 percent or greater compaction relative to a standard Proctor density. HGCMC staff utilizes a Troxler Model 3430 nuclear moisture-density gauge to measure wet density and percent moisture content of placed tailings. Dry densities are calculated and compared to laboratory measured standard Proctors.

Compaction

Summary results for 2011 are shown in Table 2.3. Standard Proctor values were measured on samples taken from the tailings-loadout facility at the 920 and submitted to an outside materials testing lab, which performed the test within the ASTM guidelines for method #D698. The standard Proctor value was 136 pcf (pounds per cubic foot). HGCMC instituted a program at its on-site lab to determine 1-point proctors at the end of 2005. The mean dry density for 25 samples taken throughout the year in 2011 was 140 pcf, and the average percent moisture was 12.7%. Results to date confirm proctor and moisture data received from the outside materials testing lab.

Field measurement results show a high degree of achieving greater than 90% compaction (with respect to an average Standard Proctor value of 146). Testing done in prior years has confirmed that density results obtained using the Troxler procedure average approximately 2 percent higher than the densities obtained via other methods.

With the codisposal of Site E materials into the Tailings Facility beginning in 2009, field measurements were not as frequent. It is unlikely that the Troxler (or other methods) would provide useful information on the codisposed material. Unlike run-of-mill tailings, which have a relatively consistent standard Proctor value to compare field densities to, the mixture of rock and tailings will not. The Proctor density of the mixture would vary with the proportion of rock added and the density of the rock fraction. As with waste rock, measuring Proctor densities of materials containing a coarse fraction is not recommended. For codisposal HGCMC will use the same method of compaction necessary to achieve the target density for straight tailings. This is typically at least two back and forth passes with the dozer and at least one back and forth pass with the roller. Visual observations of the codisposed material placed to date indicate that the mixed material compacts very well. HGCMC will continue to evaluate the placement procedures and may continue to use the Troxler in areas that receive just tailings.

Table 2.3 Summary Statistics for 2011 Tailings Compaction Testing Data

Compaction Variable	Mean	Max	Min	Std. Dev.	n
Std. Proctor[ASTM #D698] (pcf)	**139**	**143**	**136**	**5**	2
Opt. Moisture (%)	11.9%	12.6%	11.2%	1.0%	
1-pt Proctor (pcf)	140	156	124	7	25
As Received Moisture (%)	7.6%	16.1%	10.0%	1.4%	

* Percent compaction calculated with respect to corresponding monthly proctor.

Inspections

Several independent inspections are carried out at the tailings area throughout the year. Operators working at the site carry out daily visual work place inspections. The Surface Civil Engineer and/ or Surface Operations Manager or designee carry out weekly visual inspections of the Tailings

Facility area, as well as a checklist inspection of Pond 7. The environmental department carries out a monthly checklist inspection of the Tailings Facility.

ADEC representatives inspected the site three times in 2011 (June 8, September 14, and October 12). During 2011 the USFS conducted 12 routine inspections (Site inspections #326-#337) to monitor for best management practices effectiveness and compliance to the General Plan of Operations. No issues of non-compliance or poor operations practices of the Tailings Facility were noted during the routine inspections. The USFS typically noted that the facility is being developed and operated to required operations and maintenance specifications of GPO Appendix 3.

<u>Well and Piezometer Water Level Data</u>

Water level data for the Tailings Facility are presented in Figures 2.1 to 2.18. A variety of methods are used to determine water levels including:

- Measuring the depth to water by tape or sonic indicator in PVC monitoring wells (also called standpipe piezometers)
- Measuring air pressure in pneumatic piezometers where water pressure against the transducer diaphragm increases air pressure between the diaphragm and the monitoring gauge
- Measuring the frequency of vibration of a vibrating wire piezometer where water pressure creates tension on the transducer wire changing its vibration frequency

Pneumatic and vibrating wire piezometers are typically installed in locations where standpipes are impractical, such as under a liner or in active placement areas. Installation of vibrating wire piezometers allows “real time” data logging and measurement of negative pressures (matric suction). Vibrating wire piezometers can also be installed in existing PVC well casing to allow covering during liner installation and if real time data logging and water sampling is desired (e.g. MW-T-00-05A and PZ-T-00-02). A drawback of pneumatic and vibrating wire piezometers is that they do not provide a means for water sampling or aquifer testing (unless they are installed in an existing well).

Well and piezometer locations are shown on the Tailing Facility as-built (Appendix 1). The maximum saturated thickness (approximately 35 feet) occurs near the center of the main portion of the pile. However, this elevated water table level does not extend close to the down-slope toe of the pile. The foundations of the West Buttress and southern portion of the pile are well drained, as indicated by typically consistent unsaturated conditions in the blanket drains (MW-T-00-05A, Figure 2.14) and at the base of the West Buttress (piezometers 74 and PZ-T-05-08 in Figures 2.8 and 2.9). Low head elevations near the pile toe maximize the pile’s geotechnical stability. Intermittent head increases in the foundation drains are localized and of short duration and should not have an adverse effect on pile stability.

The data from standpipe and pneumatic piezometers completed above the blanket drain (Piezometer 76, PZ-T-00-01, PZ-T-00-02, PZ-T-00-03 in Figures 2.10, 2.11, 2.12, 2.13) indicate that saturated conditions can develop above the unsaturated underdrains to a thickness of approximately 12 feet. This is consistent with the low permeability of the tailings and the uncapped condition of the pile. Covering the pile will help minimize the saturated zone in the pile. This was demonstrated by the over 10 foot decrease in the water table that occurred from 1995 to 1997 when the pile was covered (see Figures 2.1 to 2.7). Water levels have rebounded to, and in some cases above, 1994 elevations in most areas. Areas where water levels exceed their

1994 values are areas where the pile is considerably thicker than it was in 1994. The increase in water levels observed in PZ-T-00-01 (and to a lesser extent in instruments nearby) from 2005 to 2007 is likely a result of new tailings placement in the area and staged decommissioning of Wet Well 2.

Periodic spikes in water levels in the wells and piezometers are due to a variety of factors including extreme weather events (e.g. Fall/Winter 2005-2006), changes to water management infrastructure (e.g. decommissioning of Wet Well 2 from 2005-2008), damage to instrumentation (Piezometer 76 in 2004), and measurement errors (e.g. MW-T-00-05A in 2002-2003 and 2007).

Water levels in four wells completed east and west of the pile are shown for comparison in Figures 2.15 to 2.18. The eastern wells, MW-T-00-03A (Figure 2.15) and MW-T-00-03B (Figure 2.16), are completed in the shallow sands 12 and 17 feet, respectively, below ground surface. The figures for these wells show that the water elevation in shallow completions in native materials can be readily influenced by abnormal weather conditions. Wells MW-T-01-03A and MW-T-01-03B are installed west of the pile. Their water levels are shown in Figures 2.17 and 2.18, respectively. MW-T-01-03A is completed in bedrock to a depth of 20 feet and MW-T-01-03B is completed in clayey silt to a depth of 12 feet. These wells show similar water level fluctuations with weather conditions as the two eastern wells. However, the water level in MW-T-01-03B shows a larger differential than MW-T-01-03A because silts and clays hold more water in tension, so a small increase in water content causes a large change in head. The ground surface elevation is 134 feet in the proximity of these two wells. Both MW-T-01-03A and MW-T-01-03B were damaged by bears in 2006 and attempts to recover them were not successful until 2010. A rapid decrease followed by a gradual increase to levels above recent historical values occurred in MW-T-01-03A in 2011. The cause for the change is not known at this point, however this type of behavior has been documented in the companion well (MW-T-01-03B).

2.4 Hydrology

A detailed review of the hydrology of the Tailings Facility was performed by Environmental Design Engineering (EDE) in 2001 (EDE 2002a), in 2006 (EDE 2007) and in 2011 (EDE 2011). For background and design information for Pond 7, the main water collection pond at the facility, see Klohn Crippen's 2005 report, and EDE's 2005 Pond 7 Hydrology Report. These reports describe the hydrogeology of the site and present calculations of anticipated post-closure hydrologic conditions. Water management at the facility consists of a complex network of drains under the pile, bentonite slurry walls around the perimeter of the site, and ditches to divert up-slope water and collect surface runoff. See the Tailings Facility as-built for locations of the site's water management components. The site is underlain by a low permeability silt/clay till and other glacial/marine deposits or an engineered HDPE liner. These features minimize the potential for the downward migration of contact waters. An upward hydrologic gradient under the site further improves contact water collection. EDE updated the hydrogeologic information for the Tailings Disposal Facility in 2009, with focus on the proposed Stage 3 tailings expansion area to the south of the existing facility. The following is a summary of that most recent report:

- Updated potentiometric surfaces for the four hydrogeologic units (bedrock, undifferentiated glacial-marine unit, peat/sand unit, and tailings) indicate no major changes in the overall flow patterns compared to results of previous investigations. Groundwater in bedrock, the undifferentiated glacial-marine unit (UGM), and the peat/sand unit appears to generally flow from east to west toward Hawk Inlet, the primary discharge area. Outcrop on the steep ridge east of the TSF may be the primary bedrock recharge area, and runoff from this mountain slope is probably an important source of recharge to all three units. Flow components to the north and to the south towards Cannery Creek and Tributary Creek were interpreted on the basis of observed groundwater discharge in these areas.

- A geotechnical and environmental drilling investigation was conducted in the Stage 3 area in summer 2011. Data collected during, and subsequent to, the investigation indicate that hydrogeologic conditions in the proposed Stage 3 tailings expansion area are similar to conditions in existing tailings placement areas.

Precipitation and temperature data are presented in Table 2.4. The Hawk Inlet precipitation bucket was malfunctioning in January, March, and April 2011. This bucket has been repaired. July and August were the warmest months while November exhibited the coolest temperatures. It was a cooler than normal year with above normal precipitation and above normal snowfall, with the Juneau annual climate summary stating for 2011:

> "Several months recorded below normal precipitation and accumulated precipitation totals lagged below normal from late February through July. Heavy rains in August made up for the earlier deficit…The snowfall exceeded the normal value by nearly 34 percent."

Flow data from Wet Wells 2 and 3 are presented with the precipitation data for 2005 – 2011 in Figure 2.19. The wet well flows respond relatively quickly to precipitation events, demonstrating a significant contribution of surface water. The use of the wet well flow meters has been discontinued since 2005 as part of the tailings expansion activities.

Table 2.4 Monthly Summaries of Tailings Area Climate Data

Month	**Avg Temp (°C)**	**Precipitation (in)**
January	-0.65	0.35*
February	-2.52	4.91
March	-0.41	0.01*
April	3.87	0.85*
May	7.90	2.06
June	10.89	2.62
July	12.68	2.93
August	11.55	6.62
September	9.71	6.51
October	6.27	4.29
November	-0.12	2.77
December	1.25	6.04
2011	**5.04**	**38.75**

*The tipping bucket used for measuring the precipitation at Hawk Inlet was sticking. Therefore, these values are an under measurement of the actual precipitation.

2.5 Water Quality

Compliance Monitoring

Sites around the surface tailings disposal facility have been monitored continuously since 1988. This sampling pre-dates the placement of tailings at this facility. The FWMP Annual Report for water year 2011 is being prepared separately and will be submitted to the Forest Service and ADEC upon completion.

Internal Monitoring

As described in Waste Management Permit Number 0211-BA001 Section 2.8.3.1, the internal plan addressed monitoring at both the surface Tailings Facility and the surface production rock disposal areas covered by the permit. The Internal Monitoring Plan describes monitoring within the pile areas, in contrast to the compliance monitoring (under the Fresh Water Monitoring Plan) at peripheral facility boundary sites. As such, data generated by the Internal Monitoring Plan effort are "… not for compliance purposes…" as noted in the above referenced permit Section 2.8.3.1, but provide a continuing perspective on in-pile geochemical processes.

The analytical results of HGCMC's internal site monitoring plan are summarized in Figures 2.20 to 2.31. Sites were distinguished between foundation wet wells (Wet Well 2 and Wet Well 3), wells completed in tailings (PZ-T-00-01, PZ-T-00-02, PZ-T-00-03, MW-T-02-5 and MW-T-02-6) and suction lysimeters (SL-T-02-4, SL-T-02-5, SL-T-02-6, and SL-T-02-7). These lysimeters are installed at various depths within the pile's vadose zone. These groups are separated on Figures 2.20 through 2.31 with the suffix a, b or c, respectively. For example, a figure number such as 2.20a would show the data for the wet wells group, 2.20b would show the data for the tailings completion wells, and 2.20c would show the data for the suction lysimeters.

An in-depth evaluation of the hydrology and geochemistry of the Tailings Facility was performed by Environmental Design Engineering (EDE) and KGCMC in late 2001, 2007 and 2011 (EDE 2002a, EDE 2002b, EDE 2007, EDE 2011, KGCMC 2002a) and during the Tailings Expansion EIS (USFS 2003). The observations made under the 2011 internal monitoring plan are consistent with the findings of the EDE, KGCMC/HGCMC and USFS reports.

All internal monitoring waters are captured and treated prior to discharge to the ocean floor under HGCMC's discharge permit (AK 004320-6). Authority over the federal permitting, compliance and enforcement NPDES program transferred to the State (ADEC - APDES) in November of 2010 for the mining industry.

Most values of pH remained between 6.0 and 8.5 for all internal monitoring site samples in 2011 (Figures 2.20a, b and c). PZ-T-00-01, PZ-T-00-2 and PZ-T-00-3, which screen the lower ten feet of the tailings pile, have the highest pH on average of the internal monitoring sites. This is likely a result of microbial sulfate reduction and equilibration with carbonate in the saturated zone of the pile. The wet wells produce water with slightly lower pH (generally between 6.5 and 7.0), reflecting minor influences from groundwater (organic acids) and oxidized surface waters (acidity from thiosalt, sulfide and iron oxidation). With the exception of SL-T-02-06, the suction lysimeters all have pH values between 6.87 and 8.03. SL-T-02-06 exhibited pH values above 8.5 between 2006 and 2009 and returned to a pH below 8.0 during the 2011 sampling event. The higher pH in SL-T-02-06 was likely a result of sulfate reduction.

Alkalinity data are presented in Figures 2.21a, b and c. Alkalinity generally ranges between 150 and 600 mg/L $CaCO_3$ within the tailings pile waters, consistent with buffering from carbonate minerals and the products of microbial sulfate reduction. The fact that these internal waters are near-neutral to alkaline and continue to show substantial alkalinity indicates that the buffering capacity of the tailings is sufficient to prevent acidification of site drainage in the near-term (at least tens of years) even though portions of this material have now been in place at this site for approximately 20 years.

The conductivity results from internal monitoring site waters are presented in Figures 2.22a, b, and c. Conductivity measurements in 2011 ranged between 3,760 (wet wells), 3,860 (wells completed in tailings) and 2,990 (suction lysimeters) uS/cm. The higher conductivity of the site contact waters reflects a larger dissolved load caused by weathering of the tailings. Pyrite oxidation and carbonate dissolution contribute dissolved ions such as sulfate, bicarbonate, calcium and magnesium to the contact waters, increasing their conductivity. Wet Well 3 has a different capture area than Wet Well 2 and shows a different pattern with respect to conductivity. The changes in conductivity observed in Wet Well 3 suggest changes in the relative contributions from runoff, addition of the Northwest Diversion Ditch flow, infiltration and groundwater as the West Buttress was constructed. The increase in conductivity seen in Wet Well 2 over the past several years likely reflects an increasing contribution from contact water in the drain system and an increase in the dissolved load from migration/remobilization of oxidation products in the pile. In 2008 Wet Well 2 was routed to Wet Well A, a new wet well located in the newly modified Pond 6 area. Suction lysimeter samples are drawn from the smallest pore spaces of the unsaturated zone. Water held in these pores is often isolated from flow paths and thus usually has higher dissolved constituent concentrations than water from the saturated zone and foundation drains.

Hardness and sulfate concentrations remain consistent with the conductivity results. Calcium and magnesium are the primary contributors to hardness (Figures 2.23a and b) and reflect dissolution of carbonate minerals, such as calcite and dolomite. Carbonate dissolution neutralizes acidity formed by sulfide oxidation, which is also the source of sulfate shown in Figures 2.24a, b, and c. Sulfate concentrations typically range between 150 and 5,000 mg/L in the tailings pile waters. The increase in sulfate and other constituents seen in PZ-T-00-03 likely reflects the replacement of interstitial process water with infiltrating surface water, which carries a higher dissolved load.

Arsenic data are presented in Figures 2.25a, b and c. The variability in arsenic concentrations observed in Wet Well 2, MW-T-02-06, and some suction lysimeters is related to evolving redox conditions in the pile. As arsenic-bearing minerals such as tetrahedrite/tennantite (and to a lesser extent pyrite) weather, the arsenic that is released is typically co-precipitated with iron oxy-hydroxides. As the pile grows, reducing conditions overtake areas that were once oxidizing. This was particularly true as the water table rose following removal of the temporary PVC cover that was placed on the pile in 1995 (removal began in 1997). Dissolution of oxyhydroxides (and possibly sulfates) is expected as the waters respond to the changing redox conditions. This will contribute arsenic and iron (Figures 2.30a, b and c) to the drainage water. Arsenic concentrations in the pile drainage will therefore decrease when redox conditions in the pile stabilize (e.g. with closure and capping of the pile). Sulfate reduction may also lower arsenic concentrations. This is apparent in the composition of waters from the saturated zone and in some of the SRMP test cells, which are discussed in more detail below.

Figures 2.26a, b and c show the concentration of zinc from the monitoring sites. Zinc levels from the saturated zone of the pile continue to remain low (Figure 2.26b), a result of sulfate reduction and/or thiosulfate disproportionation, which promote zinc sulfide precipitation. A zinc concentration of 328 ug/L was reported in PZ-T-00-02 in 2009. The cause for this value was not immediately apparent, but in 2010, the zinc in PZ-T-00-02 returned to within historical levels and remained at the historical levels during 2011. The zinc concentration in MW-T-02-06 in 2003 and 2004, along with the lower alkalinity, suggest that sulfate reduction may not yet have been occurring in this portion of the West Buttress. However, the April 2005 data showed a significant decrease in the concentration of zinc (from an average of 1,000 ug/L to less than 10 ug/L), and the zinc has continued to remain below 50 ug/L. Placement of argillite on the outer slopes of the West Buttress has also led to higher zinc concentrations in Wet Well 3 from surface runoff flushing of this material when it was initially placed. In 2003, the zinc concentration in this wet well returned to within historical limits, and has remained between 500 – 3,500 ug/L, except for a result of 6030 ug/L in the first sample of 2009. The second sample in 2009 was 1830 ug/L. The two 20 foot suction lysimeters showed zinc concentrations between 730 – 2,410 ug/L (SL-02-05, SL-02-07), and the two 40 foot lysimeters (SL-02-04, SL-02-06) had zinc concentrations less that 150 ug/L (Figure 2.26c).

The concentrations of copper and lead are considerably lower than that of zinc. Both of these metals' concentrations are generally less than 5 ug/L in water from each site (Figures 2.27a, b and c and 2.28a, b and c). Previous observations have shown that copper and lead mobility are greatest when the tailings are first placed, then decrease with time. Isolated instances of high lead concentrations (e.g. PZ-T-00-03, June 2011) may be due to laboratory error.

Cadmium data are shown in Figures 2.29a, b and c. With the exception of Wet Well 2 and 3, cadmium concentrations are very low (less than 2 ug/L). Cadmium in Wet Well 3 had a maximum value of 27 ug/L in 2002 and showed seasonal fluctuation similar to that of zinc, albeit at significantly lower concentrations. In the first 2007 sample, Wet Well 2 showed an elevated cadmium level, but the second sample was less than the detection limit, and has remained below the detection limit through 2011. Well MW-T-02-06 showed a cadmium concentration of 4.5 ug/L in June 2003; however, samples since then have all been 0.6 ug/L or less.

Iron and manganese data are presented in Figures 2.30 a, b and c and 2.31 a, b and c, respectively. Concentrations of iron and manganese are high in the wet wells, groundwater and most of the suction lysimeters due to oxidation/reduction and buffering reactions. Lower concentrations of iron and other metals in PZ-T-00-01, PZ-T-00-02 and PZ-T-00-03 likely indicate sulfide precipitation resulting from sulfate reduction and/or thiosulfate disproportionation in these waters.

In previous years, Wet Well 3 reflected surface effects while Wet Well 2 was influenced more by internal-pile contact water and foundation groundwater. However, in recent years, the compositions of Wet Well 2 and Wet Well 3 waters have become similar, reflecting a decrease in surface effects. Before it was decommissioned in 2007, MW-T-02-06 water had evolved toward compositions indicative of sulfate reduction, similar to those seen in PZ-T-00-01, PZ-T-00-02 and PZ-T-00-03.

Acid Base Accounting (ABA) Analyses

ABA analyses of monthly composite samples were taken of tailings at the Mill filter press. Figure 2.32 shows the monthly composite sample ABA results for 2001 through 2011. The average net neutralization potential (NNP) results are shown in Table 2.5. The variability from year to year is primarily due to fluctuations in acid potential (AP), which is an indication of the pyrite content of the ore. Neutralization potential (NP) values, which primarily reflect carbonate content, are generally more constant.

Table 2.5 Average Tailings NNP - Mill Filter Press

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Average NNP ($tCaCO_3$/kt)	-281	-197	-194	-200	-134	-123	-156	-237	-289	-226	-257

The results of ABA analyses on grid samples taken from the Tailing Facility from 2002 to 2008 are presented in Figures 2.33 and 2.34. The grid included portions of the pile that had exposures of tailings, argillite slope armoring, road rock, and ditch sediment. Figure 2.33 shows the acid generation potential (AP) versus neutralization potential (NP) of all grid samples. The pure tailings samples plot in the upper half of this figure, indicating that they are potentially acid generating. However, the high carbonate content of the tailings (NP >100 $CaCO_3$/1000t) indicates there is substantial buffering capacity remaining in the tailings. These results remain consistent with previous studies of the mine's tailings. Samples of weathered tailings (after approximately 12 years of exposure) have been shown to still retain a considerable amount of neutralization potential, equivalent to approximately 20% calcium carbonate (KGCMC 2002b). This suggests that the potential lag time to acid generation of exposed tailings is on the order of decades. This long lag time allows time for construction and adequate closure of the site (including covering the pile with a composite soil cover designed to minimize oxygen ingress).

Figure 2.34 shows the relationship of pH to net neutralization potential for the same suite of samples shown in Figure 2.33. Rinse pH is a measure of the pH of a one-to-one mixture of "as received" fines and water. The rinse pH of all of the samples of pure tailings are above 6.0, indicating that the exposed surfaces of the tailings pile remain well buffered. Grid samples with positive NNP values are not representative of tailings and may include argillite and ditch sediments. Samples containing peat can produce a lower pH because of acids formed from the natural decomposition of organic matter.

Sulfate Reduction Monitoring Program (SRMP)

Following the USFS 2003 EIS Record of Decision for expansion of the tailings pile, HGCMC began a mandated 30 month study to determine the feasibility of promoting long term sulfate reduction at the facility. HGCMC assembled a team comprised of personnel from the University of Waterloo, HGCMC and independent consultants to develop and implement the investigation. The primary objective of the sulfate reduction monitoring program (SRMP) is to determine the feasibility of meeting closure objectives related to water quality by promoting in-situ microbial processes that increase alkalinity and reduce the concentration of constituents of concern.

A summary report of the 2006 data was distributed to regulatory agencies in 2007. The report and submittal explained the need to extend the study beyond the originally envisioned 30 month time period. A summary report from University of Waterloo including data from the 2007 and 2008 field seasons was submitted in March 2011 (Lindsay and Blowes 2011). A second phase of the Waterloo investigation commenced in 2009 and continued through 2010. Findings from this second phase will be presented in a follow-up report expected in 2012.

Field test program

Seven field test cells were constructed and instrumented in the fall of 2004 to monitor the effects of adding different carbon sources to an unsaturated portion of the pile. Cell treatments are summarized in Table 2.6. The cells are 10 feet square and 13 feet deep. A synthetic liner was installed around the vertical sides of the excavations (Cells 2-7) to isolate the cells from lateral flow while allowing vertical flow through the cells. Pore water and core samples are taken annually from multiple depths through each cell and soil suction, moisture content and temperature profiles are also collected.

Table 2.6 SRMP Cell Treatments

	Tailings (volume %)	Peat (volume %)	Spent Brewing Grain (volume %)	Municipal Biosolids (volume %)	
Cell 1	100	0	0	0	Unexcavated
Cell 2	100	0	0	0	Excavated
Cell 3	95	5	0	0	Amended
Cell 4	95	2.5	2.5	0	Amended
Cell 5	95	2.5	0	2.5	Amended
Cell 6	95	2.5	1.25	1.25	Amended
Cell 7	90	5	2.5	2.5	Amended

The conclusions and technical considerations from Lindsay and Blowes (2011) are quoted as follows:

Results of this five-year research study demonstrate that amendment of tailings with a small dispersed mass of organic carbon can support (thio)sulfate reduction and/or thiosulfate disproportionation and support pore-water treatment. Amendment of freshly deposited tailings supported increases in populations of sulfate-reducing bacteria, dissimilatory sulfate reduction, the precipitation of secondary metal-sulfide minerals and increases in carbonate alkalinity. Consequently, large decreases in pore-water concentrations of sulfate, thiosulfate, and several metals and metalloids were observed under sulfate-reducing conditions. The addition of organic carbon also supported reductive mobilization of iron and arsenic; however, sulfate reduction and metal-sulfide precipitation has potential to promote subsequent attenuation of these elements.

The influence of sulfate reduction on tailings pore-water chemistry varied among the organic carbon amendments evaluated in this study. Over the duration of this study, peat generally proved ineffective for inducing and supporting dissimilatory sulfate reduction. This source of organic carbon, which was evaluated in each of the field trail cells, is generally comprised of complex ligno-cellulose carbon molecules. The refractory character of peat was evident by the general absence of sulfate reduction within tailings amended with this organic carbon source. Similar results were observed for the laboratory batch experiments; however, data indicated that sulfate-reducing conditions may have started developing near the end of these experiments. In contrast, spent brewing grain was a common component of organic carbon amendments that supported extensive sulfate reduction, metal-sulfide precipitation and alkalinity generation. Production of labile organic compounds (i.e. acetate) by fermentative bacteria likely sustained growth of sulfate-reducing bacteria in cells amended with spent brewing grain. A general lack of sulfate reduction was observed for batch experiments that contained dried spent brewing grain. The high amendment rates (50 wt. %) utilized for these experiments may have limited the effectiveness of dried spent brewing grain as a tailings amendment. Treatment of simulated tailings pore water using amendments containing wet spent brewing grain was more effective during a secondary phase of batch experiments. Municipal biosolids supported rapid development of reducing conditions; however, sulfate reduction associated with this material was short lived during the field experiments. Decreases in aqueous sulfate concentrations were, however, observed in tailings amended with municipal biosolids, in addition to peat and spent brewing grain. Composted fish waste, which was evaluated in the laboratory batch experiments, supported sulfate reduction but was generally a less effective source of organic carbon than spent brewing grain. Nonetheless, this material likely supported relative increases in pore-water pH compared to other organic carbon sources evaluated during the batch experiments.

The introduction of organic carbon to tailings supported reductive mobilization of iron and arsenic. The magnitude of increase in aqueous concentrations of these elements was dependent on the rate of mass transfer from the solid to aqueous phase. This mass transfer rate was in turn dependent on the proportion and type of organic carbon introduced. Amendments containing municipal biosolids supported rapid increases in iron and arsenic concentrations. Increases in the rate of organic carbon amendment also resulted in enhanced iron and arsenic mobilization. Organic carbon sources that rapidly contribute labile organic carbon may thereby limit the effectiveness of this technique for tailings pore-water treatment. Subsequent attenuation of iron and arsenic was observed for amendments which sustained sulfate reducing conditions for longer durations. Decreases in the solid-phase mass of reducible iron and arsenic may, however, prove beneficial when tailings are subjected to reducing conditions under a cover system. Nonetheless, highly labile sources of organic carbon, such as municipal biosolids, have the potential to generate elevated concentrations of iron and arsenic in tailings pore water. The introduction of organic carbon to oxidized tailings or waste rock may support large increases in pore-water concentrations of these elements.

Amendment rates were evaluated during the field trial experiments and laboratory column experiments. Removal of (thio)sulfate, metals and trace elements, and carbonate alkalinity production generally were more effective at an amendment rate of 10 vol. % compared to the same organic carbon sources added at 5 vol. %. However, mobilization of iron and arsenic was more rapid and maximum concentrations were much higher with the 10 vol. % amendment rate. An organic carbon amendment rate of 2 vol. % was assessed during the laboratory column experiments; however, the results indicate that 5 vol. % was more effective in supporting thiosulfate removal and the attenuation of metals and trace elements. Similar to results from the field trial experiments, increasing the amendment rate also enhanced iron and arsenic mobilization in the laboratory column experiments. The amendment rate of 5 vol. % resulted in effective removal of (thio)sulfate, metals and trace elements, and supported lower rates of reductive mobilization of iron and arsenic.

The tailings characterization study and field trial experiments identified elevated concentrations of thiosulfate in recently placed mill tailings. The presence of thiosulfate in tailings pore water was attributed to the flotation reagent sodium isopropyl xanthate in residual process water or adhered to mineral surfaces. Reduction and/or disproportionation of thiosulfate contributes to metal(loid) attenuation by generating hydrogen sulfide and promoting metal-sulfide precipitation. Enhanced rates of thiosulfate removal were observed in organic carbon amended versus non-amended tailings. This difference in thiosulfate removal is partially attributed to differences in rates of reduction compared to disproportionation. Disproportionation or reduction of thiosulfate in non-amended tailings may have contributed to previously observed increases in hydrogen sulfide concentrations coupled with metal and trace element attenuation.

The precipitation of secondary calcium-bearing minerals also influenced tailings pore-water chemistry. Saturation of pore water with respect to gypsum was common in the absence of dissimilatory sulfate reduction. Precipitation of this mineral phase is therefore an important control on aqueous sulfate concentrations in Greens Creek tailings. However, alkalinity production supported the development of conditions favorable to calcium carbonate (i.e. calcite or aragonite) precipitation. Decreases in aqueous calcium concentrations due to carbonate precipitation will limit the effectiveness of gypsum as a control on aqueous sulfate concentrations. Precipitation of gypsum below the oxidation zone also consumes calcium. Due to a two-to-one stoichiometry of sulfate generated by pyrite oxidation to calcium generated by dolomite dissolution, gypsum becomes a less effective control on sulfate concentrations near the tailings surface. Decreases in aqueous calcium concentrations resulting from these reactions will facilitate increased sulfate concentrations in the absence of sulfate-reducing conditions.

Extensive sulfate removal was followed by increases in pore-water concentrations of barium and methane in some cells. Increases in barium concentrations were observed in pore waters from field trial cells that supported large depletions in dissolved sulfate. Methanogenic conditions developed under low sulfate conditions in the field trial cells. Competition for organic carbon substrates among sulfate reducing bacteria and methanogenic archaea may occur under these conditions. However, methane concentrations remained low in cells that exhibited elevated sulfate concentrations and sulfate reduction is expected to dominate under these conditions.

The stoichiometry of sulfur to divalent metals (i.e. Fe and Zn) in tailings pore water also may limit the potential for pore-water treatment. The ratio of sulfur to metals will determine the extent of removal that can be achieved via metal-sulfide precipitation under sulfate-reducing conditions. An excess of either sulfur or divalent metals will result in limited removal once aqueous concentrations of either reactant becomes limited.

Finally, exhaustion of available organic carbon would limit the potential for longterm pore-water treatment via sulfate reduction. Decreased organic carbon availability due to consumption in amended tailings may result in declining rates of sulfate reduction with time. This limitation may be minimized with subsequent placement of overlying organic carbon amended tailings. Dissolved organic carbon contributed by overlying amended tailings should support ongoing sulfate reduction.

Technical Considerations

The following also should be considered if full-scale amendment of tailings is carried out:

- Amending tailings with organic carbon at a rate of 5 vo. % has potential to support sulfate reduction and overall improvements in the quality of tailing pore water. Higher amendment rates have potential for iron, arsenic and barium mobilization, whereas (thio)sulfate reduction and metal removal may be limited at lower amendment rates.
- Materials that primarily consist of highly labile (i.e. municipal biosolids) and refractory (i.e. peat) organic carbon are likely to be ineffective as individual amendments. These forms of organic carbon could, however, be utilized sparingly in conjunction with less reactive organic carbon sources.
- The reactivity of the organic carbon sources may vary temporally and/or spatially. Such variations will likely influence the potential for sulfate reduction and therefore tailings pore-water treatment.
- Tailings mineralogy varies according to the composition of the ore body. Therefore, achievable improvements in pore-water quality may vary, both spatially and temporally, within the Tailings Facility.
- Compaction influences porosity, hydraulic conductivity and moisture contents within the Tailings Facility. Achieving consistent compaction will ensure pore-water migration rates and therefore residence times within the Tailings Facility are spatially consistent.

- Amending weathered tailings or waste rock with organic carbon may result in increases in the mobility of some elements. Accumulation of iron(III) (oxy)hydroxides within these materials are subject to reductive dissolution in the presence of organic carbon. Liberation of iron, arsenic and other metal(loid)s associated with these secondary may have a negative impact on tailings pore-water quality.

HGCMC awaits the final report from University of Waterloo for data collected through 2010. Determination of production-scale logistics and evaluation of potential geotechnical effects of carbon amendment on the tailings are contingent on successful field and laboratory geochemical testing of carbon amendment.

2.6 General Site Management

<u>Tailings Operation and Management</u>

The General Plan of Operations (GPO) Appendix 3 includes the general operating and management goals to achieve site stability and satisfy regulatory requirements for the HGCMC Tailings Facility. In Appendix 3, Section 2.1.4, HGCMC operations place tailings in the impoundment using specific criteria established by Klohn Crippen Engineering in 1999 for the placement of tailings in cellular configurations with compaction standards. HGCMC continued to place tailings in this manner through 2011.

HGCMC continues the use of off-highway lidded trailered trucks to transport the tailings to the surface placement area. The material is end dumped, spread and compacted using a bulldozer, followed by a smooth-drum vibratory compactor. Compaction checks using a Troxler density and moisture gauge confirm the resultant performance in the placement area, as per the GPO Appendix 3. See Section 2.3 for a discussion of compaction results.

HGCMC does not expect any changes to the placement methodology in 2012 and will continue placement according to the established criteria. Continued development of placement areas for the remaining mine life are a part of the Stage 2 Expansion Project, approved in January 2004. The 2003 Stage II Tailings Expansion Environmental Impact Statement (EIS) is summarized in HGCMC Tailing and Production Rock Site 2004 Annual Report (KGCMC 2005). In 2011 the majority of tailings were placed in the Northwest Expansion area. Construction activities for 2011 included:

- Cleaned sediment from the lined degrit basins that were installed in 2009
- Completed construction of the East Ridge Expansion area including powerline relocation, B-Road relocation, and liner installation
- Completed the extension of Wet Well A in Pond 6 area
- Electrical decommission of Wet Well 1

HGCMC submitted an updated West Tailings Facility Monitoring Action Plan on December 15, 2009 (HGCMC 2009). The plan described processes affecting water quality in the area and presented an updated monitoring plan. Key aspects of the plan and a summary of 2011 findings are as follows. Table 2.7 shows the data for the West Tailings area.

- A complex history of disturbance in the area poses challenges to identifying potential leakage from the facility; however, leakage would likely produce a chemical signature similar to Wet Well 3.

- Zinc in the drainage was an order of magnitude or more lower than contact water suggesting that effects from seepage, if any, from the tailings pile are minimal.
- Further Seep zinc concentrations remained relatively unchanged since 2000.
- Zinc in the upper portion of the Further Creek drainage (Site 610) increased with construction and tailings placement activity (likely dust) in the area.
- Zinc in the southern portion of the Further Creek drainage (Site 611) increased from 2004 to 2009, but the absence of manganese suggests that the source of the loading is not tailings leachate. The maximum zinc concentration at Site 611 decreased to 166 ug/L in 2010 from a high in 2009 of 214 ug/L. Sulfate also decreased to 111 mg/L in 2010 from a high of 451 mg/L in 2009.
- Site 609 is an appropriate monitoring site for tracking all facility related influences to Further Creek. Figures 2.40 and 2.41 show the concentrations of zinc and lead at Site 609. The increase in zinc and lead concentrations at Site 609 in 2011 may be result of lower than average precipitation and deposition of dust from placement activities in the northwest expansion area. Despite the increase, the values for both metals were well below the Alaska Water Quality Standard in 2011.
- The composition of waters in the Further Creek drainage is expected to improve as effects from previous disturbance, rock fill, dust and other sources decrease. Some element concentrations may temporarily increase as the drainage pH approaches its naturally acidic, dilute condition. The expected reduction in hardness would lower the Alaska Water Quality Standard (AWQS) for hardness dependent elements and may cause exceedances despite the improvement in water quality.
- Quarrying and construction of Pond 7 in 2004/2005 caused an increase in conductivity, sulfate, pH, hardness, and trace and major elements. Following installation of a pump to collect drainage from the pond foundation the Althea Creek drainage (Site 60) started to return to pre-construction conditions
- Zinc and lead concentrations at Site 60 area shown in Figures 2.42 and 2.43. Zinc concentrations are very low (< 11 ug/L). As the hardness at Site 60 decreases toward background conditions, the AWQS for lead, which is hardness dependent, may approach the lead concentration at Site 60.
- The nearly two orders of magnitude difference in zinc concentration above and below the liner indicates that the liner is intact and functioning as designed.
- As efforts to reduce the sources of sulfate and metals loading to Althea Creek and Further Creek continue, HGCMC expects these drainages to approach pre-disturbance compositions. Background conditions typical of these muskeg drainages preclude compliance with AWQS for pH, alkalinity, aluminum and iron at sites 60 and 609. The concentrations of some metals and trace elements (e.g. lead, zinc, cadmium, mercury and manganese) are expected to exceed background levels and may not meet AWQS as the pH and hardness in the drainages decrease to background levels. The magnitude of the exceedance is expected to be small and temporary.

Table 2.7: West Tailings Monitoring Data

Site	Date	Conductivity (uhmos/cm)	Field pH	Alkalinity (mg/l)	Hardness (mg/l)	SO4 (mg/l)	As (ug/l)	Cd (ug/l)	Fe (ug/l)	Pb (ug/l)	Mn (ug/l)	Ni (ug/l)	Zn (ug/l)	Hg (ug/l)
609	07/15/2003	84.4	5.67	4.59	33.4	18.6	1.1	0.1	2010	2.82	59.1	3.27	30.8	
609	10/27/2003	131	4.5	0.5	49.7	41.1	1.35	0.1	1600	1.35	104	3.25	51.9	0.1
609	12/28/2004	105.7	4.49	0.5	41.7	33.9	0.968	0.045	1100	1.1	70.6	2.13	53.7	
609	09/14/2006	78.3	5.14	0.5	33	26.8	1.42	0.146	714	2.01	69.3	3.07	54.8	0.1
609	05/31/2007	97.4	5.05	0.5	35	27	0.964	0.193	852	1.46	74.1	2.38	55.7	
609	09/27/2007	387	4.91	0.5	140	163	2.35	1	1050	1.93	102	6.41	147	0.0001
609	05/07/2008	276	6.41	7.96	110	95.2	0.762	0.5	436	0.568	52.1	2.78	46.6	
609	10/14/2008	199.2	6.71	11.9	95	71.4	0.22	0.31	1060	0.15	55.6	2.89	39.8	0.1
609	08/24/2009	430	6.57	7.07	200	182	0.513	0.31	852	0.556	117	8.31	54.9	0.095
609	05/04/2010	340	6.56	12	142	115	0.6	0.05	480	0.3	45.1	2.4	27	0
609	11/10/2010	350	6.72	10	162	128	0.8	0.05		0.3	54.6	9.4	32	
609	04/14/2011	329	6.63	12	146	112	0.25	0.1	250	0.4	65.7	3.4	48	0
609	07/13/2011	360	7.26	10	161	138	1	0.05	430	0.7	34	3.4	41	0
609	08/22/2011	329	6.96	7	154	127	1.8	0.2	870	1.3	68.3	4.5	62	
610	12/29/2004	37.2	4.35	0.5	8.53	2.35	1.2	0.045	730	1.11	47.3	1.51	15.2	
610	09/14/2006	44.3	5.64	2.76	26	6.25	2.22	0.131	832	1.4	26.4	2.29	49.6	0.1
610	05/10/2007	125.6	6.14	2.9	41	26.9	3.99	0.5	163	1.45	117	1.07	31.7	
610	09/27/2007	1019	6.51	25.6	410	424	1.87	1	111	0.5	224	11.1	60.3	0.0001
610	05/07/2008	873	6.97	47.8	400	365	0.694	0.2	115	0.1	12.9	5.57	23.1	
610	10/14/2008	520	7.32	78.1	250	173	0.691	0.31	152	0.15	27.2	5.55	22.3	0.1
610	09/24/2009	791	7.38	1	490	318	1.05	0.23	110	0.18	16	12.6	38.1	0.025
610	05/10/2010	763	6.89	77	393	259	0.25	0.1	50	0.3	16.3	4.3	35	0.015
610	11/10/2010	867	7.13	5	520	399	0.7	0.1		0.5	35.1	8.6	71	
610	04/14/2011	632	7.09	54	310	233	0.7	0.2	20	0.2	9.3	6.2	40	0
610	07/13/2011	894	7.08	61		391	0.6	0.2	30	0.2	17.6	6.1	39	
610	08/22/2011	693	7.47	61	390	305	1.5	0.4	120	1.3	25.6	12.3	110	
611	12/29/2004	317	6.09	9.97	155	126	1.91	0.045	170	1.32	8.73	1.24	31.8	
611	09/14/2006	436	6.42	20.5	220	177	2.19	0.1	211	0.521	16.6	3.73	42.2	0.1
611	09/27/2007	440	5.66	6.89	190	201	3.41	1	203	0.5	18.3	3.53	97	0.0001
611	10/14/2008	341	6.07	12.4	26	119	1.82	0.31	792	0.636	19.6	1.77	96.6	0.1
611	10/01/2009	981	6.42	34	530	451	1.74	0.31	95.2	0.593	11.3	8.55	214	0.025
611	05/04/2010	499	5.96	23	219	183	2	0.05	210	0.5	27.7	2.3	96	0
611	11/04/2010	217	5.57	6	138	111	3	0.2	170	1.1	38.8	2.4	166	
611	04/14/2011	264	6.01	15	111	77	2.5	0.1	120	64.6	12.8	2	109	0
611	07/13/2011	651	7.12	27		247	2.2	0.05	340	1.3	75.6	2.9	114	
611	08/22/2011	407	6.29	16	203	160	5	0.2	240	0.8	21.3	3.1	145	

nondetect data reported as 1/2 detection limit

Codisposal Studies

HGCMC compared the relative costs of recountouring and covering the existing Site E production rock pile versus consolidating it with another surface facility, and found that relocating the material to the surface Tailings Facility is the most economical and environmentally protective solution.

Geochemical results, as well as a geotechnical summary and a site excavation plan, are presented in the Site E Removal: Waste Rock and Tailings Codisposal Plan (HGCMC 2009). This plan was approved by the agencies on June 16, 2009. The plan outlined the removal activities and associated best management practices (BMPs) to be used during active removal (summer construction season) and inactive periods (fall rainy season and winter). Between June and September 2009 and 2010, HGCMC removed approximately 40,000 cubic yards of waste rock and reclamation material from Site E each year. Between May and September 2011, HGCMC removed approximately 8,000 cubic yards of waste rock from Site E. The 2011 waste rock removal was less than previous years due to a number of factors, the main one being that the tailings placement area during the spring and summer months was in the northwest portion of the site, where placement was near the liner system. The standard operating procedure for codisposal is to place at least 3 lifts of tailings only on top of the liner system because codisposed materials may have the potential to compromise the liner. The plan for Site E in 2012 is continued removal of waste rock for codisposal with tailings; however, similar placement issues seen in 2011 will likely be encountered in 2012 due to commissioning of the new East Ridge placement area (i.e., placement will be in a new area directly on top of the liner system). On December 30, 2010 HGCMC requested a modification to the Plan to allow for year round codisposal operations with additional BMPs being implemented. Figure 2.38 is a photograph taken during the removal activities at Site E.

Dust Monitoring and Abatement

Monitoring performed under the Freshwater Monitoring Program has identified lead levels in three shallow peat wells south (Site 27) and west (Site 29 and Site 32) of the tailings pile that approach or exceed freshwater quality standards (KGCMC 2007). The formation water in these wells is generally very dilute (low conductivity and hardness) and acidic (due to organic acids), which is ideal for promoting lead mobility. Dust from the tailings pile may contribute to the lead levels observed in these wells.

Visual observations and operational experience indicate that dust loss from the tailings pile occurs when dry, windy conditions persist at the site. These conditions typically occur for short periods between mid December and late February when high pressure systems produce cold, dry weather and strong northerly winds.

Warm, dry conditions occur periodically during the spring and summer months, but wind direction and velocity are not typically as favorable for dust entrainment during these periods. Salt formation on tailings surfaces and application of water to access roads further reduces the potential for dust formation during warmer months.

Snow samples were collected just prior to the loss of snow cover each spring in 2007, 2008, 2009, and 2011. Sample locations are shown on Figure 2.35. Additional sites were added in 2009 to provide data around the entire pile. The objective of the sampling was to quantify the amount of tailings dust that had accumulated on the snow pack when conditions for dust loss were greatest (typically December through February). The samples were analyzed for total lead concentrations, and a lead load per square meter was calculated (Table 2.8). The 2006 to 2009 data contained a calculation error. The data reported below have been changed to correct the error.

Table 2.8 Tails Snow Dust Loading Table

Sample Location		Date	Lead Load (mg/m2)	Zinc Load (mg/m2)	Feet from Pile Center (E40180, N53229)
1007	MW 3S, Site 29	4/14/2007	177	177	825
1007		2/20/2008	10	8	
1007		4/16/2009	90	28	
1008	MW 5, Site 32	4/14/2007	20	14	980
1008		2/20/2008	8	6	
1008		4/16/2009	29	10	
1008		3/9/2011	29	54	
1009	Wet Well 1 75' S	4/14/2007	347	462	860
1009		2/20/2008	84	52	
1009		4/16/2009	73	31	
1010	MW 1S, Site 25	4/14/2007	135	150	1495
1010		2/20/2008	64	33	
1010		4/16/2009	22	12	
1010		3/9/2011	296	565	
1011	MW 2S, Site 27	4/14/2007	85	58	1695
1011		2/20/2008	79	86	
1011		4/16/2009	7	5	
1011		3/9/2011	223	440	
1012	Lease Line South	4/14/2007	423	509	1215
1012		2/20/2008	150	209	
1012		4/16/2009	12	7	
1013	Main Embkmnt Toe	4/14/2007	1048	3427	910
1013		2/20/2008	366	899	
1013		4/16/2009	24	13	
1013		3/9/2011	575	968	
1014	MW-T-02-07	4/14/2007	1190	2321	890
1014		2/20/2008	404	1367	
1014		4/16/2009	128	66	
1015	MW-T-00-04A	4/17/2007	2370	5286	875
1015		2/20/2008	244	321	
1015		4/16/2009	42	18	
1044	MW-T-00-03B	4/16/2009	44	33	545
1044		3/9/2011	38	23	
1045	MW-T-00-02B	4/16/2009	289	451	640
1045		3/9/2011	28	74	
1046	MW-T-00-01B	4/16/2009	15	11	870
1047	MW-T-95-5B	4/16/2009	12	7	725
1047		3/9/2011	35	139	
1048	MW-T-05-04	4/16/2009	9	6	1075
1049	MW-T-01-03B	4/16/2009	622	174	710
1049		3/9/2011	577	738	

The data indicate that the loading is observable up to 1600 feet from the pile and that the loading has decreased each year since 2007 (Figure 2.36). Several factors, including fewer dust-producing weather events, a shorter snow accumulation period and improved abatement measures, likely contributed to the reduction in calculated loading values.

Lead levels in water from the three wells do not correlate directly with lead loading values. In fact, the well with the highest lead concentration (Site 32, ~ 6.5ug/l) actually has one of the lowest lead loading values determined from the snow survey. Site 32 is downwind of the Wet Well 1 building, Outfall Shack and a stand of pine trees, which may collectively act as a dust trap, preventing accumulation of dust in the immediate vicinity of the Site 32 well. Tailings dust that settles on the peat up-gradient from Site 32 may be the source of the lead observed in the well. The chemical composition of the water at Site 32 suggests that its completion zone is better suited for lead mobility than the completion zones at Site 27 and Site 29. It is the most dilute of the three waters and there is very little in the water that would cause the lead to precipitate. Complexing with organic ligands may also promote lead mobility in these peat waters.

A direct link between dust accumulation and lead concentrations in the wells has not yet been established. However the lead loading determined from snow surveys suggests that the amount of lead accumulating on the peat in the vicinity of the wells is sufficient to account for the lead values observed in the wells. This is based on the simplifying assumption that all of the lead is leached from the dust and that it is distributed evenly in a two-meter column of water (saturated peat).

HGCMC evaluated air sampling methods that may augment the lead loading analysis from snow sampling. This would allow year-round monitoring, which will help quantify the temporal distribution of loading at the site. Standard air sampler devices were determined to be an inefficient method for monitoring at this site. Maintenance issues with the air samplers and a lack of available power at most remote locations prevented the air samplers from operating effectively.

HGCMC researched additional methods for lead loading analysis and is evaluating a more passive monitoring system. This passive system involves the use of a 10 liter Atmospheric Depositional Pail (ADP) mounted approximately 1.3 meters off the ground. In January 2011 five ADP systems were deployed 50-100 meters from the base of the dry stack tailings pile. Four of the APDs loosely correlate to the cardinal points on a compass, with the fifth system in the southwest position. On a two week cycle the ADPs were collected and filtered through a pre-weighed 47 mm glass fiber filter with a 1.5 micron pore size. Next, the filters were dried then weighed in order to measure the total loading. Following this process the filters were then analyzed for total lead and total zinc. Results from the analysis equate to the amount of material that passed through the opening of the ADP over a two week period. Therefore it is possible to calculate the average daily load per given area. HGCMC accepts that there are some limitations and possible artifacts introduced into the data using the ADP systems, however the consistency of the trends between the five ADP systems suggest that this was a very effective tool for monitoring loading. Along with the ADP systems HGCMC also monitors and records the hourly meteorological conditions near the dry stack Tailings Facility. These measurements include wind direction, wind velocity, relative humidity, rainfall, air temperature, and barometric pressure. Furthermore the surface operations department maintains a log of where in the Tailings Facility they have been placing and working. One final piece of data being collected is the temperature of the tailings pile at depth.

This data supports and verifies the statements made previously about the seasonality (winter) of this issue (Figure 2.37): it occurs under cold dry desiccating conditions with moderate wind speeds from the north or northeast. Out of the five ADP systems deployed in 2011, three received a higher rate of loading than the other two; they were ADP systems in the west, southwest, and south. Out of these three systems the south had the highest yearly accumulative lead load of 172,474 ug/m^2/year and the west system was similar with accumulative lead load of 168,699 ug/m^2/year. The system to the southwest was approximately 1/5th of these values with a lead load of 35,908 ug/m^2/year (Table 2.9). This lower load may reflect that the ADP system here is farther away from the pile than the other two.

Table 2.9 Loading per Biweekly Sample Period Along With Seasonal Totals

	West			Southwest			South		
	Lead			Lead			Lead		
Period StartDate	ug/m2/period			ug/m2/period			ug/m2/period		
1/9/2011	60,713			8,638			92,793		
1/23/2011	15,857			4,122			353		
2/6/2011	6,457			2,029			3,969		
2/20/2011	28,021			6,706			23,024		
3/6/2011	31,895			8,001			18,694		
3/20/2011	2,731	161,416	ug/m2/period 1	1,537	33,813	ug/m2/period 1	4,026	168,234	ug/m2/period 1
4/3/2011	792	95.7%		73	94.2%		235	97.5%	
4/17/2011	451			175			477		
5/1/2011	1,097			123			1,784		
5/16/2011									
6/5/2011	539			181			300		
6/21/2011	1,384			72			74		
7/4/2011	*			97			168		
7/17/2011				63			153		
7/25/2011	280			76			96		
8/8/2011	176			79			168		
8/22/2011	224			63			70		
9/7/2011	201			59			108		
9/19/2011	2,140			427			250		
10/3/2011				80			79		
10/18/2011				79			114		
10/31/2011		7,283	ug/m2/period 2	448	2,094	ug/m2/period 2	164	4,240	ug/m2/period 2
11/14/2011	4,779	4.3%		1,112	5.8%		971	2.5%	
11/28/2011	8,921			1,111			23,034		
12/12/2011	570			163			332		
12/26/2011	1,472			395			1,039		
Total	168,699	ug/m2/year		35,908	ug/m2/year		172,474	ug/m2/year	
Period 1	01/09/2011 through 04/03/2011			140 days	38.4%				
Winter	11/14/2011 through 01/09/2012								
Period 2	04/03/2011 through 11/14/2011			225 days	61.6%				
Spring, Summer, Fall									
* Periods during which the collection system was not operational; during this time the previous loading rate was used for calculation purposes.									

Based on the predominant winds out of the north / northeast and the fact that placement occurred mostly in the northeast the expected area of loading would occur to the west of tails as supported by the data. However, the higher loading to the south suggests that there is a localized source for this material. At the base of the tailings southern slope is where Pond 6 used to be located. HGCMC stopped using Pond 6 shortly after the completion of Pond 7 and eventually turned the area into part of the tailings dry stack. This area has been in use intermittently for tailings placement since then and during the winter the base of this slope can be very windy. Coupled with low desiccating air temperatures in the winter this area potentially was the source of material for loading to the south.

Approximately 95% of the load collected was deposited in 140 days out of the 365 days that were monitored. This period consisted of two sub-periods that were from 1/9/2011 – 4/3/2011 and 11/14/2011 -1/9/2011. Overall this is a little longer period than previously mentioned of mid-December through February. However, the 2012 results show that maximum loading occurred in January and dropped off dramatically in February / March; whereas loading occurred until the end of March in 2011. The difference between these two years can be attributed to the varying meteorological conditions. Based on the temperature profile from the Tailings Facility, the 2010-2011 winter season was colder than the 2011-2012 season as indicated by the colder temperatures at depth. Desiccation of tailings has the potential to be greater at colder temperatures, resulting in a larger ‘pool’ of material that could be liberated.

The following measures are taken to reduce dust loss from the tailings pile:

- Snow fence and concrete block wind breaks were installed on the crest of the tailings pile
- Snow removal is limited to only active placement areas
- Interim slopes are covered with rock
- Outer slopes are hydroseeded where appropriate

Visual observations and snow sample assays suggest that these mitigation measures have helped reduce the dispersion of dust at the Tailings Facility; however, additional efforts are still warranted. Continued snow, water and air monitoring will determine the effectiveness of the control measures.

2.7 Site as-built

As-built drawings for the Tailings Facility are presented in Appendix 1. The drawings depict the 2011 year-end topography, water management features, monitoring device locations and other significant features of the site. An additional tailings drawing includes cross sections that show the following information:

- existing topographic surface
- prepared ground upon which the pile was constructed
- projected locations of piezometers from Figures 2.1 – 2.18

Photographs from 2011 are presented in Figures 2.39 to 2.40 (Appendix 4). Figure 2.39 is an aerial photo of the Tailings Facility on September 25, 2011.

2.8 Reclamation/Closure Plan

<u>Reclamation Plan</u>

In November 2001, as part of the ADEC Waste Management Permit requirements, Greens Creek submitted a “Detail Reclamation Plan with Cost Estimates” as an attachment to the GPO Appendix 14. A Federal/State/Municipal inter-agency team approved this attachment to Appendix 14, as the basis of current site reclamation bonding levels. Bonding levels were set for $24,400,000 in conjunction with the approved site reclamation plan. The Detail Reclamation Plan includes all estimated costs (labor, materials, equipment, consumables, administration, monitoring, and long term maintenance) for task specific work associated with the final closure of the property under a default scenario. HGCMC detailed a scope of work to accommodate the physical reclamation projects and the reclamation monitoring and maintenance of all site facilities by segmenting the overall reclamation closure project work at the mine into 7 elements:

- Roads
- Production Rock Sites
- Tailings Area
- Site General
- Water Systems
- Maintenance and Monitoring
- Administration

Each of the above elements of the Detail Reclamation Plan include narrative and cost estimates to define the closure of the property by discipline (type of work) and area. The elements of the plan encompass the entire mine site, and also include reclamation performance monitoring and facility maintenance after final closure according to the Waste Disposal Permit standards.

The Stage 2 Tailings Expansion process included a National Environmental Policy Act (NEPA) review through an Environmental Impact Statement (2003 EIS) to analyze the potential environmental effects of the project. As part of the tailings expansion, a reclamation review was requested to update the current General Plan of Operations (GPO) Appendix 14 – Reclamation Plan (the Plan) and the costs associated with the tailings expansion area and to revise the Plan's cost estimates to year 2003 values. The request was made in a joint letter dated October 16, 2003 from the Alaska Department of Natural Resources (ADNR), USFS, and ADEC. HGCMC submitted this cost estimate revision as Attachment A.1 to the Plan on October 22, 2003. The estimated reclamation cost detailed in this document, including the anticipated first, 5-year Tailings area expansion development phase, was approximately $26,200,000, a difference of approximately $1,800,000 from the 2001 estimate. As noted above, the regulatory agencies accepted this bond revision amount and the company deposited the necessary funds in the Forest Service administered Federal reserve account.

The value of the reclamation bonding fund was recalculated in 2005 for an internal Rio Tinto closure review. Based on this new estimate, HGCMC proposed an adjustment increase of $2,765,371 in the fund level from the then current $26,200,000 to $29,000,000 as discussed in the 2006 annual presentation meeting and then presented in a 17 August 2006 letter to the regulatory agencies. The regulatory agencies provided their review response to HGCMC on 19 January 2007, raising 21 points for consideration and further elaboration. HGCMC fully responded to these issues with a 25 February 2007 letter.

A fully updated Reclamation Plan and proposed bond amount were submitted to regulatory agencies in April 2008. The 2008 submittal fulfills a portion of the ADEC requirements for the renewal of the Waste Management Permit. SRK Consultants, in their environmental audit of the mine in 2008, reviewed the updated Reclamation Plan and proposed bond amount, and provided comments in their audit report. The agencies submitted comments to HGCMC on the Reclamation Plan in November 2010, and comments on the proposed bond amount in June 2011. HGCMC has retained SRK Consultants to update the Reclamation Plan and proposed bond amount. Upon approval, HGCMC will take the necessary steps to formally update the bond amount.

Reclamation Projects

HGCMC continued using past interim reclamation measures, such as hydroseeding and various erosion controls at the Tailings Facility, to improve and maintain established site controls. A growth medium (six inches to one foot) of native soils was placed on selected slopes of the tailings pile to promote the hydroseeded growth. HGCMC also continued the use of other sediment control measures including silt fencing, jute mat, rock check dams, solid and flexible runoff collection pipes, coarse-rock slope armoring and slope contouring throughout the site. HGCMC is committed to the continued use of site controls as the operation has consistently demonstrated the benefits of these interim reclamation programs to reduce impacts during the operational period.

The Waste Management Permit allows time to gather cover performance information for further analysis, prior to installing the covers en mass. Continued evaluation of the cover performance remains ongoing since its installation in 2000 to justify and improve closure cover technology. Extensive reviews in 2002 of the cap performance also took place during the HGCMC Stage 2 Tailings Expansion project work with the USFS. HGCMC recognizes that the soil covers represent a significant part of the site reclamation plan. Therefore, HGCMC has continued to commit resources to develop and monitor the performance of the cover at Site 23. See Section 3.8 for more details on the Site 23 test cover performance.

Underground Hydrology Study

Environmental Design Engineering (EDE) is assisting HGCMC with a study of the hydrology and geochemistry of the underground workings. Key aspects of the study include:

- Determining the current water table and hydrologic characteristics of the bedrock and backfill
- Consolidating information on the location of drill holes, headings, stopes and related mine features
- Characterizing the geochemistry of underground waters
- Developing a water balance for the mine system
- Estimating the stored soluble load in backfill and on rock surfaces
- Modeling natural and manual flooding scenarios
- Predicting post-closure flow rates and drainage compositions
- Evaluating potential active and passive treatment options for mine waters

HGCMC received an interim report (EDE 2010), which included several key findings summarized below:

- Large scale dewatering has not occurred as a result of Greens Creek mining operations. Instead, it appears that mining operations have created a dewatered halo of limited extent around underground workings.
- The hydraulic conductivity of bedrock in the mine area is low (10^{-6} cm/s to 10^{-8} cm/s), thus there is a limited water supply to re-saturate the dewatered halo to feed seeps and boreholes at depth.
- The quality of potential future deep groundwater inflows may be characterized by high concentrations of barium and elevated concentrations of arsenic and chromium.

Precipitation of barite would attenuate high barium concentrations if the background water mixed with oxidized sulfate-rich contact water.

- Near-surface background water is expected to be of better quality and will have a greater effect on underground water chemistry because there is a greater contribution from near-surface sources.
- Measurements indicate approximately 4-8 gpm of inflow from boreholes and seeps below the 1350 level. The composition of this water is variable and dependent upon differences in source rocks, type of backfill the water may drain through, residence time, drainage rates, ventilation of source areas and proximity to the surface. Concentrations of some constituents can be locally high. Reclaim water and Greens Creek surface waters pumped into the mine can also influence seepage compositions.
- Borehole tests, flow measurements, and comparison of water compositions indicate that perennial flows from some boreholes and seeps appear to be related to fault zones or other near-surface structures that have greater connectivity with surface recharge sources. The near-surface sources tend to produce dilute water containing relatively low concentrations of constituents of concern.
- The water balance indicates that the greatest source of water to the underground workings (excluding operations-related inflows) is inflow that accumulates in the 1350 level. Of the estimated total inflow from natural sources (30 gpm), approximately 80% is drainage collected at the 1350 portal. The water is a result of better connectivity to surface recharge areas, is fairly dilute and has major ion compositions similar to near-surface background water types. Metal and sulfate concentrations are relatively low compared to other underground waters.
- Water collected from a cemented paste backfill zone contained thiosulfate and had elevated DOC and very high alkalinity and pH. Concentrations of antimony, arsenic, barium, lead and molybdenum were very high and selenium and zinc were elevated. It is estimated that nearly 80% of the workings will be filled at closure and approximately half of the fill will be cemented paste backfill.
- Water from the 33 Decline probably represents the upper end of the range of concentrations of constituents to be expected in flooded workings. The water resulted from flooding old, oxidized, mineralized, backfilled workings with contact water. It is characterized by near-neutral pH and elevated acidity. Concentrations of cadmium, manganese, nickel, zinc, sulfate and chloride are particularly high compared to other underground waters. High concentrations of calcium and magnesium and near-neutral pH attest to the buffering capacity of the wall rock and backfill materials.
- Possible closure scenarios include, but are not limited to, submergence of the mine workings via natural or controlled flooding to minimize oxidation of potentially acid-generating material. Results of a preliminary numerical model indicate that natural flooding of the void volume may require approximately 50 years. Simple rate/volume calculations indicate that voids that are not backfilled could be flooded in approximately 2 years (assuming a constant inflow of 700 gpm). Preliminary calculations suggest that saturation of all cemented paste backfill could theoretically occur in less than 5 years.
- It is likely that maintaining flooded conditions above the 920 level may not be possible. When the workings become flooded to an elevation of the Greens Creek base level the

head gradients would favor leakage from the underground mine to the creek or to land surface. If structural features or boreholes create preferential flow paths from mine workings that cannot be completely sealed, release of contact water is possible. Alternatives to flooding the entire mine void, such as flooding the lower workings below the Greens Creek valley base elevation or flooding only selected mine areas above that elevation that can be sealed via bulkheads, should be considered.

- Calculated mass loads based on wall rinse tests represent a portion of the stored soluble load because of incomplete capture and dissolution of oxidation products and additional load present in less soluble forms and in fractures further from wall surfaces. The estimated concentration of constituents based on wall rinse testing represent the low end of the range of concentrations that might be expected in flooded workings. At this low range, concentrations of cadmium and potentially copper, iron, nickel, lead, manganese and zinc may exceed water quality standards.
- Results of biostimulation testing indicate that sulfate reduction may be a viable option for in situ treatment of mine water. Continued testing is recommended.
- Further characterization of mine backfill materials, stored soluble load, buffering capacity and acid generation potential of wall rocks, locations of critical fracture zones and drill holes, and flooding options is recommended.

3.0 Site 23/D

3.1 Introduction

Hecla Greens Creek Mining Company (HGCMC) has prepared this report in accordance with the mine's General Plan of Operations (Appendix 11) and Alaska Department of Environmental Conservation Waste Management Permit 0211-BA001. A summary of all operational and monitoring activities performed in 2011 is provided. Refer to GPO Appendix 11 and Permit 0211-BA001 for a detailed description of Site 23, Site D and associated monitoring requirements.

Operation of Site 23 (HGCMC's only active production rock disposal facility) continued in 2011. See the Site 23 as-built in Appendix 2 for facility layout. Approximately 2,470 cubic yards of production rock were placed at Site 23 during this report period. HGCMC estimates the projected remaining capacity at Site 23 at approximately 544,011 cubic yards, based on the current design.

3.2 Placement Records

Site 23 survey data and truck count haulage information are presented in Table 3.1. Site 23 received approximately 4,181 tons of production rock in 2011 as calculated from HGCMC surveyed volumes. HGCMC estimates 1,099,296 tons of waste rock have been placed in Site 23. A tonnage factor of 1.7 tons/yd^3 was used to convert surveyed volume to tonnage. The difference between truck count totals and calculated totals based on survey data reflects variations in tonnage factors, small differences in load capacities and double handling of materials. The surveyed volume reported in cubic yards has the least uncertainty relative to other quantities reported in Table 3.1. It is difficult to determine the amount of time remaining before permitted space at Site 23 is consumed because placement rates are highly variable and dependent on the underground mine's areas of production. Estimates based on the mine's current plans have determined that there will be sufficient area available for placement at Site 23 through the current life of the mine (10 years).

The acid base accounting data presented in Section 3.5 indicate that HGCMC continues to conservatively classify its production rock. Some of the phyllite that is visually classified as Class 3 is actually chemically Class 2 (i.e. laboratory testing demonstrates a NNP between 100 and –100 tons $CaCO_3$/1000t).

Table 3.1 Production Rock Placement Data

PRODUCTION ROCK PLACED AT SITE 23					ADDITIONAL PRODUCTION ROCK HAULED					
2011	Surveyed (cy)		Surveyed (tons)		Hauled To Tails from Site 23 (tons)		From UG Truck Counts (tons)			
Date	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative	Class 1	Class 2	Class 3	Total
1/31/2011	0	0	0	0	140	140	0	0	0	0
2/28/2011	0	0	0	0	0	140	0	0	0	0
3/31/2011	0	0	0	0	950	1,090	20	0	0	0
4/30/2011	0	0	0	0	0	1,090	0	0	0	0
5/31/2011	1,166	1,166	1,974	1,974	70	1,160	300	840	0	1,140
6/30/2011	0	1,166	0	1,974	563	1,723	240	390	0	630
7/31/2011	0	1,166	0	1,974	1,323	3,046	0	0	0	0
8/31/2011	0	1,166	0	1,974	0	3,046	1,260	0	0	1,260
9/30/2011	0	1,166	0	1,974	2,213	5,259	3,330	0	0	3,330
10/31/2011	0	1,166	0	1,974	355	5,614	660	0	0	660
11/30/2011	0	1,166	0	1,974	798	6,412	1,500	0	0	1,500
12/31/2011	1.304	2,470	2,207	4,181	1,222	7,834	2,430	0	0	2,430
TOTAL	**2,470**		**4,181**		**7,634**		**9,720**	**1,230**	**0**	**10,950**

* No survey taken due to equipment failure or excessive snow

3.3 Stability

Klohn Crippen conducted a stability assessment of Site 23 and Site D in 2003. The stratigraphy and geology were reassessed using the results from drilling programs by HGCMC and Klohn Crippen, historical drill hole data, seismic refraction data, geological mapping and piezometer data. This assessment enabled the previous stratigraphic interpretations to be revised as follows (from top to bottom): a layer of colluvium and blocky rubble about 80 feet thick; a layer of glacial till and sediment about 120 feet thick; a comparatively thin layer of weathered bedrock about 10 to 20 feet thick; and unweathered bedrock (Klohn Crippen 2004). The blocky colluvium is interpreted to be historical (likely ancient) landslide debris.

Limit-equilibrium stability analyses and the liquefaction potential of the foundation materials were evaluated for Site 23 and Site D, using the reinterpreted geological model. Site 23 has calculated static Factors of Safety greater than 1.6 for the existing configuration, and 1.7 for the proposed final build-out geometry at 1,120 feet with 3H:1V exterior slopes. The static calculated Factor of Safety of the backslope above Site 23 ranges from 1.0 for shallow surficial slips to 1.3 for deeper surfaces.

The excavation of the soil from the slope behind Site 23 (temporary construction condition) reduces the calculated Factor of Safety for those sections of the backslope, but this temporary reduction is not expected to cause serious backslope instability. Placement of rock fill within the excavation and construction of the final build-out geometry for the production rock site increases the calculated Factor of Safety to slightly above those for the pre-excavation condition.

Approximately 20 feet of saturated fill material identified at the base of drill holes DH-00-03 (north-central) and DH-02-14 (east end) at Site D was found to be potentially liquefiable under design basis earthquake (DBE) and maximum design earthquake (MDE) loading. Liquefaction of this fill material will impact the stability of Site D, but will not reduce the stability of Site 23 to unacceptable levels.

Site D is projected to fail under a significant earthquake. In its current configuration, Site D is expected to fail under the 1/475-year magnitude design earthquake. This represents an approximate probability of failure of about 0.21% annually, or about 2% during the mine's current projected remaining operational period of about 10 years.

Inspections

Several independent inspections are carried out at Site 23 throughout the year. Operators working at the site carry out daily visual work place inspections. The Surface Civil Engineer and or Surface Operations Manager carry out weekly visual inspections. The environmental department carries out a monthly checklist inspection. No visible signs of physical instability were observed at Site 23 during this report period.

ADEC representatives inspected the site three times in 2011 (June 8, September 14, and October 12). During 2011 the USFS conducted 12 routine inspections (Site inspections #326-#337) to monitor for best management practices effectiveness and compliance to the General Plan of Operations. No issues of non-compliance at Site 23/D were noted during the routine inspections. The USFS typically noted that the facility is being developed and operated to required operations and maintenance specifications of GPO Appendix 11.

Slope Monitoring

Slope monitoring at Site 23/D consisted of GPS monitoring of 13 survey hubs distributed across the sites. The resolution was felt sufficient to identify large potential movement and no such movements were identified. An additional three permanent GPS sites were installed in 2010 alongside the inclinometer sites to collect full time surface movement data and were online starting in 2011.

Inclinometers are used to measure potential subsurface displacement and aid in characterizing slope stability. A total of seven inclinometers have been installed at various locations including Site 23/D, the Tailings Facility, the Mill Backslope, and along the 1350 access road. One inclinometer was installed in 2005; the other six were installed in 2010. A summary of the inclinometer installations by location is shown below.

Location	Site ID	Target Geological Unit Depth	VW Piezo Target Geological Unit
Tailings Facility	IN-T-10-21	Marine clay	1 – Tailings 1 – Marine Sand
Site 23/D	IN-23-05-01	Bedrock	1 – Glacial Till 1 – Landslide Rubble
	IN-23-10-01	Glacial Till	1 – Colluvium
	IN-23-10-02	Glacial Till	1 – Landslide 1 – Landslide Rubble
	IN-23-10-08	Bedrock	1 – Glacial Till 1 - Clay
Mill Backslope	IN-920-10-05	Glacial Till	1 – Glacial Till 1 – Glacial Till
1350	IN-1350-10-01	Bedrock	1 – Bedrock 1 – Weathered Rock

The digital inclinometer probe used for 2010 instrumentation monitoring was recalibrated in October 2010. Data taken in September (prior to instrument calibration) and November 2010 (after instrument calibration) indicate no documentable shift in data accuracy with the use of this instrument post-calibration. However, for the inclinometers installed in 2010, the November 2010 data will be used as the baseline for future monitoring. The inclinometer installations and associated intended monitoring objectives are summarized by site location in the following paragraphs.

Inclinometer IN-23-05-01 was installed at Site 23 at the end of 2005 to aid with stability monitoring at Site 23/D. This inclinometer, located at the central area of the site, has been monitored since 2006, with the baseline reading taken in October 2006. The measurements are presented in two forms, absolute position and incremental displacement. The view of absolute position (Figure 3.31) shows the orientation of the inclinometer casing. A positive deviation on the A axis and a negative deviation on the B axis indicate southerly (downslope) and easterly (up valley) deviations, respectively. The deviation from vertical in this view likely represents deflection of the bore hole that occurred during drilling. The displacements measured since the initial readings are too small to show up in this view and the curves plot on top of each other. The incremental displacement chart (Figure 3.30) shows the location and magnitude of displacement since the initial 2006 reading. Displacements at the top of the hole are attributed to frost heaving, grout settling, and damage from bear activity. The incremental displacement view shows the amount of movement has been approximately 12.2 mm (since 2006), with 2.0 mm movement from November 2010 to December 2011. Movement appears to be confined to a surface approximately 79.3 feet below ground level (85 feet was previously reported in 2009; however, that value did not consider above ground casing). This depth roughly corresponds to the base of the slide/colluvium unit and the top of the dense till in the foundation.

Three additional inclinometers were installed at Site 23 during the summer of 2010 and baseline readings were taken September and November (after instrument calibration). Readings in inclinometers IN-23-10-01, IN-23-10-02, and IN-23-10-08 are consistent with the data obtained previously from IN-23-05-01. Inclinomter IN-23-10-01 was installed in the lower portion of Site D and no movement has been observed in this inclinometer. Inclinometer IN-23-10-02 was installed west of the mid-slope of Site 23 and approximately 1.6 mm of movement was observed at approximately 114.4 ft bgs from November 2010 to November 2011. Inclinometer IN-23-10-08 was installed at the top of Site 23 and the movement zone ranges from 125.8 to 135.8 ft bgs. The maximum movement in this zone was about 1.2 mm at 131.8 ft bgs from November 2010 to November 2011. The identified movement rates appear to be constant based on quarterly readings taken from 2010 and 2011, therefore inclinometer monitoring will be reduced from quarterly monitoring to semi-annual monitoring unless significant site condition changes are identified (either operational or earthquake related). HGCMC is in the process of revising the stability assessment for the site.

One inclinometer was installed in the west/southwest slope of the existing tailings pile in 2010 to monitor the stability of that slope area. There appears to be slight movement at 3 depths (47.7 ft, 67.7 ft, and 79.7 ft bgs at less than 0.5 mm). These very minor movements at depth do not show consistent downslope displacement and are likely due to consolidation of the tailings pile. Quarterly readings were taken in 2011. Given the small rate of movement, it is appropriate to reduce the reading frequency to semi-annual monitoring. Monitoring frequency will be adjusted as appropriate based on any changing site data.

One inclinometer was installed in the central area of the Mill Backslope in 2010. This inclinometer was installed to monitor the slope above the main mill site. The original slope was cut between 1987 and 1989 to create the bench for the mill site area infrastructure. Shortly after excavation, slope movement was identified and drains were installed to lower water levels and improve slope stability. Water levels are monitored and maintained to minimize the potential for slope failure. The slight movement (less than 0.5 mm over 1 year of monitoring) at 12.7 ft bgs (approx. 970.9 ft; lithology classified as glacial till) is expected given the past and current slope conditions. These data, in correlation with the piezometer data, indicate that the dewatering system continues to be effective at controlling large-scale movement of the slope. Quarterly inclinometer readings were taken in 2011. Given the small rate of movement, the reading frequency will be reduced to semi-annual monitoring. Monitoring frequency will be adjusted as appropriate based on any changing site data.

One inclinometer was installed along the 1350 Area access road in 2010. This inclinometer was installed to evaluate whether the landslide materials observed during installation of groundwater monitoring instruments are associated with an inactive or active slide zone. Three readings were taken over the last year, with no monitoring performed during winter months due to access road constraints. There appears to be slight movement at 83.5 ft bgs (1032 ft elevation) at a transition zone between sand and silt lithology (approx. 1 to 2 mm over the 1 year monitored period). Confirmation of movement will follow collection of additional readings in 2012. Monitoring shall continue on a semi-annual basis.

Well and Piezometer Water Level Data

Well and piezometer water level data are provided in Figures 3.1 to 3.12. The lack of significant pressure in piezometers installed close to the base of Site 23 (piezometers 52-55, Figures 3.1 to 3.4) demonstrates that the pile remains free draining. This is consistent with the construction of a network of finger drains under the pile and a blanket drain at the pile toe. Comparison of historic versus modeled flow from the finger drains and the curtain drain indicated they are performing as designed and as necessary (EDE 2004). See Appendix 2 for piezometer and finger drain locations. The lack of pore pressure at the toe indicates that pile stability has been maximized. Water levels from several monitoring locations are shown in Appendix 2. The inferred water table is 30 to 60 feet below the base of the production rock pile material up-slope of the Site 23 active placement area and 5 to 20 feet below the base of material placed in Site D and the toe of Site 23, respectively (see also Figures 3.5 to 3.12). MW-23-00-03 data showed an atypical drop in water elevation in August 2007. However, data collected after that date are within the historical data range. Observations from wells completed in the colluvium below the sites indicate that perched water tables and braided flow paths exist beneath the site (e.g. compare Figure 3.6 and 3.7). This unit also shows large (up to 10 feet) fluctuations in head levels, which are consistent with perched, confined conditions and channel-like flow. There is a distinct seasonal pattern to the water level fluctuations beneath Site 23/D, particularly in the alluvial sands (Figures 3.9 and 3.11).

The silty/clay till that underlies the colluvial unit impedes downward flow and has an upward hydrologic gradient caused by its confining the more permeable bedrock below it. MW-23-98-01 (Figure 3.8) is completed in the till unit and indicates a water table near the top of the till, which is approximately 100 feet below the existing topographic surface. Alluvial sands occur between the colluvial unit and the silt/clay till near the toe of Site 23 and under Site D. Data from MW-23-A4 and MW-D-94-D3 (Figures 3.9 and 3.11) indicate that the sands are saturated. A curtain drain installed in between Site D and Site 23 in 1994 collects water that flows at the base of the colluvial unit and the top of the alluvial sands (see as-built and sections). This drain helps reduce pore pressures in the foundation of Site D, as well as capturing infiltration waters from Site 23.

3.4 Hydrology

Surface and groundwater are managed using a network of drains, ditches and sediment ponds at both Site D and Site 23. See the Site 23 as-built for locations of these features. Water that is collected in the finger drains beneath Site 23 is routed to Pond 23 along with Site 23 runoff via a lined ditch. Pond 23 also periodically receives stormwater via pipeline from the 920 area. A curtain drain below the toe of Site 23 captures groundwater from the colluvial unit beneath the site and reports to the Pond D wet well via pipelines. Pond D also captures surface water and drainage from seeps near the toe of Site D. Pond D water is returned to the Pond 23 pump station where it is either sent to the Mill or down to the Pond 7 water treatment facility. An 18" HDPE pipeline was installed in 2008 to carry stormwater from Pond 23 (which receives water from Pond D) to the Pond 7 water treatment facility. This pipeline, along with the installation of new pumps, increased the stormwater handling capacity of Site 23/D to a 25-year 24-hour storm.

Flow data for Pond D are shown with precipitation in Figure 3.13. The Pond D flow meter was not operating from July 2008 through 2011 due to changes in pumping/piping as noted above. Once all equipment is in place and operating, flow measurements will resume.

Monthly temperature and precipitation data are provided in Table 3.2. March was the driest month with 1.29 inches of precipitation. July and August were the warmest months while February exhibited the coolest temperatures.

The production rock and colluvium units respond rapidly to hydrologic events such as snowmelt and rainfall, indicating very local recharge and discharge (EDE 2004).

Table 3.2 Monthly Summaries of Mill Site Climate Data

Month	Avg Temp (°C)	Precipitation (in)
January	-3.13	5.39
February	-4.70	4.53
March	-2.10	1.29
April	2.37	2.14
May	7.13	2.94
June	10.08	4.00
July	11.83	3.47
August	10.53	10.84
September	8.43	9.39
October	4.42	6.91
November	-2.26	6.21
December	-0.87	8.83
2011	**3.48**	**65.94**

3.5 Water Quality

An in-depth re-evaluation of the geochemistry and hydrology of Site 23 and Site D was performed in 2003 by Environmental Design Engineering (EDE) and HGCMC in accordance with the ADEC Waste Management Permit Section 4.1.1. In general, metal concentrations in the production rock are above crustal averages and are higher than those of the underlying till, colluvium, and alluvium units. Site contact water, therefore, has a generally higher dissolved load than background surface water and groundwater. Bruin Creek and Greens Creek have specific conductivities that range seasonally from 50 to 225 µS/cm. The lack of significant differences between upgradient and downgradient sites on these two creeks demonstrates that effects from Site 23/D are negligible.

Groundwater upgradient and downgradient of Site 23/D also varies between sites and seasonally, with specific conductivity ranging from 200 to 800 µS/cm. Compositional differences between upgradient and downgradient wells demonstrate that the slide unit hosts a series of disconnected, perched water tables of varying water qualities.

Monitoring data from surface water and groundwater sites indicate that the combination of finger drains, curtain drain, ditches and ponds is effectively collecting contact waters and that downgradient effects from Site 23/D are negligible.

Data collected from basal drains, the curtain drain and Pond D show a progressive, down-slope increase in the groundwater component of the flow. This is consistent with the hydrologic interpretation that water infiltrates through the slide material and daylights as springs near the toe of this unit. As Site 23 expands, the proportion of contact water in the flow increases, as demonstrated by the increase in the curtain drain dissolved load since 1995. While the volume of contact water has increased, the dissolved load of the contact water has not increased over time. This is a positive result because it demonstrates that acid generation is not imminent.

A dissolved load analysis based on calculated TDS was performed to determine the relative proportions of various source waters in downgradient waters. Based on this analysis, Pond D contains 12% contact water, and approximately 80% of the Pond D flow is contributed by the curtain drain.

Representative water quality analyses for the major water types are consistent with the conductivity and TDS results and help to further define the geochemical processes occurring at the site. Alkalinity and pH values from all site waters support the conclusion that carbonate minerals are effectively neutralizing acids formed by oxidation of pyrite in the production rock. Zinc, cadmium, manganese, nickel and arsenic are more mobile than other metals of interest in the drainage. Precipitation of iron oxy-hydroxides and manganese oxides controls the concentrations of iron, manganese, and arsenic. Zinc, cadmium and nickel are controlled by mixing and sorption mechanisms. Gypsum is controlling the concentration of calcium in the drainage and will slowly be removed from the system after the pile is covered.

Compliance Monitoring

Water sampling sites around the Site 23/D production rock disposal area have been monitored for various periods. Sites have been added and deleted over time as rock disposal area development is required. The full FWMP Annual Report for water year 2011 is being prepared separately and will be submitted to the Forest Service and ADEC upon completion.

Internal Monitoring

In May 2001 Greens Creek submitted an Internal Monitoring Plan to the Alaska Department of Environmental Conservation – Solid Waste Management Program. This submittal satisfied Section 2.8.3.1 of the HGCMC Waste Disposal Permit Number 0111-BA001.

As described in Section 2.8.3.1 of the permit, the internal plan addressed monitoring at both the surface Tailings Facility and the surface production rock disposal areas covered by the permit. The Internal Monitoring Plan describes monitoring of the pile areas, in contrast to the compliance monitoring (under the Fresh Water Monitoring Plan) at peripheral facility boundary sites. As such, data generated by the Internal Monitoring Plan effort are "… not for compliance purposes…" as noted in the above referenced permit Section 2.8.3.1.

Waters represented by the internal monitoring sites are captured, routed to the Mill or Tailings Facility and treated prior to discharge to the ocean floor under HGCMC's discharge permit (AK 004320-6). Authority over the federal permitting, compliance and enforcement NPDES program transferred to the State (ADEC - APDES) in November of 2010 for the mining industry.

Production rock Site 23 and the adjacent production rock Site D are treated as a single entity, primarily due to their conterminous positions making isolation from one another impractical. Consequently, they are referred to as Site 23/D in this report.

The results of HGCMC's Site 23/D internal site monitoring plan are summarized in Figures 3.14 to 3.26. Personnel issues and EIS field activities contributed to a reduction in monitoring of these internal sites in 2011. Review of the prior years' data suggests that changes in chemical composition were not imminent, and HGCMC ensured that these sites or replacements were monitored in 2012. Sites were distinguished between finger drains and groundwater. These groups are separated on the Figures 3.14 through 3.26 with the suffix a or b, respectively. For example, a figure number such as 3.14a would show the pH data for the finger drains, and 3.14b would show the pH data for the groundwater sites. Sample collection from the Site 23 finger drains is dependent upon their flow. Flow from several of these finger drains is very irregular, responding directly to precipitation-induced infiltration and groundwater fluctuations (Figure 3.27). Monthly sampling of the flowing drains has identified the typical range of concentrations of constituents in the drain waters. HGCMC reduced the frequency of sampling to quarterly for all internal monitoring sites starting in 2003.

Figure 3.14a shows the pH of waters collected from Site 23 Finger Drains 2 through 8, and Figure 3.14b shows the pH of monitoring wells MW-23-A2D, MW-23-A4, MW-D3 and Pond D (see as-built in Appendix 2 for locations). Values of pH were between 6.3 and 8.0 for all internal monitoring site samples in 2011. The lower pH values (generally pH 6.0 to 7.0) were recorded in MW-23-A4 and MW-D3, both of which are completed in alluvial sands beneath Site 23 and Site D, respectively. MW-23-A2D, which screens colluvium upgradient of Site 23, typically has the highest pH (generally pH 7.0 to 8.5). The Site 23 finger drains fluctuate at values between those of the monitoring wells. Figures 3.14a and b suggest that waters from different foundation units have different pH values and that Site 23 and Site D contact waters and the materials with which they are in contact exhibit sufficient buffering capacity to prevent acidification of site drainage in the near term. Seasonal fluctuations are apparent in the finger drains with highest pH values occurring in winter months and lower pH in mid to late summer.

As with pH, high alkalinity values (Figures 3.15a and b) indicate that the waters are well buffered. Fluctuations in alkalinity correlate with those of other parameters, such as hardness (Figures 3.16a and b) and conductivity (Figures 3.17a and b), and also appear to be seasonal. Carbonate minerals in the production rock contribute to the high alkalinity of the drainage from the finger drains. Alkalinity is lowest in samples with the highest groundwater component (e.g. the monitoring wells, Pond D, 23FD-5 and 23FD-7). Calcium and magnesium are the primary contributors to hardness (Figure 3.16a) and reflect dissolution of carbonate minerals, such as calcite and dolomite. Carbonate dissolution neutralizes acidity formed by sulfide oxidation, which is also the source of sulfate shown in Figure 3.18a.

Conductivity results from internal monitoring site waters are presented in Figures 3.17a and b. The 2011 conductivity measurements continue to range up to 4,420 uS/cm. MW-23-A2D and MW-D3 have the lowest conductivity. MW-D3 is completed in alluvial sands below the fill placed at Site D. The finger drains with the highest flow (e.g. 23FD-5, which directly drains an excavated spring) generally have lower conductivities than the drains with lower flow. This reflects a larger contribution from groundwater to the high-flow drains relative to a higher proportion of site contact water in the other finger drains. The significant decrease in conductivity in 23FD-7 that occurred in 2000 is probably the result of incorporation of groundwater collected in the upper portion of the drain above the active placement area. The presence of contact water in the alluvial sand below Site 23 (as seen in MW-23-A4) is not surprising given the permeable nature of the colluvium that lies immediately beneath the site. A clay till layer underlies the colluvium and alluvial sands beneath the site. The clay till serves as a barrier to downward flow; however, as discussed earlier, it occurs well below the base of both piles. The fact that MW-D3 does not show signs of a contribution from contact water suggests that an upward hydrologic gradient may exist beneath Site D.

Finger Drain 23FD-2 has the highest conductivity but consistently low flow, suggesting no significant influence from groundwater. In fact, lack of flow from this drain typically precludes sampling. In 2009 it was dropped from the routine sampling list. The higher conductivity of the site contact waters reflects a larger dissolved load caused by weathering of the production rock. As with tailings, pyrite oxidation and carbonate dissolution contribute dissolved ions such as sulfate, bicarbonate, calcium and magnesium to the contact waters, increasing their conductivity. Sulfate concentrations for the finger drains and groundwater wells are plotted in Figures 3.18a and 3.18b and match closely the relative value patterns of conductivity. The drier than average spring and summer in 2009 and 2010 likely contributed to a greater buildup of oxidation products and reduced groundwater contribution to the water balance. This may result in higher conductivity and sulfate values for some sample sites.

Arsenic data are presented in Figures 3.19a and b and are generally quite low. All finger drains and MW-23-A4 experienced increases in their arsenic concentrations in September 2003, with subsequent decreases back down to historical levels in October. The flows in the finger drains positively correlate with these changes. Fluctuations in arsenic values in 23FD-2 can be attributed to changes in redox conditions. Low arsenic and iron (Figures 3.25 a and b) concentrations indicate that these metals are precipitating as oxyhydroxides on rock surfaces in the pile.

Figures 3.20a and b show the concentration of zinc in the internal monitoring locations at Site 23/D. Zinc levels appear to be controlled by seasonal conditions. The changes in zinc concentrations mimic those for conductivity and sulfate. 23FD-2 had a zinc concentration of approximately 70 mg/L in June 2002. Although, zinc averages have fluctuated since 2002, there has been an overall decreasing trend. In 2008 zinc levels in 23FD-2 were near 20 mg/L. Zinc concentrations in the range of 20 to 70 mg/L are consistent with laboratory kinetic weathering tests performed on samples of argillite and serpentinite (Vos 1993). The zinc concentrations recorded for Pond D are generally below 0.9 mg/L and reflect contributions from several source waters. Pond D receives water from Site D surface runoff, seeps on the slope and at the toe of the site and the effluent from the curtain drain that HGCMC installed between Site D and Site 23. MW-D3 showed elevated zinc concentrations in both 2005 samples: zinc levels rose from an average of 10 ug/L in 1998-2004 to an average of 177 ug/L in 2005. Average sulfate also increased by approximately 30 mg/L in 2005 compared to average values from 2002-2004. The zinc and sulfate returned to within historical limits in 2006. The cause for the increases in 2005 is not immediately apparent; however, if it was the arrival of a contact water front, a significant increase in conductivity, sulfate, calcium and magnesium should have preceded an increase in metals such as lead and zinc.

Cadmium concentrations (Figures 3.21a and b) correlate well with those of zinc for the internal monitoring sites although at much lower values (0 to 35 ug/L).

The concentrations of copper and lead (Figures 3.22a and b and 3.23a and b) are considerably lower than that of zinc in the Site 23/D internal monitoring sites. Both of these metals show the same general trends as zinc with the exception of one anomalous lead result in a sample from 23FD-2 in 1999. The nickel concentrations presented in Figures 3.24a and b support the observation that the drainage from 23FD-2 is different than that of other drainages. It is possible that the material that supplies water to this drain has a greater proportion of serpentinite, which was shown to produce higher zinc and nickel concentrations than other rock types such as argillite and phyllite (Vos 1993). What appeared to be a linear increase in nickel concentrations in 23FD-2 prior to 2002 now appears to be decreasing or at least cyclical. The December 2005 sample from MW-23-A2D was an order of magnitude higher than historical values and was likely an analytical error as it did not correspond with the conductivity and TDS of that sample. Also, the more recent metal concentrations for this site have returned within historical data values. Monitoring will continue to determine trends.

An overall increase in arsenic cadmium, copper and zinc concentrations was apparent in the majority of finger drain samples between 2005 and 2006, though the elevated levels remained within historical limits. This may be the result of capturing the flow from a spring along the site's backslope.

Manganese concentrations (Figures 3.26a and b) are generally less than 50 ug/L for MW23-A2D, MW23-A4, and three of the finger drains (23FD-3, 23FD-5 and 23FD-8). The other three finger drains (23FD-2, 23FD-6 and 23FD-7) and MW-D3 and Pond D have elevated manganese concentrations, indicative of the different redox conditions. Precipitation/dissolution of iron oxyhydroxides and manganese oxides controls the concentrations of iron and manganese in these waters. After further evaluation, the previously reported increase in iron concentrations as been determined to be an analytical error.

<u>Acid Base Accounting Data</u>

Acid base accounting (ABA) results from 89 underground rib composites collected in 2011 are presented in Table 3.3 and Figure 3.28. Class 1 rib samples had an average neutralization potential (NP) of 311 tons $CaCO_3$/1000t, which is equivalent to about 30% carbonate. The Class 1 samples had an average acid potential (AP) of 111 tons $CaCO_3$/1000t, which produced an average net neutralization potential (NNP) of 219 tons $CaCO_3$/1000t. Class 1 production rock does not have the potential to generate acid rock drainage; however, HGCMC recognizes the potential for metal mobility (primarily zinc) from this argillite rock. HGCMC has long-recognized this characteristic of Class 1 production rock and handles the material accordingly by placing it in controlled facilities, such as Site 23 and the tailings area.

Class 2 production rock rib samples had a moderate average NP value of 250 tons $CaCO_3$/1000t and an average AP of 121 tons $CaCO_3$/1000t. The resulting average NNP for the Class 2 rib samples was 144 tons $CaCO_3$/1000t. Class 3 rib samples had an average NP, AP and NNP of 206, 227 and, 17 tons$CaCO_3$/1000t, respectively. Negative values for NNP indicate that the materials are potentially acid generating, thus requiring appropriate ARD control measures. Carbonate in the Class 2 and Class 3 production rock prevents ARD formation in the short term, allowing time for placement of a composite soil cover to be constructed during reclamation. The soil cover is designed to inhibit ARD formation by minimizing oxygen and water infiltration into the underlying production rock. Class 4 rib samples produced an average NNP of -192 tons $CaCO_3$/1000t. Class 4 material is retained underground.

Figure 3.28 compares actual class designation based on ABA analyses to the results of visual designation use underground to classify the production rock. Of the 89 composites, visual classification assigned 14 samples (16%) to a lower, less conservative class. Fifty-one (57%) of the composites were assigned to the appropriate class and 24 (27%) to a higher, more conservative class. These data represent an 84% success rate for the visual classification program.

Table 3.3 ABA Data Summary for Underground Rib Samples and Site 23

2011	Class 1		Class 2		Class 3		Class 4
	Site 23 #1	Rib Sample #1	Site 23 #2	Rib Sample #2	Site 23 #3	Rib Sample #3	Rib Sample
NP	NA	311	NA	250	NA	206	177
AP	NA	111	NA	121	NA	277	320
NNP	NA	219	NA	144	NA	17	-192

Notes: Values are averages from 89 samples for rib samples
ABA units are tons $CaCO_3$/1000t
NP determined by modified Sobek method
AP determined from total sulfur assay (converted to pyrite equivalent)

Due to the minimal volume of material hauled to Site 23 and placed during 2011, no ABA data were taken from Site 23. 2010 ABA results from the Site 23 active placement areas are shown in Figure 3.29. Active placement area ABA results from previous years as well as the 2006-2008 grid data are also shown on Figure 3.29. The AP to NP distribution in the Site 23 samples differs from that of the underground rib samples. The Class 2 and Class 3 stockpiles areas are frequently empty except for a safety berm, which is constructed of Class 1 rock in the absence of other material. It is probable that several of the samples included this berm material. The grid sampling is also skewed toward higher NNP values because most of the outer surface of the pile is covered with Class 1 rock.

3.6 General Site Management

The construction method used at Site 23 (bottom-up construction) limits the site's complexity. Designated placement zones are marked on the active lift of the site and production rock is placed according to class. No activities other than routine monitoring occurred at Site 23 in 2011.

In 2005 HGCMC modified placement methods to minimize the formation of permeable areas, or chimneys, between placement zones. The homogenous, planar placement surface that resulted from the new method created surface drainage challenges. HGCMC experimented with a ridge and swale pattern that appeared to improve drainage during the rainy season but was susceptible to drifting snow in the winter months. Fine tuning of methods to improve drainage and accessibility continued in 2010.

In 2008, HGCMC received approval from ADEC to construct an interim disposal area for waste rock to be backfilled underground (see photo Figure 3.35). This 25,000 cubic yard capacity area was constructed to aid in concurrent reclamation efforts and can potentially be utilized on a continual 12-month schedule. This is a large increase over the previous 920 remuck bay which had a seasonal 700 cubic yard capacity. The area is layered with 6" of sand; a 36 mil reinforced polypropylene liner, another 6" layer of sand, 3' of class 3 production rock, and finally a geofabric layer. An HDPE pipe collects water from the area which is sloped to a central collection point. The water collected in this area drains to Pond 23. Material placed in this area is treated with up to 1 wt% lime. Waste rock from the B and D Pond berms, the 1350 and segments of the pipeline excavation were placed at the Site 23 temporary disposal area. These materials are backfilled underground as space and resources become available.

Approximately 5,000 cubic yards of material was excavated from the backslope of Site 23 during the 2005 construction season. The material was used as fill in the 960 road base and the Mill

Backslope road. Additional material that was removed is stored at 4.9 on the B Road for future site reclamation activities. In 2007, approximately 8,000 cubic yards were removed from this area for site development and other various projects. In 2008, 360 cubic yards were excavated for the B Pond berm project. In 2009, improvements in the D pond area included installation of a larger pump system to increase pumping capacity. Also, approximately 4,500 cubic yards of waste rock and pyritic berm material were removed, and replaced with clean fill. The majority of the fill was sourced from the backslope of Site 23, with minor amounts of sand and gravel used for drains. In 2010, approximately 9 cy of Pond D berm material was removed and replaced with clean fill. Also, the construction of the 860 pad was completed adjacent to Site 23.

3.7 Site as-built

As-built drawings for Site 23/D are presented in Appendix 2. Three drawings from the Site 23/D Hydrogeology and Geochemistry Analysis Report (EDE 2004) (Site 23/D conceptual model, Site 23/D colluvium potentiometric surface and Site 23/D cross section) are also included in Appendix 2. The drawings show the year-end topography, water management features, monitoring device locations, and other significant features of the site. The as-built also includes cross sections that show the following information:

- existing topographic surface
- prepared ground upon which the pile was constructed
- original unprepared ground
- fill design level

Figure 3.34 shows a photo of Site 23 in February 2011. The interim disposal area at Site 23 is shown in Figure 3.35.

3.8 Reclamation

HGCMC has monitored the performance of a one-acre composite soil cover plot on Site 23 since September 2000 (see Site 23 as-built in Appendix 2 for plot location). Key performance aspects of the cover system through 2011 include:

- The total precipitation recorded during the monitoring period was 64.3 inches, which falls slightly below the 11-year average annual precipitation of 67.9 inches calculated from measured precipitation from 2001 to 2011. The Site 23 station experienced loss of data from January - August 2011, therefore the total precipitation for 2011 was taken from measurements by the Mill station. Measurement of snow depth at the site showed no consistent snowpack development; therefore all precipitation was based on data measured at the Mill station.
- Calculated potential evaporation (PE) for 2011 was 14.3 inches (long term average, 15.9 inches) and estimated actual evapotranspiration was 11.3 inches. The data capture rate was 65% for the 2011 monitoring period as all automated sensors were functioning at the end of the monitoring period. The primary reason for the relative low data capture rate was the fact that no manual neutron moisture probe data were collected. Excluding the neutron moisture probe measurements, the data capture rate was 100%.
- The degree of saturation in the barrier layer was greater than 85% for the entire monitoring period. This is a positive cover performance aspect and implies that the oxygen diffusion coefficient of the barrier material was minimized, thus minimizing the ingress of atmospheric oxygen with respect to diffusion through the pore-air space.

- The recorded temperatures within the growth medium layer and the compacted barrier layers have been similar for the 11 years of monitoring. The data show that freezing conditions have not been encountered in the compacted barrier layer, suggesting that freeze/thaw cycling is not impacting the barrier layer structure.
- Vegetative cover continues to be dominated by the hydroseeded grass and clover plant species. However natural invasion, primarily by spruce seedlings, is evident, particularly on the western-most portion of the cover area.

In December 2006 HGCMC began collaborating with Oregon State University (OSU) and M.A. O'Kane Consultants Inc. to further characterize the hydrology of the cover plot and evaluate how evolution of native forest vegetation (spruce-hemlock forest) may affect cover system performance. Key findings from OSU's 2010 final report (Hopp et al. 2010) and associated paper (Hopp et al. 2011) include:

- Approximately 50% of the rainfall during the monitoring period was captured at the collection trench. Tipping bucket malfunctions contributed to an underestimation of subsurface "runoff" coefficient relative to previous years. Between 20-30% of subsurface flow are collected from the growth medium and 70-80% are contributed by the upper capillary break (drainage layer) of the cover system.
- The subsurface flow responds quickly to precipitation events. Short-lived transient water tables develop at the interface between the upper capillary break and the barrier layer preceeding subsurface flow.
- The hydrological model HYDRUS-2D was used to evaluate cover performance and compare the effects of potential design modifications including removal of one or both of the capillary breaks, a thicker growth medium, and a less permeable barrier layer.
- The upper capillary break significantly increases lateral subsurface flow and prevents surface runoff and development of positive pressure heads in the growth medium and barrier layer. Positive pressure heads occur in the growth medium in scenarios without the upper capillary break and in some cases persist for extended periods.
- A growth medium (> 1 m) in the absence of an upper capillary break cannot prevent surface runoff during the modeled fall rain events.
- A lower hydraulic conductivity of the barrier layer (1 x 10^{-7} cm/s vs 1 x 10^{-6} cm/s) dramatically decreases vertical percolation through the base of the cover (from ~10% to ~0.1% of incident precipitation).
- The current design, especially in combination with a barrier layer with even lower hydraulic conductivity, still seems to be the most effective design with respect to generation of lateral subsurface flow, minimizing percolation through the barrier layer and preventing the build-up of shallow water tables in the growth medium and surface runoff. However, the simplified cover design without the lower capillary break and with the lower hydraulic conductivity barrier layer shows very similar results.
- Increasing the growth medium thickness to 1 meter, as recommended in the vegetation study to sufficiently protect the underlying capillary break and barrier layer from exposure by windthrow, shows very similar results to the current design. This has the added benefit of allowing mature forest to develop without affecting cover performance.
- In the absence of continual intervention, the site will be forested. Allowing the development of a forest on the site is the best means of protecting the barrier layer. With a slight increase in the depth of the growth medium to 100 cm or more there is a high confidence that neither windthrow (uprooting) nor erosion/mass wasting will expose and compromise the function of the barrier layer.

- Natural processes (reforestation with alder, Sitka spruce, and western hemlock, soil evolution, and windthrow (uprooting)) are the best strategy for protecting the barrier layer.
- The resulting stand would likely be uneven-aged Sitka spruce and western hemlock in a hummocky topography with micro-relief of about 1 m. Soils would be subject to periodic mixing via uprooting, which is the dominant process through which SE Alaskan forests maintain productivity and avoid stagnation and paludification (bog formation).
- Windthrow helps break up the placic horizon (a product of podsolization), improving vertical percolation and minimizing soil erosion.
- Rooting development depends on the distance to the soil water table and depth to bedrock, but the typical depth of rooting is 1 m. Roots cannot grow into soils with a bulk density > 1.6 g/cm. Roots are highly unlikely to penetrate the barrier layer.
- Pit depths 1 year after uprooting are expected to be ~40 cm and mound heights ~70 cm. The deepest area of possible freezing is about 45 cm above the barrier layer. It appears highly unlikely that the barrier layer would be exposed or frozen due to uprooting (blow down).
- Other than increasing the growth medium to a depth of at least 1 m, no other changes in the cover system appear necessary from the perspectives of vegetation cover and the function of the barrier layer.

In 2008 HGCMC began monitoring oxygen and carbon dioxide concentrations in the instrumentation trench building (the "Chalet") installed over the cover plot to determine if conditions were unsafe for human entrance. Gas levels showed a slight seasonal fluctuation, but did not approach unsafe levels. Figures 3.32 and 3.33 show oxygen levels decreased slightly and carbon dioxide levels increased slightly in the summer months and were at atmospheric conditions in the winter months (20.9% oxygen and 0% carbon dioxide). These monitoring results are consistent with the conceptual model of pile gas transport. When the internal temperature of the pile is colder than the external air temperature, oxygen-deficient, carbon dioxide-rich air flows out the toe of the pile. When the pile temperature is warmer than external air temperature, oxygen rich air is drawn in at the base of the pile. HGCMC personnel will continue to monitor gas levels in the summer months prior to entering into the building.

<u>Reclamation Plan</u>

The HGCMC Reclamation Plan, as well as its implementation is discussed above in Section 2.8 of this report. Please refer to that discussion for aspects relevant to Site 23/D area reclamation.

4.0 References

ADEC, 2004, Letter to KGCMC, Subject: Greens Creek Mine Site 23 Production Rock Placement Modification Under Waste Management Permit #0211-BA001 and General Plan of Operations, Appendix 11, 13 May 2004.

Environmental Design Engineering (EDE), 2002a, Kennecott Greens Creek Mining Company Stage II Tailings Expansion Hydrologic Analysis, February 5, 2002.

Environmental Design Engineering (EDE), 2002b, Kennecott Greens Creek Mining Company Stage II Tailings Expansion Geochemistry Report, February 5, 2002.

Environmental Design Engineering (EDE), 2004, Site 23/D Hydrogeology and Geochemistry Analysis, March 2004.

Environmental Design Engineering (EDE), 2005, Pond 7 Hydrology Report, April 2005.

Environmental Design Engineering (EDE), 2010, Greens Creek Mine Underground Hydrology Investigation Interim Report 2010, May 2010.

Environmental Design Engineering (EDE), 2011, Greens Creek Mine Tailings Storage Facility Stage III Expansion Groundwater Hydrology Update, September 2011.

Hecla Greens Creek Mining Company (HGCMC), 2012, Tailings and Production Rock Site 2011 Annual Report, April 2012.

Hecla Greens Creek Mining Company (HGCMC), 2011, Tailings and Production Rock Site 2010 Annual Report, April 2011.

Hecla Greens Creek Mining Company (HGCMC), 2010, Tailings and Production Rock Site 2009 Annual Report, April 2010.

Hopp, L., Giesen, T., and McDonnell, J., 2010, Hydrologic Performance of Cover Systems at the Greens Creek Mine: Combined Field-Modeling Analysis, Final Project Report, June 2010.

Hopp, L., McDonnell, J., and Condon, P., 2011, Lateral Subsurface Flow in a Soil Cover over Waste Rock in a Humid Temperate Environment, Vadose Zone Journal Vol 10, January, 2011.

Hecla Greens Creek Mining Company (HGCMC), 2009a, Tailings and Production Rock Site 2008 Annual Report, April 2009.

Hecla Greens Creek Mining Company (HGCMC), 2009b, Site E Removal: Waste Rock and Tailings Codisposal Plan, April 2009.

Hecla Greens Creek Mining Company (HGCMC), 2009c, West Tailings Facility Monitoring Action Plan, December 2009.

Kennecott Greens Creek Mining Company (KGCMC), 2002a, Update of Information and Action Plan on Seeps West of the Current Tailings Disposal Facility, January 2002a.

Kennecott Greens Creek Mining Company (KGCMC), 2007, Sulfate Reduction Monitoring Plan 2007 Update. December 2007.

Kennecott Greens Creek Mining Company (KGCMC), 2002b, Tailings and Production Rock Site 2002 Annual Report, April 2002b.

Kennecott Greens Creek Mining Company (KGCMC), 2004, Tailings and Production Rock Site 2003 Annual Report, December 2004.

Kennecott Greens Creek Mining Company (KGCMC), 2005, Tailings and Production Rock Site 2004 Annual Report, August 2005.

Kennecott Greens Creek Mining Company (KGCMC), 2006, Tailings and Production Rock Site 2005 Annual Report, June 2006.

Kennecott Greens Creek Mining Company (KGCMC), 2007, Tailings and Production Rock Site 2006 Annual Report, June 2007.

Kennecott Greens Creek Mining Company (KGCMC), 2008, Tailings and Production Rock Site 2007 Annual Report, April 2008.

Klohn Crippen, 2002, Existing Tailings Facility Southeast Expansion Construction Summary, November 2002.

Klohn Crippen, 2004, Engineering Assessment of Production Rock Sites 23 and D, June 2004.

Klohn Crippen, 2005, Stage 2 Tailings Facility Expansion – Pond 7 Storm Water Facility ADNR Design Summary, March 2005.

Klohn Crippen, 2007, Existing Tailings Facility Southeast Expansion Construction Summary, December 2007.

Klohn Crippen, 2008, Tailings Storage Facility, Northwest/Pit 5 Expansion Construction Summary, January 2009.

Klohn Crippen, 2008, Tailings Storage Facility, Pond 6 Expansion Construction Summary, January 2009.

Klohn Crippen, 2008, Monotonic and Cyclic Testing of “High” quality in-Situ Tailings Samples. January 2009.

Lindsay and Blowes, 2011, Investigations into Tailings Pore-Water Treatment at the Greens Creek Mine, Alaska, USA, Final Report on SRMP Research 2004-2008, March 2011.

O’Kane Consultants Inc. (O’Kane), 2005, Performance Monitoring Program for the Production Rock Site 23 Cover System, Report # 657-09, January 2005.

O’Kane Consultants Inc. (O’Kane), 2007, Performance Monitoring Program for the Production Rock Site 23 Cover System, Report # 657-10, January 2005-December 2006.

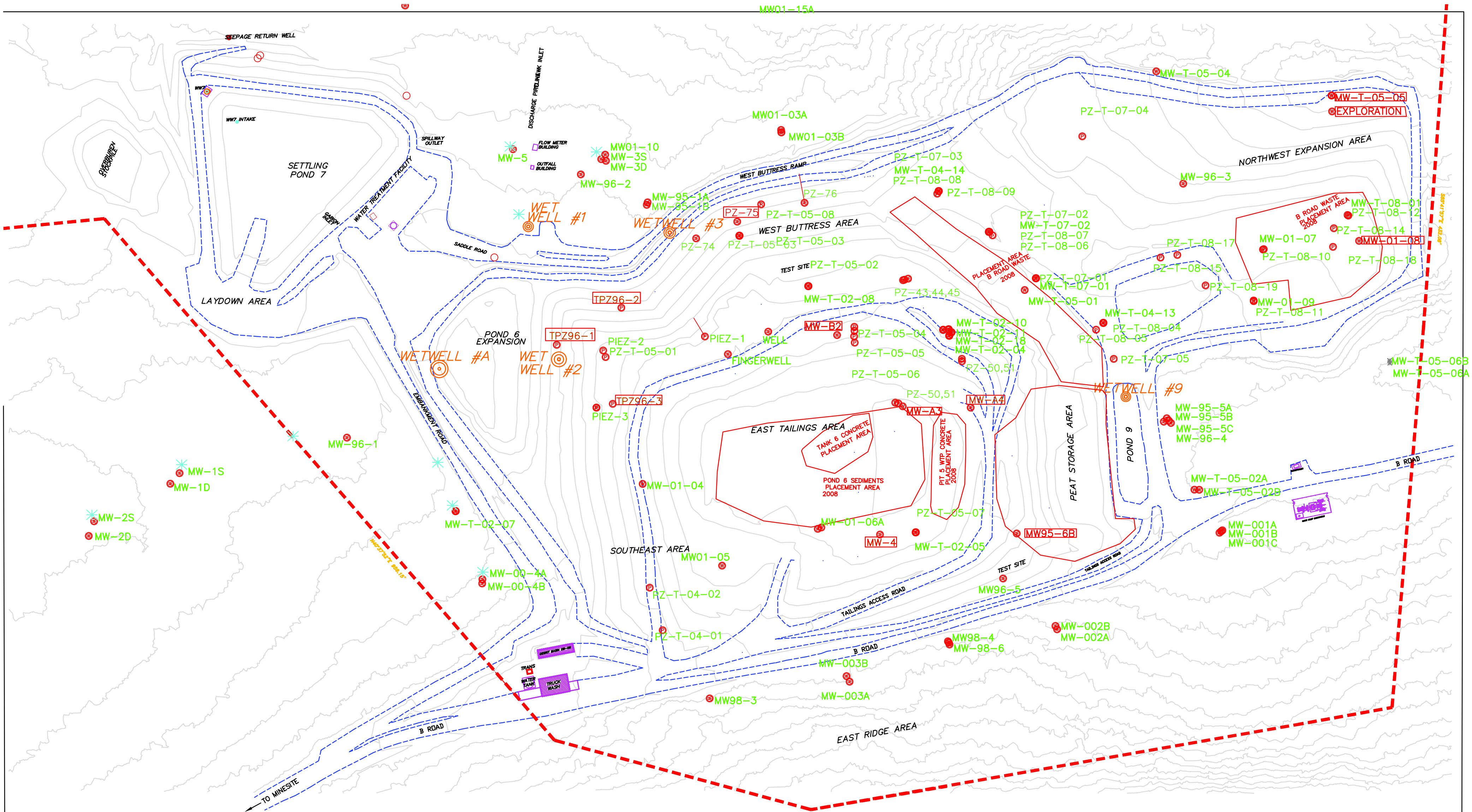
O'Kane Consultants Inc. (O'Kane), 2012, Performance Monitoring Program for the Production Rock Site 23 Cover System, Monitoring Report for Year 11. Report # 657/4-01, January 2011-December 2011.

University of Waterloo, 2006, Investigations into Tailings Pore Water Remediation at the Greens Creek Mine, Juneau, Alaska, USA, 2005 Progress Report, February 2006.

Vos, R.J., 1993, Weathering Characteristics of Waste Rock From Admiralty Island Deposit (23 Month Report, B.C. Research Inc., July 1993.

APPENDIX 1

Tailings Facility 2011 As-built and Cross Sections



LEGEND:

ROADS/DITCHES	
WATER UTILS	
BOUNDARY	
MONITORING WELL	
PIEZOMETER	
WET WELL	
DECOMISSIONED WELL	
SNOW SAMPLE LOCATION	

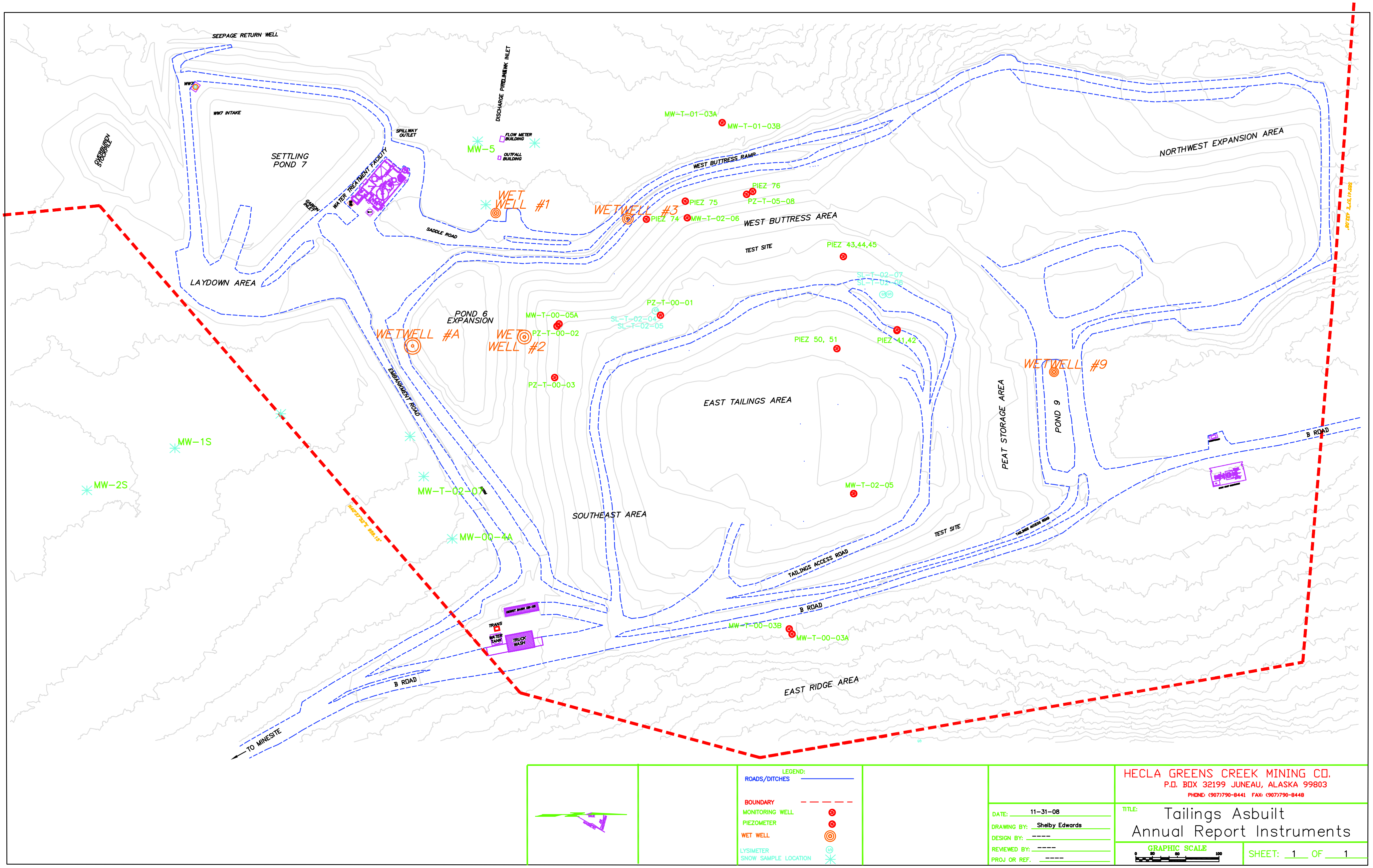
HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448

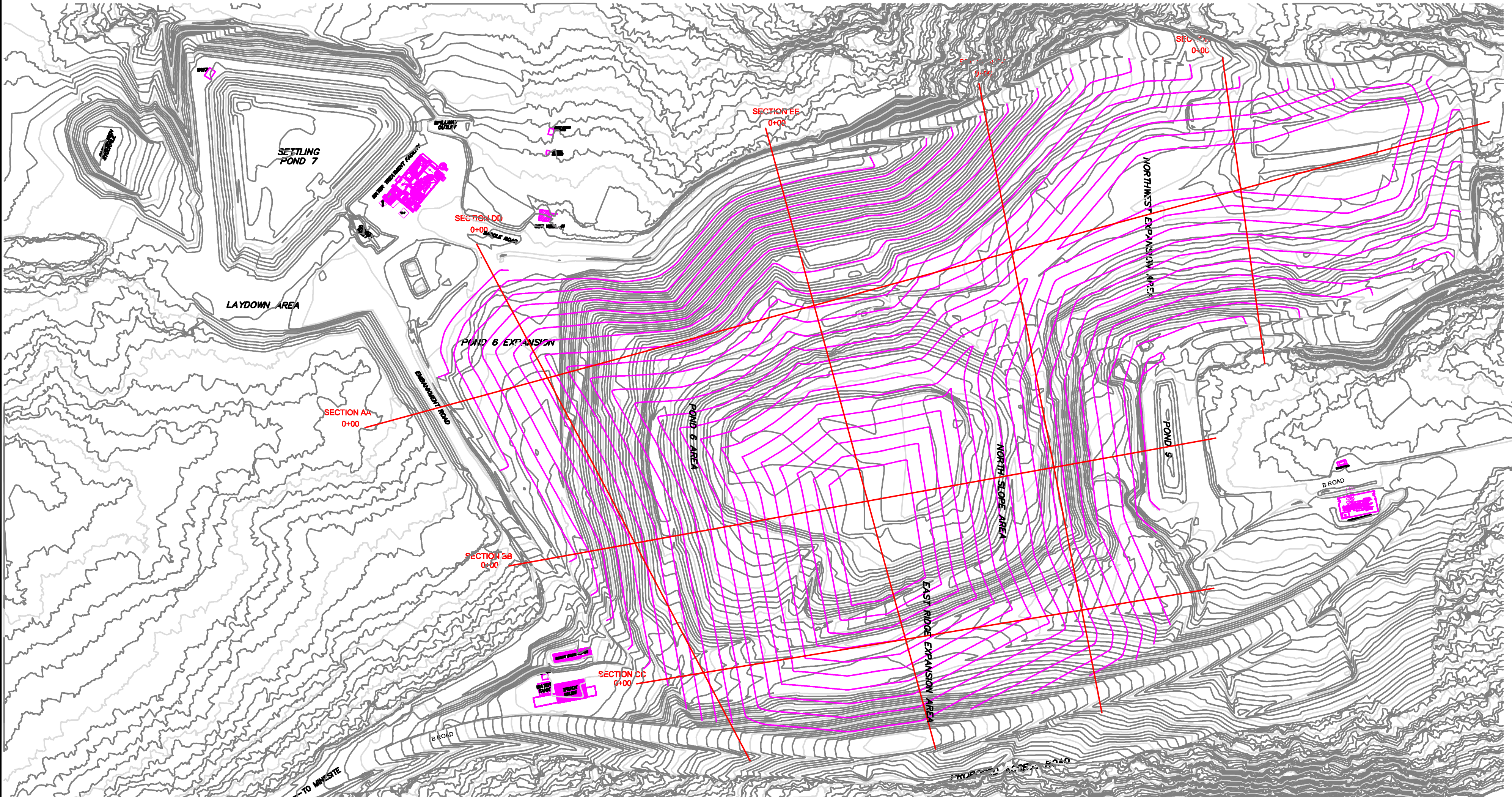
DATE: 11-31-08
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----

TITLE:
Tailings Asbuilt Wells and Piezometers

GRAPHIC SCALE

SHEET: 1 OF 1


SEEPAGE RETURN WELL
WW7 INTAKE
SETTLING POND 7
DISCHARGE PIPELINE
SPILLWAY OUTLET
FLOW METER BUILDING
OUTFALL BUILDING
WATER TREATMENT FACILITY
MW-5
WET WELL #1
SADDLE ROAD
WETWELL #3
WEST BUTTRESS RAMP
MW-T-01-03A
MW-T-01-03B
PIEZ 76
PIEZ 75
PZ-T-05-08
PIEZ 74
MW-T-02-06
WEST BUTTRESS AREA
TEST SITE
PIEZ 43,44,45
NORTHWEST EXPANSION AREA
LAYDOWN AREA
POND 6 EXPANSION
WETWELL #A
WET WELL #2
MW-T-00-05A
PZ-T-00-02
PZ-T-00-01
SL-T-02-04
SL-T-02-05
SL-T-02-07
SL-T-02-08
PIEZ 50, 51
PIEZ 41,42
PZ-T-00-03
EMBANKMENT ROAD
EAST TAILINGS AREA
WETWELL #9
POND 9
PEAT STORAGE AREA
B ROAD
MW-1S
MW-2S
MW-T-02-07
MW-00-4A
SOUTHEAST AREA
MW-T-02-05
TEST SITE
TAILINGS ACCESS ROAD
TRUCK WASH
WATER TANK
MW-T-00-03B
MW-T-00-03A
EAST RIDGE AREA
TO MINESITE
LEGEND:
ROADS/DITCHES
BOUNDARY
MONITORING WELL
PIEZOMETER
WET WELL
LYSIMETER
SNOW SAMPLE LOCATION
HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448
DATE: 11-31-08
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----
TITLE: Tailings Asbuilt Annual Report Instruments
GRAPHIC SCALE
0 20 50 100
SHEET: 1 OF 1



TAILINGS FACILITY 2011 AS-BUILT AND CROSS SECTIONS

LEDGEND:
DESIGN PLAN
ORIGINAL GROUND
EXISTING GROUND
EXISTING ROADS
CROSS SECTIONS

SYMBOLS:
FIRE HYDRANT
MONITORING POINT
BOLLARDS
POWER POLES
WATER VALVE
CATCH BASIN

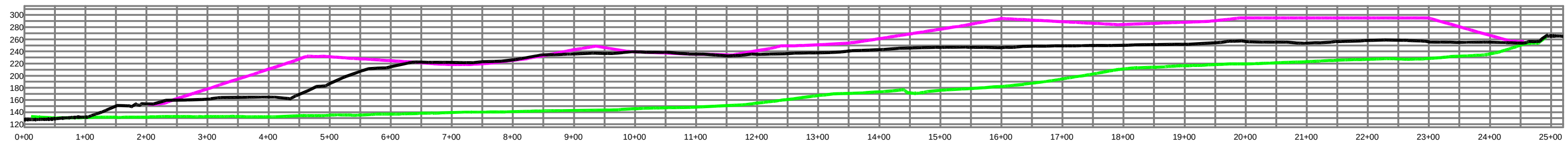
DATE: 12-31-11
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----

HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448

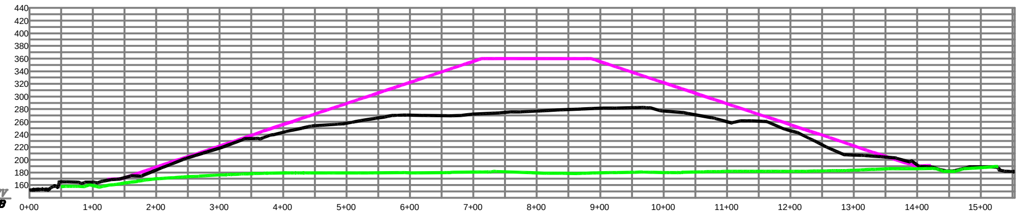
TITLE: 2011 STAGE 2 TAILINGS EXISTING DESIGN & QUANTITIES

0 20 50 100

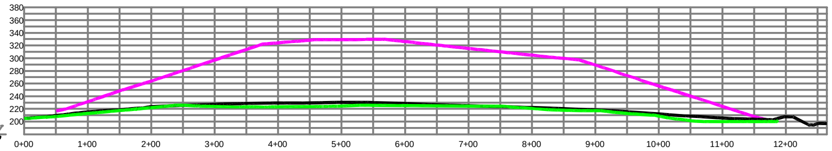
SHEET: 1 OF 1



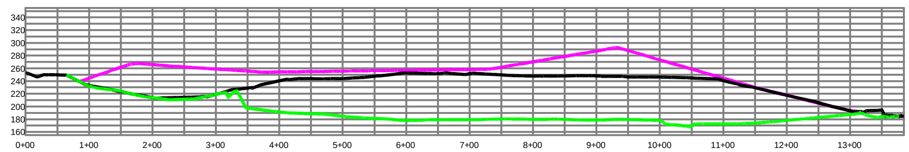
DATUM ELEV
SECTION AA



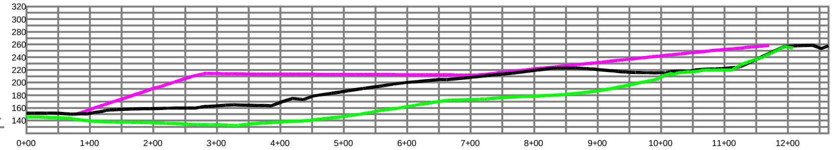
DATUM ELEV
SECTION BB



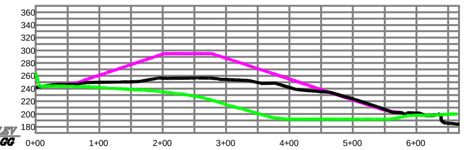
DATUM ELEV
SECTION CC



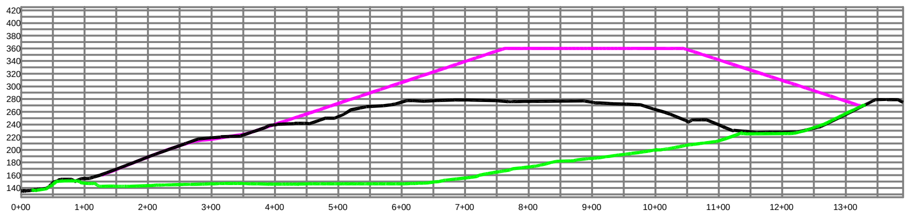
DATUM ELEV
SECTION FF



DATUM ELEV
SECTION DD



DATUM ELEV
SECTION GG



DATUM ELEV
SECTION EE

LEDGEND:

- EXISTING GROUND
- ORIGINAL GROUND
- EAST RIDGE DESIGN
- NORTHWEST DESIGN

SYMBOLS:

- FIRE HYDRANT
- BOLLARDS
- WATER VALVE
- MONITORING POINT
- POWER POLES
- CATCH BASIN

DATE: 12-31-11
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. ----

HECLA GREENS CREEK MINING CO.
P.O. BOX 32199 JUNEAU, ALASKA 99803
PHONE: (907)790-8441 FAX: (907)790-8448

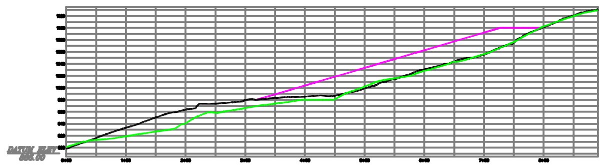
TITLE:
2011 STAGE 2 TAILINGS PROFILE VIEWS

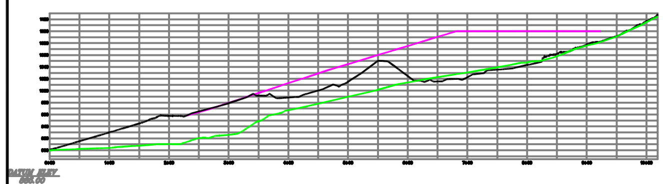
0 20 50 100

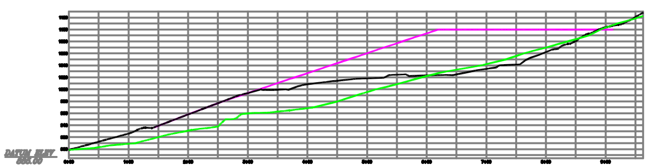
SHEET: 1 OF 1

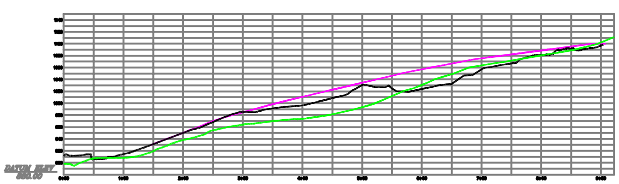
APPENDIX 2

Site 23/D 2011 As-built and Cross Section







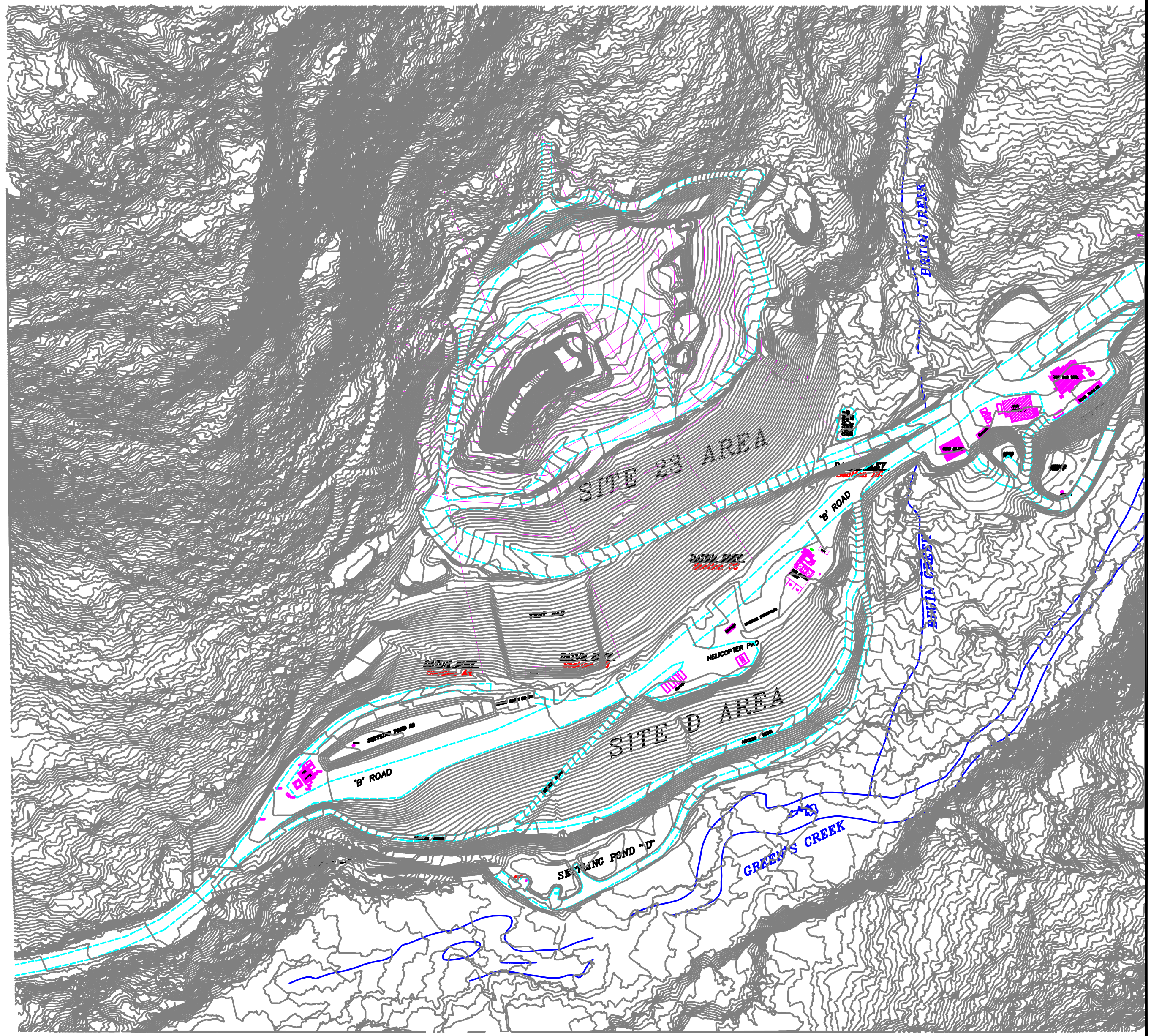


LEDGEND:

ORIGINAL GROUND TOPO

EXISTING GROUND

FINAL FILL DESIGN



SITE 23 REMAINING VOLUMES AS OF 12-31-11

Site	Stratum	Surf1	Surf2	FILL	CUT	Net	Method
12-31	comp2	n0101	2011 design	1449	428666	427217 (F)	Grid

HECLA GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

WASTE SITE 23
LOM PILE DESIGN
W/ CROSS SECTIONS

DATE: 12-31-11
DRAWING BY: Shelby Edwards
DESIGN BY: ----
REVIEWED BY: ----
PROJ OR REF. # ----

PREPARED BY:
Greens Creek Mining Co.
JUNEAU, ALASKA
PHONE: (907)790-8441 FAX: (907)790-8448

GCMC DWG

SCALE: 1"=60'

SHEET: 1 OF 1

KENNECOTT MINERALS

KENNECOTT GREENS CREEK MINING CO.

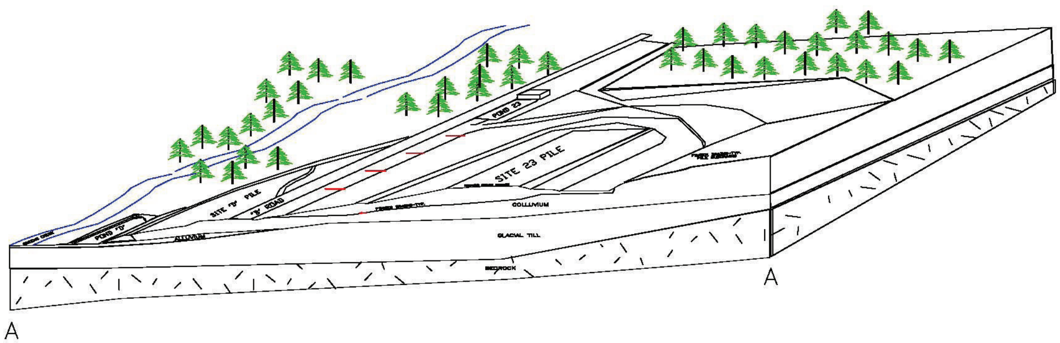
DATE: 4-30-03
DRAWING BY: TZ
DESIGN BY: PC
REVIEWED BY: ----
PROJ OR REF. EDE-Site 23/D Hydrology

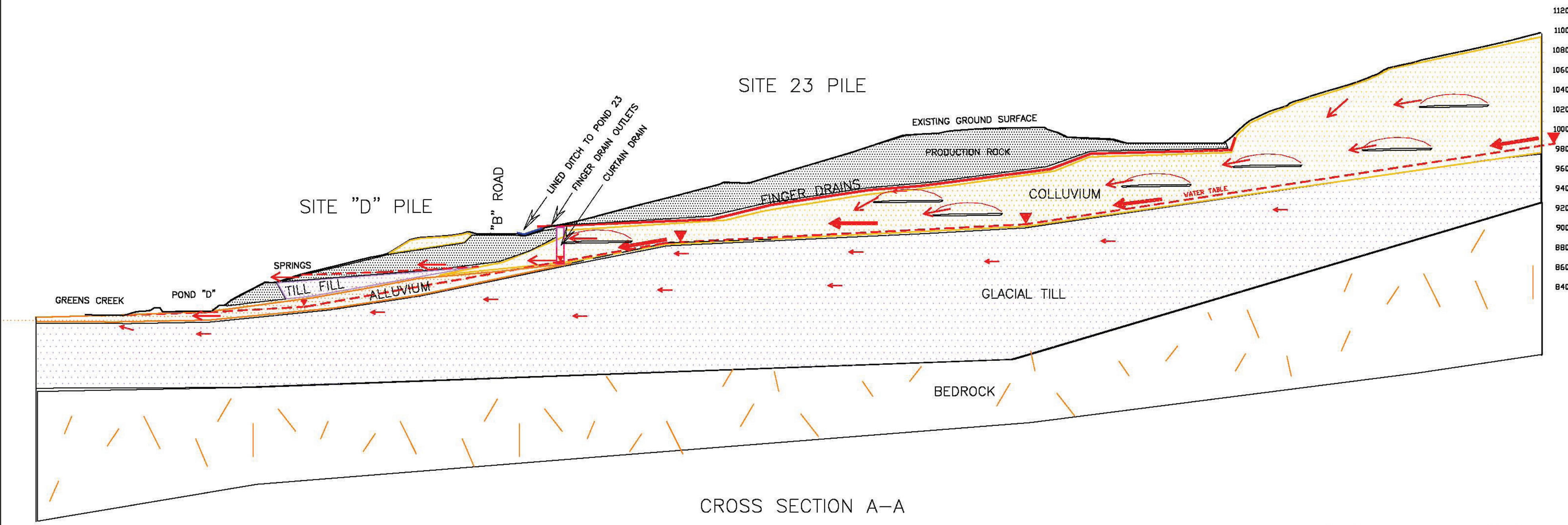
TITLE:
SITE 23/D CONCEPTUAL GROUNDWATER FLOW

LEGEND:

- CLAY LENSES WITH PERCHED WATER
- WATER TABLE
- WATER FLOW VECTORS – FLOW RATE PROPORTIONAL
- EXISTING GROUND
- PRODUCTION ROCK FILL
- FINGER DRAINS TYPICAL
- COLLUVIUM
- ALLUVIUM
- GLACIAL TILL LAYER
- BEDROCK

FIGURE 2

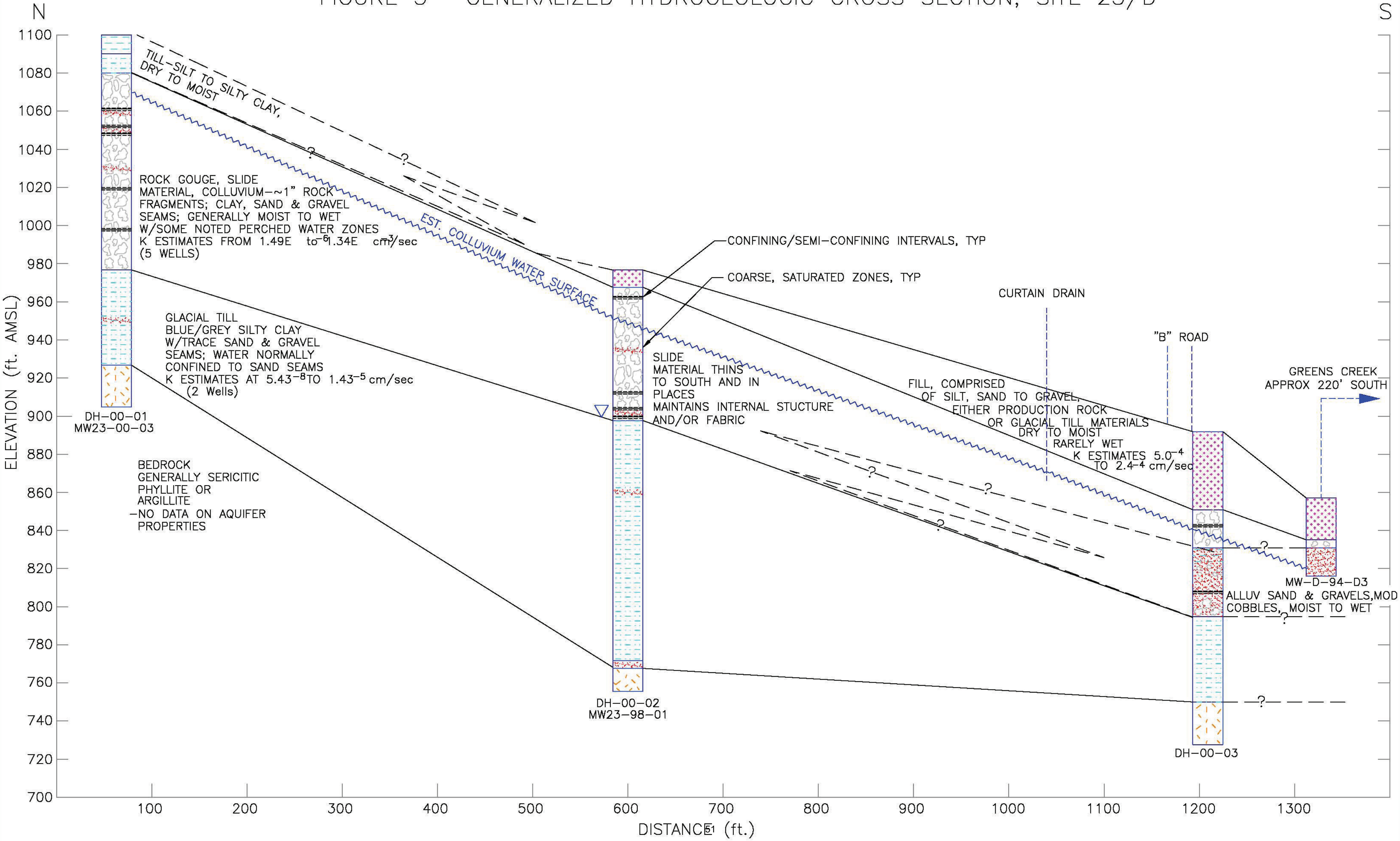


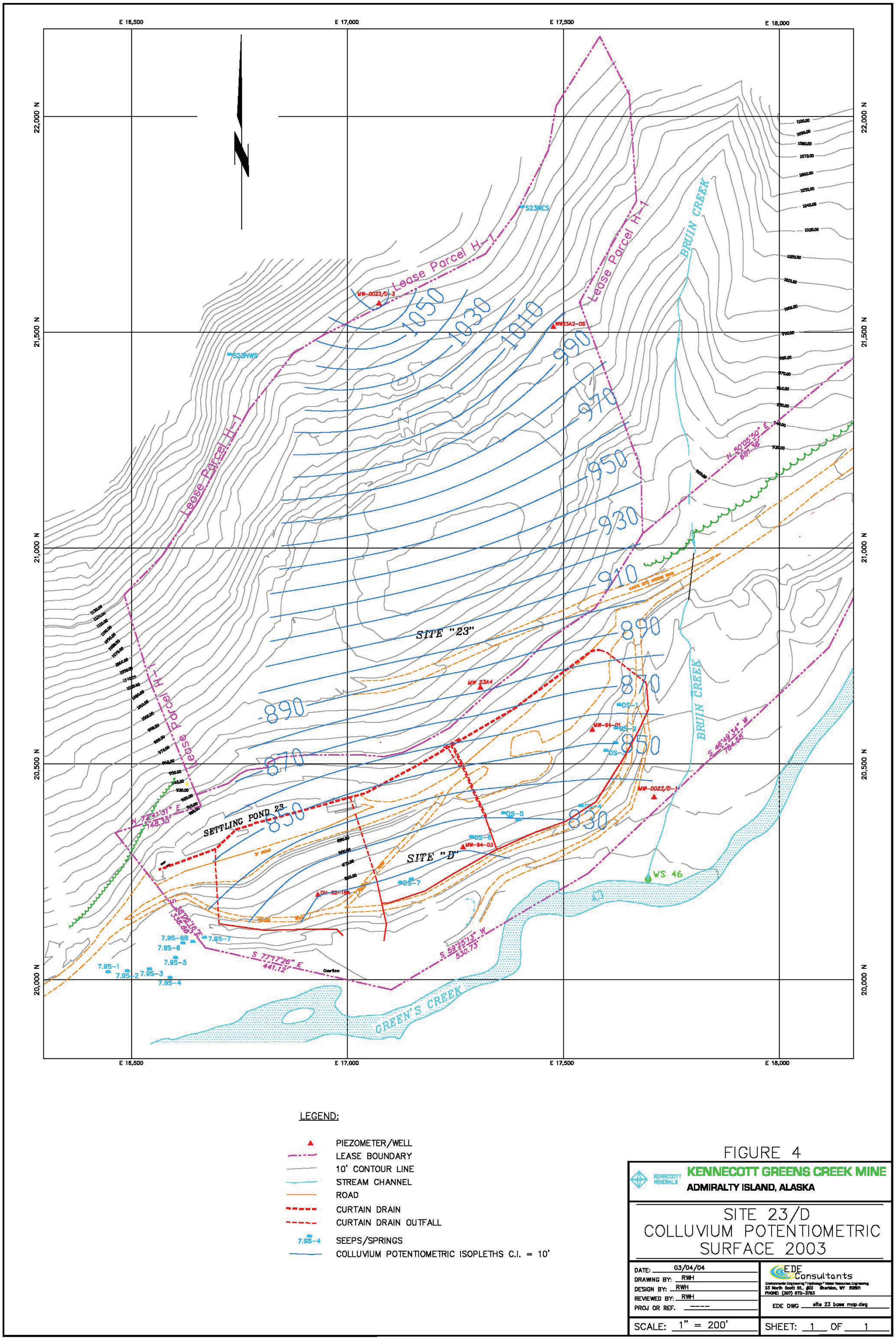


CROSS SECTION A–A

South North

FIGURE 3--GENERALIZED HYDROGEOLOGIC CROSS SECTION, SITE 23/D




E 16,500
E 17,000
E 17,500
E 18,000
22,000 N
21,500 N
21,000 N
20,500 N
20,000 N
Lease Parcel H-1
BRUIN CREEK
GREEN'S CREEK
SITE "23"
SITE "D"
SETTLING POND 23
S23NES
S23NWS
MW-0023/D-3
MW23A2-DS
MW 23A4
MW-0023/D-1
WS 46
1050
1030
1010
990
970
950
930
910
890
870
850
830
LEGEND:
PIEZOMETER/WELL
LEASE BOUNDARY
10' CONTOUR LINE
STREAM CHANNEL
ROAD
CURTAIN DRAIN
CURTAIN DRAIN OUTFALL
SEEPS/SPRINGS
COLLUVIUM POTENTIOMETRIC ISOPLETHS C.I. = 10'
FIGURE 4
KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA
SITE 23/D
COLLUVIUM POTENTIOMETRIC
SURFACE 2003
DATE: 03/04/04
DRAWING BY: RWH
DESIGN BY: RWH
REVIEWED BY: RWH
PROJ OR REF.
EDE Consultants
EDE DWG site 23 base map.dwg
SCALE: 1" = 200'
SHEET: 1 OF 1

APPENDIX 3

Data Figures

Figure 2.1 Water Level Data for Piezometer 41

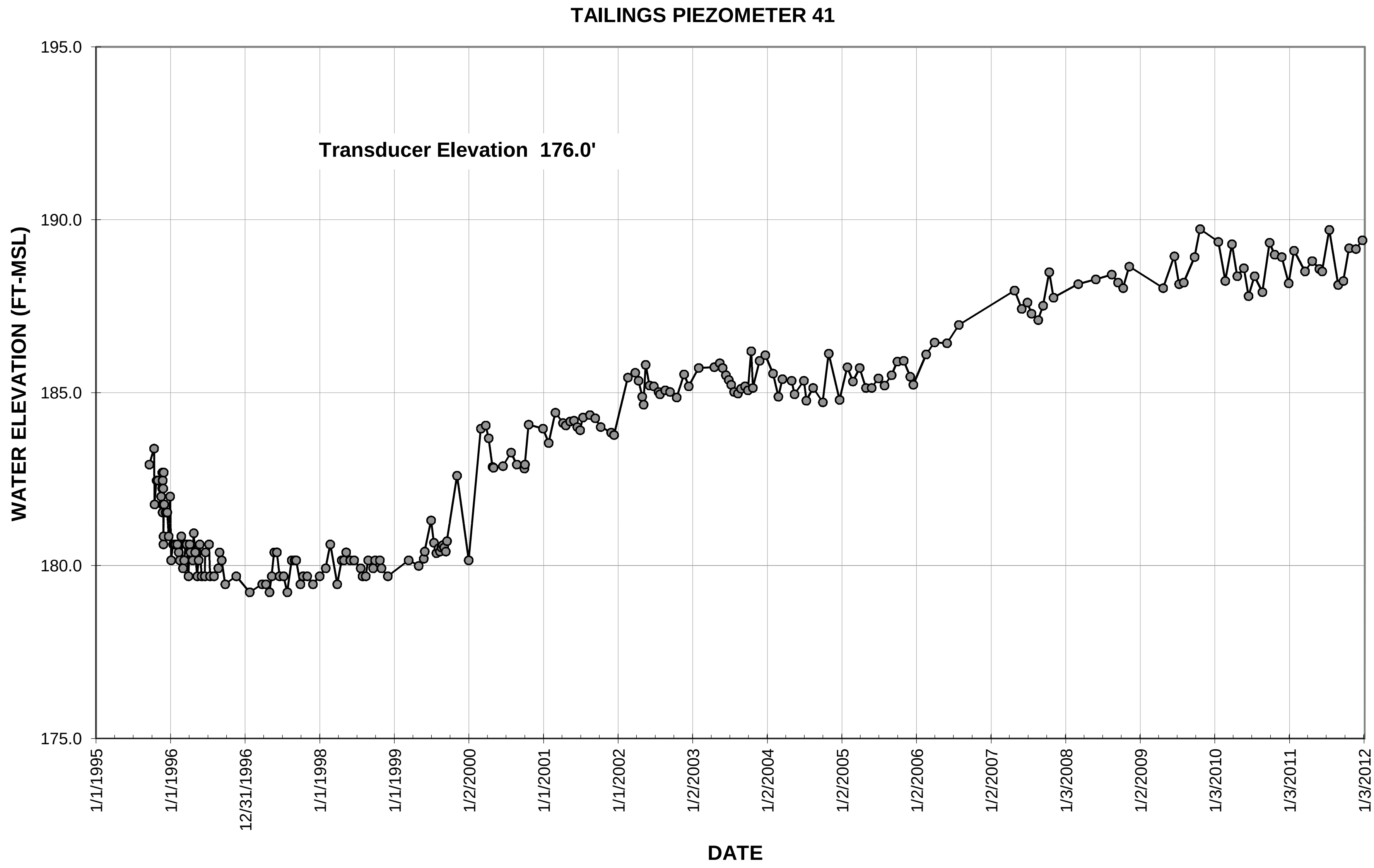


Figure 2.2 Water Level Data for Piezometer 42

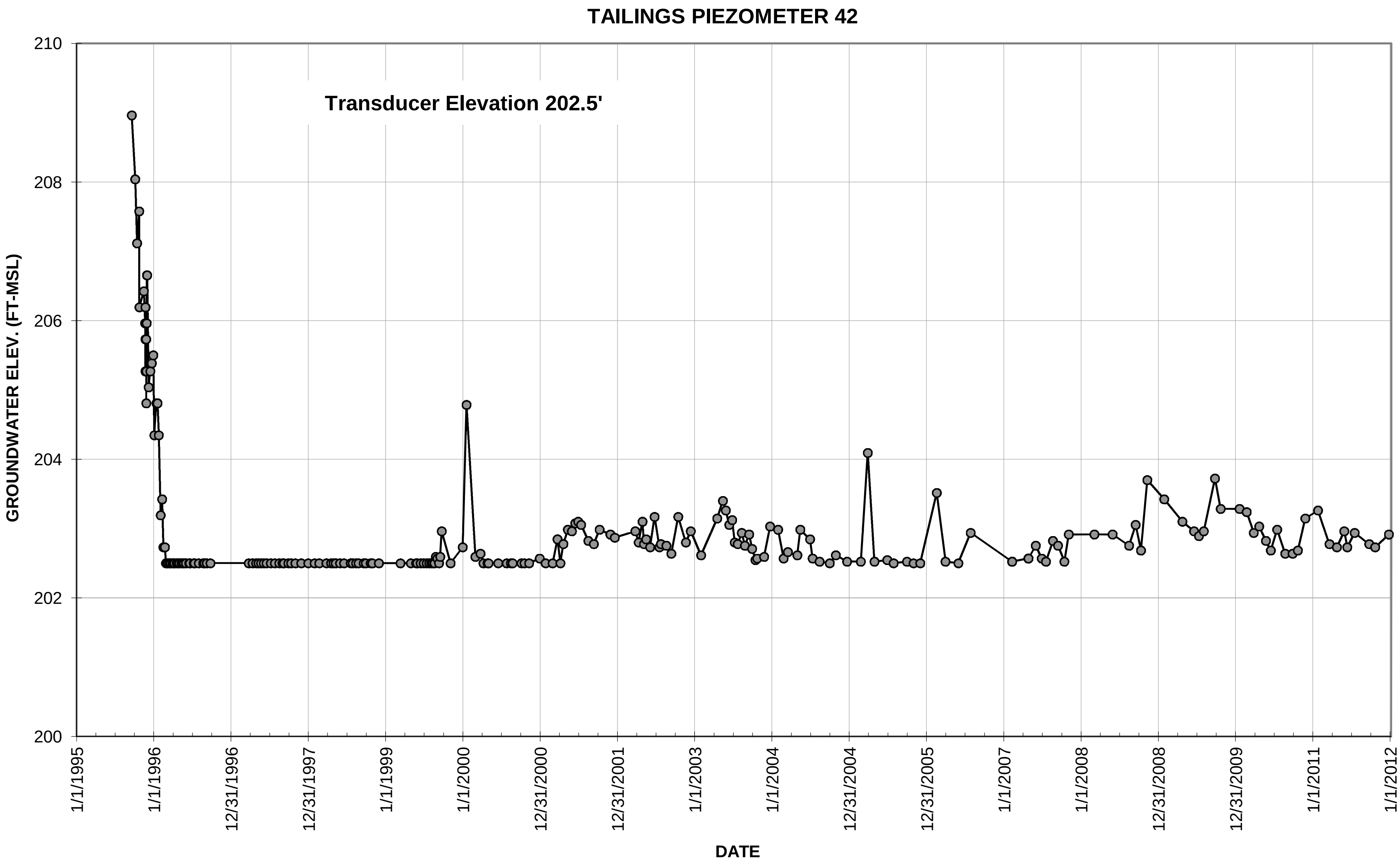


Figure 2.3 Water Level Data for Piezometer 44

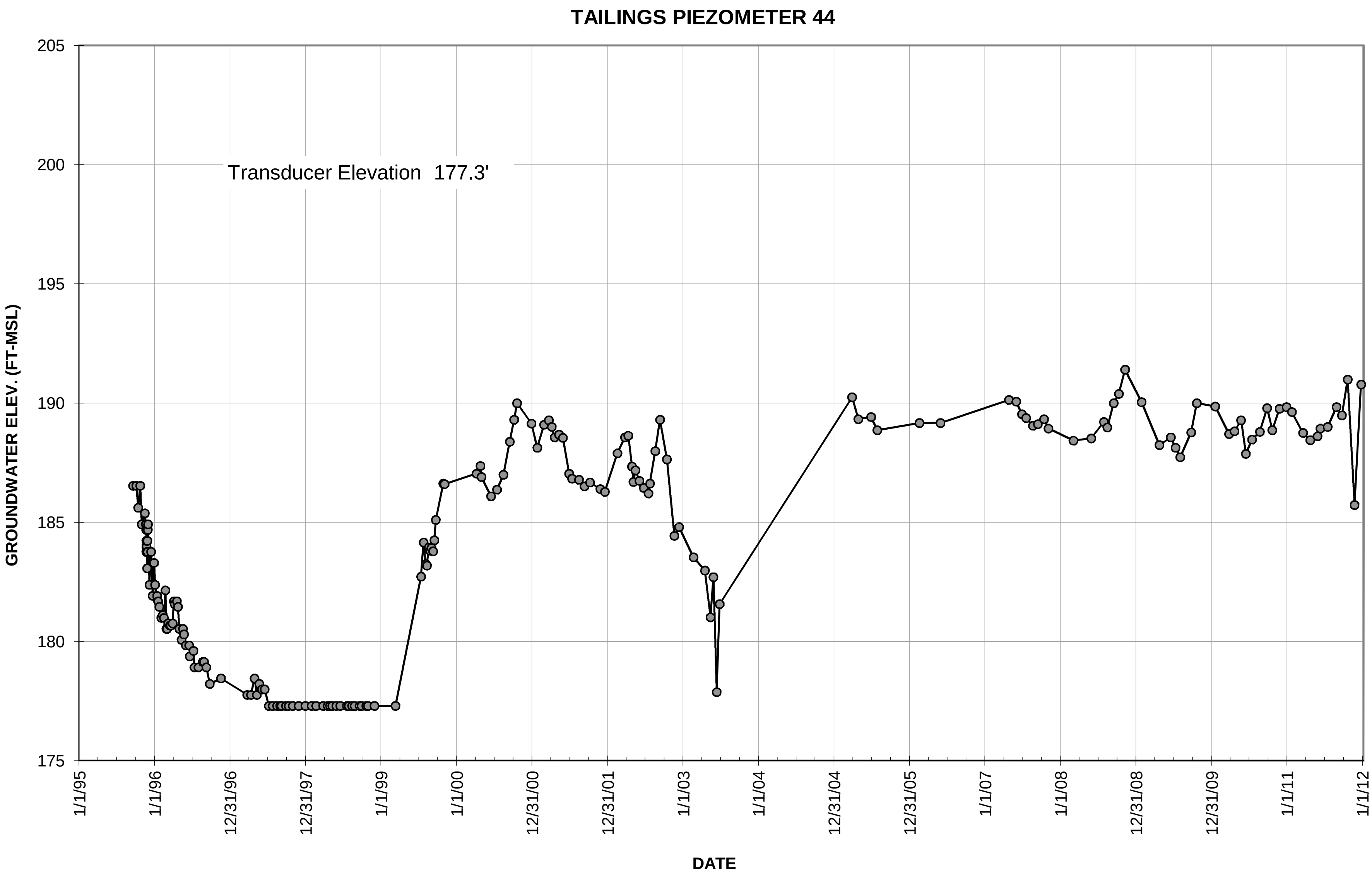


Figure 2.4 Water Level Data for Piezometer 46

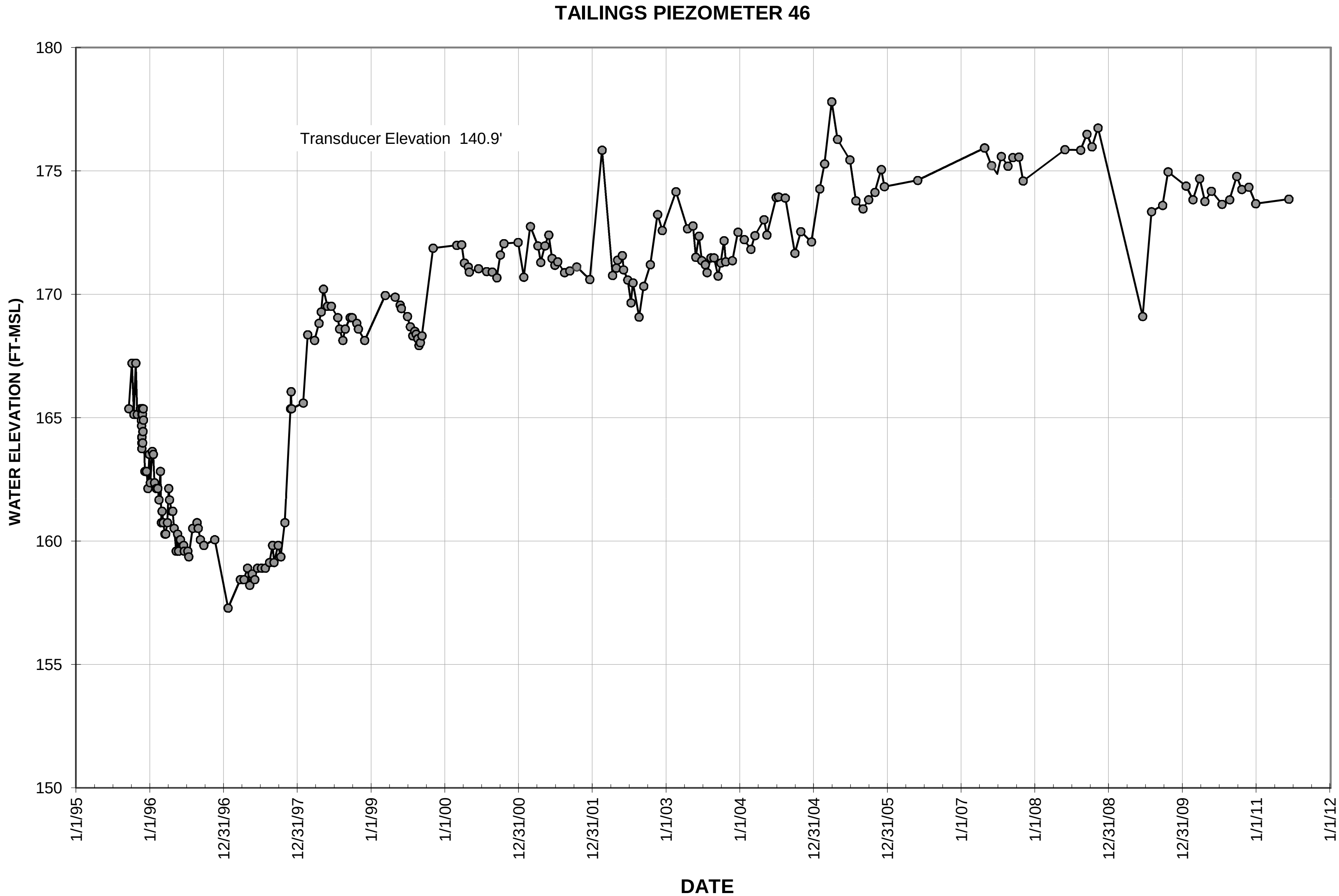


Figure 2.5 Water Level Data for Piezometer 47

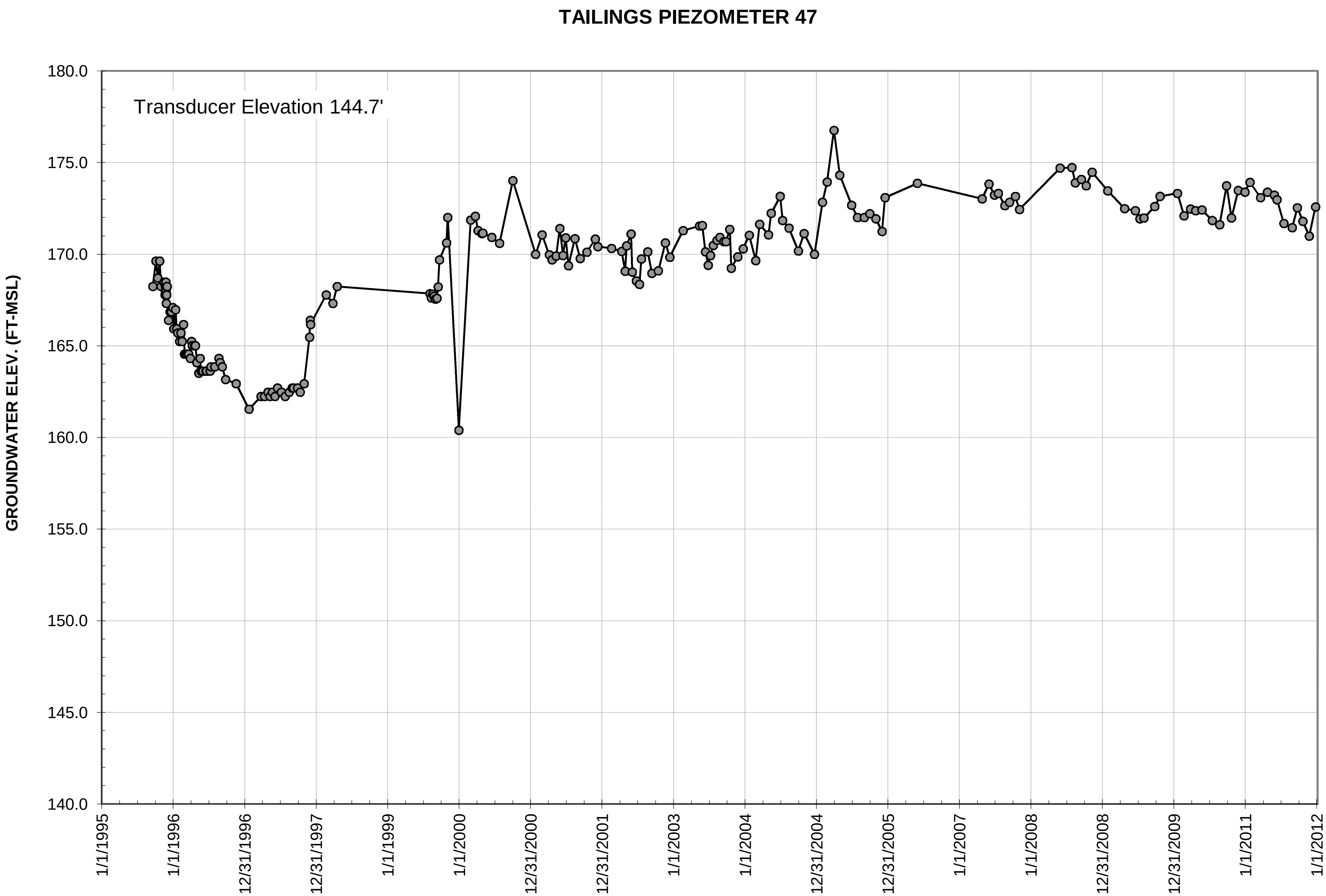


Figure 2.6 Water Level Data for Piezometer 50

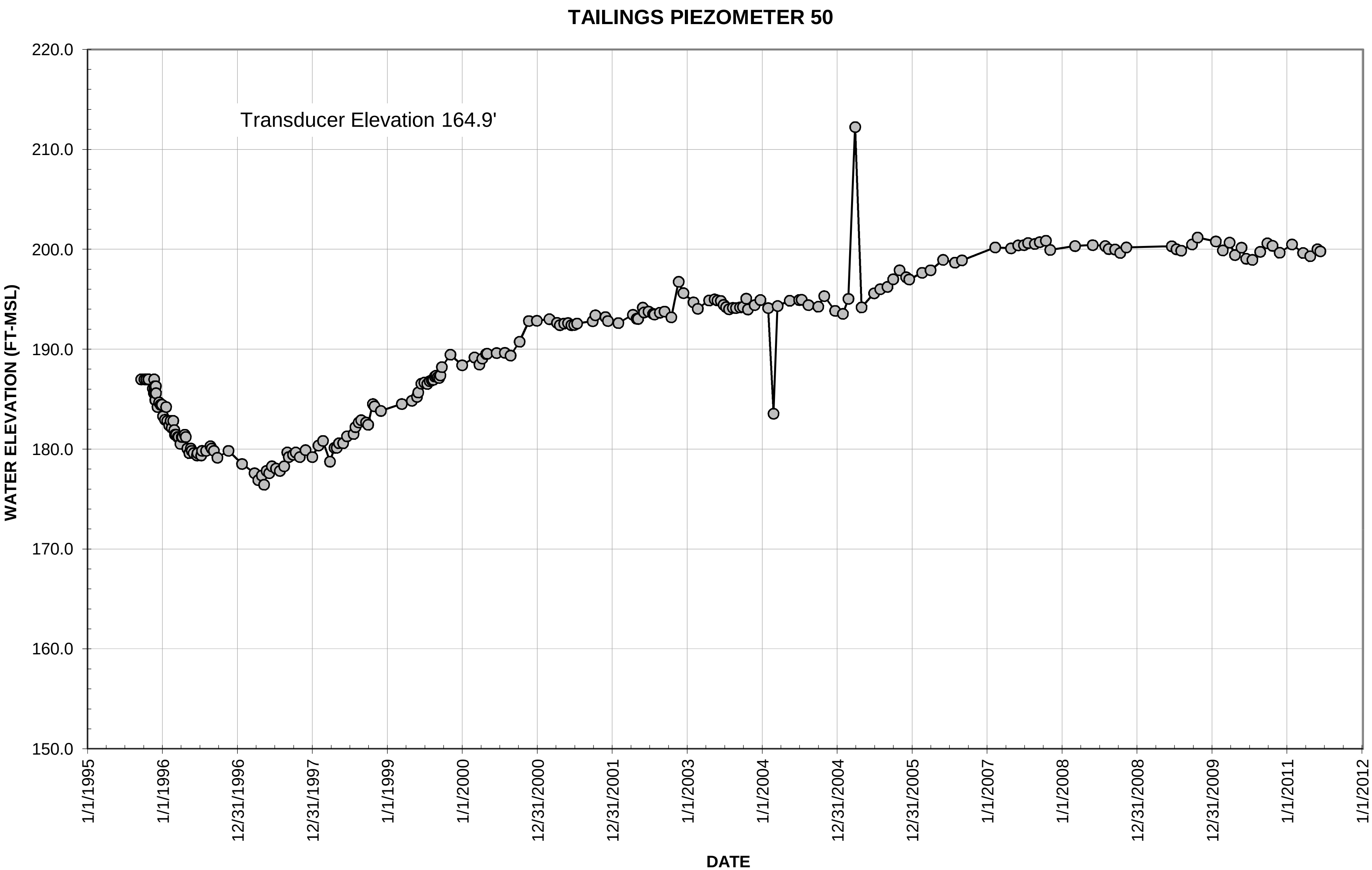


Figure 2.7 Water Level Data for Piezometer 51

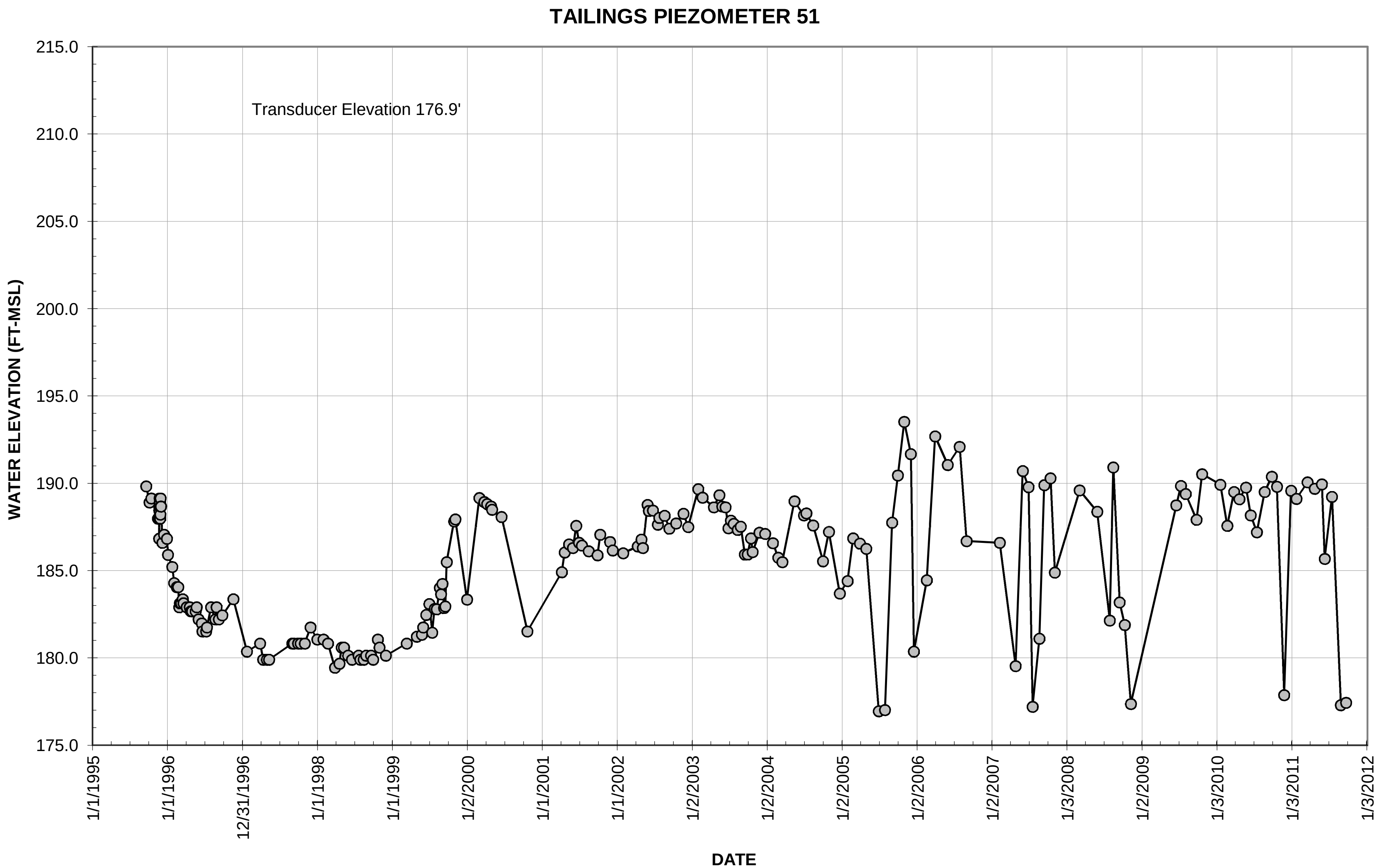


Figure 2.8 Water Level Data for Piezometer 74

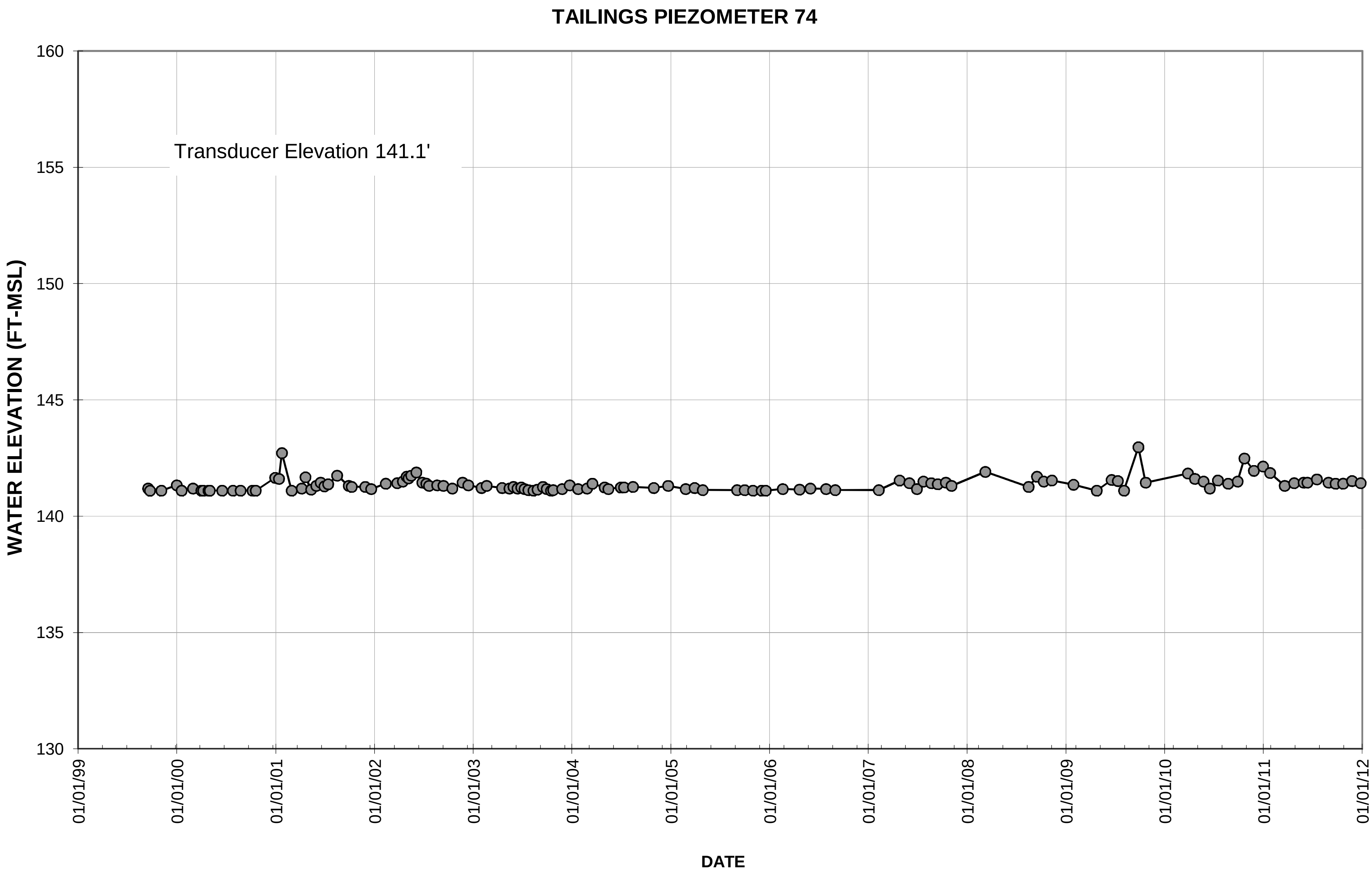


Figure 2.9 Water Level Data for Piezometer PZ-T-05-08 VW

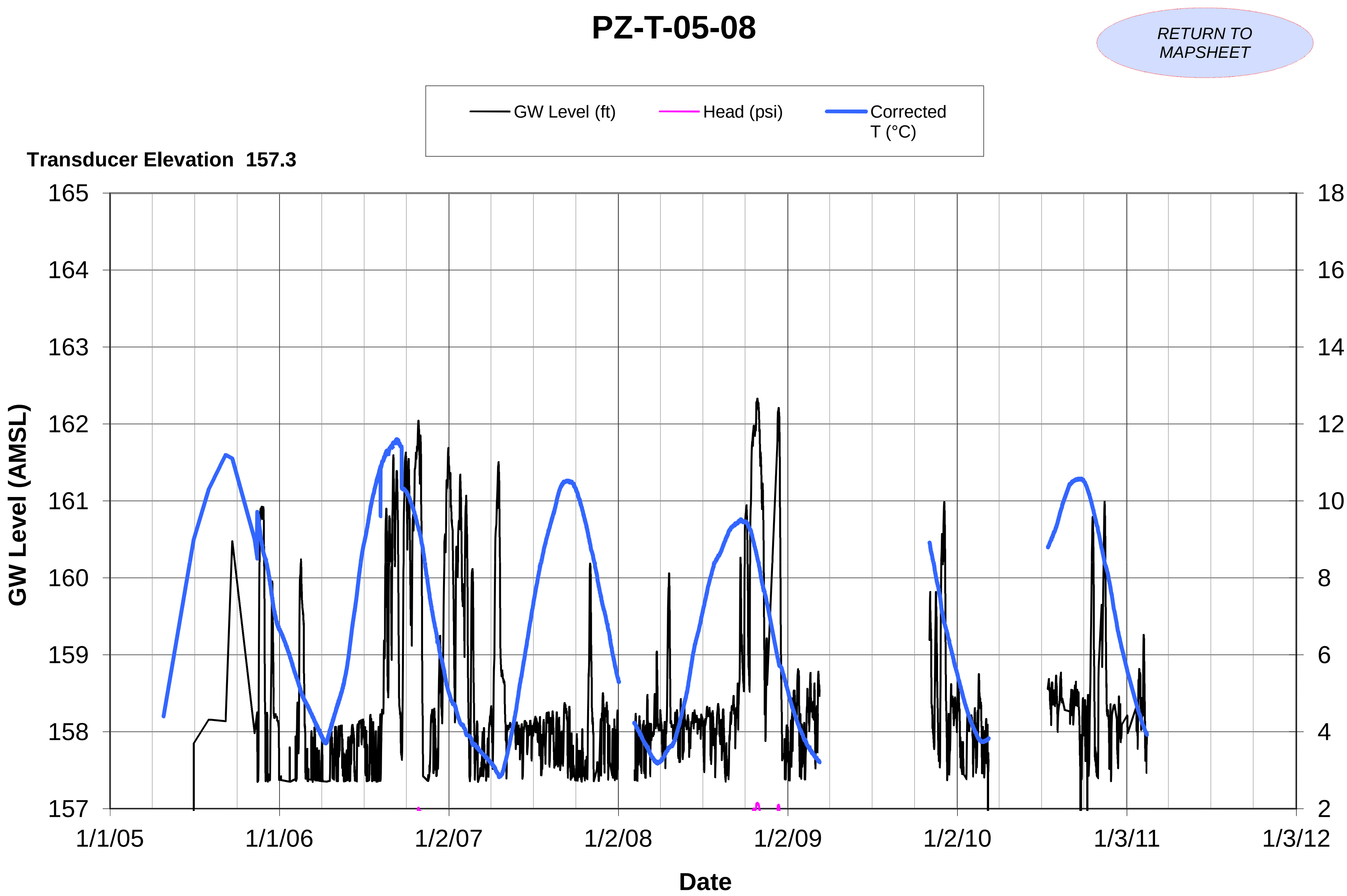


Figure 2.10 Water Level Data for Piezometer 76

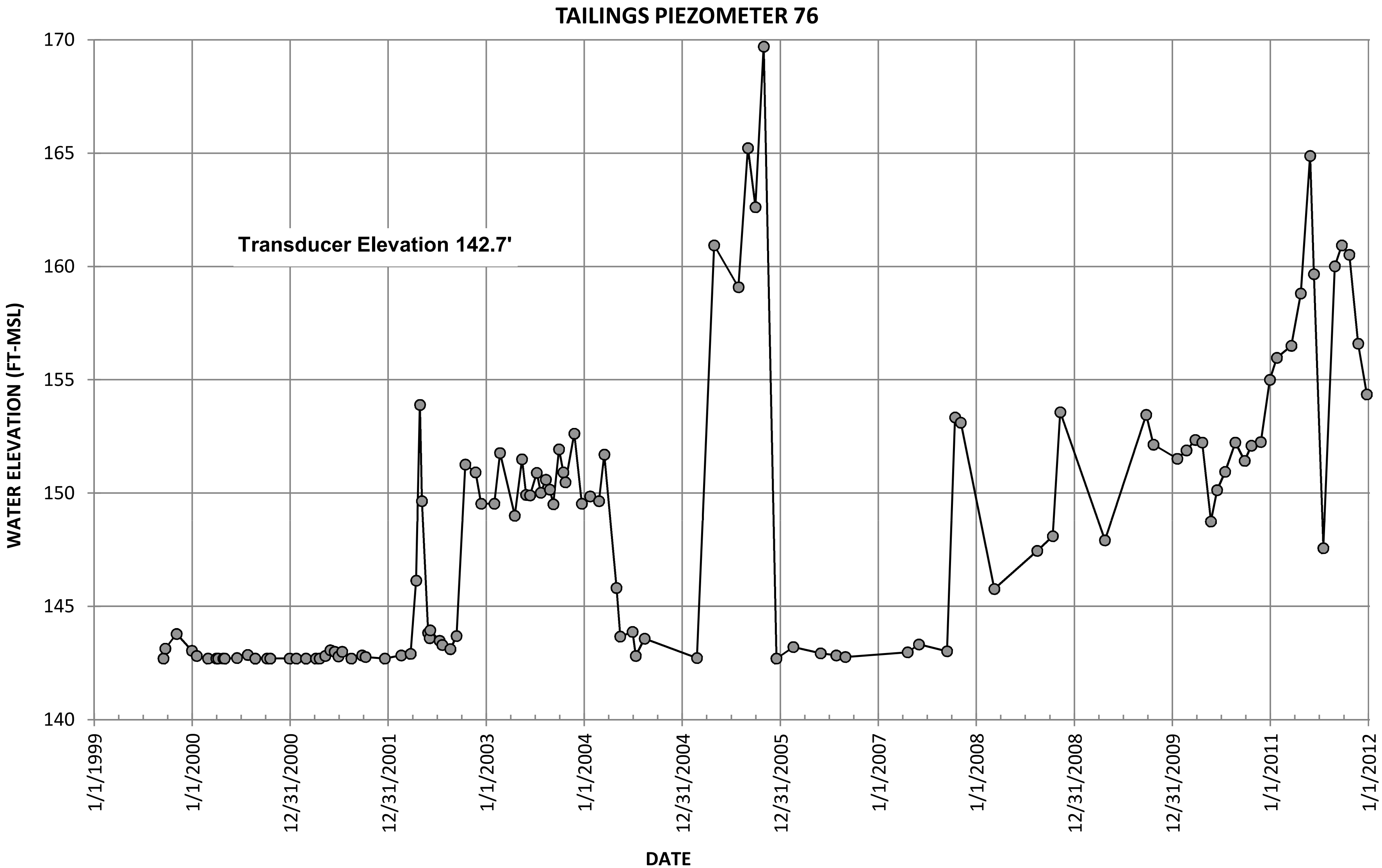


Figure 2.11 Water Level Data for Standpipe Piezometer PZ-T-00-01

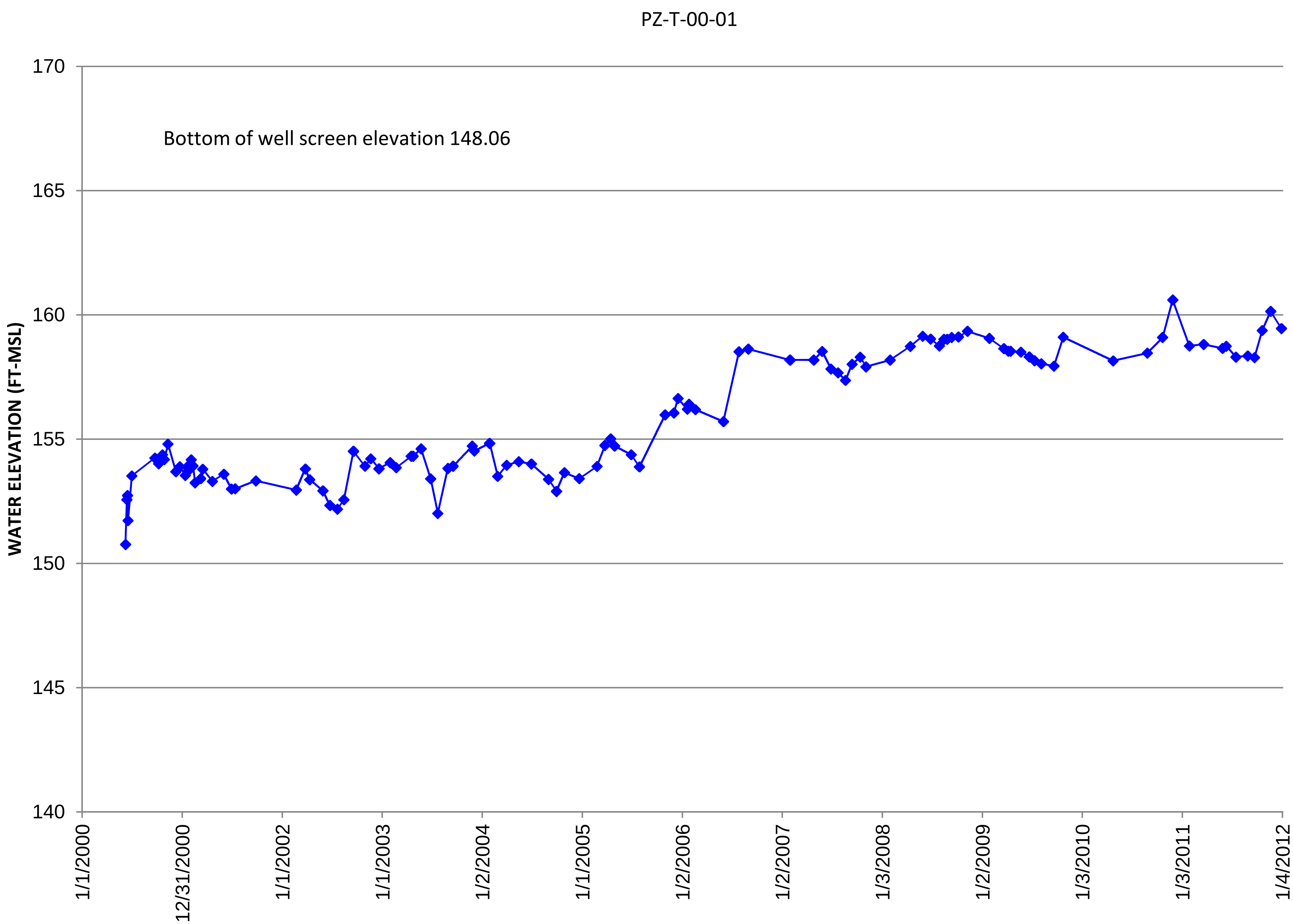


Figure 2.12 Water Level Data for Standpipe Piezometer PZ-T-00-02

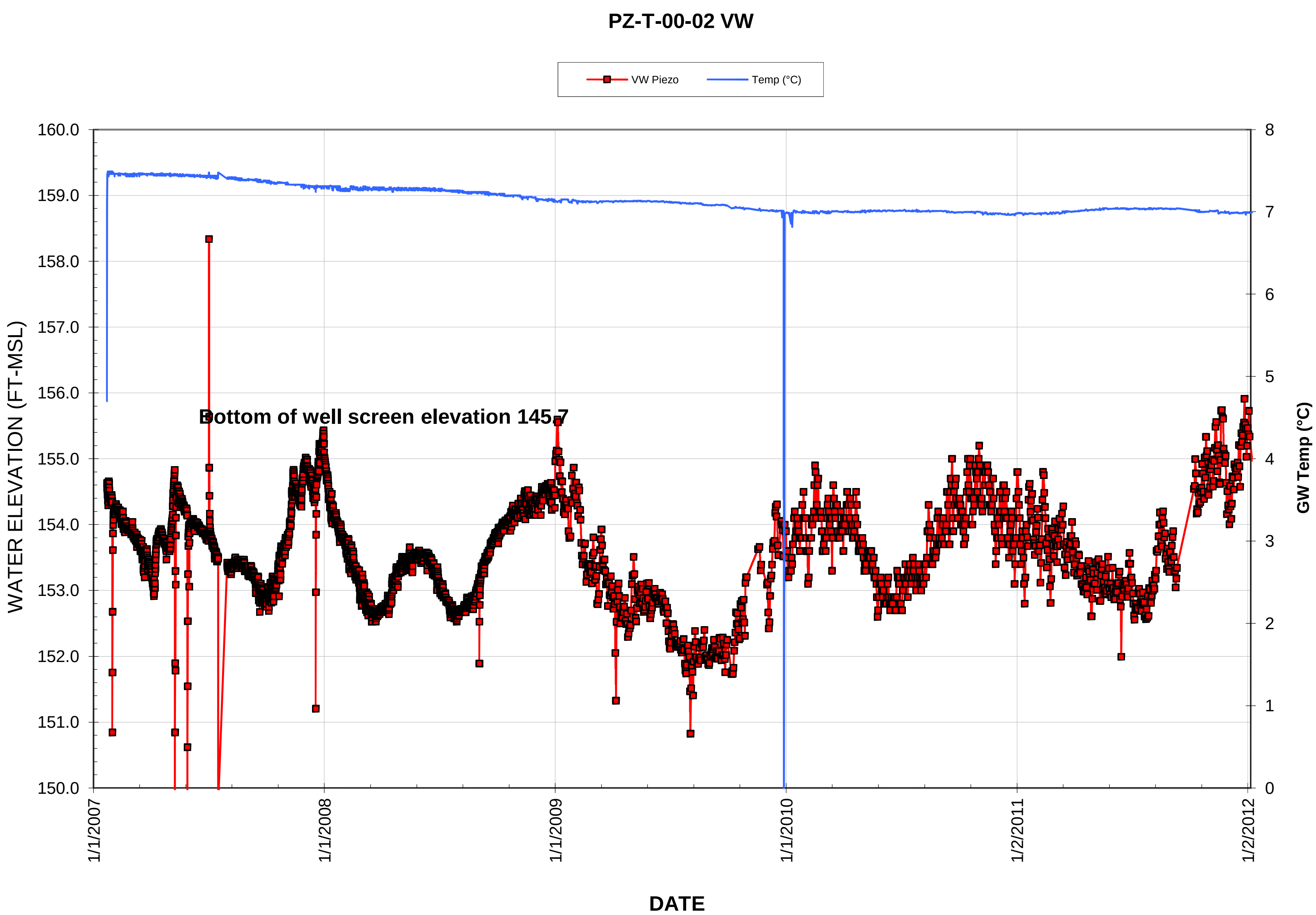


Figure 2.13 Water Level Data for Standpipe Piezometer PZ-T-00-03

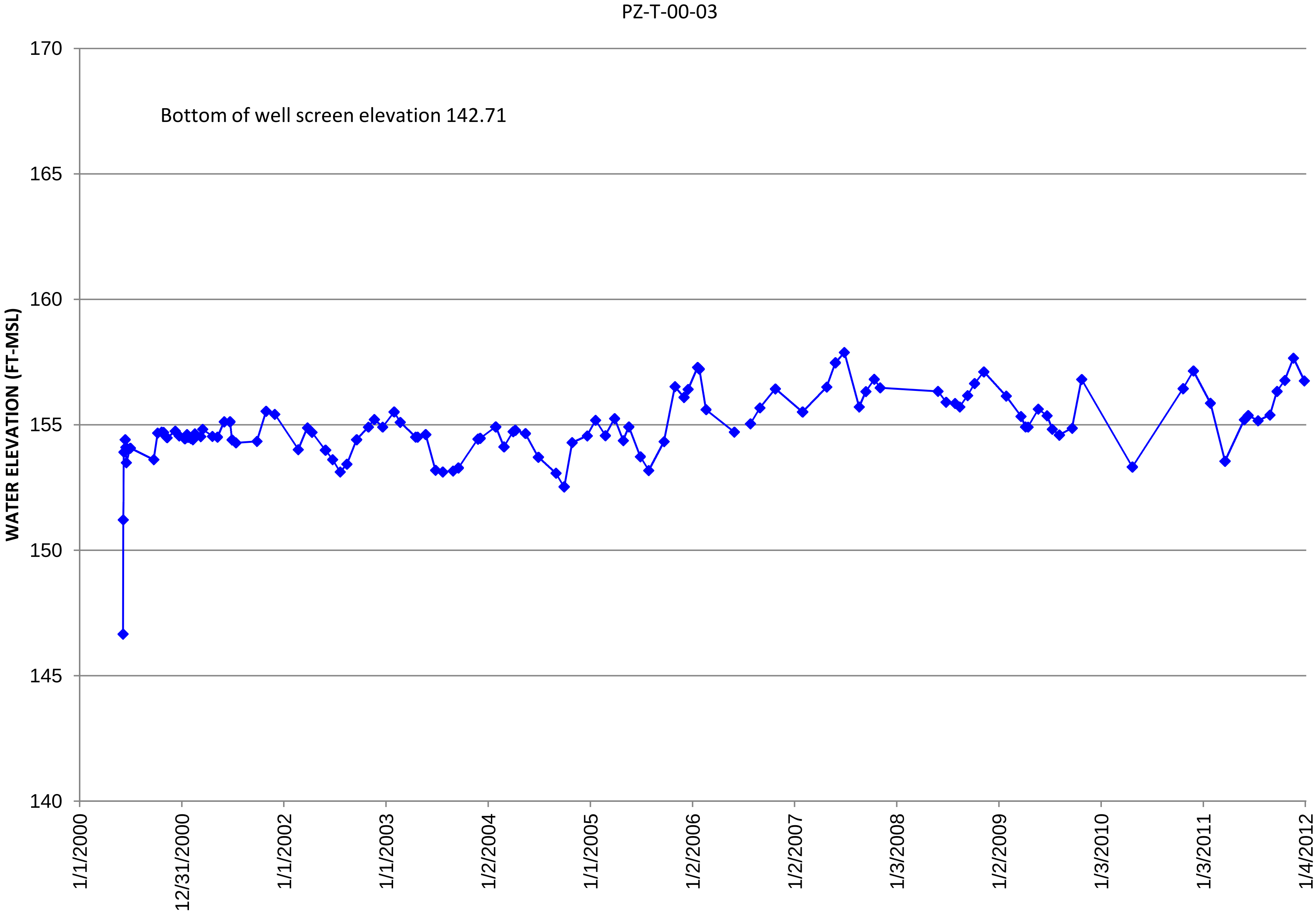


Figure 2.14 Water Level Data for Standpipe Piezometer MW-T-00-05A

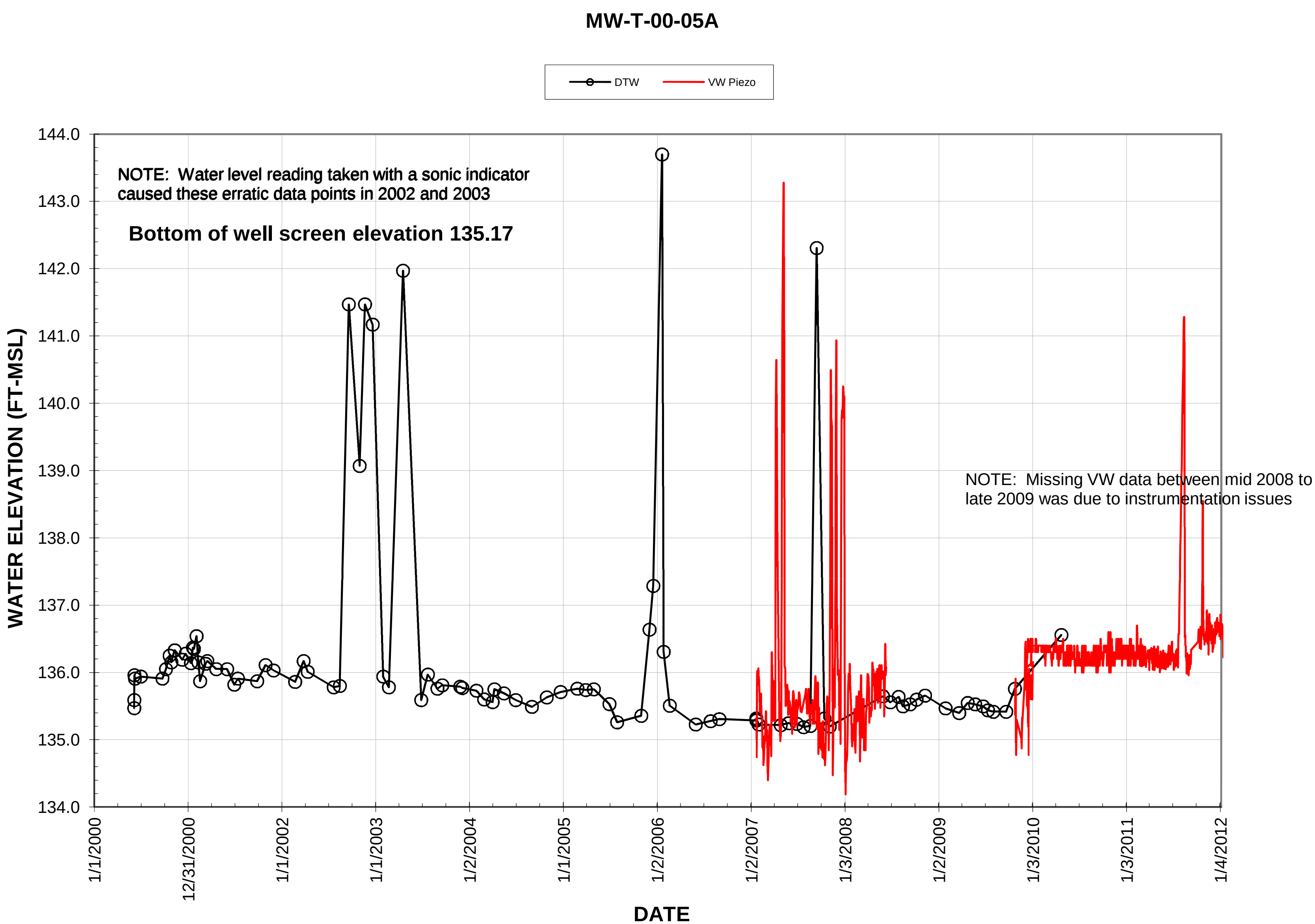


Figure 2.15 Water Level Data for Well MW-T-00-03A

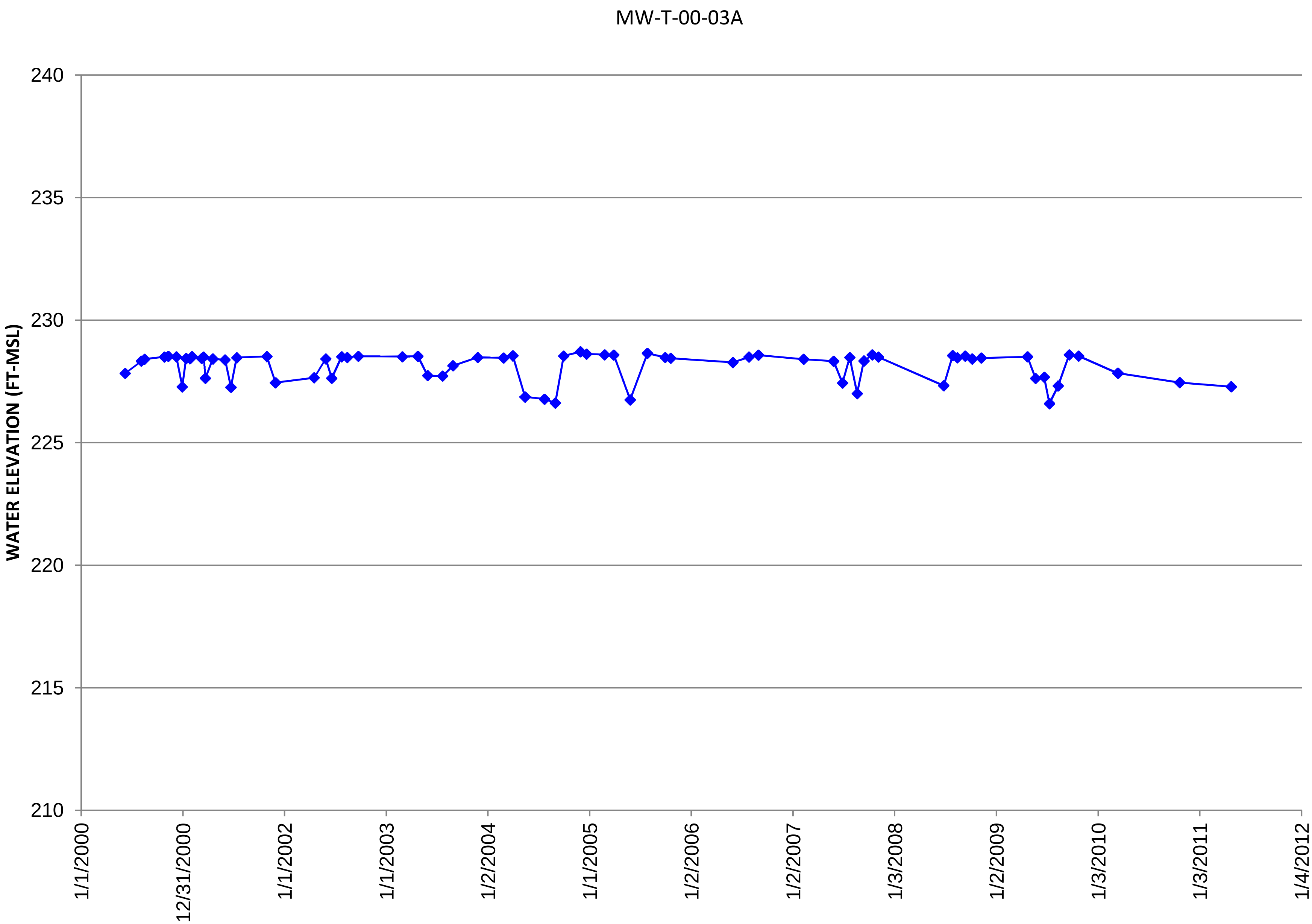


Figure 2.16 Water Level Data for Well MW-T-00-03B

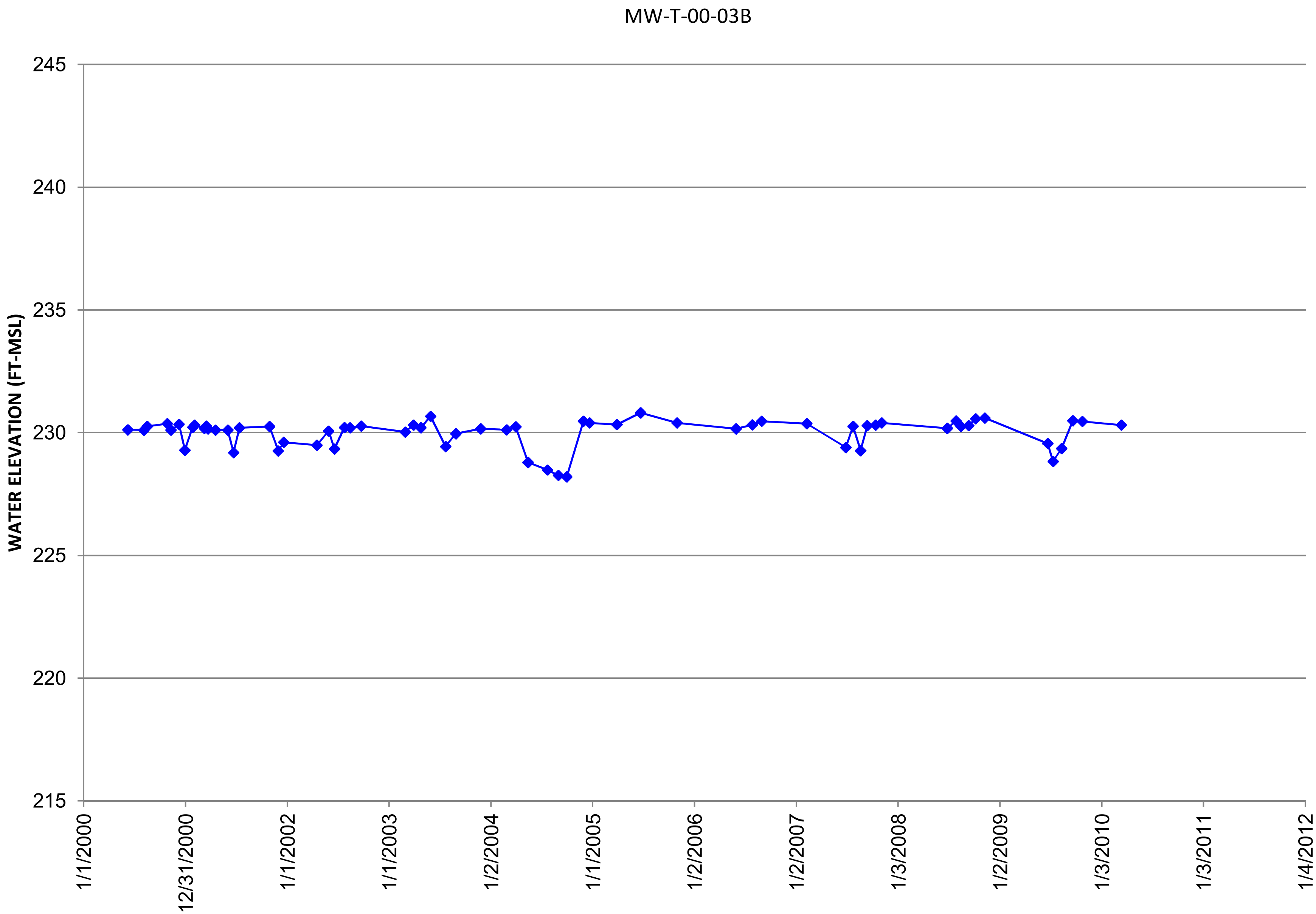


Figure 2.17 Water Level Data for Well MW-T-01-03A

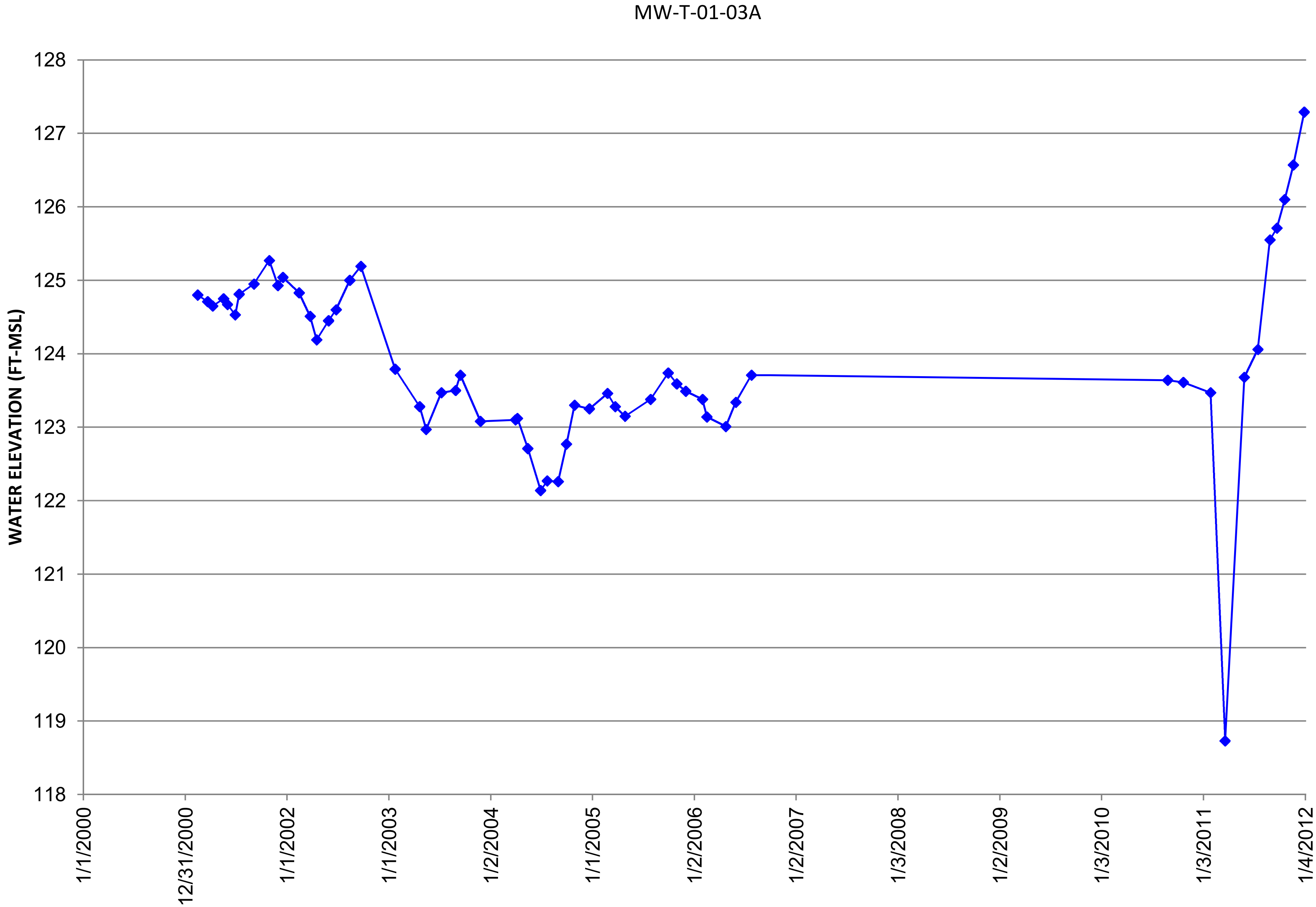


Figure 2.18 Water Level Data for Well MW-T-01-03B

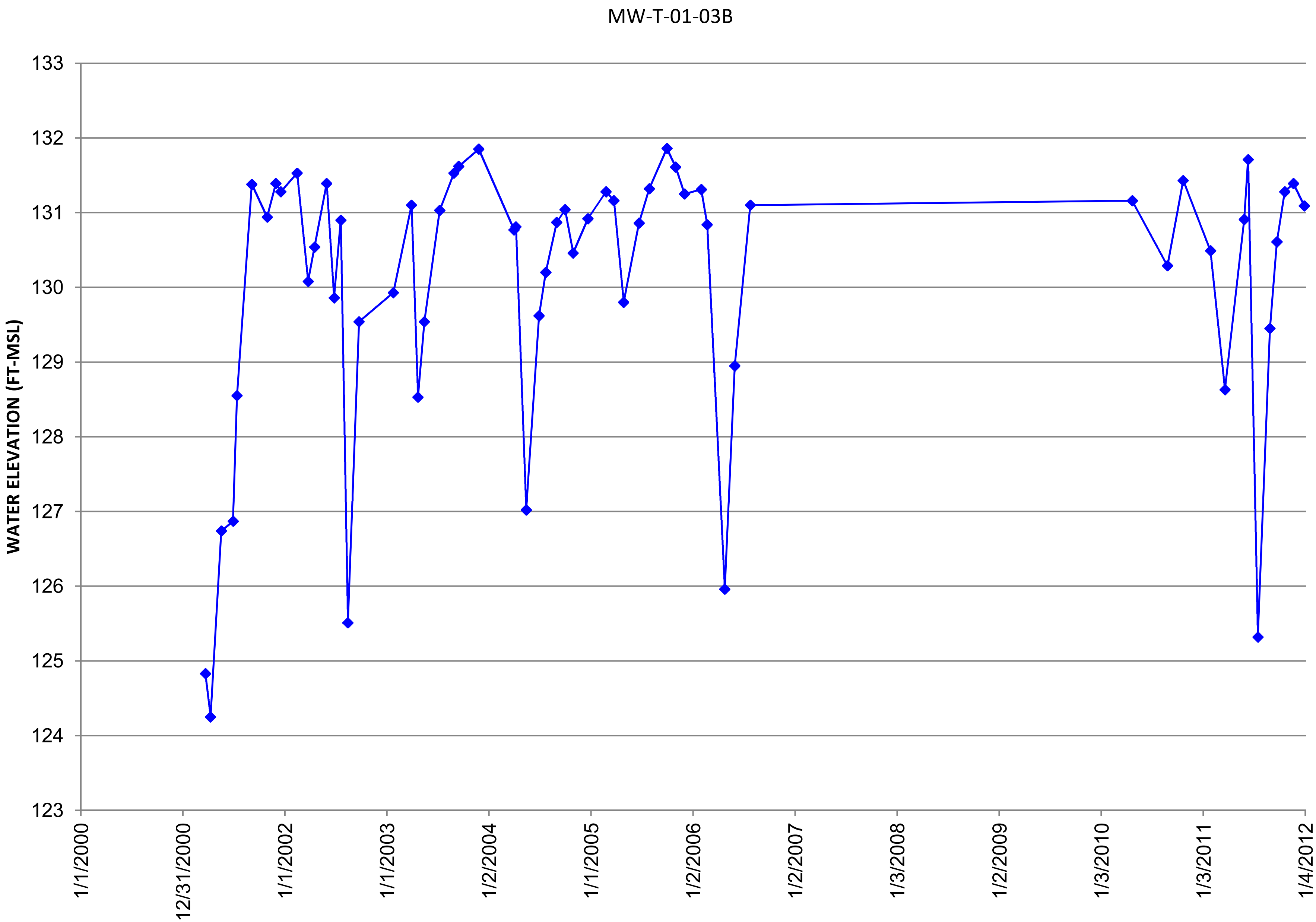


Figure 2.19 Tailings Area Wet Well Flow Data

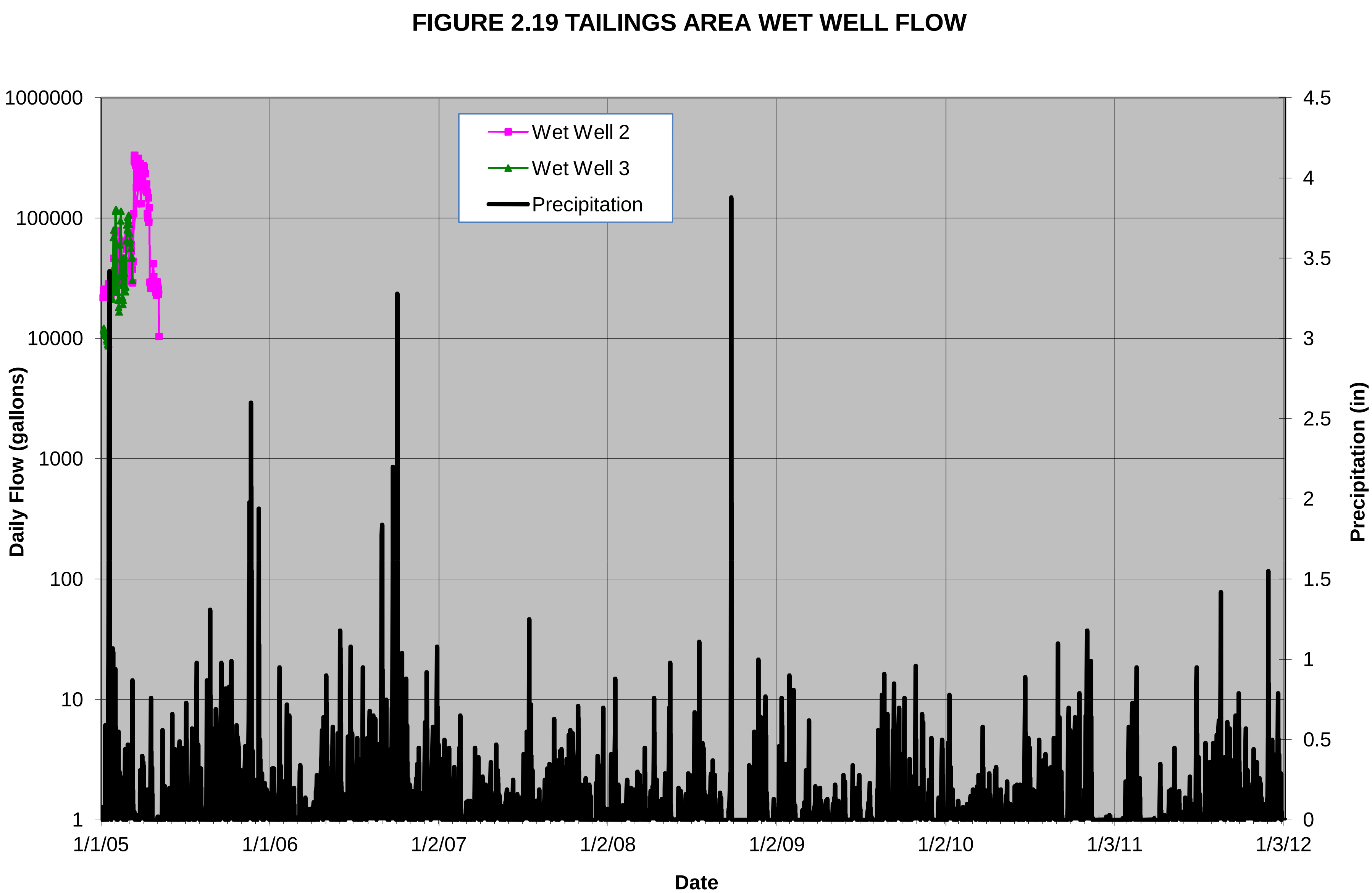


Figure 2.20a GREENS CREEK TAILINGS AREA INTERNAL MONITORING SITES: WET WELLS - pH DATA

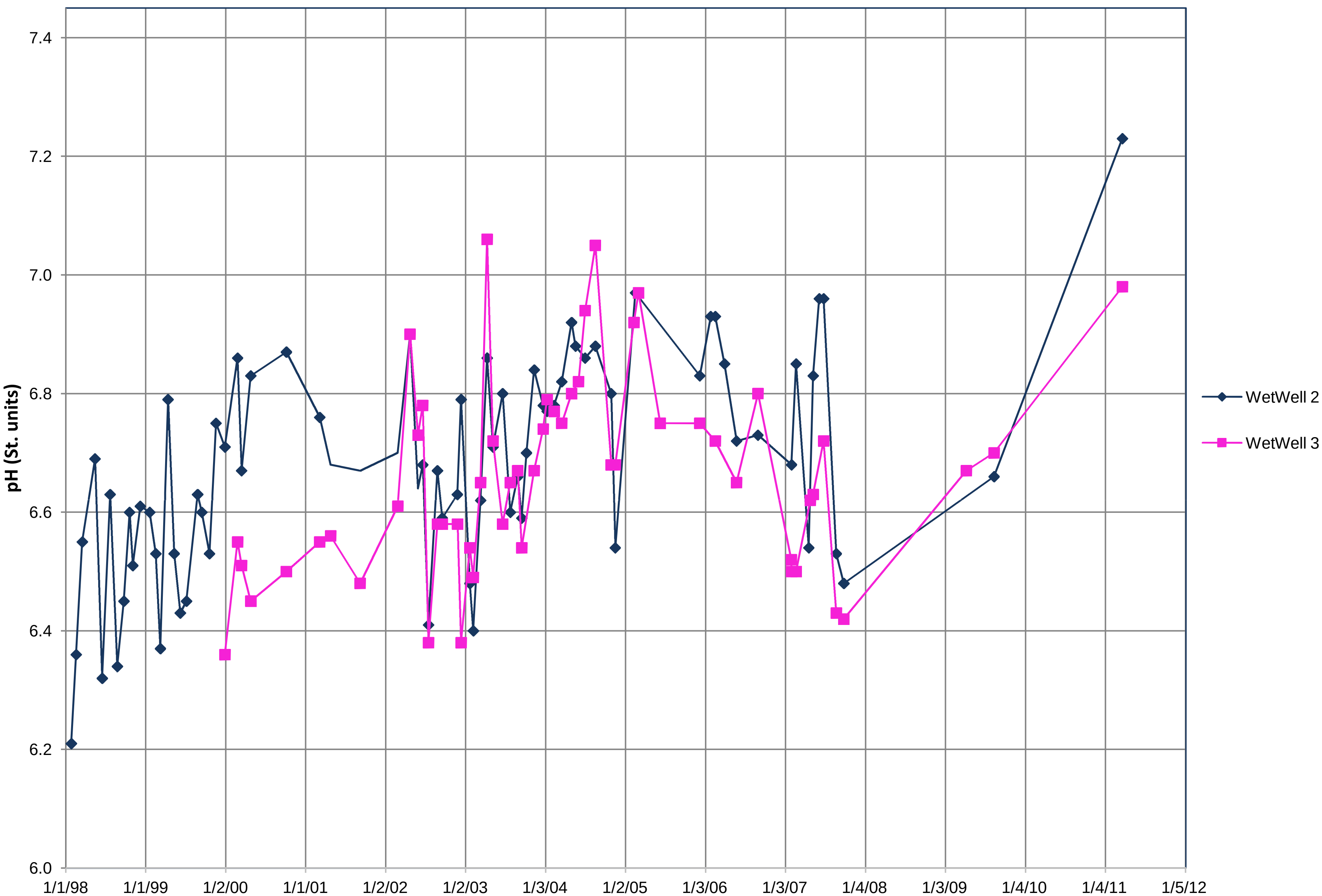


Figure 2.20b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - pH DATA

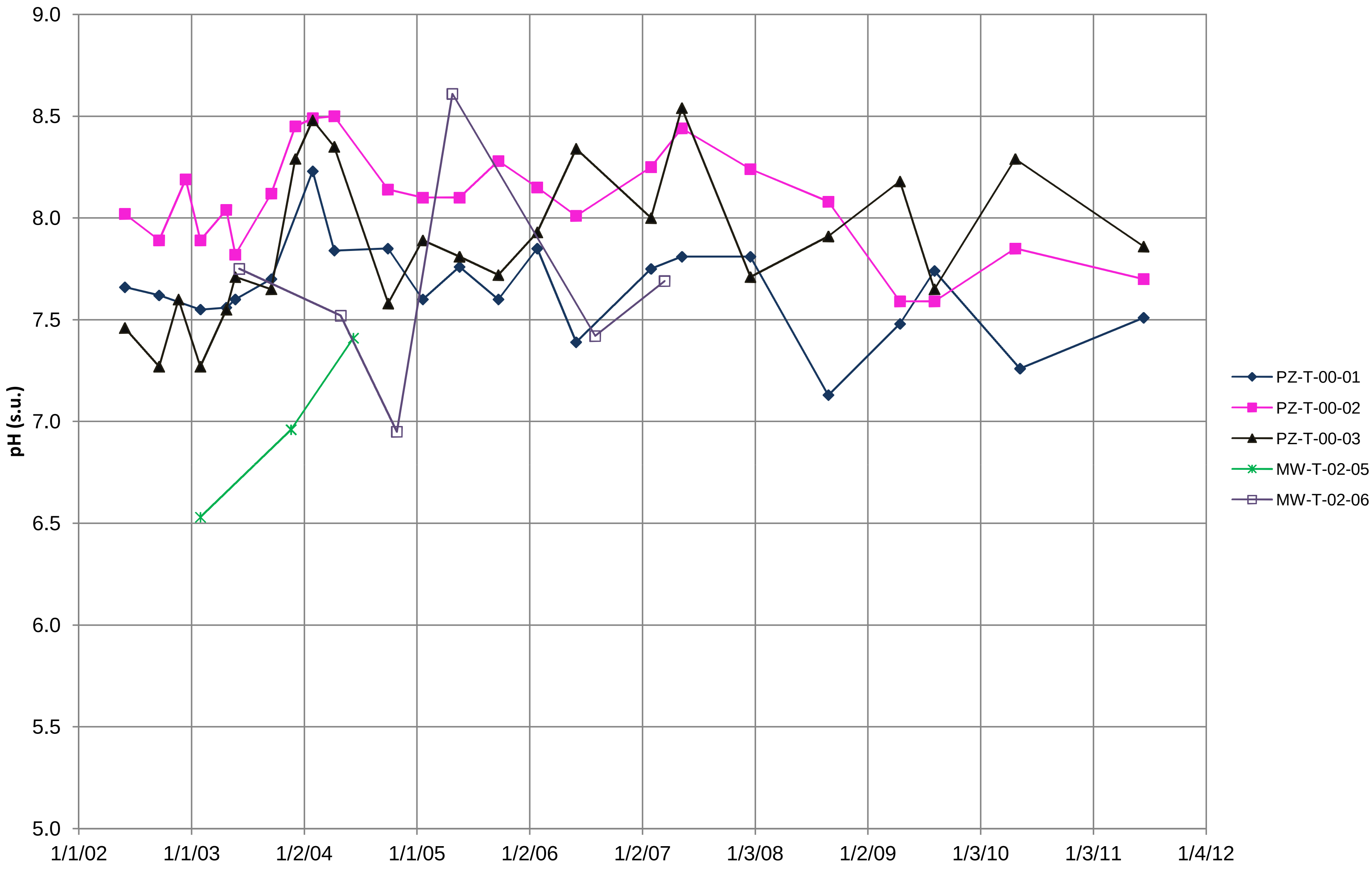


Figure 2.20c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - pH

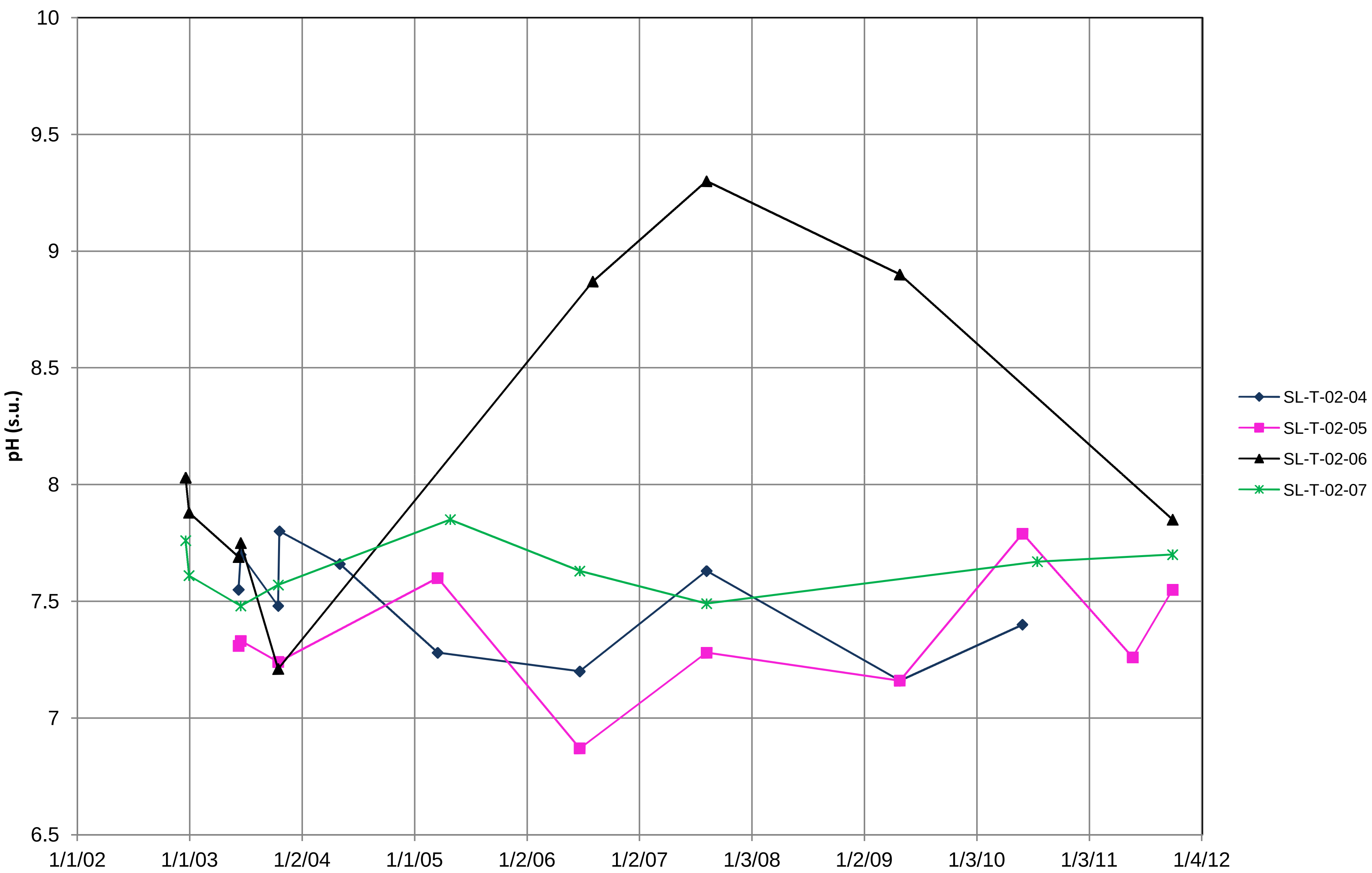


Figure 2.21a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - ALKALINITY
(Non-detectable analysis plotted as zero)

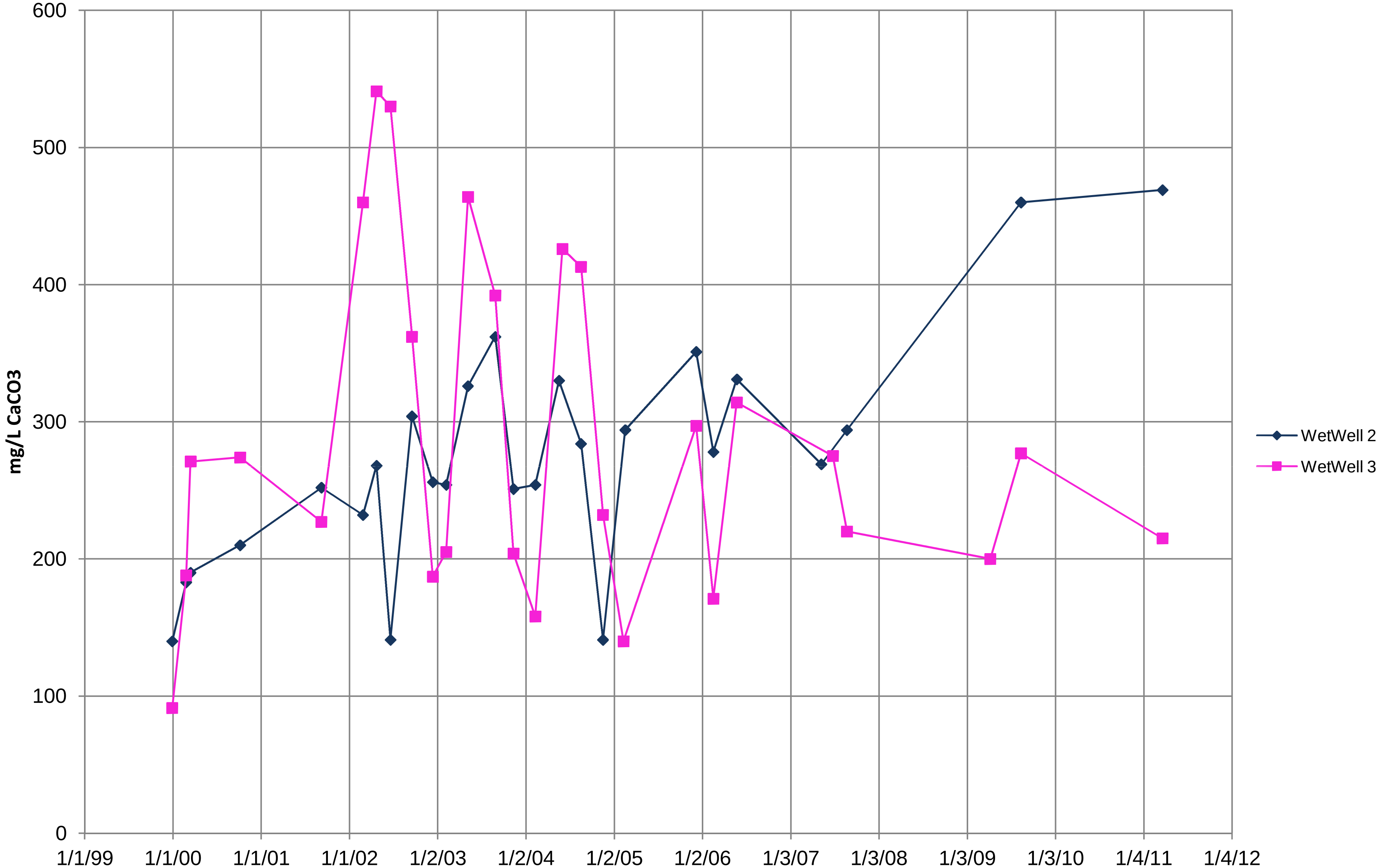


Figure 2.21b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ALKALINITY DATA (Non-detectable analysis plotted as zero)

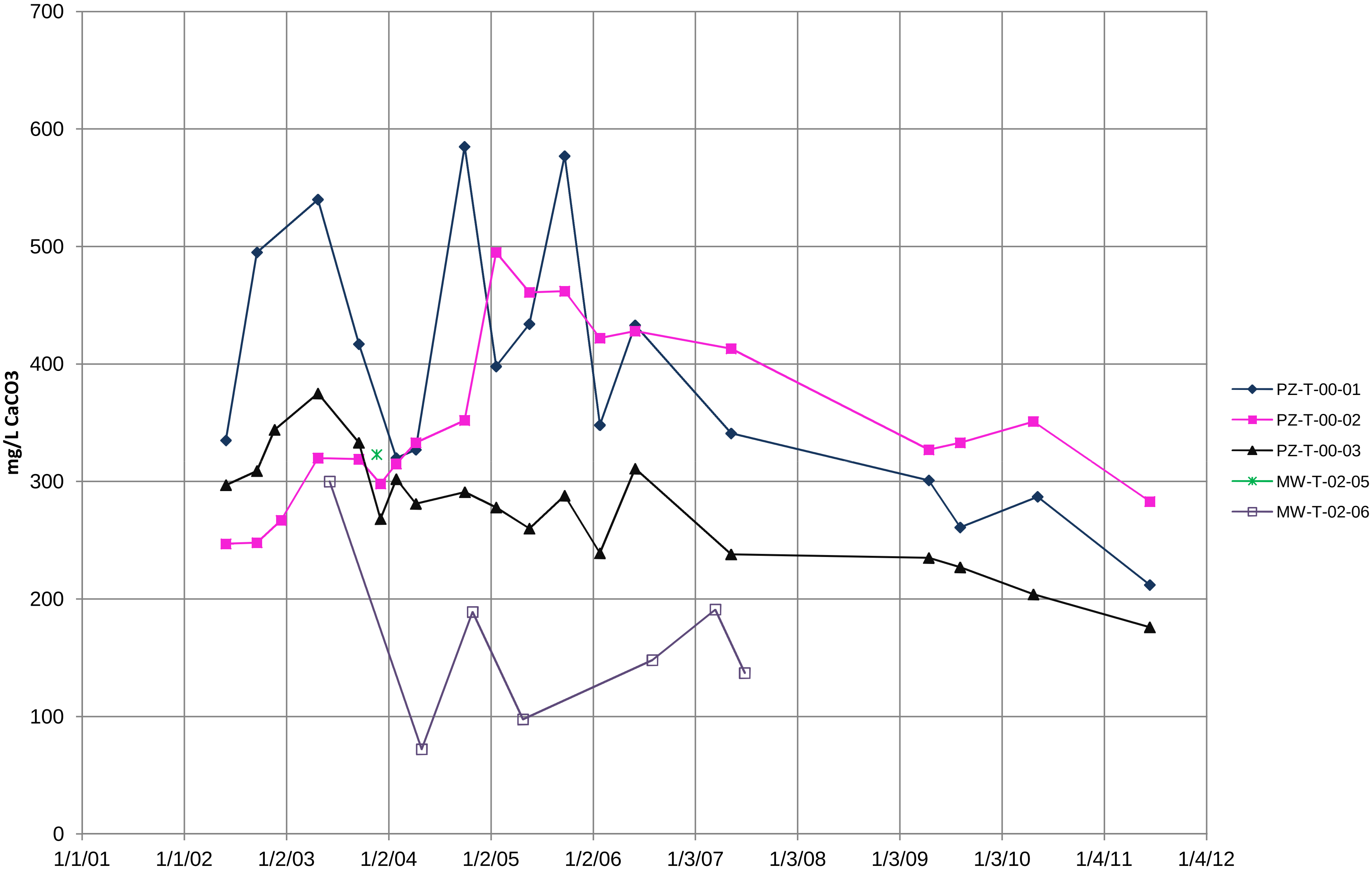


Figure 2.21c GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
SUCTION LYSIMETERS - FIELD ALKALINITY

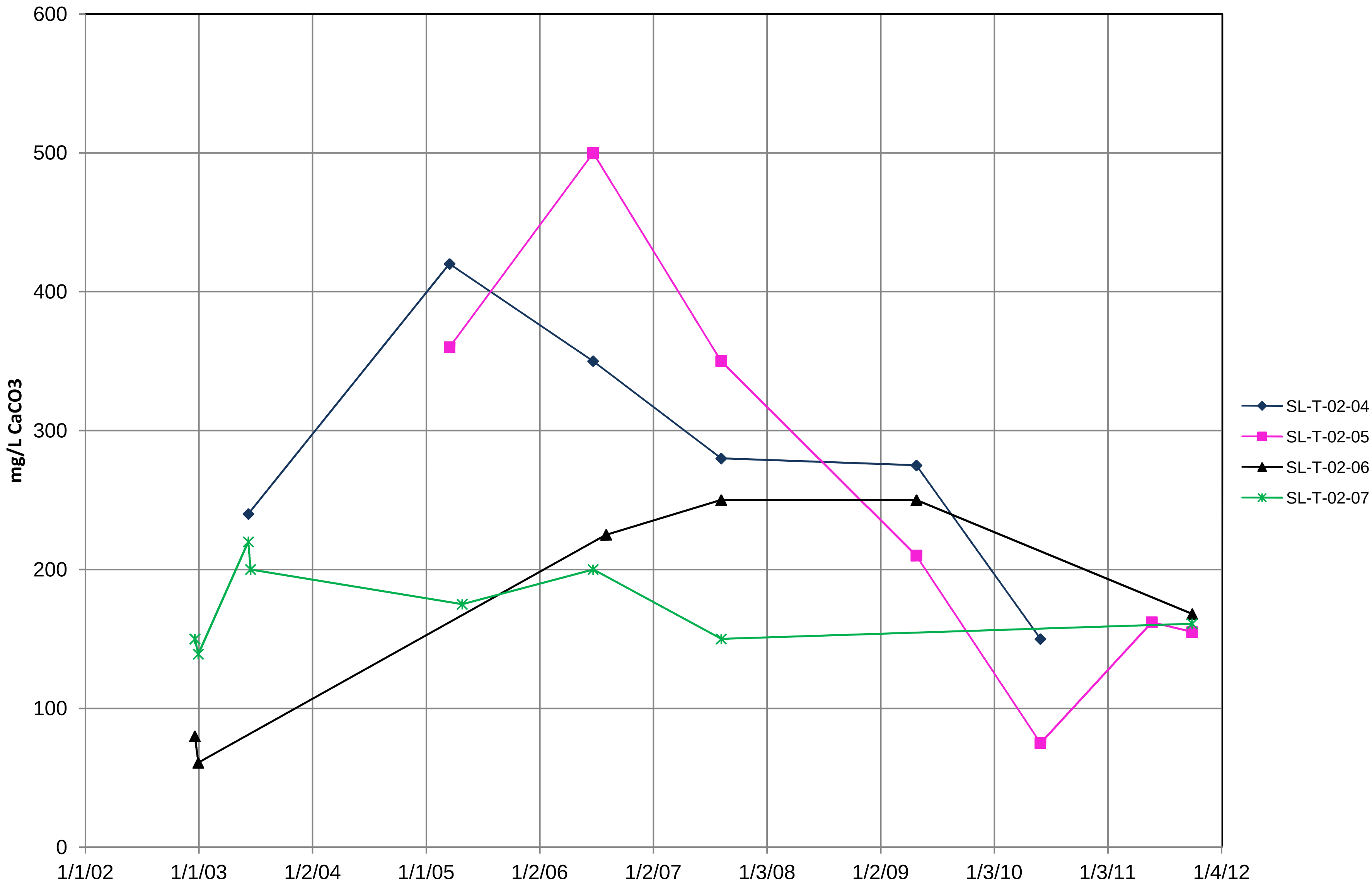


Figure 2.22a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - CONDUCTIVITY DATA

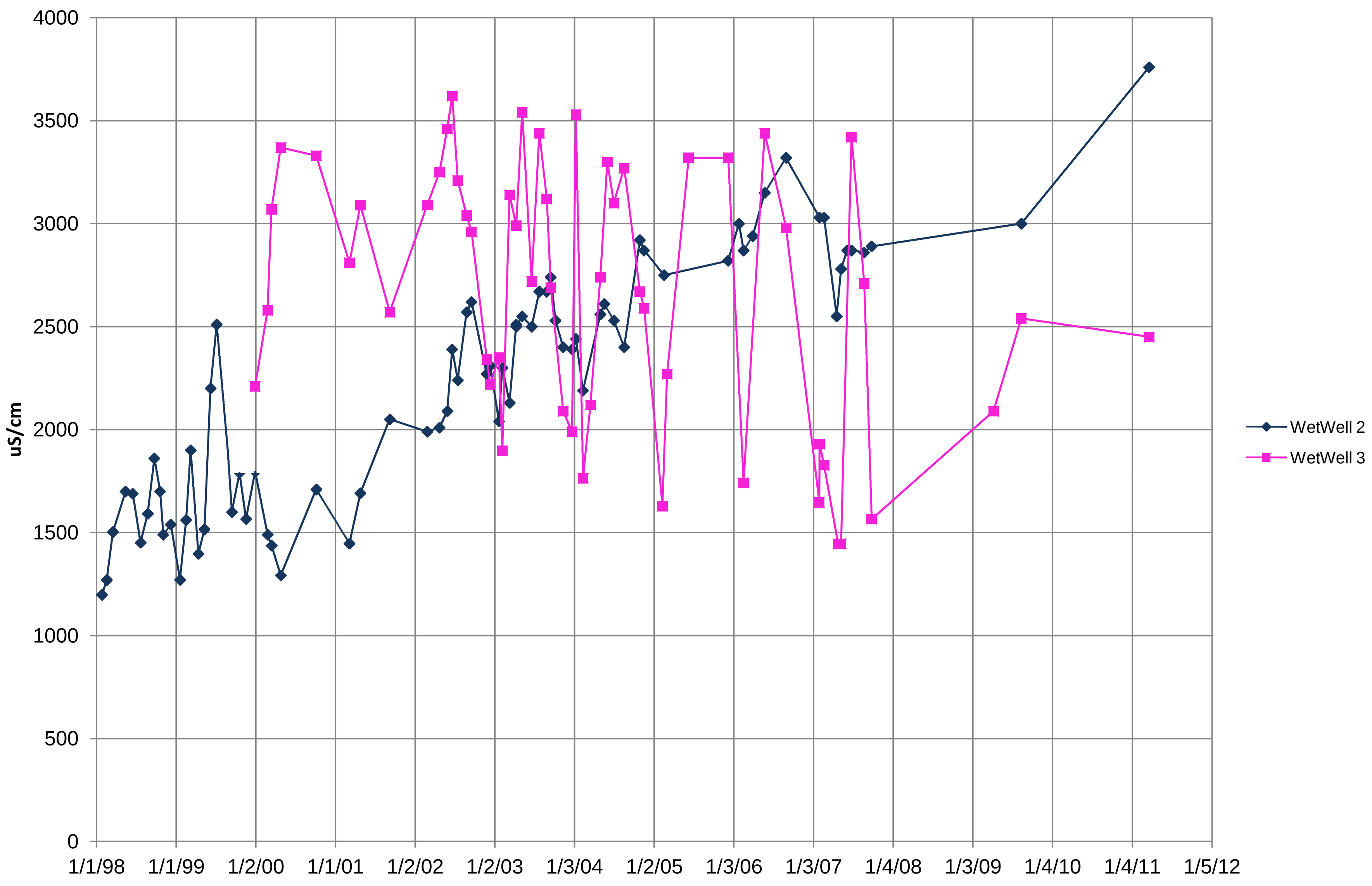


Figure 2.22b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - CONDUCTIVITY DATA

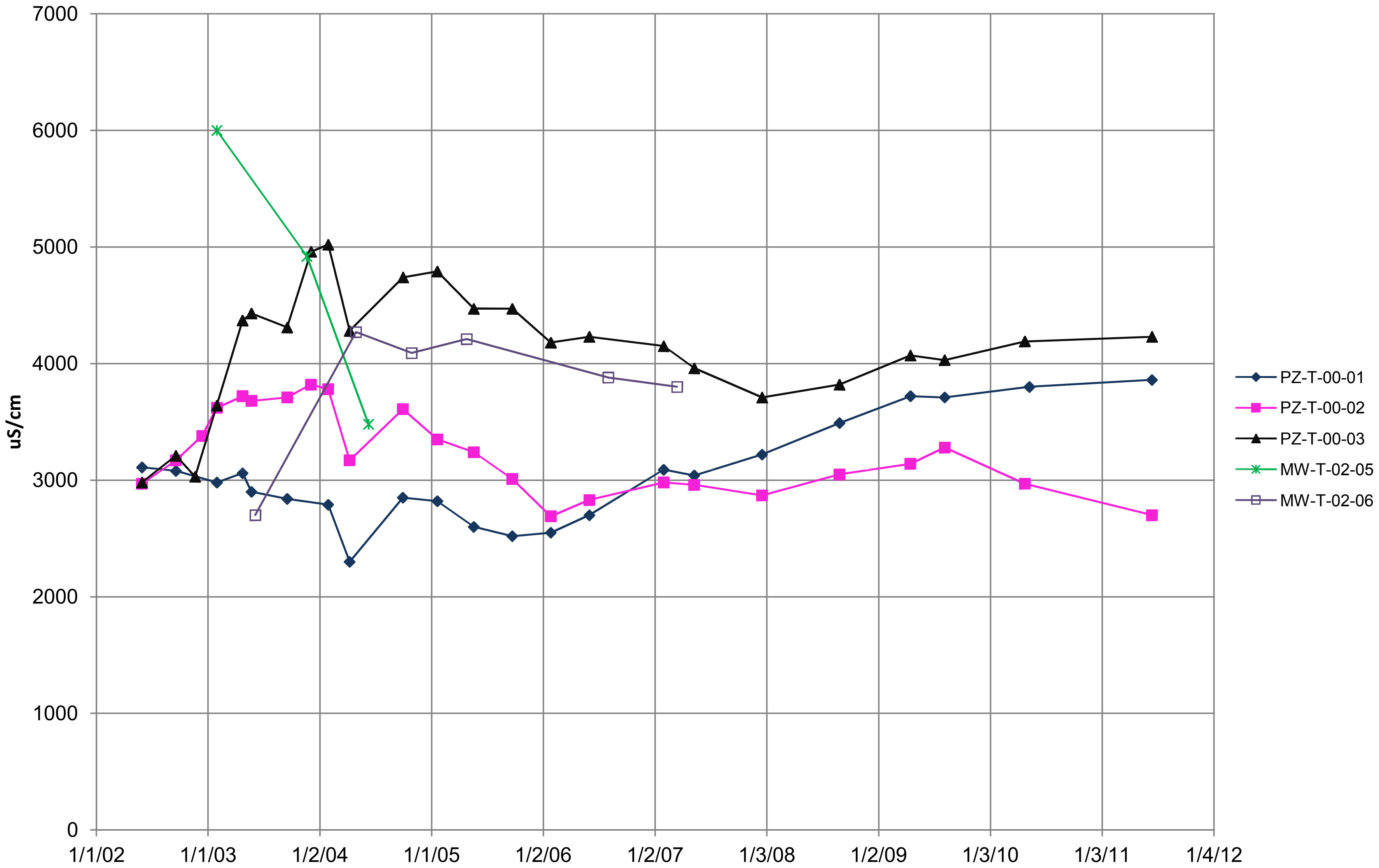
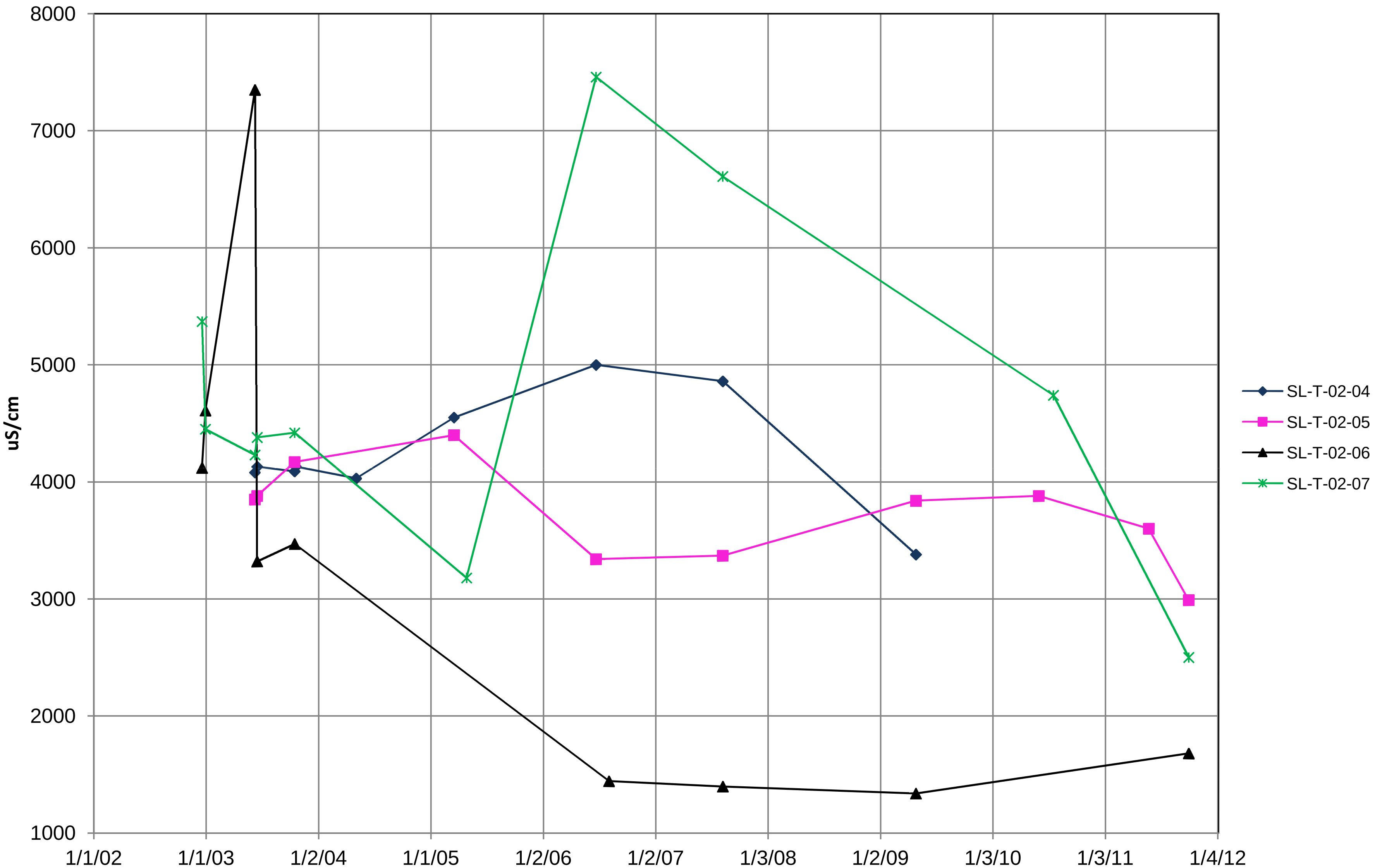


Figure 2.22c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - CONDUCTIVITY



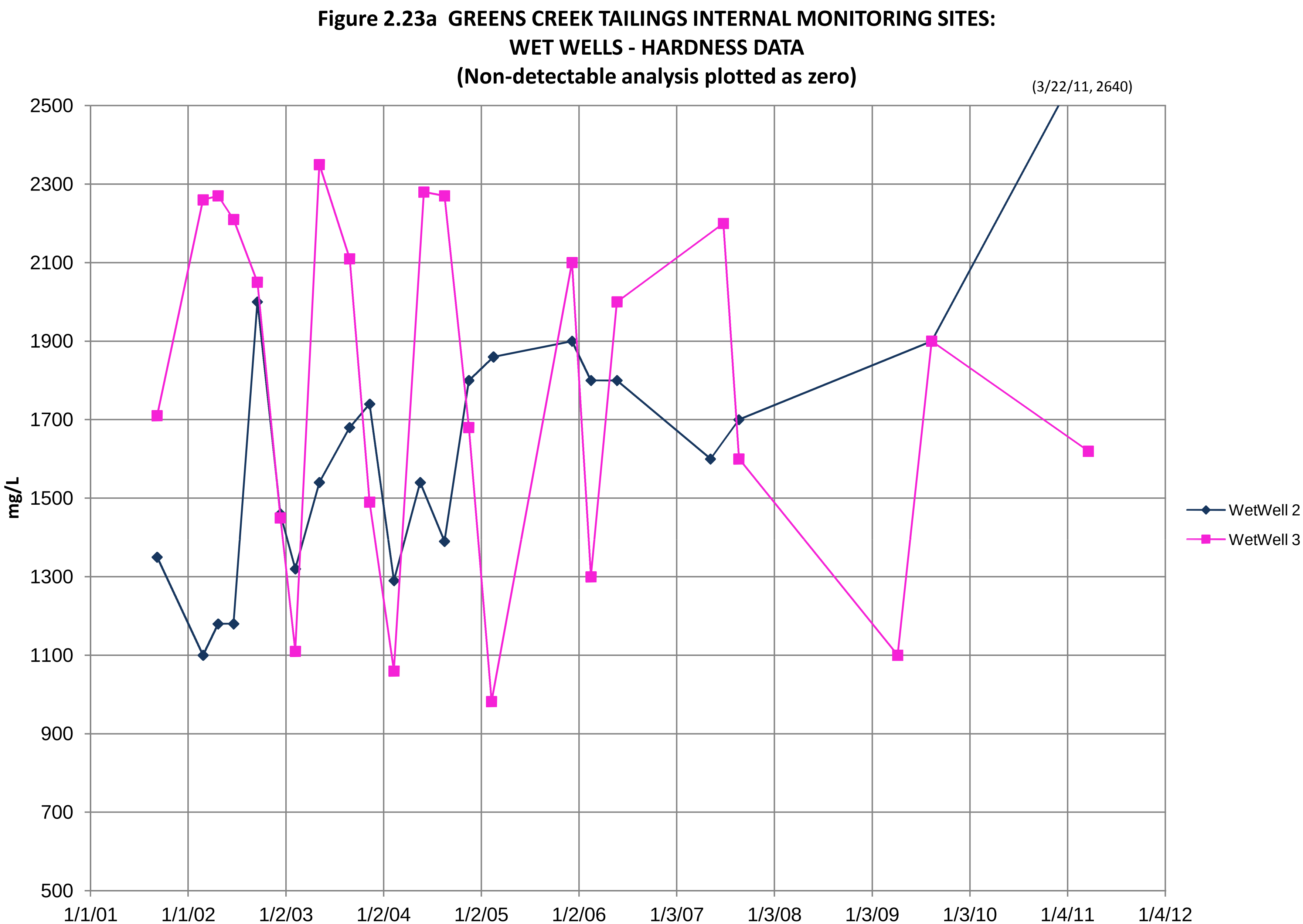


Figure 2.23a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - HARDNESS DATA
(Non-detectable analysis plotted as zero)
(3/22/11, 2640)
mg/L
2500
2300
2100
1900
1700
1500
1300
1100
900
700
500
1/1/01
1/1/02
1/2/03
1/2/04
1/2/05
1/2/06
1/3/07
1/3/08
1/3/09
1/3/10
1/4/11
1/4/12
WetWell 2
WetWell 3

Figure 2.23b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - HARDNESS DATA (Non-detectable analysis plotted as zero)

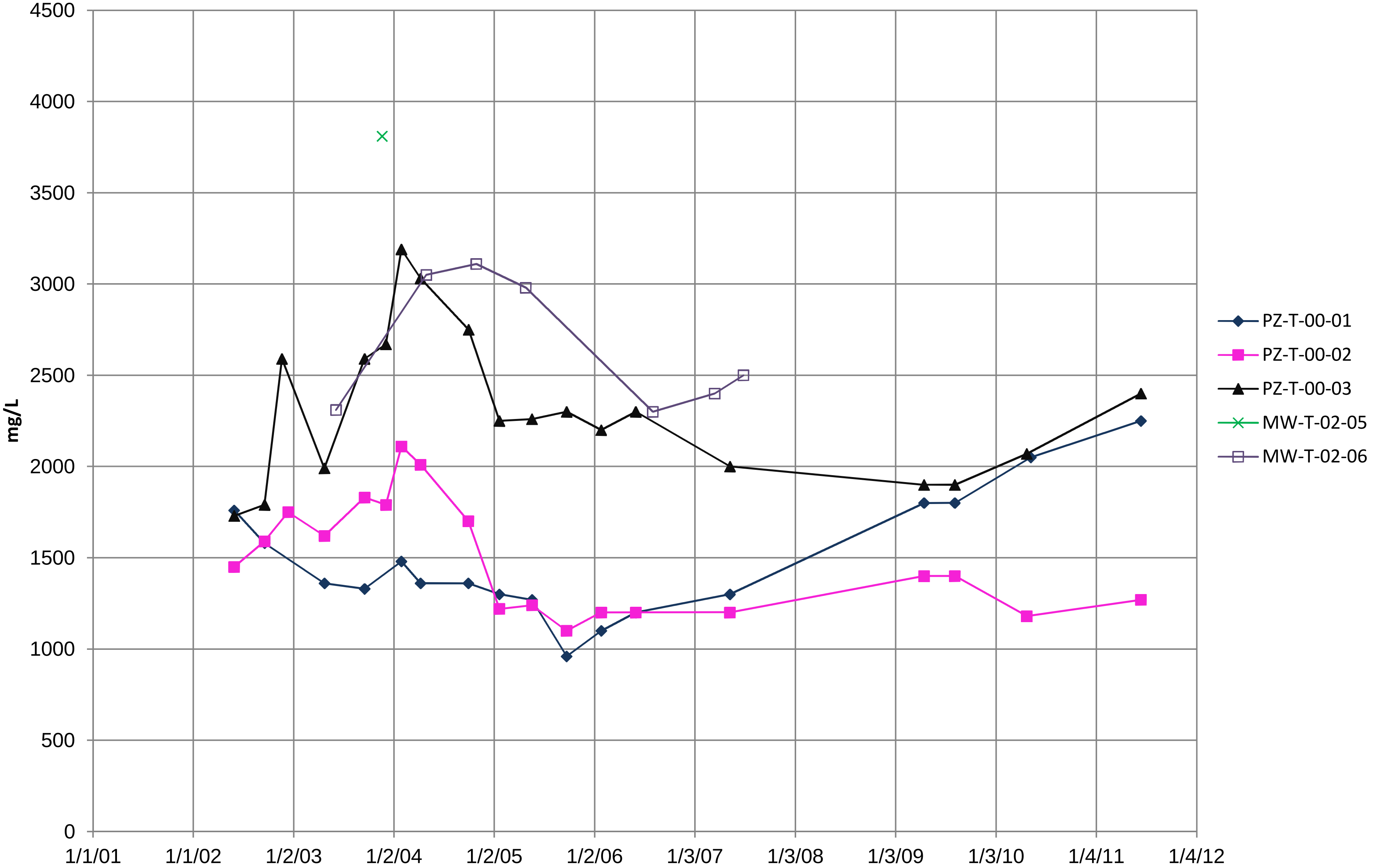


Figure 2.24a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - SULFATE DATA (Non-detectable analysis plotted as zero)

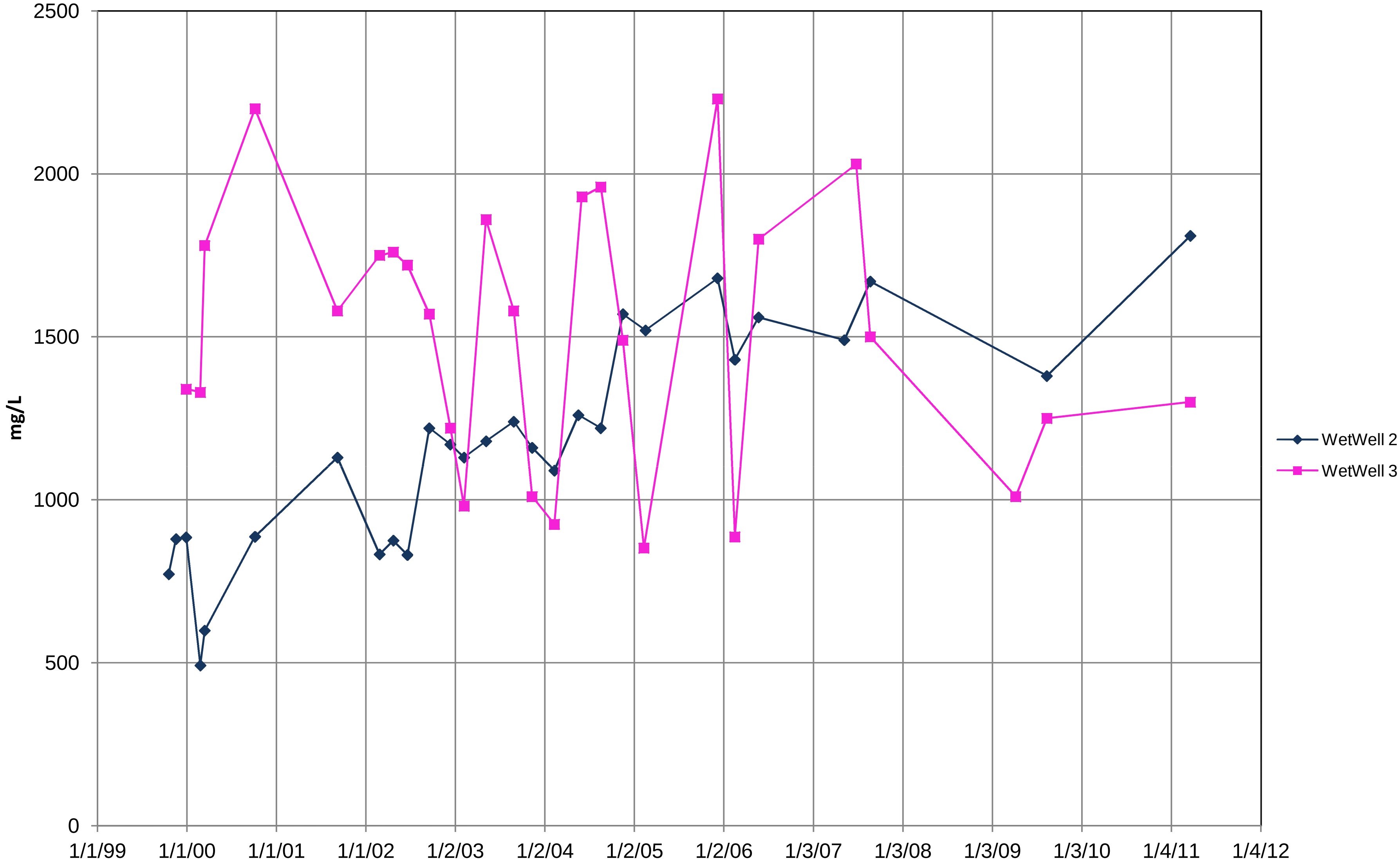


Figure 2.24b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - SULFATE DATA (Non-detectable analyses plotted as zero)

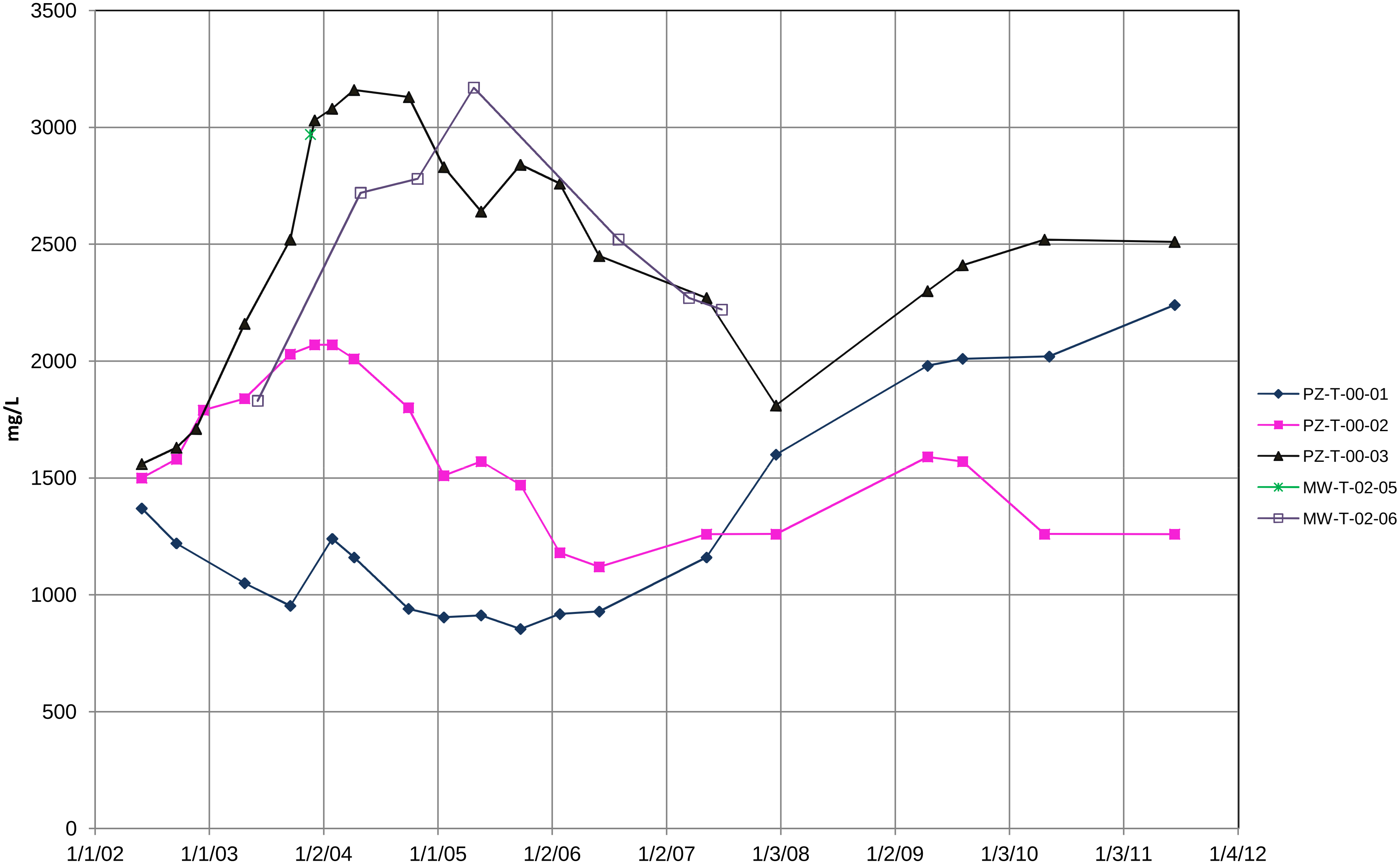
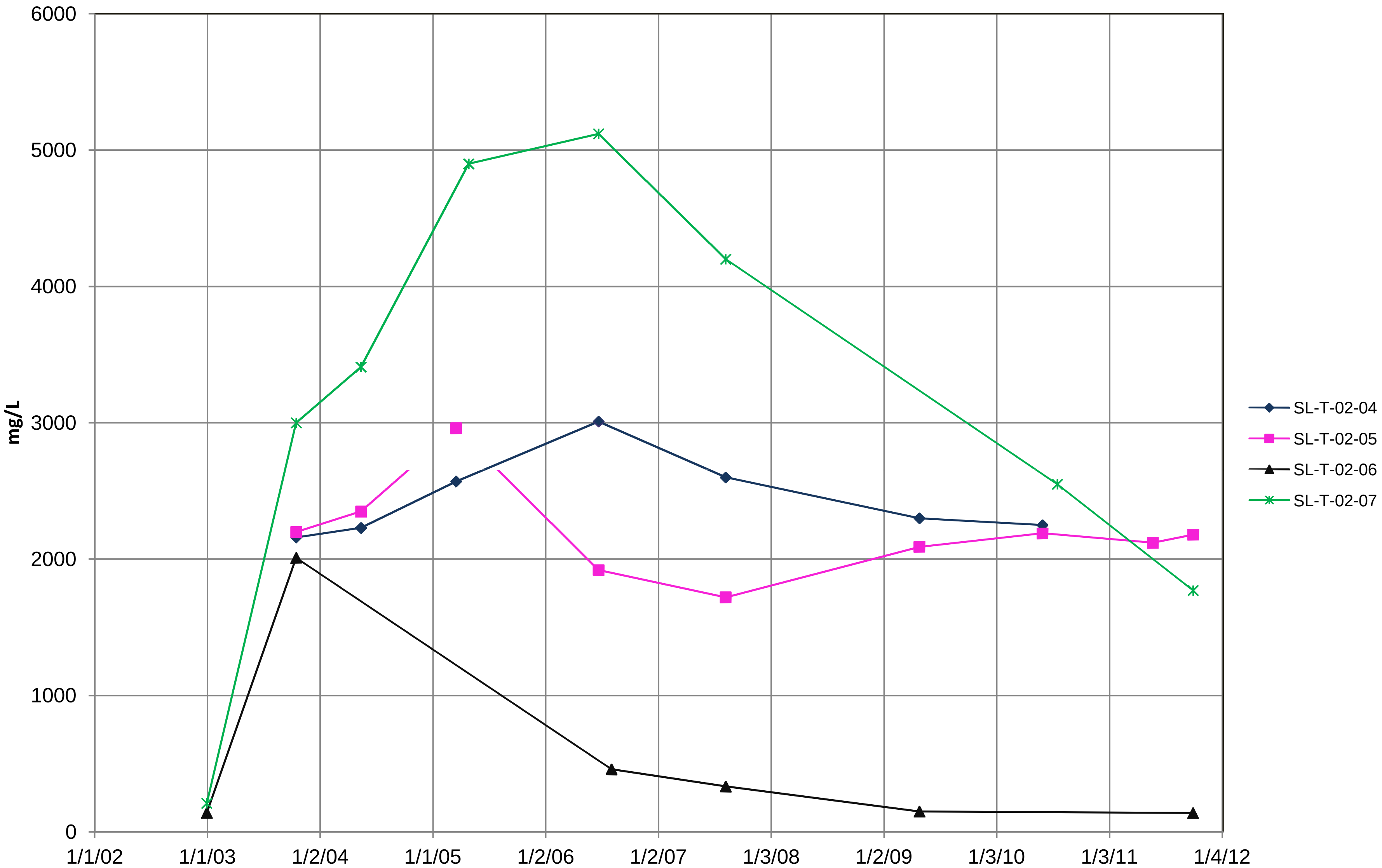


Figure 2.24c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - SULFATE DATA (Non-detectable analysis plotted as zero)



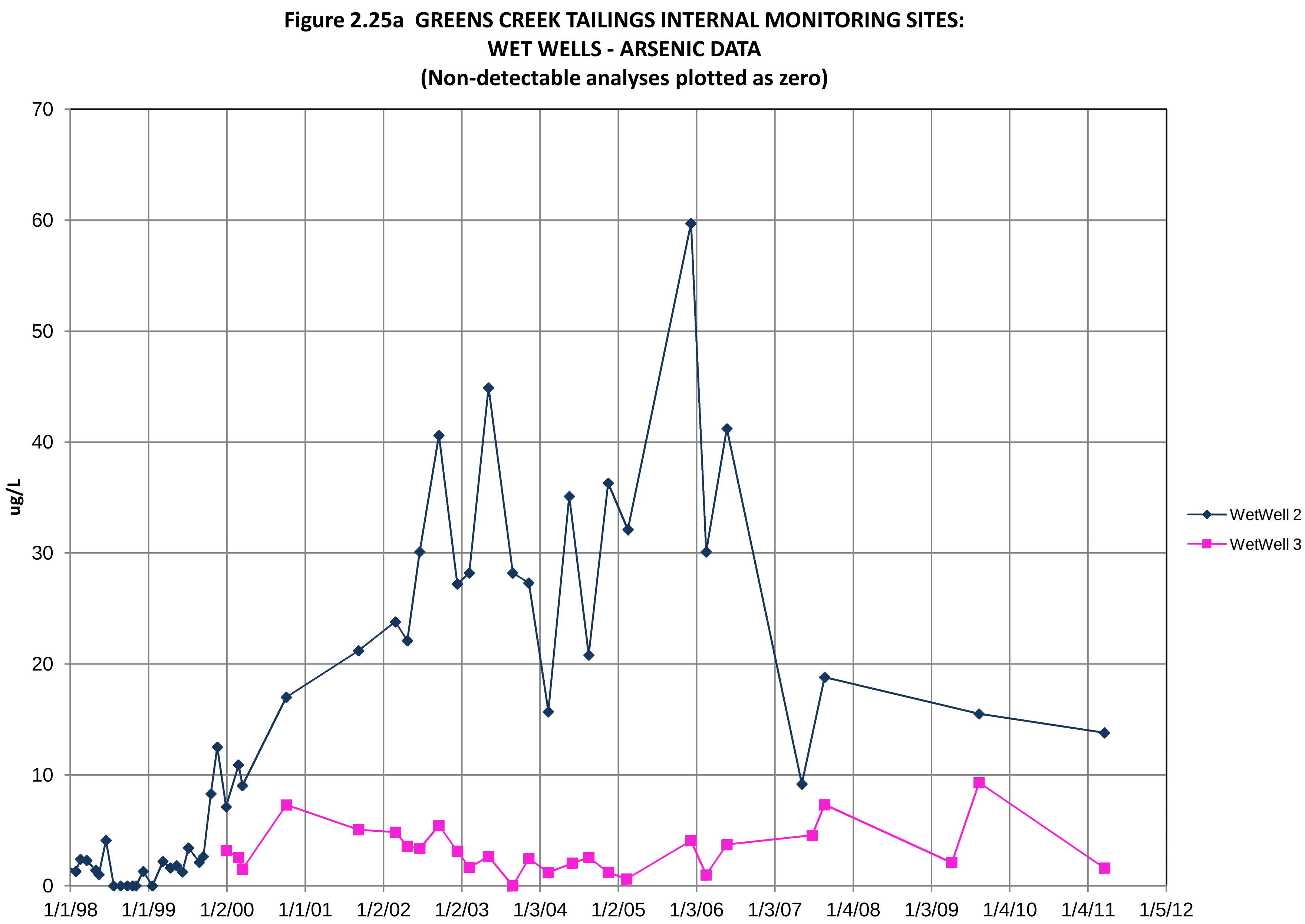


Figure 2.25a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - ARSENIC DATA
(Non-detectable analyses plotted as zero)
ug/L
70
60
50
40
30
20
10
0
1/1/98
1/1/99
1/2/00
1/1/01
1/2/02
1/2/03
1/3/04
1/2/05
1/3/06
1/3/07
1/4/08
1/3/09
1/4/10
1/4/11
1/5/12
WetWell 2
WetWell 3

Figure 2.25b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ARSENIC DATA (Non-detectable analyses plotted as zero)

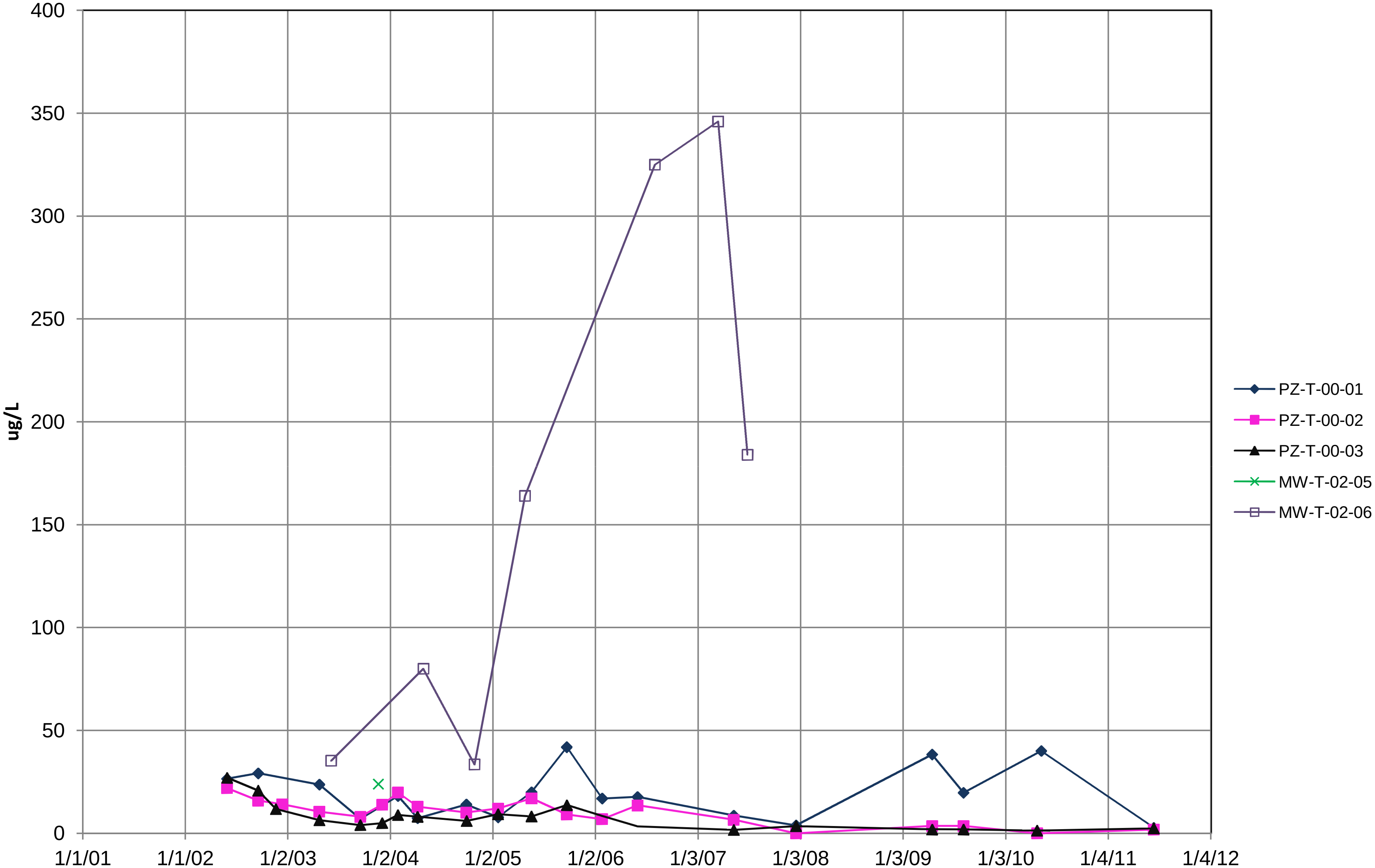


Figure 2.25c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - ARSENIC DATA (Non-detectable analyses plotted as zero)

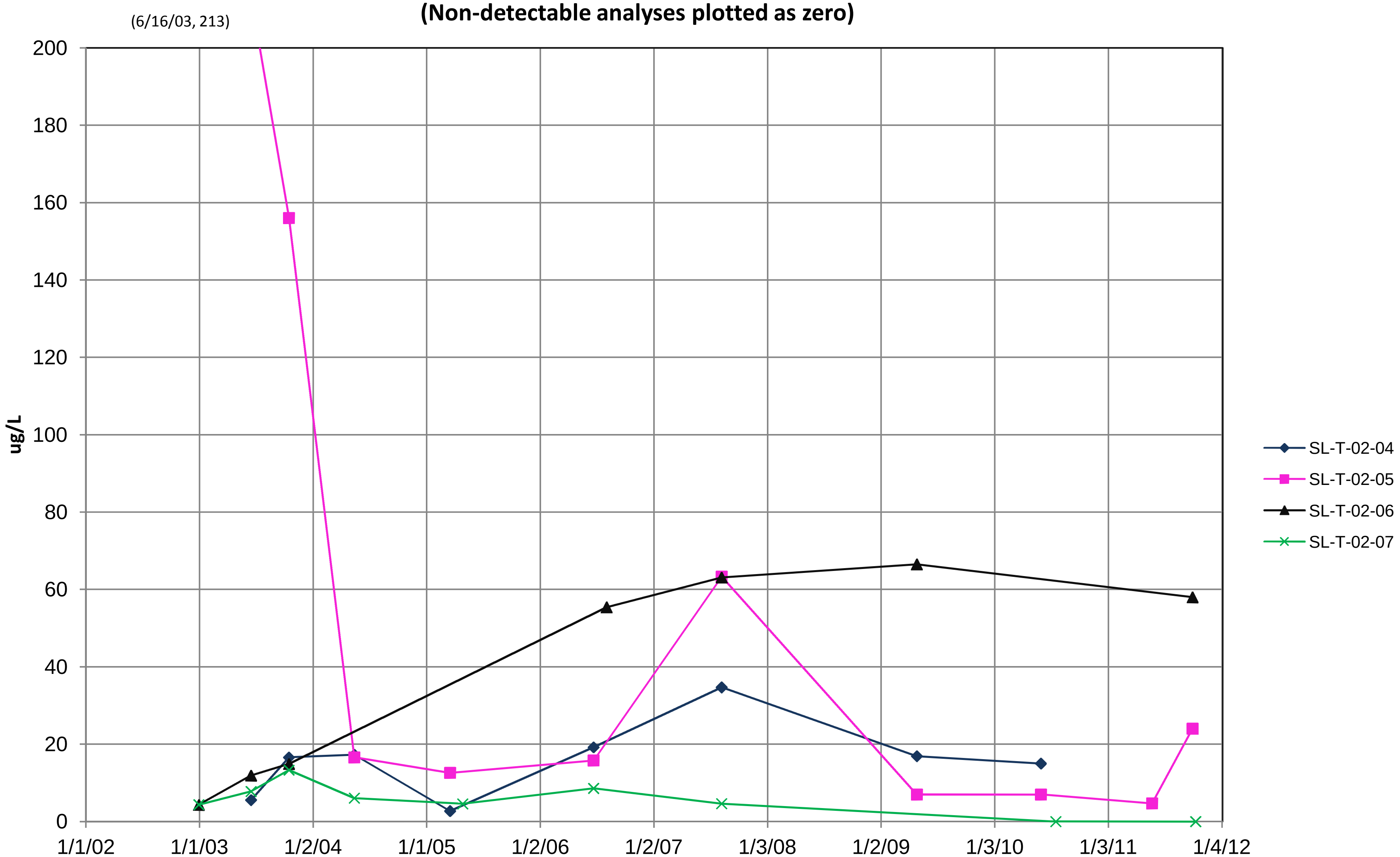


Figure 2.26a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - ZINC DATA (Non-detectable analyses plotted as zero)

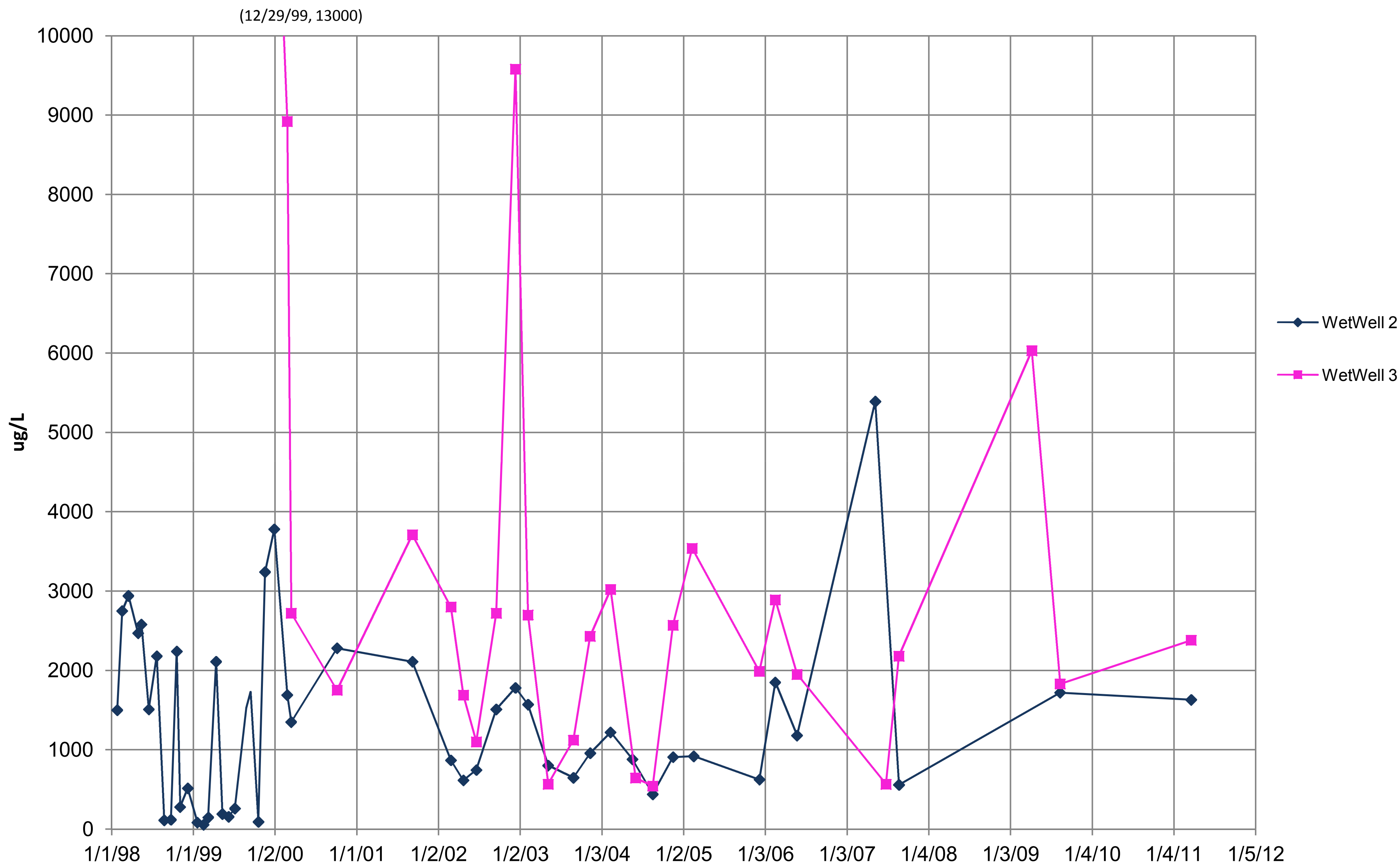


Figure 2.26b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - ZINC DATA (Non-detectable analyses plotted as zero)

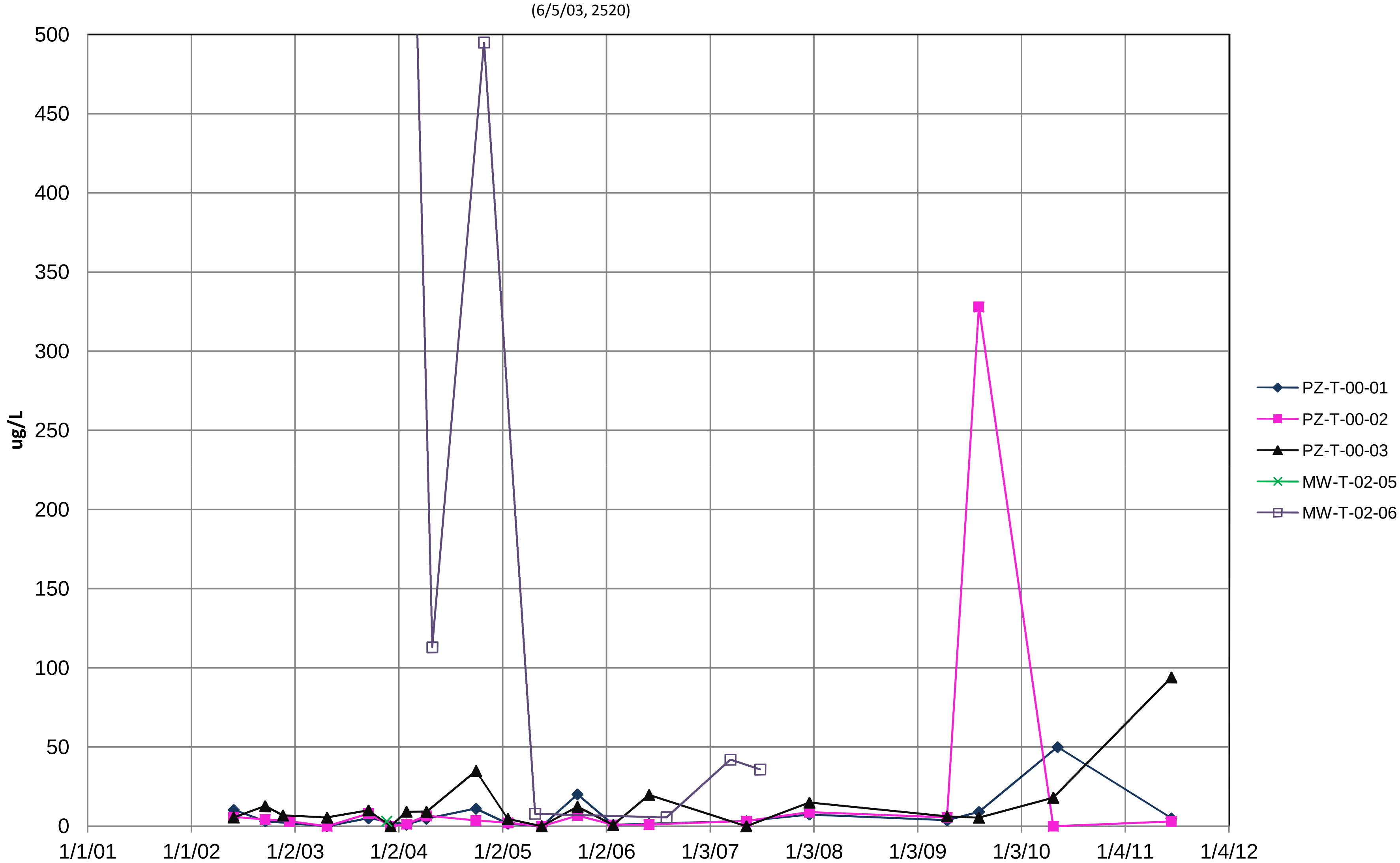


Figure 2.26c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - ZINC DATA
(Primary and secondary y axis: Non-detectable analysis plotted as zero)

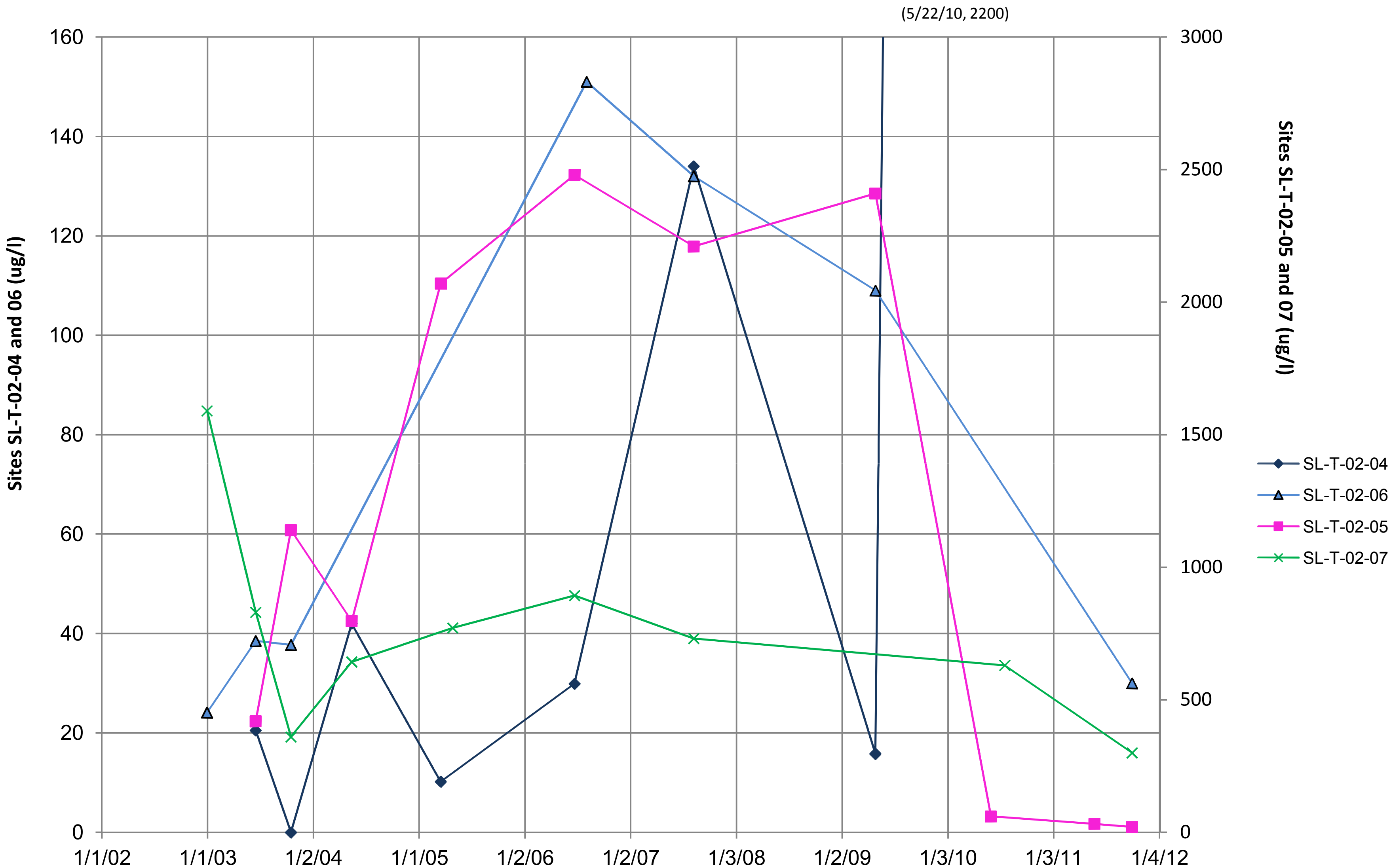


Figure 2.27a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - COPPER DATA
(Non-detectable analyses plotted as zero)

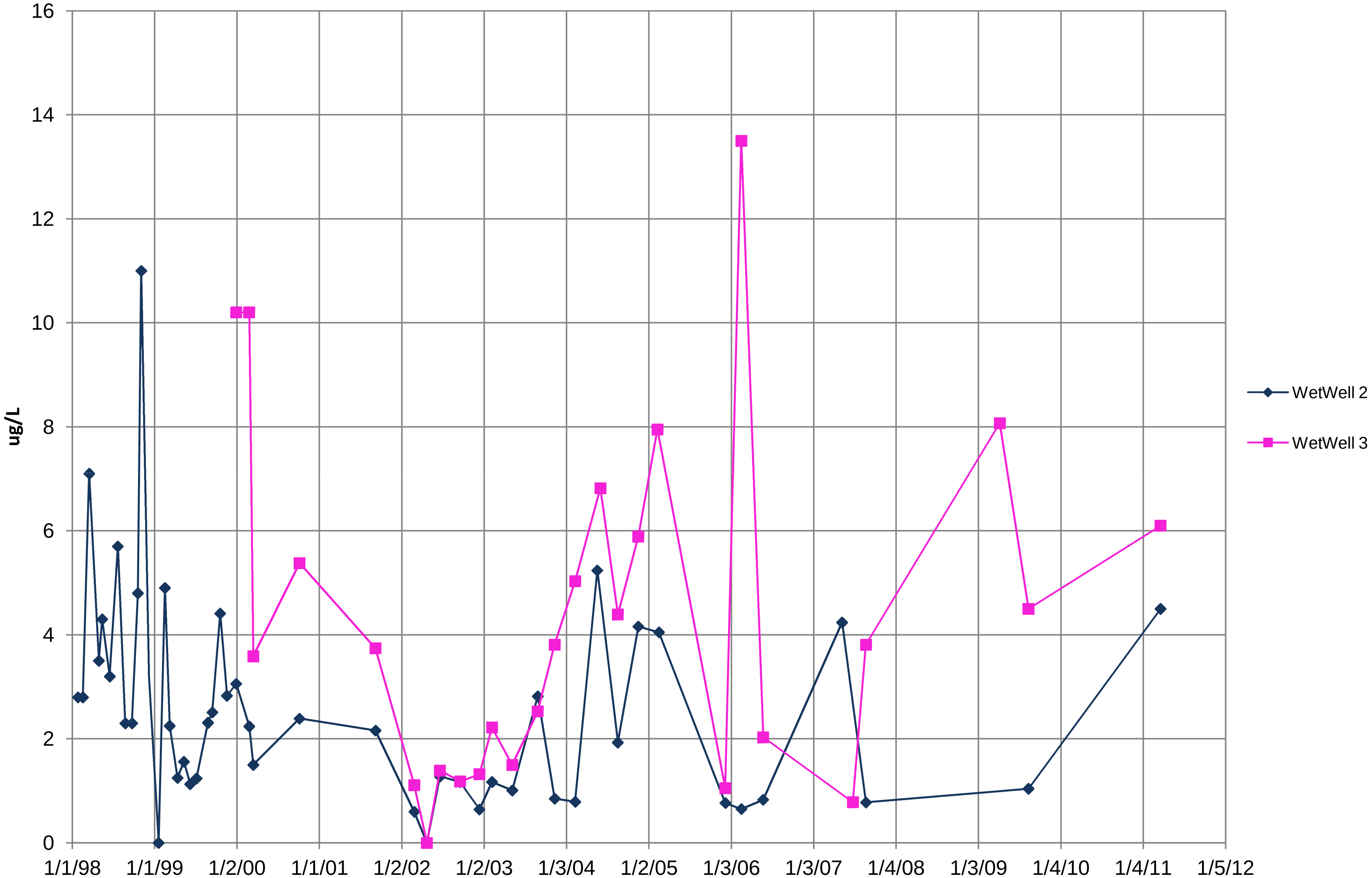


Figure 2.27b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - COPPER DATA (Non-detectable analyses platted as zero)

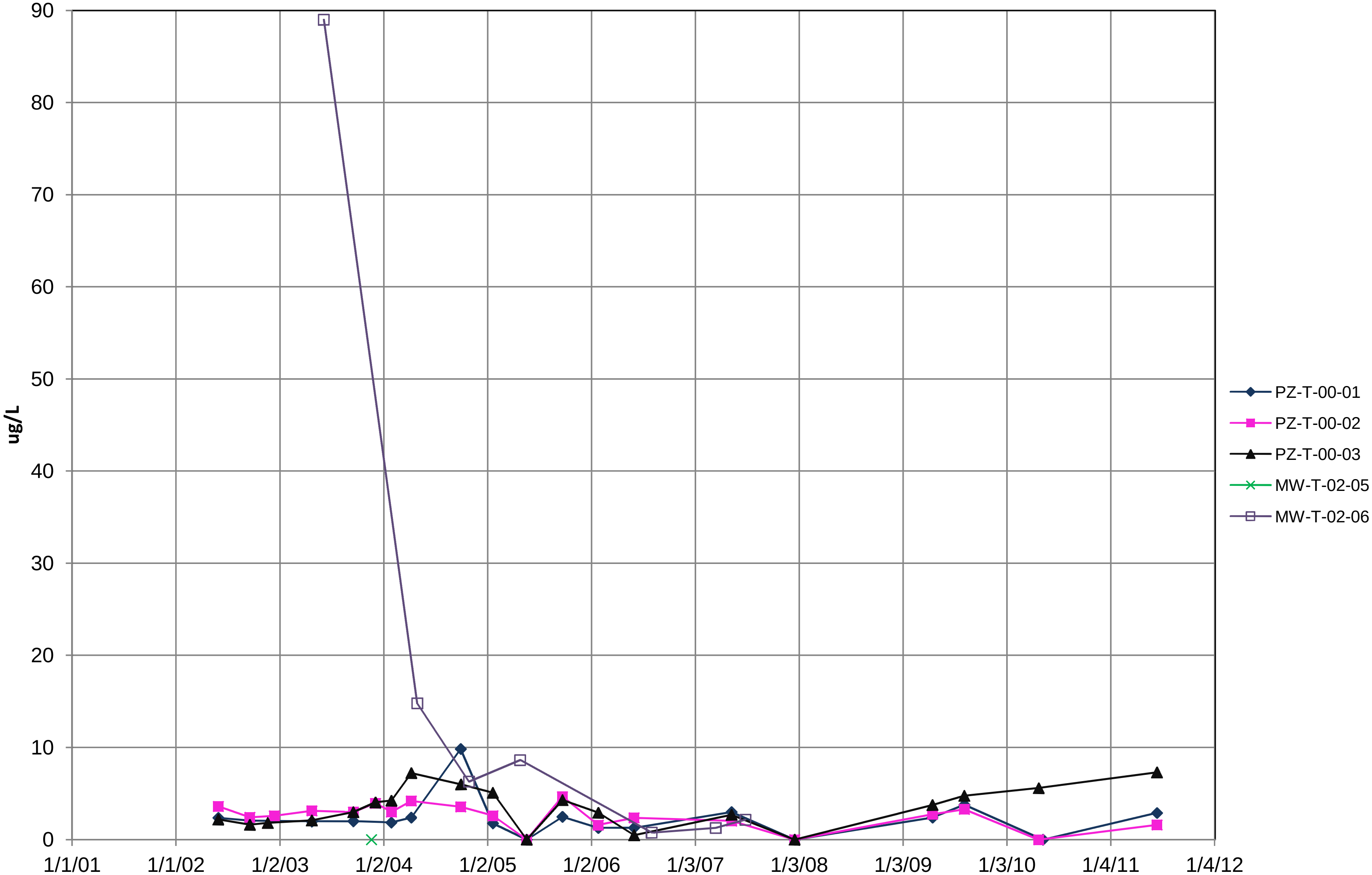


Figure 2.27c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - COPPER DATA (Non-detectable analyses plotted as zero)

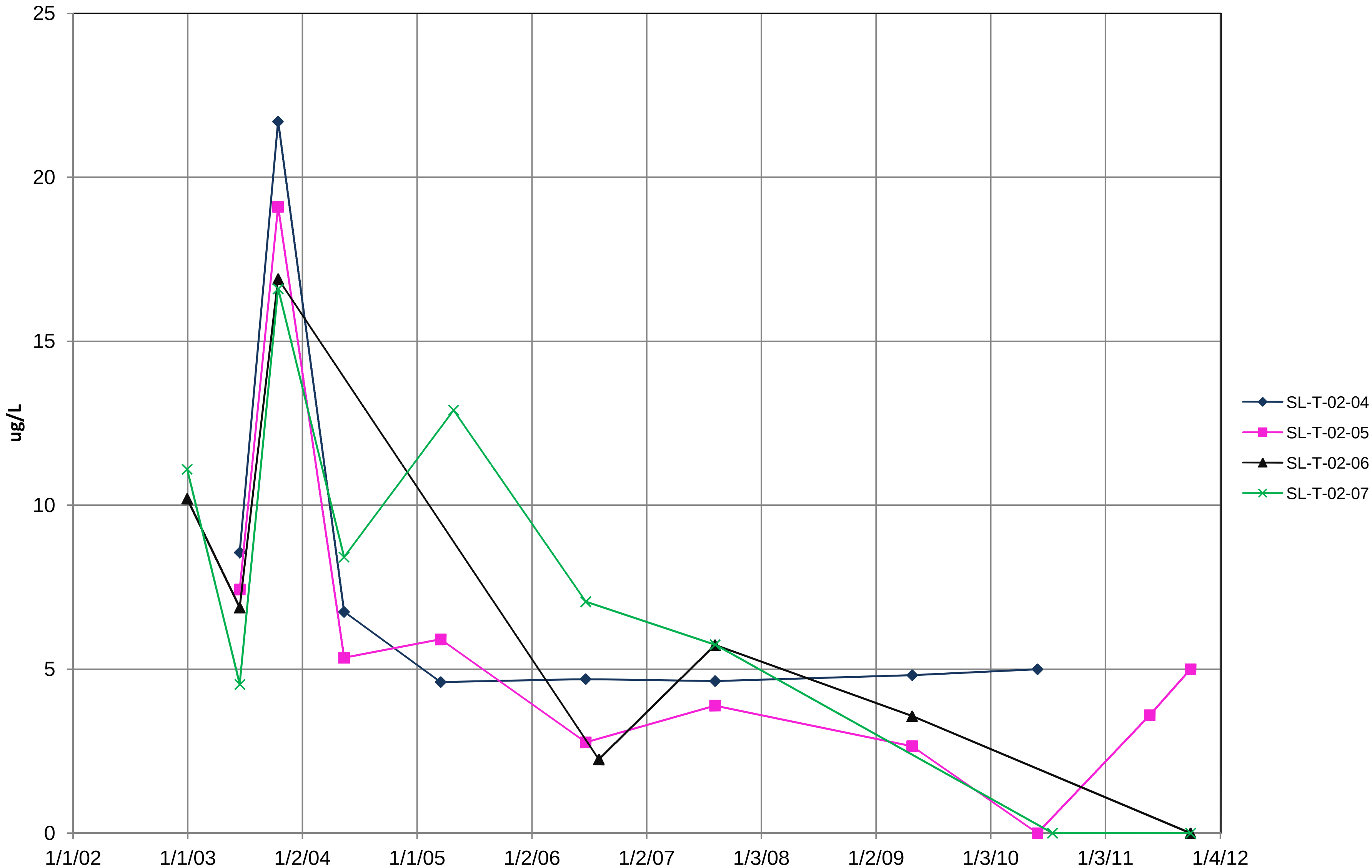


Figure 2.28a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - LEAD DATA (Non-detectable analyses plotted as zero)

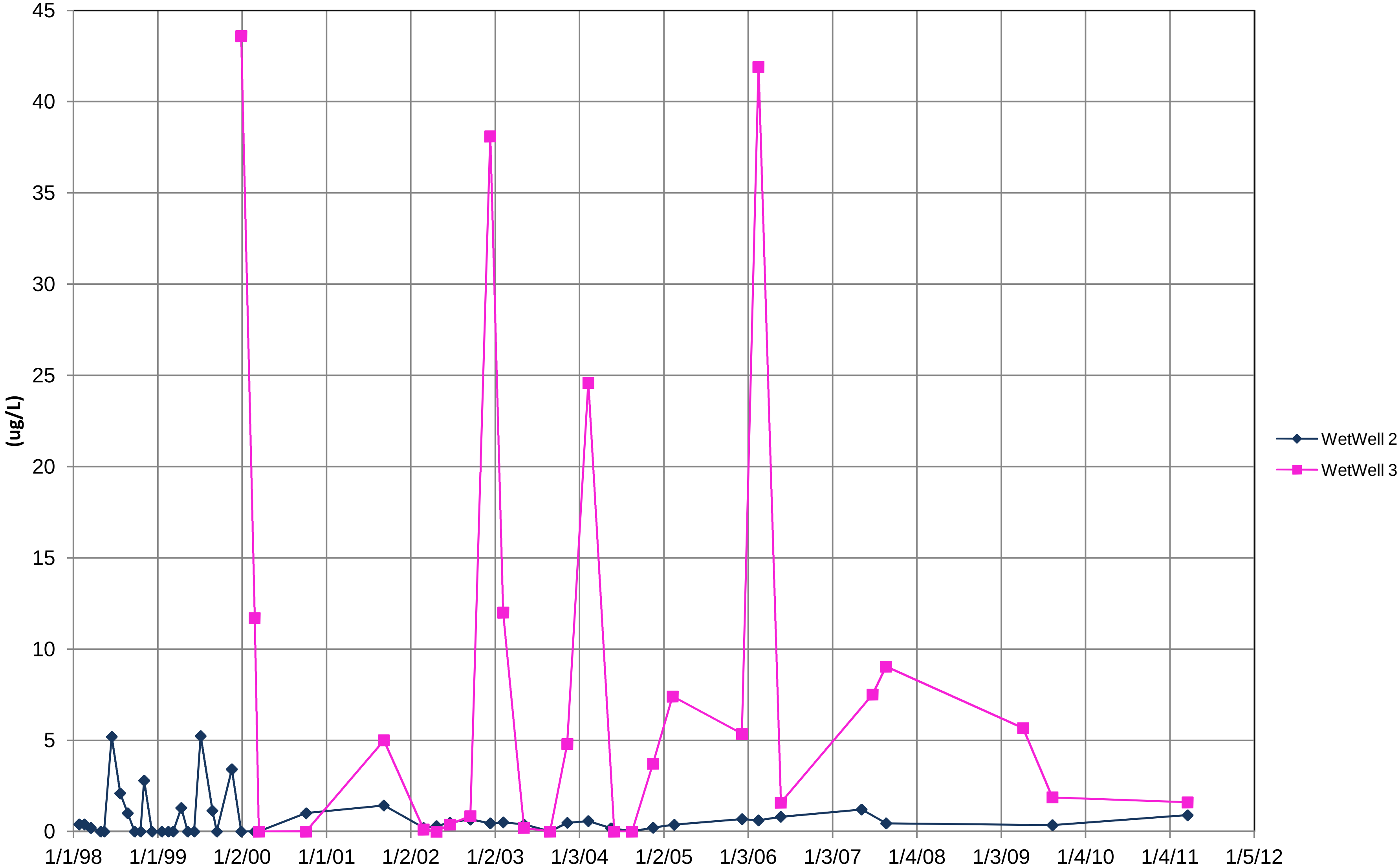


Figure 2.28b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - LEAD DATA (Non-detectable analyses plotted as zero)

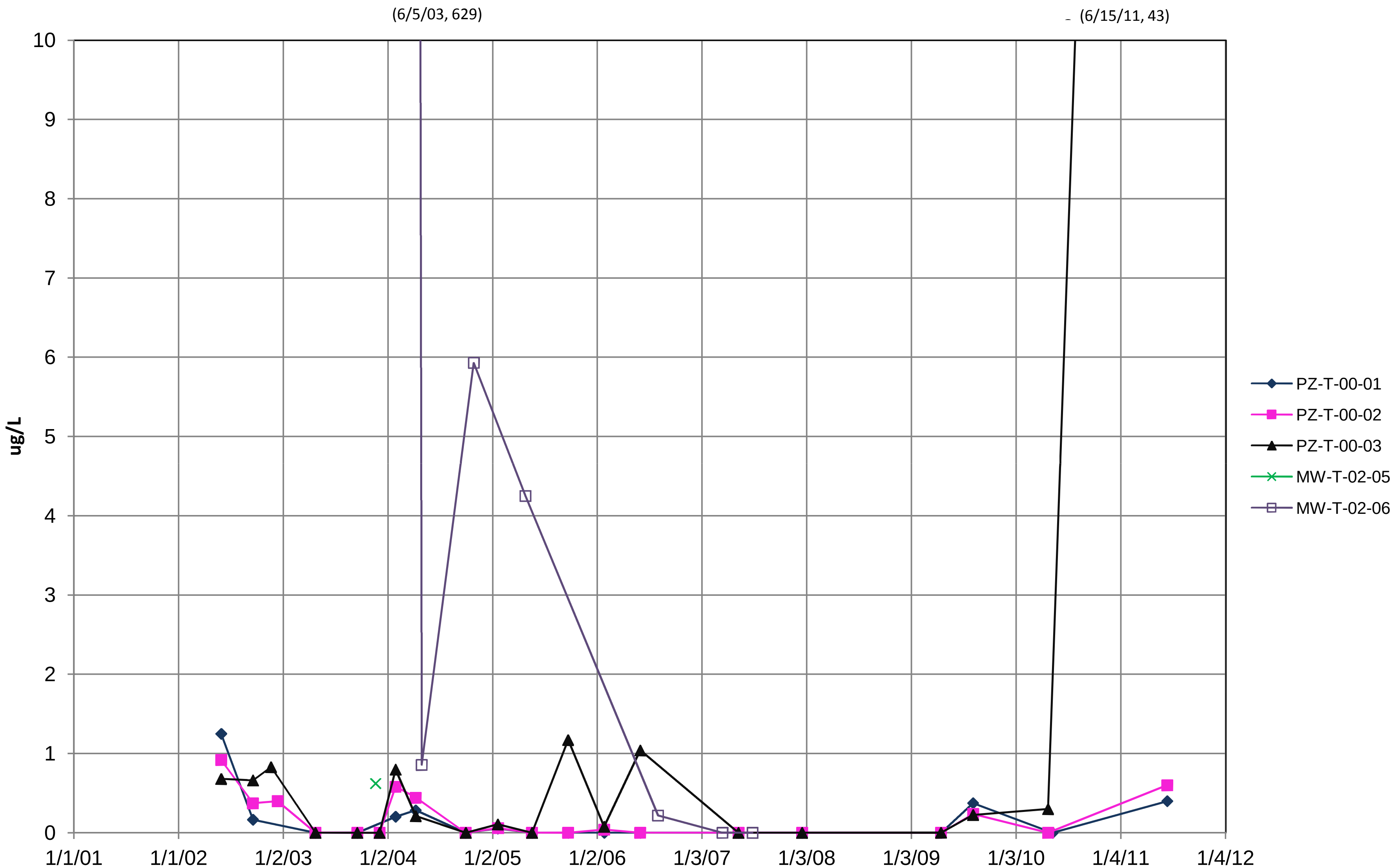


Figure 2.28c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - LEAD DATA (Non-detectable analyses plotted as zero)

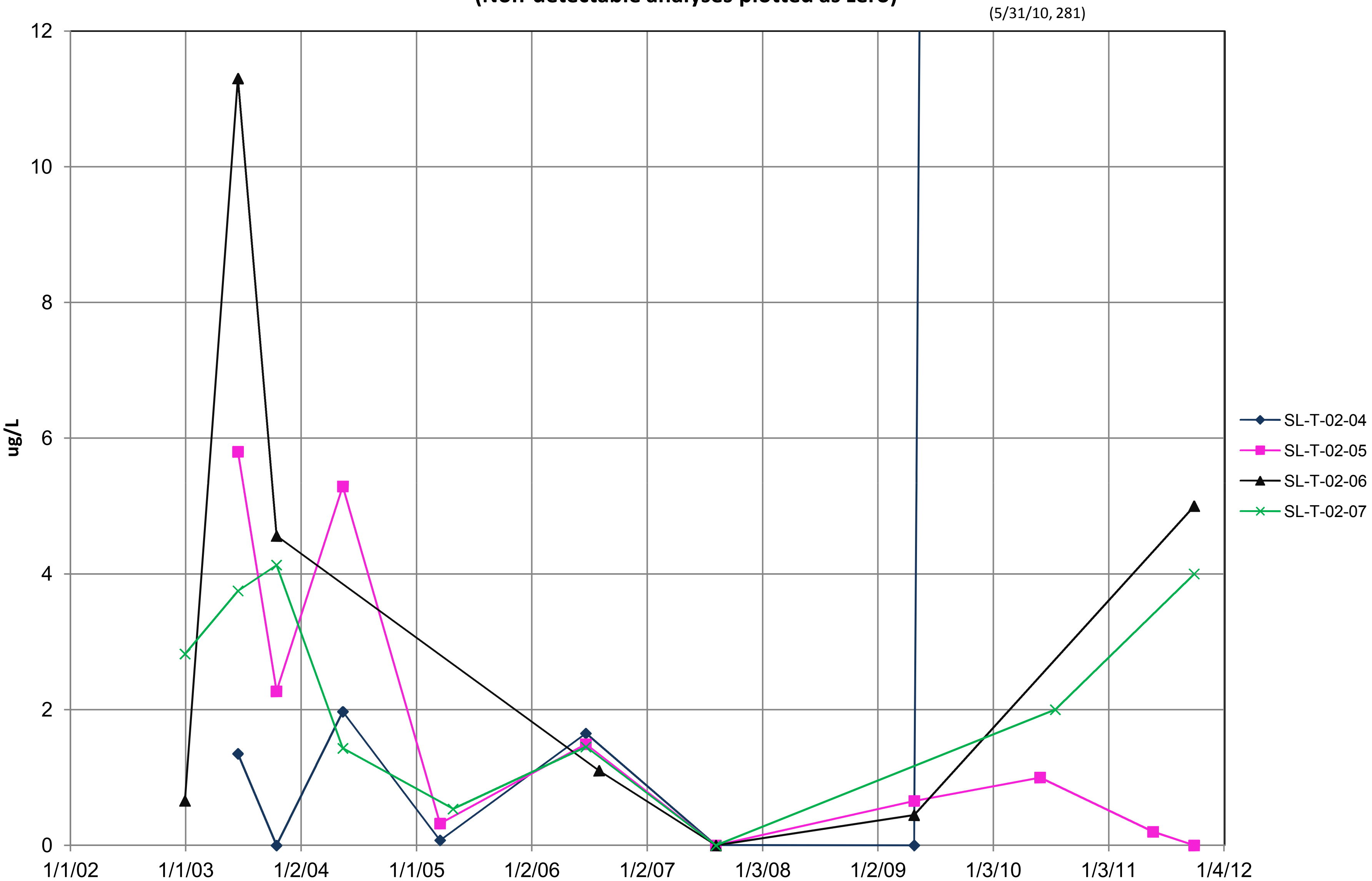


Figure 2.29a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - CADMIUM DATA
(Non-detectable analyses plotted as zero)

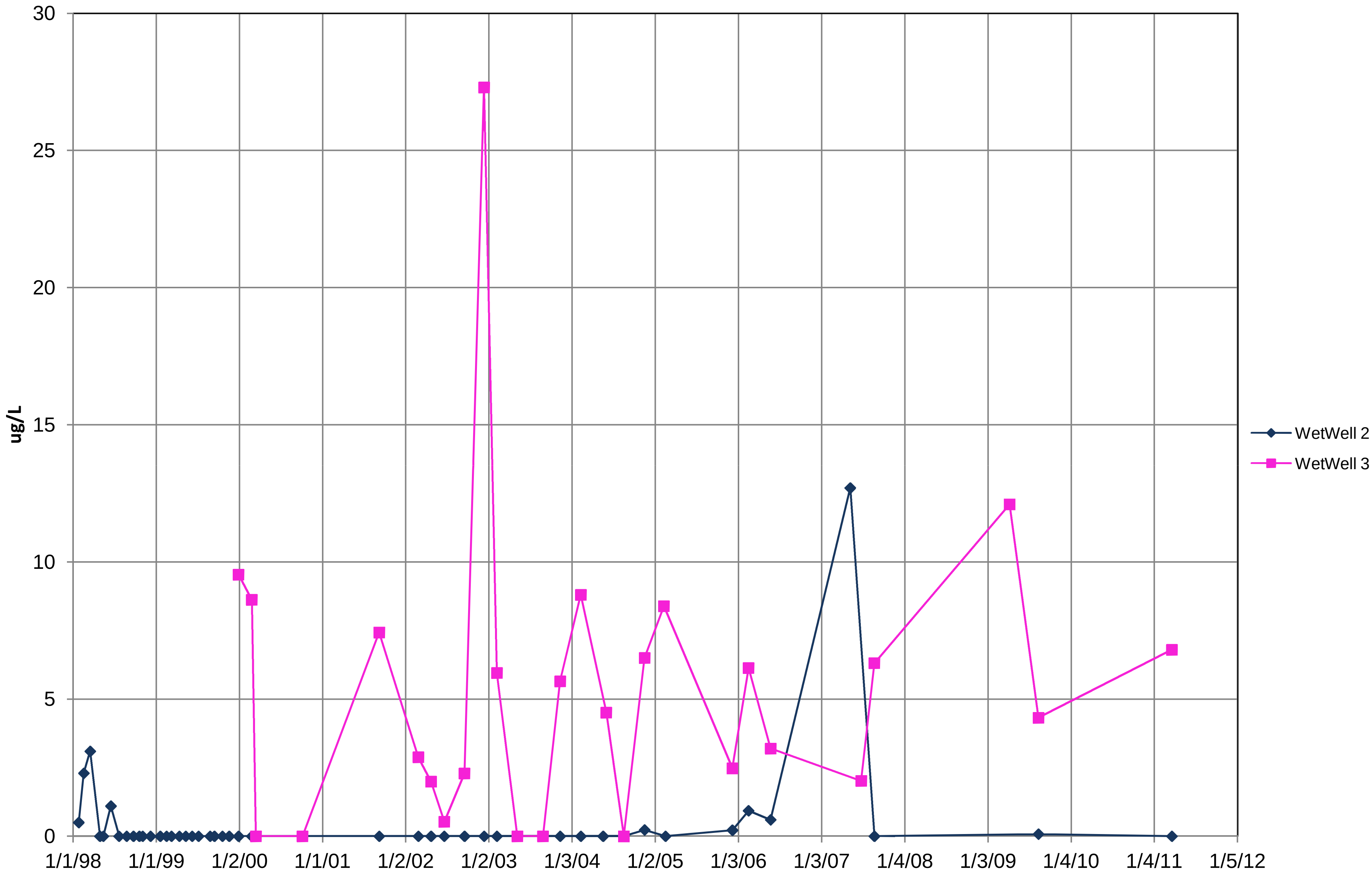


Figure 2.29b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - CADMIUM DATA (Non-detectable analyses plottes as zero)

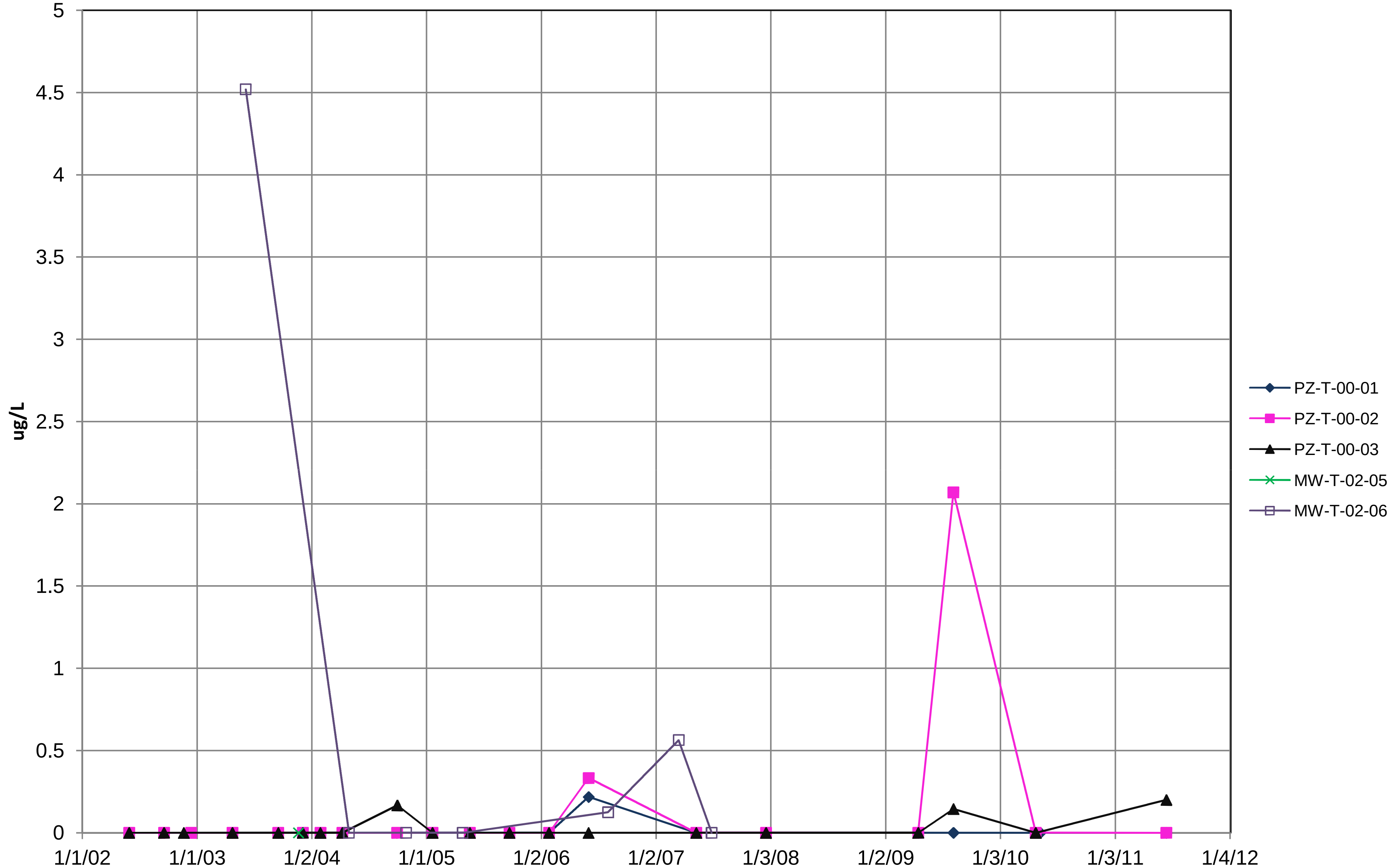
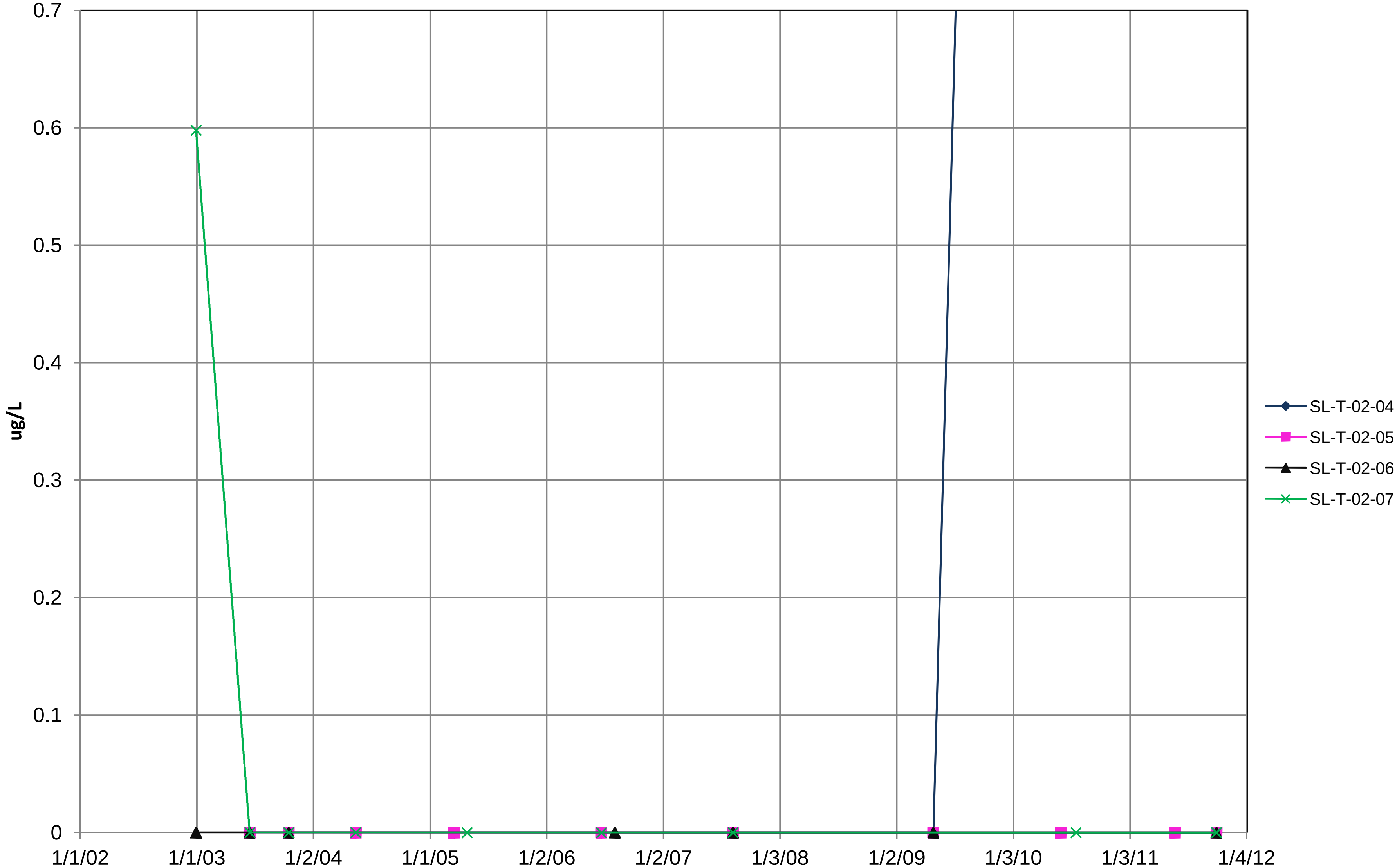


Figure 2.29c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - CADMIUM DATA (Non-detectable analyses plotted as zero)

(5/31/10, 4)



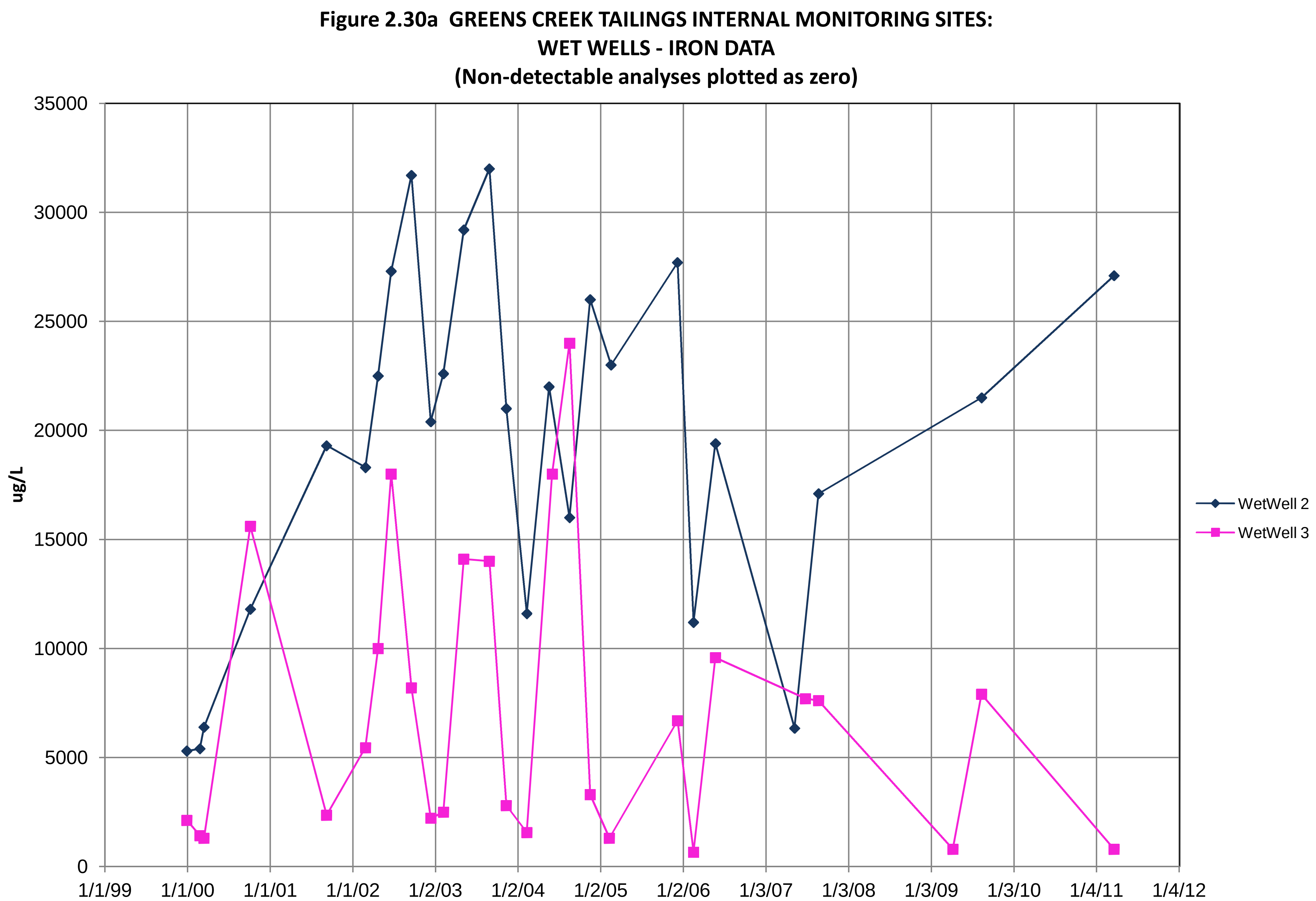


Figure 2.30a GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
WET WELLS - IRON DATA
(Non-detectable analyses plotted as zero)
ug/L
35000
30000
25000
20000
15000
10000
5000
0
1/1/99
1/1/00
1/1/01
1/1/02
1/2/03
1/2/04
1/2/05
1/2/06
1/3/07
1/3/08
1/3/09
1/3/10
1/4/11
1/4/12
WetWell 2
WetWell 3

Figure 2.30b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - IRON DATA
(Non-detectable analyses plotted as zero)

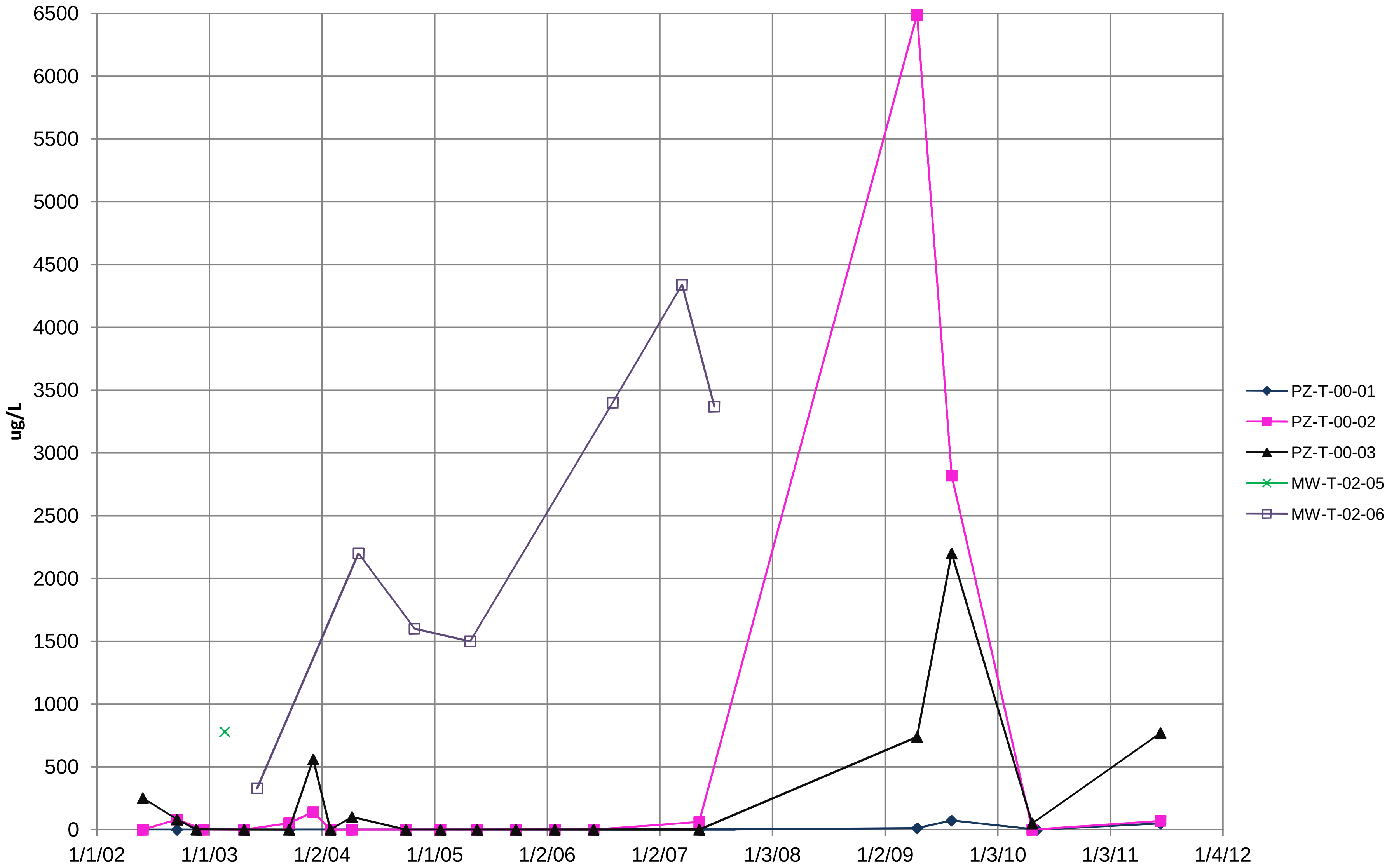


Figure 2.30c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - IRON DATA (Non-detectable analyses plotted as zero)

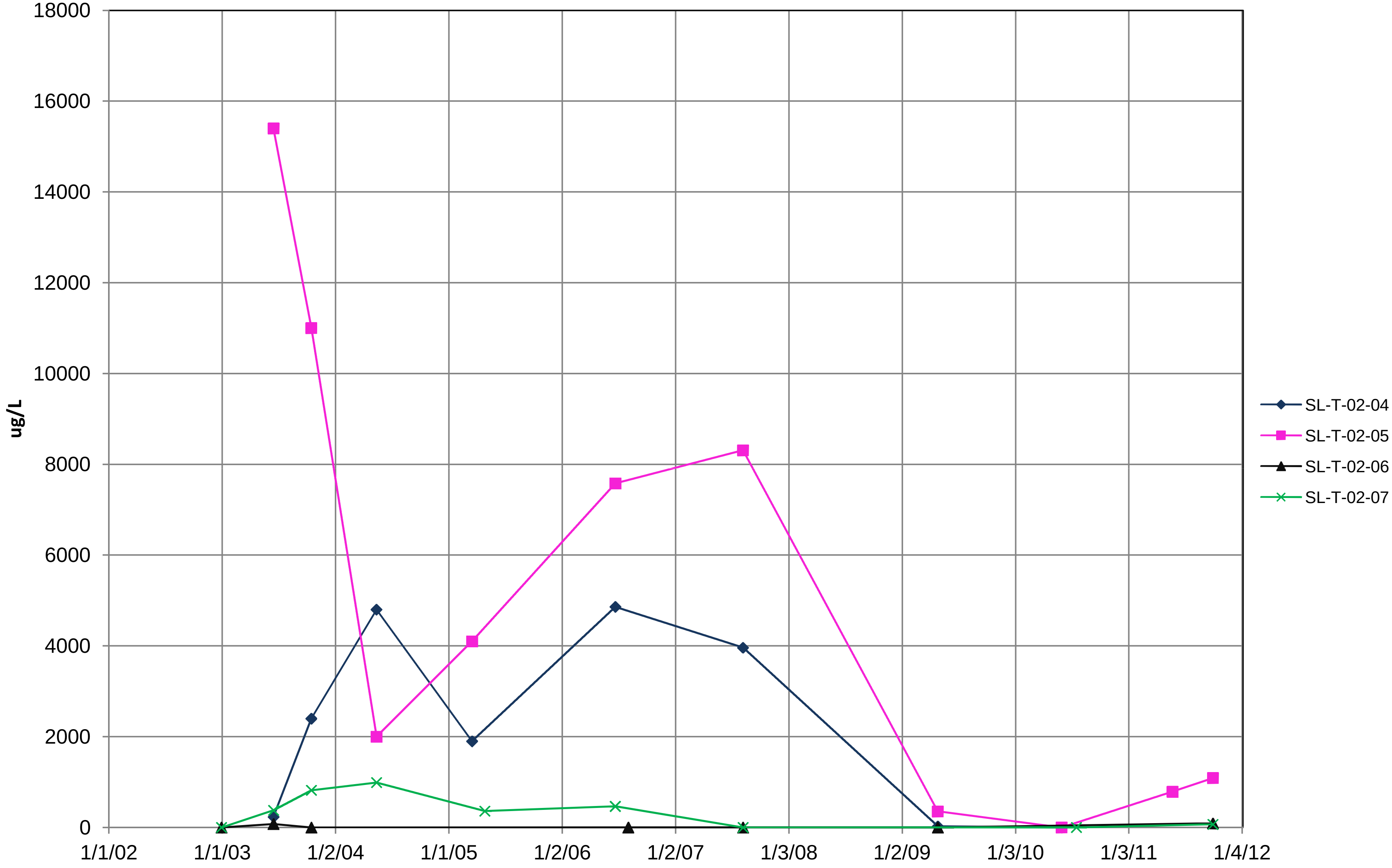


Figure 2.31a GREENS CREEK TAILINGS INTERNAL MONITORING SITES: WET WELLS - MANGANESE DATA (Non-detectable analyses plotted as zero)

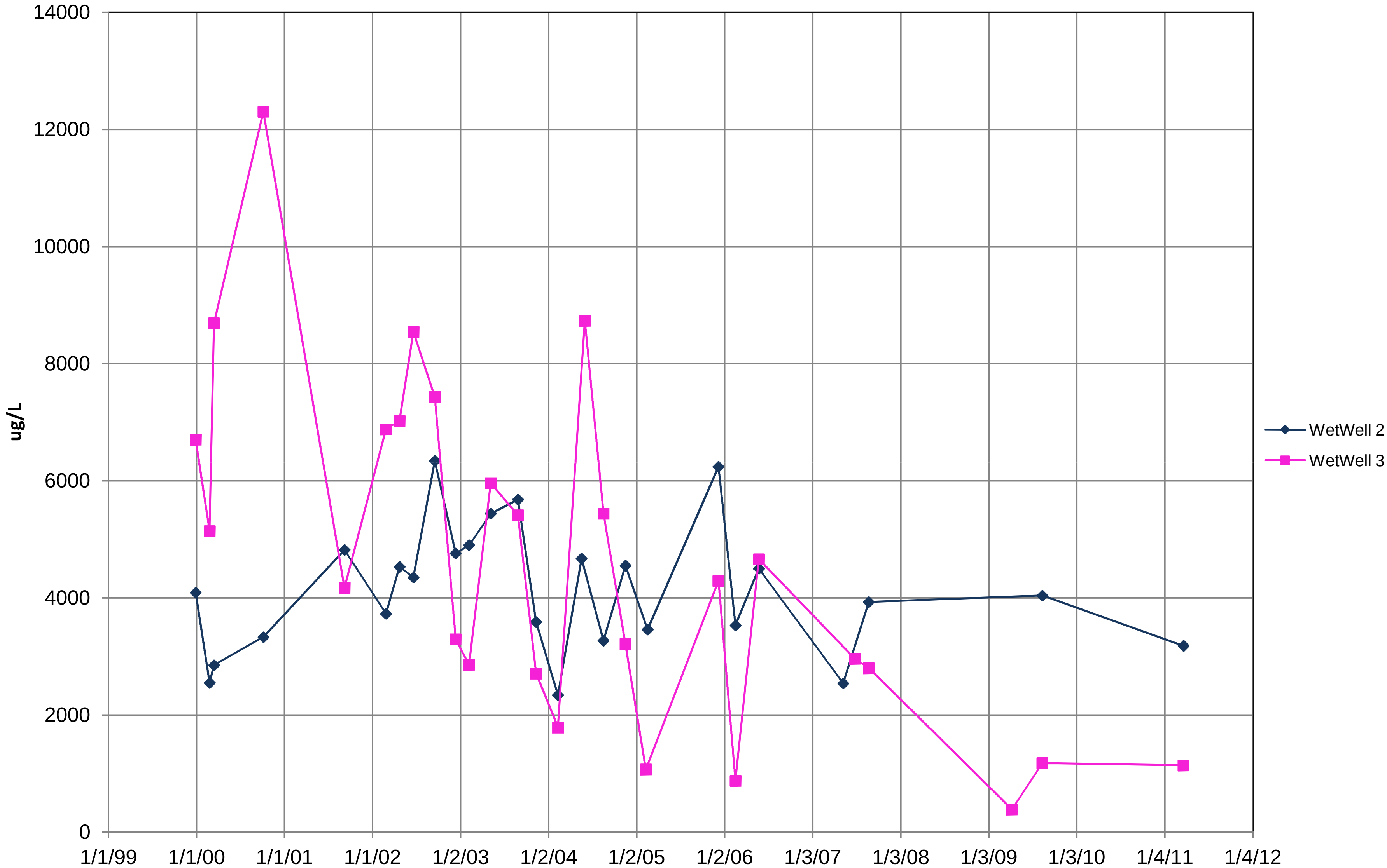


Figure 2.31b GREENS CREEK TAILINGS INTERNAL MONITORING SITES: TAILINGS COMPLETIONS - MANGANESE DATA (Non-detectable analyses plotted as zero)

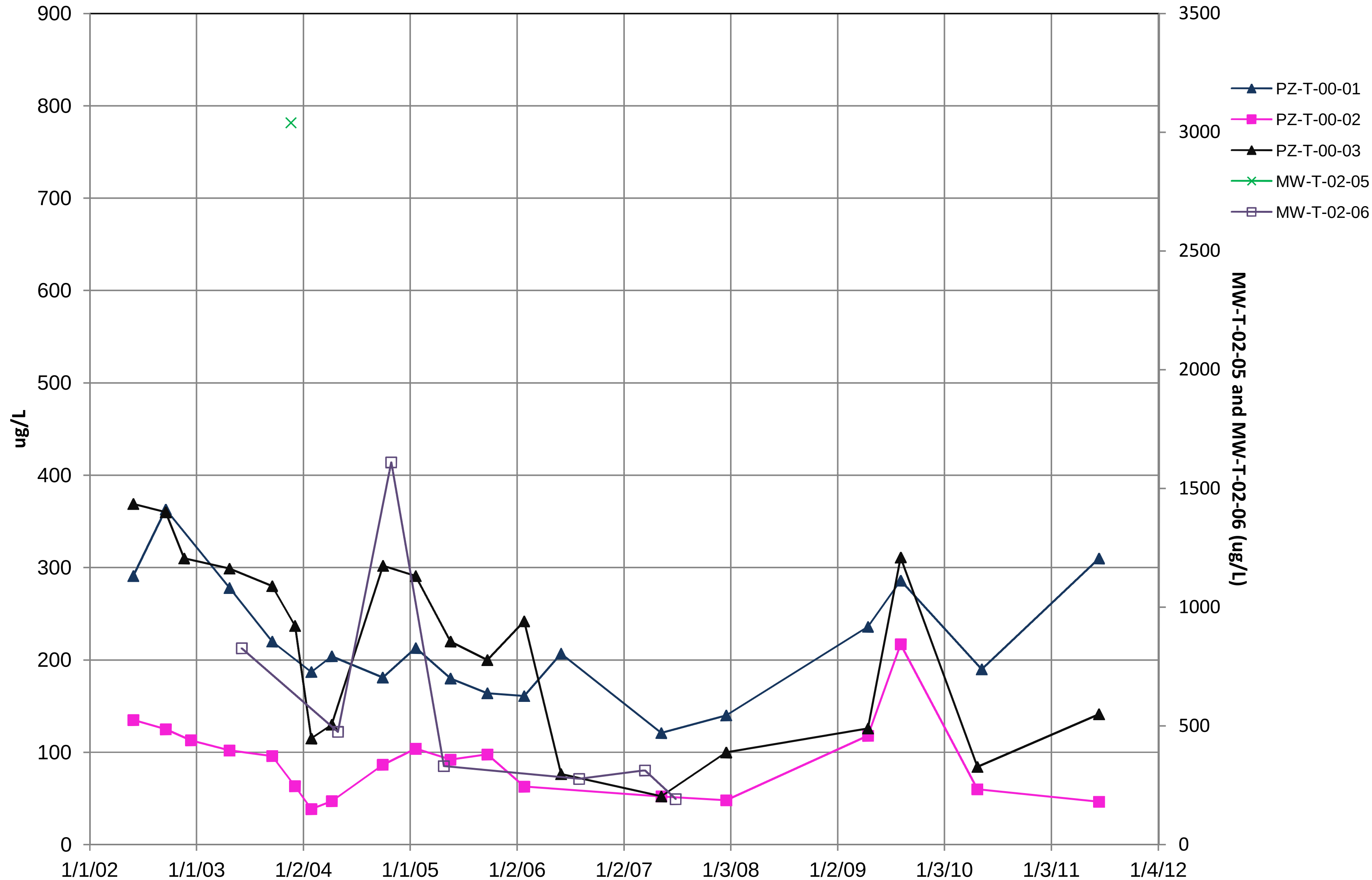


Figure 2.31c GREENS CREEK TAILINGS INTERNAL MONITORING SITES: SUCTION LYSIMETERS - MANGANESE DATA (Non-detectable analyses plotted as zero)

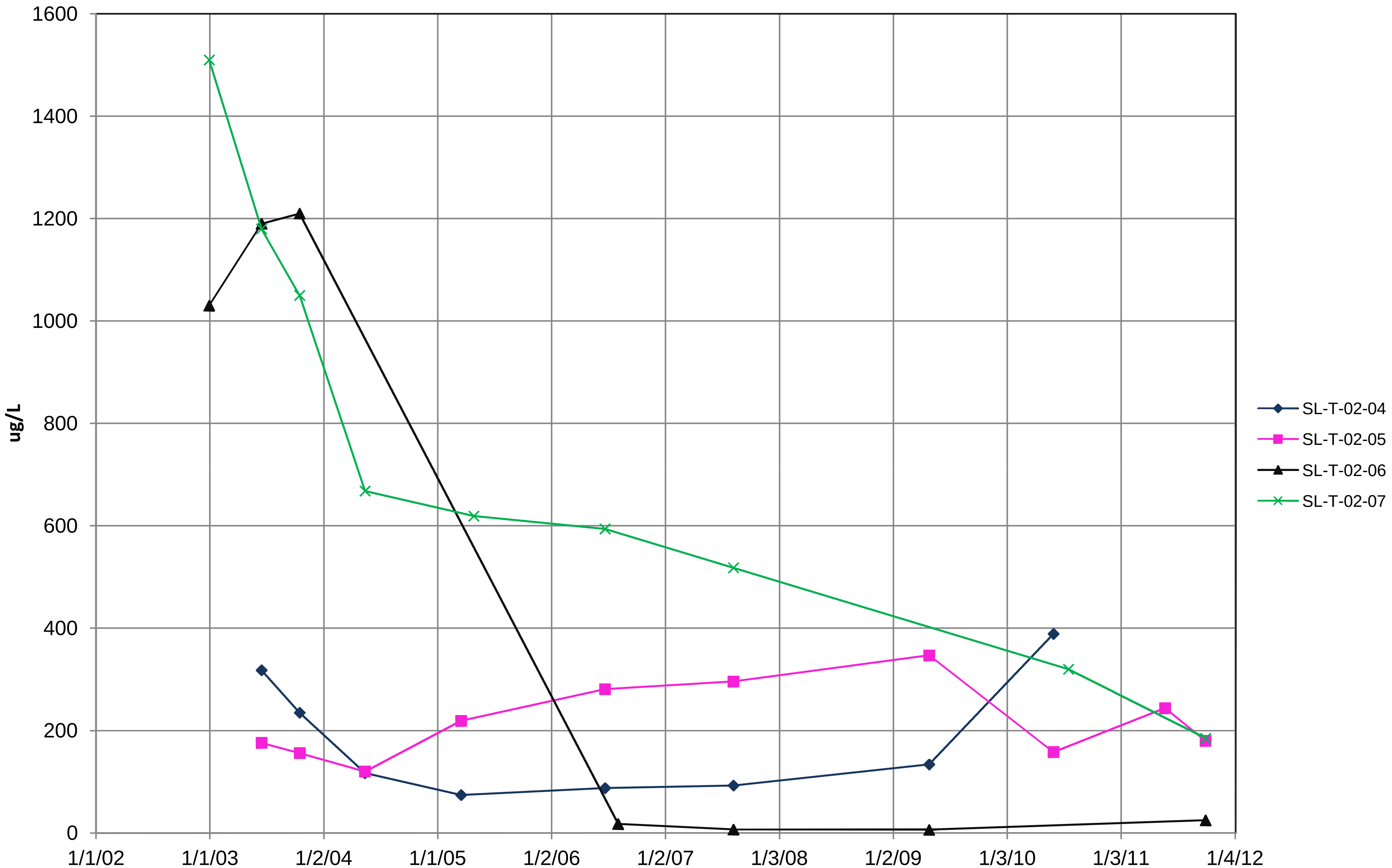


Figure 2.32

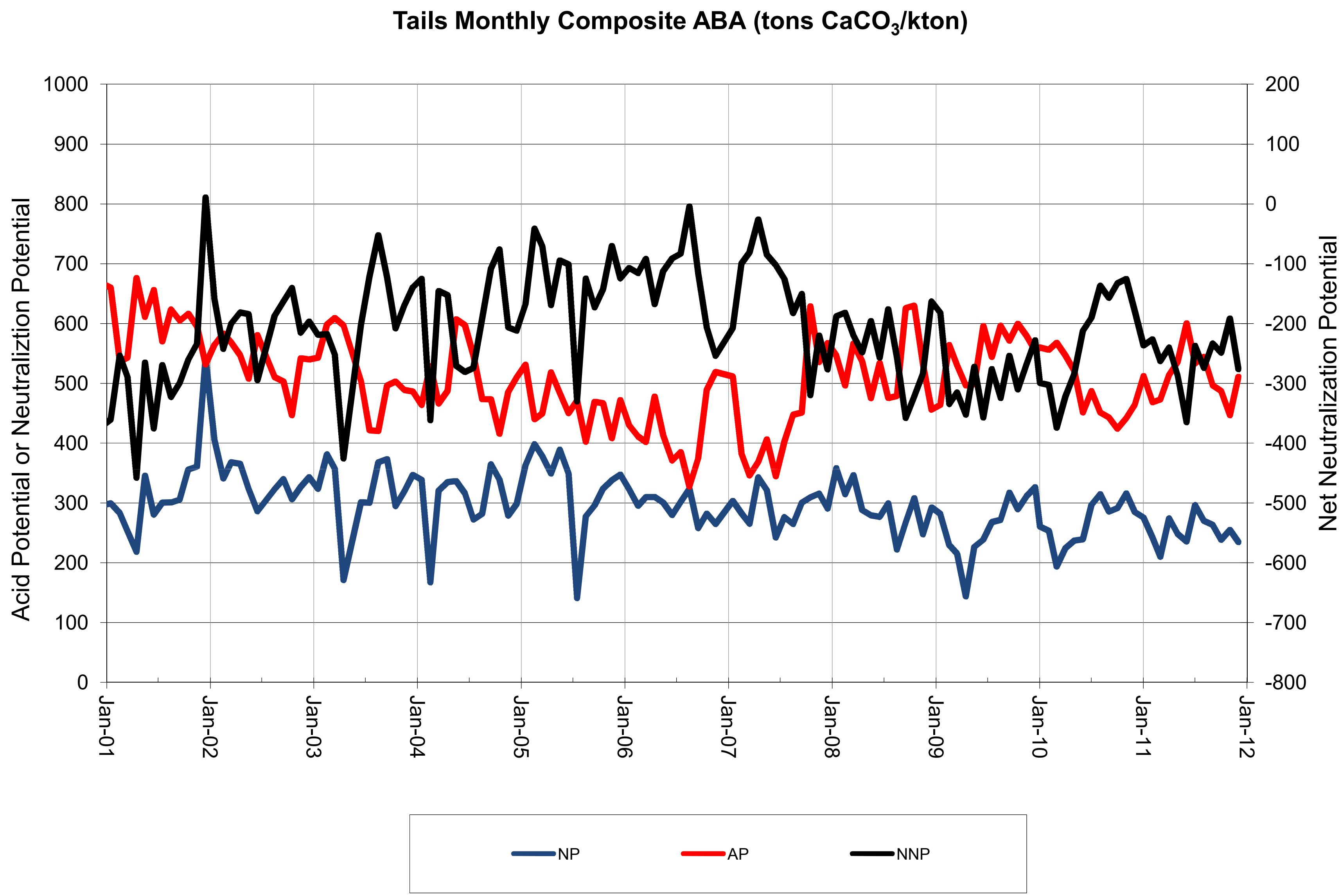

Tails Monthly Composite ABA (tons $CaCO_3$/kton)
Acid Potential or Neutraliztion Potential
Net Neutralization Potential
1000
900
800
700
600
500
400
300
200
100
0
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
NP
AP
NNP

Figure 2.33 Tailings ABA Data

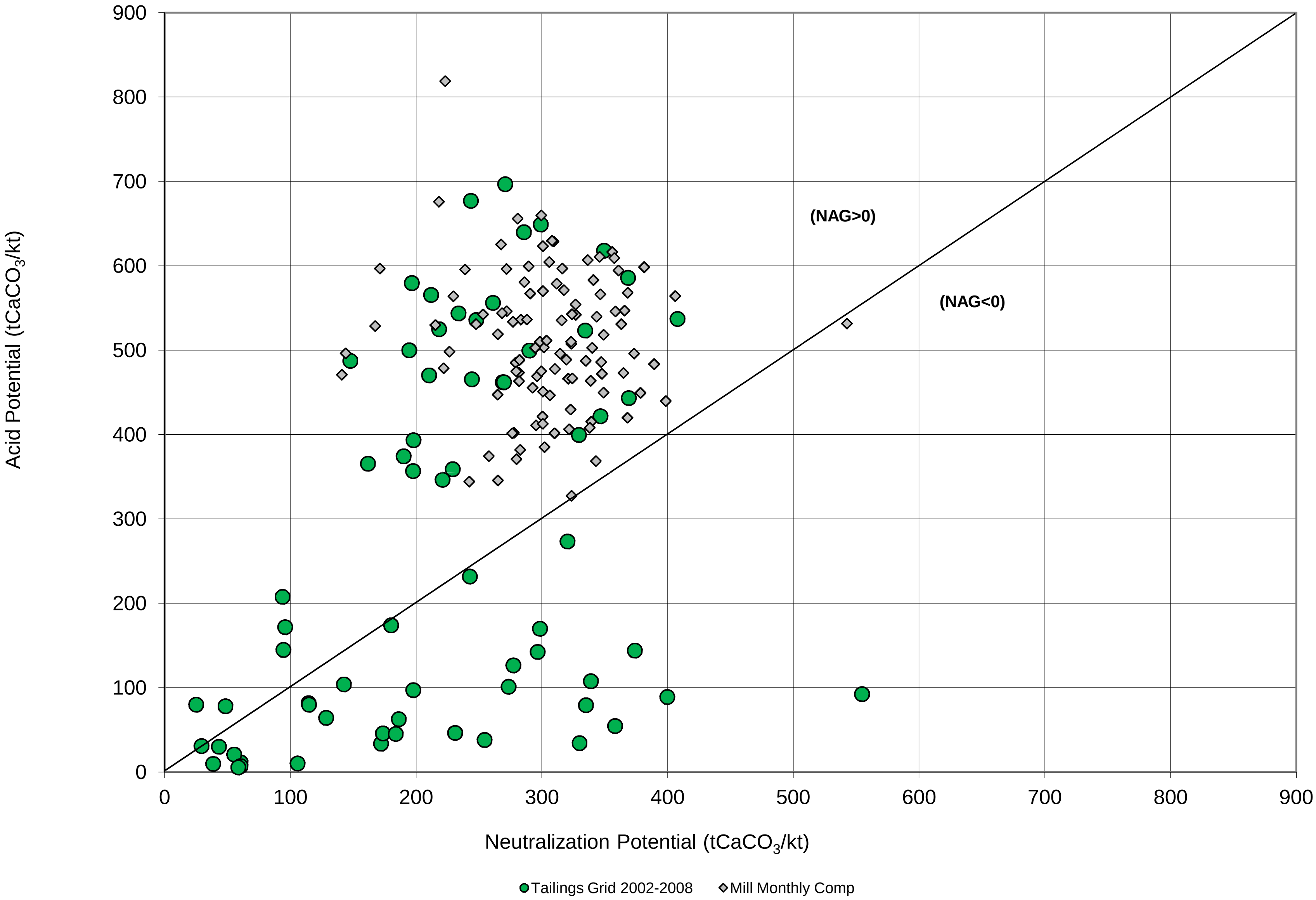


Figure 2.34 Tailings Grid ABA Data

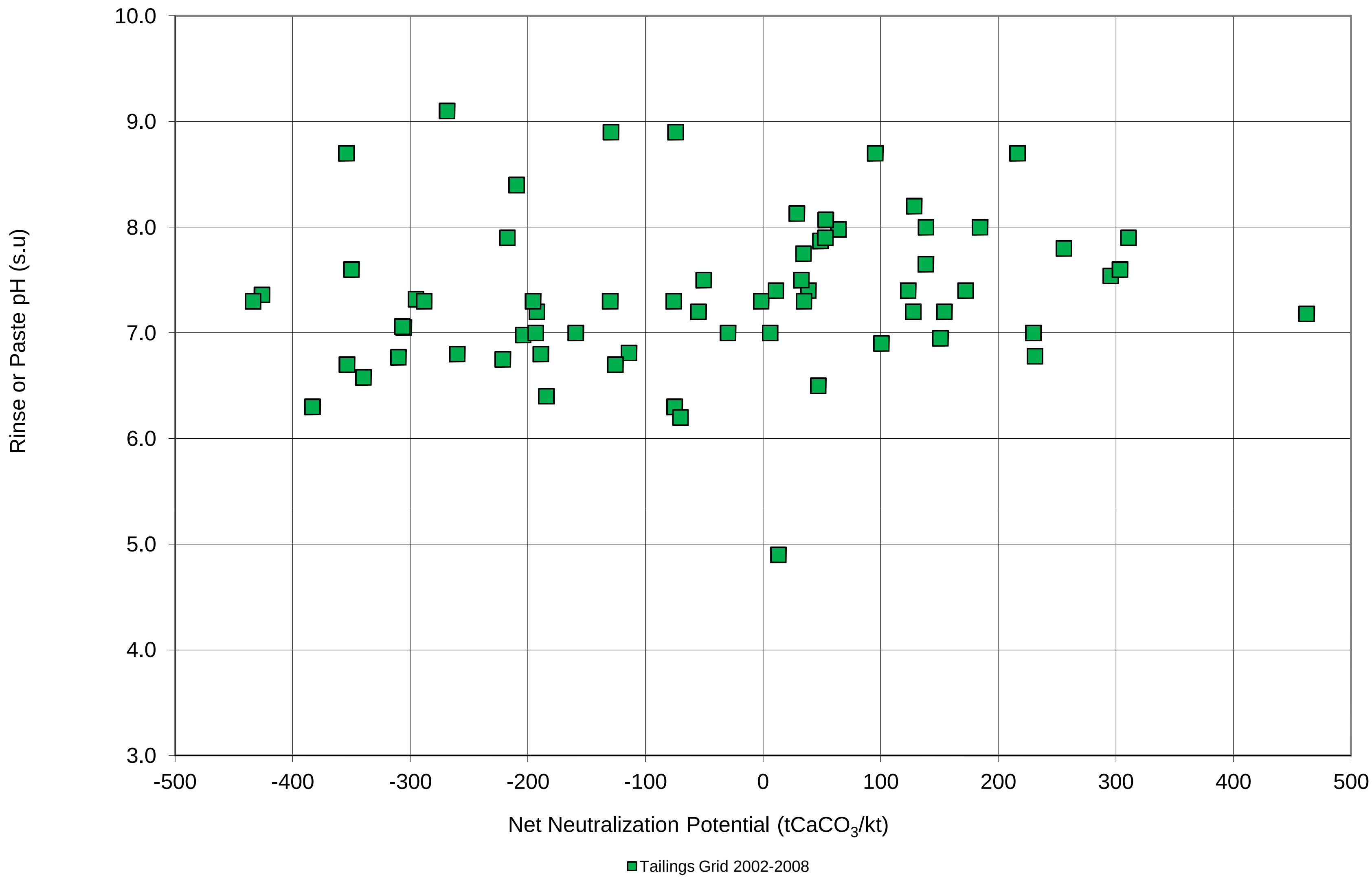
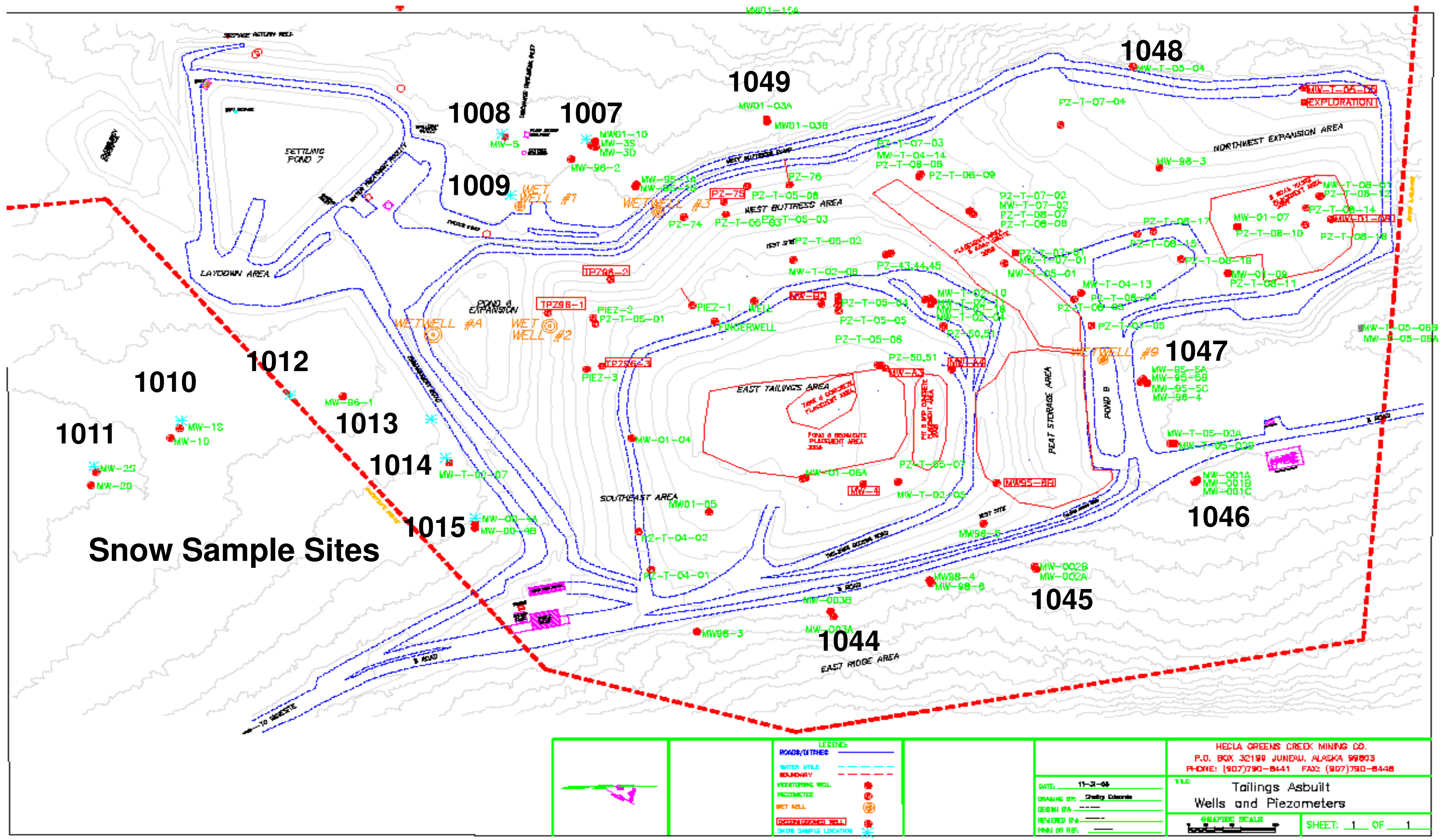


Figure 2.35a Tails Snow Sample Sites



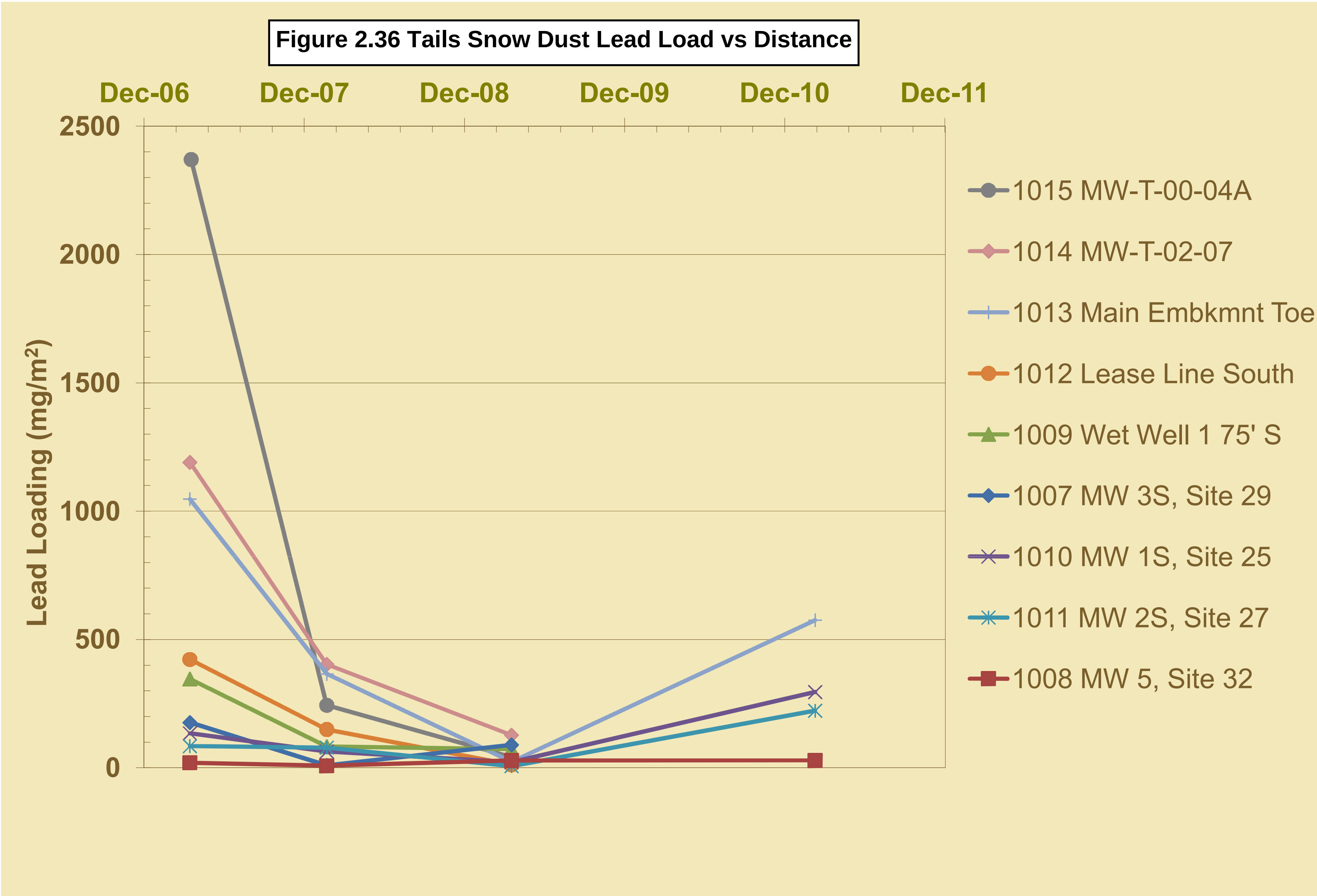


Figure 2.36 Tails Snow Dust Lead Load vs Distance
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
2500
2000
1500
1000
500
0
Lead Loading (mg/m2)
1015 MW-T-00-04A
1014 MW-T-02-07
1013 Main Embkmnt Toe
1012 Lease Line South
1009 Wet Well 1 75' S
1007 MW 3S, Site 29
1010 MW 1S, Site 25
1011 MW 2S, Site 27
1008 MW 5, Site 32

Figure 2.37 Average Daily Load of Lead and Zinc Captured by the Atmoshperic Deposition Pails at the Tailings Facility - South

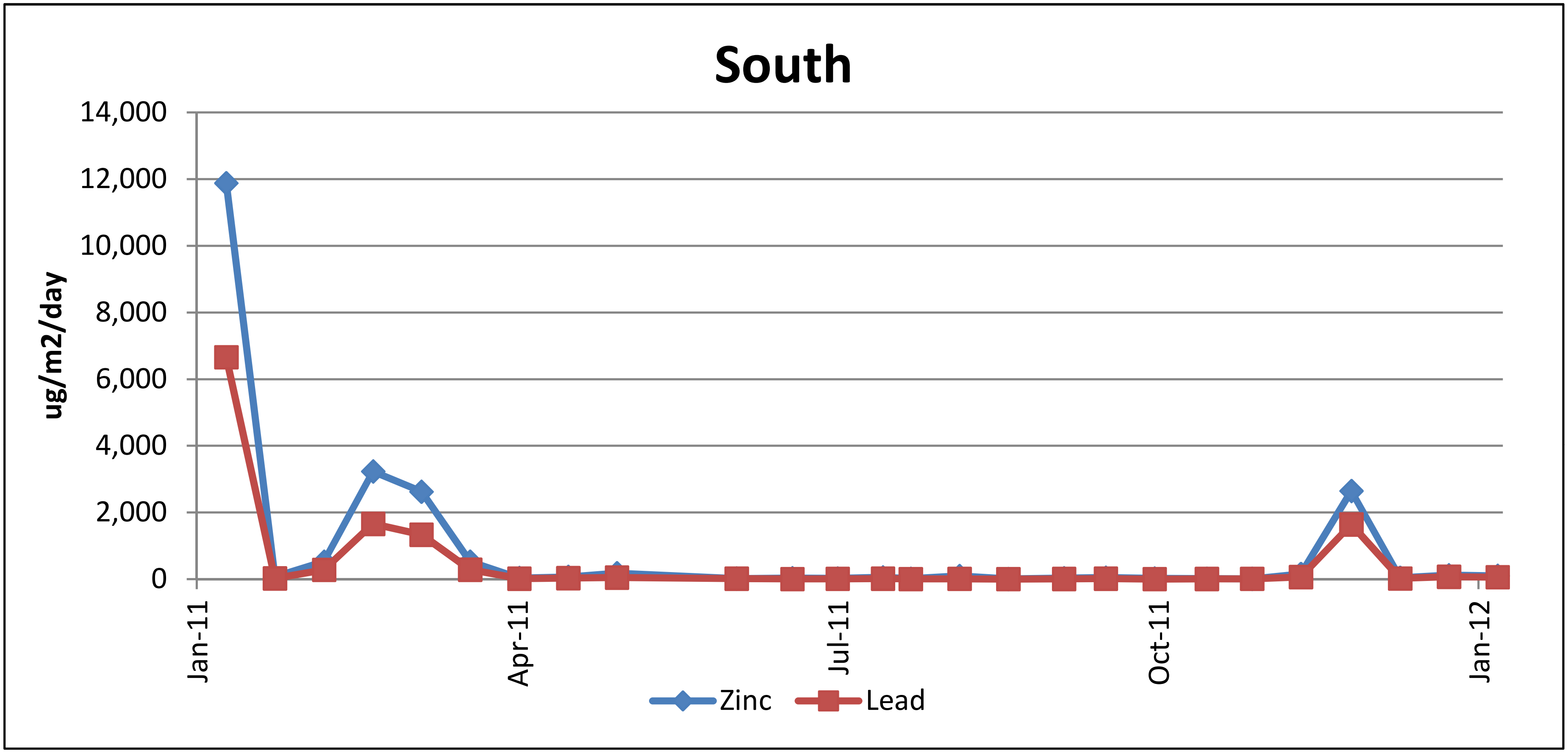


Figure 2.37 Average Daily Load of Lead and Zinc Captured by the Atmoshperic Deposition Pails at the Tailings Facility - Southwest

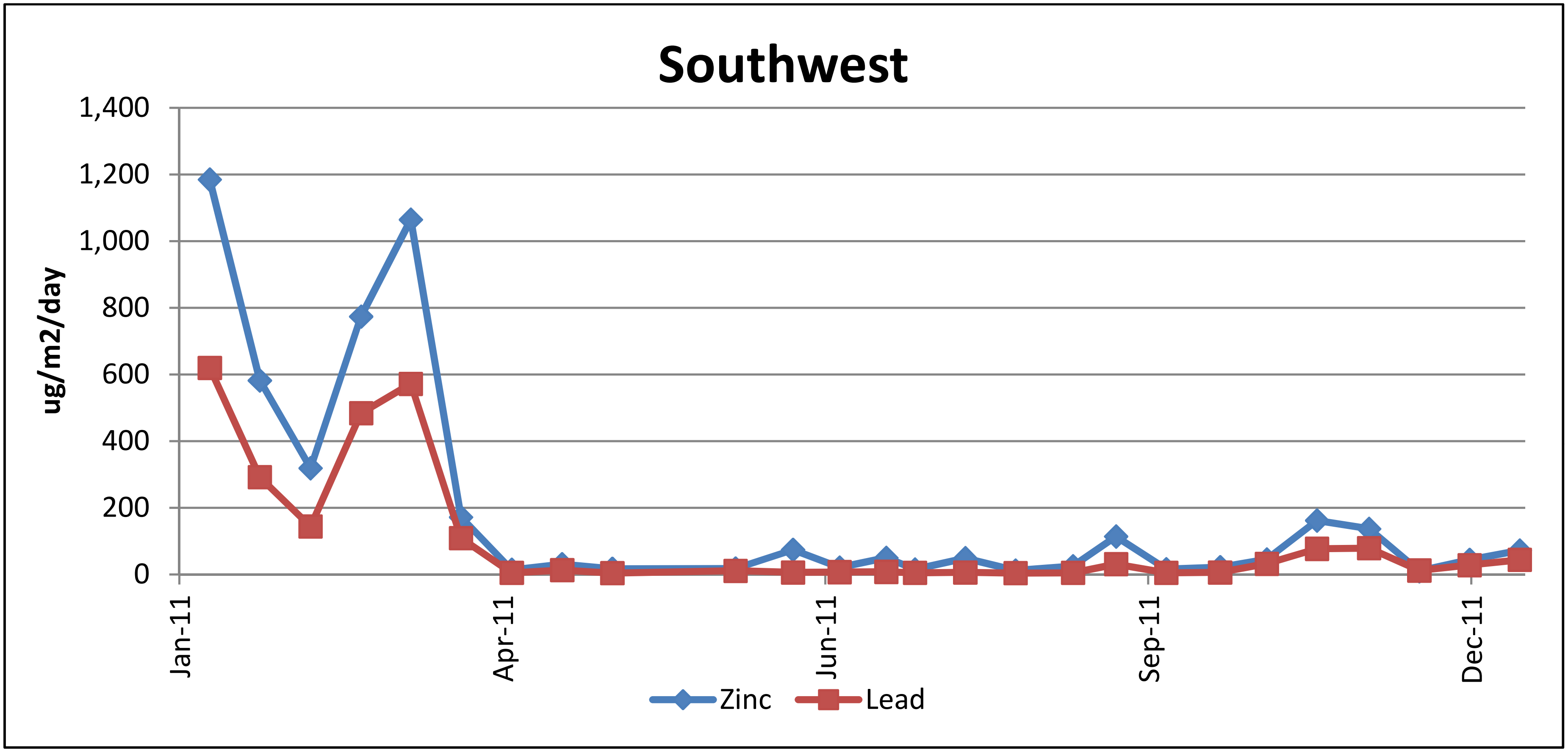


Figure 2.37 Average Daily Load of Lead and Zinc Captured by the Atmoshperic Deposition Pails at the Tailings Facility - West

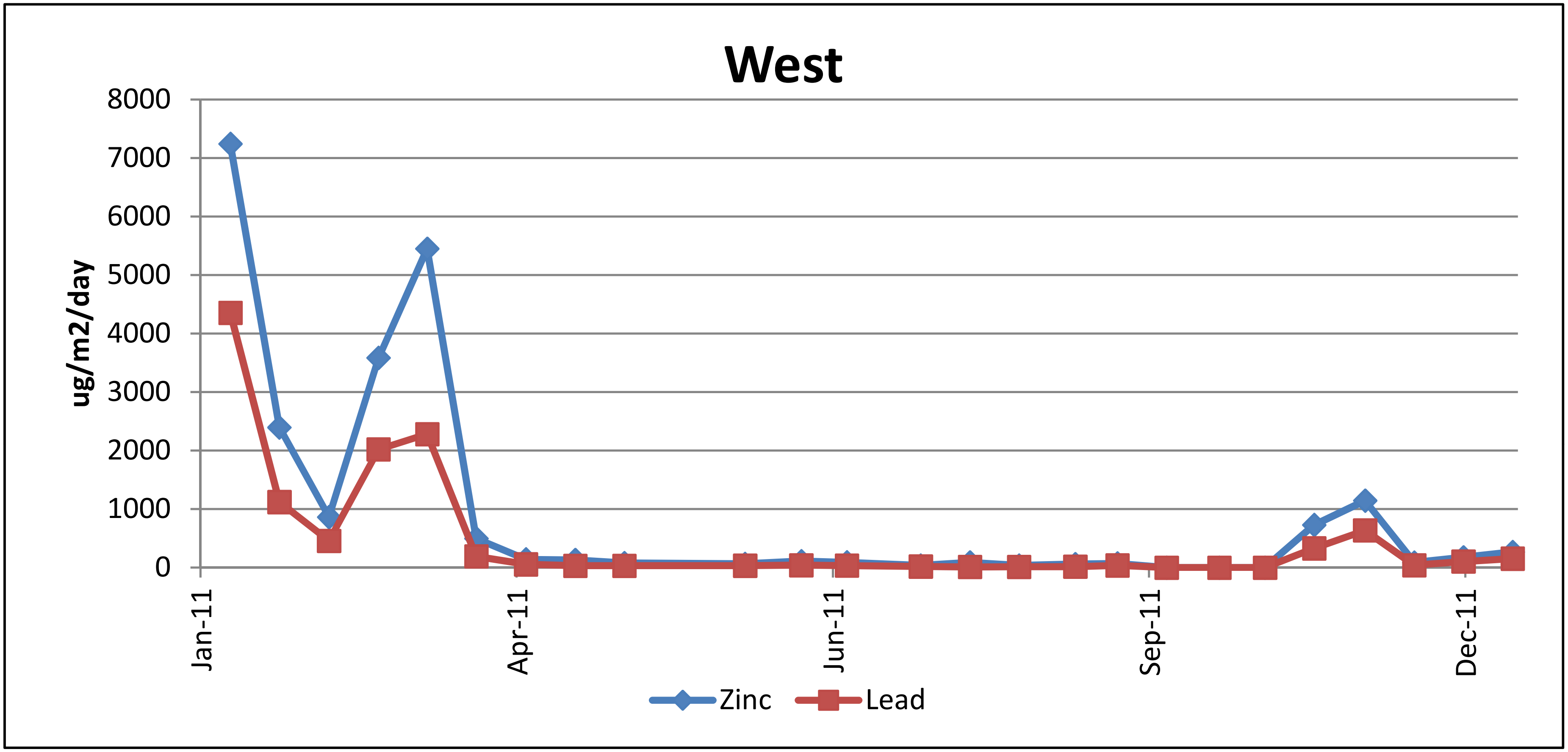


Figure 2.40 Site 609 Zinc Concentrations

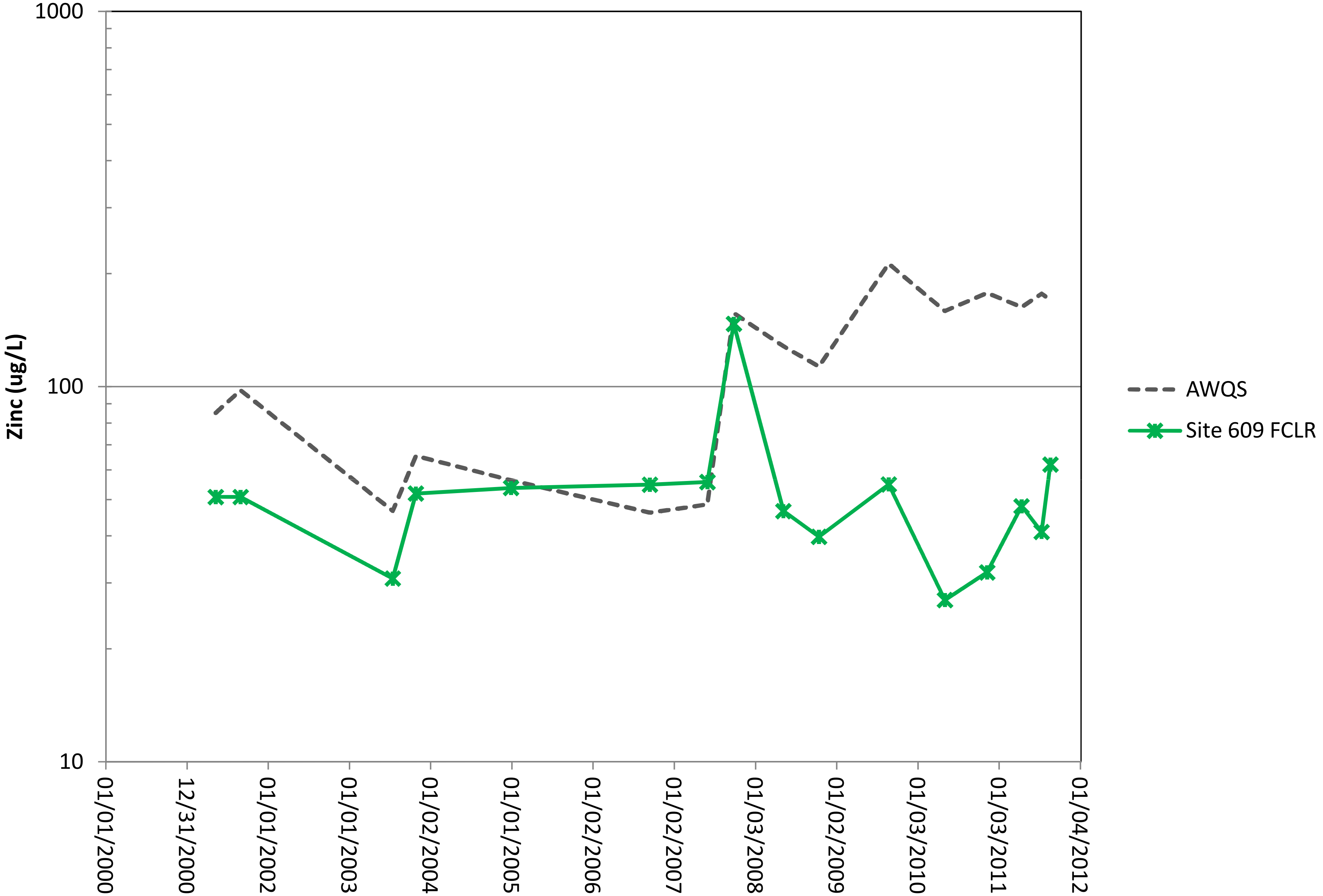


Figure 2.41 Site 609 Lead Concentrations

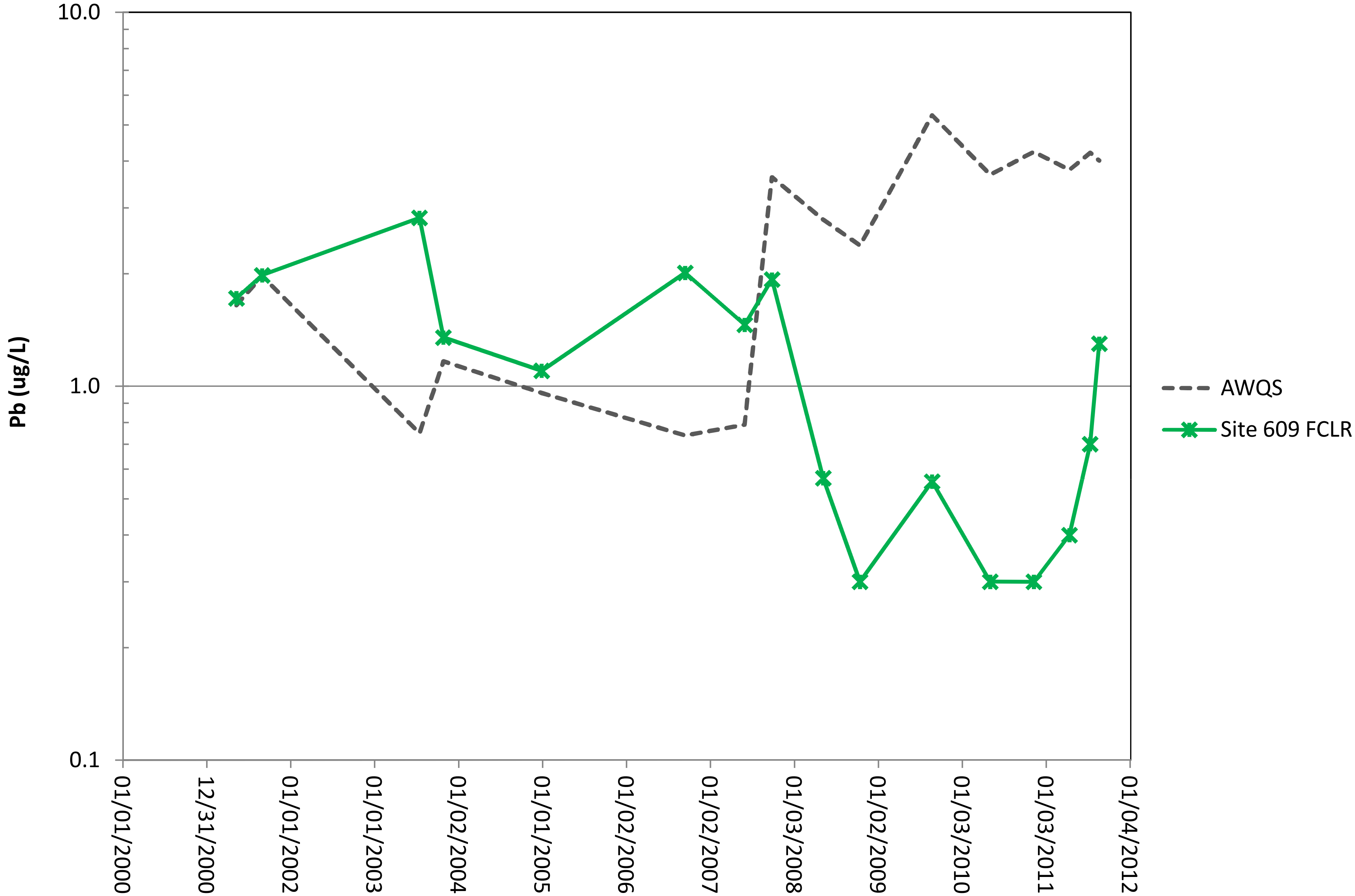


Figure 2.42 Site 60 Zinc Concentration

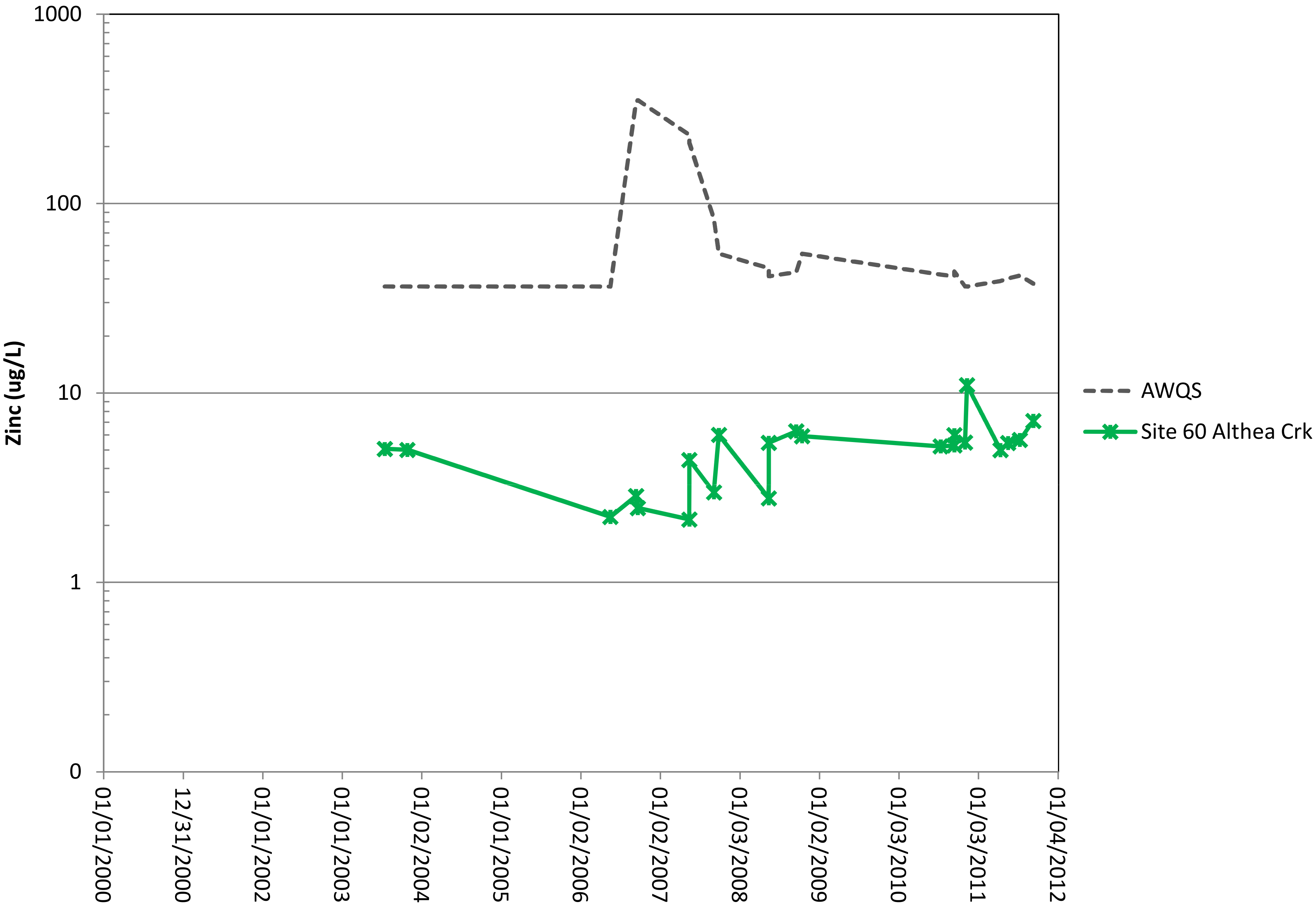


Figure 2.43 Site 60 Lead Concentration

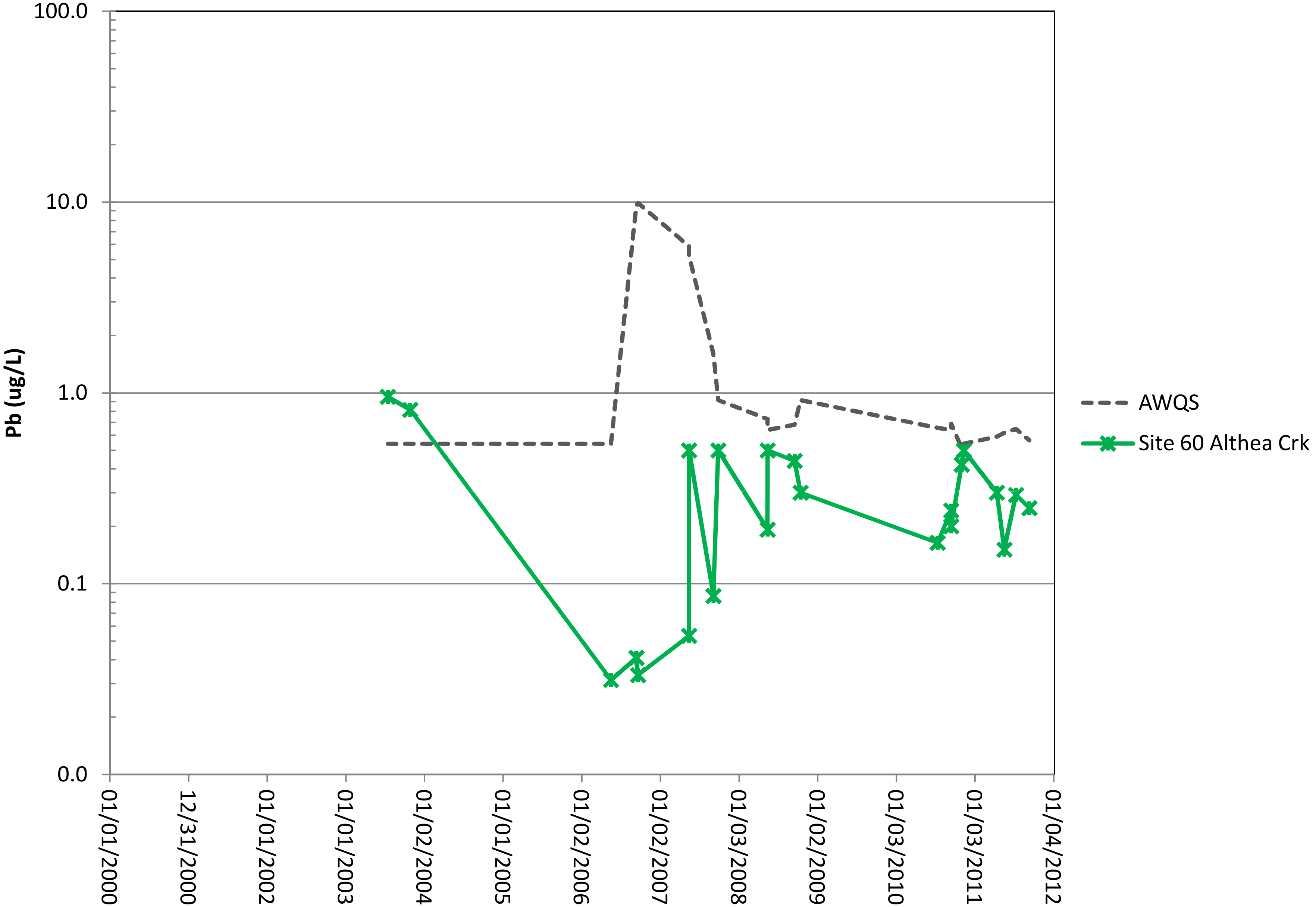


Figure 3.1 Pressure Data for Piezometer 52

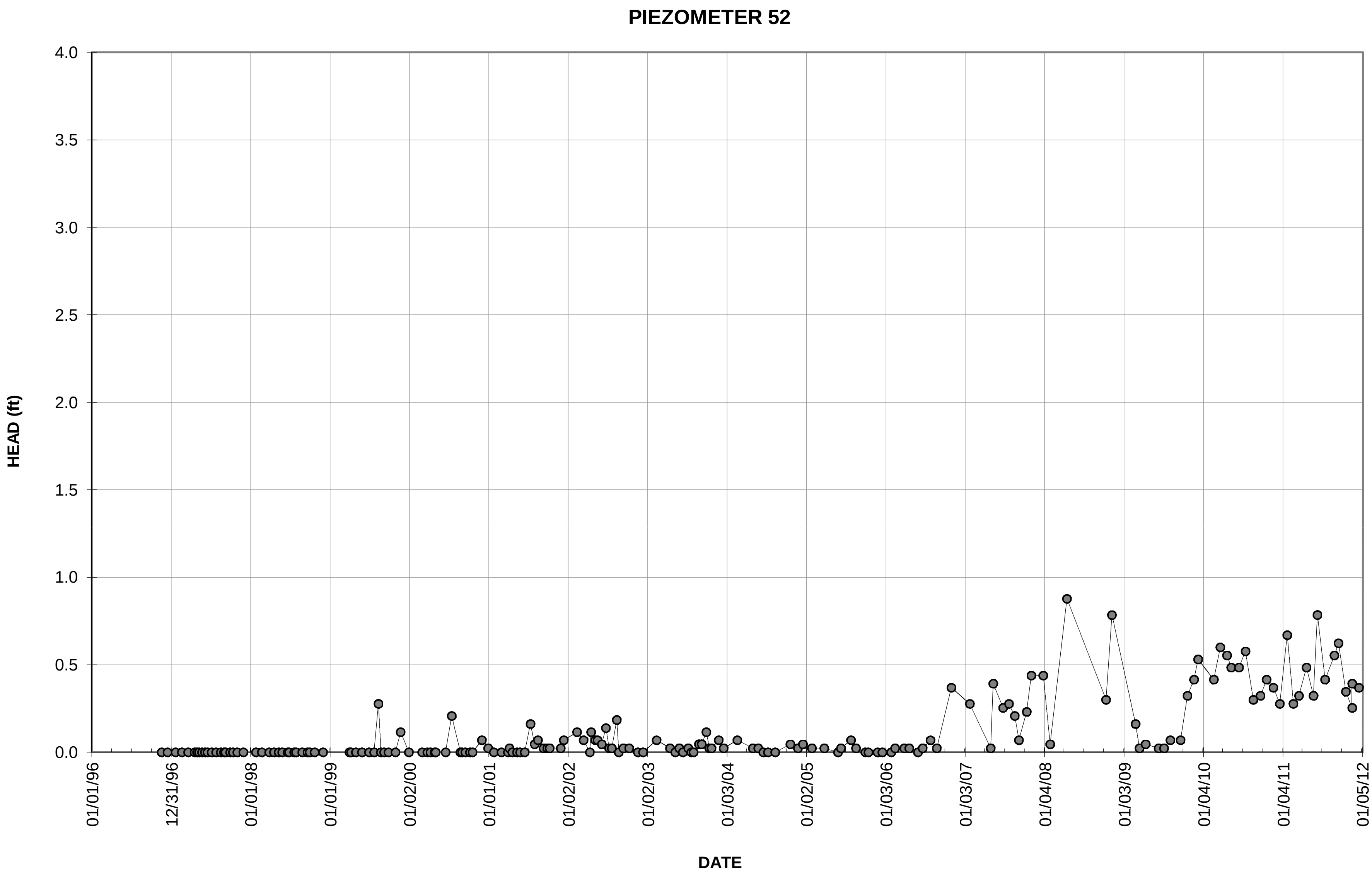


Figure 3.2 Pressure Data for Piezometer 53

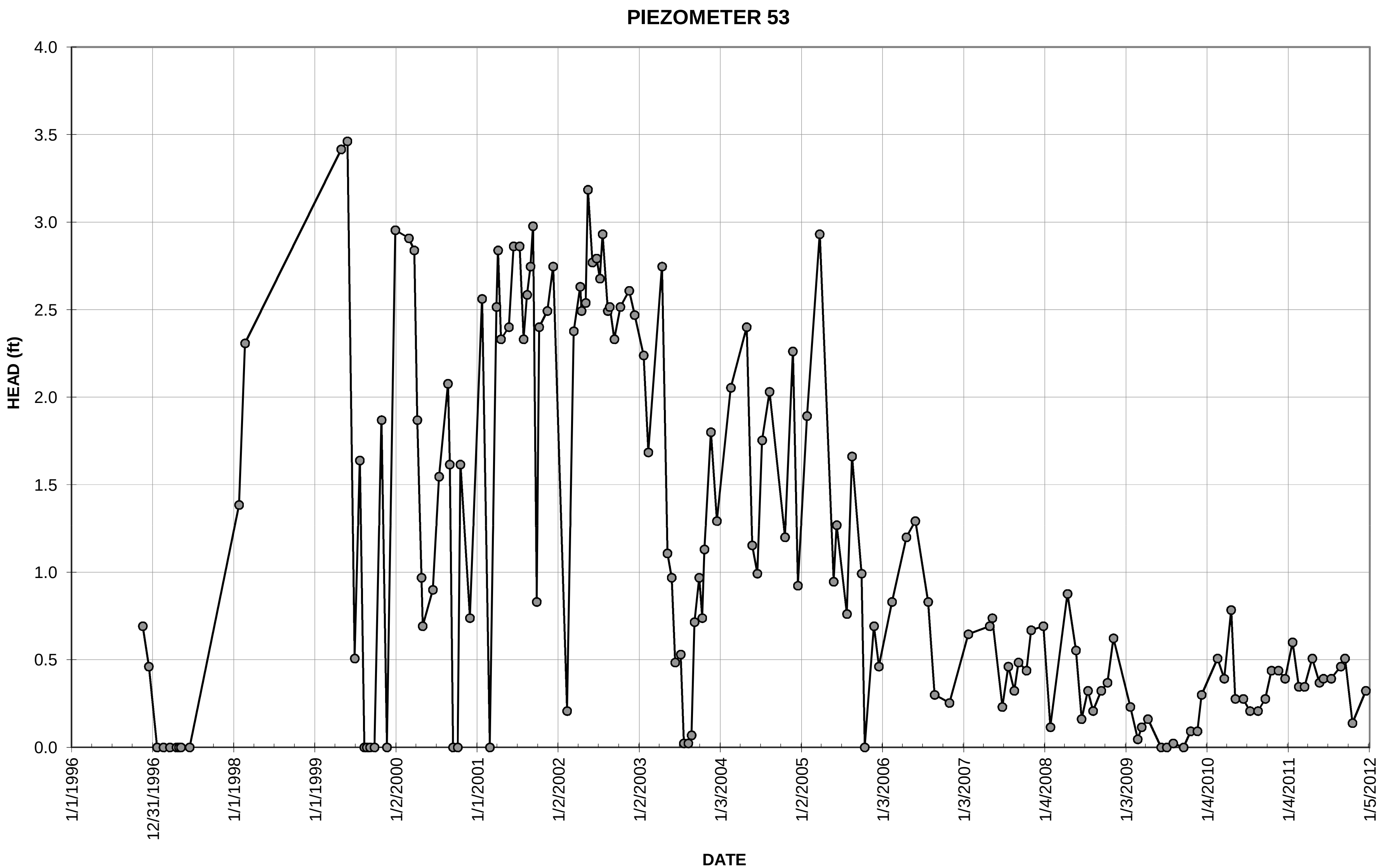


Figure 3.3 Pressure Data for Piezometer 54

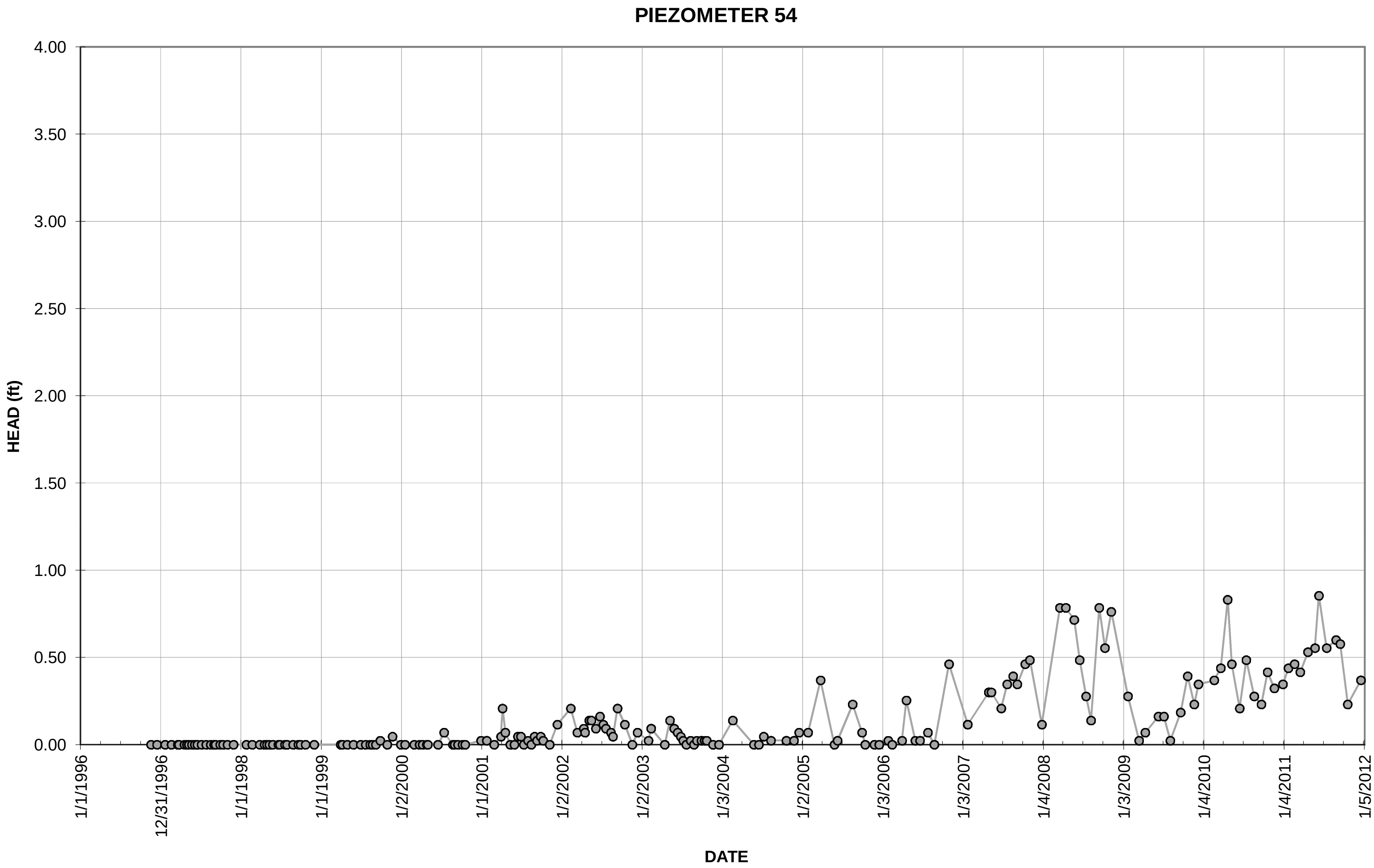


Figure 3.4 Pressure Data for Piezometer 55

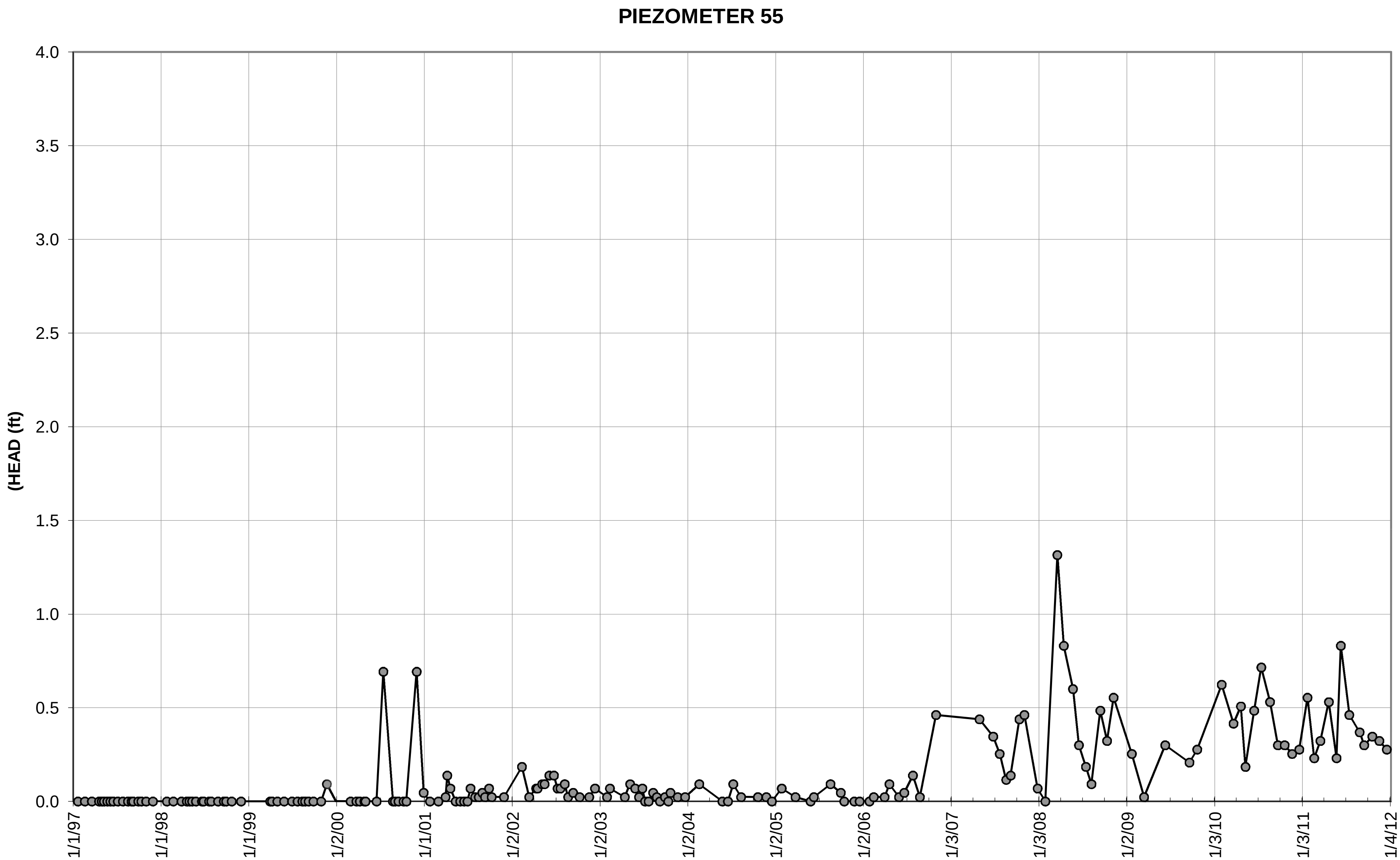


Figure 3.5 Water Level Data for Well MW-23/D-00-03

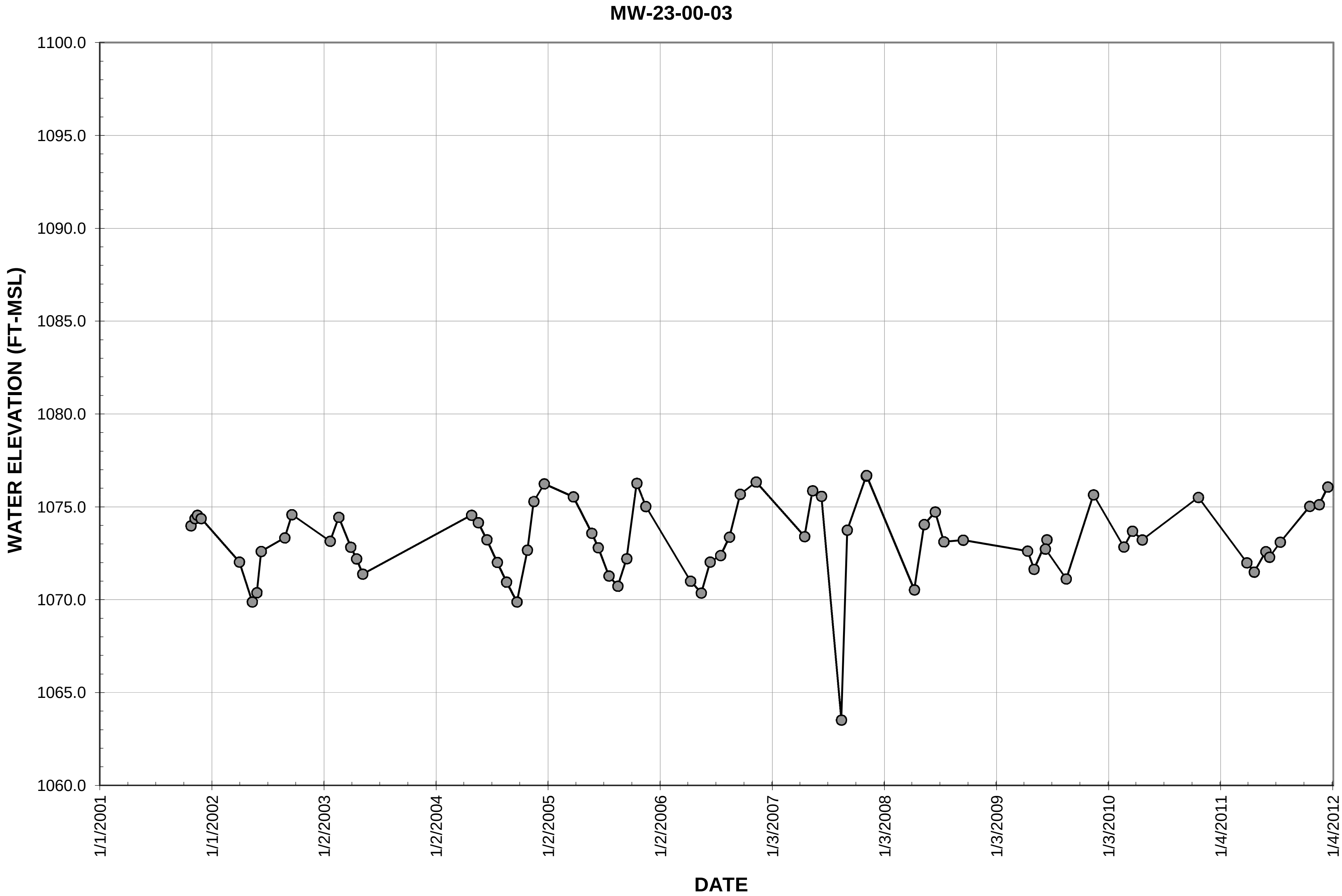


Figure 3.6 Water Level Data for Well MW-23-A2D

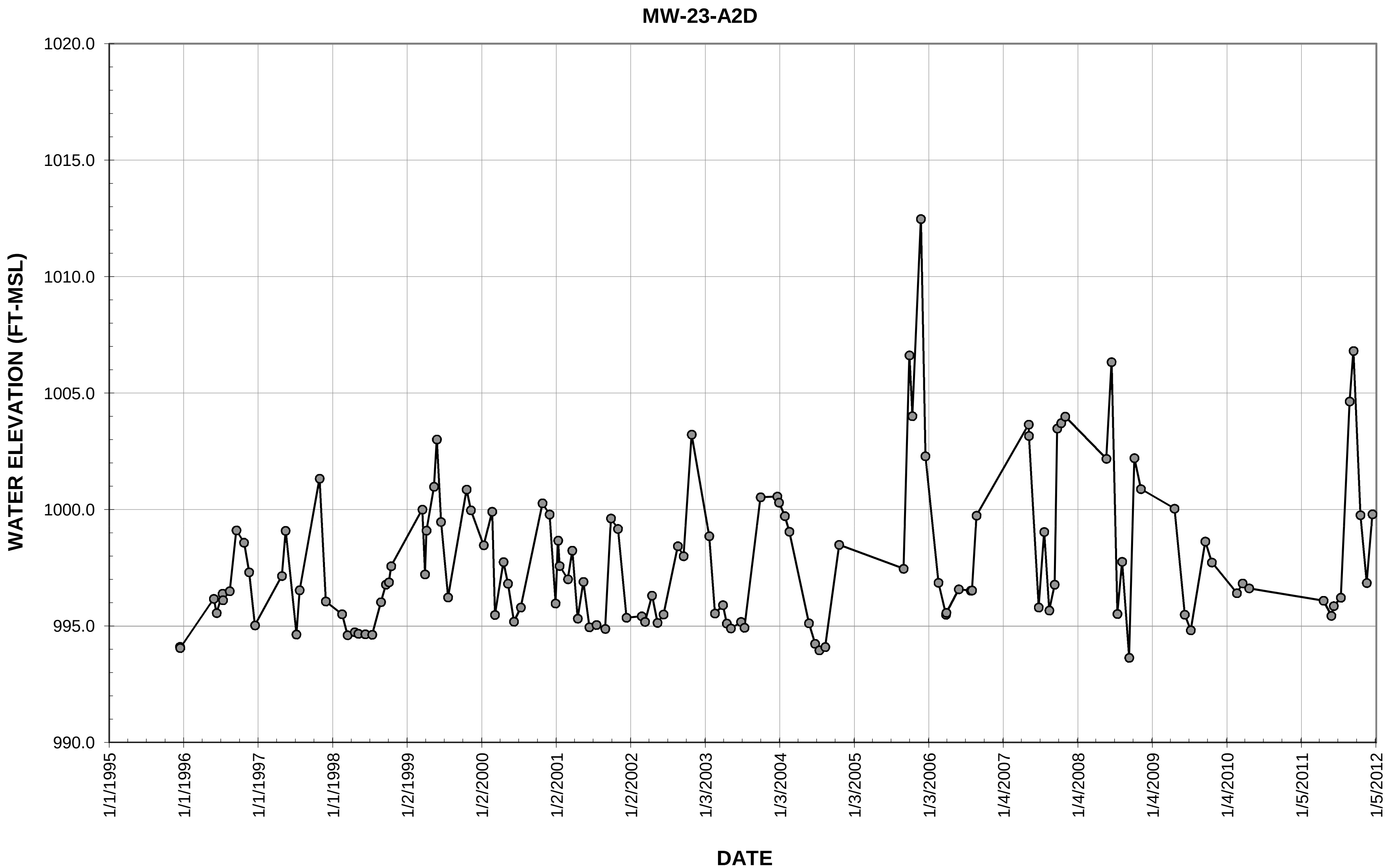


Figure 3.7 Water Level Data for Well MW-23-A2S

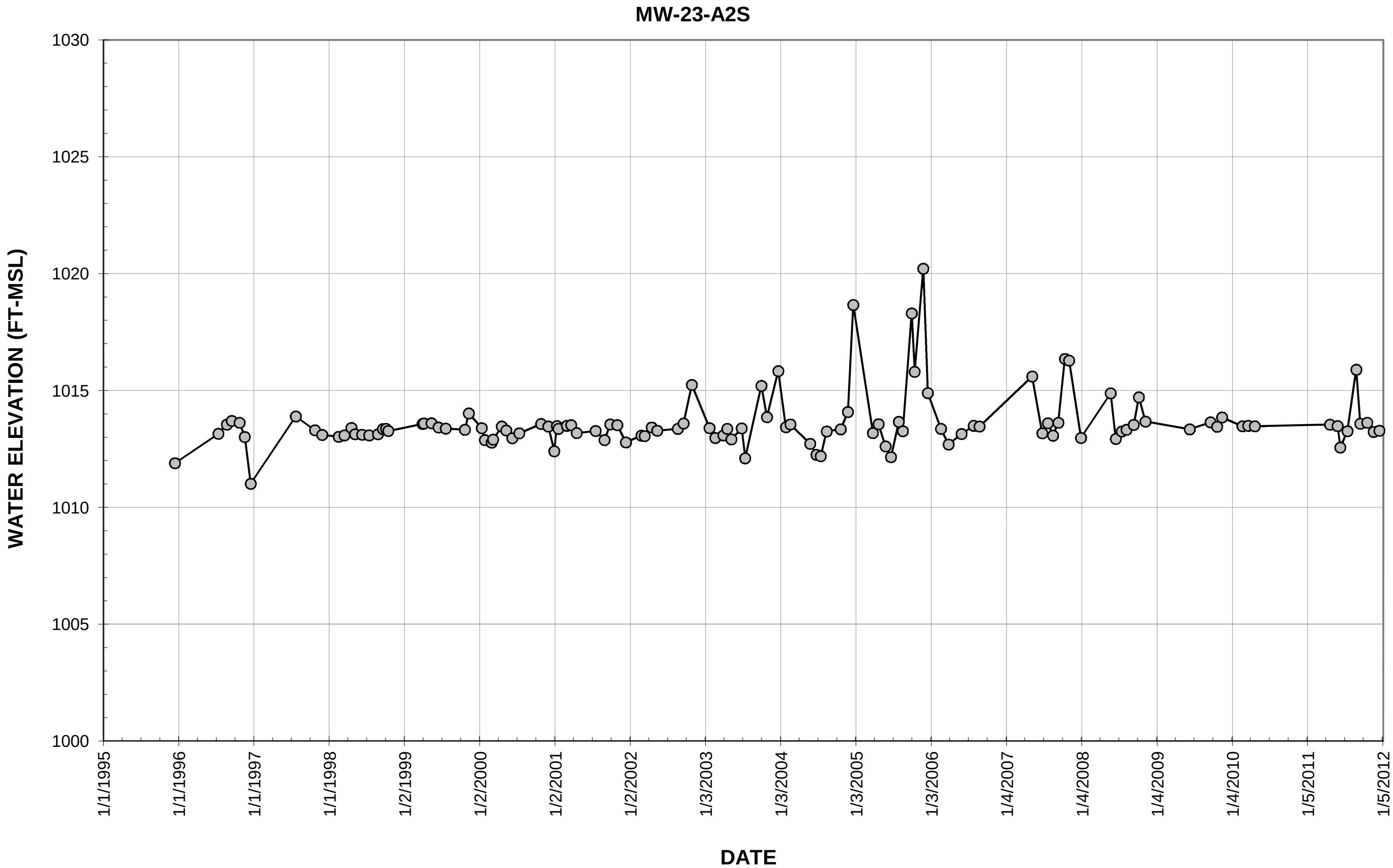


Figure 3.8 Water Level Data for Well MW-23-98-01

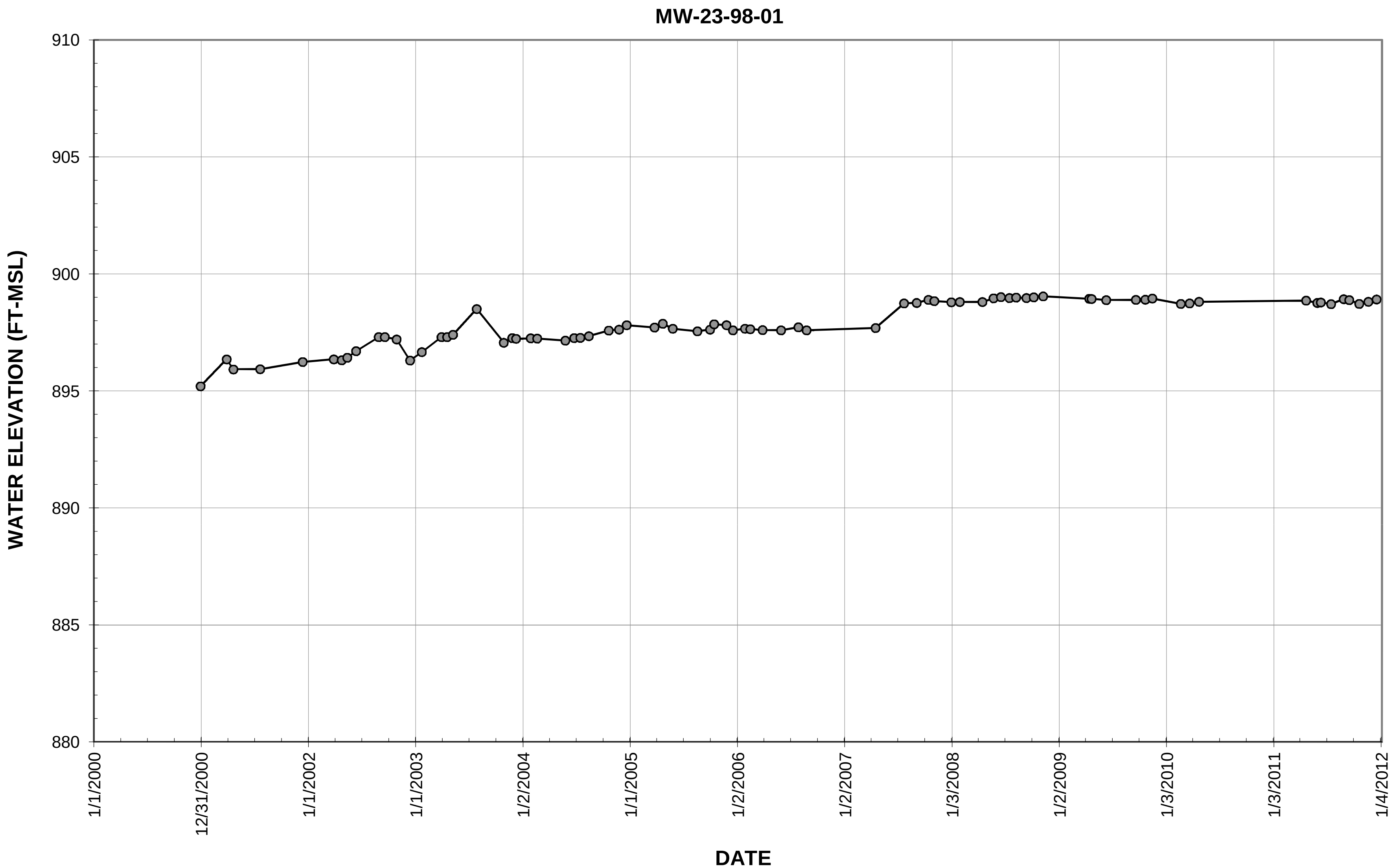


Figure 3.9 Water Level Data for Well MW-23-A4

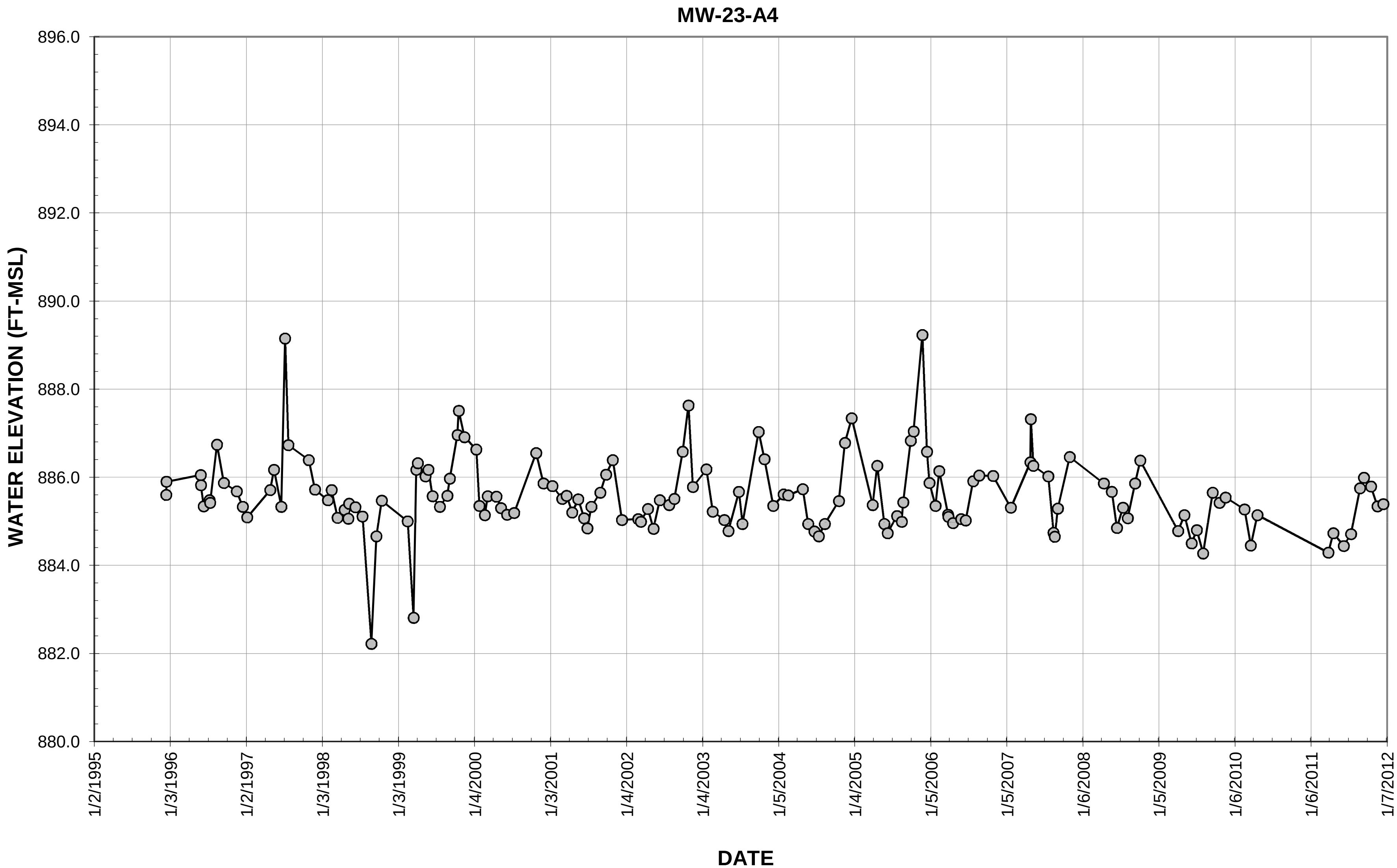


Figure 3.10 Water Level Data for MW-23/D-00-01

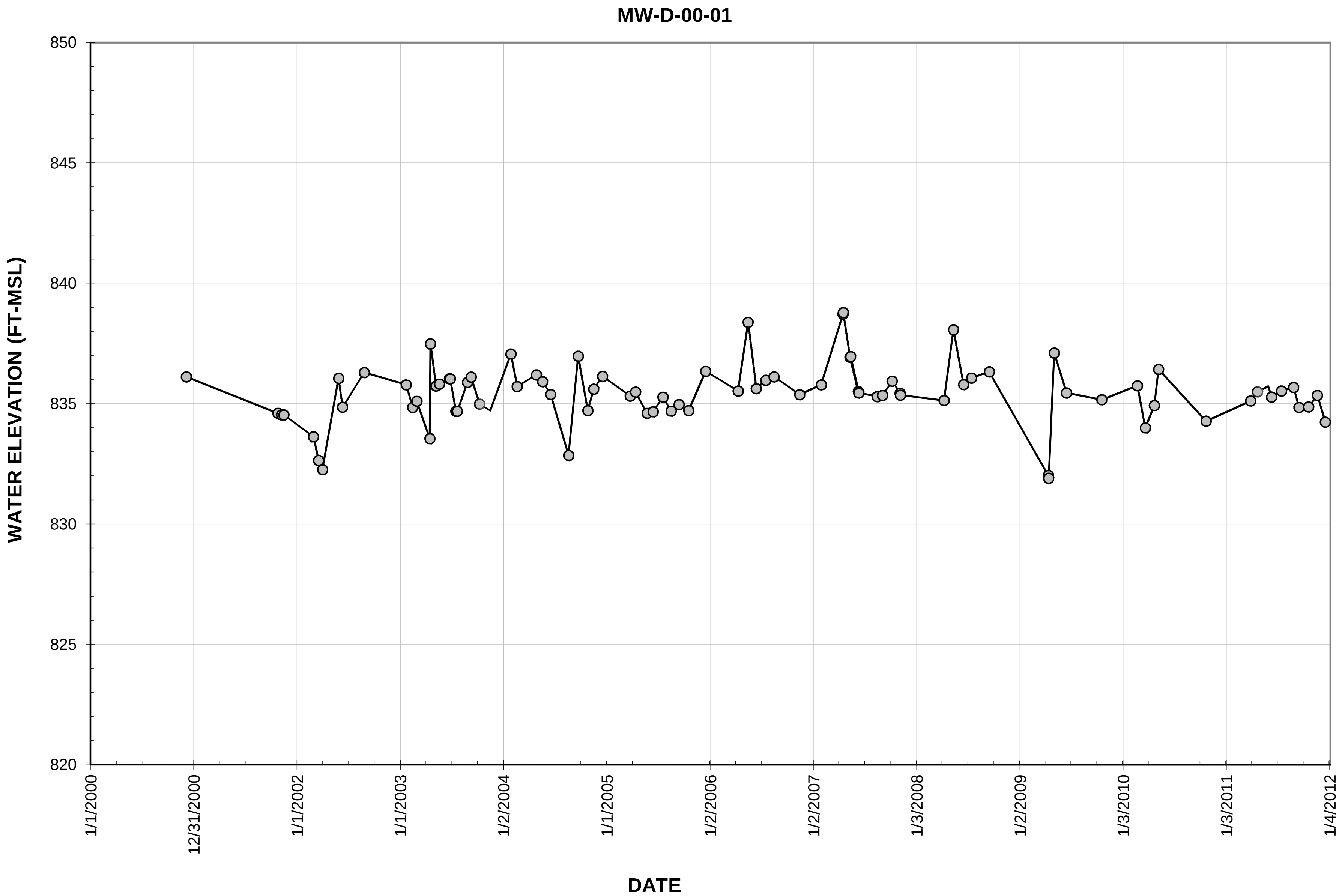


Figure 3.11 Water Level Data for Well MW-D-94-D3

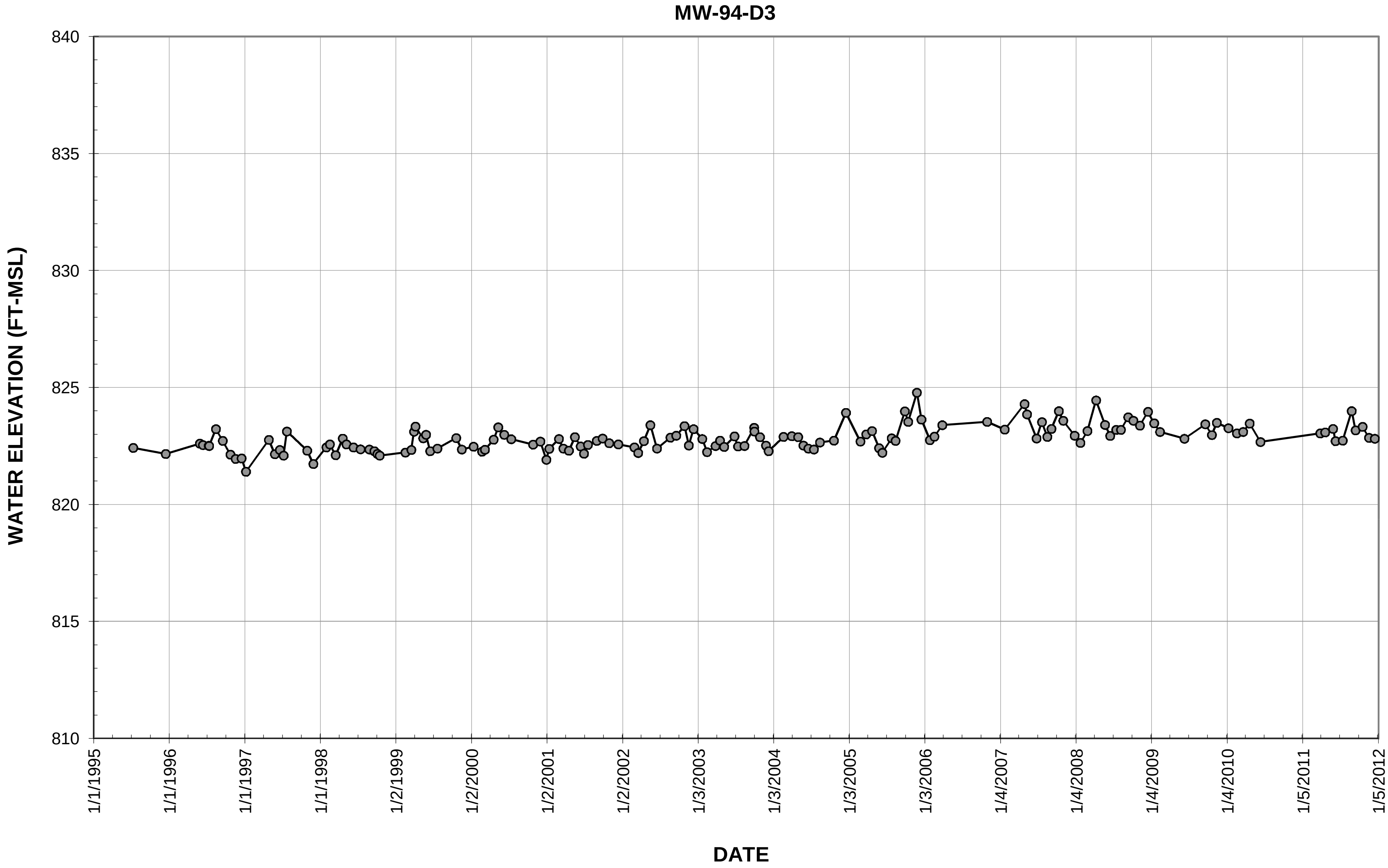


Figure 3.12 Water Level Data for Well MW-D-94-D4

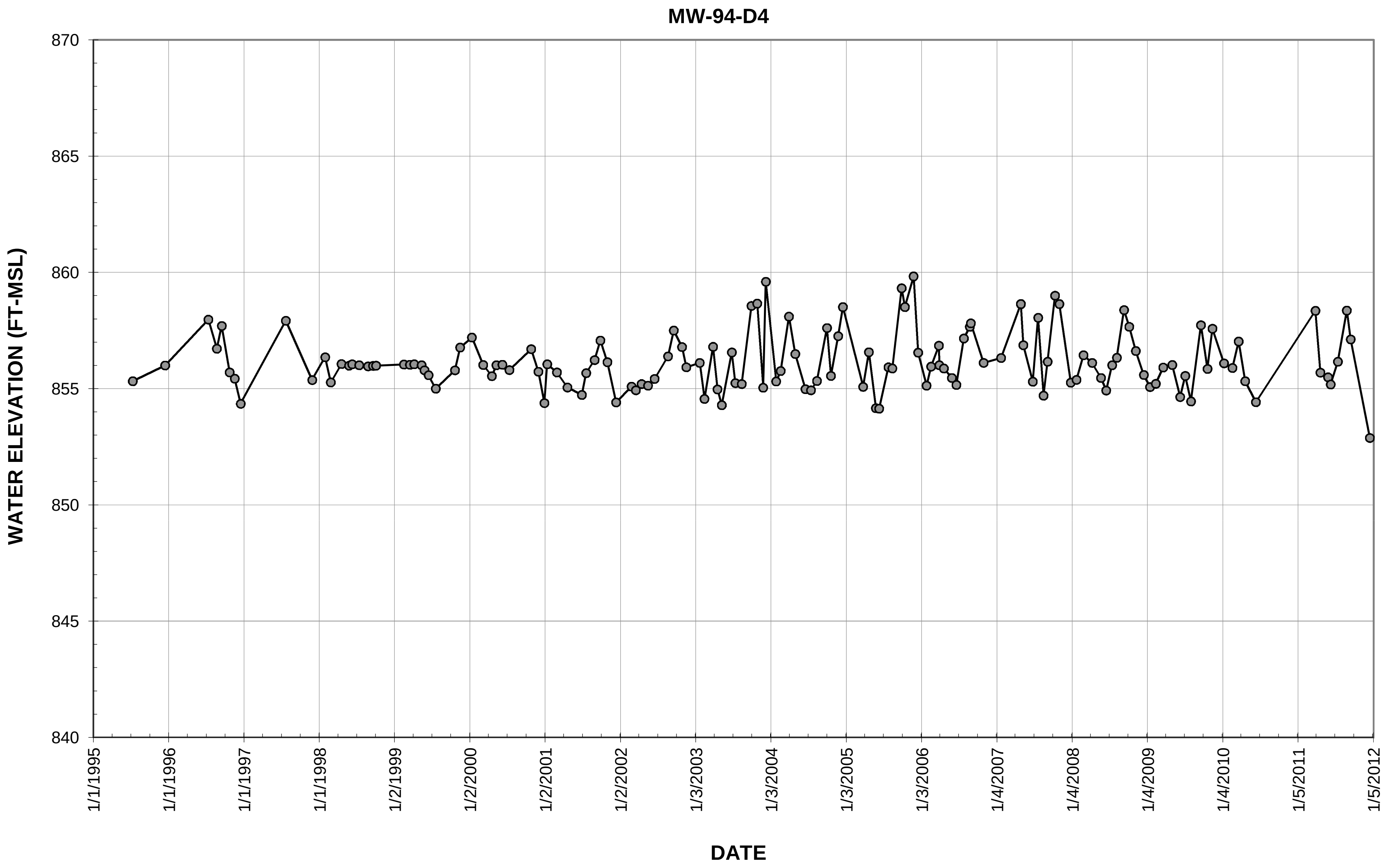


FIGURE 3.13 POND D FLOW DATA

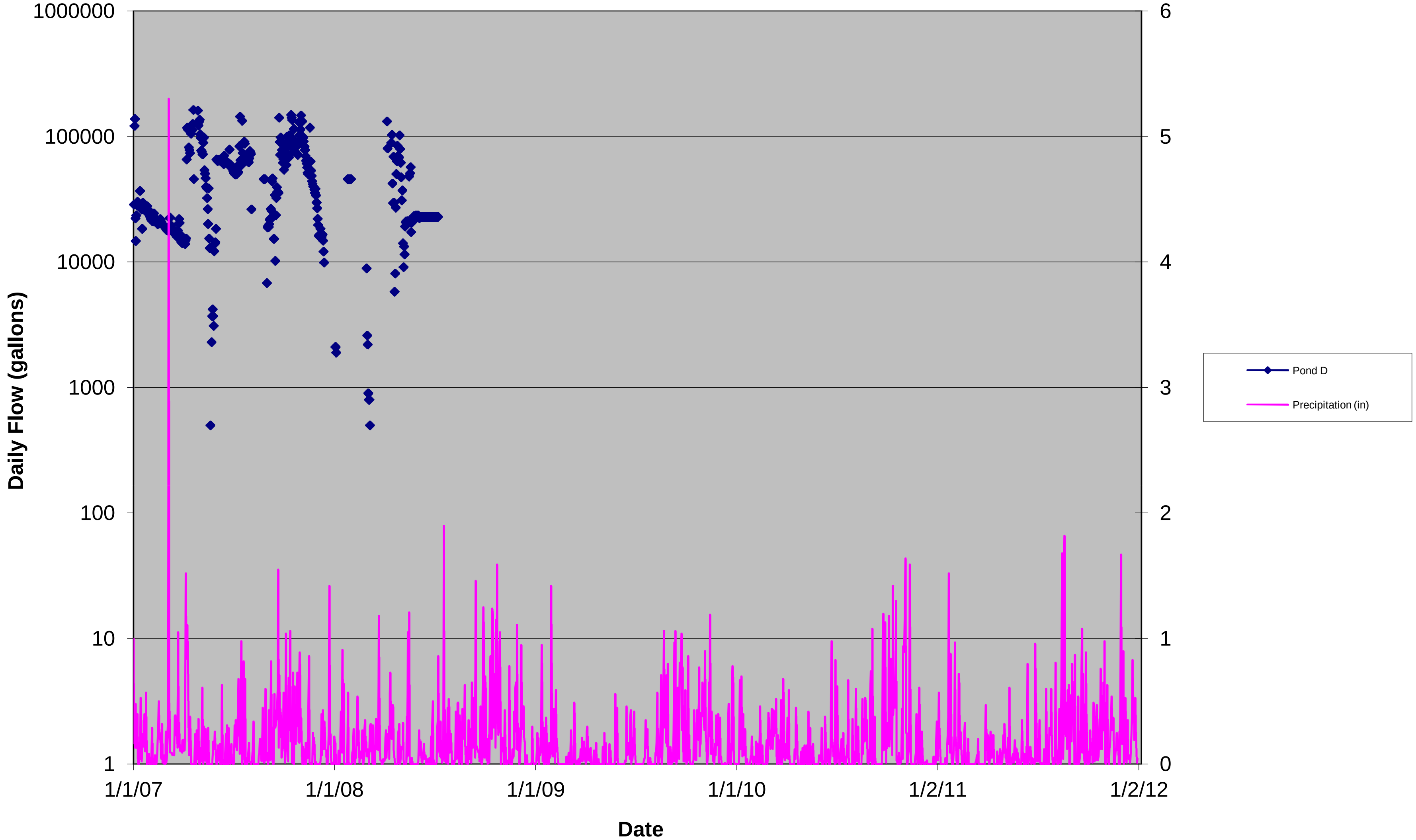


Figure 3.14a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - pH DATA

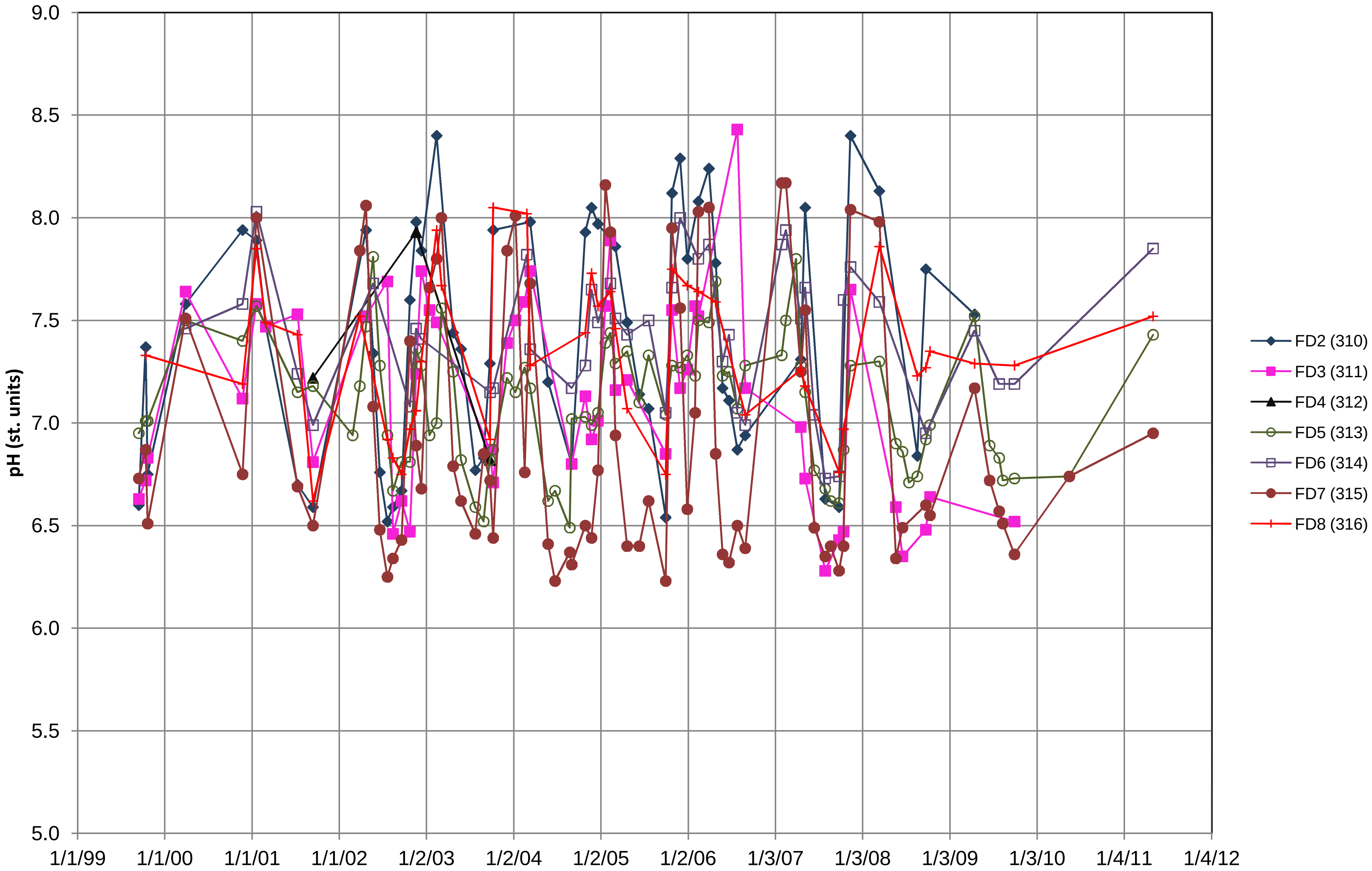


Figure 3.14b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - pH DATA

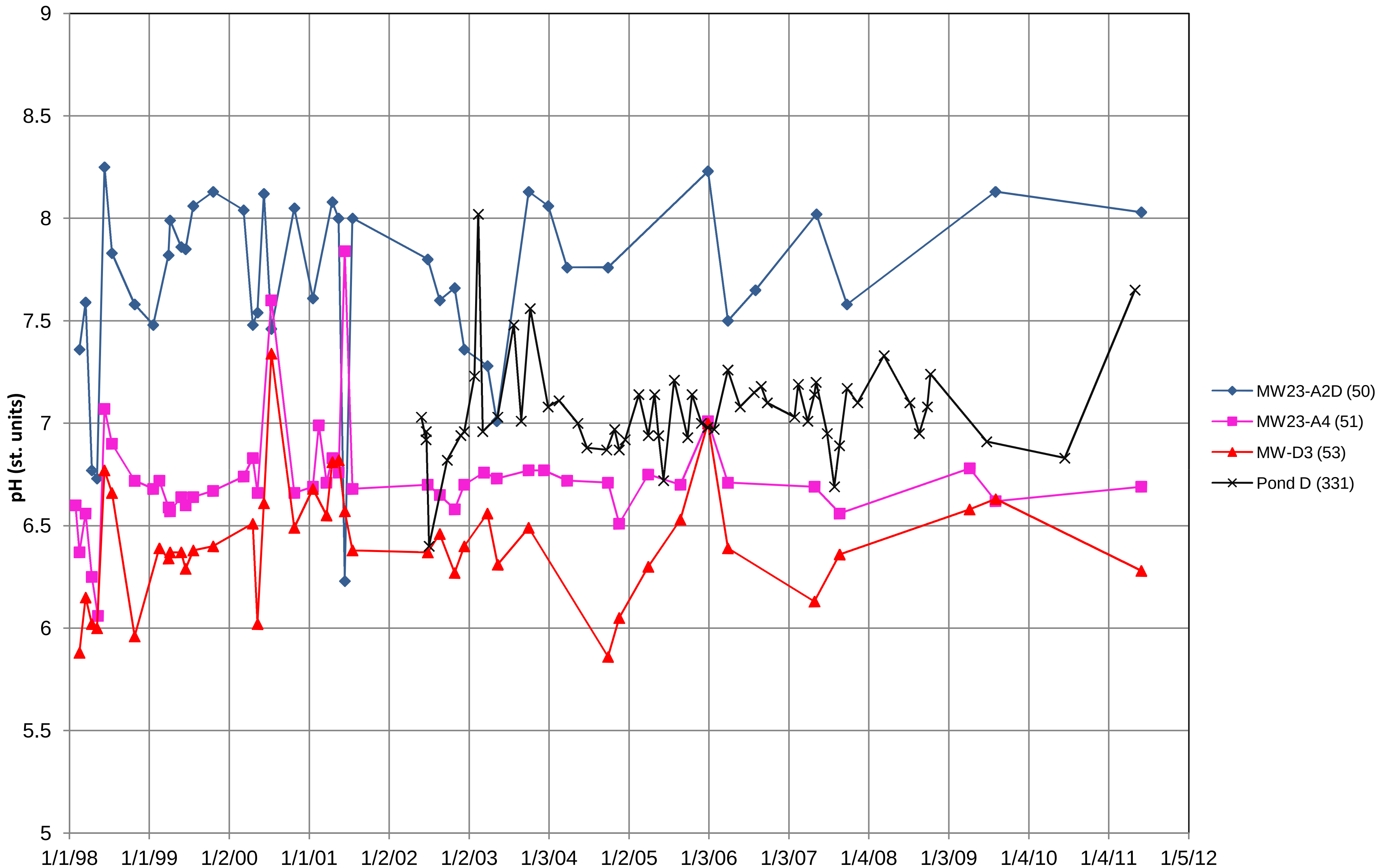
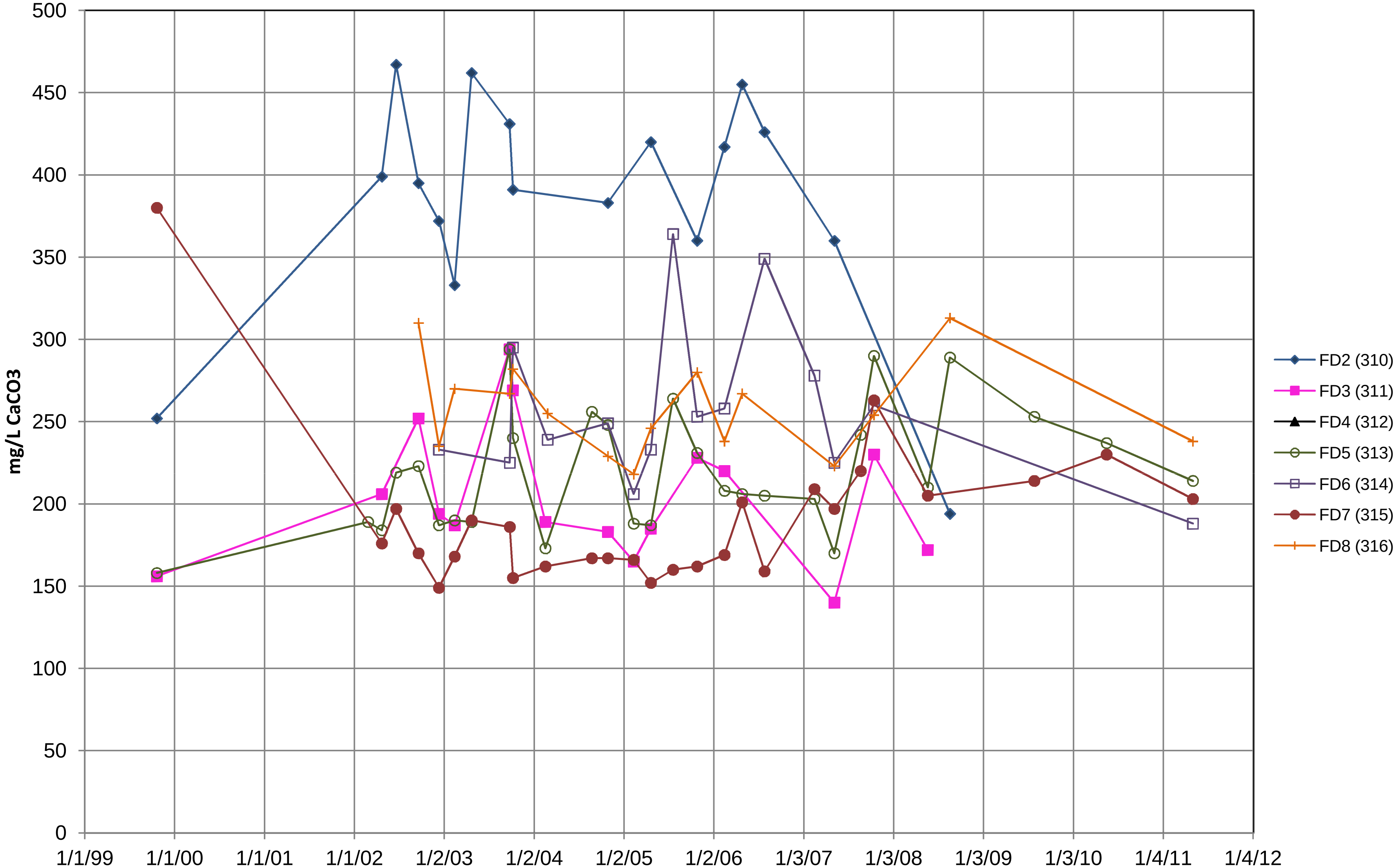


Figure 3.15a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
FINGER DRAINS - ALKALINITY DATA
(Non-detectable analyses plotted as zero)



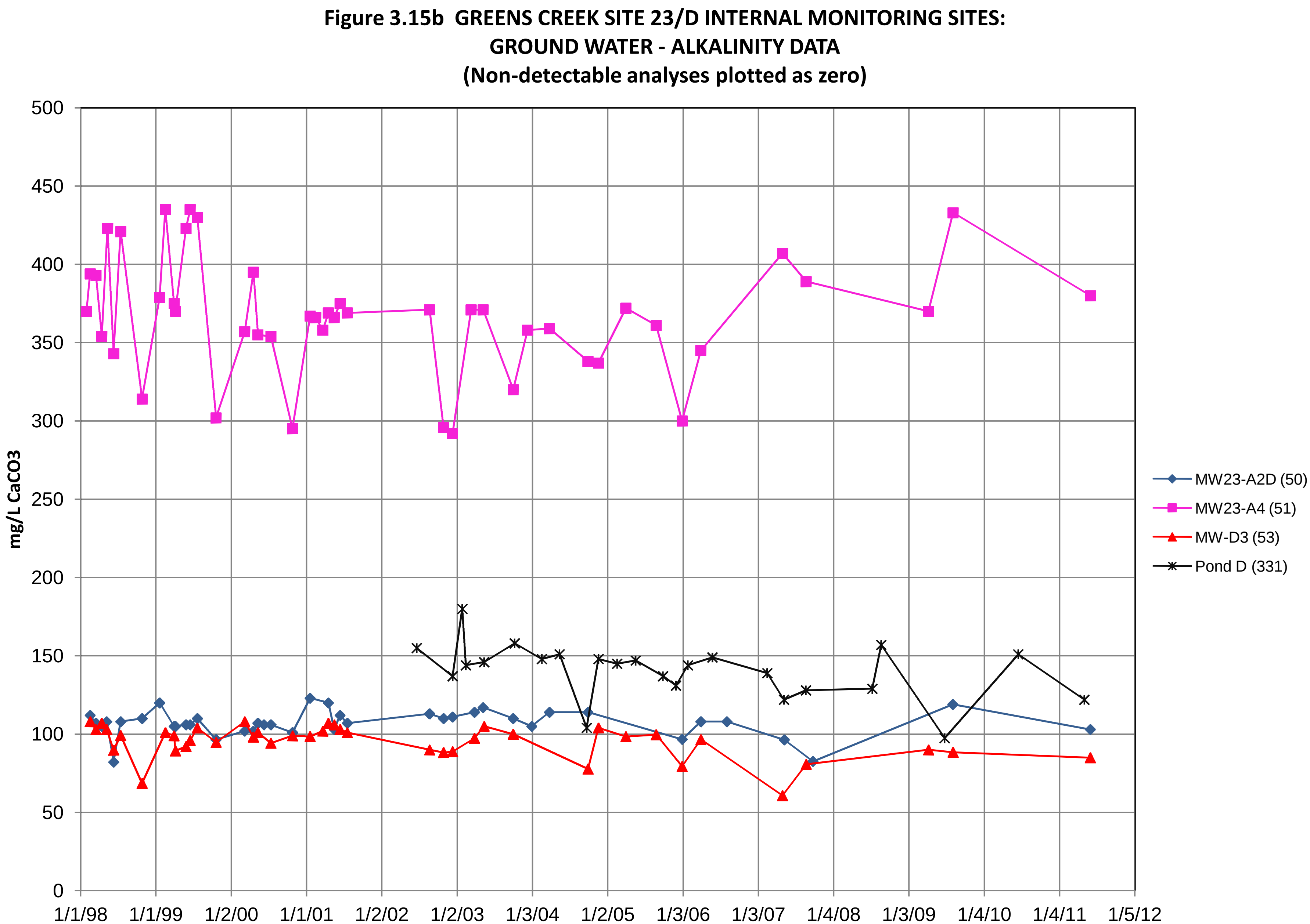


Figure 3.15b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
GROUND WATER - ALKALINITY DATA
(Non-detectable analyses plotted as zero)
mg/L CaCO3
500
450
400
350
300
250
200
150
100
50
0
1/1/98
1/1/99
1/2/00
1/1/01
1/2/02
1/2/03
1/3/04
1/2/05
1/3/06
1/3/07
1/4/08
1/3/09
1/4/10
1/4/11
1/5/12
MW23-A2D (50)
MW23-A4 (51)
MW-D3 (53)
Pond D (331)

Figure 3.16a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES
FINGER DRAINS - HARDNESS DATA
(Non-detectable analyses plotted as zero)

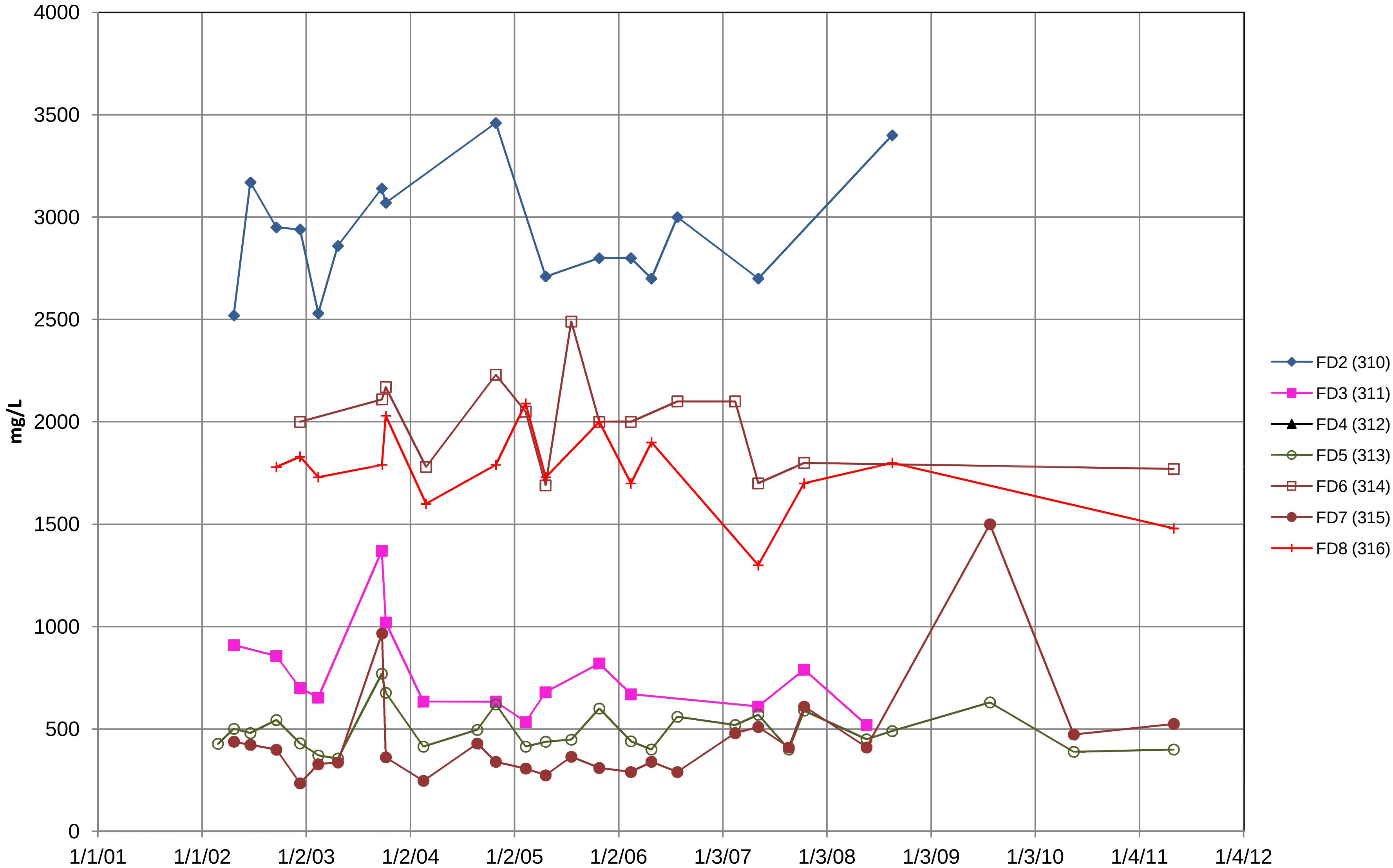
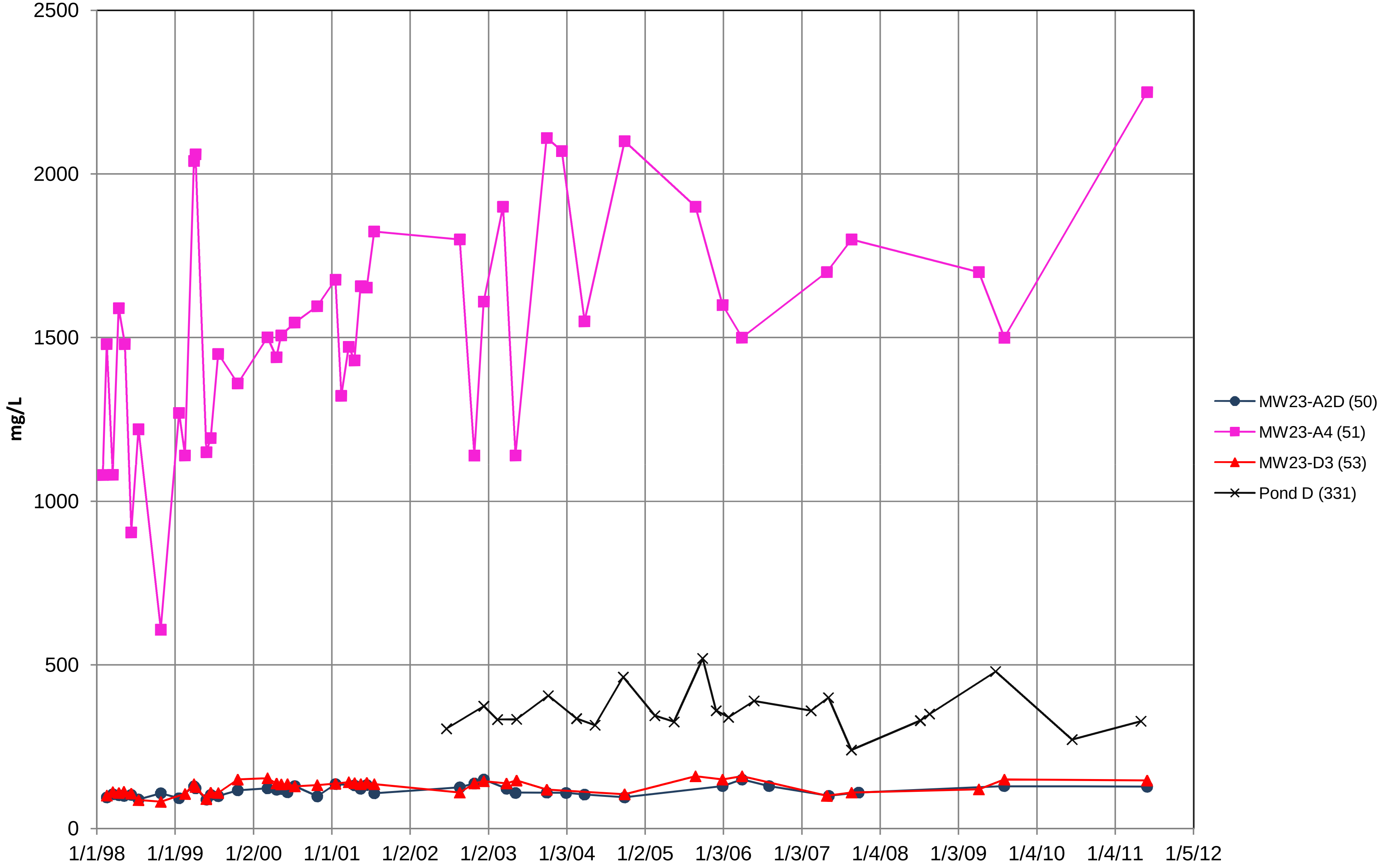


Figure 3.16b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - HARDNESS DATA (Non-detecable analyses plotted as zero)



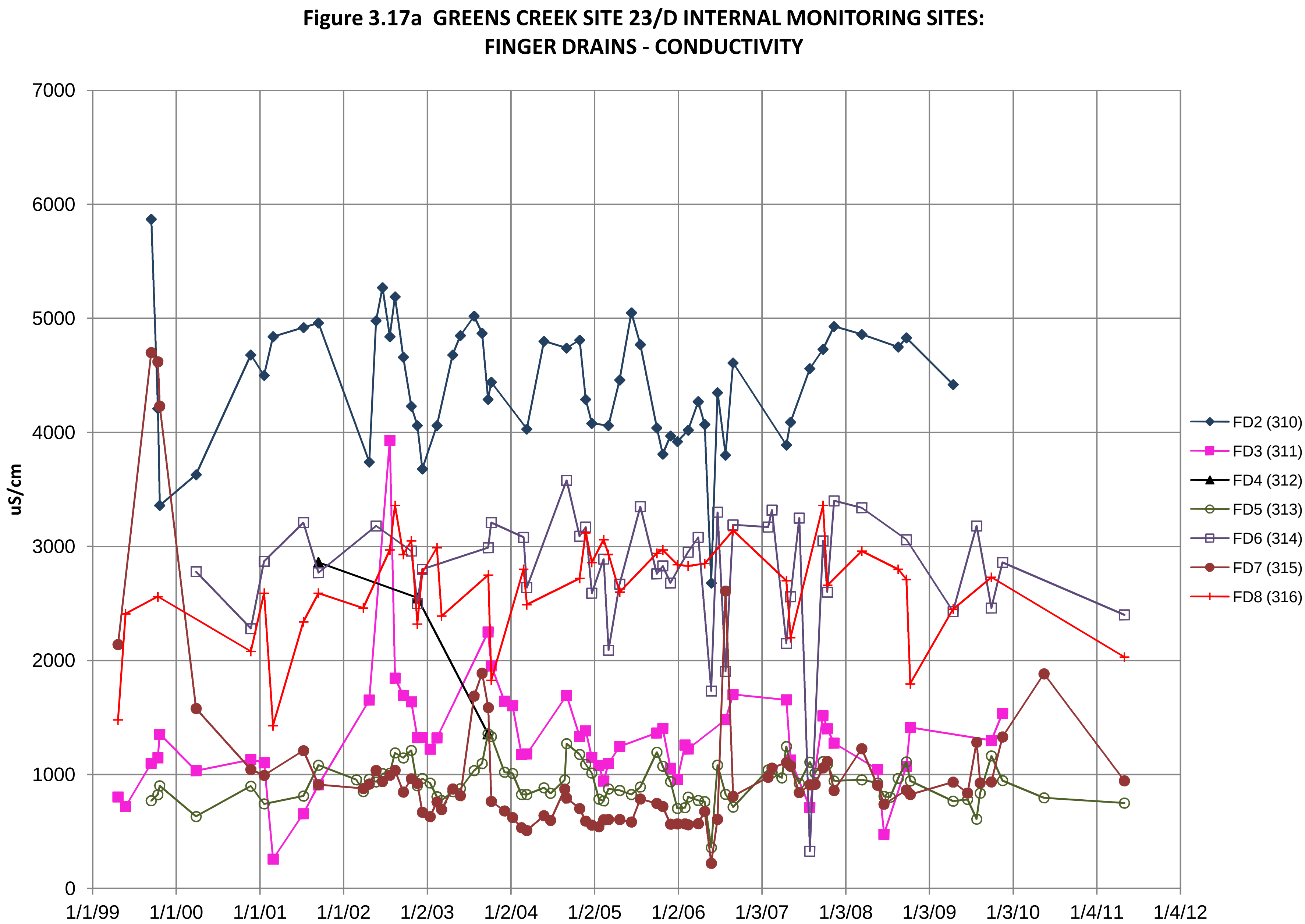


Figure 3.17a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
FINGER DRAINS - CONDUCTIVITY
uS/cm
7000
6000
5000
4000
3000
2000
1000
0
1/1/99
1/1/00
1/1/01
1/1/02
1/2/03
1/2/04
1/2/05
1/2/06
1/3/07
1/3/08
1/3/09
1/3/10
1/4/11
1/4/12
FD2 (310)
FD3 (311)
FD4 (312)
FD5 (313)
FD6 (314)
FD7 (315)
FD8 (316)

Figure 3.17b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - CONDUCTIVITY

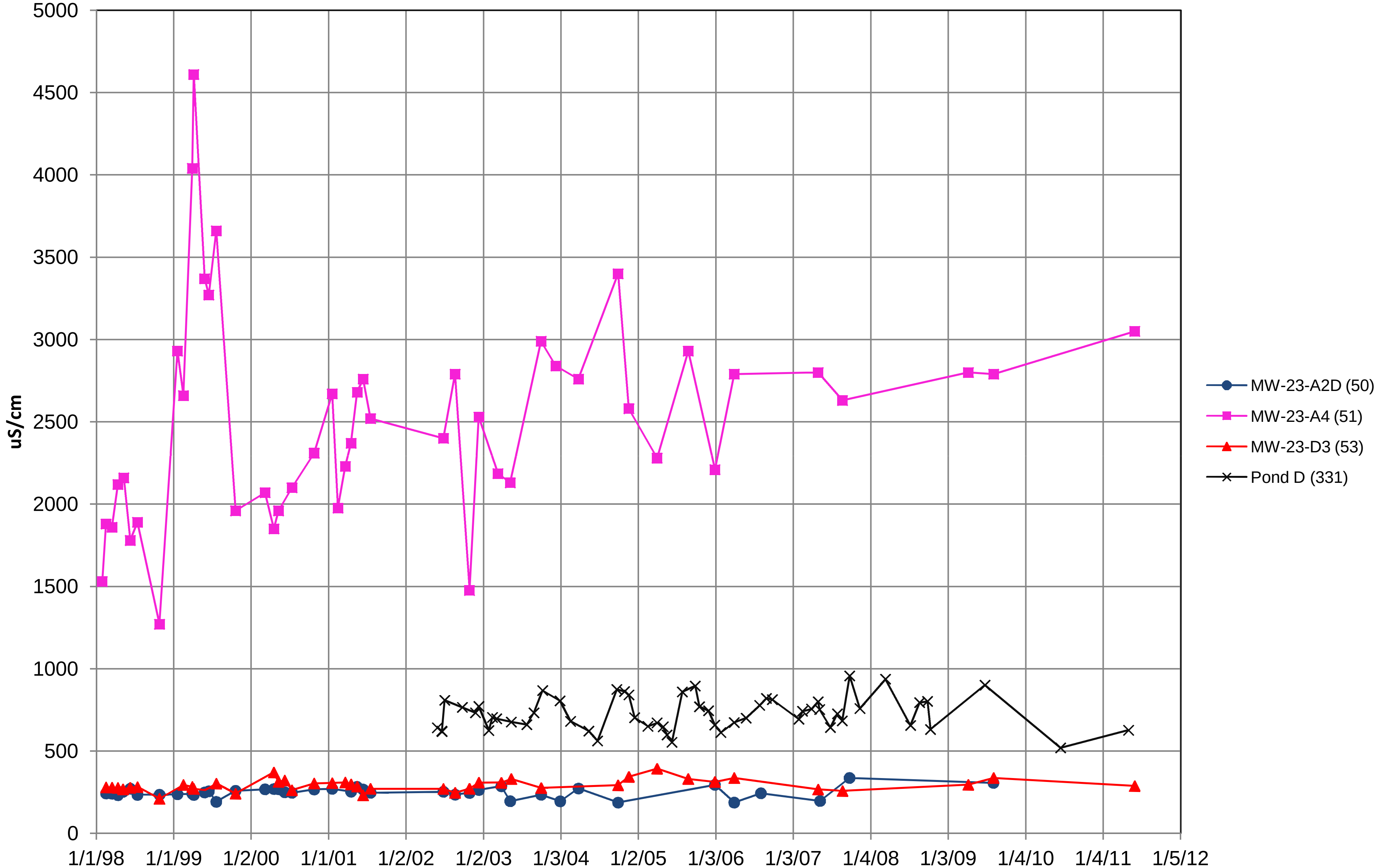


Figure 3.18a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - SULFATE DATA (Non-detectable analyses plotted as zero)

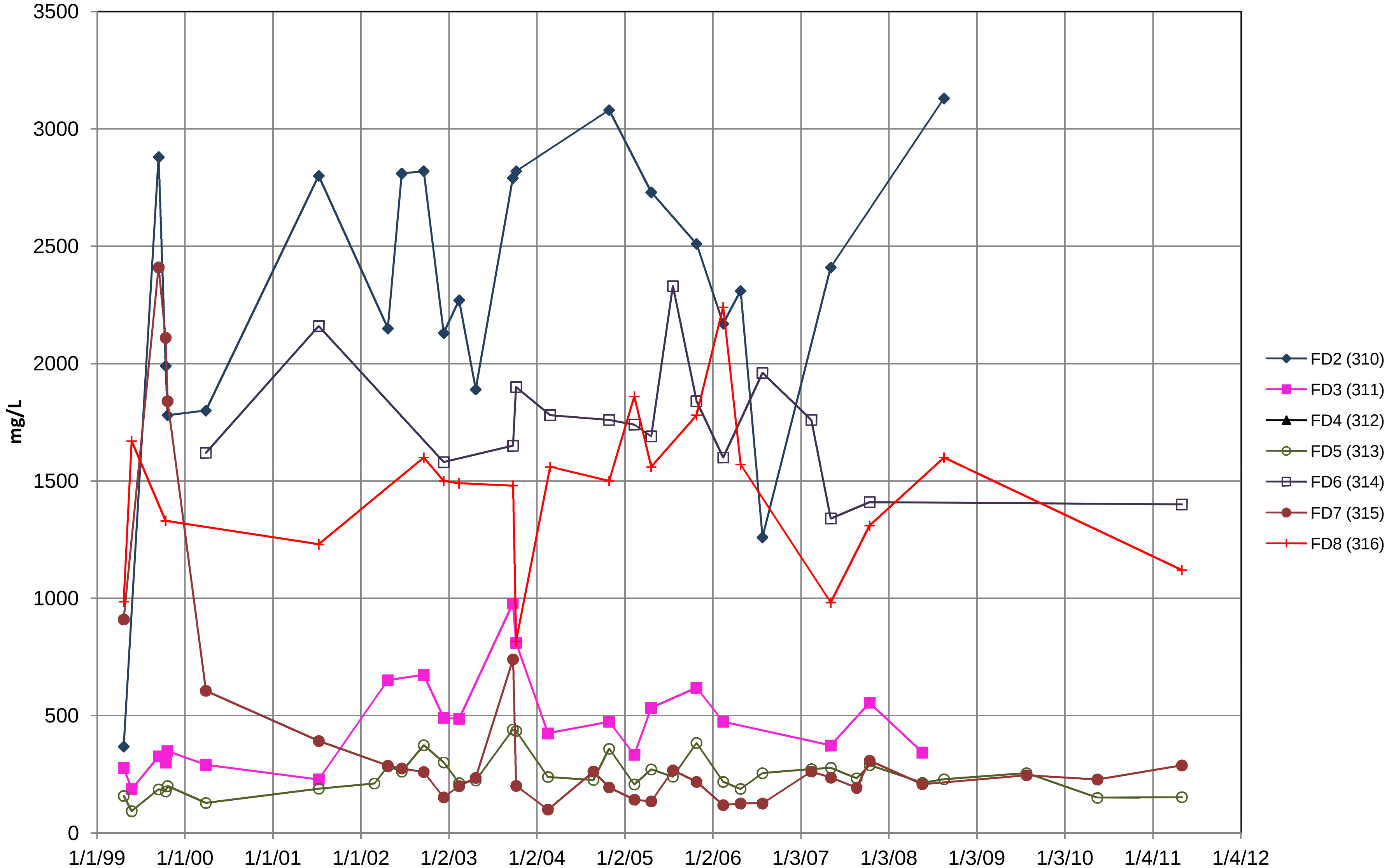


Figure 3.18b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - SULFATE (Non-detectable analyses plotted as zero) (8/5/09, 3160)

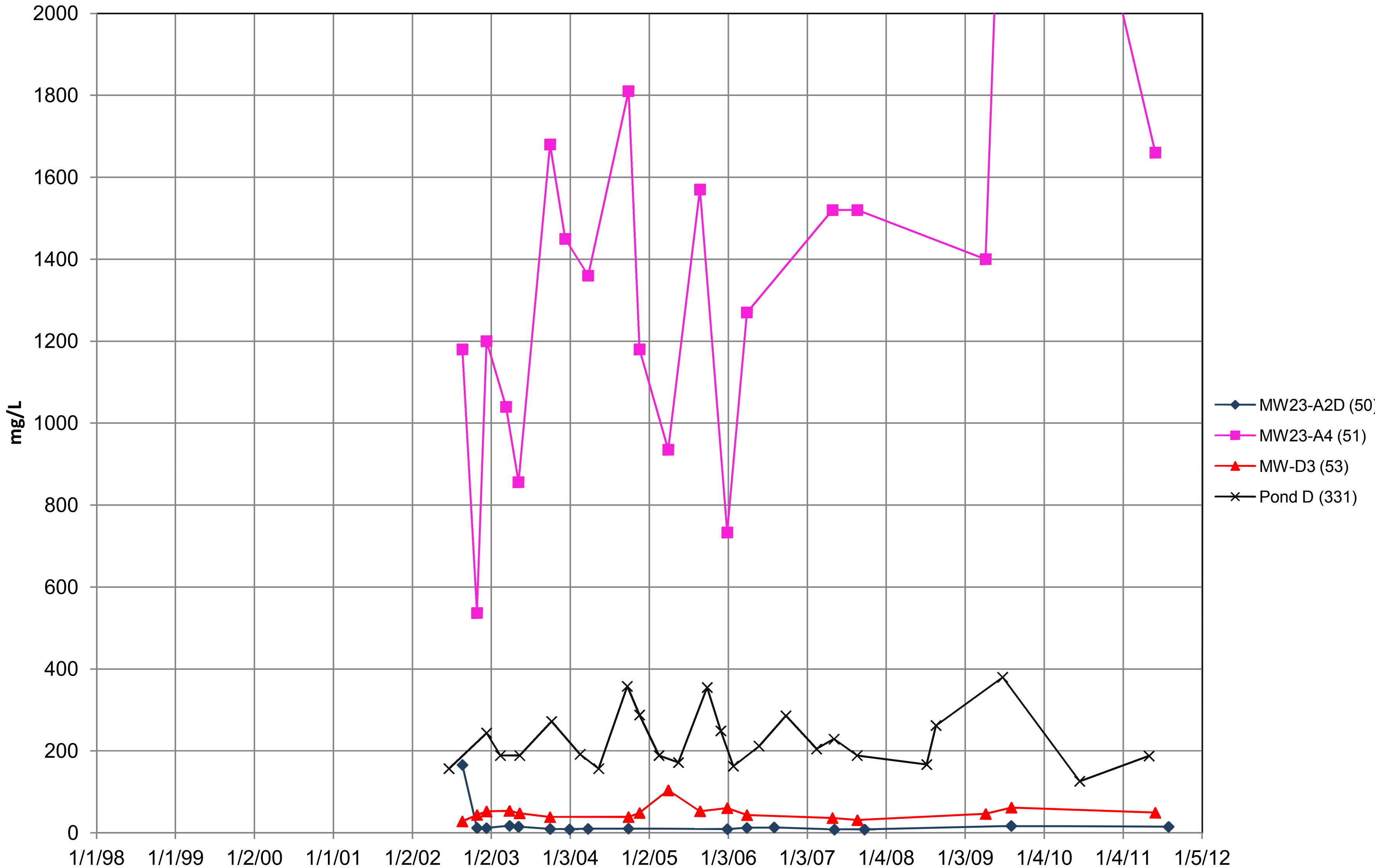


Figure 3.19a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - ARSENIC DATA (Non-detectable analyses plotted as zero)

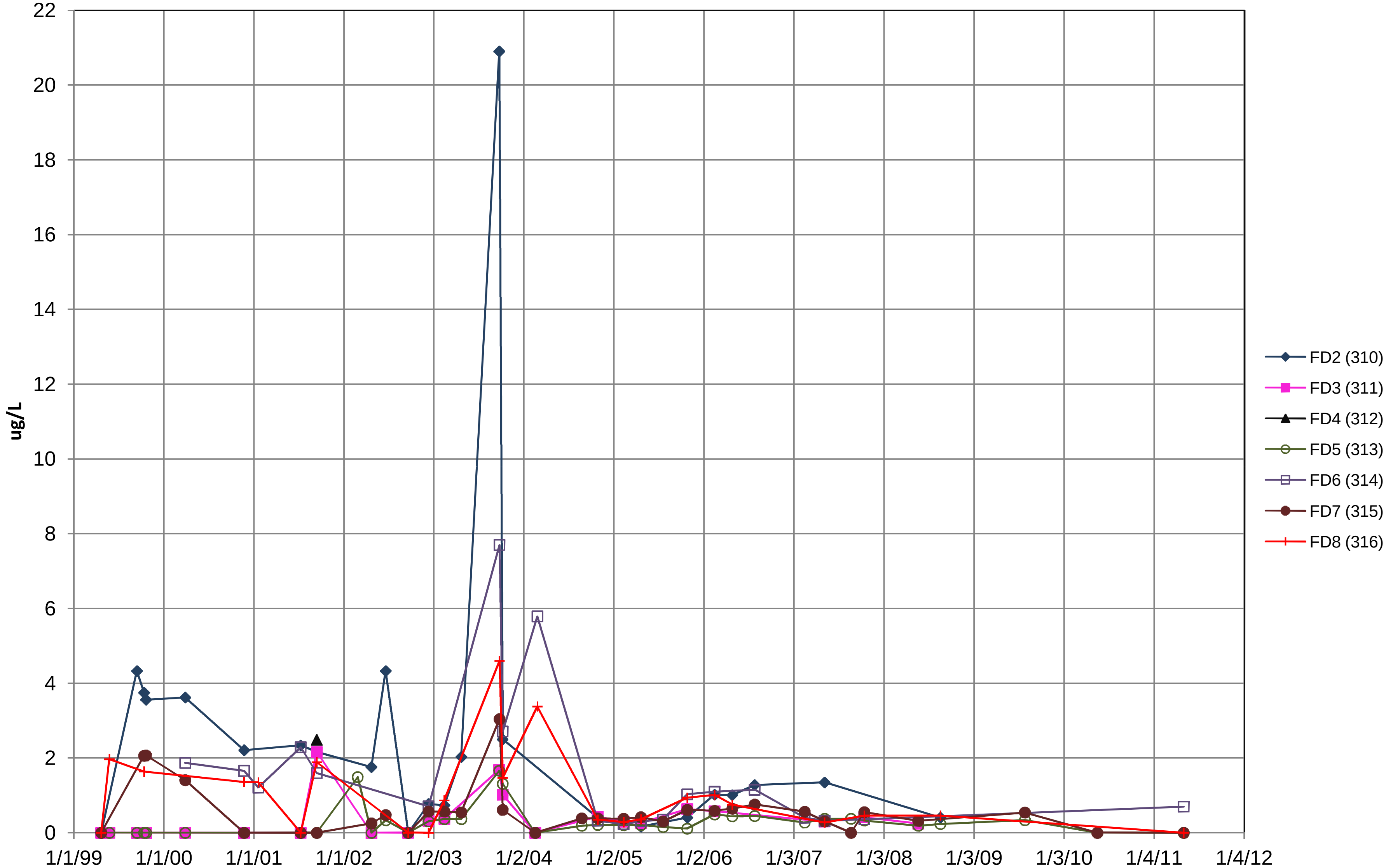


Figure 3.19b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - ARSENIC DATA (Non-detectable analyses plotted as zero)

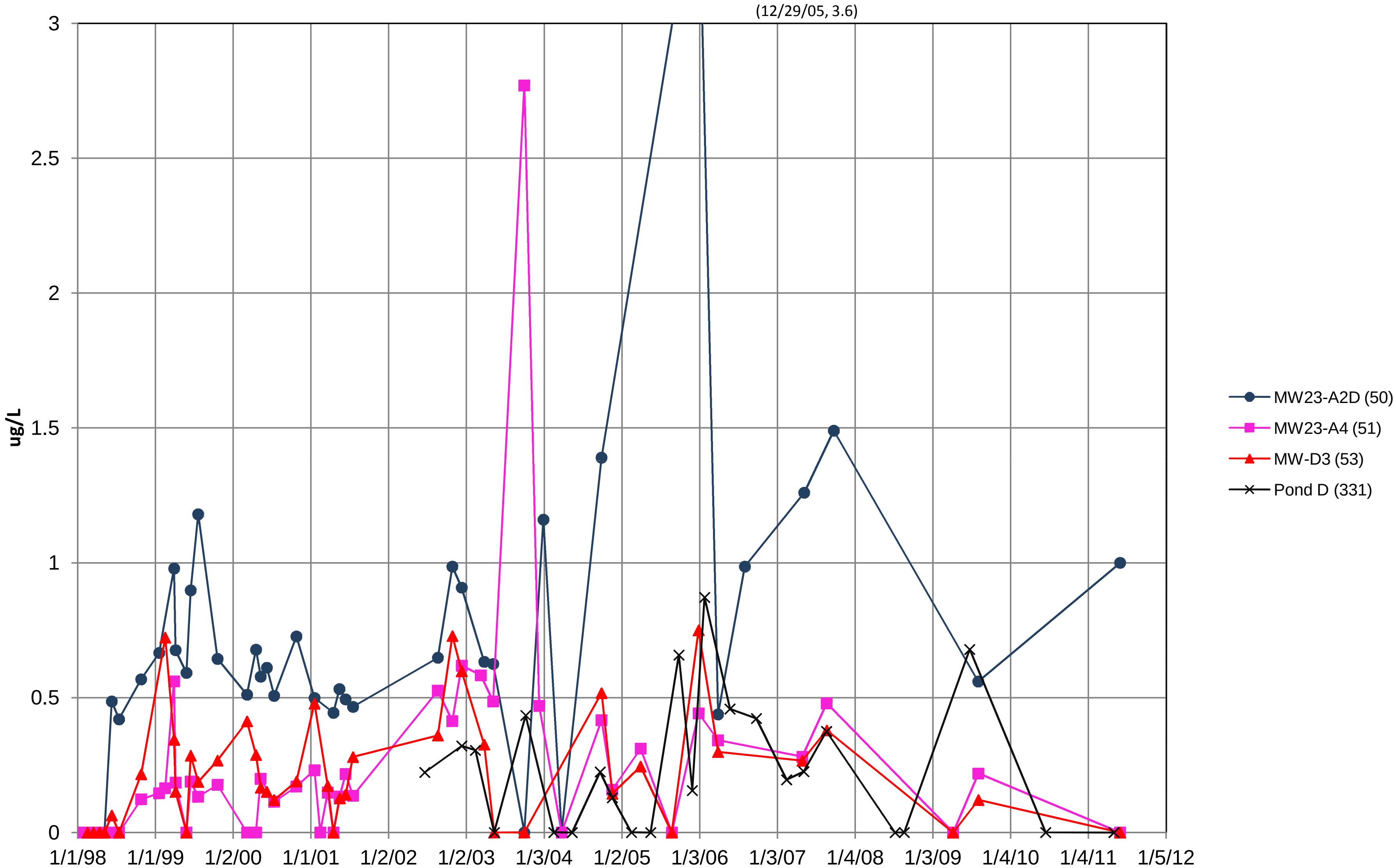
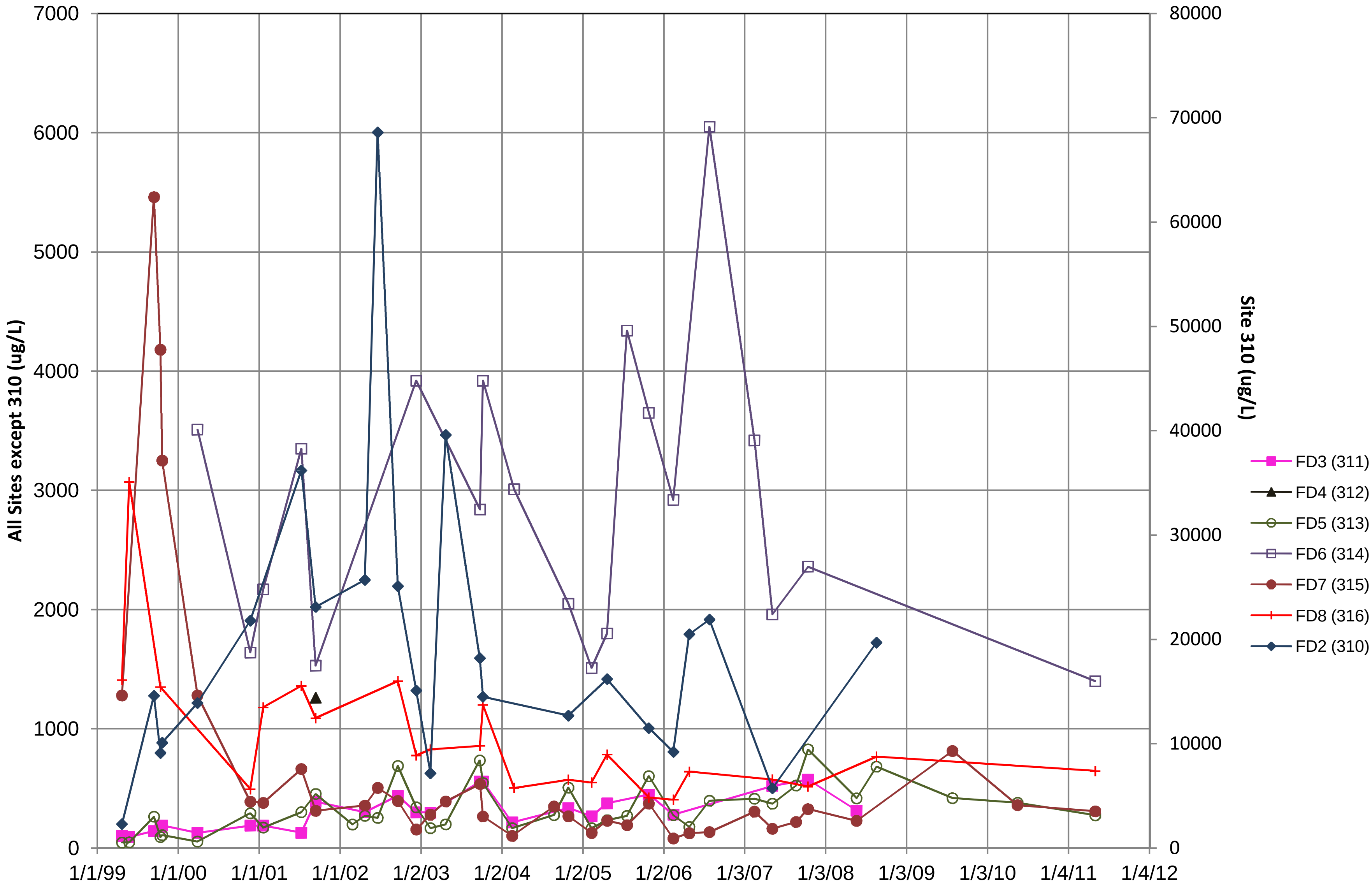


Figure 3.20a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - ZINC DATA
(Non-detectable analyses plotted as zero)



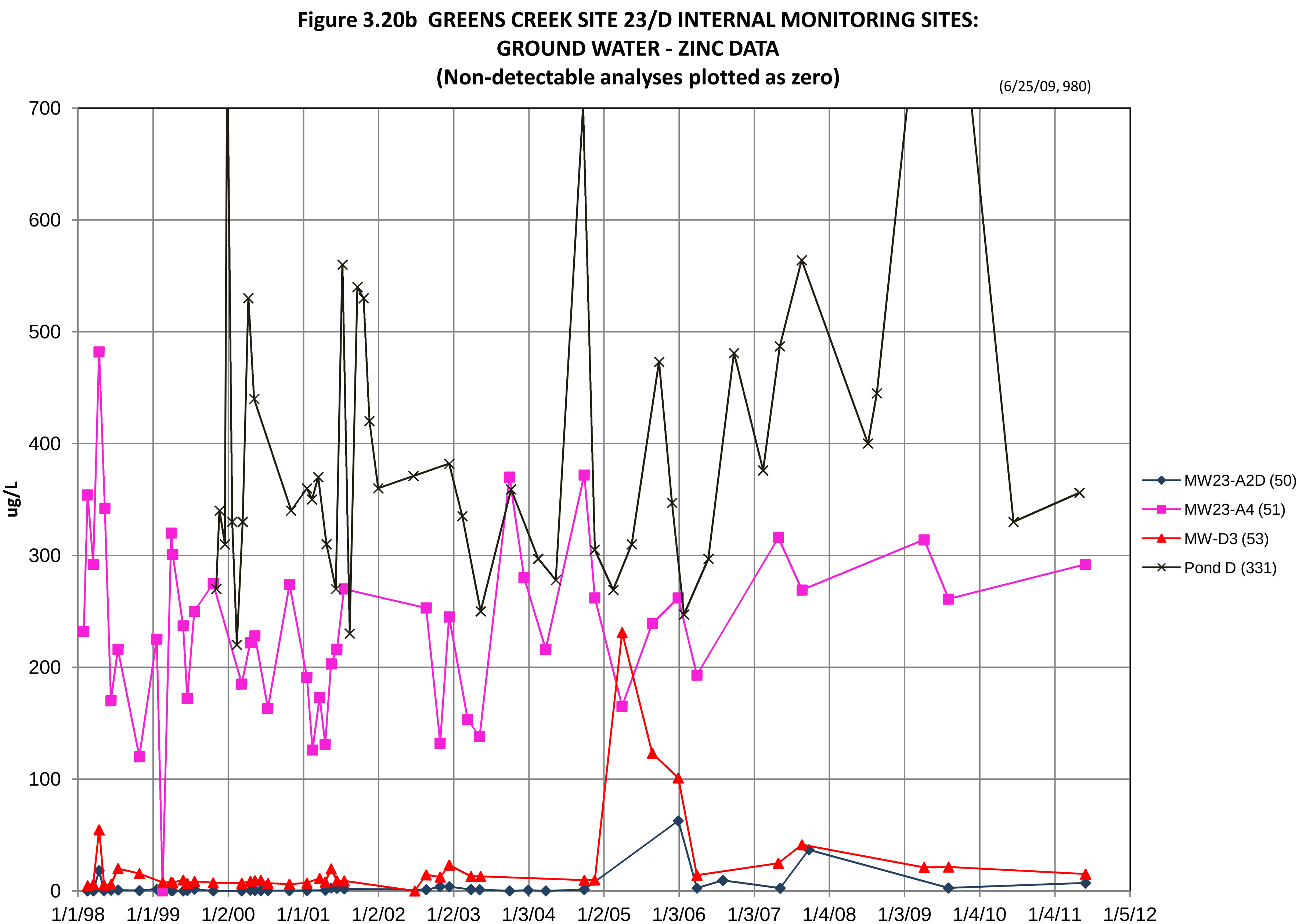


Figure 3.20b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES:
GROUND WATER - ZINC DATA
(Non-detectable analyses plotted as zero)
(6/25/09, 980)
ug/L
700
600
500
400
300
200
100
0
1/1/98
1/1/99
1/2/00
1/1/01
1/2/02
1/2/03
1/3/04
1/2/05
1/3/06
1/3/07
1/4/08
1/3/09
1/4/10
1/4/11
1/5/12
MW23-A2D (50)
MW23-A4 (51)
MW-D3 (53)
Pond D (331)

Figure 3.21a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - CADMIUM DATA
(Non-detectable analyses plotted as zero)

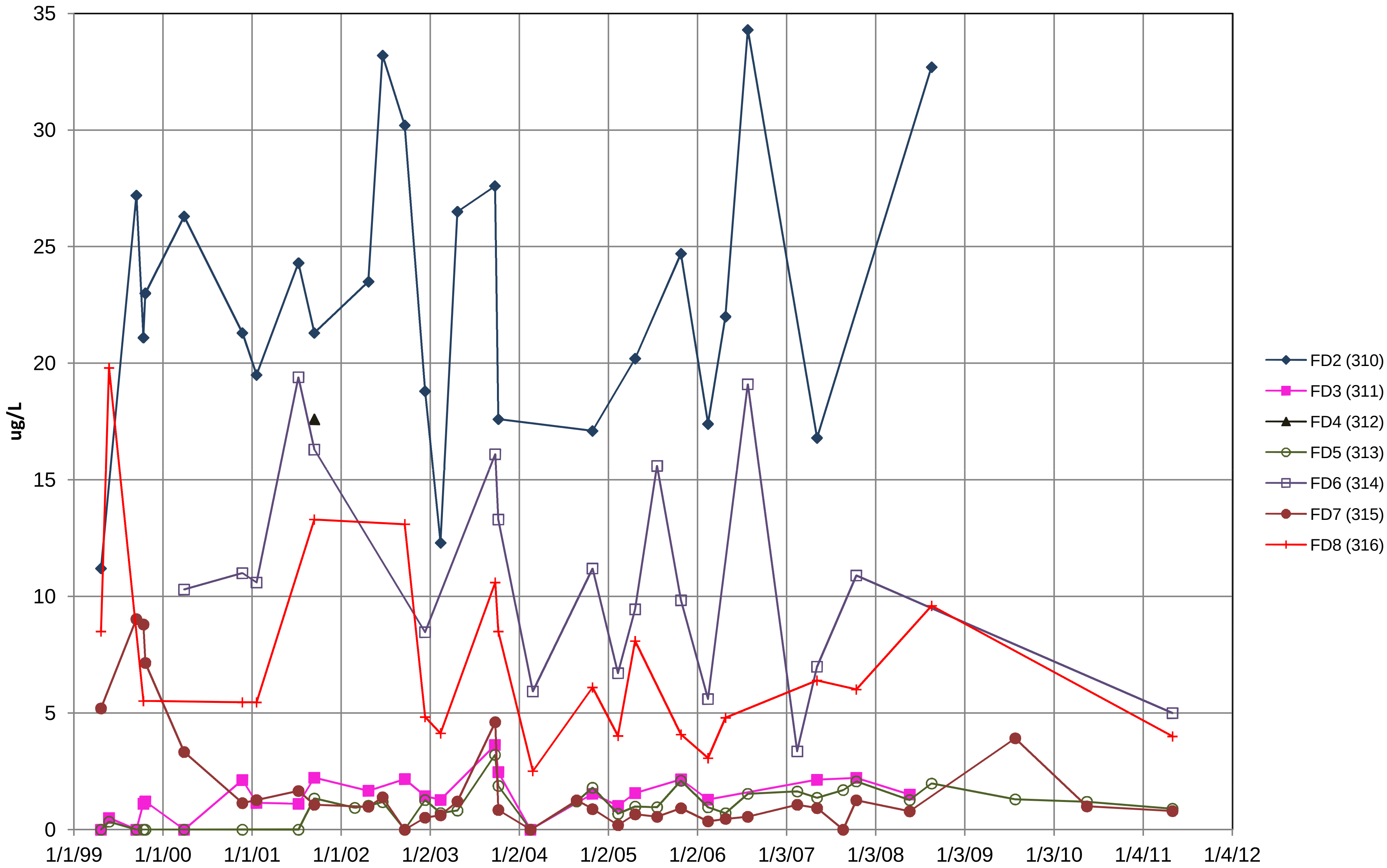


Figure 3.21b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - CADMIUM DATA (Non-detectable analyses plotted as zero)

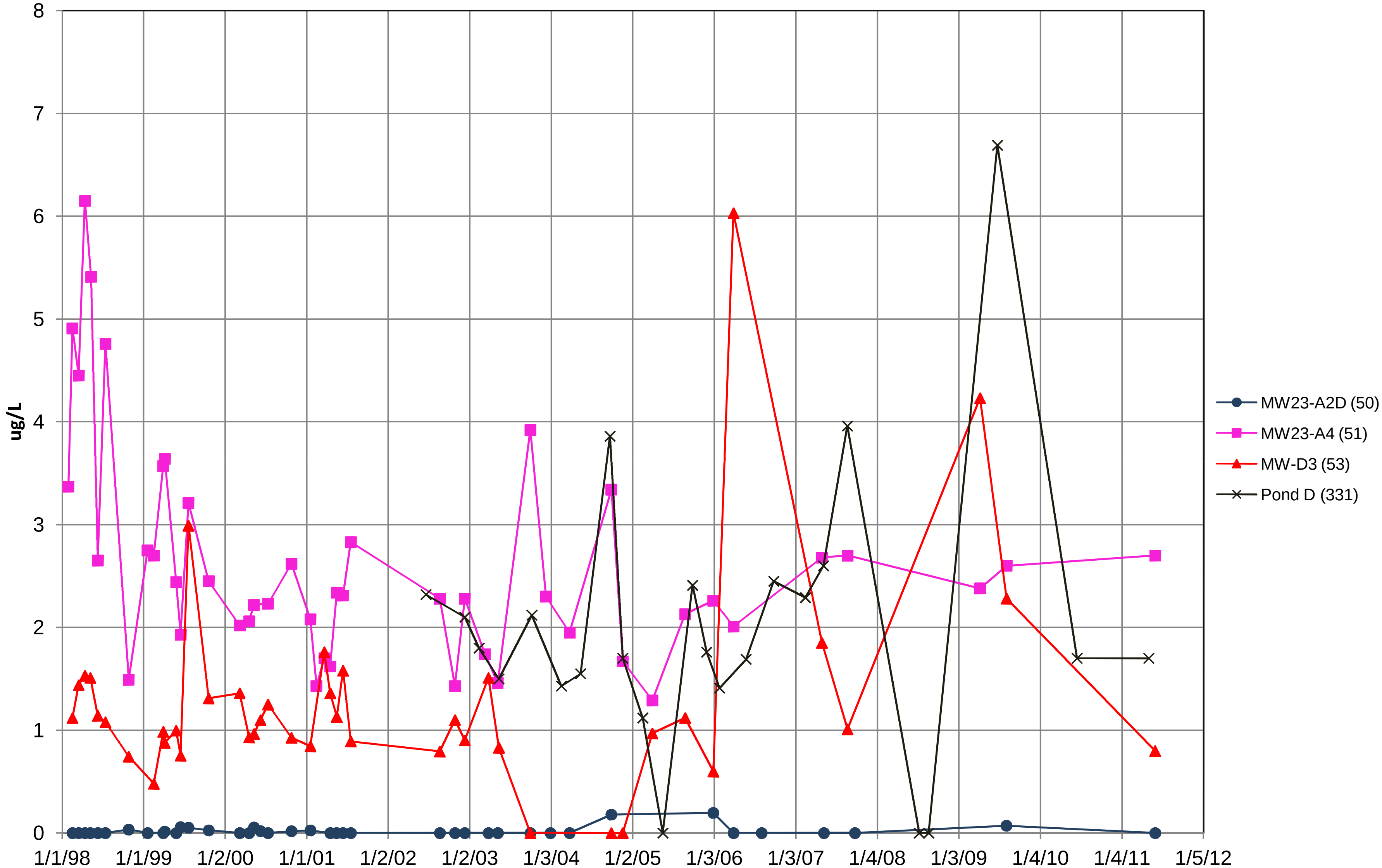


Figure 3.22a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - COPPER DATA (Non-detectabe analyses plotted as zero)

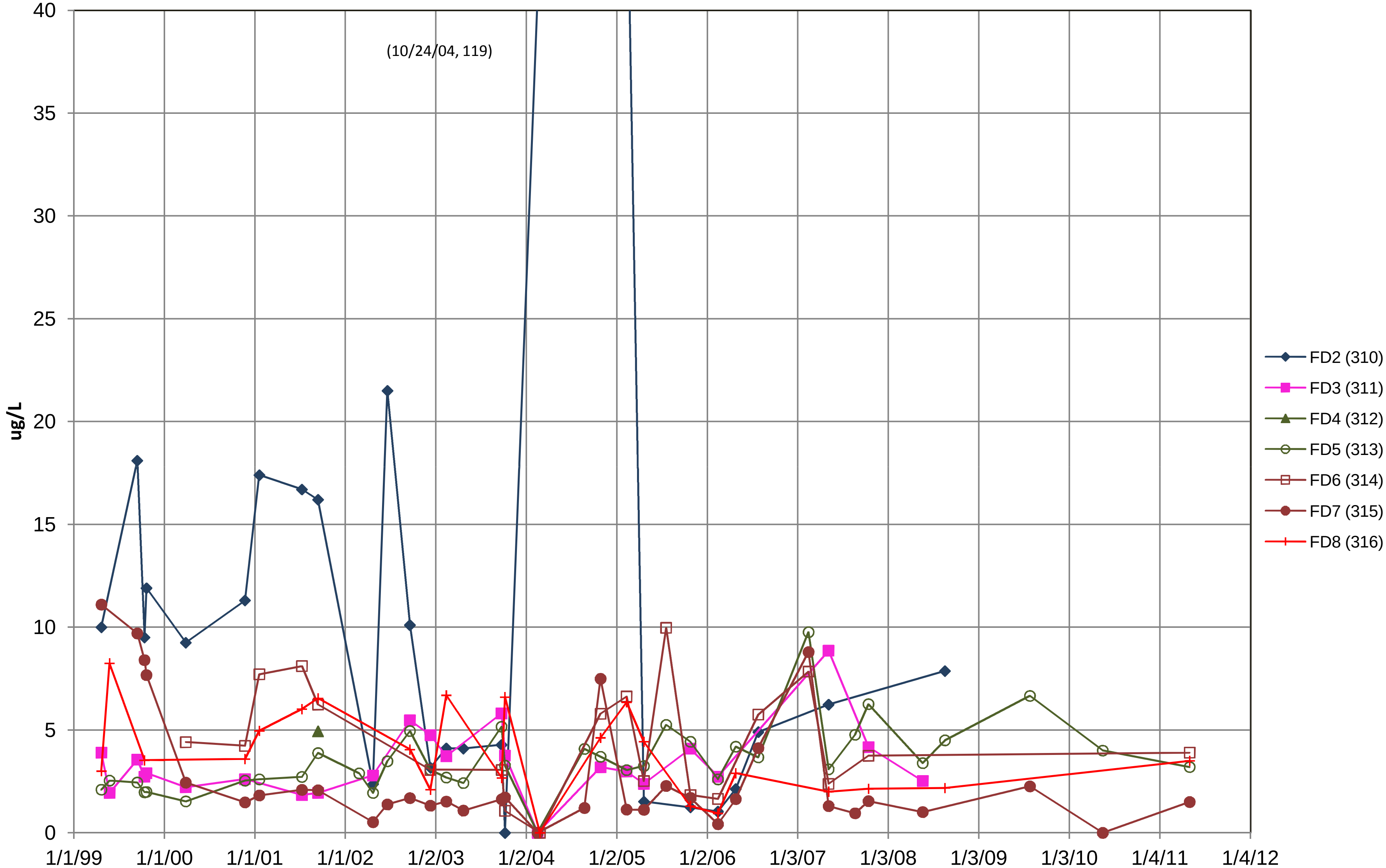


Figure 3.22b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - COPPER DATA (Non-detectable analyses plotted as zero)

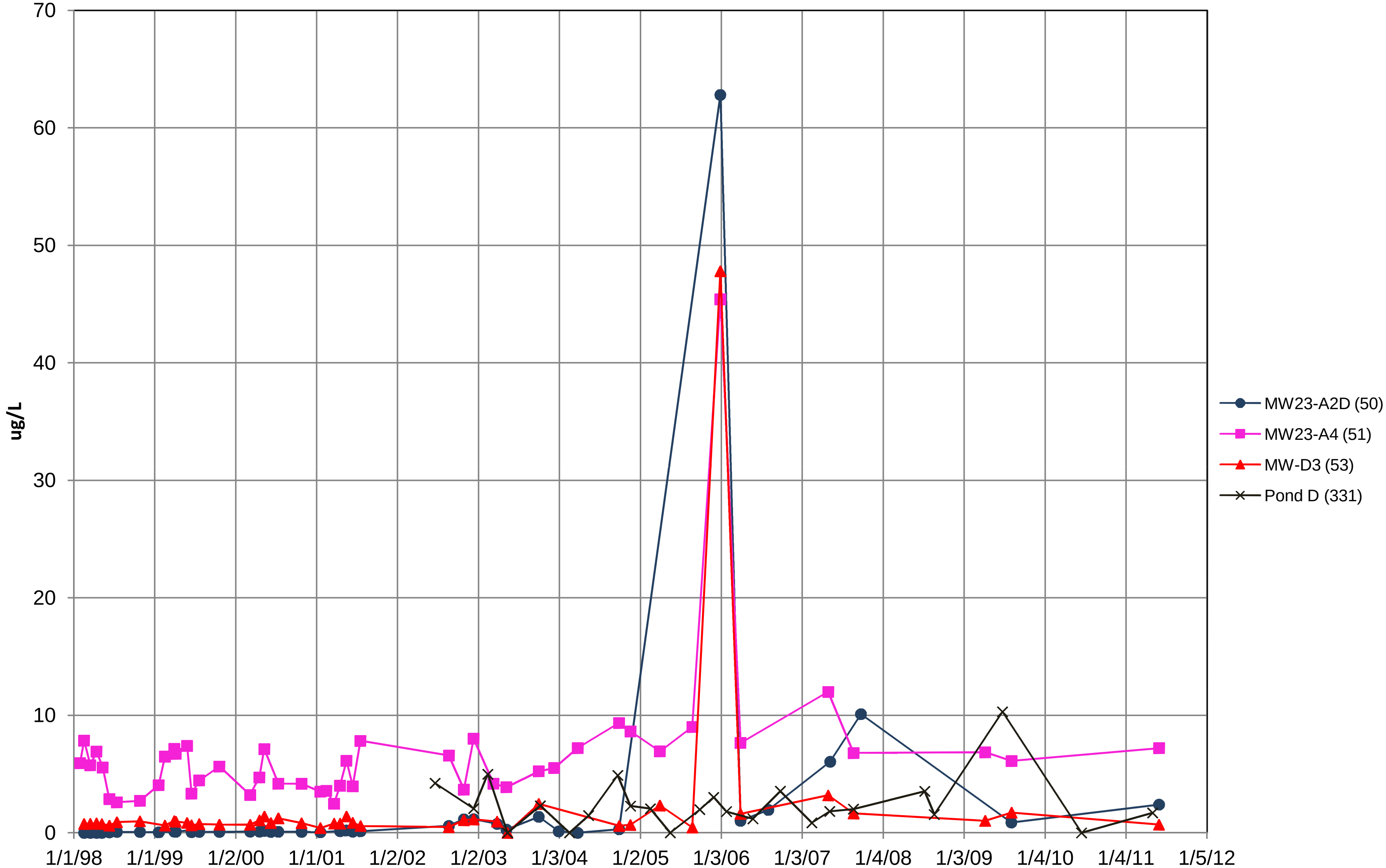


Figure 3.23a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - LEAD DATA (Non-detectable analyses plotted as zero)

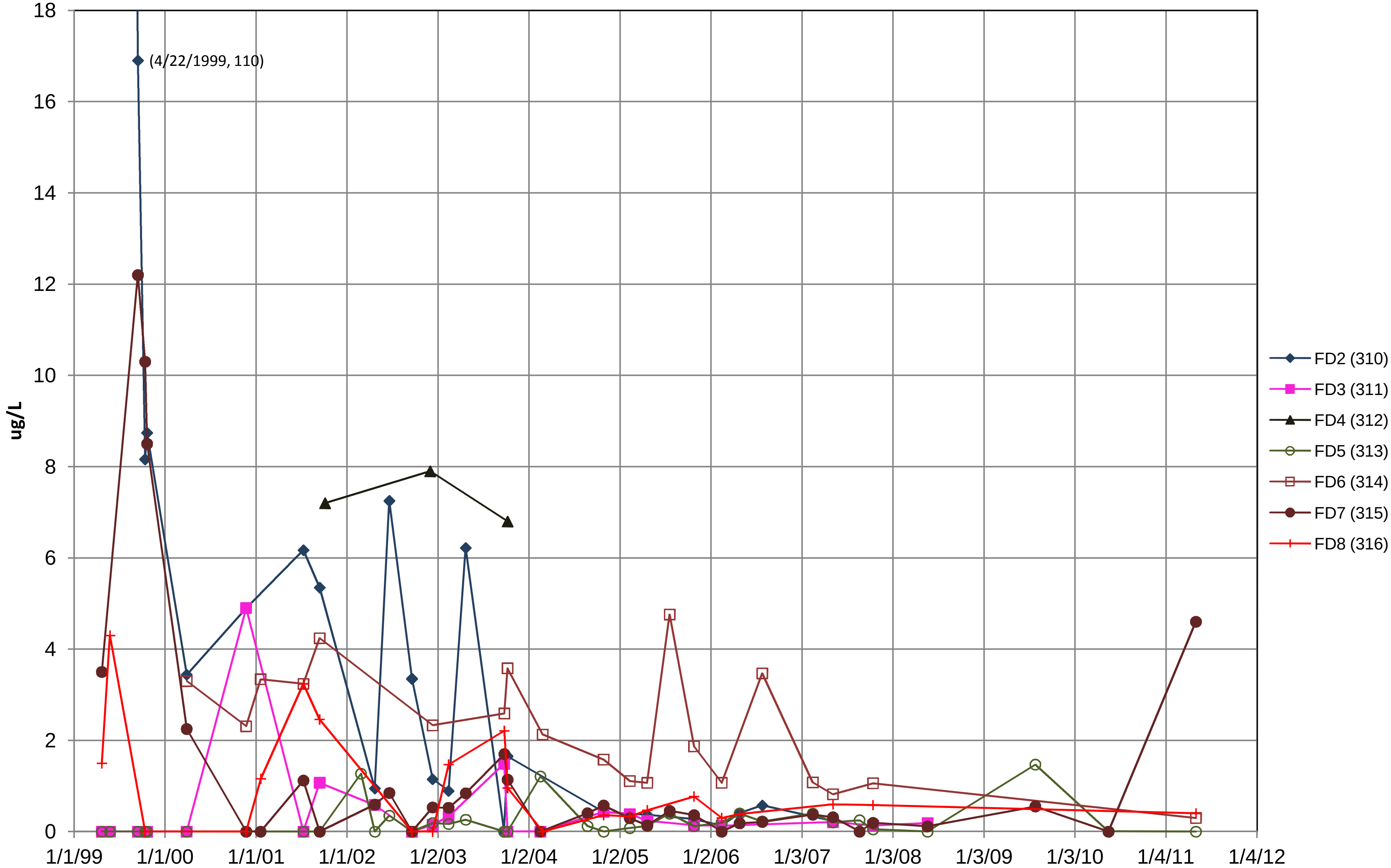


Figure 3.23b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - LEAD DATA (Non-detectable analyses plotted as zero)

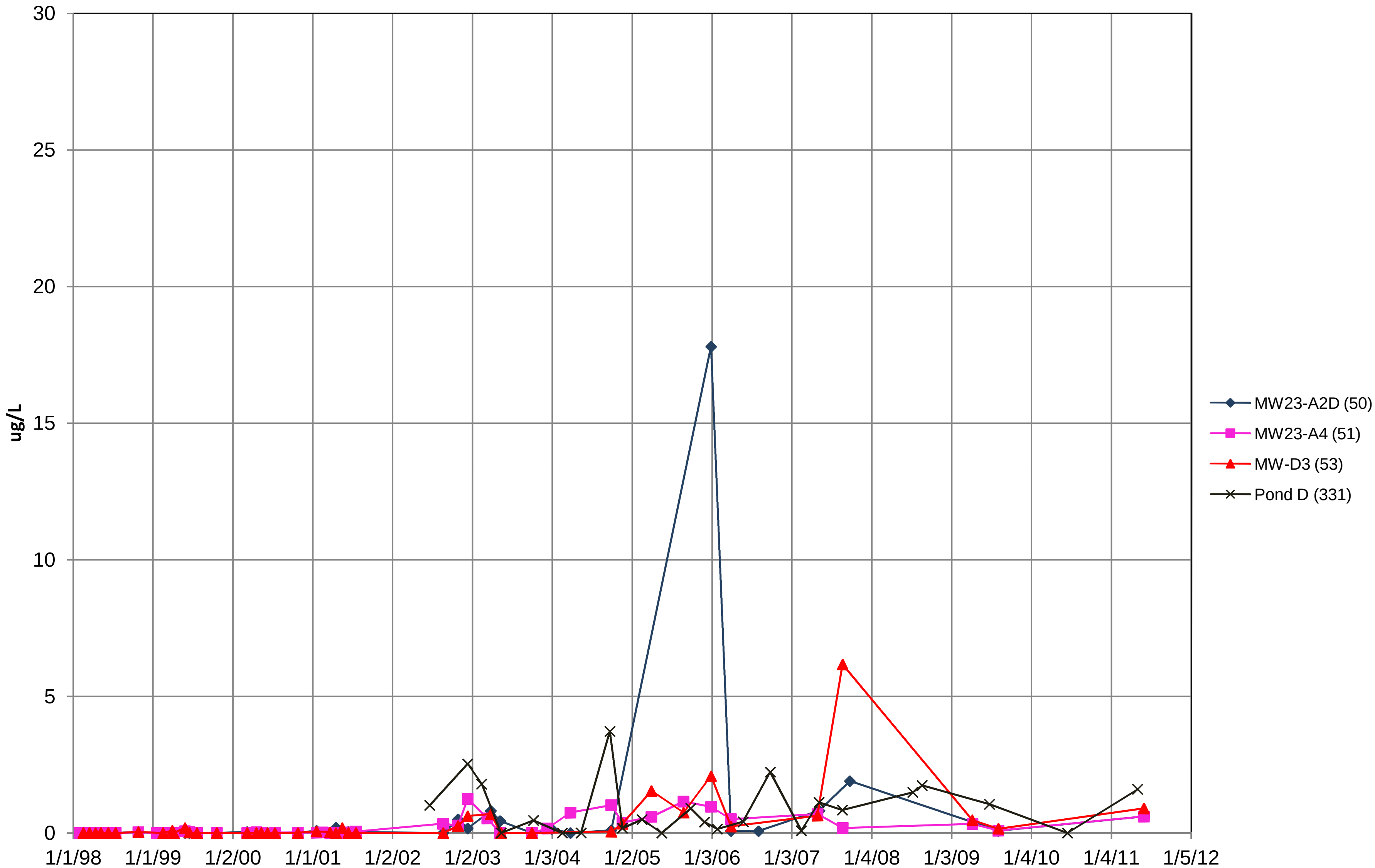


Figure 3.24a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - NICKEL DATA
(Non-detectable analyses plotted as zero)

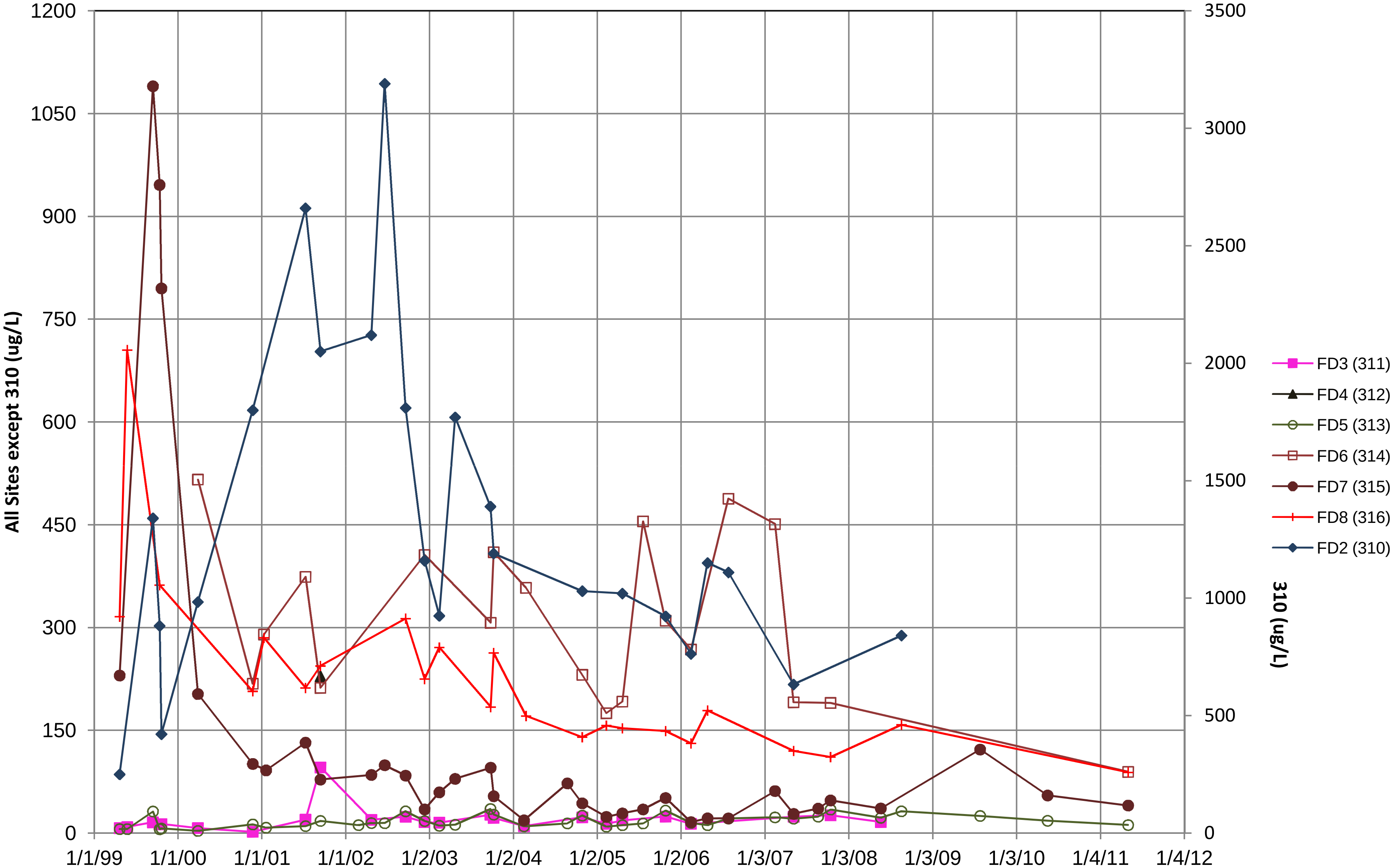


Figure 3.24b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - NICKEL DATA (Non-detectable analyses plotted as zero)

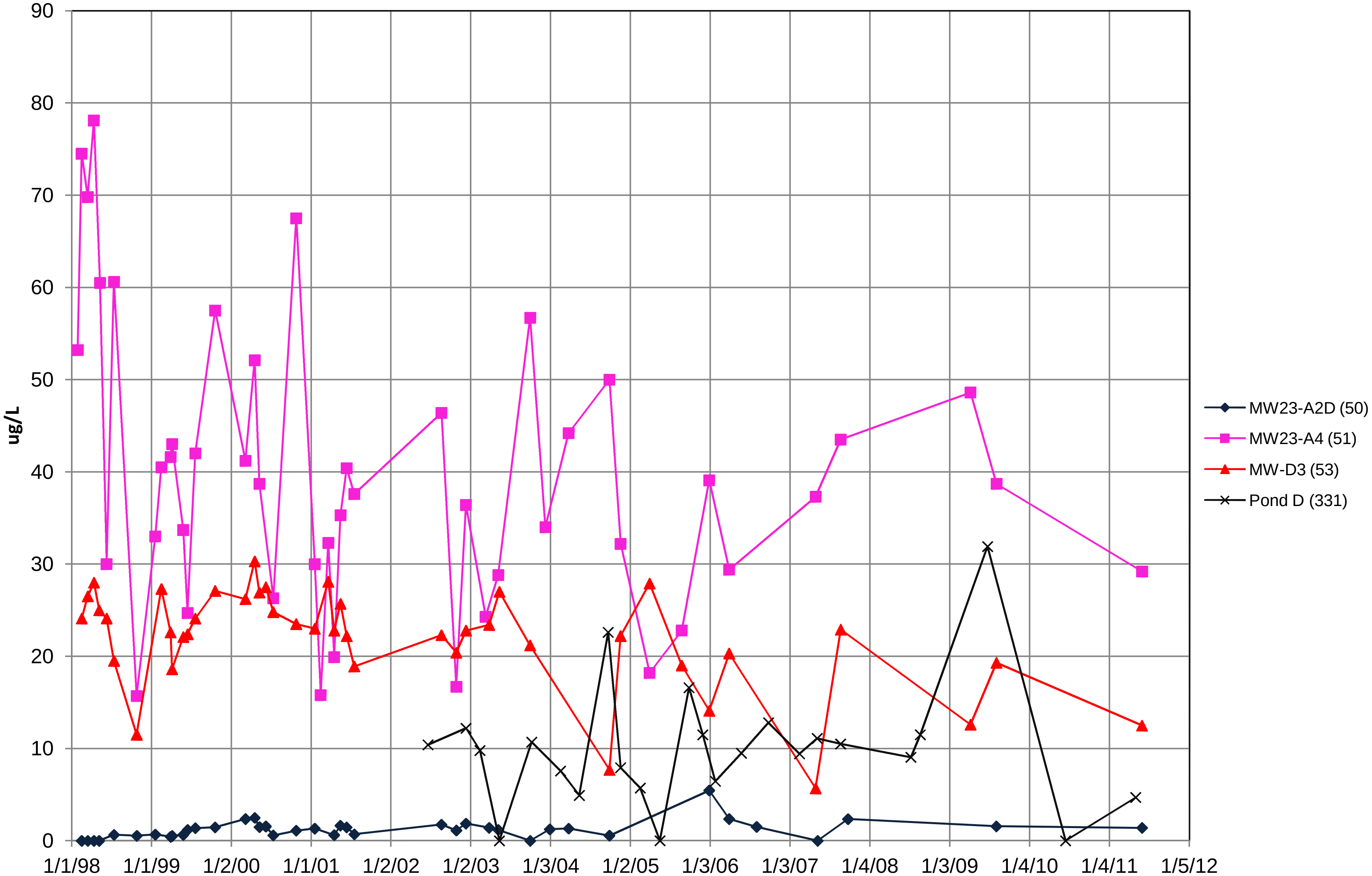


Figure 3.25a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - IRON DATA (Non-detectable analyses plotted as zero)

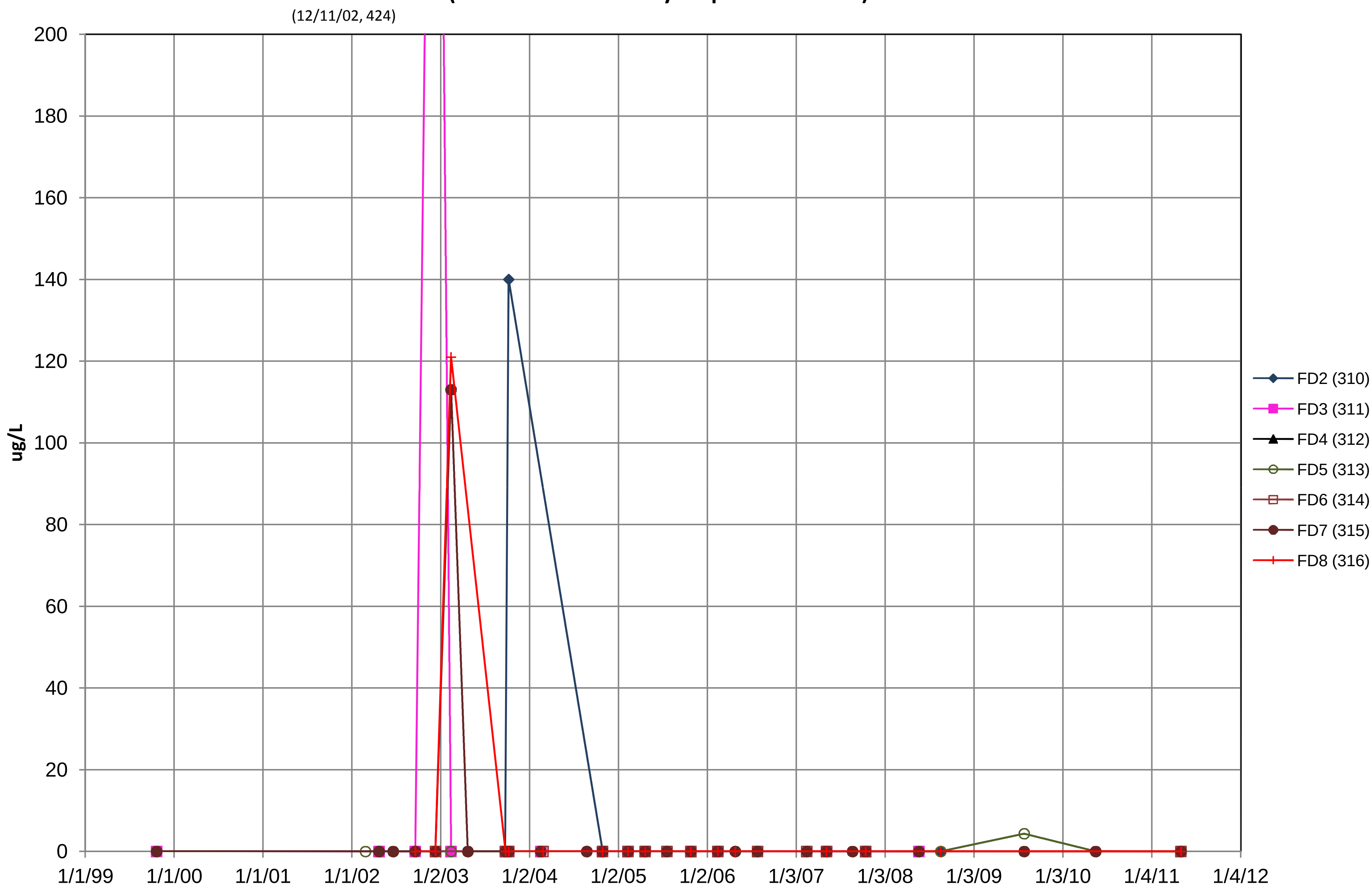


Figure 3.25b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - IRON DATA (Non-detectable analyses plotted as zero)

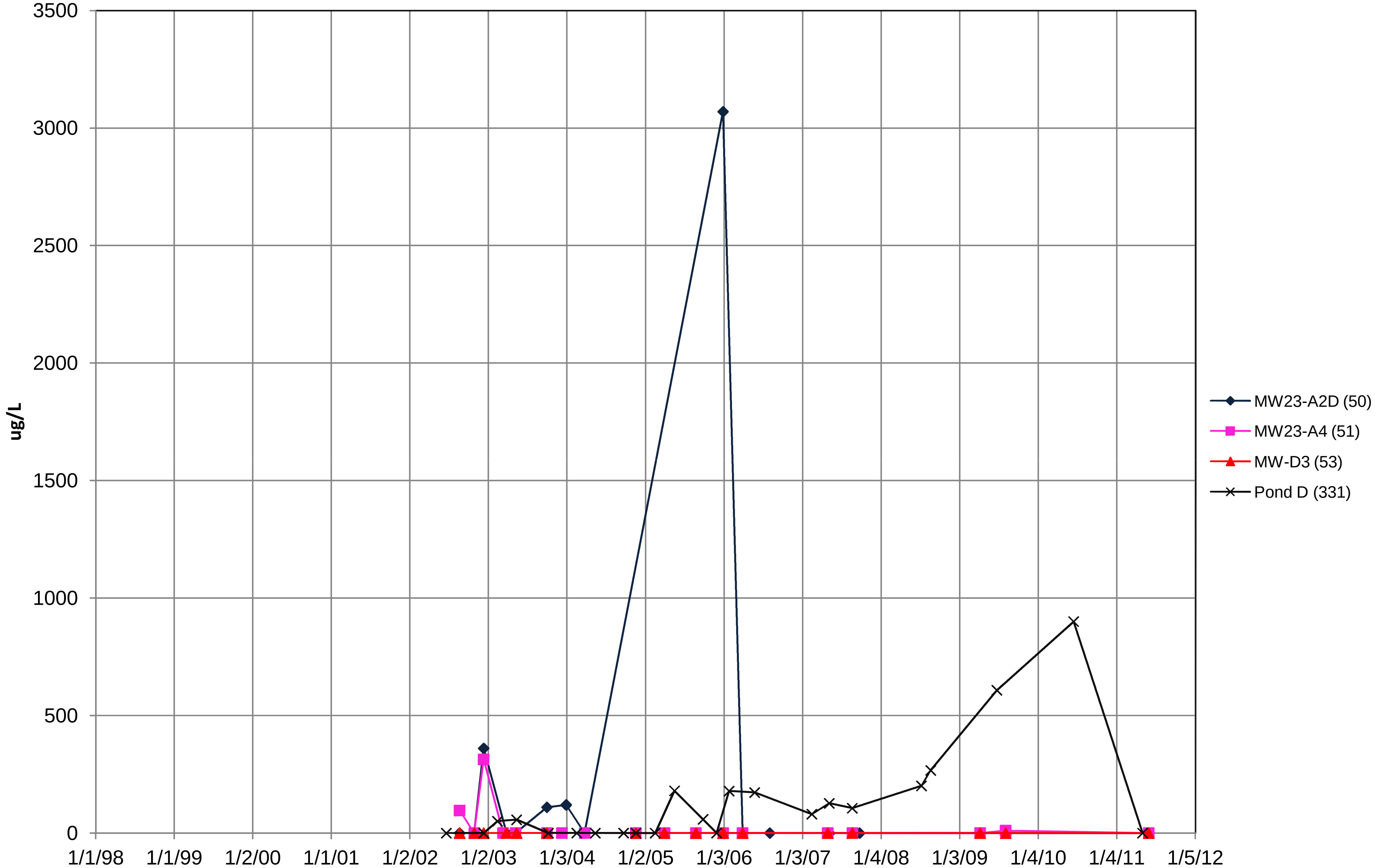


Figure 3.26a GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - MANGANESE DATA (Non-detectable analyses plotted as zero)

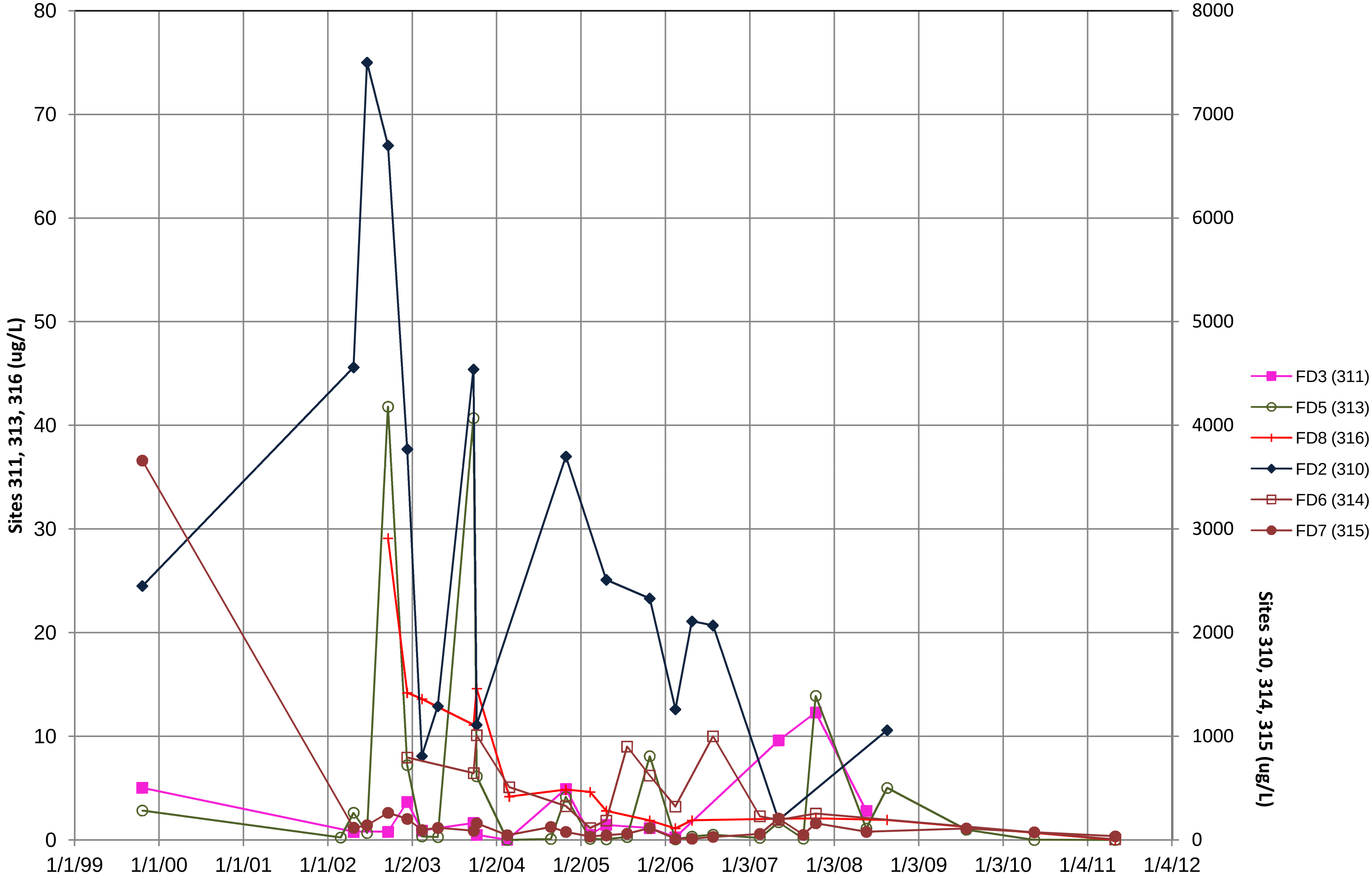


Figure 3.26b GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: GROUND WATER - MANGANESE DATA (Non-detectable analyses plotted as zero)

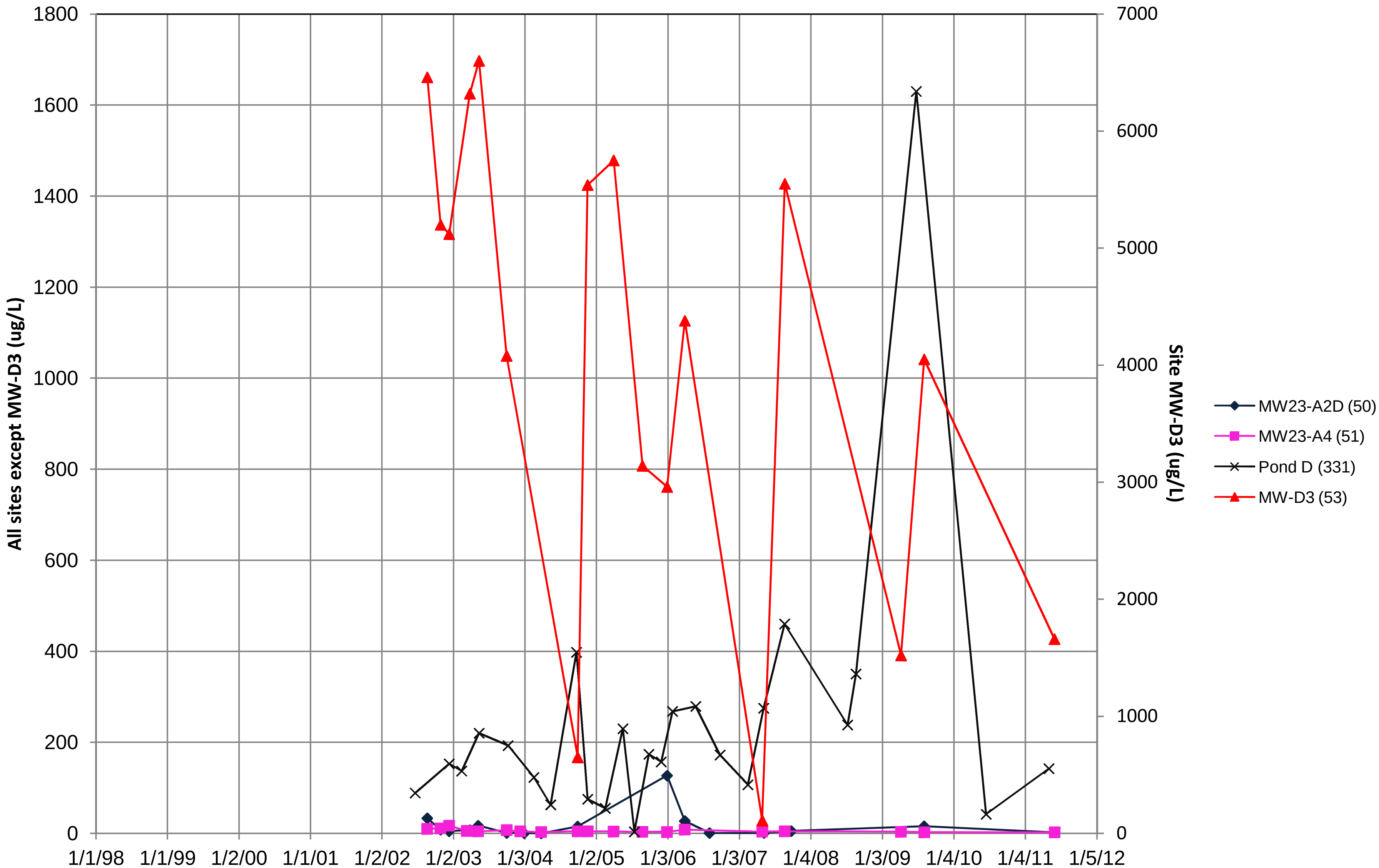


Figure 3.27 GREENS CREEK SITE 23/D INTERNAL MONITORING SITES: FINGER DRAINS - FLOW

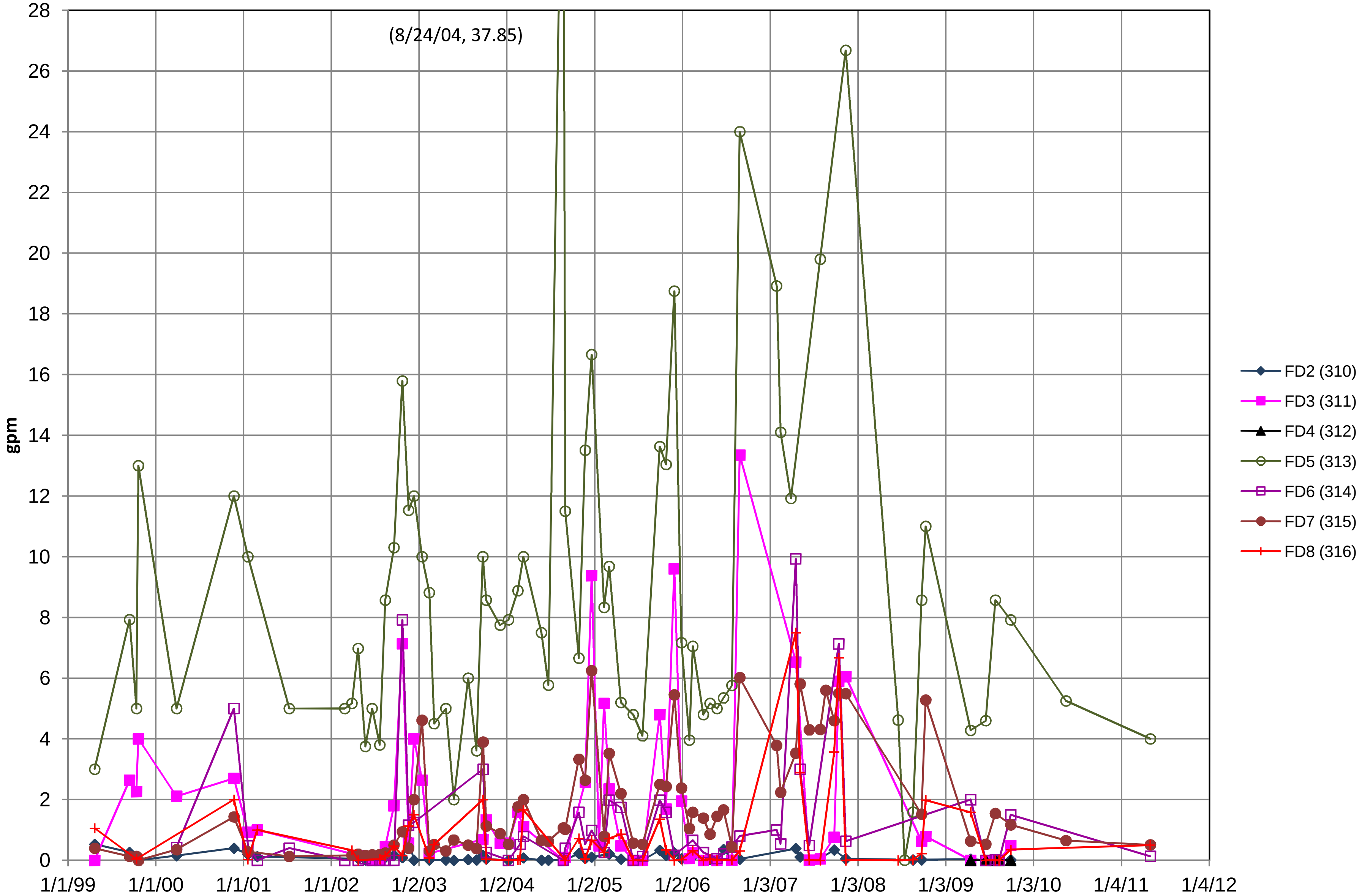


FIGURE 3.28 2011 ABA DATA FROM UNDERGROUND RIB SAMPLES

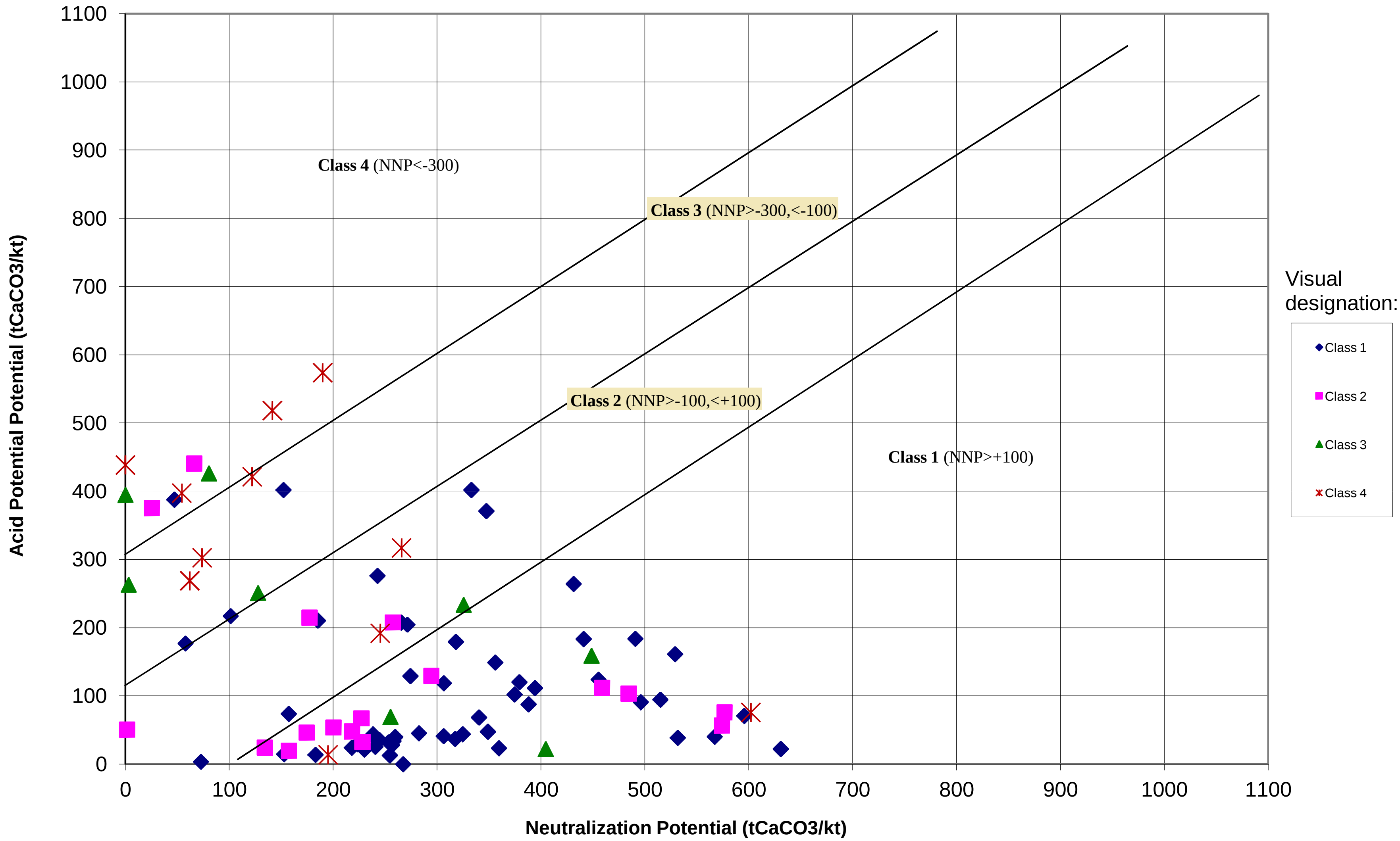


FIGURE 3.29a SITE 23 ABA DATA

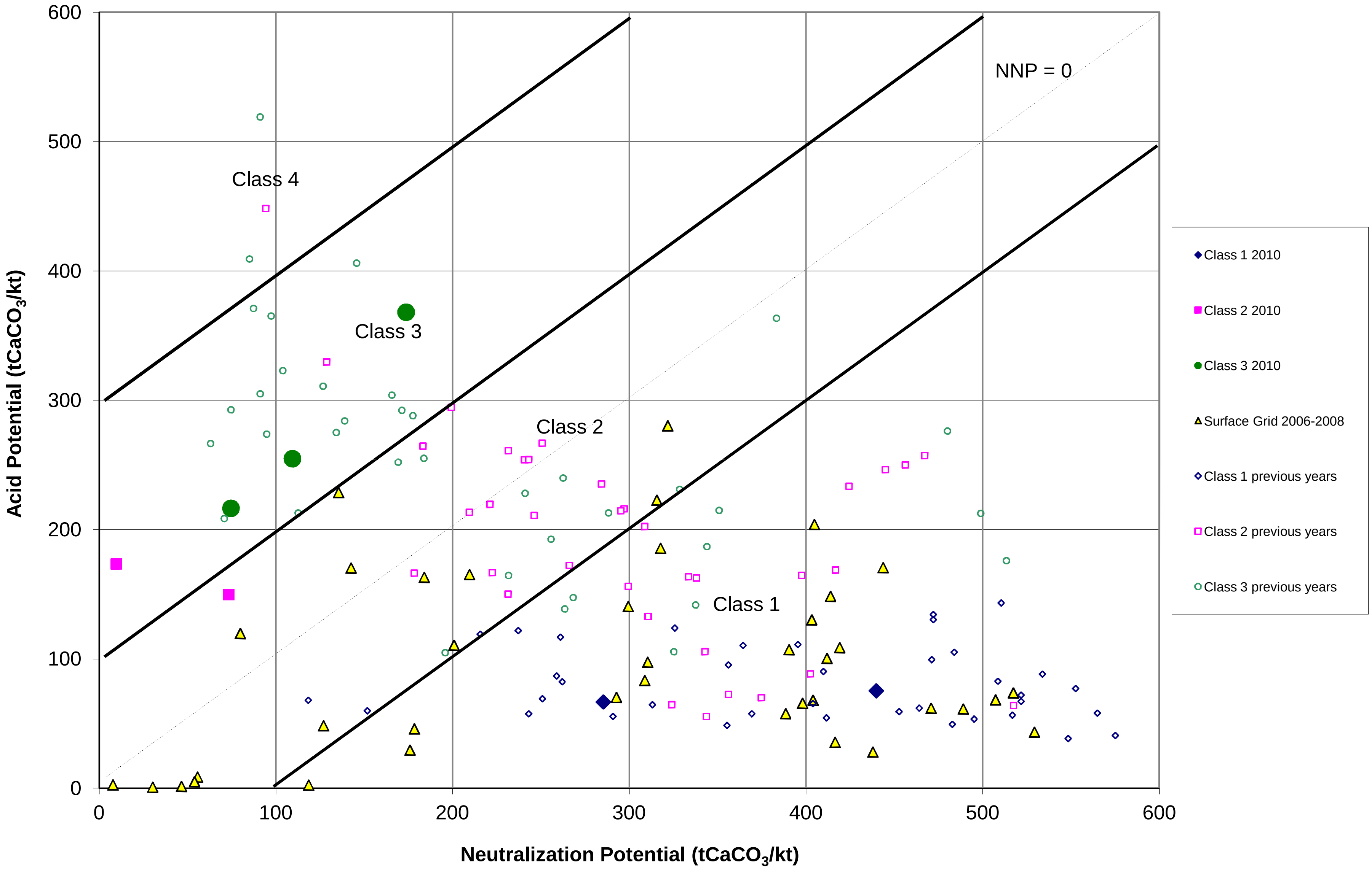
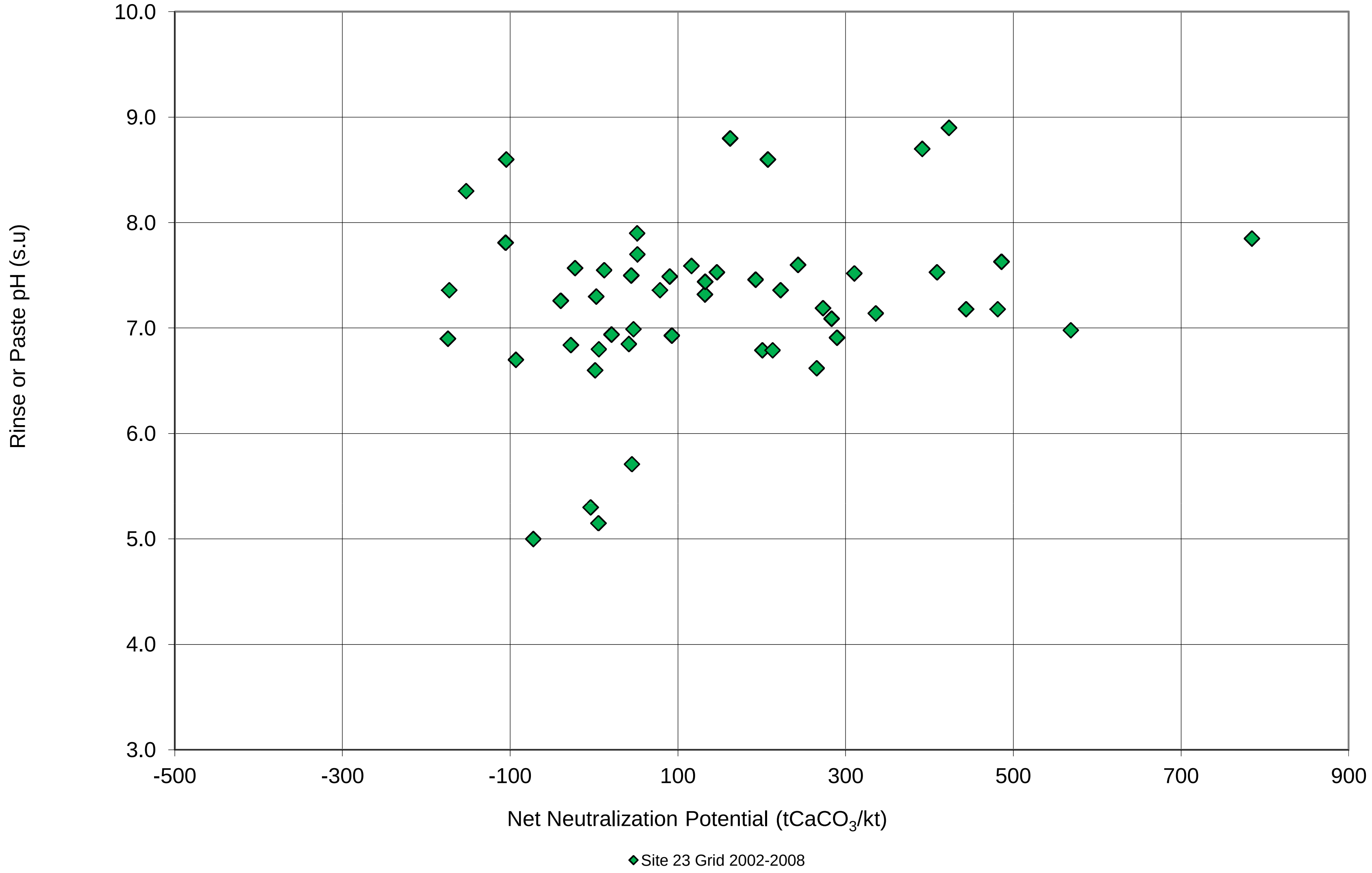


FIGURE 3.29b SITE 23 GRID ABA DATA



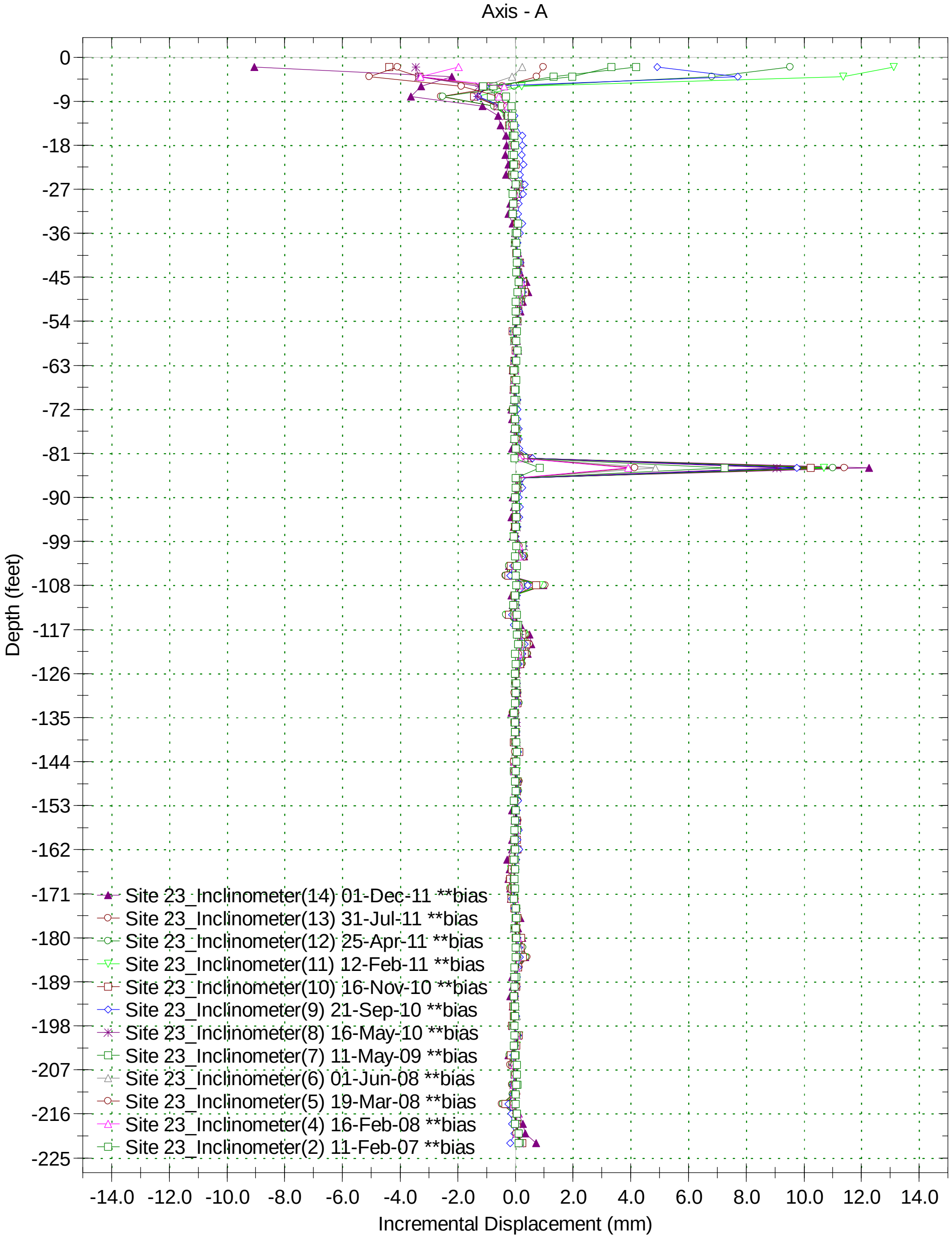
RST Instruments Ltd.

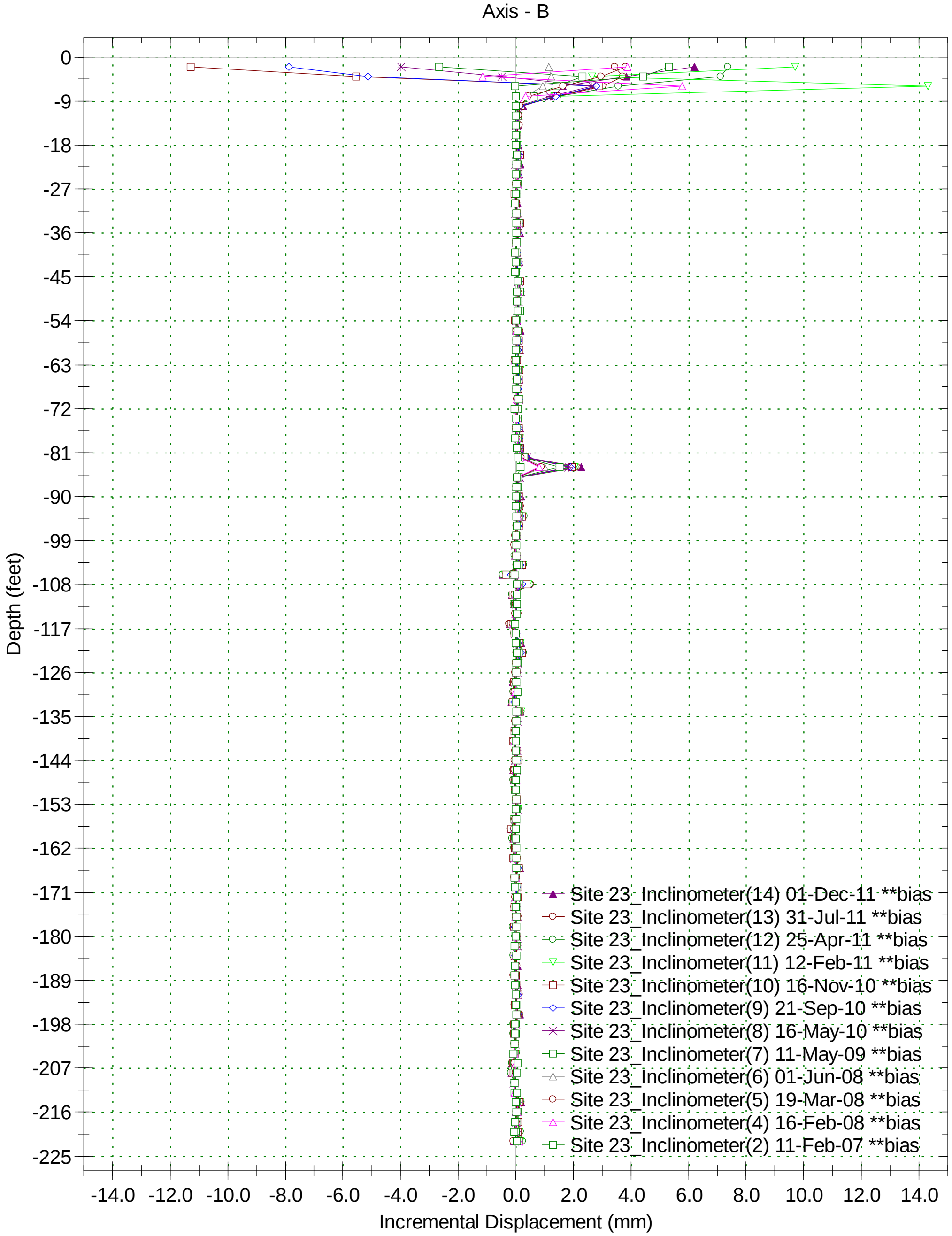
Borehole : Inclinometer
Project : Site 23
Location : IN-23-05-01
Northing : 20671.4520 ft
Easting : 17186.4160 ft

Figure 3.30 Site 23 Inclinometer Incremental Displacement

Inclinalysis

Spiral Correction : N/A
Collar Elevation : 948.840 ft
Borehole Total Depth : 222.0 feet
North Groove Azimuth :
Base Reading : 2006 Oct 07 10:28





Notes:
Zero reference is top of casing, at ~4.7 ft above ground surface.
Top section of casing/damage joint replaced in July 2011.
Bias-shift correction by pinning data sets at 150-ft depth (A_B axis).

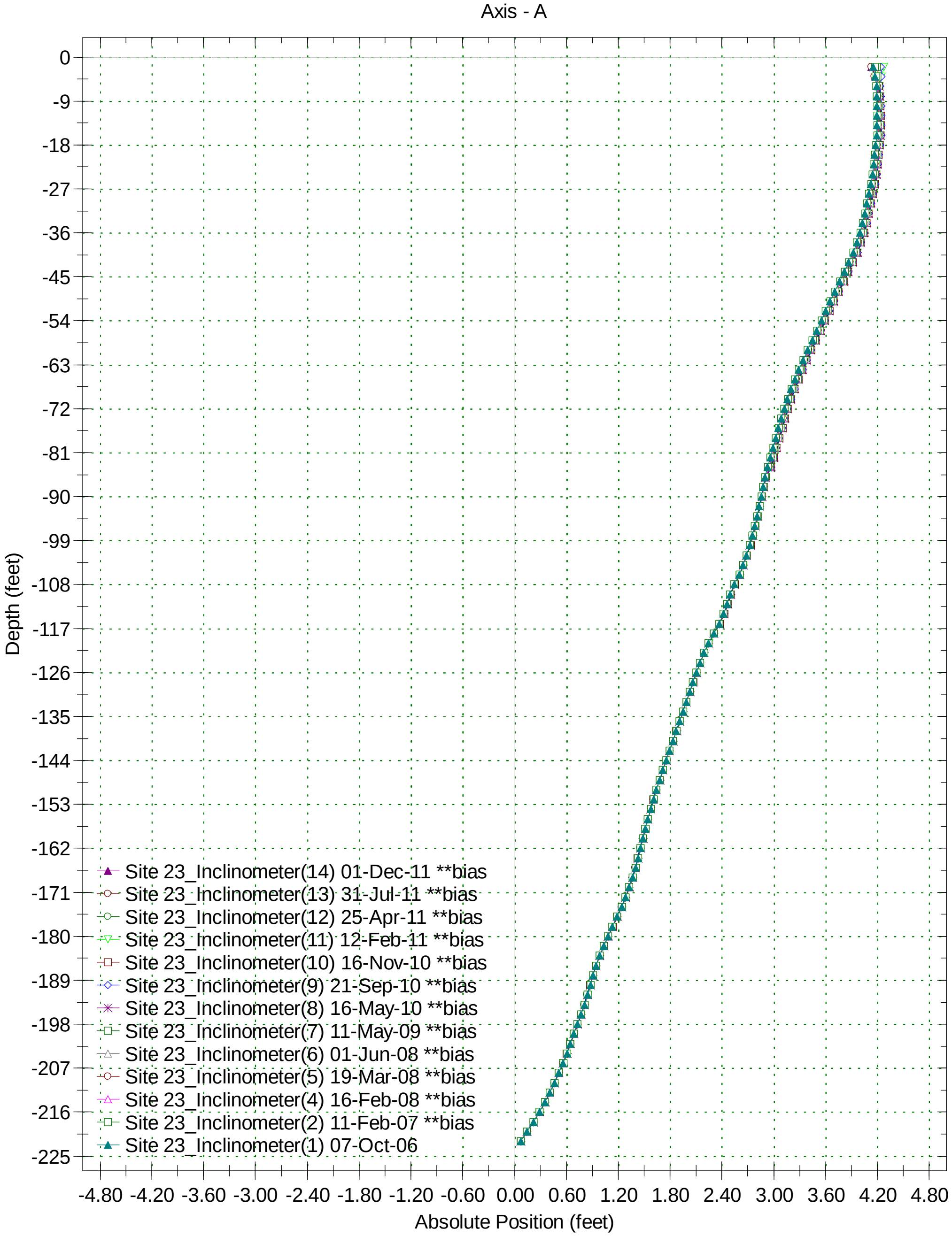
RST Instruments Ltd.

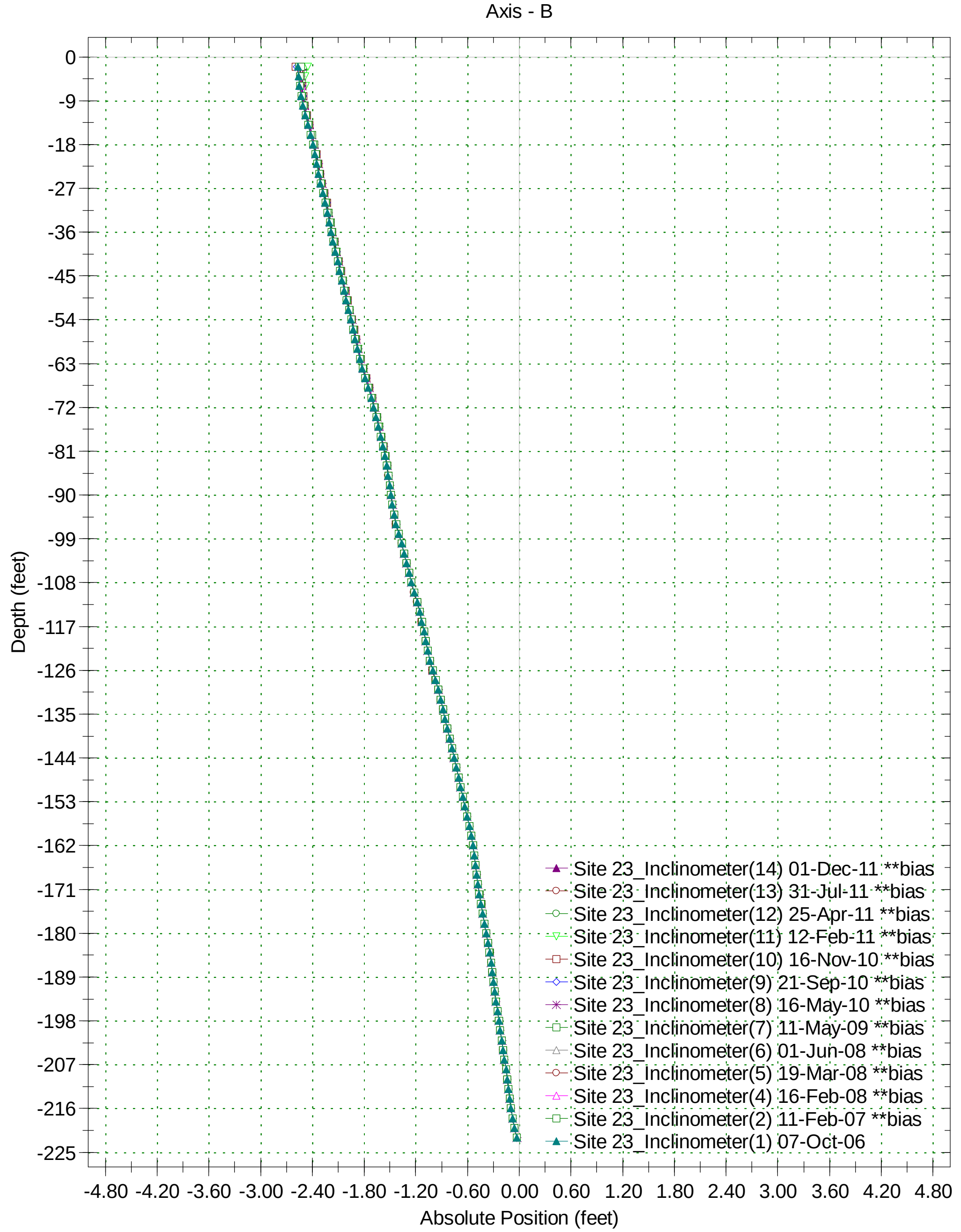
Borehole : Inclinometer
Project : Site 23
Location : IN-23-05-01
Northing : 20671.4520 ft
Easting : 17186.4160 ft

Figure 3.31 Site 23 Inclinometer Absolute Displacement

Inclinalysis

Spiral Correction : N/A
Collar Elevation : 948.840 ft
Borehole Total Depth : 222.0 feet
North Groove Azimuth :
Base Reading : 2006 Oct 07 10:28





Notes:
Zero reference is top of casing, at ~4.7 ft above ground surface.
Top section of casing/damage joint replaced in July 2011.
Bias-shift correction by pinning data sets at 150-ft depth (A_B axis).

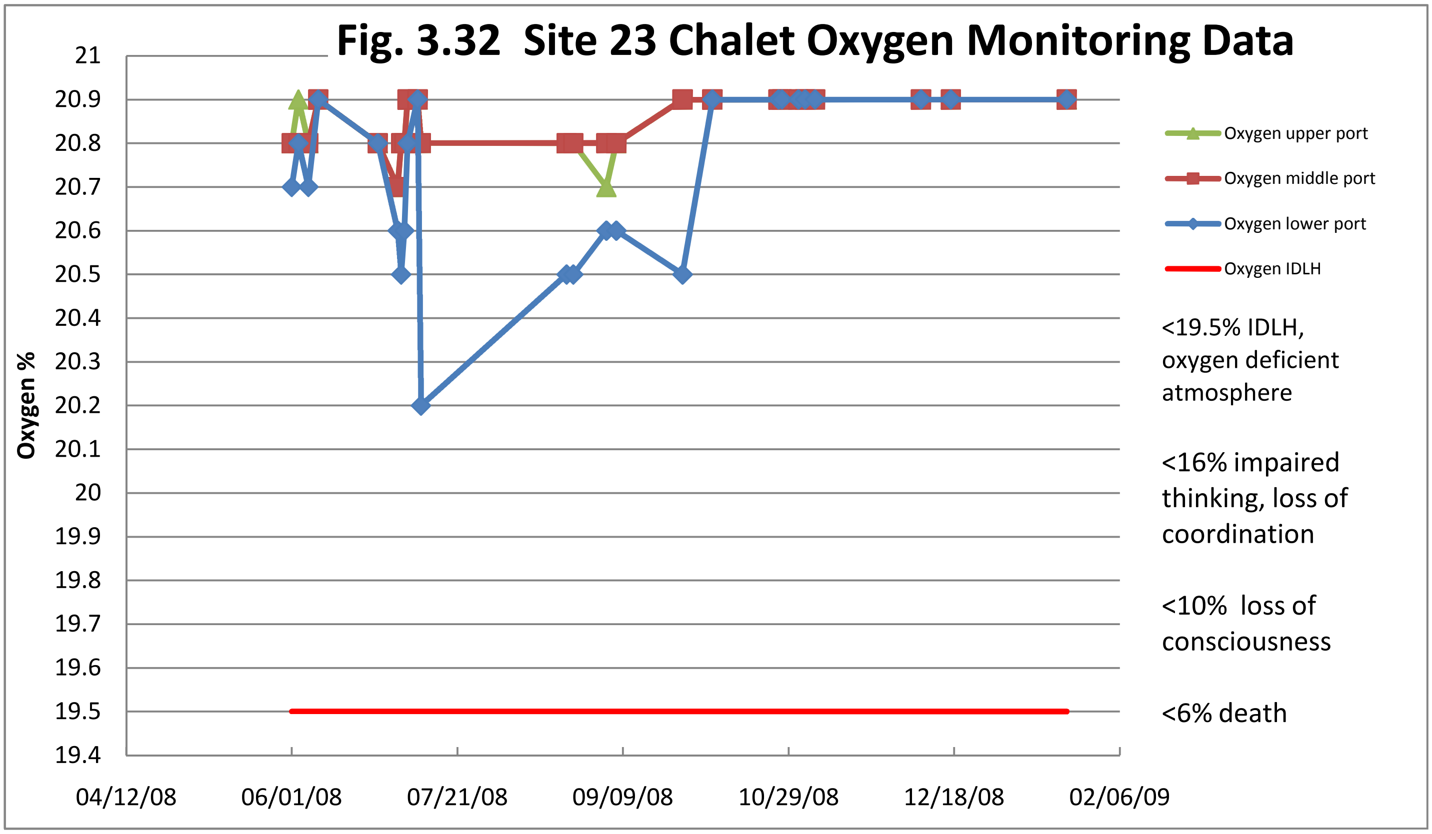


Fig. 3.32 Site 23 Chalet Oxygen Monitoring Data
Oxygen %
21
20.9
20.8
20.7
20.6
20.5
20.4
20.3
20.2
20.1
20
19.9
19.8
19.7
19.6
19.5
19.4
04/12/08
06/01/08
07/21/08
09/09/08
10/29/08
12/18/08
02/06/09
Oxygen upper port
Oxygen middle port
Oxygen lower port
Oxygen IDLH
<19.5% IDLH, oxygen deficient atmosphere
<16% impaired thinking, loss of coordination
<10% loss of consciousness
<6% death

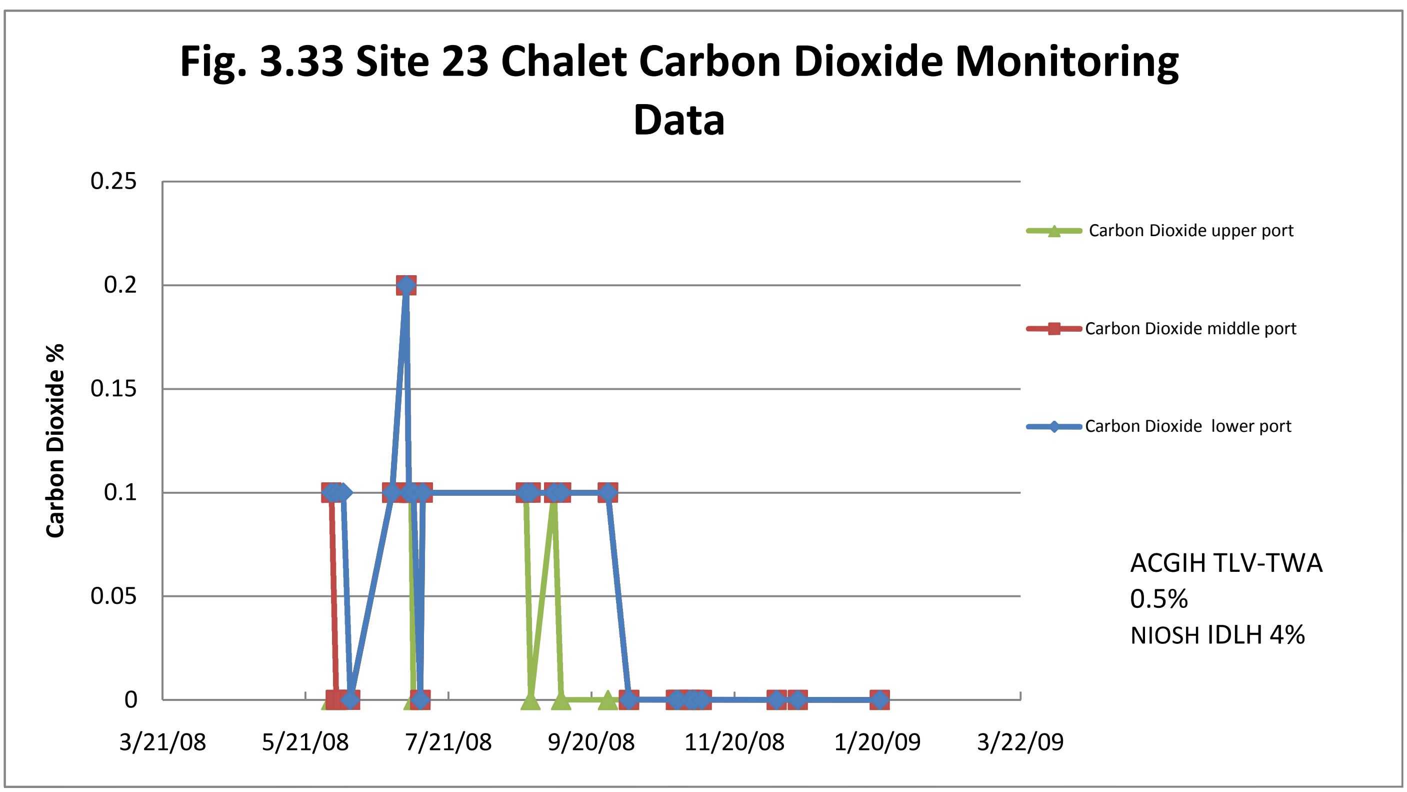


Fig. 3.33 Site 23 Chalet Carbon Dioxide Monitoring Data
Carbon Dioxide %
0.25
0.2
0.15
0.1
0.05
0
3/21/08
5/21/08
7/21/08
9/20/08
11/20/08
1/20/09
3/22/09
Carbon Dioxide upper port
Carbon Dioxide middle port
Carbon Dioxide lower port
ACGIH TLV-TWA 0.5%
NIOSH IDLH 4%

APPENDIX 4

Site Photographs

Figure 2.38 Site E Area September 2011

Figure 2.39 Tailings Aerial Photo September 25, 2011

Figure 3.34 Site 23- February 2011

Figure 3.35 Site 23 Temporary Disposal Area- June 2011