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The Kwajalein Bioremediation Demonstration: Final Technical Report

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THE KWAJALEIN BIOREMEDIATION DEMONSTRATION:

FINAL TECHNICAL REPORT

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EXECUTIVE SUMMARY

The U.S. Army Kwajalein Atoll (USAKA) Base, located in the Republic of the Marshall Islands (RMI) in the east-central Pacific Ocean, has significant petroleum hydrocarbon contamination resulting from years of military activities. Because of its remoteness, the lack of on-site sophisticated remediation or waste disposal facilities, the amenability of petroleum hydrocarbons to biodegradation, and the year-round temperature favorable for microbial activity, USAKA requested, through the Hazardous Waste Remedial Actions Program (HAZWRAP), that a project be conducted to evaluate the feasibility of using bioremediation for environmental restoration of contaminated sites within the atoll.

The project was conducted in four distinct phases: (1) initial site characterization and on-site biotreatability studies, (2) selection of the demonstration area and collection of soil columns, (3) laboratory column biotreatability studies, and (4) an on-site bioremediation demonstration. The results of phases (1) and (3) have been detailed in previous reports. This report summarizes the results of phases (1) and (3) and presents phases (2) and (4) in detail. A short documentary video that highlights the approach, the field activities on Kwajalein Island, and the results is available.

An initial characterization visit was made by a four-member team that examined two sites to assess contamination and to determine if bioremediation appeared feasible. The future water desalination area and the diesel fuel storage tank area were examined for contamination. Subsurface soil was characterized as coral-derived sands that were alkaline and nutrient deficient. Groundwater was found to occur at depths of approximately 5 ft and the water table chemistry showed no marine influence. The site adjacent to the aboveground diesel fuel storage tank had high concentrations of diesel fuel, both in the soil and in the groundwater beneath the site. At the water table, hydrocarbon concentrations approached 9000 parts per million (ppm). These concentrations are well above the accepted levels of 10 to 100 ppm for contaminated soil in need of remediation. Microorganisms capable of degrading diesel fuel contaminants were present in the first 10 to 12 in. of soil. At the lower limits the toxic effects of the contamination seemed to retard microbial growth. The final conclusion reached from the initial visit was that bioremediation was feasible but that high pH and nutrients deficiencies could hinder biological remediation.

A second visit was made to Kwajalein 5 months later to obtain soil core samples for conducting studies to determine the biotreatability of contaminated soil at Kwajalein. Twenty-five columns of coral sands were collected from approximately 3- to 6-ft depths at various contaminated locations and were sent to the Center for Environmental Biotechnology at The University of Tennessee for analysis. Several sets of three columns each were set up to receive various combinations of water, nutrients, and air. Treatment of soil columns continued for about 9 months. Weekly analyses were conducted for various parameters such as pH, conductivity, nutrient concentrations, carbon dioxide evolution, total petroleum hydrocarbons, and the number of viable colonies. These studies showed that, in general, the addition of water and nutrients resulted in enhanced biodegradation. Studies suggested that the soil and groundwater of Kwajalein contain a wide variety of microorganisms capable of degrading fractions of the hydrocarbons if nutrients are added to the soil.

Initial field demonstrations, consisting of 12 in situ plots and associated equipment, began in April 1993. Treatment regimens for the in situ system included a control plot and various combinations of water, air, and nutrients. During operations, nutrients were fed four times per day and air was delivered in 4-h cycles, four times per day, between nutrient feedings. The nutrient solution contained nitrate, phosphate, and trace quantities of minerals.

Soil and groundwater samples were collected monthly to monitor the effects of the biological process on the environment and to evaluate the biodegradation of hydrocarbons present in the soil and groundwater. An analytical support laboratory was set up on the island to perform the majority of necessary analyses.

Ex situ treatment was also evaluated. Six ex situ plots, framed with treated lumber and exterior plywood, were installed approximately 30 ft behind the in situ plots. Soil to be placed in the ex situ plots was taken from a site near the Kwajalein Post Office where a diesel tank had previously been removed. The interior of the frames was covered with poly-liner to isolate the test soil and retain liquids added during treatment. Polyvinyl covers were placed over each plot to prevent the entry of rainwater. Bioventing of the soil was accomplished with stainless steel piping.

During construction of the ex situ plots the integrity of the liners was disrupted, allowing the liquids to escape. Therefore, definitive conclusions on the fate of the contaminants could not be drawn.

Both the in situ and ex situ systems were shut down after about 9 months of operation. All equipment and wells were removed from the site and disposed of as required by the USAKA. The site was returned to its preexisting vegetative state as required by the work plan.

Significant results and conclusions from this demonstration include:

- The three plots receiving air, water, and nutrients showed decreases in hydrocarbons over time that are statistically significant at the 90% confidence level. These same plots and one other plot receiving air also showed a statistically significant increase in the number of colony-forming units at the 95% confidence level. Plots not influenced by air showed no increase. A column study conducted on-site in the Kwajalein laboratory found that the phosphate contained in the nutrient media was not permeating the soil, but was being bound in the upper layers of the soil column. This, along with the fact that no phosphates from the nutrient feed were found in the groundwater while nitrates from the feed were found, suggests that the microorganisms may have been phosphate limited.
- The diesel fuel contamination at the Kwajalein site appeared to be well-weathered, as evidenced by the lack of the low-molecular-weight compounds characteristic of fresh diesel fuel. These

low-molecular-weight compounds may have been washed from the subsurface soil over time, may have volatilized, or may have been biodegraded earlier by the indigenous microorganisms shown to be present in the soil at the demonstration site.

- Growth of microorganisms early in the demonstration was stimulated by addition of water, air, and mineral nutrients (containing no carbon source) to the subsurface soils. Some diesel contaminants may have been consumed by the microorganisms to support growth.

1. INTRODUCTION

1.1 BIOREMEDIATION OF PETROLEUM HYDROCARBONS

It has been known for many years that soil microorganisms can degrade a wide variety of petroleum-based hydrocarbons in situ. As early as 1973, attempts were made to enhance this microbial activity to clean up an oil pipeline spill.[1] The interest in in situ bioremediation has intensified dramatically in recent years. Recently, laboratory and field studies related to this topic have increased dramatically. Attempts to review these activities necessarily lag behind the rate at which experience and knowledge are accumulating.[2,3]

A study of the pertinent literature indicates that several common lessons have been learned to date regarding in situ bioremediation.[4] First, results are highly site-specific. Local rainfall, temperature, and soil permeability have a major influence on the likelihood of success; to metabolize actively, organisms must have water, a favorable temperature, and access to nutrients.

Second, a general agreement exists that the addition of oxygen and inorganic nutrients such as nitrogen and phosphorous is desirable. Difficulties are often encountered in delivering these components to the soil locations that contain the organic contaminants. If, for example, the soil is highly impermeable or contains channels that divert the essential components, further environmental modification would be necessary to make bioremediation successful.

Third, inoculation of a site with microorganisms often is not necessary. In most trials, the inoculated organisms do not seem to establish themselves in the contaminated environments, particularly if an existing natural population of bacteria already occupies the site.

Fourth, it is very difficult to establish that the disappearance of a contaminant from a test site is the result of metabolism by microorganisms. The introduction of wells, the pumping of air and other nutrients, the movement of groundwater, and a variety of other processes may all contribute to the disappearance of contaminants. Establishing that a true bioremediation has taken place requires a combination of field observations and confirmatory laboratory experiments.[4]

Although in situ bioremediation has the potential for degrading a wide variety of organic compounds, existing technology and field experience have been focused primarily on the removal of petroleum and certain petroleum derivatives. The development of organisms and field techniques applicable to other compounds such as polychlorinated biphenyls and halogenated carbon structures is rapidly evolving, but only limited experience has accumulated to date. Even in the case of petroleum much is yet to be learned. It is already known that "weathered" products, which have accumulated over long periods, are difficult to degrade.

In addition to the metabolic degradation to innocuous products such as CO_2 and water, the stimulation of in situ microbial populations may have other consequences. For example, the microbial biomass may sorb hydrophobic organic molecules. A large amount of biomass accumulating in a path of contaminant migration may slow or stop contaminant movement. In addition, microorganisms may alter a local environment by oxidizing or reducing chemical species that may cause metals to precipitate or dissolve. For example, Fe^{2+} is frequently oxidized to $Fe^{3,+}$ which precipitates as ferric hydroxide; SO_4^{2-} may be reduced to S^{2-} that, in the presence of Fe^{3+}, precipitates as pyrite; and U^{6+} may be reduced to insoluble U^{4+} that then precipitates as UO_2. These types of activities may enhance, or hinder, the remediation process.[5]

An important and logical outgrowth of in situ soil bioremediation technology has been the development of methods for on-site, ex situ treatment.[6] In general, these involve moving soil from a contaminated area to a nearby, convenient location. The contaminated soil is isolated by a system of plastic liners, berms, etc. Provision is made for introducing nutrients by conduits or by tilling the soil. Additional microorganisms may be added.[7,8] These ex situ approaches represent an attractive alternative to in situ techniques when the volume of contaminated soil is small enough to be economically moved and treated on site. Clearly, these approaches allow much greater control of factors such as nutrient and water availability for the microorganisms. They do not, however, ensure that the most appropriate population of microorganisms will be established and flourish. The mechanical disruption required for soil removal and confinement may itself influence the nature and numbers of microorganisms that are metabolically active as well as alter the distribution of soil contaminants.

Clearly, the use of microorganisms for remediation purposes is a technology in its early stages of development. However, a significant number of field trials have been successful, and laboratory research suggests that we have only begun to appreciate the potential of this approach. Additional field experience and the development of new microbial and engineering methodology will undoubtedly produce a mature and valuable technology for the remediation of contaminated environments.

1.2 THE KWAJALEIN BIOREMEDIATION DEMONSTRATION

The U.S. Army Kwajalein Atoll (USAKA) Base is located in the Republic of the Marshall Islands (RMI) in the west-central Pacific Ocean. The Kwajalein Atoll forms the largest enclosed lagoon in the world and consists of ~100 small islands with a total land area of ~5.6 miles^2. Kwajalein Island, which is the largest island within the atoll, is ~3.5 miles long by 0.3 to 0.5 miles wide with a land surface area of ~1.2 miles^2. Kwajalein is located ~2100 miles southwest of Honolulu, Hawaii, and about 700 nautical miles north of the equator (Fig. 1). The USAKA population is ~3000 and includes Army and subcontractor personnel and their families.

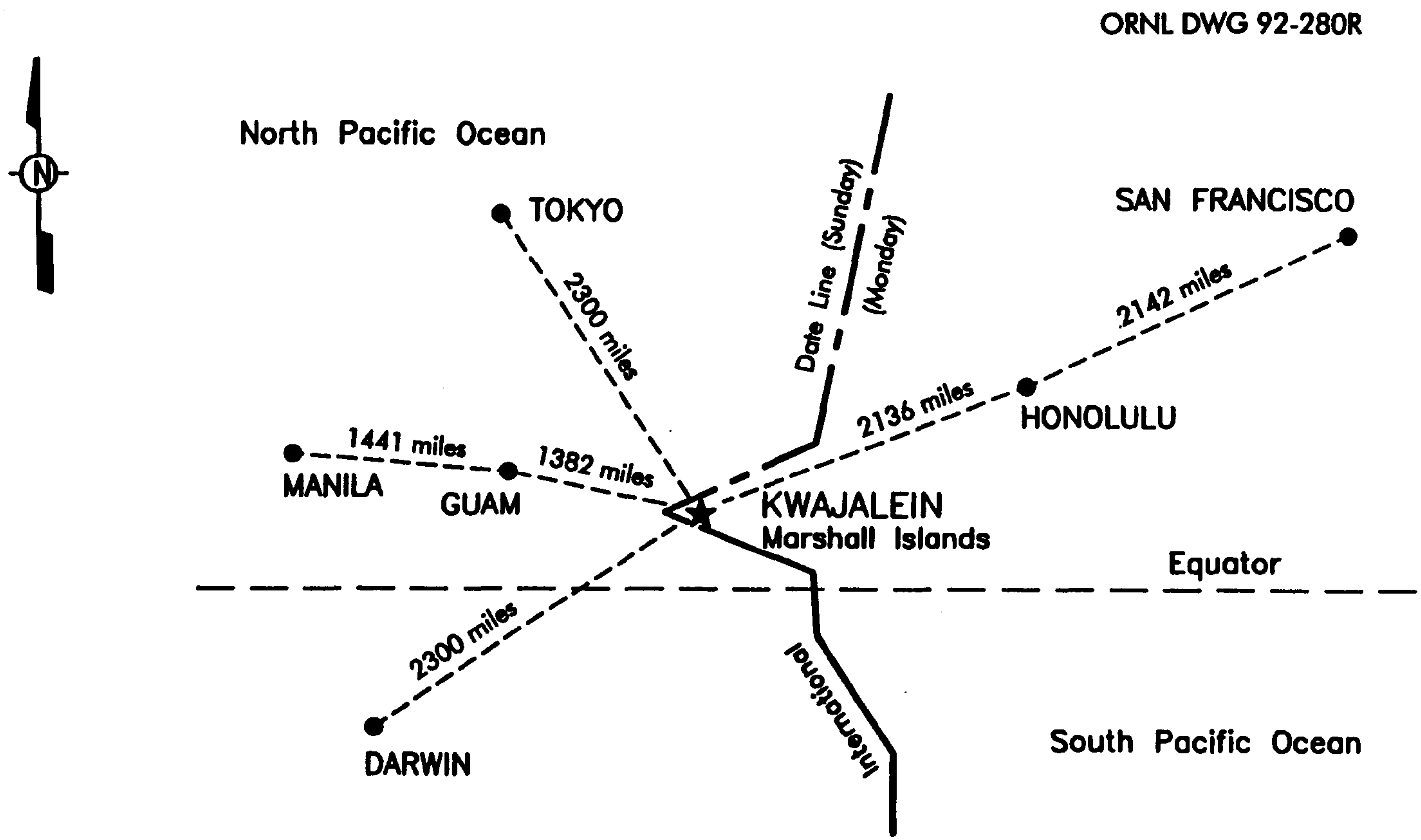

Fig. 1. Geographical location of the U. S. Army Kwajalein Atoll Base.

A Compact of Free Association allows the United States exclusive use of 11 islands within the Kwajalein Atoll. This Compact stipulates that the environment of the atoll will be protected in accordance with U.S. environmental laws (e.g., Comprehensive Environmental Response, Compensation, and Liability Act; Toxic Substance Control Act; and Clean Water Act). However, the mechanism for implementing and verifying compliance is not clear. For example, the U.S. Environmental Protection Agency (EPA), Region IX, has determined that it has no regulatory authority over the Kwajalein Atoll.

USAKA has significant petroleum hydrocarbon contamination resulting from years of military activities. Given its remoteness, the lack of on-site sophisticated remediation or waste disposal facilities, the amenability of petroleum hydrocarbons to biodegradation, and the year-round temperatures favorable for microbial activity, USAKA requested, through the Hazardous Waste Remedial Actions Program (HAZWRAP), that a project be initiated to evaluate the feasibility of using bioremediation for environmental restoration of contaminated sites within the atoll. In January 1991, HAZWRAP commissioned a team of scientists and engineers from Oak Ridge National Laboratory (ORNL), Oak Ridge Associated Universities (ORAU), and The University of Tennessee (UT) to undertake this project. The project was conducted in four distinct phases: (1) initial site characterization and on-site biotreatability studies, (2) selection of the demonstration area and collection of soil columns, (3) laboratory column biotreatability studies, and (4) an on-site bioremediation demonstration. The results of phases one and three have been detailed in previous reports.[9-11] This report will summarize the results of phases one and three and will present phases two and four in detail.

1.2.1 Site Characterization and On-site Biotreatability Studies

The site characterization and on-site biotreatability studies were initiated in February 1991. The purpose of the study was to determine if locations selected for new construction on Kwajalein Island were contaminated by petroleum hydrocarbons as suspected and, if so, whether bioremediation appeared to be a feasible technology for environmental restoration. Two different sites were evaluated: (1) the site planned for a freshwater production facility and (2) a site adjacent to an aboveground diesel fuel storage tank. The results of this on-site investigation were detailed previously[9] and are summarized below.

- Subsurface soil materials at the sites were characterized as coral-derived sands that were alkaline and nutrient deficient. Bacteria were present at concentrations of 10^3 to 10^6 organisms per gram of soil. Groundwater occurred at a depth of ~5 ft below ground surface (bgs), and the water table chemistry showed no marine influence.
- Within the proposed construction zone for the freshwater production facility, total petroleum hydrocarbons (TPH) were either absent or present at low levels. At some locations, trace-to-low concentrations of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs) were noted. The concentrations of organic compounds measured were below commonly accepted reference values for assessing soil as contaminated and in need of remediation. No notable concentrations of heavy metal contaminants were detected.
- Characterization data for the site adjacent to the aboveground diesel fuel storage tank southeast of the old diesel power plant revealed high concentrations of diesel fuel in the soil and groundwater beneath the site. TPH concentrations increased from low levels near the ground surface to concentrations approaching 9000 mg/kg (ppm) in the soil at the groundwater table. The concentrations of TPH measured were well above the commonly accepted reference values

of 10 to 100 mg/kg for assessing soil as contaminated and in need of remediation. Only trace-to-low concentrations of VOCs and SVOCs and no notable concentrations of heavy metals were measured.

- On-site biotreatability experiments suggested that microorganisms within the subsurface at those locations where petroleum contamination was present were adapted and able to degrade the hydrocarbon contaminants in the soil. In contrast, microorganisms in the uncontaminated area were not adapted nor were they readily capable of biodegrading fresh hydrocarbons.

Results of this investigation indicated that bioremediation appeared to be a viable environmental restoration technique for petroleum-contaminated soils on Kwajalein. It was noted that high concentrations of diesel fuel, which were likely weathered and nutrient deficient, might hinder the bioremediation process but that these problems could be overcome by design and operation. Results of the on-site biotreatability studies indicated that further experimentation and field demonstration were required to determine the design and operating conditions that provide for optimum biodegradation and restoration of the petroleum-contaminated soils.[9]

In addition to making on-site observations regarding the microbial abundance and distribution of petroleum contaminants, soil and groundwater samples were transported to Oak Ridge for more detailed analyses and to confirm the results of the on-site investigation. Results of the laboratory analyses were reported previously[10] and are summarized below.[10]

- The soil and groundwater of Kwajalein Atoll contain a wide variety of aerobic and anaerobic microorganisms. Although the concentration of live organisms varied from site to site, no sterile environments were found. The number of organisms per gram of soil ranged from 10^3 to 10^8.

- Some organisms present in the soil samples containing petroleum contaminants had the ability to degrade certain fractions of the hydrocarbons present; however, some evidence existed that the more heavily weathered hydrocarbons (i.e., generally larger molecules with partially oxidized substituents) might be relatively difficult to degrade by biological methods. The biological activity of the native populations of organisms could be stimulated by the addition of inorganic and/or organic nutrient supplements. The addition of commercially available bacterial preparations to Kwajalein soil enhanced biological activity.
- Experiments with bioluminescent reporter strains of bacteria demonstrated that naphthalene and toluene were biologically available in some Kwajalein soil samples. The application of gene probe techniques to Kwajalein soil samples did not reveal the presence of hydrocarbon-degrading genes. However, the only probes available were derived from gram-negative organisms and may not have been sufficiently homologous to the genes of the predominantly gram-positive populations present in the Kwajalein soil samples.
- The assay of ester-linked phospholipid fatty acids (PLFAs) from the Kwajalein soil samples suggested that an actinomycete population is present, along with a variety of other bacteria. No fatty acids derived from eukaryotes were observed. The fatty acid profiles suggested that most of the microorganisms were not actively dividing and may be starved for certain essential nutrients.

In general, the biological observations made on the USAKA soil and water samples supported the concept that bioremediation may be an effective way to remove at least some of the hydrocarbons contaminating Kwajalein Atoll. It was recommended that the technical approach include the additions of nutrients. Also, the addition of certain microorganisms might be useful to increase the rate of hydrocarbon degradation.[10]

1.2.2 Demonstration Area Selection and Soil Column Collection

In July 1992, a team of scientists and engineers visited Kwajalein to initiate work on the column biotreatability studies and the on-site bioremediation demonstration. The objectives of this trip included (1) identifying and delineating the demonstration area, (2) conducting a geophysical subsurface mapping of the demonstration area, (3) sampling and on-site analysis of soils across the demonstration area, (4) obtaining core samples from the demonstration area to be shipped back to ORNL for use in column biotreatability studies, and (5) demonstrating the use of the equipment that would be used to drive the necessary wells and the coring equipment into the test cells used during the on-site demonstration.

The area identified for the possible on-site bioremediation demonstration, which is shown in Figs. 2 and 3, was located adjacent to a diesel fuel power plant. Test pits 4, 5, and 6 (Fig. 3) were areas sampled during the February 1991 site characterization and on-site treatability studies summarized earlier. The dashed lines in Fig. 3 represent the fence installed to enclose the demonstration area. A Geonics EM-31 terrain conductivity meter was used to gather information about possible subsurface obstacles in the proposed demonstration area. The EM-31 survey indicated that the subsurface within the identified demonstration area contained no large objects (e.g., unexploded ordnance) that would interfere with the planned bioremediation demonstration.

Soil samples were taken within the potential demonstration area to determine the extent to which the site was contaminated and if a sufficient portion of the site was contaminated to conduct the bioremediation demonstration. The area was fenced off and a 30- x 30-ft grid was laid out (Fig. 4). Grid points were then sampled at depths below the ground surface of 1 to 2 ft, 2 to 3 ft, 3 to 4 ft, 4 to 5 ft, and/or 5 to 6 ft and analyzed on-site for total hydrocarbons using a "Hamby Kit." The "Hamby Kit" is a colormetric method that uses Freon to extract the hydrocarbons from the soil samples. The kit provides a rough estimate of the quantity of hydrocarbons present and would indicate if a more detailed site characterization would be necessary if the demonstration were to be conducted on this area.

In general, the soil in an area of ~128 ft (along Industrial Road) (Fig. 4) by ~60 ft (perpendicular to Industrial Road) was shown to be contaminated with hydrocarbons (Table 1), and the majority of these hydrocarbons were located 3 to 6 ft bgs level. The results of the analyses indicated that the site was adequate for conducting a bioremediation demonstration.

Four piezometers (designated P1, P2, P3, and P4) were installed to sample groundwater within the proposed demonstration area (Fig. 4). Samples taken from the groundwater surface in the piezometers were analyzed for hydrocarbons using the "Hamby Kit." No hydrocarbons were detected in P1 and P2. Hydrocarbon concentrations were 10 and 50 mg/L in P3 and P4, respectively. No floating hydrocarbons were noted in any of the groundwater samples. From a comparison of the hydrocarbon concentrations in the soil and the groundwater surface, it appears that most of the hydrocarbon contamination was distributed in the soil at a depth of 3 to 6 ft bgs.

Tests were also conducted at the proposed demonstration area at the sites PER-1 and PER-2 (Fig. 4) to determine the air permeability of the soil. An in situ permeability test described by Wilson et al.[12] was used to conduct these tests. The results indicated that the demonstration area soil had a permeability of about 8×10^{-8} cm^2. This translates to a hydraulic conductivity of about 8×10^{-3} cm/sec.[13] Because literature studies have determined that soils with hydraulic conductivities of 10^{-4} cm/sec or greater are most amenable to in situ bioremediation, the soil permeability was determined to be adequate for the demonstration.

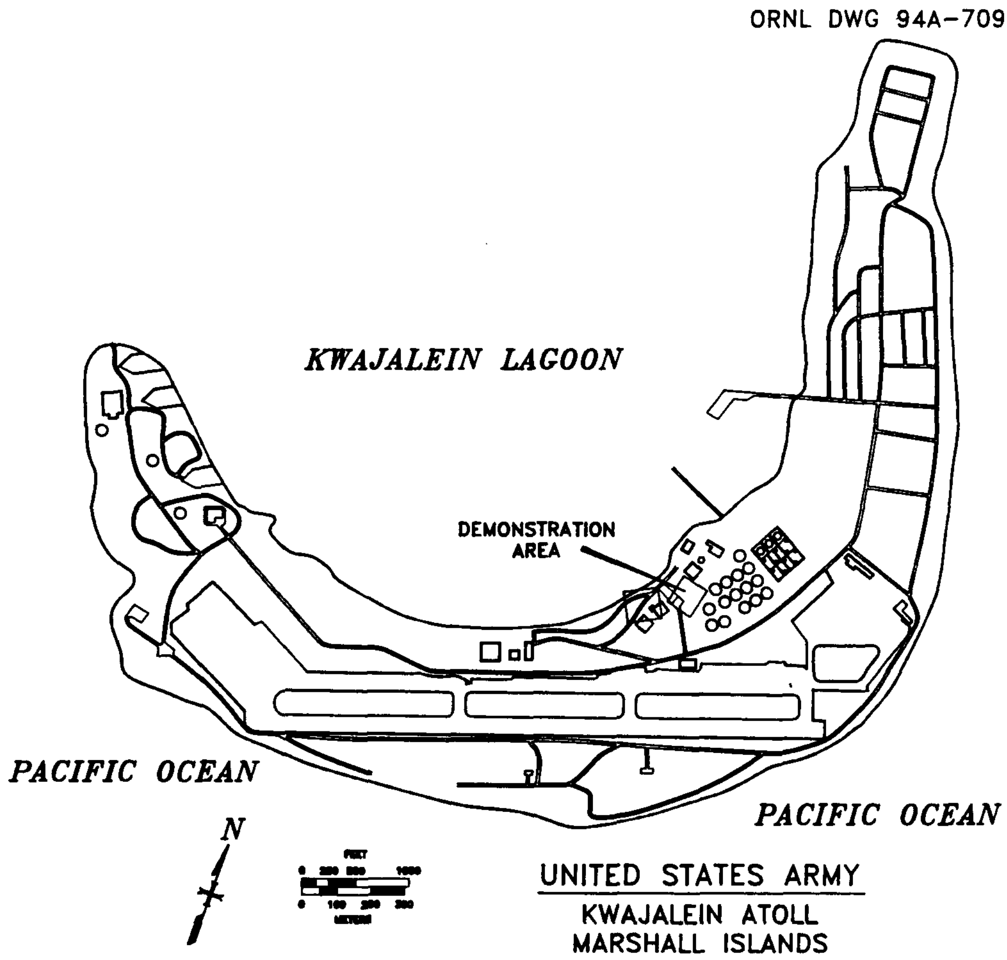

Fig. 2. Location of the demonstration area on Kwajalein Island.

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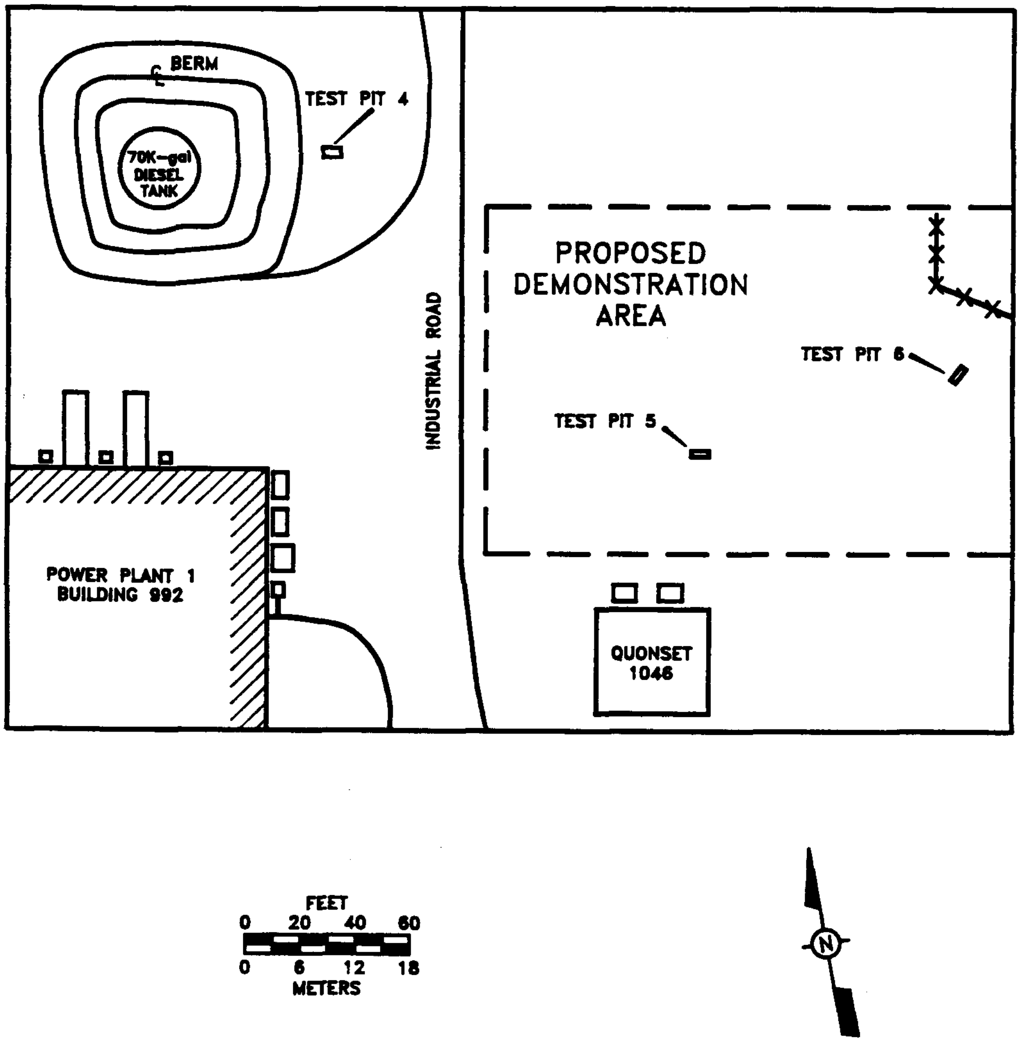

Fig. 3. Site map of the demonstration area on Kwajalein Island.

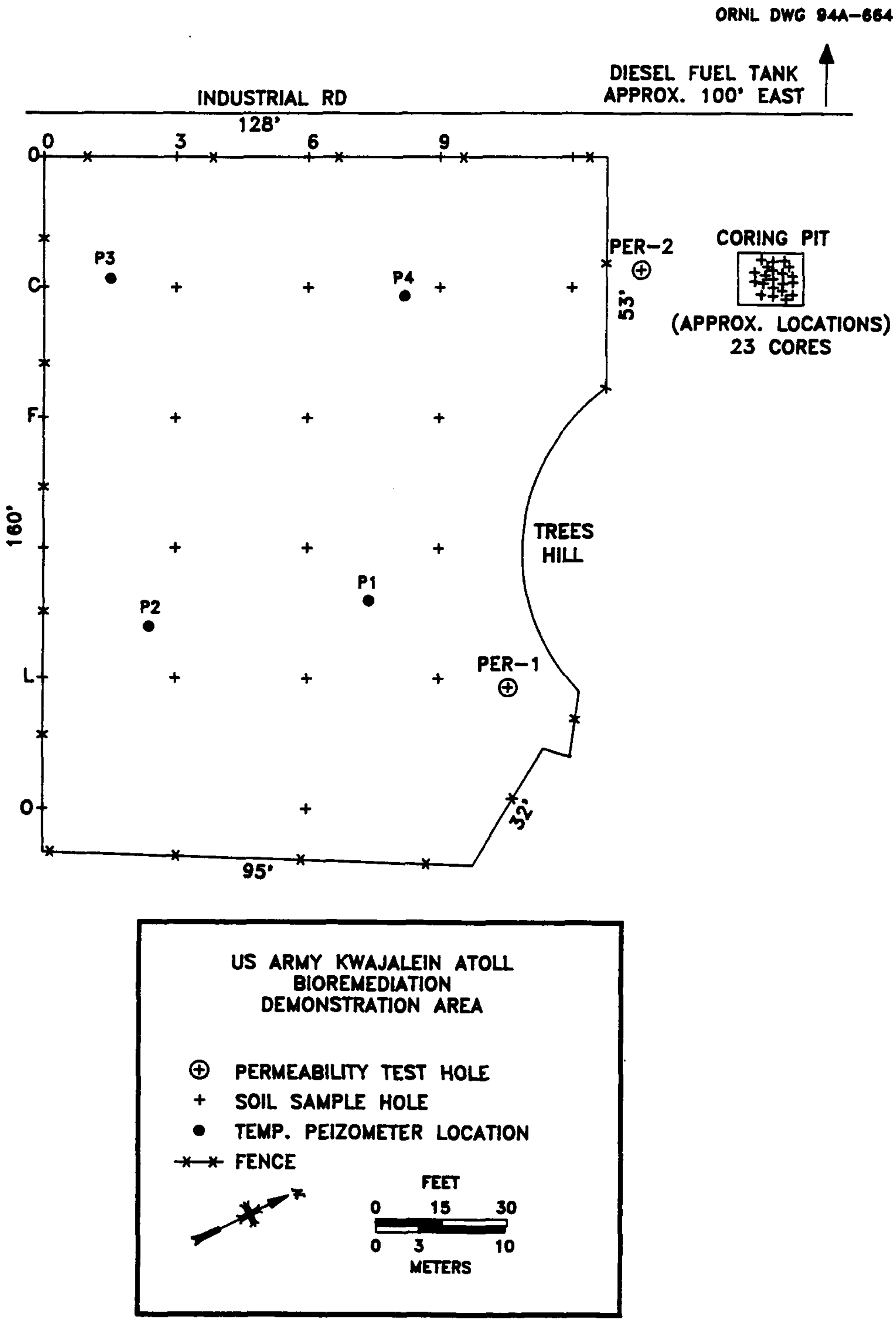

Fig. 4. Detailed layout of the bioremediation demonstration area.

Table 1. Summary of Hamby Kit analysis for total hydrocarbons in Kwajalein soils, (July 9–24, 1991)

	Total hydrocarbon concentration (mg/L) by Hamby Kit				
Depth bgs[a]	Grid Location				
(ft)	0-0	0-3	0-6	0-9	0-12
1-2			10-50	ND[b]	50-100
2-3	1000-2000	ND	10-50	ND	50
3-4	>3000	1500	50	ND	700-800
4-5	>3000	2000	1000	2000	>3000
5-6	>3000	>2000	>3000		
Depth bgs	Grid location				
(ft)	C-0	C-3	C-6	C-9	C-12
1-2					
2-3	500		ND	ND	<10
3-4	>3000		10	ND	ND
4-5	>3000	>3000	>3000	1000	50
5-6			2000	1500	3000
Depth bgs	Grid location				
(ft)	F-0	F-3	F-6	F-9	F-12
1-2					
2-3	10-20	1000	<10	ND	
3-4	10-20	500	500	ND	
4-5	3000	3000	>3000	1000	
5-6	2000	1000	>3000	1000	
Depth bgs	Grid location				
(ft)	I-0	I-3	I-6	I-9	I-12
1-2					
2-3	ND	100-200	ND	ND	
3-4	ND	<10	ND	ND	
4-5	ND	<10	ND	ND	
5-6	ND	ND	ND	ND	
Depth bgs	Grid location				
(ft)	L-0	L-3	L-6	L-9	L-12
1-2					
2-3	ND	ND	ND	100	
3-4	ND	ND	10	10	
4-5	ND	ND	ND	10	
5-6	ND	ND	ND	100	
Depth bgs	Grid location				
(ft)	O-0	O-3	O-6	O-9	O-12
1-2					
2-3			ND		
3-4			ND		
4-5			ND		
5-6			ND		

[a]bgs = below ground surface.
[b]ND = not detected; no entry = not sampled or analyzed.

Twenty-five stainless steel tubes, 3 in. diam by 3 ft long, were used to collect soil samples for transport to and testing at ORNL and/or UT. These samples were obtained from an area of approximately 8 x 8 ft, and the sample location is identified in Fig. 4 as "coring pit." Before sample collection, the sample tubes were decontaminated and wrapped in aluminum foil until ready for use. The decontamination procedure included (1) scrubbing the tubes several times with detergent, (2) rinsing with isopropyl alcohol, (3) triple rinsing with deionized water, (4) steam cleaning, and (5) air drying. The soil columns were transported to ORNL in insulated containers to minimize temperature variations during shipment.

The equipment identified for use in installing soil instruments and taking soil samples during the bioremediation demonstration was tested. The combination of the Pionjar Vibrating Hammer and the Geoprobe Sampling System (for soil and groundwater) worked very well at the demonstration site. The weak link in the sampling equipment appeared to be attachments between the Pionjar Hammer and the Geoprobe sampling equipment. New adapters were designed, and it was recommended that adapters based on these new designs be built before conducting any on-site demonstration.

1.2.3 Column Biotreatability Studies

Of the 25 soil columns collected and transported to ORNL in July 1992, 16 were used for treatment studies, 3 were used as control columns, 3 were used for characterization to provide a baseline against which the results of the treatment studies could be compared, and 3 were too badly damaged to be used. Treatment regimes tested included (1) water only, (2) water + nutrients, (3) water + nutrients + microbes, (4) water + air, (5) water + air + nutrients, and (6) water + air + nutrients + microbes. The results of these studies were detailed previously[11] and are summarized below.

- Total colony-forming units (CFUs) of approximately 10^7 CFU/g, determined by plate count methods in the uppermost 10 in. of Kwajalein soils, were typical of surface soils. Below 10 in. bacterial numbers decreased. In the most contaminated zones below 3 ft, bacterial numbers were low, possibly showing effects of toxicity caused by severe hydrocarbon contamination. Test results demonstrated that many of the organisms present in soil samples containing petroleum contaminants were capable of degrading certain fractions of hydrocarbons. The degradative activity of the native population of organisms was stimulated by the addition of air and nutrients. However, bioaugmentation, the addition of microorganisms to the columns, did not permanently increase the biomass.
- In terms of hydrocarbon removal from the columns, the greatest differences from controls occurred as a result of water flushing. The addition of air and/or nutrients had an effect in some treatments, but the addition of microorganisms did not appear to facilitate TPH biodegradation.
- The column biotreatability studies indicated that biodegradation of diesel-fuel contaminants in Kwajalein Island soils was possible using indigenous microbes. The results suggested that bioremediation of soils is technically feasible as an environmental restoration process on Kwajalein Island; however, the reduction of diesel-fuel contamination to residual levels below 100 mg/L by an in situ bioremediation process might be a difficult and lengthy process because of the proportion of more slowly biodegradable, higher molecular-weight hydrocarbons (i.e., weathered diesel fuel) present. In addition, it was suggested that treatment combinations with surfactants might be worthy of consideration and that treatment of a few years with water + air + nutrients could significantly reduce the concentration of lighter petroleum hydrocarbons.

1.2.4 On-Site Bioremediation Demonstration

In general, the results of the column studies agreed with those of the previous on-site biotreatability and laboratory studies. These results included the following: (1) indigenous microorganisms on Kwajalein were capable of degrading certain fractions of hydrocarbons, (2) bioremediation appeared to be a viable alternative for environmental restoration at Kwajalein, (3) the addition of air and nutrients would be required to increase the numbers of microorganisms in the areas of contamination to enhance bioremediation, (4) high concentrations of weathered diesel fuel might be difficult to biodegrade, and (5) on-site demonstration was required to further evaluate bioremediation for environmental restoration at Kwajalein and to determine the design and operating conditions necessary to optimize the process.

As a result of these findings, an on-site bioremediation demonstration project was conducted on Kwajalein Island. The project looked at both in situ and ex situ treatment systems. This report details the results of the on-site demonstration.

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2. MATERIALS AND METHODS

2.1 IN SITU TREATMENT CELL DESIGN

A schematic diagram showing the layout and design of the individual in situ treatment cells used in the Kwajalein bioremediation demonstration is presented in Fig. 5. The vadose zone was the first 3 ft of soil, the capillary fringe was in the area from ~3 to 7 ft bgs, and the saturated zone was below ~7 ft. The mean groundwater level was ~7 ft below ground surface, and the tidal fluctuation varied from ~1 to 2 ft. Each in situ cell covered an area ~8 x 8 ft and was surrounded by a plot border constructed of treated lumber. Each cell also contained a sparge well, a monitoring well, and vapor implants.

The sparge well was located in the center of the plot and consisted of a 1 1/4-in. diam stainless steel pipe with a 1-ft-long screened section. The slots in the screen were 0.020 in. apart and the bottom of the screened section was located 10 ft bgs. This 1-ft-long screened section, which was in the saturated zone and thus always below the surface of the groundwater, was used to supply air to the subsurface.

The monitoring well located in each in situ cell was also constructed from 1 1/4-in. stainless steel. The bottom of this well was located 9 ft bgs and the well length was screened from 3 to 9 ft. The monitoring well was used to take groundwater samples and to monitor groundwater levels.

Vapor implants consisting of a 6-in.-long stainless steel tube with a 10-μ pore size were located in each in situ plot at depths of 2.5 and 4.5 ft bgs. The implant at 2.5 ft was located in the vadose zone and the implant at 4.5 ft was located in the capillary fringe. These implants were used for sampling soil gas.

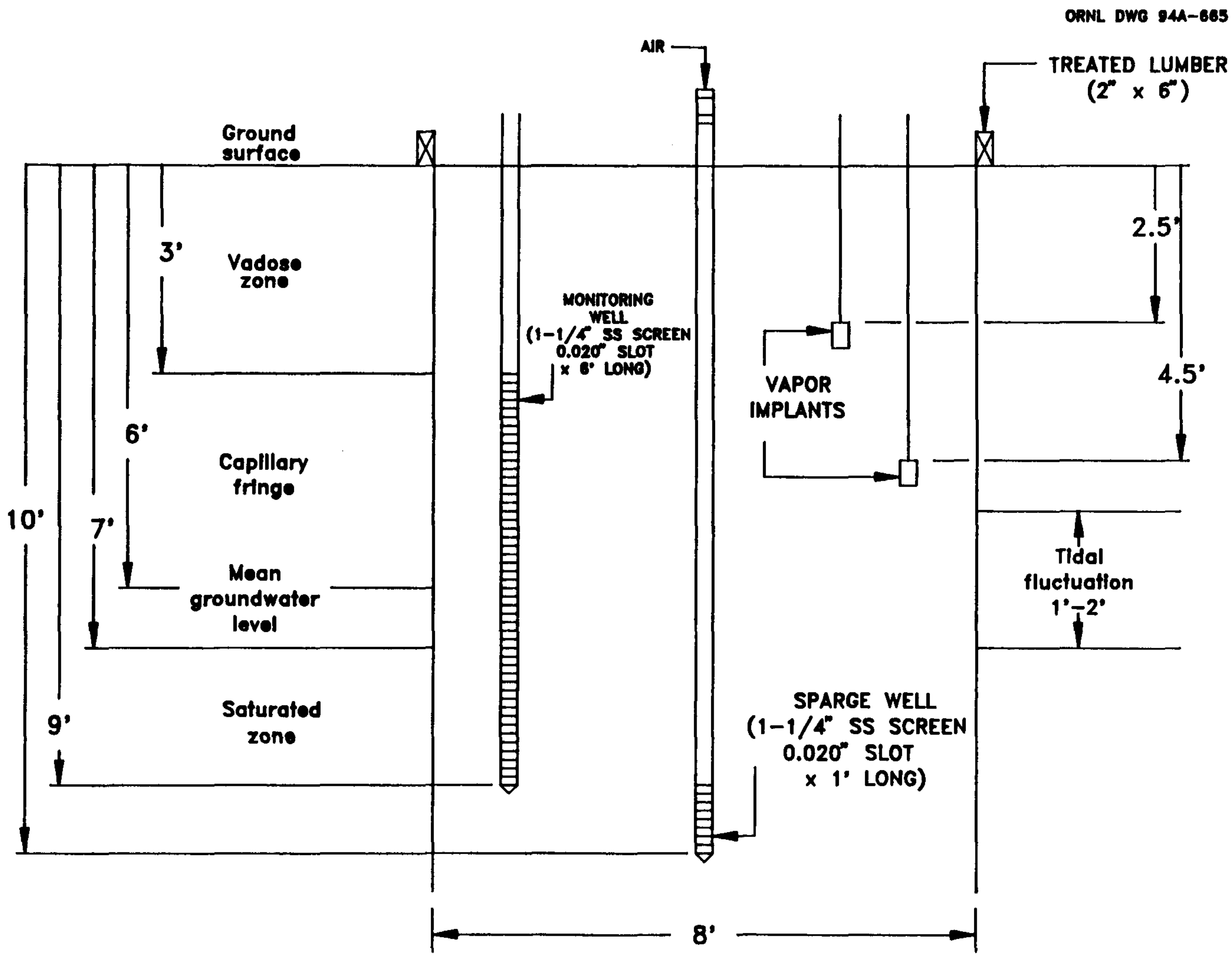

Fig. 5. Cross section of an in situ test cell.

2.2 EX SITU TREATMENT CELL DESIGN

A schematic diagram showing the design of the ex situ treatment cell is shown in Fig. 6. Each ex situ cell was constructed from 3/4-in. exterior plywood and was ~8 ft wide x 8 ft long x 2 ft high. The interior of each cell was covered with a poly-liner to prevent liquids from leaking out. Excavated soil from an area contaminated with petroleum hydrocarbons was placed in the ex situ cell inside of the poly-liner. A tarpaulin was placed over each plot to prevent the entry of rainwater. Five lines, which consisted of 1/2-in. PVC pipe with 3/8-in. diam holes drilled on each side at ~2-in. intervals, were used to provide amendments to the plots. A 1 1/4-in. diam screened pipe was placed about 6 in. beneath the excavated soil in the bottom of each plot and hooked to a vacuum system. The vacuum system, when operating, pulled outside air through the perforated pipe located on the bottom of each plot and was used to pump out liquids that collected in the bottom of the ex situ cell as a result of amendment additions.

2.3 LAYOUT AND DESIGN OF THE IN SITU AND EX SITU SYSTEMS

There were 12 in situ plots, 6 ex situ plots, and 8 monitoring wells (Figs. 7 and 8). Each of the in situ plots had a sparge well used to supply air to the plot subsurface as necessary. All in situ plots were 8 x 8 ft and were separated by a distance of about 12 ft.

The seven in situ plots located in the first row (P1 through P7) were closest to the 6-in. underground fuel line and to the 70,000-gal diesel storage tank (see Fig. 2), which were assumed to be the source(s) of contamination for the demonstration area. The in situ plots in the second row (P8 through P12) were located approximately 12 ft from the plots in the first row. An MW was

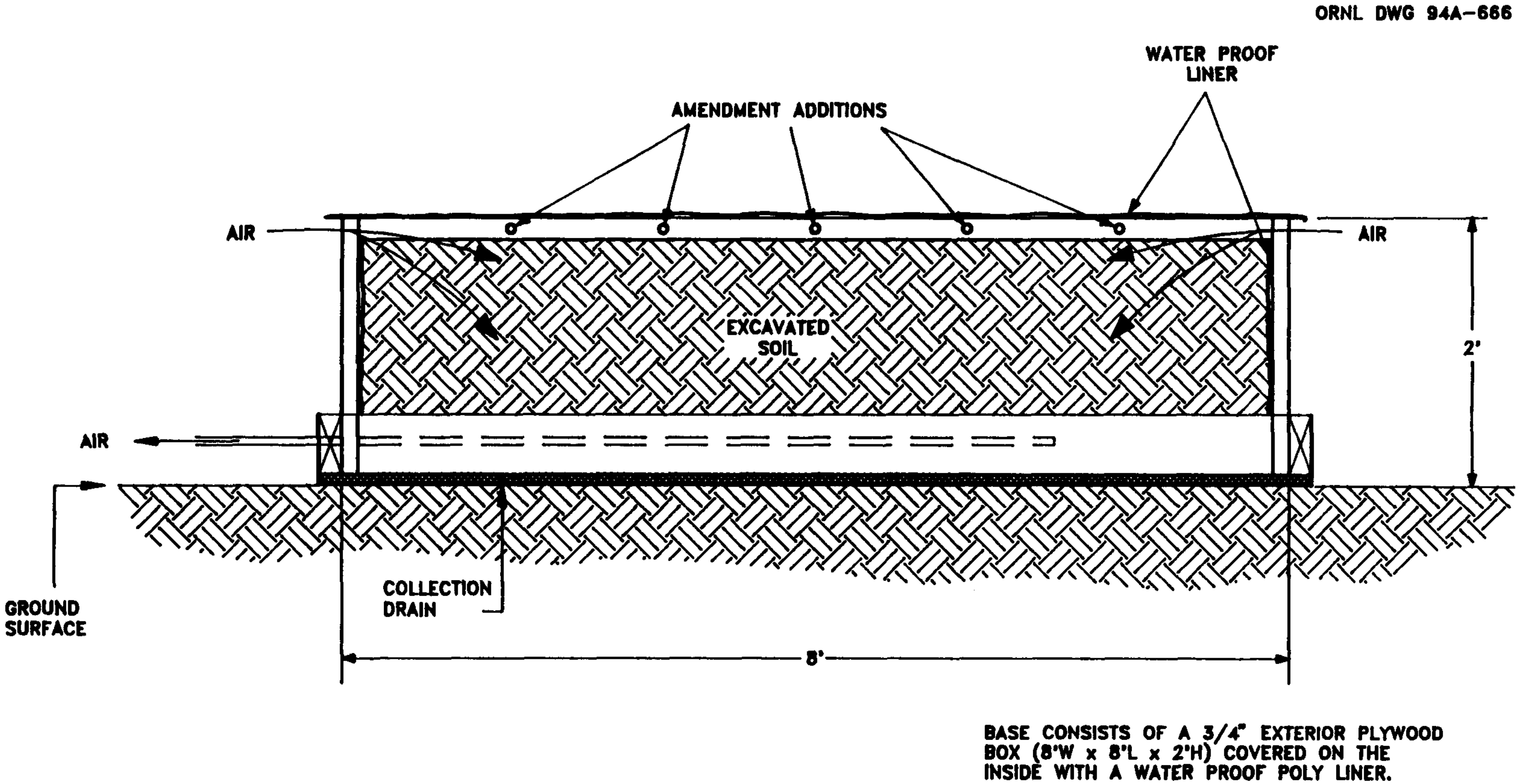

Fig. 6. Cross section of an ex situ plot.

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TOP VIEW OF DEMONSTRATION SITE INDICATION APPROXIMATE PLACEMENT OF PLOTS, MONITORING WELLS, AND SPARGE WELLS

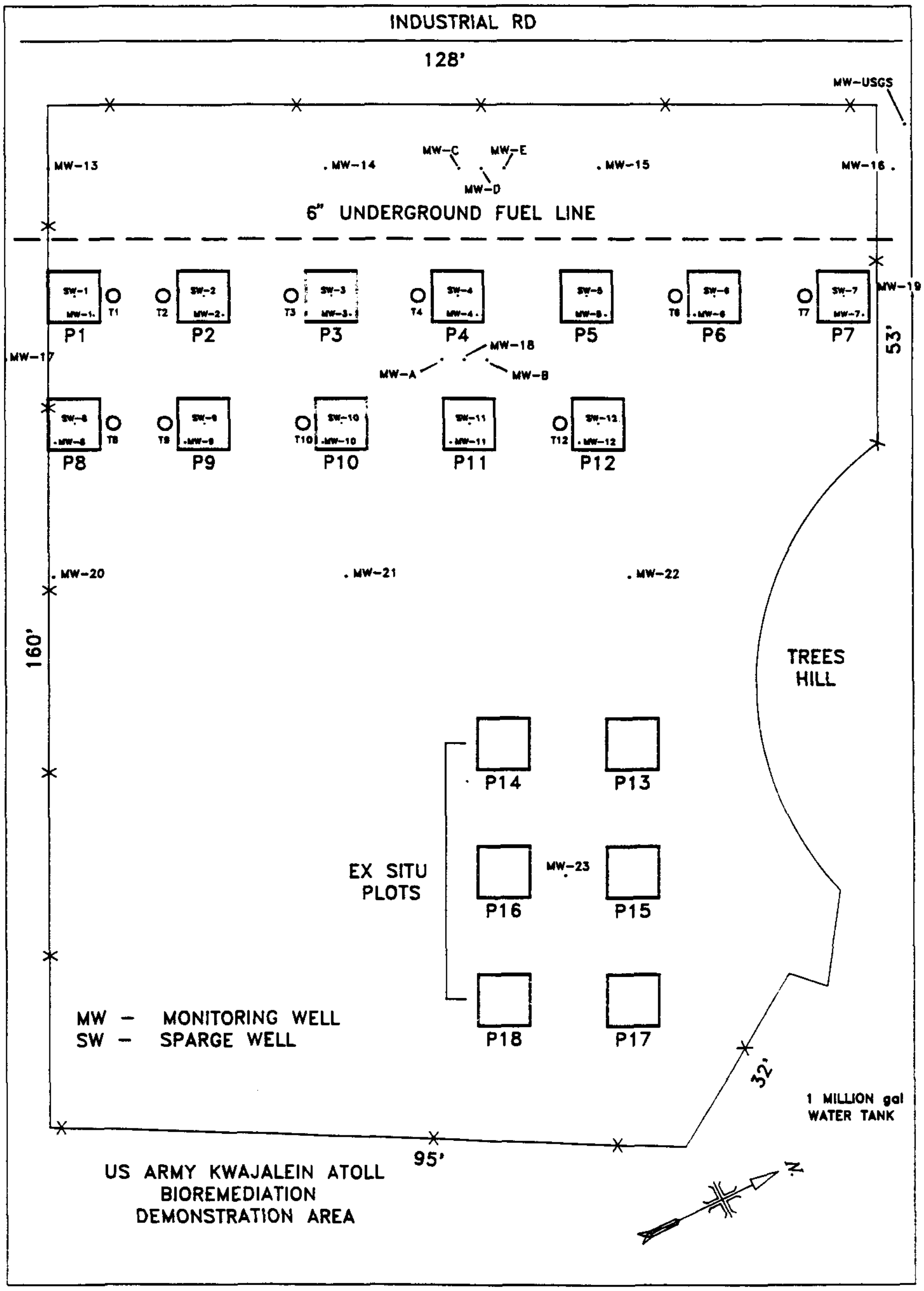

Fig. 7. Top view of demonstration site indicating approximate placement of plots, monitoring wells, and sparge wells.

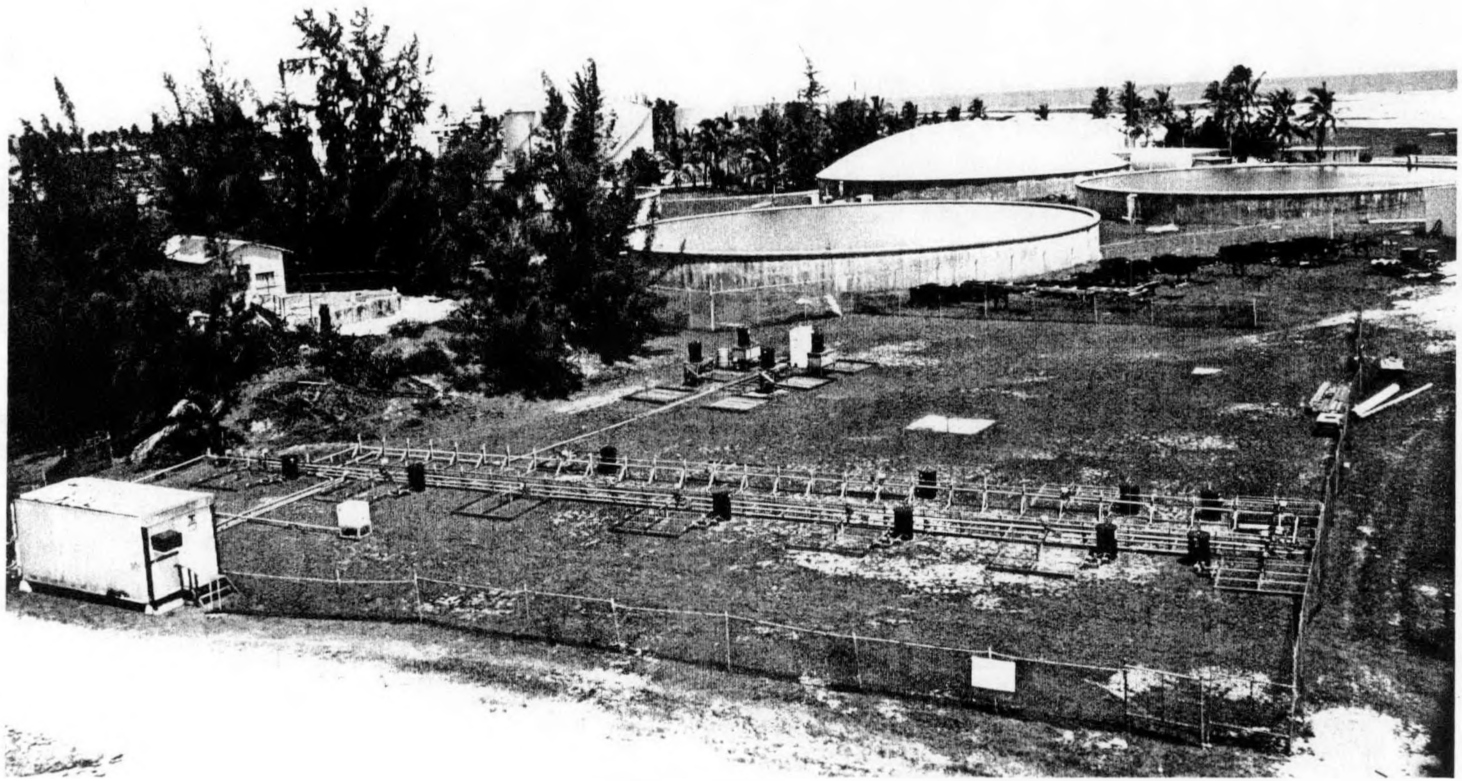

Fig. 8. Photograph of the in situ and ex situ systems on the biodemonstration area.

located within each in situ plot, and an additional 15 MWs were placed around, or between, the two rows of in situ plots. An MW located outside the demonstration area, which was previously installed by the U.S. Geological Service (USGS), was also sampled occasionally. The ex situ plots were located approximately 30 ft from the in situ plots, with approximately 12 ft between the individual plots. A single MW was placed among the ex situ plots.

To assess the biotreatability of the petroleum hydrocarbon contaminated soils at Kwajalein Island, treatment regimens were developed that fed different combinations of air, water, and nutrients to the in situ and ex situ plots. The treatment regimens used for the on-site demonstration came from information provided from the column biotreatability studies previously conducted at ORNL and UT (see Sect. 1.2.3). A statistician was consulted to help determine which combination of treatment parameters and how many duplicate cells should be evaluated based on the given area of contamination at the demonstration site. Several treatment regimens were used for the in situ and ex situ treatment systems (Tables 2 and 3). Additional design parameters developed from the column studies for the in situ system included (1) feeding 25 gals of water and/or amendment to the plots four times daily and (2) adding air for about 16 hr per day at a rate of 0.5 cfm per plot. The design parameters for the ex situ plots included one 50-gal feeding per day over a 15-min period and addition of air at 2 cfm for 20 hr/day. The compositions and concentrations of nutrients fed to the in situ and ex situ system during the on-site demonstration are discussed in Sect. 3.3.

To supply water, air, and nutrients to the treatment plots, amendment, blower, and control systems were designed and installed for both the in situ and ex situ demonstrations. These systems included all equipment, tanks, piping, and instrumentation necessary to operate, control, and monitor the biosystems. A simplified process flow diagram of the amendment system and a process flow diagram of the blower system, with associated instrumentation and controls, for the in situ demonstration are presented in Figs. 9 and 10, respectively. The process flow diagram, which

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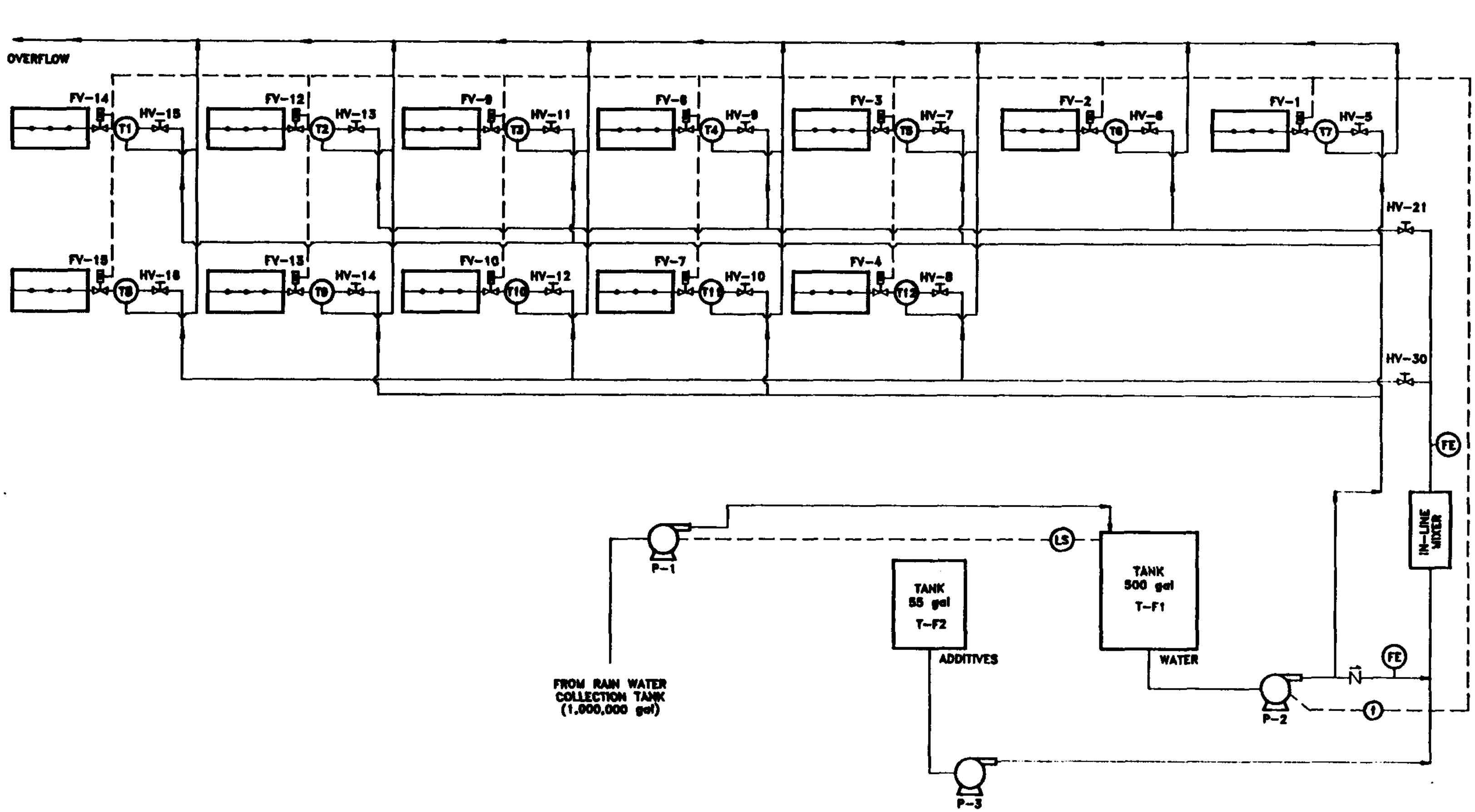

Fig. 9. Process flow diagram of the amendment system for the in situ bioremediation demonstration.

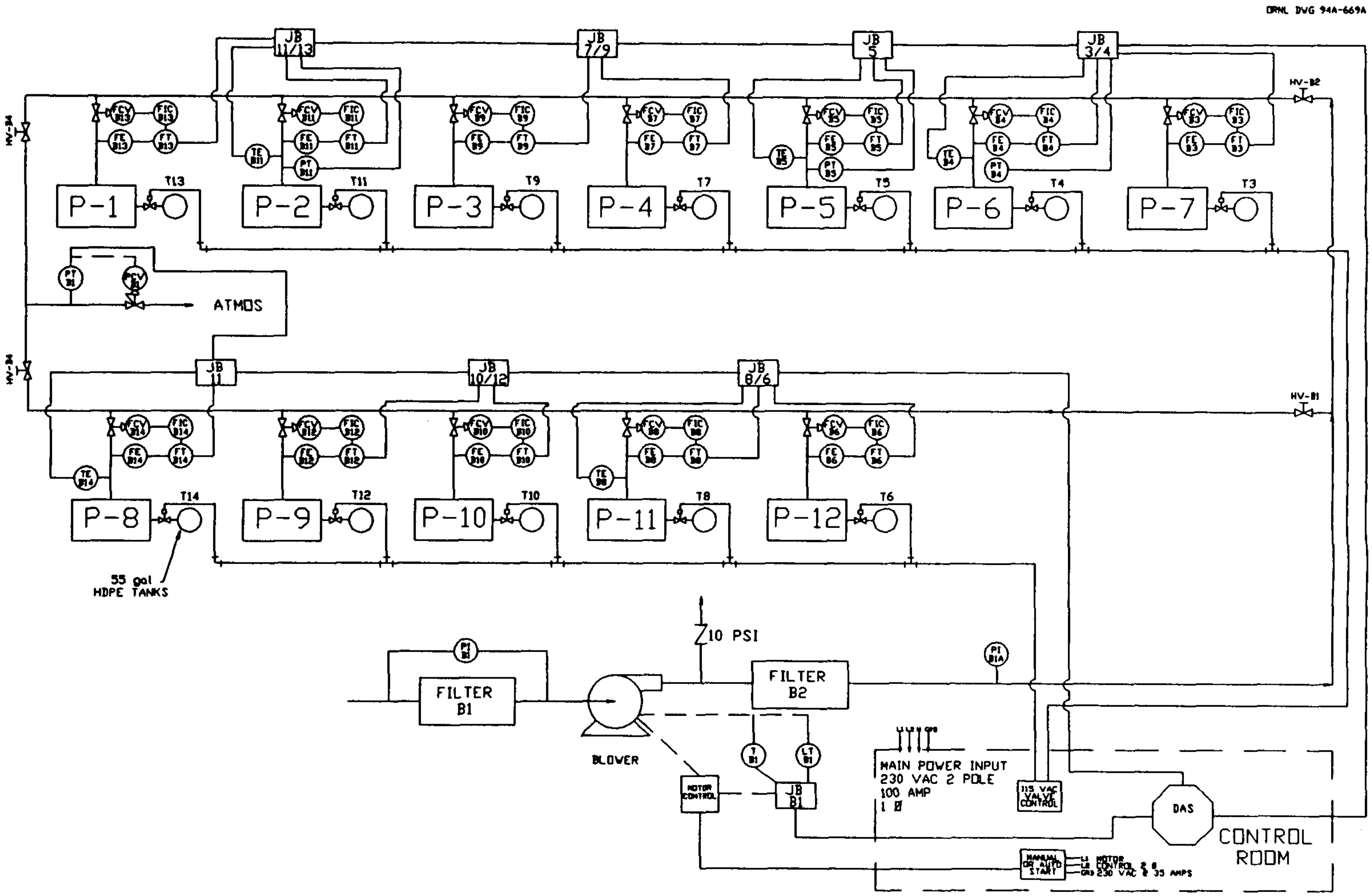

Fig. 10. Process flow diagram of the blower system, with associated instruments and controls.

Table 2. Treatment regimen for the in situ plots

Plot numbers	Treatment regimen
Plots 1 and 9	Periodic additions of air and water
Plots 2, 4, and 8	Periodic additions of air, water, and nutrients
Plots 3 and 7	Periodic additions of water
Plots 6, 10, and 12	Periodic additions of water and nutrients
Plots 5 and 11	No additions (controls)

Table 3. Treatment regimen for the ex situ plots

Plot numbers	Treatment regimen
Plots 13 and 14	No additions (controls)
Plots 15 and 17	Periodic additions of air and nutrients
Plots 16 and 18	Periodic additions of nutrients

includes associated instruments and controls for the ex situ demonstration, is presented in Fig. 11.

For the in situ system, water was pumped from an ~1,000,000-gal rain collection tank into a 500-gal high density polyethylene (HDPE) tank (T-F1) and stored until ready for use. A concentrated nutrient solution was also prepared and stored in a 55-gal HDPE tank (T-F2). The water from T-F1 was either mixed with additives from T-F2 (plots 2, 4, 6, 8, 10, and 12) or pumped directly (plots 1, 3, 7, and 9) into individual plot amendment tanks (T1-T12). A metering pump was used to provide the correct quantity of concentrated nutrient solution to the plots. The individual amendment tanks were 55-gal HDPE tanks, and the total volume in each of these was controlled by overflow lines located on the tanks. The water and/or amendment solutions were distributed across the individual plots through 3/4-in. PVC pipe with 3/32-in. orifices. The pumps and solenoid valves for the in situ system were controlled by timers so that the water and/or amendments could be supplied to the plots on a specified schedule. The plots were fed 25 gal of water or amendment

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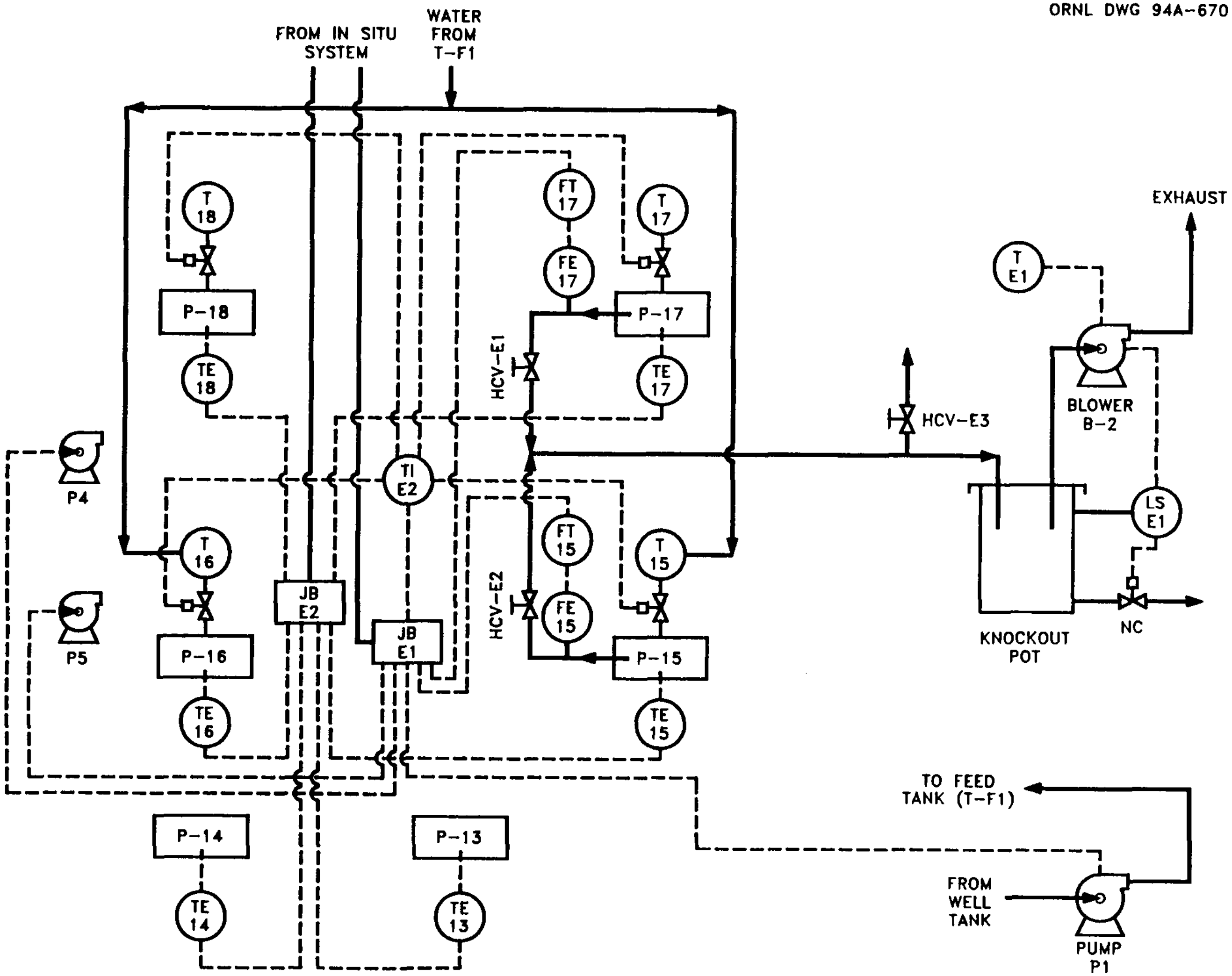

Fig. 11. Process flow diagram for the ex situ bioremediation demonstration.

solution over a 15-min period four times per day. A photograph of the in situ plots with the associated piping, controls, and amendment tanks is shown in Fig. 12.

Air was supplied to the in situ system by a Model 22 Dresser/Roots Universal RAI blower that contained a 5-hp motor and operated at 3600 rpm. The unit was designed to provide up to 40 cfm of air at 24.7 psig. The blower was attached to a 1 1/2- in. diam PVC header which supplied air to the individual in situ plots. Pressure control valve PCV-B1 maintained the header pressure at 4 to 5 psig, and flow control valves on the air supply lines to the individual plots maintained the flow to the plots at 0.5 cfm.

For the ex situ system, 200 L of water from tank T-F2 were pumped into each of the ex situ amendment tanks (T15-T18). The water in each tank was mixed with 2.5 L of nutrient concentrate from tank T-F2 and fed to the ex situ plots once each day. Air was supplied to the ex situ plots by a model DR-101 Rotron regenerative blower. This blower was rated for a maximum flow of 29 scfm and a maximum vacuum of 1.8 in. of mercury. The blower was installed to pull air from the bottom of the ex situ plots causing air to enter the soil from the surface of the plots. Air flow from the plots was maintained at ~2 cfm by manually setting throttling valves.

Flow, pressure, and level transmitters and thermocouples were used to continuously monitor process parameters for both the in situ and ex situ systems. These data were logged using a personal computer and the DIANNA Data Acquisition System (DAS).

2.4 SAMPLE COLLECTION AND ANALYSIS

Soil, groundwater, soil gas, and process feed samples were collected and analyzed during the on-site demonstration. These analyses were used to provide a baseline against which to compare

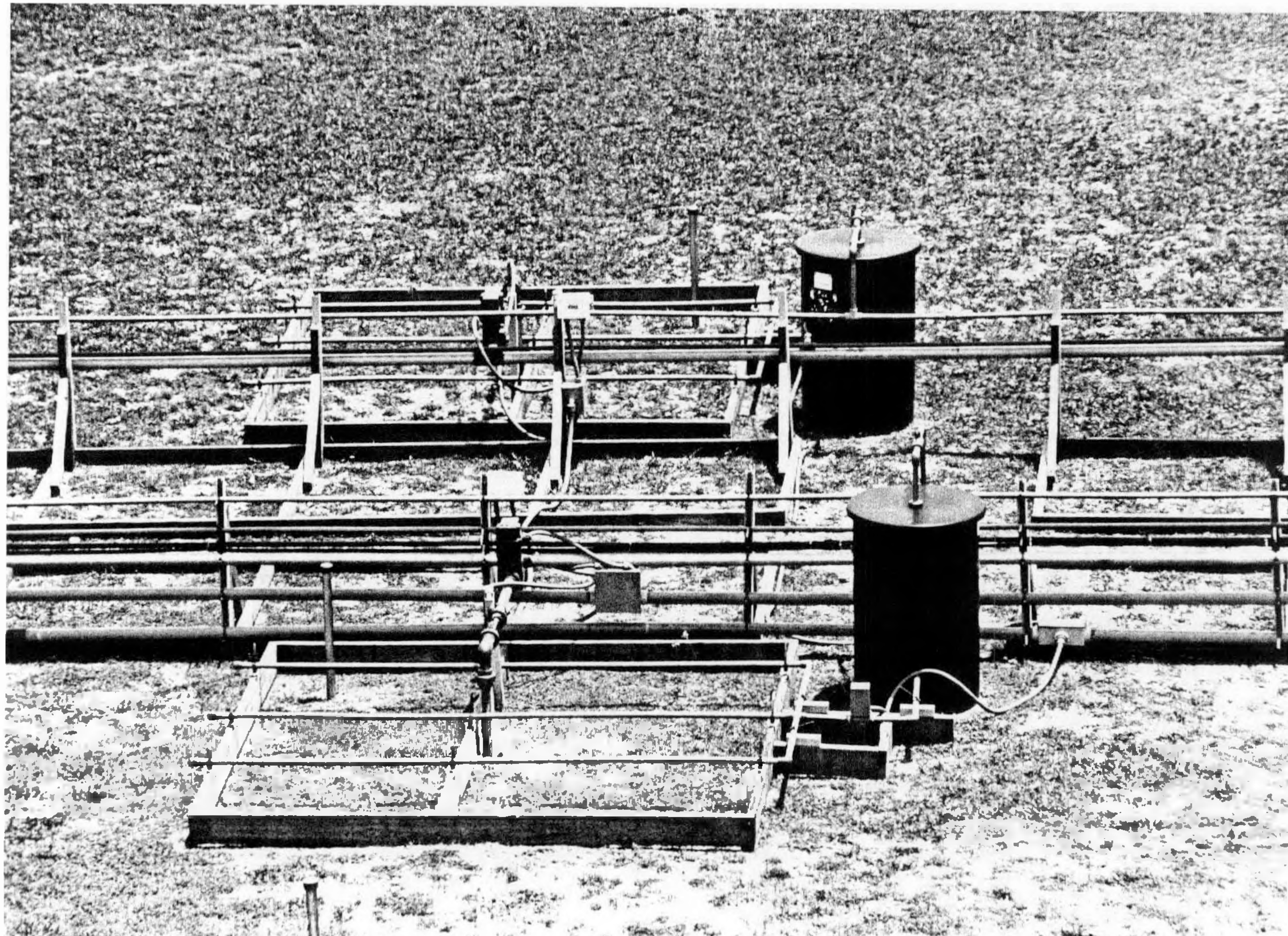

Fig. 12. Photograph of the in situ plots, with associated piping, controls, and amendment tanks.

future analysis results, to monitor the effects of the biological process on the environment, and to evaluate the biodegradation of hydrocarbons present in the soil and groundwater. Because of the logistical and technical problems associated with shipping samples to the United States from the RMI, the remote location of the site, and the need for real-time information to enable field interpretation and decision making, most of the analytical support work was conducted on-site. A copy of the procedure used for each analysis conducted on-site is presented in Appendix A. When deemed necessary, samples were shipped off-site and analyzed to provide information that could not be produced on-site. The materials and methods used for sample collection and analysis are discussed below.

2.4.1 Decontamination Procedures

Before conducting a sampling campaign, the equipment to be used for sampling was decontaminated. The decontamination procedure consisted of (1) scrubbing the sampling equipment with detergent, (2) rinsing the equipment with isopropyl alcohol, (3) triple rinsing with deionized water, and (4) air drying. After decontamination the sampling equipment was wrapped in aluminum foil until ready for use.

2.4.2 Sampling Equipment and Procedures

Analyses were conducted on groundwater, soil gas, and soil samples, as well as on process feed samples. Groundwater samples were collected from the monitoring wells that had been installed across the demonstration area. A peristaltic pump was used to pump the water from the monitoring well, through a Teflon tube, and into a labeled glass jar. Soil gas was collected from the vapor implants located within the in situ treatment plots. The gas sample was pulled using a 500-mL syringe, and the sample was then injected into a gas sample bag and held for analysis. Process feed samples were obtained from the nutrient concentrate tank (T-F2) and from the individual plot amendment tanks (T1-T18). These were grab samples taken in glass jars.

Because of the small areas used for the treatment plots, it was important to minimize the size of the soil samples and not disturb the remainder of the plot. The Geoprobe Systems® sampling equipment was chosen for soil sampling. The Geoprobe sampling tubes were constructed of stainless steel and were ~1 in. in diam. Both 1-ft long and 2-ft long tubes were used. The 2-ft tubes contained a liner that could be removed from the tube, capped, and cut into lengths for analyses. Soil cores were taken from ground surface to depths up to 9 ft bgs. A Pionjar 120 gasoline-powered vibrating hammer was used to drive the sampling tubes to the desired depth. These cores were divided into 1-ft lengths and the 1-ft lengths were then placed in glass jars and mixed well before analysis.

2.4.3 Groundwater Tracer Tests

Tracer tests using sodium bromide were conducted on the groundwater in the demonstration area to examine the movement of groundwater caused by tidal fluctuations and site activities. The following procedure was used for the bromide tracer tests (see Fig. 7 for MW locations):

1. A mixture of 3,785 L (1000 gal) of 700 mg/L bromide solution was prepared using sodium bromide salt. This solution was pumped into MW-18 at a rate of 1.5 gal/min using a peristaltic pump. Teflon tubing was used to deliver the bromide solution to the top of the screened section. The temperature of the feed solution was maintained within 5°F of the groundwater temperature to minimize density effects.

2. The nested MWs around the injection well (MW-18) (i.e., MW-A and MW-B) were sampled at time zero and every hour for the first 4 h and then every 4 h thereafter. The surrounding monitoring wells located close to the injection well and approximately one-half of the outlying wells were also sampled every 4 h until bromide breakthrough occurred in the inner circle of wells. Once breakthrough occurred in the inner circle of wells, the sampling effort was modified to look at those wells that were anticipated to be impacted next. After completion of the injection of the bromide solution into MW-18, this well was sampled at least once per day to monitor dissipation of the tracer solution.

3. For monitoring wells in which the screened area extended above the groundwater level, samples were taken midway between the surface of the groundwater and the bottom of the screened area. For monitoring wells in which the entire screened area was below the water level, samples were taken at the midpoint of the screened section. All samples were consistently collected at the same point within each well for the duration of the test.

4. Samples were obtained using a peristaltic pump and Teflon tubing. Distilled water was used to rinse the sample tubing between sample locations. The samples were collected in either 250-mL glass or HDPE containers, and all bromide analyses were run within 28 d so that no preservation was necessary.

5. Bromide analyses were conducted using an Orion Model 94-35 bromide electrode attached to an Orion Model 420A pH/ISE meter. (The analytical procedure used can be found in Appendix A.)

2.4.4 On-site Sample Analysis

A list of the primary on-site analyses, the sample points, and the sample frequency used during the Kwajalein Bioremediation Demonstration project is included in Table 4. Groundwater samples from each monitoring well were analyzed before startup and approximately every 4 weeks thereafter for TPH, chemical oxygen demand (COD), pH, conductivity, nitrate, phosphate, and hydrocarbons. Groundwater samples from select monitoring wells were also periodically analyzed for dissolved oxygen (DO) and coliform. Soil samples were analyzed from each in situ and ex situ plot before startup and approximately every 4 weeks thereafter for TPH, pH, hydrocarbons, moisture, and microbes. Samples of soil gas were periodically taken from the vapor implants in the in situ plots and analyzed for oxygen, carbon dioxide, and hydrocarbons. Samples of the concentrated feed and

Table 4. Primary on-site analyses for the Kwajalein demonstration program

Media	Analysis	Sample points (total)	Frequency
Groundwater	TPH COD pH Conductivity Nitrate Phosphate	Each of the monitoring wells (~23 total wells)	Before startup and approximately every 4 weeks thereafter
Groundwater	Coliform	Designated monitoring wells	As necessary
Soil	TPH pH Hydrocarbons Moisture Microbes	Each of the in situ and ex situ plots (18 total plots)	Before startup and approximately every 4 weeks thereafter
Soil gas	Oxygen Carbon dioxide Hydrocarbons	Each of the vapor implants (24 total implants)	Periodic
Liquid feed	pH Conductivity Nitrate Phosphate	Feed streams to plots	Periodic

the feed to the individual in situ and ex situ plots were also taken and analyzed for pH, nitrate, phosphate, and conductivity, when needed.

A summary of the containers, preservations, holding times, and analytical methods used for the on-site analyses is presented in Table 5. Groundwater samples from each of the MWs and soil samples from each of the treatment plots were collected in individual 500-mL glass containers. Soil gas samples were collected in 2-L and 600-mL Tedlar bags. These samples were then transported to the on-site laboratory for analysis. For the groundwater and soil samples, aliquots for the various analyses to be run were split out and preserved as shown in Table 5. All samples were run within the designated holding times shown. For those analyses listed with holding times as "analyze ASAP," analyses were run within 4 hr of sample collection.

Table 5. Summary of on-site analytical methods for bioremediation demonstration

Media/parameter	Container	Preservation	Holding time	Analytical method
Groundwater/feed				
Dissolved oxygen	None	None	None	Membrane electrode (in situ)
pH	500-mL glass bottle	None	2 h	Electrometric
Conductivity	500-mL glass bottle	4°C	28 d	Electrometric
Total petroleum hydrocarbons	500-mL glass bottle	HCl to pH<2, 4°C	28 d	Modified EPA 418.1
Coliform	500-mL glass bottle	None	Analyze ASAP[a]	Millpore Coli-Count Sampler
NO_3, NO_2, PO_4	500-mL glass bottle	None	Analyze ASAP	Chemet test kits
Chemical oxygen demand	500-mL glass bottle	H_2SO_4 to pH 2	28 d	Hach 0 to 1500-mg/L test kits
Hydrocarbons	500-mL glass bottle	HCl to pH 2	28 d	Isooctane extraction, GC[b] with FID[c]
Soil				
Total petroleum hydrocarbons	1-L glass bottle	4°C	28 d	EPA 418.1
Water content	1-L glass bottle	4°C	28 d	Oven dry at 105°C
pH	1-L glass bottle	4°C	28 d	Electrometric
Microbes	1-L glass bottle	None	Analyze ASAP	Plate count
Hydrocarbons	1-L glass bottle	4°C	28 d	Isooctane extraction, GC with FID
Soil gas				
CO_2	2-L Tedlar bag	None	Analyze ASAP	Infrared analysis
O_2	2-L Tedlar bag	None	Analyze ASAP	Electrochemical analysis
Hydrocarbons	600-mL Tedlar bag	None	Analyze ASAP	GC with FID

[a] ASAP = as soon as possible
[b] GC = gas chromatograph
[c] FID = flame ionization detector

2.4.5 Off-Site Analyses

Soil samples were shipped from Kwajalein to UT for PLFA analysis and for metals analysis via emission spectroscopy using inductively coupled plasma (ICP). Core soil samples from in situ plots 2, 4, 5, 8, and 11 between both 4 to 5 and 5 to 6 ft bgs were taken on November 1, 1993, and January 18 and February 14, 1994, and shipped for analysis. Composite soil samples from the surface to a depth of 15 in. were obtained from ex situ plots 13 and 17 on November 1, 1993 and shipped for analysis. All samples shipped from Kwajalein were stored in glass containers, placed in an insulated cooler, and covered with "Blue Ice" before to shipment by commercial airlines.

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3. RESULTS AND DISCUSSION

One groundwater tracer test was conducted before starting the on-site demonstration and another was conducted after the demonstration was completed. The in situ system was sampled on nine different dates and the ex situ system was sampled on four different dates. Dates for the various sampling campaigns are presented in Table 6. A complete listing of the analytical data for soil and groundwater samples taken during the on-site demonstrations is presented in Appendixes B and C, respectively. Meteorological data for the demonstration period are presented in Appendix D.

3.1 BROMIDE TRACER TESTS

Before conducting the bioremediation demonstration, a groundwater tracer test was conducted to determine the velocity and direction of movement of the groundwater within the demonstration area. Information regarding the movement of groundwater could be useful in determining if the remediation system could be situated to take advantage of the natural movement of water through the contaminated area. Bromide was chosen for use as the tracer because it typically has low background levels in groundwater, is biologically stable, and appears not to be lost by precipitation, absorption, or adsorption.[15] Also, the soils at Kwajalein are primarily calcium carbonate, and the calcium carbonate concentration can interfere with fluorescent dyes typically used in groundwater tracer studies.[15,16] The results of this bromide tracer test are detailed in a report by Molsbee et al.[17] and are summarized below.

Information on the accuracy of the bromide ion-specific electrode for the Kwajalein groundwater samples, the background concentration of bromide in the groundwater, and the change in the

Table 6. Chronology of events for the various sampling campaigns during the Kwajalein bioremediation demonstration

Date	Event
12/8/92 - 1/21/93	Groundwater tracer test #1
12/19/92 - 1/1/93 and 3/6/93 - 3/14/93	In situ sampling period #1 (pre-startup)
3/29/93	Startup in situ system
5/3/93 -5/7/93	In situ sampling period #2
6/21/93 - 6/24/93	In situ sampling period #3
7/19/93 - 7/21/93	In situ sampling period #4
8/16/93 - 8/19/93	In situ sampling period #5
9/13/93 - 9/16/93	In situ sampling period #6
10/11/93 - 10/14/93	In situ sampling period #7
1/10/94 - 1/14/94	In situ sampling period #8
2/14/94 - 2/16/94	In situ sampling period #9
7/2/93	Ex situ sampling period #1 (pre-startup)
7/12/93	Startup ex situ system
8/18/93	Ex situ sampling period #2
9/15/93	Ex situ sampling period #3
10/13/93	Ex situ sampling period #4
2/26/94 - 2/28/94	Groundwater tracer test #2

groundwater level (distance from the ground surface to the groundwater surface) with the rise and fall of the tide was gathered before conducting the tracer test to aid in analysis of the data.

Because the procedure for the tracer test called for injection of bromide at a concentration of ~700 mg/L, bromide solutions ranging from ~0.5 to 1,000 mg/L were prepared with sodium bromide and distilled water and tested with the Orion model 94-35 bromide electrode. The results are presented in Fig. 13. When the bromide concentration was plotted versus the electrode potential on a semilogarithmic graph, a straight line resulted, which indicated that the bromide probe should be accurate over the range of interest.

Tests were also conducted using groundwater samples spiked with sodium bromide. In these tests the groundwater samples were analyzed for bromide, spiked with various concentrations of NaBr, and analyzed a second time to determine if the bromide electrode could be used to detect changes in the bromide concentration within the groundwater. The results are presented in Table 7.

Table 7. Accuracy of the Orion model 94-35 bromide electrode for groundwater samples spiked with sodium bromide

Bromide concentration added to groundwater sample (mg/L)	Calculated spiked bromide concentration of groundwater sample (mg/L)	Measured concentration of spiked groundwater sample (mg/L)	Difference between spiked concentration and measured spiked concentration (%)
0.1	0.56	0.62	10.7
0.5	1.70	2.52	48.2
1.0	1.77	2.56	44.6
5.0	5.48	5.83	6.4
10.0	11.12	11.12	0.0

At bromide additions of 1 mg/L or less, the bromide probe did not accurately detect the change in bromide concentration within the groundwater samples. With additions of 5 and 10 mg/L of bromide, the percent differences between the calculated bromide concentrations (the initial bromide concentration plus the added NaBr) and the values determined by the bromide electrode were approximately 6 and 0%, respectively. These data indicated that for the purpose of the tracer test, the Orion model 94-35 bromide probe could adequately detect bromide changes within the groundwater at the Kwajalein bioremediation demonstration site of 5 mg/L and greater; however, bromide changes less than 5 mg/L should be disregarded.

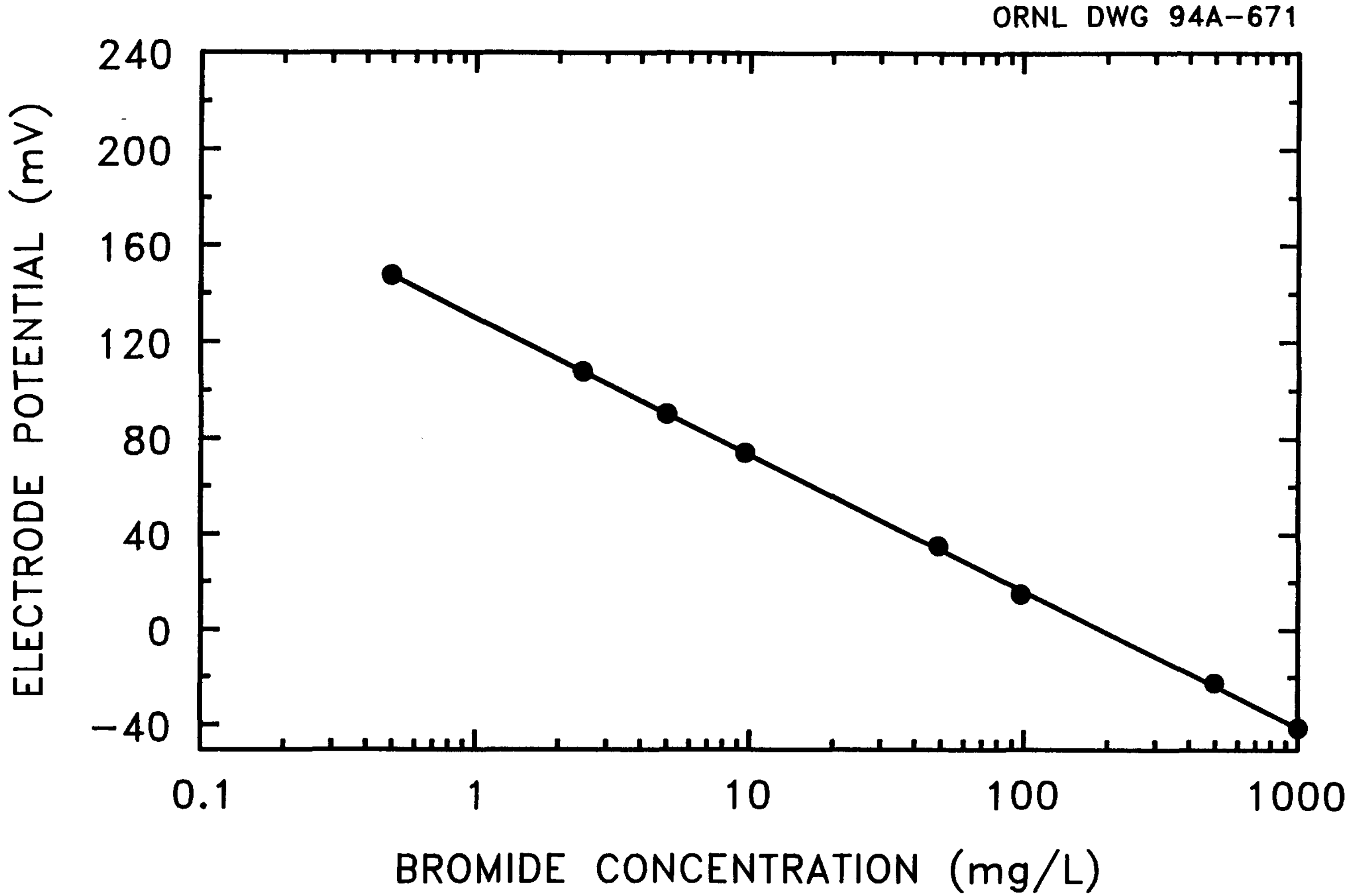

Fig. 13. Response of the Orion model 94-35 bromide probe with solutions of distilled water and sodium bromide from ~0.5 to 1000 mg/L bromide.

The bromide concentrations in MWs 1 and 7 were checked at high and low tide over a 7- and 6-d period, respectively, to determine the background bromide concentration in the groundwater within the demonstration area. The bromide concentration varied from 0.5 to 1.4 mg/L in MW-1 and from 1.3 to 2.9 mg/L in MW-7 (Fig. 14). The change in tide level seemed to have no significant impact on the background bromide concentration in the monitoring wells tested. These analyses indicated that the background bromide concentration at the demonstration site was not large enough to interfere with the planned tracer test.

Data used to examine the effect of the change in tide on the vertical movement of the groundwater in the demonstration area are presented in Figs. 15 and 16. In these figures, the solid line represents the tide level calculated from Tide. 1, the commercial software used by Aeromet, Inc., to calculate tides on Kwajalein. The individual data points on Figs. 15 and 16 represent the measured distance from the ground surface to the groundwater surface in MW-1, MW-7, MW-10, and MW-11 across the demonstration area and in a well installed by the USGS approximately 50 ft from the demonstration area (see Fig. 7), respectively. A smooth curve was drawn through the data points on Fig. 16 to help compare the change in the level of the groundwater in the USGS well to the change in tide. In this figure the distance from the ground surface to the surface of the groundwater should be smallest when the tide is at its peak. Figure 16 indicates that a lag time of ~6 hours occurs between the tide and the respective level change in the USGS well.

By comparing Figs. 15 and 16, it can be seen that the groundwater levels in MW-1, MW-7, MW-10, and MW-11 varied by less than 2 in., while the level in the USGS well varied by more than 2.5 ft over the same time period. This could indicate that the monitoring wells across the demonstration area were not well developed and that very fine calcium carbonate soil particles had packed around the screened section of the monitoring well and prevented water, and potentially

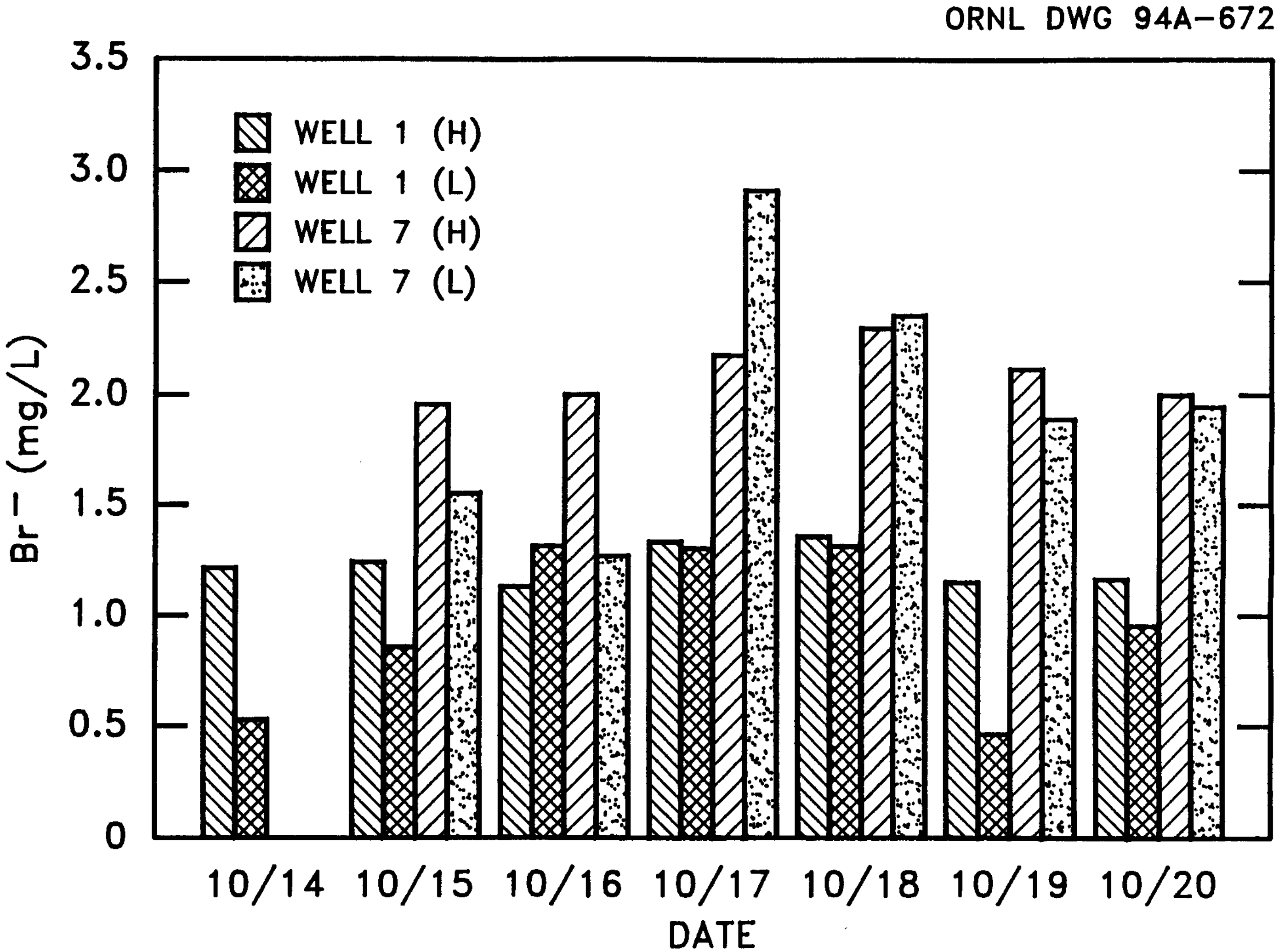

Fig. 14. Bromide concentration at high and low tide for wells 1 and 7 (October 14-20, 1992).

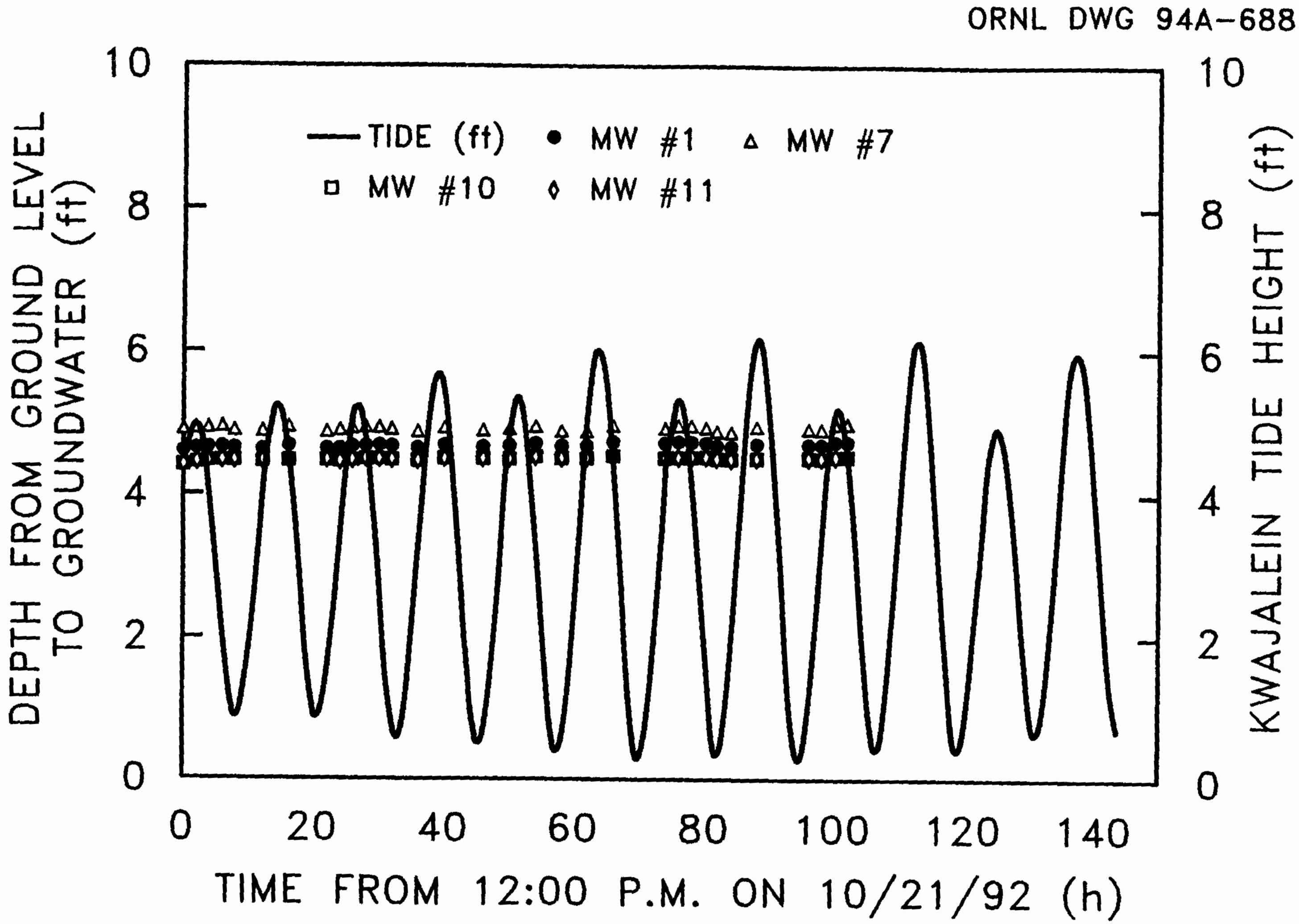

Fig. 15. Changes in groundwater levels in monitoring wells (MW) 1, MW-7, MW-10, and MW-11 compared with levels of the tides.

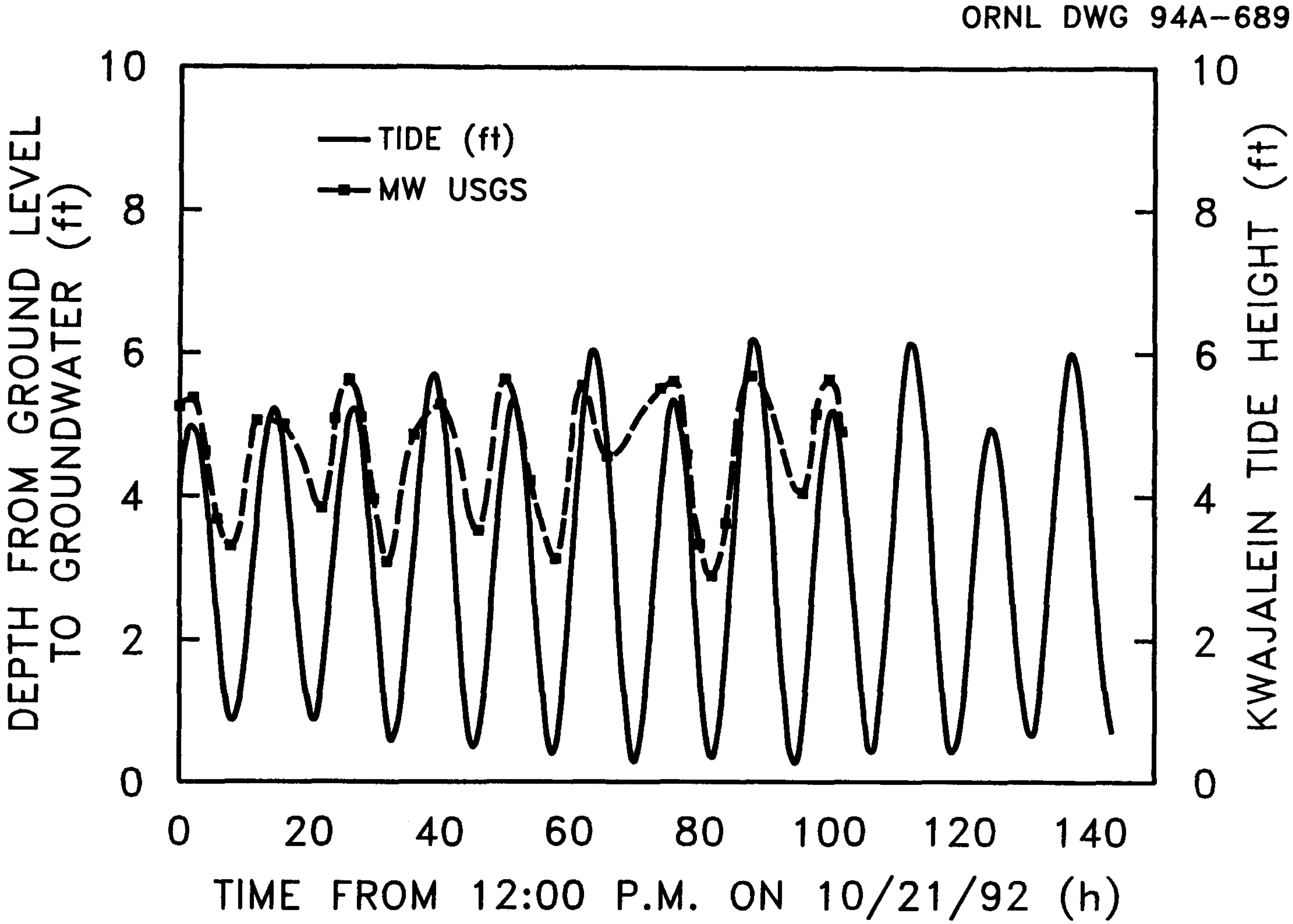

Fig. 16. Changes in groundwater level in the U.S. Geologic Service monitoring well compared with the tide.

bromide during the tracer test, from entering the well. A hydrologist from HAZWRAP indicated this condition would not interfere with the tracer tests. Because all monitoring wells were constructed and set in place the same way, the response of each well in the aquifer should be similar. Although there might be a "skin-effect" around each well that would delay the breakthrough of the bromide in the wells by a small amount of time, this would not inhibit or reduce the potential to collect samples and measure bromide.[16] As a result, bromide tracer test was initiated.

The bromide tracer test was initiated on December 8, 1992, at ~ 8:30 a.m. with 3,785 L (1000 gal) of ~700 mg/L bromide solution being pumped into MW-18 over an 11-h period. The bromide concentration in the injection well and in other wells across the demonstration area were then monitored over the next 83 days. The bromide concentration in the injection well held constant at ~680 mg/L for approximately 500 h (21 d) and then steadily declined to a concentration of ~100 mg/L over the next 1500 h (62 d) (Fig. 17).

In addition to the injection well, samples from 24 different MWs and the USGS well were analyzed for bromide over the test period. The bromide results (Fig. 18) for the nested MWs (MWs A-E), were typical of all MWs. The bromide concentration in the monitoring wells sampled remained below ~2 mg/L, and no change in bromide concentration was detected over the test period. Fine soil particles may have packed around the MWs and prevented the movement of groundwater into the MWs. Because the groundwater level in the USGS well rises and falls with the tide and the level in the MWs installed for the biodemonstration does not rise, the groundwater may not be entering the MWs. This could result from the different installation methods used to install the well. Since the soil in the bioremediation demonstration in-situ plots could not be disturbed before the demonstration, a vibrating hammer was used to drive stainless steel monitoring wells into place. This vibration had the potential to break the soil into fine particles and to pack particles around the well. The USGS wells were installed with an auger. The fact that the water level in the USGS wells fluctuated indicated the presence of groundwater movement.

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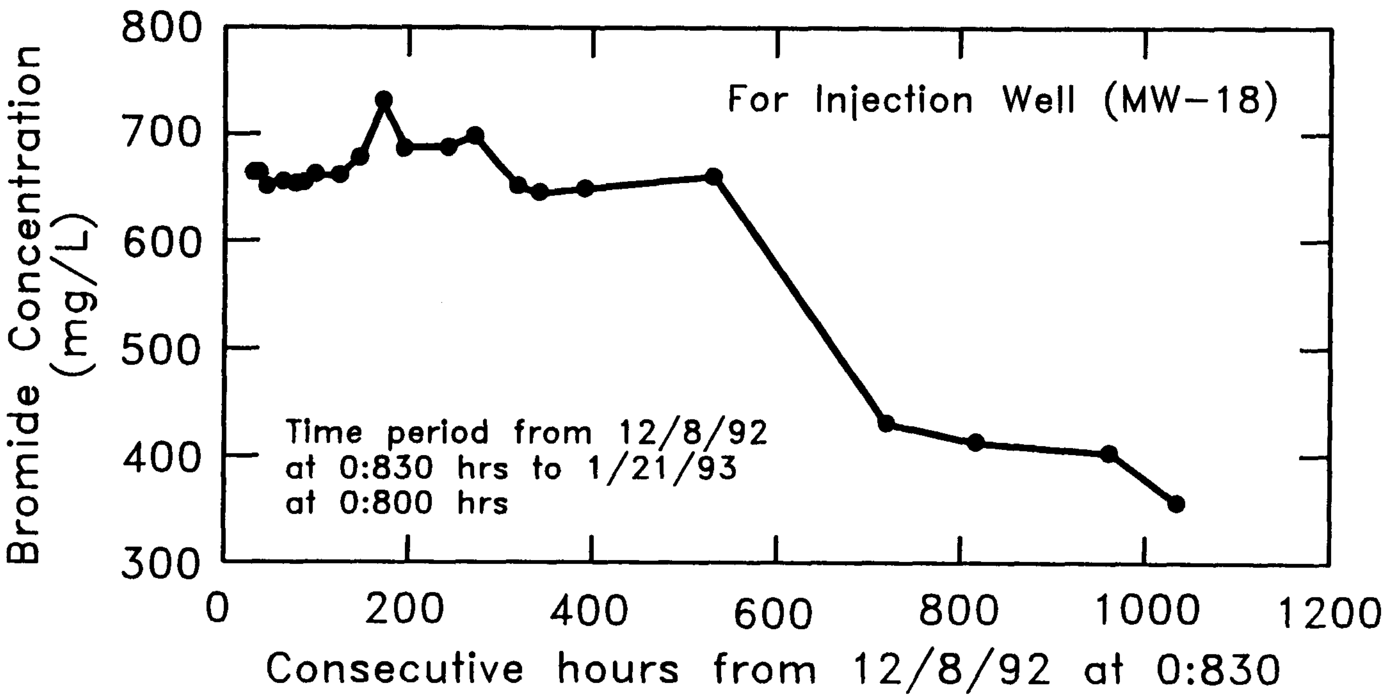

Fig. 17. Bromide concentrations in the injection well (monitoring well-18) during the pre-startup tracer test.

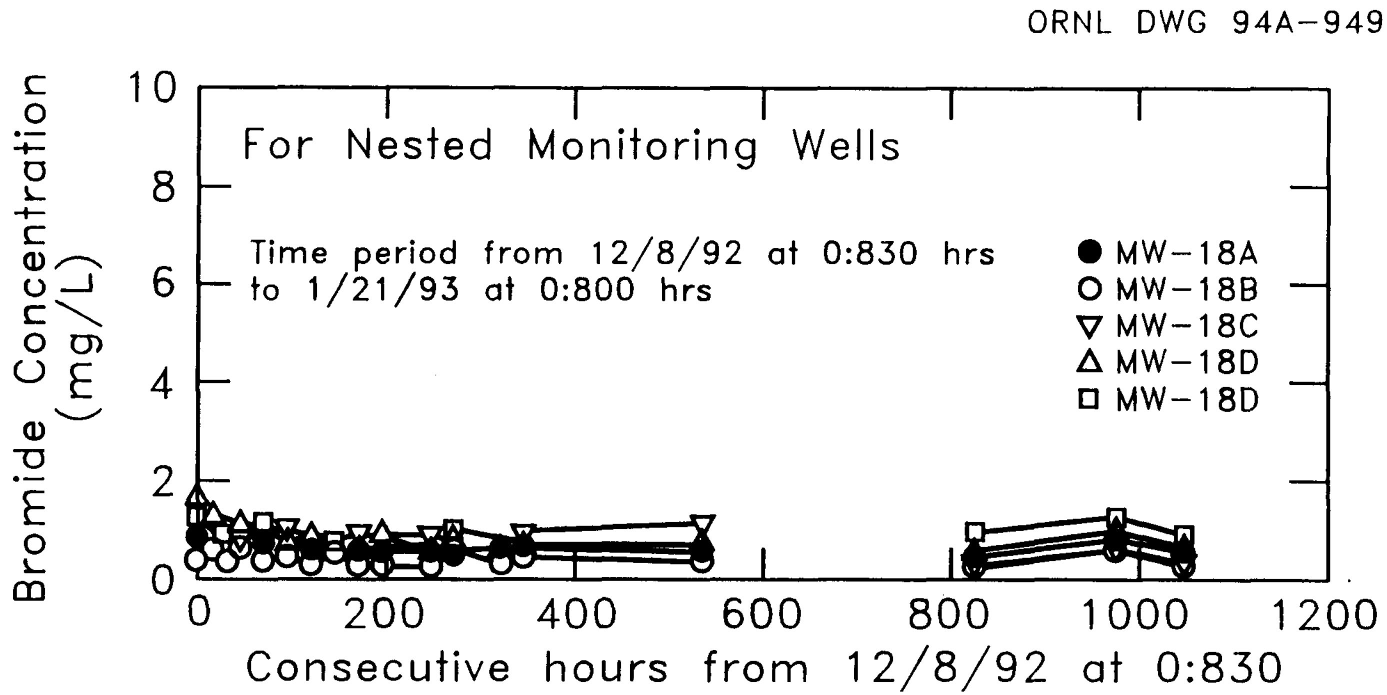

Fig. 18. Bromide concentration in monitoring wells 18A through 18E during the pre-startup tracer test.

Because the results of the bromide tracer test were inconclusive, a second tracer test was conducted. The results from the first test were used to assist in the design of the second tracer test. The results of the second tracer test were detailed in a report by Molsbee et al.[17] and are summarized below.

- Because the method used for installing the MWs before the first groundwater tracer test may have promoted plugging of the wells, all wells were extracted from the ground, cleaned of sand/silt and biomass, and then reinstalled using a 2-step procedure. First, a pilot hole was driven into the saturated zone using a solid length of well casing. This actionpushed the soil away from the boring and helped minimize clogging of the well screen as it was pushed through this interval. Next, a clean well (made of well casing and screen) was placed in the pilot hole and pushed to the specified depth. The injection well was relocated approximately 20 ft south of the initial injection well, and 26 MWs were then installed around the injection well. The location of the MWs in relation to the injection well is presented in Fig. 19.
- The injection well (well T1S) was screened across the water table from 5 to 8 ft below ground surface. Two monitoring wells, T1M (screened from 10 to 13 ft) and T1D (screened from 20 to 23 ft), were installed at depths below the injection interval to monitor vertical movement of the bromide plume. A ring of monitoring wells was placed on a 3-ft radius around the injection well with screened intervals of either 5 to 8 ft (wells T2 through T9) or 14 to 20 ft (wells 2D through 9D). A ring of monitoring wells with a screened interval from 5 to 11 ft was also placed around well T1S on a 10-ft radius.
- Injection, sampling, and analytical procedures used during the second tracer test were similar to those used during the initial tracer test except that a bromide concentration increase in the groundwater from the MWs of at least one order of magnitude was deemed to be necessary to be considered significant. This was done to ensure that potential influences from the first tracer test were eliminated.

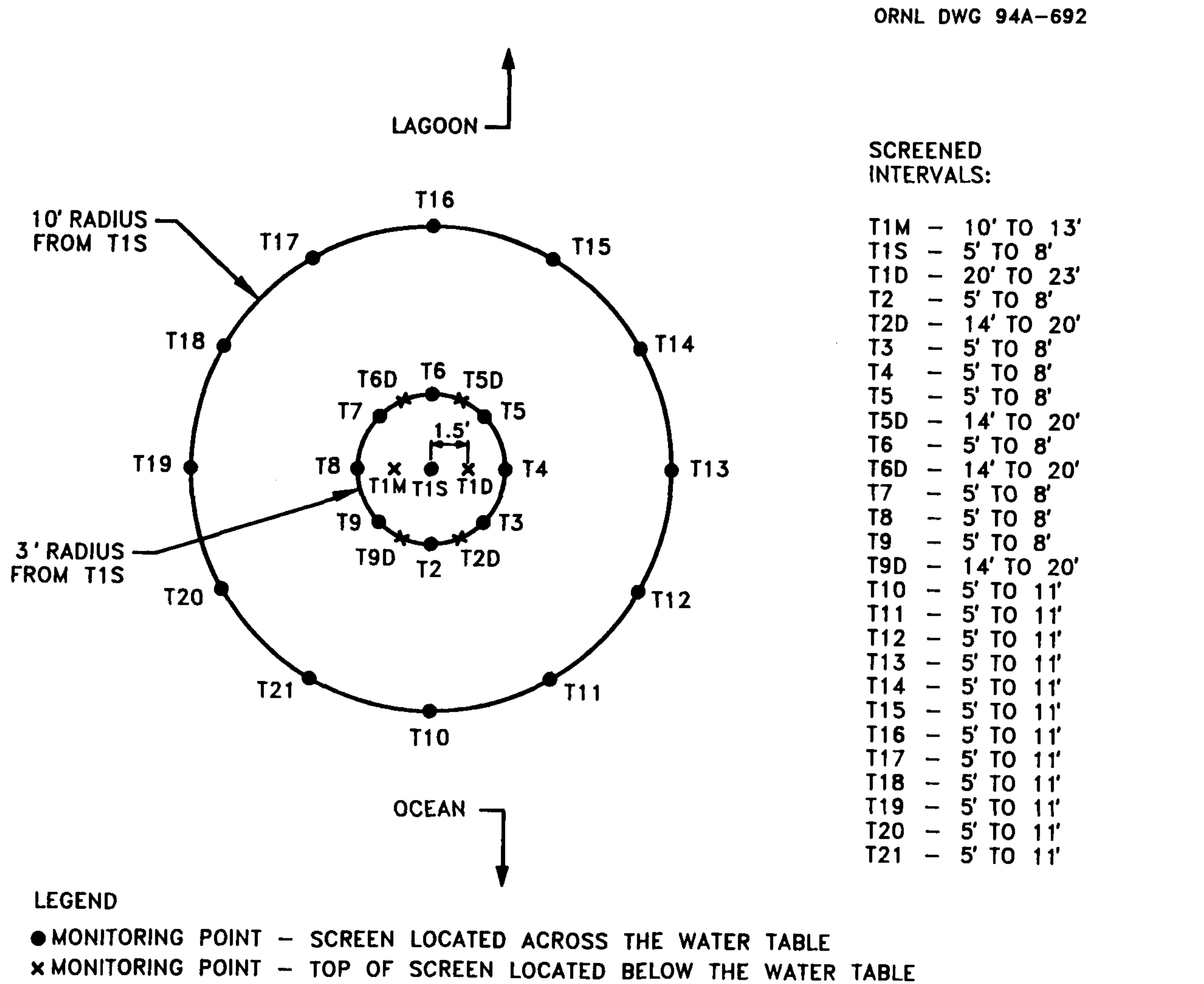

Fig. 19. Location of the monitoring wells with respect to the injection well (T1S) in the second bromide tracer test.

- Several groundwater samples were collected from the MWs to ascertain the background bromide concentration before adding the bromide solution to the injection well. The analytical results showed the background bromide concentration to be ~10 to 15 mg/L, approximately one order of magnitude higher than the background bromide concentration before the first tracer test and which could be attributed to residual bromide dispersed through the area from the first test.
- The test was initiated at ~2:00 p.m. on February 26, 1994, with 3,785 L (1,000 gal) of ~500-mg/L bromide solution pumped into injection well T1S at 5.7 L/min (1.5 gal/min) and was terminated at 9:00 a.m. on February 28, 1994, when the site had to be turned over to the Army Corps of Engineering for construction activities. Approximately 2 h after the test was initiated, significant concentrations of bromide (an increase of at least one order of magnitude) were noted in wells T2, T4, and T5. Within the next 3 h all shallow wells (screened over the 5-to 8-ft interval) within the inner ring of wells showed significant increases in the bromide concentration. Significant increases in the tracer concentration occurred in deep wells T5D, T6D, and T9D approximately 15 to 19 h into the test. Once the bromide concentration increased within the shallow wells, it remained high for the remainder of the test period; the concentration within the deep wells tended to be brief, as if a slug of tracer passed the sampling point.
- No significant bromide increase was noted in the deep wells at the injection point (T1M and T1D), indicating that there was no significant vertical movement of the bromide plume at the injection point.
- Bromide was detected at elevated concentrations in practically all shallow, inner-ring wells at the same time. This result indicated that the bromide solution was flowing away from the injection well in a radial pattern during the initial hours of the test. The results of the bromide tracer tests for the outer MWs support the conclusion that as the tide rises the predominant

groundwater flow across the demonstration site area moves toward the lagoon. A movement perpendicular to the lagoon appeared to be a local effect. This was most likely caused by underground pipelines previously installed at the demonstration site. The 6-in. fuel line located across the northern portion of the test area was above the water table in the vicinity of the demonstration area and did not significantly impact the movement of groundwater across the demonstration site. Data were too limited to determine the full impact of the tides on the vertical and horizontal movement of the tracer; however, bromide tracer tests should be conducted at any site within the RMI before the initiation of bioremediation to ensure that amendments are added at the proper location to get them into the contamination plume.

3.2 COLONY FORMING UNITS — SOIL SAMPLES FROM THE IN-SITU PLOTS

Microbial abundance for each plot was assessed by plate count methods before startup (sample period one) and for eight additional sampling periods (sample periods two through nine) thereafter at 4- to 6-week intervals. The mean number of CFUs per gram of soil from 3 to 7 ft for each plot was obtained by plating a representative soil sample from 3 to 4 ft, from 4 to 5 ft, from 5 to 6 ft, and from 6 to 7 ft and then averaging the values obtained. The average CFU/g from 3 to 7 ft was selected because the contamination was confined to an area between 3 and 7 ft bgs. The mean CFU/g for each of the treatment options was compared to those obtained in the control plots and is presented graphically in Figs. 20 to 23. Table 8 presents the average and the standard deviation of the CFU/g for the in situ treatments for each of the sample periods. Table 9 shows the percent change in the number of CFUs between the pre-startup and post-startup sampling periods for each individual plot as well as an average value for each of the treatments. Figures 20 and 21 show that the addition of water, or a combination of water and nutrients, did not cause a significant increase in

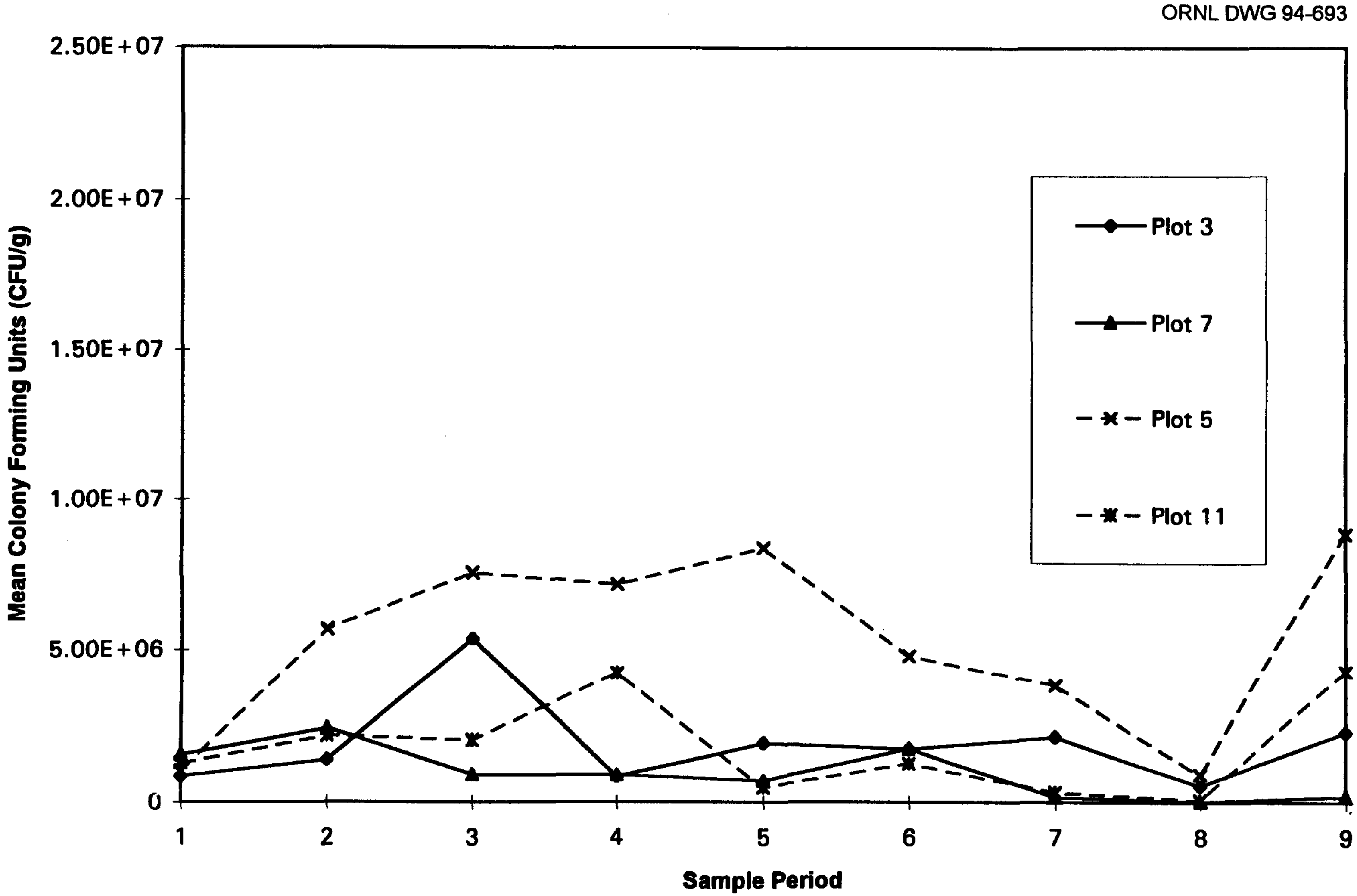

Fig. 20. Plot of the mean colony-forming units from 3 to 7 ft for plots receiving water (plots 3 and 7) and the control plots (plots 5 and 11).

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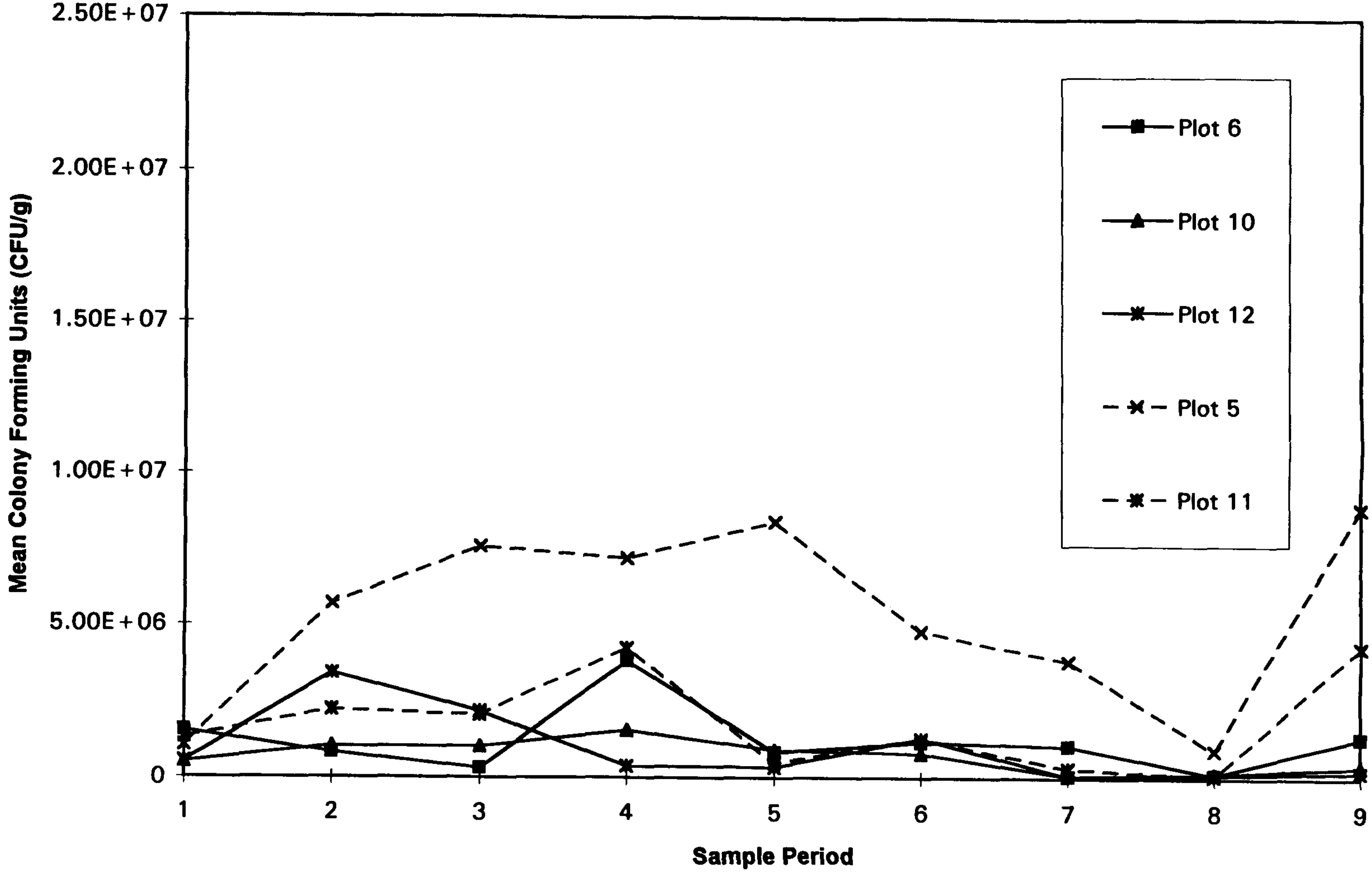

Fig. 21. Plot of the mean colony-forming units from 3 to 7 ft for plots receiving water and nutrients (plots 6, 10, and 12) and the control plots (plots 5 and 11).

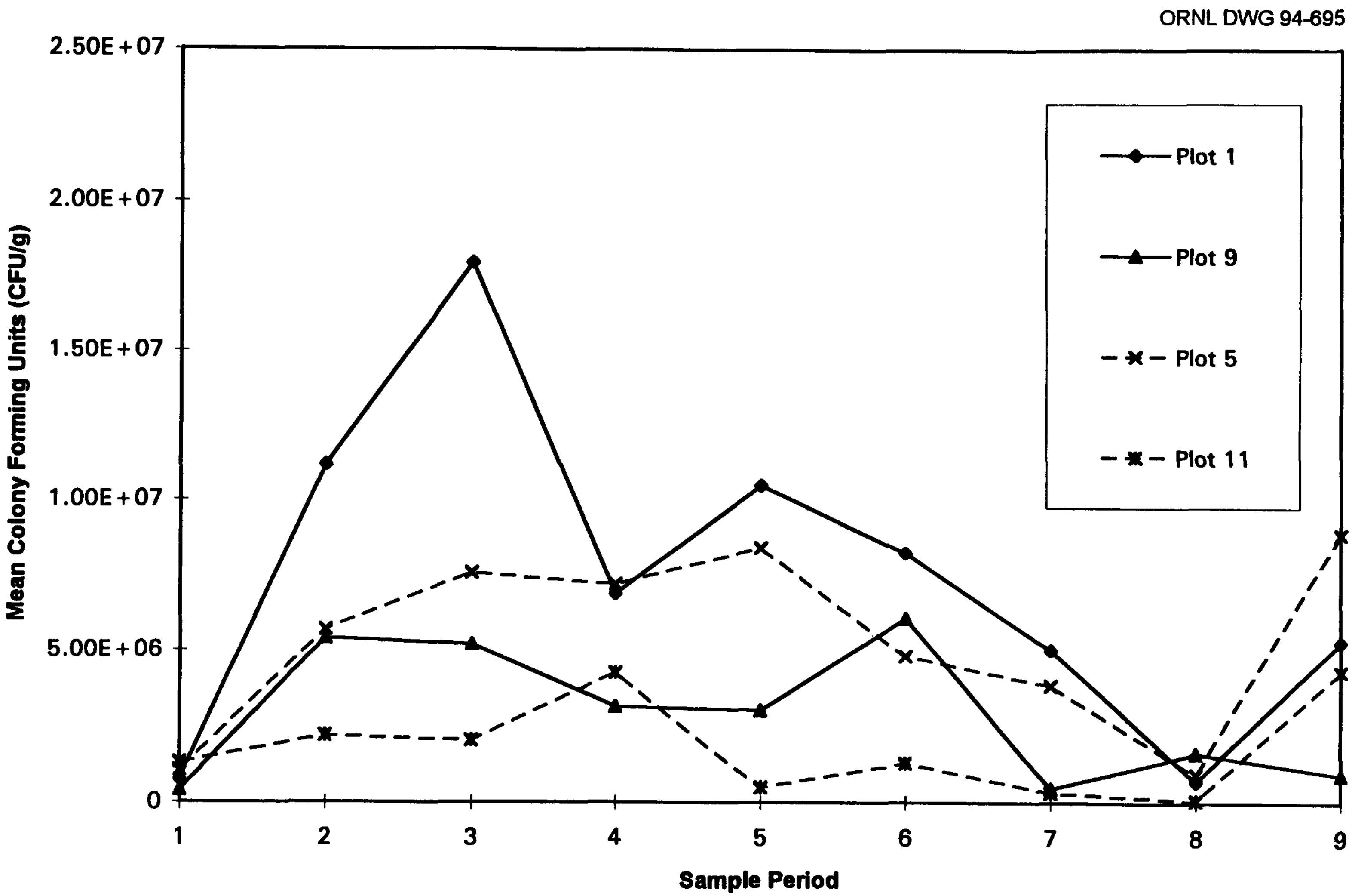

Fig. 22. Plot of the mean colony-forming units from 3 to 7 ft for plots receiving water and air (plots 1 and 9) and the control plots (plots 5 and 11).

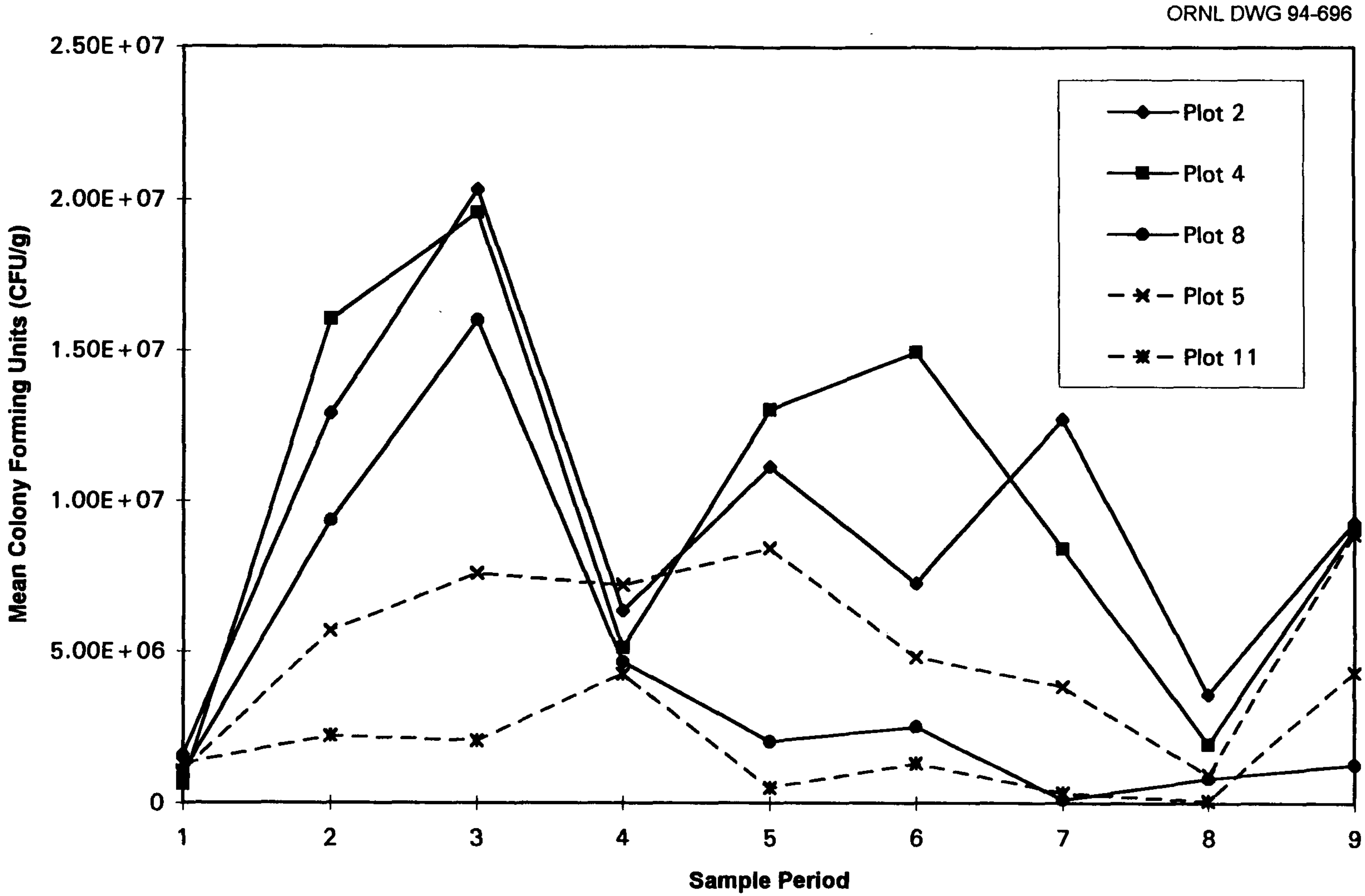

Fig. 23. Plots of the mean colony-forming units from 3 to 7 ft for plots receiving water, air, and nutrients (plots 2, 4, and 8) and the control plots (plots 5 and 11).

Table 8. Colony-forming units per gram (CFU/g) for in situ plots as a function of treatment

Treatments	Average CFU for in situ treatments								
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	Period 9
Control (Plots 5 and 11)									
Average CFU in plots 5 and 11	1.19E+06	3.95E+06	4.81E+06	5.72E+06	4.45E+06	3.05E+06	2.07E+06	4.96E+05	6.59E+06
Standard Deviation	1.79E+05	2.48E+06	3.91E+06	2.09E+06	5.59E+06	2.49E+06	2.48E+06	6.05E+05	3.23E+06
Water only (Plots 3 and 7)									
Average CFU in plots 3 and 7	1.23E+06	1.94E+06	3.15E+06	8.83E+05	1.34E+06	1.77E+06	1.16E+06	2.86E+05	1.25E+06
Standard Deviation	5.06E+05	7.23+05	3.15E+06	4.60E+04	8.76E+05	1.33E+05	1.40E+06	3.68E+05	1.51E+06
Water + Air (Plots 1 and 9)									
Average CFU in plots 1 and 9	5.79E+05	8.29E+06	1.16E+07	5.00E+06	6.73E+06	7.15E+06	2.73E+06	1.16E+06	3.09E+06
Standard Deviation	2.42E+05	4.07E+06	9.01E+06	2.65E+06	5.28E+06	1.56E+06	3.23E+06	6.52E+05	3.09E+06
Water + Nutrients (Plots 6, 10, and 12)									
Average CFU in plots 6, 10, and 12	8.59E+05	1.76E+06	1.16E+06	1.91E+06	7.00E+05	1.08E+06	4.00E+05	1.35E+05	6.44E+05
Standard Deviation	5.83+05	1.44E+06	9.31E+05	1.74E+06	3.07E+05	2.56E+05	5.61E+05	2.28E+04	5.97E+05
Water + Nutrients + Air (Plots 2, 4, and 8)									
Average CFU in plots 2, 4, and 8	1.07E+06	1.28E+07	1.86E+07	5.37E+06	8.70E+06	8.22E+06	7.06+06	2.10E+06	6.52+06
Standard Deviation	4.99+05	3.35E+06	2.31E+06	8.80E+05	5.88E+06	6.28E+06	6.39E+06	1.39E+06	4.56E+06

Table 9. Change in the microbial population colony-forming units/g (CFU/g) between the pre-startup samples [sample period 1 (not shown)] and post-startup samples (sample period 2-9) for the in situ plots

	Percent change by plot								
Period	Plot 5	Plot 11	Average	Plot 3	Plot 7	Average	Plot 1	Plot 9	Average
2	436	67	232	63	54	57	1390	1227	1332
3	612	55	304	515	-42	156	2290	1172	1896
4	576	222	380	-3	-42	-28	817	666	763
5	689	-63	273	124	-55	9	1294	634	1062
6	352	-2	156	102	12	44	1000	1383	1135
7	259	-76	74	146	-90	-6	568	10	372
8	-13	-95	-58	-38	-98	-77	-7	297	100
9	734	227	454	165	-88	2	603	121	433

Table 9. (continued)

	Percent change by plot							
Period	Plot 6	Plot 10	Plot 12	Average	Plot 2	Plot 4	Plot 8	Average
2	-46	104	539	105	703	2485	849	1092
3	-80	98	303	35	1165	3055	1528	1641
4	149	202	-27	123	295	727	373	402
5	-46	80	-35	-19	591	1997	104	713
6	-24	56	142	26	351	2307	153	668
7	-32	-85	-86	-53	691	1250	-88	560
8	-91	-69	-79	-84	122	212	-18	97
9	-13	-26	-58	-25	477	1356	28	509

the mean CFU within the contaminated area. In general, within the plots receiving water or a combination of water and nutrients, the CFUs were less than or equal to the number of CFUs found in the control plots for post-startup sampling periods.

By comparing CFU data in Fig. 22 with those in Table 9, it can be seen that for all sampling periods except sample period 9 the increase in average CFU was greater in those plots receiving air than in those plots not receiving air. For example, for sample periods 2 through 6 the average CFU/g for the in situ plots receiving water and air increased 1332, 1896, 763, 1062, and 1135% from the pre-startup samples, while the average for the control plots increased 232, 304, 380, 273, and 156 percent for the same periods. These data indicate that the addition of air had a significant impact on the increase in CFU within the contaminated zone.

CFU data for those plots receiving water, air, and nutrients are presented in Fig. 23. By comparing Fig. 23 and Table 9, it can be seen that the increase in CFU was greater in those plots receiving water, air, and nutrients than in the control plots for all sampling periods. For example, in sampling periods 2 through 6, the average CFU/g for the in situ plots receiving water, air, and nutrients increased by 1092, 1641, 402, 713, and 668% from the pre-startup samples, while the average for the control plots increased 232, 304, 380, 273, and 156% for the same periods. Also, Table 9 shows that for several sample periods (i.e., periods 2, 3, 4, 5, 6, and 9) the increase in the average microbial count was higher in plots receiving water and air than in plots receiving water, air, and nutrients. These results indicate that the addition of air was as important, if not more important, in increasing and maintaining the microbial density within the contaminated zone of the in situ plots than was the addition of nutrients. These results are consistent with those found in the column studies conducted by Phelps and Siegrist.[11]

It is also interesting to compare the CFU data for control plot 5 with other plots not receiving air (i.e., plots 3, 6, 7, 10, 11, and 12). Figures 20 and 21 show that the microbial population in plot 5 was consistently larger than that in other plots not receiving air. This raises the possibility that air from surrounding treatment plots was entering plot 5 and influencing the microbial activity within that treatment cell. Data taken from soil gas samples obtained from a vapor implant located 2.5 ft bgs in plot 5 and presented in Fig. 24 indicate that air from surrounding plots was reaching plot 5. As can be seen, the percent oxygen in the soil steadily decreased when the blower was off and steadily increased when the blower was operating. To what extent air was reaching those plots not designed to receive air was not determined; however, data for the mean CFU for those plots receiving air and for those plots the farthest from air sparge wells are presented in Fig. 25. As can be seen, the CFUs in those plots receiving air were significantly higher than those in plots located farthest from the air spargers. This again indicates the importance of air in developing and maintaining microbial growth in the petroleum-contaminated soils at Kwajalein.

3.3 NUTRIENT LOADING TO THE IN SITU PLOTS

Nutrients (Table 10) were supplied to various treatment plots to facilitate the increase in the microbial population. Four 25-gal batches of nutrients were fed daily to each plot receiving nutrients.

The initial nutrient addition was formulated on the basis of the results of the column biotreatability studies conducted on the samples collected in July 1991 (see Sect. 1.1.3). During the first 8 to 10 weeks of operation, the microbial population for those plots receiving water, air, and nutrients increased from about 10^6 to about 10^7 CFU/g; however, several additional weeks of operation resulted in no additional increase in the population.

A microbial population on the order of 10^8 CFU/g of hydrocarbon degraders may be necessary to bioremediate a contaminated site within a period of a few months.[18] When it became apparent that the microbial population would not reach this level, it was suspected that a particular nutrient might be limiting. Phosphate was suspected because no phosphate had been detected in any of the groundwater samples collected up to that time. As a result, soil column laboratory tests using a combination of mono-basic potassium phosphate and triethylphosphate (TEP) were conducted. These tests indicated that the phosphate probably was being tied up in the first 3 ft of soil

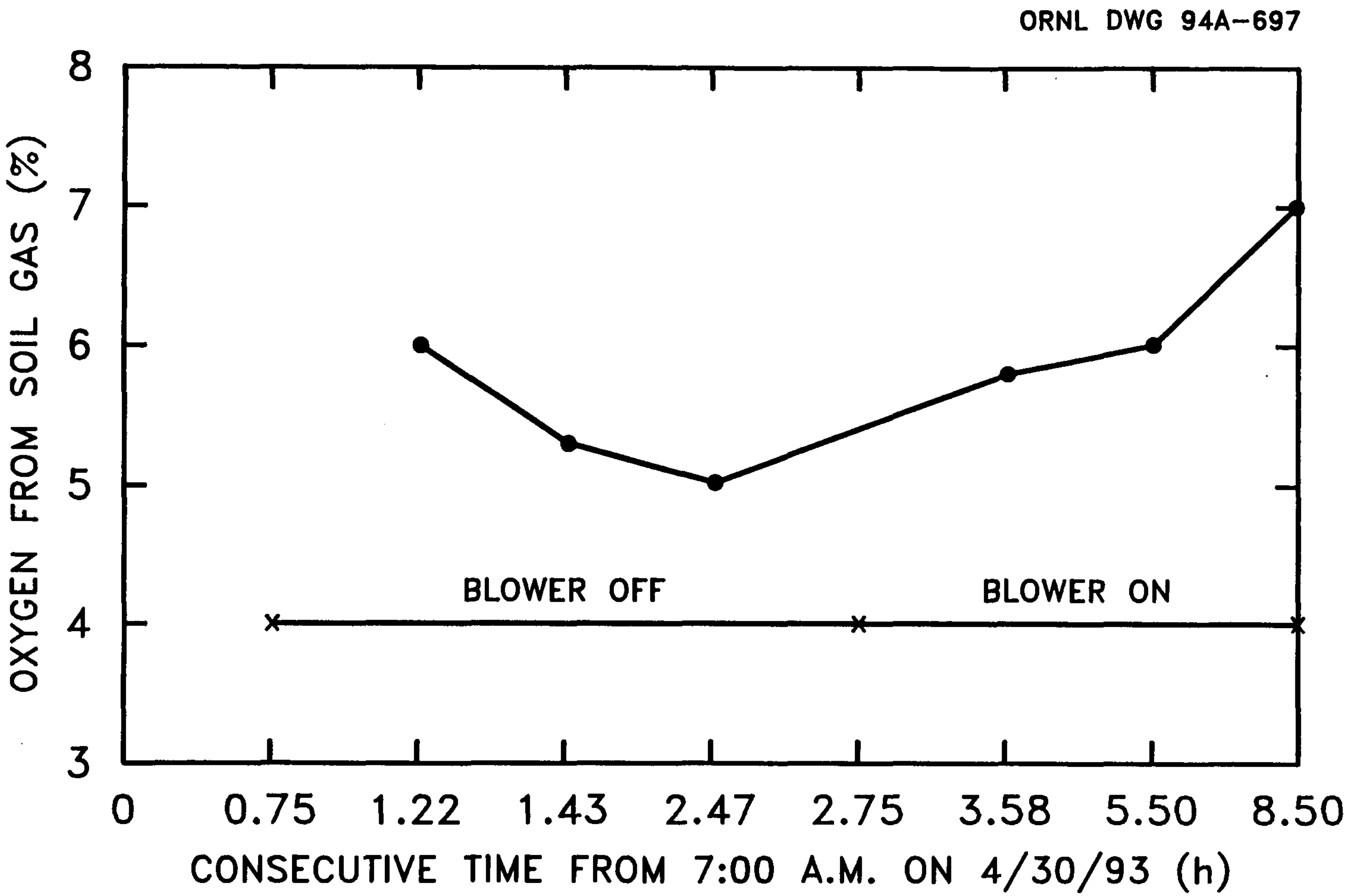

Fig. 24. Oxygen content of soil gas in plot 5 over time.

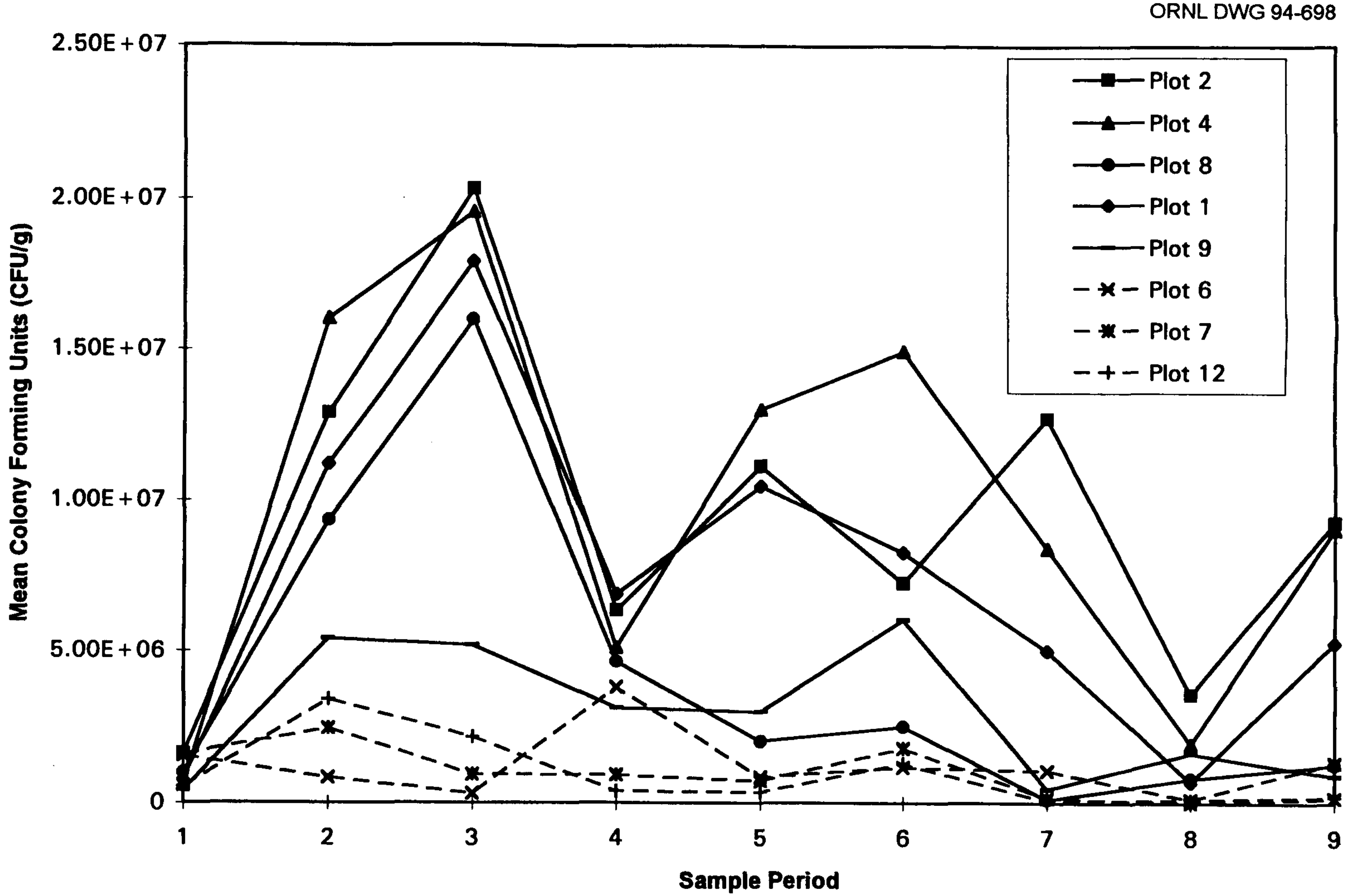

Fig 25. Comparison of mean colony-forming units for plots receiving air (plots 2, 4, 8, 1, and 9) and those plots farthest from the air source (plots 6, 7, and 12).

Table 10. Concentration of nutrients added to the in situ plots during the Kwajalein bioremediation demonstration

Time period	Component	Concentration to plot (mg/L)	Comments
3/29/93-6/15/93	K_2HPO_4	61	Initial nutrient concentration from column studies
	KH_2PO_4	6	
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea ($H_2N•CO•NH_2$)	15	
	TEP [$(C_2H_5O)_3PO$]	61	
	Trace minerals	a	
6/16/93-7/6/93	KH_2PO_4	54	Change in phosphate form to reduce pH to plots to 7.5-8.0 range
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea	15	
	TEP	61	
	Trace minerals	a	
7/7/93-11/1/93	KH_2PO_4	52	Added KCl to make up for potassium lost in change from K_2HPO_4 to KH_2PO_4
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea	15	
	TEP	61	
	KCL	25	
	Trace minerals	a	
11/2/93-1/15/94	KH_2PO_4	54	Increased organic phosphate by a factor of 10 and added yeast extract
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea	15	
	TEP	610	
	KCL	25	
	Yeast extract	500	
	Trace minerals	a	
1/16/94-1/19/94	KH_2PO_4	54	Reduced organic phosphate casued by shortage in TEP
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea	15	
	TEP	58	
	KCL	25	
	Yeast extract	500	
	Trace minerals	a	
1/20/94-2/13/94	KH_2PO_4	54	
	$NaNO_3$	230	
	NH_4Cl	42	
	Urea	15	
	TEP	0	
	KCL	25	
	Yeast extract	500	
	Trace minerals	a	

[a]Trace mineral concentration to each plot.

	mg/L		mg/L
NTA/EDTA	0.32	$ZnCl_2$	3.6×10^{-2}
$FeCl_2•4H_2O$	5.3×10^{-2}	$CuCl2•2H_2O$	2×10^{-3}
$MgCl_2•5H_2O$	7.0×10^{-2}	H_3BO_3	4×10^{-4}
Na tungstate	1.5×10^{-2}	Namolybdate	6×10^{-3}
$MnCl•4H_2O$	7.0×10^{-2}	Na_2SeO_3	1.3×10^{-2}
$CoCl_2•6H_2O$*	7.0×10^{-2}	$NiCl_2•6H_2O$	1.7×10^{-2}
$CaCl_2•2H_2O$	7.0×10^{-2}		

*$CaCl_2•2H_2$ was deleted from the trace mineral mix on 6/17/93

soil before it reached the contaminated area located in the band from 3 to 7 ft bgs. The tests also showed that the phosphate in the TEP broke through the soil column much quicker than the phosphate from the mono-basic potassium phosphate (which never broke through during the laboratory tests).

Based on these results, the TEP concentration to the plots was increased by a factor of 10 and yeast extract was added to the nutrient mix in an attempt to increase the microbial population. The biosystem operated for approximately 2.5 months at this higher loading of phosphate and yeast extract; however, the microbial population did not increase above the level of ~10^7-CFU/g. During the last month of operation, the TEP concentration to the plots was decreased because of problems in obtaining adequate TEP.

3.4 ESTER-LINKED PHOSPHOLIPID FATTY ACID ANALYSIS OF IN SITU SOILS

Subsurface sediments on Kwajalein Island were collected between the depths of 4 and 6 ft and shipped to UT for analysis of ester-linked PLFA content. These assays were performed on in situ populations, which eliminated the need to culture organisms on prescribed media and thus eliminated any bias induced by the culturing process. The recovery of cellular lipid components, such as PLFA, provides both a sensitive and a quantitative description of the in situ microbial communities. By obtaining a PLFA profile, insight into shifts in microbial biomass, community structure, and metabolic status was obtained with respect to treatment regimens. The results of these analyses are summarized below and detailed in a report by Ringelberg, Sutton, and White.[19]

- Composite soil samples between both 4 to 5 and 5 to 6 ft bgs were taken from the control plots (plots 5 and 11) and from the plots receiving water, air, and nutrients (plots 2, 4, and 8) on November 1, 1993, and January 18 and February 14, 1994 and were analyzed for PLFA content. Analysis of these data by multivariant statistics indicated that differences in PLFA composition existed among samples.

- The mean PLFA concentration for each treatment at 4 to 5 and 5 to 6 ft is presented in Fig. 26. As can be seen at both depths, the addition of air, water, and nutrients resulted in an increase in the PLFA concentration over that of the controls, indicating a relatively large enhancement in microorganisms as a result of treatment. By using established values of cells/g per mole of PLFA/g, the concentration of microbial cells was estimated to be 7.3×10^7 for the control plot from 4 to 5 ft, 2.9×10^7 for the control plot from 5 to 6 ft, 1.4×10^8 for the plots receiving air, water, and nutrients at 4 to 5 ft, and 8.4×10^7 for plots receiving water, air, and nutrients from 5 to 6 ft.
- A comparison of the PLFA content with respect to plot instead of treatment is presented in Fig. 27. Again, it can be seen that in those plots receiving water, air, and nutrients the concentration of PLFA was greater than that in the control plots. Note that samples taken from the same depth often were variable and had large standard deviations. The high degree of variability between treatments within plots is likely due to spatial heterogeneity.
- The sum percentages of PLFA, grouped according to molecular structure, are presented in Tables 10 and 11. These groupings reflect different fatty acid biosynthetic pathways that are descriptive of different bacterial types (indicated in Table 12). The presence of terminally branched saturated PLFA generally indicates the presence of gram positive bacteria. The higher abundance of iso configuration than the of anteiso may be indicative of sulfate-reducing bacteria and/or Actinomycetes. Signature lipid biomarkers were detected for both sulfate-reducing bacteria and Actinomycetes in these sediments. The two PLFA 10me16:0 and i17:1w7c are prominent in Desulfobacter and Desulfovibrio species, respectively. The branched saturate 10me16:0 comprised 1 to 6% of the total in all of the samples analyzed.

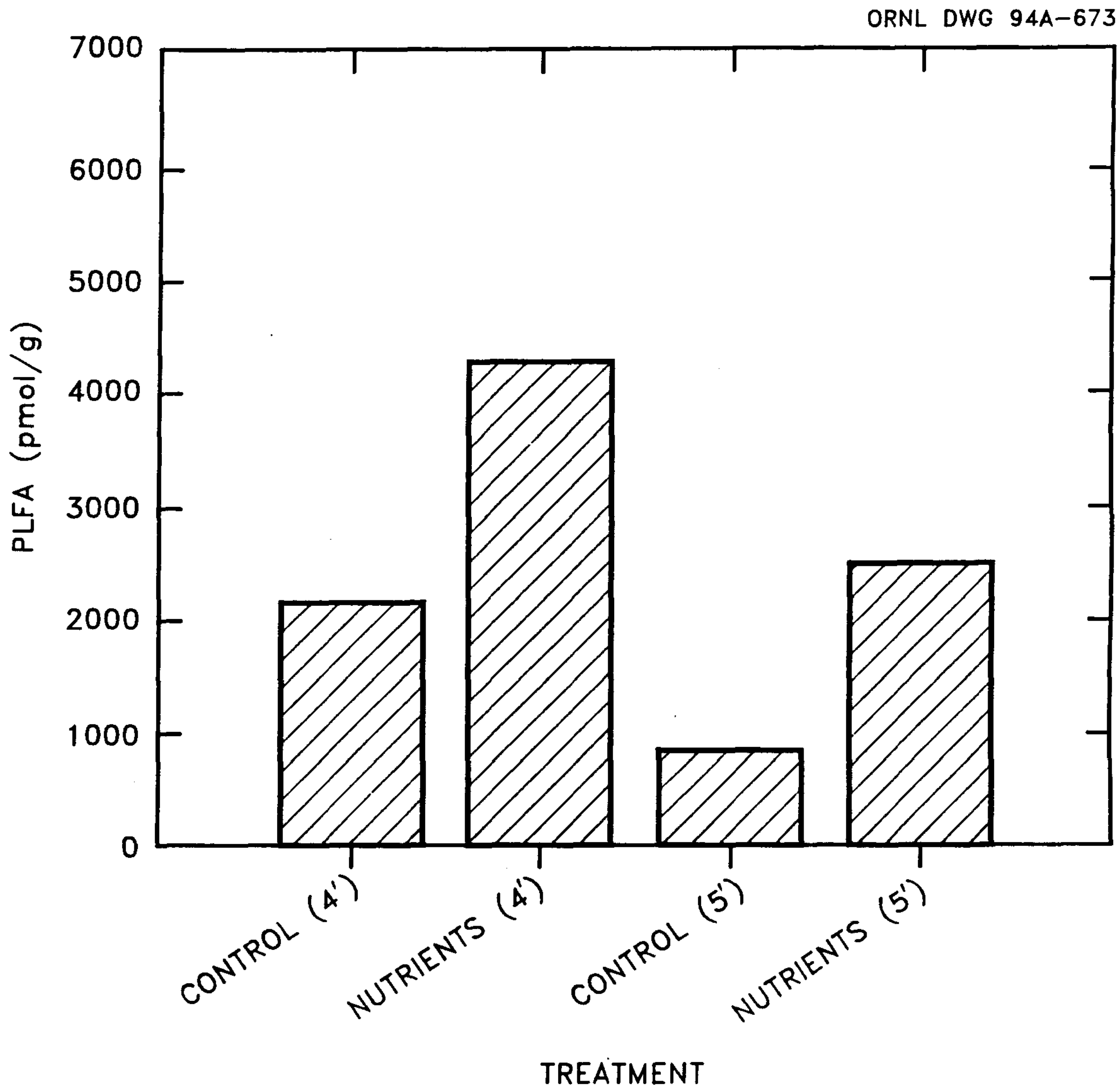

Fig. 26. Viable microbial biomass as total phospholipid fatty acids per gram of sediment. Numbers within parentheses indicate depth (in feet) from which the sample was recovered.

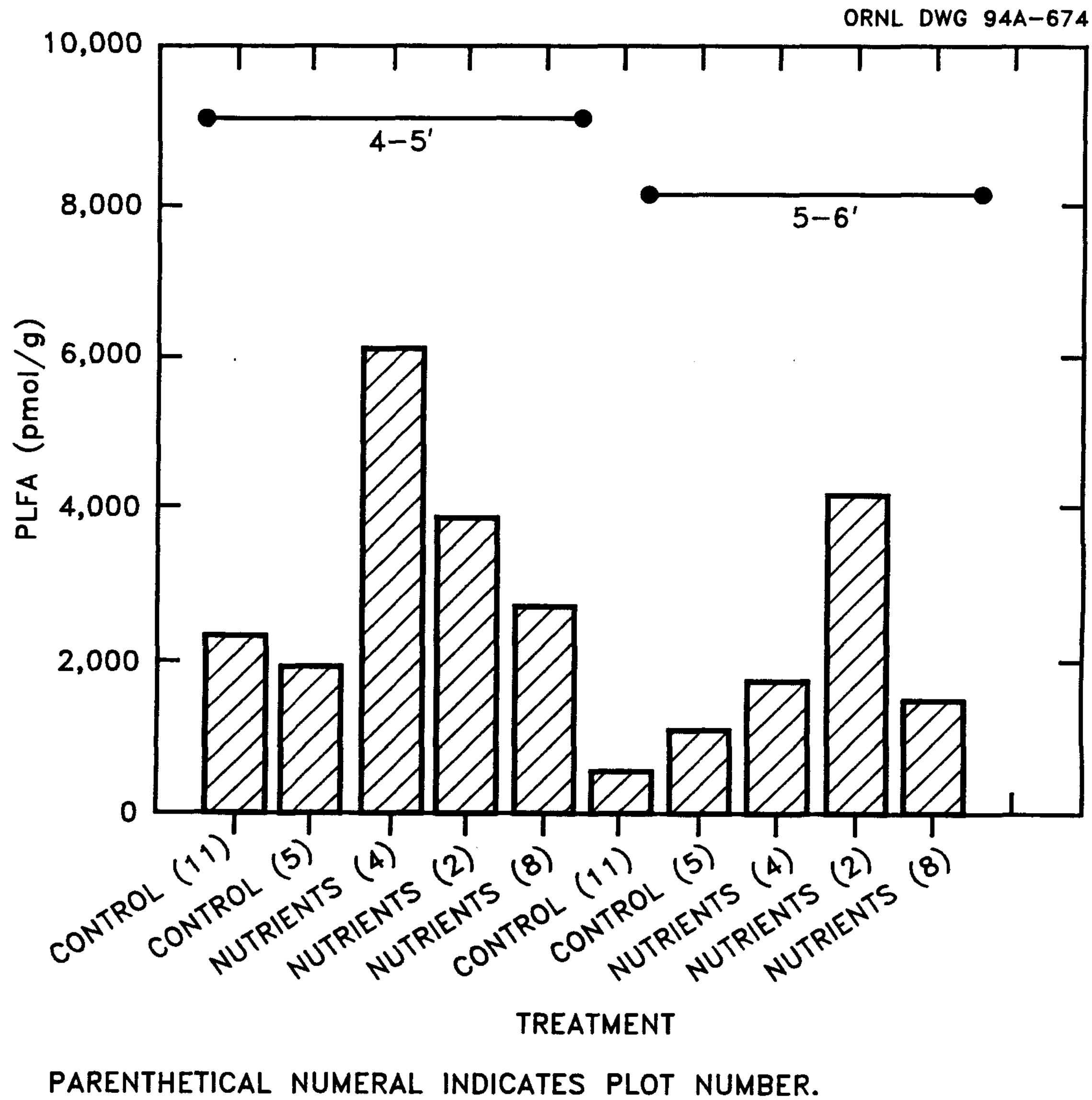

Fig. 27. Viable microbial biomass as total phospholipid fatty acids per gram of sediment by plot designation and depth. Numbers within parentheses indicate the plot number.

Table 11. Mean values of replicates of phospholipid fatty acids analyses of Kwajalein subsurface sediments

Treatment	Depth (ft)	n valve	Biomass (pmol PLFA/g)		Metabolic Status 16:1w7t/7c		18:1w7t/7c		cy17:0/16:fw7c		cy19:0/18:tw7c	
			Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Control	4-5	6	2159	1004	0.1	0.1	0.2	0.1	3.0	0.8	1.7	0.4
Control	5-6	6	860	927	0.4	0.5	0.1	0.1	2.8	1.0	1.2	0.4
Ex situ	0-1.3	2	3488	1685	0.1	0.0	0.1	0.0	2.0	0.5	2.1	0.5
Water, air, nutrients	4-5	8	4278	2184	0.1	0.0	0.1	0.0	2.1	1.0	1.7	0.5
Water, air, nutrients	5-6	9	2478	2262	0.4	0.6	0.1	0.1	2.1	0.9	1.3	0.6

Table 11. (continued)

Treatment	Depth (ft)	n valve	Community structure NSats		TerBrSats		MidBrSats		BrMonos		Monos		Polys	
			Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
Control	4-5	6	29.1	2.4	11.0	3.7	8.4	3.2	2.1	1.2	48.7	8.0	0.7	0.8
Control	5-6	6	25.6	3.1	14.2	5.8	8.2	5.4	3.2	2.3	48.6	10.7	0.2	0.2
Ex Situ	0-1.3	2	27.8	2.7	13.7	1.5	7.3	4.2	2.3	0.2	48.6	0.1	0.3	0.3
Water, air, nutrients	4-5	8	30.8	3.2	11.8	2.0	6.6	1.4	1.8	0.7	48.6	4.7	0.3	0.1
Water, air, nutrients	5-6	9	29.8	3.3	11.3	1.5	4.9	1.6	2.0	0.6	51.5	3.7	0.3	0.3

Table 12. Principal components analysis of the top six coefficients of loading

Variable	Loading
16:0	0.669
cy19:0	0.507
18:1w7c	0.352
cy17:0	0.287
10me16:0	0.141
16:1w7c	0.136

PC1 accounted for 98% of the variance within the data set.

The branched monoenoic i17:1w7c comprised a lower percentage of the total, between 0.3 and 3%. The detection of 10me18:0 (tuberculostearic acid) suggests the presence of Actinomycetes. This acid was detected at a lower abundance, accounting for only 0.2 to 1.3% of the total PLFA detected. Recently, data have been accumulated on some Actinomycete species (specifically the Streptomyces) that show the presence of branched monoenoics as well as branched saturates as membrane fatty acids.

- The only polyenoic detected was the diunsaturate 18:2w6. Polyenoics are indicative of eukaryotes (micro and macro), and 18:2w6 has been shown to be prominent in a number of soil fungal species. This PLFA accounted for <1% of the total in all of the samples analyzed.
- The monosaturated PLFA comprised the largest proportion (~50%) of the fatty acids detected. Monosaturates are indicative of all gram negative bacteria, in particular ones such as Pseudomonas, Methanotrophs, Xanthomonas, etc. The monosaturated PLFA also showed the greatest response to treatment. The mole percentages of the most positively weighted PLFA treatment means are presented in Figs. 28 and 29 for depths at 4 to 5 ft and 5 to 6 ft, respectively. (Please refer to the original report by Ringelberg et al.[19] for more detailed

information on the multivariant statistics performed on these data.) As can be seen, the most substantial change in percentage with respect to treatment occurred in the two cyclopropyl PLFAs, cy19:0 and cy17:0. The mean percentage of cy17:0 decreased from control to plots receiving nutrients, whereas cy19:0 increased. Both of the corresponding monounsaturated precursor PLFA 18:1w7c and 16:1w7c increased in percentage between the control and the plots receiving nutrients. Similar relationships were observed at both 4-to 5- and 5- to 6-ft depths. These differences suggest that one or more components of the gram-negative community were affected differently by the addition of air, water, and nutrients. The decrease in the ratio of cy17:0/16:1w7c can indicate an increase in cell activity or growth, while the greater percentage in cy19:0 suggests an increase in the abundance of organisms responsible for its synthesis. Therefore, the gram-negative bacteria responsible for the presence of both cyclopropyls appear to have been affected favorably.

- The influence of the normal saturate, 16:0, on the data set was largely due to its abundance. This particular fatty acid was detected at the largest mole percentage, between 18 and 25%, in all samples tested. The percentage of 16:0 increased between the control and amended plots, but not significantly. The other positively weighted saturated PLFA, 10me16:0, did not show any consistent trend with respect to treatment.
- An assessment of change within the gram-negative bacterial community with respect to metabolic status is presented in Fig. 30. Ratios of the cyclopropyl to monoenoic precursor and trans/cis monoenoics have been tied to the nutritional status of gram-negative bacteria. For instance, Guckert et al.[20] showed an increase in trans fatty acids with starvation and an increase in cyclopropyl fatty acids as the bacteria moved from a logarithmic to a stationary phase of growth. No change was observed in either the trans/cis or cy19:0/18:1w7c ratios; however, a decrease in the ratio of 17:0/16:1w7c was observed between the control and the

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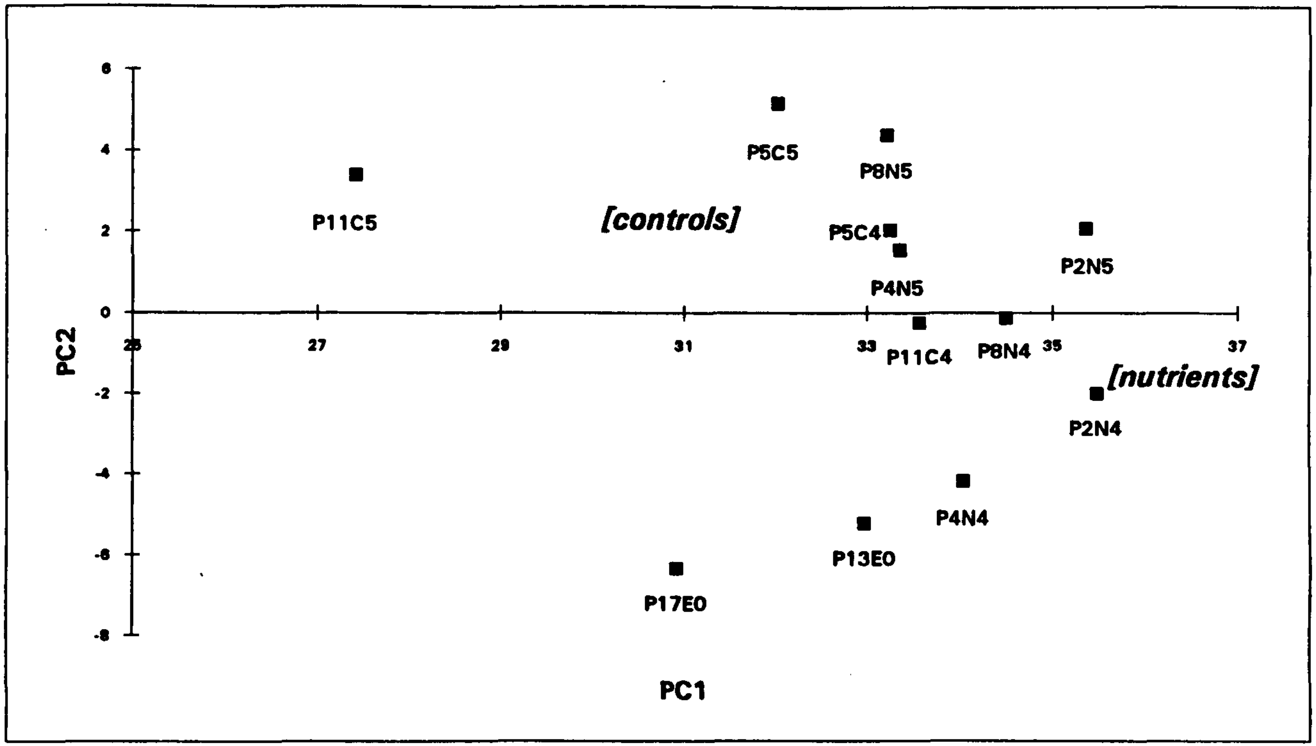

P - indicates plot which is followed by the plot number
N - indicates air, water, and nutrient amendment
C - indicates control samples
E - indicates exsitu treatment
N,C, and E are followed by either 4 (for 4-5' depth) or 5 (for 5-6' depth)

Fig. 28. Principal components analysis of the mean mole percentage profiles obtained from plot averages at the three depths sampled. PC1 indicates the first principal component and PC2 the second.

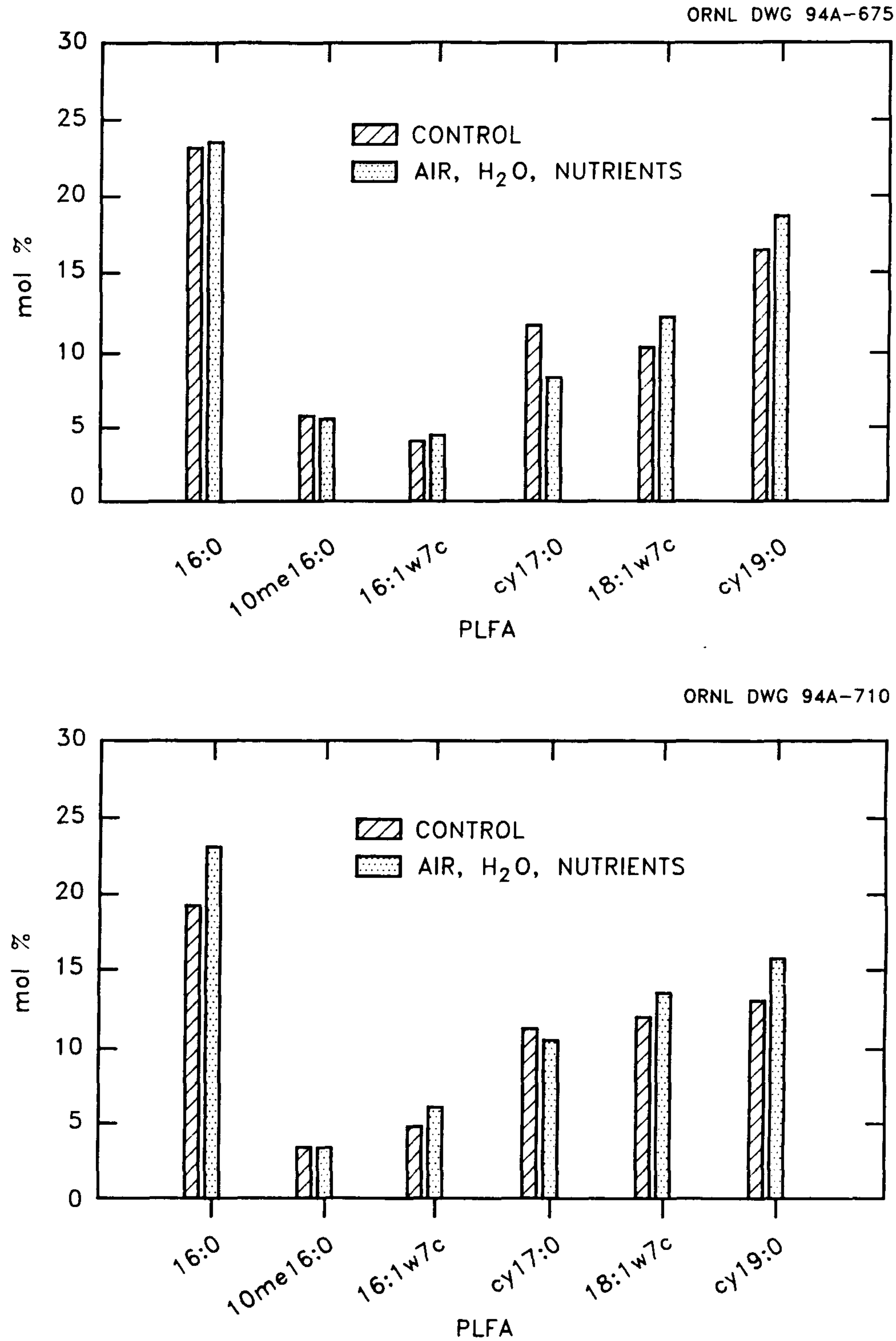

Fig. 29. Comparison of the mole percentages of phospholipid fatty acids (PLFAs) at a depth of 4 to 5 ft (panel A) and 5 to 6 ft (panel B) for the six PLFAs assigned the greatest coefficients of loading.

nutrient-amended or ex situ plots. This decrease was likely related to either an increase in aerobic potential, a decrease in the number of stationary phase microorganisms, or both. Comparison of the PLFA analyses before startup with those after startup suggests a shift from a predominantly gram-positive population [10] to a population of about 50% gram-negative bacteria.[19] There also appears to have been an increase in the bacterial population between pre-startup and post-startup samples. The mean cell populations, as determined from PLFA analyses, comparing pre-startup, post-startup controls, and post-startup amended soils are presented in Fig 31. As can be seen, there was a substantial increase between pre- and post-startup soil samples, as well as between post-startup control and post-startup amended soils. This increase was seen at both the 4- to 5-ft and the 5- to 6-ft levels.

Some of the bacterial populations identified in the PLFA analyses, including Pseudomonas, Xanthomyces, and Actinomycetes, contain species that are known to degrade petroleum components.[21,22,23] Many other additional, as-yet unidentified, strains of bacteria capable of biodegrading hydrocarbons are likely to occur in nature.[21] No one species of microorganism is capable of degrading all the components of a given oil; therefore, many different species are usually required for cleanup of a petroleum-contaminated site. From the PLFA analyses it appears that during treatment (1) there was a substantial increase in the bacterial population, (2) there was a shift in the bacterial population present, and (3) microorganisms from the post-startup soil samples showed an increase in aerobic potential and/or a decrease in the number of stationary-phase microorganisms compared to pre-startup soils. Because petroleum hydrocarbons were the primary carbon source in the subsurface, the shift in the bacterial community and the increase in cell population could have occurred as a result of the bacteria using the added amendments (air, water, and nutrients) to degrade the petroleum hydrocarbons.

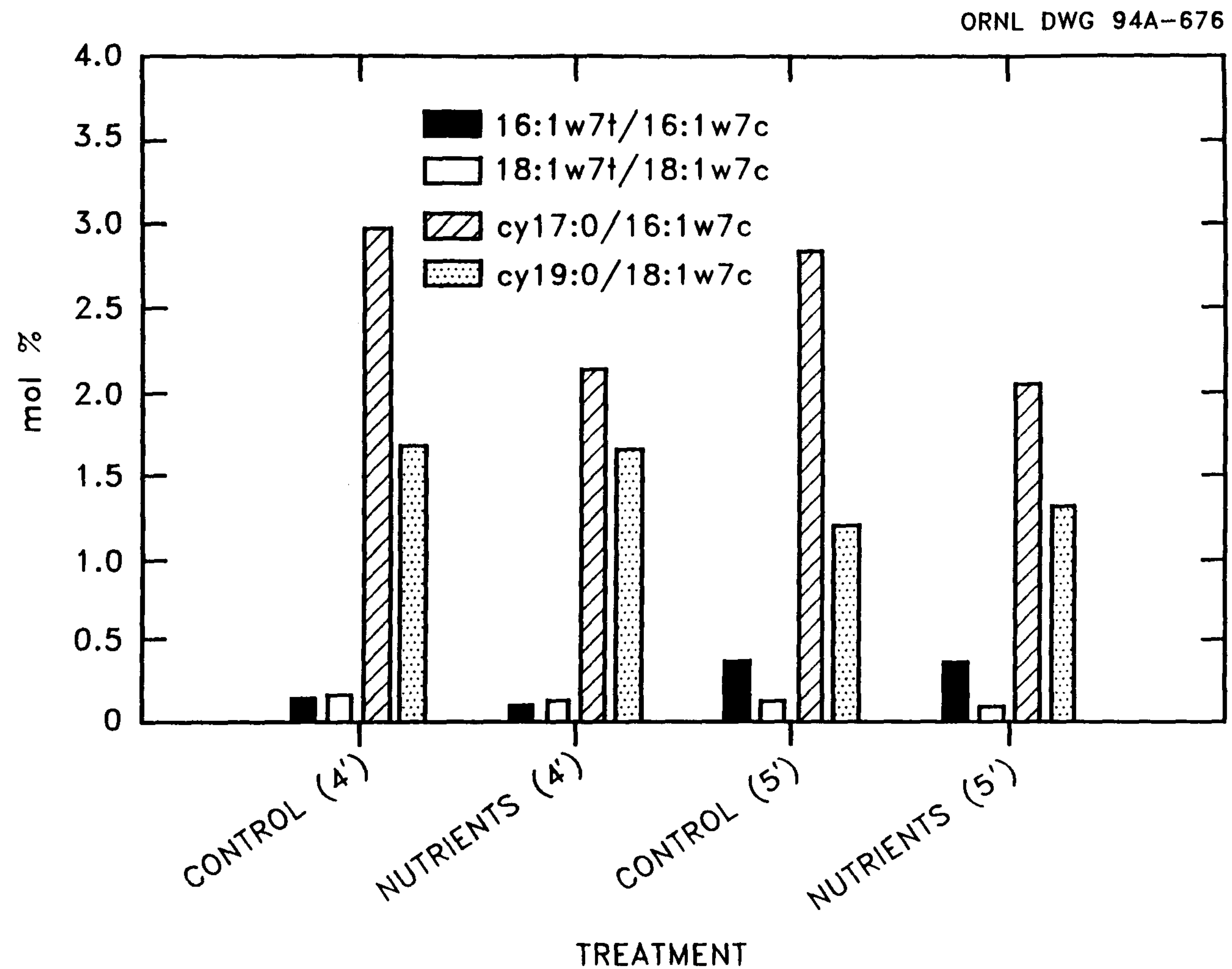

Fig. 30. Ratios of mean specific phospholipid fatty acids reflecting gram-negative bacterial metabolic status.

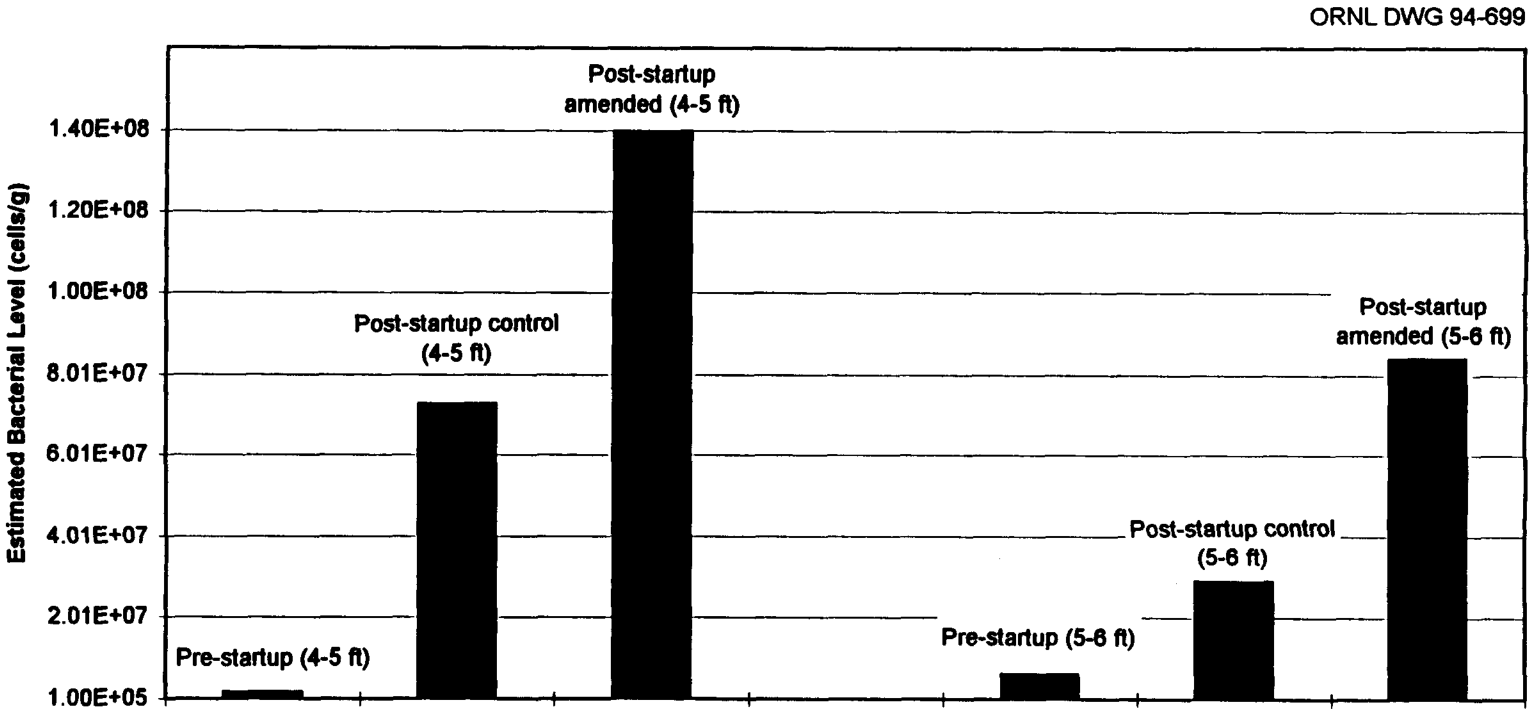

Fig. 31. Mean estimated levels of bacterial cells by phospholipid fatty acids analysis in pre- and post-startup soil samples.

3.5 METALS ANALYSIS OF IN SITU SOIL SAMPLES

Soil core samples from the in situ plots receiving water, air, and nutrients (plots 2, 4, and 8) and from the in situ control plots (plots 5 and 11) were sampled at both 4 to 5 and 5 to 6 ft bgs on November 1, 1993, and January 18 and February 14, 1994 and analyzed for metals by emission spectroscopy using ICP. The detailed ICP results for these samples can be found in Appendix E. The mean concentrations of the most abundant chemical species identified in the Kwajalein in situ soils by the ICP analyses are presented in Table 13. The primary constituent was calcium, which can be expected from coral-based soils. All other elements identified in Table 14 are typically found in seawater and could be expected to be present in the soils at Kwajalein.[24]

3.6 HYDROCARBON EVALUATION OF SOIL SAMPLES FROM IN SITU SYSTEM

Gas chromatograph (GC) and TPH (using a Horiba analyzer) analyses of soil samples from each in situ treatment plot were conducted before startup and for eight subsequent sampling periods to evaluate changes in hydrocarbon concentration as a function of time and treatment method. Standard curves were prepared using samples of diesel fuel obtained from Kwajalein power plant Number 1. The two GC standard curves developed to calculate the hydrocarbon concentration for diesel concentrations less than or equal to 1500 mg/L and greater than 1500 mg/L are presented in Figs. 32 and 33, respectively. The equation for concentrations less than 1500 mg/L had a correlation coefficient of 0.94, while the equation for concentrations above 1500 mg/L had a correlation coefficient of 0.91.

Chromatograms of a fresh diesel sample obtained from the holding tank at Kwajalein power plant Number 1 and from a hydrocarbon sample obtained from a monitoring well located at the

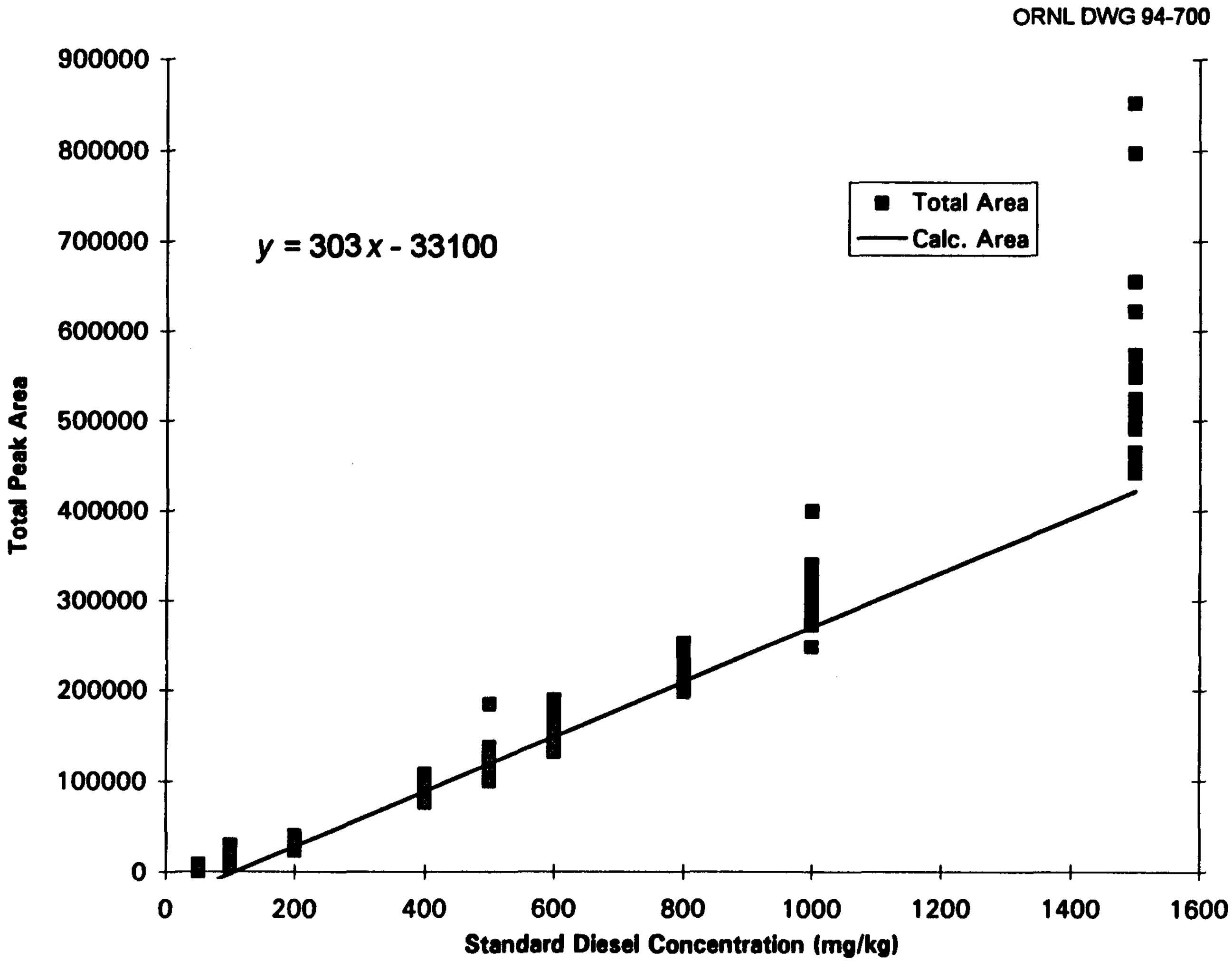

Fig. 32. Gas chromatography calibration for diesel concentrations ≤1500 mg/kg for diesel standards February 1 to October 8, 1993.

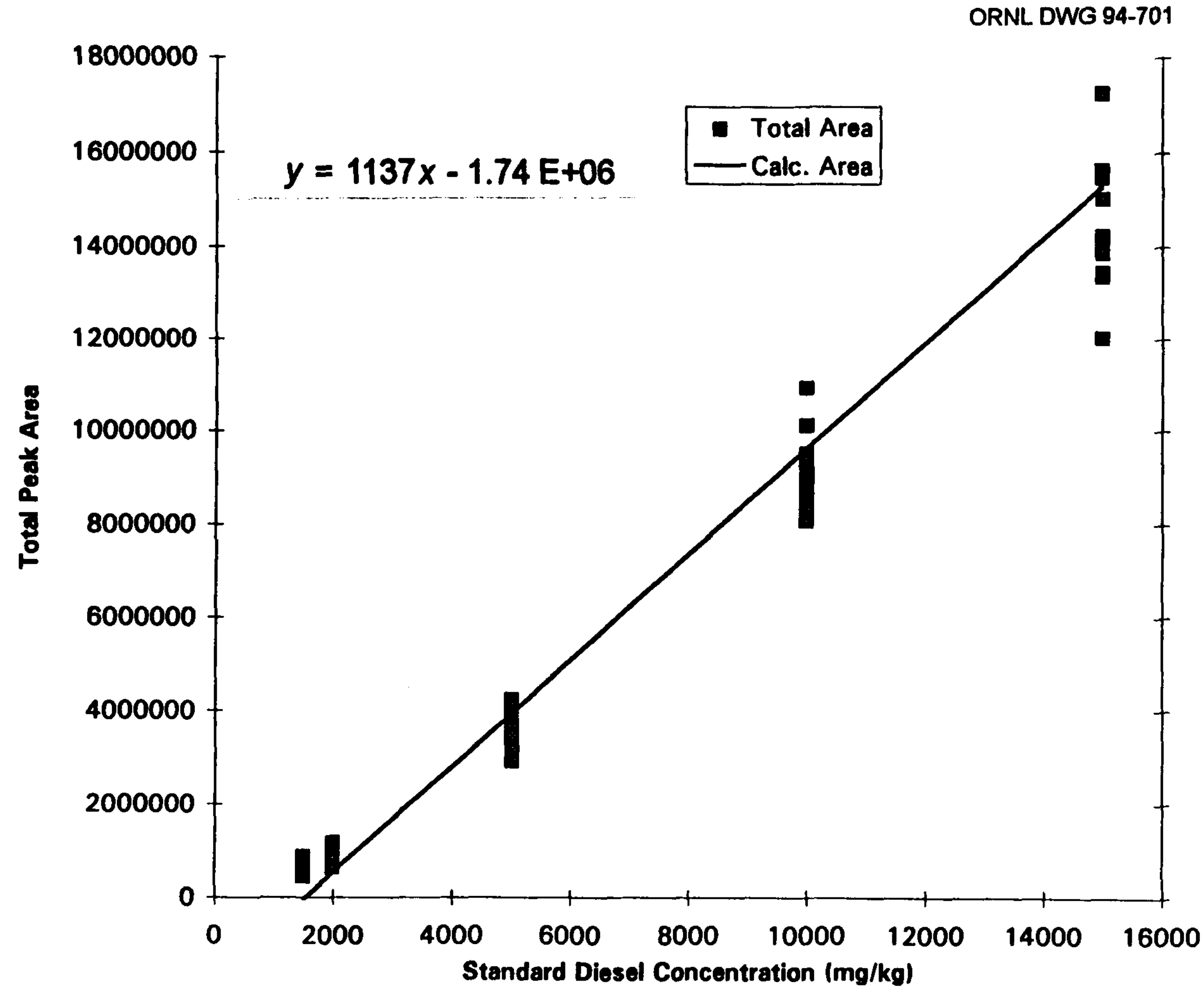

Fig. 33. Gas chromatography calibration for diesel concentrations ≥1500 mg/kg for diesel standards February 1 to October 8, 1993.

Table 13. Mean concentrations of most abundant chemical species found in Kwajalein soil samples

Sample identification	Ca (mg/kg)	K (mg/kg)	Mg (mg/kg)	Na (mg/kg)	P (mg/kg)	Si (mg/kg)	Sr (mg/kg)
In situ with amendments (4-5 ft)	3.61E+05	1.54E+03	6.10E+03	2.60E+03	4.08E+02	1.60E+02	6.08E+03
In situ with amendments (5-6 ft)	3.62E+05	1.53E+03	5.61E+03	2.47E+03	4.16E+02	1.66E+02	6.17E+03
In situ control (4-5 ft)	3.62E+05	1.52E+03	6.15E+03	2.52E+03	4.33E+02	1.78E+02	5.93E+03
In situ control (5-6 ft)	3.60E+05	1.55E+03	5.97E+03	2.48E+03	4.60E+02	6.10E+03	6.10E+03

demonstration site are shown in Figs. 34 and 35, respectively. Many of the lighter components from the demonstration area sample are not present, or are present at lower concentrations than in the fresh diesel sample. This indicates that the contamination at the demonstration area was weathered, verifying the analyses in the previous soil column studies.

A comparison of the mean hydrocarbon concentration via GC analysis for each of the treatment methods with that of the controls over the entire demonstration period is presented graphically in Figs. 36 through 39. Each point in these graphs represents the mean hydrocarbon concentration from 3 to 7 ft taken from each plot during that particular sampling period. (In general, two sample cores were taken from each treatment plot during each sampling period. The mean concentration of these cores is presented in Figs. 36 through 39). Examination of these figures quickly reveals that there is substantial scatter in the data. Statistical analyses of the data indicate that reductions in the hydrocarbon concentration during the demonstration period occurred only in those plots receiving a combination of water, air, and nutrients (plots 2, 4, and 8). The change in hydrocarbons in plots 2 and 8 fell within the 95% confidence interval.

A bar graph showing hydrocarbon concentration with time for the three plots receiving water, air, and nutrients is shown in Fig. 40. The hydrocarbon reduction rate ranged from 6 to 12 mg/kg per

Table 14. Source of the phospholipid fatty acids (PLFA) detected in Kwajalein sediments at depths of 0 to 15 in., 4 to 5 ft, and 5 to 6 ft

PLFA detected	Bacterial source
Normal saturates	All bacteria
14:0	
15:0	
16:0	
17:0	
18:0	
Terminally branched saturates	Predominately gram-positive bacteria
i14:0	
i15:0	(Also found in sulfate-reducing bacteria and some Actinomycetes)
a15:0	
i16:0	
a17:0	
i18:0	
Mid-chain branched saturates	Predominately soil microorganisms
br15:0	
br16:0	
10me16:0	(Sulfate-reducing bacteria, Desulfobacter)
12me16:0	
br17:0	
10me18:0	(Actinomycetes)
Branched monounsaturates	Predominately the sulfate-reducing bacteria
i17:1w7c	(Desulfovibrio)
br19:1w6c	
brcy19:0	
Monounsaturates	Predominately gram-negative bacteria
16:1w11c	
16:1w9c	
16:1w7c	(Terminal point in a biosynthetic pathway utilized by all
16:1w7t	gram-negative bacteria)
16:1w5c	
17:1w6c	(Type II Methanotrophs)
18:1w8c	
18:1w9c	(Terminal point in a biosynthetic pathway utilized by all
18:1w7c	gram-negative bacteria)
18:1w7t	
18:1w5c	
cy17:0	
cy19:0	
Polyunsaturates	Predominately eukaryotic
18:2w6	(Fungal)

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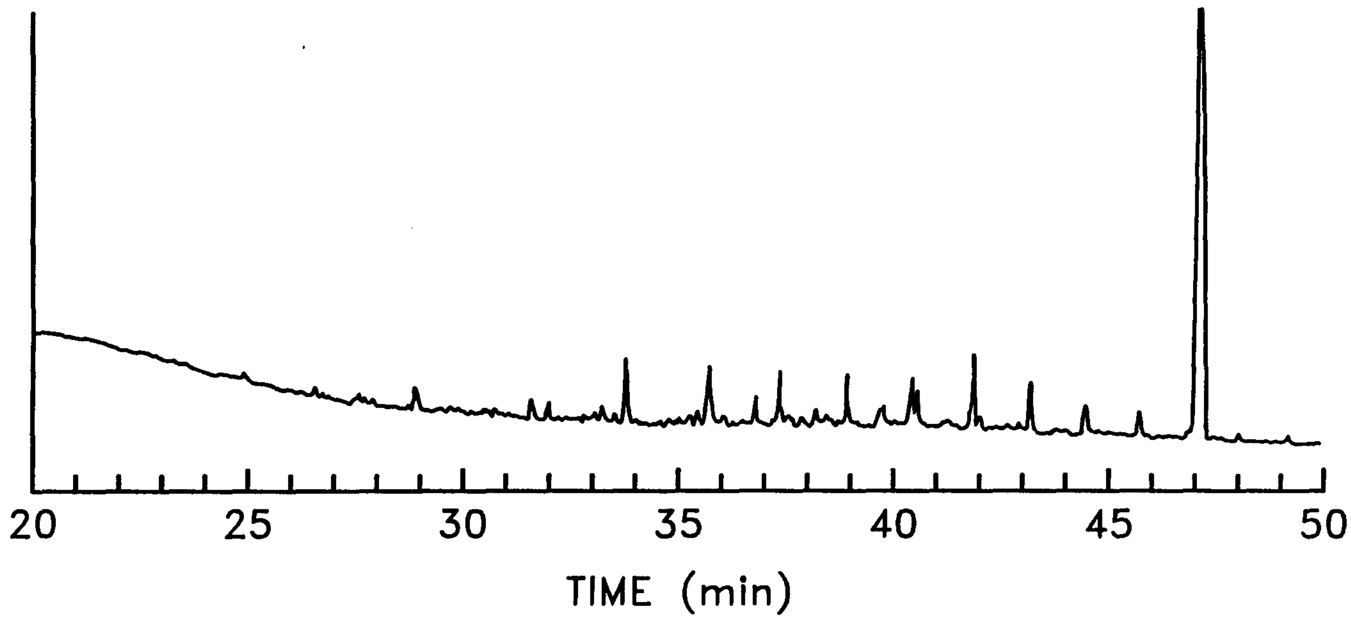

Fig. 34. Gas chromatography fingerprint for 1000-ppm Kwajalein diesel standard.

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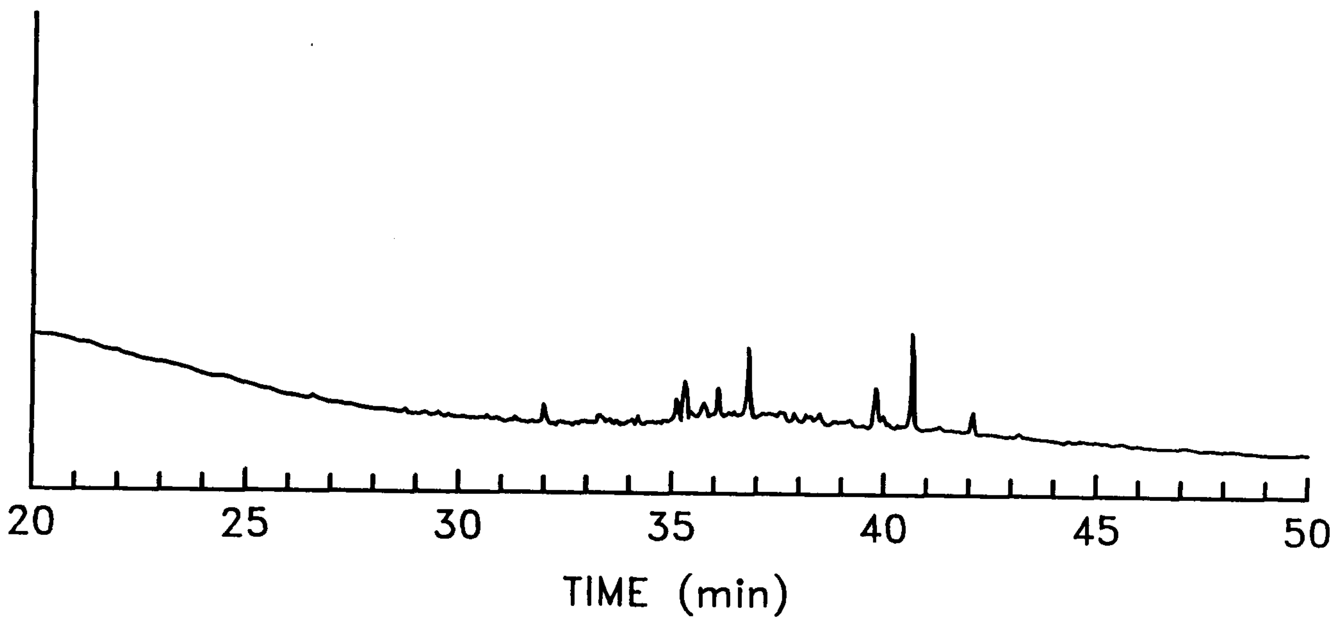

Fig. 35. Gas chromatography fingerprint for 1000-ppm of oil collected from monitoring well 14 in isooctane.

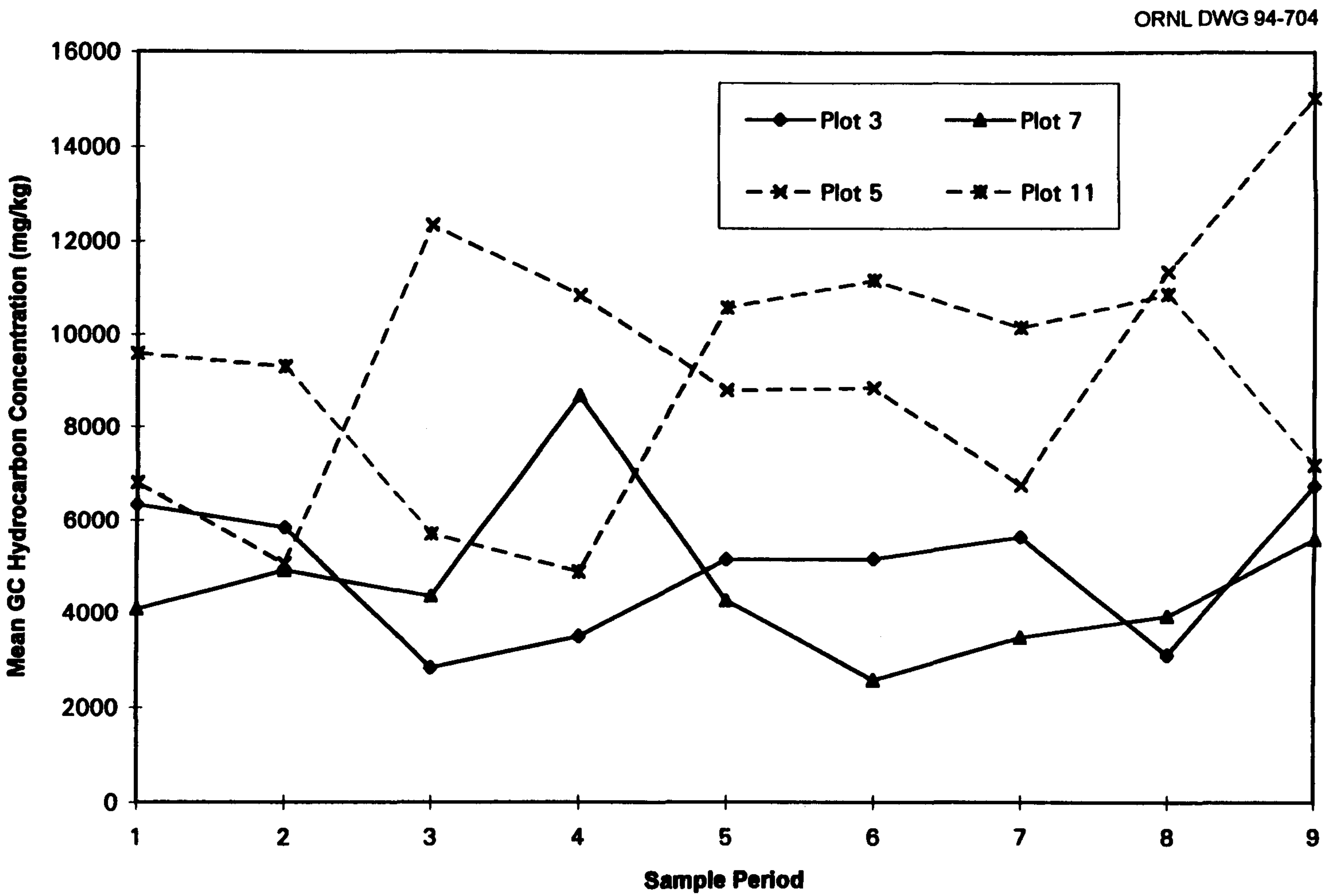

Fig. 36. Mean hydrocarbon concentration (by gas chromatography with flame ionization detector) from 3 to 7 ft as a function of time in plots receiving water (plots 3 and 7) and in the control plots (plots 5 and 11).

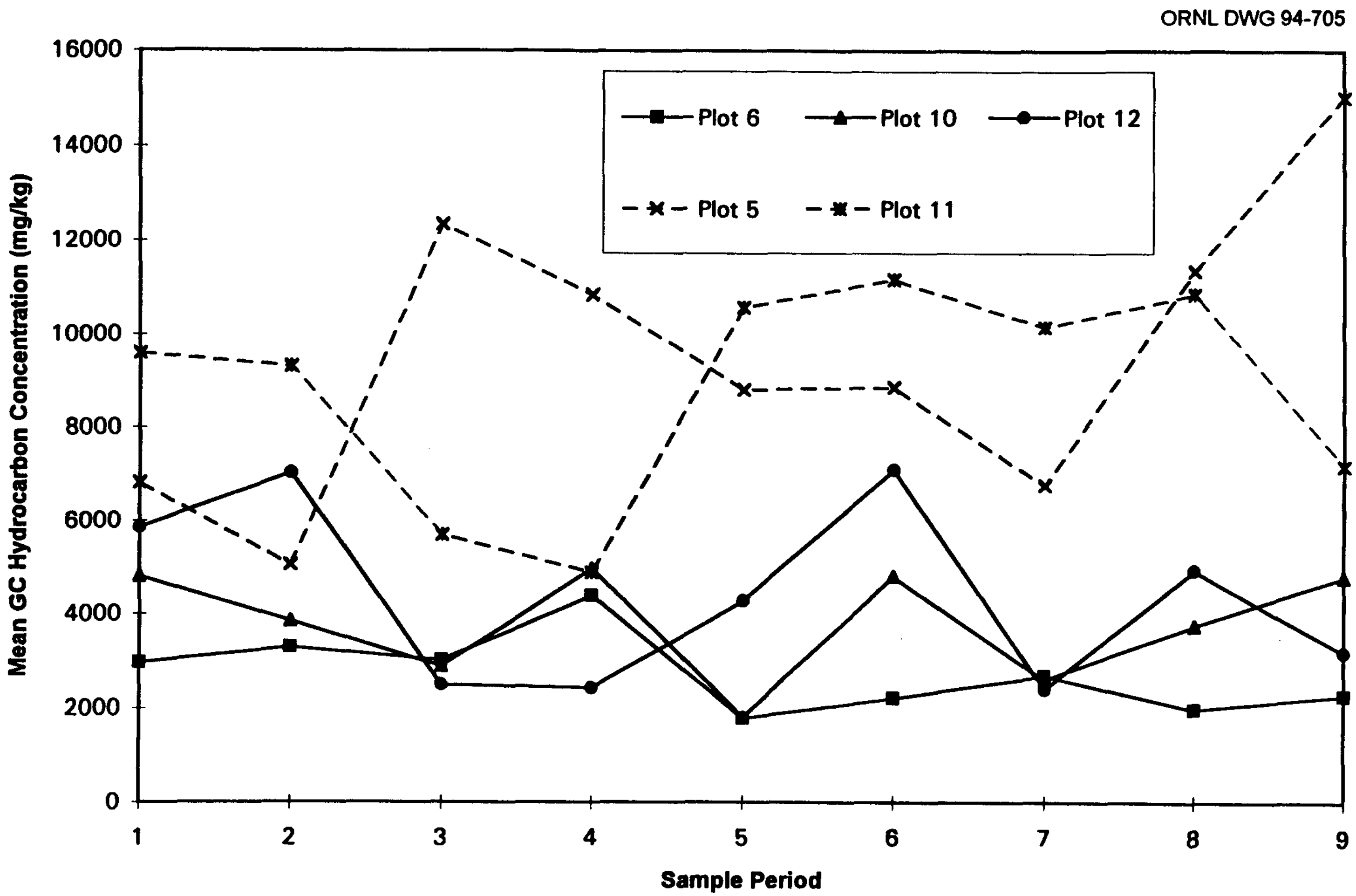

Fig. 37. Mean hydrocarbon concentration (by gas chromatography with flame ionization detector) from 3 to 7 ft as a function of time in plots receiving water and nutrients (plots 6, 10, and 12) and in the control plots (plots 5 and 11).

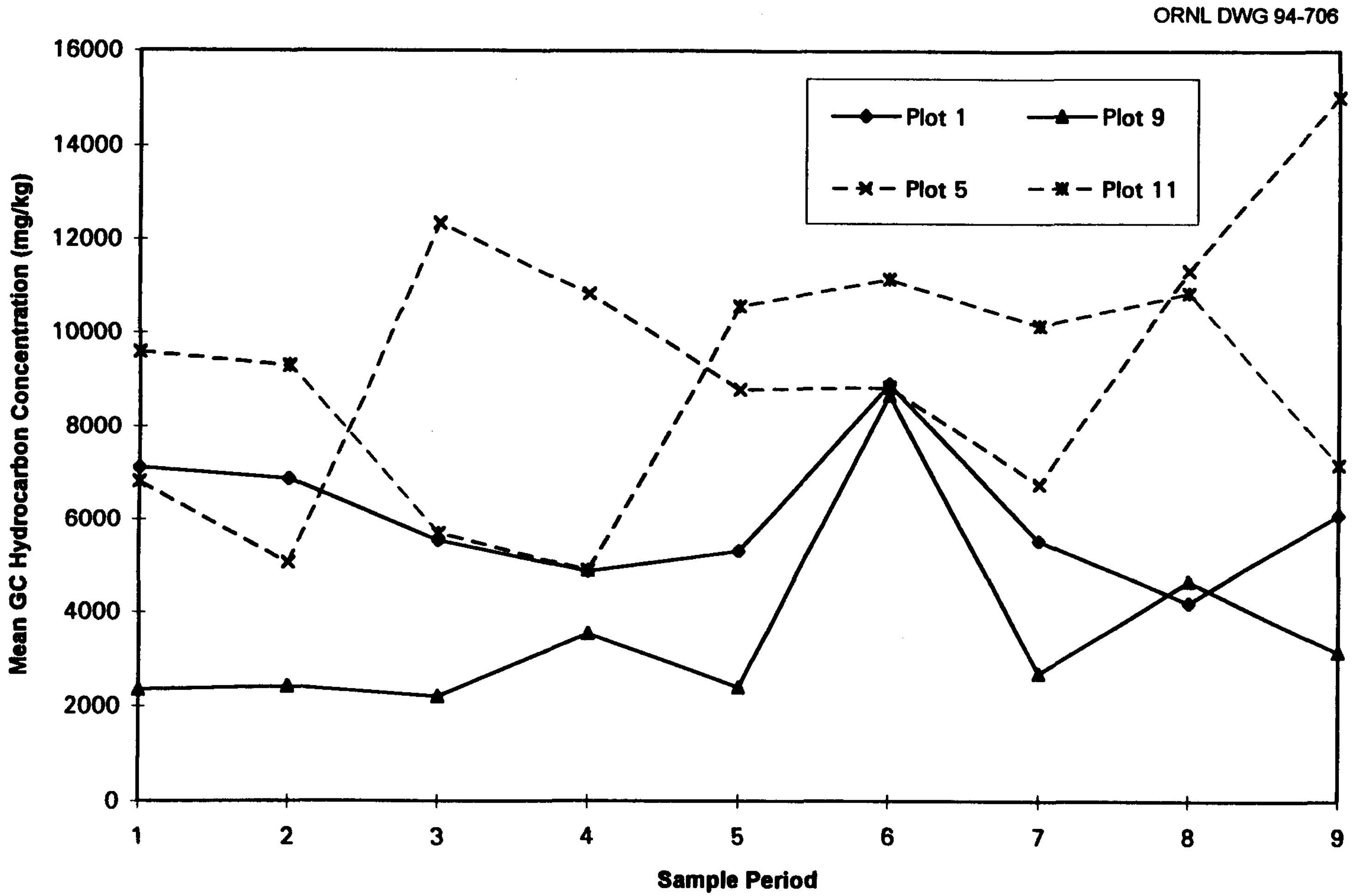

Fig. 38. Mean hydrocarbon concentration (by gas chromatography with flame ionization detector) from 3 to 7 ft as a function of time in plots receiving water and air (plots 1 and 9) and in the control plots (plots 5 and 11).

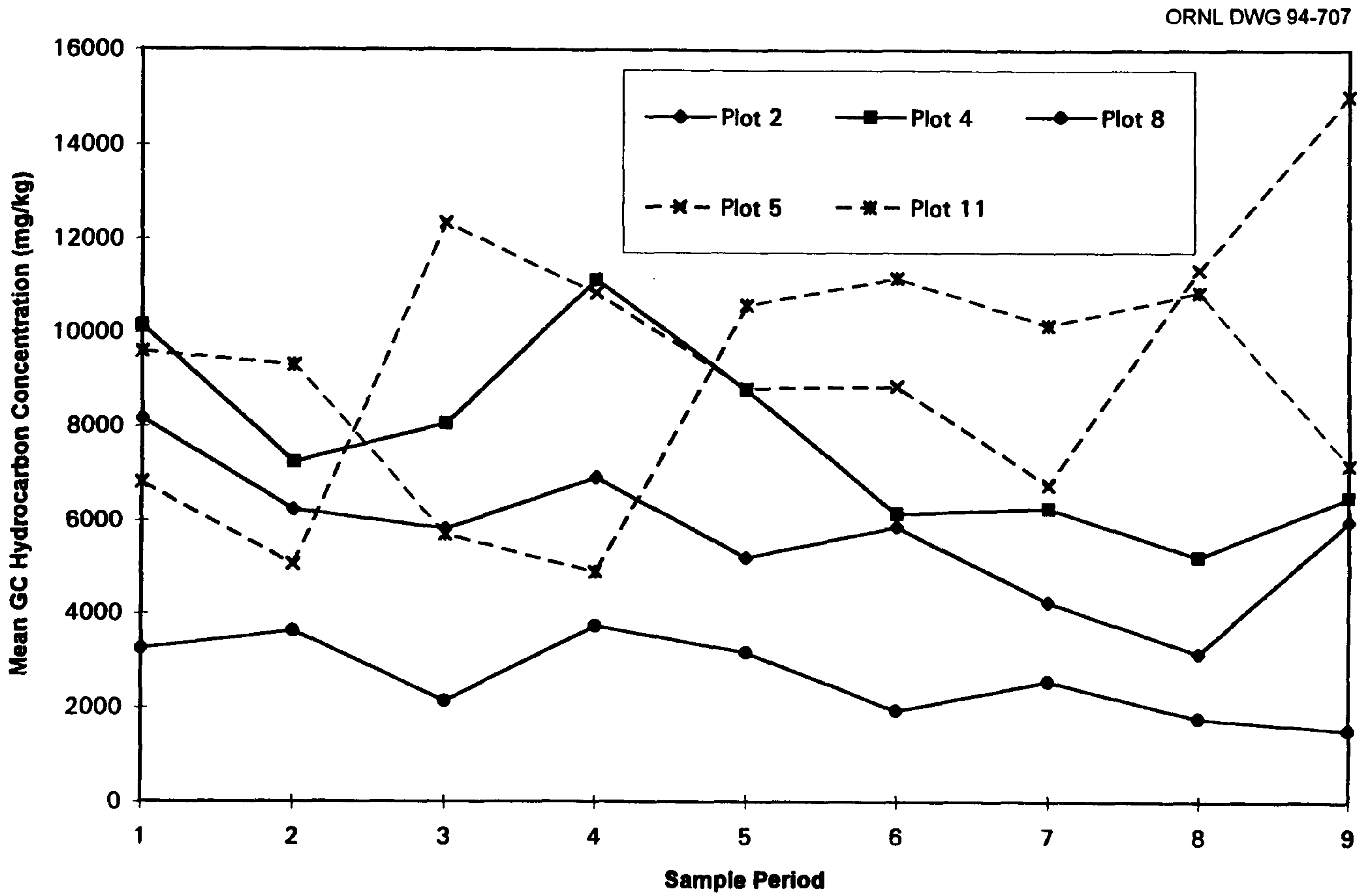

Fig. 39. Mean hydrocarbon concentration (by gas chromatography with flame ionization detector) from 3 to 7 ft as a function of time in plots receiving water, air, and nutrients (plots 2, 4, and 8) and in the control plots (5 and 11).

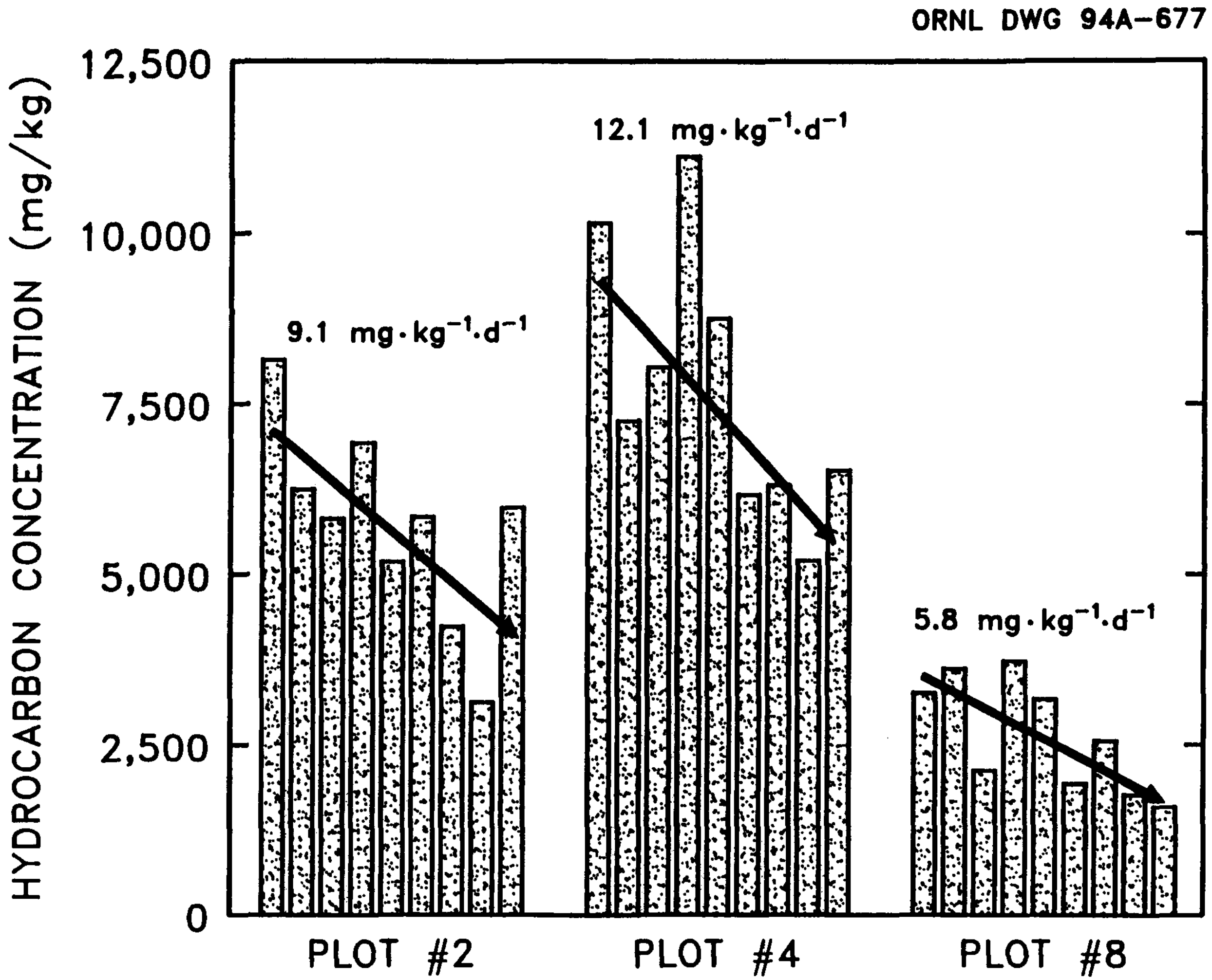

Fig. 40. Concentration of hydrocarbons with time and rate of hydrocarbon reduction for those plots receiving water, air, and nutrients.

day. If the average rate could be maintained, about 3 years would be required to completely remediate the demonstration site. However, it is likely that the degradation rate would slow because the lightest remaining hydrocarbons in the weathered diesel fuel would probably be degraded first, leaving successively higher molecular weight hydrocarbons that would be more difficult to biodegrade.

While it cannot be shown definitively that the decrease in hydrocarbons in the in situ plots is due to biological degradation, results of this study indicate that at least a portion of the decrease was caused by biological degradation. The following evidence supports this conclusion:

- The hydrocarbons at the demonstration site consisted of weathered diesel; the components left were not likely to be easily volatilized.
- PLFA analyses indicated that before the demonstration, bacteria present within the contaminated soils were not actively dividing; however, soil samples taken during the demonstration indicated that there had been a decrease in the number of stationary-phase bacteria and/or the microorganisms showed an increase in aerobic potential.
- Only plots receiving a combination of air, water, and nutrients — those components necessary for biodegradation — showed a decrease in hydrocarbons over the demonstration period.

By observing the control plots (plots 5 and 11) in Figs. 36 through 39, it can be seen that there were large swings (both increases and decreases) in the hydrocarbon concentrations from sample period to sample period. This suggests that at least some of the hydrocarbons present within the demonstration area are not adsorbed onto the soil particles but may be moving within the demonstration area because of tidal fluctuations, air sparging, etc. Some evidence of this was noted during the demonstration period when groundwater levels within the monitoring wells were recorded. A heavy hydrocarbon coating was occasionally observed on the level probe as it was removed from various monitoring wells. Also, while sampling MW-14 on February 19, 1994, an oily substance was discovered floating on the surface of the groundwater within the monitoring well. A GC analysis of the oily substance showed that it was probably weathered diesel fuel. This substance had not been noted in any of the previous samples taken from MW-14 and adds further evidence that hydrocarbons are moving within the demonstration area. The movement of hydrocarbons within the demonstration area would make it difficult to detect changes in the hydrocarbon concentrations as a result of the various treatments methods used for the in situ plots.

There were also large variations in hydrocarbon concentrations within the same plot. This is evidenced by data for plots 3 and 7, presented graphically in Figs. 41 and 42, and tabulated in Table 15. In 9 of the 18 sample sets (9 sample periods for plot 3 and 9 sample periods for plot 7) there was >25% difference in sample concentrations taken from the same plot during the same sampling period. These variations in hydrocarbon concentrations of several thousand milligrams per liter occurred in samples taken 1 to 2 ft apart and within 1 h of each other.

Comparisons of the hydrocarbon concentrations determined by GC analysis and by the Horiba TPH analyzer for plots 3 and 7 are presented in Figs. 43 and 44 and Table 16. These results are also typical of the other treatment plots. There was >25% variation in the differences between the average hydrocarbon concentrations as determined by GC and the Horiba analyzer for 5 of the 18 total sample periods. The average concentrations usually agreed to within 15%.

3.7 WATER CONTENT AND pH OF SOIL SAMPLES FROM THE IN SITU SYSTEM

All soil samples taken during the nine sample periods were analyzed for water content. The results are summarized in Table 17. The percent moisture for all plots at the 3- to 4-ft bgs level averaged 14.9% over the entire demonstration period, while that for the 6- to 7-ft bgs level averaged 28.9%. The groundwater level was always below the 3- to 4-ft level and always above the 6- to 7-ft level. Depending on the change in tide, most or all of the 5- to 6-ft level and a portion of the 4- to 5-ft level was below the groundwater surface. Soil pH analyses were also run on all soil samples

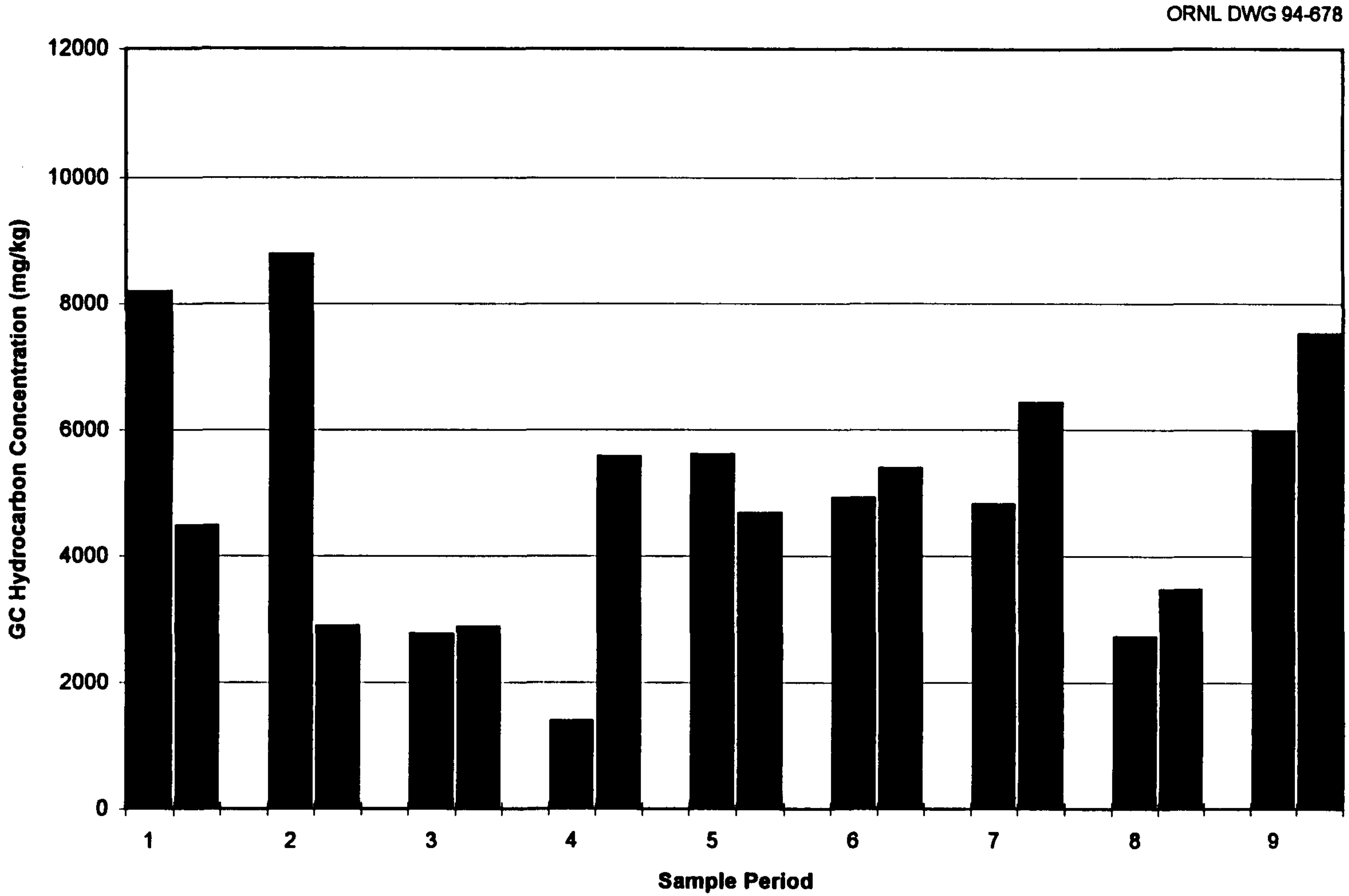

Fig. 41. Hydrocarbon concentration by gas chromatography for plot 3 over the nine sampling periods.

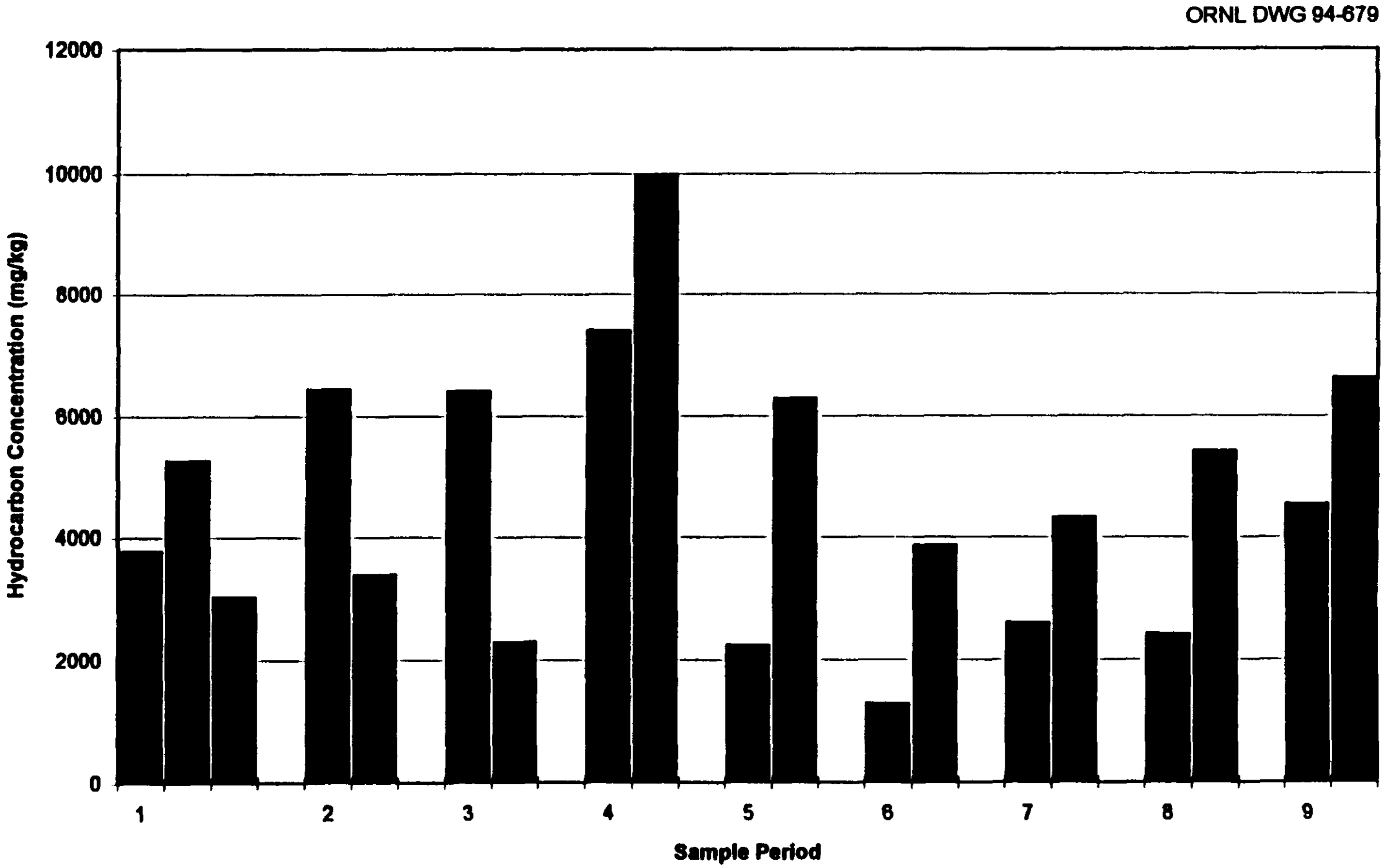

Fig. 42. Hydrocarbon concentration by gas chromatography for plot 7 over the nine sampling periods.

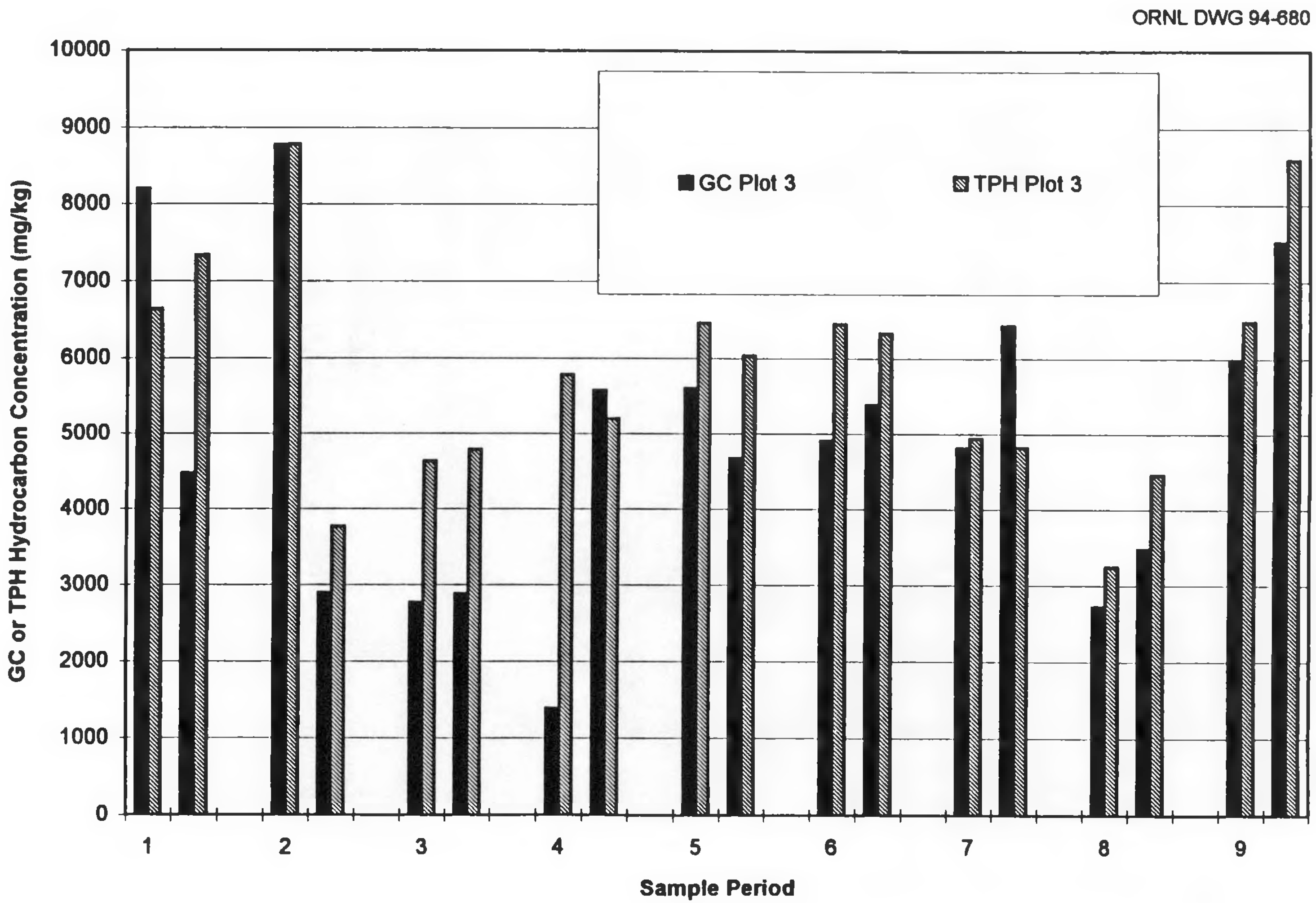

Fig. 43. Comparison of gas chromatography (GC) and total petroleum hydrocarbon (TPH) concentrations for plot 3.

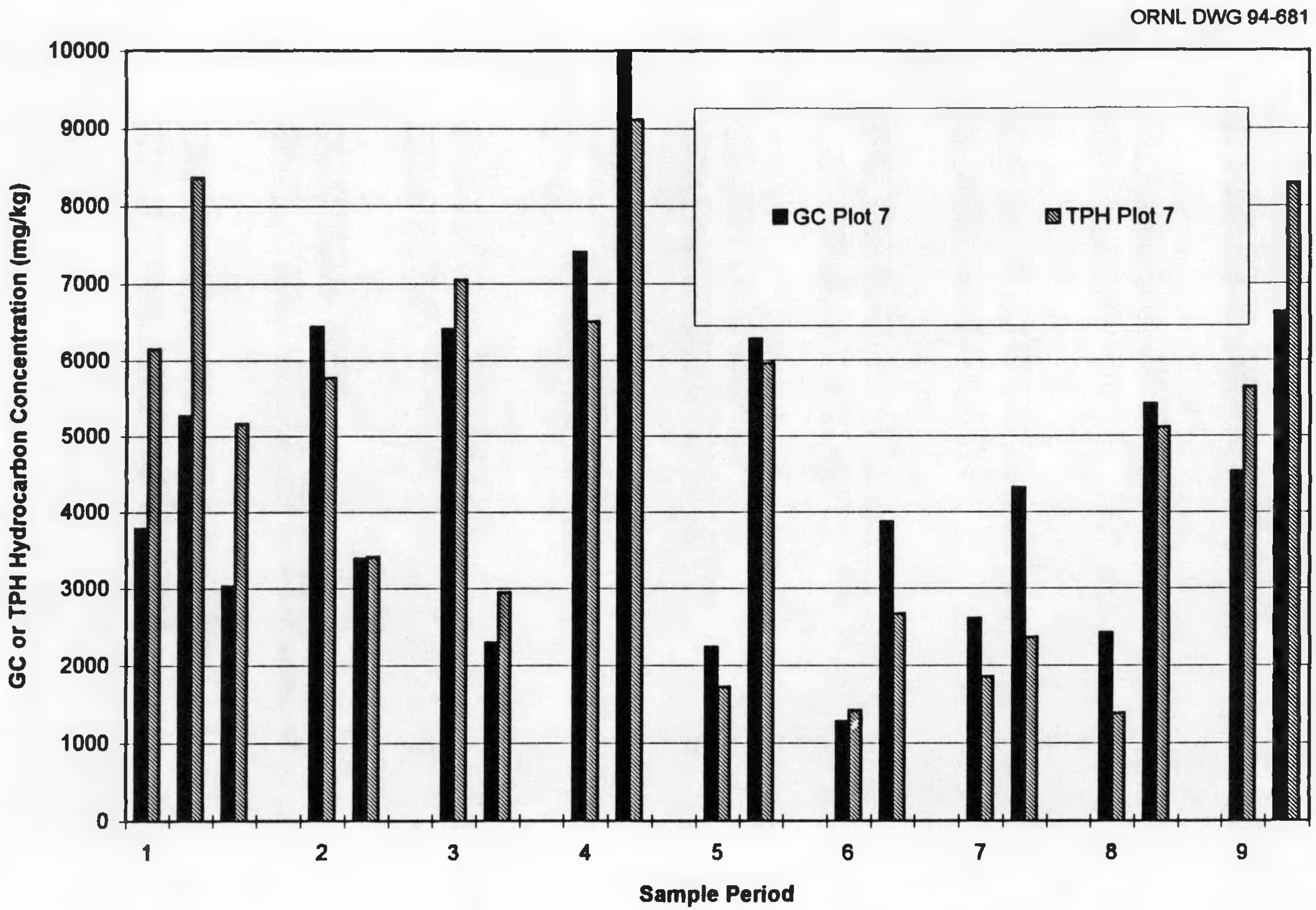

Fig. 44. Comparison of gas chromatography (GC) and total petroleum hydrocarbon (TPH) concentrations for plot 7.

Table 15. Hydrocarbon concentrations by gas chromatography (GC) in replicate soil samples from plots 3 and 7

Sample period	GC concentration (mg/L) Plot 3	Average concentration (mg/L)	Difference from average (%)	Sample period	GC concentration (mg/L) Plot 7	Average concentration (mg/L)	Difference from average (%)
1	8195	6334	29	1	3787	4028	-6
	4472	6334	-29		5268	4028	31
					3031	4028	-25
2	8775	5835	50	2	6437	4912	31
	2894	5835	-50		3388	4912	-31
3	2770	2826	-2	3	6406	4348	47
	2882	2826	2		2290	4348	-47
4	1388	3481	-60	4	7411	8685	-15
	5574	3481	60		9958	8685	15
5	5600	5137	9	5	2233	4255	-48
	4675	5137	-9		6277	4255	48
6	4916	5150	-5	6	1278	2572	-50
	5384	5150	5		3867	2572	50
7	4815	5618	-14	7	2600	3457	-25
	6421	5618	14		4315	3457	25
8	2723	3100	-12	8	2416	3918	-38
	3477	3100	12		5421	3918	38
9	5967	6742	-12	9	4533	5578	-19
	7518	6742	12		6623	5578	19

Table 16. Hydrocarbon concentrations by gas chromatography (GC) and total petroleum hydrocarbons (TPH) in replicate soil samples from plots 3 and 7

Period	GC Plot 3	TPH Plot 3	Difference (%)	Difference Between Averages (%)	Period	GC Plot 7	TPH Plot 7	Difference (%)	Difference Between Averages (%)
1	8195	6637	-23	9	1	3787	6147	-38	-39
	4472	7337	39			5268	8365	-37	
						3031	5160	-41	
2	8775	8786	0	7	2	6437	5766	12	7
	2894	3763	23			3388	3409	-1	
3	2770	4634	40	40	3	6406	7053	-9	-13
	2882	4789	40			2290	2942	-22	
4	1388	5785	76	37	4	7411	6509	14	11
	5574	5195	-7			9958	9111	9	
5	5600	6457	13	18	5	2233	1721	30	11
	4675	6030	22			6277	5958	5	
6	4916	6444	24	19	6	1278	1418	-10	26
	5384	6327	15			3867	2664	45	
7	4815	4943	3	-15	7	2600	1851	40	64
	6421	4821	-33			4315	2358	83	
8	2723	3240	16	19	8	2416	1386	74	21
	3477	4460	22			5421	5112	6	
9	5967	6481	8	10	9	4533	5643	-20	-20
	7518	8585	12			6623	8292	-20	

Table 17. Summary of the water content of in situ soil samples taken during the Kwajalein bioremediation demonstration

Depth (ft)	Average moisture (%)	Standard deviation
3-4	14.9	2.2
4-5	20.6	3.4
5-6	26.8	2.8
6-7	28.9	1.7

taken during the demonstration period. In general there was very little variation in the soil pH during the demonstration period. The pH at the 3- to 4-ft level averaged 8.07 with an s.d. of 0.33, the pH at the 4- to 5-ft level averaged 7.97 with an s.d. of 0.17, the pH at the 5- to 6-ft level averaged 7.91 with an s.d. of 0.17, and the pH of the 6- to 7-ft level averaged 7.96 with an s.d. of 0.13.

3.8 GROUNDWATER ANALYSES FROM THE DEMONSTRATION AREA

During each sample period, groundwater samples from select monitoring wells located both within and outside of the in situ plots were analyzed for pH, conductivity, coliform, nitrate, nitrite, phosphate, sulfide, chemical oxygen demand (COD), hydrocarbons via GC, and TPH via the Horiba analyzer.

The results of the GC, COD, and TPH analyses indicated that there was little hydrocarbon contamination in the groundwater at the demonstration site. The TPH concentration averaged 6.6 mg/L (based on a diesel standard), with an s.d. of 5.4 mg/L, over the demonstration period for all monitoring wells sampled.

Analytical results for nitrate in groundwater within the plots receiving nutrients varied from 0 to 220 mg/L. In general, little to no nitrate was detected in the groundwater from the plots not receiving nutrients and from the surrounding monitoring wells. Nitrite was not detected in any monitoring well. Phosphate was detected in only three monitoring wells during the entire sampling period, and the concentration was at the lowest level detectable with the test kit (i.e., 10 mg/L). These data indicate that the phosphate may have been tied up as calcium phosphate in the first 3 ft of soil before reaching the contaminated area and may not have been available for use by the bacteria. Also, there was no detectable increase in the conductivity within any of the test plots over the demonstration period, which indicates that nutrient levels were not building up in the groundwater within the plots. Sulfide concentrations up to 10 mg/L were detected in a few monitoring wells. The sulfide may indicate the presence of anaerobic activity in these wells.

During the demonstration period the pH of the groundwater remained fairly constant within all monitoring wells. The average pH for all wells tested during the demonstration period was 7.42, with an s.d. of 0.37. It should also be noted that no coliform colonies were detected in any of the groundwater samples taken during the demonstration period.

3.9 COLONY-FORMING UNITS FROM SOIL SAMPLES FROM THE EX SITU SYSTEM

Microbial abundance for each ex situ plot was assessed by plate count methods before startup (sample period 1) and for three additional sampling periods thereafter at 4- to 6-week intervals. The mean CFU per gram for the treatments used is compared to the control plots for the top ~15 in. of soil in each plot and is presented graphically in Figs. 45 and 46. Each of the ex situ plots is ~24 in. in depth. Comparing the control plots with the plots receiving water and nutrients (Fig. 45), it can be seen that the addition of water and nutrients did not cause an increase in the CFU over that of the control plots. Figure 46 shows that the CFU in both of the plots receiving water, air, and nutrients increased between the pre-startup sampling (sample period 1) and the first post-startup sampling. These data again highlight the importance of air in increasing the bacterial density within the subsurface.

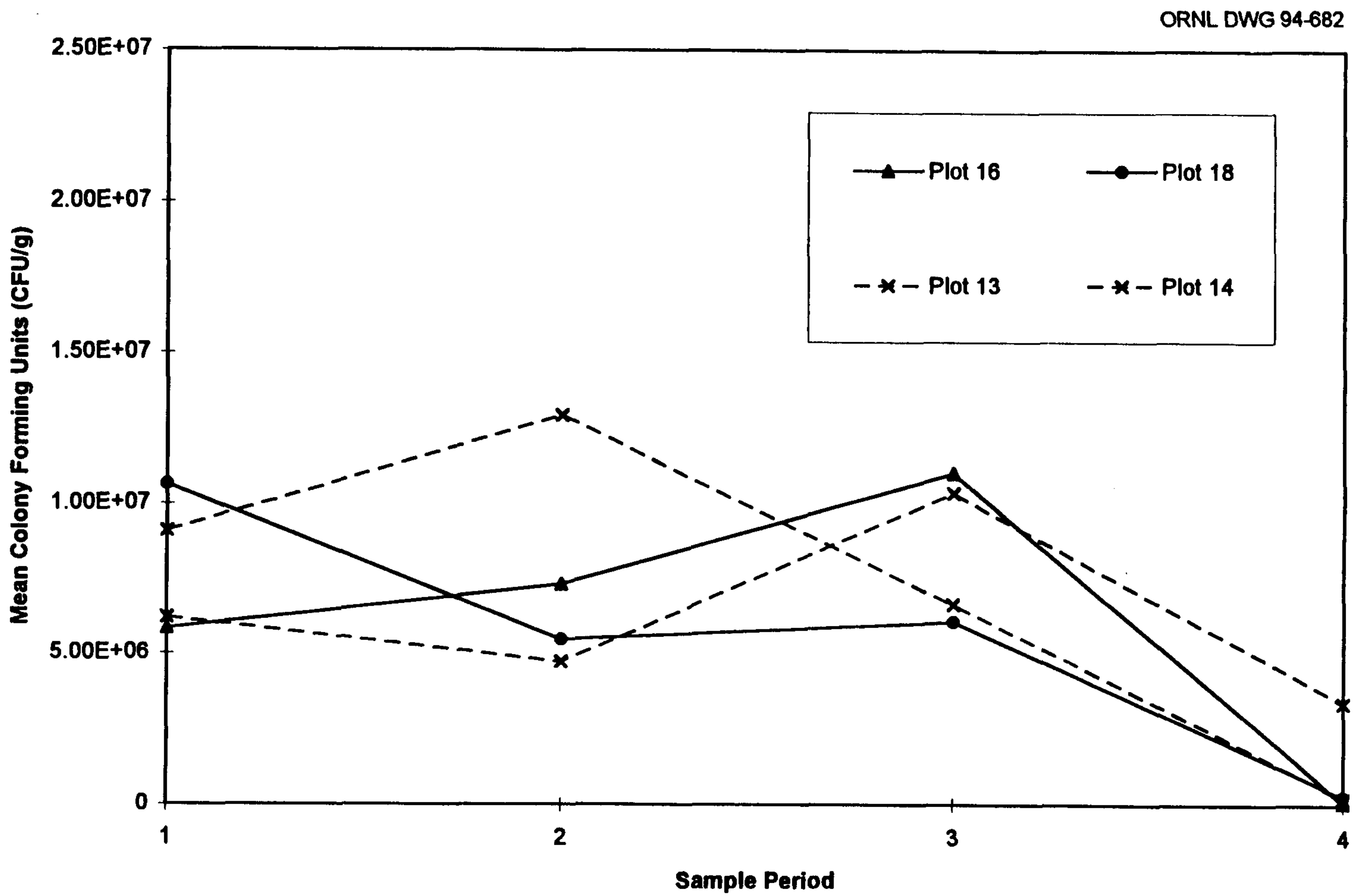

Fig. 45. Mean colony-forming units for ex situ plots receiving water and nutrients (plots 16 and 18) and for the control plots (plots 13 and 14).

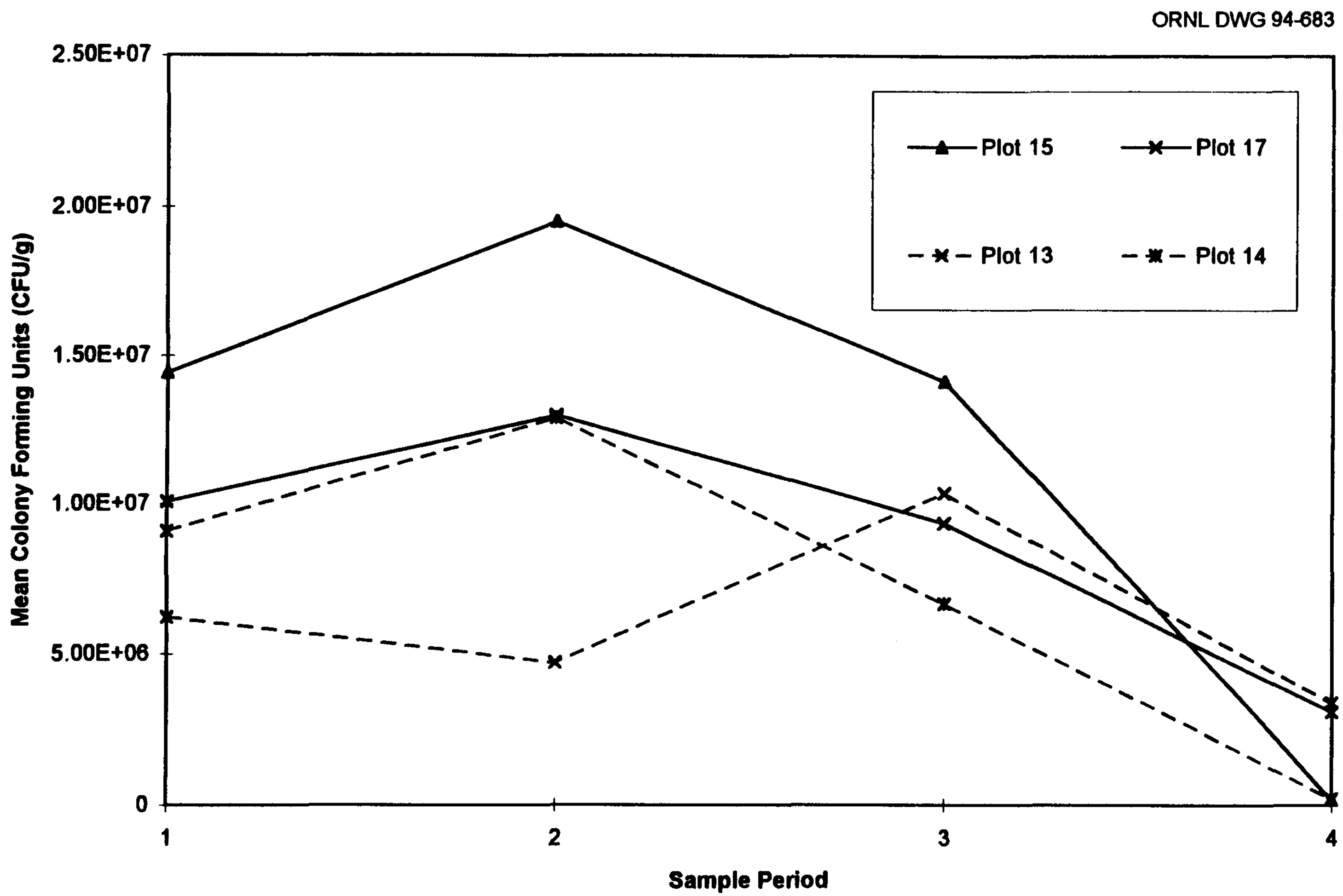

Fig. 46. Mean colony-forming units for ex situ plots receiving water, air, and nutrients (plots 15 and 17) and for the control plots (plots 13 and 14).

It should also be noted that in a comparison of the pre-startup samples from the ex situ plots with those from the in situ plots, the average CFU/g in the ex situ plots (9.4×10^6) was about an order of magnitude greater than that found in the in situ plots (9.8×10^5). This is also probably the result of the air being more likely to diffuse from the atmosphere into the top 15 in. of soil in the ex situ plots, where the samples were taken, than to diffuse to a depth of 3 to 7 ft where the in situ plots were sampled. Also, the maximum concentration of bacteria obtained in both the in situ and ex situ systems was approximately 2×10^7 CFU/g and was obtained in plots receiving both air and nutrients. After reaching this value the bacterial population steadily declined for the remainder of the demonstration period even though the concentration of air and nutrients fed these plots was not decreased. This indicates that there may have been a limiting nutrient that prevented maintenance of or an increase of the bacterial population density.

3.10 ESTER-LINKED PHOSPHOLIPID FATTY ACID ANALYSIS OF EX SITU SOILS

Composite soil samples from the top 15 in. of one ex situ control plot and one ex situ plot which had received water, air, and nutrients were collected and shipped to UT for PLFA analyses. These analyses indicated that the microbial biomass in the nutrient-amended plot was actually lower than that observed in the control plot (2453 pmol/g vs 4964 pmol/g). This was the opposite of that observed for the in situ plots.

The PLFA analyses suggest that the two ex situ plots also contained a slightly different microbial community than that observed in the in situ soils. The most prominent difference noted was in the percent of mid-chain branched saturates, specifically 10me16:0 and 10me18:0, which were observed at higher percentages in the two ex situ plots. These mid-chain branched saturates increased with nutrient amendment while the percent of normal saturates decreased. This result was opposite to that observed in the in situ samples. The percent of terminally branched saturates also decreased slightly with nutrient addition in the ex situ soils; however, this coincides with in situ observations.

The metabolic status of the extant microbiota in the ex situ plots was similar to that observed in the in situ populations. The only difference between the two treatments was in the ratio of cy19:0/18:1w7c, which was unchanged in the in situ plots and decreased (with nutrient amendment) in the ex situ plots. This difference may reflect a response of a unique (to the ex situ plot) gram-negative bacterial component to the nutrient amendment. This response may have been more pronounced in the ex situ plot because the ex situ plot contained a greater density of this component.

The differences noted between the ex situ and in situ samples may have been related to (1) the differences in chemistry associated with the different sediment depths, (2) the fact that the soils for the ex situ plots were obtained from a different part of the island than in situ plots, or (3) differences in nutrient additions between the in situ and ex situ plots.

3.11 METAL ANALYSIS OF EX SITU SOIL SAMPLES

Soil samples from the top 15 in. of one of the ex situ plots receiving water, air, and nutrients (plot 17; see Fig. 7) and from one of the ex situ control plots (plot 13; Fig. 7) were analyzed for metals by ICP. Detailed analytical results for these samples are presented in Appendix E. The analytical results were very similar to those found in the in situ soils. The primary constituent was calcium, and the other major elements identified are typically found in seawater and could be expected to be present in coral-based soils.

3.12 HYDROCARBON EVALUATION OF SOIL SAMPLES FROM THE EX SITU SYSTEM

GC and TPH analyses of soil samples for each ex situ treatment plot were conducted before startup and for three subsequent sampling periods to evaluate changes in hydrocarbon concentration as a function of time and treatment method. Standard curves prepared from diesel fuels obtained from Kwajalein power plant 1 were used to relate the total hydrocarbon concentrations of the GC and the TPH methods. Sect. 3.6 of this report provides information regarding the standard curves.

A comparison of the mean hydrocarbon concentration for each treatment method with the controls for the ex situ plots is presented graphically in Figs. 47 and 48 and a comparison of the two treatment methods used is presented in Fig. 49. Each point in these graphs represents the mean hydrocarbon concentration (average of the diesel concentration by both GC and TPH methods) in the top 15 in. of soil for each plot. The change in mean hydrocarbon concentration for the treatment methods and for the control plots between sampling periods is also tabulated in Table 18. As can be seen from Figs. 47 through 49 and Table 18, there was a significant reduction in hydrocarbon concentration for all plots between the pre-startup (sample period 1) and the first post-operational sampling period (sample period 2), with the hydrocarbon concentration in the plots receiving treatment dropping approximately twice as much as those of the control plots. During this period the mean hydrocarbon concentration dropped 3322 mg/L for the control plots, 6595 mg/L for the plots receiving water and air , and 6740 mg/L for the plots receiving water, air, and nutrients. For the final two sampling periods the reduction of hydrocarbons in all plots was roughly equivalent (~800 to 1100 mg/L removed from each plot per sampling period), with the exception of the final sampling period for the plots receiving water, air, and nutrients where no reduction in hydrocarbons was noted. The final concentration in 5 of the 6 plots was approximately the same (between ~1000 and 2000 mg/L).

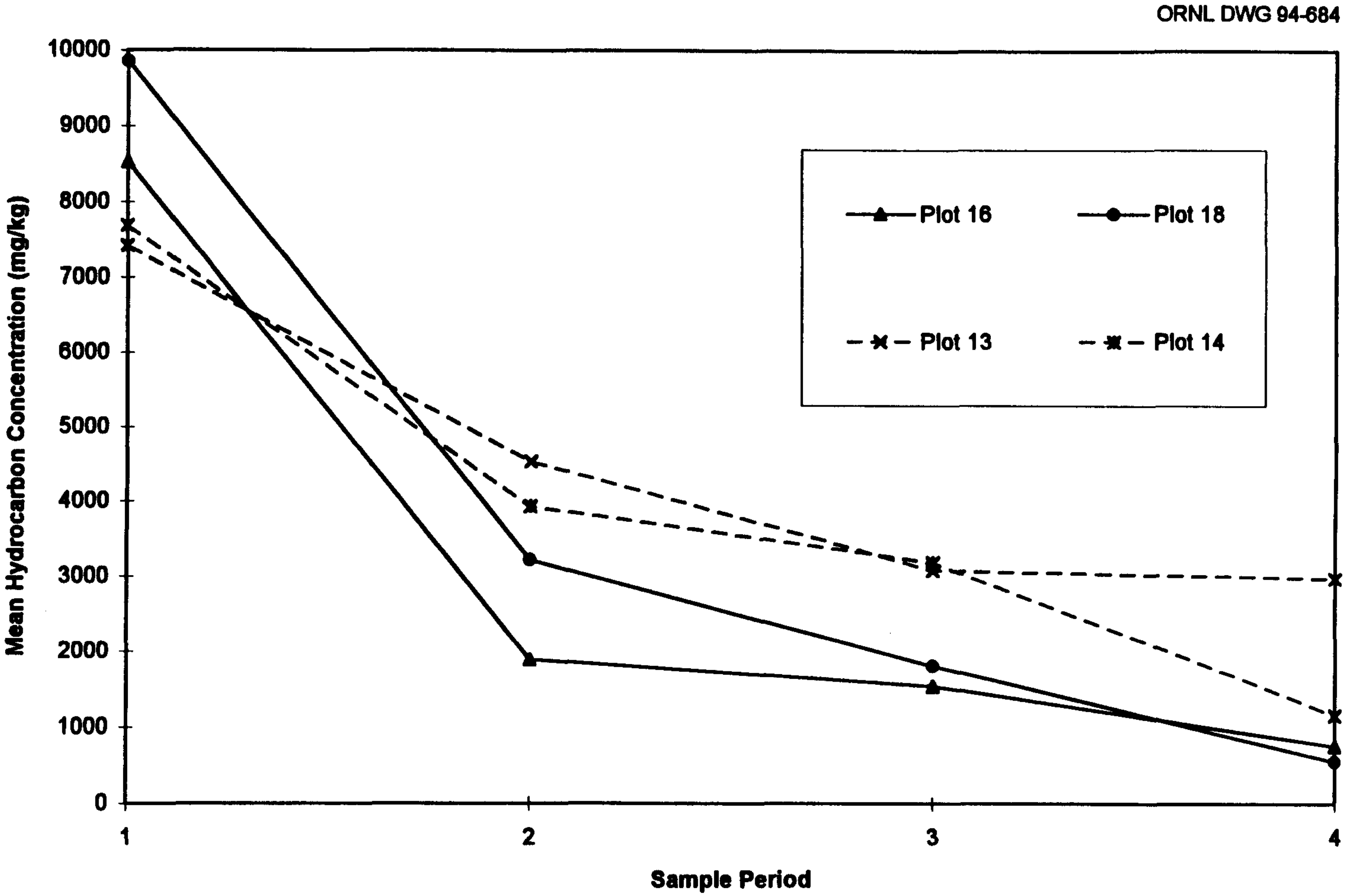

Fig. 47. Mean hydrocarbon concentration for plots receiving water and nutrients (plots 16 and 18) and the control plots (plots 13 and 14).

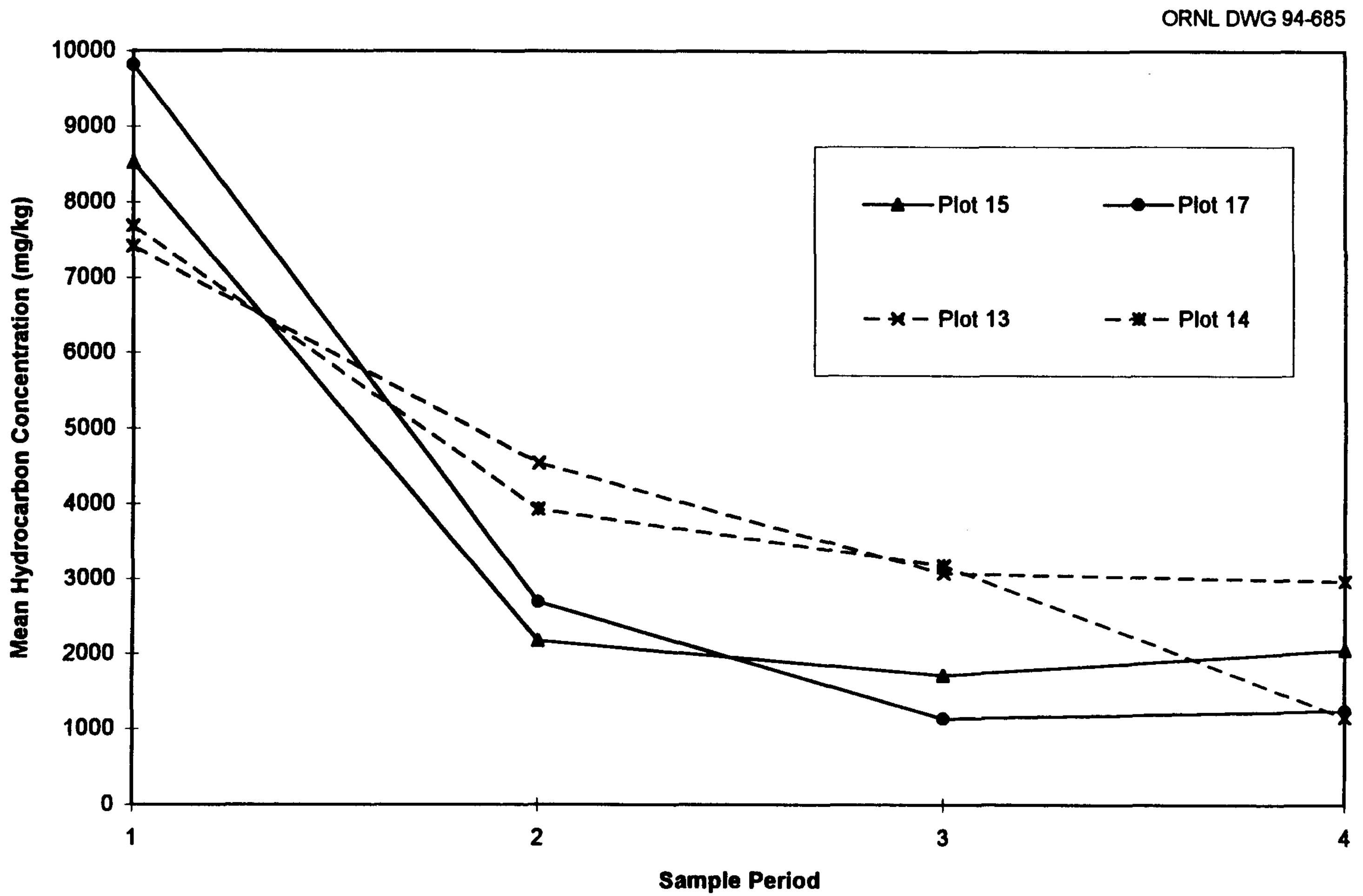

Fig. 48. Mean hydrocarbon concentration for plots receiving water, air, and nutrients (plots 15 and 17) and the control plots (plots 13 and 14).

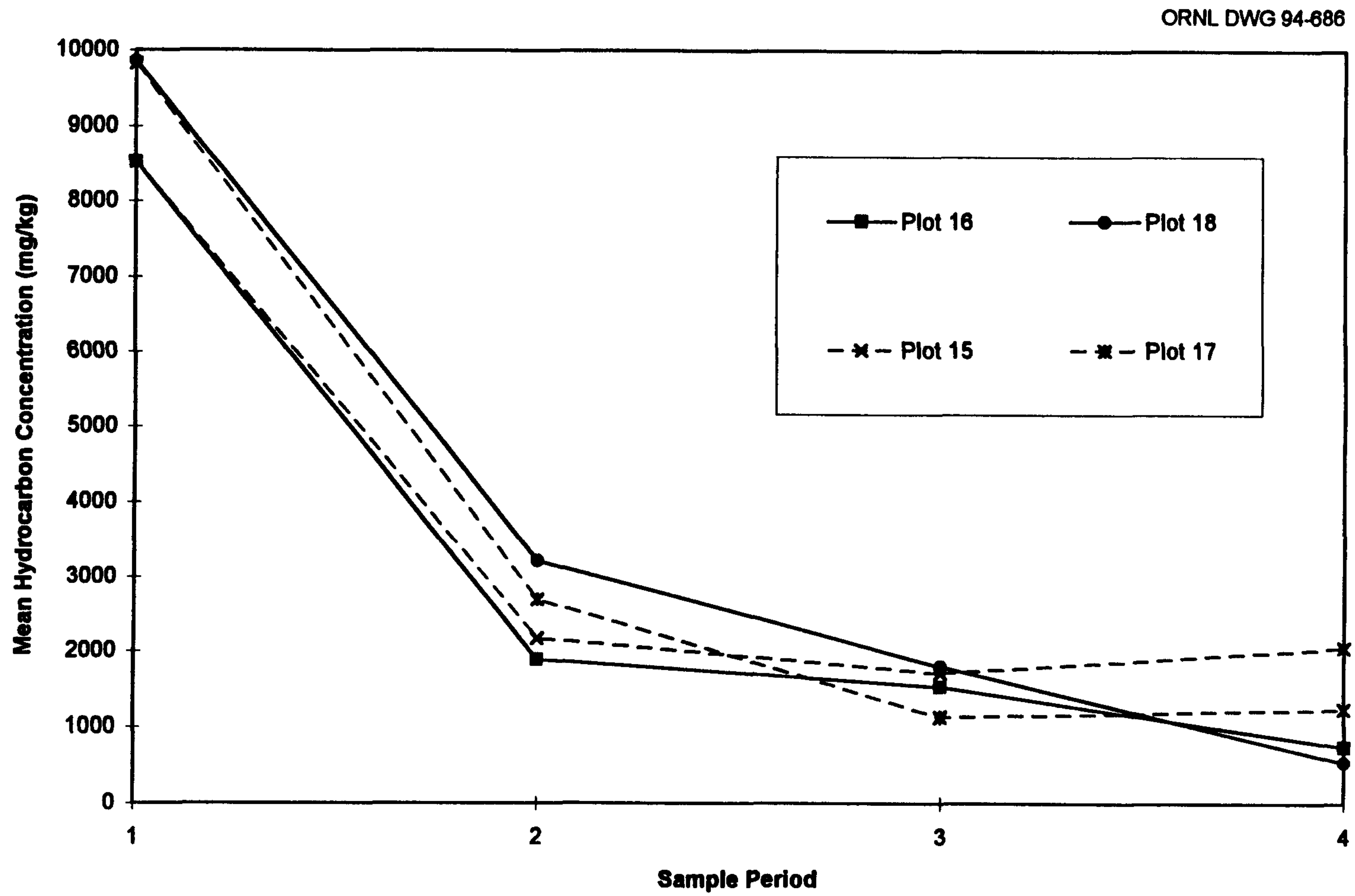

Fig. 49. Mean hydrocarbon concentration for ex situ plots receiving water and nutrients (plots 16 and 18) and plots receiving water, air, and nutrients (plots 15 and 17).

Table 18. Change in mean hydrocarbon concentration (mg/kg) between sampling periods

Period	Control plots	Water and nutrients	Water, nutrients, and air
1-2	3322	6595	6740
2-3	1106	1062	1005
3-4	1060	816	-226

A comparison of the percent of hydrocarbons at various GC retention times, as determined by peak areas, is presented in Fig. 50. As can be seen, with the possible exception of plot 16, no shift in the "fingerprint" of the hydrocarbon contamination was detected within the ex situ plots over time. If hydrocarbons were being degraded, one would expect a decrease over time in the percentage of lighter hydrocarbons, which are easier to biodegrade.

These data suggest that the hydrocarbons in the ex situ plots were not being biodegraded at a rate that could be detected, but were being washed from the soils by the water percolating down from the surface. While the control plots were covered and water was not intentionally added to these plots, rainwater probably entered the plots through holes that developed in the poly-covers as a result of the sun, wind, and blowing rain on Kwajalein. This could explain why the hydrocarbon reduction in the plots receiving water was twice that of the control plots for the early part of the demonstration (some rain was entering the control plots but not nearly as much as was being added to the plots receiving treatments). The hydrocarbon concentration in the final period approached that found in the treatment plots because the tarps had deteriorated and rain was able to flow freely into the control plots. This water leaching of hydrocarbons is consistent with observations made in the soil column treatability studies.

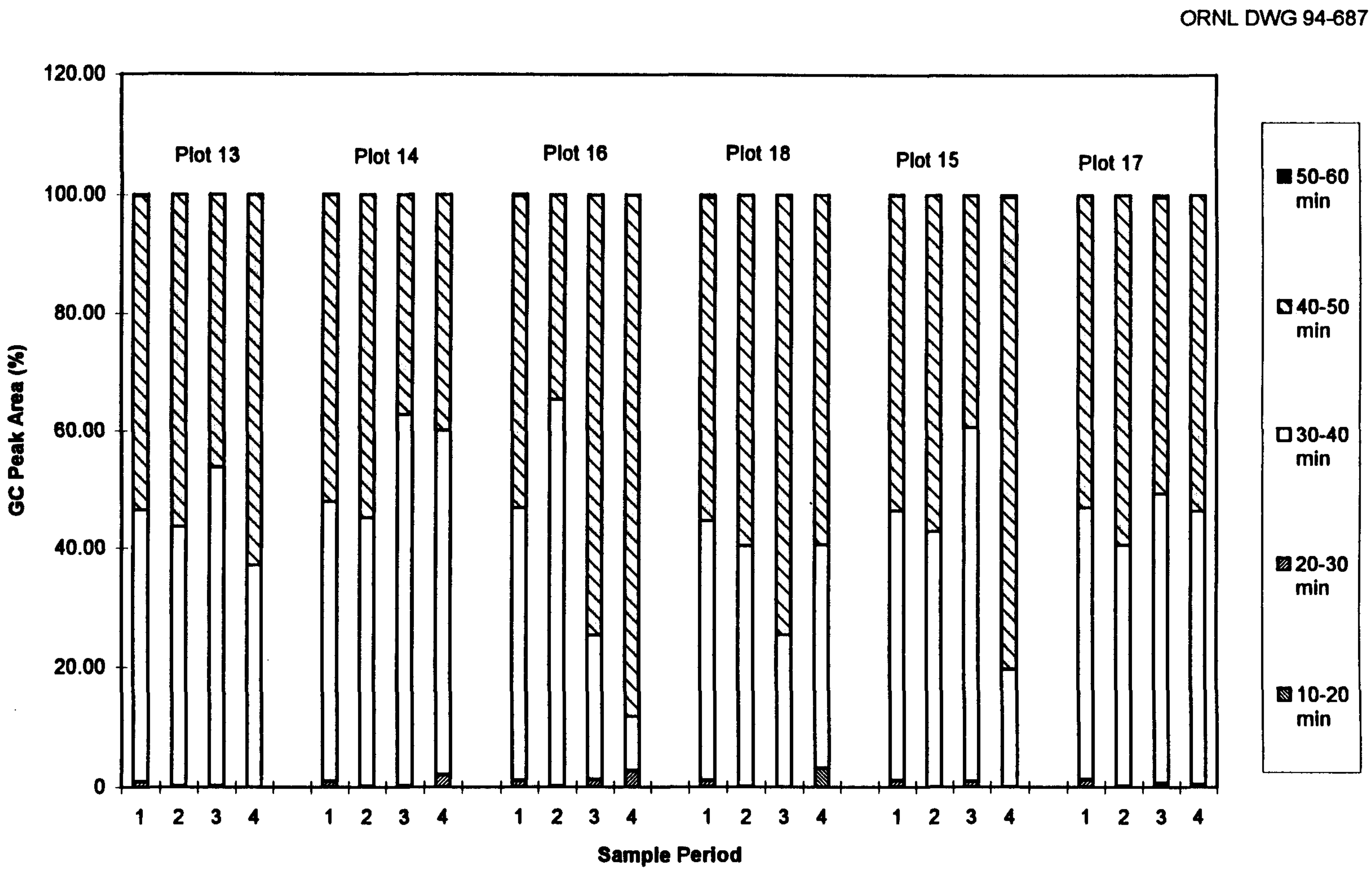

Fig. 50. Percent of gas chromatography (GC) hydrocarbons by GC retention time for the ex situ plots.

4. SUMMARY

A project was conducted to evaluate the feasibility of bioremediation for environmental restoration of soils contaminated with petroleum hydrocarbons on Kwajalein Island, RMI. The project was conducted in four distinct phases: (1) initial site characterization and on-site biotreatability studies, (2) selection of the demonstration site and collection of soils for laboratory column studies, (3) laboratory column biotreatability studies, and (4) on-site bioremediation demonstration.

The initial site characterization and on-site biotreatability studies indicated that bioremediation appeared to be a viable environmental restoration technique for petroleum-contaminated soil on Kwajalein. It was noted that high concentrations of diesel fuel, which were likely weathered and nutrient deficient, might hinder the bioremediation process but it was judged these problems could be overcome by design and operation. Results of the on-site biotreatability studies indicated that further experimentation and a field demonstration were required to determine the design and operating conditions that would provide optimum biodegradation and restoration of the petroleum-contaminated soils.

In the second phase of the project the hydrocarbon concentration throughout the demonstration area was determined, equipment to be used for sampling and installation of the demonstration system was tested, and soil columns were collected for laboratory biotreatability studies. Analysis of the demonstration site indicated that soil in an area of ~128 x 60 ft was contaminated with petroleum hydrocarbons at concentrations >3000 mg/L. This contamination was contained in a narrow band 3 to 6 ft bgs. Hydrocarbon concentrations up to 50 mg/L were detected in some groundwater samples. It was determined that a combination of the Pionjar Vibrating Hammer and the Geoprobe Sampling System was adequate for soil sampling, groundwater sampling, and installation of wells and other demonstration equipment. Twenty-five soil columns, approximately 3 ft diam by 3 ft long, were collected and shipped to ORNL for biotreatability studies.

The column biotreatability studies used 25 columns to characterize the bacterial population as well as to evaluate biological treatment using various combinations of water, air, nutrient, and microbial additions. It was determined that the bacterial population in the upper 10 in. of Kwajalein soils was typical of surface soils and that the bacterial numbers decreased below a soil depth of 10 in. Test results demonstrated that many of the organisms present in the soil samples were capable of degrading certain fractions of hydrocarbons and that the degradative activity of the native population was stimulated by the addition of air and nutrients. However, bioaugmentation, which is the addition of microorganisms to the columns, did not permanently increase the biomass. In terms of hydrocarbon removal, the greatest change from controls occurred as a result of water flushing. The column biotreatability studies concluded that biodegradation of diesel fuel contaminants in Kwajalein soils was possible using indigenous microbes. However, the reduction to levels below 100 mg/L by an in situ bioremediation process might be a difficult and lengthy process because of the proportion of more slowly biodegradable, higher molecular weight fuel (i.e., weathered diesel fuel) present.

In general, the results of the column studies agreed with those from the initial on-site and laboratory biotreatability studies. This included the following: (1) indigenous microorganisms on Kwajalein were capable of degrading certain fractions of hydrocarbons, (2) bioremediation appeared to be a viable alternative for environmental restoration at Kwajalein, (3) addition of air and nutrients would be required to increase the numbers of microorganisms in the areas of contamination to enhance bioremediation, (4) high concentrations of weathered diesel fuel might be difficult to biodegrade, and (5) an on-site demonstration was required to further evaluate bioremediation for environmental restoration of petroleum contaminated soils on Kwajalein Island.

An on-site demonstration of an in situ biological system was conducted over an 11-month period and an ex situ system was evaluated over a 3-month period. These systems evaluated the use of various combinations of water, air, and nutrients for increasing the bacterial density and decreasing the hydrocarbon concentration within the demonstration area. Ester-linked PLFA analyses for the in situ system indicated that the addition of air and nutrients resulted in an increase in the bacterial population by approximately 1 to 2 orders of magnitude over pre-startup samples. PLFA analyses also indicated that (1) before the demonstration the bacteria were not actively dividing and appeared to be starved for certain essential nutrients, (2) there was a shift in the bacteria from a predominantly gram-positive population before conducting the demonstration to a population of ~50% gram-negative bacteria in the post-startup soil samples, and (3) the microorganisms from post-startup soil samples showed an increase in aerobic potential and/or a decrease in the number of stationary phase microorganisms. Some evidence indicated that phosphate was being bound in the top 3 ft of soil was thus not available as a nutrient for bacteria in the contaminated area. This situation may have prevented maintenance or an increase in the bacterial population density. Statistical analysis of the data indicated that reductions in the hydrocarbon concentration during the bioremediation demonstration occurred only in those plots receiving a combination of water, air, and nutrients. The hydrocarbon reduction rate in those three plots receiving water, air, and nutrients ranged from 6 to 12 mg/kg per day with an average of 9 mg/kg per day. If this average removal rate could be maintained, it would take ~3 years to remediate the demonstration site. However, it is likely that the degradation rate would slow down because the lightest remaining hydrocarbons in the weathered diesel fuel would probably be degraded first, leaving successively higher molecular weight hydrocarbons that would be more difficult to biodegrade.

While it cannot be proven that the decrease in hydrocarbon concentration in the in situ plots is caused by biological degradation, results of this study indicate that at least a portion of the decrease is the result of biological degradation. The following evidence supports this conclusion: (1) the hydrocarbons at the demonstration site consisted of weathered diesel fuel; the weather components left were not likely to be easily volatilized; (2) PLFA analysis before the demonstration indicated that bacteria present within the contaminated soils were not actively dividing; however, soil samples taken during the demonstration indicated that there had been a decrease in the number of stationary-phase bacteria and/or the microorganisms showed an increase in aerobic potential; and (3) only plots receiving a combination of air, water, and nutrient — those components necessary for biodegradation — experienced a decrease in hydrocarbon concentration over the demonstration period.

The CFUs in the ex situ plots receiving a combination of water, air, and nutrients increased over the first ~30 days of operation, reaching numbers similar to those obtained in the in situ plots receiving a combination of water, air, and nutrients, and then decreased for the remainder of the demonstration period. The hydrocarbon concentration in all ex situ plots experienced a significant decrease over the demonstration period; however, evaluation of the data indicated the hydrocarbons were probably washed from the ex situ plots and not biodegraded.

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APPENDIX A

ANALYTICAL AND BIOLOGICAL PROCEDURES USED FOR ON-SITE ANALYSES DURING THE BIOREMEDIATION DEMONSTRATION AT KWAJALEIN ISLAND

Bromide

Equipment

Orion Model 420A pH/ISE meter
Orion Model 90-02 double junction reference electrode
Orion Model 94-35 bromide electrode
magnetic stirrer
polishing strips for bromide probe (if necessary)

Solutions/reagents

1000 ppm Br^- stock solution (or 0.1M NaBr activity standard, Orion 943506)
ionic strength adjustor (ISA), 5M $NaNO_3$ (Orion 940011)
reference electrode filling solutions
- inner chamber, green colored solution saturated with AgCl (Orion 900002)
- outer chamber, 10% KNO_3 (Orion 900003)

distilled water

Procedure for sample measurement

1. Prepare the electrodes as directed in their respective instruction manuals and connect the electrodes to the meter. Make sure meter is set to measure mV.

2. Prepare a 50 ppm standard solution using the 1000 ppm Br^- stock solution (25 mL 1000 ppm Br^- and fill to mark with distilled water in 500 mL volumetric flask) for comparison to the current calibration curve.

3. Measure 100 mL of the 50 ppm standard into a 250-400 mL beaker. Add 2 mL ISA and stir thoroughly.

4. Rinse electrodes with distilled water, blot dry, and place in beaker containing the standard. When stable reading is displayed, record the mV value.

5. Using the current calibration curve, determine the concentration corresponding to the mV value obtained in Step 4. If the concentration is not 50 +/- 5 ppm, prepare a new calibration curve using the procedure outlined on the following page. If the concentration is in the specified range, proceed with sample measurement in Step 6.

6. Measure 100 mL sample into beaker (using 100 mL graduated cylinder). Add 2 mL ISA. Rinse electrodes with distilled water, blot dry, and place in beaker containing the sample. When stable reading is displayed, record the mV value. **If electrode response is slow, the membrane may contain a surface layer of contaminants. Restore performance by polishing the electrode membrane with a polishing strip and rinsing with distilled water.**

7. Determine sample [Br^-] using the calibration curve.

8. Repeat steps 6-7 for all samples. Rinse probes, beakers, and graduated cylinder between samples. Verify calibration after every 10 samples by placing electrodes in an aliquot of standard solution.

(continued)

Bromide

Procedure for direct calibration: Preparation of calibration curve

1. Prepare the electrodes as directed in their respective instruction manuals and connect the electrodes to the meter. Make sure meter is set to measure mV.

2. Use the 1000 ppm Br^- stock solution to prepare 3 standards by serial dilution that bracket the expected sample range and differ in concentration by a factor of ten.

3. Measure 100 mL of the most dilute standard into a 250-400 mL beaker. Add 2 mL ISA and stir thoroughly.

4. Rinse electrodes with distilled water, blot dry, and place in the beaker. When a stable reading is displayed, record the mV value and the corresponding standard concentration.

5. Repeat steps 3-4 for the other two standard solutions. (Measure the most concentrated standard solution last.)

6. To obtain the calibration curve, prepare a semi-log plot with mV values on the linear axis and standard concentrations on the logarithmic axis.

7. Regress data with Lotus 1-2-3 to obtain a linear equation relating mV values and [Br^-] that can be used to determine [Br^-] in samples.

Total Coliform (soil)[1]

Equipment
Millipore Coli-Count Sampler
Incubator with temperature range to 35°C
Illuminated magnifier at least 5X
Sterile water if dilution is required

Procedure

1. Weigh a given amount (specify???) of soil in a Whirl-pak bag. Dilute with 100 mL sterile water. Seal the bag and place into a sonic bath and run for 2-4 minutes. Allow any solids to settle.

2. Remove the sampler from its plastic bag and write on the case with an indelible marker the sample identification number.

3. Aseptically (???) pour the upper layer of sample liquid from the Whirl-pak bag (or dilution)[2] into the Sampler case, filling to the upper graduation (18 mL).

4. Insert the Sampler paddle firmly into the case containing the sample and carefully lay the unit with the membrane facing down onto a flat surface. Make certain that the membrane is uniformly wet, and while in this position, the unit should **not** be agitated. Allow **30 seconds** for the sample to be drawn through the filter. If the sample is viscous, the paddle should remain in the case for additional time (up to 2 minutes). **Note: If the entire membrane is properly wetted, the Coli-Count filter (grid) will appear very light gray.**

5. Remove the paddle and with a firm snap of the wrist, shake off the excess liquid. Empty the case aand reinsert the paddle. **To prevent the paddle from drying out during incubation, it should be firmly seated in the case to form an airtight seal.**

6. Incubate the Sampler, gridded side down, at 35°C for 22-24 hours.

7. After the incubation period, remove the paddle from the case and examine the filter surface with an illuminated magnifier. **Coliforms are blue in color. Non-coliforms are green, gray, or cream color.**

8. **REWORK FOR SOIL TO GIVE COLIFORM/SOIL MASS.** Total coliform should be reported as the number per 100 mL of sample; therefore, in undiluted samples count the number of blue colonies and multiply by 100 to obtain the coliform/100 mL. If the sample was diluted (see note 2 below), multiply the 100 mL count by the appropriate dilution factor to obtain colifrom/ 100 mL.

(continued)

Total Coliform (soil)[1]

<u>Notes</u>:

1 Sample containing residual chlorine must be neutralized with sodium thiosulfate (0.1 mL of 10% solution/4 oz. sample) prior to testing with the Coli-Count Sampler.

2 Where ***exact*** counts are ***not*** required, samples containing an estimated microorganism level of up to 400/mL (i.e., 400 colonies counted on the grid) may be tested without dilution. For ***exact*** counts, any sample containing more than 200/mL should be diluted. If a 1:10 dilution is required, simply fill the Sampler case with sample up to the lower graduated line (1.8 mL), add sterile water to the upper graduation line (18 mL) and proceed with test. For a 1:100 dilution, pipette 0.18 mL of sample into the case, add sterile water to the 18 mL mark and proceed with the test. For higher dilutions, a Millipore dilution kit is recommended.

Total Coliform (liquid)[1]

Equipment
Millipore Coli-Count Sampler
Incubator with temperature range to 35°C
Illuminated magnifier at least 5X
Sterile water if dilution is required

Procedure

1. Remove the sampler from its plastic bag and write on the case with an indelible marker the sample identification number.

2. Pour sample liquid (or dilution)[2] into the Sampler case, filling to the upper graduation (18 mL).

3. Insert the Sampler paddle firmly into the case containing the sample and carefully lay the unit with the membrane facing down onto a flat surface. Make certain that the membrane is uniformly wet, and while in this position, the unit should not be agitated. Allow 30 seconds for the sample to be drawn through the filter. If the sample is viscous, the paddle should remain in the case for additional time (up to 2 minutes). **Note: If the entire membrane is properly wetted, the Coli-Count filter (grid) will appear very light gray.**

4. Remove the paddle and with a firm snap of the wrist, shake off the excess liquid. Empty the case and reinsert the paddle. **To prevent the paddle from drying out during incubation, it should be firmly seated in the case to form an airtight seal.**

5. Incubate the Sampler, gridded side down, at 35°C for 22-24 hours.

6. After the incubation period, remove the paddle from the case and examine the filter surface with an illuminated magnifier. **Coliforms are blue in color. Non-coliforms are green, gray, or cream color.**

7. Total coliform should be reported as the number per 100 mL of sample; therefore, in undiluted samples count the number of blue colonies and multiply by 100 to obtain the coliform/100 mL. (Recall that the Coli-Count test is based on 1 mL of sample being taken up by the media.) If the sample was diluted (see note 2 below), multiply the 100 mL count by the appropriate dilution factor to obtain coliform/ 100 mL.

Notes:

1 Sample containing residual chlorine must be neutralized with sodium thiosulfate (0.1 mL of 10% solution/4 oz. sample) prior to testing with the Coli-Count Sampler.

2 Where *exact* counts are *not* required, samples containing an estimated microorganism level of up to 400/mL (i.e., 400 colonies counted on the grid) may be tested without dilution. For *exact* counts, any sample containing more than 200/mL should be diluted. If a 1:10 dilution is required, simply fill the Sampler case with sample up to the lower graduated line (1.8 mL), add sterile water to the upper graduation line (18 mL) and proceed with test. For a 1:100 dilution, pipette 0.18 mL of sample into the case, add sterile water to the 18 mL mark and proceed with the test. For higher dilutions, a Millipore dilution kit is recommended.

Carbon Dioxide (CO_2) and Oxygen (O_2): (soil gas)

<u>Equipment</u>

- Gastechtor Model 3252OX Carbon dioxide/oxygen indicator
- 500 mL syringe with connection for vapor implants
- gas sample bags with connection for 500 mL syringe and Gastech analyzer
- Digital thermometer set to read °C
- CO202.SHT and CO2O2CAL.SHT data sheets
- **for the 4.5 ft implant only:** "knockout pot" (i.e., 250-500 mL erlenmeyer w/ two-hole rubber stopper fitted with connections to the vapor implant and the 500 mL syringe and/or the Gastech analyzer)

<u>Instrument Preparation</u>

1. Connect probe and hose to fitting on front of instrument.

2. Press **POWER** switch to turn instrument on; orange indicator dot shows. Meter will initially deflect upscale and pulsing alarm signal will sound. If alarm does not sound, switch the **ALARM** switch to the **OUT** position. Audible hum of pump will be noticed.

3. With range select switch in CO_2 position (OUT), press **BATT CK** button and note meter reading. If reading is below **BATT CHECK** mark on meter, turn off instrument and replace battery pack.

4. Allow to warm up in CO_2 range until the meter stabilizes (about a minute). With probe inlet in a normal air location, turn **CO_2 ZERO** shaft to bring meter to halfway between 0 and the first increment on the CO_2 scale (approximately 0.05%).

5. Next, put the range switch in **OXY** position (IN). Verify that probe is in a normal air location; then turn **OXY CAL** control to bring meter to 21% (CAL) indication.

6. Verify normal operations by breathing out through your mouth and letting the probe sample your breath.

   Oxygen reading should move downscale and activate the alarm at 19.5%. In CO_2 range, reading should come up to about 2.5%. Both alarm lights and a steady audible alarm tone should come on during this test. If instrument reacts appropriately during this test, it is ready to use.

7. Deactivate the audible tone by pushing in the **ALARM** switch in.

8. Proceed with sample collection as outlined below.

(Continued)

Carbon Dioxide (CO_2) and Oxygen (O_2): (soil gas)

<u>Sample Collection and Analysis Procedure</u>

For the 2.5 ft implant (i.e., 2.5 ft below ground surface and the implant located closer to the plot center):

1. Connect the Gastech analyzer to the implant to be sampled and record %O_2 and %CO_2. **Note: The %CO_2 will probably be above the detection range (i.e., >5%).** The %O_2 reading can be used as a check for the value backcalulated from the diluted sample (Step 4).

2. Connect the 500 mL syringe securely to the vapor implant and collect a 500 mL sample.

3. Allow a few minutes for sample to reach the temperature of the ambient air that will be used for dilution air.

4. Record ambient temperature using the digital thermometer set to read °C.

3. Inject 500 mL sample and 1500 mL dilution air into gas sample bag.

4. Attach gas sample bag to prepared analyzer (see INSTRUMENT PREPARATION above) and record %CO_2 and %O_2. It should take 3-4 minutes for the sample bag to empty. Record the highest concentration observed.

5. Calculate actual concentrations using prepared spreadsheet.

For the 4.5 ft implant (i.e., 4.5 ft below ground surface and the implant closer to the outside corner of each plot):

1. If the 4.5 ft vapor implant is to be sampled: Prior to sampling, use the Solinst water level meter to measure the depth to the surface of the groundwater to ensure that the level of the groundwater is below the depth of the implant that is to be sampled. If the depth to groundwater surface is greater than 4.5 ft, use the "knockout pot" and follow Steps 1-5 above for the 2.5 ft implant. **DO NOT SAMPLE IF THE DEPTH TO THE SURFACE OF THE GROUNDWATER IS LESS THAN OR EQUAL TO 4.5 FT.**

Procedure: Chemical Oxygen Demand (COD)

Comment: This procedure details the COD analysis for the Hach 0-1500 mg/L COD analysis using the DR-100 colorimeter. The chloride level of the sample should be not be greater than 2,000 mg/L chloride.

1. Preheat COD reactor to 150°C. Label COD vials with the appropriate sample numbers.

2. Wrap a towel around a High Range COD vial and cautiously remove the cap. While holding vial at a 45-degree angle pipet 2.00 mL of sample into the vial. (Spilled reagent will affect test results and is hazardous to the skin. Do not run analyses on vials which have reagents spilled from them.)

3. Wrap a towel around the vial, replace the cap, and wipe vial clean. Holding the vial by the cap over an empty sink, gently invert several times to mix the contents. (The vial will become hot during mixing.)

4. Prepare a reagent blank by repeating steps 3-5, substituting 2 mL of distilled water for the groundwater sample. (One blank from the same lot of vials must be run with each set of samples.)

5. Prepare a standard by repeating steps 3-5, substituting 2 mL of KHP stock solution (500 ppm COD) for the groundwater sample. (One standard from the same lot of vials must be run with each set of samples.)

6. Place the vials in the preheated COD reactor and incubate the vials for 2 hours at 150°C.

7. Turn the reactor off and let the vials cool to 120°C or less. Invert each vial several time while still warm, place them in a cooling rack, and allow them to come to room temperature.

8. Measure the COD in the Colorimeter.

9. Open the light shield and turn the Right Set control fully clockwise. Place the COD Vial Adapter into the sample well in the Left Set position and cover with the light shield.

10. Hold the On button down while adjusting the Left Set control to align the meter needle with the arrow at the extreme left of the scale arc.

11. Rotate the COD vial adapter to the Right Set position, remove the light shield and insert the vial containing the reagent blank. Replace the light shield.

12. Hold the On button down while adjusting the Right Set control for a meter reading of 0 mg/L.

13. Remove the light shield and reagent blank. Place the vial containing the test sample into the adapter and cover with the light shield. (The vials should be placed in the holder with the with the logo facing the front. The vials must be kept free of finger prints and scratches.) Read the mg/L COD from the meter scale.

Procedure: Isooctane Extraction Of Soil And Ground Water Samples For GC Analysis

1. Place duplicate sample identification on 100mm screw cap with PTFE liner test tubes. One of the tubes will be used for sonicating the sample along with the isooctane extraction solvent. The other test tube will be used for the extraction aliquots.

2. Add 3 mL of ground water or 3 +/- 0.03 grams of soil sample to a 100 mm test tube. If a soil sample is added, tap soil to the bottom of the vial.

3. Pipet 2 mL of isooctane (containing C19) into the 100 mm test tube containing the sample to be analyzed.

4. Place a clean, dry teflon lined cap on the 100 mm test tube and tighten the cap.

5. Vortex the test tube for approximately 30 seconds.

6. Place test tube into test tube rack which been placed in the sonicator.

7. Repeat steps 1-7 for all samples to be run.

8. Sonicate for 16 hours on a 30 minute on, 30 minute off cycle using the automatic timer.

9. At the end of the 16 hour sonication cycle, centrifuge the samples for 5 minutes at 1800 rpm (a blue pen mark on the centrifuge speed knob denotes the speed setting for the required rpm). Transfer the ~2 mL isooctane aliquots to the previously labelled clean, dry 100 mm test tubes using pasteur pipets (one for each sample and each containing a cotton plug).

10. Add another 1 mL aliquot of isooctane to the original soil (or water) sample, vortex for 30 seconds, and place in the test tube rack located in the sonicator.

11. Sonicate the samples containing the 1 mL isooctane aliquot for 8 hours on a 30 minute on, 30 minute off cycle.

12. After 8 hours sonification, centrifuge the samples for 10 minutes at 1800 rpm. Use pasteur pipets to remove the 1 mL aliquots, and place the 1 mL isooctane extraction aliquots in the appropriately labeled, 100 mm test tubes containing the initial 2 mL isooctane aliquots. Vortex the test tubes to mix well.

13. Store extraction aliquots in the freezer until ready for GC analysis.

14. To prepare sample aliquots for GC analysis, add a septum and cap to the appropriate number of GC vials. Place the sample number or appropriate identification on each GC vial. Vortex the samples to mix. Using a separate pasteur pipet for each sample, transfer ~1 mL of isooctane extraction aliquot from each test tube in step 14 into a 12 x 32 mm GC vial and cap tightly.

15. Run samples on the GC using the FID detector.

RUNNING THE GC WITH STANDARDS AND SAMPLES

1. Check the carrier gas flow in the column. (You need to do this after set-up, changing column pressure, or anything else which might affect the times at which the GC standards travel through the capillary column).

   a) Build the appropriate GC method (See Appendix 1. List of GC Method Parameters.)

      The method should contain the following: Inital Temp= 50, Hold Time= 5 min, Final Col Temp= 200, Rate= 2/min, Relay= 0.05, Injector Temp= 100, Detector Temp= 250

   b) Select Method

   c) Make sure gases for PID are off and gases for FID are on and the front column is set to 22 psig.

   e) Turn on flame or verify that flame is on.

   f) Make sure integrator is set for FID and hooked to correct plug on GC.

   g) Hit the following on the GC: <STATUS> <METHOD _> <ENTER>

   h) Inject 2 microliters of butane into detector, start integrator, and note time interator detects peak after injection (time on GC pannel). The flow of the carrier gas can be calculated from the following formula:

$$\text{Flow (mL/min)} = \frac{11 r^2 L}{T}$$

where

11 = 3.14
r = radius
L = column length in cm
T = time in min.

   For a 0.53 mm ID, 30 meter column, divide 6.62 by the time it took for the butane to exit the column. The ideal flow should be 30 mL/min. As long as you are close to 30 and have a constant flow you are alright. (We had a flow of 22 mL/min with the rental unit).

(continued)

RUNNING THE GC WITH STANDARDS AND SAMPLES

2. BETEX Calibration For FID: Should run at least two standards in the morning, one at approximatly noon, and one in the afternoon. Run the first standard with CA=0 to verify the library. If the library is not correct you will have to rebuild the library (ie., run with CA=1 and input residence times (RT) and concentrations into the library.

   a) Set the intergrator as shown in Part A of Appendix 2. - Integrator Method For FID with FI=1 (1 for FID) and CA=0 (0 for no calibration).

      Also enter <SHIFT-DIALOG> on integrator and identify analyst, sample name, sample volume, GC method, etc,

      Make sure CA=0 is you do not want to replace your library with the numbers in this run

      <ATTN> and set attenuation on integrator

   b) Set and activate the appropriate GC method. (See Appendix 1. List of GC Method Parameter). The method should have the following parameter:

      Initial Temp= 40, Hold Time= 5 min, Final Col Temp= 200, Rate= 8/min, Relay= 0.05

   c) Make sure flame is on and that temperatures and detector baseline are stable.

   d) Inject 1 microliter BTEX standard. (You can abort run and integration after about 8 minutes.) Compare the results of this run with the results stored in the library and make sure you have the right retention times, the right concentratios, and the correct order of standards coming off the column. If not you will have to rebuild the library.

      If your concentrations do not agree within +/- 5% with the library standards, inject a second BTEX standard with CA=0. If the runs are not within +/- 5%, rubuild the library. (Check Angie's written notes for rebuilding library).

3. Run Samples with FID Detector.

   a) Run standards (#2 above) to verify calibration.

   b) Set up integrator as shown in Part A of Appendix 2. - Integrator Method For FID. **Make sure CA=0**

(continued)

RUNNING THE GC WITH STANDARDS AND SAMPLES

c) Set and activate the appropriate GC method. (See Appendix 1. List of GC Method Parameters). The method should have the following parameter:

Initial Temp= 40, Hold Time= 5 min, Final Col Temp= 200,
Hold Time= 50 min, Rate= 8/min, Relay= 0.05

d) Make sure flame is on and that temperatures and detector baseline are stable and the integrator is plugged into DET B on the GC.

e) Inject 1 microliter sample into injector and activate the integrator.

4. Run Samples with FID Detector.

a) Run standards (#2 above) to verify calibration.

b) Set up integrator as shown in Part A of Appendix 3. - Integrator Method For ID. Make sure CA=0

c) Set and activate the appropriate GC method. (See Appendix 1. List of GC Method Parameters). The method should have the following parameter:

Initial Temp= 40, Hold Time= 5 min, Final Col Temp= 200,
Hold Time= 50 min, Rate= 8/min, Relay= 0.05

d) Make sure lamp is on and that temperatures and detector baseline are stable and the integrator is plugged into DET A on the GC.

e) Inject 1 microliter sample into injector and activate the integrator.

5. At end of sampling day.

a) Run column with no injection to make sure it is not contaminated. If it is contaminated you will have to burn column. (See Appendix 1. List of GC Method Parameters) for method to run on GC.

b) If it is not contaminated set up unit for PID run before leaving. (Make sure lamp and flame are off).

c) Turn off hydrogen flow at bottle and on GC pannel.

SETUP AND STARTUP OF VARIAN 3400 GC

1. Hook up integrator to GC

   a) On the back of the integrator connect the white wire to the positive terminal, the black wire to the negative terminal, and the green, green ground wire to the chassis of the integrator.

   b) Plug in the connector on the other end of the cord to the appropriate detector (**Detector A (PID) or Detector B (FID)**).

2. Place pressure regulators on the gas cylinders.

3. Connect 1/8" copper tubing to the brass fittings located on the pressure regulators.

4. Set pressure regulators on the gas cylinders.

Carrier gas (helium or nitrogen)	80 psi
Hydrogen	40 psi
Air	60 psi

5. Close the needle valves on the copper supply lines to prevent gas from flowing when the valve on the top of the cylinder is open.

6. Open the valve on the top of the gas cylinders.

7. Open the need valves on the gas supply lines long enough to blow out any dust, etc. which may have collected in the lines and then close the needle valves.

8. Connect the gas lines to the appropriate fitting on the back of the GC.

9. Remove the rod locking the GC fan in place and place it on top of the GC.

10. Open the panel on the front of the GC and close the flow control valves to all gases (for both the PID and FID).

11. Open the needle valves on the gas cylinders all the way open to supply gas to the GC.

12. Use snoop detector to check for leaks at the cylinders and at the back of the instrument.

Note You will install the capillary column for either the PID (Step 13a) or the FID (Step 13b).

13a. Installation of capillary column to PID detector and split/splitless injector.

   a) Turn off oven if it is on, allow it to cool to less than 50°C, and remove the insulated oven door.

b) Place the end of the fitting cap which will be connected to the injector 5.7 cm from the end of the capillary tube (the end of the tube must be smooth and round) and mark at the 5.7 cm mark with liquid paper.

c) Connect the cap to the injector and make sure the fitting does not slip from the 5.7 cm position marked with liquid paper.

d) Place the end of the fitting cap which will be connected to the PID detector 12.0 cm from the end of the tube (the end of the tube must be smooth and round) and mark the 12.0 cm mark with liquid paper.

e) Connect the cap to the PID detector and make sure the fitting does not slip from the 12.0 cm position marked with the liquid paper.

f) Make sure the capillary column in supported by the metal support around the capillary column. The capillary collumn should not be touching any internal portion of the oven except the connectors at the injector and detector.

13b. Installation of capillary column to FID detector and split/splitless injector.

a) Turn off oven if it is on and allow it to cool to less than 50°C and remove the insulated door.

b) Place the end of the fitting cap which will be connected to the injector 5.7 cm from the end of the capillary tube (the end of the tube must be smooth and round) and mark at the 5.7 cm mark with liquid paper.

c) Connect the cap to the injector and make sure the fitting does not slip from the 5.7 cm position marked with liquid paper.

d) Place the end of the fitting cap which will be connected to the FID detector 11.5 cm from the end of the tube (the end of the tube must be smooth and round) and mark the 11.5 cm mark with liquid paper.

e) Connect the cap to the FID detector and make sure the fitting does not slip from the 11.5 cm position marked with the liquid paper.

f) Make sure the capillary column is supported by the metal support around the capillary column. The capillary column should not be touching any internal portion of the oven except the connectors to the injector and detector.

(continued)

SETUP AND STARTUP OF VARIAN 3400 GC

14. Install Septum In Split/Splitless Injector

    a) Make sure injector temperature is less than 80°C. Turn column pressures to 0.

    b) Using tweezers, place septum (red) in ispropyl alcohol, soak for a few minutes, and place in injector with tweezer making sure the septum is seated properly.

    c) Set pressure of column 1 to 22 psig and column 2 to 7 psig (if this is not the initial set up of the GC and the flows to the PID and FID are already set).

15) Set gas flows for operation of the PID.

    a) Turn off the GC oven if it is on (Shift) (Column Oven Off)

    b) Let oven cool to less than 50°C, turn off all gas flows to the PID and FID on the GC pannel, and remove the insulated door.

    c) Connect the rubber tube on the "Bubble Tube Flow Meter" to the stainless steel tube on the PID detector inside the oven.

    d) Open the flow meter for the makeup gas (inside the cover) all the way. Also, set column 1 pressure at 22 psig using the gauge on the GC pannel.

    e) Set the flow of the makeup gas to 30 mL/min using a jewelers screw driver.

16. Set gas flow for operation of the FID

    a) Turn off the GC oven if it is on (Shift) (Column Oven Off)

    b) Let oven cool to less than 50°C, turn off all gas flow to the PID and FID on the GC pannel, and remove the insulated door.

    c) Place the rubber stopper with the stainless tube inserted into the hole on the top of the FID and connect the rubber tube on the "Bubble Tube Flow Meter" to the stainless steel tube located on the stopper which has been place in the FID detector.

    d) Turn off the air and makeup gas to the FID detector (inside the GC cover).

    e) Open the flow meter for the hydrogen (inside the cover) all the way. Also, set the pressure to column 1 at 22 psig using the gauge on the GC pannel.

    f) Set the flow of the hydrogen to 30 mL/min using a jewelers screw driver.

(continued)

SETUP AND STARTUP OF VARIAN 3400 GC

g) Leave the hydrogen gas at 30 mL/min and open the flow meter for the makeup gas on all the way.

h) Adjust the makeup gas using a jewelers screw driver and set the total flow at 60 mL/min (30 mL/min hydrogen + 30 mL/min makeup (helium)).

i) Leave the hydrogen flow at 30 mL/min, the makeup at 30 mL/min, and open the flow control valve for the air completely.

j) Set the total flow to 360 mL/min (30 mL/min hydrogen, 30 mL min makeup (helium) 300 mL/min air.

k) Remove the plug from the top of the FID and replace the insulated door.

17. Configure GC

a) (GC Config) This configuration for PID

Set time or date?		N
Set temp limit?	N	
Set checks for GC ready?		N
Set lock code?	N	
Turn hardware on/off?	Y (for detectors)	
Set detector A on?		Y (A=PID)
Set detector B on?		N (B=FID)
Detector oven on?		Y
Injector oven on?		Y
Auxiliary oven on?		N (No auxiliary oven present)
Coolant to column?		N
Other configuration		N
GC Configure Table Complete		

(Status) To get out of configuration.

(continued)

18. Build a method

a) (Build Modify)

Select Method/Selection or Table		(Method 2)	Here method 2 is for PID
Initial col temp?		40	
Initial col holding time?	5		
Pgm 1 final col temp?		200	
Pgm 1 col rate in o/min?		8.0	
Pgm 1 col hold time?		15.0	
Add next col program?	N	This is for 2nd gradient.	
Injection temp?	250	No higher than 350	
Detector temp?	250	No higher than 350	
Detector A or B?		A	A=PID
PID A initial attenuation?		8	
PID A initial range?		11	Default is 9
PID autozero on?		Y	
Time program PID A?	N		
Add FID B selection?	N		
Add relay selection?		Y	
Initial relay?		-1	-1 for splitless
Time program		N	N for splitless, Y for split
Add integrator section?	N	For internal integrator	
Add time event section?	N		
Add peak table section?	N		
Method complete - End time XX			XX is min. to configure

19. Prior to starting the GC check the following:

a) The insulated door to the GC oven is in place.

b) The pressure of the Front Column is 22 psig and the back column is at 7 psig.

c) The gas flows are set properly and the unit is set up for flows for PID.

d) <Activate> <Method X> where X = 1, 2, 3, or 4 and the contains method to be used for the burn in test.

e) Turn on flame or lamp if this is not the burn in test and wait approximately 20 min. for the detector's baseline to stablilze.

f) Change chord to from integrator to use the PID (Detector A) or the FID Detector B).

SETUP AND STARTUP OF VARIAN 3400 GC

20. Start GC run

    a) <Column Oven On>

    b) Activate appropriate method

    c) Run the unit over night to burn the unit in before running any stanadards, analyses, etc. (If this is a burn in test you should not have the flame or lamp on, you should also make sure hydrogen is turned off before leaving).

Dissolved Oxygen (DO)

Equipment
YSI Model 57 DO meter with YSI 5739 DO probe

Instrument Preparation

1. Place instrument in intended operating position: vertical, tilted, or on its back. **Note: Readjustment may be necessary when the instrument operating position is altered.**

2. With the switch set to **OFF**, adjust to zero with the screw in the center of the meter panel. Do not force this adjustment or you may damage the meter.

3. Switch to **RED LINE** and adjust the **RED LINE** knob until the meter needle aligns with the red mark at the 31°C position. **Note: The amount of remaining adjustment is an indication of battery condition. Replace batteries when the RED LINE knob is at its extreme adjustment or at least annually.**

4. Switch to **ZERO** and adjust to zero with the zero control knob.

5. Attach the prepared probe[1] to the **PROBE** connector of the instrument and adjust the retaining ring finger tight.

6. Before calibrating, allow 15 minutes for optimum probe stabilization. Repolarize whenever the instrument has been **OFF** or the probe has been disconnected.

Air Calibration (calibrate daily or after each series of measurements)

1. Place the probe in moist air or leave in the storage bottle containing the damp towel. Wait approximately 10 minutes for temperature stabilization.

2. Switch to **TEMPERATURE** and read. Refer to Table I: **Solubility of Oxygen in Fresh Water** to determine the calibration value. **Note: A correction for altitude is not required since Kwajalein is at sea level.**

3. Switch to the appropriate mg/L range, set the **SALINITY** knob to zero and adjust the **CALIBRATE** knob until the meter reads the correct calibration value from Step 2. Wait 2 minutes to verify calibration stability. Readjust if necessary.

Measurement

1. With the instrument prepared for use and the probe calibrated, place the probe in the sample and stir. If a submersible stirrer is not used, provide manual stirring by raising and lowering the probe about 1 ft/sec.

2. Adjust the **SALINITY** knob to the salinity of the sample (assume 0, fresh water).

(continued)

Dissolved Oxygen (DO)

3. Allow sufficient time (10 seconds - 1 minute) for the probe to equilibrate to the sample temperature and dissolved oxygen. Read dissolved oxygen in mg/L. Note: **If response time under any operating conditions exceeds 2 minutes, probe service is indicated.**

Notes: [1]See instructions filed with the meter manual for preparing the YSI 5739 probe. On average, membranes require replacement every 2-4 weeks. This may be indicated by erratic readings or physical evidence of membrane damage.

Soil Moisture Content Procedure

1. Tare a dried and labelled 50 mL beaker.

2. Place 50 +/- 0.5 grams of soil sample in the dried beaker.

3. Remove the beaker from the balance and tare the balance. Reweigh the beaker containing the undried sample. Record the weight of the beaker plus the undried soil in the appropriate column on the soil moisture data sheet.

4. Place the beaker from step number 3 into an oven at 105°C for a 24 hour period. Reweigh and record the weight of the beaker plus dried sample.

5. Place the beaker from step 3 back into the oven and dry for another 24 hour period. Reweigh and record the weight of the beaker plus the dried sample. If the weights in steps 4 and 5 agree within 5%, record the weight of the beaker plus dried sample on the soil moisture data sheet and use this number to calculate the soil moisture content (%).

6. If the weights in steps 4 and 5 do not agree within 5%, all of the water has not evaporated. Repeat steps 3 and 4 until the weights agree within 5%.

7. Calculate the soil moisture content as follows:

   % Moisture =[(wt. beaker + undried soil) - (wt. beaker + dried soil)] / 50 grams * 100%

Nitrite (0.2-0.8 ppm)

Equipment

LaMotte test kit LP-55

Procedure

1. Place one Nitricol tablet into the 10 mL test tube provided with the kit.

2. Pipet 2 mL of sample water into the 10 mL test tube in Step 1.

3. Crush the tablet with the provided tablet crusher.

4. Dilute with sample water to the 10 mL line on the test tube. Cap and invert to mix. Wait 5 minutes.

5. Hold the comparator at eye level so that light enters from the back. Place the test tube upright against the plastic comparator surface. Match sample color with a color standard and record as ppm nitrite.

Nitrate (0-1 ppm & 1-5 ppm)

Equipment
CHEMet test kit K-6902

Procedure

1. Pipet 25 mL of sample into an appropriately labelled centrifuge tube (or fill to 25 mL mark with sample plus distilled H_2O for dilution if necessary). If sample dilution is required, be sure to record the volumes of sample and dilution water so that the dilution factor can be calculated and perhaps referred to in subsequent analyses.

2. Using the clipper provided in the kit, clip the end off one of the A-6900 cadmium capsules and empty the contents into the sample tube.

3. Place the cap on the sample tube and shake the cup vigorously for 3 minutes.

4. Allow the sample to sit undisturbed for approximately 30 seconds. This allows any undissolved solids to settle.

5. Place the CHEMets tapered tip of the ampoule into the sample and snap the tip by pressing the ampoule against the side of the tube. The sample will fill the ampoule and begin to mix with the reagent. Note: **A small bubble of inert gas will remain in the ampoule to facilitate mixing.**

6. Remove the fluid filled CHEMet from the tube. Mix its contents by inverting it several times allowing the bubble the travel from end to end each time.

7. Wipe all liquid from the exterior of the ampoule and wait 10 minutes.

8. After 10 minutes, use the appropriate comparator (cylindrical comparator[1] for the 0-1 ppm and flat comparator[2] for the 1-5 ppm) to determine the level of nitrate-nitrogen, NO_3-N, in the sample.[3]

9. Multiply the test result by 4.4 to convert mg/L (ppm) NO_3-N to nitrate as NO_3. Also multiply by the dilution factor if a dilution was required to get the sample concentration in the readable range.

Notes: [1] When using the **lower range comparator**, the CHEMet is placed in the center tube with the flat end downward. The top of the cylinder is then directed toward a source of bright, white light while viewing from the bottom (fig. 2). Hold the comparator in a nearly horizontal position and rotate it until the color below the CHEMet shows the closest match.

(continued)

Nitrate (0-1 ppm & 1-5 ppm)

[2] **The high range comparator** should be illuminated by a strong, white light directly above the comparator. The filled CHEMet should be placed between the color standards for viewing (fig. 3). It is very important that the CHEMet be compared by placing it on **both** sides of the standard tube before concluding that it is lighter, darker, or equal to the standard.

[3] Nitrite interferes with the efficiency of the cadmium reduction. Samples containing nitrite will give erroneous, high results. Since we will also be performing nitrite analyses, actual nitrate concentration can be determined by subtracting the nitrite concentration from the nitrate concentration determined in Step 9 above.

pH (liquid)

Equipment
Orion Model 420A pH/ISE meter
Orion Model 91-62 combination pH electrode, 0-12 pH
magnetic stirrer (suggested for precision measurements)

Solutions/reagents
electrode filling solution, 4M KCl saturated with AgCl (Orion 900011)
pH buffers - pH 7&4 or pH 7&10 to bracket expected sample range
pH electrode storage solution (Orion 910001)

Soil pH

Comments: For calcareous soils a calcium chloride solution must be added. The following procedure is for sample preparation and pH measurement in calcareous soils.

1. Preparation of 0.01 M Calcium Chloride Solution: Dilute 50 mL of the stock 3.6 M calcium chloride solution prepared at ORNL with 18 L of Type II water. If the pH of this solution is not between 5.and 6.5, adjust the pH by adding a little $Ca(OH)_2$ or HCl. As a check on the preparation of this solution, measure its electrical conductivity. The specific conductivity should be 2.32 + 0.08 mmho per cm at 25° C.

2. Calibrate the pH meter with pH buffers 7 and ____.

3. Add 10 g of soil and 20 mL of 0.01 M $CaCl_2$ solution to a 50 mL beaker. Stir the mixture several times over the next 30 minutes.

4. let the soil suspension sit for 30 minutes to let most of the soil to settle to the bottom.

5. Measure the pH of the solution with the combination electrode.

6. Report the value as "soil pH measured in 0.01 M $CaCl_2$."

7. Repeat steps 3-6 for each sample. Be sure to thoroughly rinse electrodes between samples.

8. Run a duplicate and a standard check after every 10 samples.

Phosphate[2] (10-150 ppm)

Equipment

CHEMet test kit K-8515

Procedure

1. Pipet ~25 mL of sample into an appropriately labelled centrifuge tube (or fill to the 25 mL mark with sample plus distilled dilution H_2O if dilution is necessary). If sample dilution is required, be sure to record the volumes of sample and dilution water so that the dilution factor can be calculated and perhaps referred to in subsequent analyses.

2. Place the CHEMets tapered tip of the ampoule into the sample tube and snap the tip by pressing the ampoule against the side of the tube. The sample will fill the ampoule and begin to mix with the reagent. **Note: A small bubble of inert gas will remain in the ampoule to facilitate mixing.**

3. Remove the fluid filled CHEMet from the tube. Mix its contents by inverting it several times allowing the bubble the travel from end to end each time.

4. Wipe all liquid from the exterior of the ampoule and wait 5 minutes.

5. After 5 minutes, use the appropriate comparator[1] to determine the level of phosphate[2], as PO_4^-, in the sample. If a dilution was performed, multiply by the appropriate dilution factor to obtain the concentration of phosphate in the sample.

[1] The **comparator** should be illuminated by a strong, white light directly above the comparator. The filled CHEMet should be placed between the color standards for viewing (fig. 3). It is very important that the CHEMet be compared by placing it on **both** sides of the standard tube before concluding that it is lighter, darker, or equal to the standard.

[2] Only **orthophosphate** is detected with the Chemet test kit. Phosphorus in the form of soluble pyrophosphates, metaphosphates, or organic phosphates will not respond to the Chemet test kit. To determine total phosphate and/or organic phosphate, use the Hach Total Phosphate Test Kit to pretreat the sample. Pretreatment using the Hach test kit converts total phosphate to orthophosphate. After pretreatment total phosphate (now converted to orthophosphate) in the sample can be determined using the Chemet test kit.

HORIBA OCMA-220 OIL CONTENT ANALYZER

Procedure for Span Calibration Using Span Solution

1. Turn instrument on and wait 30 minutes for instrument to stabilize.

2. Press **RANGE** to select measuring range.

3. Set **EXTRACTION TIME** to 40 seconds.

4. Set **EXTRACTOR** valve to **CLOSE**.

5. Inject 30 mL of span solution[1] if using the external extraction procedure.

6. Depress **EXTRACT** button to start calibration. Extraction automatically stops when preset time is over.

7. Turn **DISCHARGE** valve to **CLOSE**.

8. Turn **EXTRACTOR** valve to **OPEN**. Wait ~1 minute for the overflow solution to drain through the discharge outlet.

9. Depress **MEASURE** button (light comes on) and record the reading.

10. Turn **MEASURE** button **OFF** (light goes off).

11. Turn **EXTRACTOR** valve to **CLOSE**.

12. Open **DISCHARGE** valve to empty the sample cell.

13. Close **DISCHARGE** valve.

14. Open **EXTRACTOR** valve to allow more span solution into the sample cell.

15. Turn **MEASURE** button **ON** (light comes on). If the reading is the same as in Step 9, adjust the **SPAN ADJUST** to the prescribed span adjustment value (i.e., 160.0 for 200 ppm range or 40.0 for 50 ppm range - See Page 6-4 of Horiba Instruction Manual). If not, repeat steps 10-14 until 2 consecutive readings are the same. Then adjust the **SPAN ADJUST** to the prescribed span adjustment value.

16. Repeat Steps 10-13.

17. Take one additional reading to make sure the reading in Step 14 is repeatable.

18. Perform a routine span check as outlined in the "Procedure for Routine Span Check" to obtain a value that can be used for calibration until another full span calibration with span solution is performed.

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[1]See the "Procedure for Preparation of Span Solution" for preparing the correct span solution.

HORIBA OCMA-220 OIL CONTENT ANALYZER

Procedure for Routine Span Check

This should be performed each time a span calibration with span solution is completed. The reading obtained by pressing the CHECK button should be recorded. The reading can be used to check the instrument calibration between full span calibrations (i.e., calibration with span solution). However, the calibration with "SPAN CHECK" is only a simple routine procedure and calibration with span solution is recommended once a week.

1. After performing the **SPAN CALIBRATION**, perform the **ZERO CALIBRATION** again per written procedures. Confirm that the last measurement is 0.0 and leave the instrument ready for reading indication (i.e., leave solvent in the sample cell and the **MEASURE** button on).

2. Make sure **DISCHARGE** valve is at the **CLOSE** position.

3. Check the meter for zero reading.

4. Hold the **CHECK** button depressed for about 15 seconds. Record the digital display reading. This reading can be referenced as a "routine **SPAN** check" anytime the analyzer is zeroed with pure solvent.

5. Depress the **MEASURE** button to make the instrument standby.

6. Turn **DISCHARGE** valve to **OPEN** for discharging. Instrument is ready for sample measurement.

Procedure for Span Calibration Using Span Check

This procedure assumes that a **ZERO CALIBRATION** has just been performed and the instrument is ready for reading indication (i.e., leave solvent in the sample cell and the **MEASURE** button on).

1. With the **SPAN CHECK** button pressed and held, adjust the display to the value obtained during the span check procedure outlined above. Instrument is ready for sample measurement.

NOTE: For best results calibration should be performed in the order **ZERO, SPAN, ZERO, CHECK**, then **MEASUREMENT OF SAMPLE**. However, since calibration with span solution is prescribed only once per week, analyses will also be performed in the order **ZERO, SPAN CHECK** (calibration using the span check value rather than span solution), then **MEASUREMENT OF SAMPLE**.

HORIBA OCMA-220 OIL CONTENT ANALYZER

Procedure for Preparation of Span Solution for 200 ppm range[1]

1. Clean glassware, rinse with pure extraction solvent (Freon-113), and dry in air before use.

2. Transfer

   15 mL isooctane (2,2,4-trimethylpentane),
   15 mL cetane (n-hexadecane), and
   10 mL chlorobenzene

   into a 100-250 ml Erlenmeyer flask using the appropriate size transfer pipet and keeping the flask closed between transfers. Quickly close the flask and shake to mix. The specific gravity of the mixture is 0.826 at 20°C.

3. Using the microsyringe, transfer 13.0 uL of the mixture prepared in Step 2 into a 250 mL volumetric flask. Be sure to remove excess solution from the tip of the syringe before transferring. Also be sure to reomve the final drop of the solution from the syringe after transferring by touching the tip to the side of the flask.

4. Fill the 250 mL flask to the mark with Freon-113, quickly close the flask, and shake well. The resultant mixture is span solution.

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[1] See Page 6-4 of the Horiba manual for preparing span solution for the 50 ppm range.

HORIBA OCMA-220 OIL CONTENT ANALYZER

Procedure for Zero Calibration

1. Turn instrument on and wait 30 minutes for instrument to stabilize.
2. Press **RANGE** to select measuring range.
3. Set **EXTRACTION TIME** to 40 seconds.
4. Set **EXTRACTOR** valve to **CLOSE**.
5. Inject 30 mL of clean solvent if using the external extraction procedure.
6. Depress **EXTRACT** button to start calibration. Extraction automatically stops when preset time is over.
7. Turn **DISCHARGE** valve to **CLOSE**.
8. Turn **EXTRACTOR** valve to **OPEN**. Wait ~1 minute for the overflow solvent to drain through discharge outlet.
9. Depress **MEASURE** button (light comes on) and record the reading.
10. Turn **MEASURE** button to **OFF** (light goes off).
11. Turn **EXTRACTOR** valve to **CLOSE**.
12. Open **DISCHARGE** valve to empty the sample cell.
13. Close **DISCHARGE** valve.
14. Open **EXTRACTOR** valve to allow more solvent into the sample cell.
15. Depress **MEASURE** button. If the reading is the same as in Step 9, adjust the **ZERO ADJUST** to zero. If not, repeat steps 10-14 until 2 consecutive readings are the same. Then adjust the **ZERO ADJUST** to zero.
16. Repeat Steps 10-13.
17. Take one additional reading to make sure the zero is repeatable.

Preparation Of 1% PTYG Medium (Balkwill Media)

Comments: This procedure details the preparation of the 1% PTYG medium (agar) which is to be used in the preparation of pour plates for determination of cell forming units.

1. Add 1.5 liters of distilled water to a 2 liter Erlenmeyer flask.

2. Add the following ingredients to the 2000 mL Erlenmeyer flask:

Glucose	1.5 g
Yeast extract	1.5 g
Peptone	1.5 g
Tryptone	1.5 g
$MgSO_4.7H_2O$	0.1 g
NaCl	1.4 g
NH_4Cl	0.45 g
K_2HPO_4	0.21 g
mineral water	15 mL
Kodak Granulated Agar	13.5 g

3. Stir using a large magnetic stirring bar until all solids have been dissolved.

4. Adjust the pH of the above solution to 7.25 +/- 0.05 using 2M HCl or 2M NaOH. (Check the pH after 30 minutes and readjust if necessary.)

5. While stirring with a large magnetic stirring bar heat the medium at 75-85°C to dissolve the agar. The agar will be "straw colored" when melted. (Note: You can boil the mixture but you have to watch it closely to prevent boiling over.)

6. When the agar reaches a "straw" color, transfer 350-400 mL to each 500 mL culture bottle. Leave the lids on the culture bottles loose (i.e., tighten the lids completely and then back off a half turn). Note: **To verify that the agar is ready to transfer, a "test plate" can be poured.**

7. Place a piece of autoclave tape on each culture bottle of agar and autoclave 22 minutes at 121°C. Allow the agar to cool in the sealed autoclave to ~60°C before attempting to remove it.

8. Remove the culture bottles containing the agar, tighten the caps, and tape around the cap with polyethylene tape. Check the autoclave tape to make sure the agar has been properly sterilized.

9. Label bottles with the date prepared and the preparer's initials.

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(continued)

Preparation Of 1% PTYG Medium (Balkwill Media)

10. Store in refrigerator until ready for use.

11. When ready for use check to make sure the water (condensate) which has collected in the bottle is clear and not cloudy. (If the water that has collected is cloudy discard the agar. The agar is irretrievably lost once it becomes contaminated.)

Procedure: Cell Forming Units (CFU's) for Soils

Comments: This procedure details the steps necessary to perform total aerobic bacterial plate counts (i.e., Cell Forming Units) using the pour plate method for soil samples.

1. The following should be prepared and on hand prior to starting the CFU's procedure:

ITEM		
Sodium Pyrophosphate Solution (0.1%)	(S/P)	**(Note: 25 mL portions of sterile S/P and PBS in sterile centrifuge tubes.)**
Phosphate Buffered Saline Solution	(PBS)	
PTYG Medium (1%)		

2. Approximately 24 hours prior to plating, remove the required amount of buffers from the freezer and place under UV light to allow to stabilize at room temperature.

3. When ready to commence analysis, label one centrifuge tube containing S/P buffer and two centrifuge tubes containing PBS buffer as follows:

   1) S/P-10^{-1}
   2) PBS-10^{-3}
   3) PBS-10^{-5}

4. Four plates will be poured from each PBS centrifuge tube. Label sterilized petri dishes in duplicate with sample identification (e.g., sample number) and dilution as shown in Figure 1. This results in 8 plates per sample with two each being labelled 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, respectively. Save the petri dish bags to use to rebag the poured plates.

5. When ready to commence plating, take a 500 mL bottle of prepared agar (1% PTYG Medium) from the refrigerator. Check to make sure any condensate which has collected in the bottle is clear. If condensate is clear, slightly loosen bottle cap and place bottle in a microwave.

6. Heat in a microwave on medium high for 2 minutes, swirl to mix contents of bottle, heat for another 2 minutes, and swirl to mix contents of bottle again. (This can be done while weighing soil portions into the S/P buffer.)

7. Repeat step 3 until the agar has reached a completely liquid state. **Once the agar is mostly liquified, it must be monitored closely to prevent boiling over in the microwave.**

8. Weigh 2.5 grams of soil in a centrifuge tube containing the Sodium Pyrophosphate Solution (labeled S/P 10^{-1}). Shake briskly 100 times.

9. When ready to begin actual plating, vortex the centrifuge tube containing the sample for 30 seconds and then let the solids settle to the bottom.

10. Pipet (using an autopipet with a cotton plug) 0.25 mL of sample from the centrifuge tube labeled S/P 10^{-1} into the tube labeled PBS-10^{3}. Discard the pipet tip.

11. Vortex the PBS-10^{3} tube for 30 seconds. Using a new pipet tip, pipet (in duplicate) 1.0 mL of sample from the test tube labeled PBS-10^{3} to the 10^{3} plates and 0.1 mL of sample to the 10^{4} plates. Pipet 0.25 mL of sample into the tube labeled PBS-10^{5}. Discard the pipet tip.

12. Vortex the PBS-10^{5} tube for 30 seconds. Using a new pipet tip, pipet (in duplicate) 1.0 mL of sample from the test tube labeled PBS-10^{5} to the 10^{5} plates and 0.1 mL of sample to the 10^{6} plates. Discard the pipet tip.

13. Cover approximately 2/3 of the bottom of the petri dish with the agar (PTYG Medium) which has been cooled to 45°C (the plate should be poured when you can hold the bottle without experiencing any discomfort) and swirl gently to spread the agar and sample across the bottom of the plate.

14. Allow the plate contents to cool and solidify.

15. Repeat steps 9-14, as shown in Figure 1, until all plates have been poured and solidified.

16. Rebag the poured plates (20 per petri dish bag), seal with label tape, and label with the date of analysis. If sampling and analysis is to be conducted more than one day, use a different color tape to seal the bag so that identification will be easier at counting time. Place the bagged plates in a cardboard box (the petri dish box works well).

17. Store petri dishes upside down in the box, at ambient temperatures which are similar to the subsurface temperatures at Kwajalein (21-24°C). As long as the plates are boxed, the UV light can be used in the cabinet to keep contamination to a minimum.

18. Count colonies on each plate at 7 days and 15 days. Record colony count in a prepared table. Use an average value to obtain the CFU's count. (Optimally, the plate count used in the averaging should be between 30 and 300).

19. Place all used materials (pipet tips, petri dishes, tape, centrifuge tubes, etc.) into an autoclavable garbage bag. Place the garbage bag into an autoclavable pan. Autoclave contents for at least 25 minutes at 125°C.

Procedure: Cell Forming Units (CFU's) for Groundwater Samples

Comments: This procedure details the steps necessary to perform total aerobic bacterial plate counts (i.e., Cell Forming Units) using the pour plate method for groundwater samples.

1. The following should be prepared and on hand prior to starting the CFU's procedure:

ITEM	
Phosphate Buffered Saline Solution (PBS)	(Note: 25 mL portions of sterile PBS in sterile centrifuge tubes.)
PTYG Medium (1%)	

2. Approximately 24 hours prior to plating, remove the required amount of buffers from the freezer and place under UV light to allow to stabilize at room temperature.

3. When ready to commence analysis, label two centrifuge tubes containing PBS buffer as follows:

   1) PBS-10^{-2}
   2) PBS-10^{-4}

4. Four plates will be poured from the PBS centrifuge tube labelled PBS-10^{-2}. Two plates will be prepared from the PBS centrifuge tube labelled PBS-10^{-4}. Label sterilized petri dishes in duplicate with sample identification (e.g., sample number) and dilution as shown in Figure 1. This results in 6 plates per sample with two each being labelled 10^{-2}, 10^{-3}, and 10^{-4}, respectively. Save the petri dish bags to use to rebag the poured plates.

5. When ready to commence plating, take a 500 mL bottle of prepared agar (1% PTYG Medium) from the refrigerator. Check to make sure any condensate which has collected in the bottle is clear. If condensate is clear, slightly loosen bottle cap and place bottle in a microwave.

6. Heat in a microwave on medium high for 2 minutes, swirl to mix contents of bottle, heat for another 2 minutes, and swirl to mix contents of bottle again.

7. Repeat step 3 until the agar has reached a completely liquid state. **Once the agar is mostly liquified, it must be monitored closely to prevent boiling over in the microwave.**

8. Pipet 0.25 mL of water sample in a centrifuge tube containing the Phosphate Buffered Saline Solution (labeled PBS 10^{-2}). Discard the pipet tip. Shake the tube briskly 100 times.

9. When ready to begin actual plating, vortex the centrifuge tube containing the sample for 30 seconds.

10. Using a new pipet tip, pipet (in duplicate) 1.0 mL of sample from the test tube labeled PBS-10^{-2} to the 10^{-2} plates and 0.1 mL of sample to the 10^{-3} plates. Pipet 0.25 mL of sample into the tube labeled PBS-10^{-4}. Discard the pipet tip.

11. Vortex the PBS-10^{-4} tube for 30 seconds. Using a new pipet tip, pipet (in duplicate) 1.0 mL of sample from the test tube labeled PBS-10^{-4} to the 10^{-4}. Discard the pipet tip.

12. Cover approximately 2/3 of the bottom of the petri dish with the agar (PTYG Medium) which has been cooled to 45°C (the plate should be poured when you can hold the bottle without experiencing any discomfort) and swirl gently to spread the agar and sample across the bottom of the plate.

13. Allow the plate contents to cool and solidify.

14. Repeat steps 9-14, as shown in Figure 1, until all plates have been poured and solidified.

15. Rebag the poured plates (20 per petri dish bag), seal with label tape, and label with the date of analysis. If sampling and analysis is to be conducted more than one day, use a different color tape to seal the bag so that identification will be easier at counting time. Place the bagged plates in a cardboard box (the petri dish box works well).

16. Store petri dishes upside down in the box, at ambient temperatures which are similar to the subsurface temperatures at Kwajalein (21-24°C). As long as the plates are boxed, the UV light can be used in the cabinet to keep contamination to a minimum.

17. Count colonies on each plate at 7 days and 15 days. Record colony count in a prepared table. Use an average value to obtain the CFU's count. (Optimally, the plate count used in the averaging should be between 30 and 300).

18. Place all used materials (pipet tips, petri dishes, tape, centrifuge tubes, etc.) into an autoclavable garbage bag. Place the garbage bag into an autoclavable pan. Autoclave contents for at least 25 minutes at 125°C.

APPENDIX B

RESULTS OF ON-SITE ANALYSES OF SOIL SAMPLES DURING THE BIOREMEDIATION DEMONSTRATION AT KWAJALEIN ISLAND

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
300	12/31/92	1	1	4.00	2.00	1.50	5.28	128	10.5	-9.99	210000
301	12/31/92	1	1	4.00	2.00	2.50	5.28	3070	11.2	-9.99	140000
302	12/31/92	1	1	4.00	2.00	3.50	5.28	24064	10.7	-9.99	500000
303	12/31/92	1	1	4.00	2.00	4.50	5.28	58956	14.2	-9.99	1370000
304	12/31/92	1	1	4.00	2.00	5.50	5.28	39391	23.3	-9.99	160000
305	12/31/92	1	2	4.00	2.00	2.50	5.24	144	12.7	-9.99	1225000
306	12/31/92	1	2	4.00	2.00	3.50	5.24	32166	14.3	-9.99	310000
307	12/31/92	1	2	4.00	2.00	4.50	5.24	73688	16.0	-9.99	3130000
308	12/31/92	1	2	4.00	2.00	5.50	5.24	32681	26.3	-9.99	2320000
309	12/31/92	1	3	4.00	2.00	2.50	5.30	624	13.4	-9.99	490000
310	12/31/92	1	3	4.00	2.00	3.50	5.30	32357	13.6	-9.99	1030000
311	12/31/92	1	3	4.00	2.00	4.50	5.30	48536	16.3	-9.99	470000
312	12/31/92	1	3	4.00	2.00	5.50	5.30	24160	27.4	-9.99	1330000
313	12/31/92	1	4	4.00	2.00	2.50	5.40	3927	12.7	-9.99	570000
314	12/31/92	1	4	4.00	2.00	3.50	5.40	57926	10.4	-9.99	425000
315	12/31/92	1	4	4.00	2.00	4.50	5.40	64204	14.2	-9.99	620000
316	12/31/92	1	4	4.00	2.00	5.50	5.40	62566	22.8	-9.99	500000
317	12/31/92	1	5	4.00	2.00	2.50	5.42	127	11.9	-9.99	345000
318	12/31/92	1	5	4.00	2.00	3.50	5.42	22861	10.8	-9.99	615000
319	12/31/92	1	5	4.00	2.00	4.50	5.42	112809	14.8	-9.99	2590000
320	12/31/92	1	5	4.00	2.00	5.50	5.42	25817	22.1	-9.99	385000
321	12/31/92	1	6	4.00	2.00	2.50	5.50	433	14.6	-9.99	675000
322	12/31/92	1	6	4.00	2.00	3.50	5.50	318	11.0	-9.99	1280000
323	12/31/92	1	6	4.00	2.00	4.50	5.50	20536	19.9	-9.99	485000
324	12/31/92	1	6	4.00	2.00	5.50	5.50	23968	24.0	-9.99	3700000
325	12/31/92	1	7	4.00	2.00	1.50	5.48	270	12.8	-9.99	265000
326	12/31/92	1	7	4.00	2.00	2.50	5.48	270	11.9	-9.99	590000
327	12/31/92	1	7	4.00	2.00	3.50	5.48	4646	11.9	-9.99	2320000
328	12/31/92	1	7	4.00	2.00	4.50	5.48	42292	20.3	-9.99	1010000
329	12/31/92	1	7	4.00	2.00	5.50	5.48	52110	24.0	-9.99	1090000
330	1/1/93	1	8	4.00	6.00	2.50	5.26	363	11.2	-9.99	134000
331	1/1/93	1	8	4.00	6.00	3.50	5.26	21029	11.8	-9.99	445000
332	1/1/93	1	8	4.00	6.00	4.50	5.26	41101	18.4	-9.99	1060000
333	1/1/93	1	8	4.00	6.00	5.50	5.26	15100	28.2	-9.99	2390000
334	1/1/93	1	9	4.00	6.00	2.50	5.10	579	10.6	-9.99	270000
335	1/1/93	1	9	4.00	6.00	3.50	5.10	184	14.2	-9.99	155000
336	1/1/93	1	9	4.00	6.00	4.50	5.10	36335	22.9	-9.99	500000
337	1/1/93	1	9	4.00	6.00	5.50	5.10	23411	29.2	-9.99	310000
338	1/1/93	1	10	4.00	6.00	2.50	5.14	391	12.2	-9.99	240000
339	1/1/93	1	10	4.00	6.00	3.50	5.14	22952	12.7	-9.99	300000
340	1/1/93	1	10	4.00	6.00	4.50	5.14	46048	23.2	-9.99	280000
341	1/1/93	1	10	4.00	6.00	5.50	5.14	31632	23.8	-9.99	800000
342	1/1/93	1	11	4.00	6.00	2.50	5.14	1441	13.3	-9.99	135000
343	1/1/93	1	11	4.00	6.00	3.50	5.14	53610	12.7	-9.99	4490000
344	1/1/93	1	11	4.00	6.00	4.50	5.14	86885	20.8	-9.99	700000
345	1/1/93	1	11	4.00	6.00	5.50	5.14	13209	27.8	-9.99	65000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
346	1/1/93	1	12	4.00	6.00	2.50	5.32	76	10.5	-9.99	870000
347	1/1/93	1	12	4.00	6.00	3.50	5.32	28848	15.4	-9.99	1210000
348	1/1/93	1	12	4.00	6.00	4.50	5.32	41944	17.9	-9.99	640000
349	1/1/93	1	12	4.00	6.00	5.50	5.32	16548	26.8	-9.99	180000
350	12/31/92	1	1	4.00	2.00	0.50	5.28	1597	9.1	-9.99	7800000
351	12/31/92	1	1	5.00	2.00	6.50	5.28	126	31.8	-9.99	970000
352	12/31/92	1	2	4.00	2.00	6.50	5.24	1908	28.3	-9.99	666300
353	12/31/92	1	2	4.00	2.00	7.50	5.24	2978	26.9	-9.99	-9999999
354	12/31/92	1	3	4.00	2.00	6.50	5.30	4221	25.5	-9.99	666300
355	12/31/92	1	4	4.00	2.00	6.50	5.40	1437	32.1	-9.99	935000
356	12/31/92	1	3	4.00	2.00	7.50	5.30	2020	23.6	-9.99	4690000
357	12/31/92	1	5	4.00	2.00	6.50	5.42	5393	30.5	-9.99	666300
358	12/31/92	1	6	4.00	2.00	6.50	5.50	4464	30.2	-9.99	666300
359	12/31/92	1	7	4.00	2.00	6.50	5.48	2160	27.3	-9.99	1940000
361	12/31/92	1	8	4.00	6.00	6.50	5.26	105	28.5	-9.99	35500
362	1/1/93	1	9	4.00	6.00	6.50	5.10	0	27.0	-9.99	666300
363	1/1/93	1	10	4.00	6.00	6.50	5.14	1000	30.7	-9.99	666300
364	1/1/93	1	11	4.00	6.00	6.50	5.14	298	28.9	-9.99	11500
365	1/1/93	1	12	4.00	6.00	6.50	5.32	644	26.9	-9.99	106000
437	3/6/93	1	1	2.00	2.00	3.50	5.26	29596	-999.9	-9.99	-9999999
438	3/6/93	1	1	2.00	2.00	4.50	5.26	47716	-999.9	-9.99	-9999999
439	3/6/93	1	1	2.00	2.00	5.50	5.26	47112	-999.9	-9.99	-9999999
440	3/6/93	1	2	2.00	2.00	3.50	5.24	54360	-999.9	-9.99	-9999999
441	3/6/93	1	2	2.00	2.00	4.50	5.24	65836	-999.9	-9.99	-9999999
442	3/6/93	1	2	2.00	2.00	5.50	5.24	27180	-999.9	-9.99	-9999999
443	3/6/93	1	3	2.00	2.00	3.50	5.38	24764	-999.9	-9.99	-9999999
444	3/6/93	1	3	2.00	2.00	4.50	5.38	56776	-999.9	-9.99	-9999999
445	3/6/93	1	3	2.00	2.00	5.50	5.38	32616	-999.9	-9.99	-9999999
446	3/6/93	1	3	2.00	2.00	6.50	5.38	6644	-999.9	-9.99	-9999999
447	3/6/93	1	4	2.00	2.00	3.50	5.54	29596	-999.9	-9.99	-9999999
448	3/6/93	1	4	2.00	2.00	4.50	5.54	84560	-999.9	-9.99	-9999999
449	3/6/93	1	4	2.00	2.00	5.50	5.54	80936	-999.9	-9.99	-9999999
450	3/6/93	1	5	2.00	2.00	3.50	5.90	560	-999.9	-9.99	-9999999
451	3/6/93	1	5	2.00	2.00	4.50	5.90	58588	-999.9	-9.99	-9999999
452	3/6/93	1	5	2.00	2.00	5.50	5.90	43488	-999.9	-9.99	-9999999
453	3/6/93	1	5	2.00	2.00	6.50	5.90	19328	-999.9	-9.99	-9999999
454	3/6/93	1	6	2.00	2.00	3.50	5.62	1392	-999.9	-9.99	-9999999
455	3/6/93	1	6	2.00	2.00	4.50	5.62	30200	-999.9	-9.99	-9999999
456	3/6/93	1	6	2.00	2.00	5.50	5.62	48924	-999.9	-9.99	-9999999
457	3/7/93	1	7	2.00	2.00	3.50	5.88	20536	-999.9	-9.99	-9999999
458	3/7/93	1	7	2.00	2.00	4.50	5.88	65836	-999.9	-9.99	-9999999
459	3/7/93	1	7	2.00	2.00	5.50	5.88	51340	-999.9	-9.99	-9999999
460	3/7/93	1	8	2.00	6.00	3.50	5.14	2304	-999.9	-9.99	-9999999
461	3/7/93	1	8	2.00	6.00	4.50	5.14	32616	-999.9	-9.99	-9999999
462	3/7/93	1	8	2.00	6.00	5.50	5.14	19328	-999.9	-9.99	-9999999
463	3/7/93	1	9	2.00	6.00	3.50	5.00	2864	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
464	3/7/93	1	9	2.00	6.00	4.50	5.00	42280	-999.9	-9.99	-9999999
465	3/7/93	1	9	2.00	6.00	5.50	5.00	28388	-999.9	-9.99	-9999999
466	3/7/93	1	10	2.00	6.00	3.50	5.04	16308	-999.9	-9.99	-9999999
467	3/7/93	1	10	2.00	6.00	4.50	5.04	68252	-999.9	-9.99	-9999999
468	3/7/93	1	10	2.00	6.00	5.50	5.04	38052	-999.9	-9.99	-9999999
469	3/7/93	1	11	2.00	6.00	3.50	5.04	67648	-999.9	-9.99	-9999999
470	3/7/93	1	11	2.00	6.00	4.50	5.04	87560	-999.9	-9.99	-9999999
471	3/7/93	1	11	2.00	6.00	5.50	5.04	39260	-999.9	-9.99	-9999999
472	3/7/93	1	12	2.00	6.00	3.50	5.22	74896	-999.9	-9.99	-9999999
473	3/7/93	1	12	2.00	6.00	4.50	5.22	64628	-999.9	-9.99	-9999999
474	3/7/93	1	12	2.00	6.00	5.50	5.22	8456	-999.9	-9.99	-9999999
475	3/7/93	1	1	2.00	2.00	6.50	5.26	3624	-999.9	-9.99	-9999999
476	3/14/93	1	5	3.00	2.00	3.50	5.36	14496	-999.9	-9.99	-9999999
477	3/14/93	1	5	3.00	2.00	4.50	5.36	59796	-999.9	-9.99	-9999999
478	3/14/93	1	5	3.00	2.00	5.50	5.36	58588	-999.9	-9.99	-9999999
479	3/14/93	1	5	3.00	2.00	6.50	5.36	28160	-999.9	-9.99	-9999999
480	3/14/93	1	6	3.00	2.00	3.50	5.36	720	-999.9	-9.99	-9999999
481	3/14/93	1	6	3.00	2.00	4.50	5.36	19932	-999.9	-9.99	-9999999
482	3/14/93	1	6	3.00	2.00	5.50	5.36	35032	-999.9	-9.99	-9999999
483	3/14/93	1	6	3.00	2.00	6.50	5.36	14080	-999.9	-9.99	-9999999
484	3/14/93	1	7	3.00	2.00	3.50	5.46	6040	-999.9	-9.99	-9999999
485	3/14/93	1	7	3.00	2.00	4.50	5.46	41676	-999.9	-9.99	-9999999
486	3/14/93	1	7	3.00	2.00	5.50	5.46	33824	-999.9	-9.99	-9999999
487	3/14/93	1	7	3.00	2.00	6.50	5.46	3416	-999.9	-9.99	-9999999
488	3/14/93	1	11	3.00	6.00	3.50	4.88	67648	-999.9	-9.99	-9999999
489	3/14/93	1	11	3.00	6.00	4.50	4.88	84560	-999.9	-9.99	-9999999
490	3/14/93	1	11	3.00	6.00	5.50	4.88	25368	-999.9	-9.99	-9999999
491	3/14/93	1	11	3.00	6.00	6.50	4.88	1464	-999.9	-9.99	-9999999
492	3/14/93	1	12	3.00	6.00	3.50	5.04	42884	-999.9	-9.99	-9999999
493	3/14/93	1	12	3.00	6.00	4.50	5.04	59192	-999.9	-9.99	-9999999
494	3/14/93	1	12	3.00	6.00	5.50	5.04	24764	-999.9	-9.99	-9999999
495	3/14/93	1	12	3.00	6.00	6.50	5.04	2440	-999.9	-9.99	-9999999
505	5/3/93	2	1	3.00	2.00	3.50	4.44	42280	13.3	7.75	288000
506	5/3/93	2	1	3.00	2.00	4.50	4.44	62212	17.2	7.91	6400000
507	5/3/93	2	1	3.00	2.00	5.50	4.44	20536	27.3	7.71	26900000
508	5/3/93	2	1	3.00	2.00	6.50	4.44	4832	28.4	7.84	11100000
509	5/3/93	2	1	3.00	3.00	3.50	4.44	38656	-999.9	-9.99	-9999999
510	5/3/93	2	1	3.00	3.00	4.50	4.44	59796	-99.9	-9.99	-9999999
511	5/3/93	2	1	3.00	3.00	5.50	4.44	38656	-999.9	-9.99	-9999999
512	5/3/93	2	1	3.00	3.00	6.50	4.44	3624	-999.9	-9.99	-9999999
513	5/3/93	2	2	3.00	2.00	3.50	4.66	30804	15.3	8.03	7700000
514	5/3/93	2	2	3.00	2.00	4.50	4.66	89996	20.3	7.90	17200000
515	5/3/93	2	2	3.00	2.00	5.50	4.66	26576	26.8	7.92	18100000
516	5/3/93	2	2	3.00	2.00	6.50	4.66	4928	24.5	7.97	8600000
517	5/3/93	2	2	3.00	3.00	3.50	4.66	41676	-999.9	-9.99	-9999999
518	5/3/93	2	2	3.00	3.00	4.50	4.66	87580	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
519	5/3/93	2	2	3.00	3.00	5.50	4.66	35636	-999.9	-9.99	-9999999
520	5/3/93	2	2	3.00	3.00	6.50	4.66	2416	-999.9	-9.99	-9999999
521	5/3/93	2	3	3.00	2.00	3.50	4.80	71272	14.8	8.03	1390000
522	5/3/93	2	3	3.00	2.00	4.50	4.80	54964	19.9	8.04	2800000
523	5/3/93	2	3	3.00	2.00	5.50	4.80	7248	28.1	7.86	490000
524	5/3/93	2	3	3.00	2.00	6.50	4.80	11160	23.8	7.96	1020000
525	5/3/93	2	3	3.00	3.00	3.50	4.80	10872	-999.9	-9.99	-9999999
526	5/3/93	2	3	3.00	3.00	4.50	4.80	37448	-999.9	-9.99	-9999999
527	5/3/93	2	3	3.00	3.00	5.50	4.80	12080	-999.9	-9.99	-9999999
528	5/3/93	2	3	3.00	3.00	6.50	4.80	1540	-999.9	-9.99	-9999999
529	5/3/93	2	4	3.00	2.00	3.50	5.06	22952	14.8	10.10	9500000
530	5/3/93	2	4	3.00	2.00	4.50	5.06	57380	22.9	8.02	29000000
531	5/3/93	2	4	3.00	2.00	5.50	5.06	32012	27.1	8.11	17500000
532	5/3/93	2	4	3.00	2.00	6.50	5.06	4092	29.7	8.06	8100000
533	5/3/93	2	4	3.00	3.00	3.50	5.06	53152	-999.9	-9.99	-9999999
534	5/3/93	2	4	3.00	3.00	4.50	5.06	57380	-999.9	-9.99	-9999999
535	5/3/93	2	4	3.00	3.00	5.50	5.06	32012	-999.9	-9.99	-9999999
536	5/3/93	2	4	3.00	3.00	6.50	5.06	10664	-999.9	-9.99	-9999999
537	5/3/93	2	5	3.00	3.00	3.50	5.14	5436	13.0	8.04	3210000
538	5/3/93	2	5	3.00	3.00	4.50	5.14	59192	20.1	8.03	4900000
539	5/3/93	2	5	3.00	3.00	5.50	5.14	47112	25.0	7.92	7100000
540	5/3/93	2	5	3.00	3.00	6.50	5.14	34648	27.5	7.97	7600000
541	5/3/93	2	5	2.00	3.00	3.50	5.14	396	-999.9	-9.99	-9999999
542	5/3/93	2	5	2.00	3.00	4.50	5.14	41676	-999.9	-9.99	-9999999
543	5/3/93	2	5	2.00	3.00	5.50	5.14	35636	-999.9	-9.99	-9999999
544	5/3/93	2	5	2.00	3.00	6.50	5.14	14632	-999.9	-9.99	-9999999
545	5/3/93	2	6	3.00	3.00	3.50	5.16	28	14.0	8.08	1950000
546	5/3/93	2	6	3.00	3.00	4.50	5.16	14496	19.3	8.08	780000
547	5/3/93	2	6	3.00	3.00	5.50	5.16	50132	28.2	8.04	170000
548	5/3/93	2	6	3.00	3.00	6.50	5.16	17812	27.0	8.03	390000
549	5/3/93	2	6	2.00	3.00	3.50	5.16	88	-999.9	-9.99	-9999999
550	5/3/93	2	6	2.00	3.00	4.50	5.16	12080	-999.9	-9.99	-9999999
551	5/3/93	2	6	2.00	3.00	5.50	5.16	19328	-999.9	-9.99	-9999999
552	5/3/93	2	6	2.00	3.00	6.50	5.16	3904	-999.9	-9.99	-9999999
553	5/4/93	2	7	3.00	3.00	3.50		13288	14.7	7.82	6200000
554	5/4/93	2	7	3.00	3.00	4.50		36240	18.2	7.91	2150000
555	5/4/93	2	7	3.00	3.00	5.50		41676	24.2	7.89	900000
556	5/4/93	2	7	3.00	3.00	6.50		3720	30.9	7.79	540000
557	5/4/93	2	7	2.00	3.00	3.50		10872	-999.9	-9.99	-9999999
558	5/4/93	2	7	2.00	3.00	4.50		29596	-999.9	-9.99	-9999999
559	5/4/93	2	7	2.00	3.00	5.50		12684	-999.9	-9.99	-9999999
560	5/4/93	2	7	2.00	3.00	6.50		2976	-999.9	-9.99	-9999999
561	5/4/93	2	8	3.00	6.00	3.50		3624	13.5	7.84	3700000
562	5/4/93	2	8	3.00	6.00	4.50		27180	20.1	7.64	18800000
563	5/4/93	2	8	3.00	6.00	5.50		15704	24.5	7.49	10900000
564	5/4/93	2	8	3.00	6.00	6.50		1860	26.9	7.59	3900000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
565	5/4/93	2	8	3.00	5.00	3.50		11476	-999.9	-9.99	-9999999
566	5/4/93	2	8	3.00	5.00	4.50		47716	-999.9	-9.99	-9999999
567	5/4/93	2	8	3.00	5.00	5.50		28992	-999.9	-9.99	-9999999
568	5/4/93	2	8	3.00	5.00	6.50		7440	-999.9	-9.99	-9999999
569	5/4/93	2	9	3.00	6.00	3.50		264	14.7	8.02	90000
570	5/4/93	2	9	3.00	6.00	4.50		16912	22.9	7.87	12900000
571	5/4/93	2	9	3.00	6.00	5.50		18120	30.1	7.77	5400000
572	5/4/93	2	9	3.00	6.00	6.50		8432	26.9	7.91	3250000
573	5/4/93	2	9	3.00	4.50	3.50		1860	-999.9	-9.99	-9999999
574	5/4/93	2	9	3.00	4.50	4.50		27784	-999.9	-9.99	-9999999
575	5/4/93	2	9	3.00	4.50	5.50	4.86	17516	-999.9	-9.99	-9999999
576	5/4/93	2	9	3.00	4.50	6.50		2728	-999.9	-9.99	-9999999
577	5/5/93	2	10	3.00	6.00	3.50	4.74	4832	13.3	7.94	1420000
578	5/5/93	2	10	3.00	6.00	4.50	4.74	48320	20.9	7.83	2290000
579	5/5/93	2	10	3.00	6.00	5.50	4.74	13892	27.1	7.82	300000
580	5/5/93	2	10	3.00	6.00	6.50	4.74	2356	28.2	7.84	162000
581	5/5/93	2	10	3.00	5.00	3.50	4.74	6040	-999.9	-9.99	-9999999
582	5/5/93	2	10	3.00	5.00	4.50	4.74	44696	-999.9	-9.99	-9999999
583	5/5/93	2	10	3.00	5.00	5.50	4.74	16912	-999.9	-9.99	-9999999
584	5/5/93	2	10	3.00	5.00	6.50	4.74	2604	-999.9	-9.99	-9999999
585	5/5/93	2	11	2.50	6.00	3.50	4.74	74896	13.8	7.58	5100000
586	5/5/93	2	11	2.50	6.00	4.50	4.74	74896	21.2	7.81	3000000
587	5/5/93	2	11	2.50	6.00	5.50	4.74	30200	28.0	7.68	540000
588	5/5/93	2	11	2.50	6.00	6.50	4.74	1860	29.3	7.97	141000
589	5/5/93	2	11	2.50	5.00	3.50	4.74	44696	-999.9	-9.99	-9999999
590	5/5/93	2	11	2.50	5.00	4.50	4.74	56776	-999.9	-9.99	-9999999
591	5/5/93	2	11	2.50	5.00	5.50	4.74	6040	-999.9	-9.99	-9999999
592	5/5/93	2	11	2.50	5.00	6.50	4.74	4960	-999.9	-9.99	-9999999
593	5/5/93	2	12	2.50	6.00	3.50	4.92	48320	-999.9	7.91	5000000
594	5/5/93	2	12	2.50	6.00	4.50	4.92	54964	-999.9	8.04	5000000
595	5/5/93	2	12	2.50	6.00	5.50	4.92	10872	-999.9	7.92	3400000
596	5/5/93	2	12	2.50	6.00	6.50	4.92	9548	-999.9	7.77	254000
597	5/5/93	2	12	2.50	5.00	3.50	4.92	43488	15.6	-9.99	-9999999
598	5/5/93	2	12	2.50	5.00	4.50	4.92	41676	19.0	-9.99	-9999999
599	5/5/93	2	12	2.50	5.00	5.50	4.92	9060	26.9	-9.99	-9999999
600	5/5/93	2	12	2.50	5.00	6.50	4.92	5084	27.6	-9.99	-9999999
630	6/21/93	3	1	2.00	3.00	3.50	4.88	15704	13.2	7.84	10400000
631	6/21/93	3	1	2.00	3.00	4.50	4.88	53756	18.0	8.06	29100000
632	6/21/93	3	1	2.00	3.00	5.50	4.88	45300	25.3	7.97	17500000
633	6/21/93	3	1	2.00	3.00	6.50	4.88	16244	28.9	8.14	14700000
634	6/21/93	3	1	1.00	3.00	3.50	4.88	38052	-999.9	-9.99	-9999999
635	6/21/93	3	1	1.00	3.00	4.50	4.88	63420	-999.9	-9.99	-9999999
636	6/21/93	3	1	1.00	3.00	5.50	4.88	50736	-999.9	-9.99	-9999999
637	6/21/93	3	1	1.00	3.00	6.50	4.88	16616	-999.9	-9.99	-9999999
638	6/21/93	3	2	2.00	3.00	3.50	4.88	33220	16.4	8.06	32700000
639	6/21/93	3	2	2.00	3.00	4.50	4.88	79124	21.1	7.98	28400000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
640	6/21/93	3	2	2.00	3.00	5.50	4.88	37448	31.6	7.74	18200000
641	6/21/93	3	2	2.00	3.00	6.50	4.88	2604	27.8	7.97	2010000
642	6/21/93	3	2	1.00	3.00	3.50	4.88	41072	-999.9	-9.99	-9999999
643	6/21/93	3	2	1.00	3.00	4.50	4.88	89996	-999.9	-9.99	-9999999
644	6/21/93	3	2	1.00	3.00	5.50	4.88	12080	-999.9	-9.99	-9999999
645	6/21/93	3	2	1.00	3.00	6.50	4.88	4092	-999.9	-9.99	-9999999
646	6/21/93	3	3	2.50	3.00	3.50	4.90	4832	15.5	8.09	380000
647	6/21/93	3	3	2.50	3.00	4.50	4.90	39260	21.8	8.01	10900000
648	6/21/93	3	3	2.50	3.00	5.50	4.90	24764	27.6	7.87	7000000
649	6/21/93	3	3	2.50	3.00	6.50	4.90	7440	30.2	7.89	3230000
650	6/21/93	3	3	1.00	3.00	3.50	4.90	12684	-999.9	-9.99	-9999999
651	6/21/93	3	3	1.00	3.00	4.50	4.90	50736	-999.9	-9.99	-9999999
652	6/21/93	3	3	1.00	3.00	5.50	4.90	12080	-999.9	-9.99	-9999999
653	6/21/93	3	3	1.00	3.00	6.50	4.90	3348	-999.9	-9.99	-9999999
654	6/21/93	3	4	2.00	3.00	3.50	5.10	31408	15.2	7.79	5400000
655	6/21/93	3	4	2.00	3.00	4.50	5.10	51340	22.4	7.96	52500000
656	6/21/93	3	4	2.00	3.00	5.50	5.10	44092	25.0	7.90	17800000
657	6/21/93	3	4	2.00	3.00	6.50	5.10	4588	27.3	8.06	2540000
658	6/21/93	3	4	1.00	3.00	3.50	5.10	22952	-999.9	-9.99	-9999999
659	6/21/93	3	4	1.00	3.00	4.50	5.10	88184	-999.9	-9.99	-9999999
660	6/21/93	3	4	1.00	3.00	5.50	5.10	45300	-999.9	-9.99	-9999999
661	6/21/93	3	4	1.00	3.00	6.50	5.10	11160	-999.9	-9.99	-9999999
662	6/22/93	3	5	4.00	3.00	3.50	5.10	25972	13.5	8.09	4500000
663	6/22/93	3	5	4.00	3.00	4.50	5.10	131068	18.2	8.05	5500000
664	6/22/93	3	5	4.00	3.00	5.50	5.10	64628	24.7	7.91	11100000
665	6/22/93	3	5	4.00	3.00	6.50	5.10	18848	30.4	7.94	9200000
666	6/22/93	3	5	5.00	3.00	3.50	5.10	79728	-999.9	-9.99	-9999999
667	6/22/93	3	5	5.00	3.00	4.50	5.10	120800	-999.9	-9.99	-9999999
668	6/22/93	3	5	5.00	3.00	5.50	5.10	45904	-999.9	-9.99	-9999999
669	6/22/93	3	5	5.00	3.00	6.50	5.10	20832	-999.9	-9.99	-9999999
670	6/22/93	3	6	4.00	3.00	3.50	5.20	336	14.0	7.84	630000
671	6/22/93	3	6	4.00	3.00	4.50	5.20	10872	21.3	7.77	410000
672	6/22/93	3	6	4.00	3.00	5.50	5.20	26576	29.7	7.74	60000
673	6/22/93	3	6	4.00	3.00	6.50	5.20	504	25.9	7.78	120000
674	6/22/93	3	6	5.00	3.00	3.50	5.20	980	-999.9	-9.99	-9999999
675	6/22/93	3	6	5.00	3.00	3.50	5.20	44696	-999.9	-9.99	-9999999
676	6/22/93	3	6	5.00	3.00	5.50	5.20	36844	-999.9	-9.99	-9999999
677	6/22/93	3	6	5.00	3.00	6.50	5.20	4172	-999.9	-9.99	-9999999
678	6/22/93	3	7	4.00	3.00	3.50	5.16	30804	13.9	7.67	1100000
679	6/22/93	3	7	4.00	3.00	4.50	5.16	51944	18.8	8.02	1900000
680	6/22/93	3	7	4.00	3.00	5.50	5.16	27784	27.0	8.06	221000
681	6/22/93	3	7	4.00	3.00	6.50	5.16	5580	28.8	7.99	460000
682	6/22/93	3	7	2.00	4.00	3.50	5.16	1860	-999.9	-9.99	-9999999
683	6/22/93	3	7	2.00	4.00	4.50	5.16	19328	-999.9	-9.99	-9999999
684	6/22/93	3	7	2.00	4.00	5.50	5.16	24764	-999.9	-9.99	-9999999
685	6/22/93	3	7	2.00	4.00	6.50	5.16	2480	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
686	6/22/93	3	8	2.00	4.00	3.50	4.90	13892	14.6	7.96	380000
687	6/22/93	3	8	2.00	4.00	4.50	4.90	22952	20.5	7.71	24000000
688	6/22/93	3	8	2.00	4.00	5.50	4.90	26576	25.0	7.75	29300000
689	6/22/93	3	8	2.00	4.00	6.50	4.90	5952	28.4	8.15	10300000
690	6/22/93	3	8	5.00	5.00	3.50	4.90	7936	-999.9	-9.99	-9999999
691	6/22/93	3	8	5.00	5.00	4.50	4.90	33824	-999.9	-9.99	-9999999
692	6/22/93	3	8	5.00	5.00	5.50	4.90	30804	-999.9	-9.99	-9999999
693	6/22/93	3	8	5.00	5.00	6.50	4.90	4092	-999.9	-9.99	-9999999
694	6/22/93	3	9	4.00	5.00	3.50	4.74	3348	15.6	8.25	710000
695	6/22/93	3	9	4.00	5.00	4.50	4.74	43488	24.2	7.51	8600000
696	6/22/93	3	9	4.00	5.00	5.50	4.74	27180	27.4	7.87	7700000
697	6/22/93	3	9	4.00	5.00	6.50	4.74	3596	26.9	7.99	3740000
698	6/22/93	3	9	5.00	5.00	3.50	4.74	1736	-999.9	-9.99	-9999999
699	6/22/93	3	9	5.00	5.00	4.50	4.74	38656	-999.9	-9.99	-9999999
700	6/22/93	3	9	5.00	5.00	5.50	4.74	17516	-999.9	-9.99	-9999999
701	6/22/93	3	9	5.00	5.00	6.50	4.74	992	-999.9	-9.99	-9999999
702	6/23/93	3	10	4.00	5.00	3.50	4.70	10268	16.2	8.08	332000
703	6/23/93	3	10	4.00	5.00	4.50	4.70	39260	26.3	7.92	2210000
704	6/23/93	3	10	4.00	5.00	5.50	4.70	34428	28.9	7.80	780000
705	6/23/93	3	10	4.00	5.00	6.50	4.70	11160	26.6	7.89	730000
706	6/23/93	3	10	5.00	5.00	3.50	4.70	26576	-999.9	-9.99	-9999999
707	6/23/93	3	10	5.00	5.00	4.50	4.70	35032	-999.9	-9.99	-9999999
708	6/23/93	3	10	5.00	5.00	5.50	4.70	21744	-999.9	-9.99	-9999999
709	6/23/93	3	10	5.00	5.00	6.50	4.70	10168	-999.9	-9.99	-9999999
710	6/23/93	3	11	4.00	5.00	3.50	4.60	38656	15.7	8.11	7000000
711	6/23/93	3	11	4.00	5.00	4.50	4.60	68856	21.1	8.01	760000
712	6/23/93	3	11	4.00	5.00	5.50	4.60	14496	29.9	7.88	244000
713	6/23/93	3	11	4.00	5.00	6.50	4.60	5952	28.8	7.90	159000
714	6/23/93	3	11	5.00	5.00	3.50	4.60	53152	-999.9	-9.99	-9999999
715	6/23/93	3	11	5.00	5.00	4.50	4.60	68856	-999.9	-9.99	-9999999
716	6/23/93	3	11	5.00	5.00	5.50	4.60	18724	-999.9	-9.99	-9999999
717	6/23/93	3	11	5.00	5.00	6.50	4.60	8432	-999.9	-9.99	-9999999
718	6/23/93	3	12	4.00	5.00	3.50	4.80	8456	19.4	10.00	310000
719	6/23/93	3	12	4.00	5.00	4.50	4.80	25972	24.3	8.89	4450000
720	6/23/93	3	12	4.00	5.00	5.50	4.80	11284	29.6	7.87	3110000
721	3/23/93	3	12	4.00	5.00	6.50	4.80	2044	26.1	7.90	730000
722	6/23/93	3	12	5.00	5.00	3.50	4.80	8456	-999.9	-9.99	-9999999
723	6/23/93	3	12	5.00	5.00	4.50	4.80	27784	-999.9	-9.99	-9999999
724	6/23/93	3	12	5.00	5.00	5.50	4.80	15704	-999.9	-9.99	-9999999
725	6/23/93	3	12	5.00	5.00	6.50	4.80	1736	-999.9	-9.99	-9999999
765	7/19/93	4	1	6.00	2.00	3.50	4.86	4216	13.8	8.07	500000
766	7/19/93	4	1	6.00	2.00	4.50	4.86	39260	15.8	7.95	8500000
767	7/19/93	4	1	6.00	2.00	5.50	4.86	40468	20.2	7.90	11500000
768	7/19/93	4	1	6.00	2.00	6.50	4.86	30200	28.2	7.83	7000000
769	7/19/93	4	1	6.00	3.00	3.50	4.86	3596	-999.9	-9.99	-9999999
770	7/19/93	4	1	6.00	3.00	4.50	4.86	28388	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
771	7/19/93	4	1	6.00	3.00	5.50	4.86	58588	-999.9	-9.99	-9999999
772	7/19/93	4	1	6.00	3.00	6.50	4.86	35032	-999.9	-9.99	-9999999
773	7/19/93	4	2	5.00	2.00	3.50	4.86	112	14.2	8.13	400000
774	7/19/93	4	2	5.00	2.00	4.50	4.86	51340	15.8	7.98	4000000
775	7/19/93	4	2	5.00	2.00	5.50	4.86	95432	24.0	8.00	12000000
776	7/19/93	4	2	5.00	2.00	6.50	4.86	41072	28.1	7.91	9000000
777	7/19/93	4	2	6.00	2.00	3.50	4.86	224	-999.9	-9.99	-9999999
778	7/19/93	4	2	6.00	2.00	4.50	4.86	26576	-999.9	-9.99	-9999999
779	7/19/93	4	2	6.00	2.00	5.50	4.86	59192	-999.9	-9.99	-9999999
780	7/19/93	4	2	6.00	2.00	6.50	4.86	54360	-999.9	-9.99	-9999999
781	7/19/93	4	3	5.00	2.00	3.50	4.92	416	17.4	7.93	450000
782	7/19/93	4	3	5.00	2.00	4.50	4.92	24160	15.6	8.06	1025000
783	7/19/93	4	3	5.00	2.00	5.50	4.92	33220	20.6	7.91	975000
784	7/19/93	4	3	5.00	2.00	6.50	4.92	37448	28.3	8.24	950000
785	7/19/93	4	3	6.00	2.00	3.50	4.92	368	-999.9	-9.99	-9999999
786	7/19/93	4	3	6.00	2.00	4.50	4.92	25368	-999.9	-9.99	-9999999
787	7/19/93	4	3	6.00	2.00	5.50	4.92	26576	-999.9	-9.99	-9999999
788	7/19/93	4	3	6.00	2.00	6.50	4.92	33220	-999.9	-9.99	-9999999
789	7/19/93	4	4	5.00	2.00	3.50	5.11	8680	16.1	7.82	2500000
790	7/19/93	4	4	5.00	2.00	4.50	5.11	57380	16.1	8.01	4500000
791	7/19/93	4	4	5.00	2.00	5.50	5.11	90600	19.9	8.08	10250000
792	7/19/93	4	4	5.00	2.00	6.50	5.11	69460	25.3	8.19	3250000
793	7/19/93	4	4	6.00	2.00	3.50	5.11	10416	-999.9	-9.99	-9999999
794	7/19/93	4	4	6.00	2.00	4.50	5.11	66440	-999.9	-9.99	-9999999
795	7/19/93	4	4	6.00	2.00	5.50	5.11	65836	-999.9	-9.99	-9999999
796	7/19/93	4	4	6.00	2.00	6.50	5.11	44696	-999.9	-9.99	-9999999
797	7/19/93	4	5	5.00	2.00	3.50	5.12	1088	12.4	8.14	775000
798	7/19/93	4	5	5.00	2.00	4.50	5.12	43488	11.8	8.17	4500000
799	7/19/93	4	5	5.00	2.00	5.50	5.12	89996	15.8	8.05	9000000
800	7/19/93	4	5	5.00	2.00	6.50	5.12	69460	26.0	8.10	14500000
801	7/19/93	4	5	6.00	2.00	3.50	5.12	928	-999.9	-9.99	-9999999
802	7/19/93	4	5	6.00	2.00	4.50	5.12	33220	-999.9	-9.99	-9999999
803	7/19/93	4	5	6.00	2.00	5.50	5.12	90600	-999.9	-9.99	-9999999
804	7/19/93	4	5	6.00	2.00	6.50	5.12	63420	-999.9	-9.99	-9999999
805	7/19/93	4	6	5.00	2.00	3.50	5.20	1680	15.7	7.95	5500000
806	7/19/93	4	6	5.00	2.00	4.50	5.20	8184	14.0	8.00	4750000
807	7/19/93	4	6	5.00	2.00	5.50	5.20	52548	19.6	8.17	4500000
808	7/19/93	4	6	5.00	2.00	6.50	5.20	22348	26.7	7.98	500000
809	7/19/93	4	6	6.00	2.00	3.50	5.20	3472	-999.9	-9.99	-9999999
810	7/19/93	4	6	6.00	2.00	4.50	5.20	12080	-999.9	-9.99	-9999999
811	7/19/93	4	6	6.00	2.00	5.50	5.20	19932	-999.9	-9.99	-9999999
812	7/19/93	4	6	6.00	2.00	6.50	5.20	35636	-999.9	-9.99	-9999999
813	7/20/93	4	7	5.00	2.00	3.50	5.18	1456	13.8	8.11	750000
814	7/20/93	4	7	5.00	2.00	4.50	5.18	8456	15.2	8.10	1775000
815	7/20/93	4	7	5.00	2.00	5.50	5.18	53756	20.3	8.06	925000
816	7/20/93	4	7	5.00	2.00	6.50	5.18	43488	28.8	7.92	210000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
817	7/20/93	4	7	6.00	2.00	3.50	5.18	3836	-999.9	-9.99	-9999999
818	7/20/93	4	7	6.00	2.00	4.50	5.18	13288	-999.9	-9.99	-9999999
819	7/20/93	4	7	6.00	2.00	5.50	5.18	50736	-999.9	-9.99	-9999999
820	7/20/93	4	7	6.00	2.00	6.50	5.18	82144	-999.9	-9.99	-9999999
821	7/20/93	4	8	5.00	6.00	3.50	4.90	640	12.6	8.12	650000
822	7/20/93	4	8	5.00	6.00	4.50	4.90	11160	14.7	8.12	1925000
823	7/20/93	4	8	5.00	6.00	5.50	4.90	39864	21.0	7.91	8500000
824	7/20/93	4	8	5.00	6.00	6.50	4.90	44696	28.8	8.24	7500000
825	7/19/93	4	8	6.00	6.00	3.50	4.90	192	-999.9	-9.99	-9999999
826	7/20/93	4	8	6.00	6.00	4.50	4.90	9920	-999.9	-9.99	-9999999
827	7/20/93	4	8	6.00	6.00	5.50	4.90	24160	-999.9	-9.99	-9999999
828	7/20/93	4	8	6.00	6.00	6.50	4.90	27180	-999.9	-9.99	-9999999
829	7/20/93	4	9	5.00	6.00	3.50	4.75	224	13.3	8.17	475000
830	7/20/93	4	9	5.00	6.00	4.50	4.75	336	13.7	8.29	15000
831	7/20/93	4	9	5.00	6.00	5.50	4.75	30804	24.6	7.92	8500000
832	7/20/93	4	9	5.00	6.00	6.50	4.75	12080	28.7	7.97	3500000
833	7/20/93	4	9	6.00	6.00	3.50	4.75	960	-999.9	-9.99	-9999999
834	7/20/93	4	9	6.00	6.00	4.50	4.75	2000	-999.9	-9.99	-9999999
835	7/20/93	4	9	6.00	6.00	5.50	4.75	43488	-999.9	-9.99	-9999999
836	7/20/93	4	9	6.00	6.00	6.50	4.75	18120	-999.9	-9.99	-9999999
837	7/20/93	4	10	5.00	6.00	3.50	4.68	3136	14.5	8.08	975000
838	7/20/93	4	10	5.00	6.00	4.50	4.65	30200	18.4	8.08	2450000
839	7/20/93	4	10	5.00	6.00	5.50	4.68	65232	27.0	7.98	1850000
840	7/20/93	4	10	5.00	6.00	6.50	4.68	18724	28.6	7.79	900000
841	7/20/93	4	10	6.00	6.00	3.50	4.68	280	-999.9	-9.99	-9999999
842	7/20/93	4	10	6.00	6.00	4.50	4.68	18120	-999.9	-9.99	-9999999
843	7/20/93	4	10	6.00	6.00	5.50	4.68	53152	-999.9	-9.99	-9999999
844	7/20/93	4	10	6.00	6.00	6.50	4.68	36240	-999.9	-9.99	-9999999
845	7/20/93	4	11	5.00	6.00	3.50	4.60	1932	12.8	8.07	1000000
846	7/20/93	4	11	5.00	6.00	4.50	4.60	18724	14.1	8.09	1200000
847	7/20/93	4	11	5.00	6.00	5.50	4.60	65232	24.0	7.98	4000000
848	7/20/93	4	11	5.00	6.00	6.50	4.60	27784	26.8	7.88	10750000
849	7/20/93	4	11	6.00	6.00	3.50	4.60	1512	-999.9	-9.99	-9999999
850	7/20/93	4	11	6.00	6.00	4.50	4.60	3020	-999.9	-9.99	-9999999
851	7/20/93	4	11	6.00	6.00	5.50	4.60	41072	-999.9	-9.99	-9999999
852	7/20/93	4	11	6.00	6.00	6.50	4.60	19328	-999.9	-9.99	-9999999
853	7/20/93	4	12	5.00	6.00	3.50	4.78	128	13.3	8.15	325000
854	7/20/93	4	12	5.00	6.00	4.50	4.78	5460	19.9	7.95	110000
855	7/20/93	4	12	5.00	6.00	5.50	4.78	34428	25.8	7.86	900000
856	7/20/93	4	12	5.00	6.00	6.50	4.78	25368	28.4	7.79	215000
857	7/20/93	4	12	6.00	6.00	3.50	4.78	80	-999.9	-9.99	-9999999
858	7/20/93	4	12	6.00	6.00	4.50	4.78	4088	-999.9	-9.99	-9999999
859	7/20/93	4	12	6.00	6.00	5.50	4.78	27180	-999.9	-9.99	-9999999
860	7/20/93	4	12	6.00	6.00	6.50	4.78	6040	-999.9	-9.99	-9999999
890	8/16/93	5	1	6.00	5.00	3.50	5.18	27180	16.1	8.07	11750000
891	8/16/93	5	1	6.00	5.00	4.50	5.18	37324	22.5	8.03	13250000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
892	8/16/89	5	1	6.00	5.00	5.50	5.18	27692	26.3	7.82	15000000
893	8/16/93	5	1	6.00	5.00	6.50	5.18	216	30.5	8.15	1825000
894	8/16/93	5	1	7.00	5.00	3.50	5.18	21140	-999.9	-9.99	-9999999
895	8/16/93	5	1	7.00	5.00	4.50	5.18	62514	-999.9	-9.99	-9999999
896	8/16/93	5	1	7.00	5.00	5.50	5.18	32616	-999.9	-9.99	-9999999
897	8/16/93	5	1	7.00	5.00	6.50	5.18	682	-999.9	-9.99	-9999999
898	8/16/93	5	2	6.00	5.00	3.50	-9.99	43790	14.2	8.15	9750000
899	8/16/93	5	2	6.00	5.00	4.50	-9.99	53152	20.9	7.90	20000000
900	8/16/93	5	2	6.00	5.00	5.50	-9.99	6342	29.4	8.17	14250000
901	8/16/93	5	2	6.00	5.00	6.50	-9.99	0	27.5	8.08	400000
902	8/16/93	5	2	7.00	5.00	3.50	-9.99	24160	-999.9	-9.99	-9999999
903	8/16/93	5	2	7.00	5.00	4.50	-9.99	47112	-999.9	-9.99	-9999999
904	8/16/93	5	2	7.00	5.00	5.50	-9.99	18422	-999.9	-9.99	-9999999
905	8/16/93	5	2	7.00	5.00	6.50	-9.99	376	-999.9	-9.99	-9999999
906	8/16/93	5	3	6.00	5.00	3.50	4.98	21744	15.7	8.25	975000
907	8/16/93	5	3	6.00	5.00	4.50	4.98	51340	19.6	8.15	4250000
908	8/16/93	5	3	6.00	5.00	5.50	4.98	24462	28.1	8.08	1300000
909	8/16/93	5	3	6.00	5.00	6.50	4.98	8758	30.4	8.04	1300000
910	8/16/93	5	3	7.00	5.00	3.50	4.98	4154	-999.9	-9.99	-9999999
911	8/16/93	5	3	7.00	5.00	4.50	4.98	52850	-999.9	-9.99	-9999999
912	8/16/93	5	3	7.00	5.00	5.50	4.98	34730	-999.9	-9.99	-9999999
913	8/16/93	5	3	7.00	5.00	6.50	4.98	7550	-999.9	-9.99	-9999999
914	8/16/93	5	4	6.00	5.00	3.50	5.02	30200	18.1	8.10	5000000
915	8/16/93	5	4	6.00	5.00	4.50	5.02	110166	26.0	7.87	24250000
916	8/16/93	5	4	6.00	5.00	5.50	5.02	57984	24.8	7.95	15500000
917	8/16/93	5	4	6.00	5.00	6.50	5.02	7248	31.7	8.07	7250000
918	8/16/93	5	4	7.00	5.00	3.50	5.02	24160	-999.9	-9.99	-9999999
919	8/16/93	5	4	7.00	5.00	4.50	5.02	59192	-999.9	-9.99	-9999999
920	8/16/93	5	4	7.00	5.00	5.50	5.02	45300	-999.9	-9.99	-9999999
921	8/16/93	5	4	7.00	5.00	6.50	5.02	6040	-999.9	-9.99	-9999999
922	8/16/93	5	5	6.00	5.00	3.50	5.00	62816	12.3	8.10	3250000
923	8/16/93	5	5	6.00	5.00	4.50	5.00	86976	19.8	8.19	22250000
924	8/16/93	5	5	6.00	5.00	5.50	5.00	53152	25.2	8.03	5750000
925	8/16/93	5	5	6.00	5.00	6.50	5.00	13288	30.9	8.20	5000000
926	8/16/93	5	5	7.00	5.00	3.50	5.00	64628	-999.9	-9.99	-9999999
927	8/16/93	5	5	7.00	5.00	4.50	5.00	39864	-999.9	-9.99	-9999999
928	8/16/93	5	5	7.00	5.00	5.50	5.00	24160	-999.9	-9.99	-9999999
929	8/16/93	5	5	7.00	5.00	6.50	5.00	2720	-999.9	-9.99	-9999999
930	8/16/93	5	6	6.00	5.00	3.50	5.02	32	14.5	8.56	2725000
931	8/16/93	5	6	6.00	5.00	4.50	5.02	4464	21.9	8.24	180000
932	8/16/93	5	6	6.00	5.00	5.50	5.02	7248	29.5	7.96	200000
933	8/16/93	5	6	6.00	5.00	6.50	5.02	0	27.8	8.12	227500
934	8/16/93	5	6	7.00	5.00	3.50	5.02	160	-999.9	-9.99	-9999999
935	8/16/93	5	6	7.00	5.00	4.50	5.02	18120	-999.9	-9.99	-9999999
936	8/16/93	5	6	7.00	5.00	5.50	5.02	5436	-999.9	-9.99	-9999999
937	8/16/93	5	6	7.00	5.00	6.50	5.02	0	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
938	8/17/93	5	7	6.00	5.00	3.50	4.82	688	15.8	8.20	1050000
939	8/17/93	5	7	6.00	5.00	4.50	4.82	23912	23.7	8.19	1200000
940	8/17/93	5	7	6.00	5.00	5.50	4.82	3660	27.9	8.17	170000
941	8/17/93	5	7	6.00	5.00	6.50	4.82	80	28.5	8.09	450000
942	8/17/93	5	7	7.00	5.00	3.50	4.82	32452	-999.9	-9.99	-9999999
943	8/17/93	5	7	7.00	5.00	4.50	4.82	58072	-999.9	-9.99	-9999999
944	8/17/93	5	7	7.00	5.00	5.50	4.82	7564	-999.9	-9.99	-9999999
945	8/17/93	5	7	7.00	5.00	6.50	4.82	0	-999.9	-9.99	-9999999
946	8/17/93	5	8	6.00	3.00	3.50	4.60	1200	14.8	8.27	300000
947	8/17/93	5	8	6.00	3.00	4.50	4.60	22936	26.9	7.78	6500000
948	8/17/93	5	8	6.00	3.00	5.50	4.60	1240	28.0	8.11	875000
949	8/17/93	5	8	6.00	3.00	6.50	4.60	0	28.4	8.19	350000
950	8/17/93	5	8	7.00	3.00	3.50	4.60	1808	-999.9	-9.99	-9999999
951	8/17/93	5	8	7.00	3.00	4.50	4.60	44408	-999.9	-9.99	-9999999
952	8/17/93	5	8	7.00	3.00	5.50	4.60	15372	-999.9	-9.99	-9999999
953	8/17/93	5	8	7.00	3.00	6.50	4.60	32	-999.9	-9.99	-9999999
954	8/17/93	5	9	6.00	3.00	3.50	4.42	7688	18.3	8.10	1000000
955	8/17/93	5	9	6.00	3.00	4.50	4.42	29280	26.1	8.03	5750000
956	8/17/93	5	9	6.00	3.00	5.50	4.42	732	29.7	8.12	5000000
957	8/17/93	5	9	6.00	3.00	6.50	4.42	80	29.4	8.18	225000
958	8/17/93	5	9	7.00	3.00	3.50	4.42	12152	-999.9	-9.99	-9999999
959	8/17/93	5	9	7.00	3.00	4.50	4.42	43676	-999.9	-9.99	-9999999
960	8/17/93	5	9	7.00	3.00	5.50	4.42	14640	-999.9	-9.99	-9999999
961	8/17/93	5	9	7.00	3.00	6.50	4.42	32	-999.9	-9.99	-9999999
962	8/17/93	5	10	6.00	3.00	3.50	4.38	4464	17.6	8.16	550000
963	8/17/93	5	10	6.00	3.00	4.50	4.38	35868	25.4	8.21	1150000
964	8/17/93	5	10	6.00	3.00	5.50	4.38	9760	29.0	8.11	1500000
965	8/17/93	5	10	6.00	3.00	6.50	4.38	32	30.1	8.16	475000
966	8/17/93	5	10	7.00	3.00	3.50	4.38	4000	-999.9	-9.99	-9999999
967	8/17/93	5	10	7.00	3.00	4.50	4.38	26108	-999.9	-9.99	-9999999
968	8/17/93	5	10	7.00	3.00	5.50	4.38	9028	-999.9	-9.99	-9999999
969	8/17/93	5	10	7.00	3.00	6.50	4.38	0	-999.9	-9.99	-9999999
970	8/17/93	5	11	6.00	3.00	3.50	4.36	40748	16.4	7.98	1600000
971	8/17/93	5	11	6.00	3.00	4.50	4.36	81540	23.5	8.24	145000
972	8/17/93	5	11	6.00	3.00	5.50	4.36	12688	28.7	8.17	120000
973	8/17/93	5	11	6.00	3.00	6.50	4.36	96	27.7	8.12	95000
974	8/17/93	5	11	7.00	3.00	3.50	4.36	33428	-999.9	-9.99	-9999999
975	8/17/93	5	11	7.00	3.00	4.50	4.36	54656	-999.9	-9.99	-9999999
976	8/17/93	5	11	7.00	3.00	5.50	4.36	10492	-999.9	-9.99	-9999999
977	8/17/93	5	11	7.00	3.00	6.50	4.36	0	-999.9	-9.99	-9999999
978	8/17/93	5	12	6.00	3.00	3.50	4.50	12200	19.1	8.31	145000
979	8/17/93	5	12	6.00	3.00	4.50	4.50	41480	26.0	8.24	1050000
980	8/17/93	5	12	6.00	3.00	5.50	4.50	4880	29.2	8.09	160000
981	8/17/93	5	12	6.00	3.00	6.50	4.50	0	28.5	8.08	40000
982	8/17/93	5	12	7.00	3.00	3.50	4.50	2480	-999.9	-9.99	-9999999
983	8/17/93	5	12	7.00	3.00	4.50	4.50	26352	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
984	8/17/93	5	12	7.00	3.00	5.50	4.50	6344	-999.9	-9.99	-9999999
985	8/17/93	5	12	7.00	3.00	6.50	4.50	0	-999.9	-9.99	-9999999
1027	9/13/93	6	1	2.00	4.50	3.50	-9.99	24160	16.2	8.07	7750000
1028	9/13/93	6	1	2.00	4.50	4.50	-9.99	64628	20.7	7.88	17500000
1029	9/13/93	6	1	2.00	4.50	5.50	-9.99	27784	27.1	7.84	5750000
1030	9/13/93	6	1	2.00	4.50	6.50	-9.99	592	29.7	8.03	2000000
1031	9/13/93	6	1	1.00	4.50	3.50	-9.99	48320	-999.9	-9.99	-9999999
1032	9/13/93	6	1	1.00	4.50	4.50	-9.99	88184	-999.9	-9.99	-9999999
1033	9/13/93	6	1	1.00	4.50	5.50	-9.99	33824	-999.9	-9.99	-9999999
1034	9/13/93	6	1	1.00	4.50	6.50	-9.99	784	-999.9	-9.99	-9999999
1035	9/13/93	6	2	2.00	4.50	3.50	-9.99	65232	19.3	7.95	9500000
1036	9/13/93	6	2	2.00	4.50	4.50	-9.99	48924	23.5	7.81	10750000
1037	9/13/93	6	2	2.00	4.50	5.50	-9.99	8456	28.7	7.75	8000000
1038	9/13/93	6	2	2.00	4.50	6.50	-9.99	0	29.0	7.99	750000
1039	9/13/93	6	2	1.00	4.50	3.50	-9.99	25368	-999.9	-9.99	-9999999
1040	9/13/93	6	2	1.00	4.50	4.50	-9.99	50736	-999.9	-9.99	-9999999
1041	9/13/93	6	2	1.00	4.50	5.50	-9.99	5436	-999.9	-9.99	-9999999
1042	9/13/93	6	2	1.00	4.50	6.50	-9.99	112	-999.9	-9.99	-9999999
1043	9/13/93	6	3	2.00	4.50	3.50	5.04	53152	17.0	8.07	1800000
1044	9/13/93	6	3	2.00	4.50	4.50	5.04	40468	21.0	8.01	2450000
1045	9/13/93	6	3	2.00	4.50	5.50	5.04	11476	27.6	8.08	1750000
1046	9/13/93	6	3	2.00	4.50	6.50	5.04	992	25.5	8.05	1050000
1047	9/13/93	6	3	1.00	4.50	3.50	5.04	24160	-999.9	-9.99	-9999999
1048	9/13/93	6	3	1.00	4.50	4.50	5.04	67648	-999.9	-9.99	-9999999
1049	9/13/93	6	3	1.00	4.50	5.50	5.04	12080	-999.9	-9.99	-9999999
1050	9/13/93	6	3	1.00	4.50	6.50	5.04	272	-999.9	-9.99	-9999999
1051	9/13/93	6	4	2.00	4.50	3.50	5.18	24160	16.5	7.74	10250000
1052	9/13/93	6	4	2.00	4.50	4.50	5.18	57984	20.6	7.70	47500000
1053	9/13/93	6	4	2.00	4.50	5.50	5.18	34428	26.4	7.89	1425000
1054	9/13/93	6	4	2.00	4.50	6.50	5.18	384	30.8	7.88	525000
1055	9/13/93	6	4	1.00	4.50	3.50	5.18	16912	-999.9	-9.99	-9999999
1056	9/13/93	6	4	1.00	4.50	4.50	5.18	44696	-999.9	-9.99	-9999999
1057	9/13/93	6	4	1.00	4.50	5.50	5.18	28388	-999.9	-9.99	-9999999
1058	9/13/93	6	4	1.00	4.50	6.50	5.18	512	-999.9	-9.99	-9999999
1059	9/13/93	6	5	2.00	4.50	3.50	5.20	27784	14.7	7.90	2250000
1060	9/13/93	6	5	2.00	4.50	4.50	5.20	40468	23.0	7.92	3000000
1061	9/13/93	6	5	2.00	4.50	5.50	5.20	25368	27.3	7.98	3500000
1062	9/13/93	6	5	2.00	4.50	6.50	5.20	18848	28.7	8.01	10500000
1063	9/13/93	6	5	1.00	4.50	3.50	5.20	224	-999.9	-9.99	-9999999
1064	9/13/93	6	5	1.00	4.50	4.50	5.20	23556	-999.9	-9.99	-9999999
1065	9/13/93	6	5	1.00	4.50	5.50	5.20	48924	-999.9	-9.99	-9999999
1066	9/13/93	6	5	1.00	4.50	6.50	5.20	46508	-999.9	-9.99	-9999999
1067	9/13/93	6	6	2.00	4.50	3.50	5.22	112	14.5	8.00	2325000
1068	9/13/93	6	6	2.00	4.50	4.50	5.22	13764	21.8	8.11	1275000
1069	9/13/93	6	6	2.00	4.50	5.50	5.22	26576	27.6	8.09	105000
1070	9/13/93	6	6	2.00	4.50	6.50	5.22	624	28.6	8.05	950000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1071	9/13/93	6	6	1.00	4.50	3.50	5.22	320	-999.9	-9.99	-9999999
1072	9/13/93	6	6	1.00	4.50	4.50	5.22	12080	-999.9	-9.99	-9999999
1073	9/13/93	6	6	1.00	4.50	5.50	5.22	13288	-999.9	-9.99	-9999999
1074	9/13/93	6	6	1.00	4.50	6.50	5.22	1328	-999.9	-9.99	-9999999
1075	9/14/93	6	7	2.00	4.50	3.50	5.12	1120	18.1	7.95	5750000
1076	9/14/93	6	7	2.00	4.50	4.50	5.12	4960	16.0	7.89	575000
1077	9/14/93	6	7	2.00	4.50	5.50	5.12	16912	25.5	7.93	350000
1078	9/14/93	6	7	2.00	4.50	6.50	5.12	352	27.3	8.01	450000
1079	9/14/93	6	7	1.00	4.50	3.50	5.12	2016	-999.9	-9.99	-9999999
1080	9/14/93	6	7	1.00	4.50	4.50	5.12	13288	-999.9	-9.99	-9999999
1081	9/14/93	6	7	1.00	4.50	5.50	5.12	28388	-999.9	-9.99	-9999999
1082	9/14/93	6	7	1.00	4.50	6.50	5.12	176	-999.9	-9.99	-9999999
1083	9/14/93	6	8	2.00	2.50	3.50	-9.99	592	13.6	8.08	2000000
1084	9/14/93	6	8	2.00	2.50	4.50	-9.99	13892	24.2	7.74	4000000
1085	9/14/93	6	8	2.00	2.50	5.50	-9.99	10044	29.1	7.67	3500000
1086	9/14/93	6	8	2.00	2.50	6.50	-9.99	112	29.2	7.88	450000
1087	9/14/93	6	8	1.00	2.50	3.50	-9.99	1136	-999.9	-9.99	-9999999
1088	9/14/93	6	8	1.00	2.50	4.50	-9.99	18724	-999.9	-9.99	-9999999
1089	9/14/93	6	8	1.00	2.50	5.50	-9.99	10268	-999.9	-9.99	-9999999
1090	9/14/93	6	8	1.00	2.50	6.50	-9.99	80	-999.9	-9.99	-9999999
1091	9/14/93	6	9	2.00	2.50	3.50	4.90	26412	15.1	7.82	7750000
1092	9/14/93	6	9	2.00	2.50	4.50	4.90	56172	26.5	7.70	10750000
1093	9/14/93	6	9	2.00	2.50	5.50	4.90	21328	29.8	7.81	4750000
1094	9/14/93	6	9	2.00	2.50	6.50	4.90	96	30.1	7.95	950000
1095	9/14/93	6	9	1.00	2.50	3.50	4.90	25972	-999.9	-9.99	-9999999
1096	9/14/93	6	9	1.00	2.50	4.50	4.90	53152	-999.9	-9.99	-9999999
1097	9/14/93	6	9	1.00	2.50	5.50	4.90	19096	-999.9	-9.99	-9999999
1098	9/14/93	6	9	1.00	2.50	6.50	4.90	80	-999.9	-9.99	-9999999
1099	9/14/93	6	10	2.00	2.50	3.50	4.82	2604	14.3	8.05	300000
1100	9/14/93	6	10	2.00	2.50	4.50	4.82	40468	23.8	7.82	475000
1101	9/14/93	6	10	2.00	2.50	5.50	4.82	37448	27.2	7.80	2250000
1102	9/14/93	6	10	2.00	2.50	6.50	4.82	496	30.6	7.92	167500
1103	9/14/93	6	10	1.00	2.50	3.50	4.82	9920	-999.9	-9.99	-9999999
1104	9/14/93	6	10	1.00	2.50	4.50	4.82	47716	-999.9	-9.99	-9999999
1105	9/14/93	6	10	1.00	2.50	5.50	4.82	42280	-999.9	-9.99	-9999999
1106	9/14/93	6	10	1.00	2.50	6.50	4.82	784	-999.9	-9.99	-9999999
1107	9/14/93	6	11	2.00	2.50	3.50	4.82	25972	16.1	7.62	3000000
1108	9/14/93	6	11	2.00	2.50	4.50	4.82	87580	21.1	7.93	1250000
1109	9/14/93	6	11	2.00	2.50	5.50	4.82	44092	26.6	8.00	112500
1110	9/14/93	6	11	2.00	2.50	6.50	4.82	368	29.7	7.87	800000
1111	9/14/93	6	11	1.00	2.50	3.50	4.82	24160	-999.9	-9.99	-9999999
1112	9/14/93	6	11	1.00	2.50	4.50	4.82	111740	-999.9	-9.99	-9999999
1113	9/14/93	6	11	1.00	2.50	5.50	4.82	32012	-999.9	-9.99	-9999999
1114	9/14/93	6	11	1.00	2.50	6.50	4.82	640	-999.9	-9.99	-9999999
1115	9/14/93	6	12	2.00	2.50	3.50	4.96	12028	19.1	7.95	500000
1116	9/14/93	6	12	2.00	2.50	4.50	4.96	40468	24.6	7.71	2550000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1117	9/14/93	6	12	2.00	2.50	5.50	4.96	16308	30.1	7.81	1875000
1118	9/14/93	6	12	2.00	2.50	6.50	4.96	80	28.7	7.95	245000
1119	9/14/93	6	12	1.50	2.50	3.50	4.96	1488	-999.9	-9.99	-9999999
1120	9/14/93	6	12	1.50	2.50	4.50	4.96	64628	-999.9	-9.99	-9999999
1121	9/14/93	6	12	1.50	2.50	5.50	4.96	13288	-999.9	-9.99	-9999999
1122	9/14/93	6	12	1.50	2.50	6.50	4.96	32	-999.9	-9.99	-9999999
1163	10/11/93	7	1	2.00	4.00	3.50	-9.99	14260	15.7	7.79	2800000
1164	10/11/93	7	1	2.00	4.00	4.50	-9.99	49528	20.3	7.82	6750000
1165	10/11/93	7	1	2.00	4.00	5.50	-9.99	20536	29.3	7.95	9250000
1166	10/11/93	7	1	2.00	4.00	6.50	-9.99	160	31.8	8.02	1250000
1167	10/11/93	7	1	1.00	4.00	3.50	-9.99	12080	-999.9	-9.99	-9999999
1168	10/11/93	7	1	1.00	4.00	4.50	-9.99	47112	-999.9	-9.99	-9999999
1169	10/11/93	7	1	1.00	4.00	5.50	-9.99	44696	-999.9	-9.99	-9999999
1170	10/11/93	7	1	1.00	4.00	6.50	-9.99	992	-999.9	-9.99	-9999999
1171	10/11/93	7	2	1.00	4.00	3.50	-9.99	31408	18.3	7.77	25500000
1172	10/11/93	7	2	1.00	4.00	4.50	-9.99	19328	20.2	8.13	20000000
1173	10/11/93	7	2	1.00	4.00	5.50	-9.99	9300	27.7	7.85	5250000
1174	10/11/94	7	2	1.00	4.00	6.50	-9.99	48	30.7	8.02	67500
1175	10/11/93	7	2	2.00	4.00	3.50	-9.99	25972	-999.9	-9.99	-9999999
1176	10/11/93	7	2	2.00	4.00	4.50	-9.99	39864	-999.9	-9.99	-9999999
1177	10/11/93	7	2	2.00	4.00	5.50	-9.99	4464	-999.9	-9.99	-9999999
1178	10/11/93	7	2	2.00	4.00	6.50	-9.99	0	-999.9	-9.99	-9999999
1179	10/11/93	7	3	1.00	4.00	3.50	-9.99	21140	16.0	8.02	1125000
1180	10/11/93	7	3	1.00	4.00	4.50	-9.99	37448	23.9	7.82	6000000
1181	10/11/93	7	3	1.00	4.00	5.50	-9.99	12684	27.1	7.75	275000
1182	10/11/93	7	3	1.00	4.00	6.50	-9.99	10112	31.2	7.78	1200000
1183	10/11/93	7	3	2.00	4.00	3.50	-9.99	31408	-999.9	-9.99	-9999999
1184	10/11/93	7	3	2.00	4.00	4.50	-9.99	33220	-999.9	-9.99	-9999999
1185	10/11/93	7	3	2.00	4.00	5.50	-9.99	9664	-999.9	-9.99	-9999999
1186	10/11/93	7	3	2.00	4.00	6.50	-9.99	5084	-999.9	-9.99	-9999999
1187	10/11/93	7	4	1.00	4.00	3.50	-9.99	13892	16.6	7.78	1500000
1188	10/11/93	7	4	1.00	4.00	4.50	-9.99	58588	21.1	7.68	29500000
1189	10/11/93	7	4	1.00	4.00	5.50	-9.99	38052	29.2	7.67	2100000
1190	10/11/93	7	4	1.00	4.00	6.50	-9.99	528	31.7	7.86	387500
1191	10/11/93	7	4	2.00	4.00	3.50	-9.99	13288	-999.9	-9.99	-9999999
1192	10/11/93	7	4	2.00	4.00	4.50	-9.99	33220	-999.9	-9.99	-9999999
1193	10/11/93	7	4	2.00	4.00	5.50	-9.99	27784	-999.9	-9.99	-9999999
1194	10/11/93	7	4	2.00	4.00	6.50	-9.99	240	-999.9	-9.99	-9999999
1195	10/11/93	7	5	1.00	4.00	3.50	-9.99	140	12.7	8.13	300000
1196	10/11/93	7	5	1.00	4.00	4.50	-9.99	16912	24.0	7.90	2250000
1197	10/11/93	7	5	1.00	4.00	5.50	-9.99	27784	21.9	7.81	7750000
1198	10/11/93	7	5	1.00	4.00	6.50	-9.99	24764	31.4	7.73	5000000
1199	10/11/94	7	5	2.00	4.00	3.50	-9.99	4216	-999.9	-9.99	-9999999
1200	10/11/93	7	5	2.00	4.00	4.50	-9.99	32616	-999.9	-9.99	-9999999
1201	10/11/93	7	5	2.00	4.00	5.50	-9.99	43488	-999.9	-9.99	-9999999
1202	10/11/93	7	5	2.00	4.00	6.50	-9.99	20536	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1203	10/11/93	7	6	1.00	4.00	3.50	-9.99	80	13.8	8.01	3750000
1204	10/11/93	7	6	1.00	4.00	4.50	-9.99	6448	20.7	7.91	122500
1205	10/11/93	7	6	1.00	4.00	5.50	-9.99	13892	27.5	7.95	50000
1206	10/11/93	7	6	1.00	4.00	6.50	-9.99	3312	31.7	7.90	270000
1207	10/11/93	7	6	3.00	4.00	3.50	-9.99	48	-999.9	-9.99	-9999999
1208	10/11/93	7	6	3.00	4.00	4.50	-9.99	4216	-999.9	-9.99	-9999999
1209	10/11/93	7	6	3.00	4.00	5.50	-9.99	19328	-999.9	-9.99	-9999999
1210	10/11/93	7	6	3.00	4.00	6.50	-9.99	10044	-999.9	-9.99	-9999999
1211	10/12/93	7	7	1.00	4.00	3.50	-9.99	3104	16.1	7.90	400000
1212	10/12/93	7	7	1.00	4.00	4.50	-9.99	13392	25.2	7.89	77500
1213	10/12/93	7	7	1.00	4.00	5.50	-9.99	13892	25.1	7.94	142500
1214	10/12/93	7	7	1.00	4.00	6.50	-9.99	80	27.4	7.89	40000
1215	10/12/93	7	7	3.00	4.00	3.50	-9.99	3024	-999.9	-9.99	-9999999
1216	10/12/93	7	7	3.00	4.00	4.50	-9.99	15100	-999.9	-9.99	-9999999
1217	10/12/93	7	7	3.00	4.00	5.50	-9.99	20536	-999.9	-9.99	-9999999
1218	10/12/93	7	7	3.00	4.00	6.50	-9.99	160	-999.9	-9.99	-9999999
1219	10/12/93	7	8	1.00	4.00	3.50	-9.99	176	14.2	8.11	55000
1220	10/12/93	7	8	1.00	4.00	4.50	-9.99	15100	22.9	7.90	300000
1221	10/12/93	7	8	1.00	4.00	5.50	-9.99	10044	30.0	7.88	152500
1222	10/12/93	7	8	1.00	4.00	6.50	-9.99	0	28.6	7.97	20000
1223	10/12/93	7	8	3.00	4.00	3.50	-9.99	3680	-999.9	-9.99	-9999999
1224	10/12/93	7	8	3.00	4.00	4.50	-9.99	19344	-999.9	-9.99	-9999999
1225	10/12/93	7	8	3.00	4.00	5.50	-9.99	7812	-999.9	-9.99	-9999999
1226	10/12/93	7	8	3.00	4.00	6.50	-9.99	32	-999.9	-9.99	-9999999
1227	10/12/93	7	9	1.00	4.00	3.50	-9.99	1056	14.4	8.10	35000
1228	10/12/93	7	9	1.00	4.00	4.50	-9.99	32616	25.0	7.91	1625000
1229	10/12/93	7	8	1.00	4.00	5.50	-9.99	26784	25.4	7.88	27500
1230	10/12/93	7	9	1.00	4.00	6.50	-9.99	544	29.3	7.93	115000
1231	10/12/93	7	9	2.00	4.00	3.50	-9.99	1008	-999.9	-9.99	-9999999
1232	10/12/93	7	9	2.00	4.00	4.50	-9.99	28992	-999.9	-9.99	-9999999
1233	10/12/93	7	9	2.00	4.00	5.50	-9.99	10540	-999.9	-9.99	-9999999
1234	10/12/93	7	9	2.00	4.00	6.50	-9.99	11904	-999.9	-9.99	-9999999
1235	10/12/93	7	10	1.00	4.00	3.50	-9.99	1648	16.5	8.00	10000
1236	10/12/93	7	10	1.00	4.00	4.50	-9.99	37448	24.6	7.90	190000
1237	10/12/93	7	10	1.00	4.00	5.50	-9.99	13144	29.4	7.89	107500
1238	10/12/93	7	10	1.00	4.00	6.50	-9.99	64	29.1	7.87	7500
1239	10/12/93	7	10	2.00	4.00	3.50	-9.99	2336	-999.9	-9.99	-9999999
1240	10/12/93	7	10	2.00	4.00	4.50	-9.99	16308	-999.9	-9.99	-9999999
1241	10/12/93	7	10	2.00	4.00	5.50	-9.99	14384	-999.9	-9.99	-9999999
1242	10/12/93	7	10	2.00	4.00	6.50	-9.99	224	-999.9	-9.99	-9999999
1243	10/12/93	7	11	1.00	4.00	3.50	-9.99	24924	15.1	8.10	750000
1244	10/12/93	7	11	1.00	4.00	4.50	-9.99	21140	23.1	7.99	500000
1245	10/12/93	7	11	1.00	4.00	5.50	-9.99	17608	29.1	7.84	20000
1246	10/12/93	7	11	1.00	4.00	6.50	-9.99	16	29.8	7.84	12500
1247	10/12/93	7	11	2.00	4.00	3.50	-9.99	35032	-999.9	-9.99	-9999999
1248	10/12/93	7	11	2.00	4.00	4.50	-9.99	57984	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1249	10/12/93	7	11	2.00	4.00	5.50	-9.99	9424	-999.9	-9.99	-9999999
1250	10/12/93	7	11	2.00	4.00	6.50	-9.99	32	-999.9	-9.99	-9999999
1251	10/12/93	7	12	1.00	4.00	3.50	-9.99	1488	17.8	8.09	65000
1252	10/12/93	7	12	1.00	4.00	4.50	-9.99	12276	25.8	7.93	182500
1253	10/12/93	7	12	1.00	4.00	5.50	-9.99	15704	29.4	7.78	25000
1254	10/12/93	7	12	1.00	4.00	6.50	-9.99	32	29.6	7.77	20000
1255	10/12/93	7	12	2.00	4.00	3.50	-9.99	4216	-999.9	-9.99	-9999999
1256	10/12/93	7	12	2.00	4.00	4.50	-9.99	12684	-999.9	-9.99	-9999999
1257	10/12/93	7	12	2.00	4.00	5.50	-9.99	5084	-999.9	-9.99	-9999999
1258	10/12/93	7	12	2.00	4.00	6.50	-9.99	0	-999.9	-9.99	-9999999
1315	1/10/94	8	1	2.00	6.00	3.50	-9.99	14336	15.9	8.04	170000
1316	1/10/94	8	1	2.00	6.00	4.50	-9.99	23556	19.7	8.04	1940000
1317	1/10/94	8	1	2.00	6.00	5.50	-9.99	67648	28.0	7.93	610000
1318	1/10/94	8	1	2.00	6.00	6.50	-9.99	84	30.9	8.06	63000
1319	1/10/94	8	1	3.00	6.00	3.50	-9.99	10788	-999.9	-9.99	-9999999
1320	1/10/94	8	1	3.00	6.00	4.50	-9.99	24764	-999.9	-9.99	-9999999
1321	1/10/94	8	1	3.00	6.00	5.50	-9.99	14496	-999.9	-9.99	-9999999
1322	1/10/94	8	1	3.00	6.00	6.50	-9.99	80	-999.9	-9.99	-9999999
1323	1/10/94	8	2	2.00	6.00	3.50	3.92	15252	15.6	8.09	7100000
1324	1/10/94	8	2	2.00	6.00	4.50	3.92	45300	22.0	7.90	7100000
1325	1/10/94	8	2	2.00	6.00	5.50	3.92	2108	28.4	7.88	70000
1326	1/10/94	8	2	2.00	6.00	6.50	3.92	0	-999.9	7.99	18000
1327	1/10/94	8	2	3.00	6.00	3.50	3.92	22940	-999.9	-9.99	-9999999
1328	1/10/94	8	2	3.00	6.00	4.50	3.92	30200	-999.9	-9.99	-9999999
1329	1/10/94	8	2	3.00	6.00	5.50	3.92	2976	-999.9	-9.99	-9999999
1330	1/10/94	8	2	3.00	6.00	6.50	3.92	0	-999.9	-9.99	-9999999
1331	1/10/94	8	3	1.50	6.00	3.50	3.96	9424	14.8	8.16	83000
1332	1/10/94	8	3	1.50	6.00	4.50	3.96	36844	19.3	8.05	1840000
1333	1/10/94	8	3	1.50	6.00	5.50	3.96	7068	27.8	7.94	221000
1334	1/10/94	8	3	1.50	6.00	6.50	3.96	0	30.7	7.92	39000
1335	1/10/94	8	3	2.00	7.00	3.50	3.96	21452	-999.9	-9.99	-9999999
1336	1/10/94	8	3	2.00	7.00	4.50	3.96	38052	-999.9	-9.99	-9999999
1337	1/10/94	8	3	2.00	7.00	5.50	3.96	13892	-999.9	-9.99	-9999999
1338	1/10/94	8	3	2.00	7.00	6.50	3.96	32	-999.9	-9.99	-9999999
1339	1/10/94	8	4	2.00	6.00	3.50	4.12	5952	16.6	8.22	400000
1340	1/10/94	8	4	2.00	6.00	4.50	4.12	31408	23.2	8.00	6900000
1341	1/10/94	8	4	2.00	6.00	5.50	4.12	30804	25.5	8.07	440000
1342	1/10/94	8	4	2.00	6.00	6.50	4.12	576	30.4	7.97	2000
1343	1/10/94	8	4	3.00	6.00	3.50	4.12	9424	-999.9	-9.99	-9999999
1344	1/10/94	8	4	3.00	6.00	4.50	4.12	27784	-999.9	-9.99	-9999999
1345	1/10/94	8	4	3.00	6.00	5.50	4.12	34428	-999.9	-9.99	-9999999
1346	1/10/94	8	4	3.00	6.00	6.50	4.12	272	-999.9	-9.99	-9999999
1347	1/11/94	8	5	2.00	6.00	3.50	4.26	10872	11.0	8.17	590000
1348	1/11/94	8	5	2.00	6.00	4.50	4.26	85768	11.9	8.11	2800000
1349	1/11/94	8	5	2.00	6.00	5.50	4.26	37448	26.4	8.14	217000
1350	1/11/94	8	5	2.00	6.00	6.50	4.26	15872	31.1	8.19	90000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1351	1/11/94	8	5	3.00	6.00	3.50	4.26	24428	-999.9	-9.99	-9999999
1352	1/11/94	8	5	3.00	6.00	4.50	4.26	60400	-999.9	-9.99	-9999999
1353	1/11/94	8	5	3.00	6.00	5.50	4.26	46508	-999.9	-9.99	-9999999
1354	1/11/94	8	5	3.00	6.00	6.50	4.26	9424	-999.9	-9.99	-9999999
1355	1/11/94	8	6	2.00	6.00	3.50	4.32	1184	13.5	8.09	1000
1356	1/11/94	8	6	2.00	6.00	4.50	4.32	9424	17.9	8.07	500000
1357	1/11/94	8	6	2.00	6.00	5.50	4.32	16912	29.4	8.09	34000
1358	1/11/94	8	6	2.00	6.00	6.50	4.32	924	-999.9	8.04	0
1359	1/11/94	8	6	3.00	6.00	3.50	4.32	704	-999.9	-9.99	-9999999
1360	1/11/94	8	6	3.00	6.00	4.50	4.32	19932	-999.9	-9.99	-9999999
1361	1/11/94	8	6	3.00	6.00	5.50	4.32	25972	-999.9	-9.99	-9999999
1362	1/11/94	8	6	3.00	6.00	6.50	4.32	336	-999.9	-9.99	-9999999
1363	1/11/94	8	7	2.00	6.00	3.50	4.35	176	15.5	7.99	38000
1364	1/11/94	8	7	2.00	6.00	4.50	4.35	13288	19.3	8.00	31000
1365	1/11/94	8	7	2.00	6.00	5.50	4.35	9300	26.3	8.07	33000
1366	1/11/94	8	7	2.00	6.00	6.50	4.35	48	26.5	7.95	0
1367	1/11/94	8	7	3.00	6.00	3.50	4.35	4092	-999.9	-9.99	-9999999
1368	1/11/94	8	7	3.00	6.00	4.50	4.35	60400	-999.9	-9.99	-9999999
1369	1/11/94	8	7	3.00	6.00	5.50	4.35	19328	-999.9	-9.99	-9999999
1370	1/11/94	8	7	3.00	6.00	6.50	4.35	336	-999.9	-9.99	-9999999
1371	1/11/94	8	8	6.00	2.00	3.50	3.95	1764	12.6	8.17	2100000
1372	1/11/94	8	8	6.00	2.00	4.50	3.95	25368	20.8	8.06	920000
1373	1/11/94	8	8	6.00	2.00	5.50	3.95	8184	30.4	7.98	169000
1374	1/11/94	8	8	6.00	2.00	6.50	3.95	0	30.5	7.89	18000
1375	1/11/94	8	8	5.00	2.00	3.50	3.95	1568	-999.9	-9.99	-9999999
1376	1/11/94	8	8	5.00	2.00	4.50	3.95	21744	-999.9	-9.99	-9999999
1377	1/11/94	8	8	5.00	2.00	5.50	3.95	23556	-999.9	-9.99	-9999999
1378	1/11/94	8	8	5.00	2.00	6.50	3.95	0	-999.9	-9.99	-9999999
1379	1/12/94	8	9	5.00	2.00	3.50	3.76	18600	14.2	8.05	85000
1380	1/12/94	8	9	5.00	2.00	4.50	3.76	73084	23.3	7.93	6200000
1381	1/12/94	8	9	5.00	2.00	5.50	3.76	16912	29.9	7.90	18000
1382	1/12/94	8	9	5.00	2.00	6.50	3.76	0	30.1	7.97	170000
1383	1/12/94	8	9	6.00	2.00	3.50	3.76	8804	-999.9	-9.99	-9999999
1384	1/12/94	8	9	6.00	2.00	4.50	3.76	30804	-999.9	-9.99	-9999999
1385	1/12/94	8	9	6.00	2.00	5.50	3.76	9060	-999.9	-9.99	-9999999
1386	1/12/94	8	9	6.00	2.00	6.50	3.76	0	-999.9	-9.99	-9999999
1387	1/12/94	8	10	5.00	2.00	3.50	3.76	3224	14.8	8.21	440000
1388	1/12/94	8	10	5.00	2.00	4.50	3.76	50736	19.3	8.05	89000
1389	1/12/94	8	10	5.00	2.00	5.50	3.76	9664	26.7	7.97	102000
1390	1/12/94	8	10	5.00	2.00	6.50	3.76	768	30.5	7.85	5000
1391	1/12/94	8	10	6.00	2.00	3.50	3.76	3968	-999.9	-9.99	-9999999
1392	1/12/94	8	10	6.00	2.00	4.50	3.76	36240	-999.9	-9.99	-9999999
1393	1/12/94	8	10	6.00	2.00	5.50	3.76	10872	-999.9	-9.99	-9999999
1394	1/12/94	8	10	6.00	2.00	6.50	3.76	0	-999.9	-9.99	-9999999
1395	1/12/94	8	11	5.00	2.00	3.50	3.76	18972	14.7	8.27	170000
1396	1/12/94	8	11	5.00	2.00	4.50	3.76	102076	19.8	8.14	76000

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1397	1/12/94	8	11	5.00	2.00	5.50	3.76	19328	27.1	8.44	26000
1398	1/12/94	8	11	5.00	2.00	6.50	3.76	1920	30.4	7.98	1575
1399	1/12/94	8	11	6.00	2.00	3.50	3.76	5332	-999.9	-9.99	-9999999
1400	1/12/94	8	11	6.00	2.00	4.50	3.76	89392	-999.9	-9.99	-9999999
1401	1/12/94	8	11	6.00	2.00	5.50	3.76	9664	-999.9	-9.99	-9999999
1402	1/12/94	8	11	6.00	2.00	6.50	3.76	2304	-999.9	-9.99	-9999999
1403	1/12/94	8	12	5.00	2.00	3.50	3.96	7936	23.3	8.19	130000
1404	1/12/94	8	12	5.00	2.00	4.50	3.96	50132	22.9	8.02	250000
1405	1/12/94	8	12	5.00	2.00	5.50	3.96	12684	28.2	7.84	28000
1406	1/12/94	8	12	5.00	2.00	6.50	3.96	0	30.3	7.87	46000
1407	1/12/94	8	12	6.00	2.00	3.50	3.96	0	-999.9	-9.99	-9999999
1408	1/12/94	8	12	6.00	2.00	4.50	3.96	40468	-999.9	-9.99	-9999999
1409	1/12/94	8	12	6.00	2.00	5.50	3.96	13288	-999.9	-9.99	-9999999
1410	1/12/94	8	12	6.00	2.00	6.50	3.96	0	-999.9	-9.99	-9999999
1446	2/14/94	9	1	6.00	4.00	3.50	-9.99	25132	15.3	8.05	1300000
1447	2/14/94	9	1	6.00	4.00	4.50	-9.99	54360	19.6	8.09	7000000
1448	2/14/94	9	1	6.00	4.00	5.50	-9.99	31408	29.2	7.99	12700000
1449	2/14/94	9	1	6.00	4.00	6.50	-9.99	144	30.5	8	88000
1450	2/14/94	9	1	7.00	4.00	3.50	-9.99	22568	-999.9	-9.99	-9999999
1451	2/14/94	9	1	7.00	4.00	4.50	-9.99	58588	-999.9	-9.99	-9999999
1452	2/14/94	9	1	7.00	4.00	5.50	-9.99	32616	-999.9	-9.99	-9999999
1453	2/14/94	9	1	7.00	4.00	6.50	-9.99	112	-999.9	-9.99	-9999999
1454	2/14/94	9	2	5.50	4.00	3.50	5.12	77092	18.0	8.05	2000000
1455	2/14/94	9	2	5.50	4.00	4.50	5.12	52548	23.7	7.73	25200000
1456	2/14/94	9	2	5.50	4.00	5.50	5.12	24764	31.2	7.89	9700000
1457	2/14/94	9	2	5.50	4.00	6.50	5.12	0	31.3	7.9	187000
1458	2/14/94	9	2	7.00	4.00	3.50	5.12	34648	-999.9	-9.99	-9999999
1459	2/14/94	9	2	7.00	4.00	4.50	5.12	61608	-999.9	-9.99	-9999999
1460	2/14/94	9	2	7.00	4.00	5.50	5.12	22952	-999.9	-9.99	-9999999
1461	2/14/94	9	2	7.00	4.00	6.50	5.12	48	-999.9	-9.99	-9999999
1462	2/14/94	9	3	6.00	4.00	3.50	5.22	33428	14.4	8.07	110000
1463	2/14/94	9	3	6.00	4.00	4.50	5.22	45300	19.2	7.96	5300000
1464	2/14/94	9	3	6.00	4.00	5.50	5.22	20536	28.1	7.74	1320000
1465	2/14/94	9	3	6.00	4.00	6.50	5.22	7440	28.1	7.84	2540000
1466	2/14/94	9	3	7.00	4.00	3.50	5.22	44896	-999.9	-9.99	-9999999
1467	2/14/94	9	3	7.00	4.00	4.50	5.22	51944	-999.9	-9.99	-9999999
1468	2/14/94	9	3	7.00	4.00	5.50	5.22	38052	-999.9	-9.99	-9999999
1469	2/14/94	9	3	7.00	4.00	6.50	5.22	6448	-999.9	-9.99	-9999999
1470	2/14/94	9	4	6.00	4.00	3.50	5.43	38796	17.5	7.9	7800000
1471	2/14/94	9	4	6.00	4.00	4.50	5.43	62816	23.2	7.83	10900000
1472	2/14/94	9	4	6.00	4.00	5.50	5.43	59796	27.9	7.76	11700000
1473	2/14/94	9	4	6.00	4.00	6.50	5.43	608	29.4	7.9	5700000
1474	2/14/94	9	4	7.00	4.00	3.50	5.43	28304	-999.9	-9.99	-9999999
1475	2/14/94	9	4	7.00	4.00	4.50	5.43	25368	-999.9	-9.99	-9999999
1476	2/14/94	9	4	7.00	4.00	5.50	5.43	56172	-999.9	-9.99	-9999999
1477	2/14/94	9	4	7.00	4.00	6.50	5.43	7504	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1478	2/14/94	9	5	6.00	4.00	3.50	5.47	57380	10.4	8.15	5600000
1479	2/14/94	9	5	6.00	4.00	4.50	5.47	168560	17.0	8.02	20200000
1480	2/14/94	9	5	6.00	4.00	5.50	5.47	63420	25.1	7.94	4800000
1481	2/14/94	9	5	6.00	4.00	6.50	5.47	15128	29.3	7.93	4900000
1482	2/14/94	9	5	7.00	4.00	3.50	5.47	40504	-999.9	-9.99	-9999999
1483	2/14/94	9	5	7.00	4.00	4.50	5.47	102680	-999.9	-9.99	-9999999
1484	2/14/94	9	5	7.00	4.00	5.50	5.47	40468	-999.9	-9.99	-9999999
1485	2/14/94	9	5	7.00	4.00	6.50	5.47	20212	-999.9	-9.99	-9999999
1486	2/14/94	9	6	6.00	4.00	3.50	4.98	0	13.1	7.87	1100000
1487	2/14/94	9	6	6.00	4.00	4.50	4.98	20536	20.9	7.8	210000
1488	2/14/94	9	6	6.00	4.00	5.50	4.98	25368	30.2	7.76	3900000
1489	2/14/94	9	6	6.00	4.00	6.50	4.98	3904	28.5	7.68	102000
1490	2/14/94	9	6	7.00	4.00	3.50	4.98	532	-999.9	-9.99	-9999999
1491	2/14/94	9	6	7.00	4.00	4.50	4.98	8456	-999.9	-9.99	-9999999
1492	2/14/94	9	6	7.00	4.00	5.50	4.98	19932	-999.9	-9.99	-9999999
1493	2/14/94	9	6	7.00	4.00	6.50	4.98	256	-999.9	-9.99	-9999999
1494	2/15/94	9	7	6.00	4.00	3.50	5.01	13392	16.7	7.91	500000
1495	2/15/94	9	7	6.00	4.00	4.50	5.01	39864	20.8	8.00	55000
1496	2/15/94	9	7	6.00	4.00	5.50	5.01	38052	27.4	7.80	42000
1497	2/15/94	9	7	6.00	4.00	6.50	5.01	1600	28.4	7.86	156000
1498	2/15/94	9	7	7.00	4.00	3.50	5.01	25620	-999.9	-9.99	-9999999
1499	2/15/94	9	7	7.00	4.00	4.50	5.01	74292	-999.9	-9.99	-9999999
1500	2/15/94	9	7	7.00	4.00	5.50	5.01	36240	-999.9	-9.99	-9999999
1501	2/15/94	9	7	7.00	4.00	6.50	5.01	368	-999.9	-9.99	-9999999
1502	2/15/94	9	8	6.00	4.00	3.50	5.10	1860	13.0	8.22	1350000
1503	2/15/94	9	8	6.00	4.00	4.50	5.10	24764	20.8	7.75	1980000
1504	2/15/94	9	8	6.00	4.00	5.50	5.10	7564	28.5	7.73	1450000
1505	2/15/94	9	8	6.00	4.00	6.50	5.10	16	27.1	7.90	245000
1506	2/15/94	9	8	7.00	4.00	3.50	5.10	1008	-999.9	-9.99	-9999999
1507	2/15/94	9	8	7.00	4.00	4.50	5.10	15100	-999.9	-9.99	-9999999
1508	2/15/94	9	8	7.00	4.00	5.50	5.10	5456	-999.9	-9.99	-9999999
1509	2/15/94	9	8	7.00	4.00	6.50	5.10	0	-999.9	-9.99	-9999999
1510	2/15/94	9	9	6.00	4.00	3.50	4.97	608	13.6	8.08	59000
1511	2/15/94	9	9	6.00	4.00	4.50	4.97	32012	23.2	7.66	1540000
1512	2/15/94	9	9	6.00	4.00	5.50	4.97	10872	31.3	7.03	1860000
1513	2/15/94	9	9	6.00	4.00	6.50	4.97	48	28.7	7.68	144000
1514	2/15/94	9	9	7.50	4.00	3.50	4.97	1488	-999.9	-9.99	-9999999
1515	2/15/94	9	9	7.50	4.00	4.50	4.97	45904	-999.9	-9.99	-9999999
1516	2/15/94	9	9	7.50	4.00	5.50	4.97	26576	-999.9	-9.99	-9999999
1517	2/15/94	9	9	7.50	4.00	6.50	4.97	64	-999.9	-9.99	-9999999
1518	2/15/94	9	10	6.00	4.00	3.50	4.96	2480	15.0	8.08	143000
1519	2/15/94	9	10	6.00	4.00	4.50	4.96	33824	22.3	7.87	265000
1520	2/15/94	9	10	6.00	4.00	5.50	4.96	26576	29.4	7.76	980000
1521	2/15/94	9	10	6.00	4.00	6.50	4.96	588	29.3	7.78	131000
1522	2/15/94	9	10	7.00	4.00	3.50	4.96	1860	-999.9	-9.99	-9999999
1523	2/15/94	9	10	7.00	4.00	4.50	4.96	42884	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Sample Date	Sample Period	Plot Number	Sample Position X	Sample Position Y	Sample Depth (ft)	Groundwater Level (ft)	TPH (mg OCB/kg)	Percent Moisture (%)	pH	CFU (mg CFU/g)
1524	2/15/94	9	10	7.00	4.00	5.50	4.96	47112	-999.9	-9.99	-9999999
1525	2/15/94	9	10	7.00	4.00	6.50	4.96	288	-999.9	-9.99	-9999999
1526	2/15/94	9	11	6.00	4.00	3.50	5.03	13640	11.0	7.96	3200000
1527	2/15/94	9	11	6.00	4.00	4.50	5.03	81540	19.6	7.87	13600000
1528	2/15/94	9	11	6.00	4.00	5.50	5.03	15100	26.7	7.76	340000
1529	2/15/94	9	11	6.00	4.00	6.50	5.03	288	28.7	7.85	72000
1530	2/15/94	9	11	7.00	4.00	3.50	5.03	35032	-999.9	-9.99	-9999999
1531	2/15/94	9	11	7.00	4.00	4.50	5.03	95432	-999.9	-9.99	-9999999
1532	2/15/94	9	11	7.00	4.00	5.50	5.03	68856	-999.9	-9.99	-9999999
1533	2/15/94	9	11	7.00	4.00	6.50	5.03	128	-999.9	-9.99	-9999999
1534	2/15/94	9	12	6.00	4.00	3.50	5.15	504	16.7	7.77	370000
1535	2/15/94	9	12	6.00	4.00	4.50	5.15	40468	23.0	7.90	144000
1536	2/15/94	9	12	6.00	4.00	5.50	5.15	43488	27.1	7.55	370000
1537	2/15/94	9	12	6.00	4.00	6.50	5.15	32	29.1	7.59	18000
1538	2/15/94	9	12	7.00	4.00	3.50	5.15	2480	-999.9	-9.99	-9999999
1539	2/15/94	9	12	7.00	4.00	4.50	5.15	33220	-999.9	-9.99	-9999999
1540	2/15/94	9	12	7.00	4.00	5.50	5.15	15704	-999.9	-9.99	-9999999
1541	2/15/94	9	12	7.00	4.00	6.50	5.15	0	-999.9	-9.99	-9999999

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
300	0	0	0	0	0	0					
301	0	0	0	0	0	0					
302	0	75000	3668300	3179900	0	6923200	0	19	108	96	0
303	0	552200	10544300	10051800	201400	21349700	0	63	109	115	21
304	6000	589900	8029100	6513000	20700	15158700	1	52	74	78	5
305	0	0	0	0	0	0					
306	0	120400	4571600	4298700	0	8990700	0	26	112	108	0
307	56700	785100	13206000	10995300	0	25043100	5	29	45	45	0
308	0	335400	4793800	3912200	27200	9068600	0	34	42	39	3
309	0	0	0	0	0	0					
310	0	63800	5211300	6794000	0	12069100	0	16	108	120	0
311	0	544100	11226700	10005100	44800	21820700	0	46	71	75	6
312	0	134300	1951700	1504600	0	3590600	0	29	105	85	0
313	0	0	19100	0	0	19100					
314	0	208600	9896000	9276100	0	19380700	0	36	109	106	0
315	4800	687000	11796800	9711700	176100	22376400	2	51	71	76	13
316	8800	512700	7992200	6145100	23700	14682500	3	46	72	77	6
317	0	0	0	0	0	0					
318	0	26200	3284400	3543800	0	6854400	0	8	95	103	0
319	69600	1243500	22068000	17358600	63000	40802700	4	46	74	85	5
320	0	237500	4016100	2845700	2500	7101800	0	38	72	68	1
321	0	0	0	0	0	0					
322	0	0	0	0	0	0	0	0	0	0	0
323	0	194900	3259700	3042400	28500	6525500	0	22	42	43	4
324	0	102500	1554400	994600	0	2651500	0	23	102	80	0
325	0	0	0	0	0	0					
326	0	0	0	0	0	0					
327	0	2400	52000	26900	0	81300	0	1	14	4	0
328	0	409000	6222100	5973100	38800	12643000	0	43	71	75	6
329	0	111400	1881600	1702300	0	3695300	0	25	109	90	0
330	0	0	0	0	0	0					
331	0	6800	2327700	3300600	0	5635100	0	2	76	100	0
332	0	87500	2152400	1799400	0	4039300	0	22	106	90	0
333	0	199600	4379000	4257500	75900	8912000	0	40	107	115	7
334	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999					
335	0	2400	0	0	0	2400	0	1	0	0	0
336	0	274700	3839600	3147300	0	7261600	0	44	109	98	0
337	0	110900	1173000	764100	0	2048000	0	18	44	37	0
338	0	2200	0	0	0	2200					
339	0	13000	3035600	4220500	0	7269100	0	4	64	72	0
340	0	255800	6393400	7032900	83400	13765500	0	41	113	116	8
341	0	121500	1728000	1462000	0	3311500	0	19	48	35	0
342	0	3400	0	0	0	3400					
343	0	180300	7569400	9934300	380300	18064300	0	20	46	43	9
344	0	785700	12598500	12111300	85500	25581000	0	26	44	41	3
345	0	93100	1122000	820500	0	2035600	0	19	44	37	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
346	0	0	0	0	0	0					
347	0	2600	2742400	4842900	217000	7804900	0	1	75	116	7
348	0	116300	3314400	3079800	0	6510500	0	26	109	112	0
349	0	140400	2011000	1558900	0	3710300	0	21	47	36	0
350	0	0	0	0	0	0					
351	0	0	0	0	0	0	0	0	0	0	0
352	0	0	36300	19100	0	55400	0	0	10	3	0
353	0	0	24600	15100	0	39700					
354	0	24000	357700	81800	0	463500	0	8	69	17	0
355	0	0	8600	5900	0	14500	0	0	3	1	0
356	0	0	20600	9400	0	30000					
357	0	50300	967600	440000	0	1457900	0	16	78	51	0
358	0	25300	420300	94800	0	540400	0	9	71	17	0
359	0	0	74400	26100	0	100500	0	0	22	4	0
361	0	0	21400	12100	0	33500	0	0	8	3	0
362	0	0	0	0	0	0	0	0	0	0	0
363	0	0	20300	12100	0	32400	0	0	7	3	0
364	0	0	0	0	0	0	0	0	0	0	0
365	0	0	6000	7700	0	13700	0	0	2	2	0
437	1800	83300	3266800	3374100	0	6726000	1	20	73	70	0
438	0	317700	4860600	4471400	20600	9670300	0	34	45	38	2
439	5600	218400	2881900	2140000	0	5245900	4	56	108	92	0
440	2600	247600	6465500	6268900	26000	13010600	2	33	41	36	2
441	12600	648200	10646600	8564300	40000	19911700	6	60	77	77	11
442	1200	111100	1540300	750600	0	2403200	1	39	101	69	0
443	0	37700	2435600	2891200	0	5364500	0	15	69	65	0
444	1200	291700	5167100	4095200	0	9555200	1	49	70	74	0
445	1500	147400	1815600	1156400	0	3120900	1	47	103	81	0
446	0	22400	219400	56900	0	298700	0	14	68	16	0
447	0	27600	2734100	3041300	0	5803000	0	10	69	66	0
448	4600	628000	12107200	9021200	0	21761000	3	60	72	72	0
449	13800	644300	8735500	6891100	73300	16358000	6	47	42	38	4
450	0	0	2300	0	0	2300	0	0	1	0	0
451	3800	269100	5344100	4255800	0	9872800	3	57	112	99	0
452	4400	243500	3999100	2780000	0	7027000	3	62	110	95	0
453	0	54900	1121900	575100	0	1751900	0	25	97	60	0
454	0	0	0	5000	0	5000	0	0	0	3	0
455	2400	232300	3185700	2738200	0	6158600	2	33	44	41	0
456	7600	469500	4983800	3847300	0	9308200	4	58	74	78	0
457	0	25900	1767400	2203900	1600	3998800	0	13	100	88	2
458	7500	597100	7665600	6349700	8200	14628100	4	58	72	75	6
459	1200	277900	2861300	1876200	2600	5019200	1	56	107	86	2
460	0	3000	1400	1400	0	5800	0	1	1	1	0
461	0	122800	2662100	2452600	2400	5239900	0	40	101	94	2
462	1200	156100	1518300	730400	0	2406000	1	50	102	70	0
463	0	0	5600	2800	0	8400	0	0	3	1	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
464	0	200000	3253000	3306100	25000	6784100	0	30	45	38	3
465	0	132200	1433200	695200	0	2260600	0	47	101	71	0
466	1100	3400	856600	729100	0	1590200	1	2	69	65	0
467	1000	377100	6693500	6180500	8700	13260800	1	36	45	43	1
468	3300	142200	1476600	840000	0	2462100	2	46	102	72	0
469	0	274800	9482000	11214400	632900	21604100	0	32	48	41	17
470	2000	701000	12090200	10136400	34400	22964000	1	59	71	73	6
471	0	132800	1689700	1210000	0	3032500	0	46	101	82	0
472	0	211400	9351200	9488900	22700	19074200	0	46	106	124	15
473	0	300200	6791700	6362700	27900	13482500	0	47	70	77	7
474	1000	86900	1252000	868200	0	2208100	1	35	69	47	0
475	0	35000	449800	108400	0	593200	0	18	81	25	0
476	0	1000	444400	84900	0	530300	0	1	65	26	0
477	0	214500	5209000	3538000	0	8961500	0	48	111	105	0
478	4500	235300	3773400	2232900	0	6246100	3	56	101	86	0
479	1600	99500	1453200	553600	0	2107900	1	37	94	61	0
480	0	0	1200	1800	0	3000	0	0	1	1	0
481	0	149700	2012800	1190200	0	3352700	0	33	71	55	0
482	1800	164600	1852400	1020300	0	3039100	1	47	104	72	0
483	0	40000	400000	73800	0	513800	0	19	75	22	0
484	0	3400	100700	20500	0	124600	0	1	21	5	0
485	1000	239700	3631800	2731700	0	6604200	1	50	102	97	0
486	1800	233600	2823600	1864800	0	4923800	1	56	114	90	0
487	0	6800	184400	43600	0	234800	0	5	54	12	0
488	0	255000	8912100	9872800	201200	19241100	0	51	106	120	21
489	1200	754300	12638800	11663800	215200	25273300	1	60	69	72	14
490	1100	145000	1930500	1300300	0	3376900	1	38	74	58	0
491	4700	0	68500	14000	1000	88200	2	0	29	2	1
492	0	52100	4577100	5173400	38900	9841500	0	21	105	116	2
493	0	334700	7897000	6721700	19500	14972900	0	49	71	84	4
494	0	92900	1399600	582800	0	2075300	0	35	101	68	0
495	0	3000	58800	17300	0	79100	0	1	25	4	0
505	0	153300	5398300	4505600	0	10057200	0	37	108	101	0
506	0	421800	8641600	6861400	51400	15976200	0	71	108	121	9
507	1200	216000	3193000	2332900	7600	5750700	1	36	47	40	1
508	0	45000	618300	119300	0	782600	0	21	90	28	0
509	0	96900	4673000	4804200	0	9574100	0	32	105	107	0
510	0	352700	7140900	5764200	17800	13275600	0	50	67	78	4
511	2800	225800	3028400	1857800	0	5114800	2	55	94	84	0
512	0	51200	662900	140000	0	854100	0	23	90	28	0
513	0	128400	3285600	2596300	0	6010300	0	23	48	34	0
514	11800	603400	9582500	6565900	8600	16772200	7	64	68	80	4
515	0	100200	1475700	531800	0	2107700	0	35	93	59	0
516	0	27800	509100	106400	0	643300	0	17	62	19	0
517	0	155600	4123500	3046100	4600	7329800	0	26	47	40	1
518	9500	592700	10586600	8559800	13400	19762000	4	77	112	115	5

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
519	0	152000	2136100	962400	0	3250500	0	47	105	72	0
520	0	0	19800	7200	0	27000	0	0	11	2	0
521	0	255100	10470500	10181600	144300	21051500	0	48	109	123	16
522	0	525600	10127900	7759300	156700	18569500	0	51	69	78	14
523	0	65200	638000	113100	4200	820500	0	26	97	25	4
524	0	46200	506600	129200	0	682000	0	21	90	28	0
525	0	5400	663000	217200	0	885600	0	3	79	42	0
526	0	284000	4640500	3200000	0	8124500	0	58	110	111	0
527	0	75500	859600	256700	0	1191800	0	32	90	42	0
528	0	5300	63100	14100	0	82500	0	3	29	3	0
529	0	16300	1924900	1790200	0	3731400	0	7	71	58	0
530	1200	312300	6650900	5141000	38600	12144000	1	32	45	40	3
531	13900	477100	6838600	4163000	0	11492600	7	78	105	108	0
532	2700	0	114200	33100	0	150000	1	0	39	5	0
533	0	111200	5679200	5250500	35800	11076700	0	27	68	74	5
534	2300	503500	9020900	6411600	21100	15959400	1	71	113	115	6
535	9100	470300	6531000	4273600	4400	11288400	5	61	67	76	3
536	0	34800	602200	114000	0	751000	0	19	65	21	0
537	0	0	79100	16700	0	95800	0	0	25	4	0
538	5300	425300	7933500	5519600	4700	13888400	4	57	69	78	3
539	9300	347200	5087900	3205900	0	8650300	6	68	101	104	0
540	4500	173600	2492800	1215100	0	3886000	3	50	97	75	0
541	0	0	0	0	0	0	0	0	0	0	0
542	3200	267000	4948200	3456400	0	8674800	2	60	105	102	0
543	0	242300	3488800	2010600	0	5741700	0	58	99	85	0
544	2400	153700	2282400	1142500	0	3581000	2	45	100	75	0
545	0	1600	0	0	0	1600	0	1	0	0	0
546	1100	115800	1544400	611700	0	2273000	1	35	95	78	0
547	6300	300900	3272900	2432700	0	6012800	3	41	45	39	0
548	0	129800	1137300	440700	0	1707800	0	40	94	63	0
549	1500	0	0	0	0	1500	1	0	0	0	0
550	0	68200	1264000	518700	0	1850900	0	27	96	66	0
551	26400	649100	6644600	4585700	0	11905800	11	61	73	72	0
552	0	108400	1114900	421000	0	1644300	0	39	99	60	0
553	1100	13300	1921800	2157300	6000	4099500	1	8	63	64	4
554	3100	363700	6683300	5871000	33200	12954300	2	59	114	115	6
555	19600	479300	5695500	4519400	1200	10715000	8	59	71	75	1
556	3700	36800	418000	83700	0	542200	2	20	80	23	0
557	0	4200	569400	661800	0	1235400	0	3	70	69	0
558	13100	238900	3636100	2754300	0	6642400	7	46	102	96	0
559	5700	213900	2446400	1642000	0	4308000	3	50	99	85	0
560	0	15600	209900	49500	0	275000	0	11	42	13	0
561	6500	0	119100	29600	0	155200	3	0	29	8	0
562	9200	93700	3378700	3073100	0	6554700	4	30	66	71	0
563	2200	129200	1679200	707300	0	2517900	1	40	97	68	0
564	5200	6400	91400	29600	0	132600	2	2	38	7	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
565	0	5000	728900	611400	0	1345300	0	1	47	33	0
566	0	176100	5652800	5896900	67800	11793600	0	36	69	80	7
567	1300	193300	2635300	1615900	0	4445800	1	49	97	80	0
568	0	64600	876900	394600	0	1336100	0	25	91	54	0
569	0	2200	0	0	0	2200	0	1	0	0	0
570	3000	155500	1748700	987500	0	2894700	2	43	100	74	0
571	1600	152400	1727200	947000	0	2828200	1	42	99	74	0
572	1600	31600	364200	64800	0	462200	1	18	72	19	0
573	0	0	8100	0	0	8100	0	0	5	0	0
574	0	291900	4786700	3710700	0	8789300	0	59	111	104	0
575	0	97200	969400	359600	0	1426200	0	32	97	55	0
576	0	18800	172400	51100	0	242300	0	12	57	14	0
577	4300	3100	154000	55000	0	216400	3	1	43	16	0
578	1200	235200	5851200	5599100	36300	11723000	1	27	46	38	2
579	4800	277300	3116200	2104200	0	5502500	3	62	100	94	0
580	0	8800	144200	39600	0	192600	0	5	48	10	0
581	4300	0	135100	26700	0	166100	1	0	30	8	0
582	0	201300	5069800	4432000	0	9703100	0	48	105	106	0
583	6700	276000	2903600	1825400	0	5011700	5	52	72	57	0
584	0	5000	154900	36800	0	196700	0	4	45	9	0
585	2600	307100	10944400	10347000	56700	21657800	1	53	108	114	9
586	0	543700	11372900	9791000	87400	21795000	0	69	112	120	13
587	10200	148700	2422600	1763500	0	4345000	2	35	72	57	0
588	0	1200	161700	34300	0	197200	0	1	46	7	0
589	0	160300	6564700	5881300	0	12606300	0	23	45	39	0
590	3600	764600	12085200	11151400	253100	24257900	3	63	69	76	16
591	5800	168200	2020900	1209400	0	3404300	2	48	100	76	0
592	7000	42100	611500	150400	0	811000	2	20	89	38	0
593	0	80900	6128300	6889700	116900	13215800	0	26	105	120	9
594	0	341700	8440700	7057600	84500	15924500	0	59	110	120	16
595	11400	182200	2742800	1947200	0	4883600	3	30	45	38	0
596	4800	108700	1340200	840200	0	2293900	2	25	49	30	0
597	0	59500	5740100	5677400	1400	11478400	0	22	108	118	1
598	0	260200	6400400	5535600	6400	12202600	0	42	72	83	3
599	1000	153400	2017000	1365200	0	3536600	1	32	49	34	0
600	3700	12900	205500	76800	0	298900	3	9	57	18	0
630	0	1300	372700	108000	0	482000	0	1	56	15	0
631	0	153900	3581400	2514100	0	6249400	0	43	107	101	0
632	0	212700	2838100	1534300	0	4585100	0	51	104	86	0
633	0	56200	828800	206200	0	1091200	0	22	93	39	0
634	0	32400	2414200	2111700	0	4558300	0	12	64	55	0
635	3100	470400	9063200	7552800	13000	17102500	2	68	108	117	6
636	7200	459100	5363200	3725200	2500	9557200	4	73	105	110	1
637	1200	164800	1882500	919200	0	2967700	1	37	71	45	0
638	0	100800	3367400	2622700	0	6090900	0	29	67	63	0
639	3800	393100	7969800	6703700	0	15070400	2	55	67	76	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
640	1100	100700	1699200	767400	0	2568400	1	38	101	64	0
641	0	0	56900	18100	0	75000	0	0	20	3	0
642	0	155100	4427500	3671100	0	8253700	0	37	65	69	0
643	4700	471200	9793100	8125000	15000	18409000	3	74	112	118	5
644	0	47300	824100	230200	0	1101600	0	20	87	36	0
645	0	10800	235300	68400	0	314500	0	7	63	15	0
646	0	1300	24300	6400	0	32000	0	1	10	4	0
647	1000	14700	3762700	3512400	0	7290800	1	33	69	68	0
648	1200	137700	1298600	503700	0	1941200	1	46	97	60	0
649	0	34100	354900	94800	0	483800	0	18	67	20	0
650	0	4200	219400	43700	0	267300	0	1	43	8	0
651	2000	328600	5259900	4062300	2500	9655300	1	63	112	111	1
652	2500	96600	789000	158100	0	1036200	1	36	112	34	0
653	0	1600	68400	27900	0	97900	0	1	26	7	0
654	0	9200	1207500	983400	0	2200100	0	3	65	35	0
655	0	424500	10221000	8335100	18800	18999400	0	63	115	121	7
656	9300	485900	6822600	4940300	5400	12263500	4	60	70	77	3
657	0	17100	218200	71500	0	306800	0	10	58	14	0
658	0	5200	1465900	1286400	0	2757500	0	2	64	48	0
659	6700	720900	14842800	12913500	154500	28638400	4	70	109	114	19
660	3900	375600	5182400	3714100	1300	9277300	3	57	72	72	1
661	0	32400	405000	104800	0	542200	0	19	79	23	0
662	0	6100	649500	188500	0	844100	0	4	76	31	0
663	18200	1014400	21666700	16121200	50500	38871000	7	60	74	78	8
664	6500	278500	4450000	2676700	0	7411700	4	61	105	102	0
665	3900	169400	2019200	873700	0	3066200	3	50	103	70	0
666	1600	474100	10246100	8257300	30500	19009600	1	54	69	75	7
667	34200	1262200	21642600	17777900	448600	41165500	12	76	113	114	34
668	3800	250500	3960000	2728700	0	6943000	3	57	103	103	0
669	0	152000	2579900	1320400	0	4052300	0	35	69	49	0
670	3600	109200	1921000	1219100	0	3252900	2	33	101	83	0
671	1500	0	0	0	0	1500	1	0	0	0	0
672	10000	256500	2889500	1724900	0	4880900	4	57	106	89	0
673	0	102400	1054600	407800	0	1564800	0	33	99	54	0
674	0	0	0	0	0	0	0	0	0	0	0
675	13700	588400	7422100	5996000	22400	14042600	6	75	109	119	6
676	8200	342600	3543700	2073700	0	5968200	3	63	110	97	0
677	0	19800	216000	74000	0	309800	0	10	61	15	0
678	0	39700	2219800	2137700	0	4397200	0	17	99	91	0
679	3300	637300	9885000	8838100	37900	19401600	2	67	107	120	10
680	2000	262700	3019500	2023000	0	5307200	1	44	75	65	0
681	0	3300	136800	34300	0	174400	0	2	45	10	0
682	0	1900	6100	0	0	8000	0	1	4	0	0
683	1200	183200	2296700	2106800	0	4587900	1	45	103	93	0
684	3400	241500	2413600	1367000	0	4025500	2	43	74	58	0
685	0	0	36500	10300	0	46800	0	0	18	3	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
686	0	0	85000	14300	0	99300	0	0	29	4	0
687	4600	51000	2751000	2402800	0	5209400	1	21	109	93	0
688	0	102700	1347000	659100	0	2108800	0	35	98	63	0
689	0	2100	164800	42400	0	209300	0	1	49	9	0
690	0	0	41500	4600	0	46100	0	0	16	2	0
691	0	69600	2290500	2088200	0	4448300	0	27	104	93	0
692	0	85100	1149500	547400	0	1782000	0	27	100	66	0
693	2200	6000	178000	51600	0	237800	1	4	53	11	0
694	0	1500	13600	0	0	15100	0	1	7	0	0
695	0	157600	1893300	1057000	0	3107900	0	40	103	85	0
696	0	107300	1239800	486300	0	1833400	0	38	98	61	0
697	0	18000	181300	50200	0	249500	0	10	53	12	0
698	0	0	5600	0	0	5600	0	0	4	0	0
699	3100	339700	4633400	3807100	1600	8784900	2	38	44	34	1
700	1100	148500	1221800	458900	0	1830300	1	42	101	61	0
701	0	0	4900	4200	0	9100	0	0	3	2	0
702	0	0	112300	17200	0	129500	0	0	28	8	0
703	1700	124600	3260800	2633300	0	6020400	1	36	108	96	0
704	0	100000	885200	225200	0	1210400	0	37	96	45	0
705	0	26200	271100	64500	0	361800	0	16	70	20	0
706	0	4400	1747300	2021500	0	3773200	0	2	85	95	0
707	0	171400	3206600	2617500	0	5995500	0	41	73	68	0
708	0	127200	1357100	891800	0	2376100	0	28	47	32	0
709	0	25100	235700	80700	0	341500	0	15	68	18	0
710	0	44800	2348100	2393000	0	4785900	0	14	67	65	0
711	0	464900	7403200	6177200	1700	14047000	0	55	65	75	1
712	0	47500	443300	100700	0	591500	0	21	86	24	0
713	0	6900	186700	46500	0	240100	0	4	49	11	0
714	0	93400	5428300	5928300	30200	11480200	0	24	71	77	7
715	0	412400	8409100	7221900	12400	16055800	0	65	110	119	5
716	0	67100	1103500	457300	0	1627900	0	28	99	58	0
717	0	8400	251700	230200	83500	573800	0	2	24	15	10
718	0	0	147100	61000	0	208100	0	0	30	16	0
719	0	69900	2818700	2284400	0	5173000	0	28	107	98	0
720	0	40800	900100	315900	0	1256800	0	18	88	49	0
721	0	0	46100	13800	0	59900	0	0	19	2	0
722	0	0	446600	462700	0	909300	0	0	36	26	0
723	0	131300	4236500	3774000	0	8141800	0	35	104	104	0
724	0	50300	1053800	407600	0	1511700	0	20	91	54	0
725	0	0	47300	14100	0	61400	0	0	19	2	0
765	0	0	0	0	0	0	0	0	0	0	0
766	0	27085	3111043	3847726	10603	6996457	0	13	67	67	5
767	0	322581	5957068	5197813	25832	11503294	0	48	73	78	6
768	1109	129468	1785316	981577	0	2897470	1	40	99	70	0
769	0	0	0	0	0	0	0	0	0	0	0
770	0	10162	1851067	1619504	0	3480733	0	4	69	57	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
771	0	351093	7476743	6235015	23959	14086810	0	52	71	75	7
772	0	228952	2309161	1321445	0	3859558	0	59	108	77	0
773	0	0	0	0	0	0	0	0	0	0	0
774	0	200984	6037869	4500187	0	10739040	0	47	119	99	0
775	6244	604481	12482464	10531176	28132	23652497	5	74	108	111	5
776	0	119423	2152344	1235631	0	3507398	0	35	105	75	0
777	0	0	0	0	0	0	0	0	0	0	0
778	0	118675	2818711	2200274	0	5137660	0	36	67	55	0
779	0	355677	7544828	6061148	6347	13968000	0	67	114	120	4
780	1299	280928	4640145	3303851	0	8226223	1	60	110	96	0
781	0	0	0	0	0	0	0	0	0	0	0
782	0	11104	964482	799680	0	1775266	0	5	85	67	0
783	0	23083	241676	69165	0	333924	0	14	69	18	0
784	0	81373	716711	175672	0	973756	0	29	95	36	0
785	0	4256	350474	108062	0	462792	0	2	44	18	0
786	0	30259	3680307	4845887	59848	8616301	0	11	72	77	8
787	0	246697	4628747	3812431	0	8687875	0	36	72	72	0
788	5969	324864	3348504	2135374	0	5814711	3	62	104	89	0
789	0	0	26600	20600	0	47200	0	0	8	3	0
790	0	115108	6082661	6777318	35398	13010485	0	28	68	74	7
791	0	673482	17134888	14144056	39564	31991990	0	67	109	114	18
792	6818	529391	8316610	5749345	0	14602164	4	73	114	111	0
793	0	0	31700	18500	0	50200	0	0	12	4	0
794	0	150880	5868800	5077881	0	11097561	0	38	113	105	0
795	0	557865	12866772	10018246	94200	23537083	0	67	108	116	14
796	13219	600440	9098207	6895984	25002	16632852	7	58	71	77	6
797	0	0	0	0	0	0	0	0	0	0	0
798	0	65475	3730171	3188717	0	6984363	0	23	101	97	0
799	11510	771982	14048916	11718672	225818	26776898	6	61	72	78	16
800	7930	533363	8036090	6969277	25972	15572632	4	59	71	79	6
801	0	0	0	5400	6400	11800	0	0	0	3	4
802	0	87508	4671945	4668549	21314	9449316	0	29	105	114	5
803	23244	931791	17982761	14545724	50354	33533874	9	77	108	112	21
804	22893	615896	8720851	6525429	10342	15895321	11	62	72	81	5
805	0	0	1100	2400	0	3500	0	0	1	1	0
806	0	1049	440877	355508	0	797434	0	1	52	37	0
807	5763	579614	7491513	6301537	135545	14513972	3	58	73	79	13
808	4786	291437	3331887	2407967	0	6036077	3	57	104	103	0
809	0	0	13800	16800	0	30600	0	0	7	3	0
810	0	36019	1546341	1221135	0	2803495	0	16	96	85	0
811	1084	241365	3302420	2450838	0	5995707	1	53	103	99	0
812	7967	361402	3811286	2932613	0	7113268	4	54	71	72	0
813	0	0	12000	2000	1100	15100	0	0	5	1	1
814	0	2447	283889	68420	0	354756	0	2	36	23	0
815	11285	889848	12169965	10335021	32777	23438896	6	63	76	79	6
816	7417	567263	6276142	5203942	1295	12056059	4	75	107	108	1

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
817	0	0	9100	0	0	9100	0	0	6	0	0
818	0	5971	1018844	1088977	0	2113792	0	3	62	39	0
819	3075	552529	8079857	7271361	38095	15944917	2	56	75	78	8
820	34004	1338980	15970671	13754789	29960	31128404	11	82	112	115	12
821	0	0	1900	0	0	1900	0	0	1	0	0
822	0	2500	188348	116254	0	307102	0	1	44	27	0
823	0	169275	5061650	4559292	3199	9793416	0	43	110	108	2
824	0	296679	3877818	2940963	1304	7116764	0	63	108	101	1
825	0	0	1300	0	0	1300	0	0	1	0	0
826	0	2363	374071	140166	6852	523452	0	1	49	40	4
827	1217	114802	4066912	3976826	0	8159757	1	38	103	103	0
828	0	221899	2852941	1914540	0	4989380	0	56	108	85	0
829	0	0	0	0	0	0	0	0	0	0	0
830	0	0	0	0	0	0	0	0	0	0	0
831	0	410384	5797840	5119670	25862	11353756	0	68	111	118	6
832	0	167768	1630450	1265038	2390	3065646	0	22	30	22	1
833	0	0	0	0	0	0	0	0	0	0	0
834	0	0	14200	0	0	14200	0	0	6	0	0
835	1089	492724	7662370	6753741	20426	14930350	1	68	110	118	6
836	1596	195414	1474197	670607	0	2341814	1	50	106	68	0
837	0	0	0	0	0	0	0	0	0	0	0
838	0	34308	3720927	4393805	9461	8158501	0	13	71	77	4
839	0	181662	4969300	4868704	12964	10032630	0	45	114	116	6
840	1351	233426	2477109	2050113	0	4761999	1	33	49	40	0
841	0	0	0	0	0	0	0	0	0	0	0
842	0	9541	673668	244235	0	927444	0	3	81	42	0
843	0	214618	5697661	5081443	0	10993722	0	50	112	109	0
844	16212	513521	5018801	3513987	0	9062521	8	58	72	71	0
845	0	0	0	0	0	0	0	0	0	0	0
846	0	2126	441455	258082	0	701663	0	1	64	55	0
847	0	628473	10957559	10505668	297312	22389012	0	61	75	78	17
848	1029	232927	2729289	1814892	0	4778137	1	56	107	90	0
849	0	0	0	0	0	0	0	0	0	0	0
850	0	0	15000	1200	0	16200	0	0	6	1	0
851	0	205068	5181776	4574498	0	9961342	0	50	111	108	0
852	1381	334251	3813006	2604532	1382	6754552	1	63	110	96	1
853	0	0	0	0	0	0	0	0	0	0	0
854	0	0	49400	8500	0	57900	0	0	18	5	0
855	0	200323	4938874	4339309	1875	9480381	0	52	108	102	1
856	0	121485	1966008	1260084	0	3347577	0	41	100	82	0
857	0	0	0	0	0	0	0	0	0	0	0
858	0	35100	10000	0	0	45100	0	12	4	0	0
859	0	70053	2814264	2618464	0	5502781	0	31	104	100	0
860	0	19696	459794	128844	0	608334	0	12	79	28	0
890	0	6834	1296528	1346559	0	2649921	0	2	72	71	0
891	0	118660	4721857	3949461	20332	8810310	0	30	63	73	6

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
892	1197	143869	2967385	2175096	0	5287547	1	46	110	85	0
893	0	0	0	1800	0	1800	0	0	0	1	0
894	0	1637	1859529	1831728	0	3692894	0	1	71	88	0
895	0	299588	10163749	8976340	60255	19499932	0	22	48	43	3
896	1156	238727	4165097	3222380	0	7627360	1	40	72	66	0
897	0	0	0	0	0	0	0	0	0	0	0
898	0	104805	4119775	3508298	1299	7734177	0	35	101	100	1
899	1671	452502	9961183	9001449	104733	19521538	1	38	43	39	4
900	0	9235	347876	95804	0	452915	0	6	68	21	0
901	0	0	0	0	0	0	0	0	0	0	0
902	0	16742	775083	214600	0	1006425	0	8	79	24	0
903	7042	344862	8455744	7324634	28379	16160661	1	58	108	118	6
904	0	35477	890252	406490	0	1332219	0	17	83	53	0
905	0	0	0	1700	0	1700	0	0	0	1	0
906	0	16882	1200026	1133641	0	2350549	0	8	84	66	0
907	1920	463215	9212544	8177512	126984	17982175	1	29	44	40	7
908	1131	115990	1614053	1171892	0	2903066	1	39	94	80	0
909	0	20362	372316	95924	0	488602	0	13	74	26	0
910	1700	0	0	0	0	1700	1	0	0	0	0
911	0	249557	7890390	7348284	18883	15507114	0	45	109	116	4
912	0	147469	1968799	1558008	0	3674276	0	43	99	77	0
913	0	37923	666741	381453	0	1086117	0	19	45	28	0
914	0	25812	2469842	2407143	0	4902797	0	11	96	81	0
915	0	781992	17107277	16927933	441668	35258870	0	38	40	37	10
916	3092	406619	6760219	5611043	65173	12846146	2	50	74	71	8
917	0	4914	379030	150602	0	534546	0	2	59	27	0
918	1098	4165	1185499	1705854	0	2896616	1	2	63	50	0
919	0	336924	9244556	8533977	155141	18270598	0	46	73	73	14
920	1248	252525	4520695	3370035	0	8144503	1	56	109	94	0
921	0	0	195449	50554	0	246003	0	0	37	10	0
922	0	268299	5820528	4147935	0	10236762	0	53	106	98	0
923	4199	536852	9890065	7077931	1492	17510539	3	55	69	75	1
924	13831	522850	8332444	6665741	25930	15560796	7	57	72	73	6
925	0	24160	642225	228141	0	894526	0	13	83	33	0
926	5251	619090	12029388	9494152	171766	22319647	3	56	71	77	13
927	0	230208	4745659	3666382	0	8642249	0	30	43	39	0
928	8539	303310	4697497	3510189	0	8519535	5	61	103	97	0
929	0	1091	75428	27581	0	104100	0	1	27	5	0
930	0	0	0	0	0	0	0	0	0	0	0
931	1527	218869	3679681	3207665	1627	7109369	1	50	111	108	1
932	0	32592	369925	119639	0	522156	0	17	76	29	0
933	1200	0	0	0	0	1200	1	0	0	0	0
934	0	0	0	0	0	0	0	0	0	0	0
935	1099	174589	2547548	2306369	0	5029605	1	27	45	37	0
936	0	11208	283013	88162	0	382383	0	5	38	14	0
937	0	0	0	0	0	0	0	0	0	0	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
938	0	0	63200	17100	0	80300	0	0	17	9	0
939	0	336033	4605886	4020005	2422	8964346	0	59	106	106	1
940	0	3882	206020	51396	0	261298	0	2	54	15	0
941	0	0	0	0	0	0	0	0	0	0	0
942	0	8174	506208	152656	0	667038	0	5	70	44	0
943	27871	969473	12148723	11363291	144159	24653517	10	77	110	118	17
944	2242	157257	2046366	1648786	0	3854651	2	46	102	86	0
945	0	0	0	0	0	0	0	0	0	0	0
946	0	0	0	0	0	0	0	0	0	0	0
947	0	205589	4114445	3801301	0	8121335	0	44	73	69	0
948	0	0	15100	6700	0	21800	0	0	8	2	0
949	0	0	0	0	0	0	0	0	0	0	0
950	0	0	1100	1000	0	2100	0	0	1	1	0
951	36512	822629	9970421	7005849	1795	17837206	12	64	70	73	1
952	0	116149	1754562	1165304	0	3036015	0	37	96	77	0
953	0	0	0	0	0	0	0	0	0	0	0
954	0	0	64800	16300	0	81100	0	0	23	5	0
955	1432	243231	3583687	3076040	0	6904390	1	53	108	105	0
956	0	83713	1280579	757990	0	2122282	0	30	96	66	0
957	0	0	0	0	0	0	0	0	0	0	0
958	0	0	22800	1300	0	24100	0	0	9	1	0
959	4954	427538	4688293	3475972	0	8596757	3	74	107	105	0
960	0	88817	766129	164011	0	1018957	0	33	99	34	0
961	0	0	0	0	0	0	0	0	0	0	0
962	0	0	24100	2700	0	26800	0	0	10	1	0
963	0	219408	4648852	4060388	7188	8935836	0	52	112	107	4
964	0	61902	924732	285800	0	1272434	0	24	97	46	0
965	0	0	0	0	0	0	0	0	0	0	0
966	0	0	1000	0	0	1000	0	0	1	0	0
967	0	57381	1526200	1202213	0	2785794	0	23	97	78	0
968	0	5276	234827	46664	0	286767	0	3	54	12	0
969	0	0	0	0	0	0	0	0	0	0	0
970	0	131206	6100408	6497440	7029	12736083	0	36	110	118	3
971	1029	653318	13087985	11994156	295402	26031890	1	74	110	119	23
972	0	106514	1590420	1004446	0	2701380	0	35	100	74	0
973	0	0	0	0	0	0	0	0	0	0	0
974	0	42969	4348189	6076289	13876	10481323	0	15	69	79	4
975	7502	918555	17740461	16090289	233467	34990274	5	59	73	75	15
976	26073	795206	10161591	7339810	0	18322680	11	62	74	72	0
977	0	0	0	1200	0	1200	0	0	0	1	0
978	0	1321	2051763	2805614	0	4858698	0	1	70	94	0
979	2708	265472	7777113	7803639	208744	16057676	2	54	110	125	16
980	0	12875	271255	69971	0	354101	0	9	67	17	0
981	0	0	0	0	0	0	0	0	0	0	0
982	0	0	70000	4200	0	74200	0	0	22	3	0
983	4663	405544	7550061	6879282	99835	14939385	3	57	73	81	11

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
984	0	71407	1304869	687427	0	2063703	0	27	96	62	0
985	0	0	0	1100	0	1100	0	0	0	1	0
1027	0	6399	3303866	970481	4286	4285032	0	3	77	71	1
1028	1412	465843	10914184	10133133	191944	21706516	1	54	67	76	15
1029	5751	289494	4064645	2794272	0	7154162	4	62	107	103	0
1030	0	0	8700	5100	0	13800	0	0	6	2	0
1031	0	62782	4319068	5068527	20891	9471268	0	22	98	112	4
1032	2475	762690	17732057	17307465	511716	36316403	2	74	105	119	29
1033	12627	394293	4431233	2940517	0	7778670	7	67	106	100	0
1034	10100	0	38900	2400	0	51400	6	0	2	1	0
1035	2631	176965	7528195	7100681	22838	14831310	2	42	96	116	10
1036	7832	230554	6892102	6364134	74060	13568682	4	51	108	111	9
1037	0	25692	384556	126077	0	536325	0	15	72	26	0
1038	4200	0	0	0	0	4200	2	0	0	0	0
1039	0	14626	1474352	1115510	0	2604488	0	7	89	61	0
1040	12516	640742	11766134	9879725	168395	22467512	6	74	115	122	25
1041	2277	9575	186869	75516	0	274237	1	5	53	13	0
1042	1900	4900	0	0	0	6800	1	1	0	0	0
1043	25957	40111	2834999	2849040	1017	5751124	6	15	99	105	1
1044	6388	426462	7260235	5933192	28102	13654379	3	65	110	119	6
1045	5360	130745	1379345	577381	0	2092831	3	36	103	63	0
1046	2000	4000	13500	5400	0	24900	1	2	7	2	0
1047	1236	10289	158925	20156	0	190606	1	3	32	5	0
1048	15799	723329	12393516	10990864	203766	24327274	6	58	71	81	16
1049	1834	42018	491329	101612	0	636793	1	19	85	28	0
1050	6100	17000	0	1000	0	24100	3	3	0	1	0
1051	16590	7330	1925902	1876598	0	3826411	6	3	83	77	0
1052	3689	292646	9215055	8052603	91951	17655944	1	41	69	73	11
1053	20794	533992	6558711	4593375	7431	11714303	8	58	69	76	4
1054	6300	6200	2900	3300	0	18700	3	1	1	1	0
1055	1800	5600	32000	17500	0	56900	1	1	12	2	0
1056	0	451908	10394801	8929247	98875	19874831	0	62	109	114	13
1057	2235	221096	2893906	1589967	0	4707204	2	58	101	84	0
1058	0	1300	5900	6000	0	13200	0	1	3	2	0
1059	3850	5198	3259372	3874433	18335	7161188	2	3	63	70	4
1060	8544	323225	7963853	6320710	28131	14644463	5	62	112	119	7
1061	14238	306445	4545793	3185339	0	8051815	8	61	104	104	0
1062	6092	202306	3595281	2616716	0	6420395	3	52	112	89	0
1063	4100	1700	0	0	0	5800	2	1	0	0	0
1064	35037	745011	10817223	8526242	127739	20251252	11	62	70	83	12
1065	18714	473924	6876829	5247975	23451	12640893	9	61	69	73	6
1066	28604	487555	8043364	6831505	80654	15471682	12	62	70	76	11
1067	10400	1600	0	0	0	12000	4	1	0	0	0
1068	26053	128245	2261240	1678044	0	4093582	7	39	104	98	0
1069	23255	373378	4151469	3203399	0	7751501	4	67	107	104	0
1070	0	2400	13600	6300	0	22300	0	1	7	2	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1071	0	0	0	0	0	0	0	0	0	0	0
1072	8618	67432	1994812	1527279	0	3598141	5	27	100	86	0
1073	4144	78677	801856	188622	0	1073299	2	29	99	40	0
1074	0	0	42300	17100	0	59400	0	0	16	3	0
1075	1000	0	5400	3700	0	10100	1	0	1	2	0
1076	1606	8808	187228	50254	0	247896	1	3	56	16	0
1077	1724	190451	2231383	1493104	0	3916662	1	29	49	32	0
1078	0	0	0	1000	0	1000	0	0	0	1	0
1079	0	3700	6400	1300	0	11400	0	1	4	1	0
1080	1293	207644	3635987	2937427	0	6782351	1	49	110	92	0
1081	19105	519672	5416513	4632215	0	10587505	8	73	105	108	0
1082	0	0	0	4500	7600	12100	0	0	0	3	4
1083	0	0	0	0	0	0	0	0	0	0	0
1084	0	34701	1804018	1547197	0	3385916	0	16	98	78	0
1085	0	38322	627152	188268	0	853742	0	19	86	34	0
1086	2500	0	0	0	0	2500	1	0	0	0	0
1087	2700	4000	1200	15000	14100	37000	1	1	1	7	6
1088	0	162331	3964117	4366278	28794	8521520	0	33	64	65	6
1089	0	68248	661028	173544	4766	907586	0	27	98	36	3
1090	0	0	0	0	0	0	0	0	0	0	0
1091	0	58189	4513641	5213400	0	9785230	0	18	67	70	0
1092	11159	794128	12619773	11620660	229837	25275557	6	68	110	117	26
1093	0	116215	1899681	1155516	0	3171412	0	35	105	75	0
1094	0	0	0	0	0	0	0	0	0	0	0
1095	0	200940	7658743	9037025	283342	17180050	0	35	69	80	17
1096	10304	848940	12635626	11333539	268120	25096529	6	73	106	117	18
1097	0	196693	2357895	1446890	0	4001478	0	52	109	83	0
1098	0	0	0	0	0	0	0	0	0	0	0
1099	0	4100	2200	16800	11100	34200	0	1	1	8	6
1100	0	169057	4523885	4610235	23544	9326721	0	36	75	81	5
1101	10617	423479	4396344	3241157	1942	8073539	7	71	106	106	1
1102	0	0	6300	3900	0	10200	0	0	5	2	0
1103	0	0	80938	14163	0	95101	0	0	25	7	0
1104	0	260193	7932707	7992826	130653	16316379	0	48	106	124	15
1105	28608	589385	5805235	4395597	0	10818825	9	68	72	75	0
1106	0	0	0	1500	0	1500	0	0	0	1	0
1107	0	13057	2744710	3277936	0	6035703	0	6	95	102	0
1108	5622	919910	18480234	17553539	651757	37611062	4	72	109	117	43
1109	6477	297536	3402808	2328581	10652	6046054	4	39	47	35	2
1110	0	0	0	2100	0	2100	0	0	0	1	0
1111	2220	15635	2839854	3646009	1030	6504748	1	7	97	103	1
1112	17444	1257110	23570914	23181480	1183095	49210043	7	69	107	121	54
1113	6296	332356	3397838	2414276	0	6150766	3	65	105	98	0
1114	0	0	6900	2900	4500	13900	0	0	5	1	3
1115	0	1091	1365246	1581552	0	2947889	0	1	60	47	0
1116	0	317886	10123412	10450555	377013	21268866	0	31	43	42	10

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1117	2922	153701	2474128	1543725	0	4174476	2	44	106	85	0
1118	0	0	0	0	0	0	0	0	0	0	0
1119	0	0	3000	0	0	3000	0	0	3	0	0
1120	1370	544118	15853761	17545966	681723	34626938	1	40	40	40	15
1121	6105	249315	3234666	2265142	1068	5756296	4	39	47	39	1
1122	0	0	0	0	0	0	0	0	0	0	0
1163	0	0	364940	64560	0	429500	0	0	42	15	0
1164	0	192397	6225195	6067765	19099	12504456	0	47	110	111	5
1165	5356	355736	4542410	3176999	0	8080501	3	63	107	99	0
1166	0	0	0	1400	0	1400	0	0	0	1	0
1167	0	5402	594016	136990	0	736408	0	3	64	26	0
1168	0	294241	7594178	7625227	74246	15587892	0	57	116	113	11
1169	9654	510198	6757751	5105967	4286	12387856	6	67	108	109	3
1170	0	0	13500	6800	0	20300	0	0	7	2	0
1171	0	32648	4092126	4090803	2532	8218109	0	15	95	106	2
1172	0	27337	2744376	2238509	0	5010222	0	12	97	81	0
1173	0	32407	1131129	451567	0	1615103	0	15	91	50	0
1174	0	0	0	0	0	0	0	0	0	0	0
1175	0	20069	2870794	2670090	0	5560953	0	10	92	84	0
1176	0	285779	7765577	7044335	31910	15127601	0	62	105	115	6
1177	0	27869	433438	114035	0	575342	0	16	66	22	0
1178	0	0	0	0	0	0	0	0	0	0	0
1179	0	20386	2388110	2754639	0	5163135	0	8	68	60	0
1180	0	342063	6661059	6263554	86726	13353402	0	48	71	78	10
1181	0	93384	1440623	716939	0	2250946	0	34	98	66	0
1182	0	1100	51600	20600	0	73300	0	1	19	5	0
1183	0	62645	4677967	5363380	1716	10105708	0	19	105	115	1
1184	4386	426806	8064359	7327520	42563	15865634	2	63	108	115	8
1185	1110	125558	1620428	779285	0	2526381	1	39	98	66	0
1186	0	26761	237458	77154	16906	358279	0	15	66	21	7
1187	0	4448	1731494	858697	0	2594639	0	3	88	57	0
1188	1109	468967	11399102	9999182	114176	21982536	1	65	109	117	18
1189	12632	509332	6811476	5050497	18855	12402792	6	56	68	81	6
1190	1500	0	6800	13600	12900	34800	1	0	4	7	5
1191	0	5723	1062714	365203	0	1433640	0	3	78	39	0
1192	0	158763	6052545	5612218	0	11823526	0	33	67	62	0
1193	8313	307956	4292308	2856297	0	7464874	5	62	108	94	0
1194	0	0	1200	2100	0	3300	0	0	1	1	0
1195	0	0	0	0	0	0	0	0	0	0	0
1196	1818	233976	4541597	3332359	1059	8110809	1	53	106	98	1
1197	3948	334106	5894366	4682787	20060	10935267	2	38	44	40	2
1198	2610	170023	3753958	2486779	0	6413370	2	45	109	84	0
1199	0	4094	99057	29205	0	132356	0	1	20	6	0
1200	9800	515918	10732646	8379903	89322	19727589	5	69	112	118	11
1201	16091	481180	6836200	5147221	17729	12498421	7	67	59	73	5
1202	0	136849	3185603	1966987	0	5289439	0	41	106	77	0

*Note: Negativa values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1203	0	0	0	0	0	0	0	0	0	0	0
1204	0	40725	1132322	646530	0	1819577	0	17	89	64	0
1205	2652	243401	2764064	1860052	0	4870169	2	32	46	36	0
1206	0	10252	271553	62951	0	344756	0	5	39	14	0
1207	1400	0	0	0	0	1400	1	0	0	0	0
1208	1213	21722	859103	497234	0	1379272	1	11	67	40	0
1209	16680	461338	5079102	3764125	0	9321245	7	69	109	101	0
1210	4443	104103	1185495	378177	0	1672218	2	35	99	57	0
1211	0	0	39900	13900	0	53800	0	0	9	7	0
1212	3777	221313	3498256	2654205	0	6377551	2	40	75	70	0
1213	5278	206577	2409132	1438443	0	4059430	3	47	100	84	0
1214	0	0	0	0	0	0	0	0	0	0	0
1215	13500	0	19400	1300	0	34200	5	0	8	1	0
1216	15627	293244	5622325	4974481	1047	10906724	7	44	73	74	1
1217	13240	435314	4837380	3573151	0	8859085	7	66	106	103	0
1218	2900	1300	0	1200	0	5400	2	1	0	1	0
1219	0	0	0	0	0	0	0	0	0	0	0
1220	12310	158872	3934285	3074434	0	7179901	5	48	105	91	0
1221	12671	87436	1009821	334122	0	1444050	7	28	95	49	0
1222	13500	0	0	0	0	13500	5	0	0	0	0
1223	4900	0	18600	6200	0	29700	2	0	7	2	0
1224	1391	169166	4341909	3510787	0	8023253	1	26	47	37	0
1225	2181	23023	982247	574316	0	1581767	2	13	88	57	0
1226	0	0	0	0	0	0	0	0	0	0	0
1227	0	0	0	0	0	0	0	0	0	0	0
1228	4420	280226	5193834	4207397	0	9685877	2	56	111	107	0
1229	4747	239293	2896932	1897542	0	5038514	2	52	106	87	0
1230	0	0	5000	4600	0	9600	0	0	3	2	0
1231	0	0	0	0	0	0	0	0	0	0	0
1232	3823	274741	4614405	3829149	0	8722118	2	56	108	110	0
1233	0	98434	1233757	571310	0	1903501	0	35	96	61	0
1234	0	7700	0	0	0	7700	0	1	0	0	0
1235	0	0	0	0	0	0	0	0	0	0	0
1236	0	180515	4512549	3709013	0	8402077	0	46	111	100	0
1237	5272	230268	2618361	1588856	0	4442757	3	53	101	81	0
1238	0	0	0	0	0	0	0	0	0	0	0
1239	0	0	0	0	0	0	0	0	0	0	0
1240	1184	148885	3220973	2625953	0	5996995	1	35	73	63	0
1241	0	155264	1559882	746426	0	2461572	0	44	99	69	0
1242	0	0	0	1700	0	1700	0	0	0	1	0
1243	0	34275	3683256	3726563	0	7444094	0	14	103	103	0
1244	3704	777278	17693201	15191016	28703	33693902	1	69	106	115	13
1245	0	116785	1647753	795967	0	2560505	0	37	102	72	0
1246	0	0	0	0	0	0	0	0	0	0	0
1247	0	160446	8929903	9998566	34746	19123661	0	40	110	118	6
1248	1218	822993	18159099	16128805	29690	35141805	1	70	110	115	13

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1249	0	117774	1662899	851985	0	2632658	0	39	101	69	0
1250	0	0	0	0	0	0	0	0	0	0	0
1251	0	0	8700	0	0	8700	0	0	4	0	0
1252	0	42017	2915642	2786826	0	5744485	0	17	66	69	0
1253	1169	179845	2749623	1709912	0	4640549	1	47	104	86	0
1254	0	0	0	0	0	0	0	0	0	0	0
1255	4367	93308	4500456	3685760	0	8283891	2	31	106	96	0
1256	2100	0	142800	4800	0	149700	1	0	20	3	0
1257	3215	17834	265109	80484	0	366642	1	11	65	19	0
1258	0	0	0	0	0	0	0	0	0	0	0
1315	0	2440	330466	164095	0	497001	0	2	58	27	0
1316	0	156834	5178854	4172663	0	9508351	0	43	108	90	0
1317	0	281170	3693665	2159009	0	6133844	0	51	111	81	0
1318	0	0	0	1174	0	1174	0	0	0	1	0
1319	1527	0	103556	43546	0	148629	1	0	33	8	0
1320	0	276993	7331200	5557631	0	1.32E+07	0	57	108	97	0
1321	0	244297	4102299	2765160	0	7111756	0	52	111	87	0
1322	0	1730	0	0	0	1730	0	1	0	0	0
1323	0	13428	1047639	326859	0	1387926	0	5	79	37	0
1324	0	137304	5384988	3925239	0	9447531	0	38	110	90	0
1325	0	0	70071	24311	0	94382	0	0	20	5	0
1326	0	2420	0	0	0	2420	0	1	0	0	0
1327	0	1775	2093159	1678376	0	3773310	0	1	89	67	0
1328	0	146309	6183837	5071128	0	11401270	0	37	107	95	0
1329	2016	5151	155506	48335	0	211008	1	2	31	10	0
1330	0	0	0	0	0	0	0	0	0	0	0
1331	0	3467	541018	286636	0	831121	0	2	54	21	0
1332	0	270982	5176714	3850461	0	9298157	0	55	109	90	0
1333	0	14912	201693	64016	0	280621	0	7	53	13	0
1334	0	2560	0	0	0	2560	0	1	0	0	0
1335	1795	8404	582430	183487	0	776116	1	5	74	26	0
1336	0	363609	6414020	5169807	0	1.19E+07	0	63	108	107	0
1337	0	57159	719117	181880	0	958156	0	23	92	35	0
1338	0	5856	0	0	0	5856	0	2	0	0	0
1339	0	4446	144185	68332	0	216963	0	1	29	9	0
1340	1638	205157	6332814	5610551	1623	12151780	1	40	68	67	1
1341	8762	396644	4886846	3203745	0	8495997	4	51	71	64	0
1342	0	0	5427	3315	0	8742	0	0	4	1	0
1343	0	0	107624	43157	0	150781	0	0	20	4	0
1344	3103	511620	1.02E+07	7906932	11233	1.86E+07	2	68	110	110	5
1345	12023	401191	5133408	3318459	0	8865081	5	67	100	84	0
1346	0	0	2417	2229	1393	6039	0	0	2	1	1
1347	0	34447	3196776	2871712	0	6102935	0	11	63	60	0
1348	34926	1233217	2.36E+07	18005390	32091	4.29E+07	11	75	108	113	15
1349	9726	480046	6869418	4399739	0	1.18E+07	4	68	107	99	0
1350	2550	145416	2922335	1619666	0	4689967	2	41	107	78	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1351	0	0	3612	5907	0	9519	0	0	3	2	0
1352	41746	1071939	1.65E+07	12551130	138378	3.03E+07	13	82	105	116	15
1353	16876	512899	6372621	4341482	1383	11245260	7	60	68	73	1
1354	4876	202011	3115528	1658258	0	4980673	3	51	103	78	0
1355	0	3473	4498	4972	0	12943	0	1	3	2	0
1356	0	80719	1668117	966804	0	2715640	0	29	100	73	0
1357	1941	205160	2408419	1438660	0	4054180	1	48	102	79	0
1358	0	0	23262	11195	0	34457	0	0	9	3	0
1359	0	2046	0	0	0	2046	0	1	0	0	0
1360	1915	251887	3405166	2482040	0	6141008	1	50	105	93	0
1361	0	68160	797662	273418	0	1139240	0	27	96	46	0
1362	0	0	0	0	0	0	0	0	0	0	0
1363	0	2617	0	0	1397	4014	0	1	0	0	1
1364	2941	347582	4329784	3329822	1642	8011771	1	48	74	66	1
1365	1878	84609	1126092	391715	0	1604294	1	29	97	59	0
1366	0	0	0	0	0	0	0	0	0	0	0
1367	0	0	0	0	0	0	0	0	0	0	0
1368	11111	653285	8346288	6863739	0	1.59E+07	4	65	113	109	0
1369	30042	550813	5529407	4237954	0	10348220	10	70	106	103	0
1370	0	0	0	0	0	0	0	0	0	0	0
1371	0	0	1900	0	0	1900	0	0	1	0	0
1372	0	176662	4271784	2991061	0	7439507	0	42	107	84	0
1373	0	15436	461667	104114	0	581217	0	10	72	24	0
1374	0	0	1223	0	0	1223	0	0	1	0	0
1375	0	2893	1304	0	0	4197	0	1	1	0	0
1376	0	47019	1429639	417287	0	1893945	0	20	101	49	0
1377	0	120856	1534467	504505	0	2159828	0	35	100	55	0
1378	0	0	0	0	0	0	0	0	0	0	0
1379	0	5381	1693588	1559161	0	3258130	0	2	87	75	0
1380	6355	761775	13233970	12372680	121663	26496440	4	69	110	121	12
1381	0	92731	1807601	988968	0	2889300	0	29	101	71	0
1382	0	0	0	0	0	0	0	0	0	0	0
1383	0	0	139847	24058	0	163905	0	0	33	5	0
1384	0	218931	4496260	3405769	0	8120960	0	52	109	94	0
1385	0	39661	623761	148553	0	811975	0	16	89	29	0
1386	0	0	0	0	0	0	0	0	0	0	0
1387	0	4656	1171	0	0	5827	0	1	1	0	0
1388	0	328388	8050421	7247566	24207	15650580	0	61	109	119	4
1389	0	134756	1764952	768973	0	2668681	0	39	103	64	0
1390	0	0	1035	1890	0	2925	0	0	1	1	0
1391	1771	3474	0	0	0	5245	1	1	0	0	0
1392	2383	225684	6706766	5749752	1849	12686430	1	48	107	115	1
1393	0	147104	1681843	732496	0	2561443	0	42	103	66	0
1394	0	4519	0	0	0	4519	0	1	0	0	0
1395	0	133619	5909581	5167172	0	11210370	0	37	110	103	0
1396	6645	1305269	25565290	23339230	923576	51140010	3	41	35	40	19

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1397	4811	270591	2887672	1378903	0	4541977	3	62	101	77	0
1398	0	5771	272464	50387	0	328622	0	3	57	10	0
1399	1732	1086	224428	135455	0	362701	1	1	25	17	0
1400	1195	908353	19863510	17261440	409413	38443920	1	74	109	114	28
1401	0	85704	1319446	501255	0	1906405	0	32	99	58	0
1402	0	0	14477	0	0	14477	0	0	5	0	0
1403	0	0	106386	11150	0	117536	0	0	29	7	0
1404	9004	700773	13255100	11751950	193711	25910540	4	62	74	79	11
1405	4075	86438	1229231	379551	0	1699295	2	35	99	48	0
1406	0	0	0	0	0	0	0	0	0	0	0
1407	0	0	0	0	0	0	0	0	0	0	0
1408	12178	483458	9372836	8046022	35718	17950210	6	75	113	123	8
1409	0	48547	644274	139735	0	832556	0	18	87	29	0
1410	2181	0	0	0	0	2181	1	0	0	0	0
1446	0	0	556480	190803	0	747283	0	0	60	25	0
1447	2048	219767	9627430	9168715	101921	19119880	1	42	100	120	11
1448	0	180922	6030074	4537207	0	10748200	0	44	111	95	0
1449	0	3832	1096	2231	0	7159	0	1	1	1	0
1450	0	9207	209640	91401	0	310248	0	2	33	15	0
1451	0	262881	9097222	7829688	0	17189790	0	48	104	106	0
1452	0	109450	4807224	3870692	0	8787366	0	25	66	68	0
1453	1851	0	1060	1705	0	4616	1	0	1	1	0
1454	0	13254	661900	165255	0	840409	0	6	68	27	0
1455	7268	256776	9038477	7854859	3642	17161020	1	51	111	110	2
1456	0	102165	2118215	1143798	0	3364178	0	23	45	30	0
1457	0	0	0	119898	0	119898	0	0	0	2	0
1458	0	72054	4212610	2650171	0	6934835	0	25	99	78	0
1459	8960	155574	10764640	11410090	149106	22488370	2	38	113	119	14
1460	0	101374	2380343	1254683	0	3736400	0	30	99	73	0
1461	0	0	0	0	0	0	0	0	0	0	0
1462	0	34974	2689837	2486350	0	5211161	0	14	101	82	0
1463	0	399999	8701229	6450687	1795	15553710	0	50	76	72	1
1464	2797	245914	2728130	1459738	0	4436579	2	55	107	76	0
1465	0	27253	415775	88964	0	531992	0	16	78	22	0
1466	0	48853	3905831	3574963	0	7529647	0	19	102	102	0
1467	0	522260	9757719	7611963	11834	17903780	0	65	111	115	3
1468	28871	575845	5611522	3392133	0	9608371	10	70	106	101	0
1469	0	9861	162027	43622	0	215510	0	7	47	11	0
1470	0	20988	2035137	1830959	0	3887084	0	7	94	78	0
1471	0	226260	13369160	12311310	140585	26047320	0	46	113	118	14
1472	8247	501400	8412830	5293780	1288	14217550	5	56	68	71	1
1473	0	3692	6762	6687	0	17141	0	1	3	2	0
1474	0	9083	986604	364798	0	1360485	0	4	83	43	0
1475	0	34803	2932669	2233834	0	5201306	0	16	102	80	0
1476	7667	381417	5819108	3388165	0	9596357	4	62	112	92	0
1477	0	2933	17893	11549	0	32375	0	1	8	2	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1478	0	510500	11330720	8287428	11070	20139710	0	62	112	115	4
1479	47156	2047329	33872860	26831250	769445	63568040	14	78	104	116	34
1480	2231	287489	4583307	2577094	0	7450121	2	56	105	83	0
1481	1575	89754	1618321	533650	0	2243300	1	30	99	56	0
1482	0	207306	5706034	3722437	0	9635777	0	45	109	105	0
1483	17391	1177698	19887620	15437190	216207	36736110	7	80	107	116	20
1484	6292	369362	5466364	3616332	20001	9478351	3	39	46	37	2
1485	0	48232	1051906	372342	0	1472480	0	23	92	45	0
1486	0	4796	0	0	0	4796	0	1	0	0	0
1487	1281	182449	2783286	1740259	0	4707275	1	40	102	85	0
1488	5971	265102	2691417	1563690	0	4526180	4	46	74	57	0
1489	0	28088	250061	52694	0	330843	0	15	63	14	0
1490	0	18736	308934	99819	0	427489	0	5	45	13	0
1491	0	2392	247704	55166	0	305262	0	1	52	14	0
1492	5360	292681	3146035	1868819	0	5312895	3	58	108	86	0
1493	1358	0	2457	0	0	3815	1	0	1	0	0
1494	0	3429	508566	475038	0	987033	0	3	33	21	0
1495	2899	400196	6256901	4785031	1388	11446420	2	51	70	75	1
1496	5843	343488	3884691	2611706	0	6845728	3	58	105	89	0
1497	2289	0	36581	17565	0	56435	1	0	14	5	0
1498	0	23819	1774345	1582044	0	3380208	0	11	65	54	0
1499	22078	835215	10965300	9759723	94973	21677290	7	63	70	75	4
1500	3669	295867	3318583	2248240	0	5866359	2	55	105	90	0
1501	0	0	2567	2810	0	5377	0	0	2	2	0
1502	0	0	0	0	0	0	0	0	0	0	0
1503	0	136115	3850636	2825550	0	6812301	0	37	106	83	0
1504	0	11134	163484	42404	0	217022	0	4	45	9	0
1505	0	0	0	0	0	0	0	0	0	0	0
1506	0	7052	0	0	0	7052	0	1	0	0	0
1507	1705	45658	2474442	1805449	0	4327254	1	18	107	78	0
1508	0	1985	159936	38662	0	200583	0	1	44	9	0
1509	1700	0	0	0	0	1700	1	0	0	0	0
1510	0	0	0	0	0	0	0	0	0	0	0
1511	1838	274467	4631593	3510635	0	8418533	1	57	109	100	0
1512	0	29006	361226	74645	0	464877	0	16	77	19	0
1513	0	0	0	0	0	0	0	0	0	0	0
1514	1298	0	0	0	0	1298	1	0	0	0	0
1515	5994	627889	8471910	6175945	1466	15283200	3	70	111	112	1
1516	0	102092	2000483	1243265	0	3345840	0	31	101	73	0
1517	0	0	0	0	0	0	0	0	0	0	0
1518	0	49450	855309	246197	0	1150956	0	23	93	41	0
1519	4474	505988	8635976	6777569	6532	15930540	3	70	108	116	3
1520	2863	213152	2436447	1288416	0	3940878	2	50	107	77	0
1521	4806	250200	2802721	1530108	0	4587835	3	57	107	81	0
1522	0	0	0	0	0	0	0	0	0	0	0
1523	2657	193480	4112677	3409135	0	7717949	2	41	76	70	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for soil samples taken during the Kwajalein bioremediation demonstration project*

Sample Number	Peak Area 10-20 min	Peak Area 20-30 min	Peak Area 30-40 min	Peak Area 40-50 min	Peak Area 50-60 min	Peak Area Total (0-60 min)	Number of Peaks 10-20 min	Number of Peaks 20-30 min	Number of Peaks 30-40 min	Number of Peaks 40-50 min	Number of Peaks 50-60 min
1524	15530	491275	5021454	3010901	0	8539160	6	70	108	90	0
1525	1210	5429	0	1258	0	7897	1	1	0	1	0
1526	0	1254	157917	73825	0	232996	0	1	45	15	0
1527	0	560911	13639000	11794900	148481	26143290	0	69	113	120	14
1528	0	65868	762105	141690	0	969663	0	25	96	27	0
1529	0	3286	0	1191	0	4477	0	1	0	1	0
1530	0	3129	433951	346456	0	783536	0	2	47	25	0
1531	0	823696	18695540	16117390	343234	35979850	0	70	108	109	23
1532	5685	261963	3020959	1689814	0	4978421	4	60	101	85	0
1533	0	0	0	0	0	0	0	0	0	0	0
1534	0	0	0	0	0	0	0	0	0	0	0
1535	0	149563	6828836	5732608	0	12711010	0	39	112	110	0
1536	2168	15745	319382	63468	0	400763	1	9	53	12	0
1537	0	0	0	0	0	0	0	0	0	0	0
1538	0	0	2020	0	0	2020	0	0	1	0	0
1539	0	68373	6817023	6529451	28162	13443010	0	20	103	121	5
1540	0	71949	1054532	469590	0	1596071	0	19	48	24	0
1541	0	2658	0	0	0	2658	0	1	0	0	0

*Note: Negative values indicate that the analysis was not run on that sample

APPENDIX C

RESULTS OF ON-SITE ANALYSES OF GROUNDWATER SAMPLES DURING THE BIOREMEDIATION DEMONSTRATION AT KWJALEIN ISLAND

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	Sample Date	Sample Period	Well Number	Groundwater Level (ft)	Sample Depth (ft)	pH	Coliform (per 100 mL)	CFU (CFU/mL)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Sulfide (mg/L)
254	12/19/92	1	13	5.42	6.25	6.98	0	46000	0.0	0.0	0.0	-9999.9
255	12/19/92	1	14	5.34	6.25	6.94	-999	-99999	0.0	0.0	0.0	-9999.9
256	12/19/92	1	15	5.40	6.25	7.02	-999	3700	0.0	0.0	0.0	-9999.9
257	12/19/92	1	16	5.44	6.25	7.05	-999	-99999	0.0	0.0	0.0	-9999.9
258	12/19/92	1	17	5.18	6.25	6.94	-999	-99999	0.0	0.0	0.0	-9999.9
259	12/19/92	1	18	5.40	6.25	7.38	-999	84000	0.0	0.0	0.0	-9999.9
260	12/19/92	1	19	5.44	6.25	6.99	-999	-99999	0.0	0.0	0.0	-9999.9
261	12/19/92	1	20	4.86	6.25	7.39	-999	-99999	0.0	0.0	0.0	-9999.9
262	12/19/92	1	21	4.96	6.25	7.08	-999	26000	0.0	0.0	0.0	-9999.9
263	12/19/92	1	22	5.04	6.25	7.42	-999	4000	0.0	0.0	0.0	-9999.9
264	12/19/92	1	99	4.50	19.00	7.71	0	3600	0.0	0.0	0.0	-9999.9
266	12/20/92	1	1	5.12	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
267	12/20/92	1	2	5.12	6.25	7.10	-999	-99999	0.0	0.0	0.0	-9999.9
268	12/20/92	1	3	5.23	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
269	12/20/92	1	4	5.40	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
270	12/20/92	1	5	5.46	6.25	7.10	-999	-99999	0.0	0.0	0.0	-9999.9
271	12/20/92	1	6	5.52	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
272	12/20/92	1	7	5.42	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
273	12/20/92	1	8	5.14	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
274	12/20/92	1	9	4.98	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
275	12/20/92	1	10	5.00	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
276	12/20/92	1	11	5.02	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
277	12/20/92	1	12	5.20	6.25	7.00	-999	-99999	0.0	0.0	0.0	-9999.9
601	5/7/93	2	1	5.04	6.25	7.99	-9999999	-9999999	4.4	-9999.9	0.0	0.0
602	5/7/93	2	2	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
603	5/7/90	2	3	5.10	6.25	7.07	-9999999	-9999999	0.0	-9999.9	0.0	0.0
604	5/7/93	2	4	5.24	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
605	5/7/93	2	5	5.26	6.25	7.32	-9999999	-9999999	0.0	-9999.9	0.0	0.0
606	5/7/93	2	6	5.30	6.25	7.05	-9999999	397000	35.0	-9999.9	0.0	0.0
607	5/7/93	2	7	5.32	6.25	7.05	-9999999	-9999999	0.0	-9999.9	0.0	8.0
608	5/7/93	2	8	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
609	5/7/93	2	9	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
610	5/7/93	2	10	4.90	6.25	7.36	-9999999	-9999999	11.0	-9999.9	0.0	0.0
611	5/7/93	2	11	4.86	6.25	7.10	-9999999	-9999999	0.0	-9999.9	0.0	0.5
612	5/7/93	2	12	5.00	6.25	7.08	-9999999	-9999999	110.0	-9999.9	0.0	0.0
613	5/7/93	2	13	5.34	6.25	7.76	0	1000000	0.0	-9999.9	0.0	0.0
614	5/7/93	2	14	5.22	6.25	7.08	-9999999	-9999999	0.0	-9999.9	0.0	0.0
615	5/7/93	2	15	5.28	6.25	6.96	0	63000	0.0	-9999.9	0.0	0.0
616	5/7/93	2	16	5.22	6.25	7.05	0	-9999999	0.0	-9999.9	0.0	0.0
617	5/7/93	2	17	5.14	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
618	5/7/93	2	18	5.32	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
619	5/7/93	2	19	5.18	6.25	7.01	-9999999	-9999999	0.0	-9999.9	0.0	8.0
620	5/7/93	2	20	4.68	6.25	7.50	0	-9999999	0.0	-9999.9	0.0	0.0
621	5/7/93	2	21	4.90	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
622	5/7/93	2	22	4.88	6.25	7.16	0	31400	0.0	-9999.9	0.0	0.0
623	5/7/93	2	99	5.22	19.00	7.86	-9999999	430	0.0	-9999.9	0.0	13.0

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	Sample Date	Sample Period	Well Number	Groundwater Level (ft)	Sample Depth (ft)	pH	Coliform (per 100 mL)	CFU (CFU/mL)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Sulfide (mg/L)
726	6/24/93	3	1	4.40	6.25	8.19	0	31300	22.0	0.0	0.0	0.0
727	6/24/93	3	2	4.75	6.25	8.04	-9999999	-9999999	17.6	0.0	0.0	0.0
728	6/24/93	3	3	4.80	6.25	7.53	-9999999	-9999999	0.0	-9999.9	0.0	0.0
729	6/24/93	3	4	5.36	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
730	6/24/93	3	5	5.06	6.25	7.69	-9999999	-9999999	6.6	0.0	0.0	0.0
731	6/24/93	3	6	5.08	6.25	7.49	0	95000	165.0	4.0	0.0	0.0
732	6/24/93	3	7	5.10	6.25	7.66	0	27500	0.0	-9999.9	0.0	8.0
733	6/24/93	3	8	4.68	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
734	6/24/93	3	9	4.44	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
735	6/24/93	3	10	4.60	6.25	7.85	-9999999	-9999999	66.0	1.5	0.0	0.0
736	6/24/93	3	11	4.60	6.25	7.37	0	540000	15.4	2.0	0.0	0.0
737	6/24/93	3	12	4.76	6.25	7.33	-9999999	-9999999	176.0	2.5	0.0	0.0
738	6/24/93	3	13	5.10	6.25	8.13	0	241000	1.0	-9999.9	0.0	0.0
739	6/24/93	3	14	5.00	6.25	7.45	-9999999	-9999999	0.0	-9999.9	0.0	0.0
740	6/24/93	3	15	5.02	6.25	7.54	0	200000	0.0	-9999.9	0.0	0.0
741	6/24/93	3	16	5.07	6.25	7.42	-9999999	-9999999	0.0	-9999.9	0.0	0.0
742	6/24/93	3	17	4.95	6.25	7.95	-9999999	-9999999	0.0	-9999.9	0.0	0.0
743	6/24/93	3	18	5.07	6.25	7.84	0	450000	35.0	1.0	0.0	0.0
744	6/24/93	3	19	5.07	6.25	7.32	-9999999	-9999999	0.0	-9999.9	0.0	8.0
745	6/24/93	3	20	4.60	6.25	7.68	-9999999	-9999999	0.4	-9999.9	0.0	0.0
746	6/24/93	3	21	4.60	6.25	8.03	0	86000	3.5	-9999.9	0.0	0.0
747	6/24/93	3	22	4.70	6.25	7.57	0	35000	0.0	-9999.9	0.0	0.2
748	6/24/93	3	99	4.20	19.00	8.09	0	1800	0.0	-9999.9	0.0	13.0
749	6/24/93	3	0	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
861	7/21/93	4	1	4.66	6.25	8.32	0	380000	15.4	0.0	0.0	0.0
862	7/21/93	4	2	4.94	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
863	7/21/93	4	3	4.92	6.25	7.51	-9999999	-9999999	0.0	-9999.9	0.0	0.0
864	7/21/93	4	4	5.06	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
865	7/21/93	4	5	5.10	6.25	7.82	-9999999	-9999999	6.6	0.0	0.0	0.0
866	7/21/93	4	6	5.12	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
867	7/21/93	4	7	5.06	6.25	7.65	0	3800	0.0	-9999.9	0.0	10.0
868	7/21/93	4	8	4.92	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
869	7/21/93	4	9	4.84	6.25	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
870	7/21/93	4	10	4.72	6.25	7.92	0	87000	35.2	2.5	0.0	0.0
871	7/21/93	4	11	4.70	6.25	7.73	0	160000	22.0	-9999.9	0.0	0.0
872	7/21/93	4	12	4.82	6.25	7.60	-9999999	-9999999	165.0	3.0	0.0	0.0
873	7/21/93	4	13	5.34	6.25	8.15	0	18000	0.0	-9999.9	0.0	0.0
874	7/21/93	4	14	5.06	6.25	7.62	-9999999	-9999999	0.0	-9999.9	0.0	0.0
875	7/21/93	4	15	5.08	6.25	7.47	0	26000	0.0	-9999.9	0.0	0.0
876	7/21/93	4	16	5.06	6.25	7.17	-9999999	-9999999	0.0	-9999.9	0.0	2.0
877	7/21/93	4	17	4.98	6.25	8.10	-9999999	-9999999	0.0	-9999.9	0.0	0.0
878	7/21/93	4	18	5.12	6.25	7.97	0	40000	44.0	2.0	0.0	0.0
879	7/21/93	4	19	5.04	6.25	7.51	-9999999	-9999999	0.0	-9999.9	0.0	2.0
880	7/21/93	4	20	4.60	6.25	7.69	-9999999	-9999999	0.0	-9999.9	0.0	0.0
881	7/21/93	4	21	4.66	6.25	8.19	0	22000	1.3	-9999.9	0.0	0.0
882	7/21/93	4	22	4.72	6.25	7.62	0	9000	0.4	-9999.9	0.0	0.0

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	Sample Date	Sample Period	Well Number	Groundwater Level (ft)	Sample Depth (ft)	pH	Coliform (per 100 mL)	CFU (CFU/mL)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Sulfide (mg/L)
883	7/21/93	4	0	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
998	8/19/93	5	1	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
999	8/19/93	5	2	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1000	8/19/93	5	3	4.32	6.25	7.37	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1001	8/19/93	5	4	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1002	8/19/93	5	5	4.36	6.25	7.77	-9999999	-9999999	1.7	-9999.9	0.0	0.0
1003	8/19/93	5	6	4.42	6.25	7.68	0	44000	53.2	-9999.9	0.0	0.0
1004	8/19/93	5	7	4.40	6.25	7.66	0	3400	0.0	-9999.9	0.0	5.0
1005	8/19/93	5	8	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1006	8/19/93	5	9	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1007	8/19/93	5	10	4.10	6.25	7.68	-9999999	-9999999	66.4	-9999.9	0.0	0.0
1008	8/19/93	5	11	4.06	6.25	7.26	0	120000	0.0	-9999.9	0.0	5.0
1009	8/19/93	5	12	4.13	6.25	7.34	-9999999	-9999999	66.4	-9999.9	0.0	0.0
1010	8/19/93	5	13	4.54	6.25	7.93	0	7000	0.0	-9999.9	0.0	0.0
1011	8/19/93	5	14	4.40	6.25	7.34	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1012	8/19/93	5	15	4.30	6.25	7.45	0	6700	0.0	-9999.9	0.0	0.0
1013	8/19/93	5	16	4.40	6.25	7.26	-9999999	-9999999	0.0	-9999.9	0.0	1.0
1014	8/19/93	5	17	4.44	6.25	7.91	-9999999	-9999999	0.4	-9999.9	0.0	0.0
1015	8/19/93	5	18	4.46	6.25	7.55	0	90000	2.7	-9999.9	0.0	0.0
1016	8/19/93	5	19	4.46	6.25	7.27	-9999999	-9999999	0.0	-9999.9	0.0	2.0
1017	8/19/93	5	20	4.10	6.25	7.57	-9999999	-9999999	0.4	-9999.9	0.0	0.0
1018	8/19/93	5	21	4.10	6.25	7.94	0	61000	0.8	-9999.9	0.0	0.0
1019	8/19/93	5	22	4.14	6.25	7.62	0	13000	1.3	-9999.9	0.0	0.0
1020	8/19/93	5	23	4.10	6.25	7.77	0	1600	3.5	-9999.9	0.0	0.0
1021	8/19/93	5		-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1135	9/16/93	6	1	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1136	9/16/93	6	2	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1137	9/16/93	6	3	5.00	6.25	7.79	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1138	9/16/93	6	4	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1139	9/16/93	6	5	5.24	6.25	7.36	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1140	9/16/93	6	6	5.26	6.25	7.41	0	440000	220.0	-9999.9	0.0	0.0
1141	9/16/93	6	7	5.22	6.25	7.42	0	17000	0.0	-9999.9	0.0	5.0
1142	9/16/93	6	8	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1143	9/16/93	6	9	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1144	9/16/93	6	10	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1145	9/16/93	6	11	4.80	6.25	7.29	0	162000	0.0	-9999.9	0.0	0.0
1146	9/16/93	6	12	4.92	6.25	7.25	-9999999	-9999999	176.0	-9999.9	0.0	0.0
1147	9/16/93	6	13	5.28	6.25	7.76	0	72000	4.4	-9999.9	0.0	0.0
1148	9/16/93	6	14	5.18	6.25	7.23	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1149	9/16/93	6	15	5.28	6.25	7.40	0	25000	0.0	-9999.9	0.0	0.0
1150	9/16/93	6	16	5.30	6.25	7.09	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1151	9/16/93	6	17	5.08	6.25	7.88	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1152	9/16/93	6	18	5.30	6.25	7.52	0	27000	30.8	-9999.9	0.0	0.0
1153	9/16/93	6	19	5.24	6.25	7.17	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1154	9/16/93	6	20	4.72	6.25	7.44	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1155	9/16/93	6	21	4.90	6.25	8.03	0	210000	4.4	-9999.9	0.0	0.0

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	Sample Date	Sample Period	Well Number	Groundwater Level (ft)	Sample Depth (ft)	pH	Coliform (per 100 mL)	CFU (CFU/mL)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Sulfide (mg/L)
1156	9/16/93	6	22	4.80	6.25	7.30	0	31200	0.0	-9999.9	0.0	0.0
1157	9/16/93	6	23	4.96	6.25	7.77	0	11400	22.0	-9999.9	0.0	0.0
1271	10/14/93	7	1	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1272	10/14/93	7	2	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1273	10/14/93	7	3	5.00	6.25	7.68	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1274	10/14/93	7	4	-9.99	-99.99	-9.99	-9999999	-9999999	-9999.9	-9999.9	-9999.9	-9999.9
1275	10/14/93	7	5	5.16	6.25	7.54	-9999999	-9999999	2.6	-9999.9	0.0	0.0
1276	10/14/93	7	6	5.18	6.25	7.55	0	36000	198.0	-9999.9	0.0	0.0
1277	10/14/93	7	7	5.14	6.25	7.57	0	3900	0.0	-9999.9	0.0	2.0
1278	10/14/93	7	8	4.60	6.25	8.39	0	1400	110.0	-9999.9	0.0	0.0
1279	10/14/93	7	9	4.74	6.25	8.22	-9999999	-9999999	4.4	-9999.9	0.0	0.0
1280	10/14/93	7	10	6.25	4.74	7.60	-9999999	-9999999	66.0	-9999.9	0.0	0.0
1281	10/14/93	7	11	4.72	6.25	7.23	0	15400	0.0	-9999.9	0.0	0.0
1282	10/14/93	7	12	4.84	6.25	7.38	-9999999	-9999999	220.0	-9999.9	0.0	0.0
1283	10/14/93	7	13	5.20	6.25	7.87	0	400	0.9	-9999.9	0.0	0.0
1284	10/14/93	7	14	5.09	6.25	7.19	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1285	10/14/93	7	15	5.20	6.25	7.29	0	8200	0.0	-9999.9	0.0	0.0
1286	10/14/93	7	16	5.22	6.25	7.14	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1287	10/14/93	7	17	5.00	6.25	7.70	-9999999	-9999999	2.6	-9999.9	0.0	0.0
1288	10/14/93	7	18	5.22	6.25	7.38	0	35000	0.0	-9999.9	0.0	0.0
1289	10/14/93	7	19	5.16	6.25	7.25	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1290	10/14/93	7	20	4.64	6.25	7.34	-9999999	-9999999	0.4	-9999.9	0.0	0.0
1291	10/14/93	7	21	4.62	6.25	8.03	0	10500	4.4	-9999.9	0.0	0.0
1292	10/14/93	7	22	4.72	6.25	7.40	0	9400	0.0	-9999.9	0.0	0.5
1293	10/14/93	7	23	4.88	6.25	7.78	0	0	66.0	-9999.9	0.0	0.0
1411	1/14/94	8	1	-9.99	6.25		-9999999	-9999999		-9999.9		
1412	1/14/94	8	2	3.92	6.25	7.74	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1413	1/14/94	8	3	3.96	6.25	7.05	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1414	1/14/94	8	4	4.12	6.25	7.58	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1415	1/14/94	8	5	4.26	6.25	7.32	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1416	1/14/94	8	6	4.32	6.25	7.34	0	75600	0.0	-9999.9	10.0	0.0
1417	1/14/94	8	7	4.35	6.25	7.56	0	6773	0.0	-9999.9	0.0	1.0
1418	1/14/94	8	8	3.95	6.25	8.31	0	13860	35.2	-9999.9	0.0	0.0
1419	1/14/94	8	9	3.76	6.25	8.05	-9999999	-9999999	0.2	-9999.9	0.0	0.0
1420	1/14/94	8	10	3.76	6.25	7.54	-9999999	-9999999	2.6	-9999.9	0.0	0.0
1421	1/14/94	8	11	3.76	6.25	7.15	0	31500	0.0	-9999.9	10.0	0.0
1422	1/14/94	8	12	3.96	6.25	7.20	-9999999	-9999999	0.7	-9999.9	0.0	0.0
1423	1/14/94	8	13	4.40	6.25	7.45	0	1307250	0.0	-9999.9	0.0	0.0
1424	1/14/94	8	14	4.30	6.25	7.11	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1425	1/14/94	8	15	4.30	6.25	7.12	0	26303	0.0	-9999.9	0.0	0.0
1426	1/14/94	8	16	4.23	6.25	7.18	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1427	1/14/94	8	17	4.02	6.25	7.15	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1428	1/14/94	8	18	4.18	6.25	7.49	0	89775	0.0	-9999.9	0.0	0.0
1429	1/14/94	8	19	4.40	6.25	7.39	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1430	1/14/94	8	20	3.80	6.25	7.69	-9999999	-9999999	2.6	-9999.9	0.0	0.0
1431	1/14/94	8	21	3.85	6.25	8.04	0	1260	0.0	-9999.9	0.0	0.0

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	Sample Date	Sample Period	Well Number	Groundwater Level (ft)	Sample Depth (ft)	pH	Coliform (per 100 mL)	CFU (CFU/mL)	Nitrate (mg/L)	Nitrite (mg/L)	Phosphate (mg/L)	Sulfide (mg/L)
1432	1/14/94	8	22	3.91	6.25	8.05	0	315	0.7	-9999.9	0.0	0.0
1433	1/14/94	8	23	3.78	6.25	7.96	0	0	35.2	-9999.9	0.0	0.0
1434	1/14/94	8	99	-9.99	6.25	8.48	-9999999	-9999999	0.0	-9999.9	0.0	0.0
1542	2/16/94	9	2	5.12	6.25	7.82	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1543	2/16/94	9	3	5.22	6.25	7.00	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1544	2/16/94	9	4	5.43	6.25	7.69	-9999999	-9999999	0.7	-9999.9	0.0	0.2
1545	2/16/94	9	5	5.47	6.25	7.13	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1546	2/16/94	9	6	4.98	6.25	7.09	0	1500	0.0	-9999.9	10.0	7.5
1547	2/16/94	9	7	5.01	6.25	7.18	0	100	0.0	-9999.9	0.0	5.0
1548	2/16/94	9	8	5.10	6.25	7.73	0	2300	0.0	-9999.9	0.0	0.2
1549	2/16/94	9	9	4.97	6.25	8.12	-9999999	-9999999	0.7	-9999.9	0.0	0.2
1550	2/16/94	9	10	4.96	6.25	7.26	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1551	2/16/94	9	11	5.03	6.25	6.97	0	1200	0.0	-9999.9	0.0	7.5
1552	2/16/94	9	12	5.15	6.25	7.13	-9999999	-9999999	35.2	-9999.9	0.0	0.2
1553	2/16/94	9	13	4.97	6.25	7.34	0	700	0.0	-9999.9	0.0	0.2
1554	2/16/94	9	14	5.03	6.25	6.95	-9999999	-9999999	0.0	-9999.9	0.0	1.0
1555	2/16/94	9	15	5.49	6.25	7.11	0	500	0.0	-9999.9	0.0	1.0
1556	2/16/94	9	16	5.45	6.25	6.85	-9999999	-9999999	0.0	-9999.9	0.0	1.5
1557	2/16/94	9	17	5.19	6.25	7.18	-9999999	-9999999	0.2	-9999.9	0.0	0.2
1558	2/16/94	9	18	5.38	6.25	7.13	0	700	0.0	-9999.9	0.0	10.0
1559	2/16/94	9	19	4.97	6.25	7.10	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1560	2/16/94	9	20	4.92	6.25	7.37	-9999999	-9999999	0.0	-9999.9	0.0	0.2
1561	2/16/94	9	21	5.04	6.25	7.60	0	100	1.3	-9999.9	0.0	0.2
1562	2/16/94	9	22	5.05	6.25	7.16	0	200	0.0	-9999.9	0.0	0.2
1563	2/16/94	9	23	4.98	6.25	7.88	0	0	35.2	-9999.9	0.0	0.2
1564	2/16/94	9	99	-9.99	6.25	7.33	-9999999	-9999999	0.0	-9999.9	0.0	0.2

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	TPH (mg OCB/L)	GC Peak Area 10-20 min	GC Peak Area 20-30 min	GC Peak Area 30-40 min	GC Peak Area 40-50 min	GC Peak Area 50-60 min	GC Peak Area 0-60 min
254	10	0	0	0	0	0	0
255	12	0	0	0	0	0	0
256	68	0	2000	10100	0	0	12100
257	22	0	0	0	0	0	0
258	20	0	0	0	0	0	0
259	6	0	0	0	0	0	0
260	36	0	0	0	0	0	0
261	6	0	0	0	0	0	0
262	12	0	0	0	0	0	0
263	4	0	0	0	0	0	0
264	-99999	0	0	0	0	0	0
266	22	0	0	0	0	0	0
267	8	0	0	0	0	0	0
268	20	0	0	0	0	0	0
269	18	0	0	0	0	0	0
270	10	0	0	0	0	0	0
271	16	0	0	0	0	0	0
272	4	0	0	0	0	0	0
273	24	0	0	0	0	0	0
274	18	0	0	0	0	0	0
275	12	0	0	0	0	0	0
276	18	0	0	0	0	0	0
277	16	0	0	0	0	0	0
601	12	0	0	0	0	0	0
602	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
603	16	0	0	0	0	0	0
604	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
605	18	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
606	22	4300	1600	0	0	0	5900
607	34	4000	0	0	0	0	4000
608	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
609	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
610	52	0	0	0	0	0	0
611	36	0	3900	0	0	0	3900
612	64	0	0	0	0	0	0
613	16	0	0	0	0	0	0
614	26	0	0	0	0	0	0
615	36	0	3400	0	0	0	3400
616	58	0	0	0	0	0	0
617	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
618	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
619	26	0	0	0	1000	3200	4200
620	14	0	0	0	0	0	0
621	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
622	18	0	1900	0	0	0	1900
623	8	0	5200	0	0	0	5200

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	TPH (mg OCB/L)	GC Peak Area 10-20 min	GC Peak Area 20-30 min	GC Peak Area 30-40 min	GC Peak Area 40-50 min	GC Peak Area 50-60 min	GC Peak Area 0-60 min
726	10	0	0	3100	0	0	3100
727	8	0	0	0	0	0	0
728	6	0	0	0	0	0	0
729	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
730	6	0	0	0	0	0	0
731	8	0	0	0	0	0	0
732	14	1000	0	0	0	0	1000
733	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
734	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
735	12	0	0	0	4300	7500	11800
736	44	0	0	0	0	0	0
737	24	0	0	0	0	0	0
738	12	0	0	0	0	0	0
739	34	0	0	0	0	0	0
740	34	0	0	0	0	0	0
741	78	0	0	0	0	0	0
742	20	0	0	0	0	0	0
743	18	0	0	0	0	0	0
744	22	0	0	0	0	0	0
745	10	0	0	0	6400	10200	16600
746	16	0	0	0	0	0	0
747	18	0	0	0	0	0	0
748	6	0	0	0	0	0	0
749	0	0	0	0	0	0	0
861	8	0	0	9900	4200	0	14100
862	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
863	6	0	0	0	0	0	0
864	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
865	10	0	0	0	0	0	0
866	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
867	11	0	0	0	0	0	0
868	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
869	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
870	44	0	0	0	0	0	0
871	37	0	0	0	0	0	0
872	9	0	0	0	0	0	0
873	7	0	0	0	0	0	0
874	25	0	1532	0	0	0	1532
875	62	0	0	0	0	0	0
876	33	0	0	0	0	0	0
877	12	0	0	0	0	0	0
878	14	0	0	0	0	0	0
879	25	0	0	0	0	0	0
880	5	0	0	0	0	0	0
881	3	0	0	2964	0	0	2964
882	39	0	0	0	0	0	0

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	TPH (mg OCB/L)	GC Peak Area 10-20 min	GC Peak Area 20-30 min	GC Peak Area 30-40 min	GC Peak Area 40-50 min	GC Peak Area 50-60 min	GC Peak Area 0-60 min
883	-99999	0	0	0	0	0	0
998	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
999	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1000	11	0	0	0	0	0	0
1001	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1002	27	0	0	0	0	0	0
1003	17	0	0	0	0	0	0
1004	14	0	0	0	0	0	0
1005	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1006	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1007	17	0	0	0	0	0	0
1008	71	0	0	0	0	0	0
1009	31	0	0	0	0	0	0
1010	9	0	0	0	0	0	0
1011	27	0	0	0	0	0	0
1012	62	0	0	0	0	0	0
1013	68	0	0	0	0	0	0
1014	40	0	0	0	0	0	0
1015	69	0	0	0	0	0	0
1016	59	0	0	0	0	0	0
1017	8	0	0	0	0	0	0
1018	36	0	0	0	0	0	0
1019	21	0	0	0	0	0	0
1020	34	0	0	0	0	0	0
1021	-99999	0	0	0	0	0	0
1135	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1136	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1137	17	0	0	0	0	0	0
1138	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1139	27	0	0	0	0	0	0
1140	16	0	0	0	0	0	0
1141	16	0	0	0	0	0	0
1142	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1143	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1144	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1145	39	0	0	0	0	0	0
1146	35	0	0	0	24100	25200	49300
1147	12	0	0	0	0	0	0
1148	24	0	0	0	0	0	0
1149	39	0	0	0	6100	7300	13400
1150	48	0	0	0	0	0	0
1151	14	0	0	0	0	0	0
1152	17	0	0	0	0	0	0
1153	49	0	0	0	0	0	0
1154	16	0	0	0	0	0	0
1155	18	0	3200	0	0	0	3200

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	TPH (mg OCB/L)	GC Peak Area 10-20 min	GC Peak Area 20-30 min	GC Peak Area 30-40 min	GC Peak Area 40-50 min	GC Peak Area 50-60 min	GC Peak Area 0-60 min
1156	50	0	0	0	0	0	0
1157	19	0	0	0	0	0	0
1271	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1272	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1273	-99999	0	0	0	41700	0	41700
1274	-99999	-999999999	-999999999	-999999999	-999999999	-999999999	-999999999
1275	-99999	2500	0	0	4600	0	7100
1276	-99999	0	0	31000	0	0	31000
1277	-99999	0	0	25000	0	0	25000
1278	-99999	0	0	2900	0	0	2900
1279	-99999	0	0	1300	0	0	1300
1280	-99999	0	0	0	0	0	0
1281	-99999	0	0	261000	0	0	261000
1282	-99999	0	3500	0	0	0	3500
1283	-99999	0	0	0	0	0	0
1284	-99999	0	1200	0	0	0	1200
1285	-99999	0	0	0	0	0	0
1286	-99999	1100	0	0	0	0	1100
1287	-99999	1700	4700	0	0	0	6400
1288	-99999	0	0	0	0	0	0
1289	-99999	0	0	0	0	0	0
1290	-99999	2000	0	0	0	0	2000
1291	-99999	0	2300	0	0	0	2300
1292	-99999	0	0	0	0	0	0
1293	-99999	0	0	0	0	0	0
1411							
1412	11	0	0	0	0	0	0
1413	11	0	3680	0	0	0	3680
1414	26	0	0	0	0	0	0
1415	15	0	0	0	0	0	0
1416	8	0	2809	0	0	0	2809
1417	7	0	3203	0	0	0	3203
1418	7	0	0	0	0	0	0
1419	7	0	0	0	0	0	0
1420	15	0	0	0	0	0	0
1421	32	0	0	0	0	0	0
1422	22	5686	0	0	0	0	5686
1423	121	0	0	0	0	0	0
1424	18	0	0	0	0	0	0
1425	36	0	0	0	0	0	0
1426	50	0	2271	0	0	0	2271
1427	18	0	2492	0	0	0	2492
1428	84	0	0	0	0	0	0
1429	17	0	0	0	0	0	0
1430	3	0	0	0	0	0	0
1431	10	0	2594	0	0	0	2594

*Note: Negative values indicate that the analysis was not run on that sample

Data for ground water samples taken during the Kwajalein bioremediation project *

Sample Number	TPH (mg OCB/L)	GC Peak Area 10-20 min	GC Peak Area 20-30 min	GC Peak Area 30-40 min	GC Peak Area 40-50 min	GC Peak Area 50-60 min	GC Peak Area 0-60 min
1432	48	0	4916	0	0	0	4916
1433	4	0	0	0	0	0	0
1434	3	0	0	0	0	0	0
1542	4	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1543	8	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1544	12	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1545	10	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1546	4	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1547	5	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1548	17	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1549	8	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1550	6	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1551	37	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1552	12	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1553	25	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1554	15	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1555	23	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1556	62	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1557	17	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1558	31	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1559	16	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1560	22	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1561	10	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1562	15	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1563	5	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999
1564	25	-9999999	-9999999	-9999999	-9999999	-9999999	-9999999

*Note Negative values indicate that the analysis was not run on that sample

APPENDIX D

METEOROLOGICAL DATA FOR KWAJALEIN ISLAND DURING THE BIOREMEDIATION DEMONSTRATION PERIOD

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: JAN
Year: 1993

Latitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit : Precip(in.): Snow : Wind : Fastest 1-Min: Sunshine : Sky : Peak Wind

<==== Columns ====>

-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	83	75	79	-3	0	14	0.64	0.0	0	18.1	21	04			10		32	E
2	85	79	82	0	0	17	0.00	0.0	0	14.3	18	04			10		23	NE
3	84	77	81	-1	0	16	0.01	0.0	0	14.4	20	03			10		30	NE
4	80	75	78	-4	0	13	0.99	0.0		20.5	29	06			10		37	NE
5	82	76	79	-3	0	14	0.39	0.0	0	20.1	23	07			10		35	NE
6	84	78	81	0	0	16	0.01	0.0	0	21.1	25	07			10		36	E
7	85	78	82	1	0	17	0.07	0.0	0	19.0	23	06			10		29	NE
8	85	79	82	1	0	17	0.00	0.0	0	18.1	21	08			10		28	E
9	83	76	80	-1	0	15	T	0.0	0	20.4	23	08			10		35	E
10	84	75	80	-1	0	15	0.02	0.0	0	20.0	25	07			10		32	E
11	85	77	81	0	0	16	0.01	0.0	0	19.2	23	08			10		29	E
[illegible]	85	78	82	1	0	17	0.02	0.0	0	19.3	23	07			10		30	NE
[illegible]	85	78	82	1	0	17	T	0.0		19.3	23	06			10		28	NE
14	85	79	82	1	0	17	0.00	0.0	0	16.5	20	06			10		30	NE
15	85	79	82	1	0	17	0.00	0.0	0	17.4	22	06			10		28	NE
16	85	78	82	1	0	17	0.01	0.0	0	19.5	23	07			6		32	E
17	84	79	82	1	0	17	0.00	0.0	0	18.1	21	06			10		31	E
18	85	79	82	1	0	17	0.00	0.0	0	19.5	23	07			7		31	NE
19	85	78	82	1	0	17	0.05	0.0	0	19.2	25	06			5		35	NE
20	85	79	82	1	0	17	0.08	0.0		18.1	26	06			6		31	NE
21	86	80	83	2	0	18	T	0.0	0	15.3	20	06			5		28	NE
22	85	78	82	1	0	17	0.35	0.0	0	13.8	21	06			9		29	NE
23	85	78	82	1	0	17	0.19	0.0	0	16.5	25	08			10		33	E
24	84	76	80	-1	0	15	0.07	0.0	0	19.6	29	07			10		37	NE
25	85	79	82	0	0	17	0.01	0.0	0	17.9	23	06			10		31	NE
26	85	78	82	0	0	17	T	0.0	0	17.5	23	05			7		31	NE
27	85	79	82	0	0	17	0.00	0.0	0	13.3	16	05			3		21	NE
28	85	78	82	0	0	17	0.00	0.0	0	11.0	13	04			9		17	NE
29	85	78	82	0	0	17	0.00	0.0	0	12.0	16	06			10		21	NE
30	84	78	81	-1	0	16	0.00	0.0	0	12.8	20	05			10		23	NE
31	84	77	81	-1	0	16	0.05	0.0	0	10.5	14	06			10		21	NE
Sum	2617	2411			0	507	2.97	0.0		532.3					277			
Avg	84.4	77.8								17.2	Fast	Dir.	Psbl	%	8.9		Max (mph)	
								Misc -------->			29#	07	21720				037	NE #

Notes:
Last of several occurrences
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: FEB
Year: 1993

Latitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	84	76	80	-1	0	15	0.10	0.0	0	13.3	17	04			10		23	NE
2	85	79	82	1	0	17	0.00	0.0	0	13.9	16	06			10		22	E
3	85	78	82	1	0	17	0.00	0.0	0	13.2	17	06			10		23	NE
4	85	76	81	0	0	16	0.03	0.0	0	11.1	17	09			10		22	E
5	85	75	80	-1	0	15	0.13	0.0	0	14.1	18	05			10		23	NE
6	85	79	82	1	0	17	0.00	0.0	0	13.4	16	05			10		20	NE
7	84	77	81	-1	0	16	0.01	0.0	0	15.1	21	05			10		29	NE
8	85	78	82	0	0	17	0.00	0.0	0	16.3	21	06			10		26	NE
9	85	79	82	0	0	17	0.00	0.0	0	13.4	17	06			10		24	E
10	85	78	82	0	0	17	T	0.0	0	13.2	21	04			10		25	NE
11	86	79	83	1	0	18	0.00	0.0	0	10.6	14	07			10		21	NE
[illegible]	85	78	82	0	0	17	T	0.0	0	13.3	17	05			10		23	NE
[illegible]	85	79	82	0	0	17	0.00	0.0	0	11.9	16	07			10		20	NE
14	83	79	81	-1	0	16	T	0.0	0	14.5	20	07			10		26	E
15	85	80	83	1	0	18	0.00	0.0	0	18.0	21	08			10		28	NE
16	86	77	82	0	0	17	0.02	0.0	0	15.2	20	05			10		29	NE
17	85	77	81	-1	0	16	0.11	0.0	0	14.8	18	08			10		28	NE
18	85	77	81	-1	0	16	0.08	0.0	0	15.6	18	05			10		28	NE
19	86	77	82	0	0	17	T	0.0	0	15.4	22	06			10		26	NE
20	85	77	81	-1	0	16	0.56	0.0	0	14.0	22	08			10		30	E
21	85	78	82	0	0	17	1.13	0.0	0	14.9	22	07			10		31	E
22	85	79	82	0	0	17	0.00	0.0	0	14.8	17	07			10		25	E
23	85	78	82	0	0	17	0.00	0.0	0	14.0	17	06			10		26	E
24	85	78	82	0	0	17	0.04	0.0	0	15.7	21	07			10		29	NE
25	86	77	82	0	0	17	0.07	0.0	0	14.6	17	05			10		24	NE
26	85	78	82	0	0	17	0.01	0.0	0	14.2	18	06			10		23	NE
27	84	77	81	-1	0	16	0.43	0.0	0	11.9	20	06			10		25	E
28	85	80	83	1	0	18	0.00	0.0	0	19.7	22	07			10		29	NE
Sum	2379	2180			0	468	2.72	0.0		400.1					280			
Avg	85.0	77.9								14.3	Fast	Dir.	Psbl	%	10.0		Max	(mph)
								Misc -------->			22#	07	19911				031	E

Notes:

Last of several occurrences

[illegible]lumn 9 readings are taken at 99

[illegible]n 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: MAR
Year: 1993

Latitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	85	80	83	1	0	18	0.00	0.0	0	19.0	22	07			10		29	NE
2	81	77	79	-3	0	14	0.08	0.0	0	19.5	30	07			10		40	E
3	85	76	81	-1	0	16	0.30	0.0	0	15.4	22	08			10		36	E
4	85	79	82	0	0	17	T	0.0	0	16.9	22	08			10		29	E
5	86	78	82	0	0	17	T	0.0	0	17.6	21	07			10		30	NE
6	85	79	82	0	0	17	0.00	0.0	0	16.4	20	07			10		26	E
7	86	80	83	1	0	18	0.00	0.0	0	17.2	22	07			10		26	E
8	84	77	81	-1	0	16	0.20	0.0	0	18.5	25	06			10		32	NE
9	84	78	81	-1	0	16	0.22	0.0	0	21.9	29	07			10		37	E
10	83	77	80	-2	0	15	0.19	0.0	0	19.6	26	08			10		35	E
11	85	77	81	-1	0	16	1.27	0.0	0	19.5	32	09			10		40	E
12	85	80	83	1	0	18	0.01	0.0	0	16.1	22	09			10		29	E
13	86	78	82	0	0	17	0.39	0.0	0	17.1	26	10			10		36	E
14	85	79	82	0	0	17	0.00	0.0	0	16.1	20	08			10		31	E
15	85	80	83	0	0	18	0.00	0.0	0	13.3	18	06			10		23	NE
16	85	79	82	-1	0	17	0.00	0.0	0	10.4	14	07			10		16	E
17	85	80	83	0	0	18	0.03	0.0	0	11.8	14	09			10		21	E
18	85	80	83	0	0	18	0.00	0.0	0	14.6	18	09			10		22	E
19	85	80	83	0	0	18	0.00	0.0	0	12.6	17	07			10		22	E
20	85	78	82	-1	0	17	0.00	0.0	0	9.4	14	08			10		18	E
21	86	79	83	0	0	18	T	0.0	0	10.8	14	05			10		15	NE
22	86	77	82	-1	0	17	0.16	0.0	0	15.0	20	08			10		29	E
23	86	76	81	-2	0	16	0.50	0.0	0	12.7	20	10			10		25	E
24	85	77	81	-1	0	16	0.33	0.0	0	13.6	18	07			10		25	E
25	86	80	83	1	0	18	0.00	0.0	0	14.1	20	05			9		21	NE
26	86	76	81	-1	0	16	0.18	0.0	0	14.7	20	06			10		25	NE
27	86	77	82	0	0	17	1.10	0.0	0	18.3	21	08			10		31	NE
28	86	80	83	1	0	18	0.00	0.0	0	16.5	21	08			10		26	E
29	86	78	82	0	0	17	T	0.0	0	17.8	22	07			10		28	E
30	85	77	81	-1	0	16	0.87	0.0	0	16.1	25	09			10		32	E
31	85	74	80	-2	0	15	1.04	0.0	0	13.4	25	11			10		38	E
Sum	2638	2423			0	522	6.87	0.0		485.9					309			
Avg	85.1	78.2								15.7	Fast	Dir.	Psbl	%	10.0		Max	(mph)
									Misc -------->		32	09	22469				040	E #

Notes:
[illegible] of several occurrences
[illegible] 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

..iminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: APR
Year: 1993

.atitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :		Fastest 1-Min:		Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	85	80	83	0	0	18	T	0.0	0	11.6	14	08			10		22	E
2	85	79	82	-1	0	17	0.02	0.0	0	14.3	21	08			10		24	E
3	86	80	83	0	0	18	0.00	0.0	0	11.8	15	07			10		21	E
4	86	79	83	1	0	18	0.00	0.0	0	12.9	16	05			10		21	E
5	85	79	82	0	0	17	T	0.0	0	14.1	20	07			10		28	NE
6	86	79	83	1	0	18	T	0.0	0	15.1	21	08			10		24	E
7	86	79	83	1	0	18	0.00	0.0	0	14.7	18	07			10		23	NE
8	86	78	82	0	0	17	0.03	0.0	0	15.4	24	08			10		26	E
9	86	79	83	1	0	18	0.00	0.0	0	11.7	15	05			10		21	NE
10	86	80	83	1	0	18	0.00	0.0	0	12.8	16	06			10		20	E
11	87	79	83	1	0	18	T	0.0	0	13.9	17	06			10		23	NE
12	87	79	83	1	0	18	0.02	0.0	0	16.3	20	06			10		25	NE
13	86	80	83	1	0	18	0.00	0.0	0	13.8	17	06			10		22	E
14	86	80	83	1	0	18	0.00	0.0	0	14.3	18	06			10		23	NE
15	87	80	84	2	0	19	0.00	0.0	0	14.5	17	07			10		22	E
16	86	78	82	0	0	17	0.07	0.0	0	12.4	17	10			10		24	E
17	83	75	79	-3	0	14	1.37	0.0	0	13.1	20	08			10		25	E
18	85	78	82	0	0	17	0.06	0.0	0	12.3	18	07			10		24	E
19	86	80	83	1	0	18	T	0.0	0	12.7	16	08			10		20	E
20	86	79	83	1	0	18	T	0.0	0	13.7	16	08			10		22	E
21	86	78	82	0	0	17	0.03	0.0	0	14.2	17	06			10		22	NE
22	86	80	83	1	0	18	0.00	0.0	0	14.3	16	07			10		20	E
23	86	78	82	0	0	17	T	0.0	0	16.4	20	06			10		25	E
24	86	80	83	1	0	18	0.00	0.0	0	16.2	21	05			10		26	NE
25	87	76	82	0	0	17	0.05	0.0	0	14.4	20	07			10		25	E
26	86	75	81	-1	0	16	0.11	0.0	0	16.2	18	07			10		25	NE
27	86	78	82	0	0	17	0.01	0.0	0	17.1	21	07			10		26	E
28	87	78	83	1	0	18	0.27	0.0	0	16.0	18	06			10		28	E
29	86	79	83	1	0	18	0.00	0.0	0	14.6	18	07			10		22	E
30	84	77	81	-1	0	16	0.44	0.0	0	17.5	21	07			10		30	E
Sum	2576	2359			0	524	2.48	0.0		428.3					300			
Avg	85.9	78.6								14.3	Fast	Dir.	Psbl	%	10.0		Max	(mph)
									Misc ------>		24	08	22177				030	E

Notes:
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: MAY
Year: 1993

Latitude +0844 | Longitude -167.44 | Gnd Elev. 8 ft. | Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):		Snow :	Wind :	Fastest 1-Min:		Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	86	77	82	0	0	17	0.84	0.0	0	13.0	22	07			10		26	E
2	84	76	80	-2	0	15	1.98	0.0	0	15.6	21	08			10		29	E
3	86	80	83	1	0	18	0.00	0.0	0	13.9	17	06			10		23	E
4	85	80	83	1	0	18	0.02	0.0	0	14.3	18	07			10		28	E
5	86	80	83	1	0	18	0.00	0.0	0	13.0	17	07			10		20	NE
6	86	80	83	1	0	18	0.00	0.0	0	13.2	16	11			10		20	E
7	86	80	83	1	0	18	T	0.0	0	13.9	16	05			10		22	NE
8	87	80	84	2	0	19	0.00	0.0	0	10.9	13	08			10		16	E
9	86	80	83	1	0	18	0.04	0.0	0	11.7	15	08			10		25	E
10	87	79	83	1	0	18	0.06	0.0	0	14.3	17	07			10		23	E
11	87	80	84	2	0	19	0.00	0.0	0	14.4	18	07			10		22	E
12	86	78	82	0	0	17	0.01	0.0	0	11.1	16	07			10		18	E
13	87	80	84	2	0	19	0.00	0.0	0	15.3	20	06			10		23	E
14	86	78	82	0	0	17	0.10	0.0	0	14.1	20	06			10		26	E
15	82	76	79	-3	0	14	0.91	0.0	0	13.3	20	09			10		24	NE
16	85	75	80	-2	0	15	0.38	0.0	0	9.9	18	25			10		26	W
17	86	75	81	-1	0	16	0.59	0.0	0	11.6	16	11			10		21	E
18	86	80	83	1	0	18	0.05	0.0	0	10.1	12	10			10		17	E
19	86	81	84	2	0	19	0.00	0.0	0	12.1	14	07			10		18	NE
20	86	80	83	1	0	18	T	0.0	0	12.1	16	09			3		22	E
21	86	79	83	1	0	18	0.04	0.0	0	12.2	20	08			10		23	E
22	86	80	83	1	0	18	T	0.0	0	15.2	21	08			10		23	E
23	86	79	83	1	0	18	0.14	0.0	0	11.9	15	09			10		23	E
24	87	77	82	0	0	17	0.27	0.0	0	8.9	12	11			10		17	E
25	86	80	83	1	0	18	T	0.0	0	12.6	17	08			10		20	E
26	86	78	82	0	0	17	0.14	0.0	0	13.1	25	09			10		31	E
27	87	77	82	0	0	17	0.24	0.0	0	15.0	22	08			10		29	E
28	87	80	84	2	0	19	0.02	0.0	0	15.1	17	07			10		26	E
29	87	79	83	1	0	18	0.11	0.0	0	12.5	18	07			10		28	E
30	87	81	84	2	0	19	T	0.0	0	11.9	15	06			10		15	NE
31	87	82	85	3	0	20	0.00	0.0	0	13.6	17	09			10		21	E
Sum	2668	2447			0	548	5.94	0.0		399.8					303			
Avg	86.1	78.9								12.9	Fast	Dir.	Psbl	%	9.8		Max	(mph)
								Misc	--------->		25	09	23293				031	E

Notes:
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

[illegible]iminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: JUN
Year: 1993

Latitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	87	80	84	2	0	19	0.08	0.0	0	13.1	16	07			10		22	E
2	86	77	82	0	0	17	1.01	0.0	0	12.3	18	07			10		26	NE
3	87	81	84	2	0	19	0.00	0.0	0	11.2	14	08			10		17	E
4	85	77	81	-1	0	16	0.40	0.0	0	12.3	22	10			10		28	E
5	87	81	84	2	0	19	0.00	0.0	0	13.2	20	07			10		18	E
6	87	81	84	2	0	19	0.00	0.0	0	12.9	16	06			10		22	E
7	87	81	84	2	0	19	T	0.0	0	13.5	17	07			10		21	E
8	88	82	85	3	0	20	0.00	0.0	0	14.3	17	05			10		20	E
9	87	82	85	3	0	20	0.00	0.0	0	14.5	18	06			10		22	NE
10	88	82	85	3	0	20	0.00	0.0	0	13.7	18	06			10		23	NE
11	87	80	84	2	0	19	0.03	0.0	0	14.8	22	04			10		24	NE
12	87	78	83	1	0	18	0.19	0.0	0	16.1	25	08			10		33	E
13	85	77	81	-1	0	16	0.39	0.0	0	14.4	28	13			10		33	SE
14	87	81	84	2	0	19	0.00	0.0	0	14.2	17	07			10		21	E
15	86	79	83	1	0	18	0.40	0.0	0	12.4	24	09			10		29	E
[illegible]	85	77	81	-1	0	16	0.78	0.0	0	11.4	21	08			10		25	E
17	87	79	83	1	0	18	0.01	0.0	0	10.1	13	05			10		21	NE
18	87	78	83	1	0	18	0.43	0.0	0	11.4	15	11			10		22	E
19	86	78	82	0	0	17	0.24	0.0	0	12.0	17	11			10		23	E
20	86	80	83	1	0	18	0.38	0.0	0	14.3	18	07			10		31	SE
21	87	79	83	1	0	18	0.03	0.0	0	12.4	21	06			9		24	NE
22	87	81	84	2	0	19	T	0.0	0	12.0	15	07			10		21	NE
23	87	77	82	0	0	17	0.52	0.0	0	12.6	22	07			10	3	26	E
24	86	78	82	0	0	17	0.43	0.0	0	14.4	17	07			10		23	NE
25	86	77	82	0	0	17	0.72	0.0	0	13.9	20	06			10		26	NE
26	87	78	83	1	0	18	0.35	0.0	0	17.7	26	09			10		30	E
27	83	77	80	-2	0	15	1.26	0.0	0	13.3	25	09			10		33	SE
28	87	80	84	2	0	19	0.02	0.0	0	14.5	20	10			10		24	E
29	87	79	83	1	0	18	T	0.0	0	13.6	17	06			10		20	E
30	87	81	84	2	0	19	0.05	0.0	0	11.9	17	07			10		20	E
Sum	2596	2378			0	542	7.72	0.0		398.4					299			
Avg	86.5	79.3								13.3	Fast	Dir.	Psbl	%	10.0		Max	(mph)
								Misc ------>			28	13	22718				033	SE #

Notes:
Last of several occurrences
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: JUL
Year: 1993

Latitude +0844 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	87	81	84	2	0	19	0.00	0.0	0	11.2	14	07			10		21	NE
2	88	79	84	2	0	19	T	0.0	0	14.0	20	06			10		24	NE
3	87	82	85	3	0	20	0.00	0.0	0	14.0	17	07			4		24	E
4	85	78	82	0	0	17	0.10	0.0	0	13.7	18	11			10		23	E
5	86	80	83	1	0	18	T	0.0	0	12.5	20	06			10		24	NE
6	87	81	84	2	0	19	0.00	0.0	0	13.1	16	08			10		21	E
7	87	81	84	2	0	19	T	0.0	0	15.2	17	06			10		22	E
8	88	80	84	2	0	19	0.01	0.0	0	11.5	16	06			10		17	E
9	88	80	84	2	0	19	0.00	0.0	0	10.3	15	07			10		16	E
10	87	79	83	2	0	18	0.05	0.0	0	10.3	16	09			10		18	E
11	88	82	85	4	0	20	0.00	0.0	0	9.7	12	07			10		16	E
[illegible]	87	79	83	2	0	18	0.16	0.0	0	12.3	17	08			10		22	E
[illegible]	86	79	83	1	0	18	0.08	0.0	0	11.3	15	08			10		20	E
14	87	80	84	2	0	19	0.03	0.0	0	11.6	16	08			10		20	E
15	88	79	84	2	0	19	0.15	0.0	0	14.9	24	10			10		29	E
16	85	79	82	0	0	17	0.55	0.0	0	13.0	24	10			10		29	E
17	85	77	81	-1	0	16	0.56	0.0	0	13.2	20	07			10		26	E
18	86	76	81	-1	0	16	0.85	0.0	0	13.5	23	09			10		31	E
19	87	79	83	1	0	18	0.03	0.0	0	15.3	20	07			10		31	NE
20	87	80	84	2	0	19	0.01	0.0	0	16.4	20	08			8		28	NE
21	86	76	81	-1	0	16	0.85	0.0	0	15.5	25	07			10		31	E
22	86	77	82	0	0	17	0.61	0.0	0	16.0	29	08			10		35	E
23	87	80	84	2	0	19	0.02	0.0	0	13.7	17	07			10		23	NE
24	88	79	84	2	0	19	0.11	0.0	0	9.1	17	11			10		22	E
25	86	81	84	2	0	19	T	0.0	0	8.3	14	07			10		16	E
26	88	77	83	1	0	18	0.55	0.0	0	11.3	22	09			10		28	E
27	86	77	82	0	0	17	0.80	0.0	0	12.6	21	10			10		25	E
28	87	79	83	1	0	18	0.07	0.0	0	14.8	29	09			10		35	E
29	85	76	81	-1	0	16	1.63	0.0	0	14.4	29	07			10		40	E
30	86	78	82	0	0	17	0.08	0.0	0	14.3	18	09			10		29	E
31	86	81	84	2	0	19	0.10	0.0	0	15.8	22	07			10		30	E
Sum	2687	2452			0	562	7.40	0.0		402.8					302			
Avg	86.7	79.1								13.0	Fast	Dir.	Pcbl	%	9.7		Max	(mph)
										Misc ———>	298	07	23385				040	E

Notes:
* Last of several occurrences
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: AUG
Year: 1993

Latitude +08.44 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :		Fastest 1-Min:		Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	86	77	82	0	0	17	0.38	0.0	0	13.5	22	11			10		28	E
2	83	75	79	-3	0	14	2.80	0.0	0	9.2	25	14			10		29	SE
3	87	76	82	0	0	17	0.01	0.0	0	12.5	15	09			10		24	NE
4	88	81	85	3	0	20	0.01	0.0	0	9.7	14	12			10		17	E
5	89	78	84	2	0	19	0.44	0.0	0	9.7	21	04			10		29	NE
6	86	77	82	0	0	17	0.73	0.0	0	10.8	15	06			10		20	NE
7	84	77	81	-1	0	16	0.32	0.0	0	12.5	25	10			10		31	SE
8	88	78	83	1	0	18	0.14	0.0	0	5.5	10	13			10		16	SE
9	88	81	85	3	0	20	0.00	0.0	0	6.0	08	16			3		15	SE
10	89	75	82	0	0	17	0.83	0.0	0	5.3	13	06			7		16	NE
11	85	78	82	0	0	17	0.41	0.0	0	5.8	16	10			10		25	NE
12	86	80	83	1	0	18	0.01	0.0	0	9.8	13	08			10		17	E
13	87	81	84	2	0	19	0.00	0.0	0	9.1	16	11			9		25	E
14	87	78	83	1	0	18	0.05	0.0	0	6.7	16	11			10		17	N
[illegible]	88	81	85	3	0	20	T	0.0	0	8.4	12	05			10		17	NE
16	87	79	83	1	0	18	0.12	0.0	0	7.3	12	12			10		20	E
17	85	77	81	-2	0	16	1.37	0.0	0	8.3	18	10			10		22	E
18	84	77	81	-2	0	16	2.08	0.0	0	12.1	23	24			10		33	SW
19	87	76	82	-1	0	17	0.29	[illegible]	0	11.7	18	30			10		25	NW
20	86	76	81	-2	0	16	0.27	[illegible]	0	9.7	17	34			10		26	N
21	87	78	83	0	0	18	0.16	[illegible]	0	5.9	14	25			10		14	W
22	87	80	84	1	0	19	0.00	0.0	0	8.5	21	08			10		26	E
23	87	82	85	3	0	20	0.00	0.0	0	7.2	10	12			10		14	S
24	88	76	82	0	0	17	1.09	0.0	0	4.7	14	01			10		21	N
25	87	80	84	2	0	19	T	0.0	0	5.1	09	04			10		10	NE
26	86	79	83	1	0	18	0.16	0.0	0	6.2	09	10			10		20	SE
27	88	81	85	3	0	20	0.01	0.0	0	5.4	09	20			10		14	SW
28	85	75	80	-2	0	15	1.39	0.0	0	6.0	24	06			10		28	NE
29	87	79	83	1	0	18	T	0.0	0	5.8	09	11			10		17	NE
30	87	79	83	1	0	18	0.00	0.0	0	6.1	09	11			10		14	E
31	88	81	85	3	0	20	0.00	0.0	0	5.0	09	06			10		12	NE
Sum	2687	2428			0	552	13.07	0.0		249.5					299			
Avg	86.7	78.3								8.0	Fast	Dir.	Psbl	%	9.6		Max	(mph)
									Misc ------->		25#	10	23051				033	SW

Notes:
Last of several occurrences
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

[illegible]eliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: SEP
Year: 1993

Latitude 08.44 | Longitude -167.44 | Gnd Elev. 8 ft. | Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	87	79	83	0	0	18	0.11	0.0	0	8.3	14	16			10		26	E
2	87	79	83	0	0	18	0.01	0.0	0	2.9	10	21			10		14	SW
3	89	79	84	1	0	19	0.00	0.0	0	5.5	09	01			10		15	N
4	87	80	84	2	0	19	0.00	0.0	0	7.7	13	03			10		17	NE
5	87	79	83	1	0	18	0.05	0.0	0	6.3	08	12			10		18	SE
6	87	81	84	2	0	19	0.00	0.0	0	5.6	09	07			5		13	E
7	86	75	81	-1	0	16	0.88	0.0	0	4.3	09	17			10		12	S
8	88	77	83	1	0	18	0.39	0.0	0	7.5	17	07			10		24	E
9	87	80	84	2	0	19	0.02	0.0	0	11.5	15	07			10		21	E
10	88	80	84	2	0	19	0.05	0.0	0	11.7	28	08			10		32	E
11	88	76	82	0	0	17	0.34	0.0	0	8.5	25	12			10		31	SE
12	84	76	80	-2	0	15	0.65	0.0	0	7.2	18	03			10		23	NE
1[illegible]	88	78	83	1	0	18	0.00	0.0	0	4.5	08	09			10		14	NE
14	87	81	84	2	0	19	0.00	0.0	0	4.8	08	17			10		13	E
15	89	80	85	3	0	20	0.05	0.0	0	7.3	12	36			10		17	N
16	88	77	83	1	0	18	0.84	0.0	0	9.7	18	22			10		23	SW
17	89	79	84	2	0	19	0.01	0.0	0	6.9	14	24			10		16	SW
18	88	82	85	3	0	20	0.00	0.0	0	6.5	09	17			3		12	S
19	89	80	85	3	0	20	T	0.0	0	5.2	12	03			10		16	E
20	88	79	84	2	0	19	0.01	0.0	0	4.9	15	05			10		17	S
21	87	77	82	0	0	17	0.25	0.0	0	6.7	17	09			10		25	E
22	87	76	82	0	0	17	0.39	0.0	0	6.7	16	19			10		21	S
23	88	78	83	1	0	18	0.15	0.0	0	9.8	21	11			10		28	E
24	89	77	83	1	0	18	0.20	0.0	0	7.7	17	04			10		23	NE
25	87	75	81	-1	0	16	1.56	0.0	0	7.8	22	20			10		28	NE
26	87	77	82	0	0	17	0.72	0.0	0	7.6	25	06			10	3	29	NE
27	89	80	85	3	0	20	0.27	0.0	0	6.0	14	22			10		18	N
28	89	79	84	2	0	19	0.01	0.0	0	6.2	10	03			9		15	N
29	88	80	84	2	0	19	0.08	0.0	0	13.4	17	05			3		28	E
30	88	80	84	2	0	19	0.03	0.0	0	11.8	15	08			10		24	NE
Sum	2630	2356			0	548	7.07	0.0		220.5					280			
Avg	87.7	78.5								7.4	Fast	Dir.	Psbl	%	9.3		Max (mph)	
									Misc ------>		28	08	21903				032	E

Notes:
C[illegible]an 9 readings are taken at 99
[illegible]an 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: OCT
Year: 1993

Latitude	Longitude		
08.44	-167.44	Gnd Elev. 8 ft.	Std Time: 180E

Temperature in Fahrenheit : Precip(in.): Snow : Wind : Fastest 1-Min: Sunshine : Sky : Peak Wind

Columns

-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
	87	77	82	0	0	17	0.65	0.0	0	7.2	14	18			10	1	23	E
	87	77	82	0	0	17	1.01	0.0	0	5.8	12	06			10		22	NE
	86	77	82	0	0	17	0.89	0.0	0	8.4	21	06			10		28	E
	87	79	83	1	0	18	0.07	0.0	0	9.5	21	11			10		29	E
	88	82	85	3	0	20	0.01	0.0	0	7.8	10	13			10		15	SE
	87	78	83	1	0	18	0.34	0.0	0	7.1	13	09			10		29	E
	88	80	84	2	0	19	0.12	0.0	0	7.1	12	08			10		22	E
	88	77	83	1	0	18	1.14	0.0		5.4	17	09			10	3	23	E
	87	77	82	0	0	17	0.46	0.0	0	8.0	17	33			10		23	NW
	88	80	84	2	0	19	0.03	0.0	0	7.0	14	10			10	3	24	E
11	87	78	83	1	0	18	0.10	0.0	0	6.4	15	09			10		25	N
12	88	78	83	1	0	18	0.18	0.0	0	8.9	23	06			10		28	NE
13	84	78	81	-1	0	16	0.36	0.0	0	8.1	16	17			10		22	NE
14	84	78	81	-2	0	16	0.18	0.0	0	11.3	23	03			10		29	NE
15	88	80	84	1	0	19	0.02	0.0	0	5.6	14	07			10		20	E
16	87	80	84	1	0	19	0.16	0.0	0	4.0	07	24			10		14	NW
17	88	79	84	1	0	19	0.14	0.0	0	7.3	12	28			10		16	W
18	88	79	84	1	0	19	0.35	0.0	0	14.6	24	26			10		32	W
19	86	76	81	-2	0	16	2.67	0.0	0	19.7	32	24			10	3	47	SW
20	87	77	82	0	0	17	0.32	0.0	0	16.9	30	25			10		40	W
21	87	75	81	-1	0	16	0.34	0.0	0	12.4	18	07			10		23	N
22	88	82	85	3	0	20	0.00	0.0	0	12.9	18	07			10		21	N
23	89	83	86	4	0	21	0.00	0.0	0	13.7	17	03			10		23	NE
24	89	82	86	4	0	21	0.00	0.0	0	12.5	17	05			8		22	NE
25	89	81	85	3	0	20	T	0.0	0	10.1	18	01			10		18	N
26	89	81	85	3	0	20	0.00	0.0	0	5.4	10	01			9		12	N
27	88	82	85	3	0	20	0.00	0.0	0	4.7	08	12			9		10	SE
28	89	80	85	3	0	20	T	0.0	0	5.7	12	06			10		16	NE
29	89	78	84	2	0	19	0.41	0.0	0	5.8	15	17			10		21	S
30	87	80	84	2	0	19	T	0.0	0	6.6	12	20			10		16	S
31	86	79	83	1	0	18	0.36	0.0	0	8.2	16	07			10		21	SE
Sum	2710	2450			0	571	10.31	0.0		274.1					306			
Avg	87.4	79.0								8.8	Fast	Dir.	Psbl	%	9.9		Max	(mph)
										Misc ——>	32	24	22203				047	SW

Notes:
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: NOV
Year: 1993

.atitude	Longitude		
-08.44	-167.44	Gnd Elev. 8 ft.	Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow	: Wind	: Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	89	79	84	2	0	19	0.05	0.0	0	5.8	09	03			10		13	NE
2	86	80	83	1	0	18	T	0.0	0	7.8	13	06			10		22	NE
3	88	80	84	2	0	19	0.02	0.0	0	7.0	12	18			9		17	S
4	87	79	83	1	0	18	0.14	0.0	0	6.7	14	09			10		21	S
5	87	80	84	2	0	19	T	0.0	0	10.2	16	07			10		24	E
6	88	79	84	2	0	19	0.35	0.0	0	9.4	15	06			10		30	NE
7	84	77	81	-1	0	16	0.58	0.0	0	11.8	23	13			10		33	E
8	87	77	82	0	0	17	0.26	0.0	0	13.6	22	08			10		32	E
9	88	78	83	1	0	18	0.21	0.0	0	18.1	22	08			10		36	E
10	86	79	83	1	0	18	0.14	0.0	0	16.0	23	06			10		35	NE
11	83	77	80	-2	0	15	0.84	0.0	0	10.5	21	04			10	3	26	NE
12	83	76	80	-2	0	15	1.41	0.0	0	8.1	22	11			10		26	E
13	85	76	81	-1	0	16	1.66	0.0	0	5.5	13	25			10		18	W
14	86	76	81	-1	0	16	T	0.0	0	4.2	10	13			10		14	SE
15	88	78	83	1	0	18	0.00	0.0	0	6.7	12	05			10		18	NE
16	89	81	85	3	0	20	0.02	0.0	0	6.0	12	05			10		12	SW
17	83	78	81	-1	0	16	0.44	0.0	0	9.1	17	14			10		24	S
18	87	78	83	1	0	18	0.14	0.0	0	7.1	15	05			10		18	NE
19	86	79	83	1	0	18	0.02	0.0	0	11.5	15	08			10		17	NE
20	85	77	81	-1	0	16	1.30	0.0	0	7.7	23	08			10	3	31	E
21	86	77	82	0	0	17	0.26	0.0	0	11.1	17	05			9		24	E
22	87	78	83	1	0	18	0.22	0.0	0	11.8	22	09			10		26	E
23	87	76	82	0	0	17	1.36	0.0	0	14.7	25	12			10		30	E
24	87	80	84	2	0	19	0.01	0.0	0	10.7	14	08			10		18	E
25	86	80	83	1	0	18	0.11	0.0	0	12.3	20	07			10		25	NE
26	87	79	83	1	0	18	0.18	0.0	0	11.1	16	07			10	3	28	E
27	84	79	82	0	0	17	0.14	0.0	0	14.2	28	12			10		36	SE
28	86	80	83	1	0	18	0.07	0.0	0	10.1	20	09			10		23	E
29	87	82	85	3	0	20	0.01	0.0	0	14.0	20	07			10		23	E
30	86	80	83	1	0	18	0.32	0.0	0	16.4	26	08			10		31	E
Sum	2588	2355			0	529	10.26	0.0		309.2					298			
Avg	86.3	78.5								10.3	Fast	Dir.	Psbl	%	9.9		Max	(mph)
									Misc ------->		28	12	21125				036	SE #

Notes:
Last of several occurrences
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: DEC
Year: 1993

atitude 08.44 Longitude -167.44 Gnd Elev. 8 ft. Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):		Snow :	Wind :	Fastest 1-Min:		Sunshine :		Sky		: Peak Wind	
.-	-2-	-3-	-4-	-5-	-6a-	-6b-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-
ay	Max	Min	Avg	Dep.	HDD	CDD	Water	Snow	Depth	Avg.	Speed	Dir	Mins.	%PSBL	SR-SS	Weather	Speed	Dir
1	87	78	83	1	0	18	0.18	0.0	0	22.2	30	06			10		40	NE
2	84	77	81	-1	0	16	0.32	0.0	0	14.3	22	12			10		30	E
3	87	80	84	2	0	19	0.02	0.0	0	19.2	24	07			10		33	NE
4	87	80	84	2	0	19	0.17	0.0	0	21.8	28	05			10		36	NE
5	86	78	82	0	0	17	0.57	0.0	0	19.7	31	10			10		41	E
6	86	76	81	-1	0	16	2.22	0.0	0	16.5	28	09			10		32	E
7	86	81	84	2	0	19	0.00	0.0	0	13.7	17	05			1		21	NE
8	87	81	84	2	0	19	0.03	0.0	0	8.9	14	11			2		20	SE
9	87	79	83	1	0	18	0.06	0.0	0	8.4	18	11			7		23	E
10	87	80	84	2	0	19	0.06	0.0	0	11.9	16	07			10		23	E
11	87	80	84	2	0	19	0.01	0.0	0	13.0	17	06			10		25	E
12	86	80	83	1	0	18	0.13	0.0	0	11.2	15	10			10		23	E
13	83	78	81	-1	0	16	0.11	0.0	0	10.9	18	07			10		26	NE
14	87	80	84	2	0	19	T	0.0	0	15.9	18	07			10		25	E
15	85	78	82	0	0	17	0.22	0.0	0	13.9	17	06			10		28	E
16	86	77	82	0	0	17	0.74	0.0	0	16.5	28	07			10		33	E
17	87	79	83	1	0	18	0.06	0.0	0	18.2	20	05			10		29	NE
18	85	78	82	0	0	17	0.26	0.0	0	19.0	29	06			10		37	NE
19	83	76	80	-2	0	15	0.91	0.0	0	18.0	26	10			10		35	E
20	85	78	82	0	0	17	0.05	0.0	0	17.6	23	07			10		30	NE
21	86	80	83	1	0	18	0.00	0.0	0	15.4	17	05			10		23	E
22	85	80	83	1	0	18	T	0.0	0	16.5	18	07			10		25	E
23	85	80	83	2	0	18	0.00	0.0	0	17.8	21	07			10		25	E
24	85	77	81	0	0	16	0.32	0.0	0	19.0	28	08			10		37	E
25	86	81	84	3	0	19	T	0.0	0	16.0	20	07			10		24	E
26	85	80	83	2	0	18	0.00	0.0	0	16.2	20	06			10		25	NE
27	85	80	83	2	0	18	0.00	0.0	0	17.2	20	07			10		25	NE
28	85	77	81	0	0	16	0.12	0.0	0	17.1	22	07			10		29	NE
29	85	78	82	1	0	17	0.83	0.0	0	16.0	24	06			10		33	NE
30	83	76	80	-1	0	15	2.42	0.0	0	11.0	20	12			10		28	E
31	84	76	80	-1	0	15	0.97	0.0	0	12.8	23	13			10		32	SE
Sum	2652	2439			0	541	10.78	0.0		485.8					290			
Avg	85.5	78.7								15.7	Fast	Dir.	Psbl	%	9.4		Max	(mph)
									Misc ------->		31	10	21642				041	E

Notes:
Column 9 readings are taken at 99
Column 17 Peak Wind in M.P.H.

[illegible]H1 PKWA 011945
CLIMAT 01994
91366 1281 0095 0278 28709 01795 ///// /0000

Preliminary Local Climatological Data (WS Form: F-6)

Station: KWAJALEIN MARSHALL ISLANDS
Month: JAN
Year: 1994

Latitude	Longitude		
+08.44	-167.44	Gnd Elev. 8 ft.	Std Time: 180E

Temperature in Fahrenheit							: Precip(in.):	Snow :	Wind :	Fastest 1-Min:			Sunshine :		Sky		: Peak Wind	
-1- Day	-2- Max	-3- Min	-4- Avg	-5- Dep.	-6a- HDD	-6b- CDD	-7- Water	-8- Snow	-9- Depth	-10- Avg.	-11- Speed	-12- Dir	-13- Mins.	-14- %PSBL	-15- SR-SS	-16- Weather	-17- Speed	-18- Dir
1	85	79	82	0	0	17	0.01	0.0	0	14.8	18	08			10		32	E
2	85	81	83	1	0	18	0.02	0.0		16.2	20	10			10		25	E
3	86	81	84	2	0	19	0.00	0.0	0	13.6	16	07			10		21	E
4	85	80	83	1	0	18	0.00	0.0	0	13.4	16	08			9		24	E
[illegible]	85	81	83	1	0	18	0.00	0.0	0	14.4	23	07			10		24	E
[illegible]	86	79	83	2	0	18	T	0.0	0	11.5	15	05			10		23	NE
7	85	80	83	2	0	18	0.00	0.0	0	11.0	15	07			10		20	E
8	85	76	81	0	0	16	0.10	0.0	0	13.3	25	08			10		33	E
9	85	79	82	1	0	17	0.00	0.0	0	12.7	15	08			10		24	NE
10	86	80	83	2	0	18	0.02	0.0	0	12.8	15	07			10		23	E
11	86	78	82	1	0	17	0.01	0.0	0	14.8	17	10			10		24	E
12	85	81	83	2	0	18	0.00	0.0	0	16.8	21	08			10		26	E
13	86	80	83	2	0	18	T	0.0	0	13.9	17	06			10		24	NE
14	82	75	79	-2	0	14	5.30	0.0	0	16.0	28	05			10		40	NE
15	85	80	83	2	0	18	0.00	0.0	0	18.1	23	07			10		29	E
16	84	80	82	1	0	17	0.00	0.0	0	14.9	18	07			10		25	E
17	85	76	81	0	0	16	0.22	0.0	0	13.6	20	14			10		26	E
18	85	77	81	0	0	16	0.03	0.0	0	14.1	17	09			10		25	E
19	85	81	83	2	0	18	T	0.0	0	10.6	13	08			10		15	E
20	85	80	83	2	0	18	0.00	0.0		9.4	14	07			10		16	NE
21	85	78	82	1	0	17	0.27	0.0		14.6	20	07			10		28	E
22	86	78	82	1	0	17	0.32	0.0	0	15.3	21	08			10		33	E
23	85	80	83	2	0	18	0.00	0.0	0	17.3	21	05			10		28	NE
24	86	76	81	0	0	16	0.04	0.0	0	14.2	20	06			10		32	NE
25	85	79	82	0	0	17	0.00	0.0	0	15.5	21	06			10		30	NE
26	84	78	81	-1	0	16	0.09	0.0	0	17.3	21	07			10		33	NE
27	84	77	81	-1	0	16	0.17	0.0	0	19.6	25	07			10		37	E
28	85	79	82	0	0	17	0.00	0.0	0	15.8	21	06			10		26	NE
29	85	79	82	0	0	17	0.00	0.0	0	11.6	14	07			10		23	E
30	84	77	81	-1	0	16	0.46	0.0	0	12.9	17	07			10		26	E
[illegible]	85	80	83	1	0	18	0.00	0.0	0	12.3	16	06			10		20	NE
Sum	2635	2445			0	532	7.06	0.0		442.3					309			
Avg	35.0	78.9								14.3	Fast	Dir.	Psbl	%	10.0		Max	(mph)
								Misc ------->			28	05	21739				040	NE

February 1994 Kwajalein Precipitation Log

KWAJ DATE	DAILY	MONTH	NORM MONTH	DELTA MONTH	YEAR	NORM YEAR	DELTA YEAR
1	0.00	0.00	0.12	-0.12	7.06	4.68	2.38
2	0.18	0.18	0.24	-0.06	7.24	4.80	2.44
3	0.09	0.27	0.36	-0.09	7.33	4.92	2.41
4	0.01	0.28	0.48	-0.20	7.34	5.04	2.30
5	Trace	0.28	0.60	-0.32	7.34	5.16	2.18
6	0.00	0.28	0.72	-0.44	7.34	5.28	2.06
7	0.00	0.28	0.84	-0.56	7.34	5.40	1.94
8	Trace	0.28	0.96	-0.68	7.34	5.52	1.82
9	0.10	0.38	1.08	-0.70	7.44	5.64	1.80
10	Trace	0.38	1.20	-0.82	7.44	5.76	1.68
11	Trace	0.38	1.32	-0.94	7.44	5.88	1.56
12	Trace	0.38	1.44	-1.06	7.44	6.00	1.44
13	0.03	0.41	1.56	-1.15	7.47	6.12	1.35
14	0.00	0.41	1.68	-1.27	7.47	6.24	1.23
15	Trace	0.41	1.80	-1.39	7.47	6.36	1.11
16	Trace	0.41	1.91	-1.50	7.47	6.47	1.00
17	0.00	0.41	2.02	-1.61	7.47	6.58	0.89

KWAJALEIN RAINFALL REVIEW 1993

MONTH	TOTAL	NORM	DELTA MONTH	YEAR TOTAL	DATE & AMOUNT OF MAX	DELTA YEAR
January	2.43	4.56	-2.13	2.43	3/ 0.99	-2.13
February	2.62	3.23	-0.61	5.05	20/ 1.13	-2.74
March	6.87	4.10	2.77	11.92	10/ 1.27	-0.02
April	3.32	7.55	-4.23	15.24	16/ 1.37	-4.20
May	5.18	9.98	-4.80	20.42	1/ 1.98	-9.00
June	7.64	9.62	-1.98	28.06	26/ 1.26	-10.98
July	7.78	10.44	-2.66	35.84	28/ 1.63	-13.64
August	12.80	10.11	2.69	48.64	1/ 2.80	-10.95
September	7.07	11.83	-4.76	55.60	25/ 1.56	-15.82
October	10.31	11.91	-1.60	65.91	19/ 2.67	-17.42
November	10.26	10.66	-0.40	76.17	13/ 1.66	-17.82
December	10.78	8.10	2.68	86.95	30/ 2.42	-15.14

January 1994 Kwajalein Precipitation Log

KWAJ DATE	DAILY	MONTH	NORM MONTH	DELTA MONTH	YEAR	NORM YEAR	DELTA YEAR
1	0.01	0.01	0.19	-0.18	0.01	0.19	-0.18
2	0.02	0.03	0.38	-0.35	0.03	0.38	-0.35
3	0.00	0.03	0.57	-0.54	0.03	0.57	-0.54
4	0.00	0.03	0.75	-0.72	0.03	0.75	-0.72
5	0.00	0.03	0.93	-0.90	0.03	0.93	-0.90
6	Trace	0.03	1.10	-1.07	0.03	1.10	-1.07
7	0.00	0.03	1.27	-1.24	0.03	1.27	-1.24
8	0.10	0.13	1.44	-1.31	0.13	1.44	-1.31
9	0.00	0.13	1.60	-1.47	0.13	1.60	-1.47
10	0.02	0.15	1.76	-1.61	0.15	1.76	-1.61
11	0.01	0.16	1.92	-1.76	0.16	1.92	-1.76
12	0.00	0.16	2.07	-1.91	0.16	2.07	-1.91
13	Trace	0.16	2.22	-2.06	0.16	2.22	-2.06
14	5.30	5.46	2.37	3.09	5.46	2.37	3.09
15	0.00	5.46	2.51	2.95	5.46	2.51	2.95
16	0.00	5.46	2.65	2.81	5.46	2.65	2.81
17	0.22	5.68	2.79	2.89	5.68	2.79	2.89
18	0.03	5.71	2.93	2.78	5.71	2.93	2.78
19	Trace	5.71	3.06	2.65	5.71	3.06	2.65
20	0.00	5.71	3.19	2.52	5.71	3.19	2.52
21	0.27	5.98	3.32	2.66	5.98	3.32	2.66
22	0.32	6.30	3.45	2.85	6.30	3.45	2.85
23	0.00	6.30	3.58	2.72	6.30	3.58	2.72
24	0.04	6.34	3.71	2.63	6.34	3.71	2.63
25	0.00	6.34	3.84	2.50	6.34	3.84	2.50
26	0.09	6.43	3.96	2.47	6.43	3.96	2.47
27	0.17	6.60	4.08	2.52	6.60	4.08	2.52

APPENDIX E

DATA FROM ANALYSES OF KWAJALEIN SOIL SAMPLES USING EMISSION SPECTROSCOPY USING INDUCTIVELY COUPLED PLASMA (ICP)

Metals concentration by ICP analysis for plots receiving water, air, and nutrients from core samples taken from 4-5 feet below ground surface

Sample Date	Plot	Ag (mg/kg)	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)
11/1/93	2	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	7.00E+00	1.30E+00	3.60E+05	< 3.80E+00	< 3.00E+00	< 3.00E+00
	4	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	7.20E+00	1.30E+00	3.60E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
	8	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	9.20E+00	1.10E+00	3.60E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
1/18/94	2	< 3.70E+00	< 3.70E+01	< 3.70E+01	< 5.90E+01	7.20E+00	1.10E+00	3.70E+05	< 3.70E+00	< 3.00E+00	< 3.00E+00
	4	< 3.50E+00	< 3.50E+01	< 3.50E+01	< 5.60E+01	6.90E+00	1.10E+00	3.70E+05	< 3.50E+00	< 2.80E+00	< 2.80E+00
	8	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.30E+00	1.00E+00	3.70E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
2/14/94	2	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	6.60E+00	1.00E+00	3.50E+05	< 3.80E+00	< 3.10E+00	1.50E+01
	4	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.00E+01	6.30E+00	1.30E+00	3.50E+05	< 3.80E+00	< 3.00E+00	8.60E+00
	8	< 3.80E+00	3.80E+01	3.80E+01	< 6.10E+01	6.80E+00	1.20E+00	3.60E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
Mean*		< 3.79E+00	< 3.79E+01	< 3.79E+01	< 6.04E+01	7.06E+00	1.16E+00	3.61E+05	< 3.79E+00	< 3.03E+00	< 4.98E+00
St. Dev.*		< 1.27E-01	< 1.27E+00	< 1.27E+00	< 1.94E+00	8.72E-01	1.24E-01	7.82E+03	< 1.27E-01	< 1.00E-01	< 4.19E+00

*Note: If the mean or standard deviation is preceded by a <, then the minimum detection limit shown in the above table was used to calculate the mean and the standard deviation.

Sample Date	Plot	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	Li (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Na (mg/kg)	Ni (mg/kg)	P (mg/kg)
11/1/93	2	< 5.30E+00	7.50E+01	< 1.50E+03	< 3.80E+00	6.20E+03	1.90E+00	< 3.00E+01	2.70E+03	< 7.60E+00	< 2.30E+02
	4	< 5.40E+00	< 3.90E+01	< 1.50E+03	< 3.90E+00	6.00E+03	2.20E+00	< 3.10E+01	2.40E+03	8.00E+00	< 2.30E+02
	8	< 5.40E+00	2.10E+02	1.70E+03	< 3.90E+00	6.30E+03	5.40E+00	< 3.10E+01	2.70E+03	< 7.70E+00	5.70E+02
1/18/94	2	< 5.20E+00	7.30E+01	< 1.50E+03	< 3.70E+00	6.30E+03	2.10E+00	< 3.00E+01	2.80E+03	< 7.40E+00	2.80E+02
	4	< 4.90E+00	< 3.50E+01	< 1.40E+03	< 3.50E+00	5.70E+03	1.60E+00	< 2.80E+01	2.50E+03	< 7.00E+00	2.30E+02
	8	< 5.40E+00	< 3.90E+01	< 1.60E+03	< 3.90E+00	6.10E+03	9.00E-01	< 3.10E+01	2.70E+03	< 7.80E+00	< 2.30E+02
2/14/94	2	< 5.40E+00	6.50E+01	< 1.50E+03	< 3.80E+00	6.00E+03	1.80E+00	< 3.10E+01	2.60E+03	1.00E+01	5.90E+02
	4	< 5.30E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	6.30E+03	7.80E-01	< 3.00E+01	2.50E+03	< 7.60E+00	6.10E+02
	8	< 5.30E+00	< 3.80E+01	1.70E+03	< 3.80E+00	6.00E+03	1.30E+00	< 3.10E+01	2.50E+03	< 7.60E+00	7.00E+02
Mean*		< 5.29E+00	< 6.80E+01	< 1.54E+03	< 3.79E+00	6.10E+03	2.00E+00	< 3.03E+01	2.60E+03	< 7.86E+00	< 4.08E+02
St. Dev.*		< 1.62E-01	< 5.57E+01	< 1.01E+02	< 1.27E-01	2.00E+02	1.37E+00	< 1.00E+00	1.32E+02	< 8.50E-01	< 2.03E+02

Sample Date	Plot	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Si (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
11/1/93	2	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.20E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	4	< 3.90E+01	< 3.90E+01	< 3.90E+01	1.70E+02	< 3.90E+01	6.10E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
	8	< 3.90E+01	< 3.90E+01	< 3.90E+01	2.00E+02	< 3.90E+01	6.30E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
1/18/94	2	< 3.70E+01	< 3.70E+01	< 3.70E+01	< 1.50E+02	< 3.70E+01	6.20E+03	< 1.50E+01	< 1.50E+00	< 3.70E+00	< 1.50E+01
	4	< 3.50E+01	< 3.50E+01	< 3.50E+01	1.50E+02	< 3.50E+01	6.10E+03	< 1.40E+01	< 1.40E+00	< 3.50E+00	< 1.40E+01
	8	< 3.90E+01	< 3.90E+01	< 3.90E+01	1.70E+02	< 3.90E+01	6.10E+03	< 1.60E+01	2.10E+00	< 3.90E+00	< 1.60E+01
2/14/94	2	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	4	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	5.90E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	8	< 3.80E+01	< 3.80E+01	3.80E+01	< 1.50E+02	< 3.80E+01	5.80E+03	1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
Mean*		< 3.79E+01	< 3.79E+01	< 3.79E+01	< 1.60E+02	< 3.79E+01	6.08E+03	< 1.50E+01	< 1.56E+00	< 3.79E+00	< 1.50E+01
St. Dev.*		< 1.27E+00	< 1.27E+00	< 1.27E+00	< 1.73E+01	< 1.27E+00	1.56E+02	< 5.00E-01	< 2.07E-01	< 1.27E-01	< 5.00E-01

Metals concentration by ICP analysis for plots receiving water, air, and nutrients from core samples taken from 5-6 feet below ground surface

Sample Date	Plot	Ag (mg/kg)	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)
11/1/93	2	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.40E+00	1.10E+00	3.60E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
	4	< 3.60E+00	< 3.60E+01	< 3.60E+01	< 5.80E+01	5.30E+00	1.20E+00	3.60E+05	< 3.60E+00	< 2.90E+00	8.00E+00
	8	< 3.60E+00	< 3.60E+01	< 3.60E+01	< 5.80E+01	5.50E+00	1.40E+00	3.40E+05	< 3.60E+00	< 2.90E+00	< 2.90E+00
1/18/94	2	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	6.30E+00	1.40E+00	3.70E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
	4	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	6.20E+00	1.30E+00	3.70E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
	8	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.00E+01	6.00E+00	9.60E-01	3.70E+05	< 3.80E+00	< 3.00E+00	< 3.00E+00
2/14/94	2	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.60E+00	1.20E+00	3.70E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
	4	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.20E+00	1.20E+00	3.60E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
	8	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.00E+01	6.10E+00	1.20E+00	3.60E+05	< 3.80E+00	< 3.00E+00	< 3.00E+00
Mean*		< 3.79E+00	< 3.79E+01	< 3.79E+01	< 6.04E+01	6.07E+00	1.22E+00	3.62E+05	< 3.79E+00	< 3.03E+00	< 3.60E+00
St. Dev.*		< 1.17E-01	< 1.17E+00	< 1.17E+00	< 1.59E+00	4.18E-01	1.39E-01	9.72E+03	< 1.17E-01	< 8.66E-02	< 1.65E+00

*Note: If the mean or standard deviation is preceded by a <, then the minimum detection limit shown in the above table was used to calculate the mean and the standard deviation.

Sample Date	Plot	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	Li (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Na (mg/kg)	Ni (mg/kg)	P (mg/kg)
11/1/93	2	< 5.40E+00	< 3.90E+01	< 1.60E+03	< 3.90E+00	5.90E+03	< 7.80E-01	< 3.10E+01	2.60E+03	1.10E+01	< 2.30E+02
	4	< 5.10E+00	< 3.60E+01	< 1.50E+03	< 3.60E+00	4.10E+03	8.90E-01	< 2.90E+01	2.30E+03	8.00E+00	< 2.20E+02
	8	< 5.10E+00	< 3.60E+01	< 1.50E+03	< 3.60E+00	6.00E+03	< 7.30E-01	< 2.90E+01	2.40E+03	< 7.30E+00	6.40E+02
1/18/94	2	< 5.40E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	5.30E+03	1.20E+00	< 3.10E+01	2.50E+03	< 7.70E+00	< 2.30E+02
	4	< 5.40E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	5.40E+03	< 7.70E-01	< 3.10E+01	2.50E+03	< 7.70E+00	< 2.30E+02
	8	< 5.30E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	6.50E+03	< 7.50E-01	< 3.00E+01	2.50E+03	7.60E+00	< 2.30E+02
2/14/94	2	< 5.40E+00	4.10E+01	1.70E+03	< 3.90E+00	6.10E+03	1.80E+00	< 3.10E+01	2.40E+03	< 7.70E+00	7.20E+02
	4	< 5.40E+00	< 3.90E+01	< 1.50E+03	< 3.90E+00	5.40E+03	< 7.70E-01	< 3.10E+01	2.60E+03	< 7.70E+00	5.60E+02
	8	< 5.30E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	5.80E+03	< 7.50E-01	< 3.00E+01	2.40E+03	< 7.50E+00	6.80E+02
Mean*		< 5.31E+00	< 3.81E+01	< 1.53E+03	< 3.79E+00	5.61E+03	< 9.38E-01	< 3.03E+01	2.47E+03	< 8.02E+00	< 4.16E+02
St. Dev.*		< 1.27E-01	< 1.54E+00	< 7.07E+01	< 1.17E-01	6.86E+02	< 3.55E-01	< 8.66E-01	1.00E+02	< 1.13E+00	< 2.26E+02

Sample Date	Plot	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Si (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
11/1/93	2	< 3.90E+01	< 3.90E+01	< 3.90E+01	< 1.60E+02	< 3.90E+01	6.30E+03	< 1.60E+01	< 1.60E+00	< 3.90E+00	< 1.60E+01
	4	< 3.60E+01	< 3.60E+01	< 3.60E+01	1.60E+02	< 3.60E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.60E+00	< 1.50E+01
	8	< 3.60E+01	< 3.60E+01	< 3.80E+01	< 1.50E+02	< 3.60E+01	5.90E+03	< 1.50E+01	< 1.50E+00	< 3.60E+00	< 1.50E+01
1/18/94	2	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.40E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	4	< 3.80E+01	< 3.80E+01	< 3.80E+01	1.70E+02	< 3.80E+01	6.30E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	8	< 3.80E+01	< 3.80E+01	< 3.80E+01	1.70E+02	< 3.80E+01	6.30E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
2/14/94	2	< 3.90E+01	< 3.90E+01	< 3.90E+01	1.70E+02	< 3.90E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
	4	< 3.90E+01	< 3.90E+01	< 3.90E+01	2.10E+02	< 3.90E+01	6.20E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
	8	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.10E+03	< 1.50E+01	1.60E+00	< 3.80E+00	< 1.50E+01
Mean*		< 3.79E+01	< 3.79E+01	< 3.81E+01	< 1.66E+02	< 3.79E+01	6.17E+03	< 1.51E+01	< 1.52E+00	< 3.79E+00	< 1.51E+01
St. Dev.*		< 1.17E+00	< 1.17E+00	< 9.28E-01	< 1.88E+01	< 1.17E+00	1.73E+02	< 3.33E-01	< 4.41E-02	< 1.17E-01	< 3.33E-01

Metals concentration by ICP analysis for control plots from core samples taken from 4-5 feet below ground surface

Sample Date	Plot	Ag (mg/kg)	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)
11/1/93	5	< 3.60E+00	< 3.60E+01	< 3.60E+01	< 5.70E+01	7.90E+00	1.10E+00	3.60E+05	< 3.60E+00	< 2.90E+00	2.00E+01
	11	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.40E+00	1.40E+00	3.50E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
1/18/94	5	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	8.00E+00	9.70E-01	3.70E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
	11	< 3.70E+00	< 3.70E+01	< 3.70E+01	< 6.00E+01	7.00E+00	1.10E+00	3.80E+05	< 3.70E+00	< 3.00E+00	< 3.00E+00
2/14/94	5	< 3.70E+00	< 3.70E+01	< 3.70E+01	< 5.90E+01	6.20E+00	1.20E+00	3.60E+05	< 3.70E+00	< 3.00E+00	< 3.00E+00
	11	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	6.20E+00	1.30E+00	3.50E+05	< 3.90E+00	< 3.10E+00	9.70E+00
Mean*		< 3.77E+00	< 3.77E+01	< 3.77E+01	< 6.02E+01	6.95E+00	1.18E+00	3.62E+05	< 3.77E+00	< 3.03E+00	< 6.98E+00
St. Dev.*		< 1.21E-01	< 1.21E+00	< 1.21E+00	< 1.94E+00	8.29E-01	1.55E-01	1.17E+04	< 1.21E-01	< 8.16E-02	< 6.91E+00

*Note: If the mean or standard deviation is preceded by a <, then the minimum detection limit shown in the above table was used to calculate the mean and the standard deviation.

Sample Date	Plot	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	Li (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Na (mg/kg)	Ni (mg/kg)	P (mg/kg)
11/1/93	5	9.70E+00	2.50E+02	< 1.40E+03	< 3.60E+00	6.90E+03	5.10E+00	< 2.90E+01	2.60E+03	2.80E+01	< 2.10E+02
	11	< 5.50E+00	< 3.90E+01	< 1.60E+03	< 3.90E+00	6.20E+03	1.30E+00	< 3.10E+01	2.50E+03	< 7.80E+00	6.80E+02
1/18/94	5	< 5.30E+00	9.30E+01	< 1.50E+03	< 3.80E+00	5.20E+03	1.90E+00	< 3.10E+01	2.50E+03	< 7.60E+00	< 2.30E+02
	11	< 5.20E+00	8.80E+01	< 1.50E+03	< 3.70E+00	7.20E+03	2.40E+00	< 3.00E+01	2.70E+03	8.50E+00	2.30E+02
2/14/94	5	< 5.20E+00	< 3.70E+01	< 1.50E+03	< 3.70E+00	5.90E+03	< 7.40E-01	< 3.00E+01	2.50E+03	< 7.40E+00	6.50E+02
	11	< 5.50E+00	4.80E+01	< 1.60E+03	< 3.90E+00	5.50E+03	8.60E-01	< 3.10E+01	2.30E+03	1.10E+01	6.00E+02
Mean*		< 6.07E+00	< 9.25E+01	> 1.52E+03	< 3.77E+00	6.15E+03	< 2.05E+00	< 3.03E+01	2.52E+03	< 1.17E+01	< 4.33E+02
St. Dev.*		< 1.79E+00	< 8.09E+01	< 7.53E+01	< 1.21E-01	7.82E+02	< 1.62E+00	< 8.16E-01	1.33E+02	< 8.09E+00	< 2.32E+02

Sample Date	Plot	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Si (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
11/1/93	5	< 3.60E+01	< 3.60E+01	< 3.60E+01	2.10E+02	< 3.60E+01	5.80E+03	< 1.40E+01	1.80E+00	< 3.60E+00	< 1.40E+01
	11	< 3.90E+01	< 3.90E+01	< 3.90E+01	< 1.60E+02	< 3.90E+01	5.80E+03	< 1.60E+01	< 1.60E+00	< 3.90E+00	< 1.60E+01
1/18/94	5	< 3.80E+01	< 3.80E+01	< 3.80E+01	1.70E+02	< 3.80E+01	5.90E+03	< 1.50E+01	2.10E+00	< 3.80E+00	< 1.50E+01
	11	< 3.70E+01	< 3.70E+01	< 3.70E+01	2.20E+02	< 3.70E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.70E+00	< 1.50E+01
2/14/94	5	< 3.70E+01	< 3.70E+01	< 3.70E+01	< 1.50E+02	< 3.70E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.70E+00	< 1.50E+01
	11	< 3.90E+01	< 3.90E+01	< 3.90E+01	< 1.60E+02	< 3.90E+01	6.10E+03	< 1.60E+01	< 1.60E+00	< 3.90E+00	< 1.60E+01
Mean*		< 3.77E+01	< 3.77E+01	< 3.77E+01	< 1.78E+02	< 3.77E+01	5.93E+03	< 1.52E+01	< 1.68E+00	< 3.77E+00	< 1.52E+01
St. Dev.*		< 1.21E+00	< 1.21E+00	< 1.21E+00	< 2.93E+01	< 1.21E+00	1.21E+02	< 7.53E-01	< 2.32E-01	< 1.21E-01	< 7.53E-01

Metals concentration by ICP analysis for control plots from core samples taken from 5-6 feet below ground surface

Sample Date	Plot	Ag (mg/kg)	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)
11/1/93	5	< 3.70E+00	< 3.70E+01	< 3.70E+01	< 5.90E+01	6.50E+00	1.30E+00	3.70E+05	< 3.70E+00	< 3.00E+00	< 3.00E+00
	11	< 3.90E+00	< 3.90E+01	< 3.90E+01	< 6.20E+01	5.70E+00	1.30E+00	3.50E+05	< 3.90E+00	< 3.10E+00	< 3.10E+00
1/18/94	5	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	7.70E+00	1.00E+00	3.70E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
	11	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.00E+01	5.90E+00	1.10E+00	3.70E+05	< 3.80E+00	< 3.00E+00	< 3.00E+00
2/14/94	5	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.00E+01	6.70E+00	1.30E+00	3.50E+05	< 3.80E+00	< 3.00E+00	< 3.00E+00
	11	< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.10E+01	5.50E+00	1.20E+00	3.50E+05	< 3.80E+00	< 3.10E+00	< 3.10E+00
Mean*		< 3.80E+00	< 3.80E+01	< 3.80E+01	< 6.05E+01	6.33E+00	1.20E+00	3.60E+05	< 3.80E+00	< 3.05E+00	< 3.05E+00
St. Dev.*		< 6.32E-02	< 6.32E-01	< 6.32E-01	< 1.05E+00	8.14E-01	1.26E-01	1.10E+04	< 6.32E-02	< 5.48E-02	< 5.48E-02

*Note: If the mean or standard deviation is preceded by a <, then the minimum detection limit shown in the above table was used to calculate the mean and the standard deviation.

Sample Date	Plot	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	Li (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Na (mg/kg)	Ni (mg/kg)	P (mg/kg)
11/1/93	5	< 5.20E+00	< 3.70E+01	< 1.50E+03	< 3.70E+00	6.80E+03	1.40E+00	< 3.00E+01	2.60E+03	8.40E+00	< 2.20E+02
	11	< 5.40E+00	< 3.90E+01	< 1.50E+03	< 3.90E+00	5.80E+03	< 7.70E-01	< 3.10E+01	2.40E+03	< 7.70E+00	7.10E+02
1/18/94	5	< 5.40E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	5.80E+03	7.90E-01	< 3.10E+01	2.70E+03	8.20E+00	< 2.30E+02
	11	< 5.30E+00	< 3.80E+01	< 1.50E+03	< 3.80E+00	6.70E+03	< 7.50E-01	< 3.00E+01	2.50E+03	9.10E+00	< 2.30E+02
2/14/94	5	< 5.30E+00	< 3.80E+01	1.60E+03	< 3.80E+00	5.30E+03	1.30E+00	< 3.00E+01	2.60E+03	9.50E+00	6.10E+02
	11	< 5.40E+00	< 3.80E+01	1.70E+03	< 3.80E+00	5.40E+03	< 7.60E-01	< 3.10E+01	2.10E+03	< 7.60E+00	7.60E+02
Mean*		< 5.33E+00	< 3.80E+01	< 1.55E+03	< 3.80E+00	5.97E+03	< 9.62E-01	< 3.05E+01	2.48E+03	< 8.42E+00	< 4.60E+02
St. Dev.*		< 8.16E-02	< 6.32E-01	< 8.37E+01	< 6.32E-02	6.41E+02	< 3.03E-01	< 5.48E-01	2.14E+02	< 7.57E-01	< 2.60E+02

Sample Date	Plot	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Si (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
11/1/93	5	< 3.70E+01	< 3.70E+01	< 3.70E+01	< 1.50E+02	< 3.70E+01	6.40E+03	< 1.50E+01	< 1.50E+00	< 3.70E+00	< 1.50E+01
	11	< 3.90E+01	< 3.90E+01	< 3.90E+01	< 2.20E+02	< 3.90E+01	6.00E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
1/18/94	5	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.40E+03	< 1.50E+01	1.80E+00	< 3.80E+00	< 1.50E+01
	11	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	6.10E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
2/14/94	5	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	5.90E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
	11	< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.50E+02	< 3.80E+01	5.80E+03	< 1.50E+01	< 1.50E+00	< 3.80E+00	< 1.50E+01
Mean*		< 3.80E+01	< 3.80E+01	< 3.80E+01	< 1.62E+02	< 3.80E+01	6.10E+03	< 1.50E+01	< 1.55E+00	< 3.80E+00	< 1.50E+01
St. Dev.*		< 6.32E-01	< 6.32E-01	< 6.32E-01	< 2.86E+01	< 6.32E-01	2.53E+02	< 0.00E+00	< 1.22E-01	< 6.32E-02	< 0.00E+00

Metals concentration by ICP analysis for ex-situ control plot (plot 13) and ex-situ plot receiving water, air, and nutrients (plot 17)

Sample Date	Plot	Ag (mg/kg)	Al (mg/kg)	As (mg/kg)	B (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Ca (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)
11/1/93	13	< 3.60E+00	< 3.60E+01	< 3.60E+01	< 5.80E+01	9.90E+00	1.20E+00	3.40E+05	< 3.60E+00	< 2.90E+00	< 2.90E+00
	17	< 3.70E+00	< 3.70E+01	< 3.70E+01	< 5.90E+01	8.30E+00	1.10E+00	3.50E+05	< 3.70E+00	< 3.00E+00	< 3.00E+00

Sample Date	Plot	Cu (mg/kg)	Fe (mg/kg)	K (mg/kg)	Li (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Na (mg/kg)	Ni (mg/kg)	P (mg/kg)
11/1/93	13	1.30E+01	4.60E+02	< 1.50E+03	< 3.60E+00	2.00E+04	6.50E+00	< 2.90E+01	2.30E+03	7.90E+00	6.40E+02
	17	5.40E+00	5.20E+02	< 1.50E+03	< 3.70E+00	1.30E+04	5.90E+00	< 3.00E+01	2.50E+03	7.80E+00	7.20E+02

Sample Date	Plot	Pb (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Si (mg/kg)	Sn (mg/kg)	Sr (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)	Zr (mg/kg)
11/1/93	13	< 3.60E+01	< 3.60E+01	< 3.60E+01	2.20E+02	< 3.60E+01	3.90E+03	< 1.50E+01	< 1.50E+00	< 3.90E+00	< 1.50E+01
	17	< 3.70E+01	< 3.70E+01	< 3.70E+01	1.70E+02	< 3.70E+01	4.70E+03	< 1.50E+01	< 1.50E+00	< 3.70E+00	< 1.50E+01

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