PLUM BROOK STATION
PRELIMINARY ASSESSMENT

June 1991

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EXECUTIVE SUMMARY

This report documents the findings, conclusions, and recommendations developed during a preliminary assessment of potential sources of environmental contamination at Plum Brook Station. Plum Brook Station is a Federal government facility administered and operated by the National Aeronautics and Space Administration (NASA). Plum Brook Station occupies 6400 acres in Erie County, Ohio near the city of Sandusky.

Plum Brook Station was originally developed as the Plum Brook Ordnance Works by the U.S. Army in 1941. Activities conducted on the site during the 1940s were the manufacture of trinitrotoluene, dinitrotoluene, and pentolite for World War II. NASA's predecessor organization, National Advisory Council for Aeronautics (NACA), acquired the site in the 1950s. Since the late 1950s, the site has been used for research and development of space propulsion and power systems.

The preliminary assessment was conducted according to United States Environmental Protection Agency (U.S. EPA) regulations and guidance promulgated under Comprehensive Environmental Response Compensation and Liability Act (CERCLA)/Superfund Amendments and Reauthorization Act (SARA) authority, to determine if there had been any releases of hazardous substances from the facility that posed a potential threat to human health and the environment. To perform the assessment, documentation from NASA and a variety of local, state, and federal government agencies was compiled and reviewed to obtain all available information pertaining to hazardous substance management at the facility, local and regional environmental conditions, demographics, and indications of hazardous substance contamination in and around the facility. Long-time facility employees were also interviewed regarding their personal recollections of hazardous substance management practices and historical releases.

In conducting the preliminary assessment, 32 potential sources of environmental contamination were identified and organized into 14 operable units. Ten potential sources, comprising 4 operable units, were found to be the sites of documented/verifiable releases to the environment.

The 14 operable units were evaluated using an abbreviated version of the Hazard Ranking System (HRS) provided by the U.S. Environmental Protection Agency Region V. None of the operable units received scores above 28.5, using this system.

The 14 operable units were assigned low, medium, and high priorities for further investigation. Only Operable Unit 2, Red Water Ponds, was assigned a high priority.

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ACRONYMS

ACM	asbestos-containing material
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
D&D	decontamination and decommissioning
DNT	dinitrotoluene
DOA	Department of Agriculture
DOI	Department of Interior
DOE	Department of Energy
DSHWM	Division of Solid and Hazardous Waste Management
EIS	environmental impact statement
ERD	environmental resource document
GSA	General Services Administration
HERERF	High Energy Rocket Engine Research Facility
HRS	Hazard Ranking System
HTF	Hypersonic Tunnel Facility
LeRC	Lewis Research Center
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	Nuclear Regulatory Commission
NReC	National Response Center
OEP	Office of Environmental Programs
OEPA	Ohio Environmental Protection Agency
ODNR	Ohio Department of Natural Resources

ACRONYMS

(Continued)

PA	preliminary assessment
PBOW	Plum Brook Ordnance Works
PBRF	Plum Brook Reactor Facility
PCB	polychlorinated biphenyl
PE	pentaerythritol
PETN	pentaerythritol tetranitrate
PTI	Permit to Install
PTO	Permit to Operate
RCRA	Resource Conservation and Recovery Act
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SOW	scope of work
SPF	Space Power Facility
SPRF	Spacecraft Propulsion Research Facility
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
TSCA	Toxic Substances Control Act
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound

1. INTRODUCTION

The following report describes and documents the activities performed and conclusions developed during a preliminary assessment (PA) of potential sources of environmental contamination at the National Aeronautics and Space Administration (NASA) Lewis Research Center (LeRC) Plum Brook Station located near Sandusky, Ohio. This PA was performed under the authority of the NASA Office of Environmental Programs (OEP). A PA was also conducted for the NASA LeRC facility in Cleveland, Ohio; the results of which are documented under separate cover.

1.1 Purpose and Scope of the Preliminary Assessment

The scope of this PA was to evaluate the current and past waste management and hazardous material handling practices at Plum Brook Station, focusing on the activities conducted by the U.S. Army and NASA. These activities occurred from 1940 through the present. Through documentation investigations and interviews with current and former Plum Brook employees, the potential has been evaluated for residual chemical contamination to the environment at Plum Brook Station. Based on the evaluations, a list has been compiled of operable units that require further investigation through the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) process. A simplified diagram of the CERCLA process showing the relationship between the PA and further phases is provided in Figure 1-1.

The PA was conducted in accordance with the revised Scope of Work (SOW) Science Applications International Corporation (SAIC) submitted to NASA LeRC OEP on March 8, 1991. The specific goals as outlined in the March 8 SOW are as follows:

- Compile and assimilate existing information to identify all potential sources of environmental contamination;
- Identify sites that require immediate response;

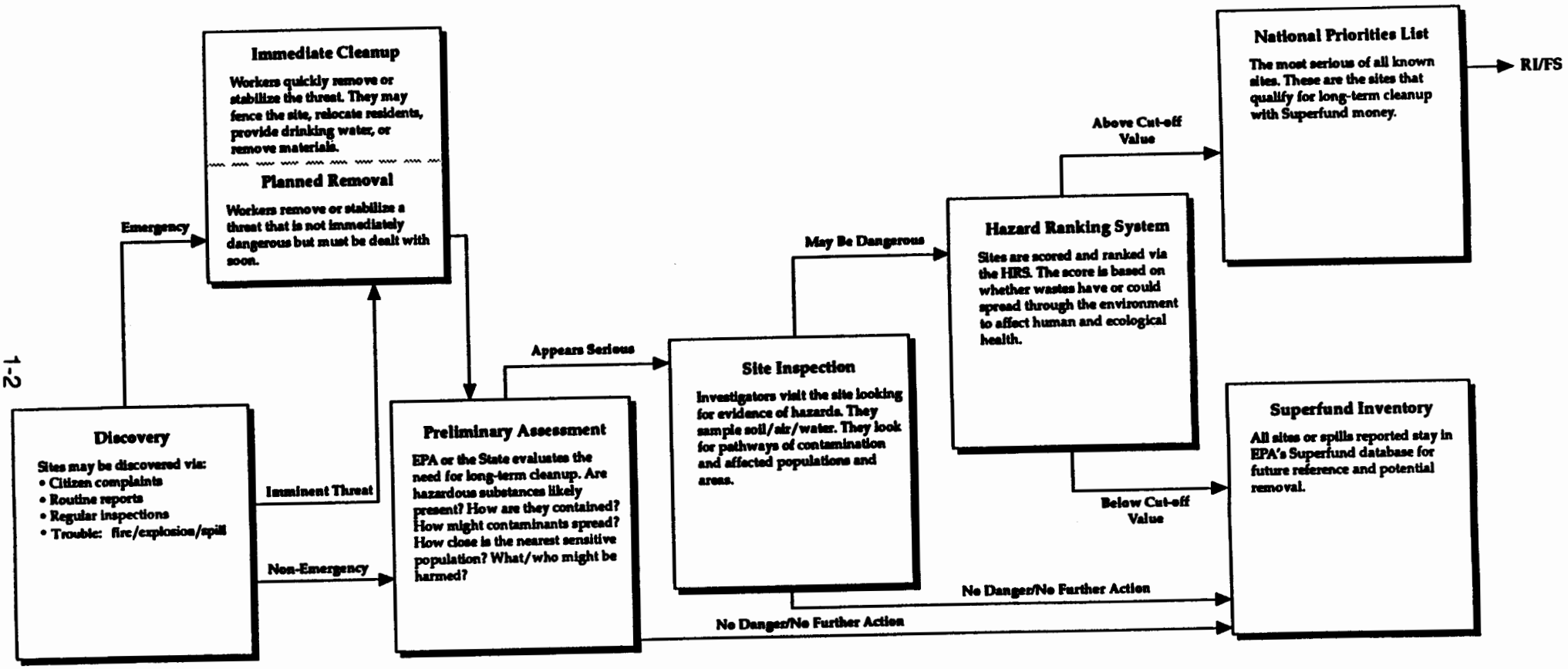

FIGURE 1-1. SIMPLIFIED DIAGRAM OF CERCLA SITE DISCOVERY AND STUDY PROCESS

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- Determine if further action is required under CERCLA; and
- Identify data needs and set priorities for follow-up CERCLA actions.

The scope of this PA investigation included existing known facilities and activities, as well as historical activities, that had the potential for a release (planned or unplanned) or a known release of CERCLA hazardous substances in reportable quantities.

1.2 Technical Approach to the Preliminary Assessment

The PA involved the collection of existing information and data obtained by the project team through NASA file searches, interviews with current and former Plum Brook Station employees, and interviews with state, federal, and local agencies. State, federal, and local agencies contacted included:

- Ohio Environmental Protection Agency - Northwest District Office
- Ohio Department of Natural Resources
- U.S. Fish and Wildlife Service
- National Oceanic and Atmospheric Administration
- Toledo Council of Governments
- Erie County Health Department
- National Climatic Data Center
- Sandusky Water Treatment Plant
- Erie County Planning Commission
- Erie County Water Department
- Detroit Regional Census Office
- Ohio Data User's Center
- U.S. Coast Guard
- Huron Water Department

- Ottawa County Regional Planning Commission
- Marblehead Water Treatment Plant.

The project was performed in five sequential phases as discussed in the March 1991 SOW, which included:

- Phase I - Initial Planning
- Phase II - Information Gathering
- Phase III - Assimilation of Information
- Phase IV - Data Verification
- Phase V - Report Preparation.

Phase I consisted of the initial project planning, which included a review of readily available site information to develop a preliminary list of suspected releases and to plan the overall approach and methodology for the PA. Phase II involved the actual identification and acquisition of all available data which had the potential to support the identification or quantification of a source of hazardous substance release. Data acquisition activities from NASA sources included:

- Review of operational logs, planning documents, environmental reports, engineering design and construction reports, shipping/receiving manifests of hazardous substances, facility drawings, and any other available documentation which pertained to hazardous materials handling practices;

- Interviews with current and former employees working at Plum Brook Station (NASA, Sverdup, Garrett Corporation);

- Review of Plum Brook Station Fire Department daily activity logs;

- Review of current and historical aerial photographs of Plum Brook Station (1937 through 1990).

Phase III involved the assimilation of the information acquired into a comprehensive picture of the environmental conditions and problems on and around Plum Brook Station. Data from multiple sources were compared and combined to allow development of a complete list of all potential sources of environmental contamination. Sources were also organized into "operable units" to focus activities and introduce some economies of scale into the process. Individual sources were organized into operable units based on the following criteria:

- General patterns of waste disposal from specific processes or facilities;
- Spatial relationship to other units;
- Physical characteristics of the source;
- Waste characteristics of the source; and
- Anticipation of similar remedial action strategy.

Phase IV involved verification of the quantity and quality of the data available for each operable unit. Contradictory or inconsistent information identified in Phase III was reviewed and clarified. Gaps in the necessary information base for each unit were filled.

Based on the verified information from the previous activities, Phase V included the preparation of a draft report, review of the draft report by cognizant NASA personnel, and publication of this final report. Development of preliminary Hazard Ranking System (HRS) scores for each of the operable units was also part of Phase V.

A records retention system was established to maintain control of all materials acquired during the information gathering phase. All documents, drawings, contact reports, and any other articles utilized to prepare this PA were assigned tracking numbers and entered into a customized computerized database. All information gathered was contained in a secured filing cabinet to limit access to the information. A printout of information sources contained in the database is provided as Appendix A.

1.3 Organization of the Report

Chapter 1 of this report is an introduction to Plum Brook Station. Chapter 2 describes Plum Brook Station and provides current and historical information relative to the ownership, operation, and regulatory status of Plum Brook Station. Chapter 3 discusses the environmental setting of the facility, including the geology, hydrogeology, climatic conditions, air quality, and the possible receptor populations, both human and environmental. Chapter 4 describes the historical and current hazardous substance management practices (waste and product materials) at Plum Brook Station. Chapter 5 discusses operable units identified through evaluation of current and historical hazardous substance management practices at Plum Brook Station. For each identified operable unit, provided are the rationale for the unit's inclusion, an evaluation of the potential environmental impact associated with the unit, and the preliminary Hazard Ranking System (HRS) score for the unit. Chapter 6 provides the conclusions and recommendations for further action at each operable unit. Section 7 is the list of references used as information resources in evaluating sites as operable units.

To facilitate review of this report, a matrix has been developed that correlates the report sections to the PA Deficiency Checklist received from the U.S. EPA Region V by NASA OEP earlier this year. This matrix is presented as Table 1-1.

TABLE 1-1. NASA PLUM BROOK STATION PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX

U.S. EPA Checklist Item	Corresponding Report Section
1. OVERVIEW/SITE HISTORY	
A. Describe site operations (manufacturing, storage, waste disposal practices, etc.) include the following:	Section 2.0
• History of site/years in operation	2.2
• Topographic map of surrounding area	3.1.2.3
• Site map or sketch	2.1
• Regulatory history of site (i.e., RCRA site, CERCLA site, NPDES permits, etc.).	2.2.2
B. Describe any emergency or remedial actions that have occurred at the site.	2.2.2.2
C. Describe any releases of wastes to groundwater, surface water, or air.	2.2.2.2, 5.0
D. Give the following population information:	3.2.1
• 0 - 1/4 mile from site	
• 1/4 - 1/2 mile from site	
• 1/2 - 1 mile from site	
• 1 - 2 miles from site	
• 2 - 3 miles from site	
• 3 - 4 miles from site.	
E. Describe any prior spills that occurred at the site.	2.2.2.2
F. Describe site security (e.g., fences monitoring, patrols, gates, etc.)	2.1

TABLE 1-1. NASA PLUM BROOK STATION PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
2. WASTE/SOURCE INFORMATION	
A. Describe as specifically as possible the types of wastes produced at the site and the methods in which these wastes were treated, stored, or disposed.	4.2
B. Describe as specifically as possible the amount (volume, weight, etc.) of each waste type produced at the site.	4.2.1
C. Describe each waste management unit (e.g., landfill) on-site.	4.2, 5.0
D. Describe as specifically as possible the amount of waste treated, stored, or disposed in each waste management unit on-site (e.g., landfills, impoundments, tanks, etc.)	5.0
E. Describe as specifically as possible the condition/integrity of each waste management unit (e.g., are landfills equipped with liners or caps).	5.0
F. Describe any secondary containment features/ structures associated with each waste management unit (e.g., precipitation run-on and run-off systems, leachate collection systems, gas collection systems).	5.0
G. Describe the size/volume/capacity of each waste management unit.	5.0

TABLE 1-1. NASA PLUM BROOK STATION PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
3. GROUNDWATER PATHWAY INFORMATION	
A. Determine if the groundwater within 4 miles of the site is used for any of the following purposes: • private or public drinking water source • commercial • irrigation (5 acre minimum) • industrial • not used, but useable • unusable.	3.2.2.2
B. Identify the nearest well within 4 miles of the site that is a source of drinking water.	3.2.2.2
C. Provide a map (or sketch) locating all drinking water wells within a 4-mile area of the site.	3.2.2.2
D. Describe the population that drinks groundwater drawn from wells within 4 miles of the site.	3.2.2.2
E. Describe known or probable groundwater flow direction.	3.1.3.2
F. Describe, as precisely as possible, the geology and hydrogeology of the site area (including formation names, thickness, types of material and depth from surface, soils).	3.1.2
G. Discuss any evidence of aquitards between aquifers within 4 miles of the site.	3.1.2

TABLE 1-1. NASA PLUM BROOK STATION PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
H. Describe any evidence of interconnections between the uppermost aquifer and aquifers used for drinking water supply within 4 miles of the site.	3.1.2
I. Estimate annual net precipitation at the site.	3.1.1
J. Discuss soil or geologic conditions that might inhibit or facilitate groundwater migration.	3.1.2
K. Identify if any underlying aquifers are "sole source" as designated by Section 1424(e) of the Safe Drinking Water Act.	3.1.3.2
L. Determine if site is located in an area of Karst terrain.	3.1.2
4. SURFACE WATER PATHWAY INFORMATION	
A. Describe surface water bodies within 15 miles of the site or provide a map.	3.2.2.1
B. Discuss the probable surface runoff pattern from the site to surface waters, including the distance to the nearest body of surface water, or provide a map.	3.1.3.1
C. Describe the points at the site where hazardous substances begin to migrate and their probable point of entry into a surface water body.	3.1.3.1

TABLE 1-1. NASA PLUM BROOK PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
D. Identify if surface water drawn from intakes within 15 miles from the probable point of entry is used for any of the following purposes: • commercial livestock watering • commercial food preparation • commercial industrial purposes other than drinking water, recreation, or fishery uses.	3.2.2.1
E. Identify the nature and size of any of the following targets associated with surface water bodies within 15 miles downstream of the probable point of entry. • population served by intakes of drinking water • population associated with recreational use • sensitive environments (including wetlands [5 acre minimum] and critical habitats of a federally endangered species). • economically important resources (e.g., shellfish).	3.2.2.1
F. Discuss any qualitative, quantitative, or circumstantial evidence of contamination of surface waters caused by management of hazardous substances on-site.	2.2.2.2, 5.0
G. Estimate the size of the upgradient drainage area from the site.	3.1.3.1

TABLE 1-1. NASA PLUM BROOK PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
H. Determine the 2-year, 24-hour rainfall for the site.	3.1.1.1
I. Discuss the average annual stream-flow associated with surface water within 15 miles of the site.	3.1.3.1
J. Discuss if fisheries (recreational or commercial) exist in surface water bodies within 15 miles of the site.	3.1.3.1
• describe production rate of fisheries.	
5. AIR PATHWAY INFORMATION	
A. Describe if there has been an observed release of a hazardous substance to the atmosphere.	5.2
B. Determine the shortest distance to the closest residence or regularly occupied building or area from any on-site air emission source.	3.1.4
C. Describe the following types of land use near the site, and indicate their distance from any on-site emission source:	3.2.1.2
• commercial/industrial/institutional • single family residential • multi-family residential	

TABLE 1-1. NASA PLUM BROOK PRELIMINARY ASSESSMENT REPORT REVIEW MATRIX (Continued)

U.S. EPA Checklist Item	Corresponding Report Section
• parks • prime agricultural • non-prime agricultural.	
D. Determine if sensitive environments are within 4 miles of an on-site emission source.	3.2.3
6. ON SITE INFORMATION	
A. Describe any areas of contamination that are within 2 feet of ground surface.	5.0
B. Provide the number of children under seven years old living, attending school or daycare where contamination is less than 2 feet of ground surface.	3.2.1.1
C. Describe the measures taken to limit access to areas with contamination (e.g., fences, guards, etc.).	2.1, 5.2

2. SITE BACKGROUND

Plum Brook Station is a satellite operation of NASA's LeRC in Cleveland, Ohio. Most of the aerospace test facilities established in the 1960s at Plum Brook Station are in standby or inactive condition. This section of the PA report includes a description and history of Plum Brook Station.

2.1 Site Description

Plum Brook Station is 50 miles west of LeRC, approximately 4 miles south of the Lake Erie port of Sandusky, Ohio, in an area that is primarily agricultural and rural.[1] Most areas surrounding Plum Brook Station are used for crop production. Most of Plum Brook Station is undisturbed forested land. Much of Plum Brook Station is located in Perkins and Oxford townships. There are small portions of the site along the eastern boundary that extend into Huron and Milan townships. Figure 2-1 shows the location of Plum Brook Station. Figure 2-2 is a 1987 aerial photograph of Plum Brook Station. In Figure 2-2, the lines of demarcation between green forested and dark agricultural lands are the site boundaries.

Plum Brook Station is located on what was originally a flat lake bottom from glacial melt waters. It derives its name from the major stream that flows through its boundary: Plum Brook.

The original Plum Brook Station had an area of 9,009 acres. Approximately 6,500 acres of the original site constitute the station as it exists today. The northern most boundary of Plum Brook Station occurs at latitude 41°23'39" and extends as far south as latitude 41°20'04". The westernmost longitude occurs at 82°43'12" and extends as far east as 82°38'39." NASA's LeRC controls the land associated with Plum Brook Station

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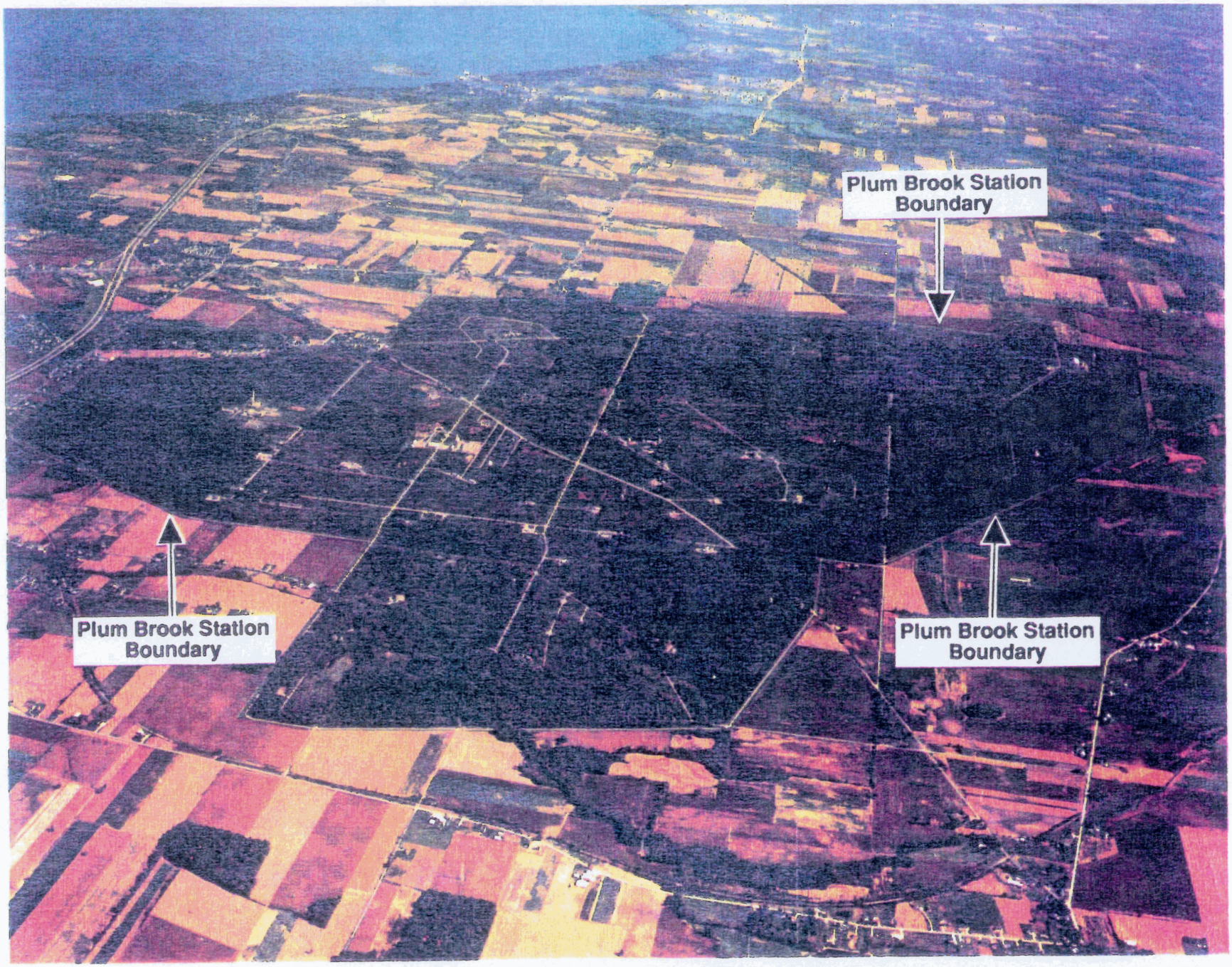
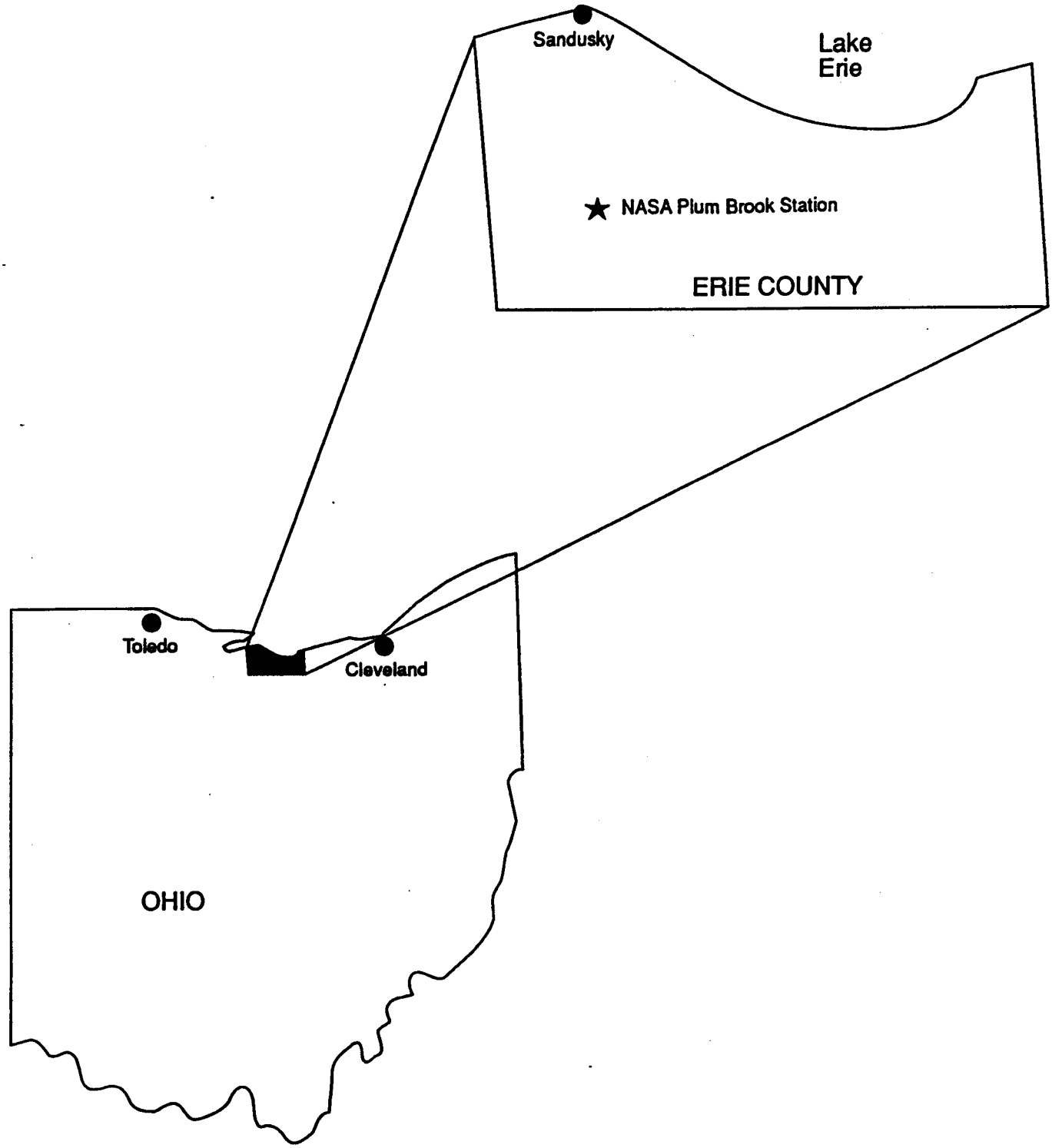


FIGURE 2-2. AERIAL PHOTOGRAPH OF PLUM BROOK STATION



NASA PLUM BROOK STATION

FIGURE 2-1 FACILITY LOCATION MAP

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through the following: ownership of title; use of easements, leases, and permits; and ownership of development rights.[2] NASA LeRC management has responsibility for both the Cleveland Center and Plum Brook Station.

There are approximately 106 permanent buildings and structures on the Plum Brook Station site and 99 munitions bunkers which were constructed when the facility was an ordnance plant.[3] The munitions bunkers are currently used for the storage of materials, equipment, and records. The remaining buildings and structures include offices, test facilities, mechanical or process equipment, and shipping and receiving areas. An additional 28 structures on the site include substations, sanitary wastewater treatment facilities, and cooling towers. All the test facilities located at the site are remotely located from each other, as original use dictated hazard-exclusion distances.

Electric power is provided to the facility by Ohio Edison Company.[4] Potable water is supplied by the City of Sandusky. Raw water, used for cooling, testing, and fire protection, is provided by a Plum Brook Station-owned intake in Lake Erie (Big Island Pump Station). Another raw water intake (Rye Beach Pump Station) was also used until 1985, when use was discontinued due to a blocked line.[5] Plum Brook Station has five sanitary waste treatment systems. Three are currently operating; the largest of which is a 110,000-gallon-per-day high-rate trickling-filter secondary treatment plant located on Taylor Road.

An 8-foot-high security fence surrounds Plum Brook Station. Unauthorized site access is prohibited. Access to the site is gained through a security guard house located on Columbus Avenue. The guard house is manned by armed guards 24 hours a day. During each eight-hour shift, a security guard patrols the inside perimeter road (Patrol Road) of the facility. All persons entering Plum Brook Station must enter through the guard house. Persons gain access to the station by showing the guard a badge that authorizes entry into the station. Persons not holding badges are issued a badge by a guard after the guard verifies with Plum Brook personnel that entry is authorized.

The site is served by an internal paved road system totaling 62.5 miles and a currently unused 15.7-mile rail system.[4] The site is bounded on the north by Bogart Road, on the south by Mason Road, on the east by U.S. Highway 250, and on the west by County Road 43.

2.2 Site History

The ownership and regulatory histories of Plum Brook Station are described in this section.

2.2.1 Site Ownership History

Plum Brook Station was established by the U.S. Army in the early 1940s to manufacture ordnance [trinitrotoluene (TNT), dinitrotoluene (DNT), and pentolite] for World War II. The U.S. Army entered into a contract with Trojan Powder Company for the purpose of manufacturing this ordnance. The official title for the site during this time was the Plum Brook Ordnance Works (PBOW). Ground-breaking to construct facilities to support the manufacturing of ordnance began on April 15, 1941.[6] Production began on December 16, 1941 and continued throughout late 1945. Production ceased two weeks after V-J Day. During the production period more than one billion pounds of ordnance was manufactured.

PBOW was placed in standby condition from 1945 to 1946. Throughout this time, the Army conducted decontamination and decommissioning (D&D) of many of the buildings and structures associated with the manufacturing of ordnance. Decontamination efforts on all TNT and DNT lines began in September 1945.[7] Decontamination of TNT lines, acid lines, pentolite lines, and DNT lines was halted during the last quarter of 1945. Typical D&D methods for buildings and structures involved removal and relocation of all explosives to a burning ground where they were burned.[8] Where possible, remaining buildings and structures were burned to the ground. Steam lines, drain lines, etc., were

flushed and dismantled.[8,9] There is no indication in PBOW historical records of where lines were flushed. Appendix B to this PA report contains procedures followed by the Army to decontaminate the PBOW in 1945.

It is estimated that 65 percent of the necessary decontamination of PBOW was completed by December 1945.[7] On midnight of December 17, the physical custody of the PBOW was transferred from Trojan Powder Company to the U.S. Army Ordnance Department. The Ordnance Department became the accountable agency and the U.S. Army Corps of Engineers assumed responsibility for maintenance and custodial duties at the PBOW from January 1 through June 30, 1946. After further decontaminaton efforts were completed, and the extent of contamination certified, PBOW was transferred to the War Assets Administration in August 1946. From 1946 to 1949 the property was protected and maintained by Matthew-Levio and Sons. In 1949 it was transferred to the General Services Administration (GSA), which maintained oversight of the facility until August 1954. Ravenna Arsenal conducted further decontamination efforts from 1954 to 1958. NASA accepted the facility in 1963 after Ravenna Arsenal certified that the PBOW had been completely decontaminated and was suitable for unrestricted future use. After acceptance of the PBOW, NASA identified further areas that required decontamination. In 1964, NASA continued site decontamination and the removal of structures.

The site remained virtually "mothballed" from 1945 until 1956, when the National Advisory Committee for Aeronautics (NACA) determined that the former PBOW was a suitable site to locate a new test reactor. An agreement was made in 1956 for a lease of 500 acres of the north portion of the site to construct and operate the Plum Brook Reactor Facility (PBRF). In October 1958, NACA became the National Aeronautics and Space Administration (NASA). NASA operated the PBRF from 1963-1973 under a license agreement with the Atomic Energy Commission (AEC). NASA currently has a license agreement with the Nuclear Regulatory Commission (NRC) for the safe protective storage of the PBRF.

NASA acquired an additional 6,000 acres of the former PBOW on March 15, 1963, for the purpose of conducting various aerospace research activities. NASA continues to use the site today. Throughout the 1960s, various test and research facilities were constructed at Plum Brook Station to support NASA's aerospace program. The major research facilities that evolved in the 1960s are:[10]

- *Liquid Hydrogen Pump Site (A Site Complex)* - This facility was utilized to test liquid hydrogen research pumps of various designs up to pump speeds of 60,000 revolutions per minute.

- *High Energy Rocket Engine Research Facility (B1 Site Complex)* - This facility was designed to test propellant systems at altitude conditions.

- *Space Propulsion Research Facility (B2 Site Complex)* - This facility was utilized to test space vehicles and upper stage rocket engines in a simulated space environment.

- *Rocket Dynamics and Control Facility (B3 Site Complex)* - This facility was utilized for altitude tests on various components for large rocket engines as well as for other research and development projects.

- *Turbo Pump Site (C Site Complex)* - This facility was utilized for research on liquid hydrogen turbo pumps and pump inducers.

- *Controls and Turbine Test Site (D Site Complex)* - This facility was utilized to test research turbines in order to design drive turbines for rocket propellant pumps for chemical and nuclear engines.

- *Dynamics Stand (E Site Complex) Space Power Facility* - This facility is a 144 feet test stand equipped with electromagnetic shake devices. It was used to simulate forces spacecraft are expected to encounter during launch and in flight.

- *Hydraulics Lab (F Site Complex)* - At this test site, cryogenic liquid such as liquid hydrogen was passed through test set-ups to obtain data on various fluid flow conditions.

- *G Site Complex* - This test site was utilized to test turbo pumps. During a 1964 test, hydrogen leaking from a pump caused an explosion and the complete destruction of the G Site Complex. The research being conducted

at the site was near completion at that time. The site was demolished and has not been used since.

- *Fluorine Pump Site (I Site Complex)* - At this site, liquid fluorine pumps with speeds up to 20,000 revolutions per minute and flow rates of 50 pounds per second were tested.

- *Oxidizer Hydraulics Lab (J Site Complex)* - Rocket engine oxidizer system components were tested at this facility to determine how they reacted with other materials.

- *Cryogenic Propellant Tank Site (K Site Complex)* - This facility was used to test propellant tank insulation systems and to determine pressurizing gas requirements during propellant outflow. The tank served as a research test chamber where liquid hydrogen rocket fuel tanks were tested.

- *Hypersonic Tunnel Facility (HTF)* - In this facility, air velocities and temperatures were created to simulate rocket flight speeds up to seven times the speed of sound and altitude conditions up to 120,000 feet.

- *Space Power Facility (SPF)* - This facility is a very large vacuum tank used for the testing of spacecraft and/or their subsystems and components in a simulated space environment. The vacuum chamber is the largest ever built. It was also designed to accommodate tests involving reactor operations but was never utilized for that purpose. In 1979, the facility was modified for use by Garrett Corporation to produce uranium hexafluoride gas centrifuges for the Department of Energy (DOE). The facility was utilized for this purpose from August 1979 through November 1986. The facility has since been restored to support additional NASA vacuum tests and is currently in use today.

On June 30, 1974, Plum Brook Station was placed in a standby condition. A skeleton crew of NASA personnel provided maintenance and oversight of Plum Brook Station during its standby period. NASA declared approximately 2,152 acres of the original 9,009 acres as excess in April 1978. The Perkins Board of Education received 46 of the excess acres, which included buildings 7142, 7144, 7191, 7192, 7193, 7231, 7232, 8191, 8232, and 8431. The Perkins Board of Education uses the land as a bus transportation center.

NASA manages the remaining excess land and has a use permit with the Ohio National Guard for 604 acres. Approximately 900 acres is leased to local farmers. NASA presently controls 6,435.5 acres.

From 1980 through 1986, the Space Power Facility (SPF) was utilized by Garrett Corporation to produce uranium hexafluoride gas centrifuges for the Department of Energy (DOE). In 1988 Plum Brook Station began emerging from standby status and utilizing the following major aerospace facilities: SPF, B-2 Facility/Space Propulsion Research Facility (SPRF), the Cryogenic Propellant Tank Site (K-Site), and the Hypersonic Tunnel Facility (HTF). In the interval between standby and reactivation, some of the facilities were demolished.

In addition to NASA activities currently conducted at Plum Brook Station, the Department of Agriculture, Department of Interior, Department of Labor, the Immigration and Naturalization Services, and the Federal Bureau of Investigation have offices at Plum Brook Station for non-aerospace activities. Table 2-1 summarizes the current and historical uses of the major Plum Brook Station aerospace research facilities.

2.2.2 Site Regulatory History

This section of the PA report contains information on environmental permits, known hazardous material releases, and remediation activities.

2.2.2.1 Environmental Permits Issued or Applied For/Other Environmental Considerations

Environmental permits currently held by NASA LeRC Plum Brook Station are as follows:

TABLE 2-1. HISTORICAL USE AND CURRENT STATUS OF PLUM BROOK STATION NASA FACILITIES 1963-PRESENT

FACILITY	HISTORICAL USE	AGENCY	CURRENT STATUS/USE	AGENCY
Plum Brook Reactor Facility	1963-1973/Nuclear reactor	NASA	Inactive, licensed through NRC for safe protection and storage	NASA
Space Power Facility	1960s-1974/Environmental test chamber 1979-1986/Production of uranium hexafluoride gas centrifuges	NASA Garrett Corp.	1988 - Present/ Environmental test chamber See Above	NASA
A Site Complex. Liquid Hydrogen Pump Site	1960s-1974/Testing of liquid hydrogen research pumps	NASA	Inactive	NASA
B1 Site Complex. High Energy Rocket Engine Research Facility	1960s-1974/Testing of rocket propellant systems at altitude conditions	NASA	Inactive	NASA
B2 Site Complex. Spacecraft Propulsion Research Facility	1960s-1974/Testing of space vehicles and upper stage rocket engines in simulated space environments	NASA	1988-Present/ Environmental test chamber. Plan to fully reactivate in 1994.	NASA
B3 Site Complex. Rocket Dynamics and Control Facility	1960s-1974/Altitude tests on large rocket engines	NASA	Inactive	NASA

TABLE 2-1. HISTORICAL USE AND CURRENT STATUS OF PLUM BROOK STATION NASA FACILITIES 1963-PRESENT

FACILITY	HISTORICAL USE	AGENCY	CURRENT STATUS/USE	AGENCY
B Control and Instrument Building	1960s-1974/Control and instrument area for HTF, B-1, B-2, B-3	NASA	Operational - Being revamped to support HTF activities.	NASA
C Site Complex. Turbo Pump Site	1960s-1974/Research on liquid hydrogen turbopumps and pump inducers.	NASA	Inactive - Used in the past to store chemicals and waste. May be modified to store F-Site materials.	NASA
D Site Complex. Controls and Turbine Test Site	1960s-1974/Research turbines and develop and test control systems for use at PBS test sites	NASA	Used by Departments of Agriculture and Interior for storage and work areas.	NASA
E Site Complex. Dynamics Stand	1960s-1974/Simulation of forces encountered during launching and landing of spacecraft	NASA	Inactive	NASA
F Site Complex Hydraulics Lab	1960s-1974/Testing of cryogenic and other fluids to support rocket engine concepts	NASA	Inactive - Except for crate storage. May be used in future to support K-Site Activities	NASA
G Site Complex	1960s-1964/Testing of turbo pumps using liquid hydrogen.	NASA	Facility is nonexistent. Demolished in 1965.	NASA

TABLE 2-1. HISTORICAL USE AND CURRENT STATUS OF PLUM BROOK STATION NASA FACILITIES 1963-PRESENT

FACILITY	HISTORICAL USE	AGENCY	CURRENT STATUS/USE	AGENCY
H Control and Instrument Building	1960s-1974/Control and instrument area for Plum Brook Station research sites	NASA	Inactive	NASA
I Site Complex. Fluorine Pump Site	1960s-1974/Testing of liquid fluorine pumps	NASA	Inactive	NASA
J Site Complex. Oxidizer Hydraulics Lab	1960s-1974/Evaluation of oxidizing system components for rocket engine systems	NASA	Inactive	NASA
K Site Complex. Cryogenic Propellant Tank Site	1960s-1974/Testing of super propellant tank insulation systems	NASA	Active - Used to conduct liquid and slush hydrogen propellant research.	NASA
Hypersonic Tunnel Facility	1960s-1974/Simulation of flight speeds and altitude conditions	NASA	Being revamped for future use	NASA

- Open Burning Permit
- National Pollutant Discharge Elimination System (NPDES) Permit.

Open Burning Permit

The Plum Brook Station Open Burning Permit is actually a written authorization obtained on a yearly basis from the Ohio Environmental Protection Agency (OEPA) Northwest District Office. The Open Burning Permit is requested by Plum Brook Station yearly in writing to allow the burning of open fields each spring. The field burning is conducted in order to eradicate noxious weeds and to propagate field grasses that the site wildlife feed upon. A burn campaign, lasting approximately three months, is conducted and terminated prior to the nesting of Plum Brook Station wildlife. Each year, alternating northern and southern halves of the station are burned. The northern half was burned in the spring of 1991.

NPDES Permit

NASA LeRC Plum Brook Station has a NPDES permit (application no. OH0001392) for nine outfalls.[12] The permit was originally issued by USEPA for seven outfalls. In March 1983, USEPA transferred primary authority for the NPDES permit program for federal facilities in Ohio to OEPA. Two new outfalls were added to the permit in April 1991. Three of the nine permitted outfalls are process/stormwater discharges to Kuebeler Ditch (outfall 001), Ransom Brook (outfall 002), and Plum Brook at Pentolite Road (outfall 003). Four outfalls (004 - 007) are effluent from Plum Brook Station sewage treatment plants, which also discharge to Kuebeler Ditch, Ransom Brook, and Plum Brook. Outfall 008 is effluent from the B/Control Building sewage package plant which ultimately discharges to the Box Factory Road Ditch. Outfall 009 is non-contact cooling water from K Site that is discharged onto the ground 100 feet from the building. The most recent NPDES permit granted to Plum Brook Station by the OEPA (OEPA Permit No. 2I000002*CD) has an effective date of December 22, 1988, and will expire at midnight on

December 13, 1993. OEPA's Northwest District Office in Bowling Green is the administrative and enforcement agency of Plum Brook Station's permit. A copy of Plum Brook Station's NPDES permit is included as Appendix C. Examples of NPDES violation reports are also provided in Appendix C.

Other Permit Considerations and Environmental Documentation

Resource Conservation and Recovery Act

NASA LeRC Plum Brook Station has registered with the OEPA as a generator of Resource Conservation and Recovery Act (RCRA) hazardous waste and has received an EPA identification number (#OH3800015379). Plum Brook Station operations (with the exception of ongoing underground storage tank removal projects) generate significant quantities of RCRA hazardous waste. Wastes generated from routine operations are stored in Building 9206, which is managed as a less-than-90-day storage area. As no RCRA hazardous wastes are stored on-site for greater than 90 days, and no hazardous wastes are treated or disposed of on-site, Plum Brook Station is not required to submit either a RCRA Part A or Part B permit application.

Air Permits

In order to comply with the Federal Clean Air Act (CAA), the State of Ohio through its CAA State Implementation Program requires Permits to Install (PTI) New Sources of Pollution for sources installed since 1974, and Permits to Operate (PTO) for all air pollution sources. Small emissions sources (typically less than 10 tons/year) often receive "Registration Status" or "T Status" on the OEPA records. In response to a 1972 request from the Ohio Board of Health, Plum Brook Station pre-registered potential air pollution sources with the Ohio Air Pollution Control Board for information purposes only.[13] Plum Brook Station did not and has not applied for any OEPA air permits to date, as the facility was placed in standby condition in 1974. Many of the test facilities remain

inactive today; therefore, many potential air emission sources are not operating at this time. Potential sources include rocket testing activities, gas/liquid storage, cooling towers, boilers, paint-spray booth, incinerator, and construction activities. Even if these activities were occurring, the emissions would be very small. Plum Brook Station is planning to conduct an air pollution source inventory in the near future. Additionally, if a significant portion of Plum Brook Station were reactivated or a significant new source were installed, emissions would be evaluated to determine, what, if any, air emissions required permitting.

Permission to Use Chemicals in Cooling Tower

Plum Brook Station has applied to OEPA for permission to use additives (algicide and corrosion inhibitors) in the two SPF cooling towers.[14] A list of the proposed chemicals to be used in the cooling towers was provided to the OEPA on September 25, 1989. The OEPA approved some of the chemicals for use, but has yet to approve the use of all the proposed chemicals. Plum Brook Station is currently gathering data in order to resubmit its request for permission to use additives in the cooling towers.

National Environmental Policy Act Documentation

NASA LeRC prepared an environmental impact statement (EIS) in 1971 for both the Cleveland and Plum Brook Station sites. The 1971 EIS was superseded by a 1978 EIS which was submitted to the OEPA. Currently, Environmental Resources Documents (ERDs) are prepared to supplement the 1978 EIS. The current ERD was prepared in August 1990 and addresses management of hazardous substances and hazardous wastes at the Cleveland site and Plum Brook Station.

2.2.2.2 Environmental Remediation History

The OEPA conducted a PA of the Plum Brook Station in 1983.[15] The areas of interest were the red water ponds and the 1981 spill of approximately 170 gallons of polychlorinated biphenyls (PCBs) that occurred at Building 9206. An on-site inspection of these sites was conducted by the OEPA Division of Solid and Hazardous Waste Management (DSHWM). The potential for groundwater and surface water contamination from the Army's production of explosives in the 1940s was assessed at that time as well as the possibility for the spilled PCBs to contaminate soil and groundwater. DSHWM recommended that further sampling be conducted at the areas of concern due to the limited amount of information available.

Red Water Discharges

Throughout the years that NASA has operated Plum Brook Station, leakage/seepage has been observed from the red water ponds. On the afternoon of April 13, 1977, a small surface ditch adjacent to the Pentolite Road Red Water Pond was observed to contain localized pockets of reddish-brown water.[16] It was discovered that one of the drain tiles on the southeast corner of the spoils area associated with the red water pond had broken. The spoils area were created by the Army in the early 1940s by spreading neutralized chemical waste from the production of explosives onto the ground. Retention dikes and sump pits were excavated immediately to prevent leakage of the red water to surface streams. The surface ditch was diverted. Approximately 60,000 gallons of red water were removed from the pond by a private disposal contractor and hauled off-site. The pond was backfilled and measures were taken to eliminate ponding and to provide better surface drainage to local drainage ditches.

On April 3, 1990 and again on February 19, 1991, reddish-brown water was observed discharging into the Pentolite Ditch from an underground discharge pipe.[17,18,19] It was assumed that the source of the red water was runoff. In both instances, the OEPA

and the National Response Center (NReC) were contacted. The amount of red water released to the Pentolite Ditch is unknown, but the estimated flow rate during the April 1990 incident was 5 gallons per minute. Water samples were taken upstream of the discharge, at the discharge point, and downstream of the discharge at the Plum Brook weir but no toxic or hazardous substances were detected in the analysis. By the time the red water mixed with the water in Pentolite Ditch, it became diluted.

The red water ponds are not inspected on a routine basis for overflow or discharge into the onsite streams or ditches. If a heavy rainfall occurs, it is possible that these areas will be inspected at that time, particularly the discharge pipe into the Pentolite Ditch.[20]

Various samples have been taken of the standing water in the ponds, the sediments in the pond, and the soils surrounding the pond. A summary of analytical results is included in Section 5 of this PA report.

The U.S. Army Corps of Engineers under the Defense Environmental Restoration Program conducted an environmental assessment in 1989 of the potential areas of contamination caused by PBOW.[21] The assessment involved an investigation of remaining Department of Defense structures and the contiguous groundwater, surface water, and soil for possible contamination by any hazardous substance associated with the PBOW. Results of the investigation are currently being evaluated. The U.S. Army has committed to remediate any sites identified as contaminated from PBOW operations.[22]

PCB Spill at Building 9206

In 1981, a spill of approximately 170 gallons of PCB-contaminated oil occurred on the concrete floor of Building 9206 while a contractor was moving a PCB-contaminated transformer.[23] One hundred twenty gallons of the spilled oil were recovered from the warehouse floor. The remaining PCB oil leaked under the concrete floor and contaminated the soil. Concentrations of PCBs were found in the soil up to 2,400 ppm.

Some contaminated soil and all free liquids were removed, and four monitoring wells were installed to detect groundwater contamination. After several years of groundwater monitoring, no contamination was found. Total decontamination was performed in 1989. Post decontamination groundwater monitoring showed no PCB concentrations. The decision to discontinue groundwater monitoring was made in 1990 after discussions with USEPA.[24]

Other Releases

Although the above releases were the focus of the OEPA's 1983 PA of Plum Brook Station, other releases of petroleum materials have been observed and documented as discussed below. The releases discussed below are not considered to include all releases that may have occurred at Plum Brook Station; however, they are of large volumes and were recorded or reported to NASA officials or federal and state agencies.

Spill of Diesel Fuel at Space Power Facility

On October 4, 1980, a spill of several thousand gallons of diesel oil occurred at the SPF while Garrett Corporation was using the facility.[25] The source of the spill was an underground tank which had overflowed. Diesel fuel was siphoning from a 100,000-gallon above-ground tank to the smaller underground tank, causing it to overflow. The spilled oil was released to the SPF sewage treatment plant, which discharges to Kuebeler Ditch, and was also found in a sump pit at SPF. Dams were constructed to preclude further release to the ditch; oil was skimmed from the STP and pumped from the sump pit; straw bales were brought in to absorb the oil from the ditch water; other on-site ditches that became contaminated were cleaned by means of a backhoe. All contaminated dirt and straw were disposed of at the county landfill. Recovered diesel fuel and contaminated water were collected and hauled off-site for disposal.

A Garrett Corporation employee, acting as a private citizen, contacted the U.S. Coast Guard and reported the spill. The Coast Guard investigated the spill on October 6, 1980. The Coast Guard was satisfied that no pollution had occurred. Due to the classified nature of Garrett Corporation's activities at the SPF, NASA had no involvement in the cleanup efforts or notification to federal, state, or local agencies.

Naphtha Spill at "A" Site Complex

On August 5, 1978, approximately 1600 gallons of raw, untreated coal tar-derived naphtha leaked from a fuel storage trailer at A Site Complex.[26] The trailer was located at the site in an excavated earthen retention basin. The base of the retention basin was hard clay and considered to be impermeable. The spilled naphtha was contained in the retention basin and therefore did not result in a release to surface waters. An off-site disposal company was contracted to pump the spilled naphtha from the retention basin the same day the spill was discovered. Approximately 900 gallons of raw material were removed by the disposal company from the basin and hauled off-site for disposal. An unknown amount of naphtha was pumped into drums for use in fire training exercises conducted in the burn pit on Snake Road. After all the raw material had been removed from the basin, the basin was flushed with water.

No. 2 Fuel Oil Spill at PBRF

On December 28, 1976, 50-75 gallons of No. 2 fuel oil leaked from a 200-gallon above-ground tank which fed fuel to a boiler in the PBRF service building.[27] The above-ground tank failed and the contents were released to a concrete catch basin that flows to the Pentolite Ditch. Approximately 1,000 feet of the ditch were contaminated with the released oil. Containment dams were constructed at the ditch to prevent the oil from flowing further down the ditch. Oil-contaminated water was pumped from the catch basin, and absorbent pillows were used to absorb small pockets of oil in the ditch. All brush

and reeds contaminated with the oil were excavated and removed and the surface area of the ditch cultivated for degradation. The catch basin and culvert were flushed with high-pressure hoses. Water samples were obtained daily from the ditch for a three-month period and analyzed to monitor the plume and to ensure that clean-up efforts were effective. The U.S. Coast Guard and USEPA were notified of the release. It was determined that there was no release to public streams or waterways.

Asbestos Abatement

A 1986 environmental audit of Plum Brook Station showed that there was considerable degradation of the asbestos insulation on outside steam pipes and associated systems throughout the facility.[1] It was apparent from the audit that an extensive asbestos abatement program needed to be implemented in order to remove or encapsulate asbestos-containing material (ACM). An area of particular concern was the ACM on the pipes from the B-boiler building (Building 5221) to the steam accumulators, at the accumulators, and from the accumulators to the ~~B-2~~ Facility (Building 3211). Also of concern were the accumulator tanks, headers, transfers lines, and valves at the accumulator system. Large pieces of asbestos insulation were observed lying on the ground beneath the 30-inch steam line and around the associated system components. Air samples were taken downwind of the contaminated systems. Asbestos was detected in the samples. Visual observations indicated contamination in the soil and ponds in the area. 5231

An asbestos abatement program was implemented at Plum Brook Station in 1988. The program's purpose was to identify the extent of asbestos contamination at the facility and to identify areas requiring immediate abatement. In the abatement program, asbestos insulation was removed from the 30-inch steam line, the accumulators, and the associated systems. Asbestos insulation that had fallen to the ground or accumulated in the trenches at the B test site was removed and disposed of by the abatement contractor. Top soil beneath the steam line was removed from the areas where asbestos

was observed on the soil and disposed of off-site with the asbestos. Soil samples collected before removal indicated asbestos contamination.

Underground Storage Tank Program

Following a 1989 assessment of the 19 underground storage tanks (USTs) associated with Plum Brook Station operations, 15 tanks were identified for removal.[28] These tanks were removed during July through December 1989. The 15 tanks were removed in the following order:

- 9 tanks at the Garage and Maintenance Area (Buildings 7121, 7131, and 7132);
- 2 tanks at the Space Power Facility (Building 1411);
- 1 tank at the Pump Station (Building 8133);
- 3 tanks at the Plum Brook Reactor Facility (Building 1131).

Six of the tanks removed contained waste oil mixed with solvents or petroleum products (gasoline or diesel fuel). The remaining tanks contained water prior to their removal, but at some point during their operating lifetime contained solvents, gasoline, or diesel fuel. All the tanks except one showed evidence of leaking while in the ground. All excavations exhibited some amount of visible contamination. All visibly contaminated soil was removed from the excavations, and the excavations were backfilled with clean sand. Based on preliminary post-removal sampling, further soil remediation at the tank removal sites is required. NASA has contracted a firm to conduct a remedial investigation/feasibility study (RI/FS) of the tank removal sites to identify the extent of residual contamination and to proceed with further corrective actions.

The remaining four USTs will be removed as part of the Plum Brook Station Underground Storage Tank Compliance Program. Removal is scheduled for 1991 and 1992.

3. ENVIRONMENTAL SETTING

This section of the PA report describes the environmental setting at Plum Brook Station. Information provided herein includes descriptions of general environmental conditions and target populations.

3.1 Environmental Media Surrounding Facility

3.1.1 Climatic Data

The climate of northern Ohio is continental in character but is strongly influenced by Lake Erie. In north-central Ohio (Erie County) predominant westerly winds parallel the lake shore and do not come inland as frequently as they do on eastern reaches of Lake Erie. The weather changes every few days when warm and cold fronts move through the area.

Summers are moderately warm and humid. Temperatures occasionally exceed 90°F. Temperatures rarely exceed 100°F. Winters are cold and cloudy. Temperatures are sub-zero an average five days per winter. Daily temperature range is greatest in summer and least in winter. Annual temperature extremes usually occur after late June and in December. On an average, the temperature falls to freezing first in October. The last freezing temperature occurs in April.

3.1.1.1 Precipitation

Climatic data prepared by NOAA are available for the City of Sandusky, 3.5 miles to the north of Plum Brook Station. The normal annual precipitation at Sandusky is 33.90 inches, based on the 1951-1980 record.[29] The two year-24 hour rainfall event for Sandusky is 2.45 inches.[30]

Average annual water loss is estimated to be 22.5 inches for Plum Brook Station. This figure is based on data compiled from 1931-1980.[32] Water loss is defined as the difference between precipitation over a drainage area and the stream flow from the drainage area.[31] Water is lost through evapotranspiration, infiltration, and evaporation.

3.1.1.2 Flood Plain Data

Peak discharges for Pipe Creek, Plum Brook, and Storrs-Hemminger Ditch are presented in Table 3-1. The data were obtained from the National Flood Insurance Program.[32]

Figure 3-1 (7 sheets) shows the on-site land areas that would be inundated by 100- and 500-year flooding of Pipe Creek, Plum Brook, Ransom Ditch, and Lindsley Ditch.

Two operable units are within the 100-year and 500-year floodplains: Unit 2, West Area Red Water Ponds A-1 and A-2 and Unit 12, Disposal Area 2A. Red Water Pond A-2 is entirely within both the 100-year and 500-year floodplains. Red Water Pond A-1 is within the 500-year floodplain. Approximately half of Disposal Area 2A is within both the 100-year and 500-year floodplains.[33]

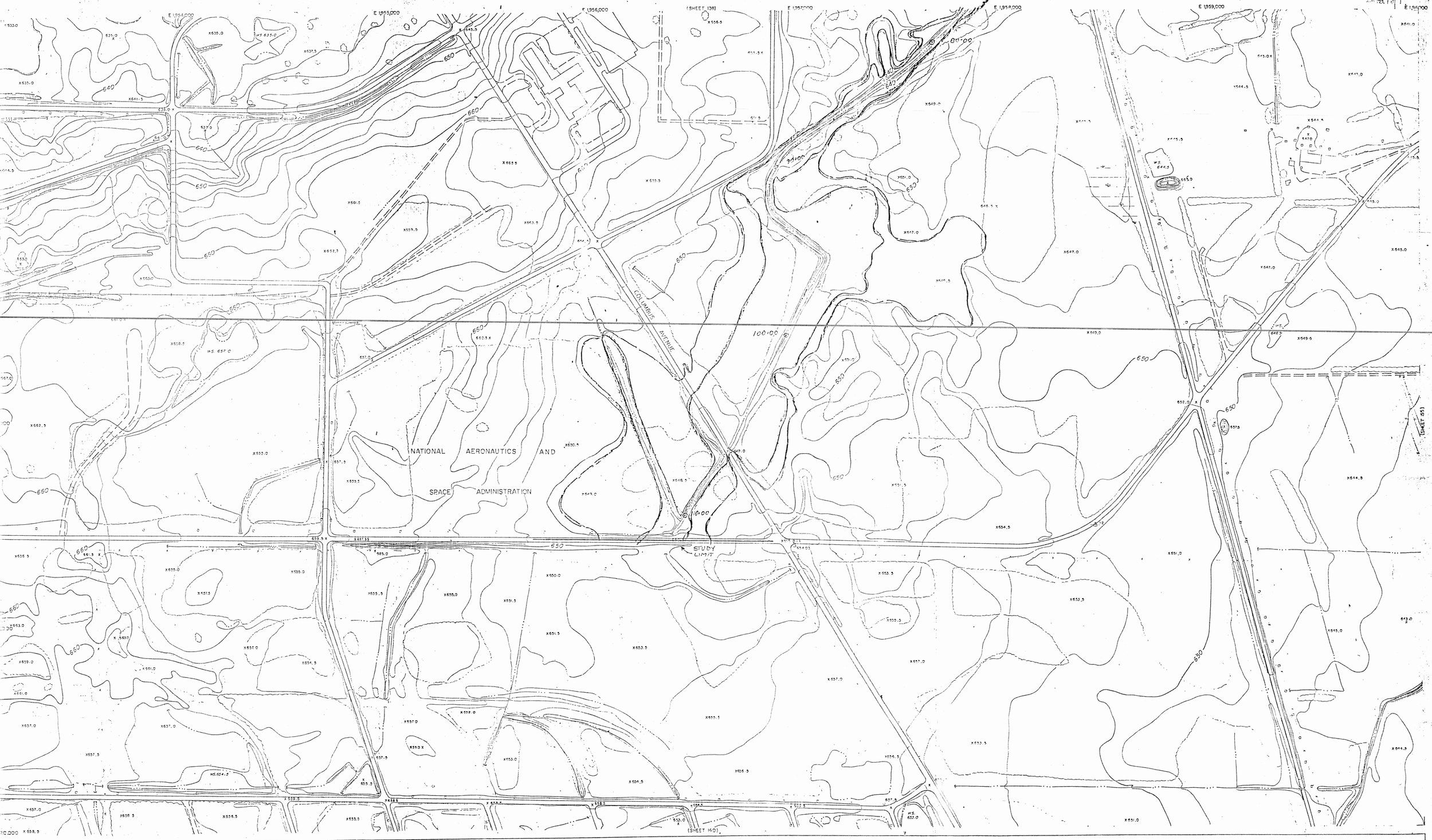
3.1.1.3 Monthly Wind Rose Data

The NOAA does not prepare a monthly wind rose diagram for Sandusky or Erie County.[30] The most current wind rose for the Plum Brook Station area was prepared in 1956 by NACA.[45] This wind rose is presented in Figure 3-2. It is known that wind direction is southwest 55 percent of the time through all 12 months. There is an increased frequency of northerly and northeasterly winds during spring and summer months due to onshore lake breezes created by temperature inversions.[34]

TABLE 3-1. PEAK DISCHARGES

Flooding Source and Location	Drainage Area (mi^2)	Peak Discharges (cfs)		
		10-year	100-year	500-year
Pipe Cr. above Taylor Ditch	23.6	2110	2525	2790
Storrs-Hemminger at Rte. 2	0.4	93	164	200
Plum Brook at Perkins Avenue	7.1	901	1603	1955

PAS024-26



TOPOGRAPHIC MAPS
PREPARED BY
KUCERA & ASSOCIATES, INC
PHOTOGRAMMETRIC ENGINEERS
MENTOR, OHIO

FLOODED AREAS
ERIE COUNTY, OHIO
LINDSEY DITCH
SCALE: 1"=200'

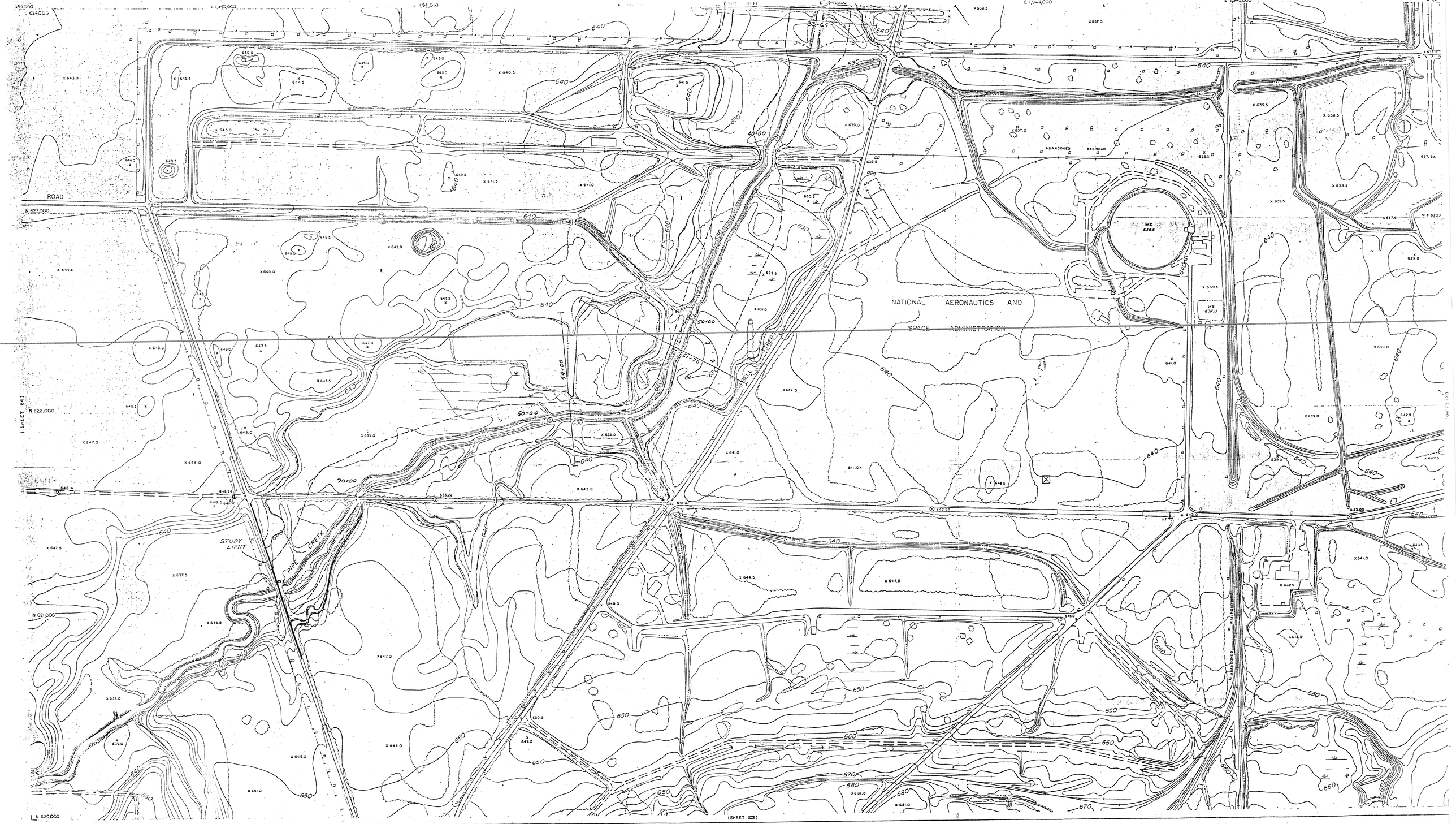
200 0 200 600 1000

DATE OF PHOTOGRAPHY: MAY 9, 1971 CONTOUR INTERVAL: 2'

LEGEND
100 YR FLOOD
500 YR FLOOD

PREPARED FOR
BOARD OF COUNTY COMMISSIONERS
J. P. GASTEIER, CHAIRMAN
ALVIN J. VAITH — JOHN W. SCHAEFFER
K. A. POLTA, ENGINEER

PLATE 11
SHEET 139



TOPOGRAPHIC MAPS
PREPARED BY
KUCERA & ASSOCIATES, INC
PHOTOGRAMMETRIC ENGINEERS
MENTOR, OHIO

N

FLOODED AREAS
ERIE COUNTY, OHIO
PIPE CREEK
SCALE: 1"=200'

200 0 200 600 1000

DATE OF PHOTOGRAPHY: MAY 9, 1971 CONTOUR INTERVAL: 2'

LEGEND
100 YR FLOOD
500 YR FLOOD
FLOODWAY

PREPARED FOR
BOARD OF COUNTY COMMISSIONERS
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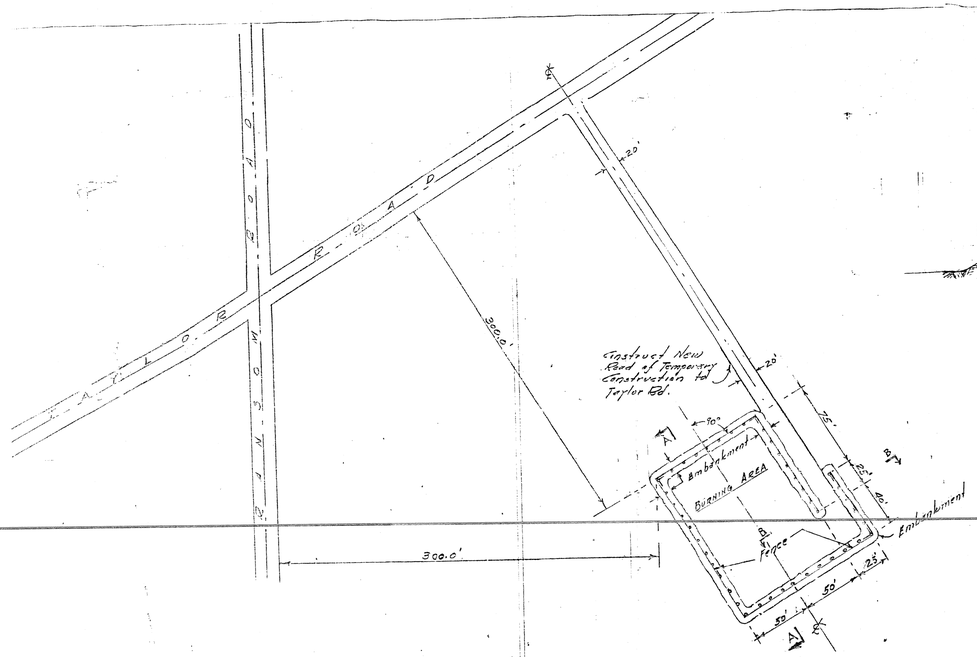
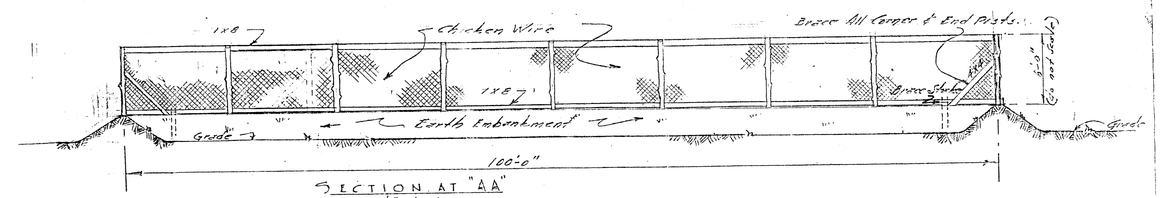
ALVIN J. VAITH – JOHN W. SCHAEFFER
K. A. POLTA, ENGINEER

PLATE 5
SHEET 101

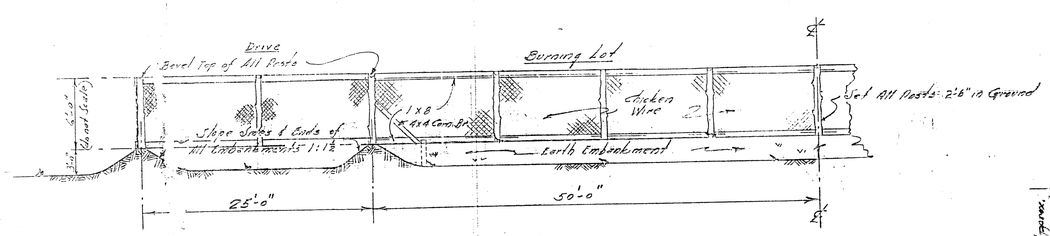


PLOT LAYOUT
1" = 60'-0"

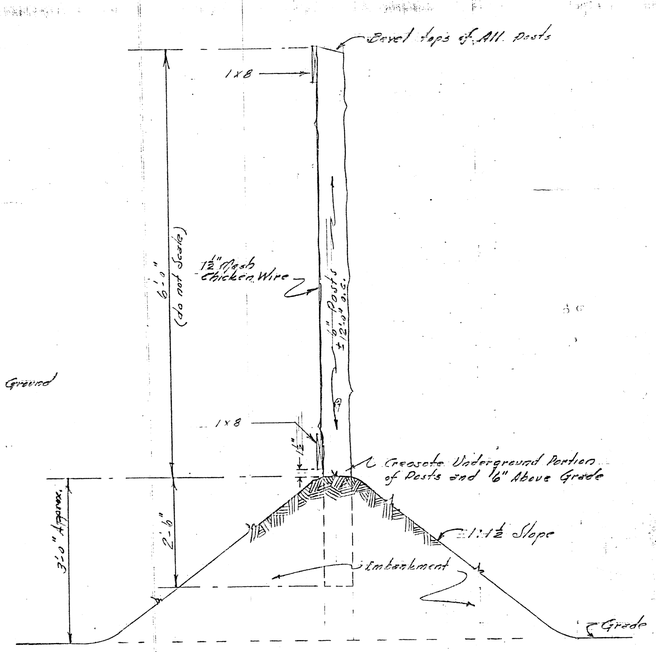


SECTION AT "AA"
1/8" = 1'-0"

Note:
Remove Earth in Burning Area to depth of Sod & Use for Embankments.
Provide 8" V.Tile Thru Embankments at Natural Low Points in Ground for Drainage.



SECTION AT "BB"
1/8" = 1'-0"



TYPICAL EMBANKMENT DETAIL
3/4" = 1'-0"

RUBBISH BURNING GROUND AT TAYLOR & RANSOM RDS.

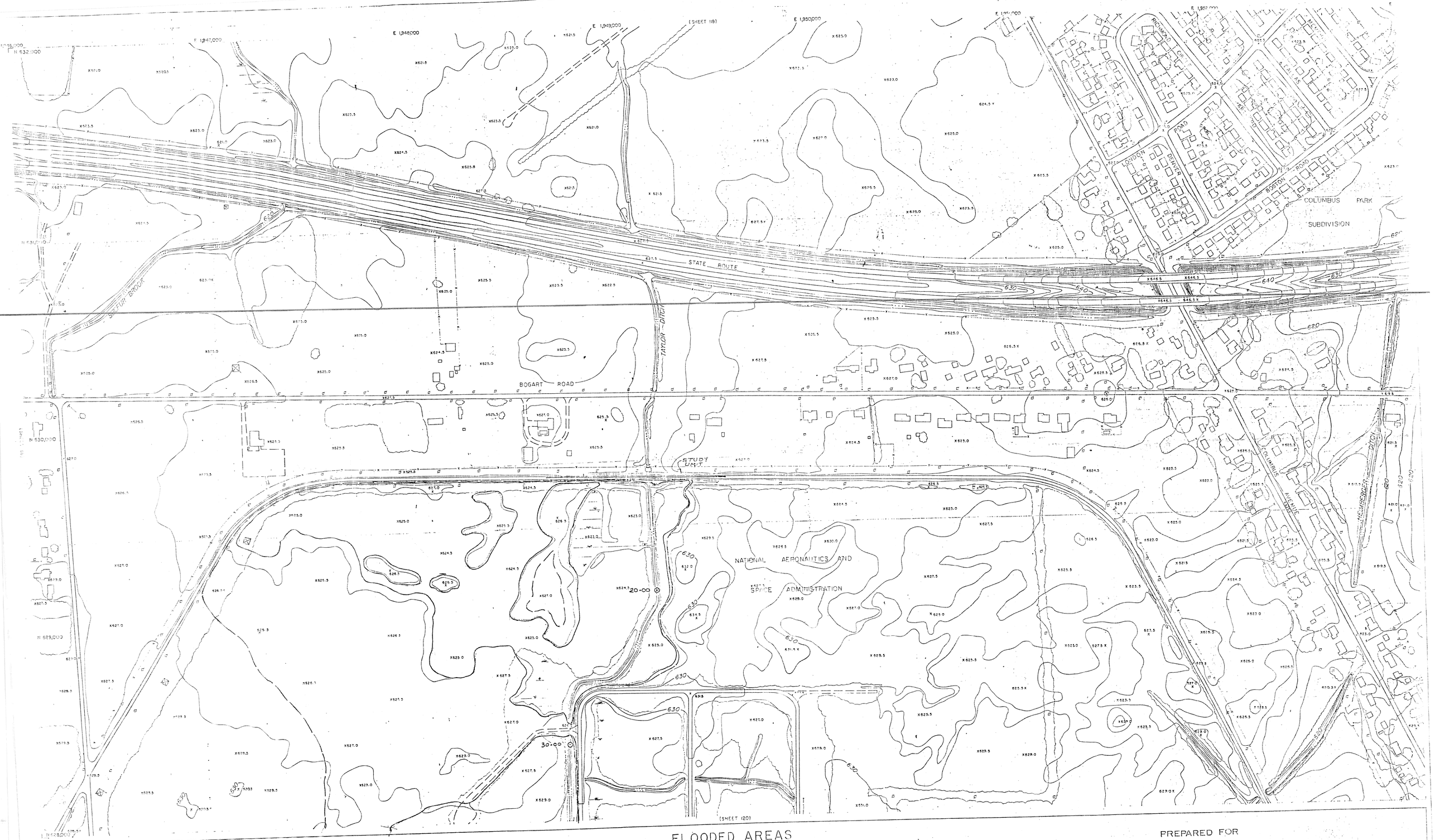
TROJAN POWDER COMPANY
PLUM BROOK ORDNANCE WORKS
SANDUSKY, OHIO

Scale Noted	Dr. Em.	Chkd by	App. by
Date 5-3-44		5/4/44	
Drawn by A.S.			

ORDNANCE APPROVAL	TROJAN APPROVAL
J. R. Fisher	T. R. Kelley

DATE OF ISSUE

DRAWING No. 9300
1669-T-603-9-1/2



TOPOGRAPHIC MAPS
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N

FLOODED AREAS
ERIE COUNTY, OHIO
RANSOM (TAYLOR) DITCH
SCALE: 1"=200'

LEGEND
100 YR FLOOD
500 YR FLOOD

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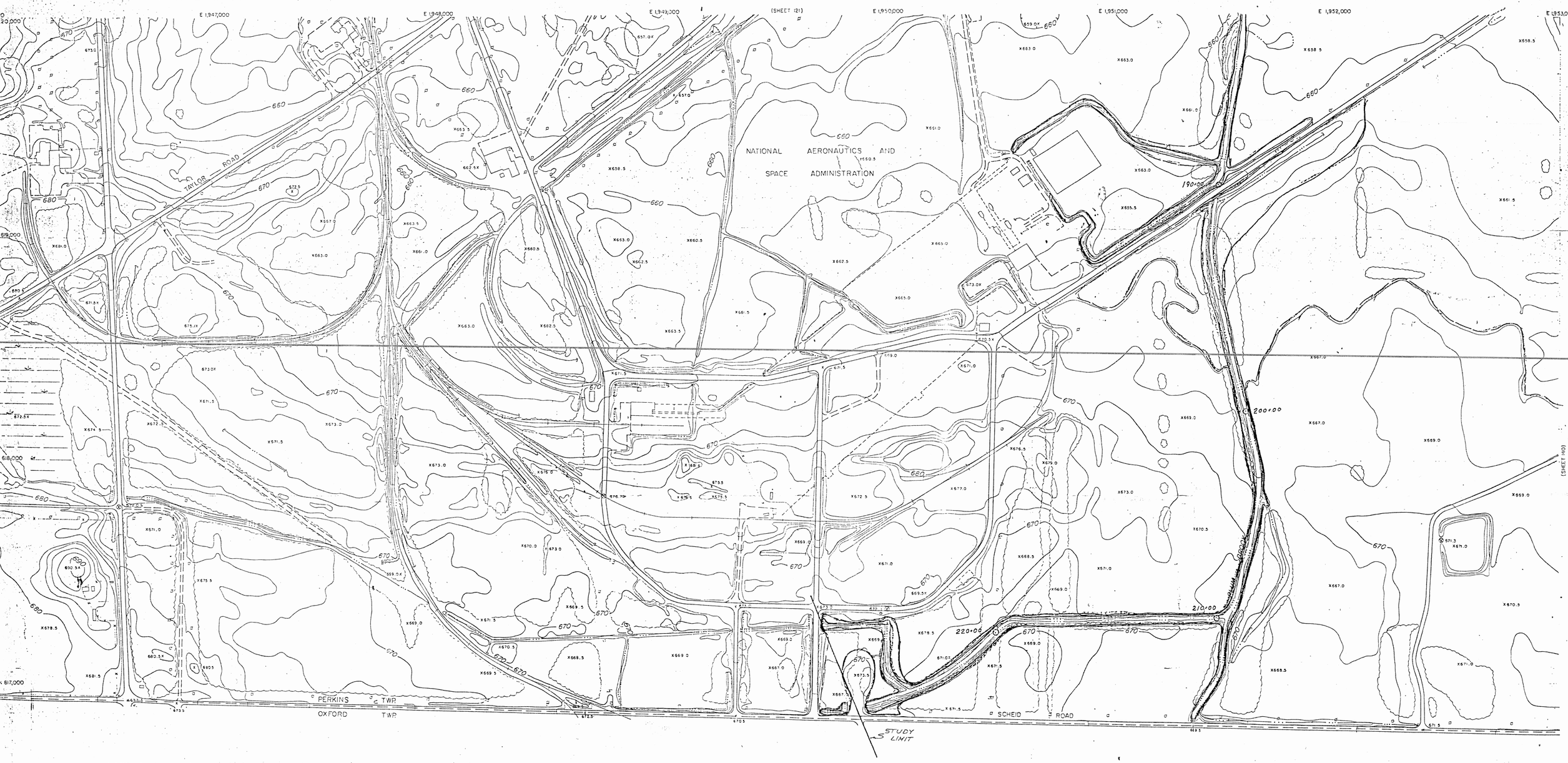
Sheet 4 of 7



TOPOGRAPHIC MAPS
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N

FLOODED AREAS
ERIE COUNTY, OHIO
PLUM BROOK

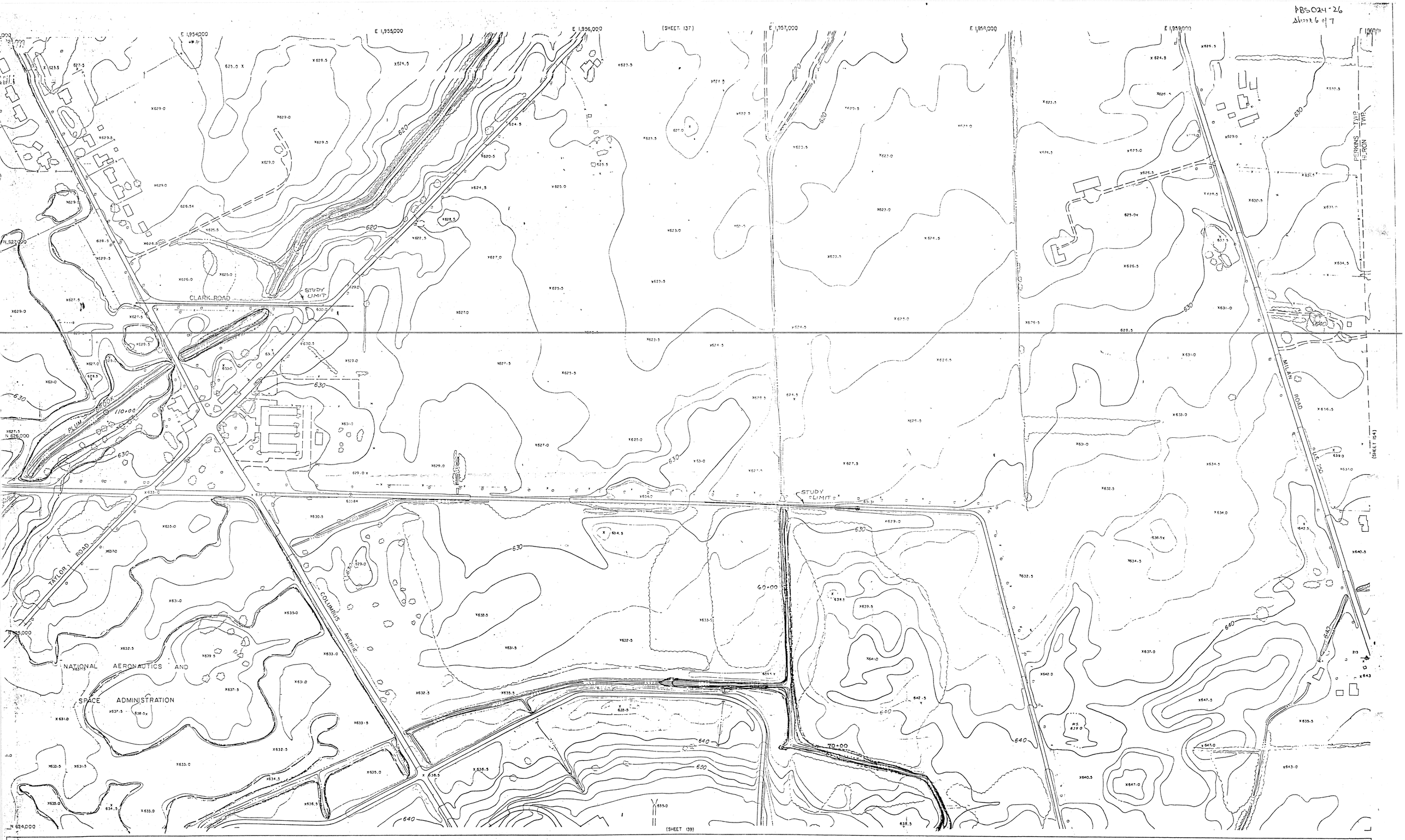
SCALE: 1"=200'

200 0 200 600 1000

LEGEND
100 YR FLOOD
500 YR FLOOD

PREPARED FOR
BOARD OF COUNTY COMMISSIONERS
J. P. GASTEIER, CHAIRMAN
ALVIN J. VAITH — JOHN W. SCHAEFFER

PB5024-26
Sheet 6 of 7



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MENTOR, OHIO

N

FLOODED AREAS
ERIE COUNTY, OHIO
PLUM BROOK – LINDSEY DITCH
SCALE: 1"=200'

LEGEND
100 YR FLOOD
500 YR FLOOD

PREPARED FOR
BOARD OF COUNTY COMMISSIONERS
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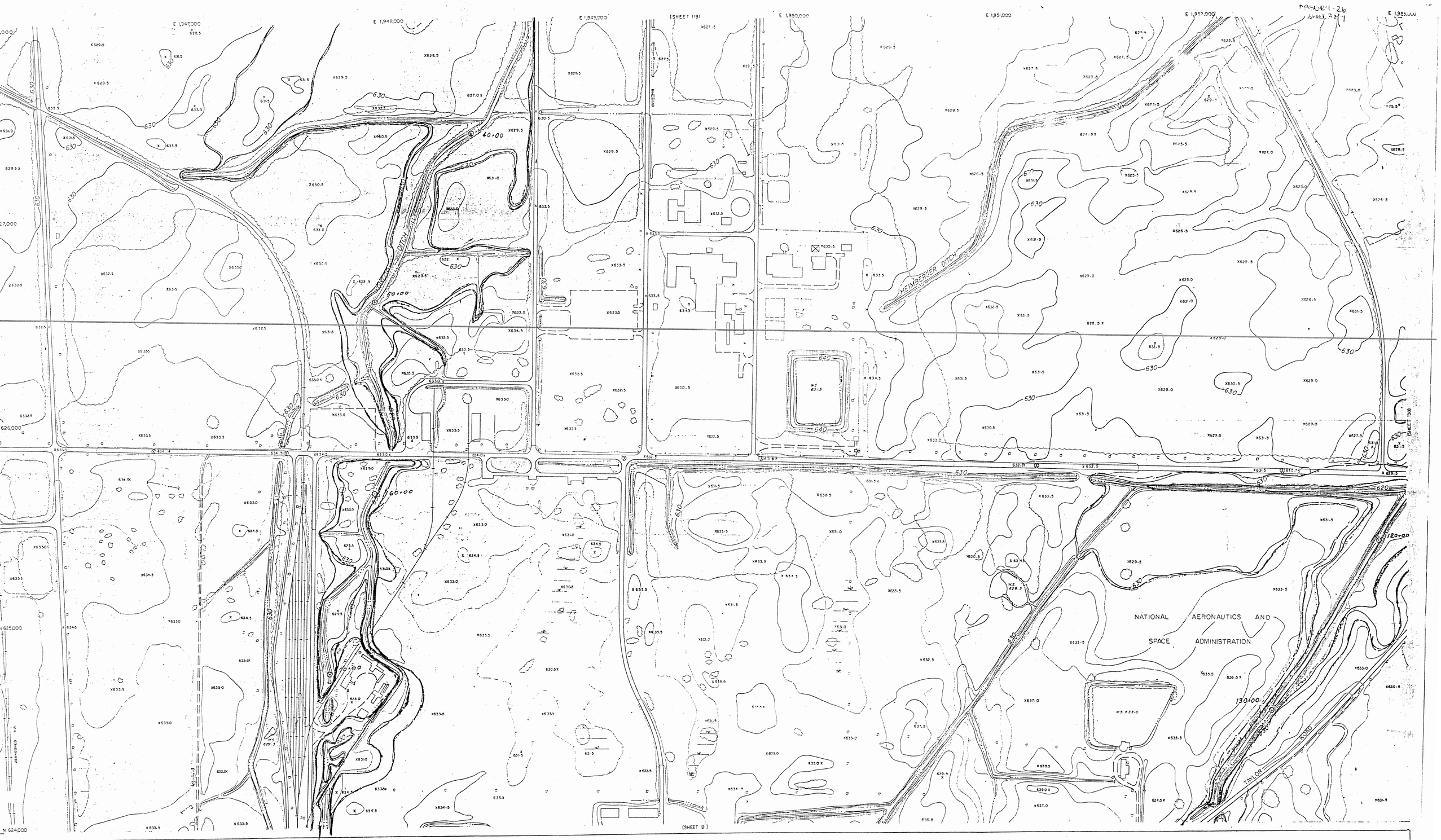
ALVIN J. VAITH – JOHN W. SCHAEFFER

PLATE 10



TOPOGRAPHIC MAPS
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KUCERA & ASSOCIATES, INC
PHOTOGRAMMETRIC ENGINEERS

N

FLOODED AREAS
ERIE COUNTY, OHIO
RANSOM DITCH – PLUM BROOK
SCALE: 1"=200'

200 0 200 600 1000

LEGEND
100 YR FLOOD
500 YR FLOOD

PREPARED FOR
BOARD OF COUNTY COMMISSIONERS
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ALVIN J. VAITH – JOHN W. SCHAEFFER

PLATE 7

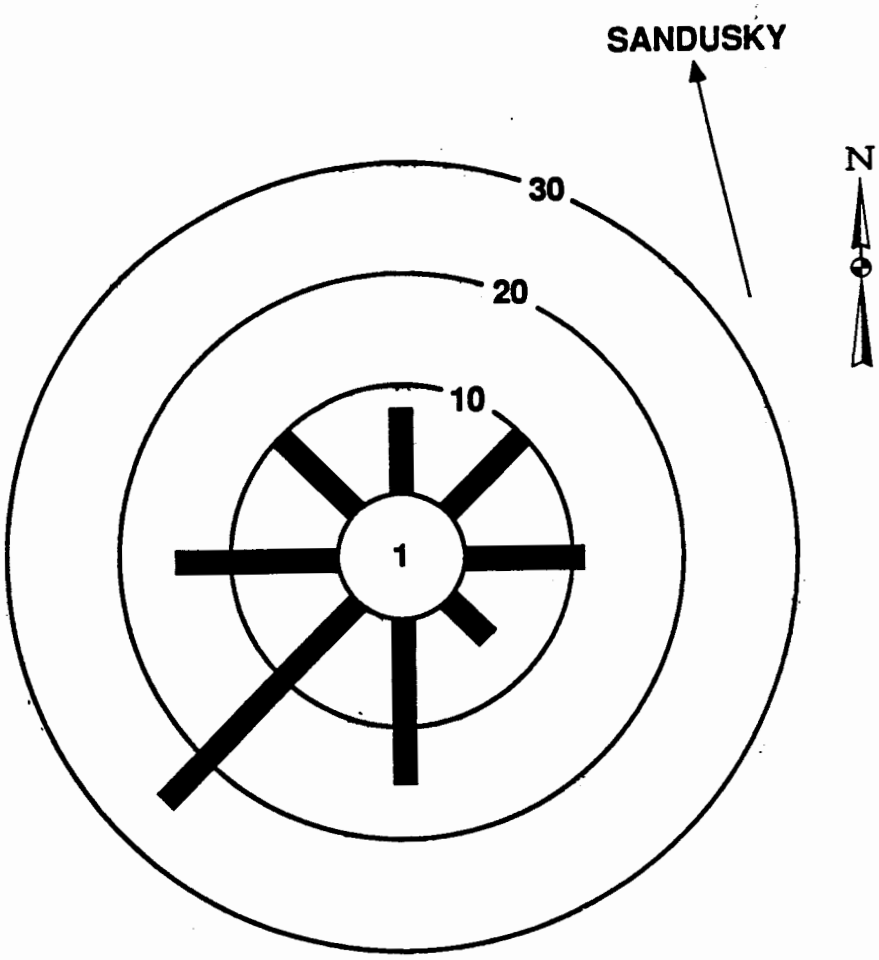


FIGURE 3-2. SANDUSKY WIND ROSE

3.1.2 Geologic Setting

3.1.2.1 Soil Formations Underlying Area

Two soil associations are present at Plum Brook Station based on mapping by the Ohio Department of Natural Resources (ODNR) in cooperation with the U.S. Department of Agriculture.[32] The Arkport-Galen association occurs in the northern and western portions of Plum Brook Station, and the Prout association occurs in the southern and eastern portions of the site.

The Arkport-Galen association is characterized by deep, nearly level to moderately sloping, well drained to moderately well drained soils that have a subsoil of loamy fine sand and fine sand and occur on sandhills and ridges. These soils formed in very fine sand deposited by wind and water as beaches, sand bars, and sand dunes. This association is made up of about 40 percent Arkport soils, 30 percent Galen soils, and 30 percent minor soils.

The Arkport soils are gently to moderately sloping and well drained. The Galen soils are nearly level and moderately well drained. The minor soils occur in level to depressional areas and in the flat areas between the sandhills and ridges. The minor soil associations are either very poorly or somewhat poorly drained.[32]

The Prout association, characteristic of the eastern and southern portion of Plum Brook Station, has moderately deep to deep, nearly level to gently sloping, somewhat poorly drained soils that have a subsoil of heavy silt loam to silty clay loam. This association occurs on uplands such as the sides of stream valleys, shale outcrop ridges, along drainageways and in some steeper areas.

The Prout soils are nearly level to gently sloping, dark colored, and somewhat poorly drained. These soils are underlain by shale bedrock at a depth ranging from 20

to 40 inches for the Prout soils, and at a depth ranging from 40 to 60 inches for the Prout soils, deep variant. The minor soils in this association include a broad spectrum of nearly level to depressional and very poorly drained to nearly level to gently sloping and well drained.

Soils across Plum Brook Station are highly variable in terms of thicknesses and permeabilities. The Arkport soils are loamy fine sands with very high permeabilities. The Galen soils are loamy fine sands with high permeabilities. The Prout soils are very sandy loams with moderately low permeabilities. Estimated ranges for these parameters are provided in Table 3-2. More details on soils are presented in Section 5.

3.1.2.2 Bedrock Geology

The bedrock formations of northwestern Ohio consist of carbonates (limestone and dolomite) and clastics (sandstones and shales) that regionally dip to the east. The study area is underlain by a relatively flat-lying sequence of Paleozoic sedimentary rocks which range in age from Precambrian to Devonian. The Silurian and Devonian formations that outcrop in Erie County are illustrated on Figure 3-3. The approximate thickness of formations that underlay Plum Brook Station is also illustrated on Figure 3-3. Bedrock at Plum Brook Station consists of four Devonian Formations (from oldest to youngest): the Columbus Limestone, the Delaware Limestone, the Plum Brook Shale/Prout Limestone, and the Ohio Shale.[34] The Columbus and Delaware Limestones occur in the northern and western portions of the study area, and the Plum Brook Shale/Prout Limestone and Ohio Shale occur in the southern portion of the site.

The Columbus Limestone consists of dolomite and limestone. The Delaware Limestone consists of finely crystalline, thin-bedded brown to gray fossiliferous limestone and dolomite. Karst topography has selectively developed in some of the Silurian and Devonian carbonate bedrock in the northern and western portion of Erie County, resulting

TABLE 3-2. ESTIMATED SOIL THICKNESSES AND PERMEABILITIES

Soil Type	Soil Description	Thickness (feet)	Permeability (In./hour)
Arkport	Loamy fine sand	0 - 5	12
Galen	Loamy fine sand	0 - 5	6.3 - 12
Prout	Very sand loam	0 - 5	0.2 - 0.63

Age	Formation/Group	Depth to Top (ft)	Thickness (ft) a	Hydrologic Unit b	Rock Description
DEVONIAN	Ohio Shale	c	300	Zone 3	Shale : *black, thin-bedded with bituminous and carbonaceous material.*
	Prout Limestone/ Plum Brook Shale	Surface	210		Shale : *light grey, calcareous.*
	Delaware Limestone	40	50	Zone 1 and Zone 2	Limestone : *buff, earthy, foss. interbedded with brown crystalline dolomite.*
	Columbus Limestone	90	110		Limestone : *brown to grey, fine crystalline, foss. with tan to buff-grey, partly sandy dolomite at base.*
	Lucas Dolomite	200	70		Dolomite : *brown, crystalline, porous, chert.*
	Amherstburg Dolomite	270	20		Dolomite : *tan to grey, microcrystalline, sl. argillaceous.*
SILURIAN	Bass Island Dolomite	290	30		
	Salina	320	590'		Dolomite : *anhydrite and shale sequence. Interbedded and intercalated. Dolomite is tan to brown and mostly tight. Scattered shale laminae. Few scattered oil stains. Some dolomite is shaly. few massive beds of dolomite and anhydrite.*

a. Depth to formation, formation thickness, and lithology based on deep borehole located at N 288+68, E 155+54.

b. Refer to Figure 5. for areal distribution of Zones 1, 2, and 3.

c. The Ohio shale was not encountered in the deep borehole, it outcrops in the southeasternmost portion of Plum Brook Station.

FIGURE 3-3. GENERALIZED STRATIGRAPHIC SECTION OF SILURIAN AND DEVONIAN STRATA UNDERLYING PLUM BROOK STATION

in cavernous porosity.[35] Karst terrain occurs in the underlying carbonates mapped in the western and northernmost portions of Plum Brook Station.[34]

The Plum Brook Shale/Prout Limestone sequence consists of a blue-gray, calcareous shale or mudstone overlain by a thin, fossiliferous limestone or dolomitic mudstone.[35] The Ohio Shale is black and thin-bedded. The lithologic changes in the bedrock across the site affect the groundwater potential of the area. The depth to bedrock across Plum Brook Station is highly variable based on data obtained from soil borings and monitoring wells. Limestone bedrock was encountered at a depth of 25 feet below the surface at the PBRF. A monitoring well installed in the vicinity of the red water ponds located in the western portion of the site encountered limestone bedrock at an approximate depth of 19 feet. Shale bedrock in the southern portion of the station has been encountered from depths of 2 to 12 feet.

3.1.2.3 Site Topography

Plum Brook Station is located on relatively flat country characterized by topography that slopes gently northward towards Lake Erie. The ground surface has an average slope of less than six percent.[32] The surficial deposits and landforms were produced by glacial processes.[35] The elevation of the site ranges from approximately 625 feet in the northern portion of Plum Brook Station to approximately 675 feet at the southern and western boundaries of the site.[36] Locally, the bedrock surface at Plum Brook Station dips to the northeast towards Lake Erie. Copies of U.S. Geological Survey (USGS) 7.5-minute topographic maps of the Plum Brook Station and surrounding area are provided as Appendix D. The USGS maps cover the entire Plum Brook Station and the surrounding area within 15 miles of the Plum Brook Station boundary.

Points of run-off entry to surface water bodies are at heads of streams and overland flow along their lengths. The level topography of the site would not facilitate a great amount of run-off, and the streams could receive part of their volume from groundwater discharge. There are no catch basins on site specifically constructed to collect run-off.

Upgradient and downgradient drainage areas (in acres) for the 11 streams are presented in Table 3-3.[38]

Lake Erie is within 15 miles of the Plum Brook Station boundary. Lake Erie is a major fresh water fishery. The annual sports fish catch is estimated to exceed 12 million fish. The commercial catch is estimated to be greater than 10 million fish. Sandusky Bay and Lake Erie are both fished commercially. Most commercial fishing occurs in Sandusky Bay. Yields for 1990 were as follows: 400,000 - 500,000 pounds from open Lake Erie in the vicinity of Cedar Point; and approximately 1.3 million pounds from Sandusky Bay.[39]

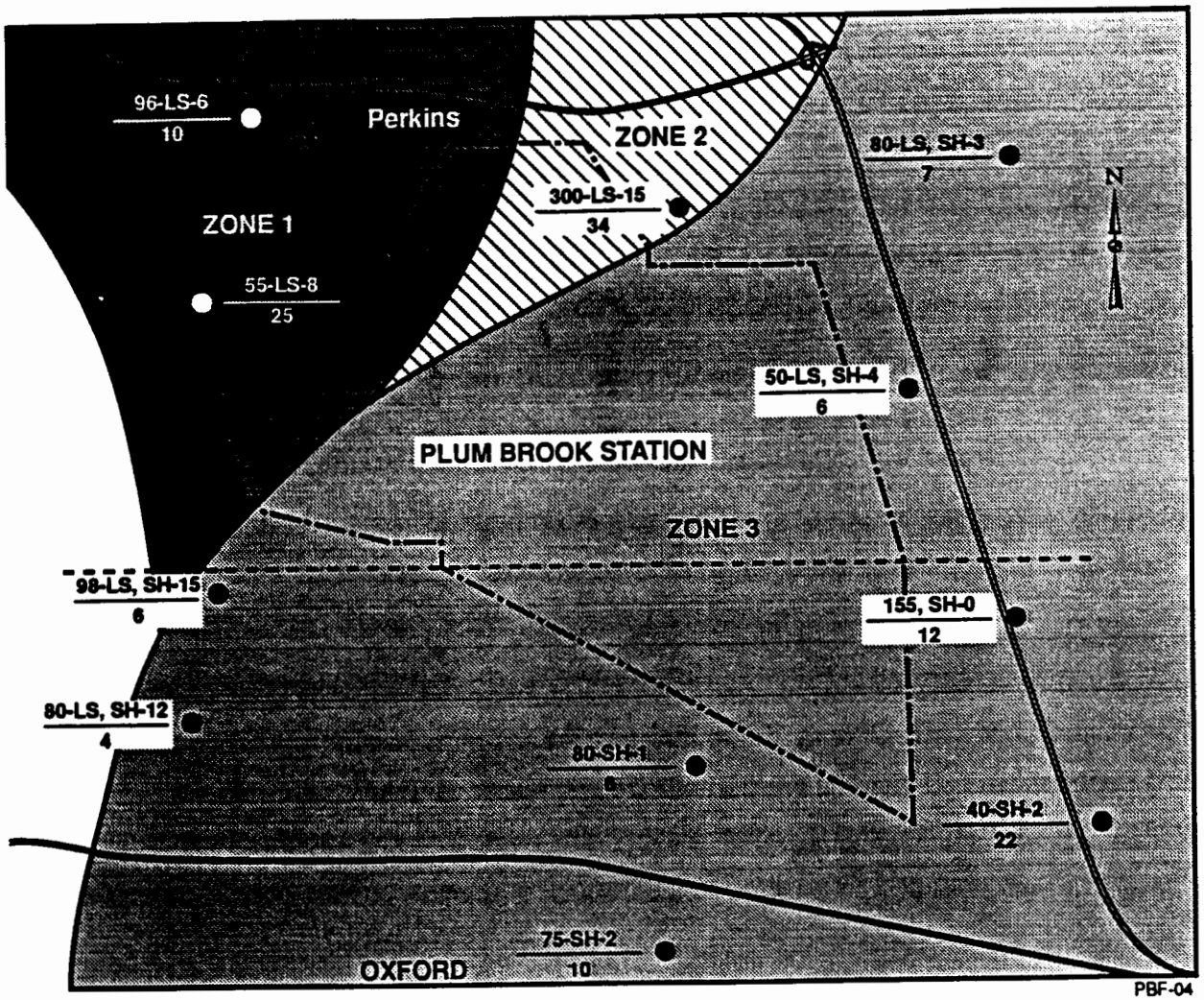
3.1.3.2 Groundwater Hydrology

Two principal bedrock aquifers occur in the study area. These aquifers are used for drinking water in portions of Erie County. A highly productive limestone aquifer (Zone 1, Figure 3-7) is used in the western portion of the county, and a poorly productive shale aquifer (Zone 3, Figure 3-7) is used to the east.[35] Plum Brook Station overlies the transition from the western carbonate aquifer to the eastern clastic aquifer (Figure 3-7). Both aquifers are overlain by glacial drift.

Groundwater within the carbonate (limestone and dolomite) aquifer occurs in a network of interconnected fractures, bedding planes, and solution channels comprising the subterranean karst terrain.[35] Well yields in the carbonate aquifer are highest to the west and decrease to the east as the transition to the sandstone and shale aquifer is

TABLE 3-3. UPGRADIENT AND DOWNGRADIENT DRAINAGE AREAS (ACRES)

Stream	Entering	Leaving
Pipe Creek	11,800	12,600
Ransom Brook	--	824
Storrs-Hemminger Ditch	--	130
Plum Brook	260	1,960
E.C. Smith Ditch	--	44
Lindsley Ditch	--	722
Schlessman Ditch	--	238
Wm. Scheid Ditch	--	505
Kuebeler Ditch	148	658
Scheid-Ohlemacher Ditch	40	273
Scherer Ditch	754	778



LEGEND

ZONE 1

AREAS IN WHICH YIELDS OF 100 TO 500 GALLONS PER MINUTE MAY BE DEVELOPED.

Yields of more than 500 gallons per minute have been developed at depths of less than 200 feet in cavernous limestone and dolomite. Domestic supplies are generally obtained at depths of around 100 feet.

Hydrogen sulfide, in varying amounts, may be encountered in the bedrock.

ZONE 2

AREAS IN WHICH YIELDS OF 5 TO 25 GALLONS PER MINUTE MAY BE DEVELOPED.

Yields of 15, or less, gallons per minute are developed from wells drilled into the limestone. Hydrogen sulfide may be present in varying amounts.

ZONE 3

AREAS IN WHICH YIELDS SELDOM EXCEED 3 GALLONS PER MINUTE

Limited quantities of ground water are obtained from thin, discontinuous sand and gravel deposits interbedded in fine, sandy clay or from the underlying shale. Drilling deeper than 30 feet into the shale is not recommended. Occasional gas or salt noted in the eastern half of the county.

Larger yields may be obtained in western Huron and Oxford townships and southeastern Perkins Township. Wells may encounter water-bearing limestone beneath as much as 60 feet of impervious shale.

SCALE

1 0 1 mile

Depth (ft)

75-SH-2

10

- Existing Domestic Wells
- Water-bearing formation
- Yield (gpm)
- Depth to bedrock (ft.)

FIGURE 3-7. REGIONAL WATER-BEARING ZONES IN THE BEDROCK AQUIFERS (Modified from Walker, 1986)

approached. The direction of groundwater flow in the carbonate aquifer is to the north to points of discharge in Lake Erie. The shale aquifer that occurs in central Erie County and the southeastern portion of Plum Brook Station has low yields because of the fine-grained texture of the shale. Locally, shales outcropping at the surface may be highly fractured from weathering, providing the shale with some capacity to store and transmit water.[35]

The ODNR mapped three groundwater zones within the principal aquifers based on well yield. These zones are informally referred to as Zones 1, 2, and 3 on Figure 3-7. Zones 1 and 2 are developed in the carbonate aquifer, and Zone 3 is developed in either discontinuous sand and gravel deposits interbedded in sandy clay or from the underlying shale. Zone 1 occurs in the northwestern and western portion of Plum Brook Station and includes wells with yields of 100 to 500 gallons per minute (gpm) developed in cavernous limestone and dolomite encountered at depths of less than 100 feet. However, development of cavernous porosity within this zone is highly erratic as indicated by a well located just outside of the Plum Brook Station boundary, which had a yield of 8 gpm in the same aquifer.

The second groundwater zone mapped by ODNR (Zone 2) occurs deeper in the carbonate aquifer at an approximate depth of 300 feet near Plum Brook with well yields of 15 gpm or less.[40] This area encompasses the northeastern portion of the station inclusive of the PBRF area. Limited quantities of groundwater are obtained from Zone 3 groundwater resources which are developed over the southern and eastern portions of Plum Brook Station. Depth to this zone varies from 50 to 100 feet. Well yields rarely exceed 3 gpm.[40]

A thin layer of glacial drift consisting of both glacial till and lacustrine deposits covers the bedrock surface. Glacial drift is not considered to be a major aquifer, although it does contain discontinuous lenses of sand and gravel which may be water-bearing.[35] Numerous shallow water-bearing sand lenses have been encountered in the drift deposits

at Plum Brook Station at depths of less than 10 feet. These shallow surficial aquifers would be classified as Zone 3 in the ODNR classification. Glacial till generally has a low hydraulic conductivity because of the high clay/silt content, thus making it a poor source of groundwater. However, it frequently has an interconnected network of vertical fractures that may enhance the capability for vertical groundwater flow. Sand and gravel lenses in glacial till may also be a source of recharge for bedrock aquifers and a source of groundwater for domestic wells.[35]

3.1.4 Air Quality Data for Surrounding Area

Erie County is in compliance with all the Natural Ambient Air Quality Standards primarily because of the rural character of the area. The OEPA operates one monitoring station for total suspended particulates in the county that consistently is in compliance with particulate standards. The major emission sources for the county include the Ford Motor Company in Sandusky, several greenhouses, and some larger coal-fired, institutional boilers. Erie County is classified as an attainment area for all air quality parameters.

3.2 Target Populations

3.2.1 Area Demographics

The population of Erie County in 1990 was 76,779 with 32,827 total housing units. Total populations of geographic entities bordering or near Plum Brook Station are presented in Table 3-4.[41]

3.2.1.1 Population Distributions Within Four Miles

The population distributions within 4-mile radii of the Plum Brook Station boundary are listed in Table 3-5.

3.1.3 Hydrologic Setting

3.1.3.1 Surface Water Hydrology

Numerous ponds (man-made and natural) and streams lie within a 15-mile radius of Plum Brook Station. Lake Erie and Sandusky Bay are the largest surface water bodies within that radius (approximately 3.5 miles to the north). Bellevue Reservoir #5 is approximately 14 miles to the SSW. The Huron River and its branches, located approximately 3.5 miles east of Plum Brook Station, are the major streams (refer to Figure 3-4).

The dominant surface water feature in northern Ohio is Lake Erie. The lake has an area of 9919 square miles and a volume of 113 cubic miles.

Eleven streams pass through or originate on Plum Brook Station (Figure 3-5). Each of these streams could receive contaminants from runoff and groundwater discharge in the event of a spill at Plum Brook Station. They flow north- and northeastward to converge into Ransom Creek, Storrs Ditch, Plum Brook, and Sawmill Creek, which flow to Lake Erie. Additionally, ditches totaling approximately 380,000 lineal feet are within Plum Brook Station.[37] Seventeen isolated ponds and reservoirs and three red water ponds are located on Plum Brook Station (Figure 3-6). The ponds are probably fed by shallow surficial groundwater. Pond water levels remain high even during dry months.[37]

Drainage is north to Lake Erie. The drainage pattern is dendritic where streams are incised to bedrock; the drainage pattern on glacial material is erratic and poorly to moderately developed.

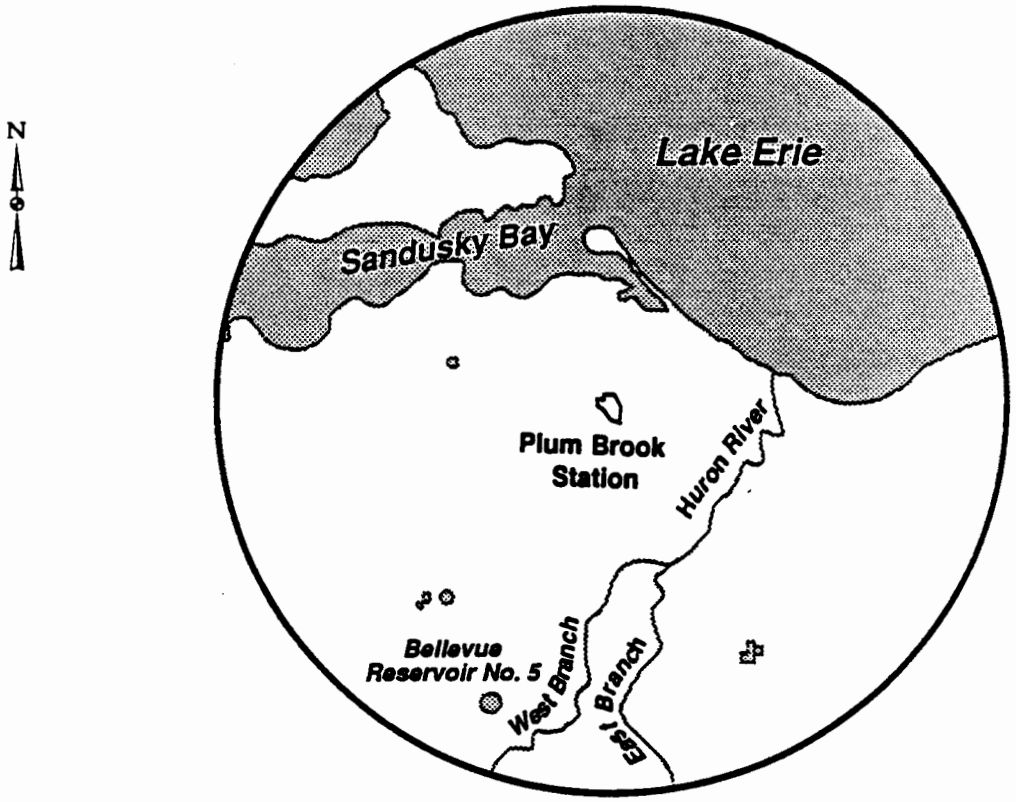
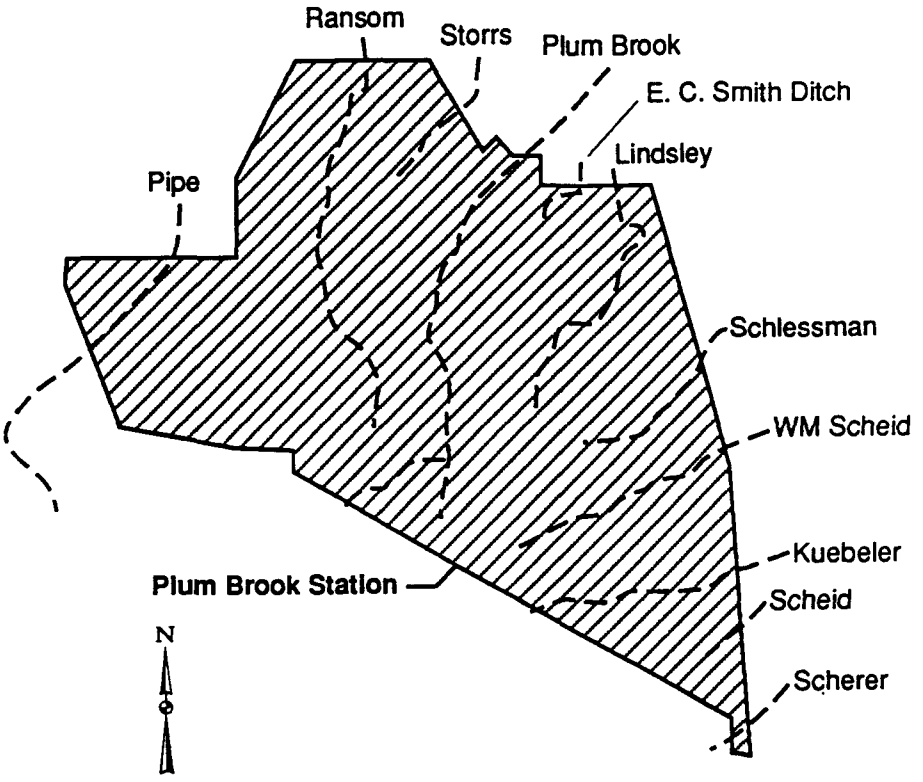


FIGURE 3-4. MAJOR SURFACE WATER BODIES WITHIN A 15-MILE RADIUS OF PLUM BROOK STATION



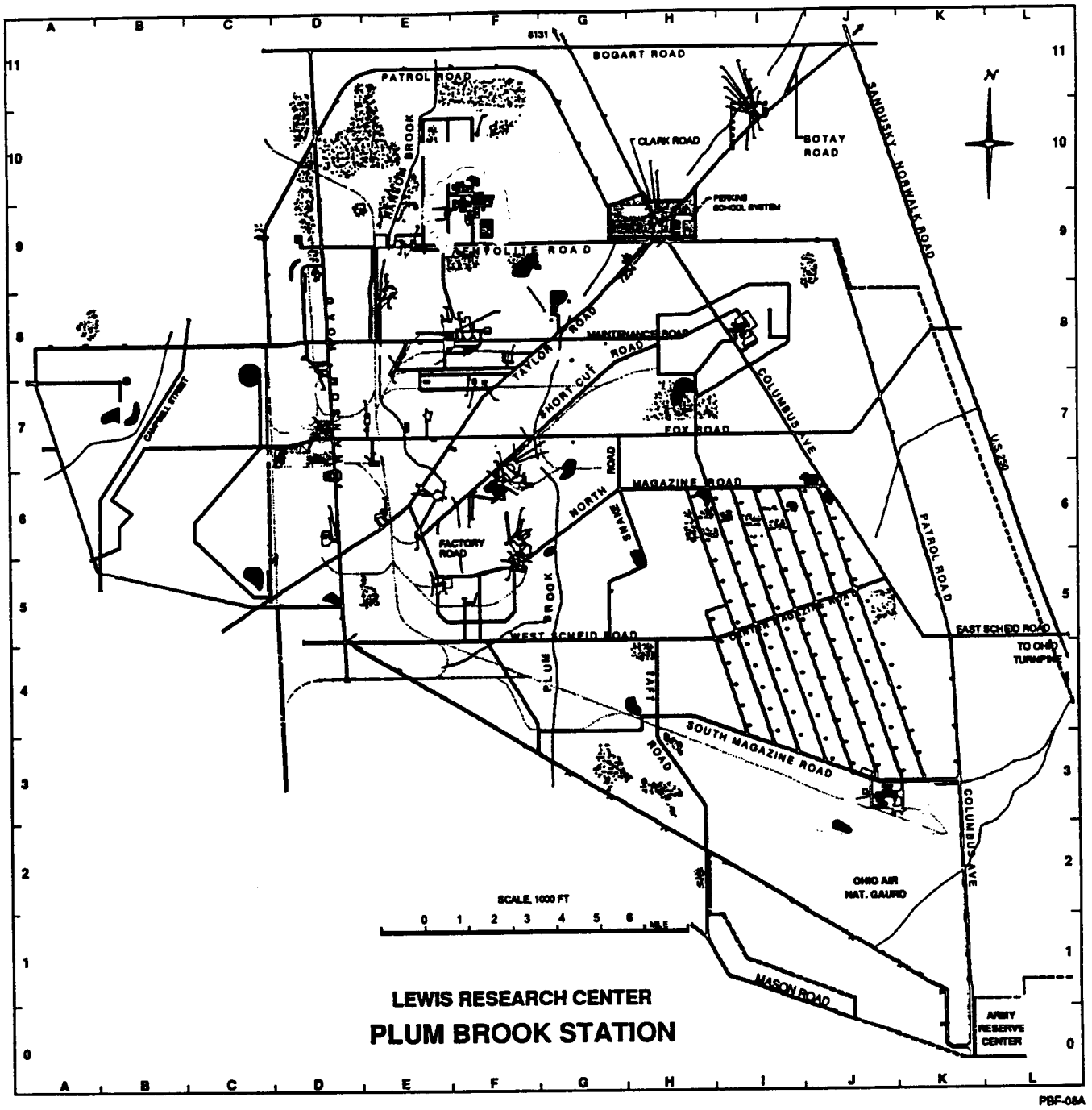
Stream	Drainage Areas in Acres	
	Entering	*Leaving*
Pipe Creek	11,800	12,600
Ransom Brook	*	824
Storrs-Hemminger Ditch	*	130
Plum Brook	260	1,960
E.C. Smith Ditch	*	44
Lindsley Ditch	*	722
Schlessman Ditch	*	238
William Scheid Ditch	*	505
Kuebeler Ditch	148	658
Scheid-Ohlemacher Ditch	40	273
Scherer Ditch	754	778

PBF-01

* Stream originates within station boundaries.

Surface drainage watershed boundaries

Figure 3-5. Map Showing Streams Through PBS



● Blackened areas designate ponds, reservoirs, and lagoons

FIGURE 3-6. LOCATIONS OF PONDS AND RESERVOIRS

TABLE 3-4. AREA DEMOGRAPHICS IN PLUM BROOK STATION VICINITY

Entity	Population	Total Households
Huron City	7030	3204
Huron Twp (excluding Huron City)	2267	958
Sandusky City	29,764	13,416
Perkins Twp (excluding Sandusky City)	10,793	3895
Groton Twp	1245	438
Margaretta Twp	6255	2419
Oxford Twp	1150	400
Milan Twp	3149	1234
TOTAL	61,653	25,964

TABLE 3-5. ESTIMATED POPULATION DISTRIBUTIONS IN PLUM BROOK STATION VICINITY

Distance (miles)	Population
0 to 0.25	600
0.25 to 0.50	450
0.50 to 1.0	2150
1.0 to 2.0	5500
2.0 to 3.0	9100
3.0 to 4.0	13,450

There is no permanent resident population within Plum Brook Station boundaries. Plum Brook Station currently employs 150 people. The employees work for various organizations as listed below:

- NASA - 13
- Sverdrup - 110
- Department of Agriculture, Interior, and Labor, Federal Bureau of Investigation, Immigration and Naturalization Services - 27.

The 1990 census figures are preliminary. Data distinguishing single- versus multi-family dwellings will become available in June 1991.[42] No data regarding schools and day care center enrollments were collected in 1980 or 1990.[43] However, it is known that children under seven years old do not live or attend school on Plum Brook Station or anywhere near suspected contamination caused by Plum Brook Station operations within 2 feet of ground surface. Business and industrial populations are not known. On any given day in the summer months, the population of Sandusky is estimated to be 50 percent higher due to tourism. Tourist traffic to Cedar Point approaches 50,000 to 60,000 cars per day on some summer weekends.[44]

3.2.1.2 Land Use in Vicinity

Land usage within a 4-mile radius of Plum Brook Station is primarily residential and agricultural. Several commercial food processing plants are located within 4 miles of Plum Brook Station: Toft Dairy, Sandusky Dressed Beef Co., Routh Packing (Huron Twp.), and Prepared Foods of Sandusky. The Sandusky area supports a large amount of tourism and recreational use during summer months.

3.2.2 Water Utilization

3.2.2.1 Location and Usage of Surface Water Intakes Within 15 Miles

The city of Sandusky uses Lake Erie as its public, commercial, and industrial water supply. The city sells water to the Erie County Water Department which distributes water to the villages of Castalia and Bay View (pop. 915 and 522, respectively). In addition, county water lines extend south to Bogart Road, and south on State Route 250 as far as Milan's water lines.[46] The villages of Castalia and Bay View also utilize water from this system.[47,48] Plum Brook Station obtains its drinking water from the city of Sandusky.

Plum Brook Station maintains two raw water intakes: one at Rye Beach (near Huron), the other (Big Island, off Cedar Point) an intake shared with the Sandusky city water plant.[49] The Big Island intake is 3000 feet offshore in 25 feet of water.[50] The Station's Rye Beach intake is 3000 feet offshore in 30 feet of water.[34] It has been plugged since 1985 with no immediate plans for repair.

The Lorain/Elyria Rural Water Authority offers water service to parts of Huron Avery, Mud Brook, Scheid, Rye Beach, and Bogart Roads. Their intake is in Lorain/Elyria. This service is new. The water lines have been installed and are functional. Residents have been given sixty days to complete tie-ins.

The cities of Bellevue, Norwalk, Monroeville, Lakeside, Marblehead, and Huron also use surface water as a public water supply. Bellevue's reservoir is approximately 14.5 miles SSW of Plum Brook Station. Huron obtains its water from intakes in Lake Erie. Huron's intake is located 2200 feet offshore, due north of its water plant. Huron's intake supports 2500 distribution system tie-ins.[51]

Bellevue's reservoirs are approximately 14.5 miles south-southwest of Plum Brook Station and are fed by tributaries to the west branch of the Huron River. Norwalk has

three reservoirs, also fed by the west branch of the Huron River. Monroeville has an intake in the Huron River (see Figure 3-8).[48]

Huron sells water to the Erie County Water Department which supplies outlying areas of Huron, including the village of Berlin Heights.[41,48] Marblehead's water supply system uses a rock channel leading to a shore well on the northwest side of town.[48] Lakeside has its own intake in Lake Erie.[52]

The Erie County Health Department does not permit surface water to be used as a private drinking water supply.[46] No surface water within Plum Brook Station is used as a drinking water supply. It is not known if ponds are used to water livestock in the area. Lake Erie and Sandusky Bay support a great deal of recreational boating, fishing, and swimming during summer months. Crop irrigation is not common in Ohio.

A map showing known surface water intakes described in this section is provided as Figure 3-8.

3.2.2.2 Location and Usage of Groundwater Within 4 Miles

There are 179 permitted private drinking water wells within a 4-mile radius of Plum Brook Station on record at the Erie County Health Department.[53] The Erie County Health Department does not require a permit for wells intended for agricultural use. Permitted drinking water wells within the 4-mile target distance of the Plum Brook Station boundary are listed in Table 3-6. Wells in the area that are known by SAIC to be used for drinking water supplies are located in Figure 3-9.

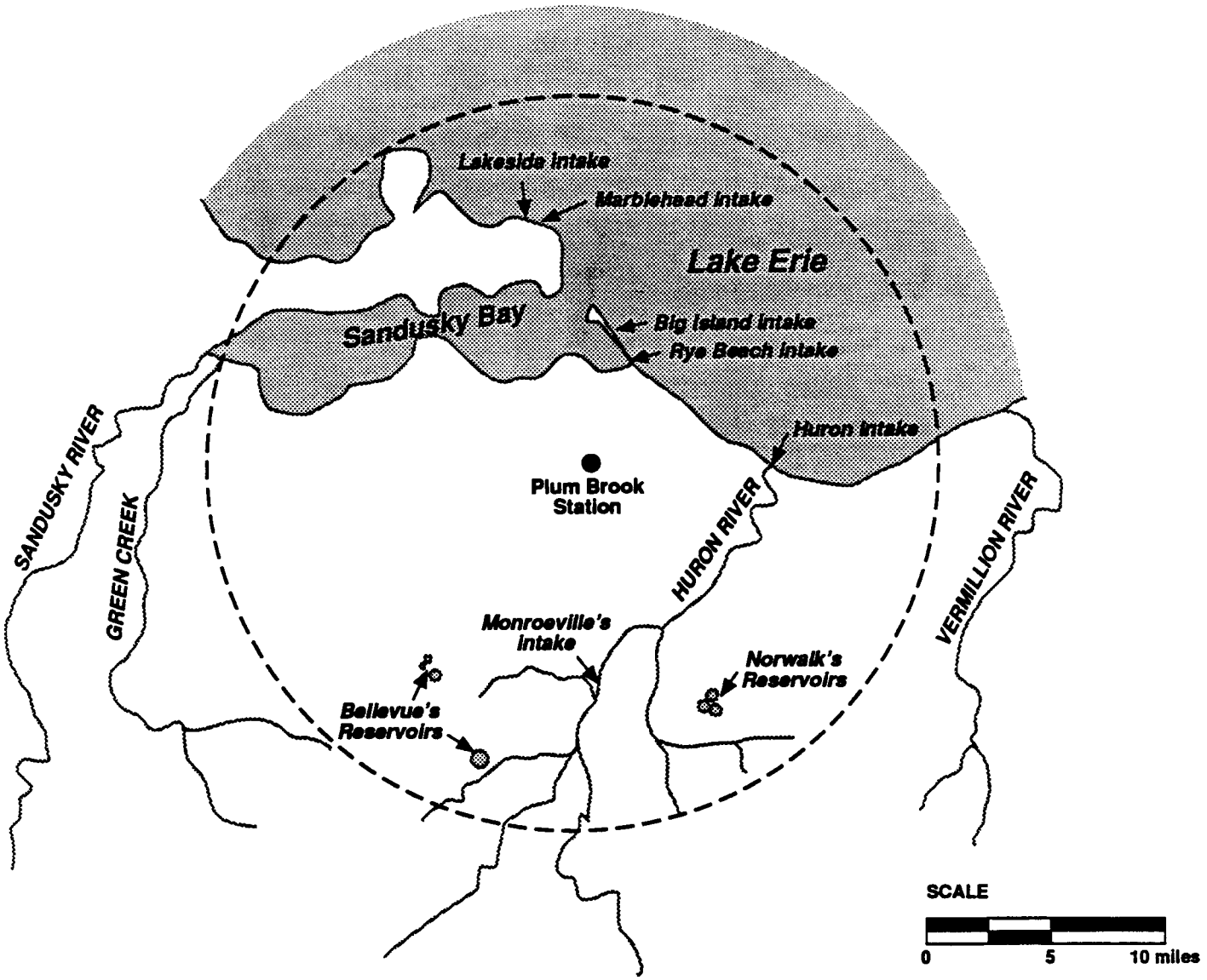


FIGURE 3-8. SURFACE WATER INTAKES

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TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE

Owner	Property Address	Township
Michael Benko	5020 Harris Road	Groton
Donald Brindley	7304 Strecker Road	Groton
Duane Butler	9614 S.R. 99	Groton
Lennie Campbell	7601 S.R. 99	Groton
Ben Chapman	9713 S.R. 99	Groton
Charles Clark	9512 S.R. 4	Groton
Daniel Colvin	8209 Strecker Road	Groton
Thomas Cullen	8406 Portland Road	Groton
Glen Davis	7404 Magill Road	Groton
Ronald Dorski	9912 S.R. 4	Groton
Ken Edwards	7211 Maple Ave.	Groton
Rebecca Endicott	1906 Stacy Road	Groton
James Everett	10006 S.R. 4	Groton
Paul Fannin	7712 Mason Road	Groton
James Fields	at Skadden and Portland	Groton
Walter Foreman	9518 S.R. 99	Groton
Ron Fryer	9404 Bemis Road	Groton
Philip Gasteier	8606 S.R. 4	Groton
John Highlander	7210 Magill Road	Groton
John Highlander	7312 Magill Road	Groton
John Highlander	7402 Magill Road	Groton
Kathy Hill	7312 Portland	Groton
Bill Hodges	6919 Maple Avenue	Groton
Delana Hummel	1/3 mi E of S.R. 4 on Strecker	Groton
Steven Jarrett	8918 Ranson Road	Groton

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Kerry Jett	7215 Magill Road	Groton
James Keen, Sr.	7509 S.R. 99	Groton
Jeffrey Moretz	10116 S.R. 4	Groton
Anthony Pollack	4902 Harris Road	Groton
Neil Reiter	9615 S.R. 99	Groton
Jeffrey Ries	4614 Harris Road	Groton
Robert Shippel, Jr.	5010 Harris Road	Groton
Tracy Thornton	9512 S.R. 99	Groton
Marshall Tucker	8313 Portland Road	Groton
Ralph Voltz	7617 S.R. 99	Groton
Carl Wahl	9112 Mason Road	Groton
David Amburn	3218 Fox Road	Huron
Mary Boos	2515 Fox Road	Huron
Donald Bozicevich	3303 Huron-Avery Road	Huron
Alpha Construction	2708 Huron-Avery Road	Huron
Alpha Construction	2700 Huron-Avery Road	Huron
Timothy Crapsey	2907 Camp Road	Huron
Jack Davis	2912 Huron-Avery Road	Huron
Jack Davis	2820 Huron-Avery Road	Huron
Jack Davis	2704 Huron-Avery Road	Huron
Jack Davis	2916 Huron-Avery Road	Huron
R.E. & Pat Dwight	3213 W. Cleveland Road	Huron
Gary Howell	3219 Huron-Avery Road	Huron
Leamon Jenkins	1912 Huron-Avery Road	Huron
Carol King	1719 Rye Beach Road	Huron
Daniel P. Klonk	3803 Fox Road	Huron

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Mark Koelsch	3718 Bogart Road	Huron
George Mingus	1626 Camp Road	Huron
Todd Sommer	3910 Bogart Road	Huron
Dowzell Swayngim	3414 Fox Road	Huron
Chester Wade	3818 Bogart	Huron
Karl Washburn	2402 Huron-Avery Road	Huron
Thomas Work	3306 Fox Road	Huron
John Bailey	4020 Maple Ave.	Margaretta
Chester Bango	4416 Bardshar Road	Margaretta
Milford Barnard	4912 Tiffin Ave.	Margaretta
Robert Biggs	4015 Bardshar Road	Margaretta
Robert Biggs	3909 Bardshar Road	Margaretta
Pauline Biggs	3901 Bardshar Road	Margaretta
Robert Biggs	3915 Bardshar Road	Margaretta
Raymond Bollin	4211 Maple Ave.	Margaretta
Joseph Corwin	4406 Bardshar	Margaretta
Donald Cyr	5318 Tiffin Ave.	Margaretta
Clifford Dickman	4120 Miller Road	Margaretta
Raymond Downing	5527 Tiffin Ave.	Margaretta
James Elliott	5605 Maple Ave.	Margaretta
Charles Elswick	5503 Maple Ave.	Margaretta
Donald Fox	4606 Bardshar	Margaretta
Jerome Gessner	NE corner of Old Rail - road & Miller Roads	Margaretta
James Gibson	5419 Skadden Road	Margaretta
Brian Glovinsky	6020 Maple Road	Margaretta

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Lynn & Mary Gruhlke	3906 Bardshar Road	Margaretta
Victoria Hartenfeld	4402 Bardshar Road	Margaretta
David Hoffer	5519 Skadden Road	Margaretta
Daniel Howell	6505 Old Railroad	Margaretta
Robert Howell	4606 Miller Road	Margaretta
Larry Hummel	6108 Skadden Road	Margaretta
Tom Jenkins	5204 Skadden Road	Margaretta
William Johnson	3912 Bardshar	Margaretta
Kenny Kingsborough	4112 Maple Ave.	Margaretta
Joseph Kingsborough	4116 Maple Ave.	Margaretta
Norman Kuns	5407 Bardshar Road	Margaretta
Dale Lee	6316 Old Railroad	Margaretta
Mike Long	4014 Maple Ave.	Margaretta
Howard Longnecker	5315 Tiffin Road	Margaretta
Douglas Marshall	4916 Tiffin Road	Margaretta
William Marske	5711 Skadden Road	Margaretta
Sandra McClaflin	4016 Maple Ave.	Margaretta
Ernest McClellan	3801 Maple Ave.	Margaretta
George McPeek	6412 Parker Road	Margaretta
Dan Meisler	4110 Miller Road	Margaretta
Dale Meyer	5307 Skadden Road	Margaretta
Allen Miller	2219 Bardshar Road	Margaretta
John Parker	3908 Maple Ave.	Margaretta
Walter Salisbury	4102 Maple Ave.	Margaretta
Walter Salisbury	5711 Maple Ave.	Margaretta
Timothy Schoewe	5104 Tiffin Ave.	Margaretta

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Delmon Smith	4110 Maple Ave.	Margaretta
Steven Smith	5613 Maple Ave.	Margaretta
Richard Spatafora	3914 Maple Ave.	Margaretta
John Strouse	4216 Maple Ave.	Margaretta
Leslie Toney	4004 Maple Ave.	Margaretta
Gaston VanCauwenbe	5414 Tiffin Road	Margaretta
Richard VanNess	6102 Maple Ave.	Margaretta
David Veverka	Parker between Billings & Maple	Margaretta
Michael Voegle	5707 Maple Ave.	Margaretta
Kitty Ward	5112 Tiffin Road	Margaretta
James Whited	5702 Tiffin Road	Margaretta
James Yontz	4019 Maple Ave.	Margaretta
David Cameron	7503 Mason Road	Milan
John Collins	10314 Huron Avery Road	Milan
Dean Cox	10327 U.S. 250 N	Milan
Robert Disbrow	11216 Kelly Road	Milan
Div. of Wildlife	1704 S.R. 113 W	Milan
Don Eddy	619 Strecker Road	Milan
Todd Enderle	2016 Mason Road	Milan
Timothy Finton	2000 Mason Road	Milan
Ft. Avery Farm	1108 Hoover Road	Milan
David & Vicky Graziani	11312 Kelley Road	Milan
Curtis Jeffers	11314 Kelley Road	Milan
David Kluding	10303 U.S. 250 N	Milan
Howard Leber	11907 River Road	Milan

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Richard Mummey	9700 Hoover Road	Milan
Paul Newyear	9113 Huron Avery Road	Milan
Richard Riesterer	2002 Mason Road	Milan
John & Jim Rockwell	10069 Hoover Road	Milan
Robert & Janet Runner	2008 Mason Road	Milan
Peter Schlacter	10313 Milan Road	Milan
Roger Schnee	2004 Rt. 113 W	Milan
James Stieber	2111 Rt. 113 W	Milan
Ian Wallace	11719 River Road	Milan
Florence Zorn	Rt. 250 and Scheid	Milan
Donald Baum	9820 Thomas Road	Oxford
Central Erie Supply & Elevator	4414 Mason Road	Oxford
Dennis Downing	5315 Delamatre	Oxford
Craig Eastman	3814 Mason Road	Oxford
Melvin Engelman	6617 Mason Road	Oxford
James Gingo	8907 Patten Tract	Oxford
Larry Gingo	9111 Patten Tract	Oxford
Matthew Glancy	6718 Portland Road	Oxford
Jerome Gravenhorst	4101 Strecker Road	Oxford
Hilda Hackett	8409 Ransom Road	Oxford
Ivan Hill	4809 Delematre	Oxford
Steve Hurst	4608 Delematre	Oxford
Max Jarrett	8918 Ransom Road	Oxford
Maudie Koch	1316 Mason Road	Oxford
Matthew Krause	8805 Patten Tract	Oxford

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Randy Leber	8701 Ransom Road	Oxford
Ralph Lee	2806 Higbee Road	Oxford
Robert Lepley	6628 Portland Road	Oxford
John Lublow	6603 Portland	Oxford
Douglas McClellan	3906 Mason Road	Oxford
Kerry Myers	5219 Taylor	Oxford
Helen Myers	3808 Strecker Road	Oxford
Ernest Nixon	10306 Route 99	Oxford
Charles Ohlemacher	5519 Mason	Oxford
Kenneth Popke	6615 Portland Road	Oxford
Duane Rohrbacher	3718 Harris Road	Oxford
Donna Sisson	Thomas Road - 3rd on right off Rt. 113	Oxford
Edward Stallkamp	4011 Harris Road	Oxford
James Stewart	8719 Ransom Road	Oxford
Larry Talley	6701 Mason Road	Oxford
Jerry Tallman	2914 Higbee	Oxford
Merritt Vickery	7018 Mason Road	Oxford
James Weilnau	2707 Strecker Road	Oxford
Leroy Weyer	10320 Patten Tract	Oxford
Beulah Winebarger	5217 Delamatre Road	Oxford
Ted Winebarger	5209 Delamatre Road	Oxford
Dorothy Wood	N side Rt. 113 - 2.5 mi. W of US 250	Oxford
Douglas Galloway	1810 Schenk Road	Perkins
Roy & Doris Homegardner	2914 Old Railroad	Perkins

TABLE 3-6. PERMITTED DRINKING WATER WELLS WITHIN 4-MILE TARGET DISTANCE (Continued)

Owner	Property Address	Township
Randall Koch	5912 Patten Tract	Perkins
Carol Kromer	6114 Campbell St.	Perkins
Donald Ortner	6104 Patten Tract Road	Perkins

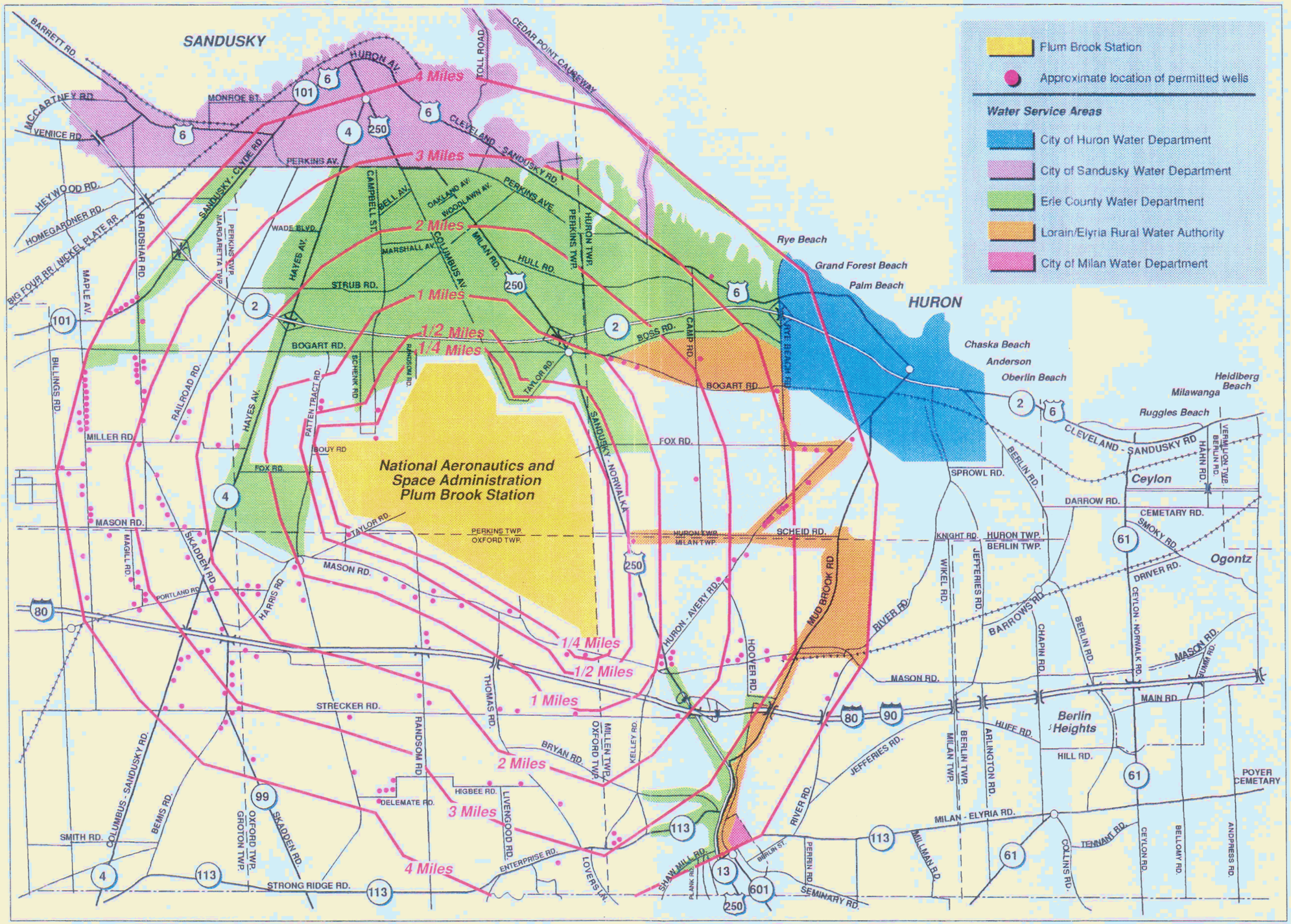

FIGURE 3-9. PERMITTED DRINKING WATER WELL LOCATIONS WITHIN A FOUR-MILE RADIUS OF PLUM BROOK STATION, AND WATER SERVICE AREAS.

At this time, city and rural water systems serve residences north and east of Plum Brook Station. Residences south and west of the Station continue to rely on wells and/or cisterns.[46] The nearest recorded downgradient well is at 6115 Schenk Road; a closer well was observed at 1810 Schenk Road, but no located log has been obtained for this well. No well within Plum Brook Station is used as a drinking water supply.

Two wells serve as public (used by 25 or more people at least 60 days per year) drinking water supplies: Woussickett Golf Course clubhouse (6311 Mason Road) and Stanley's Tavern (4408 Mason Road).[46] All commercial and industrial water is obtained from the City of Sandusky. Groundwater yields (at 20 gpm in limestone and <2 gpm in shale) are too low to support large-scale production.[35,40] Finally, no wells are used solely for crop irrigation, as Ohio's climate is humid with adequate precipitation.

All aquifers in the area of Plum Brook Station are used as sources of drinking water.[40]

3.2.3 Potential Impacted Wetlands, Parks, Protected or Sensitive Areas, Endangered Species

Milan State Wildlife Area is located three miles south (upgradient) of Plum Brook Station in Oxford and Milan townships, at the juncture of the West Branch and the East Branch of the Huron River. It is upstream of Plum Brook Station. The Erie Sand Barrens State Nature Preserve is approximately 1000 feet south of Plum Brook Station, at the intersection of Taylor and Scheid Roads. It is upstream of Plum Brook Station.

Sheldon's Marsh State Natural Preserve is approximately 3.75 miles northwest of Plum Brook Station. It is downstream of Plum Brook Station in an "intra-basin" area between Plum Brook and Sawmill Creek at their discharges to Lake Erie.

Federally endangered animal species in Erie County are the Indiana bat (Myotis sodalis) and the bald eagle (Haliaeetus leucocephalus).[54] Approximately four breeding pairs of bald eagles occur within 5 to 10 miles of Plum Brook Station.[55] No survey has been conducted to identify habitats of the Indiana bat in the Plum Brook area. The Indiana bat is listed as a state-endangered species.

The following seven state-endangered moth species have been collected from Rest Haven Wildlife Area and Old Woman's Creek State Natural Preserve:[56]

- Speveria idalia (Regal Fritillary) - its locale is listed only as "Erie Co.";
- Papaipema silphii - associated with Prairie Dock (a prairie grass);
- Spartiniphaga inops - associated with wetlands;
- Hypocoena enervata - associated with wetlands;
- Trichoclea artesta - collected from Old Woman's Creek;
- Tricolita notata - collected from Rest Haven; and
- Papaipema beeriana - collected from Rest Haven.

Three of these species (Papaipema silphii, Spartiniphaga inops, and Hypocoena enervata) are associated with habitats (wetlands and Prairie Dock) that exist on Plum Brook Station.

There are several state-designated threatened and potentially threatened plant communities on and near Plum Brook Station.[3] The species are listed in Table 3-7. There are no federally-endangered fish, or shellfish species in Erie County.[54]

TABLE 3-7. STATE-DESIGNATED ENDANGERED (E), THREATENED (T), OR POTENTIALLY-THREATENED (P) PLANT COMMUNITIES ON OR NEAR PLUM BROOK STATION

Equisetum variegatum - variegated scouring rush (T)
Xyris torta - twisted yellow-eyed grass (T)
Carex conoidea - field sedge (T)
Eleocharis Olivacea - olivaceoius spikerush (T)
Hemicarpha micrantha - dwarf bullrush (T)
Hypericum gymnanthum - least St. John's wort (E)
Hypericum majus - tall St. John's wort (P)
Juncus platyphyllus - flat-leaved rush (T)
Linum sulcatum - grooved flax (P)
Rhexia virginica - Virginia meadow beauty (P)
Viola lanceolata - lance-leaved violet (T)
Xyris torta - twisted yellow-eyed grass (T)
Hemicarpha micrantha - dwarf bullrush (T)
Baptisia lactea - prairie false indigo (T)
Gratiola virginiana - round-fruited hedge hyssop (T)
Helianthus mollis - ashy sunflower (T)
Carex alata - broad-winged sedge (T)

4. HAZARDOUS SUBSTANCE MANAGEMENT PRACTICES

This section provides descriptions of current and historical hazardous substance management at Plum Brook Station. The management of both hazardous materials and wastes are addressed.

4.1 Hazardous Material Usage

This section summarizes management practices for hazardous materials (petroleum products and virgin chemicals) at Plum Brook Station.

4.1.1 Types and Quantities of Hazardous Materials Used

Hazardous materials used at Plum Brook Station are of four basic types:

1. Materials used in research and development (laboratory chemicals).
2. Materials used in operations and testing (propellants, gases, rocket fuels, alkalies, cryogenic fluids).
3. Materials used in construction and maintenance (coatings, lubricants, paints, herbicides).
4. Heating and motor vehicle fuels.

Since most of Plum Brook Stations research facilities are currently inactive, most of the hazardous materials used at Plum Brook Station today are of Types 2, 3, and 4.

As most of the Plum Brook Station research facilities are currently in standby or inactive status, large quantities of hazardous substances are not stored at the facility. An inventory of all chemical and petroleum based products in use or storage is conducted at the station each year. The purpose of the inventory was to identify and dispose of

excess amounts of hazardous substances that had accumulated throughout the years and were no longer needed to support ongoing operations or research programs. Approximately 110 buildings were inventoried, including 11 of the munitions bunkers (igloos) which are used by NASA to store hazardous substances (primarily product). Hazardous substances identified by this effort as "unwanted" were disposed of through the NASA LeRC Logistics Management Division. Bulk quantities of substances that were retained were consolidated in central locations as discussed below. Locations and amounts of all materials identified as hazardous substances are listed in the 1990 Chemical Inventory of the Plum Brook Station, which is Appendix E to this PA report.[57] The Plum Brook Station chemical inventory is updated annually.

Building 9140, a former munitions bunker, is currently utilized for the storage of bulk quantities of combustible liquids. Combustible liquids stored in Building 9140 include shielding window oil, propellant, kerosene, and lubricating oil. This bunker remains locked at all times and is inspected monthly. The entrance door is posted with a warning sign marked "Caution. Combustible Liquids. No Smoking, Matches, or Open Flames."

Building 9208 is a warehouse that was modified to store materials similar to those stored at 9140. Typical materials stored at Building 9208 are oils, antifreeze, pesticides, and solvents that are used in various Plum Brook Station activities.

Buildings 9151 and 9208 are used to store pesticides. Pesticides are normally purchased on an as-needed basis. Storage occurs only prior to their use. If the inventory of pesticides is not completely used during the application season, it is stored. The purchase of additional pesticides is evaluated based on the remaining inventory.

Building 2211 was used to store hazardous substances such as gasolines, solvents, and acids until 1990. As part of the chemical inventory conducted in 1989 and the attempt by Plum Brook Station to consolidate the storage of hazardous substances, storage in Building 2211 was discontinued.

Other hazardous substances utilized at Plum Brook Station are in small quantities typically stored at or near the location they are used in. The chemical inventory in Appendix E lists the locations and amounts of items identified by Plum Brook Station as hazardous substances.

The Department of Agriculture and the Department of the Interior use Buildings 7141, 2311, and 2321 for storage. The U.S. Army Reserve and Ohio Air National Guard use some of the former munitions bunkers for storage. The Reserve stores lubricants and the Guard stores small arms munitions and tear gas. Each of the tenant agencies performs its own annual inventories and provides copies of the inventory to the Plum Brook Station Management Office. NASA does not inventory the tenant agency's bunkers.

4.1.2 Receiving, Storage, and Distribution to Users

If it is determined that a hazardous substance is required for use at Plum Brook Station, the individual requesting the material must determine if the item needed is currently available. If it is determined that the item is not available, the individual prepares a purchase request. A purchase request for a hazardous material must be reviewed by the Plum Brook Management Office for concurrence and approval.

In order to store hazardous substances at Plum Brook Station for future use, a Safety Permit is required. Additionally, the requestor must complete a Retention Request and Storage Permit (C-386). These requests are submitted to the Area Safety Committee and Logistics Management Division, respectively, for review and approval before permitted storage can occur. Storage is controlled by an appointed Authorized Hold Storage Coordinator.

4.2 Waste Generation and Disposal

This section of the PA report describes waste generation and disposal activities at Plum Brook Station.

4.2.1 Types and Quantities of Wastes Generated

Throughout the 50-year history of Plum Brook Station, various wastes have been generated by Garrett, the U.S. Army, NASA, and other agencies that have leased facilities at the station. Types and quantities of waste generated have not been routinely recorded.

4.2.2 Waste Disposal Methods

4.2.2.1 Industrial Wastewaters

Industrial wastewater discharges at Plum Brook Station are directly proportional to the number of research projects being conducted at a given time. As most of the facility is currently in a standby mode, the facility is not generating a large quantity of industrial wastewater. Industrial wastewater is generated from the SPF cooling towers. Non-contact cooling water is generated from ongoing K-Site slush hydrogen tests.

When the PBRF was operational, a large volume [one million gallons per day (gpd)] of radiologically uncontaminated cooling water was discharged. The PBRF was decommissioned in 1973 and currently remains in standby status.

Industrial wastewater discharges are monitored and addressed in the Plum Brook Station NPDES permit as outfalls 001, 002, 003, and 009. This permit is discussed in Section 2.2.2.1 of this PA report.

4.2.2.2 Sanitary Wastewaters

The northeast portion of Plum Brook Station is connected to a sanitary sewer system. The plant was constructed in 1941-1942 to handle 110,000 gpd, but flows typically range from 40,000 to 200,000 gpd. This plant provides primary and secondary treatment by means of a trickling filter and settling tank. The system serves the Engineering Building, K-Site, the Garage and Maintenance Area, approximately 43 private homes on Columbus Avenue and Taylor Roads, and the offices and garage facilities owned by the Perkins Township School District. The PBRF was also connected to this system. The SPF, B-2 Site, B/Control Building, and J Site are served by package sewage treatment plants. The SPF and B/Control Building package plants are operational at this time. The B-2 package plant operates when the facility is active. The J Site package plant is inactive. All other Plum Brook Station buildings and facilities are served by 1,000-gallon septic tanks that drain to 300-400 feet of leach field.

Sanitary waste discharges are monitored and addressed in the Plum Brook Station NPDES permit as outfalls 004, 005, 006, 007, and 008. This permit is discussed in Section 2.2.2.1 and included as Appendix C of this report.

4.2.2.3 Storm Water

Plum Brook Station storm water discharges are not monitored separately or isolated from industrial wastewater discharges. There is no engineered collection system for storm water runoff at the station. Storm water collects in the station's ditches and streams, which are monitored and addressed in the Plum Brook Station NPDES permit as outfalls 001, 002, and 003. Streams monitored are Kuebeler Ditch (Outfall 001), Ransom Brook (Outfall 002), and Plum Brook (Outfall 003). Flow rates reported in 1990 are listed in Table 4-1.[58,59]

TABLE 4-1. STREAM FLOWS AT PLUM BROOK STATION*

Stream	Low	High	Average
Kuebeler Ditch	0.179	0.927	0.491
Ransom Brook	0.188	0.777	0.459
Plum Brook	0.458	2.386	1.214

* million gallons per day

4.2.2.4 Industrial Solid Waste

Plum Brook Station has contracted with an off-site disposal company to remove domestic waste from the station and dispose of it at the Erie County landfill. Approximately 6 to 32 cubic yards of solid waste are generated per week. Solid waste consists of office waste, scrap parts, and equipment. Solid waste is accumulated in dumpsters located throughout Plum Brook Station. Other solid waste generated at the station is/has been disposed of at any one of three on-site disposal areas as discussed below.

In the 1960s, NASA established three distinct disposal areas for solid waste generated at Plum Brook Station: Disposal Area 1, Disposal Area 2, and Disposal Area 3.[60] Although these areas were primarily used to dispose of or store solid waste or unwanted materials, evidence exists that they may have been used for the disposal of hazardous waste (see Section 4.2.2.5). Figure 4-1 shows the locations of these disposal areas.

Disposal Area 1 actually had two sub-areas and thus is referred to as Disposal Area 1A and Disposal Area 1B. Disposal Area 1A has been used to deposit non-contaminated salvageable scrap (metal). Disposal Area 1B is discussed as an operable unit in Section 5 of this PA report since it is possible that hazardous wastes were also disposed of in this area.

Non-combustible, non-contaminated (i.e., free of chemicals and explosives) rubble such as waste glass, soil, concrete, and asbestos is/was deposited in an area referred to as Disposal Area 2. Within the last two years, NASA has made a concentrated effort to identify and remove ACM disposed of at Disposal Area 2. Disposal Area 2 is discussed as an operable unit in Section 5.

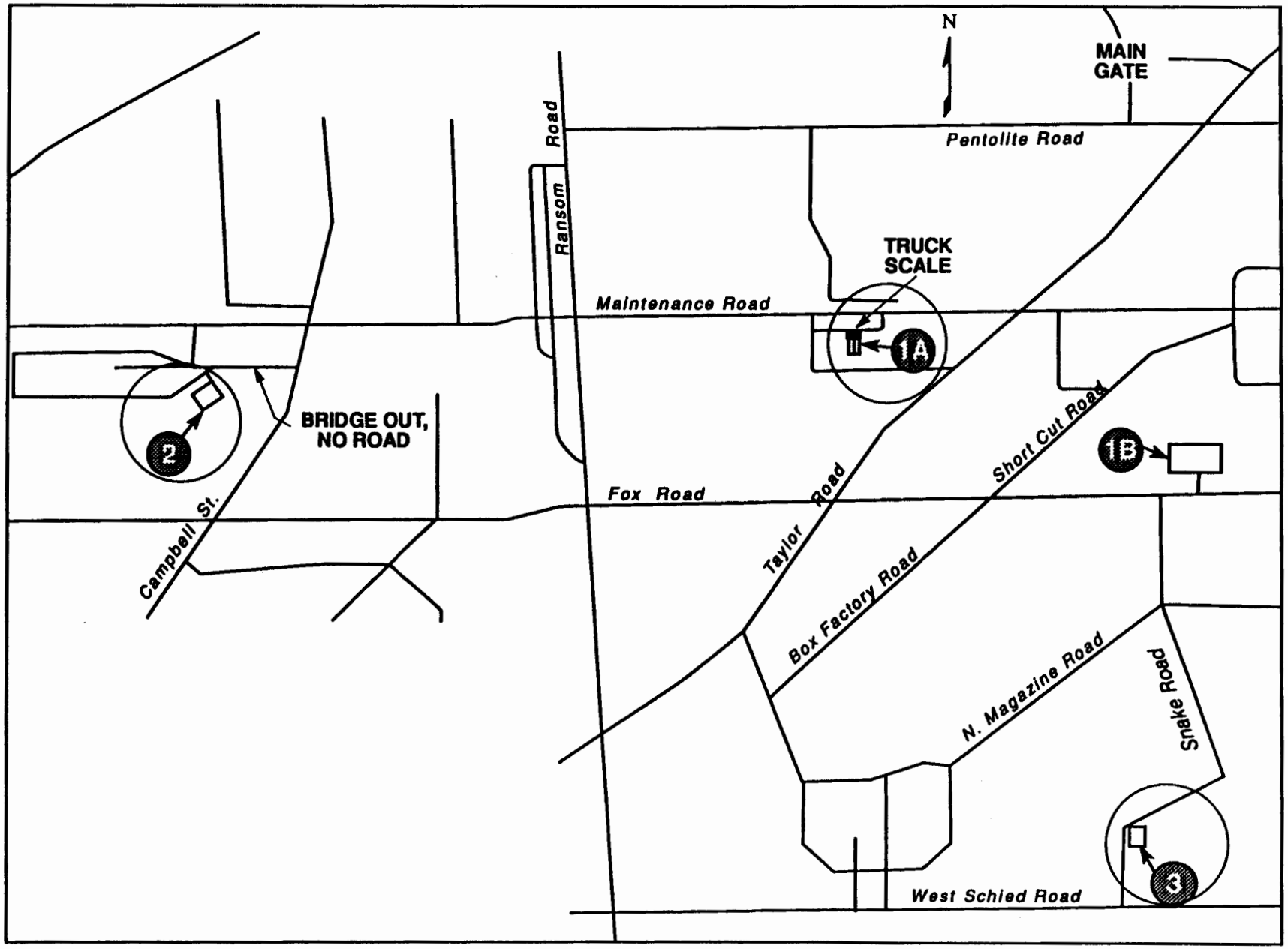

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FIGURE 4-1. LOCATIONS OF DISPOSAL AREAS 1, 2, AND 3

Disposal Area 3 consists of the burning grounds located on the east and west side of Snake Road. These burning grounds were originally used by the Army to destroy explosive wastes. NASA has continued to use these burning grounds throughout the years. Paper and cardboard wastes are deposited inside the burn cage located on the east side of Snake Road. When a sufficient amount of waste accumulates in the cage, it is burned.

Wastes considered not to be contaminated with explosives or materials producing significant toxic combustion products are also deposited inside an embankment on the east side of Snake Road, where they are burned. Types of waste deposited in a burn pile at this location are plywood, discarded wooden displays, and wooden shipping crates. There is no routine schedule for burning or surveillance of the types of materials that are deposited in the burn pile. The waste is typically burned when a sufficient quantity of material is accumulated.

Liquid wastes were deposited in a burn pit located on the west side of Snake Road. This practice is described in more detail in Section 4.2.2.5.

Construction-type waste (concrete, dirt, sand blast grit, etc.) was deposited in a rubble pile located northwest of the SPF. The exact types and volumes of waste deposited in this area are unknown. This rubble pile was solely for waste generated from the SPF reactivation. This rubble pile is discussed as an operable unit in Section 5.

A NASA employee recalled that dead deer were once deposited in the southwest corner of Plum Brook Station. He also recalled an area near C-Area where paper records and old tires were deposited in an excavated area and buried. NASA eventually recovered 200-300 tires from this area and hauled them off-site.[61]

4.2.2.5 Hazardous Liquid and Solid Waste

Since the contractors and uses of the Plum Brook Station have changed throughout the years, hazardous waste practices are discussed by contractor below.

NASA

Since NASA began operating Plum Brook Station, waste has typically been segregated according to whether it was treated, disposed of, or stored. Many of NASA's hazardous waste management practices at Plum Brook Station have been modified to comply with evolving environmental regulations.

NASA continued to conduct D&D at Plum Brook Station long after the Army left. Waste discovered during NASA's D&D efforts that was contaminated or potentially contaminated with explosives or acids was burned at NASA's Disposal Area 3 (Army Disposal Area Two) in a burn pit located on the west side of Snake Road. Interviews with Plum Brook employees indicate that common practice was to accumulate combustible/explosive waste in the burn pit and douse it with chemical waste prior to setting the waste pile on fire.[62,63] On May 14, 1973, a fire occurred at Disposal Area 3.[64] The probable cause was stated to be possible spontaneous combustion due to chemicals and oils dumped together or discarded smoking materials. The types and volumes of waste disposed of in this manner were not documented. This practice was discontinued. In the late 1970s, ash was removed from the burn pit and buried near Line Road 16 and North Magazine Road. The burn pit was then backfilled.

When not disposed of by an off-site contractor, waste oil and solvent were deposited in a smaller pit on the west side of Snake Road and burned. The volumes and types of solvents and waste oils disposed of in this manner were not documented. This practice was typically in conjunction with on-site fire-fighting training conducted in the pit. The pit was filled with water and oil or kerosene and set ablaze. The training exercise

consisted of using foam to suppress the fire. This practice was discontinued approximately seven years ago. Besides fire training, the pit was also used on at least two occasions to dispose of waste.[65] On one occasion, the pit was used to dispose of fuel oil filters. The filters were placed in the pit and set on fire in order to burn the fuel off. The remaining metal pieces associated with the filters were removed from the pit and disposed of as landfill waste. On the other occasion, about 10 years ago, the pit was used to dispose of a small amount of Class C explosives. Some metal pieces also remained after the explosives were burned (having not detonated during the process). The metal pieces were also removed from the pit and disposed of as landfill waste.

RCRA hazardous waste currently generated at Plum Brook Station consists primarily of waste solvents and oils that at one time were discharged to USTs (tanks nos. 7121-1, 7131-1, 1411-1, and 1131-3). These USTs were recently pumped of any remaining liquid and removed from the ground. Waste oil and solvents are now collected in drums and stored in Building 9206 prior to off-site disposal at a permitted facility.

Acids, spent acids, and non-flammable solvents resulting from cleaning, treating, or testing of a system or tank are accumulated as needed at satellite areas near B1 Shop (Building 3131), the SPF (Building 1411), and K-Site (Building 2811) and disposed of by an off-site contractor. Plum Brook Station is a large-quantity generator. Volumes of RCRA hazardous waste generated were not tracked prior to 1981. However, based on the 1989 Generator Hazardous Waste Report, approximately 650 gallons of hazardous waste are generated monthly at Plum Brook Station. The hazardous waste generated is primarily waste oil and solvents and does not include waste generated from the UST removal program.

Some wastes regulated under the Toxic Substances Control Act (TSCA) are also generated at Plum Brook Station: PCBs and asbestos. NASA has conducted an extensive program to retrofill or replace electrical transformers containing PCBs. PCB-contaminated transformer oil recovered by this effort is stored at Building 9206 away from

the solvent and used oil waste in an area of the building that has been modified to conform with TSCA requirements for PCB storage.

Asbestos waste was stored in two of the 99 munitions bunkers (igloos) located in the southeast area of the station. At one time, approximately 4,680 cubic feet of asbestos waste was stored in cardboard boxes in the two igloos.[66] An off-site contractor was contracted by the NASA LeRC Safety Office to package and remove the asbestos waste from the igloos, transport, and dispose of the asbestos waste at an authorized off-site location. The igloos are no longer used for the storage of asbestos waste.

Small amounts of solid radioactive waste are generated by maintenance activities at the PBRF. Routine radiological surveys are conducted at the PBRF by on-site health physics technicians. Solid radioactive waste generated from this activity is stored in the waste handling building within the fenced PBRF. Currently there are 17 drums of radioactive waste stored at PBRF. This waste has been generated since the facility was shut down.[67] The storage area is inspected by health physics technicians on a quarterly basis. Prior to shutdown, radioactive solid waste was packaged in casks and transported off-site through a contract with a commercial carrier and disposed of at Maxey Flats. Radioactive liquid waste was also generated at the PBRF during its operating life. All liquid waste (except sanitary waste) passed through an effluent monitoring system.[8,69] Flow was measured, composite samples were obtained, and radioactivity levels were measured. If the radioactivity level exceeded a set limit, the liquid waste was left in a retention basin. The water was retained until the radioactivity dropped to an acceptable level or was diluted with uncontaminated water and released to Plum Brook. This practice was managed by a permit issued by the State of Ohio Department of Health, Water, and Pollution Board to NASA for discharge of industrial waste into Plum Brook.

Additionally, approximately 8000 cubic yards of lime sludge was removed from the PBRF settling basin and disposed of at Plum Brook Station at the area shown on Figure 4-2.[70] The last lime sludge disposal occurred in 1973.

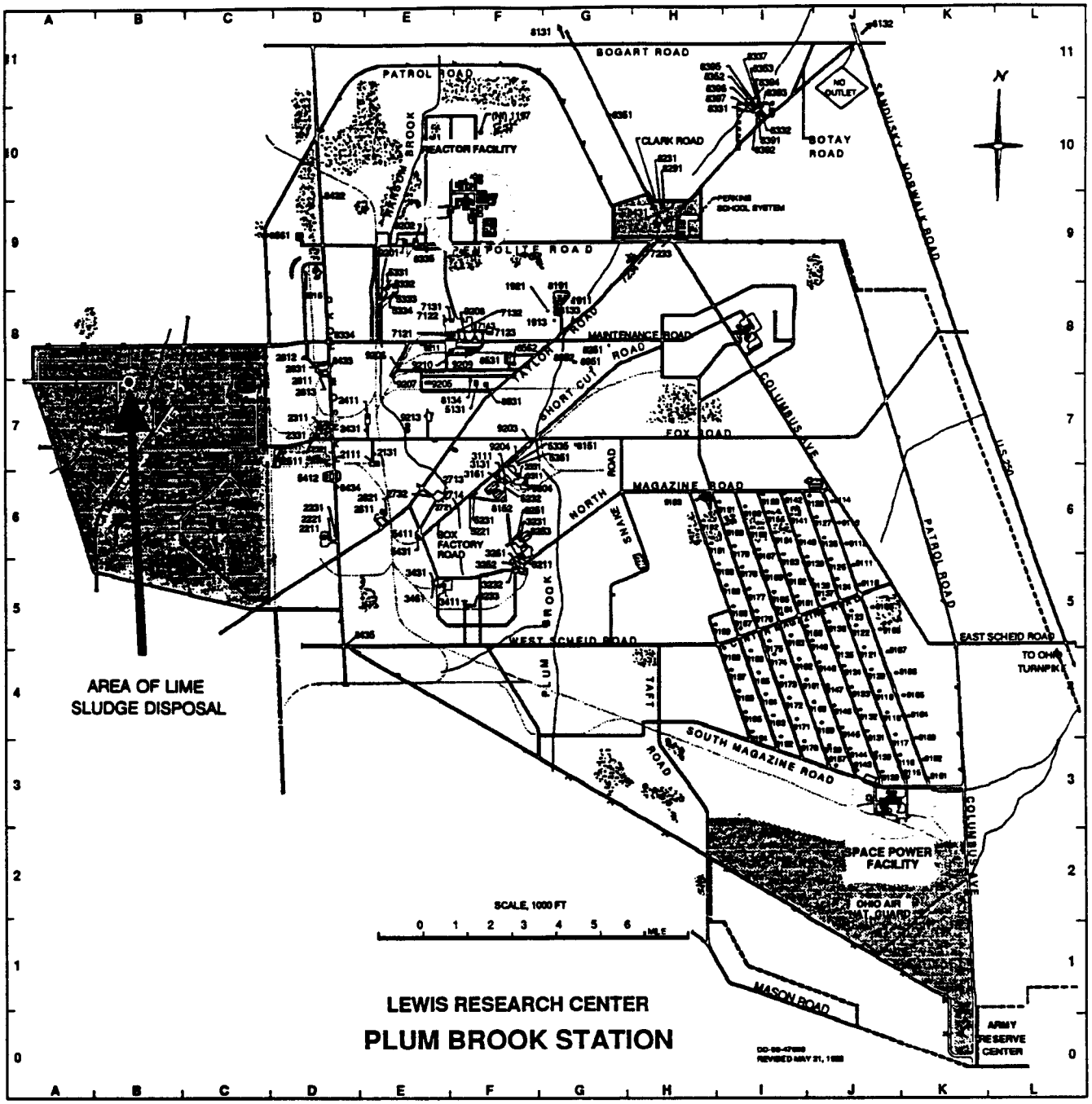


FIGURE 4-2. LOCATION OF LIME SLUDGE DISPOSAL

In the Maintenance Area, two chemical reaction chambers were used to neutralize the chemical wastes from the cleaning room and the chemical laboratory.[69] The chambers were filled with graded limestone. The chemical laboratory chambers discharged into a branch of Plum Brook, and the cleaning room chamber discharged into the sanitary sewer.

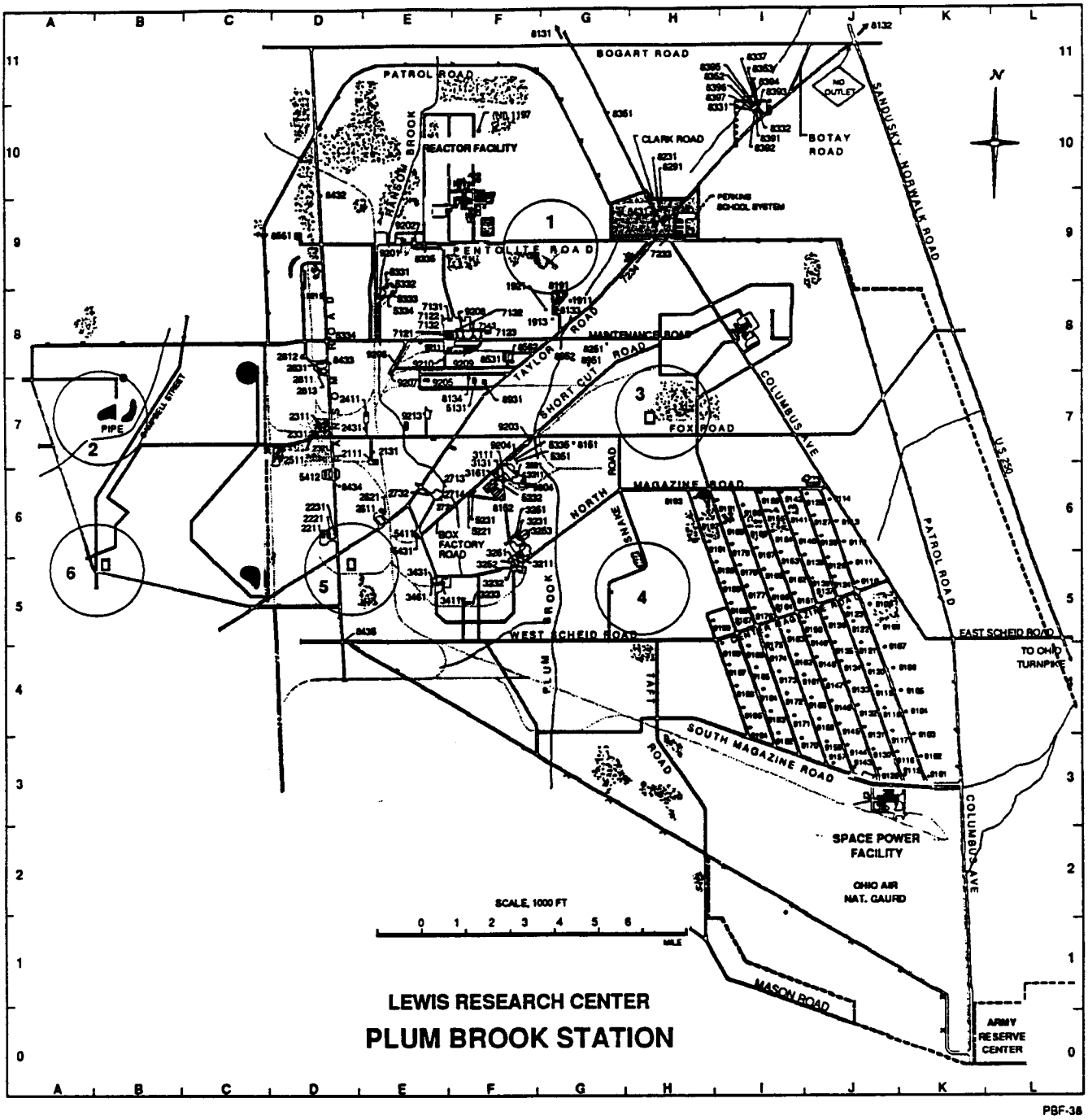
U.S. Army

Wastes produced by the U.S. Army at the PBOW during the manufacturing of ordnance for WWII were primarily red water and explosive solid residues. The red water generated was discharged to ponds. The red water ponds are discussed in Section 5.2.2 as an operable unit.

As discussed earlier, the U.S. Army established the Snake Road burning grounds, which are still used by NASA. In addition to the Snake Road burning grounds, the Army used burning grounds in three other locations: located off Taylor Road; on Fox Road; and west of the raw water pond. The Army burning grounds are discussed further in Section 5.2.4 as an operable unit.

Figure 4-3 shows the location of the red water ponds and the U.S. Army burning grounds.

Many underground wooden drain lines (flumes) were constructed at the PBOW to carry the process wastewater to the red water ponds. The wooden flumes often became plugged with residual TNT. Instead of cleaning the flumes, the Army constructed new wooden flumes around the existing lines to provide continued drainage to the red water retention basins. Construction drawings existed for the original wooden flume lines, but the additional bypass lines that were constructed were never recorded on drawings.



LEGEND	
1	Pentolite Road Red Water Pond
2	West Area Red Water Ponds
3-6	Burning Grounds

FIGURE 4-3. LOCATIONS OF RED WATER PONDS AND BURNING GROUNDS

During NASA's decontamination effort, all known lines shown on engineering drawings and all visually identified lines were removed and burned. NASA has encountered additional wooden flumes during subsequent construction activities. It is believed that there are still unidentified flumes and deposits of TNT and DNT yet to be discovered at Plum Brook Station. These unknown underground flumes are discussed in Section 5.2.3 as an operable unit.

Garrett Waste Management Practices

From August 1979 through November 1986, Garrett Corporation used the SPF to manufacture uranium hexafluoride gas centrifuges for the DOE. The gas centrifuges were fabricated from steel, aluminum, glass fiber, and carbon fiber components. Wastes generated during the production of gas centrifuges included:

- Metal finishing wastes such as sulfuric acid anodizing solution, nickel plating solutions, chromium plating solutions, hydrofluoric acid passivation solutions, and paint-related materials;
- lubricating and cutting oils;
- aluminum chips and fines;
- unreacted and reacted resins and hardeners;
- glass and carbon fiber; and
- solvents such as Freon TA, Freon TF, acetone, isopropanol, methylene chloride, methyl ethyl ketone, methyl isobutyl ketone, and 1,1,1-trichloroethane.

These wastes were classified for national security reasons at the time of their generation. The gas centrifuge program was cancelled by DOE in 1985. At that time, all of the program-related wastes were transported by DOE from Plum Brook Station to the Oak Ridge Gaseous Diffusion Plant in Oak Ridge, Tennessee. Although waste

management records remain classified and unavailable to NASA, it is speculated that large quantities of the wastes (at least 10,000 gallons) were generated and shipped to Oak Ridge.

4.2.2.6 Atmospheric Emissions

Because most of the Plum Brook Station research facilities are still in standby status, many of the emissions sources at the Station are currently not operating. In the past, an incinerator was utilized at the station, but it is not operational today. There are numerous boilers, space heaters, and generators on the site, most of which are also not operational at this time. A paint spray booth in the maintenance area is also inactive. NASA has conducted aerospace research activities since 1988; however, emissions from these operations are not a current air pollution consideration. The major source of atmospheric emissions at Plum Brook Station is the annual open burning of one-half of the Station's brush. This burning is conducted with OEPA approval by issuance of an open-burning permit.

5. POTENTIAL SOURCES OF ENVIRONMENTAL CONTAMINATION

This section of the PA report describes the identities, locations, and characteristics of potential contamination sources at Plum Brook Station.

5.1 Identification of Potential Contamination Sources

This section discusses the potential sources of environmental contamination and the preliminary operable units into which they have been grouped. These sources and units were identified through document reviews, site surveillance, and interviews with Plum Brook Station employees. To determine potential sources of environmental contamination all current management and handling practices for hazardous substances (waste and product) were evaluated including receipt, storage, use, and disposal of all CERCLA listed substances at Plum Brook Station. Practices were evaluated to determine whether they resulted in planned or unplanned releases of hazardous constituents to the environment. The historical management of products and wastes at Plum Brook Station was also evaluated. Through these evaluations, 14 operable units were identified at Plum Brook Station. Several of these operable units consist of multiple potential sources of environmental contamination which have been grouped to streamline further CERCLA investigations and remedial actions. Table 5-1 lists the operable units at Plum Brook Station, identifies the hazardous constituents suspected of being present at the units, and describes the possible receptors of the hazardous constituents. Sections 5.2.1 through 5.2.14 discuss in detail the known or suspected hazards associated with each operable unit. Table 5-2 lists the coordinates (longitude and latitude) for the 14 identified operable units. For units of large areal extent, the coordinates listed in Table 5-2 correlate to the centers of the units.

TABLE 5-1. PLUM BROOK STATION OPERABLE UNITS

Operable Units	Suspected Hazardous Constituents	Potentially Impacted Media
Unit 1 TNT Areas - A,B,C (Spills associated with ordnance production and D&D efforts)	Nitroexplosives, toluene, acetone, acids, asbestos	Soil
Unit 2, Red Water Ponds West Area Red Water Ponds (2 each) Pentolite Road Red Water Pond (includes spoils area)	Nitroexplosives, heavy metals	Soil, surface waters, groundwater
Unit 3 Underground Wastewater Flumes (unidentified bypass lines installed during ordnance production)	Nitroexplosives	Soil
Unit 4 Burning Grounds (2 on Snake Road, 1 off Taylor Road, 1 west of raw water pond, 1 east of Guard House G-8, 1 on Fox Road)	Solvents, unknown chemicals	Soil
Unit 5 Waste Lagoons in Pentolite Area	Acetone, TNT, and pentaerythritol	Soil
Unit 6 Fly Ash Spoil Piles	Heavy metals, organics	Soil
Unit 7 Toluene Storage Tanks - 6 each	Toluene	Soil

TABLE 5-1. PLUM BROOK STATION OPERABLE UNITS (Continued)

Operable Units	Suspected Hazardous Constituents	Potentially Impacted Media
Unit 8 UST Removal Areas - Maint. Area (7121, 7131, 7132) - Pump Station (8133) - PBRF Service Equip. Bldg. (1131) - SPF Bldg. (1411)	Solvents (TCA, TCE, acetone), hydrocarbons, heavy metals	Soil, groundwater
Unit 9 Asbestos Contamination	Asbestos	Soil, surface waters, air
Unit 10 SPF Rubble Pile	Heavy Metals	Soil
Unit 11 Disposal Area 1B	Solvents and Paint Related Compounds	Soil
Unit 12 Disposal Area 2	Unknown Chemicals	Soil
Unit 13 Rail Car Unloading Area	Toluene	Soil
Unit 14 Lime Sludge Disposal Area	Heavy Metals, pH	Soil

TABLE 5-2. COORDINATES OF OPERABLE UNITS

Unit	Name	Latitude	Longitude	Also Known As
1	TNT Areas			
	TNT Area A	41°22'44"	82°39'36"	
	TNT Area B	41°21'44"	82°40'59"	
	TNT Area C	41°22'04"	82°42'37"	
2	Red Water Ponds			
	Pentolite Road Red Water Pond	41°22'55"	82°40'43"	Red Water Disposal Area One
	West Area Red Water Pond A-1	41°22'28"	82°42'42"	Red Water Disposal Area Two
	West Area Red Water Pond A-2	41°22'28"	82°42'48"	Red Water Disposal Area Two
3	Underground Wastewater Flumes	Exact locations of flume lines are unknown.	Exact locations of flume lines are unknown.	
4	Burning Grounds			
	Fox Rd. Burn Ground	41°22'23"	82°40'09"	
	Res. #2 Burn Ground	41°22'37"	82°42'21"	
	G-8 Burn Ground	41°21'54"	82°42'52"	
	Taylor Rd. Burn Ground	41°21'55"	82°41'38"	
	Snake Rd. Burn Pit	41°21'43"	82°40'25"	
5	Waste Lagoons in Pentolite Area	41°23'05"	83°41'05"	
6	Fly Ash Spoil Piles			
	Ash Pit#1	41°22'51"	82°40'41"	Ash Settling Pit
	Ash Pit#3	41°22'35"	82°41'51"	Ash Pit
7	Toluene Storage Tanks			
	Toluene Tank 645 & 655	41°21'49"	82°41'06"	Tanks 8951, 8952
	Toluene Tank 425 & 435	41°22'12"	82°41'22"	
	Toluene Tank 255 & 265	41°22'34"	82°40'28"	
8	UST Removal Areas			
	UST Area 1	41°23'11"	82°41'00"	
	UST Area 2	41°22'43"	82°41'07"	
	UST Area 3	41°22'49"	82°40'36"	
	UST Area 4	41°20'58"	82°39'00"	

TABLE 5-2. COORDINATES OF OPERABLE UNITS (Continued)

Unit	Name	Latitude	Longitude	Also Known As
9	Asbestos Contamination	Extent and locations of contamination are unknown	Extent and locations of contamination are unknown	
10	SPF Rubble Pile	41°20'57	82°39'09"	
11	Disposal Area 1B	41°22'23"	82°40'09"	Fox Rd. Burn Ground
12	Disposal Area 2 Disposal Area 2A Disposal Area 2B	 41°22'35" 41°22'41"	 82°42'39" 82°43'05"	Lime Sludge Disposal
13	Rail Car Unloading Area	41°22'41"	82°41'15"	
14	Lime Sludge Disposal Area	41°22'35"	82°42'39"	Disposal Area 2A

5.2 Characteristics of Potential Contamination Sources

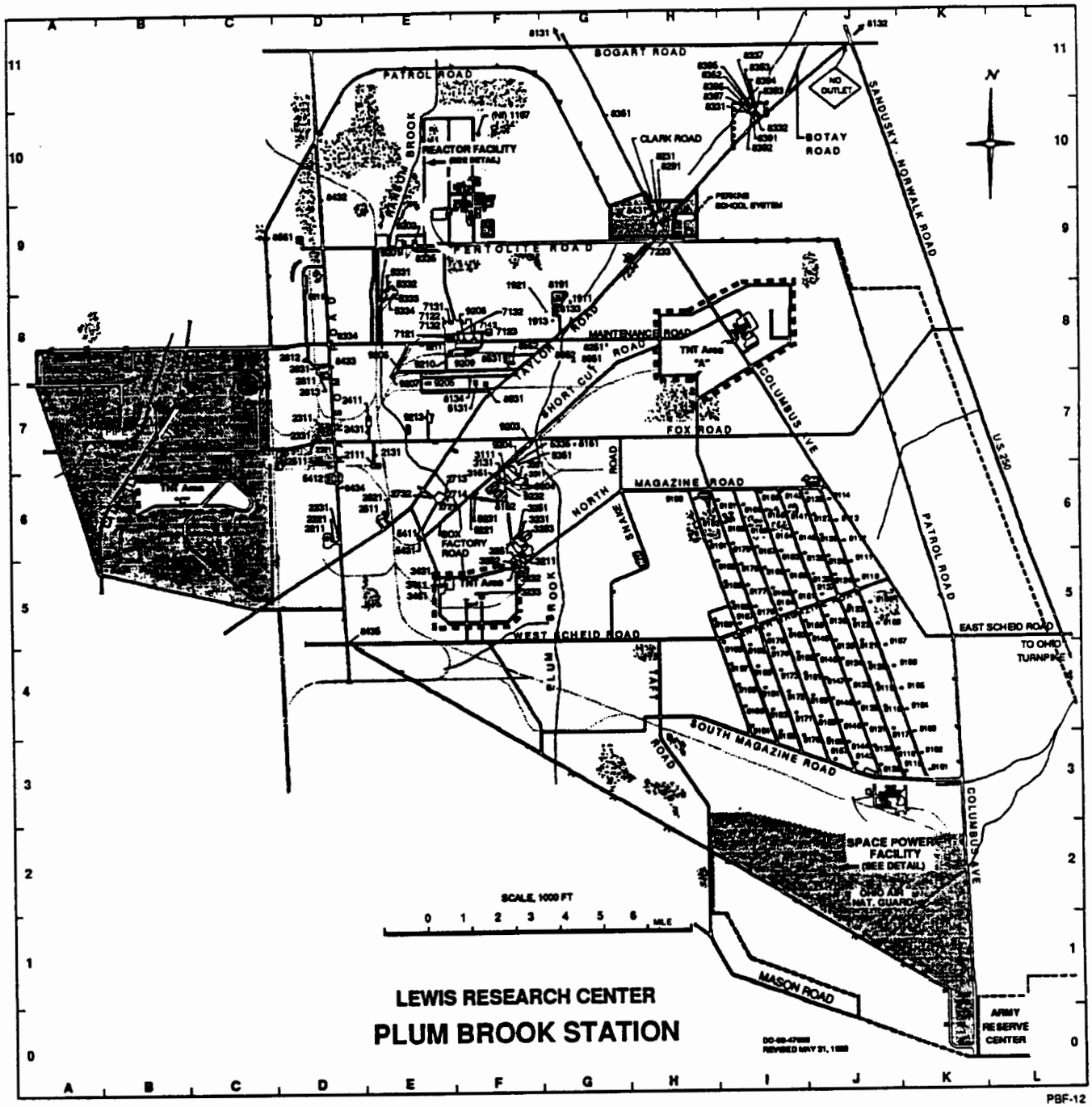
This section of the PA report describes the characteristics of Operable Unit 1, TNT Areas. The TNT Areas have been included in this PA report as suspected sources of environmental contamination by nitroexplosives, toluene, acetone, and other hazardous materials. The TNT Areas were operated by the Army.

5.2.1 Operable Unit 1, TNT Areas

5.2.1.1 Nature and Description

The TNT areas (A, B, and C) are considered as possible sources of environmental contamination because of the potential for unplanned product release during the production of ordnance in the 1940s. Contaminants may have also been released to the environment during decontamination of these areas in the 1950s and 1960s. Although these areas are geographically dispersed, they are considered as a single operable unit throughout this report, since the same manufacturing process occurred at all three sites. The potential contaminants are the same. The potential for soil and groundwater contamination is similar. Any remedial actions required at the sources will be similar.

TNT Area A is located on the east side of Plum Brook Station in the present location of NASA Building 7141. TNT Area B is located in the southern portion of the station. The HTF is located on the northwest side of former TNT Area B, and the B2 Facility is located on the northeast side. TNT Area C is located on the west side of the station where there are presently no NASA facilities. Refer to Figure 5-1 for locations of the TNT Areas.



TNT	NASA Facilities
A	Building 7141
B	Building 3233
C	None

FIGURE 5-1. LOCATIONS OF FORMER TNT MANUFACTURING AREAS

TNT was produced by progressively nitrating toluene with successively greater concentrations of nitric acid to produce mono-, then di-, and finally trinitrotoluene. The mixture of nitric and sulfuric acid remaining from production of TNT was used to manufacture DNT. Over 888 million pounds of nitric acid, 61 million pounds of sulfuric acid, and greater than 400 million pounds of toluene were consumed to produce a total of 821,551,100 pounds of TNT prior to the cessation of operations on August 24, 1945.[71] An additional 37 million pounds of nitric acid, 2.5 million pounds of sulfuric acid, and 25 million pounds of toluene were consumed to produce a total of 46 million pounds of DNT.[71]

5.2.1.2 Physical Characteristics of Units

TNT Area A covered approximately 113 acres and contained four TNT lines of six buildings each and two DNT lines of one building each.[49,72] TNT Area B covered approximately 48 acres and contained three TNT lines of six buildings each and one DNT line of one building. TNT Area C covered approximately 113 acres and contained five TNT lines of six buildings each. The three TNT manufacturing areas consisted of widely scattered buildings of temporary construction of wood frame, asbestos, and sheet metal.[49] Fifty-nine structures along with the adjacent grounds of approximately 10 acres were identified as heavily contaminated with TNT and DNT prior to the start of decontamination efforts in the mid-1950s.

The TNT Areas presently are unused, rough-graded land areas. There are no physical barriers to prevent contamination migration. Any residual contaminants have the potential to migrate from soils into surface water, groundwater, and air.

5.2.1.3 Hazardous Substance Management

The potential contaminants in the TNT areas vary depending on location within a given manufacturing area. Soil and possibly groundwater contamination with toluene and

with the acid/toluene mixes (mono-, bi-, and tri- "oil") are suspected in the southern portions of the TNT manufacturing complex, since this is where the liquid processing occurred.[73,74,75] Difficulties in the liquid process were encountered because of high heat generation and vigorous foaming especially in the tri-mix addition. Often uncontrollable temperatures necessitated the dumping of the entire mix to avoid possible fire or explosion. Spillage may have occurred by this method, or leakage may have occurred along piping at valves or flanges. Potential soil contamination with solid nitroexplosives is suspected in the northern portion of the TNT manufacturing complex, since this is where the underground flumes were located (see discussion in Section 5.2.2).

It is documented that during plant operations water flowed to surface creeks and into Sandusky Bay, resulting in sizable fish kills. Since the TNT areas were not initially decontaminated until 1955, 10 years after plant operations ceased, since D&D was not resumed until the 1960s, and since residual nitroexplosives and toluene contamination are suspected, it is postulated that the shallow aquifer(s) in the glacial till have become contaminated.

Asbestos contamination of the soil may also have occurred throughout the TNT areas. The buildings in these areas were decontaminated in 1963 by burning in place.[72,76] Since the buildings were constructed with asbestos, this decontamination method may have resulted in further dispersal of asbestos. In other cases, the insulation was stripped from lines and tanks and removed to the burning grounds.[8,77] The extent and depth of contamination is unknown.

After TNT operations ceased in 1945, the site was maintained by the GSA in an "as is" condition until the mid-1950s. In 1955, preliminary decontamination of the TNT areas was initiated. At this time, the ground around the contaminated structures in Area A was excavated to "a depth necessary to obtain samples of earth that showed no contamination..." and a total of 1700 feet of wooden underground flume were removed.[77] From 1962 to 1963, the TNT areas underwent additional decontamination in three phases:

removal of surface contamination; removal of contaminated facilities by flashing; and removal of buried contamination in selected areas by "scraping and flashing the earth to whatever depth necessary."[76] At the end of this effort, the former building sites were rough graded.

5.2.1.4 Evaluation of Potential Environmental Impacts

The existence of residual contamination by nitroexplosives, toluene, and other hazardous substances at the TNT Areas was not confirmed during the PA. Using an abbreviated Hazard Ranking System (HRS) model provided by USEPA Region V, the following scores were calculated for the operable unit:

- groundwater pathway - 4.8
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.24.

HRS score sheets are provided in Appendix G. The site score of 4.38 is well below the USEPA action level of 28.5. A significant adverse environmental impact is not evident. This operable unit should be given a low priority for further investigation.

The potential for groundwater contamination of the shallow aquifers from any residual contaminant sources in the glacial till would be high, since all three former manufacturing areas are underlain by a discontinuous water-bearing "yellow sand."[78] Data are not available to determine the lateral continuity of these sands. However, it is unlikely that they are continuous across the study area given the probable origin of these sands. Depth to bedrock varied from 3 to 17 feet at Area A, from 5 to 6 feet at Area B, and from 2 to 12 feet at Area C. It is unlikely that the bedrock groundwater aquifers would be

contaminated by the previous activities in these areas since the test boreholes reached a total depth in the top of the bedrock surface well above the water-bearing zones.

Given the hydrology and hydrogeology of the TNT Areas, any further investigations of Operable Unit 1 should be concentrated on the surface water and groundwater pathways.

5.2.2 Operable Unit 2, Red Water Ponds

This section of the PA report describes the characteristics of Operable Unit 2, Red Water Ponds. The Red Water Ponds are suspected sources of environmental contamination by nitroexplosives and heavy metals. The Red Water Ponds were constructed and operated by the Army.

5.2.2.1 Nature and Description

Red water waste was generated during the operation of the PBOW from 1940 through 1945. The red water waste stream was generated in the final TNT production purification process. A by-product of TNT production via nitration of toluene is DNT. A purification step to remove the DNT is called the "Sellite" process. Aqueous sodium sulfite is used in the Sellite process to wash the TNT product. The resultant wash solution containing DNT is red. TNT- and DNT-related compounds, when exposed to sunlight, degrade slowly to materials that are pink/red in color.[79]

To dispose of the red water generated from the production of ordnance at the PBOW, the U.S. Army established red water ponds in two locations, as shown in Figure 4-3. The Army referred to the two areas as Disposal Area One or Site B (referred to as Pentolite Road Red Water Pond by NASA) and Disposal Area Two or Site A (referred to as West Area Red Water Ponds A-1 and A-2 by NASA). No wastewater has

been discharged to the red water ponds since the production of ordnance ceased in 1945.[80]

5.2.2.2 Physical Characteristics

The Pentolite Road Red Water Pond and spoils area are located in the northern portion of Plum Brook Station adjacent to Plum Brook. It consists of a small unlined pond (a surface impoundment) and large spoil areas. The area of the pond is approximately 1/2 acre. The depth of the pond is unknown; therefore, the volume of water in the pond is also unknown. The spoil areas were created by the spreading of neutralized chemical wastes from the explosives production over clay beds near the pond area. Figure 5-2 is a photograph of the Pentolite Road Red Water Pond and Figure 5-3 is a photograph of the spoil areas.

Approximately two years ago, a small red water pond was discovered by NASA and U.S. EPA personnel near the Pentolite Road Red Water Pond. It is assumed that this pond was not an engineered disposal area excavated by the Army but rather that it resulted from the accumulation of run-off from adjacent areas contaminated with solid TNT/DNT residues. The size and depth of this pond are unknown.

The West Area Red Water Ponds are located in the westernmost part of the Plum Brook Station along Pipe Creek. The West Area Red Water Ponds are two unlined surface impoundments, A-1 and A-2, which cover a total area of approximately 8 acres. A-2 is the pond closest to Pipe Creek. Both ponds were excavated and are surrounded by 3-foot earthen dikes. Figure 5-4 is an aerial photograph (circa 1960) of the Red Water Ponds A-1 and A-2, as originally configured. Pond A-1 was originally approximately 4-1/2 acres but has expanded to about 6 acres. Pond A-1 has an overflow tile 8 inches in diameter that allows the basins to overflow into Pipe Creek. The depth of the pond is

FIGURE 5-2. PHOTOGRAPH OF PENTOLITE ROAD RED WATER POND

NASA
C-89-12281

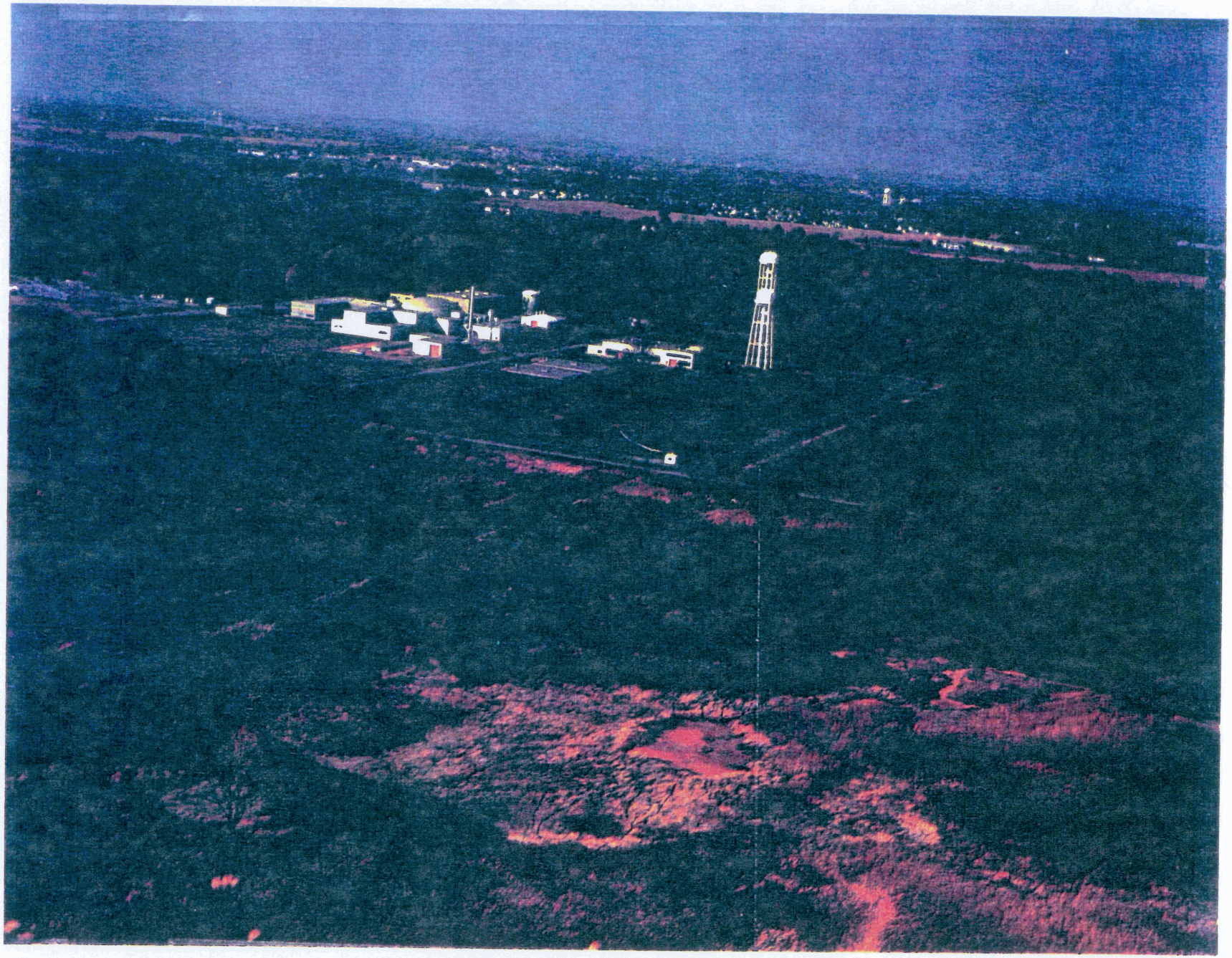


FIGURE 5-3. PHOTOGRAPH OF SPOIL AREAS

NASA
-54841

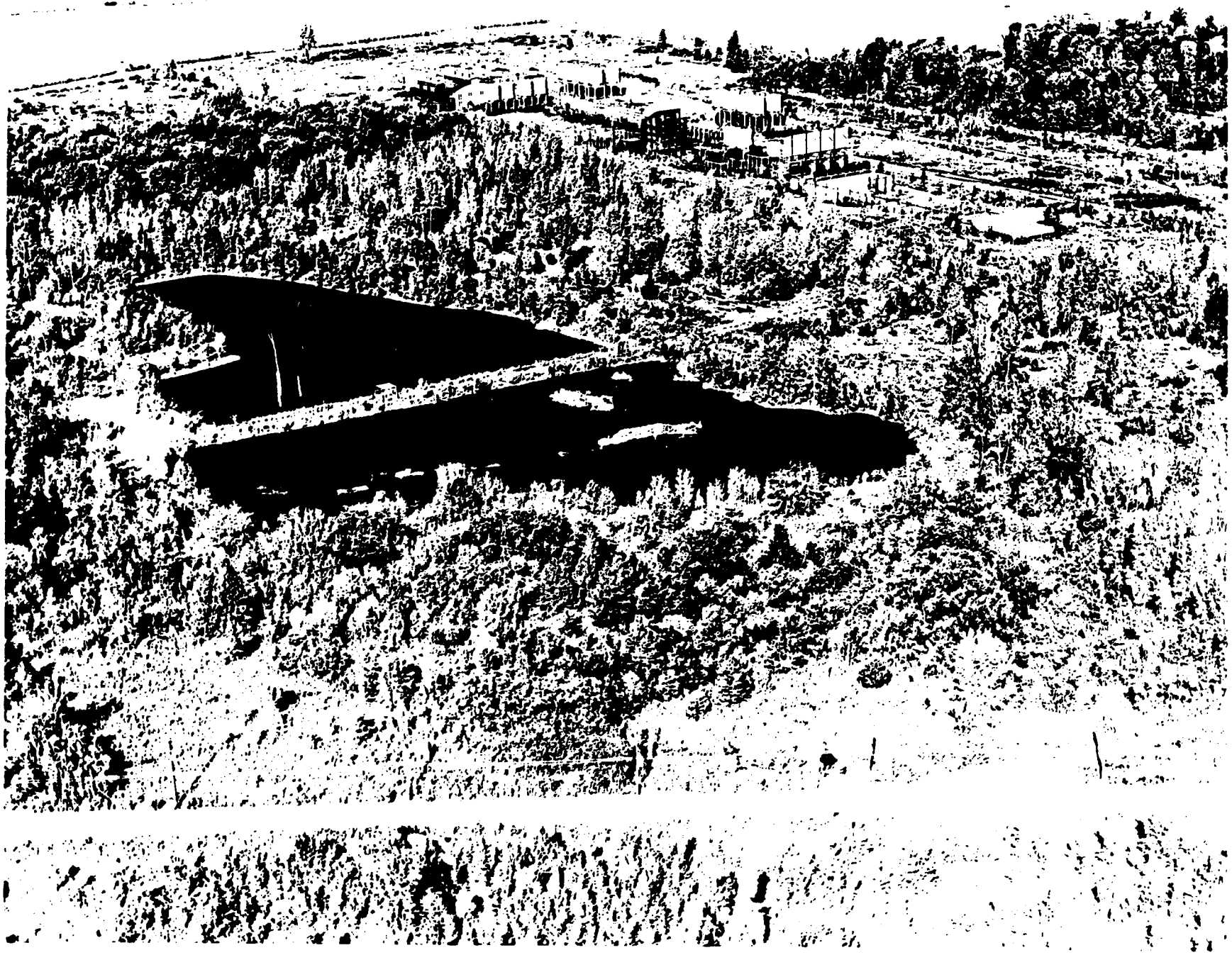


FIGURE 5-4. AERIAL PHOTOGRAPH OF WEST AREA RED WATER PONDS

FIGURE 5-5. PHOTOGRAPH OF RED WATER POND A-1

unknown. Pond A-1 is filled with red water year round. Because the depth of this pond is unknown, the volume of water in the pond is also unknown. Red Water Pond A-1 is within the 500-year floodplain of Pipe Creek.[33] Figure 5-5 is a photograph of Red Water Pond A-1.

Pond A-2 contains very little red water but has significant areas of red residue at its bottom. Red Water Pond A-2 is within both the 100-year and 500-year floodplains of Pipe Creek.[33]

The red water ponds were originally constructed with earthen dikes to preclude run-off. The integrity of the dike system has deteriorated with time. Run-off to surface water has been documented.

There are no engineered barriers to preclude migration to soil, groundwater, and air receptors.

5.2.2.3 Hazardous Substance Management

PBOW operating records indicate that the following chemicals were used in large quantities to produce ordnance and may be present (in addition to residual deposits of TNT and DNT) in the soils and waters at Plum Brook Station.[81]

- nitric acid
- sulfuric acid
- ammonia
- soda ash
- sulfur
- sodium sulfite
- acetone
- toluene.

Throughout the years, NASA and the U.S. Army have endeavored to determine if the red water ponds, pond sediments, and soils are toxic or hazardous in any way. Red water is a listed RCRA hazardous waste assigned the waste code K047. Analytical results indicate low levels of TNT, DNT, and heavy metals in the soils and groundwater associated with the red water ponds.

The most recent analysis of the Red Water Ponds occurred in October 1989.[21] The U.S. Army Corp of Engineers contracted IT Corporation to perform a contamination evaluation at the Plum Brook Station to determine the extent of contamination from PBOW operations. The evaluation included the Army's red water ponds. The evaluation involved installation of a groundwater monitoring wells, downgradient to each pond. Samples of groundwater, surface water, and soil were obtained and analyzed to determine the extent of contamination and migration at Plum Brook Station. Sample locations are illustrated in Figures 5-6 and 5-7. A partial summary of analytical results (volatile organics, semi-volatile organics, nitroexplosives, and metals) is provided in Table 5-3.

Soil samples collected in the vicinity of the Pentolite Road Red Water Pond showed significant concentrations (greater than or equal to 740 ppb) of 2,6-dinitrotoluene and 2,4-dinitrotoluene. Soil contamination did not appear to be impacting groundwater conditions. No semivolatile compounds were detected in the groundwater sample collected from the monitoring well installed at this site.[21]

Soil samples collected in the vicinity of the West Area Red Water Ponds showed high concentrations of manganese (2,600 ppm). Both disposal areas showed high levels of sodium (1,040 ppm to 2,820 ppm) and sulfates (1,800 ppm to 2,500 ppm) in soil samples analyzed.[21]

Samples were obtained from the groundwater monitoring wells installed in the areas. West Area Red Water Ponds groundwater samples showed significant

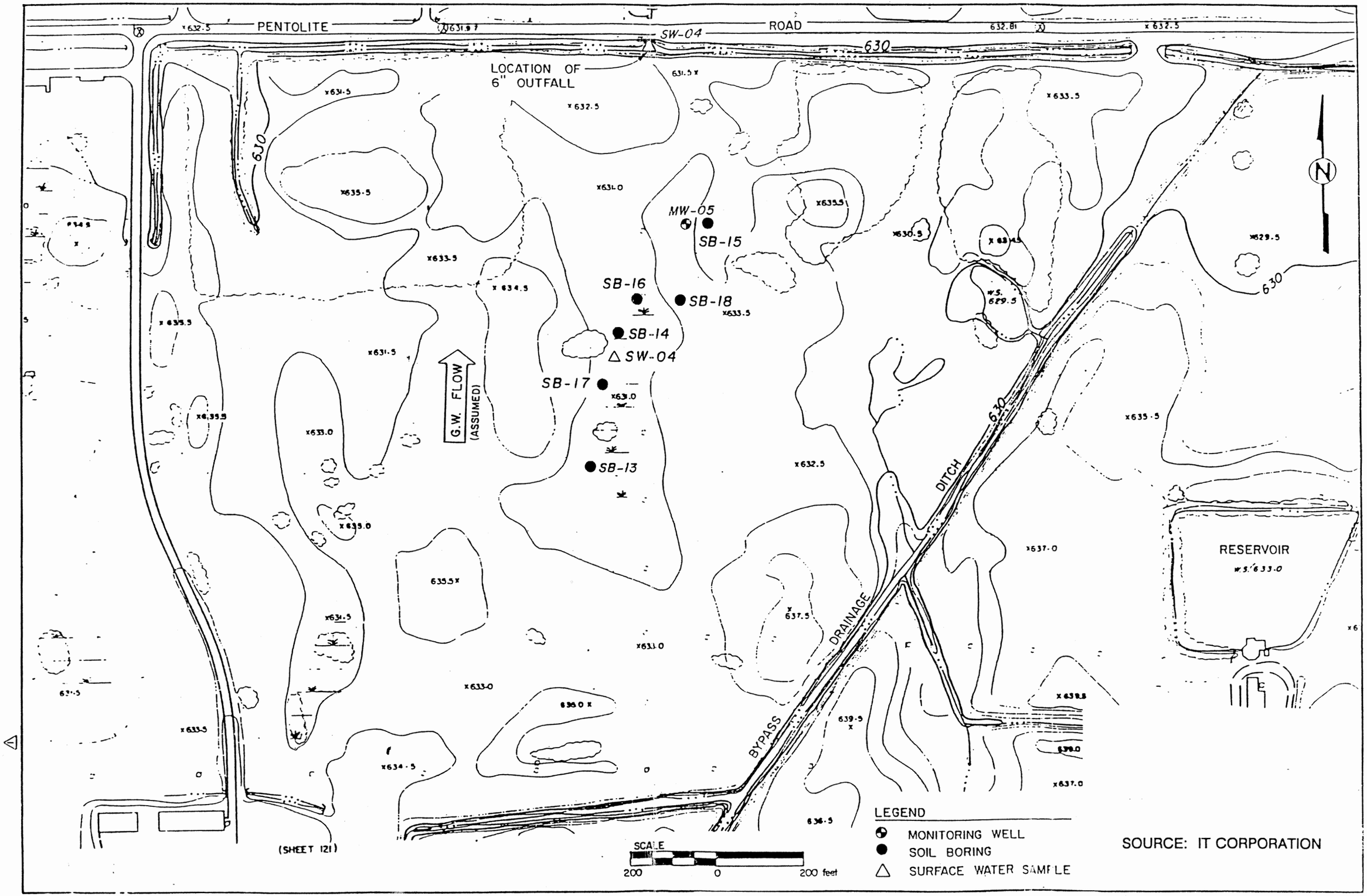
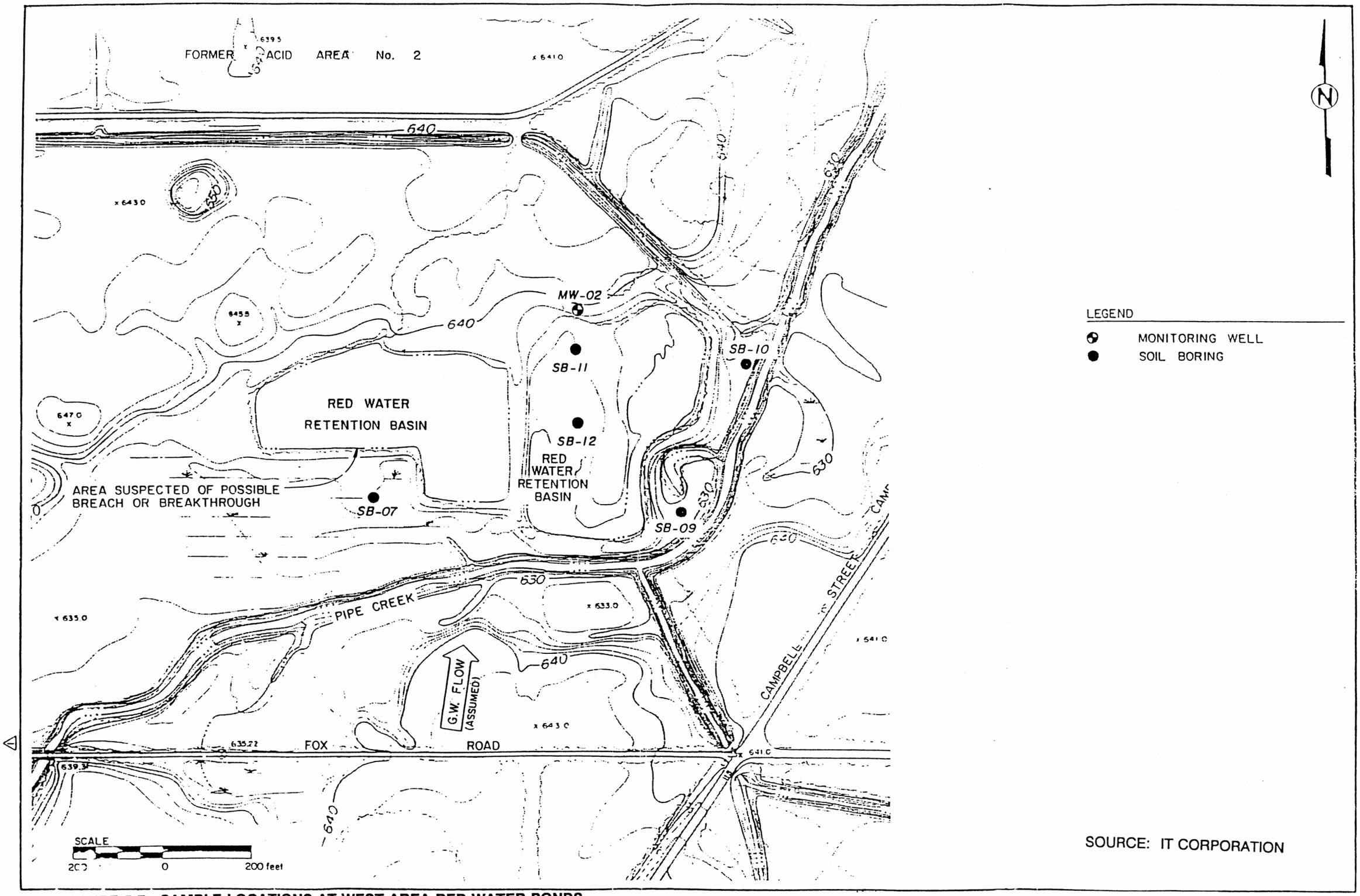


FIGURE 5-6. SAMPLE LOCATIONS AT PENTOLITE ROAD RED WATER POND



SOURCE: IT CORPORATION

FIGURE 5-7. SAMPLE LOCATIONS AT WEST AREA RED WATER PONDS

TABLE 5-3. PARTIAL SUMMARY OF SOIL, GROUNDWATER, AND SURFACE WATER SAMPLE RESULTS FOR RED WATER PONDS

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
SB-07/Soil	Acetone, 2300 ppb	None detected	1,3,5-Trinitrobenzene, 0.41 ppm 2,4-Dinitrotoluene, 0.23 ppm	Barium, 77.8 ppm Chromium, 17 ppm Iron, 23,200 ppm Lead, 20 ppm Manganese, 530 ppm Sodium, 1360 ppm
SB-09/Soil	Methylene Chloride, 8 ppb	None detected	None detected	Barium, 66.7 ppm Chromium, 14 ppm Iron, 16,300 ppm Lead, 21 ppm Manganese, 104 ppm Sodium, 205 ppm
SB-10/Soil	None detected	None detected	None detected	Barium, 63.3 ppm Cadmium, 0.6 ppm Chromium, 14 ppm Iron, 17,800 ppm Lead, 27 ppm Manganese, 271 ppm Sodium, 174 ppm
SB-11 Soil	Methylene Chloride, 10 ppb	None detected	None detected	Arsenic, 2.3 ppm Barium, 48.4 ppm Chromium, 11 ppm Iron, 12,800 ppm Lead, 14 ppm Manganese, 211 ppm Sodium, 539 ppm

TABLE 5-3. PARTIAL SUMMARY OF SOIL, GROUNDWATER, AND SURFACE WATER SAMPLE RESULTS FOR RED WATER PONDS (Continued)

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
SB-12/Soil	Acetone, 56 ppb Methylene Chloride, 8 ppb	None detected	1,3,5-Trinitrobenzene, 3.4 ppm 1,3-Dinitrobenzene, 0.59 ppm 2,4,6-Trinitrotoluene, 0.68 ppm 2,4-Dinitrotoluene, 0.91 ppm	Barium, 52.2 ppm Chromium, 10 ppm Iron, 18,000 ppm Lead, 14 ppm Manganese, 262 ppm Sodium, 1660 ppm
SB-13/Soil	Acetone, 170 ppb Methylene Chloride, 6 ppb	2,4-Dinitroluene, 1600 ppb	1,3,5-Trinitrotoluene, 0.73 ppm 1,3-Dinitrobenzene, 0.62 ppm 2,4-Dinitrotoluene, 2.2 ppm	Barium, 56.7 ppm Chromium, 13 ppm Iron, 15,500 ppm Lead, 9 ppm Manganese, 263 ppm Sodium, 2590 ppm
SB-14/Soil	Acetone, 80 ppb Methylene Chloride, 9 ppb	2,6-Dinitrotoluene, 1700 ppb 2,4-Dinitrotoluene, 11,000 ppb	1,3,5-Trinitrobenzene, 14 ppm 1,3-Dinitrobenzene, 3.7 ppm 2,4-Dinitrotoluene, 20 ppm	Arsenic, 1.8 ppm Barium, 51.6 ppm Chromium, 10 ppm Iron, 12,000 ppm Lead, 11 ppm Manganese, 146 ppm Sodium, 3420 ppm
SB-15/Soil	Methylene Chloride, 7 ppb	None detected	None detected	Arsenic, 4.6 ppm Barium, 14.1 ppm Chromium, 8 ppm Iron, 10,900 ppm Lead, 11 ppm Manganese, 181 ppm Sodium, 96.9 ppm

TABLE 5-3. PARTIAL SUMMARY OF SOIL, GROUNDWATER, AND SURFACE WATER SAMPLE RESULTS FOR RED WATER PONDS (Continued)

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
SB-16/Soil	Acetone, 160 ppb	2,4-Dinitrotoluene, 1900 ppb	1,3,5-Trinitrotoluene, 1.2 ppm 1,3-Dinitrotoluene, 0.55 ppm Nitrobenzene, 0.48 ppm 2,4,6-Trinitrotoluene, 0.74 ppm 2,6-Dinitrotoluene, 0.53 ppm 2,4-Dinitrotoluene, 3.2 ppm Nitrotoluene, 0.48 ppm	Arsenic, 2.8 ppm Barium, 16.5 ppm Chromium, 8 ppm Iron, 5910 ppm Lead, 5 ppm Manganese, 78.2 ppm Sodium, 1040 ppm
SB-17/Soil	Acetone, 150 ppb	2,4-Dinitrotoluene, 740 ppb	1,3,5-Trinitrotoluene, 0.67 ppm 2,4-Dinitrotoluene, 1.1 ppm	Arsenic, 0.8 ppm Barium, 21.9 ppm Chromium, 6 ppm Iron, 8370 ppm Lead, 8 ppm Manganese, 141 ppm Sodium, 205 ppm
SB-18/Soil	None detected	2,6-Dinitrotoluene, 1000 ppb 2,4-Dinitrotoluene, 5900 ppb	1,3,5-Trinitrotoluene, 10 ppm 1,3-Dinitrobenzene, 5.0 ppm 1,3,5-Dinitrotoluene, 19 ppm	Arsenic, 1.3 ppm Barium, 20.2 ppm Chromium, 5 ppm Iron, 6890 ppm Lead, 11 ppm Manganese, 97.6 ppm Sodium, 1980 ppm

TABLE 5-3. PARTIAL SUMMARY OF SOIL, GROUNDWATER, AND SURFACE WATER SAMPLE RESULTS FOR RED WATER PONDS (Continued)

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
MW-02/Groundwater	Acetone, 12 ppb	2,6-Dinitrotoluene, 27 ppb 2,4-Dinitrotoluene, 160 ppb	None detected	Barium, 0.068 ppm Iron, 2.7 ppm Manganese, 2.8 ppm Sodium, 401 ppm
MW-05/Groundwater	None detected	None detected	None detected	Barium, 0.21 ppm Iron, 0.8 ppm Manganese, 0.053 ppm Sodium, 17 ppm
SW-04/Surface Water	None detected	None detected	None detected	Barium, 0.079 ppm Chromium, 0.01 ppm Iron, 9.6 ppm Manganese, 0.37 ppm Sodium, 92.7 ppm

concentrations of 2,4-dinitrotoluene. The only volatile organic compound (VOC) detected in the samples obtained from this well was acetone (12 ppb). High concentrations of iron, manganese, and sulfate were also detected in the groundwater samples from groundwater at the West Area Red Water Ponds. The groundwater samples from the Pentolite Road Red Water Pond showed no evidence of contamination.[21]

Surface water from standing water at the Pentolite Road Red Water Pond and three NPDES monitoring points was analyzed. No nitroexplosive compounds were detected above analytical detection limits. All metals with the exception of iron, manganese, and sodium were below detection limits.[21]

On-site inspections of the red water ponds by NASA employees, state and federal agencies, and firms contracted to conduct assessments show that vegetation grows around the ponds, and that aquatic life including fish, frogs, and waterfowl is present in the ponds. Additionally, local wildlife such as deer, groundhogs, and racoons, drink from the ponds. Of concern from an environmental impact standpoint, however, are the observations that vegetation growth in the spoil areas is sparse and that the red water ponds are devoid of vegetation.

As discussed in Section 2.2.2.2, several red water discharges have been observed primarily to the Pentolite Ditch. The 1977 discharge was caused by a broken drain tile near the Pentolite Road Red Water Pond. The 1989, 1990, and 1991 discharges were caused by drainage from an agricultural tile.

5.2.2.4 Evaluation of Potential Environmental Impacts

Releases of red water to surface water have been documented. Soil and groundwater contamination have been quantified through chemical analysis of environmental samples collected at the Red Water Ponds.

Using the abbreviated HRS model, the following scores were calculated for the operable unit:

- groundwater pathway - 26.66
- surface water pathway - 12
- soil pathway - 12
- air pathway - 30.3
- site - 21.9.

HRS score sheets are provided in Appendix G. The site score of 21.9 is below the USEPA action level of 28.5 but is high enough to indicate significant adverse environmental impact. It is possible that continuing investigations may produce data that will increase the HRS score to a number above 28.5. This operable unit should be given a high priority for further investigation.

5.2.3 Operable Unit 3, Underground Wastewater Flumes

This section of the PA report describes the characteristics of Operable Unit 3, Underground Wastewater Flumes. The flumes, which were constructed and operated by the Army, are suspected sources of environmental contamination by nitroexplosives.

5.2.3.1 Nature and Description

The wastewater disposal system at the TNT manufacturing areas described in the previous section consisted of above- and below-ground wooden flumes and the red water ponds. Although a concerted D&D effort was aimed at removing and destroying all of the pipe and flumes, NASA suspects that significant lengths of explosives-contaminated flume remain. Remaining flume would be a potential source of environmental contamination.

Wooden flumes were used to dispose of liquid and solid waste that accumulated in catch basins located at the wash houses at each of the three TNT manufacturing areas. Wastes accumulated in catch basins were transported by gravity flow to three wooden settling tanks located in the northernmost portion of each TNT manufacturing area before being pumped to one of the red water ponds. The wooden settling tanks were 40 feet in diameter and 4 feet deep. The wooden flumes were used only during operation of the PBOW from 1941 to 1945.

5.2.3.2 Physical Characteristics

Four-inch-diameter wood flumes drained wastes from the DNT nitrator buildings and from the wash house catch basins to the settling tanks. The wooden flumes had dimensions of 6 by 10 inches and were capable of transporting large volumes of waste and possibly waste solids from the wash house catch basins to the settling tanks. After the waste had segregated in the settling tanks, the waste slurry was pumped via either a 4- or 6-inch pipe to the raw waste storage tank prior to disposal in the red water ponds. Table 5-4 summarizes the linear footage of wooden pipe and box flumes documented on PBOW engineering drawings and maps prior to D&D.

The flumes were underground wooden waste conduits. There were no engineered barriers to migration surrounding the flumes. Given the age of the flumes and current site conditions, migration of any residual contaminants to soil, groundwater, surface water, and air is possible.

5.2.3.3 Hazardous Substance Management

Liquid wastes contaminated with nitroexplosives and possibly solid chunks of TNT were disposed of during operation of the PBOW. Within the former TNT manufacturing areas, the potential hazard from unidentified underground flumes is greatest in the

TABLE 5-4. SUMMARY OF WOODEN PIPE AND FLUME FOOTAGE AT TNT MANUFACTURING AREAS

Area	4-Inch Pipe	5-Inch Pipe	6-Inch Pipe	6x10-Inch Flume
A	4900	1550	0	3425
B	2150	500	100	1325
C	2500	0	0	2575
Other Areas	11,275	0	11,150	1550
TOTALS	20,825	2050	11,250	8,875

Sources: PBOW Sewerage and Waste Disposal Systems, Sheets 2, 3, and 4[82]
PBOW TNT Area A Composite[73]
PBOW TNT Area C Composite[75]

northern portion of the areas. The locations of the underground flumes are unknown. NASA has encountered unidentified underground flumes contaminated with TNT during construction activities.[66] It is suspected that additional underground lines may exist, presenting a potential explosion hazard. Soil and shallow groundwater contamination may exist along the traverse of any of the pipes where wood has deteriorated. The depth of potential contamination is unknown, but during D&D operations underground flumes were removed from depths of 3 to 7 feet.[72]

An initial decontamination of the PBOW occurred in 1955. The TNT manufacturing areas underwent further decontamination and were renovated for use by NASA from 1963 to 1965. A standard operating procedure was written and used for the removal of explosive contaminated flumes.[83] Surface contamination was eliminated first, and then the flumes were excavated and removed to the burning grounds for destruction. All known flumes were removed at this time. However, during preliminary decontamination operations in 1955, the Army noted that "many of the waste disposal sewers were not shown on the drawings but were discovered in the course of digging for known sewers."[77] Apparently, when a flume became plugged and inoperable, a bypass was laid in close proximity. The locations of bypasses were not documented on engineering drawings. As noted above, NASA has encountered unidentified flumes during subsequent construction activity. The total footage of wooden flume removed from Plum Brook Station during D&D was not documented. The total footage and locations of flume remaining are unknown.

5.2.3.4 Evaluation of Potential Environmental Impacts

Since the locations of the underground flumes are unknown, it is difficult to predict the potential for contaminant migration. If the wood has deteriorated, contaminants would enter the environment via the soil pathway. Depending on whether the underlying

lithology is sand or shale, the migration potential would be enhanced or minimized, respectively.

Releases to the environment from this operable unit were not confirmed during the PA. Accordingly, application of the abbreviated HRS model to this unit produced the following low scores:

- groundwater pathway - 4.36
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.12.

HRS score sheets are provided in Appendix G. Based on the absence of documented releases and the low HRS scores, this operable unit should be given low priority for further investigation.

5.2.4 Operable Unit 4, Burning Grounds

This section describes the characteristics of Operable Unit 4, Burning Grounds. The burning grounds are suspected sources of environmental contamination by solvents and other hazardous chemicals. The burning grounds have been operated by the Army and by NASA.

5.2.4.1 Nature and Description

Burning grounds have been used by the Army and NASA for destruction of both hazardous and nonhazardous material. These burning grounds are considered potential sources of environmental contamination because they were disposal sites for

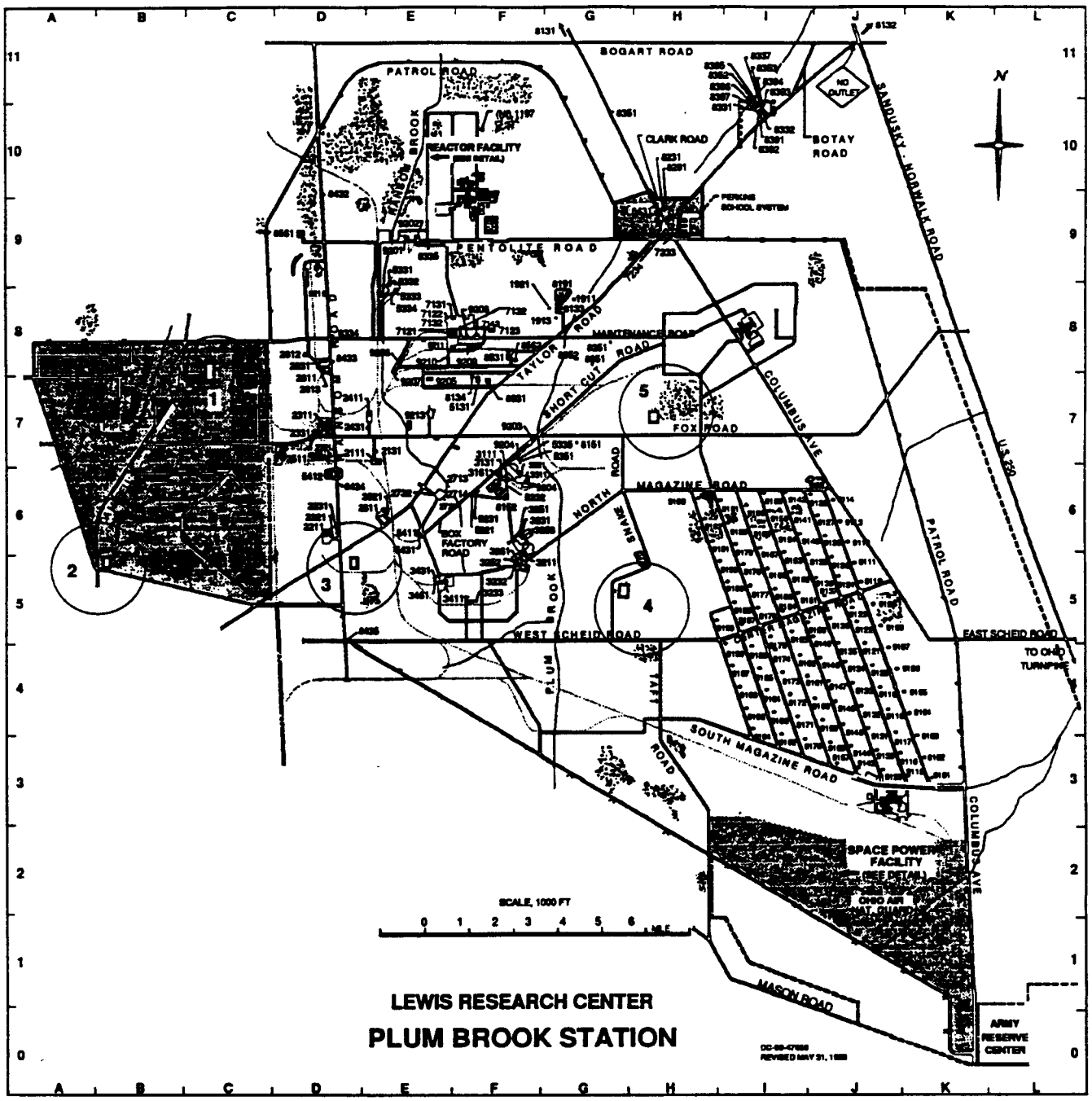
contaminated wastes. The contaminants included explosives, acids, asbestos, waste oil, and solvents. Five burning grounds formerly used by the Army were identified (see Figure 5-8). NASA has continued to use three of the burning grounds. It is suspected that additional burning grounds may have been used by the Army, but their locations are unknown.

Burning grounds were used by the Army during the D&D of the PBOW. These grounds were used for the destruction of explosives-contaminated wastewater flumes, intermediate settling tanks, and catch basins from the TNT areas. Also burned were contaminated putty, packing, and asbestos insulation removed from buildings at the TNT areas.[8] All contaminated building material from the pentolite production area was also destroyed at the burning grounds. Excavated contaminated soil from the TNT areas and from removal of underground flume was treated at the burning grounds.

NASA has used burning grounds located at Taylor Road, Fox Road, and Snake Road. The Taylor Road burning ground was used for the destruction of combustible wastes that were not contaminated with acids or explosives.[60] The Fox Road area was used around 1962 for both combustible and non-combustible waste contaminated or potentially contaminated with acids and explosives. The Snake Road burning ground was used for combustible, non-contaminated solid waste and for waste oil and flammable solvents. The Snake Road burning ground continues to be used today for the destruction of non-contaminated combustible solid wastes.

5.2.4.2 Physical Characteristics

The present surface dimensions of the Taylor Road and the Snake Road burning grounds are approximately 125 by 140 feet and 100 by 200 feet, respectively. The dimensions of the other burning grounds are unknown. Prior to D&D of the PBOW, the



Burning Ground	Name	Use	Comment
1	West of Reservoir #2	DOD	Location approximated, dimensions unknown
2	East of G-8	DOD	Location approximated, dimensions unknown
3	Taylor Road	DOD/NASA	Approximately 100 x 140 feet
4	Snake Road	DOD/NASA	Approximately 100 x 200 feet
5	Fox Road	NASA	

FIGURE 5-8. LOCATIONS OF BURNING GROUNDS

burning ground at Taylor Road was enlarged to approximately twice its former size. A 200-foot firebreak was cleared around the burning grounds used for the D&D of the PBOW. The Taylor, Snake, and Fox Road burning grounds are located in depressions and have soil revetments surrounding them. Aside from the revetments, there are no other engineered barriers to migration.

5.2.4.3 Hazardous Substance Management

Hazardous substances destroyed at the burning grounds by the Army included materials contaminated with DNT, TNT, pentolite, and asbestos. The quantity of Army waste destroyed at the burning grounds is unknown. Hazardous materials disposed of at the burning grounds by NASA may have included waste oils, solvents, and other chemicals. A fire report dated May 14, 1973, noted that a fire at the Snake Road burning ground may have been caused by the spontaneous combustion of chemicals and oils dumped together.[64]

Before transfer of the property to NASA, the burning grounds located west of Reservoir #2 and east of Guard-house G-8 were decontaminated. The procedures contained in War Department Supply Bulletin SB-5-52 were followed and decontamination was accomplished by conducting a visual inspection of the surface and sampling at various locations within a burning ground to a depth of 12 inches.[9,84] In areas where explosives were encountered, controlled burning was conducted. After destruction by fire, the ground was plowed to a depth of 6 inches and tested again for explosive material. If explosives were detected, the process was repeated.

Soil samples were collected in October 1989 from the Taylor Road and Snake Road burning grounds to approximate depths of 4 feet. Two samples were collected from the Taylor Road burning ground and four were collected from Snake Road (refer to Figures 5-9 and 5-10 for sample locations). A partial summary of analytical results is provided in Table 5-5. Acetone was detected in concentrations up to 4,300 ppb at Snake

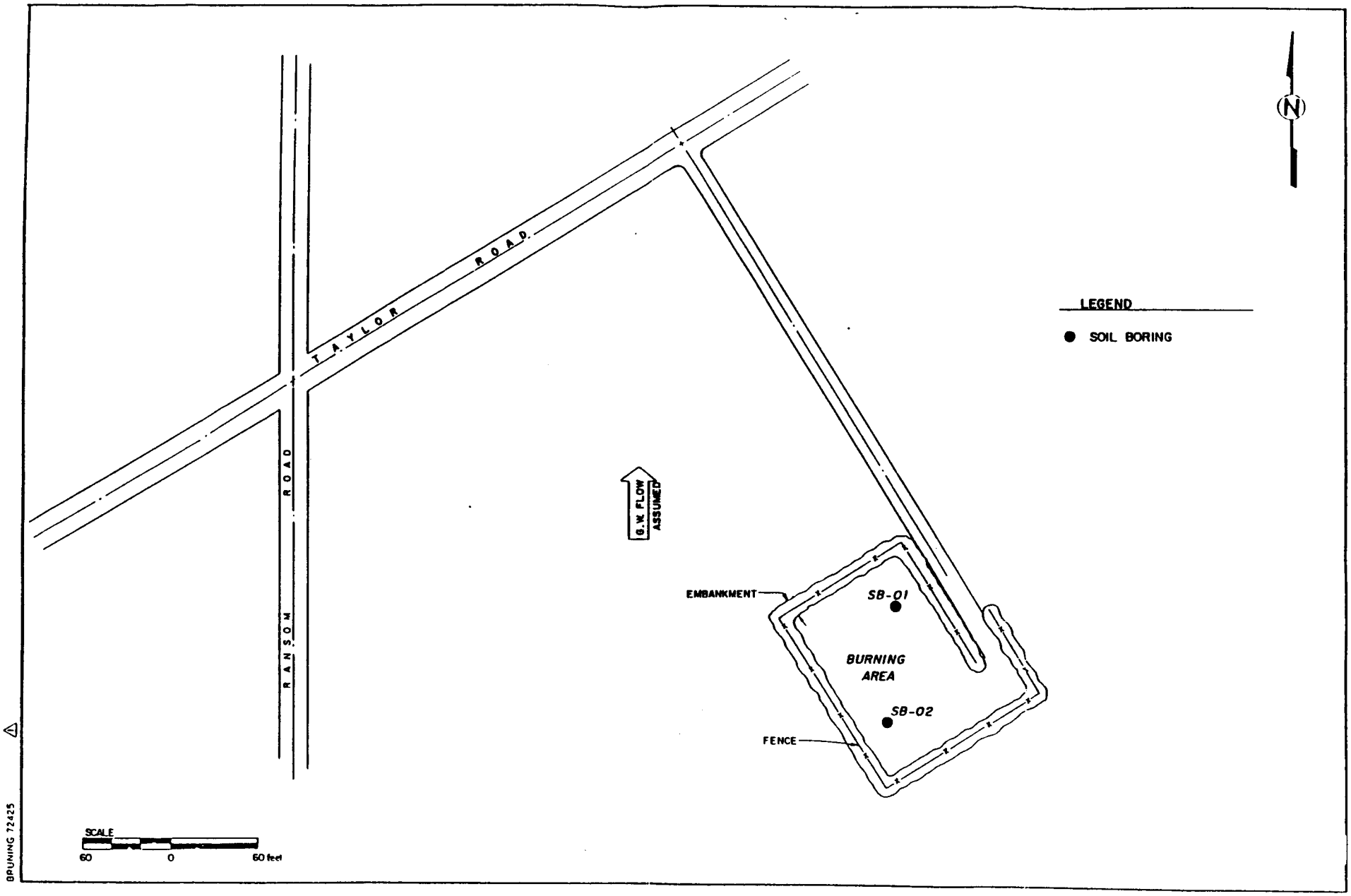


FIGURE 5-9. SAMPLE LOCATIONS AT TAYLOR ROAD BURNING GROUNDS

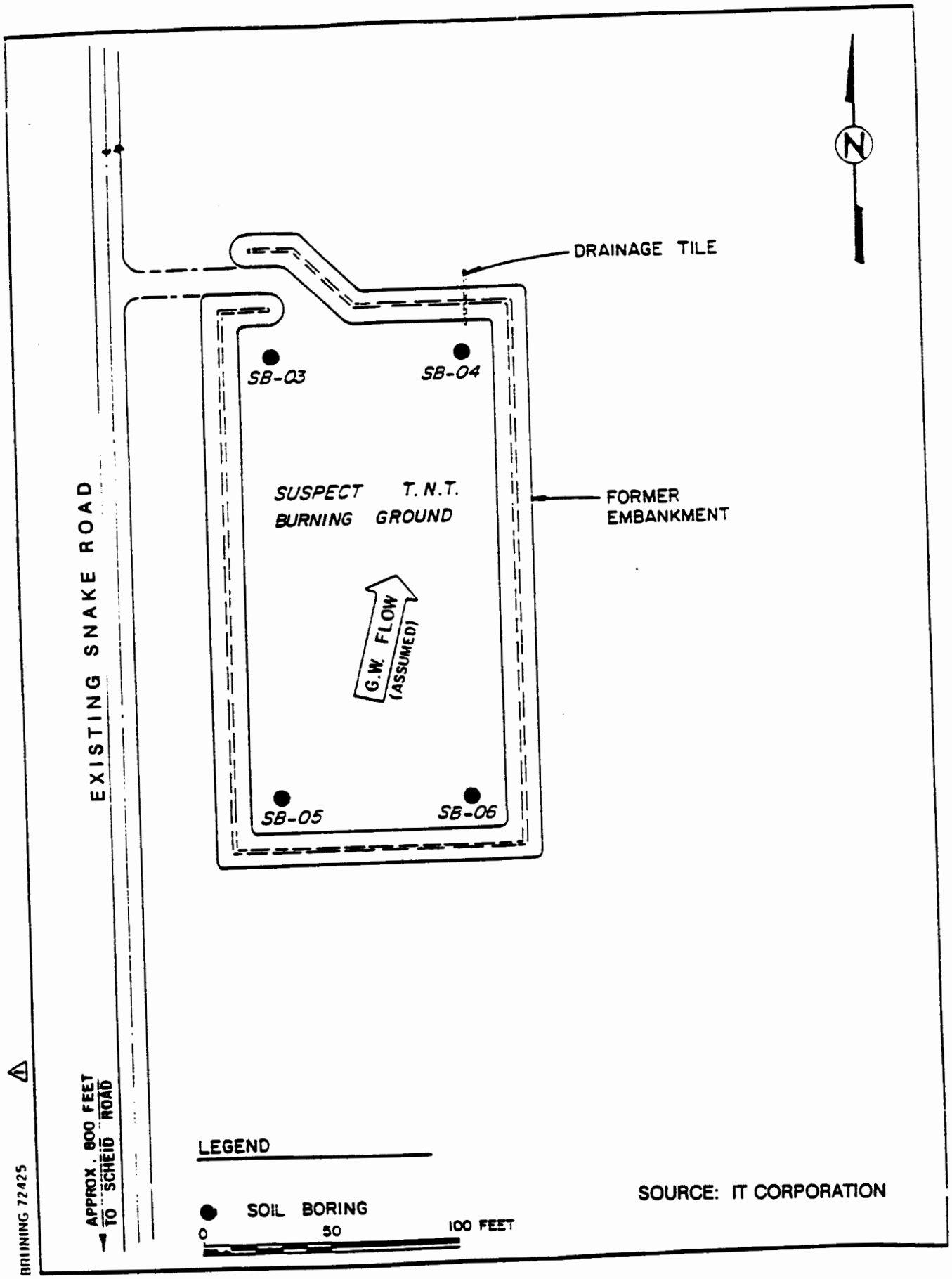


FIGURE 5-10. SAMPLE LOCATIONS AT SNAKE ROAD BURNING GROUNDS

TABLE 5-5. PARTIAL SUMMARY OF SOIL SAMPLE RESULTS FOR BURNING GROUNDS

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
SB-01/Soil	Methylene Chloride, 10 ppb	Bis-phthalate, 400 ppb	None detected	Arsenic, 7 ppm Barium, 51 ppm Chromium, 7 ppm Iron, 10,200 ppm Lead, 10 ppm Manganese, 300 ppm Sodium, 65 ppm
SB-02/Soil	None detected	None detected	None detected	Arsenic, 2.8 ppm Barium, 51.3 ppm Chromium, 11 ppm Iron, 15,400 ppm Lead, 10 ppm Manganese, 180 ppm Sodium, 110 ppm
SB-03/Soil	Acetone, 990 ppb Methylene Chloride, 10 ppb	Bis-phthalate, 380 ppb	1,3,5-Trinitrobenzene, 0.093 ppm	Barium, 31.6 ppm Chromium, 10 ppm Iron, 15,600 ppm Lead, 50 ppm Manganese, 71.3 ppm Sodium, 76 ppm
SB-04/Soil	Acetone, 65 ppb Methylene Chloride, 8 ppb	Bis-phthalate, 1200 ppb	None detected	Barium, 41.0 ppm Chromium, 7 ppm Iron, 11,000 ppm Lead, 16 ppm Manganese, 14.5 ppm Silver, 0.5 ppm Sodium, 45 ppm

TABLE 5-5. PARTIAL SUMMARY OF SOIL SAMPLE RESULTS FOR BURNING GROUNDS (Continued)

Sample No./Media	Volatile Organics	Semivolatile Organics	Nitroexplosives	Metals
SB-05/Soil	Acetone, 4,300 ppb	Bis-phthalate, 420 ppb	None detected	Arsenic, 2 ppm Barium, 21.1 ppm Chromium, 4 ppm Iron, 4940 ppm Lead, 9 ppm Manganese, 35.0 ppm Sodium, 32 ppm
SB-06/Soil	Acetone, 2300 ppb	Bis-phthalate, 470 ppb	None detected	Barium, 58.9 ppm Chromium, 6 ppm Iron, 6420 ppm Lead, 16 ppm Manganese, 129 ppm Sodium, 80 ppm

Road but was not detected at Taylor Road. IT Corporation suspected that the elevated acetone concentrations could be attributed to the use of isopropyl alcohol that was used as a final rinse during decontamination of sampling equipment. However, groundwater monitoring wells installed to establish background concentrations also detected acetone. The only other detected contaminant was a minor amount of 1,3,5-trinitrobenzene (0.093 ppb) in a single sample from the Snake Road burning grounds. Installation of groundwater monitoring wells had been planned for these two burning ground areas. Based on soil sampling results that suggested minimal subsurface contamination, groundwater monitoring wells were not installed.[21]

5.2.4.4 Evaluation of Potential Environmental Impacts

The extent and depth of potential contamination at the burning grounds are unknown. The limited soil sampling conducted at the Taylor and Snake Road burning grounds indicates that minimal soil contamination has occurred and therefore groundwater contamination is unlikely.

Application of the abbreviated HRS model to this operable unit produced the following low scores:

- groundwater pathway - 4.36
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.12.

HRS score sheets are provided in Appendix G.

The low HRS scores suggest that environmental impacts from the burning grounds are not significant. Accordingly, this operable unit should be given low priority for further investigation.

5.2.5 Operable Unit 5, Waste Lagoons in Pentolite Area

This section of the PA report describes the characteristics of Operable Unit 5, Waste Lagoons in Pentolite Area. The waste lagoons are suspected sources of environmental contamination by acetone, TNT, and pentaerythritol. The waste lagoons were constructed and operated by the Army.

5.2.5.1 Nature and Description

Two wastewater lagoons were located in the former pentolite dry storage area, now inside the Plum Brook Reactor Facility fence. Their location is shown in Figure 5-11. This operable unit is a suspected environmental hazard due to unplanned releases and seepage of wastes from the lagoons.

Both of these lagoons contained wastewater generated during pentolite production. Pentolite was produced in a mixing process of (usually 50/50) trinitrotoluene (TNT) and pentaerythritol tetranitrate (PETN). The stoichiometry of pentolite production is described below:[85,86]

- Pentaerythritol (PE) + HNO_3 + H_2O → PETN + wastewater (nitric acid as 5%)
- PETN + acetone + ammonia bicarb + H_2O → preliminary filtered neutralized PETN + wastewater
- (TNT + acetone) + (PETN + H_2O) → pentolite + wastewater.

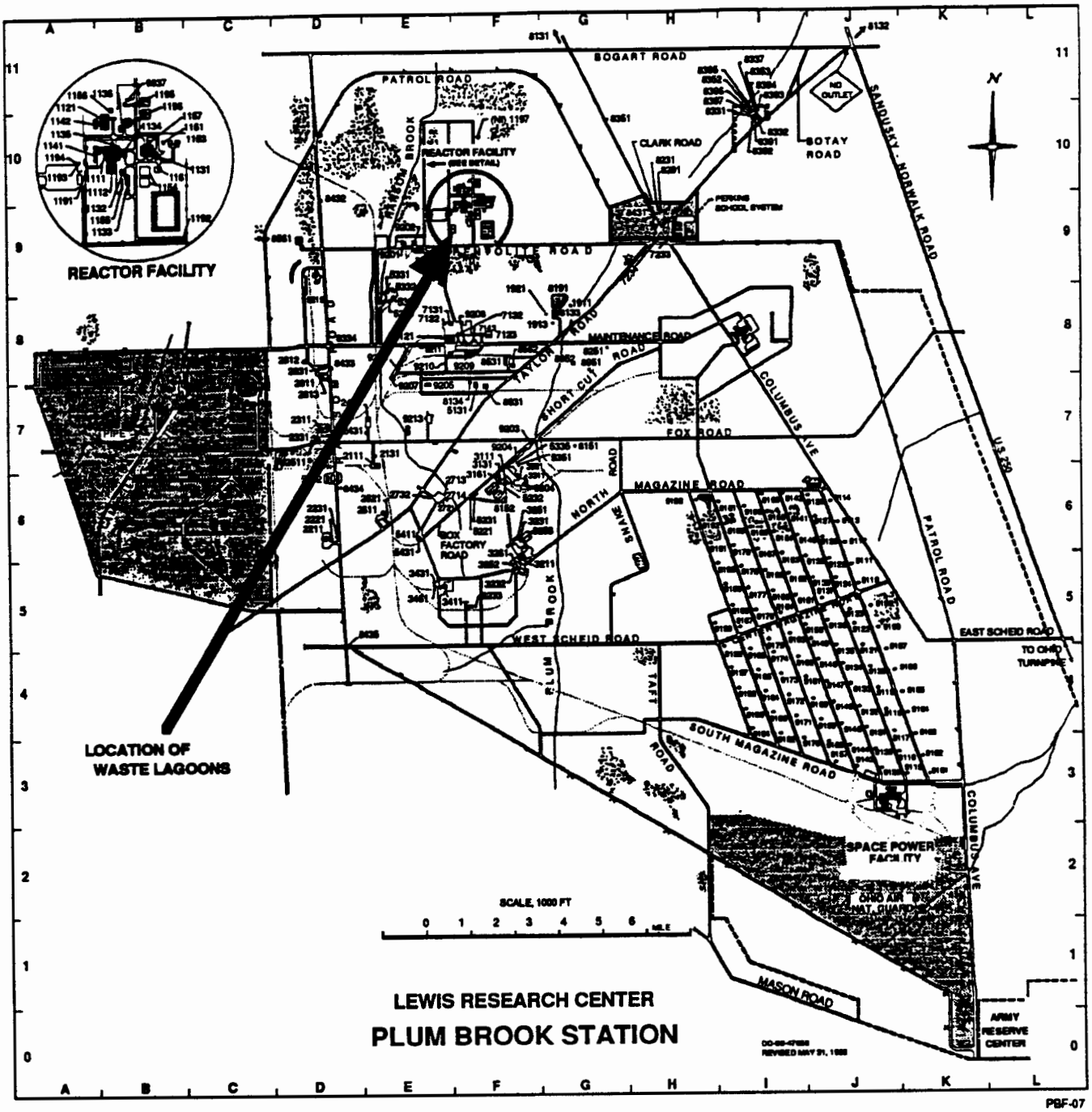


FIGURE 5-11. LOCATION OF WASTE LAGOONS

Based on the stoichiometry of the process, the wastewater probably contained significant concentrations of PE, PETN, acetone, and TNT.

Disposal corresponded with PBOW years of operation (1942-1945). Decontamination was achieved by draining the impoundments, flushing the limestone bed and basin with a high-pressure hose, removing the wet limestone, and flushing the basin. The basin was then visually inspected for accumulated explosives.[8] The decontamination procedures did not include instructions for removal of the concrete slabs.

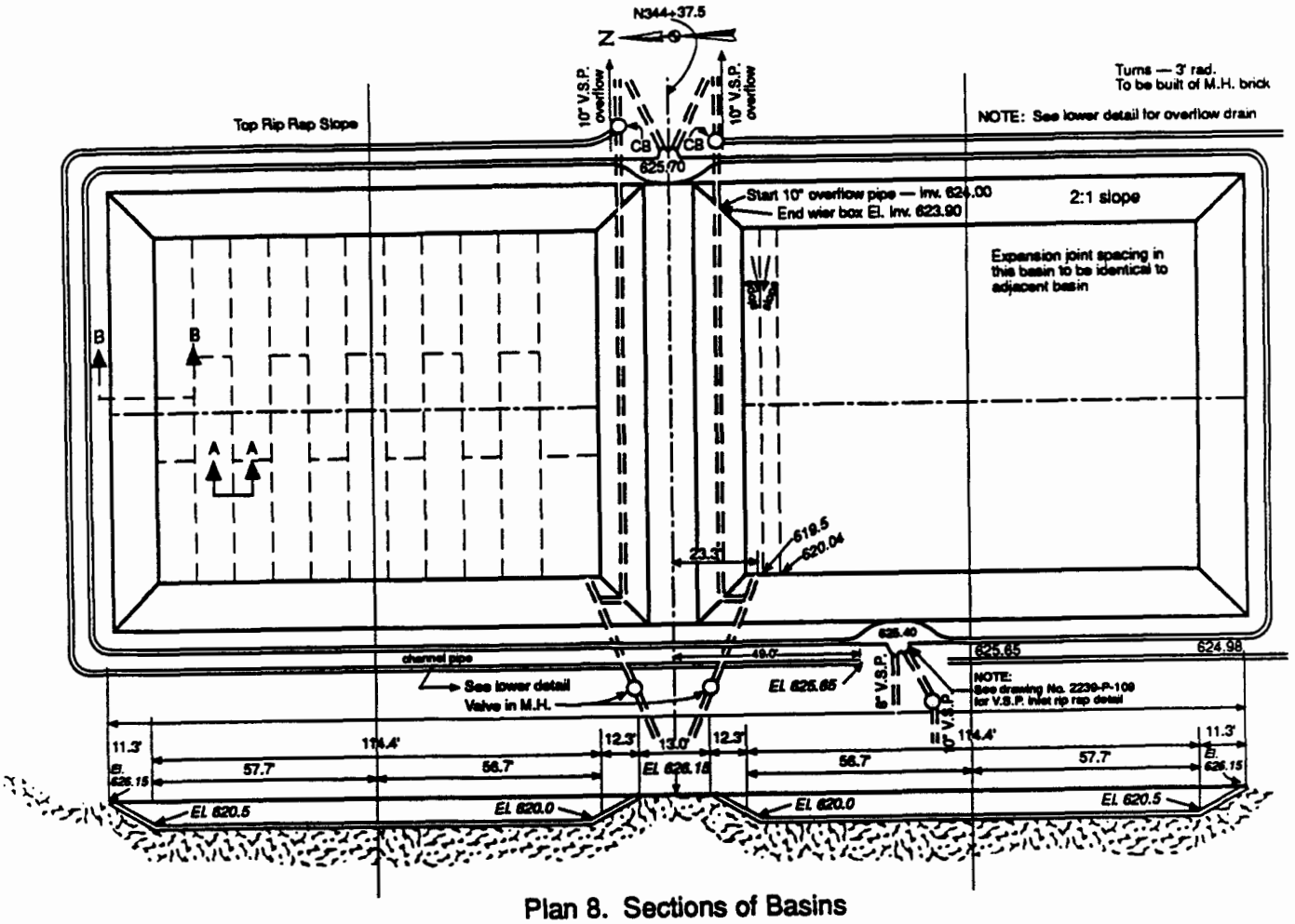
The settling basins do not appear on current Plum Brook Station maps. One source reported that the lagoons were probably removed during reactor construction. Apparently, the pentolite area was chosen for the PBRF specifically because of its cleanliness. Earth at the entire pentolite area was heavily moved, and the surface was filled and regraded to meet reactor site specifications.[87] It is likely that any lagoon-contaminated substrata were removed or dispersed during PBRF construction.

5.2.5.2 Physical Characteristics

Each lagoon measured 114.2 by 112 feet. They were constructed with precast 15 by 9 foot 9 inch blocks of concrete with asphaltic-filled expansion joints. The concrete was placed on 4-6 inches of gravel or #4 stone.[88] Construction details are shown in Figure 5-12.

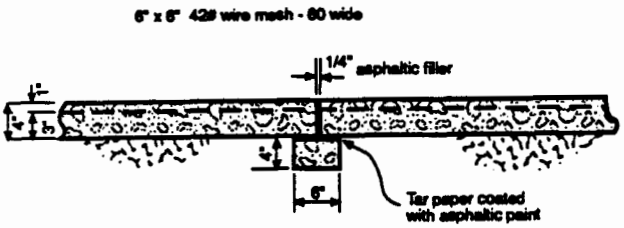
5.2.5.3 Hazardous Substance Management

Specific treatment details and the volume of the wastewater treated at the lagoons are not documented. Sludge disposal details are not documented. The suspected releases are unknown amounts of acetone, TNT, and PE.[71] Depth and extent of contamination have not been evaluated. Records of emergency and/or remedial actions have not been found. Storrs-Hemminger Ditch was the nearest surface water receptor.



Plan 8. Sections of Basins
Scale: 1"=20'

NOTE: Provide 4" to 6" of gravel under concrete slabs



Section — "A-A"
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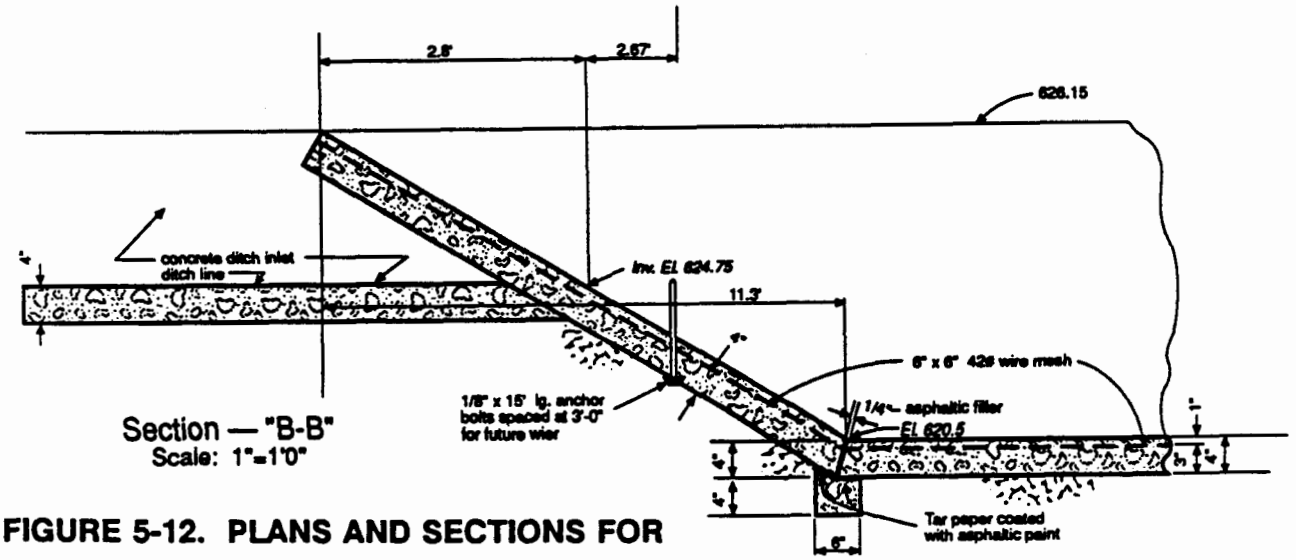


Section — "B-B"
Scale: 1"=1'0"

FIGURE 5-12. PLANS AND SECTIONS FOR PENTOLITE WASTEWATER SETTLING BASINS

5.2.5.4 Evaluation of Potential Environmental Impacts

Releases of hazardous substances to the environment were not confirmed during the PA. The following moderately low scores were calculated using the abbreviated HRS model:

- groundwater pathway - 8.53
- surface water pathway - 3.84
- soil pathway - 5.2
- air pathway - 9.7
- site - 7.22.

HRS score sheets are provided in Appendix G.

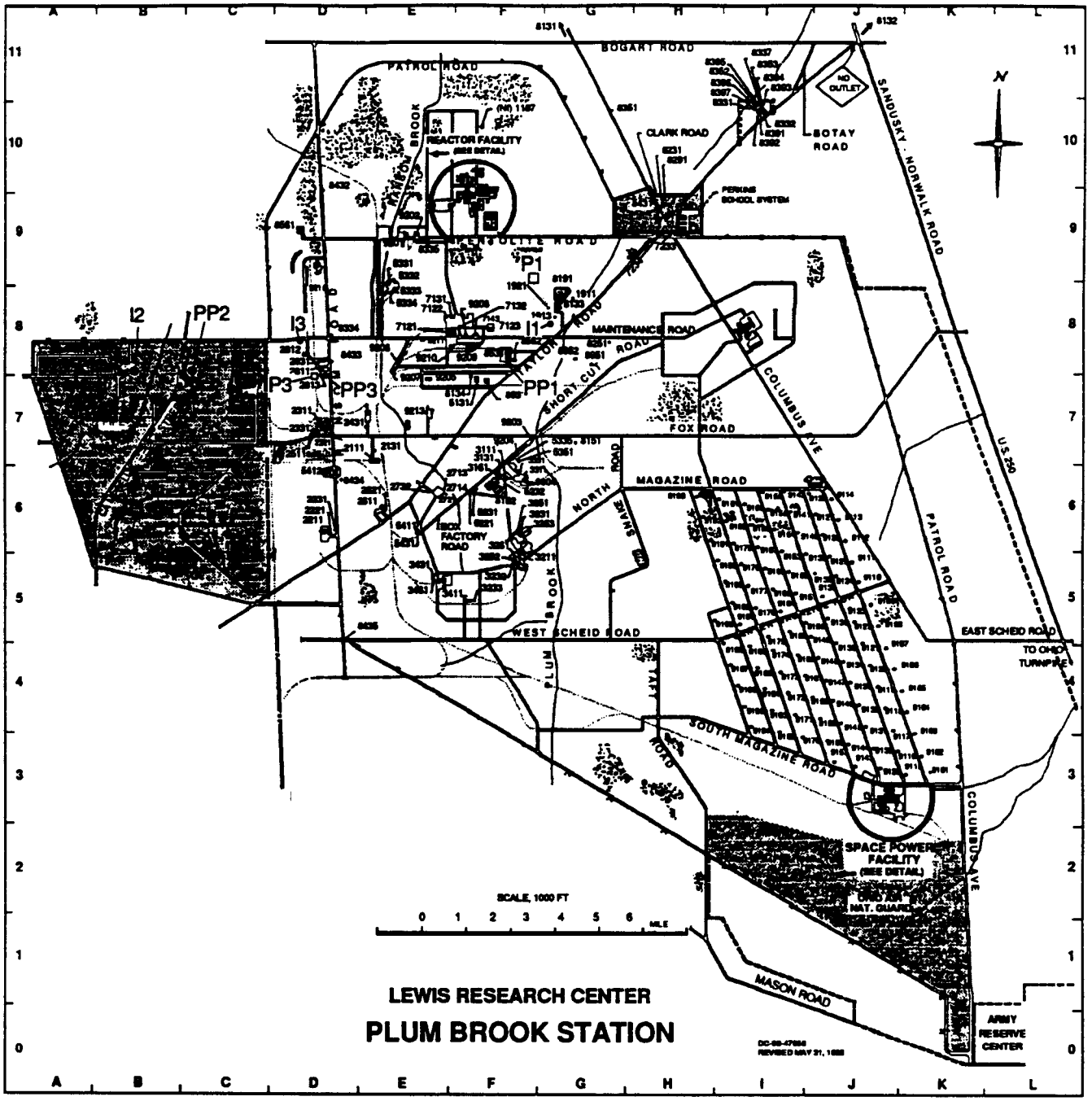
It is possible that data acquired during further investigations could result in higher HRS scores. It is, however, improbable that scores approaching 28.5 could be attained. Accordingly, this operable unit should be given medium priority for further investigation.

5.2.6 Operable Unit 6, Fly Ash Spoil Piles

This section of the PA report describes the characteristics of Operable Unit 6, Fly Ash Spoil Piles. The spoil piles are suspected sources of environmental contamination by heavy metals and organic chemicals. The spoil piles were operated by the Army.

5.2.6.1 Nature and Description

Two large fly ash spoil piles (pits) were mapped on PBOW specification sheets.[82,89] Locations are shown on Figure 5-13. Pit #3 was adjacent to Power Plant #3 at Power



KEY
P1 = Ash settling basin at Power & Maintenance Area 1 P3 = Ash pit at Power & Maintenance Area 3
PP1 = Power Plant #1 PP2 = Power Plant #2 PP3 = Power Plant #3
I1 = Incinerator #1 I2 = Incinerator #2 I3 = Incinerator #3

FIGURE 5-13. LOCATIONS OF FLY ASH PITS

& Maintenance Area #3, and Pit #1 was east of Reservoir #1, near Power & Maintenance Area #1.

The pits served as disposal areas for fly ash and ash generated at power plants and incinerator buildings. There were three power plants and three incinerator buildings at PBOW corresponding to Power & Maintenance Areas #1, #2, and #3.

Each power plant had two to four pulverized coal boilers and a feed water treatment system.[49] Each incinerator building had an ash pit/slurry. No ash surface impoundment is indicated on the map in the vicinity of Power & Maintenance Area #2.[82] It is possible that ash from Power Plant #2 and Incinerator Building #2 was disposed of in the impoundment at Power & Maintenance Area #3 (closest); it is equally possible Power & Maintenance Area #2 had its own unmapped informal disposal yard. Years of fly ash disposal corresponded with operational years of PBOW (1942-1945).

5.2.6.2 Physical Characteristics

Ash Disposal Pit #3 is approximately 300 by 250 feet; Ash Disposal Pit #1 is 200 by 400 feet.[82,89] Construction details and the presence of secondary containment features are not documented.

5.2.6.3 Hazardous Substance Management

The fly ash disposed of at the two locations is suspected to be hazardous with respect to pH, metals, and possibly organics. There is no documented evidence of releases to the environment. Extent and depth of potential contamination have not been evaluated. Records of previous emergency or remedial actions have not been found. Entry of hazardous constituents into environmental media as leachate to soil and groundwater or runoff to surface water is possible. Pipe Creek would be the receptor of

runoff from Ash Pit #3. The Pentolite Road Red Water Pond would receive runoff from Ash Pit #1.

5.2.6.4 Evaluation of Potential Environmental Impacts

Releases of hazardous substances to the environment from this operable unit were not confirmed during the PA. Application of the abbreviated HRS model produced the following low scores:

- groundwater pathway - 4.8
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.24.

HRS score sheets are provided in Appendix G.

Significant environmental impacts are not indicated by the low HRS scores or by visible site conditions. This operable unit should be given low priority for further investigation.

5.2.7 Operable Unit 7, Toluene Storage Tanks

This section of the PA report describes the characteristics of Operable Unit 7, Toluene Storage Tanks. The tanks are suspected sources of environmental contamination by toluene. The tanks were installed and operated by the Army. NASA has used some of the tanks to store petroleum products.

5.2.7.1 Nature and Description

The six above-ground toluene tanks were originally located as shown in Figure 5-14. The tanks served as bulk storage for toluene used in TNT production (1942-1945). There were two tanks for each TNT production area. Tanks 645 and 655, supported TNT Area C. Tanks 425 and 435, supported TNT Area B. Tanks 255 and 265, supported TNT Area A.

The tanks were decommissioned in 1945 by pumping out their contents to the lowest possible level, draining the transfer lines, and opening top and bottom flanges for ventilation.[8]

Tank 655 was moved (c. 1974) to the reactor facility to be used for cooling water storage.[90] Tanks 265 and 255 have been renumbered as 8951 and 8952 by NASA and are used for fuel oil storage. Tank 8951 (SE tank) holds 5,000-10,000 gallons of fuel oil; Tank 8952 (W tank) is now empty. The other four tanks are presently empty.[91]

5.2.7.2 Physical Characteristics

Each tank was designed with a 200,000-gallon capacity. It is not known if the transfer lines were above or below ground. A cursory field inspection on May 22, 1991 revealed that tanks 8951 and 8952 are each surrounded by earthen dikes approximately 6 feet high; each tank rests on a concrete foundation of the same circumference as the base of the tank. The diking at tanks 8951 and 8952 may not be representative of diking at the other tanks. No diking was observed during a cursory field survey of Tank 645 by SAIC on June 12, 1991. Dead trees in the vicinity of one tank were observed by SAIC during the same field survey.

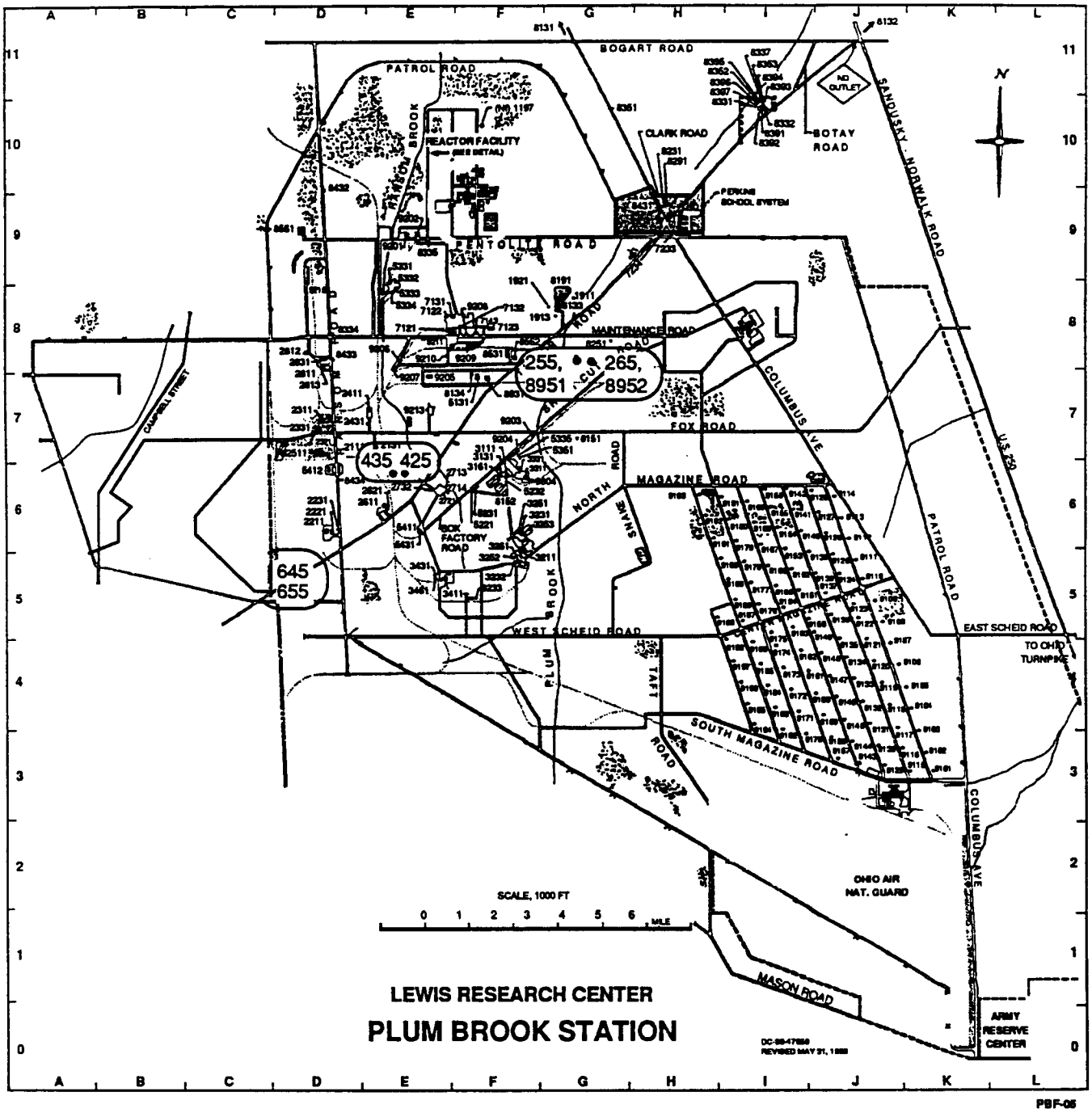


FIGURE 5-14. LOCATIONS OF SIX PBOW TOLUENE TANKS

5.2.7.3 Hazardous Substance Management

All six tanks held toluene; two have also held fuel oil and #2 diesel fuel. Unplanned releases of toluene, fuel oil, and #2 diesel fuel to groundwater and soil are suspected, although records of previous emergency and/or remedial actions have not been found. Extent and depth of contamination have not been evaluated. Points of entry to soil and groundwater are at transfer stations and transfer line valves and the base of tanks. The earthen dikes would act as effective barriers to runoff to surface waters but would not preclude migration to soil, groundwater, or air.

5.2.7.4 Evaluation of Potential Environmental Impacts

Releases of hazardous substances to the environment from this operable unit were not confirmed during the PA. Application of the abbreviated HRS model produced the following moderately low scores:

- groundwater pathway - 8.53
- surface water pathway - 3.84
- soil pathway - 5.2
- air pathway - 9.7
- site - 7.22.

HRS score sheets are provided in Appendix G.

The moderately low HRS scores do not indicate a significant adverse environmental impact. The historical use of the toluene tanks, coupled with the observations of dead vegetation, do indicate a need for further data on environmental contamination. Accordingly, this operable unit should be given medium priority for further investigation.

5.2.8 Operable Unit 8, UST Removal Areas

This section of the PA report describes the characteristics of Operable Unit 8, UST Removal Areas. This operable unit encompasses 15 underground storage tanks operated by NASA and the Army. Four geographic areas were identified as potential sources of environmental contamination because of unplanned releases from underground storage tanks to the soil and/or groundwater. These areas are illustrated on Figure 5-15 and are located at the PBRF (Building 1131), the Garage and Maintenance Area (buildings 7121, 7131, and 7132), Pump Station No. 1 (Building 8133), and the SPF (Building 1411). Table 5-6 summarizes the numbers, identification numbers, ages, capacities, and former contents of the tanks in the four UST areas. Table 5-7 is a partial summary of environmental media analytical data from the UST areas.[93,95,96,97] A complete package of analytical data from the soil sampling at these locations is provided in Appendix F. Groundwater monitoring wells were installed at all four UST areas during November and December 1990. Only data from the groundwater monitoring wells at Building 7132 were available at the time of this report.

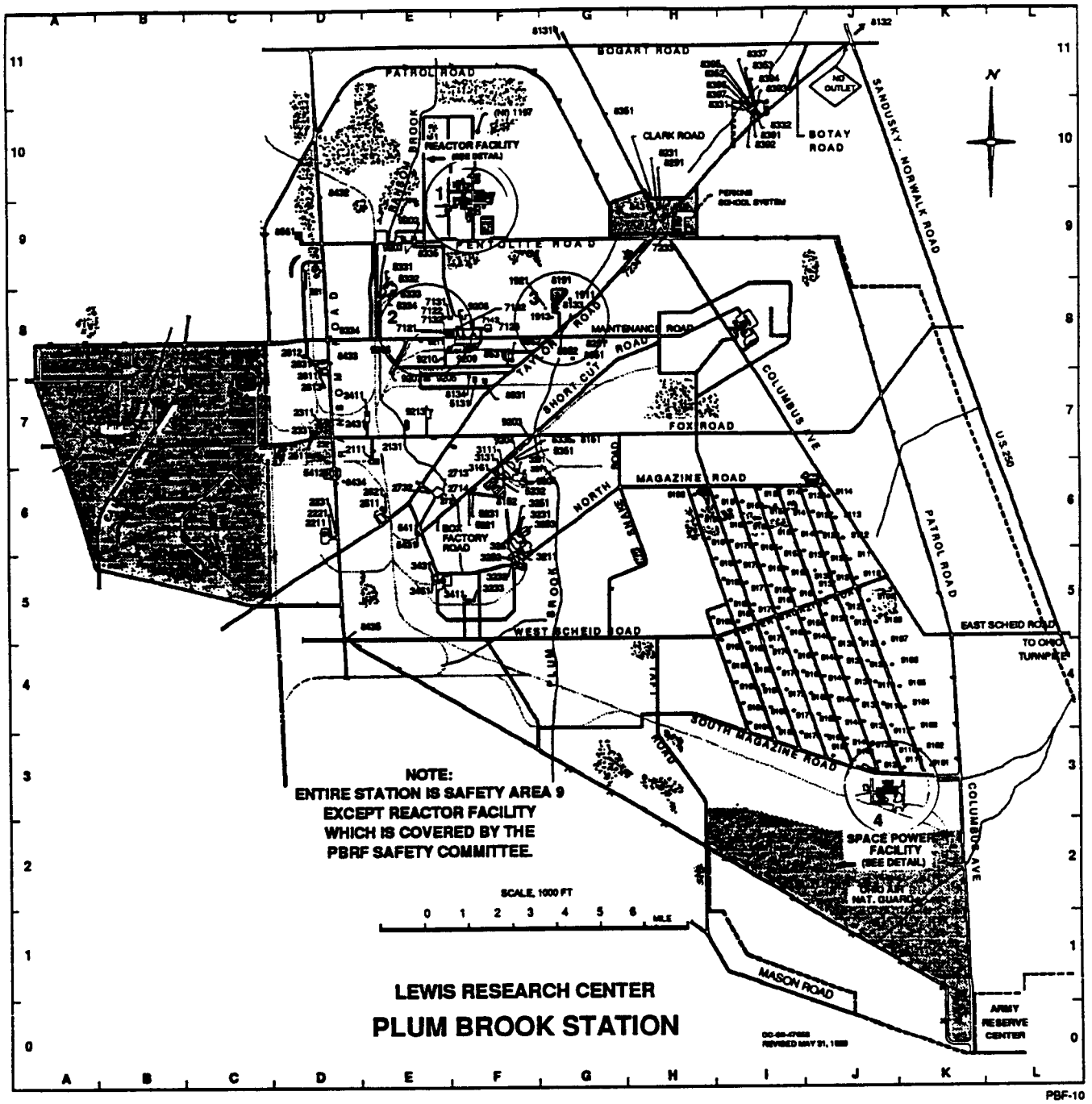
5.2.8.1 Plum Brook Reactor Facility

5.2.8.1.1 Nature and Description

Three underground storage tanks were removed from the south side of Building 1131, the Service Equipment Building, at the PBRF in December 1989. These tanks were installed by NASA in 1961 and the last date of use is estimated to be 1982.[92] These tanks were used for the storage of fuel oil (two tanks), waste oil, and solvents.

5.2.8.1.2 Physical Characteristics

The three tanks were constructed of steel and located next to each other in a north-south orientation. All tanks were removed in a single excavation.[93] The tanks were



UST Area	Name	Building No.
1	Plum Brook Reactor Facility	1131
2	Garage and Maintenance Area	7121, 7131, 7132
3	Pump Station #1	8133
4	Space Power Facility	1411

FIGURE 5-15. LOCATIONS OF UST OPERABLE UNITS

TABLE 5-6. TANK SUMMARY

Location	No. of Tanks	Tank ID Nos.	Date Installed	Capacity	Former Tank Contents
Plum Brook Reactor Facility					
Building 1131	2	21,22	1961	7,500	Gasoline, diesel, fuel oil
	1	23	1961	500	Waste oil, solvents
Space Power Facility					
Building 1411	1	24	1968	1,000	Waste oil, solvents
	1	25	1968	1,000	Fuel oil
Garage and Maintenance Area					
Building 7121	1	28	1942	3,000	Waste oil, solvents
	3	29,30,31	1964	700	Acetone, TCE, TCA
Building 7131	1	32	1942	1,500	Waste oil, solvents
Building 7132	3	33,34,35	1942	9,000	Gasoline
	1	36	1982	9,000	Diesel Fuel
Pump Station					
Building 8133	1	39	1942	250	Gasoline/ Diesel

TABLE 5-7. PARTIAL SUMMARY OF UST ANALYTICAL DATA

NOTE: DATA PRESENTED IN RANGES FROM LOWEST TO HIGHEST CONCENTRATIONS

Location	No Samples	TPH (mg/kg)	Benzene (µg/kg)	Toluene (µg/kg)	Ethyl-Benzene (µg/kg)	Total Xylenes (µg/kg)	Trichloro-ethene (µg/kg)	1,1,1-Tri-Chloro-ethane (µg/kg)	Carbon Tetra-Chloride (µg/kg)	Tetra-Chloro-Ethene (µg/kg)	1,3,5-Tri-Methyl Benzene (µg/kg)	1,2,4-Tri-Methyl Benzene (µg/kg)	Naphtha-lene (µg/kg)
PBRF													
- Soil Column	8	U-3050	U-32	U-26	U-1093	U-739	U-997	U-891	U-91	U-1043	U-1775	U-2470	223-633
- Surface Soil	3	801-3570	U-25	U-41	140-548	U-1115	U-1019	U-123	U	U	178-4365	204-4413	1255-13388
SPF													
- Soil Column	5	243-2030	U-2	U-16	U-45	U-43	27-1087	4-601	U5-119	U5-342	U-496	U-541	2-1094
- Surface Soil	4	93-1120	U-11	U-6	U-23	I-26	72-1432	7-1254	U5-213	U1-70	NA, 43	NA, 48	NA,110
Garage and Maintenance Area													
7121 (Tanks 29, 30, & 31)													
- Soil Column	2	U	U	2	U-1	U-2	55-200	12-150	U-22	2-6	NA	NA	NA
- Surface Soil	2	287	U	U-1	U	U	58-110	490-610	69-94	5-8	NA	NA	NA
7121 (Tank 28)													
- Soil Column	3	U-67	U	2-25	U-3	U-4	1000-1605	203-1100	36-140	157-192	U-5	U-6	1-20
- Surface Soil	2	192-284	1-14	82-1101	86-411	6-137	3674-21142	6043-7770	1-431	3048-10048	22-442	15-479	88-260
7131													
- Soil Column	3	120-244	U	U-1	U	U	359-606	3-6	U	U	V	U	1-4
- Surface Soil	2	U-193	U	U-1	U-2	U2	464-728	10-23	1-2	U-17	U-366	1-349	1-159
7132													
- Soil Column	8	29-616.6	<4-4300	<4-30000	4.9-11000	12-96000	NA	NA	NA	NA	NA	NA	NA
- Surface Soil	4	.076-621	0.22-1.3	0.22-0.47	0.22-10	0.22-51	NA	NA	NA	NA	NA	NA	NA
- Groundwater	4*	<1.0	58	1.6	0.4	6.1	NA	NA	NA	NA	NA	NA	NA
7132 (Tank 36)													
- Soil Column	3	U-8.28	U	U	U	U	NA	NA	NA	NA	NA	NA	NA
- Surface Soil	3	U-1020	U	U	U	U	NA	NA	NA	NA	NA	NA	NA
Pump Station No. 1													
- Soil Column	1	U	0.19	0.77	U0.27	0.94	NA	NA	NA	NA	NA	NA	NA
- Surface Soil	2	U-655	62-1400	103-7200	15-4400	65-16000	NA	NA	NA	NA	NA	NA	NA

TABLE 5-7. PARTIAL SUMMARY OF UST ANALYTICAL DATA (Continued)

NOTES:

NA = Not Analyzed
U = Undetected at given concentration
* = Four wells were sampled; results given for Well #1 only.

located approximately 6 feet below grade and the soil was initially excavated to an approximate depth of 9 feet. Because of apparent contamination indicated by photoionizer readings and visual inspection, the excavation was deepened to approximately 13 feet below the surface.

5.2.8.1.3 Hazardous Substance Management

The two 7500-gallon tanks were used for storage of fuel oil and were filled with water prior to their removal. The 500-gallon tank contained waste oil and solvent before being removed. Eleven soil samples were collected for total petroleum hydrocarbons (TPH) and for VOC analysis. Eight samples of the soils underlying the tanks were collected to detect past or ongoing leaks, and three samples of the tank cover soil were collected to assess surface spillage, overfilling, or piping failures. Of the eight soil samples from underlying tanks, two were collected from the pit bottom after the additional soil was removed.

The results of the sampling indicated that the surrounding soils were contaminated to a depth of 13 feet. High concentrations of TPH were found in soil samples collected to a depth of 9 feet, and VOCs were found in all soil samples (Table 5-7). Since the tanks were not rusted nor punctured, it is assumed that the contamination was from surface spillage. This area is currently being investigated under the UST Corrective Actions RI/FS. Groundwater monitoring data are not available for this site to date.

5.2.8.2 Garage and Maintenance Area

Nine USTs were removed from the Garage and Maintenance Area from five locations shown on Figure 5-16.

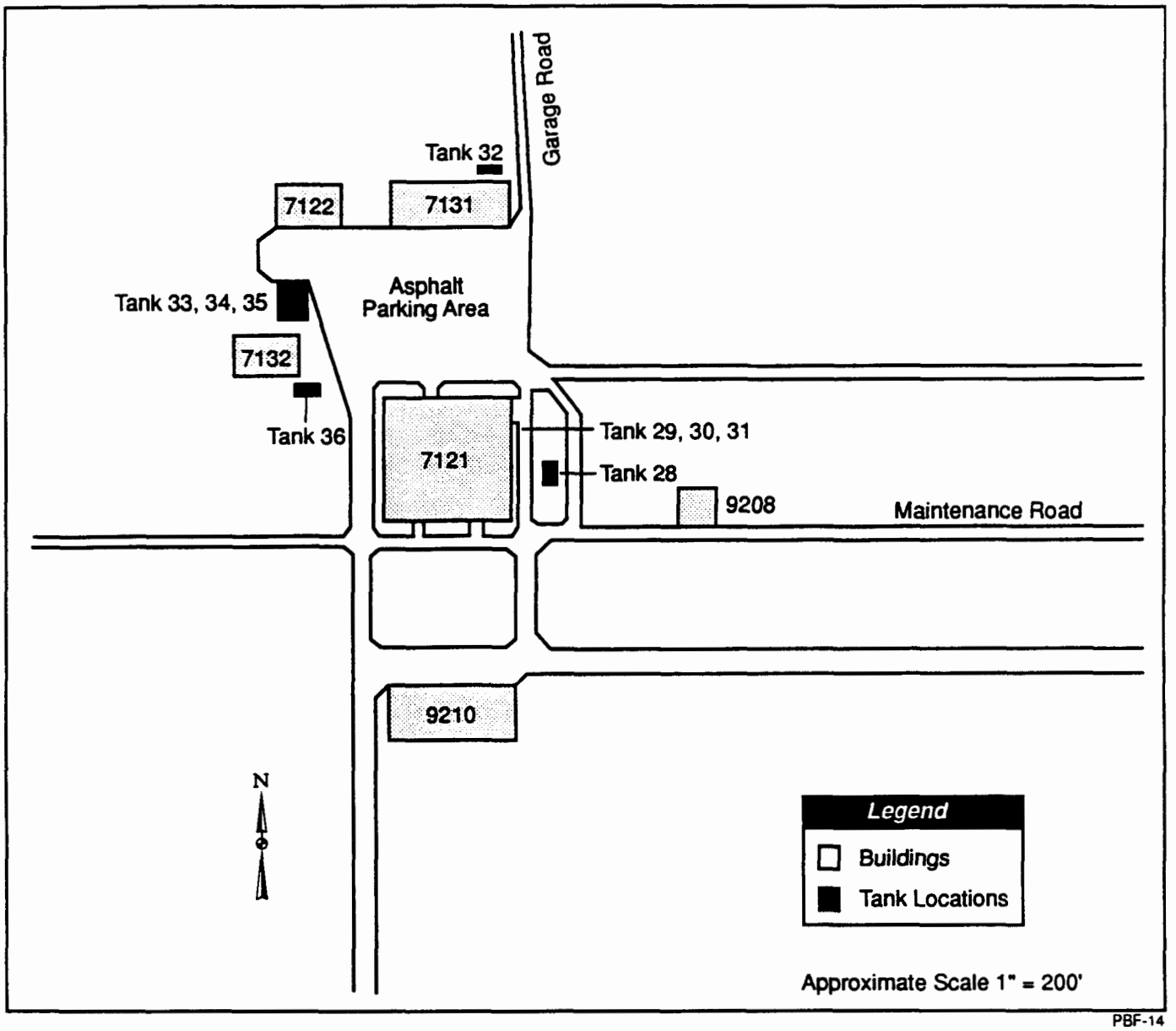


FIGURE 5-16. LOCATIONS OF UNDERGROUND STORAGE TANKS IN THE GARAGE AND MAINTENANCE AREA

5.2.8.2.1 Nature and Description

Of the nine tanks at this location, five were installed by the Army and the remaining four were installed by NASA. The suspected contaminant sources at the site are unplanned product spills or leaks from the tanks. This area was originally used by the Army as a garage and maintenance area.

5.2.8.2.2 Physical Characteristics

Capacities for all tanks at the Garage and Maintenance Area are summarized in Table 5-6. All tanks were constructed of steel. Five excavations were made in the Garage and Maintenance Area to remove tanks, as follows: tank 28; tanks 29, 30, and 31; tank 32; tanks 33, 34, and 35; and tank 36. Corrosion was observed on tanks 33, 34, and 35 excavated from the northeast side of Building 7132.[96] The dimensions and depths of excavations are not documented, except at tank 36, which was excavated to a depth of 13 feet.

5.2.8.2.3 Hazardous Substance Management

The hazardous substances stored in the USTs located at the Garage and Maintenance Area included gasoline, diesel fuel, waste oil and solvents, acetone, trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA). Representative samples were collected from the tank pit bottoms at all locations to determine the depth of contamination and to assess whether additional soil removal was required. Samples were also collected from the excavated soils to determine the contaminant concentrations. The sample analyses and number of samples from each location are shown in Table 5-7. Groundwater monitoring wells were installed upgradient and downgradient of tanks 33, 34, and 35 northeast of Building 7132 to assess the extent of groundwater contamination.

The sampling results indicate various levels of soil contamination at the Garage and Maintenance Area and some groundwater contamination. A subsequent soil gas survey of the Garage and Maintenance Area confirmed soil contamination in the area.[94] Additional groundwater monitoring wells were installed in this area in November-December 1990. All sample analysis data are not yet available from the groundwater monitoring program.

The potential for groundwater contamination of the shallow surficial aquifers is high in this area since the surficial sediments are either a sandy loam or "yellow sand."[78] The detection of benzene in a groundwater monitoring well at Building 7132 indicates there is limited contamination of the surficial aquifer in this area; however, none of the downgradient wells detected contaminants. The shallow water-bearing sands are underlain by a clay layer that could impede the vertical migration of contaminants. The lateral continuity of the shallow sands and the clay layer is unknown. The bedrock aquifer in this area is separated from the surface by approximately 50 to 100 feet of shale.[40]

5.2.8.3 Pump Station No. 1

5.2.8.3.1 Nature and Description

Tank 39 was installed in 1942 by the Army and was used for the storage of gasoline and diesel fuel.[94] The potential contaminant source at this site was the unplanned product release from the tank.

5.2.8.3.2 Physical Characteristics

The capacity of Tank 39 was 250 gallons and it was constructed of steel. Holes were found in the tank upon removal.[95] The dimensions and depth of the excavated pit are not documented.

5.2.8.3.3 Hazardous Substance Management

Tank 39 was used for the storage of gasoline and diesel fuel. Soil in the tank pit was visibly contaminated to a depth of 7 feet, where a water main was encountered.[95] Three soil samples were collected from this area: one from the pit bottom and two from the excavated soils. Results of the sampling indicated that the contamination was limited to the excavated soil that surrounded the tank and that the sample from the bottom of the pit had concentrations within Bureau of Underground Storage Tank Regulations (BUSTR) limits. A soil gas survey conducted subsequent to the tank excavation confirmed the soil contamination. Interim measures have been taken to abate contaminant migration by removing gross contamination and backfilling the excavated pit with clean sand and limestone.[94] Four groundwater monitoring wells were installed at this location: one well located upgradient to assess background concentrations and three in the vicinity of Building 8133. Data are not yet available from the groundwater monitoring program.

Shallow soil borings indicate that this area is underlain by approximately 13 feet of clay that transitions to sand laterally within 200 feet. If the tank is located in an area underlain by clay, the potential for contamination of the shallow surficial aquifers is reduced. Soil sampling indicated that minimal contamination has occurred at the base of the tank pit, suggesting no vertical migration. However, if the tank was excavated from a sandy horizon overlying a clay layer, then contaminants could migrate horizontally. The soil gas survey indicated limited horizontal migration.

5.2.8.4 Space Power Facility

5.2.8.4.1 Nature and Description

Tanks 24 and 25 were installed by NASA at the SPF in 1968 for the storage of waste oil, fuel oil, and solvents. The potential contaminant source at the site was the

unplanned product release from the two underground storage tanks. Tank 24 was still in use prior to removal and it is estimated that Tank 25 was taken out of service in 1982.[95]

5.2.8.4.2 Physical Characteristics

Both tanks were constructed of steel and had capacities of 1,000 gallons each. The tanks were excavated from a single pit to a maximum depth of 12 feet, where shale bedrock was encountered.[95] Surface dimensions of the pit are not documented.

5.2.8.4.3 Hazardous Substance Management

The tanks at SPF were used for the storage of fuel oil, waste oil, and solvents. Five samples of the tank bottom and four samples of the excavated soil were taken during tank excavation. The results of this sampling indicated that the pit area had elevated levels of total petroleum hydrocarbons and volatile organics. A subsequent soil gas survey confirmed horizontal migration of contaminants. Groundwater monitoring wells have been installed at the area, but data are not available from this program to date. Interim measures have been taken to abate contaminant migration by removing gross contamination and backfilling the excavated pit with either clean sand or limestone.[94]

Shallow soil borings of the SPF area indicate that the facility is underlain by approximately 5 to 9 feet of "stiff brown clay."[98] No shallow surficial sand aquifers were noted. The surficial clay was underlain by a 1-foot weathered shale zone and then a massive shale sequence. There is very low potential for contamination of the regional bedrock aquifer.

5.2.8.5 Evaluation of Potential Environmental Impacts

Sampling and analysis conducted to date confirm hazardous substance releases to the environment from this operable unit. Application of the abbreviated HRS model produced the following moderately low scores:

- groundwater pathway - 8.53
- surface water pathway - 3.84
- soil pathway - 5.2
- air pathway - 9.7
- site - 7.22.

HRS score sheets are provided in Appendix G.

It is probable that data collected during the ongoing UST Corrective Action RI/FS will indicate adverse environmental impacts more significant than those documented to date. This operable unit should, accordingly, be given medium priority for further investigation.

5.2.9 Operable Unit 9, Asbestos Contamination

This section of the PA report describes the characteristics of Operable Unit 9, Asbestos Contamination. Asbestos contamination is suspected in several areas operated by NASA.

5.2.9.1 Nature and Description

Degrading asbestos insulation on pipes and systems in outside areas of Plum Brook Station has resulted in releases of asbestos to the environment. The primary areas

5231 ?

of degradation were the 30-inch steam lines from the boiler complex (Building 5221) to the steam accumulators, at the accumulators, and from the accumulators to the B-2 facility.[1]

5.2.9.2 Physical Characteristics

The surface dimensions of soils contaminated by asbestos are unknown. The asbestos-insulating materials on the pipes and systems at Plum Brook Station have been analyzed and are friable. The potential for asbestos contamination to soils and surface waters in areas other than B-2 facility is likely, not only from the releases at the B-2 site but from other areas of the Station where asbestos insulation is degrading. There are no existing engineered barriers to migration.

5.2.9.3 Hazardous Substance Management

An extensive asbestos abatement project was conducted at the B test site as discussed in Section 2.2.2.2, however, NASA believes that asbestos contamination is still present in the soils, ponds, and trenches. Photographs taken at the B test site after contaminated soil had been removed indicate the potential for further contamination. Figure 5-17 is an aerial photograph of the area of suspected residual asbestos contamination.

A follow-on abatement project is planned by NASA LeRC to sample the soil, remove asbestos contaminated soil, and place a tar and chip cap over the area, as recommended by OEPA.

The trenches at B test site in and around the steam accumulators have not been certified as being free from contamination, nor have the ponds in the vicinity. The ponds are considered to contain residual asbestos contamination.[99] Per OEPA's

FIGURE 5-17. AERIAL PHOTOGRAPH OF AREA OF SUSPECTED RESIDUAL ASBESTOS CONTAMINATION

recommendation, contaminated ponds and trenches will be abated and post-abatement samples will be analyzed to verify the existence or non-existence of residual contamination.

The amount of asbestos released to the environment from the degradation of asbestos insulation and the extent of the contamination at Plum Brook Station are unknown. Of concern is that weather conditions may cause asbestos not previously discovered in the soils to become exposed.[100] Additionally, the decontamination and decommissioning of buildings and structures related to PBOW may have contaminated the soils and ponds at Plum Brook Station. The asbestos abatement program at Plum Brook Station continues with efforts concentrated on outside areas of the site where the potential for further releases from degrading asbestos insulation exists. A complete survey of the site for asbestos contamination in soils and ponds has not been conducted.

5.2.9.4 Evaluation of Potential Environmental Impacts

Releases of asbestos to the environment were confirmed during the PA. Application of the abbreviated HRS model produced the following low scores:

- groundwater pathway - 2.97
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 3.8.

HRS score sheets are provided in Appendix G.

The low HRS scores doe not indicate a significant adverse environmental impact from this operable unit. Given the fact that the asbestos abatement program at Plum

Brook Station is continuing, this operable unit should be given low priority for investigations outside the scope of the asbestos abatement program.

5.2.10 Operable Unit 10, SPF Rubble Pile

This section of the PA report describes the characteristics of Operable Unit 10, SPF Rubble Pile. The SPF Rubble Pile is a suspected source of environmental contamination by heavy metals and other hazardous chemicals. The SPF Rubble Pile was created by NASA during SPF reactivation.

5.2.10.1 Nature and Description

The SPF rubble pile is a landfill. NASA personnel indicated that the rubble pile was utilized solely for wastes generated from reactivation activities at the SPF.

5.2.10.2 Physical Characteristics

The SPF rubble pile is approximately 1 acre in area and is located northwest of the SPF. Access to the area is gained from South Magazine Road on a dirt road which is currently heavily overgrown with vegetation. There are no records indicating when waste was first deposited in the rubble pile or the amounts and types of waste. Wastes observed at the rubble pile during this PA were sand blast grit containing paint chips, concrete, asphalt, and large metal bolts. Disposing of waste in this rubble pile requires no special notification or approval. Figure 5-18 is a photograph of the SPF rubble. There are no engineered barriers to migration at the SPF rubble pile.

FIGURE 5-18 PHOTOGRAPH OF SPF RUBBLE PILE

5.2.10.3 Hazardous Substance Management

It is not known whether any hazardous substances were deposited in the rubble pile. Of concern is the waste sand blast grit that was generated from sand blasting (refer to Figure 5-19) the SPF dome. NASA analyzed samples of the SPF dome paint for heavy metals. The analytical results indicate that no regulatory limits for heavy metals were exceeded. The sand blast grit, therefore, is not considered a RCRA hazardous waste.[101]

5.2.10.4 Evaluation of Potential Environmental Impacts

Releases of hazardous substances from the SPF Rubble Pile to the environment were not confirmed during the PA. The following low scores were calculated upon application of the abbreviated HRS model:

- groundwater pathway - 4.36
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.11.

HRS score sheets are provided in Appendix G.

Existing analytical data and the low HRS scores do not indicate significant environmental impacts from the SPF Rubble Pile. This operable unit should be given low priority for further investigation.

FIGURE 5-19. PHOTOGRAPH OF SAND BLASTING GRIT

5.2.11 Operable Unit 11, Disposal Area 1B

This section of the PA report describes the characteristics of Operable Unit 11, Disposal Area 1B. This unit, created by NASA in the 1960s, is a suspected source of environmental contamination by solvents and paint-related compounds.

5.2.11.1 Nature and Description

Disposal Area 1B is a landfill. Waste has been deposited randomly within this area. NASA personnel questioned about this disposal area were unfamiliar with its use and sources contributing to its use.

5.2.11.2 Physical Characteristics

Disposal Area 1B is located to the north of Fox Road in a wooded area. The location is shown in Figure 4-1. Access is gained to this area by means of an unmarked gravel road. The area is approximately 5 acres and is surrounded on the west and north sides by an embankment. The largest section is flat and appears to have been scraped of vegetation at one time. The landfilled waste extends beyond the flat area into the trees and brush. Figure 5-20 is a photograph of Disposal Area 1B. There are no engineered barriers to migration at Disposal Area 1B.

5.2.11.3 Hazardous Substance Management

This area was designated by NASA in the 1960s as an area to dispose of non-contaminated, salvageable scrap metal. However, the types of waste observed in this area during an SAIC site visit included wood, several empty rusted drums, drum bands, transformer insulators, broken glass, nuts, bolts, and gaskets. Several metal container labels which read "Vapor, Degreaser" and oil can lids were also observed lying on the ground. It appeared that this area might have also been used as a burning ground, as

FIGURE 5-20. PHOTOGRAPH OF DISPOSAL AREA 1B

evidence existed that at least one building had been burned at this site. Other items observed include a broken toilet and what appeared to be the dried-up paint from paint cans and containers used to clean paint brushes.

NASA environmental personnel were interviewed as to the use of this site. They were not familiar with the site nor how the waste got to the site. Disposal Area 1B has been closed by administrative action.

5.2.11.4 Evaluation of Potential Environmental Impacts

Hazardous substance releases from Disposal Area 1B to the environment were not confirmed during the PA. The following low scores were obtained when the abbreviated HRS model was applied:

- groundwater pathway - 4.8
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.24.

HRS score sheets are provided in Appendix G.

A significant adverse environmental impact is not indicated by observed site conditions and the HRS scores. This operable unit should be given low priority for further investigation.

5.2.12 Operable Unit 12, Disposal Area 2

This section of the PA report describes the characteristics of Operable Unit 12, Disposal Area 2. Disposal Area 2, created by NASA, was included in this evaluation because of its historical use as a landfill.

5.2.12.1 Nature and Description

Disposal Area 2 consists of Disposal Area 2A and Disposal Area 2B. The two waste disposal areas are located on the west side of Plum Brook Station. Both locations are shown in Figure 5-21. These disposal areas have been designated as an operable unit due to the unknown nature and volume of the wastes deposited therein. No records have been kept regarding the materials deposited at the site. Therefore, there is no conclusive evidence that hazardous materials were disposed.

Disposal Area 2A is an active disposal area near Pipe Creek. Dead wood, cement, asphalt, floor tiles, and scrap pipe were observed at Disposal Area 2A by SAIC during a site visit. The ground in the area appeared to be covered with an unidentified fill material. The area is sparsely vegetated.

To acquire background on Disposal Area 2A, SAIC interviewed Plum Brook Station employees on several occasions. One employee indicated that disposal pits had been excavated in the area for waste materials. The employee specifically recalled that fire brick generated during the decommissioning of two power houses and non-asbestos floor tile from K-Site were buried at Disposal Area 2A. The employee further recalled that an empty 500-gallon gasoline tank had been buried somewhere between Disposal Area 2A and the West Area Red Water Ponds.[102]

Reviews of Plum Brook Station documents and maps indicate that Disposal Area 2A was also the Lime Sludge Disposal Area (refer to Section 5.2.14).

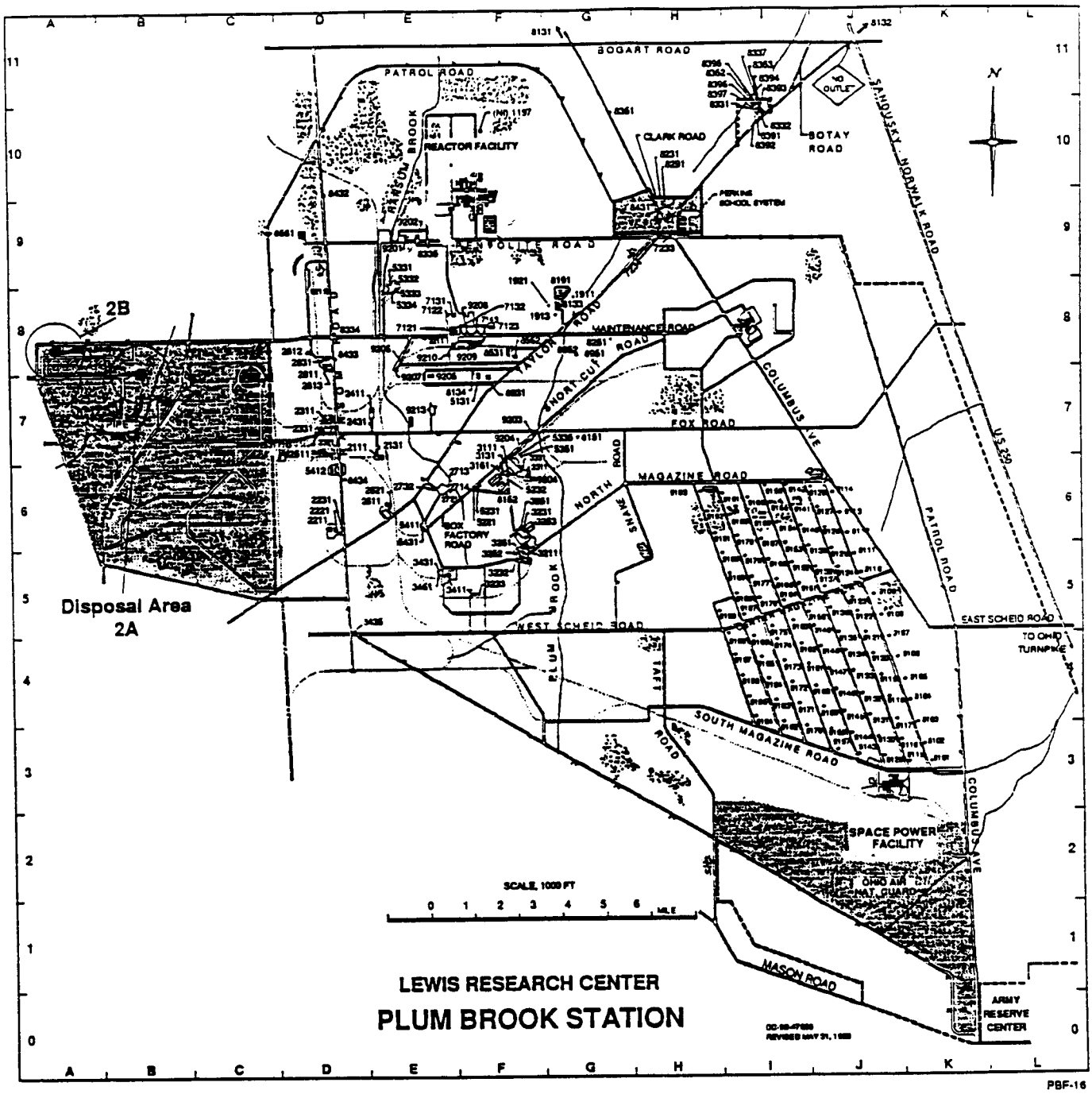


FIGURE 5-21. APPROXIMATE LOCATIONS OF DISPOSAL AREA 2A AND DISPOSAL AREA 2B

Disposal Area 2B is a cleared area between Patrol Road and the north leg of the Power and Maintenance Area #2 Road. Scrap culvert (cement and steel), utility poles, pipe (metal and polyvinyl chloride), and a scrap fence were observed at Disposal Area 2B. Based on observations made by SAIC during visual surveillance of the area, recent use of Disposal Area 2B has not occurred. Facilities and processes related to this area and the source history are unknown.

5.2.12.2 Physical Characteristics

The area of Disposal Area 2A is approximately 2 acres, and the area of Disposal Area 2B is approximately 1 acre. Neither are engineered sites. Secondary containment features were not observed.

5.2.12.3 Hazardous Substance Management

It is not documented whether either site received hazardous wastes. The wastes observed by SAIC were deposited directly on the ground. The lack of vegetation at Disposal Area 2A is indicative of an adverse environmental impact. The extent and depth of any contamination have not been evaluated at either site, and records of emergency or remedial actions have not been found.

Contaminants could be introduced to the environment via infiltration to soil and groundwater, and runoff to surface water. Both sites are located in the Pipe Creek drainage basin. Approximately half of Disposal Area 2A is within both the 100-year and 500-year floodplains of Pipe Creek.[33] Man-made ditching and culverting in the areas of both sites would facilitate drainage to Pipe Creek.

5.2.12.4 Evaluation of Potential Environmental Impacts

Hazardous substance releases to the environment from Disposal Area 2 were not confirmed during the PA. The following low scores were obtained using the abbreviated HRS model:

- groundwater pathway - 4.8
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.24.

HRS score sheets are provided in Appendix G.

Significant adverse environmental impacts were not observed during the PA or indicated by the HRS scores. This operable unit should be given low priority for further investigation.

5.2.13 Operable Unit 13, Rail Car Unloading Area

This section of the PA report describes the characteristics of Operable Unit 13, Rail Car Unloading Area. This unit, which was operated by the Army, is a suspected source of environmental contamination by toluene.

5.2.13.1 Nature and Description

This area is located on the north side of Maintenance Road, as shown in Figure 5-22, and was used by the Army for unloading toluene from rail cars. The area

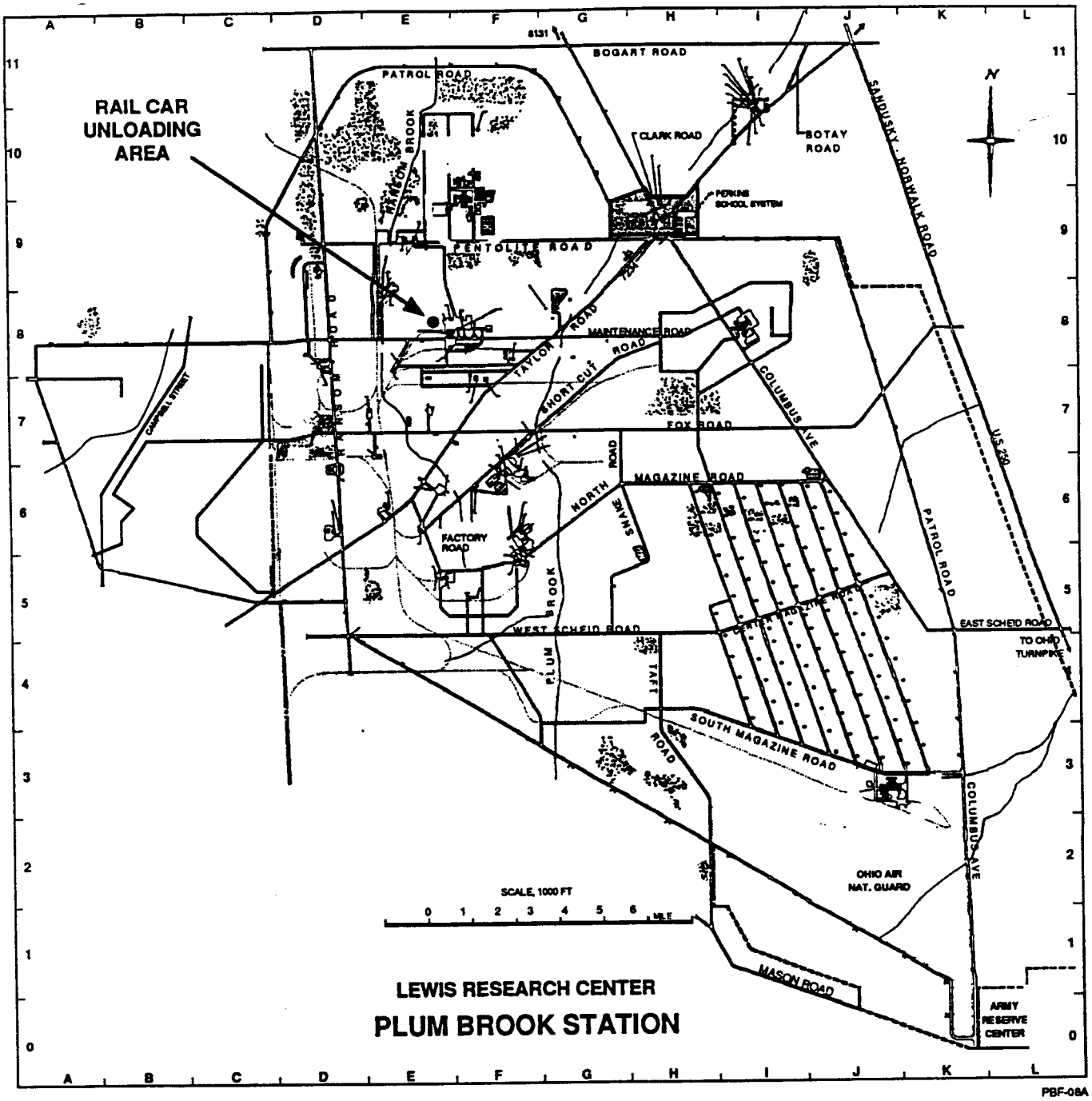


FIGURE 5-22. LOCATION OF RAIL CAR UNLOADING AREA

is considered an operable unit because of the potential for spills during unloading operations. The toluene was used in the process of manufacturing TNT during operation of the PBOW from 1942-1945.

Other rail car unloading areas also existed during the PBOW era. Although no evidence was found during the PA, other releases from rail car unloading operations are possible.

5.2.13.2 Physical Characteristics

The Rail Car Unloading Area is approximately 1 acre in size. Structures which existed during PBOW operations have been removed. Approximately 1/4 acre of the area is bare and supports no vegetation. The area surrounding the site supports lush vegetation. A photograph of the site is provided as Figure 5-23. There are no engineered barriers to migration at the site.

5.2.13.3 Hazardous Substance Management

Toluene was unloaded from rail cars in this area. It is suspected that the soil may be contaminated by toluene, as indicated by the lack of vegetation. The volume of spillage and the extent of potential contamination are not documented. However, given the fact that over 400 million pounds of toluene were unloaded in the area, it is possible that thousands of gallons of toluene were inadvertently released.

5.2.13.4 Evaluation of Potential Environmental Impacts

Shallow groundwater from the surficial aquifer was encountered at approximately 4.5 feet in shallow boreholes in this area.[78] Since this area is underlain by a yellow sand, some contamination of the shallow aquifer may have occurred. The water-bearing sand

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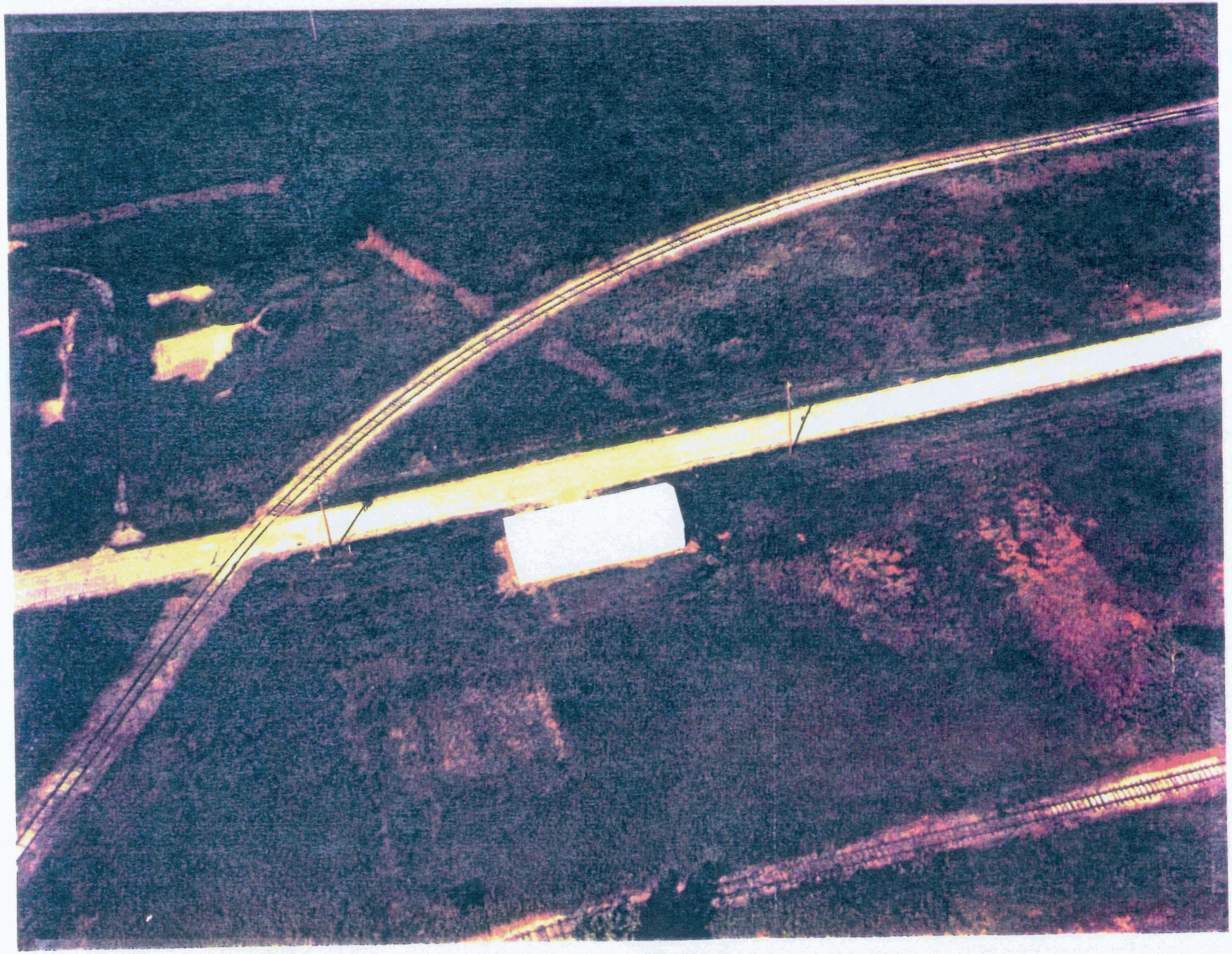

FIGURE 5-23. PHOTOGRAPH OF RAIL CAR UNLOADING AREA

is underlain by a clay which may impede vertical migration. The shallow surficial aquifers across Plum Brook Station are highly discontinuous; therefore, it is suspected that any contamination present would be highly localized.

Hazardous substance releases to the environment from this operable unit were not confirmed during the PA. The scores for this operable unit calculated upon application of the abbreviated HRS model were:

- groundwater pathway - 8.53
- surface water pathway - 3.84
- soil pathway - 5.20
- air pathway - 9.70
- site - 7.22.

HRS score sheets are provided in Appendix G.

Observations of stressed vegetation in the area and the moderately low HRS scores indicate the potential for an adverse environmental impact from this operable unit. Accordingly, the Rail Car Unloading Area should be given medium priority for further investigation.

5.2.14 Operable Unit 14, Lime Sludge Disposal Area

This section of the PA report describes the characteristics of Operable Unit 14, Lime Sludge Disposal Area. This unit, a disposal area created by NASA, is a suspected source of environmental contamination by heavy metals.

5.2.14.1 Nature and Description

A lime sludge disposal area was located in the area shown in Figure 4-2. This location is common to Disposal Area 2A (refer to Section 5.2.12). This waste disposal area is considered an operable unit due to the volume of waste deposited, the unknown chemical characteristics of the lime sludge, and the possible contamination of soil, groundwater, and surface water.

This area received approximately 8000 cubic yards of lime sludge from the PBRF settling basins.[103] The PBRF had two settling basins (200 square feet each) that were used to condense lime sludge from cooling water pre-treatment. Lime sludge was removed from the settling basins and taken to the waste disposal area.[103]

The first disposal at the lime sludge disposal area probably occurred some time after reactor start-up in 1963. The last disposal was in 1973. Disposal after 1973 were made off site in authorized landfills.[103]

5.2.14.2 Physical Characteristics

Surface dimensions of this waste area are not documented, nor are construction and secondary confinement details.

5.2.14.3 Hazardous Substance Management

The lime sludge may be hazardous with respect to pH and metals. Releases would be in the form of runoff to Pipe Creek and infiltration to groundwater and soil. Depth and extent of contamination have not been evaluated. There is no evidence of emergency or remedial actions. There are no known man-made conditions that would facilitate or mitigate contamination.

5.2.14.4 Evaluation of Potential Environmental Impacts

Hazardous substance releases to the environment from this operable unit were not confirmed during the PA. The following low scores were calculated using the abbreviated HRS model:

- groundwater pathway - 4.8
- surface water pathway - 2.16
- soil pathway - 3.8
- air pathway - 5.45
- site - 4.24.

HRS score sheets are provided in Appendix G.

Significant environmental impacts are not indicated by observed site conditions and HRS scores. The Lime Sludge Disposal Area should be given low priority for further investigation.

6. CONCLUSIONS AND RECOMMENDATIONS

The PA investigation documented by the preceding sections has attempted to identify all possible sources of hazardous substance contamination at Plum Brook Station that would have any potential to affect human health or the environment. Identification of possible sources was based largely on circumstantial and anecdotal evidence, due to the dearth of documentation describing hazardous substance management practices and the absence of systematic environmental monitoring at the site. Accordingly, the PA was conducted using a conservative approach, assuming that any indication of a problem should be investigated thoroughly and retained on the list of suspected sources unless there was clearly no potential for a release to the environment.

The following sections summarize the nature and extent of the possible release sources identified and analyze the potential impacts of these sources on the environment. Recommendations and priorities for future activities are also provided.

6.1 Documented and Suspected Releases

Of the 32 potential sources of environmental contamination identified at Plum Brook Station and the resulting 14 operable units designated, only ten sources in four operable units have been documented to have had releases of hazardous substance to the environment. The releases are listed in Table 6-1. When reviewing information in Table 6-1, note that groundwater monitoring data for the three operable units were not available at the time this report was prepared. Consequently, the impacted media may, in fact, include groundwater.

The remaining 22 sources must be considered only suspected problem areas until additional sampling and/or observation provides more-definitive information.

TABLE 6-1. DOCUMENTED PLUM BROOK STATION RELEASES TO THE ENVIRONMENT

Operable Unit	Release Source	Environmental Impacted Media	Hazardous Substances	Basis/ Documentation
2	Red Water Ponds 1, 2, and 3	Soil and Surface Water	Nitroexplosives, Heavy Metals	Sampling
4	Burning Grounds	Soil	Acetone, Methylene Chloride, Bis-phthalate	Sampling
8	UST Removal Areas 1, 2, 3, and 4	Soil	Solvents, Petroleum Hydrocarbons, Heavy Metals	Sampling
9	Steam Piping Systems	Soil, Surface Water	Asbestos	Sampling

Aside from asbestos released from steam piping, no documented airborne releases of other hazardous substances to the environment were identified during this PA investigation. The lack of airborne release information is probably attributable to the lack of site-wide air monitoring performed at Plum Brook Station. Generally, only local monitoring to ensure worker safety is conducted on site. A contributing factor may also have been the lack of knowledge of the hazard potential of some past activities at the time they were conducted. Explosives manufacturing and testing of rocket engines were the major activities at the facility. These activities certainly had the potential for airborne hazardous substance releases. This pathway should be considered when further evaluating potential sources of anomalous constituents identified in soil sampling results that do not appear to be related to known activities in that area. Near-surface contamination may be from airborne releases rather than spills directly to the soil. If the potential for soil contamination from an airborne release can be established in this manner, it may be possible to reconstruct the nature, source, and extent of the airborne release.

6.2 Populations and Environmental Media Potentially Impacted by Documented and Suspected Releases

All of the documented and suspected releases to the environment at Plum Brook Station involve soil contamination. This is undoubtedly skewed, however, by the emphasis on soil sampling in current Plum Brook Station environmental characterization and remediation activities. Limited sampling or monitoring has been performed on groundwater, surface water, or stream sediment media. The preponderance of soil contamination problems appears to identify the soil exposure and groundwater migration routes as the principal pathways of concern. However, several factors, including the lack of groundwater receptors and the restricted access to most contaminated areas discount much of this hazard potential. Conversely, the proximity of surface water and its significant ecological and human receptors, combined with the man-made and natural propensity for run-off to surface water, increase the potential hazard through the surface

water pathway. Although Plum Brook Station units are within the 15-mile target distance of the Sandusky and Huron municipal water supply intakes on Lake Erie (and the resulting 48,000 receptors) the realistic potential of releases to impact these water supply systems seems remote. Releases to the environment have been sporadic and generally of short duration. The dilution factors of several miles of river and of Lake Erie would seem to be adequate to absorb these types of releases.

Areas that would seem to be potentially impacted by releases are the stream valleys immediately downstream from Plum Brook Station. Any human health or environmental impacts arising from Plum Brook Station activities would probably surface in these areas. Future characterization activities should concentrate on the surface water pathway and receptors in the Plum Brook, Ransom Brook, Pipe Creek, other creek systems, and the Huron River.

6.3 HRS Evaluation

To quantify the potential hazard resulting from identified sources at Plum Brook Station, each operable unit was assigned a score using the U.S. EPA's Hazard Ranking System (HRS). A draft PA version provided by EPA Region V was applied to all operable units identified. This version is an abbreviated form of the HRS being developed by EPA as a simplified initial screening tool.

6.3.1 Description of HRS Method

The HRS is the scoring system EPA uses to assess the relative threat associated with the release or potential release of hazardous substances from a waste site. The HRS score is the primary criterion EPA uses to determine whether a site should be placed on the National Priority List (NPL). The NPL identifies sites that warrant further investigation to determine if they pose risks to public health or the environment. Sites on the NPL are eligible for long-term "remedial action" financed under CERCLA, as amended by SARA.

The original HRS, adopted in 1982, evaluated the relative threat of a site over five pathways. The HRS score was based on the evaluation of the following migration pathways: groundwater, surface water, and air. The two other pathways, direct contact and fire/explosion, were evaluated to determine the need for immediate removal (emergency) action. HRS scores ranged from 0 to 100. Sites that scored 28.5 and above on the original HRS were eligible for the NPL.

The revised HRS retains the same cut-off score and basic approach as the original HRS, while incorporating SARA requirements as well as improvements identified as necessary by EPA and the public. The revised HRS retains the groundwater, surface water, and air pathways, drops the direct contact and fire/explosion pathways, and adds a fourth pathway, soil exposure.

6.3.2 Assumptions Used for HRS Scoring

In generating the HRS scores for Plum Brook Station, a number of assumptions had to be made to compensate for limited data. The most significant assumptions were generally made in the assignment of the Waste Characterization Factor Values, which are based on the types of unit and the quantity of waste. Estimates of unit volume or area had to be relied on because of the lack of specific information for almost all units. Intuitively, there seemed to be a high probability that the actual volume of hazardous substances release by some units over their 50-year existence would be underestimated. However, with essentially no information available on hazardous substance quantities, estimation of volume/area was the only alternative.

Other factor values which required some assumptions were the Likelihood of Release Category and the Sensitive Environment factors. Releases were generally assumed based on proximity to media and source type. No area within the target distance was found to be a State or Federal designated area for ecological preservation.

This assumed that there was no designated habitat for any threatened or endangered species.

No airborne releases were assumed from any operable unit.

6.3.3 Summary of HRS Results

The complete scoresheet packages for all operable units are included in Appendix G. The results of the scoring are summarized in Table 6-2.

Only one operable unit scored near the 28.5 cut-off: Operable Unit 2, Red Water Ponds. This unit scored 21.9. Table 6-2 also includes the individual pathway scores.

When interpreting the HRS scores, note that, in general, the scores have been calculated using limited quantitative data on contamination of environmental media. The scores must be considered to be preliminary. As additional data are collected in subsequent site investigations, the HRS scores should be recomputed.

6.3.4 Applicability of HRS

As mentioned in the previous section, only one out of the 14 operable units scored near the U.S. EPA-designated 28.5 cut-off score. This was a surprise based on qualitative and intuitive evaluations of the site by the PA investigating team. The low scores can be traced principally to generally low values assigned to Target and Waste Characteristics Factor Values. While Target demographics are generally well known and are probably reasonably accurate, the Waste Characteristics Factor Values may not be as representative. The low Waste Characteristics Factor Values may be due, in part, to limited information on waste quantities, which necessitated reliance on volume or area

TABLE 6-2. SUMMARY OF HRS SCORING

Operable Unit	Ground-water Pathway	Surface Water Pathway	Soil Exposure Pathway	Air Pathway	Site
1	4.80	2.16	3.80	5.45	4.24
2	26.7	12.0	12.0	30.3	21.9
3	4.36	2.16	3.80	5.45	4.12
4	4.36	2.16	3.80	5.45	4.12
5	8.53	3.84	5.20	9.70	7.22
6	4.80	2.16	3.80	5.45	4.24
7	8.53	3.84	5.20	9.70	7.22
8	8.53	3.84	5.20	9.70	7.22
9	2.97	2.16	3.80	5.45	3.8
10	4.36	2.16	3.80	5.45	4.12
11	4.80	2.16	3.80	5.45	4.24
12	4.80	2.16	3.80	5.45	4.24
13	8.53	3.84	5.20	9.70	7.22
14	4.80	2.16	3.88	5.45	4.24

calculations that did not account for the age of many units (see Section 6.3.2). However, another significant factor may have been the dilution effect of scoring the entire Plum Brook Station as 14 operable units. Although this approach improved the organization and focuses of the PA effort, it may have precluded complete examination of the cumulative effects of the multiple release sources from the entire facility. Therefore, an overall score was generated considering all identified sources and overall site conditions. This scoring produced a site score of 34.8, developed from a groundwater pathway score of 33.3, a surface water pathway score of 28.7, a soil exposure pathway score of 28.7, and an air pathway score of 45.5. Based on this approach, the Plum Brook Station cumulative score would clearly exceed the 28.5 cut-off. Modifications to the operable unit organization may be appropriate to more realistically reflect the hazards posed by all the sources.

6.3.5 Priorities for Further Action

The HRS scoring results quantified one observation that was apparent early in the PA investigation: releases to the adjacent surface water bodies are the most significant hazard to the environment posed by Plum Brook Station. Any subsequent investigations should concentrate on quantitatively and comprehensively characterizing the nature, magnitude, and extent of releases to and contamination of the ponds and surface water bodies. Priorities for further investigation should accordingly be placed on those operable units that are known to regularly discharge to the surface water. Similar priority should be given to those units that are adjacent to a surface water body and may be releasing to it.

Most of the Operable Units investigated by SAIC were assigned low HRS scores. The following units had overall site scores less than 6:

- Operable Unit 1 - TNT Areas
- Operable Unit 3 - Underground Wastewater Flumes

- Operable Unit 4 - Burning Grounds
- Operable Unit 6 - Fly Ash Spoil Piles
- Operable Unit 9 - Asbestos Contamination
- Operable Unit 10 - SPF Rubble Pile West
- Operable Unit 11 - Disposal Area 1B
- Operable Unit 12 - Disposal Area 2
- Operable Unit 14 - Lime Sludge Disposal Area.

The above-listed Operable Units also had low individual pathway scores. These units will continue to have low HRS scores, even as more analytical data are acquired. SAIC, accordingly, does not recommend further investigation of these 9 Operable Units.

The following four Operable Units had HRS site scores greater than 6 and moderate individual pathway scores:

- Operable Unit 5 - Waste Lagoons in Pentolite Area
- Operable Unit 7 - Toluene Storage Tanks
- Operable Unit 8 - UST Removal Areas
- Operable Unit 13 - Rail Car Unloading Area.

It is possible that, as additional analytical data are acquired, some of these four units' HRS scores could approach or exceed 28.5. SAIC, accordingly, recommends their inclusion in further investigations as medium priority Operable Units.

Operable Unit 2, Red Water Ponds, received a HRS site score of 21.9 and relatively high individual pathway scores. SAIC recommends inclusion of Operable Unit 2 in further investigations as a high priority Operable Unit.

Table 6-3 summarizes the findings and recommendations of this PA report. The table states whether the suspected contamination potential of each of the originally identified sources was verified and provides a recommended priority for further action for each operable unit. A "high" priority recommendation indicates that the unit might receive an HRS score of greater than 28.5 after a complete site inspection. Operable units assigned a "medium" priority are considered to have some potential to score greater than 28.5 after a Site Inspection but such a score is not considered likely. Those units receiving a "low" priority are considered to have little to no probability of receiving an HRS score greater than 28.5 after a full Site Inspection.

6.4 Additional Information Needs

The information provided in the previous chapters of this report, and the analyses described above, indicate that the most pressing information needs lie in characterizing the nature and extent of past and present contamination of the surface water bodies adjacent to and downstream of Plum Brook Station. Acquisition of this type of information should be the priority for any subsequent investigations. Characterization data from the surface water media would also allow source-specific investigations to be better focused and prioritized. This should include characterization of the groundwater-to-surface-water pathway. Full characterization of the groundwater system would appear to be of a second-order priority due to the lack of receptors along this pathway.

A second recommendation is to improve general data availability. A major impediment to this PA was the lack of a centralized document control and/or retention system. No single NASA organization or location systematically controlled all internal environmental-related data or reports. Development of a system for controlling documentation generated in subsequent investigations is essential.

TABLE 6-3. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Operable Units	Suspected Contaminants	Suspected Contaminant Source Verified	Recommended Priority for Further Action
1, TNT Areas	Nitroexplosives, toluene, acetone, acids, asbestos	No	Low
2, Red Water Ponds	Nitroexplosives, heavy metals	Yes	High
3, Underground Wastewater Flumes	Nitroexplosives	No	Low
4, Burning Grounds	Solvents, unknown chemicals	Yes	Low
5, Waste Lagoons in Pentolite Area	Acetone, TNT, and pentaerythritol	No	Medium
6, Fly Ash Spoil Piles	Heavy metals, organic chemicals	No	Low
7, Toluene Storage Tanks	Toluene	No	Medium
8, UST Removal Areas	Solvents, hydrocarbons, heavy metals	Yes	Medium
9, Asbestos Contamination	Asbestos	Yes	~~Medium~~ Low
10, SPF Rubble Pile	Heavy metals	No	Low
11, Disposal Area 1B	Solvents and paint related compounds	No	Low
12, Disposal Area 2	Unknown chemicals	No	Low
13, Rail Car Unloading Area	Toluene	No	Medium
14, Lime Sludge Disposal Area	pH and heavy metals	No	Low

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