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PLUM BROOK STATION REVIEW

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Lewis Research Center, Cleveland, Ohio
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SECTION I

INTRODUCTION

This report will familiarize the reader with NASA's Plum Brook Station and its facilities. The report summarizes the development of the Station, reviews its role in the NASA program, describes its current status and suggests several options regarding its future.

Section II is a brief summary of the Station history and the recent events giving rise to its current status. Section III provides capsule descriptions of several of the major facilities located at the Station, identifies some prospective users and suggests possible future uses that should be considered. Section IV offers four specific options regarding the possible retention or disposition of the facilities. Section V is a general statement of other considerations related to the fundamental matter of determining the future status of the Station.

SECTION II

THE BEGINNING

The land now comprising NASA's Plum Brook Station was first acquired by the U. S. Army under rights of "eminent domain" in the early 1940's for the specific purpose of setting up an ordnance works to support the nation's needs for high explosives during World War II. About 9,000 acres of lightly populated farmland 3 miles south of the Lake Erie port of Sandusky, Ohio and 56 miles west of Cleveland were appropriated for that purpose. The Plum Brook Ordnance Works was devoted to the manufacture of TNT and Pentolite. While the facilities were government-owned the actual manufacturing was performed by a private contractor, the Trojan Powder Company. Nearly one billion pounds of high explosives were produced at the plant during its 3½ year operation.

The end of the war in 1945 terminated the need for large quantities of high explosives and the Station was officially closed shortly thereafter. The liquidation of operations and disposition of the plant fell to the War Assets Administration. Some 3,000 acres of land used as a buffer zone were returned to local farmers for farming and uncontaminated equipment was sold to recoup as much of the government's investment as possible. Contamination of the operating areas and the surrounding acreage and the temporary nature of most of the buildings made it difficult to dispose of the plant in any final sense.

NASA ENTERS THE PICTURE

In 1955 The National Advisory Committee for Aeronautics (NACA) was actively seeking a suitable location for its planned nuclear test reactor. The Plum Brook Ordnance Works was one of twenty sites considered. The absence of high density population centers, a vital concern for reactors in those days, and the proximity of the site to the programmatic home base, the Lewis Research Center, ultimately led to its selection. The site had several additional advantages such as the availability of large quantities of water from Lake Erie as well as some existing utility systems.

NACA negotiated a use agreement with the U. S. Army for 500 acres at the north end of the Plum Brook Ordnance Works. Following decontamination of the area, ground-breaking for the reactor facility took place in October of 1956. While the reactor was under construction, it became apparent that other research and development programs -- work with cryogenic fuels and oxidizers such as liquid hydrogen and fluorine -- at Lewis would require some of the open land areas available at Plum Brook. A second use agreement was therefore negotiated for the remainder of the manufacturing area and limited operations were begun in what was to become the Rocket Systems Area. Shortly thereafter the Army declared the balance of its real estate holdings excess to its needs. Transfer of formal title from the Army to NASA through the General Services Administration took place on March 15, 1963.

NASA DEVELOPMENT

NASA promptly began the task of necessary cleanup and restoration. This effort proceeded in an orderly fashion at a sufficient pace to insure the availability of the land and facilities required for NASA operations as the need arose. Care was taken to remove unneeded ordnance manufacturing facilities and decontaminate the surrounding areas to permit full and free access for NASA operations. Roadways, railroads, utility systems and structures needed for or adaptable to anticipated NASA requirements were rehabilitated and restored to operational levels.

In addition to these cleanup and restoration efforts, NASA undertook the construction of a variety of unique testing facilities. The 60-megawatt reactor facility was essentially completed in 1961. The Rocket Systems Area grew to incorporate twelve individual test sites including the High Energy Rocket Engine Research Facility (B-1), the Space Propulsion Research Facility (B-2), the Rocket Dynamics Control Facility (B-3) and the Hypersonic Tunnel Facility (HTF) as well as eight smaller component test facilities. The thirty million dollar Space Power Facility (SPF) was completed in 1969 and the Wind Turbine Generator, undertaken in cooperation with the Energy Research and Development Administration (ERDA), became operational in the Fall of 1975.

To support these varied test facilities the Station also has a variety of program support facilities. For example, the Rocket System Area is serviced by two fully instrumented control buildings (B and H Control). A Steam Generating Facility with four Babcock and Wilcox boilers each having a rated capacity of 28,000 pounds per hour of saturated steam at 500 psig also supports this area. An Air Compressor Building provides service air to the Rocket Systems Area complex and the Station shops. The Gas Handling Area provides storage and transfer facilities for liquid hydrogen, liquid nitrogen and helium along with compressor and vaporization capability as well. Gas handling capability is further enhanced by the existence of a Station rail system including a locomotive, several gas cars and dewars. Additionally, some 37 high pressure gas tube trailers are available.

General support Facilities include a Maintenance Shop, a Carpenter Shop, a Locomotive Shop, a Garage and a Plant Protection Building. General administrative space, including office space totals about 97,000 square feet. Twenty-three thousand thirty-one (23,031) square feet of this space is located in the reactor facility complex and includes a library and a large drafting room. Another 16,092 square feet is located in the Space Power Facility (SPF). The balance of 57,625 square feet is located in the Engineering Building which stands alone as the Station's major administrative building. This building has four large conference rooms, a library and a multi-purpose area serving as a 200-seat cafeteria or a 500-seat auditorium (see Photo No. 1). The total capital

investment in the Plum Brook Station is approximately $120,886,712. Table Number 1 provides a more detailed summary of NASA's capital investment by cost category. It is important to keep in mind that the values listed are stated in terms of 1950-1965 dollars. The cost to replace any of the facilities would be considerably higher.

PROGRAM CONTRIBUTIONS

At its high point the Station employed as many as 635 civil servants along with 132 support service contractors. The skills employed represented the wide range of scientific, engineering, administrative, technical and clerical knowledge required for the maintenance and operation of this important NASA facility.

As NASA's only reactor facility the 60-megawatt facility contributed to the knowledge of radiation effects on a wide range of materials and components. The Rocket Systems area facilitated the testing and development of the Centaur launch vehicle, provided basic test data on elements of the NERVA-propellant feed system and contributed greatly to the overall development of liquid hydrogen fuel technology. The Space Power Facility provided simulated space environmental testing opportunities for programs ranging from the Skylab shroud to a 10 kilowatt (electric) space powerplant and successfully demonstrated a capability for cloud physics research. All of this, as well as the other work described later on, constitutes an important contribution to the Agency's programs and the nation's technology base that would not have been possible without the unique capabilities that make up NASA's Plum Brook Station.

PHASE OUT

In late 1972 programmatic considerations resulted in NASA's decision to phase out the operation of the Plum Brook Station. The Reactor Facility was to be shut down by June 30, 1973. Rocket Systems Facilities were to be placed in standby effective June 30, 1974. The Space Power Facility (SPF) was continued in operation until October of 1975 in order to bring to a meaningful conclusion programs that were already underway. Personnel were to either be released or absorbed in the total Lewis Research Center complement which itself was reduced some 700 positions. The Wind Turbine Generator, a new effort in conjunction with ERDA, was, of course, unaffected.

Five of the Station's major research facilities have been placed in "standby". They are the Space Power Facility (SPF), the Space Propulsion Research Facility (B-2), the Hypersonic Tunnel Facility (HTF), the Reactor Facility and the Cryogenic Propellant Tank Facility (K-Site) plus the support facilities for these R&D facilities. The total number of structures placed in "standby" condition is now fifty-five. "Standby" means that the facility should be capable of being on line and in operation within 90 days. Facility maintenance and utility service is limited to that necessary to prevent deterioration and insure operating capability. Thirty-one structures have been placed in an inactive status meaning that they have been completely closed down with all utilities and plant equipment shut off. Buildings have been secured to avoid wildlife or weather damage so as to minimize the cost of reactivation should that become necessary.

CURRENT STATUS

The only NASA facility presently operating at the Plum Brook Station is the 100 KW Wind Turbine Generator (see Photo No. 2), the related weather tower, and the associated control room housed in Building No. 8133.

Station utility systems are summarized as follows:

Electrical Power -- Ohio Edison Company provides electric power by means of two widely separated 138 kilovolt transmission lines to the primary Plum Brook substation. Relaying protection and reclosing features provide what amounts to a dual source of power.

Natural Gas -- Columbia Gas of Ohio serves the Station. Natural gas is distributed throughout the Station by 9.24 miles of metered 6-inch steel gas lines.

Heating Oil -- Several of the major facilities have heating plants that are equipped to burn either natural gas of No. 2 oil. Adequate storage exists at each of these facilities to support oil heat. In addition, the Station has two 200,000 gallon tanks for storage of backup oil supplies.

Domestic Water -- Potable water is supplied by the City of Sandusky and is stored in three vessels containing a total of 700,000 gallons.

Raw Water -- Raw water, used for cooling, testing, and fire protection, is provided by a Plum Brook owned intake in Lake Erie and another owned by the City of Sandusky. The existing systems can supply the Station with 10,000,000 gallons of water per day.

Sewage -- The Station's main sanitary sewage treatment facility is located approximately 2500 feet outside the Plum Brook Station perimeter on a non-contiguous property. In addition to serving the Station it also serves some thirty-five residential customers in the immediate area. Although operating at a very low level, all Station utilities are in active operating status.

There are six storage yards, sixteen warehouses and ninety-nine igloos located at Plum Brook. Indoor storage consists of approximately 880,000 cubic feet covering about 160,000 square feet. Outdoor storage amounts to approximately 75,000 square feet. All of these are presently being used for the storage of Lewis materials and records. Those items formerly held for the Plum Brook Station and its operation have now been integrated with the Lewis material. Records are maintained on almost all of this material. The majority of the space is devoted to the storage of equipment and material. Six igloos are used for records storage. There is almost a constant flow of material and records between Lewis and Plum Brook.

The following structures are presently occupied at the Plum Brook Station:

Structure No.	Title	Use
7131	Garage	Occupied by personnel responsible for Station roads and grounds maintenance and repair and maintenance of vehicles and heavy equipment.

Structure No.	Title	Use
7141	Engineering Bldg.	Offices occupied are as follows: NASA -- 6 Service Contractor -- 5 Army Reserve -- 15 Department of Interior -- 12 Environmental Protection Agency -- 10 Federal Bureau of Investigation -- 2
7143	Chemical Lab.	Occupied by the Station Environmental Health-Safety and facility maintenance staff.
7191	Main Gate Guard House	This building functions as the Station's Main Gate and is occupied by Station security personnel.
7192	Medical Building	A portion of this building houses the small Station custodial force and related equipment and supplies.
7231	Plant Protection Building	This building contains the Station Communication Center, damage control equipment, and Plant Protection personnel.
9209	Warehouse	Occupied by personnel responsible for control and redistribution of equipment and supplies.

Current land holdings amount to 8,000 acres -- 5,400 within a Station perimeter fence and an additional 2,600 outside and retained as a buffer zone, some of which is leased to local farmers for agricultural purposes. (See Photo No. 3 and the Plum Brook Station Location Plan.)

Since the phase out in 1974 NASA has cooperated with local, state and other Federal organizations by making Station real estate and facilities available for non-NASA endeavors. As a result, there are now thirteen tenants using or occupying NASA property. Each of these situations is covered by a use agreement between the tenant and NASA. Most of the tenants are using NASA facilities without any modification. Some minor modifications have occurred in the buildings occupied by the Environmental Protection Agency (EPA). EPA has also built its own Test Control Building and Test Track on NASA property. (See Photo No. 4 and Photo No. 5.)

A detailed listing of non-NASA tenants currently located at the Plum Brook Station may be found in Table No. 2. This table also lists the reimbursement received from each tenant and includes some information on income derived from the lease of land in the buffer zones for agricultural purposes. Finally, the total civil service staff at Plum Brook, excluding Lewis operations, is four people. On-site service contractors now number forty-five.

SECTION

The facilities at the Plum Brook S ion offer some truly unique facilities along with some large open land areas that afford attractive opportunities for a wide range of research and testing. There follows a brief summary description of some of the major facilities along with an indication of prospective users, candidate programs and potential future uses for each facility.

SPACE POWER FACILITY (SPF)

The Space Power Facility is the largest controlled environment test chamber in the world. (See Photo No. 6.) It is also the only large vacuum chamber in the country capable of testing nuclear reactors or fusion devices. The test chamber is aluminum to minimize nuclear activation and is surrounded with a 6- to 7-foot thick concrete enclosure for nuclear shielding and containment. The test chamber is 100 feet in diameter and 120 feet high, providing 800,000 cubic feet of unobstructed volume. Access to the chamber is provided through two, 50-foot square doors connecting the chamber to adjacent high bay areas for assembly and disassembly of test articles. Three standard gage railroad tracks are available to move heavy test articles from one area to another. The high bay disassembly area is shielded with six feet of concrete and is suitable for remote disassembly or maintenance of radioactive devices. Operations can be observed through nine large oil filled shielded windows.

The outstanding facility and test support equipment capabilities include:

- o A 400-kilowatt arc lamp, which is 25 times more intense than presently used sources--This lamp provides high quality solar simulation with variable geometries up to 450 square feet vertical or horizontal beam. Beam intensities range from Earth orbit to terrestrial to Mars orbit.
- o A vacuum facility with an altitude capability from sea level to 10^{-8} torr--the pumping system utilizes 32 oil diffusion pumps 48-inches in diameter with LN_2 baffles. The roughing pumps can remove 120,000 pounds of air per hour allowing small engines to be operated in the chamber at typical altitudes.
- o A cryogenic system capable of removing up to 15 megawatts thermal power--This system provides sink temperatures from $-300^{o}F$.
- o A 7-megawatt dynamic radiant heater for higher temperature thermal simulation.
- o Instrumentation, control, and data acquisition systems (e.g., an XDS 930 computer, FM high-speed recording systems, and a PDP8E minicomputer) with versatile capability for recording and display and for automatic control or monitoring.
- o Chamber floor and ceiling load carrying members designed to allow very heavy devices to be supported in the chamber.
- o A full complement of support shops and offices, a spacious test control center, cryogenic storage areas, etc.

The assembly area is currently equipped with an expandable clean room. The disassembly area provides a volume of over 700,000 cubic feet,

with extensive ventilation and contamination control areas. This concrete room can readily be made into a very large clean room. Access can be controlled through available change-room facilities.

Program Accomplishments

Among the major programs performed in SPF are the following:

Isotope Brayton System - This program involved the development testing of a 10 kilowatt (electric) space power plant in a simulated earth orbit.

Skylab Shroud Test - This test was the flight qualification checkout of the shroud for the Skylab Project.

T/C Aerodynamic Shroud Test - This test was a heated jettison test of the Titan/Centaur aerodynamic shroud using a specially built seven megawatt shroud heater.

Shuttle Base Heating Experiment - This test was performed by Rockwell International using a 1/25th scale model of the shuttle main engines. Over 200 hot firings of the model were run with each test lasting only 30-40 milliseconds. Shockwave travel time from the model to the wall and back again were critical to these tests.

Centaur LOX Boost Pump - This test was a simulation of the ascent pressure history of the Titan/Centaur-1 flight. Conditions preventing rotation of the turbine were identified to permit the establishment of operating parameters through the entire firing sequence.

MSFC Electron Gun - This program was to study the performance of the Ball Brothers Research Corporation's electron accelerator to determine if it was suitable for flight. This effort was part of the

Atmospheric-Magnetospheric-Physics-Systems (AMPS) Program to study plasma physics in near earth orbit as recommended by the National Academy of Science in a 1973 study.

Aeronomy - This effort conducted by the University of Pittsburgh under a contract from the National Science Foundation (NSF) was to explore the excitation of aeronomically important metastable and Rydberg states investigating their subsequent destruction in collisions with a variety of target gases.

Laser Atmospheric Density Experiment - This test sponsored by the Air Force's Cambridge Research Laboratory involved the calibration and flight qualification of a sounding rocket payload including a laser backscatter instrument to measure atmospheric density. Altitudes from 90 to 160 Km were simulated.

Cloud Physics - This experiment demonstrated the facility's capacity to create long lived stable coulds. Dense clouds apparently free from convection currents were formed and sustained in the chamber for nearly an hour. Additional tests with improved instrumentation verified the ability to create clouds of different densities. Future programs to measure the effects of atmospheric contaminants are clearly possible.

Current Interest

Some current possibilities for SPF include the following:

Fusion-Superconducting Magnets - The Oak Ridge National Laboratory is presently considering the use of SPF as a vacuum chamber to test out the operation of its Experimental Power Reactor. SPF is the only existing

facility capable of accommodating a fusion reactor of this size and weight.

Isotope/Solar Brayton - This program is one currently being considered by the Lewis Research Center as part of its effort to scope new ideas for ERDA.

Power Satellites and Related Technology - The following efforts have been considered in the last few years:

Dynamics of Large Arrays - MSFC

Solar Receivers & Heat Exchangers - Lincoln Labs

Ion Engine/High Voltage Solar Array Interactions - LeRC

Solar Electric Propulsion - MSFC & LeRC

Large Antennas In Space - Harris Corp., LaRC, SAMSO

Shuttle Payloads - A variety of Shuttle payload experiments have been discussed from time-to-time. Among them are the following:

SAGE - LaRC ozone measuring satellite

Large Space Telescope - MSFC, Itek Corporation

Solar Furnace - MSFC

Systems Generated Electron Magnetic Pulse (SGEMP) Program - this is a test currently being considered by the Department of Defense, Defense Nuclear Agency.

Potential Use

Potentially, SPF seems ideally suited to the testing of fusion reactors because of its size and extraordinary floorloading tolerances. Similarly, its altitude simulation, cold wall and solar heating capabilities make it attractive for space simulation testing of such things as space power systems and satellites. Finally, the chamber's ability to create and sustain controlled cloud formations make it a unique tool for cloud physics work and general upper atmospheric science experiments.

SPACE PROPULSION RESEARCH FACILITY (B-2)

The Space Propulsion Research Facility is designed for hot firing of full-size space vehicles in an environment simulating conditions at an orbital altitude of 100 miles. (See Photo No. 7)

Salient facility features include:

- Thrust capability to 100,000 pounds and, with minor modifications, to 500,000 pounds.
- A 38-foot-diameter by 55-foot high stainless-steel test chamber
- A 27-foot-diameter test chamber access door
- Liquid nitrogen cooled cold walls
- A 5×10^{-8} torr ultimate static vacuum
- Quartz lamp thermal simulators
- Steam ejectors to pump rocket exhaust products - run times in excess of five minutes
- Space soak (30 days)
- Repetitive engine starts after simulated space coast period
- Storable, cryogenic, and solid propellant capability (fluorine not excluded)
- Propellant safety dump tanks

In operation, an entire vehicle can be vacuum "soaked" to the proper environmental space conditions in preparation for engine test firing. With the $-320^{\circ}F$ cold walls and 5×10^{-8} torr vacuum, rocket engines can be ignited in the chamber under space conditions. As chamber pressure

builds up because of the exhaust gas, an 11-foot-diameter valve opens in 0.4 second to connect the chamber to a steam ejector system. Two parallel steam ejectors remove the engine exhaust products from the chamber while maintaining a moderate vacuum level. Three large dump tanks are located in the exhaust spray chamber to receive propellants in an emergency situation.

The exhaust system includes a 250,000 gallon-per-minute water spray system for cooling the rocket exhaust. The spray system water is recirculated through the 1.75-million-gallon catch basin under the chamber.

Program Accomplishments

Among the major programs performed in B-2 are the following:

Test Firing of the Improved Centaur - The test involved the actual test firing of a Centaur without benefit of the H_2O_2 driven Hydrogen and Oxygen boost pumps.

Centaur Multiple Start Tests - This test verified the second burn capability of the liquid hydrogen fueled Centaur vehicle. This capability was critical to interplanetary missions such as Viking. The starting envelope was fully identified to permit maximum flexibility in making propellant-payload tradeoffs.

Air Force Rocket Plume Studies (Secret) - This project dealt with the IR signatures of rocket plumes.

Federal Records Recovery - This project was in response to a water disaster at the Federal records center in St. Louis, Missouri. Forty truckloads of vital water logged Federal records were dried out and returned to the records center in usable condition.

Current Interest

Some current possibilities for B-2 include the following:

Advanced H_2O_2 Engines, Breadboard Engine,

Aerospike - LeRC and MSFC

RL-10 Follow-on (Tank Head Idle Mode and

Two Position Extendable Nozzle) - MSFC and LeRC

IUS Support - Interim Upper Stage Project Office, SAMSO

Potential Use

Potentially B-2 affords the capability of performing a variety of future programs of foreseeable interest. Among them would be such things as:

Testing of complete Space Tug vehicle

~~Testing of Shuttle Orbiter main engine~~

Testing of complete altitude control and orbital maneuvering systems

Testing of payload landing systems for planetary exploration

Investigation of rocket plume effects on radio signals

Contamination studies of photocells and optical systems by rocket exhausts

Study of rocket plume "signatures"

Generally speaking, the ability to soak a model in a deep space environment, hot fire the engine and resoak on a cyclic basis limited only by the limitations of supporting facility equipment make this facility a unique tool of great importance to the nation's R&D capability.

HYPERSONIC TUNNEL FACILITY (HTF)

The Hypersonic Tunnel Facility is a free-jet wind tunnel designed for aerodynamic testing at Mach 5, 6, and 7. (See Photo No. 8) The airstream is uncontaminated (nonvitiated) and can be heated to stagnation temperatures from 1800° to 3500°F. The supersonic Jet is 42-inches in diameter and will accommodate models up to about 2-feet in diameter and 10-feet in length.

The tunnel test section is housed in a cylindrical test chamber 25-feet in diameter and 20-feet high. The mounting system for the test article is designed to accommodate model injection as well as fixed-position mounting. The mounting system can measure the angle of attack and thrust.

The facility has the following outstanding capabilities:

- Operation with a noncontaminated airstream
- Operation at Mach 5, 6, and 7
- Test-altitude simulation from 60,000 to 120,000 feet
- Heater operation to 1200 pounds per square inch and 4500°F
- Hot nitrogen flow rates up to 128 pounds per second
- Electrical induction system rating of 1.5 megawatts
- Hydrogen pebble-bed heater operation to 1200°F and 1200 pounds per square inch.

The clean tunnel airstream is synthesized by blending hot and cold gaseous nitrogen with cold gaseous oxygen to produce the desired temperature and gas composition. The nitrogen is heated in a large

storage-type graphite bed which, in turn, is heated inductively. The graphite bed is approximately 5-feet in diameter and 35-feet long and is thoroughly insulated from its pressure storage vessel (rated for 1200 psi). The nitrogen vessel is a railroad car with a capacity of about 750,000 standard cubic feet at a working pressure of 5,000 pounds per square inch.

The facility has a gaseous hydrogen fuel system that is used to supply hot hydrogen fuel to the ramjet engine being tested, and the fuel lines are electrically trace heated.

The single stage steam ejector system is supported by the centralized Steam Plant serving the Rocket Systems Area and data acquisition is provided through the Plum Brook Data Acquisition and Control System.

Program Accomplishments

The HTF was used principally on the Hypersonic Ramjet Program. This was a Langley program using hardware built by Airesearch-Garrett Corporation. Hot engine firings were done at Mach 5, 6 and 7.

Current Interest

Interest in HTF centers on the continuation of hypersonic work and the possibility of magnetohydrodynamics (MHD) experiments. Langley has periodically expressed an interest in some scramjet tests as has Wright-Patterson AFB. Only three such facilities exist in the country. The Ames and Arnold facilities were both badly damaged as of 1975.

There is now pending a proposal to ERDA, supported by Congressman Mosher, to use HTF for MHD work leading to the engineering optimization and study of MHD generator performance. This proposal involves Lewis and General Electric's Valley Forge facility.

Potential Use

Future uses of HTF also focus on hypersonics and MHD but are not necessarily limited to them. The 1.5 megawatt induction heater in HTF suggests the possibility of its use as a multiple purpose process oven with attainable temperatures to 4500°F. The facility also will be an extremely useful tool if any problems should arise with the Shuttle thermal protection system. Finally, the possibility exists of using the facility as a high temperature nozzle test facility.

ROCKET DYNAMICS AND CONTROL FACILITY (B-3)

The Rocket Dynamics and Control Facility was designed primarily for altitude testing large rocket propellant and turbopump systems. (See Photo No. 9) It has a complete gas and cryogenic supply system including a 200,000 gallon LH_2 storage dewar. The test stand base is 50-feet square and 210 feet high. It is totally enclosed above the 74-foot level and has electrically operated roll doors on three sides to allow access by the 65-ton crane for model installation and free ventilation during fueled tests. Test articles are generally mounted at the 73½-foot level. At this elevation the test area is 32 by 27½-feet and can extend to the roof. Movable floors and work platforms provide

access to the test article. Like the B-1 facility, B-3 has hazardous fuel capability and utilizes the B complex scrubber system and Plum Brook steam and data acquisition system.

Program Accomplishments

Among the programs performed in B-3 are the following:

T/C Shroud-Cryogenic Unlatch Tests - This test was designed to verify the Titan/Centaur shroud's ability to unlatch in a cold space environment. The driver was the Viking requirement.

T/C Shroud - Structural Loading Tests - This test on what was basically the Viking shroud was to determine the degree of structural integrity in both a hot (SPF) and cold (B-3) environment. Cold testing was taken to the shroud limits to establish limit tolerances.

T/C Shroud - Insulation Tests - This test, also Viking driven, resulted in a major redesign of the shroud's insulation system.

NERVA Feed Systems Work - This work was a system test of the feed system and checkout of the starting sequence.

NERVA Turbopump Tests - Some full scale turbopump testing of both centrifical and axial pumps were performed in support of the NERVA Program.

Current Interest

The only known interest in B-3 is that expressed on the part of Continental Aircraft Engine (Teledyne in Toledo) in using the facility as a VTOL Engine Testing Stand. Such a use would exploit the physical characteristics of the facility but represent less than optimum use of its operating capabilities.

Potential Uses

Apart from the possibility of lift fan engine tests the B-3 facility is capable of testing large turbopump systems such as those used in the electric power industry. The possibility also exists of using the facility for structural testing of upper stage vehicles. The presence of a 200,000 gallon cryogenic tank suggests the further possibility of some form of cryogenic testing. Finally, the versatility of the test stand (high bay area, extensive piping, data acquisition, etc.) allow its possible use for a wide variety of non-space related high technology work including fluidized bed combustor and turbine research, coal gasification and fuel oil cracking. High powered chemical laser work might also be yet another possibility.

HIGH ENERGY ROCKET ENGINE RESEARCH FACILITY (B-1)

The High Energy Rocket Engine Research Facility was designed for hot firing tests on a variety of engine systems at altitude conditions. (See Photo No. 9) The stand has a 34- by 42-foot base, is 135 feet high, and is equipped with three large, electrically activated rollup doors. It Is enclosed above the 68-foot level. Two test-mounting methods are available; a 13½-foot-diameter by 30-foot-long vacuum capsule is used for testing entire engines in a space environment, and a steel test carriage is used for cold flow tests. Engines with thrust up to 6000 pounds can be run for approximately 6 minutes by using the existing format; the thrust capacity can be increased to 30,000 pounds with minor modifications.

Support systems including cryogenic run tanks, exhaust gas scrubbers and large gaseous and cryogenic storage cars and tanks allow testing of hazardous cryogenic, storable and solid rocket motors, systems, or components. Vacuum pumping is provided by a two stage steam ejector system and the B-1 Data Acquisition System is part of the centralized Plum Brook primary data system.

Program Accomplishments

Among the programs performed in B-1 are the following:

Proof Test of Centaur Feed System - This test involved the preliminary work leading to the development of an Improved Centaur eliminating the H_2O_2 driven Hydrogen and Oxygen boost pumps in the Centaur feed system. This is the system that was later test fired in B-2.

NERVA Rocket Propellant Feed System Tests - These tests contributed to the design and development of the LH_2 feed system for the NERVA nuclear rocket. Problems of tankage, turbopumps and reactor heat transfer were dealt with as part of this effort.

Current Interest

Apart from the possibility of diverting B-1 to lift fan engine testing (similar to B-3) there exists a possibility here also for high powered laser work. Such a possibility has been raised in past years by the Air Force and the Pratt-Whitney Florida R&D Center.

Potential Uses

The potential uses of B-1 are generally the same as those enumerated for B-3 but on a smaller scale. Cryogenic testing could be performed

on this site but structural testing, as suggested for B-3, would not be feasible. This facility does have both a vacuum and hot engine firing capability.

REACTOR FACILITY (RF)

Plum Brook's 60-megawatt reactor facility is an extremely versatile experimental complex. (See Photo No. 10) It allows complete irradiation testing and analysis of materials, devices, and components over a wide range of conditions. Neutron fluxes up to 10^{15} neutrons per square centimeter per second (thermal energies) and $3x10^{14}$ neutrons per square centimeter per second (greater than 1 Mev) and gamma energies up to 25 watts per gram (water) are available. These fluxes are provided in six beam holes (6 in. diam), two through holes (12 in. diam), an in-core test facility, 41 reflector test holes, and various other in-tank experiment positions.

The reactor has these unique features:

- o A major cryogenic testing facility, which permits irradiation and subsequent testing of specimens in gaseous helium at temperatures from -400F to ambient
- o A lubrication testing facility, which permits friction and wear testing while the lubricant is being irradiated
- o Remote experiment-positioning devices and ample instrumentation leadouts

- Twenty-five foot deep water-filled canals for convenient transportation of radioactive materials from the reactor to a completely equipped hot laboratory.

The hot laboratory has seven high-level cells completely equipped for post-irradiation testing and examination. In addition, radiochemistry, and metallurgy laboratories are provided. A mockup reactor, nearly identical to the Plum Brook Reactor and used for reactivity and flux measurements, is located in one of the canals.

The reactor complex includes these additional features:

- Various auxiliaries such as deionized water, compressed air, helium and argon pure gas, and cooling water
- Office space for over 200 persons
- Machine and electrical shops
- Electronics laboratory
- Complete waste storage monitoring and cleanup facilities.

Program Accomplishments

During its operation the Reactor Facility performed several hundred tests on the effects of radiation at cryogenic temperatures on a variety of materials, components and fuel elements. This work was an important element of the Agency's ~~ill-fated~~ nuclear research program.

Current Interest

There is no known interest in the use of the Plum Brook Reactor Facility as a radiation effects facility. A license amendment is now pending to permit the isolation of two Reactor complex buildings so that they may be turned over to EPA for general use.

Potential Uses

Unless a need arises for material and radiation effects studies related to space nuclear power plants, fusion reactors or advanced nuclear ground based power plants, there is no foreseeable need for the reactor facility.

CRYOGENIC PROPELLANT TANK FACILITY (K-SITE)

The Cryogenic Propellant Tank Facility is a 25-foot diameter spherical vacuum test chamber with a 20-foot access door. The facility is designed for performance testing of a wide variety of rocket vehicle propellant tank systems. It is the only known chamber in the country with LH_2 capability allowing experiments on long term storage of cryogenics in space. This chamber is equipped with cold walls that can be cooled with either liquid nitrogen ($-325^{o}F$) or liquid hydrogen ($-425^{o}F$). Vacuum levels of the order of 10^{-8} torr are attainable. A shaker system is installed which can:

- o simulate the fluid mechanisms of propellant sloshing
- o produce the vibration environment required to study the effects of vibration on insulation systems and their performance.

Program Accomplishments

Generally K-site has been devoted to the testing of insulation schemes. The facility permits the simulation of earth orbit and deep space conditions. Work has consisted primarily of basic research on lightweight high-performance cryogenic insulation systems. Work at this site did lead to the development of a hydrogen tank which could be

successfully sealed for the one to two year period necessary to accomplish interplanetary flight to other planets (Mars). Additionally, some propellant expulsion testing was done. Tests were also performed using dynamic sloshing to study heat transfer effects from pressurant gases to fuel.

Current Interest

There is no known interest in the use of the K-Site.

Potential Uses

Potential uses for the K-site hinge upon future interest in insulation related problems. Beyond this potential uses may be dictated by the interest in the facility's shaker capability or its possible use as a low cost vacuum chamber. In this regard, the facility may be somewhat unique representing as it does a 25 foot diameter vacuum chamber with LH_2 cold wall capability.

TURBOPUMP FACILITY (C-SITE)

The Turbopump Facility was designed for research on pump inlets, and inducers. Complete hot-gas fired turbopumps can be operated at the site allowing research into all areas of combustion, turbines, and pumps. The facility has an externally fired preheater capable of operation at 180 psi. Endurance or prototype testing of catalytic combustion can be performed. The research pump casing is constructed of transparent material and is submerged in a Dewar that has viewing ports and a strobe lighting system. This arrangement permits photographic studies of the fluid flow

through the pump inducers. The facility is suitable for use with normal liquids as well as cryogen, including liquid hydrogen.

Program Accomplishments

C-site was devoted principally to hydrogen pump research. Pump cavitation was a problem explored in depth. Considerable work was done on the lowering of Net Positive Suction Head (NPSH) pressure. The lower the NPSH the lighter the tank could be and smaller the amount of auxiliary pressurant gas needed. The obvious objective was weight reduction. Tests demonstrated the ability to operate with zero NPSH. This represents a contribution to the basic research technology and has accordingly benefitted all hydrogen fueled rocket systems including Centaur, Saturn and the Shuttle.

Current Interest

Three areas of work are known to have an interest in C-Site. One is the possibility of doing some 24/hour a day unattended tests of catalytic combustors. Another is the study of combustor emissions by Continental Aircraft Engine (Teledyne). The third is the possibility of doing some combustor and turbine testing using dirty fuels.

Potential Uses

Apart from a revival of interest in cryogenic or general pump research C-site seems most adaptable to small or moderate size compressor research. Combustor work could also productively use the facility's high pressure air system. The possibility of work on the Stirling engine at the site has also been mentioned.

OTHER FACILITIES

In addition to the facilities just described, the Station includes the following facilities:

Liquid Hydrogen Pump Facility - A facility designed for hydrogen and oxygen pump research.

Dynamics Stand - A 144-foot high structure with shaker equipment rated at 20,000 pounds force operating at frequencies from about 20 to 2000 hertz.

Fluorine Pump Facility - A test faiclity for liquid fluorine pumps.

The Wind Turbine Generator (WTG) has not been described in detail since it remains an operating facility as of this date.

SECTION IV

In considering the future of the Plum Brook Station many possibilities exist. The choice to be made depends to a great extent upon the foreseeable programmatic interest of NASA and the projected research needs of the nation. If current hopes and plans are even partially realized, it seems likely that the Lewis Research Center will have an expanding role in energy-related work. Some of this work will doubtlessly require expansion of existing capabilities. Lewis is landlocked and already highly concentrated. Pressures already exist to take away what limited expansion the Center has to expand the adjacent city airport. Plum Brook may well represent the only room for expansion available to the Center.

The programmatic possibilities and the potential uses of the Station facilities have been summarized in the preceding section. Against all of these considerations must be weighed the cost of maintaining the facilities year after year if they are to be retained. Four options have been developed and are presented for consideration. Costs have been computed for each of these with estimates provided for both recurring and non-recurring costs. Recurring costs are those that would occur on an annual basis for each year of operation under the option described. Non-recurring costs are one-time expenses incurred to adapt to the option in question. Information is also provided on income which would accrue to the Government under each option as a result of reimbursements from tenants or lessees.

Options 1-3 require the continuation of an on-site service contractor. Obviously the size of the contractor's staff diminishes as the size of the Station shrinks. Option 4 assumes an off-site arrangement for

security and janitorial services. A summary of the manpower array for each option may be found in Table Number 3. Please note that the on-site service contract includes a warehousing function. The majority of this activity and the warehousing facilities at the Station are used to service the needs of the Lewis Research Center in Cleveland. In the strict sense of the word these costs are not solely attributable to the Plum Brook Station. Warehousing costs have therefore been highlighted in each cost summary.

Options 3 and 4 would both involve the decommissioning of the Reactor Facility. This involves working out a plan with the Nuclear Regulatory Commission (NRC), the licensing body, for the return of the Reactor complex to a safe unlicensed state. A preliminary estimate from Teledyne Isotopes, the contractor now monitoring the facility in its present "standby" condition, indicates a probable cost on the order of $2,000,000 to complete the necessary work. Actual performance of the task was scheduled over a three-year period and predicated on NRC's approval of on-site burial of radioactive material.

Finally, each facility at the Plum Brook Station has its own exclusion area dictated by safety and operating requirements. These exclusion areas are shown on the Plum Brook Exclusion Areas Map included in this report. Note that an exclusion area is also shown for the existing EPA test facility. Note also that the exclusion area for the Space Propulsion Research Facility (B-2) includes a down wind area when the facility is run with toxic storables. Translation of these areas into geographic boundaries occurs on the Plot Plans provided with each option.

OPTION 1

This option retains the present Station configuration. This is in fact the situation as it Now exists. The costs are therefore actual costs now being incurred. (See Plot Plan No. 1 for present Station boundary.)

Cost Summary

Utility Services	$150,000	
Major Maintenance & Repair	200,000	
On-Site Service Contract (includes $150,000 for Warehousing)	820,000	
Total Recurring Cost		$1,170,000
Reimbursement from Tenants	$ 45,309	
Current Lease Income	37,129	
Future Lease Income	27,000	
Total Income		$ 109,438
Net Recurring Cost to Government		$1,060,562

Advantages

- o From NASA's point of view the Station's existing facilities and capabilities are fully protected and retained.
- o Room for possible expansion or tests requiring large exclusion areas would be retained.
- o Storage and warehousing facilities required by Lewis are undisturbed.
- o Maintenance, plant protection and security services for NASA and tenants are consolidated in a single contractor and therefore more manageable and cost effective.

Disadvantages

- o Recurring costs at the present level continue each year that the Station is maintained.
- o NASA will have to bear the burdens of being a landlord for tenant agencies and probably not recover all related costs attributable to Station-wide systems.

OPTION 2

This option retains the following facilities and the related exclusion areas:

Space Power Facility (SPF)

Space Propulsion Research Facility (B-2)

Hypersonic Tunnel Facility (HTF)

Rocket Dynamics and Control Facility (B-3)

Reactor Facility (RF)

Cryogenic Propellant Tank Facility (K-Site)

Turbopump Facility (C-Site)

Wind Turbine Generator (WTG)

All other facilities, structures and real property would be excessed. (See Plot Plan No. 2 for revised Station boundary.)

Cost Summary

Utility Services	$ 125,000	
Major Maintenance & Repair	150,000	
On-Site Service Contract (includes $125,000 for Warehousing)	725,000	
Total Recurring Cost		$1,000,000
Reimbursement from Tenants	$ 26,750	
Current Lease Income	20,000	
Total Income		$ 46,750
~~Net~~ Recurring Cost to Government		$ 953,250
Non-Recurring Cost		315,000

Advantages

- o Recurring costs would be slightly reduced.
- o Some room for possible expansion or tests requiring large exclusion area would still be retained.
- o Maintenance, plant protection and security services for NASA and tenants would remain consolidated in a single contractor and therefore be more manageable and cost effective.

- NASA would be relieved of the responsibility for nine tenant agencies.
- Twenty-six hundred (2600) acres would be released for other Governmental or public use. (See Plot Plan No. 2.)
- Area and facility maintenance problems would be somewhat reduced.

Disadvantages

- Four of the sixteen warehouses and three of the six storage yards at the Station would be eliminated.
- Wildlife may become a problem for local farmers and traffic in the area once the existing perimeter fence is left unattended. The Station has a sizeable deer herd in what is essentially a protected habitat.

OPTION 3

This option retains only the following facilities and the related exclusion areas:

Space Power Facility (SPF)

Space Propulsion Research Facility (B-2)

Hypersonic Tunnel Facility (HTF)

Wind Turbine Generator (WTG)

All other facilities, structures and real property would be excessed. (See Plot Plan No. 3 for revised Station boundary.)

Cost Summary

Utility Services	$ 100,000	
Major Maintenance & Repair	100,000	
On-Site Service Contract (includes $100,000 for Warehousing)	500,000	
Total Recurring Cost		$ 700,000
Reimbursement from Tenants	$ 2,600	
Current Lease Income	20,000	
Total Income		22,600
~~Net~~ Recurring Cost to Government		$ 677,400
Non-Recurring Cost		
Facility Related Costs	$ 435,000	
Reactor Decommissioning (based on site burial over a 3-yr period)	$2,000,000	
Total Non-Recurring Cost		$2,435,000

Advantages

- o Recurring costs would be substantially reduced.
- o Major R&D facilities having foreseeable interest and greatest potential use would be preserved.
- o Limited room for possible expansion or tests requiring large exclusion areas would still be retained.
- o Maintenance, plant protection and security services for NASA and tenants would remain consolidated with the advantages inherent in such an arrangement even though the number of tenants would be significantly reduced.
- o NASA would be relieved of the responsibility for twelve tenant agencies.

- Four Thousand (4000) acres would be released for other Government or public use. (See Plot Plan No. 3.)
- Area and facility maintenance problems would be significantly reduced.
- Health-safety and security responsibilities associated with the reactor would be eliminated.
- Office areas and other outlying buildings associated with the reactor would become available for general use (Government or public) without restriction.

Disadvantages

- Non-recurring costs arising from the decommissioning of the reactor are high.
- Fourteen Of the sixteen warehouses and five of the six storage yards at the Station would be eliminated.
- Wildlife may become a problem for local farmers and traffic in the area once the existing perimeter fence is left unattended. The Station has a sizeable deer herd in what is essentially a protected habitat.

OPTION 4

This option would retain only the Wind Turbine Generator (WTG) and surrounding area. All other facilities and real estate would be excessed.

Cost Summary

Utility Services	$ 30,000	
Major Maintenance & Repair	15,000	
Off-Site Service Contract (Security)	20,000	
Total Recurring Cost		$ 65,000
Non-Recurring Cost		
Facility Related Costs	220,000	
Reactor Decommissioning (based on site burial over a 3-yr period)	2,000,000	
Total Non-Recurring Cost		$2,220,000

Advantages

- o Recurring costs would be almost totally eliminated.
- o NASA would be relieved of the responsibility for all tenant agencies.
- o Seventy-eight hundred (7800) acres would be released for other Governmental or public use.
- o The need for an on-site service contractor would be eliminated.
- o Area and facility maintenance problems would be limited to operating areas.
- o Health-safety and security responsibilities associated with the reactor would be eliminated.
- o Office areas and other outlying buildings associated with the reactor would become available for general use (Government or public) without restriction.

Disadvantages

- Non-recurring costs arising from the decommissioning of the reactor are high.
- Room for possible expansion or tests requiring large exclusion areas would be lost.
- All warehousing and storage capability -- sixteen warehouses, six storage yards and ninety-nine igloos -- would be lost to Lewis.
- Wildlife may become a problem for local farmers and traffic in the area once the existing perimeter fence is left unattended. The Station has a sizeable deer herd in what is essentially a protected habitat.

SECTION V

In addition to the options set forth in the preceding section, there are some more matters that merit some consideration. Four of them suggest further possible savings on recurring costs. One of them raises the possibility of additional lease income and the last one suggests yet another approach, however remote it may be, to the question of what to do with Plum Brook. Adjustment costs are one-time expenditures necessary to bring about the annual savings claimed in each case.

Revised Perimeter Fencing

Each of the options presented in the preceding section assumed the installation of a new perimeter fence drawn close around each of the facilities retained. Exclusion areas, though retained, would not be fenced. As a result there would effectively be no Station perimeter fence (assuming the ultimate abandonment of the existing fence). The possibility of maintaining a Station perimeter fence does exist for both Options 2 and 3. (Please note that this proposal and the one on Lease of Open Exclusion Areas are mutually exclusive.) The cost impact for such revisions are estimated as follows:

Option 2 -- $ 13,000 (Savings)

Option 3 -- $119,000 (Incremental Cost)

Lease of Open Exclusion Areas

If the Plum Brook Station real property holdings are reduced and the exclusion areas of the retained facilities are left unattended, as was assumed in the options presented in the preceding section, they could be made available for agricultural leases. This would eliminate the cost associated with maintaining these open areas. Further, it would

provide additional income to the Federal Government, thereby lowering the cost of maintaining the buffer properties in addition to releasing the fallow land for agricultural productivity. (This proposal and the one on Revised Perimeter Fencing are mutually exclusive.)

Estimated Annual Income -- $30,000

Station Fire Protection

The present Plum Brook Plant Protection/Security Force consists of a three man crew on each 8 hour shift, 24 hours a day, seven days a week. This limited staff provides the Station with prescribed security patrols, main gate control, immediate response to Station emergencies, and continual observation of the Station Alarm and Communications Center. If NASA is willing to rely on local fire departments for fire-fighting protection, it would be possible to reduce this crew to two men per shift. The two men would be capable of manning the Communication Center and completing the security patrols on a reduced schedule. Local fire-fighting service could possibly be contracted for on an "as-required" hourly rate basis. It should be recognized, however, that such a reduction in the staff would most assuredly mean greater delays in arriving at a fire or other Station emergency which could result in more extensive damage and costlier repairs to Station property.

Estimated Annual Savings -- $40,000

Adjustment Cost -- 1,000

Raw Water Systems

The Plum Brook Station is presently served with two raw water pumping and distribution systems to provide fire water protection and cooling water to Plum Brook Station facilities. This raw water supply is vital to the adequate fire protection of SPF and critical for the process water

needs of both B-2 and the reactor. The Big Island pumping station serves as a backup system to the Rye Beach raw water system. It is reasonable to consider eliminating the Big Island backup system and retaining only the Rye Beach system which has a much higher pumping capacity and a concrete delivery line as opposed to the steel delivery line from the Big Island pumping station. The concrete line from Rye Beach requires much less maintenance than the steel line which has a consistent history of waterline breaks. Releasing the Big Island line would eliminate the necessity of maintaining the pumping station in operating condition and repairing recurring breaks in the steel delivery line.

Estimated Annual Savings	--	$10,000
Adjustment Cost	--	1,500

Heat In Standby Facilities

Minimal heat is now maintained in certain portions of the Reactor, and the Space Power Facility. A review of the Space Power Facility standby requirements and the NRC approval of the Reactor Standby License may permit the heat in these facilities to be shut off totally. This would save significant expense during the winter months, not only in the cost of heating these facilities, but in the labor costs associated with maintaining facility heating plants.

Estimated Annual Savings	--	$25,000
Adjustment	--	10,000

GSA As Landlord

Finally, another possibility of maintaining Plum Brook facilities in a standby condition, would be to turn the whole Station over to the General Services Administration, assuming they would be willing to accept

it. That agency could then act as a landlord for all Station tenants. NASA, along with the other users of Station facilities, would pay GSA the costs for maintaining the desired NASA facilities in either a standby or operational condition and a fair share of commonly distributed costs. Under this proposal, all utilities, railroads, grounds, and roads would remain intact. The capacities of the supporting systems would also be available should they be required in the future for facility reactivation and operation. All Station maintenance, plant protection and security services would be under one total contractor, providing a more efficient and economic service for all using organizations.

Estimated Annual Savings	--	$100,000
Adjustment Cost	--	50,000

SUMMARY OF CAPITAL INVESTMENT

PLUM BROOK STATION

BLDG. OR FACILITY NUMBER	TITLE OR DESCRIPTION	NUMBER OF STRUCTURES	CAPITAL COST
1111 - 1197	Reactor Facility	25	$18,597,891
1411 - 1492	Space Power Facility	12	30,601,890
1911 - 1913	Wind Turbine Generator Facilities	2	186,942
2111 - 3461	Rocket Facilities	36	29,764,294
2311 - 2331	"D" Facility Garage & Shop	2	1,314,074
2511 - 2531	"F" Site - EPA Pre-Test Preparation Area		1,271,874
5131 - 5431	Rocket Facilities Support	15	4,529,742
7121 - 7132 - 8931 - 8952	General Facility Support Facilities	8	710,107
7141 - 7198 (flag pole)	Administration	13	1,928,436
7191 - 7232 - 7199	Plant Protection	4	73,973
8131 - 8192	Raw Water System	9	2,328,595
8231 - 8291	Domestic Water System	5	2,016,624
8331 - 8397 - 9370	Sewage System	19	1,237,254
8431 - 8470	Natural Gas System	6	199,646
8531 - 8570	Electrical Distribution System	6	3,549,713
8670	Communications System	1	171,040

TABLE NO. 1

BLDG. OR FACILITY NUMBER	TITLE OR DESCRIPTION	NUMBER OF STRUCTURES	CAPITAL COST
8770	Railroad		$ 647,018
9101 - 9199	Igloos	99	1,277,100
9201 - 9216	Warehouses	16	506,509
9320	Land Parcels and Site Improvement		3,872,890
9340 - 9360 - 9380	Roads, Parking, Open Storage		2,803,224
9410	Fences, Gates, Monuments		156,774
----	Capitalized Equipment		12,441,102
		TOTAL	$120,886,712

TABLE NO. 1 - CONTINUED

NON-NASA TENANTS LOCATED AT NASA'S PLUM BROOK STATION

TENANT	FACILITY	FUNCTION	NASA PROVIDED SERVICES	ANNUAL AMOUNT REIMBURSED TO NASA FOR SVS
Civil Air Patrol		The area unit of the CAP utilizes Station office facilities for their weekly training and meeting sessions.	Meeting Room	-------
US Coast Guard	7122	The local Coast Guard unit utilizes this building for maintenance and repair of their small boats.	Electricity Heating Security	250.00
Federal Bureau of Investigation	7141 (portion) 8251	The area FBI office occupies two offices in this building. The FBI maintains an antenna with-related receiving and transmitting equipment for their area radio communications.	All utilities custodial, minor maintenance & repair, security	$2,168.12
State of Ohio Department of Natural Res.	8931	Space is provided in this building for the storage of two boats.	----------	---------
US Environmental Protection Agency	7141 (portion) 2300 Complex 2500 Complex Test Control Bldg & Test Track 1121 ATS	The EPA Noise Enforcement Facility occupies 12 offices in this building for their administrative and engineering staff. This building is used by EPA for equipment maintenance & repair. This building is used by EPA as a pretest preparation area. This facility is utilized for testing and establishing noise standards for various types of engines-driven equipment. This building is presently in the process of being converted for use an an Engine Emission Enforcement Test Facility.	All utilities, custodial, minor maintenance & repair, snow-plowing, grounds keeping, security.	$23,905.39

TABLE NO. 2

TENANT	FACILITY	FUNCTION	NASA PROVIDED SERVICES	ANNUAL AMOUNT REIMBURSED TO NASA FOR SVS
Department of Army US Army Reserve (Continued)	2700 "J-Site" 10 acres of land	The 2700 series structures are utilized by the USAR for storage and maintenance of equipment used in their field training exercises. This 10 acre plot is to be used by the USAR for the future construction of a reserve armory and training center when funds are appropriated.		
Ohio Air National Guard	371 acres of land	This area is utilized during the Spring, Summer and Fall months for military tactical training exercises.	Electricity Water Security	$ 600.00
Ohio Army National Guard	----	This unit utilizes the general area of the Station for Weekend training exercises. They are also using 6 Igloos for storage of explosives used in National Guard training exercises.	---------	----------
Huriott Flying Club	------	This organization utilizes a portion of the Station land for operating radio controlled aircraft	---------	----------
Boy Scouts of America Firelands Chapter	------	This unit of the Boy Scouts utilizes various portions of the PBS for re-forestation and rare species wildlife conservation and propogation programs. These programs are coordinated with the local DOI office.	---------	----------

TABLE NO. 2 - CONTINUED

TENANT	FACILITY	FUNCTION	NASA PROVIDED SERVICES	ANNUAL AMOUNT REIMBURSED TO NASA FOR SERVICES
Department of Interior Animal Damage Control	Portion of 7192	This unit functions in a multi-State area surveying animal damage and instituting corrective measures to prevent recurrence of such problems. In addition, NASA has a working agreement with this office for management of PBS wildlife.	All utilities, custodial svs, minor facility repair & maintenance, security services.	$1,500.00
Department of Interior Animal Depradation	7142	This buildings houses this Agency's office and lab personnel and supplies and equipment utilized in their research activities regarding animal depredation to crops.	All utilities, custodial svs, minor facility repair & maintenance, security services	7,063.84
	21 Acres	This parcel of land is planted with grain crops and utilized as a research test and control area.		
	38 acres	This parcel of land is to be used at some future date for the construction of office and lab facilities for this agency.		
Department of the Army US Army Reserve (Continued)	7144	This building houses the Reserve administrative staff and is used for weekend and evening training exercises, primarily administrative & educational programs.	All utilities, custodial svs, minor facility repair & Maintenance, security services.	9,821.72

TABLE NO. 2 - CONTINUED

TENANT	FACILITY	FUNCTION	NASA PROVIDED SERVICES	ANNUAL AMOUNT REIMBURSED TO NASA FOR SVS
City of Sandusky	Weapons Firing Range	The City of Sandusky Police Department shares the use of this facility with NASA security and area FBI personnel for weapons practice and proficiency testing.	-------	------

Total number of Use Agreements - 13

Total amount reimbursed to NASA - $45,309.07

There are 1330 acres of buffer zone land presently leased for agricultural purposes. These leases provide an annual income to the Government of $37,129.00. In addition, some of the purchase agreements for buffer zone property acquired included free preiods of use for the land which have not yet expired. Upon the expiration of the free use periods, an additional 900 acres of land will be available for lease at an approximate $27,000.00 per annum.

TABLE NO. 2 - CONTINUED

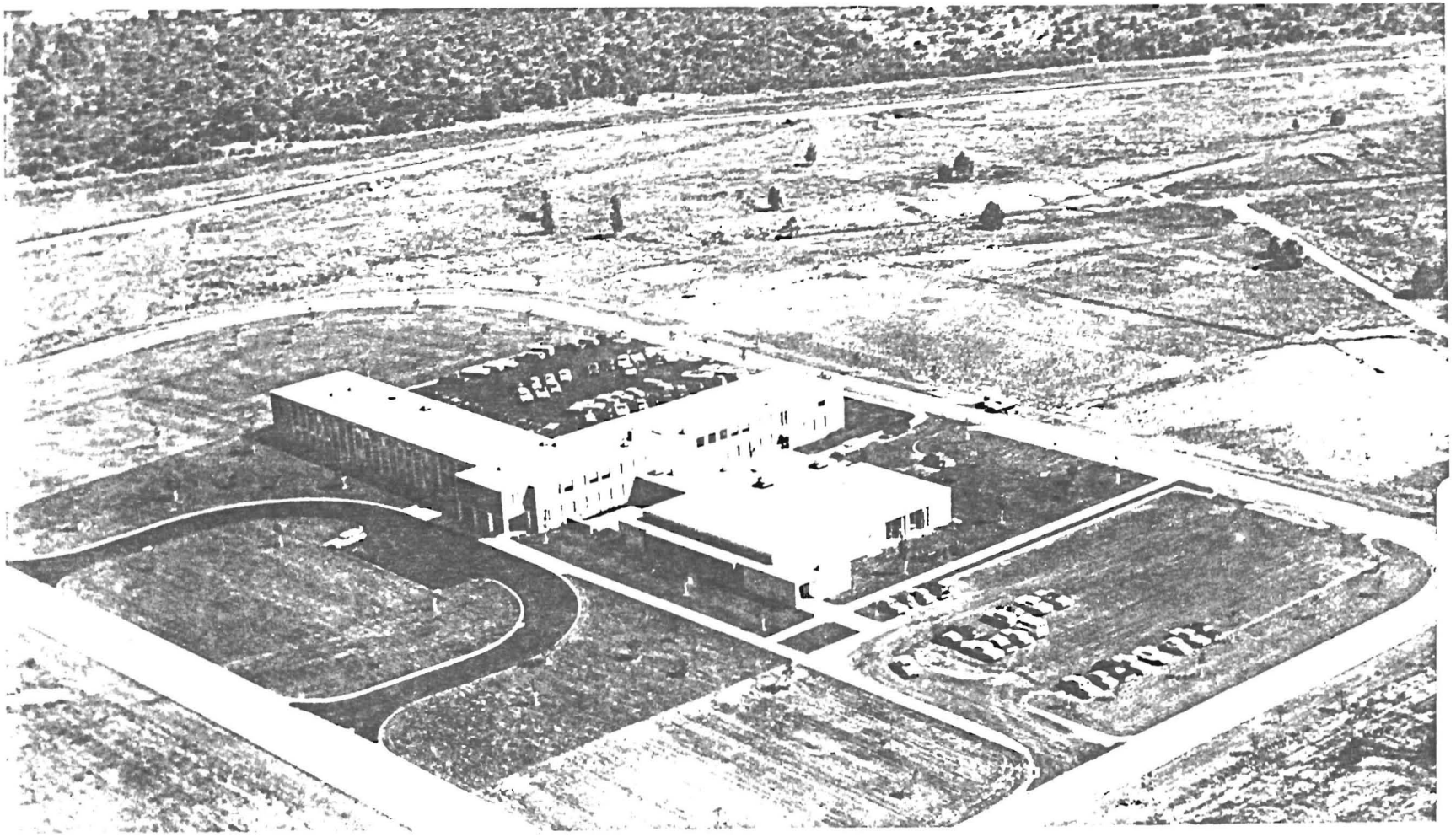
TABLE NUMBER 3

MANPOWER ARRAY
ON-SITE SERVICE CONTRACTOR
PLUM BROOK STATION

FUNCTION	OPTION			
	1	2	3	4
Administrative & Mgmt.	4	3	2	0
Fire & Security Protection	16	16	16	0
Facility Maintenance	6	4	3	0
Health Physics, Safety & Electronics	3	2	1	0
Area Maintenance	4	3	1	0
Heavy Equipment & Vehicle Maintenance	2	2	1	0
Janitorial	3	3	2	0
Warehousing	7	7	4	0
TOTALS	45	40	30	0*

* Option 4 does include an off-site arrangement to provide for off-shift and weekend security checks of WTG and janitorial services. If unattended operations are achieved on-shift checks may also be necessary. Manpower estimates are for about 2 manyears of effort.

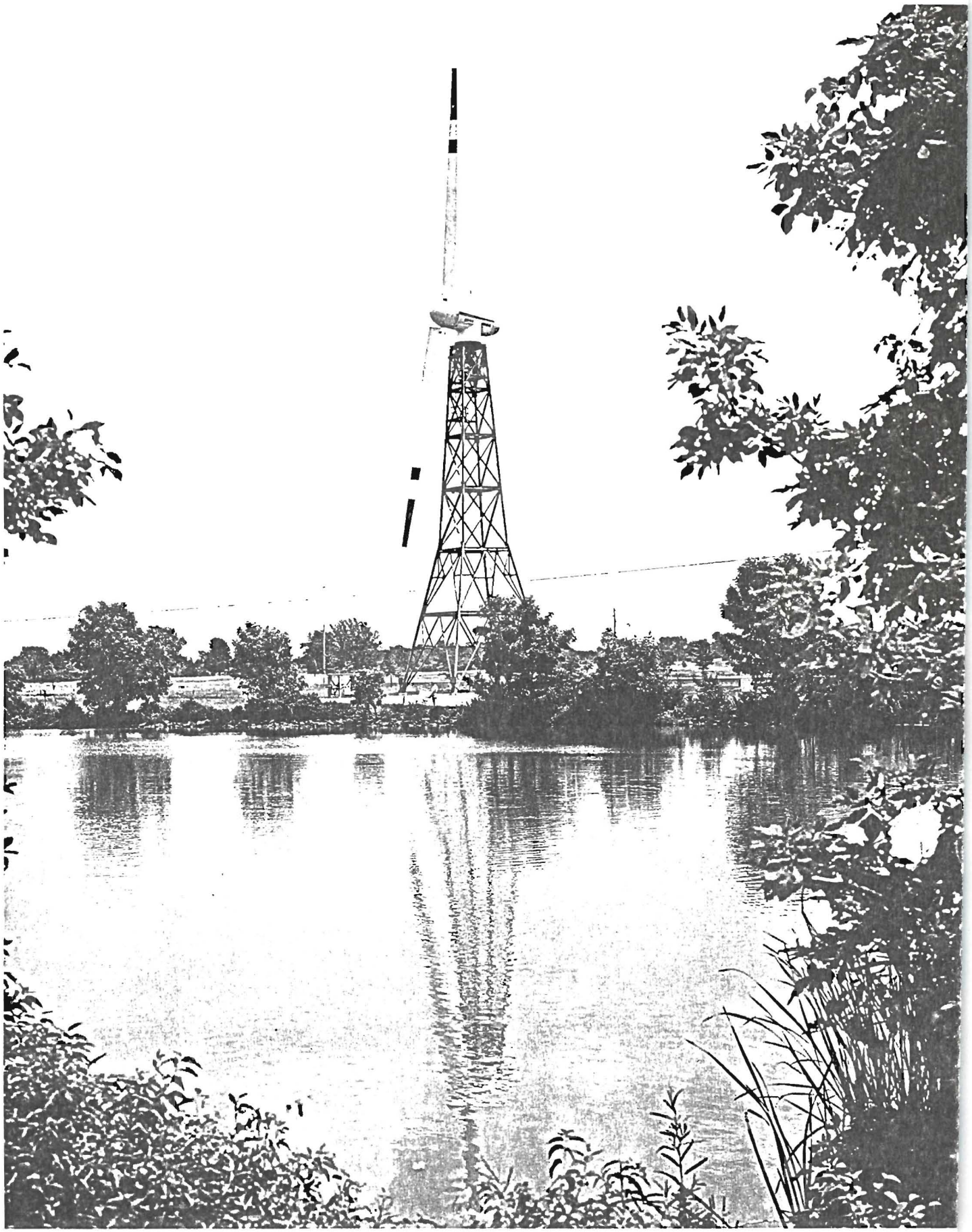
NASA
CS-48642



7141 - Engineering Building

PHOTO NUMBER 1

PHOTO NUMBER 2



ERDA/NASA 100kW EXPERIMENTAL WIND TURBINE

P65-2287

LEWIS RESEARCH CENTER

PLUM BROOK STATION

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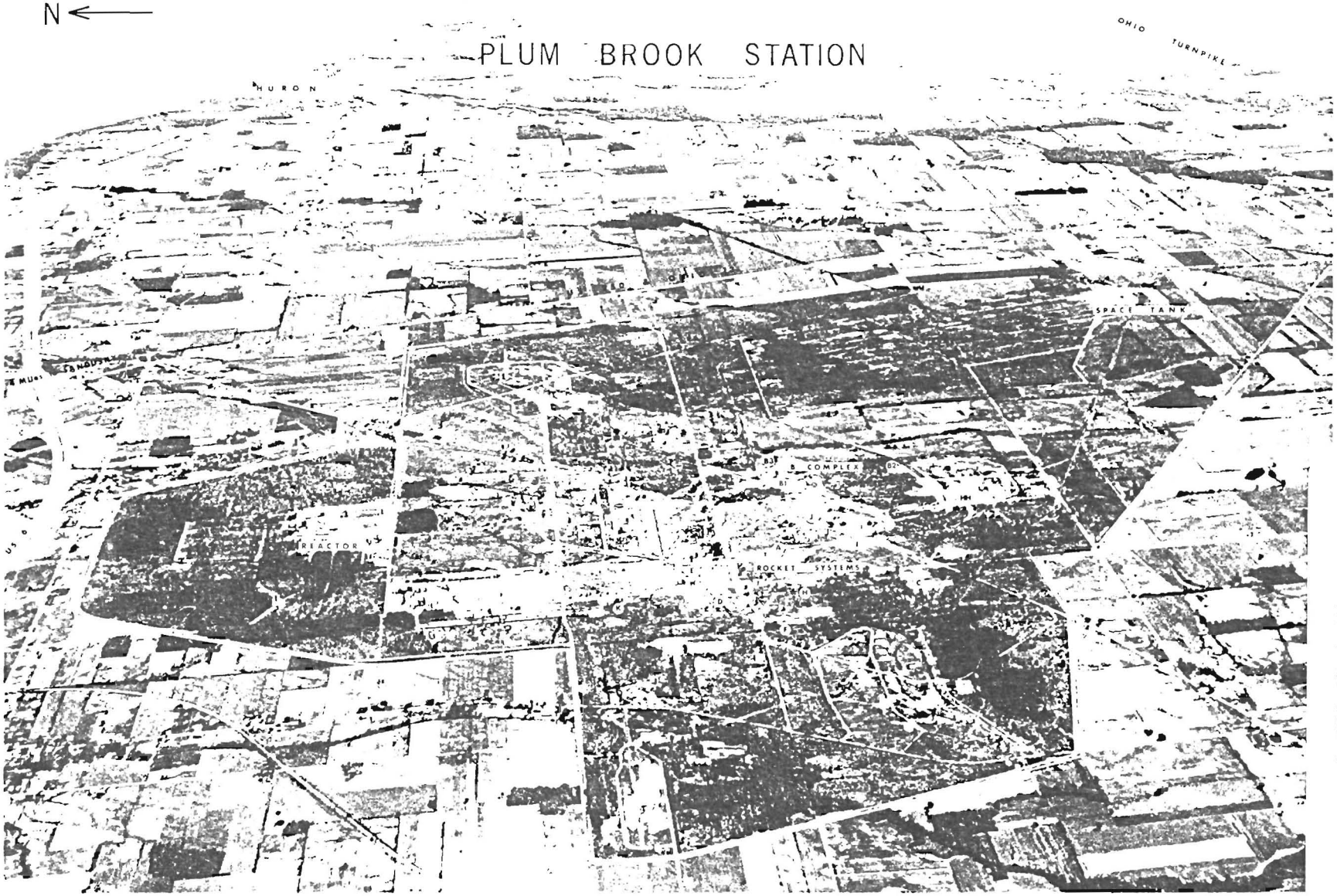


This picture depicts fenceline boundaries.
Actual Station property lines are shown on
Location Plan - CD-10048-34.

PHOTO NUMBER 3

C-76-388

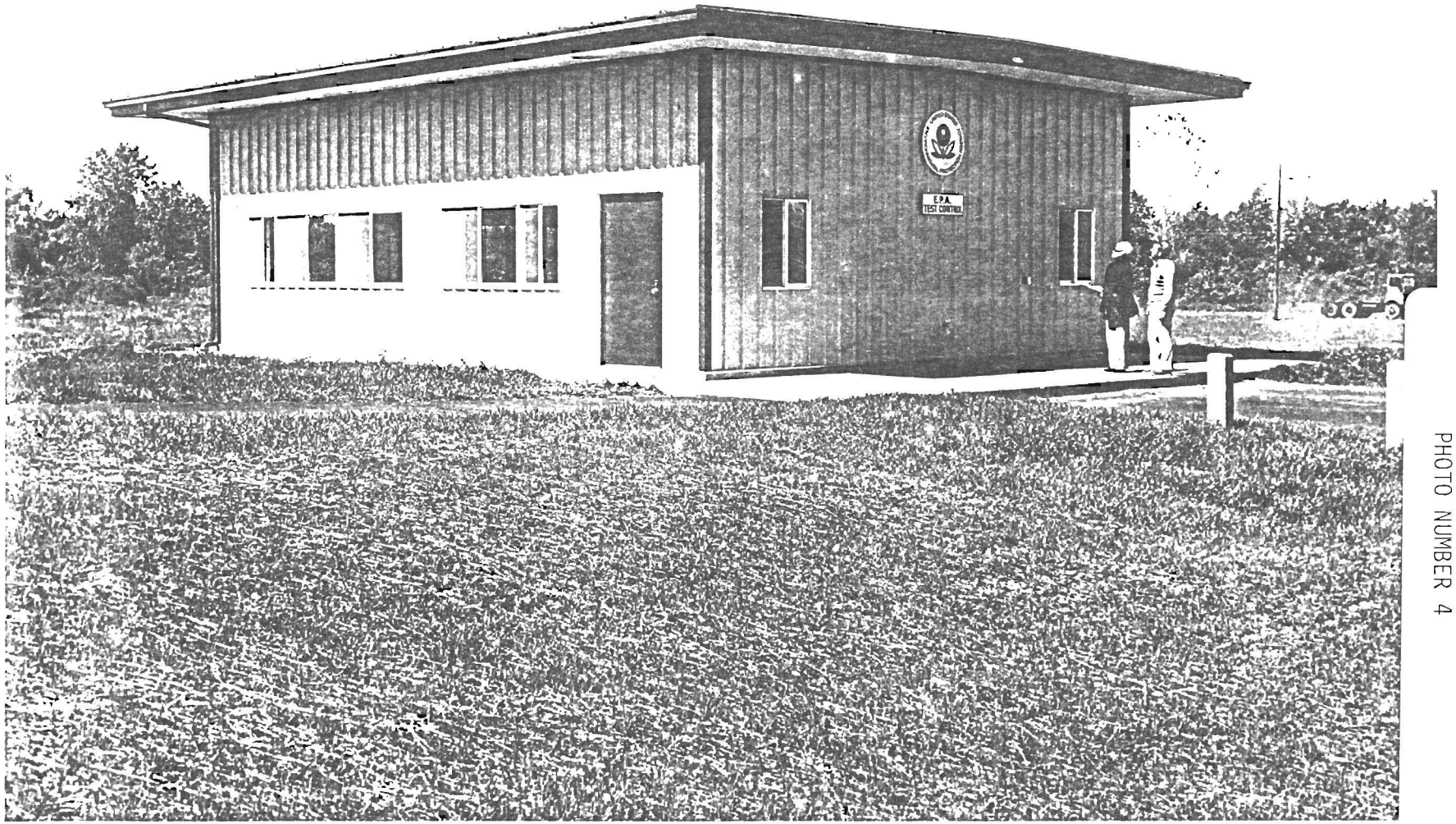
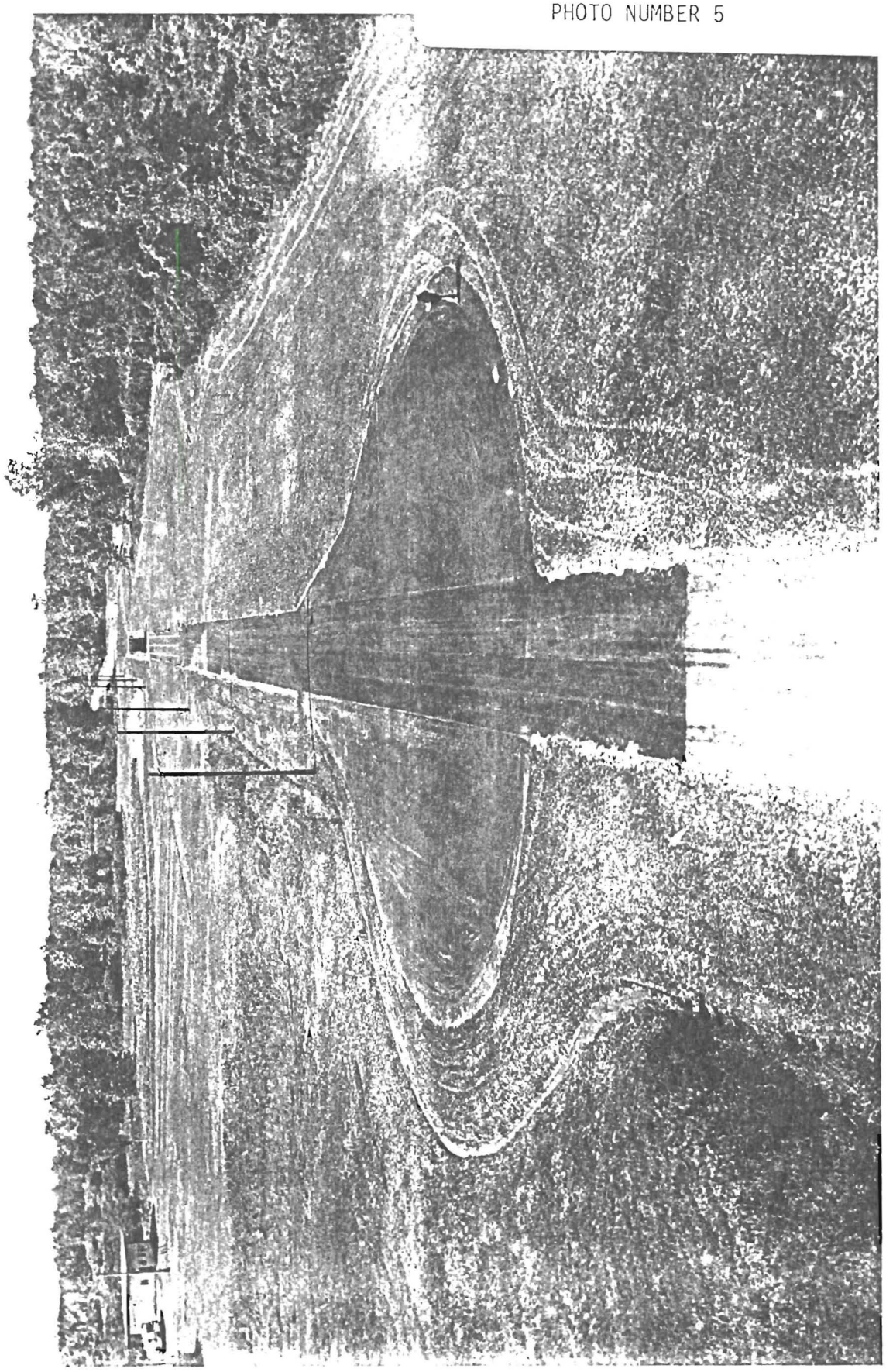


PHOTO NUMBER 4

EPA Test Control Bldg

PHOTO NUMBER 5



EPA Test Track

C-76-388

NASA
C3-4C216

SPACE POWER FACILITY

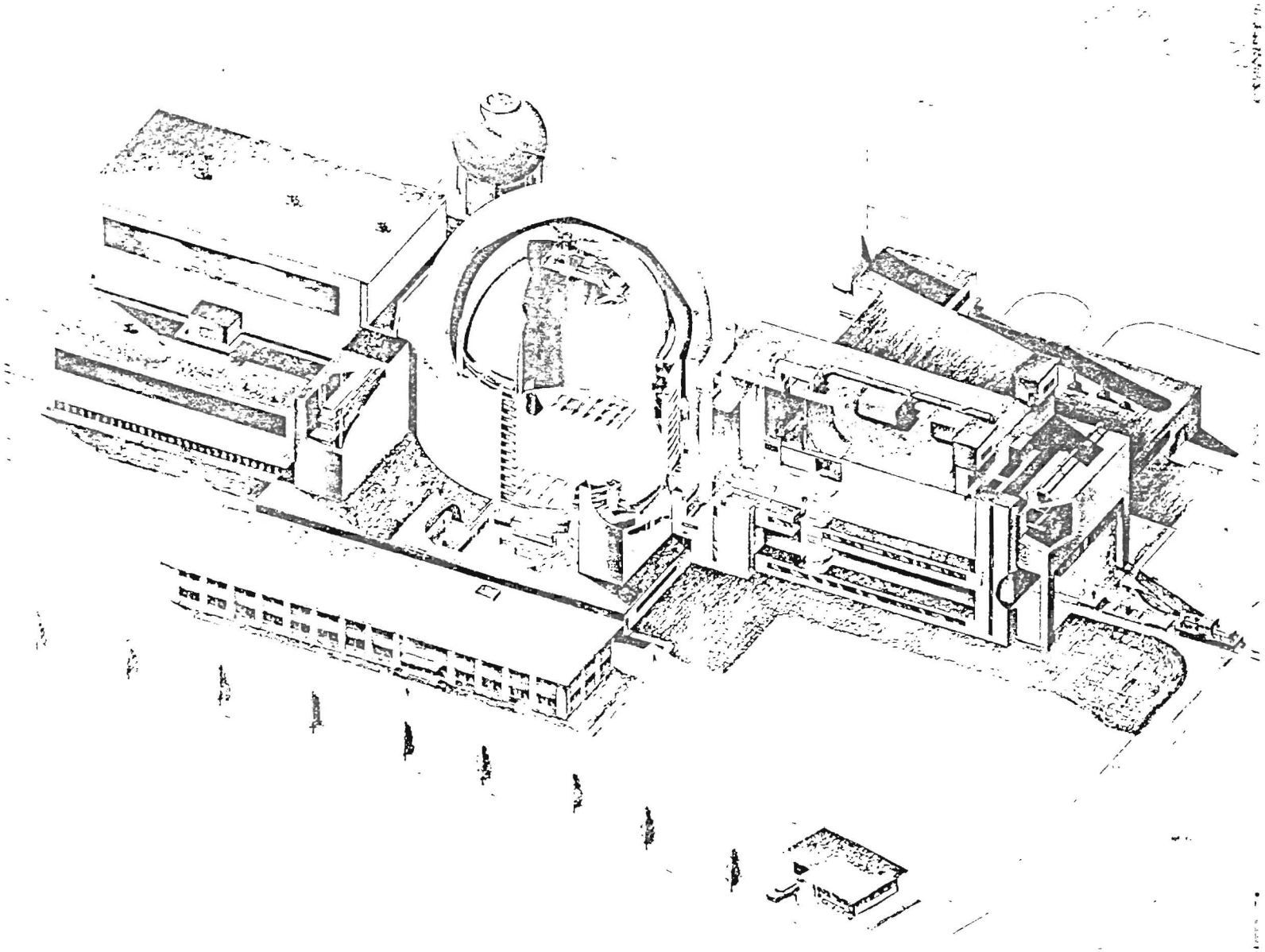
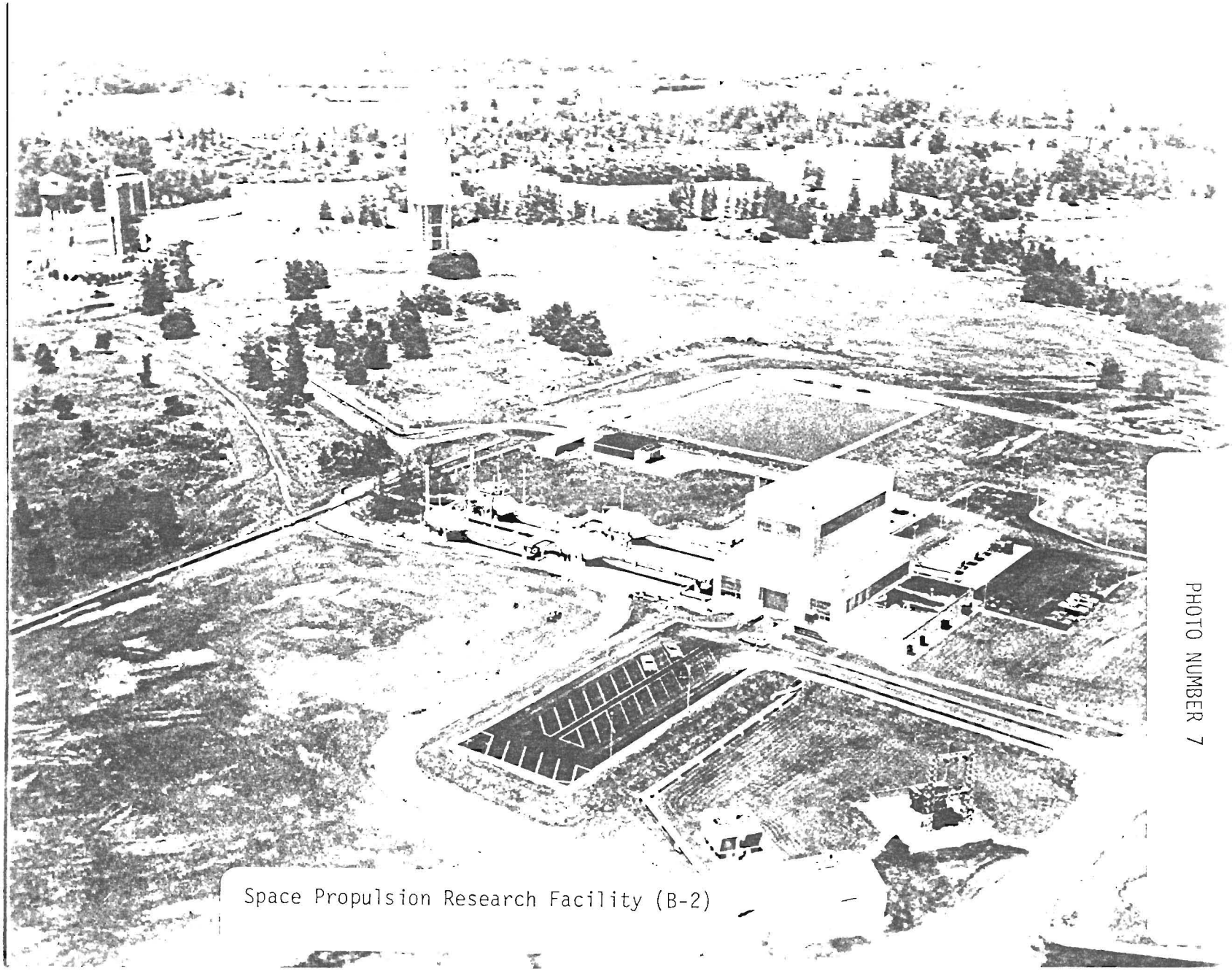


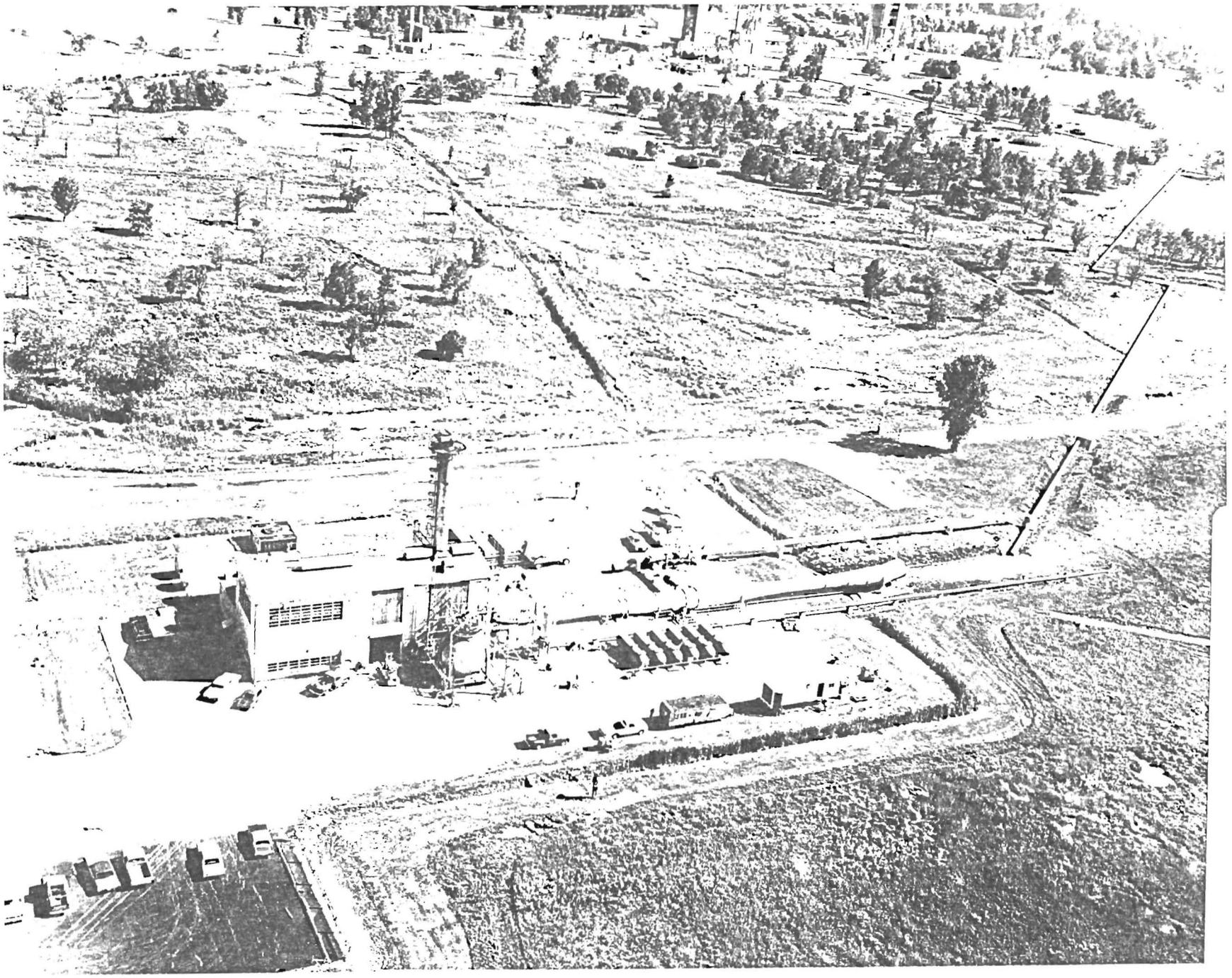
PHOTO NO. 6



Space Propulsion Research Facility (B-2)

PHOTO NUMBER 7

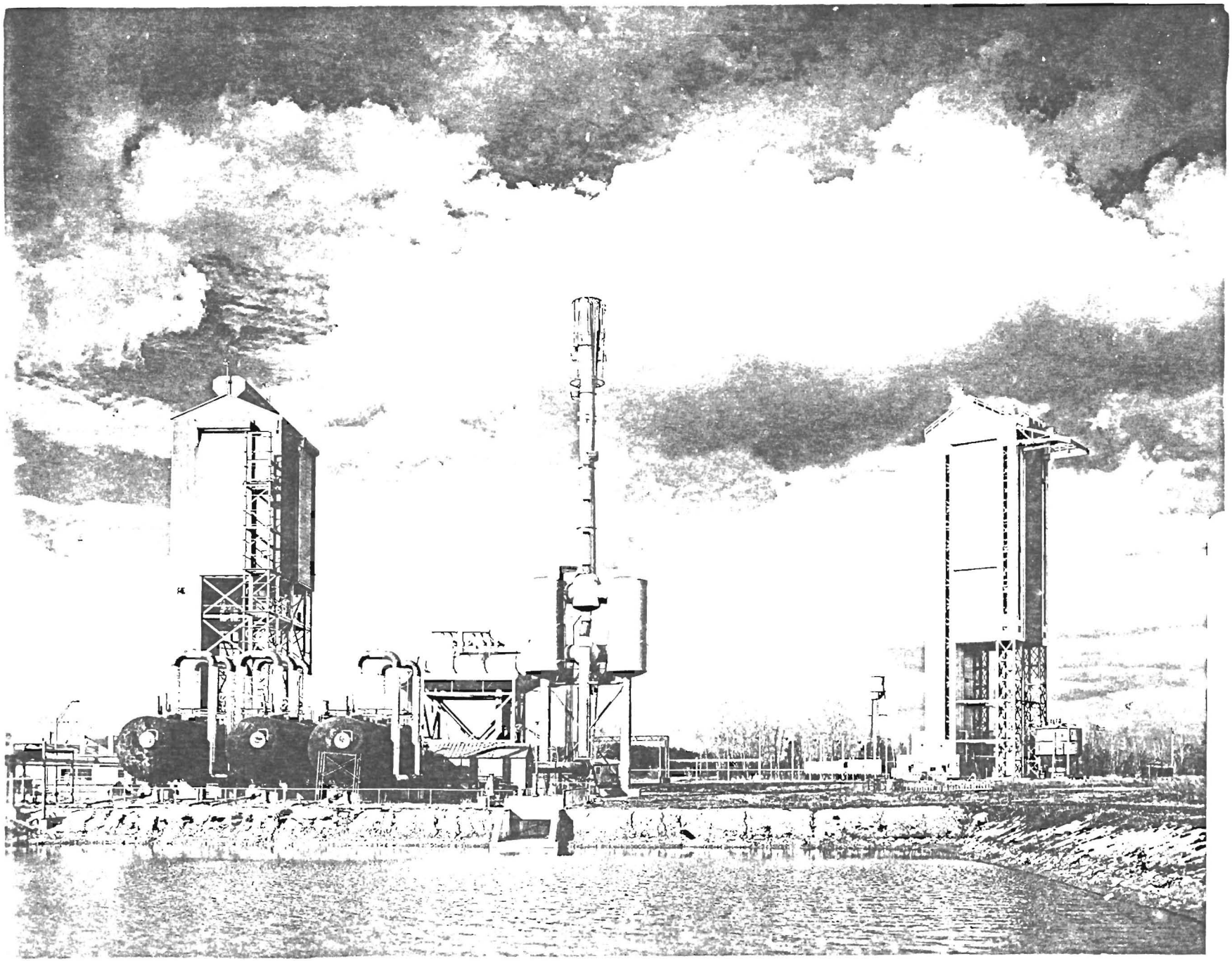
NASA
C-71-3065



Hypersonic Tunnel Facility

PHOTO NUMBER 8

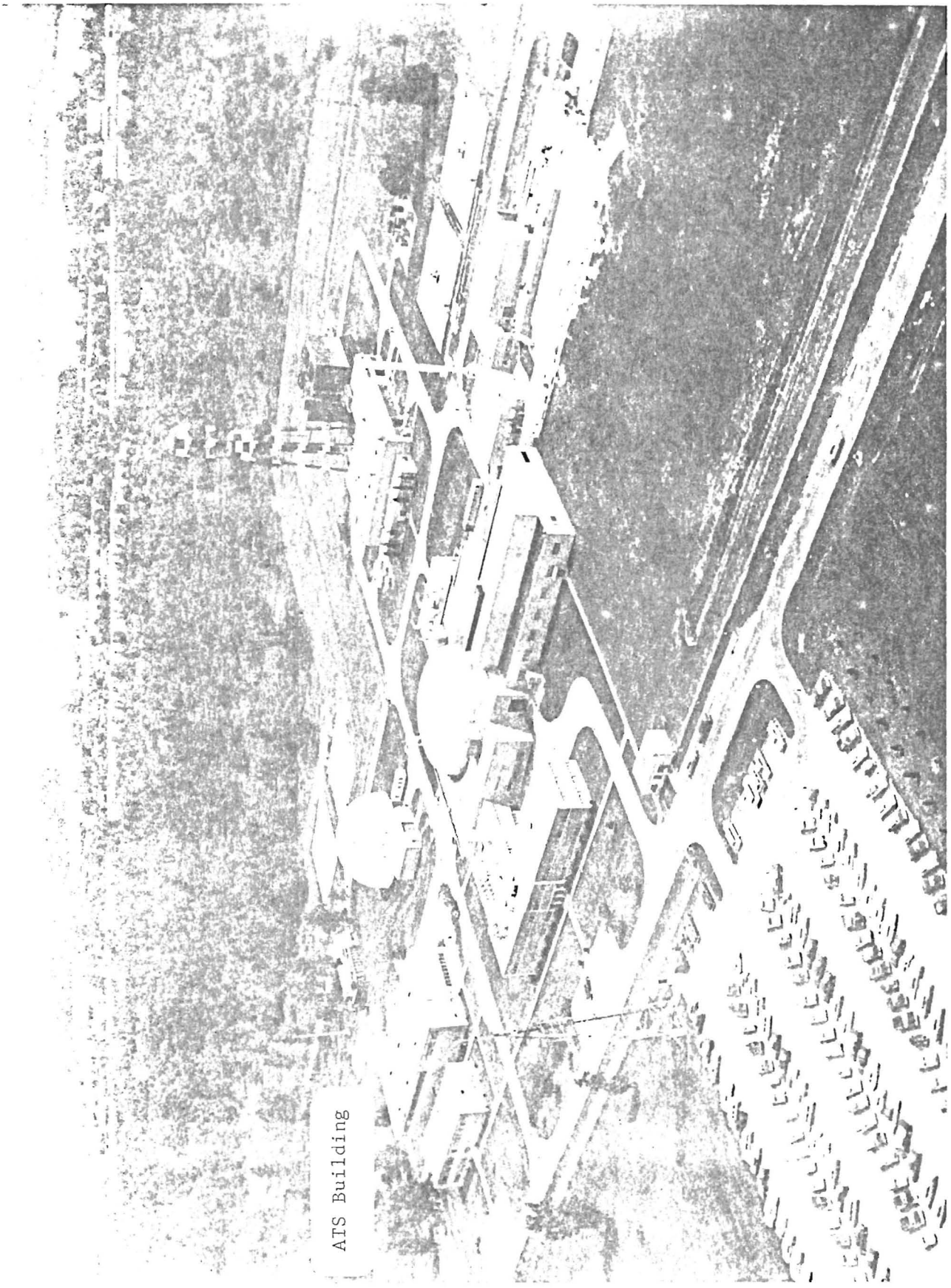
NASA
P64-131C



B-1 & B-3 Facility

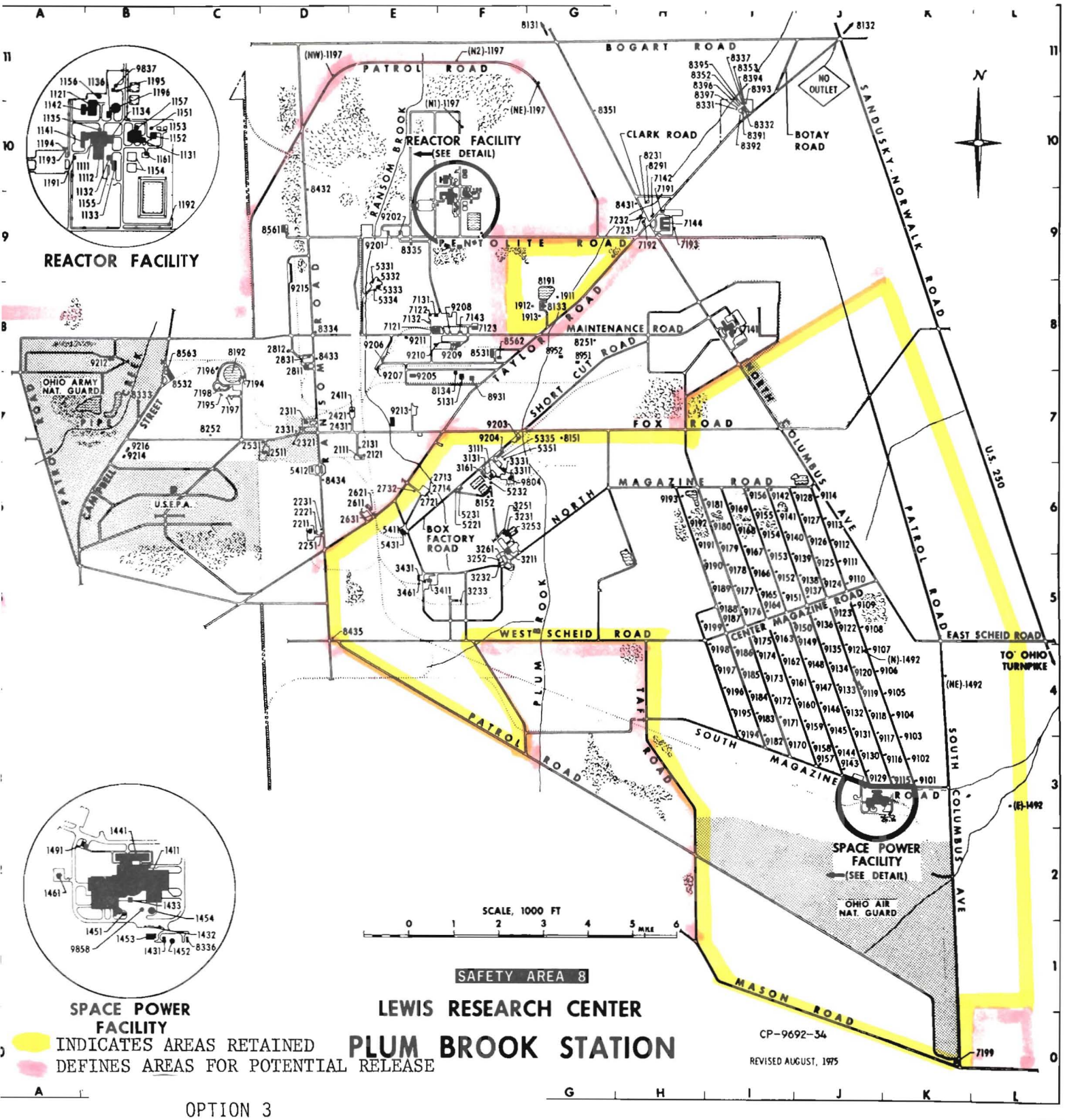
PHOTO NUMBER 9

PHOTO NUMBER 10



Plum Brook
Reactor Facility

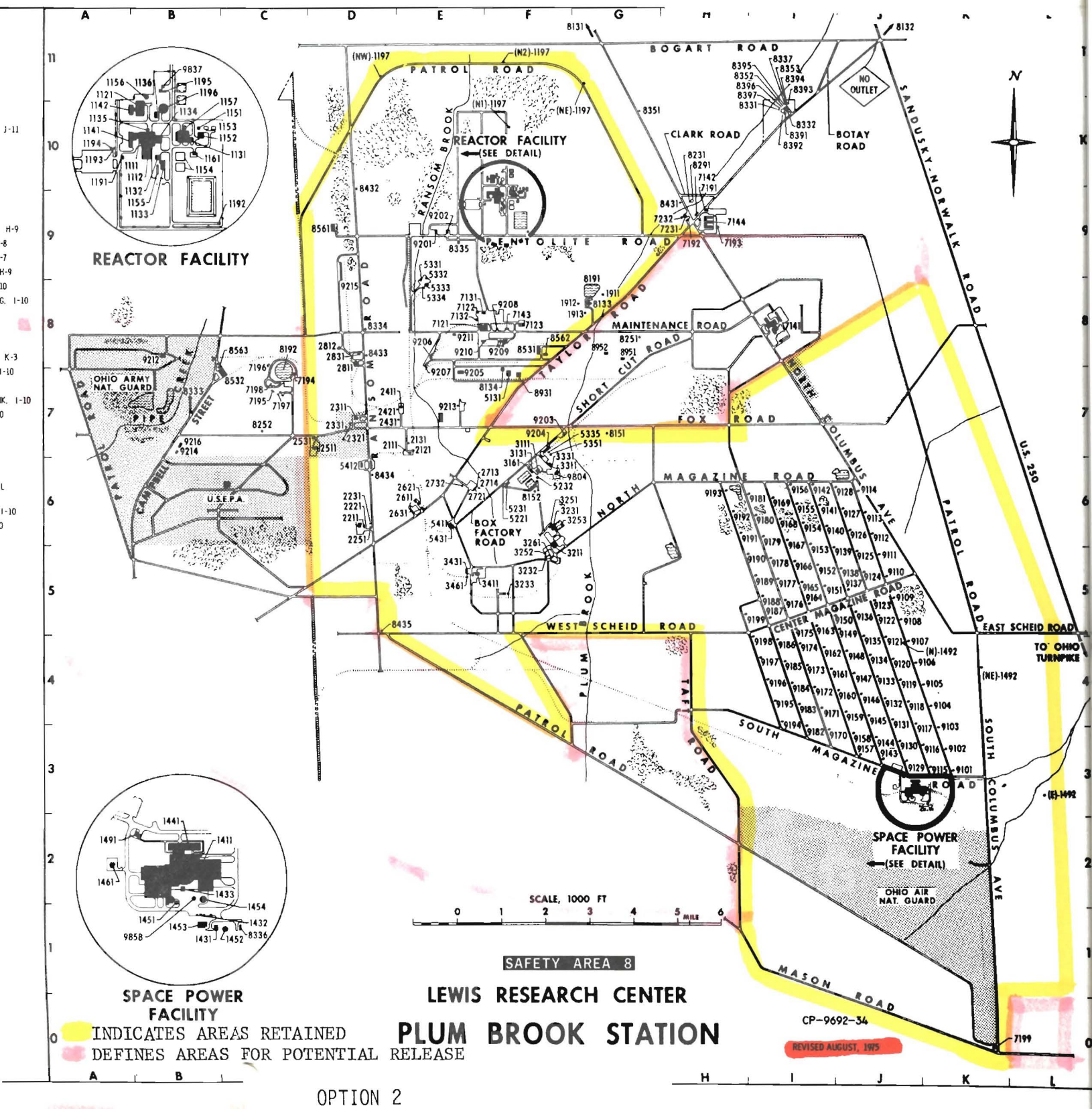
PLOT PLAN NO. 3



INDICATES AREAS RETAINED
DEFINES AREAS FOR POTENTIAL RELEASE

OPTION 3

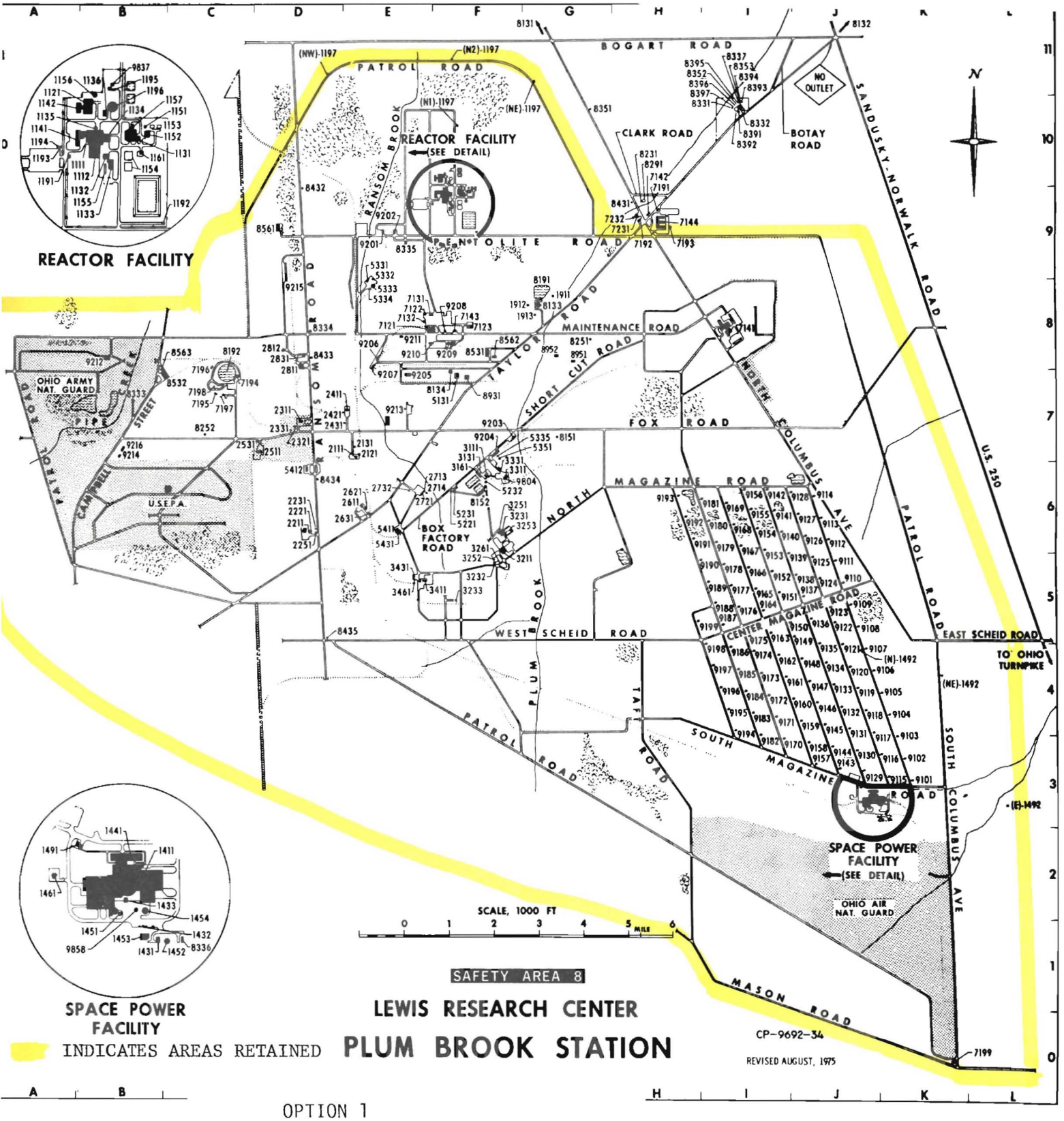
PLOT PLAN NO. 2



INDICATES AREAS RETAINED
DEFINES AREAS FOR POTENTIAL RELEASE

OPTION 2

PLOT PLAN NO. 1



OPTION 1