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ARMSTRONG LABORATORY

BORON INVESTIGATION SURVEY, MARCH AIR FORCE BASE, CALIFORNIA

John G. Garland III, Major, USAF, BSC

OCCUPATIONAL AND ENVIRONMENTAL
HEALTH DIRECTORATE
Brooks Air Force Base, TX 78235-5000

July 1992

Final Technical Report for Period 27 January 1992 – 7 February 1992

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JOHN G. GARLAND III, Maj, USAF, BSC
Chief, Water Quality Branch

EDWARD F. MAHER, Col, USAF, BSC
Chief, Bioenvironmental Engineering Division

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13. ABSTRACT *(Maximum 200 words)*

Armstrong Laboratory conducted a field survey to investigate the source of boron in the March AFB CA wastewater treatment plant effluent. The survey measured boron contributions from drinking water, domestic sources, and industrial sources over a 10-day period. The survey also evaluated the effluent to the treatment plant over the same 10 days. Boron results at the regulatory discharge point averaged 0.48 mg/l, which complies with the base permit. The results also showed drinking water levels averaged 0.225 mg/l, domestic contribution combined with drinking water levels averaged 0.396 mg/l, and mixed industrial and domestic levels ranged from 0.246 mg/l to 1.84 mg/l. The report presents bulk boron sample results from a variety of soaps and bleaches. Recommendations include further investigation into industrial activity generating high boron levels, discouraging the use of boron-containing products by military, contract, and domestic users, and negotiating with the regulating agency for permitting boron at a higher level.

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INTRODUCTION

Armstrong Laboratory (AL), Environmental Engineering Branch, Water Quality Function, conducted a boron investigation survey at March Air Force Base (AFB), CA, from 27 Jan 92 to 7 Feb 92. The purpose of the survey was to investigate the cause of excess levels of boron in the base's wastewater treatment plant effluent.

On 11 Apr 91, the 22d Strategic Hospital/SG requested AL conduct the survey. The purpose of the survey was to provide March AFB with on-site assistance in determining remediation actions needed to control releases of boron into the wastewater discharge.

Maj Garland conducted a presurvey from 5-8 Jun 91 and collected bulk samples of various soap products suspected of containing boron. AL provided the base these results in an 18 Jun 91 letter. This report includes the results of the presurvey bulk sampling.

On 11 Jun 91, AL proposed a field survey plan. The base concurred with the plan. Between Jun 91 and Dec 91, the base took aggressive action to remove all boron-containing soaps from use. The base also began a monitoring program at the wastewater treatment plant.

In Nov 91, when the monitoring data showed removal of boron-containing soaps would not reduce the boron levels enough for the base to meet their permit levels, the base Bioenvironmental Engineer requested AL conduct a field survey as previously planned.

Maj John Garland, 2d Lt Anita Acker, and SSgt Robert Davis conducted the field survey.

DISCUSSION

Background

March AFB is located east of the city of Riverside and south of Moreno Valley in Riverside County, California (Figure 1). March AFB is the site for active duty, reserve, and Air National Guard operations. The active duty operations include air

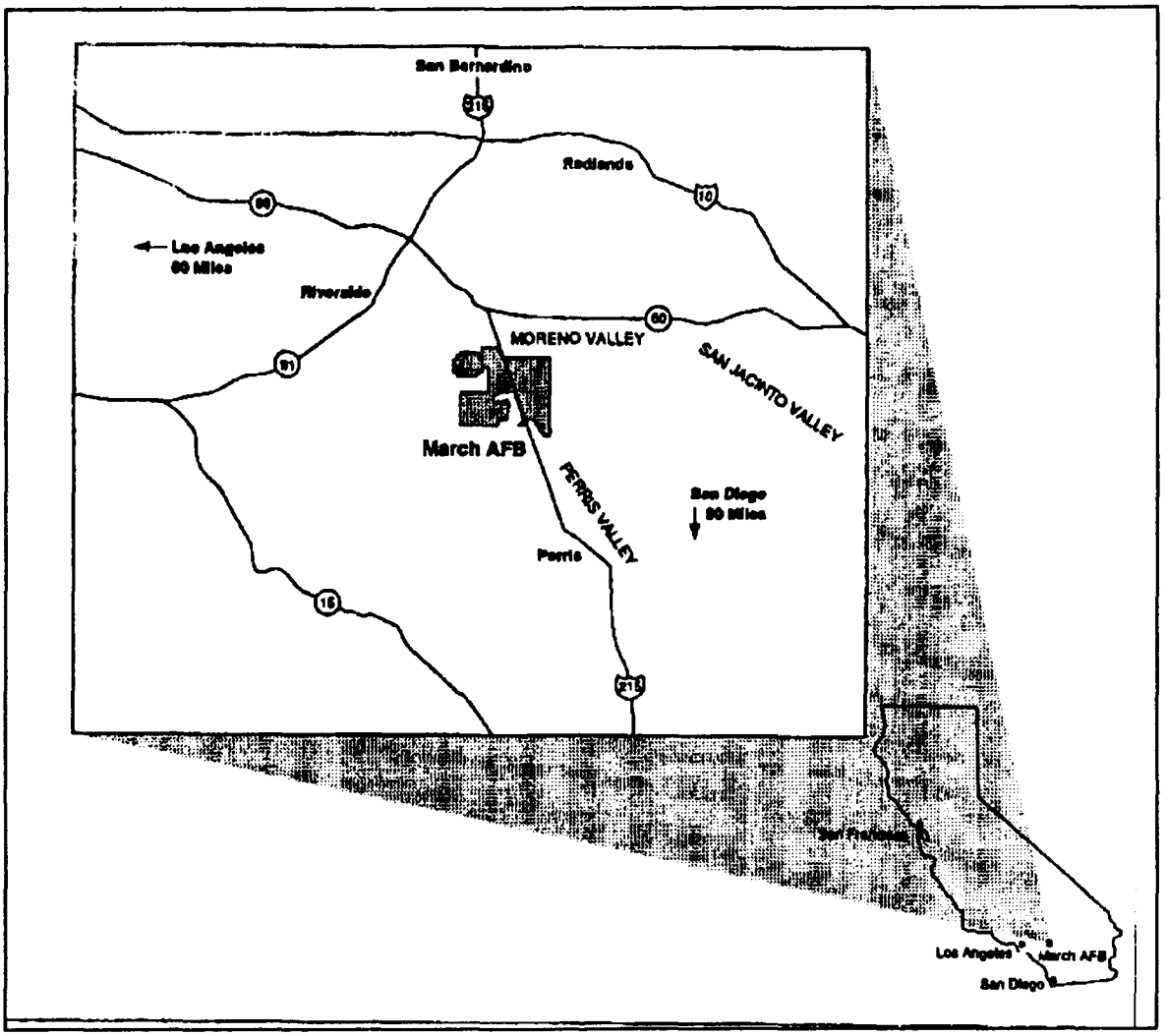


Figure 1. March AFB Location

refueling by the 22d Air Refueling Wing and Headquarters 15th Air Force support. Since 1963, Headquarters Strategic Air Command (SAC) has stationed B-52 bombers, KC-135 refueling tankers, and KC-10 refueling tankers at March AFB. B-52 bombers retired from March AFB in 1982. The base hosts the Southwest Air Defense Sector, a tactical warning and assessment unit of the Tactical Air Command's First Air Force. There are no major aircraft weapon systems located at March AFB in support of this mission.

The principal reserve operation is the 452d Air Refueling Wing and the 943d Tactical Airlift Group. These units operate and maintain KC-10 and C-130 aircraft. The C-130 aircraft support the U.S. Forest Service through Modular Airborne Firefighting Systems missions (MAFFS). MAFFS employs chemicals to inhibit combustion of trees and shrubs.

The California Air National Guard operates the 163d Tactical Reconnaissance Group operating F-4 Phantom's and RF-4s. The 163d Tactical Reconnaissance Group provides photoprocessing support for their reconnaissance mission.

U.S. Customs Aviation Operations Center West operates on March AFB. The customs operation includes an aviation response center and the support of several types of aircraft and helicopters.

The Base Realignment and Closure (BRAC) action at March AFB will expand the base's mission in several areas and require the support of additional aircraft.

Permit Standards

March AFB discharges around 0.020 cubic meters/sec of treated domestic and industrial wastewater for landscape impoundment and irrigation at the base golf course and the Riverside National Cemetery. The California Regional Water Quality Board, Santa Ana Region, regulates the boron discharge from the wastewater treatment plant (WWTP) with National Pollution Discharge Elimination System (NPDES) permit order number 88-24, Waste Discharge and Producer Reclamation Requirements. The permit prohibits the discharge of wastes where the 4-month average concentration of boron exceeds 0.5 mg/l.

The permit requires monitoring in accordance with the Environmental Protection Agency (EPA) guidelines in Code of Federal Regulations, Title 40, Part 122(1). The permit also requires analyses be performed by a laboratory certified by the State Department of Health Services for the constituent analyzed and requires the base to perform compliance calculations (averages) using all monitoring conducted with approved test procedures at locations specified in the order. Compliance with the boron specification is based on the moving arithmetic average of all sample analyses performed during any 4-month period. The permit directs the base to take a 24-hour composite sample for boron on the 15th working day of each month.

The March AFB wastewater treatment plant is located in the Perris-North Ground Water Subbasin. California has specified the

following beneficial uses of the water: municipal and domestic supply, agricultural supply, industrial service supply, and industrial process supply.

Sampling Strategy

AL's overall sampling strategy was to conduct a mass-balance for boron. The team measured incoming, or background, boron from drinking water with a fully flushed tap sample on a daily basis. The team also measured boron at the regulatory sampling point, sending these samples to a California-certified laboratory for analysis. The net difference between the two boron levels was the boron contributed by the domestic and industrial activity on the base.

The team delineated domestic and industrial activity by taking samples in a line exclusively carrying wastewater from the base housing area in Arnold Heights. This sampling consisted of four daily composite samples: two from weekday activity and two from weekend activity.

The strategy further characterized the industrial boron contribution with discrete and composite samples from wastewater lines on the main portion of the base. Some of these samples included both industrial and domestic discharges as the wastewater lines served both housing and work areas. Some samples were exclusively workplace activity.

To reduce analytical costs, yet still obtain important data, the survey team screened sites with composite samples and followed high boron levels with 24-hour discrete samples. Composite samples were taken in major branches of the wastewater collection system. Composites were express-mailed to AL for same-day analysis. AL called the results to the field team. If the boron levels exceeded 0.5 mg/l (the permit level), 24 discrete samples were taken. If the boron level was below 0.5 mg/l, the team continued to collect a single daily composite sample. The survey total number of boron samples was 313.

Figure 2 shows the sample site locations, and Appendix A describes each site

Analytical Support

The survey team sent all samples taken at the permit point of compliance (i.e., the wastewater treatment plant effluent) to Clayton Environmental Consultants, a California state-certified laboratory for Clean Water Act sampling.

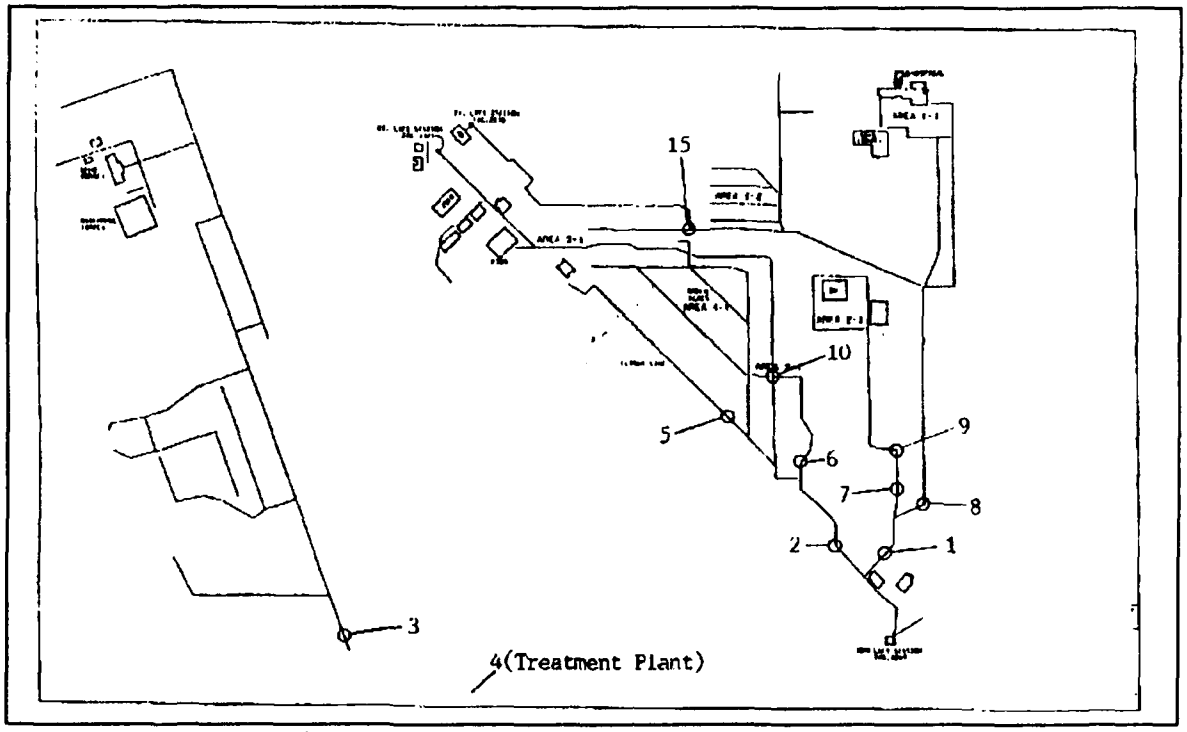


Figure 2. Sampling Site Locations

The team sent the remaining investigative samples to AL for analysis. AL was not a California state-certified laboratory for Clean Water Act sampling at the time of the survey.

Sampling Methods

The AL team followed the guidance contained in Standard Methods(2) and Air Force Occupational and Environmental Health Laboratory Sampling Guide, March 1989(3), for the collection and analysis of all samples. The team took additional bulk samples of products suspected to contain boron in small polyethylene containers. The team collected daily water samples in polyethylene containers from a fully flushed tap in the Bioenvironmental Engineering office (building 500). The team collected wastewater samples either as composite or discrete samples over a 24-hour period. Composites were time-proportional--a fixed volume every 1-hour period--and either composited manually or automatically. Automatic samplers collected hourly discrete samples which the team transferred to glass or polyethylene sample containers.

Both AL and Clayton performed all analyses by inductively

coupled plasma emission spectroscopy (ICP-ES), EPA method 200.7(4).

Quality Assurance/Quality Control (QA/QC)

The AL survey team submitted reagent blanks, equipment blanks, spike samples, and duplicate samples to both analytical support laboratories.

Both laboratories meet the requirements of the U.S. EPA for accreditation. These requirements include monthly blind sample controls, use of National Institute Standards and Technology Standard Reference Materials traceable standards and control samples with each analytical run, corrective action for quality assurance problems, establishing sample detection limits, proficiency surveys, interlaboratory quality evaluation programs, and plotting and tracking of all quality control samples and trends by analytical section.

Drinking Water

The Western Municipal Water District (WMWD) provides the base drinking water, primarily from well water. Historical data were limited to one or two sporadic samples collected by different agencies and analyzed by different laboratories.

Wastewater Collection and Treatment System

The March AFB wastewater collection system consists of a network of gravity flow lines with lift stations. The collection system is old and, because of the flat terrain and flat slope, leads to low sewage velocity and the accompanying clogging and flow problems due to solids settling. Other problems associated with the system include rough, older pipes, misaligned joints, tree roots, etc. Infiltration is likely to occur during rainfall and excessive grass watering.

There are no accurate flow values for the base's wastewater. The approximate flow range is 0.033 cubic meters/second to 0.053 cubic meters/second.

Treatment consists of a primary clarifier, trickling filter, anaerobic sludge digestion, and chlorine contact chamber. The plant effluent is temporarily held in a holding basin and then pumped to the base golf course and the Riverside National Cemetery for irrigation.

Base sample records, based mainly on analytical results from AL, using the Carmine colorimetric method from Standard

Methods(2), show the base has violated the boron discharge limit on a continuous basis during recent years (see Appendix B). Sampling by the base in Aug, Sep, and Oct 91 show the base discharged boron at levels of around 5 mg/l (Appendix B). Hourly discrete samples in Aug 91 confirmed the base to be generating a constant background of around 5 mg/l of boron in their wastewater (Appendix B).

Soil, Geology, and Weather

The two major soil associations that exist in the March AFB area include the Cieneba-Rockland-Fallbrook association and the Monserate-Arlington-Exeter association. These soils are typically 1 to 3 feet thick and have a surface layer of sandy loam to fine sandy loam. The soils are typically underlain by a shallow, relatively low permeability silica hardpan at a depth of 28 to 50 inches.

Weather for 2 weeks prior to the survey was sunny with no precipitation. Rainfall began 5 Feb 92 and continued in a steady drizzle for the duration of the survey.

Boron

Boron is a naturally occurring material used for both industrial and domestic products. It is an essential nutrient to plants but can be toxic above certain concentrations to aquatic and terrestrial organisms. Concentrations high enough to produce toxic effects in laboratory tests are found in areas where weathering of boron-rich formations and deposits occurs, such as in the southwestern United States.

EPA's water quality criteria for boron recommend 0.75 mg/l for long-term irrigation on sensitive crops(5).

A common source of boron is soap containing sodium borate or perborate bleaches. Sodium borate ($Na_2B_4O_7$ $10H_2O$) is found in salt lakes and alkali soil. Its commercial name is borax, also known as tincal and decahydrate. Sodium perborate (sodium metaborate peroxyhydrate--$NaBO_2$ $3H_2O$) is a bleaching powder found in many soaps. It is frequently listed as a perborate bleach or an oxygen bleach as a soap content.

Other sources of boron include photo development rinse water. From 5-11 Jan 91, Fluor Daniel, Inc., characterized the wastewater flow from the Photo Lab at building 2630. The results showed a range of 0.1-1.7 mg/l boron, with an average value of 0.7 mg/l and an average flow of 946 l/day.

RESULTS

Field Quality Assurance/Quality Control(QA/QC)

Table 1 shows the field QA/QC results. The detection limit for EPA method 200.7 is 5 μg/l. Precision and bias information for boron in the range of 19-5189 μg/l as described for total digestion in Standard Methods for the Examination of Water and Wastewater(2) are as follows:

$$X = 0.8807C + 0.47$$
$$S = 0.1150X + 14.1$$
$$SR = 0.0742X + 23.2$$

Where X is the mean recovery in μg/l, C is the true value in μg/l, S is the multilaboratory standard deviation in μg/l, and SR is the single-analyst standard deviation in μg/l. These values pertain to laboratory prepared versus field QA/QC samples and are provided here for general information.

TABLE 1. FIELD QUALITY ASSURANCE/QUALITY CONTROL

Sample Number	Type QA/QC	Result (mg/l)	Nbr.	Pair Result(mg/l)	Pair Delta(mg/l)
24	Duplicate	0.328*	22	0.381*	0.053
47	Duplicate	0.524*	48	0.440**	0.084
37	Equipment Blank(EB)	<0.05*	n/a	n/a	n/a
38	EB	<0.05**	n/a	n/a	n/a
39	EB	<0.05*	n/a	n/a	n/a
40	EB	<0.05**	n/a	n/a	n/a
				Spike(mg/l)	
26	Spike	3.532*	n/a	4.0	-0.468(11.7%)
27	Spike	3.800**	n/a	4.0	-0.200(5.0%)
28	Spike	1.744*	n/a	2.0	-0.256(12.8%)
29	Spike	2.000**	n/a	2.0	0.000(0%)
30	Spike	2.306*	n/a	2.0	+0.306(15.3%)
31	Spike	3.591*	n/a	4.0	-0.409(10.2%)
32	Spike	3.900**	n/a	4.0	-0.100(2.5%)

* Sample analyzed by Armstrong Laboratory
** Sample analyzed by Clayton Laboratory

The single AL duplicate showed a precision range of approximately 15% from an average reported value of 0.3545 mg/l. The interlaboratory duplicate showed a precision of 17% from an

average reported value of 0.482 mg/l. Concerning accuracy, the average percent deviation from the four field spike values for AL was 12.4% with a net percent recovery of 95.15%. The average percent deviation from Clayton Laboratory was 3.75% with a net percent recovery of 96.25%.

Drinking Water Boron Levels

Table 2 displays drinking water boron results. The average level was 0.225 mg/l. The maximum value was 0.246 mg/l. The minimum value was 0.191 mg/l. The standard deviation was 0.02 mg/l.

TABLE 2. DRINKING WATER BORON LEVELS

Date	Sample Type	Results(mg/l)
28 Jan 92	Grab	0.245
29 Jan 92	Grab	0.246
30 Jan 92	Grab	0.245
31 Jan 92	Grab	0.211
1 Feb 92	Grab	0.206
2 Feb 92	Grab	0.197
3 Feb 92	Grab	0.191
4 Feb 92	Grab	0.238
5 Feb 92	Grab	0.239
6 Feb 92	Grab	0.230

Wastewater Treatment Plant Boron Effluent Levels

Table 3 shows the results of the composite samples at the wastewater treatment plant. The average discharge value was 0.48 mg/l with a standard deviation of 0.031 mg/l.

TABLE 3. DISCHARGE BORON LEVELS

Collection Date	Sample Type	Result(mg/l)
30 Jan 92	Composite	0.47
31 Jan 92	Composite	0.45
1 Feb 92	Composite	0.49
2 Feb 92	Composite	0.445*
3 Feb 92	Composite	0.46
4 Feb 92	Composite	0.54
5 Feb 92	Composite	0.50
6 Feb 92	Composite	0.49

*Average value of two duplicate samples, 0.45 mg/l and 0.44 mg/l.

Domestic Boron Contribution

Table 4 shows the results of the sampling from the Arnold Heights housing area. The average weekend boron concentration from the Arnold Heights housing area was 0.396 mg/l with a standard deviation of 0.093 mg/l.

TABLE 4. DOMESTIC BORON LEVELS

Collection Date	Sample Type	Result(mg/l)	Weekday
30 Jan 92	Composite	0.353	Wed-Thur
31 Jan 92	Composite	0.3545*	Thur-Fri
1 Feb 92	Composite	0.311	Fri-Sat
2 Feb 92	Composite	0.411	Sat-Sun
3 Feb 92	Composite	0.550	Sun-Mon

*Average value of two duplicate samples, 0.381 mg/l and 0.328 mg/l.

Industrial Boron Levels

Flight line-related industrial boron levels were best represented by site 5 (southeast flight line) and site 6 (northwest flight line). Table 5 shows the results of all industrial and mixed--industrial-domestic--composite samples. Appendix C contains the results of the discrete sampling.

TABLE 5. MIXED INDUSTRIAL AND DOMESTIC BORON LEVELS

Site	Collection Date	Sample Type	Result(mg/l)	Weekday
1	31 Jan 92	Composite[a]	0.494	Thur-Fri
1	1 Feb 92	Composite[a]	0.415	Fri-Sat
1	2 Feb 92	Composite[a]	0.646	Sat-Sun
1	3 Feb 92	Composite[a]	0.541	Sun-Mon
1	4 Feb 92	Composite[a]	0.479	Mon-Tue
2	30 Jan 92	Composite[a]	0.554	Wed-Thur
2	31 Jan 92	Composite[ab]	0.373	Thur-Fri
2	1 Feb 92	Composite[a]	0.765	Fri-Sat
5	2 Feb 92	Composite[ac]	0.336	Sat-Sun
5	3 Feb 92	Composite[a•]	0.252	Sun-Mon
5	4 Feb 92	Composite[af]	0.246	Mon-Tue
5	5 Feb 92	Composite[a]	0.424	Tue-Wed
5	6 Feb 92	Composite[a]	0.306	Wed-Thur
5	7 Feb 92	Composite[a]	0.689	Thur-Fri
6	2 Feb 92	Composite[ad]	0.710	Sat-Sun
6	3 Feb 92	Composite[a]	1.84	Sun-Mon
6	4 Feb 92	Composite[a]	0.517	Mon-Tue
7	6 Feb 92	Composite[a]	0.717	Wed-Thu
8	7 Feb 92	Composite[a]	0.353	Thur-Fri
15	7 Feb 92	Composite[a]	0.272	Thur-Fri

[a] Samples manually composited from discrete bottles in the field.
[b] Composite represents only 3 hours (0940-1240) due to equipment clogging.
[c] Composite represents only 14 hours (missing 2040-0640) due to equipment clogging.
[d] Composite represents only the first 6 hours of sampling on 1 Feb 92 (1150 to 1750) due to equipment clogging.
[•] Composite represents all hourly sample times except 1308. The equipment did not take a sample at that time.
[f] Composite represents four samples from noon and midafternoon of 3 Feb 92.

The average composite value from site 1 was 0.515 mg/l with a low variability (standard deviation 0.086 mg/l). Weekend activity contributed more boron than weekday activity. Figure 3 displays the results of the discrete samples at site 1 between 29 Jan 92 and 31 Jan 92. Levels are consistently above background drinking water levels of 0.2 mg/l and generally equal domestic levels of 0.4 mg/l. Peaks above domestic levels occur early morning (0500), late morning (1000), early afternoon (1500), and between 2100 and midnight. These peaks indicate an industrial contribution, albeit slight, during the respective times.

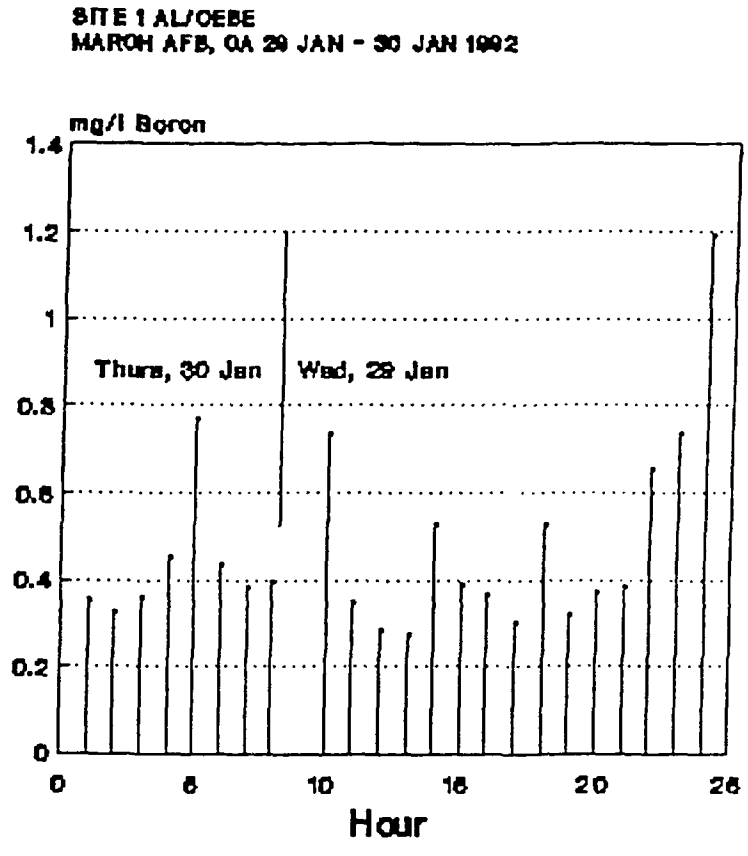
The average composite value from site 2 was 0.564 mg/l with a standard deviation of 0.196. Figure 4 displays the results of the discrete samples at site 2 between 29 Jan 92 and 1 Feb 92. The discrete samples show boron levels to generally reflect domestic background levels. Three peaks probably associated with repetitive industrial activity occur at 1100, 1500, and 2000-2200. The highest peak occurred around 1100 on Friday, 31 Jan 92.

The average composite value from site 5 was 0.3755 mg/l with a standard deviation of 0.167. Figure 5 displays the results of the discrete samples at site 5 on Sunday, 2 Feb 92 and Monday, 3 Feb 92. An industrial process using a boron compound appears to have occurred on Sunday afternoon at 1400.

Site 6 samples showed the highest average boron levels (1.022 mg/l) and the greatest variability (standard deviation of 0.715). Figure 6 displays the results of the discrete samples at site 6. A large sustained peak occurred on Sunday, 2 Feb 92, between 1600 and 2200. A similar sustained peak of one-tenth the magnitude occurred Monday, 3 Feb 92, beginning around 1000, peaking at 1500, and returning to background levels Sunday evening. From Tuesday evening, 4 Feb 92, through Thursday, 6 Feb 92, boron levels return to near domestic levels. This pattern points to weekend (Sunday) industrial activity as a cause of the high boron levels.

Figure 7 shows the results of the discrete sampling from site 8. The average value of the discrete samples was 0.376 mg/l with a standard deviation of 0.105 mg/l. The sample values approximate domestic boron levels.

Figure 8 shows the results of the discrete sampling from site 15. The average value of the discrete samples was 0.284 mg/l with a standard deviation of 0.031 mg/l. The waste approximates background levels and appears homogeneous.



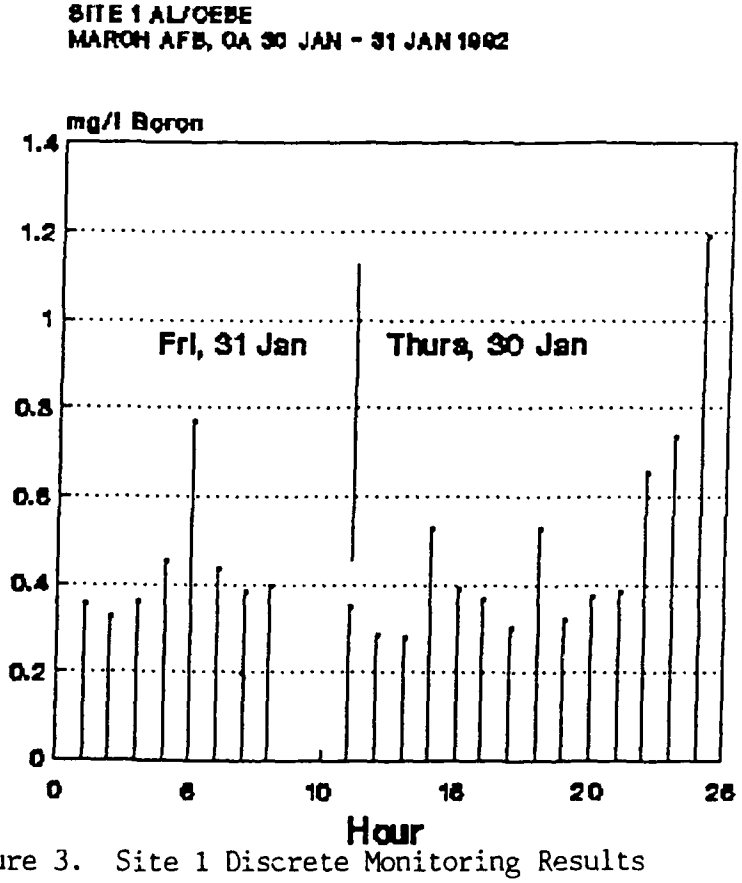
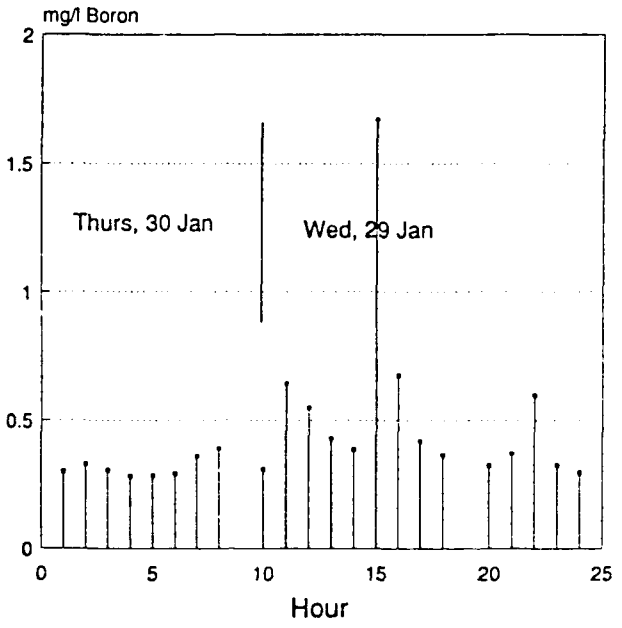


Figure 3. Site 1 Discrete Monitoring Results

FIGURE 4. SITE 2 DISCRETE MONITORING
MARCH AFB, CA 29-30 JAN 1992



MARCH AFB, CA 31 JAN - 1 FEB 1992

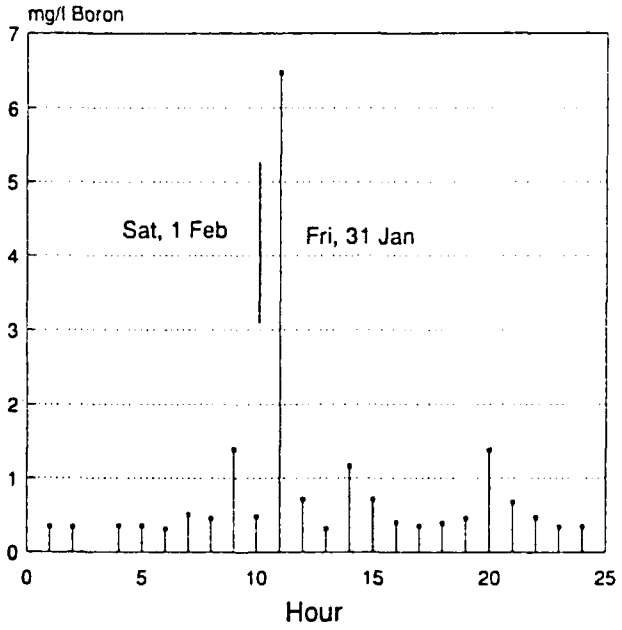


Figure 4. Site 2 Discrete Monitoring Results

FIGURE 5. SITE 5 DISCRETE MONITORING
MARCH AFB, CA 2 FEB - 3 FEB 1992

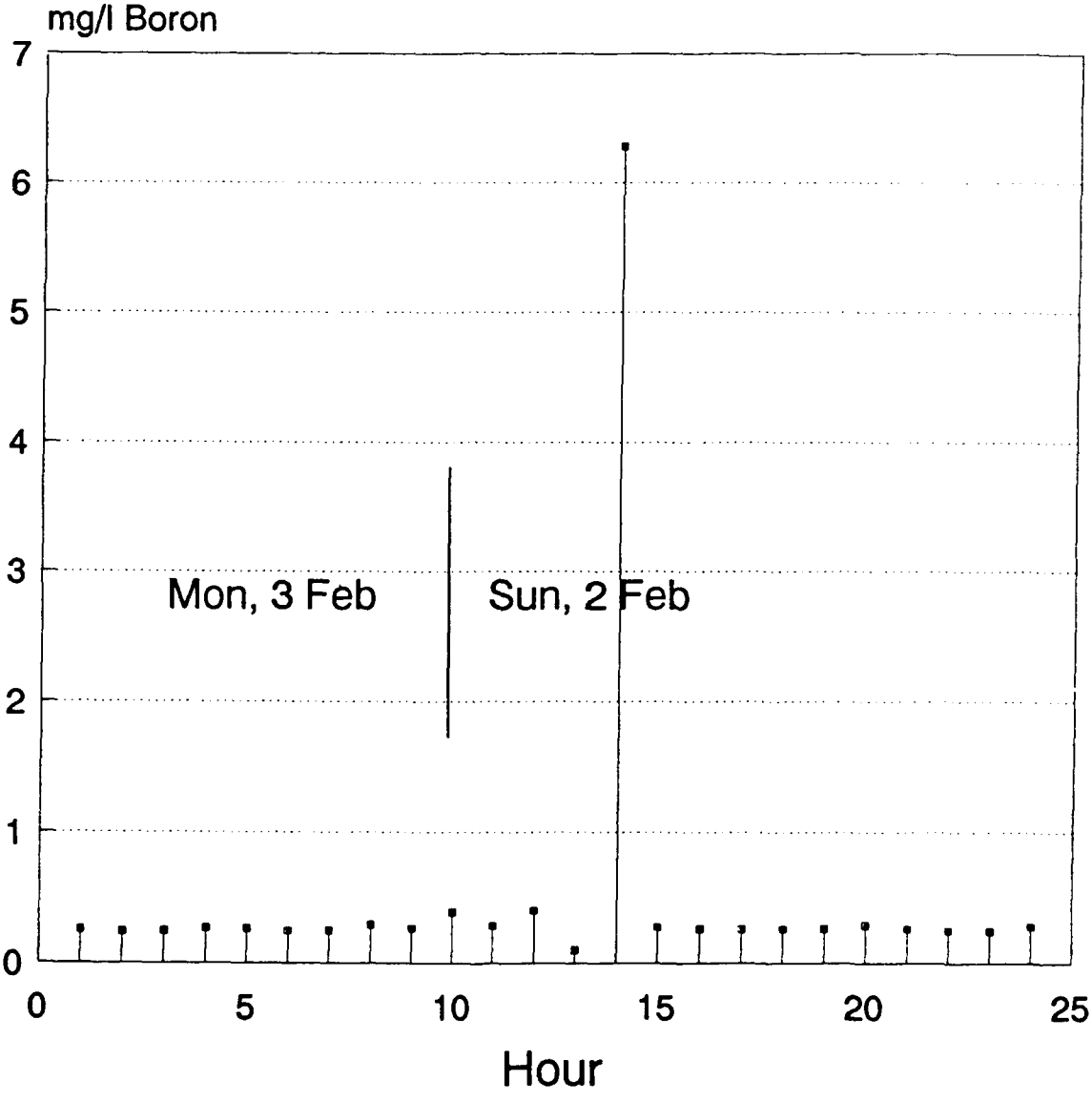


Figure 5. Site 5 Discrete Monitoring Results

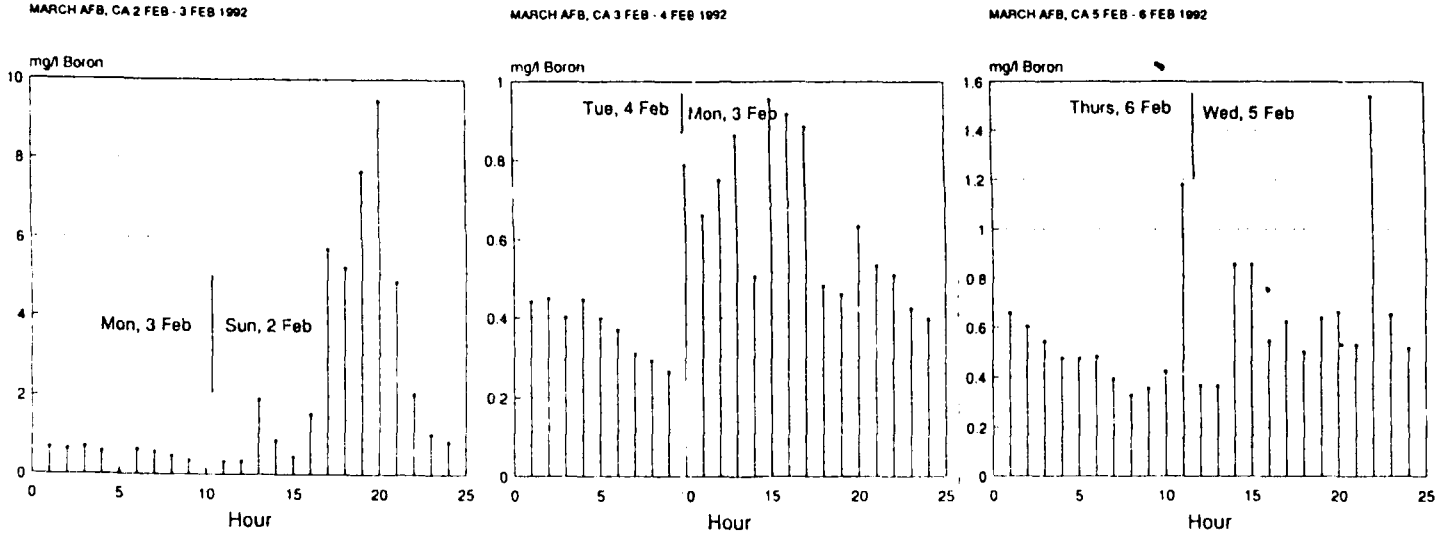


Figure 6. Site 6 Discrete Monitoring Results

FIGURE 7. SITE 8 DISCRETE MONITORING
MARCH AFB, CA 5 FEB - 6 FEB 1992

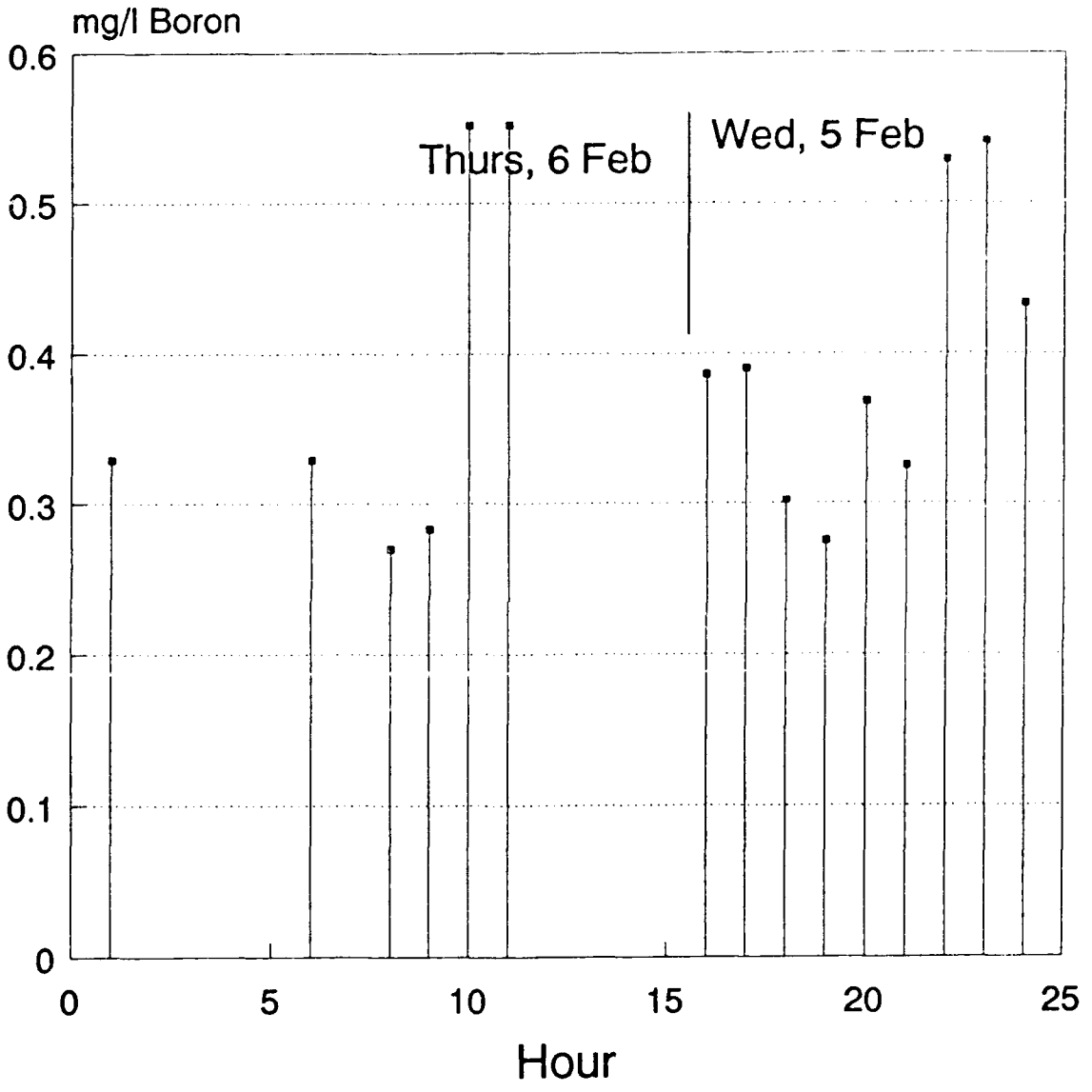


Figure 7. Site 8 Discrete Monitoring Results

FIGURE 8. SITE 15 DISCRETE MONITORING
MARCH AFB, CA 5 FEB - 6 FEB 1992

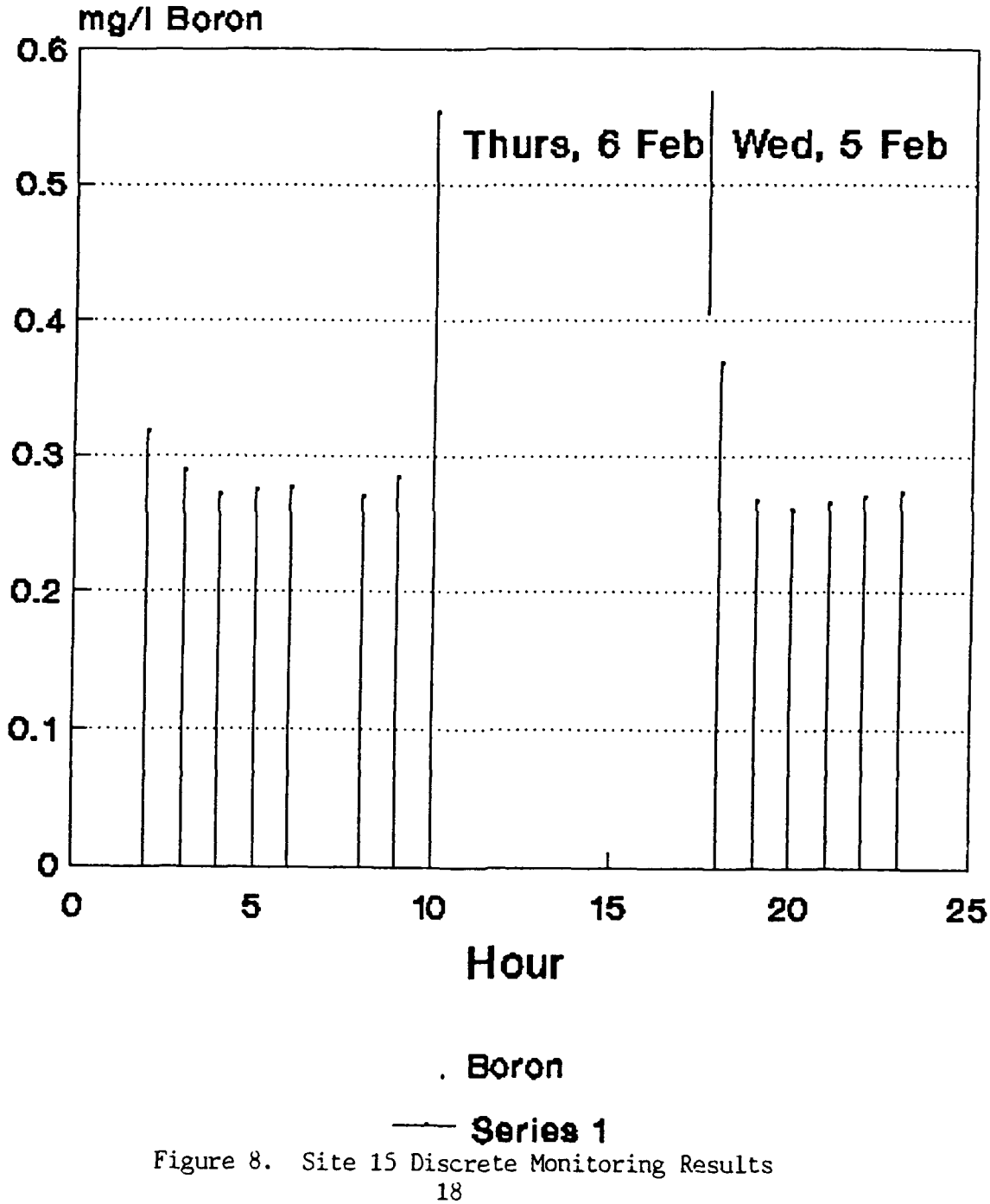


Figure 8. Site 15 Discrete Monitoring Results

Bulk Cleaner and Soap Results

Appendix D contains the results of bulk sampling of soaps and cleansers performed during the presurvey and survey.

CONCLUSIONS

Quality Assurance/Quality Control Data

The QA/QC field data indicate high recovery percentages and reasonable precision of survey data.

Survey Differences from Historical Data

Differences in data between this survey and historical data are caused by the differences in the analytical methods and the base's efforts to reduce the use of boron-containing soaps.

Detailed historical and survey data are available for the effluent to the wastewater treatment plant. The historical base sampling data are significantly higher than the data obtained during this survey. During Aug, Sep, and Oct of 91, the base results showed approximately 5 mg/l at the treatment plant effluent, compared to the average data in this survey of 0.48 mg/l.

This difference in data can probably be attributed to two factors. The first factor is the difference in analytical methods used in the two data sets. The historical data analyzed by Armstrong Laboratory was analyzed using a colorimetric method (4500-B) listed in Standard Methods(2), but not approved by EPA. The curcumin method should be used when analyzing for boron levels in the 0.10- to 1.0-mg/l range. However, Standard Methods(2) describes interference from NO_3^--N concentrations above 20 mg/l, calcium and magnesium hardness above 100 mg/l as calcium carbonate ($CaCO_3$). Moderate hardness can also cause a considerable percentage error in the low boron range. The alternative colorimetric method is the carmine method, suitable for the range of 1.0 mg/l to 10 mg/l, and therefore generally not suitable for the wastestream at March AFB. The carmine method has no interference from ions commonly found in water and wastewater.

The second factor contributing to the lower boron values is the base's efforts to remove boron-containing products from use in industrial areas. For example, several months ago at our suggestion, one of the base-wide services contractors substituted

the borax-containing soap in Figure 9 for the "Cool Hands" boron-free soap. The formerly used soap contained 55,700 μg/g (5.57%) boron while the new soap contained 21 μg/g boron (0.0021%). The 163d Civil Engineering Squadron's elimination of all boron-containing soaps from use in their areas is another outstanding example of the base-wide effort to reduce the use of boron-containing soaps.

Industrial Boron

Industrial activity on the base continues to make minor contributions to the overall boron discharge from the base. The data indicate a primary source of industrial boron is the area drained by site 6. Because of the significant Sunday afternoon peak, the weekend guard or reserve organizations probably still continue to use products containing high boron levels. The data from sites 7 and 8, although limited, indicate the higher source of boron is in the site 7 leg of the system.

Domestic and Background Boron

Background and domestic boron make significant contributions to the base boron discharge levels. Background drinking water levels of boron remained constant during the course of the survey. The average value of 0.225 mg/l represents 45% of the 0.5 mg/l discharge limitation imposed on March AFB. Domestic activity in Arnold Heights averaged 0.3395 mg/l during weekdays and 0.4805 mg/l on weekends. Domestic weekday activity represents 68% of the discharge limitation, and weekend activity represents 96% of the discharge limitation.

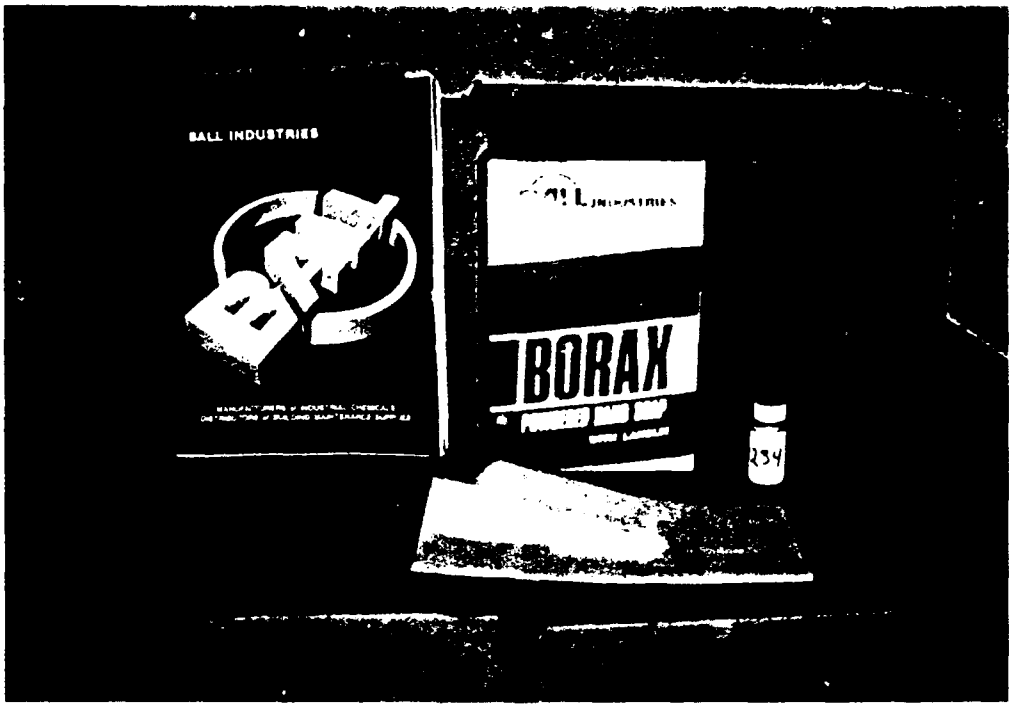
While not specifically the focus of the survey, the base boron discharge to the golf course and cemetery does not appear to damage agricultural products or contribute significantly to groundwater boron levels.

RECOMMENDATIONS

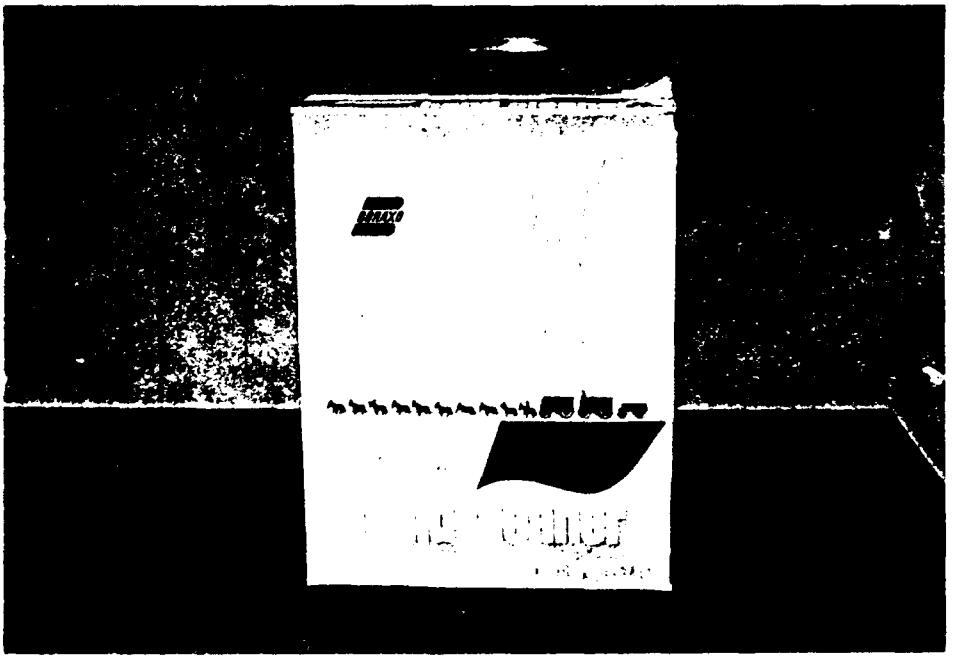
Continue base efforts to minimize industrial boron contributions by prohibiting the use of boron-containing soaps and bleaches by contractors and in the workplace. The base should focus their efforts in the site 6 and site 7 areas.

Minimize domestic boron contributions through public education. Encourage the reduction of commissary sales of products containing large percentages of boron.

Meet with state regulators to increase the base permitted



Soap Containing 5.57% boron.



Boron-free soap.
Figure 9. Example Soap Substitution

levels for boron to 0.75 mg/l or higher. This level appears more reasonable than the present standard of 0.50 mg/l in light of the background and domestic data and the present reuse of the wastewater.

REFERENCES

1. Code of Federal Regulations, Title 40, EPA Administered Permit Programs: The National Pollutant Discharge Elimination System, Part 122, April 1983.

2. Standard Methods for the Examination of Water and Wastewater, 17th Edition, American Public Health Association, Washington, D.C., 1989.

3. Hossain, M., AFOEHL Sampling Guide, March 1989.

4. Code of Federal Regulations, Title 40, Guidelines Establishing Test Procedures for the Analysis of Pollutants, Part 136, October 1983.

5. United States Environmental Protection Agency, Quality Criteria for Water, EPA/440/5-86-001, May 1986.

APPENDIX A

SAMPLING SITES

Site Descriptions

Site 1: Site 1, manhole S-237A, is predominantly nondomestic waste. Its location is behind the Non-Destructive Inspection Shop near building 1238. Site 1 receives discharges from the hospital, theater, base exchange, commissary, auto hobby shop, service station, Air National Guard (ANG) composite maintenance and services building, and civil engineering yard. (Figure A-1)

Site 2: Site 2, manhole S-492, is industrial and domestic waste. Its location is across the street from building 1211. Site 2 receives domestic discharges from base administrative areas like finance and personnel, Green Acres housing area, and dormitories. Site 2 receives industrial discharges from 163 ANG Fuel Cell Dock, the Pride Hanger, Fuel Systems Maintenance Hanger, 452 AREFW & 303RD TAS AGE Shop, 163 ANG CEF, 943 Aerial Port Facility and Composite Maintenance Facility, 452 AREFW, 163 ANG Avionics, 163 TFG, and the base Aero Club. Site 2 also receives industrial discharges from the motor pool. (Figure A-2)

Site 3: Site 3, manhole 10-705, is domestic waste. Its location is east of the cemetery. Site 3 receives domestic discharges from Arnold Heights housing area. (Figure A-3)

Site 4: Site 4 is the wastewater treatment plant effluent. This site was in the chlorine contact chamber immediately before the discharge point from the chlorine contact chamber. (Figure A-4)

Site 5: Site 5, manhole 6-423, is industrial waste. Its location is in front of building 385. Site 5 receives industrial discharges from 163 ANG Fuel Cell Dock, the Pride Hanger, Fuel Systems Maintenance Hanger, 452 AREFW & 303 TAS AGE Shop, 163 ANG CEF, and the base Aero Club. (Figure A-5)

Site 6: Site 6, manhole 4-481, is domestic and industrial waste. Its location is in front of building 601, Supply. Site 6 receives domestic waste from Green Acres. Site 6 receives industrial discharges from 943 Aerial Port Facility and Composite Maintenance Facility, 452 AREFW, 163 ANG Avionics, and 163 TFG.

Site 7: Site 7, manhole 5-236, is primarily nondomestic waste. Its location is next to building 1254, Cryogenic Storage. Site 7 receives waste from base exchange, theater, commissary, auto-hobby shop, recreation center, Southwest Area Defense Sector, and KC-10 Flight Simulator.

Site 8: Site 8, manhole S-194, is primarily nondomestic waste. Its location is in the field east of building 1254. This line receives waste from the hospital, service station, Air National Guard (ANG) composite maintenance and services building, and civil engineering yard.

Site 9: Site 9, manhole 3-22, is primarily nondomestic waste. Its location is next to the intersection of W and L streets. Site 9 receives waste from base exchange, theater, commissary, auto-hobby shop, and recreation center.

Site 10: Site 10, manhole G-465, is domestic and industrial waste. Its location is near house number 220. Site 10 receives domestic waste from the Green Acres housing area. Site 10 receives industrial waste from 943 Aerial Port Facility and Composite Maintenance Facility, 452 AREFW, 163 ANG Avionics, and 163 TFG.

Site 11: Site 11, manhole 7-317, is primarily industrial waste. Its location is in front of the Officer's Club conference building. Site 11 receives industrial waste from 943 Aerial Port Facility and Composite Maintenance Facility, 452 AREFW, 163 ANG Avionics, and 163 TFG.

Sites 12-14: Not used.

Site 15: Site 15, manhole 1-163, is primarily industrial waste. Its location is in the front of building 2421, near the corner of O and Myer streets. Site 15 receives industrial waste from the 163 ANG composite maintenance and services buildings.

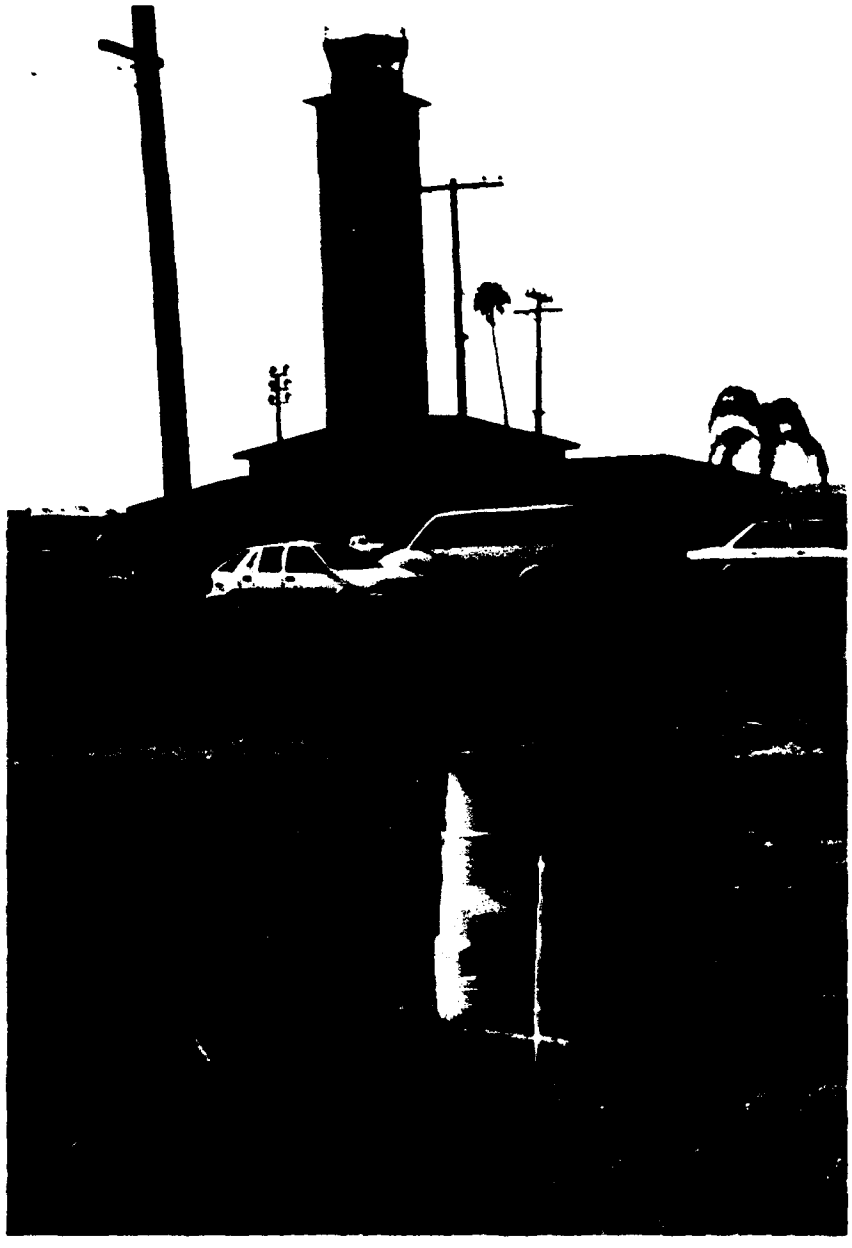


Figure A-1. Sampling Site 1

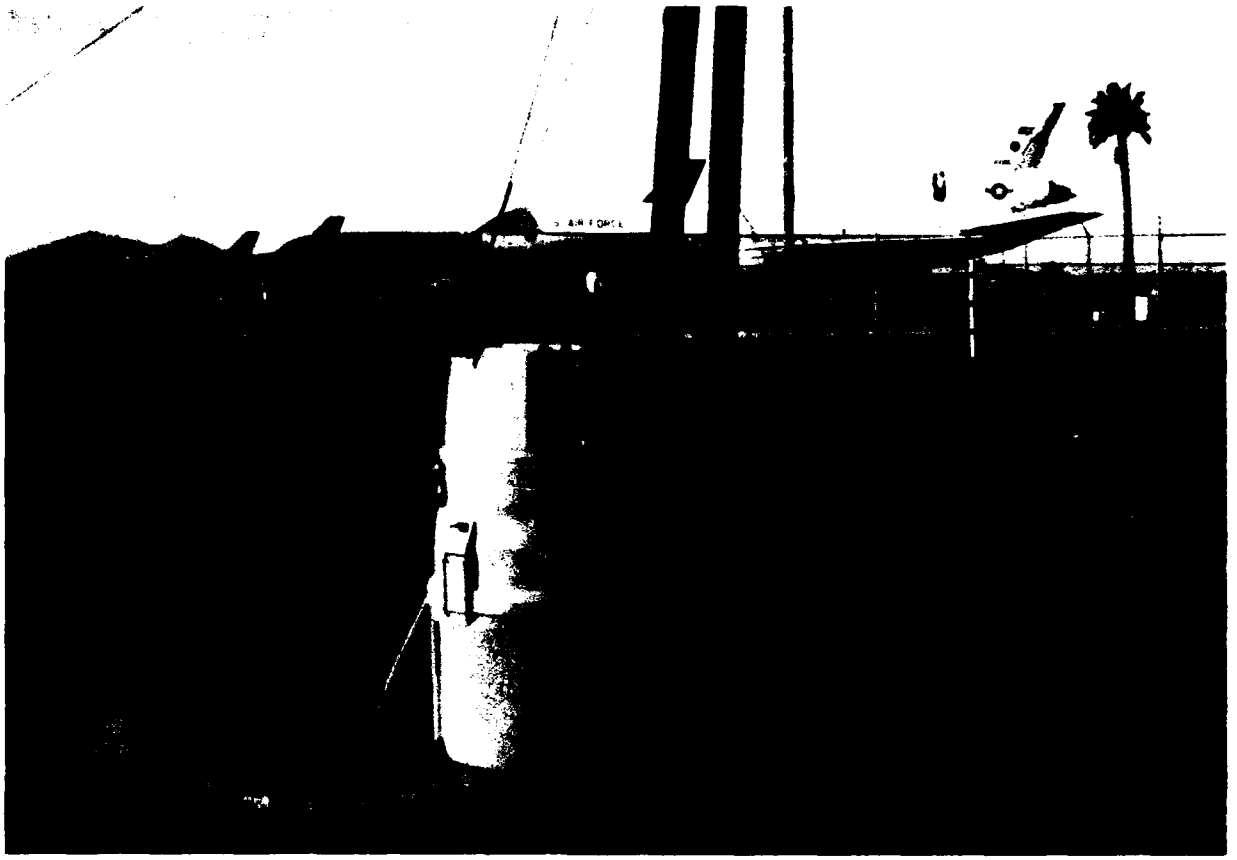


Figure A-2. Sampling Site 2

Figure A-3. Sampling Site 3

Figure A-4. Sampling Site 4

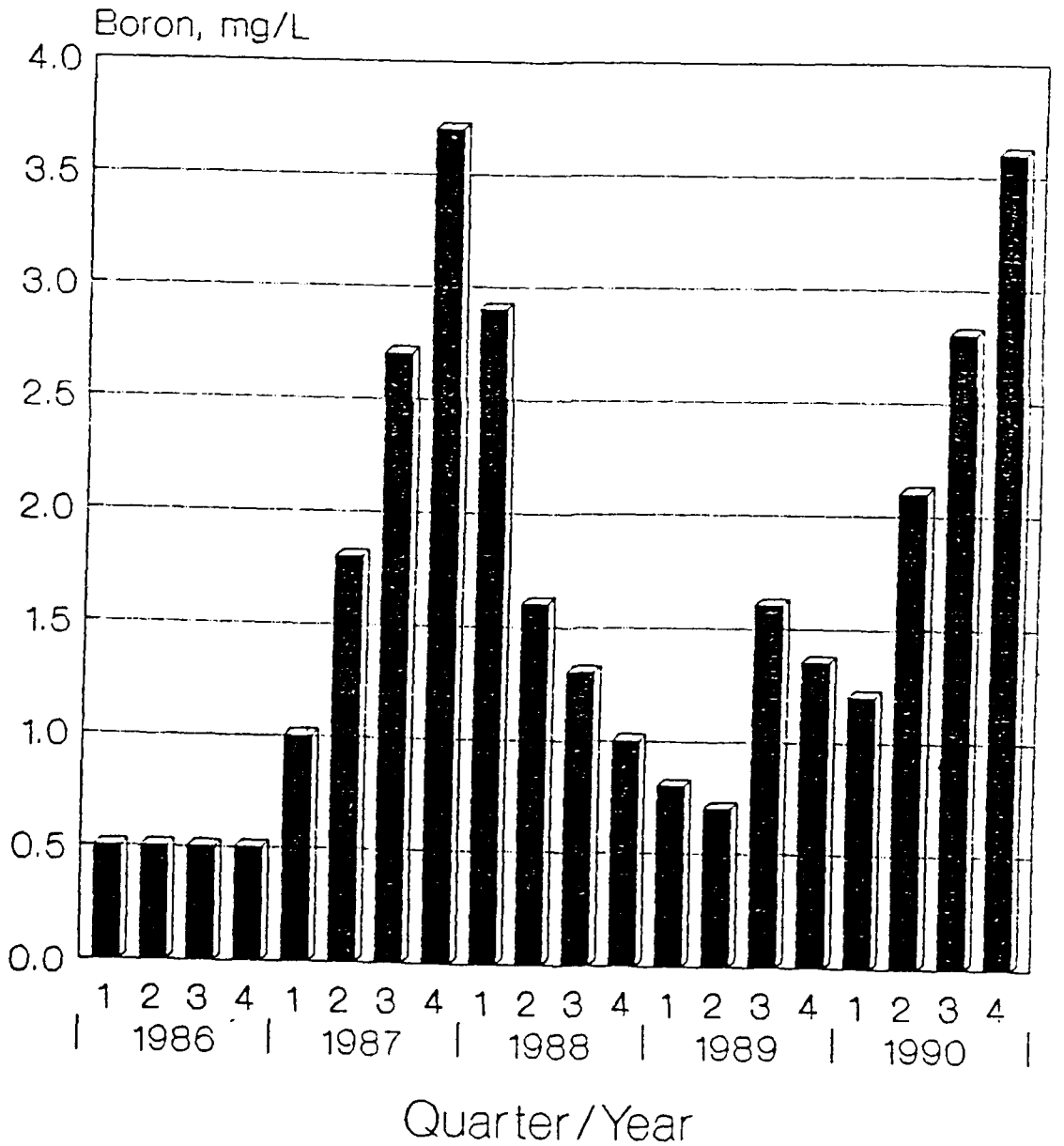
Figure A-5. Sampling Site 5

APPENDIX B

BASE BORON DATA

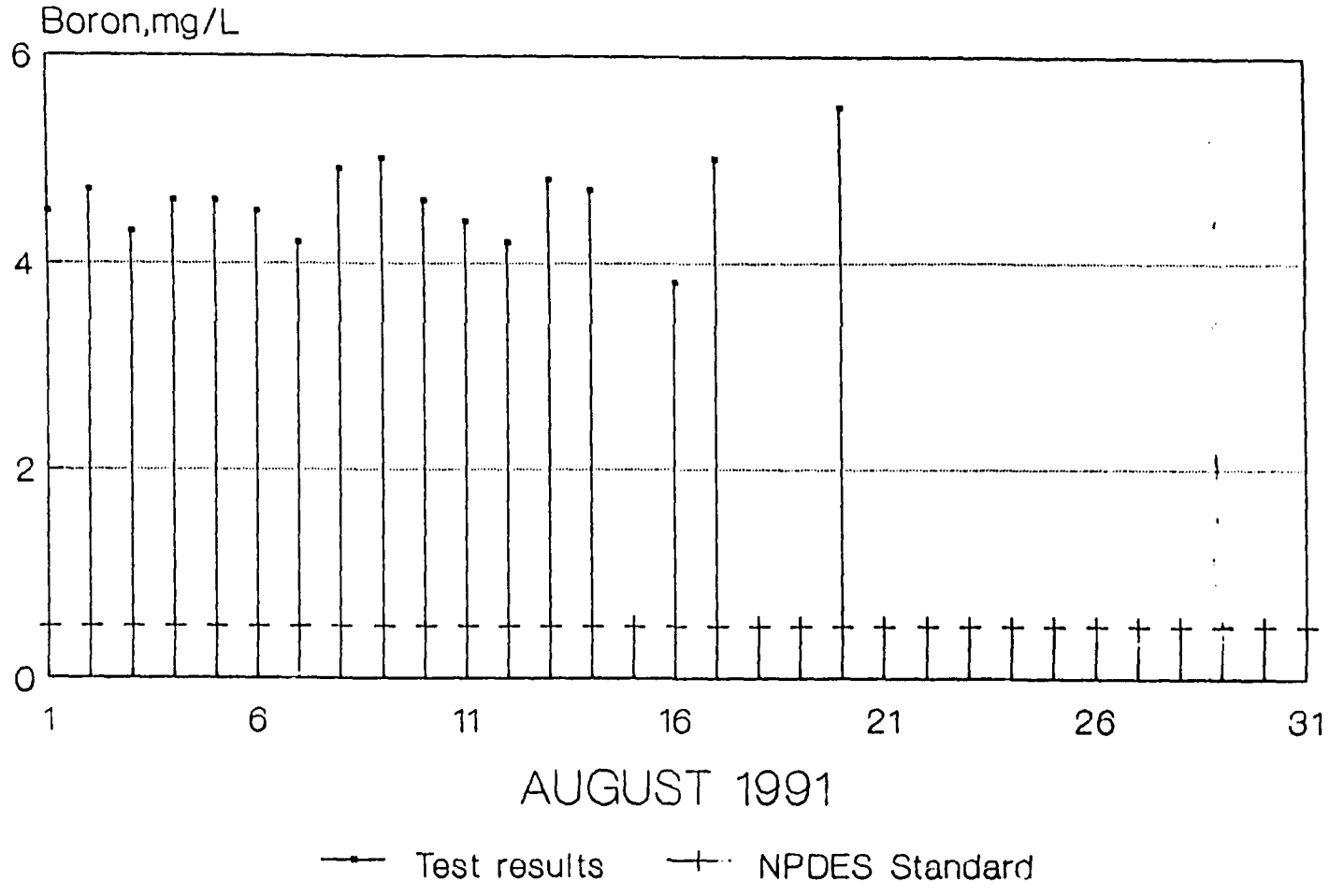
22D STRATEGIC HOSPITAL

BIOENVIRONMENTAL ENGINEERING
BORON RESULTS 1985 TO 1991
QUARTERLY NPDES MONITORING

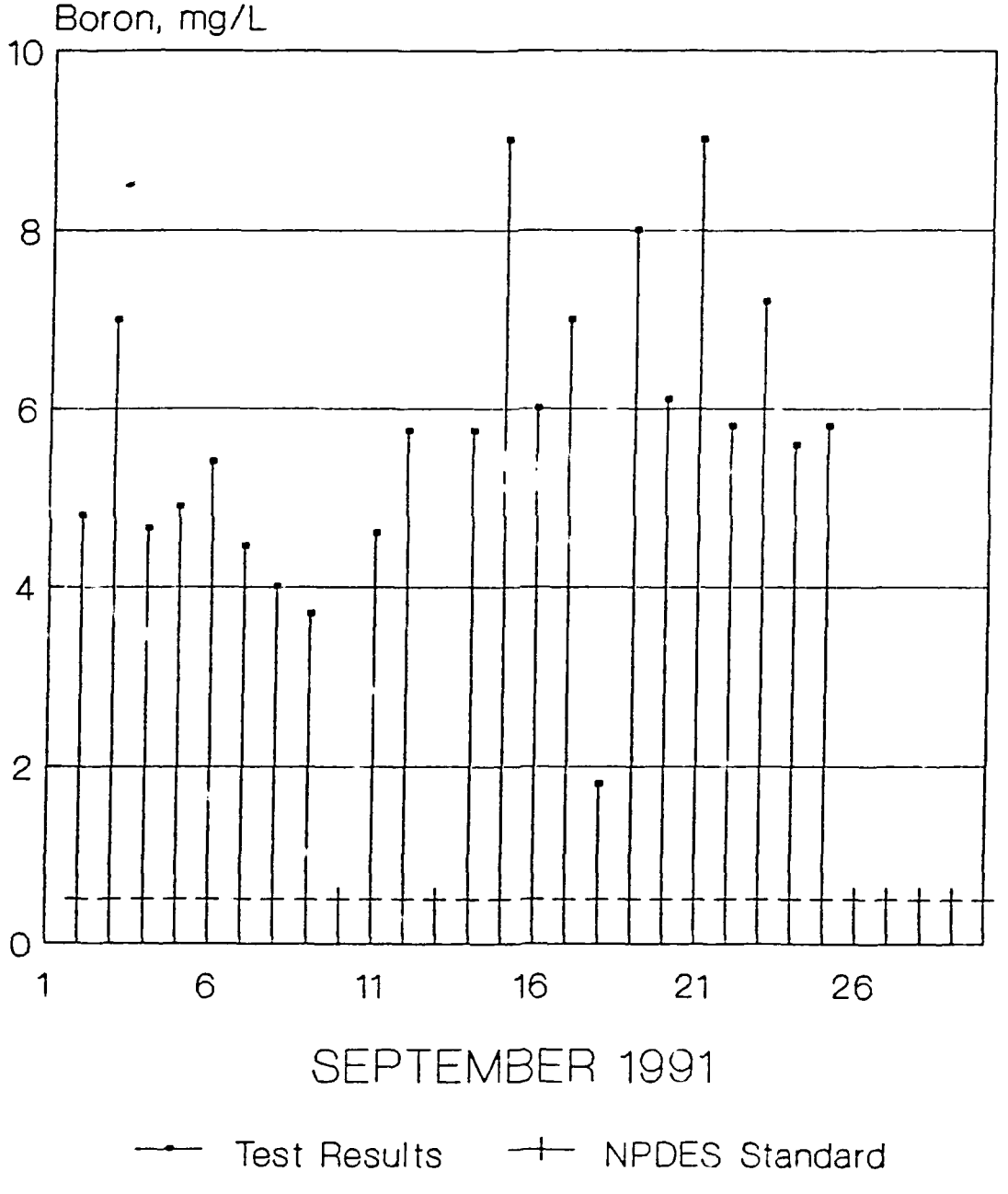


NPDES PERMIT LIMIT FOR BORON 0.5 mg/L

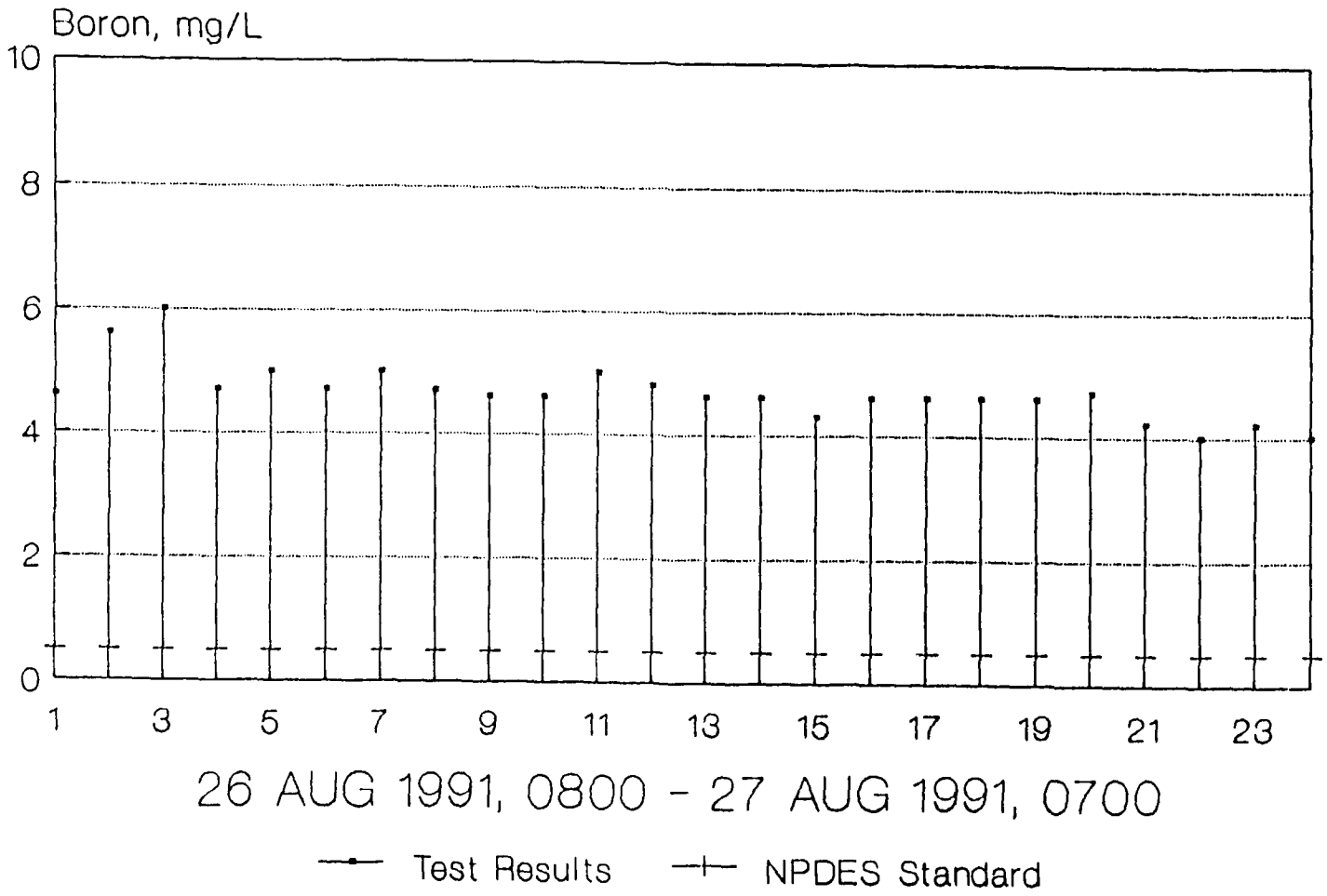
BORON ANALYSIS
NPDES MONITORING DATA



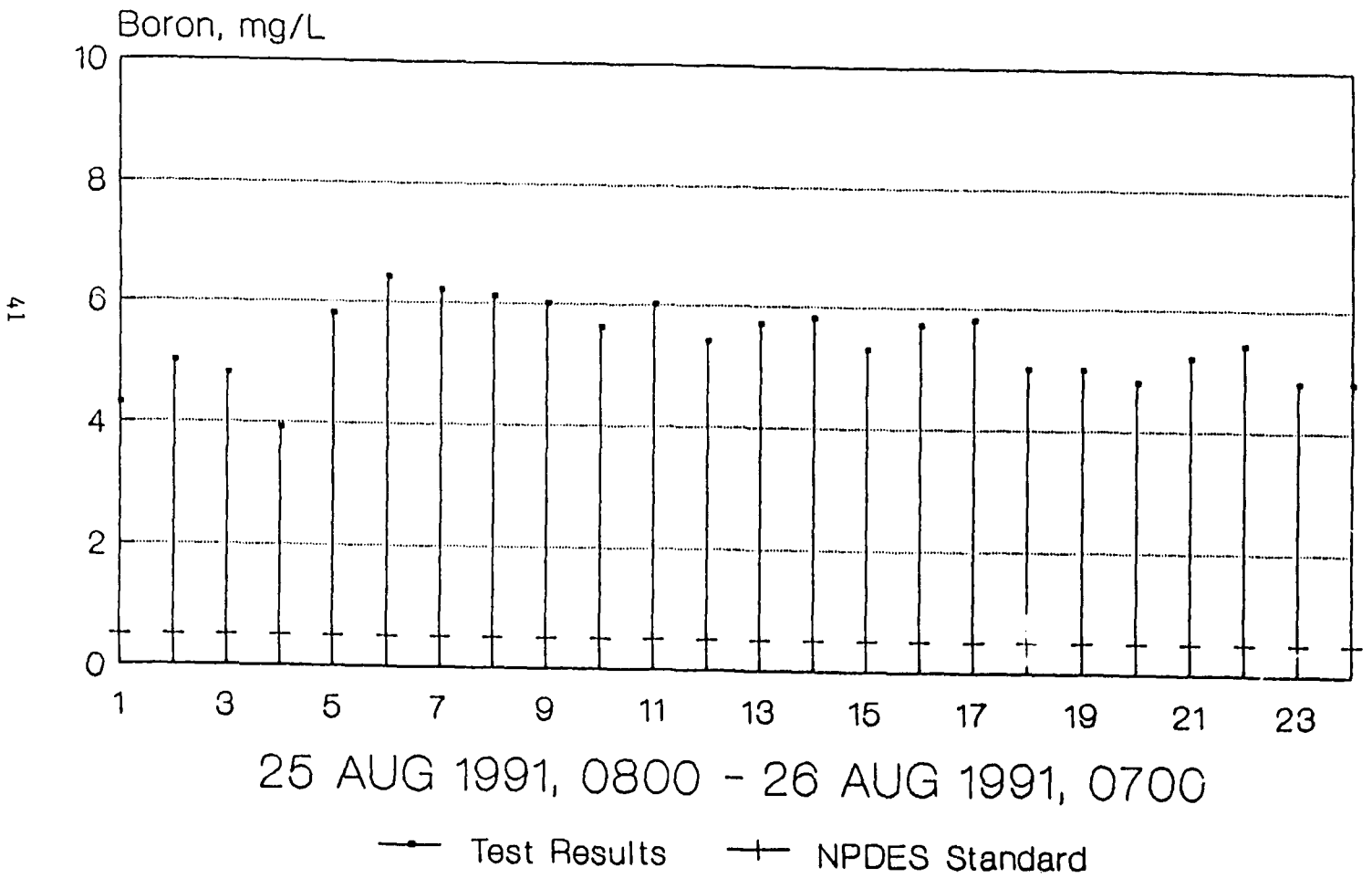
BORON ANALYSIS
NPDES MONITORING DATA



BORON ANALYSIS
HOURLY MONITORING DATA



BORON ANALYSIS
HOURLY MONITORING DATA



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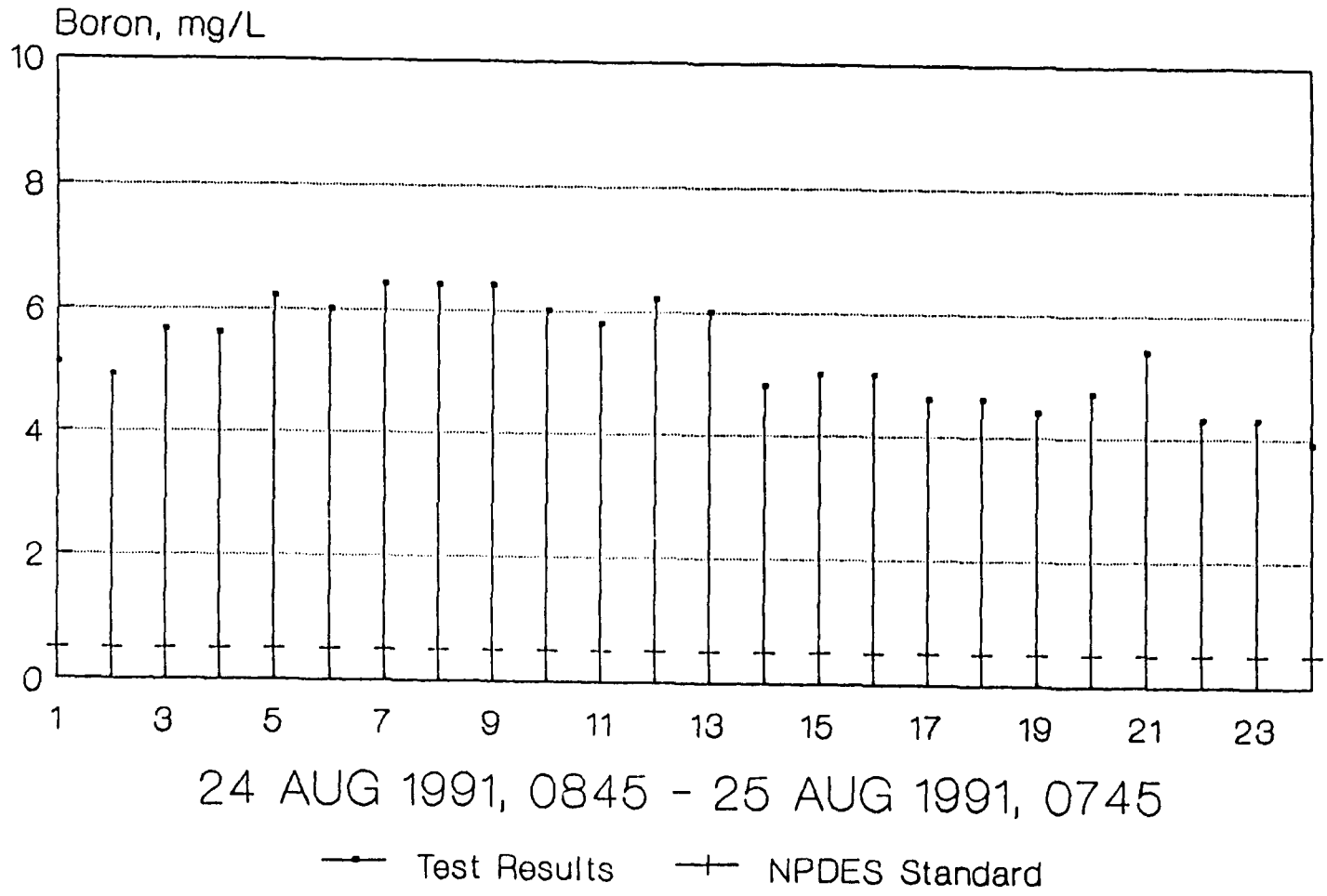

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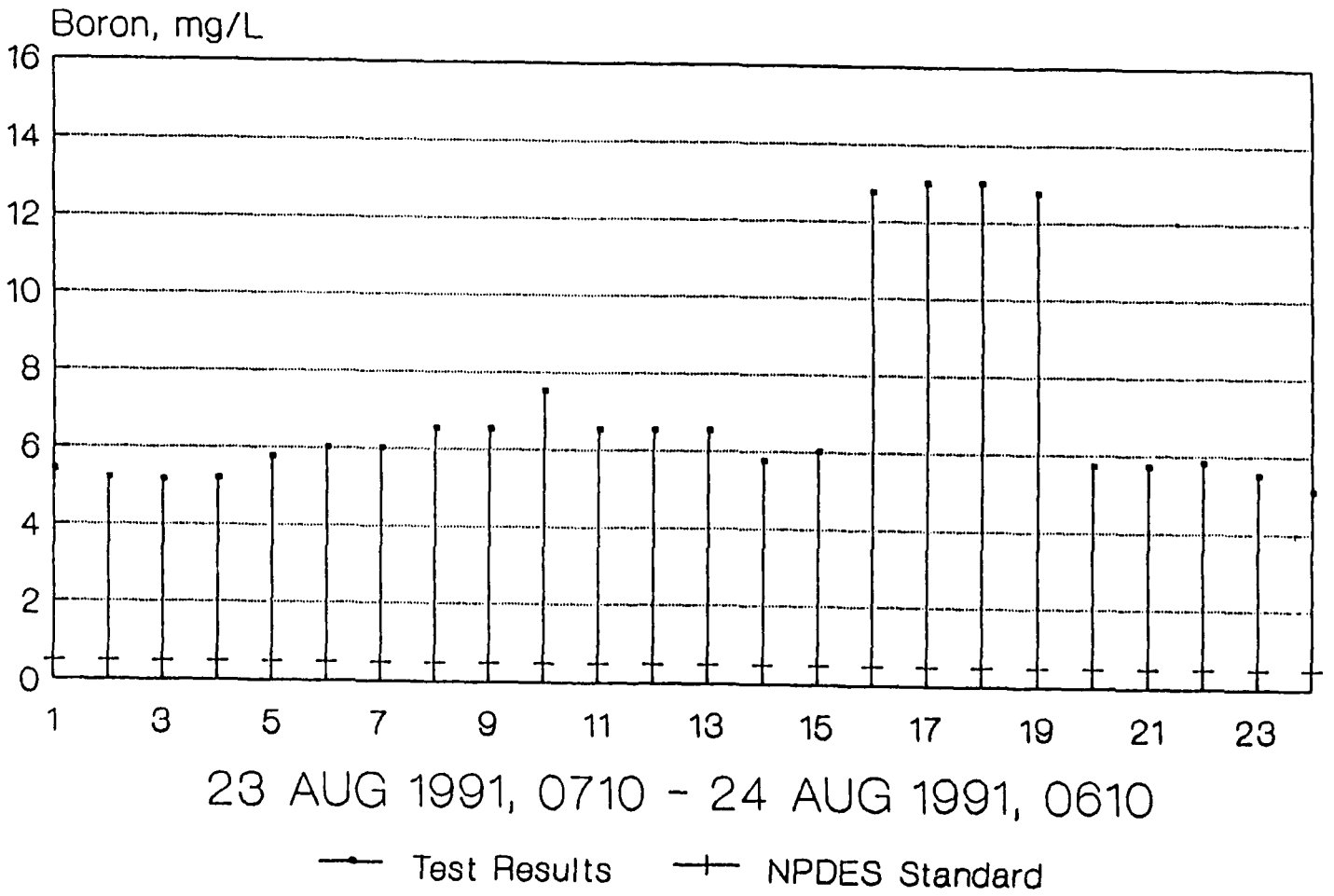

APPENDIX C

DISCRETE SAMPLING RESULTS

TABLE C-1. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 1

DATE	TIME	RESULT	DATE	TIME	RESULT
29 JAN	1100	0.348	30 JAN	1000	0.735
29 JAN	1200	0.284	30 JAN	1100	0.326
29 JAN	1300	0.272	30 JAN	1200	0.308
29 JAN	1400	0.522	30 JAN	1300	0.452
29 JAN	1500	0.388	30 JAN	1400	0.404
29 JAN	1600	0.364	30 JAN	1500	0.346
29 JAN	1700	0.302	30 JAN	1600	0.529
29 JAN	1800	0.522	30 JAN	1700	0.886
29 JAN	1900	0.318	30 JAN	1800	0.355
29 JAN	2000	0.371	30 JAN	1900	0.719
29 JAN	2100	0.382	30 JAN	2000	LEAKED
29 JAN	2200	0.654	30 JAN	2100	0.350
29 JAN	2300	0.730	30 JAN	2200	0.350
29 JAN	2400	1.187	30 JAN	2300	0.431
30 JAN	0100	0.354	30 JAN	2400	0.609
30 JAN	0200	0.322	31 JAN	0100	0.452
30 JAN	0300	0.358	31 JAN	0200	0.443
30 JAN	0400	0.451	31 JAN	0300	0.427
30 JAN	0500	0.770	31 JAN	0400	0.440
30 JAN	0600	0.430	31 JAN	0500	0.667
30 JAN	0700	0.382	31 JAN	0600	0.491
30 JAN	0800	0.392	31 JAN	0700	0.464
			31 JAN	0800	0.381
			31 JAN	0900	0.535

TABLE C-2. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 2

DATE	TIME	RESULT	DATE	TIME	RESULT
29 JAN	0910	LEAKED	31 JAN	1040	6.476
29 JAN	1010	0.307	31 JAN	1140	0.722
29 JAN	1110	0.645	31 JAN	1240	0.319
29 JAN	1210	0.549	31 JAN	1340	1.159
29 JAN	1310	0.427	31 JAN	1440	0.720
29 JAN	1410	0.384	31 JAN	1540	0.401
29 JAN	1510	1.676	31 JAN	1640	0.354
29 JAN	1610	0.676	31 JAN	1740	0.396
29 JAN	1710	0.418	31 JAN	1840	0.459
29 JAN	1810	0.361	31 JAN	1940	1.376
29 JAN	1910	Lost	31 JAN	2040	0.676
29 JAN	2010	0.322	31 JAN	2140	0.473
29 JAN	2110	0.368	31 JAN	2240	0.346
29 JAN	2210	0.597	31 JAN	2340	0.350
29 JAN	2310	0.323	1 FEB	0040	0.350
30 JAN	0010	0.293	1 FEB	0140	0.343
30 JAN	0110	0.299	1 FEB	0240	LEAKED
30 JAN	0210	0.325	1 FEB	0340	0.359
30 JAN	0310	0.303	1 FEB	0440	0.353
30 JAN	0410	0.280	1 FEB	0540	0.316
30 JAN	0510	0.282	1 FEB	0640	0.513
30 JAN	0610	0.290	1 FEB	0740	0.463
30 JAN	0710	0.375	1 FEB	0840	1.392
30 JAN	0810	0.389	1 FEB	0940	0.479

*Composite only sample from 30-31 Jan 92 due to equipment clogging.

TABLE C-2(Cont.)

DATE	TIME	RESULT
30 JAN	1040	6.476
30 JAN	1140	0.722
30 JAN	1240	0.319
30 JAN	1340	1.159
30 JAN	1440	0.720
30 JAN	1540	0.401
30 JAN	1640	0.354
30 JAN	1740	0.396
30 JAN	1840	0.459
30 JAN	1940	1.376
30 JAN	2040	0.676
30 JAN	2140	0.473
30 JAN	2240	0.346
30 JAN	2340	0.350
31 JAN	0040	0.350
31 JAN	0140	0.343
31 JAN	0240	LEAKED
31 JAN	0340	0.359
31 JAN	0440	0.353
31 JAN	0540	0.316
31 JAN	0640	0.513
31 JAN	0740	0.463
31 JAN	0840	1.392
31 JAN	0940	0.479

TABLE C-3. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 5

DATE	TIME	RESULT
2 FEB	1008	0.387
2 FEB	1108	0.283
2 FEB	1208	0.400
2 FEB	1308	ND*
2 FEB	1408	6.283
2 FEB	1508	0.274
2 FEB	1608	0.264
2 FEB	1708	0.259
2 FEB	1808	0.260
2 FEB	1908	0.264
2 FEB	2008	0.289
2 FEB	2108	0.260
2 FEB	2208	0.251
2 FEB	2308	0.244
3 FEB	0008	0.279**
3 FEB	0108	0.252
3 FEB	0208	0.241
3 FEB	0308	0.245
3 FEB	0408	0.268
3 FEB	0508	0.263
3 FEB	0608	0.246
3 FEB	0708	0.250
3 FEB	0808	0.290
3 FEB	0908	0.265

* Equipment did not take a sample at this time. Team substituted a sterile water blank.
** Sample looked like fresh oil.

TABLE C-4. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 6

DATE	TIME	RESULT	DATE	TIME	RESULT
2 Feb	1030	0.319	3 Feb	0930	0.248
2 FEB	1130	0.329	3 FEB	1020	0.787
2 FEB	1230	1.899	3 FEB	1120	0.660
2 FEB	1330	0.868	3 FEB	1220	0.749
2 FEB	1430	0.445	3 FEB	1320	0.861
2 FEB	1530	1.537	3 FEB	1420	0.504
2 FEB	1630	5.694	3 FEB	1520	0.954
2 FEB	1730	5.219	3 FEB	1620	0.916
2 FEB	1830	7.659	3 FEB	1720	0.883
2 FEB	1930	9.456	3 FEB	1820	0.480
2 FEB	2030	4.870	3 FEB	1920	0.458
2 FEB	2130	2.033	3 FEB	2020	0.632
2 FEB	2230	1.024	3 FEB	2120	0.531
2 FEB	2330	0.892	3 FEB	2220	0.508
3 FEB	0030	0.691	3 FEB	2320	0.422
3 FEB	0130	0.650	4 FEB	0020	0.395
3 FEB	0230	0.703	4 FEB	0120	0.440
3 FEB	0330	0.586	4 FEB	0220	0.448
3 FEB	0430	ND*	4 FEB	0320	0.400
3 FEB	0530	0.631	4 FEB	0420	0.445
3 FEB	0630	0.579	4 FEB	0520	0.396
3 FEB	0730	0.472	4 FEB	0620	0.368
3 FEB	0830	0.349	4 FEB	0720	0.308
			4 FEB	0820	0.290
			4 FEB	0920	0.263

* Inconsistent data.

TABLE C-4(Cont.)

DATE	TIME	RESULT	DATE	TIME	RESULT
4 FEB	1020	0.787	5 FEB	1213	0.365
4 FEB	1120	0.660	5 FEB	1313	0.364
4 FEB	1220	0.749	5 FEB	1413	0.855
4 FEB	1320	0.861	5 FEB	1513	0.855
4 FEB	1420	0.504	5 FEB	1613	0.544
4 FEB	1520	0.954	5 FEB	1713	0.621
4 FEB	1620	0.916	5 FEB	1813	0.499
4 FEB	1720	0.883	5 FEB	1913	0.634
4 FEB	1820	0.480	5 FEB	2013	0.658
4 FEB	1920	0.458	5 FEB	2113	0.526
4 FEB	2020	0.632	5 FEB	2213	1.538
4 FEB	2120	0.531	5 FEB	2313	0.648
4 FEB	2220	0.508	6 FEB	0013	0.513
4 FEB	2320	0.422	6 FEB	0113	0.656
5 FEB	0020	0.395	6 FEB	0213	0.602
5 FEB	0120	0.440	6 FEB	0313	0.541
5 FEB	0220	0.448	6 FEB	0413	0.474
5 FEB	0320	0.400	6 FEB	0513	0.472
5 FEB	0420	0.445	6 FEB	0613	0.480
5 FEB	0520	0.396	6 FEB	0713	0.392
5 FEB	0620	0.368	6 FEB	0813	0.327
5 FEB	0720	0.308	6 FEB	0913	0.352
5 FEB	0820	0.290	6 FEB	1013	0.420
5 FEB	0920	0.263	6 FEB	1113	1.178

TABLE C-5. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 8

DATE	TIME	RESULT
5 FEB	1630	0.291
5 FEB	1730	0.390
5 FEB	1830	0.302
5 FEB	1930	0.275
5 FEB	2030	0.368
5 FEB	2130	0.325
5 FEB	2230	0.529
5 FEB	2330	0.541
6 FEB	0030	0.433
6 FEB	0130	*
6 FEB	0230	*
6 FEB	0330	*
6 FEB	0430	*
6 FEB	0530	*
6 FEB	0630	0.329
6 FEB	0730	*
6 FEB	0830	0.270
6 FEB	0930	0.283
6 FEB	1030	0.552

* Insufficient flow for sample

TABLE C-6. RESULTS OF DISCRETE BORON SAMPLING IN MG/L SITE 15

DATE	TIME	RESULT
5 FEB	1746	0.369
5 FEB	1846	0.266
5 FEB	1946	0.260
5 FEB	2046	0.264
5 FEB	2146	0.270
5 FEB	2246	0.272
5 FEB	2346	LEAKED
6 FEB	0146	0.318
6 FEB	0246	0.289
6 FEB	0346	0.271
6 FEB	0446	0.274
6 FEB	0556	0.276
6 FEB	0646	0.286

APPENDIX D

SOAP SAMPLE RESULTS

MANUFACTURER	NAME/DESCRIPTION	NSN	BLDG NO.	OTHER	BORON CONCENTRATION
AAA Janitor Supply Co. 6939 A. Indiana Riverside CA 92506	Dan D. Products, Pink Lotion, Hand Soap	None	2276		#262 32 µg/g
Alfa Chemical Company	Alfa Kleen Sanitizer Cleaner	7930-01-014-1067	LP 2310 Store		#237 226 µg/g
B & B Tritech Miami, FL33166	B&B Zozo NY	6850-01-184-3182	2307		#256 116 µg/g
Ball Industry El Segundo 90245	Ball Lotion/Hand Soap Pink	None	2403	Mil/Fed Spec Reorder #36-604	#233 <112 µg/g
Ball Industry El Segundo 90245	Borax powdered Handsoap in Lanolin	None	2403	Lot #K01626 Mil/Fed Spec Item #WBX 5	#234 55,700 µg/g
Calgon Vestal Labs St Louis MO 63133	Lotion Soap with Protein	85200P12-170	LP 2310 Store		#243 <141 µg/g
Champion Chem 8319 South Greenleaf Ave Whittier CA 90602	Versatile Detergent/Disin	None	2276		#264 <57 µg/g
Chem Lite Ind 4305 Eileen Riverside CA 92504	Lemon Coco Liquid Handsoap	8520-123-4000-3	2276	Ang Contract #1-91-85-31	#261 <35 µg/g
Clayton Chem Los Angeles CA 90061	Fixer/Washer System Cleaner	6750-00-037-9099	2273	Lot #811075	#254 137 µg/g

MANUFACTURER	NAME/DESCRIPTION	NSN	BLDG NO.	OTHER	BORON	CONCENTRATION
Lighthouse for the Blind St Louis MO 63132	So Sure Rug & Upholstery	7930-00-113-1913	LP2310 Store	Note: Butyl Cellosolve	#236	254 µg/g
Lighthouse for the Blind St Louis MO 63132	Dishwashing Compound	7930-00-880-4454	2273	Lot #633	#250	65 µg/g
Maintex 312300 E.Nelson Avenue Industry CA 91746	Maintex Fresh & Clean Restroom Cleaner		2276		#265	<51 µg/g
The Merit Group 1214 W. Jon St Torrance CA 90502	Pink Borax with Lanolin	None	2274		#257	81,800 µg/g
Mission Kleen-sweep Prod Inc	White Borax Soft Touch Powdered Handsoap		2276		#263	79,200 µg/gm
Omega Labs Houston TX 77080	Fleet Care Concentrate		1246		#269	67 µg/g
Proctor & Gamble Cincinnati OH 45202	Comet Liquid Disinfectant Cleanser		LP2310 Store		#249	160 µg/g
Puma Chem Co Grand Prairie TX 75050	Detergant General Purpose	7930-00-558-111	LP2310 Store		#238	270 µg/g
Safety Kleen New Berlin WI 53151	General Purpose Cleaner 666		941		#270	<89 µg/g

MANUFACTURER	NAME/DESCRIPTION	NSN	BLDG NO.	OTHER	BORON CONCENTRATION
SaniFresh Int San Antonio TX 78218	SaniFresh Hand Cleaner	8520P;1Z8	LP2310 Store		#240 66 µg/g
SaniFresh Int San Antonio TX 78218	ProCare Spectra Care Handsoap		LP2310 Store		#248 262 µg/g
Space Chemical Indiana PA 15701	Cleaning Compound Aircraft Type 1	6850-01-184-3187	2273	Mil/Fed Spec MILC-87936A	#255 201 µg/g
Super Soap Co 2655 Ingalls St San Francisco CA 94124	Borax Powdered Handsoap	8520-270-00658	2276		#260 82,700 µg/g
U.S. Borax & Chemical Corp Los Angeles CA 90010	Boraxo Powdered Handsoap		420		#268 103,000 µg/g
Vita-ERB LTO Springfield MO 65802	Soap, Borax with Lanolin	8520-00-270-0065	LP2310 Store	Lot#679	#244 56,700 µg/g
Vita-ERB LTO Springfield MO 65802	Soap Borax with Lanolin	8520-00-270-0065	LP2310 Store	Lot#082	#245 50,790 µg/g
Vita-ERB LTO Springfield MO 65802	Soap Toilet G	8520-00-634-1594	LP2310 Store	Lot#0109	#246 385 µg/g
Vita-ERB LTO Springfield MO 65802	Handcleaner Waterless Cream	8520-00-082-2146	2273		#253 <84 µg/g

MANUFACTURER	NAME/DESCRIPTION	NSN	BLDG NO.	OTHER	BORON CONCENTRATION
Vexford Labs Kirkwood MO 63122	WEX-CIDE Germicidal Detergent		LP2310 Store	Lot #051711	#247 167 µg/g
Zep Mfgr Co Atlanta GA 30301	Zep Formula 4358	None	2274	Lot Product #0407	#258 151 µg/g