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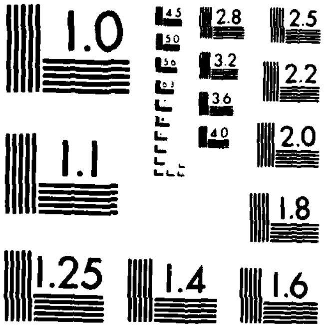

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Installation Restoration Program

A148 687

AD-A148 687

Final Report
Phase II Stage I Study
McGuire Air Force Base
Burlington County, New Jersey

Prepared For:

United States Air Force
Occupational and Environmental Health Laboratory (OEHL)
Brooks Air Force Base, Texas

October 1984

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report covers the second part (Phase II) of the Installation Restoration Program (IRP) confirmation study at McGuire AFB NJ. This study was directed by the Department of Defense. The overall objective of the IRP is to identify and evaluate past disposal sites and to control the migration of hazardous environmental contamination resulting from such sites. This work may be followed by a Phase IIa effort to define the extent of contaminated migration in those cases where this question has not been answered.

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EXECUTIVE SUMMARY

ES1.0 Introduction

Roy F. Weston, Inc. (WESTON) was retained by the U.S. Air Force Occupational and Environmental Health Laboratory (OEHL) under Contract No. F33615-80-D-4006 to provide general engineering, hydrogeological and analytical services. These services were applied to the Installation Restoration Program (IRP) Phase II Stage 1 effort at McGuire Air Force Base (McGAFB) under Task Order 0020 of this contract.

In 1976 the Department of Defense (DoD) devised a comprehensive IRP. The purpose of the IRP is to assess and control migration of environmental contamination that may have resulted from past operation of hazardous contaminants. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites on DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

Phase I - Problem Identification/Records Search
Phase II - Problem Confirmation and Quantification
Phase III - Technology Base Development
Phase IV - Corrective Action

Only the Phase II Problem Confirmation Stage 1 portion of the IRP effort at McGuire Air Force Base was part of this Task Order.

ES2.0 Scope of Work

McGuire Air Force Base occupies 3,536 acres of land in south central New Jersey, near the community of Wrightstown, Burlington County. Since the start of operations in 1937 as a single dirt-strip runway, activities at McGAFB in support of operational missions have resulted in the occurrence on the installation of a number of waste disposal sites of special interest.

The field investigation under Task Order 20 included nine areas listed below:

- Zone 1: Landfill 4 (Site No. 1), Landfill 5 (Site No. 9), Landfill 6 (Site No. 11) and the wastewater treatment plant sludge disposal area (Site No. 12).
- Site No. 2, Landfill 2
- Site No. 3, Landfill 3
- Site No. 4, BOMARC Missile Site, JPX Discharge Pit
- Site No. 5, Pesticide Wash Area
- Site No. 6, DPDO Storage Facility
- Site No. 7, Fire Training Area 1
- Site No. 8, Bulk Fuel Storage Area
- Site No. 14, Civil Engineering Compound Drum Burial Site.

Eight of these sites are located on Figure ES-1, Site 4 is located approximately 11 miles to the east of the main Base.

The scope of the investigation included: two soil borings at Site No. 5 and five soil borings at Site No. 6 to recover 21 soil samples for chemical analyses; three stream water and sediment samples for chemical analysis at Site No. 5; a geophysical survey of the C. E. Compound (Site No. 14); and drilling and construction of a total of 17 ground-water monitoring wells at the landfill sites (Zone 1, Site Nos. 2 and 3) and Site Nos. 4, 7, 8 and 14.

All wells were surveyed for elevation and ground-water surface maps were prepared for three sites. One round of ground-water samples for chemical analyses was taken from the wells. All water quality and soil samples were analyzed

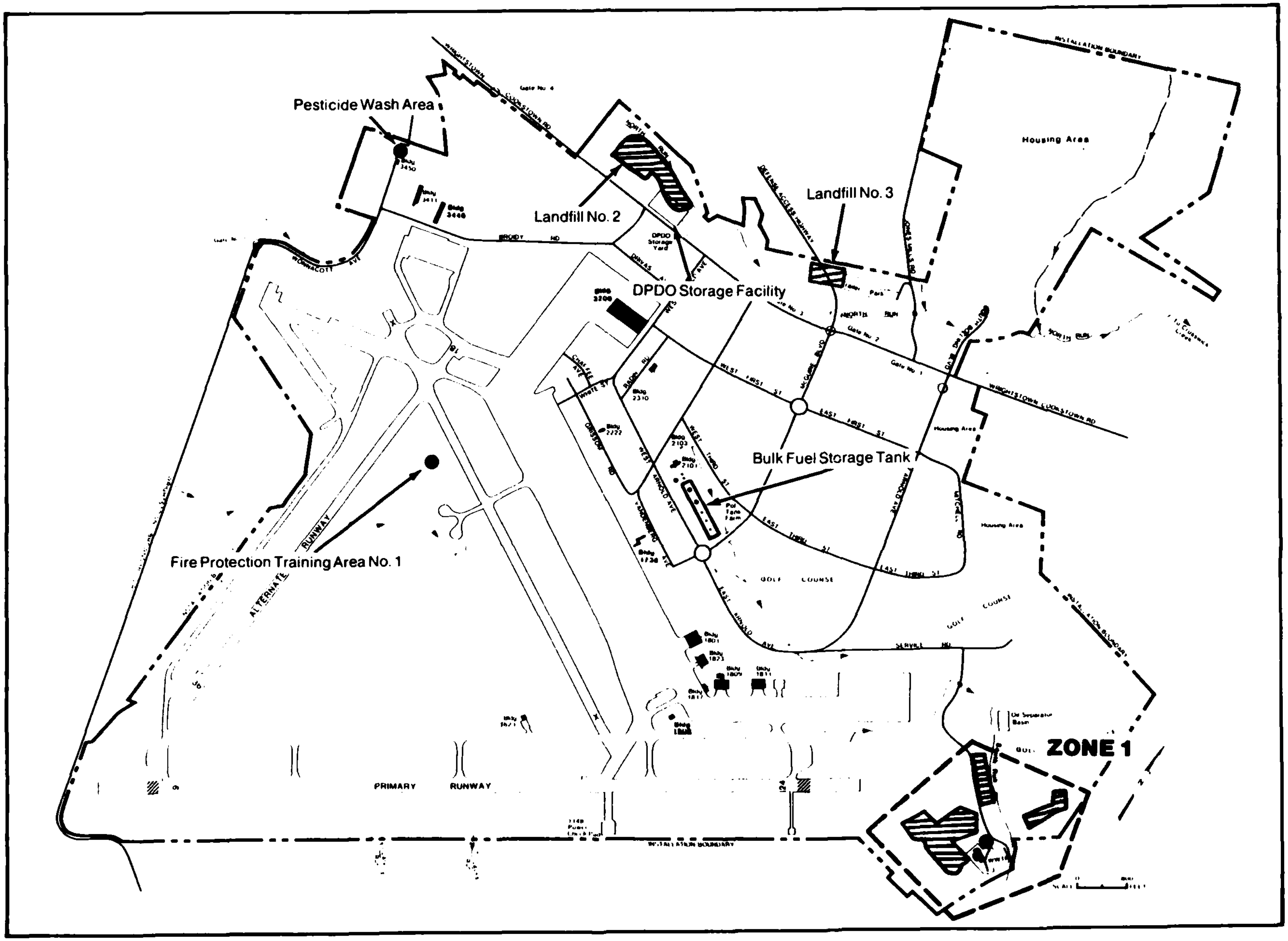


FIGURE ES-1 LOCATION OF ALL PHASE II SITES AT McGUIRE AFB in WESTON's laboratory in accordance with USEPA Standard Methods.

ES3.0 Major Findings

Based on the analyses performed, levels of contamination were found in soils and ground water that warrant further investigation and possible future action.

The major potential ground-water contaminants indicated by the available data are organic halogens. Total Organic Halogens (TOX) levels ranged from 3.7 to 443.9 mg/l in the 15 wells sampled (wells at the BOMARC Site, Site No. 4, were not sampled for TOX analyses). Four samples exceeded 100 ug/l and five samples had concentrations ranging from 10 to 100 ug/l. Each landfill area (Zone 1, Landfills No. 2 and No. 3) had at least one well with TOX concentrations exceeding 100 ug/l. Monitor Well 12 at the Bulk Fuel Storage Area (Site No. 8) had a TOX concentration of 81.7 ug/l. Wells at Fire Training Area No. 1 (Site No. 7) had the lowest TOX levels - 6.1 and 6.3 ug/l. USEPA water quality criteria for Human Health have been published for numerous compounds falling within the group contributing to TOX levels. Many of these criteria are in the range of 1 ug/l or less. Recommended Maximum Contaminant Levels (RMCLs) were published recently, which also included several of the compounds indicated by TOX data. Thus, TOX concentrations in the well samples from McGuire AFB indicate a high probability that these health criteria are exceeded in the case of one or more compounds.

Oil and grease was found in 13 of the 17 wells and at all of the sites at concentrations above the taste and oder threshold of 0.01 mg/l. In the remaining 4 samples oil and grease was not found at a detection limit for this program of 0.1 mg/l.

The pesticide levels observed in the subsurface soil samples at the Pesticide Wash Area (Site No. 5) are not considered by WESTON to be a factor of concern. The aqueous solubilities of these compounds are low and the impact on ground-water quality beneath the site should be minimal. Levels of chlordane, DDT and DDE in excess of 1,000 ug/kg in the stream sediments, however, show that some off-site migration of contaminated sediments has occurred. The relatively low concentrations of pesticides in the stream water indicates that the contaminants are migrating principally by sediment transport. The farthest downstream sampling point contained significant concentrations of pesticide compounds, so that it was not determined how far downstream the contaminated sediments have been carried. The stream that passes the Pesticide Wash Area flows to South Run, which exits the installation to the east.

The distribution of PCB in the soils analyzed from the DPDO Storage Facility (Site No. 6) indicate that PCB only occurs in near-surface samples (1-2 feet) and was not found at depth. PCB was found in 3 of the borings at very low concentrations ranging from 14 to 30 ug/kg: TB-3 in the drum storage area; and TB-5 and TB-7 near the buried tank location in the storage yard, where transformers were stored in the past.

Elevated oil and grease concentrations were found in soils at the DPDO Storage Facility (Site No. 6) at all depths. The highest concentrations were found at depths of 4-5 feet in the buried tank area (16,000 - 234,000 mg/kg) and 1-2 feet at the drum storage area (132 - 6,360 mg/kg). While the PCB in near surface soils appears limited and probably associated with past storage of transformers, the oil and grease appears related to surface drum storage and the buried storage tank. It does not appear that the waste oil from the buried storage tank contained PCB.

The results of the geophysical survey indicate that there is a potential for buried wastes to exist beneath the surface at the Civil Engineering Compound.

ES4.0 Conclusions

Based on the results of the Phase II survey at McGAFB, the following conclusions have been drawn:

1. Ground water directly beneath McGuire AFB and the BOMARC Missile Site occurs under unconfined or water table conditions with the water table occurring between 1 and 25 feet below ground surface. Sediments encountered during the drilling consisted of interbedded fine to medium sands, silts and clays of the Kirkwood and Cohansey Formations.

2. Regional ground water flow in the Cohansey and Kirkwood Formations is generally down formational dip to the southeast. However, most of the flow in the upper aquifer, where the monitoring wells are screened, is lateral to-

ward local streams where discharge occurs.

3. The fate of contaminants infiltrating from the landfills to the water table is to move laterally toward the streams where discharge occurs. Based upon an estimate of soil permeability, the rate of lateral ground-water flow (seepage velocity) was calculated to be approximately one foot per day. Given the ages of the landfills and their proximity to surface streams, combined with the ground-water seepage velocity, it is apparent that ground-water contaminant plumes, as observed in the well water quality analyses, have already reached the surface water discharge areas.

4. The most immediate potential for migration of contaminants off-Base is from the landfill-generated contaminants reaching North and South Runs through the ground water. These streams both leave Base property a short distance from where they pass the landfills, with Landfill No. 2 situated less than one-half mile from the North Run exit point, and Landfills No. 4, 5 and 6 (Zone 1) are less than 500 feet from the South Run exit point of the Base.

5. Total Organic Halogens (TOX) were found in concentrations in excess of 200 ug/l in at least one well at each of the three landfill sites. TOX concentrations were 18.1 and 81.7 ug/l in the Bulk Fuel Storage Area (Site No. 8) wells, and were 6.1 and 6.3 ug/l in Fire Training Area No. 1 (Site No. 7) wells. These results indicate the possible presence of elevated levels of one or more specific volatile organic priority pollutants in the ground water at these sites.

6. Concentrations of oil and grease in excess of the taste and odor threshold were found at all but 4 wells and at all sites where ground water was monitored.

7. Concentrations of five pesticide compounds were found in soils at the Pesticide Wash Area (Site No. 5). The migration of pesticides vertically into the subsoil appears slight. However, levels of DDT, DDE and chlordane in excess of 1,000 ug/kg were found in the stream sediments downstream of the site. This indicates that off-site migration of pesticides is occurring by surface sediment transport. Pesticide concentrations in surface waters were in excess of 1 ug/l in only one stream sample (SW-2). Because of low solubilities, the compounds are remaining adsorbed in the sediments. The stream flowing past the Pesticide Wash Area is not close to a Base boundary, although the extent of the pesticide occurrence in sediments further down stream is not known.

8. Soil boring samples at three depth intervals from the DPDO Storage Facility (Site No. 8) were analyzed for oil and grease and PCB. PCB was found in the drum storage area and buried tank area in the 1-2 foot depth samples from three borings: TB-3, TB-5, and TB-7. PCB was detected in concentrations of 14-30 ug/kg, well below the USEPA action level of 50 mg/kg.

9. The results of the geophysical investigation of the Civil Engineering Compound, combined with the examination of historical aerial photos, show that areas exist at the site that have been disturbed in the past. Magnetic anomalies associated with these areas indicate that buried drums or other metallic scrap may be present.

10. Based on the limited analyses completed, the ground water quality at Fire Training Area No. 1 (Site No. 7)appears less degraded than the other sites sampled. TOX concentrations were among the lowest of wells tested. Since the

site has not been in use since the 1950's, the data indicate that any contaminants which may have been at the site in the past have been flushed out of the site to a great extent.

ES5.0 Recommendations

Based upon the Phase II Confirmation Study conducted at McGuire Air Force Base, the following recommendations are made by site:

ES5.1 Zone 1 - Recommendations

The following additional work is recommended for the Zone 1 Area (Landfills 4, 5, 6 and the Sludge Disposal Area).

1. An additional round of samples should be taken from existing wells MW-1 through MW-5 to verify the results obtained from the first sampling round. Samples from all five wells should also be analyzed for USEPA Priority Pollutant volatile organic compounds and landfill leachate indicator parameters such as nitrates, iron, ammonia-nitrogen and boron. In addition, samples from MW-3 should be analyzed for USEPA Priority Pollutant acid and base/neutral compounds and pesticide/PCB compounds. Three surface water samples should be taken along South Run upstream of Zone 1, downstream of the small tributary passing by MW-3 and downstream of the waste treatment plant. These samples should be analyzed for the same parameters as the 5 well samples.

2. A Ground Penetrating Radar survey should be performed on Landfill No. 4 to determine boundaries, depth, and possible buried barrel nests. The investigation should be followed by 10 soil borings in Landfill 4 to confirm depth of fill and depth to water.

3. If the results of the above analyses are positive, at least eight additional groundwater monitoring wells should be drilled in the Zone 1 area, including three wells at the locations of borings in Landfill 4 and two upgradient wells, one each above Landfills 4 and 5.

4. The new and existing wells should be sampled for key parameters identified in the previous sampling of the existing wells. In addition, samples from South Run should be taken at locations upstream, opposite the landfills and where the stream crosses the installation boundary and analyzed for a similar suite of key parameters.

ES5.2 Site No. 2, Landfill 2 - Recommendations

The following additional work is recommended for Landfill 2:

1. The existing wells at the site should be resampled to verify the results of the first water quality analyses. All samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds.

2. Production Well A, located adjacent to the barrel storage area, should be sampled for the same suite of parameters as above.

3. In addition to the above parameters, MW-7 should be sampled for USEPA Priority Pollutant acid compounds, base/neutral compounds and pesticide/PCB compounds.

4. A Ground Penetrating Radar (GPR) survey should be conducted on the landfill to assess depths to the base of fill and the location of possible barrels. Six soil borings should be completed subsequently to calibrate the GPR results and confirm the depth of fill and the location of the water table.

5. Three additional monitoring wells should be installed to the east of the landfill to define potential groundwater flow in that direction. One well should be adjacent to Production Well "A" and the DPDO barrel storage area.

6. All wells should be sampled for specific contaminants based on the results of the previous sampling round. The list of

analytes should also include landfill leachate parameters such as nitrates, iron, ammonia-nitrogen and boron.

7. Water quality samples should also be collected along North Run upstream from the landfill, downstream, and opposite the landfill, and analyzed for the suite of analytes identified above.

ES5.3 Site No. 3, Landfill 3 - Recommendations

WESTON makes the following recommendations for further investigation at Landfill 3:

1. Resample existing wells to verify the first round of analyses, plus analyze all samples for USEPA Priority Pollutant volatile organic compounds. In addition, MW-9 should be sampled for USEPA Priority Pollutant acid compounds, base/neutral compounds and pesticide/PCB compounds.

2. Three additional monitoring wells should be installed between the landfill and the Base boundary.

3. All wells should be sampled for those key parameters indicated in the previous round of sampling, plus nitrate, ammonia-nitrogen, iron, and boron.

4. Three surface water samples should be taken along North Run; upstream, opposite the landfill, and downstream. These samples should be analyzed for the same parameters as the wells.

ES5.4 Site No. 4, BOMARC Missile Site - Recommendations

WESTON makes the following recommendations for further investigation at the BOMARC Missile Site:

1. Resample existing wells to verify the first round of analyses, plus analyze the samples for USEPA Priority Pollutant volatile organic compounds and xylene.

ES5.5 Pesticide Wash Area - Recommendations

Contamination of stream bed sediments is the principal problem in the Pesticide Wash Area. WESTON, therefore, recommends that the following sampling be completed to determine the extent of this contamination:

1. Sediment and grab samples should be taken at three locations downstream of SS-3 and upstream of the culvert entrance, at three manhole locations along the storm drain system, and at one location upstream of the pesticide wash area. All samples should be analyzed for pesticides.

2. Two-foot core samples should be taken at locations SS-1, SS-2 and SS-3 to obtain samples at depth. Each core should be divided into two depth increments and analyzed for pesticides to determine the depth of the contaminated sediment.

ES5.6 Site No. 6, DPDO Storage Area - Recommendations

WESTON recommends that the following work be completed at the DPDO site to determine the extent of soil and groundwater contamination at the DPDO Storage Area.

1. Surface soil samples should be taken at twelve locations around the drum storage and buried tank areas. Three composite samples should be analyzed for PCB with the remaining portion of the samples stored for possible future analysis.

2. A monitoring well should also be installed between the buried tank area and North Run. This well should be sampled for oil and grease, volatile organic compounds and xylene. The monitoring well recommended in Section 6.1.2, to be located near production Well "A", will also monitor the barrel storage area.

ES5.7 Site No. 7, Fire Training Area - Recommendations

WESTON does not consider Fire Training Area 1 to be a high priority site at this time, and recommends only that MW-14 and MW-15 be resampled to verify the original analytical results. Samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds and xylene.

ES5.8 Site No. 8, Bulk Fuel Storage Area - Recommendations

WESTON recommends that the following work be done at the Bulk Fuel Storage Area:

1. A second round of well samples should be analyzed to confirm initial results. Samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds plus xylene.

2. Approximately twenty soil borings should be completed around the Bulk Fuel Storage Area. Temporary PVC well points should be installed and a groundwater elevation survey completed. Samples from the well points can be visually examined for floating fuel products.

3. Based on the information gathered from the temporary well points, up to six permanent groundwater monitoring wells should be installed in critical locations around the bulk fuel storage area including one upgradient, background location.

4. All wells at the site should be sampled for oil and grease, lead, USEPA Priority Pollutant volatile organic compounds, and xylene.

ES5.9 Site No. 14, Civil Engineering Compound - Recommendations

Based on the results of the geophysical survey and the examination of historical photographs, WESTON recommends that a subsurface investigation be conducted at the Civil Engineering Compound to confirm whether hazardous materials are buried at the site. WESTON recommends:

1. Backhoe test pits should be completed at those locations identified as potential burial sites by the geophysical survey. The work should be conducted while observing

strict safety procedures, including personal body and respiratory protection. Air quality should be monitored with an organic vapor detector, and soil samples should be obtained in areas where physical appearance or detected vapors indicate contamination.

This excavation activity is to be for the confirmation of whether barrels or contaminated soils are present. If barrels are encountered, they will not be disturbed or sampled. Only suspected contaminated soils will be sampled. All procedures for this investigation will be reviewed prior to the work with appropriate State and Federal regulatory agencies.

2. Selected soil samples should be analyzed for USEPA Priority Pollutant organic compounds and metals.

3. If the results of the chemical analyses of the soils is positive, four groundwater monitoring wells should be placed around the burial site; one well upgradient and three wells downgradient. Groundwater samples should be obtained from these wells and analyzed for key compounds indicated by the soils analyses to determine the impact of the waste on groundwater quality. Appropriate response for remedial action should also be developed.

ES6.0 SUMMARY OF RECOMMENDATIONS

The recommendations which have been made as a result of this Stage 1 Study at McGuire Air Force Base are summarized in Table ES-1.

TABLE ES-1: SUMMARY OF RECOMMENDATIONS

Site	Recommendations	Rationale
Zone 1	Resample and analyze existing monitor wells	Verify Stage 1 results
	Expand suite of analytes	Characterization of contaminants
	Surface water sampling	Assess leachate discharge to adjacent creeks
	Ground Penetrating Radar Survey	Landfill boundary determination, assess presence of drums
	Borings and monitor wells within landfills	Determine if ground-water table is within fill material
	Additional monitor wells	Assess magnitude and extent of contamination
Site 2	Resample and analyze existing monitor wells	Verify Stage 1 results
	Priority Pollutant Scan	Characterize contaminants
	Ground Penetrating Radar Survey presence of drums	Determine depth of fill and
	Additional monitor wells, sampling and analysis	Assess magnitude and extent of contamination
	Sampling and analysis of surface waters	Assess leachate discharge to adjacent creeks
Site 3	Resample and analyze existing monitor wells	Verify Stage 1 results
	Expanded suite of analytes and Priority Pollutant Scan	Characterization of contaminants

TABLE ES-1: SUMMARY OF RECOMMENDATIONS (cont.)

Site	Recommendations	Rationale
	Additional monitor wells, sampling and analysis	Assess magnitude and extent of contamination
	Sampling and analysis of surface waters	Assess leachate discharge to adjacent creeks
Site 4	Resample and analyze existing monitor wells	Verify Stage 1 results
Site 5	Sampling and analysis of additional bottom sediments	Determine extent of downstream contaminant migration
Site 6	Sampling and analysis of additional surface soils	Determine extent of soil contamination
	Additional monitor well, sampling and analysis	Assess magnitude and extent of contamination
Site 7	Resample and analyze existing monitor wells	Verify Stage 1 results
Site 8	Resample and analyze existing monitor wells	Verify Stage 1 results
	Drill and sample soil borings	Determine magnitude and extent of soil contamination
	Additional monitor wells, sampling and analysis	Determine magnitude and extent of ground-water contamination
Site 14	Test pits and target sites identified by Ground Penetrating Radar Survey	Confirm presence or absence of buried drums
	Soil sampling and analysis	Characterization of contaminants
	Installation of monitor wells, sampling and analysis	Determine magnitude and extent of ground-water contamination

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

In 1976 the Department of Defense (DoD) devised a comprehensive Installation Restoration Program (IRP). The purpose of the IRP is to assess and control migration of environmental contamination that may have resulted from past operations and disposal practices on DoD facilities, and probable migration of hazardous contaminants. In response to the Resource Conservation and Recovery Act of 1976 (RCRA) and in anticipation of the Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA, or "Superfund"), the DoD issued a Defense Environmental Quality Program Policy Memorandum (DEQPPM) dated June, 1980 (DEQPPM 80-6), requiring identification of past hazardous waste disposal sites DoD agency installations. The U.S. Air Force implemented DEQPPM 80-6 by message in December, 1980. The program was revised by DEQPPM 81-5 (11 December 1981) which reissued and amplified all previous directives and memoranda on the IRP. The Air Force implemented DEQPPM 81-5 by message on 21 January 1982. The Installation Restoration Program has been developed as a four-phase program as follows:

Phase I - Problem Identification/Records Search
Phase II - Problem Confirmation and Quantification
Phase III - Technology Base Development
Phase IV - Corrective Action

Only the Phase II Problem Confirmation Stage 1 portion of the IRP effort at McGuire Air Force Base was included in the effort described in this Report. Definitions of the terms and acronyms used in this report are in Appendix A.

1.2 PROGRAM HISTORY AT McGUIRE AIR FORCE BASE

Roy F. Weston, Inc. (WESTON) has been retained by the United States Air Force Occupational and Environmental Health Laboratory (OEHL) under Contract Number F33615-80-D-4006, to provide general engineering, hydrogeological and analytical services. The Phase I, Problem Identification/Records Search for McGuire Air Force Base (McGAFB) was accomplished by Engineering Science Inc. (ESI) in August 1982, and their Final Report was dated November 1982. In response to the findings contained in the ESI Phase I Final Report, the OEHL issued Task Order 0014 to WESTON, directing that a pre-survey site inspection be conducted at McGAFB. The purpose of this pre-survey was to obtain sufficient information to develop a work scope and cost estimate for the conduct of a Phase II, Stage 1 study at McGAFB.

The Pre-Survey report for McGAFB was submitted by WESTON in April 1983. Following modifications in the scope of work, Task Order 0020, dated 28 July 1983, was issued, which authorized a Phase II Stage 1 Study for 9 sites at McGAFB. A copy of the formal Task Order authorizing this work is included here as Appendix B.

On 20 September 1983 WESTON met with representatives of the Bioenvironmental and Civil Engineering Departments of McGuire Air Force Base, and the drilling subcontractor, Empire Soils Investigations, Inc., to review the goals of the investigation, review drilling procedures and locations, and to establish the field schedule. Soil borings and monitoring well construction commenced on 3 October 1983 and were completed by 25 October. Groundwater and surface sediment sampling was completed during the weeks of 28 November 1983.

1.3 BASE PROFILE

McGuire Air Force Base (McGAFB) occupies 3,536 acres of land located in south central New Jersey, approximately 18 miles southwest of the City of Trenton. Figure 1-1 presents an index map showing the location of McGuire Air Force Base. The northern border of McGAFB is the community of Wrightstown, Burlington County, while the eastern, southern and western borders are occupied by the U.S. Army Fort Dix installation. The base is in a rural area of the New Jersey Pine Barrens, with most adjacent lands being either vacant or wooded, or being used for agricultural or military purposes. The area of McGAFB is under the management of the New Jersey Pinelands Commission.

McGAFB began in 1937 as a single dirt-strip runway with a few maintenance and administrative buildings. The airfield, called Rudd Field at the time, was developed as an adjunct to the U.S. Army Training Center, Fort Dix, and was operated by the Army Air Corps. During the period 1940 through 1942, the U.S. Army Air Corps, under Command Headquarters located at New Castle Air Base, Delaware, made extensive improvements to the Fort Dix Airfield, including expanded aircraft pavements and landing strips to meet World War II transitional training requirements. The airfield remained under Army control until 1948.

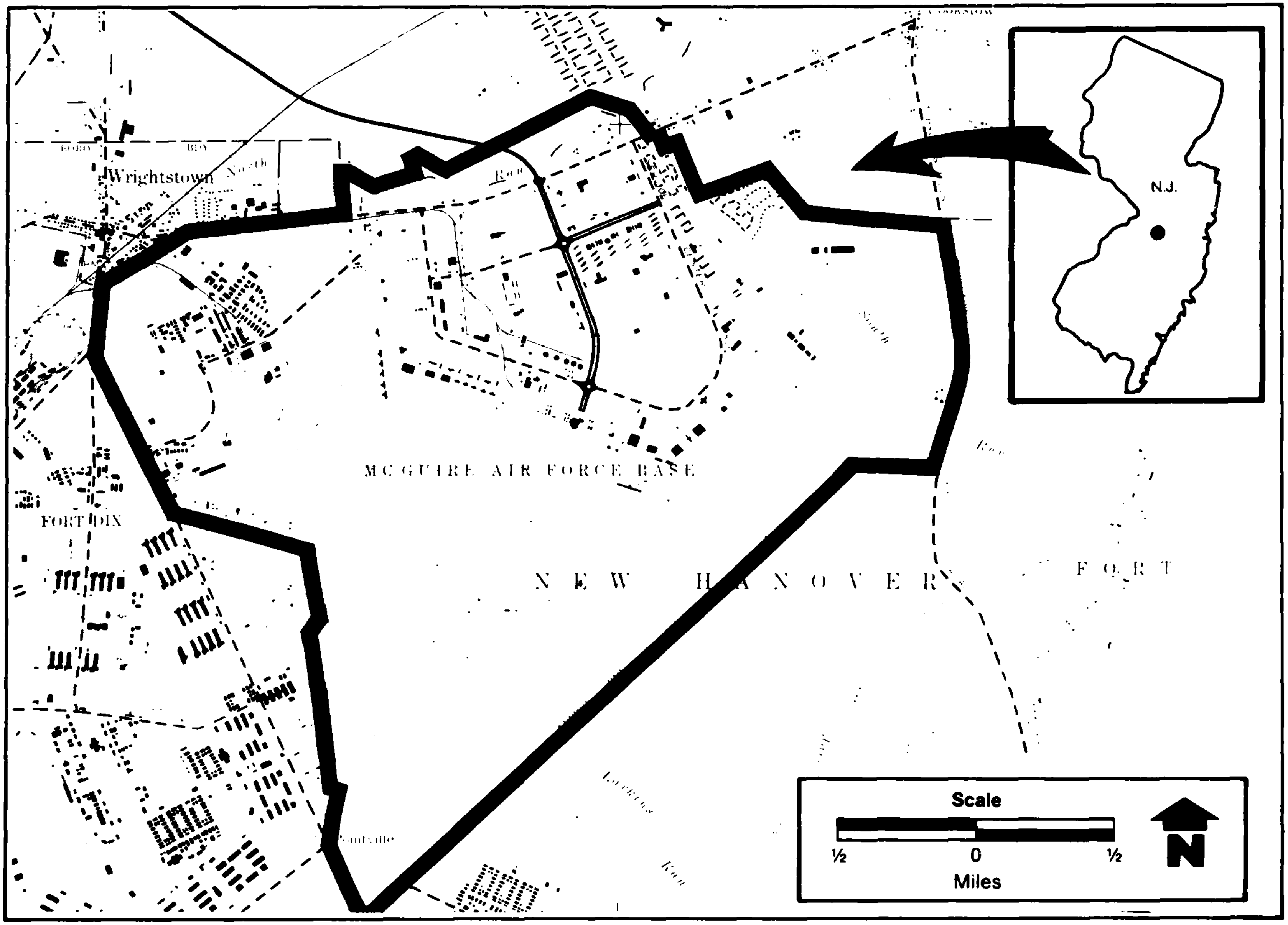


FIGURE 1-1 INDEX MAP OF McGUIRE AFB

In 1948, the Fort Dix Airfield and all existing facilities were transferred to the U.S. Air Force, and the installation was officially designated McGuire Air Force Base. The installation was assigned to the Strategic Air Command (SAC) until September 1949, when it was transferred to the Continental Air Command (CAC). In 1952 a major program of development was initiated to provide a port of aerial embarkation for Atlantic Division, Military Air Transport Services (MATS).

In July 1954, the Base was officially assigned to the Military Air Transport Service with Air Defense Command (ADC) and the New Jersey Air National Guard (NJANG) as major tenant organizations. The NJANG consolidated its activities on the west side of the Base supported by a Major Construction Program (MCP). Subsequently, SAC and CAC tenant units were assigned to McGAFB. In January 1966, the Military Air Transport Service became the Military Airlift Command (MAC) with headquarters at Scott AFB, IL. Eastern Transport Air Force became the 21st Air Force with headquarters at McGAFB, and the 1611th Air Transport Wing became the 438th Military Airlift Wing (MAW). The SAC Tanker Squadron left McGAFB in 1965 and its facilities were occupied by the 170th Air Transport Group NJANG.

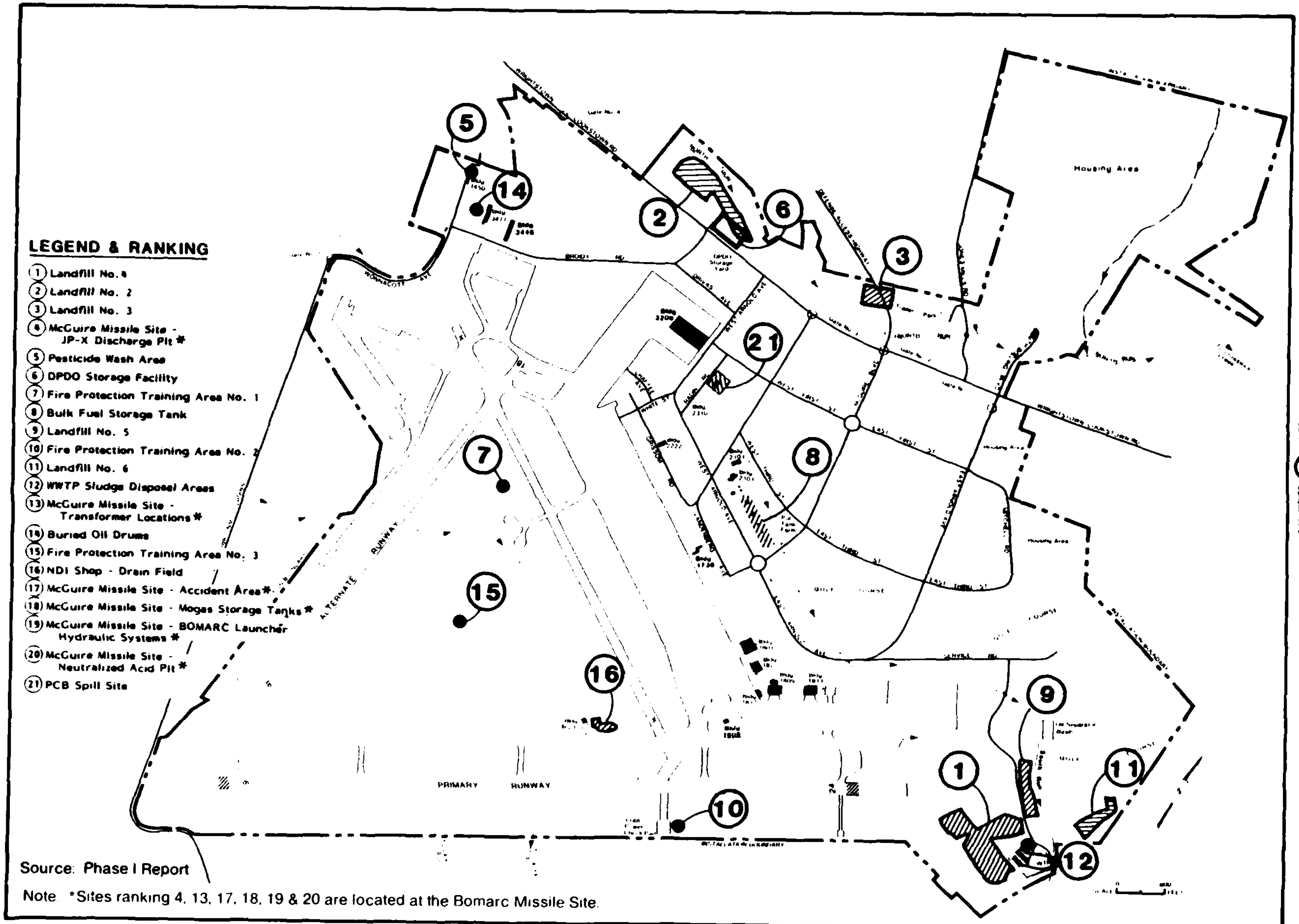
The present host organization at McGAFB is the 438th MAW, whose primary mission is to provide quick reacting, concentrated, massive airlift capabilities for emplacement of Department of Defense forces into combat situations in a fighting posture, and then to furnish materials support to those forces. The Wing is also responsible for operating McGAFB and for providing adequate support to a large number of tenant units.

Past Air Force activities at McGAFB in support of operational missions have resulted in the occurrence on the Base of several waste disposal sites of potential concern. Each of these sites was rated by ESI during Phase I activities in accordance with the IRP Hazard Assessment Rating Method (HARM). The results of these ratings are summarized in Table 1-1 (from the ESI report). Figure 1-2 shows the locations of all sites at McGAFB receiving HARM score rankings. Figure 1-3 shows sites receiving HARM score rankings at the BOMARC Missile Site. Based upon these ratings and all other pertinent data, ESI recommended that Phase II activities con-

TABLE 1-1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES McGUIRE AFB (FROM PHASE I REPORT)

Rank	Site Name	Date of Operation or Occurence	HARM SCORE
1	Landfill No. 4	1958-1973	73
2	Landfill No. 2	1950-1956	66
3	Landfill No. 3	1956-1957	65
4	McGuire Missile Site JP-X Discharge Pit	1958-1972	59
5	Pesticide Wash Area	1974-Present	58
6	DPDO Storage Facility	1960-1979	56
7	Fire Protection Training Area No. 1	Late 1940's-1958	54
8	Bulk Fuel Storage Tank	1963-1970	53
9	Landfill No. 5	1970-1973	52
10	Fire Protection Training Area No. 2	1958-1968	51
11	Landfill No. 6	1973-1976	50
11	WWTP Sludge Disposal Areas	1953-present	50
11	McGuire Missile Site - Transformer Locations	1958-present	50
14	Buried Oil Drums	Early 1950's	49
15	Fire Protection Training Area No. 3	1973-1976, 1982	48
16	NDI Shop - Drain Field	1960's-1972	47
17	McGuire Missile Site Accident Area	1960	46
18	McGuire Missile Site Mogas Storage Tanks	1958-present	45
19	McGuire Missile Site BOMARC Launcher Hydraulic Systems	1958-present	39
20	McGuire Missile Site Neutralized Acid Pit	1958-1972	37
21	PCB Spill Site	1982	6



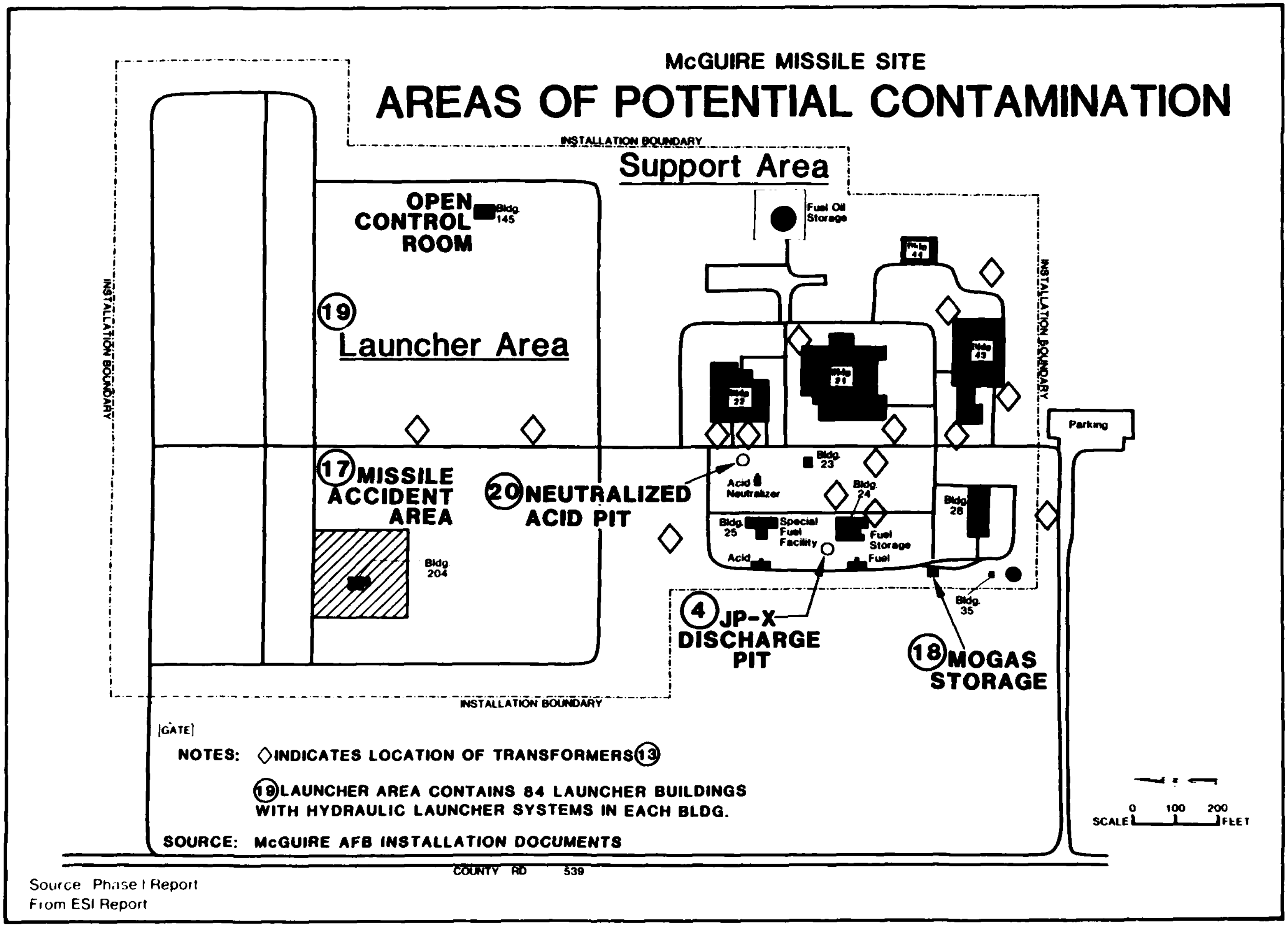
LEGEND & RANKING

- ① Landfill No. 4
- ② Landfill No. 2
- ③ Landfill No. 3
- ④ McGuire Missile Site - JP-X Discharge Pit *
- ⑤ Pesticide Wash Area
- ⑥ DPDO Storage Facility
- ⑦ Fire Protection Training Area No. 1
- ⑧ Bulk Fuel Storage Tank
- ⑨ Landfill No. 5
- ⑩ Fire Protection Training Area No. 2
- ⑪ Landfill No. 6
- ⑫ WWTP Sludge Disposal Areas
- ⑬ McGuire Missile Site - Transformer Locations *
- ⑭ Buried Oil Drums
- ⑮ Fire Protection Training Area No. 3
- ⑯ NDI Shop - Drain Field
- ⑰ McGuire Missile Site - Accident Area *
- ⑱ McGuire Missile Site - Mogas Storage Tanks *
- ⑲ McGuire Missile Site - BOMARC Launcher Hydraulic Systems *
- ⑳ McGuire Missile Site - Neutralized Acid Pit *
- ㉑ PCB Spill Site

Source: Phase I Report

Note: *Sites ranking 4, 13, 17, 18, 19 & 20 are located at the Bomarc Missile Site.

FIGURE 1-2 LOCATION OF ALL POTENTIAL SOURCES OF CONTAMINATION AT McGUIRE AFB RECEIVING PHASE I HARM SCORE RANKINGS



NOTES: ◇INDICATES LOCATION OF TRANSFORMERS ⑬

⑲LAUNCHER AREA CONTAINS 84 LAUNCHER BUILDINGS WITH HYDRAULIC LAUNCHER SYSTEMS IN EACH BLDG.

SOURCE: McGUIRE AFB INSTALLATION DOCUMENTS

Source Phase I Report
From ESI Report

FIGURE 1-3 LOCATION OF ALL POTENTIAL SOURCES OF CONTAMINATION AT THE BOMARC MISSILE SITE RECEIVING PHASE I HARM SCORE RANKINGS centrate on the sites numbered 1 through 8, and Site 14, in Table 1-1.

From the Phase II Pre-Survey Report nine areas were identified to require confirmatory investigations. One of these areas includes four adjacent landfills which are treated in the Phase II investigation as one site. The following listed sites, illustrated in Figure 1-4, comprise the sites evaluated during the Phase II Stage 1 Study:

- Zone 1, Landfill 4 (Site No. 1), Landfill 5 (Site No. 9), and Landfill 6 (Site No. 11), and (Site No. 12) the Wastewater Treatment Plant Sludge Disposal Area.
- Site 2, Landfill 2.
- Site 3, Landfill 3.
- Site 4, BOMARC Missile Site, JPX Discharge Pit.
- Site 5, Pesticide Wash Area.
- Site 6, DPDO Storage Facility.
- Site 7, Fire Training Area No. 1.
- Site 8, Bulk Fuel Storage Area.
- Site 14, Civil Engineering Compound Drum Burial Site.

The following text provides a brief history and description of each site.

1.3.1 History and Description of Zone 1

The disposal sites comprising Zone 1 lie to the east of Primary Runway 24 near the Base wastewater treatment plant, as shown on Figure 1-4. Figure 1-5 depicts the Zone 1 landfills which border the installation boundary to the east along Browns Mills Road. The zone is dissected and drained by South Run Creek, which flows southeasterly off the installation boundary after receiving the McGAFB wastewater treatment plant discharge immediately north of Browns Mills Road.

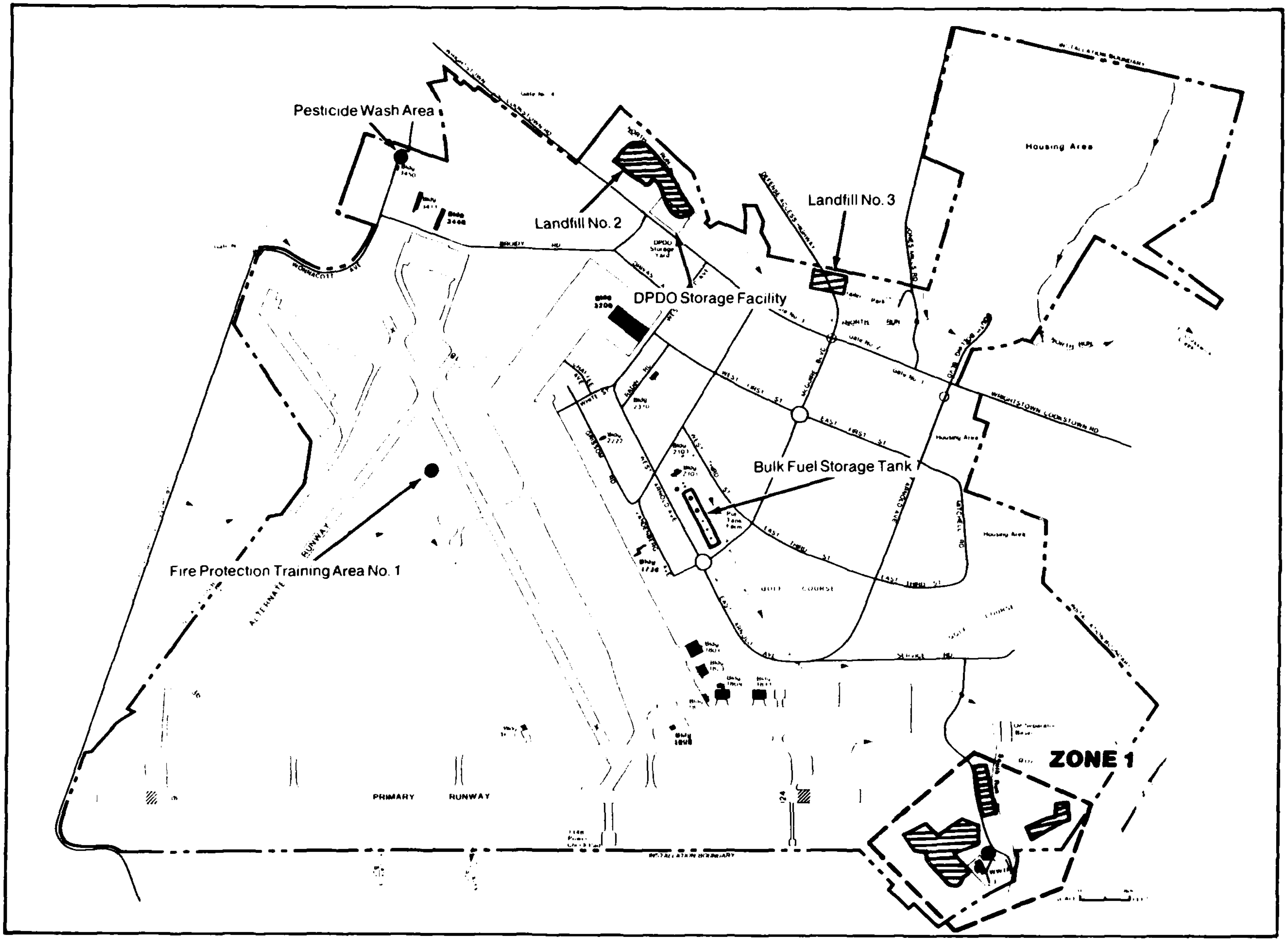
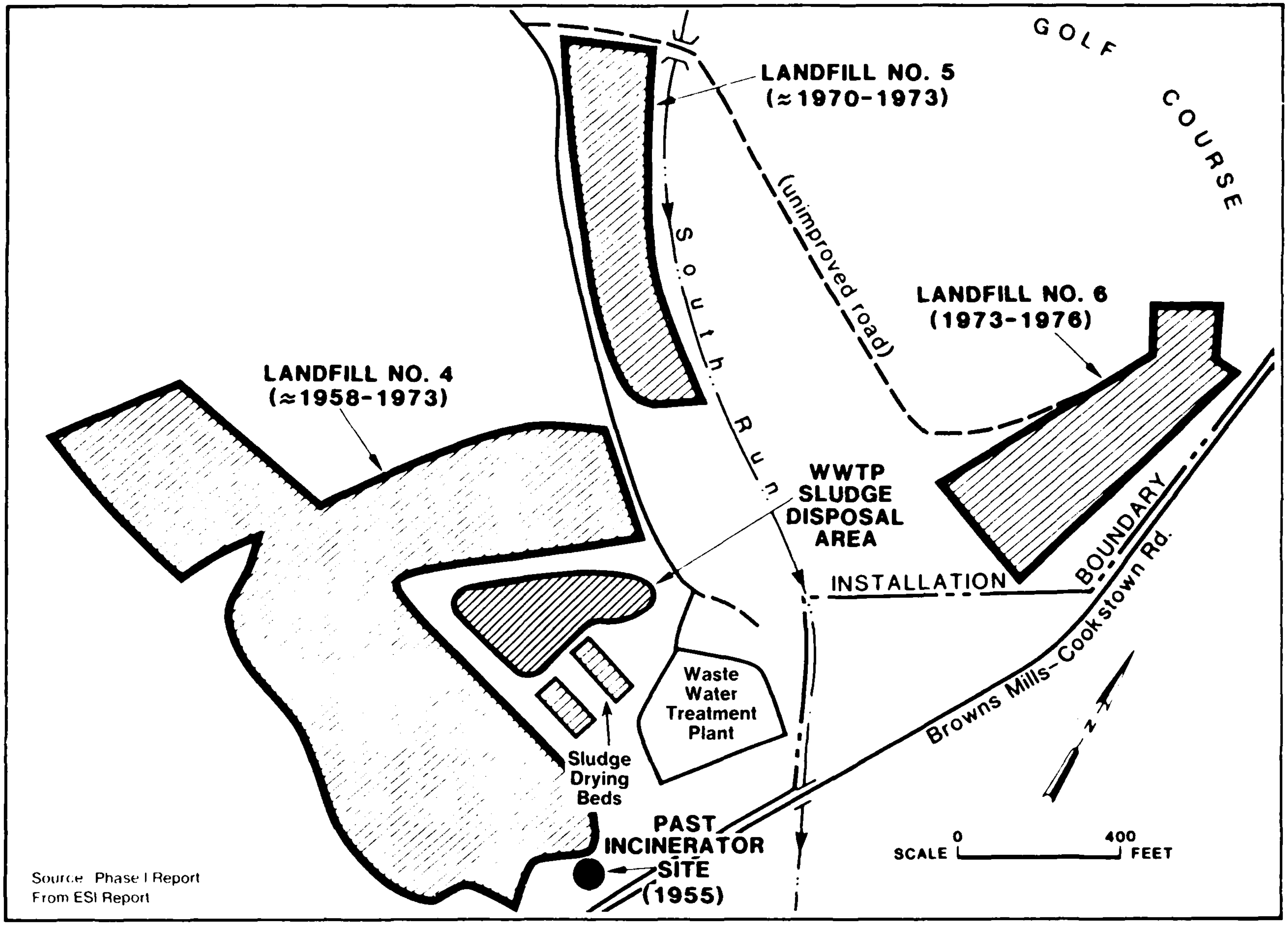


FIGURE 1-4 LOCATION OF ALL PHASE II SITES AT McGUIRE AFB



Source: Phase I Report
From ESI Report

FIGURE 1-5. GENERAL SITE MAP FOR ZONE 1 LANDFILLS

1.3.1.1 Site No. 1, Landfill No. 4

Landfill No. 4 is a long, irregularly T-shaped 18-acre site located to the south of South Run, as shown in Figure 1-5. Disposal operations began in this area about 1958 and continued to the early 1970's. Fill operations began in the southernmost section of the landfill (now a portion of the EOD training area), then expanded to the west toward the main runway. By 1968, the section west of the wastewater treatment plant was actively used for landfilling. The landfill was operated primarily in a trench and fill manner. Reportedly, trenches were approximately 15 feet deep and extended into the water table, which occurs less than 5 feet from the surface. No burning occurred in this landfill. Wastes which were cited as being disposed within this area included general refuse, coal ash and miscellaneous industrial chemicals, some in 55 gallon drums. A few empty 55 gallon drums were observed in a drainage swale which partially incises a portion of the landfill. The site has been closed; however, furrows in the land are still evident indicating the location and orientation of the trenches. The site has been covered with a sandy soil supporting local grasses. During wet periods leachate has emerged along the northern side of the landfill bordering the access road. Iron staining is evident next to and on the road surface.

1.3.1.2 Site No. 9, Landfill No. 5

Landfill No. 5 was operated from about 1970 to 1973, simultaneously with the latter phase of Landfill No. 4 activity. The approximately three acre landfill comprised a long narrow parcel located between the access road and the bank of South Run Creek (Figure 1-5). This landfill was primarily used for the disposal of coal ash, wood and metal wastes; however, it was indicated by landfill personnel that waste chemical compounds occasionally may have been disposed of in this landfill. Waste materials were routinely burned to reduce volume. The site has been covered with sandy soil and presently supports grass and shrub vegetation. The landfill surface is soft and uneven. The toe of the landfill drops steeply to within a few feet of South Run which lies about 15 feet below the surface of the landfill.

1.3.1.3 Site No. 11, Landfill No. 6

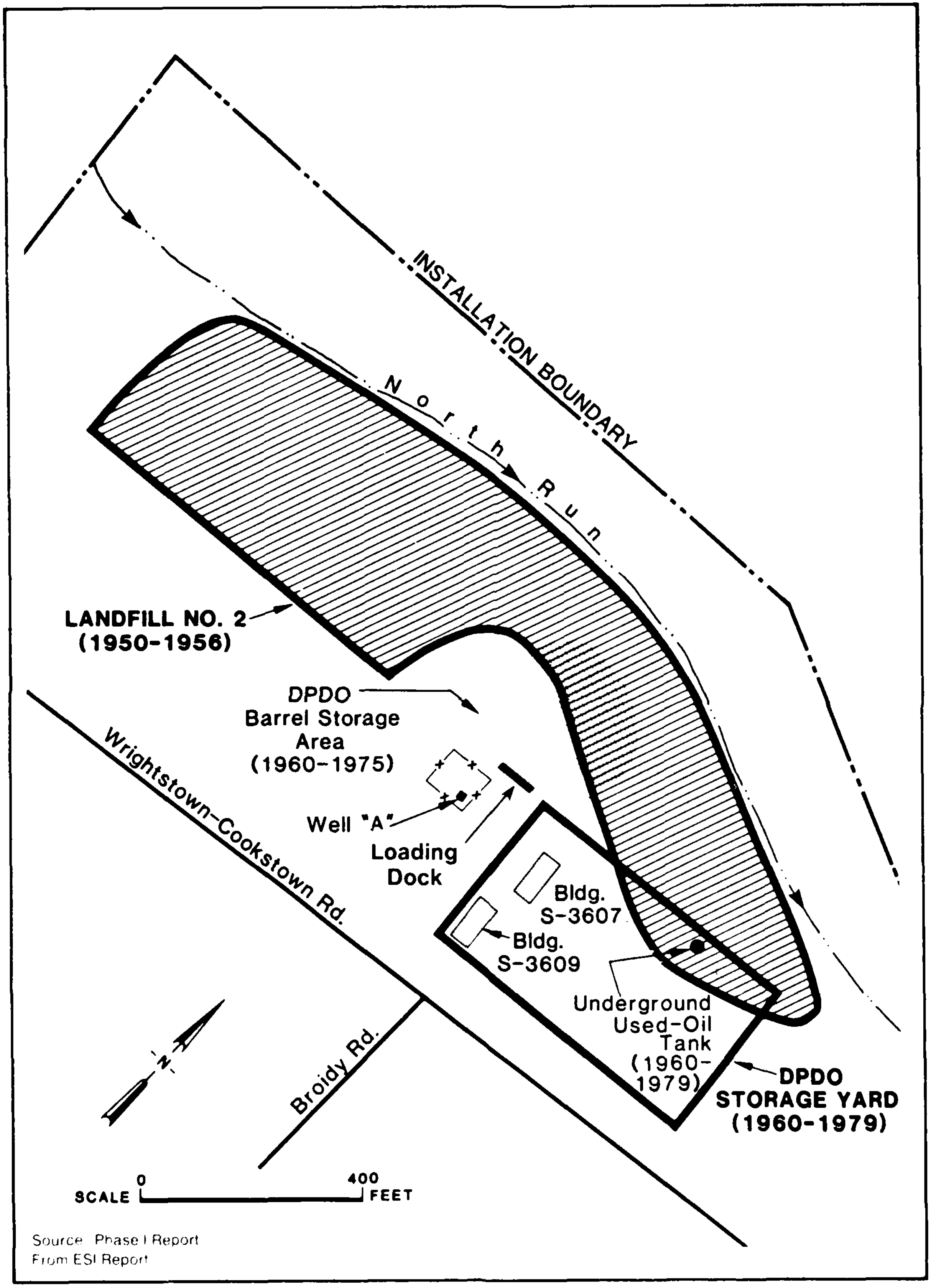
Landfill No. 6 was the most recent landfill operated at McGuire AFB. Operation of the landfill occurred between 1973 and 1976. The landfill covers approximately 4.5 acres situated on the north side of South Run along the eastern boundary of the Base (Figure 1-5). Landfill operations involved trench and fill techniques. The depth of the trenches was estimated at fifteen feet and was described to have extended into the water table. The landfill was primarily used to dispose of general refuse generated on the Base. Standard sanitary landfill practices were employed, and no burning was permitted. During the period when Landfill No. 6 was active, there were several programs established to collect and dispose of hazardous industrial chemicals. Therefore, there is little likelihood that significant quantities of industrial chemicals were disposed of in this landfill. The area was used from 1976 to 1981 as a Civil Engineering storage area for various types of equipment and materials. At the time of the Phase I site visit in August 1982, a project was underway to add additional cover to the landfill. The site is now level with a significant amount of exposed soil and only sparse vegetation along its fringes. Extensive erosion gullies are forming along the southern end of the site.

1.3.1.4 Site No. 12, Sewage Treatment Plant Sludge Disposal Area

Sludge from the wastewater treatment plant is anaerobically digested then dewatered in sludge drying beds. Between 1970 and 1980, a sludge disposal area located to the northwest of the sludge drying beds was used to dispose of excess sludge (Figure 1-5). In 1981, a portion of the sludge disposal area was closed and the sludge was hauled to the Fort Dix landfill. A large mound of sludge still remains in the area, and is presently covered with dense vegetation.

1.3.2 History and Description of Site No. 2, Landfill 2

As shown on Figure 1-4, Landfill 2 is located at the northwest boundary of the installation between Wrightstown Road and North Run. The site, shown in detail on Figure 1-6, covers approximately 11 acres of land that lies on the north side of the Base. The DPDO area is adjacent to, and may partially cover Landfill 2. The landfill was open from around 1950 to 1956, during which time all wastes generated at the installation were disposed of at the landfill. Disposal procedures included trench and fill methods with burning to reduce volume. Trenches were reportedly dug to the water table, were 20 feet wide, 300 feet long and oriented north-south. Wastes disposed of in Landfill 2 may have included waste oil and industrial chemicals, according to the Phase I report.



Source: Phase I Report
From ESI Report

FIGURE 1-6 GENERAL SITE MAP OF LANDFILL 2 AND THE DPDO STORAGE AREA

In early 1975, in response to an EPA inspection report, the area was regraded and surface debris was removed or buried. The landfill presently has a cover of sandy soil overgrown with native grasses. The landfill toe abuts the stream and its narrow floodplain. The landfill rises steeply from the floodplain to a height of about 25 feet above the surface of the creek. Tension cracks in the landfill behind the toe slope give evidence of slope instability.

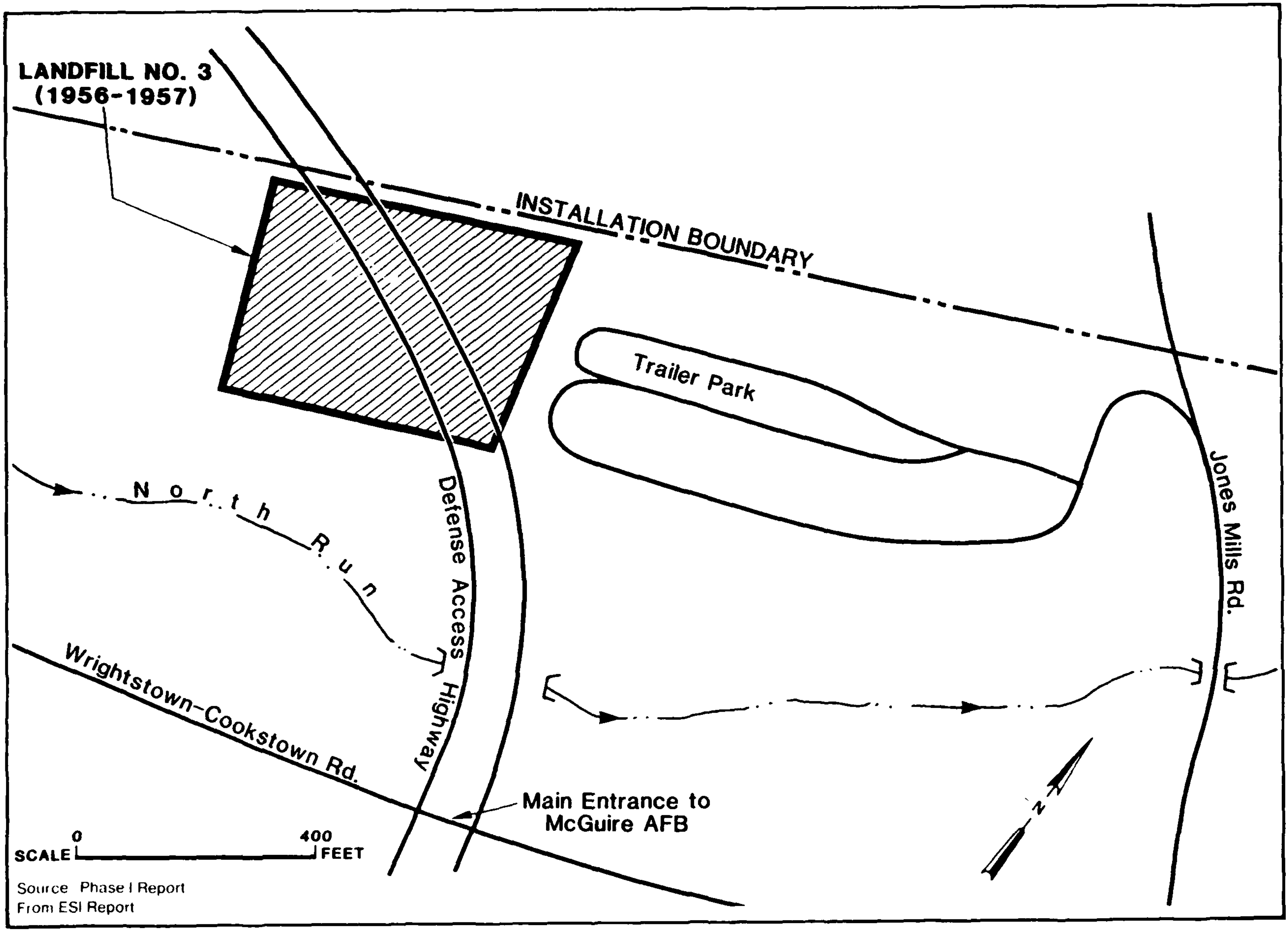
1.3.3 History and Description of Site No. 3, Landfill 3

Landfill 3 is located as shown on Figure 1-4 along the northern installation border to the north of the installation's main gate and North Run. The site covers about 4 acres adjacent to a Base trailer park (Figure 1-7) and is presently bisected by the Defense Access Highway which was installed across the landfill. Landfill 3 was operated between 1956 and 1957 and received general Base refuse as well as miscellaneous industrial wastes of unknown character or quantity. Wastes were reportedly buried in excavations made to the water table approximately 10 feet below land surface. Some of the waste was probably removed during construction of the highway subbase. The area covers both sides of the roadway and is covered with sandy soil vegetated with native grass and small tree cover.

1.3.4 History of Site No. 4, BOMARC Missile Site, JP-X Discharge Pit

The McGuire Missile Site (BOMARC) is located on the Fort Dix Military Reservation approximately 11 miles to the east of McGAFB on the east side of New Jersey Route 539. The site, shown on Figure 1-3, was constructed in the mid 1950's and is on Fort Dix property that has been leased to McGAFB. It was the operational site of the 46th Air Defense Missile Squadron (ADMS) and initially housed 56 liquid fueled BOMARC missiles. In the early 1960's the launch area was expanded and launchers for 28 solid fuel BOMARC missiles were added to the northern end of the launch area. In the early 1970's the missiles became obsolete and the site was deactivated in 1972.

Facilities associated with the missile fueling and defueling activities included fuel storage, spill control and decontamination facilities for the two fuel components used for the liquid fueled missiles. These fuel components were nitric



Source Phase I Report
From ESI Report

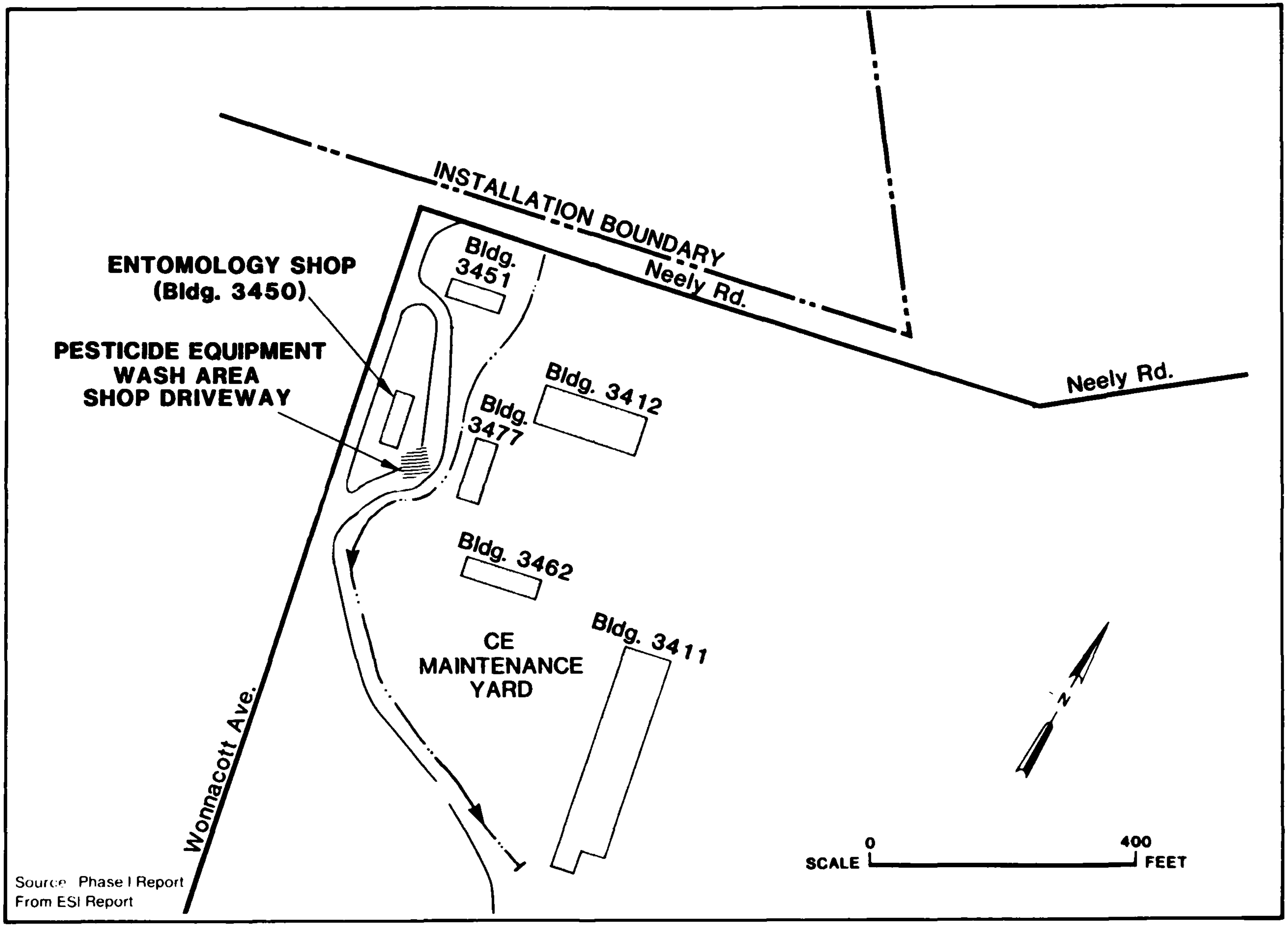
FIGURE 1-7 GENERAL SITE MAP OF LANDFILL 3 acid and JP-X (60% JP-4 and 40% hydrazine). Nitric acid was stored in four tanks located in a below-ground sump adjacent to Building 25. JP-X was stored in six below-ground tanks adjacent to Building 24. Sumps to collect spilled fuels were provided at the fuel transfer stations adjacent to each building. Acid fuel spills were directed to the acid neutralizer, a concrete basin containing lime-rock. The effluent from the acid was pumped to the neutralized acid pit, a brick-lined, 3-foot diameter well which extended at least 20 feet below grade. The base of the well was open and allowed for the percolation of liquid wastes entering the pit. The JP-X fuel spills were directed to a similarly constructed pit located near Building 24 and also allowed to percolate into the ground.

Fueling and defueling the missiles normally occurred in conjunction with most missile maintenance activities. Prior to servicing, a missile would be defueled in the launch area using a fueling vehicle. The fuel was then hauled to the fueling facilities and unloaded into the storage tanks. The missile was then hooked to the fueling facilities and the fuel residues were rinsed out of the missile using hot water for the acid tanks and a soap solution for the JP-X tanks. These rinse solutions were flushed to the respective waste sumps.

1.3.5 History and Description of Site No. 5, Pesticide Wash Area

Since 1974, the Entomology Shop had been located in Building 3450, in the area shown on Figure 1-4, when new procedures were implemented for rinsing spray equipment and empty pesticide containers. Some rinse waters were saved for reuse as makeup water and some were allowed to drain into the sanitary sewer system. Triple rinsing procedures for empty pesticide containers began in the late 1970's. The containers were then punctured and disposed of with general refuse. It has been estimated that approximately 30 to 35 drums and 100 cans per year have been disposed of by the shop. The larger truck-mounted spray equipment has been rinsed on the driveway adjacent to Building 3450. The driveway is situated on a rise which drains toward a small surface drainage ditch (See Figure 1-8).

In March of 1982, the New Jersey Bureau of Pesticide Control conducted an inspection to evaluate the pesticide program at McGAFB. During the site visit, three soil samples were col-



Source Phase I Report
From ESI Report

FIGURE 1-8 GENERAL SITE MAP OF THE PESTICIDE WASH AREA AND CIVIL ENGINEERING COMPOUND lected from areas that received runoff from the equipment cleaning operation. The samples were collected from a grassy area located at the bottom of the driveway, the bank of the drainage ditch adjacent to Building 3450 and the sediments within the drainage ditch. The analytical results showed the presence of low to moderate levels (up to 19 ppm) of pesticides with long residual periods. The data indicated moderate levels of DDT-related products in the sediment samples collected from within the ditch. All of the samples showed the presence of chlordane. The samples collected from the bottom of the driveway and the bank of the drainage ditch also contained low levels of dieldrin. Since 1974, most pesticides used on the base have been stored in a separate room within Building 3450.

1.3.6 History and Description of Site No. 6, DPDO Storage Facility

The Defense Property Disposal Office is located north of Wrightstown Road, adjacent to Landfill 2 as shown in Figure 1-4. The site, shown on large scale on Figure 1-6, consists of a fenced area of approximately four acres containing storage and administrative buildings and a storage yard. Outside the northwest corner of the site is an abandoned earth ramp truck loading dock. To the west of the DPDO area is the installation's production well "A." The DPDO has arranged for the disposal of used petroleum products, out-of-service transformers, and most hazardous wastes for both McGAFB and Fort Dix.

Prior to disposal, waste materials have been held at or adjacent to the DPDO area. The used petroleum products disposed of through DPDO have included used oils, fuels, hydraulic fluid and spent solvents. Until 1979 these products were collected and held at DPDO prior to contractor disposal. Storage was either in a 10,000-gallon underground holding tank within the DPDO area or in barrels in a separate storage area behind the loading dock (Figure 1-6). This area is northwest of the DPDO yard above closed Landfill No. 2. In 1975 the barrel storage area was relocated inside the DPDO storage yard (fence area). Use of the holding tank was terminated in 1979, and since that time used oils generated at McGAFB have been primarily stored in a 25,000-gallon underground tank near Building 1736 (Tank B-7). Several smaller used oil storage tanks located throughout the base have also been utilized.

Out-of-service transformers were temporarily held prior to disposal in the DPDO area until 1978. Approximately 30 to 40 transformers were stored at DPDO and reportedly there was leakage from these transformers. In 1978, out-of-service transformer storage was relocated to the CE service yard located behind Building 3411. Since 1981, the PCB transformers have been stored in the hazardous waste storage area, Facility 2310.

1.3.7 History and Description of Site No. 7, Fire Training Area 1

The Fire Department has operated three fire training areas since the activation of McGAFB. From the late 1940's until 1958, the Fire Department conducted fire protection training exercises at Fire Training Area 1 located within the runway triangle northwest of the hazardous cargo parking pads (Figure 1-4).

The site is located within a small topographic depression. Close examination of the area detected discolored charred soils with pods of fuel residues scattered on the surface. Grasses now cover the entire site. During the period the site was in use, various types of combustible waste chemicals generated at the Base were burned during training exercises. The combustible materials included waste oils, waste Avgas and jet fuel, hydraulic fluid, spent solvents and alcohols. The combustible waste materials were brought to the area in 55 gallon drums and stacked temporarily until the contents of the drums could be burned. The burn area did not have a liner system nor was there any pre-application of water to retard the percolation of the waste chemicals into the soil. The extinguishing agents used during that period included CO_2, protein foam and water.

Aerial photographs available for the site from 1952 and 1962 show a circular area marking the fire training area's burning pad, as shown in Figure 1-9. The 1962 photograph also shows one large and several smaller dark-stained areas that are probably associated with the temporary storage of combustible waste chemicals. The ground surface at the fire training area slopes gently to the south toward a small stream which is a tributary to South Run Creek.

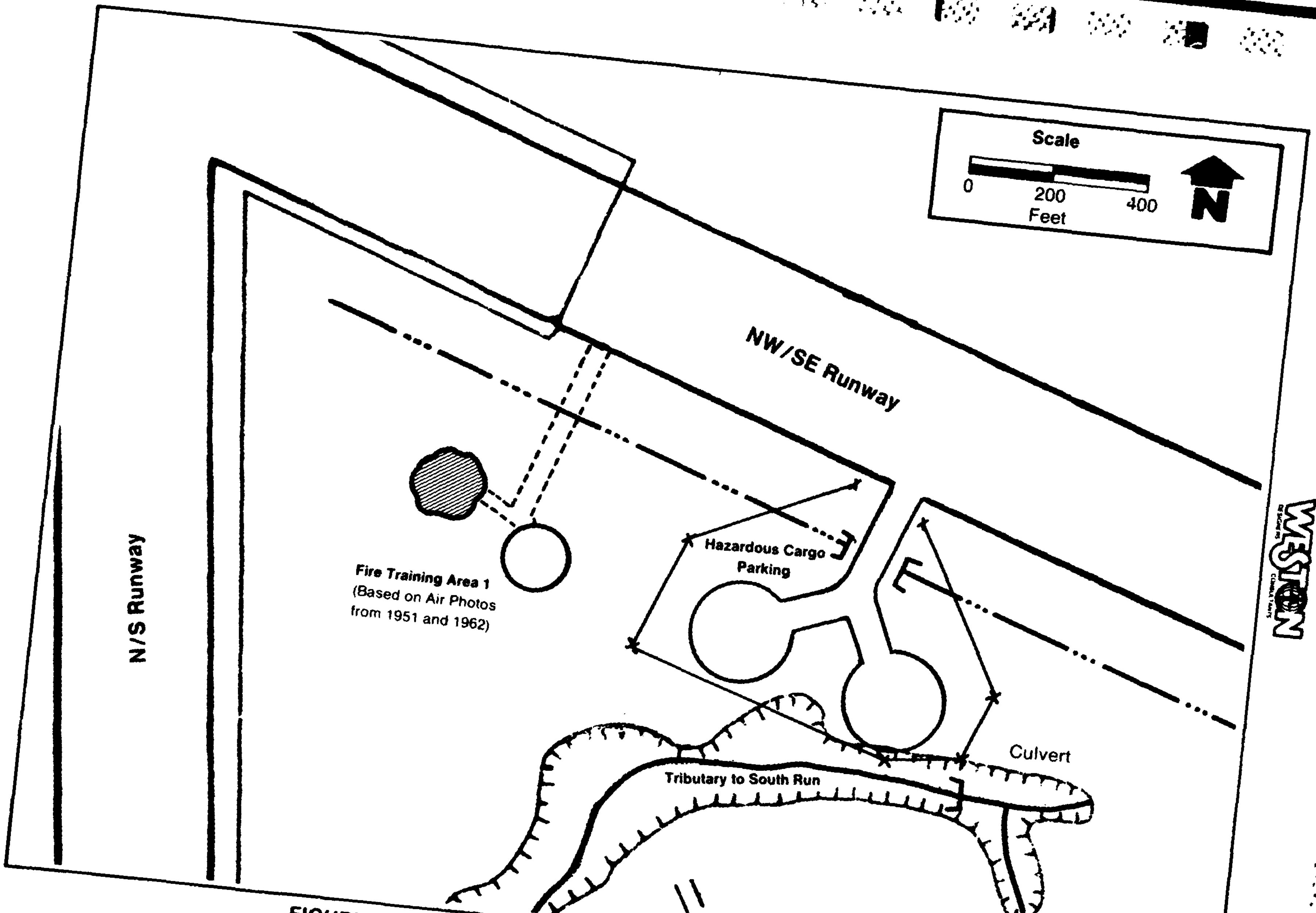


FIGURE 1-9 GENERAL SITE MAP OF FIRE TRAINING AREA I

1.3.8 History and Description of Site No. 8, Bulk Fuel Storage Area

The Bulk Fuel Storage Area, the general location of which is shown on Figure 1-4, consists of eight above-ground storage tanks located to the north of the runway triangle and south of South Run Creek. Figure 1-10 is a map of Site No. 8 showing the site layout. The petroleum, oil and lubricants (POL) tanks have been in service since 1963. The tanks in this area are surrounded by asphalt covered earthen dikes. The tanks were initially used to store Avgas, JP-4 and fuel oil. Subsequently, the Avgas storage was phased out and additional storage allocated to JP-4.

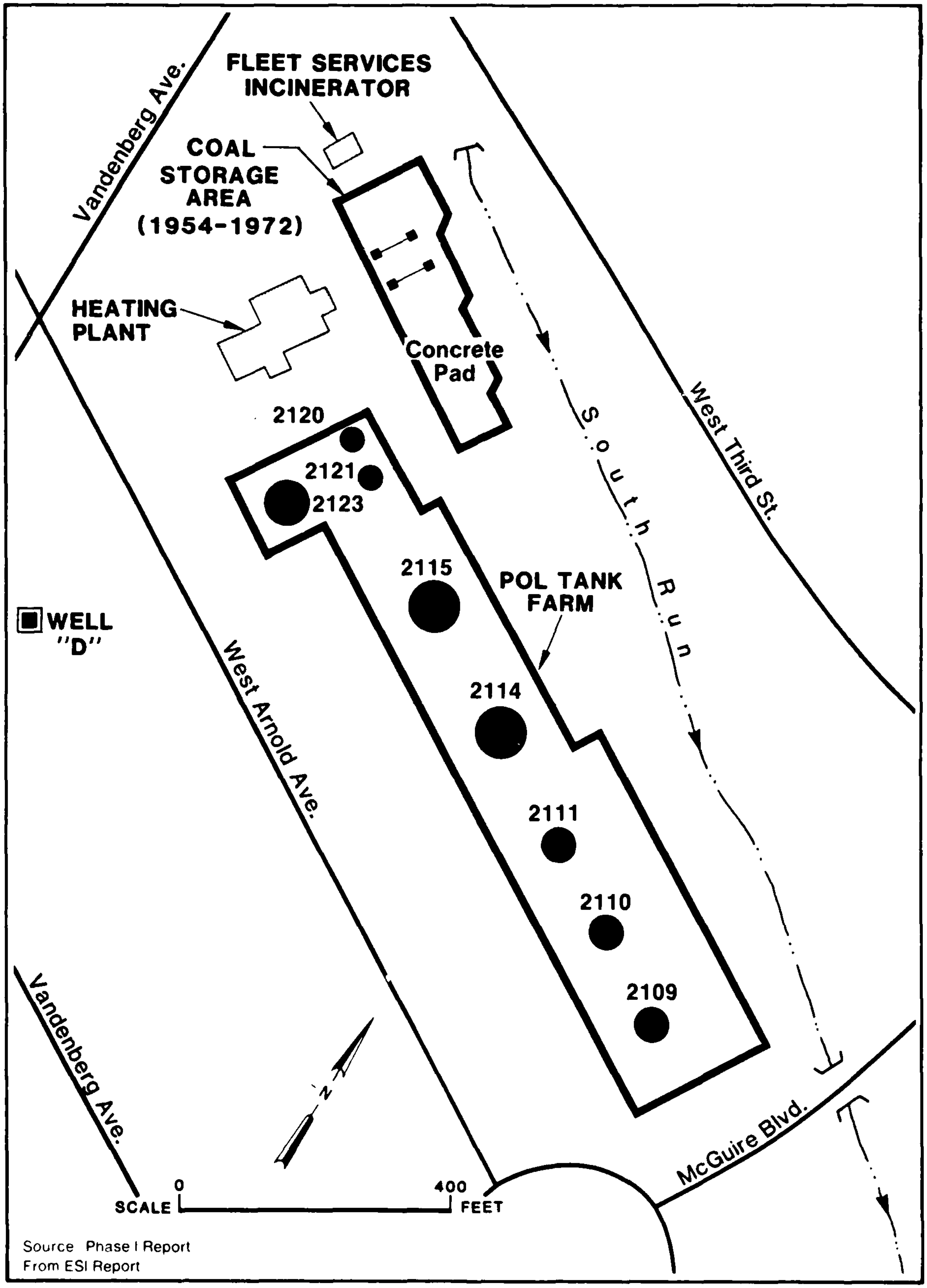
Fuel storage tanks are cleaned about every three years. In past years fuel sludges accumulating on the bottoms of the storage tanks were buried within the fuel tank dikes. Holes were dug in the floor of the diked areas and up to 2,000 gallons of fuel sludge were disposed of within these pits. No preliminary weathering was accomplished prior to disposal. Since 1970, the sludge has been weathered and temporarily stored in the waste fuels storage tank prior to contract removal, arranged by DPDO.

1.3.9 History and Description to Site No. 14, Civil Engineering Compound Drum Waste Burial Site

The Civil Engineering Compound is located to the north of the runway triangle adjacent to the Civil Engineering Building, as shown on Figure 1-4. The area is fenced and covers approximately 2 acres. As shown in Figure 1-8 the area now contains several buildings, is asphalt paved and serves as a storage area for equipment and vehicles.

A drummed-waste burial area is suspected to exist under the paved lot of the Civil Engineering compound. Around 1950, approximately fifty 55-gallon drums containing heavy waste oils were reported by an equipment operator to have been buried about 6 feet below the surface. It is not known if these drums were later removed or if they are still present.

Aerial photographs taken in 1951 show that the basic site boundaries were established but without the present buildings. In 1951, the site was clearly being used for materials storage and some excavation was going on as evidenced by surface scars and what may be a mound of soil and a pit.



Source Phase I Report
From ESI Report

FIGURE 1-10 GENERAL SITE MAP OF THE BULK FUEL STORAGE AREA

1.4 CONTAMINATION PROFILE

Historically, most of the wastes containing hazardous substances have been generated by industrial aircraft maintenance or overhaul missions. Waste oils and solvents from cleaning and painting operations are the primary wastes of concern. Fuel sludges from storage tanks or tank cleaning operations also were generated in the past and pose a concern. Much of the combustible wastes have either been burned in fire training exercises or disposed of through DPDO.

Prior to 1973 however, quantities of industrial chemicals were probably disposed of in installation Landfills 2, 3 and 4. In addition, chemicals were allowed in the past to enter the soils by storage and burning practices at Fire Training Area 1, equipment washing at the Pesticide Wash Area, and leaking storage containers at the DPDO area. Disposal of sludge from the waste water treatment plant in an unlined landfill may also contribute to the introduction of contaminants to surface and groundwater.

Based on the McGAFB Phase I Records Search the key chemical parameters of potential concern are: volatile organic compounds (VOA), PCB, pesticides, oils and greases and select metals. To develop an initial determination of whether or not past operational and disposal practices have adversely impacted the environment, soils, and groundwater and surface water in and around the four sites were sampled and analyzed for the parameters listed in Table 1-2. The details of the field work accomplished are described in Section 3 of this report.

1.5 PROJECT TEAM

The Phase II Confirmation Study at McGAFB was conducted by staff personnel of Roy F. Weston, Inc. and was managed through WESTON's home office in West Chester, Pennsylvania. The following personnel served lead functions in this project:

MR. PETER J. MARKS, PROGRAM MANAGER: Corporate Vice President and Manager of Laboratory Services, Master of Science (M.S.) in Environmental Science, 18 years of experience in laboratory analysis and applied environmental sciences.

MR. FREDERICK BOPP, III, PH.D., P.G. PROJECT MANAGER: Doctor of Philosophy (Ph.D.) in Geology and Geochemistry, Regis-

TABLE 1-2 ANALYTICAL PROTOCOL

Site	Potential Contaminant	Medium	Analytes
Zone 1 (Landfills 4,5,6 and Sludge Disposal Site)	Industrial chemicals and heavy metals	Water	TOX, TOC, oil and grease cyanide, phenol, copper, cadmium, chromium, lead, arsenic and nickel
Landfill 2	Industrial chemicals	Water	
Landfill 3	Industrial chemicals	Water	
Bomarc Site Fuel Handling Area	Waste Fuel products	Water	TOC, oil and grease hydrazine and nitrates
Pesticide Wash Area	Pesticides	Water and Soil	Aldrin, Dieldrin, Chlordane DDT isomers, Endrin Heptachlor, Heptachlorepoxide, BHC Compounds, Methoxychlor
DPDO Storage Area	Spent Solvents and PCB's, waste oils	Soil	Oil and grease, PCB
Bulk Fuel Storage Area	Petroleum Products	Water	Oil and grease, TOC, TOX Cadium, chromium, lead and nickel
Fire Training Area	Waste petroleum products and spent solvents	Water	TOC, TOX, oil and grease

tered Professional Geologist (P.G.), over 8 years of experience in hydrogeology and applied geological sciences.

MR. RICHARD C. JOHNSON, PROJECT GEOLOGIST: Master of Arts (M.A.) in Geological Sciences, seven years experience in geotechnical engineering and hydrogeology.

MR. WALTER M. LEIS, P.G., GEOTECHNICAL QUALITY ASSURANCE OFFICER: Corporate Vice President and Manager of the Geosciences Department, M.S. in Geological Sciences, Registered Professional Geologist, over 10 years of experience in hydrogeology and applied geological services.

MR. JAMES S. SMITH, PH.D., LABORATORY QUALITY ASSURANCE OFFICER: Ph.D. in Chemistry, over 16 years of experience in laboratory analysis.

MR. THEODORE F. THEM, PH.D., PROJECT CHEMIST: Ph.D. in Analytical Chemistry, over 10 years of experience in laboratory analysis.

Professional profiles of these key personnel, as well as other project personnel are contained in Appendix C.

1.5.1 Subcontracting

The drilling and well installation work of this project was performed by Empire Soils Investigations, Inc. of Edison, New Jersey. The well elevation survey was completed by Richard A. Alaimo Associates, Consulting Engineers of Mt. Holly, New Jersey, and licensed New Jersey surveyors.

1.6 FACTORS OF CONCERN

Several factors of concern should be highlighted at the outset of this Confirmation Study Report which the reader should consider in the review of the following sections:

- McGuire AFB overlies permeable unconsolidated sediments of the Cohansey and Kirkwood Formations which form a water table aquifer in the area. Although most domestic and industrial water is presently derived from the deeper confined Raritan-Magothy aquifer, the shallow unconfined aquifer is high yielding and of good quality. This water resource could be exploited in the future. Of more immediate concern is the fact that the water table aquifer provides base-flow recharge to local streams in the McGAFB area. Since several streams flow through McGuire AFB, contaminants reaching the groundwater table at the Base could reach surface waters and, thereby, migrate off-site in a relatively short time.

Most of the sites included in this investigation are located close to surface streams which eventually drain off-base. All of the landfills are located adjacent to major streams and near Base boundaries, thus limiting the available buffer zones and increasing the potential for dispersion off-base.

SECTION 2

ENVIRONMENTAL SETTING

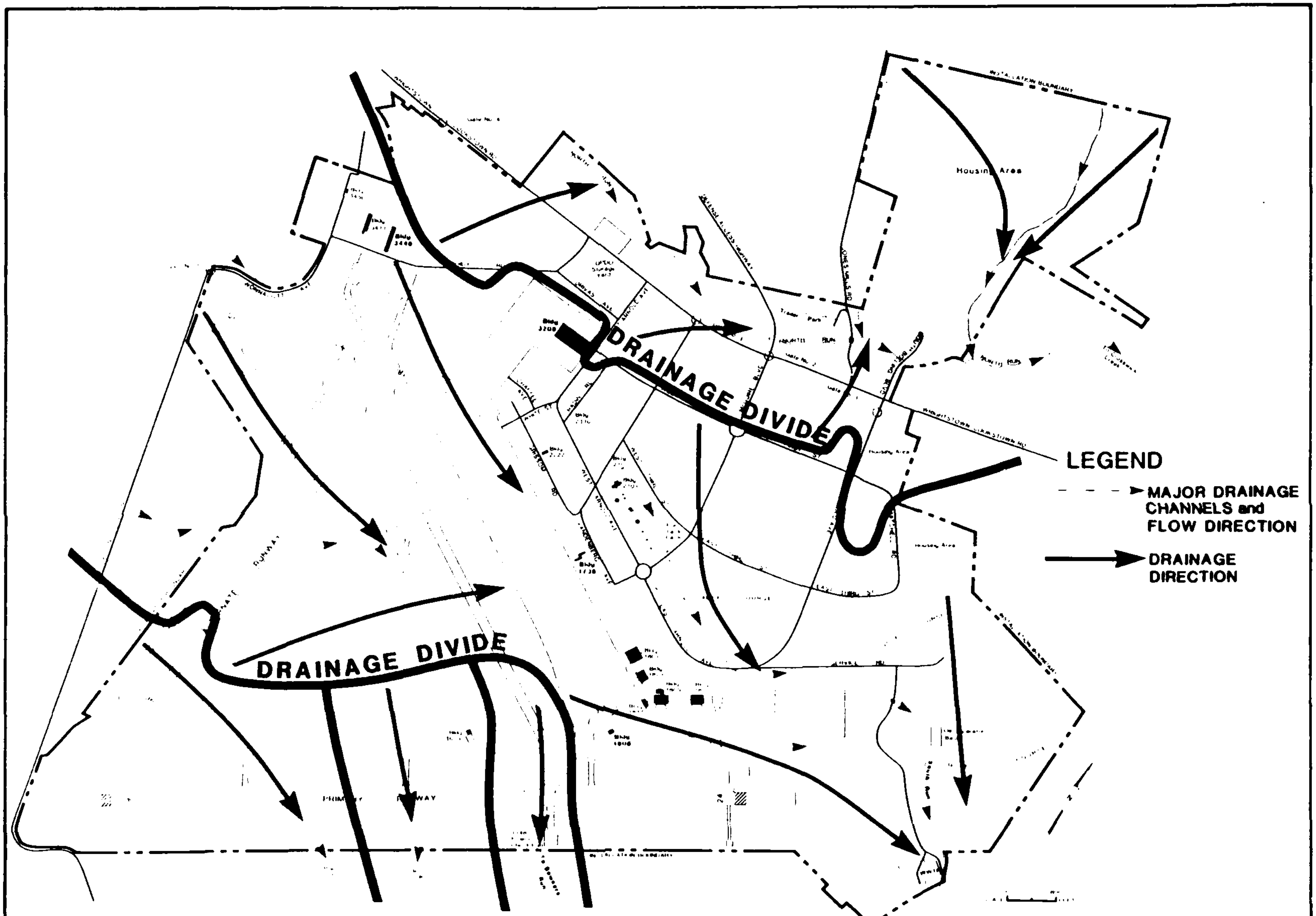
2.1 GEOGRAPHY

McGuire Air Force Base is located along the southern boundary of the inner coastal plain section of the Atlantic Coastal Plain Physiographic Province. This physiographic division, characterized by low dissected hills and broad sandy plains, occurs in a narrow belt some ten to twenty miles wide and extends northeasterly along the southern Delaware Valley to the Raritan Bay. The major topographic features of the inner coastal plain include nearly level plains, gently rolling uplands, extensive surficial dissection, mature streams and swampy areas. The topography at McGAFB ranges from generally level to gently rolling in appearance. Local relief is primarily the result of dissection by erosional activity or stream channel development. Surface elevations at McGAFB range from a low of 80 feet above mean sea level (MSL) along the South Run stream channel to 144 feet MSL at the southwest Base boundary. The north portion of the Base drains to the North and South Runs of Crosswicks Creek. The south and east sections of the Base drain to Bowker's Run, Jack's Run and Larkin's Run, all of which are tributaries of Rancocas Creek. Figure 2-1 depicts the major drainage patterns at McGAFB. Locally, drainage is predominately to the southeast or northeast.

2.2 SITE GEOLOGY

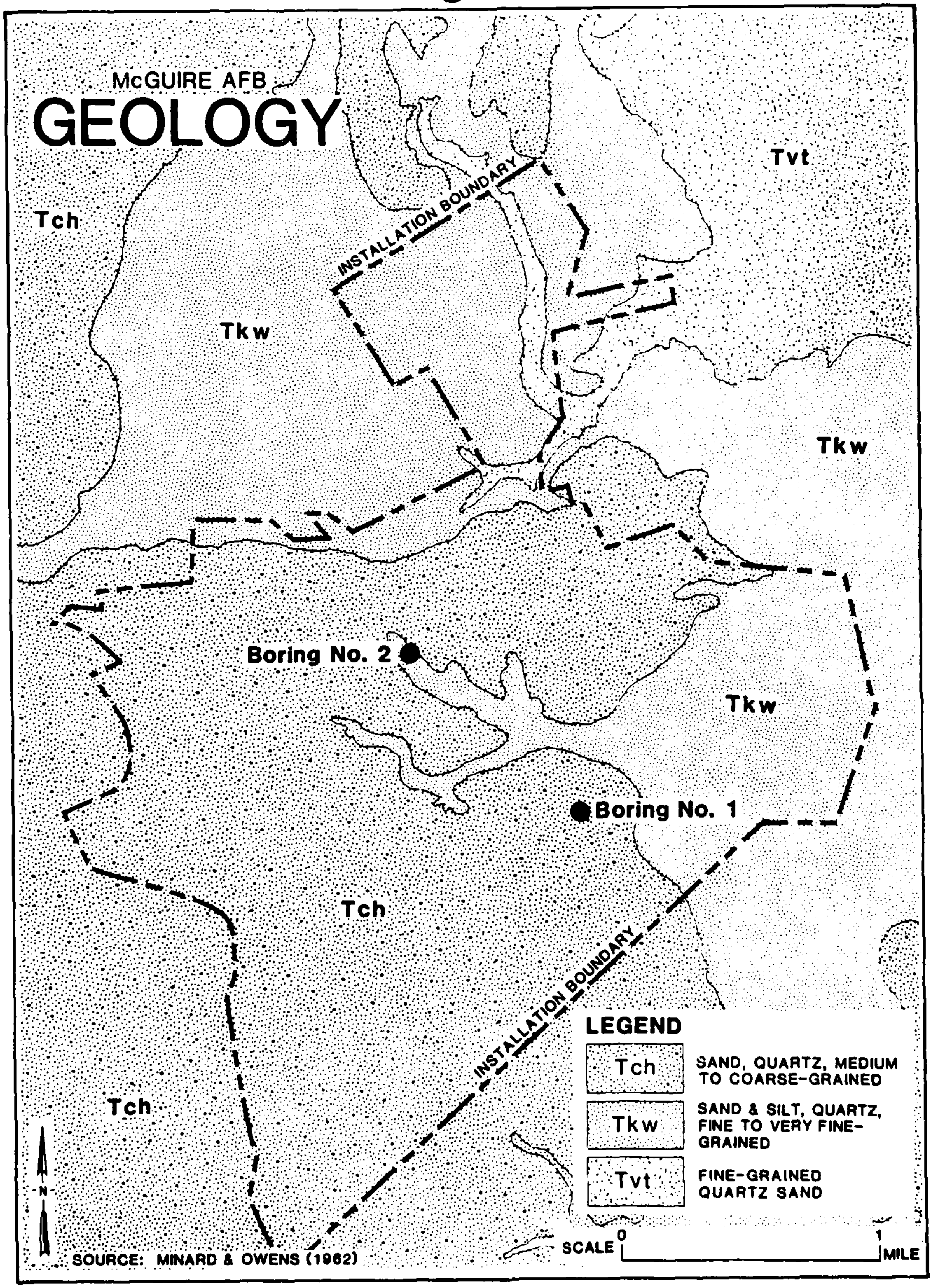
Geologic units ranging in age from Cretaceous to Quaternary have been identified in the New Jersey Coastal Plain. These units are typically unconsolidated materials consisting of gravel, sand, silt, clay, glauconite, marl and organic materials, reposing on a Pre-Cambian/Lower Paleozoic crystalline basement complex. Coastal Plain sediments form a southeasterly dipping wedge thickening to the southeast, with individual geologic units tending to thicken downdip and possessing an average unit dip ranging from 10 to 45 feet per mile.

The geology of McGAFB is dominated by interbedded continental and nearshore marine sands and clays of the Cohansey (Tch), Kirkwood (Tkw) and Vincentown (Tvt) Formations. The surficial geology of McGAFB is illustrated on Figure 2-2. The Kirkwood and Vincentown stratigraphic units reach a combined maximum thickness of approximately 50 feet in the



Source: McGuire AFB Installation Documents Phase I Report

FIGURE 2-1 PRINICIPAL DRAINAGE PATTERNS AT McGUIRE AFB



SOURCE: MINARD & OWENS (1962)

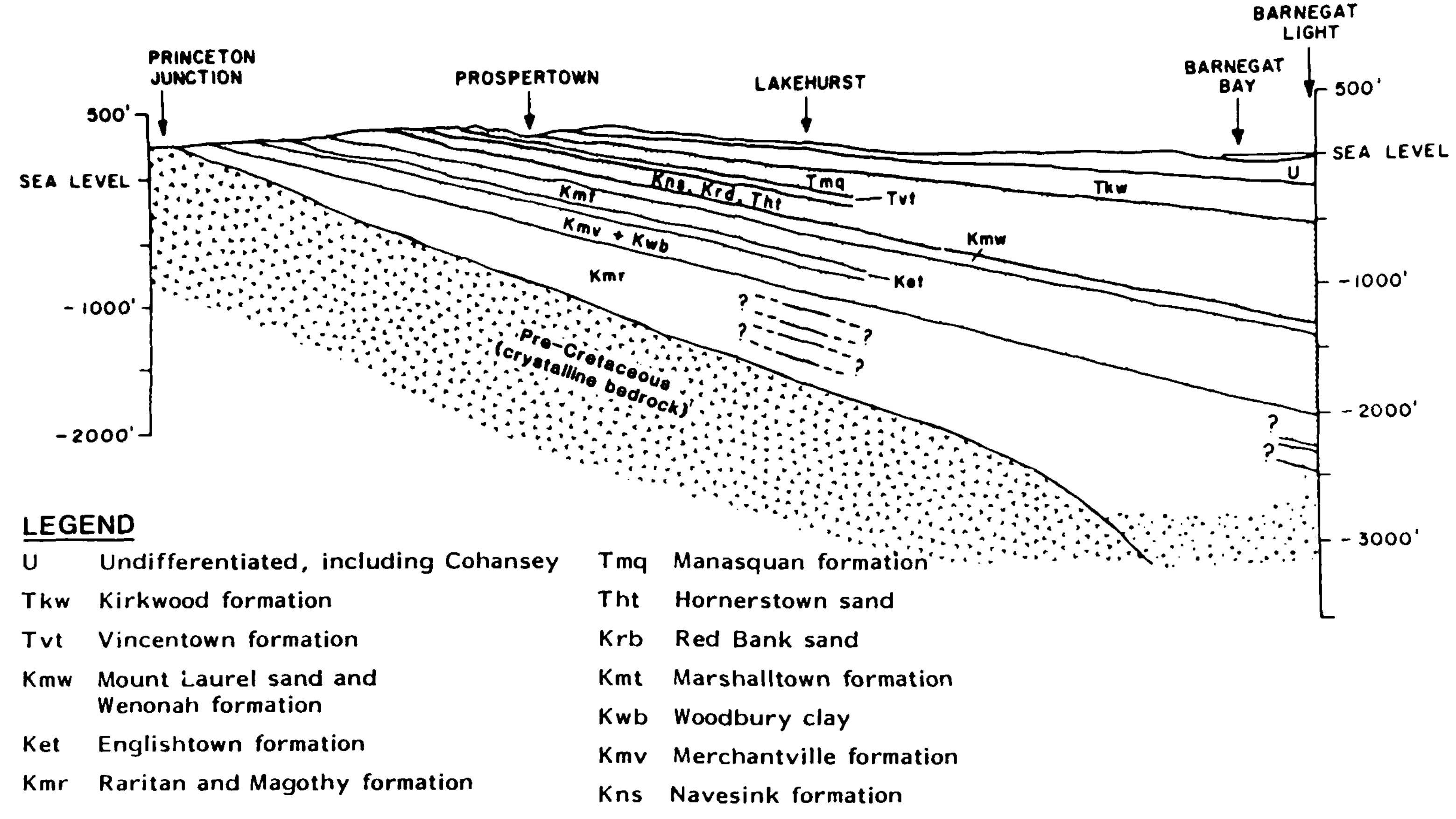
FIGURE 2-2 SURFICIAL GEOLOGY OF McGUIRE AFB general area of McGAFB. The Cohansey forms a thin veneer over much of the Base, which is in hydraulic connection with the underlying Kirkwood Formation. The Cohansey, Kirkwood and Vincentown Formations are of hydrogeologic interest because they occur at or near ground surface in the vicinity of McGAFB. These hydrogeologic units are, generally, permeable and relatively thin. The Cohansey consists of coarse to medium sands which overlie the fine to medium sands and clay interbeds of the Kirkwood Formation.

2.3 HYDROGEOLOGY

Ground water occurs at shallow depths (<10 feet) in the shallow units under water table (unconfined) conditions. Artesian or semi-artesian conditions may occur locally. The Cohansey and Kirkwood are hydraulically connected locally. The Vincentown contains water in localized water-bearing beds that may yield small to moderate quantities of water to wells screened within them.

Recharge of the Cohansey and Kirkwood Formations occurs primarily by direct precipitation in the outcrop area. Most of the land area of McGAFB is situated in the Cohansey-Kirkwood recharge zone. Once water enters the hydraulic regime, it flows under water table conditions toward zones of decreasing hydraulic head. The shallow water table system possesses fairly short flow paths. Under normal climatic conditions and typical hydraulic gradients, the flow rate in the shallow water table is estimated to be on the order of four feet per day. Water detention time for the Cohansey-Kirkwood is not expected to exceed five years. It has been estimated that 85 percent of the precipitation which infiltrates to the surficial aquifer system follows the shallow flow path and is discharged to a surface water body as base flow (N.J. Pinelands Commission, 1980).

The Potomac-Raritan-Magothy (Kmr) aquifer system of Lower Cretaceous Age underlies the previously described tertiary deposits at depth. The Kmr is regional in extent and is the primary source for potable water supplies in the Base area. This unit occurs at an approximate elevation of -450 feet (MSL), and is about 550 feet thick under McGAFB. The Kmr reposes on crystalline basement rock; its upper limit is accepted to be the Late Cretaceous Merchantville Formation and the Woodbury Clay. It thickens to over 2,000 feet in a down dip direction. A generalized section of the formations of the New Jersey Coastal Plain is illustrated in Figure 2-3.



SOURCE: MEANS (1981)

NOTE: Vertical scale greatly exaggerated

FIGURE 2-3 GENERALIZED GEOLOGIC SECTION OF THE NEW JERSEY COSTAL PLAIN

2.4 ENVIRONMENTAL RESOURCES

McGAFB derives its water from four deep wells, all presumably screened into the deep Kmr aquifer system. The locations of these wells are shown on Figure 2-4. Two shallow inactive wells are present at the McGuire BOMARC Missile Site. These wells are reported to be small diameter (six inch) and are apparently screened into the Kirkwood Formation. The adjacent Borough of Wrightstown obtains its municipal water supplies from deep wells screened into the Kmr aquifer system. Due to groundwater withdrawals from this aquifer, not necessarily related to withdrawals at McGAFB, the piezometric surface is over 150 feet below land surface.

The presence of extensive confining formations (the Merchantville and Woodbury Formations) overlying the Kmr system, reduce the probability of the Kmr aquifer becoming contaminated by Base activities. The aquifers of greatest concern at McGAFB are the Cohansey Sand (Tch) and underlying and hydraulically interconnected Kirkwood Formation (Tkw). While, locally, these shallow aquifers are not currently widely used for water supply, their combined potential is immense, and waters from these aquifers are under on-going consideration as supplementary supplies for the Philadelphia and New York metropolitan areas.

The nearby community of Cookstown and other area public water supplies typically derive their water from deep wells penetrating the Kmr. Rural residents generally rely on the shallow water resources derived from overlying formations.

McGuire AFB is located in the northeast corner of a large tract of land classified as the New Jersey Pinelands Area, designated as such by the New Jersey Pinelands Protection Act. The Pinelands Area was designated as the country's first Natural Reserve. The Reserve concept has as its primary goal the management of the lands by innovative means, combining the capabilities and resources of the local, State and Federal governments and the private sector. The main emphasis in the New Jersey Pinelands Comprehensive Management Plan has been the development of programs to safeguard the Pinelands' resources while the land remains in the care of the local people and governmental agencies (Phase I, IRP).

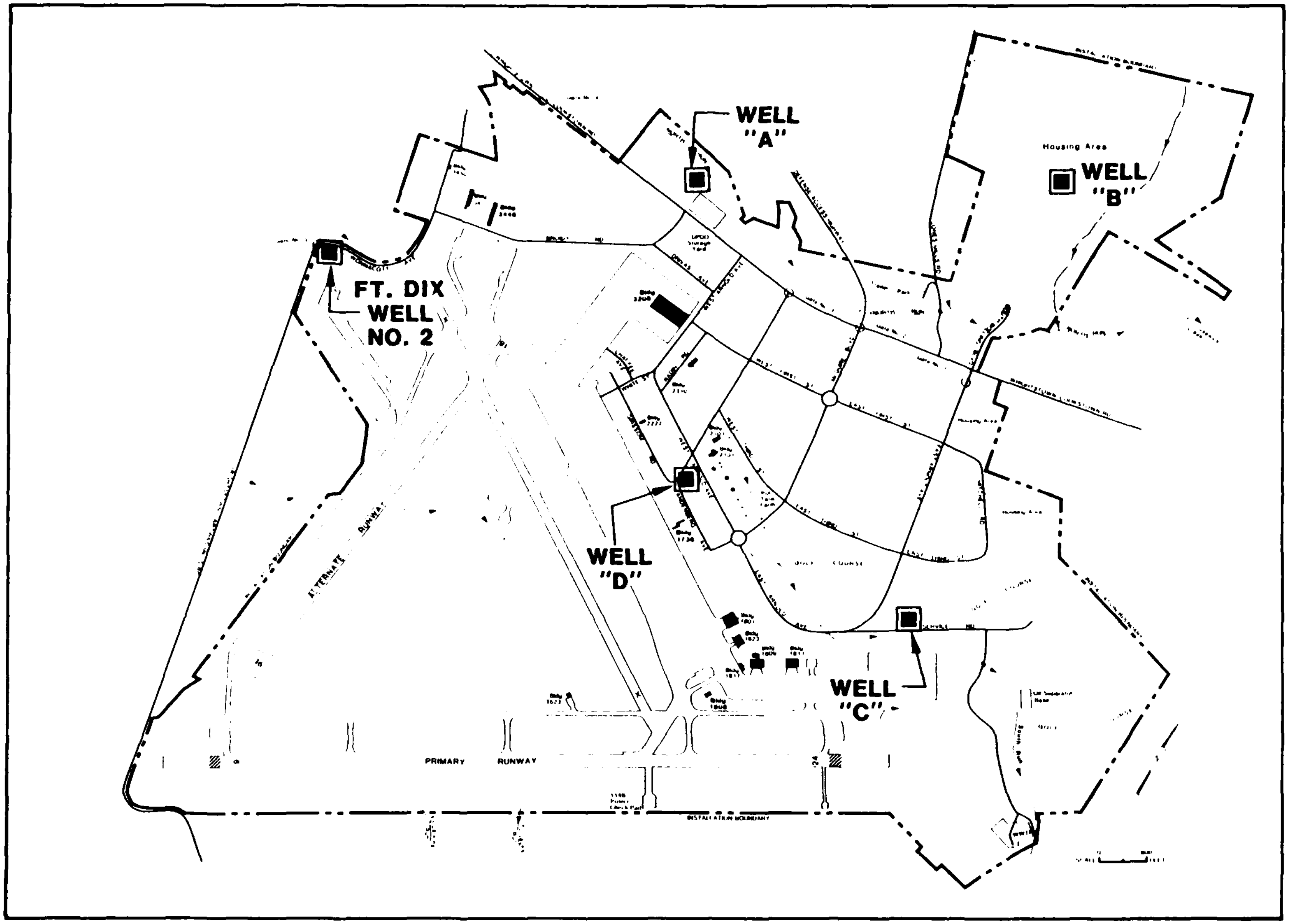


FIGURE 2-4 BASE WELL LOCATIONS AT McGUIRE AFB

SECTION 3

FIELD PROGRAM

3.1 PROGRAM DEVELOPMENT

Task Order 0020 (Appendix B) was issued on the basis of the Phase II Pre-Survey Report. All sites recommended for Confirmation Stage Work in the Phase I Report (ESI) were, in fact, addressed in the Phase II program with modifications incorporated from the Phase II Pre-Survey Report.

The following text discusses the approved field investigation for all nine areas considered in this Phase II Problem Confirmation Stage 1 Study Report.

3.1.1 Zone 1

By design of the Phase II Work Plan developed by WESTON, Zone I included the following individual sites:

- Site No. 1, Landfill No. 4
- Site No. 9, Landfill No. 5
- Site No. 11, Landfill No. 6
- Site No. 12, Wastewater Treatment Plant Sludge Disposal Area

The WESTON Phase II Pre-Survey Report recommended that groundwater monitoring wells be located around all the sites in Zone 1 to detect the overall impact, if any, of the disposal areas on groundwater quality. Since the sites included in Zone 1 are close to one another and overlie the shallow water-table aquifer which discharges to North Run, the monitoring of groundwater flow and contaminant migration was approached on a general area scale. The final approved Scope of Work included the installation of five groundwater monitoring wells located downgradient and between the sites and South Run. These wells would be screened in the upper portions of the shallow unconfined aquifer and intercept any contaminants migrating towards the stream. A groundwater and surface water elevation survey would be completed to define groundwater flow directions and gradients and relationships between ground and surface waters. A single round of groundwater samples would be taken from the wells for analysis of the parameters shown in Table 1-2.

3.1.2 Site No. 2, Landfill 2

The WESTON Phase II Pre-Survey Report recommended that groundwater monitoring wells be located around Landfill #2 to monitor the impact of that disposal site on groundwater quality. The approved Scope of Work included the installation of three groundwater monitoring wells to be located between Landfill 2 and South Run. These wells were to be screened in the upper part of the groundwater table to intercept contaminants migrating toward the stream. Because the landfill toe extends to the floodplain, access difficulties required that the wells would be set in the landfill itself. In this case the well screens were to be set deep enough to enable the wells to be properly grout-sealed into the sediments below the landfill base.

A groundwater and surface water elevation survey was to be completed to define groundwater flow directions and gradients. A single round of groundwater samples was to be taken from the wells for analyses of the parameters listed in Table 1-2.

3.1.3 Site No. 3, Landfill 3

The WESTON Pre-Survey Report recommended that groundwater monitoring wells be located around the landfill to monitor the impact of the disposal site on groundwater quality. The final approved Scope of Work included the installation of three groundwater monitoring wells between Landfill 3 and North Run. Following the same procedures as the other landfill sites, the wells were to be screened in the upper part of the groundwater table to intercept contaminants migrating toward the stream; groundwater and surface water elevation surveys were to be performed to define groundwater flow directions and gradients. A single round of groundwater samples was to be taken from the wells for analyses of the parameters listed in Table 1-2.

3.1.4 Site No. 4, BOMARC Missile Site JP-X Discharge Pit

The WESTON Pre-Survey Report proposed to install groundwater monitoring wells around the JP-X discharge pit to assess the potential or real impacts of leakage from the pit on groundwater quality. Task Order 0020 approved the installation of two groundwater monitoring wells to be screened in the upper part of the groundwater table. A groundwater elevation survey was to be completed to define the vector of flow between the two wells. A single round of groundwater samples was taken from the wells for analysis of the parameters listed in Table 1-2.

3.1.5 Site No. 5, Pesticide Wash Area

WESTON recommended that soil borings be drilled in the drainage path for the pesticide wash area for the purpose of sampling soils at discrete depth intervals. These soil samples would be analyzed for pesticides to determine whether contamination may have entered the soil and migrated downward toward the water table. The final approved Scope of Work included the completion of two soil borings to the top of the water table. Soil samples were to be taken at depths of two feet, five feet and at the water table. Initially, the two-foot depth samples were to be analyzed. If positive results were found, the deeper samples were to be analyzed iteratively.

Stream water and sediment samples were also to be taken at three locations in the small stream adjacent to the pesticide wash area, one sample location opposite the wash area and two downstream locations.

3.1.6 Site No. 6, DPDO Storage Area

WESTON recommended that soil borings be completed in the vicinity of the underground holding tank and the barrel storage area. Soil samples would be recovered at discrete depth intervals and analyzed for PCB and oil and grease. The final approved Scope of Work included five soil borings to be drilled to the water table. Samples would be taken at depths of two feet, five feet and at the water table. Initially, the two-foot depth samples were to be analyzed for PCB and oil and grease. If results were positive, the deeper samples were to be analyzed iteratively.

3.1.7 Site No. 7, Fire Training Area 1

WESTON proposed in the Pre-Survey Report to install groundwater monitoring wells around the Fire Training Area 1 in order to assess the impact on groundwater quality of contaminants in the soils in that area. The final approved Scope of Work included the installation of two groundwater monitoring wells, to be screened in the upper water table, and to be located between the fire training area and the nearby tributary to South Run. A groundwater and surface water survey would be completed to determine groundwater flow directions and gradients. One round of groundwater samples were to be taken at the wells and samples were to be analyzed for the parameters listed in Table 1-2.

3.1.8 Site No. 8, Bulk Fuel Storage Area

Because fuel oils and associated wastes may be entering the ground at the bulk fuel storage area, WESTON proposed that monitoring wells be located around that facility to identify possible dissolved contaminants, as well as free floating fuel products in the ground water. As part of Task Order 20, two groundwater monitoring wells were to be installed between the tank farm and South Run. These wells were to be screened to above the water table in order to intercept any floating fuel products present. Both wells were to be sampled for the parameters listed in Table 1-2.

3.1.9 Site No. 14, Civil Engineering Compound

Task Order 20 required that a geophysical survey be conducted at the Civil Engineering Compound to determine whether indications exist of subsurface disturbances and waste drum burial sites. To accomplish this, the area was to be marked off in a grid and a combined ground penetrating radar (GPR) and magnetometer survey was to be conducted.

3.1.10 Analytical Protocol

The analytical protocol summarized in Table 1-2 was selected for the nine sites addressed in this Phase II study. The parameters chosen are specific and non-specific indicators of contamination.

3.1.11 Formal Scope of Work

Task Order 0020 formalized the proposed work and is included in this report in Appendix B. Task Order 0020 provided the basis for the implementation of the field program described in the following sections.

3.2 HYDROGEOLOGIC INVESTIGATION

A field investigation has been conducted to define the hydrologic and geologic setting at McGuire AFB and to determine the possible presence of hazardous environmental contaminants that may have resulted from past product storage and handling practices or waste disposal operations at the Base. Information regarding potential or actual impacts of the nine sites on area groundwater was obtained from a total of 17 on-site monitoring wells, seven additional exploratory soil borings, and three surface water and stream sediment sampling locations. During the drilling of monitoring wells split-spoon samples were taken at regular intervals to obtain samples of the unconsolidated sediments in the unsaturated and saturated zones for visual inspection. The wells also provided measuring points for determining groundwater flow gradients and directions in the unconfined, shallow water table at some of the sites. A stream elevation survey provided additional information on the interrelationship between ground and surface waters. The field work is summarized on a site-by-site basis in Table 3-1.

3.2.1 Schedule of Activity

The field investigation at McGuire AFB was commenced on September 20, 1983, and was completed on February 28, 1984. Table 3-2 is a summary of WESTON's field activities schedule at McGuire AFB.

3.2.2 Drilling Program

The field program at McGuire AFB included the installation of 17 groundwater monitoring wells and the completion of seven soil borings to recover subsurface soil samples for chemical analysis. The work was conducted by drilling crews of Empire Soils Investigations, Inc. of Edison, New Jersey. Two drilling rigs were on-site to complete the work. Both were Model CME 55 auger boring rigs. One was mounted on a truck bed and the other was a trailer mounted rig. The latter mount was required for Landfills 2 and 3 where soft ground made access difficult.

Representative soil samples from each sampling interval were taken with split-spoon samplers and standard penetration test (SPT) procedures in accordance with ASTM Test D-1586. During drilling and sampling, boring logs of results were prepared, and these logs are in Appendix D. Samples taken during drilling were preserved in glass jars for later exam-

TABLE 3-1
SUMMARY OF FIELD ACTIVITY

Site	Activity
Zone 1 - Landfills 4, 5, 6 and Sludge Disposal Disposal Area	Install 5 groundwater monitoring wells for TOX, TOC, oil and grease, cyanide, phenol, Cu, Cd, Cr, Pb, As and Ni. Perform well and ground water elevation survey.
Landfill 2	Install 3 groundwater monitoring wells. Sample wells for TOX, TOC, cyanide, phenol, oil and grease, Cu, Cd, Pb, As and Ni. Perform well and groundwater elevation survey.
Landfill 3	Install 3 groundwater monitoring wells. Sample wells for TOC, TOX, cyanide, phenol, oil and grease, Cu, Cd, Cr, Pb, As and Ni. Perform well and groundwater elevation survey.
BOMARC Missile Site JP-X Discharge Pit	Install 2 groundwater monitoring wells. Sample wells for TOC, oil and grease, hydrazine and nitrates.
Pesticide Wash Area	Complete 2 soil borings to water table. Sample soil at 2 ft., 5 ft. and water table. Analyze soil at 2 ft. for pesticides. Perform analyses of deeper soils if results are positive.
	Collect three surface water and sediment samples. Analyze for pesticides.
DPDO Storage Facility	Complete 5 soil borings to water table. Sample soils at 2 ft., 5 ft. and water table. Analyze 2 ft. samples for PCB and oil and grease. Analyze deeper samples if results are positive.
Fire Training Area	Install 2 groundwater monitoring wells. Sample wells for TOX, TOC and oil and grease. Perform well and groundwater elevation survey.
Civil Engineering Compound	Perform a geophysical survey of area using ground penetrating radar and magnetometer to locate possible buried drums.
Bulk Fuel Storage Area	Install 2 groundwater monitoring wells. Sample wells for TOX, TOC, oil and grease, lead, cadmium, chromium and nickel.

TABLE 3-2

FIELD ACTIVITY SCHEDULE

Date	Activity
20 September 1983	Site visit with drilling contractor to locate well and boring sites, and confirm schedule.
3-25 October 1983	Drilling rigs on site. Installation of monitoring wells. Soil borings and soil sampling at DPDO storage area, and Pesticide Wash Area.
28 November - 2 December 1983	Monitor well sampling. Stream water and sediment sampling at the Pesticide Wash Area.
8-9 March 1984	Well evaluation and location survey.

ination. Where soil samples were taken for chemical analyses, specific procedures were followed to ensure sample integrity. These procedures are summarized in Appendix E. At the completion of soil borings where wells were not installed, the bore holes were backfilled with a bentonite-cement grout by pumping the grout through the augers to the bottom of the boring as the augers were withdrawn, and the areas regraded to ensure that the disturbed soils did not become avenues for surface contamination migrating to the groundwater.

3.2.2.1 Monitor Well Construction

The 17 groundwater monitoring wells were installed in selected borings in the following manner. The auger was advanced to the required depth below the water table. Then appropriate lengths of 4-inch diameter, flush-joint, threaded PVC screen and riser pipe were assembled and inserted through the auger. The augers were then withdrawn to several feet above the screen as a sand pack was poured into the annular space around the well screen to the base of the auger. Next, bentonite pellets were placed on top of the sandpack to seal the screened interval from vertical infiltration through the annular space. The seal was completed by pouring a bentonite-cement grout through the augers into the annular space as the augers were withdrawn. Care was taken to prevent collapse of the annular space and to produce a continuous grout seal above the sandpack. Each well was completed with the installation of a 6-inch diameter steel protective casing that was cemented in place over the top of the well seal. A typical well construction diagram is presented in Figure 3-1. Well completion summaries for all monitoring wells are presented in Appendix D. Each well was developed by pumping a minimum of 5 times the volume of standing water in the well casings. No foreign water was introduced into any well during auger drilling or development, and no solvents or glues were used at the casing joints.

3.2.2.2 Zone 1

A total of five groundwater monitoring wells, screened in the upper part of the groundwater table, were installed in Zone 1. The wells, numbered MW-1 through MW-5, were generally located at sites estimated in the field to be hydrologically downgradient of the disposal sites, between those sites and South Run. These locations are shown on Figure 3-2. MW-1, -2 and -3 are located downgradient of Landfill 4 and the sludge disposal site. MW-4 is located at

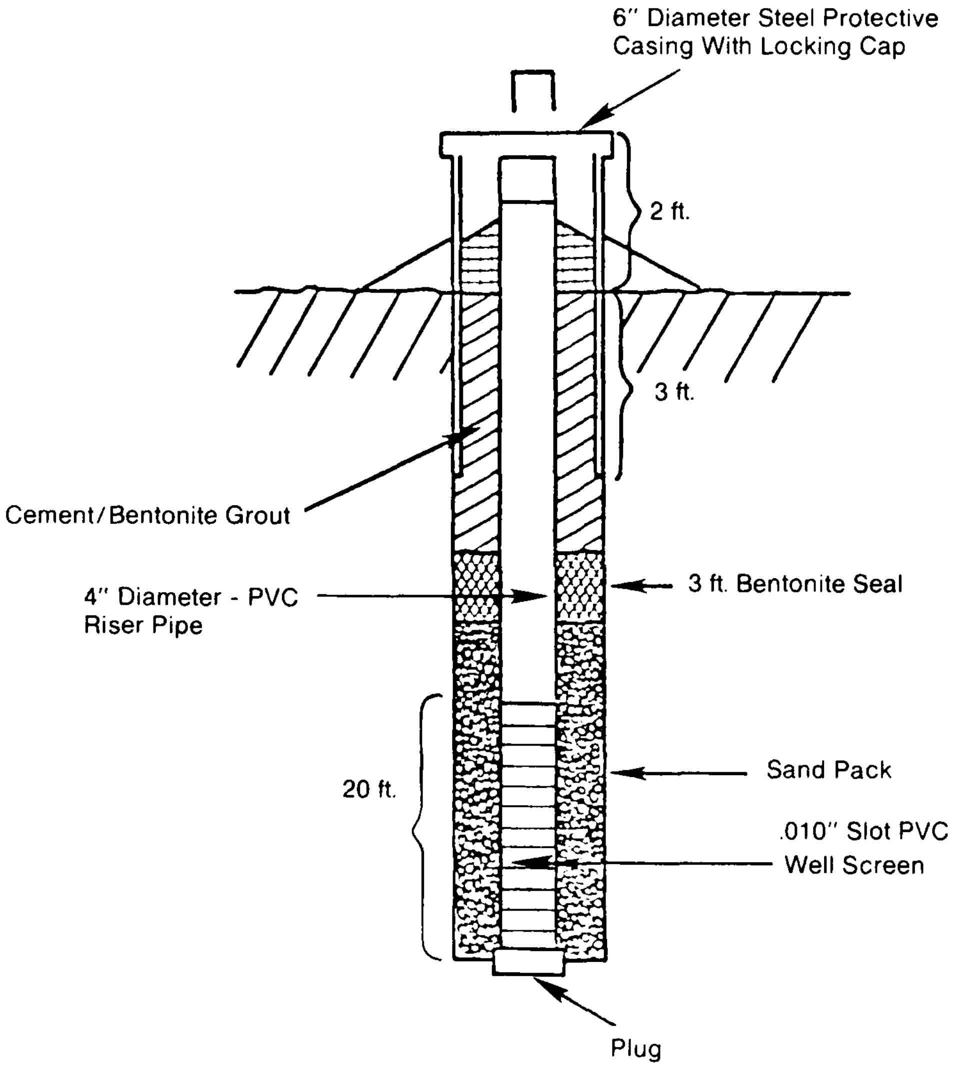
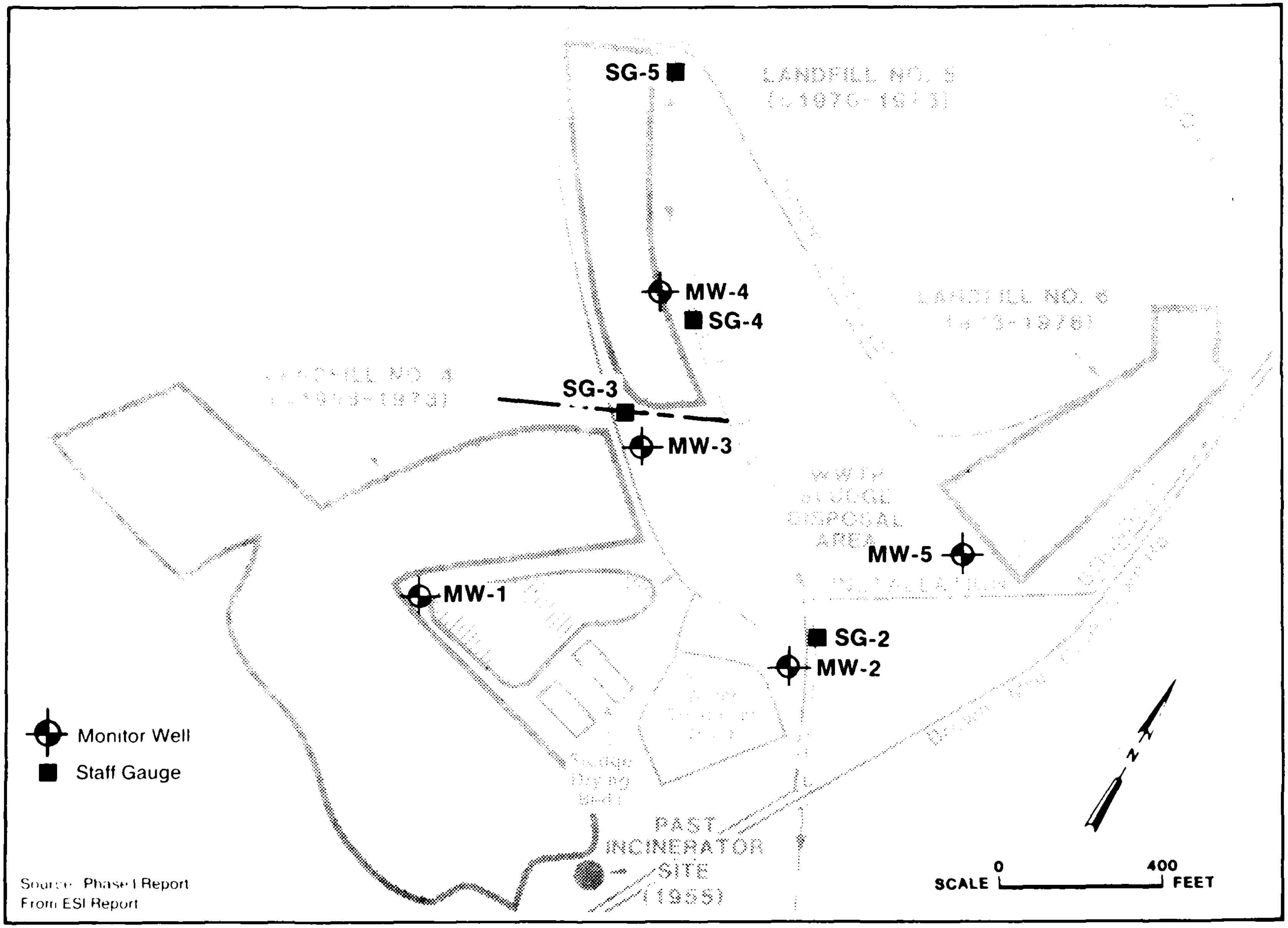


FIGURE 3-1 SCHEMATIC OF MONITOR WELL CONSTRUCTION



Source: Phase I Report
From ESI Report

FIGURE 3-2 LOCATIONS OF MONITORING WELLS AT ZONE 1 the toe of Landfill 5. MW-5 is located downgradient of Landfill 6, on the opposite side of South Run in relation to the other wells. The monitoring wells ranged in depth from 23 to 28 feet below the land surface. Groundwater was encountered at depths of from 1 to 17 feet. The wells were screened in fine sands and silts to the top of the water table. In the borings for wells MW-1 through MW- 5, clay-rich sediments were encountered at the bottom of the borings. MW-4 was located on the toe of Landfill 5, which extends within 10 feet of South Run. Special care was taken to grout the annular space above the well screen to ensure that vertical infiltration of water and leachate from the landfill would not occur around the well casing. A complete discussion of subsurface conditions is presented in Section 4.1. Table 3-3 summarizes the well construction details and Figure 3-3 graphically presents the well construction details.

An H-NU organic vapor detector with an 11.7eV bulb was used to monitor air quality at each well location during drilling and well construction. Background air quality was 9 parts per million (ppm) or less at all locations and no change in quality was observed at the top of the boreholes. The water from the wells, however, had a strong septic odor.

3.2.2.3 Site No. 2, Landfill 2

A total of three groundwater monitoring wells numbered MW-6, MW-7, and MW-8, were placed near the edge of Landfill 2 through the landfill itself. All three wells were positioned in the line of groundwater flow between the landfill and the adjacent North Run. As discussed in Section 1.3.2, Landfill 2 extends to the edge of the narrow floodplain of North Run. The top of the landfill lies about 25 feet above the stream and the slope was too steep for drilling equipment to negotiate. The three wells were therefore placed at the top of the landfill toe where groundwater was 20 to 25 feet below ground surface. The locations of the wells are shown in Figure 3-4. The wells were from 34 to 35 feet deep and were screened for 10 feet in undisturbed sediments beneath the landfill.

The refuse mass ranged in thickness from nine feet in MW-6 to 17 feet in MW-7 and MW-8. As with MW-4, special care in grouting the well casings was taken to avoid vertical infiltration of water from the landfill to the well screen. The

TABLE 3-3 SUMMARY OF WELL CONSTRUCTION DETAILS, McGUIRE AFB

Monitor Well Number	Approx. Land Surface Elevation In Feet	Top of PVC Casing Elevation In Feet	Screen Interval Depth In Feet	Sandpack Depth Interval in Feet	
Zone 1					
MW-1	98.8	100.61	8-28	6-28	-Black Fine SAND w/ some silt and clay organic odor
MW-2	85.7	87.26	7-27	5-27	-Black Fine glauconitic SAND, some silt and clay
MW-3	91.0	93.02	8-23	6-23	-Grey brown fine SAND grading down to sandy clay
MW-4	96.2	97.53	19-29	17.5-29	-Grey f-m SAND, BLACK SILT and Silty SAND
MW-5	92.9	9.42	10-25	8-25	-Grey silty SAND and green glauconitic SAND, some clay.
Landfill 2					
MW-6	126.1	127.61	20-35	18-35	-Brown and grey SAND and silty SAND
MW-7	124.8	126.10	25-35	24-35	-Green grey f-m SAND
MW-8	120.8	122.94	24-34	22.5-34	-Olive silty SAND
Landfill 3					
MW-9	112.4	113.43	19.5-29.5	18.5-29.5	-Green grey f-m SAND w/ a little silt
MW-10	111.1	111.42	10-30	8-30	-Grey f-m SAND
MW-11	115.0	116.19	9-29	7-29	-Olive grey silty SAND
Bulk Fuel Storage					
MW-12	108.8	111.32	7-27	5-27	-Olive-Brown f-m silty SAND interbeds of gravel and clay
MW-13	107.2	109.73	7-27	5-27	-Olive Brown silty SAND and silty CLAY
Fire Training Area 1					
MW-14	114.7	116.75	5-25	4-25	Olive-grey fine SAND
MW-15	115.4	117.44	5-25	4-25	Green-grey fine SAND, a little silt
BOMARC Site					
MW-16	150.5	152.99	21-36	18-36	Yellow f-m SAND/PEAT
MW-17	150.6	150.73	14-29	12.9-29	Yellow f-m SAND/PEAT/Grey Silty SAND

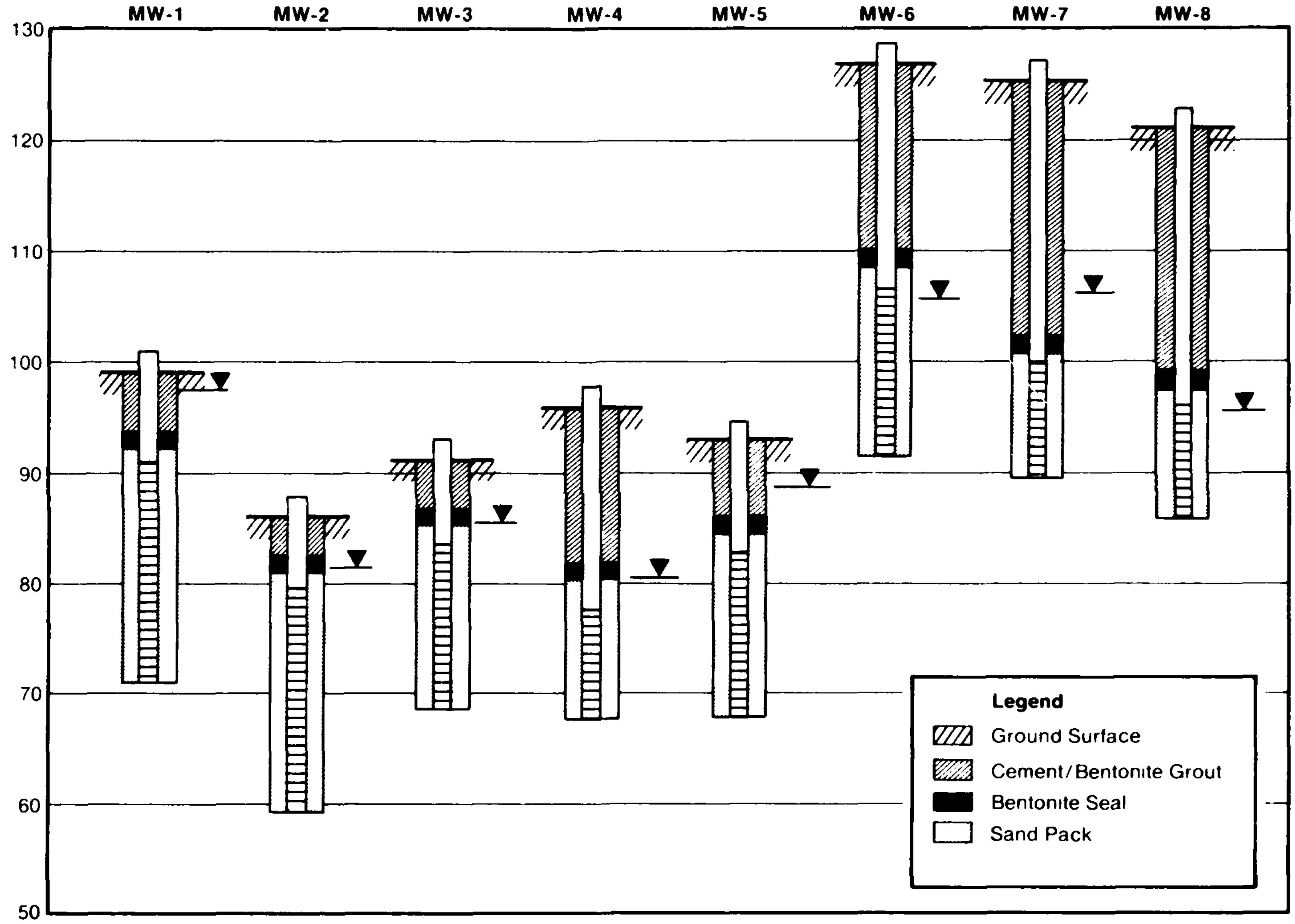


FIGURE 3-3 WELL CONSTRUCTION SUMMARY, MW-1 THROUGH MW-8

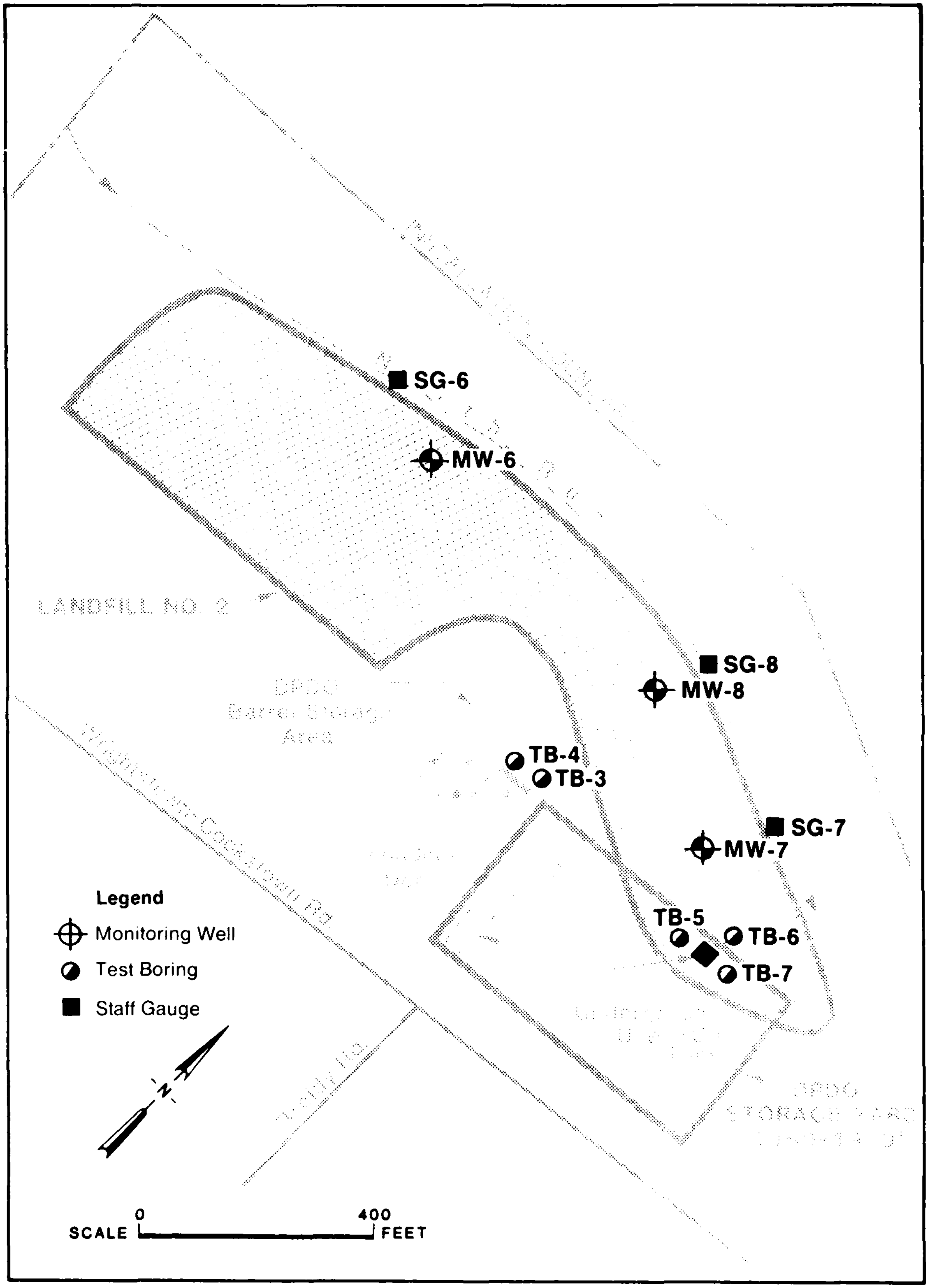


FIGURE 3-4 LOCATION OF WELLS AND TEST BORINGS AT LANDFILL 2 AND THE DPDO STORAGE AREA

wells were screened in intervals of fine silty sand with occasional fine to medium sand and clayey sand. A detailed discussion of site geology is presented in Section 4.1. Well construction details are summarized in Table 3-3 and Figure 3-3.

An organic vapor detector was used during the drilling and well installation to monitor air quality at the boreholes. No change in reading above background was observed at any of the drilling sites.

3.2.2.4 Site No. 3, Landfill 3

A total of three groundwater monitoring wells were placed at Landfill 3 between the landfill and North Run in a downgradient position, as shown on Figure 3-5. Groundwater was encountered approximately 12 feet below land surface. Wells MW-10 and MW-11 were 30 and 29 feet deep, respectively, and they were screened in 20 feet of sediments. MW-9 was 29.5 feet deep and was screened in only ten feet of sediments. Since nine feet of waste material was encountered at MW-9, the shorter screen enabled the setting of a grout seal in the annular space above the screen and below the base of the landfill. The wells at Landfill 3 were screened in sediments consisting of fine to medium sands and silty sands with occasional clay lenses. Well construction details are summarized in Table 3-3 and Figure 3-7.

3.2.2.5 Site No. 4, BOMARC Missile Site

Two groundwater monitoring wells, MW-16 and MW-17, were installed at the BOMARC Missile Site at a location judged to be hydrologically downgradient from the JP-X fuel storage area and JP-X discharge pit, based on surface topography and drainage direction at the site. The location of wells is shown on Figure 3-6. MW-16 is 36 feet deep and MW-17 is 29 feet deep with the water table at approximately 24 feet below ground surface. The wells are screened in fine sands with a peat horizon encountered at a depth of 30 feet in borings for both wells. Subsurface conditions are discussed in more detail in Section 4.1. A well construction summary is presented in Table 3-3 and Figure 3-7.

3.2.2.6 Site No. 5, Pesticide Wash Area

Two soil borings were completed in the pesticide wash area to recover soil samples at discrete depth intervals for lab-

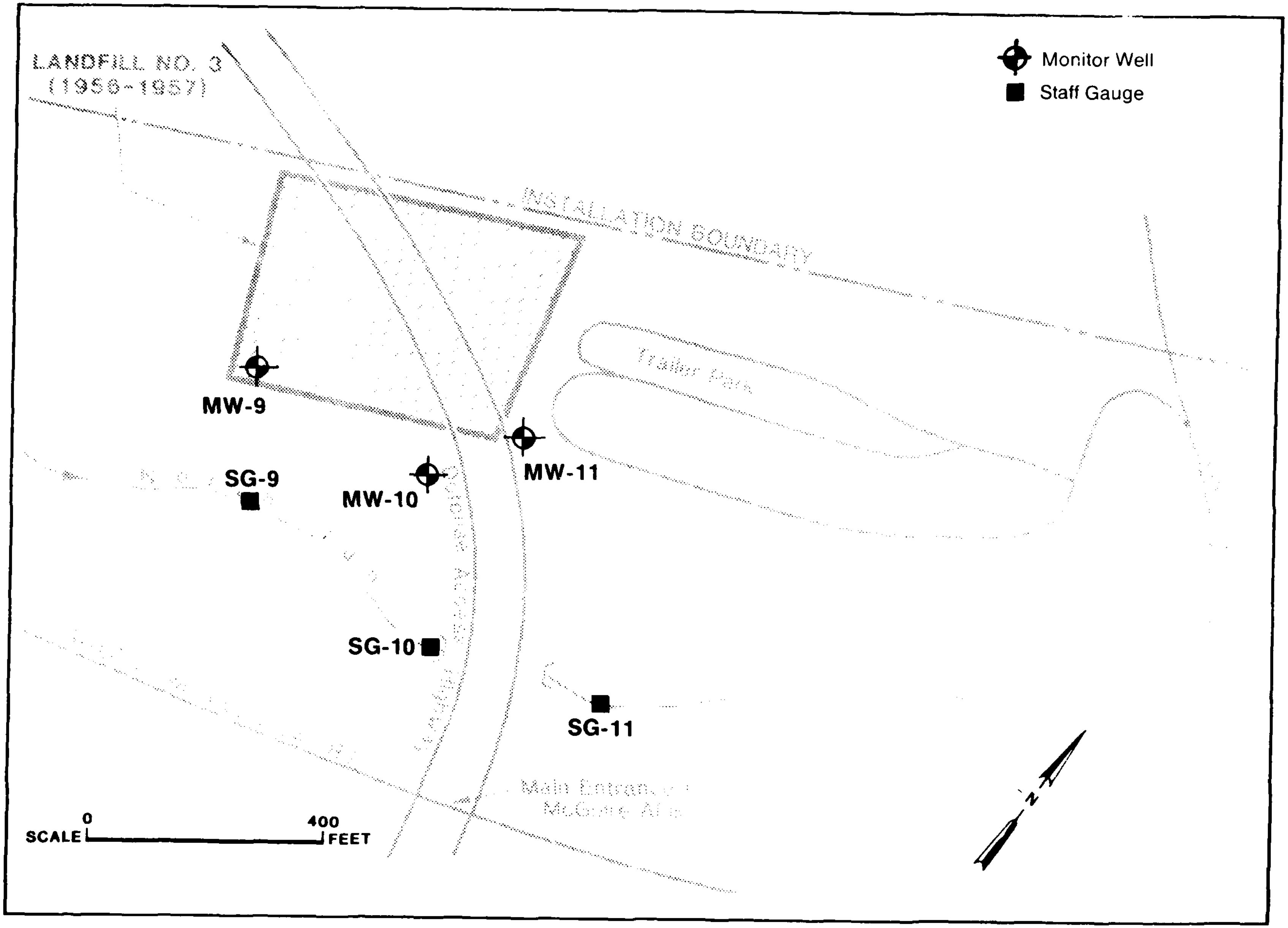


FIGURE 3-5 LOCATION OF MONITORING WELLS AT LANDFILL 3

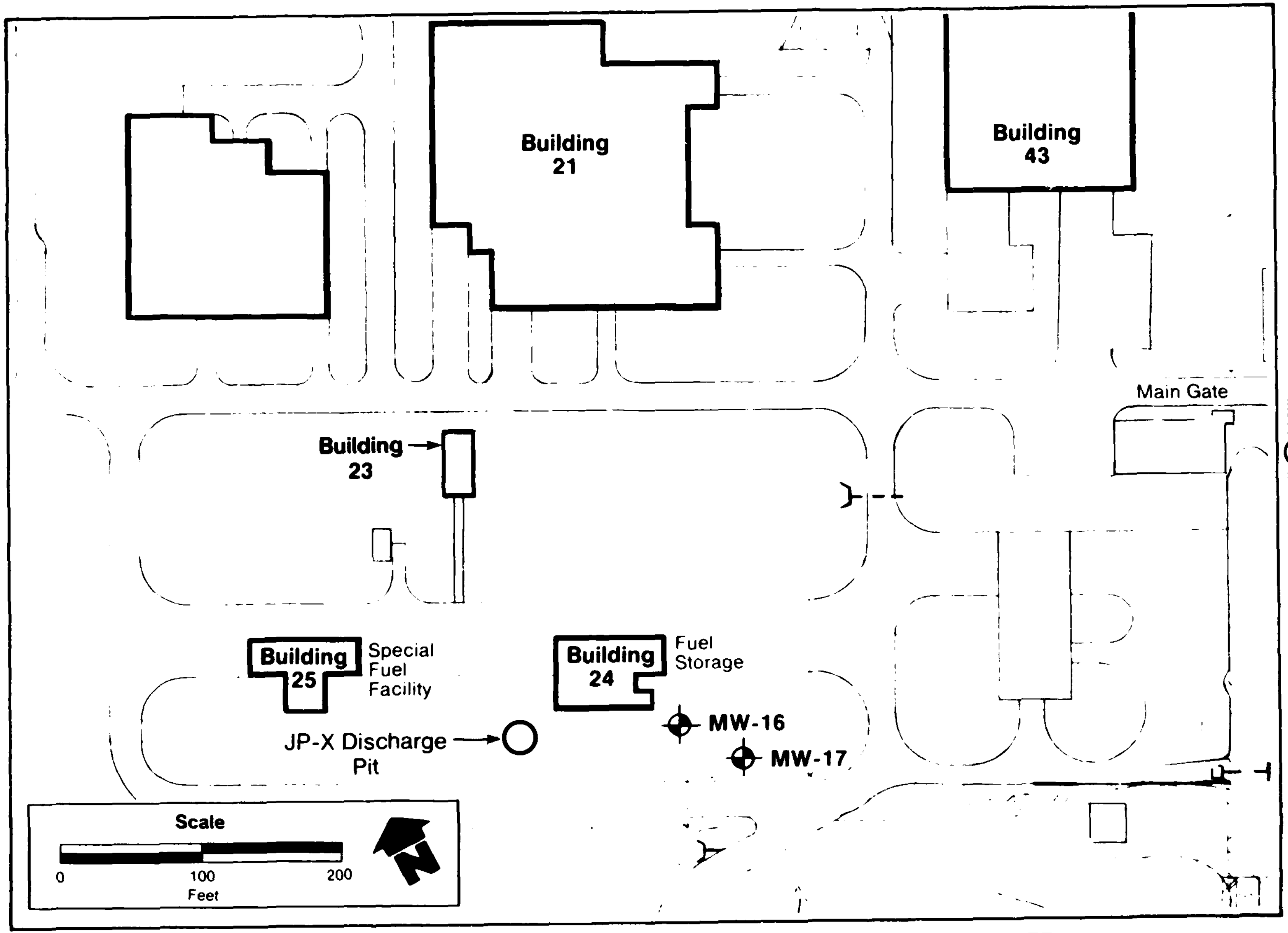


FIGURE 3-6 LOCATION OF MONITORING WELLS AT THE BOMARC MISSILE SITE

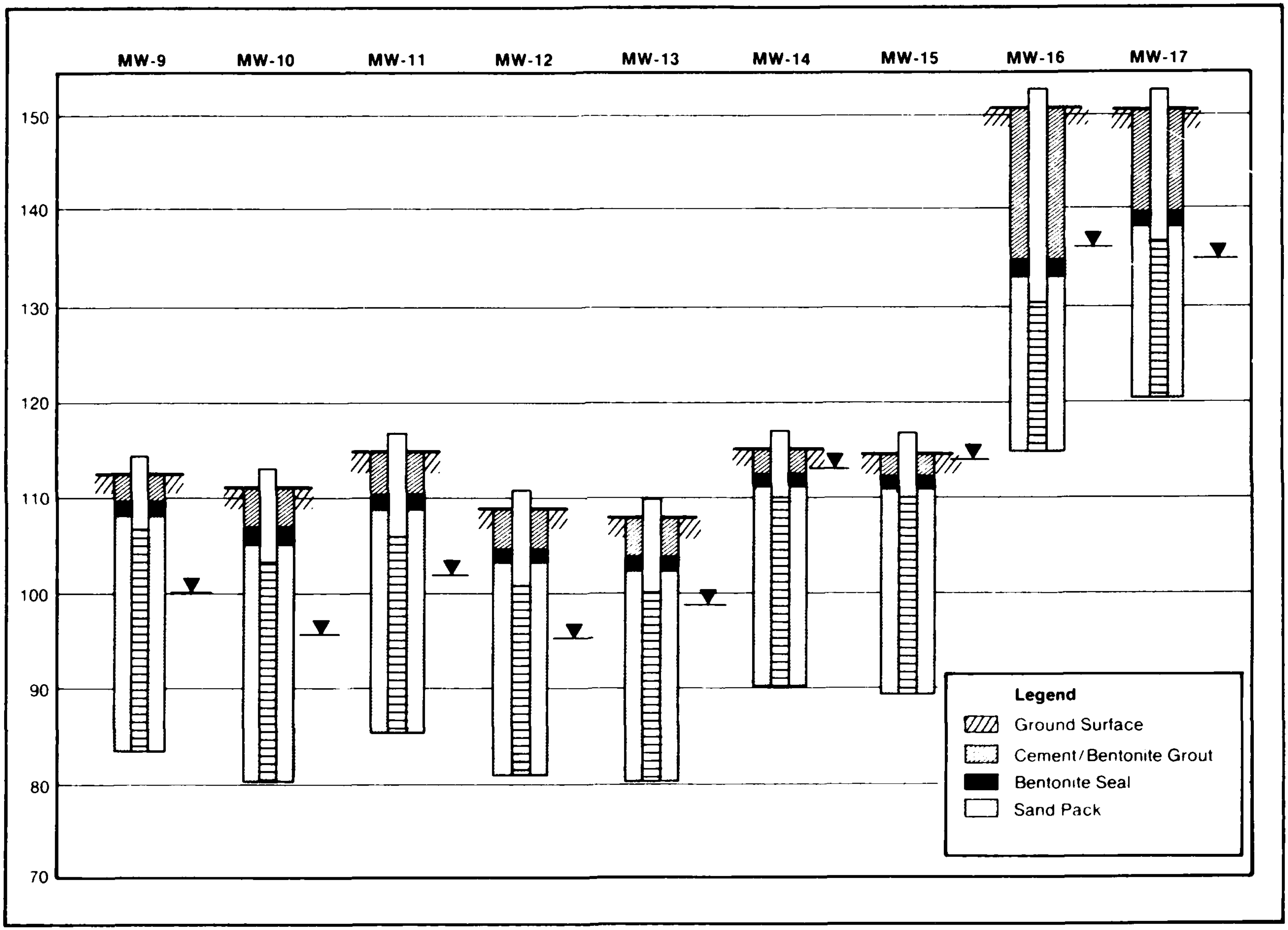


FIGURE 3-7 WELL CONSTRUCTION SUMMARY, MW-9 THROUGH MW-17

oratory analysis. The borings TB-1 and TB-2 were located between the equipment washing area and the stream gully, as shown on Figure 3-8. The borings were advanced to the water table, about 6 feet below ground surface. Continuous split spoon samples were taken, and samples were collected and logged at each one-foot interval. Specific sampling procedures are outlined in Appendix E of this report. The samples for pesticides analysis were placed in prepared 1-liter brown-glass jars.

3.2.2.7 Site No. 6, DPDO Storage Facility

Five test borings were completed to the groundwater table, about 17 feet below ground surface, in the DPDO storage area. The boring locations, numbered TB-3 through TB-7, are shown on Figure 3-4. TB-3 and TB-4 were located adjacent to the temporary drum storage pad and borings TB-5, TB-6 and TB-7 were located near the buried tank site. Split spoon samples were recovered continuously to the water table (approximately 17 feet) and samples logged at one-foot intervals (See Appendix D). Samples for PCB analysis and oil and grease analysis were placed in separate prepared 1-liter brown-glass jars. A complete discussion of sampling and preservation procedures is presented in Appendix E of this report.

3.2.2.8 Site No. 7, Fire Training Area 1

Two groundwater monitoring wells were installed at the Fire Training Area 1. The wells, numbered MW-14 and MW-15, were located hydrologically downgradient of the site, between the site and a nearby drainageway, as shown on Figure 3-9. Monitor Well MW-15 was located near the boundary of the site, as determined from aerial photographs, in an area of observed soil staining. MW-14 was located approximately 100 yards away from the circular burning site, closer to the drainageway. Wells MW-14 and MW-15 are both 25 feet deep and screened from 5 to 15 feet below grade in sands and clayey sands. The water table on the site was encountered at approximately 2 feet below the ground surface.

3.2.2.9 Site No. 8, Bulk Fuel Storage Area

Two groundwater monitoring wells were installed at the Bulk Fuel Storage Area. The wells, numbered MW-12 and MW-13 were located between the tank farm and South Run as shown on Figure 3-10. Both wells are 27 feet deep with 20 feet of slotted screen. The screens extend above the water table in

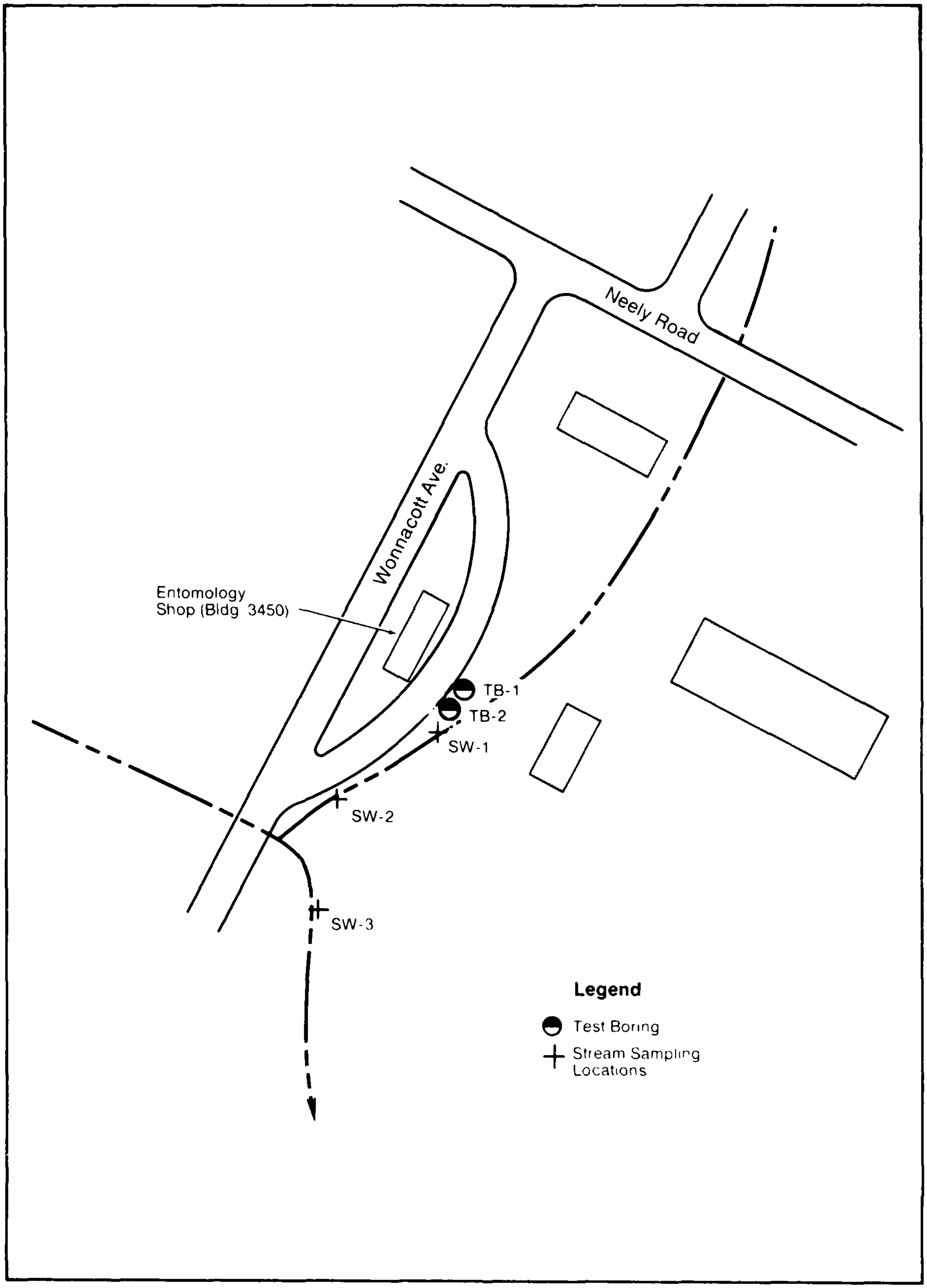


FIGURE 3-8 LOCATION OF TEST BORINGS AND STREAM SAMPLING LOCATIONS AT THE PESTICIDE WASH AREA

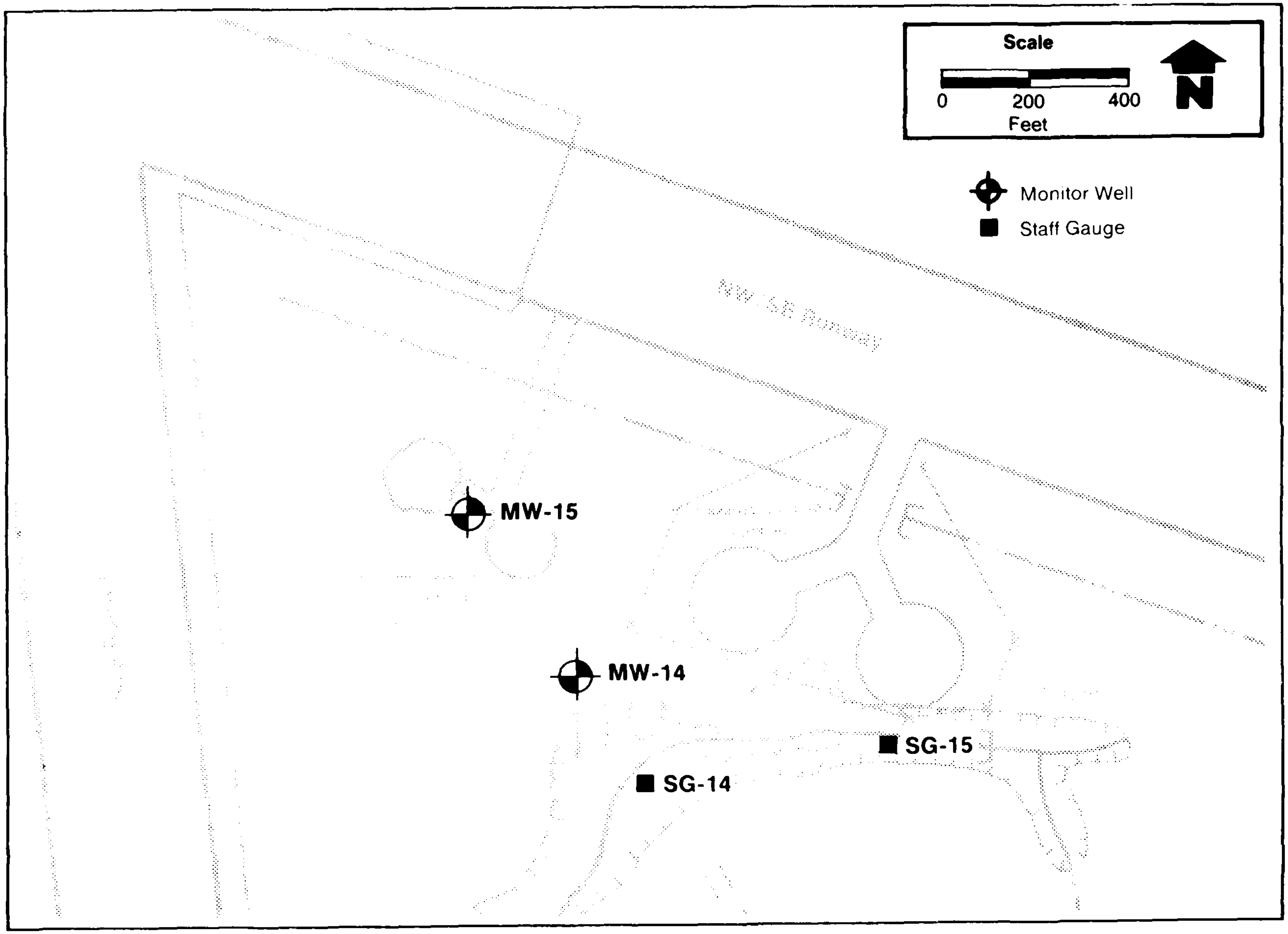


FIGURE 3-9 LOCATION OF MONITORING WELLS AT FIRE TRAINING AREA 1

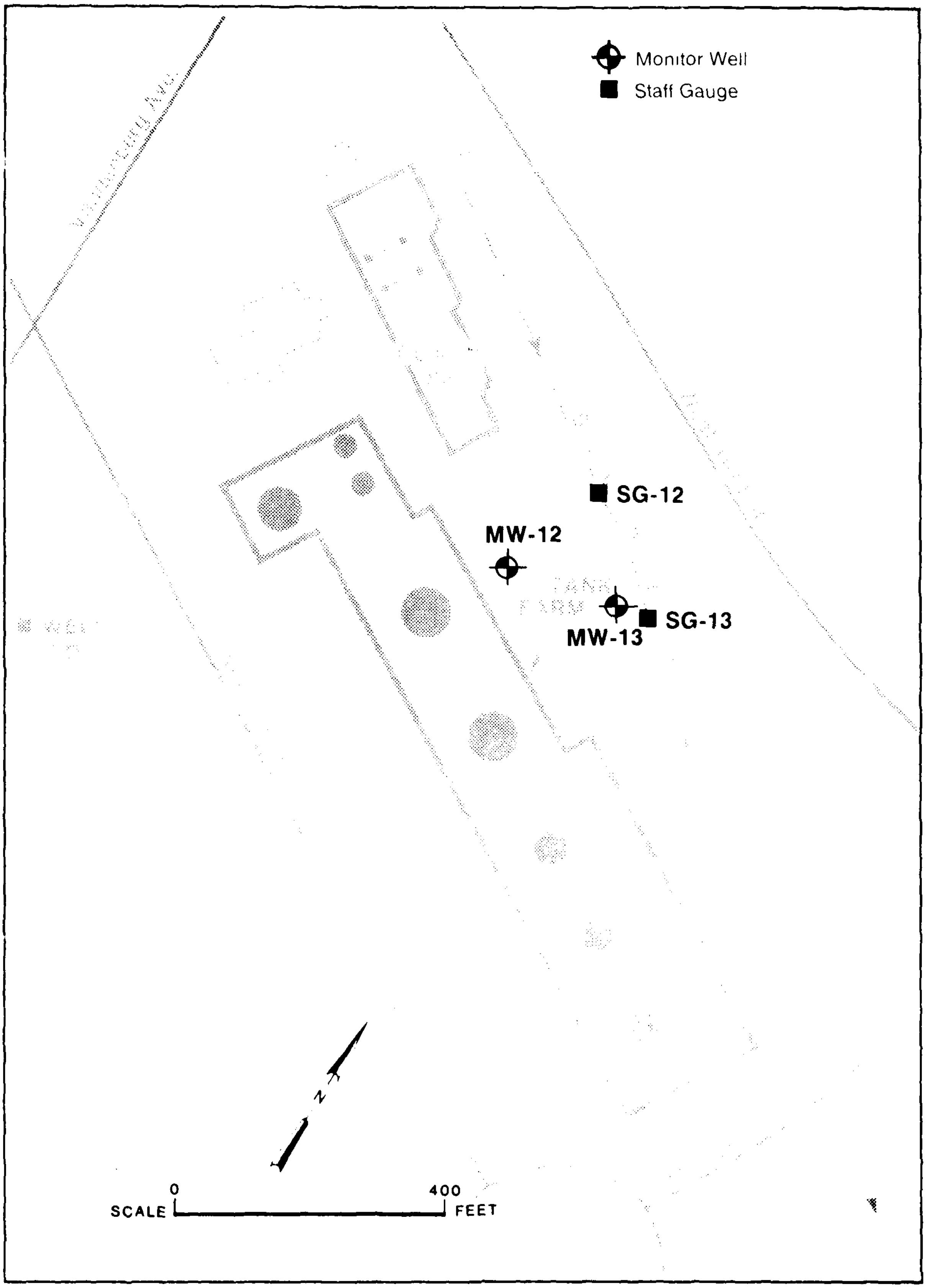


FIGURE 3-10 LOCATION OF MONITORING WELLS AT THE BULK FUEL STORAGE AREA

order to intercept any fuel oil floating on the groundwater surface.

The wells in the bulk fuel storage area were screened in olive grey and brown fine silty sands. The water table was encountered at approximately 12 feet below the ground surface. Well construction details are summarized in Table 3-3 and Figure 3-7.

3.2.3 Geophysical Survey - Site No. 14, Civil Engineering Compound

A geophysical field investigation of the Civil Engineering Compound substructure was conducted by WESTON between 11 October and 20 October 1983. Geophysical mapping at the Civil Engineering Compound provided a direct comparison of results obtained from the application of two different geophysical techniques: (1) Ground Penetrating Radar (GPR) and (2) Magnetometry. The two types of data can be used in a complimentary manner to locate disturbed areas and metal objects which are both indicators of possible waste burial sites. Since the exact locations of the drums and other facilities suspected to be buried beneath the compound are not known, the survey was completed in grid fashion covering the entire portion of the yard that was accessible. Prior to the field investigation the CE Compound was subdivided into a ten foot by ten foot survey grid, as shown in Figure 3-11. The resulting cartesian grid was oriented with the X axis traversing NW to SE and the Y axis traversing SW to NE, and with the origin (0,0) located at the SW corner of Building S-3462.

3.2.3.1 Objectives of the Geophysical Survey

The purpose of the geophysical surveying program was to identify, insofar as possible at the level of a confirmation survey, the location, depth and areal extent of disturbed areas and metallic objects that may be associated with waste depositories in the immediate subsurface environment. The combination of Magnetometer and GPR response signatures indicate the presence of a variety of subsurface anomalies with the C.E. Compound.

The magnetic data were used to provide a semi-quantitative measure of the distribution of magnetic anomalies produced by subsurface metallic sources. The GPR provided qualitative information characteristic of the substructure and its components. Utilizing both geophysical techniques in an in-

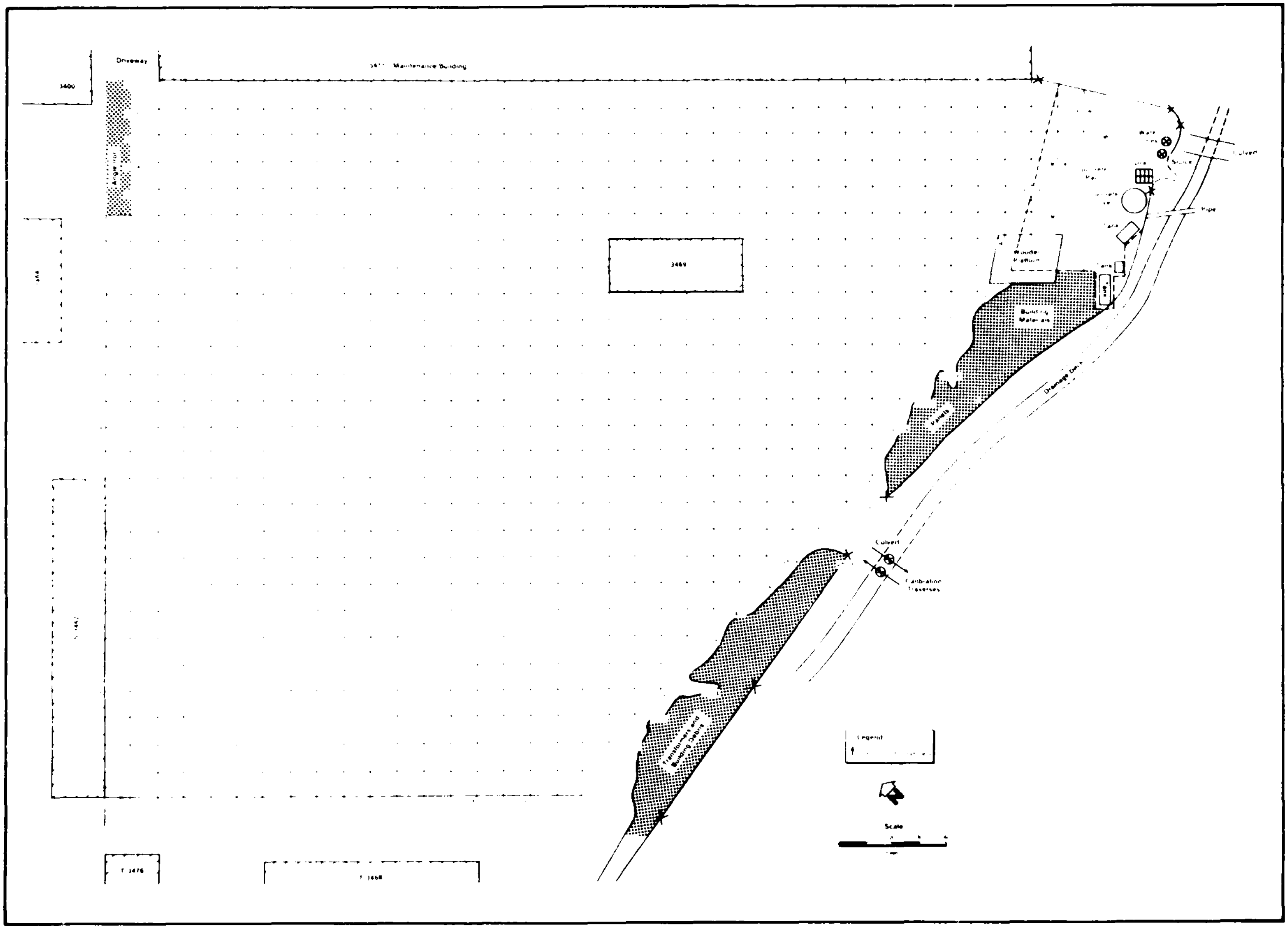


FIGURE 3-11 CIVIL ENGINEERING STORAGE COMPOUND, TRAVERSE GRID LAYOUT FOR GEOPHYSICAL SURVEY

tegrated approach allowed a rapid convergence of information necessary for assessing subsurface conditions within the C.E. compound. A correlation between data acquired by these two techniques is reported in the following Sections.

3.2.3.2 Magnetometer Survey

The magnetometer survey of the Civil Engineering Compound was conducted on 20 October 1983. Utilizing the 10' X 10' grid established for the GPR Survey, magnetometer readings were taken at ten foot node spacings. Background magnetic signatures were established at five randomly selected locations outside the compound where similar paving existed. Magnetic signatures were measured at each grid node using a vertical field flux gate magnetometer. Results of these measurements were compared against ambient background signatures and a magnetic anomaly map was constructed.

3.2.3.3 Ground Penetrating Radar Survey

The Ground Penetrating Radar (GPR) Survey of the Civil Engineering Compound was conducted by WESTON between 11 October and 20 October 1983. After establishing the survey grid the next step was to calibrate the GPR system. To calibrate the system either the dielectric constant (E_r) of the survey medium, or the depth to a particular object or interface must be known. Calibration of the Radar system was performed at the C.E. Compound using a two-step operation. Initial calibration was calculated using a dielectric constant (E_r) of 16, based upon on-site soil and moisture conditions (moist fine to medium sand and silt). Next, for quality assurance purposes, calibration traverses were run over a three-foot diameter culvert at a known depth of approximately three and a half feet (Figure 3-11). From this calibration procedure a vertical depth profile scale of 1" = 2.4' was constructed.

Subsequent to system calibration survey, traverses were conducted over the compound. Surveying was accomplished by traversing the compound (with the GPR antennae) along each parallel grid line in a NW to SE direction (starting at node 0+0 and ending at node 0+26), then perpendicular in a SW to NE direction (starting at node 0+0, ending at node 37+26). The product of the GPR Survey was a series of real-time subsurface profiles. To standardize the data, marks were fixed on the profile for any given traverse, at ten foot intervals and ten foot grid intersections. The profiles were transported back to the WESTON lab for analysis and interpretation.

3.2.3.4 Geophysical Survey Analysis

Before magnetic readings were contoured, certain correction factors had to be applied. The daily (diurnal) variation of the earth's magnetic field had to be taken into account in reducing data taken with the field magnetometer. A diurnal variation curve and subsequently a correction factor was established for the C.E. area by returning to a pre-determined base station adjacent to Building S-3428 and taking readings at fixed intervals throughout the survey period. By plotting the reading at the base station against time it was possible to construct a variation curve for the day's work. After the reduced magnetic readings were computer plotted and contoured on a base map of the C.E. compound, a qualitative examination of the contour map was performed, and structural trends, discontinuities, and magnetic deviations were noted.

Data analysis of GPR survey data involved the interpretation of each profile individually and then comparing the results collectively. The interpretation process had two objectives:

- Applying specific knowledge of known signature densities and configurations to the identification of pipes, drums, trenches, soil structures, discontinuities and surface disturbances.
- Identifying trends and conditions by comparing standard profiles one to another. This process identified soil interfaces, buried utilities and groundwater data.

The GPR profiles produced as a result of this survey exhibited high resolution, clearly defining changes in soil characteristics and highlighting individual targets beneath the C.E. Compound.

Upon incorporating the results from both surveys it was then possible to confirm or discount previously suspect anomalies.

However, it must be kept in mind that, as with most remote sensing devices, certain ambiguities do arise through a variety of uncontrollable mechanisms (eg. structural interference, magnetic storms), that reflect definite conditions that cannot safely be interpreted. It should be noted that two conditions favorable to these geophysical techniques do exist in the substructure of the C.E. compound.

- The predominantly homogenous medium to coarse sand underlying the site.
- A shallow water table (approximately 8 to 12 feet) below grade.

3.2.4 Field Testing

3.2.4.1 Groundwater Elevation Survey

The tops of PVC casing of all 17 monitoring wells were surveyed for elevation to the nearest 0.1 foot by a New Jersey State licensed surveyor in accordance with New Jersey Department of Environmental Protection Regulations. Stream elevation references were also established at locations near the monitoring wells. The purpose of the survey was to establish references from which to measure groundwater and surface water in order that the gradient and direction of flow of groundwater to nearby stream discharge points could be established. All elevations were referenced to permanent benchmarks located on the Base property. Table 3-4 presents a list and description of well and surface water reference point elevations.

3.2.4.2 Water Level Measurements

Two complete rounds of water level measurements were made. One round was made at the time of sampling during the period November 28-30, 1983, and another round was made independently of sampling activities on March 8, 1984. All readings of monitoring wells were referenced to the top of PVC casing using a Soil Test Model DR 706A Water Level Probe. The surface water levels were measured with a ruler against a wooden staff gauge. Table 3-4 lists all readings and calculated water surface elevations.

3.2.4.3 Field Testing for Water Quality

While taking groundwater samples for laboratory analyses during the week of November 28, the WESTON field team also an-

TABLE 3-4 SUMMARY OF MONITORING WELL AND SURFACE WATER ELEVATION SURVEY

Location	Well	Depth to Water in Feet 11/28/83	Depth to Water in Feet 3/8/84	Elevation Top of Casing	Groundwater Elevations	
					11/28/83	3/8/84
Zone 1	1	4.95	2.96	100.61	95.66	97.65
	2	6.23	6.46	87.26	81.03	80.80
	3	5.85	5.15	93.02	87.17	87.87
	4	17.20	17.32	97.53	80.33	80.21
	5	5.15	3.58	94.22	89.07	90.64
Landfill 2	6	23.41	19.71	127.67	104.26	107.96
	7	21.31	19.02	126.10	104.79	107.08
	8	26.66	22.76	122.94	96.28	100.18
Landfill 3	9	13.41	13.86	113.43	100.02	99.57
	10	13.75	12.04	111.12	97.37	99.08
	11	14.85	12.58	116.19	102.05	104.32
Bulk Fuel Storage Area	12	15.55	13.33	111.32	95.77	97.99
	13	10.67	9.60	109.73	99.06	100.13
Fire Training Area	14	3.01	2.75	116.75	113.74	114.00
	15	2.30	2.25	117.44	115.14	115.19
Bomarc Missile Site	16	26.8	23.74	152.99	126.19	129.73
	17	26.0	23.58	150.73	124.73	127.15

TABLE 3-4 (cont.)

Location	Stream Staff Guage	Top of Staff Elevation In Feet	Depth to Water (Ft.) 3/8/84	Water Elevation In Feet
Zone 1	SG-2	78.26	1.62	76.64
	SG-3	87.72	2.08	85.64
	SG-4	80.07	1.92	78.15
	SG-5	90.92	12.03	78.89
Landfill 2	SG-6	102.39	2.20	100.19
	SG-7	99.73	2.0	97.73
	SG-8	100.59	1.85	98.74
Landfill 3	SG-9	93.78	1.90	91.78
	SG-10	91.96	1.95	90.01
	SG-11	91.52	1.75	89.77
Fuel Storage Area	SG-12	94.42	1.80	94.62
	SG-13	94.40	1.80	94.60
Fire Training Area 1	SG-14	103.43	1.67	101.76
	SG-15	103.29	1.60	101.69

alyzed grab samples from each well for temperature, specific conductance and pH. The pH was measured with a Markson Model-6 portable pH meter. Temperature and specific conductance was measured with a Markson Model 36 Conductivity Meter. The results of these tests are presented in Table 3-5.

3.2.5 Water Quality Sampling

Between 25 November and 2 December 1983 a complete round of groundwater samples was taken from the 17 monitoring wells installed at McGuire AFB. Samples from each well were packaged and preserved according to analyses required at each sampling location and outlined in Section 3.1.10.

The purpose of the water quality sampling program was to identify, insofar as possible at the level of a confirmation survey, the location, concentration and areal extent of any contamination present in the hydrogeologic environment. From this information it would be possible to deduce the general direction in which these contaminants are migrating and their probable origin. To achieve these goals efficiently, specific field procedures were followed for purging the wells, collecting the samples, and ensuring field quality control. These procedures have been used to obtain a single complete set of representative samples for chemical analysis from the monitoring wells and surface water. The sampling and quality assurance plans used to accomplish these goals are contained in Appendix E. Sample chain-of-custody documentation is contained in Appendix F. Standard laboratory analysis protocols used in the analysis of these samples are contained in Appendix G.

3.2.6 Surface Water and Sediment Sampling

The scope of work for the pesticide wash area included the collection of surface water and bottom sediment samples for analyses of pesticides from the small stream running next to the facility. Samples of water and sediment were taken at 3 locations along the stream, as shown on Figure 3-8. All samples were taken in one-liter brown-glass jars with Teflon lids, prepared in the laboratory. Water samples were taken directly from the stream. Sediment samples were taken with a stainless steel scoop that was rinsed with dionized water between samples. The sample containers were packed with the groundwater samples and handled in the same manner as outlined in Appendix E.

TABLE 3-5
SUMMARY OF FIELD TESTED WATER QUALITY PARAMETERS

Well	Location	Temp (C^{O})	Specific Conductance	Ph
1	Zone 1	10	741	5.7
2	Zone 1	9	368	6.7
3	Zone 1	8	808	5.7
4	Zone 1	8	810	6.6
5	Zone 1	12	285	4.0
6	Landfill 2	11	525	5.1
7	Landfill 2	10	1550	6.1
8	Landfill 2	10	780	5.7
9	Landfill 3	10	962	5.8
10	Landfill 3	9	290	4.7
11	Landfill 3	12	330	5.1
12	Bulk Fuel Storage	11	1761	5.3
13	Bulk Fuel Storage	11	195	4.3
14	Fire Training Area #1	6	89	4.6
15	Fire Training Area #1	10	118	4.7
16	BOMARC	10	1660	11.5
17	BOMARC	10	154	5.8

SECTION 4

RESULTS

4.1 SITE INTERPRETIVE GEOLOGY

Based on the geologic records reviewed during the Records Search and the Phase II investigation at McGuire AFB, all of the sites located on the main installation which were addressed in the Phase II investigation are underlain by the Kirkwood Formation. Minor thin veneers and erosional outliers of Cohansey Sand occur at the Base, but do not appear to exert a major influence upon the hydrodynamic regime of McGAFB. In general, the seventeen borings for monitor wells installed at the Base encountered grey-green and grey-brown fine sands, and grey-green glauconitic silts and clays. The BOMARC Missile Site, located to the east of the Base is directly underlain by the Cohansey Formation which overlies the Kirkwood. The two well logs for the BOMARC site encountered light colored fine to medium sands with a peat layer at a depth of 30 feet.

Structural fills were encountered in the DPDO Area, and the Fuel Storage Area. These were generally native sandy soils, used to grade the sites. The fill in the fuel storage area lies over a marshy organic horizon, approximately 10 feet below ground surface. The only other surface disturbances are the landfills themselves. Landfills 1 through 6 and the sludge disposal area are generally poorly graded and covered with permeable soils. Their bases are directly on permeable subsoils. The boring logs in Appendix D describe the soils encountered during the Phase II investigation.

4.2 SITE GROUNDWATER CONDITIONS

As evidenced by the water level readings in the newly installed monitoring wells at the main Base and the BOMARC Missile site, groundwater occurs at shallow water table conditions in the Kirkwood and Cohansey Formations which underlie the sites. The groundwater table occurs between 1 and 25 feet below land surface throughout the area and is contiguous with nearby streams. Groundwater elevations in wells MW-1 through MW-15 were higher than the elevations of nearby streams, indicating that a horizontal hydraulic gradient of flow exists from the wells to the streams. This confirms that the streams are a discharge line for shallow groundwater.

The landfills which were penetrated by the drilling were composed of permeable waste material. No perched water zones within refuse were observed within or at the base of the landfills.

The apparent large variations between groundwater elevations in the wells and the surface elevations of the streams reflect groundwater mounding in the areas around the landfills, which is caused by the relatively low vertical permeabilities of the fine-grained stratified sediments. For example, in Zone 1, MW-4 near South Run exhibits a static water table consistent with the stream (80.3 feet). Well MW-1 exhibits a comparatively high water table (95.7 feet) remote from the stream and immediately below the Landfill 4. A generalized water table map illustrating the lowest water level readings from November 1983 was prepared and shown on Figure 4-1. This map shows a generally east, southeasterly gradient to the flow regime over McGAFB. Because the uppermost unconsolidated sediments are of moderately low permeability, steep hydraulic gradients occur where there is topographic relief, namely through the stream channels up on to the airfield proper. Localized flow anomalies in these areas should be evaluated on a site by site basis as discussed below.

The following subsections describe findings regarding groundwater flow at those sites where wells were constructed. These wells were limited to areas inferred to be downgradient of the suspect site. Static groundwater levels at each site were survey referenced to nearby surface waters to develop a flow gradient interpretation on a localized basis. No upgradient wells were constructed; therefore the interpretation is limited to the portions of each site within and downgradient of the landfills or other possible contaminant sources.

4.2.1 Groundwater Flow - Zone 1

Table 3-4 presents a summary of the groundwater survey conducted at McGuire AFB. Groundwater elevations obtained from wells MW-1 through MW-5, plus stream surface elevations, were used to develop the groundwater surface map illustrated in Figure 4-2. As the figure shows, the gradient of flow is toward South Run. The horizontal gradient near the stream where the landfills are located is steep at approximately

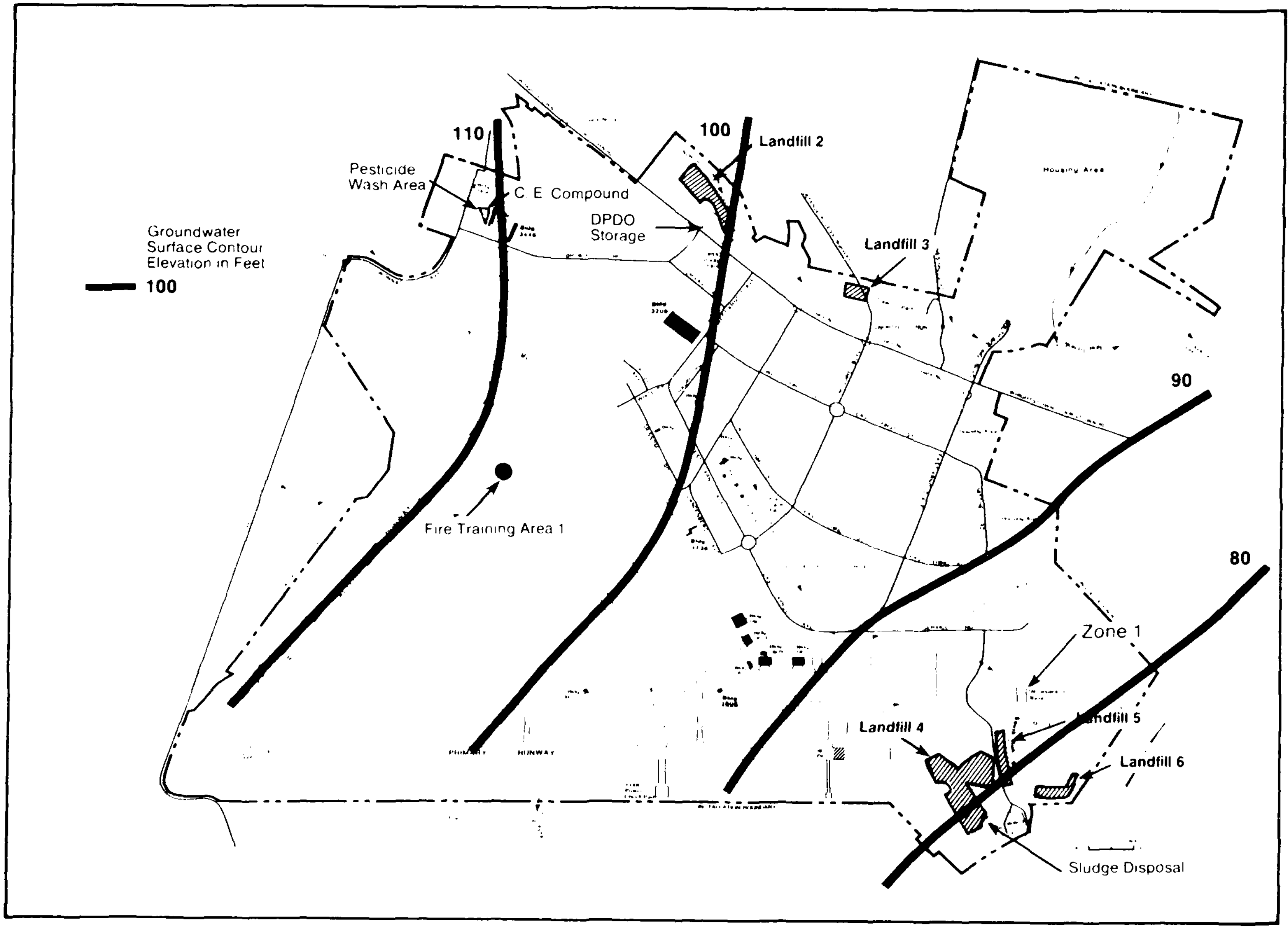


FIGURE 4-1 GENERAL GROUNDWATER SURFACE MAP OF McGUIRE AFB

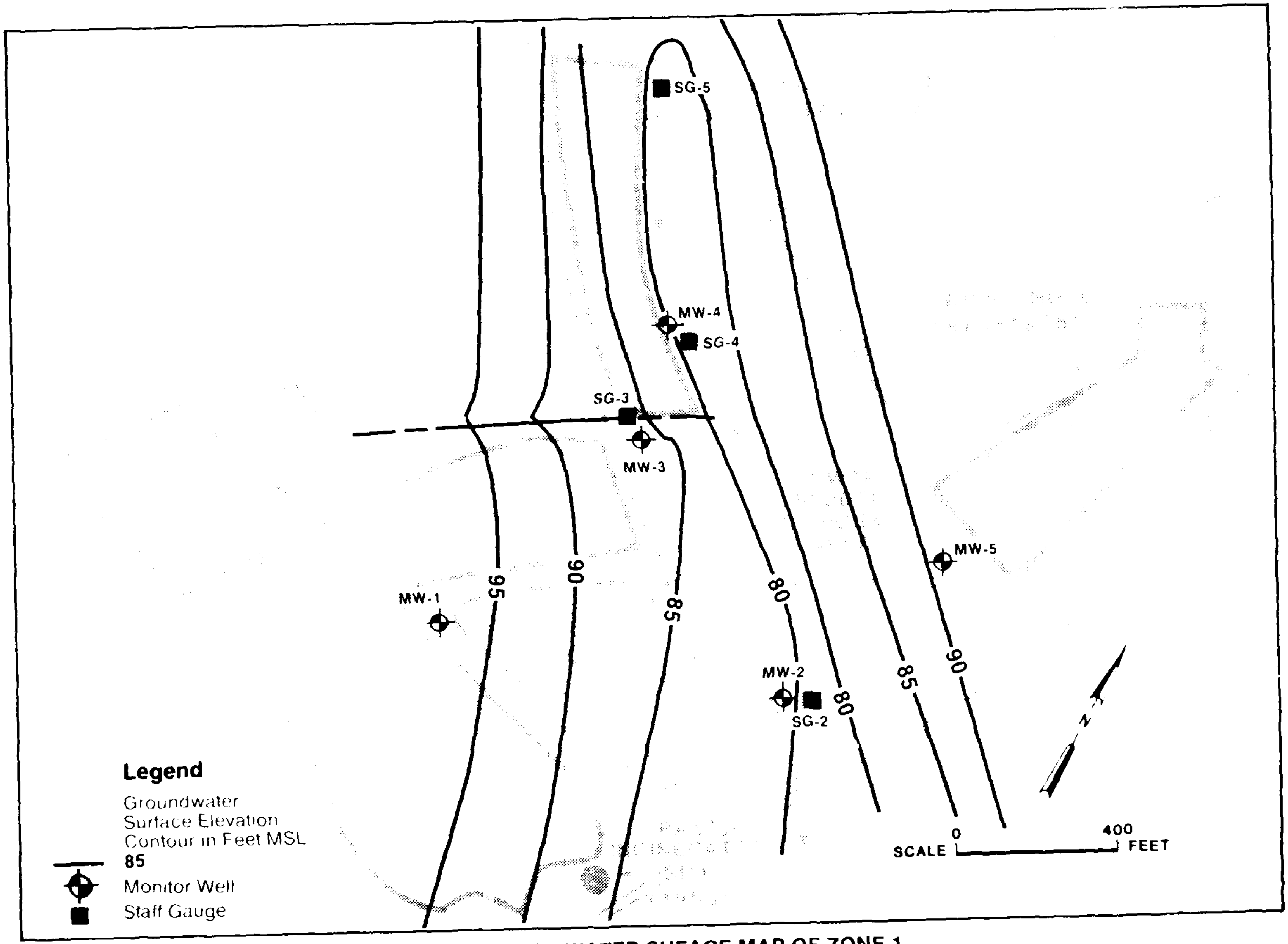


FIGURE 4-2 GROUNDWATER SUFACE MAP OF ZONE 1

.025, or 2.5 feet of head loss over a horizontal distance of approximately 100 feet.

Groundwater seepage velocity, Vs, is related to the hydraulic gradient, i, and the hydraulic conductivity, K, of the sediments by the following relationship:

$$Vs = \frac{Ki}{n}$$

where n is the effective porosity of the sediments.

Porosity varies over a narrow range in sandy sediments and can be estimated at 0.3 without producing significant error. Hydraulic conductivity, the amount of water flowing through a unit area of aquifer under a hydraulic gradient of 1, can be estimated from sediment type. Based on a hydraulic conductivity for fine sands of 10 feet/day (Todd, 1980), an estimate of groundwater velocity at Zone 1 may be calculated to be:

$$Vs = \frac{(10 \text{ feet/day})(0.025)}{.3} = 0.8 \text{ feet/day}$$

Since the farthest point of any landfill is about 1800 feet from the nearest stream the maximum travel time to the stream for any contaminants reaching the groundwater is 2250 days, or 6.2 years. The most recent landfill, No. 6, was in operation by 1973, and none of the landfills are isolated from the water table by more than a few feet of porous soil. It can be assumed, then, that any leachate being produced in any of landfills is already reaching a discharge line along South Run.

The boring logs for MW-1 through MW-5 (see Appendix D) also show finer silt and clay rich sediments at depths of 20 to 25 feet below ground surface. This indicates a partial local barrier to vertical groundwater flow and supports the assumption that most of the shallow groundwater flow is horizontal toward South Run.

4.2.2 Groundwater Flow - Site No. 2, Landfill 2

Figure 4-3 presents a groundwater surface contour map for the Landfill 2 area, based on the groundwater surface elevations for wells MW-6, MW-7 and MW-8 and stream elevations at staff guages 6, 7 and 8. The landfill is adjacent to North Run, and the wells are located parallel to the stream so that the hydraulic gradient shown represents the steep gradi-

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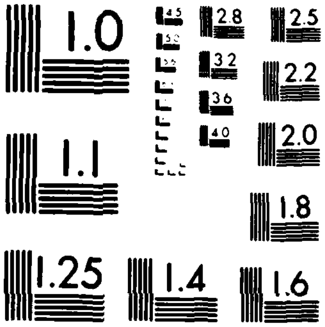

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ent that occurs adjacent to the discharge line and does not represent the general gradient for the area. This gradient may be enhanced by groundwater mounding beneath the landfill. In any case, groundwater flow is directly toward the creek whose surface is about 8 feet below the highest groundwater elevation, which is shown in MW-6.

Well screens for the three wells at Landfill 2 are set and grout-sealed below the landfill itself, which is nine feet thick at MW-6 and 17 feet thick at MW-7 and MW-8. Groundwater levels in the wells during the first round of measurements in November, 1983, were from 4-13 feet below the base of the landfill. The levels taken in March, 1984, were approximately 11 feet below the base of the landfill at MW-6, 5 feet at MW-7 and at the base of the landfill at MW-8. The period before the last round of measurements was relatively, but not abnormally, wet. Thus it can be assumed that during wetter times of the year, some parts of the landfill are in direct contact with the water table.

4.2.3 Groundwater Flow - Site No. 3, Landfill 3

Figure 4-4 presents a groundwater surface contour map for Landfill 3 based on groundwater surface elevations for monitoring wells MW-9, -10, and -11 and stream elevations at staff gauges 9 and 10. Unlike landfill 2, landfill 3 is set from 100 to 200 feet back from North Run. The three wells, located at or near the landfill toe, show a steep gradient of groundwater flow towards the creek of approximately 0.1 feet/foot. Based on the one boring through the landfill, MW-9, the water table is approximately 3 feet below the base of the landfill which lies over moderately permeable sandy sediments.

Because of the above conditions, and the age of the landfill, any contaminant plume generated by the landfill has probably reached the groundwater discharge line along the stream.

4.2.4 Groundwater Flow - Site No 4, BOMARC Missile Site

The borings for the two wells located at the BOMARC Missile Site, east of the Base, encountered fine to medium sands that appear to be part of the Cohansey Formation which outcrops in that area. A peat layer was encountered at a depth of 30 feet in both wells. The wells are less than 100 feet apart and the extent of the peat layer and its affect on groundwater flow is not known. There is a fairly steep hy-

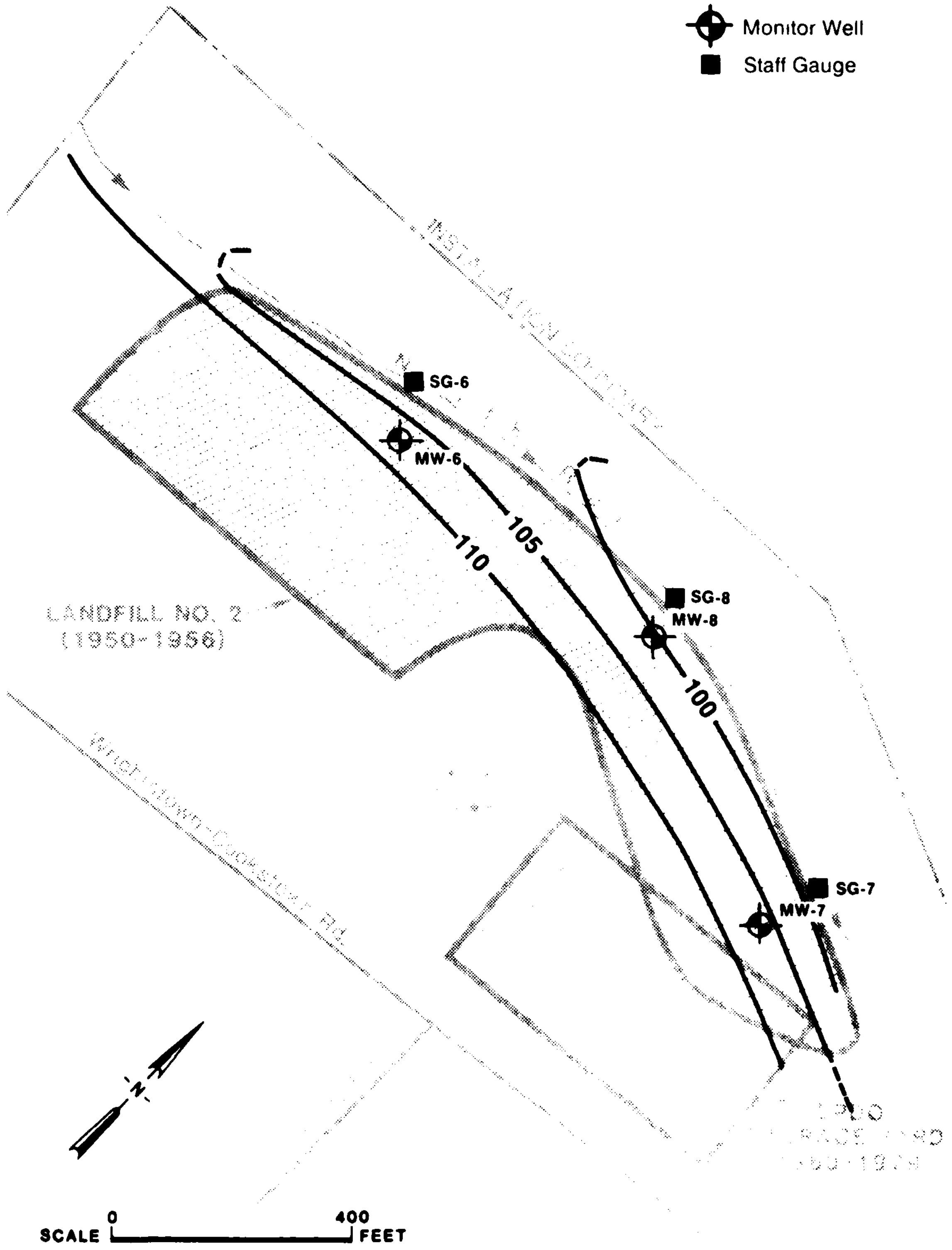
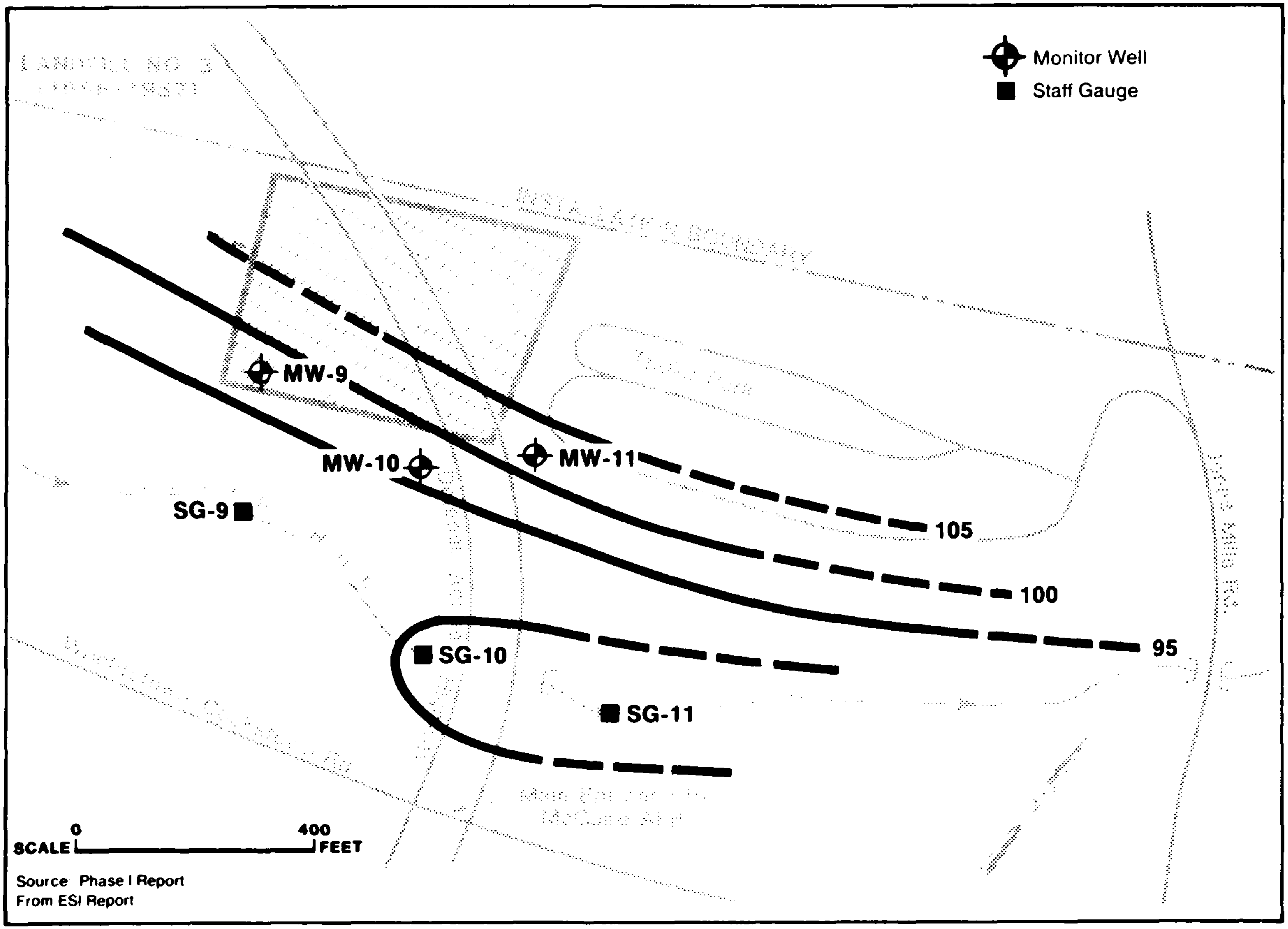


FIGURE 4-3 GROUNDWATER SURFACE MAP FOR LANDFILL 2



Source Phase I Report
From ESI Report

FIGURE 4-4 GROUNDWATER SURFACE MAP OF LANDFILL 3 draulic gradient of approximately 0.02 between the two wells in a direction from the acid neutralization pit. The site lies on a topographic high and the ground surface slopes to the southeast where streams and wetlands indicate a groundwater discharge area.

4.2.5 Site No 7, Groundwater Flow - Fire Training Area 1

Although the Fire Training Area is located on natural ground that is slightly higher, by a few feet, than the surrounding area, the water table was found to be approximately one foot below grade and higher by ten feet or more than most other well water elevations measured. The upper ten feet of soils encountered in the borings for MW-14 and MW-15 were light colored sands that may be part of the Cohansey Formation which outcrops as a thin veneer over parts of the Base. Underlying the light sands are darker colored, clayey sands which appear to belong to the Kirkwood Formation. The permeability of the Kirkwood sands are lower than the Cohansey because of the clay content.

Although it is not possible to develop a ground water contour map from the two well elevations, the hydraulic gradient between the wells and the nearby stream (Figure 3-9) shows a vector of flow which is probably close to the general direction of groundwater flow in the area - southeast with a gradient of 0.002. Because of the higher permeability of the upper ten feet of sediments, most of the lateral ground water flow is probably in these sediments.

4.2.6 Groundwater Flow - Bulk Fuel Storage Area

The area between the tank farm and South Run where monitoring wells MW-12 and MW-13 are located is underlain by approximately ten feet of sandy fill, a horizon of sandy soil and peat, and dark clayey sands of the Kirkwood Formation. The groundwater table occurs below the base of the fill. When compared with the elevation of the stream, the well water elevations show the groundwater gradient to be in the direction of the stream that parallels the site. Because the two wells are not in line to the stream they do not lie in the principle direction of flow and so do not define a major groundwater gradient. However, there is a seven foot drop in head between MW-13 and the stream, resulting in a gradient of 0.05. The stream bed itself lies directly on Kirkwood sediments, below the elevation of the fill.

4.3 RESULTS OF WATER QUALITY ANALYSES

4.3.1 Groundwater Quality - Zone 1

The results of the water quality analyses for wells MW-1 through MW-5 located in Zone 1 are presented in Table 4-1. All of the wells are located downgradient from the landfills (Figure 4-2) and therefore no well can be considered a background sampling point. The results of the water sample analyses are summarized below.

Of the metals, no lead, chromium, or cadmium was detected in any of the samples. Arsenic was detected in well MW-5 at a concentration of 11.8 ug/l which is below the Drinking Water Standard of 50 mg/l. Copper was found in all 5 samples in concentrations ranging from 50 to 160 ug/l, below the ambient water criterion of 1,000 ug/l. Nickel was found in all samples in concentrations of 110 to 170 ug/l which is in excess of the 13.4 ug/l ambient water quality standard.

Cyanide was found in all 5 wells in concentrations of 20 to 79 ug/l, all below the Federal Ambient Water Quality Criterion of 200 ug/l. Phenols were found in concentrations of 10 to 456 ug/l; well MW-3, at 456 ug/l, was in excess of the taste and odor threshold of 300 ug/l. Oil and grease was detected in all wells except MW-2 in concentrations ranging from 0.15 to 6.29 mg/l. The taste and odor threshold for oil and grease is 0.01 mg/l.

TOC (total organic carbon) concentrations ranged from 18.6 mg/l to 133 mg/l. This is a general indicator and not referenced to a specific standard. Elevated TOC concentrations were found in wells MW-1 and MW-5 (133 and 130 mg/l, respectively) while the TOC range in Wells MW-2, MW-3 and MW-4 was between 18.6 and 25.1 mg/l. Water in both wells MW-1 and MW-5 was observed to have strong organic odors. These wells are located immediately downgradient of Landfills 4 and 6, respectively. TOX (total organic halogens) was found in concentrations ranging from 5.1 to 260.2 ug/l in the five well samples tested. MW-3, downgradient of Landfills 4 and 5, had TOX concentration of 260.2 ug/l. The other four wells had concentrations of 17.3 ug/l or less. The significance of the general indicator parameters TOC and TOX is discussed in Section 4.6

4.3.2 Groundwater Quality - Site No. 2, Landfill 2

The results of the water quality analyses for wells MW-6, MW-7 and MW-8 are presented in Table 4-1. All three wells

TABLE 4-1 SUMMARY OF WATER QUALITY ANALYTICAL RESULTS ZONE 1 AND LANDFILLS 2 AND 3

Well	Location	TOC mg/l	TOX ug/l	CN- ug/l	Phenol ug/l	O&G mg/l	Cu ug/l	Cd ug/l	Ni ug/l	As ug/l	Cr ug/l	Pb ug/l
1	Zone 1	133	17.3	30	60	1.1	160	<10	170	<10	<50	<20
2	Zone 1	18.6	5.1	27	10	<0.1	60	<10	120	<10	<50	<20
3	Zone 1	20.8	260.2	45	456	6.29	210	<10	130	<10	<50	<20
4	Zone 1	25.1	<5.0	79	11	0.15	50	<10	120	<10	<50	<20
5	Zone 1	130	9.9	20	115	0.66	60	<10	110	11.8	<50	<20
6	Landfill 2	28.4	82.9	13	21	<0.1	60	<10	140	10	<50	<20
7	Landfill 2	7.5	443.9	<10	166	1.08	<50.0	<10	130	41.1	<50	<20
8	Landfill 2	4.1	229.8	18	398	<0.1	<50.0	<10	140	<10	<50	<20
9	Landfill 3	730	332.1	<10	99	0.38	110	<10	130	<10	<50	<20
10	Landfill 3	15.1	14.3	20	9	0.22	70	<10	120	<10	<50	<20
11	Landfill 3	17.4	16.2	40	< 1	<0.1	50	<10	100	<10	<50	<20
Detection Limit		1	5.0	10	1	0.1	50	10	100	10	50	20

penetrated refuse near the toe of Landfill 2 (Figure 4-3) and are screened in the sediment below the landfill. The results of the water quality analyses is summarized in the following paragraphs.

Of the metals, no lead, chromium, or cadmium was detected in any of the samples. Arsenic was detected in one sample, MW-7, at 41.1 ug/l, which is just below the drinking water standard of 50 ug/l. Copper was found in wells MW-6 and MW-8 at 60 and 30 ug/L, respectively, which is well below the ambient water quality criterion of 1,000 ug/l. Nickel was found in all three wells at concentrations in the range of 130-140 ug/l, which is above the ambient water quality criterion of 13.4 ug/l.

Cyanide was found in Well MW-6 (13 ug/L) and MW-8 (18 ug/l), well below the Federal Ambient Water Quality Criterion of 200 ug/l. Phenols were found in all three wells in concentrations ranging from 21 to 398 ug/l. Only well MW-8 (398 ug/l) exceeded the taste and odor threshold of 300 ug/l. Only well MW-6 contained oil and grease at concentrations of 1.08 mg/l: the taste and odor threshold for oil and grease is .01 mg/l.

TOC (total organic carbon) was found in all wells in concentrations ranging from 4.1 to 28.4 mg/l. Although there is no background sampling point for this general indicator the 4.1 mg/L concentration in MW-8 was the lowest value for any of the 17 wells. TOX (total organic halogens) was found in all three wells in concentrations ranging from 82.9 to 443.9 ug/l. The highest concentration occurred at MW-7 and is also the highest concentration found in any of the 15 wells sampled for TOX. The significance of the general indicator parameters TOC and TOX will be discussed in Section 4.6.

4.3.3 Groundwater Quality - Site No.3, Landfill 3

The results of the water quality analyses for wells MW-9, MW-10 and MW-11 are presented in Table 4-1. All three wells are downgradient wells located near the landfill toe. MW-9 penetrated waste material and is screened in the sediments below the waste. The results of the water quality analyses are summarized in the following paragraphs.

Of the metals, no lead, chromium, cadmium or arsenic was detected in any of the samples. Copper was found in all three wells in a range of from 50 to 110 ug/l, which is well below ambient water quality criterion of 1,000 ug/l. Nickel was found in all three wells in concentrations of 100-130 ug/l, which is above the ambient water quality criterion of 13.4 ug/l. Cyanide was found in wells MW-10 and MW-11 at Landfill 3 in concentrations of 20 and 40 ug/l, respectively, well below the Federal Ambient Water Quality Criterion of 200 ug/l. Phenols were found in wells MW-9 (99 ug/l) and MW-10 (9 ug/l) both below the taste and odor threshold of 300 ug/l.

TOC (total organic carbon) concentrations were highest in MW-9 at 730 mg/l. This was the highest value obtained for any of the 17 wells analyzed for TOC. TOC levels for Wells MW-10 and MW-11 were 15.1 and 17.4 mg/l, respectively. TOX (total organic halogens) was found in Well MW-9 at a concentration of 332.1 ug/l, and in MW-10 and MW-11 at 14.3 and 16.2 ug/l, respectively. The significance of the general indicator parameters TOC and TOX is discussed in Section 4.6.

4.3.4 Groundwater Quality - Site No. 4, BOMARC Missile Site

Samples from Wells MW-16 and MW-17 at the BOMARC Missile Site were analyzed for TOC, oil and grease, hydrazine (a missile fuel component) and nitrates. The results of these analyses are presented in Table 4-2. The water quality results for the BOMARC site are summarized as follows.

TOC (total organic carbon) was found in concentrations of 15.8 mg/l and 4.7 mg/l. These values are in the lower range of results for the 17 well samples analyzed. The significance of results for the general indicator TOC is discussed in Section 4.6. Oil and grease was found in levels above the taste and odor threshold of 0.01 mg/L: 0.66 mg/l in MW-16 and 0.16 mg/l in MW-17. Nitrate concentrations of 0.88 mg/l and 8.5 mg/l were below the primary drinking water standard of 10 mg/l. No hydrazine was detected in samples from either well.

MW-16 also had the only alkaline pH observed in the wells (11.5) and a relatively high conductivity (1660 mhos/cm) compared to all other wells tested (see Table 3-5). This may be an indication of influence from the acid neutralization pit or residual caustics from some other aspect of past operations at the site..

TABLE 4-2 SUMMARY OF WATER QUALITY ANALYTICAL RESULTS FOR BOMARC, BULK FUEL STORAGE AND FIRE TRAINING AREA

Well	Location	TOC mg/l	TOX ug/l	Oil & Grease mg/l	Hydrazine ug/l	Nitrates mg/l	Cd ug/l	Ni ug/l	Cr ug/l	Pb ug/l
12	Bulk Fuel Storage	81.0	81.7	6.37	-	-	<10	130	< 50	< 20
13	Bulk Fuel Storage	10.5	18.1	0.46	-	-	<10	160	< 50	< 20
14	Fire Training Area 1	5.5	6.3	0.66	-	-	-	-	-	-
15	Fire Training Area 1	7.5	6.1	0.16	-	-	-	-	-	-
16	BOMARC	15.8	-	0.25	< 50	0.88	-	-	-	-
17	BOMARC	4.7	-	0.16	< 50	8.5	-	-	-	-
Detection Limit		1	5	0.10	50	0.1	10	100	50	20

- Not analyzed

4.3.5 Surface Water Quality - Site No. 5, Pesticide Wash Area

The results of the chemical analysis of stream samples taken at the Pesticide Wash area are presented in Table 4-3. The water quality standard for maximum protection to human health for these compounds is zero. Discussion of risk based criteria is found in Section 4.6. The results of analysis of sediment samples are also presented in Table 4-3 and these data are discussed in Section 4.4.1.

As discussed in Section 3.2.6, three surface water samples were taken from a small stream gully that runs past the pesticide wash area (see Figure 3-8). The samples were analyzed for pesticides with the following results.

Surface water sample SW-1 (adjacent to the wash area) contained only DDD at 0.6 ug/l. Four pesticide compounds were detected in SW-2: dieldrin (0.17 ug/l), DDE (0.18 ug/l), DDT (1.5 ug/l), and chlordane (1.8 ug/l). SW-2 is located about 100 feet downstream of the wash area. SW-3, located after the confluence of the pesticide area stream and another similar small stream, contained only DDD at a concentration of 0.7 ug/l.

4.3.6 Groundwater Quality - Site No. 7, Fire Training Area

Samples from Wells MW-14 and MW-15 at Fire Training Area 1 were analyzed for TOX, TOC, and oil and grease. MW-15 is located within the Fire Training Area (Figure 3-9) and MW-14 is located between the Fire Training Area and the nearby stream. The results of the water quality analyses are presented in Table 4-2. Concentrations of oil and grease were above the taste and odor threshold of 0.01 mg/l in both wells: 0.66 mg/l in MW-14 and 0.16 mg/l in MW-15.

Concentrations of TOC (total organic carbon) were 5.5 mg/l and 7.5 mg/l for MW-14 and MW-15, respectively. Concentrations of TOX (total organic halogens) were 6.3 ug/l for MW-14 and 6.1 ug/l for MW-15. Although there were no background water quality sampling points, these TOC and TOX results are in the low range of the wells sampled. The significance of the general indicator parameters TOC and TOX are discussed in Section 4.6

4.3.7 Groundwater Quality - Site No. 8, Bulk Fuel Storage Area

The results of the chemical analyses of water samples from Wells MW-12 and MW-13 are presented in Table 4-2. The re-

TABLE 4-3 SUMMARY OF SOIL AND WATER ANALYTICAL RESULTS FOR THE PESTICIDE WASH AREA

Soil Boring Samples	Dieldrin (ug/kg)	DDE (ug/kg)	DDT (ug/kg)	DDD (ug/kg)	Chlordane (ug/kg)
TB-1 1-2'	4.5	9.0	110	.02	39
TB-1 4-5'	2.1	1.3	7.6	.02	19
TB-2 1-2'	3.2	1.6	13	13	< .02
Surface Water	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
SW-1	< .02	< .02	< .02	0.6	< .02
SW-2	.17	.18	1.7	1.5	1.8
SW-3	< .02	< .02	0.7	< .02	< .02
Detection Limit H_2O	.02	.02	.02	.02	.02
Stream Sediments	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
SS-1	150	120	1,600	2,800	12,000
SS-2	250	200	1,800	3,700	8,800
SS-3	20	40	360	430	3,600
Detection Limit Soils	.02	.02	.02	.02	.02

sults of the water quality analysis for the Bulk Fuel Storage area are summarized as follows.

No lead, chromium, or cadmium was detected in either Well MW-12 or MW-13. Nickel was found in both wells in concentrations of 130 ug/l (MW-12), and 160 ug/l (MW-13); above the Federal Ambient Water Quality Criterion of 13.4 ug/l.

TOC (total organic carbon) was found in concentrations of 81.5 mg/l in MW-12 and 10.5 mg/l in MW-13. The results for MW-12 were in the medium range for TOC of the 17 well samples analyzed. TOX (total organic halogens) were found in concentrations of 81.7 ug/l (MW-12) and 18.1 ug/l (MW-13). The results for MW-12 were higher than 9 of the 15 samples analyzed. The significance of the results for the general indicator parameters TOC and TOX are discussed in Section 4.6

Oil and grease was found in concentrations of 6.37 mg/l in MW-12 and 0.46 mg/l in MW-13. Both results are above the taste and odor threshold of 0.01 mg/l, and the oil and grease concentration in MW-12 was the highest for the 17 groundwater samples analyzed.

4.4 RESULT OF SEDIMENT QUALITY ANALYSES

In addition to the water quality testing, two sites were evaluated for contamination by performing selected analyses on soils.

4.4.1 Site No. 5, Pesticide Wash Area

4.4.1.1 Subsurface Samples

As discussed in Section 3.2.2.7, two soil borings were completed in the Pesticide Wash area (Figure 3-8) to obtain soil samples at discrete depth intervals above the water table (approximately 6 feet). Soil samples from a depth of two feet in each boring were analyzed for pesticides. As shown in Table 4-3, both contained measurable concentrations of four compounds. Since boring TB-1 had significantly higher concentrations, an additional sample, at a depth of 5 feet was consequently analyzed. These results are also shown on Table 4-3.

Of the pesticides found, DDT had the highest concentrations: 110 ug/kg in TB-1, 1'-2'; 7.6 ug/kg in TB-1, 4'-5'; and 13 ug/kg in TB-2, 1-2'. Chlordane was found only in TB-1 at 39 ug/kg at 1-2 feet, and 19 ug/kg at 4-5 feet. DDD was found only in TB-2 at a concentration of 13 ug/kg. DDE and dieldrin were also found in all three samples from the two test borings at concentrations of from 2.1 to 4.5 ug/kg for dieldrin and 1.3 to 9.0 ug/kg for DDE.

4.4.1.2 Stream Bottom Sediment Samples

Sediment samples from the gully stream bottom were taken at the same time and at the same locations as the surface water samples (see Section 4.3.5). Sample locations are shown on Figure 3-8. Pesticide concentrations in the stream sediments were generally several orders of magnitude higher than those in the subsurface borings. The highest concentrations were of chlordane from 3,600 to 12,000 ug/kg. DDD ranged from 430 to 2,800 ug/kg, and DDT ranged from 360 to 1,800 ug/kg. DDE and dieldrin occurred at lower ranges: from 20 to 150 ug/kg for DDE, and 40 to 200 ug/kg for dieldrin.

Pesticide concentrations vary only slightly from SS-1 adjacent to the wash area, to SS-2, 100 feet downstream of the wash area. Although there is a greater drop in pesticide concentration between SS-2 and SS-3, levels in SS-3 are still relatively high compared to levels found in the subsurface samples.

4.4.2 Site No. 6, DPDO Storage Area

Soil samples from the one to two foot depth interval from the five borings at the DPDO Storage Area were submitted for analyses of PCB, and oil and grease. The results of the analysis of these samples, mostly fine to medium sands, is presented in Table 4-4. The location of the sampling points is shown on Figure 3-4. Three samples from the one to two foot interval in borings TB-3, TB-5 and TB-7 had measureable total PCB (arochlor 1242, 1254, 1221, 1232, 1248, 1206, 1016) in concentrations of 24 ug/kg (TB-3) to 30 ug/kg (TB-5) and 14 ug/kg (TB-7). Oil and grease concentrations were found in all five 1-2 foot samples in concentrations ranging from 617 mg/kg (TB-7) to 6,360 mg/kg (TB-3). All PCB levels detected were well below the USEPA Action Level of 50 mg/kg.

Based on concentrations of oil and grease in the 1-2 foot depth samples, additional analyses were performed on samples at the 4-5 foot depth interval and the top of the water table (approximately 17 feet). The results of these analyses are also presented in Table 4-4.

TABLE 4-4

SUMMARY OF SOILS ANALYTICAL RESULTS FOR THE DPDO STORAGE AREA

Location	Boring No.	Depth (ft.)	Oil & Grease (mg/kg)	PCB (as 1260) (ug/kg)
DPDO	TB-3	1-2	6360.0	24
Loading and Drum Storage Area	TB-3	4.5-6	31.4	<10
"	TB-3	15-16	53.5	<10
"	TB-4	1-2	132.0	<10
"	TB-4	4-5	20.8	--
"	TB-4	14.5-16	17.5	--
DPDO, Buried Tank Area	TB-5	1-2	3430.0	30
"	TB-5	4-5	234,000.0	<10
"	TB-5	14.5-16	149.0	<10
"	TB-6	1-2	1,454.0	<10
"	TB-6	4-5	25,400.0	<10
"	TB-6	14.5-16	97.5	<10
"	TB-7	1-2	617.0	14
"	TB-7	4-5	16,600.0	<10
"	TB-7	16-18	112.0	10
DETECTION LIMIT			0.1	10

In all samples below two feet analyzed, no PCB was detected. Oil and grease were found in all of the deeper samples analyzed. Concentrations of oil and grease in the borings adjacent to the buried tank (TB-5, TB-6 and TB-7) were highest at the 4-5 foot depth interval (16,000 to 234,000 mg/kg) and dropped off to from 97 to 149 mg/kg at 16 feet. The high concentrations at the intermediate depth are probably associated with leakage from the buried tank. Oil and grease concentrations at the drum storage area (TB-3 and TB-4) are much lower at depth (17.5 mg/kg - 53.5 mg/kg) than in the 1-2 foot interval reflecting a surface source of contamination.

4.5 GEOPHYSICAL SURVEY RESULTS

Both the magnetometer and GPR surveys produce results which require individual interpretations. The interpretations of the data is enhanced by comparing the results of each method. The inherent limitations of any single technique of remote sensing can be lessened by cross-referencing two or more geophysical techniques. The following subsections describe the results of the geophysical survey.

4.5.1 Magnetometer

Figure 4-5 shows the magnetic anomaly contour map developed from the vertical magnetic intensities obtained on 20 October 1983. WESTON used a Radian CPS-1 computer graphic contour plotting system to construct the contour solutions for the node locations surveyed.

When the magnetic contour map exhibits an exaggerated areal magnetic variation, then a more complex and extended source is suspected. According to Heiland (1939) there should be no railroad tracks within 125 yd, no automobiles with 30 yds, and no wire fencing (particularly in the north-south direction) within 35 yds. Power lines, culverts, and buildings should be avoided. Therefore similar conditions existing within the CC compound, (i.e. mobile generators and construction vehicles, angle iron and building materials, and a cyclone fence paralleling the Southern boundary) may be responsible for interferences within the normal field and subsequently greatly exaggerate areal magnetic variations. An examination of Figure 4-5 reveals exaggerated contour gradients at Building No. 3469, and at the concrete pad in the southeastern portion of the site. This condition characteristically exemplifies interferences within the normal magnet-

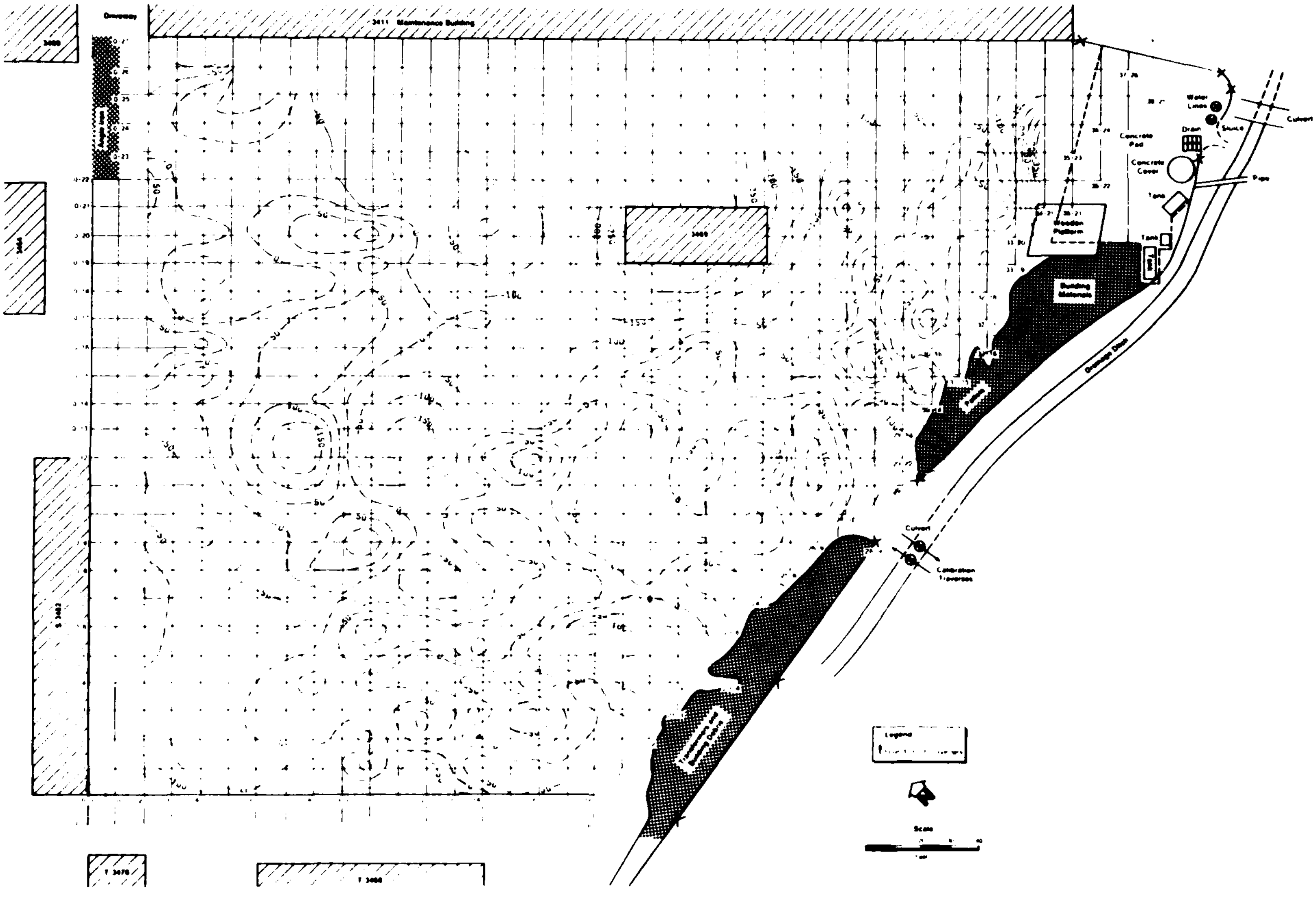


FIGURE 4-5 CIVIL ENGINEERING COMPOUND - MAGNETIC ANOMALY CONTOUR MAP

ic field induced by these two sources. However, at distance from these, and other contributing interference sources, certain generalized anomalies are apparent. These anomalies may represent the shapes of magnetic force fields generated by buried magnetic bodies. Magnetic highs and lows are exhibited by mounds and depressions, respectively, in the contour gradient. Typical examples of three mounds are evident at approximate node locations 7+12, 16+12, and 28+15. Magnetic depressions are apparent at approximate node locations 12+12 and 18+5 and are represented by solid lines.

4.5.2 Ground Penetrating Radar

Figure 4-6 represents an interpretive subsurface plot map of the Civil Engineering Compound. This figure depicts the various subsurface phenomena encountered by the GPR. Individual targets were prioritized as either high or low depending upon the density and geometric configuration of the profile signature. These highly suspect targets are plotted on Figure 4-6.

High priority targets were extremely good signal reflectors exhibiting a dense, parabolic signature. This type of signature is characteristic of rounded objects such as pipes, boulders, or drums. In contrast, the signatures produced by the low-priority targets were characteristically less dense and variable in geometric configuration. Occasionally this signature difference is a result of the orientation of the buried object with respect to the antenna traverse, (ie: A buried drum in a vertical plane with the ground surface, typically exhibits a hyperbolic signature.)

Figure 4-6 also shows areas of disturbed sub-soil and suspected trench locations. The plots of these phenomenon are a result of the collective interpretations of the GPR profiles. What appears to be a buried electrical utility or conduit was encountered between grid nodes 24 + 27, and 23 + 21.

4.5.3 Summary of Geophysical Findings

When the magnetic anomoly map is superimposed upon the GPR plot map, similar subsurface trends are reflected. Most of the suspect trench and the disturbed soil areas are characterized by magnetically high contours. Individual targets are represented by varying magnetic contours and can only be located with some degree of confidence from the GPR plot map. The contrast between the two types of data may be a re-

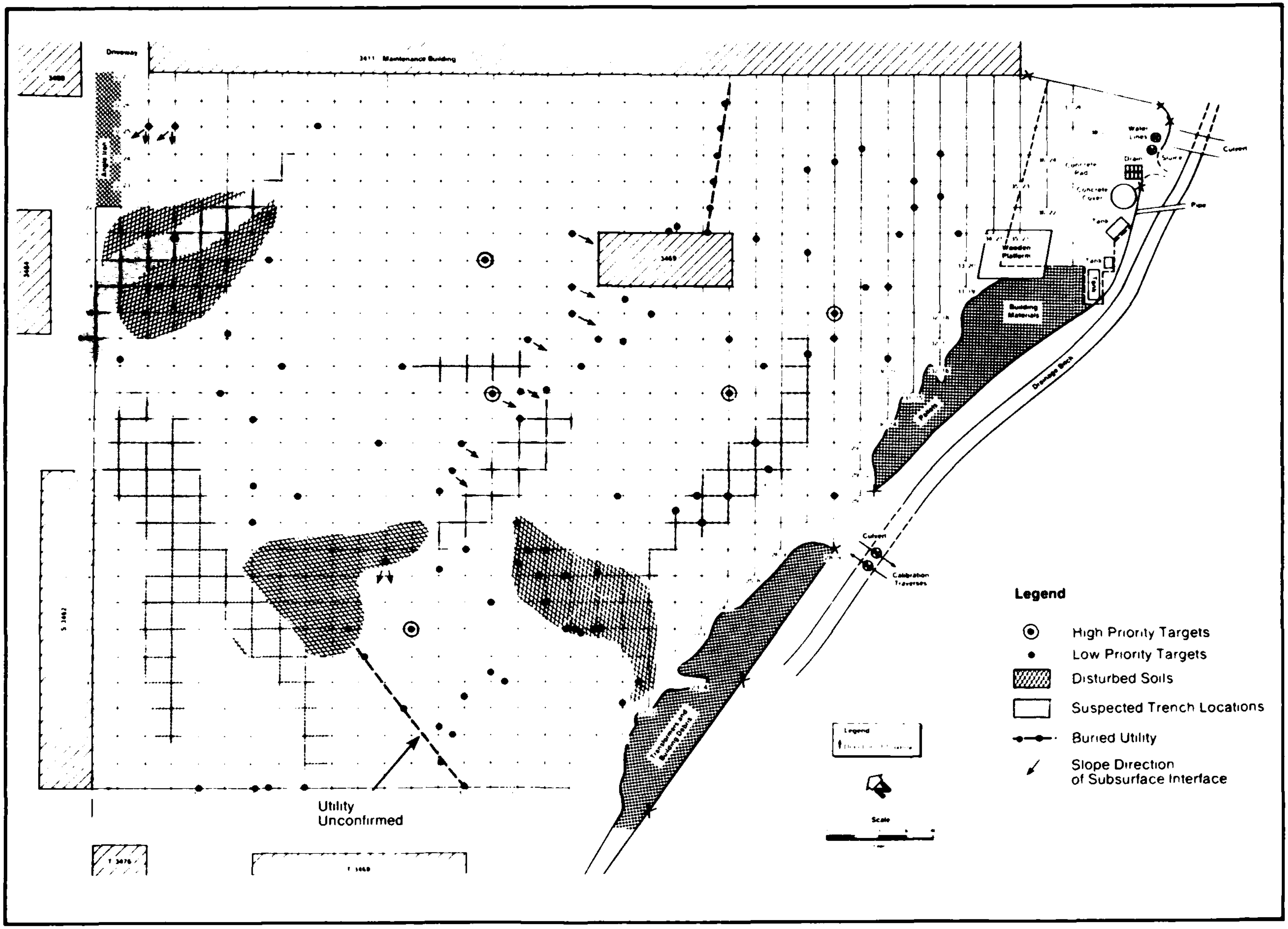


FIGURE 4-6 CIVIL ENGINEERING COMPOUND - INTERPRETIVE MAP OF SUBSURFACE CONDITIONS BASED ON GEOPHYSICAL DATA

sult of the variable magnetic interferences cited in section 4.5.1. All subsurface features detected, such as trenches, disturbed soils, utilities, and suspected targets are plotted on figure 4.6. A 1962 aerial photograph shows the CE compound as a black top surface. However, in a 1950 aerial photograph the compound is unpaved. Soil excavation was occuring and certain boundaries existing in that photo do correlate with the GPR plot map.

4.6 SIGNIFICANCE OF FINDINGS

4.6.1 Water Quality - General

The principal objective of the Phase II Confirmation Study was to determine whether past hazardous waste operations or disposal practices had resulted in environmental degradation. The analytical results of the Phase II study represent a single round of sampling at selected surface water quality stations and newly installed monitor wells. The conclusions drawn from this information should be evaluated with this understanding.

Groundwater and surface water quality results are in Tables 4-1, 4-2, 4-3, and 4-4. Appendix H includes all analytical results from monitoring the Phase II sites. Appendix I contains a complete listing of Federal and State drinking water and human health standards, criteria, and guidelines applicable in the State of New Jersey.

On November 28, 1980, the U.S. Environmental Protection Agency issued criteria for 64 toxic pollutants or pollutant categories which could be found in surface waters. The criteria established recommended maximum concentrations for acute and chronic exposure to these pollutants by both humans and aquatic life. The derivation of these exposure values was based upon cancer risk, toxic properties, and organoleptic properties.

The limits set for the cancer risk are not based upon a safe level for carcinogens in water. The criteria state that for maximum protection for human health, the concentration should be zero. However, where this cannot be achieved, a range of concentrations corresponding to incremental cancer risks of from 1 to 10 million to 1 in 100,000 was presented (10^{-7} to 10^{-5}).

Toxic limits were established at levels for which no adverse effects would be produced. These are the health related limits which have been used in this report to evaluate potential impacts. It should be noted that the cancer risk column is based upon one cancer case in one million, (10^{-6}). The EPA's evaluation criteria under CERCLA (Annex XIII) for selecting contaminant levels to protect public health call for the remedial action to "attain levels of contamination which represent an incremental risk of contracting cancer between 10^{-5} and 10^{-6})". The 10^{-6} value was used to achieve the maximum protection to the public.

In addition to the cancer risk assessment criteria, the U.S. EPA Office of Drinking Water provides advice on health effects upon request, concerning unregulated contaminants found in drinking water supplies. This information suggests the level of a contaminant in drinking water at which adverse health effects would not be anticipated with a margin of safety; it is called a SNARL (Suggested No Adverse Response Level). Normally values are provided for one-day, 10-day and longer-term exposure periods where available data exists. A SNARL does not condone the presence of a contaminant in drinking water, but rather provides useful information to assist in the setting of control priorities in cases when they have been found.

SNARLs are not legally enforceable standards. They are not issued as an official regulation, and they may or may not lead ultimately to the issuance of a national standard or Maximum Contamination Level (MCL). The latter must take into account occurrence and relative source contribution factors, in addition to health effects. It is quite conceivable that the concentration set for SNARL purposes might differ from an eventual MCL. The SNARLS may also change as additional information becomes available. In short SNARLs are offered as advice to assist those who are dealing with specific contamination situations to protect public health.

The above information concerning SNARLs was taken directly from guidance documentation authorized by the EPA and made available to WESTON. The SNARLs levels for various compounds were also used in evaluating the results of ground and surface water sampling.

4.6.2 Water Quality at McGuire AFB

The applicable guidelines for water quality analyses conducted at McGuire AFB are summarized in Table 4-5, with detailed reference material included in Appendix I. No standards ex-

TABLE 4-5

COMPARISON OF McGUIRE WATER QUALITY RESULTS WITH APPLICABLE STANDARDS GUIDELINES AND CRITERIA

Detected Parameters	Water Quality Standard *	Reference
TOX	None	General Indicator.
TOC	None	General Indicator.
Oil & Grease	10 ug/l	Taste and odor threshold.
Cyanide	100 ug/l	Federal Primary Drinking Water Standards.
Phenol	300 ug/l	Taste and odor threshold.
Copper	1,000 ug/l	Federal Ambient Water Criterion
Nickel	13.4 ug/l	Federal Ambient Water Criterion
Arsenic	50 ug/l	Federal Ambient Water Criterion
Lead	50 ug/l	Federal Primary Drinking Water Standards
Nitrates	10 ug/l	Federal Primary Drinking Water Standards
Hydrazine	None	None
DDT DDE DDD	0 0 0	Federal Water Quality Criterion. Non-threshhold.
Dieldrin ChlordAne	0 0	Assumption level. Other criteria are based on a determined health risk factor. (Appendix I).

*See Appendix I for a discussion of these criteria.

ist for the general indicator parameters TOC (total organic carbon) and TOX (total organic halogens). Because more than half of the EPA list of volatile organic Priority Pollutants are halogenated, the TOX parameter provides a method of screening samples for these contaminants before proceeding to specific analyses.[1] (Harper, 1984)

Of the metals included in the analyses of ground-water samples, only nickel was found in concentrations exceeding the Federal ambient water criterion (13.4 ug/l). Nickel was found in all samples in ranges of from 100 to 170 ug/l (the detection limit was 100 ug/l).

Oil and grease was found in 13 of the 17 wells and at all of the sites at concentrations above the taste and oder threshold of 0.01 mg/l. The remaining 4 samples had no detectable oil and grease at 0.01 mg/l, the detection limit for this program.

The major potential ground-water contaminants indicated by the available data are organic halogens. TOX levels ranged from 5.1 to 443.9 ug/l in 14 of the 15 wells sampled (BOMARC site samples were not analyzed for TOX). Four samples exceeded 100 ug/l and six samples had concentrations ranging from 10 to 100 ug/l. Each landfill area (Zone 1, Landfills 2 and 3) had at least one well with TOX concentrations exceeding 100 ug/l. MW-12 at the bulk fuel storage area had TOX concentrations at 81.7 ug/l. The fire training area wells had the lowest TOX levels - 6.1 and 6.3 ug/l.

USEPA water quality criteria for Human Health have been set for numerous compounds falling within the group contributing to TOX levels. Most of these standards are in the range of 1 ug/l or less. Thus TOX concentrations in the well samples from McGuire AFB indicate a high probability that these health criteria are exceeded in the case of one or more compounds.

4.6.3 Soil Contamination at McGuire AFB

With the exception of a USEPA action level of 50 mg/kg for PCB, there are currently no quality standards, guidelines, or criteria for soil quality regarding the majority of contaminants. For clean-up purposes target concentrations for specific contaminants are usually established on a case-by-case basis by the regulatory agency having jurisdiction.

4.6.3.1 Site No. 5, Pesticide Wash Area

The pesticide levels observed in the subsurface soil samples at the pesticide wash area are not considered by WESTON to be a factor of concern. Aqueous solubilities of these compounds are low and the impact on ground-water quality beneath the site should be minimal. Levels of chlordane, DDT and DDE in excess of 1,000 ug/kg in the stream sediments, however, show that some offsite migration of contaminated sediments has occurred. The relatively low concentrations of pesticides in the stream water indicates that the contaminants are migrating principally by sediment transport. The farthest downstream sampling point contained significant concentrations of pesticide compounds, so that it was not determined how far downstream the contaminated sediments have been carried. The stream that passes the pesticide wash area flows to South Run, which exits the installation to the east.

4.6.3.2 DPDO STORAGE AREA

The distribution of PCB in the soils analyzed from the DPDO facility indicate that PCB only occurs in near-surface samples (1-2 feet) and were not found at depth. PCB was found in 3 borings at very low concentrations of from 14 to 30 ug/kg: TB-3 in the drum storage area, and TB-5 and TB-7 near the buried tank location in the storage yard, where transformers were stored in the past.

PCB was not found at depth and appears to be limited to near-surface soils. Oil and grease concentrations were found at all depths and highest at depths of 4-5 feet in the buried tank area (16,000 - 234,000 mg/kg) and 1-2 feet at the drum storage area (132 - 6360 mg/kg). While the PCB in near surface soils appears limited and probably associated with past storage of transformers, the oil and grease appears related to surface drum storage and the buried storage tank. It does not appear that the waste oil from the buried storage tank contained PCB.

4.6.4 CONCLUSIONS

Based on the results of the Phase II Conformation Study at McGuire Air Force Base, the following key conclusions have been drawn:

1. Groundwater directly beneath McGuire AFB and the BOMARC Missile Site occurs at water table conditions with the water table occurring from 1 to 25 feet below ground surface. Sediments encountered during the drilling consisted of interbedded fine to medium sands, silts and clays of the Kirkwood and Cohansey Formations.

2. Regional ground water flow in the Cohansey and Kirkwood Formations is generally down formational dip to the southeast. However, most of the flow in the upper aquifer, where the monitoring wells are screened, is lateral toward local streams where discharge occurs.

3. The fate of contaminants infiltrating from the landfills to the water table is to move laterally toward the streams where discharge occurs. Given the permeability of the sediments, the ages of the landfills, and the proximity of the landfills to surface streams, this lateral migration occurs fairly rapidly and ground-water contaminant plumes, as observed in the well water quality analyses, have already reached the surface water discharge areas.

4. The most immediate potential for migration of contaminants off-Base is from the landfill generated contaminants reaching North Run and South Run through the ground water. These streams both leave Base property a short distance from where they pass the landfills.

5. TOX (Total Organic Halogens) were found in concentrations in excess of 100 ug/l in at least one well at each of the three landfill sites. TOX concentrations were 18.1 and 81.7 ug/l in the Bulk Storage Area wells and 6.1 and 6.3

ug/l in the Fire Training Area wells. These results indicate the possible presence of elevated levels of one or more specific organic priority pollutants in the ground water at these sites.

6. Concentrations of oil and grease in excess of the taste and odor threshold were found at all but 4 wells and at all sites where ground water was monitored.

7. Concentrations of five pesticide compounds were found in soils at the Pesticide Wash Area. The migration of pesticides vertically into the subsoil appears slight. However, levels of DDT, DDE and chlordane in excess of 1,000 ug/kg were found in the stream sediments downstream of the site. This indicates that off-site migration of pesticides is occurring by surface sediment transport. Pesticide concentrations in surface waters were in excess of 1 ug/l in only one stream sample (SW-2). Because of low solubilities, the compounds are remaining adsorbed in the sediments. The stream flowing past the Pesticide Wash Area is not close to a Base boundary, although the extent of the pesticide occurence in down stream sediments is not known.

8. Soil boring samples at three depth intervals from the DPDO Storage Area were analyzed for oil and grease and PCB. PCB was found in the drum storage area and buried tank area in the 1-2 foot depth samples from three borings: TB-3, TB-5, and TB-7. PCB was detected in concentrations of 14-30 ug/kg, well below the USEPA action level of 50 ug/kg.

9. The results of the geophysical investigation of the Civil Engineering Compound, combined with the examination

of historical aerial photos, show that areas exist at the site that have been disturbed in the past. Magnetic anomalies associated with these areas indicate that buried drums or other metallic scrap may be present.

10. Based on the limited analyses completed, the ground water quality at the Fire Training Area appears less degraded than the other sites sampled. TOX concentrations were among the lowest of wells tested. Since the site has not been in use since the 1950's, existing contaminants are likely to have been dispersed.

SECTION 5

ALTERNATIVES

5.1 GENERAL

The principal goal of this Phase II Confirmation Stage 1 Study at McGuire AFB was to determine whether or not environmental degradation was occurring as a result of past practices of materials handling at the installation. The results presented in Section 4 confirm that each of the 8 sites where environmental sampling was comoleted has affected the quality of groundwater, surface water, or soils in their immediate area. In addition, the results of the geophysical investigation at the Civil Engineering Storage Area indicates that metallic waste, such as drums may be buried on site. These preliminary findings presented in Section 4 require additional verification which is discussed in Sections 5 (Alternatives) and 6 (Recommendations).

The evaluation of remedial action alternatives is not part of this scope of work. The alternative measures discussed below focus on the problem definition aspects of environmental contamination at McGuire AFB. The problem definition approach itself is based on the need to provide a basis for possible future remedial action. The alternative actions to be discussed fall into the following categories:

Actions	Site
1. Quantification Stage Water Monitoring at Existing Wells	All Sites
2. Expanding the Groundwater Monitoring Network and Surface Water Sampling Points	Zone 1, Landfills 2 & 3, Fuel Storage Area
3. Additional Soil Sampling and Analyses	Civil Engr. Compound Pesticide Waste Area, DPDO Area
4. Preliminary Concept Engineering Evaluation	Zone 1, Landfills 2 & 3

These alternative measures are discussed site by site in the following sections. Based on these possible alternative actions, specific recommendations are presented in Section 6.

5.1.1 Zone 1 Alternatives

All of the existing wells in Zone 1 (Landfills 4, 5, 6 and the Sludge Disposal Site) contain measurable levels of potential contaminants. Because there are a variety of potential sources, and the analytical parameters and sampling locations were limited, alternative actions in Zone 1 need to address the identification of specific contaminants and the boundaries of groundwater contamination at the site. Additional wells are required to define the extent of the groundwater contamination in the upper aquifer and upgradient (background) monitoring points need to be established. A verification stage analysis should be performed on samples from the existing wells to provide key indicators for sampling the expanded well network. Stream sampling points should also be established for locations along South Run to establish the impact on surface water quality.

Landfill 4 is the largest and oldest landfill in Zone 1. It has the highest probability of containing Priority Pollutant compounds. In addition, the water table appears high in the area around Landfill 4. The depth to the water table and the thickness of waste should be identified by a geophysical survey and soil borings in order to enable future remedial action assessment for the Landfill.

5.1.2 Site No. 2, Landfill 2, and Site No 3, Landfill 3 Alternatives

Landfills 2 and 3 have similar histories and are similarly located along North Run. The confirmation study included the installation of 3 monitoring wells at each site and the sampling of those wells for a similar suite of parameters. The results of the chemical analyses of groundwater samples from both sites was similar. TOX, in particular, was relatively high in several wells from both sites. Groundwater flow was also similar at the two sites; the upper water table is toward North Run, which is a line of groundwater discharge. Additional investigation of the two sites should therefore involve the same steps.

Initially, additional investigation at Landfills 2 and 3 should include a resampling of the existing wells to verify the first round of analytical results. At both Landfills 2 and 3 there is large drop in hydraulic head between the wells and North Run, which indicates possible groundwater mounding caused by the landfill. There could thus be a component of groundwater flow and contaminant migration away from North Run on the back side of the landfills. In the case of Landfill 3, this is toward the Base boundary that is adjacent to the landfill. Monitoring wells should be located on the opposite sides of the landfills from the existing wells to assess these possibilities.

In addition, production well "A", located adjacent to Landfill 2 and the drum storage area, should be sampled. This is a deep well, but its isolation from surface contamination should be confirmed.

5.1.3 Site No 4, BOMARC Missile Site Alternatives

A verification round of sampling and analysis should be accomplished, with volatile organic compounds and xylene added to the list of analytes. Negative results for these compound-specific analyses would result in deleting the site from future concern.

5.1.4 Site No. 5, Pesticide Wash Area Alternatives

The analyses of subsurface and stream sediments and stream water samples at the Pesticide Wash Area indicates that the principal contaminant migration path for pesticide compounds is in sediments washed down to the stream from the site, and then transported by the stream. Additional sampling and analysis of the stream sediments at down-stream locations is necessary to determine the extent of contaminated sediment transport. An up-stream sampling point also needs to be established to determine background sediment quality. Specific sampling recommendations are made in Section 6.

5.1.5 Site No. 6, DPDO Storage Facility Alternatives

PCB was detected in shallow boring samples only (1-2 feet) in the drum storage area and within the fence line of the main storage yard. Although PCB has apparently not migrated deep into the soil, the areal extent of soil contamination is not known and would need to be confirmed by a program of sampling and analysis of surface soils in this area. In contrast, oil and grease were found throughout the soil column. The source appears to be surface leakage in the drum storage area, and subsurface leakage in the buried tank area. Surface soil sampling should be adequate to identify the extent of oil and grease contamination in the drum storage area.

Since the contaminants from the DPDO area may be reaching the groundwater, a monitoring well would be required between the storage yard and North Run to intercept possible contaminants in the groundwater. Specific recommendations for soil sampling and monitoring well installation are presented in Section 6.

5.1.6 Site No. 7, Fire Training Area 1 Alternatives

The Fire Training Area 1 has not been in use since the early 1950's. It is located on permeable soils and no obvious soil contamination is evident at the surface, other than slight staining in some places. TOX concentrations in the wells sampled were among the lowest observed. In addition, the site is in the center of the Base at distance from the installation boundary. Therefore, additional investigation should be limited to verifying the water quality results already reported by conducting an additional round of sampling. Identification of volatile organic Priority Pollutants (VOA) should also be considered.

5.1.7 Site No. 8, Bulk Fuel Storage Area Alternatives

At the existing two wells at the Bulk Fuel Storage Area, another round of groundwater samples should be taken to verify the existing analytical results. In addition, analysis of these wells for specific organic Priority Pollutant compounds is required to determine the significance of the TOX concentrations observed in the first sampling rounds.

It has been WESTON's experience that unknown or undocumented leakages occur in storage tanks and service lines of bulk fuel storage areas such as the one at McGuire AFB. Therefore, the possibility of groundwater contamination from these sources is frequently not identified in routine records searches. Since the two monitoring wells already installed cover only a small portion of the site, additional monitoring wells are required to monitor groundwater flow across the entire site. Specific recommendations for groundwater sampling and monitor well installation are presented in Section 6.

5.1.8 Site No. 14, Civil Engineering Compound Alternatives

The results of the geophysical survey have confirmed historical information indicating that the area has been disturbed in the past and that barrels and other wastes may be buried there. A verification study should be conducted to determine the nature of the identified anomalies. A series of test pits would be required at locations determined by the geophysical survey to locate buried barrels, if present, monitor excavations for organic vapors, and sample potential contaminated soils and waste material.

The verification investigation would be followed, if necessary, with a Quantification Stage investigation to determine the amount of buried waste present and its impact on groundwater quality. This level of investigation, if required, would involve additional soil borings or test pits and the installation of groundwater monitoring wells , if the risk of groundwater contamination is determined.

SECTION 6

RECOMMENDATIONS

6.1 GENERAL

The findings of the Phase II Confirmation Study at the nine sites at McGuire AFB and the BOMARC Missile Site indicate the need for follow-up investigation which should include the following:

1. General verification of the results of the first round of water quality sampling.

2. An expanded monitoring and sampling program with an emphasis on determining the nature and extent of contamination by Priority Pollutants.

6.1.1 Zone 1

The following additional work is recommended for the Zone 1 Area (Landfills 4, 5, 6 and the Sludge Disposal Area).

1. An additional round of samples should be taken from existing wells MW-1 through MW-5 to verify the results obtained from the first sampling round. Samples from all five wells should also be analyzed for USEPA Priority Pollutant volatile organic compounds and landfill leachate indicator parameters such as nitrates, iron, ammonia-nitrogen and boron. In addition, samples from MW-3 should be analyzed for USEPA Priority Pollutant acid and base/neutral compounds and pesticide/PCB compounds. Three surface water samples should be taken along South Run upstream of Zone 1, downstream of the small tributary passing by MW-3 and downstream of the waste treatment plant. These samples should be analyzed for the same parameters as the 5 well samples.

2. A Ground Penetrating Radar survey should be performed on Landfill No. 4 to determine boundaries, depth, and possible buried barrel nests. The investigation should be followed by 10 soil borings in Landfill 4 to confirm depth of fill and depth to water.

3. If the results of the above analyses are positive, at least eight additional groundwater monitoring wells should be drilled in the Zone 1 area, including three wells at the locations of borings in Landfill 4 and two upgradient wells, one each above Landfills 4 and 5.

4. The new and existing wells should be sampled for key parameters identified in the previous sampling of the existing wells. In addition, samples from South Run should be taken at locations upstream, opposite the landfills and where the stream crosses the installation boundary and analyzed for a similar suite of key parameters.

6.1.2 Site No. 2, Landfill 2

The following additional work is recommended for Landfill 2:

1. The existing wells at the site should be resampled to verify the results of the first water quality analyses. All samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds.

2. Production Well A, located adjacent to the barrel storage area, should be sampled for the same suite of parameters as above.

3. In addition to the above parameters, MW-7 should be sampled for USEPA Priority Pollutant acid compounds, base/neutral compounds and pesticide/PCB compounds.

4. A Ground Penetrating Radar (GPR) survey should be conducted on the landfill to assess depths to the base of fill and the location of possible barrels. Six soil

borings should be completed subsequently to calibrate the GPR results and confirm the depth of fill and the location of the water table.

5. Three additional monitoring wells should be installed to the east of the landfill to define potential groundwater flow in that direction. One well should be adjacent to Production Well "A" and the DPDO barrel storage area.

6. All wells should be sampled for specific contaminants based on the results of the previous sampling round. The list of analytes should also include landfill leachate parameters such as nitrates, iron, ammonia-nitrogen and boron.

7. Water quality samples should also be collected along North Run upstream from the landfill, downstream, and opposite the landfill, and analyzed for the suite of analytes identified above.

6.1.3 Site No. 3, Landfill 3

WESTON makes the following recommendations for further investigation at Landfill 3:

1. Resample existing wells to verify the first round of analyses, plus analyze all samples for USEPA Priority Pollutant volatile organic compounds. In addition, MW-9 should be sampled for USEPA Priority Pollutant acid compounds, base/neutral compounds and pesticide/PCB compounds.

2. Three additional monitoring wells should be installed between the landfill and the Base boundary.

3. All wells should be sampled for those key parameters indicated in the previous round of sampling, plus nitrate, iron, ammonia-nitrogen and boron.

4. Three surface water samples should be taken along North Run; upstream, opposite the landfill, and downstream. These samples should be analyzed for the same parameters as the wells.

6.1.4 Site No. 4, BOMARC Missile Site

WESTON makes the following recommendations for further investigation at the BOMARC Missile Site:

1. Resample existing wells to verify the first round of analyses, plus analyze the samples for USEPA Priority Pollutant volatile organic compounds and xylene.

6.1.5 Site No. 5, Pesticide Wash Area

Contamination of stream bed sediments is the principal problem in the Pesticide Wash Area. WESTON, therefore, recommends that the following sampling be completed to determine the extent of this contamination:

1. Sediment and grab samples should be taken at three locations downstream of SS-3 and upstream of the culvert entrance, at three manhole locations along the storm drain system, and at one location upstream of the pesticide wash area. All samples should be analyzed for pesticides.

2. Two-foot core samples should be taken at locations SS-1, SS-2 and SS-3 to obtain samples at depth. Each core should be divided into two depth increments and analyzed for pesticides to determine the depth of the contaminated sediment.

6.1.6 Site No. 6, DPDO Storage Area

WESTON recommends that the following work be completed at the DPDO site to determine the extent of soil and groundwater contamination at the DPDO Storage Area.

1. Surface soil samples should be taken at twelve locations around the drum storage and buried tank areas. Three composite samples

should be analyzed for PCB with the remaining portion of the samples stored for possible future analysis.

2. A monitoring well should also be installed between the buried tank area and North Run. This well should be sampled for oil and grease, volatile organic compounds and xylene. The monitoring well recommended in Section 6.1.2, to be located near production Well "A", will also monitor the barrel storage area.

6.1.7 Site No. 7, Fire Training Area

WESTON does not consider Fire Training Area 1 to be a high priority site at this time, and recommends only that MW-14 and MW-15 be resampled to verify the original analytical results. Samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds and xylene.

6.1.8 Site No. 8, Bulk Fuel Storage Area

WESTON recommends that the following work be done at the Bulk Fuel Storage Area:

1. A second round of well samples should be analyzed to confirm initial results. Samples should also be analyzed for USEPA Priority Pollutant volatile organic compounds plus xylene.

2. Approximately twenty soil borings should be completed around the Bulk Fuel Storage Area. Temporary PVC well points should be installed and a groundwater elevation survey completed. Samples from the well points can be visually examined for floating fuel products.

3. Based on the information gathered from the temporary well points, up to six permanent groundwater monitoring wells should be installed in critical locations around the bulk fuel storage area including one upgradient, background location.

4. All wells at the site should be sampled for oil and grease, lead, USEPA Priority Pollutant volatile organic compounds, and xylene.

6.1.8 Site No. 14, Civil Engineering Compound

Based on the results of the geophysical survey and the examination of historical photographs, WESTON recommends that a subsurface investigation be conducted at the Civil Engineering Compound to confirm whether hazardous materials are buried at the site. WESTON recommends:

1. Backhoe test pits should be completed at those locations identified as potential burial sites by the geophysical survey (Figure 4-6). The work should be conducted while observing strict safety procedures, including personal body and respiratory protection. Air quality should be monitored with an organic vapor detector, and soil samples should be obtained in areas where physical appearance or detected vapors indicate contamination.

   This excavation activity is to be for the confirmation of whether barrels or contaminated soils are present. If barrels are encountered, they will not be disturbed or sampled. Only suspected contaminated soils will be sampled. All procedures for this investigation will be reviewed prior to the work with appropriate State and Federal regulatory agencies.

2. Selected soil samples should be analyzed for USEPA Priority Pollutant organic compounds and metals.

3. If the results of the chemical analyses of the soils is positive, four groundwater monitoring wells should be placed around the burial site; one well upgradient and three wells downgradient. Groundwater samples should be obtained from these wells and analyzed for key compounds indicated by the soils analyses to determine the impact of the waste on groundwater quality.

Appropriate response for remedial action should also be developed.

6.2 SUMMARY OF RECOMMENDATIONS

The recommendations which have been made as a result of this Stage 1 Study at McGuire Air Force Base are summarized in Table 6-1.

TABLE 6-1: SUMMARY OF RECOMMENDATIONS

Site	Recommendations	Rationale
Zone 1	Resample and analyze existing monitor wells	Verify Stage 1 results
	Expand suite of analytes	Characterization of contaminants
	Surface water sampling	Assess leachate discharge to adjacent creeks
	Ground Penetrating Radar Survey	Landfill boundary determination, assess presence of drums
	Borings and monitor wells within landfills	Determine if ground-water table is within fill material
	Additional monitor wells	Assess magnitude and extent of contamination
Site 2	Resample and analyze existing monitor wells	Verify Stage 1 results
	Priority Pollutant Scan	Characterize contaminants
	Ground Penetrating Radar Survey	Determine depth of fill and presence of drums
	Additional monitor wells, sampling and analysis	Assess magnitude and extent of contamination
	Sampling and analysis of surface waters	Assess leachate discharge to adjacent creeks
Site 3	Resample and analyze existing monitor wells	Verify Stage 1 results
	Expanded suite of analytes and Priority Pollutant Scan	Characterization of contaminants

TABLE 6-1: SUMMARY OF RECOMMENDATIONS (cont.)

Site	Recommendations	Rationale
	Additional monitor wells, sampling and analysis	Assess magnitude and extent of contamination
	Sampling and analysis of surface waters	Assess leachate discharge to adjacent creeks
Site 4	Resample and analyze existing monitor wells	Verify Stage 1 results
Site 5	Sampling and analysis of additional bottom sediments	Determine extent of downstream contaminant migration
Site 6	Sampling and analysis of additional surface soils	Determine extent of soil contamination
	Additional monitor well, sampling and analysis	Assess magnitude and extent of contamination
Site 7	Resample and analyze existing monitor wells	Verify Stage 1 results
Site 8	Resample and analyze existing monitor wells	Verify Stage 1 results
	Drill and sample soil borings	Determine magnitude and extent of soil contamination
	Additional monitor wells, sampling and analysis	Determine magnitude and extent of ground-water contamination
Site 14	Test pits and target sites identified by Ground Penetrating Radar Survey	Confirm presence or absence of buried drums
	Soil sampling and analysis	Characterization of contaminants
	Installation of monitor wells, sampling and analysis	Determine magnitude and extent of ground-water contamination

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APPENDIX A

ACRONYMS, DEFINITIONS, NOMENCLATURE AND UNITS OF MEASUREMENT

AFB	Air Force Base
ASTM	American Society for Testing and Materials
Bldg.	Building
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
cm/s	Centimeters per second
DEQE	Massachusetts Department of Environmental Quality Engineering
DEQPPM	Defense Environmental Quality Program Policy Memorandum
DoD	Department of Defense
°C	Degrees Centigrade
°F	Degrees Fahrenheit
ft/min	Feet per minute
gpm	Gallons per minute
HARM	Hazard Assessment Rating Method
hr	Hour
in	Inches
IRP	Installation Restoration Program
MAC	Military Airlift Command
MS	Master of Science Degree
McGAFB	Mc Guire Air Force Base
ug/l	Micrograms per liter (equivalent to parts per billion in water)
umho/cm	Micromhos per centimeter (units of Specific Conductance)
mg/l	Milligrams per liter (equivalent to parts per million in water)
mgd	Million gallons per day
MSL	Mean Sea Level Datum
N	North
No.	Number
O & G	Oil and Grease
OEHL	Occupational and Environmental Health Laboratory

%	Percent
P.G.	Registered Professional Geologist
Ph.D.	Doctor of Philosophy Degree
ppb	parts per billion (equivalent to ug/l in water)
ppm	parts per million (equivalent to mg/l in water)
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act of 1976
TOC	Total Organic Carbon
USAF	United States Air Force
USEPA	United States Environmental Protection Agency

APPENDIX B

Scope of Work TASK ORDER 0020

INSTALLATION RESTORATION PROGRAM

Phase IIB Field Evaluation

McGuire AFB, New Jersey

I. Description of Work:

The purpose of this task is to determine if environmental contamination has resulted from waste disposal practices at McGuire AFB NJ; to provide estimates of the magnitude and extent of contamination, should contamination be found; to identify any additional investigations and their attendant costs necessary to identify the magnitude and direction of movement of discovered contaminants.

The presurvey report (mailed under separate cover) and Phase I IRP report (mailed under separate cover) incorporated background and description of the sites for this task. To accomplish the survey effort, the contractor shall take the following steps:

A. General

1. Determine the areal extent of each site and zone by reviewing available aerial photos of the base, both historical and the most recent panchromatic and infrared.

2. Locations where surface water samples are collected shall be marked with a permanent marker, and the location recorded on a site/zone map.

3. A total of 17 monitoring wells shall be installed. The exact location of wells shall be determined in the field.

4. Wells shall be of sufficient depth to collect samples representative of aquifer quality and to intercept contaminants if they are present. Wells installed during this effort shall be constructed with 20 feet of well screen below the water table. All wells shall be developed, water levels measured, and locations surveyed and recorded on a site/zone map.

5. All water samples shall be analyzed on site by the contractor for pH, temperature and specific conductance. Sampling, maximum holding time and preservation of samples shall comply strictly with the following references: Standard Methods for the Examination of Water and Wastewater, 15th Ed. (1980), pp. 35-42; ASTM, Part 31, pp. 72-82, (1976), Method D-3370; and Methods for Chemical Analysis of Waters and Wastes, EPA Manual 600/4-79-020, pp. xiii to xix (1979). All water samples shall be analyzed using minimum detection levels, as specified in Attachment 1.

6. Field data collected for each site and zone shall be plotted and mapped. The nature of contamination and the magnitude and potential for contaminant flow within each site and zone to receiving streams and ground waters shall be determined or estimated. Upon completion of the sampling and analysis, the data shall be tabulated in the next R&D Status report as specified in Item VI below.

B. In addition to items delineated in A above, conduct the following specific actions at sites identified on McGuire AFB.

1. Zone 1. Landfills 4, 5, and 6, and Wastewater Treatment Plant Sludge Disposal Area

a. Install a maximum of five ground-water monitoring wells at this zone.

1-5 b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for total organic halogens (TOX), total organic carbon (TOC), cyanide, phenol, oil & grease-infrared method (O&G/IR), copper, cadmium, chromium, lead, arsenic and nickel.

2. Site 2. Landfill 2

6-8 a. Install a maximum of three monitoring wells at this site.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for TOX, TOC, cyanide, phenol, O&G/IR, copper, cadmium, chromium, lead, arsenic, and nickel.

3. Site 3. Landfill 3

9-11 a. Install a maximum of three monitoring wells at this site.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for TOX, TOC, cyanide, phenol, O&G/IR, copper, cadmium, chromium, lead, arsenic, and nickel.

4. Site 4. McGuire Missile Site JP-X Discharge Pit

a. Install a maximum of three monitoring wells at this site.

b. Collect one ground-water sample from each well.

c. Each ground-water sample shall be analyzed for TOC, O&G/IR, hydrazine, and nitrates.

5. Site 5. Pesticide Wash Area

a. Two soil borings shall be drilled in the drainage path from the pesticide wash area. These borings shall be advanced to the water table with soil samples retained for analysis at depths of 2 ft, 5 ft, and at the water table.

b. Soil samples shall be analyzed on a phased basis for chlorinated hydrocarbon pesticides, and common organo-phosphate pesticides, as specified in Attachment 1, using Gas Chromatograph (GC) methods. Samples at 5 ft shall be analyzed only in borings where the pesticides are encountered in the 2 ft samples, and continuing iteratively.

c. Three surface soil and three surface water (if present) samples shall be collected in the drainage ditch near the Entomology Shop. One soil sample and one water sample shall be collected at each of the following three locations: (1) adjacent to the Entomology shop, (2) at the bottom of the shop driveway, and (3) about 30 yards downstream of the shop driveway.

d. The soil and water samples shall be analyzed for chlorinated hydrocarbon pesticides and common organo-phosphate pesticides, as specified in Attachment 1, using GC methods.

6. Site 6. DPDO Storage Facility

a. Five soil borings shall be drilled inside the fenced Defense Property Disposal Office (DPDO) compound. These borings shall be advanced to the water table, with samples retained for analysis at depths of 2 ft, 5 ft and at the water table.

b. Soil samples shall be analyzed on a phased basis for PCBs (GC) and O&G/IR, as specified in Attachment 1. Samples at 5 ft shall be analyzed only in borings where PCBs or O&G are encountered in the 2 ft samples, and continuing iteratively.

7. Site 7. Fire Training Area No. 1

a. Install a maximum of two monitoring wells at this site.

14-15

b. Collect one ground-water sample at each well.

c. Each ground-water sample shall be analyzed for TOX, TOC, and O&G/IR.

8. Site 8. Bulk Fuel Storage Tank Farm

a. Install a maximum of two monitoring wells at this site.

13-14

b. Collect one ground-water sample at each well.

c. Each ground-water sample shall be analyzed for TOX, TOC, O&G/IR, cadmium, chromium, lead, and nickel.

9. Site 14. Buried Oil Drums

Conduct magnetometer and ground penetrating radar surveys to determine whether or not the suspected buried drums are located under the paved lot of the Civil Engineering compound.

C. Well Installation and Cleanup

Well and boring locations shall be cleaned up following the completion. Drill cuttings shall be removed and the general area cleaned.

D. Data Review

Results of sampling and analysis shall be tabulated and incorporated into the monthly R&D Status Reports and forwarded to the USAF OEHL for review as soon as they become available as specified in Item VI below.

E. Reporting

1. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL as specified in Item VI below for Air Force review and comment. This report shall include a discussion of the regional hydrogeology, well logs of all project wells, data from water level surveys, water quality analysis results, magnetometer and ground penetrating radar survey results and maps, available geohydrologic cross sections, ground-water surface and gradient vector maps, any available vertical and horizontal flow vectors and laboratory quality assurance information. The report shall follow the USAF OEHL supplied format (mailed under separate cover).

2. Estimates shall be made of the magnitude and direction of movement of contaminants discovered. Potential environmental consequences of discovered contamination shall be identified or estimated. Where survey data are insufficient to properly determine or estimate the magnitude and direction of movement of discovered contaminants, fully justified specific recommendations shall be made for additional efforts required to properly evaluate contamination migration and included in a separately bound appendix to the draft final report (see F below).

3. Specific requirements, if any, for future ground-water and surface water monitoring must be identified.

F. Cost Estimates

The contractor shall provide cost estimates for all additional work recommended to permit proper determination of contaminants. The recommendations provided shall include all efforts required to determine the magnitude and direction of movement of discovered contaminants along with an estimate of the time required to accomplish the proposed effort. This information shall be provided in a separately bound appendix to the draft final report.

II. Site Location and Dates:

McGuire AFB
USAF Clinic/SGPB
Dates to be established

III. Base Support: None

IV. Government Furnished Property: None

V. Government Points of Contact:

1. 1Lt Dulcie Weisman
USAF OEHL/ECQ
Brooks AFB TX 78235
(512) 536-3305
AV 240-3305

2. LtCol Dean Nelson
HQ MAC/SGPE
Scott AFB IL 62225
(618) 256-2306
AV 638-2306

3. Capt John Ellis
USAF Clinic/SGPB
McGuire AFB NJ 08641
(609) 724-4170/2411
AV 440-4170/2411

VI. In addition to sequence numbers 1, 5 and 11 listed in Atch 1 to the contract, which are applicable to all orders, the reference numbers below are applicable to this order. Also shown are data applicable to this order.

Sequence Nr	Block 10	Block 11	Block 12	Block 13	Block 14
4*	ONE/R	84FEB15	84MAR15	84JUN15	*

*Contractor shall supply the USAF OEHL with 20 copies of the draft report and 50 copies plus the original camera ready copy of the final report.

Levels of Detection Required

TOX	5 µg/L
TOC	1 mg/L
cyanide	10 µg/L
phenol	1 µg/L
O&G/IR	0.1 mg/L (waters); 100 µg/g (soil)
hydrazine	50 µg/L
nitrates	0.1 mg/L
copper	50 µg/L
cadmium	10 µg/L
chromium	50 µg/L
lead	20 µg/L
arsenic	10 µg/L
nickel	100 µg/L

Pesticides Analyses

For waters, analyze samples for chlorinated hydrocarbon and organophosphate type insecticides. Analyze for the following specific pesticides and detection levels: aldrin, 0.02 µg/L; DDT isomer, 0.02; dieldrin, 0.02; endrin, 0.02; heptachlor, 0.02; heptachlor epoxide, 0.02; lindane, 0.01; methoxychlor, 0.20; diazinon, 0.02; malathion, 0.10; parathion, 0.02.

For soils, use detection levels shown above, but report values as micrograms pesticide per gram of soil.

PCBs in soil

Use minimum detection level of 1µg/g and identify type, if possible.

APPENDIX C

PROFESSIONAL PROFILES OF KEY PERSONNEL

Peter J. Marks

Fields of Competence

Project management; environmental analytical laboratory analysis; hazardous waste, groundwater and soil contamination; source emissions/ambient air sampling; wastewater treatment; biological monitoring methods; and environmental engineering.

Experience Summary

Eighteen years in Environmental Laboratory and Environmental Engineering as Project Scientist, Project Engineer, Process Development Supervisor, and Manager of Environmental Laboratory with WESTON. Experience in analytical laboratory, wastewater surveys, hazardous waste, groundwater and soil contamination, DoD-specific wastes, stream surveys, process development studies, and source emission and ambient air testing. In-depth experience in pulp and paper, steel, organic chemicals, pharmaceutical, glass, petroleum, petrochemical, metal plating, food industries and DoD.

Applied research on a number of advanced wastewater treatment projects funded by Federal EPA.

Credentials

B.S., Biology—Franklin and Marshall College (1963)

M.S., Environmental Engineering and Science—Drexel University (1965)

American Society for Testing and Materials

Water Pollution Control Federation

Water Pollution Control Association of Pennsylvania

Employment History

1965-Present	WESTON
1963-1964	Lancaster County General Hospital Research Laboratory for Analytical Methods Development

Key Projects

USAF/OEHL Brooks AFB. Program Manager for this three-year BOA contract provides technical support in environmental engineering surveys, wastewater characterization programs, geological investigations, hydrogeological studies, landfill leachate monitoring and landfill siting investigations, bioassay studies, wastewater and hazardous waste treatability studies, and laboratory testing and/or field investigations of environmental instrumentation/equipment. Collection, analysis, and reporting of contaminants present in water and wastewater samples in support of Air Force Environmental Health Programs.

United States Army Toxic and Hazardous Materials Agency (USATHAMA), Aberdeen Proving Ground, Maryland. Program Manager for three-year basic ordering agreement contract to provide research and development for technology in support of the DOD Installation Restoration Program. The objective of the Program is to identify and develop treatment methods/technology for containment and/or remedial action. Technology development for remedial action is to include groundwater, soils, sediments, and sludges.

Confidential Client, Ohio. Project Manager of an on-going contract to conduct corporate environmental testing and special projects at client's U.S. and overseas plants. WESTON must be able to assign up to four professionals to a project within a two week notice.

Confidential Client (Inorganic and Organic Chemicals). Product Manager of a current contract to conduct wastewater sampling and analysis of plant effluent for priority pollutants. The project also includes a wastewater treatability study to evaluate a number of process alternatives for removal of priority pollutants from the present effluent.

Confidential Client, Utah. Technical Project Manager for in-depth wastewater survey, in-plant study, treatability study, and concept engineering study in support of the client's objectives to meet 1983 effluent limitations. WESTON had two project engineers, two chemists, five technicians and an operating laboratory in the field. Field effort is six months duration.

Professional Profile

Frederick Bopp III, Ph.D., P.G.

Registration

Registered Professional Geologist in the State of Indiana

Fields of Competence

Groundwater resources evaluation; hydrogeologic evaluation of sanitary landfills and other waste disposal sites. detection and abatement of groundwater pollution. digital modeling of groundwater flow and solute transport: statistical analysis of geological and geochemical data; geochemical prospecting; estuarine geology and geochemistry: trace metal and aqueous geochemistry.

Experience Summary

Seven years experience in hydrogeology and geochemistry, involving such activities as: assessment of subsurface water and soil contamination; development of contamination profiles; evaluation of remediation actions for groundwater quality restoration; quantitative chemical analysis of water and soil; ore assay and ore body evaluation; drilling supervisor; hydrogeologic assessment; pollution detection and abatement: estuarine pollution analysis; application of flow and solute transport computer models; computer programming; project management; teaching environmental geology and geochemistry.

Credentials

B.A., Geology—Brown University (1966)

M.S., Geology—University of Delaware (1973)

Ph.D., Geology—University of Delaware (1979)

Sigma Xi, The Scientific Research Society of North America

Geological Society of America, Hydrology Division

National Water Well Association, Technical Division

American Association for the Advancement of Science

Estuarine Research Federation: Atlantic Estuarine Research Society

Employment History

1979-Present	WESTON
1977-1979	U.S. Army Corps of Engineers Waterways Experiment Station
1976-1977	University of South Florida Department of Geology
1970-1976	University of Delaware Department of Geology
1974-1976	Earth Quest Associates President and Principal Partner
1974 (Summer)	WESTON
1966-1970	United States Navy Commissioned Officer

Key Projects

Project manager on seven task orders for environmental assessment services at United States Air Force facilities in nine states.

Task manager for a Superfund site evaluation in Ohio.

Site manager for drum recovery operations in Pennsylvania and New Jersey.

Project manager for site assessments of oil and fuel spills in four states.

Project manager for closure plan development at a hazardous waste landfill in New Jersey.

Definition and abatement of groundwater contamination from chemical manufacturing in Delaware.

Flow and solute transport digital model of a heavily-pumped regional aquifer in southern New Jersey.

Definition and abatement of groundwater contamination from chemical manufacturing in the Denver area.

Hydrogeologic impact assessment of on-land dredge spoil disposal in coastal North Carolina.

Geochemical prospecting and ore body analysis in Arizona.

Professional Profile

Richard C. Johnson

Experience Summary

Over six years experience in geotechnical and geological investigations, including hydrologic and geological investigation of landfill sites; quantitative and qualitative groundwater analysis; industrial waste disposal assessment; evaluation of soil mass stability and bearing capacity at proposed sites of building and tank structures; development of remedial actions. Supervision of engineering of laboratory programs for soil and waste material testing; supervision of well installation, well monitoring, and sampling program.

Credentials

B.A.—LaSalle College (1969)

M.A., Geology—Temple University (1976)

Graduate course work in soil mechanics, engineering geology and hydrology—Drexel University (1979-1981)

National Water Well Association

U.S. National Group of Engineering Geology

American Geophysical Union

Employment History

1981-Present	WESTON
1979-1981	Valley Forge Laboratories, Soils and Materials Testing Laboratory
1978-1979	Ambric Engineering
1976-1977	American Cancer Society Philadelphia Division
1972-1975	Temple University Department of Geology
1969-1971	City of Philadelphia Department of Licenses and Inspections

Key Projects

Project Geologist for investigations of existing and proposed hazardous waste disposal sites in Pennsylvania, New Jersey, Ohio, and Maine. Studies included drilling and soil sampling programs; the interpretation of hydrogeologic conditions; and evaluation of the physical stability of earth impoundments.

Project Geologist for U.S. Air Force Installation Restoration Program Phase II studies in New York, New Jersey, Pennsylvania, and Minnesota. Supervised field investigation of waste disposal and spill sites related to base activities.

Principal Hydrogeologist for a groundwater and geologic investigation at the Milan Army Ammunition Plant, Tennessee for the U.S. Army Toxic and Hazardous Materials Agency.

Development and implementation of a program for the interception and recovery of hydrocarbons in groundwater at a chemical processing plant in the Pittsburgh area.

Interpretation of hydrologic and geologic conditions related to migration of chlorinated hydrocarbons in groundwater in the vicinity of production wells at a chemical processing plant in Ohio.

Hydrogeologic investigation of the Bruin Lagoon Superfund project in Butler County, Pennsylvania.

Project Manager and Principal Investigator for a subsurface investigation to determine soil conditions at the proposed site of 55,000 barrel fuel storage tanks in a flood plain area in northeast Pennsylvania. Supervised soil borings and performed analyses to predict settlement of flexible pad foundations.

Supervised exploratory drilling and developed foundation recommendations for proposed building construction projects in southeastern Pennsylvania.

Conducted geological site investigations in limestone sinkhole areas to develop recommendations for remedial action around threatened structures.

Developed and directed a testing program to evaluate preliminary rock anchor designs in a sewage facility construction project, Montgomery County, Pennsylvania.

Supervised laboratory testing program for sulfite sludges and coal burning wastes. Evaluated alternative methods of physical and chemical stabilization of the wastes, and developed applications for stabilized material in landfill, and earth stabilization problems.

Publications

Johnson, R. and Myer, G., "Sillimanite Nodules in the Wissahickon Schist, Philadelphia," *Journal of the Pennsylvania Academy of Sciences*, Vol. 49, 1975.

Walter M. Leis, P.G.

Registration

Registered Professional Geologist in the States of Georgia (No. 440) and Indiana.

Fields of Competence

Detection and abatement of groundwater contamination; design of artificial recharge wells; deep well disposal; simulation of groundwater systems; hydrogeologic evaluation of hazardous waste sites and landfills; practical applications of geophysical surveys to hydrologic systems, site investigations, and borehole geophysical surveys. Geochemical studies of acid mine drainage and hazardous wastes.

Experience Summary

Sixteen years experience as field hydrogeologist, field supervisor, project director, research director. Six years research involving two consecutive projects: 1) application of geophysical techniques in evaluating groundwater supplies in fractured rock terrain in Delaware and Pennsylvania; 2) project director for an artificial recharge and deep well disposal study. Provided consultation for waste disposal and aquifer quality problems for coastal communities.

Developed geochemical sampling techniques for deep mine sampling. Evaluated synthetic and field hydrologic data for deep formulational analysis in coal field projects.

Earlier research experience involved developing techniques for mapping subsurface regional structures having interstate hydrologic significance, and defining ore bodies by geochemical prospecting.

Credentials

B.S., Biochemistry—Albright College (1966)

M.S., Hydrogeology—University of Delaware (1975)

Cooperative Program Environmental Engineering—University of Pennsylvania

Additional special course work in Geology and Hydrology, Franklin and Marshall College and Pennsylvania State University

Remote Sensing Data Processing Training, Goddard Space Center (1978)

OWRR Research Fellow, 1973

National Water Well Association, Technical Division.

Geological Society of America, Engineering Geological Division.

Society of Economic Paleontologists and Mineralogists

Employment History

1974-Present	WESTON
1973-1974	University of Delaware Water Resources Center
1971-1973	University of Delaware
1967-1971	Pennsylvania Department of Environmental Resources

Key Projects

Definition of groundwater contamination from sanitary landfill leachate and recovery of contaminants to protect heavily used aquifer in Delaware.

Field design studies for artificial recharge and waste disposal wells.

Design and construction of hydrologic isolation systems for various class hazardous wastes.

Design and supervision of chemical and physical rehabilitation of groundwater collection systems in fractured rock and coastal plain areas.

Principal investigator for six projects involving subsurface migration of PCB's in New York, New Jersey, Pennsylvania, and Oklahoma.

Design and construction supervision of hydrocarbon recovery wells in Pennsylvania.

Professional Profile

James S. Smith, Ph.D.

Fields of Competence

Analytical laboratory management; organic chemistry; mass spectrometry, GC/MS/DS, high and low resolution, chemical ionization and special techniques; gas chromatography including capillary column techniques; high performance liquid chromatography (HPLC); the uses of NMR, IR, UV, visible, inorganic analyses, electrochemical, thermal techniques and surface methodologies (SEM, ESCA, SIMS) to solve industrial problems; the development of quality control measures in analytical protocols; the testing of laboratory safety methodologies; innovation of new analytical techniques and methods to solve industrial, product liability, production and environmental problems.

Experience Summary

Eleven years experience in the supervision of an analytical group involved in solving all types of industrial problems including environmental, product safety, production, research and development. The main emphasis was on the innovative development of analytical methods utilizing instrumental technologies. In-depth experience in the organic chemicals, inorganic chemicals polymer, fiber, tire, solvent, fluorine chemicals, coke and coal tar industries. Numerous scientific presentations. Contributor to three Chemical Manufacturers Association Task Groups: Environmental Monitoring, Groundwater, and Hazardous Waste Response Center.

Taught general chemistry, analytical chemistry, organic chemistry, and instrumental analysis for four years at Eastern Michigan University and the University of Illinois.

Credentials

B.A., Chemistry—Williams College (1960)

Ph.D., Organic Chemistry—Iowa State University (1964)

Postdoctoral Organic Chemistry—University of Illinois (1966)

Postdoctoral Mass Spectroscopy—Cornell University (1969)

American Chemical Society

American Society for Testing Materials

American Society of Mass Spectroscopists

Employment History

1981-Present	WESTON
1969-1981	Allied Chemical Corporation Corporate Research Center
1966-1968	Eastern Michigan University Assistant Professor of Chemistry
1965-1966	University of Illinois

Key Projects

Directed analytical group for five years of intensive sampling and analysis of a toxic insecticide. Analyses involved soil, air, water, sludge, blood, bile, feces, urine, animal feed, and plant samples to detect the compound at the low parts-per-billion level. The project involved rapid development of new and accurate analytical methods.

Developed an industrumental analytical laboratory consisting of trace environmental analyses, gas chromatography, high performance liquid chromatography, mass spectrometry, surface analyses, X-ray photoelectron spectroscopy and nuclear magnetic resonance spectroscopy including the design and manufacture of instrument modifications, purchasing instruments, and hiring of key personnel.

Isolated, identified, and developed a method of analysis for a colored impurity on a bulk chemical product. Synthesized the colorant for proof of identification and as a standard for future analysis. Proved the mechanism of the development of the color from the packaging materials. Designed new specifications eliminating the problem.

Conducted corporate plant environmental laboratory QA/QC audits including the development of a corporate QA/QC manual.

Professional Profile

10/83

Theodore F. Them, Ph.D.

Fields of Competence

Inorganic and organic chemistry; instrumental analytical techniques; synthesis of organic chemicals; laboratory management; chemical research and education.

Experience Summary

Nine years experience in inorganic and organic chemistry with strong synthetic organic and instrumental analytical background. Experienced researcher and teacher. Background in conceptualizing, founding, effecting, and administering a chemical consulting firm.

Credentials

M.S., Chemistry—University of New Mexico (1975)

Ph.D., Chemistry—University of New Mexico (1977)

American Chemical Society

The Society of Sigma Xi

Southwest Association of Forensic Scientists—Associate Member

Society of Applied Spectroscopy, Rio Grande Section

Employment History

1982-Present	WESTON
1981-1982	Bell Petroleum Services, Inc.
1982-1982	Bell Petroleum Laboratories
1977-1981	AnaChem, Inc. Co-Founder, Vice President
1975-1977	University of New Mexico

Practical Experience

Familiarity with use, maintenance, and operation of gas chromatographs with flame ionization, electron capture, thermal conductivity, and photoionization detectors. Experience includes methods development, separation optimization, and data reduction.

Familiarity with use, maintenance, and operation of gas chromatograph/mass spectrometer/data system (GC/MS/DS) in separations and identifications of complex mixtures and molecules. Experience includes methods development, separation enhancement, packed and capillary column techniques, and data reduction.

Familiarity with use and operation of various infrared, nuclear magnetic resonance (NMR), atomic absorption (AA), and liquid chromatographic (LC) instrumentation.

Familiarity with use, maintenance, and operation of Tekmar Models LSC-2 and ALS purge/trap and liquid sample concentrator devices and associated gas chromatographic methods.

Familiarity with use, maintenance, and operation of Fisher Model 490 Coal Analyzer for analysis of moisture, volatiles and ash in coal.

Familiarity with use, maintenance, and operation of Fisher Sulfur Analyzer System for analysis of sulfur in coal and hydrocarbon fuels.

Familiarity with use, maintenance, and operation of Parr Adiabatic Bom Calorimeter and associated Master Controller in calorimetric analysis of coal and coke, foodstuffs, and fuels.

Familiarity with use, maintenance, and operation of Fisher Models Titralyzer II (Fixed End Point) and Tritrimeter II automatic titration systems for analysis of water by pH or millivolt-sensitive methods.

Publications

Hazardous Properties and Environmental Effects of Materials Used in Solar Heating and Cooling (SHAC) Technologies: Interim Handbook, J.Q. Search (ed.), August 1978. Sandia Laboratories report Sand 78-0842, available from National Technical Information Service, Springfield, Virginia.

Professional Profile

"Isomerism in Complexes of Bidentate Ligands with Enantiotopic Donor Atoms", R.E. Tapscott, J.D. Mather, and T.F. Them, *Coordination Chemistry Reviews,* Vol. 19, Nos. 2/3, September 1979.

"Stereochemical Studies on Diastereomers of Tris (2,3-butanediamine)-Colbalt (III)", C.J. Hilleary, T.F. Them, R.E. Tapscott, *Inorganic Chemistry*, Vol. 19, No. 102, 1980.

"Staying Abreast of PCB Regulations: TESTING", R.M. Holland and T.F. Them, *Professional Trade Publication,* June 1980.

"Stereochemistry of Arsenic (III) and Antimony (III) 1,2-DihydroxyEychohexane-1,2-dicarboxylates," D. Marcovich, E.N. Duesler, R.E. Tapscott, and T.F. Them, *Inorganic Chemistry*, 1982.

Bruce W. Benyish

Fields of Competence

Broad range of experience involving subsurface exploration programs, supervising the construction of monitoring and production wells, conducting sustained pump tests, hydrogeologic data analysis, and technical report preparation.

Credentials

B.S., Earth Science—Pennsylvania State University (1979)

National Water Well Association, Technical Division

Employment History

1983-Present	WESTON
1983	Suburban Water Testing Labs, Inc.
1980-1982	Gilbert/Commonwealth
1980	General Battery Corporation

Key Projects

Served as a field geologist at hazardous waste sites during the USAF Installation Restoration Programs. Responsibilities included supervision of the installation of monitoring wells, procurement of representative soil samples for documentation, and collection of groundwater samples for analysis of various organic and inorganic chemical constituents. Participated in the preparation of Installation Restoration Program Reports.

Participated in the development of water well fields for municipal water supplies. Performed aerial photograph fracture trace analysis to assist in selecting optimum water well sites. Supervised sustained well pumping tests and analyzed data to determine safe yields. Prepared hydrogeologic reports incorporating pumping test data and geologic literature. Submitted reports to regulatory agencies to obtain groundwater withdrawal permits.

Supervised the drilling of foundation test borings and monitoring well installations pertaining to an Environmental Impact Assessment (EIA) feasibility study for a coal-fired power plant. Participated in the preparation of EIA Report.

Participated in water table aquifer decontamination programs. Scope of involvement included supervising the withdrawal of hazardous sludges from pre-existing wells, pumping, sampling, and treating contaminated groundwater, and scheduling shipment of non-treatable groundwater to certified waste disposal sites.

John A. Williams, Jr.

Fields of Competence

Geologic and geophysical investigations; geological and groundwater sampling techniques and instrumentation technology; design, operation, and evaluation of geophysical survey, equipment, testing and analysis of aquifers, and groundwater pollution.

Experience Summary

Three years experience in geologic and geophysical investigtions including subsurface profiling using Ground Penetrating Radar (GPR), electrical resistivity and electromagnetic conductivity for numerous private and government facilities; groundwater sampling and aquifer pump tests, six years experience in bathymetric, hydrographic and biological studies.

Credentials

A. S., Marine Technology - Cape Fear Technical Institute (1975)

B. S., Earth Science (Geology) - West Chester State College (1983)

Certified Ground Penetrating Radar Operator

Certified NAUI/PADDI Scuba Diver

Geological Society of America

Employment History

1982 - Present	WESTON
1980-1982	Environmental Resources Management, Inc.
1977-1980	WESTON
1976-1977	Highway Service Marineland
1975-1976	Lawler, Matusky, Skelly Engineers

Key Projects

Coordinated and supervised geophysical investigations to locate buried drums and to delineate the boundaries of a buried waste lagoon for a scrap recovery plant in Rhode Island.

Geophysical field investigation to locate buried trenches and waste lagoons for a government facility in California.

Geophysical field investigation, well installation and sample collection to determine the distribution of leachate, and the extent of contamination in a heavily-used aquifer in New York.

Geophysical investigation to define the lateral and vertical effect of fill deposition for a facility in Massachusetts.

Soils investigation to determine the extent of contamination from old waste lagoons and fire training areas for a government facility in Arizona.

Hydrogeologic investigation for a scrap recovery facility in western Pennsylvania.

Responsible for deploying benthic and water quality sampling gear and an electronic navigation system for a dredge spoils disposal study in Lake Erie.

Geophysical investigation (ground penetrating radar and electrical resistivity) to locate buried drums and delineate trench boundaries for a government facility in Ohio.

Professional Profile

Lisa A. Hamilton

Fields of Competence

Hydrogeologic investigation and evaluation of existing and potential sanitary and hazardous waste landfills; design and installation of groundwater monitoring systems; interpretation of Federal and state environmental regulations; computer processing and interpretation of ground motion and geophysical data; groundwater pollution detection and abatement.

Experience Summary

Four years in geological studies, including hydrogeologic evaluations of groundwater contamination cases; collection, interpretation and evaluation of groundwater quality data; hydrogeologic suitability evaluation of proposed sanitary landfills. Design and installation of groundwater monitoring networks; technical assistance in emergency response and cleanup of oil and hazardous materials spills. One year of computer processing and interpretation of ground motion and geophysical data for stability of structures impacted by earthquakes.

Credentials

B.S., Geology—University of Delaware (1979)

National Water Well Association, Technical Division

Association for Women Geoscientists

Employment History

1982-Present	WESTON
1980-1982	Delaware Division of Environmental Control Water Supply Branch
1979-1980	U.S. Geological Survey Geologic Division Denver, Colorado

Key Projects

Continuing program of leachate control for a sanitary landfill in New Castle County, Delaware, including water-level monitoring, collection and analysis of water samples, rehabilitation of recovery wells, maintenance of well field records and long-term data assessment.

Data collection, analysis and evaluation of hydrogeologic data to determine the existence of contamination at a former coal gasification facility in Cape May County, New Jersey.

Data collection, analysis and evaluation of hydrogeologic data to determine the extent of contamination at a coal pile in Mercer County, New Jersey.

Design, installation and evaluation of a groundwater monitoring system at a sanitary landfill in Kent County, Delaware.

Evaluation of the impact of landfill leachate on a stream and receiving pond in Kent County, Delaware.

Evaluation and interpretation of ground motion and geophysical data from simulated earthquakes in Idaho, Utah, and Nevada.

Coordinator of "Superfund" projects in the State of Delaware.

Geologic mapping in the Spring Mountains, Nevada.

Publications

King, K.W., Hays, W.W., Hamilton, L.A., Jungblut, W.L., 1979. "A Seismic Wave Attenuation Study of the Snake River Plain, Idaho." Presented at the Annual Fall Meeting of the American Geophysical Union, San Francisco, California, 1979.

Joseph R. Althouse

Fields of Competence

Data collection; groundwater sampling; hazardous waste surveys; wastewater sampling; flow measurement in-house treatability systems; analytical methods in wet laboratory; air pollution testing; chain-of-custody protocols; maintenance of laboratory and field equipment for projects; infiltration and inflow programs; construction estimating; quantity take-off; pricing; and on-site sewer construction inspection. Trained and certified in all safety requirements for sampling at hazardous waste sites.

Experience Summary

Eleven years experience in wastewater, groundwater, and hazardous waste field surveys. Coordination of field equipment for projects ranging from groundwater surveys, stream surveys, hazardous waste, and air pollution. Inflow/infiltration studies, bioassays, construction estimating, and on-site construction inspection.

American Red Cross Certification in Cardiopulmonary Resuscitation (CPR) and Multimedia First Aid

Basic life support course in Self-Contained Breathing Apparatus (SCBA)

Employment History

1980-Present	WESTON
1979-1980	Charles E. Moore Associates
1974-1979	Rexnord Instrument Products
1967-1974	WESTON
1965-1967	Lukens Steel Company
1963-1965	Firestone Tire and Rubber Company

Key Projects

Project Leader responsible for project planning and preparation, conducting surveys, data management, and report development for a Pennsylvania Power Company, New Castle, PA, contract.

Project Leader responsible for planning and execution of field efforts and for data management activities on a project at Brunner Island Unit 3 for Pennsylvania Power and Light Company, Hazleton, PA.

Sewer construction inspection; infiltration/inflow analyses and sewer system evaluation studies, including surface inspection, physical inspection, and flow measurements for West Whiteland Township, Pennsylvania.

Wastewater survey for U.S. Steel, Texas, including collecting flow data and wastewater samples, and constructing and maintaining test equipment.

Wastewater survey for Pennsylvania Power and Light and Philadelphia Electric Company, Pennsylvania, including the collection of flow data and wastewater samples for National Pollution Discharge Elimination System.

Senior Field Technician on hazardous waste remedial action project for the City of Philadelphia. Project included groundwater and soil sampling for priority pollutants and other hazardous organics and inorganics.

Senior Field Technician on Installation/Restoration Program project for the Griffiss Air Force Base, Rome, New York. Field sampling included soil borings for PCB's and groundwater sampling for a variety of organic and inorganic compounds.

Senior Field Technician for soil and swab sampling for Dioxins under an emergency response contract (TAT) with the U.S. EPA for the Times Beach, Missouri cleanup.

Responsible for field sampling on long-term groundwater monitoring program for chlorinated volatile organics for Uniform Tubes, Collegeville, Pennsylvania.

Field technician on hydrographic studies in the Delaware River Estuary for Public Service Electric and Gas, New Jersey. Project included thermal studies, bathymetric profiles, current studies, and tidal marsh heat flux studies.

Field project for a confidential client at a hazardous waste site in Pennsylvania. Sampling included soil, groundwater, 55-gallon drums, tanks, and lagoons for organic and inorganic analysis.

APPENDIX D

Boring Logs and Well Completion Summaries

WESTON

DRILLING LOG

WELL NUMBER: MW-2
OWNER: USAF
LOCATION: Zone 1 North of Treatment Plant
ADDRESS: McGuire AFB
TOTAL DEPTH 28.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/4/83
DRILLER: T S
HELPER: A H
LOG BY: L.A.H

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1	SS	3/3	0-1.5 Brown SAND, fine, trace	0
				4	clay, moist	
5		2	SS	2/1	5-6.5 Yellowish brown SAND, fine	0
				1	with hydrocarbon odor	
		3	SS	3/5	7-8.5 Dark grayish brown SAND,	0
				5	medium to coarse, some	
					coarse, rounded gravel, trace	
10					clay, wet	
		4	SS	3/3	12-13.5 Black SAND, fine, trace	0
				3	clay, wet, micaceous	
15						
		5	SS	3/4	17-18.5 Black SAND, fine, trace	0
				7	gravel, some clay, grading	
					to glauconite	
20						

* A.S.T.M. D1586 ✱ HNU measurements analyzed in laboratory.

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW- 2
OWNER: USAF
OCATION: Zone 1 North of Treatment Plant
ADDRESS: McGuire
TOTAL DEPTH 28.5
URFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/4/83
DRILLER: TS
HELPER: A H
OG BY: L.A.H

SKETCH MAP

NOTES:

EPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
		6	SS	5/6	22 - 23.5 Dark olive gray sandy	0
				9	CLAY, dry	
		7	SS	4/6	27 - 28.5 Dark olive gray sandy	0
				10	CLAY, dry	
					E~~nd of boring 28.5'~~	

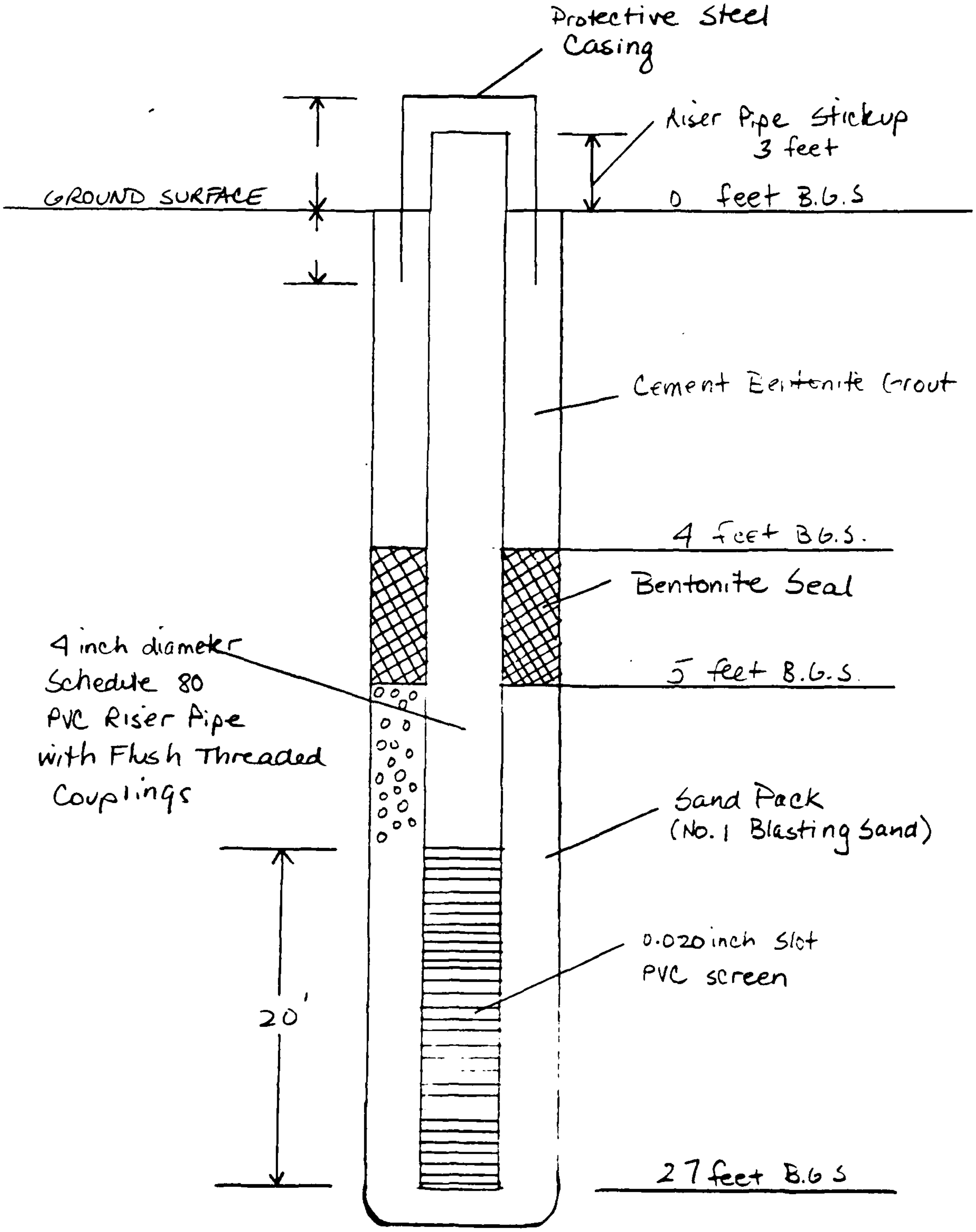
* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ________ DATE ________ DIV ________ SHEET ________ OF ________
CHKD BY ________ DATE ________ DEPT ________ W.O. NO. ________
PROJECT ________
SUBJECT ________



Well Construction Log McGuire AFB
Well Number MW 2

RFW 330-5-81

WESTON

DRILLING LOG

WELL NUMBER: MW-3
OWNER: USAF
LOCATION: Zone 1 Approx 450 NW of WWTP
ADDRESS: McGuire AFB
TOTAL DEPTH 24.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10-5-83
DRILLER: T.S.
HELPER: A H
LOG BY: L.A.H.

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1	SS	4/9	0-1.5 Olive yellow silty SAND,	0
				12	some cobbles, white concrete pieces,	
					Olive gray SAND, fine, some gravel	
		2	SS	2/4	3-4.5 Olive gray silty SAND, fine,	0
5				4	some gravel; Reddish yellow	
					SAND, fine, trace clay, moist	
		3	SS	3/4	8-9.5 Dark gray SAND, fine, some	0
				4	Dark grayish brown clay laminations, micaceous	
10						
		4	SS	3/6	13-14.5 Dr grayish brown SAND, fine,	0
				5	trace brown clay laminations, wet micaceous	
15						
		15	SS	2/4	18.0-19.5 Dr grayish brown SAND, fine,	0
				10	some clay, wet, micaceous	
20						

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET ___ OF ___

WESTON

DRILLING LOG

WELL NUMBER: MW-3
OWNER: USAF
LOCATION: ZONE 1
Approx 450' NW of
WWTP
ADDRESS: McGuire AFB
TOTAL DEPTH 24.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/5/83
DRILLER: T.S.
HELPER: A.H.
LOG BY: L.A.H

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20						
		6	SS	6/6	23.0 - 24.5 Dr olive gray sandy CLAY,	0
				10	trace gravel, sand glauconitic	
					End of boring 24.5'	
25						

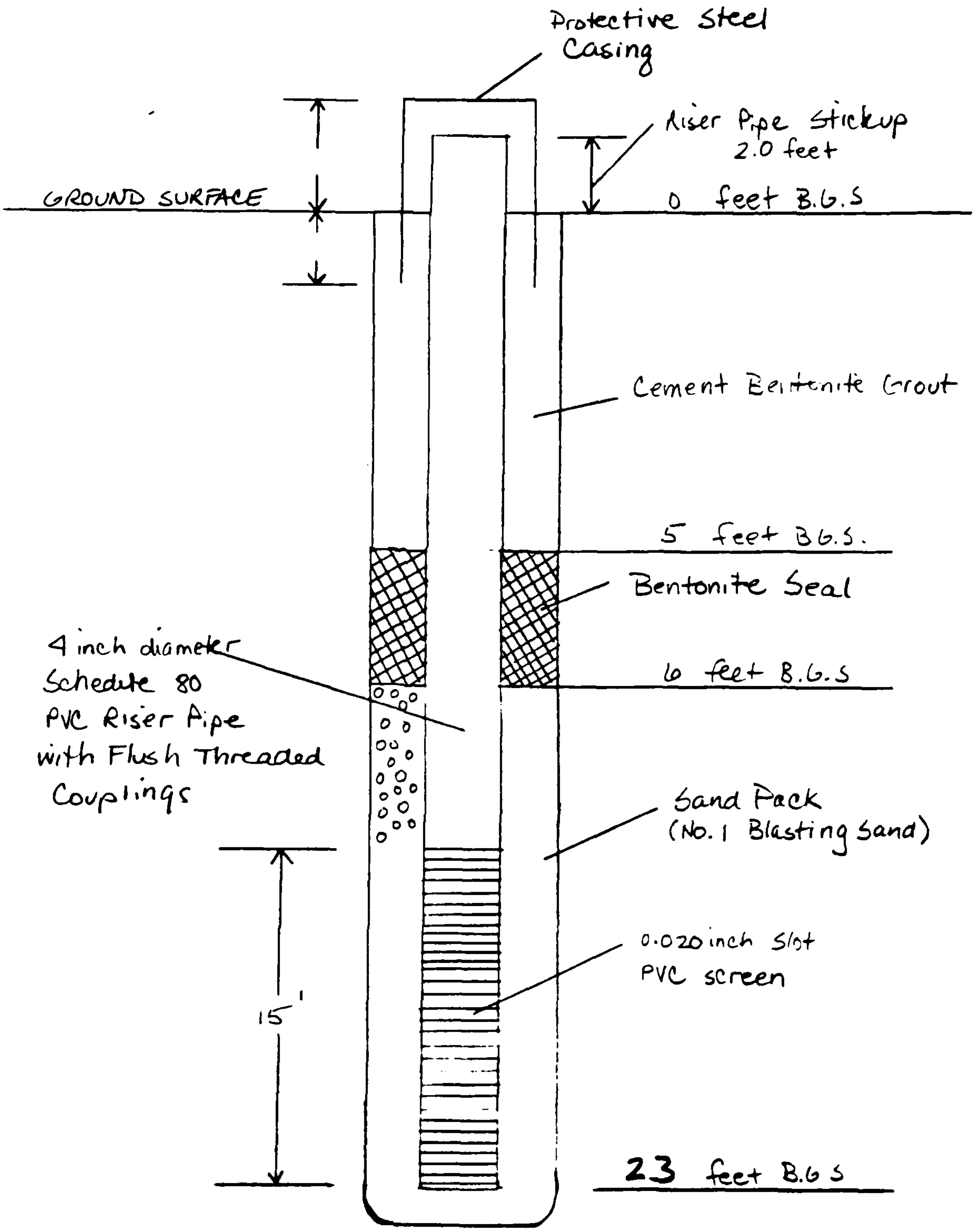
* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET ___ OF ___

WESTON

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT ______
SUBJECT ______



Well Construction Log McGuire AFB
Well Number MW3

RFW 338-5-81

WESTON

DRILLING LOG

WELL NUMBER: MW-4
OWNER: USAF
LOCATION: Zone 1 Landfill
ADDRESS: McGuire AFB
TOTAL DEPTH:
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10-17-83
DRILLER: R E
HELPER: B H
LOG BY: RJ/BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1		1/1 2	0.0-1.5 Black FILL bottom ash silty fine sand size, trace of fine gravel sized slag	0
5		2		2/2 2	5.0-6.5 Black FILL bottom ash, silty fine sand size, trace of fine gravel sized slag	0
					Out of Fill approx: 8-9'	
10		3		4/4 5	10.0 - 11.5 Light gray SAND, fine to medium, damp, with dark laminations	0
15		4		3/3 2	15.0-16.5 Dr gray SAND, fine to medium little fine gravel, damp; sand grades to medium	0

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW- 4
OWNER: USAF
LOCATION: Zone 1
Land Fill-5
ADDRESS: McGuire
TOTAL DEPTH:
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: TS
HELPER: A H
LOG BY: RJ/BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20		5	SS	4/4	20-21.5 Black SILT, trace fine sand, trace clay, low plastic moist	0
				4		
25		6	SS	5/9	25.0-26.5 Dark olive brown silt, SAND, fine, trace clay, wet; Dark greenich gray SAND, some silt, trace of clay, moist, glauconitic	0
				13		
30						

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
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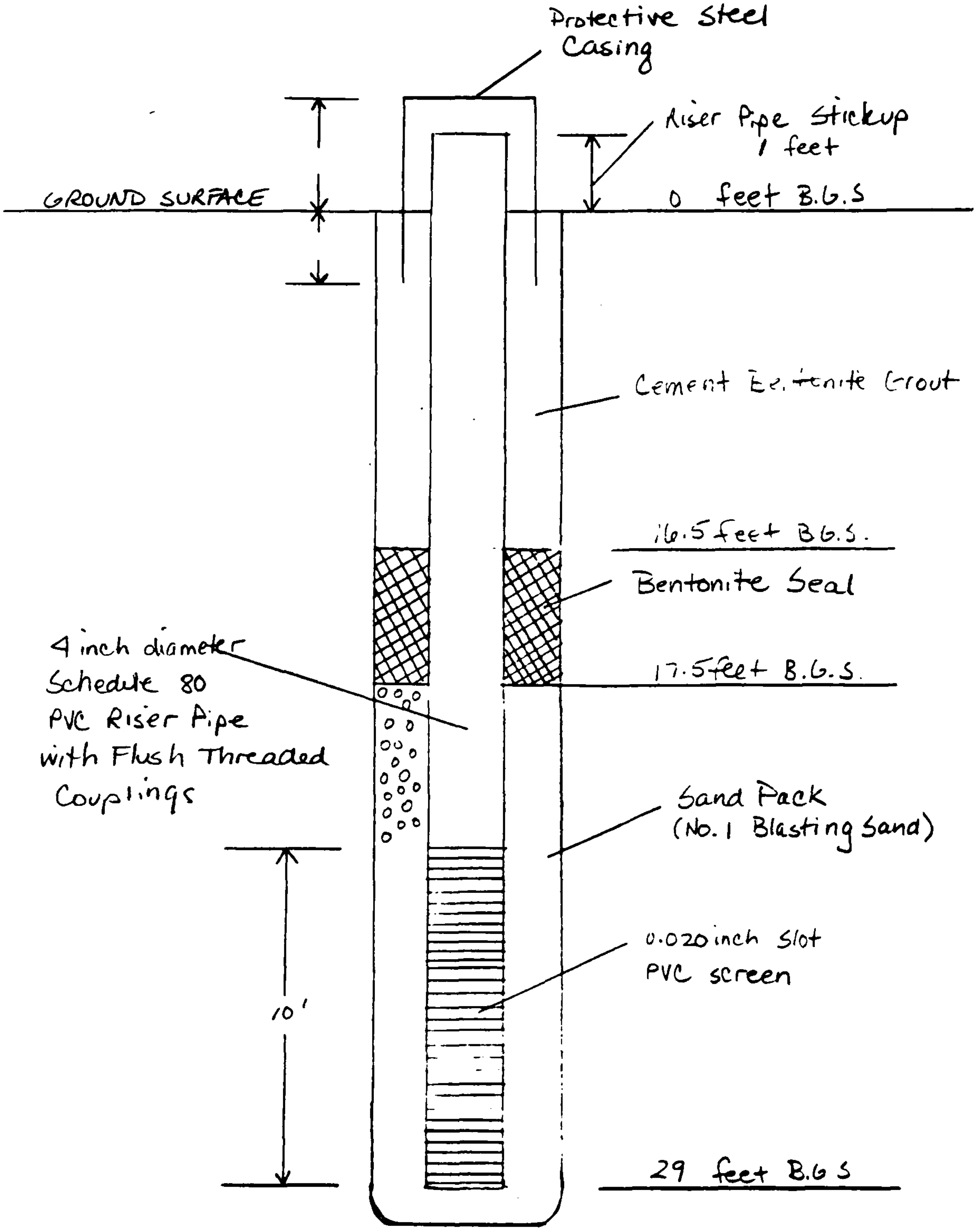

Well Construction Log McGuire AFB

Well Number MW4

RFW 338-5-01

WESTON

DRILLING LOG

WELL NUMBER: MW-5
OWNER: USAF
LOCATION: ZONE 1 LANDFILL-6
ADDRESS: McGuire AFB
TOTAL DEPTH 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10-17-83
DRILLER: TS
HELPER: AH
LOG BY: JW

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1		2/3 5	0-1.5 Black FILL bottom ash, sand and silt size; Olive yellow SAND, fine to medium, trace silt, Dry Bottom of fill At 1'	0
5		2		4/4 5	5-6.5 Black silty SAND to sandy SILT, fine sand, low plastic, wet, micaceous, grades to light yellow [illegible]	1
10		3		4/6 7	10.0-11.5 Black clayey SILT, some fine sand, low to medium plastic, wet, micaceous	0
15		4		4/6 9	15-16.5 Very dark grayish brown silty SAND, fine, wet, micaceous	0
20						

*A.S.T.M. D1586

HNU measurements analyized in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-5
OWNER: USAF
LOCATION: ZONE 1 LANDFILL 6
ADDRESS: McGuire AFB
TOTAL DEPTH 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10-17-83
DRILLER: TS
HELPER: AH
LOG BY: JW

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20		5		4/7	20 - 21.5 Very dark grayish brown silty	0
				10	SAND, wet, micaceous	
25		6		6/8	25 - 26.5 Dark greenish gray clayey	0
				7	SAND, fine, wet, glauconitic	

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
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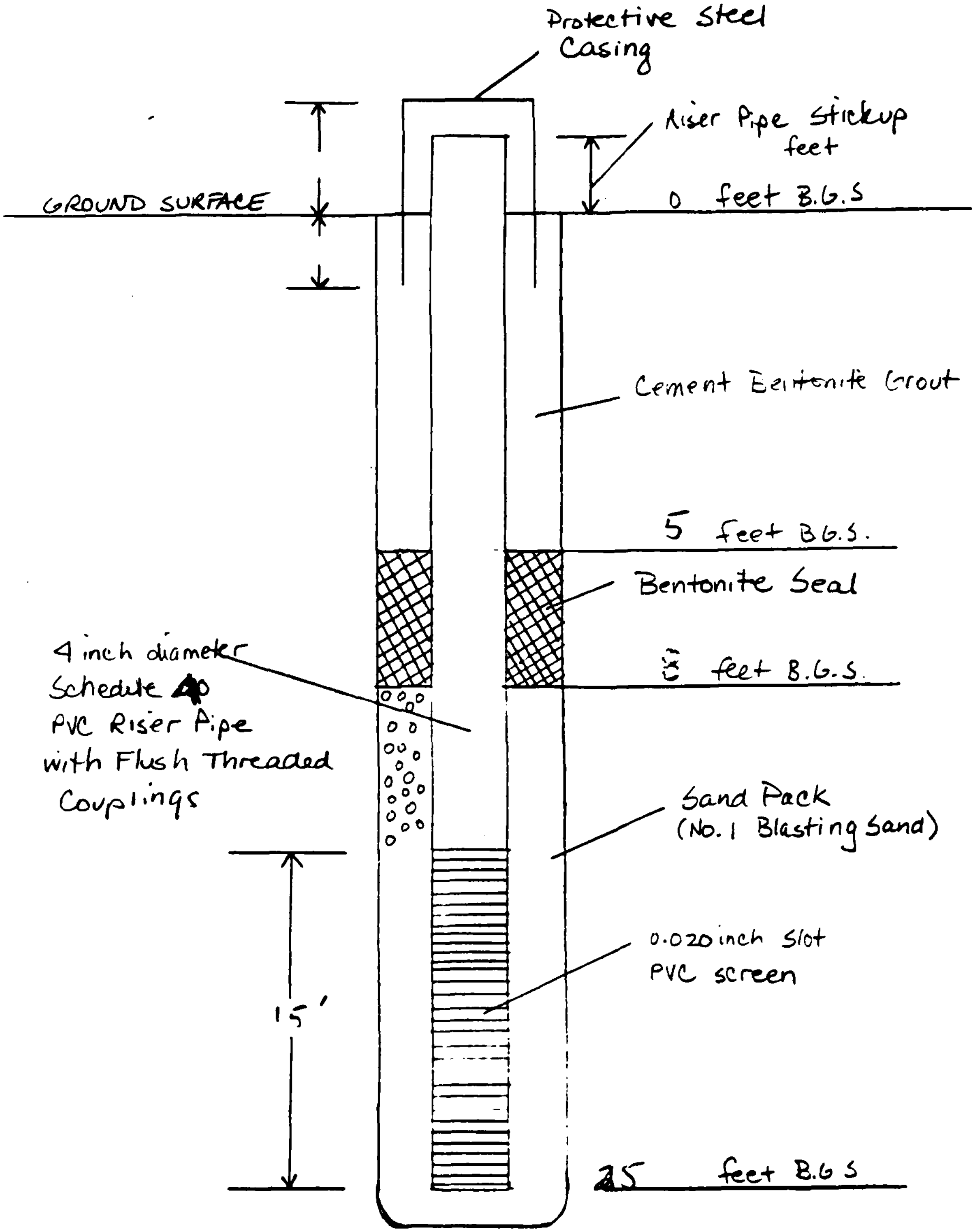

Well Construction Log McGuire AFB

Well Number MW5

RFW 308-5-81

WESTON

DRILLING LOG

WELL NUMBER: MW-6
OWNER: USAF
LOCATION: SITE 2 LANDFILL-2
ADDRESS: McGuire AFB
TOTAL DEPTH 36.5'
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/20/83
DRILLER: TS
HELPER: AH
LOG BY: JND/BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1	SS	2/5 9	0-1.5 Olive SAND, fine, some medium, trace silt, damp, (FILL COVER)	0
5		2		2/2 4	5-6.5 Black ASH and Olive brown silty SAND, damp	2
					Bottom of Fill approx: 7-9'	
10		3		4/6 7	10-11.5 Olive yellow SAND, fine to medium, trace silt, moist,	0
15		4		3/5 5	15-16.5 Brownish yellow silty SAND, fine, moist to wet, with some reddish brown clay laminations, lowplastic	0
20						

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-6 OWNER: USAF
LOCATION: SITE 2 ADDRESS: McGuire AFB
LAND FILL - 2
TOTAL DEPTH 36.5
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: EMPIRE DRILLING METHOD: Auger DATE DRILLED: 10/20/83
DRILLER: TS HELPER: A H
LOG BY: JND / BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (
20		5	SS	2/4	20 - 21.5 Light brownish gray SAND, fine	0
				4	some clay, wet	
					Pesticide odor	
25		6	SS	3/3	25.0-26.5 Olive brown [illegible] SAND fine	0
				5	some clay, wet	
					Pesticide odor	
30		7	SS	3/3	30 - 31.5 Dark greenish gray SAND,	0
				5	fine to medium, tr coarse sand,	
					some silt, wet, Fecal odor	
35		8	SS		35. - 36.5 Dark greenish gray SAND,	0
					fine to medium, some silt, wet	
					no odor	
					~~End of boring 36.5~~'	

*A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY________ DATE________ DIV________ SHEET________ OF________
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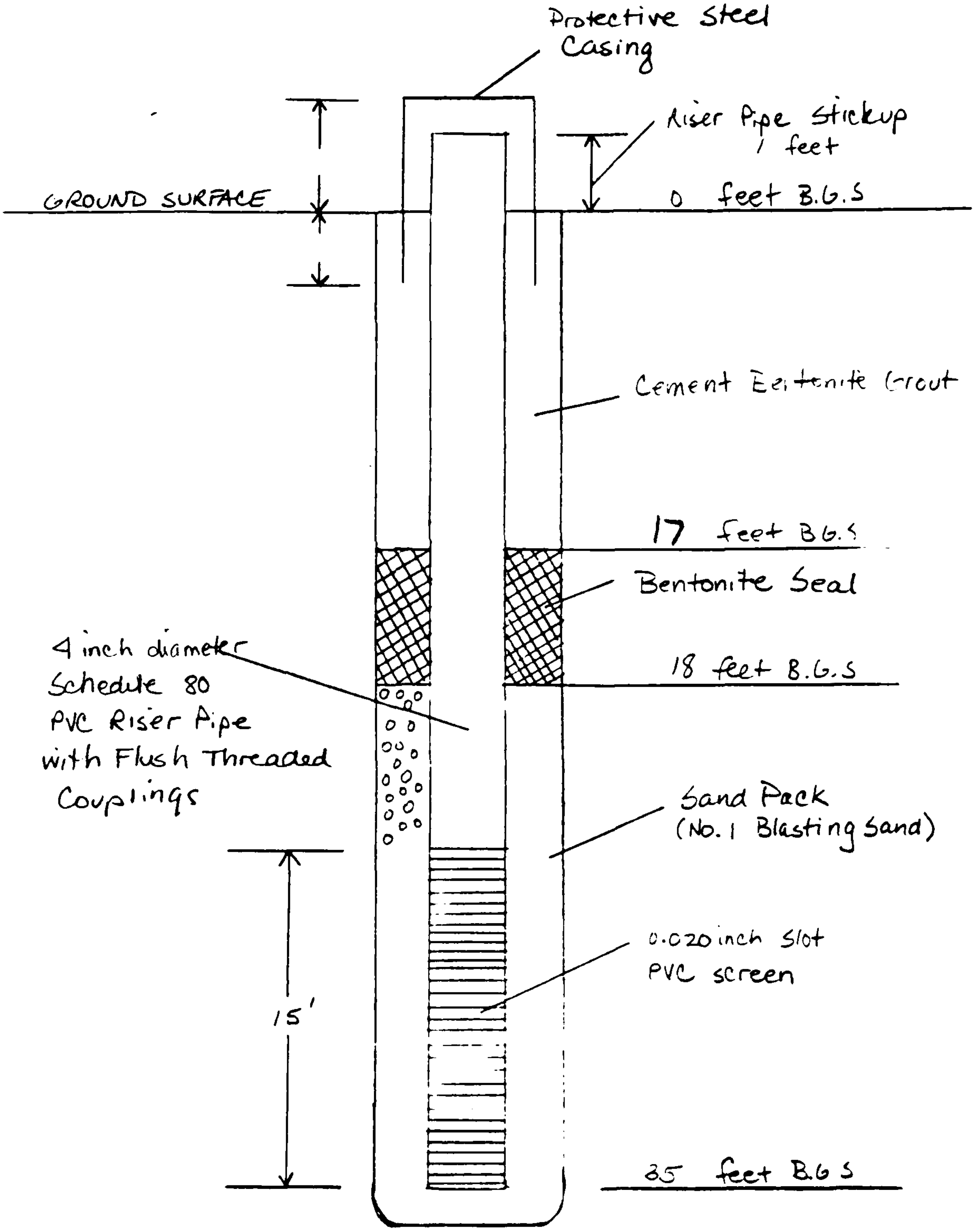
SUBJECT________



Well Construction Log McGuire AFB
Well Number MW46

WESTON

DRILLING LOG

WELL NUMBER: MW-7
OWNER: USAF
LOCATION: SITE-2
LANDFILL-2
ADDRESS: McGuire AFB
TOTAL DEPTH 36.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/21/83
DRILLER: T S
HELPER: A H
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
0		1	SS	10/21	0 - 1.5 Very dark grayish brown FILL,	0
				16	damp; fine gravel and fine	
					to medium silt, sand	
5		2	SS	3/5	5-6.5 Black FILL Ash s[illegible] size	0
				10	damp Dark grayish brown SAND,	
					fine, some silt, damp	
10		3	SS	4/4	10 - 11.5 Light olive brown SAND, fine	0
				6	some silt, damp; Black FILL	
					Ash, wood, paper	
15		4	SS	8/12	15.0-16.5 Dark greenish gray FILL,	5
				14	fine to coarse sand, little silt	
					trace gravel, wood in sample	
					Bottom of fill approx 17'	
20						

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-7
OWNER: USAF
LOCATION: SITE-2 LANDFILL-2
ADDRESS: McGuire
TOTAL DEPTH 36.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/22/83
DRILLER: T.S.
HELPER: A.H.
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	7/11 14	20-21.5 Dark olive gray SAND, fine to medium, trace fine gravel, some silt, moist to wet,	2
25		6	SS	6/10 10	25-26.5 Pale yellow SAND, fine, trace silt, saturated, with mottled light gray, reddish yellow sand	0
30		7	SS	3/5 5	30-31.5 Dark greenish gray SAND, fine to medium, some silt, saturated, glauconitic	0
35		8	SS		35-36.5 Dark greenish gray SAND, fine to medium, some silt, saturated, glauconitic	0
					~~End of boring 36.5'~~	

* ASTM D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
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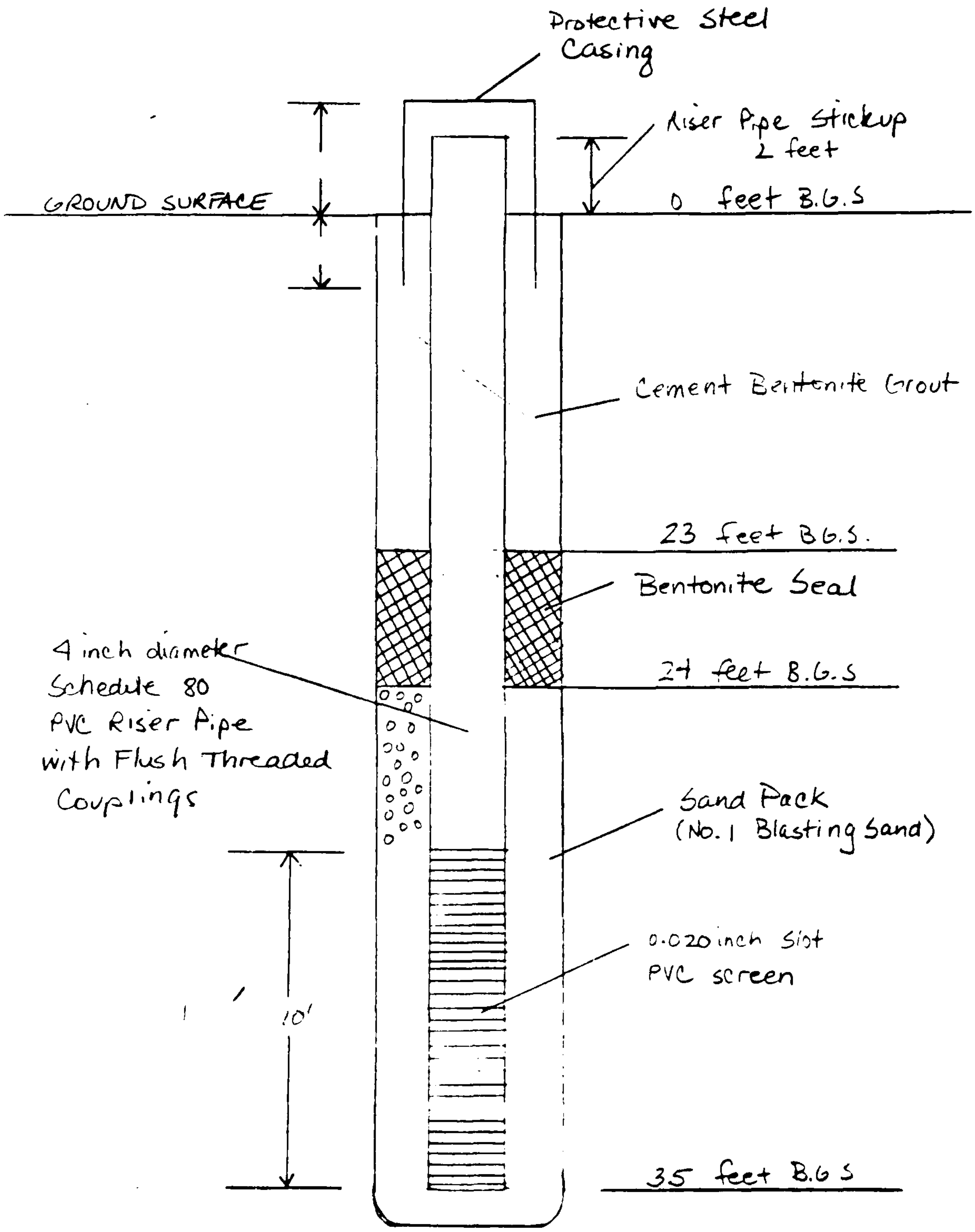

Well Construction Log McGuire AFB

Well Number MW07

WESTON

SKETCH MAP

DRILLING LOG

WELL NUMBER: MW-8 OWNER: USAF

LOCATION: SITE-2 ADDRESS: McGuire AFB
LANDFILL-2

TOTAL DEPTH 36.5

SURFACE ELEVATION: WATER LEVEL:

DRILLING COMPANY: EMPIRE DRILLING METHOD: Auger DATE DRILLED: 10-17-83

DRILLER: R E HELPER: B H

LOG BY: B W B

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
0		1	SS	2/3	0-1.5 Black FILL Ash; fine sand	0
				4	And silt size, damp	
5		2	SS	3/2	5.0-6.5 Black FILL Ash; fine	4
				3	sand and silt size, dry	
10		3	SS	7/15	Brown FILL, paper	35
				10	paper jammed in spoon	
					no soil recovery	
					note: high HNU	
15		4	SS	3/4	Olive SAND, fine, trace fine	
				5	gravel, some medium sand, trace	
					silt, some Black ASH - possible caved material	<1
					Bottom of fill 16-17'	
20						

* ASTM D1586

HNU measurement analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-8
OWNER: USAF
LOCATION: SITE 2
LANDFILL-2
ADDRESS: McGuire
TOTAL DEPTH 36.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10-17-83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	3/5	20 - 21.5 Olive SAND, fine, trace	0
				4	fine gravel, some medium sand,	
					trace silt, damp	
25		6	SS	6/4	25 - 26.5 Dark grayish brown sandy	0
				5	clayey SILT, moist, some Black organic	
					fibers	
30		7	SS	5/3	30 - 31.5 Olive SAND, fine, little	0
				9	silt, wet to saturated, micaceous	
35		8	SS	10/13	35 - 36.5 Olive gray Gravel, fine	<1
				15	some fine to coarse sand, Dr	
					greenish gray SAND, fine	
					to medium, trace silt, saturated	
					End of ~~boring 36.5~~	

* A.S.T.M. D1586

HNU measurement analyzed in laboratory

SHEET 2 OF 2

WESTON

BY ____ DATE ____ DIV ____ SHEET ____ OF ____

CHKD BY ____ DATE ____ DEPT ____ W.O. NO. ____

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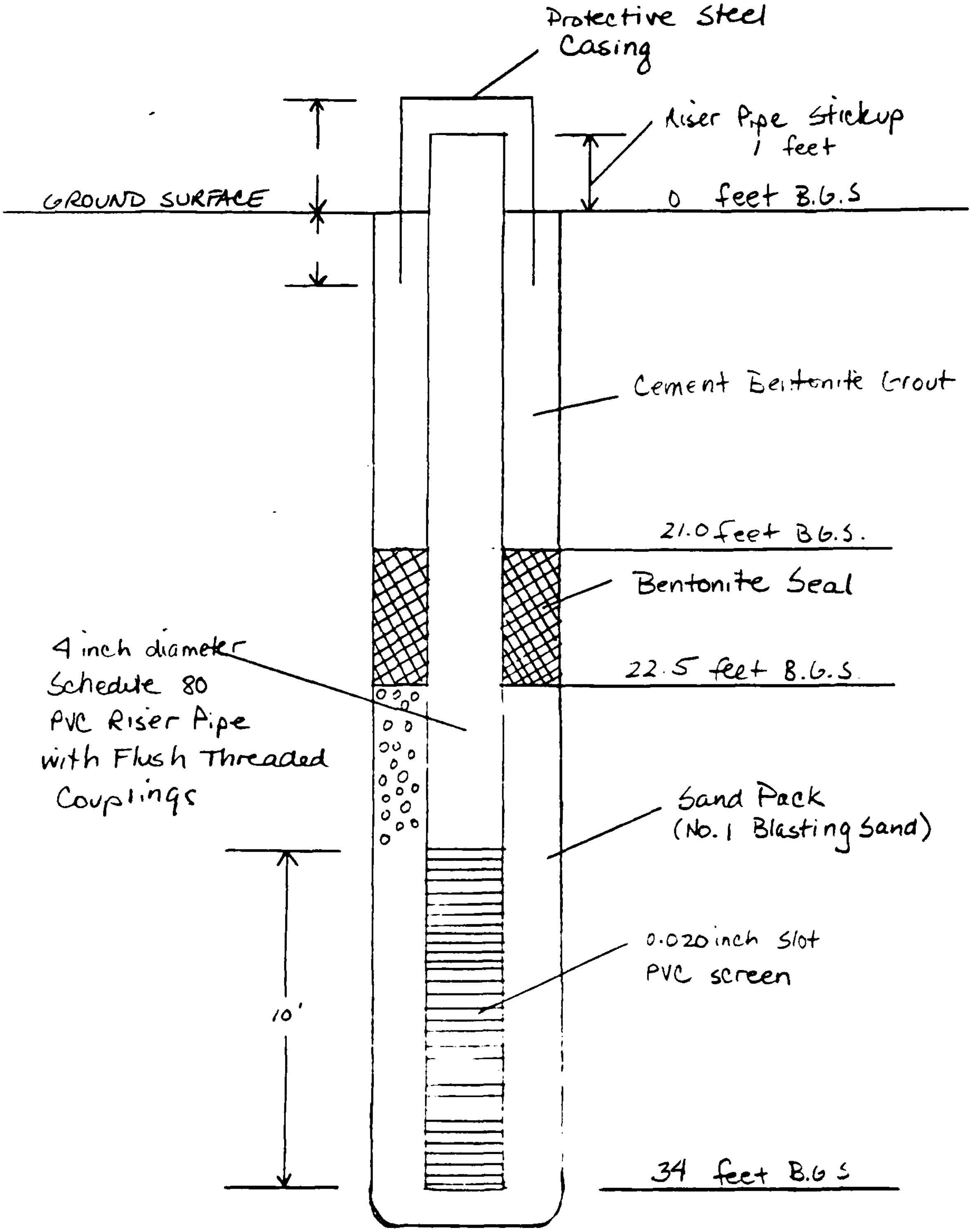

Well Construction Log McGuire AFB

Well Number MW8

WESTON

DRILLING LOG

WELL NUMBER: MW-9
OWNER: USAF
LOCATION: SITE-3 LANDFILL-3
ADDRESS: McGuire
TOTAL DEPTH 31.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 11-13-83
DRILLER: R E
HELPER: B H
LOG BY: B W B

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
0		1	SS	3/7	0 – 1.5 Mottled Olive, olive brown silty SAND, fine, some medium to	0
				5	coarse sand, moist –	
			Aug		1.5 – 5 FILL; plastic, wood, metal	
					foil	
5		2	SS	9/11	5–6.5 Very dark gray silty SAND, fine	0
				9	saturated; FILL organic	
					fibers, plastic	
					glauconite cuttings @ 9'	
					Bottom of fill approx 9'	
10		3	SS	11/15	10 – 11.5 Olive gray SAND, fine, wet	0
				23	laminated with Olive fine sand,	
					gravel on bottom of spoon	
15		4	SS	2/2	15 - 16.5 Light olive brown sandy SILT	0
				1	to silty SAND, fine, little clay,	
					saturated,	
20						

* A.S.T.M. D1586

HNU measurement analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-9
OWNER: USAF
LOCATION: SITE-3 LANDFILL-3
ADDRESS: McGuire AFB
TOTAL DEPTH 31.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 11-13-83
DRILLER: RF
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
20		6	SS	9/10 11	20-21.5 Very dark grayish brown silty CLAY, little fine sand, low to medium plastic moist, micaceous; Dr greenish gray SAND, fine to medium, little silt wet to saturated	0
25		7	SS	5/9 14	25-26.5 Dark greenish gray SAND, fine to medium, little silt, wet to saturated, has a sewage odor	1
30		8		2/2 5	30-31.5 Dark greenish gray SAND, fine to medium, little silt, wet to saturated	0

* A.S.T.M. D1586 HNU measurement analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ____ DATE ____ DIV ____ SHEET ____ OF ____
CHKD BY ____ DATE ____ DEPT ____ W.O. NO. ____
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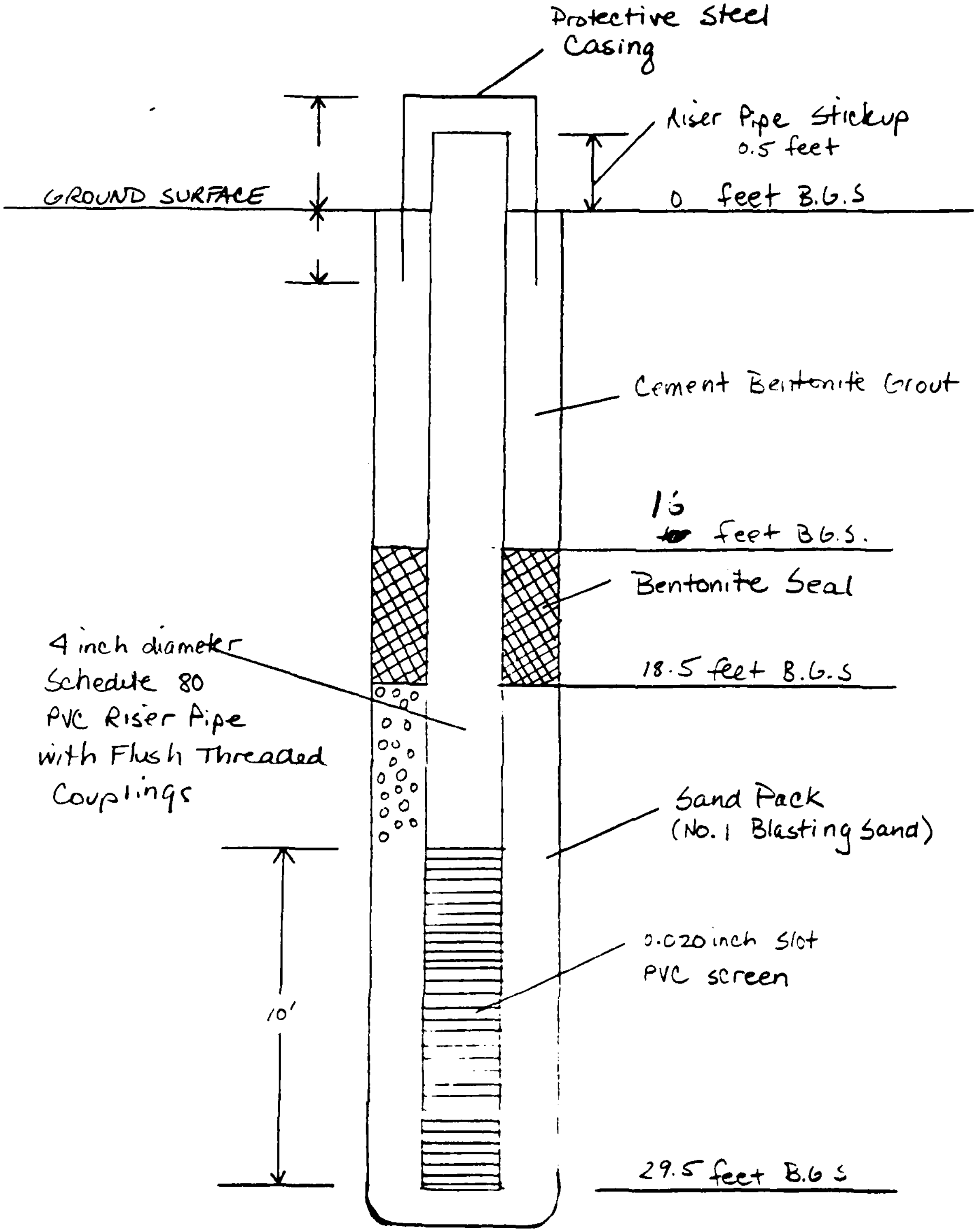

Well Construction Log McGuire AFB

Well Number MW[illegible]9

WESTON

DRILLING LOG

WELL NUMBER: MW-10
OWNER: USAF
LOCATION: SITE-3 LANDFILL-3
ADDRESS: McGuire
TOTAL DEPTH 31.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/13/83
DRILLER: TS
HELPER: AH
LOG BY: RJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
0		1	SS	3/6 12	0-1.5 Very dark grayish brown SAND, fine, trace fine gravel, trace silt, damp	0
5		2	SS	6/11 14	5-6.5 Light olive brown SAND, fine to medium, moist	0
10		3	SS	7/14 14	10.-11.5 Light gray SAND, fine, trace fine gravel, wet	0
15		4	SS	4/5 9	Reddish yellow silty CLAY, trace fine sand, moist to wet, micaceous	0

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-10
OWNER: USAF
LOCATION: SITE -3 LANDFILL-3
ADDRESS: McGuire
TOTAL DEPTH 31.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/13/83
DRILLER: TS
HELPER: AH
LOG BY: RJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
20		5	SS	4/6	20 - 21.5 Light brownish gray SAND,	0
				9	fine to medium, moist, micaceous;	
					Dark greenish gray SAND,	
					fine to medium, trace silt, moist	
25		6	SS	4/4	25 - 26.5 Dark greenish gray SAND	0
				11	medium, trace silt, moist	
30		7	SS	4/3	30 - 31.5 Dark greenish gray silty	0
				4	SAND, fine, trace clay,	
					wet	
					~~End of boring 31.5~~	

* A.S.T.M. D1586

HNU measurement analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ________ DATE ________ DIV ________ SHEET ________ OF ________
CHKD BY ________ DATE ________ DEPT ________ W.O. NO. ________
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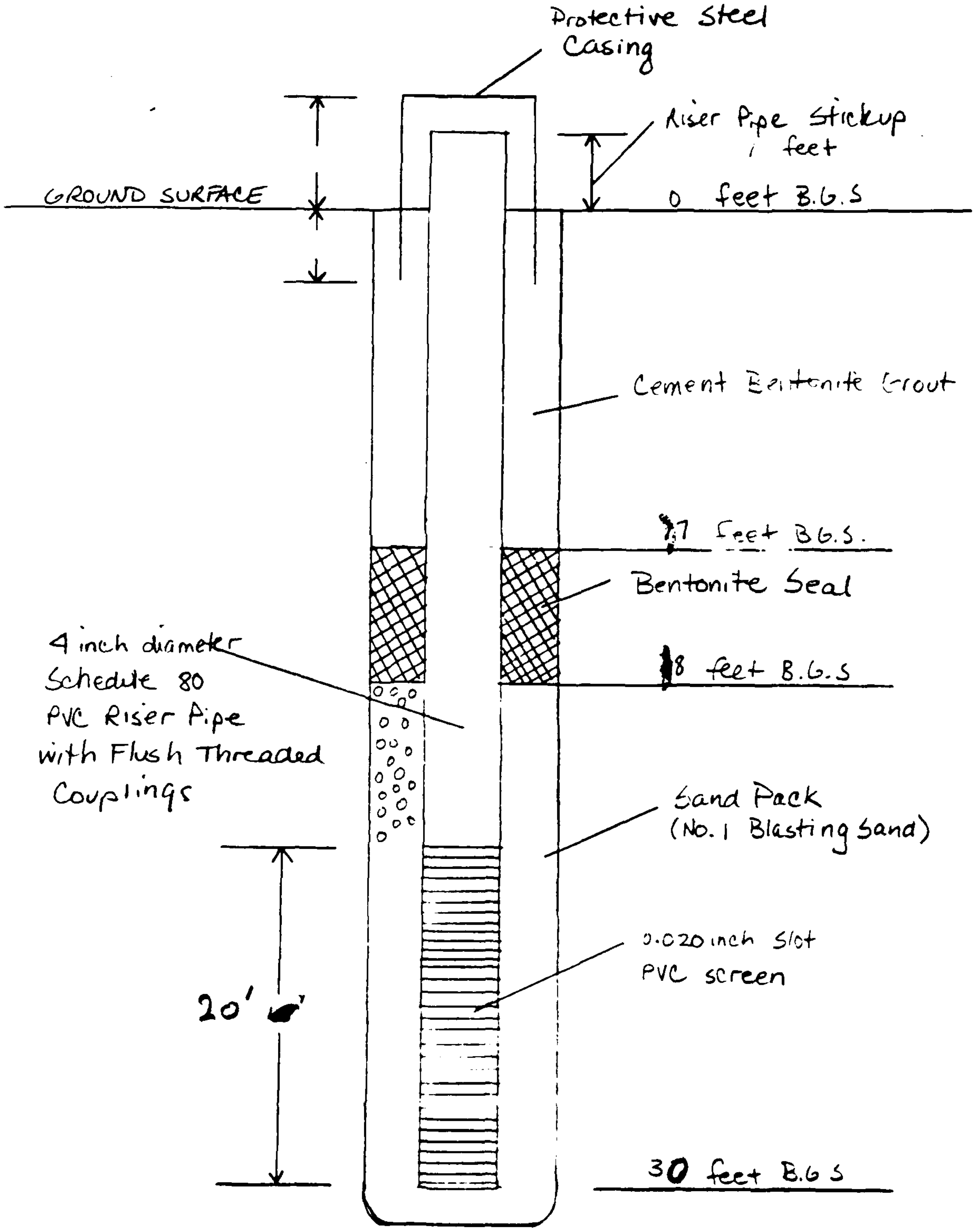
SUBJECT ________



Well Construction Log McGuire AFB
Well Number MW10

WESTON

SKETCH MAP

DRILLING LOG

WELL NUMBER: MW-11 OWNER: USAF
LOCATION: SITE-3 LANDFILL-3 ADDRESS: McGuire AFB
TOTAL DEPTH *31.5
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: EMPIRE DRILLING METHOD: Auger DATE DRILLED: 11-13-83
DRILLER: RE HELPER: BH
LOG BY: BWB

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT ppm
0		1	SS	3/8 20	0-1.5 Dark grayish brown silty SAND, fine, moist, some organic fibers	0
5		2	SS	5/6 6	5-6.5 Brownish yellow SAND, fine little to some silt, moist	0
10		3	SS	5/5 8	10-11.5 Light gray SAND, fine trace silt, moist to wet, micaceous	0
15		4	SS	6/5 9	15-16.5 Olive yellow SAND, coarse AND GRAVEL, fine, some medium sand, wet to saturated	0

* A.S.T.M. D1586

HNU measurement analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-11
OWNER: USAF
LOCATION: SITE -3
LANDFILL -3
ADDRESS: McGuire
TOTAL DEPTH 31.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/13/83
DRILLER: TS
HELPER: AH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	3/3 16	20 - 21.5 Olive yellow SAND, course, and GRAVEL, fine, some medium sand, wet to saturated; Reddish yellow silty Clay, low to medium plastic, wet	0
25		6	SS	3/4 9	25-26.5 Dark olive gray silty SAND, fine, wet to saturated, glauconitic	0
30		7	SS	3/4 8	30 - 31.5 Dark olive gray silty SAND, fine, wet to saturated, glauconitic	0
					~~End of boring 31.5~~	

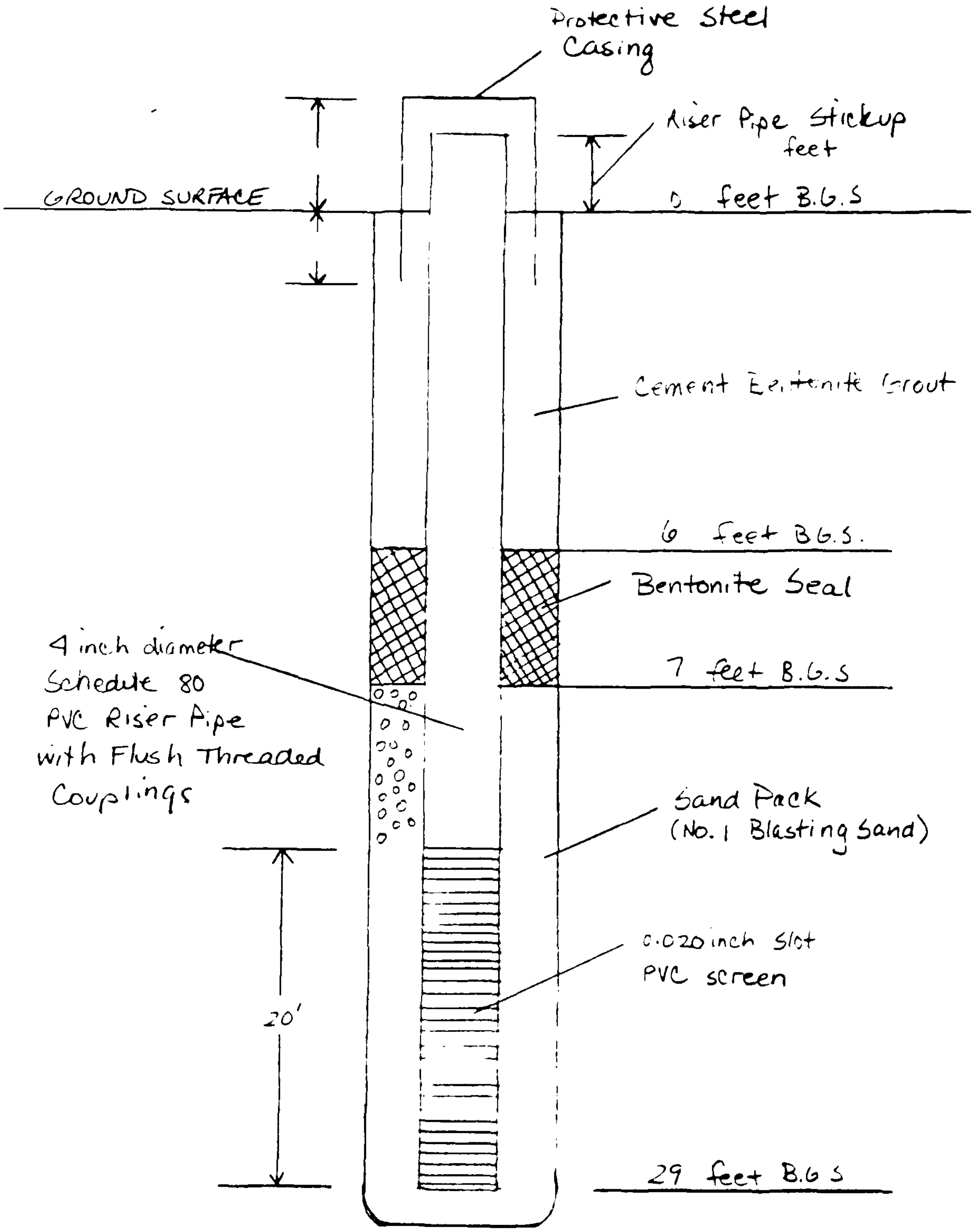
* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ____________ DATE ________ DIV ____________ SHEET ____________ OF ________
CHKD BY ______ DATE ________ DEPT ____________ W.O. NO. ____________________
PROJECT ____
SUBJECT ____



Well Construction Log McGuire AFB

Well Number MW 11

WESTON

DRILLING LOG

WELL NUMBER: MW-12 OWNER: USAF
LOCATION: SITE-8 FUEL STORAGE ADDRESS: McGuire AFB
TOTAL DEPTH 28.5
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: Empire DRILLING METHOD: Auger DATE DRILLED: 10/11/83
DRILLER: R E HELPER: B H
LOG BY: L.A.H

SKETCH MAP

NOTES:

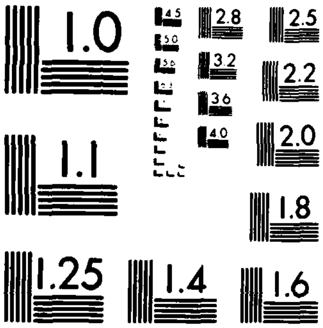
DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1	SS	5/10	0-1.5 Olive silty SAND, fine to	0
				13	medium, gravel; Black coal	
					fragments, cynders	
5		2	SS	21/20	5-6.5 Brownish yellow SAND, fine,	0
				16	some silt, moist,	
10		3	SS	**/2	10-11.5 Light olive brown SAND,	0
				3	fine; Black SILT, wet	
					with organic fibers, marshy	
					odor	
15		4	SS	2/2	15-16.5 Olive brown to black SAND, fine	0
				2	some silt, wood fibers,	
					marshy odor	
					xx Weight of hammer	

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

AD-A148 687   INSTALLATION RESTORATION PROGRAM PHASE II STAGE I STUDY   3/4
MCGUIRE AIR FORCE..(U) WESTON (ROY F) INC WEST CHESTER
PA OCT 84 F33615-80-D-4006

UNCLASSIFIED   F/G 13/2   NL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4.5
5.0
5.6
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

APPENDIX D

Boring Logs and Well Completion Summaries

WESTON

DRILLING LOG

WELL NUMBER: MW-12
OWNER: USAF
LOCATION: SITE-8 FUEL STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH 28.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/11/83
DRILLER: R E
HELPER: B H
LOG BY: L A. H

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
0		1	SS	5/10	0-1.5 Olive silty SAND, fine to	0
				13	medium, gravel; Black coal	
					fragments, cynders	
5		2	SS	21/20	5-6.5 Brownish yellow SAND, fine,	0
				16	some silt, moist,	
10		3	SS	**/2	10-11.5 Light olive brown SAND,	0
				3	fine; Black SILT, wet	
					with organic fibers, marshy	
					odor	
15		4	SS	2/2	15-16.5 Olive brown to black SAND, fine	0
				2	some silt, wood fibers,	
					marshy odor	
					xx Weight of hammer	

* A.S.T.M. D1586

** - - -

HNU measurements analyized in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

NUMBER: TB-1
OWNER: USAF
LOCATION: SITE-5 PESTICIDE WASH AREA
ADDRESS: McGuire AFB
TOTAL DEPTH 8.0'
SURFACE ELEVATION:
WATER LEVEL: 6.0'
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10-19-83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
0		1	SS	7/5	0-2 Light grayish brown SAND, fine	
		2	SS	8/8	to medium, trace silt, moist	
		3	SS	7/6	2-4 Olive SAND, fine, some medium	
		4	SS	5/4	sand, little silt, wet	
		5	SS	4/11	4-6 Olive brown silty SAND, fine, little	
5.		6	SS	20/23	clay, wet; Grayish brown SAND, fine	
		7	SS	24/28	to coarse, trace silt, wet	
		8	SS	24/28	6-8 Reddish brown SAND, fine to	
					coarse, saturated, fine gravel	
					layer at 7.0 to 7.2'	
10					Note: "No ionized organics	
					detected by HNU	

* A.S.T.M. D1586

SHEET 1 OF 1

WESTON

SKETCH MAP

NOTES:

DRILLING LOG

NUMBER: TB-2
OWNER: USAF
LOCATION: SITE-5 PESTICIDE WASH AREA
ADDRESS: McGuire AFB
TOTAL DEPTH: 8.0'
SURFACE ELEVATION:
WATER LEVEL: 6.0'
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/19/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
0		1	SS	5/5	0-2 light grayish brown SAND fine to	
		2	SS	7/6	medium, trace silt, moist; at 1.5' grades Olive	
		3	SS	6/4	2-4 Olive SAND, fine to medium, trace	
		4	SS	2/2	silt, moist	
		5	SS	6/13	4-6 Reddish brown SAND, fine, some	
5		6	SS	28/30	silt, wet; Reddish gray SAND, fine	
		7	SS	36/36	to coarse, wet to saturated	
		8	SS	29/20	6-8 Reddish brown SAND, medium to coarse and GRAVEL, fine,	
					saturated.	
10					~~End of Boring 8.0~~	
					Note: No ionized organics	
					detected by HNU	

* A.S.T.M. D1586

SHEET 1 OF 1

WESTON

DRILLING LOG

NUMBER: TB-3
OWNER: USAF
LOCATION: SITE -6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 19.0
SURFACE ELEVATION:
WATER LEVEL: 17.0'
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/18/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		1	SS	9/9	0-1.5 Light grayish brown SAND, fine to	
				10	medium, trace silt, damp	
		2	SS	7/9	1.5-3 Olive SAND, fine to medium, trace silt, damp	
				9		
		3	SS	11/9	3.0-4.5 Olive SAND, fine to medium, trace silt, damp	
				14		
		4	SS	14/9	4.5-6. Reddish brown, light gray SAND, fine,	
				9	some silt, moist, mottled	
		5	SS	10/9	6-7.5 no recovery	
				11		
		6	SS	9/9	7.5-9. Reddish brown, light gray SAND,	
				12	fine, some medium sand, moist, mottled	
		7	SS	10/13	9-10.5 Light brown SAND, fine to	
				15	medium, moist	
		8	SS	14/13	10.5-12 Light gray, reddish brown	
				14	SAND, fine to medium, moist mottled	
		9	SS	15/10	12-13.5 Light grayish brown GRAVEL, fine and	
				9	SAND, fine to medium, moist	

*ASTM D1586

SHEET 1 OF 2

WESTON

DRILLING LOG TB-3

WELL NUMBER: (cont)
OWNER: USAF
LOCATION: SITE-6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 19.0'
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/18/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DEPTH	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		10	SS		13.5-15	Reddish brown sandy SILT, ~~[illegible]~~	
						~~clay~~, low plastic, moist, with	
						light gray clay laminations	
		11A	SS	7/9	15'-17	Reddish brown SAND, fine,	
		11B	SS	9/12		little silt, moist, with light gray sand lenses	
		12A	SS	9/11	17-19	Reddish Brown SAND, fine,	
		12B	SS	11/12		little silt, saturated	
						Note No ionized organics detected by HNU	

* ASTM D158

SHEET 2 OF 2

WESTON

SKETCH MAP

DRILLING LOG

TB-4

WELL NUMBER:
OWNER: USAF
LOCATION: SITE-6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 17.5'
SURFACE ELEVATION:
WATER LEVEL: 16.0'
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/18/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		1A	SS	15/10	0-2 Greenish gray SAND, fine to medium,	
		1B	SS	9/7	trace silt, damp	
		2A	SS	7/9	2-4 Light brownish gray SAND, fine to medium little silt, damp	
		2B	SS	10/12		
		3A	SS	10/11	4-6 Light brownish gray SAND, fine to medium	
		3B	SS	11/12	trace silt, damp	
		4A	SS	9/7	6-8 Reddish brown, light gray, SAND, fine to	
		4B	SS	5/7	medium, [illegible] damp, mottled	
		5A	SS	10/11	8-10 Reddish brown, light gray, SAND, fine to	
		5B	SS	12/13	medium, little silt, damp mottled	
		6	SS	10/16	10-11.5 Reddish brown, light gray, SAND,	
				43	fine to medium, little silt, damp, mottled	
		7	SS	20/17	11.5-13 Reddish brown SAND, fine to medium,	
				12	trace silt, moist	
		8	SS	10/9	13-14.5 Reddish brown sandy SILT, fine sand, trace	
				12	clay, low plastic, moist, with light gray laminations	
		9	SS	5/8	14.5-16 Reddish brown sandy SILT, fine	
				13	sand, trace clay, low plastic with light gray lamination	
		10	SS	13/13	16-17.5 Light brownish gray SAND, fine, little	
				21	silt, saturated	

*A.S.T.M. D1586

Note: No ionized organics detected by HNU

SHEET 1 OF 1

WESTON

SKETCH MAP

DRILLING LOG

WELL NUMBER: TB-5
OWNER: USAF
LOCATION: SITE 6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH 19.0
SURFACE ELEVATION:
WATER LEVEL: 17.0
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10-19-83
DRILLER: RE
HELPER: BH
LOG BY: BWB

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		1A	SS	13/13	0-2 Light brownish gray SAND, fine to coarse, some gravel, damp; Greenish gray	
		1B	SS	16/16	SAND fine to medium, trace silt, damp	
		2B	SS	14/20	2-4 Greenish gray SAND, fine to medium,	
		2B	SS	29/41	trace silt, damp	
		3B	SS	10/11	4-6 Light brownish gray SAND, fine, some medium sand, trace silt, damp	
		3B	SS	11/12		
		4A	SS	12/11	6-8 Reddish brown, light brownish gray SAND,	
		4B	SS	10/12	fine, some silt, damp, mottled	
		5A	SS	7/7	8-10 Reddish brown, light brownish gray SAND,	
		5B	SS	7/7	fine, some silt, damp, mottled	
		6	SS	9/11	10-11.5 Greenish gray SAND, fine, some silt,	
				10	damp; Greenish gray SAND, fine to	
		7	SS	16/21	Coarse, little fine gravel, little silt, moist 11.5-13 Greenish gray SAND, fine to coarse,	
				29	little fine gravel, moist	
		8	SS	28/16	13-14.5 Greenish gray SAND, fine to course, little gravel, little silt, moist; Light grayish	
				10	brown SAND, fine little silt, moist,	
					with light gray laminations	
		9	SS	5/7	14.5-16 Light grayish brown SAND, fine, little	
				9	silt, moist; Greenish gray SAND, fine	
					to coarse, trace gravel, trace silt, moist	

*ASTM D1586

SHEET 1 OF 2

WESTON

DRILLING LOG TB-5

WELL NUMBER: – (cont)
OWNER: USAF
LOCATION: SITE 6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 19.0
SURFACE ELEVATION:
WATER LEVEL: 17.0
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/19/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		10	SS	12/12	16 - 17.5 Greenish gray SAND, fine to coarse,	
				12	trace gravel, trace silt, wet	
		11		10/20	17.5-19 Light gray SAND, fine, trace silt,	
				18	Saturated	
					Note: Ionized organics detected	
					in all soil samples	

* ASTM D1586

SHEET 2 OF 2

WESTON

DRILLING LOG

WELL NUMBER: TB-6
OWNER: USAF
LOCATION: SITE-6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 20'
SURFACE ELEVATION:
WATER LEVEL: 18'
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10-20-83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		1	SS	7/10	0-2 Black FILL, ash; silty sand sized; Greenish gray	
			SS	11/11	SAND, fine to medium, trace silt, moist	
		2	SS	9/7	2-4 Greenish gray SAND, fine to medium,	
			SS	5/5	trace silt, moist	
		3	SS	6/10	4-6 Greenish gray SAND, fine to medium,	
			SS	10/9	trace silt, moist; [illegible]	
		4	SS	7/11	6-8 Black FILL ash silt, sand size; Dark	
			SS	11/11	greenish gray SAND, fine to medium, little to some silt, moist	
		--			Bottom [illegible] - 7.0'	
		5		9/7	8-10 Dark greenish gray SAND, fine to	
				7/7	medium, little to some silt, moist; grades	
					mostly fine sand, siltier @ 9.0'	
		6		7/6	10-11.5 Dr greenish gray SAND, fine, some	
				5	medium sand, some silt, moist	
		7		6/7	11.5-13 Dr greenish gray SAND, fine, some	
				11	medium sand, some silt, moist	
		8		11/7	13-14.5 Dr greenish gray SAND, fine, little	
				7	medium sand, some silt, wet; some	
					fine gravel on bottom	

* ASTM D1586

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: TB-6 (cont)
OWNER: USAF
LOCATION: SITE-6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH:
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		9	SS	7/12	14.5 – 16.0 Dr greenish GRAVEL, fine, wet;	
				16	And Dr greenish gray SAND, fine to	
					coarse, wet, with laminated Light greenish gray silty sand	
		10	SS	16/14	16 – 18 Light greenish gray silty SAND fine,	
				14/21	wet; Light gray SAND, fine,	
					Trace silt, wet to saturated	
		11	SS	19/14	18-20 Light gray SAND, fine, Trace	
				16/17	silt, saturated; grade to	
					Coarse @ 19.5'	
					Note: Ionized organics	
					detected in all samples	
					HNU registers 250 ppm	
					when probe inserted into	
					boring hole	

*ASTM D1586

SHEET 2 OF 2

WESTON

DRILLING LOG

WELL NUMBER: TB-7
OWNER: USAF
LOCATION: SITE - 6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH 20'
SURFACE ELEVATION:
WATER LEVEL: 18'
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/19/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		1A	SS	10/10	0-2 Light brownish gray, reddish brown SAND,	
		1B	SS	10/10	fine to medium, damp mottled;	
					grades greenish gray @1.5'	
		2A	SS	10/12	2-4 Greenish gray SAND, fine to	
		2B	SS	13/13	medium, trace silt, wet	
		3A	SS	7/7	4-6 Light grayish brown SAND, fine	
		3B	SS	7/7	to medium, damp	
		4	SS	7/5	6-8 Reddish brown, greenish gray SAND,	
			SS	6/7	fine to medium, some silt,	
					damp, mottled	
		5	SS	6/6	8-10 Reddish brown, greenish gray, SAND	
				6/6	fine to medium, some silt,	
					damp mottled	
		6		6/5	10-11.5 Greenish gray SAND fine to	
				3	medium, trace silt, damp	
		7		5/4	11.5-13 Greenish gray SAND, fine	
				4	to coarse, damp	

* A.S.T.M. D1586

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: TB-7 (Cont)
OWNER: USAF
LOCATION: SITE-6 DPDO STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 20'
SURFACE ELEVATION:
WATER LEVEL: 18'
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/19/83
DRILLER: RE
HELPER: BH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
		8	SS	4/3 5	13-14.5 Greenish gray SAND, fine to coarse, damp; Greenish gray SAND, fine, some medium sand trace silt, damp	
		9		4/7 12	14.5-16 Greenish gray SAND, fine, some medium sand, trace silt damp	
		10		10/16 13/21	16-18 Light gray SAND, fine, some medium sand, trace silt, moist to wet'	
		11		10/8 7/8	18-20 Light gray SAND, fine, some medium sand, trace silt, saturated; sand grades fine to coarse, black @ 19.5'	
					Note: Ionized organics detected in all samples	

* ASTM D1586

SHEET 2 OF 2

DRILLING LOG

WELL NUMBER: MW-1
OWNER: USAF
LOCATION: Zone 1 Adjacent Boundry Fence
ADDRESS: McGuire AFB
TOTAL DEPTH: 29.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/6/83
DRILLER: T.S.
HELPER: A H
LOG BY: R.J.

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	* HNU MEASUREMENT (PPM)
0		1	SS		0-1.5 Olive yellow SAND, fine, trace	0
					silt, mottled olivebrown, brick	
					(fill)	
		2	SS	6/12	3-4.5 Mottled yellowish brown SAND,	0
				14	fine to medium, trace silt,	
5					Olive yellow SAND, fine to	
					medium, Tr silt, wet	
		3	SS	3/4	8-9.5	0
				5	Dark olive SAND, fine, little	
10					silt, little clay, damp	
		4		3/5	13-14.5	0
				7	Black SAND, fine, little	
15					clay, moist	
		5		2/5	18-19.5 Black SAND, fine, some	3
				7	silt, with olivebrown fine	
20					sand laminations	

* A.S.T.M. D1586

* HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-1
OWNER: USAF
LOCATION: Zone 1 Adjacent Boundry Fence
ADDRESS: McGuire AFB
TOTAL DEPTH:
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/6/83
DRILLER: T.S.
HELPER: A.H.
LOG BY: R.J.

SKETCH MAP

NOTES:

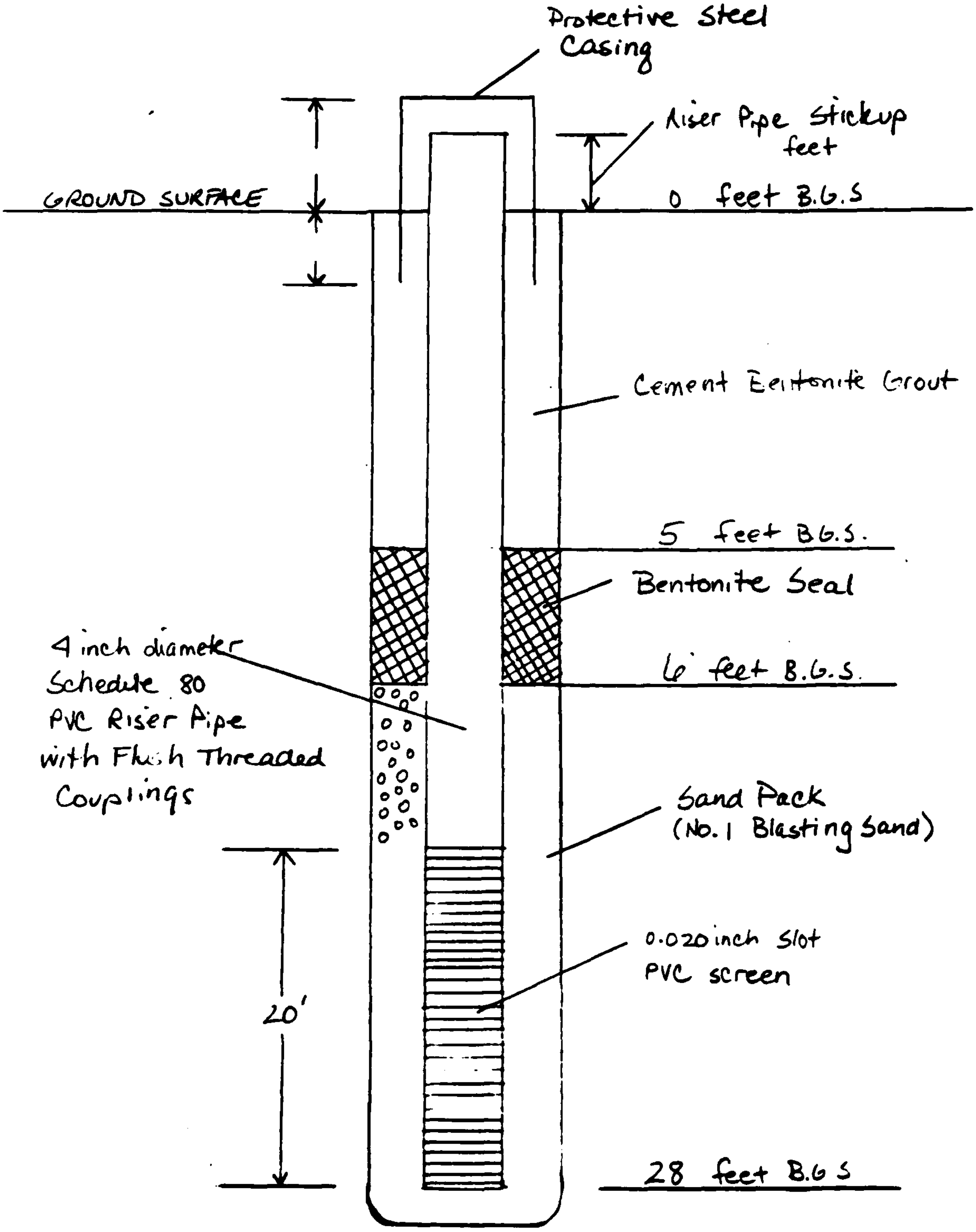
DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20'						
		6	SS	1/3	23.-24.5 Black SAND, fine, some	1
				8	silt, with olive brown fine	
					sand laminations	
25						
		7	SS	4/4	28-29.5 Black SAND, fine, some	1
				8	clay, firm	
30						
					END OF BORING 29.5'	

* A.S.T.M. D1586 * HNU measurements analyized in laboratory

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY________ DATE________ DIV________ SHEET ________ OF ________
CHKD BY ________ DATE________ DEPT ________ W.O. NO. ________
PROJECT ________
SUBJECT ________



Well Construction Log McGuire AFB
Well Number MW1

RFW 550-5-81

WESTON

DRILLING LOG

WELL NUMBER: MW-12
OWNER: USAF
LOCATION: SITE 8 Fuel STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH 28.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/11/83
DRILLER: R E
HELPER: B H
LOG BY: L.A.H.

SKETCH MAP

NOTES:

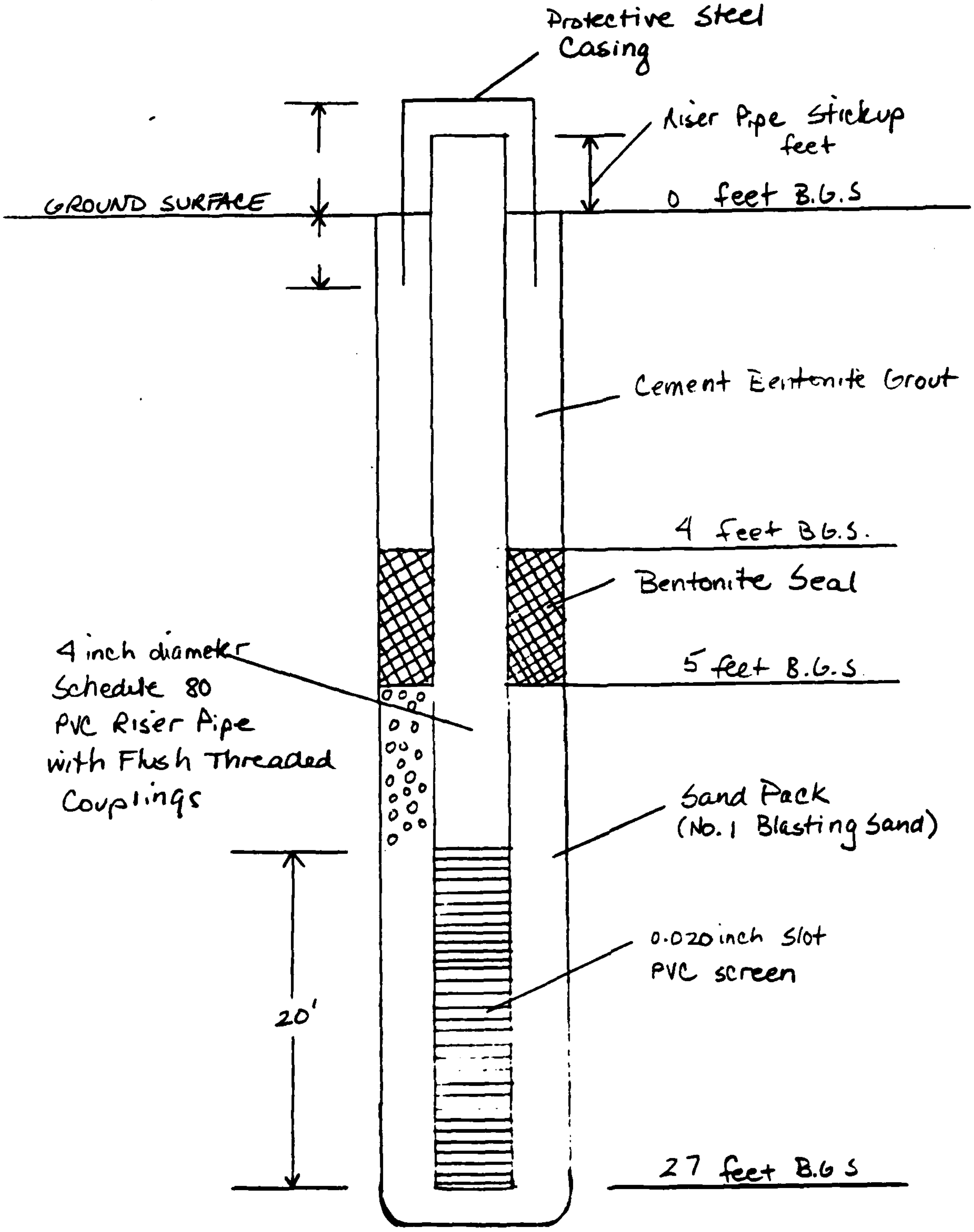
DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	3/4	20 - 21.5 Black silty SAND, fine	0
				5	to medium, lenses of coarse	
					sand and gravel	
25		6	SS	4/5	25 - 26.5 Olive brown silty CLAY;	0
				10	Dr olive gray SAND, fine	
					to medium, glauconitic	
		7	SS	4/5	27 - 28.5 Dr olive gray SAND,	0
				7	fine to medium, some silt, with shell fragments	
					~~End of boring 28.5~~	

* A.S.T.M. D1586

SHEET 2 OF 2

WESTON
DESIGNERS CONSULTANTS

BY ____________ DATE ________ DIV __________ SHEET __________ OF ______
CHKD BY ______ DATE ________ DEPT __________ W.O. NO. ______________
PROJECT ____
SUBJECT ____



Well Construction Log McGuire AFB

Well Number MW12

WESTON

SKETCH MAP

NOTES:

DRILLING LOG

WELL NUMBER: MW-13
OWNER: USAF
LOCATION: SITE-8 FUEL STORAGE
ADDRESS: McGuire AFB
TOTAL DEPTH: 28.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/11/83
DRILLER: TS
HELPER: AH
LOG BY: BWB

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
0		1	SS	5/7	0-1.5 Light olive brown, SAND, fine	0
				9	little to some silt, moist, trace	
		2	SS	11/20	glauconitic	
				22	3-4.5 Olive SAND, fine, some	0
					silt, moist, tr glauconitic	
5						
		3	SS	5/7	7-8.5 Olive brown SAND, some silt	
				7	trace clay, moist, with	
					organic fibers, fuel odor	10
10		4	SS	4/4	12-13.5 Olive brown SAND, fine,	
				4	little silt, grades moist to wet	
					, organics, fuel odor	15
15						
		5	SS	4/7	17-18.5 Olive brown silty SAND, fine	6
				9	wet to saturated, micaceous;	
					Dr olive brown silty CLAY, low to	
					medium plastic, moist to wet	

*A.S.T.M.D1586 — HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-13
OWNER: USAF
LOCATION: SITE 8 FUEL STORAGE
ADDRESS: McGuire
TOTAL DEPTH: 28.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED: 10/11/83
DRILLER: TS
HELPER: AH
LOG BY: BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20						
		6	SS	5/5	22-23.5 Dr olive brown silty CLAY,	0
				7	low to medium plastic, moist to	
					wet; Dr olive brown silty	
25					SAND, fine, some medium sand	
					saturated, ~~glauconitic~~	
		7	SS	4/4	27-28.5 Dr olive brown clayey	1
				9	SILT, some fine sand, low plastic	
					saturated; Dr greenish gray	
					silty SAND, fine to medium,	
					saturated, glauconitic	
					~~End of boring 28.5~~	

*A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

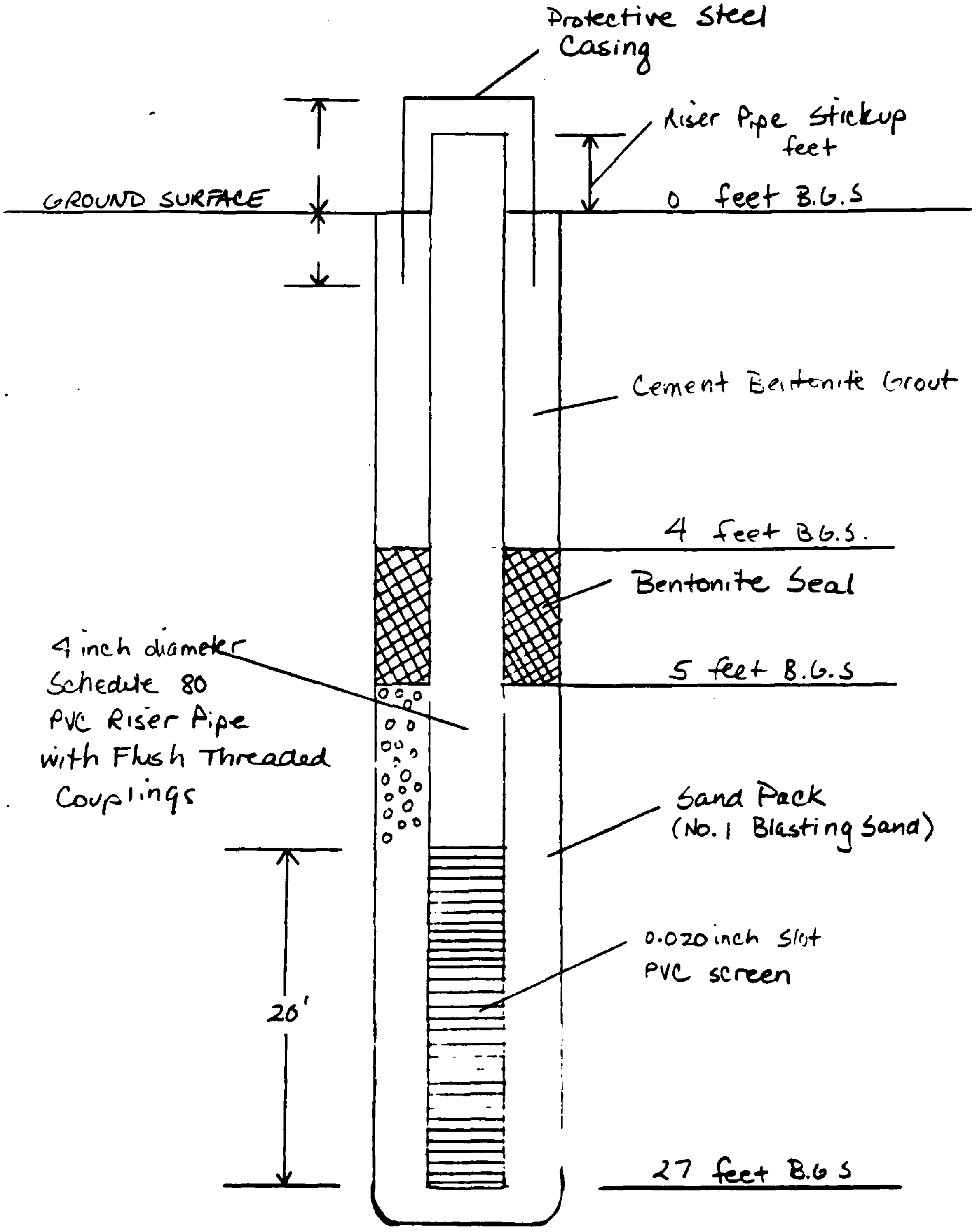
WESTON

BY _____ DATE _____ DIV _____ SHEET _____ OF _____

CHKD BY _____ DATE _____ DEPT _____ W.O. NO. _____

PROJECT _____

SUBJECT _____



Well Construction Log McGuire AFB

Well number MW3

[illegible] 5-81

WESTON

DRILLING LOG

WELL NUMBER: MW-14
OWNER: USAF
LOCATION: SITE-7 TRIANGLE
ADDRESS: McGuire
TOTAL DEPTH: 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: TS
HELPER: AH
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT PPM
0		1	SS	2/7	0-1.5 Olive brown SAND, fine to	0
				10	coarse, damp	
5		2	SS	5/8	5-6.5 Olive yellow SAND, medium	0
				10	to coarse, some fine to medium	
					gravel, wet	
10		3	SS	4/9	10-11.5 Olive yellow SAND, fine,	0
				10	trace silt, wet.	
15		4	SS	6/7	15-16.5 Very dark gray SAND, fine;	0
				7	Very dark gray CLAY, plastic	
					moist	

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-14
OWNER: USAF
LOCATION: SITE-7 TRIANGLE
ADDRESS: McGuire
TOTAL DEPTH * 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: TS
HELPER: AH
LOG BY: RCJ

SKETCH MAP

NOTES:

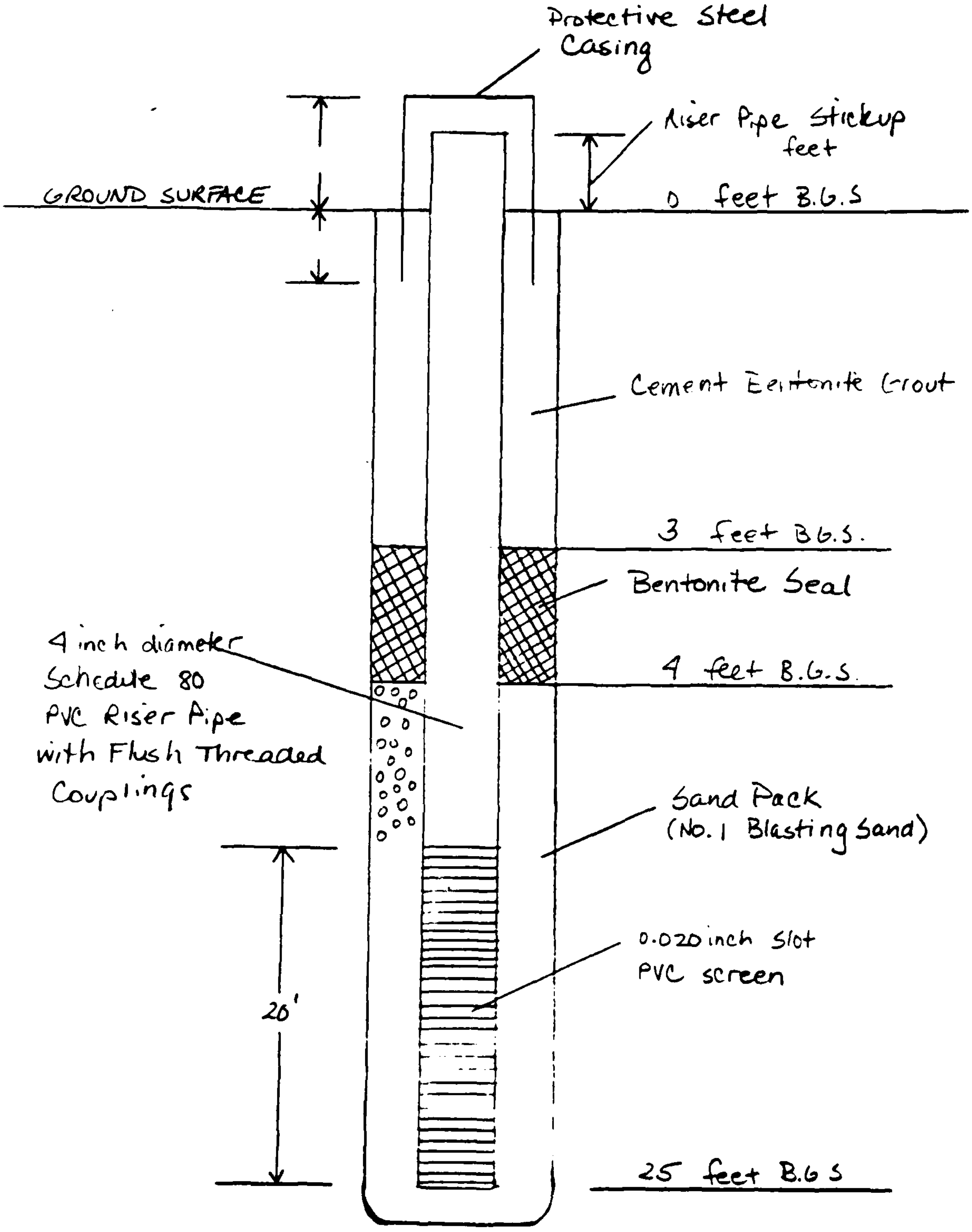
DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	4/4	20-21.5 Very dark gray SAND,	0
				6	fine, little plastic clay, moist	
25		6	SS	4/3	25-26.5 Dark olive gray SAND,	0
				4	fine, little plastic clay, moist	
					~~End of boring - 26.5'~~	

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT ______
SUBJECT ______



Well Construction Log McGuire AFB

Well Number MW14

WESTON

DRILLING LOG

WELL NUMBER: MW-15
OWNER: USAF
LOCATION: SITE-7 TRIANGLE
ADDRESS: McGuire AFB
TOTAL DEPTH: 26.5
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: TS
HELPER: AL
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
		1	SS	2/4 9	0-1.5 Yellowish brown SAND, course and GRAVEL, fine, damp	0
5		2	SS	6/7 12	5-6.5 Brownish yellow SAND, fine trace gravel, wet	0
10		3	SS	4/6 9	10-11.5 Pale yellow SAND, fine, trace gravel, wet	0
15		4	SS	4/4 7	15-16.5 Dark greenish gray SAND, fine, little silt, little low plastic clay, moist	0

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-15 OWNER: USAF
LOCATION: SITE-7 TRIANGLE ADDRESS: McGuire AFB
TOTAL DEPTH: 26.5
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: Empire DRILLING METHOD: Auger DATE DRILLED:
DRILLER: TS HELPER: AL
LOG BY: RCJ

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT (PPM)
20		5	SS	3/3 5	20-21.5 Dark greenishgray SAND, fine, trace plastic clay, moist	0
25		6	SS	3/3 6	25-26.5 Dark greenishgray SAND, fine, little plastic clay, moist	0
					~~End of boring 26.5'~~	

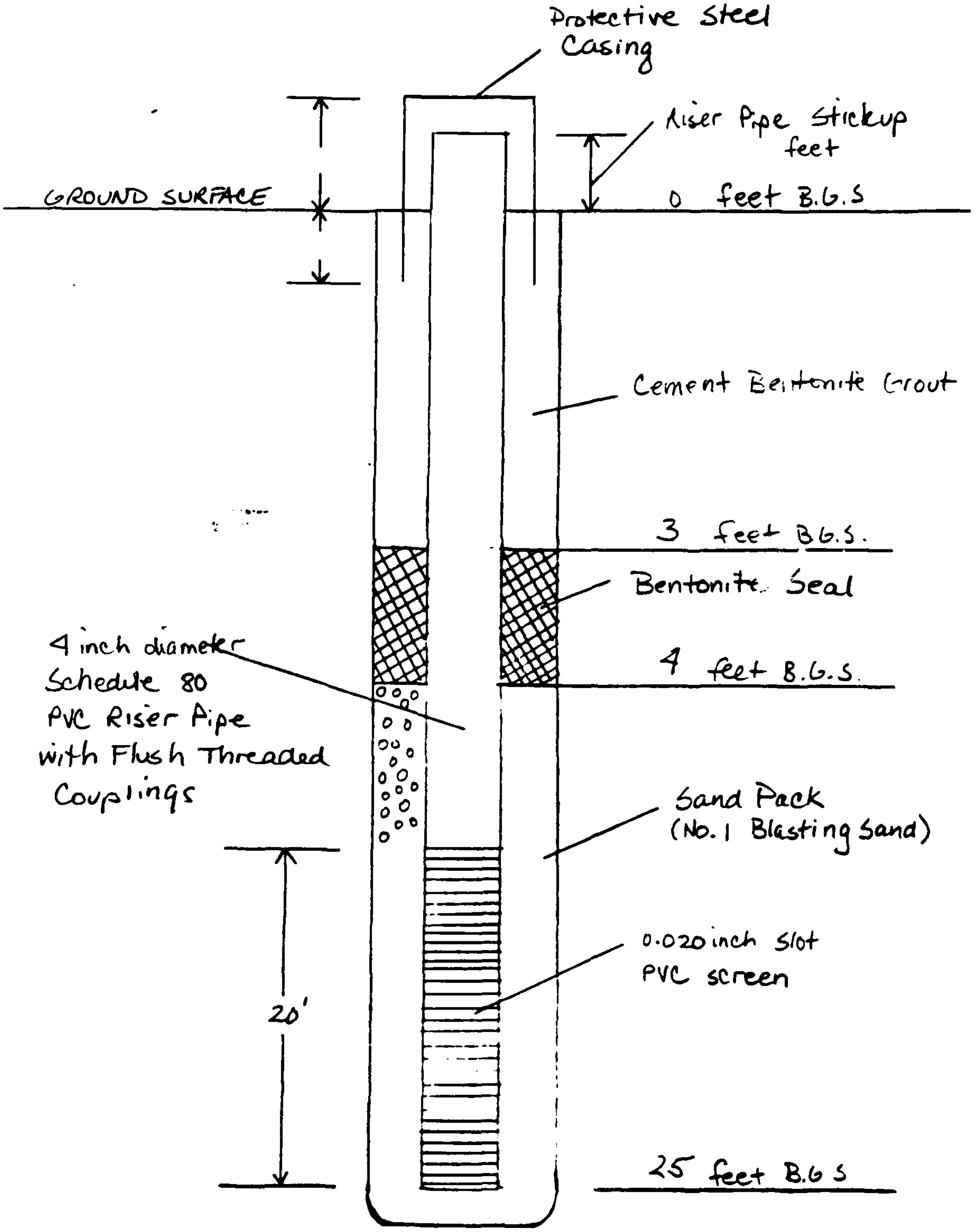
* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT ______
SUBJECT ______



Well Construction Log McGuire AFB
Well Number MW15

WESTON

DRILLING LOG

WELL NUMBER: MW-16
OWNER: USAF
LOCATION: SITE-4 BomARC
ADDRESS: McGuire
TOTAL DEPTH:
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: EMPIRE
DRILLING METHOD: Auger
DATE DRILLED:
DRILLER: RE
HELPER: BH
LOG BY: BWB/JND

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	3/2	20-21.5 Yellow SAND, fine to medium,	0
				2	trace coarse sand, trace silt, wet	
25		6	SS	10/11	25-26.5 Yellow SAND, fine to medium	0
				14	trace coarse sand, trace silt wet	
30		7	SS	3/16	30-31.5 Yellow SAND, fine to	0
				23	medium, wet; [illegible] brown	
					PEAT	
					End of boring 31.5	

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-16 OWNER: USAF
LOCATION: SITE-4 BOMARC ADDRESS: McGuire
TOTAL DEPTH: 31.5
SURFACE ELEVATION: WATER LEVEL:
DRILLING COMPANY: Empire DRILLING METHOD: Auger DATE DRILLED: 10/20/83
DRILLER: R E HELPER: BH
LOG BY: BWB/JND

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
0		1	SS	11/11	0-1.5 GRAVEL, course; Olive yellow	0
				9	SAND, fine to medium, damp	
5		2	SS	16/27	5-6.5 Yellow brown SAND, fine	0
				30	to medium, some coarse, damp	
10		3	SS	10/8	10-11.5 Very pale brown SAND, fine	0
				12	to medium, damp	
15		4	SS	8/16	15-16.5 Brownish yellow SAND,	0
				20	fine to medium, trace silt	

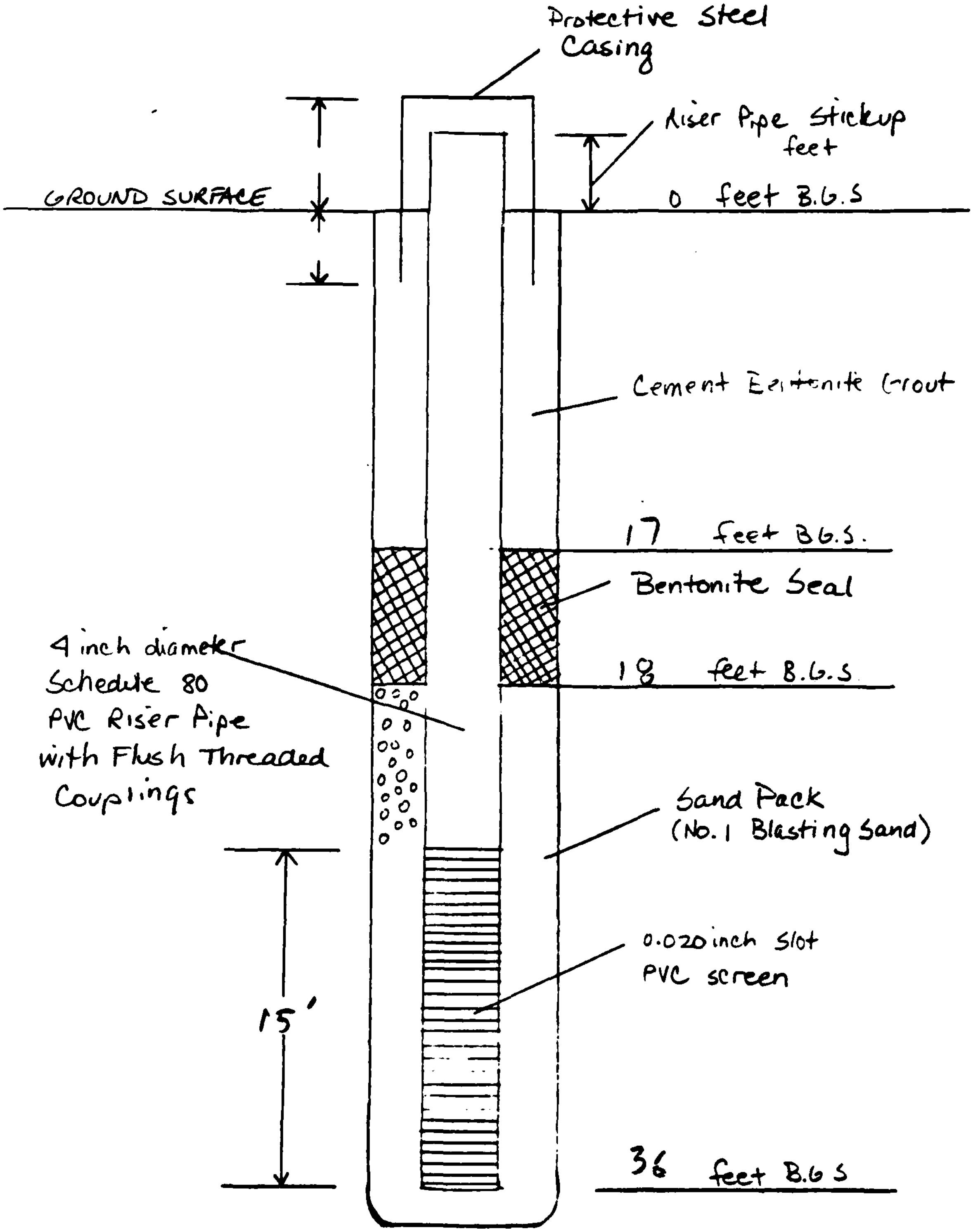
* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 2 OF 2

WESTON

BY ____________ DATE ____________ DIV ____________ SHEET ____________ OF ______
CHKD BY ________ DATE ____________ DEPT ____________ W.O. NO. ____________
PROJECT ____
SUBJECT ____



Well Construction Log McGuire AFB

Well Number MW 16

WESTON

DRILLING LOG

WELL NUMBER: MW-17
OWNER: USAF
LOCATION: SITE-4 BOMARC
ADDRESS: Mc Guire AFB
TOTAL DEPTH: 40'
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/19/83
DRILLER: TS
HELPER: AH
LOG BY: F.B. / BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
0		1	SS	11/10 9	0-1.5 Yellowish brown SAND, fine to coarse, little gravel, trace silt, dry	0
5		2	SS	16/27 30	5-6.5 Brownish yellow SAND, fine to medium, trace silt, dry	0
10		3	SS	10/8 12	10-11.5 Brownish yellow SAND, fine, trace medium sand, trace silt, dry	0
15		4	SS	8/16 20	15-16.5 Brownish yellow SAND, fine to medium, trace course, trace silt, damp	0

* A.S.T.M. D1586

HNU measurements analyzed in laboratory

SHEET 1 OF 2

WESTON

DRILLING LOG

WELL NUMBER: MW-17
OWNER: USAF
LOCATION: SITE-4 BOMARC
ADDRESS: McGuire
TOTAL DEPTH: 40'
SURFACE ELEVATION:
WATER LEVEL:
DRILLING COMPANY: Empire
DRILLING METHOD: Auger
DATE DRILLED: 10/18/83
DRILLER: TS
HELPER: AH
LOG BY: F.B. / BWB

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)	HNU MEASUREMENT
20		5	SS	4/10 15	20-21.5 Yellow SAND, fine, some silt, dry	0
25		6	SS	10/14 14	25-26.5 Yellow SAND, fine to coarse, wet	0
30		7	SS	4/8 14	30-31.5 Yellow SAND, fine to medium SAND trace silt, saturated; Black PEAT	0
35		8	SS	5/4 5	35-36.5 Black silty SAND, fine saturated	0
40					40' sand heaving in auger - no sample ~~End of boring 40~~'	

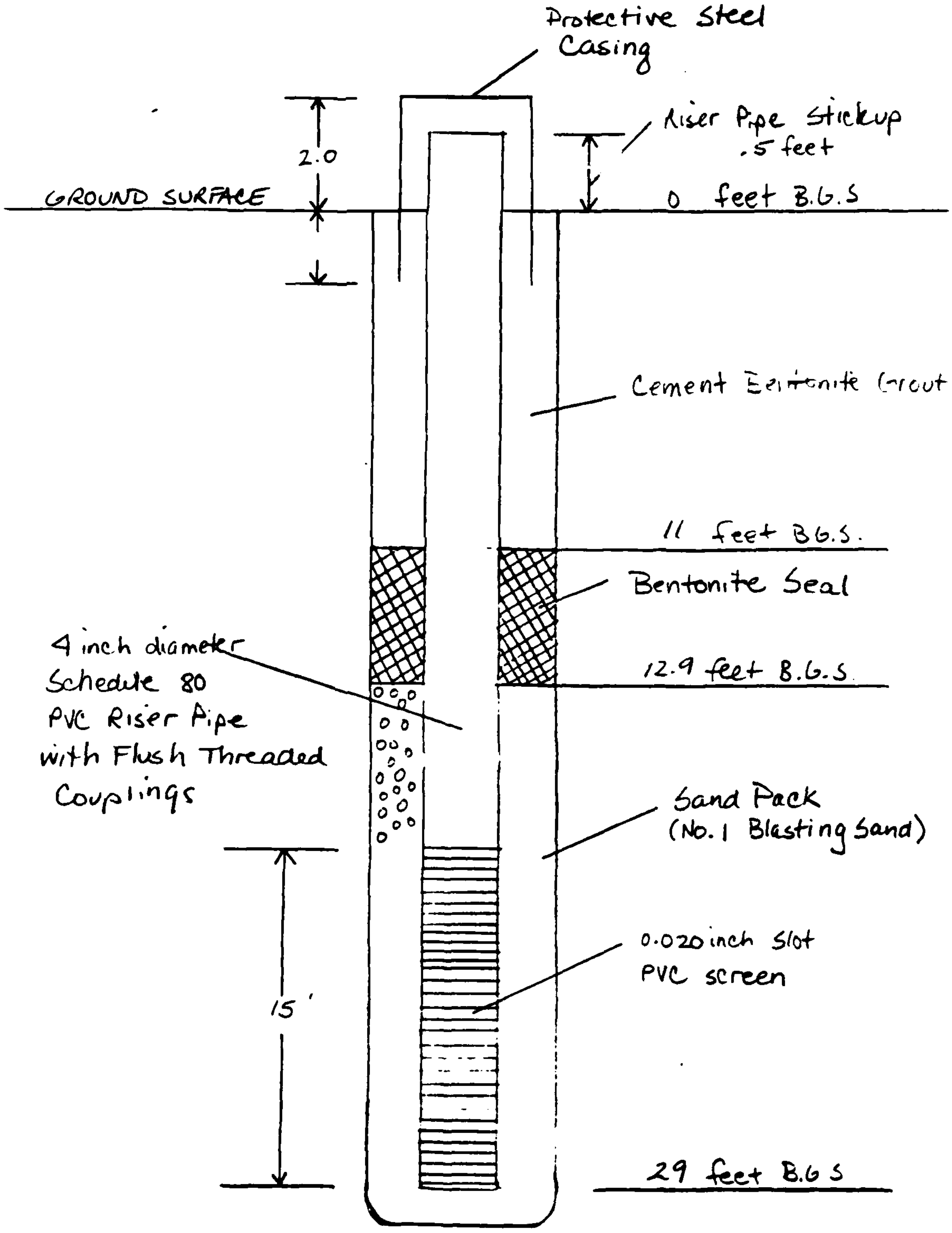
* A.S.T.M. D1586

HNU measurements analyized in laboratory

SHEET 2 OF 2

WESTON

BY ______ DATE ______ DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT ______
SUBJECT ______



Well Construction Log McGuire AFB
Well Number MW17

RFW 228 5-91

APPENDIX E

Sampling and Quality Assurance Plans

APPENDIX E

SAMPLING AND QA/QC PLANS

E-1.1 MONITORING WELL PURGING

All groundwater sampling was accomplished after the installed monitoring wells were properly developed and had stabilized for a period of at least two weeks. Prior to collecting samples, each well was purged by pumping a minimum of three volumes of standing water in the well using a Johnson-Keck submersible pump.[1] This ensured that a representative sample of the aquifer was collected during the sampling process. The field procedures used for monitoring well purging included the following guidelines:

1. Prior to placing any equipment into the well, the equipment was scrubbed with Alconox (detergent) and water solution and rinsed with distilled water.
2. Before purging, the depth to water from the reference measuring point on the top of the well casing was measured and recorded.
3. The volume of water to be purged based on the amount of standing water in the well casing was calculated.
4. The well was purged by pumping, removing at least three times the calculated volume of standing water in the well casing.
5. The pump was disconnected and removed from the well. The equipment was decontaminated by scrubbing with Alconox and flushing with deionized water.
6. The protective security caps were locked.

E-1.2 MONITOR WELL SAMPLE COLLECTION

Groundwater sampling was directed toward the detection of:

1. Total Organic Carbon (TOC)
2. Total Organic Halogen (TOX)
3. Cyanide
4. Phenols
5. Oil and Grease
6. Safe Drinking Water Act Trace Metals

APPENDIX D

Boring Logs and Well Completion Summaries

5. Nitrate samples, due to a 24-hour holding time requirement, were transported in daily batches to Weston's laboratory in West Chester, Pennsylvania. The remaining samples were transported to the same location, but in larger batches.

E-1.3 SOIL SAMPLING

All soil sampling accomplished using a drill rig employed the Standard Penetration Test (ASTM Method 1586) using a steel split-spoon sampler. Prior to taking each sample, the following procedures were followed:

1. The split-spoon sampler was washed thoroughly with an Alconox and water solution, and rinsed in tap water from the Base-approved source for drilling.

2. After assembly of the sampler, the sampler was lowered into the boring and the sample taken by the Standard Penetration Test Method.

3. Upon recovery of the sampler the spoon was split and the sample examined for soil characteristics.

4. The sample was then cleaned of any smeared sample around the outside of the sampler, and the cleaned, representative sample was put in a marked and labelled 1 liter clear glass sampling jar with a screw cap.

5. Samples for analysis of Oil and Grease, Pesticides or PCB were stored for analysis in washed and baked sample jars of amber glass, equipped with a washed aluminum foil inner seal.

All soil sampling not accomplished using a drill rig was done using a Teflon scoop, or a PVC-lined coring device. Care was taken to ensure that the sample taken for analysis was as undisturbed as possible, in order that any contaminants present would not be winnowed out of the sample (in a subaqueous site). As above, only specially prepared sample jars were used for taking and storing samples for pending analyses.

Soil samples at McGuire AFB were taken for analyses of:

1. Oil and Grease

2. Polychlorinated biphenyls (PCB)

3. Safe Drinking Water Act pesticides.

Note 1--The Johnson-Keck Model SP-81 Sampling Pump is a 1.5-inch diameter, all stainless steel, archimedes-screw impellor submersible pump capable of a steady discharge of about 1 gpm.

E -2.1 QUALITY ASSURANCE PLAN

WESTON Analytical Services enforces a rigid QA/QC program toward maintenance of validity and reliability of all analytical data. The Laboratory QA/QC Manual (Table of Contents thereof is Attachment No. 1 to this appendix) outlines the specifics of the QA/QC plan. This plan is patterned after the EPA Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA-600/4-79-019, March 1979), augmented by general applicable experience and interaction with the QA/QC plan of the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). All methods and procedures followed by WESTOn are either USEPA or ASTM-approved. Any variations from such procedures, regardless of cause, are documented by the responsible analyst(s) and are documentable, and, literature-traceable. A general review of this QA/QC plan is in the following paragraphs.

Although specific QA/QC measures for each method are designated in WESTON's Laboratory Quality Assurance Manual, the general QA/QC program normally includes:

- EPA-acceptable sample preparation and analytical methods.
- Instrument calibration via use of Standard Analytical Reference Materials (SARMS).
- Regular equipment maintenance and servicing.
- Use of SARMS and QA/QC samples (spikes, laboratory blanks, replicates, and splits) to ascertain overall precision.
- Statistical evaluation of data to delineate acceptable limits.
- Documentation of system/operator performance.
- Suitable chain-of-custody procedures.
- Maintenance and archiving of all records, charts, and logs generated in the above.
- Proper reporting.

Acceptable analyses at WESTON's Analytical Laboratory Services include, but are not limited to, the above.

In general, WESTON's QA/QC sequence follows the following diagram (Figure E-1). Documentation (as available from instrument recordings and technicians' notebooks) is sufficient to validate each step in the sequence.

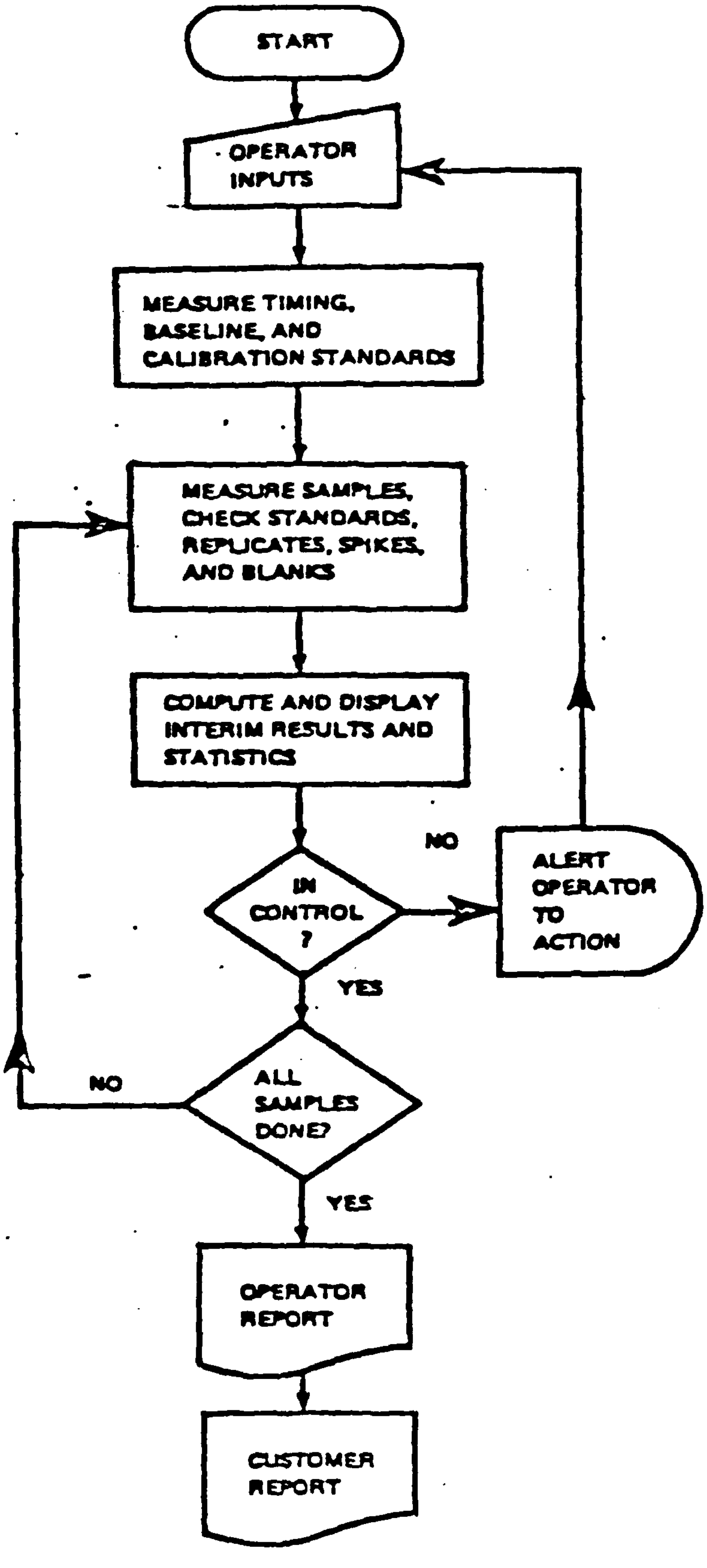


Figure E-1 Flow Chart of the Sequence of Events during a Controlled Series of Laboratory Measurements.

E.2.2 CONTAINER PREPARATION

Another consideration in this, or any, analytical project is that of sample container preparation. Accordingly, all appropriate sample bottles shall be cleaned in a manner mandated by the U.S. EPA to insure maximal cleanliness (and minimal contamination) before the containers go to the field. Sufficient bottles to accommodate both laboratory and field blank requirements will be prepared in a single batch mode for each sampling requirement.

E.2.3 VERIFICATION/VALIDATION

In the laboratory, the analytical scheme begins with initial verification, which is comprised of:

- Lab Blanks - To insure that no background level of specific analytes is introduced by laboratory procedures.
- Standard Analytical Reference Materials (SARMS) - To determine the accuracy and precision of procedures.
- Spikes - To determine the percent recovery of analyte(s).

If the laboratory QA/QC program is extended to the field, it includes a fifth item:

- Field Blanks - To provide a check on contamination of containers and/or preservatives and to establish "practical" detection limits.

WESTON has used all of the above in this project. All data resulting from these verification media have been archived for future reference, retrieval, or processing.

E.2.4 DATA HANDLING - LABORATORY

Use of any analytical data should be preceded by an assessment of its quality. The assessment should be based on accuracy, precision, completeness, representativeness, and comparability. These criteria are, in turn, assessed as follows:

- Accuracy - Is it acceptable for the planned use? QA/QC shall measure the accuracy of all data.
- Precision - Is it acceptable for the planned use? QA/QC shall reflect the reproducibility of the measurements.
- Completeness - Are the data sufficient for the planned use? QA/QC shall identify the quantity of data needed to match the goals.
- Representativeness -Do the data accurately reflect actual site conditions, sampling procedures, and analytical method? QA/QC shall ensure this.
- Comparability - Is the report self-consistent in format, units, and standardization of methods used to generate it? QA/QC shall ensure this.

Additionally, statistical methods outlined in the QA/QC program have been applicable to data evaluation.

The Laboratory Supervisor and the Laboratory QA/QC Officer have been responsible for the evaluation of the above criteria and for enforcement of analytical protocols that will necessarily lead to acceptable data quality. The signature of the Supervisor and QA/QC Officer accompany each laboratory analytical report and serve to ensure the overall validity of the reported data.

E.2.5 SAMPLE PLAN/LOG

Normal protocol demands client-and /or site-specific logging of all sample batches delivered to WESTON. Basic information -- such as client name, address, etc.; client phone number; reporting/invoicing instructions; site descriptions; and parameter-specifications and total requirements -- is initiated here. Additionally, sample storage/disposal instructions as well as turnaround requirements and sample collection requirements are addressed at this point.

The appropriate number of method blanks is also logged at this point, and in-house chain-of-custody documentation is initiated here.

E.2.6 SAMPLE RESULTS

WESTON's analytical protocols generally require five-point calibration curve plus a reagent blank s the basis for quantification analytes from a linear calibration curve. (A three-point plus blank curve vs. the original five point one is acceptable if it falls within the QA/QC requirements of ± 3 standard deviation of the original curve.) Linear regression analysis is then performed. Method- and detection limit-specific data are accessed for quantitation and report-writing from each such data set. For reporting accuracy, the algorithm

$$\frac{\begin{matrix}\text{Linear-Regressed} \\ \text{Raw Concentration} \\ \text{from Calibration Curve}\end{matrix} \quad \begin{matrix}\text{Solid Sample} \\ \text{Extract Volume} \\ \text{If Solid}\end{matrix} \quad \begin{matrix}\text{Concentration} \\ \text{or} \\ \text{Dilution Factor}\end{matrix}}{\begin{matrix}\text{Solid Sample} \\ \text{Mass If Solid}\end{matrix} \quad \begin{matrix}\text{Fraction} \\ \text{Solids If Solid}\end{matrix}} = \begin{matrix}\text{Final} \\ \text{Concen-} \\ \text{tration}\end{matrix}$$

is used for all quantitations. (All such algorithm input data are archived for long-term storage.) Detection limits for solids are generated on a per-sample basis and calculated by replacing "LINEAR-REGRESSED RAW CONCENTRATION FROM CALIBRATION CURVE" with "DETECTION LIMIT OF ANALYTE IN LIQUID MATRIX" in the above equation.

E.2.7 CHAIN-OF-CUSTODY

Since they document the history of samples, chain-of-custody procedures are a crucial part of a sampling/analysis program. Chain-of-custody documentation enables identification and tracking of a sample from collection to analysis to reporting.

WESTON's chain-of-custody program necessitates the use of EPA-approved sample labels, secure custody, and attendant recordkeeping. Depending on the client's requirements, WESTON also offers container sealing during unattended transportation of samples.

In essence, WESTON considers a sample in custody if it: is in a WESTON employee's physical possession; it is in view of that WESTON employee; is secured by that WESTON employee to prevent tampering; or is secured by that WESTON employee in an area that is restricted to authorized personnel.

Each time a sample is relinquished from one analyst to another or from one major location to another, WESTON's analytical personnel are required to make appropriate entries. Personnel-specific initials are used as identifiers of analysts, as are location codes for various locations (refrigerators, extraction areas, analytical areas, etc.) within the laboratory. Each transaction for each sample is accompanied by a specific reason for transfer. Chain-of-custody documentation is given in Appendix G.

E.2.8 QA/QC OFFICER

Toward maintenance of a rigid, credible QA/QC regimen, WESTON Analytical Services maintains a full-time, in-house QA/QC officer who retains independent authority to declare out-of-control situations, thereby precluding reporting of unacceptable data. The QA/QC officer has been available, as needed, on the project.

APPENDIX F

CHAIN OF CUSTODY DOCUMENTATION

CHAIN OF CUSTODY

1. RFW # 9114 THROUGH 9120

2. No. of bottles on this sheet:

40 ml	
100 ml	
250 ml	
500 ml	
1000 ml	7
Total	7

3. Sampled by: BENYISH/JOHNSON

4. Samples preserved and prepared according to S.O.P.: ____ Initials

Relinquished	Received by	Time	Date	Reason for Change of Custody
Bruce Bonyish	Vicki Dondero	2:40	10/27	Analysis

COMMENTS:

CLIENT McGuire AFB

PRIORITY/HAZARD

WO#/PO# 0628-05-20-12

SUBMITTED BY

DATE RECEIVED 10/27/83

MISC. 001 563

RFW#	SAMPLE DESCRIPTION	DATE COLLECTED	PA	PA	PA	PA	PA	PA	PA
1 9114	Site 6 TB-3/S-2 1.5-3.0'	10/18	PCB	O/G					
2 9115	Site 6 TB-4/S-2A 2.0-3.0'	"							
3 9116	Site 6 TB-5/S-2A 2.0-3.0'	10/19							
4 9117	Site 6 TB-6/S-2	10/20							
5 9118	Site 6 TB-7/S-2A	10/19							
6 9119	Site 5 TB-1/S-3	"	Pest						
7 9120	Site 5 TB-2/S	"							
8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									
19.									
20.									
21.									
22.									
23.									
24.									
25.									

CHAIN OF CUSTODY

1. RFW # 10114 THROUGH 1037

2. No. of bottles on this sheet:

40 ml	
100 ml	2
250 ml	82
500 ml	14
1000 ml	6
Total	104

3. Sampled by: BENYISH/ALTHOUSE

4. Samples preserved and prepared according to S.O.P.: BWB
Initials

Relinquished	Received by	Time	Date	Reason for Change of Custody
		4:20PM	12/2/83	ANALYSIS

COMMENTS: SEE ATTACHED LOG-IN SHEET

WO#/~~PO#~~ 0628 05 20 SUBMITTED BY Ken Altthouse

Oil + grease by IR

DATE RECEIVED 12/2/83 MISC. CC3 603

NOTE: see attached for revisions

RFW#	SAMPLE DESCRIPTION		DATE COLLECTED	PA	PA	PA	PA	PA	PA	PA
									METALS	
10114	MC GUIRE WELL# 1		11/29/83	TOC	Tox	CN⁻	Phenol	oil & Grease	Cu Cd Ni As	CR Pb
10115	WELL# 2			✓	✓	✓	✓	✓		
10116	WELL #3	LF 4,5,6		✓	✓	✓	✓	✓	✓	✓
10117	WELL# 4		11/29	✓	✓	✓	✓	✓	✓	✓
10118	WELL# 5			✓	✓	✓	✓	✓	✓	✓
10119	WELL #5D		↓	✓	✓	✓	✓	✓	✓	✓
10120	" #6	LF2	11/30	✓	✓	✓	✓	✓	✓	✓
10121	" #7			✓	✓	✓	✓	✓	✓	✓
10122	" #8		↓	✓	✓	✓	✓	✓	✓	✓
10123	" #9	LF3	11/29	✓	✓	✓	✓	✓	✓	✓
10124	" #10		11/30	✓	✓	✓	✓	✓	✓	✓
10125	" #11		11/29	✓	✓	✓	✓	✓	✓	✓
10126	" #12	[illegible]	11/29	✓	✓	NO	NO	Cd	Cr Pb	Ni
10127	#13		"	✓	✓	NO	NO	✓	" "	"
10128	" 14	Triangle	12/1/83	✓	✓	oil and grease				
29	" 15			✓	✓	↓				
30	" 16	Missile		✓	✓	oil Grease		Nitrate		hydrazine
31	" 17	Site	↓	✓	✓	↓		↓		↓
32	Gulley 1 H_2O WASH Area		12/1/83	Pesticides:						
33	" 1 Soil			① chlorinated hydrocarbons						
34	" 2 H_2O			② organo-phosphate						
35	" 2 Soil			(GC)						
36	" 3 H_2O									
37	" 3 Soil		↓	↓						
[illegible]	Blank 004		647-0010							

APPENDIX G

Standard Laboratory Analytical Protocols

ORGANIC CARBON, TOTAL

Method 415.1 (Combustion or Oxidation)

STORET NO. Total 00680
Dissolved 00681

1. Scope and Application
   1.1 This method includes the measurement of organic carbon in drinking, surface and saline waters, domestic and industrial wastes. Exclusions are noted under Definitions and Interferences.
   1.2 The method is most applicable to measurement of organic carbon above 1 mg/1.
2. Summary of Method
   2.1 Organic carbon in a sample is converted to carbon dioxide (CO_2) by catalytic combustion or wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 is directly proportional to the concentration of carbonaceous material in the sample.
3. Definitions
   3.1 The carbonaceous analyzer measures all of the carbon in a sample. Because of various properties of carbon-containing compounds in liquid samples, preliminary treatment of the sample prior to analysis dictates the definition of the carbon as it is measured. Forms of carbon that are measured by the method are:
      A) soluble, nonvolatile organic carbon; for instance, natural sugars.
      B) soluble, volatile organic carbon; for instance, mercaptans.
      C) insoluble, partially volatile carbon; for instance, oils.
      D) insoluble, particulate carbonaceous materials, for instance; cellulose fibers.
      E) soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter; for instance, oily matter adsorbed on silt particles.
   3.2 The final usefulness of the carbon measurement is in assessing the potential oxygen demanding load of organic material on a receiving stream. This statement applies whether the carbon measurement is made on a sewage plant effluent, industrial waste, or on water taken directly from the stream. In this light, carbonate and bicarbonate carbon are not a part of the oxygen demand in the stream and therefore should be discounted in the final calculation or removed prior to analysis. The manner of preliminary treatment of the sample and instrument settings defines the types of carbon which are measured. Instrument manufacturer's instructions should be followed.

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4. Sample Handling and Preservation

4.1 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples.

NOTE 1: A brief study performed in the EPA Laboratory indicated that distilled water stored in new, one quart cubitainers did not show any increase in organic carbon after two weeks exposure.

4.2 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the lapse of time between collection of samples and start of analysis should be kept to a minimum. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

4.3 In instances where analysis cannot be performed within two hours (2 hours) from time of sampling, the sample is acidified ($pH \leq 2$) with HCl or H_2SO_4.

5. Interferences

5.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

5.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particles which may be included in the sample.

6. Apparatus

6.1 Apparatus for blending or homogenizing samples: Generally, a Waring-type blender is satisfactory.

6.2 Apparatus for total and dissolved organic carbon:

6.2.1 A number of companies manufacture systems for measuring carbonaceous material in liquid samples. Considerations should be made as to the types of samples to be analyzed, the expected concentration range, and forms of carbon to be measured.

6.2.2 No specific analyzer is recommended as superior.

7. Reagents

7.1 Distilled water used in preparation of standards and for dilution of samples should be ultra pure to reduce the carbon concentration of the blank. Carbon dioxide-free, double distilled water is recommended. Ion exchanged waters are not recommended because of the possibilities of contamination with organic materials from the resins.

7.2 Potassium hydrogen phthalate, stock solution, 1000 mg carbon/liter: Dissolve 0.2128 g of potassium hydrogen phthalate (Primary Standard Grade) in distilled water and dilute to 100.0 ml.

NOTE 2: Sodium oxalate and acetic acid are not recommended as stock solutions.

7.3 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with distilled water.

7.4 Carbonate-bicarbonate, stock solution, 1000 mg carbon/liter: Weigh 0.3500 g of sodium bicarbonate and 0.4418 g of sodium carbonate and transfer both to the same 100 ml volumetric flask. Dissolve with distilled water.

7.5 Carbonate-bicarbonate, standard solution: Prepare a series of standards similar to step 7.3.

NOTE 3: This standard is not required by some instruments.

7.6 Blank solution: Use the same distilled water (or similar quality water) used for the preparation of the standard solutions.

8. Procedure

8.1 Follow instrument manufacturer's instructions for calibration, procedure, and calculations.

8.2 For calibration of the instrument, it is recommended that a series of standards encompassing the expected concentration range of the samples be used.

9. Precision and Accuracy

9.1 Twenty-eight analysts in twenty-one laboratories analyzed distilled water solutions containing exact increments of oxidizable organic compounds, with the following result:

Increment as TOC mg/liter	Precision as Standard Deviation TOC, mg/liter	Accuracy as	
		Bias, %	Bias, mg/liter
4.9	3.93	+15.27	+0.75
107	8.32	+ 1.01	+1.08

(FWPCA Method Study 3, Demand Analyses)

Bibliography

1. Annual Book of ASTM Standards, Part 31, "Water", Standard D 2574–79, p 469 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 53 Method 505, (1975).

OIL AND GREASE, TOTAL RECOVERABLE

Method 413.2 (Spectrophotometric, Infrared)

STORET NO. 00560

1. Scope and Application
   1.1 This method includes the measurement of fluorocarbon-113 extractable matter from surface and saline waters, industrial and domestic wastes. It is applicable to the determination of hydrocarbons, vegetable oils, animal fats, waxes, soaps, greases and related matter.
   1.2 The method is applicable to measurement of most light petroleum fuels, although loss of about half of any gasoline present during the extraction manipulations can be expected.
   1.3 The method covers the range from 0.2 to 1000 mg/l of extractable material.
   1.4 While this method can be used to obtain an estimate of the oil and grease that would be measured gravimetrically, in many cases the estimate more accurately describes the parameter, as it will measure volatiles more effectively and is not susceptible to interferences such as extractable sulfur. It can be used with the Petroleum Hydrocarbon procedure to obtain an oil and grease value and a petroleum hydrocarbon value on the same sample.
2. Summary of Method
   2.1 The sample is acidified to a low pH (< 2) and extracted with fluorocarbon-113. The oil and grease is determined by comparison of the infrared absorbance of the sample extract with standards.
3. Definitions
   3.1 The definition of oil and grease is based on the procedure used. The source of the oil and/or grease, and the presence of extractable non-oily matter will influence the material measured and interpretation of results.
4. Sampling and Storage
   4.1 A representative sample of 1 liter volume should be collected in a glass bottle. If analysis is to be delayed for more than a few hours, the sample is preserved by the addition of 5 ml HCl (6.1) at the time of collection and refrigerated at 4°C.
   4.2 Because losses of grease will occur on sampling equipment, the collection of a composite sample is impractical. Individual portions collected at prescribed time intervals must be analyzed separately to obtain the average concentration over an extended period.
5. Apparatus
   5.1 Separatory funnel, 2000 ml, with Teflon stopcock.
   5.2 Infrared spectrophotometer, scanning. Non-scanning instruments may also be used but can be subject to positive interferences in complex chemical wastewaters.
   5.3 Cells, 10 mm, 50 mm, and 100 mm path length, sodium chloride or infrared grade glass.
   5.4 Filter paper, Whatman No. 40, 11 cm.

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6. Reagents

6.1 Hydrochloric acid, 1:1. Mix equal volumes of conc. HCl and distilled water.

6.2 Fluorocarbon-113, (1,1,2-trichloro-1,2,2-trifluoroethane), b. p. 48°C.

6.3 Sodium sulfate, anhydrous crystal.

6.4 Calibration mixtures:

6.4.1 Reference oil: Pipet 15.0 ml n-hexadecane, 15.0 ml isooctane, and 10.0 ml chlorobenzene into a 50 ml glass stoppered bottle. Maintain the integrity of the mixture by keeping stoppered except when withdrawing aliquots.

6.4.2 Stock standard: Pipet 1.0 ml reference oil (6.4.1) into a tared 200 ml volumetric flask and immediately stopper. Weigh and dilute to volume with fluorocarbon-113.

6.4.3 Working standards: Pipet appropriate volumes of stock standard (6.4.2) into 100 ml volumetric flasks according to the cell pathlength to be used. Dilute to volume with fluorocarbon-113. Calculate concentration of standards from the stock standard.

7. Procedure

7.1 Mark the sample bottle at the water meniscus for later determination of sample volume. If the sample was not acidified at time of collection, add 5 ml hydrochloric acid (6.1) to the sample bottle. After mixing the sample, check the pH by touching pH-sensitive paper to the cap to insure that the pH is 2 or lower. Add more acid if necessary.

7.2 Pour the sample into a separatory funnel.

7.3 Add 30 ml fluorocarbon-113 (6.2) to the sample bottle and rotate the bottle to rinse the sides. Transfer the solvent into the separatory funnel. Extract by shaking vigorously for 2 minutes. Allow the layers to separate.

7.4 Filter the solvent layer into a 100 ml volumetric flask through a funnel containing solvent-moistened filter paper.

NOTE: An emulsion that fails to dissipate can be broken by pouring about 1 g sodium sulfate (6.3) into the filter paper cone and slowly draining the emulsion through the salt. Additional 1 g portions can be added to the cone as required.

7.5 Repeat (7.3 and 7.4) twice more with 30 ml portions of fresh solvent, combining all solvent in the volumetric flask.

7.6 Rinse the tip of the separatory funnel, filter paper, and the funnel with a total of 5–10 ml fluorocarbon-113 and collect the rinsings in the flask. Dilute the extract to 100 ml, and stopper the flask.

7.7 Select appropriate working standards and cell pathlength according to the following table of approximate working ranges:

Pathlength	Range
10 mm	2–40 mg
50 mm	0.4–8 mg
100 mm	0.1–4 mg

7.8 Scan standards and samples from 3200 cm^{-1} to 2700 cm^{-1} with fluorocarbon-113 in the reference beam and record the results on absorbance paper. The absorbances of samples and standards are measured by constructing a straight baseline over the range of the scan and measuring the absorbance of the peak maximum at 2930 cm^{-1} and subtracting the baseline absorbance at that point. For an example of a typical oil spectrum and baseline construction, see Gruenfeld(3). Non-scanning instruments should be operated according to manufacturer's instructions, although calibration must be performed using the standards described above (6.4). If the absorbance exceeds 0.8 for a sample, select a shorter pathlength or dilute as required.

7.9 Use a calibration plot of absorbance vs. mg oil prepared from the standards to determine the mg oil in the sample solution.

8. Calculation

8.1 mg/1 total oil and grease $= \frac{R \times D}{V}$

where:

R = oil in solution, determined from calibration plot, in milligrams.
D = extract dilution factor, if used.
V = volume of sample, determined by refilling sample bottle to calibration line and correcting for acid addition if necessary, in liters.

9. Precision and Accuracy

9.1 The two oil and grease methods in this manual were tested by a single laboratory (EMSL) on sewage. This method determined the oil and grease level in the sewage to be 1[illegible].5 mg/1. When 1 liter portions of the sewage were dosed with 14.0 mg of a mixture of #2 fuel oil and Wesson oil, the recovery was 99% with a standard deviation of ±1.4 mg/l.

Bibliography

1. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p 5[illegible], Method 502B, (1975).
2. American Petroleum Institute, "Manual on Disposal of Refinery Wastes", Vol. IV, Method 733-58 (1958).
3. Gruenfeld, M., "Extraction of Dispersed Oils from Water for Quantitative Analysis by Infrared Spectroscopy", Environ. Sci. Technol. 7, 636 (1973).

PHENOLICS, TOTAL RECOVERABLE

Method 420.1 (Spectrophotometric, Manual 4-AAP with Distillation)

STORET NO. 3273

1. Scope and Application
   - 1.1 This method is applicable to the analysis of drinking, surface and saline waters, domesti and industrial wastes.
   - 1.2 The method is capable of measuring phenolic materials at the 5 ug/l level when th colored end product is extracted and concentrated in a solvent phase using phenol as standard.
   - 1.3 The method is capable of measuring phenolic materials that contain more than 50 ug/ in the aqueous phase (without solvent extraction) using phenol as a standard.
   - 1.4 It is not possible to use this method to differentiate between different kinds of phenols.
2. Summary of Method
   - 2.1 Phenolic materials react with 4-aminoantipyrine in the presence of potassiu ferricyanide at a pH of 10 to form a stable reddish-brown colored antipyrine dye. Th amount of color produced is a function of the concentration of phenolic material.
3. Comments
   - 3.1 For most samples a preliminary distillation is required to remove interfering materials.
   - 3.2 Color response of phenolic materials with 4-amino antipyrine is not the same for a compounds. Because phenolic type wastes usually contain a variety of phenols, it is no possible to duplicate a mixture of phenols to be used as a standard. For this reason phen has been selected as a standard and any color produced by the reaction of other phenoli compounds is reported as phenol. This value will represent the minimum concentratio of phenolic compounds present in the sample.
4. Sample Handling and Preservation
   - 4.1 Biological degradation is inhibited by the addition of 1 g/l of copper sulfate to th sample and acidification to a pH of less than 4 with phosphoric acid. The sample shoul be kept at 4°C and analyzed within 24 hours after collection.
5. Interference
   - 5.1 Interferences from sulfur compounds are eliminated by acidifying the sample to a pH o less than 4 with H_3PO_4 and aerating briefly by stirring and adding $CuSO_4$.
   - 5.2 Oxidizing agents such as chlorine, detected by the liberation of iodine upon acidificatio in the presence of potassium iodide, are removed immediately after sampling by th addition of an excess of ferrous ammonium sulfate (~~6.5~~ 7.5). If chlorine is not removed, th phenolic compounds may be partially oxidized and the results may be low.

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6. Apparatus

6.1 Distillation apparatus, all glass consisting of a 1 liter pyrex distilling apparatus with Graham condenser.

6.2 pH meter.

6.3 Spectrophotometer, for use at 460 or 510 nm.

6.4 Funnels.

6.5 Filter paper.

6.6 Membrane filters.

6.7 Separatory funnels, 500 or 1,000 ml.

6.8 Nessler tubes, short or long form.

7. Reagents

7.1 Phosphoric acid solution, 1 + 9: Dilute 10 ml of 85% H_3PO_4 to 100 ml with distilled water.

7.2 Copper sulfate solution: Dissolve 100 g $CuSO_4 \cdot 5H_2O$ in distilled water and dilute to 1 liter.

7.3 Buffer solution: Dissolve 16.9 g NH_4Cl in 143 ml conc. NH_4OH and dilute to 250 ml with distilled water. Two ml should adjust 100 ml of distillate to pH 10.

7.4 Aminoantipyrine solution: Dissolve 2 g of 4AAP in distilled water and dilute to 100 ml.

7.5 Potassium ferricyanide solution: Dissolve 8 g of $K_3Fe(CN)_6$ in distilled water and dilute to 100 ml.

7.6 Stock phenol solution: Dissolve ~~1.0 g~~ 1.00g phenol in freshly boiled and cooled distilled water and dilute to 1 liter. 1 ml = 1 mg phenol.

7.7 Working solution A: Dilute 10 ml stock phenol solution to 1 liter with distilled water. 1 ml = 10 ug phenol.

7.8 Working solution B: Dilute 100 ml of working solution A to 1000 ml with distilled water. 1 ml = 1 ug phenol.

7.9 Chloroform

8. Procedure

8.1 Distillation

8.1.1 Measure 500 ml sample into a beaker. Lower the pH to approximately 4 with 1 + 9 H_3PO_4 (7.1), add 5 ml $CuSO_4$ solution (7.2) and transfer to the distillation apparatus. Omit adding H_3PO_4 and $CuSO_4$ if sample was preserved as described in 4.1.

8.1.2 Distill 450 ml of sample, stop the distillation, and when boiling ceases add 50 ml of warm distilled water to the flask and resume distillation until 500 ml have been collected.

8.1.3 If the distillate is turbid, filter through a prewashed membrane filter.

8.2 Direct photometric method

8.2.1 Using working solution A (7.7), prepare the following standards in 100 ml volumetric flasks.

ml of working solution A	Conc. ug/l
0	0.0
0.5	50.0
1.0	100.0
2.0	200.0
5.0	500.0
8.0	800.0
10.0	1000.0

8.2.2 To 100 ml of distillate or an aliquot diluted to 100 ml and/or standards, add 2 ml of buffer solution (7.3) and mix. The pH of the sample and standards should be 10 ±0.2.

8.2.3 Add 2.0 ml aminoantipyrine solution (7.4) and mix.

8.2.4 Add 2.0 ml potassium ferricyanide solution (7.5) and mix.

8.2.5 After 15 minutes read absorbance at 510 nm.

8.3 Chloroform extraction method

8.3.1 Using working solution B (7.8), prepare the following standards. Standards may be prepared by pipetting the required volumes into the separatory funnels and diluting to 500 ml with distilled water.

ml of working solution B	Conc. ug/l
0.0	0.0
3.0	6.0
5.0	10.0
10.0	20.0
20.0	40.0
25.0	50.0

8.3.2 Place 500 ml of distillate or an aliquot diluted to 500 ml in a separatory funnel. The sample should not contain more than 25 ug phenol.

8.3.3 To sample and standards add 10 ml of buffer solution (7.3) and mix. The pH should be 10 ±0.2.

8.3.4 Add 3.0 ml aminoantipyrine solution (7.4) and mix.

8.3.5 Add 3.0 ml potassium ferricyanide solution (7.5) and mix.

8.3.6 After three minutes, extract with 25 ml of chloroform (7.9). Shake the separatory funnel at least 10 times, let $CHCl_3$ settle, shake again 10 times and let chloroform settle again.

8.3.7 Filter chloroform extracts through filter paper. Do not add more chloroform.

8.3.8 Read the absorbance of the samples and standards against the blank at 460 nm.

9. Calculation

9.1 Prepare a standard curve by plotting the absorbance value of standards versus the corresponding phenol concentrations.

9.2 Obtain concentration value of sample directly from standard curve.

10. Precision and Accuracy

10.1 Using the extraction procedure for concentration of color, six laboratories analyzed samples at concentrations of 9.6, 48.3, and 93.5 ug/1. Standard deviations were ±0.99, ±3.1 and ±4.2 ug/1, respectively.

10.2 Using the direct photometric procedure, six laboratories analyzed samples at concentrations of 4.7, 48.2 and 97.0 mg/1. Standard deviations were ±0.18, ±0.48 and ±1.58 mg/1, respectively.

Bibliography

1. Annual Book of ASTM Standards, Part 31, "Water", Standard D1783-70, p553 (1976).
2. Standard Methods for the Examination of Water and Wastewater, 14th Edition, p574-581, Method 510 through 510C, (1975).

Appendix IV.—Inductively Coupled Plasma Optical Emission Spectrometric Method (ICP) for Trace Element Analysis of Water and Wastes

Inductively Coupled Plasma (ICP) Optical Emission Spectrometric Method for Trace Element Analysis of Water and Wastes

Interim

U.S. Environmental Protection Agency,
Environmental Monitoring and Support
Laboratory, Cincinnati, Ohio 45268

October 1979.

Foreword

This method has been prepared by the staff of the Environmental Monitoring and Support Laboratory—Cincinnati, with the cooperation of the EPA-ICP Users Group. Their cooperation and support is gratefully acknowledged.

This method represents the current state-of-the-art, but as time progresses, improvements are anticipated. Users are encouraged to identify problems and assist in updating the method by contacting the Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.

Inductively Coupled Plasma (ICP) Optical Emission Spectrometric Method for Trace Element Analysis of Water and Wastes

1. Scope and Application.

1.1 This method may be used for the determination of dissolved, suspended, or total elements in surface water, drinking water, and domestic and industrial wastewaters.

1.2 Dissolved elements are determined in filtered and acidified samples. Appropriate steps must be taken to ensure that potential interference are taken into account when dissolved solids exceed 1500 mg/l. (See 4.2)

1.3 Total elements are determined after appropriate digestion procedures are performed. Since digestion techniques increase the dissolved solids content of the samples, appropriate steps *must* be taken to correct for potential interference effects.

1.4 Table 1 lists elements for which this method applies along with recommended wavelengths and typical estimated instrumental detection limits. Actual working detection limits are sample dependent and as the sample matrix varies, these concentrations may also vary. In time, other elements may be added as more information becomes available.

1.5 Because of the differences between various makes and models of satisfactory instruments, no detailed instrumental operating instructions can be provided. Instead, the analyst is referred to the instructions provided by the manufacturer of the particular instrument.

Table 1—*Recommended Wavelengths* [1] and Estimated Instrumental Detection Limits

Element	Wavelength, nm	Estimated detection limit, µg/l [2]
Aluminum	308.2	45
Arsenic	193.7	53
Barium	455.5	2
Beryllium	313.0	0.3
Boron	249.8	5
Cadmium	226.5	4
Calcium	317.9	10
Chromium	267.7	7
Cobalt	228.6	7
Copper	324.7	6
Iron	259.9	7
Lead	220.3	42
Lithium	670.7	4
Magnesium	279.1	30
Manganese	257.6	2

Table 1—*Recommended Wavelengths* [1] and Estimated Instrumental Detection Limits—Continued

Element	Wavelength, nm	Estimated detection limit, µg/l [2]
Molybdenum	202.0	8
Nickel	231.6	15
Potassium	766.4	see [3]
Selenium	196.0	75
Silica (SiO_2)	288.1	27
Silver	328.0	7
Sodium	589.0	29
Strontium	407.7	0.5
Vanadium	292.4	8
Zinc	213.8	2

[1] The wavelengths listed are recommended because of their sensitivity and overall acceptance. Other wavelengths may be substituted if they can provide the needed sensitivity and are treated with the same corrective techniques for spectral interference. (See 4.1.1).

[2] The estimated instrumental detection limits as shown are taken from "Inductively Coupled Plasma-Optical Emission Spectroscopy Prominent Lines," EPA-600/4-[illegible]-017. Detection limits are sample dependent and as the sample matrix varies, these concentration values may also vary.

[3] Highly dependent on operating conditions and plasma position.

2. Summary of Method.

2.1 The method describes a technique for the simultaneous or sequential multielement determination of trace elements in solution. The basis of the method is the measurement of atomic emission by an optical spectroscopic technique. Samples are nebulized and the aerosol that is produced is transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency inductively coupled plasma (ICP). The spectra are dispersed by a grating spectrometer and the intensities of the lines are monitored by photomultiplier tubes. The photocurrents from the photomultiplier tubes are processed and controled by a computer system. A background correction technique is required to compensate for variable background contribution to the determination of trace elements. Background must be measured adjacent to analyte lines on samples during analysis. Additional interferences named in 4.1 should also be recognized and appropriate corrections made.

3. Definitions.

3.1 *Dissolved*—Those elements which will pass through a 0.45 µm membrane filter.

3.2 *Suspended*—Those elements which are retained by a 0.45 µm membrane filter.

3.3 *Total*—The concentration determined on an unfiltered sample following vigorous digestion (Section 8.3), or the sum of the dissolved plus suspended concentrations (Section 8.1 plus 8.2).

3.4 *Total recoverable*—The concentration determined on an unfiltered sample following treatment with hot, dilute mineral acid (Section 8.4)

3.5 *Instrumental detection limit*—The concentration equivalent to a signal, due to the analyte, which is equal to three times the standard deviation of a series of ten replicate measurements of a reagent blank signal at the same wavelength.

3.6 *Sensitivity*—The slope of the analytical curve, i.e. funtional relationship between emission intensity and concentration.

3.7 *Instrument check standard*—A multielement standard of known concentrations prepared by the analyst. Should be included in the analytical scheme with a frequency of 10%. (See 6.6.1.)

3.8 *Reference standard*—A solution obtained from an outside source having known, verified values. Must be used initially to verify the calibration standards and analyzed thereafter as a blind sample on a weekly frequency. (See 6.6.2.)

3.9 *Calibration standards*—A series of known standard solutions used by the analyst for calibration of the instrument (i.e., preparation of the analytical curve). (See 6.4.)

3.10 *Linear dynamic range*—The concentration range over which the analytical curve remains linear.

3.11 *Reagent blank*—A volume of deionized, distilled water containing the same acid matrix as the calibration standards carried through the entire analytical scheme. (See 6.5.2.)

3.12 *Calibration blank*—A volume of deionized, distilled water acidified with HNO$_3$ and HCl. (See 6.5.1.)

3.13 *Method of standard addition*—The standard addition technique involves the use of the unknown and the unknown plus a known amount of standard. (See 9.8.1.)

4. Interferences.

4.1 Several types of interference effects may contribute to inaccuracies in the determination of trace elements. They can be summarized as follows:

4.1.1 *Spectral interferences* can be categorized as (1) overlap of a spectral line from another element; (2) unresolved overlap of molecular band spectra; (3) background contribution from continuous or recombination phenomena; and (4) background contribution from stray light from the line emission of high concentration elements. The first of these effects can be compensated by utilizing a computer correction of the raw data, requiring measurement of the interfering element. The second effect may require selection of an alternate wavelength. The third and fourth effects can usually be compensated by a background correction adjacent to the analyte line.

4.1.2 *Physical interferences* are generally considered to be effects associated with the sample nebulization and transport processes. Such properties as change in viscosity and surface tension can cause significant inaccuracies especially in samples which may contain high dissolved solids and/or acid concentrations. (See Note 1.) If these types of interferences are operative, they must be reduced by dilution of the sample and/or utilization of standard addition techniques.

Note 1.—The use of a peristaltic pump may lessen these interferences.

4.1.3 *Chemical interferences* are characterized by molecular compound formation, ionization effects and solute vaporization effects. Normally these effects are not pronounced with the ICP technique, however, if observed they can be minimized by careful selection of operating conditions (that is, incident power, observation position, and so forth), by buffering of the sample, by matrix matching, and by standard addition procedures. These types of interferences can be highly dependent on matrix type and the specific analyte element.

4.2 It is recommended that whenever a new or unusual sample matrix is encountered, a series of tests be performed prior to reporting concentration data for analyte elements. These tests, as outlined in 4.2.1 through 4.2.4, will ensure the analyst that neither positive nor negative interference effects are operative on any of the analyte elements thereby distorting the accuracy of the reported values.

4.2.1 *Serial dilution*—If the analyte concentration is sufficiently high (minimally a factor of 10 above the instrumental detection limit after dilution), an analysis of a dilution should agree within 5 percent of the original determination (or within some acceptable control limit (13.3) that has been established for that matrix). If not, a chemical or physical interference effect should be suspected.

4.2.2 *Spike addition*—The recovery of a spike addition added at a minimum level of 10X the instrumental detection limit (maximum 100X) to the original determination should be recovered to within 90 to 110 percent or within the established control limit for that matrix. If not, a matrix effect should be suspected. The use of a standard addition analysis procedure can usually compensate for this effect.

Caution.—The standard addition technique does not detect coincident spectral overlap. If suspected, use of an alternate wavelength or comparison with an alternate method is recommended (See 4.2.3).

4.2.3 *Comparison with alternate method of analysis*—When investigating a new sample matrix, comparison tests may be performed with other analytical techniques such as atomic absorption spectrometry, or other approved methodology.

4.2.4 *Wavelength scanning of analyte line region*—If the appropriate equipment is available, wavelength scanning can be performed to detect potential spectral interferences.

5. Apparatus.

5.1 Inductively Coupled Plasma (ICP) Optical Emission Spectrometer.

5.1.1 Computer controlled atomic emission spectrometer with background correction.

5.1.2 Radiofrequency generator.

5.1.3 Argon gas supply, welding grade or better.

5.2 Operating conditions—Because of the differences between various makes and models of satisfactory instruments, no detailed operating instructions can be provided. Instead, the analyst should follow the instructions provided by the manufacturer of the particular instrument. Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be investigated and established for each individual analyte line on that particular instrument.

6. Reagents and standards.

6.1 Acids used in the preparation of standards and for sample processing must be ultra-high purity grade or equivalent. Redistilled acids are acceptable.

6.1.1 *Acetic acid*, conc. (sp gr 1.06).

6.1.2 *Aqua regia:* Mix cautiously 3 parts conc. HCl (sp gr 1.19) and 1 part conc. HNO$_3$ (sp gr 1.41) just before use.

6.1.3 *Hydrochloric acid*, conc. (sp gr 1.19).

6.1.4 *Hydrochloric acid*, (1+1): Add 500 ml conc. HCl (sp gr 1.19) to 400 ml deionized, distilled water and dilute to 1 liter.

6.1.5 *Nitric acid*, conc. (sp gr 1.41).

6.1.6 *Nitric acid*, (1+1): Add 500 ml conc. HNO$_3$ (sp gr 1.41) to 400 ml deionized, distilled water and dilute to 1 liter.

6.2 *Deionized, distilled water*: Prepare by passing distilled water through a mixed bed of cation and anion exchange resins. Use deionized, distilled water for the preparation of all reagents, calibration standards and as dilution water.

6.3 *Standard stock solutions* may be purchased or prepared from ultra high purity grade chemicals or metals

(Caution: See Note 2). All salts must be dried for 1 h at 105° C unless otherwise specified.

Note 2.—Many metal salts are extremely toxic and may be fatal if swallowed. Wash hands thoroughly after handling.

Typical stock solution preparation procedures follow:

6.3.1 *Aluminum solution, stock,* 1 ml = 100 µg Al: Dissolve 0.100 g of aluminum metal in an acid mixture of 4 ml of (1+1) HCl and 1 ml of conc. HNO_3 in a beaker. Warm gently to effect solution. When solution is complete, transfer quantitatively to a liter flask, add an additional 10 ml of (1+1) HCl and dilute to 1,000 ml with deionized, distilled water.

6.3.2 *Arsenic solution, stock,* 1 ml = 100 µg As: Dissolve 0.1320 g of As_2O_3 in 100 ml of deionized, distilled water containing 0.4 g NaOH. Acidify the solution with 2 ml conc. NHO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.3 *Barium solution, stock,* 1 ml = 100 µg Ba: Dissolve 0.1516 g $BaCl_2$ in 10 ml deionized, distilled water with 1 ml (1+1) HCl. Add 10.0 ml (1+1) HCl and dilute to 1,000 ml with deionized, distilled water.

6.3.4 *Beryllium solution, stock,* 1 ml = 100 µg Be: Dissolve 1.127 g $Be_4O(C_2H_3O_2)_6$, beryllium acetate basic, in a minimum amount of conc. acetic acid. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.5 *Boron solution, stock,* 1 ml = 100 µg B: Dissolve 0.5716 g anhydrous H_3BO_3 in deionized, distilled water and dilute to 1,000 ml. Because H_3BO_3 loses weight on drying at 105° C, use a reagent meeting ACS specifications and keep the bottle tightly stoppered to prevent the entrance of atmospheric moisture.

6.3.6 *Cadmium solution, stock,* 1 ml = 100 µg Cd: Dissolve 0.1142 g CdO in a minimum amount of (1+1) HNO_3. Heat to increase rate of dissolution. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.7 *Calcium solution, stock,* 1 ml = 100 µg Ca: Suspend 0.2498 g $CaCO_3$ dried at 180° C for 1 h before weighing in deionized, distilled water and dissolve cautiously with a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.8 *Chromium solution, stock,* 1 ml = 100 µg Cr: Dissolve 0.1923 g of CrO_3 in deionized, distilled water. When solution is complete, acidify with 10 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.9 *Cobalt solution, stock,* 1 ml = 100 µg Co: Dissolve 0.1407 g Co_2O_3 in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.10 *Copper solution, stock,* 1 ml = 100 µg Cu: Dissolve 0.1252 g CuO in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.11 *Iron solution, stock,* 1 ml = 100 µg Fe: Dissolve 0.1430 g Fe_2O_3 in 10 ml deionized, distilled water with 1 ml (1+1) HCl. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.12 *Lead solution, stock,* 1 ml = 100 µg Pb: Dissolve 0.1599 g $Pb(NO_3)_2$ in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.13 *Lithium solution, stock,* 1 ml = 100 µg Li: Dissolve 0.5323 g Li_2CO_3 slowly in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.14 *Magnesium solution, stock,* 1 ml = 100 µg Mg: Dissolve 0.1658 g MgO in a minimum amount of (1+1) HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.15 *Manganese solution, stock,* 1 ml = 100 µg Mn: Dissolve 0.5225 g $Mn(NO_3)_2 < 6H_2O$ (do not dry) in deionized, distilled water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.16 *Molybdenum solution, stock,* 1 ml = 100 µg Mo: Dissolve 0.2043 g $(NH_4)_2MoO_4$ in deionized, distilled water and dilute to 1,000 ml.

6.3.17 *Nickel solution, stock,* 1 ml = 100 µg Ni: Dissolve 0.4953 g $Ni(NO_3)_2 < 6H_2O$ in deionized, distilled water. Add 10 ml of conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.18 *Potassium solution, stock,* 1 ml = 100 µg K: Dissolve 0.1907 g KCl, dried at 110° C, in deionized, distilled water dilute to 1,000 ml.

6.3.19 *Selenium solution, stock,* 1 ml = 100 µg Se: Dissolve 0.1727 g H_2SeO_3 in deionized, distilled water and dilute to 1,000 ml.

6.3.20 *Silica solution, stock,* 1 ml = 100 µg SiO_2: *Do not dry.* Dissolve 0.4730 g $Na_2SiO_3 < 9H_2O$ in deionized, distilled water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.21 *Silver solution, stock,* 1 ml = 1 µg Ag: Dissolve 0.1575 g $AgNO_3$ in 100 ml of deionized, distilled water and 10 ml conc. HNO_3. Dilute to 1,000 ml with deionized, distilled water.

6.3.22 *Sodium solution, stock,* 1 ml = 100 µg Na: Dissolve 0.2542 g NaCl in deionized, distilled water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.23 *Strontium solution, stock,* 1 ml = 100 µg Sr: Dissolve 0.2416 g $Sr(NO_3)_2$ in deionized, distilled water. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.24 *Vanadium solution, stock,* 1 ml = 100 µg V: Dissolve 0.2297 NH_4VO_3 in a minimum amount of conc. HNO_3. Heat to increase rate of dissolution. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.3.25 *Zinc solution, stock,* 1 ml = 100 µg Zn: Dissolve 0.1245 g ZnO in a minimum amount of dilute HNO_3. Add 10.0 ml conc. HNO_3 and dilute to 1,000 ml with deionized, distilled water.

6.4 *Mixed calibration standard solutions*—Prepared mixed calibration standard solutions by combining appropriate volumes of the stock solutions in volumetric flasks. (See 6.4.1 thru 6.4.6) Add 2 ml of (1+1) HNO_3 and 2 ml of (1+1) HCl and dilute to 100 ml with deionized, distilled water. Prior to preparing the mixed standards each stock solution should be analyzed separately to determine possible spectral interference. Care shoud be taken when preparing the mixed standards that the elements are compatible and stable. Transfer the mixed standard solutions to a TFE fluorocarbon bottle for storage. Fresh mixed standards should be prepared weekly. *Some typical combinations* follow:

6.4.1 *Mixed standard solution I*—Iron, manganese, cadmium, lead and zinc.

6.4.2 *Mixed standard solution II*—Beryllium, copper, strontium, vanadium and cobalt.

6.4.3 *Mixed standard solution III*—Molybdenum, silica, lithium, and barium.

6.4.4 *Mixed standard solution IV*—Calcium, magnesium, sodium, and potassium.

6.4.5 *Mixed standard solution V*—Aluminum, arsenic, boron, chromium, nickel, and selenium.

6.4.6 *Mixed standard solution Vi*—Silver.

6.5 Two types of blanks are required for the analysis. The calibration blank (3.12) is used in establishing the analytical curve while the reagent blank (3.11) is used to correct for possible contamination resulting from varying amounts of the acids used in the sample processing.

6.5.1 *The calibration blank* is prepared by diluting 2 ml of (1+1) HNO_3 and 2 ml of (1+1) HCl to 100 ml with deionized, distilled water. Prepare a sufficient quantity to be used to flush the system between standards and samples.

6.5.2 *The reagent blank* must contain all the reagents and in the same volumes as used in the processing of the samples. The reagent blank must be carried through the complete procedure and contain the same acid concentration in the final solution as the sample solution used for analysis.

6.6 In addition to the calibration standards, an instrument check standard (3.7) and a reference standard (3.8) are also required for the analyses.

6.6.1 *The instrument check standard* is prepared by the analyst by combining compatible elements at a concentration equivalent to the midpoint of their respective calibration curves. This standard should be included in the analytical scheme with a frequency of 10%.

6.6.2 *The reference standard* should be prepared according to the instructions provided by the supplier. Following initial verification of the calibration standards, analyze weekly.

7. Sample handling and preservation.

7.1 For the determination of trace elements, contamination and loss are of prime concern. Dust in the laboratory environment, impurities in reagents and impurities on laboratory apparatus which the sample contacts are all sources of potential contamination. Sample containers can introduce either positive or negative errors in the measurement of trace elements by (a) contributing contaminants through leaching or surface desorption and (b) by depleting concentrations through adsorption. Thus the collection and treatment of the sample prior to analysis requires particular attention. Laboratory glassware including the sample bottle (whether linear polyethylene, polyproplyene or TFE-fluorocarbon) should be thoroughly washed with detergent and tap water; rinsed with (1+1) nitric acid, tap water, (1+1) hydrochloric acid, tap and finally deionized, distilled water in that order. (See Notes 3 and 4).

Note 3.—*Chromic acid may be useful to remove organic deposits from glassware; however, the analyst should be cautioned that the glassware must be thoroughly rinsed with water to remove the last traces of chromium. This is especially important if chromium is to be included in the analytical scheme. A commercial product, NOCHROMIX, available from Godax Laboratories, 6 Varick St., New York, NY 10013, may be used in place of chromic acid. Chromic acid should not be used with plastic bottles.*

Note 4.—If it can be documented through an active analytical quality control program using spiked samples and reagent blanks, that certain steps in the cleaning procedure are not required for routine samples, those steps may be eliminated from the procedure.

7.2 Before collection of the sample a decision must be made as to the type of data desired, that is dissolved, suspended or total, so that the appropriate preservation and pretreatment steps may be accomplished. Filtration, acid preservation, etc., are to be performed at the time the sample is collected or as soon as possible thereafter.

7.2.1 For the determination of dissolved elements the sample must be filtered through a 0.45-μm membrane filter as soon as practical after collection. (Glass or plastic filtering apparatus is recommended to avoid possible contamination.) Use the first 50–100 ml to rinse the filter flask. Discard this portion and collect the required volume of filtrate. Acidify the filtrate with (1+1) HNO_3 to a pH of 2 or less. Normally, 3 ml of (1+1) acid per liter should be sufficient to preserve the sample.

7.2.2 For the determination of suspended elements a measured volume of unpreserved sample must be filtered through a 0.45-μm membrane filter as soon as practical after collection. The filter plus suspended material should be transferred to a suitable container for storage and/or shipment. No preservative is required.

7.2.3 For the determinaion of total or total recoverable elements, the sample is acidified with 5 ml conc. HNO_3 per liter (pH 2) as soon as possible, preferably at the time of collection. The sample is not filtered before processing.

8. Sample Preparation.

8.1 For the determinations of dissolved elements, the filtered, preserved sample may often be analyzed as received. The acid matrix and concentration of the samples and calibration standards must be the same. If a precipitate formed upon acidification of the sample or during transit or storage, it must be redissolved before the analysis by adding additional acid and/or by heat as described in 8.3.

8.2 For the determinaton of suspended elements, transfer the membrane filter containing the insoluble material to a 250-ml Griffin beaker and add 3 ml conc. HNO_3. Cover the beaker with a watch glass and heat gently. The warm acid will soon dissolve the membrane. Increase the temperature of the hot plate and digest the material. When the acid has nearly evaporated, cool the beaker and watch glass and add another 3 ml of conc. HNO_3. Cover and continue heating until the digestion is complete, generally indicated by a light colored digestate. Evaporate to near dryness (DO NOT BAKE), cool, add 2 ml of (1+1) HNO_3 and 2 ml HCl (1+1) per 100 ml dilution and warm the beaker gently to dissolve any soluble material. Wash down the watch glass and beaker walls with deionized distilled water and filter the sample to remove insoluble material that could clog the nebulizer. Adjust the volume based on the expected concentrations of elements present. This volume will vary depending on the elements to be determined. The sample is now ready for analysis. Concentrations so determined shall be reported as "suspended."

8.3 For the determination of total elements, choose a measured, volume of the well mixed acid preserved sample appropriate for the expected level of elements and transfer to a Griffin beaker. (See Note 5.) Add 3 ml of conc. HNO_3. Place the beaker on a hot plate and evaporate to near dryness cautiously, making certain that the sample does not boil. (DO NOT BAKE.) Cool the beaker and add another 3 ml portion of conc. HNO_3. Cover the beaker with a watch glass and return to the hot plate. Increase the temperature of the hot plate so that a gentle reflux acton occurs. Continue heating, adding additional acid as necessary, until the digestion is complete (generally indicated when the digestate is light in color or does not change in appearance with continued refluxing.) Again, evaporate to near dryness and cool the beaker. Add 2 ml of 1+1 HNO_3 and 2 ml of 1+1 HCl per 100 ml of final soluton and warm the beaker to dissolve any precipitate or residue resulting from evaporation. Wash down the beaker walls and watch glass with deionized distilled water and filter the sample to remove insoluble material that could clog the nebulizer. Adjust the volume based on the expected concentrations of elements present. The sample is now ready for analysis. Concentrations so determined shall be reported as "total."

Note 5.—If low determinations of boron are critical, quartz glassware should be used.

8.4 For the determination of total recoverable elements, choose a measured volume of a well mixed, acid preserved sample appropriate for the expected level of elements and transfer to a Griffin beaker. (See Note 5.) Add 1 ml of HNO_3 (1+1) and 2 ml of HCl (1+1) to the sample and heat on a steam bath or hot plate until the volume has been reduced to 15–20 ml making certain the sample does not boil. After this treatment the sample is filtered to remove insoluble material that could clog the nebulizer, and the volume adjusted to 100 ml. The sample is then ready for analysis. Concentrations so determined shall be reported as "total."

9. Procedure.

9.1 Set up instrument with proper operating parameters established in Section 5.2. Instrument must be allowed to stabilize for at least 30 min prior to operations.

9.2 Initiate appropriaate operating configuration of computer.

9.3 Profile and calibrate instrument according to instrument manufacturer's recommended procedures, using the typical mixed calibration standard solutions described in Section 6.4. Flush the system with the calibration blank (6.5.1) between each standard. (See note 6.) (The use of the average intensity of multiple exposures for both standardization and sample analysis has been found to reduce random error.)

NOTE 6.—For boron concentrations greater than 500 µg/l extended flush times of 1 to 2 minutes may be required.

9.4 Before beginning the sample run, reanalyze the highest mixed calibration standard as if it were a sample. Concentration values obtained should not deviate from the actual values by more than 2 percent (or the established control limits). If they do, follow the recommendations of the instrument manufacturer to correct for this condition.

9.5 Begin the sample run flushing the system with the calibration blank (6.5.1) between each sample. (See Note 6.) Analyze an instrument check standard (6.6.1) each 10 samples.

9.6 If it has been found that methods of standard addition are required, the following procedure is recommended.

9.6.1 The standard addition technique (13.2) involves preparing new standards in the sample matrix by adding known amounts of standard to one or more aliquots of the processed sample solution. This technique compensates for a sample constituent that enhances or depresses the analyte signal thus producing a different slope from that of the calibration standards. It will not correct for additive intererence which causes a baseline shift. The simplest version of this technique is the single-addition method. The procedure is as follows. Two identical aliquots of the sample solution, each of volume V_x, are taken. To the first (labeled A) is added a small volume V_s of a standared analyte solution of concentration c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for nonanalyte signals. The unknown sample concentration c_x is calculated:

$$C_x = \frac{S_B V_s c_s}{(S_A - S_B)\ V_x}$$

where S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_s and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_s is made much less than V_x, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure. For the results from this technique to be valid, the following limitations must be taken into consideration:

1. The analytical curve must be linear.
2. The chemical form of the analyte added must respond the same as the analyte in the sample.
3. The interference effect must be constant over the working range of concern.
4. The signal must be corrected for any additive interference.

10. Calculation.

10.1 Reagent blanks (6.5.2) should be subtracted from all samples. This is particularly important for digested samples requiring large quantities of acids to complete the digestion.

10.2 If dilutions were performed, the appropriate factor must be applied to sample values.

10.3 Results should be reported to the nearest µg/l, up to three significant figures, except calcium, magnesium, sodium, and potassium which are reported to the nearest 0.1 mg/l.

11. Quality Control (Instrumental).

11.1 Check the instrument standardization by analyzing appropriate quality control check standards as follow:

11.1.1 Analyze the instrument check standard (6.6.1) made up of all the elements of interest at a frequency of 10%. This check standard is used to determine instrument drift. If agreement is not within ± 2% of the expected values or within the established control limits, the analysis is out of control.

11.1.2 For the purpose of verifying interelement and/or background correction factors, analyze a second check standard, prepared in the following manner. Select a representative sample which contains minimal concentrations of the elements of interest. Spike this sample with the analytes of interest at or near [illegible]0 µg/l. (For effluent samples of expected high concentrations, spike at an appropriate level.) Values should fall within the established control levels of 1.[illegible] times the standard deviation of the mean value of the check standard. If not, repeat the standardization.

11.1.3 A reference standard (6.6.2) from an outside source, but having known concentration values, should be analyzed as a blind sample on a weekly frequency. Values should be within the established quality control limits. If not, prepare new stock standards.

12. *Precision and Accuracy.*

12.1 In an EPA round phase [illegible] study, seven laboratories applied the ICP technique to acid-distilled water matrices that had been dosed with various metal concentrates. Table II lists the true value, the mean reported value and the mean % relative standard deviation.

Table II.—*ICP Precision and Accuracy Data*

Element	Sample No. 1			Sample No. 2			Sample No. 3		
	True value µg/l	Mean reported value µg/l	Mean percent RSD	True value µg/l	Mean reported value µg/l	Mean percent RSD	True value µg/l	Mean reported value µg/l	Mean percent RSD
Be	750	733	0.2	20	20	9.8	180	176	5.2
Mn	350	345	2.7	15	15	6.7	100	99	3.3
V	750	749	1.8	70	69	2.9	170	169	1.1
As	200	208	7.5	22	19	23	60	63	17
Cr	150	149	3.8	10	10	18	50	50	3.3
Cu	250	235	5.1	11	11	40	70	67	7.9
Fe	600	594	3.0	20	19	15	180	178	6.0
Al	700	696	5.6	60	62	33	160	161	13
Cd	50	48	12	2.5	2.9	16	14	13	16
Co	500	512	10	20	20	4.1	120	108	21
Ni	250	245	5.8	30	28	11	60	55	14
Pb	250	236	16	24	30	32	80	80	14
Zn	200	201	5.6	16	19	45	80	82	9.4
Se	40	32	21.9	6	8.5	42	10	[illegible]	8.3

Not all elements were analyzed by all laboratories.

13 References.

13.1 Winge, R. K., V. J. Peterson, and V. A. Fassel. "Inductively Coupled Plasma-Optical Emission Spectroscopy. Prominent Lines. EPA-600/4-79-017.

13.2 Winefordner, J. D., "Trace Analysis. Spectroscopic Methods for Elements." *Chemical Analysis*, Vol. 46, pp. 41-42.

13.3 Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019.

13.4 Carbarino, J. R. and Taylor, H. E. "An Inductively-Coupled Plasma Optical Emission Spectrometric Method for Routine Water Quality Testing." Applied Spectroscopy 33, No. 3 (1979).

13.5 "Methods for Chemical Analysis of Water and Wastes." EPA-600/4-79-020.

LEAD

Method 239.2 (Atomic Absorption, furnace technique)

STORET NO. Total 01051
Dissolved 01049
Suspended 01050

Optimum Concentration Range: 5–100 ug/l
Detection Limit: 1 ug/l

Preparation of Standard Solution

1. Stock solution: Prepare as described under "direct aspiration method".
2. Lanthanum Nitrate Solution: Dissolve 58.64 g of ACS reagent grade La_2O_3 in 100 ml conc. HNO_3 and dilute to 1000 ml with deionized distilled water. 1 ml = 50 mg La.
3. Working Lead Solution: Prepare dilutions of the stock lead solution to be used as calibration standards at the time of analysis. Each calibration standard should contain 0.5% (v/v) HNO_3. To each 100 ml of diluted standard add 10 ml of the lanthanum nitrate solution.

Sample Preservation

1. For sample handling and preservation, see part 4.1 of the Atomic Absorption Methods section of this manual.

Sample Preparation

1. Prepare as described under "direct aspiration method". Sample solutions for analysis should contain 0.5% (v/v) HNO_3.
2. To each 100 ml of prepared sample solution add 10 ml of the lanthanum nitrate solution.

Instrument Parameters (General)

1. Drying Time and Temp: 30 sec–125°C.
2. Ashing Time and Temp: 30 sec–500°C.
3. Atomizing Time and Temp: 10 sec–2700°C.
4. Purge Gas Atmosphere: Argon
5. Wavelength: 283.3 nm
6. Other operating parameters should be set as specified by the particular instrument manufacturer.

Analysis Procedure

1. For the analysis procedure in the calculation see "Furnace Procedure", part 9.3 of the Atomic Absorption Methods section of this manual.

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Notes

1. The above concentration values and instrument conditions are for a Perkin-Elmer HGA-2100, based on the use of a 20 *u*l injection, continuous flow purge gas and non-pyrolytic graphite. Smaller size furnace devices or those employing faster rates of atomization can be operated using lower atomization temperatures for shorter time periods than the above recommended settings.
2. The use of background correction is recommended.
3. Greater sensitivity can be achieved using the 217.0 nm line, but the optimum concentration range is reduced. The use of a lead electrodeless discharge lamp at this lower wavelength has been found to be advantageous. Also a lower atomization temperature (2400°C) may be preferred.
4. To suppress sulfate interference (up to 1500 ppm) lanthanum is added as the nitrate to both samples and calibration standards. (Atomic Absorption Newsletter Vol. 15, No. 3, p 71, May-June 1976.)
5. Since glassware contamination is a severe problem in lead analysis, all glassware should be cleaned immediately prior to use, and once cleaned, should not be open to the atmosphere except when necessary.
6. For every sample matrix analyzed, verification is necessary to determine that method of standard addition is not required (see part 5.2.1 of the Atomic Absorption Methods section of this manual).
7. For quality control requirements and optional recommendations for use in drinking water analyses, see part 10 of the Atomic Absorption Methods section of this manual.
8. If method of standard addition is required, follow the procedure given earlier in part 8.5 of the Atomic Absorption Methods section of this manual.
9. Data to be entered into STORET must be reported as *u*g/l.

Precision and Accuracy

1. In a single laboratory (EMSL), using Cincinnati, Ohio tap water spiked at concentrations of 25, 50, and 100 *u*g Pb/l, the standard deviations were ±1.3, ±1.6, and ±3.7, respectively. Recoveries at these levels were 88%, 92%, and 95% respectively.

United States
Environmental Protection
Agency

Environmental Monitoring and
Support Laboratory
Cincinnati OH 45268

Research and Development

Test Method

Organochlorine Pesticides and PCBs — Method 608

1. Scope and Application

1.1 This method covers the determination of certain organochlorine pesticides and PCBs. The following parameters can be determined by this method:

Parameter	STORET No.	CAS No.
Aldrin	39330	309-00-2
α-BHC	39337	319-84-6
β-BHC	39338	319-85-7
δ-BHC	34259	319-86-8
γ-BHC	39340	58-89-9
Chlordane	39350	57-74-9
4,4'-DDD	39310	72-54-8
4,4'-DDE	39320	72-55-9
4,4'-DDT	39300	50-29-3
Dieldrin	39380	60-57-1
Endosulfan I	34361	959-98-8
Endosulfan II	34356	33212-65-9
Endosulfan sulfate	34351	1031-07-8
Endrin	39390	72-20-8
Endrin aldehyde	34366	7421-93-4
Heptachlor	39410	76-44-8
Heptachlor epoxide	39420	1024-57-3
Toxaphene	39400	8001-35-2
PCB-1016	34671	12674-11-2
PCB-1221	39488	11104-28-2
PCB-1232	39492	11141-16-5
PCB-1242	39496	53469-21-9
PCB-1248	39500	12672-29-6
PCB-1254	39504	11097-69-1
PCB-1260	39508	11096-82-5

1.2 This is a gas chromatographic (GC) method applicable to the determination of the compounds listed above in municipal and industrial discharges as provided under 40 CFR 136.1. When this method is used to analyze unfamiliar samples for any or all of the compounds above, compound identifications should be supported by at least one additional qualitative technique. This method describes analytical conditions for a second gas chromatographic column that can be used to confirm measurements made with the primary column. Method 625 provides gas chromatograph/mass spectrometer (GC/MS) conditions appropriate for the qualitative and quantitative confirmation of results for all of the parameters listed above, using the extract produced by this method.

1.3 The method detection limit (MDL, defined in Section 14.1)[1] for each parameter is listed in Table 1. The MDL for a specific wastewater may differ from those listed, depending upon the nature of interferences in the sample matrix.

1.4 The sample extraction and concentration steps in this method are essentially the same as in methods 606, 609, 611 and 612. Thus, a single sample may be extracted to measure the parameters included in the scope of each of these methods. When cleanup is required, the concentration levels must be high enough to permit selection of aliquots as necessary to apply appropriate cleanup procedures. The analyst is allowed the latitude to select gas chromatographic conditions appropriate for the simultaneous measurement of combinations of these parameters.

1.5 Any modification of this method, beyond those expressly permitted, shall be considered as major modifications subject to application and approval of alternate test procedures under 40 CFR 136.4 and 136.5.

1.6 This method is restricted to use by or under the supervision of analysts experienced in the use of gas chromatography and in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method using the procedure described in Section 8.2.

2. Summary of Method

2.1 A measured volume of sample, approximately one-liter, is solvent extracted with methylene chloride using a separatory funnel. The methylene chloride extract is dried and exchanged to hexane, during concentration to a final volume of 10 mL or less. Gas chromatographic conditions are described which permit the separation and measurement of the parameters in the extract by electron capture GC(2).

2.2 The method provides a Florisil column procedure and elemental sulfur removal procedure to aid in the elimination of interferences that may be encountered.

3. Interferences

3.1 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in gas chromatograms. All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory reagent blanks as described in Section 8.5.

3.1.1 Glassware must be scrupulously cleaned(3). Clean all glassware as soon as possible after use by rinsing with the last solvent used in it. This should be followed by detergent washing with hot water, and rinses with tap water and distilled water. It should then be drained dry and heated in a muffle furnace at 400 °C for 15 to 30 minutes. Some thermally stable materials, such as PCBs, may not be eliminated by this treatment. Solvent rinses with acetone and pesticide quality hexane may be substituted for the muffle furnace heating. Thorough rinsing with such solvents usually elminates PCB interference. Volumetric ware should not be heated in a muffle furnace. After drying and cooling, glassware should be sealed and stored in a clean environment to prevent any accumulation of dust or other contaminants. Store inverted or capped with aluminum foil.

3.1.2 The use of high purity reagents and solvents helps to minimize interference problems. Purification of solvents by distillation in all-glass systems may be required.

3.2 Interferences by phthalate esters can pose a major problem in pesticide analysis when using the elution capture detector. These compounds generally appear in the chromatogram as large eluting peaks, especially in the 15 and 50% fractions from Florisil. Common flexible plastics contain varying amounts of phthalates. These phthalates are easily extracted or leached from such materials during laboratory operations. Cross contamination of clean glassware routinely occurs when plastics are handled during extraction steps, especially when solvent wetted surfaces are handled. Interferences from phthalates can best be minimized by avoiding the use of plastics in the laboratory. Exhaustive cleanup of reagents and glassware may be required to eliminate background phthalate contamination(4,5). The interferences from phthalate esters can be avoided by using a microcoulometric or electrolytic conductivity detector.

3.3 Matrix interferences may be caused by contaminants that are coextracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature and diversity of the industrial complex or municipality being sampled. The cleanup procedures in Section 11 can be used to overcome many of these interferences, but unique samples may require additional cleanup approaches to achieve the MDL listed in Table 1.

4. Safety

4.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely defined, however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material data handling sheets should also be made available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available and have been identified(6-8) for the information of the analyst.

4.2 The following parameters covered by this method have been tentatively classified as known or suspected, human or mammalian carcinogens: 4,4'-DDT, 4,4'-DDD, the BHCs, and the PCBs. Primary standards of these toxic compounds should be prepared in a hood.

5. Apparatus and Materials

5.1 Sampling equipment, for discrete or composite sampling.

5.1.1 Grab sample bottle—Amber glass, one-liter or one-quart volume, fitted with screw caps lined with Teflon. Foil may be substituted for Teflon if the sample is not corrosive. If amber bottles are not available, protect samples from light. The container must be washed, rinsed with acetone or methylene chloride, and dried before use to minimize contamination.

5.1.2 Automatic sampler (optional)—Must incorporate glass sample containers for the collection of a minimum of 250 mL. Sample containers must be kept refrigerated at 4 °C and protected from light during compositing. If the sampler uses a peristaltic pump, a minimum length of compressible one rubber tubing may be used before use, however the compressible tubing should be thoroughly rinsed with methanol, followed by repeated rinsings with distilled water to minimize the potential for contamination of the sample. An integrating flow meter is required to collect flow proportional composites.

5.2 Glassware (All specifications are suggested. Catalog numbers are included for illustration only).

5.2.1 Separatory funnel - 2000-mL, with Teflon stopcock.

5.2.2 Drying column - Chromatographic column approximately 400 mm long × 19 mm ID, with coarse frit.

5.2.3 Chromatographic column - Pyrex, 400 mm long × 22 mm ID, with coarse fritted plate and Teflon stopcock (Kontes K-42054 or equivalent).

5.2.4 Concentrator tube, Kuderna-Danish - 10-mL, graduated (Kontes K-570050-1025 or equivalent). Calibration must be checked at the volumes employed in the test. Ground glass stopper is used to prevent evaporation of extracts.

5.2.5 Evaporative flask, Kuderna-Danish - 500-mL (Kontes K-570001-0500 or equivalent). Attach to concentrator tube with springs.

5.2.6 Snyder column, Kuderna-Danish three ball macro (Kontes K-503000-0121 or equivalent).

5.2.7 Vials Amber glass, 10- to 15-mL capacity, with Teflon-lined screw cap.

5.3 Boiling chips approximately 10/40 mesh. Heat to 400 °C for 30 minutes or Soxhlet extract with methylene chloride.

5.4 Water bath - Heated, with concentric ring cover, capable of temperature control (± 2 °C). The bath should be used in a hood.

5.5 Balance Analytical, capable of accurately weighing 0.0001 g.

5.6 Gas chromatograph - An analytical system complete with gas chromatograph suitable for on-column injection and all required accessories including syringes, analytical columns, gases, detector, and strip-chart recorder. A data system is recommended for measuring peak areas.

5.6.1 Column 1 - 1.8 m long × 4 mm ID glass, packed with 1.5% SP-2250/1.95% SP-2401 on Supelcoport (100/120 mesh) or equivalent. Column 1 was used to develop the method performance statements in Section 14. Guidelines for the use of alternate column packings are provided in Section 12.1.

5.6.2 Column 2 - 1.8 m long × 4 mm ID glass, packed with 3% OV-1 on Supelcoport (100/120 mesh) or equivalent.

5.6.3 Detector - Electron capture. This detector has proven effective in the analysis of wastewaters for the parameters listed in the scope, and was used to develop the method performance statements in Section 14. Guidelines for the use of alternate detectors are provided in Section 12.1.

6. Reagents

6.1 Reagent water - Reagent water is defined as a water in which an interferent is not observed at the MDL of each parameter of interest.

6.2 Sodium hydroxide solution (10 N) - (ACS). Dissolve 40g NaOH in reagent water and dilute to 100 mL.

6.3 Sodium thiosulfate - (ACS). Granular.

6.4 Sulfuric acid solution (1 + 1) - (ACS). Slowly, add 50 mL H_2SO_4 (sp. gr. 1.84) to 50 mL of reagent water.

6.5 Acetone, hexane, isooctane (2,2,4-trimethylpentane), methylene chloride - Pesticide quality or equivalent.

6.6 Ethyl ether - Pesticide quality or equivalent, redistilled in glass if necessary.

6.6.1 Must be free of peroxides as indicated by EM Laboratories Quant test strips (Available from Scientific Products Co., Cat. No. P1126-8, and others suppliers.)

6.6.2 Procedures recommended for removal of peroxides are provided with the test strips. After cleanup, 20 mL ethyl alcohol preservative must be added to each liter of ether.

6.7 Sodium sulfate - (ACS) Granular, anhydrous. Purify by heating at 400 °C for 4 hours in a shallow tray.

6.8 Florisil - PR grade (60/100 mesh); purchase activated at 1250 °F and store in dark in glass containers with glass stoppers or foil-lined screw caps. Before use, activate each batch at least 16 hours at 130 °C in a foil covered glass container.

6.9 Mercury - Triple distilled.

6.10 Copper powder - Activated.

6.11 Stock standard solutions (1.00 µg/µL) - Stock standard solutions can be prepared from pure standard materials or purchased as certified solutions.

6.11.1 Prepare stock standard solutions by accurately weighing about 0.0100 grams of pure material. Dissolve the material in isooctane, dilute to volume in a 10-mL volumetric flask. Larger volumes can be used at the convenience of the analyst. If compound purity is certified at 96% or greater, the weight can be used without correction to calculate the concentration of the stock standard. Commercially prepared stock standards can be used at any concentration if they are certified by the manufacturer or by an independent source.

6.11.2 Transfer the stock standard solutions into Teflon-sealed screw-cap bottles. Store at 4 °C and protect from light. Stock standard solutions should be checked frequently for signs of degradation or evaporation, especially just prior to preparing calibration standards from them. Quality control check standards that can be used to determine the accuracy of calibration standards will be available from the U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.

6.11.3 Stock standard solutions must be replaced after six months, or sooner if comparison with check standards indicate a problem.

7. Calibration

7.1 Establish gas chromatographic operating parameters which produce retention times equivalent to those indicated in Table 1. The gas chromatographic system may be calibrated using the external standard technique (Section 7.2) or the internal standard technique (Section 7.3).

7.2 External standard calibration procedure:

7.2.1 Prepare calibration standards at a minimum of three concentration levels for each parameter of interest by adding volumes of one or more stock standards to a volumetric flask and diluting to volume with isooctane. One of the external standards should be at a concentration near, but above, the MDL and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.

7.2.2 Using injections of 2 to 5 µL of each calibration standard, tabulate peak height or area responses against the mass injected. The results can be used to prepare a calibration curve for each compound. Alternatively, if the ratio of response to amount injected (calibration factor) is a constant over the working range (<10% relative standard deviation, RSD), linearity through the origin can be assumed and the average ratio or calibration factor can be used in place of a calibration curve.

7.2.3 The working calibration curve or calibration factor must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than ± 10%, the test must be repeated using a fresh calibration standard. Alternatively, a new calibration curve or calibration factor must be prepared for that compound.

7.3 Internal standard calibration procedure. To use this approach, the analyst must select one or more internal standards that are similar in analytical behavior to the compounds of interest. The analyst must further demonstrate that the measurement of the internal standard is not affected by method or matrix interferences. Because of these limitations, no internal standard can be suggested that is applicable to all samples.

7.3.1 Prepare calibration standards at a minimum of three concentration levels for each parameter of interest by adding volumes of one or more stock standards to a volumetric flask. To each calibration standard, add a known constant amount of one or more internal standards, and dilute to volume with isooctane. One of the standards should be at a concentration near, but above, the MDL and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.

7.3.2 Using injections of 2 to 5 µL of each calibration standard, tabulate peak height or area responses against concentration for each compound and internal standard, and calculate response factors (RF) for each compound using equation 1.

Eq. 1. $RF = (A_sC_{is})/(A_{is}C_s)$

where:

A_s = Response for the parameter to be measured.

A_{is} = Response for the internal standard.

C_{is} = Concentration of the internal standard, (µg/L).

C_s = Concentration of the parameter to be measured, (µg/L).

If the RF value over the working range is a constant (<10% RSD), the RF can be assumed to be invariant and the average RF can be used for calculations. Alternatively, the results can be used to plot a calibration curve of response ratios, A_s/A_{is}, vs. RF.

7.3.3 The working calibration curve or RF must be verified on each working day by the measurement of one or more calibration standards. If the response for any parameter varies from the predicted response by more than ± 10%, the test must be repeated using a fresh calibration standard. Alternatively, a new calibration curve must be prepared for that compound.

7.4 The cleanup procedure in Section 11 utilizes Florisil chromatography. Florisil from different batches or sources may vary in absorptive capacity. To standardize the amount of Florisil which is used, the use of lauric acid value(9) is suggested. The referenced procedure determines the adsorption from hexane solution of lauric acid (mg) per gram Florisil. The amount of Florisil to be used for each column is calculated by dividing this factor into 110 and multiplying by 20 g.

7.5 Before using any cleanup procedure, the analyst must process a series of calibration standards through the procedure to validate elution patterns and the absence of interferences from the reagents.

8. Quality Control

8.1 Each laboratory that uses this method is required to operate a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and the analysis of spiked samples as a continuing check on performance. The laboratory is required to maintain performance records to define the quality of data that is generated. Ongoing performance checks must be compared with established performance criteria to determine if the results of analyses are within accuracy and precision limits expected of the method.

8.1.1 Before performing any analyses, the analyst must demonstrate the ability to generate acceptable accuracy and precision with this method. This ability is established as described in Section 8.2.

8.1.2 In recognition of the rapid advances that are occurring in chromatography, the analyst is permitted certain options to improve the separations or lower the cost of measurements. Each time such modifications are made to the method, the analyst is required to repeat the procedure in Section 8.2.

8.1.3 The laboratory must spike and analyze a minimum of 10% of all samples to monitor continuing laboratory performance. This procedure is described in Section 8.4.

8.2 To establish the ability to generate acceptable accuracy and precision, the analyst must perform the following operations.

8.2.1 Select a representative spike concentration for each compound to be measured. Using stock standards, prepare a quality control check sample concentrate in acetone 1000 times more concentrated than the selected concentrations. Quality control check sample concentrates, appropriate for use with this method, will be available from the U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.

8.2.2 Using a pipet, add 1.00 mL of the check sample concentrate to each of a minimum of four 1000-mL aliquots of reagent water. A representative wastewater may be used in place of the reagent water, but one or more additional aliquots must be analyzed to determine background levels, and the spike level must exceed twice the background level for the test to be valid. Analyze the aliquots according to the method beginning in Section 10.

8.2.3 Calculate the average percent recovery, (R), and the standard deviation of the percent recovery (s), for the results. Wastewater background corrections must be made before R and s calculations are performed.

8.2.4 Using Table 2, note the average recovery (X) and standard deviation (p) expected for each method parameter. Compare these to the calculated values for R and s. If $s > 2p$ or $|X - R| > 2p$, review potential problem areas and repeat the test.

8.2.5 The U.S. Environmental Protection Agency plans to establish performance criteria for R and s based upon the results of interlaboratory testing. When they become available, these criteria must be met before any samples may be analyzed.

8.3 The analyst must calculate method performance criteria and define the performance of the laboratory for each spike concentration and parameter being measured.

8.3.1 Calculate upper and lower control limits for method performance:

Upper Control Limit (UCL) = R + 3s
Lower Control Limit (LCL) = R − 3s

where R and s are calculated as in Section 8.2.3. The UCL and LCL can be used to construct control charts(10) that are useful in observing trends in performance. The control limits above be replaced by method performance criteria as they become available from the U.S. Environmental Protection Agency.

8.3.2 The laboratory must develop and maintain separate accuracy statements of laboratory performance for wastewater samples. An accuracy statement for the method is defined as R ± s. The accuracy statement should be developed by the analysis of four aliquots of wastewater as described in Section 8.2.2, followed by the calculation of R and s. Alternately, the analyst may use four wastewater data points gathered through the requirement for continuing quality control in Section 8.4. The accuracy statements should be updated regularly(10).

8.4. The laboratory is required to collect a portion of their samples in duplicate to monitor spike recoveries. The frequency of spiked sample analysis must be at least 10% of all samples or one sample per month, whichever is greater. One aliquot of the sample must be spiked and analyzed as described in Section 8.2. If the recovery for a particular parameter does not fall within the control limits for method performance, the results reported for that parameter in all samples processed as part of the same set must be qualified as described in Section 13.5. The laboratory should monitor the frequency of data so qualified to ensure that it remains at or below 5%.

8.5 Before processing any samples, the analyst should demonstrate through the analysis of a one-liter aliquot of reagent water, that all glassware and reagent interferences are under control. Each time a set of samples is extracted or there is a change in reagents, a laboratory reagent blank should be processed as a safeguard against laboratory contamination.

8.6 It is recommended that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. Field duplicates may be analyzed to monitor the precision of the sampling technique. When doubt exists over the identification of a peak on the chromatogram, confirmatory techniques such as gas chromatography with a dissimilar column, specific element detector, or mass spectrometer must be used. Whenever possible, the laboratory should perform analysis of standard reference materials and participate in relevant performance evaluation studies.

9. Sample Collection, Preservation, and Handling

9.1 Grab samples must be collected in glass containers. Conventional sampling practices(11) should be followed, except that the bottle must not be prewashed with sample before collection. Composite samples should be collected in refrigerated glass containers in accordance with the requirements of the program. Automatic sampling equipment must be as free as possible of Tygon tubing and other potential sources of contamination.

9.2 The samples must be iced or refrigerated at 4 °C from the time of collection until extraction. If the samples will not be extracted within 72 hours of collection, the sample should be adjusted to a pH range of 5.0 to 9.0 with sodium hydroxide or sulfuric acid. Record the volume of acid or base used. If aldrin is to be determined, add sodium thiosulfate when residual chlorine is present. U.S. Environmental Protection Agency methods 330.4 and 330.5 may be used to measure chlorine residual(12). Field test kits are available for this purpose.

9.3 All samples must be extracted within 7 days and completely analyzed within 40 days of extraction(2).

10. Sample Extraction

10.1 Mark the water meniscus on the side of the sample bottle for later determination of sample volume. Pour the entire sample into a two-liter separatory funnel.

10.2 Add 60 mL methylene chloride to the sample bottle, seal, and shake 30 seconds to rinse the inner surface. Transfer the solvent to the separatory funnel and extract the sample by shaking the funnel for two minutes with periodic venting to release excess pressure. Allow the organic layer to separate from the water phase for a minimum of 10 minutes. If the emulsion interface between layers is more than one-third the volume of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample, but may include stirring, filtration of the emulsion through glass wool, centrifugation, or other physical methods. Collect the methylene chloride extract in a 250-mL Erlenmeyer flask.

10.3 Add a second 60-mL volume of methylene chloride to the sample bottle and repeat the extraction procedure a second time, combining the extracts in the Erlenmeyer flask. Perform a third extraction in the same manner.

10.4 Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporative flask. Other concentration devices or techniques may be used in place of the Kuderna Danish if the requirements of Section 8.2 are met.

10.5 Pour the combined extract through a drying column containing about 10 cm of anhydrous sodium sulfate, and collect the extract in the K-D concentrator. Rinse the Erlenmeyer flask and column with 20 to 30 mL of methylene chloride to complete the quantitative transfer.

10.6 Add one or two clean boiling chips to the evaporative flask and attach a three-ball Snyder column. Prewet the Snyder column by adding about 1 mL methylene chloride to the top. Place the K-D apparatus on a hot water bath (60 to 65 °C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 15 to 20 minutes. At the proper rate of distillation the balls of the column will actively chatter but the chambers will not flood with condensed solvent. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus and allow it to drain and cool for at least 10 minutes.

10.7 Increase the temperature of the hot water bath to about 80 °C. Momentarily remove the Snyder column, add 50 mL of hexane and a new boiling chip and reattach the Snyder column. Prewet the column by adding about 1 mL of hexane to the top. Concentrate the solvent extract as before. The elapsed time of concentration should be 5 to 10 minutes. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus and allow it to drain and cool at least 10 minutes.

10.8 Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 1 to 2 mL of hexane. A 5-mL syringe is recommended for this operation. Stopper the concentrator tube and store refrigerated if further processing will not be performed immediately. If the extracts will be stored longer than two days, they should be transferred to Teflon-sealed screw-cap bottles. If the sample extract requires no further cleanup, proceed with gas chromatographic analysis. If the sample requires cleanup, proceed to Section 11.

10.9 Determine the original sample volume by refilling the sample bottle to the mark and transferring the liquid to a 1000 mL graduated cylinder. Record the sample volume to the nearest 5 mL.

11. Cleanup and Separation

11.1 Cleanup procedures may not be necessary for a relatively clean sample matrix. The cleanup procedures recommended in this method have been used for the analysis of various clean waters and industrial effluents. If particular circumstances demand the use of an alternative cleanup procedure, the analyst must determine the elution profile and demonstrate that the recovery of each compound of interest is no less than 85%. The Florisil column allows for a select fractionation of the compounds and will eliminate polar materials. Elemental sulfur interferes with the electron capture gas chromatography of certain pesticides, but can be removed by the techniques described below.

11.2 Florisil column cleanup:

11.2.1 Add a weight of Florisil (nominally 21 g) predetermined by calibration (Section 7.4 and 7.5), to a chromatographic column. Settle the Florisil by tapping the column. Add sodium sulfate to the top of the Florisil to form a layer 1 to 2 cm deep. Add 60 mL of hexane to wet and rinse the sodium sulfate and Florisil. Just prior to exposure of the sodium sulfate to air, stop the elution of the hexane by closing the stopcock on the chromatography column. Discard the eluate.

11.2.2 Adjust the sample extract volume to 10 mL with hexane and transfer it from the K-D concentrator tube to the Florisil column. Rinse the tube twice with 1 to 2 mL hexane, adding each rinse to the column.

11.2.3 Place a 500-mL K-D flask and clean concentrator tube under the chromatography column. Drain the column into the flask until the sodium sulfate layer is nearly exposed. Elute the column with 200 mL of 6% ethyl ether in hexane (V/V) (Fraction 1) using a drip rate of about 5 mL min. Remove the K-D flask and set aside for later concentration. Elute the column again, using 200 mL of 15% ethyl ether in hexane (V/V)(Fraction 2), into a second K-D flask. Perform the third elution using 200 mL of 50% ethyl ether in hexane (V/V)(Fraction 3). The elution patterns for the pesticides an PCB's are shown in Table 2.

11.2.4 Concentrate the eluates by standard K-D techniques (Section 10.6), substituting hexane for the glassware rinses and using the water bath at about 85 °C. Adjust final volume to 10 mL with hexane. Analyze by gas chromatography.

11.3 Elemental sulfur will usually elute entirely in Fraction 1 of the Florisil column cleanup. To remove sulfur interference from this fraction or the original extract, pipet 1.00 mL of the concentrated extract into a clean concentrator tube or Teflon-sealed vial. Add one to three drops of mercury and seal(13). Agitate the contents of the vial for 15 to 30 seconds. Prolonged shaking (two hours) may be required. If so, this may be accomplished with a reciprocal shaker. Alternatively, activated copper powder may be used for sulfur removal(14). Analyze by gas chromatography.

12. Gas Chromatography

12.1 Table 1 summarizes the recommended operating conditions for the gas chromatograph. This table includes retention times and MDL that were obtained under these conditions. Examples of the parameter separations achieved by column 1 are shown in Figures 1 to 10. Other packed columns, chromatographic conditions, or detectors may be used if the requirements of Section 8.2 are met. Capillary (open-tubular) columns may also be used if the relative standard deviations of responses for replicate injections are demonstrated to be less than 6% and the requirements of Section 8.2 are met.

12.2 Calibrate the system daily as described in Section 7.

12.3 If the internal standard approach is being used, the internal standard must be added to the sample extract and mixed thoroughly immediately, before injection into the instrument.

12.4 Inject 2 to 5 μL of the sample extract using the solvent-flush technique(15). Smaller (1.0 μL) volumes can be injected if automatic devices are employed. Record the volume injected to the nearest 0.05 μL, the total extract volume, and the resulting peak size in area or peak height units.

12.5 The width of the retention time window used to make identifications should be based upon measurements of actual retention time variations of standards over the course of a day. Three times the standard deviation of a retention time for a compound can be used to calculate a suggested window size, however, the experience of the analyst should weigh heavily in the interpretation of chromatograms.

12.6 If the response for the peak exceeds the working range of the system, dilute the extract and reanalyze.

12.7 If the measurement of the peak response is prevented by the presence of interferences, further cleanup is required.

13. Calculations

13.1 Determine the concentration of individual compounds in the sample.

13.1.1 If the external standard calibration procedure is used, calculate the amount of material injected from the peak response using the calibration curve or calibration factor in Section 7.2.2. The concentration in the sample can be calculated from equation 2:

$$\text{Eq. 2. Concentration, } \mu g/L = \frac{(A)(V_t)}{(V_i)(V_s)}$$

where:

A = Amount of material injected, in nanograms.
V_i = Volume of extract injected (μL).
V_t = Volume of total extract (μL).
V_s = Volume of water extracted (mL).

13.1.2 If the internal standard calibration procedure was used, calculate the concentration in the sample using the response factor (RF) determined in Section 7.3.2 and equation 3.

Eq. 3

$$\text{Concentration, } \mu g/L = \frac{(A_s)(I_s)}{(A_{is})(RF)(V_o)}$$

where:

A_s = Response for the parameter to be measured.
A_{is} = Response for the internal standard.
I_s = Amount of internal standard added to each extract (μg).
V_o = Volume of water extracted, in liters.

13.2 When it is apparent that two or more PCB (Aroclor) mixtures are present, the Webb and McCall procedure(16) may be used to identify and quantify the Aroclors.

13.3 For multicomponent mixtures (chlordane, toxaphene and PCBs) match retention times of peaks in the standards with peaks in the sample. Quantitate every identifiable peak unless interference with individual peaks persist after cleanup. Add peak height or peak area of each identified peak in the chromatogram. Calculate as total response in the sample versus total response in the standard.

13.4 Report results in micrograms per liter without correction for recovery data. When duplicate and spiked samples are analyzed, report all data obtained with the sample results.

13.5 For samples processed as part of a set where the laboratory spiked sample recovery falls outside of the control limits in Section 8.3, data for the affected parameters must be labeled as suspect.

14. Method Performance

14.1 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero(1). The MDL concentrations listed in Table 1 were obtained using reagent water(17). Similar results were achieved using representative wastewaters.

14.2 This method has been tested for linearity of spike recovery from reagent water and has been demonstrated to be applicable over the concentration range from 4 × MDL up to 1000 × MDL with the following exceptions: Chlordane recovery at 4 × MDL was low (60%); Toxaphene recovery was demonstrated linear over the range of 10 × MDL to 1000 × MDL(17).

14.3 In a single laboratory (Southwest Research Institute), using spiked wastewater samples, the average recoveries presented in Table 3 were obtained(4). Each spiked sample was analyzed in triplicate on two separate days. The standard deviation of the percent recovery is also included in Table 3.

14.4 The U.S. Environmental Protection Agency is in the process of conducting an interlaboratory method study to fully define the performance of this method.

References

1. See Appendix A

2. "Determination of Pesticides and PCBs in Industrial and Municipal Wastewaters." Report for EPA Contract 68-03-2606. In preparation.

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17. "Method Detection Limit and Analytical Curve Studies, EPA Methods 606, 607, and 608," Special letter report for EPA Contract 68-03-2606. Environmental Monitoring and Support Laboratory – Cincinnati, Ohio 45268.

Table 1. Chromatographic Conditions and Method Detection Limits

Parameter	Retention Time (min.) Column 1	Retention Time (min.) Column 2	Method Detection Limit µg/L
α-BHC	1.35	1.82	0.003
γ-BHC	.70	2.13	0.004
β-BHC	1.90	1.97	0.006
Heptachlor	2.00	3.35	0.003
δ-BHC	2.15	2.20	0.009
Aldrin	2.40	4.10	0.004
Hepachlor epoxide	3.50	5.00	0.083
Endosulfan I	4.50	6.20	0.014
4,4'-DDE	5.13	7.15	0.004
Dieldrin	5.45	7.23	0.002
Endrin	6.55	8.10	0.006
4,4'-DDD	7.83	9.08	0.011
Endosulfan II	8.00	8.28	0.004
4,4'-DDT	9.40	11.75	0.012
Endrin aldehyde	11.82	9.30	0.023
Endosulfan sulfate	14.22	10.70	0.066
Chlordane	mr	mr	0.014
Toxaphene	mr	mr	0.24
PCB-1016	mr	mr	nd
PCB-1221	mr	mr	nd
PCB-1232	mr	mr	nd
PCB-1242	mr	mr	0.065
PCB-1248	mr	mr	nd
PCB-1254	mr	mr	nd
PCB-1260	mr	mr	nd

Column 1 conditions: Supelcoport (100/120 mesh) coated with 1.5% SP-2250/1.95% SP-2401 packed in a 1.8 m long × 4 mm ID glass column with 5% Methane/95% Argon carrier gas at a flow rate of 60 mL/min. Column temperature isothermal at 200°C, except for PCB-1016 through PCB-1248, which should be measured at 160°C.

Column 2 conditions: Supelcoport (100/120 mesh) coated with 3% OV-1 in a 1.8 m long × 4 mm ID glass column with 5% Methane/95% Argon carrier gas at a flow rate of 60 mL/min. Column temperature, isothermal at 200°C, for the pesticides; 140°C for PCB-1221 and 1232; 170°C for PCB-1016 and 1242 to 1268.

mr — Multiple peak response. See Figures 2 thru 10.

nd — Not determined.

Table 2. Distribution of Chlorinated Pesticides and PCBs into Florisil Column Fractions[2]

Parameter	Percent Recovery by Fraction Fraction 1	Fraction 2	Fraction 3
Aldrin	100		
α-BHC	100		
β-BHC	97		
δ-BHC	98		
γ-BHC	100		
Chlordane	100		
4,4'-DDD	99		
4,4'-DDE	98		
4,4'-DDT	100		
Dieldrin	0	100	
Endosulfan I	37	64	
Endosulfan	0	7	91
Endosulfan sulfate	0	0	106
Endrin	4	96	
Endrin aldehyde	0	68	26
Heptachlor	100		
Heptachlor epoxide	100		
Toxaphene	96		
PCB-1016	97		
PCB-1221	97		
PCB-1232	95	4	
PCB-1242	97		
PCB-1248	103		
PCB-1254	90		
PCB-1260	95		

Eluant composition by fraction:

Fraction 1 — 6% ethyl ether in hexane

Fraction 2 — 15% ethyl ether in hexane

Fraction 3 — 50% ethyl ether in hexane

Table 1. Chromatographic Conditions and Method Detection Limits

Parameter	Retention Time (min.) Column 1	Retention Time (min.) Column 2	Method Detection Limit μg/L
α-BHC	1.35	1.82	0.003
γ-BHC	.70	2.13	0.004
β-BHC	1.90	1.97	0.006
Heptachlor	2.00	3.35	0.003
δ-BHC	2.15	2.20	0.009
Aldrin	2.40	4.10	0.004
Hepachlor epoxide	3.50	5.00	0.083
Endosulfan I	4.50	6.20	0.014
4,4'-DDE	5.13	7.15	0.004
Dieldrin	5.45	7.23	0.002
Endrin	6.55	8.10	0.006
4,4'-DDD	7.83	9.08	0.011
Endosulfan II	8.00	8.28	0.004
4,4'-DDT	9.40	11.75	0.012
Endrin aldehyde	11.82	9.30	0.023
Endosulfan sulfate	14.22	10.70	0.066
Chlordane	mr	mr	0.014
Toxaphene	mr	mr	0.24
PCB-1016	mr	mr	nd
PCB-1221	mr	mr	nd
PCB-1232	mr	mr	nd
PCB-1242	mr	mr	0.065
PCB-1248	mr	mr	nd
PCB-1254	mr	mr	nd
PCB-1260	mr	mr	nd

Column 1 conditions: Supelcoport (100/120 mesh) coated with 1.5% SP-2250/1.95% SP-2401 packed in a 1.8 m long × 4 mm ID glass column with 5% Methane/95% Argon carrier gas at a flow rate of 60 mL/min. Column temperature isothermal at 200°C, except for PCB-1016 through PCB-1248, which should be measured at 160°C.

Column 2 conditions: Supelcoport (100/120 mesh) coated with 3% OV-1 in a 1.8 m long × 4 mm ID glass column with 5% Methane/95% Argon carrier gas at a flow rate of 60 mL/min. Column temperature, isothermal at 200°C, for the pesticides; 140°C for PCB-1221 and 1232; 170°C for PCB-1016 and 1242 to 1268.

mr – Multiple peak response. See Figures 2 thru 10.

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Table 2. Distribution of Chlorinated Pesticides and PCBs into Florisil Column Fractions[2]

Parameter	Percent Recovery by Fraction: Fraction 1	Fraction 2	Fraction 3
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α-BHC	100		
β-BHC	97		
δ-BHC	98		
γ-BHC	100		
Chlordane	100		
4,4'-DDD	99		
4,4'-DDE	98		
4,4'-DDT	100		
Dieldrin	0	100	
Endosulfan I	37	64	
Endosulfan	0	7	91
Endosulfan sulfate	0	0	106
Endrin	4	96	
Endrin aldehyde	0	68	26
Heptachlor	100		
Heptachlor epoxide	100		
Toxaphene	96		
PCB-1016	97		
PCB-1221	97		
PCB-1232	95	4	
PCB-1242	97		
PCB-1248	103		
PCB-1254	90		
PCB-1260	95		

Eluant composition by fraction:
Fraction 1 – 6% ethyl ether in hexane
Fraction 2 – 15% ethyl ether in hexane
Fraction 3 – 50% ethyl ether in hexane

Table 3. Single Operator Accuracy and Precision

Parameter	Average Percent Recovery	Standard Deviation %	Spike Range (μg/L)	Number of Analyses	Matrix Types
Aldrin	89	2.5	2.0	15	3
α-BHC	89	2.0	1.0	15	3
β-BHC	88	1.3	2.0	15	3
δ-BHC	86	3.4	2.0	15	3
γ-BHC	97	3.3	1.0	15	3
Chlorane	93	4.1	20	21	4
4-4'-DDD	92	1.9	6.0	15	3
4,4'-DDE	89	2.2	3.0	15	3
4,4'-DDT	92	3.2	8.0	15	3
Dieldrin	95	2.8	3.0	15	2
Endosulfan I	96	2.9	3.0	12	2
Endosulfan II	97	2.4	5.0	14	3
Endosulfan sulfate	99	4.1	15	15	3
Endrin	95	2.1	5.0	12	2
Endrin aldehyde	87	2.1	12	11	2
Heptachlor	88	3.3	1.0	12	2
Heptachlor epoxide	93	1.4	2.0	15	3
Toxaphene	95	3.8	200	18	3
PCB-1016	94	1.8	25	12	2
PCB-1221	96	4.2	55-110	12	2
PCB-1232	88	2.4	110	12	2
PCB-1242	92	2.0	28-56	12	2
PCB-1248	90	1.6	40	12	2
PCB-1254	92	3.3	40	18	3
PCB-1260	91	5.5	80	18	3

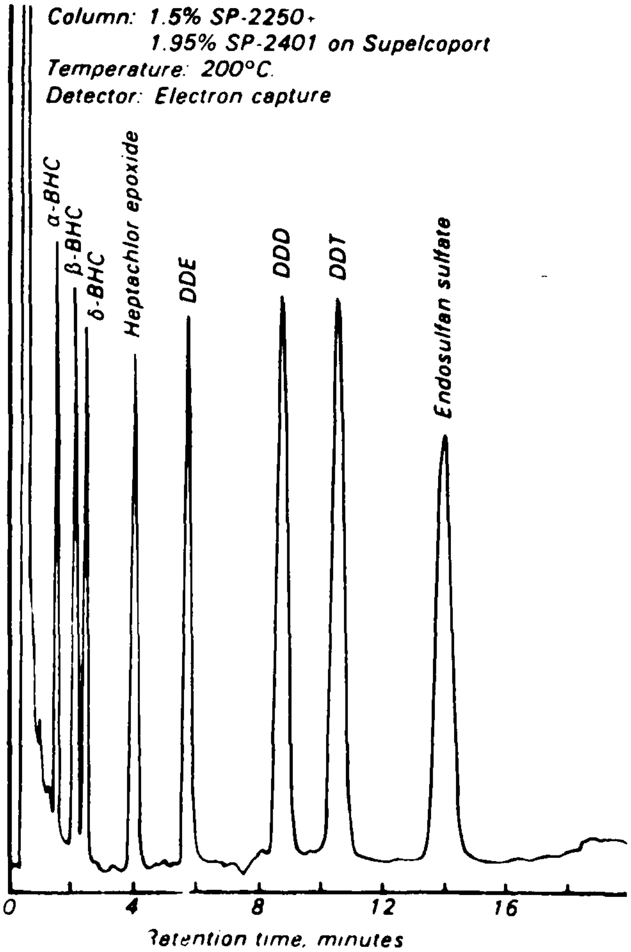
Column: 1.5% SP-2250+
1.95% SP-2401 on Supelcoport
Temperature: 200°C.
Detector: Electron capture

Figure 1. *Gas chromatogram of pesticides*

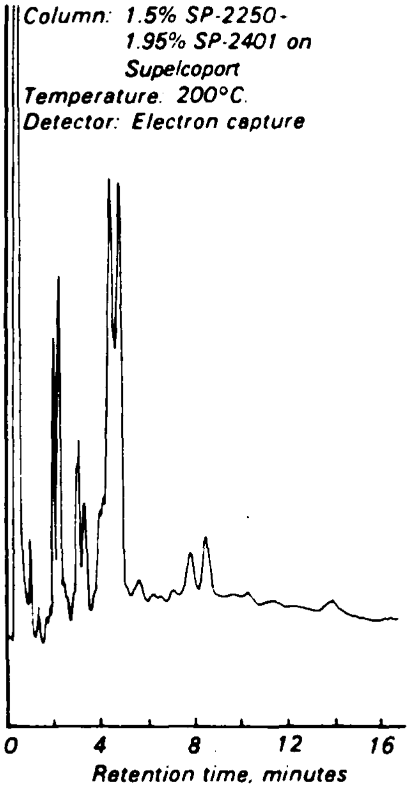
Column: 1.5% SP-2250-
1.95% SP-2401 on
Supelcoport
Temperature: 200°C.
Detector: Electron capture

Figure 2. *Gas chromatogram of chlordane*

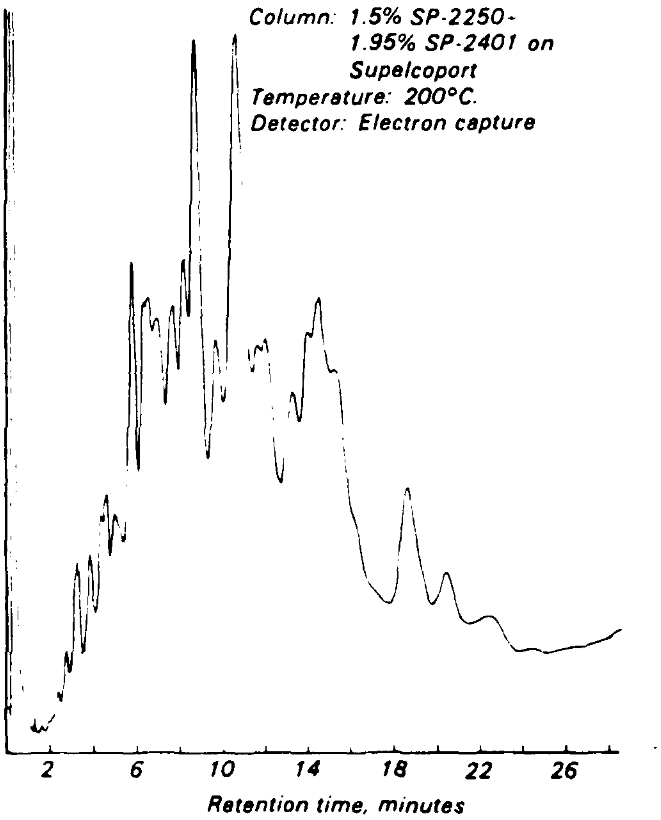

Figure 3. *Gas chromatogram of toxaphene.*

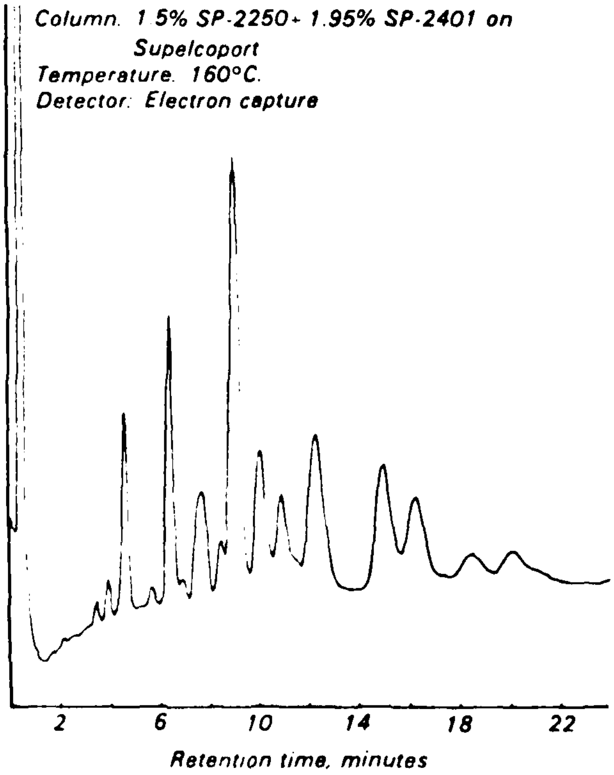

Figure 4. *Gas chromatogram of PCB-1016*

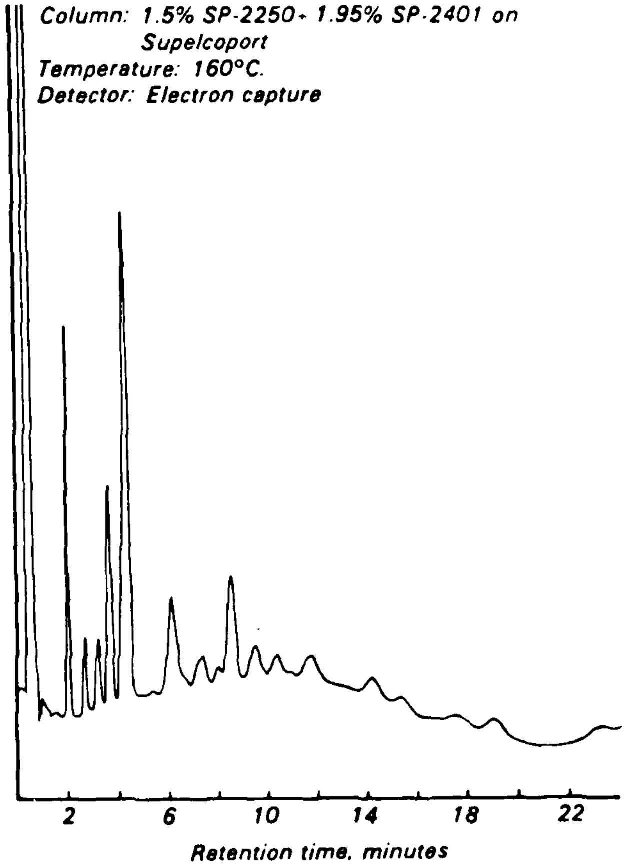

Figure 5. *Gas chromatogram of PCB-1221.*

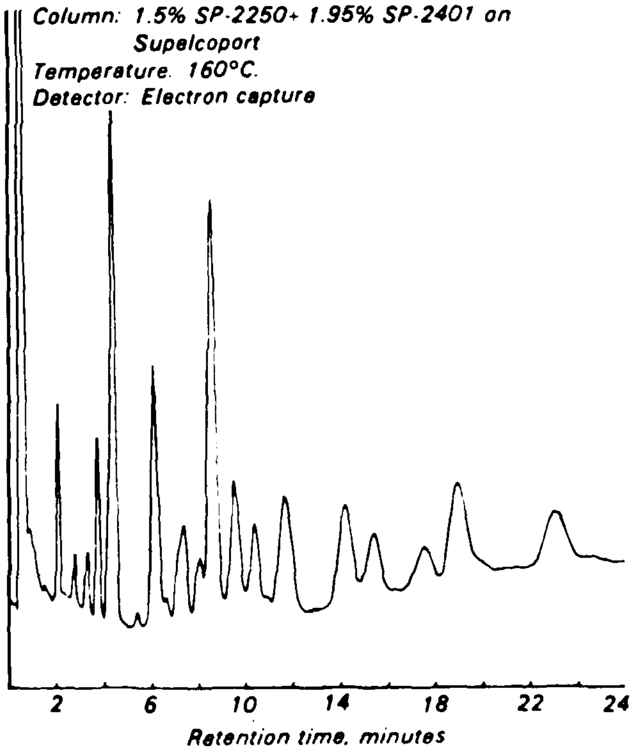

Figure 6. *Gas chromatogram of PCB-1232*

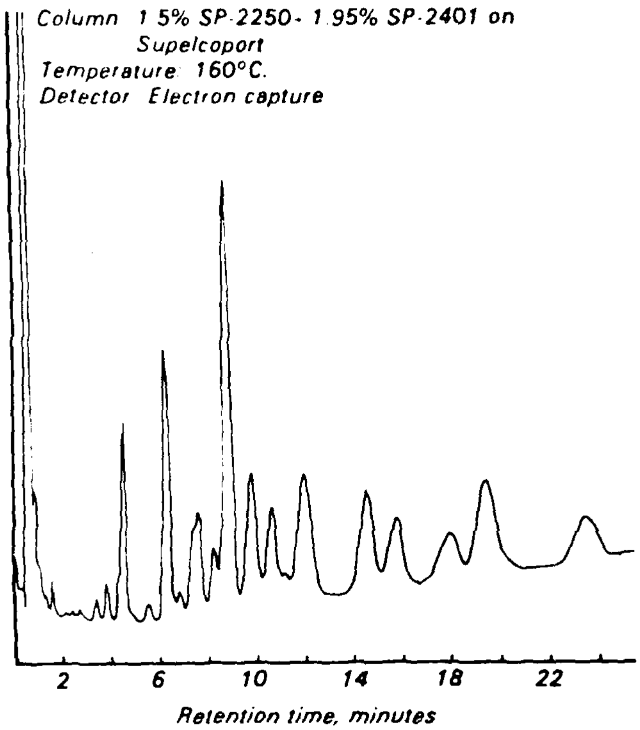

Figure 7. Gas chromatogram of PCB-1242.

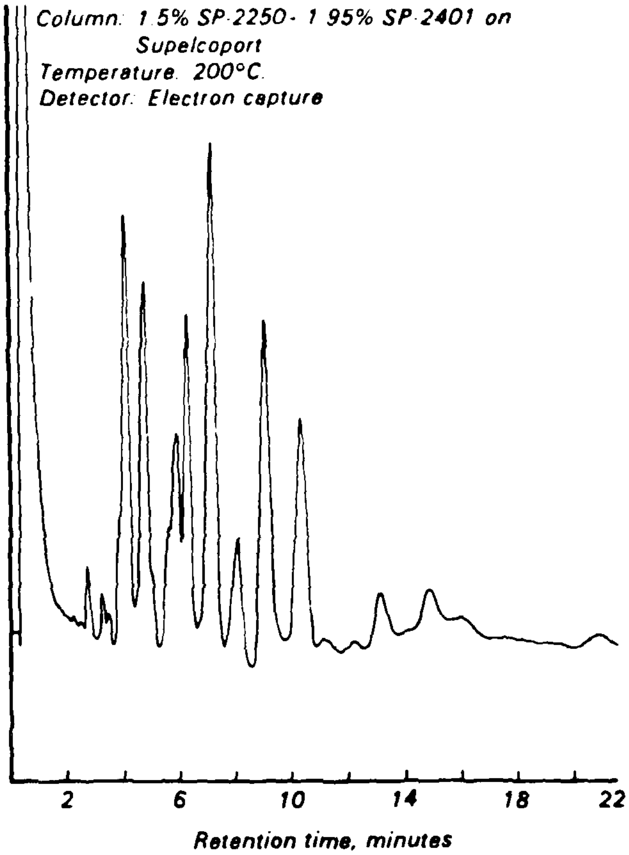

Figure 9. Gas chromatogram of PCB-1254.

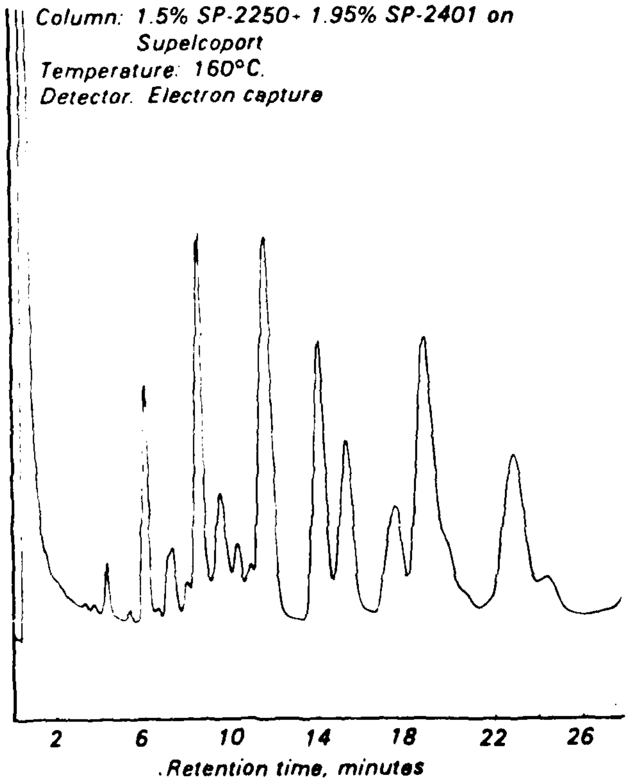

Figure 8. Gas chromatcgram of PCB-1248.

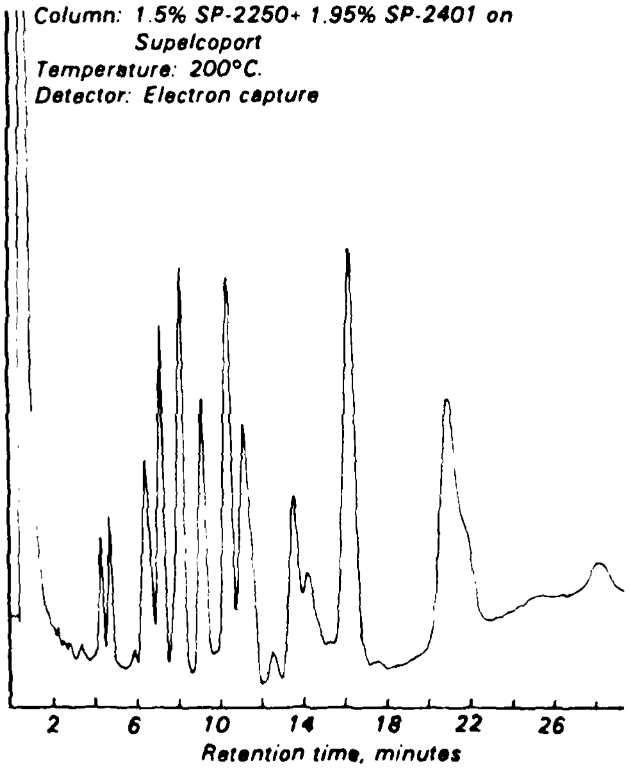

Figure 10. Gas chromatogram of PCB-1260.

APPENDIX H

Raw Laboratory Data

TABLE 4-1 SUMMARY OF WATER QUALITY ANALYTICAL RESULTS
ZONE 1 AND LANDFILLS 2 AND 3

Well	Location	TOC mg/l	TOX ug/l	CN- ug/l	Phenol ug/l	O&G mg/l	Cu ug/l	Cd ug/l	Ni ug/l	As ug/l	Cr ug/l	Pb ug/l
1	Zone 1	133	17.3	30	60	1.1	160	<10	170	<10	<50	<20
2	Zone 1	18.6	5.1	27	10	<0.1	60	<10	120	<10	<50	<20
3	Zone 1	20.8	260.2	45	456	6.29	210	<10	130	<10	<50	<20
4	Zone 1	25.1	<5.0	79	11	0.15	50	<10	120	<10	<50	<20
5	Zone 1	130	9.9	20	115	0.66	60	<10	110	11.8	<50	<20
6	Landfill 2	28.4	82.9	13	21	<0.1	60	<10	140	10	<50	<20
7	Landfill 2	7.5	443.9	<10	166	1.08	<50.0	<10	130	41.1	<50	<20
8	Landfill 2	4.1	229.8	18	398	<0.1	<50.0	<10	140	<10	<50	<20
9	Landfill 3	730	332.1	<10	99	0.38	110	<10	130	<10	<50	<20
10	Landfill 3	15.1	14.3	20	9	0.22	70	<10	120	<10	<50	<20
11	Landfill 3	17.4	16.2	40	< 1	<0.1	50	<10	100	<10	<50	<20
Detection Limit		1	5.0	10	1	0.1	50	10	100	10	50	20

SUMMARY OF WATER QUALITY ANALYTICAL RESULTS FOR BOMARC, BULK FUEL STORAGE AND FIRE TRAINING AREA

Well	Location	TOC mg/l	TOX ug/l	Oil & Grease mg/l	Hydrazine ug/l	Nitrates mg/l	Cd ug/l	Ni ug/l	Cr ug/l	Pb ug/l
12	Bulk Fuel Storage	81.0	81.7	6.37	-	-	<10	130	<50	<20
13	Bulk Fuel Storage	10.5	18.1	0.46	-	-	<10	160	<50	<20
14	Fire Training Area 1	5.5	6.3	0.66	-	-	-	-	-	-
15	Fire Training Area 1	7.5	6.1	0.16	-	-	-	-	-	-
16	BOMARC	15.8	-	0.25	< 50	0.88	-	-	-	-
17	BOMARC	4.7	-	0.16	< 50	8.5	-	-	-	-
Detection Limit		1	5	0.10	50	0.1	10	100	50	20

\- Not analyzed

SUMMARY OF SOIL AND WATER ANALYTICAL RESULTS FOR THE PESTICIDE WASH AREA

Soil Boring Samples	Dieldrin (ug/kg)	DDE (ug/kg)	DDT (ug/kg)	DDD (ug/kg)	Chlordane (ug/kg)
TB-1 1-2'	4.5	9.0	110	.02	39
TB-1 4-5'	2.1	1.3	7.6	.02	19
TB-2 1-2'	3.2	1.6	13	13	< .02
Surface Water	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
SW-1	< .02	< .02	< .02	0.6	< .02
SW-2	.17	.18	1.7	1.5	1.8
SW-3	< .02	< .02	0.7	< .02	< .02
Detection Limit H_2O	.02	.02	.02	.02	.02
Stream Sediments	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
SS-1	150	120	1,600	2,800	12,000
SS-2	250	200	1,800	3,700	8,800
SS-3	20	40	360	430	3,600
Detection Limit Soils	.02	.02	.02	.02	.02

SUMMARY OF SOILS
ANALYTICAL RESULTS FOR THE DPDO STORAGE AREA

Location	Boring No.	Depth (ft.)	Oil & Grease (mg/kg)	PCB (as 1260) (ug/kg)
DPDO	TB-3	1-2	6360.0	24
Loading and Drum Storage Area	TB-3	4.5-6	31.4	<10
"	TB-3	15-16	53.5	<10
"	TB-4	1-2	132.0	<10
"	TB-4	4-5	20.8	--
"	TB-4	14.5-16	17.5	--
DPDO, Buried Tank Area	TB-5	1-2	3430.0	30
"	TB-5	4-5	234,000.0	<10
"	TB-5	14.5-16	149.0	<10
"	TB-6	1-2	1,454.0	<10
"	TB-6	4-5	25,400.0	<10
"	TB-6	14.5-16	97.5	<10
"	TB-7	1-2	617.0	14
"	TB-7	4-5	16,600.0	<10
"	TB-7	16-18	112.0	10
DETECTION LIMIT			0.1	10

APPENDIX I

Federal and State Drinking Water and Human Health Standards Applicable in the State of New Jersey

GUIDE TO GROUND-WATER STANDARDS OF THE UNITED STATES

API PUBLICATION 4366

JULY 1983

Prepared by
Ecological Analysts, Inc.
15 Loveton Circle
Sparks, Maryland 21152

3. *FEDERAL PROTECTION OF GROUND-WATER QUALITY*

The federal programs dealing with the protection of ground-water quality are administered largely by the Environmental Protection Agency (EPA). The federal programs which provide the framework for state regulations are summarized in this section.

3.1 GROUND-WATER PROTECTION POLICY

At this writing, February 1983, U.S. EPA's final policy on ground-water protection, scheduled for September 1982 release, has not been published. Based on the proposed strategy published by EPA in November 1980 and recent press releases, it appears that EPA will be implementing a policy that would give the states lead responsibility in the protection of ground-water quality. EPA's efforts apparently will be focused in three major areas:

1. Development of an internally consistent federal approach to ground-water protection
2. Monitoring, research and development efforts directed toward more comprehensive problem definition and new detection, controls, and clean-up technology development
3. Guidance, coordination, and assistance to states in the development of state policies

A significant component of EPA's policy is expected to be a ground-water classification system which could be used to determine the degree of protection needed for various types of ground water. Ground-water classification is discussed in Chapter 4.

3.2 CLEAN WATER ACT

This statute refers to ground-water protection in municipal waste water treatment, planning, and research programs. Its principal regulatory programs, however, focus on surface water. Section 303 empowers EPA to approve states' water quality standards which are based on the states' classification of rivers and streams. Many states have included ground water in their definition of "waters of the state" for purposes of this act (state summaries). On this basis the National (state) Pollutant Discharge Elimination System (NPDES/SPDES) permitting process may be invocable for purposes of ground-water protection. In addition the act empowers EPA to

1. Develop a comprehensive program for ground-water pollution control [Section 102(a)]
2. In cooperation with states, equip and maintain a surveillance system for monitoring ground-water quality [Section 104(a)(5)]
3. Provide grants to states and area-wide agencies to develop ground-water quality management plans to identify salt water intrusion and control disposal of pollutants in subsurface excavations, and control disposition of wastes. (May include authority for comprehensive ground-water management plans, including conjunctive use with surface water) [Section 102(c), 208(b)]
4. Require development of Best Management Practices (BMP) to control nonpoint source pollution problems to ground-water quality [Section 208(b)]
5. Develop criteria for ground-water quality considering kind and extent of effects on health and welfare from the presence of pollutants [Section 304(a)]
6. Determine information necessary to restore and maintain chemical, physical, and biological integrity of ground water [Section 304(a)]
7. Issue information on the factors necessary to restore and maintain chemical, physical, and biological integrity of ground water [Sections 304(a)(2)]

3.3 SAFE DRINKING WATER ACT

This statute authorizes EPA to set maximum contaminant levels (MCLs) and monitoring requirements for public water systems and provides for the protection of underground sources of drinking water. The MCLs regulate the quality of "finished" water, i.e., water as delivered, not the quality of the source water. As discussed below, the MCLs have been utilized by EPA and the states as the basis for other regulations dealing with ground-water quality and protection

3.3.1 National Interim Primary Drinking Water Regulations

EPA initiated a detailed study of the health effects of various contaminants in water soon after the Safe Drinking Act (SDWA) was signed into law. So that the regulations could include the findings of this and other studies, the primary drinking water regulations were to be developed in two stages: an interim version and a final version. The interim version of the regulation became effective 24 June 1977. SDWA provides for delegation of authority to the states. State Primary Drinking Water Regulations must be at least as stringent as the federal regulations.

The National Interim Primary Drinking Water Regulations define Maximum Contaminant Level as the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system, except in the case of turbidity (applicable to surface water only) where the maximum permissible level is measured at the point of entry to the distribution system. The MCLs are provided with the state summaries.

3.3.2 National Secondary Drinking Water Regulations

These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. At considerably higher concentrations of these contaminants health implications may also exist as well as aesthetic degradation. The National Secondary Drinking Water Regulations are not federally enforceable but are intended as guidelines for the states.

Secondary Maximum Contaminant Levels (SMCLs) are defined as the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system. Federal and state SMCLs are provided in the state summaries. The states may establish higher or lower levels which may be appropriate depending upon local conditions such as unavailability of alternate sources of water or other compelling factors, provided the public health and welfare are not adversely affected.

3.3.3 Sole Source Aquifer

The Sole Source Aquifer provisions of SDWA allow EPA to designate an aquifer as the sole source of drinking water for an area thereby guaranteeing protection from contamination by federally assisted activities. Local, regional, or state agencies can petition EPA for sole source designation. The EPA Administrator may designate an aquifer which is a sole or principal drinking water source if its contamination would create a significant hazard to public health. If the designation is made, no federal money or financial commitment may be made for any project which the Administrator determines may contaminate the designated aquifer through its recharge zone.

At this writing, February 1983, EPA has designated the following ten sole source aquifers:

Biscayne Aquifer - Florida
Buried Valley Aquifer - New Jersey
Edwards Aquifer - Texas
Camano Island—Whidbey Island Aquifer - Washington
Spokane-Rathdrum Aquifer - Washington and Idaho
Nassau and Suffolk counties - New York
Cape Cod - Massachusetts
Fresno - California
Ten Mile Creek - Maryland
Northern Guam Lens - Guam

The following eighteen are under consideration:

Arizona
  Santa Cruz, Upper Santa Cruz, Aura-Altar Basins

  California
  Scotts Valley

Delaware
  New Castle County

Florida
  Volusia - Floridan Aquifer

Idaho
  Snake River Plain

Louisiana
  Baton Rouge
  DeSota Parish

New Jersey
  Coastal Plain
  Ridgewood
  Upper Rockaway

New York
  Kings and Queens counties
  Sardinia
  Schenectady
  Vestal

Pennsylvania
  Seven Valleys

Texas
  Carrizo-Wilcox Aquifer

Texas and New Mexico
  Delaware Basin

Wisconsin
  Niagara Aquifer

3.6 RESOURCE CONSERVATION AND RECOVERY ACT

The Solid Waste Disposal Act and the Resource Recovery Act of 1970, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), require EPA to establish a national program to regulate the management of waste materials.

3.6.1 Solid Waste

Subtitle D of RCRA established a broad-based national program to improve solid waste management through the development of state and regional solid waste management plans. The act offered federal financial assistance to states interested in developing and implementing a solid waste management plan. The state plans, under federal guidelines, identify respective responsibilities of local, state, and regional authorities, and encourage resource recovery and conservations and the application and enforcement of environmentally sound disposal practices.

A major element of the Subtitle D program is the open dump inventory. Section 4005 of RCRA prohibits open dumping. Federal criteria for classifying solid waste management facilities are provided in 40 CFR 257. EPA cannot approve a state solid waste management program with less stringent criteria. Solid waste management facilities failing to satisfy the criteria are considered open dumps. In order to satisfy these criteria, a facility or practice (in addition to other environmental considerations) shall not contaminate an underground drinking water source beyond the solid waste boundary or beyond an alternative boundary established by the state or in court persuant to the stipulations of 40 CFR 257.3-4. The federal criteria define contamination as an exceedence of the MCLs provided in the National Interim Primary Drinking Water Regulations or an increase in concentration of any parameter for which the ambient concentration exceed the MCL.

3.6.2 Hazardous Waste

EPA has issued a series of hazardous waste regulations under Subtitle C of RCRA (40 CFR 260 to 267 and 122 to 124). On 19 May 1980, EPA issued a comprehensive set of standards for generators and transporters of hazardous waste and "interim status" standards for facilities in existence on 19 November 1980, that treat, store, or dispose of hazardous waste. Such facilities were allowed to operate under interim status until they received an RCRA permit. Subsequently, EPA issued standards for granting RCRA permits to treatment and storage facilities. Standards for land disposal facilities were issued on 26 July 1982—virtually completing the program for controlling hazardous waste under RCRA.

The standards for permitting land disposal facilities were issued after a wide range of regulatory options were considered. Over a period of several years, EPA proposed two different sets of land disposal standards and solicited comments on various issues. On 13 February 1981, EPA issued temporary standards for new land disposal facilities. The 26 July regulations replace those temporary standards except for Class I underground injection wells. These will remain subject to the temporary standards until final standards are issued.

The regulations consist primarily of two complementary sets of performance standards:

1. A set of design and operating standards tailored to each of four types of facilities
2. Ground-water monitoring and response regulations applicable to all land disposal facilities

The design and operating standards implement a liquids management strategy that has two goals:

1. Minimize leachate generated at the facility
2. Remove leachate generated to minimize its chance of reaching ground water

The major requirements include

1. Liner
   - Requirement: design to prevent migration of waste out of the facility during its active life
   - Applicability: landfills, surface impoundments, and waste piles
2. Leachate collection and removal
   - Requirement: collect and remove leachate from the facility and ensure that leachate depth over the liner does not exceed 30 centimeters (1 foot)
   - Applicability: landfills and waste piles

3. Run-on and runoff control systems
    - Requirement: design to control flow during at least 25-year storm
    - Applicability: landfills, waste piles, land treatment
4. Wind dispersal controls
    - Requirement: cover waste or otherwise manage unit to control wind dispersal
    - Applicability: landfills, waste piles, and land treatment units that contain particulate matter
5. Overtopping controls
    - Requirement: prevent overtopping or overfilling
    - Applicability: surface impoundments
6. Disposal unit closure
    - Requirement: final cover (cap) over waste unit designed to minimize infiltration of precipitation
    - Applicability: landfills and surface impoundments (if used for disposal)
7. Storage unit closure
    - Requirement: remove waste and decontaminate
    - Applicability: surface impoundments used for treatment or storage and waste piles
8. Postclosure Care
    - Maintain effectiveness of final cover
    - Operate leachate collection and removal system
    - Maintain ground-water monitoring system (and leak detection system where double liner is used)
    - Continue 30 years after closure

The goal of the ground-water monitoring and response program is to detect and correct any ground-water contamination. There are four main elements:

1. A detection monitoring program which requires the permittee to install a system to monitor ground water in the uppermost aquifer to determine if a leachate plume has reached the edge of the waste management area.
2. A ground-water protection standard is set when a hazardous constituent is detected. The standard specifies concentration limits, compliance point, and compliance period.
3. A compliance monitoring program determines if the facility is complying with its ground-water protection standard.
4. Corrective action is required when the ground-water protection standard is violated. The permittee must either remove the contamination or treat it in place to restore ground-water quality.

Until hazardous waste management facilities are issued permits, existing facilities will continue to operate under interim status standards. Facilities operating under interim status will be required to file Part B applications for final permits.

Under Subtitle C of RCRA, EPA approves state hazardous waste management programs in two phases. Phase I authorization gives states the right to control transportation and generation of hazardous wastes within their borders and to regulate existing treatment, storage, and disposal facilities. Phase II authorization includes the permitting of new facilities.

3.7 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

This statute (CERCLA), commonly referred to as Superfund, authorizes EPA to respond to releases or threatened releases into the environment, including ground water, of any hazardous substance which may present an imminent and substantial danger to public health. The act provides funds for emergency action and has cost recovery provisions.

3.3.4 Underground Injection Control

The Underground Injection Control (UIC) program regulates the uses of underground injection wells to protect an underground source of drinking water (USDW). USDW means an aquifer or its portion which

1. supplies any public water system or contains a sufficient quantity of ground water to supply a public water system;
2. currently supplies drinking water for human consumption or contains less than 10,000 mg/liter total dissolved solids; and
3. is not an exempted aquifer (40 CFR 146.04 provides criteria for exemption).

SDWA requires any state designated by EPA as requiring a UIC program to develop and submit a state UIC program for EPA approval. EPA has designated each of the fifty states.

The federal program classifies injection wells as follows:

Class I—Wells used to inject hazardous waste, or other industrial and municipal disposal wells which inject fluids beneath the lower-most formation containing a USDW within one-quarter mile of the well bore.

Class II—Wells that inject fluids

1. which are brought to the surface as part of conventional oil or natural gas production and may be mixed with production waste waters from gas plants, unless those waters are classified as a hazardous waste at the time of injection;
2. for enhanced recovery of oil or natural gas; and
3. for storage of hydrocarbons which are liquid at standard temperature and pressure.

Class III—Wells that inject for extraction of minerals including

1. mining of sulfur by the Frasch process;
2. in situ production of uranium or other metals. This category includes only in situ production from ore bodies which have not been conventionally mined. Solution mining of conventional mines such as stopes leaching is included in Class V; and
3. solution mining of salts or potash.

Class IV—Wells used to dispose of hazardous or radioactive waste into or above a formation which contains a USDW within one-quarter mile of the well. Also, wells used to inject hazardous waste that cannot be classified as Class I or Class IV under the above criteria are Class IV wells.

Class V—All other injection wells (40 CFR 146.05(e) and 146.51 provide specific information and exemptions).

Underground injection is controlled through the permitting process. Construction, operation, monitoring and reporting activities are controlled. Individual state programs are based upon, and must be essentially equivalent to, the federal criteria and standards (40 CFR 146).

3.4 TOXIC SUBSTANCE CONTROL ACT

This statute (TSCA) authorizes EPA to restrict or prohibit the manufacture, distribution, and use of products which may result in unreasonable risk to health and the environment. Although ground water is not specifically named in the Act, EPA has taken the position that the protection of health and the environment includes the protection of ground water.

3.5 FEDERAL INSECTICIDE, FUNGICIDE, RODENTICIDE ACT

This statute (FIFRA) gives EPA the responsibility to control the sale and use of all pesticides to prevent unreasonable adverse environmental and health effects. The use and disposal of pesticide packages and containers is also regulated. In deciding whether to register, cancel, suspend, or change the classification of a pesticide, EPA considers a broad range of environmental impacts including those affecting ground water.

NEW JERSEY

Classification–Ground water is included in the definition of "waters" as found in the New Jersey Water Pollution Control Laws. A ground-water classification system is in effect, with ground water classified according to total dissolved solids content. Class I ground waters have a TDS content of 500 mg/liter or less. Class 2 ground waters have a TDS content of 10,000 mg/liter or less. Ground water of the Pine Lands is classified separately for special protection.

Quality Standards–Ground-water quality standards have been adopted that are the same as the federal primary drinking water standards. These standards are part of the NJPDES permit program.

Drinking Water Standards–The New Jersey Department of Environmental Protection has adopted the federal primary and secondary drinking water standards.

Appropriation–The reasonable use system governs ground-water allocations in New Jersey. All users of ground water in excess of 100,000 gallons per day need a diversion permit from the Department of Environmental Protection.

Controlled Use Areas–The Pinelands area is subject to special requirements for ground-water withdrawals

Well Construction–Well permits and records are required for all wells drilled in New Jersey.

Underground Injection Control–New Jersey has developed a state UIC program that has been submitted for EPA approval. The Division of Waste Management in the Department of Environmental Protection will be the lead agency in the program. Currently, Class V injection wells are permitted by the DEP, and Class IV wells are prohibited.

Waste Management Facilities–The solid and hazardous waste management programs are administered by the Department of Environmental Protection.

> **Solid Waste**–The New Jersey Solid Waste Regulations and NJPDES Regulations state that all disposal sites must install a ground-water monitoring system. Minimum requirements are established for quarterly and annual monitoring. All disposal sites must receive a NJPDES permit.
>
> **Hazardous Waste**–New Jersey has received interim status authority for its RCRA Phase I program and is seeking Phase II authority. Ground-water monitoring requirements are included in the NJPDES regulations and are equivalent to 40 CFR 265, F.

Sole Source Aquifers–The Buried Valley aquifer in Passaic County has been designated as such, and the Coastal Plain aquifers and the towns of Ridgewood and Upper Rockaway are under consideration by EPA.

Geological Surveys–

New Jersey Geological Survey
Division of Water Resources
Department of Environmental
Protection
P.O. Box CN029
Trenton, NJ 08625
609-292-2576
State Geologist:
Mr. Frank Markewicz

Water Resources Division
U.S. Geological Survey
Room 430, Federal Building
402 E. State St.
Trenton, NJ 08608
609-989-2162
District Chief:
D.E. Vaupel

References–

New Jersey Water Pollution Control Regulations
(N.J.A.C., Title 7, Ch. 14, Part 1)

New Jersey Solid and Hazardous Waste
Management Regulations
(N.J.A.C., Title 7, Ch. 26)

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Comments provided by Mr. Haig Kasabach in a letter received March 1983

ENVIRONMENTAL PROTECTION AGENCY NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

(40 CFR 141; 40 FR 59565, December 24, 1975; Amended by 41 FR 28402, July 9, 1976; 44 FR 68641, November 29, 1979; Corrected by 45 FR 15542, March 11, 1980; 45 FR 57342, August 27, 1980)

Title 40 -Protection of Environment
CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER D—WATER PROGRAMS

PART 141 —NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Subpart A—General

Subpart B—Maximum Contaminant Levels

Subpart C—Monitoring and Analytical Requirements

Subpart D—Reporting, Public Notification, and Record keeping

Subpart E—Special Monitoring Regulations for Organic Chemicals

Authority: Secs. 1412, 1414, 1445, and 1450 of the Public Health Service Act, 88 Stat. 1660 (42 U.S.C. 300g-1, 300g-3, 300j-4, and 300j-9).

Subpart A—General

§ 141.1 Applicability.

This part establishes primary drinking water regulations pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93-523); and related regulations applicable to public water systems.

§ 141.2 Definitions.

As used in this part, the term:

(a) "Act" means the Public Health Service Act, as amended by the Safe Drinking Water Act, Pub. L. 93-523.

(b) "Contaminant" means any physical, chemical, biological, or radiological substance or matter in water.

(c) "Maximum contaminant level" means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

(d) "Person" means an individual, corporation, company, association, partnership, State, municipality, or Federal agency.

(e) "Public water system" means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. A public water system is either a "community water system" or a "no
community water system."

(i) "Community water system" mea
a public water system which serves
least 15 service connections used by yea
round residents or regularly serves
least 25 year-round residents.

(ii) "Non-community water syste
means a public water system that is
a community water system.

(f) "Sanitary survey" means an
site review of the water source, fac
ties, equipment, operation and main
nance of a public water system for
purpose of evaluating the adequacy
such source, facilities, equipment,
eration and maintenance for produc
and distributing safe drinking water.

(g) "Standard sample" means
aliquot of finished drinking water tha
examined for the presence of colif
bacteria.

(h) "State" means the agency of
State government which has juris
tion over public water systems. Du
any period when a State does not
primary enforcement responsib
pursuant to Section 1413 of the Act,
term "State" means the Regional
ministrator, U.S. Environmental Pro
tion Agency.

(i) "Supplier of water" means
person who owns or operates a p
water system.

(j) "Dose equivalent" means the
uct of the absorbed dose from ion
radiation and such factors as accoun
differences in biological effectiveness
to the type of radiation and its dist
tion in the body as specified by the
ternational Commission on Radiolo
Units and Measurements (ICRU).

(k) "Rem" means the unit of
equivalent from ionizing radiation to
total body or any internal organ or o
system. A "millirem (mrem)" is 1
of a rem.

(l) "Picocurie (pCi)" means that q
tity of radioactive material prod
2.22 nuclear transformations per min

(m) "Gross alpha particle acti
means the total radioactivity du
alpha particle emission as inferred
measurements on a dry sample.

(n) "Man made beta particle and
ton emitters" means all radionu
emitting beta particles and/or ph

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listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure*, NBS Handbook 69, except the daughter products of thorium 232, uranium 235 and uranium 238.

(o) "Gross beta particle activity" means the total radioactivity due to beta particle emission as inferred from measurements on a dry sample.

[41 FR 28402, July 9, 1976]
[141.2 (p)-(t) added by 44 FR 68641, November 29, 1979]

(p) "Halogen" means one of the chemical elements chlorine, bromine or iodine.

(q) "Trihalomethane" (THM) means one of the family of organic compounds, named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure.

(r) "Total trihalomethanes" (TTHM) means the sum of the concentration in milligrams per liter of the trihalomethane compounds (trichloromethane [chloroform], dibromochloromethane, bromodichloromethane and tribromomethane [bromoform]), rounded to two significant figures.

(s) "Maximum Total Trihalomethane Potential (MTP)" means the maximum concentration of total trihalomethanes produced in a given water containing a disinfectant residual after 7 days at a temperature of 25° C or above.

(t) "Disinfectant" means any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone added to water in any part of the treatment or distribution process, that is intended to kill or inactivate pathogenic microorganisms.

§ 141.3 Coverage.

This part shall apply to each public water system, unless the public water system meets all of the following conditions:

(a) Consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(b) Obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(c) Does not sell water to any person; and

(d) Is not a carrier which conveys passengers in interstate commerce.

§ 141.4 Variances and exemptions.

Variances or exemptions from certain provisions of these regulations may be granted pursuant to Sections 1415 and 1416 of the Act by the entity with primary enforcement responsibility. Provisions under Part 142, *National Interim Primary Drinking Water Regulations Implementation*—subpart E (Variances) and subpart F (Exemptions) apply where EPA has primary enforcement responsibility.

§ 141.5 Siting requirements.

Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall notify the State and, to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(a) Is subject to a significant risk from earthquakes, floods, fires or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(b) Except for intake structures, is within the floodplain of a 100-year flood or is lower than any recorded high tide where appropriate records exist.
The U.S. Environmental Protection Agency will not seek to override land use decisions affecting public water systems siting which are made at the State or local government levels.

§ 141.6 Effective dates.

[141.6 revised by 44 FR 68641, November 29, 1979]

(a) Except as provided in paragraph (b) of this section, the regulations set forth in this part shall take effect on *June 24, 1977.*

(b) The regulations for total trihalomethanes set forth in § 141.12(c) shall take effect 2 years after the date of promulgation of these regulations for community water systems serving 75,000 or more individuals, and 4 years after the date of promulgation for communities serving 10,000 to 74,999 individuals.

(c) The regulations set forth in 141.11 (a), (c) and (d); 141.14(a)(1); 141.14(b)(1)(c); 141.14(b)(2)(i); 141.14(d); 141.21 (a), (c) and (i); 141.22 (a) and (e); 141.23 (a)(3) and (a)(4); 141.23(f); 141.24(a)(3); 141.24 (e) and (f); 141.25(e); 141.27(a); 141.28 (a) and (b); 141.31 (a), (c), (d) and (e); 141.32(b)(3); and 141.32(d) shall take effect immediately upon promulgation.

(d) The regulations set forth in 141.41 shall take effect 18 months from the date of promulgation. Suppliers must complete the first round of sampling and reporting within 12 months following the effective date.

(e) The regulations set forth in 141.42 shall take effect 18 months from the date of promulgation. All requirements in 141.42 must be completed within 12 months following the effective date.

[141.6 (c)-(e) added by 45 FR 57342, August 27, 1980]

Subpart B—Maximum Contaminant Levels

§ 141.11 Maximum contaminant levels for inorganic chemicals.

(a) The MCL for nitrate is applicable to both community water systems and non-community water systems except as provided by in paragraph (d). The levels for the other organic chemicals apply only to community water systems. Compliance with MCLs for inorganic chemicals is calculated pursuant to § 141.23.

[141.11(a) amended by 45 FR 57342, August 27, 1980]

(b) The following are the maximum contaminant levels for inorganic chemicals other than fluoride:

Contaminant	Level, milligrams per liter
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

(c) When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature Degrees Fahrenheit	Degrees Celsius	Level, milligrams per liter
53.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

(c) Fluoride at optimum level in drinking water has been shown to have beneficial effects in reducing the occurrence of tooth decay.

[141.11 (c) amended by 45 FR 57342, August 27, 1980]

(d) At the discretion of the State, nitrate levels not to exceed 20 mg/l may be allowed in a non-community water system if the supplier of water demonstrates to the satisfaction of the State that:

(1) Such water will not be available to children under 6 months of age; and

(2) There will be continuous posting of the fact that nitrate levels exceed 10 mg/l and the potential health effects of exposure; and

(3) Local and State public health authorities will be notified annually of nitrate levels that exceed 10 mg/l; and

(4) No adverse health effects shall result.

[141.11 (d) added by 45 FR 57342, August 27, 1980]

federal register

Friday
November 28, 1980

Part V

Environmental Protection Agency

Water Quality Criteria Documents; Availability

§ 141.12 Maximum contaminant levels for organic chemicals.

[141.12 revised by 44 FR 68641, November 29, 1979]

The following are the maximum contaminant levels for organic chemicals. The maximum contaminant levels for organic chemicals in paragraphs (a) and (b) of this section apply to all community water systems. Compliance with the maximum contaminant levels in paragraphs (a) and (b) is calculated pursuant to § 141.24. The maximum comtaminant level for total trihalomethanes in paragraph (c) of this section applies only to community water systems which serve a population of 10,000 or more individuals and which add a disinfectant (oxidant) to the water in any part of the drinking water treatment process. Compliance with the maximum contaminant level for total trihalomethanes is calculated pursuant to § 141.30.

	Level, milligrams per liter	
(a) Chlorinated hydrocarbons:		
Endrin (1,2,3,4,10, 10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene).	0.0002	0.2 ppb
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer).	0.004	4 ppb
Methoxychlor (1,1,1-Trichloro-2, 2-bis [p-methoxyphenyl] ethane).	0.1	100 ppb
Toxaphene ($C_{10}H_{10}Cl_8$, Technical chlorinated camphene, 67-69 percent chlorine)	0.005	5 ppb
(b) Chlorophenoxys		
2,4-D, (2,4-Dichlorophenoxyacetic acid)	0.1	100 ppb
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid)	0.01	10 ppb

(c) Total trihalomethanes (the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform)) 0.10 mg/l.

[141.12(c) added by 44 FR 68641, November 29, 1979]

§ 141.13 Maximum contaminant levels for turbidity.

The maximum contaminant levels for turbidity are applicable to both community water systems and non-community water systems using surface water sources in whole or in part. The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system are:

(a) One turbidity unit (TU), as determined by a monthly average pursuant to § 141.22, except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not do any of the following:

(1) Interfere with disinfection;

(2) Prevent maintenance of an effective disinfectant agent throughout the distribution system; or

(3) Interfere with microbiological determinations.

(b) Five turbidity units based on an average for two consecutive days pursuant to § 141.22.

§ 141.14 Maximum microbiological contaminant levels.

The maximum contaminant levels for coliform bacteria, applicable to community water systems and non-community water systems, are as follows:

(a) When the membrane filter technique pursuant to § 141.21(a) is used, the number of coliform bacteria shall not exceed any of the following:

[141.14(a)(1) revised by 45 FR 57342, August 27, 1980]

(1) One per 100 milliliters as the arithmetic mean of all samples examined per compliance period pursuant to § 141.21(b) or (c), except that, at the primacy Agency's discretion systems required to take 10 or fewer samples per month may be authorized to exclude one positive routine sample per month from the monthly calculation if: (i) as approved on a case-by-case basis the State determines and indicates in writing to the public water system that no unreasonable risk to health existed under the conditions of this modification. This determination should be based upon a number of factors not limited to the following: (A) the system provided and had maintained an active disinfectant residual in the distribution system, (B) the potential for contamination as indicated by a sanitary survey, and (C) the history of the water quality at the public water system (e.g. MCL or monitoring violations), (ii) the supplier initiates a check sample on each of two consecutive days from the same sampling point within 24 hours after notification that the routine sample is positive, and each of these check samples is negative, and (iii) the original positive routine sample is reported and recorded by the supplier pursuant to § 141.31(a) and § 141.33(a). The supplier shall report to the State its compliance with the conditions specified in this paragraph and the summary of the corrective action taken to resolve the prior positive sample results. If a positive routine sample is not used for the monthly calculation, another routine sample must be analyzed for compliance purposes. This provision may be used only once during two consecutive compliance periods.

(2) Four per 100 milliliters in more than one sample when less than 20 are examined per month; or

(3) Four per 100 milliliters in more than five percent of the samples when 20 or more are examined per month.

(b)(1) When the fermentation tube method and 10 milliliter standard portions pursuant to § 141.21(a) are used, coliform bacteria shall not be present in any of the following:

[141.14(b)(1)(i) revised by 45 FR 57342, August 27, 1980]

(i) More than 10 percent of the portions (tubes) in any one month pursuant to § 141.21 (b) or (c) except that, at the State's discretion, systems required to take 10 or fewer samples per month may be authorized to exclude one positive routine sample resulting in one or more positive tubes per month from the monthly calculation if: (A) as approved on a case-by-case basis the State determines and indicates in writing to the public water system that no unreasonable risk to health existed under the conditions of this modification. This determination should be based upon a number of factors not limited to the following: (*1*) the system provided and had maintained an active disinfectant residual in the distribution system, (*2*) the potential for contamination as indicated by a sanitary survey, and (*3*) the history of the water quality at the public water system (e.g. MCL or monitoring violations); (B) the supplier initiates a check sample on each of two consecutive days from the sampling point within 24 hours after notification that the routine sample is positive, and each of these check samples is negative; and (C) the original positive routine sample is reported and recorded by the supplier pursuant to § 141.31(a) and § 141.33(a). The supplier shall report to the State its compliance with the conditions specified in this paragraph and report the action taken to resolve the prior positive sample result. If a positive routine sample is not used for the monthly calculation, another routine sample must be analyzed for compliance purposes. This provision may be used only once during two consecutive compliance periods.

(ii) Three or more portions in more than one sample when less than 20 samples are examined per month; or

(iii) Three or more portions in more than five percent of the samples when 20 or more samples are examined per month.

(2) When the fermentation [illegible]

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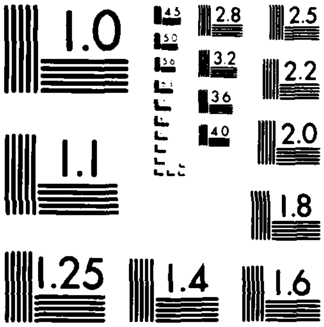

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ENVIRONMENTAL PROTECTION AGENCY

[FRL 1623-3]

Water Quality Criteria Documents; Availability

AGENCY: Environmental Protection Agency.

ACTION: Notice of Water Quality Criteria Documents.

SUMMARY: EPA announces the availability and provides summaries of water quality criteria documents for 64 toxic pollutants or pollutant categories. These criteria are published pursuant to section 304(a)(1) of the Clean Water Act.

AVAILABILITY OF DOCUMENTS: Summaries of both aquatic-based and health-based criteria from the documents are published below. Copies of the complete documents for individual pollutants may be obtained from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, (703–487–4650). A list of the NTIS publication order numbers for all 64 criteria documents is published below. These documents are also available for public inspection and copying during normal business hours at: Public Information Reference Unit, U.S. Environmental Protection Agency, Room 2404 (rear), 401 M St., S.W., Washington, D.C. 20460. As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services. Copies of these documents are also available for review in the EPA Regional Office libraries. [redacted] below. Requests sent to that office will be forwarded to NTIS or returned to the sender.

1. Acenaphthene, PB81–117269.
2. Acrolein, PB81–117277.
3. Acrylonitrile, PB81–117285.
4. Aldrin/Dieldrin, PB81–117301.
5. Antimony, PB81–117319.
6. Arsenic, PB81–117327.
7. Asbestos, PB81–117335.
8. Benzene, PB81–117293.
9. Benzidine, PB81–117343.
10. Beryllium, PB81–117350.
11. Cadmium, PB81–117368.
12. Carbon Tetrachloride, PB81–117376.
13. Chlordane, PB81–117384.
14. Chlorinated benzenes, PB81–117392.
15. Chlorinated ethanes, PB81–117400.
16. Chloroalkyl ethers, PB81–117418.
17. Chlorinated naphthalene, PB81–117426.
18. Chlorinated phenols, PB81–117434.
19. Chloroform, PB81–117442.
20. 2-chlorophenol, PB81–117459.
21. Chromium, PB81–117467.
22. Copper, PB81–117475.
23. Cyanides, PB81–117483.
24. DDT, PB81–117491.
25. Dichlorobenzenes, PB81–117509.
26. Dichlorobenzidine, PB81–117517.
27. Dichloroethylenes, PB81–117525.
28. 2,4-dichlorophenol, PB81–117533.
29. Dichloropropanes/propenes, PB81–117541.
30. 2,4-dimethylphenol, PB81–117558.
31. Dinitrotoluene, PB81–117566.
32. Diphenylhydrazine, PB81–117731.
33. Endosulfan, PB81–117574.
34. Endrin, PB81–117582.
35. Ethylbenzene, PB81–117590.
36. Fluoranthene, PB81–117608.
37. Haloethers, PB81–117616.
38. Halomethanes, PB81–117624.
39. Heptachlor, PB81–117632.
40. Hexachlorobutadiene, PB81–117640.
41. Hexachlorocyclohexane, PB81–117657.
42. Hexachlorocyclopentadiene, PB81–117665.
43. Isophorone, PB81–117673.
44. Lead, PB81–117681.
45. Mercury, PB81–117699.
46. Naphthalene, PB81–117707.
47. Nickel, PB81–117715.
48. Nitrobenzene, PB81–117723.
49. Nitrophenols, PB81–117749.
50. Nitrosamines, PB81–117756.
51. Pentachlorophenol, PB81–117764.
52. Phenol, PB81–117772.
53. Phthalate esters, PB81–117780.
54. Polychlorinated biphenyls (PCBs), PB81–117798.
55. Polynuclear aromatic hydrocarbons, PB81–117806.
56. Selenium, PB81–117814.
57. Silver, PB81–117822.
58. Tetrachloroethylene, PB81–117830.
59. Thallium, PB81–117848.
60. Toluene, PB81–117855.
61. Toxaphene, PB81–117863.
62. Trichloroethylene, PB81–117871.
63. Vinyl chloride, PB81–117889.
64. Zinc, PB81–117897.

FOR FURTHER INFORMATION CONTACT: Dr. Frank Gostomski, Criteria and Standards Division (WH–585), United States Environmental Protection [redacted]

SUPPLEMENTARY INFORMATION:

Background

Pursuant to section 304(a)(1) of the Clean Water Act, 33 U.S.C. 1314(a)(1), EPA is required to periodically review and publish criteria for water quality accurately reflecting the latest scientific knowledge:

(A) on the kind and extent of all identifiable effects on health and welfare including, but not limited to, plankton, fish, shellfish, wildlife, plant life, shorelines, beaches, esthetics, and recreation which may be expected from the presence of pollutants in any body of water, including ground water, (B) on the concentration and dispersal of pollutants, or their byproducts, through biological, physical, and chemical processes, and (C) on the effects of pollutants on biological community diversity, productivity, and stability, including information on the factors affecting rates of eutrophication and rates of organic and inorganic sedimentation for varying types of receiving waters.

EPA is today announcing the availability of criteria documents for 64 of the 65 pollutants designated as toxic under section 307(a)(1) of the Act. The document on TCDD (Dioxin) will be published within the next month after review of recent studies. Criteria for the section 307(a)(1) toxic pollutants being published today will replace the criteria for those same pollutants found in the EPA publication, *Quality Criteria for Water*, (the "Red Book.") Criteria for all other pollutants and water constituents found in the "Red Book" remain valid. The criteria published today have been derived using revised methodologies for determining pollutant concentrations that will, when not exceeded, reasonably protect human health and aquatic life. Draft criteria documents were made available for public comment (44 FR 15926, March 15, 1979, 44 FR 43660, July 25, 1979, 44 FR 56628, October 1, 1979). These final criteria have been derived after consideration of all comments received.

These criteria documents are also issued in satisfaction of the Settlement Agreement in *Natural Resources Defense Council, et al.* v. *Train*, 8 E.R.C. 2120 (1976), modified, 12 E.R.C. 1833 (D.D.C. 1979). Pursuant to paragraph 11 of that agreement, EPA is required to publish criteria documents for the 65 pollutants which Congress, in the 1977 amendments to the Act, designated as toxic under section 307(a)(1). These documents contain recommended maximum permissible pollutant concentrations consistent with the protection of aquatic organisms, human health, and some recreational activities. Although paragraph 11 imposes certain obligations on the Agency, it does not create additional authority.

The Development of Water Quality Criteria

Section 304(a)(1) criteria contain two essential types of information: (1) discussions of available scientific data on the effects of pollutants on public health and welfare, aquatic life and recreation, and (2) quantitative concentrations or qualitative assessments of the pollutants in water which will generally ensure water quality adequate to support a specified water use. Under section 304(a)(1), these criteria are based solely on data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects. Criteria values do not reflect considerations of economic or technological feasibility.

Publication of water quality criteria of this type has been an ongoing process which EPA, and its predecessor Agency, the Federal Water Pollution Control Administration, have been engaged in since 1968. At that time the first Federal compilation of water quality criteria, the so-called "Green Book" *(Water Quality Criteria)*, was published. As now, these criteria contained both narrative discussions of the environmental effects of pollutants on a range of possible uses and concentrations of pollutants necessary to support these uses. Since that time, water quality criteria have been revised and expanded with publication of the "Blue Book" *(Water Quality Criteria 1972)* in 1973 and the "Red Book" *(Quality Criteria for Water)* in 1976.

Since publication of the Red Book there have been substantial changes in EPA's approach to assessing scientific data and deriving section 304(a)(1) criteria. Previous criteria were derived from a limited data base. For many pollutants, an aquatic life criterion was derived by multiplying the lowest concentration known to have acute lethal effect on half of a test group of an aquatic species (the LC50 value) by an application factor in order to protect against chronic effects. If data showed a substance to be bioaccumulative or to have other significant long-term effects, a factor was used to reduce the indicated concentrations to a level presumed to be protective. Criteria for the protection of human health were similarly derived by considering the pollutants' acute, chronic, and bioaccumulative effects on non-human mammals and humans.

Although a continuation of the process of criteria development, the criteria published today were derived using revised methodologies (Guidelines) for calculating the impact of pollutants on human health and aquatic organisms. These Guidelines consist of systematic methods for assessing valid and appropriate data concerning acute and chronic adverse effects of pollutants on aquatic organisms, non-human mammals, and humans. By use of these data in prescribed ways, criteria are formulated to protect aquatic life and human health from exposure to the pollutants. For some pollutants, bioconcentration properties are used to formulate criteria protective of aquatic life uses. For almost all of the pollutants, bioconcentration properties are used to assess the relative extent of human exposure to the pollutant either directly through ingestion of water or indirectly through consumption of aquatic organisms. Human health criteria for carcinogens are presented as incremental risks to man associated with specific concentrations of the pollutant in ambient water. The Guidelines used to derive criteria protective of aquatic life and human health are fully described in appendices B and C, respectively, of this Notice.

The Agency believes that these Guidelines provide criteria which more accurately reflect the effects of these pollutants on human health and on aquatic organisms and their uses. They are based on a more rational and consistent approach for using scientific data. These Guidelines were developed by EPA scientists in consultation with scientists from outside the Agency and they have been subjected to intensive public comment.

Neither the Guidelines nor the criteria are considered inflexible doctrine. Even at this time, EPA is taking action to employ the resources of peer review groups, including the Science Advisory Board, to evaluate recently published data, and EPA is conducting its own evaluation of new data to determine whether revisions to the criteria documents would be warranted.

The criteria published today are based solely on the effect of a single pollutant. However, pollutants in combination may have different effects because of synergistic, additive, or antagonistic properties. It is impossible in these documents to quantify the combined effects of these pollutants, and persons using criteria should be aware that site-specific analysis of actual combinations of pollutants may be necessary to give more precise indications of the actual environmental impacts of a discharge.

Relationship of the Section 304(a)(1) Criteria to Regulatory Programs

Section 304(a)(1) criteria are not rules and they have no regulatory inpact. Rather, these criteria present scientific data and guidance on the enviromental effect of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts. Under the Clean Water Act, these regulatory requirements may include the promulgation of water quality-based effluent limitations under section 302, water quality standards under section 303, or toxic pollutant effluent standards under section 307. States are encouraged to begin to modify or, if necessary, develop new programs necessary to support the implementation of regulatory controls for toxic pollutants. As appropriate, States may incorporate criteria for toxic pollutants, based on this guidance, into their water quality standards.

Section 304(a)(1) criteria have been most closely associated with the development of State water quality standards, and the "Red Book" values have, in the past, been the basis for EPA's assessments of the adequacy of State requirements. However, EPA is now completing a major review of its water quality standards policies and regulations. After consideration of comments received on an advance Notice of Proposed Rulemaking (43 FR 29588, July 10, 1978) and the draft criteria documents, the Agency intends to propose, by the end of this year, a revised water quality standards regulation which will clarify the Agency's position on a number of significant standards issues.

With the publication of these criteria, however, it is appropriate to discuss EPA's current thinking on standards issues relating to their use. This discussion does not establish new regulatory requirements and is intended as guidance on the possible uses of these criteria and an indication of future rulemaking the Agency may undertake. No substantive requirements will be established without further opportunity for public comment.

Water Quality Standards

Section 303 of the Clean Water Act provides that water quality standards be developed for all surface waters. A water quality standard consists basically of two parts: (1) A "designated use" for which the water body is to be protected (such as "agricultural," "recreation" or "fish and wildlife"), and (2) "criteria" which are numerical pollutant concentration limits or narrative statements necessary to preserve or achieve the designated use. A water quality standard is developed through State or Federal rulemaking proceedings and must be translated into enforceable effluent limitations in a point source (NPDES) permit or may form the basis of best management practices applicable to nonpoint sources under section 208 of the Act.

Relationship of Section 304(a)(1) Criteria to the Criteria Component of State Water Quality Standards

In the ANPRM, EPA announced a policy of "presumptive applicability" for section 304(a)(1) criteria codified in the "Red Book." Presumptive applicability meant that a State had to adopt a criterion for a particular water quality parameter at least as stringent as the recommendation in the Red Book unless the State was able to justify a less stringent criterion based on: natural background conditions, more recent scientific evidence, or local, site-specific information. EPA is rescinding the policy of presumptive applicability because it has proven to be too inflexible in actual practice.

Although the section 304(a)(1) criteria represent a reasonable estimate of pollutant concentrations consistent with the maintenance of designated water uses, States may appropriately modify these values to reflect local conditions. In certain circumstances, the criteria may not accurately reflect the toxicity of a pollutant because of the effect of local water quality characteristics or varying sensitivities of local populations. For example, in some cases, ecosystem adaptation may enable a viable, balanced aquatic population to exist in waters with high natural background levels of certain pollutants. Similarly, certain compounds may be more or less toxic in some waters because of differences in alkalinity, temperature, hardness, and other factors.

Methods for adjusting the section 304(a)(1) criteria to reflect these local differences are discussed below.

Relationship of Section 304(a)(1) Criteria to Designated Water Uses:

The criteria published today can be used to support the designated uses which are generally found in State standards. The following section discusses the relationship between the criteria and individual use classifications. Where a water body is designated for more than one use, criteria necessary to protect the most sensitive use should be applied.

1. *Recreation:* Recreational uses of water include such activities as swimming, wading, boating and fishing. Although insufficient data exist on the effects of toxic pollutants resulting from exposure through such primary contact as swimming, section 304(a)(1) criteria based on human health effects may be used to support this designated use where fishing is included in the State definition of "recreation." In this situation only the portion of the criterion based on fish consumption should be used.

2. *Protection and Propagation of Fish and Other Aquatic Life:* The section 304(a)(1) criteria based on toxicity to aquatic life may be used directly to support this designated use.

3. *Agricultural and Industrial Uses:* The section 304(a)(1) criteria were not specifically developed to reflect the impact of pollutants on agricultural and industrial uses. However, the criteria developed for human health and aquatic life are sufficiently stringent to protect these other uses. States may establish criteria specifically designed to protect these uses.

4. *Public Water Supply:* The drinking water exposure component of the human health effects criteria can apply directly to this use classification or may be appropriately modified depending upon whether the specific water supply system falls within the auspices of the Safe Drinking Water Act's (SDWA) regulatory control, and the type and level of treatment imposed upon the supply before delivery to the consumer. The SDWA controls the presence of toxic pollutants in finished ("end-of-tap") drinking water. A brief description of relevant sections of this Act is necessary to explain how the SDWA will work in conjunction with section 304(a)(1) criteria in protecting human health from the effects of toxics due to consumption of water.

Pursuant to section 1412 of the SDWA, EPA has promulgated "National Interim *Primary Drinking* Water Standards" for certain organic and inorganic substances. These standards establish "maximum contaminant levels" ("MCLs") which specify the maximum permissible level of a contaminant in water which may be delivered to a user of a public water system now defined as serving a minimum of 25 people. MCLs are established based on consideration of a range of factors including not only the health effects of the contaminants but also technological and economic feasibility of the contaminants' removal from the supply. EPA is required to establish revised primary drinking water regulations based on the effects of a contaminant on human health, and include treatment capability, monitoring availability, and costs. Under Section 1401(1)(D)(i) of the SDWA, EPA is also allowed to establish the minimum quality criteria for water which may be taken into a public water supply system.

Section 304(a)(1) criteria provide estimates of pollutant concentrations protective of human health, but do not consider treatment technology, costs and other feasibility factors. The section 304(a)(1) criteria also include fish bioaccumulation and consumption factors in addition to direct human drinking water intake. These numbers were not developed to serve as "end of tap" drinking water standards, and they have no regulatory significance under the SDWA. Drinking water standards are established based on considerations, including technological and economic feasibility, not relevant to section 304(a)(1) criteria. Section 304(a)(1) criteria may be analogous to the recommended maximum contaminant levels (RMCLs) under section 1412(b)(1)(B) of the SDWA in which, based upon a report from the National Academy of Sciences, the Administrator should set target levels for contaminants in drinking water at which "no known or anticipated adverse effects occur and which allows an adequate margin of safety". RMCLs do not take treatment, cost, and other feasibility factors into consideration. Section 304(a)(1) criteria are, in concept, related to the health-based goals specified in the RMCLs. Specific mandates of the SDWA such as the consideration of multi-media exposure, as well as different methods for setting maximum contaminant levels under the two Acts, may result in differences between the two numbers.

MCLs of the SDWA, where they exist, control toxic chemicals in finished *drinking* water. However, because of variations in treatment and the fact that only a relatively small number of MCLs have been developed, ambient water criteria may be used by the States as a *supplement to SDWA* regulations. States will have the option of applying MCLs, section 304(a)(1) human health effects criteria, modified section 304(a)(1) criteria or controls more stringent than these three to protect against the effects of toxic pollutants by ingestion from drinking water.

For untreated drinking water supplies, States may control toxics in the ambient water through either use of MCLs (if they exist for the pollutants of concern), section 304(a)(1) human health effects criteria, or a more strigent conaminant level than the former two optims.

For treated drinking water supplies serving less than 25 people, States may choose toxics control through application of MCLs (if they exist for the pollutants of concern and are attainable by the type of treatment) in the finished drinking water. States also have the options to control toxics in the ambient water by choosing section 304(a)(1) criteria, adjusted section 304(a)(1) criteria resulting from the reduction of the direct drinking water exposure component in the criteria calculation to the extent that the treatment procedure reduces the level of pollutants, or a more stringent contaminant level than the former three options.

For treated drinking water supplies serving 25 people or greater, States *must* control toxics down to levels at least as stringent as MCLs (where they exist for the pollutants of concern) in the finished drinking water. However, States also have the options to control toxics in the ambient water by choosing section 304(a)(1) criteria, adjusted section 304(a)(1) criteria resulting from the reduction of the direct drinking water exposure component in the criteria calculation to the extent that the treatment process reduces the level of pollutants, or a more stringent contaminant level than the former three options.

Inclusion of Specific Pollutants in State Standards:

To date, EPA has not required that a State address any specific pollutant in its standards. Although all States have established standards for most conventional pollutants, the treatment of toxic pollutants has been much less extensive. In the ANPRM, EPA suggested a policy under which States would be required to address a set of pollutants and incorporate specific toxic pollutant criteria into water quality standards. If the State failed to incorporate these criteria, EPA would promulgate the standards based upon these criteria pursuant to section 303(c)(4)(B).

In the forthcoming proposed revision to the water quality standard regulations, a significant change in policy will be proposed relating to the incorporation of certain pollutants in State water quality standards. This proposal will differ from the proposal made in the ANPRM. The ANPRM proposed an EPA-published list of pollutants for which States would have had to develop water quality standards. This list might have contained some (or all) of the 65 toxic pollutants. However, the revised water quality standards regulation will propose a process by which EPA will assist States in identifying specific toxic pollutants required for assessment for possible inclusion in State water quality standards. For these pollutants, States will have the option of adopting the published criteria or of adjusting those criteria based on site-specific analysis.

These pollutants would generally represent the greatest threat to sustaining a healthy, balanced ecosystem in water bodies or to human health due to exposure directly or indirectly from water. EPA is currently developing a process to determine which pollutants a State must assess for possible inclusion in its water quality standards. Relevant factors might include the toxicity of the pollutant, the frequency and concentration of its discharge, its geographical distribution, the breadth of data underlying the scientific assessment of its aquatic life and human health effects, and the technological and economic capacity to control the discharge of the pollutant. For some of the pollutants, all States may be required to assess them for possible inclusion in their standards. For others, assessment would be restricted to States or limited to specific water bodies where the pollutants pose a particular site-specific problem.

Criteria Modification Process

Flexibility is available in the application of these and any other valid water quality criteria to regulatory programs. Although in some cases they may be used by the States as developed, the criteria may be modified to reflect local environmental conditions and human exposure patterns before incorporation into programs such as water quality standards. If significant impacts of site-specific water quality conditions in the toxicities of pollutants can be demonstrated or significantly different exposure patterns of these pollutants to humans can be shown, section 304(a)(1) criteria may be modified to reflect these local conditions. The term "local" may refer to any appropriate geographic area where common aquatic environmental conditions or exposure patterns exist. Thus, "local" may signify a Statewide, regional, river reach, or entire river basin area. On the other hand, the criteria of some pollutants might be applicable nationwide without the need for adaptation to reflect local conditions. The degree of toxicity toward aquatic organisms and humans characteristic of these pollutants would not change significantly due to local water quality conditions.

EPA is examining a series of environmental factors or water quality parameters which might realistically be expected to affect the laboratory-derived water quality criterion recommendation for a specific pollutant. Factors such as hardness, pH, suspended solids, types of aquatic organisms present, etc. could impact on the chemical's effect in the aquatic environment. Therefore, local information can be assembled and analyzed to adjust the criterion recommendation if necessary.

The Guidelines for deriving criteria for the protection of aquatic life suggest several approaches for modifying the criteria. First, toxicity data, both acute and chronic, for local species could be substituted for some or all of the species used in deriving criteria for the water quality standard. The minimum data requirements should still be fulfilled in calculating a revised criterion. Second, criteria may be specifically tailored to a local water body by use of data from toxicity tests performed with that ambient water. A procedure such as this would account for local environmental conditions in formulating a criterion relevant to the local water body. Third, site-specific water quality characteristics resulting in either enhancement or mitigation of aquatic life toxicity for the pollutant could be factored into final formulation of the criterion. Finally, the criteria may be made more stringent to ensure protection of an individual species not otherwise adequately protected by any of the three modification procedures previously mentioned.

EPA does not intend to have States assess every local stream segment and lake in the country on an individual basis before determining if an adjustment is necessary. Rather, it is envisioned that water bodies having similar hydrological, chemical, physical, and biological properties will be grouped for the purpose of criteria adjustment. The purpose of this effort is to assist States in adapting the section 304(a) criteria to local conditions where needed, thereby precluding the setting of arbitrary and perhaps unnecessarily stringent or underprotective criteria in a water body. In all cases, EPA will still be required, pursuant to section 303(c), to determine whether the State water quality standards are consistent with the goals of the Act, including a determination of whether State-established criteria are adequate to support a designated use.

Criteria for the Protection of Aquatic Life

Interpretation of the Criteria

The aquatic life criteria issued today are summarized in Appendix A of this Federal Register notice. Criteria have been formulated by applying a set of Guidelines to a data base for each pollutant. The criteria for the protection of aquatic life specify pollutant concentrations which, if not exceeded, should protect most, but not necessarily all, aquatic life and its uses. The Guidelines specify that criteria should be based on an array of data from organisms, both plant and animal, occupying various trophic levels. Based on these data, criteria can be derived which should be adequate to protect the types of organisms necessary to support an aquatic community.

The Guidelines are not designed to derive criteria which will protect all life stages of all species under all conditions. Generally some life stage of one or more tested species, and probably some untested species, will have sensitivities below the maximum value or the 24-hour average under some conditions and would be adversely affected if the highest allowable pollutant concentrations and the worst conditions existed for a long time. In actual practice, such a situation is not likely to occur and thus the aquatic community as a whole will normally be protected if the criteria are not exceeded. In any aquatic community there is a wide range of individual species sensitivities to the effects of toxic pollutants. A criterion adequate to protect the most susceptible life stage of the most sensitive species would in many cases be more stringent than necessary to protect the overall aquatic community.

The aquatic life criteria specify both maximum and 24-hour average values. The combination of the two values is designed to provide adequate protection of aquatic life and its uses from acute and chronic toxicity and bioconcentration without being as restrictive as a one-number criterion would have to be to provide the same amount of protection. A time period of 24 hours was chosen in order to ensure that concentrations not reach harmful levels for unacceptably long periods. Averaging for longer periods, such as a week or a month for example, could permit high concentrations to persist long enough to produce significant adverse effects. A 24-hour period was chosen instead of a slightly longer or shorter period in recognition of daily fluctuations in waste discharges and of the influence of daily cycles of sunlight and darkness and temperature on both pollutants and aquatic organisms.

The maximum value, which is derived from acute toxicity data, prevents significant risk of adverse impact to organisms exposed to concentrations above the 24-hour average. Merely specifying the average value over a specified time period is insufficient because concentrations of chemicals higher than the average value can kill or cause irreparable damage in short periods. Furthermore, for some chemicals the effect of intermittent high exposures is cumulative. It is therefore necessary to place an upper limit on pollutant concentrations to which aquatic organisms might be exposed. The two-number criterion is intended to describe the highest average ambient water concentration which will produce a water quality generally suited to the maintenance of aquatic life while restricting the extent and duration of the excursions over that average to levels which will not cause harm. The only way to assure the same degree of protection with a one-number criterion would be to use the 24-hour average as a concentration that is not to be exceeded at any time in any place.

Since some substances may be more toxic in freshwater than in saltwater, or vice versa, provision is made for deriving separate water quality criteria for freshwater and for saltwater for each substance. However, for some substances sufficient data may not be available to derive one or both of these criteria using the Guidelines.

Specific aquatic life criteria have not been developed for all of the 65 toxic pollutants. In those cases where there were insufficient data to allow the derivation of a criterion, narrative descriptions of apparent threshold levels for acute and/or chronic effects based on the available data are presented. These descriptions are intended to convey a sense of the degree of toxicity of the pollutant in the absence of a criterion recommendation.

Summary of the Aquatic Life Guidelines

The Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and its Uses were developed to describe an objective, internally consistent, and appropriate way of ensuring that water quality criteria for aquatic life would provide, on the average, a reasonable amount of protection without an unreasonable amount of overprotection or underprotection. The resulting criteria are not intended to provide 100 percent protection of all species and all uses of aquatic life all of the time, but they are intended to protect most species in a balanced, healthy aquatic community. The Guidelines are published as Appendix B of this Notice. Responses to public comments on these Guidelines are attached as Appendix D.

Minimum data requirements are identified in four areas: acute toxicity to animals (eight data points), chronic toxicity to animals (three data points), toxicity to plants, and residues. Guidance is also given for discarding poor quality data.

Data on acute toxicity are needed for a variety of fish and invertebrate species and are used to derive a Final Acute Value. By taking into account the number and relative sensitivities of the tested species, the Final Acute Value is designed to protect most, but not necessarily all, of the tested and untested species.

Data on chronic toxicity to animals can be used to derive a Final Chronic Value by two different means. If chronic values are available for a specified number and array of species, a final chronic value can be calculated directly. If not, an acute-chronic ratio is derived and then used with the Final Acute Value to obtain the Final Chronic Value.

The Final Plant Value is obtained by selecting the lowest plant toxicity value based on measured concentrations.

The Final Residue Value is intended to protect wildlife which consume aquatic organisms and the marketability of aquatic organisms. Protection of the marketability of aquatic organisms is, in actuality, protection of a use of that water body ("commercial fishery"). Two kinds of data are necessary to calculate the Final Residue Value: a bioconcentration factor (BCF) and a maximum permissible tissue concentration, which can be an FDA action level or can be the result of a chronic wildlife feeding study. For lipid soluble pollutants, the BCF is normalized for percent lipids and then the Final Residue Value is calculated by dividing the maximum permissible tissue concentration by the normalized BCF and by an appropriate percent lipid value. BCFs are normalized for percent lipids since the BCF measured for any individual aquatic species is generally proportional to the percent lipid in that species.

If sufficient data are available to demonstrate that one or more of the final values should be related to a water quality characteristic, such as salinity, hardness, or suspended solids, the final value(s) are expressed as a function of that characteristic.

After the four final values (Final Acute Value, Final Chronic Value, Final Plant Value, and Final Residue Value) have been obtained, the criterion is established with the Final Acute Value becoming the maximum value and the lowest of the other three values becoming the 24-hour average value. All of the data used to calculate the four final values and any additional pertinent information are then reviewed to determine if the criterion is reasonable. If sound scientific evidence indicates that the criterion should be raised or lowered, appropriate changes are made as necessary.

The present Guidelines have been revised from the earlier published versions (43 FR 21506, May [illegible], 1978; 43 FR 29028, July 5, 1978; 44 FR [illegible], March 15, 1979). Details have been added in many places and the concept of a minimum data base has been incorporated. In addition, three adjustment factors and the species sensitivity factor have been deleted. These modifications were the result of the Agency's analysis of public comments and comments received from the Science Advisory Board on earlier versions of the Guidelines. These comments and the Resultant modifications are addressed fully in Appendix D to this notice.

Criteria for the Protection of Human Health

Interpretation of the Human Health Criteria

The human health criteria issued today are summarized in Appendix A of this Federal Register notice. Criteria for the protection of human health are presented for 62 of the 65 pollutants based on their carcinogenic, toxic, or organoleptic (taste and odor) properties. The meanings and practical uses of the criteria values are distinctly different depending on the properties on which they are based.

The objective of the health assessment portions of the criteria documents is to estimate ambient water concentrations which, in the case of non-carcinogens, prevent adverse health effects in humans, and in the case of suspect or proven carcinogens, represent various levels of incremental cancer risk.

Health assessments typically contain discussions of four elements: Exposure, pharmacokinetics, toxic effects, and criterion formulation.

The exposure section summarizes information on exposure routes: ingestion directly from water, indirectly from consumption of aquatic organisms found in ambient water, other dietary sources, inhalation, and dermal contact. Exposure assumptions are used to derive human health criteria. Most criteria are based solely on exposure from consumption of water containing a specified concentration of a toxic pollutant and through consumption of aquatic organisms which are assumed to have bioconcentrated pollutants from the water in which they live. Other multimedia routes of exposure such as air, non-aquatic diet, or dermal are not factored into the criterion formulation for the vast majority of pollutants due to lack of data. The criteria are calculated using the combined aquatic exposure pathway and also using the aquatic organism ingestion exposure route alone. In criteria reflecting both the water consumption and aquatic organism ingestion routes of exposure, the relative exposure contribution varies with the propensity of a pollutant to bioconcentrate, with the consumption of aquatic organisms becoming more important as the bioconcentration factor (BCF) increases. As additional information on total exposure is assembled for pollutants for which criteria reflect only the two specified aquatic exposure routes, adjustments in water concentration values may be made. The Agency intends to publish guidance which will permit the States to identify significantly different exposure patterns for their populations. If warranted by the demonstration of significantly different exposure patterns, this will become an element of a process to adapt/modify human health-based criteria to local conditions, somewhat analogous to the aquatic life criteria modification process discussed previously. It is anticipated that States at their discretion will be able to set appropriate human health criteria based on this process.

The pharmacokinetics section reviews data on absorption, distribution, metabolism, and excretion to assess the biochemical fate of the compounds in the human and animal system. The toxic effects section reviews data on acute, subacute, and chronic toxicity, synergistic and antagonistic effects, and specific information on mutagenicity, teratogenicity, and carcinogenicity. From this review, the toxic effect to be protected against is identified taking into account the quality, quantity, and weight of evidence characteristic of the data. The criterion formulation section reviews the highlights of the text and specifies a rationale for criterion development and the mathematical derivation of the criterion number.

Within the limitations of time and resources, current published information of significance was incorporated into the human health assessments. Review articles and reports were used for data evaluation and synthesis. Scientific judgment was exercised in reviewing and evaluating the data in each criteria document and in identifying the adverse effects for which protective criteria were published.

Specific health-based criteria are developed only if a weight of evidence supports the occurrence of the toxic effect and if dose/response data exist from which criteria can be estimated.

Criteria for suspect or proven carcinogens are presented as concentrations in water associated with a range of incremental cancer risks to man. Criteria for non-carcinogens represent levels at which exposure to a single chemical is not anticipated to produce adverse effects in man. In a few cases, organoleptic (taste and odor) data form the basis for the criterion. While this type of criterion does not represent a value which directly affects human health, it is presented as an estimate of the level of a pollutant that will not produce unpleasant taste or odor either directly from water consumption or indirectly by consumption of aquatic organisms found in ambient waters. A criterion developed in this manner is judged to be as useful as other types of criteria in protecting designated water uses. In addition, where data are available, toxicity-based criteria are also presented for pollutants with derived organoleptic criteria. The choice of criteria used in water quality standards for these pollutants will depend upon the designated use to be protected. In the case of a multiple use water body, the criterion protecting the most sensitive use will be applied. Finally, for several pollutants no criteria are recommended due to a lack of information sufficient for quantitative criterion formulation.

Risk Extrapolation

Because methods do not now exist to establish the presence of a threshold for carcinogenic effects, EPA's policy is that there is no scientific basis for estimating "safe" levels for carcinogens. The criteria for carcinogens, therefore, state that the recommended concentration for maximum protection of human health is zero. In addition, the Agency has presented a range of concentrations corresponding to incremental cancer risks of 10^{-7} to 10^{-5} (one additional case of cancer in populations ranging from ten million to 100,000, respectively). Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Summary of the Human Health Guidelines

The health assessments and corresponding criteria published today were derived based on *Guidelines and Methodology Used in the Preparation of Health Effect Assessment Chapters of the Consent Decree Water Criteria Documents* (the Guidelines) developed by EPA's Office of Research and Development. The estimation of health risks associated with human exposure to environmental pollutants requires predicting the effect of low doses for up to a lifetime in duration. A combination of epidemiological and animal dose/response data is considered the preferred basis for quantitative criterion derivation. The complete Guidelines are presented as Appendix C. Major issues associated with these Guidelines and responses to public comments are presented as Appendix E.

No-effect (non-carcinogens) or specified risk (carcinogens) concentrations were estimated by extrapolation from animal toxicity or human epidemiology studies using the following basic exposure assumptions: a 70-kilogram male person (*Report of the Task Group on Reference Man.* International Commission for Radiation Protection, November 23, 1957) as the exposed individual; the average daily consumption of freshwater and estuarine fish and shellfish products equal to 6.5 grams/day; and the average ingestion of two liters/day of water (*Drinking Water and Health.* National Academy of Sciences, National Research Council, 1977). Criteria based on these assumptions are estimated to be protective of an adult male who experiences average exposure conditions.

Two basic methods were used to formulate health criteria, depending on whether the prominent adverse effect was cancer or other toxic manifestations. The following sections detail these methods.

Carcinogens

Extrapolation of cancer responses from high to low doses and subsequent risk estimation from animal data is performed using a linearized multi-stage model. This procedure is flexible enough to fit all monotonically-increasing dose response data, since it incorporates several adjustable parameters. The multi-stage model is a linear non-threshold model as was the "one-hit" model originally used in the proposed criteria documents. The linearized multi-stage model and its characteristics are described fully in Appendix C. The linear non-threshold concept has been endorsed by the four agencies in the Interagency Regulatory Liaison Group and is less likely to underestimate risk at the low doses typical of environmental exposure than other models that could be used. Because of the uncertainties associated with dose response, animal-to-human extrapolation and other unknown factors, because of the use of average exposure assumptions, and because of the serious public health consequences that could result if risk were underestimated, EPA believes that it is prudent to use conservative methods to estimate risk in the water quality criteria program. The linearized multistage model is more systematic and invokes fewer arbitrary assumptions than the "one-hit" procedure previously used.

It should be noted that extrapolation models provide estimates of risk since a variety of assumptions are built into any model. Models using widely different assumptions may produce estimates ranging over several orders of magnitude. Since there is at present no way to demonstrate the scientific validity of any model, the use of risk extrapolation models is a subject of debate in the scientific community. However, risk extrapolation is generally recognized as the only tool available at this time for estimating the magnitude of health hazards associated with non-threshold toxicants and has been endorsed by numerous Federal agencies and scientific organizations, including EPA's Carcinogen Assessment Group, the National Academy of Sciences, and the Interagency Regulatory Liaison Group as a useful means of assessing the risks of exposure to various carcinogenic pollutants.

Non-Carcinogens

Health criteria based on toxic effects of pollutants other than carcinogenicity are estimates of concentrations which are not expected to produce adverse effects in humans. They are based upon Acceptable Daily Intake (ADI) levels and are generally derived using no-observed-adverse-effect-level (NOAEL) data from animal studies although human data are used wherever available. The ADI is calculated using safety factors to account for uncertainties inherent in extrapolation from animal to man. In accordance with the National Research Council recommendations (*Drinking Water and Health.* National Academy of Sciences, National Research Council, 1977), safety factors of 10, 100, or 1,000 are used depending on the quality and quantity of data. In some instances extrapolations are made from inhalation studies or limits to approximate a human response from ingestion using the Stokinger-Woodward model (Journal of American Water Works Association, 1958). Calculations of criteria from ADIs are made using the standard exposure assumptions (2 liters of water, 6.5 grams of edible aquatic products, and an average body weight of 70 kg).

Dated: October 24, 1980.

Douglas M. Costle,

Administrator.

Appendix A—Summary of Water Quality Criteria

Acenaphthene

Freshwater Aquatic Life

The available data for acenaphthene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 1,700 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of acenaphthene to sensitive freshwater aquatic animals but toxicity to freshwater algae occur at concentrations as low as 520 μg/l.

Saltwater Aquatic Life

The available data for acenaphthene indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 970 and 710 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Toxicity to algae occurs at concentrations as low as 500 μg/l.

Human Health

Sufficient data is not available for acenaphthene to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 20 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Acrolein

Freshwater Aquatic Life

The available data for acrolein indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 68 and [illegible] μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for acrolein indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 55 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of acrolein to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of acrolein ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 320 μg/l.

For the protection of human health from the toxic properties of acrolein ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 780 μg/l.

Acrylonitrile

Freshwater Aquatic Life

The available data for acrylonitrile indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 7,550 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of acrylonitrile to sensitive freshwater aquatic life but mortality occurs at concentrations as low as 2,600 µg/l with a fish species exposed for 30 days.

Saltwater Aquatic Life

Only one saltwater species has been tested with acrylonitrile and no statement can be made concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of acrylonitrile through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .58 µg/l, .058 µg/l and .006 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 6.5 µg/l, .65 µg/l, and .065 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Aldrin-Dieldrin

Dieldrin

Freshwater Aquatic Life

For dieldrin the criterion to protect fresh water aquatic life as derived using the Guidelines is 0.0019 µg/l as a 24-hour average and the concentration should not exceed 2.5 µg/l at any time.

Saltwater Aquatic Life

For dieldrin the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0019 µg/l as a 24-hour average and the concentration should not exceed 0.71 µg/l at any time.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of dieldrin through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .71 ng/l, .071 ng/l, and .0071 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are .76 ng/l, .076 ng/l, and .0076 ng/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Aldrin

Freshwater Aquatic Life

For freshwater aquatic life the concentration of aldrin should not exceed 3.0 µg/l at any time. No data are available concerning the chronic toxicity of aldrin to sensitive freshwater aquatic life.

Saltwater Aquatic Life

For saltwater aquatic life the concentration of aldrin should not exceed 1.3 µg/l at any time. No data are available concerning the chronic toxicity of aldrin to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of aldrin through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .74 ng/1, .074 ng/1, and .0074 ng/1, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are .79 ng/1, .079 ng/1, and .0079 ng/1, respectively. Other concentrations respresenting different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Antimony

Freshwater Aquatic Life

The available data for antimony indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 9,000 and 1,600 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Toxicity to algae occurs at concentrations as low as 610 µg/l.

Saltwater Aquatic Life

No saltwater organisms have been adequately tested with antimony, and no statement can be made concerning acute or chronic toxicity.

Human Health

For the protection of human health from the toxic properties of antimony ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 146 µg/l.

For the protection of human health from the toxic properties of antimony ingested through contaminaed aquatic organisms alone, the ambient water criterion is determined to be 45,000 µg/l.

Arsenic

Freshwater Aquatic Life

For freshwater aquatic life the concentration of total recoverable trivalent inorganic arsenic should not exceed 440 µg/l at any time. Short-term effects on embryos and larvae of aquatic vertebrate species have been shown to occur at concentrations as low as 40 µg/l.

Saltwater Aquatic Life

The available data for toal recoverable trivalent inorganic arsenic indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 508 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of trivalent inorganic arsenic to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of arsenic through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 22 ng/l, 2.2 ng/l, and .22 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 175 ng/l, 17.5 ng/l, and 1.75 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Asbestos

Freshwater Aquatic Life

No freshwater organisms have been tested with any asbestiform mineral and no statement can be made concerning acute or chronic toxicity.

Saltwater Aquatic Life

No saltwater organisms have been tested with any asbestiform mineral and no statement can be made concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of asbestos through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 300,000 fibers/l, 30,000 fibers/l, and 3,000 fibers/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Benzene

Freshwater Aquatic Life

The available data for benzene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 5,300 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of benzene to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for benzene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 5,100 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of benzene to sensitive saltwater aquatic life, but adverse effects occur at concentrations as low as 700 µg/l with a fish species exposed for 168 days.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of benzene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 6.6 µg/l, .66 µg/l, and .066 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 400 µg/l, 40.0 µg/l, and 4.0 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Benzidine

Freshwater Aquatic Life

The available data for benzidine indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 2,500 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of benzidine to sensitive freshwater aquatic life.

Saltwater Aquatic Life

No saltwater organisms have been tested with benzidine and no statement can be made concerning acute and chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of benzidine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 1.2 ng/l, .12 ng/l, and .01 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 5.3 ng/l, .53 ng/l, and .05 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Beryllium

Freshwater Aquatic Life

The available data for beryllium indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 130 and 5.3 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Hardness has a substantial effect on acute toxicity.

Saltwater Aquatic Life

The limited saltwater data base available for beryllium does not permit any statement concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of beryllium through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 37 ng/l, 3.7 ng/l, and .37 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 641 ng/l, 64.1 ng/l, and 6.41 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Cadmium

Freshwater Aquatic Life

For total recoverable cadmium the criterion (in µg/l) to protect freshwater aquatic life as derived using the Guidelines is the numerical value given by $e^{(1.05\ln(\text{hardness}))-8.53}$ as a 24-hour average and the concentration (in µg/l) should not exceed the numerical value given by $e^{(1.05\ln(\text{hardness}))-3.73}$ at any time. For example, a hardnesses of 50, 100, and 200 mg/l as $CaCO_3$ the criteria are 0.012, 0.025, and 0.051 µg/l, respectively, and the concentration of total recoverable cadmium should not exceed 1.5, 3.0 and 6.3 µg/l, respectively, at any time.

Saltwater Aquatic Life

For total recoverable cadmium the criterion to protect saltwater aquatic life as derived using the Guidelines is 4.5 µg/l as a 24-hour average and the concentration should not exceed 59 µg/l at any time.

Human Health

The ambient water quality criterion for cadmium is recommended to be identical to the existing drinking water standard which is 10 µg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Carbon Tetrachloride

Freshwater Aquatic Life

The available date for carbon tetrachloride indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 35,200 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of carbon tetrachloride to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for carbon tetrachloride indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 50,000 µg/l and would occur at lower concentrations among species that are more sensitive that those tested. No data are available concerning the chronic toxicity of carbon tetrachloride to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of carbon tetrachloride through ingestion of contaminated water and contaminated aquatic organisms the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 4.0µg/l, .40 µg/l, and .04 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 69.4 µg/l, 6.94 µg/l, and .69 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Chlordane

Freshwater Aquatic Life

For chlordane the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0043 µg/l as a 24-hour average and the concentration should not exceed 2.4 µg/l at any time.

Saltwater Aquatic Life

For chlordane the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0040 µg/l as a 24-hour average and the concentration should not exceed 0.09 µg/l at any time.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of chlordane through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 4.6 ng/l, .46 ng/l, and .046 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 4.8 ng/l, .48 ng/l, and .048 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Chlorinated Benzenes

Freshwater Aquatic Life

The available data for chlorinated benzenes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 25[illegible] µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of the more toxic of the chlorinated benzenes to sensitive freshwater aquatic life but toxicity occurs at concentrations as low as 50 µg/l for a fish species exposed for 7.5 days.

Saltwater Aquatic Life

The available data for chlorinated benzenes indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 160 and 129 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of hexachlorobenzene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding recommended criteria are 72 ng/l, .72 ng/l, and .072 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 7.4 ng/l, .74 ng/l, and .074 ng/l, respectively.

For the protection of human health from the toxic properties of 1.2.4.5-tetrachlorobenzene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 38 µg/l

For the protection of human health from the toxic properties of 1.2.4.5-tetrachlorobenzene ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 48 µg/l.

For the protection of human health from the toxic properties of pentachlorobenzene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 74 µg/l.

For the protection of human health from the toxic properties of pentachlorobenzene ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 85 µg/l.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for trichlorobenzene.

For comparison purposes, two approaches were used to derive criterion levels for monochlorobenzene. Based on available toxicity data, for the protection of public health, the derived level is 488 μg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 20 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Chlorinated Ethanes

Freshwater Aquatic Life

The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination, and that acute toxicity occurs at concentrations as low as 118.000 μg/l for 1,2-dichloroethane, 18.000 μg/l for two trichloroethanes, 9.320 μg/l for two tetrachloroethanes, 7.240 μg/l for pentachloroethane, and 980 μg/l for hexachloroethane. Chronic toxicity occurs at concentrations as low as 20.000 μg/l for 1,2-dichloroethane, 9.400 μg/l for 1,1,2-trichloroethane, 2,400 μg/l for 1,1,2,2,-tetrachloroethane, 1,100 μg/l for pentachloroethane, and 540 μg/l for hexachloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 113.000 μg/l for 1,2-dichloroethane, 31.200 μg/l for 1,1,1-trichloroethane, 9.020 μg/l for 1,1,2,2-tetrachloroethane, 390 μg/l for pentachloroethane, and 940 μg/l for hexachloroethane. Chronic toxicity occurs at concentrations as low as 281 μg/l for pentachloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 1,2-dichloroethane through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 9.4 μg/l, .94 μg/l, and .094 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 2,430 μg/l, 243 μg/l, and 24.3 μg/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the protection of human health from the toxic properties of 1,1,1-trichloroethane ingested through water and contaminated aquatic organism, the ambient water criterion is determined to be 18.4 mg/l.

For the protection of human health from the toxic properties of 1,1,1,-trichloroethane ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 1.03 g/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 1,1,2-trichloroethane through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 6.0 μg/l, .6 μg/l, and .06 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 418 μg/l, 41.8 μg/l, and 4.18 μg/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 1,1,2,2-tetrachloroethane through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 1.7 μg/l, .17 μg/l, and .017 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 107 μg/l, 10.7 μg/l, and 1.07 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of hexachloroethane through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 19 μg/l, 1.9 μg/l, and .19 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 87.4 μg/l, 8.74 μg/l, and .87 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for monochloroethane.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for 1,1,-dichloroethane.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for 1,1,1,2-tetrachloroethane.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for pentachloroethane.

Chlorinated Naphthalenes

Freshwater Aquatic Life

The available data for chlorinated naphthalenes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 1.600 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of chlorinated naphthalenes to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for chlorinated napthalenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 7.5 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of chlorinated naphthalenes to sensitive saltwater aquatic life.

Human Health

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for chlorinated napthalenes.

Chlorinated Phenols

Freshwater Aquatic Life

The available freshwater data for chlorinated phenols indicate that toxicity generally increases with increasing chlorination, and that acute toxicity occurs at concentrations as low as 30 μg/l for 4-chloro-3-methylphenol to greater than 500,000 μg/l for other compounds. Chronic toxicity occurs at concentrations as low as 970 μg/l for 2,4,6-trichlorophenol. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available saltwater data for chlorinated phenols indicate that toxicity generally increases with increasing chlorination and that acute toxicity occurs at concentrations as low as 440 μg/l for 2,3,5,6-tetrachlorophenol and 29,700 μg/l for 4-chlorophenol. Acute toxicity would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of chlorinated phenols to sensitive saltwater aquatic life.

Human Health

Sufficient data is not available for 3-monochlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 0.1 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 4-monochlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 0.1 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 2,3-dichlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is .04 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 2,5-dichlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is .5 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 2,6-dichlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is .2 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 3,4-dichlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is .3 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 2,3,4,6-tetrachlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 1 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

For comparison purposes, two approaches were used to derive criterion levels for 2,4,5-trichlorophenol. Based on available toxicity data, for the protection of public health, the derived level is 2.6 mg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 1.0 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 2,4,6-trichlorophenol through ingestion of contaminated water and conaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 12 μg/l, 1.2 μg/l, and .12 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 36 μg/l, 3.6 μg/l, and .36 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 2 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 2-methyl-4-chlorophenol to derive a level which would protect against any potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 1800 μg/l. It should recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 3-methyl-4-chlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 3000 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Sufficient data is not available for 3-methyl-6-chlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 20 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Chloroalkyl Ethers

Freshwater Aquatic Life

The available data for chloroalkyl ethers indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 238,000 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of chloroalkyl ethers to sensitive freshwater aquatic life.

Saltwater Aquatic Life

No saltwater organisms have been tested with any chloroalkyl ether and no statement can be made concerning acute and chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of bis-(chloromethyl)-ether through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .038 ng/l, .0038 ng/l, and .00038 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 18.4 ng/l, 1.84 ng/l, and .184 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of bis (2-chloroethyl) ether through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .3 μg/l, .03 μg/l, and .003 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 13.6 μg/l, 1.36 μg/l, and .136 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the protection of human health from the toxic properties of bis (2-chloroisopropyl) ether ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 34.7 μg/l.

For the protection of human health from the toxic properties of bis (2-chloroisopropyl) ether ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 4.36 mg/l.

Chloroform

Freshwater Aquatic Life

The available data for choloroform indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 28,900 μg/l, and would occur at lower concentrations among species that are more sensitive than the three tested species. Twenty-seven-day LC50 values indicate that chronic toxicity occurs at concentrations as low as 1,240 μg/l, and could occur at lower concentrations among species or other life stages that are more sensitive than the earliest life cycle stage of the rainbow trout.

Saltwater Aquatic Life

The data base for saltwater species is limited to one test and no statement can be made concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of chloroform through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 1.9 μg/l, .19 μg/l, and .019 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 157 μg/l, 15.7 μg/l, and 1.57 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

2-Chlorophenol

Freshwater Aquatic Life

The availabe data for 2-chlorophenol indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 4,380 μg/l and would occur at lower concentrations among species that are more sensitive that those tested. No definitive data are available concerning the chronic toxicity of 2-chlorophenol to sensitive freshwater aquatic life but flavor impairment occurs in one species of fish at concentrations as low as 2,000 μg/l.

Saltwater Aquatic Life

No saltwater orgamisms have been tested with 2-chlorophenol and no statement can be made concerning acute and chronic toxicity.

Human Health

Sufficient data is not available for 2-chlorophenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 0.1 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Chromium

Freshwater Aquatic Life

For total recoverable hexavalent chromium the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.29 μg/l as a 24-hour average and the concentration should not exceed 21 μg/l at any time.

For freshwater aquatic life the concentration (in μg/l) of total recoverable trivalent chromium should not exceed the numerical value given by "e(1.03[ln(hardness)]+3.48)" at any time. For example, at hardnesses of 50, 100 and 200 mg/l as $CaCO_3$ the concentration of total recoverable trivalent chromium should not exceed 2,200, 4,700, and 9,900 μg/l, respectively, at any time. The available data indicate that chronic toxicity to freshwater aquatic life occurs at concentrations as low a 44 μg/l and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

For total recoverable hexavalent chromium the criterion to protect saltwater aquatic life as derived using the Guidelines is 18 μg/l as a 24-hour average and the concentration should not exceed 1,260 μg/l at any time.

For total recoverable trivalent chromium, the availabe data indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 10,300 μg/l, and would occur at lower concentrations amoung species that are more sensitive than those tested. No data are available concerning the chronic toxicity of trivalent chromium to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of Chromium III ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 170 mg/l.

For the protection of human health from the toxic properties of Chromium III ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 3433 mg/l.

The ambient water quality criterion for total Chromium VI is recommended to be identical to the existing drinking water standard which is 50 μg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Copper

Freshwater Aquatic Life

For total recoverable copper the criterion to protect freshwater aquatic life as derived using the Guidelines is 5.6 μg/l as a 24-hour average and the concentration (in μg/l) should not exceed the numerical value given by e(0.94[ln(hardness)]-1.23) at any time. For example, at hardnesses of 50, 100, and 200 mg/l $CaCO_3$ the concentration of total recoverable copper should not exceed 12, 22, and 43 μg/l at any time.

Saltwater Aquatic Life

For total recoverable copper the criterion to protect saltwater aquatic life as derived using the Guidelines is 4.0 μg/l as a 24-hour average and the concentration should not exceed 23 μg/l at any time.

Human Health

Sufficient data is not available for copper to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 1 mg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Cyanide

Freshwater Aquatic Life

For free cyanide (sum of cyanide present as HCN and CN^-, expressed as CN) the criterion to protect freshwater aquatic life as derived using the Guidelines is 3.5 μg/l as a 24-hour average and the concentration should not exceed 52 μg/l at any time.

Saltwater Aquatic Life

The available data for free cyanide (sum of cyanide present as HCN and CN^-, expressed as CN) indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 30 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. If the acute-chronic ratio for saltwater organisms is similar to that for freshwater organisms, chronic toxicity would occur at concentrations as low as 2.0 μg/l for the tested species and at lower concentrations among species that are more sensitive than those tested.

Human Health

The ambient water quality criterion for cyanide is recommended to be identical to the existing drinking water standard which is 200 μg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

DDT and Metabolites

Freshwater Aquatic Life

DDT

For DDT and its metabolites the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0010 μg/l as a 24-hour average and the concentration should not exceed 1.1 μg/l at any time.

TDE

The available data for TDE indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 0.6 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of TDE to sensitive freshwater aquatic life.

DDE

The available data for DDE indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 1,050 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of DDE to sensitive freshwater aquatic life.

Saltwater Aquatic Life

DDT

For DDT and its metabolites the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0010 μg/l as a 24-hour average and the concentration should not exceed 0.13 μg/l at any time.

TDE

The available data for TDE indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 3.6 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No date are available concerning the chronic toxicity of TDE to sensitive saltwater aquatic life.

DDE

The available data for DDE indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 14 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of DDE to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of DDT through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .24 ng/l, .024 ng/l, and .0024 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are .24 ng/l, .024 ng/l, and .0024 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment of an "acceptable" risk level.

Dichlorobenzenes

Freshwater Aquatic Life

The available data for dichlorobenzenes indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 1,120 and 763 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for dichlorobenzenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 1,970 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of dichlorobenzenes to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of dichlorobenzenes (all isomers) ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 400 µg/l.

For the protection of human health from the toxic properties of dichlorobenzenes (all isomers) ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 2.6 mg/l.

Dichlorobenzidines

Freshwater Aquatic Life

The data base available for dichlorobenzidines and freshwater organisms is limited to one test on bioconcentration of 3,3'-dichlorobenzidine and no statement can be made concerning acute or chronic toxicity.

Saltwater Aquatic Life

No saltwater organisms have been tested with any dichlorobenzidine and no statement can be made concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of dichlorobenzidine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero base on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .103 µg/l, .0103 µg/l, and .00103 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are .204 µg/l, .0204 µg/l, and .00204 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Dichloroethylenes

Freshwater Aquatic Life

The available data for dichloroethylenes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11,600 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of dichlorethylenes to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for dichlorethylenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 224,000 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity dichloroethylenes to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 1,1-dichloroethylene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .33 µg/l, .033 µg/l, and .0033 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 18.5 µg/l, 1.85 µg/l, and .185 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for 1,2-dichloroethylene.

2,4-Dichlorophenol

Freshwater Aquatic Life

The available data for 2,4-dichlorophenol indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 2,020 and 365 µg/l, respectively and would occur at lower concentrations among species that are more sensitive that those tested. Mortality to early life stages of one species of fish occurs at concentrations as low as 70 µg/l.

Saltwater Aquatic Life

Only one test has been conducted with saltwater organisms on 2,4-dichlorophenol and no statement can be made concerning acute or chronic toxicity.

Human Health

For comparison purposes, two approaches were used to derive criterion levels for 2,4-dichlorophenol

Based on available toxicity data, for the protection of public health, the derived level is 3.09 mg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 0.3 µg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Dichloropropanes/Dichloropropenes

Freshwater Aquatic Life

The available data for dichloropropanes indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 23,000 and 5,700 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

The available data for dichloropropenes indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 6,060 and 244 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for dichloropropanes indicate that acute and chronic toxicity to saltwater aquatic life occurs at concentrations as low as 10,300 and 3,040 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

The available data for dichloropropenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low a as 790 µg/l, and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of dichloropropenes to sensitive saltwater aquatic life.

Human Health

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for dichloropropanes.

For the protection of human health from the toxic properties of dichloropropenes ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 87 µg/l.

For the protection of human health from the toxic properties of dichloropropenes ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 14.1 mg/l.

2,4-Dimethylphenol

Freshwater Aquatic Life

The available data for 2,4-dimethylphenol indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 2,120 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of dimethylphenol to sensitive freshwater aquatic life.

Saltwater Aquatic Life

No saltwater organisms have been tested with 2,4-dimethylphenol and no statement can be made concerning acute and chronic toxicity.

Human Health

Sufficient data are not available for 2,4-dimethylphenol to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undersirable taste and odor quality of ambient water, the estimated level is 400 µg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

2,4-Dinitrotoluene

Freshwater Aquatic Life

The available data for 2,4-dinitrotoluene indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 330 and 230 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for 2,4-dinitrotoluenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 590 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of 2,4-dinitrotoluenes to sensitive saltwater aquatic life but a decrease in algal cell numbers occurs at concentrations as low as 370 µg/l.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 2,4-dinitrotoluene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 1.1 µg/l, 0.11 µg/l, and 0.011 µg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 91 µg/l, 9.1 µg/l, and 0.91 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

1,2-Diphenylhydrazine

Freshwater Aquatic Life

The available data for 1,2-diphenylhydrazine indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as [illegible]0 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of 1,2-diphenylhydrazine to sensitive freshwater aquatic life.

Saltwater Aquatic Life

No saltwater organisms have been tested with 1,2-diphenylhydrazine and no statement can be made concerning acute and chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of 1,2-diphenylhydrazine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 422 ng/l, 42 ng/l, and 4 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 5.6 µg/l, 0.56 µg/l and 0.056 µg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Endosulfan

Freshwater Aquatic Life

For endosulfan the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.056 µg/l as a 24-hour average and the concentration should not exceed 0.22 µg/l at any time.

Saltwater Aquatic Life

For endosulfan the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0087 µg/l as a 24-hour average and the concentration should not exceed 0.034 µg/l at any time.

Human Health

For the protection of human health from the toxic properties of endosulfan ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 74 µg/l.

For the protection of human health from the toxic properties of endosulfan ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 159 µg/l.

Endrin

Freshwater Aquatic Life

For endrin the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0023 µg/l as a 24-hour average and the concentration should not exceed 0.18 µg/l at any time.

Saltwater Aquatic Life

For endrin the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0023 µg/l as a 24-hour average and the concentration should not exceed 0.037 µg/l at any time.

Human Health

The ambient water quality criterion for endrin is recommended to be identical to the existing drinking water standard which is 1 µg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Ethylbenzene

Freshwater Aquatic Life

The available data for ethylbenzene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 32,000 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of ethylbenzene to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for ethylbenzene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 430 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of ethylbenzene to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of ethylbenzene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 1.4 mg/l.

For the protection of human health from the toxic properties of ethylbenzene ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 3.28 mg/l.

Fluoranthene

Freshwater Aquatic Life

The available data for fluoranthene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 3980 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of fluoranthene to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for fluoranthene indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 40 and 16 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For the protection of human health from the toxic properties of fluoranthene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 42 µg/l.

For the protection of human health from the toxic properties of fluoranthene ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 54 µg/l.

Haloethers

Freshwater Aquatic Life

The available data for haloethers indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 360 and 122 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

No saltwater organisms have been tested with any haloether and no statement can be made concerning acute or chronic toxicity.

Human Health

Using the present guidelines a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for haloethers.

Halomethanes

Freshwater Aquatic Life

The available data for halomethanes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11,000 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of halomethanes to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for halomethanes indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 12,000 and 6,400 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. A decrease in algal cell numbers occurs at concentrations as low as 11,500 µg/l.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of chloromethane, bromomethane, dichloromethane, bromodichloromethane, tribromomethane, dichlorodifluoromethane, trichlorofluoromethane, or combinations of these chemicals through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result incremental increase of cancer risk, ov the lifetimes are estimated at 10^{-5}, 10^{-}[illegible] and 10^{-7}. The corresponding criteria ar

1.9 μg/l, 0.19 μg/l and 0.019 μg/l respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 157 μg/l, 15.7 μg/l, and 1.57 μg/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Heptachlor

Freshwater Aquatic Life

For heptachlor the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.0038 μg/l as a 24-hour average and the concentration should not exceed 0.52 μg/l at any time.

Saltwater Aquatic Life

For heptachlor the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.0036 μg/l as a 24-hour average and the concentration should not exceed 0.053 μg/l at any time.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of heptachlor through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 2.78 ng/l, .28 ng/l and .028 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 2.85 ng/l, .29 ng/l, and .029 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Hexachlorobutadiene

Freshwater Aquatic Life

The available data for hexachlorobutadiene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 90 and 9.3 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for hexachlorobutadiene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 32 μg/l and would occur at lower concentrations among species that are more sensitive that those tested. No data are available concerning the chronic toxicity of hexachlorobutadiene to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of hexachlorobutadiene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 4.47 μg/l, 0.45 μg/l, and 0.045 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 500 μg/l, 50 μg/l, and 5 μg/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Hexachlorocyclohexane

Lindane

Freshwater Aquatic Life

For Lindane the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.080 μg/l as a 24-hour average and the concentration should not exceed 2.0 μg/l at any time.

Saltwater Aquatic Life

For saltwater aquatic life the concentration of lindane should not exceed 0.16 μg/l at any time. No data are available concerning the chronic toxicity of lindane to sensitive saltwater aquatic life.

BHC

Freshwater Aquatic Life

The available date for a mixture of isomers of BHC indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 100 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of a mixture of isomers of BHC to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available date for a mixture of isomers of BHC indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 0.34 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of a mixture of isomers of BHC to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of alpha-HCH through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 92 ng/l, 9.2 ng/l, and .92 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 310 ng/l, 31.0 ng/l, and 3.1 ng/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of beta-HCH through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 163 ng/l, 16.3 ng/l, and 1.63 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 547 ng/l, 54.7 ng/l and 5.47 ng/l respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of tech-HCH through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 123 ng/l, 12.3 ng/l, and 1.23 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 414 ng/l, 41.4 ng/l, and 4.14 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of gamma-HCH through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentrations should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 186 ng/l, 18.6 ng/l, and 1.86 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 625 ng/l, 62.5 ng/l, 6.25 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for delta-HCH.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for epsilon-HCH.

Hexachlorocyclopentadiene

Freshwater Aquatic Life

The available data for hexachlorocyclopentadiene indicate that acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 7.0 and 5.2 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data to hexachlorocyclopentadiene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 7.0 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of hexachlorocyclopentadiene to sensitive saltwater aquatic life.

Human Health

For comparison purposes, two approaches were used to derive criterion levels for hexachlorocyclopentadiene. Based on available toxicity data, for the protection of public health, the derived level is 206 µg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 1.0 µg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Isophorone

Freshwater Aquatic Life

The available data for isophorone indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 117,000 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of isophorone to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for isophorone indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 12,900 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of isophorone to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of isophorone ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 5.2 mg/l.

For the protection of human health from the toxic properties of isophorone ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 520 mg/l.

Lead

Freshwater Aquatic Life

For total recoverable lead the criterion (in µg/l) to protect freshwater aquatic life as derived using the Guidelines is the numerical value given by e(2.35[ln(hardness)]-9.48) as a 24-hour average and the concentration (in µg/l) should not exceed the numerical value given by e(1.22[ln(hardness)]-0.47) at any time. For example, at hardnesses of 50, 100, and 200 mg/l as $CaCO_3$ the criteria are 0.75, 3.8, and 20 µg/l, respectively, as 24-hour averages, and the concentrations should not exceed 74, 170, and 400 µg/l, respectively, at any time.

Saltwater Aquatic Life

The available data for total recoverable lead indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 668 and 25 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

The ambient water quality criterion for lead is recommended to be identical to the existing drinking water standard which is 50 µg/l. Analysis of the toxic effects data resulted in a calculated level which is protective to human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Mercury

Freshwater Aquatic Life

For total recoverable mercury the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.00057 µg/l as a 24-hour average and the concentration should not exceed 0.0017 µg/l at any time.

Saltwater Aquatic Life

For total recoverable mercury the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.025 µg/l as a 24-hour average and the concentration should not exceed 3.7 µg/l at any time.

Human Health

For the protection of human health from the toxic properties of mercury ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 144 ng/l.

For the protection of human health from the toxic properties of mercury ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 146 ng/l.

Note.—These values include the consumption of freshwater, estuarine, and marine species.

Naphthalene

Freshwater Aquatic Life

The available data to naphthalene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 2,300 and 620 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for naphthalene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2,350 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of naphthalene to sensitive saltwater aquatic life.

Human Health

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for naphthalene.

Nickel

Freshwater Aquatic Life

For total recoverable nickel the criterion (in μg/l) to protect freshwater aquatic life as derived using the Guidelines is the numerical value given by e(0.76 [ln (hardness)] + 1.06) as a 24-hour average and the concentration (in μg/l) should not exceed the numerical value given by e(0.76[ln (hardness)] + 4.02) at any time. For example, at hardnesses of 50, 100, and 200 mg/l as $CaCO_3$ the criteria are 56, 96, and 160 μg/l, respectively, as 24-hour averages, and the concentrations should not exceed 1,100, 1,800, and 3,100 μg/l, respectively, at any time.

Saltwater Aquatic Life

For total recoverable nickel the criterion to protect saltwater aquatic life as derived using the Guidelines is 7.1 μg/l as a 24-hour average and the concentration should not exceed 140 μg/l at any time.

Human Health

For the protection of human health from the toxic properties of nickel ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 13.4 μg/l.

For the protection of human health from the toxic properties of nickel ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 100 μg/l.

Nitrobenzene

Freshwater Aquatic Life

The available data for nitrobenzene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 27,000 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of nitrobenzene to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for nitrobenzene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 6,680 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of nitrobenzene to sensitive saltwater aquatic life.

Human Health

For comparison purposes, two approaches were used to derive criterion levels for nitrobenzene. Based on available toxicity data, for the protection of public health, the derived level is 19.8 mg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 30 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have no demonstrated relationship to potential adverse human health effects.

Nitrophenols

Freshwater Aquatic Life

The available data for nitrophenols indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 230 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of nitrophenols to sensitive freshwater aquatic life but toxicity to one species of algae occurs at concentrations as low as 150 μg/l.

Saltwater Aquatic Life

The available data for nitrophenols indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 4,850 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of nitrophenols to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of 2,4-dinitro-o-cresol ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 13.4 μg/l.

For the protection of human health from the toxic properties of 2,4-dinitro-o-cresol ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 765 μg/l.

For the protection of human health from the toxic properties of dinitrophenol ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 70 μg/l.

For the protection of human health from the toxic properties of dinitrophenol ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 14.3 mg/l.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for mononitrophenol.

Using the present guidelines, a satisfactory criterion cannot be derived at this time due to the insufficiency in the available data for trinitrophenol.

Nitrosamines

Freshwater Aquatic Life

The available data for nitrosamines indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 5,850 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of nitrosamines to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for nitrosamines indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 3,300,000 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of nitrosamines to sensitive saltwater aquatic life

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of n-nitrosodimethylamine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 14 ng/l, 1.4 ng/l, and .14 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 160,000 ng/l, 16,000 ng/l, and 1,600 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure of n-nitrosodiethylamine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 8 ng/l, 0.8 ng/l, and 0.08 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 12,400 ng/l, 1,240 ng/l, and 124 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure in n-nitrosodi-n-butylamine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 64 ng/l, 6.4 ng/l and .064 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 5,868 ng/l, 587 ng/l, and 58.7 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure in n-nitrosodiphenylamine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 49,000 ng/l 4,900 ng/l and 490 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 161,000 ng/l, 16,100 ng/l, and 1,610 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

For the maximum protection of human health from the potential carcinogenic effects due to exposure in n-nitrosopyrrolidine through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk, over the lifetimes are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 160 ng/l 16.0 ng/l and 1.60 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 919,000 ng/l, 91,900 ng/l, and 9,190 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Pentachlorophenol

Freshwater Aquatic Life

The available data for pentachlorophenol indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 55 and 3.2 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for pentachlorophenol indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 53 and 34 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For comparison purposes, two approaches were used to derive criterion levels for pentachlorophenol. Based on available toxicity data, for the protection of public health, the derived level is 1.01 mg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 30 μg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Phenol

Freshwater Aquatic Life

The available data for phenol indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 10,200 and 2,560 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for phenol indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 5,800 ug/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of phenol to sensitive saltwater aquatic life.

Human Health

For comparison purposes, two approaches were used to derive criterion levels for phenol. Based on available toxicity data, for the protection of public health, the derived level is 3.5 mg/l. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 0.3 mg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criterion have limitations and have no demonstrated relationship to potential adverse human health effects.

Phthalate Esters

Freshwater Aquatic Life

The available data for phthalate esters indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 940 and 3 µg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for phthalate esters indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2944 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of phthalate esters to sensitive saltwater aquatic life but toxicity to one species of algae occurs at concentrations as low as 3.4 µg/l.

Human Health

For the protection of human health from the toxic properties of dimethyl-phthalate ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 313 mg/l.

For the protection of human health from the toxic properties of dimethyl-phthalate ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 2.9 g/l.

For the protection of human health from the toxic properties of diethyl-phthalate ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 350 mg/l.

For the protection of human health from the toxic properties of diethyl-phthalate ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 1.8 g/l.

For the protection of human health from the toxic properties of dibutyl-phthalate ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 34 mg/l.

For the protection of human health from the toxic properties of dibutyl-phthalate ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 154 mg/l.

For the protection of human health from the toxic properties of di-2-ethylhexyl-phthalate ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 15 mg/l.

For the protection of human health from the toxic properties of di-2-ethylhexyl-phthalate ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 50 mg/l.

Polychlorinated Biphenyls

Freshwater Aquatic Life

For polychlorinated biphenyls the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.014 µg/l as a 24-hour average. The available data indicate that acute toxicity to freshwater aquatic life probably will only occur at concentrations above 2.0 µg/l and that the 24-hour average should provide adequate protection against acute toxicity.

Saltwater Aquatic Live

For polychlorinated biphenyls the criterion to protect saltwater aquatic life as derived using the Guidelines is 0.030 µg/l as a 24-hour average. The available data indicate that acute toxicity to saltwater aquatic life probably will only occur at concentrations above 10 µg/l and that the 24-hour average should provide adequate protection against acute toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of PCBs through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are .79 ng/l, 0.79 ng/l and .0079 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are .79 ng/l, .079 ng/l, and .0079 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Polynuclear Aromatic Hydrocarbons (PAHs)

Freshwater Aquatic Life

The limited freshwater data base available for polynuclear aromatic hydrocarbons, mostly from short-term bioconcentration studies with two compounds, does not permit a statement concerning acute or chronic toxicity.

Saltwater Aquatic Life

The available data for polynuclear aromatic hydrocarbons indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 300 ug/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of polynuclear aromatic hydrocarbons to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of PAHs through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 28 ng/l, 2.8 ng/l, and .28 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 311 ng/l, 31.1 ng/l, and 3.11 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Selenium

Freshwater Aquatic Life

For total recoverable inorganic selenite the criterion to protect freshwater aquatic life as derived using the Guidelines is 35 µg/l as a 24-hour average and the concentration should not exceed 260 µg/l at any time.

The available data for inorganic selenate indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 760 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of inorganic selenate to sensitive freshwater aquatic life.

Saltwater Aquatic Life

For total recoverable inorganic selenite the criterion to protect saltwater aquatic life as derived using the Guidelines is 54 μg/l as a 24-hour average and the concentration should not exceed 410 μg/l at any time.

No data are available concerning the toxicity of inorganic selenate to saltwater aquatic life.

Human Health

The ambient water quality criterion for selenium is recommended to be identical to the existing drinking water standard which is 10 μg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Silver

Freshwater Aquatic Life

For freshwater aquatic life the concentration (in μg/l) of total recoverable silver should not exceed the numerical value given by "e(1.72(ln (hardness)-6.52))" at any time. For example, at hardnesses of 50, 100, 200 mg/l as $CaCO_3$ the concentration of total recoverable silver should not exceed 1.2, 4.1, and 13 μg/l, respectively, at any time. The available data indicate that chronic toxicity to freshwater aquatic life may occur at concentrations as low as 0.12 μg/l.

Saltwater Aquatic Life

For saltwater aquatic life the concentration of total recoverable silver should not exceed 2.3 μg/l at any time. No data are available concerning the chronic toxicity of silver to sensitive saltwater aquatic life.

Human Health

The ambient water quality criterion for silver is recommended to be identical to the existing drinking water standard which is 50 μg/l. Analysis of the toxic effects data resulted in a calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms. The calculated value is comparable to the present standard. For this reason a selective criterion based on exposure solely from consumption of 6.5 grams of aquatic organisms was not derived.

Tetrachloroethylene

Freshwater Aquatic Life

The available data for tetrachloroethylene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 5,280 and 840 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Saltwater Aquatic Life

The available data for tetrachloroethylene indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations low as 10,200 and 450 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of tetrachloroethylene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 8 μg/l, .8 μg/l, and .08 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 88.5 μg/l, 8.85 μg/l, and .88 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Thallium

Freshwater Aquatic Life

The available data for thallium indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 1,400 and 40 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested. Toxicity to one species of fish occurs at concentrations as low as 20 μg/l after 2,600 hours of exposure.

Saltwater Aquatic Life

The available data for thallium indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2,130 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of thallium to sensitive saltwater aquatic life.

Human Health

For the protection of human health from the toxic properties of thallium ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 13 μg/l.

For the protection of human health from the toxic properties of thallium ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 48 μg/l.

Toluene

Freshwater Aquatic Life

The available data for toluene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 17,500 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of toluene to sensitive freshwater aquatic life.

Saltwater Aquatic Life

The available data for toluene indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 6,300 and 5,000 μg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Human Health

For the protection of human heath from the toxic properties of toluene ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 14.3 mg/l.

For the protection of human heath from the toxic properties of toluene ingested through contaminated aquatic organisms alone, the ambient water criterion is determined to be 424 mg/l.

Toxaphene

Freshwater Aquatic Life

For toxaphene the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.013 μg/l as a 24-hour average and the concentration should not exceed 1.6 μg/l at any time.

Saltwater Aquatic Life

For saltwater aquatic life the concentration of toxaphene should not exceed 0.070 μg/l at any time. No data

20 August [illegible]

SUMMARY

SNARLS

Assumptions:

1. Looking at sensitive population.
2. Using a child weighing 10 kg. who drinks one liter of water per day.
3. Considering only toxic effects. rather than carcinogenic

Health Advisories

Compound	1 day	7 days	10 days	1 month	life-time
trichloroethylene	2 mg/1		200 ug/1		75 ug/1
tetrachloroethylene	2.3 mg/1		180 ug/1		40 ug/1
1,1,1-trichloroethane					1 mg/1
benzene		350 ug/1			
polynuclear aromatic hydrocarbons		25 ug/1			

Length of Exposure

Cancer Risks

Assumptions:

1. There is some risk at any level of exposure, and the risk increases as lifetime exposure increases.
2. Using 70 kg. adult living 70 years who drinks two liters of water per day.

Excess Risk

Compound	One in 10^{-6}	One in 10^{-5}	Two in 10^{-5}	Six in 10-
trichloroethylene	4.5 ug/1	45 ug/1	75 ug/1	
tetrachloroethylene	3.5 ug/1	35 ug/1		20 ug/1

are available concerning the chronic toxicity of toxaphene to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of toxaphene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 7.1 ng/l, .71 ng/l, and .07 ng/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 7.3 ng/l, .73 ng/l and .07 ng/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Trichloroethylene

Freshwater Aquatic Life

The available data for trichloroethylene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 45,000 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of trichloroethylene to sensitive freshwater aquatic life but adverse behavioral effects occurs to one species at concentrations as low as 21,900 μg/l.

Saltwater Aquatic Life

The available data for trichloroethylene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2,000 μg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of trichloroethylene to sensitive saltwater aquatic life.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of trichloroethylene through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 27 μg/l, 2.7 μg/l, and .27 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 807 μg/l, 80.7 μg/l, and 8.07 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Vinyl Chloride

Freshwater Aquatic Life

No freshwater organisms have been tested with vinyl chloride and no statement can be made concerning acute or chronic toxicity.

Saltwater Aquatic Life

No saltwater organisms have been tested with vinyl chloride and no statement can be made concerning acute or chronic toxicity.

Human Health

For the maximum protection of human health from the potential carcinogenic effects due to exposure of vinyl chloride through ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero based on the non-threshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 10^{-5}, 10^{-6}, and 10^{-7}. The corresponding criteria are 20 μg/l, 2.0 μg/l, and .2 μg/l, respectively. If the above estimates are made for consumption of aquatic organisms only, excluding consumption of water, the levels are 5,246 μg/l, 525 μg/l, and 52.5 μg/l, respectively. Other concentrations representing different risk levels may be calculated by use of the Guidelines. The risk estimate range is presented for information purposes and does not represent an Agency judgment on an "acceptable" risk level.

Zinc

Freshwater Aquatic Life

For total recoverable zinc the criterion to protect freshwater aquatic life as derived using the Guidelines is 47 μg/l as a 24-hour average and the concentration (in μg/l) should not exceed the numerical value given by $e^{(0.83[\ln(\text{hardness})]+1.95)}$ at any time. For example, at hardnesses of 50, 100, and 200 mg/l as $CaCO_3$ the concentration of total recoverable zinc should not exce 180, 320, and 570 μg/l at any time.

Saltwater Aquatic Life

For total recoverable zinc the criteri to protect saltwater aquatic life as derived using the Guidelines is 58 μg/l as a 24-hour average and the concentration should not exceed 170 μg/l at any time.

Human Health

Sufficient data is not available for zinc to derive a level which would protect against the potential toxicity of this compound. Using available organoleptic data, for controlling undesirable taste and odor quality of ambient water, the estimated level is 5 mg/l. It should be recognized that organoleptic data as a basis for establishing a water quality criteria have limitations and have not demonstrated relationship to potential adverse human health effects.

Appendix B—Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Its Uses

Introduction

This version of the Guidelines provides clarifications, additional details, and technical and editorial changes in the last version published in the Federal Register [44 FR 15970 (March 15, 1979)]. This version incorporates changes resulting from comments on previous versions and from experience gained during U.S. EPA's use of the previous versions. Future versions of the Guidelines will incorporate new ideas and data as their usefulness is demonstrated.

Criteria may be expressed in several forms. The numerical form is commonly used, but descriptive and procedural forms can be used if numerical criteria are not possible or desirable. The purpose of these Guidelines is to describe an objective, internally consistent and appropriate way of deriving numerical water quality criteria for the protection of the uses of, as well as the presence of, aquatic organisms.

A numerical criterion might be thought of as an estimate of the highest concentration of a substance in water which does not present a significant risk to the aquatic organisms in the water and their uses. Thus the Guidelines are intended to derive criteria which will protect aquatic communities by protecting most of the species and their uses most of the time, but not

Draft SNARLS (not to be released)

Assumptions:

1. Looking at sensitive population.
2. Using a child weighing 10 kg. who drinks one liter of water per day.
3. Considering only toxic effects.

Compound	Length of Exposure				
	1 day	7 days	10 days	1 month	life-time
methylene chloride	13 mg/l		1.3-1.5 mg/l		150 ug/l
carbon tetrachloride	200 ug/l		20 ug/l		
toluene			1 mg/l		
methyl ethyl ketone			1 mg/l		
acrylonitrile			35 ug/l	3 ug/l	
polychlorinated biphenyls				1 ug/l	0.3 ug/l
dibromochloropropane					0.05 ug/l
1,4-dioxane			20 ug/l		
xylenes	12 mg/l		1.4 mg/l		620 ug/l
chlordane	63 ug/l		63 ug/l		8 ug/l
1,1 Dichloroethylene	1.0 mg/l				70 ug/l
Trans-1,2 Dichloroethylene	2.7 mg/l		0.27 mg/l		
Cis-1,2 Dichloroethylene	4.0 mg/l		0.40 mg/l		
Ethylene Glycol	19 mg/l				5.5 mg/l

METHOD 9020

TOTAL ORGANIC HALIDES (TOX)

1.0 Scope and Application

1.1 Method 9020 determines Total Organic Halides (TOX) as Cl^- in drinking and ground waters. The method uses carbon adsorption with a microcoulometric-titration detector. It requires that all samples be run in duplicate. Under conditions of duplicate analysis, the reliable limit of sensitivity is 5 µg/l.

1.2 Method 9020 detects all organic halides containing chlorine, bromine and iodine that are adsorbed by granular activated carbon under the conditions of the method. Fluorine-containing species are not determined by this method.

1.3 Method 9020 is applicable to samples whose inorganic-halide concentration does not exceed the organic-halide concentration by more than 20,000 times.

1.4 Method 9020 is restricted to use by, or under the supervision of, analysts experienced in the operation of a pyrolysis/microcoulometer and in the interpretation of the results.

1.5 This method is provided as a recommended procedure. It may be used as a reference for comparing the suitability of other methods thought to be appropriate for measurement of TOX (i.e., by comparison of sensitivity, accuracy, and precision data).

2.0 Summary of Method

2.1 A sample of water that has been protected against the loss of volatiles by the elimination of headspace in the sampling container, and that is free of undissolved solids, is passed through a column containing 40 mg of activated carbon. The column is washed to remove any trapped inorganic halides, and is then analyzed to convert the adsorbed organohalides to a titratable species that can be measured by a microcoulometric detector.

3.0 Interferences

3.1 Method interferences may be caused by contaminants, reagents, glassware, and other sample processing hardware. All these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running method blanks.

3.1.1 Glassware must be scrupulously cleaned. Clean all glassware as soon as possible after use by treating with chromate cleaning solution. This should be followed by detergent washing in hot water. Rinse with tap water and distilled water, drain dry, and heat in a muffle furnace at 400° C for 15 to 30 min. Volumetric ware should not be heated in a muffle furnace. Glassware should be sealed and stored in a clean environment after drying and cooling to prevent any accumulation of dust or other contaminants.

3.1.2 The use of high purity reagents and gases helps to minimize interference problems.

3.2 Purity of the activated carbon must be verified before use. Only carbon samples that register less than 1000 ng/40 mg should be used. The stock of activated carbon should be stored in its granular form in a glass container with a Teflon seal. Exposure to the air must be minimized, especially during and after milling and sieving the activated carbon. No more than a two-week supply should be prepared in advance. Protect carbon at all times from all sources of halogenated organic vapors. Store prepared carbon and packed columns in glass containers with Teflon seals.

4.0 Apparatus and Materials

4.1 Adsorption system

4.1.1 Dohrmann adsorption module (AD-2), or equivalent, pressurized, sample and nitrate-wash reservoirs.

4.1.2 Adsorption columns: Pyrex, 5-cm-long x 6-mm-O.D. x 2-mm-I.D.

4.2.3 Granular activated carbon (GAC): Filtrasorb-400, Calgon-APC or equivalent, ground or milled, and screened to a 100/200 mesh range. Upon combustion of 40 mg of GAC, the apparent-halide background should be 1000 mg Cl^- equivalent or less.

4.1.4 Cerafelt (available from Johns-Manville), or equivalent: Form this material into plugs using a 2-mm-I.D. stainless-steel borer with ejection rod (available from Dohrmann) to hold 40 mg of GAC in the adsorption columns. CAUTION: Do not touch this material with your fingers.

4.1.5 Column holders (available from Dohrmann).

4.1.6 Volumetric flasks: 100-ml, 50-ml. A general schematic of the adsorption system is shown in Figure 1.

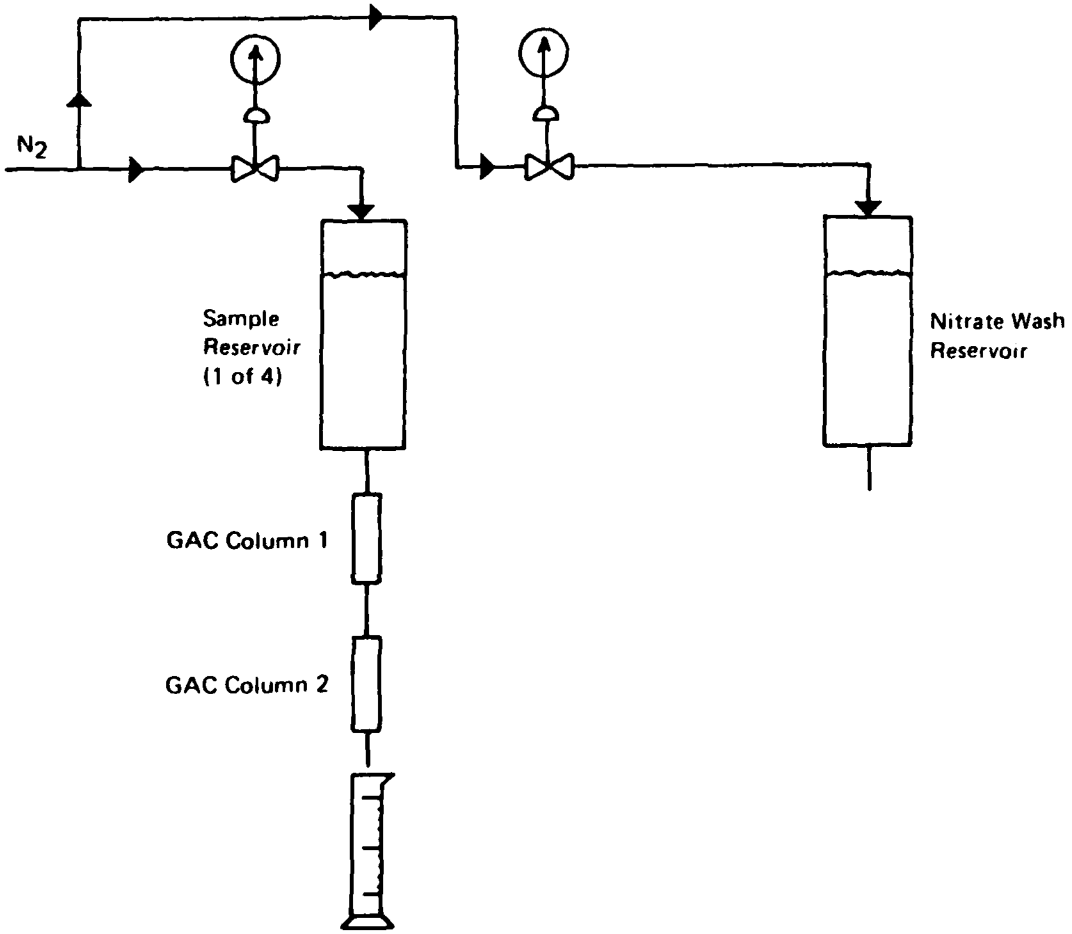

Figure 1. Schematic of Adsorption System.

4.2 Dohrmann microcoulometric-titration system (MCTS-20 or DX-20), or equivalent, containing the following components:

4.2.1 Boat sampler.

4.2.2 Pyrolysis furnace.

4.2.3 Microcoulometer with integrator.

4.2.4 Titration cell: A general description of the analytical system is shown in Figure 2.

4.3 Strip chart recorder.

5.0 Reagents

5.1 Sodium sulfite: 0.1 M, ACS reagent grade (12.6 g/liter).

5.2 Nitric acid: Concentrated.

5.3 Nitrate-wash solution (5000 mg NO_3^-/l): Prepare a nitrate-wash solution by transferring approximately 8.2 g of potassium nitrate into a 1-liter volumetric flask and diluting to volume with reagent water.

5.4 Carbon dioxide: Gas, 99.9% purity.

5.5 Oxygen: 99.9% purity.

5.6 Nitrogen: Prepurified.

5.7 70% acetic acid in water: Dilute 7 volumes of acetic acid with 3 volumes of water.

5.8 Trichlorophenol solution, stock (1 µl = 10 µg Cl^-): Prepare a stock solution by weighing accurately 1.856 g of trichlorophenol into a 100-ml volumetric flask. Dilute to volume with methanol.

5.9 Trichlorophenol solution, calibration (1 µl = 500 ng Cl^-): Dilute 5 ml of the trichlorophenol stock solution to 100 ml with methanol.

5.10 Trichlorophenol standard, instrument-calibration: First, nitrate-wash a single column packed with 40 mg of activated carbon as instructed for sample analysis, and then inject the column with 10 µl of the calibration solution.

5.11 Trichlorophenol standard, adsorption-efficiency (100 µg Cl^-/liter): Prepare an adsorption-efficiency standard by injecting 10 µl of stock solution into 1 liter of reagent water.

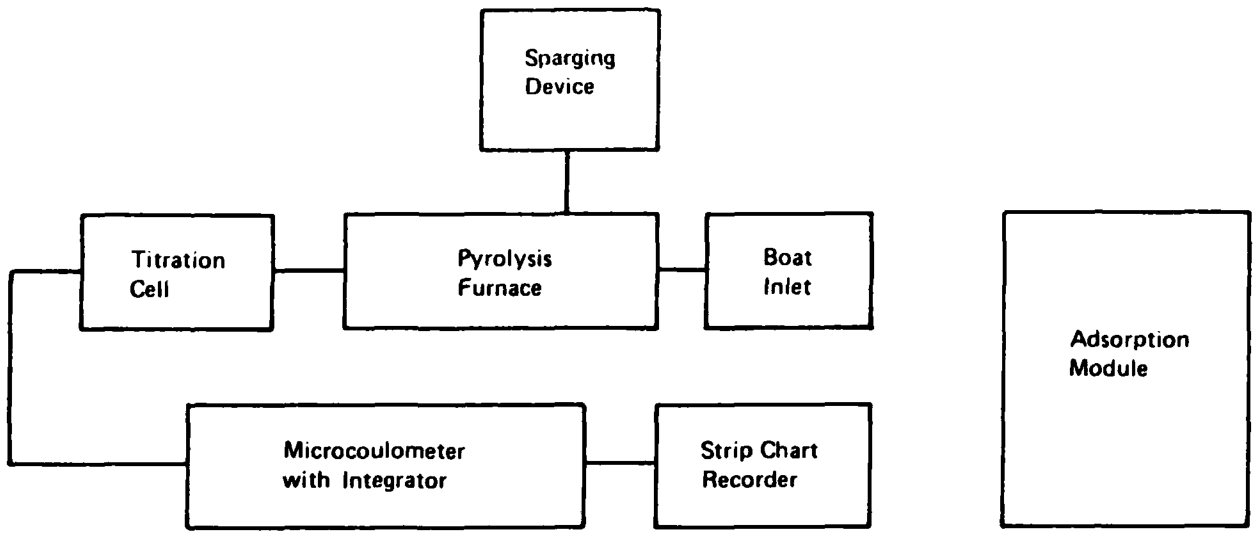

Figure 2. Schematic diagram of CAOX analysis system.

5.12 Reagent water: Reagent water is defined as a water in which an interferent is not observed at the method detection limit of each parameter of interest.

5.13 Blank standard: The reagent water used to prepare the calibration standard should be used as the blank standard.

6.0 Sample Collection, Preservation, and Handling

6.1 All samples must have been collected using a sampling plan that addresses the considerations discussed in Section One of this manual.

6.2 All samples should be collected in bottles with teflon septa (e.g., Pierce #12722 or equivalent) and be protected from light. If this is not possible, use amber glass, 250-ml, fitted with teflon-lined caps. Foil may be substituted for teflon if the sample is not corrosive. Samples must be protected against loss of volatiles by eliminating headspace in the container. If amber bottles are not available, protect samples from light. The container must be washed and muffled at 400° C before use, to minimize contamination.

6.3 All glassware must be dried prior to use according to the method discussed in 3.1.1.

7.0 Procedure

7.1 Sample preparation

7.1.1 Special care should be taken in handling the sample in order to minimize the loss of volatile organohalides. The adsorption procedure should be performed simultaneously on duplicates.

7.1.2 Reduce residual chlorine by adding sulfite (1 ml of 0.1 M per liter of sample). Sulfite should be added at the time of sampling if the analysis is meant to determine the TOX concentration at the time of sampling. It should be recognized that TOX may increase on storage of the sample. Samples should be stored at 4° C without headspace.

7.1.3 Adjust the pH of the sample to approximately 2 with concentrated HNO_3 just prior to adding the sample to the reservoir.

7.2 Calibration

7.2.1 Check the adsorption efficiency of each newly-prepared batch of carbon by analyzing 100 ml of the adsorption-efficiency standard, in duplicate, along with duplicates of the blank standard. The net recovery should be within 5% of the standard value.

7.2.2 Nitrate-wash blanks (method blanks): Establish the repeatability of the method background each day by first analyzing several nitrate-wash blanks. Monitor this background by spacing nitrate-wash blanks between each group of eight pyrolysis determinations. The nitrate-wash blank values are obtained on single columns packed with 40 mg of activated carbon. Wash with the nitrate solution as instructed for sample analysis, and then pyrolyze the carbon.

7.2.3 Pyrolyze duplicate instrument-calibration standards and the blank standard each day before beginning sample analysis. The net response to the calibration-standard should be within 3% of the calibration-standard value. Repeat analysis of the instrument-calibration standard after each group of eight pyrolysis determinations, and before resuming sample analysis after cleaning or reconditioning the titration cell or pyrolysis system.

7.3 Adsorption procedure

7.3.1 Connect two columns in series, each containing 40 mg of 100/200-mesh activated carbon.

7.3.2 Fill the sample reservoir, and pass a metered amount of sample through the activated-carbon columns at a rate of approximately 3 ml/min. NOTE: 100 ml of sample is the preferred volume for concentrations of TOX between 5 and 500 µg/l; 50 ml for 501 to 1000 µg/l, and 25 ml for 1001 to 2000 µg/l.

7.3.3 Wash the columns-in-series with 2 ml of the 5000-mg/l nitrate solution at a rate of approximately 2 ml/min to displace inorganic chloride ions.

7.4 Pyrolysis procedure

7.4.1 The contents of each column are pyrolyzed separately. After rinsing with the nitrate solution, the columns should be protected from the atmosphere and other sources of contamination until ready for further analysis.

7.4.2 Pyrolysis of the sample is accomplished in two stages. The volatile components are pyrolyzed in a CO_2-rich atmosphere at a low temperature to ensure the conversion of brominated trihalomethanes to a titratable species. The less volatile components are then pyrolyzed at a high temperature in an O_2-rich atmosphere. NOTE: The quartz sampling boat should have been previously muffled at 800° C for at least 2 to 4 min as in a previous analysis, and should be cleaned of any residue by vacuuming.

7.4.3 Transfer the contents of each column to the quartz boat for individual analysis.

7.4.4 If the Dohrmann MC-1 is used for pyrolysis, manual instructions are followed for gas flow regulation. If the MCTS-20 is used, the information on the diagram in Figure 3 is used for gas flow regulation.

7.4.5 Position the sample for 2 min in the 200° C zone of the pyrolysis tube. For the MCTS-20, the boat is positioned just outside the furnace entrance.

7.4.6 After 2 min, advance the boat into the 800° C zone (center) of the pyrolysis furnace. This second and final stage of pyrolysis may require from 6 to 10 min to complete.

7.5 Detection: The effluent gases are directly analyzed in the microcoulometric-titration cell. Carefully follow manual instructions for optimizing cell performance.

7.6 Breakthrough. The unpredictable nature of the background bias makes it especially difficult to recognize the extent of breakthrough of organohalides from one column to another. All second-column measurements for a properly operating system should not exceed 10% of the two-column total measurement. If the 10% figure is exceeded, one of three events can be happening. Either (1) the first column was overloaded and a legitimate measure of breakthrough was obtained, in which case taking a smaller sample may be necessary; or (2) channeling or some other failure occurred, in which case the sample may need to be rerun; or (3) a high random bias occurred and the result should be rejected and the sample rerun. Because it may not be possible to determine which event occurred, a sample analysis should be repeated often enough to gain confidence in results. As a general rule, any analysis that is rejected should be repeated whenever sample is available. If the second-column measurement is equal to or less than the nitrate-wash blank value, the second-column value should be disregarded.

7.7 Calculations: TOX as Cl^- is calculated using the following formula:

$$\frac{(C_1-C_3) + (C_2-C_3)}{V} = \mu g/l \text{ Total Organic Halide}$$

where:

C_1 = µg Cl^- on the first column in series

C_2 = µg Cl^- on the second column in series

C_3 = predetermined, daily, average, method-blank value (nitrate-wash blank for a 40-mg carbon column)

V = the sample volume in liters.

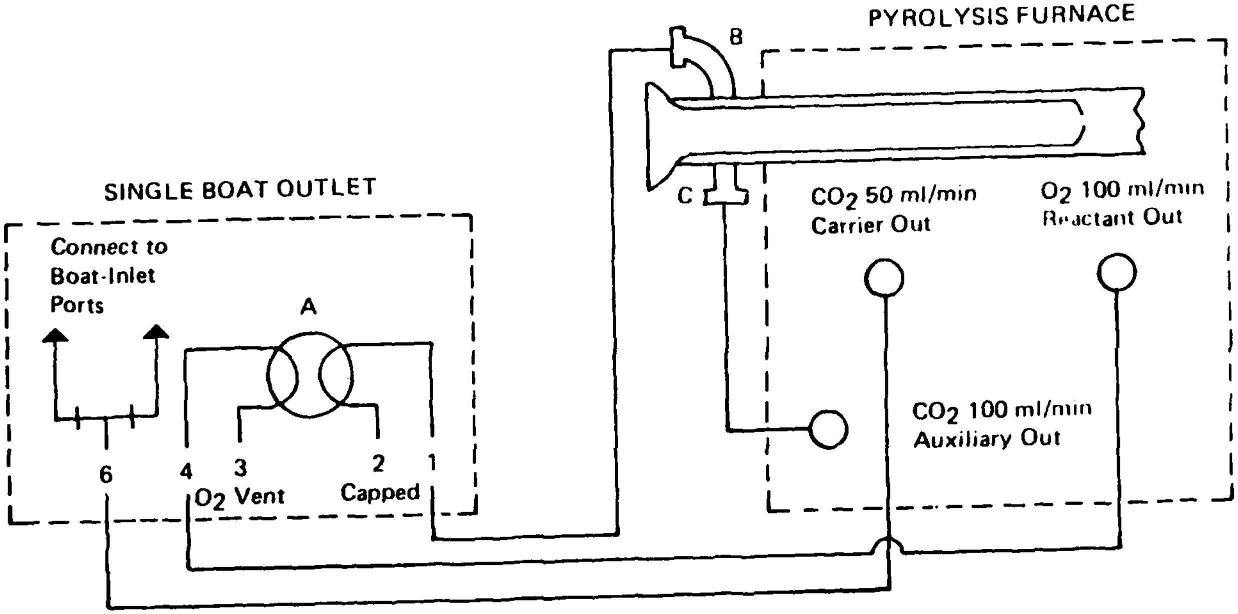

Figure 3. Rear-view plumbing schematic for MCTS–20 System. Valve A is set for first-stage combustion, O_2 venting (push/pull valve out). Port B enters inner combustion tube; Port C enters outer combustion tube.

8.0 Quality Control

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Before performing any analyses, the analyst must demonstrate the ability to generate acceptable accuracy and precision with this procedure by analyzing appropriate quality-control check samples.

8.3 The laboratory must develop and maintain a statement of method accuracy for their laboratory. The laboratory should update the accuracy statement regularly as new recovery measurements are made.

8.4 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.5 Run check standard after approximately every 15 samples.

8.6 Run one duplicate sample for every 10 samples. A duplicate sample is a sample brought through the whole sample preparations process.

8.7 It is recommended that the laboratory adopt additional quality-assurance practices for use with this method. The specific practices that would be most productive will depend upon the needs of the laboratory and the nature of the samples. Field duplicates may be analyzed to monitor the precision of the sampling technique. Whenever possible, the laboratory should perform analysis of standard reference materials and participate in relevant performance-evaluation studies.