

**INACTIVE PRODUCTION ROCK SITES AND QUARRIES
2005 ANNUAL REPORT**



Kennecott Greens Creek Mining Company

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TABLE OF CONTENTS

1.0	EXECUTIVE SUMMARY	1
2.0	INACTIVE PRODUCTION ROCK SITES	2
2.1	Introduction	2
2.2	1350 Site	4
2.3	960 Site	5
2.4	Mill Backslope	6
2.5	Site C	7
2.6	Site E	7
3.0	QUARRIES	9
3.1	Introduction	9
3.2	Pit 405	10
3.3	Pit 6	11
3.4	Pit 174	11
3.5	Pit 5	11
3.6	Pit 7	12
4.0	REFERENCES	13

TABLES

Table 2.1	2005 Summary Statistics for Inactive Production Rock Sites	2
Table 3.1	2005 Summary Statistics for Quarry Sites.....	9

FIGURES

(See Appendix 1 for figures)

Figure 2.1	Site Location Map
Figure 2.2	Site E Sampling Site Locations
Figure 2.3	2005 Inactive Production Rock Site Acid Base Accounting Data
Figure 2.4	2005 Inactive Production Rock Site Rinse pH Data
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 2.10	Inactive Production Rock Site Magnesium Data

Figure 2.11	Inactive Production Rock Site Hardness Data
Figure 2.12	Inactive Production Rock Site Zinc Data
Figure 2.13	Inactive Production Rock Site Copper Data
Figure 2.14	Inactive Production Rock Site Lead Data
Figure 2.15	Inactive Production Rock Site Cadmium Data
Figure 2.16	Inactive Production Rock Site Nickel Data
Figure 2.17	Inactive Production Rock Site Arsenic Data
Figure 2.18	Inactive Production Rock Site Iron Data
Figure 2.19	Inactive Production Rock Site Manganese Data
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
Figure 2.26	Inactive Production Rock Site E Hardness Data
Figure 2.27	Inactive Production Rock Site E Zinc Data
Figure 2.28	Inactive Production Rock Site E Copper Data
Figure 2.29	Inactive Production Rock Site E Lead Data
Figure 2.30	Inactive Production Rock Site E Cadmium Data
Figure 2.31	Inactive Production Rock Site E Nickel Data
Figure 2.32	Inactive Production Rock Site E Arsenic Data
Figure 2.33	Inactive Production Rock Site E Iron Data
Figure 2.34	Inactive Production Rock Site E Manganese Data
Figure 3.1	Quarry Site Flow Data
Figure 3.2	Quarry Site pH Data
Figure 3.3	Quarry Site Alkalinity Data
Figure 3.4	Quarry Site Conductivity Data
Figure 3.5	Quarry Site Sulfate Data
Figure 3.6	Quarry Site Magnesium Data
Figure 3.7	Quarry Site Hardness Data
Figure 3.8	Quarry Site Zinc Data
Figure 3.9	Quarry Site Copper Data
Figure 3.10	Quarry Site Lead Data

- Figure 3.11 Quarry Site Cadmium Data
- Figure 3.12 Quarry Site Nickel Data
- Figure 3.13 Quarry Site Arsenic Data
- Figure 3.14 Quarry Site Iron Data
- Figure 3.15 Quarry Site Manganese Data
- Figure 3.16 ABA Data for Pit 7

1.0 Executive Summary

This annual report has been prepared by Kennecott Greens Creek Mining Company (KGCMC) in accordance with the mine's General Plan of Operations Appendix 11, Attachment C. 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 is currently the only quarry where active rock excavation still occurs.

The 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. Figures summarizing iron and manganese water quality data have been added to this year's report for the inactive and quarry sites. 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.

Acid base accounting results from grid samples collected at inactive production rock sites in 2004 and 2005 support previous investigations. The sites contain a mixture of acid generating and acid neutralizing rock and except for specific Mill backslope and Site 1350 samples, the bulk of the material has near-neutral pH. All inactive sites have drainage dominated by near-neutral waters having sulfate and metals concentrations consistent with exposed production rock. Base flows at inactive site sample locations are low (generally less than 10 gpm), and no significant influence on sensitive receiving areas has been identified.

The exposures in the rock quarries generally contain far less pyrite and carbonate than is contained in production rock. Two of the five quarries (Pit 405 and Pit 174) have zones of potentially acid generating rock that are of significance; however, the volume of runoff from these zones is small. Lower sulfide contents and smaller surface areas yield a lower flux of oxidation products from quarries compared to production rock sites. Water monitoring indicates that metal loading from pit walls is also lower than loading from production rock sites. Metal loading identified in the drainage from Pit 5 does not appear to be solely associated with the pit walls and may reflect influences from the water treatment plant and the tailings facility.

2.0 Inactive Production Rock Sites

2.1 Introduction

Kennecott Greens Creek Mining Company (KGCMC) has prepared this section of the Annual Report in accordance with the mine's General Plan of Operations (Appendix 11, Attachment C). A summary of all operational and monitoring activities performed at inactive production rock sites in 2005 is provided. Site locations are shown on Figure 2.1. Refer to GPO Appendix 11 for a detailed description of the facilities and associated monitoring requirements. Aspects of the inactive Site D are covered in the Tailings and Production Rock Site 2005 Annual Report (KGCMC, 2006), which also covers the adjacent active production rock Site 23, and the tailings facility.

Surface sampling entails collecting material from a grid that randomly produces the specified number of samples. Small sites are sampled by taking material from roughly equidistant locations along a transect across the site. The sampling technique is intended to minimize bias toward any one material type.

Summary statistics for KGCMC's inactive production rock sites are presented in Table 2.1. Acid Base Accounting (ABA) data are summarized in Figures 2.3 and 2.4. 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 in Figures 2.20 to 2.32. A general summary of trends is discussed in this section, followed by individual site discussions in the subsequent sections. Refer to Figure 2.1 for general site locations, and Figure 2.2 for Site E sampling locations.

The results of grid sampling and water monitoring in 2005 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 maintains a pH greater than 6.0 and that sensitive receiving areas continue to be adequately protected. This annual 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.

Table 2.1 2005 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
Total Volume (yds)	40,000	5,000	ND	50,000	365,000
Prod Rock Vol (yds)	40,000	5,000	ND	ND	ND
Reclamation Material (yds)	0	0	0	0	10,000
Average NP (tCaCO ₃ /kt)	ND	Site Removed in 2005	134	ND	ND
Average AP (tCaCO ₃ /kt)	ND		224	ND	ND
Average NNP (tCaCO ₃ /kt)	ND		-90	ND	ND
Average Rinse pH	ND		4.80	ND	ND

Figure 2.3 compares Acid Potential (AP) with Neutralization Potential (NP) from 2005 surface grid samples. Surface grid samples were taken from the Mill backslope in 2005, during and after material removal activities. The inactive sites were constructed prior to development of the classification protocol that KGCMC currently uses. At the time the inactive piles were constructed KGCMC did not classify or segregate its 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. Six of the ten samples would be classified as Class 2 under the current classification procedure. Regardless of pyrite content, almost all production rock at Greens Creek contains substantial carbonate (5 to 40%). This carbonate content indicates that there is a relatively long lag time to potential acid generation for the majority of the samples.

A long lag time to potential acid generation explains why only a few samples show signs of acidification and indicates sufficient time remains available to reclaim the sites, pending availability of backfill space underground, development of suitable disposal space at the tailings facility and development of cover material borrow areas. Figure 2.4 shows the relationship between surface rock grid sample rinse pH and net neutralization potential (NNP) for Mill backslope samples taken in the area where removal activities occurred in 2005. NNP is the balance between NP and AP. A negative NNP typically indicates the sample is potentially acid generating. Rinse pH is a measure of the pH of a one-to-one mixture of “as-received” fines and water. Rinse pH is different than paste pH, which is the pH of the sample after it has been pulverized and moistened. Rinse pH is often lower than paste pH because pulverizing the sample exposes fresh, sometimes alkaline, mineral surfaces. The rinse pH method also uses more water, which can dissolve surface oxidation products, lowering the pH of the solution. The previous years’ rinse pH data for the inactive production sites demonstrate that the majority of the samples retain enough buffering capacity to maintain pHs above 6.0 (KGCMC, 2004; KGCMC, 2005). The data shown in Figure 2.4 show the majority of rinse pHs to be less than 6.0 in 2005; however, these samples were taken to help identify material to be removed and are atypical for inactive production rock sites.

Flow data presented in Figures 2.5 and 2.20 demonstrate that flows at most of the sample locations are generally low (less than 10 gpm). Some of the flow data were collected as part of the NPDES stormwater monitoring program. Collected during or following storm events, flow data from these locations (e.g. Site E 356, 960 347) 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 inactive site sampling locations. 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. The sample from the Mill backslope in 1995 was runoff collected from a bench containing zones of heavily pyritized rock. For a brief period in 1998 and 1999, acidic conditions began developing at Site 960 347. KGCMC applied lime and removed 1000 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 material in 2003, 2004 and 2005 is discussed below in Section 2.3. The material removal activities may also be responsible for the pH of 8.0 measured at the 960 site in 2005. This is the highest recorded for this site. The reason for the elevated pH is likely due to the removal of pyritic rock that had consumed much of its readily available buffering capacity. Fresh carbonate mineral surfaces exposed during the excavation and the placement of the toe buttress may have contributed to the higher pH values observed. One of the four Mill backslope

site samples in 2004 and in 2005, both in September, had a pH less than 6.0. Alkalinity data presented in Figures 2.7 and 2.22 are consistent with the pH results in Figures 2.4, 2.6, and 2.21. Except for the current Mill backslope site all sample locations maintain measurable alkalinity provided by dissolution of carbonate minerals.

Conductivity data are shown in Figures 2.8 and 2.23. Conductivity indicates the amount of dissolved constituents in the water. KGCMC samples having higher conductivity values usually have higher 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. Site E 356 and Site 960 347 show an overall decreasing trend in conductivity, and Site 1350 remains unchanged. Historical conductivity data (1995-1996) from the Mill backslope Site 333-3 was slightly lower than conductivity data from 2005; however, the samples in 2005 were taken during removal activities and may reflect this disturbance. The combined drainage from the Mill backslope area (Site 341) showed a lower average dissolved load in 2005 than the past two years. Site C had a slightly lower average annual conductivity in 2005 than 2004 (1065 $\mu\text{mhos/cm}$ in 2005 versus 1107 $\mu\text{mhos/cm}$ in 2004). The 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 limit value. While this allows the results to be plotted on a logarithmic scale, 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. Manganese concentrations are elevated at most of the inactive sites, indicating the generation of secondary products from localized oxidation-buffering reactions. 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 some 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. Data in 2005 for 960 showed a decrease in most metal concentrations, with close to an order of magnitude decrease in cadmium, nickel, manganese and zinc.

2.2 1350 Site

The 1350 Site is located at 1350 feet above mean sea level (AMSL), up-slope from the main portal and concentrator facility (Figure 2.1). The site contains approximately 40,000 – 60,000 cubic yards of material derived from advancement of the 1350 portal, which began in 1978 and continued intermittently through 1985. Waters collected near the adit opening are redirected back into the mine water collection system. Flow from the site is low and the drainage remains near-neutral. Other characteristics of the drainage (Figures 2.9 to 2.19) include a sulfate load, generally low metal concentrations, and localized iron staining. The results of grid sampling in 2003 (KGCMC, 2004) demonstrate that although some of the rock is potentially acid generating,

the majority of the material remains near-neutral. Small areas containing rock with the greatest pyrite content have produced acidic oxidation products, but they are limited in extent and do not have a significant effect on the pile drainage. Monitoring in Greens Creek, below the confluence with the 1350 drainage, indicates some influence of zinc from this site.

Steep slopes preclude constructing an oxygen-limiting soil cover on the site in its current configuration. Consequently, hauling the rock back into the mine via the 920 portal is the planned reclamation strategy for this site. KGCMC will continue to monitor the site and will select an appropriate removal alternative that best suits the site's weathering performance and underground accessibility.

Approximately 7000 tons of material was removed from the 1350 in August and September 2005. A portion of this material was returned to the underground as backfill while the remainder was placed into Site 23. The material placed in Site 23 was weakly oxidized and had low-pyrite and abundant carbonate. Future removal activity prior to closure will be based on availability of backfill space underground for disposal, site accessibility, and contractor/equipment availability.

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. Approximately 1000 cubic yards of rock were removed from the site and placed at Site 23 or underground as backfill in 2000. Additional material removed in 2003, 2004 and 2005 is discussed below.

Grid sampling and water monitoring data are consistent with those of earlier reports (KGCMC, 1994 and Shepherd Miller, 2000) indicating that some of the rock is potentially acid generating. Intermittent periods of acidification have occurred, although the drainage from the site is currently near-neutral. KGCMC applied lime to the site while material was being removed in 2000. Higher metal concentrations (e.g. zinc, Figure 2.12) are attributed to influences from localized accumulations of acidic oxidation products. The 960 Site is relatively small in extent (1 acre) and drainage flows are low (typically well below 5 gpm). Monitoring in Greens Creek below the 960 Site shows some detectable signs of effects from this site or other upgradient sites.

KGCMC removed approximately 10,000 cy of material from the 960 Site and placed it in underground workings in 2003. An additional 5,000 cy of oxidized material and associated underlying soil were removed in 2004. In May and June of 2005, additional removal of road sub-base production rock material was found and removed. Butressing material was brought in as fill to ensure road stability. The site was then recontoured and allowed to regrow native species. The 960 Site will continue to be monitored for water quality changes. This work was included as an objective and target project under KGCMC's Environmental Management System (EMS).

Site 960 showed some elevated copper, zinc and cadmium concentrations in 2004. This was likely due to the removal of production rock from the area, which exposed some additional production rock materials in the base of the road. Water quality data in 2005 for the 960 showed a decrease in most metal concentrations, with close to an order of magnitude decrease in cadmium, nickel, manganese and zinc. This decrease is attributed to removal of the pyritic rock and to a lesser extent, dilution from surface drainage that now flows into the depression left by the excavation. This latter effect somewhat confounds comparative analysis with pre-removal data;

however, late in 2005 much of the surface water was re-routed back into its natural drainage to the southwest.

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. Following excavation of the site and 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.

Grid sampling of the Mill backslope rock cover and access road (Figures 2.3 and 2.4) indicates that this rock is acid generating. The average NNP for the backslope samples (-90 tCaCO₃/kt) reflects a high sulfide content and low carbonate content in the rock. The low carbonate content is likely a combination of deficient initial composition and depletion of carbonate from the fines fraction through weathering.

Historical sampling of drainage from the Mill backslope reflected two source waters. Water from the dewatering drains had low conductivity and low metal concentrations. Precipitation that infiltrates through the pyritic production rock buttress had a higher dissolved load, dominated by sulfate, calcium, magnesium, iron, zinc and other trace metals. Some samples indicated a mixture of these two sources. Drainage from one of the dewatering manifolds (MBS 338 9) had moderate levels of iron, yet appeared to have a minimal production rock component (low sulfate). This illustrates the process of iron mobility in reduced groundwater that is not related to production rock oxidation. When the reduced groundwater reaches the surface it reacts with atmospheric oxygen and produces iron oxyhydroxide (red staining). Average flows from combined Mill backslope sources are low (less than 10 gpm) and drainage is routed to water treatment facilities via a network of drains and lined ditches.

MBS 341 is a sample site created in 2003. It is located where the drainage from the 920 Mill backslope enters the lined 920 stormwater ditch which reports to A Pond. The samples taken from this site provide a good current representation of a combination of the historical Mill backslope sample sites (MBS 333, 336, 337, 338 and 339).

In 2002 KGCMC applied lime to localized areas of the Mill backslope, and has utilized in-situ treatments of lime and polyacrylamide in the past. The treatments had positive short term effects on water compositions. In-situ treatment and 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.

Removal of the oxidized material on the Mill backslope upper road occurred in 2005. Approximately 1500 cubic yards were removed and disposed of underground. The upslope run-on diversion ditch was rebuilt using clean native fill (sourced from the backslope of Site 23) and lined with HDPE. A french drain was installed in the bottom of the ditch prior to installing the liner. This work was part of an objective and target under KGCMC's EMS.

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. The 860 safety building and assay lab have been constructed on this site.

Results of ABA analyses in 2004 showed that four of the five samples were potentially acid generating (KGCMC, 2005). However the pH of the site's drainage remained near-neutral. 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 production rock. Flow from the production rock is low (generally less than 1 gpm), remains near-neutral, has elevated manganese concentrations, and has moderate sulfate, zinc, cadmium and iron concentrations,

Sporadic fluctuations in lead concentrations in Greens Creek below Site C may be related to sediments contributed from the storm water ditch that sheds water from the B Road between the 920 area and Site C. An EMS objective and target project was developed in 2004 for Site C to improve containment of sediments and decrease the potential for metal loading to the environment. Work items accomplished in 2004 included diversion of upper Pond C flow to lower Pond C, removal of road ditch sediments with enhanced sediment controls installed in this area, and construction of a swale at the 920. In 2005, oxidizing materials were removed from the Mill backslope upper road (see Section 2.4 above). Additionally, a pump-back system similar to that at Pond D will be designed and installed for the Pond C waters in 2006.

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 365,000 cubic yards of glacial till and 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. There were no grid samples taken at Site E in 2004 or 2005. However, results from water sampling in 2004 at the toe of the site demonstrate that the production rock continues to buffer the pH of the drainage near neutral. Sulfate and metal loading in these samples is relatively high (but consistent with exposed carbonate buffered pyritic production rock). 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).

In late 2002 and in 2003, three new monitoring wells were installed and 13 new surface water sampling sites were established at Site E to better understand the potential pile influence on the area. Figure 2.2 shows the locations of these sites. Water quality data for the wells and seven of the 13 surface water sites are shown on Figures 2.21 to 2.34. One of the wells (MW-E-02-03) is completed in till to a depth of approximately 99 feet, and the two other wells are completed in gravels at 76 and 86 feet (MW-E-02-09 and MW-E-02-12). The seven new surface water sites depicted in the figures represent water quality at the toe of the pile (708, 709, and 710, along with the old sites 356, South Toe and North Toe), two downgradient drainages (703 and 704) that report to Greens Creek, and two sites in Greens Creek, one upgradient of Site E (711) and one downgradient (712). Although there are a limited number of data points thus far for these new locations, in general sulfate and metal concentrations decrease as the distance from Site E increases. However, the downgradient site in Greens Creek (712) showed slightly elevated sulfate and zinc concentrations when compared to the upgradient site (711). Samples from Sites 711 and

712, along with the samples from the three wells, all met water quality standards for sulfate, cadmium and zinc in 2003 and 2004. The data for the drainage from the toe of the pile are consistent with the results of a multi-agency review of the site in 1999 (Shepherd Miller, 2000). The oxidation and neutralization processes occurring in the pile appear to have reached a steady state. Depletion of buffering capacity is evident in two small areas on the southeast and northeast surfaces of the pile. However, observations from toe seeps and test pits dug in 2005 indicate that the bulk of the material is relatively un-oxidized and contains substantial buffering capacity. These observations indicate that depletion of the neutralization capacity of the pile is not imminent. This area will continue to be closely monitored in the future.

KGCMC 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 is the most economical and environmentally protective solution. The geotechnical feasibility of blending production rock with tailings was studied in 2005 (Klohn Crippen, 2005). Laboratory tests conducted in a large scale permeameter cell measured the hydraulic and strength properties of tailings only, production rock only, and various blends of production rock and tailings. Based on the results, the following main conclusions were drawn:

- The difference in permeability between compacted production rock and compacted saturated tailings is at least 33 times. Blend ratios of 2:3 (production rock to tailings by volume) and 3:2 resulted in lower values of permeability as compared to the tailings only sample. The 2:3 blend exhibited the lowest value of permeability. This behavior is mainly attributed to the elongated length of the seepage path (and reduced seepage flow area) through the tailings dominated soil matrix and around the larger rock fragments.
- Friction angle of the 2:3 blend was similar to that of the tailings only sample showing that the tailings were dominant in the blend. As expected, the friction angle improved with the addition of more production rock in the 3:2 blend. Addition of production rock generally increased the overall strength of the compacted tailings.
- Relatively uniform mixing of the tailings and production rock was very easily obtained in the laboratory in all cases.

A production rock to tailings ratio of 3:2 (60% production rock by volume) with a permeability of 5×10^{-6} cm/s and a friction angle of 43° is recommended by Klohn Crippen as the limiting blend for blended codisposal of production rock and filter pressed tailings at Greens Creek.

These conclusions are based on geotechnical observations. The long term performance of the production rock and tailings blend will also depend on the geochemical performance of the blend. Therefore, geochemical studies in 2006 will test the recommended blend ratios for chemical stability, metal leaching, and acid generation potential.

KGCMC plans to relocate the Site E production rock material to the surface tailings facility over a two-year span from 2007 through 2008 using dedicated personnel and trucks. KGCMC anticipates recovery of the dewatered till material originally placed at this site from the Mill backslope excavation. This till material will serve to enhance the barrier layer performance of future reclamation capping efforts. Once the rock materials are removed, and the till material is assessed and consolidated as needed, KGCMC expects to utilize the remaining Site E area for the storage of additional reclamation material, minimizing the need for future disturbances in other areas.

3.0 Quarries

3.1 Introduction

This section of the Annual Report is in accordance with the mine’s General Plan of Operations (Appendix 11, Attachment C). 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 but one (Pit 5) 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 2005 is provided. Refer to GPO Appendix 11 for a detailed description of the sites and associated monitoring requirements.

The quarries were sampled in 2005 for drainage water quality data. See the Inactive Production Rock Sites and Quarries Annual Report for 2002 (KGCMC, 2003) for a detailed discussion of ABA characteristics for the quarries. Summary statistics for KGCMC’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
Acreeage	3	3	2	5	4
Total Volume (yds)	17,000	8,500	10,000	18,000	15,000
Prod Rock/other Vol (yds)	13,000	0	0	16,600	0
Reclamation Material (yds)	4,000	8,500	10,000	1400	15,000

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. Flow estimates vary from just over 100 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 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. Of 113 samples taken since 1995, 112 have pH values between 6.0 and 8.0. A pH of 5.8 was recorded from Pit 174 in 1995, but more recent samples average approximately 6.5. 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. Pit 5 has the highest carbonate content of the quarries and also may show influences from the water treatment plant located at that site and the continued quarrying activity.

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. With the exception of one well in Pit 5 (MW-T-01-07), all conductivity data are consistent with waters derived from relatively freshly exposed low to moderately mineralized quarry rock. MW-T-01-07 has considerably higher conductivity and sulfate concentrations, which may reflect an influence from the Pit 5 water treatment plant. Past treatment plant upsets have contributed water to the area around the plant. However, between 2001 and 2005, conductivity and sulfate concentrations in this well have steadily decreased. The increase in sulfate concentrations in MW-T-01-09 may indicate the movement of the sulfate-rich water from the MW-T-01-07 area to the east. These wells and their relationship to the treatment plant and the tailings facility are discussed in more detail in KGCMC, 2003. The April 2004 sample for Pit 174 showed an anomalous elevated conductivity value of 2,860 $\mu\text{mhos/cm}$; however, the lab conductivity for the same sample was 302 $\mu\text{mhos/cm}$ and the remaining samples for 2004 were within historical limits (400 – 600 $\mu\text{mhos/cm}$) for the site. 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 limit value. While this allows the results to be plotted on a logarithmic scale, 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. Metal loads from quarry sites have been consistently relatively low and either remained fairly constant or decreased with time. The decrease in metal loading is attributed to a reduction of reactive surface as reactants are consumed and coatings form on mineral surfaces.

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 16 years continue to form. As the coatings form and the amount of available pyrite decreases, so too will the already minimal dissolved load.

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 12,000 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. KGCMC 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. A standpipe was installed to a depth of 37.5 feet below the drill pad surface, but difficulties encountered during installation may have affected its completion. Development and evaluation of the standpipe will be performed in 2006 to determine if it is suitable for use as a monitoring well.

Acid base accounting data for this site can be found in the 2002 annual report (KGCMC, 2003). Monitoring of drainage downgradient of the quarry (Figures 3.1 to 3.15) demonstrates that influences from the site are negligible. Barring a significant change in downstream water quality, 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 would increase exposure of the 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 (approximately 10,000 cubic yards) were hauled to the site from the Site 23 and the 920 facility. ABA analyses in 2002 indicated that the majority of the rock exposed in the pit does not have the potential to generate acid (KGCMC, 2003). 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.

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. ABA data taken in 2002 from pit walls indicated that some zones in the rock are potentially acid generating. However, pyritic zones account for only a small fraction of the pit wall exposure. Drainage from the site has an average pH of 6.64 (Figure 3.2). 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 is located just north of the tailings facility at 0.8 mile on the B Road. Pit 5 currently houses the water treatment plant. Rock from the pit was used for construction of roads and other surface facilities infrastructure. Approximately 13,500 bank yards of rock were quarried from Pit 5 in 2002. Approximately 8,900 yards of the rock were used to construct access roads on the tailings pile in 2003, and the balance stockpiled in the pit. Approximately 30 percent of the stockpile was used in 2004 for construction activities in expansion of the tailings placement area and the remainder was used in 2005. Peat and sand from excavation of the West Buttress in 1997 was moved to the east rim of Pit 5 in 2004 and 2005 for temporary storage prior to disposal in the tailings area.

ABA analyses in 2002 from pit walls indicated that the rock does not have the potential to generate acid, although it does contain small diffuse amounts of pyrite, often occurring as isolated euhedral cubes. Drainage from the site monitored at a surface stormwater site is dominated by sulfate, calcium and magnesium and has moderate to high concentrations of several trace metals (Figures 3.8 to 3.15). The December sample in 2004 showed an increase in lead and zinc concentrations, potentially due to the increased activity in the area at the time. This drainage water is routed to the water treatment facilities via the North Retention pond located near the B Road. The ditch receives surface flow from the pit and may also be influenced by near-surface

flow from the tailings pile. Final reclamation of the Pit 5 area is contingent upon the ultimate design and construction of the tailings pile.

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 partially backfilled with tree stumps and reclamation materials derived during expansion of the tailings pile and development of the sand pit at 1.4 mile on the A Road. During the placement of these materials, the drainage at the site was rerouted, mainly to Site 571, and Site 521 was decommissioned. Despite iron staining on the south pit wall, iron staining observed in the drainage from the pit is mostly due to dissolution of iron-rich oxide horizons in the peat and gravel fill rather than from the pit walls themselves. Temporary hydroseeding of the peat has resulted in a productive grass cover of these materials. ABA analyses (Figure 3.16) from the samples of the pit walls indicate the potential for acid generation; however, the sulfur content of the samples is relatively low (<0.5%). Monitoring results of drainage from the pit is shown in Figures 3.2 to 3.15. Relatively low sulfate concentrations (approximately 200 mg/l) and low metal values support the conclusion that sulfide oxidation is not significant at Pit 7. Dissolution of iron and manganese oxides in the fill stored in the pit has produced elevated concentrations of these metals in the drainage. Oxidation of the drainage and re-precipitation of the metals is expected in the constructed wetlands at the entrance to the pit.

Following removal of stockpiled capping materials for reclamation of other sites, the Pit 7 site will be contoured and hydroseeded. The potential exists in the Pit 7 area to create more wetlands similar to those previously constructed near the entrance to the pit.

4.0 References

Kennecott Greens Creek Mining Company (KGCMC), General Plan of Operations, Appendix 11, Production Rock Piles, August 2000.

Kennecott Greens Creek Mining Company (KGCMC), Inactive Production Rock and Quarries 2002 Annual Report, August 2003.

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

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

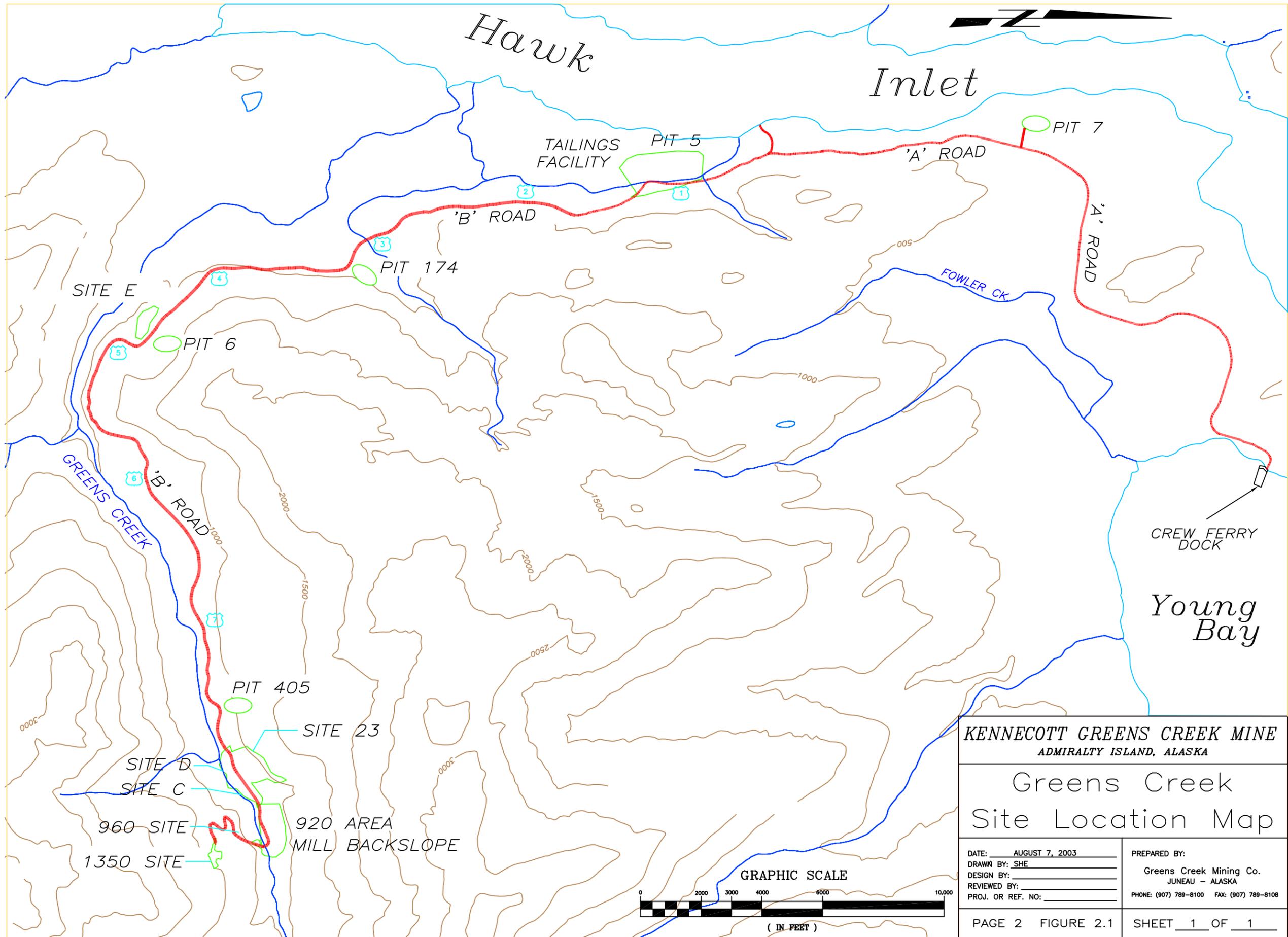
Kennecott Greens Creek Mining Company (KGCMC), Tailings and Production Rock Site 2003 Annual Report, December 2004.

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

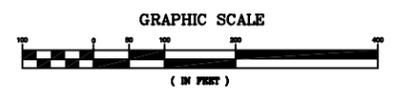
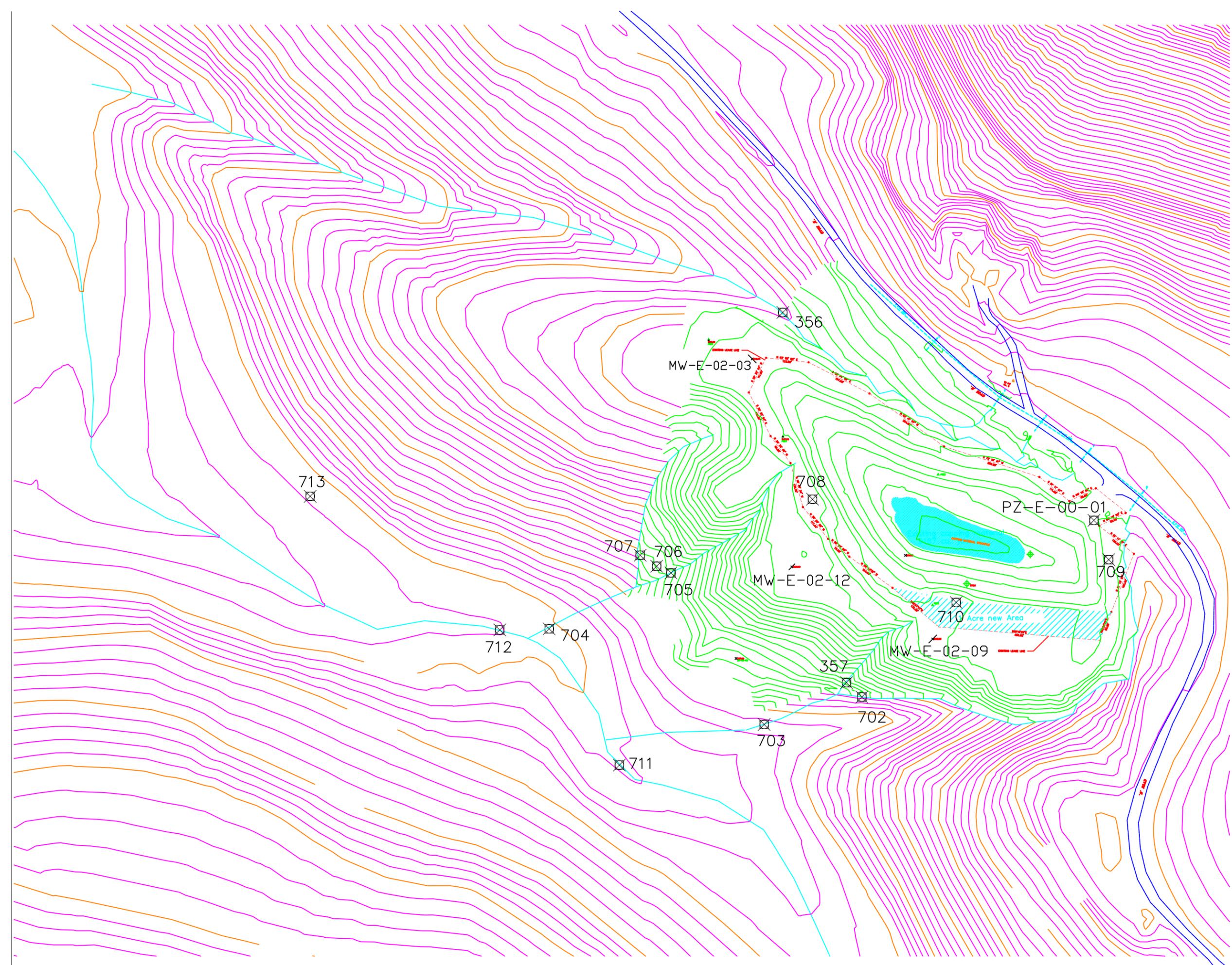
Klohn Crippen, Evaluation of Co-Disposal of Production Rock and Filter Pressed Tailings, May 2005.

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

APPENDIX 1



KENNECOTT GREENS CREEK MINE ADMIRALTY ISLAND, ALASKA	
Greens Creek Site Location Map	
DATE: AUGUST 7, 2003 DRAWN BY: SHE DESIGN BY: REVIEWED BY: PROJ. OR REF. NO:	PREPARED BY: Greens Creek Mining Co. JUNEAU - ALASKA PHONE: (907) 789-8100 FAX: (907) 789-8108
PAGE 2 FIGURE 2.1	SHEET 1 OF 1



KENNECOTT GREENS CREEK MINE
ADMIRALTY ISLAND, ALASKA

FIGURE 2-2
WASTE SITE E ASBUILT

DATE: 1-16-03	PREPARED BY: GREENS CREEK MINING CO.
DRAWING BY: Shelby Edwards	JANEAU, ALASKA
DESIGN BY: _____	PHONE: (907)790-8441 FAX: (907)790-8448
REVIEWED BY: _____	GC/MC DWG # _____
PROJ OR REF: _____	SCALE: _____
	SHEET: 1 OF 1

Figure 2.3 2005 Inactive Production Rock Site Acid-Base Accounting Analyses

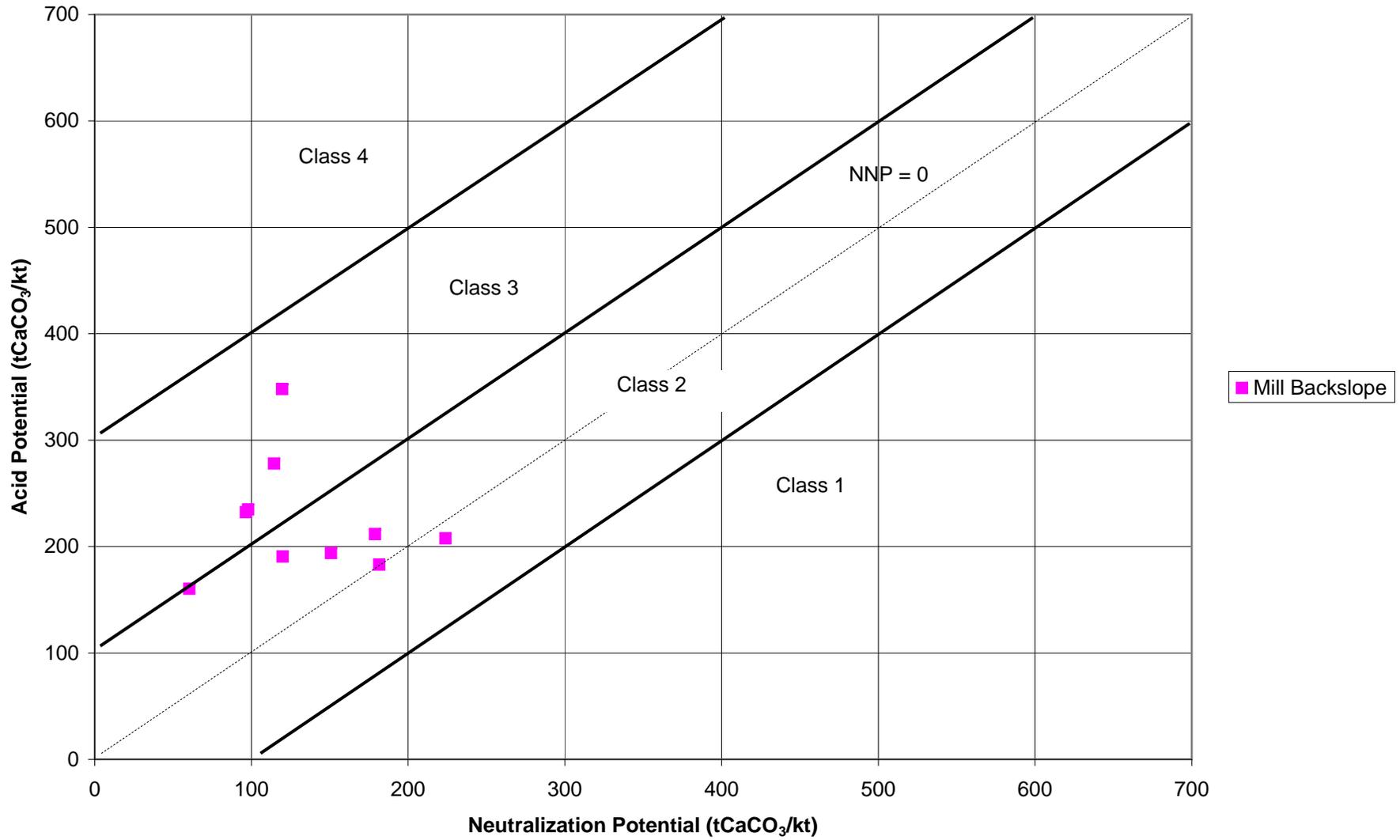


Figure 2.4 2005 Inactive Production Rock Site Rinse pH versus NNP

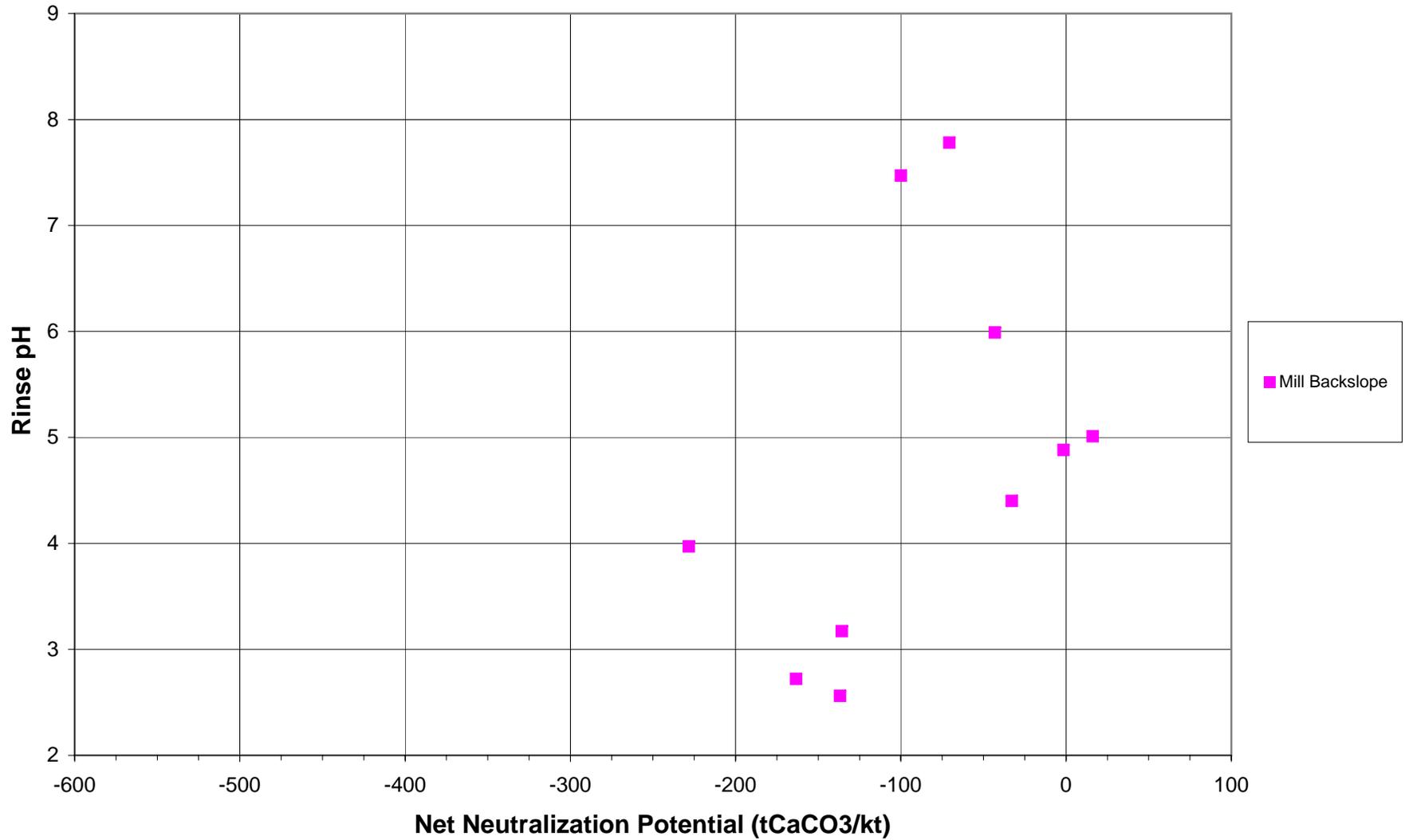


Figure 2.6 Inactive Production Rock Site pH Data

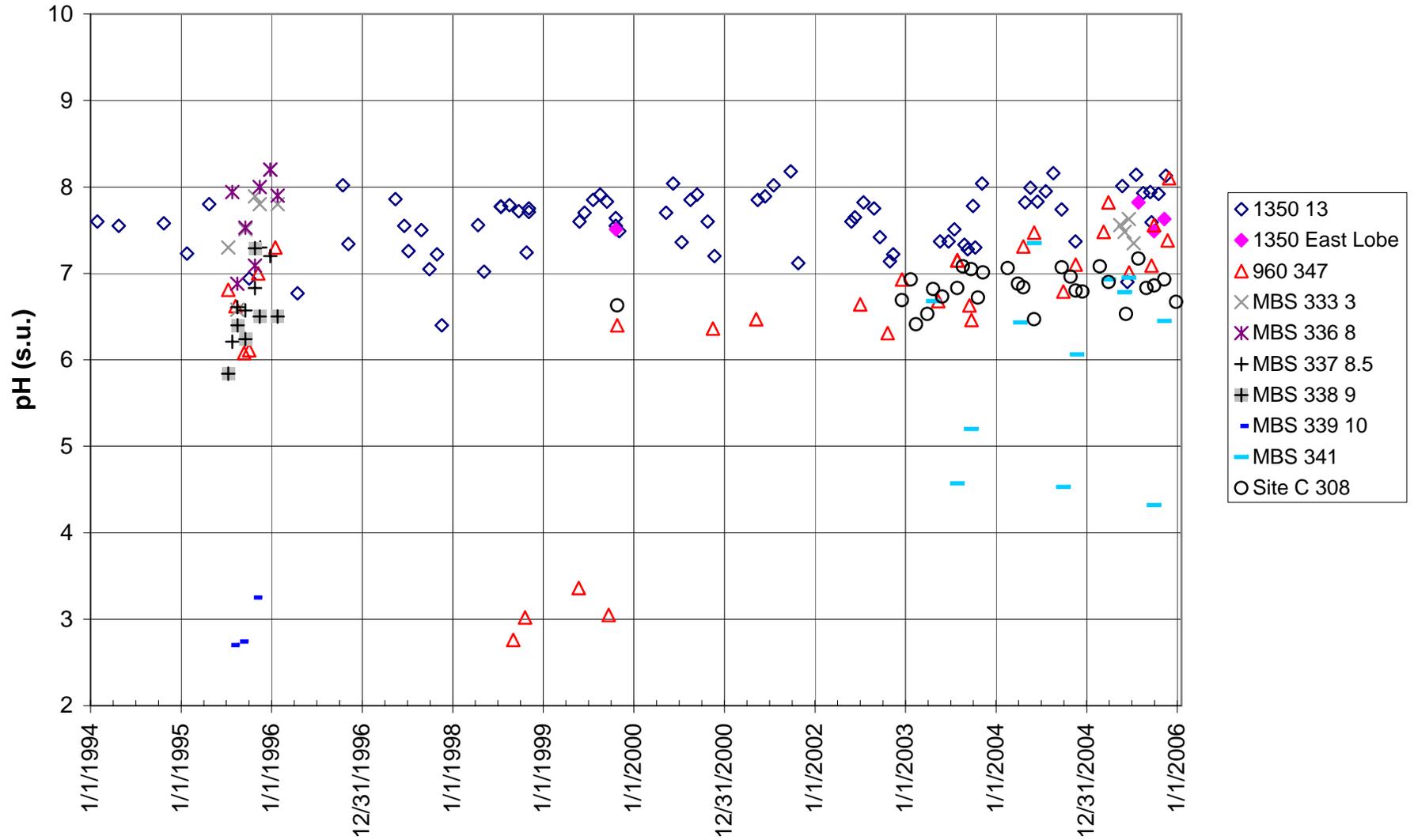


Figure 2.8 Inactive Production Rock Site Conductivity Data

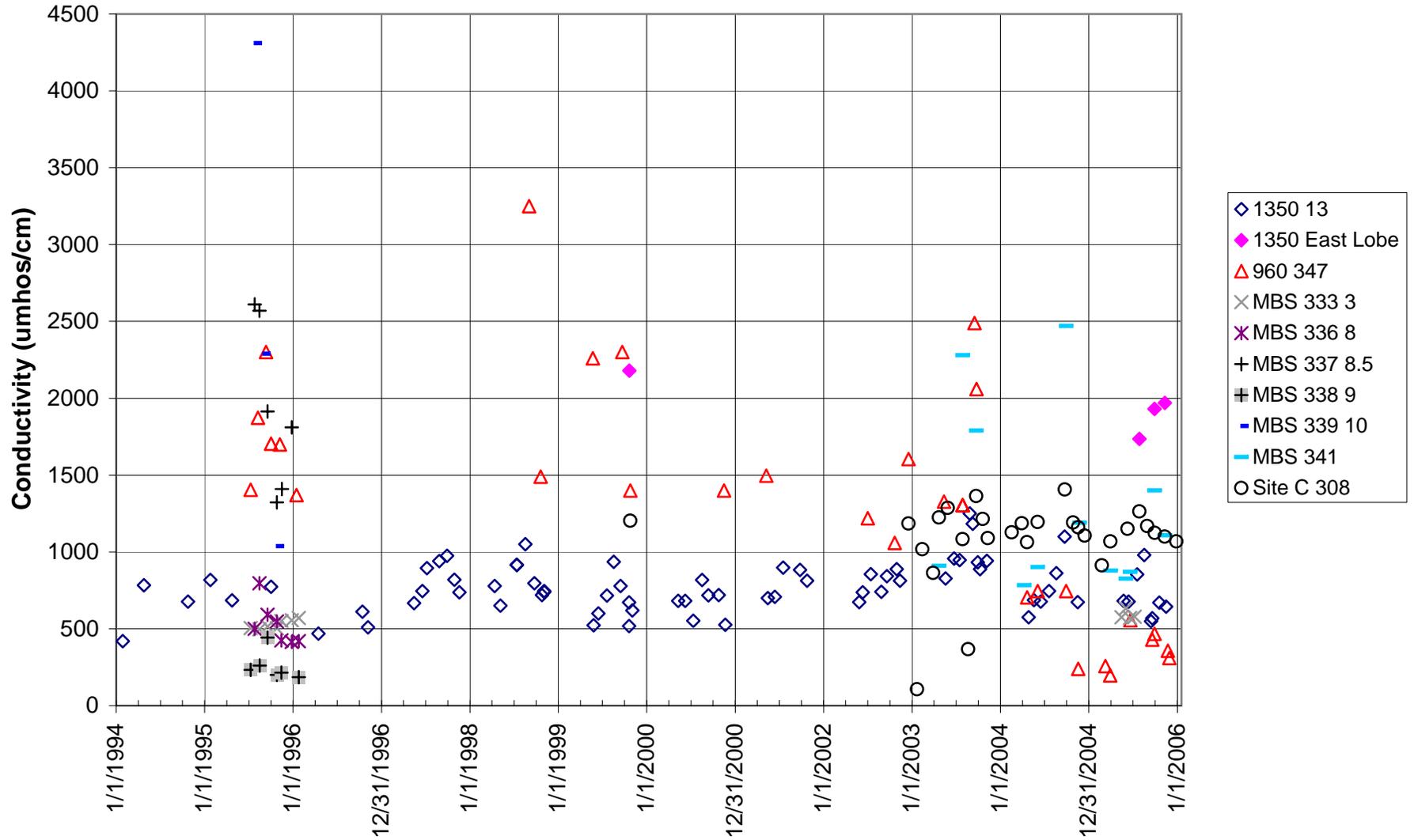


Figure 2.10 Inactive Production Rock Site Magnesium Data

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

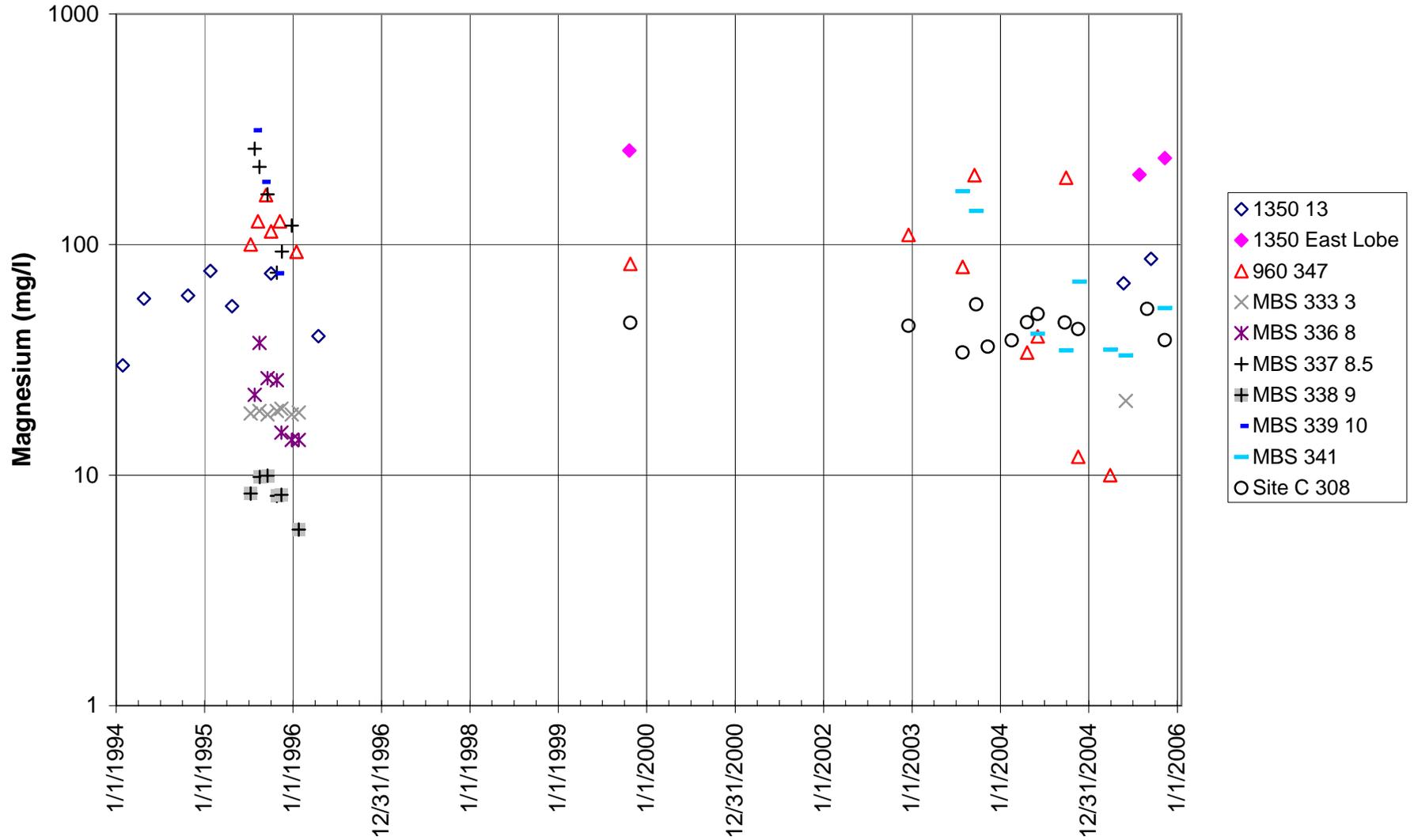


Figure 2.11 Inactive Production Rock Site Hardness Data

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

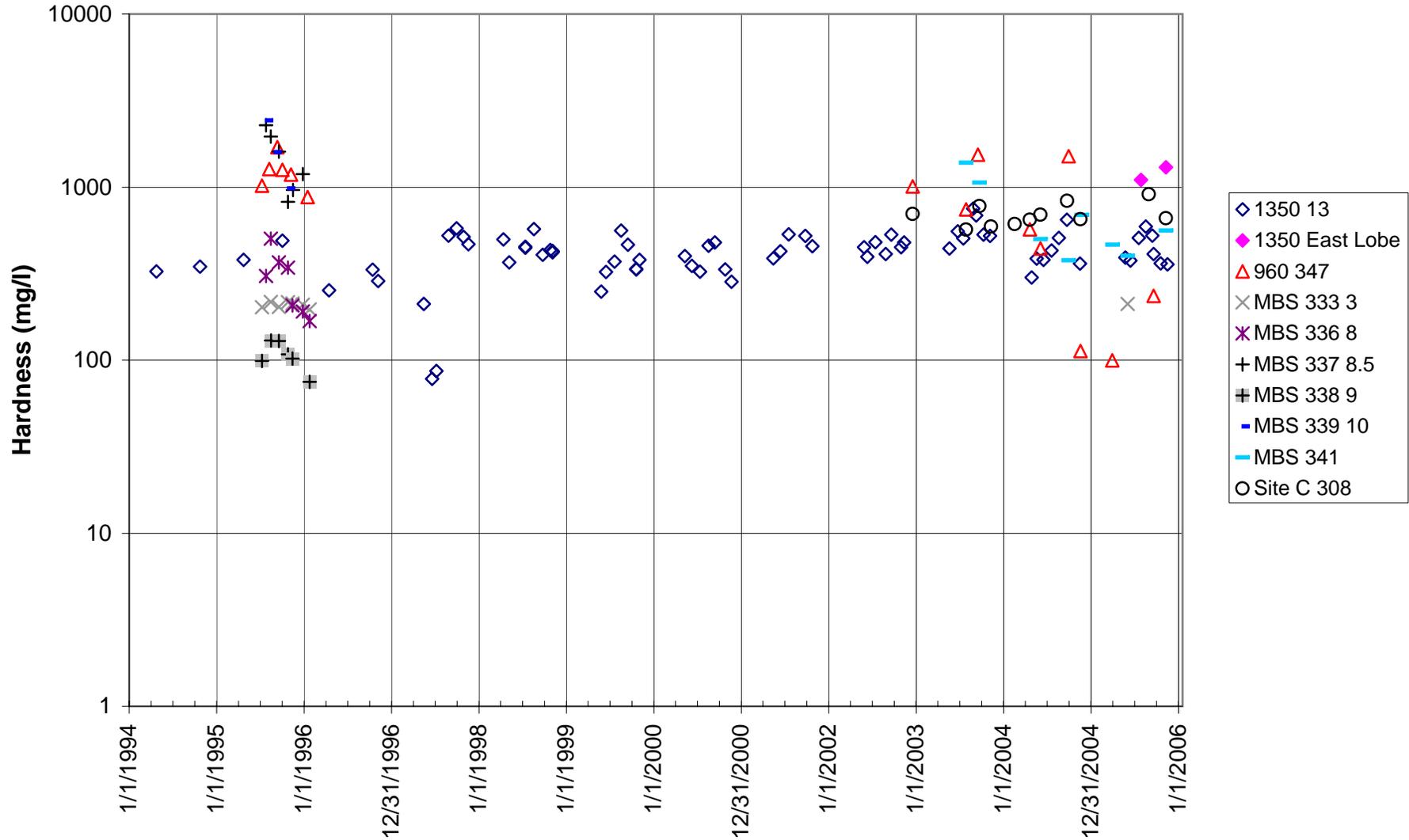


Figure 2.12 Inactive Production Rock Site Zinc Data

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

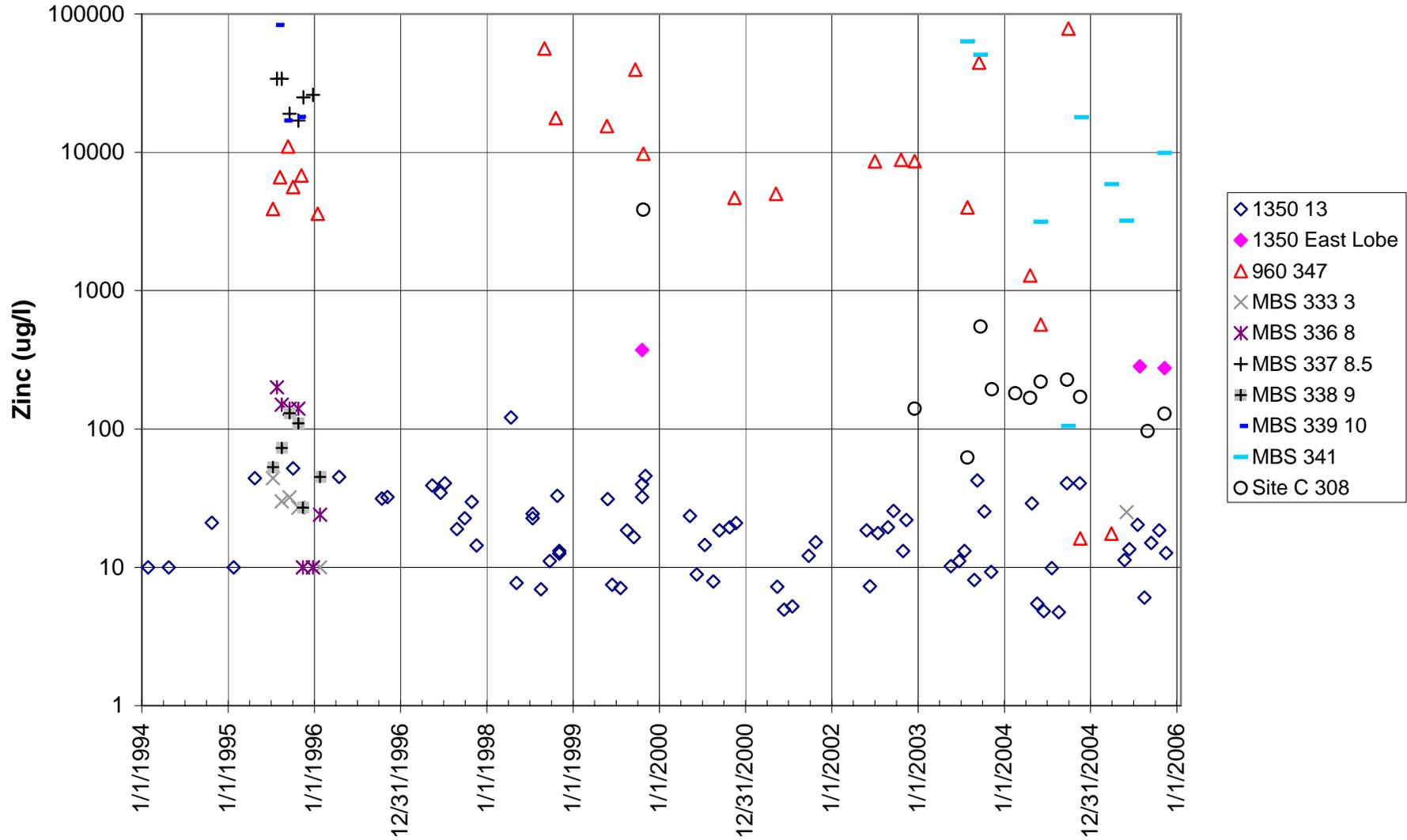


Figure 2.13 Inactive Production Rock Site Copper Data

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

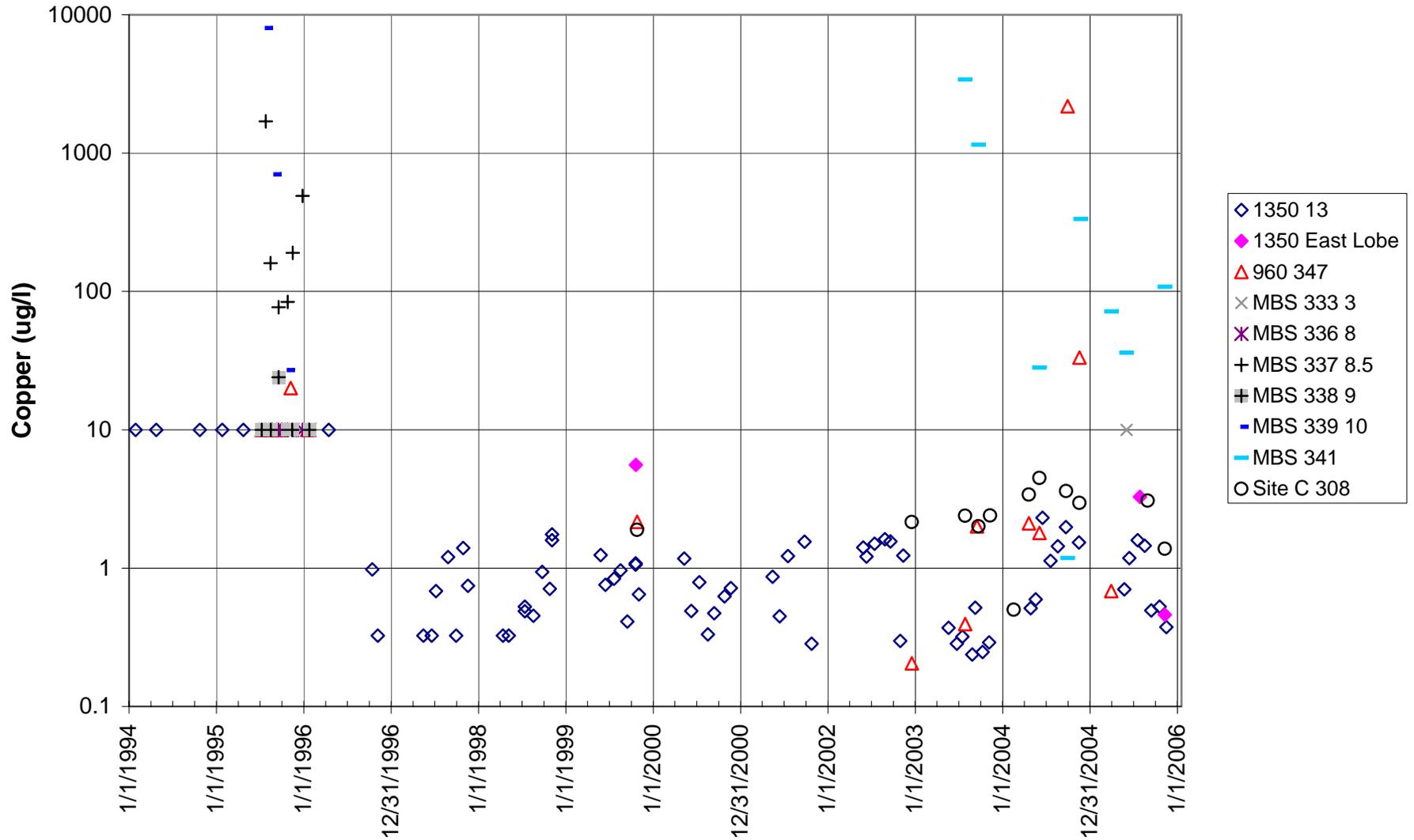


Figure 2.14 Inactive Production Rock Site Lead Data

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

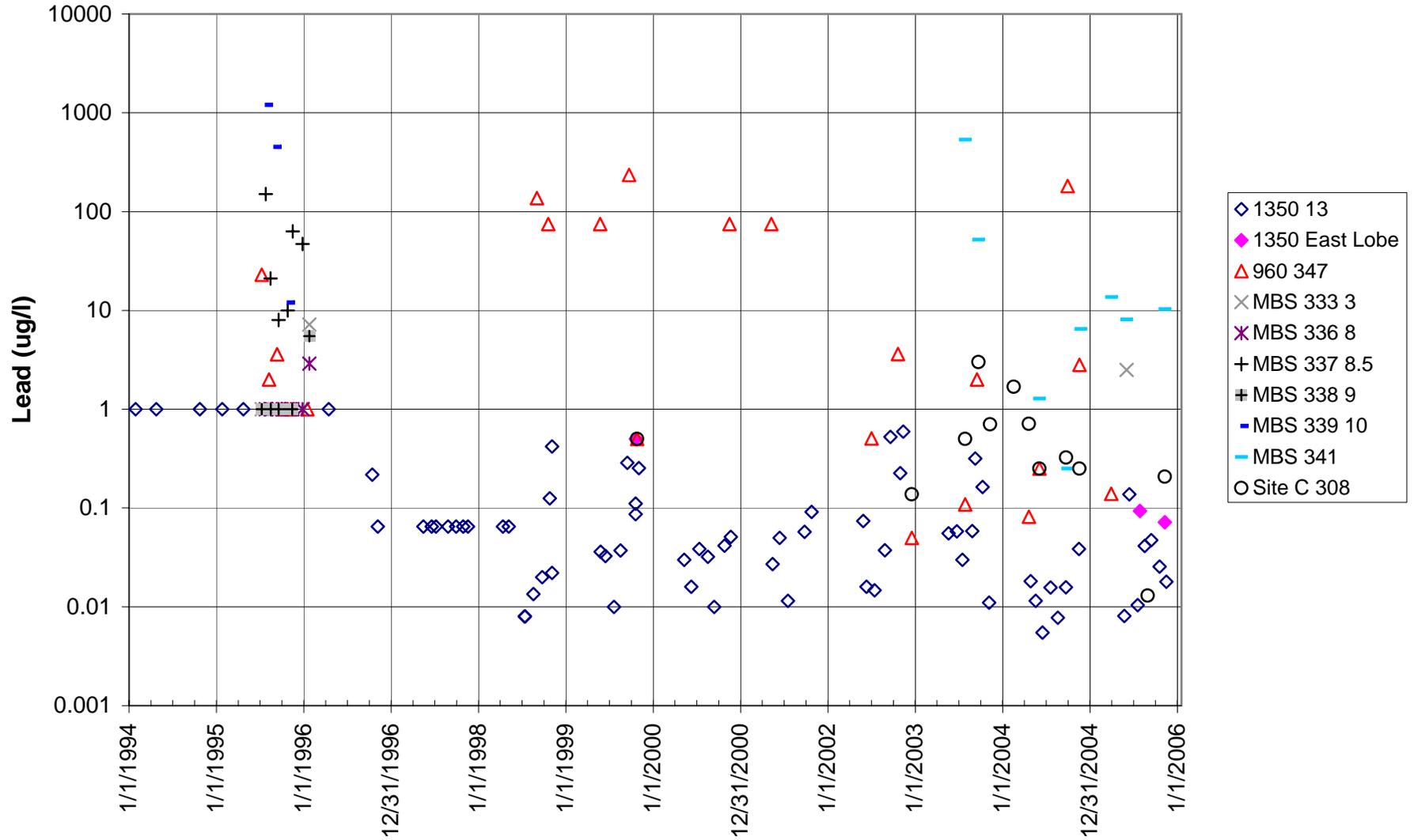


Figure 2.15 Inactive Production Rock Site Cadmium Data

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

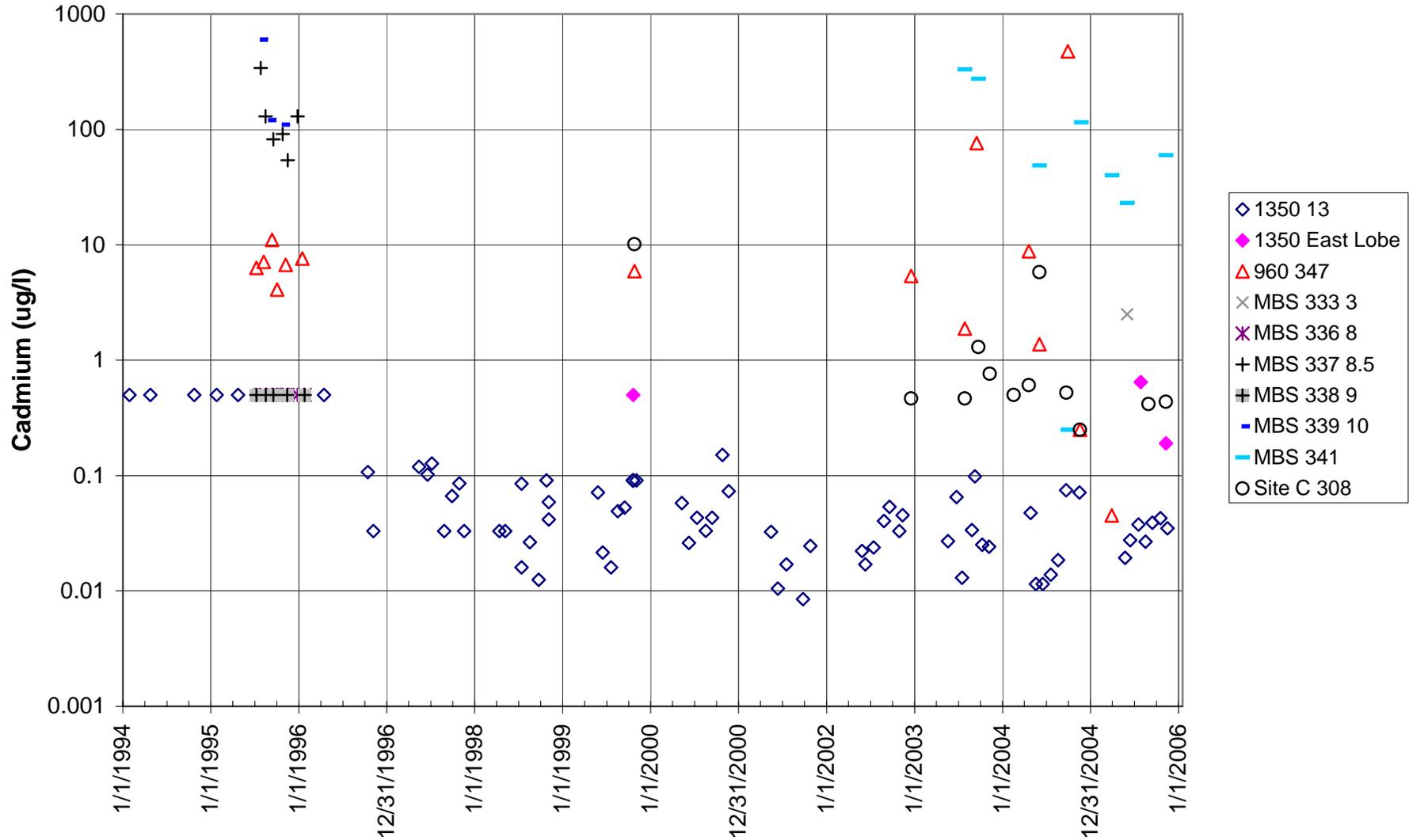


Figure 2.16 Inactive Production Rock Site Nickel Data

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

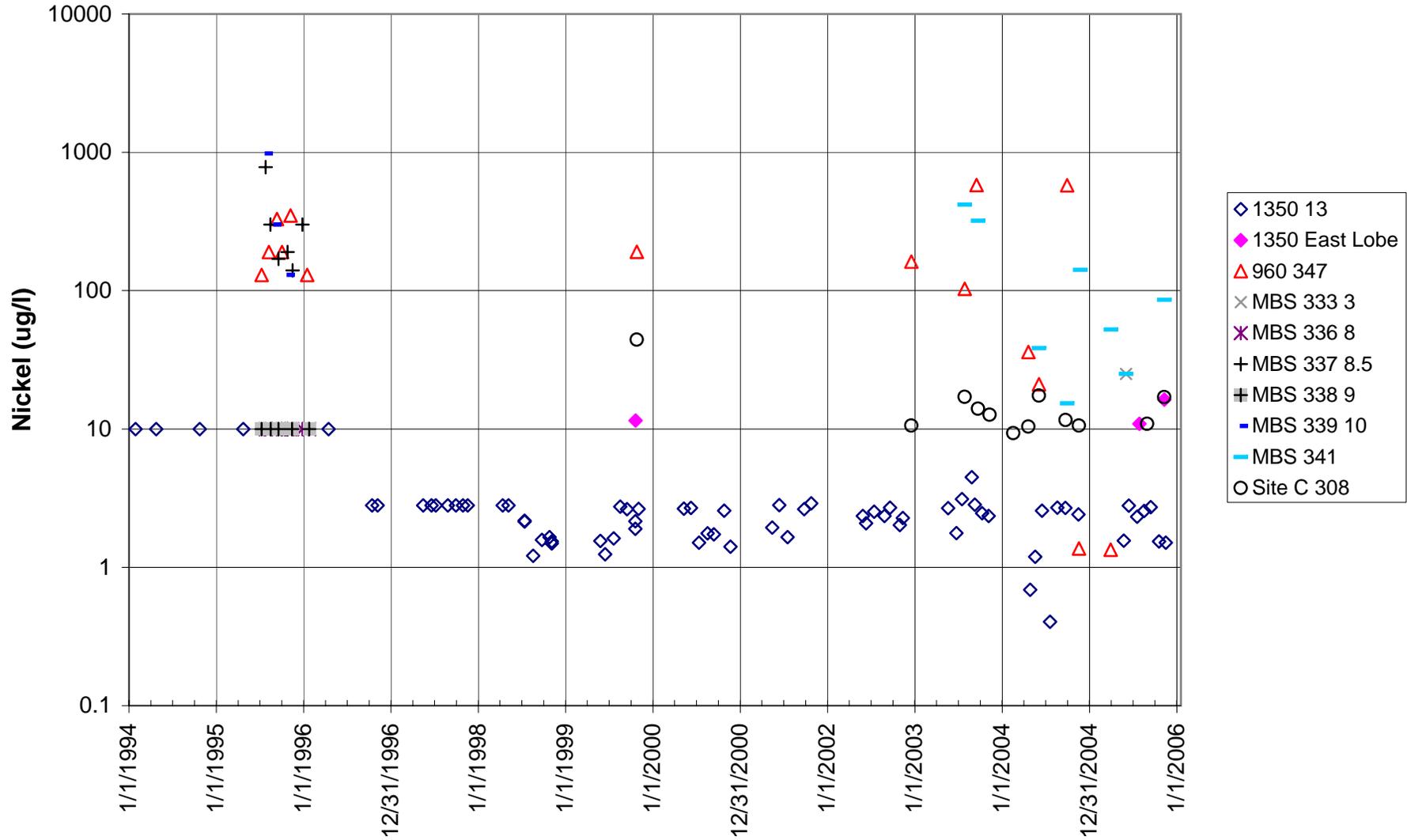


Figure 2.17 Inactive Production Rock Site Arsenic Data

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

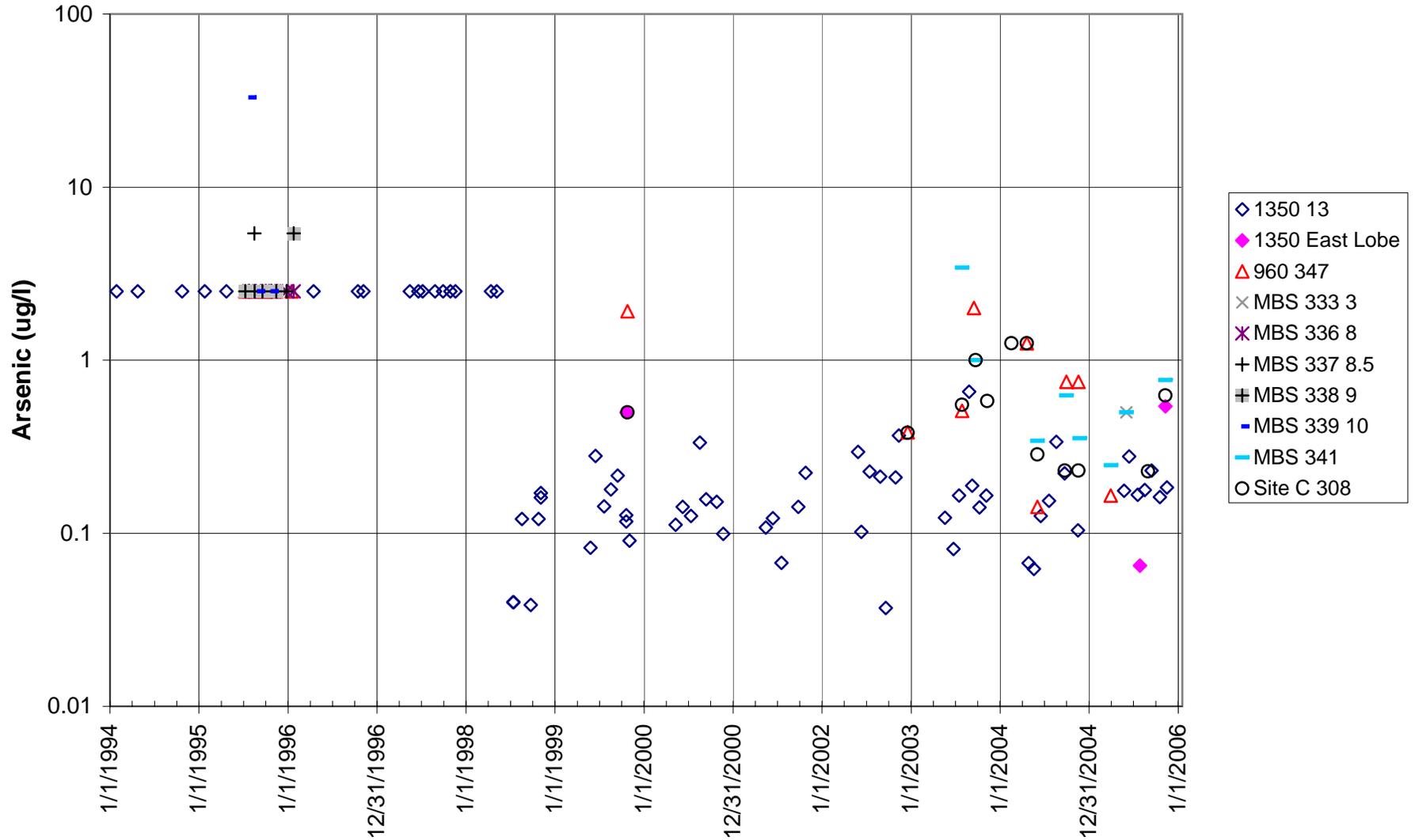


Figure 2.18 Inactive Production Rock Site Iron Data

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

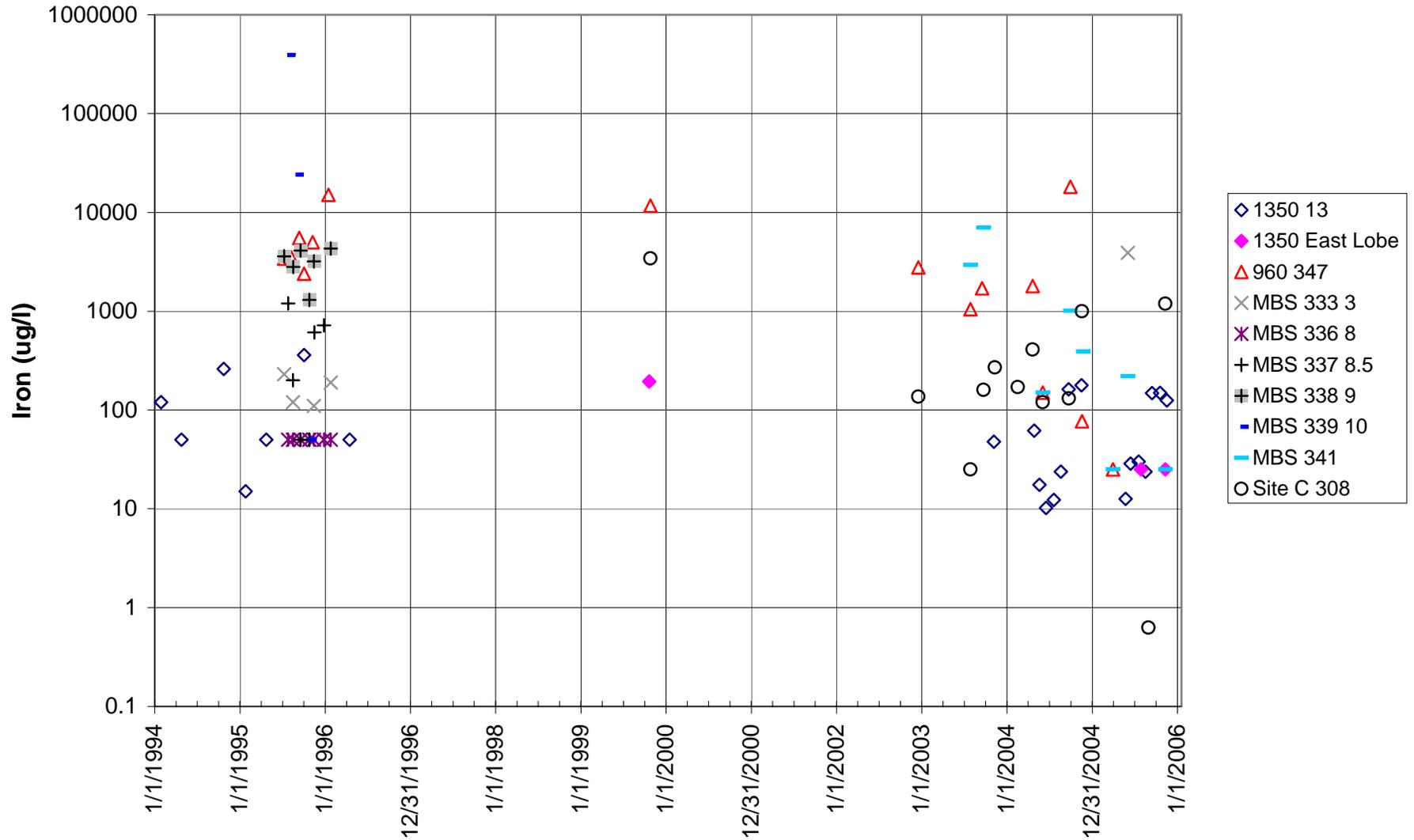


Figure 2.19 Inactive Production Rock Site Manganese Data

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

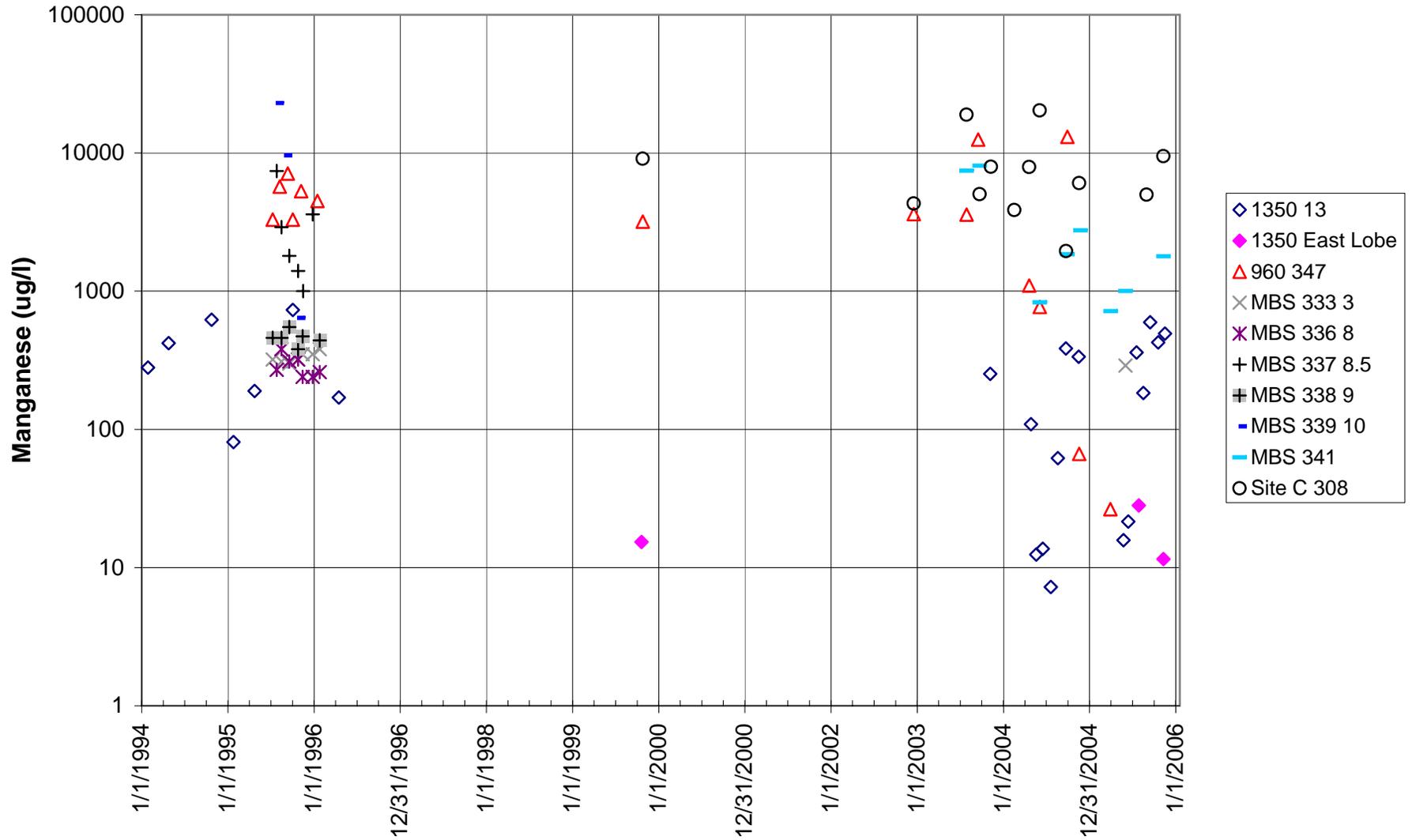


Figure 2.20 Inactive Production Rock Site E Flow Data

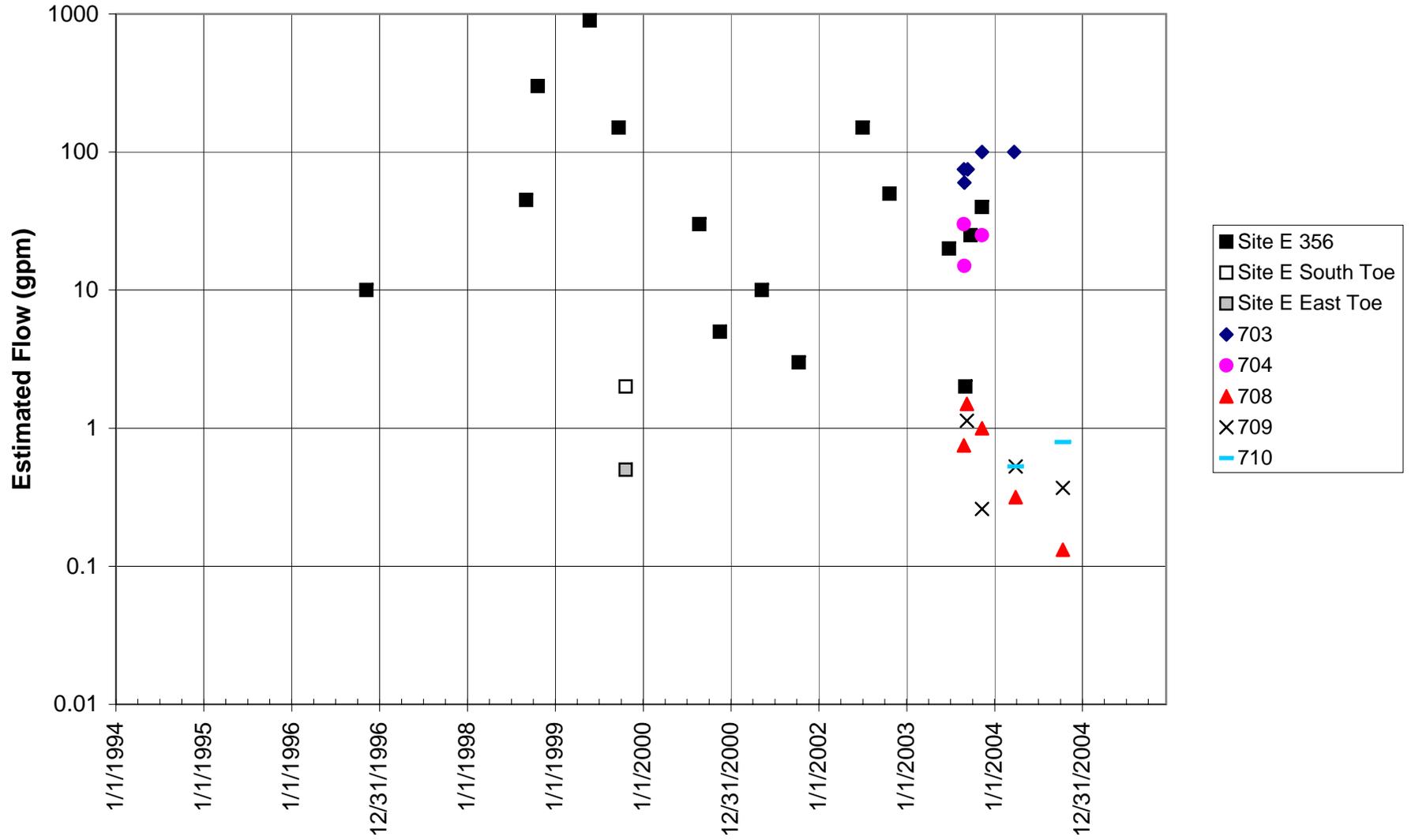


Figure 2.22 Inactive Production Rock Site E Alkalinity Data

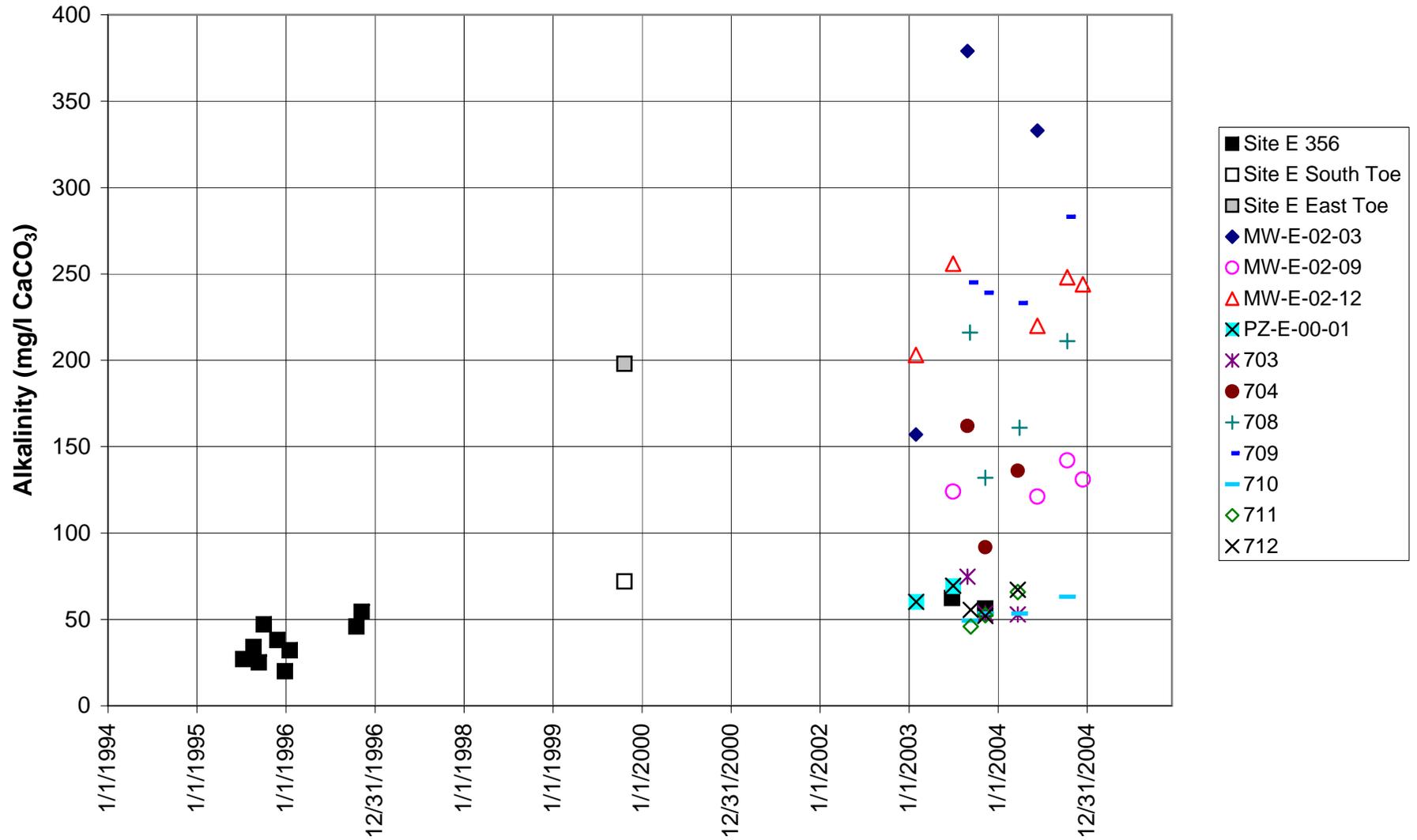


Figure 2.23 Inactive Production Rock Site E Conductivity Data

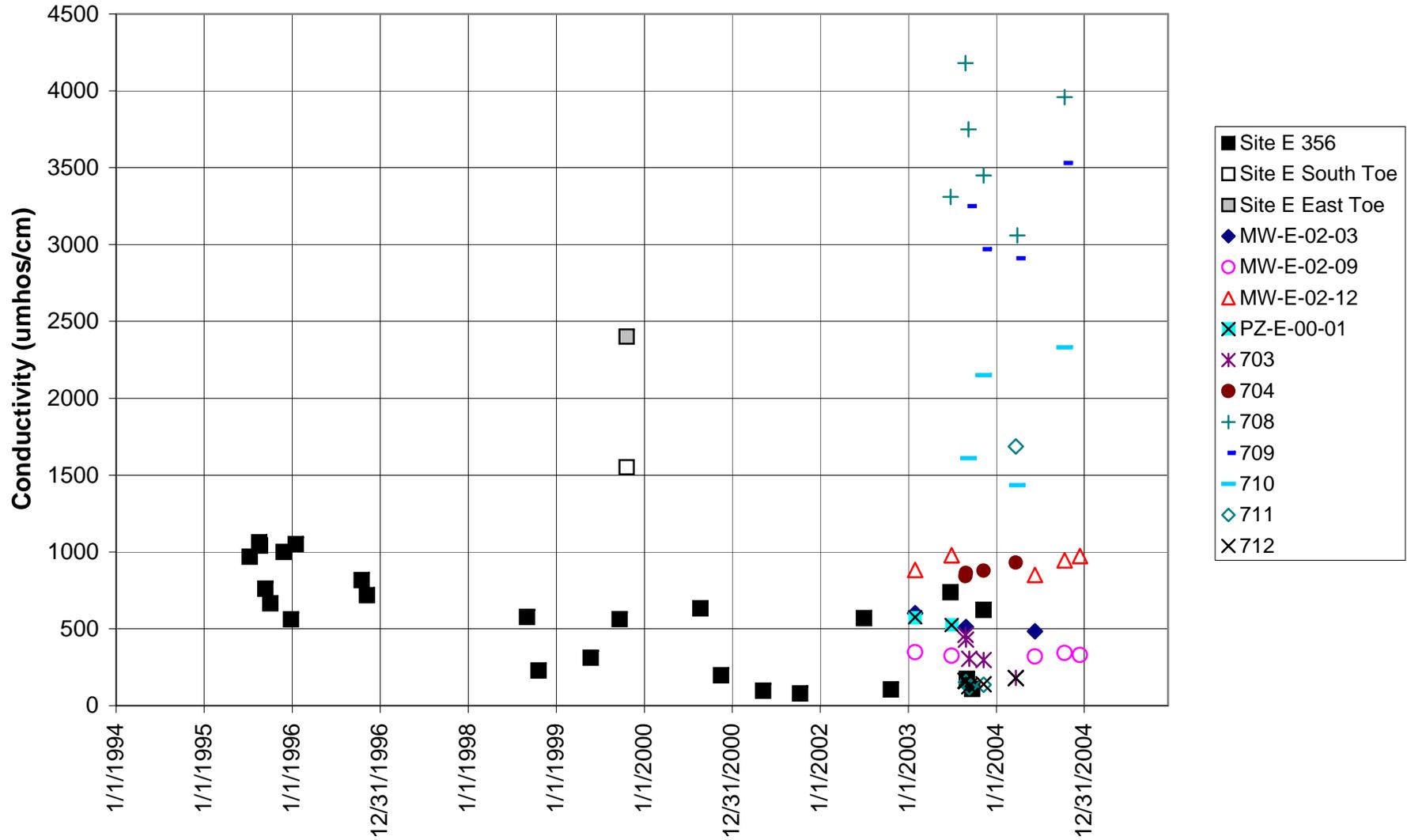


Figure 2.24 Inactive Production Rock Site E Sulfate Data

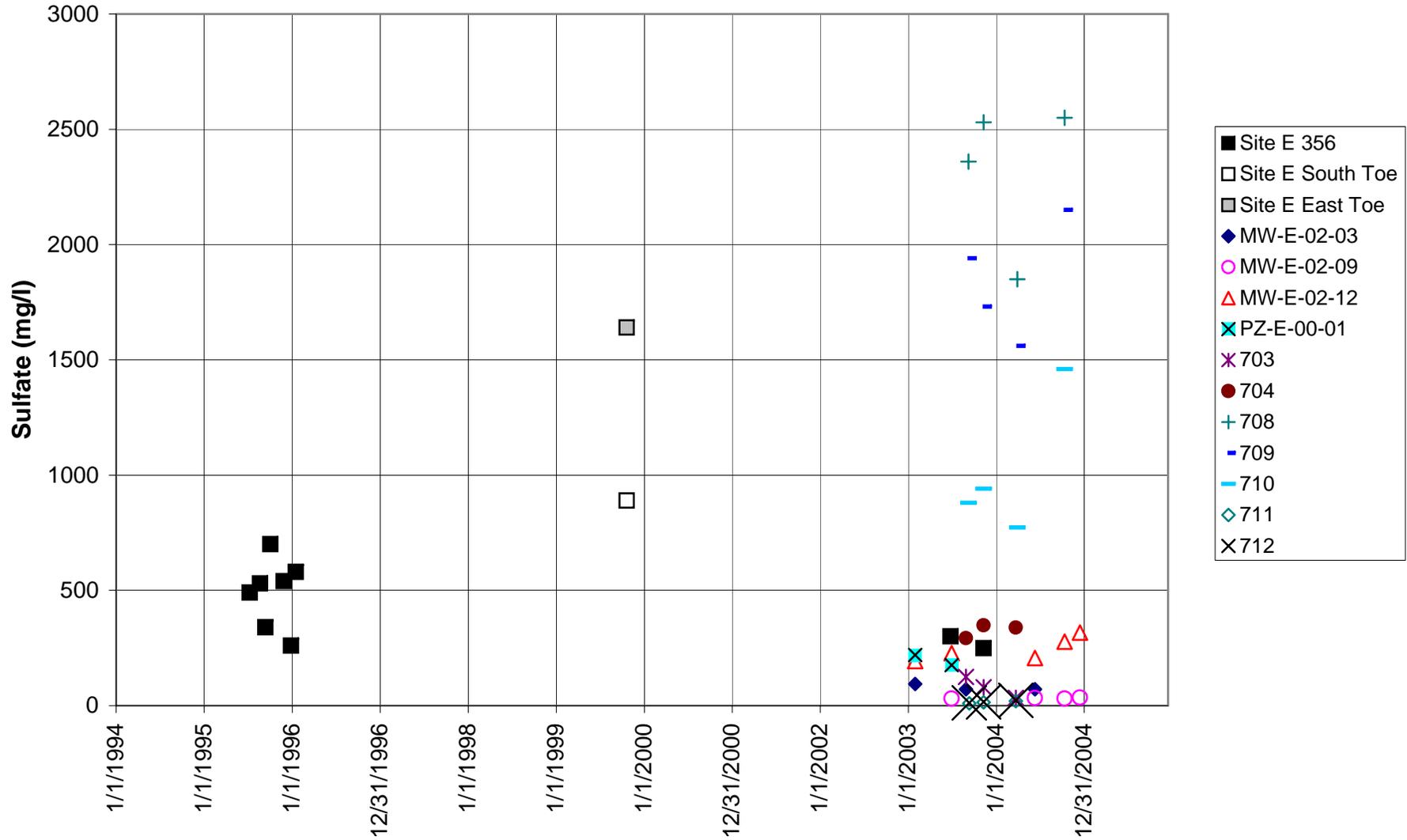


Figure 2.25 Inactive Production Rock Site E Magnesium Data

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

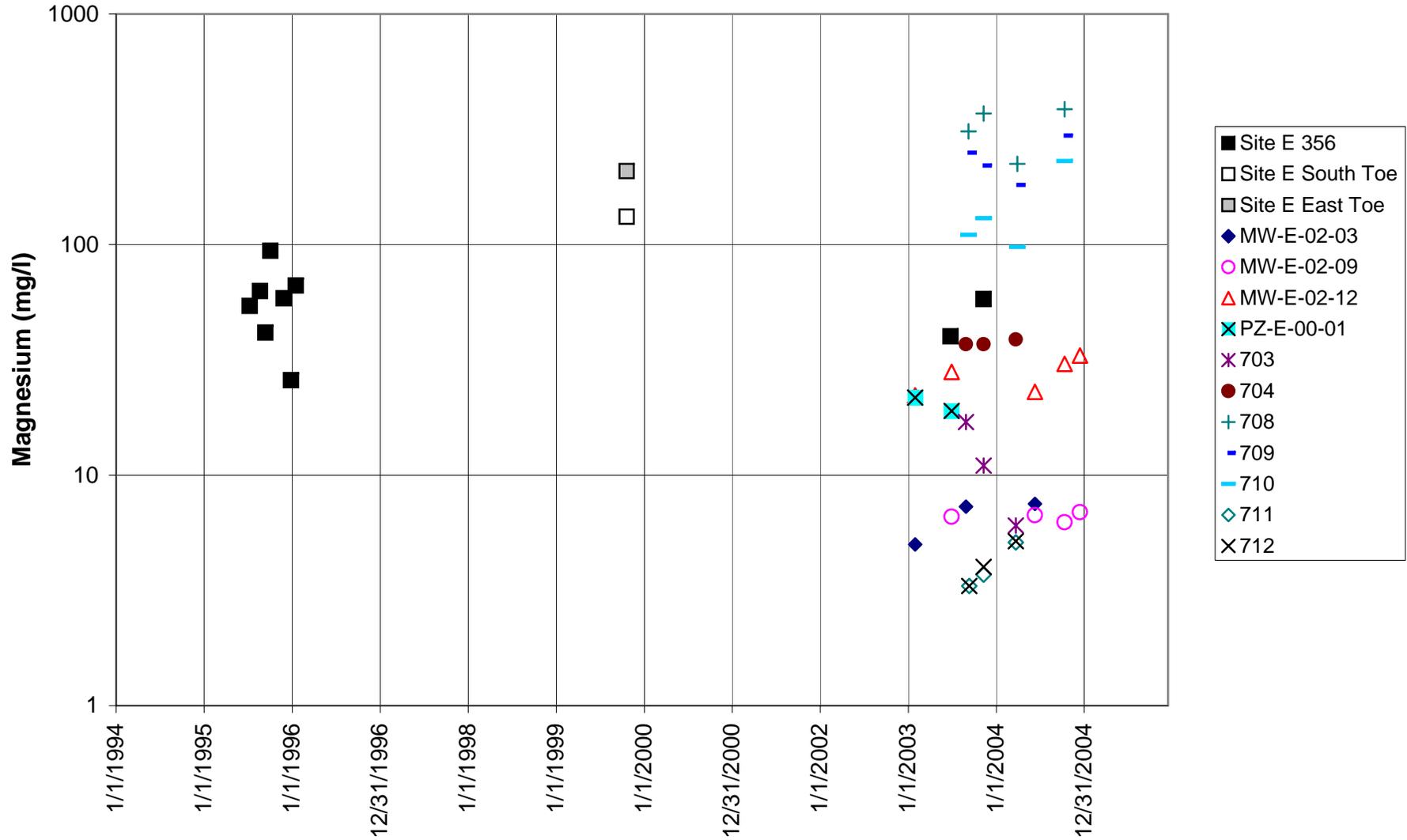


Figure 2.27 Inactive Production Rock Site E Zinc Data

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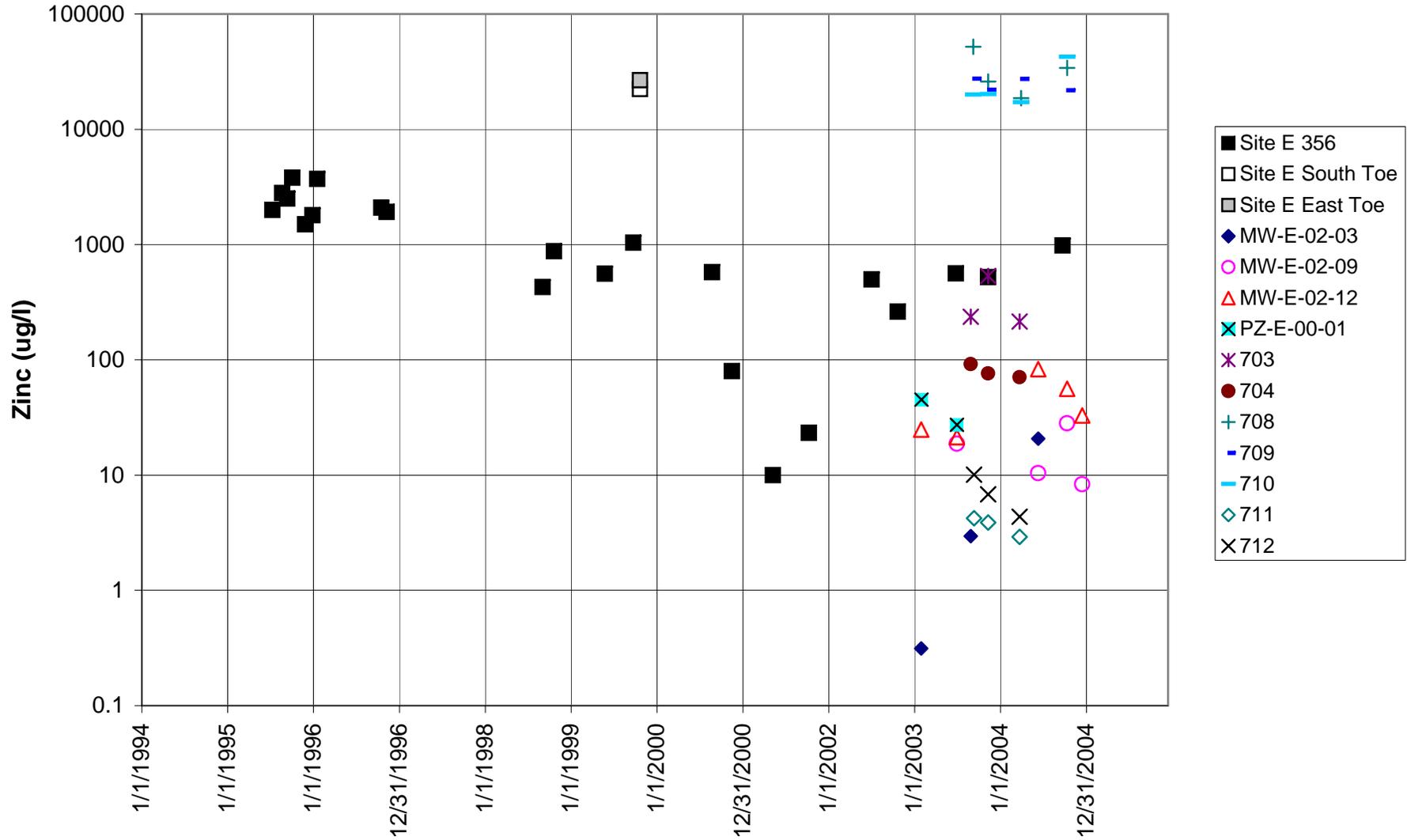


Figure 2.28 Inactive Production Rock Site E Copper Data

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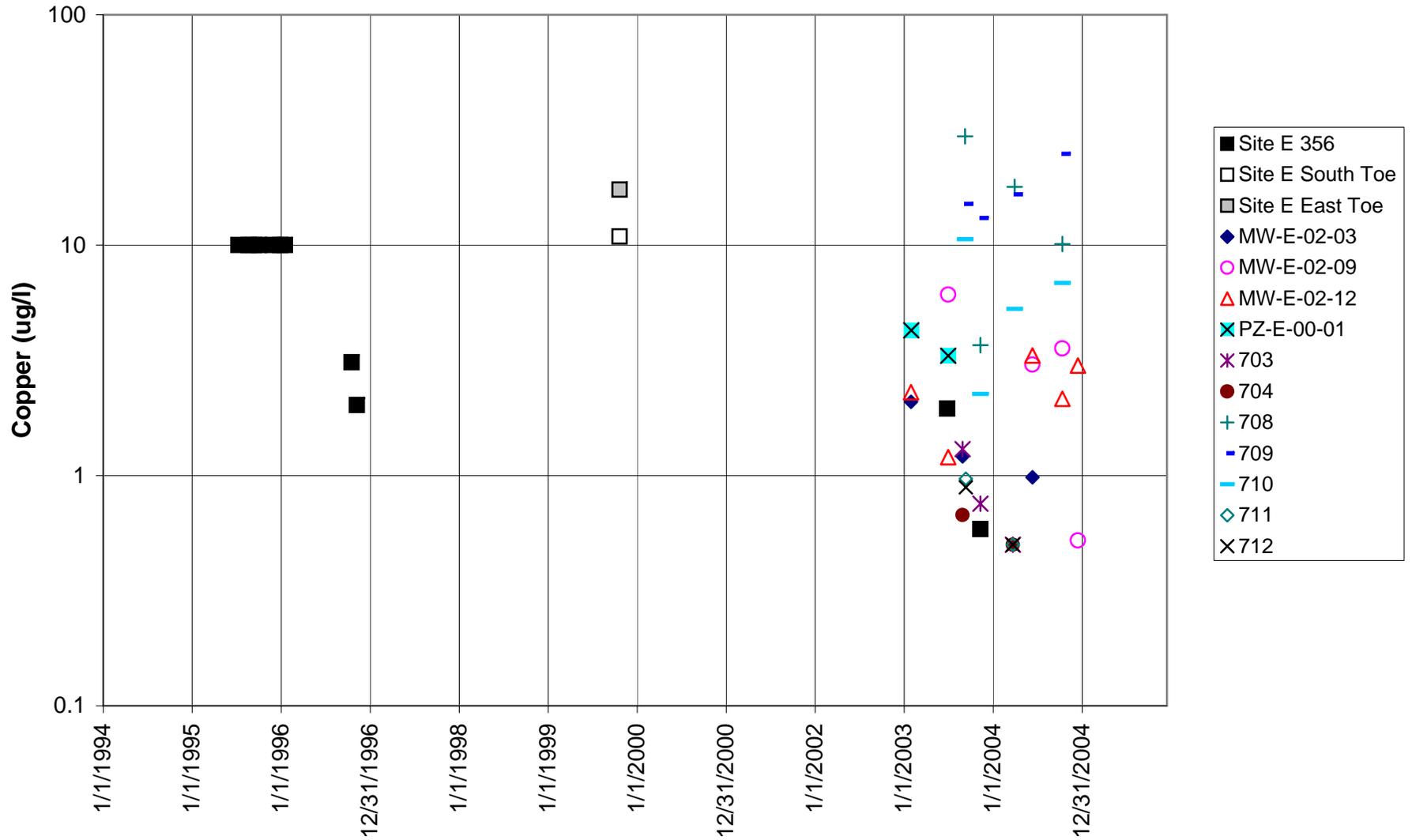


Figure 2.29 Inactive Production Rock Site E Lead Data

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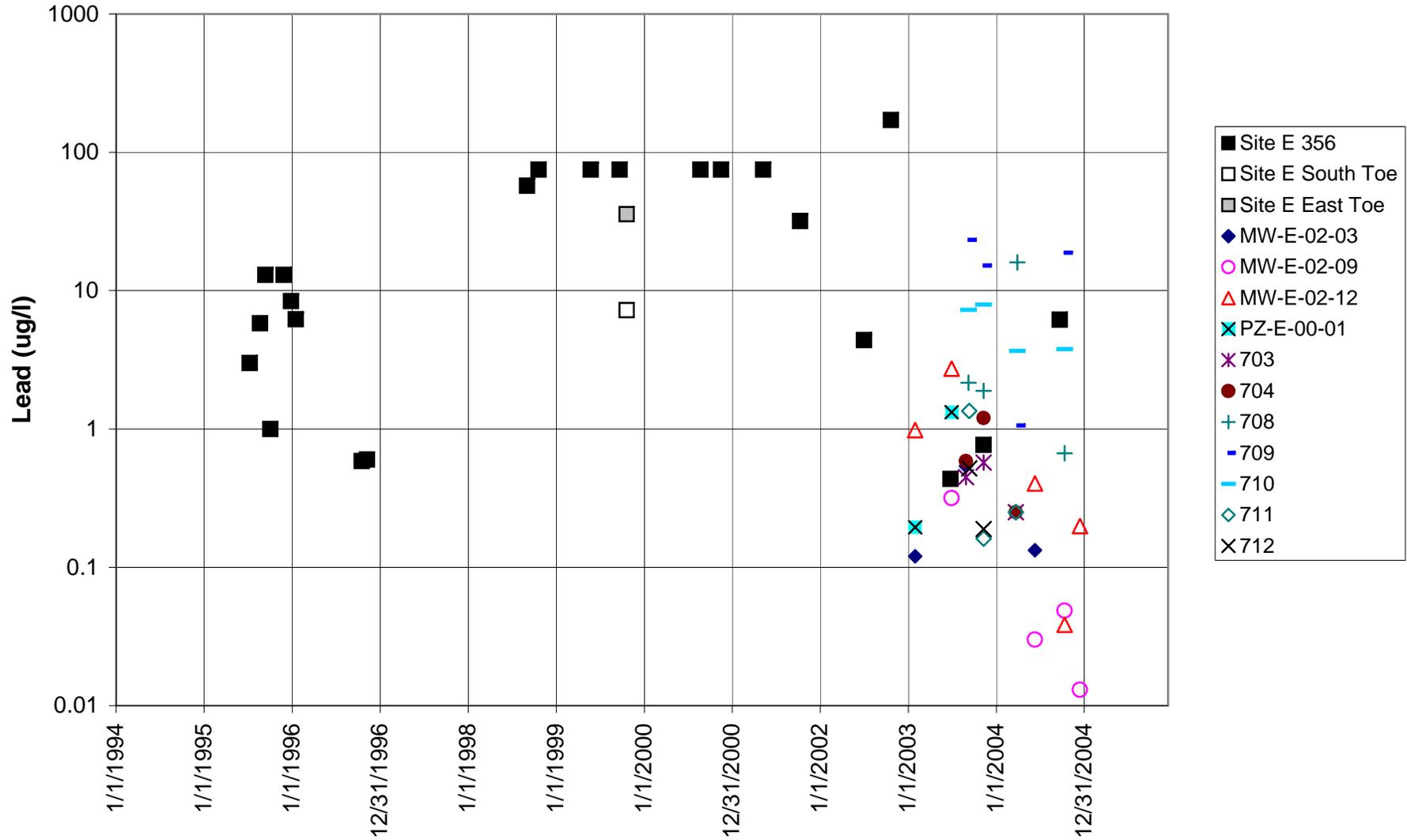


Figure 2.30 Inactive Production Rock Site E Cadmium Data

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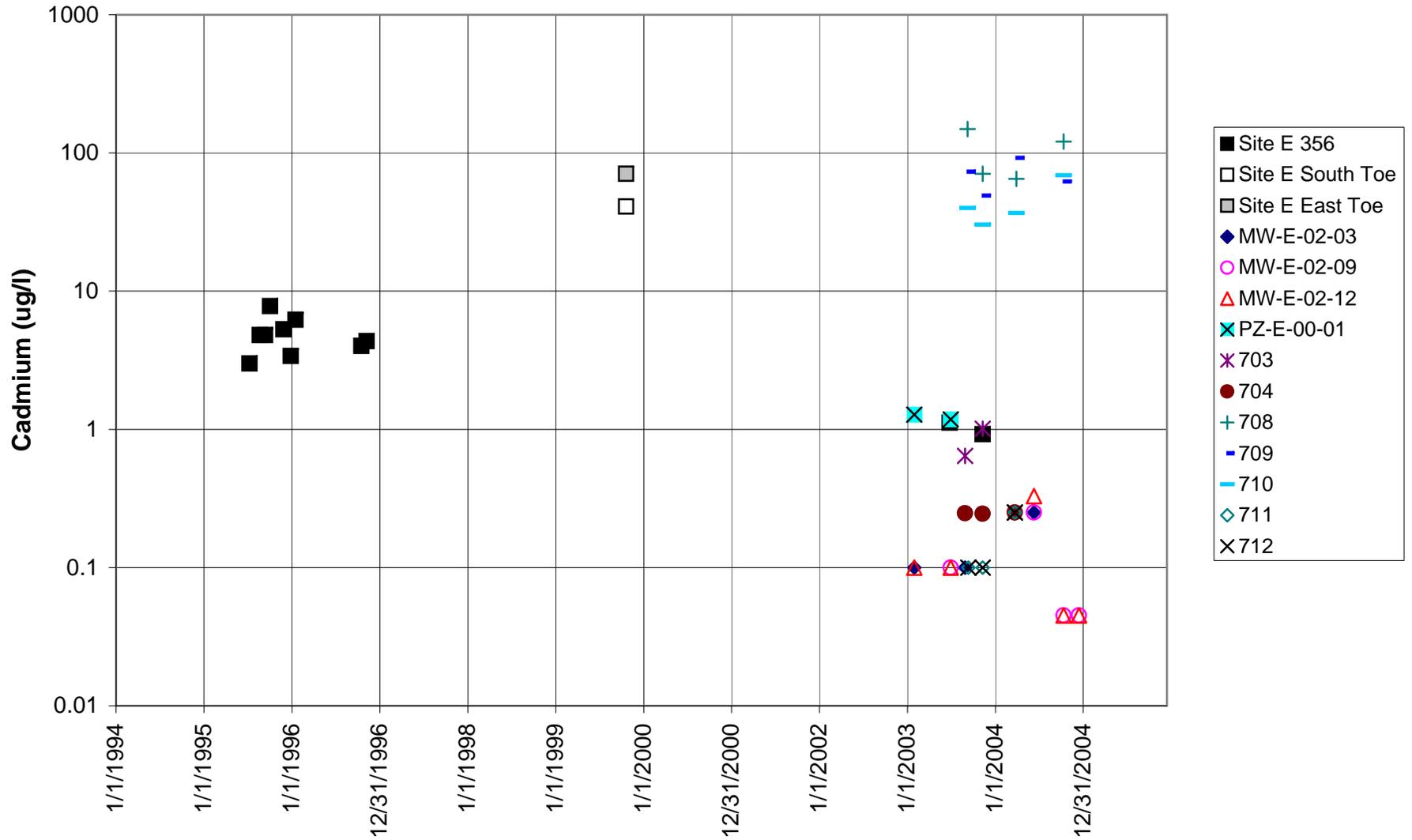


Figure 2.33 Inactive Production Rock Site E Iron Data

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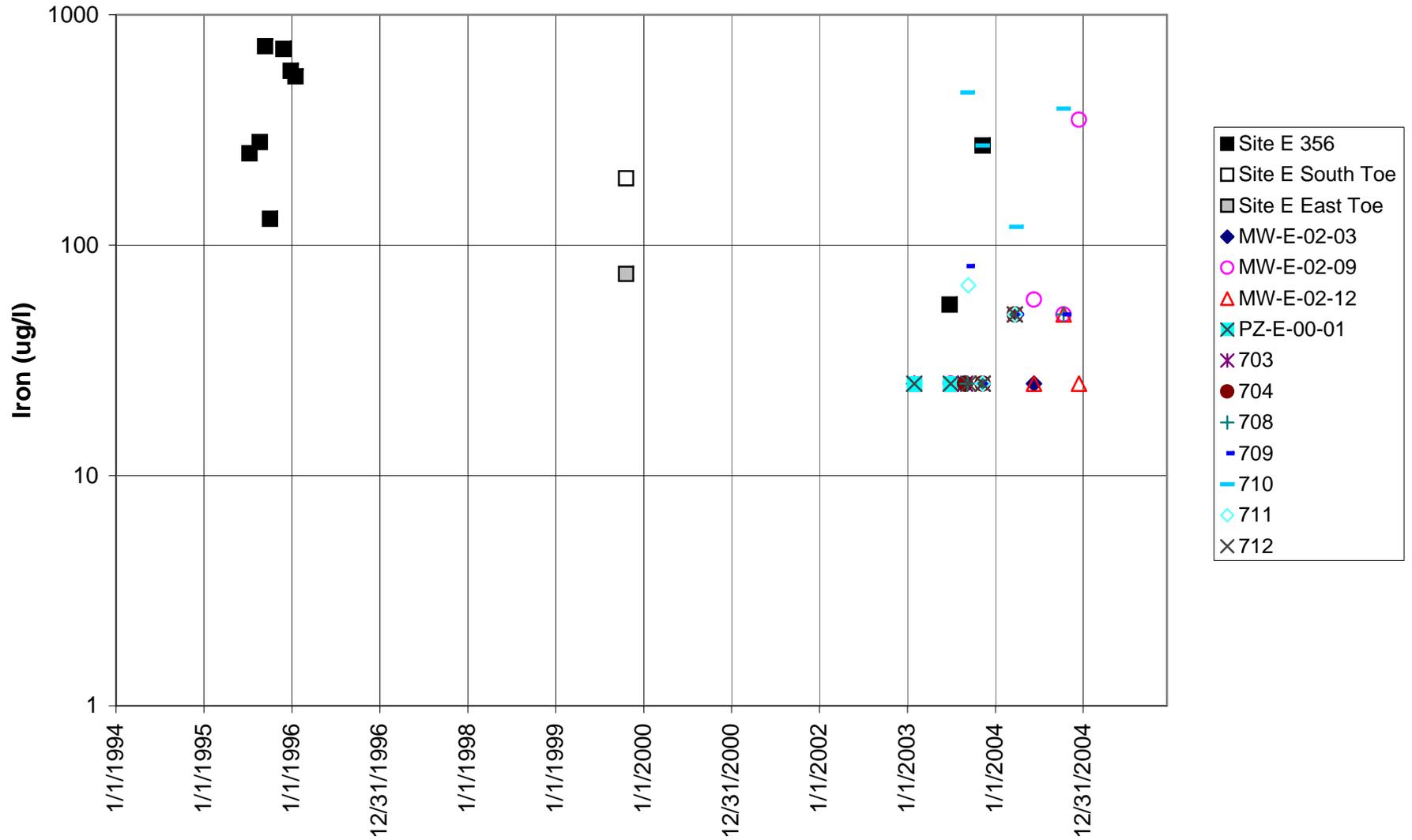


Figure 2.34 Inactive Production Rock Site E Manganese Data

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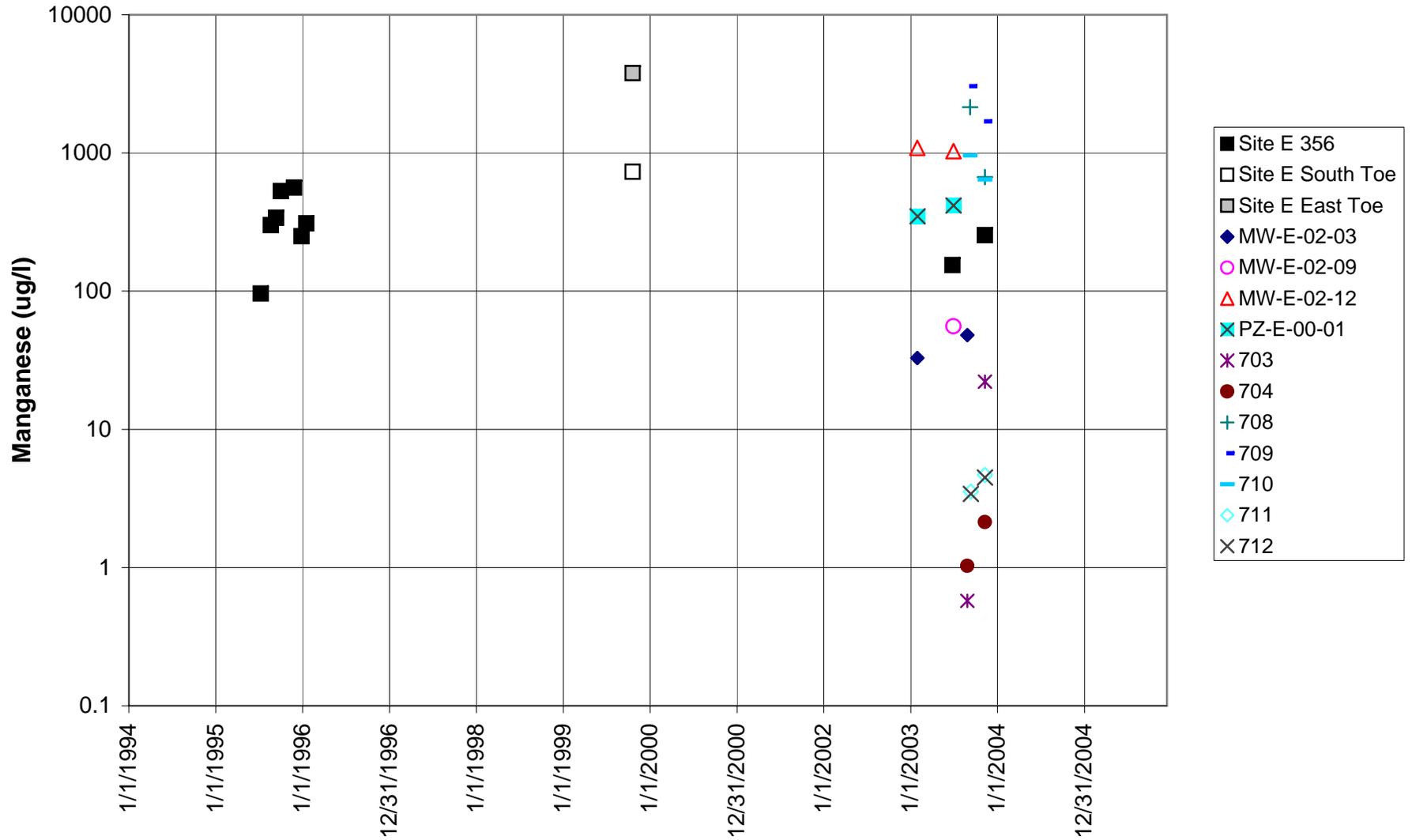


Figure 3.1 Quarry Site Flow Data

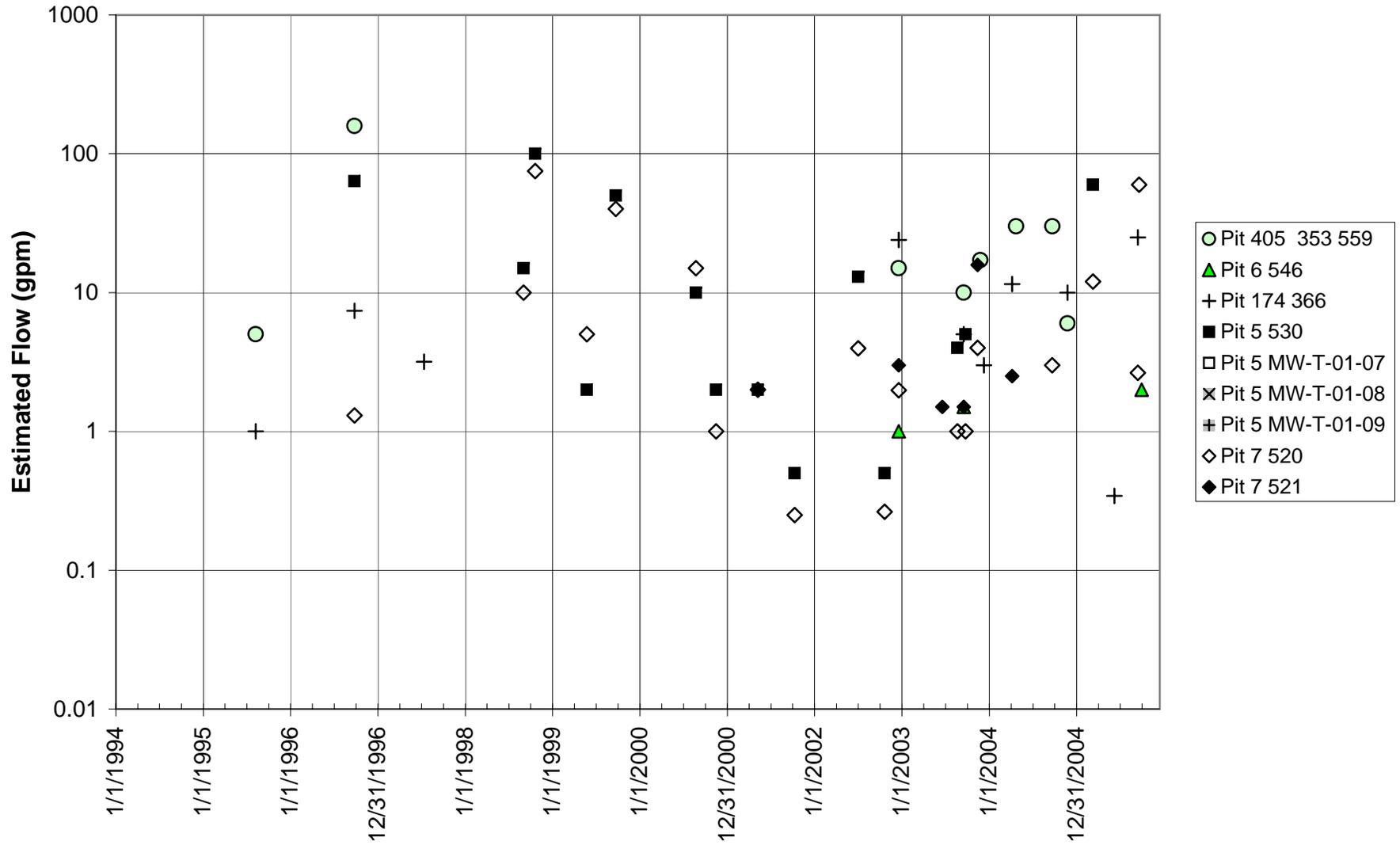


Figure 3.6 Quarry Site Magnesium Data

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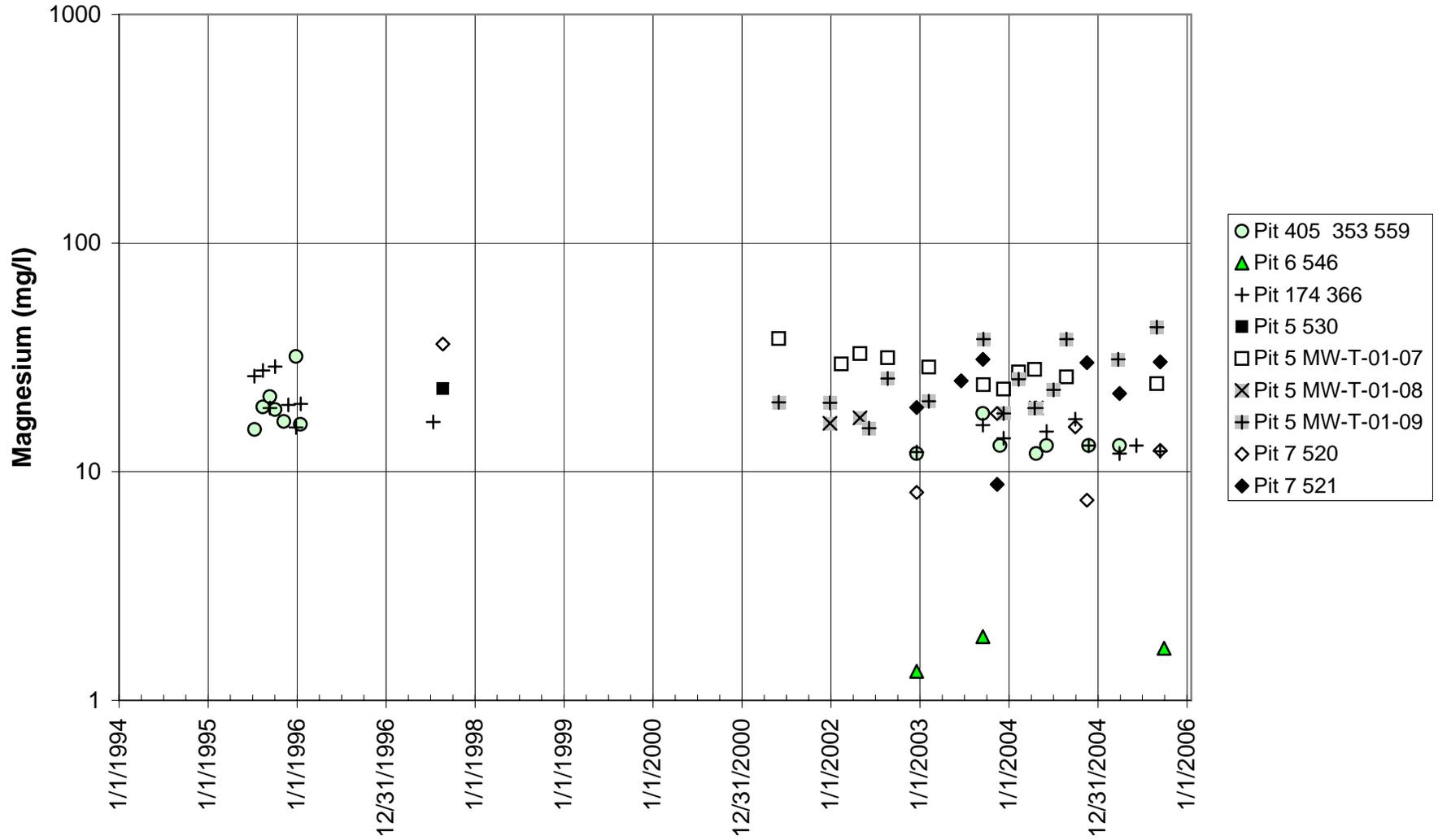


Figure 3.10 Quarry Site Lead Data

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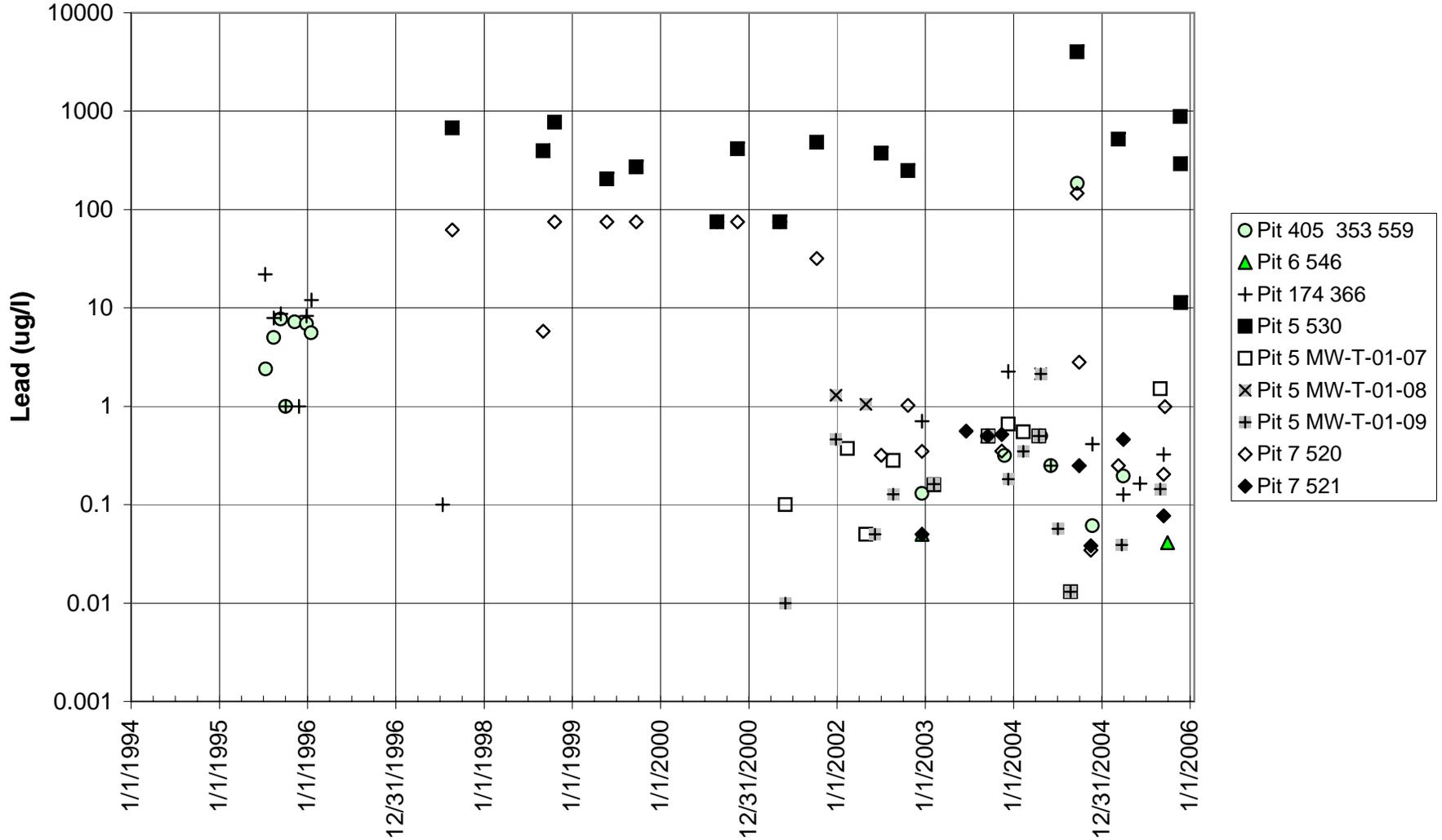


Figure 3.14 Quarry Site Iron Data

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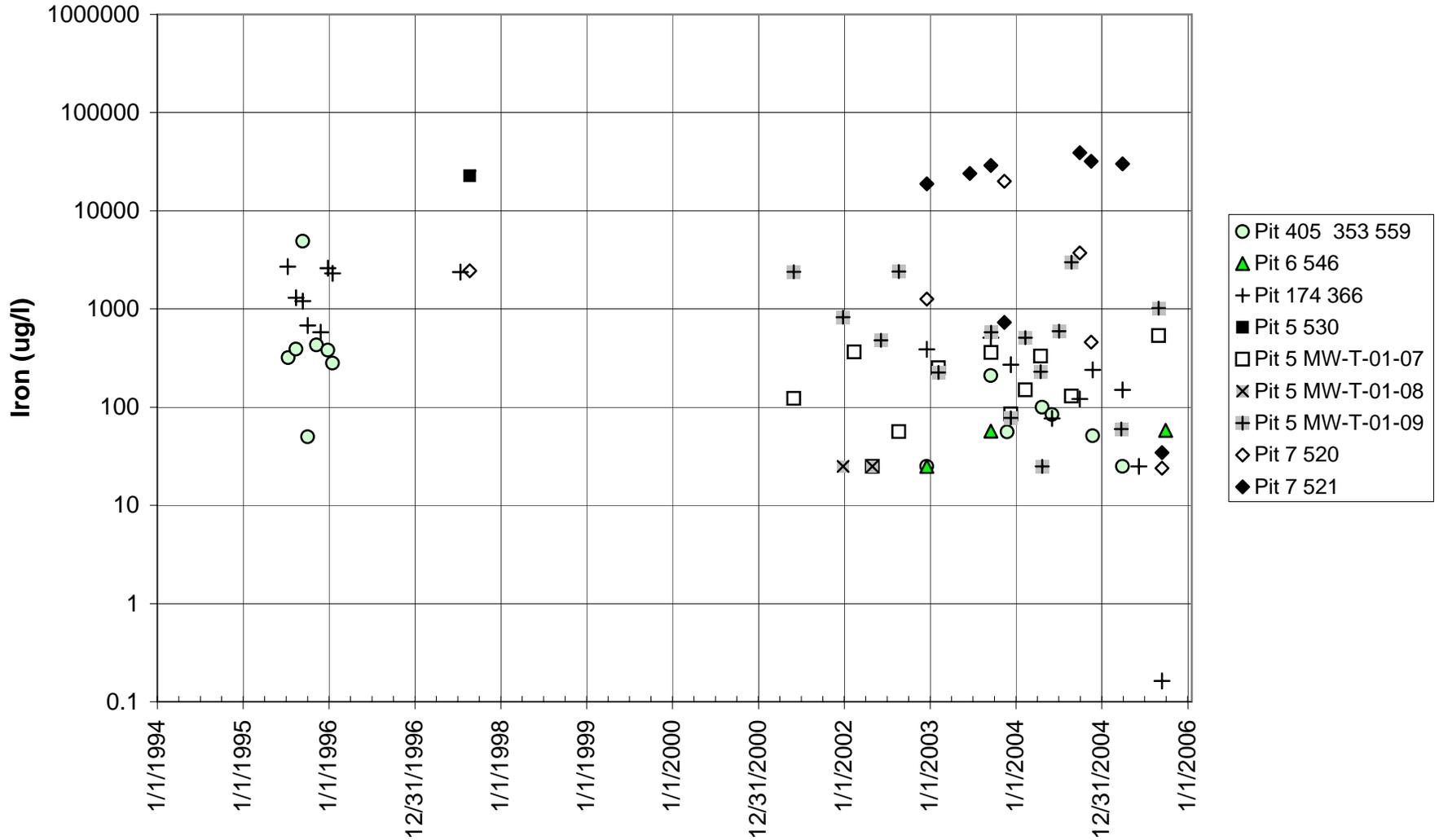


Figure 3.16 Pit 7 Acid-Base Accounting Analyses

