

Region SCR County Iowa Report Date 1/1990 Classification U/L/LFF
 Water Body: Brewery Creek
 Discharger: Mineral Point WWTP

If stream is classified as Limited Forage Fish (LFF) or Limited Aquatic Life (LAL), check any of the following Use Attainability Analysis factors that are identified in the classification report:

- Naturally occurring pollutant concentrations prevent the attainment of use
- Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met
- Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place
- Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or operate such modification in a way that would result in the attainment of the use
- Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses
- Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact

Supporting Evidence in the report (include comments on how complete/thorough data is)

- Biological Data (fish/invert)
- Chemical Data (temp, D.O., etc.) (88)
- Physical Data (flow, depth, etc.)
- Habitat Description
- Site Description/Map
- Other: photos (88)

Historical Reports in file:

- 1/13/98 - Dave Marshall
- 7/15/90 - Pat Trochell / Joe Ball memo
- 1/1990 - Dave Marshall 12/1995 - Dave Marshall / Steve Fix
- 2/1988 - Roger Schlessler

Additional Comments/How to improve report:

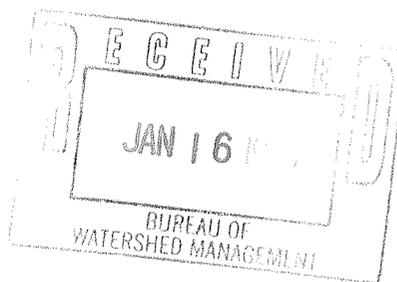
- acid leachate / heavy metal problems (96) -- can those problems, which cause LFF class'n, be fixed?
- 88 reports indicates that severe non-point pollution problem to blame. States that stream has sufficient flow & habitat to maintain a balanced FAL community
- check in W / region
- previous disagreement by Joe re. Class'n.

January 13, 1998

To: Joe Ball, Greg Searle WT/2

From: Dave Marshall

Subject: Stream Classification of Brewery Creek, Mineral Point



Enclosed are two copies of the mining waste remediation project and most recent stream classification. While the remediation study indicated substantial water quality improvements in the stream after the roaster piles were moved and capped, acutely toxic zinc levels persist in the stream due to contaminated groundwater and diffuse mining wastes throughout the watershed. High zinc concentrations prevent establishment of benthic macroinvertebrates with the exception of midge species typically found in systems degraded from mining wastes.

While a large number of pollution tolerant forage fish can be found within the stream at any given time, we believe the pollution tolerant minnows and white suckers are migrants between Rock Branch and the upper portions of Brewery Creek, above the former roaster piles and zone of severe pollution. Even before the remediation, when zinc levels were approximately 80% higher, southern redbelly dace and stonerollers were frequently found in the stream.

Whereas high numbers of forage fish would otherwise indicate full fish and aquatic life conditions (probably 99.9% of all streams), Brewery Creek is clearly a unique situation due to the toxic zinc levels coupled with the close association of the stream to other high quality waters in the watershed, i.e. Rock Branch and the upper portion of Brewery Creek.

In an effort to reflect significant water quality improvements with the realization that the stream will never become completely rehabilitated and that conventional organic loading is a minor factor in the overall water quality of this stream, we upgraded the mining waste impact zone to Limited Forage Fish downstream to the confluence with Rock Branch. Below Rock Branch, Brewery Creek is upgraded to Warmwater Fish and Aquatic Life.

cc
Bob Hansis SCR
Steve Fix SCR
Jack Soltez Dodg
Roger Schlessler SCR

DATE: July 15, 1996

FILE REF: 3200

TO: Dave Marshall - SDH
Steve Fix - SDH

FROM: Pat Trochlell - WT/2
→ Joe Ball - WT/2

SUBJECT: Brewery Creek at Mineral Point

On 9 July 1996, Dave Siebert, Pat Trochlell and Joe Ball inspected the wetlands and stream in the area of the roaster pile cleanup project. The wetland analysis is being conducted as a part of an ongoing study to document whether the wetland is experiencing noticeable changes as a result of the stream relocation project. Joe looked at the stream habitat within the relocated segment and in areas both upstream and downstream. We also used a backpack shocker to sample fish, starting from just upstream of Ferndale Road through part of the relocated section of Brewery Creek. Wetlands vegetation observations will be written up in a separate report. This memo addresses our observations of Brewery Creek habitat and fishery.

The habitat of the section of Brewery Creek downstream from the 3-culvert crossing is excellent forage fish habitat. (See attached location map). Habitat above the culverts is fair. The streambed within this area is predominantly hardpan clay with little gravel substrate or rock. "Chunks" of hardpan material provide some cover for aquatic organisms. This area also had several deep pools. Habitat improves again upstream from the wetland area, however, we did not get a chance to shock this stream segment.

The stream yielded a low number of invertebrates throughout, however, there were more invertebrates observed upstream from the wetland area. Low numbers of invertebrates sampled could be partly due to the time of year we were sampling.

Fish shocking yielded eight species of fish. Most of the species are classified as forage fish, although Black Bullhead and Common Sunfish (Pumpkinseed) were also present. Significant numbers of intolerant forage fish were also sampled. All fish appeared to be healthy. Common Shiners and Southern Redbelly Dace were in spawning colors. We observed young of the year forage fish both downstream and upstream of the 3-culvert crossing, which signify that fish reproduction had occurred this year. Although we sampled fewer fish above the 3-culvert crossing, the shocker battery was low.

Fish species and abundance are summarized in the table below.

FISH SAMPLED - 9 JULY 1996

FISH SPECIES	ABUNDANCE
Central Stoneroller	Common
Creek Chub	Abundant
Common Shiner	Abundant
Southern Redbelly Dace	Common
White Sucker	Abundant
Bluntnose Minnow	Present
Black Bullhead	Present
Common Sunfish	Present

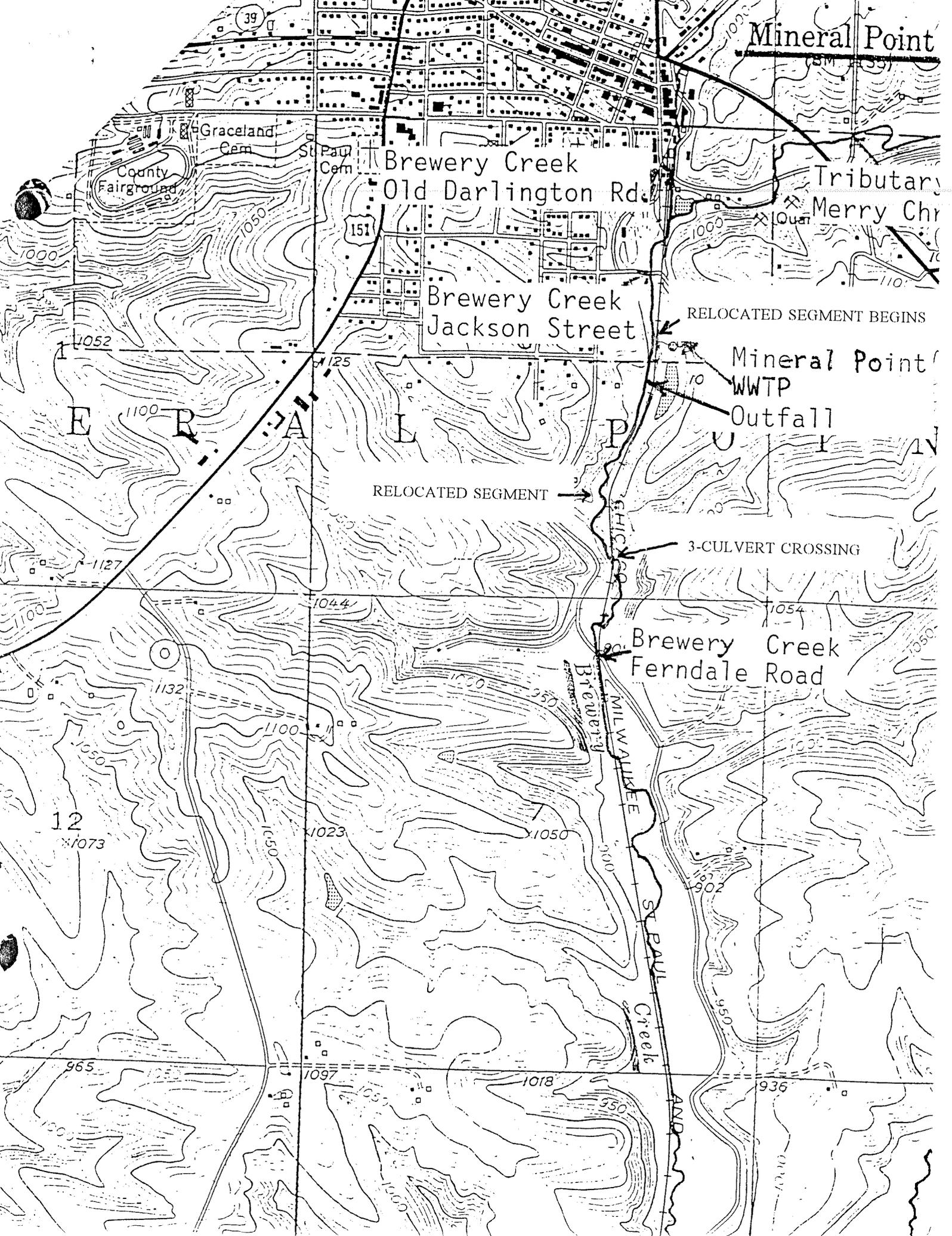
Brewery Creek currently is classified in NR 104 as supporting a limited aquatic life use. Field work conducted in 1994, shortly after the stream relocation and cleanup of mine roaster piles, recommended that the stream be upgraded to a limited forage fish classification. When the stream was assessed in 1994, only a year had passed since the mining wastes had been cleaned up and the stream had been relocated into its current channel. Fish were only beginning to migrate upstream into the new stream segment. In addition, although instream zinc levels were significantly (80%) lower than pre-cleanup concentrations, they were still at levels toxic to aquatic life. The stream was classified as supporting warm water forage fish upstream from the City of Mineral Point's wastewater discharge and as limited forage fish from the discharge point downstream to the Rock Branch.

We fully support the classification decision based upon the data used to reach that decision. However, it appears that significant recovery of the stream habitat and fishery has occurred since the 1994 data were collected. The stream clearly supports a healthy and diverse forage fish community and shows obvious signs that reproduction is occurring.

This would indicate that the stream may now be classified as supporting a warm water forage fish use (proposed WW-A). The need to reclassify this stream is important considering that NR 104 is currently being revised and that future code revisions may not occur for some time.

Please contact Joe (266-7390) or Pat (267-2453) if you have any questions.

c: Dave Siebert - EA/6
Tom Bennwitz - SDH



Mineral Point

Graceland Cem
St Paul Cem
County Fairground

Brewery Creek
Old Darlington Rd

Tributary Merry Chr

Brewery Creek
Jackson Street

RELOCATED SEGMENT BEGINS

Mineral Point
WWTP
Outfall

E R A L P U I N

RELOCATED SEGMENT

3-CULVERT CROSSING

Brewery Creek
Ferndale Road

12
1073

MILWAUKEE
ST PAUL CREEK

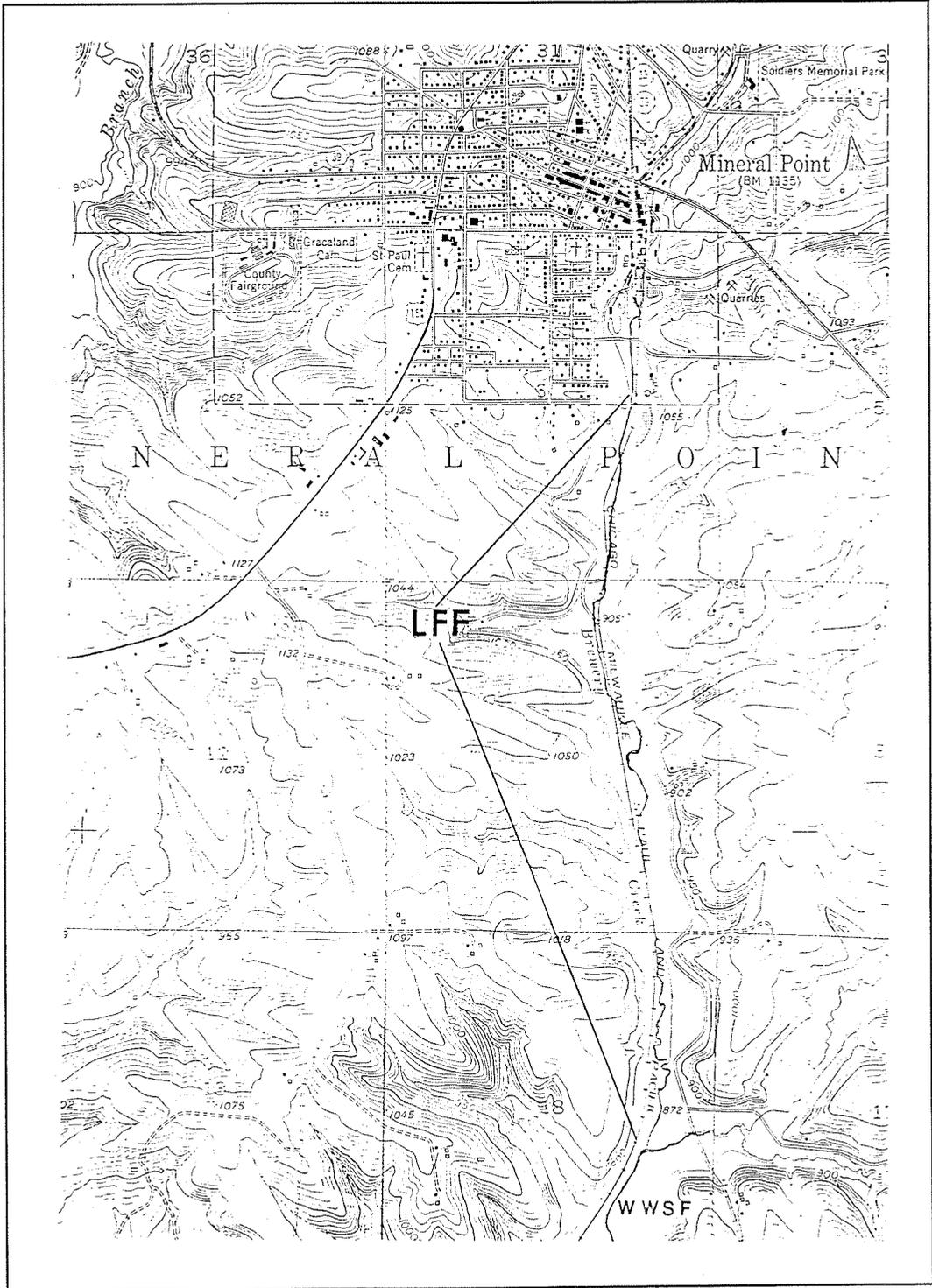
965

1097

1018

936

BREWERY CREEK at MINERAL POINT,
STREAM RECLASSIFICATION REPORT
WDNR SOUTHERN DISTRICT WRM, WMM & FM
Prepared by David W. Marshall



January, 1996

RESOURCE DESCRIPTION

Length: 5 miles, Gradient: 46 ft./mile, USGS estimated $Q_{7,10}$: 0.68 cfs above the WWTP.

Brewery Creek is a small spring-fed stream that arises northeast of Mineral Point and flows southwest to the Mineral Point Branch of the Pecatonica River. Above Mineral Point, the stream displays "fair to good" water quality and supports diverse fish and macroinvertebrate communities. Aquatic insects and crustaceans have consistently indicated "good" water quality based on the Hilsenhoff Biotic Index (HBI). The fish community is represented by five Families and most species are considered cool water forage.

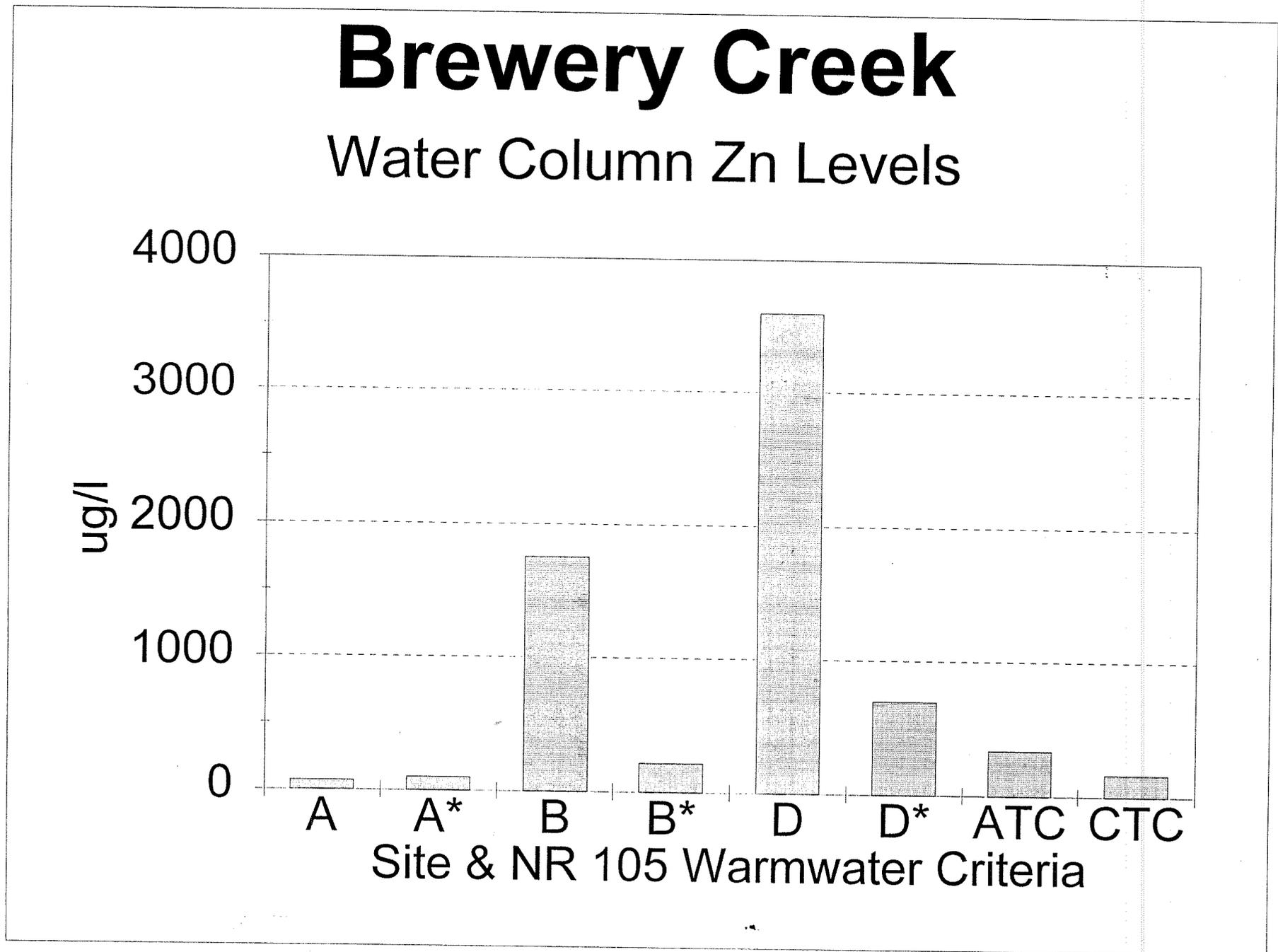
The stream had been described as "biologically dead" below Mineral Point due to acid leachate and heavy metal runoff from mining wastes. For over sixty years, five abandoned roaster piles have been the source of toxic zinc and cadmium and smothering ferric hydroxide precipitate. As leachate emanated from the roaster piles, only the most tolerant drifting invertebrates and migrating fish could be found within the rust colored water.

Construction of a now defunct railroad caused long term habitat disturbance within the contaminated zone. Much of the stream was ditched and straightened to accommodate railroad construction. Regardless of the channelization, stream habitat rated "fair" since the high gradient provided enough riffle and pool habitat for forage fish. Mining waste was clearly the primary limiting factor for fish and aquatic communities and was the primary reason the stream was classified Limited Aquatic Life (LAL) under Wisconsin Administrative Code NR 104.

Following the mining waste cleanup and containment project in 1992-93, Brewery Creek responded as water column metals decreased by approximately 80% and the stream is no longer rust colored. Diversity of fish and macroinvertebrate populations increased significantly, but most species are pollution tolerant. Even though zinc declined by nearly an order of magnitude, water column monitoring in 1994-95 revealed chronically toxic zinc below the former roaster pile above Jackson Street (also above the WWTP) and acutely toxic zinc below all five roaster piles (Figure 1). Toxic zinc concentrations prevent colonization of pollution intolerant species.

During the early planning stages of the mining waste cleanup, managers hoped that the rehabilitation effort would improve the stream enough to support a cold water sport fishery. Based on the post-cleanup monitoring efforts, high residual zinc levels prevent attainment of this goal. To better assess trout stream potential, the Coldwater Index of Biotic Integrity (IBI) was calculated from all of the fish

Figure 1: Brewery Creek Zn concentrations at A (above roaster piles), B (Jackson St), and D (Ferndale Rd) plus NR 105 criteria.



*post cleanup levels. ATC=NR 105 acute. CTC=NR 105 chronic.

collected above the cleanup site downstream to Ferndale Road. Fish collections in May and October, 1994 reflected a "very poor" cold water community (Tables 1 & 2). Very warm water temperatures in 1995 were an additional factor preventing sustained trout survival.

In 1994, nine species of fish (including low numbers of experimentally stocked brook trout) were sampled within the contaminated zone. While the observed fishery was definitely encouraging and reflects major water quality improvements, overall chemical and biological stream indicators suggest an unbalanced stream community. Recognizing that some fish will migrate through the contaminated zone, reproduction is unlikely given the high zinc toxicity. The benthic community, which is dominated by metals tolerant Chironomids, is probably a better pollution indicator than migrating fish (Figures 2 & 3).

USE CLASSIFICATION

Determining the appropriate use classification requires examining both biotic and abiotic variables, along with consideration for future stream improvement. The reach of stream above the former roaster piles displays fair to good water quality and supports a Warm Water Forage Fish Community (WWFF). Below the former roaster piles, the stream still suffers the effects of metals toxicity even though the cleanup effort significantly improved the water quality. While it can be argued that nine fish species within the contaminated zone may reflect "full fish and aquatic life uses", the pollution tolerant invertebrates and acutely toxic zinc concentrations indicate that the stream will not support balanced aquatic communities. Given the nature of the toxicity problem and substantial effort already expended, further metal reductions are unlikely and so the potential for improving the stream. Numerous groundwater seeps and diffuse mining wastes throughout the watershed persist as uncontrollable sources of zinc and other heavy metals.

Above the former roaster piles, Brewery Creek displays fair to good water quality and supports warm water forage fish (WWFF). From the Mineral Point Wastewater Treatment Plant downstream to the confluence with the Rock Branch, Brewery Creek will be upgraded from LAL to Limited Forage Fish Community (LFF). Below Rock Branch, the classification will change from LAL to Warm Water Sport Fish (WWSF) to reflect improved water quality coupled with dilution from the tributary. The overall classification upgrade reflects water quality improvements associated with the mining waste cleanup and containment.

Table 1: BREWERY CREEK COLDWATER IBI CALCULATION
Mining Waste Cleanup and Containment Project
May 16, 1994

Location: Ferndale Road to approximately 100 ft. above last bicycle bridge.

Total shocking length: ~600 ft. combining three sites.

Comments: Brook trout stocked in May, 1994. White sucker with lip tumor.

Species	# Caught	T Carnivore	Tolerant	Stenotherm
Brook trout	14*	14*	0	14*
Brook trout juv	44*	44*	0	44*
Creek chub	63	0	63	0
Common shiner	2	0	0	0
Stoneroller	32	0	0	0
S.Redbely dace	4	0	0	0
White sucker	25	0	25	0
Orangespt sf.	1	0	0	0
Green sunfish	7	0	7	0
Johnny darter	1	0	0	0
B. stickleback	2	0	0	2
Total	195* / 137	0	95	2

* includes stocked fish which are not included in the IBI.

1. Number of Intolerant Species: 0 Score = 0
2. Percent Tolerant individuals: 100 % Score = 0
3. Percent Carnivore Individuals: 0% Score = 0
4. Percent Stenothermal Cool/Coldwater Individuals: 1% Score = 0
5. Percent Salmonids that are Brook trout: 0% Score = 0

IBI Score (without stocked fish) = 0 Integrity Rating: 0 = Very Poor

(Lyons, John and Timothy D. Simonson, 1994 [Draft] An Index of Biotic Integrity for Coldwater Streams in Wisconsin)

Table 2: BREWERY CREEK COLDWATER IBI CALCULATION
Mining Waste Cleanup and Containment Project
October 14, 1994

Location: Ferndale Road to approximately 100 ft. above last bicycle bridge.

Shocking Length: ~700 ft. combining 5 sites.

Comments: Brook trout stocked in May, 1994. Creek chub with tumor.

Species	# Caught	T Carnivore	Tolerant	Stenotherm
Brook trout	13*	0	0	0
Y. bullhead	1	0	1	0
Stoneroller	35	0	0	0
Creek chub	376	0	376	0
Common shiner	59	0	0	0
White sucker	238	0	238	0
Green sunfish	1	0	1	0
Fantail darter	4	0	0	0
Johnny darter	2	0	0	0
Total	730* / 717	0	616	0

* includes stocked fish which are not included in the IBI.

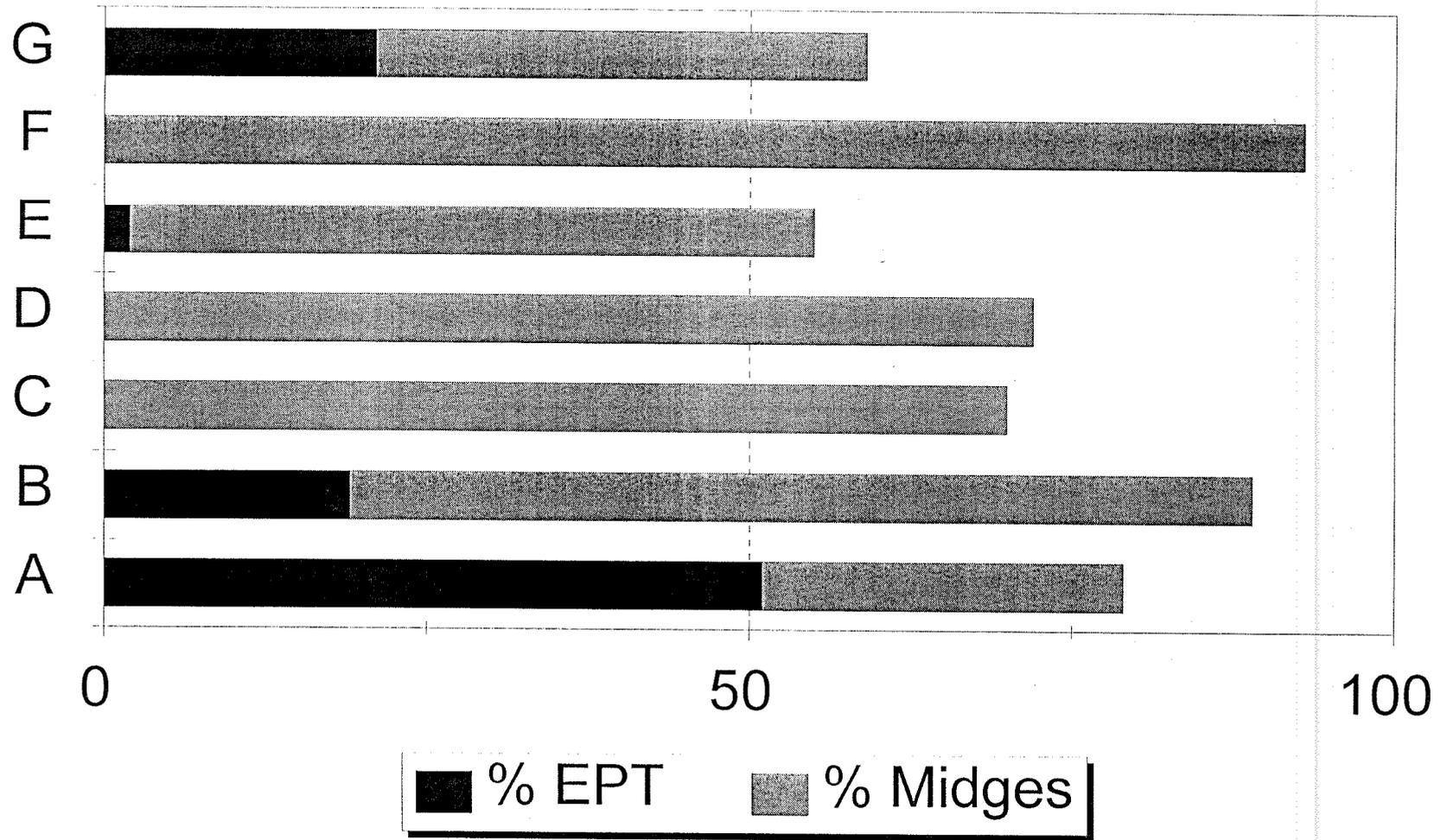
1. Number of Intolerant Species: 0 Score = 0
2. Percent Tolerant individuals: 100% Score = 0
3. Percent Top Carnivore Individuals: 0% Score = 0
4. Percent Stenothermal Cool/Coldwater individuals: 0% Score = 0
5. Percent Salmonids that are Brook trout : 0% Score = 0

IBI Score (without stocked fish) = 0

Integrity Rating: 0 = Very Poor
(Lyons, John and Timothy D. Simonson, 1994 [Draft] An Index of Biotic Integrity for Coldwater Streams in Wisconsin)

Brewery Creek

1994 Macroinvertebrate Data

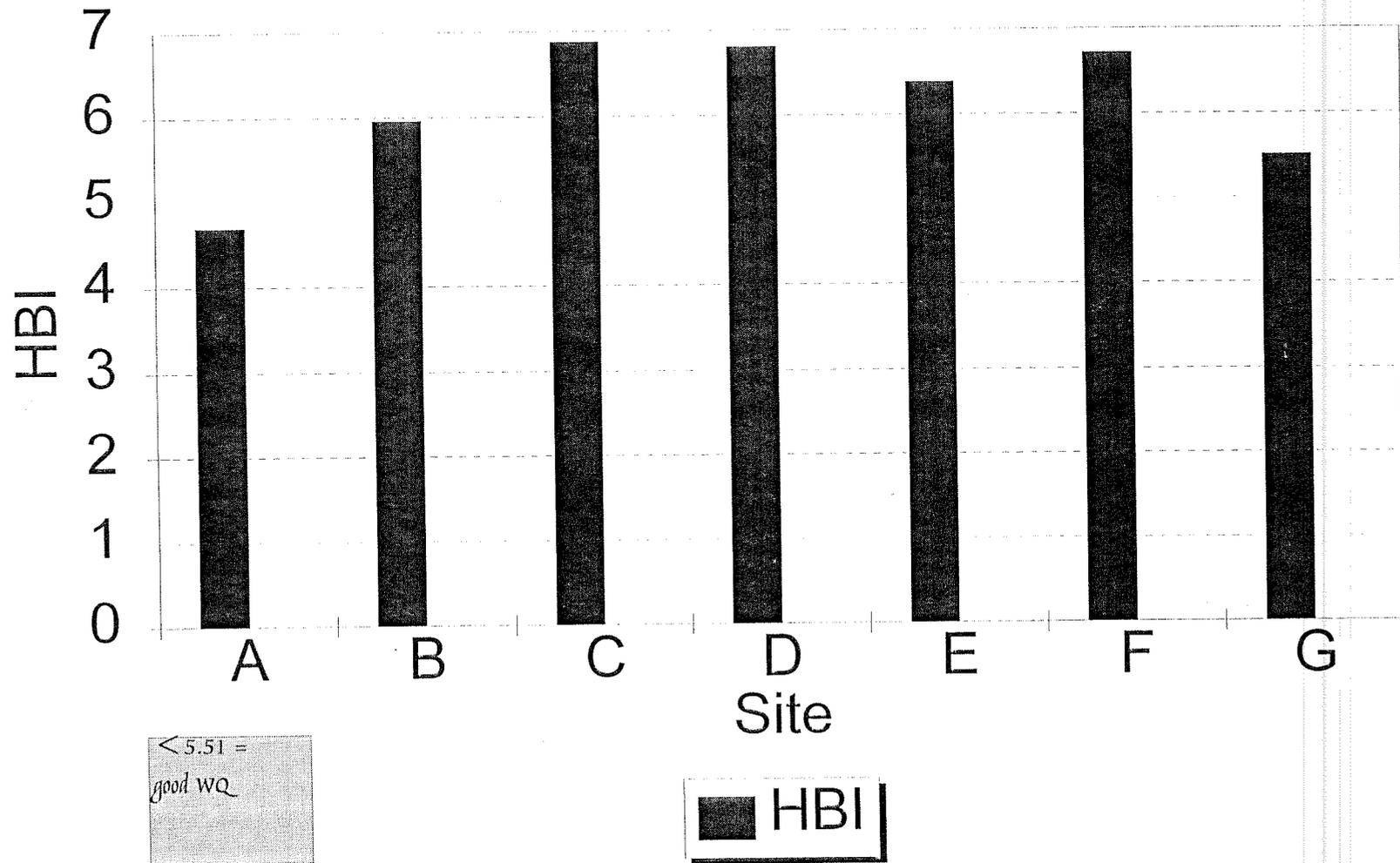


Approximate distance (Miles) from WWTP: A (-.4), B (-.2), C (.4), D (.7), E (1.0), F (1.6), G (2.3)

Figure 3: 1994 Macroinvertebrate Data

Brewery Creek

1994 Macroinvertebrate Data



Approximate distance (Miles) from WWTP: A (-.4), B (-.2), C (.4), D (.7), E (1.0), F (1.6), G (2.3)

Table 3: Summaries of Brewery Creek Baseflow data above the WWTP and June, 1995 stream temperature data.

Date	Flow (cfs)	Source
June 2, 1972	1.93	USGS
August 10, 1972	1.53	USGS
July 31, 1973	4.83	USGS
October 9, 1975	2.75	USGS
July 27, 1976	1.35	USGS
September 14, 1976	1.06	USGS
June 23, 1977	0.83	USGS
September 5, 1989	1.7	Dames & Moore
October 30, 1989	3.2	Dames & Moore
November 8, 1994	4.02	WDNR
November 11, 1994	4.23	WDNR
November 15, 1994	3.79	WDNR

Location	Temperature (°C)	D. O. (mg/l)
Site A	25	6.3
WWTP	31.7	9.2
Site D	28.6	7.4
Gordon Creek	19.7	9.0

Stream Brewery Reach Location WWTP to Rock Branch Reach Score/Rating 190 / FAIR
 County Iowa Date Jan, 1996 Evaluator Marshall Classification FFF

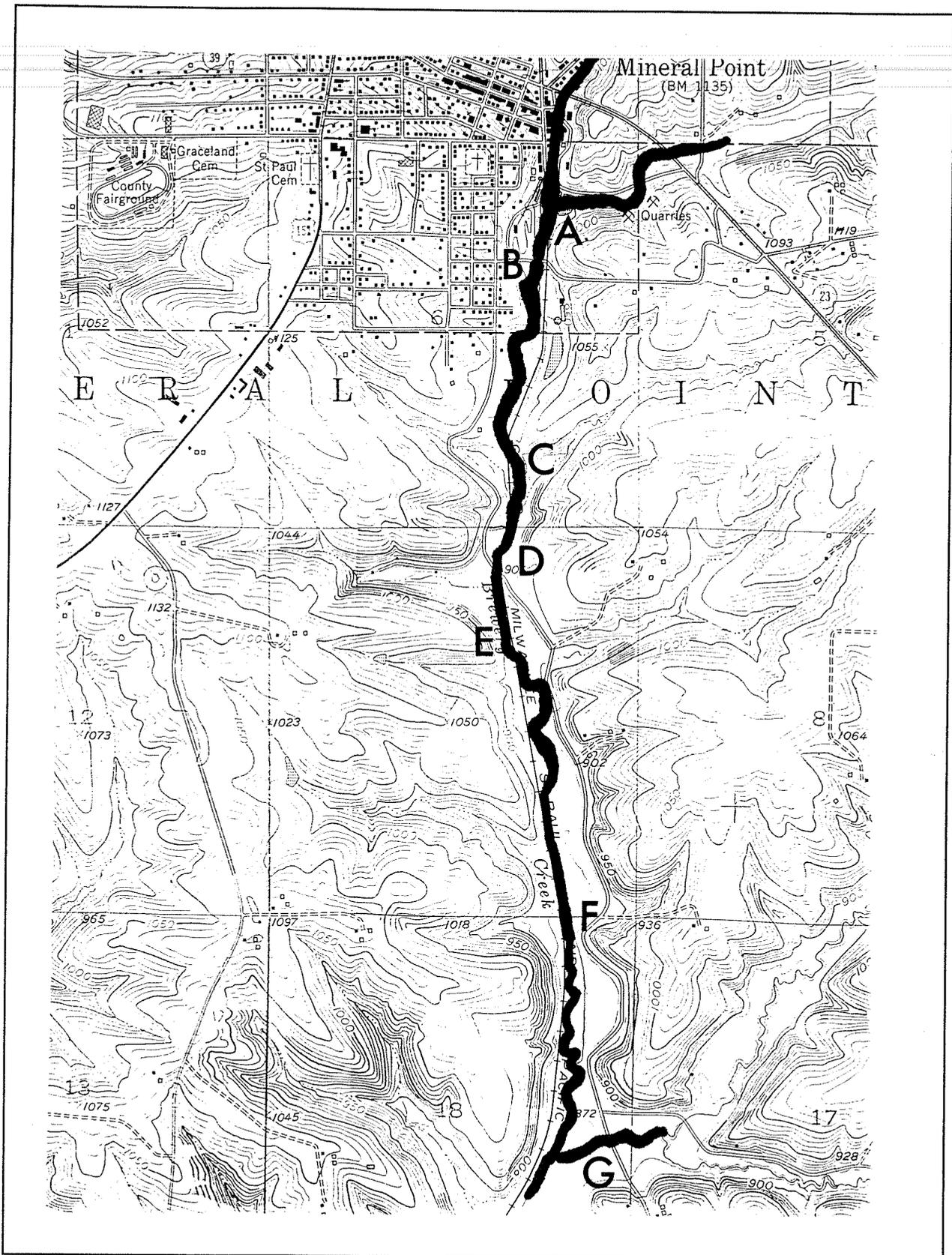
Rating Item	Category			
	Excellent	Good	Fair	Poor
Watershed Erosion	No evidence of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion. 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probable erosion from any run off. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 4	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally healthy. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ratio <7. 8	Adequate. Overbank flows rare. W/D ratio 8-15. 10	Barely contains present peaks. Occasional overbank flow. W/D ratio 15-25. 14	Inadequate, overbank flow common. W/D ratio >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation, mostly from coarse gravel. 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20
Bottom Substrate/ Available Cover	Greater than 50% rubble, gravel or other stable habitat. (2)	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 17	Less than 10% rubble gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' 0 Warm >1.5' 0	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' 0 Warm >5' 0	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 <3' 24
Flow, at Rep. Low Flow	Cold >2 cfs 0 Warm >5 cfs 0	1-2 cfs 6 2-5 cfs 6	.5-1 cfs 18 1-2 cfs 18	<.5 cfs 24 <1 cfs 24
Pool/Riffle, Run/Bend Ratio (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provide habitat. 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or un-pastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16

Column Totals: 2 188

Column Scores E 2 +G +F 188 +P = 190 = Score

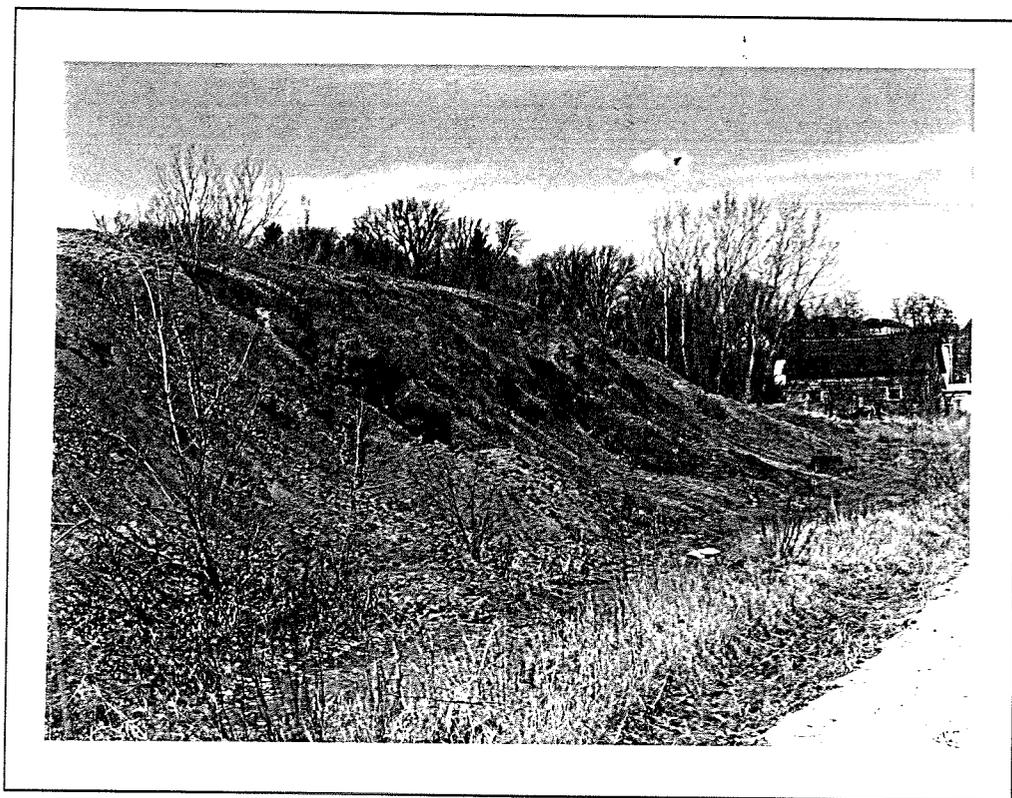
<70 = Excellent, 71-129 = Good, 130-200 = Fair, >200 = Poor

Figure 1. Brewery Creek Monitoring Stations



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Brewery Creek Water Quality Before and After a Mining Waste Cleanup Project at Mineral Point, Wisconsin



eroding roaster pile prior to remediation

Wisconsin Department of Natural Resources
Southern District Water Resources Management
Prepared by Dave Marshall and Steve Fix

December, 1995

SUMMARY

For over sixty years, abandoned mining wastes have severely polluted Brewery Creek in Mineral Point, Wisconsin. For decades, precipitation reacted with ferric sulfide in five roaster piles to form sulfuric acid, which leached heavy metals into the stream. The stream was considered "biologically dead" due to toxic metals and smothering effect of ferric hydroxide precipitate. The stream was choked by the rust colored flocculant, which covered the substrate and filled the water column. Only low numbers of the most tolerant migrating fish and drifting invertebrates could be found within the contaminated zone.

In 1992-93, four roaster piles were moved to a central containment area which was capped and vegetated. The stream was then re-routed away from the disposal site. Overall, Brewery Creek responded well to the treatment. In 1994-95, water column metals concentrations decreased by approximately 80% and the stream is no longer rust colored. Diversity and abundance of fish and invertebrate populations increased significantly, however most of the recolonizing fauna are pollution tolerant. While some of the water column metals have decreased an order of magnitude, toxic zinc concentrations persist and prevent colonization of more sensitive species. Groundwater seepage is the primary source of metals and toxic zinc levels in the stream. Time will tell whether or not the groundwater source of metals will decrease and if the stream continues to respond to the treatment.

Compared to an extensive statewide water quality monitoring data base, Brewery Creek also contains relatively high lead and zinc concentrations above the former roaster piles and project area. Although the upstream metals concentrations are not toxic, the high levels reflect diffuse mineral deposits and mining wastes throughout the watershed. High background metals, coupled with contaminated groundwater seepage within the project area, suggest that the stream will not be restored to pre-settlement conditions.

INTRODUCTION

Brewery Creek was the site of a major mining waste containment project in 1992-93. The site is located within the Upper Mississippi Lead-Zinc District, which encompasses southwest Wisconsin and parts of Illinois and Iowa. Southwestern Wisconsin has a rich mining history beginning with modest native American diggings, followed by "badger" immigrants from Germany, Norway and the British Isles. Mines within the hills and valleys of this dolomitic unglaciated area were a major lead source for the United States between 1827 and 1847, while zinc production peaked by 1904.

While the mining communities provided an interesting chapter of European settlement history, the actual mining operations left a legacy of water pollution in many southwest Wisconsin streams. Brewery Creek, in Mineral Point, Wisconsin, was one of the most severely degraded. When the Great Depression delivered a major blow to the zinc mining industry, the Mineral Point Mining Company had to shut down operations and abandoned five roaster piles next to the creek. For the next sixty years, the toxic nature of the roaster piles prevented vegetation growth and created a moonscape appearance to an otherwise fertile valley.

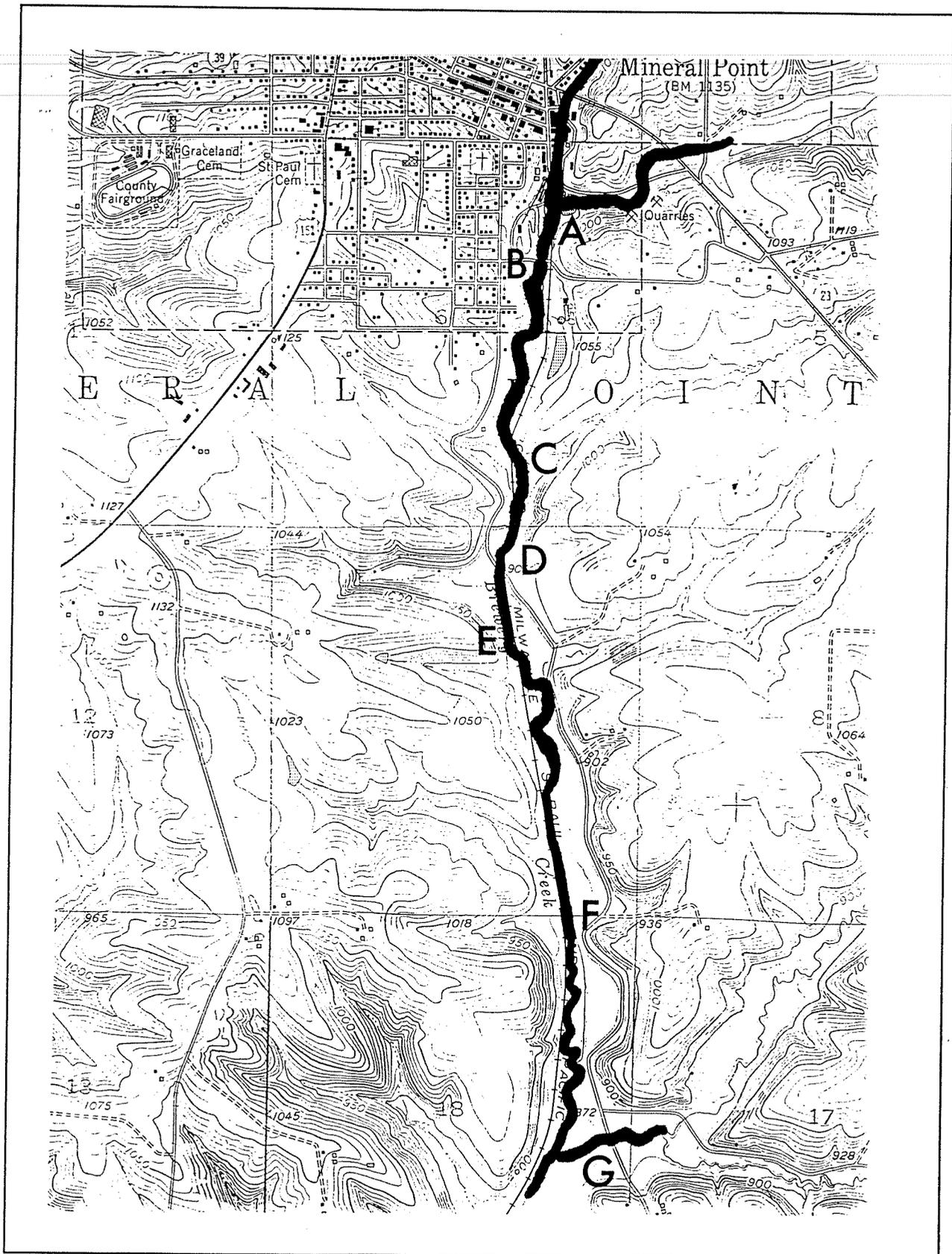
For years, acidic erosion of the roaster tailings leached heavy metals into the stream. During dry conditions, groundwater reacted with iron sulfides to yield sulfuric acid. Following rainfall and snowmelt, both physical erosion and increased acid leaching created extremely toxic conditions. The leachate gave Brewery Creek the characteristic bright orange color common to streams affected by mining wastes. Sulfuric acid runoff and toxic metals prevented growth of all but a few fish and aquatic insects. The toxicity problem was compounded with the smothering effect of ferric hydroxide precipitate on benthic organisms and fish gills. Due to the combination of these factors, the affected stream area was considered "biologically dead" prior to rehabilitation.

In an effort to restore the stream and reduce the toxic effects of the roaster piles, the site was approved for funding under the State Environmental Repair Fund. At a total cost of about \$900,000, around 180,000 cubic yards of roaster and floatation wastes were moved to a central containment area which was capped with clay. The stream was re-routed away from the containment site and the entire project area was graded and seeded with native grasses and forbs. More detailed summaries of the project have been described in articles and technical reports.

STREAM DESCRIPTION

Length: 5 miles, Gradient: 46 ft./mile, USGS estimated Q7, 10: 0.68 cfs. Brewery Creek is a small spring-fed stream that arises northeast of Mineral Point and flows

Figure 1: Brewery Creek Monitoring Stations



southwest to the Mineral Point Branch of the Pecos River. Upstream of the remediation site, the stream exhibits fair water quality and supports at least ten warm water fish species. Below the roaster piles, the stream has been classified Limited Aquatic Life (LAL) because the stream has exhibited very poor water quality for many years. Compared to the mining wastes, stream habitat has not been a serious limiting factor for fish and invertebrate populations. High metals concentrations have been the primary concern even though parts of the stream had been ditched for railroad construction years ago. Brewery Creek is a hard water alkaline stream with mean hardness values around 400 mg/l. High water hardness is a key factor reducing metals toxicity in the stream. The high gradient nature of the stream has prevented significant sludge and sediment from depositing on the predominantly gravel, boulder and bedrock substrate.

METHODS

Water Column Samples: Dissolved oxygen and temperature were measured with a YSI Model 57 or 58 meter. The meters were air calibrated and adjusted to the barometric pressure before each sampling run. Water samples were collected and analyzed at the State Laboratory of Hygiene. The Student's *t*-test was used to determine differences between data sets, consisting of pre and post remediation metals (Cd, Cu, Fe, Pb, Zn) concentrations. Pre-remediation data set was collected in 1975, 1979, 1989 and 1992. Post-remediation monitoring was conducted in 1994-95.

Precipitate analysis: Prior to the rehabilitation project (1992), an effort was made to characterize the precipitate coating stream substrates. Below the roaster piles, submersed parts of overhanging grasses were completely covered by the precipitate. The effort involved an unusual sampling and leaching process. The grasses were clipped and placed into ziplock bags using stainless steel forceps and scissors. In the lab, each bag was initially weighed, 250ml 0.5% HNO₃ added and allowed to leach for 24 hours. The liquid was poured off into clean 250ml metals bottles. As much of the vegetation plus excess liquid were removed from each bag. The weight of the empty bag was subtracted from the initial weight of the bag plus vegetation. Aliquots of the liquid leachates were digested and analyzed for metals.

Macroinvertebrates: Spring benthic macroinvertebrates were collected before and after the rehabilitation project. Samples were collected with a d-frame net and shipped to UW-Stevens Point for sorting and identification. Sample analysis included the Hilsenhoff Biotic Index (HBI), % Ephemeroptera, Plecoptera, Trichoptera (EPT) individuals, % Chironomidae individuals and total species numbers. Macroinvertebrate samples were collected in 1979, 1987, 1989, 1992 and 1994.

Electrofishing: A 12 volt battery powered AbP-3 shocker was used to collect fish which were identified and enumerated in the field before and after the rehabilitation project. Fish were sampled along 100 meter stations in 1989, 1992 and 1994.

WATER CHEMISTRY RESULTS

Several water quality investigations were conducted on Brewery Creek beginning in the mid-1970's. Very high concentrations of zinc, iron and other metals were measured during lowflow conditions in 1975, '79, '89 and '92. In 1979 and 1989, a few runoff events were sampled and even higher concentrations were revealed. Runoff events increased the rates of both physical erosion and leaching, as runoff water reacted with iron sulfides to form sulfuric acid. Zinc concentrations have been the greatest concern since levels measured in the stream were frequently an order of magnitude greater than the NR 105 acute toxicity criteria. Dissolved oxygen and conventional pollutants have been tested frequently as well, but none have indicated serious organic pollution. High gradient and high reaeration potential of the stream are also factors reducing potential impacts of conventional pollution.

Upstream of the roaster piles, the stream exhibits fairly normal characteristics and clear water during lowflow conditions. At no time during the last 20 years did the stream appear orange or become coated with iron precipitate. As expected, metals and conductivity levels were significantly lower above the roaster piles.

Prior to the rehabilitation, the upstream site appeared pristine compared to the polluted section of stream, although clearly not pure. Metals are leached from diffuse mining waste sites and mineral deposits throughout the watershed, raising concentrations higher than most streams in the state. Background conductivity levels in Brewery Creek are high and reflect relatively high metals concentrations. Mean conductivity values in Brewery Creek above the roaster piles and other Iowa County streams are 735 and 567 umhos/cm respectively. Fortunately, Brewery Creek is also a hard water stream. Metals concentrations above the roaster piles would be chronically toxic in otherwise soft water systems. Figure 2 compares zinc and lead at Site A to average concentrations of these parameters statewide.

Site B was located below a single roaster pile, at the Jackson Street bridge. Prior to roaster pile removal, copper, cadmium, iron and zinc concentrations were significantly higher than upstream levels. Zinc was an order of magnitude higher than at the reference site and concentrations exceeded acute toxicity criteria. Comparing metals concentrations at Site B before and after the roaster pile was removed, copper, cadmium, iron and zinc decreased significantly while lead concentrations were fairly constant. Zinc concentrations displayed the greatest change, however water sampling in 1994 and 1995 revealed that levels still exceed NR 105 chronic toxicity criteria.

Site D is located below the last roaster pile and final mining waste containment site. Metals at Site D were significantly higher than both Sites A and B. Over the years, Site D has displayed the worst water quality since all five roaster piles affected the stream at this location. In addition to acutely toxic zinc, cadmium levels also

exceeded chronic toxicity criteria before the project was completed.

Consistent with Site B, four of the five test metals tested at Site D decreased significantly following the stream rehabilitation. Again, lead was the exception and showed no significant change. Cadmium levels are no longer toxic and mean zinc concentrations decreased from 3600 ug/l to 695 ug/l. Currently, zinc concentrations remain acutely toxic since the mean zinc concentration is substantially higher than the acute toxic criteria value of 334 ug/l (based on 400 mg/l hardness). While water column concentrations have decreased by approximately 80%, groundwater seepage is contributing leached metals within the treatment zone.

Event monitoring, performed in 1979 and '89, demonstrated that zinc concentrations increased significantly while hardness and pH levels decreased. Lower hardness coinciding with higher metals contributes to higher overall toxicity. Due to lack of time and funding, no effort was made to characterize water quality during runoff events after mining wastes were contained. Since the roaster piles have now been consolidated and stabilized, significant runoff sources of metals are unlikely. Figures 3-7 report water column metals concentrations before and after the project completion.

PRECIPITATE ON OVERHANGING VEGETATION

In 1992, stream substrates and overhanging vegetation below roaster piles were coated with the characteristic orange precipitate. We harvested grass blades (mostly canary reed grass) submersed in the stream to estimate concentrations of heavy metals coating the plants. Due to the leaching process described in the Methods section, we do not know the relative metals concentrations of precipitate versus plant tissues. Since the highest metals concentrations were found below the roaster piles, the results suggest that the precipitate did contain significant amounts of various heavy metals. Higher than expected levels of lead and other metals were found at the reference site and indicate that plant tissues also contributed to the overall metals concentrations. Due to time constraints and limited monitoring funds, we did not repeat this effort in 1994. Figures 8-10 illustrate metals concentrations between four sampling stations in 1992.

MACROINVERTEBRATE RESULTS

Figures 11-19 display macroinvertebrate data based on % EPT vs. % Chironomidae, HBI, and total species numbers. Figures 11 and 12 represent reference site (A) macroinvertebrate data. The upstream site displayed not only the best water quality of all the sites sampled, but also better water quality in 1994 compared to 1979, 1987, 1989 and 1992. In 1994, we found the lowest HBI value (indicating best water quality), the highest percentage of Ephemeroptera and Tricoptera (EPT) and largest number of species.

Even though macroinvertebrates at Site A suggested that background conditions improved in 1994, downstream sites improved more significantly after the project was completed. Figures 13-15 display post rehabilitation water quality improvements at all sampling stations below the former roaster piles. At site B, all three macroinvertebrate metrics indicated improved water quality. At station D (Ferndale Road), no macroinvertebrates were found in 1992 while 16 species were found in 1994.

Comparing all sampling stations in 1994 (Figures 16-18), the best water quality was found at the two reference sites (A and G) while downstream sites are still affected by heavy metals leaching into the stream. Low mayfly and caddisfly numbers, as well as overall low diversity, reflect persistent zinc toxicity within the affected area. At Site D, Orthocladinae midges are the only insects thriving under the toxic conditions. Armitage (1980), Winner et al, (1980), Chadwick (1985) and Clements et al, (1988) have documented Orthocladinae tolerance of high metals concentrations in other natural and experimental streams.

FISHERIES DATA

Upstream of the roaster piles, Brewery Creek supports at least ten warm water species, based on the Wisconsin Fish Distribution Survey (1976). Most of the fish are pollution tolerant and are commonly found in southwest Wisconsin streams. Site A is located approximately .5 miles below the 1976 survey site. Compared to the 1976 survey, lower species numbers were found at Site A in 1992 and 1994 and may reflect habitat differences between the two upstream sites.

Prior to the rehabilitation, total numbers of individuals and species were extremely low below the roaster piles. Creek chub was one of just a few species found and appears to be fairly tolerant of mining waste pollution. In 1992, only seven creek chubs were collected at Site D and all of the fish were discolored or carried lesions. In addition to the creek chubs, a single southern redbelly dace was also found at Site D and six white suckers were collected at Site B.

Consistent with other biological and chemical parameters, fish responded favorably to reduced metals concentrations and ferric hydroxide precipitate in the stream. Following the remediation, total numbers increased significantly and the fish appeared to be healthier. Combining Sites B and D, nine species were collected in 1994 compared to three in 1992. Species numbers also increased at Site A in 1994 and may reflect natural variability and migrating populations now that the most of the toxic barrier has been removed. More fish sampling is requiring to better characterize fish populations in the stream and determine long term responses to the rehabilitation efforts.

CONCLUSIONS

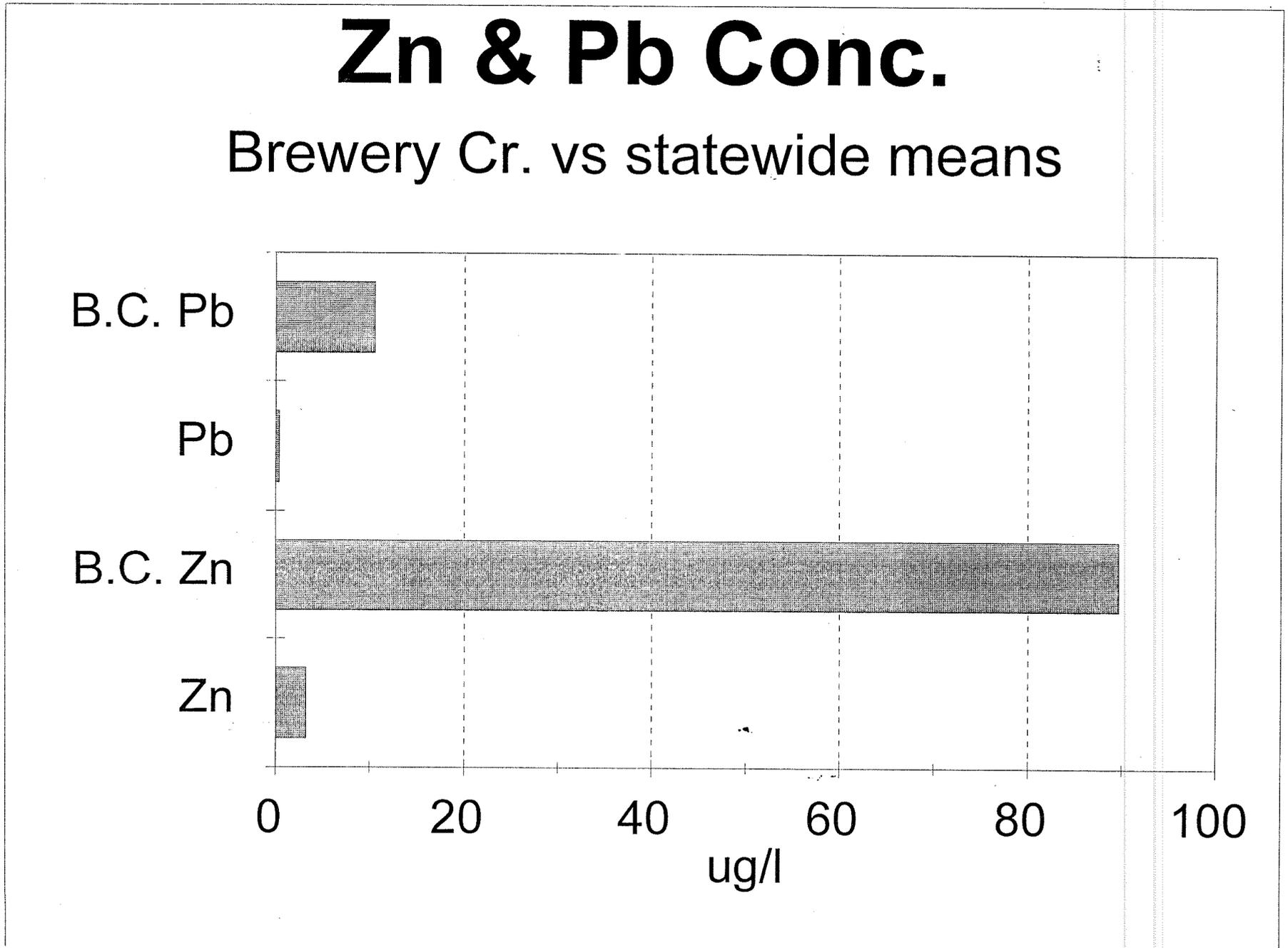
The mining waste containment - stream rehabilitation project was effective at converting a "biologically dead" stream into one that will support tolerant fish and invertebrate populations. For decades, Brewery Creek was little more rust colored soup, barely supporting the most tolerant insects that drifted into the toxic zone. With only a few remaining orange seeps as reminders of the long-term toxicity, the stream now flows clear over rocks that were previously hidden within the cloudy water.

Approximately 80% of water column metals have been removed within the first two years after the project. Yet groundwater seepage is contributing toxic levels of zinc to the stream. Long term monitoring will be necessary to determine if the containment site will remain effective and if the stream continues to respond to the treatment.

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Figure 2: Brewery Creek Zn & Pb vs statewide mean conc.

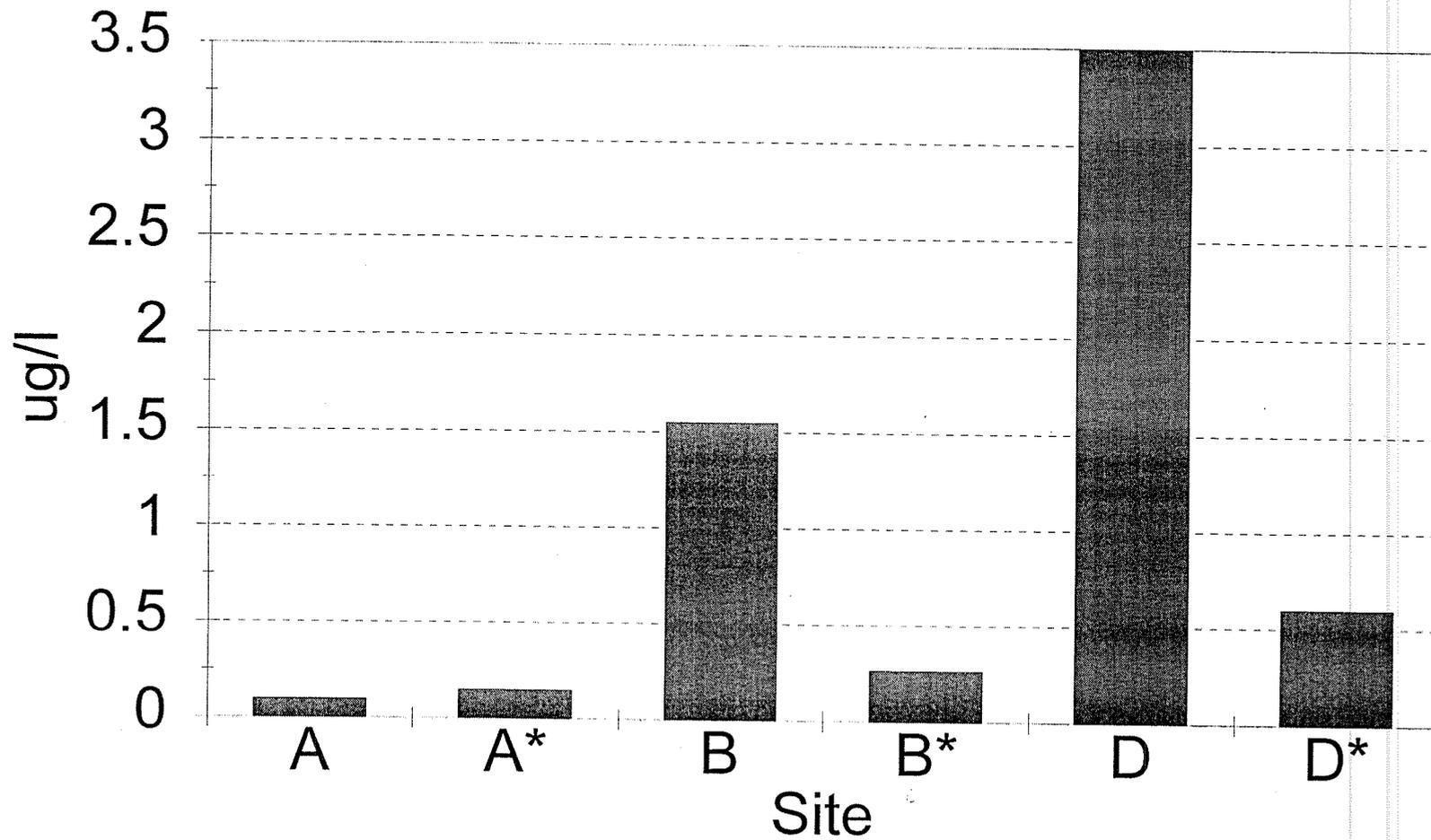


B. C. = Brewery Creek above roaster piles

Figure 3: Brewery Creek Cd concentrations

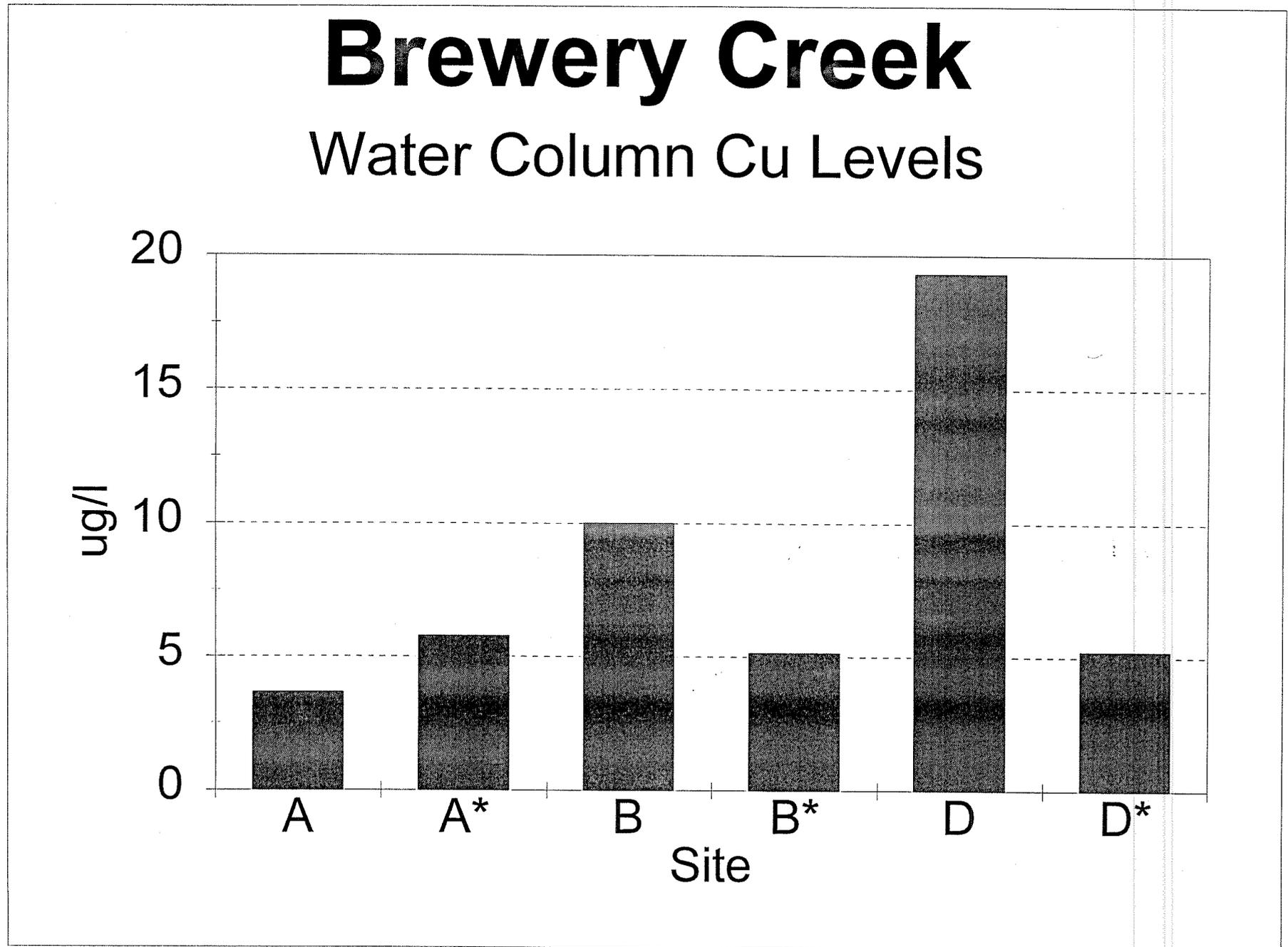
Brewery Creek

Water Column Cd Levels



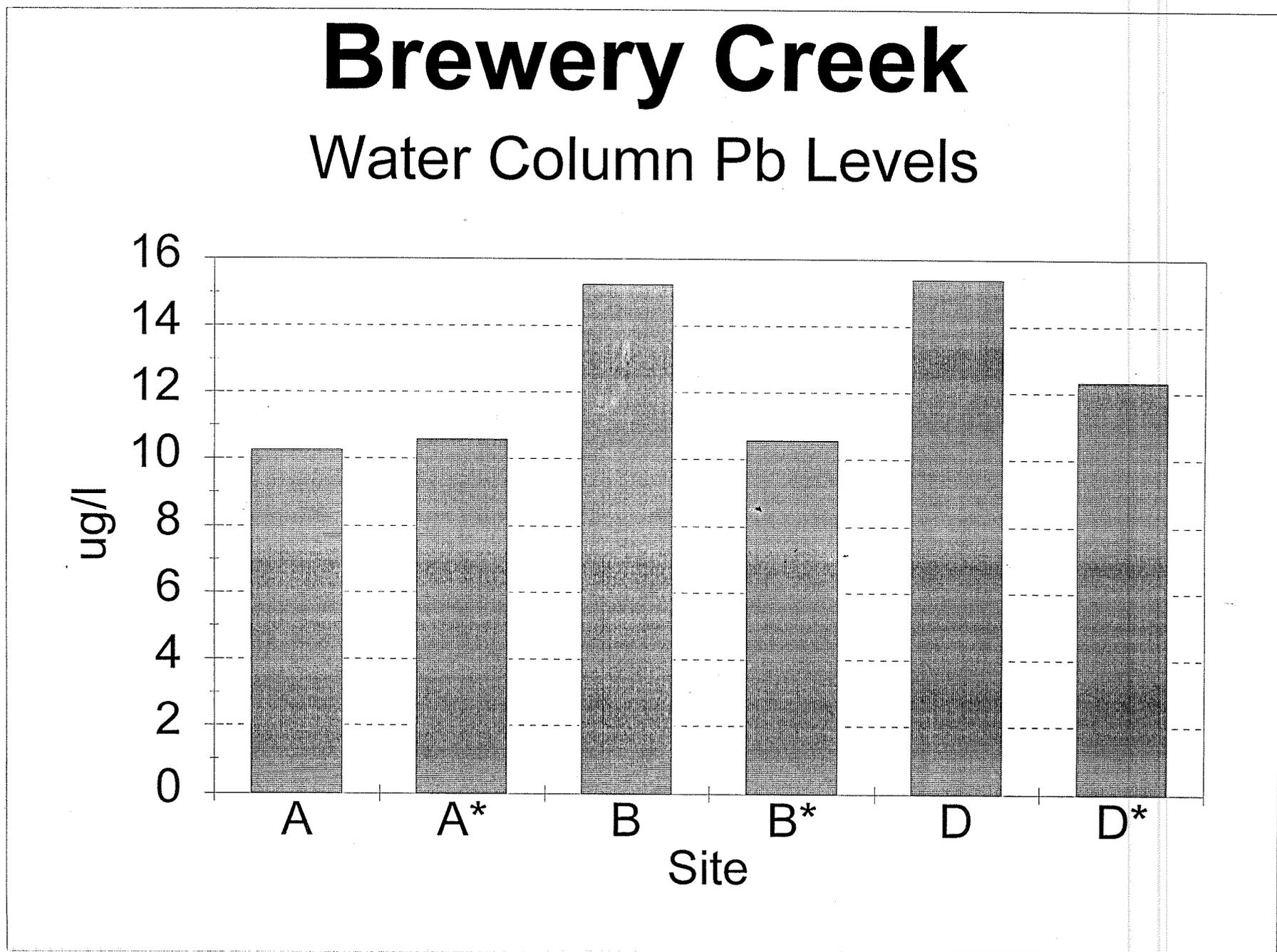
*= post rehabilitation concentrations

Figure 4: Brewery Creek Cu concentrations



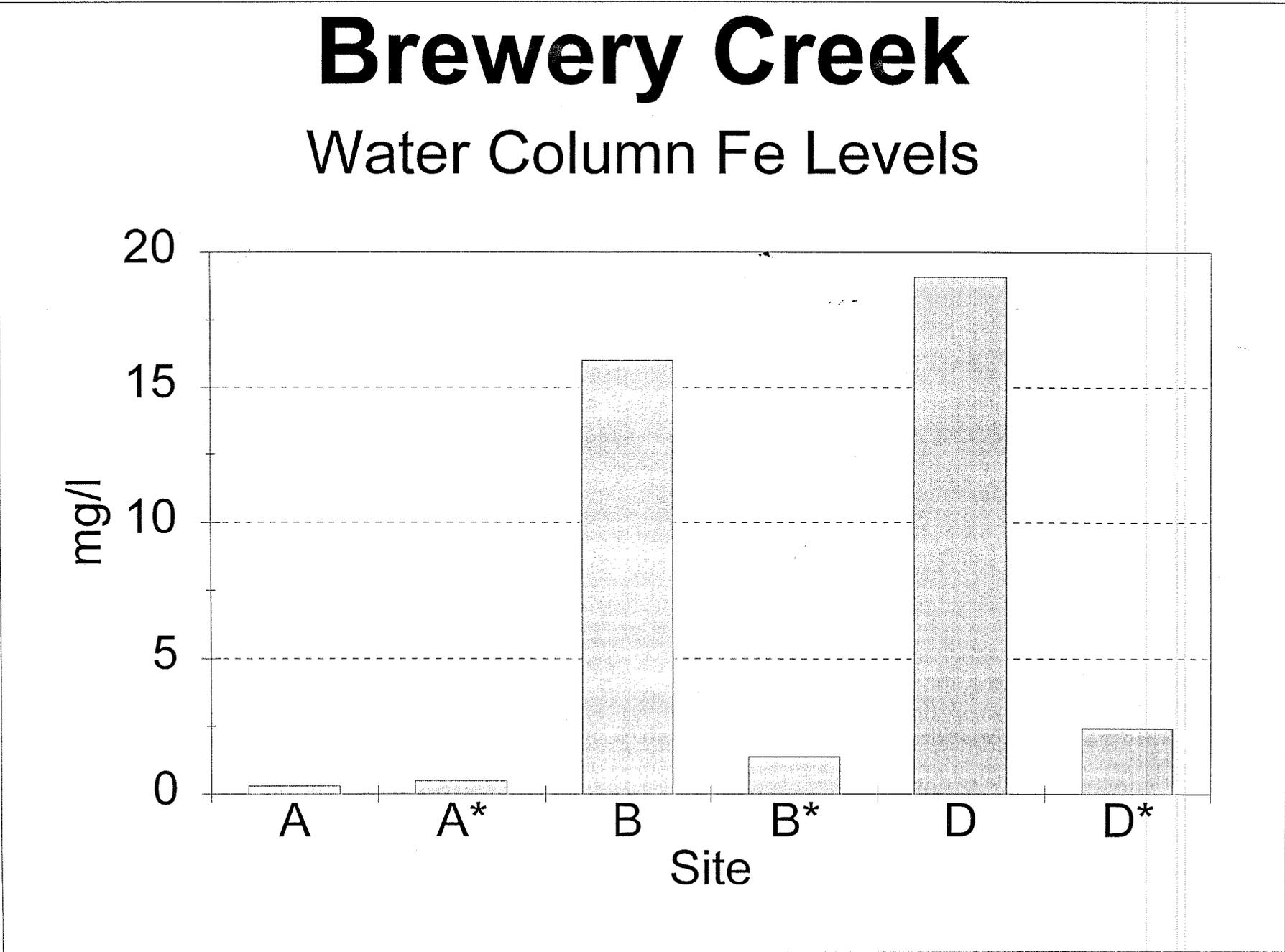
*= post rehabilitation concentrations

Figure 5: Brewery Creek Pb concentrations



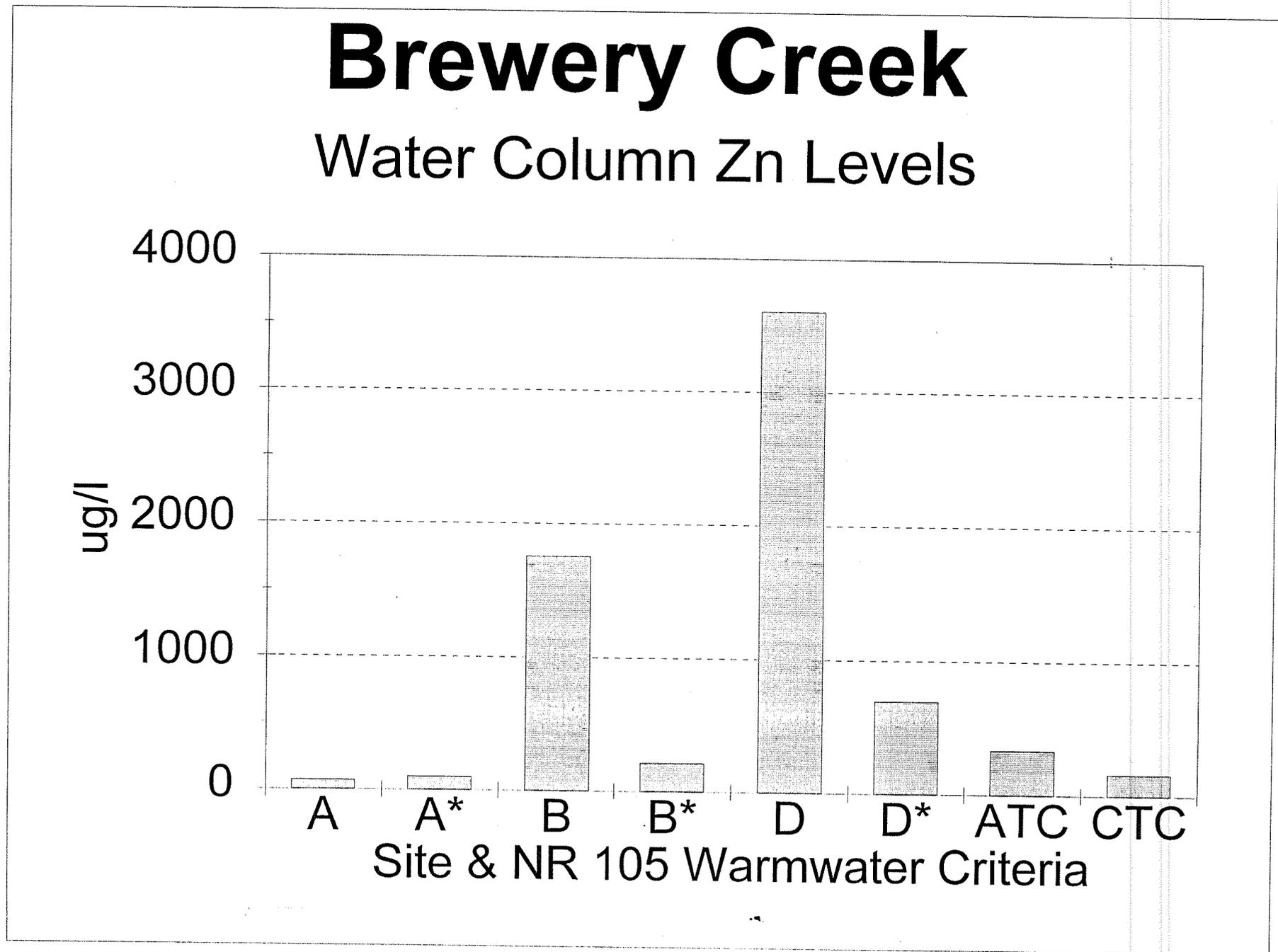
* = post rehabilitation concentrations

Figure 6: Brewery Creek Fe concentrations



*= post rehabilitation concentrations

Figure 7: Brewery Creek Zn Conc. vs Criteria



*= post-rehabilitation, ATC=acute, CTC=chronic

Figure 8: Precipitate on Overhanging Vegetation, 1992

Brewery Creek Precipitate Analysis

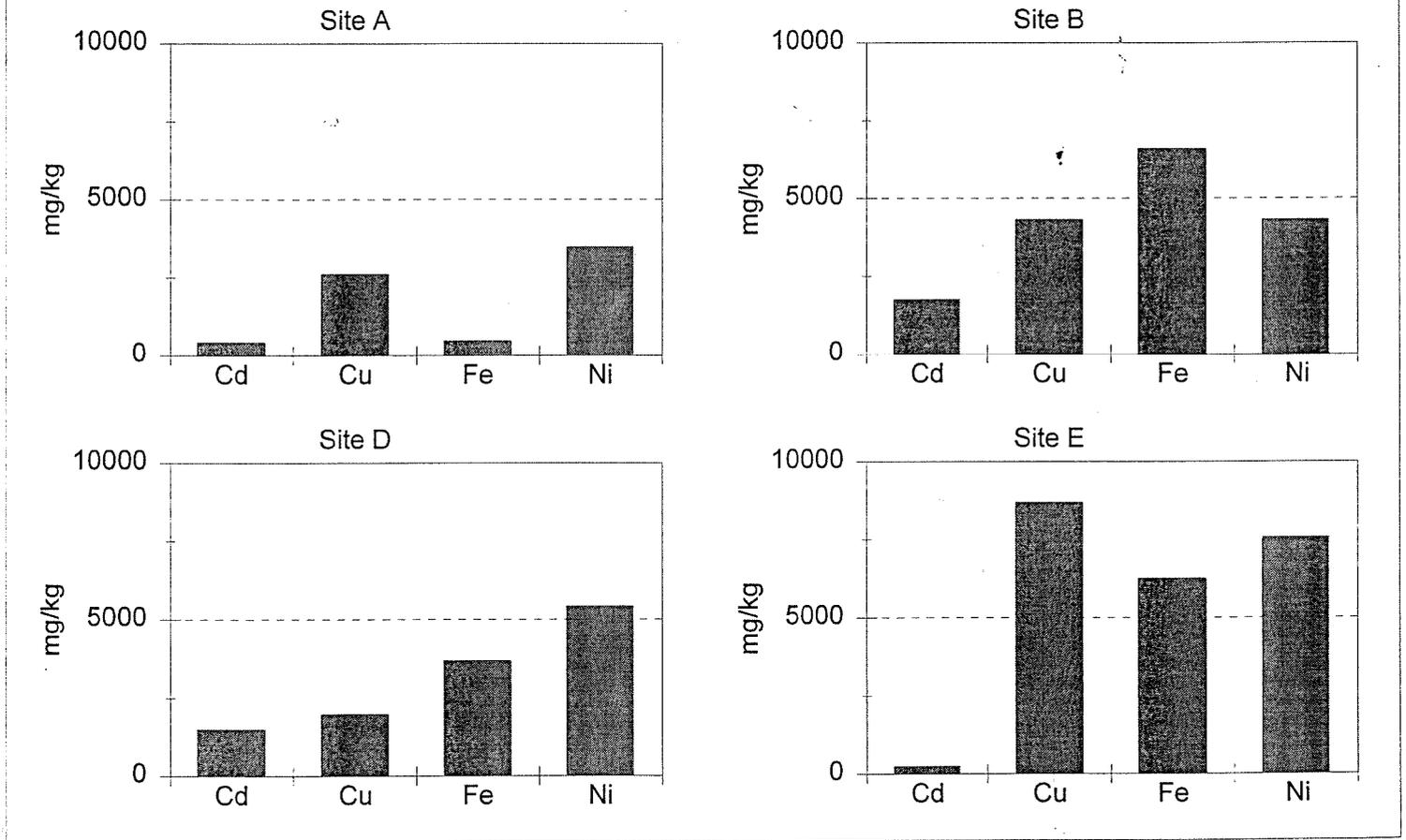


Figure 9: 1992 Pb concentrations in ferric hydroxide precipitate

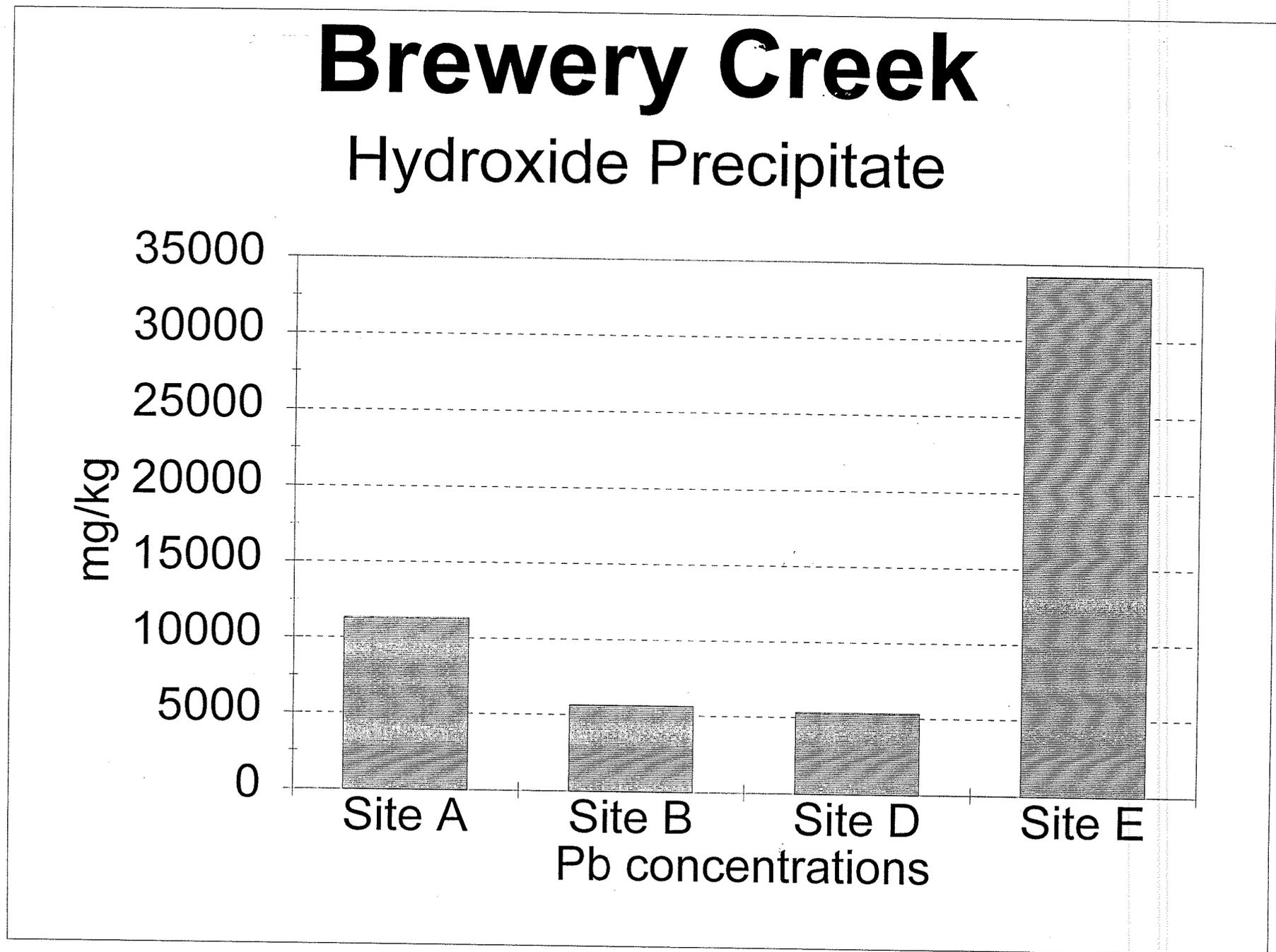


Figure 10: 1992 Zn concentrations in ferric hydroxide precipitate

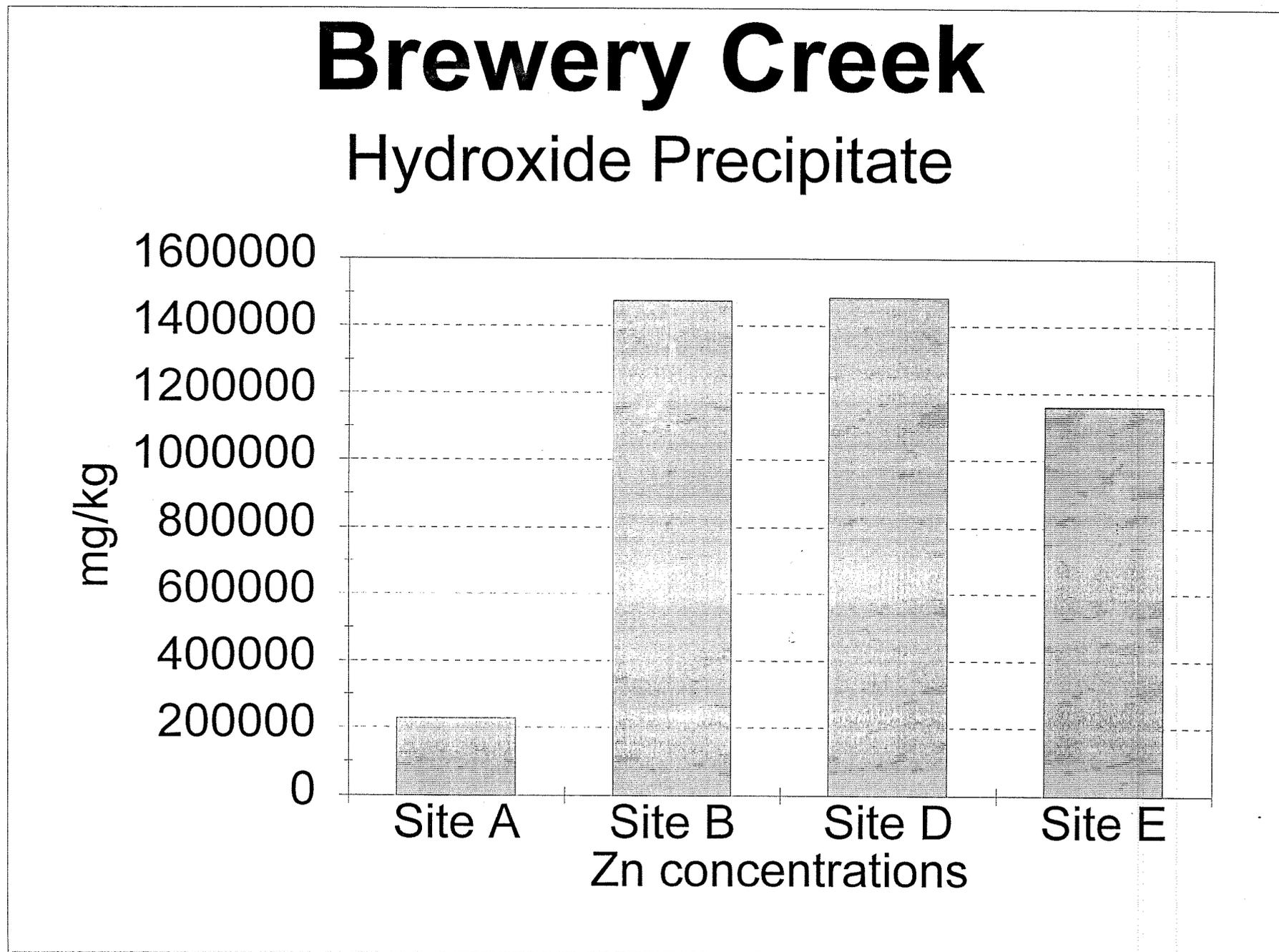


Figure 11: Site A Macroinvertebrate Data

Brewery Creek

Site A Macroinvertebrates

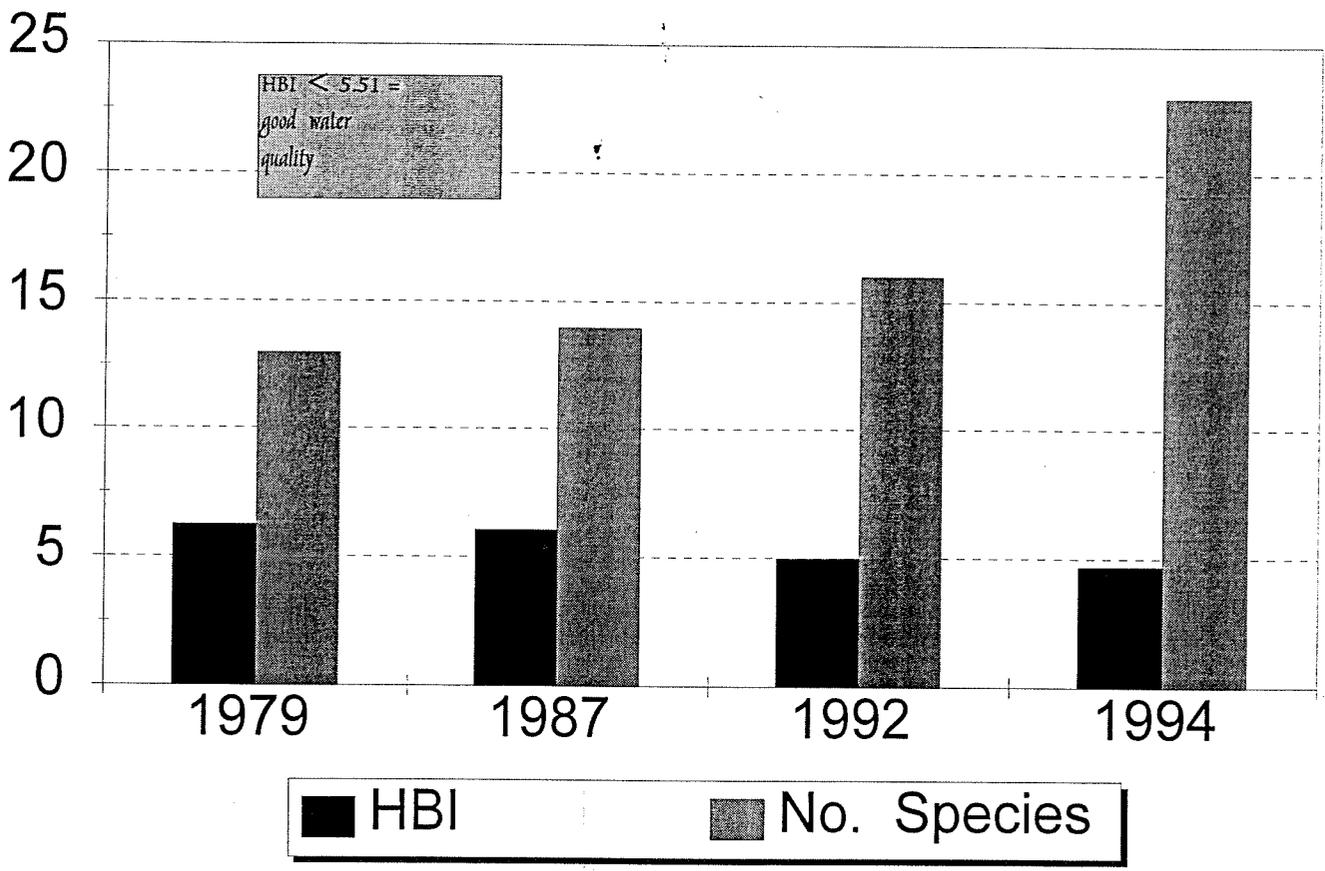


Figure 12: Site A Macroinvertebrate Data

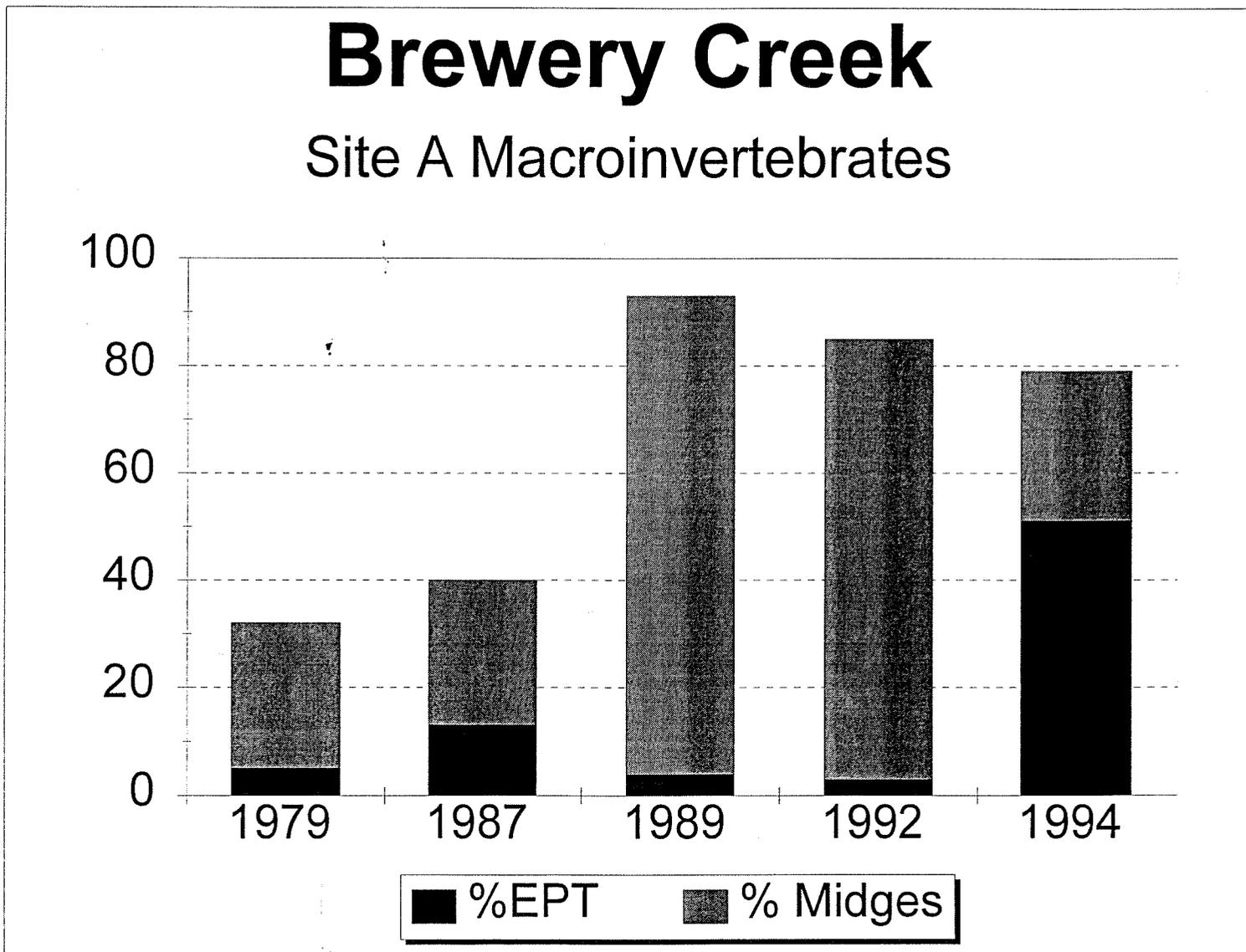


Figure 13: Site B Macroinvertebrate Data

Brewery Creek

Site B Macroinvertebrates

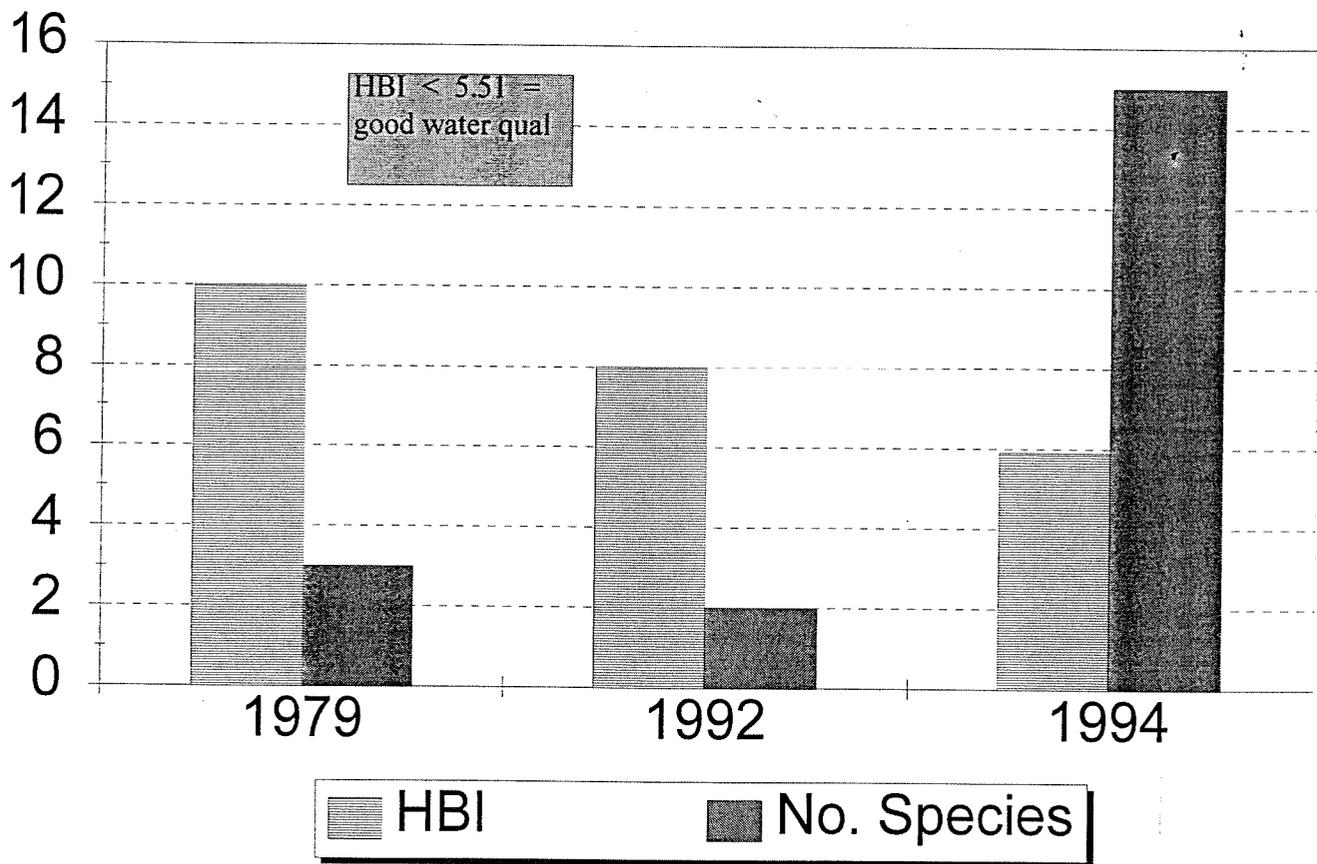


Figure 14: Site B Macroinvertebrate Data

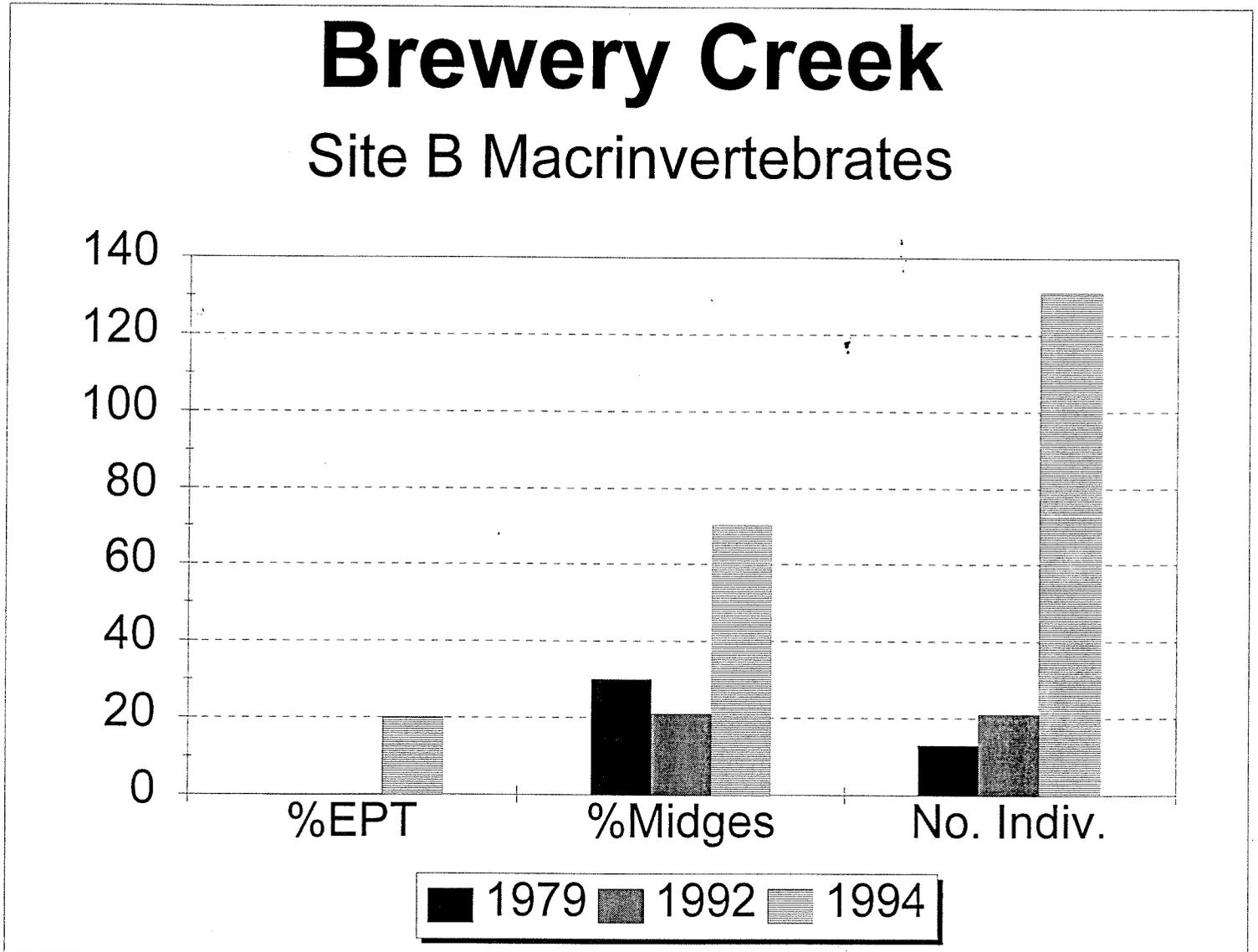


Figure 15: Site D Macroinvertebrate Data

Brewery Creek

Site D Macroinvertebrates

