THE OCCURRENCE OF CERTAIN PESTICIDES IN GROUND AND SURFACE WATERS ASSOCIATED WITH ORDOT LANDFILL IN THE PAGO RIVER BASIN, GUAM MARIANA ISLANDS

by

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Project Completion Report

for

The Occurrence of Pesticides in Ground
and Surface Waters from the
Pago River Basin, Guam

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Table of Contents

List of Figures

Introduction

The Pago River watershed is one of the four major watershed-river systems on Guam. This system is located in central Guam. The system discharges into the Pacific Ocean on the western side of the island in a shallow reef flat environment. The reef area and the river systems are used by the people for various recreational and subsistence fishing activities. The river contains shrimp (Macrobrachium), gastropods, and eels which are fished and consumed by the people. The reef flat area is also used as a source for fish, crabs, and sea weeds which are consumed. In addition, the reef area is also an important recreational area for boating and swimming.

The Pago watershed area contains two activities which could influence the water quality of the river and potentially the reef flat. Small farming operations are present in the watershed and the Ordot Landfill is located in the area.

It is of concern that pesticides used in the farming operations or disposed in the Ordot landfill could find their way into the river and eventually into the reef area. This is significant in two respects: (1) by getting into the food chain, and (2) by affecting orgnaisms and their reproductive cycles.

There is considerable subsistence and recreational fishing which occurs in these areas. For many people river and reef organisms constitute the major food source. Agricultural chemicals could contaminate these organisms and find their way into the human consumers.

Perhaps more importantly, these chemicals could adversely influence the organisms and their life cycles. It is generally agreed that the tropical reef is a sensitive and fragile area. Relatively few studies have been done on the effects of pesticides on tropical reef ecosystems but it is known that the reproductive cycles of many reef organisms are adversely affected by various chemicals in rather low concentrations. A sea cucumber fertilization inhibition bioassay is a sensitive toxicological bioassay which relies upon this principle (Horning et al, 1987).

It is also of concern that contaminated leachate from the landfill has potential to contaminate the groundwater, which is the source of most of Guam's drinking water.

Several small studies have been done to evaluate the problem. Black and Veatch Consulting Engineers (1983) conducted a two day survey of the Ordot landfill in 1982. The survey included sampling of surface water, groundwater, and soil in the vicinity of the Ordot landfill for metals, pesticides, and priority pollutants. No leachate or groundwater

downgradient from the site was obtained. The report showed contamination by "at least 12 organic compounds." The firm stated that the potential "does exist...for the landfill to become a major source of pollution." However, the analysis performed by Black and Veatch demonstrated only very low levels of organic compounds.

Camp Dresser and McKee (1987) also did a brief analytic survey which monitored surface water, groundwater, and leachate in the Ordot Landfill area. This study included a wide variety of organic and inorganic constituents, but was only a single sampling. The study included sampling for volatile, semi-volatile, pesticides, and PCB's as well as inorganics. In general, their results were that the production wells in the vicinity were not influenced by the landfill. Leachate water quality was poor, consisting mostly of increased metal concentration. The increased inorganic materials were widespread and consistently elevated at several of the sites. Only a few organic compounds were demonstrated in the monitoring wells at the landfill site. These included plasticizers, carbon disulfide, chlorobenzene, and phenol, all at low levels. These organic contaminants were not widespread and usually found only at single sampling site. The Lonfit River samples were of relatively good quality with no difference upstream of the landfill as compared to downstream. Specifically no organic compounds were identified in the Lonfit River.

The Guam Environmental Protection Agency (GEPA) does monitoring of the surface water in the Lonfit and Pago River systems on a yearly basis. Analysis is done for pesticides and inorganics. GEPA (Denton, 1989) indicates that their monitoring shows no problem with pesticides in these river systems.

Site Description

The Island of Guam is located in the Western Pacific Ocean at 13.5 degrees north latitude and 144.7 degrees east longitude and is approximately 6080 kilometers west of Hawaii and 2400 kilometers south of Japan (Figure 1). Guam is located at the boundary between the Pacific Ocean and the Philippines Sea. Guam is the largest and southern most island in the Marianas Archipelago. The Island of Guam is about 45 kilometers long and ranges from 6 to 13 kilometers wide (Figure 2) with an area of 549 square kilometers (212 square miles).

The Island is divided into two distinct physiographic provinces. The northern half of Guam is a thick limestone plateau with only a thin layer of soil. This porous substratum provides a sole-source limestone aquifer from which most of Guam's drinking water is obtained. Because of the extremely permeable nature of the limestone there are no river systems in the north. The southern half of the island

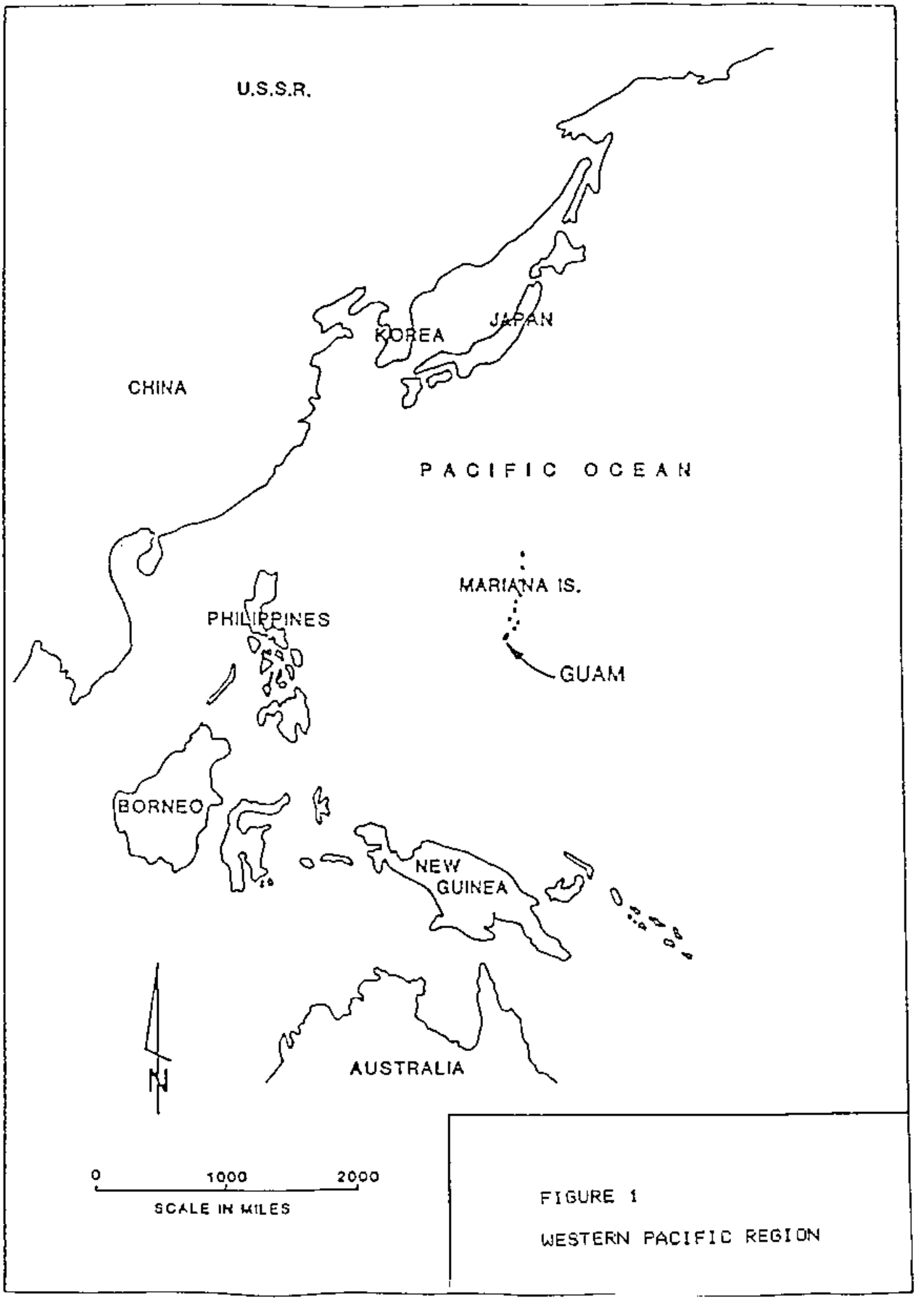

FIGURE 1

WESTERN PACIFIC REGION

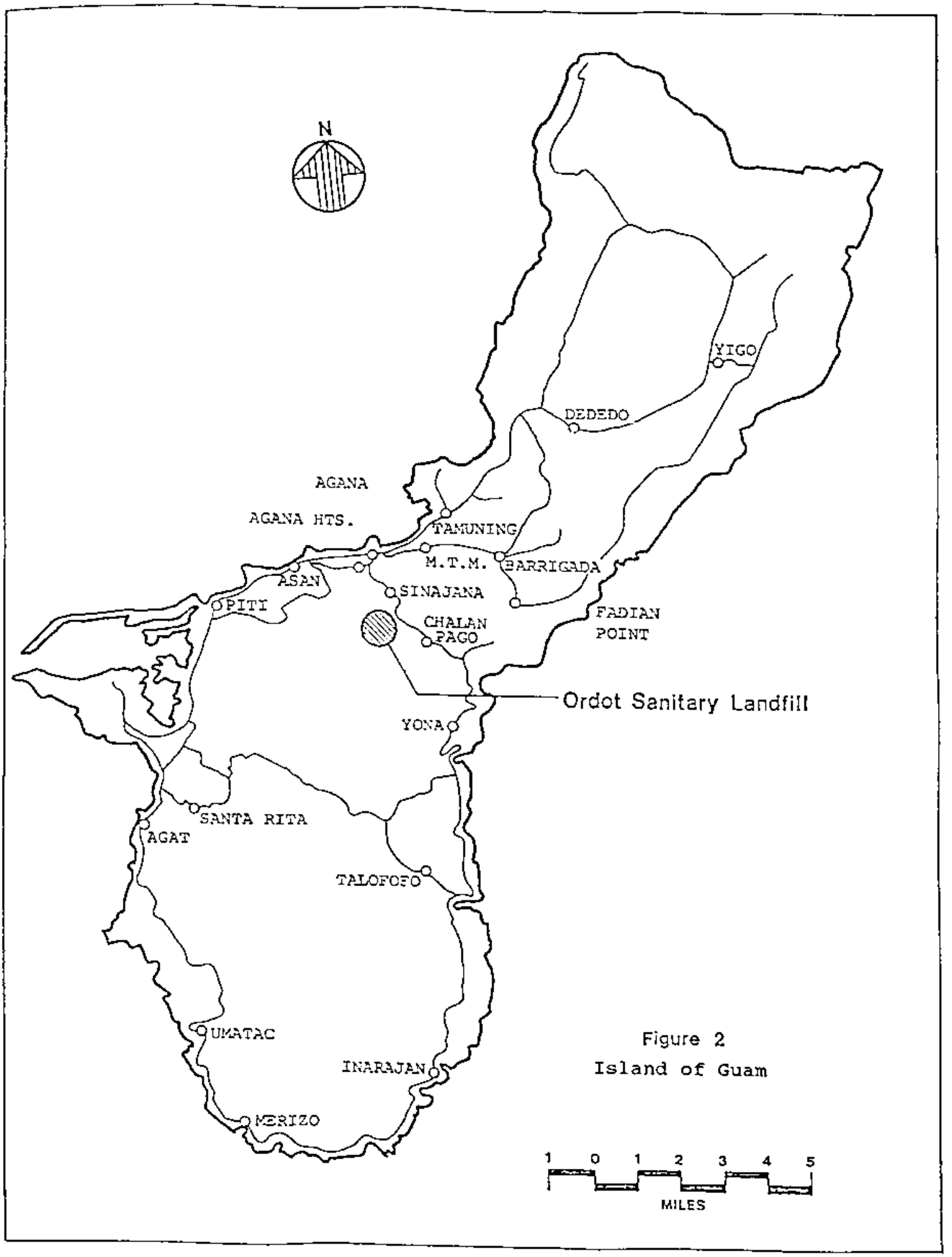

Figure 2
Island of Guam

is composed of a rugged volcanic upland. The volcanics are impermeable and allow runoff to collect in streams and small rivers with eventual discharge into the Pacific Ocean or Philippines Sea.

The Ordot landfill is located at the northern end of the volcanic physiographic division very near the fault which separates the northern limestone from the southern volcanics (Figure 3). The exact demarcation between the two geologic units is not well established.

The Ordot site is about 1/2 mile from the fault which divides the island into the northern limestone plateau and the southern volcanics. It is located in the volcanic area. The landfill is in a ravine that is a tributary to the Lonfit River. Camp Dresser and McKee (1987) has recently done a comprehensive geologic reconnaissance of the Ordot area. They believe that the site is geologically isolated from the limestone of the Northern Lens Aquifer. Most of the water entering the area probably leaves the area as surface runoff into the Lonfit. A lesser amount would infiltrate the rather impermeable high clay shales and sandstones to become ground water flow. In general the surface flow as well as the groundwater flow is away from the limestone aquifer. Figures 2 and 3 show the location of the Ordot Landfill.

Site History

The Ordot Landfill is an approximately 50 acre site located about 2.5 miles south of the capital, Agana. The landfill currently receives the majority of solid waste generated by the civilian community on Guam. The military operates several small landfills which are used exclusively for wastes generated by military operations. The Ordot site is the only public municipal landfill on Guam.

Although no records are available, it is believed that the site has been in continuous use since before World War II. Both the U.S. Military and the Japanese Military are thought to have used the site before the war. During this time the site was operated as an open dump. During the Japanese Occupation and after the recapture of Guam the landfill area was used by both the Japanese military and the U.S. military, also as an open dump. No records from this time are available but it is believed that the various hazardous materials, including munitions and solvents were disposed of at the site. In addition large amounts of DDT were used by the military and it is probable that waste pesticide was disposed of at the site.

The site was turned over to the Civilian Government (GovGuam) (from the U.S. Navy Military Government) with the 1950 Organic Act. During the 50's and 60's the Ordot site was operated as an open dump by GovGuam. No records were kept of

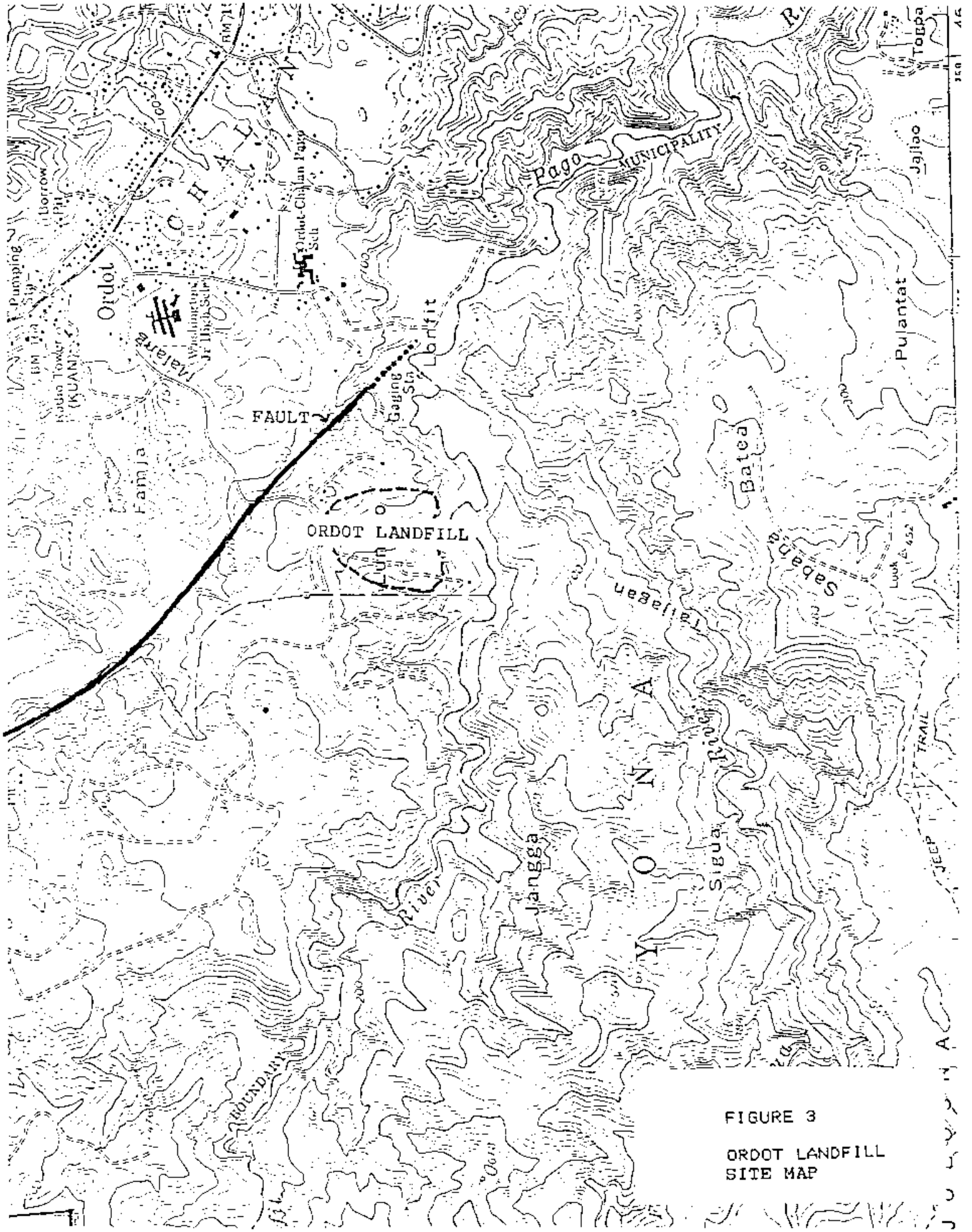

FIGURE 3

ORDOT LANDFILL
SITE MAP

disposed materials and no restrictions on disposal were enforced. In 1973 (or thereabout) four other municipal dumps were closed and Ordot became the sole dump site for the civilian community of Guam. In 1981 Ordot was closed to the disposal of hazardous waste. Prior to this time it is known that various hazardous materials, including PCB transformer oils, munitions, and other hazardous materials generated by light industrial and military operations, were disposed at the site. Since 1981 it has been unlawful to dispose of hazardous materials at the site. Unfortunately, no inspection or record of dumped materials is made.

Sampling

Sampling was designed to access the possible impact of the Ordot landfill in contaminating groundwater and the Lonfit River and ultimately the Pago River and Pago Bay with certain pesticides.

The Water and Energy Research Institute placed a series of monitoring wells to evaluate the leachate from the landfill in 1985. Several of these wells were used in this study. Figure 4 shows the general cross section of the monitoring wells. The wells are equipped with the Well Wizard (tm) (Q.E.D. Environmental Systems) pumps for sampling. This pump is an air-actuated bladder pump which is permanently positioned in the well. The bladder is constructed of teflon.

A series of eight wells were drilled into the groundwater table downgradient from the landfill site. The wells are located in three lines parallel to the landfill. The lower tier of wells include wells 1, 2, and 3. These three wells are in the Lonfit River flood plain and are all within 50 meters of the river. Only well 3 of this set was sampled. Wells 4, 5, and 6 were placed closer to the landfill and at a higher elevation. Well 4 was sampled in this study. Finally, wells 7 and 8 are closest to the landfill operations at the highest elevation. These wells are within 10 meters of each other and well 8 was used in the sampling.

Well 9 was placed upgradient of the landfill operations but on landfill property. This well was used as an upgradient control and was sampled in this study.

A production well, designated A-11, was also sampled. This well is located in the limestone aquifer and is operated by the Public Utility Agency of Guam, the local government agency which supplies water to the island. Although this well is located close to the landfill it is thought to be isolated geologically from the landfill site.

Two surface water sites were sampled. One is a stream to the south of the landfill which discharges into the Lonfit River.

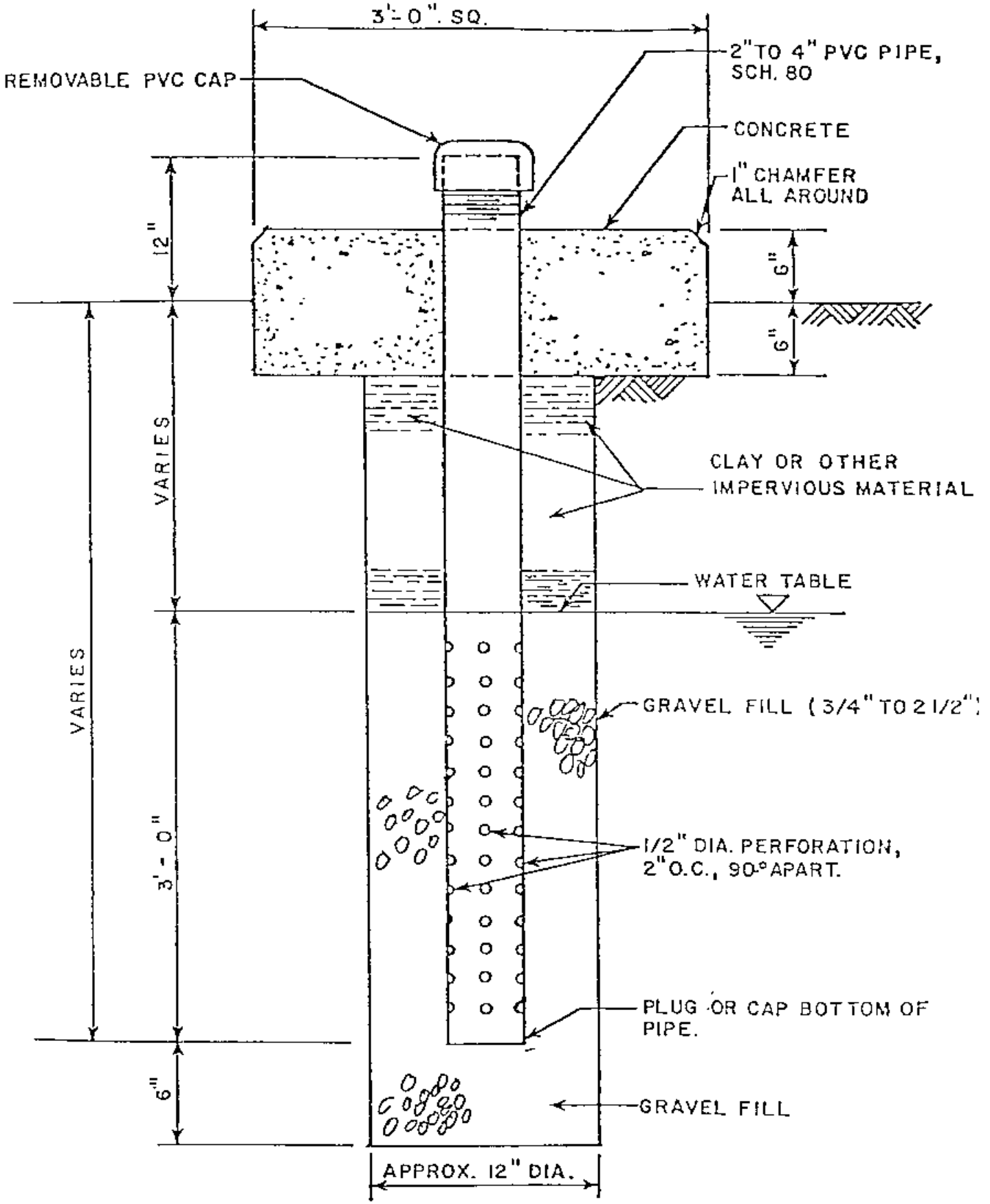

FIGURE 4

TYPICAL CROSS SECTION OF MONITORING WELL

The Lonfit River, upstream from the stream discharge, was also sampled.

Sampling sites are shown in Figure 5.

Monthly water samples were collected from each location from June 1989 thru November 1989. These samples were extracted and analyzed as indicated in the analysis section.

Analytical Procedures

Analysis for Chlorinated Pesticides was done using a modification of US EPA's Method 508 (US EPAa). A modification on US EPA's method 507 (US EPAb) was used for Nitrogen and Phosphorous containing pesticides.

Method 508: Determination of Chlorinated Pesticides in Water by Gas Chromatography with an Electron Capture Detector.

This method can be used for the determination of certain chlorinated pesticides in water. The pesticides in Table 1 were determined by the method.

TABLE 1

Pesticide	MDL (ug/l)	Pesticide	MDL (ug/l)
Aldrin	0.16	4,4'-DDD	0.4
BHC-alpha	0.16	4,4'-DDE	0.2
BHC-beta	0.4	4,4'-DDT	0.4
BHC-delta	0.2	Dieldrin	0.2
BHC-gamma	0.2	Endrin	0.2
Chlordane-alpha	0.1	Heptachlor	0.24
Chlordane-gamma	0.1	Methoxychlor	0.2

Water was collected in a 500 milliliter plastic graduated cylinder. The water was immediately poured into a one liter amber bottle and capped with a teflon lined screw cap.

On return to the laboratory the sample was buffered to pH 7 with 25 milliliters of phosphate buffer (0.0625 M). Fifty grams of sodium chloride (previously heated to 450 degrees C. for 4 hours) was added to the water in the bottle. One hundred and fifty milliliters of dichloromethane was then added and the mixture shaken on a mechanical shaker for 1 hour.

After the period of agitation the bottles were removed from the shaker and set upright to allow separation of the aqueous phase from the organic phase. After separation most of the aqueous phase was aspirated from the bottle. The organic

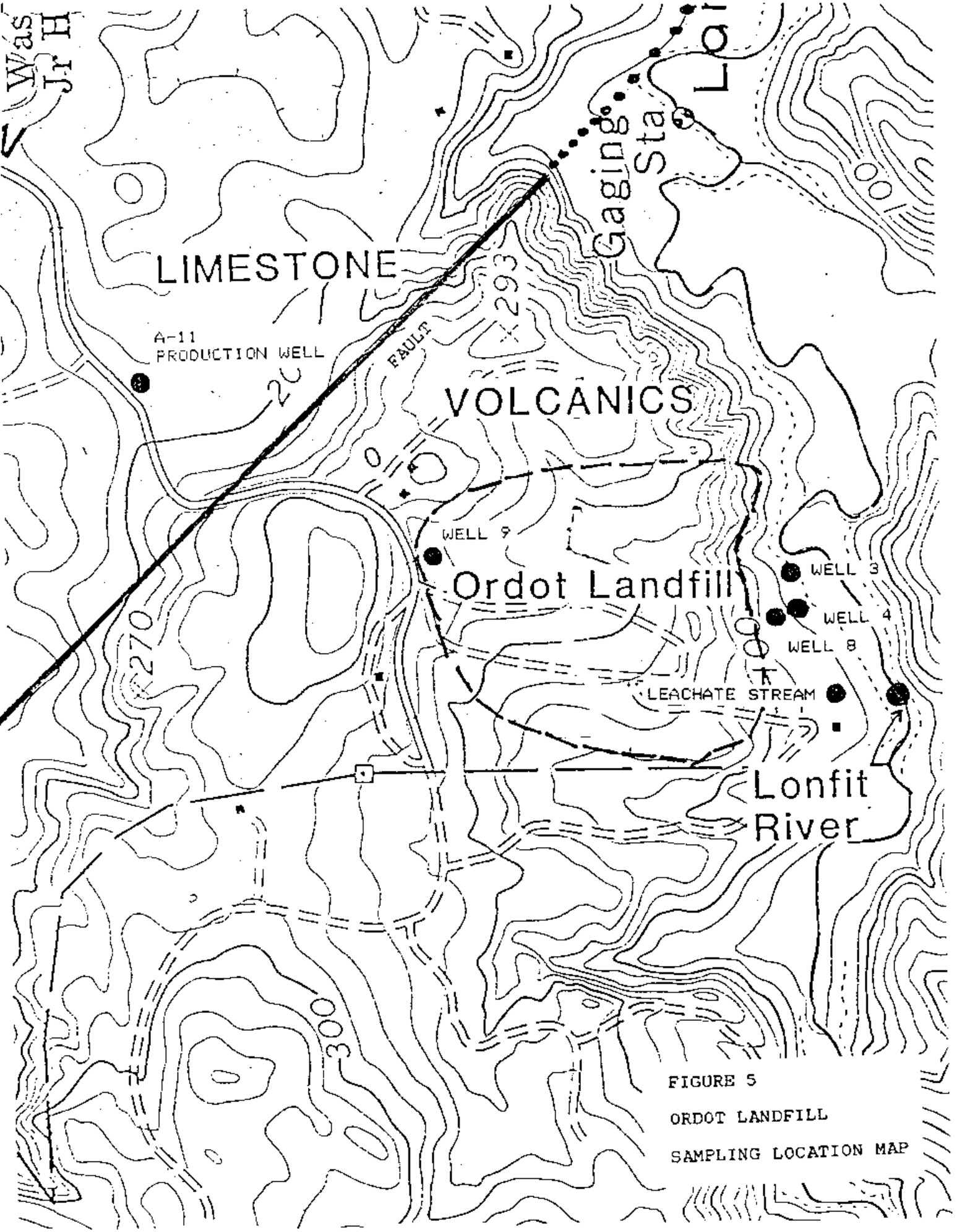

FIGURE 5

ORDOT LANDFILL

SAMPLING LOCATION MAP

phase and the remaining water phase were poured into a 500 ml teflon separatory funnel. The bottle was rinsed with two 10 milliliter aliquots of dichloromethane and poured into the separatory funnel. After a period for separation the lower organic phase was removed into a clean bottle with anhydrous sodium sulfate and allowed to sit for 30 minutes.

The dry extract was decanted into a Kuderna-Danish (K-D) concentrator with a graduated 25 milliliter tube and a 500 milliliter evaporative flask. Several teflon boiling chips were placed into the K-D. A three ball Snyder column was attached and the extract evaporated to 1 milliliter in a water bath at 70 degrees C. The dichloromethane was exchanged by adding 10 milliliters of t-butyl methyl ether and evaporation to 1 milliliter. This step was repeated with addition of another 10 milliliters of t-butyl methyl ether and evaporation to 2 milliliters. The extract was placed in a 1.8 ml autosampler vial and stored at -20 degrees C until analyses.

Analysis was done on a Perkin Elmer Sigma 300 gas chromatograph equipped with a capillary system and with an electron capture detector. Supelco SPB 608 capillary column and Supelco SPB-5 capillary columns were used for analysis.

SPB 608
Length: 15 meters
ID: 0.53 millimeters
Film Thickness: 0.5 micrometers

SPB 5
Length: 15 meters
ID: 0.53 millimeters
Film Thickness: 3 micrometers

Both columns were operated with the same program:
Flow rate: 3ml/min. Helium
Makeup gas: 60 ml/min. Nitrogen
Initial Column Temperature: 170 degrees C.
Time: 4 minutes
Programed at 8 degrees/min to 280 degrees.

Method 507: Nitrogen- and Phosphorus- Containing Pesticides in Water by Gas Chromatography with a Nitrogen-Phosphorus Detector.

This method can be used for the determination of certain nitrogen- and phosphorus- containing pesticides in water. The pesticides in Table 2 were determined by the method.

TABLE 2

Pesticide	MDL (ug/l)
Diazinon	0.4
Ethion	0.4
Malithion	4
Parathion, Ethyl	2
Parathion, Methyl	2
Naled	2

Water was collected in a 500 milliliter plastic graduated cylinder. The water was immediately poured into a one liter amber bottle and capped with a teflon lined screw cap.

On return to the laboratory the sample was buffered to pH 7 with 25 milliliters of phosphate buffer (0.0625 M). Fifty grams of sodium chloride (previously heated to 450 degrees C. for 4 hours) was added to the water in the bottle. One hundred and fifty milliliters of dichloromethane was then added and the mixture shaken on a mechanical shaker for 1 hour.

After the period of agitation the bottles were removed from the shaker and set upright to allow separation of the aqueous phase from the organic phase. After separation most of the aqueous phase was aspirated from the bottle. The organic phase and the remaining water phase were poured into a 500 ml teflon separatory funnel. The bottle was rinsed with two 10 milliliter aliquots of dichloromethane and poured into the separatory funnel. After a period for separation the lower organic phase was removed into a clean bottle with anhydrous sodium sulfate and allowed to sit for 30 minutes.

The dry extract was decanted into a Kuderna-Danish (K-D) concentrator with a graduated 25 milliliter tube and a 500 milliliter evaporative flask. Several teflon boiling chips were placed into the K-D. A three ball Snyder column was attached and the extract evaporated to 1 milliliter in a water bath at 70 degrees C. The dichloromethane was exchanged by adding 10 milliliters of t-butyl methyl ether and evaporation to 1 milliliter. This step was repeated with addition of another 10 milliliters of t-butyl methyl ether

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SPB 608
Length: 15 meters
ID: 0.53 millimeters
Film Thickness: 0.5 micrometers

SPB 5
Length: 15 meters
ID: 0.53 millimeters
Film Thickness: 3 micrometers

Both columns were operated with the same program:
Flow rate: 3ml/min. Helium.
Air: 30 psi Hydrogen: 10 psi
Initial Column Temperature: 150 degrees C.
Time: 4 minutes
Programed at 5 degrees/min to 260 degrees.

Results and Discussion

Conductivity measurements were most useful in determining the presence of leachate from the landfill. Table 3 indicates an example of changes in conductivity noted.

TABLE 3

Site	Conductivity
Well A-11	607
Well 3	1100
Well 4	1400
Well 8	1200
Well 9	400
Stream	1545
Lonfit River	400

The conductivity measurements indicated that the stream was heavily contaminated with leachate.

Analysis of water from the six sites over 6 consecutive months resulted in no instance of detection of pesticides. Other water quality parameters indicated that leachate was being sampled in the downstream wells and the stream south of the landfill.

Other eluting peaks were present in some samples using both the ECD and the NPD. These peaks could not be correlated to the chosen pesticide standards. Well 8 consistently demonstrated unidentified ECD peaks. The leachate stream contained several unidentified NPD peaks. One sample was kindly scanned by Mr. Gorman Dorsey, U.S. Navy Public Works Center Fena Laboratory by GC-MS. This sample demonstrated several peaks consistent with phthalates and the compounds N-methyl cyclohexanamine and 2-methyl butyl 1,2-benzenedicarboxylic acid.

This study did not identify the chosen pesticides in leachate, surface water or groundwater associated with the Ordot Landfill. The downstream groundwater leachate and the leachate stream from the landfill demonstrated definite water quality degradation. Indications of organic compounds were present in these waters. The upstream Ordot well demonstrated good water quality and displayed no evidence of organic contamination. The Lonfit river also demonstrated good water quality and no evidence of organic contamination. Lastly, the production well A-11 showed no evidence of influence by the Ordot landfill.

Future work in this laboratory will concentrate on the identification of organic compounds, particularly priority pollutants and volatiles, in the leachate from the Ordot landfill.

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