

**INACTIVE PRODUCTION ROCK SITES AND QUARRIES
2006 ANNUAL REPORT**



Kennecott Greens Creek Mining Company

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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. A discussion of the 2.5 mile roadcut on the B Road has also been included in this year's report.

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. 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 2005 and 2006 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).

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 exposed in the near-vertical pit walls 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. Surface drainage from the Pit 5 area is captured by the Tailings containment system and routed for treatment prior to discharge under the KGCMC NPDES permit.

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 2006 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 2006 Annual Report (KGCMC, 2007), 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. Site and sampling locations, removal areas, and Acid Base Accounting (ABA) data are summarized in Figures 2.1 through 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 introductory section, followed by individual site discussions in the subsequent sections.

The results of grid sampling and water monitoring in 2006 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.

Table 2.1 2006 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 Original Volume (yds)	40,000 – 60,000	5,000	ND	50,000	365,000
Prod Rock Volume (yds)	40,000	Site Fill Removed in 2005	ND	ND	ND
Reclamation Material (yds)	0		0	0	10,000
Material Removed in 2006 (yds)	0		0	0	7,100
Average NP (tCaCO ₃ /kt)	ND		ND	ND	336.4
Average AP (tCaCO ₃ /kt)	ND		ND	ND	188.4
Average NNP (tCaCO ₃ /kt)	ND		ND	ND	148.0
Average Rinse pH	ND		ND	ND	ND

Figure 2.3 compares Acid Potential (AP) with Neutralization Potential (NP) from 2006 surface grid samples. Figure 2.4 shows Site E after the removal of 7,100 cubic yards of material. 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. Seven of the eleven Site E 2006 samples would be classified as Class 1 (acid neutralizing) 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.

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 Site 960 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. Alkalinity data presented in Figures 2.7 and 2.22 are consistent with the pH results in Figures 2.6 and 2.21. All 2006 sample locations maintained 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 960 347 shows an overall decreasing trend in conductivity, while the Site 1350 data 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 decrease in dissolved load for 2006. Site C had a slightly higher average annual conductivity in 2006 than 2005 (1143 $\mu\text{mhos/cm}$ in 2006 versus 1065 $\mu\text{mhos/cm}$ in 2005). 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 α 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 at these 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 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. Post removal Site 960 data in 2005 and 2006 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 small but detectable influence 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.

Two ventilation shafts were drilled above the 1350 portal and a new drainage borehole was drilled from the portal to the main sump in 2006. An additional vertical borehole was drilled near the saddle between the east and west drainages to provide hydrological information. The hole is cased through the overburden. Inclement weather and lack of backfill capacity underground prevented haulage of additional waste rock from the 1350 in 2006. Haulage in 2007 will continue to be dependent on weather and underground storage capacity/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 (cy) of rock were removed from the site and placed at Site 23 or underground as backfill in 2000. The remaining additional material removed in 2003, 2004 and 2005 is discussed below.

Grid sampling and water monitoring data were consistent with those of earlier reports (KGCMC, 1994 and Shepherd Miller, 2000) indicating that some of the rock was potentially acid generating. Intermittent periods of acidification have occurred, although the drainage from the site currently continues 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. Post removal water quality data 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 confounded 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.

Localized iron staining persists, however pre- and post-removal monitoring data (Table 2.1) indicate that water quality has improved considerably. Monitoring will continue in 2007. In an effort to monitor the succession of volunteer species, KGCMC did not apply hydroseed to the reclaimed area. Ferns, moss and water tolerant grasses have colonized wet zones. Well drained areas remain free of vegetation, but gentle slopes have prevented erosion problems.

Table 2.2 Effects of Removal of 960 Site Production Rock

		Before Removal	After Removal
Site 347		9/12/95	9/28/06
pH	s.u	6.1	7.6
Sulfate	mg/l (tot)	1300	161
Calcium	mg/l (diss)	412	64
Magnesium	mg/l (diss)	164	21
Iron	mg/l (diss)	5.5	0.2
Manganese	mg/l (diss)	7.1	0.4
Zinc	mg/l (diss)	11	0.1
Lead	mg/l (diss)	0.004	<0.0001
Nickel	mg/l (diss)	0.3	0.005

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 in 2005 indicated that this rock is acid generating (KGCMC, 2006). 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.

Replacement of the access road and diversion ditch above the 920 site was completed in 2006. Slope stability monitoring continues. Localized, minor movement of some monitoring hubs has been observed, but no systematic, large-scale displacement is apparent. The majority of the site's piezometers continue to show water level variations that are consistent with seasonal variations. A few of the deeper piezometers in the slope behind the mill show a progressive increase in recent years, which may indicate diminishing capacity of some of the dewatering drains in the slope. KGCMC has discussed the issue with its geotechnical engineers and developed an action plan which includes the following elements:

- Rehabilitate the diversion ditch and french drain
- Breach the abandoned ditch at the slope crest
- Attempt cleanout of the drain manifold system
- Install an inclinometer on the slope
- Perform a new stability analysis using new water table levels
- Continue monitoring

Evaluation of potential source areas for metal loading to Greens Creek continued in 2006. The State and Forest Service requested information on areas downgradient of the mill thickener tank area at the 920. KGCMC identified four areas where intermittent drainage from the mill site rock fill enters Greens Creek. The compositions of these drainage sources are summarized in Table 2.3. The flow and composition data presented in Table 2.3 were collected during a period when flushing of stored oxidation products in the mill site fill is highest. Despite these conditions, comparison of water compositions in Greens Creek above and below the mill site toe indicates that the influence of the drainage is minimal (e.g. compare Sites 1 and 7 in Table 2.3). Elements of the action plan to minimize metals loading to Greens Creek from all identified sources include:

- Installation of a collection pump in Pond C
- Removal of pyritic rock from the access road behind the mill site
- Improved sediment control at the 920 site
- Reduced spillage of tailings from backfill trucks
- Construction of a wheel wash at the 920
- Continued monitoring

Table 2.3 Mill Site Rock Fill Drainage Compositions

Site #	pH s.u.	Cond $\mu\text{S/cm}$	Flow gpm	Alk mg/l	Mg mg/l	SO ₄ mg/l	As $\mu\text{g/l}$	Cd $\mu\text{g/l}$	Cu $\mu\text{g/l}$	Fe $\mu\text{g/l}$	Mn $\mu\text{g/l}$	Ni $\mu\text{g/l}$	Pb $\mu\text{g/l}$	Zn $\mu\text{g/l}$
0	7.9	140	13,260	46	3.5	13	0.31	0.07	1.56	<DL	14.5	1.26	0.17	7.13
1	6.8	1283	0.26	128	59.3	567	0.68	0.28	1.42	193	635	14.1	0.20	88.6
4	6.7	1752	ND	34	4.7	41	<DL	<DL	5.3	988	350	7.05	0.68	21.8
5	7.6	1543	0.03	49	90.6	761	0.50	1.28	7.16	<DL	0.92	18	0.52	135
6	3.0	2780	0.20	<DL	99.3	1410	1.11	26.8	225	16900	15000	236	68.9	5300
7	7.9	135	ND	46	3.3	14	0.39	<DL	1.33	<DL	12	1.25	0.10	8.48

NOTE: Site 0 was taken in Greens Creek upgradient of seep sites #1, 4, 5, and 6; Site 7 was taken in Greens Creek down gradient from the seeps.

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 underlying production rock. Flow from the production rock is low (generally less than 1 gpm), remains near-neutral, with elevated manganese concentrations, and 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). The caisson for the pump in the pump-back system was installed in 2006 to facilitate collection of stormwater. Installation of the pump and commissioning of the system will occur in 2007.

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. Eleven grid samples were taken at Site E in 2006 (Figure 2.3). Results from grid sampling and water sampling 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) detected 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 Alaska water quality standards for sulfate, cadmium and zinc in 2003 and 2004. Follow-up sampling at these sites is planned for 2007.

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). Although, copper, lead, and manganese showed lower concentrations in the toe samples in 2006. 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).

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 and 2007 will test the recommended blend ratios for chemical stability, metal leaching, and acid generation potential. For more information on the geotechnical and geochemical studies, see the 2006 Tailings and Waste Rock Annual Report.

A total of 7,100 cubic yards of waste rock from Site E was hauled to the tailings facility to create a stabilizing berm in the Southeast II area. A portion (1 acre) of the Site E pile was covered in the Fall of 2006 to reduce the moisture content of the waste rock in preparation for removal in 2008 and 2009. Unusually wet weather during most of 2006 delayed expansion efforts at the tailings facility, which in turn has delayed scheduled large scale removal of Site E waste rock. Surface water and groundwater monitoring at the site continues. KGCMC plans to relocate the Site E production rock material to the surface tailings facility over a two-year span from 2008 through

2009 using dedicated personnel and trucks. KGCMC anticipates recovery of the underlying 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.

2.7 2.5 Mile B Road Cut

Pyritic rock was exposed in the 1988 road cut at 2.5 mile during construction of the B Road. 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. KGCMC will use monitoring of Zinc Creek to determine if additional efforts are required at the road cut. KGCMC will select an appropriate monitoring point in Zinc Creek below the road cut to evaluate its effects on water quality. Risks related to bear activity in the area will be evaluated during development of the monitoring schedule. 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. KGCMC redirected road ditch water around the pad to reduce infiltration through the pyritic rock. Water quality has improved, but the rock lacks the buffering capacity to produce circum-neutral drainage. The effects from the site are moderated by the low flow rate relative to flows from the surrounding area. KGCMC plans to remove the pyritic material following removal of other higher priority sites. Availability of underground backfill space dictates the rate at which these sites can be removed.

Zinc Creek Bridge Abutment

Pyritic rock from the road cut at 2.5 mile B Road was 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. KGCMC maintains a NPDES stormwater 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 2.4) demonstrate that the contribution of runoff has a detectable effect on the quality of Zinc Creek. The data indicate that concentrations are below water quality standard levels for constituents having practical quantification levels (PQL) low enough to compare to the standard. The PQL for cadmium was higher than the AWQS for hardness values less than 70mg/l. For future analyses of Zinc Creek samples KGCMC will request a lower PQL for cadmium to allow comparison to the AWQS. KGCMC applied lime to the fill in 1997. 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.

Table 2.4 Zinc Creek Water Compositions

Site #	pH s.u.	Cond μ S/cm	Alk mg/l	Mg mg/l	SO4 mg/l	As μ g/l	Cd μ g/l	Cu μ g/l	Fe μ g/l	Mn μ g/l	Ni μ g/l	Pb μ g/l	Zn μ g/l
371	7.2	127	46	3.2	6.0	0.56	<0.2	0.63	<0.05	2.7	2.25	<0.1	2.4
368	7.1	121	42	3.7	11.9	0.29	<0.2	3.4	0.26	40.4	5.47	<0.1	11.8

Samples collected March 29, 2006

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 2006 is provided. Refer to GPO Appendix 11 for a detailed description of the sites and associated monitoring requirements.

The quarries were sampled in 2006 for drainage water quality data. See the Inactive Production Rock Sites and Quarries Annual Report 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
Acreage		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 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. Of 123 samples taken since 1995, 122 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 2006, conductivity and sulfate concentrations in this well have 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, and values have continued within this historic range throughout 2005 and 2006. 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 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 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 occurred in 2006. Despite installation difficulties, it appears the well is suitable for sampling, which will begin in 2007. The well is completed in pyritic bedrock so there may be some difficulty differentiating between contributions from quarry fill material and the bedrock

itself. KGCMC maintains a monitoring site in the drainage below Pit 405. The quality of water from this sampling point continues to be good (Figures 3.1 to 3.15)

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 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 (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.

A runaway truck ramp was installed at Pit 174 following a haul truck incident at the site in 2006. The water tank was also moved from the quarry to the other side of the haul road to facilitate the emergency access route to the truck ramp.

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 NPDES discharge 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 captured by the Tailings containment system through routing 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 which is designed to expand into this Pit quarry area. Construction of this expansion began in 2006 and will continue in 2007. Tailings placement locations in the Pit 5 area will be underlain with a synthetic liner tied into the natural till underlying the tailings pile to the south.

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. 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 limited sulfide oxidation is occurring 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

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

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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.

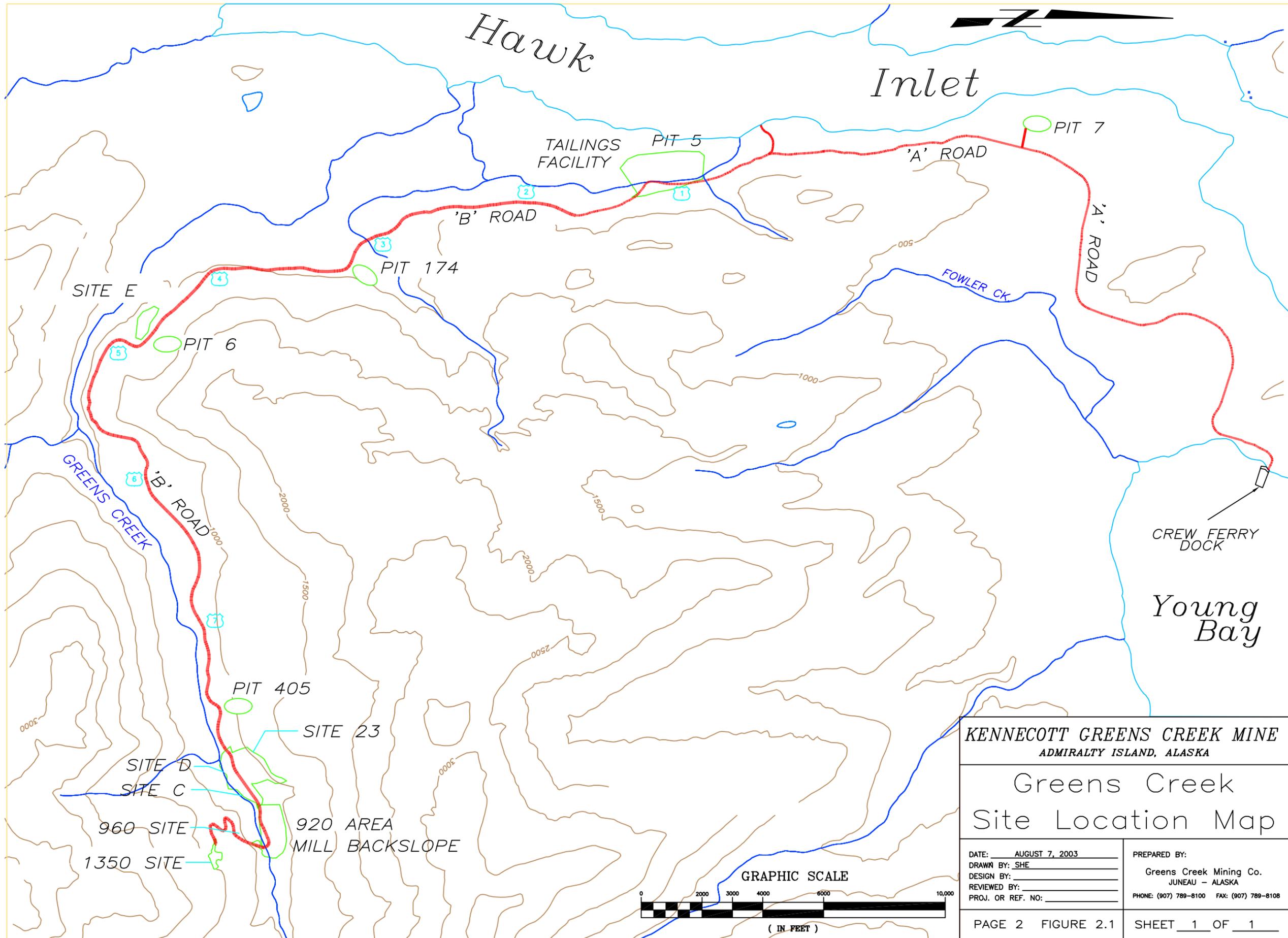
Kennecott Greens Creek Mining Company (KGCMC), Tailings and Production Rock Site 2004 Annual Report, August 2005.

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

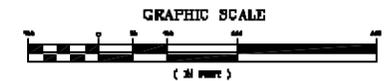
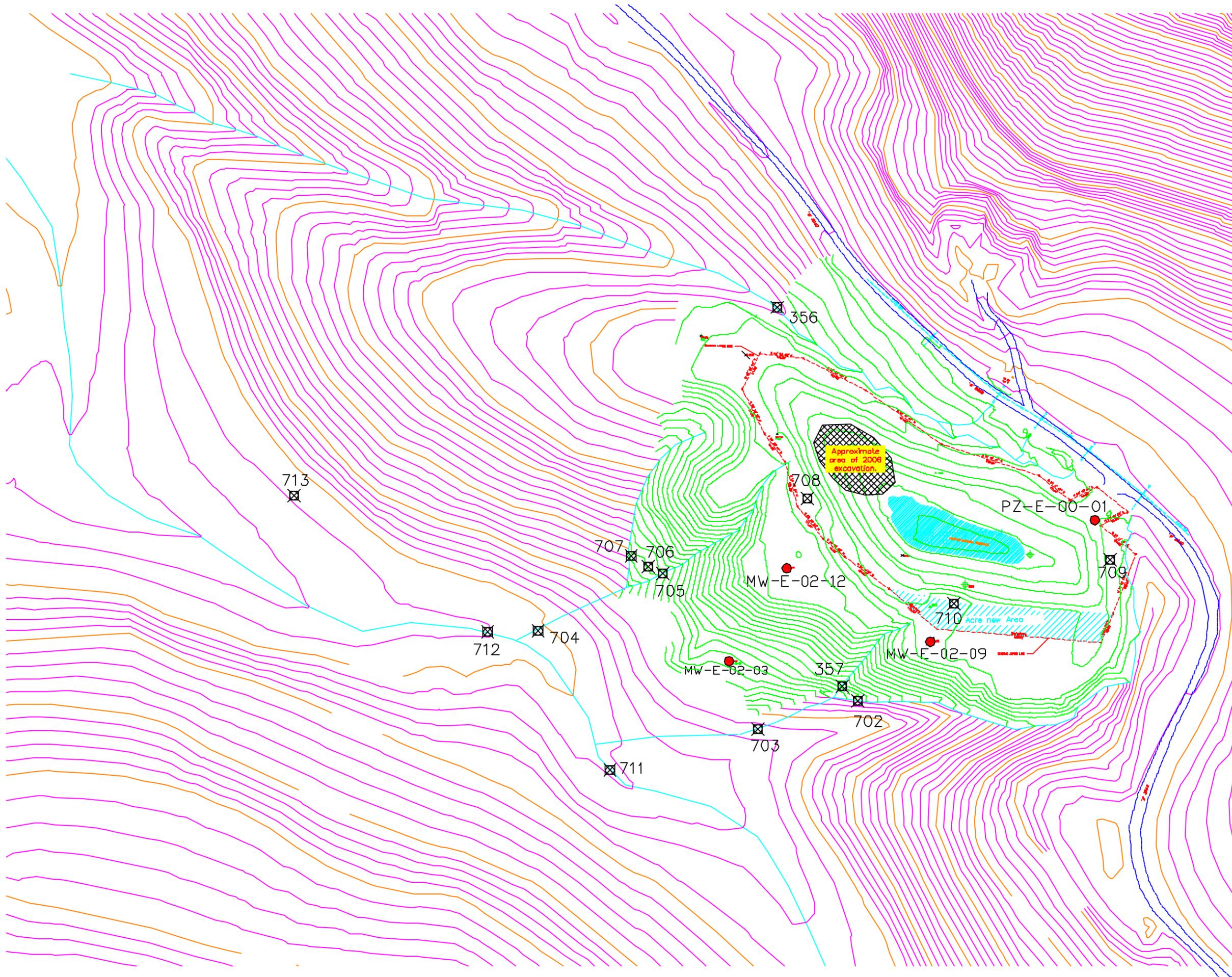
Klohn Crippen, Evaluation of Co-Disposal of Production Rock and Filter Pressed Tailings, May 2005.

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



KENECOTT GREENS CREEK MINE ADMIRALTY ISLAND, ALASKA	
FIGURE 2-2 WASTE SITE E ASBUILT	
DATE: 1-16-03	PREPARED BY: GREENS CREEK MINING CO.
DRAWN BY: Shelby Edwards	ALASKA PERMITS (907)780-8448 FAX (907)84-8448
DESIGN BY: ---	SCALE: ---
REVIEWED BY: ---	SHEET: 1 OF 1
PROJ. OR REF.:	

Figure 2.3 2006 Inactive Production Rock Site Acid-Base Accounting Analyses

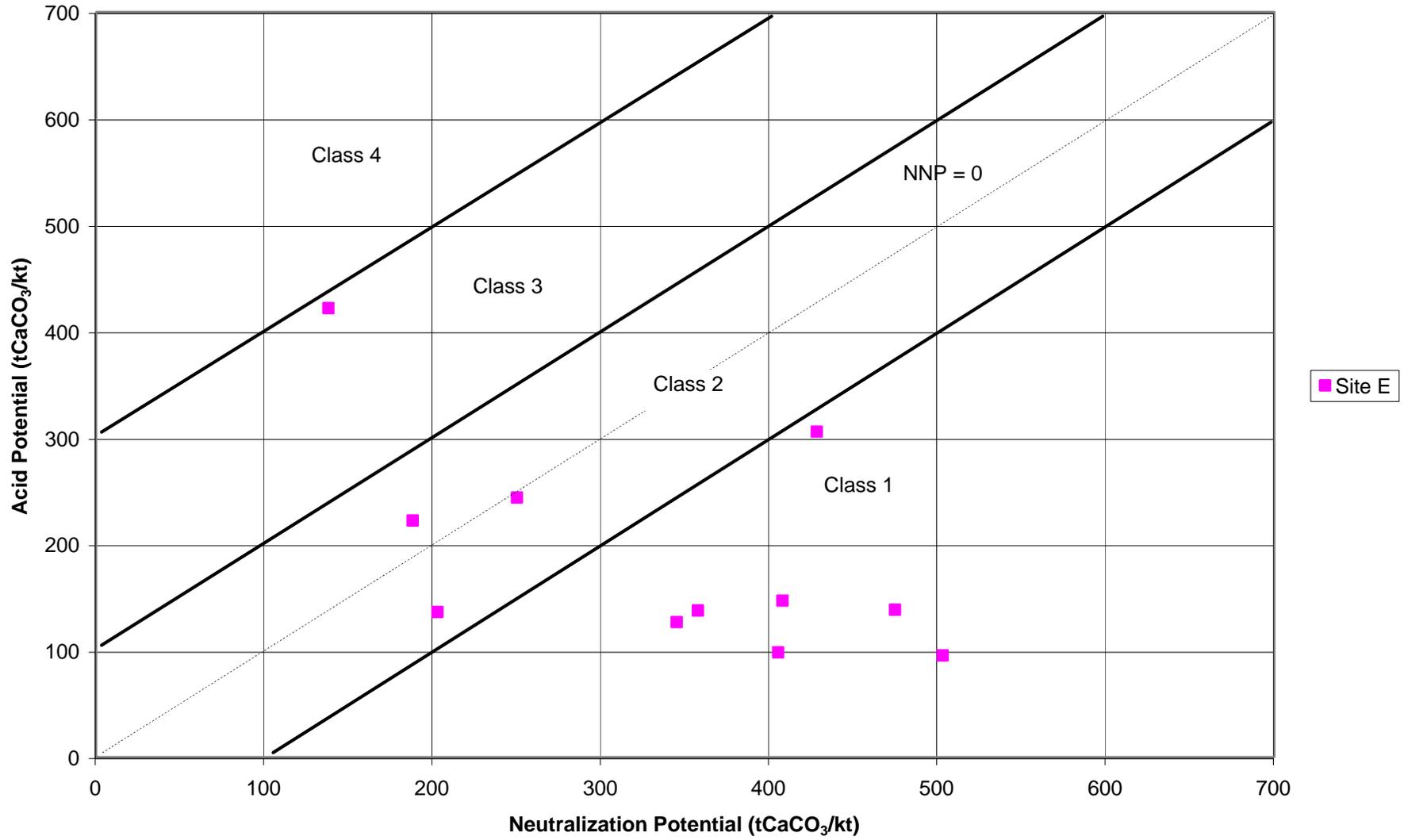




Figure 2.4 Photo of Site E excavation area, Oct-2006 (USFS).

Figure 2.6 Inactive Production Rock Site pH Data

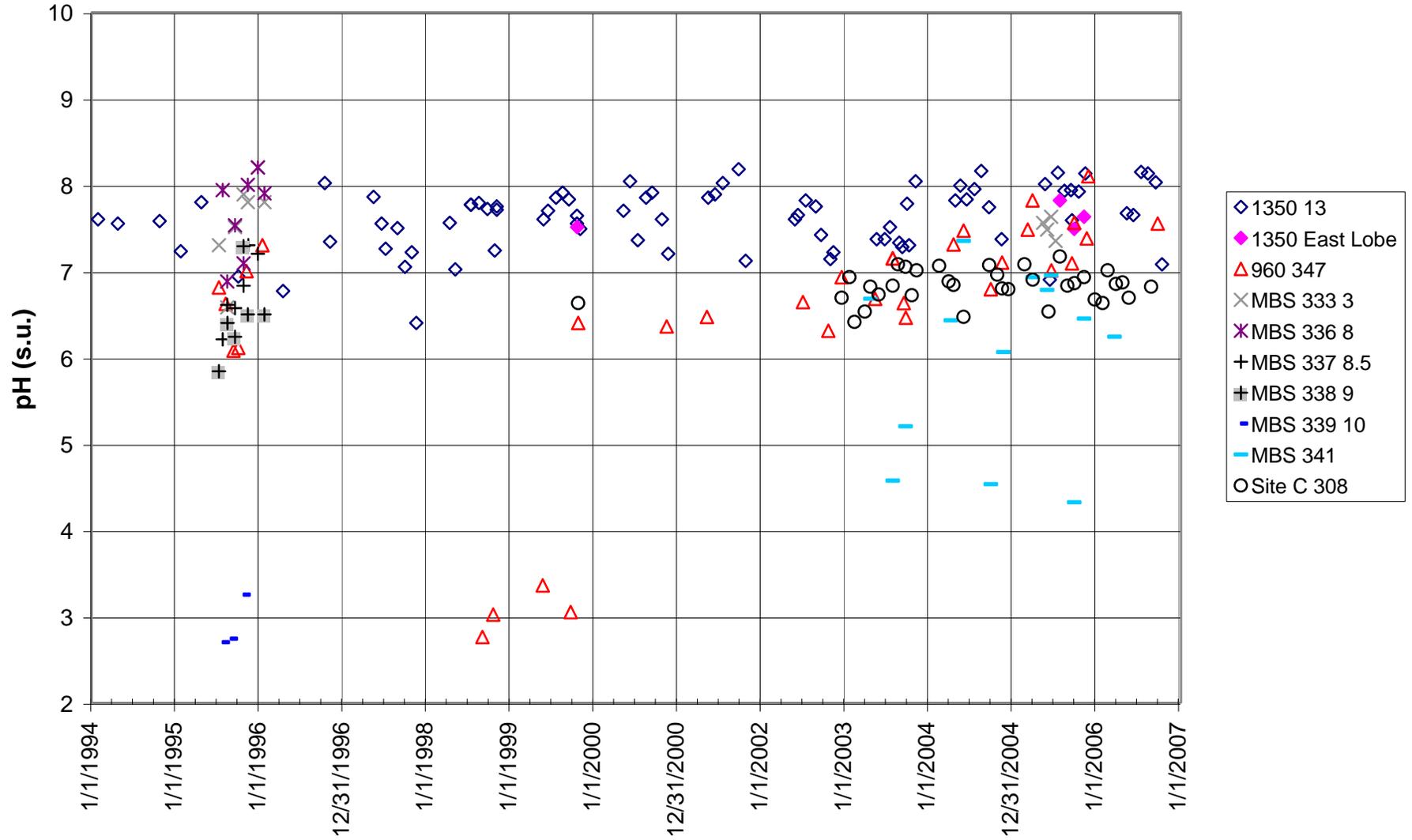


Figure 2.8 Inactive Production Rock Site Conductivity Data

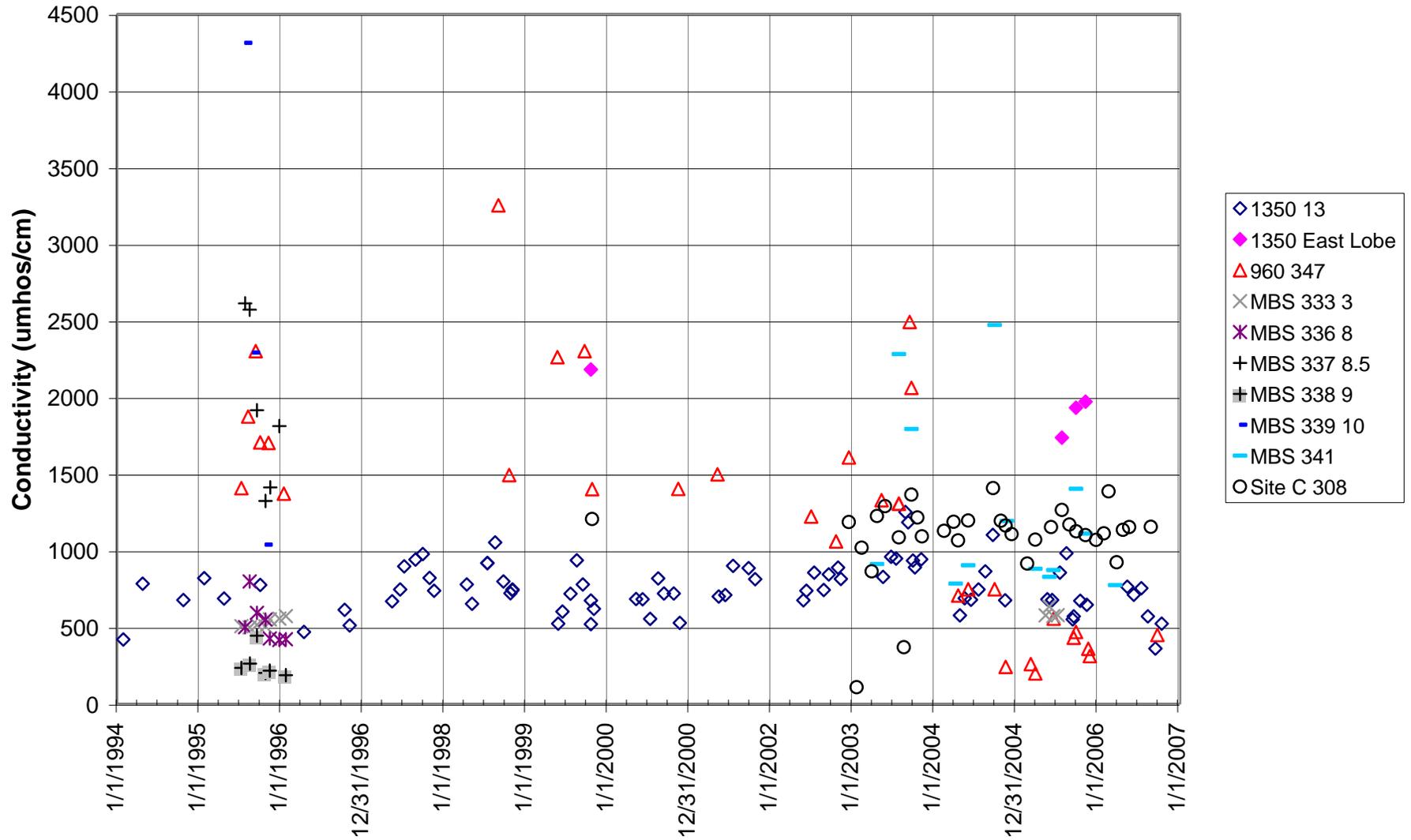


Figure 2.9 Inactive Production Rock Site Sulfate Data

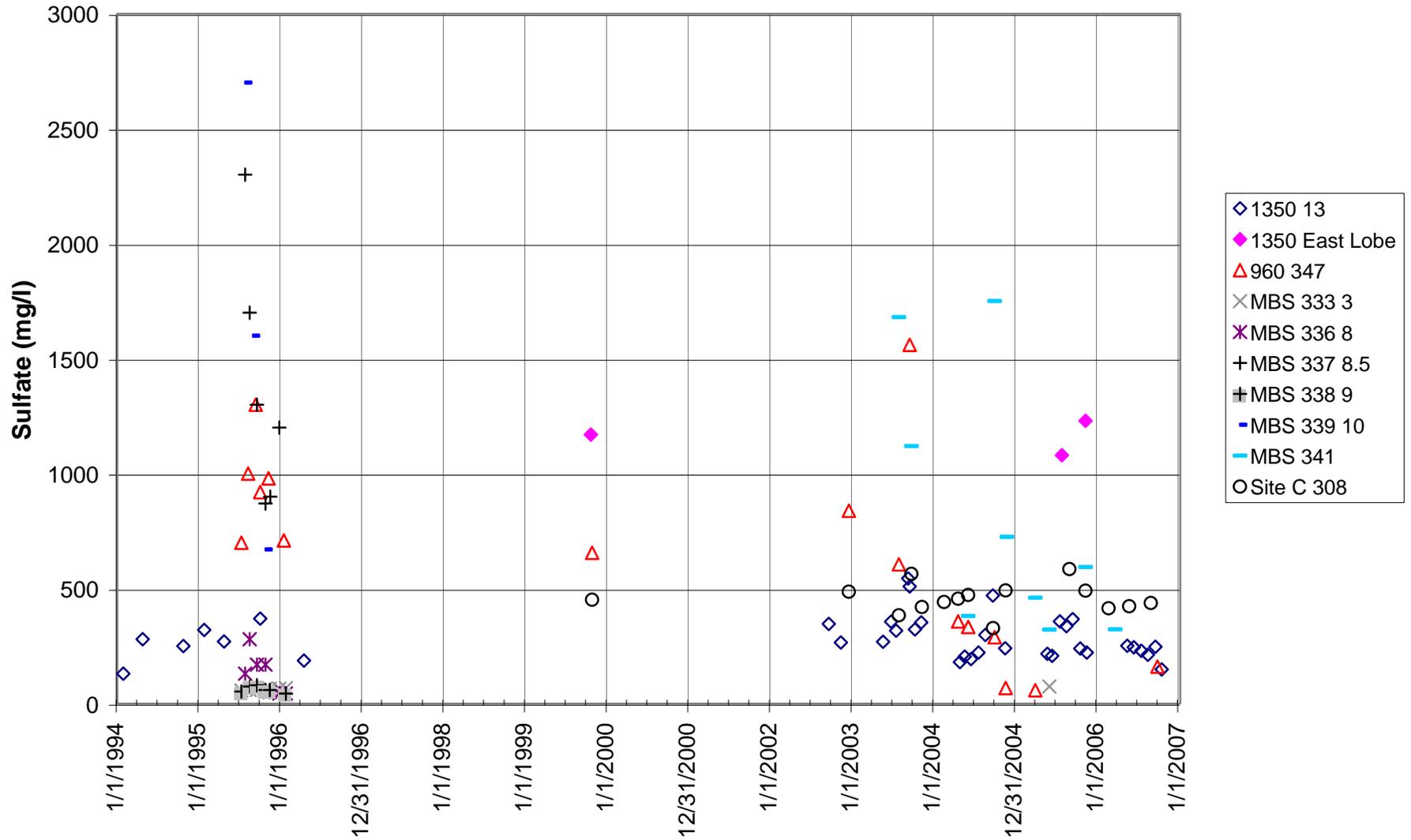


Figure 2.10 Inactive Production Rock Site Magnesium Data

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

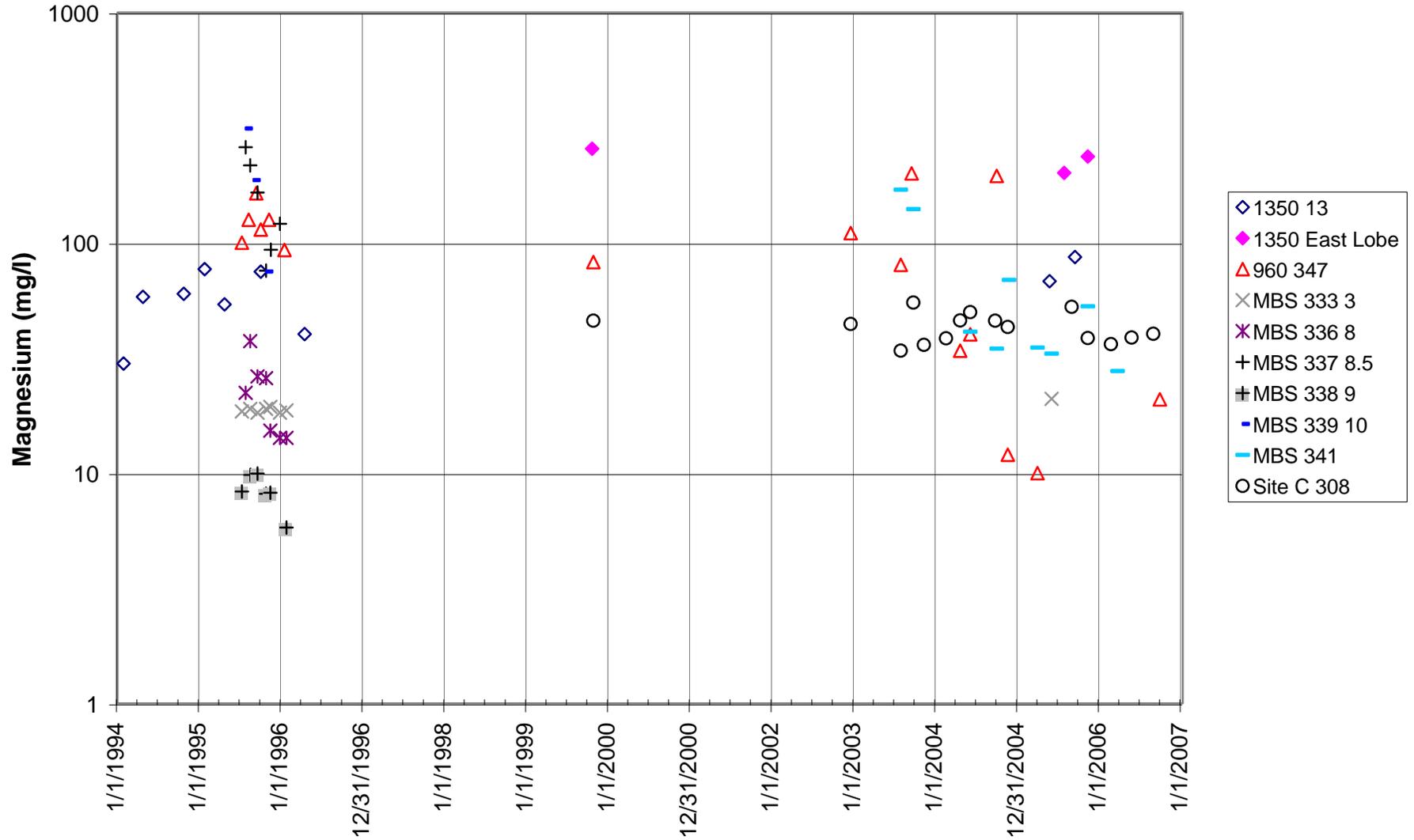


Figure 2.11 Inactive Production Rock Site Hardness Data

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

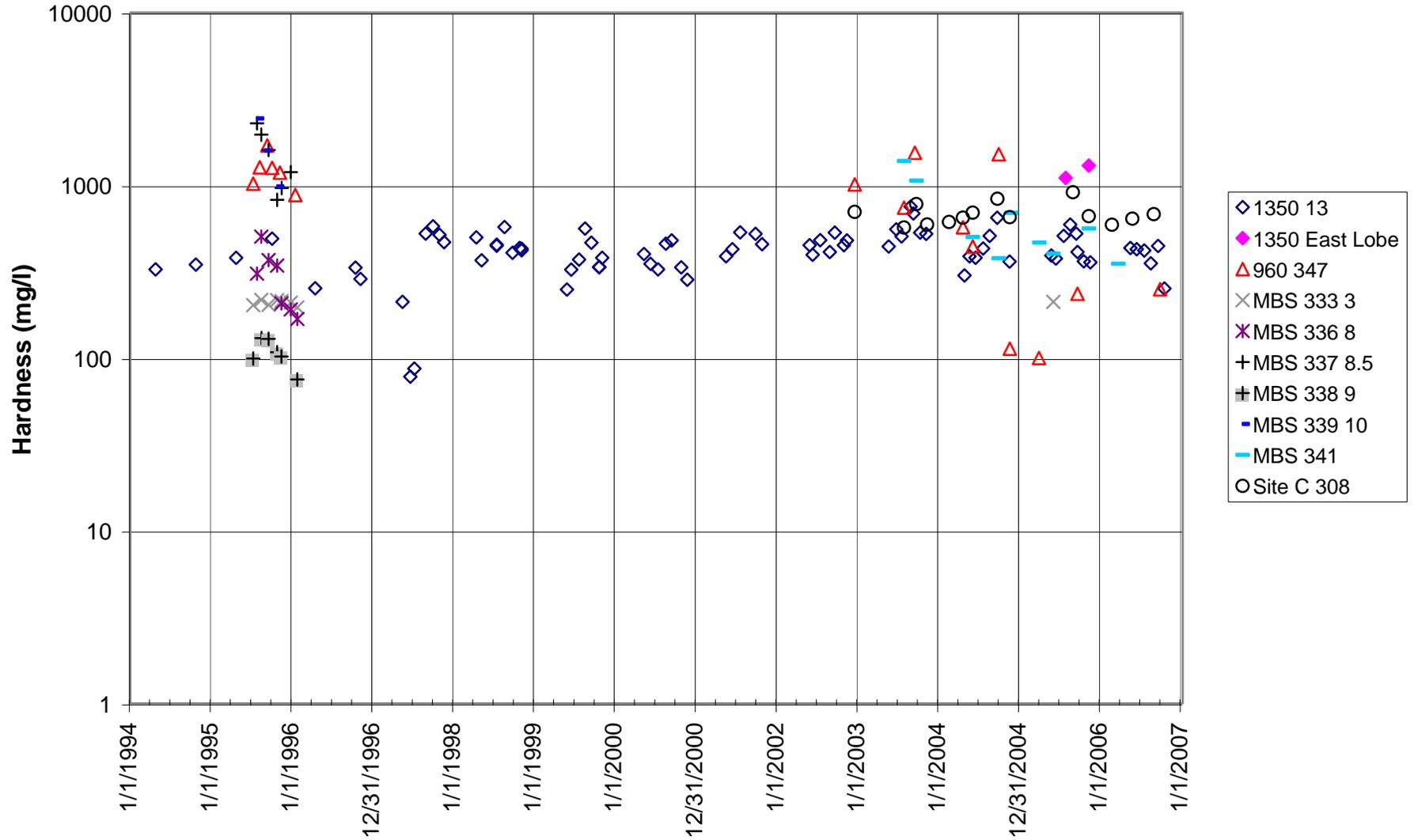


Figure 2.12 Inactive Production Rock Site Zinc Data

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

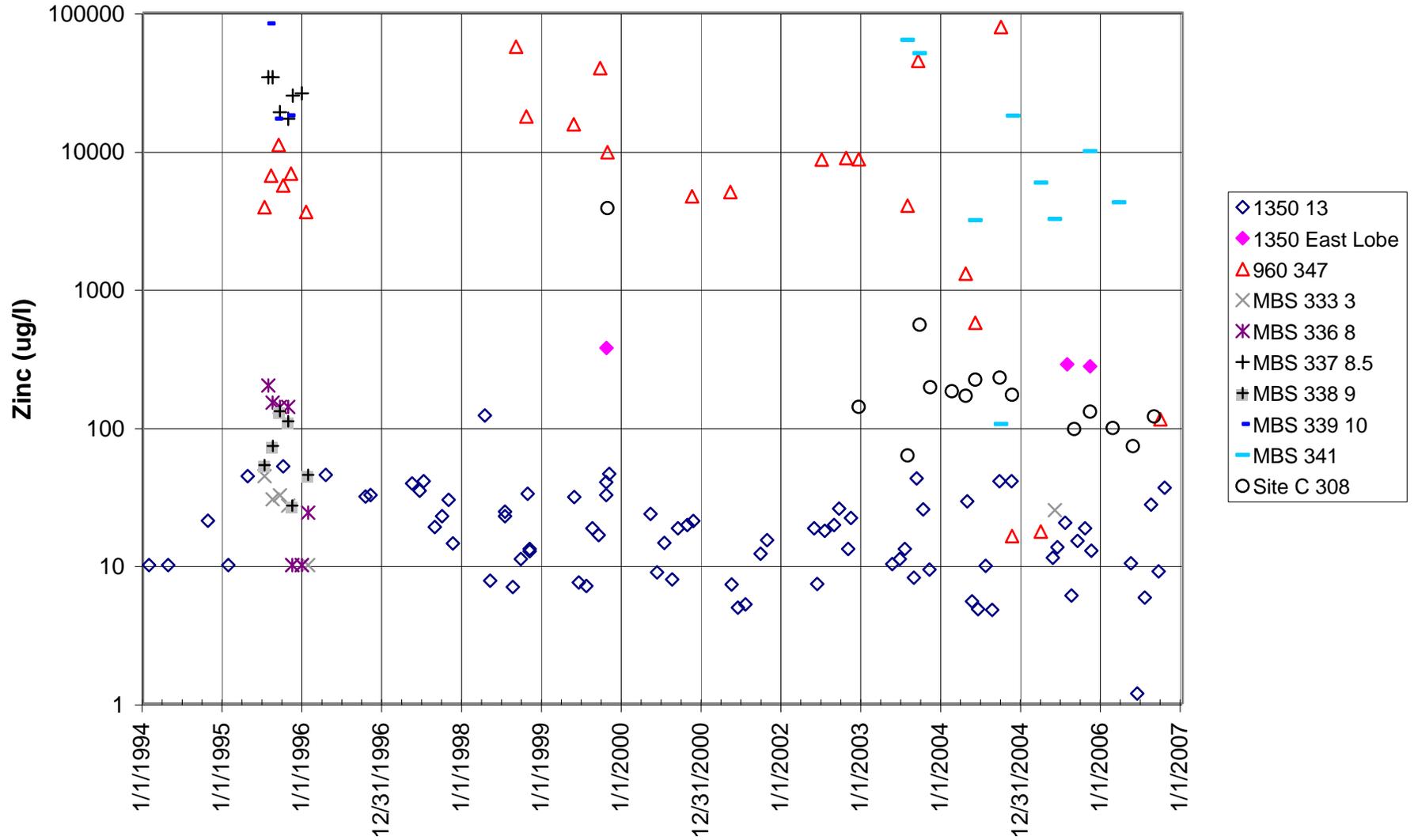


Figure 2.14 Inactive Production Rock Site Lead Data

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

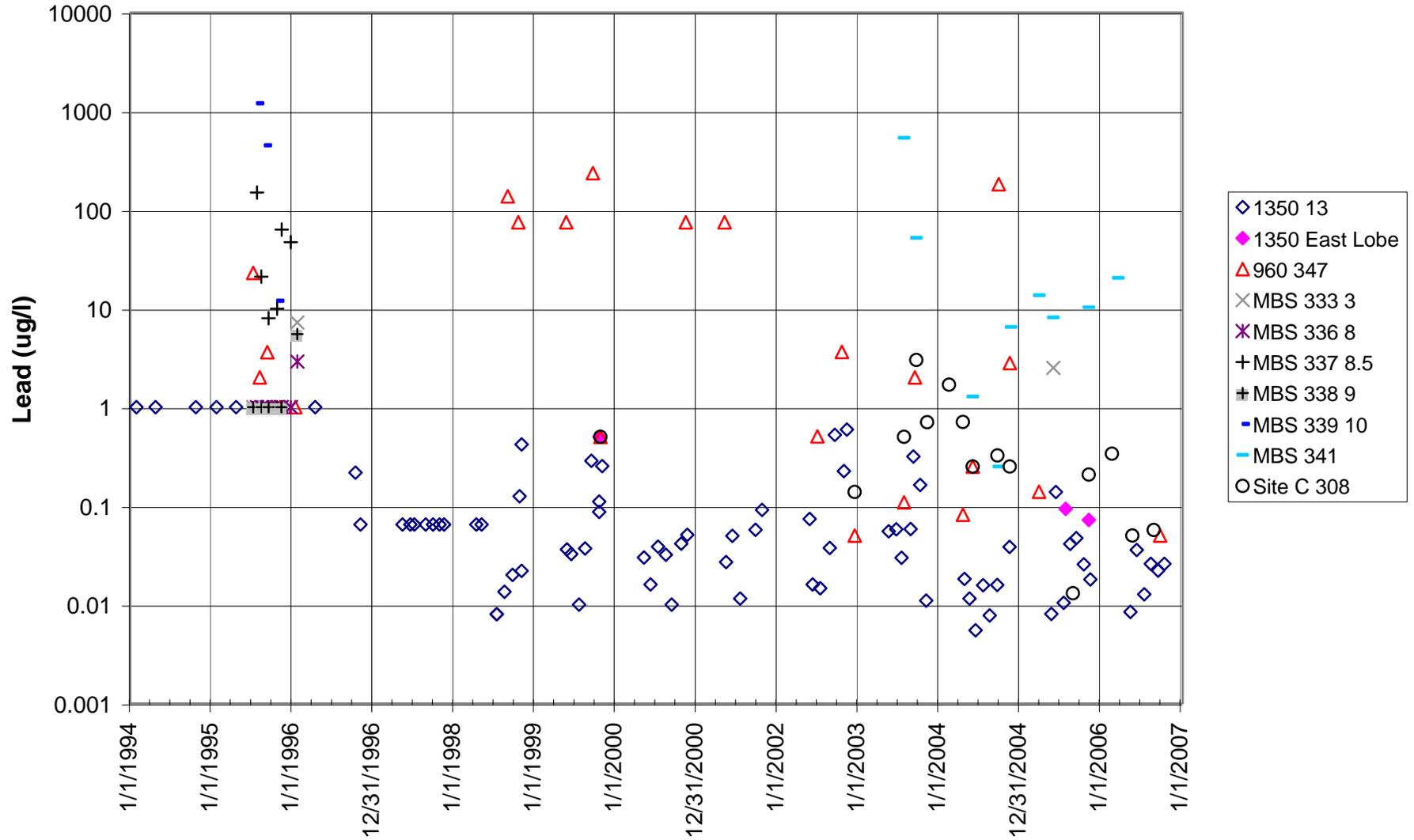


Figure 2.16 Inactive Production Rock Site Nickel Data

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

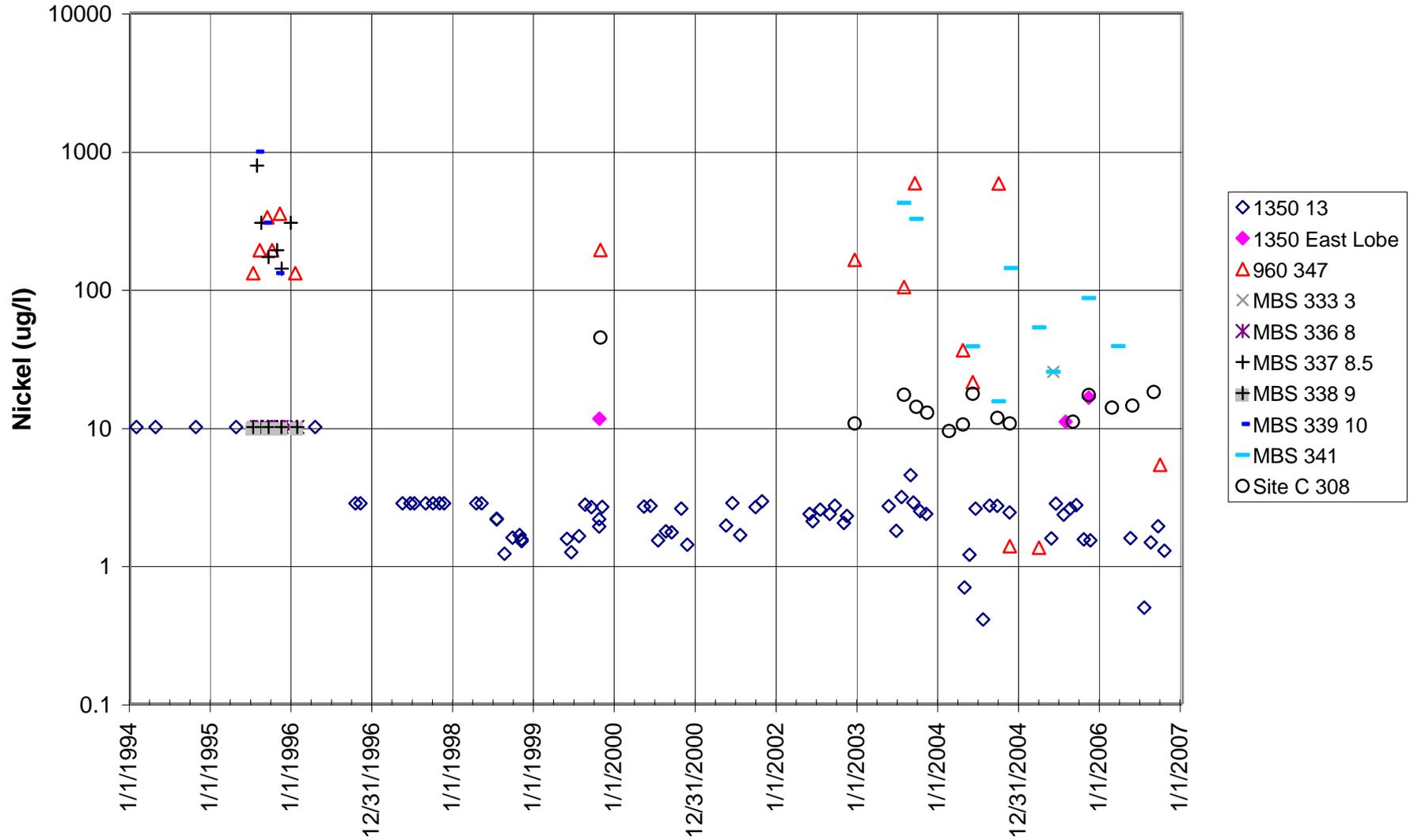


Figure 2.17 Inactive Production Rock Site Arsenic Data

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

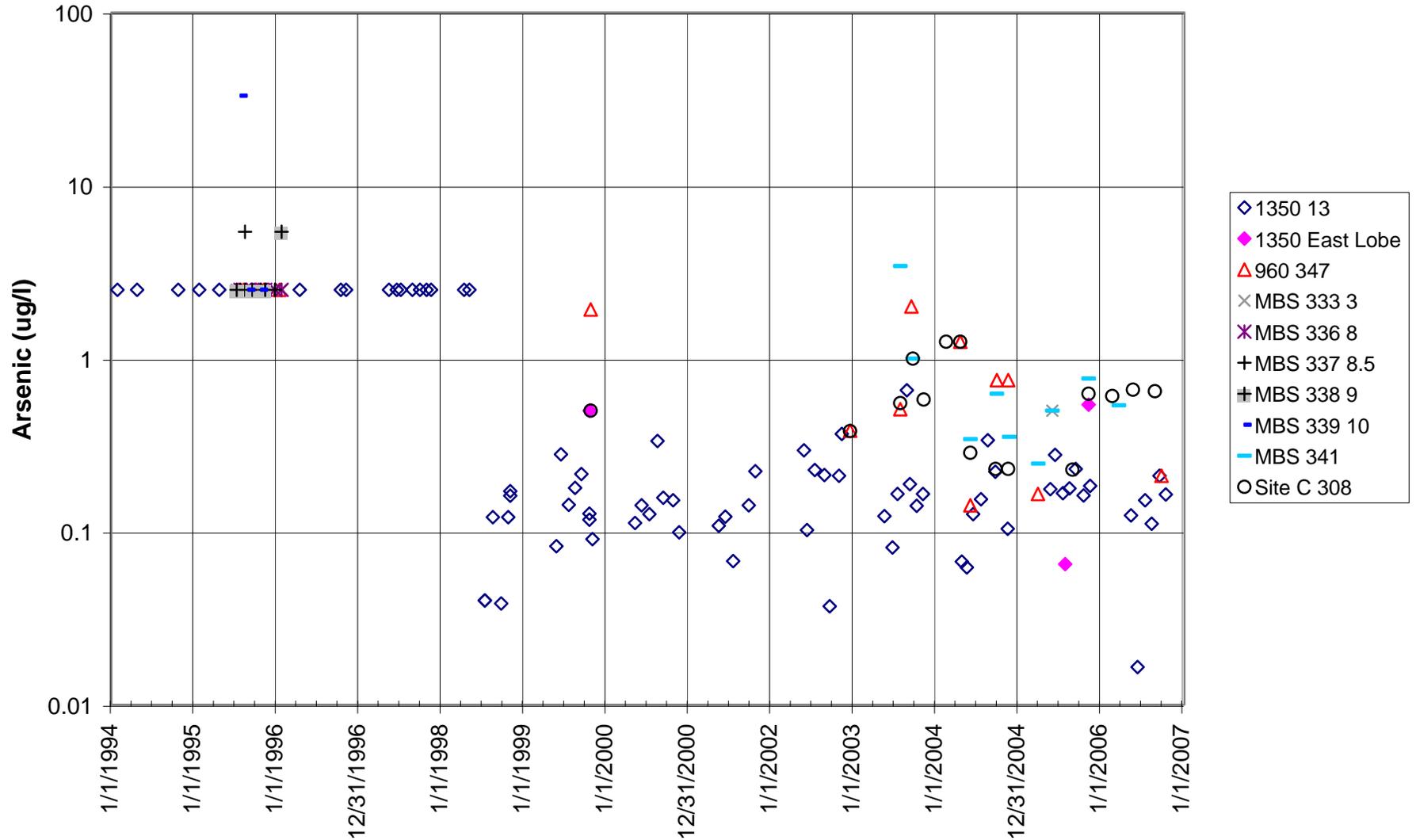


Figure 2.18 Inactive Production Rock Site Iron Data

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

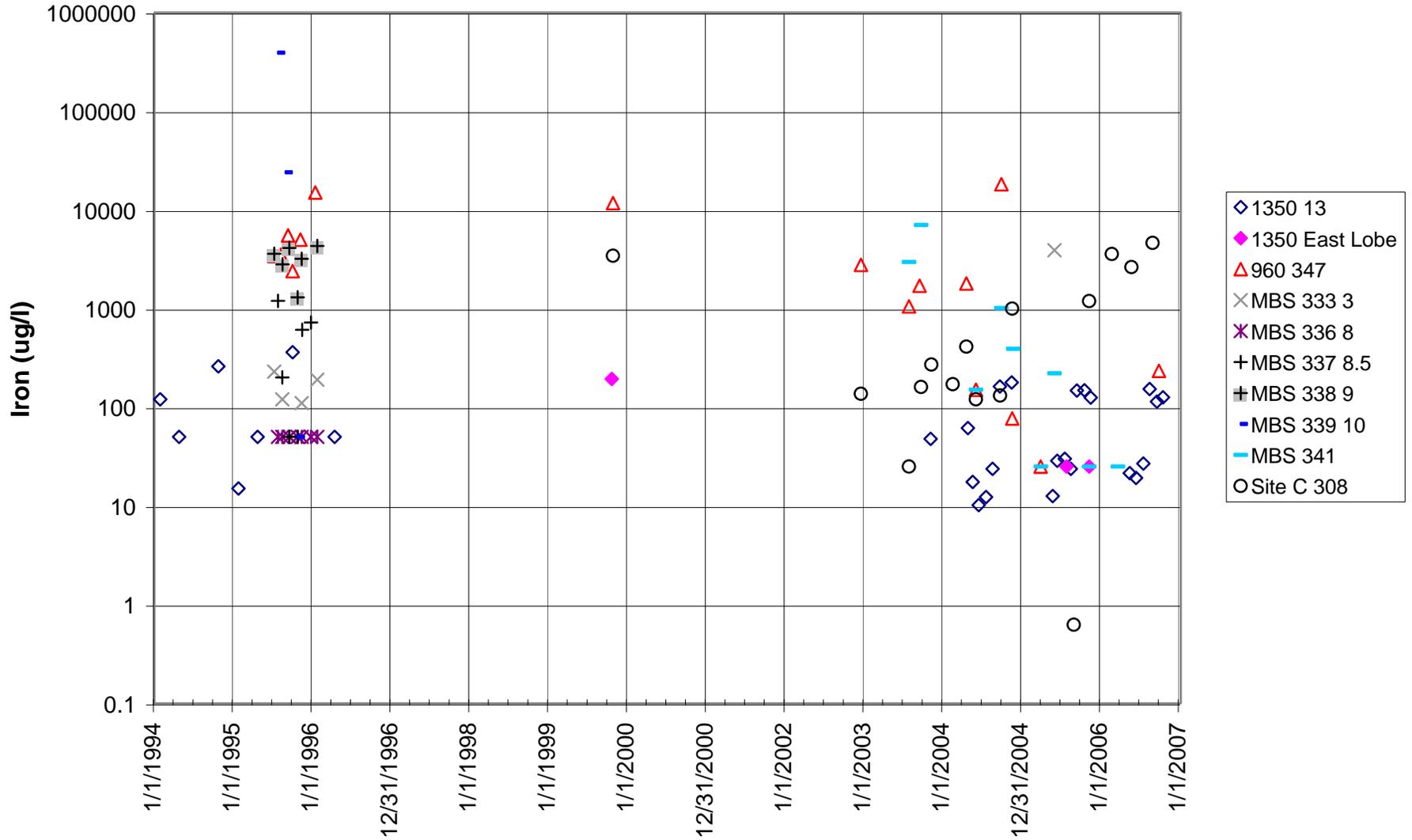


Figure 2.19 Inactive Production Rock Site Manganese Data

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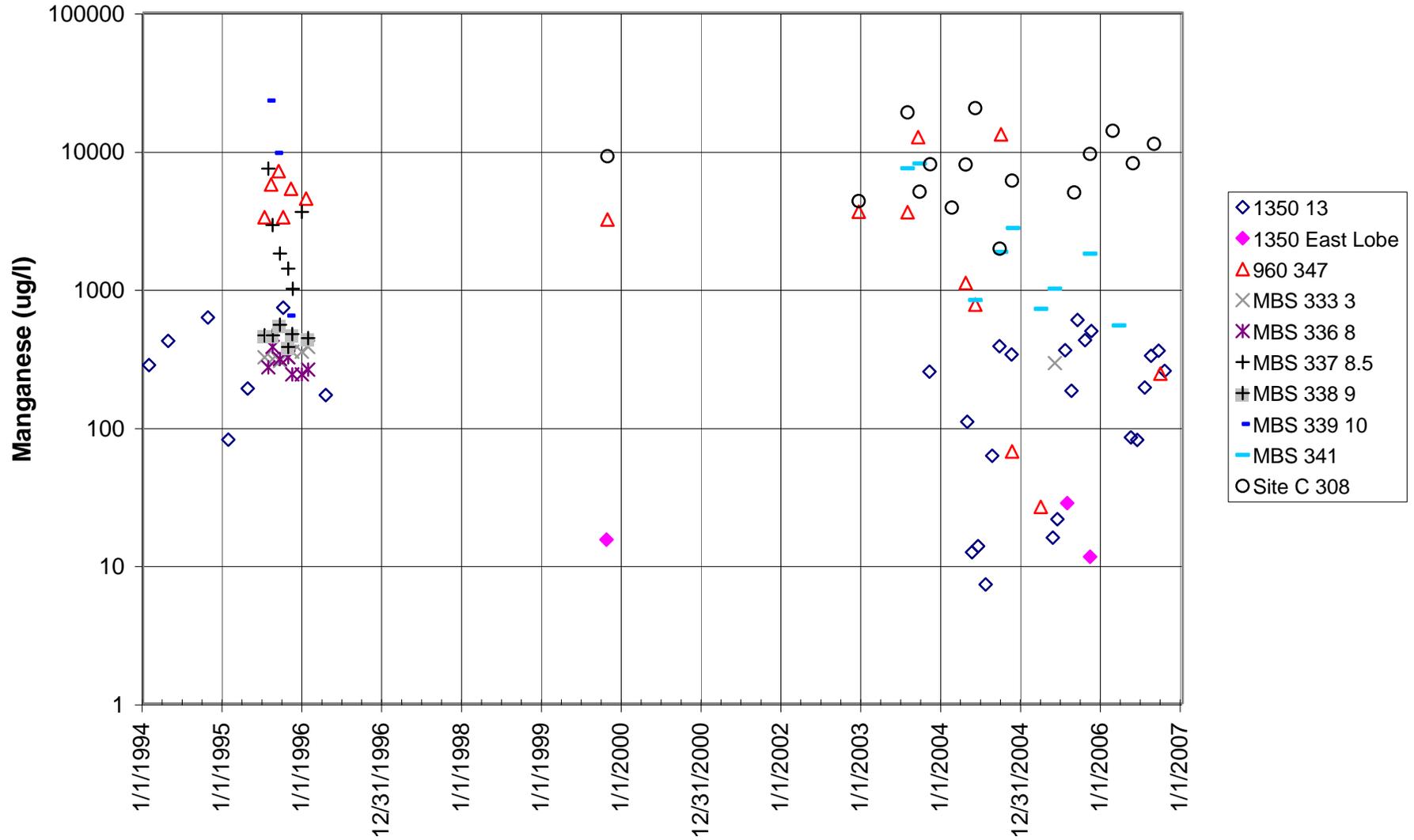


Figure 2.20 Inactive Production Rock Site E Flow Data

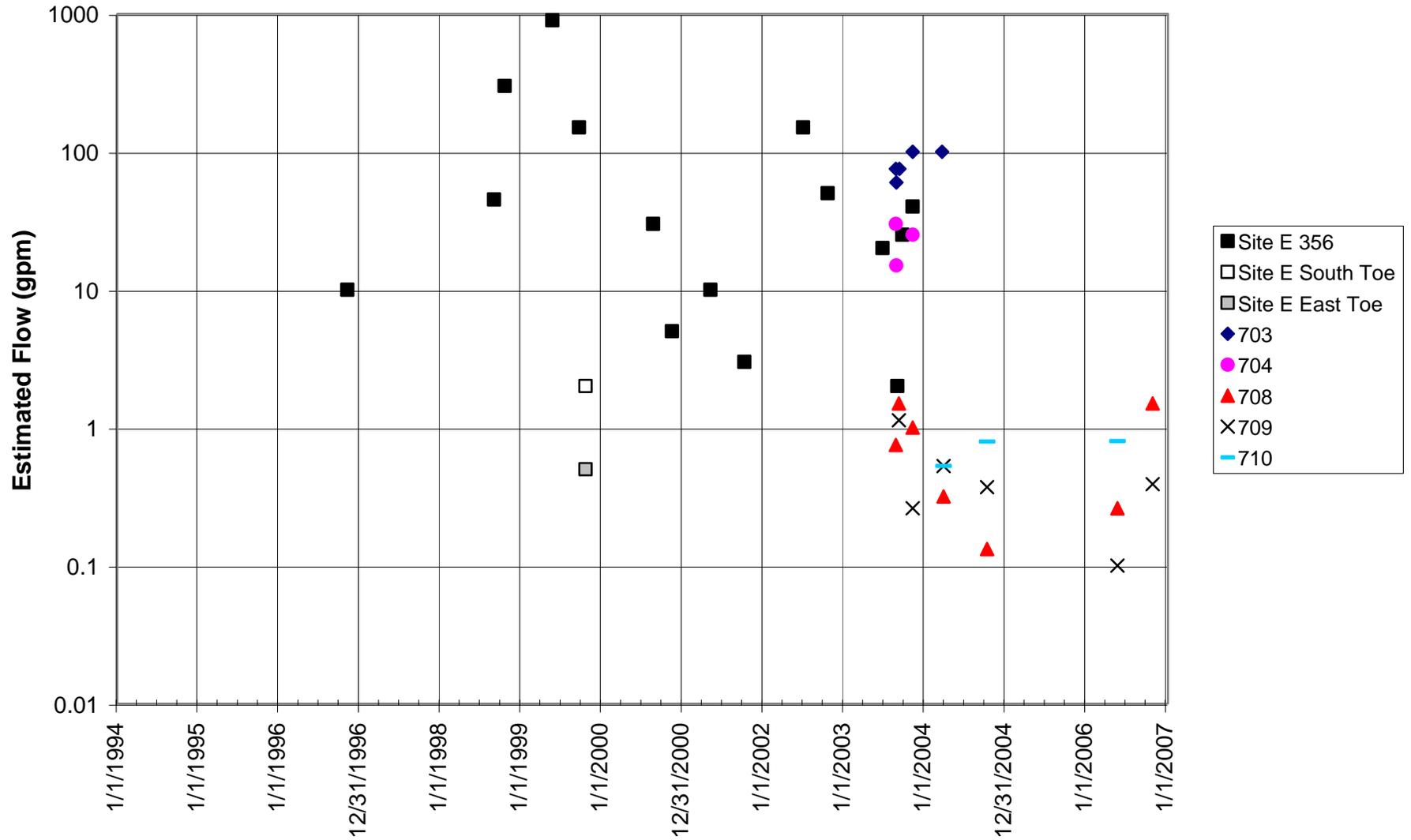


Figure 2.22 Inactive Production Rock Site E Alkalinity Data

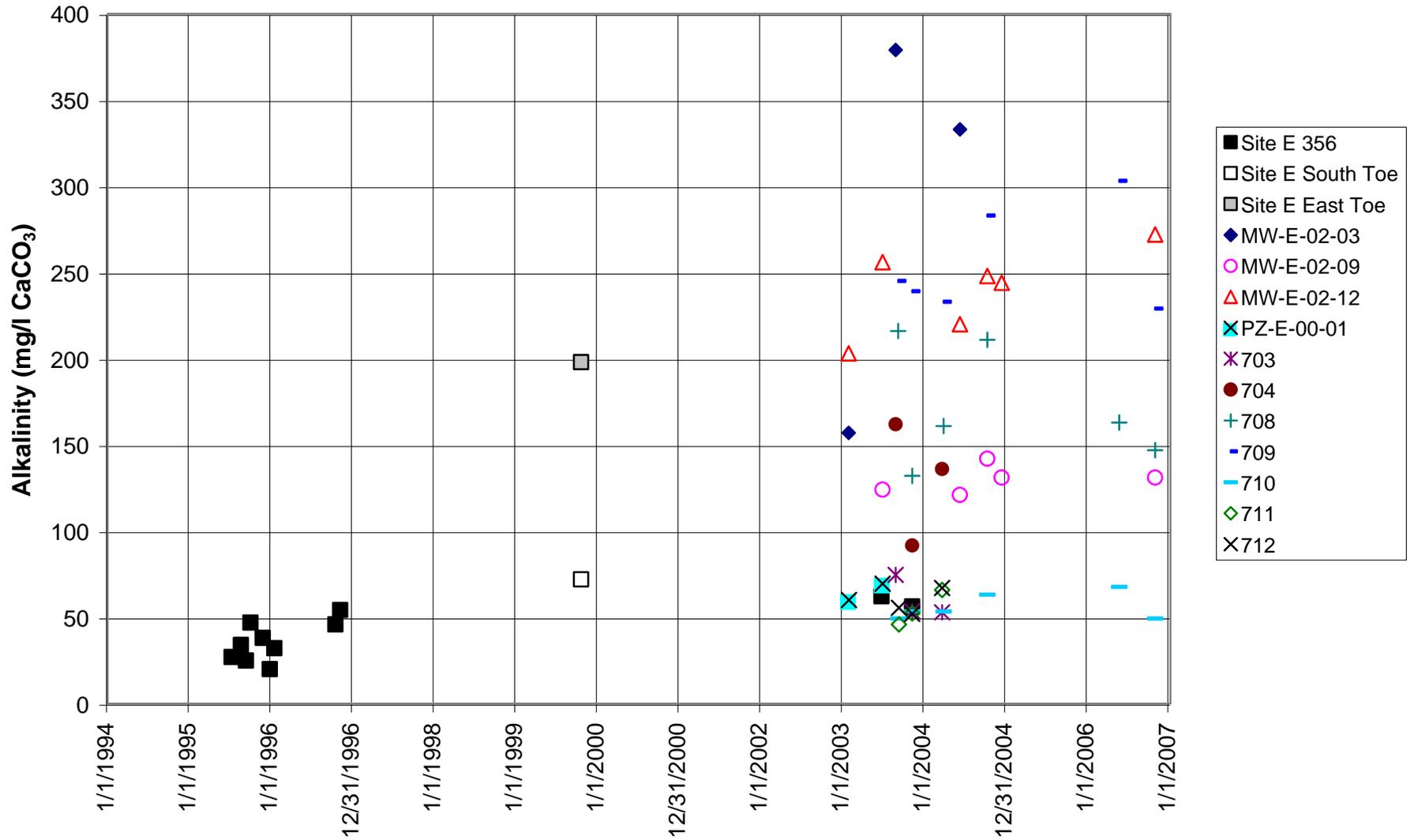


Figure 2.23 Inactive Production Rock Site E Conductivity Data

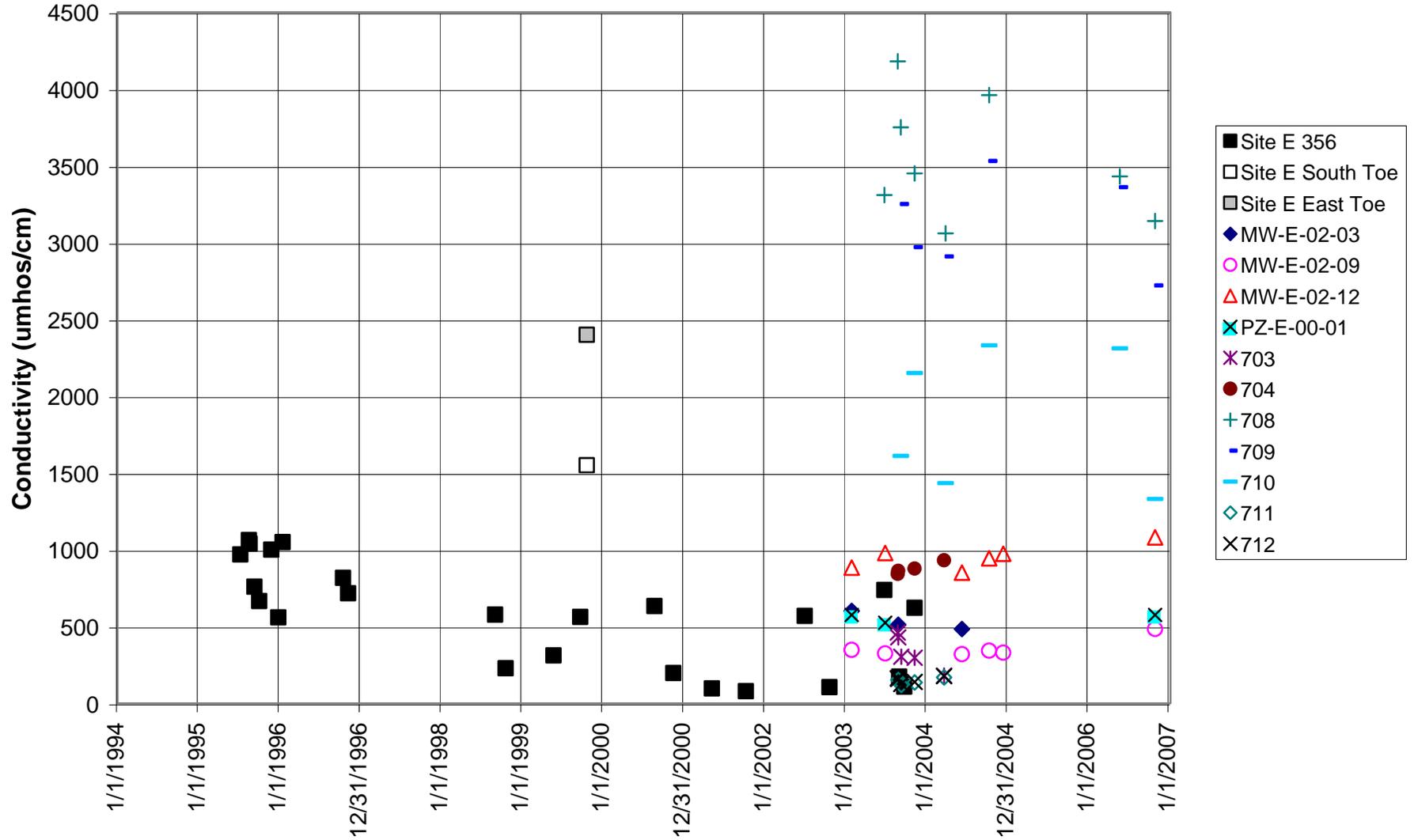


Figure 2.24 Inactive Production Rock Site E Sulfate Data

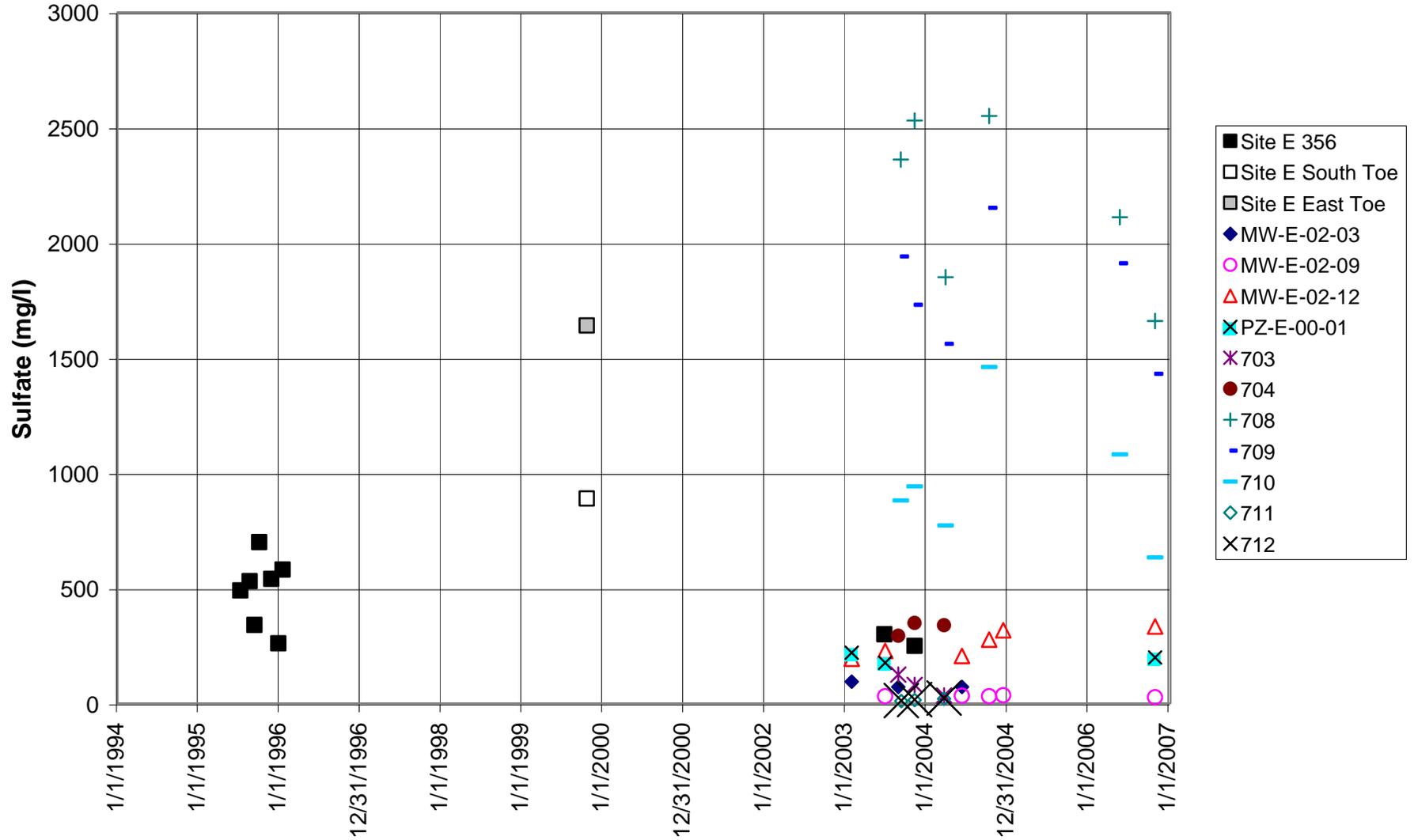


Figure 2.25 Inactive Production Rock Site E Magnesium Data

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

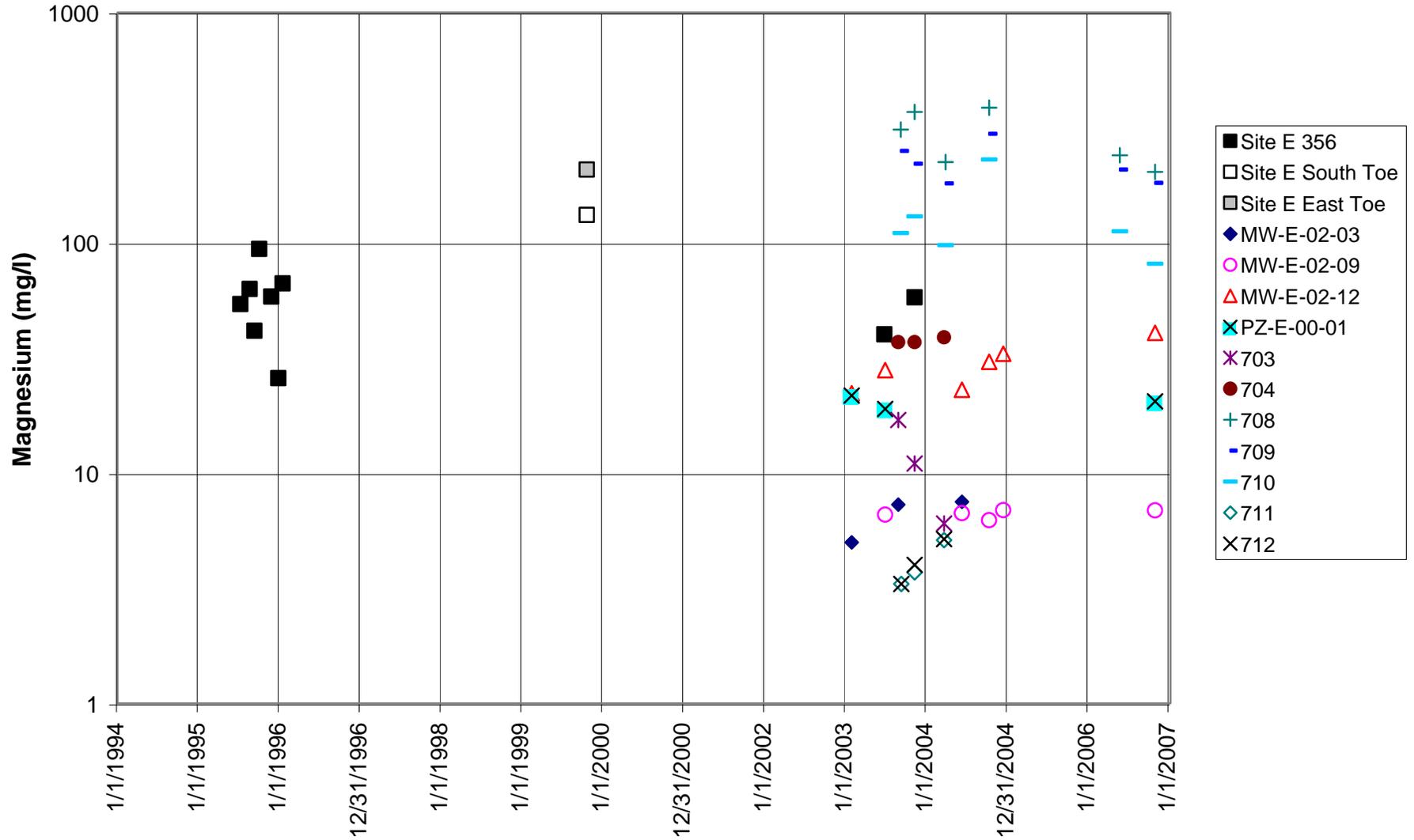


Figure 2.26 Inactive Production Rock Site E Hardness Data

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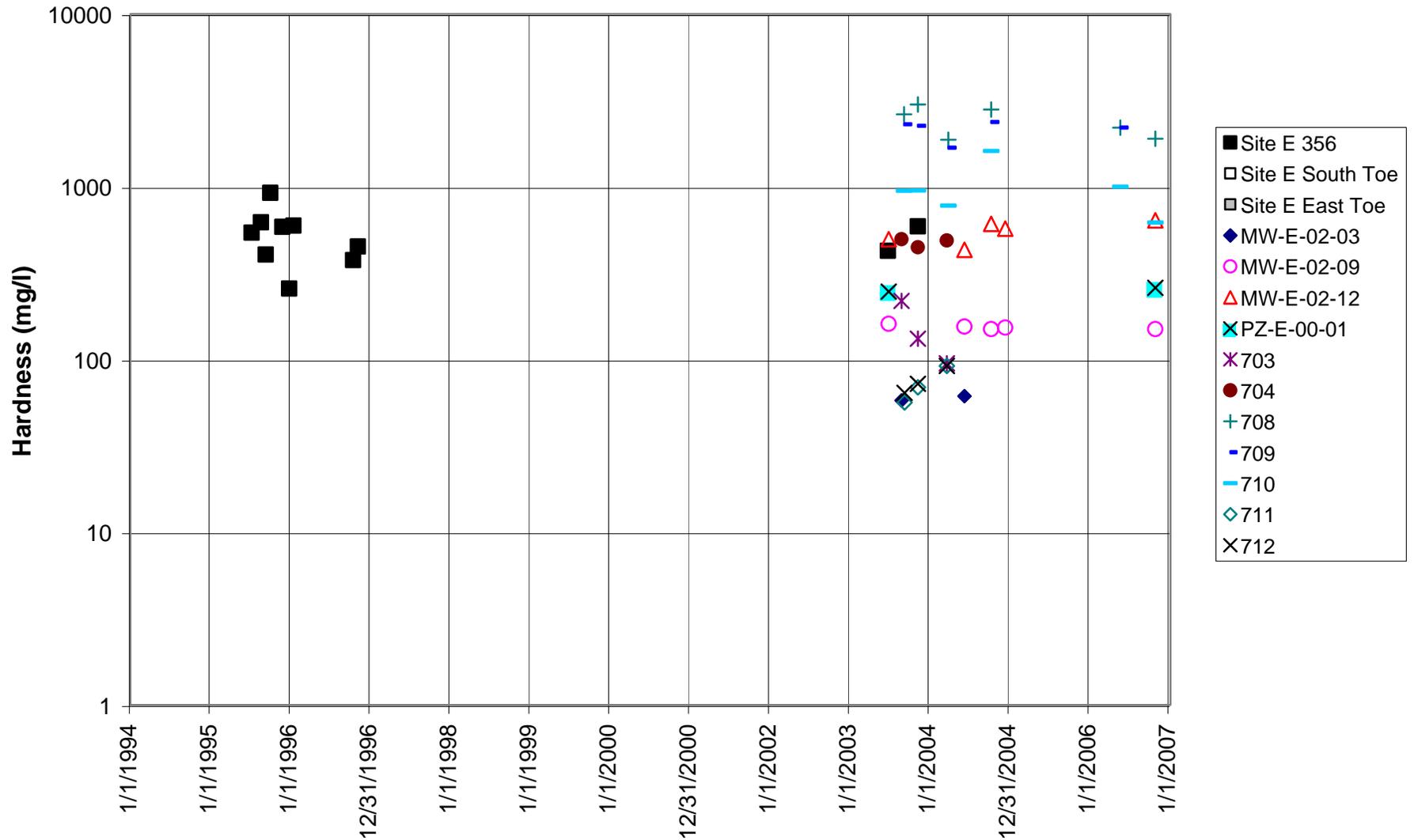


Figure 2.27 Inactive Production Rock Site E Zinc Data

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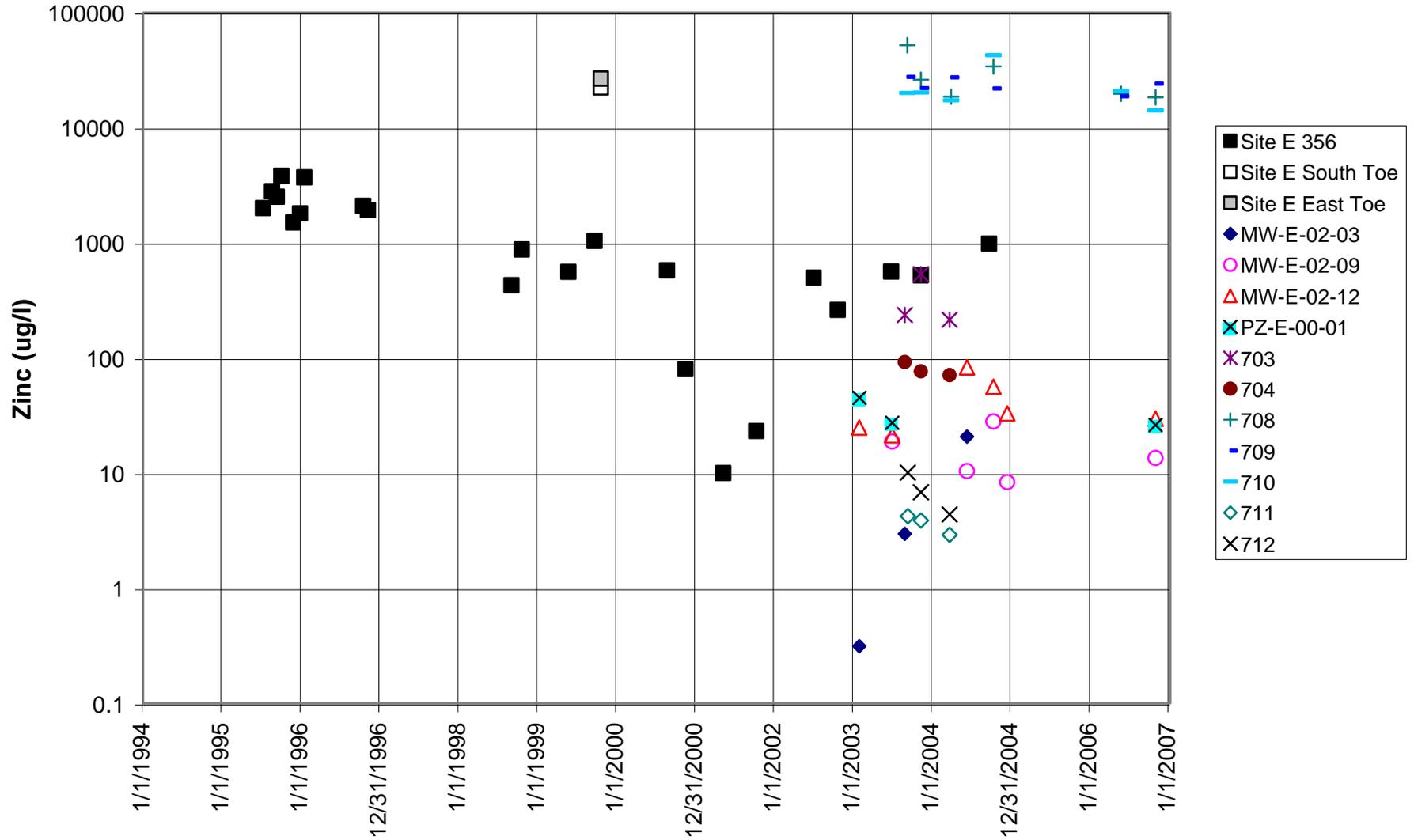


Figure 2.28 Inactive Production Rock Site E Copper Data

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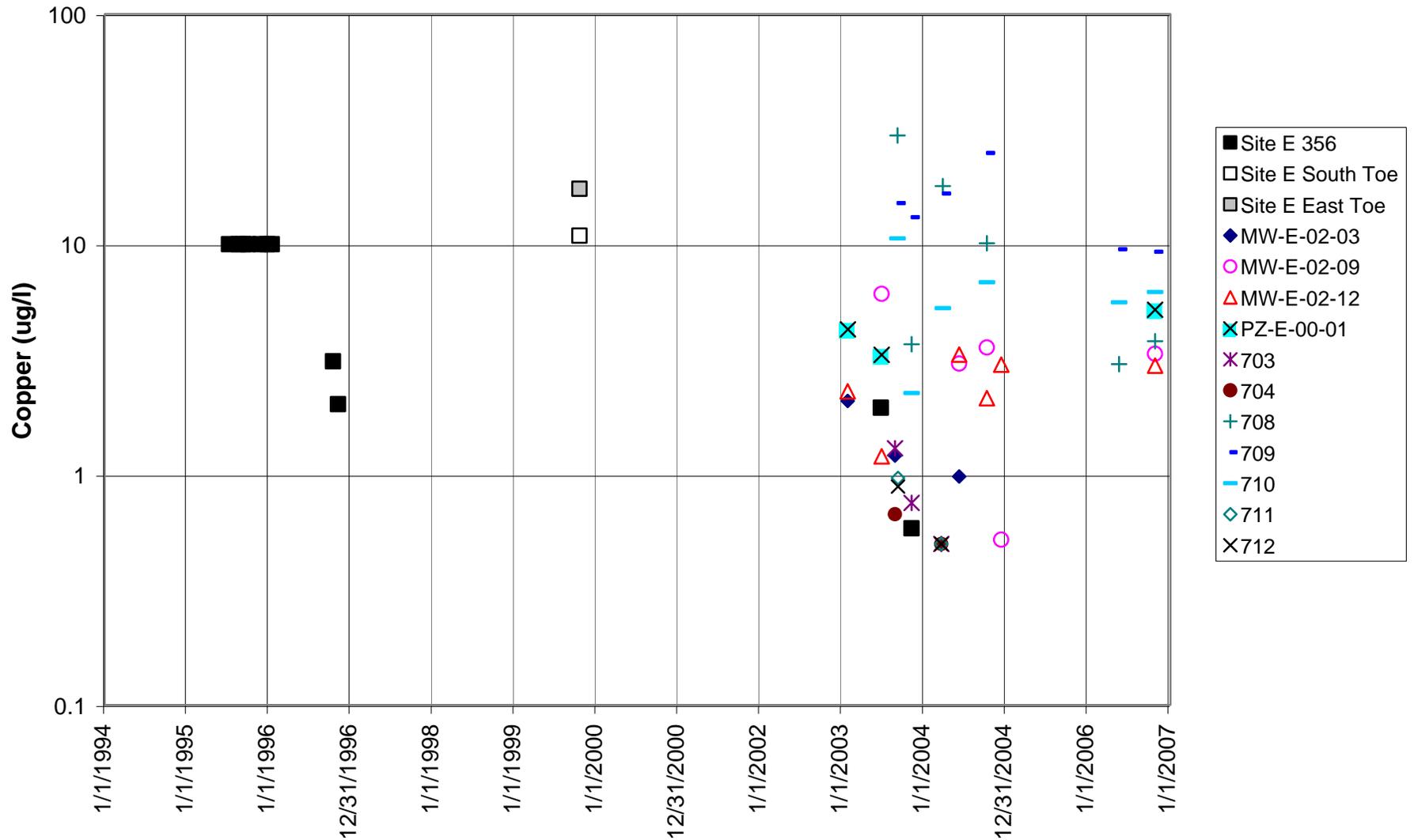


Figure 2.30 Inactive Production Rock Site E Cadmium Data

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

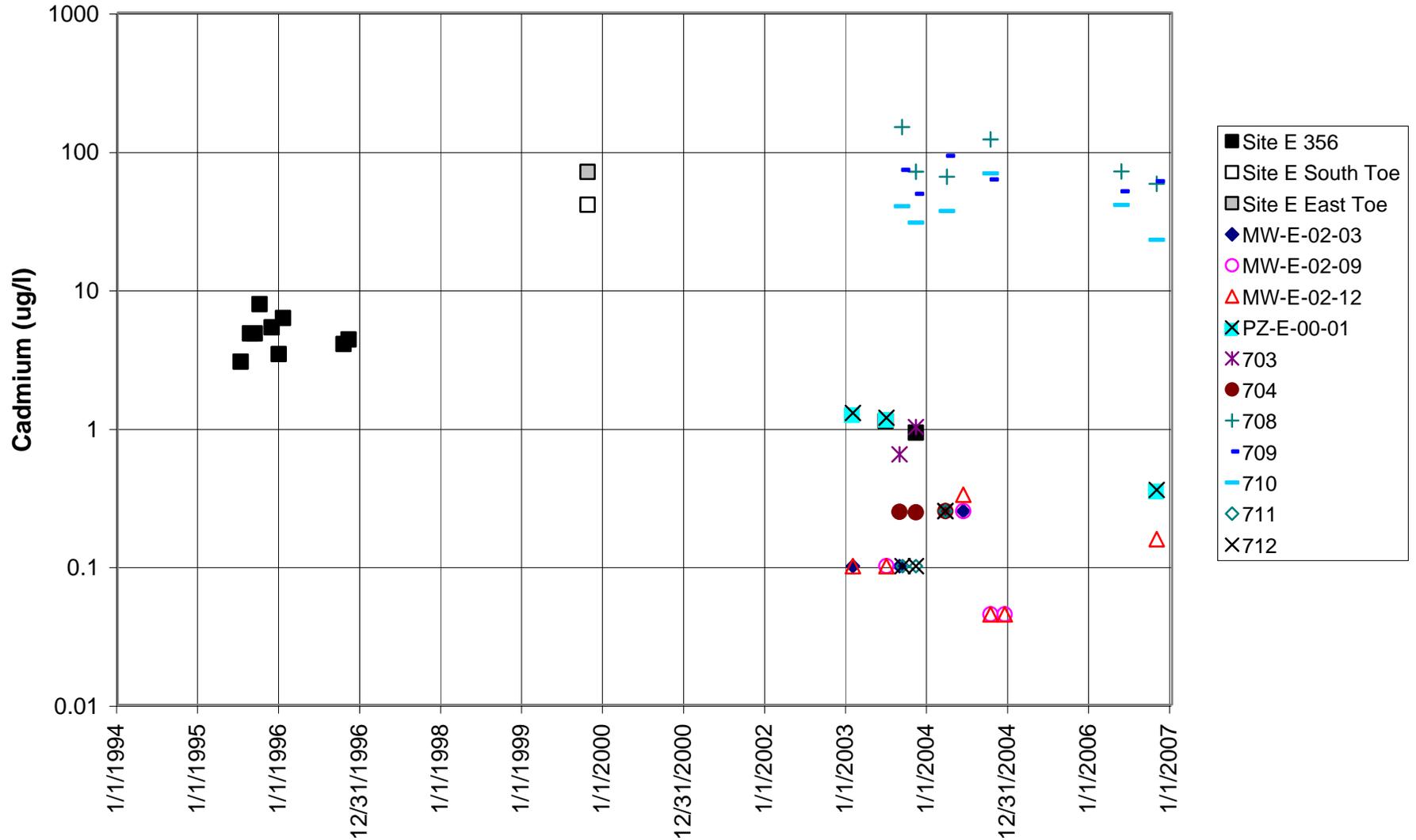


Figure 2.31 Inactive Production Rock Site E Nickel Data

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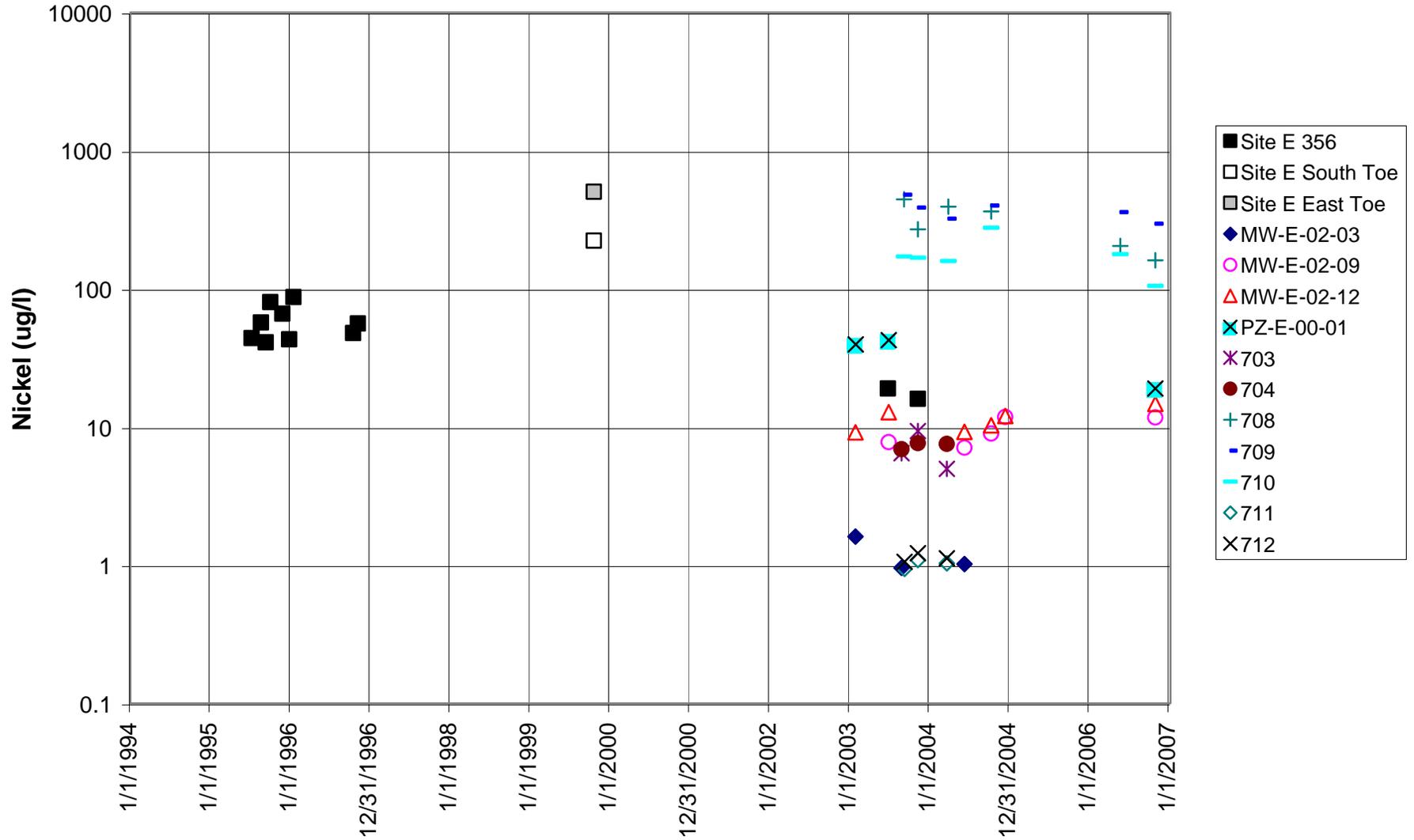


Figure 2.32 Inactive Production Rock Site E Arsenic Data

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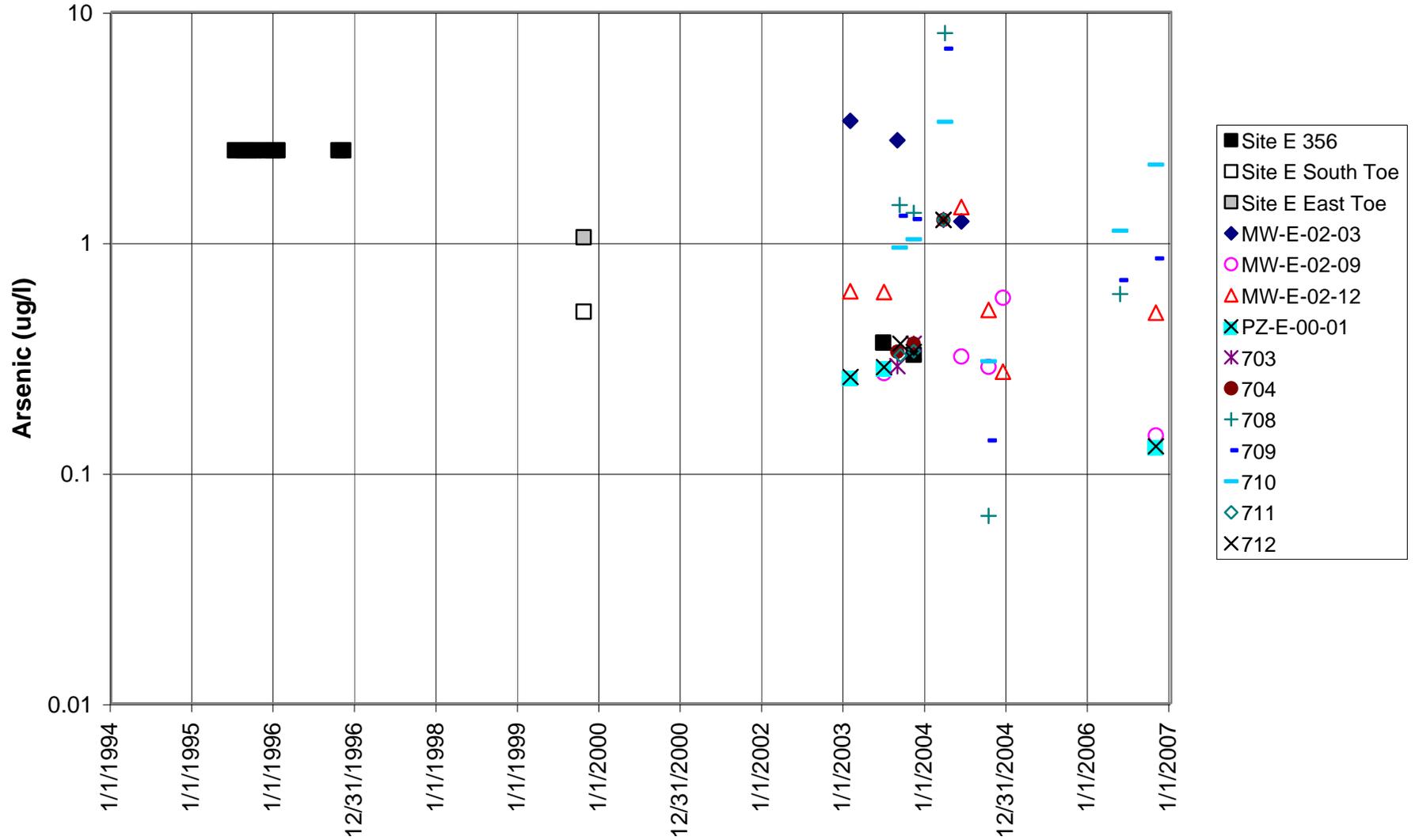


Figure 2.34 Inactive Production Rock Site E Manganese Data

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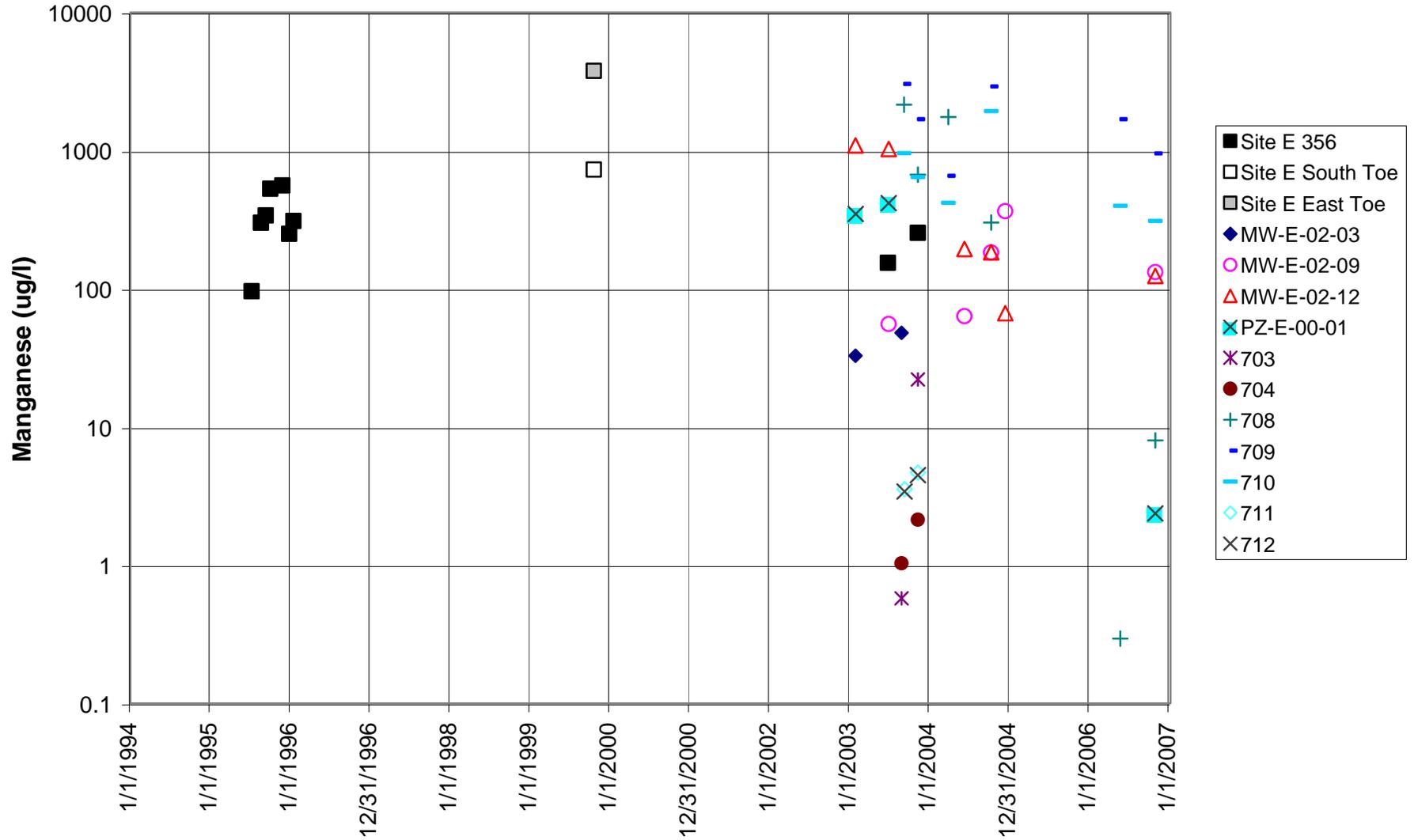


Figure 3.1 Quarry Site Flow Data

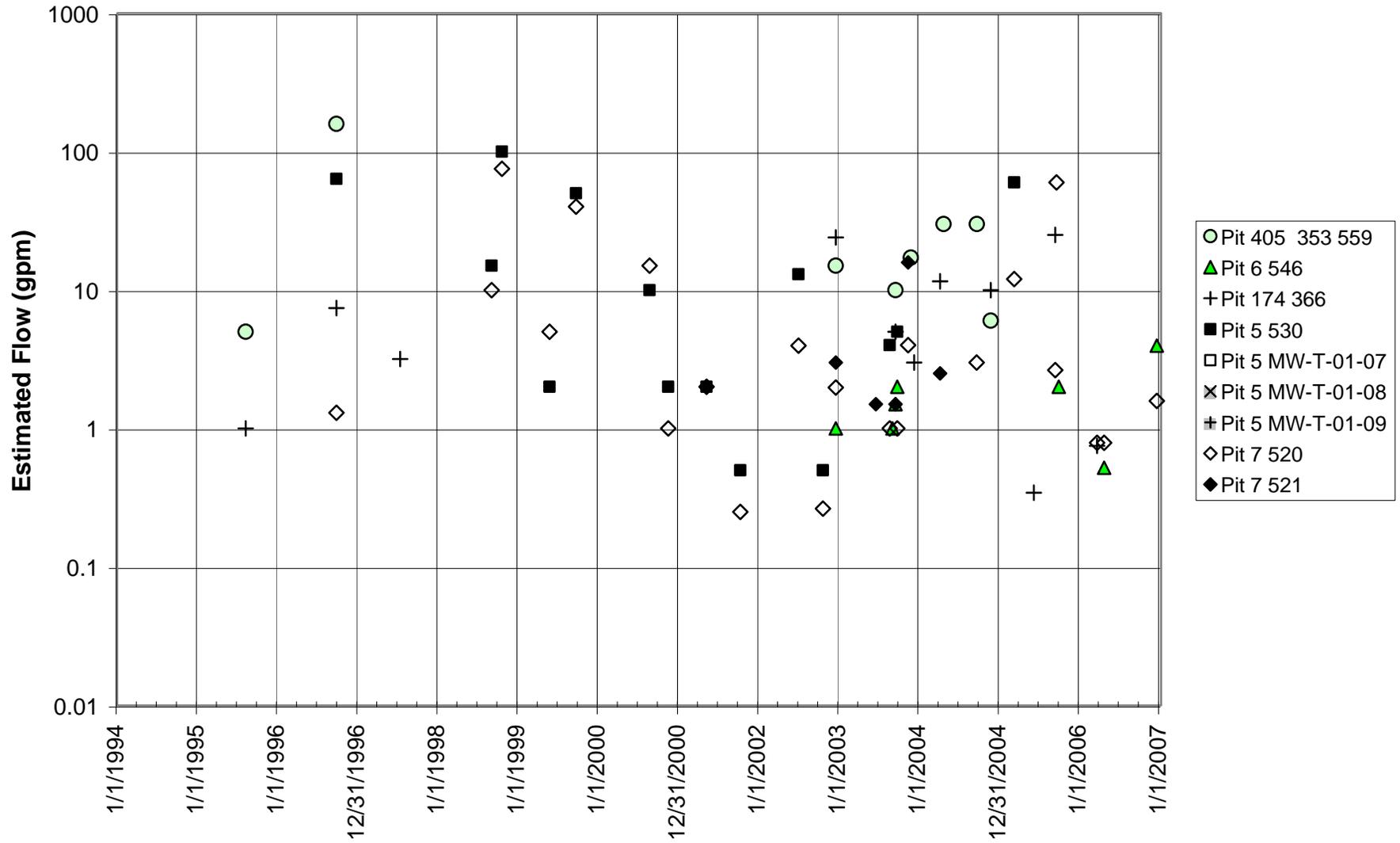


Figure 3.2 Quarry Site pH Data

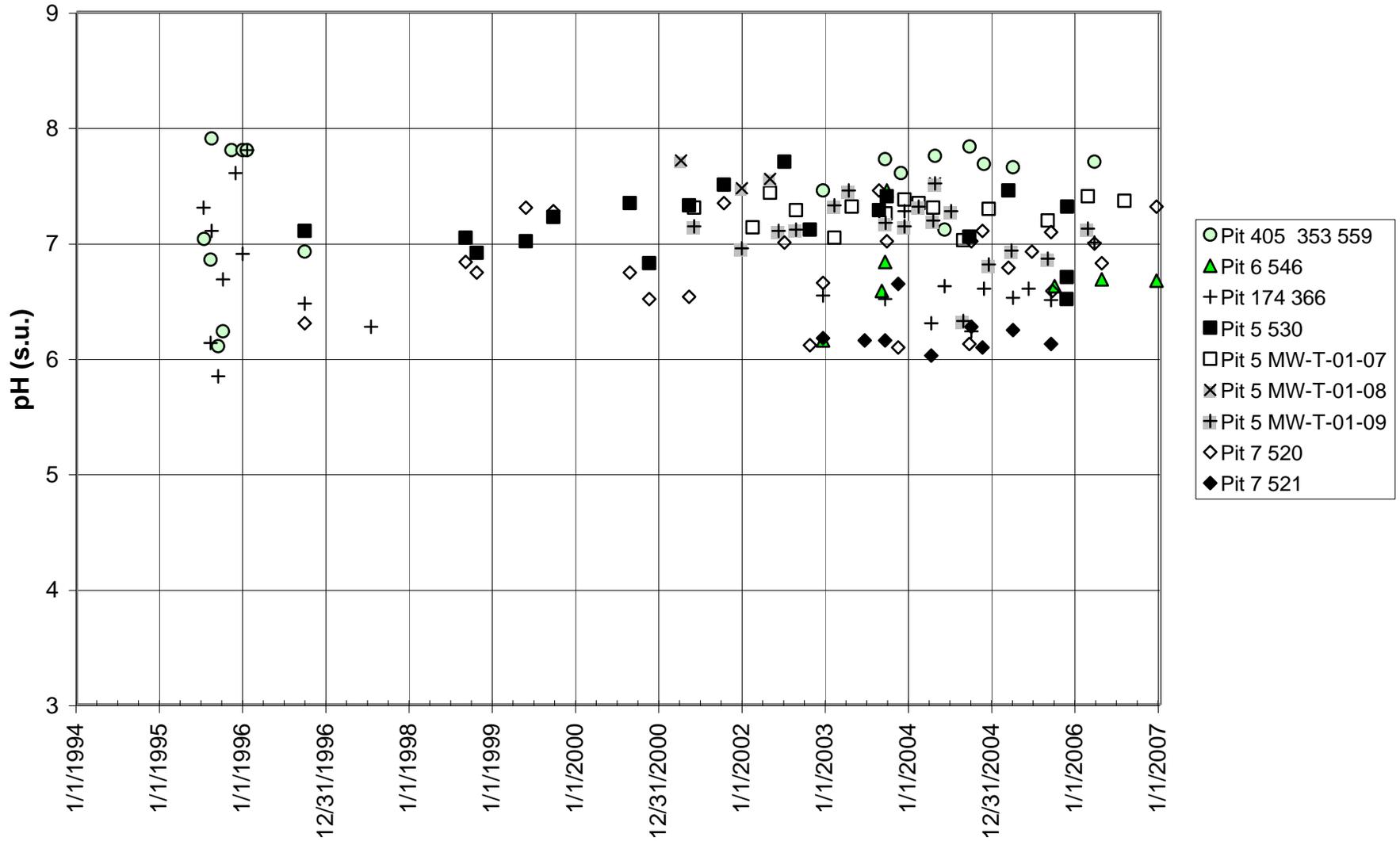


Figure 3.4 Quarry Site Conductivity Data

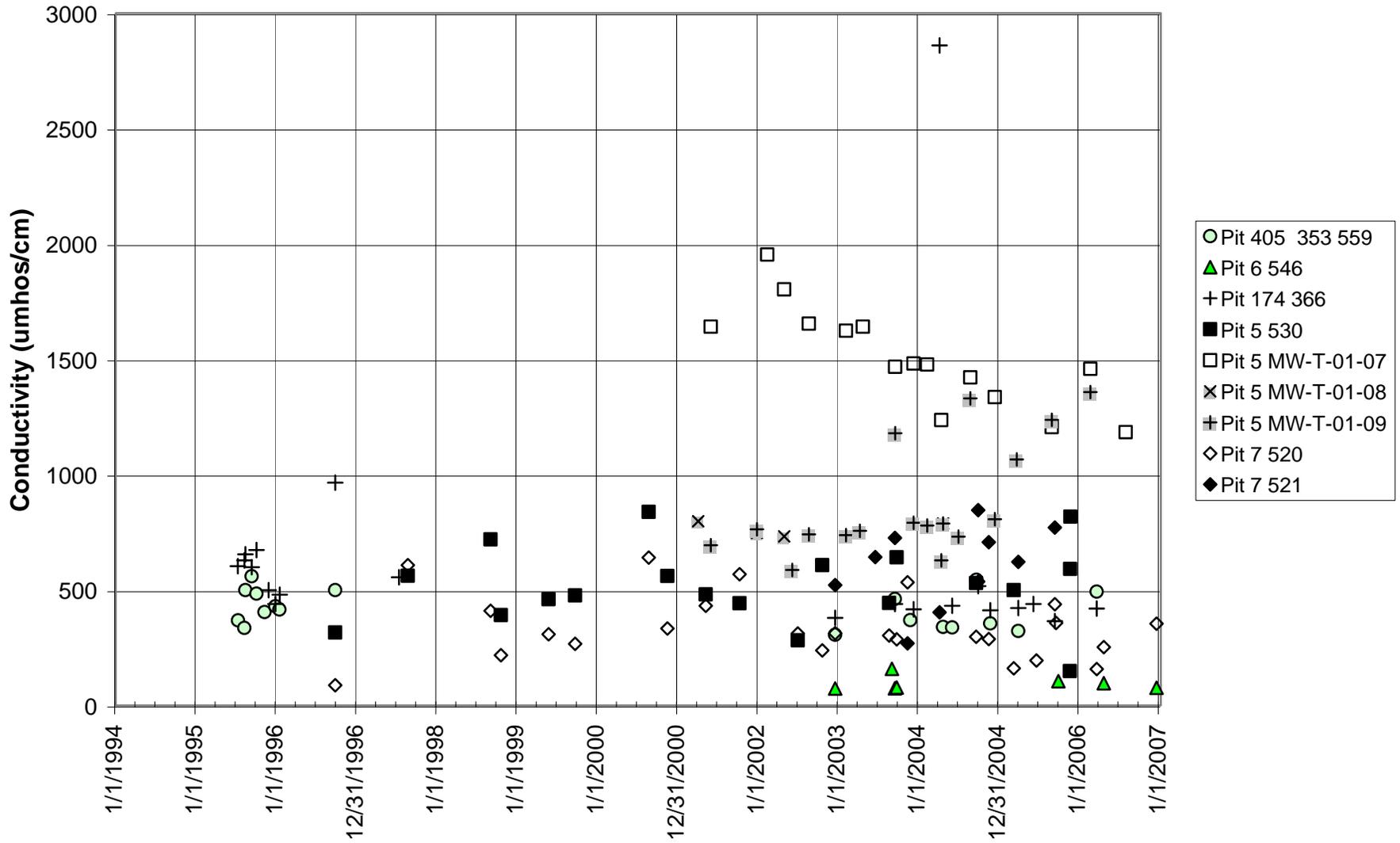


Figure 3.5 Quarry Site Sulfate Data

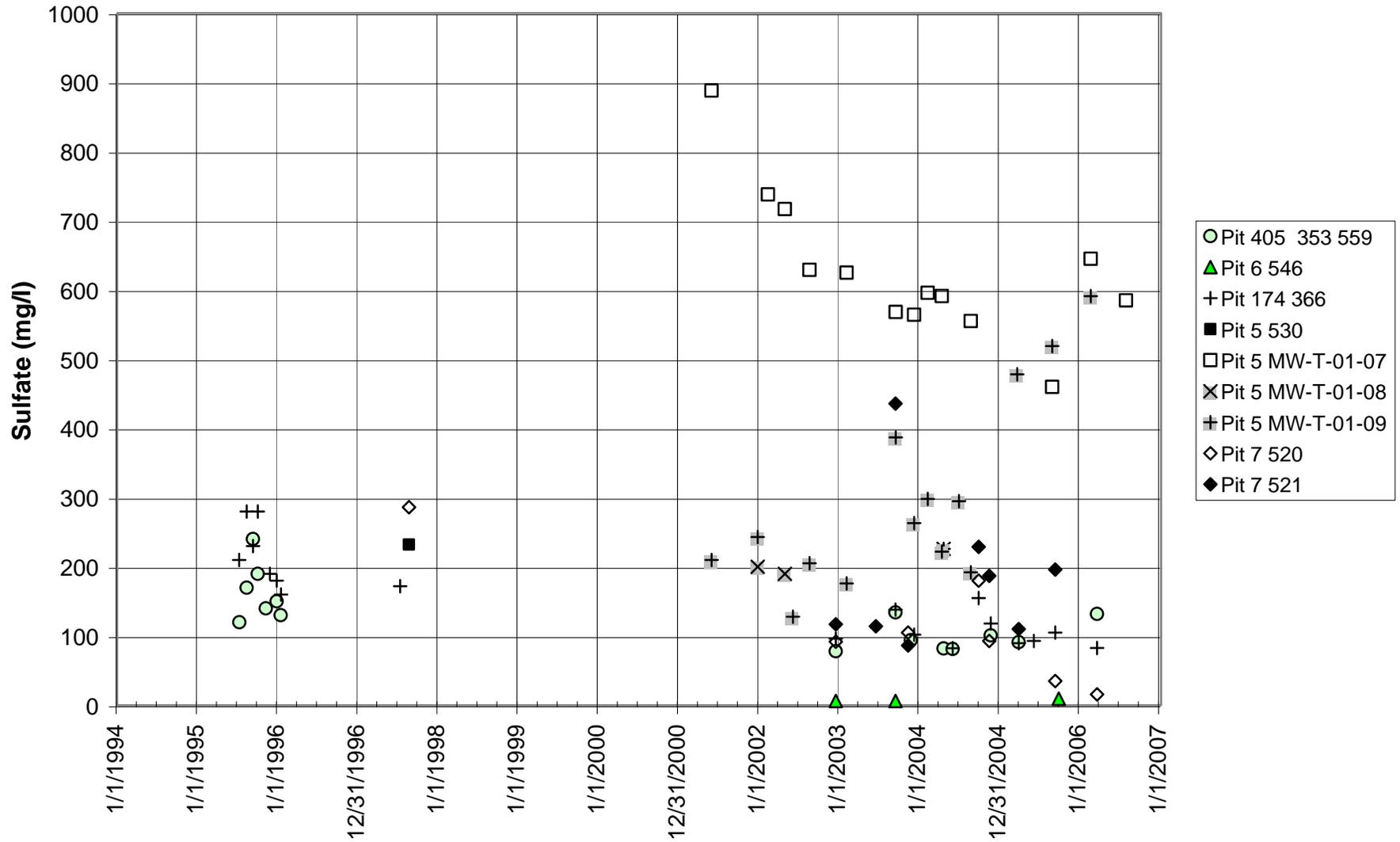


Figure 3.6 Quarry Site Magnesium Data

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

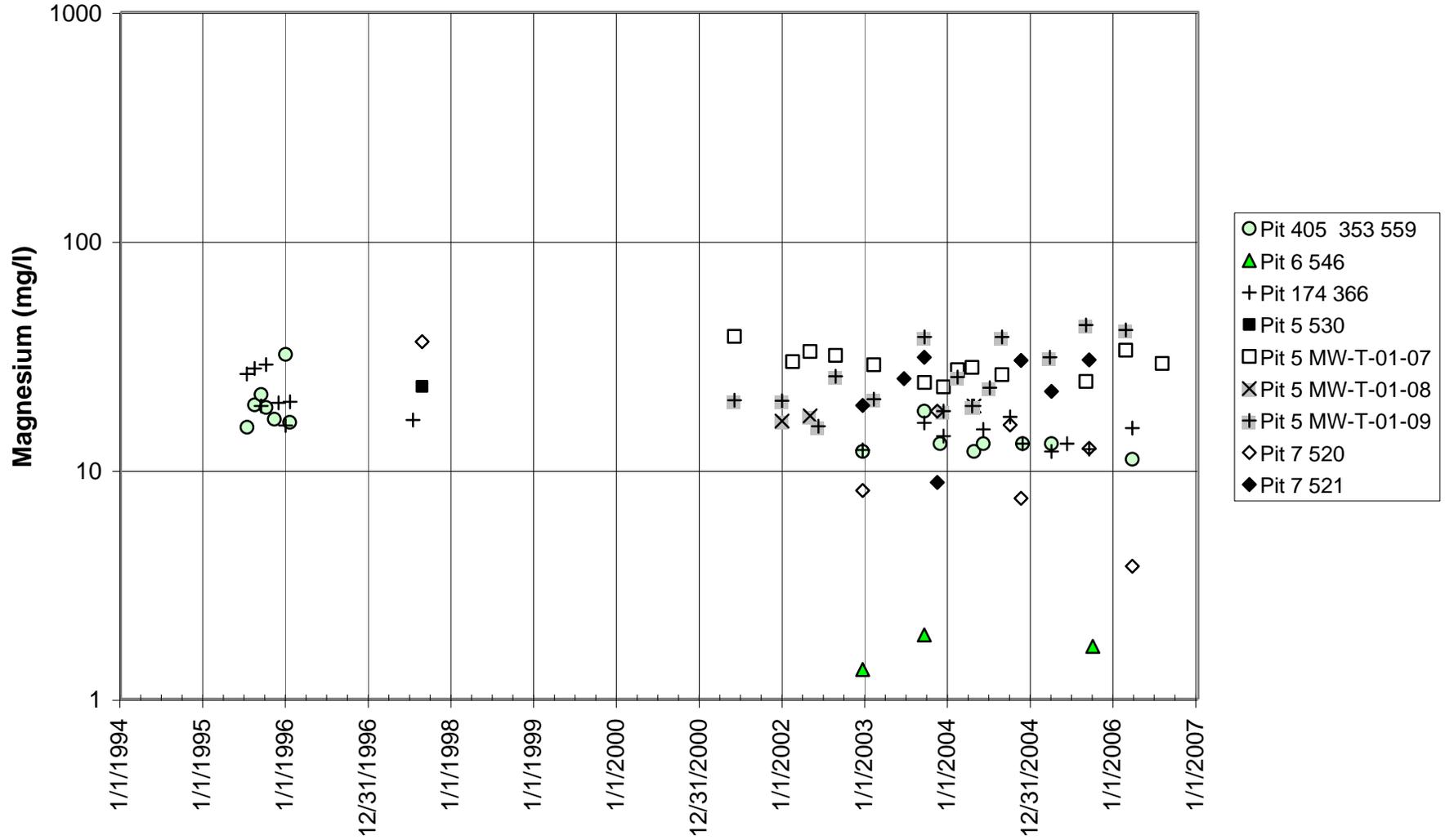


Figure 3.7 Quarry Site Hardness Data

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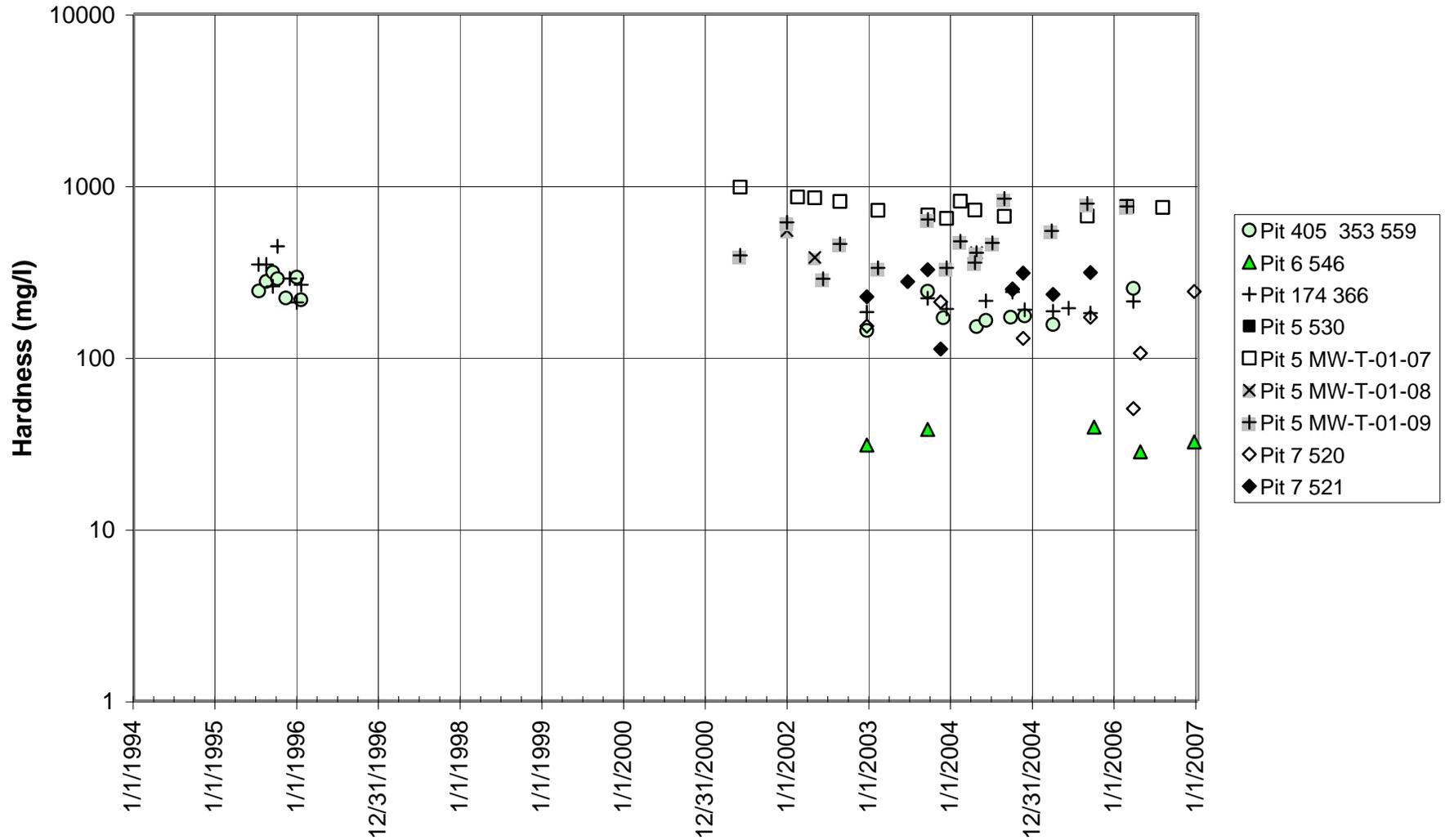


Figure 3.8 Quarry Site Zinc Data

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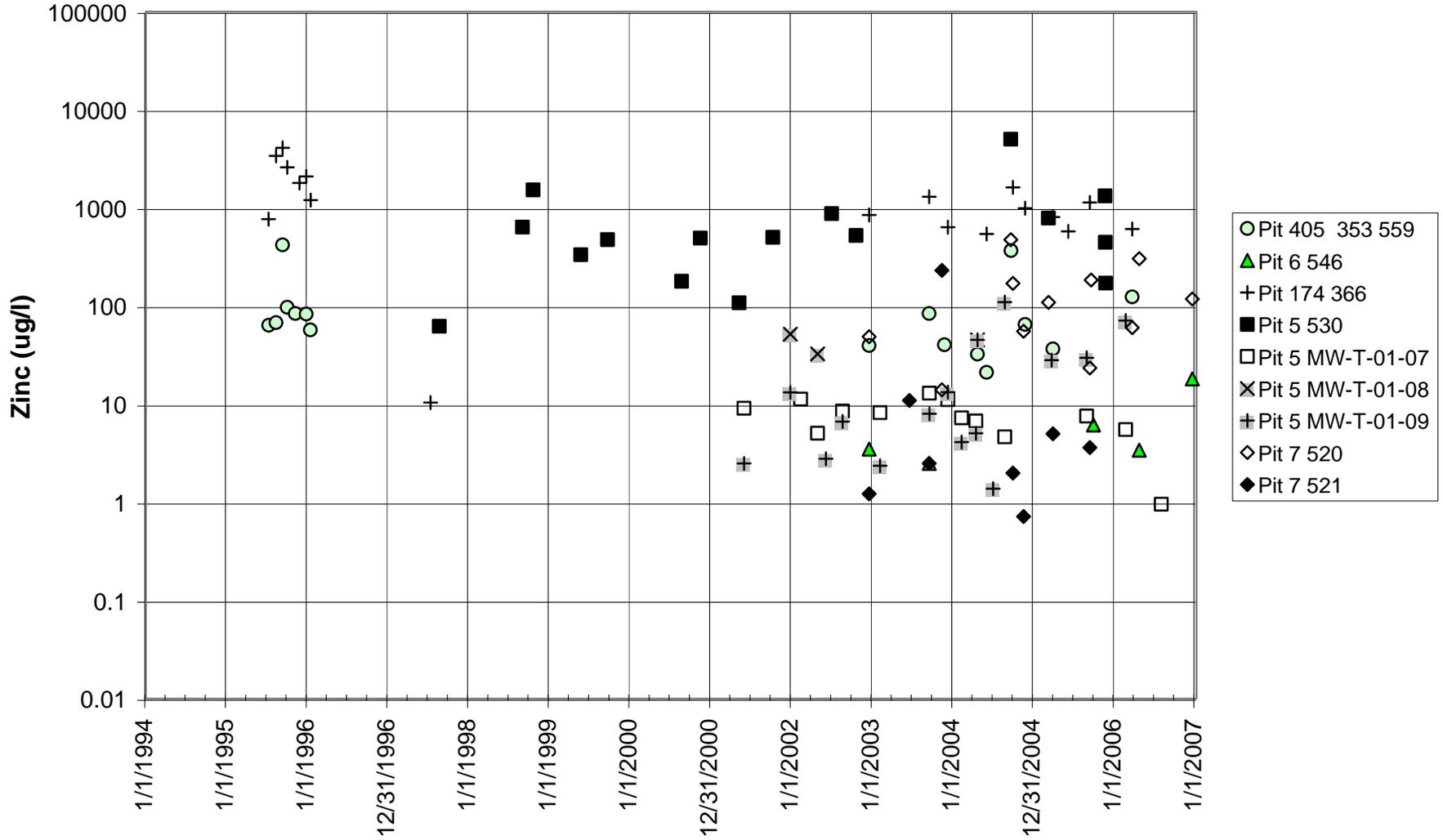


Figure 3.12 Quarry Site Nickel Data

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

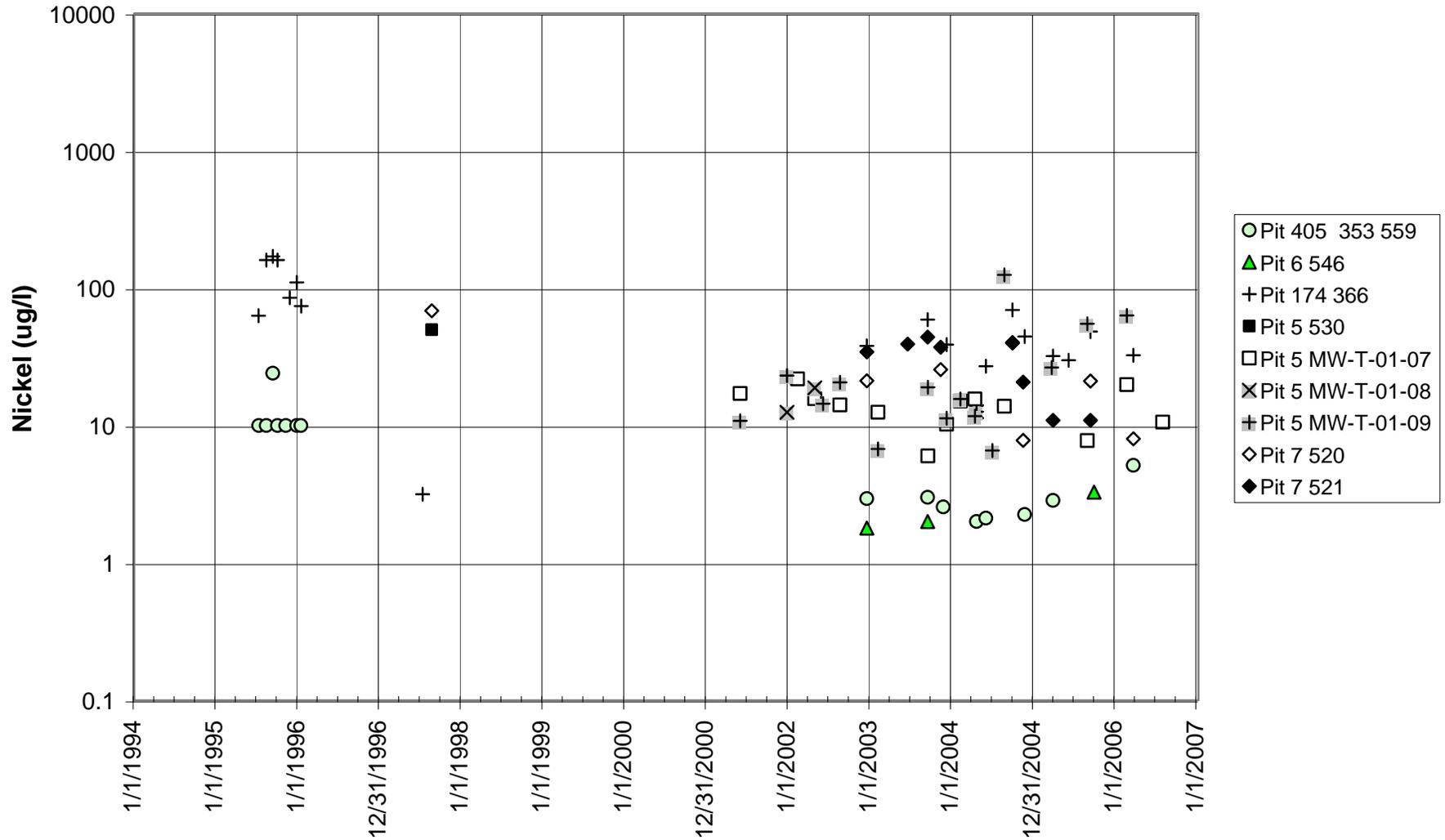


Figure 3.13 Quarry Site Arsenic Data

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

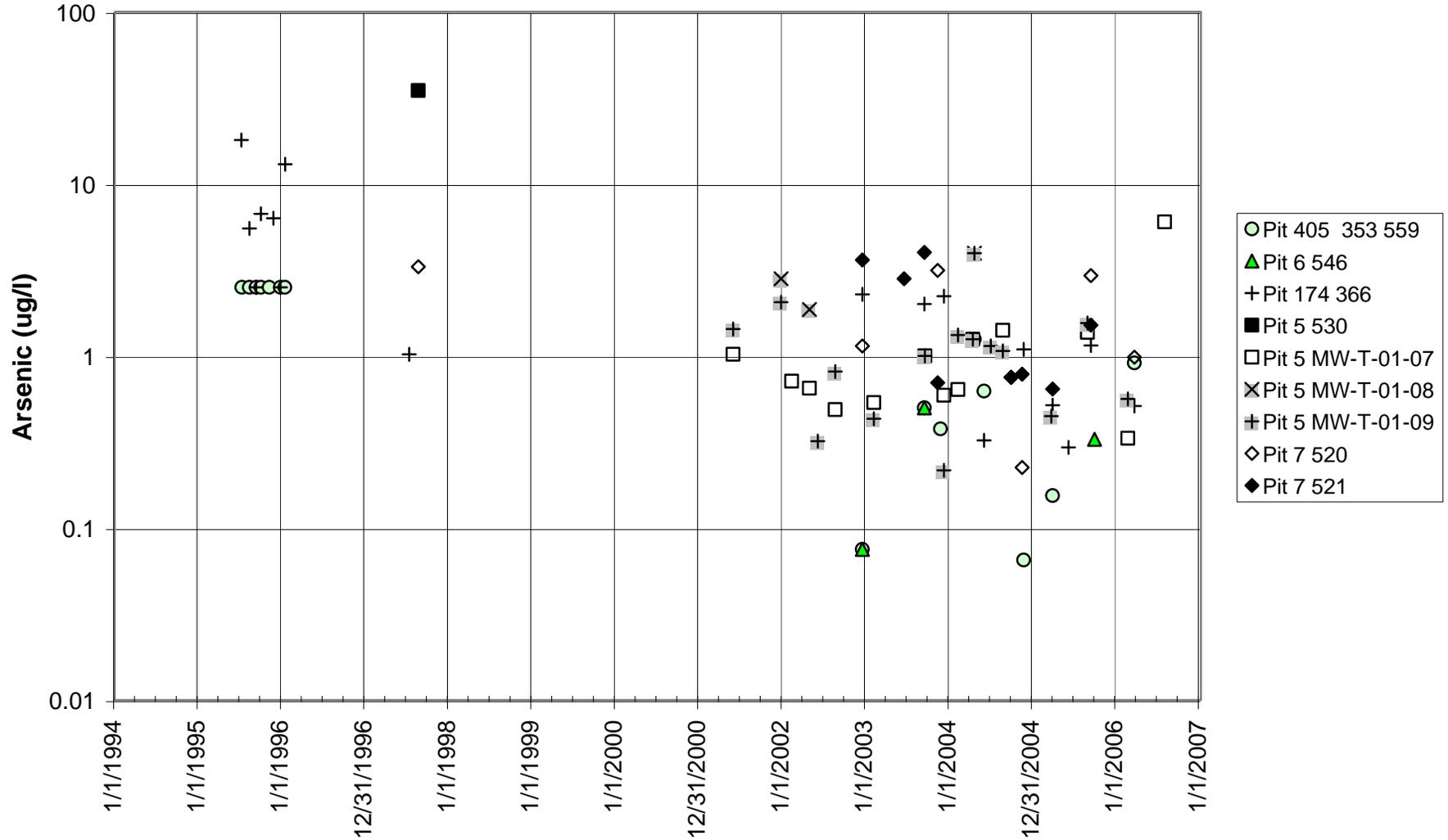


Figure 3.14 Quarry Site Iron Data

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

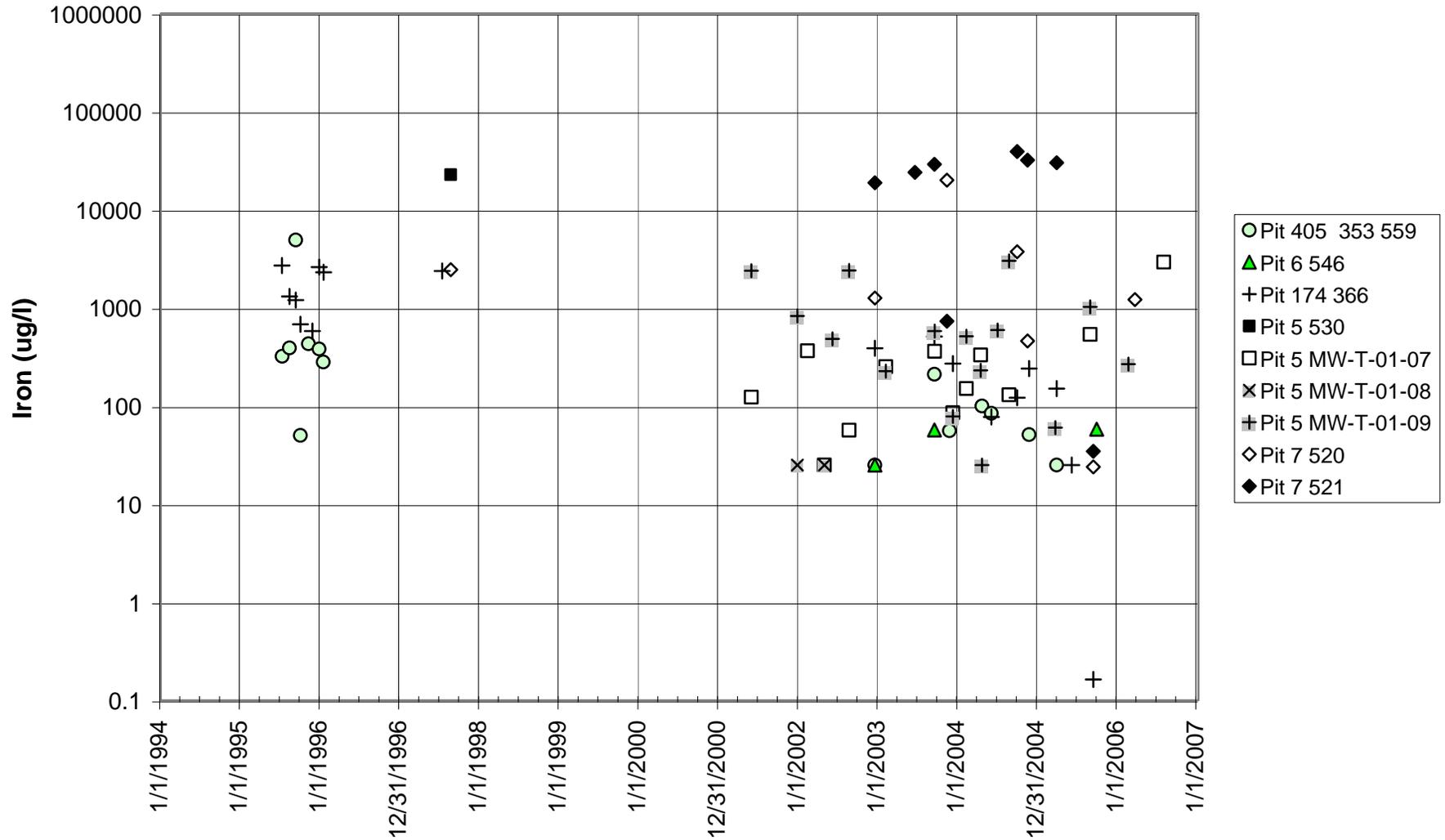


Figure 3.15 Quarry Site Manganese Data

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

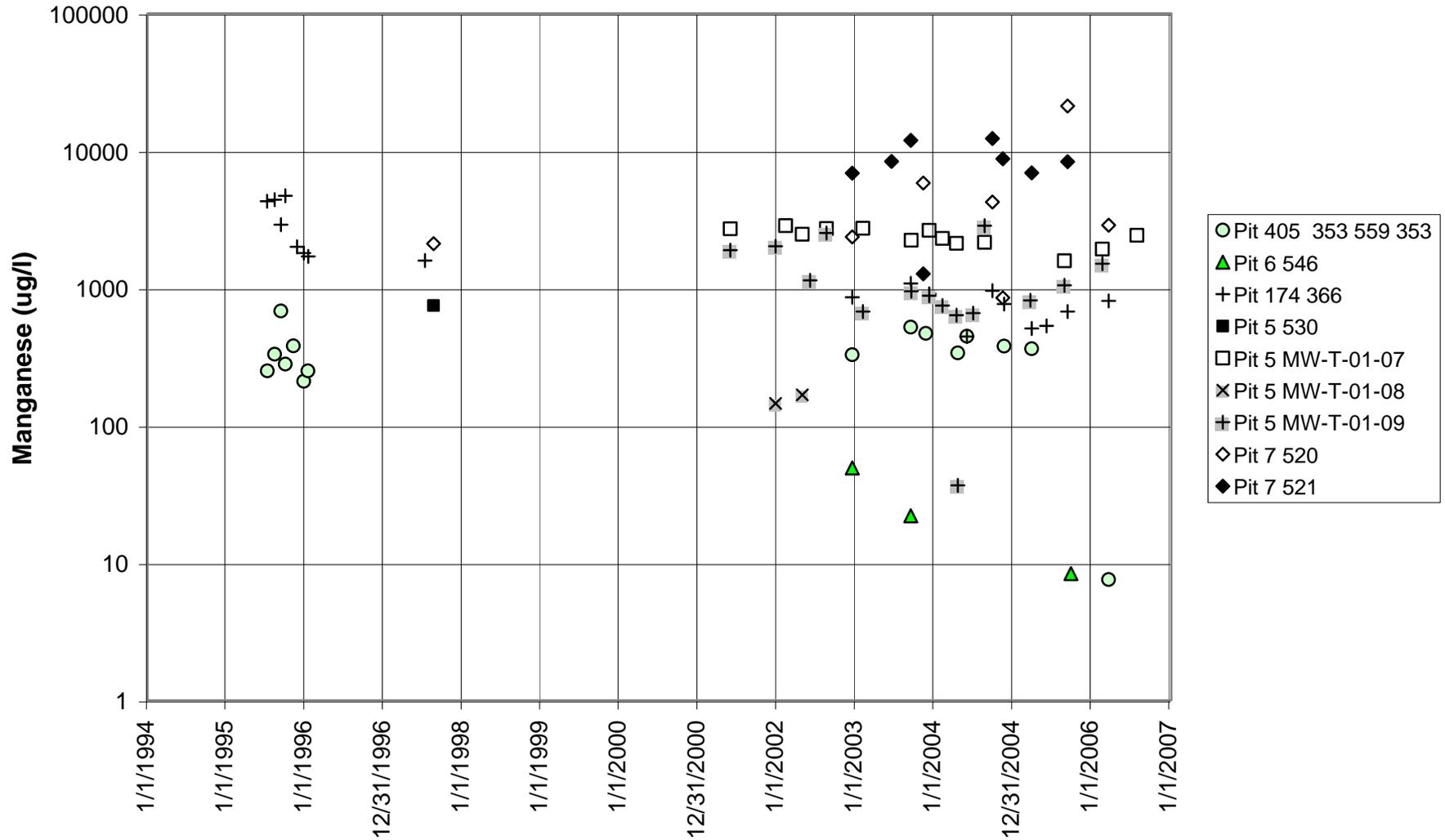


Figure 3.16 Pit 7 Acid-Base Accounting Analyses

