



**INACTIVE PRODUCTION ROCK SITES AND QUARRIES  
2016 ANNUAL REPORT**



**Hecla Greens Creek Mining Company**

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## **1.0 Executive Summary**

This annual report has been prepared by Hecla Greens Creek Mining Company (HGCMC) in accordance with the mine's General Plan of Operations Appendix 1, Integrated Monitoring Plan. Monitoring data summaries are presented for five inactive production rock sites (1350, 960, Mill Backslope, Site C and Site E) and five quarries (Pit 405, Pit 6, Pit 174, Pit 5 and Pit 7). Pit 5 was the most recent active quarry and is now part of the Northwest Tailings Expansion area. A discussion of the 2.5 mile roadcut on the B Road is also included in this report.

This report is separated such that all aspects of the inactive production rock sites are discussed first in Section 2 followed by discussion of the quarries 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.

The exposures in the rock quarries generally contain far less pyrite and carbonate than production rock. Each of the five quarries has zones of pyritic rock exposed in the pit walls; however, the volume of runoff from these zones is relatively small. Lower sulfide contents and smaller surface areas yield a lower flux of oxidation products from quarries compared to production rock sites. However, buildup of acidic oxidation products on overhanging exposures can produce low rinse pH values. Water monitoring indicates that metal loading from pit walls is also lower than loading from production rock sites.

There were no production rock removal activities from inactive sites in 2016. Work performed at the 1350 Site included the installation of a drainage collection system below the eastern edge of the remaining production rock pile that intercepts runoff from this area and routes it to treatment facilities. The area disturbed by this work was hydroseeded to establish vegetation. Work performed at Site E included the re-lining of the storm water collection pond that is utilized for managing runoff during active production rock removal activities. The pond liner was previously damaged by bears in 2015.

Work performed at quarries in 2016 included the net placement of approximately 30,100 cubic yards of reclamation material in Pit 7. This material came from development of the sand pit at 1.4-mile on the A Road and will be stored in Pit 7 for future use in final reclamation of the mine.

## 2.0 Inactive Production Rock Sites

### 2.1 Introduction

The term production rock (or waste rock) refers to material removed during mine development to access ore for mineral extraction. Production rock is typically highly mineralized, but does not possess concentrations of target minerals that make it economical for processing. It is therefore disposed of as a mine waste product. Several sites were utilized for disposal of production rock during the early operations of the Greens Creek Mine, including the 1350 Site, 960 Site, Mill Backslope, Site C and Site E. The site locations are shown on Figure 2.1. (*Note: The 960 Site, Mill Backslope and Site C are located within or adjacent to the 920 Area indicated on Figure 2.1*). These sites have been inactive since 1994 or earlier, with Site 23 being the only currently active production rock site.

The initial reclamation plan called for engineered covers to be constructed on each site to prevent acid generation and potential long-term water quality impacts. HGCMC currently plans to remove all of the production rock from each site for placement underground as backfill or disposal in the tailings facility. Removal activities were initiated in 2000 and have continued intermittently as mining operations allow. However, complete removal of some sites cannot occur until final cessation of mining operations due to the need to protect/maintain site infrastructure. A monitoring program is in place to evaluate potential impacts from each site on water quality and the acid generation potential of the material.

This section of the report provides a summary of all operational and monitoring activities performed at inactive production rock sites in 2016. Refer to GPO Appendix 11 for a description of the facilities and GPO Appendix 1 for associated monitoring requirements. Aspects of the inactive Site D are covered in the Tailings and Production Rock Site 2016 Annual Report (HGCMC 2017), which also covers the adjacent active production rock Site 23. Summary statistics for HGCMC's inactive production rock sites are presented in Table 2.1.

Table 2.1 Summary Statistics for Inactive Production Rock Sites  
 (ND=no data)

	Inactive Sites				
	1350	960	Mill Slope	Site C	Site E
Years Active (approx.)	1978-1985	1987-1988	1987-1988	1987-1988	1988-1994
Acreage	5	1	20	2	10
Approx. Total Original Volume (yds)	60,000	10,000	ND	50,000	270,000
Approx. Volume Removed (yds)	50,860	16,000	1,500	0	121,900
Approx. Volume Remaining (yds)	9,140	ND	ND	50,000	148,100

Water quality monitoring locations associated with Site E are shown on Figure 2.2. Historical acid-base accounting (ABA) data associated with the inactive production rock sites are illustrated on Figures 2.3 and 2.4. Composite flow and water quality data are summarized in Figures 2.5 to 2.19 for all inactive production rock sites except Site E, which are summarized separately in Figures

2.20 to 2.34. A general summary of trends is discussed in this introductory section, followed by individual site discussions in the subsequent sections.

The results of ABA sampling and water monitoring through 2016 are consistent with previous investigations (KGCMC 1994, & 2004; Shepherd Miller 2000; ADEC 2003). These investigations concluded that some of the material is potentially acid generating but that the vast majority of the material continues to maintain a pH greater than 6.0, and that sensitive receiving areas continue to be adequately protected. This report serves as an annual follow-up to these previous investigations and generally does not repeat data and information presented in these reports, unless doing so provides continuity and clarity.

Figure 2.3 compares acid potential (AP) with neutralization potential (NP) for samples collected between 2002 and 2013 from the surface of the inactive sites. The sites were constructed prior to development of the classification protocol that HGCMC currently uses for segregation of production rock. Symbols in Figure 2.3 represent actual laboratory data points. Lines indicating the currently utilized production rock classes are shown on Figure 2.3 for reference only. Figure 2.3 shows the distribution of potentially acid generating (upper left half of figure) and potentially acid neutralizing (lower right half of figure) samples. Many samples from Site E have more neutralization potential than those from other sites, reflecting a greater proportion of argillite in the material. Samples from the Mill Backslope and the 1350 Site generally showed a higher acid generation potential than those from the other sites. Reclamation activities at the 960, 1350 and Site E have removed significant quantities of potentially acid generating material from these sites.

Figure 2.4 shows the 2002-2013 results of rinse pH relative to net neutralization potential (NNP) for the five inactive sites. Most samples produced a rinse pH greater than 6.0; however, each site has produced at least two samples with rinse pH values less than 5.0. This is consistent with the distribution of NNP values and the duration of waste rock exposure. ABA sampling occurs at the surface of the piles where oxidation rates are greatest. Drainage from the inactive sites remains near neutral because the bulk of the material in the piles contains sufficient carbonate to neutralize the acidity formed by pyrite oxidation near the pile surface. There are a few cases where samples produced a low rinse pH and high NNP. This is likely a result of accumulated acidic oxidation products in the fines fraction of the sample and remaining carbonate minerals in the coarse fraction.

There was no ABA sampling performed at inactive production rock sites in 2016. Per the approved Integrated Monitoring Plan (GPO Appendix 1), this sampling is performed on five-year intervals. The most recent sampling was performed in 2013 and the next sampling will occur in 2018.

Flow data presented in Figures 2.5 and 2.20 show that flows at most of the sample locations are generally low (less than 10 gpm) with the exception of Site E. Some of the flow data were collected as part of the APDES storm water monitoring program. Collected during or following storm events, flow data from these locations (e.g. Site E, 356; 960 Site, 347 and 570) represent short-term maximum flow values in response to relatively large precipitation events. Lack of significant flow from inactive sites is a positive characteristic because it reflects minimization of potential off-site impacts.

Figures 2.6 and 2.21 show pH data from sampling locations associated with the inactive sites. Lower pH values can represent influences from pyrite oxidation and/or organic acids from muskeg and forest soils. The data show that the vast majority of the site drainage remains above pH 6.0. Drainage from the Mill Backslope consistently shows the lowest pH due to the quantity of pyritic rock. The drainage from this area is collected and routed to water treatment facilities prior to discharge at the permitted outfall. For a brief period in 1998 and 1999, acidic conditions began

developing at the 960 (sites 347 and 570). Hecla's predecessor Kennecott Greens Creek Mining Company (KGCMC) applied lime and removed approximately 1,000 cubic yards of oxidized pyritic rock from the site in 2000. The pH of the drainage quickly rebounded and has remained near-neutral since 2000. Removal of additional Site 960 material occurred in 2003, 2004 and 2005.

Alkalinity data presented in Figures 2.7 and 2.22 are consistent with the pH results in Figures 2.6 and 2.21. Drainage from the inactive sites continues to maintain measurable alkalinity provided by dissolution of carbonate minerals. A substantial reduction in alkalinity has been observed at monitoring locations associated with the 1350 Site (Sites 13 and 307) due to the removal of carbonate-rich production rock that began in 2005. The most notable reductions occurred following the completion of 2014 removal activities, which targeted material located directly up-gradient of Site 13. For this site, the low alkalinity is a positive sign and indicates the drainage quality is returning to its natural condition with less influence from the remaining production rock.

Conductivity data are shown in Figures 2.8 and 2.23. Conductivity indicates the amount of dissolved constituents in the water. Samples showing higher conductivity values usually have elevated sulfate, calcium and magnesium (hardness) concentrations, reflecting influences from sulfide oxidation and carbonate mineral dissolution. Water that has contacted production rock is expected to have higher conductivity values than background waters. Drainage from the 960 (Sites 347 and 570) and 1350 (Sites 13 and 307) has shown a substantial decrease in conductivity following removal of the production rock. The decreasing trends apparent in Figures 2.8 and 2.23 are the result of decreasing reactive surface area available for oxidation and dissolution. The reactive surface area decreases as reactants are consumed and mineral surfaces become coated with oxidation products. The results for sulfate, magnesium and hardness, shown in Figures 2.9 and 2.24, 2.10 and 2.25, and 2.11 and 2.26, respectively, correlate with conductivity results and are consistent with the concept of generally decreasing or static reactive surface area.

The data for zinc, copper, lead, cadmium, nickel, arsenic, iron and manganese are presented in Figures 2.12 to 2.19 and Figures 2.27 to 2.34. Sample results that were less than the detection limit are plotted at one half the detection limit value. While this allows the results to be plotted on a graph, it causes non-detect results with high detection levels to appear more concentrated than they actually are. Detection limits have varied with time and are often evident on the graphs as horizontal groupings of symbols. The results for metals generally correlate with conductivity values. Zinc concentrations reflect the higher solubility of this element relative to the other metals at near-neutral pH conditions. Manganese concentrations are elevated at most of the inactive sites, indicating the generation of secondary products from localized redox and buffering reactions as well as this metal's higher solubility in the prevailing pH conditions. Metal loads from inactive sites have either remained relatively constant or decreased with time. The decrease in metal loading is attributed to the reduction of reactive surface area discussed above.

Site 960 showed elevated copper, zinc and cadmium concentrations in 2004. This was likely due to the removal of production rock from the area, which exposed additional production rock materials in the base of the road, and rerouted additional water sources into the sampling area, confounding comparative water sampling with pre-removal data. Post removal Site 960 data since 2005 have shown a decrease in most metal concentrations, with close to an order of magnitude decrease in cadmium, nickel, manganese and zinc. A similar spike in metals concentrations was also observed at the 1350 Site following the 2014 removal activities, which occurred adjacent to and up-gradient of the monitoring site. With the majority of the production rock removal from the 1350 Site now complete, except in the immediate vicinity of the adit, future monitoring is expected to show a substantial decrease in metals and sulfate concentrations.

## **2.2 1350 Site**

The 1350 Site is located at 1,350 feet above mean sea level (AMSL), up-slope from the main portal and concentrator facility (Figure 2.1). The site contained an estimated 60,000 cubic yards of material derived from advancement of the 1350 adit, which began in 1978 and continued intermittently through 1985. Flow from the site is low, generally less than 10 gpm, and the drainage remains near-neutral. Historically, characteristics of the drainage (Figures 2.9 to 2.19) included a sulfate load, generally low metal concentrations, and localized iron staining. The results of ABA sampling through 2013 demonstrate that although some of the rock was potentially acid generating, the majority of the material remained near-neutral.

After evaluating reclamation alternatives for the 1350 Site, it was determined that removal of the production rock for disposal in the underground mine as backfill was the best option for this site. Removal activities commenced in 2005 and continued on an intermittent seasonal basis. From 2005 through 2015, a total of approximately 50,860 cubic yards of material was removed from the 1350 Site. It is estimated that 9,000 to 10,000 cubic yards of waste rock remain, all of which is in the immediate vicinity of the 1350 adit. This material will not be removed until final closure of the mine due to the need to maintain access for the mine ventilation system. The area around the adit has been graded so that surface runoff from the production rock is directed into the mine water collection system.

Following completion of the 2014 removal activities, there was a substantial spike in metals concentrations at Site 13, including cadmium, copper, lead, manganese, nickel and zinc. This was expected since the removal activities were up-gradient of the monitoring site and resulted in exposing relatively unoxidized production rock at the edge of the removal area near the 1350 adit. It was also expected that there would be a relatively short flushing period of residual oxidation products from the underlying soils beneath the recently removed waste rock. A similar spike in metals was observed in 2003 and 2004 at the 960 Site following production rock removal, and by 2005 concentrations decreased significantly to well below pre-removal levels. The 2015 and 2016 monitoring results from Site 13 show that metals concentrations are trending downward.

Cadmium and zinc concentrations at Site 13 continued to be elevated in the spring 2016 samples as a result of drainage from the remaining production rock near the 1350 Adit. To remedy this, HGCMC installed a collection trench below the eastern edge of the production rock to intercept runoff and drainage and route it to treatment facilities. The collection system became operational on September 1, and a substantial reduction in cadmium and zinc concentrations was observed in the November sample at Site 13.

## **2.3 960 Site**

The 960 Site is located just above the 920 Portal on the road to the 1350 level. Approximately 10,000 cubic yards of production rock were placed at the site in 1987 and 1988 during development of the 920 Portal and access road to the 1350 level. Placement was terminated when signs of slope instability developed below the site. The 960 Site is relatively small in extent (1 acre) and drainage flows are low (typically below 5 gpm). Monitoring in Greens Creek below the 960 Site historically showed some influence from this site or other up-gradient sites on water quality.

Between 2000 and 2004, approximately 16,000 cubic yards of production rock and underlying soils were removed and placed into the underground mine as backfill. The site was then recontoured and allowed to naturally reseed with native species.

The 960 Site showed some elevated copper, zinc and cadmium concentrations in 2003 and 2004 (Figures 2.12, 2.13 and 2.15). This was likely due to the removal activities, which exposed some additional production rock materials in the base of the road and altered drainage patterns. Comparison of pre- and post-removal monitoring data (Table 2.2) demonstrates that water quality of drainage from the 960 Site has improved considerably.

A small volume of pyritic material remains within the road prism, as evidenced by localized iron staining. An ABA sample of this material collected in 2013 showed a NNP of -30.3 (tCaCO<sub>3</sub>/kt) and a paste pH of 3.6. HGCMC plans to remove this material during final reclamation of the 1350 access road following cessation of mining operations. The 960 Site will continue to be monitored for water quality changes and potential impacts on Greens Creek.

Table 2.2 Effects of Removal of 960 Site Production Rock (ND = Non-detect)

Site 347		Before Removal	After Removal	After Removal	After Removal	After Removal	After Removal
Parameter	Unit	9/12/95	9/28/06	8/17/09	5/30/12	5/27/14	8/23/15
pH	s.u	6.1	7.6	7.5	7.7	6.6	7.1
Sulfate	mg/l (tot)	1300	161	230	119	138	146
Calcium	mg/l (diss)	412	64	102	56	53.8	68.2
Magnesium	mg/l (diss)	164	21	28	17	16.9	20.9
Iron	mg/l (diss)	5.5	0.2	ND	0.09	0.04	0.1
Manganese	mg/l (diss)	7.1	0.4	0.272	0.06	0.082	0.081
Zinc	mg/l (diss)	11	0.1	0.054	0.032	0.048	0.024
Lead	mg/l (diss)	0.004	ND	0.00008	ND	ND	ND
Nickel	mg/l (diss)	0.3	0.005	0.007	0.0016	0.0025	0.001

## 2.4 Mill Backslope

A bench was cut into the valley floor at the 920 elevation providing level ground to facilitate construction of the Mill/concentrator facility in 1987. Glacial till excavated from the site was hauled to Site D and Site E. During construction of the Mill and related facilities, tension cracks developed above the excavated slope. Approximately 100 dewatering drains were drilled into the slope to lower the water table and reduce pore pressures. Two benches of production rock were placed on the lower half of the bank to buttress the slope and protect the drain manifold system. Pyritic rock was also used in the construction of an access road above the cut slope. Numerous

piezometers were installed throughout the Mill Backslope at varying depths to monitor the pore water pressure.

Drainage from the Mill Backslope is a combination of groundwater intercepted by the dewatering drains, seepage from the surface expression of shallow groundwater, and surface runoff from precipitation. Average flows from combined Mill Backslope sources are low (less than 10 gpm). Sample site MBS 341 was established in 2003 and represents a composite of the groundwater and surface runoff. As shown in Figures 2.6 through 2.19, this site typically has the lowest pH and highest metals concentrations of all inactive production rocks sites. Water quality at site MBS 341 is monitored infrequently since all flow is captured and routed to water treatment facilities. This site was sampled in May 2016 and the results were generally consistent with past monitoring data, though the pH was neutral.

Collection and treatment of slope drainage remain the preferred near-term options for this site because removal of all of the production rock would destroy the dewatering system that maintains slope stability. Long term closure options for the slope include removing the pyritic material and either replacing it with non-pyritic fill or decreasing the slope angle to ensure long-term slope stability for closure.

## **2.5 Site C**

Site C is located near the end of the B Road just below the 920 Mill/concentrator facilities. The site received production rock in 1987 and 1988 and currently contains approximately 50,000 cubic yards of material. Results of ABA analyses (Figures 2.3 and 2.4) indicate that some of the material is potentially acid generating, however the pH of the site's drainage remains near-neutral. The 860 safety building and assay lab have been constructed on this site, therefore removal of the material will not occur until final cessation of mining activities.

During construction of the assay lab, glacial till from Site 23 was placed over much of the exposed production rock. The Site 23 material is not potentially acid generating and reduces exposure of the covered production rock to precipitation and oxygen. A network of drains and catchments diverts surface water away from the underlying production rock. Two stormwater retention ponds were constructed below Site C, the upper and lower Pond C, to contain sediments from Site C as well as from the B Road below the 920 area. The collected stormwater is pumped to water treatment facilities and discharged at the permitted outfall.

Drainage from Site C has been monitored routinely since 2002 at the toe of the slope that makes up the upper side of Pond C (Site 308). Flow at this site is low (generally less than 1 gpm), remains near-neutral, and contains elevated manganese concentrations, as well as moderate sulfate, zinc, cadmium and iron concentrations. The monitoring data for Site 308 indicate the water quality remains fairly consistent with no increasing trends.

## **2.6 Site E**

Site E is located 4.6 miles up the B Road halfway between the Hawk Inlet port facility and the 920 Mill facility (Figure 2.1). Approximately 95,000 cubic yards of glacial till and 270,000 cubic yards of production rock were placed at the site from 1988 to 1994. The glacial sediments were excavated from the 920 site during construction of the Mill facility. Once the sediments were naturally dewatered in the placement cells constructed at this site, production rock materials were placed on

top of those sediments at Site E. Flows from the site are minimal because it sits on a topographic high and only receives water from direct precipitation (e.g., no run-on or groundwater input). Water quality monitoring at Site 356, between Site E and the B Road (Figure 2.2), was initiated in 1995. The co-located Site 545 has been routinely monitored since 1998 as part of the Greens Creek Mine stormwater monitoring program.

In late 2002 and in 2003, three monitoring wells were installed and 13 surface water sampling sites were established at Site E to better understand the potential pile influence on the area. The surface water sampling program has since been reduced to only 6 sites. Figure 2.2 shows the locations of these sites. Water quality data are shown on Figures 2.21 to 2.34. The surface water sites depicted in the figures represent water quality at the toe of the pile (sites 708, 709, and 710, along with the older site 356), and two downgradient drainages (703 and 704) that report to Greens Creek. Sulfate and metals concentrations are relatively high near the toe of the pile, but decrease as the distance from Site E increases. Monitoring at Site E will continue until final reclamation is completed.

Greens Creek compared the relative costs of recountouring and covering the pile versus consolidating it with one of the other surface facilities, and found that relocating the material to the surface tailings facility for co-disposal is the most economical and environmentally protective solution. Removal of production rock material from Site E for disposal at the tailings facility commenced in 2006. Between 2006 and 2015, a total of approximately 121,900 cubic yards of material were removed from Site E. HGCMC plans to remove the remaining production rock from Site E for disposal in the tailings facility.

## **2.7 2.5 Mile B Road Cut**

Pyritic rock was exposed in the road cut at 2.5 mile during construction of the B Road in 1988. Weathering has decreased the reactive surface area of pyrite grains in the outcrop, and precipitation of hydroxide coatings has further decreased the reactivity of the rock. HGCMC will use monitoring of Zinc Creek to determine if additional efforts are required at the road cut. HGCMC has determined that Site 8 (inactive FWMP site) is an appropriate monitoring point in Zinc Creek below the road cut to evaluate its effects on water quality. Site 8 is located immediately above the confluence of Tributary Creek with Zinc Creek. Very limited sampling has occurred at this site since 1995, but semi-annual monitoring began in 2015 and will continue. The results from the sampling are included in Table 2.3 below for comparison with other up-gradient Zinc Creek monitoring data. The results show a slight increase in sulfate between the upstream Site 371 and Site 8.

Two areas along the B road corridor were filled with material from the 2.5 mile B Road cut: 1.8 mile pullout and Zinc Creek Bridge Abutment.

### **1.8 Mile Pullout**

Pyritic rock from the road cut at 2.5 mile B Road was used as fill for the 1.8 mile B Road pullout. HGCMC redirected road ditch water around the pad to reduce infiltration through the pyritic rock. HGCMC plans to continue monitoring this site, with removal of the pyritic material following removal of other higher priority sites.

### **Zinc Creek Bridge Abutment**

Pyritic rock from the road cut at 2.5 mile B Road was also used as fill in the abutment of the Zinc Creek Bridge during road construction. Iron staining and poor quality runoff has been observed at the site. HGCMC maintains an APDES storm water monitoring point at the site and has sampled

the water composition of Zinc Creek above (Site 371) and below (Site 368) the bridge. Monitoring data (Table 2.3) show there is a consistent increase in the concentrations of sulfate, iron and manganese in this stream segment. HGCMC applied lime to the fill in 2013. Additional treatments will be applied as needed prior to mine closure, when the pyritic rock will be removed with recovery and reclamation of the road. The available monitoring data does not indicate any apparent long-term water quality trends.

Table 2.3 Zinc Creek Water Compositions

	Site	Date	pH	Cond	Alk	Mg	SO4	As	Cd	Cu	Fe	Mn	Ni	Pb	Zn
			s.u.	uS/cm	mg/l	mg/l	mg/l	ug/l							
Zinc Creek Above Bridge	371	Mar-06	7.2	127.4	46	3.2	6.0	0.6	<0.2	0.6	0.0	2.7	2.3	0.1	2.4
	371	May-07	7.2	58.2	20	1.4	2.0	0.4	<0.2	0.8	51.7	2.4	2.1	0.2	9.0
	371	Dec-07	7.8	120.8	50	2.8	5.0	0.4	<0.3	0.7	<50	2.6	1.5	<0.1	4.1
	371	Aug-09	6.7	77.4	33	2.4	4.2	0.6	0.1	2.6	<27	2.4	2.9	0.1	6.6
	371	Jan-10	7.5	97.3	<2	2.4	5.2	0.4	<0.1	1.5	64.8	1.8	2.4	0.1	5.5
	371	Apr-11	7.5	107.0	35	2.4	4.3	<0.5	<0.1	1.0	50	1.8	1.7	<0.1	7.0
	371	Sept-11	6.8	79.0	37	2.4	4.2	0.5	<0.1	1.3	210	2.5	2.0	<0.1	6.0
	371	Jul-12	7.7	65.0	24	1.7	2.5	<0.2	<0.1	4.0	160	2.6	2.2	0.1	11
	371	Mar-13	7.7	125.0	45	2.9	5.0	0.4	<0.1	2.6	50	1.9	1.5	<0.1	5.0
	371	Mar-14	7.6	110.0	47	2.8	7.0	0.2	<0.1	<0.5	30	1.5	1.1	<0.1	5.0
	371	Nov-14	7.2	79.0	32.9	2.0	3.5	0.3	<0.1	0.8	150	3.4	1.9	<0.1	6.0
	371	Apr-15	6.7	79.0	32.9	2.0	3.6	0.3	<0.1	0.8	70	1.4	1.8	<0.1	3.0
	371	Oct-15	7.9	88.8	43.5	2.5	4.7	0.3	<0.1	0.9	70	2.2	2.1	<0.1	5.0
	371	May-16	7.6	49.1	21.6	1.4	2.4	0.4	<0.1	1.2	140	3.4	2.3	<0.1	8.0
371	Nov-16	7.9	119.9	49.6	2.9	6.3	0.4	<0.1	1.3	80	3.0	1.6	<0.1	<2.0	
Zinc Creek Below Bridge	368	Mar-06	7.1	121.3	42	3.7	11.9	0.3	<0.2	3.4	0.3	40	5.5	<0.1	12.0
	368	May-07	7.2	58.4	21	1.4	2.2	0.4	<0.2	0.9	59.7	3.0	2.1	0.1	8.6
	368	Dec-07	7.6	123.9	49	2.8	6.9	0.2	<0.3	1.0	120	12	2.7	<0.1	6.7
	368	Aug-09	6.8	80.4	34	2.3	4.8	0.5	0.1	2.0	<27	4.9	2.9	0.2	7.7
	368	Jan-10	7.6	101.0	<2	2.6	6.6	0.4	0.1	5.7	239	7.3	3.3	0.1	10.8
	368	Apr-11	6.6	114.0	32	2.8	8.5	0.6	<0.1	1.8	410	10.6	3.7	<0.1	12.0
	368	Sept-11	7.8	81.0	36	2.4	6.1	<0.5	<0.1	1.6	230	5.6	2.8	<0.1	8.0
	368	Jul-12	7.5	64.0	22	1.7	3.4	<0.2	<0.1	2.9	290	6.0	3.0	<0.1	12.0
	368	Mar-13	7.6	130.0	43	3.1	8.2	0.3	<0.1	2.7	240	8.4	2.6	<0.1	8.0
	368	Mar-14	7.5	117.0	46	3.2	11.3	<0.2	<0.1	1.0	270	12.3	2.3	<0.1	7.0
	368	Nov-14	7.0	80.1	32.1	2.1	4.8	0.3	<0.1	1.0	240	6.9	2.3	<0.1	6.0
	368	Apr-15	7.3	80.0	31.3	2.1	4.7	0.3	<0.1	1.0	170	4.0	2.2	<0.1	3.0
	368	Oct-15	7.8	90.8	43.0	2.6	6.3	<0.2	<0.1	1.3	180	6.6	2.5	<0.1	7.0
	368	May-16	7.5	50.8	21.4	1.5	3.3	0.2	<0.1	1.3	180	5.2	2.5	<0.1	8.0
368	Nov-16	7.8	107	49	3.2	8.4	0.4	<0.1	1.5	280	11.1	2.3	<0.1	<2.0	
Zinc Cr Above Tributary Creek	8	Apr-15	7.2	84.0	32.1	2.2	7.3	0.3	<0.1	1.0	170	4.8	2.1	<0.1	<2.0
	8	Oct-15	7.6	99.6	43.5	2.8	9.3	0.2	<0.1	1.1	180	14.1	2.3	<0.1	5.0
	8	May-16	7.4	49	16.9	1.5	4	<0.2	<0.1	1.5	260	8.1	2.5	0.1	7.0
	8	Nov-16	7.6	93.1	50.3	3.2	12.2	0.3	<0.1	1.4	180	8.8	2.1	<0.1	<2.0

### 3.0 Quarries

#### 3.1 Introduction

Five quarry sites were developed in 1987 and 1988 to provide rock for constructing roads and other infrastructure at the Greens Creek facilities. All quarries are currently inactive and are being used to stockpile reclamation materials (rock, organic soils and glacial till). A summary of all operational and monitoring activities performed at these five quarry sites (borrow pits) in 2016 is provided. Refer to GPO Appendix 1 for a description of the monitoring.

Summary statistics for HGCMC’s quarry sites are presented in Table 3.1. Flow and water quality data are summarized in Figures 3.1 to 3.15. The sites are discussed individually in subsequent sections. Refer to Figure 2.1 for site locations.

Table 3.1 Summary Statistics for Quarry Sites

	Quarries				
	Pit 405	Pit 6	Pit 174	Pit 5	Pit 7
Years Active (approx)	1987-1988	1987-1988	1987-1988	1987-2003	1987-1997
Acreage	3	3	2	Part of NW Tailings Expansion	4
Total Volume (cy)	17,000	22,800	10,000		183,900
Prod Rock/Other Vol (cy)	13,000	0	0		0
Reclamation Material (cy)	4,000	22,800	10,000		183,900

Acid Base Accounting data collected from 2002 to 2013 are summarized in Figures 3.16 and 3.17. Pit 405 and Pit 174 have significant exposures of potentially acid generating rock and produced several samples with acidic rinse pH. Pit 6 and Pit 7 produced samples showing a broad distribution of NNP and rinse pH, and Pit 5 generally produced acid neutralizing samples with alkaline rinse pH. Buildup of oxidation products (salts) on overhanging quarry walls was noted at each of the five quarry sites and may have contributed to the lower rinse pH readings for several samples.

Flow data for the quarry sites are presented in Figure 3.1. Much of the flow data prior to 2003 were collected during or shortly following storm events and represents maximum flow values. Recent flow estimates vary from 60 gpm to less than 1 gpm with most less than 10 gpm. The bowl-shaped geometry and low permeability of the quarry walls and floors tend to focus flow toward the entrance of the pits.

The amount of reactive surface area available for sulfide oxidation is considerably less for quarries than for production rock piles. Oxidation is limited to the non-coated outer face of the near-vertical quarry wall and near surface fractures. Lower sulfide contents and smaller surface area yield a lower flux of oxidation products from quarries compared to production rock sites.

Figure 3.2 shows pH data from the quarry site sampling locations. Since 1995 all but two samples have had a pH between 6.0 and 8.0. A pH of 5.8 was recorded from Pit 174; however, more recent samples from this site were above 7. Alkalinity data presented in Figure 3.3 are consistent with the pH results, with all sites maintaining measurable alkalinity provided by dissolution of carbonate minerals. The lower alkalinity value from Pit 6 represents influences from organic acids derived

from forest soils (note associated low conductivities of Pit 6 samples). Sample sites with the highest alkalinity are groundwater monitoring wells in Pit 5, which is now part of the tailings facility.

Conductivity data are shown in Figure 3.4. Conductivity indicates the amount of dissolved constituents in the water. Samples having higher conductivity values usually have higher sulfate, calcium and magnesium (hardness) concentrations, reflecting influences from sulfide oxidation and carbonate mineral dissolution. Conductivity data are consistent with waters derived from freshly exposed low to moderately mineralized quarry rock. The results for sulfate, magnesium and hardness, shown in Figures 3.5, 3.6 and 3.7, respectively, correlate with conductivity results.

The data for zinc, copper, lead, cadmium, nickel, arsenic, iron and manganese are presented in Figures 3.8 to 3.15. Sample results that were less than the detection limit are plotted at one half the detection limit value. While this allows the results to be plotted on graphs, it causes non-detect results with high detection levels to appear more concentrated than they actually are. Detection limits have varied with time and are often evident on the graphs as horizontal groupings of symbols. The results for metals generally correlate with conductivity values. Zinc and manganese concentrations reflect the higher solubility of these elements relative to the others at the near-neutral pH conditions. Dissolved metal loads from quarry sites have been consistently low and generally either remained fairly constant or decreased with time. The decrease in dissolved metal loading is attributed to a reduction of reactive surfaces as reactants are consumed and coatings form on mineral surfaces. Elevated total metal concentrations occur periodically in response to increased suspended solids during storm events. The storm water monitoring data are presented to provide a general indication of the effects of sediment loading, typically from road surfaces, and do not reflect dissolved loading from the quarry walls.

Closure options for pyritic pit walls are relatively limited. Since there are no proven long term surface treatments available, it is best to let naturally occurring coatings that have formed over the past 20 years continue to form. As the coatings form and the amount of available pyrite decreases, so too will the relatively small dissolved load generated by these surfaces.

### **3.2 Pit 405**

Pit 405 is located at 7.6 mile on the B Road. The rock from this quarry was used for construction of the B Road and other mine infrastructure. Mine records indicate that approximately 13,000 cubic yards of production rock were backfilled into the quarry in 1988. The quarry received reclamation materials (colluvium and glacial till) in 1994, 1995 and 1998 for use in future reclamation projects. HGCMC drilled a hole through the fill material in June of 2005 to characterize the materials. The profile at the center of the pit from the surface down consists of approximately two feet of glacial till and organics (fill), 15 feet of sericitic phyllite (waste rock) and 22 feet of grey silty till (fill). The foundation of the pit is fractured, pyritic, chloritic rock.

Monitoring of drainage downgradient of the quarry (Figures 3.1 to 3.15) demonstrates that influences from the site are negligible. The site will be reclaimed when the reclamation materials stored in the quarry have been utilized at other sites. The production rock in the quarry will either be removed or covered in-situ. Removal of the rock could prove detrimental as this would increase exposure of the now covered pyritic quarry wall.

### **3.3 Pit 6**

Pit 6 is located at 4.6 mile on the B Road across from Site E. The quarry produced rock for construction of the B Road in 1987. Reclamation materials were hauled to the site from Site 23 and the 920 facility during various construction seasons. Monitoring of surface drainage from the pit access ramp indicates no significant influence from the pit walls or stored material. Reclamation materials will be used to reclaim other mine facilities. Approximately 3,800 cubic yards of reclamation materials from the backslope of Site 23 were hauled and stored at Pit 6 in September 2007. Reclamation material (6,500 cy) from the top of Site E was hauled to Pit 6 in 2009. Water quality at the storm water sampling site at Pit 6 showed increases in total lead and zinc in 2009, potentially attributable to hauling the reclamation materials from Site E to Pit 6. Since 2010, lead and zinc levels have returned to within historical levels at this site. The elevated lead levels shown on Figure 3.10 in 2013 and 2014 are the result of analytical error in which the incorrect MDL was used for the analyses. The actual results were non-detect, but are plotted on the figure at one-half the MDL. Lead levels in 2016 were non-detect at a MDL of 0.1 µg/L.

### **3.4 Pit 174**

Pit 174 is located at 3.3 mile on the B road and was used for road construction in 1987. The pit has been partially backfilled with reclamation materials that will be used to reclaim other site facilities. A runaway truck ramp was installed at Pit 174 following a haul truck incident at the site in 2006. Sulfate and metal concentrations in the pit drainage are moderate, however flows are generally low (typically less than 10 gpm during rain events). Iron staining periodically occurs in the drainage below the site which collects runoff from this quarry and surrounding areas. Once the stored reclamation materials (rock, organic soils and glacial till) are utilized, the site will be reclaimed. Reclamation goals include minimizing runoff from the exposed pit wall and covering as much of the exposed pyritic rock as possible by placing a wedge of glacial till at the base of the wall.

### **3.5 Pit 5**

Pit 5 was located in the northern portion of the Tailings Facility at 0.8 mile on the B Road, and until 2008 housed the water treatment plant. The Pit 5 water treatment plant was decommissioned in June of 2008. Rock from the pit was originally used for construction of roads and other surface facility infrastructure. Approximately 13,500 cubic yards of rock were quarried from Pit 5 in 2002. Between 2006 and 2008 approximately 268,110 cubic yards of shot rock were taken from Pit 5 in conjunction with the tailings expansion. The expansion of the Tailings Facility in the Pit 5 area was completed in 2008. The Pit 5 area is now completely backfilled with tailings (northwest area) which is underlain with an HDPE liner tied into the natural till underlying the tailings pile to the south.

Lead and zinc levels in MW-T-01-07 and MW-T-01-09 have fluctuated widely since 2006. Fluctuations in metal concentrations appear to be independent of major ion concentrations and may reflect changes in carbonate speciation and sorption/desorption mechanisms resulting from covering the quarry floor with a liner.

### **3.6 Pit 7**

Pit 7 is located at 1.8 mile on the A Road between Hawk Inlet and Young Bay. The pit was initially developed in 1987 to support construction of the roads and other mine facilities. Pit 7 has been mostly backfilled with overburden material derived during expansion of the tailings pile and

development of the sand pit at 1.4 mile on the A Road. Approximately 30,100 cubic yards of material were placed in Pit 7 in 2016 from expansion of the sand pit. Pit 7 currently contains approximately 183,900 cubic yards of reclamation materials. Following removal of stockpiled capping materials for reclamation of other sites, the Pit 7 site will be contoured and hydroseeded.

#### **4.0 References**

Hecla Greens Creek Mining Company (HGCMC), 2016a, Inactive Production Rock and Quarries 2015 Annual Report, April 2016

Hecla Greens Creek Mining Company (HGCMC), 2016b, Tailings and Production Rock Site 2015 Annual Report, April 2016.

Hecla Greens Creek Mining Company (HGCMC), 2014, General Plan of Operations, Appendix 1, Integrated Monitoring Plan, November 2014.

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Kennecott Greens Creek Mining Company (KGCMC), 1995, Kennecott Greens Creek Mine Production Rock Site Characterization Study, March 1995.

Klohn Crippen, 2005, Evaluation of Co-Disposal of Production Rock and Filter Pressed Tailings, May 2005.

Shepherd Miller, 2000, Technical Review ARD/Metals Leaching and Freshwater Monitoring Plan Greens Creek Mine, February 2000.

## **APPENDIX 1**

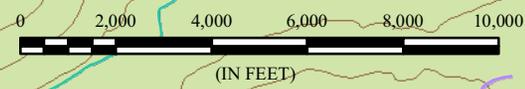


Figure 2.1

### GREENS CREEK SITE LOCATION MAP

Project No: MH000969.0001	Project Manager: E. Fernandez
Drawn By: J. Chen	Checked By: D. Helmericks

- Stormwater Monitoring Site
- Road Mile



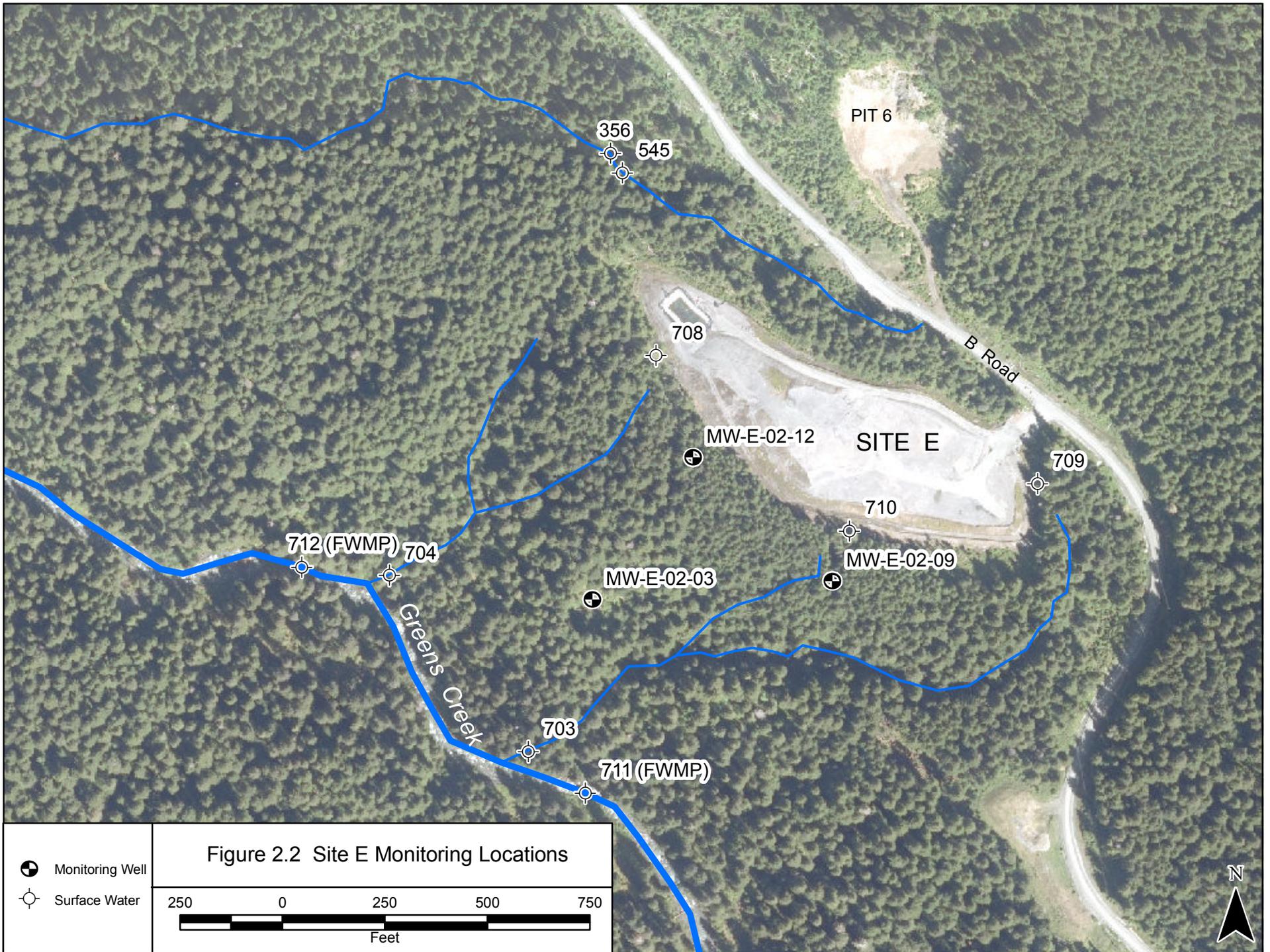


FIGURE 2.3 2002-2013 INACTIVE SITE ABA DATA

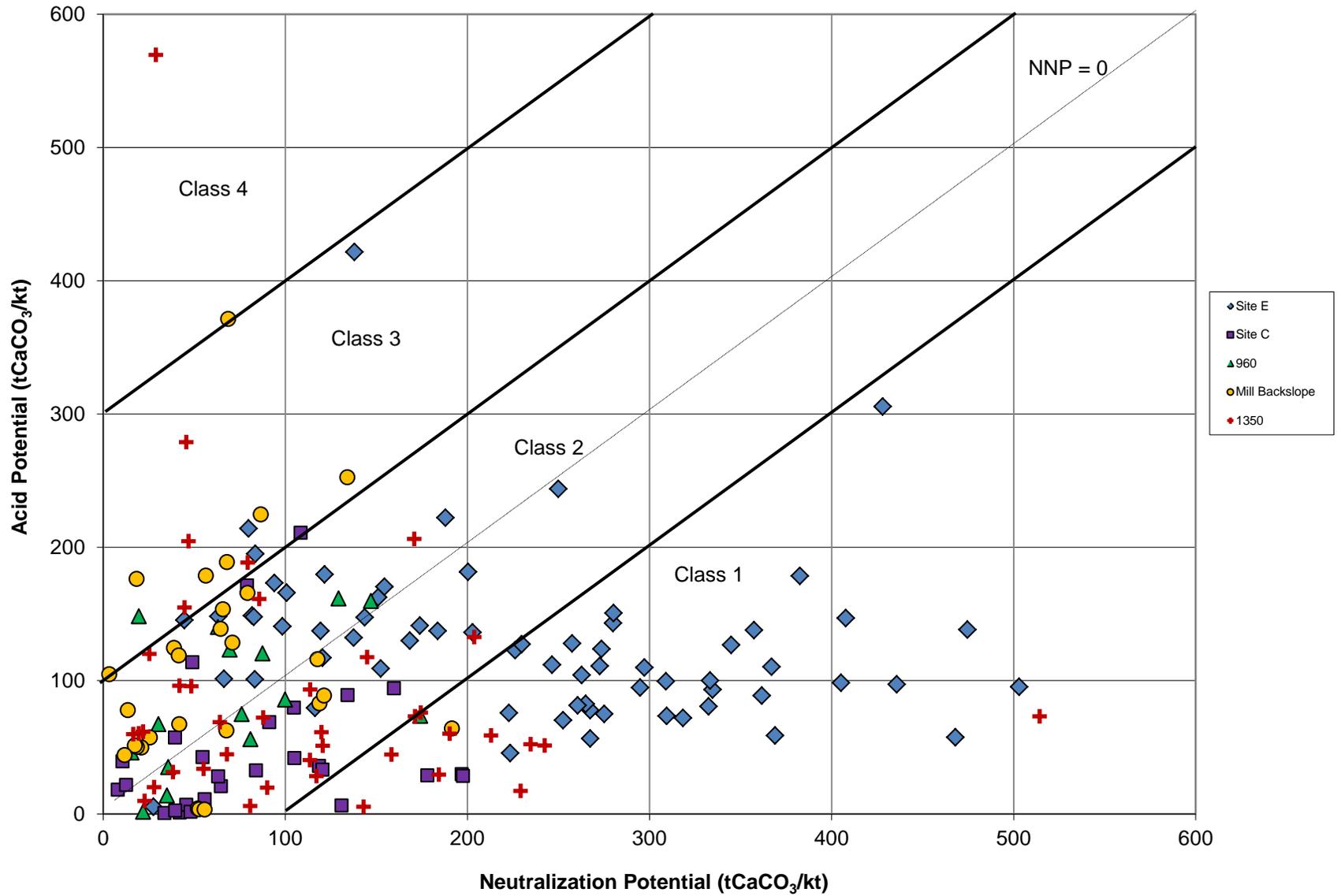


FIGURE 2.4 2002-2013 INACTIVE SITE ABA DATA (NNP vs pH)

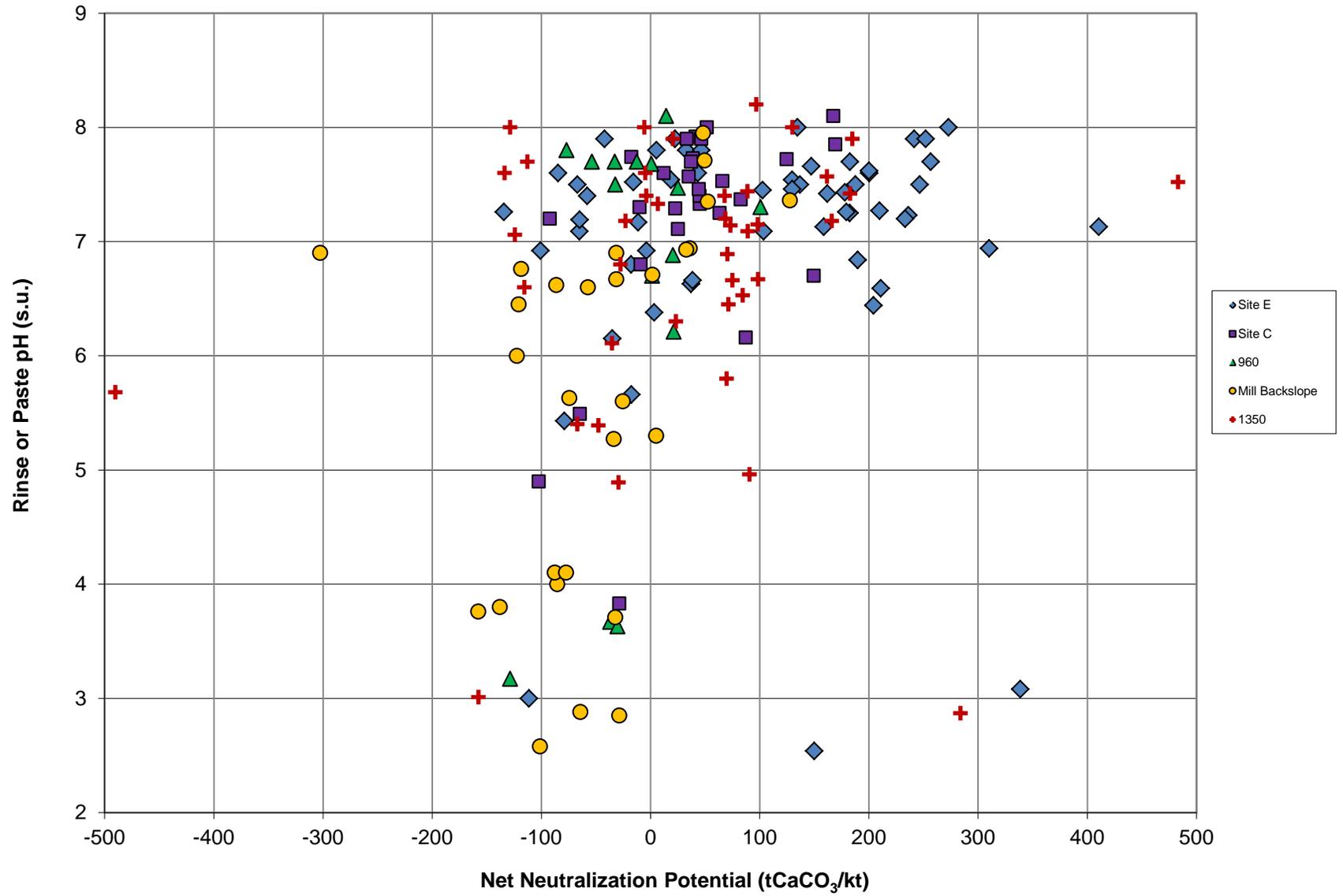


Figure 2.5 INACTIVE PRODUCTION ROCK SITE FLOW DATA

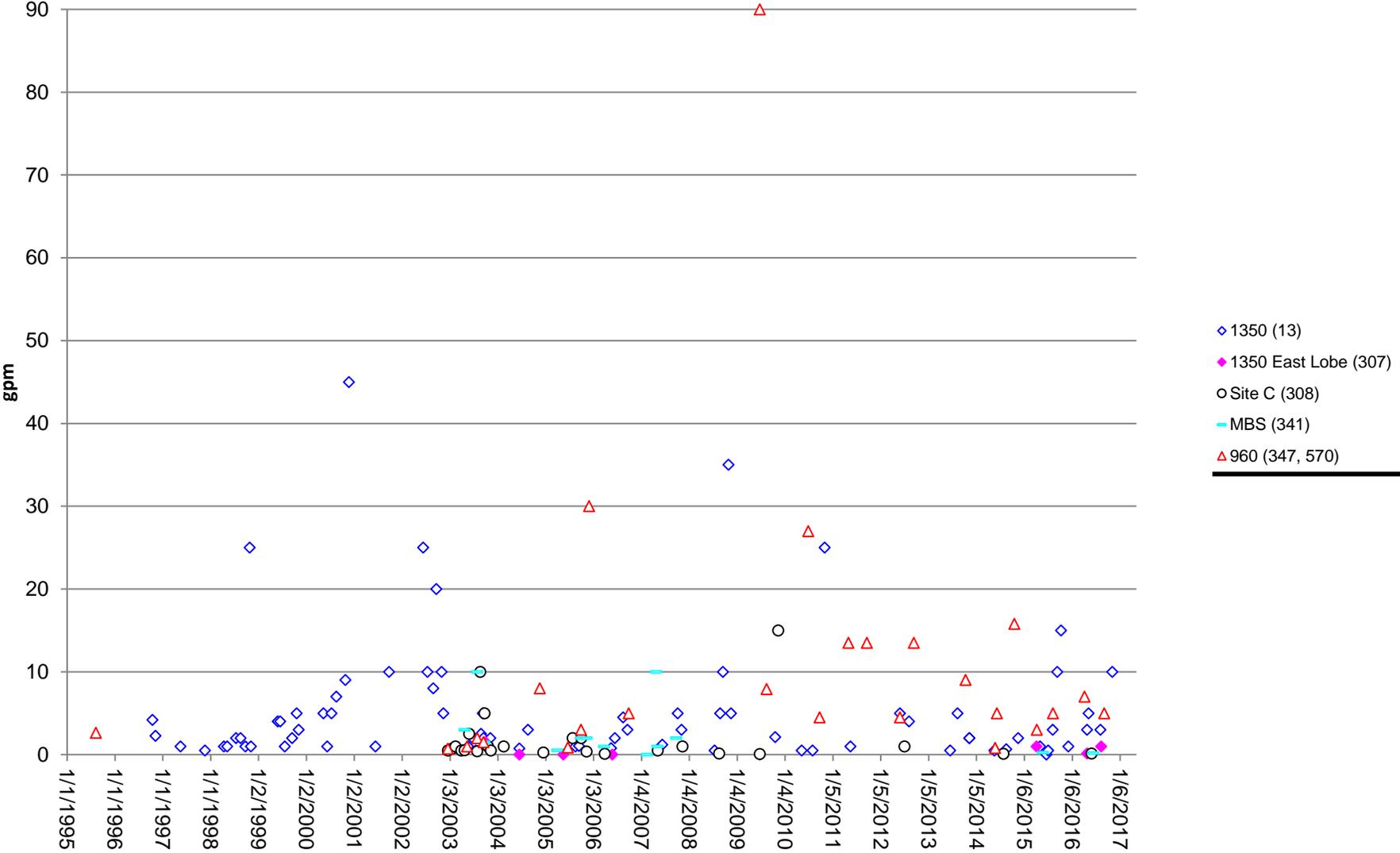


Figure 2.6 INACTIVE PRODUCTION ROCK SITE pH DATA

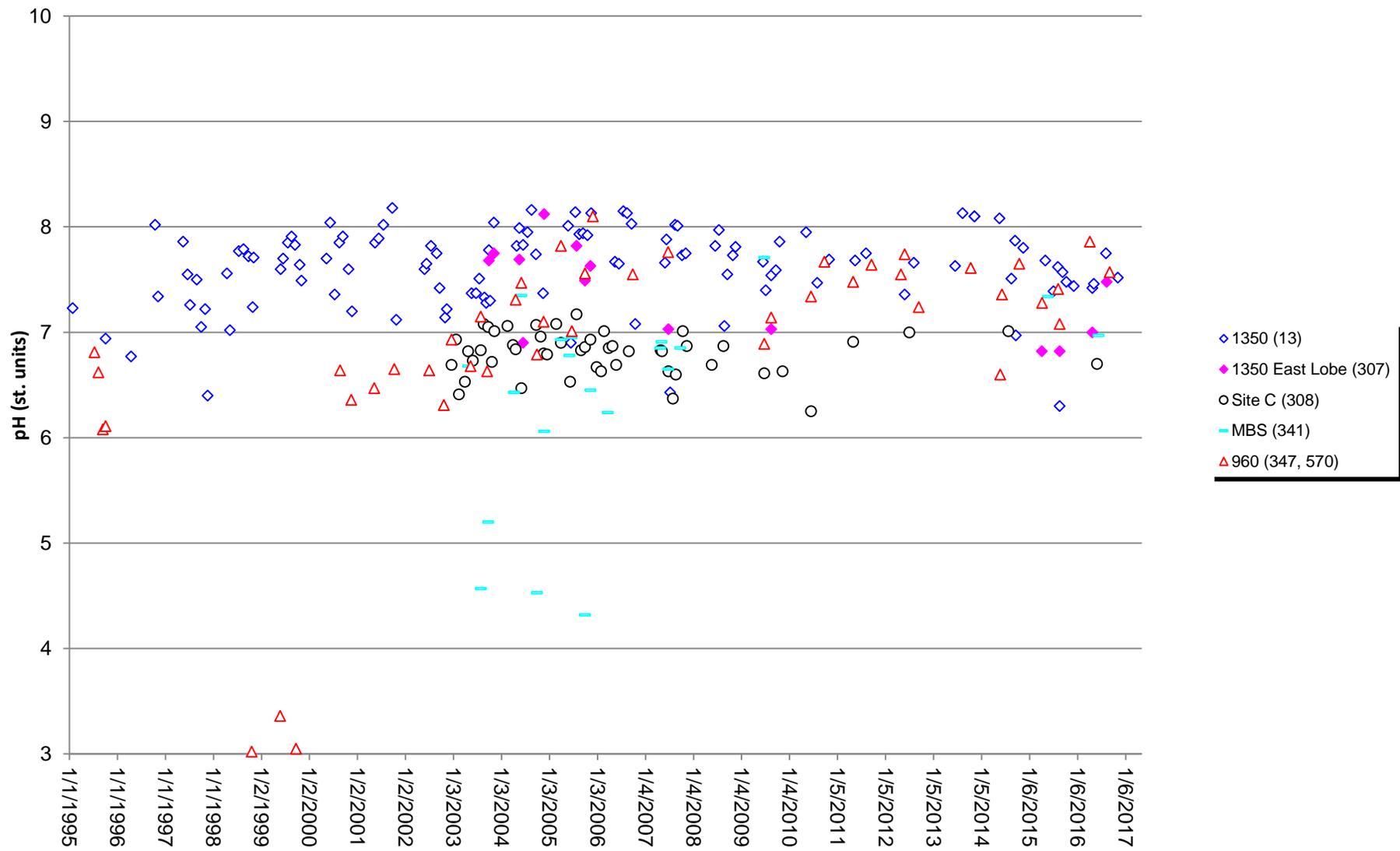


Figure 2.7 INACTIVE PRODUCTION ROCK SITE ALKALINITY DATA

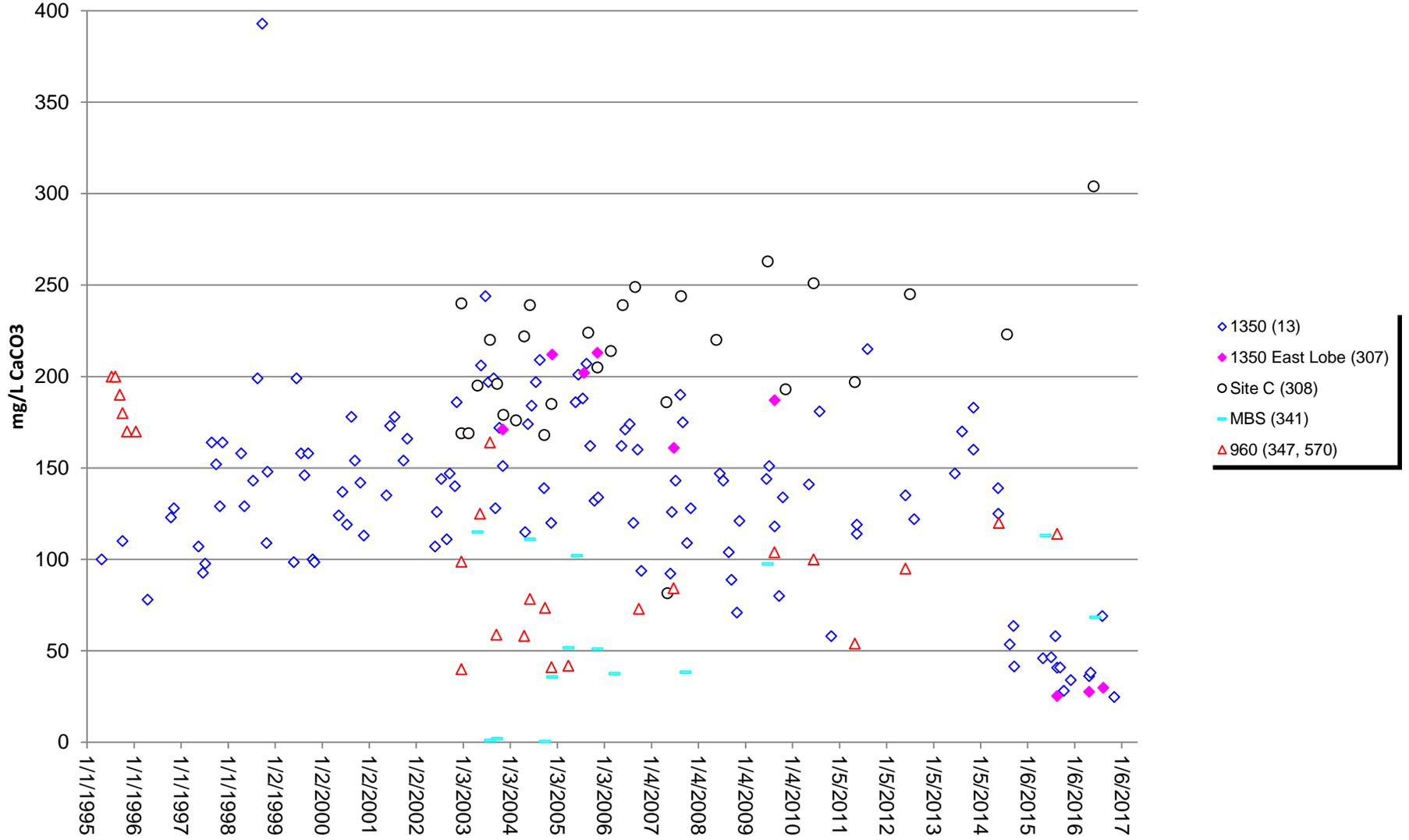


Figure 2.8 INACTIVE PRODUCTION ROCK SITE CONDUCTIVITY DATA

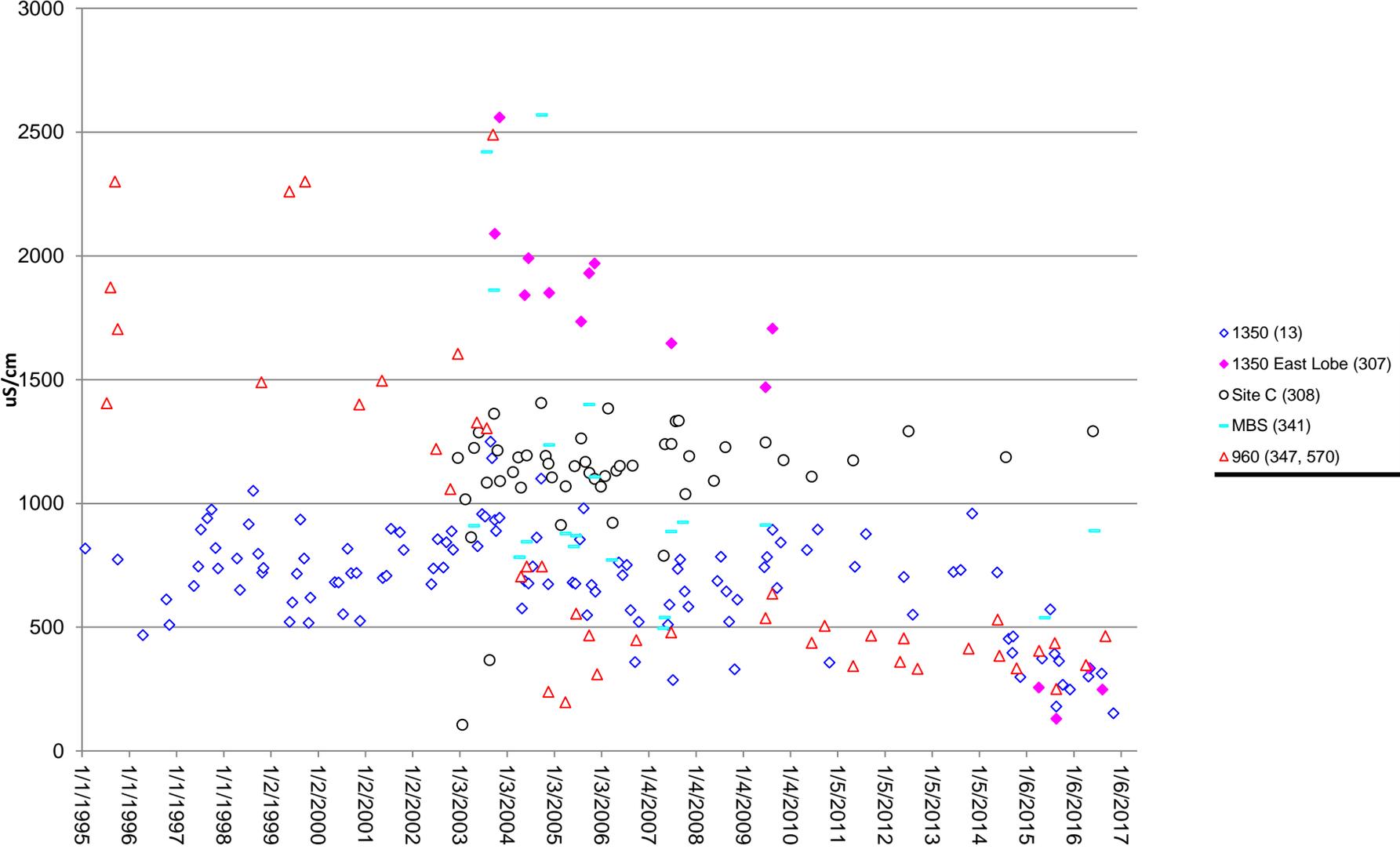
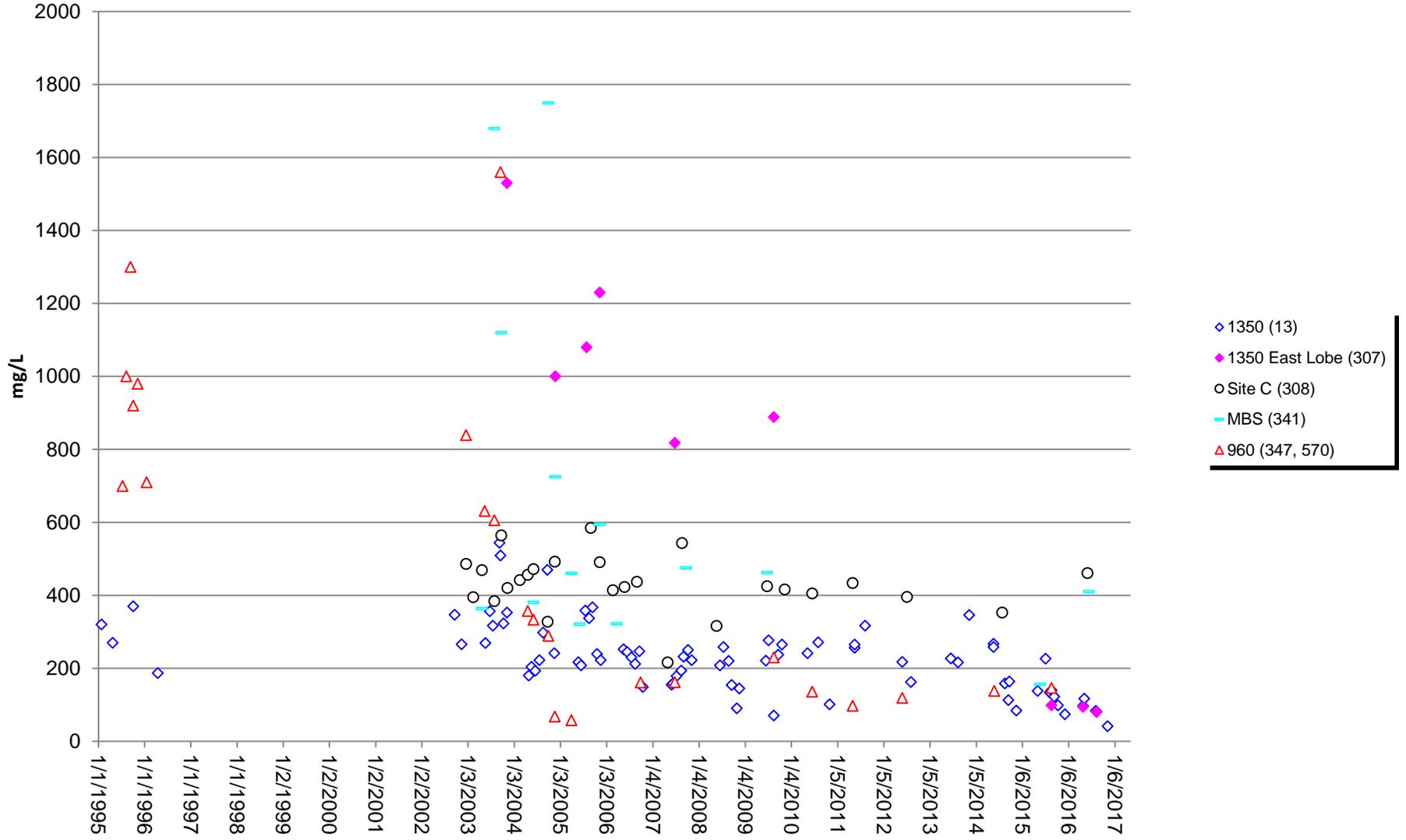


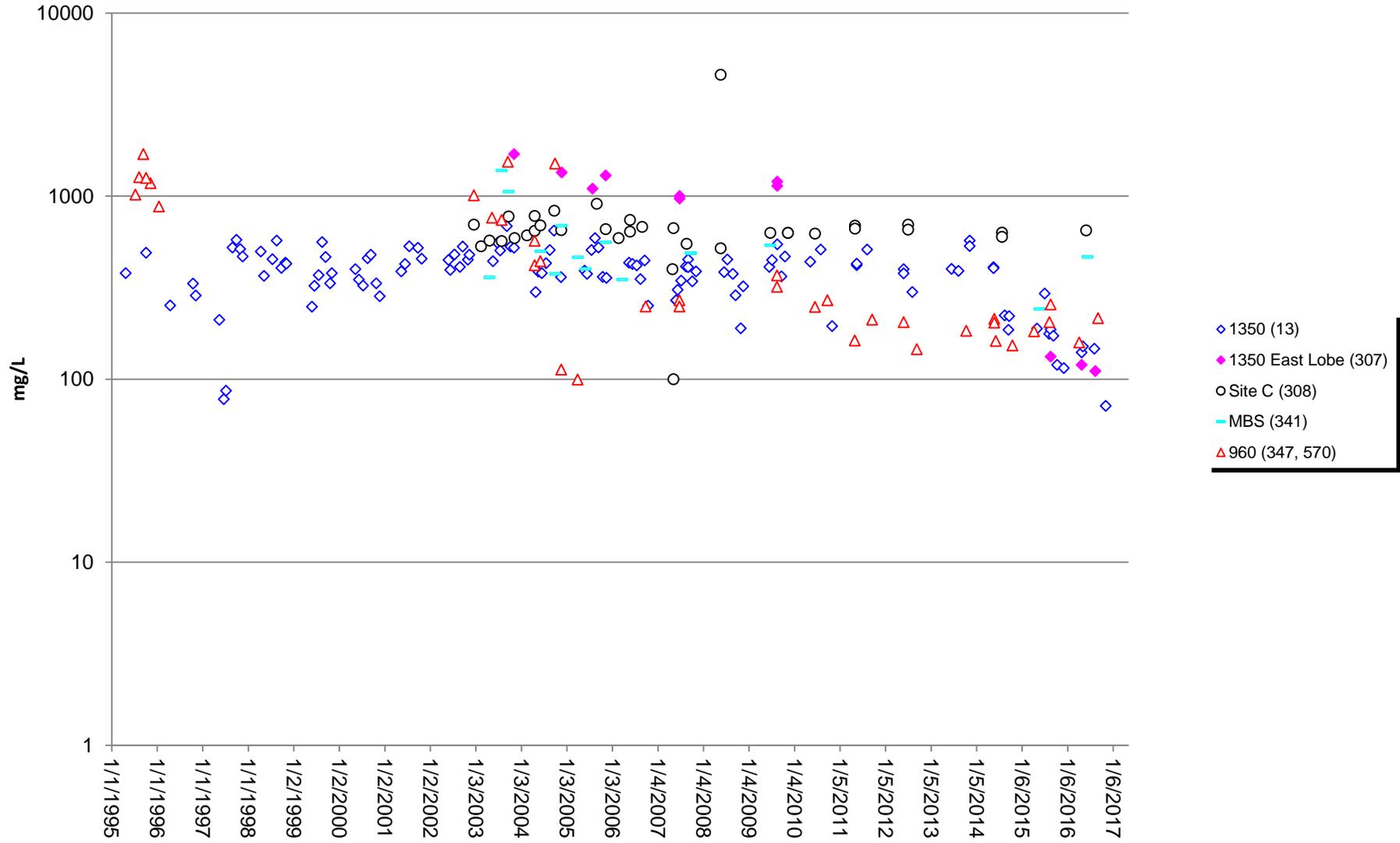
Figure 2.9 INACTIVE PRODUCTION ROCK SITE SULFATE DATA





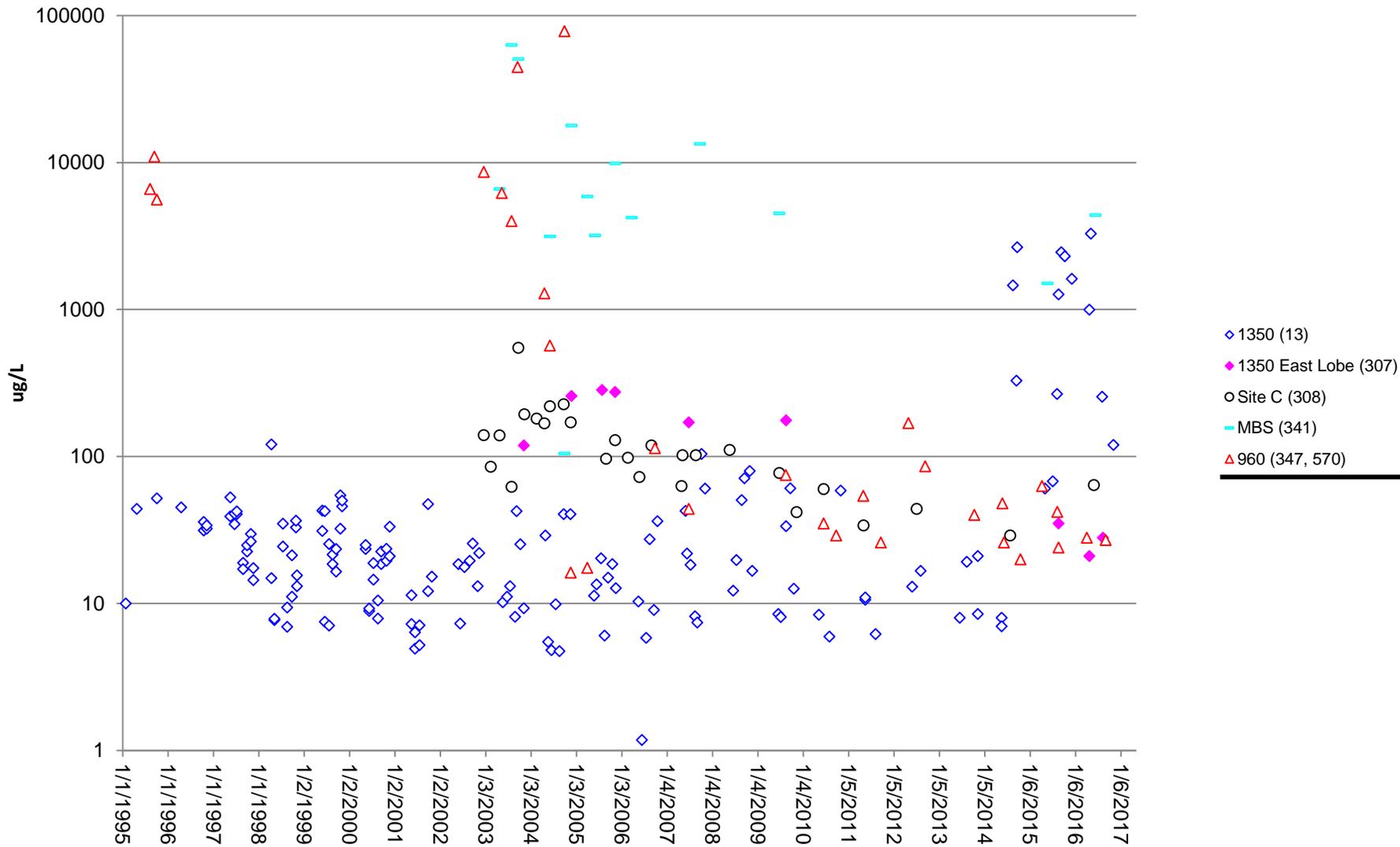
**Figure 2.11 INACTIVE PRODUCTION ROCK SITE HARDNESS DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



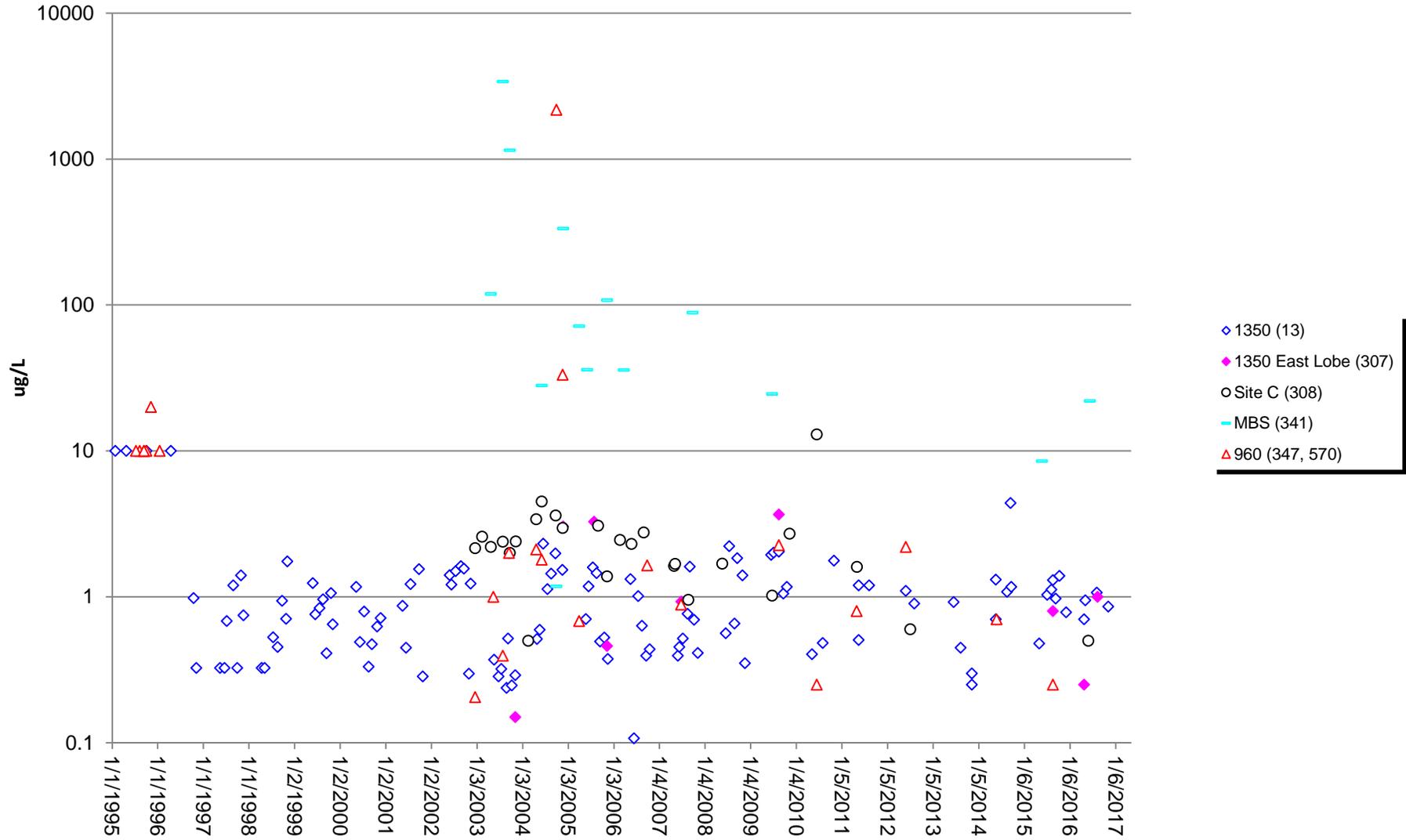
**Figure 2.12 INACTIVE PRODUCTION ROCK SITE ZINC DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



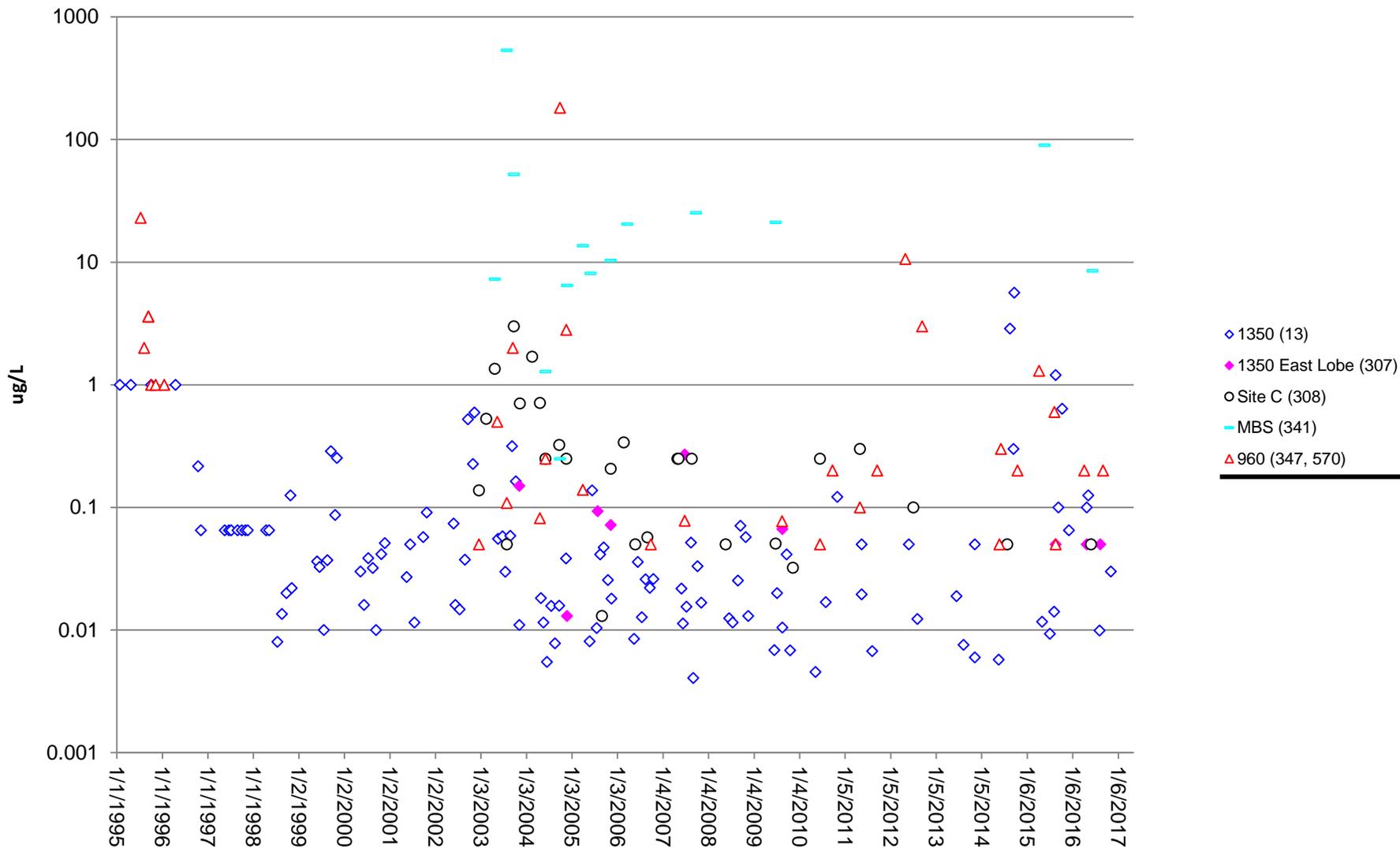
**Figure 2.13 INACTIVE PRODUCTION ROCK SITE COPPER DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



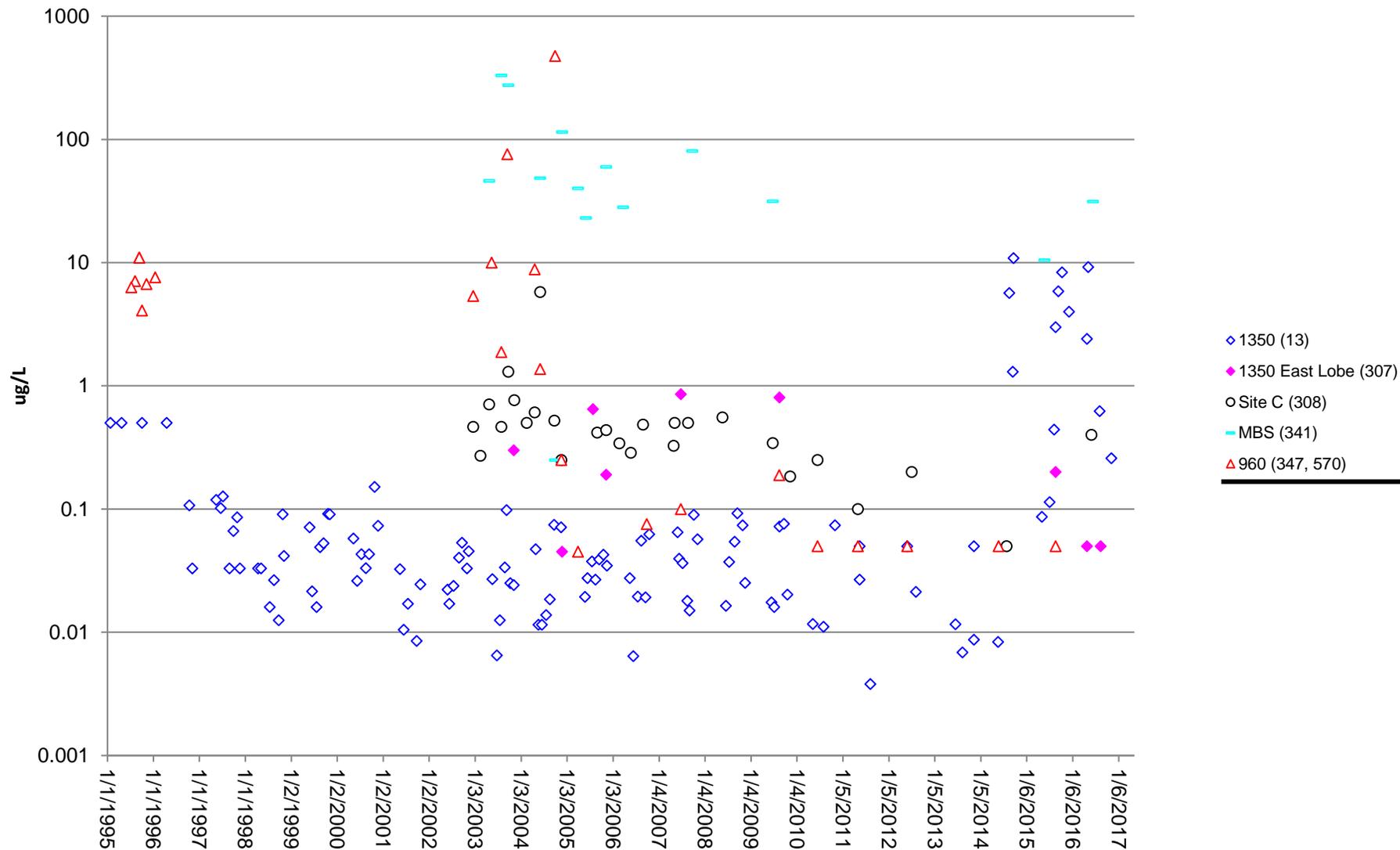
**Figure 2.14 INACTIVE PRODUCTION ROCK SITE LEAD DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



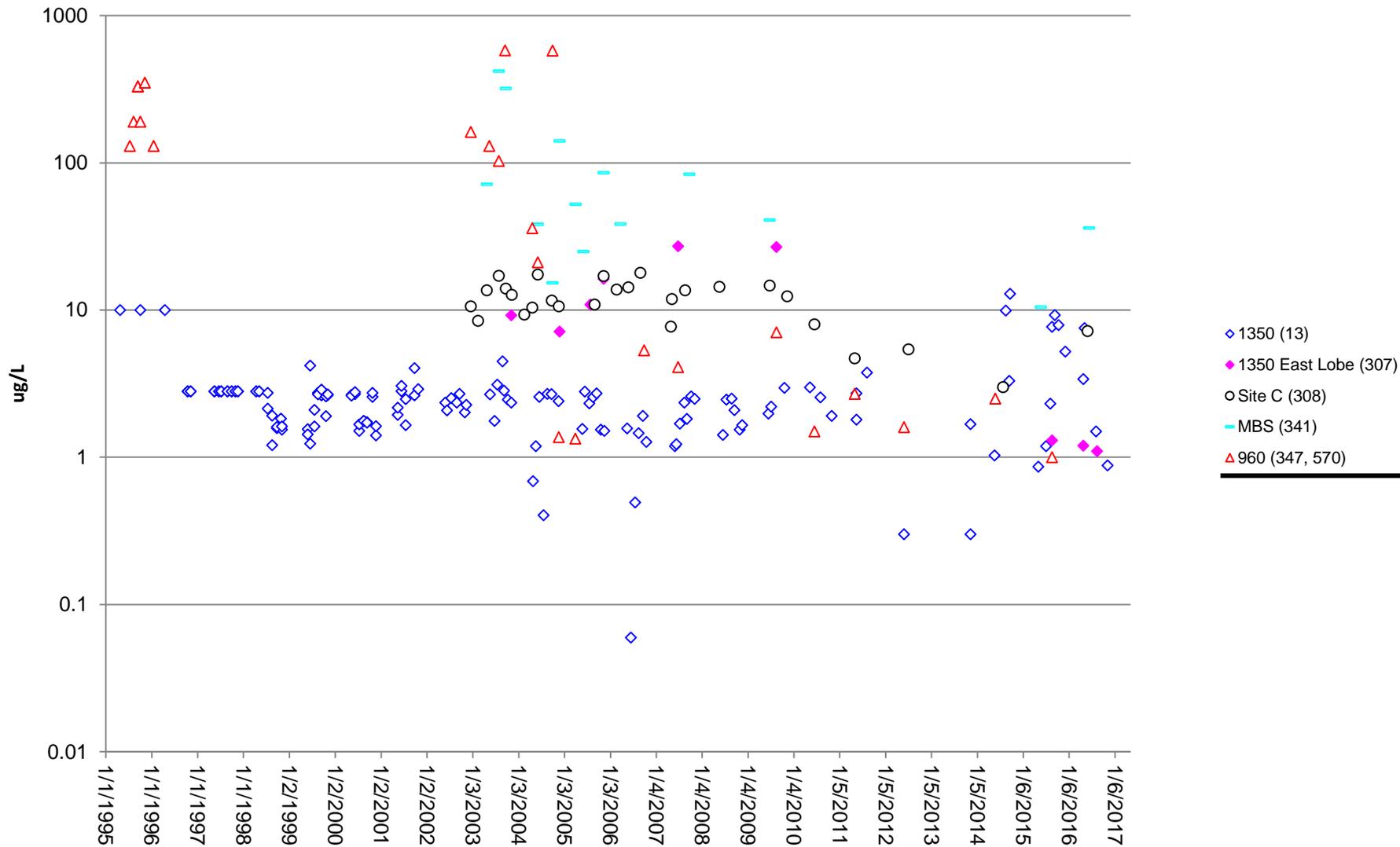
**Figure 2.15 INACTIVE PRODUCTION ROCK SITE CADMIUM DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



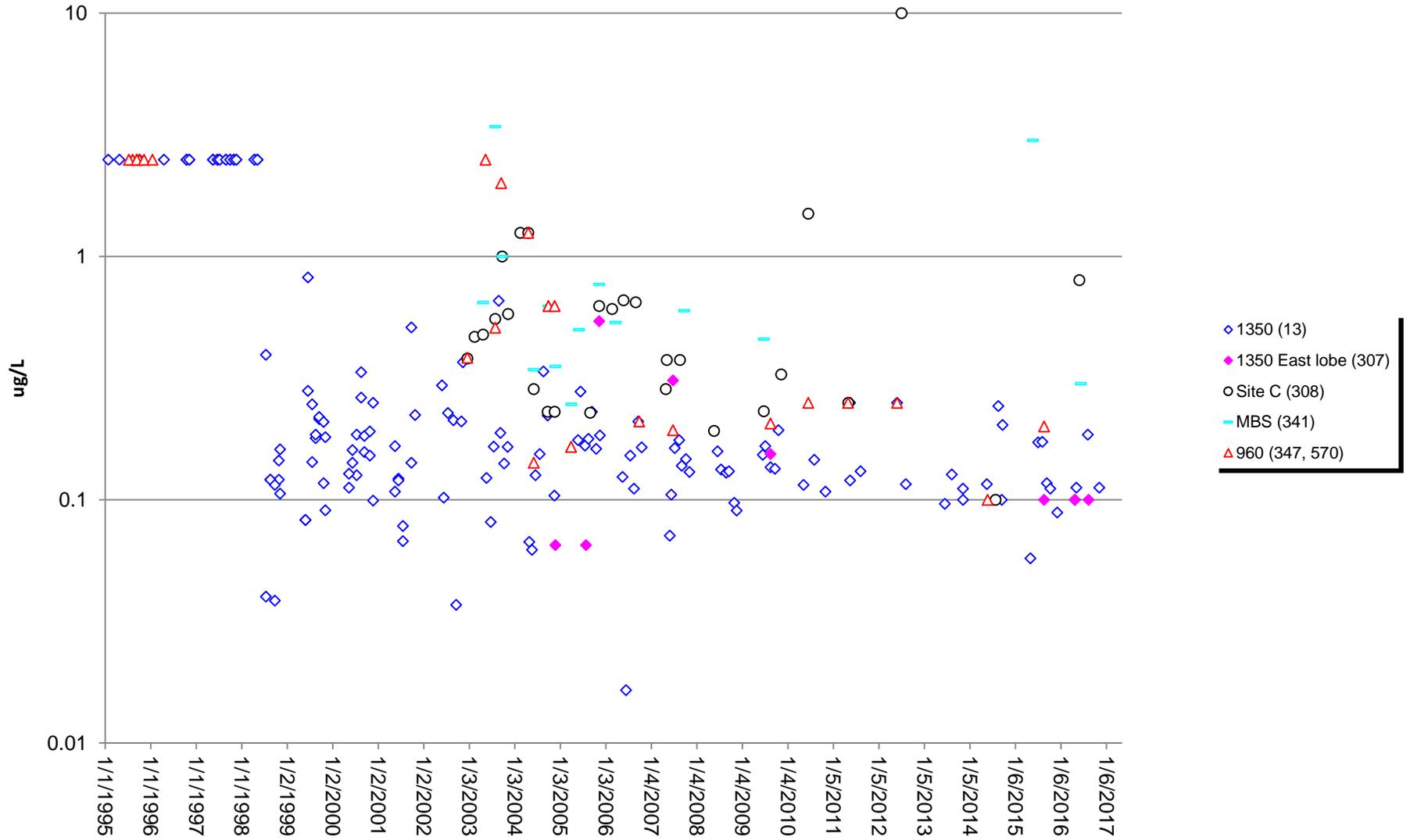
**Figure 2.16 INACTIVE PRODUCTION ROCK SITE NICKEL DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



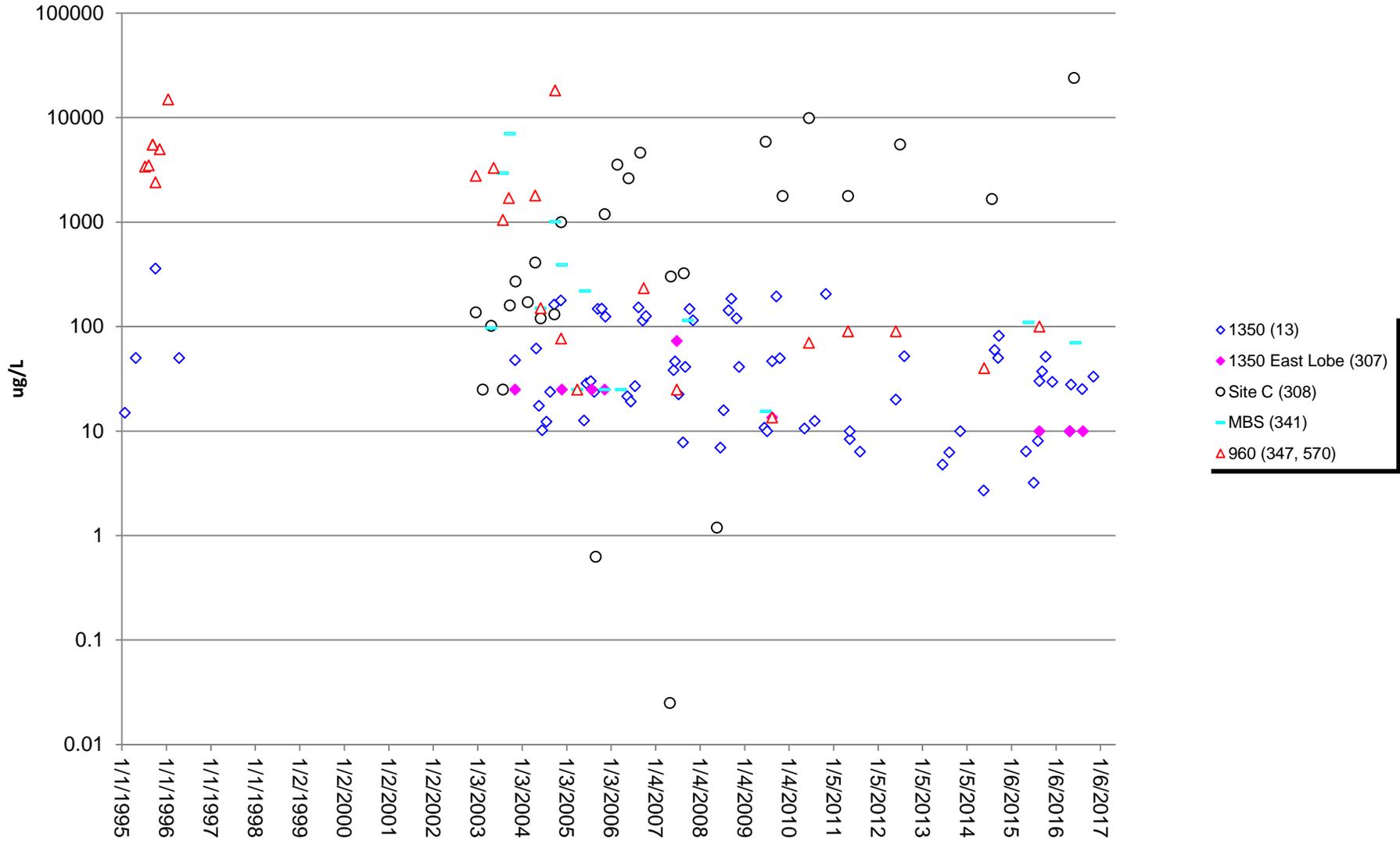
**Figure 2.17 INACTIVE PRODUCTION ROCK SITE ARSENIC DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.18 INACTIVE PRODUCTION ROCK SITE IRON DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 2.19 INACTIVE PRODUCTION ROCK SITE MANGANESE DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

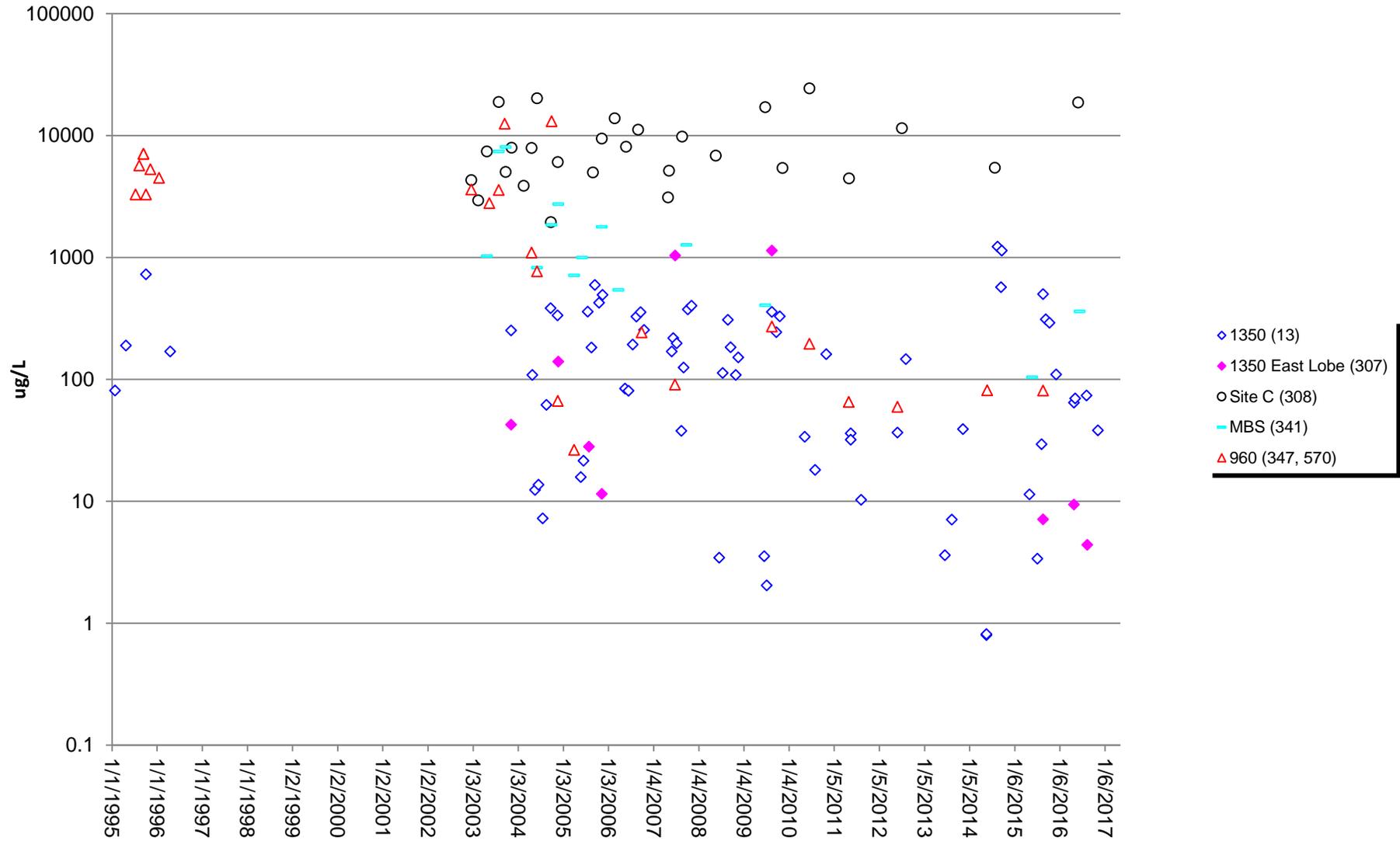


Figure 2.20 INACTIVE PRODUCTION ROCK SITE E FLOW DATA

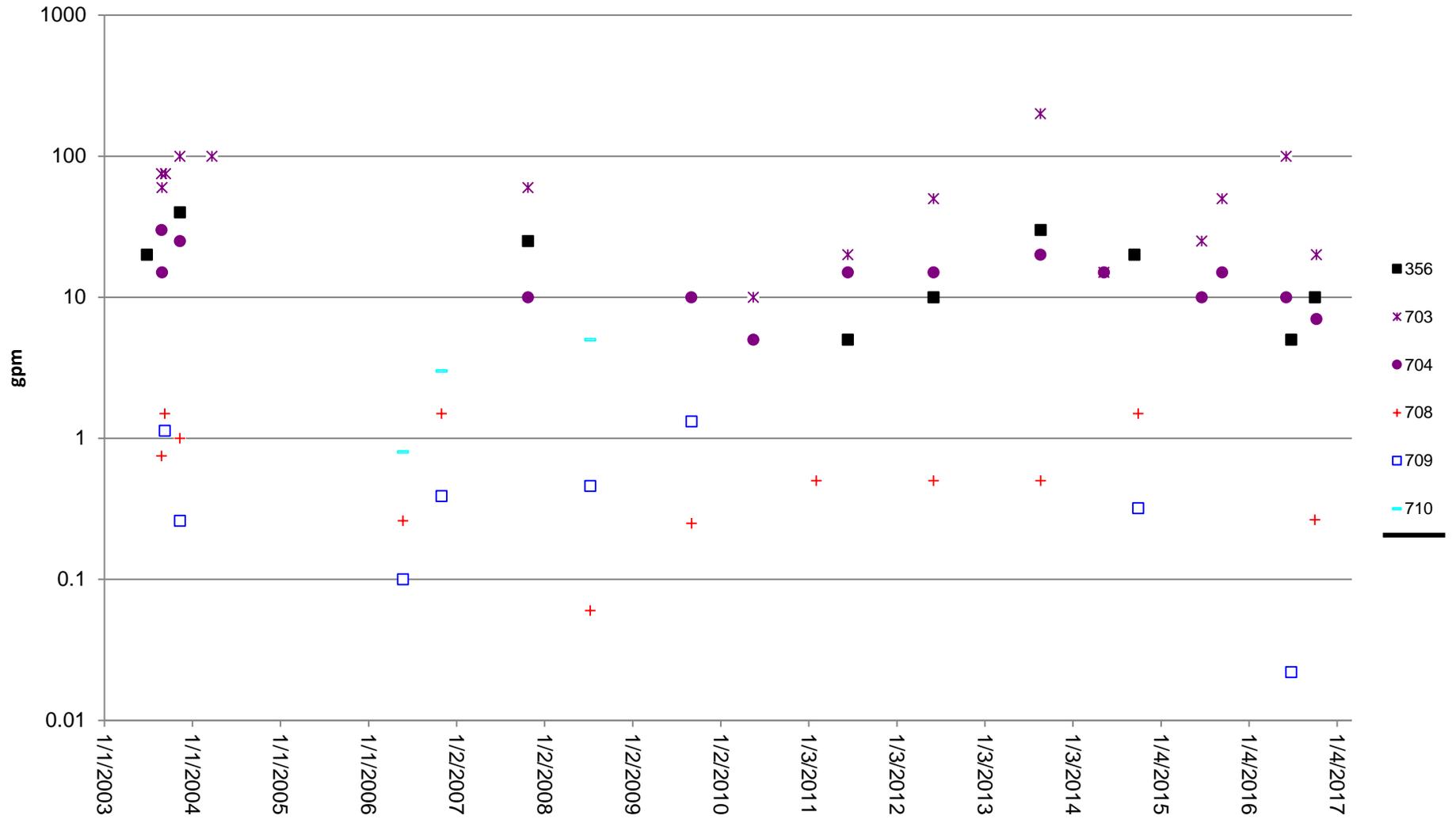


Figure 2.21 INACTIVE PRODUCTION ROCK SITE E pH DATA

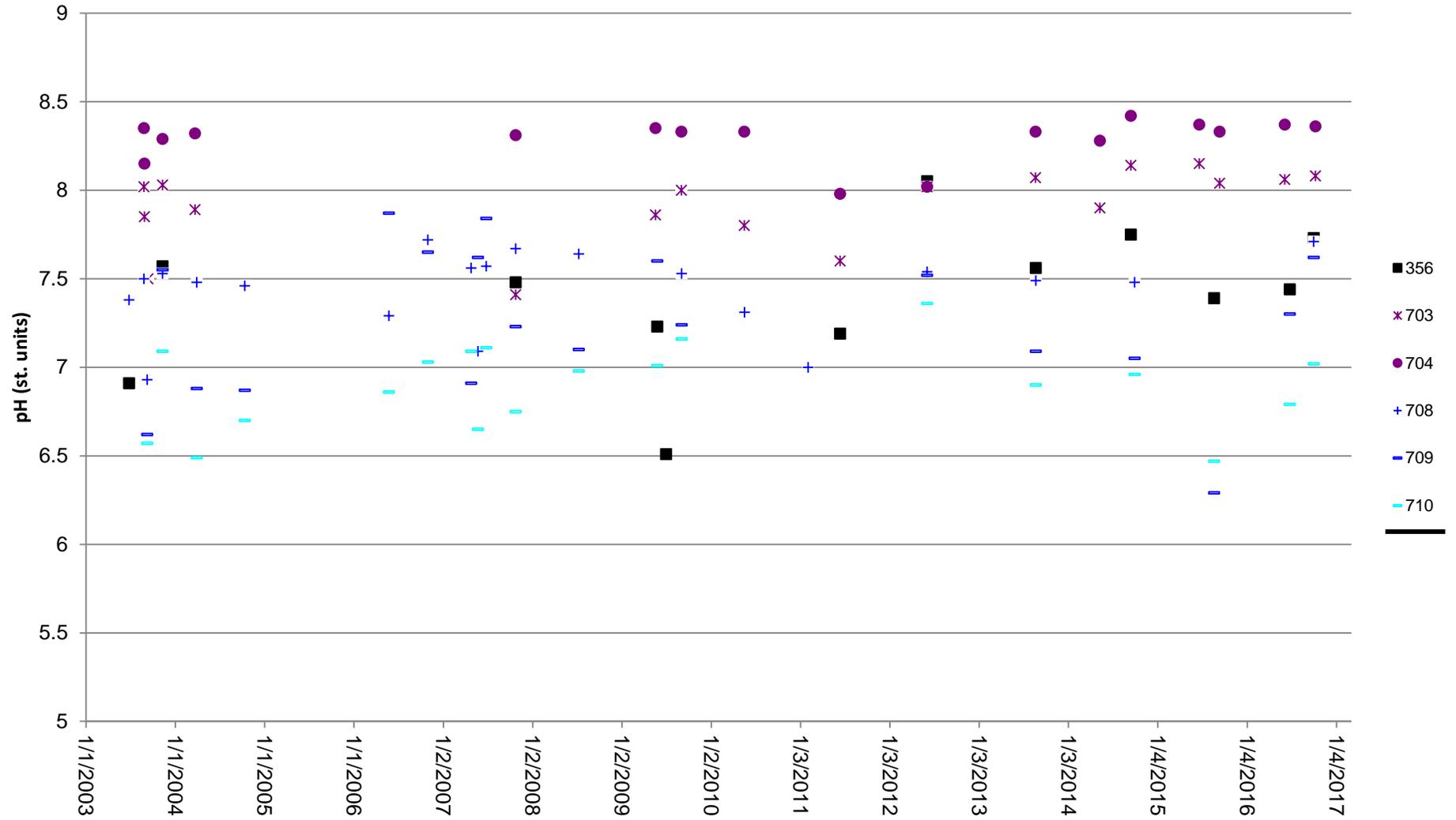


Figure 2.22 INACTIVE PRODUCTION ROCK SITE E ALKALINITY DATA

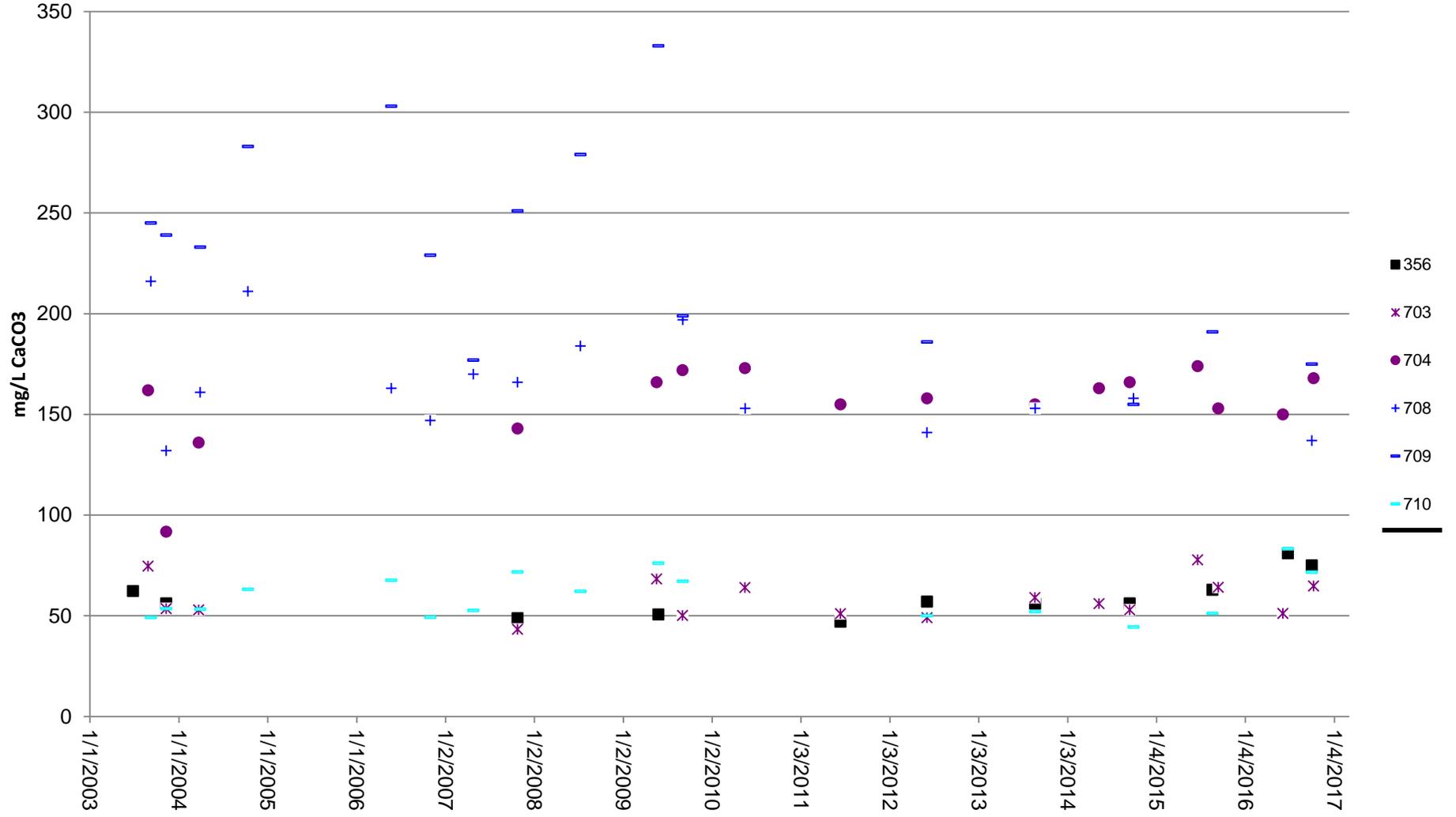


Figure 2.23 INACTIVE PRODUCTION ROCK SITE E CONDUCTIVITY DATA

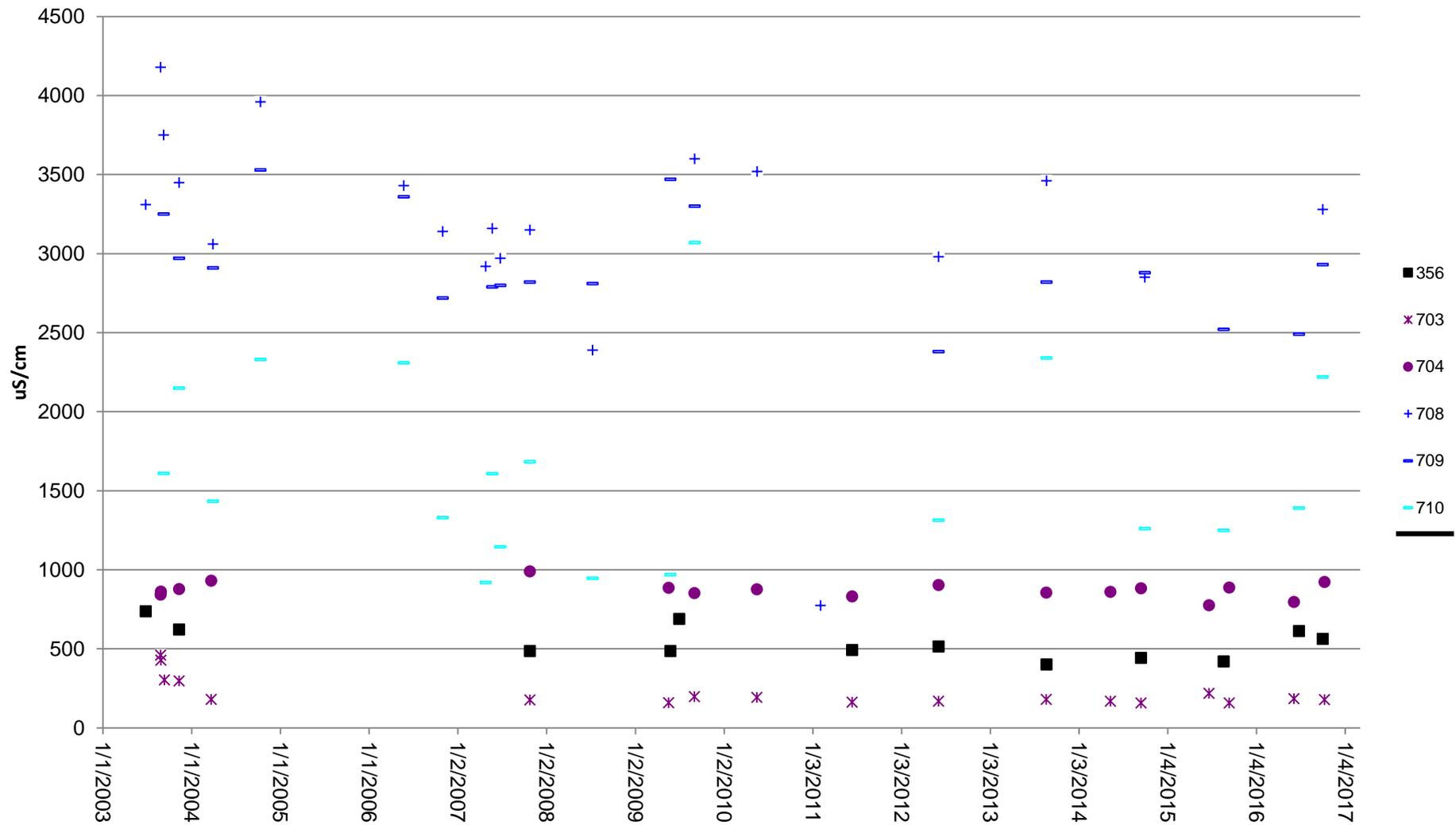
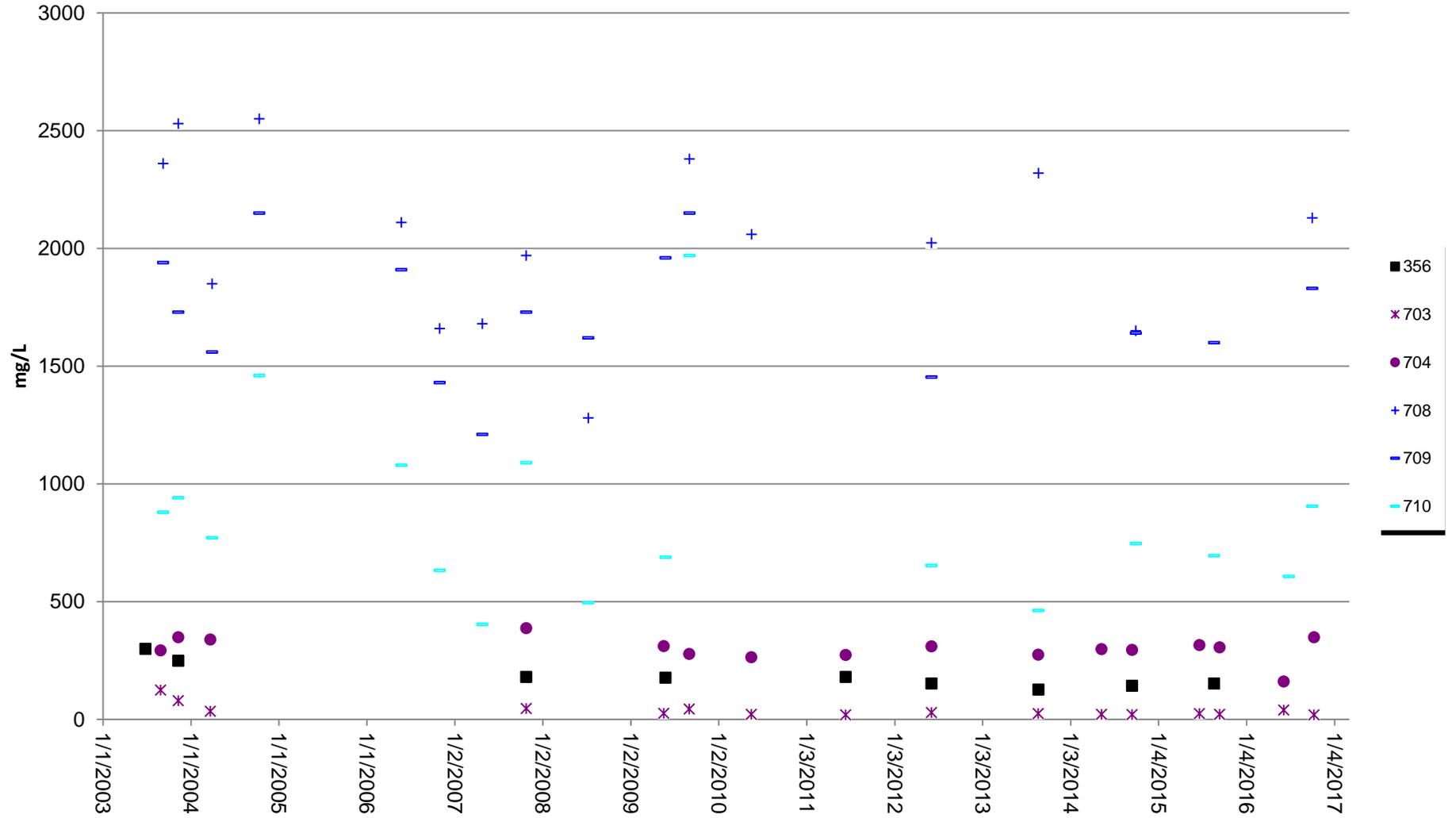


Figure 2.24 INACTIVE PRODUCTION ROCK SITE E SULFATE DATA



**Figure 2.25 INACTIVE PRODUCTION ROCK SITE E MAGNESIUM DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

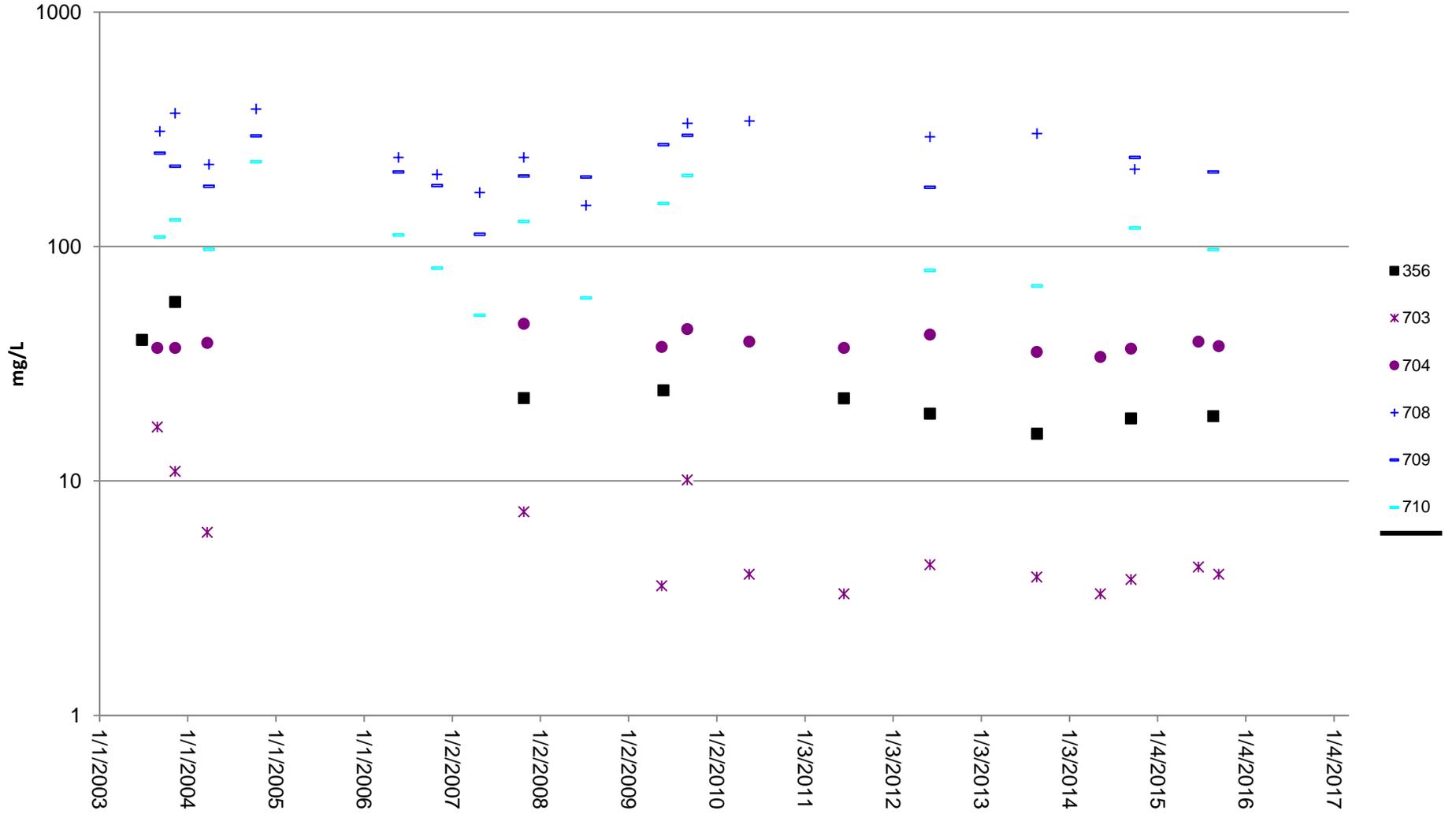
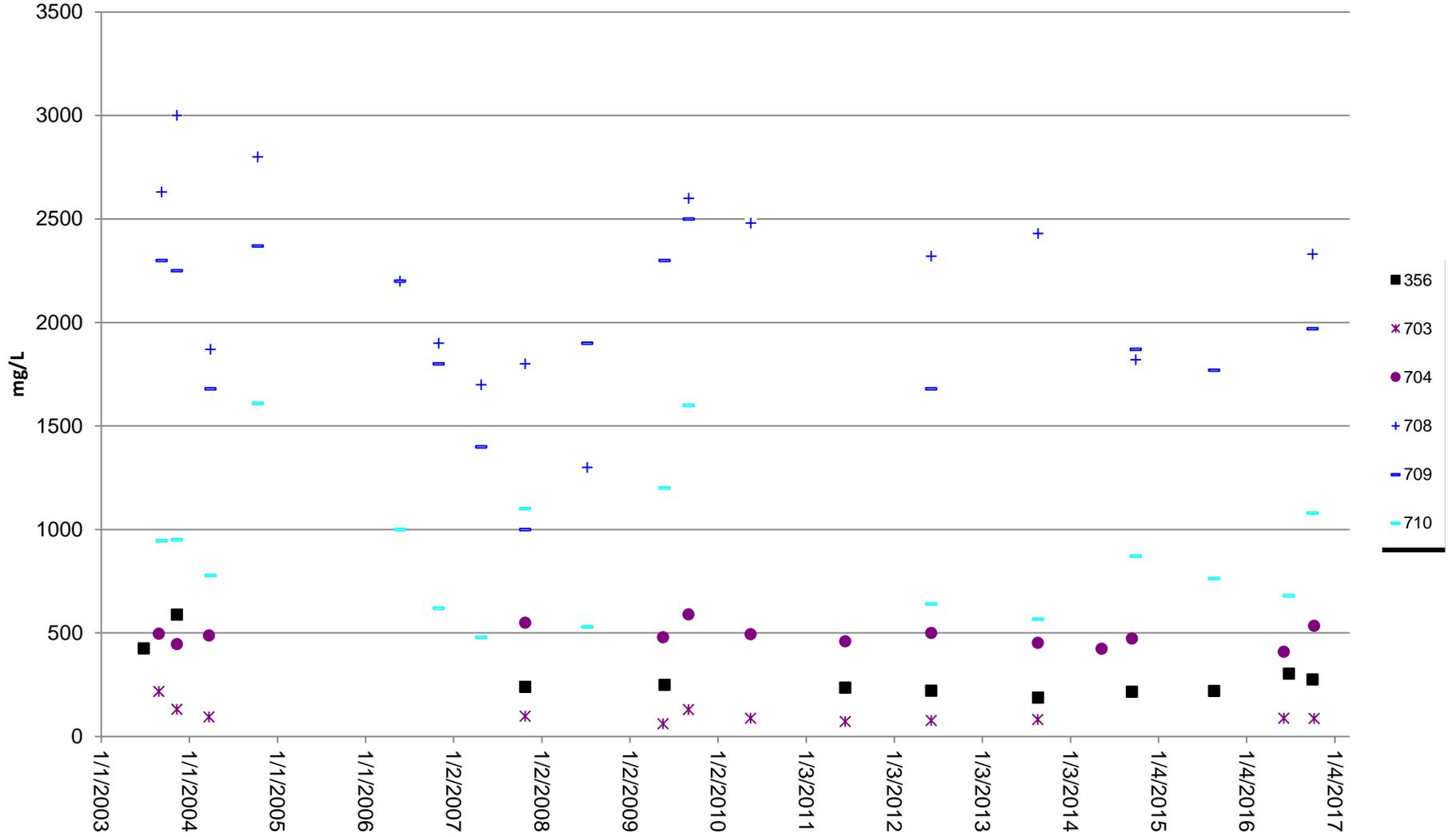


Figure 2.26 INACTIVE PRODUCTION ROCK SITE E HARDNESS DATA



**Figure 2.27 INACTIVE PRODUCTION ROCK SITE E ZINC DATA**

Non-detect results are shown at 1/2 detection limit

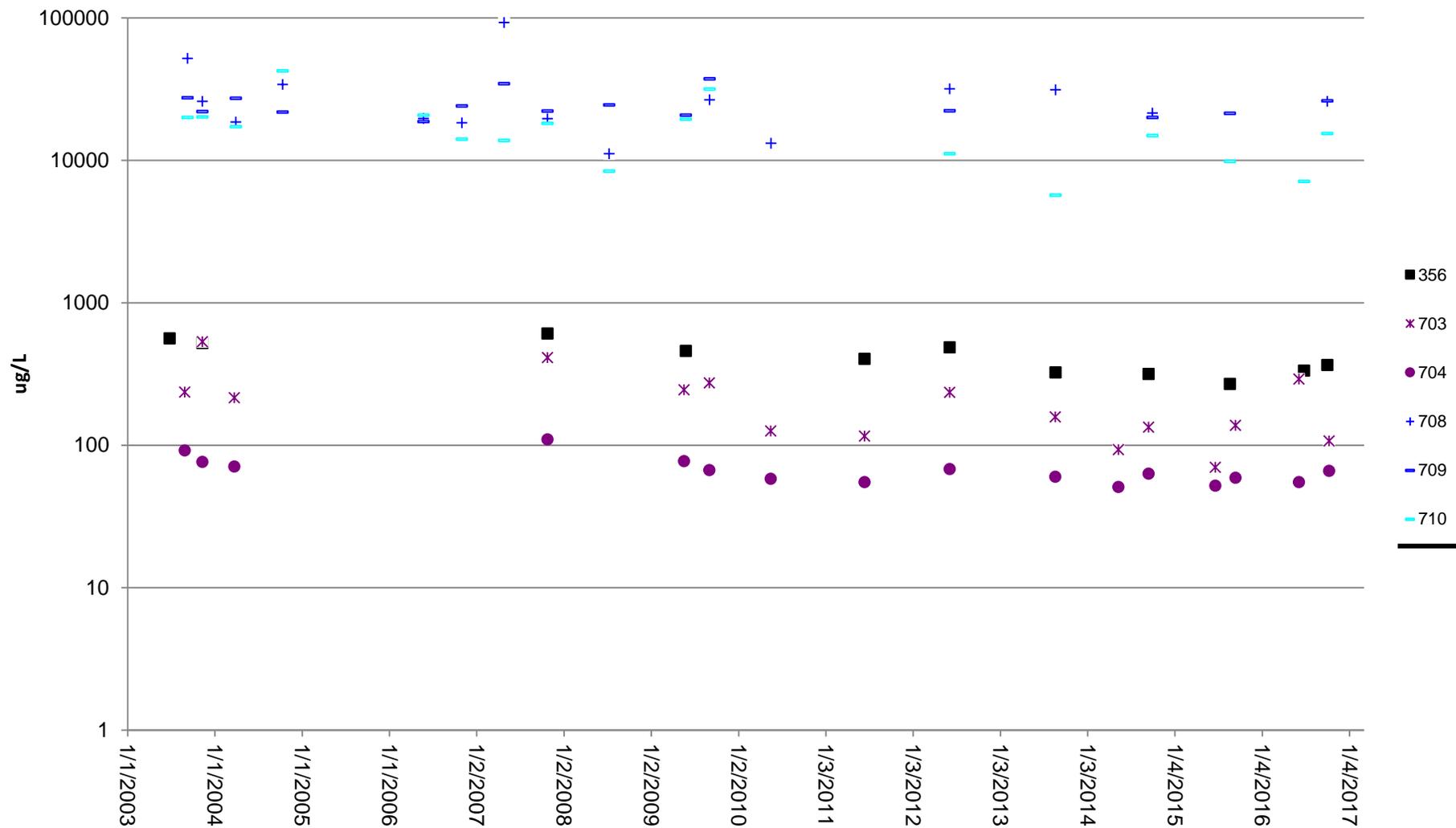


Figure 2.28 INACTIVE PRODUCTION ROCK SITE E COPPER DATA

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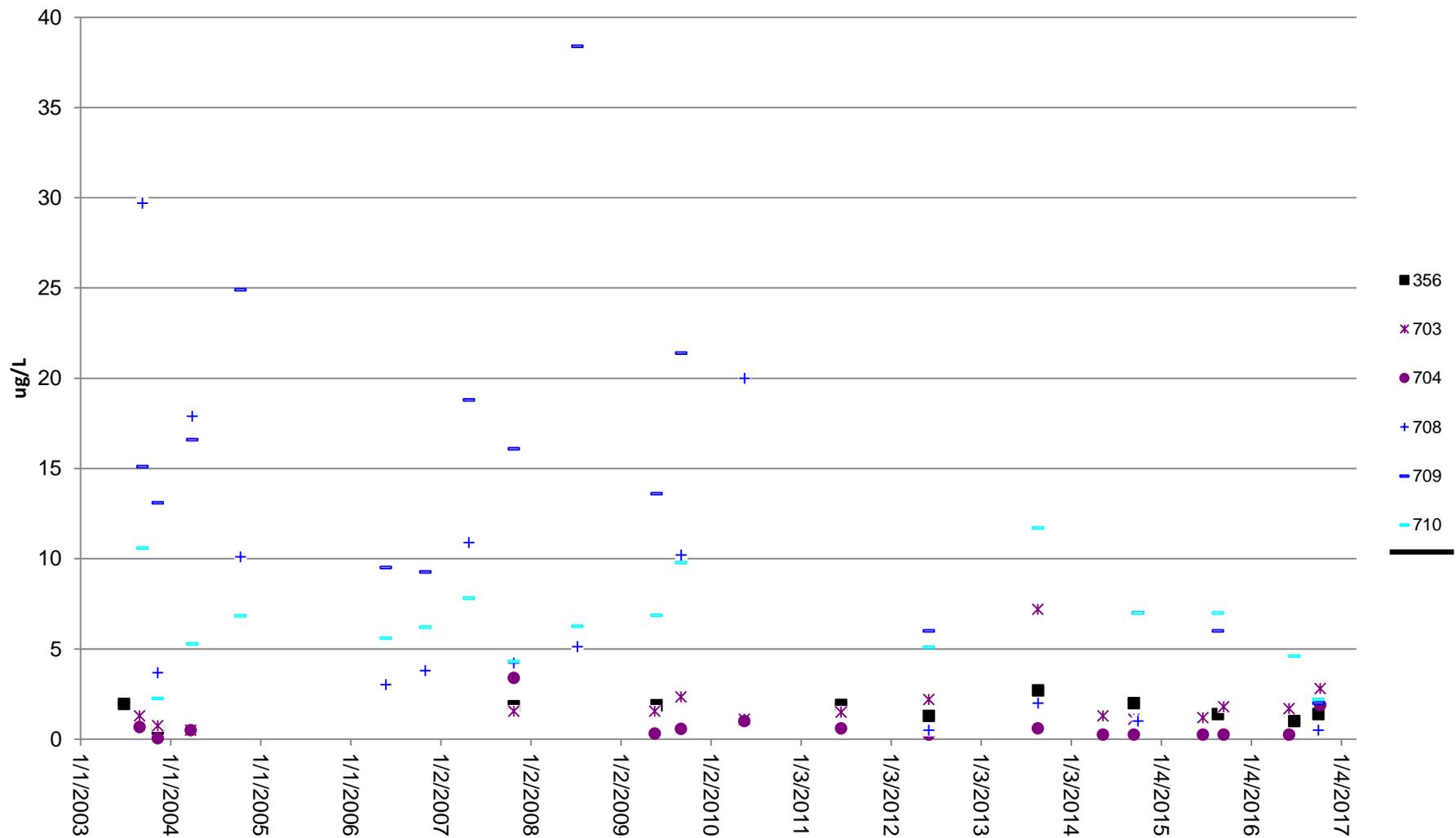


Figure 2.29 INACTIVE PRODUCTION ROCK SITE E LEAD DATA

Non-detect results shown at 1/2 detection limit

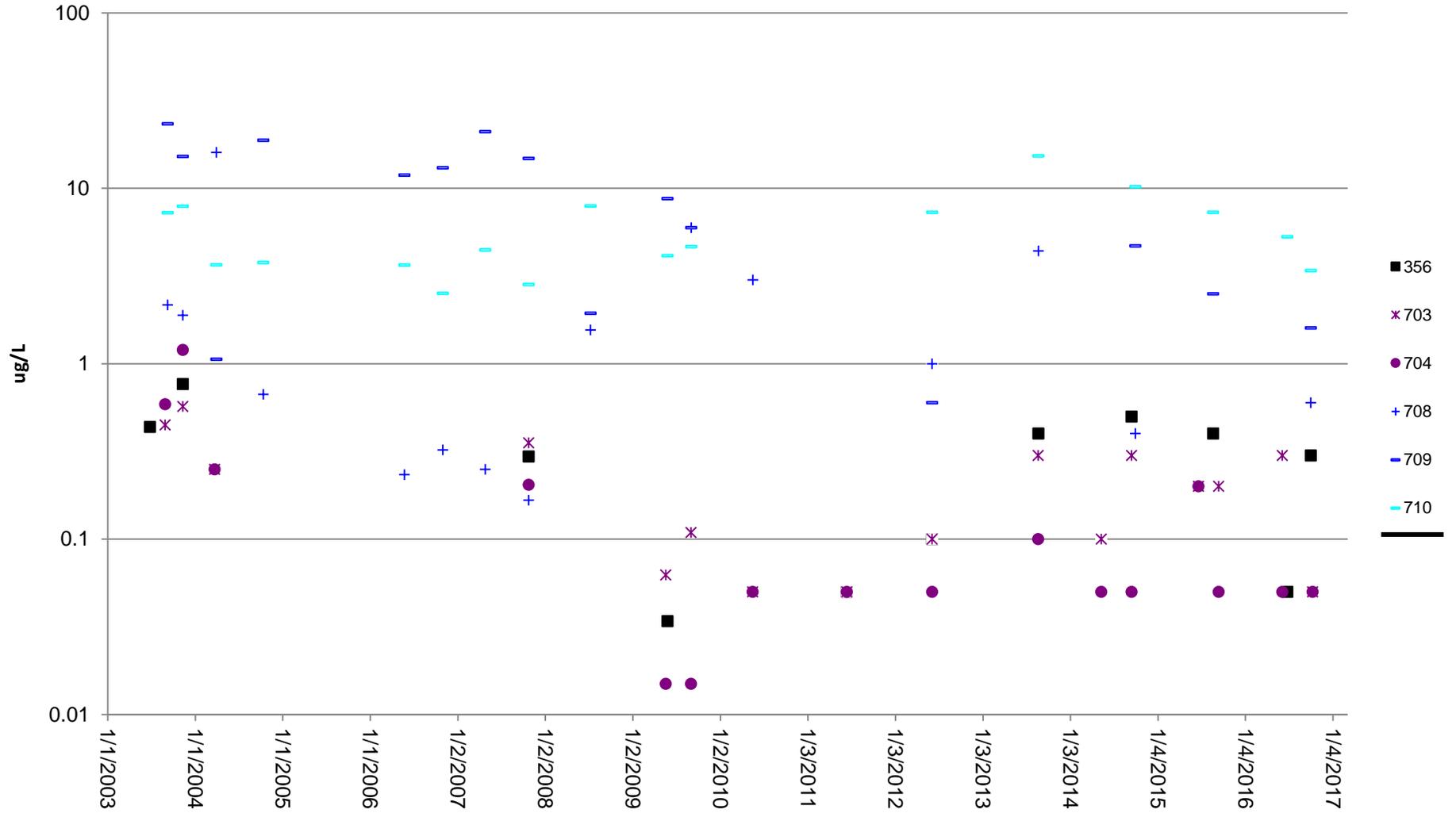


Figure 2.30 INACTIVE PRODUCTION ROCK SITE E CADMIUM DATA

Non-detect results shown at 1/2 detection limit

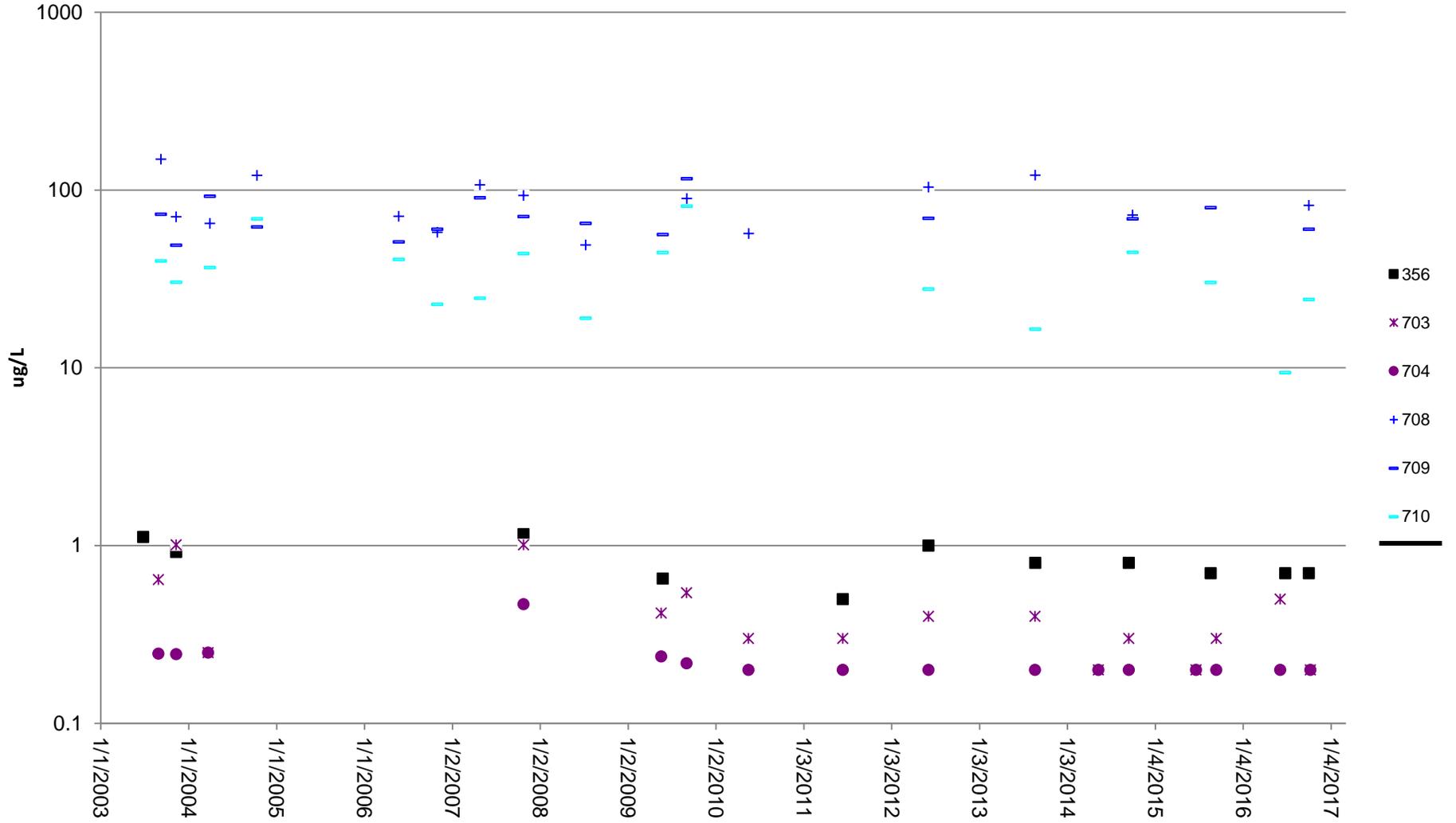


Figure 2.31 INACTIVE PRODUCTION ROCK SITE E NICKEL DATA

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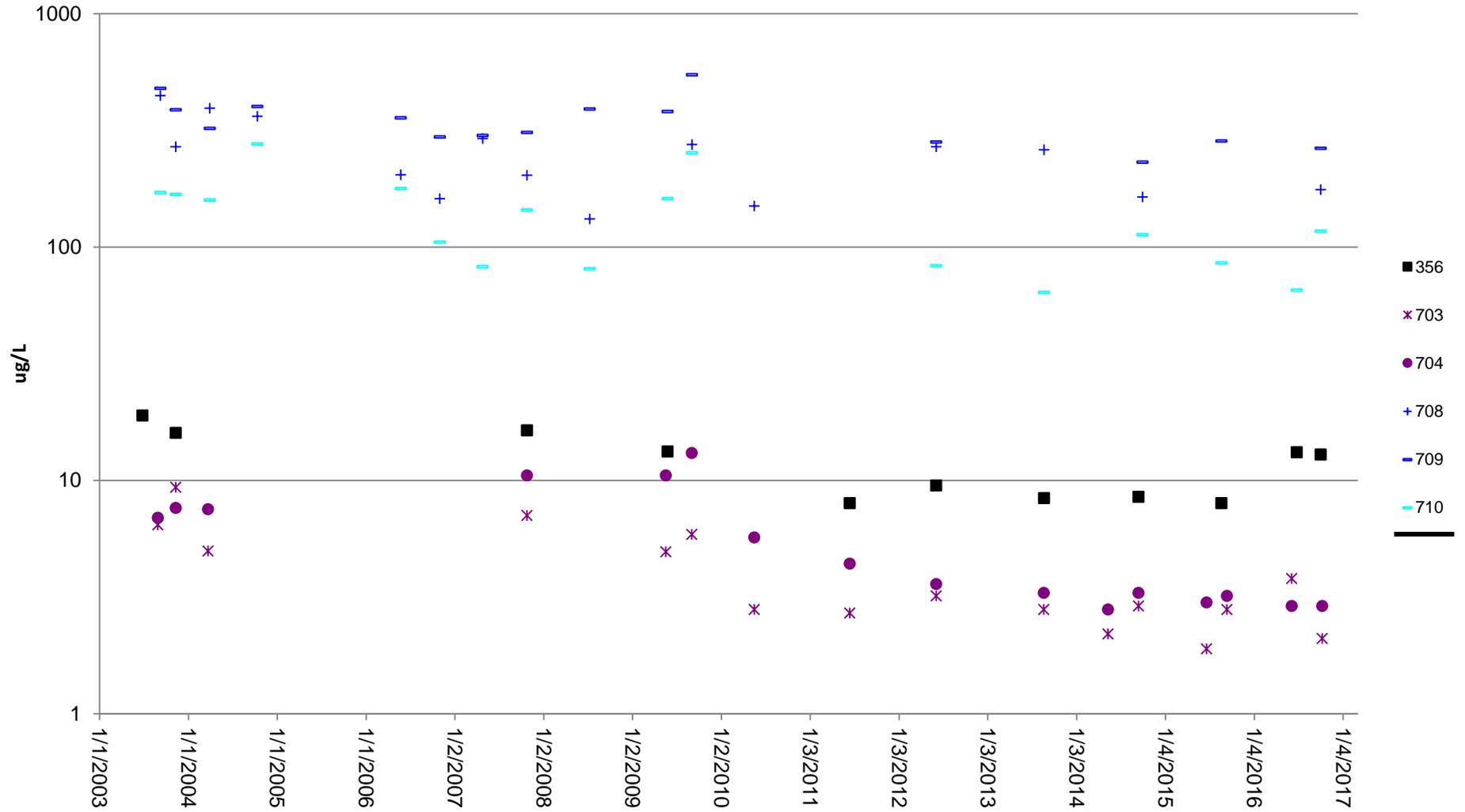


Figure 2.32 INACTIVE PRODUCTION ROCK SITE E ARSENIC DATA

Non-detect results shown at 1/2 detection limit

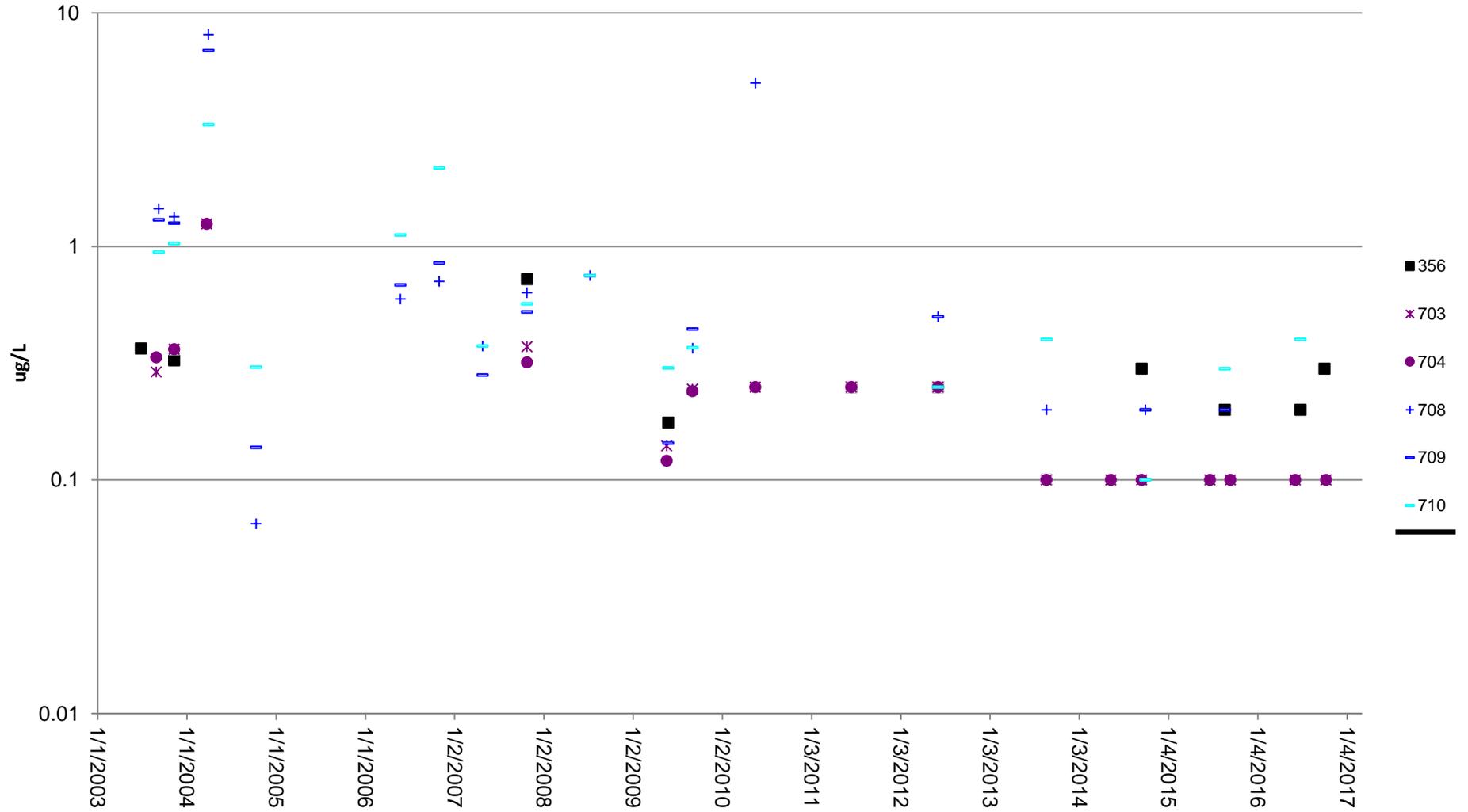


Figure 2.33 INACTIVE PRODUCTION ROCK SITE E IRON DATA

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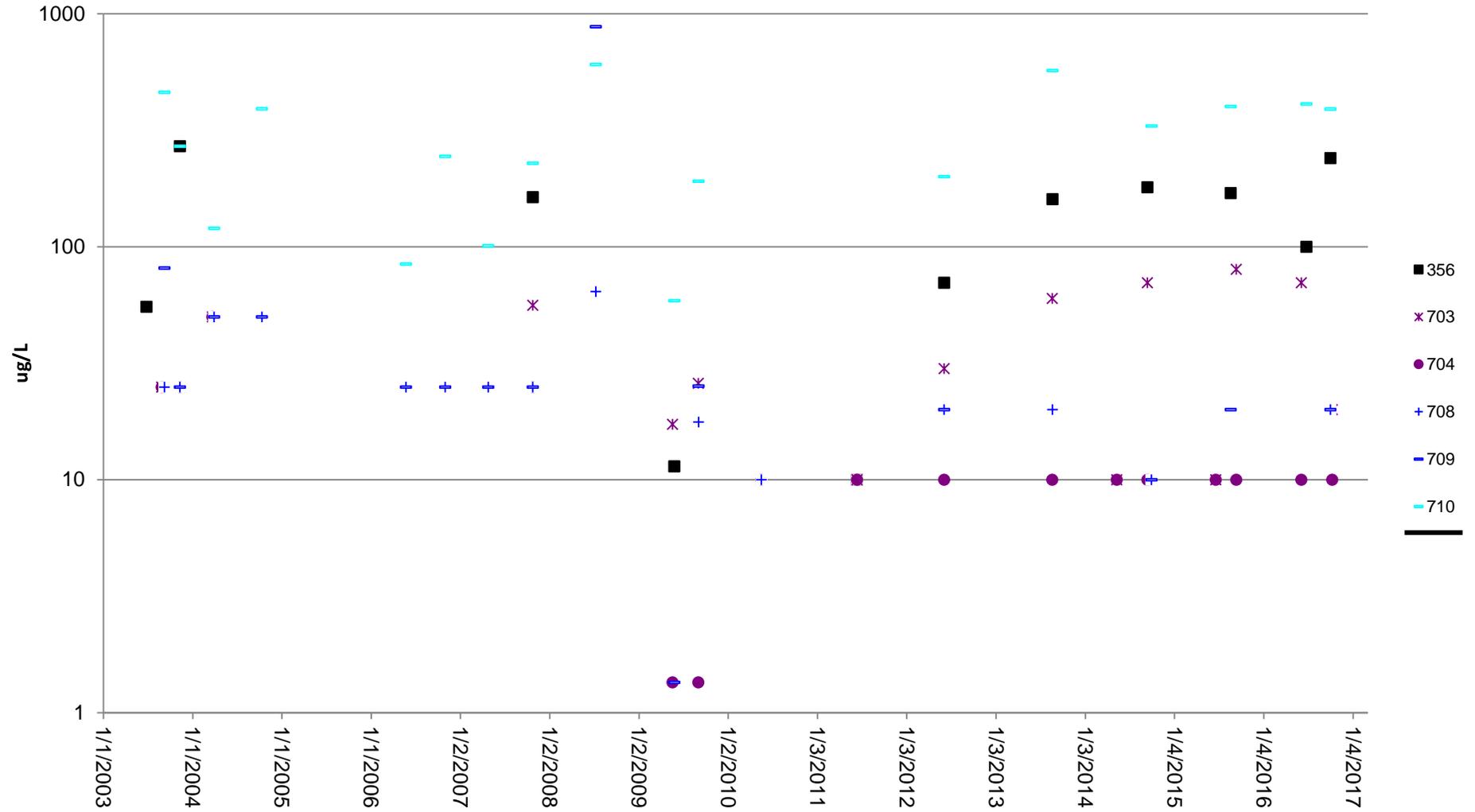


Figure 2.34 INACTIVE PRODUCTION ROCK SITE E MANGANESE DATA

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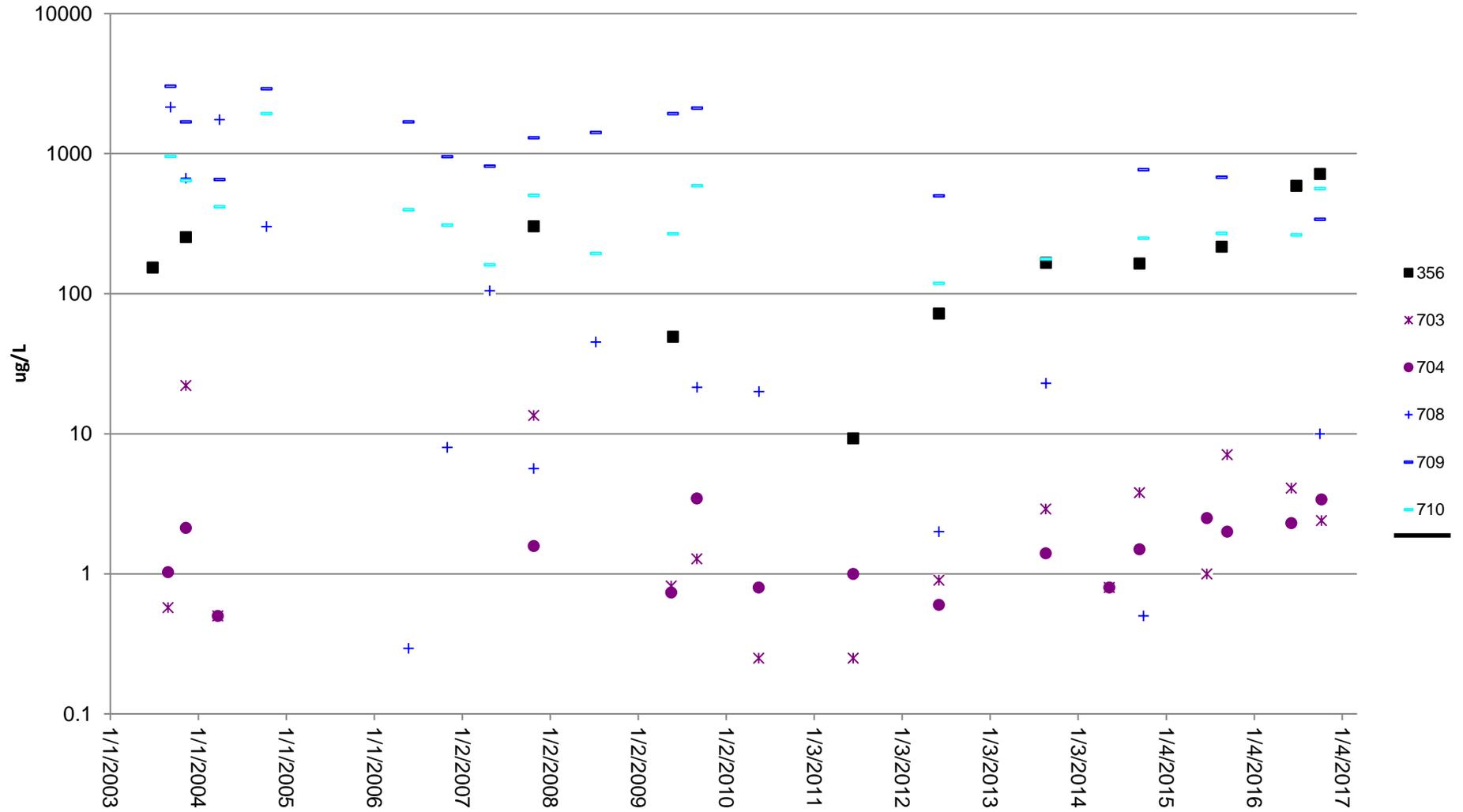


Figure 3.1 QUARRY SITE FLOW DATA

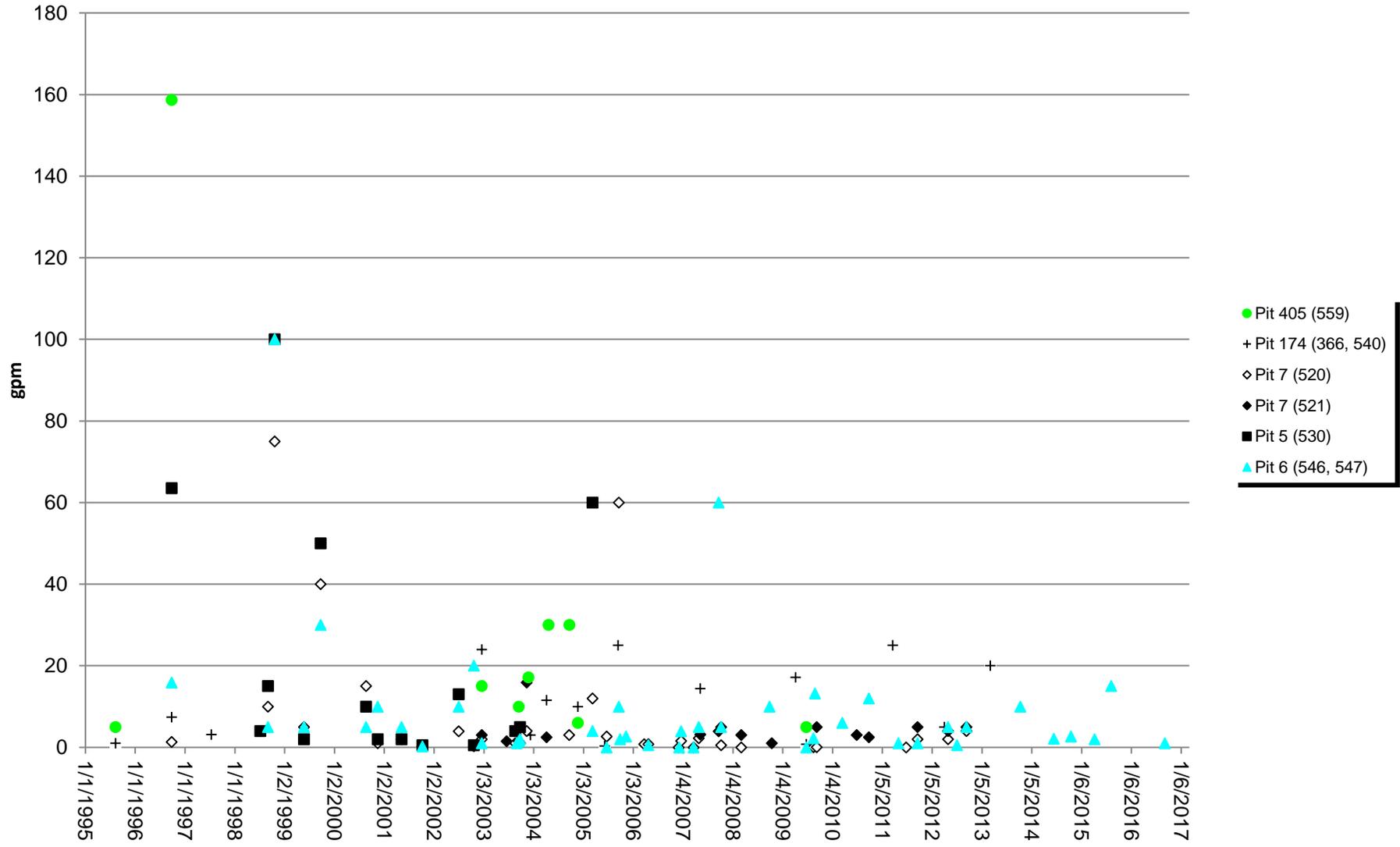


Figure 3.2 QUARRY SITE pH DATA

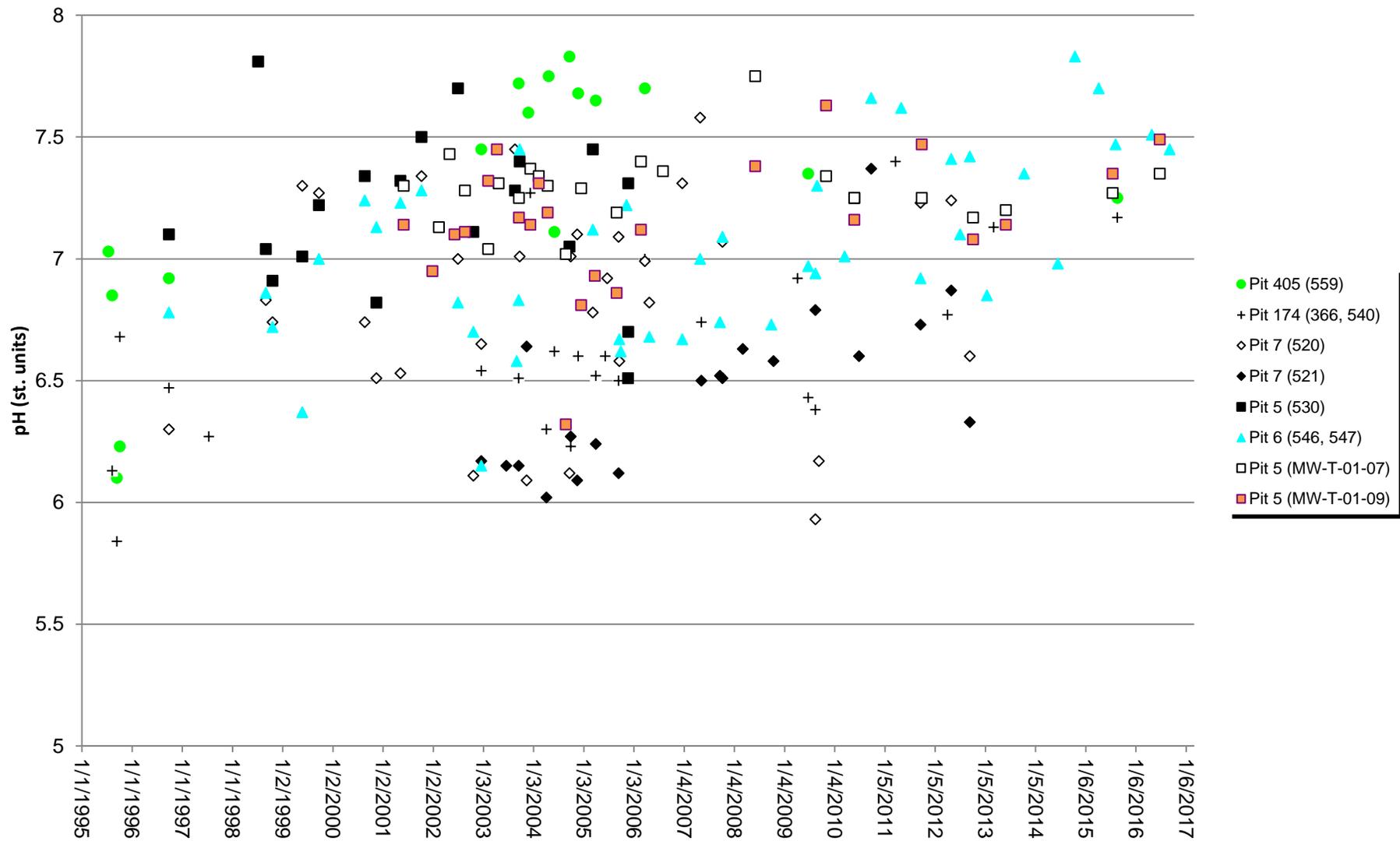
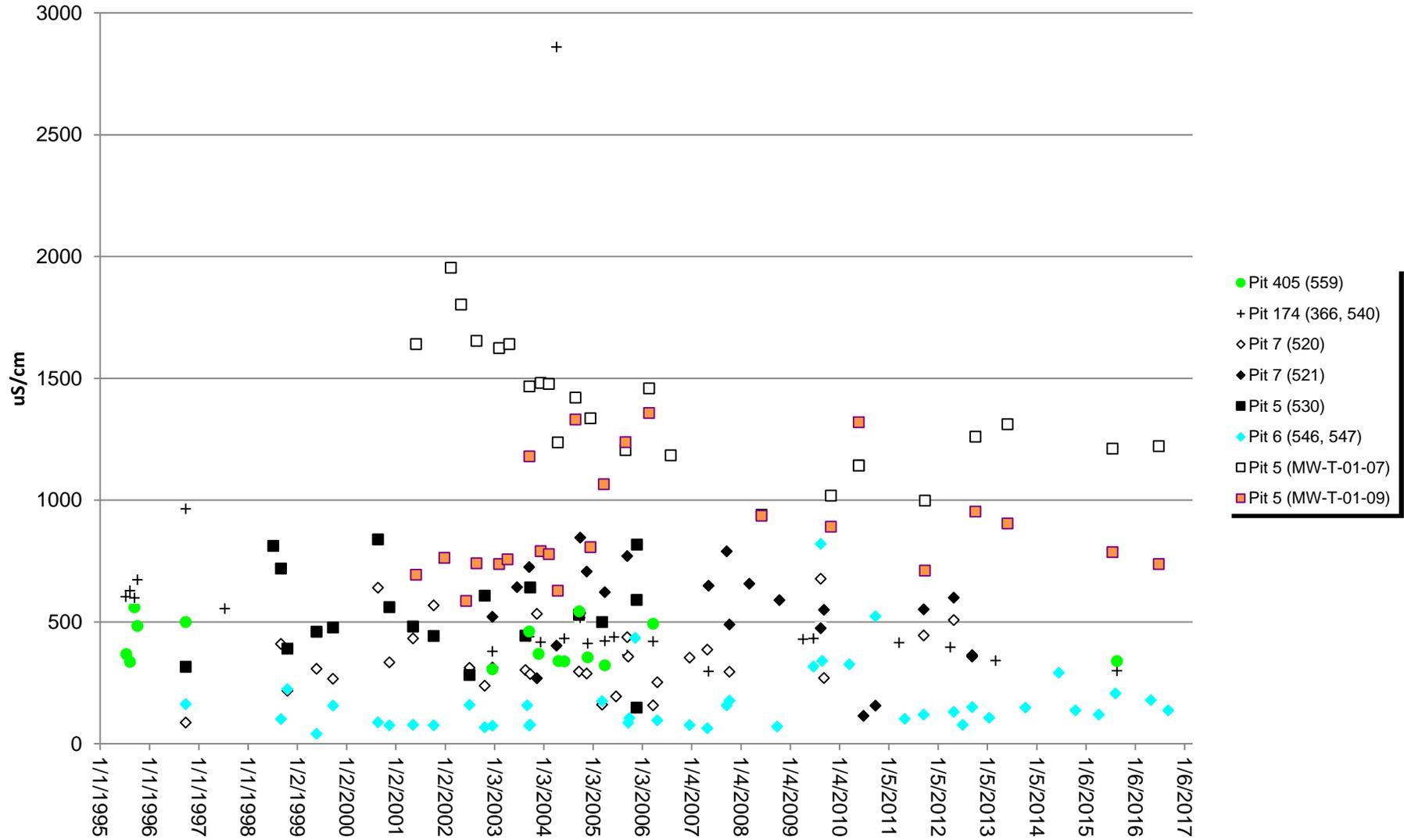




Figure 3.4 QUARRY SITE CONDUCTIVITY DATA

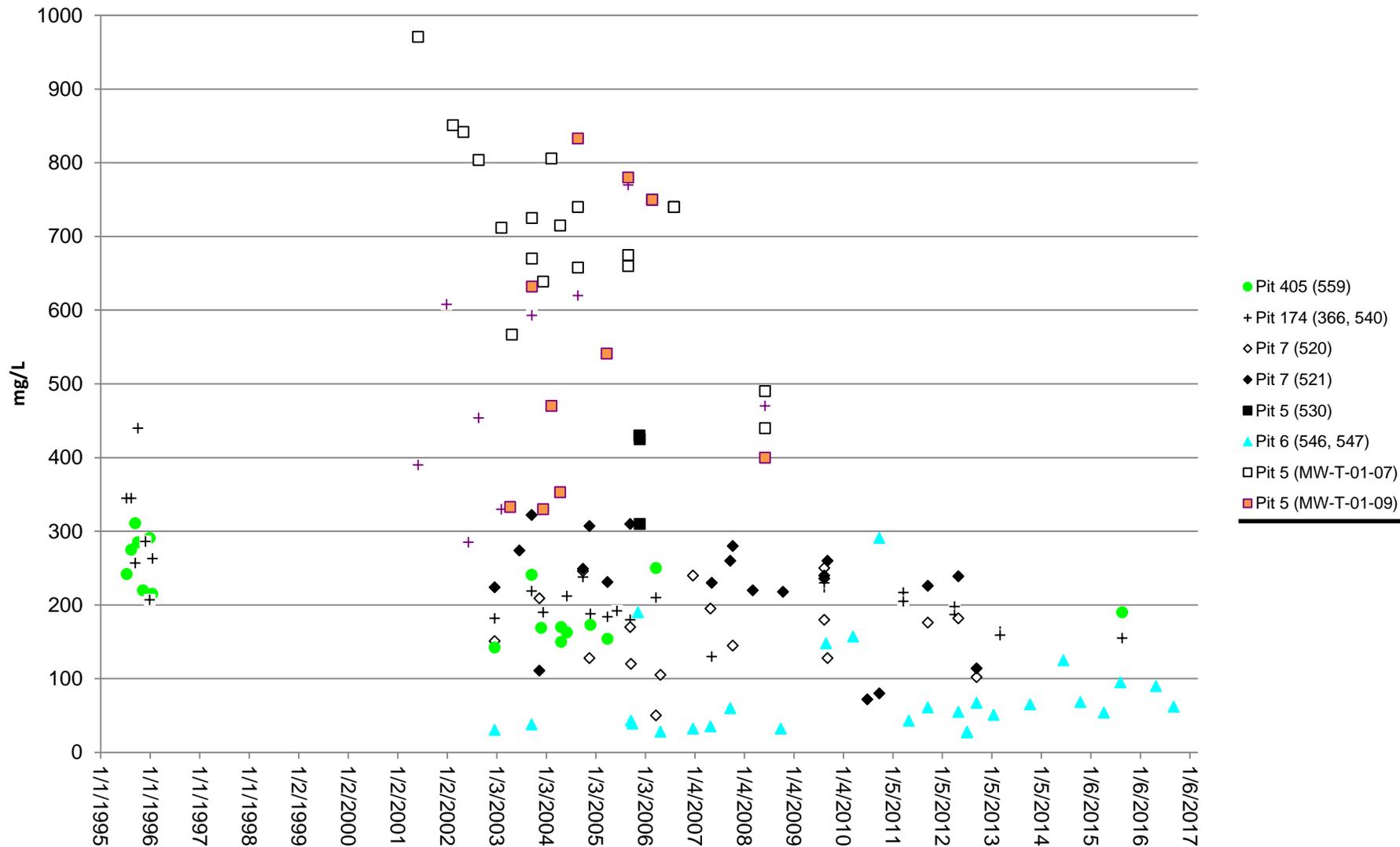






### Figure 3.7 QUARRY SITE HARDNESS DATA

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results



**Figure 3.8 QUARRY SITE ZINC DATA**

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

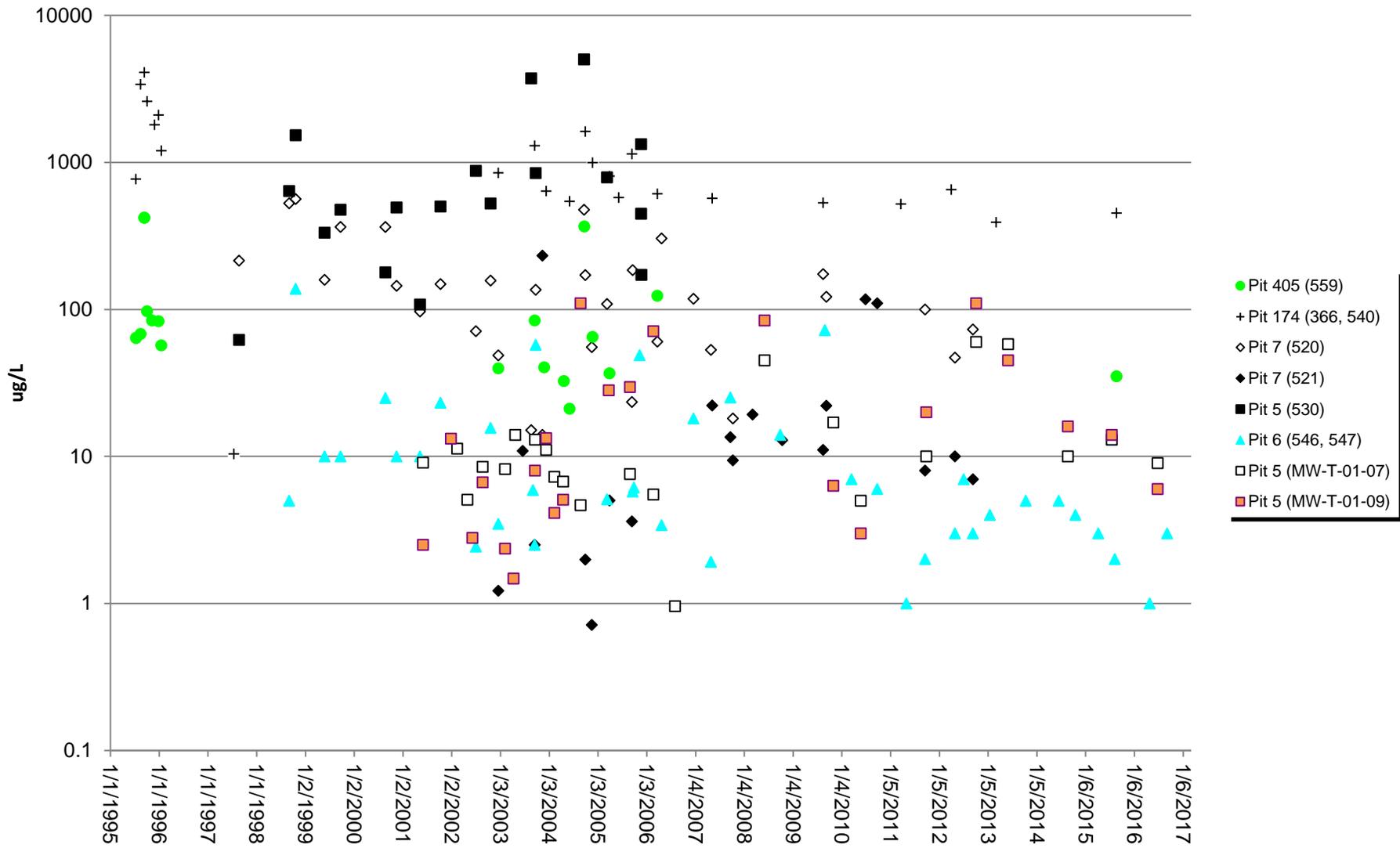




Figure 3.10 QUARRY SITE LEAD DATA

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

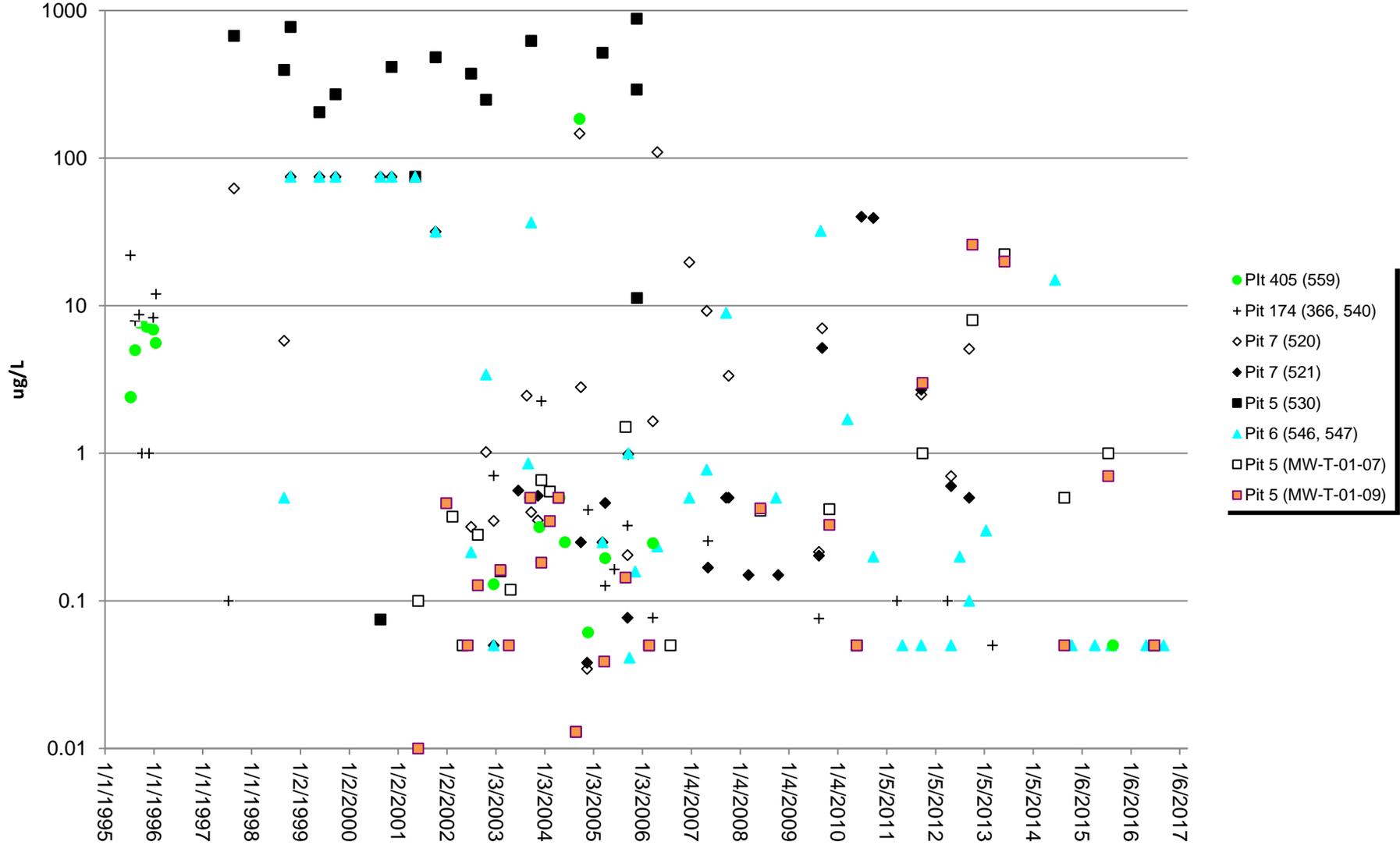
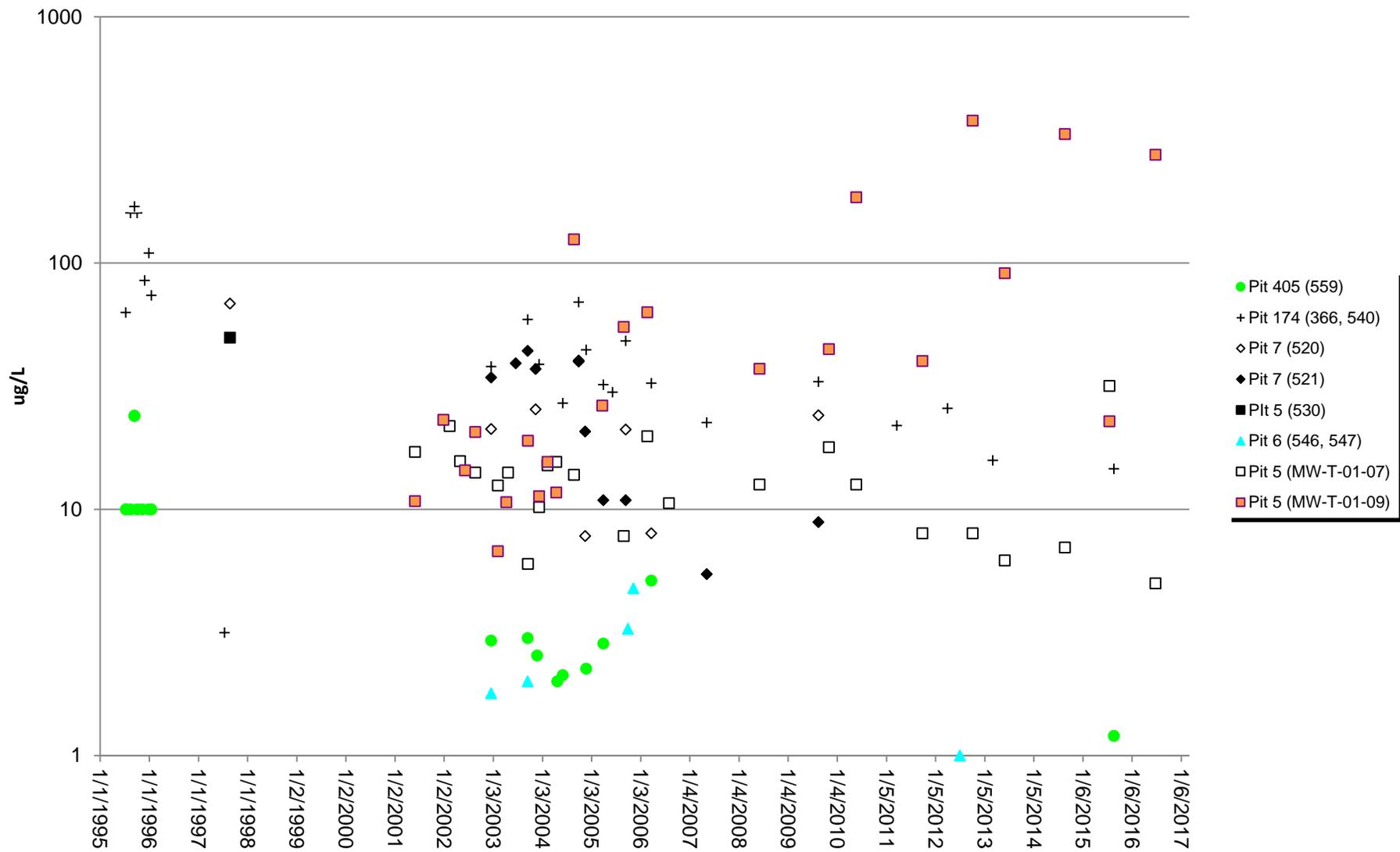




Figure 3.12 QUARRY SITE NICKEL DATA

Non-detect results shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results







**Figure 3.15 QUARRY SITE MANGANESE DATA**

Non-detect results are shown at 1/2 detection limit; Data are a composite of dissolved, total and total recoverable results

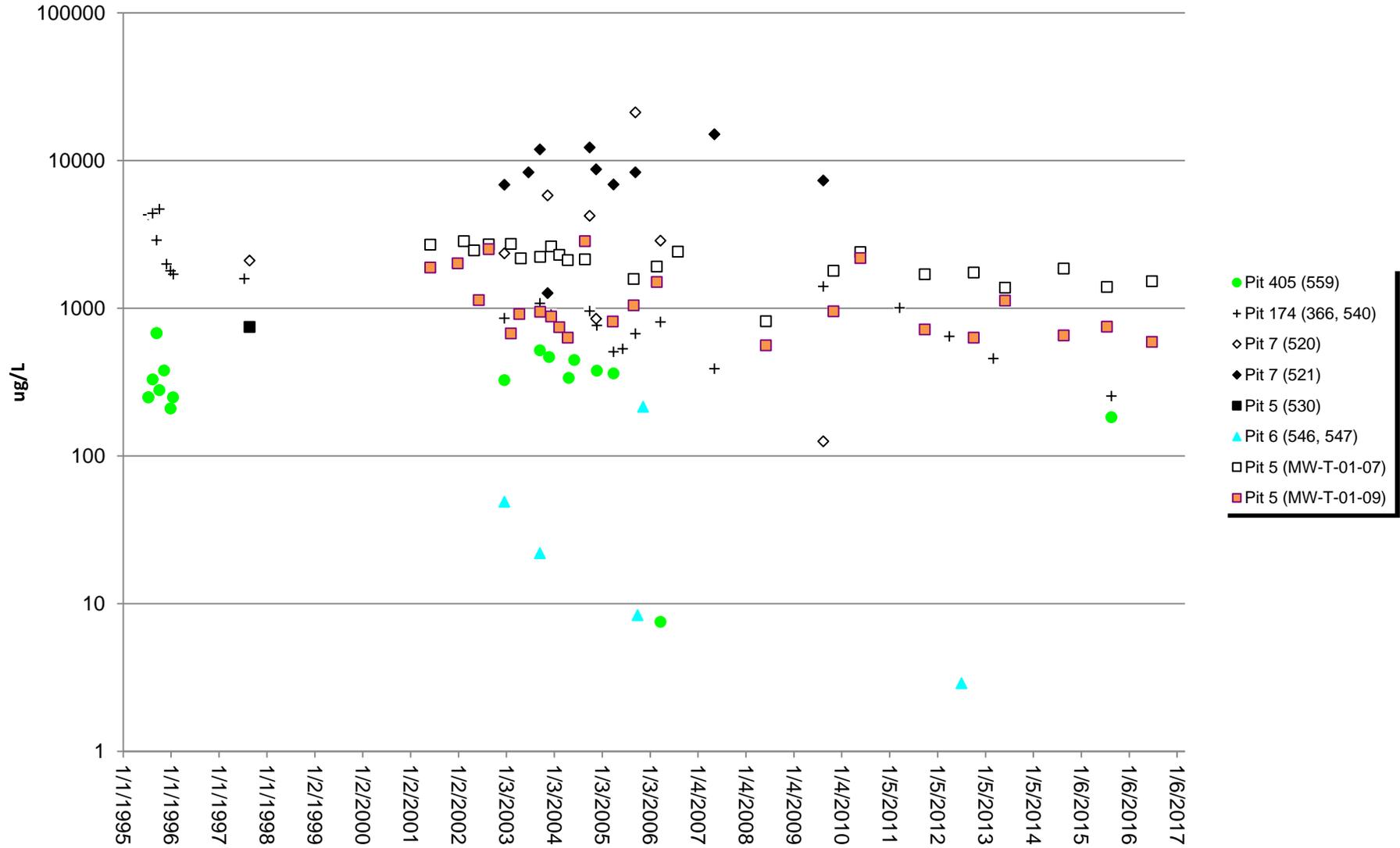


FIGURE 3.16 2002-2013 QUARRY SITE ABA DATA

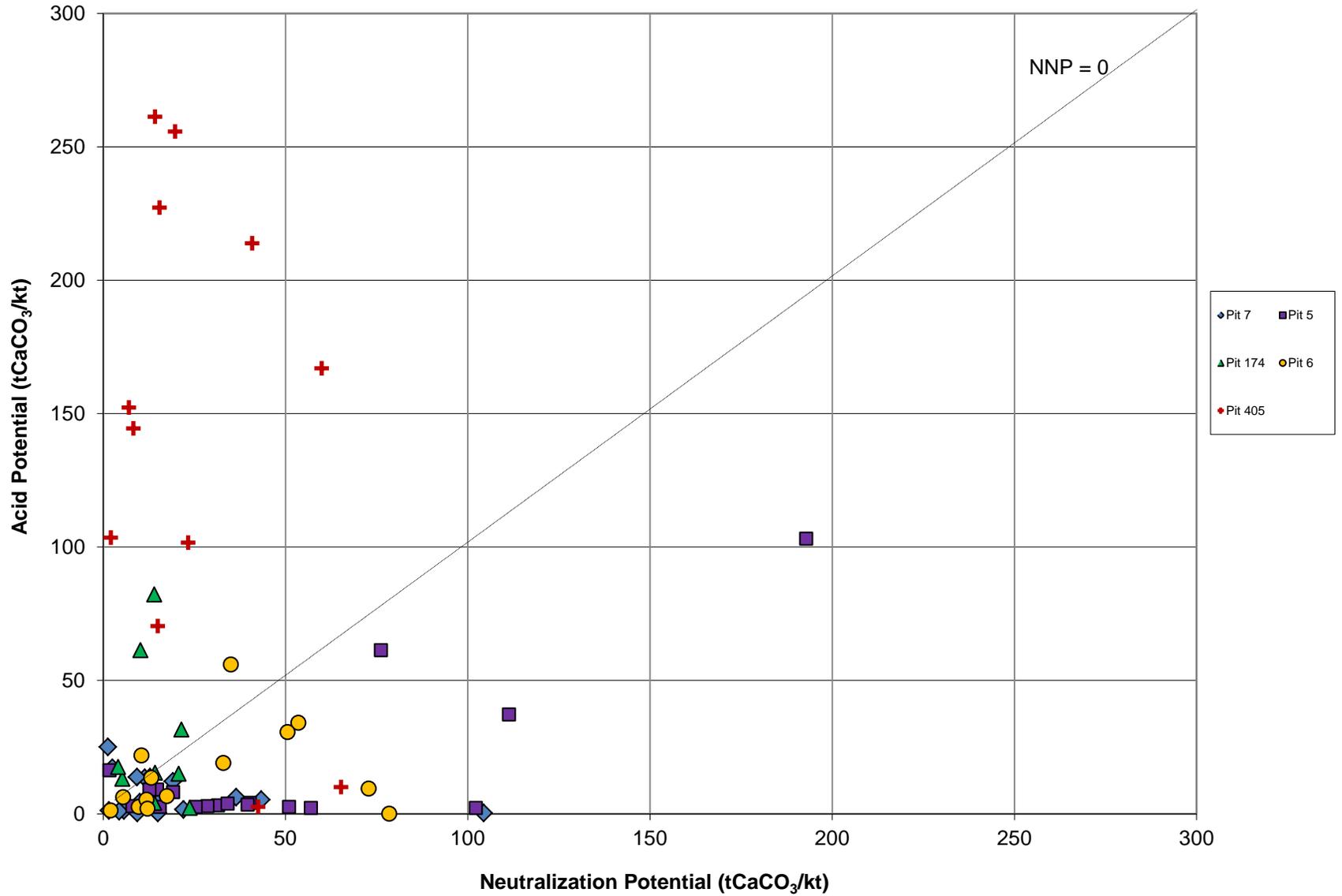


FIGURE 3.17 2002-2013 QUARRY SITE ABA DATA (NNP vs pH)

