FINAL REPORT

INVESTIGATION OF FORMER NIKE MISSILE SITES FOR POTENTIAL TOXIC AND HAZARDOUS WASTE CONTAMINATION

[redacted]

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ATLANTA, GEORGIA

LEGS JOB NO. 601

March, 1986

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAACOM	U.S. Army Anti-Aircraft Command
ARADCOM	U.S. Army Air Defense Command
ASTM	American Society for Testing and Materials
CERCLA	Comprehersive Environmental Response, Compensation, and Liability Act
CFA	Continuous Flight Auger
COE	U.S. Army Corps of Engineers
CONAD	Continental Air Defense Command
CONUS	Continental United States
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
EPA (US)	United States Environmental Protection Agency
gal	Gallons
HSA	Hollow Stem Auger
ICBM	Intercontinental Ballistic Missile
IFC	Integrated Fire Control
IRP	Installation Restoration Program
lb	Pounds
ml	Milliliter
MR	Mud Rotary
NATO	North Atlantic Treaty Organization
NORAD	North American Air Defense Command
OSHA	Occupational Safety & Health Administration
OVA	Organic Vapor Analyzer
PDP	Preliminary Determination Phase
POL	Petroleum Oils & Lubricant (Barrels) for disposal
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SCBA	Self Contained Breathing Apparatus
VOA	Volatile Organic Analysis
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

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SECTION 1.0 - EXECUTIVE SUMMARY

As part of the Department of Defense's (DOD) Defense Environmental Restoration Program (DERP), this investigation was authorized to determine the potential for toxic or hazardous contamination applicable to all former NIKE Missile Sites located throughout the Continental United States. Phase I of this study provided for specific literature reviews and related data gathering functions to provide general information about potential NIKE site contamination. This report addresses these issues. A summary of the pertinent information is presented as follows:

1. NIKE Ajax and NIKE Hercules missiles were deployed by the United States Army throughout the Continental United States to protect major metropolitan areas and strategic military installations from aerial attack. The NIKE system was generally in place in the time frame encompassing the early 1950s to the mid 1970s.

2. A NIKE site typically consisted of two separate and distinct operating units. These included the Launcher Area and the Integrated Fire Control (IFC) Area. The Launcher Area was generally located on approximately 40-60 acres of land although each site could vary significantly in size and shape. The IFC Area, generally ranged in size from 10-50 acres. The barracks facilities were either incorporated as part of the Launcher Area or the IFC Area, or a third separate and distinct Facility Area was constructed.

3. Maintenance of the missile batteries in a combat ready status required the storage, handling and disposal of missile components as well as solvents, fuels, hydraulic fluids, paints, and other materials required for support functions. Normal operating practices at NIKE batteries in the conduct of these functions possibly resulted in

contamination of the subsurface soil and/or groundwater regime.

4. Virtually all of the information concerning the potential for contamination at NIKE Sites came from interpretation of Operating Manuals and resulting questions directed to past NIKE site operators and the general discussion with these operators which followed in the interview phase of this investigation.

5. Potential contamination source areas at NIKE Sites included:

LAUNCHER AREA

- Missile Assembly Drainage and Seepage Systems
- Diesel and Fuel Oil Storage Tanks
- Magazine Sump Seepage System
- Secluded Areas Adapted to Unofficial Dumping
- Warheading/Fueling Area Drainage Systems
- Motor Pool (when present)
- Septic Systems (when present)

INTEGRATED FIRE CONTROL (IFC) AREA

- Motor Pool (when present)
- Septics Systems (when present)
- Diesel, Fuel Oil, and Gasoline Storage Tanks
- Secluded Areas Adapted to Unofficial Dumping

Of these two Areas, the Launcher Area had the greater potential for contamination.

6. Operating practices producing a potential for contamination at NIKE Sites included:

LAUNCHER AREA

- Missile Assembly and Disassembly
- Missile Fueling and Warheading
- Missile Maintenance and Testing
- General Launcher and Magazine Maintenance

INTEGRATED FIRE CONTROL (IFC) AREA

- Fire Control Operations Maintenance
- Vehicle Maintenance

GENERAL OPERATIONS

- General Facilities Maintenance
- Utility Service
- Deactivation

7. The Master Contaminants List which consists of the potential contaminants of former NIKE Sites that should be investigated for the NIKE Preliminary Determination phase (Phase II of this investigation program) includes:

   - Benzene
   - Carbon Tetrachloride
   - Chromium
   - Petroleum Hydrocarbons
   - Lead
   - Perchlorethylene
   - Toluene
   - 1,1,1-Trichloroethane
   - 1,1,2-Trichloroethane
   - Trichloroethene

SECTION 2.0 - INTRODUCTION

The Department of the Defense (DOD), conducts a number of industrial processes and manufacturing operations that are similar to private industry. In the late 1970's, DOD became aware of the negative impacts of what were previously considered acceptable disposal practices of waste materials associated with these processes and operations. In response to that knowledge, programs were developed between 1975 and 1978 by each service component to identify and assess potential contamination on active military installations. Authority to address problems of other than active installations was lacking since funds could not be spent on sites not owned by DOD.

The passage of the 1984 Defense Appropriations Act corrected this problem. Specific language in the Act directed DOD to extend its efforts to include sites formerly used by DOD and broaden the definition of "hazard" to include structures and debris which were to be abandoned or had been abandoned upon termination of its military use.

The Act directed that the Secretary of Defense assume overall management of the program to assure consistent approach and adequate resource allocation. A Defense Environmental Restoration Account was established and provided the resources for the Defense Environmental Restoration Program (DERP). The work performed relative to this study falls within the jurisdiction of the DERP program.

The objective of this investigation addresses the potential for toxic or hazardous contamination applicable to all former NIKE Missile Sites located throughout the Continental United States (CONUS). Contamination includes hazardous or toxic substances formed in ground water, surface water and soil with contaminants specified by regulatory criteria. To fulfill this objective, the work elements described in the following paragraphs were performed in accordance with the provisions of our contract. Discussion of the manner in which each work element was conducted as well as how it is reported in this document is also presented.

1) **Obtain an updated list of the CONUS NIKE sites.** This list is presented in Appendix A in the form of individual site reports, entitled "NIKE Site Listing Forms", which describe pertinent known information about each site. This data was gathered during the summer of 1985 and is not considered current beyond that date. Most of the information came from site reports on file at the Corps of Engineers, Huntsville Division offices and from data presented by the Corps of Engineers District offices. The initial working list of CONUS NIKE sites came from the report "Historical Overview of the NIKE Missile System" reference 1, Appendix B-1.

2) **Identify the primary agencies involved with the command at the time of operations of the site and identify the responsibilities of the primary agencies involved, relative to the operations of various NIKE Missile systems.** This information was gathered through interviews with site operators and basically substantiated the information presented in reference 1. Section 4.0 of this report addresses this subject.

3) **Conduct an archive search to obtain copies of the active NIKE site operating procedures, technical manuals, training manuals and field manuals, and develop a summary of information relative to activities which may have caused contamination.** Contact was made with the NIKE Project Management Office at Redstone Arsenal for specific input regarding the manuals and procedures which would give information relative to activities which may have caused contamination. Specific manuals were recommended and have

been reviewed in the context of this investigation. This information is presented in Report Sections 6.0 and 7.0.

4) **Meet with three different previous NIKE Site operators and obtain information on site operating practices. Any information relative to site contamination shall be recorded.** This task was carried out with the assistance of the NIKE Project Management office at Redstone Arsenal and included a trip to Ft. Bliss, Texas where the interviews were conducted. The information gathered in this interview process has been incorporated into the basic findings and conclusions of this report.

5) **Review the four USATHAMA reports listed and make reference to the contamination or waste associated with the particular sites.** This review was conducted and information has been used compiling the results of this report. A significant amount of background information has been incorporated from reference 1 to permit proper understanding of the history and operation of the NIKE program.

6) **Determine the location of the "As-Built" drawings for all sites and specify their locations in the report.** Each of the Corps of Engineers District offices was contacted regarding the location of the "As-Built" drawings for NIKE sites under their jurisdiction. A few of the districts reported that "As-Built" drawings were on file at the District office that had jurisdiction over a particular site. In most cases however, the "As-Built" drawings cannot be located. Information regarding the location of the "As-Built" drawings is recorded on the NIKE Site Listing Form for each site given in Appendix A.

7) **Obtain and review the deactivation plans for the NIKE Systems and provide information concerning possible contamination.** Each of the Corps of Engineers District

offices as well as the Redstone Arsenal NIKE Project Management Office was contacted regarding the location of deactivation plans. In no case was it possible to locate any site specific deactivation plans. Two generic deactivation procedures documents were located at the Redstone Arsenal NIKE Project Management Office. These were reviewed for practices concerning possible contamination and the finding were incorporated in the general findings of this report. These documents are listed as part of the reference material.

8) **List substances that may act as possible sources of contamination, such as: solvents, starting fluid mixtures (UDMH), fuels, hydraulic fluids, paints, etc. The list should also include the contaminants from each source. Any substances associated with operations, maintenance or deactivation of the NIKE site should be addressed. The substances must have been used in quantities that justifies evaluation as a contamination source.** The findings of the data gathering process as outlined in paragraphs 1-7 led to the conclusion of the listed substances that may act as possible sources of contamination. The findings as determined by this investigative process are discussed in Section 8.0.

9) **Identify any disposal, maintenance or operating practices that may have caused contamination.** The data gathering process described above also provided information that responded to that requested by this contract task. The results are presented in Section 7.0.

10) **Survey the research information and identify potential contamination source areas within the general NIKE sites.** The data gathering process described above yielded the pertinent information. The results are presented in Section 6.0.

11) **Based on the data developed from tasks 1-10, develop a Generic Sampling and Analysis Plan conforming to the requirements of Contract Annex A. Further, a Quality Control and Quality Assurance (QA/QC) Plan shall be developed along with the Sampling and Analysis Plan.** The Generic Sampling and Analysis Plan and the Quality Control and Quality Assurance Plan as specified are presented in the Appendix C of this Report. As a corollary to the Sampling and Analysis Plan, a Generic Well Installation Plan has also been developed and is presented in Appendix D of this report.

12) **Prepare a Safety Plan that meets the requirements of Annex C of the contract.** The Generic Safety Plan as required is presented in Appendix E of this Report.

Work items (1) through (12) constitute Phase I of the NIKE missile site study of potential toxic or hazardous contamination, which is the subject of this report. Phase II constitutes a Sampling and Analysis field investigation of 10 Representative NIKE Sites which will be addressed in subsequent Reports.

Subsequent sections of this report give pertinent background data regarding the NIKE missile program identify potential contamination source areas within the general NIKE site, describe disposal, maintenance or operating practices that may have caused contamination, and present a list of substances that may have acted as possible sources of contamination including the contaminants that result from these sources.

SECTION 3.0 - NIKE PROGRAM BACKGROUND

The main source of background material regarding the history of the NIKE program was included in reference 1. Portions of this reference are summarized herein to provide proper background information regarding the NIKE program.

NIKE Ajax and NIKE Hercules missiles were deployed by the United States Army throughout the Continental United States to protect major metropolitan areas and strategic military installations from aerial attack. The NIKE system was generally in place in the time frame encompassing the early 1950s to the mid 1970s. Maintenance of the missile batteries in a combat ready status required the storage, handling and disposal of missile components as well as solvents, fuels, hydraulic fluids, paints, and other materials required for support functions.

Initial development studies began on the system right after the end of World War II, with the objective of forming an air defense system capable of engaging high speed maneuverable targets at greater ranges than the conventional artillery available at that time. The research and development program for the NIKE system became accelerated in the early 1950s with initial guided missiles becoming operational for the first time in 1954 when combat ready missiles (known as NIKE Ajax) were deployed. Conventional anti-aircraft gun units were outnumbered by NIKE Ajax units by December 1956, and the conversion to guided missiles was completed by mid 1958.

During the period of its operational life, the NIKE Ajax system remained essentially unchanged. However, a second generation NIKE system, to be named NIKE Hercules, was under development by the mid 1950s. NIKE Ajax batteries were similar in design and construction with all units having similar operational components. Minimal field changes were made during the operational life of the NIKE Ajax system. These were limited to minor equipment modifications to improve operational efficiency. Beginning in late 1958, selected NIKE Ajax batteries began conversion to the more advanced NIKE/Hercules system. However, it was not until early 1964, that the last NIKE Ajax battery was deactivated and the entire operational system deployed the NIKE Hercules missile. The primary role of the NIKE Hercules system was its ability to attack high speed, high-flying aircraft formations with a single nuclear warhead. Another significant advancement concerned the nature of the rocket fuels. The NIKE Ajax system used liquid fuels which were highly toxic and had to be handled with extreme care. The NIKE Hercules missiles made more use of solid fuel which significantly simplified the fueling and maintenance operations of the missile system. The initial design guidelines for the NIKE Hercules missile provided for maximum use of proven components from the NIKE Ajax program and stipulated that both missiles must be compatible with all sets of ground and launching equipment. Therefore, a minimal amount of modification of the battery units was required to convert from the NIKE Ajax to the NIKE/Hercules system.

During its term of service in the field, the NIKE Hercules system underwent numerous design modifications. As originally conceived, the system was known as basic Hercules. However, several improvement programs were subsequently implemented to keep the system up to date. The design modifications primarily provided improved target tracking, guidance, and interception capabilities by modifying or replacing radar and electronic equipment. However, these modifications to the missile system did not produce any significant change in the battery configuration.

Not all Hercules batteries were retro-fitted for the new equipment , because of budget limitations. Guidelines provided for retro-fitting of certain batteries within any particular defense area, based on the number of batteries located in that defense area. Hence, the field deployment within a single defense area in the early 1960s may have included Ajax, basic Hercules, and improved Hercules batteries.

NIKE/Zeus, the third generation missile of the NIKE program, was the first missile developed in the United States that was designed to defend against Intercontinental Ballistic Missiles (ICBM). However, NIKE Zeus was never approved for production or deployment as a tactical system.

In 1962, the Army began transferring operation of certain NIKE batteries to National Guard Units. Shortly thereafter, deactivation of NIKE batteries began. By 1970, the Army had deactivated most CONUS NIKE sites. National Guard Units continued to maintain a few sites until the late 1970s. Some NIKE equipment is still retained in Ft. Bliss for the purpose of training troops from other North Atlantic Treaty Organization (NATO) countries that still incorporate NIKE missiles in their defense programs.

SECTION 4.0 - NIKE PROGRAM MILITARY ORGANIZATION

4.1 NATIONAL AIR DEFENSE ORGANIZATION

Background information for this Section was taken directly from reference 1 and was substantiated during the site operator interviews, with minor modifications. The reference states that the development of a missile-based air defense system (NIKE) was paralleled by changes in command structure in the defense organization, beginning in July 1950. At that time the Army placed all artillery units with continental air defense missions under the newly organized U.S. Army Anti-Aircraft Command (ARAACOM) located at Ent Air Force Base in Colorado Springs, Colorado. The installation of NIKE Ajax batteries beginning in 1953, led to further re-organization of the Continental Air Defense structure and the Army's Anti-Aircraft missions and organization. On September 1, 1954, ARAACOM and corresponding elements in the U.S. Air Force and the U.S. Navy were combined to form the Continental Air Defense Command (CONAD) at Colorado Springs under the direction of the Joint Chiefs of Staff. In 1957, the Army's air defense responsibility within CONAD was defined as point air defense by missiles fired from the ground to aerial targets not more than 100 miles away. Point defense was to include "Geographical areas, cities, and vital installations that could be defended by missile units which received their guidance information from radars near launching site" and also was to include the responsibility of a ground commander for air protection of his forces. To represent this expanded, all missile role more clearly, ARAACOM was re-designated the U.S. Army Air Defense Command (ARADCOM) on March 21, 1957.

Further development on a national scale occurred in September 1957, when the North American Air Defense Command (NORAD) was formed to combine air defense capabilities of Canada and United

States under a one Commander in Chief, who also headed CONAD. Like CONAD, NORAD elements in the United Stated report directly to the Joint Chiefs of Staff. All Army ARADCOM units were placed under the operational control of NORAD. ARADCOM continued in this basic configuration until 1975, at which time the NIKE missile program had essentially been disbanded in CONUS.

4.2 NIKE SYSTEM ORGANIZATION

The basic operational un_t of a NIKE site was the Battery. The Battery was commanded by an Army Captain. On a specific site the Battery was sub-divided into six elements. These are listed below, followed by a brief mission statement:

1) Headquarters Section: The headquarters section was responsible for the operational and administrative control of personnel and equipment.

2) Communications Section: The communications section was responsible for installing and maintaining non-commercial communication nets and operating the commercial communication nets within the Battery.

3) Fire Control Platoon: The fire control platoon was responsible for the operation and maintenance of fire control equipment in the Integrated Fire Control (IFC) area.

4) Launching Platoon: The launching platoon had administrative control over one launching platoon headquarters and three launching sections, which are described in the next paragraphs.

5) Launching Platoon Headquarters: The launching platoon headquarters was responsible for the operation and training of three launching sections. It contained personnel who assembled, tested and performed organizational maintenance

on the NIKE missile and maintained the rounds at the launching section.

6) Launching Section: The three launching sections were responsible for the preparation of the missile and booster for firing after they were delivered to the launching section from the assembly and test area. In addition, they performed the routine non-techaical tests, checks, adjustments, and organizational maintenance.

The next organizational unit above the Battery was the Battalion. Generally, there were four Batteries in each Battalion. The Battalion was typically commanded by a Lieutenant Colonel. The Battalion generally consisted of a headquarters and headquarters Battery, four Firing Batteries (described above), and a Medical Section. In addition, any motorpool maintenance activities other than the most routine, were performed at the Battalion level.

The Battalion headquarters and headquarters Battery comprised the following 7 elements:

1) Battery Headquarters
2) Battalion Administration Supply Section
3) Operation and Intelligence Section
4) Battalion Motor and Maintenance Section
5) Communications Section
6) Radar Section
7) Assembly and Service Section

The Assembly and Service Section was a team of technical experts who supervised and assisted in the assembly, testing and performance of organizational maintenance on missiles and boosters.

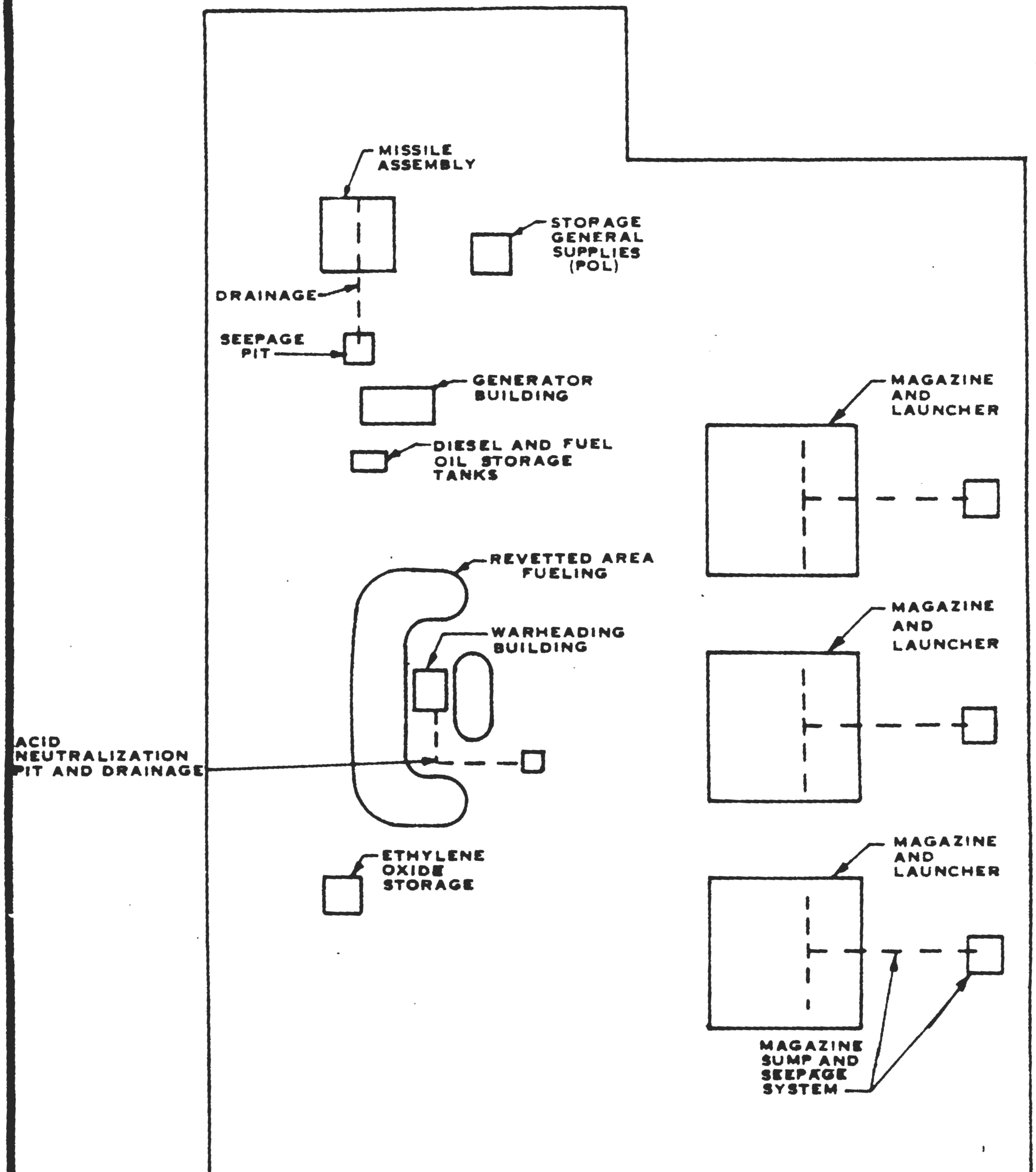
The organizational unit above the Battalion level consisted of either a Group or a Brigade. This level was usually commanded by either a Colonel or a Brigadier General. A Group had only NIKE Battalions reporting to it, whereas a Brigade could have other military entities reporting to it besides NIKE Battalions. The Group or Brigade level was organized into United States Regions. The Region was usually commanded by a Brigadier General or a Major General. The Region could have a number of different types of military units reporting to it other than NIKE Groups. As the number of United States military units increased or decreased, the number of regions also changed. The maximum number of regions that constituted the division of the United States military organization was six. The Regions reported to ARADCOM at Ent Air Force Base in Colorado. This organizational structure basically functioned during the period of the maximum activity of the NIKE program during the mid 1960s. As was previously stated, ARADCOM was disbanded in 1975.

SECTION 5.0 - NIKE BATTERY DESCRIPTION

5.1 BATTERY LAYOUT

A NIKE site typically consisted of two separate and distinct operating units. These included the Launcher Area and the Integrated Fire Control (IFC) Area. The Launcher Area was generally located on approximately 40-60 acres of land although each site could vary significantly in size and shape. The IFC Area, generally ranged in size from 10-50 acres. The Barracks facilities were either incorporated as part of the Launcher Area or the IFC Area, or a third separate and distinct Facility Area was constructed. The Launcher Area and the IFC Area would generally be located 1-2 miles apart to facilitate necessary distance and equipment restrictions that involved the successful interaction of the two Areas.

The layout of structures within each Area appears to have been site specific, although each site appeared to have certain structures in common. Figures 1 and 2 illustrate a generalized NIKE Launcher Area and a generalized NIKE IFC Area. These Figures illustrate the structural units that appeared to be common to most Batteries although their general location to each other could vary significantly. For the Launcher Area, the key structural units include the missile assembly building, general storage and supply buildings, the generator building, the warhead building, and the three magazine (Missile Storage)/launch units. The IFC Area generally included the radar units, the generator building, general storage and supply buildings, and in most cases, the motorpool. At some sites, the motorpool could have been located at the Launcher Area. In many cases, the IFC Area also had facilities for administration and barracks. Generally, the administration and barracks areas were located at the IFC Area, however, on occasion they were located at the Launcher Area or on a separate parcel of land. These sites also generally



GENERALIZED NIKE SITE

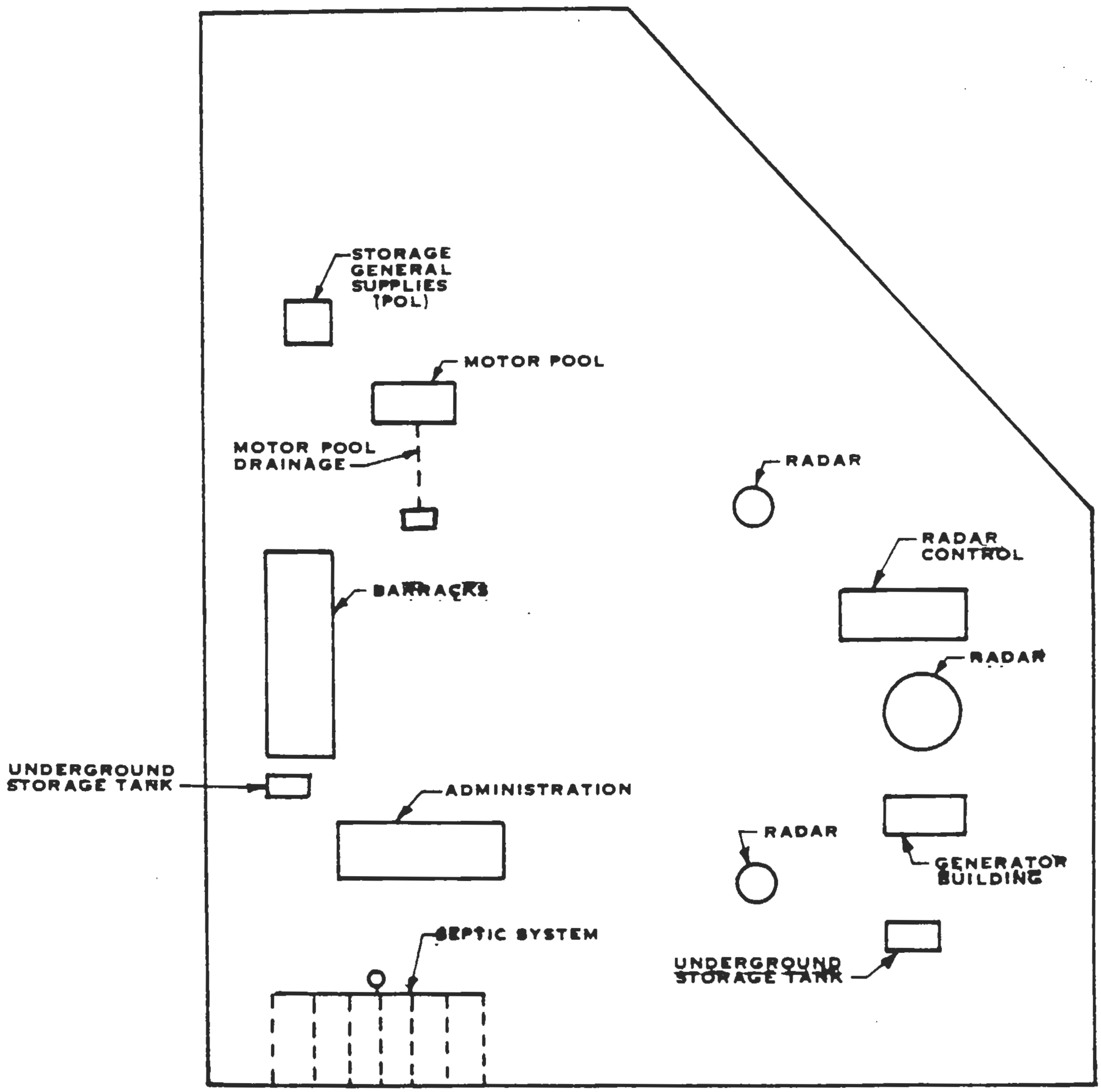
CONTRACT DACA 87-85-0104

LAW ENVIRONMENTAL SERVICES

MARIETTA, GEORGIA

LAUNCHER AREA

FIGURE



GENERALIZED NIKE SITE CONTRACT DACA [redacted]	LAW ENVIRONMENTAL SERVICES MARI[redacted]ORGIA	INTERGRATED FIRE CONTROL AREA

FIGURE [illegible]

included a number of forms of waste disposal including sump and draining systems, seepage pits, septic tanks with infiltration wells for liquid waste disposal, and occasionally on-site landfills.

5.2 GENERAL UNIT OPERATIONS

5.2.1 Launcher Area

The Launcher Area of a NIKE site was the location where the missiles and warheads were assembled, maintained, and prepared for firing. The missiles arrived at the site disassembled into 13 specific components. All operations necessary to make the missiles flight ready were then conducted in specific locations in the Launcher Area. These operations as they applied to contamination are discussed in Sections 6.0 and 7.0. In general, routine maintenance and checking procedures were performed on the missile at the Launcher Area. However, on a periodic basis missiles were returned to the Battalion support shop for more detailed maintenance and service checking. It is estimated that approximately 30 missiles per year were sent from the Battery Launch Area to the Battalion support shop. It was also common practice to randomly select certain missiles to be returned to one of the three national Depot areas for more complete maintenance and service checking operations. The national Depots were located at Letterkenny, Pennsylvania; Tooele, Utah; and Pueblo, Colorado.

Approximately 10 missiles per year were sent from a particular Battalion to Depot. Any shipping of the missile required it to be totally disassembled into its 13 component parts, packed in its original crates, and shipped. This was done at the Battery missile assembly building. It was also routine practice for the personnel of a particular Battery to be sent to McGregor Range in southern New Mexico for test firing practice, about once a year.

When this occurred, the radar units were disassembled at the Battery location for major maintenance and service checking.

5.2.2 Integrated Fire Control (IFC) Area

The IFC Area at a site contained all the radar, guidance, electronic, and communications equipment needed to identify incoming targets, launch missiles, and direct missiles in flight. These operations as they applied to contamination are discussed in Sections 6.0 and 7.0.

SECTION 6.0 - POTENTIAL CONTAMINATION SOURCE AREAS

Because of the nature of site operations, several individual source areas exist for potential contamination on former NIKE sites. Some source areas will be fairly consistent in the type and degree of contamination they present, whereas other sources will reflect site-specific variation.

Generalized site diagrams are presented in Figures 1 and 2. The intent of these Figures is primarily to indicate the major structural units for reference to areas that could have resulted in waste. As previously stated, the location of these units on any given site varied with the terrain and the general arrangement of facilities.

6.1 GENERAL - WASTE FLUID DISPOSAL

Probably the most significant general practice that occurred on site that could lead to contamination was the method of dealing with waste fluids. Standard operating practices dictated that waste fluids were to be accumulated in POL (Petroleum, Oils, Lubricants) Barrels which were periodically transported to official dumps. However waste fluids were reported to have been disposed of directly to the soil surface on occasion, rather than be transported to POL Barrels, resulting in localized contamination. The POL Barrel contents were also reported to have been occasionally dumped in a random "Unofficial" manner, creating concentrations of waste material in the soil both on-site or off-site. Locations of such dumps are predictable only by general site characteristics. This practice was discussed at length in the interviews and will be discussed further in this report relative to specific site units.

Specific site units that could have resulted in waste within the general vicinity of that unit are described in the next sections.

6.2 LAUNCHER AREA

Within the Launcher Area, three or four unit locations can be expected to have the highest probability of contamination. They were the following:

- Missile Assembly Drainage and Seepage Systems
- Diesel and Fuel Oil Storage Tanks
- Magazine Sump Seepage System
- Secluded Areas Adapted to Unofficial Dumping

Three additional areas present some possibility of contamination, however, to a less significant extent.

- Warheading/Fueling Area Drainage Systems
- Motorpool (when present)
- Septic Systems (when present)

6.2.1 Missile Assembly Drainage and Seepage Systems

The missile assembly building operations involved the use of various solvents, anticorrosion products, and paints as the missile was assembled and disassembled. The building was equipped with a full-length drainage system. Spilled or waste materials could be washed or dumped into this drainage system.

The drainage in most cases was a gravity-fed system. Waste materials were washed out of the building and into a small seepage system consisting of perforated tile or a seepage pit. The construction of the seepage system was highly variable and reflects features of the local terrain and soils. Porous soils would require a less elaborate system, since they would readily facilitate drainage. Pits were excavated and filled with gravel or other coarse fill. Seepage pits would tend to concentrate contaminants, when they were in use. It is also a possibility that seepage systems were abandoned and replaced on sites with long operating histories. Therefore, multiple pits could be present in the vicinity of each other.

6.2.2 Diesel and Fuel Oil Storage Tanks

A number of generators were reportedly used on NIKE sites and storage of diesel fuel was considerable. Tanks were also used to store fuel oil for heating purposes. These tanks were probably steel, but this could not be documented. It is probable that several tanks were present at each site, holding up to 5000 gallons each.

Tanks were usually buried underground. They probably leaked hydrocarbons to some degree into the surrounding soil, due to leakage at connections and possible spillage during transfer operations. Upon deactivation of the NIKE site, some quantities of fuel were abandoned on-site. In many cases, the tanks were never drained. It is now known that there is a high probability of tank deterioration and consequent leakage over time. According to industry standards, underground storage tanks have a working life of 10 to 15 years, and today, most of these ta have probably begun leaking because of corrosion. Under the U.S. Environmental Protection Agency program, leaking undergr storage tanks (LUST) are considered a priority hazardous wa problem. Thus, buried tanks could present an existing proble

6.2.3 Magazine Sump Seepage Systems

Within the typical NIKE magazine, a floor drainage system permitted waste materials to be washed to a central sump located under the missile elevator shaft. This sump was equipped with a pump to deliver water and waste out of the magazine and into a seepage system. Solvents, paints, and hydraulic fluid were routinely washed to the sump.

As with the assembly building seepage system, this probably entailed drainage tiles and/or seepage pits. The volume of waste material handled by the magazine sump was probably greater than that of the assembly building, and seepage pits were more likely to be in use. The arrangement of the seepage system varied with the terrain and the arrangement of the magazines and launcher sections. It is also possible that on sites with steep terrain, sumps were simply pumped to a ravine or other watercourse.

6.2.4 Secluded Areas Adapted to "Unofficial" Dumping

Dumping of various wastes was reported as common at NIKE sites. The primary factor affecting the incidence of dumping was convenience. Certain authorized disposal routes were available to NIKE sites. However, utilization of these disposal routes varied from site to site. Solid waste could be delivered to municipal landfills, and the Army POL service was responsible for removing waste solvents, oils, and paints. When the landfill was not convenient or the POL was irregular about their pick-up, other methods were used to dispose of the waste. Rural sites were particularly prone to "unofficial" dumping. Dumping reportedly occurred both on-site and off-site. On-site dumps were secluded locations which would evade the attention of inspecting military officers. Lakes, ponds, swamps, and ravines were suited to this purpose. Off-site dumps could have made use of virtually any nearby ravine or water course. It was reported during the site operator interviews that "unofficial" dumping, including off-site locations was virtually a daily practice at some rural Battery locations. There was also use of "unofficial" dumps as well as public landfills at deactivation, as was learned in the site operator interviews.

6.2.5 Warheading/Fueling Area Drainage System

The potential for contamination in this area is considered to be less than that found in other areas. Liquid fuels were rarely spilled in quantities. The IRFNA (nitric acid), UDMH (dimethyl hydrazine), and ethylene oxide were hazardous, volatile materials and were handled very carefully. It was very rare that quantities of these materials escaped accidentally. No persistent contamination would result from the spillage or leakage, due to the extreme reactivity of each.

Battery electrolyte was reportedly discarded in this area as well. Modest amounts of lead may have been introduced as a result of this operation. However, it is likely that other sources of lead, such as paint, were of much greater magnitude. Sulfates and nitrates in the warheading/fueling area would be insignificant in the concentrations at which they would occur.

6.2.6 Motor Pool

NIKE Site motor pools were not extensive. Most motor pool operations were performed at the Battalion level. However, some minor contamination by solvents, fuels, and lubricants could have occurred. Motor pools as a source of contamination are discussed in greater detail under Section 6.3.1.

6.2.7 Septic Systems

When barracks were sited on the launcher area, a septic system of significant size was required. Urban and suburban NIKE sites tied into municipal wastewater systems. However rural sites required a septic tank and leaching system. Barracks were more often sited at the IFC area, along with the battery administration and other facilities. Septic systems as a source of contamination are discussed in greater detail under Section 6.3.2.

6.3 INTEGRATED FIRE CONTROL (IFC) AREA

The IFC Area was less prone to chemical contamination than the Launcher Area. The diversity of chemicals was smaller, and the primary mission of the IFC radar operation, did not require significant chemical use. The main units of concern with regard to contamination at the IFC area were the following:

- Motor Pool
- Septic System
- Diesel, Fuel Oil, and Gasoline Storage Tanks
- Secluded Areas Adapted to Unofficial Dumping (Refer to discussion under Launch Control Area, Section 6.2.4)

6.3.1 Motor Pool

NIKE site motor pools did not involve extensive operations. Significant motor pool operations were performed at the Battalion location. However, some minor contamination by solvents, fuels, and lubricants could have occurred. In some cases, motor pools were equipped with floor drains and a drainage system similar to that of the assembly building in the Launcher Area. Thus, contamination by hydrocarbons and chlorinated hydrocarbon materials possibly occurred in the immediate vicinity of the motor pool.

6.3.2 Septic Systems

On rural sites, on-site waste water systems composed of septic tanks, distribution boxes, and leaching areas were used. The major function of these systems was handling sewage. However, on occasion, they may have been used to dispose of chemical products, and to that extent they present a potential source of contamination. In urban situations where sewage services were provided by the municipality, this source of contamination would not be present.

The materials most likely to have been disposed of via septic systems are paints and general domestic cleaning products. Of these, paints present the only threat of significant contamination in the form of oils and metallic pigments. Contamination in this instance would be spread over the area of the leaching field and within the septic tank.

Leaching fields vary in size according to the number of people using the facility and the type of soil at the site. Certain soil characteristics require much larger fields than others, depending on their ability to purify sewage product. On NIKE sites that were manned for many years, it is also likely that septic systems were occasionally replaced.

6.3.3 Diesel, Fuel Oil, and Gasoline Storage Tanks

Fuel storage tanks pose the greatest potential for contamination at the IFC areas. Tanks were present for diesel powered generators and trucks, heating oil, and gasoline for vehicles. As with the Launcher Area, large capacity diesel tanks served emergency power generators. Radar operations required considerable electricity and these generators were fairly large. Generators were routinely tested and leakage and spillage of fuel was common.

On most sites, depending on climatic condition, large volumes of fuel oil were consumed for heating purposes. Barracks and administration facilities were medium sized buildings capable of using thousands of gallons of fuel annually. Other facilities were also heated. Separate mess halls and recreational facilities were often present.

Some gasoline was stored at NIKE site motor pools, although not in quantities as extensive as those used for heating and generator operation.

As discussed earlier, underground storage tanks were reported to have leaked during NIKE site operations, however a greater source of possible contamination was material remaining in the tanks after deactivation. In many cases, fuels were not removed at the time of deactivation, and over a period of time, the likelihood of leaks from these tanks grows significantly. In all probability, most underground tanks at NIKE sites have begun to leak due to deterioration of the tanks.

SECTION 7.0 - POTENTIAL OPERATIONS PRODUCING CONTAMINATION

Virtually all chemical use at NIKE sites posed some potential for contamination. However, those chemicals used as missile fuels were controlled more strictly than maintenance and other operating materials because they were known to be toxic. In many cases, the missile fuels and igniters are strong oxidizers or reducers, and even incidental releases of them would not result in persistent contamination because of their reactivity. Other NIKE operations, including missile and launcher hydraulics, and maintenance operations, had considerably greater potential for causing contamination.

The following list of operating practices covers all major chemical uses that could potentially result in site contamination. The list is followed by a discussion of each operation. These discussions include mention of the chemicals and materials involved, as well as consideration of all factors affecting the potential for contamination.

Launcher Area

1) Missile Assembly and Disassembly
2) Missile Fueling and Warheading
3) Missile Maintenance and Testing
4) General Launcher and Magazine Maintenance

IFC Area

5) Fire Control Operations Maintenance
6) Vehicle Maintenance

General Operations

7) General Facilities Maintenance
8) Utility Service
9) Deactivation

7.1 LAUNCHER AREA

7.1.1 Missile Assembly and Disassembly

Missile assembly at NIKE sites was conducted in an assembly building located in the Launcher Area. All missile components were shipped to the sites in metal canisters and wooden fin crates. Minor chemical use occurred during assembly to remove anti-corrosion compounds, and lubricate and seal various parts. In the early phases of the NIKE program, some sanding and grinding of missile parts were conducted to repair defects. However, these operations were abandoned later in the program and defective parts were returned to the battalion or depot for repair, or return to the manufacturer.

Some painting was also conducted in the assembly building. This was done on an as-needed basis, and battalion commanders could choose to have missiles painted with optional camouflage.

Solvents used for missile preparation and cleaning included petroleum distillates (Stoddard Solvent, etc.), chlorinated solvents, and small use of alcohols. Waste solvent could be saved for POL Turn-In or, perhaps more often, was washed into drains that had a surface leaching system connected. Large quantities of certain solvents would evaporate during use. This particularly applies to the chlorinated solvents, such as carbon tetrachloride. The effects of surface leaching systems on contamination, depends greatly on the depth of the system, soil types, and local climate. Arid, sandy environments encourage further evaporation and rapid leaching of unevaporated materials. Finer grained soils (clays or silts) with routine rainfall discourage evaporation and decelerate leaching of some solvents.

Lubricants, sealants and paints are less adapted to disposal by drainage systems, although this was probably practiced for small quantities of left-over or waste material. Cans of waste and left-over material were dumped as solid waste which was delivered to local landfills. Rural sites may have frequently used unofficial dumps for disposal of these materials.

7.1.2 Missile Fueling and Warheading

Missile fueling and warheading was conducted in a revetted area separate from the assembly building. During the early period of the NIKE program, when conventional warheads were in service, this area was open. With the deployment of nuclear warheads, a Warheading Building was constructed and used for these operations.

In this area, missiles were fueled with the various materials and warheading of the missile was accomplished. The electrical batteries were installed here, as well as certain other delicate structural maintenance. Service and filling of the missile Accessory Power Supply was often conducted in this area as well.

Fueling with unsymmetrical dimethylhydrazine (UDMH), inhibited red fuming nitric acid (IRFNA), aniline, furfuryl alcohol, and ethylene oxide required care and presented fire and personnel safety hazards. Their use was governed by fairly strict protocol. Turn-In to depot for official disposal, as a mens of recycling to maintain fresh fuel on site, was probably strictly practiced. Environmental contamination was probably limited to incidental releases. With the exception of aniline and furfuryl alcohol, these materials were all reactive, and would dissipate rapidly in soil. Resulting compounds in most cases would be of low toxicity (nitrate, carbon dioxide, water, and ammonia). Reaction of UDMH and IRFNA could generate nitrosamine compounds. However, the likelihood of this occurring because of safety precautions, was very remote.

Ethylene oxide was used as a fuel for the Accessory Power Supply (APS) on the missile. It was maintained and used to test the system periodically. Ethylene oxide was routinely disposed of on-site via burning or dilution with water and subsequent surface dumping. As mentioned, ethylene oxide was used in moderate quantities and is reactive. Thus, there is virtually no possibility of persistent contamination.

As far as other fuels were concerned, the primary propellants were either hydrocarbons such as JP-4, or solid materials. JP-4 was used in the sustainer stage of the Ajax missiles and leakage could present some potential for contamination. All deployed Hercules missiles utilized sealed solid propellants with essentially no potential for release.

The fueling/warheading area had acid neutralization pits and general surface drainage. Spilled material occurring during "top-off" of fuel tanks was washed into the drainage system. Spilled battery electrolyte would also cause some light contamination from lead ions in the solution.

7.1.3 Missile Maintenance and Testing

Missile maintenance was conducted in four locations: the magazine, above ground at the launcher, the fueling area, and the assembly building. Refer to Figure 1 for the general location of these units. Where the maintenance took place depended on the specific operation. Simple procedures not involving the fuels or warhead or related electronics could be handled in the magazine. Other procedures required that the missile be taken above ground or to the fueling area. Major structural repairs required that the missile be defueled and returned to the assembly building.

Maintenance or repair of corrosion or hydraulic problems were most common. Certain missile parts were composed of magnesium or magnesium alloys and were very subject to corrosion. Hydraulic systems needed frequent checks and leakage was not uncommon.

Removal of corrosion from metal parts was conducted with at least three types of cleaners. Phosphoric acid in alcohol solution was used for aluminum parts, and alodine powder was used in water for certain minor cleaning. Most significant was the use of chromates in the form of chromium trioxide and sodium dichromate. Chromium trioxide is a solid material available in 5 pound containers. This was dissolved in water and used to wash magnesium and steel. Sodium dichromate is also a solid, but was dissolved in acids to form a pickling solution. Metal parts were dipped in this solution. These chromates may have been used in quantities large enough to cause contamination. Chromates are heavy metals, highly toxic, and in some cases are carcinogenic. Solutions used for decorrosion were undoubtedly washed into sumps and allowed to leach into the soil. It is also possible that significant dumping of chromium trioxide may have occurred during deactivation. This was discussed in the interviews.

Cleaning solvents were also used in missile maintenance. General cleaning and degreasing used Stoddard-type solvents (petroleum distillate), carbon tetrachloride, trichloroethane(s), perchlorethene, and trichloroethene, with minor use of alcohol and acetone. Chlorinated solvents are preferred degreasers and were heavily used. Solvents supplied by the depot were sometimes substituted and available excess quantities of certain solvents may have encouraged their use. Inventories of old solvents continued to be delivered to NIKE sites after the solvent was eliminated from military procurement. Perchlorethene was used on NIKE sites, but was previously unreported. This was disclosed in the interviews.

Painting of missile components also involved the use of chromium and another priority pollutant, lead. Zinc chromate paint was used to prime magnesium parts subsequent to cleaning. Lead-based paint was used for steel. Much of the paint was consumed. However, wastes resulted from the removal of old paint and unused paint remaining in cans. Paint is not well suited to drainage disposal, however, it is likely that some was eliminated in this manner. More often, leftover paint was disposed of via POL collection or "solid" waste dumping. Dumping may have been practiced on-site or off-site in unofficial dumps, or else community landfills may have been used.

Heavy metal contamination from paints may be a problem on NIKE sites. However, mobility in ground water is limited by the paint vehicle and the solubility of the metal ion. While hexavalent chrome from chromium trioxide is soluble, lead and chrome in paints is much less soluble. This somewhat decreases the probability of finding these metals in ground water samples even when they are present in soils.

Missile hydraulic fluid was replaced on a regular basis, and leakage, particularly of Ajax systems, was common. Used fluid that was drained from the missile may have been wasted to the sump, returned to POL, or dumped. Leakage was usually washed to the drainage sump. Unused hydraulic fluid also was disposed of, because once a can of fluid was opened, it was used immediately or disposed.

Aircraft turbine fluid was used for lubricating gears in the Missile Accessory Power Supply system. This fluid was probably synthetic tricresyl phosphate, which is a moderately toxic material. This was used in comparatively small quantities, however, some fluid probably did contaminate NIKE sites.

Hydraulic fluids and paints are composed primarily of petroleum oils. In instances where these were disposed of on-site, persistent contamination would occur.

The Accessory Power Supply and Hydraulic Pumping Unit provided critical power for control functions during the flight of a missile. Both systems were tested frequently, along with the electrical systems. Testing of the Accessory Power Supply sometimes utilized a "hot run" in which the ethylene oxide fuel was actually burned. Hot runs required that the missile be out of the magazine. Ethylene oxide was refueled after the run. As mentioned earlier, ethylene oxide waste was disposed of via burning or put into surface water. It is reactive, and would not have persisted on NIKE sites.

Periodic wipe testing of nuclear-armed missiles and the warheads were conducted for radiation leakage. Protocol required that rags utilized for these tests be disposed in lead-lined barrels and delivered for disposal as radioactive waste. This protocol was frequently not followed, however, and rags were often disposed as regular solid waste. No accounts of radiation leakage were identified, and since leakage of this type was taken very seriously and warheads strictly constructed, it is unlikely that rags were ever contaminated by any measurable amounts of radiation. Interviews confirmed this information.

7.1.4 General Launcher and Magazine Maintenance

Maintenance of the structural, mechanical, and hydraulic systems of the launcher and magazine were significant chemical-using operations. Similar to the maintenance functions required for the missile, the launcher and magazine required cleaning, painting, and hydraulic work. Launchers routinely leaked hydraulic fluid. The elevator used to move missiles up from underground magazines had an extensive hydraulic system.

NIKE sites varied somewhat in their magazine and launcher configuration. Underground magazines were standard, but were impractical in areas with high water tables (Florida) or permafrost (Alaska). Arrangement of the various facilities was dependent on the orientation of local terrain.

The magazine stored missiles and contained storage racks and a rail system used to deliver the missiles to the elevator. Once above ground, the missile was moved on rails to the launchers. Rail handling of missiles required that all portions of the rails, racks, and dolly wheels be clean and free of corrosion. The rail system was cleaned with metal brushes and solvent. Naphtha type solvents were routinely used to wipe down the rails, leaving a light, oily residue coating the surface. Painting of the rail structures probably utilized a lead oxide primer followed by a coat of "GI green", in accordance with Operating Manual procedures.

As with the launchers the missiles also routinely leaked hydraulic fluid and required routine maintenance. Leaking fluid was washed into surrounding soil. Used fluid that was drained from the launchers probably was collected for dumping or disposal by Army POL personnel. In some instances, disposal to a sump and subsequent subsurface leaching may have been practiced.

In the magazine, waste materials -- solvents, paints, and hydraulic fluid -- were often washed to the magazine sump located at the bottom of the elevator shaft. Leakage of fluid from elevator hydraulics could produce a considerable volume for disposal to the sump. Hydraulic system "blow-outs" occurring during operation of any hydraulic equipment would cause instant release of fluid.

Hydraulic fluid is a hydrocarbon oil of moderate viscosity. The constituents of hydraulic fluid, as with other petroleum products, are varied and numerous.

7.2 INTEGRATED FIRE CONTROL (IFC) AREA

7.2.1 Operations Maintenance

The primary mission of the IFC area was radar tracking and missile guidance. Radar, consisting of three systems, did not require extensive chemical use. Maintenance of radar was mostly electrical, utilizing small amounts of solvent for cleaning. The HIPAR System (High-Power Acquisition Radar) used a coolant pumping system consisting of an ethylene glycol circulating system and pump. The ethylene glycol was replaced annually. The pump was oil lubricated.

Paint composed the most significant chemical use on the radar systems. Disposal of paint at the IFC area was limited by the availability of disposal facilities. Waste paints were more likely to be collected and removed for off-site disposal or occasional "unofficial" dumping.

Fire control electronics also used certain electronic tubes that contain low-level radiation sources in minute amounts. These tubes were often disposed of indiscriminately in earlier portions of NIKE site operations. Tubes may have been disposed with solid waste or even "tossed" on the ground. In the latter portions of the NIKE program, these tubes were more strictly controlled. Despite possible on-site disposal, the volume and hazard of this material is minimal. A probable maximum of six of these tubes per year were discarded in this manner, according to the site interviews.

7.2.2 Vehicle Maintenance

Limited motor pool operations occurred on NIKE sites. An individual NIKE Battery did not have responsibility for vehicle maintenance. Vehicles were delivered to the battalion for all maintenance and service. Occasional minor service or emergency service may have consumed small volumes of solvents, paints, and lubricants, so that minor contamination in the area of the motor pool is possible. Some limited contamination from gasoline is also possible. It is noted that at some locations, the Battery motor pool was located in the Launcher Area.

7.3 GENERAL OPERATIONS

7.3.1 General Facilities Maintenance

Painting and cleaning were the only consistent chemical using operations for maintenance of other NIKE facilities. Buildings and structures were maintained and certain punitive functions for military personnel consumed paints and cleaning materials. The common building paints of the NIKE period used lead as a pigment (20-30 percent). On-site disposal of paint was variable. In some cases, ground leaching systems, such as the drainage at the assembly building, are likely to have been used. "Unofficial" dumping of paint was also likely. Septic systems may also have been used for disposal to a limited extent.

Water-soluble cleaning products are likely to have been discarded via surface disposal on-site, "flushing" to septic systems, or ground leaching systems. These products are unlikely to pose contamination problems, however, because of the limited quantities used.

Pesticides had some use at NIKE sites, however, their use was quite variable and probably did not pose a serious contamination hazard. Herbicides were used at some NIKE sites to maintain vegetation-free areas around site perimeters and launch areas. The function of this use was primarily fire control.

7.3.2 Utility Service

NIKE sites were supported by certain on-site utilities which pose significant potential for contamination. A number of generators were used to support emergency operation of the site, including radar on the IFC Area and missile readiness on the Launcher Area. Generators were carefully maintained and routinely tested. Diesel fuel was stored in large quantities for generator operation. Fuel was likely to have spilled during transfer and pumping operations. Tank were typically located below ground, and remained on-site after deactivation. Tanks probably leaked fuel while the site was operated, and fuel left in the tank after deactivation is likely to have leaked as the tanks deteriorated.

Tanks were also used to store fuel oil for heating purposes. Similar problems existed with these tanks, and quantities of fuel oil also are likely to have contaminated NIKE sites. These tanks could have been located either on the ground surface or below ground. Quantities of fuel oil and diesel fuel in use on NIKE sites consisted of an annual use of several thousand gallons. The extent of possible contamination from these tanks could vary considerably from site to site. The diesel and fuel oil storage tanks were sited at several locations on both the IFC Area and the Launcher Area.

Waste oils and hydraulic fluid were routinely used to control vegetation along underground cable-runs. Cable was usually run through shallow, concrete-walled troughs. Large cables connected the Launcher Area and the IFC Area . Oil was poured in or on the troughs to eliminate vegetation. This produced widespread, but low-level contamination in both the Launcher Area and the IFC Area.

Polychlorinated Biphenyls (PCBs) were also in use at NIKE sites in transformers. Release of PCBs would have been very infrequent since these are sealed units. Occasional rupture of transformers is possible and would have resulted in contamination with comparatively small volumes of material. When deactivation occurred, transformers remained on-site and eventual deterioration may also have resulted in some contamination. PCBs are relatively immobile in soil and contamination would have been limited to the area in the immediate vicinity of a leaking transformer. The quantities and infrequent release of PCBs make it unlikely that serious and consistent contamination will be found on NIKE sites.

Asbestos was in widespread use at NIKE sites for insulation purposes. It is unlikely that any quantity of asbestos was disposed on-site, since the material remained in place during operation and would require disposal as a solid waste. Although there is probably little asbestos present as a ground contaminant, it is likely to remain on-site in its original form in buildings, on piping and ductwork, until removed during demolition.

7.3.3 Deactivation

As previously stated in Section 2.0, paragraph (7), no site specific deactivation plans were obtained. The primary information concerning deactivation practices came from the site operator interviews. Two generic plans (references 8 and 9) were reviewed; however they did not address issues pertaining to chemicals or practices that may have involved contamination.

As stated, deactivation protocol according to stated procedures does not suggest any source of contamination, however, actual practice of deactivation probably resulted in disposal and/or abandonment of considerable volumes of potentially hazardous materials according to the site interviews. Specific practices varied significantly from site to site. Used chemical materials were normally returned to the depot at the time of deactivation for credit on the battalion budget. However, during deactivation, it often proved expeditious to simply abandon some materials, and partially-used or waste material was probably removed by the most efficient means. Dumping in municipal or "unofficial" dumps was reported to be widely practiced, as revealed in the interviews.

As an example of deactivation procedures at a particular site, an instance of dumping chromium trioxide (chrome VI) in excess of 100 pounds during deactivation was reported in the interviews. Waste oils, paints and solvents were discarded via sumps and other drainage. Barrel volumes of waste were delivered to landfills and dumps. On-site landfilling of waste probably occurred to some extent. Any dumping of UDMH canisters would have occurred at this time. Pesticide dumping in barrel quantities was also reported in the interviews. This could present a potentially serious, although very infrequent, contamination at the dump site. The serious possibility of contamination resulting from deactivation is difficult to address, however, because of the high variability of the disposal locations and the quantities of materials discarded. Any low-lying areas on-site which would be secluded from the primary operating area were likely candidates for some "unofficial" dumping both during site operation and at deactivation.

NIKE site operations and the resulting potential associated material contamination as discussed herein are summarized in two Tables as follows:

Table I (NIKE Site Operations and Associated Materials) presents the materials used under each NIKE site operations category together with the usual disposal method and results of such disposal.

Table II (General Materials Inventory of NIKE Sites) presents an alphabetical listing of the materials used, together with a quantity estimate of annual use, the purpose for which it was used, and the results of disposal. Table II was used to determine the Master Contaminant List for the purposes of NIKE Field Investigation Studies which is discussed in Section 8.0.

TABLE I

NIKE SITE OPERATIONS AND ASSOCIATED MATERIALS

OPERATIONS	MATERIALS	DISPOSAL METHOD	RESULTS OF DISPOSAL
1. Missile Assembly and Disassembly			
- Cleaning and Preparation	Solvents	Evaporation Drainage and Leaching	None Persistent in Soils
	Anticorrosion Compound	Solid Waste Disposal Drainage and Leaching	Minimal-Small Quantities Minimal-Small Quantities
- Lubrication, Sealing and Painting	Lubricants, Sealants, and Paints	Solid Waste Disposal POL Turn-In Drainage and Leaching	Dependant on Dumping Practices None Persistent in Soils
2. Missile Fueling and Warheading	UDMH	Depot Turn-In Burial (rare)	None None-Rapid Reactive Decay
	IRFNA	Depot Turn-In Spills (rare)	None None-Rapid Reactive Decay
	Aniline-Furfuryl Alcohol	Depot Turn-In Spills (rare)	None Minimal-Small Quantities
	JP-4	Depot Turn-In Spills	None Small-Persistent in Small Quantities
- Electrical Batteries	Sulfuric Acid (Electrolyte)	Draining and Leaching	None-Small Quantities, Reactive Deacay
	Lead	Draining and Leaching	Small-Limited Quantities

TABLE I

NIKE SITE OPERATIONS AND ASSOCIATED MATERIALS

OPERATIONS	MATERIALS	DISPOSAL METHOD	RESULTS OF DISPOSAL
3. Missile Maintenance and Testing			
- Cleaning and Corrosion Removal	Phosphoric Acid	Drainage and Leaching	None-Small Quantities, Reactive Decay
	Alodine Powder	Drainage and Leaching	Minimal-Small Quantities
	Chromium Trioxide Trioxide and Sodium Dichromate	Drainage and Leaching	Persistent in Soils
	Acids	Drainage and Leaching	Minimal-Reactive Decay
	Solvents (petroleum distillates and chlorinated hydrocarbons)	Drainage and Leaching POL Turn-In	Persistent in Soils None
- Painting	Zinc chromate and Lead	Drainage and Leaching POL Turn-In Solid Waste Disposal	Persistent in Soils None Dependent on Dumping Practices
- Hydraulic Work	Hydraulic Fluid	Drainage and Leaching POL Turn-In Solid Waste Disposal	Persistent in Soils None Dependent on Dumping Practices
- APS Testing	Ethylene Oxide	Burning Surface Dumping	None None-Rapid Reactive Decay

TABLE I

NIKE SITE OPERATIONS AND ASSOCIATED MATERIALS

OPERATIONS	MATERIALS	DISPOSAL METHOD	RESULTS OF DISPOSAL
4. General Launcher and Magazine Maintenance			
- Cleaning and Painting	Solvents, Paints, Lead	Drainage and Leaching POL Turn-In Solid Waste Disposal	Persistent in Soils None Dependent on Dumping Practics
- Hydraulic Work	Hydraulic Fluid	Drainage and Leaching POL Turn-In	Persistent in Soils None
5. Fire Control Operations Maintenance			
- Radar Operation	Ethylene Glycol	Unknown	Minimal-Small Quantities
- Electronics	Low-Level Radio-activity (Electronic Tubes)	Solid Waste Disposal Surface Dumping	Minimal-Small Quantities Minimal-Small Quantities
6. Vehical Maintenance	Solvents, Fuels, Lubricants, Paints	Drainage and Leaching Consumed POL Turn-In	Small-Limited Quantities None None
7. General Facility Maintenance			
- Painting and Cleaning	Paints, Lead	POL Turn-In Solid Waste Disposal Septic	None Dependent on Dumping Practices Persistent in Soils
- Vegetation Control	Herbicides	Consumed	Non Persistent

TABLE I

NIKE SITE OPERATIONS AND ASSOCIATED MATERIALS

OPERATIONS	MATERIALS	DISPOSAL METHOD	RESULTS OF DISPOSAL
8. Utility Service			
- Generator Operation	Diesel Fuel	Consumed Leakage	None Persistent in Soils
- Heating	Heating Oil	Consumed Leakage	None Persistent in Soils
- Vegetation Control in Cable Runs	Hydraulic Fluid and Oils	Surface Dumping	Small-Limited Quantities
- Electricity Service	Polychlorinated Biphenyls	Leakage	Small, Highly Variable
- Insulation (Fire Proofing)	Asbestos	None-Remains in structures	None (Minimal)
9. Deactivation	All Materials o Solvents o Lubricants o Fuels o Etc.	Dumping	Highly Variable-Persistent When Present

TABLE II

GENERAL MATERIALS INVENTORY OF NIKE SITES

MATERIAL	ANNUAL USE	USE CHARACTERISTICS	DISPOSAL METHOD
Acetone	20 gal.	Special Cleaning	Evaporation, Drainage and Leaching
Adhesives	50 lb.	Sealing Missile Components	Consumed, Solid Waste Disposal
Alodine Powder	10 lb.	Decorroding Metal Parts	Drainage and Leaching
Aniline	10 gal.	Ajax Fuel/Starter	Depot Turn-In, Spillage to Soil
Asbestos	500 lb.total	Insulation/Fire Proofing	Minor Release, Intact on Site
Benzene	100 gal.	Solvent	Evaporation, Drainage and Leaching
		General Solvent and Fuel Constituent	Fuel Tank Leakage
n-Butanol	20 gal.	Missile Cleaning	Drainage and Leaching
Carbon Tetrachloride	300 gal.	Solvent	Evaporation, Drainage and Leaching
Corrosion Preventatives (Pastes)	20 lb.	Metal Sealing of Missile	Consumed, Solid Waste Disposal
Chromium Trioxide	100 lb.	Decorroding Missile Parts	Drainage and Leaching, Surface Disposal

TABLE II

GENERAL MATERIALS INVENTORY OF NIKE SITES

MATERIAL	ANNUAL USE	USE CHARACTERISTICS	DISPOSAL METHOD
Diesel Fuel (Hydrocarbons)	10,000 gal.	Fuel for Generators	Consumed, Spillage to Soil, Fuel Tank Leakage
unsym.-Dimethyl Hydrazine	10 gal.	Missile Fuel/Starter	Depot Turn-In, Landfill
Dry Cleaning Solvent (Hydrocarbons)	500 gal.	Solvent	Evaporation, Drainage and Leaching
Electrical Insulating Oil	20 gal.	Electronics Lubricant	POL Turn-In, Leakage
Ethanol	20 gal.	Solvent	Drainage and Leaching
Ethylene Glycol	25 gal.	HIPAR Coolant	Unknown
Ethylene Oxide (Liquid Form)	200 gal.	APS Fuel	Burning, Surface Disposal
Freons (Chlorofuorocarbons)	Unknown	Solvent	Evaporation, Drainage and Leaching
Furfuryl Alcohol	10 gal.	Ajax Fuel/Starter	Depot Turn-In, Spillage to Soil
Gasoline (Hydrocarbons)	1,000 gal.	Vehicle Fuel	Consumed, Fuel Tank Leakage

TABLE II

GENERAL MATERIALS INVENTORY OF NIKE SITES

MATERIAL	ANNUAL USE	USE CHARACTERISTICS	DISPOSAL METHOD
Greases (Hydrocarbons)	100 lb.	Machinery Lubricant	Consumed, Drainage and Leaching, POL Turn-In
Heating Oil (Hydrocarbons)	20,000 gal.	Fuel	Consumed, Fuel Tank Leakage
Herbicides	20 lb.	Vegetation Control	Consumed
Hydraulic Fluid (Hydrocarbons)	2,000 gal.	Hydraulic Fluid	Drainage and Leaching, POL Turn-In, Surface Disposal
Isopropanol	20 gal.	Deicing of Equipment	Evaporation, Surface Disposal
JP-4 (Hydrocarbons)	500 gal.	Missile Fuel	Depot Turn-In, Drainage and Leaching
Lead (Carbonates and Oxide)	200 lb.	Paints and Battery Electrolyte	Drainage and leaching, POL Turn-In
Low-Level Radiation Sources	<1 lb.	Electrical Tubes	Solid Waste Disposal, Depot Turn-In
Lubricating Oils (Hydrocarbons)	200 gal.	Lubrication of Machinery	POL Turn-In, Drainage and Leaching Surface Disposal
Mineral Spirits (Hydrocarbons)	500 gal.	Solvent/Thinner	Drainage and Leaching

TABLE II

GENERAL MATERIALS INVENTORY OF NIKE SITES

MATERIAL	ANNUAL USE	USE CHARACTERISTICS	DISPOSAL METHOD
Molybdenum Disulfide	5 lb.	Lubricant	Consumed, Drainage and Leaching
Naphtha (Hydrocarbons)	50 gal.	Solvent/Thinner	Drainage and Leaching, Evaporation
Nitric Acid (IRFNA)	300 gal.	Missile Fuel/Starter	Depot Turn-In, Spillage to Soil
Paints (Hydrocarbons & Pigments)	300 gal.	Paint	Consumed, POL Turn-In, Drainage and Leaching, Surface Disposal, Solid Waste Disposal
Perchlorethylene (Tetrachloroethene)	100 gal.	Solvent	Evaporation, Drainage and Leaching
Phosphoric Acid	20 gal.	Cleaning Metal	Drainage and Leaching, Surface Disposal
Polychlorinated Biphenyls (PCBs)	100 gal.total	Electric Insulator	Removed, Intack on Site, Leakage to Soils
Propanol	10 gal.	Missile Cleaning	Drainage and Leaching
Selenium (Metallic)	100 lb. total	Rectifier Parts	Removal, Intact On Site, Solid Waste Disposal

TABLE II

GENERAL MATERIALS INVENTORY OF NIKE SITES

MATERIAL	ANNUAL USE	USE CHARACTERISTICS	DISPOSAL METHOD
Sodium Dichromate	50 lb.	Metal Cleaning	Drainage and Leaching
Sodium Phosphate (Tribasic)	50 lb.	Equipment Cleaning	Drainage and Leaching, Septic disposal
Stoddard Solvent (Hydrocarbons)	500 gal.	Solvent	Drainage and Leaching, Evaporation
Sulfuric Acid	30 gal.	Battery Acid	Drainage and Leaching
Toluene	50 gal.	Solvent	Drainage and Leaching
		Constituent of Fuels	Fuel Tank Leakage
1,1,1-Trichloroethane	500 gal.	Solvent	Evaporation, Drainage and Leaching
1,1,2-Trichloroethane	500 gal.	Solvent	Evaporation, Drainage and Leaching
Trichloroethene (Trichloroethylene)	500 gal.	Solvent	Evaporation, Drainage and Leaching
Tricresyl Phosphate	20 gal.	Special Lubricant	Drainage and Leaching
Zinc Chromate	100 lb.	Paint	Drainage and Leaching, POL Turn-In, Solid Waste Disposal

8.1 GENERAL

Based on the previous analysis of site operations, this section presents the Master Contaminants List which consists of the potential contaminants of former NIKE sites. These contaminants should be investigated in the NIKE Preliminary Determination Phase (Phase II of this investigative program). As shown in Tables I and II, a number of many different substances were found to have potentially contaminated NIKE sites. Many of them, however, were not used in quantities that justify evaluation as a contaminant. Certain other substances that are potential contaminants were used erratically, and have an extremely small likelihood of being discovered on NIKE sites. Other possible contaminants have very brief life expectancies in the environment, and will no longer be present.

Also, further discussion is presented of criteria used for developing the Master List from the general inventory and discusses particular materials regarding their likelihood of being considered a potential site contaminant. The Master Contaminants List is presented as Table III at the conclusion of this Section.

8.2 MASTER LIST CONTAMINANTS

Each of the substances identified on the master list was used in significant quantities on NIKE sites and has a high probability of causing contamination. Most of the other materials identified in this investigation were eliminated from consideration since the volume of use on NIKE sites was small. Certain of the chemicals identified in previous investigations conducted by the United States Army Toxic and Hazardous Materials Agency were not included on the master list. The primary criteria for not including materials on the master list included:

- the materials were used only in small quantities,

- the materials were used with extreme care such that only minor quantities could have caused contamination and,

- the materials were reactive to the environment such that possible contamination from these materials would have dissipated rapidly with time.

Specific discussions of the substances comprising the master list, and of certain significant materials that were eliminated from the list, are presented in the following paragraphs. Materials on the Master List that represent additions relative to previous studies are so designated.

<u>Benzene</u> (New Listing)

Benzene was mentioned in Manual TM 9-1400-250-15/3. Benzene was probably in use as a solvent in the early stages of the NIKE program and was eliminated from updated standard equipment inventories. It remained in the text of the unrevised portions of the manual. Benzene was removed from military use due to its toxicity, much the same as was carbon tetrachloride. Benzene is also a common constituent of other solvents and fuels. Gasoline, for example, often contains significant amounts of benzene, so that NIKE site contamination from leaking fuel tanks or other solvent use increases the threat of benzene contamination.

<u>Carbon Tetrachloride</u>

As indicated in previous studies of NIKE sites (USATHMA DRXTH-AS-IA-83016), carbon tetrachloride was used in the early portions of the NIKE program. It is a superior solvent, and was used extensively for cleaning and degreasing.

Chromium (New Listing)

Chromium originates on NIKE sites in the cleaning materials chromium trioxide and sodium dichromate, as well as in zinc chromate and other paints.

Petroleum Hydrocarbons

Fuels, non-chlorinated solvents, naphthas, lubricants, paints, and hydraulic fluid all fall into the class of petroleum hydrocarbons. Because there are thousands of different but similar hydrocarbons, they are considered as a group when dealing with contamination from the materials mentioned above. In sheer quantity, hydrocarbons constitute the most significant potential contaminant of former NIKE sites.

Lead

Lead originates on NIKE sites in battery electrolyte and lead-based paints. Paint disposal at NIKE sites may have caused extensive contamination by lead.

Perchlorethylene (New Listing)

Interviews confirmed the use of perchloroethylene on NIKE sites. It was used as a solvent, probably after carbon tetrachloride use ceased, and before the introduction of trichloroethene and trichloroethanes. High volume use could be expected during that period.

Toluene

Toluene was specified as a cleaning solvent for missile components. It is also a major component of fuels and other solvents.

1,1,1-Trichloroethane, 1,1,2-Trichloroethane, and Trichloroethene

The use of these solvents was previously documented by USATHMA and was confirmed by this investigation.

8.3 OTHER MATERIALS CONSIDERED

The materials discussed in the following paragraphs are potential contaminants that were not placed on the master list of contaminants for the reasons previously discussed, but which warrant further discussion because they are mentioned in other source material as possible contaminants.

Unsymmetrical Dimethyl Hydrazine (UDMH)

UDMH was used in small amounts and stored for use in small sealed canisters. UDMH was carefully handled and controlled on NIKE sites. Spills very rarely occurred, and only intentional landfilling would present a contamination situation. In the environment, UDMH does not persist, because of its reactivity. UDMH will not occur on NIKE sites, except in sealed canisters, and will not be found in water or soil samples.

Ethylene Oxide

Ethylene oxide was used throughout the NIKE program as a fuel for the Accessory Power Supply (APS) system. This system burned ethylene oxide primarily to power missile guidance hydraulics. The system was tested periodically with a "hot run". Waste ethylene oxide was disposed of immediately by burning or dilution in water and on-site dumping. Ethylene oxide is a reactive, volatile liquid stored at low temperatures. (It has a boiling point of 11^{o} Centigrade). In the environment, it decays in a very short time. No ethylene oxide will remain as a NIKE site contaminant.

Aniline and Furfuryl Alcohol

These starter fuels were not used in large quantities and pose very little contamination hazard.

JP-4

JP-4 is a hydrocarbon fuel. Contamination by JP-4 is considered along with other fuels under the hydrocarbon category.

Low-Level Radiation

Radiation resulting from electrical tube disposal caused extremely minute contamination with no associated hazard. Leakage from nuclear weapons did not occur to the best of our knowledge.

IRFNA (Nitric Acid)

IRFNA was an extremely hazardous material that was treated with great respect by NIKE site operators. Very little contamination via spillage occurred. The small amounts that were spilled rapidly reacted to become nitrates. Nitrates occur naturally in soils and are very commonly used as fertilizer. There is practically no chance that serious contamination of NIKE sites occurred as a result of the use of IRFNA.

Polychlorinated Biphenyls (PCBs)

PCBs were present on NIKE sites in permanent, sealed electric transformers. Small, erratic leakage of transformers probably occurred during site operation and after deactivation. Contamination resulting from PCB's would be small, localized, unpredictable, and unlikely to be discovered except from visual observation of a leaking transformer. Therefore, PCBs were not included in the Master List for screening during the Preliminary Determination Phase. If PCB contamination is suspected, it will be investigated on a site specific basis.

Asbestos

Asbestos remains on-site in its original form in buildings, on piping and ductwork. It should be removed during demolition. Asbestos was not included on the Master List for screening during the Preliminary Determination Phase.

TABLE III
MASTER LIST OF SIGNIFICANT POTENTIAL NIKE SITE CONTAMINANTS

MATERIAL	USE CHARACTERISTICS	DISPOSAL METHOD
Benzene	Solvent	Evaporation, Drainage and Leaching
	General Solvent and Fuel Constituent	Fuel Tank Leakage
Carbon Tetrachloride (Tetrachloromethane)	Solvent	Evaporation, Drainage and Leaching
Chromium (Chromates, Chrome III, IV, and VI)	Decorroding Missile Parts	Drainage and Leaching, Surface Disposal
Petroleum Hydrocarbons	Fuels, Lubricants, Hydrocarbons	Consumed, Fuel Tank Leakage, Spillage to Soil, POL Turn-In, Drainagae and Leaching, Surface Disposal
Lead (Carbonates and Oxide)	Paints and Battery Electrolyte	Drainage and Leaching, POL Turn-In
Perchlorethylene (Tetrachloroethene)	Solvent	Evaporation, Drainage and Leaching
Toluene	Solvent Constituent of Fuels	Drainage and Leaching Fuel Tank Leakage
1,1,1-Trichloroethane	Solvent	Evaporation, Drainage and Leaching
1,1,2-Trichloroethane	Solvent	Evaporation, Drainage and Leaching
Trichloroethylene	Solvent	Evaporation, Drainage and Leaching

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1) USATHMA Historical Overview of the NIKE Missile System. December, 1984. DRXTH-AS-IA-83016

2) USATHMA Assessment of Contamination: Phoenix Military Reservation Launch Control Area. August, 1984. DRXTH-AS-CR-84296

3) USATHMA Fulton Property Survey. December, 1980. DAAK-79-C-0148

4) USATHMA Survey of the Former NIKE Site, Bristol, Rhode Island. December, 1980. DRXTH-IS-TR-81088

5) Personal Communication with five former NIKE site operators.

6) Personal Communication with military radiation safety personnel.

7) Personal Communication with municipal and industry representatives.

8) U.S.Army, NIKE Hercules Phaseout Plan. February, 1981.

9) U.S.Army, NIKE Hercules Inactivation Plan. February 1974.

10) U.S.Army, TM 9-1400-250-15/3. General and Preventative Maintenance Services (NIKE-Hercules and Improved NIKE-Hercules Air Defense Guided Missile System and NIKE-Hercules Anti-Tractical Ballistic Missile System). March, 1968.

11) U.S.Army, TM 9-1410-250-12/1. Operator and Organizational Maintenance Manual: Intercept-Aerial Guided Missile MIM-14A and MIM-14B.

12) U.S.Army, TM 9-1440-252-34. DS and GS Maintenance of the Hercules Monorail Launcher, Launching-Handling Rail, Side Truss, Loading Rack Support, Launcher-Transport Modification Kit, Launcher-Subsurface Four-Rack Modification Kit, and Launcher Basis Accessory Kit. August, 1960.

DRXTH-AS-IA-83016

HISTORICAL OVERVIEW OF THE NIKE MISSILE SYSTEM

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