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REVISED CONTAMINATION ASSESSMENT PLAN AND SITE-SPECIFIC HEALTH AND SAFETY PLAN AT FLYING CLUB BUILDING A127 NAS KEY WEST FL

4/1/1994

ABB ENVIRONMENTAL SERVICES INC

CONTAMINATION ASSESSMENT PLAN AND SITE-SPECIFIC HEALTH AND SAFETY PLAN

FLYINC CLUB, BUILDING A127
NAVAL AIR STATION KEY WEST
BOCA CHICA FIELD, KEY WEST, FLORIDA

CONTRACT TASK ORDER NO. 098
NAVY CLEAN - DISTRICT I
CONTRACT NO. N62467-89-D-0317

JULY 1993

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

CONTAMINATION ASSESSMENT REPORT

FLYING CLUB SITE, BUILDING A-127
NAVAL AIR STATION KEY WEST
BOCA CHICA FIELD, KEY WEST, FLORIDA

Contract Task Order No. 098

Contract No. N62467-89-D-0317

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April 1994

FOREWORD

Subtitle I of the Hazardous and Solid Waste Amendments (HSWA) of 1984 to the Solid Waste Disposal Act (SWDA) of 1965 established a national regulatory program for managing underground storage tanks (USTs) containing hazardous materials, especially petroleum products. Hazardous wastes stored in USTs were already regulated under the Resource Conservation and Recovery Act (RCRA) of 1976, which was also an amendment to SWDA. Subtitle I requires that the U.S. Environmental Protection Agency (USEPA) promulgate UST regulations. The program was designed to be administered by the individual States, who were allowed to develop more stringent standards, but not less stringent standards. Local governments were permitted to establish regulatory programs and standards that are more stringent, but not less stringent than either State or Federal regulations. The USEPA UST regulations are found in the Code of Federal Regulations, Title 40, Part 280 (40 CFR 280) (*Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks*) and Title 40 CFR 281 (*Approval of State Underground Storage Tank Programs*). Title 40 CFR 280 was revised and published on September 23, 1988, and became effective December 22, 1988.

The Navy's UST program policy is to comply with all Federal, State, and local regulations pertaining to USTs. This report was prepared to satisfy the requirements of the Florida Department of Environmental Protection (formerly the Florida Department of Environmental Regulation) Chapter 17-770, Florida Administrative Code (FAC) (*State Underground Petroleum Environmental Response*) regulations on petroleum contamination in Florida's environment as a result of spills or leaking tanks or piping.

Questions regarding this report should be addressed to the Commanding Officer, Naval Air Station Key West, Boca Chica Field, Key West, Florida, or to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), Gabriel Magwood, Code 1849, at AUTOVON 563-0658 or (803) 743-0658.

EXECUTIVE SUMMARY

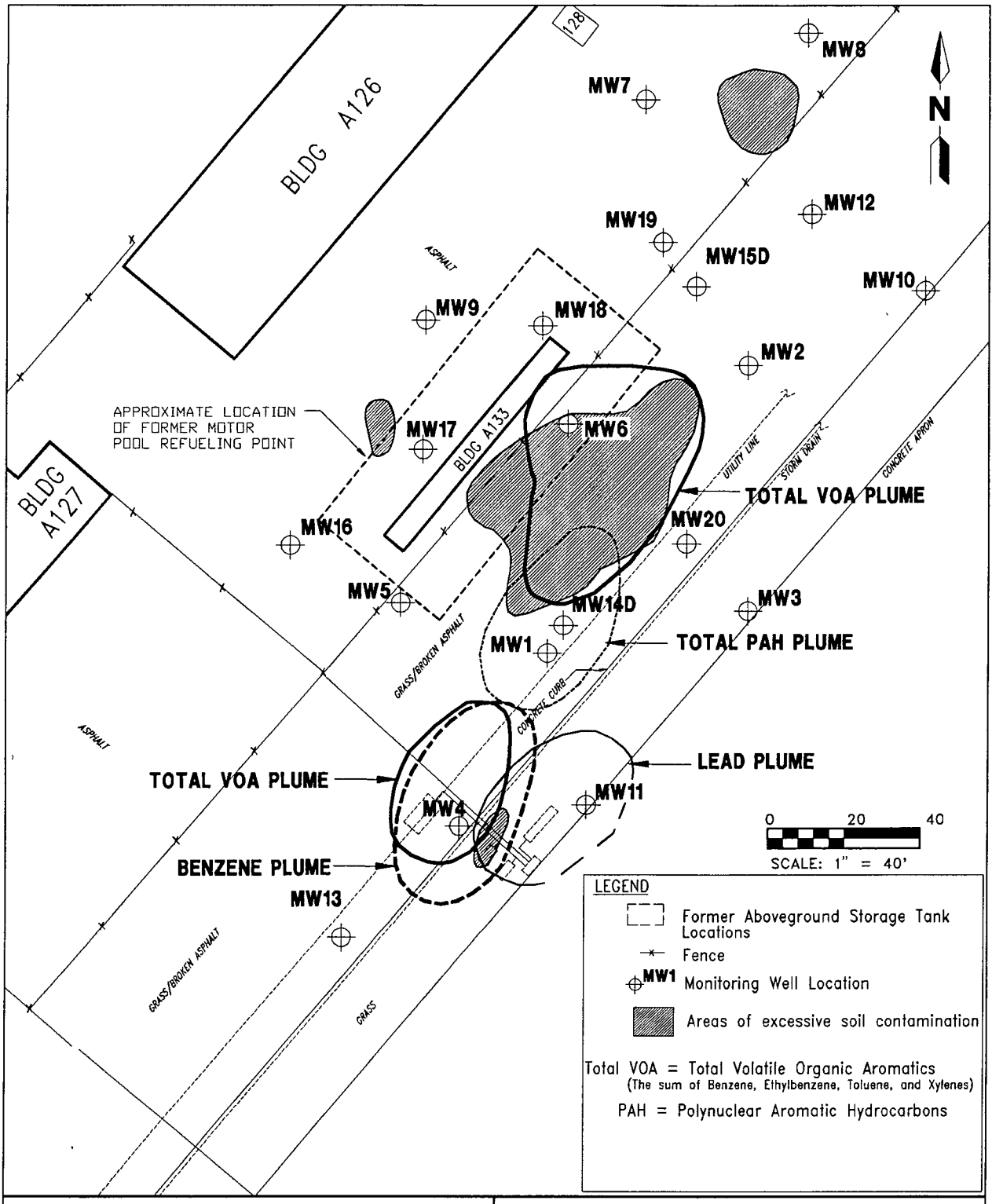
The Boca Chica Flying Club is the former location of four aboveground storage tanks (ASTs) and associated dispensers and piping, which contained aviation gasoline (AVGAS). The ASTs, fuel dispensers, and associated piping were removed from the site in February 1992.Three ASTs had capacities of 560 gallons; the fourth AST had a capacity of 1,000 gallons. According to facility personnel, the Flying Club was in operation from the until the late 1960's. The suspected cause of petroleum contamination at the site was overfilling of the ASTs. Building A-133, located approximately 70 feet north of the former ASTs (see Executive Summary Figure), is a remnant of a former motor pool refueling point and was identified as another possible source of contamination at the site. Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) contracted ABB Environmental Services, Inc. (ABB-ES), to perform a contamination assessment (CA) at the site and to prepare a contamination assessment report (CAR). ABB-ES conducted the CA from October to December 1993.

Seventy-one soil borings and 20 monitoring wells were placed at the site to assess the degree and extent of soil and groundwater contamination. Soil samples were collected and analyzed for volatile organic compounds (VOCs) by organic vapor analyzer (OVA) headspace analysis. Groundwater samples were collected from each monitoring well at the site and analyzed for kerosene analytical group constituents as defined in Chapter 17-770, Florida Administrative Code (FAC). Groundwater levels in monitoring wells were recorded to assess the groundwater flow direction, which is to the northeast.

OVA headspace analysis of soil samples indicated four areas of excessively contaminated soil (see Executive Summary Figure). Soil with VOC concentrations greater than 50 parts per million (ppm) is defined as being excessively contaminated (Chapter 17-770, FAC). The largest area of excessive soil contamination is located southeast of Building A-133. This area is approximately 70 feet long and 40 feet wide. Three smaller isolated areas were also identified: (1) the former AVGAS ASTs location, (2) the northwest side of Building A-133, near the former motor pool refueling point, and (3) the northern part of the site near MW-12. Excessive soil contamination appears to be restricted to 1 to 2 feet above the top of the water table (2 to 4 feet below land surface).

Compounds identified in monitoring well groundwater samples include benzene, ethylbenzene, toluene, xylenes, methyl tert-butyl ether (MTBE), total recoverable petroleum hydrocarbons (TRPH), lead, polynuclear aromatic hydrocarbons (PAH), and several chlorinated compounds. Groundwater contaminant concentrations were compared to Class G-III groundwater target levels in Chapter 17-770, FAC, where applicable.

Benzene, total volatile organic aromatics (VOA), and lead concentrations in groundwater exceed State target levels for Class G-III groundwater (total VOA is the sum of benzene, ethylbenzene, toluene, and xylenes). The areal extent of the benzene contamination, exceeding the Chapter 17-770, FAC target level, appears to be restricted to the vicinity of monitoring well MW-4, located at the former location of the ASTs (see Executive Summary Figure). Two total VOA contamination plumes were identified: one in the vicinity of the former ASTs, and a second in the vicinity of the former motor pool fuel refueling point, located east of



EXECUTIVE SUMMARY

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

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Building A-133. Lead concentrations in groundwater exceeded the State target level only in the vicinity of monitoring well MW-11, located east of the former ASTs. PAH (including naphthalenes) concentrations in groundwater exceed applied groundwater guidance concentrations in the vicinity of monitoring well MW-1, located downgradient of the former ASTs. Chlorinated compounds concentrations detected in groundwater were generally below groundwater guidance concentrations and do not appear to be a concern at the site.

Based on the findings, conclusions, and interpretations of the CA, ABB-ES recommends that a remedial action plan (RAP) be prepared to address excessively contamination soil and benzene, total VOA, and lead in groundwater. The PAH (and naphthalenes) contamination in the vicinity of monitoring well MW-1 should also be addressed. The manner of soil and groundwater remediation will be presented in the RAP, which will be developed pending Florida Department of Environmental Protection (FDEP) approval of this CAR.

ACKNOWLEDGMENTS

In preparing this report, the Underground Storage Tank Section of the Comprehensive Long-Term Environmental Action, (CLEAN) Group at ABB Environmental Services, Inc. (ABB-ES), commends the support, assistance, and cooperation provided by the personnel at Boca Chica Field, Naval Air Station, Key West, Florida, and Southern Division, Naval Facilities Engineering Command.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
AST	aboveground storage tank
AVGAS	aviation gasoline
bls	below land surface
CA	contamination assessment
CAP	Contamination Assessment Plan
CAR	Contamination Assessment Report
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action, Navy
CNO	Chief of Naval Operations
CompQAP	Comprehensive Quality Assurance Plan
CTO	Contract Task Order
1,1-DCA	1,1-dichloroethane
1,2-DCB	1,2-dichlorobenzene
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
EDB	ethylene dibromide
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FID	flame ionization detector
ft/day	feet per day
ft/ft	feet per foot
ft/min	feet per minute
HSWA	Hazardous and Solid Waste Amendments of 1984
ID	inside diameter
K	hydraulic conductivity
MLLW	mean lower low water
MTBE	methyl tert-butyl ether
mg/ℓ	milligrams per liter
msl	mean sea level
NAS	Naval Air Station
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
POA	Plan of Action
ppb	parts per billion

GLOSSARY (Continued)

ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
SWDA	Solid Waste Disposal Act of 1965
TCE	trichloroethene
TOC	top of casing
TRPH	total recoverable petroleum hydrocarbons
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
V	average pore water velocity
VOA	volatile organic aromatics

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), was contracted by the Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) to perform a contamination assessment (CA) and submit a Contamination Assessment Report (CAR) for the former location of the Flying Club at Boca Chica Field, Naval Air Station (NAS), Key West, Florida. The scope of services is described in Contract Task Order (CTO) No. 098, the Plan of Action (POA), and the Contamination Assessment Plan (CAP) and includes the following:

- collecting soil samples in the unsaturated zone for organic vapor analyzer (OVA) headspace analysis to assess the concentration of volatile organic compounds (VOCs) in soil,
- installing and sampling groundwater monitoring wells to assess the horizontal and vertical extent of groundwater contamination,
- collecting water level data to assess the groundwater flow direction and hydraulic gradient at the site,
- conducting a potable well inventory within a 0.25-mile radius of the site,
- conducting slug tests on selected wells to estimate aquifer characteristics,
- conducting a tidal influence study to assess the effect of tides on groundwater flow direction, and
- reducing and analyzing pertinent data gathered during the CA to complete this CAR.

The CA field investigation was conducted from October to December 1993. The following sections of this CAR present the background information, data compilation, field investigative results, and recommendations for further action at the site.

2.0 SITE BACKGROUND

NAS Key West is located approximately 150 miles southwest of Miami, Florida, in Monroe County, Florida (Figure 2-1). NAS Key West, a complex of activities located in numerous areas of the Lower Florida Keys, encompasses approximately 5,000 acres. The majority of these activities are concentrated on Boca Chica Key and Key West. The mission of NAS Key West is to maintain and operate facilities and provide services and materials to support operations of aviation activities and units designated by the Chief of Naval Operations (CNO).

The Flying Club is located along the northwest boundary of Taxiway "H" approximately 50 to 100 feet south of Building A-133 at Boca Chica Field (Figure 2-1). The Flying Club is currently inactive and was used as an aircraft parking and refueling area. The site is the former location of four aboveground storage tanks (ASTs) and associated dispensers and piping, which reportedly contained aviation gasoline (AVGAS) (Figure 2-2). Three ASTs reportedly had capacities of 560 gallons. The fourth AST reportedly had a capacity of 1,000 gallons. According to facility personnel, The Boca Chica Flying Club was in operation until the late 1960's. The ASTs, fuel dispensers, and associated piping were removed from the site in February 1992. Overfilling of the ASTs is the suspected cause of petroleum contamination at the site.

The area in the immediate vicinity of the ASTs is covered by broken asphalt, grass, and limestone. The site is bordered along the southeast by a concrete apron that is part of Taxiway "H", which is used for airplane and helicopter parking. During the site investigation, routine engine testing and refueling operations were observed to occur. A northeast-southwest trending, 6-inch high concrete curb is located approximately 20 feet northwest of Taxiway "H". An underground storm drain parallels the concrete curb over much of the site area. An underground utility line also runs parallel to the concrete curb on the northwest side of the curb. The northwest boundary of the site is bordered by an 8-foot high, chain-link fence.

There are three structures located on the northern side of the fence, Buildings A-126, A-127, and A-133. Building A-126, located approximately 150 feet northerly of the former ASTs, was formerly used as a transportation facility and is currently used as an electrical maintenance and repair facility. Building A-127, located approximately 120 feet northwest of the former ASTs, is currently inactive and was formerly used as a transportation facility. Building A-133, located approximately 70 feet north of the former ASTs, is a remnant of a former motor pool refueling point and is currently used to store transformers, some of which contain polychlorinated biphenyls (PCBs). Discussions with activity personnel indicated that underground storage tank(s) (USTs) associated with the motor pool refueling operations had been removed. Labels on the transformers indicated that they contained less than 50 parts per million (ppm) of PCBs. Interviews with NAS Key West personnel indicate that the area in the vicinity of Building A-133 may also have been used as an auto hobby shop and staging area.

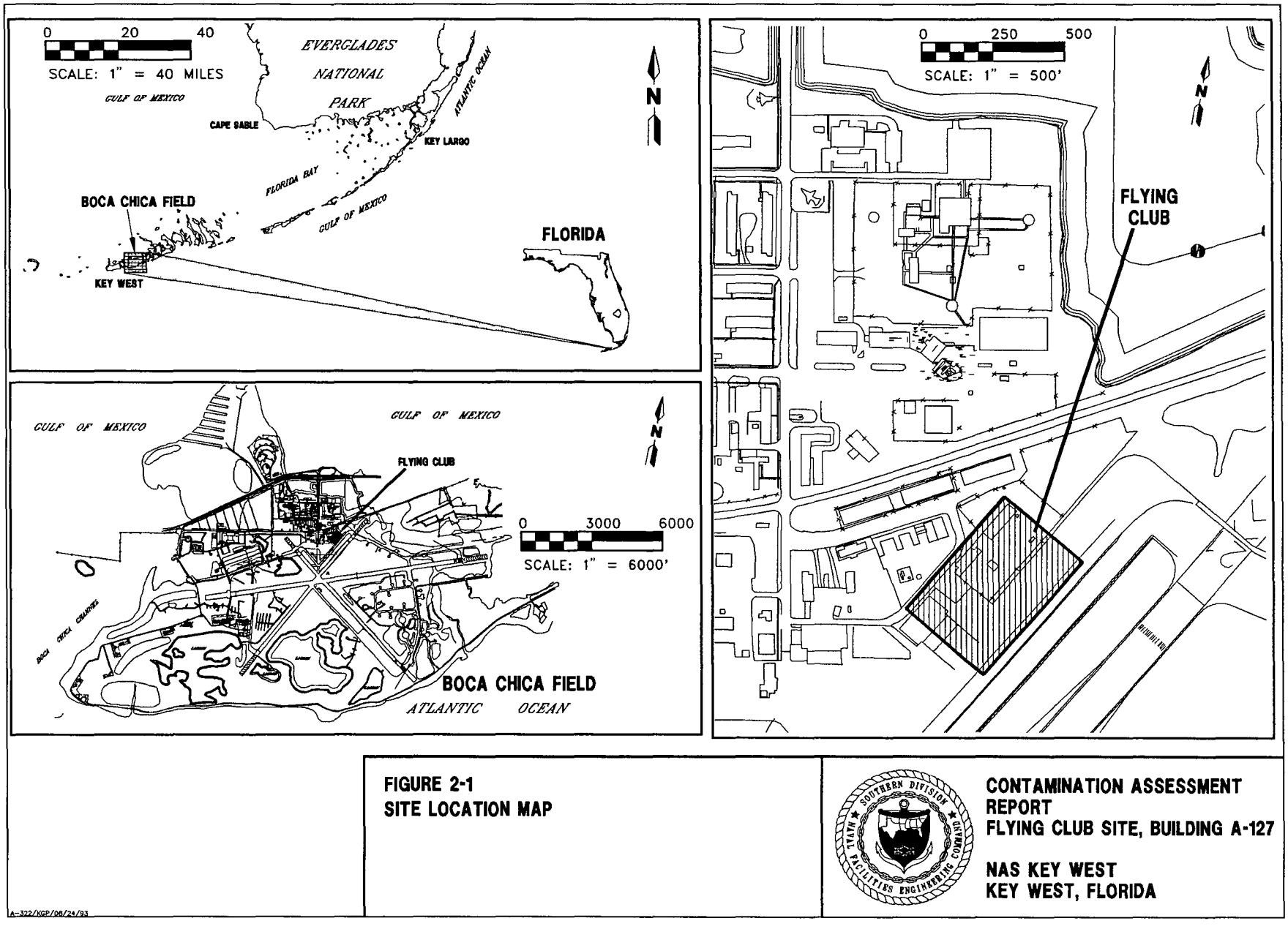

FIGURE 2-1
SITE LOCATION MAP

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

A-322/KGP/08/24/93

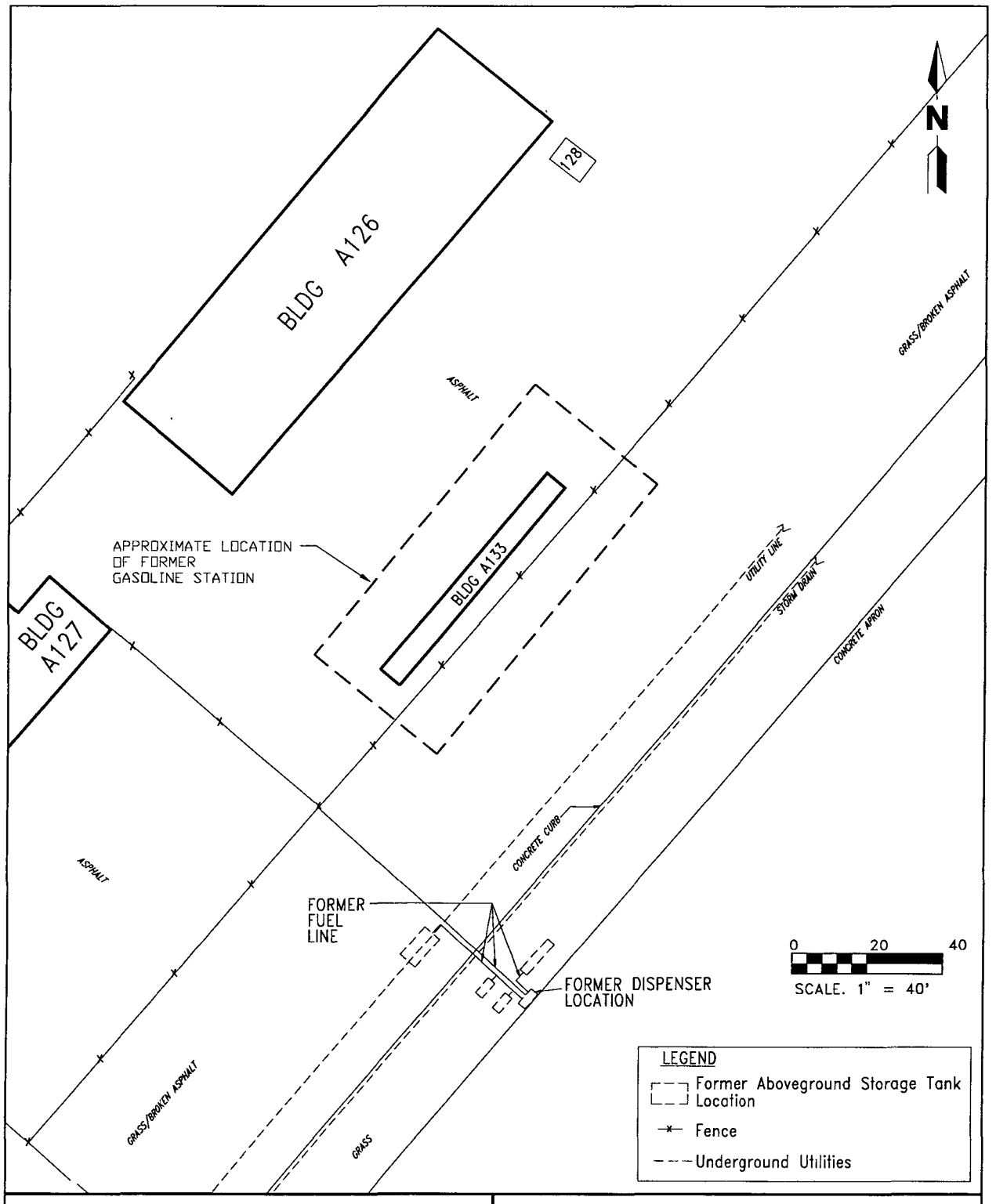

FIGURE 2-2
SITE PLAN

FLYCLUB/MAH/12/13/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

3.0 SITE CONDITIONS

3.1 PHYSIOGRAPHY. Regional physiography is discussed in Appendix A, Site Conditions. The surface topography at the site is flat, with ground elevations of approximately 5 feet above mean sea level (msl) (U.S. Geological Survey, 1971).

3.2 HYDROGEOLOGY.

3.2.1 Regional Regional hydrogeology is discussed in Appendix A.

3.2.2 Site Specific Site-specific hydrogeologic characteristics were obtained from information gathered during the site investigation. The unconfined surficial aquifer is the principal aquifer of concern in the Key West area. Rainwater infiltration appears to be the only source of freshwater recharge to the aquifer. Specific conductance of the groundwater can vary greatly depending on whether it is the "wet" season or a drought. Water quality data indicate that the surficial aquifer in the Key West area is an unlikely source of potable water (McKenzie, 1990) thus, the surficial aquifer will be treated herein as a G-III groundwater source. Potable water at NAS Key West is obtained from mainland Florida through the Florida Keys Aqueduct.

The surficial aquifer was penetrated to a depth of 32 feet below land surface (bls) during this investigation. This zone is generally composed of a mixture of oolitic sand; light gray, non-plastic clay; and limestone gravel. Some pebble-sized limestone fragments were encountered. The sand is light brown to white, and varies from fine grained to coarse grained. Clay content in the soil ranges from 0 to 30 percent, and typically averages 20 percent. The amount of gravel in the samples is typically 10 percent to 20 percent, and generally increases with depth. Because the soil borings are very shallow (less than 6 feet bls) and the lithology across the site varies very little, only the lithologic logs for borings in which monitoring wells were installed are presented in Appendix B, Lithologic Logs.

During this investigation, groundwater was encountered at depths ranging from approximately 2.5 to 4 feet bls. Groundwater flow direction in the surficial aquifer is to the northeast. A tidal influence study indicates groundwater elevations and gradients are tidally affected (see Appendix C, Tidal Influence Study); however, the direction of groundwater flow appears to be consistently to the northeast at all times during the tidal cycle.

4.0 METHODOLOGIES AND EQUIPMENT

The site investigation was conducted from October to December 1993. All methodologies and equipment used during the field investigation were in conformance with the ABB-ES, Florida Department of Environmental Protection (FDEP)-approved, Comprehensive Quality Assurance Program Plan (CompQAPP).

4.1 SOIL BORING ADVANCEMENT, SOIL SAMPLING, AND ORGANIC VAPOR ANALYZER (OVA) HEADSPACE ANALYSIS. Seventy-one soil borings (designated SB-1 through SB-71) were advanced into the water table to assess the horizontal and vertical extent of petroleum contamination in the vadose zone, to characterize the type of subsurface material, and to aid in the placement of groundwater monitoring wells. Soil boring locations are shown on Figure 4-1.

Soil borings were advanced using a truck-mounted drill rig with rotary drilling and solid-stemmed augers. Soil samples were collected at 2-foot vertical intervals until the water table was encountered. Total depth of soil borings varied from 4 feet bls to 6 feet bls, depending on the depth to the water table.

Soil samples were placed in 16-ounce glass jars and were sealed with a double layer of aluminum foil. Soil petroleum contamination was assessed by OVA headspace analysis following procedures outlined by Florida Department of Environmental Regulation (FDER) (1992). Samples were analyzed with an OVA equipped with a flame ionization detector (FID).

For each boring, OVA headspace readings of soil samples collected from 0 to 2 feet bls or from 2 to 4 feet bls, were used for soil assessment. Because samples collected from 4 to 6 feet bls were below the water table, OVA headspace readings for these samples were not used for soil assessment. The results of the soil boring and soil sampling program are discussed in Section 5.2.1.

4.2 MONITORING WELL INSTALLATION AND CONSTRUCTION. Borings for monitoring wells were advanced with a truck-mounted drill rig using rotary drilling techniques with 4.25-inch inside diameter (ID), hollow-stemmed augers. Eighteen shallow monitoring wells (designated KYW-A127-MW-1 through KYW-A127-MW13, and KYW-A127-MW-16 through KYW-A127-MW-20) were installed to depths of 12 to 13 feet bls. Two vertical extent wells (designated KYW-A127-MW-14D and KYW-A127-MW-15D) were installed at depths of 25 to 30 feet bls and 20 to 25 feet bls, respectively. Monitoring well locations are shown in Figure 4-2. For convenience, the prefix "KYW-A127" is not used in tables, figures, and text throughout this report.

Shallow wells were constructed of 2-inch ID, schedule 40, polyvinyl chloride (PVC) casing with flush-threaded joints and 10 feet of 0.010-inch machine-slotted screen. PVC well casing extends from the top of the screen to land surface. A 20/30 grade silica sand filter pack was placed in the annular space to approximately 1 foot above the top of the screened interval. A 6- to 12-inch thick bentonite seal was placed on top of the filter pack. The remaining annular space was grouted to surface with a neat cement grout. A protective traffic-bearing vault was installed to complete the well. Monitoring wells are equipped with a locking well cap and a padlock. Shallow monitoring well installation details are presented in Figure 4-3.

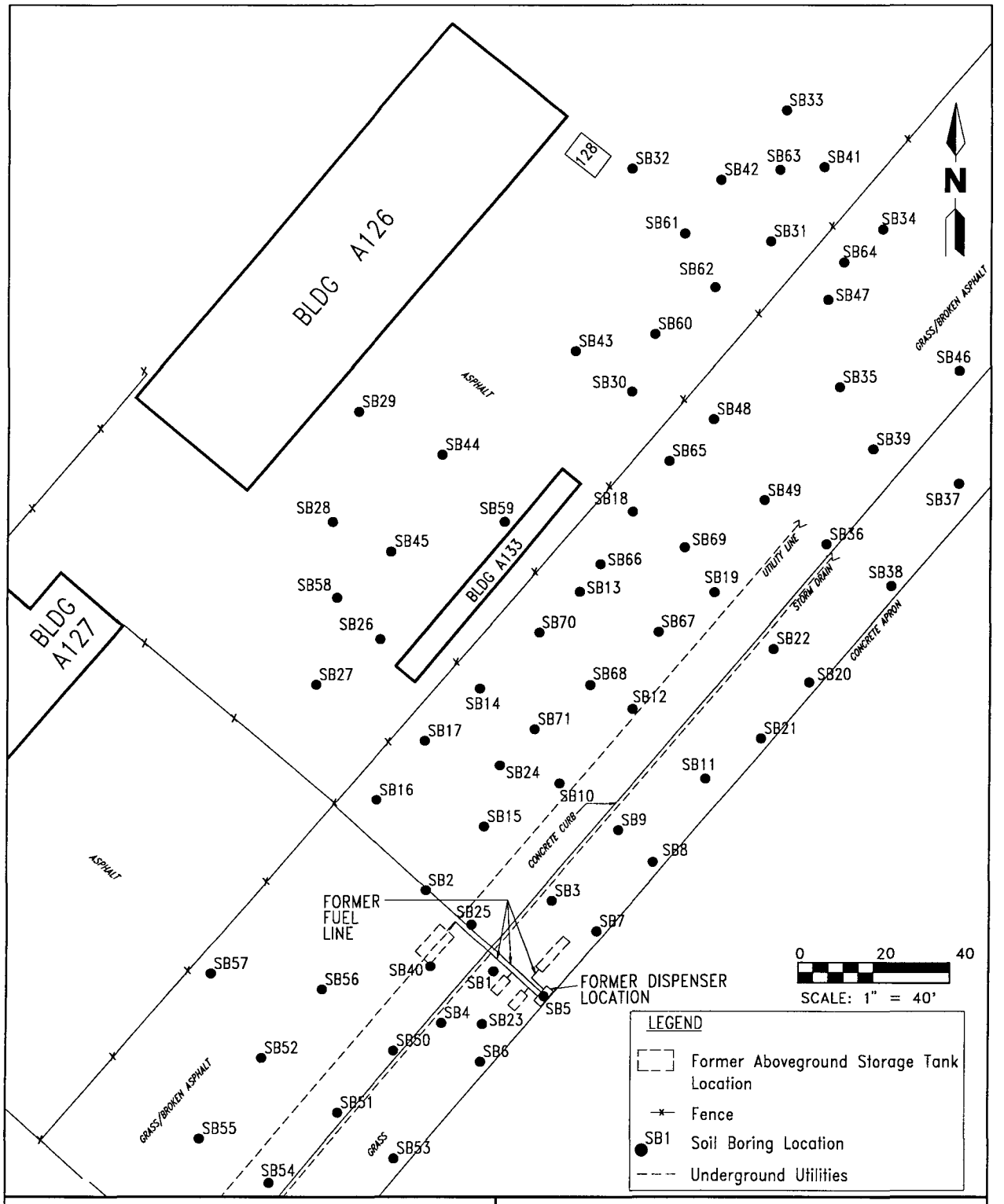

FIGURE 4-1
SOIL BORING LOCATION MAP

FLYCLUB/MAH/12/13/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

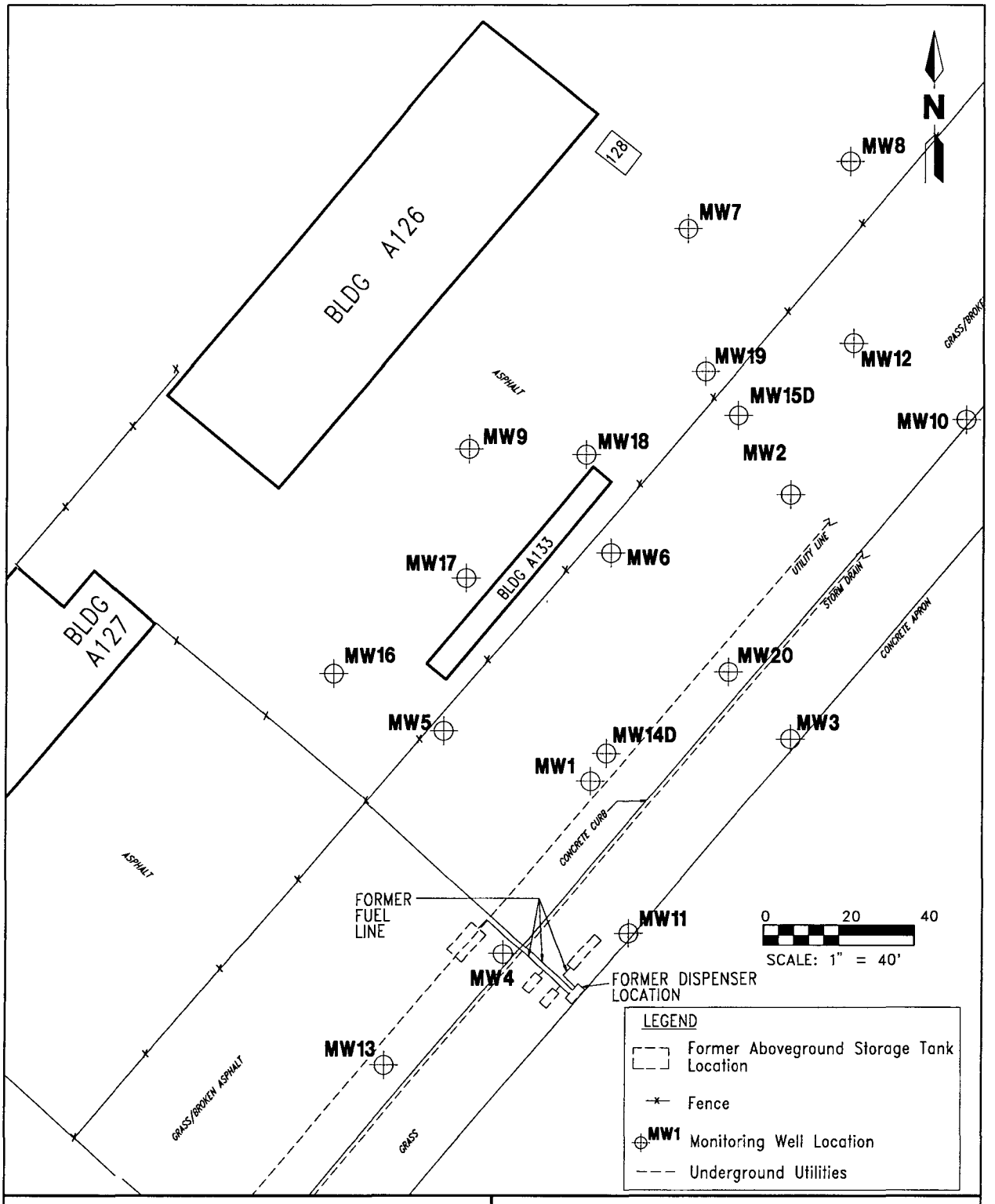

FIGURE 4-2
MONITORING WELL LOCATION MAP

FLYCLUB/WAH/12/13/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

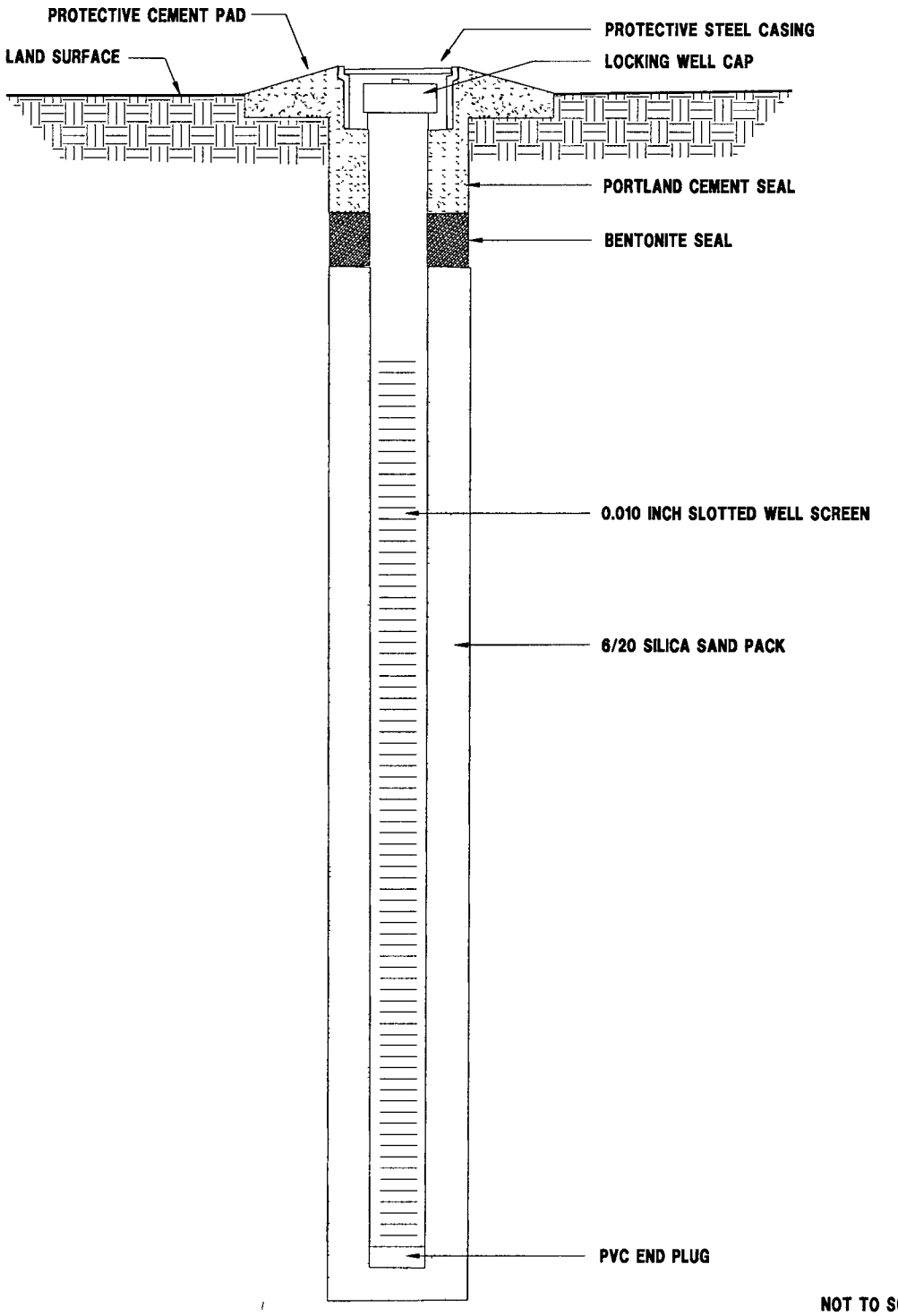

FIGURE 4-3
TYPICAL MONITORING WELL INSTALLATION DETAIL

KEYWELL/NF/1-7-93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

Construction details for the vertical extent wells are identical to those of the shallow monitoring wells, except that 5 feet of well screen were used, and the 20/30 grade sand filter pack extended to 2 feet above the screened interval.

4.3 WATER TABLE ELEVATION MEASUREMENTS. Water table elevations were recorded from each monitoring well on October 18, 1993, and December 4, 1993. Depth to groundwater was measured to the nearest 0.01-foot using an electronic water level indicator. Water table elevations were calculated by subtracting the measured depth to groundwater from the top of casing elevation for each respective well. Top of casing elevations were referenced to a datum point arbitrarily set at an elevation of 10.00 feet above msl at MW-11. Water table elevation contour maps for each date were prepared using this information and are discussed in Section 5.3 of this report.

4.4 GROUNDWATER SAMPLING AND ANALYSES. Groundwater samples were collected from each monitoring well on October 19, 1993. Before sample collection, monitoring wells were purged with a Teflon™ bailer until five well volumes had been removed from the well. Groundwater samples were then collected using the bailer. Groundwater samples were placed into appropriate containers, properly preserved, and placed on ice. Groundwater samples were sent to Wadsworth/ALERT Laboratories, Tampa, Florida, under chain-of-custody procedures. Appropriate quality assurance/quality control (QA/QC) samples were collected and analyzed.

Because of the long history of AVGAS and gasoline storage at the site and the likelihood that gasoline constituents have weathered (degraded) to kerosene-type constituents, and also because of the presence of jet fuel refueling operations on the runway east of the site, samples were analyzed for constituents of the kerosene analytical group as defined in Chapter 17-770, Florida Administrative Code (FAC). Analyses were performed for volatile organic halocarbons by U.S. Environmental Protection Agency (USEPA) Method 601, for volatile organic aromatics (VOA) and methyl tert-butyl ether (MTBE) by USEPA Method 602, for polynuclear aromatic hydrocarbons (PAH) by USEPA Method 610, for total recoverable petroleum hydrocarbons (TRPH) by USEPA Method 418.1, for ethylene dibromide (EDB) by USEPA Method 504, and for lead by USEPA Method 239.2.

4.5 AQUIFER SLUG TESTS. Rising head slug tests were conducted October 20, 1993, in monitoring wells MW-4 and MW-6 to estimate the hydraulic conductivity (K) of the surficial aquifer.

The slug test developed by Bouwer and Rice (1976) measures the saturated K value using a single well. The test method used is termed a "rising head" test and is performed by quickly withdrawing a volume of water (slug) from the well and measuring the subsequent rate of the rising water level in the well. Bouwer (1989) recommends the rising head slug test for wells with screened intervals that are only partially submerged or partially penetrate unconfined aquifers.

The slug was constructed of 1-inch, outside diameter, PVC pipe, 5 feet in length, filled with sand, and capped watertight at both ends. The water level changes in the monitoring wells were recorded using a data logger and pressure transducer. The pressure transducer was suspended near the bottom of the well,

and an initial water level was recorded prior to beginning the test. The slug was then lowered into the well to a depth below the water table. Water levels were then recorded until they stabilized at the original level. The slug was quickly removed from the well, and the rate of the rising water level in the well was recorded until the water table had recovered to the initial value at the time of slug removal. Three tests were conducted in each well to obtain an average K value. Slug test graphs and calculations are attached in Appendix D, Aquifer Parameter Calculations.

4.6 TIDAL INFLUENCE STUDY. A 38-hour tidal study was conducted from 1800 hours on November 30, 1993, to 0730 hours on December 2, 1993. The purpose of the tidal study was to assess the effect tidal fluctuations had on water table elevations and the groundwater flow direction at the site. The study was conducted during a full moon in order to observe and measure larger than average tidal fluctuations over at least one tidal cycle. Tidal study methodologies and results are discussed in Appendix C, Tidal Influence Study.

5.0 CONTAMINATION ASSESSMENT RESULTS

5.1 SITE-SPECIFIC AQUIFER CHARACTERISTICS AND HYDROGEOLOGIC PARAMETERS. Depth to water, top of casing, and water table elevations recorded October 20, 1993, and December 4, 1993, are presented in Table 5-1. Water table elevation contour maps for each date are shown in Figures 5-1 and 5-2, respectively. (Note: water table elevations from the two vertical extent wells, MW-14D and MW-15D, were not used in water table elevation contouring.) The data from the shallow wells indicate a northeasterly groundwater flow direction at the site on both dates. The tidal influence study indicates that water table elevations and hydraulic gradients are tidally influenced; however, tides do not appear to change the northeastern groundwater flow direction (See Appendix C, Tidal Influence Study).

The calculated average hydraulic gradient at the site is 1.52×10^{-3} feet per foot (ft/ft). Slug test results indicate an average K value of 9.5×10^{-1} feet per day (ft/day). The calculated pore water velocity (V) is 4.8×10^{-3} ft/day. Equations and calculations used to estimate these values are presented in Appendix D, Aquifer Parameter Calculations.

5.2 CONTAMINANT PLUME CHARACTERIZATION.

5.2.1 Soil Contamination Assessment A summary of the soil sample OVA analyses is presented in Table 5-2. Groundwater laboratory analytical results indicate that both gasoline and kerosene-type constituents are present in groundwater at the site (see subsection 5.2.2). Therefore, the soil assessment follows Chapter 17-770, FAC, guidelines for the "Mixed Products Analytical Group". For the "Mixed Products Analytical Group" soil with OVA headspace readings greater than 10 ppm is considered to be petroleum contaminated, and soil with OVA headspace readings greater than 50 ppm is defined as "excessively contaminated" (FDER, May 1992). "Excessively contaminated" soil must be remediated (FDER, May 1992).

Four areas of excessively contaminated soil were identified by OVA headspace analysis (Figure 5-3). For each boring, OVA headspace readings presented in Figure 5-3 are the highest recorded for samples collected above the water table, either from 0 to 2 feet bls or from 2 to 4 feet bls. With few exceptions, the highest reading was recorded in the sample collected just above the water table, from 2 to 4 feet bls. Excessively petroleum-contaminated soil appears to be restricted to within 1 to 2 feet above the top of the water table.

The areal extent of excessively contaminated soil is shown within the 50 ppm isoconcentration lines. The most contaminated area is located southeast of Building A-133. This area is approximately 70 feet long and 40 feet wide. Three smaller isolated areas were identified: (1) in the vicinity of the former AVGAS ASTs surrounding soil boring SB-1, (2) on the northwest side of Building A-133 at soil boring SB-45, and (3) in the northern part of the site at soil boring SB-31.

5.2.2 Groundwater Contamination Assessment Groundwater analytical laboratory results for the samples collected October 19, 1993, are presented in Appendix E, Groundwater Analytical Data, and are summarized in Table 5-3. VOA, MTBE, PAH (including naphthalenes), TRPH, lead, and several chlorinated compounds were detected in groundwater samples. Free product was not detected in any monitoring

Table 5-1
Water Table Elevation Data,
October 18 and December 4, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Monitoring Well Number	Total Well Depth	Top of Casing Elevation[1]	October 18, 1993		December 4, 1993	
			Depth to Groundwater (from TOC)	Relative Groundwater Elevation[1]	Depth to Groundwater (from TOC)	Relative Groundwater Elevation[1]
MW-1	12	10.45	3.41	7.04	3.57	6.88
MW-2	12	10.56	3.78	6.78	3.85	6.71
MW-3	12	9.55	2.62	6.93	2.74	6.81
MW-4	12	10.70	3.58	7.12	3.78	6.92
MW-5	12	10.86	3.75	7.11	3.95	6.91
MW-6	12	10.69	3.71	6.98	3.86	6.83
MW-7	12	10.78	3.93	6.85	4.06	6.72
MW-8	12	10.64	3.88	6.76	3.98	6.66
MW-9	12	10.92	3.85	7.07	4.07	6.85
MW-10	12	10.55	3.70	6.85	3.84	6.71
MW-11	12	10.00	2.97	7.03	3.09	6.91
MW-12	12	10.56	3 76	6.80	3.87	6.69
MW-13	12	10.44	3.27	7.17	3.50	6.94
MW-14D	30	10.72	3.84	6.88	3.67	7.05
MW-15D	25	10.67	3.89	6.78	3.92	6.75
MW-16	12	10.84	3.69	7.15	3 91	6.93
MW-17	12	11.00	3.90	7.10	4.09	6.91
MW-18	12	10 91	3.91	7.00	4.09	6 82
MW-19	12	10.44	3.65	6.79	3.74	6.70
MW-20	12	10.35	3.38	6.97	3.52	6.83

[1]All elevations referenced to an arbitrary benchmark of 10.00 feet established at MW-11.

Note: TOC = top of casing.

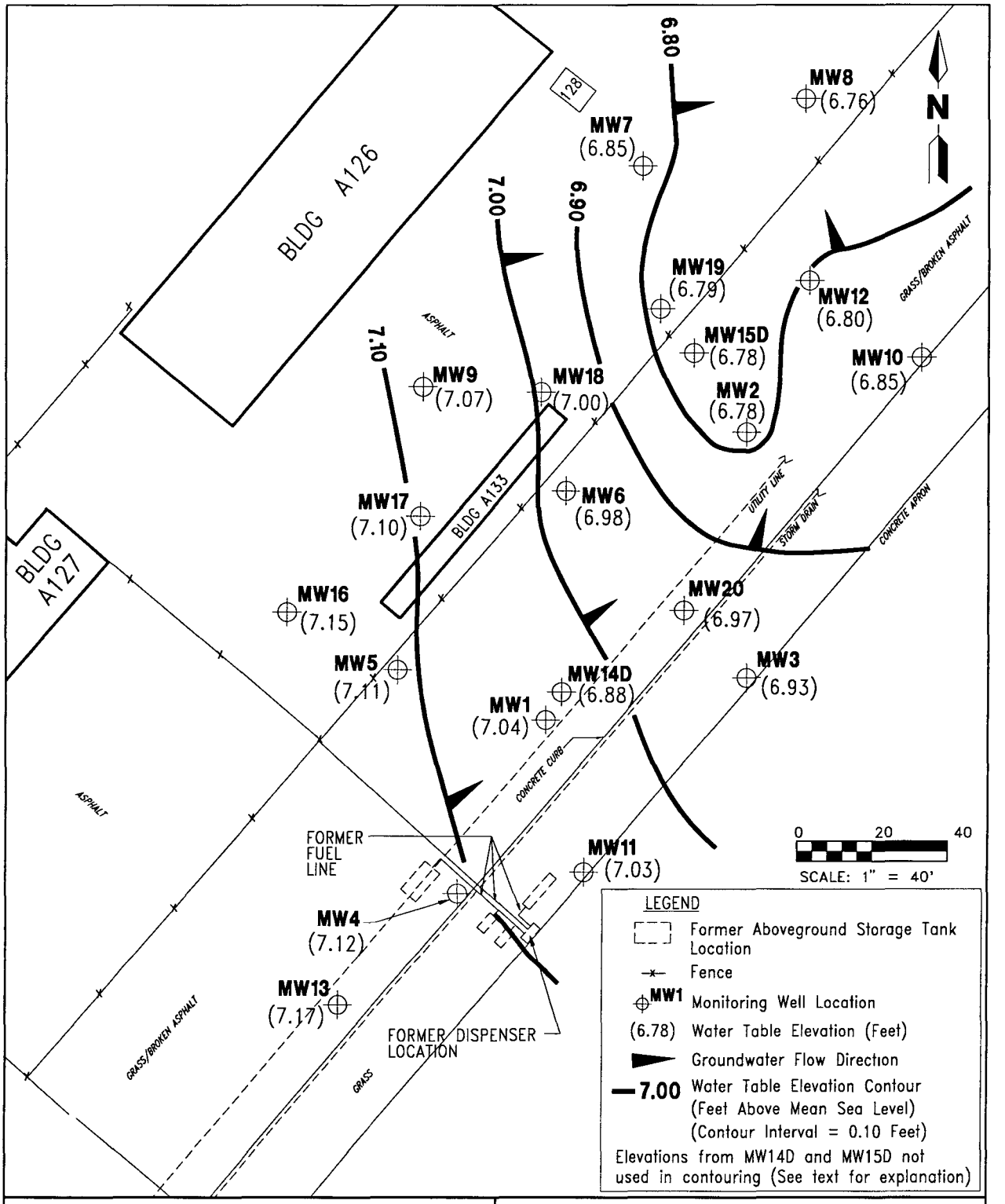

FIGURE 5-1
WATER TABLE ELEVATION CONTOUR MAP, OCTOBER 18, 1993

FLYCLUB/MAH/12/13/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

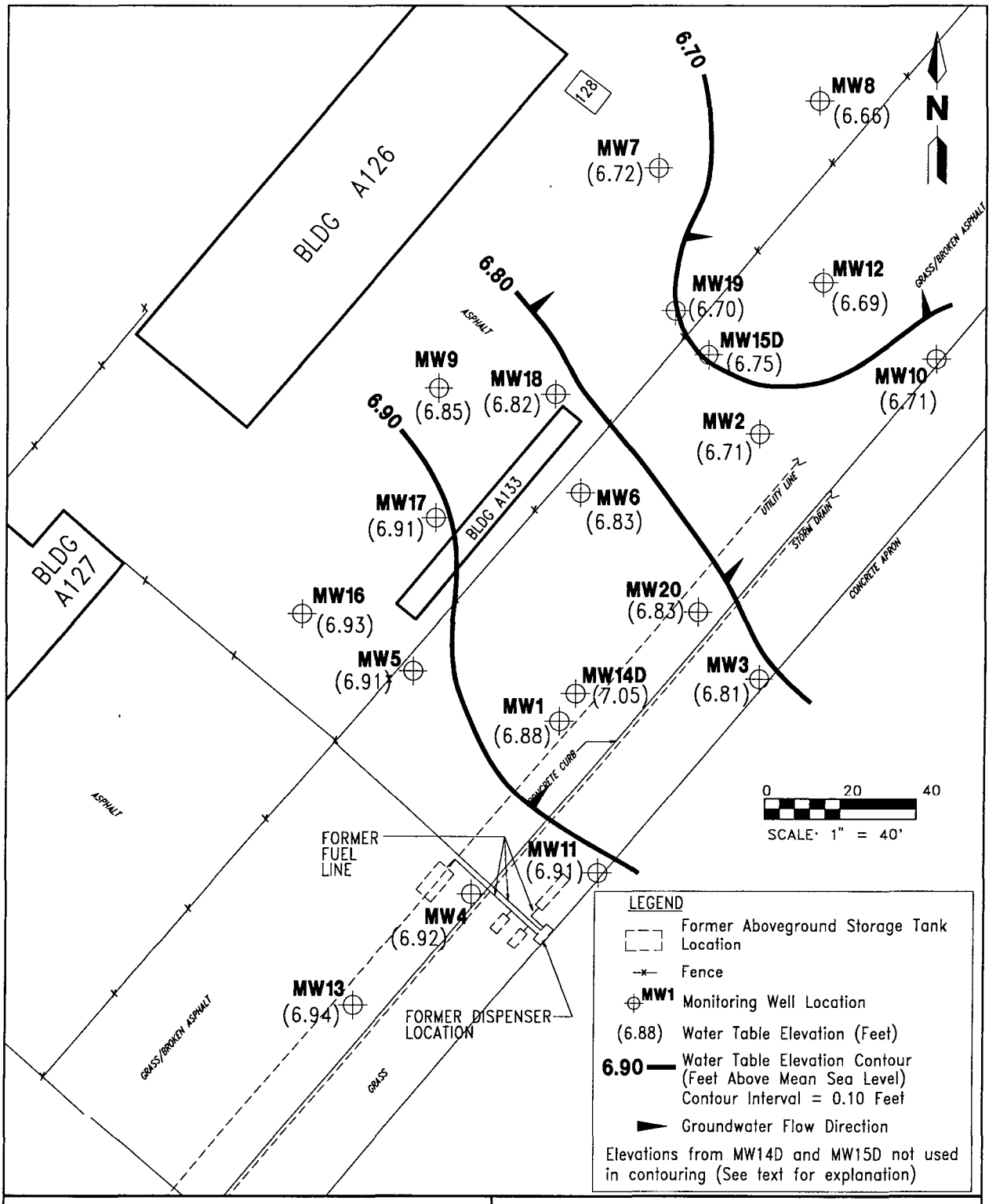

FIGURE 5-2
WATER TABLE ELEVATION CONTOUR MAP, DECEMBER 4, 1993

FLYCLUB/NMP/1/3/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

Table 5-2
Soil Sample Organic Vapor Analyzer (OVA) Analyses, October 13 through October 16, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments	Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments
SB1	0 to 2	1	No odor	SB8	0 to 2	8	
	2 to 4	60	Wet		2 to 4	1	No odor; wet
	4 to 6	2,500	Slight odor		4 to 6	1	
SB2	0 to 2	<1	No odor	SB9	0 to 2	<1	No odor
	2 to 4	<1			2 to 4	<1	Wet
	4 to 6	<1	Wet		4 to 6	1,100	Petroleum odor
SB3	0 to 2	<1	No odor	SB10	0 to 2	<1	Slight odor
	2 to 4	<1			2 to 4	<1	Wet
	4 to 6	245	Wet		4 to 6	250	Strong odor
SB4	0 to 2	<1	No odor	SB11	0 to 2	5	No odor
	2 to 4	<1			2 to 4	38	Slight odor
	4 to 6	14	Wet		4 to 6	900	Strong odor
SB5	0 to 2	<1	No odor	SB12	0 to 2	<1	Petroleum odor
	2 to 4	<1			2 to 4	16	Wet
	4 to 6	<1	Wet		4 to 6	1,500	Strong odor
SB6	0 to 2	<1	No odor	SB13	0 to 2	1,400	Petroleum odor
	2 to 4	<1	Wet		2 to 4	1,400	
	4 to 6	<1			4 to 6	1,450	Wet
SB7	0 to 2	<1	No odor	SB14	0 to 2	<1	Strong odor
	2 to 4	<1	Wet		2 to 4	6	Damp
	4 to 6	<1			4 to 6	1,450	Wet; strong odor

See notes at end of table.

Table 5-2 (Continued)
Soil Sample Organic Vapor Analyzer (OVA) Analyses,
October 13 through October 16, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments	Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments
SB15	0 to 2	2	No odor	SB22	0 to 2	1	Organics
	2 to 4	1			2 to 4	10	No odor; damp
	4 to 6	<1	Wet		4 to 6	1,700	Fuel odor; wet
SB16	0 to 2	<1	No odor	SB23	0 to 2	<1	No odor
	2 to 4	<1			2 to 4	<1	Wet
	4 to 6	<1	Wet		4 to 6	<1	
SB17	0 to 2	<1	No odor	SB24	0 to 2	1	No odor
	2 to 4	<1			2 to 4	1	
	4 to 6	<1	Wet		4 to 6	5	Wet
SB18	0 to 2	<1		SB25	0 to 2	1	No odor
	2 to 4	5	Petroleum odor		2 to 4	1	
	4 to 6	345	Wet		4 to 6	525	Wet
SB19	0 to 2	<1	Slight odor	SB26	0 to 2	2	
	2 to 4	12	Damp		2 to 4	10	Petroleum odor
	4 to 6	200	Petroleum odor		4 to 6	1,900	Wet; strong odor
SB20	0 to 2	12	Strong odor	SB27	0 to 2	<1	Slight unknown odor
	2 to 4	<5	Damp		2 to 4	<1	Wet; no odor
	4 to 6	<5	Wet		4 to 6	<1	
SB21	0 to 2	<1		SB28	0 to 2	<1	No odor
	2 to 4	<1	Wet; no odor		2 to 4	<1	Damp
	4 to 6	<1			4 to 6	6	Petroleum odor; wet

See notes at end of table.

Table 5-2 (Continued)
Soil Sample Organic Vapor Analyzer (OVA) Analyses, October 13 through October 16, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments	Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments
SB29	0 to 2	3	No odor	SB36	0 to 2	12	No odor
	2 to 4	<1	Wet; no odor		2 to 4	7	Petroleum odor
	4 to 6	<1			4 to 6	125	Wet
SB30	0 to 2	<1	No odor	SB37	0 to 2	<1	Damp; no odor
	2 to 4	<1	Damp		2 to 4	<1	
	4 to 6	90	Petroleum odor; wet		4 to 6	<1	
SB31	0 to 2	<1	No odor	SB38	0 to 2	<1	Petroleum odor
	2 to 4	800	Pinewood odor		2 to 4	<1	
	4 to 6	150	Petroleum odor		4 to 6	<1	No odor; wet
SB32	0 to 2	<1	No odor	SB39	0 to 2	2	Slight odor
	2 to 4	<1	Damp		2 to 4	1	Petroleum odor
	4 to 6	<1	Wet		4 to 6	160	Wet
SB33	0 to 2	<1	No odor	SB40	0 to 2	<1	No odor
	2 to 4	<1			2 to 4	<1	
	4 to 6	<1	Slight petroleum odor		4 to 6	<1	Wet
SB34	0 to 2	<1	No odor	SB41	0 to 2	<1	Slight odor
	2 to 4	<1			2 to 4	<1	
	4 to 6	<1	Wet; organic odor		4 to 6	2	Strong odor; wet
SB35	0 to 2	<1	No odor	SB42	0 to 2	<1	No odor
	2 to 4	<1			2 to 4	<1	Damp
	4 to 6	<1	Wet		4 to 6	<1	Wet

See notes at end of table.

Table 5-2 (Continued)
Soil Sample Organic Vapor Analyzer (OVA) Analyses,
October 13 through October 16, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments	Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments
SB43	0 to 2	<1	Slight odor	SB50	0 to 2	<1	No odor
	2 to 4	<1	Damp		2 to 4	<1	Wet
	4 to 6	<1	Wet		4 to 6	90	Slight odor
SB44	0 to 2	<1	No odor	SB51	0 to 2	2	Slight odor
	2 to 4	<1	Damp		2 to 4	<1	No odor; damp
	4 to 6	<1	Wet		4 to 6	65	
SB45	0 to 2	<1	Slight odor	SB52	0 to 2	<1	
	2 to 4	210	Damp		2 to 4	<1	
	4 to 6	800	Strong odor; wet		4 to 6	21	
SB46	0 to 2	<1	No odor	SB53	0 to 2	<1	
	2 to 4	<1			2 to 4	<1	
	4 to 6	<1	Wet		4 to 6	<1	
SB47	0 to 2	<1	No odor	SB54	0 to 2	<1	
	2 to 4	<1	Damp		2 to 4	<1	
	4 to 6	2	Wet		4 to 6	1	
SB48	0 to 2	1	No odor	SB55	0 to 2	<1	No odor
	2 to 4	1			2 to 4	<1	
	4 to 6	2,200	Petroleum odor; wet		4 to 6	<1	
SB49	0 to 2	<1	No odor	SB56	0 to 2	<1	
	2 to 4	<1			2 to 4	<1	
	4 to 6	950	Petroleum odor; wet		4 to 6	<1	

See notes at end of table.

Table 5-2 (Continued)
Soil Sample Organic Vapor Analyzer (OVA) Analyses,
October 13 through October 16, 1993

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Boring Designation	Depth (feet bls)	Concentration (ppm)	Comments
SB57	0 to 2	<1	
	2 to 4	<1	Wet
	4 to 6	<1	
SB58	0 to 2	<1	No odor
	2 to 4	<1	
SB59	0 to 2	<1	Slight odor
	2 to 4	<1	
SB60	0 to 2	<1	No odor
	2 to 4	<1	Damp
SB61	0 to 2	<1	No odor
	2 to 4	<1	Damp
SB62	0 to 2	<1	No odor
	2 to 4	<1	Damp
SB63	0 to 2	<1	No odor
	2 to 4	<1	
SB64	0 to 2	<1	No odor
	2 to 4	<1	Damp
SB65	0 to 2	24	Petroleum odor
	2 to 4	13	
SB66	0 to 2	25	Unknown odor
	2 to 4	>5,000	Strong odor
SB67	0 to 2	<1	No odor
	2 to 4	70	
SB68	0 to 2	7	No odor
	2 to 4	2,500	Petroleum odor
SB69	0 to 2	<1	No odor
	2 to 4	900	Damp; strong odor
SB70	0 to 2	38	Slight odor
	2 to 4	2,800	Damp; strong odor
SB71	0 to 2	<1	No odor
	2 to 4	2,300	Damp; strong odor

Notes: bls = below land surface.
ppm = parts per million.

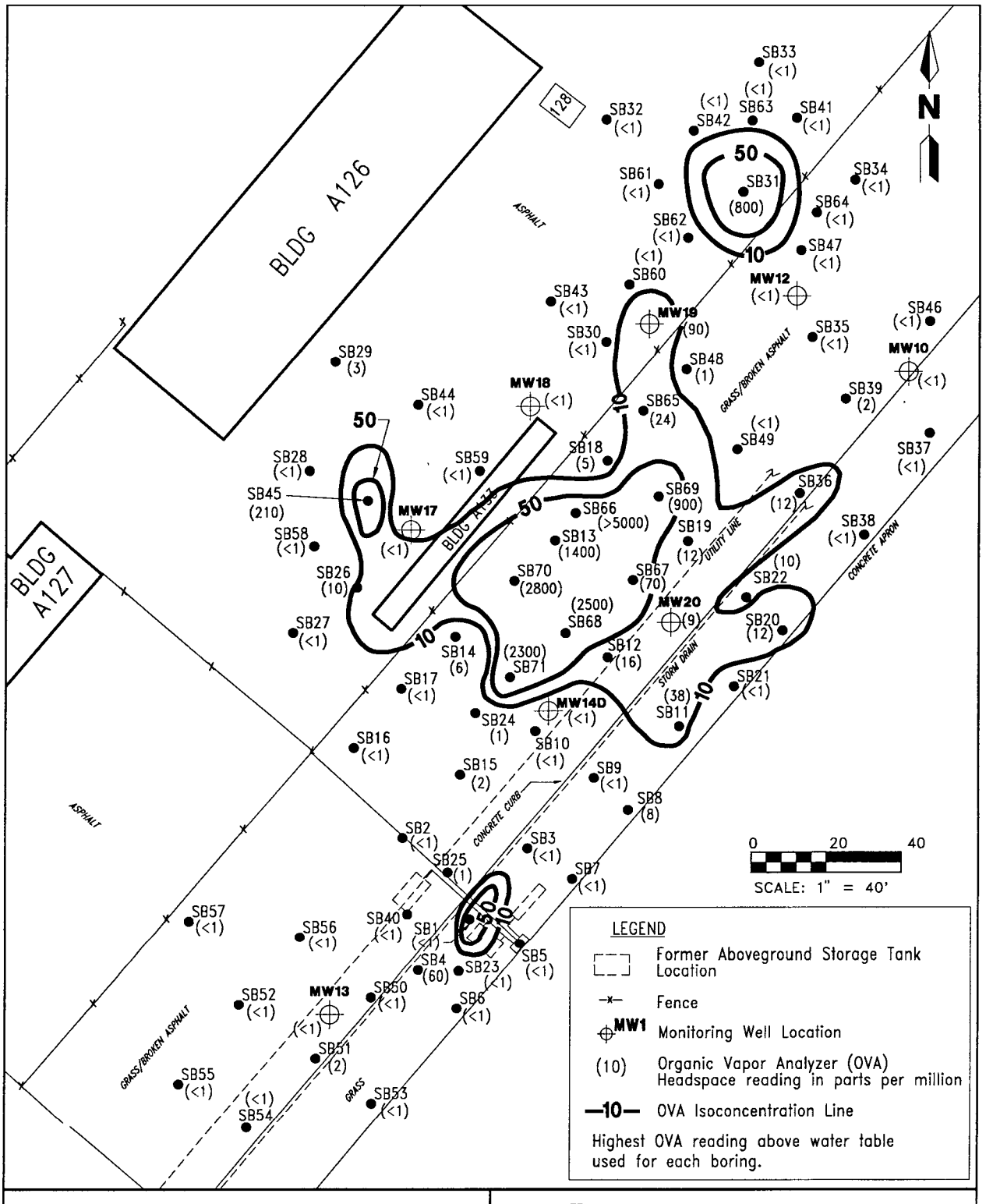

FIGURE 5-3
SOIL SAMPLE ORGANIC VAPOR ANALYZER (OVA) HEADSPACE READINGS

FLYCLUB/NMP/1/3/93

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

Table 5-3
Summary of Groundwater Analytical Results, October 19, 1993, Sampling Event

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Compound	Applied Guideline	MW 1	MW 2	MW 3	MW 4	MW 5	MW 6	DUP 1	MW 7	MW 8	MW 9	MW 10
Benzene	[1]200	13	150	1	710	<1	68	61	<1	<1	<1	2
Ethylbenzene		130	7	<1	<10	<1	140	120	<1	<1	<1	3
Toluene		12	10	<1	130	<1	15	14	<1	<1	<1	3
Xylenes		24	20	1	460	<1	82	74	<1	<1	<1	3
Total VOA	[1]200	179	187	2	1,300	ND	305	269	ND	ND	ND	11
MTBE	[2]50	25	<5	<1	11	<1	6	8	<1	<1	<1	1
Benzo(a)pyrene	[3]10	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Benzo(g,h,i)perylene	[3]10	12	<5	<5	<5	6	<5	<5	<5	<5	<5	<5
Dibenzo(a,h)anthracene	[3]10	9	<5	<5	<5	5	<5	<5	<5	<5	<5	<5
Indeno(1,2,3-cd)pyrene	[3]10	9	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total PAH	[3]10	35	ND	ND	ND	11	ND	ND	ND	ND	ND	ND
1-Methylnaphthalene		18	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Methylnaphthalene		48	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Naphthalene		120	<5	<5	<5	<5	<5	<5	7	<5	<5	<5
Total naphthalenes	[2]100	186	ND	ND	ND	ND	ND	ND	7	ND	ND	ND
TRPH	[1]5	3	2	<1	1	<1	2	2	<1	<1	<1	2
Lead	[1]50	9	<5	<5	46	5	<5	7	<5	<5	5	<5
Chlorobenzene	[3]10	<5	<5	<1	<10	<1	<5	<5	<1	3	<1	<1
1,2-Dichlorobenzene	[3]10	<5	<5	<1	<10	<1	<5	<5	<1	<1	<1	1
1,1-Dichloroethane	[3]2,400	<5	<5	<1	<10	<1	<5	<5	<1	<1	<1	<1
1,1-Dichloroethene	[3]7	<5	<5	<1	<10	<1	<5	<5	<1	<1	<1	<1
1,2-Dichloroethene	[3]4.2	<5	<5	<1	<10	<1	<5	<5	<1	1 (<1)	<1	<1
Methylene chloride	[3]5	16	11	3	<10	<1	<5	23	<1	<1	<1	<1
Trichloroethene	[3]3	<5	<5	<1	<10	<1	<5	<5	<1	<1	<1	<1

See notes at end of table.

Table 5-3 (Continued)
Summary of Groundwater Analytical Results, October 19, 1993, Sampling Event

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Compound	Applied Guideline	DUP 2	MW 11	MW 12	MW 13	MW 14D	MW 15D	MW 16	MW 17	MW 18	MW 19	MW 20
Benzene	[1]200	1	<1	<1	<1	2	<1	<1	16	<1	<1	8
Ethylbenzene		2	<1	<1	<1	1	<1	<1	6	2	<1	96
Toluene		3	<1	<1	<1	<1	<1	<1	6	2	<1	12
Xylenes		2	<1	<1	<1	3	<1	<1	15	5	<1	40
Total VOA	[1]200	8	ND	ND	ND	6	ND	ND	43	9	ND	156
MTBE	[2]50	1	<1	<1	<1	7	<1	<1	3	<1	<1	12
Benzo(a)pyrene	[3]10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Benzo(g,h,i)perylene	[3]10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibenzo(a,h)anthracene	[3]10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Indeno(1,2,3-cd)pyrene	[3]10	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total PAH	[3]10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylnaphthalene		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Methylnaphthalene		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Naphthalene		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total naphthalenes	[2]100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRPH	[1]5	<1	<1	<1	<1	<1	<1	<1	1	<1	1	2
Lead	[1]50	<5	65	<5	8	<5	<5	<5	7	<5	<5	14
Chlorobenzene	[3]10	<1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1
1,2-Dichlorobenzene	[3]10	1	<1	<1	<1	4	<1	<1	<1	<1	<1	1
1,1-Dichloroethane	[3]2,400	<1	<1	<1	<1	<1	11	<1	<1	<1	<1	<1
1,1-Dichloroethene	[3]7	<1	<1	<1	<1	<1	10	<1	<1	<1	<1	<1
1,2-Dichloroethene	[3]4.2	<1	<1	<1	<1	14(<1)	38(2)	<1	<1	2(3)	5(12)	<1
Methylene chloride	[3]5	2	<1	<1	45	6	7	1	21	<1	<1	1
Trichloroethene	[3]3	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1

[1]Class G-III groundwater guidelines, Chapter 17-770, Florida Administrative Code.
[2]Class G-II groundwater guidelines, Chapter 17-770, Florida Administrative Code.
[3]Groundwater guidance concentration (FDER, February 1989).

Notes: All concentrations reported in parts per billion (ppb), except TRPH, which is reported in parts per million (ppm).
For 1,2-dichloroethene, concentrations for cis configurations is indicated first and concentration of trans configurations is indicated in parentheses Total 1,2-dichloroethane (the sum of cis and trans configurations) concentrations are presented in Appendix E, Groundwater Analytical Data.
Methylene chloride was detected in the equipment blank, trip blank, and laboratory blank at concentrations of 14 ppb, 2 ppb, and 2 ppb, respectively.
DUP = duplicate sample. DUP1 was collected from monitoring well MW-6. DUP2 was collected from monitoring well MW-10.
Total VOA = total volatile aromatic hydrocarbons (the sum of benzene, ethylbenzene, toluene, and xylenes).
MTBE = methyl-tert-butyl ether.
ND = not detected at method detection limits.
Total PAH = total polynuclear aromatic hydrocarbons (the sum of PAH's, excluding naphthalenes).
Total naphthalenes is the sum of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene.
TRPH = total recoverable petroleum hydrocarbons.

well or soil boring at the site. For petroleum compounds regulated under Chapter 17-770, FAC, Class G-III groundwater target levels will be used, where applicable. State target levels for G-III groundwater have been established for benzene (200 parts per billion [ppb]), total VOA (200 ppb), TRPH (5 ppm), and lead (50 ppb). (Total VOA is the sum of benzene, ethylbenzene, toluene, and xylenes).

Class G-III groundwater target levels have not been established for MTBE and PAH (including naphthalenes) and the chlorinated compounds detected in groundwater samples collected at the site. Groundwater target levels for MTBE and naphthalenes are available for Class G-II groundwater (Chapter 17-770, FAC). A target level of 100 ppb for total naphthalenes (the sum of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene) has been established for Class G-II groundwater (Chapter 17-770, FAC). The MTBE target level in Class G-II groundwater is 50 ppb. For comparative purposes only, the Class G-II groundwater target levels for MTBE and naphthalenes will be applied herein, and PAH (excluding naphthalenes) and chlorinated hydrocarbon concentrations will be compared to State recommended guidance concentrations established by FDER (February 1989).

5.2.2.1 Total Volatile Organic Aromatics (VOA) in Groundwater VOAs were detected in samples collected from monitoring wells MW-1 through MW-4, MW-6, MW-10, MW-14D, MW-17, MW-18, and MW-20 (Figure 5-4). The State target level for G-III groundwater of 200 ppb for total VOA was exceeded in only the samples collected from monitoring wells MW-4 and MW-6. Total VOA concentrations for these samples were 305 ppb and 1,300 ppb, respectively. The areal extent of total VOA concentrations exceeding the State target level of 200 ppb is shown as two separate areas enclosed by the 200 ppb isoconcentration lines in Figure 5-4. The composite areal extent of both areas extends from the former locations of the AVGAS ASTs approximately 135 feet northeasterly to near the southeast corner of Building A-133.

Concentrations of benzene exceed the State target level for G-III groundwater in only the sample collected from monitoring well MW-4; in which the benzene concentration was 710 ppb. The approximate areal extent of benzene groundwater concentration above 200 ppb is shown in Figure 5-5. The highest concentrations of ethylbenzene (140 ppb, detected in the sample collected from monitoring well MW-6), toluene (130 ppb, detected in the sample collected from monitoring well MW-4), and xylenes (460 ppb, detected in the sample collected from monitoring well MW-4) are below current drinking water standards of 700 ppb, 1,000 ppb, and 10,000 ppb, respectively (Chapter 17-550, FAC).

The vertical extent of total VOA in groundwater does not appear to be significant. The total VOA concentration in the sample collected from monitoring well MW-14D, located in the approximate center of the total VOA plume, was 6 ppb, which is well below the State target level of 200 ppb. Total VOA were not detected in the sample collected from the other vertical extent monitoring well, MW-15D, which was screened from 20 to 25 feet bls and is located outside the total VOA plume.

5.2.2.2 Methyl-tert-butyl Ether (MTBE) in Groundwater MTBE was detected in groundwater samples collected from monitoring wells MW-1, MW-4, MW-6, MW-10, MW-14D, MW-17, and MW-20 (Figure 5-6). The areal extent of MTBE in groundwater is

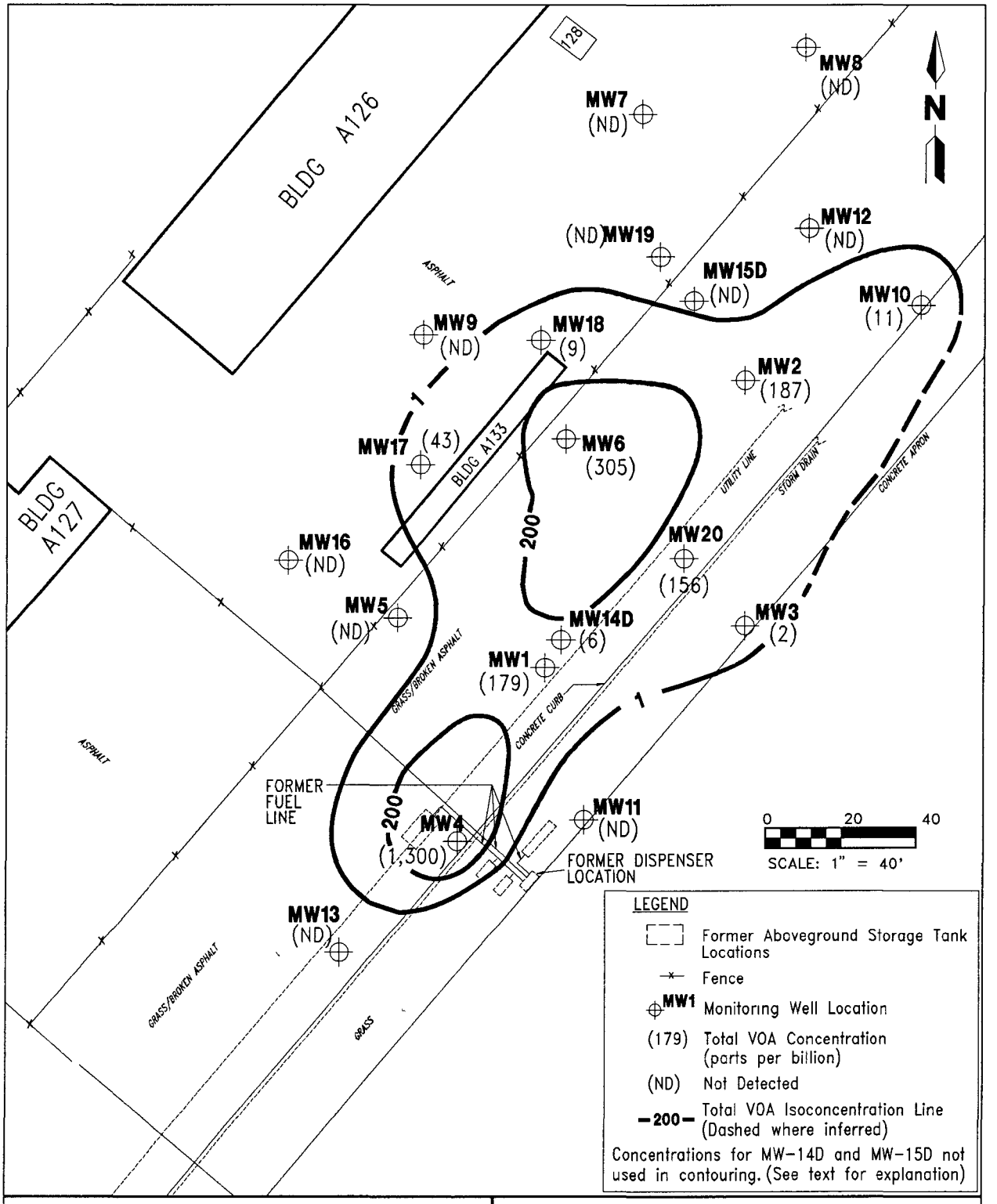

FIGURE 5-4
TOTAL VOLATILE ORGANIC AROMATICS (VOA) IN GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

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FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

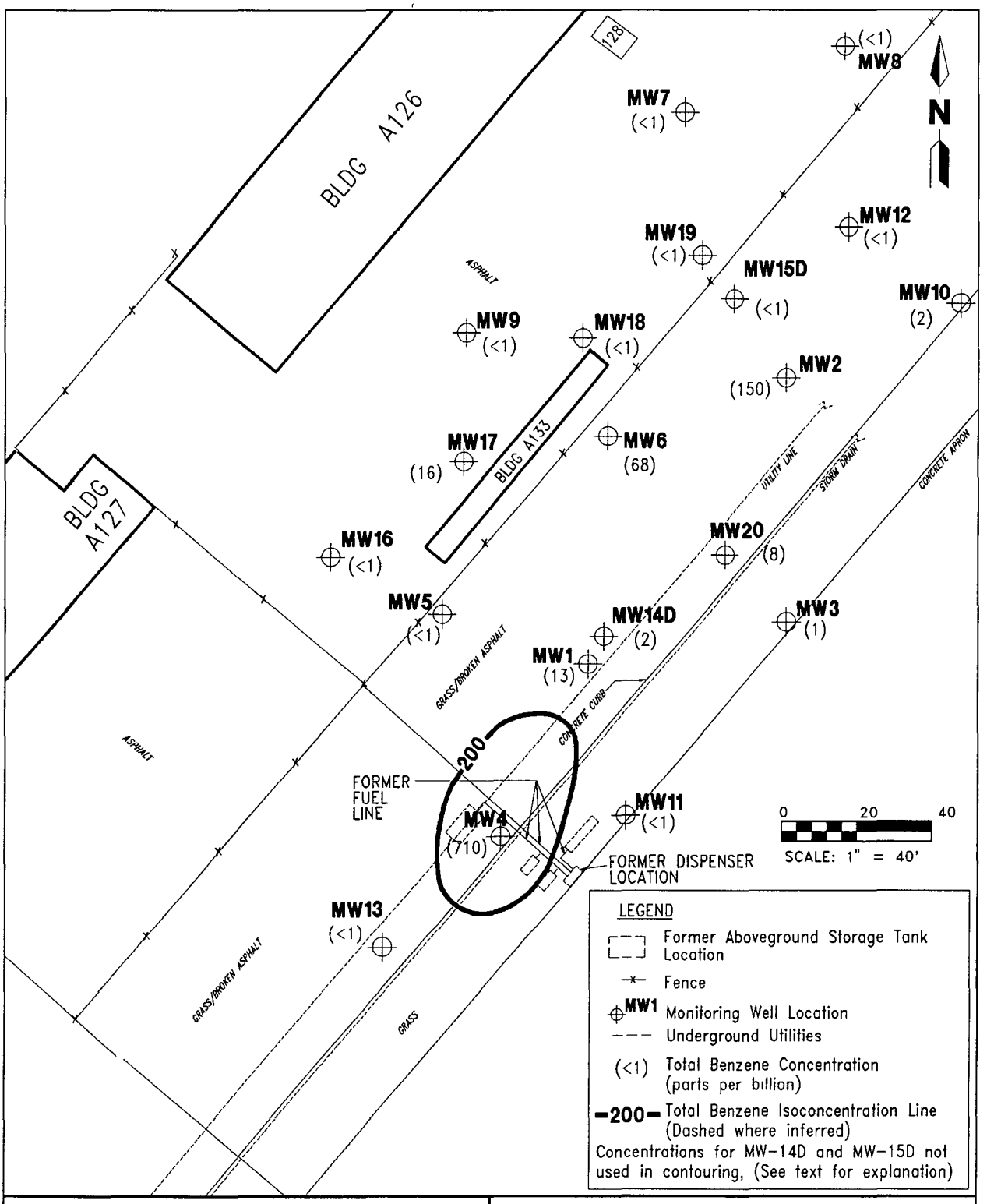

FIGURE 5-5
BENZENE IN GROUNDWATER DISTRIBUTION MAP
OCTOBER 19, 1993

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FLYING CLUB SITE, BUILDING A-127

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KEY WEST, FLORIDA

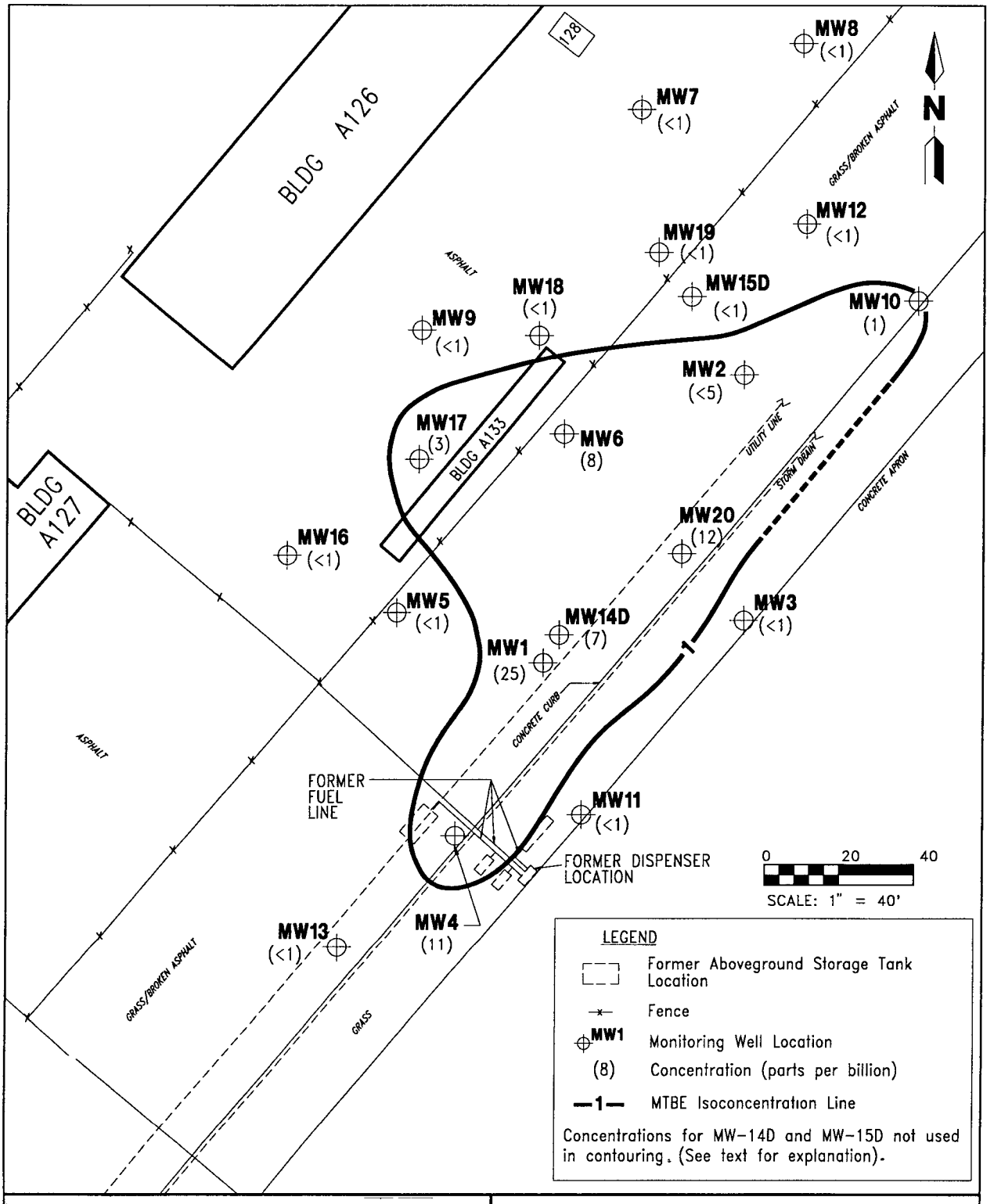

FIGURE 5-6
METHYL TERT-BUTYL ETHER IN GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

FLYCLUB/NMP/1-19-94

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST
KEY WEST, FLORIDA

designated by the area inside the 1 ppb isoconcentration lines on Figure 5-6. Reported MTBE concentrations are below the State target level of 50 ppb for G-II groundwater. The highest MTBE concentration, 25 ppb, was detected in the sample collected from monitoring well MW-1, located downgradient of the former AVGAS ASTs. MTBE concentrations in groundwater appear to decrease with depth. A concentration of 7 ppb was also detected in the sample collected from monitoring well MW-14D, located adjacent to monitoring well MW-1. Because MTBE groundwater concentrations are below State target levels for G-II groundwater, MTBE in groundwater does not appear to be a concern at the site.

5.2.2.3 Total Polynuclear Aromatic Hydrocarbons (PAH) (including Naphthalenes) in Groundwater PAHs were detected in only the samples collected from monitoring wells MW-1, MW-5, and MW-7 (Table 5-3). PAHs detected in groundwater samples include naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene, were detected in the sample collected from monitoring well MW-1, at concentrations of 120 ppb, 18 ppb, and 48 ppb, respectively. Naphthalene was also detected in the sample collected from monitoring well MW-7 at a concentration of 7 ppb. Total naphthalene concentrations exceeded the Class G-II groundwater target level of 100 ppb in only the sample collected from monitoring well MW-1, located approximately 50 feet downgradient of the former AVGAS ASTs (Figure 5-7). The areal extent of total naphthalenes in groundwater exceeding 100 ppb is approximated by the 100 ppb isoconcentration lines on Figure 5-7.

PAH (excluding naphthalenes) were detected in only the samples collected from monitoring wells MW-1 and MW-5. Total PAH (excluding naphthalenes) concentrations are presented in Table 5-3 and are graphically shown on Figure 5-7. Benzo(a)pyrene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene were detected in the sample collected from monitoring well MW-1, at concentrations of 5 ppb, 12 ppb, 9 ppb, and 9 ppb, respectively. Benzo(g,h,i)-perylene and dibenzo(a,h)anthracene were also detected in the sample collected from monitoring well MW-5 at concentrations of 6 ppb and 5 ppb, respectively. The groundwater guidance concentration for a particular PAH is 10 ppb (FDER, February 1989). The areal extent of PAH (excluding naphthalenes) groundwater concentrations exceeding the groundwater guidance concentration is enclosed within the 10 ppb isoconcentration lines on Figure 5-7. This area approximately coincides with the 100 ppb total naphthalenes isoconcentration lines, but extends closer to Building A-133 in the vicinity of monitoring well MW-5.

The vertical extent of PAH (including naphthalenes) in groundwater does not appear to extend below 25 feet bls. PAHs (including naphthalenes) were not detected in monitoring well MW-14D, which is located next to monitoring well MW-1 and is screened from 25 to 30 feet bls.

5.2.2.4 Total Recoverable Petroleum Hydrocarbons (TRPH) in Groundwater TRPH were detected in the samples collected from monitoring wells MW-1, MW-2, MW-4, MW-6, MW-10, MW-17, MW-19, and MW-20 (Figure 5-8). All reported TRPH concentrations were below the State target level of 5 ppm for Class G-III groundwater. The highest TRPH concentration (3 ppm) was detected in the sample collected from monitoring well MW-1, located approximately 50 feet downgradient of the former AVGAS ASTs.

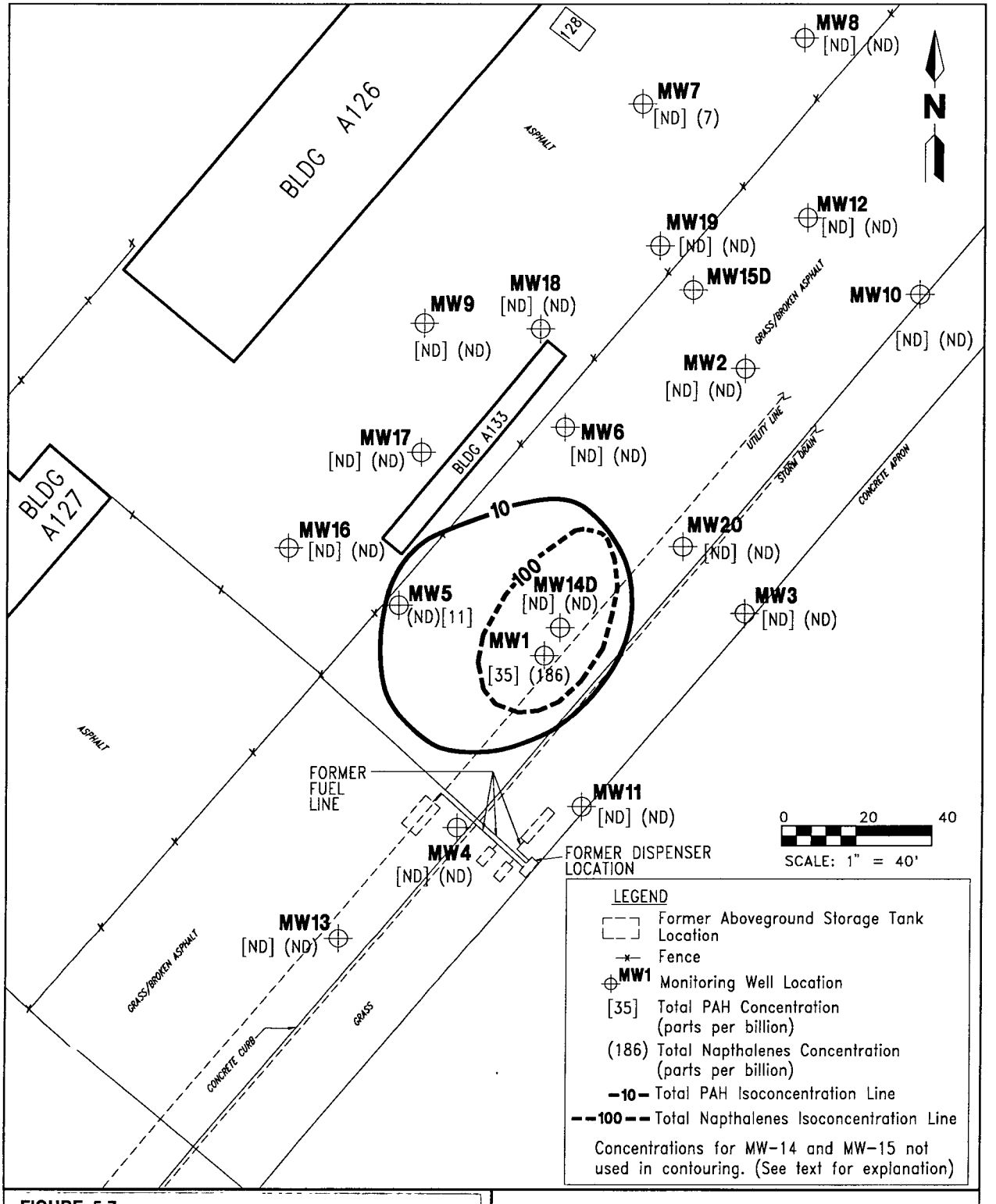

FIGURE 5-7
TOTAL PAH AND TOTAL NAPTHALENES IN GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

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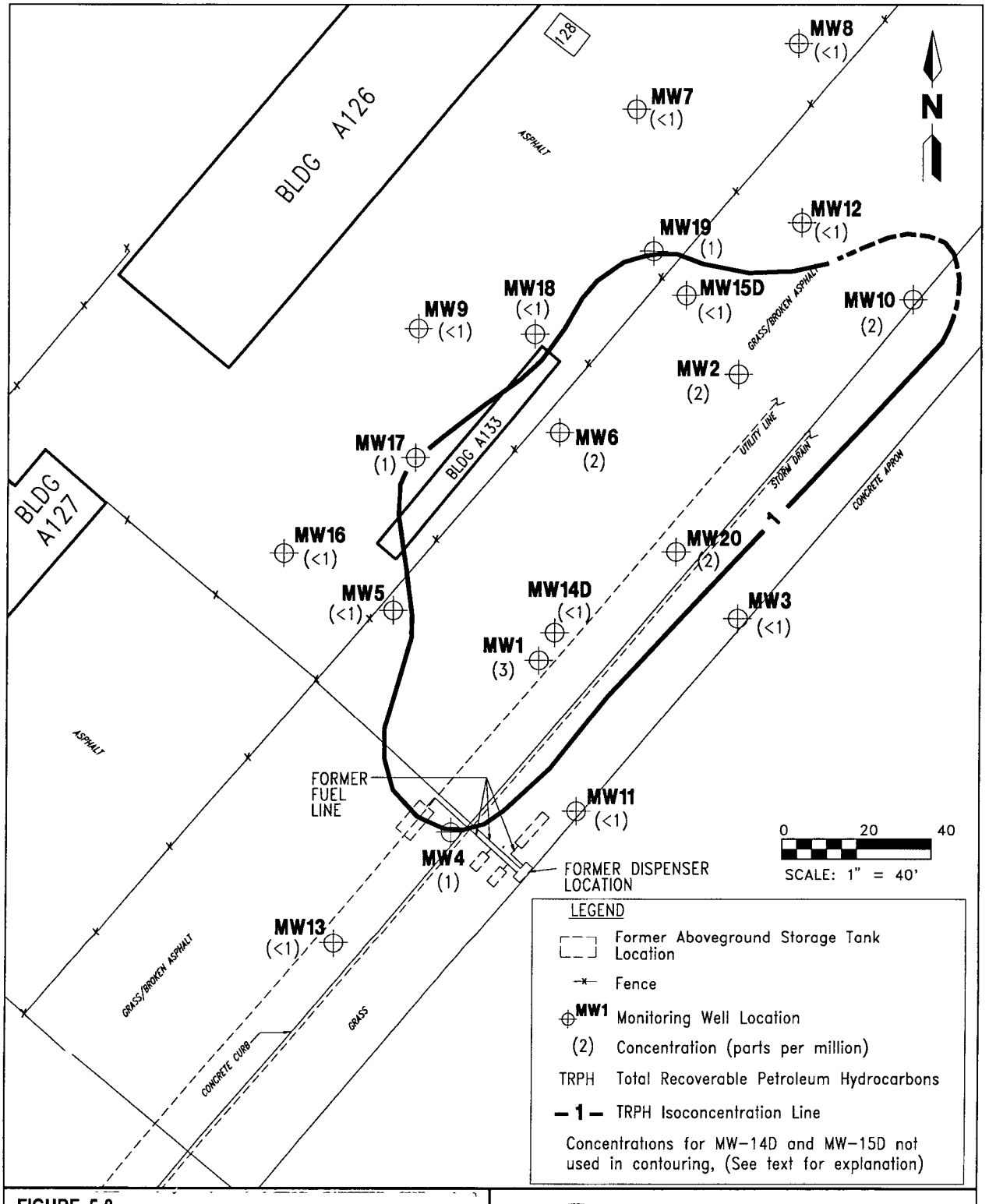

FIGURE 5-8
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

FLYCLUB/NMP/1-19-94

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Groundwater analytical data indicate the vertical extent of TRPH in groundwater does not extend below 25 feet bls. TRPHs were not detected (<1 ppm) in samples collected from the vertical extent monitoring wells (MW-14D and MW-15D).

5.2.2.5 Lead in Groundwater Lead was detected in the samples collected from monitoring wells MW-1, MW-4, MW-5, MW-6, MW-9, MW-11, MW-13, MW-17, and MW-20, at concentrations ranging from 5 ppb to 65 ppb (Figure 5-9). Lead concentrations exceeded the State target level of 50 ppb for Class G-III groundwater in only the sample collected from monitoring well MW-11 (65 ppb). Monitoring well MW-11 is located in the vicinity of the former AVGAS ASTs. Lead was not detected in the samples collected from the two vertical extent monitoring wells (MW-14D and MW-15D).

5.2.2.6 Chlorinated Compounds in Groundwater Seven chlorinated compounds were detected in groundwater samples. These include chlorobenzene, 1,2-dichlorobenzene (1,2-DCB), 1,1-dichloroethane (1,1,-DCA), 1,1-dichloroethene (1,1,-DCE), 1,2-dichloroethene (1,2-DCE), methylene chloride, and trichloroethene (TCE).

Chlorobenzene was detected in only the samples collected from monitoring wells MW-8 and MW-15D, at concentrations of 3 ppb and 2 ppb, respectively. These concentrations are less than the State groundwater guidance concentration of 10 ppb (FDER, February 1989).

The compound 1,2-DCB was detected in only the samples collected from monitoring wells MW-10 and MW-14D, at concentrations of 1 ppb and 4 ppb, respectively. These concentrations are less than the State groundwater guidance concentration of 10 ppb (FDER, February 1989). The compound 1,1-DCA was detected in only the sample collected from monitoring well MW-15D, at a concentration of 11 ppb, which is well below the State groundwater guidance concentration of 2,400 ppb (FDER, February 1989). The compound 1,1-DCE was detected in only the sample collected from monitoring well MW-15D, at a concentration of 10 ppb, which slightly exceeds the State groundwater guidance concentration of 7 ppb (FDER, February 1989).

The compound 1,2-DCE was detected in the samples collected from monitoring wells MW-8, MW-14D, MW-15D, MW-18, and MW-19. Concentrations of *cis* 1,2-DCE (Table 5-3) exceed the State groundwater guidance concentration (FDER, February 1989) of 4.2 ppb in the samples collected from monitoring wells MW-14D (14 ppb), MW-15D (38 ppb), and MW-19 (5 ppb). Concentrations of *trans* 1,2-DCE (indicated in parentheses in Table 5-3) exceed the groundwater guidance concentration of 4.2 ppb (FDER, February 1989) in only the sample collected from monitoring well MW-19 (12 ppb). It should be noted that although 1,2-DCE concentrations exceed groundwater guidance concentrations established by FDER (February 1989), *cis* 1,2-DCE and *trans* 1,2-DCE concentrations do not exceed the current primary drinking water standards of 70 ppb (USEPA, May 1993) and 100 ppb (Chapter 17-550, FAC), respectively. Total 1,2-DCE concentration (the sum of the concentrations of *cis* 1,2-DCE and *trans* 1,2-DCE) are reported in Appendix E, Groundwater Sample Analytical Data. (Note: in some instances the "total' result may not equal the sum of the *cis* and *trans* configurations due to rounding of results prior to reporting.)

TCE was detected in only the sample collected from monitoring well MW-15D, at a concentration of 1 ppb, which is less than the State groundwater guidance concentration of 3 ppb (FDER, February 1989).

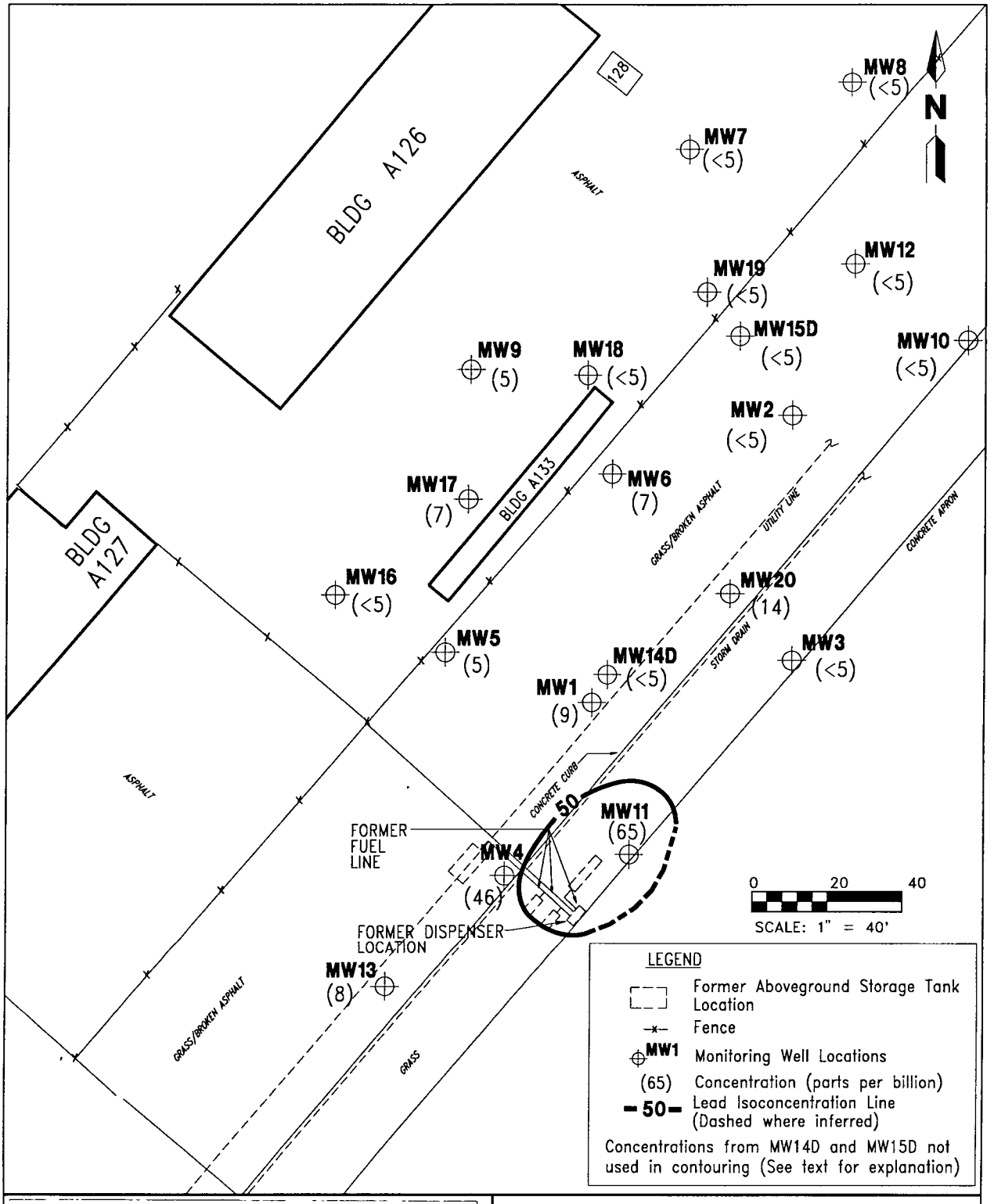

FIGURE 5-9
LEAD IN GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

FLYCLUB/MAH/1/3/93

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Concentrations of methylene chloride detected in samples collected from monitoring wells MW-1, MW-2, MW-3, MW-6, MW-10, MW-13, MW-14D, MW-15D, MW-16, MW-17, and MW-20, ranged from 1 ppb to 45 ppb. Methylene chloride concentrations detected in the equipment blank, the trip blank, and the laboratory blank were 14 ppb, 2 ppb, and 2 ppb, respectively. It appears that methylene chloride detected in groundwater samples is the result of laboratory contamination. For this reason, methylene chloride data are not presented on Figure 5-10.

5.3 POTABLE WELL SURVEY. Research of facility records indicate there are no potable wells on Boca Chica Key. Potable water at Boca Chica Field is imported from mainland Florida through the Florida Keys Aqueduct.

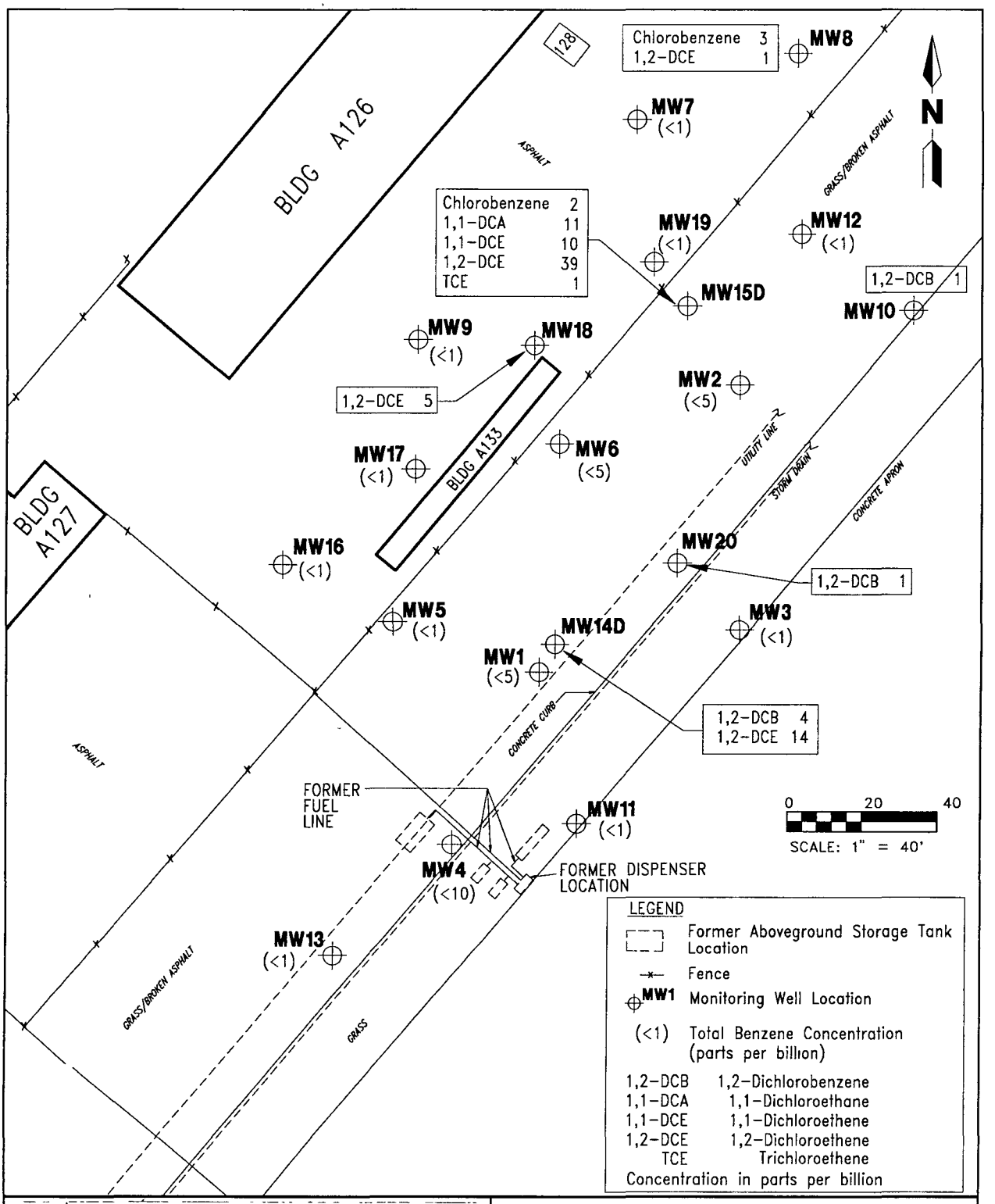

FIGURE 5-10
CHLORINATED HYDROCARBONS IN GROUNDWATER DISTRIBUTION MAP, OCTOBER 19, 1993

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6.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 SUMMARY. Based on the findings of the CA field investigations and laboratory analytical results, the following is a summary of existing conditions at the site.

- The primary water-bearing zone of concern at the site is the surficial aquifer. The surficial aquifer in the Boca Chica area is unconfined. Water quality data indicate that the surficial aquifer in the Key West area is an unlikely source of potable water (McKenzie, 1990); thus, the surficial aquifer is treated herein as a Class G-III groundwater source.

- The surficial aquifer was penetrated to a depth of 32 feet bls during this investigation. Indigenous subsurface material is generally composed of a mixture of oolitic sand; light gray, non-plastic clay; and limestone gravel.

- The water table at the site was encountered at depths ranging from 2.5 to 4.5 feet bls.

- The direction of groundwater flow in the surficial aquifer is to the northeast. A tidal influence study indicates that groundwater elevations are tidally affected; however, the direction of groundwater flow appears to be consistently to the northeast.

- Four separate areas of excessively contaminated soil were indicated by OVA headspace analyses. The most extensive soil contamination was detected along the southeast side of Building A-133 (Figure 5-3). Excessive soil contamination appears to be restricted to within 1 to 2 feet above the top of the water table.

- Total VOA, MTBE, PAH (including naphthalenes), TRPH, lead, and several chlorinated compounds were detected in groundwater samples. Total VOA, TRPH, and lead State target levels for Class G-III groundwater were applied (Chapter 17-770, FAC). Because Class G-III groundwater target levels are not available for the other contaminants, other standards were applied for comparative purposes. MTBE and total naphthalenes concentrations were compared to Class G-II groundwater target levels (Chapter 17-770, FAC). PAH (excluding naphthalenes) and chlorinated compound concentrations were compared to State groundwater guidance concentrations (FDER, February 1989).

- State target levels for Class G-III groundwater were exceeded for total VOA, benzene, and lead (See Figures 5-4, 5-5, and 5-9, respectively). Total VOA concentrations exceeded the State target level of 200 ppb in only the samples collected from monitoring wells MW-4 (1,300 ppb) and MW-6 (305 ppb). Lead exceeded the State target level of 50 ppb in only the sample collected from monitoring well MW-11 (65 ppb). TRPH concentrations were below the State target level of 5 ppm for Class G-III groundwater.

- Total naphthalenes concentrations exceed the State target level of 100 ppb for G-II groundwater in only the sample collected from monitoring well MW-1 (186 ppb) (See Figure 5-7). PAH concentrations exceed the State groundwater guidance concentration of 10 ppb in only the samples collected from monitoring wells MW-1 (35 ppb) and MW-6 (11 ppb).

- Concentrations of 1,1-DCE and 1,2-DCE exceed the State groundwater guidance concentrations of 7 ppb and 4.2 ppb, respectively. Concentrations of 1,1-DCE were detected in only the sample collected from monitoring well MW-15D (10 ppb). Concentrations of 1,2-DCE are below current drinking water standards (Chapter 17-550, FAC).

- No potable water sources were identified within a 0.25-mile radius of the site. There are no potable wells on Boca Chica Key.

- No free product was found in any site monitoring wells.

6.2 CONCLUSIONS. Based on the findings of the CA and site conditions, the following can be concluded.

- Excessively contaminated soil directly above the water table may be an indication of residual groundwater contamination rather than soil contamination. The highest OVA headspace readings were almost exclusively recorded in samples collected just above the water table. The tidal influence study indicates that significant variations in water table elevations as a result of tidal fluctuations occur at the site. The vertical movement of the groundwater as a result of tidal fluctuations will cause a spreading of contamination in the soil both immediately above and below the water table (see Appendix D, Tidal Influence Study). The high OVA readings recorded in soil samples collected just above the water table may be the result of residual groundwater contamination during periods of low water table elevations.

- The areal extent of groundwater contamination exceeding applicable (and compared) standards appears to be restricted to the vicinity of the former AVGAS ASTs and along the southeast side of Building A-133, near the former motor pool refueling point.

- Benzene is the major contaminant of concern at the site. Benzene concentrations exceed the State target level of 200 ppb for Class G-III groundwater in only the sample collected from monitoring well MW-4 (710 ppb) (see Figure 5-5).

- Groundwater petroleum contamination appears to decrease with depth. With the exception of 1,1-DCE, which was detected in the sample collected from vertical extent monitoring well MW-15D, contaminant concentrations were either not detected or were below applicable (or compared) standards in the samples collected from the vertical extent wells, MW-14D and MW-15D.

- The reported sources of groundwater contamination, the AVGAS ASTs, associated piping and dispensers, and the gasoline USTs located at the

former motor pool refueling point near Building A-133, have been removed from the site.

- Because there are no potable water sources at Boca Chica Field, the risk to human health caused by groundwater contamination at the site appears to be low.

- There is no evidence indicating that groundwater contaminants are migrating off the site. There are no surface water bodies that appear to be threatened by the contaminated area. Therefore, groundwater contamination at the site appears to be a low risk to area fish and wildlife.

6.3 RECOMMENDATIONS. Based on the findings, conclusions, and interpretations of the CA, ABB-ES recommends that groundwater remediation be implemented at the site to comply with State regulations regarding concentrations of benzene, lead, and total VOA in Class G-III groundwater. The manner of groundwater remediation will be presented in a remedial action plan (RAP), which will be developed pending FDEP approval of this CAR.

7.0 PROFESSIONAL REVIEW CERTIFICATION

This contamination assessment report was prepared using sound hydrogeologic principles and judgment. This assessment is based on the geologic investigation and associated information detailed in the text and appended to this report. If conditions are determined to exist that differ from those described, the undersigned geologist should be notified to evaluate the effects of any additional information on the assessment described in this report. This Contamination Assessment Report was developed for the Flying Club Site, Building A-127, at Boca Chica Field, Naval Air Station, Key West, Florida, and should not be construed to apply to any other site.

_____

Roger Durham
Professional Geologist
P.G. No. 1127

_____

Date

APPENDIX A

SITE CONDITIONS

Regional and Local Physiography

The State of Florida is divided into three geomorphic zones: the northern or proximal zone, the central or mid-peninsular zone, and the southern or distal zone (White, 1970). Boca Chica Key is part of the Lower Keys and is located entirely within the southern or distal zone. This area is characterized by a sparse veneer of residual soil and surface vegetation overlying eroded limestone. The topography of the Lower Keys is generally smooth and flat in the center of the key and slopes gently downward toward the shoreline (White, 1970).

Regional and Local Hydrogeology

The Lower Keys are overlain by an oolitic member of the Pleistocene Miami Limestone. The Key Largo coral reef limestone underlies the Miami Limestone. Hoffmeister (1974) reported that the Miami Limestone is 27 feet thick and the Key Largo Limestone is greater than 270 feet thick in the western part of Key West. The Key Largo Limestone is generally more porous than the Miami Limestone. Surficial and shallow subsurface features in the area have often been altered by imported fill material.

The surficial aquifer in the Boca Chica area is unconfined. The water table is found at shallow depths in the area, generally occurring from less than 1 foot to 10 feet below land surface. The surficial aquifer is contained within the Miami Limestone, the underlying Key Largo Limestone, and surficial fill materials. The limestones generally contain brackish or saline water. Recharge to the aquifer is directly from precipitation, and infiltration rates are rapid. Groundwater flow discharge is to surrounding surface waters.

APPENDIX B

LITHOLOGIC LOGS

TITLE: NAS Key West, Flying Club	LOG of WELL: KYW-A127-1	BORING NO. SB10
CLIENT. SOUTHNAVFACENGCOM		PROJECT NO: 8508-30
CONTRACTOR. Groundwater Protection, Inc	DATE STARTED: 10/15/93	COMPLTD. 10/15/93
METHOD. 4.25" HSA / CASE SIZE. 2 inch	SCREEN INT.. 2 - 12 FT	PROTECTION LEVEL. D
TOC ELEV.: 10.45 FT. / MONITOR INST.: OVA	TOT DPTH. 12FT	DPTH TO ▽ 3 57 FT
LOGGED BY. J Koch	WELL DEVELOPMENT DATE. 10/15/93	SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND silty, clayey, calcareous, medium brown to light brown, fine- coarse-grained. *Slight odor.*		SC		
				0	SAND clayey, calcareous, light brown to gray, fine- to coarse-grained with gravel *Slight odor*		GC		
5				250	As above *Strong odor*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-2		**BORING NO.** SB49
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO.** 8508-30
CONTRACTOR: Groundwater Protection, Inc		**DATE STARTED:** 10/15/93	**COMPLTD.** 10/15/93
METHOD: 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 2 - 12 FT	**PROTECTION LEVEL.** D
TOC ELEV.: 10.56 FT	**MONITOR INST..** OVA	**TOT DPTH.** 12FT	**DPTH TO ▽** 3 85 FT
LOGGED BY. J Koch	**WELL DEVELOPMENT DATE.** 10/15/93		**SITE.** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND. clayey, calcareous, light brown to white, fine- to coarse- grained with gravel. *No odor*		GC		
				0					
5				950	SAND clayey, calcareous, light brown to gray, fine- to coarse- grained with gravel *Strong petroleum odor*				
					SAND clayey, calcareous, medium gray, fine- to coarse-grained with gravel. *Slight petroleum odor.*				
10									
15									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-3		**BORING NO.** SB21
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO:** 8508-30
CONTRACTOR. Groundwater Protection, Inc		**DATE STARTED.** 10/15/93	**COMPLTD.** 10/15/93
METHOD: 4.25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 2 - 12 FT.	**PROTECTION LEVEL:** D
TOC ELEV.. 9 55 FT	**MONITOR INST.:** OVA	**TOT DPTH:** 12FT	**DPTH TO ▽** 2.74 FT.
LOGGED BY. R. Durham, J. Koch	**WELL DEVELOPMENT DATE:** 10/15/93		**SITE.** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1			LS		
				<1	LIMESTONE sandy, fine-grained, mixed with gravel, light brown. *No odor.*				▽
							SP		
5				<1	SAND. calcareous, light brown, silty to very fine-grained.				
							GC		
10					SAND. clayey, calcareous, light brown to white, fine- to coarse- grained with gravel				
15									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-4	**BORING NO.** SB1
CLIENT: SOUTHNAVFACENGCOM		**PROJECT NO.** 8508-30
CONTRACTOR: Groundwater Protection, Inc	**DATE STARTED.** 10/15/93	**COMPLTD.** 10/15/93
METHOD: 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT..** 2 - 12 FT	**PROTECTION LEVEL:** D
TOC ELEV.: 10.70 FT	**MONITOR INST.:** OVA	**TOT DPTH.** 12FT	**DPTH TO ▽** 3 78 FT
LOGGED BY: J Koch	**WELL DEVELOPMENT DATE:** 10/15/93	**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				1	SAND. clayey, silty, calcareous, medium brown, fine- to coarse- grained *No odor.*		SC		
				60	SAND. clayey, silty, calcareous, medium brown, fine- to coarse- grained with gravel.		GC		
5				2500	As above, with coarse gravel *Slight odor*				
10					SAND. clayey, calcareous, light brown to white, fine- to coarse- grained with gravel. *No odor.*				
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE. NAS Key West, Flying Club	LOG of WELL: KYW-A127-5	BORING NO. SB17
CLIENT. SOUTHNAVFACENGCOM		PROJECT NO: 8508-30
CONTRACTOR: Groundwater Protection, Inc.	DATE STARTED: 10/15/93	COMPLTD: 10/15/93
METHOD: 4 25" HSA	CASE SIZE: 2 inch	SCREEN INT.: 2 - 12 FT	PROTECTION LEVEL. D
TOC ELEV.: 10 86 FT.	MONITOR INST.: OVA	TOT DPTH: 12FT.	DPTH TO ▽ 3 95 FT
LOGGED BY. J Koch	WELL DEVELOPMENT DATE: 10/15/93	SITE: NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND. silty, calcareous, light brown, fine- to coarse-grained *No odor*		SM		
				0			SC		
5				0	SAND silty, clayey, calcareous, light brown, fine- to coarse-grained				
10					SAND clayey, calcareous, light brown to white, fine- to coarse- grained				
15									

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-6		**BORING NO.**
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO.** 8508-30
CONTRACTOR: Groundwater Protection, Inc		**DATE STARTED:** 10/15/93	**COMPLTD.** 10/15/93
METHOD: 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT..** 2 - 12 FT	**PROTECTION LEVEL:** D
TOC ELEV.: 10.69 FT.	**MONITOR INST..** OVA	**TOT DPTH.** 12FT	**DPTH TO ▽** 3.86 FT
LOGGED BY: J Koch	**WELL DEVELOPMENT DATE:** 10/15/93		**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
					SAND. clayey, calcareous, light brown, fine- to coarse-grained. *Strong petroleum odor.*		SC		
5									
							GC		
10					SAND clayey calcareous, light brown to gray, fine- to coarse-grained with gravel *Strong petroleum odor.*				
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	LOG of WELL: KYW-A127-7		BORING NO.
CLIENT: SOUTHNAVFACENGCOM			PROJECT NO. 8508-30
CONTRACTOR: Groundwater Protection, Inc		DATE STARTED. 10/15/93	COMPLTD. 10/15/93
METHOD: 4 25" HSA	CASE SIZE: 2 inch	SCREEN INT . 2 - 12 FT	PROTECTION LEVEL. D
TOC ELEV.: 10 78 FT	MONITOR INST.: OVA	TOT DPTH. 12FT	DPTH TO ▽ 4 06 FT
LOGGED BY: J Koch	WELL DEVELOPMENT DATE. 10/15/93		SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
5					SAND. clayey, calcareous, light brown to light gray, fine- to coarse- grained with gravel *No odor*		GC		
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-8	**BORING NO.** SB44
CLIENT. SOUTHNAVFACENGCOM		**PROJECT NO.** 8508-30
CONTRACTOR. Groundwater Protection, Inc.	**DATE STARTED:** 10/15/93	**COMPLTD.** 10/15/93
METHOD: 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 2 – 12 FT	**PROTECTION LEVEL:** D
TOC ELEV.: 10 64 FT.	**MONITOR INST.:** OVA	**TOT DPTH.** 12FT.	**DPTH TO ▽** 3 98 FT
LOGGED BY: J Koch	**WELL DEVELOPMENT DATE:** 10/15/93	**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND. clayey, calcareous, light brown to dark brown, fine- to coarse- grained *No odor*		SC		
				<1	SAND clayey, calcareous, light brown to white, fine- to coarse- grained with gravel		GC		
5				<1	SAND clayey, calcareous, light brown to light gray, fine- to coarse- grained with gravel				
10					SAND. clayey, calcareous, light brown to medium gray, fine- to coarse- grained with gravel				
15									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL.** KYW-A127-9		**BORING NO.** SB41
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO:** 8508-30
CONTRACTOR: Groundwater Protection, Inc.		**DATE STARTED:** 10/15/93	**COMPLTD:** 10/15/93
METHOD. 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT..** 2 - 12 FT	**PROTECTION LEVEL:** D
TOC ELEV.: 10 92 FT	**MONITOR INST..** OVA	**TOT DPTH.** 12FT	**DPTH TO ▽** 4 07 FT
LOGGED BY: R. Durham, J Koch	**WELL DEVELOPMENT DATE.** 10/15/93		**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND silty, calcareous, light brown, fine- to medium-grained *Slight odor.*		SM		
				0	SAND clayey, calcareous, light brown to white, fine- to coarse- grained with gravel. *Strong odor.*		GC		
5				2					
					SAND light brown, silty to coarse-grained with limestone gravel *No odor*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	LOG of WELL. KYW-A127-10	BORING NO.
CLIENT: SOUTHNAVFACENGCOM		PROJECT NO. 8508-30
CONTRACTOR: Groundwater Protection, Inc	DATE STARTED. 10/15/93	COMPLTD: 10/15/93
METHOD. 4 25" HSA	CASE SIZE. 2 inch	SCREEN INT.: 2 - 12 FT	PROTECTION LEVEL. D
TOC ELEV.. 10.55 FT.	MONITOR INST.: OVA	TOT DPTH: 12FT	DPTH TO ▽ 3 84 FT
LOGGED BY: R Durham	WELL DEVELOPMENT DATE: 10/15/93	SITE: NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND clayey to coarse-grained, light brown, some limestone gravel. *No odor*		GC		
				<1					
5					As above *Slight petroleum odor.*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE. NAS Key West, Flying Club		LOG of WELL. KYW-A127-11	BORING NO. SB7
CLIENT: SOUTHNAVFACENGCOM			PROJECT NO. 8508-30
CONTRACTOR. Groundwater Protection, Inc.		DATE STARTED: 10/15/93	COMPLTD. 10/15/93
METHOD. 4 25" HSA	CASE SIZE: 2 inch	SCREEN INT.. 2 - 12 FT	PROTECTION LEVEL. D
TOC ELEV.: 10 00 FT	MONITOR INST.: OVA	TOT DPTH: 12FT	DPTH TO ▽ 3.09 FT
LOGGED BY: J. Koch	WELL DEVELOPMENT DATE: 10/15/93		SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND. clayey, calcareous, light brown to light gray, fine- to medium- grained. *No odor.*		SC		
				0			GC		▽
5				0	SAND. clayey, calcareous, light brown, fine- to coarse-grained with gravel.				
10					SAND clayey, calcareous, light brown to white, fine- to coarse- grained with gravel				
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE. NAS Key West, Flying Club	LOG of WELL: KYW-A127-12		BORING NO. N/A
CLIENT. SOUTHNAVFACENGCOM			PROJECT NO: 8508-30
CONTRACTOR. Groundwater Protection, Inc		DATE STARTED. 10/15/93	COMPLTD. 10/15/93
METHOD. 4.25" HSA	CASE SIZE. 2 inch	SCREEN INT.: 2 - 12 FT	PROTECTION LEVEL D
TOC ELEV.: 10.56 FT	MONITOR INST.. OVA	TOT DPTH. 12FT	DPTH TO ▽ 3 87 FT
LOGGED BY: J Koch	WELL DEVELOPMENT DATE: 10/15/93		SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND clayey, calcareous, light brown, fine- to coarse-grained. *No odor.*		SC		
				<1					
5				1	SAND clayey calcareous, light brown to white, fine- to coarse- grained				▽
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-13	**BORING NO.** N/A
CLIENT: SOUTHNAVFACENGCOM		**PROJECT NO:** 8508-30
CONTRACTOR. Groundwater Protection, Inc.	**DATE STARTED:** 10/16/93	**COMPLTD:** 10/16/93
METHOD: 4.25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 2 - 12 FT	**PROTECTION LEVEL.** D
TOC ELEV.. 10 44 FT.	**MONITOR INST.:** OVA	**TOT DPTH:** 12FT.	**DPTH TO ▽** 3 50 FT
LOGGED BY. J. Williams	**WELL DEVELOPMENT DATE:** 10/16/93		**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND clayey, calcareous, white to light brown, coarse- to fine- grained		SC		
				0					
5				0					
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-14D		**BORING NO.** SB10
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO:** 8508-30
CONTRACTOR: Groundwater Protection, Inc		**DATE STARTED:** 10/16/93	**COMPLTD.** 10/16/93
METHOD. 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 25 - 30 FT	**PROTECTION LEVEL:** D
TOC ELEV.: FT	**MONITOR INST.:** OVA	**TOT DPTH.** 30FT	**DPTH TO ▽** 4 13 FT
LOGGED BY. J. Williams	**WELL DEVELOPMENT DATE:** 10/17/93		**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND calcareous, some silt, some clay, medium brown to light brown, fine- to coarse-grained *Slight odor*		GC		
				0	SAND calcareous, some clay, light brown, white, gray, fine- to coarse-grained with gravel, wet at 4' bls *Slight odor.*				
5				250	SAND calcareous, some clay, light brown, white, gray, fine- to coarse-grained with gravel, saturated *Strong odor.*				
15			12/24	45	ORGANICS 15-15.3 bls, dark brown to black SAND 15.3-15.5 bls, calcareous, gray, fine- to medium-grained, 25-30% silt and clay LIMESTONE 15 5-17 bls, white, highly weathered		OL LS	31/30/77/80	
20			22/24	210	LIMESTONE highly weathered, white *Slight odor.*			30/37/45/50	
25			24/24	32	LIMESTONE highly weathered, white			5/8/13/12	
30			20/24	11	LIMESTONE white, unconsolidated, well graded gravel to fine sand fragments, little silt/clay, trace phosphorous, trace quartz sand, coarse- to medium-grained, angular to sub-angular			2/2/7/8	
35									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	LOG of WELL: KYW-A127-15D	BORING NO. SB48
CLIENT: SOUTHNAVFACENGCOM		PROJECT NO: 8508-30
CONTRACTOR: Groundwater Protection, Inc	DATE STARTED: 10/16/93	COMPLTD. 10/16/93
METHOD: 4.25" HSA	CASE SIZE: 2 inch	SCREEN INT.: 20 - 25 FT	PROTECTION LEVEL. D
TOC ELEV.. FT	MONITOR INST.. OVA	TOT DPTH. 25FT	DPTH TO ▽ 4 03 FT
LOGGED BY: J. Williams	WELL DEVELOPMENT DATE: 10/17/93	SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN
				1	SAND. calcareous, some silt, some clay, medium brown to light gray, fine- to coarse-grained. *No odor*		GC	
				1	SAND calcareous, some clay, light brown, white, gray, fine- to coarse-grained with gravel *No odor*			
5				2200	SAND. calcareous, some clay, light brown, white, gray, fine- to coarse-grained with pebbles, saturated *Strong odor.*			
10							LS	
15			18/24	22	LIMESTONE highly weathered, white *Odor*			13/33/47/40
20			20/24	3	LIMESTONE highly weathered, white *Slight odor*			18/23/>100/
25								
30								
35								

WELL DATA

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	LOG of WELL. KYW-A127-16		BORING NO. SB27
CLIENT: SOUTHNAVFACENGCOM			PROJECT NO: 8508-30
CONTRACTOR: Groundwater Protection, Inc.		DATE STARTED: 10/16/93	COMPLTD: 10/16/93
METHOD: 4.25" HSA	CASE SIZE: 2 inch	SCREEN INT.: 2 - 12 FT	PROTECTION LEVEL: D
TOC ELEV.. 10 84 FT	MONITOR INST.: OVA	TOT DPTH: 12FT	DPTH TO ▽ 3 91 FT
LOGGED BY: R Durham, J. Koch	WELL DEVELOPMENT DATE. 10/16/93		SITE: NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND fine-grained to clayey, light brown, some dark gray fine-grained sand *Faint odor*		SC		
				<1	SAND very fine- to medium-grained, some limestone gravel, light brown *No odor*		GC		
5				<1	SAND. very fine-grained to silty, some limestone gravel, light brown				
10					SAND clayey, calcareous, some gravel, light brown to white, fine- to coarse-grained				
15									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-17		**BORING NO.** N/A
CLIENT: SOUTHNAVFACENGCOM			**PROJECT NO:** 8508-30
CONTRACTOR: Groundwater Protection, Inc		**DATE STARTED.** 10/16/93	**COMPLTD:** 10/16/93
METHOD: 4.25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT..** 2 - 12 FT	**PROTECTION LEVEL.** D
TOC ELEV.: 11.00 FT.	**MONITOR INST.:** OVA	**TOT DPTH:** 12FT	**DPTH TO ▽** 4 09 FT
LOGGED BY: J. Koch	**WELL DEVELOPMENT DATE:** 10/16/93		**SITE:** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND clayey, calcareous, light brown to dark brown, fine- to coarse- grained *Petroleum odor.*		SC		
				<1			GC		
5				3300	SAND clayey calcareous, some gravel, light brown to white, fine- to coarse-grained *Strong petroleum odor*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	LOG of WELL: KYW-A127-18	BORING NO. N/A
CLIENT: SOUTHNAVFACENGCOM		PROJECT NO. 8508-30
CONTRACTOR: Groundwater Protection, Inc	DATE STARTED. 10/16/93	COMPLTD. 10/16/93
METHOD: 4 25" HSA	CASE SIZE: 2 inch	SCREEN INT.: 2 - 12 FT	PROTECTION LEVEL: D
TOC ELEV.. 10.91 FT.	MONITOR INST.: OVA	TOT DPTH. 12FT	DPTH TO ▽ 4 09 FT
LOGGED BY: J. Koch	WELL DEVELOPMENT DATE: 10/16/93	SITE. NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				<1	SAND. clayey, calcareous, light brown to dark brown, fine- to coarse- grained *No odor.*		SC		
				<1	SAND clayey, calcareous, light brown to light gray, fine- to coarse- grained with gravel		GC		
5				>500	As above *Slight petroleum odor*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE. NAS Key West, Flying Club	LOG of WELL: KYW-A127-19	BORING NO. N/A
CLIENT. SOUTHNAVFACENGCOM		PROJECT NO: 8508-30
CONTRACTOR. Groundwater Protection, Inc.	DATE STARTED: 10/16/93	COMPLTD. 10/16/93
METHOD: 4 25" HSA	CASE SIZE: 2 inch	SCREEN INT.: 2 - 12 FT
TOC ELEV.. 10 44 FT.	MONITOR INST.: OVA	TOT DPTH: 12FT
LOGGED BY. J Koch	WELL DEVELOPMENT DATE: 10/16/93	SITE: NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				25	SAND silty, calcareous, dark brown to black, fine- to coarse-grained *Petroleum odor*		SM		
				90	SAND silty, clayey, calcareous, dark brown, fine- to coarse-grained *Petroleum odor*		LS		
5				370	LIMESTONE light brown to dark brown, some silt *Strong petroleum odor.*				
10									
15									

ABB ENVIRONMENTAL SERVICES, INC.

TITLE: NAS Key West, Flying Club	**LOG of WELL:** KYW-A127-20		**BORING NO.** N/A
CLIENT. SOUTHNAVFACENGCOM			**PROJECT NO.** 8508-30
CONTRACTOR: Groundwater Protection, Inc		**DATE STARTED:** 10/16/93	**COMPLTD.** 10/16/93
METHOD: 4 25" HSA	**CASE SIZE:** 2 inch	**SCREEN INT.:** 2 - 12 FT	**PROTECTION LEVEL:** D
TOC ELEV.. 10 35 FT.	**MONITOR INST.:** OVA	**TOT DPTH:** 12FT.	**DPTH TO ▽** 3 52 FT
LOGGED BY. J. Koch	**WELL DEVELOPMENT DATE:** 10/16/93		**SITE.** NAS Key West, Flying Club

DEPTH FT	LABORATORY SAMPLE ID	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	SAND clayey, calcareous sand, light brown to white, fine- to coarse- grained *No odor.*		SC		
				9	SAND. clayey, calcareous, light brown to white, fine- to coarse grained with gravel *Slight petroleum odor*		GC		
5				2900	As above *Strong petroleum odor*				
10									
15									

 ABB ENVIRONMENTAL SERVICES, INC.

APPENDIX C

TIDAL INFLUENCE STUDY

TIDAL INFLUENCE STUDY

Background. The tide is the periodic rise and fall of the earth's water resulting from gravitational interactions between the sun, moon, and earth. There are generally two high and two low waters in a day. Tides follow the Moon more closely than they do the sun, and the lunar or tidal day is about 50 minutes longer than the solar day. When the two high waters and two low waters of each tidal day are approximately equal in height, the tide is said to be semidiurnal. When there is a relatively large diurnal inequality in the high or low waters or both, the tide is said to be mixed. Finally, when there is only one high water and one low water in each tidal day, the tide is said to be diurnal. When water is falling or moving away from a shoreline, the tide is said to be an ebb tide. Under the conditions when water is rising the tide is said to be a flood tide. The time and heights of the rising and falling of the tide can be predicted based on our knowledge of these gravitational interactions. Daily tide predictions in the United States are available and are based upon analyses of tidal observations for periods of at least 1 year. Extreme meteorological conditions are excluded from the analyses and predictions, therefore, the predicted tidal heights are those expected under average weather conditions. Prolonged onshore winds or a low barometric pressure can produce higher tidal levels than predicted. In addition, prolonged offshore winds or a high barometric pressure can produce lower tidal levels than predicted.

Variations in the coastline and in the coastal bathymetry (channels, shoals, etc.) can also make a difference in the times that the tidal wave hits different points along the same coastline.

Exclusive of weather conditions, the astronomical tide is also subject to range variations. Decreased ranges may be expected near the times when the moon is in apogee (farthest from the earth) or in quadrature (angular separation of the moon and sun from the earth is 90 degrees; also called neap tides). Increased ranges may be expected when the moon is in perigee (nearest to earth in its orbit) or in a new or full position (spring tides). A larger diurnal range may also result when the moon is in its maximum declination (tropic tides). The actual tidal range will depend upon the extent to which combinations of these positions reinforce or detract from one another. These range variations based on astronomical conditions are included in the daily tide predictions. Daily predicted tide tables for the coastal United States are published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. The tide tables predict the high and low water heights based on Mean Lower Low Water (MLLW) datum and times based on a referred meridian. The tidal datum MLLW is an arithmetic mean of the lower low water heights of a mixed tide observed over a specific 19-year Metonic cycle (the national Tidal Datum Epoch). Only the lower low water of each pair of low waters, or the only low water of a tidal day is included in the mean.

Groundwater aquifers that are in hydraulic connection with surface water bodies such as rivers, lakes, oceans, etc., are influenced by fluctuations of the water bodies. These fluctuations may be the result of tidal influences, flooding, rainfall, or the influence of man made control structures such as dams and locks. During high surface water conditions the aquifer may be recharged, whereas, during low surface water conditions the aquifer will usually discharge into the

surface water body. In a groundwater aquifer, the effects of surface water fluctuations will diminish with distance from the source (river, ocean, etc.).

NAS Key West is located on Boca Chica Key. The Lower Keys, including Boca Chica Key, are overlain by an oolitic member of the Pleistocene Miami Limestone, except in those areas where fill material has been imported. The surficial aquifer is contained within this oolitic member. Groundwater at NAS Key West on Boca Chica Key is encountered from 1 to 5 feet bls. Because of the high hydraulic conductivity of this oolite, the groundwater on the entire Key is suspected of experiencing tidal fluctuations, particularly at near extreme high and low tide conditions.

Tidal Study Methodologies. The tidal study was conducted at the Flying Club site from 1800 hours on November 30, 1993 to 0730 hours on December 2, 1993. Initially, water levels were collected from a temporary surface water gauge located at the Jet Engine Test Cell and from monitoring wells MW-8, MW-6, and MW-4. During the study, water levels were recorded from these stations every 15 minutes using a Hermit™ Data Logger and pressure transducer probes.

The monitoring well stations were surveyed to a reference benchmark located at MW-11 that has an arbitrarily assigned elevation of 10.00 feet.

The water level data from the monitoring wells were then compared to the predicted tide levels in the Key West area.

Tidal Study Results. The study period was scheduled to take place within 3 days of a full Moon (November 29, 1993) so that near maximum water level fluctuations, as a result of the tide, could be observed. The actual study was conducted from 1645 hours on November 30, 1993, to 0700 hours on December 2, 1993. Comparisons of the water level fluctuations in the monitoring wells to the predicted tide levels in the Key West area indicated that local bathymetry and the location of the site (convergence of the Atlantic Ocean and the Gulf of Mexico) greatly impact the arrival time and levels of the tides in the area.

Predicted tide arrivals and levels at the Key West station, located at Truman Annex on the west side of Key West, are compared to the Boca Chica Channel Bridge station, located approximately 6.5 miles east of the Key West station. These data show the tide occurs 1.5 hours later at the Boca Chica Channel Bridge and has an approximate 60 percent reduction in tidal levels. The Key West station is located approximately 8.5 miles west of the study site, whereas the Boca Chica Channel Bridge station is only 2 miles west of the study site. For tidal stations closer to the study site, the delay in the predicted tide arrivals and levels are even more pronounced. Data from these stations are compared to the Flying Club site and are presented in Table C-1.

The closest predicted tide station to the study site (Rockland Key Channel Bridge) was used in comparing the monitoring well data to the predicted tides. The information in Table C-1 shows the high and low tides at Rockland Key occur between 5 and 6 hours after they occur at the western end of Key West. The variation in water levels during high and low tides is 0.76 to 0.88 times those of Key West. The comparison of the tidal fluctuations with time between the Rockland Key and the Key West stations is presented on Figure C-1. A comparison of the groundwater level fluctuations at the Flying Club site to the tidal fluctuations at Rockland Key is presented on Figure C-2.

Table C-1
Tidal Influence Study
Tidal Differences Between Stations in the Key West Area

Contamination Assessment Report
Flying Club Site, Building A-127
Naval Air Station Key West
Boca Chica Field, Key West, Florida

Place	Differences						Distance from Flying Club Site
	High Water		Low Water		High Water[1]	Low Water[1]	
	h	m	h	m	feet	feet	
Key West, Truman Annex	0	0	0	0	1.0	1.0	8.5 miles W.
Boca Chica Channel Bridge	+1	23	+1	29	0.57	0.67	2 miles W.
Boca Chica Key, Long Point	+3	54	+5	22	0.94	0.71	2 miles NW
Rockland Key, Rockland Channel Bridge	+5	02	+6	06	0.76	0.88	1 mile NE

[1] The water level values of the Key West station for high or low water must be multiplied by this number to obtain the correct tidal levels for the station.

Notes: h = hour.
m = minute.
W = west
NW = northwest
NE = northeast.

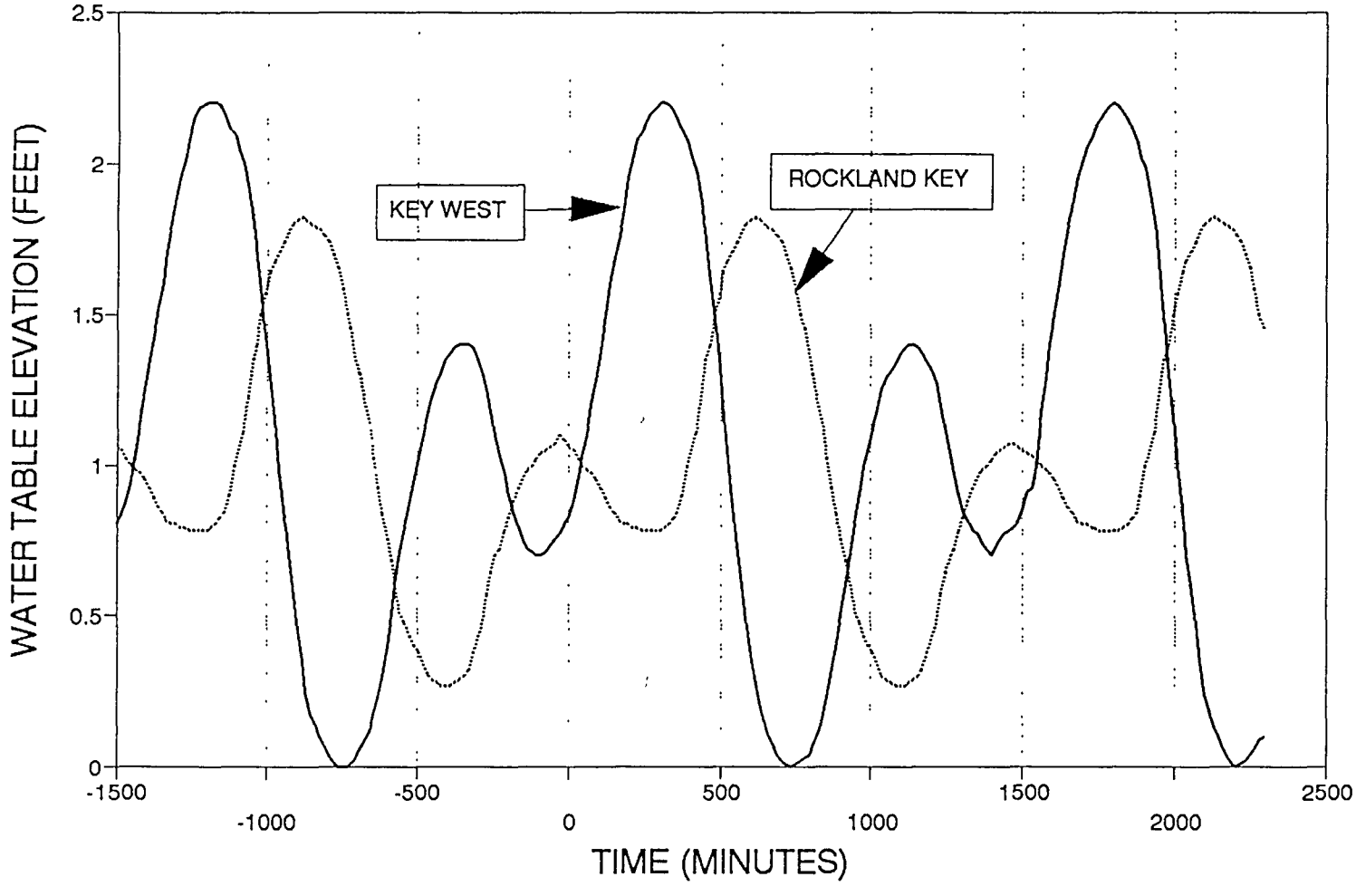


FIGURE C-1
TIDAL INFLUENCE STUDY
PREDICTED AREA TIDAL FLUCTUATIONS

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE,
BUILDING A-127
NAS KEY WEST,
KEY WEST, FLORIDA

8509-40 940131WEM

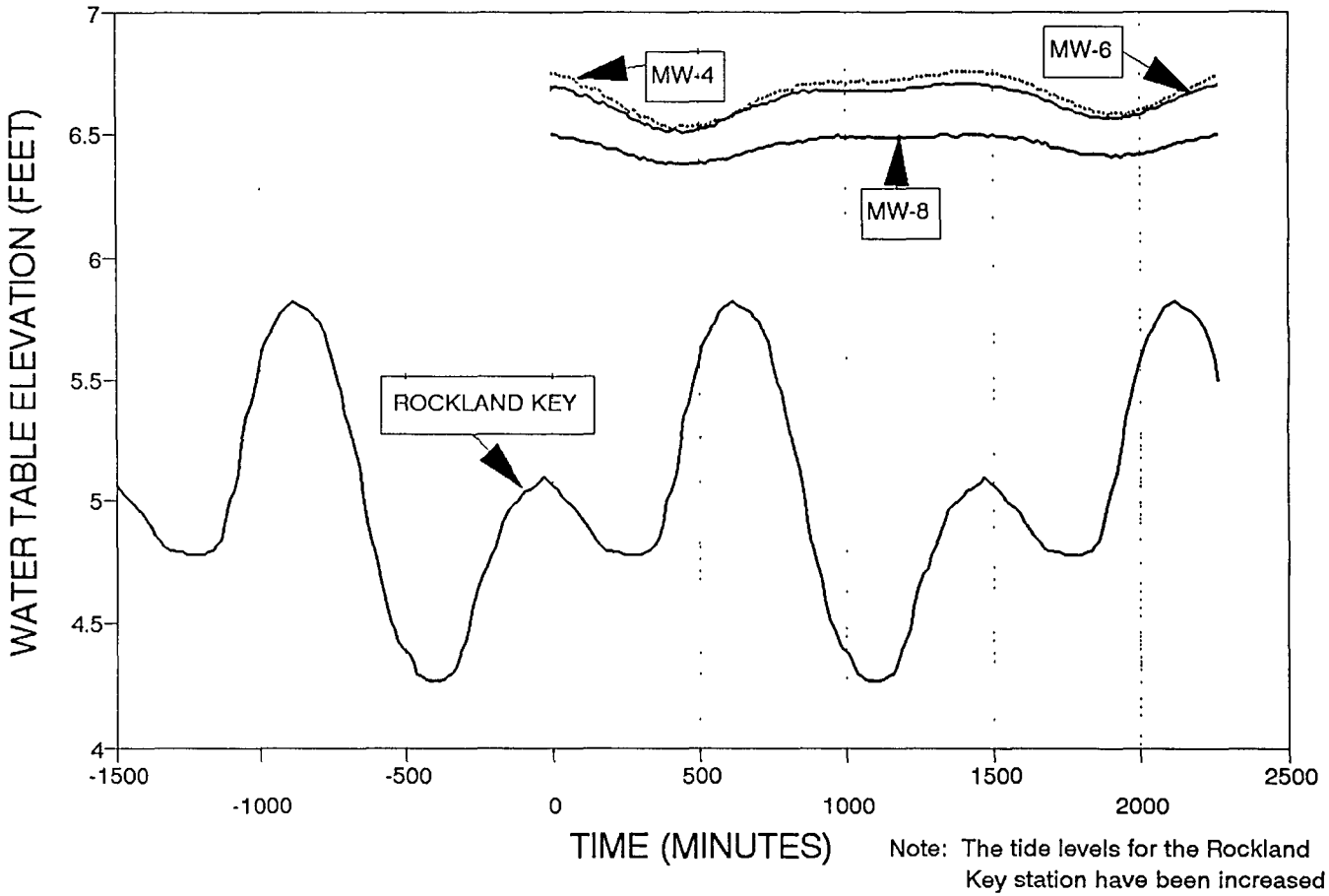


FIGURE C-2
TIDAL INFLUENCE STUDY
FLYING CLUB SITE

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE, BUILDING A-127

NAS KEY WEST,
KEY WEST, FLORIDA

8509-40 940131WEM

Figure C-2 shows maximum water level fluctuations at the site of approximately 0.22 foot in MW-4, 0.2 foot in MW-6, and 0.12 foot in MW-8.

With the groundwater fluctuations at the site showing a tidal pattern and because the site is located in the central section of Boca Chica Key, it can be inferred that all groundwater at Boca Chica Key is influenced by the tide, especially during extreme tidal events.

Although there is a fluctuation of approximately 0.2 foot in the groundwater at the site caused by the tide that will result in a temporary change in the water table gradient, these fluctuations are not expected to cause any noticeable horizontal migration of the contaminant plume. The duration of these fluctuations and their resulting gradient changes in relationship to the hydraulic conductivity of the material at the site does not suggest any significant lateral movement of water at the site. The vertical movement of the groundwater as a result of tidal fluctuations will cause a spreading of contamination in the soil directly above and below the groundwater table. However, this would be expected anyway as a result of contaminant volatilization and dissolved component migration.

APPENDIX D

AQUIFER PARAMETER CALCULATIONS

Aquifer Parameter Calculations

Hydraulic gradient

Water table elevations were plotted on a map of the site. A water table contour map was drawn with flow lines (depicting groundwater flow direction) perpendicular to the groundwater elevation contours. The groundwater hydraulic gradient was calculated by subtracting the differences in groundwater elevation (in feet) between two points on the map and dividing the elevation difference by the distance between the two points to obtain a resulting gradient in feet per foot (ft/ft). Water elevation data collected on October 18 and December 4, 1993, were used to calculate hydraulic gradients at the site. For each date, three traverses were made perpendicular to equipotential contour lines to calculate an average site hydraulic gradient. For each traverse, the hydraulic gradient was calculated as follows:

$$i = (h_1 - h_2) / d \qquad (1)$$

where

i = hydraulic gradient (ft/ft),
h_1 = water table elevation, upgradient (feet),
h_2 = water table elevation, downgradient (feet), and
d = horizontal distance (feet) between h_1 and h_2 along a flow line.

Hydraulic gradients calculated in this manner varied from 1.04×10^{-3} ft/ft to 2.04×10^{-3} ft/ft. The average hydraulic gradient at the site was calculated to be 1.52×10^{-3} ft/ft.

Hydraulic conductivity

Hydraulic conductivity (K) from slug test data was calculated following the methods of Bouwer and Rice (1976) and Bouwer (1989) for partially penetrating wells screened in unconfined aquifers. The following well information was needed to assess the hydraulic conductivity:

- radius of well casing (r_c),
- r_w = radius of borehole (r_c plus radius of the sand pack surrounding the well screen),
- length of screened interval below the water table (L_e),
- effective well radius (r_e),
- depth of well below the water table (L_w),
- depth to confining unit or bottom of aquifer below the static water table (H), and
- plot of time versus the logarithm of y, where y is the difference between the static water level outside the well and the water level inside the well.

Figure D-1 is a well diagram depicting most of the aquifer and well parameters. Calculations were made assuming that $L_w < H$. K was calculated as follows:

$$K = [R_c^2 \ln(\frac{r_e}{r_w}) - 2L_e] [\frac{1}{t} \ln(\frac{y_o}{y_t})] \quad (2)$$

where

y_0 = y at time zero, and
y_t = y at time t.

The effective well radius, r_e, and the term $[(1/t)\ln(y_0/y_t)]$ were derived by using the computer program AQTESOLV™ (Geraghty & Miller, Inc., 1989). This computer program follows procedures and assumptions outlined by Bouwer (1989).

Slug test graphs are attached at the end of this appendix. Values of y were calculated for a particular time, t, and plotted on the graph. The computer program selects a "best-fit" line through the data points by linear regression along a "straight-line" portion of the graph. The slope of the "best-fit" line is used to calculate the hydraulic conductivity, K.

Three slug tests each were performed inside monitoring wells MW-4 and MW-6. K is reported in feet per minute (ft/min) on the slug test graphs, and was recalculated to feet per day (ft/day). K was found to vary from $4.3x10^{-1}$ ft/day to 1.36 ft/day with an average K of $9.5x10^{-1}$ ft/day.

Average pore water velocity

Estimates of average pore water velocity were obtained using the following formula:

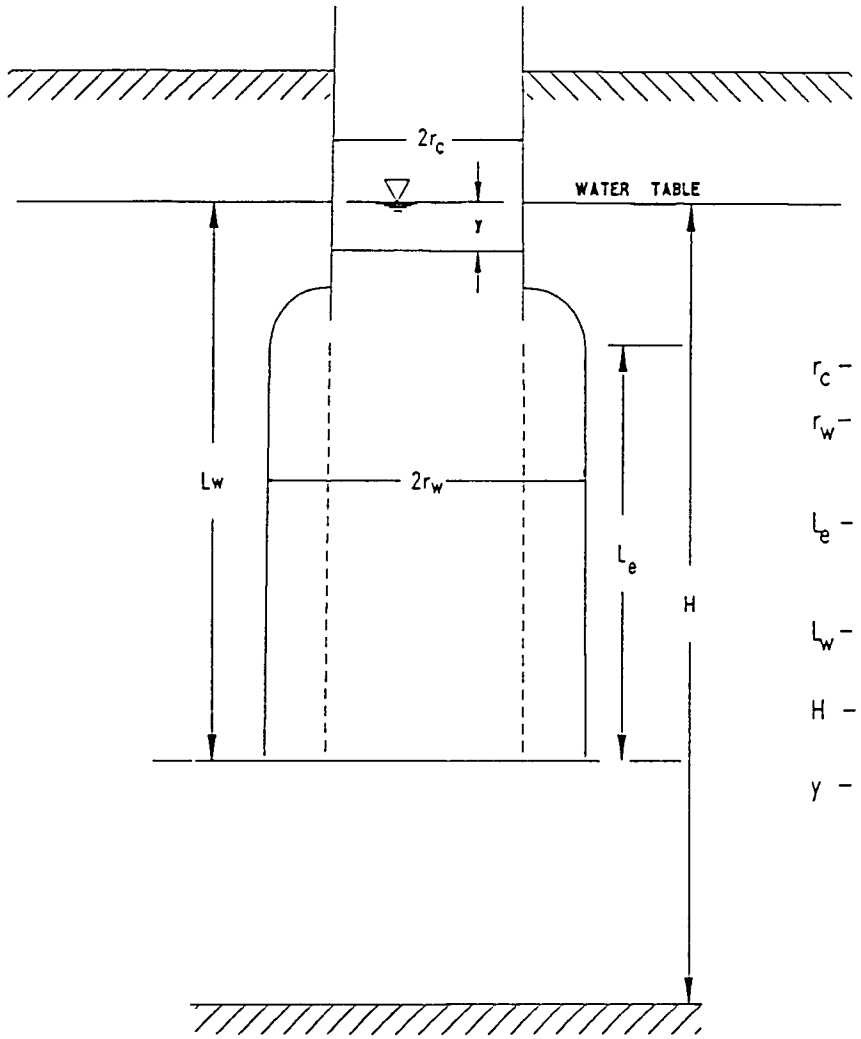
$$V = (K*I)/n \quad (3)$$

where

V = seepage velocity in ft/day,
K = hydraulic conductivity in ft/day,
i = hydraulic gradient, and
n = estimated porosity.

Assuming an estimated porosity of 30% for weathered to oolitic limestone (Davis and Dewiest, 1966), an average hydraulic gradient of $1.52x10^{-3}$ ft/ft, and an average hydraulic conductivity of $9.4x10^{-1}$ ft/day, the average pore water velocity is calculated as follows:

$V = (9.4x10^{-1}$ ft/day * $1.52x10^{-3}$ ft/ft)/ 0.30
$V = 4.8x10^{-3}$ ft/day



r_c – Radius of well

r_w – Radius of well + total thickness of the sand/gravel pack

L_e – Length of screened interval below the water table

L_w – Depth of well below water table

H – Depth to confining unit below the water table

y – Difference between static water level outside well and water level inside well

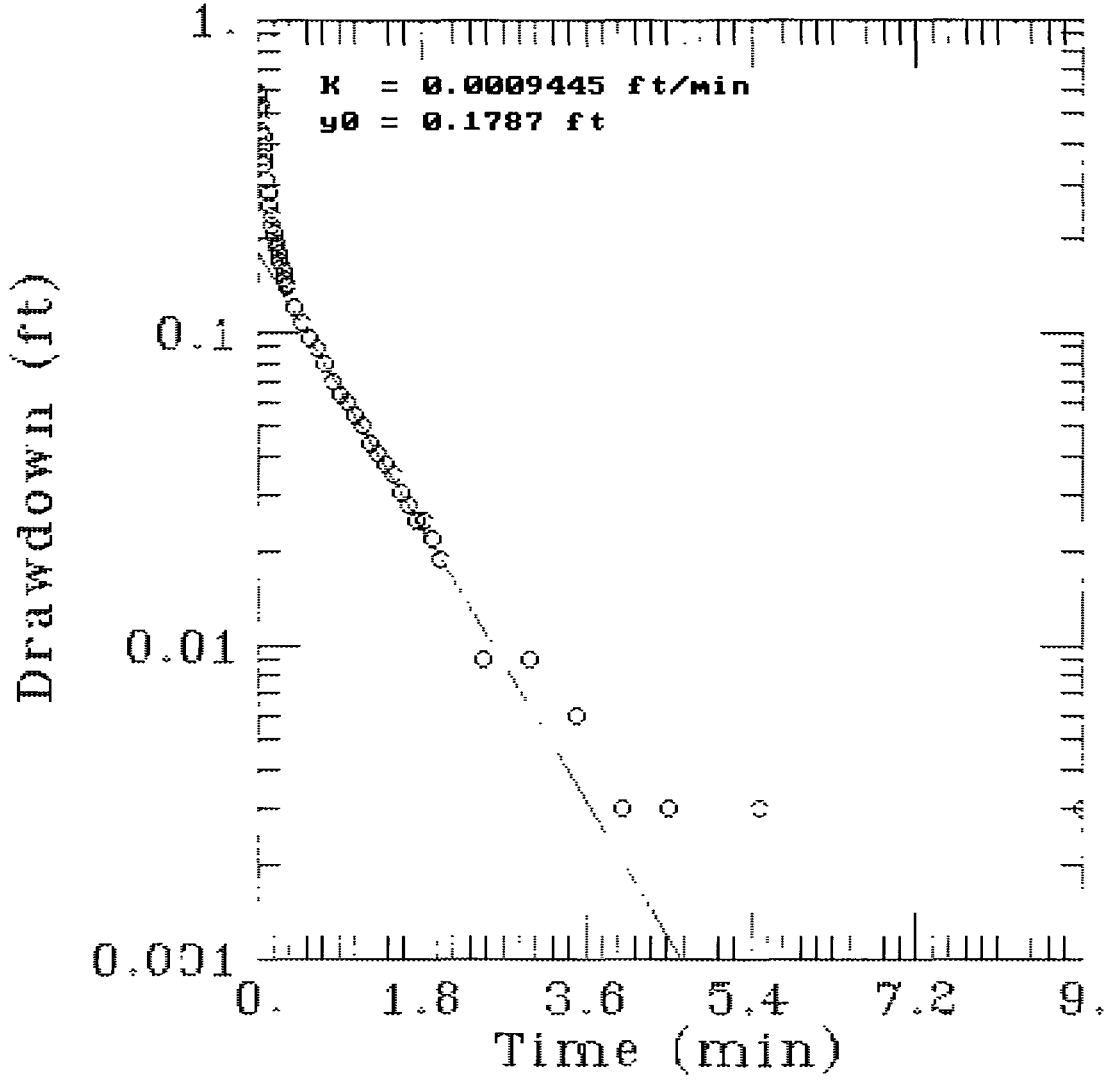
FIGURE D-1
DEFINITIONS OF SLUG TEST PARAMETERS (From Bouwer, 1989)

CONTAMINATION ASSESSMENT REPORT
FLYING CLUB SITE,
BUILDING A-127
NAS KEY WEST,
KEY WEST, FLORIDA

8509-40 940131WEM

SLUG TEST GRAPHS

KYW-127-MW4 RUN#1



AQTESOLV

GERAGHTY & MILLER, INC.

Modeling Group

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================================================================================
                                TEST DESCRIPTION

Data set........... A:127MW4R1.set
Data set title..... KYW-127-MW4 RUN#1

Knowns and Constants:
   No. of data points................. 52
   Radius of well casing.............. 0.083
   Radius of well..................... 0.334
   Aquifer saturated thickness........ 8.42
   Well screen length................. 10
   Static height of water in well..... 8.42
   Log(Re/Rw)......................... 2.46
   A, B, C............................  0.000,  0.000,  1.967

================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                     RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

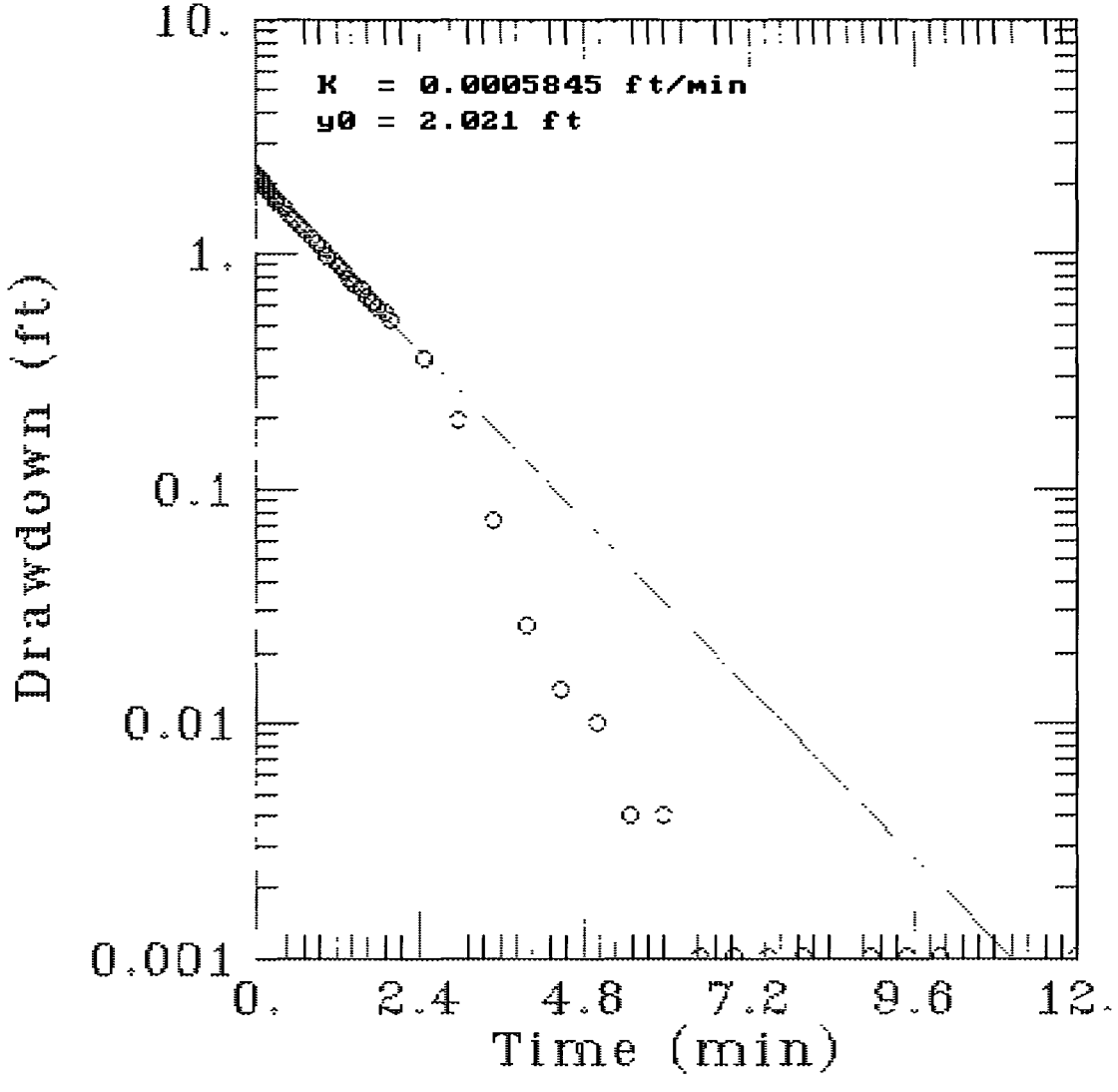
             Estimate          Std. Error
   K  =    4.1886E-003 +/-    2.5288E-004
   y0 =    5.7347E-001 +/-    1.7655E-002

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals............... 52
   Number of estimated parameters.... 2
   Degrees of freedom................ 50
   Residual mean..................... 0.01597
   Residual standard deviation....... 0.03629
```

KYW-127-MW4 RUN#2



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TEST DESCRIPTION

Data set........... A:127MW4R2.SET
Data set title..... KYW-127-MW4 RUN#2

Knowns and Constants:

No. of data points.................. 61
Radius of well casing............... 0.083
Radius of well...................... 0.334
Aquifer saturated thickness......... 8.42
Well screen length.................. 10
Static height of water in well...... 8.42
Log(Re/Rw).......................... 2.46
A, B, C............................. 0.000, 0.000, 1.967

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

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RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

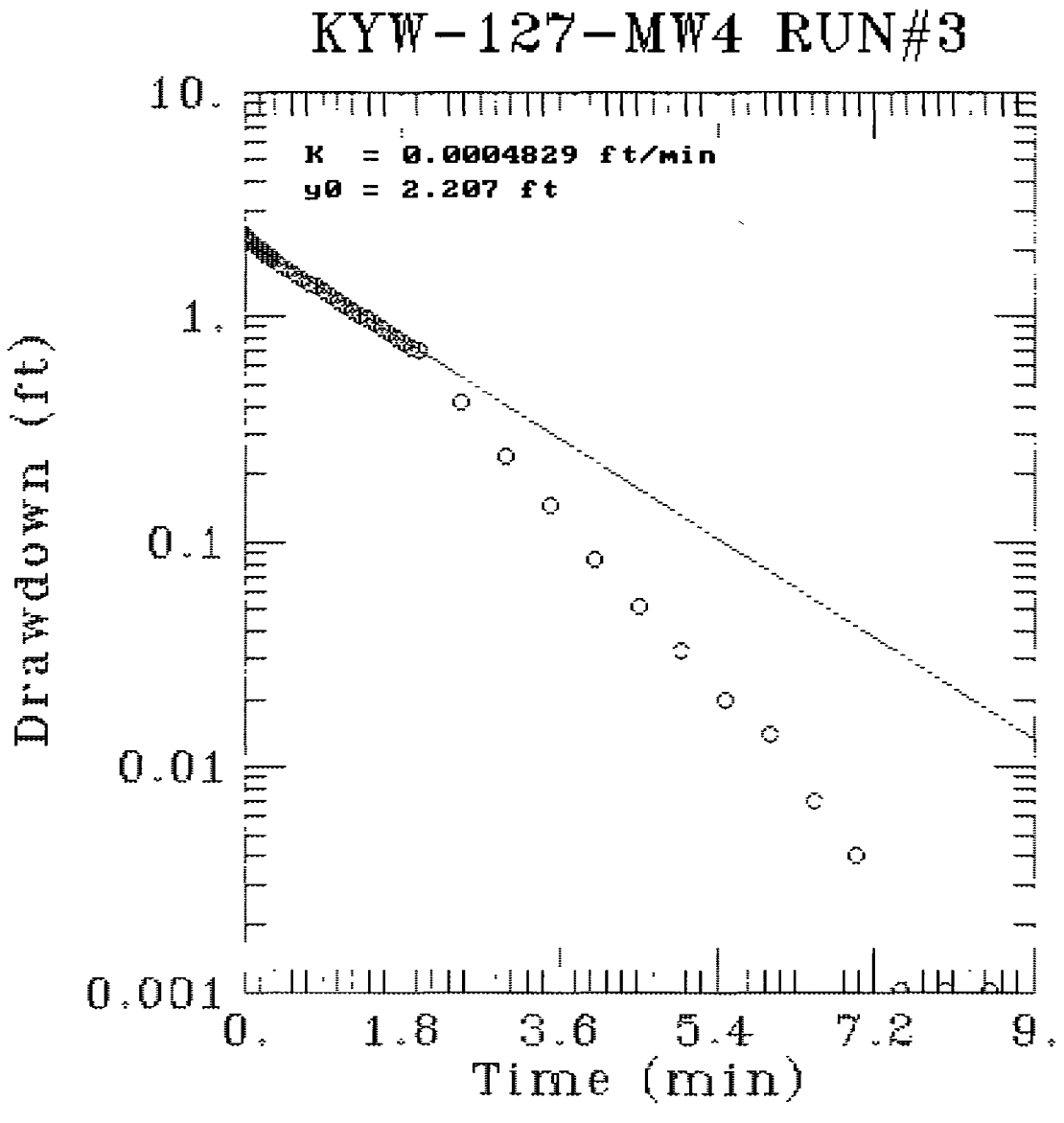
	Estimate
K =	7.4795E-004
y0 =	2.1809E+000

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

TYPE CURVE DATA

K = 5.84489E-004
y0 = 2.02064E+000

Time	Drawdown	Time	Drawdown	Time	Drawdown
0.000E+000	2.021E+000	1.200E+001	5.132E-004		



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TEST DESCRIPTION

Data set........... A:127MW4R3.SET
Data set title..... KYW-127-MW4 RUN#3

Knowns and Constants:
No. of data points.................. 58
Radius of well casing............... 0.083
Radius of well...................... 0.334
Aquifer saturated thickness......... 8.42
Well screen length.................. 10
Static height of water in well...... 8.42
Log(Re/Rw).......................... 2.46
A, B, C............................. 0.000, 0.000, 1.967

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

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RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	7.8092E-004
y0 =	2.1809E+000

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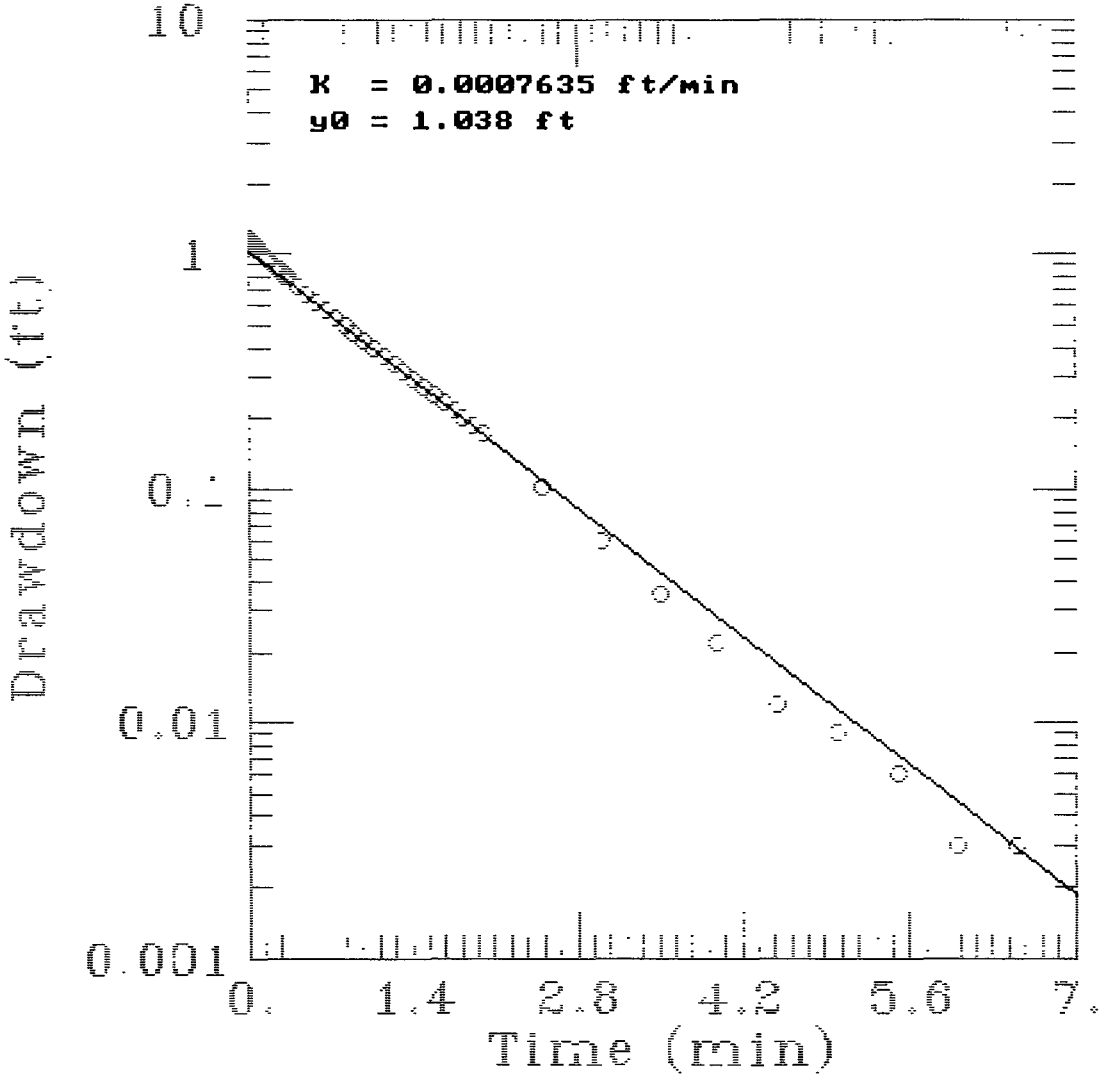
TYPE CURVE DATA

K = 4.82879E-004
y0 = 2.20746E+000

Time	Drawdown	Time	Drawdown	Time	Drawdown
0.000E+000	2.207E+000	9.000E+000	1.307E-002		

KYW-127-MW6 RUN#1



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TEST DESCRIPTION

Data set........... A:127MW6R1.SET
Data set title..... KYW-127-MW6 RUN#1

Knowns and Constants:
No. of data points.................. 54
Radius of well casing............... 0.083
Radius of well...................... 0.334
Aquifer saturated thickness......... 8.29
Well screen length.................. 10
Static height of water in well...... 8.29
Log(Re/Rw).......................... 2.45
A, B, C............................. 0.000, 0.000, 1.967

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

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RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	8.1230E-004
y0 =	0.0000E+000

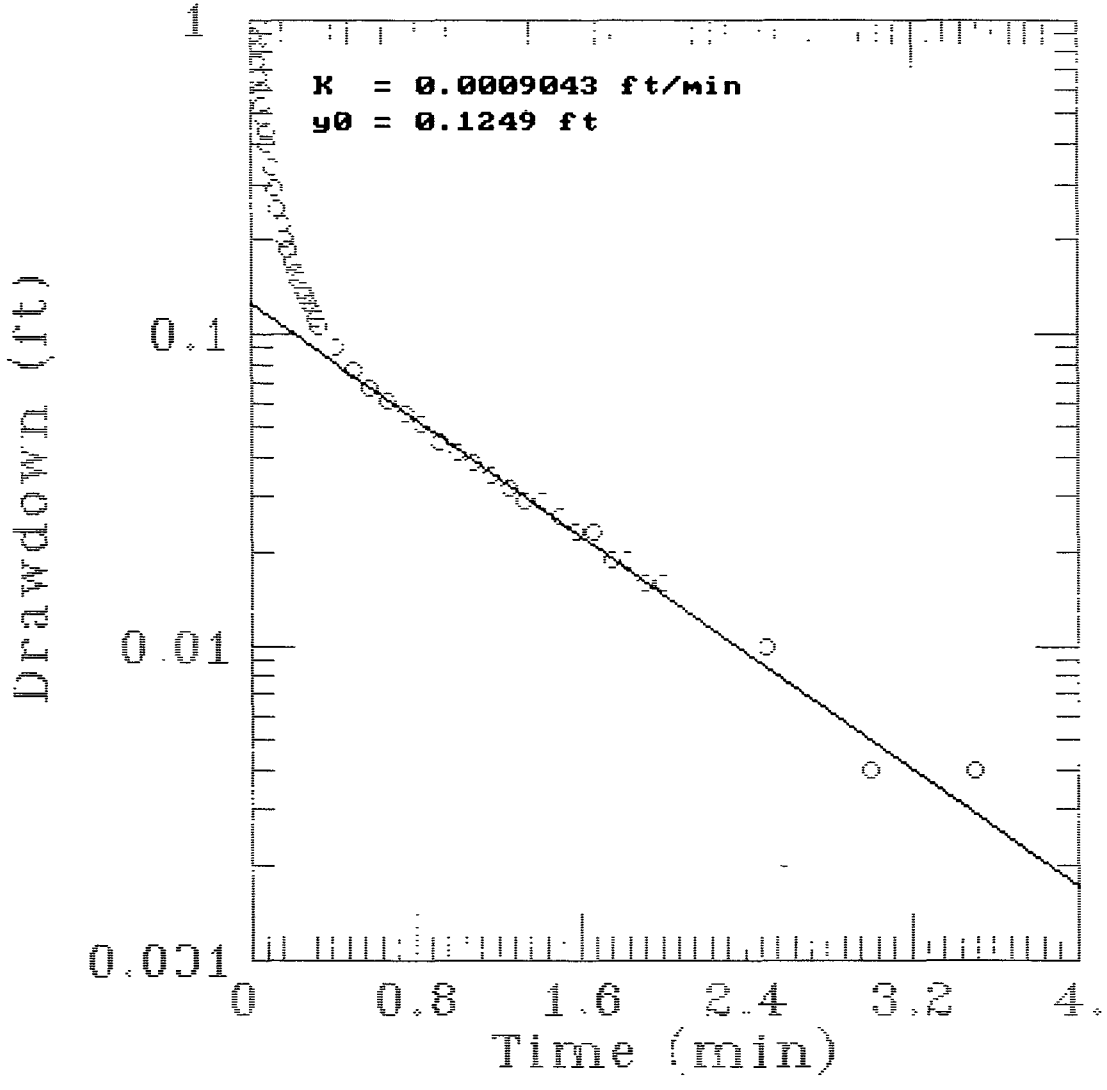
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

TYPE CURVE DATA

K = 7.63452E-004
y0 = 1.03850E+000

Time	Drawdown	Time	Drawdown	Time	Drawdown
0.000E+000	1.038E+000	7.000E+000	1.845E-003		

KYW-127-MW6 RUN#2



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TEST DESCRIPTION

Data set........... A:127MW6R2.SET
Data set title..... KYW-127-MW6 RUN#2

Knowns and Constants:

No. of data points.................. 48
Radius of well casing............... 0.083
Radius of well...................... 0.334
Aquifer saturated thickness......... 8.29
Well screen length.................. 10
Static height of water in well...... 8.29
Log(Re/Rw).......................... 2.45
A, B, C............................. 0.000, 0.000, 1.967

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

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RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	1.3017E-003
y0 =	-7.7451E+304

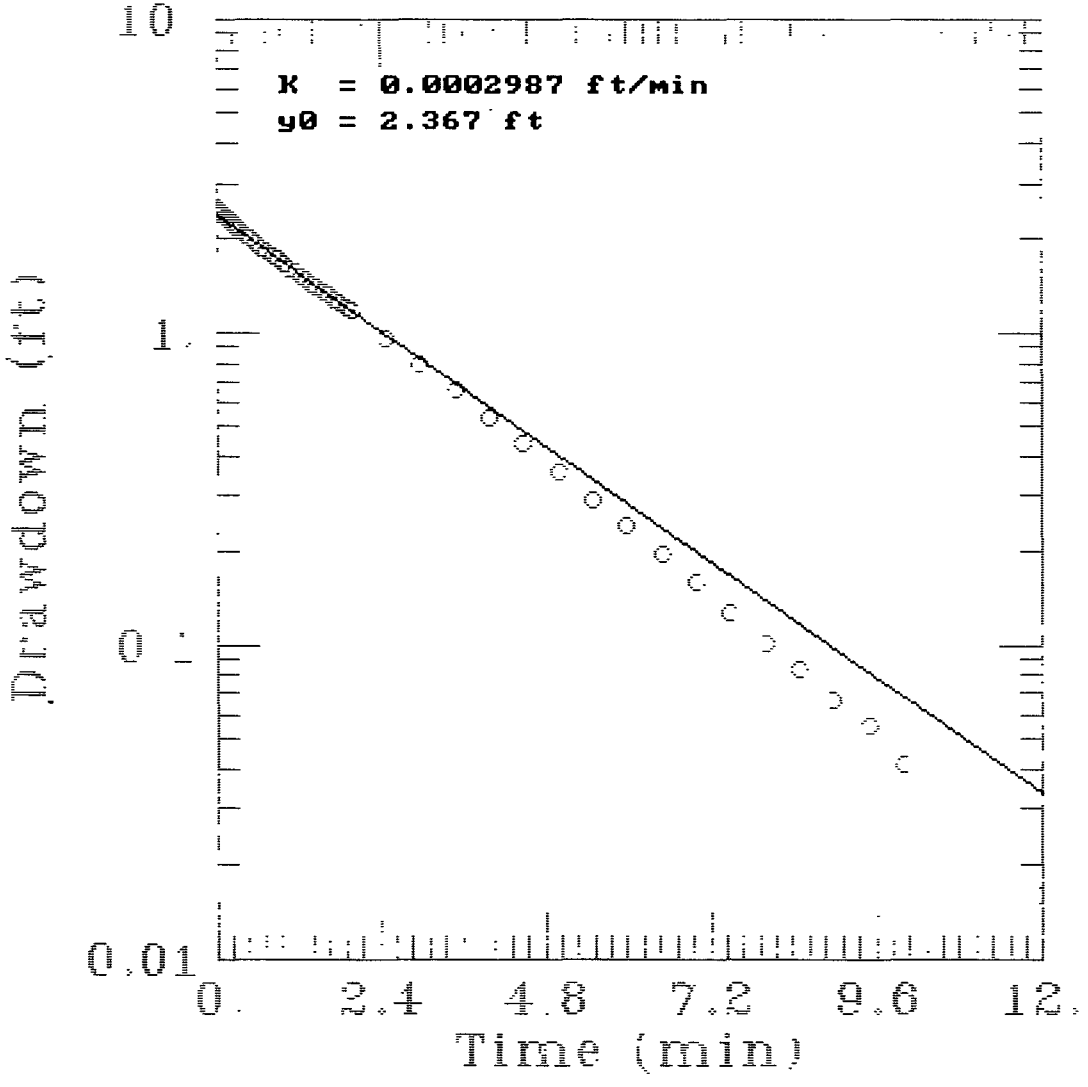
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

TYPE CURVE DATA

K = 9.04312E-004
y0 = 1.24902E-001

Time	Drawdown	Time	Drawdown	Time	Drawdown
0.000E+000	1.249E-001	4.000E+000	1.717E-003		

KYW-127-MW6 RUN#3



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Version 1.10

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TEST DESCRIPTION

Data set........... A:127MW6R3.SET
Data set title..... KYW-127-MW6 RUN#3

Knowns and Constants:
No. of data points.................. 62
Radius of well casing............... 0.083
Radius of well...................... 0.334
Aquifer saturated thickness......... 8.29
Well screen length.................. 10
Static height of water in well...... 8.29
Log(Re/Rw).......................... 2.45
A, B, C............................. 0.000, 0.000, 1.967

==

ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

==

RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

	Estimate
K =	3.3873E-004
y0 =	-7.7451E+304

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>

TYPE CURVE DATA

K = 2.98722E-004
y0 = 2.36728E+000

Time	Drawdown	Time	Drawdown	Time	Drawdown
0.000E+000	2.367E+000	1.200E+001	3.383E-002		

APPENDIX E

GROUNDWATER ANALYTICAL DATA