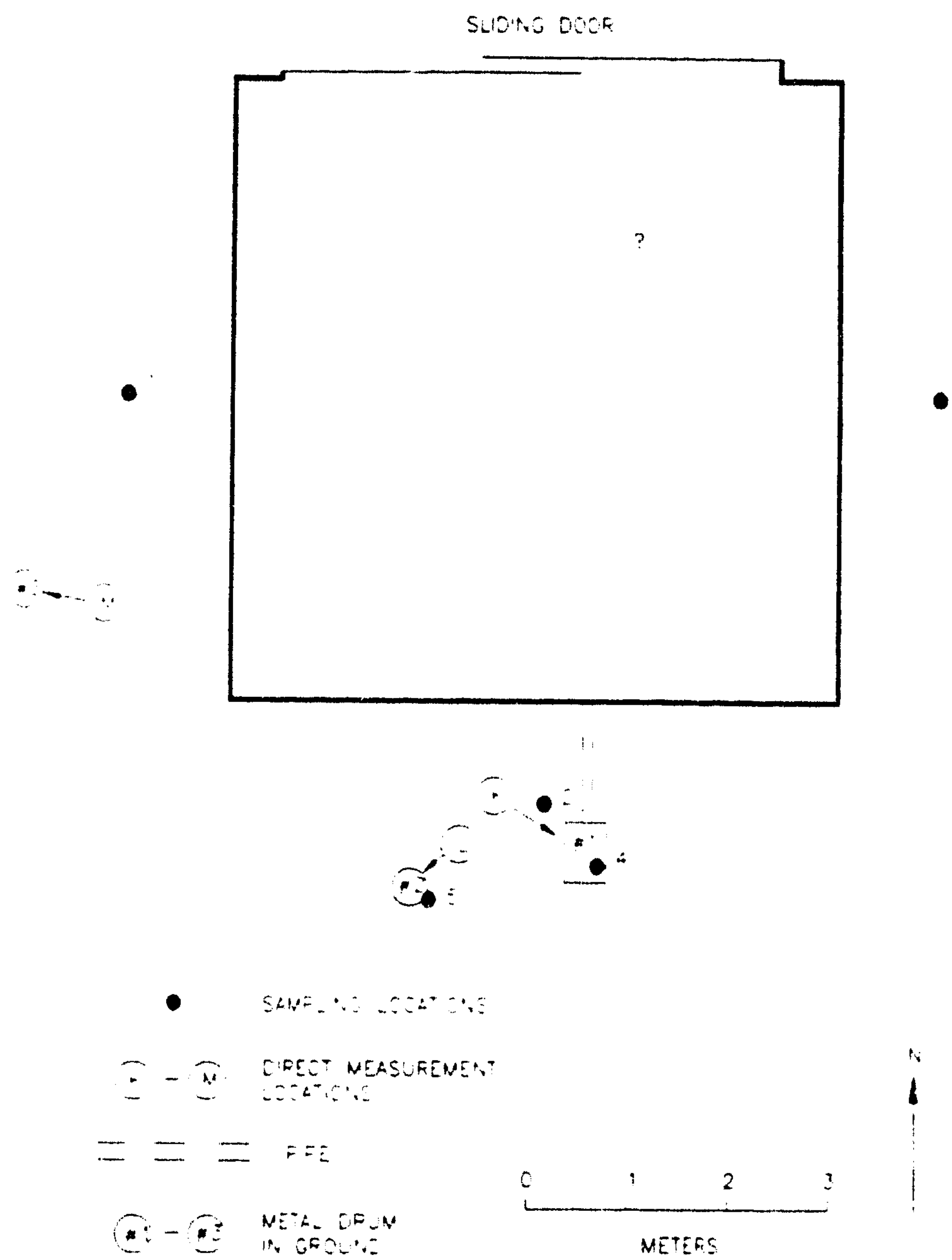

FIGURE 28. Multiple Fixture Building Showing Survey and Soil Sampling Locations

TABLE 26

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
MULTIPLE FAILURE BUILDING
NUCLEAR LAKE SITE

Location[a]	Total Contamination (dpm/100 cm^2)		Removable Contamination (dpm/100 cm^2)	
	Alpha	Beta-Gamma	Alpha	Beta
A	<25	430	<3	<6
B	<25	<410	<3	<6
C	<25	410	<3	<6
D	27	<410	<3	<6
E	36	430	<3	<6
F	<25	6200	<3	7
G	45	<410	<3	<6
H	<25	<410	<3	<6
I	<25	110000	<3	63
J	<25	71000	<3	18

[a]Refer to Figure 27.

TABLE 27

CESIUM 137 CONCENTRATIONS IN MISCELLANEOUS SOIL SAMPLES
MULTIPLE FAILURE BUILDING
NUCLEAR LAKE SITE

Location	Cesium 137 Concentrations (pCi/g)
1[a]	0.7 ± 0.1[b]
2[a]	0.6 ± 0.1
3[a]	0.8 ± 0.2
4[a]	1.0 ± 0.4
5[a]	<0.3

[a]Refer to Figure 28.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

Other Buildings

Survey Findings

Lodge

Table 28 presents the results of surface contamination measurements in the Lodge building. Total alpha beta-gamma levels ranged from <25 to 99 dpm/100 cm^2 and from <410 to 470 dpm/100 cm^2, respectively. Removable alpha was <3 dpm/100 cm^2. and removable beta was <6 to 7 dpm/100 cm^2. Walkover scans did not identify any elevated surface radiation levels inside the building or in the surrounding outside area.

Emergency Generator Building

Scans did not identify any elevated radiation levels in this building or the area surrounding it. Results of measurements, summarized in Table 29, indicate ranges of total alpha and beta-gamma contamination of <25 to 36 dpm/100 cm^2 and <410 to 730 dpm/100 cm^2, respectively. Removable contamination levels were <3 alpha dpm/100 cm^2 and <6 beta dpm/100 cm^2.

Sodium Tent

The Sodium Tent no longer exists as a building; however, the foundation and large slabs of concrete and steel remain near the former location. Gamma and beta-gamma and beta-gamma scans of the foundation and slabs did not identify any areas of elevated direct surface radiation.

Summary

Surface contamination measurements and scans did not identify any elevated areas associated with the Lodge, Emergency Generator Building, or the foundations of the Sodium Tent.

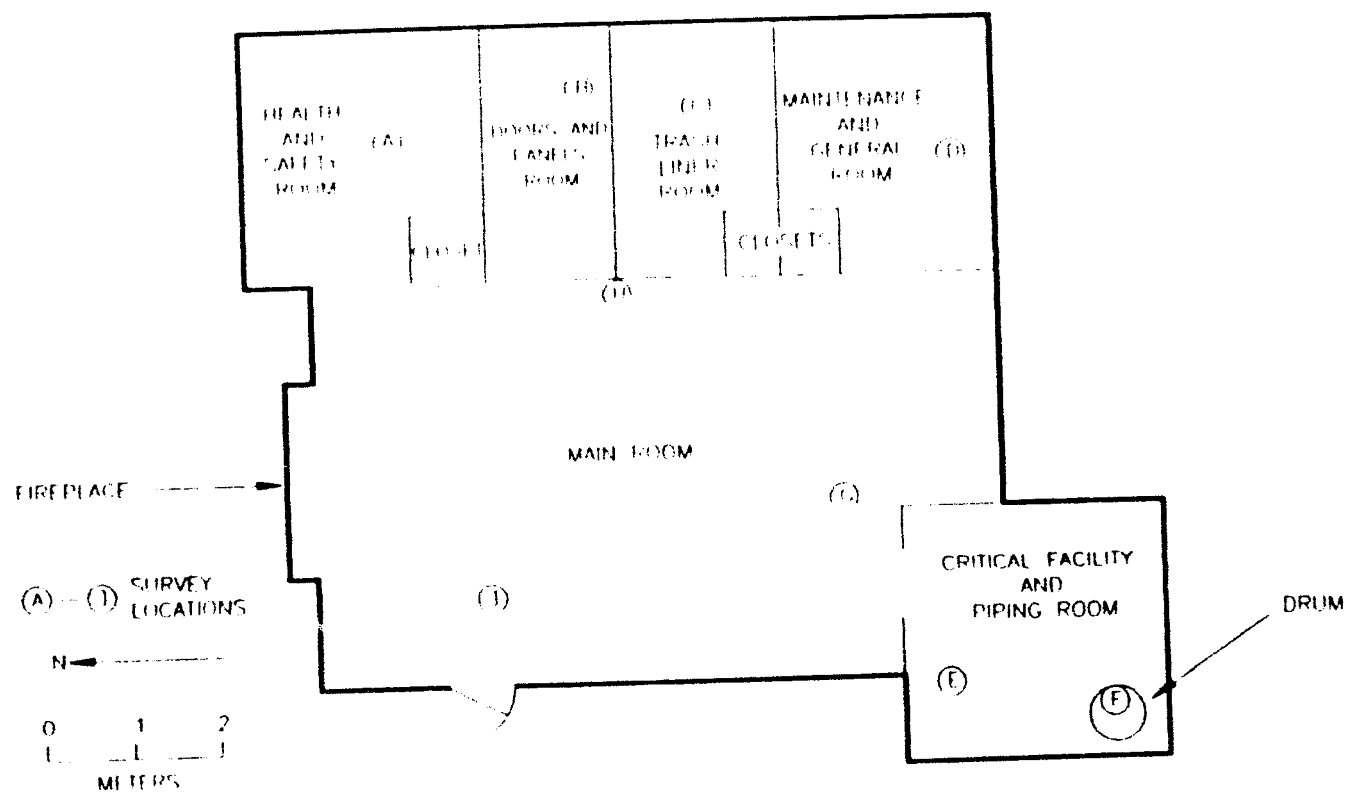

FIGURE 29: Floor Plan of the Lodge Showing Survey Locations

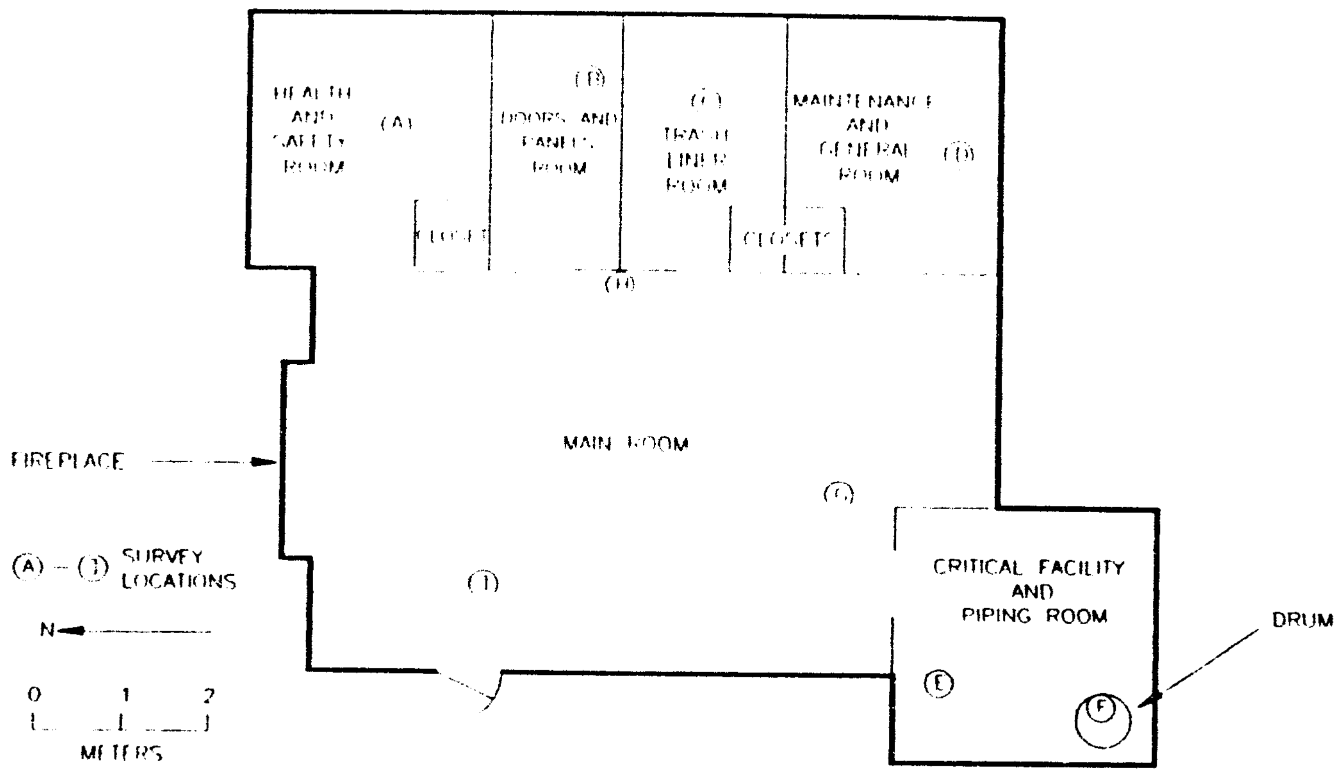

FIGURE 29. Floor Plan of the Lodge Showing Survey Locations

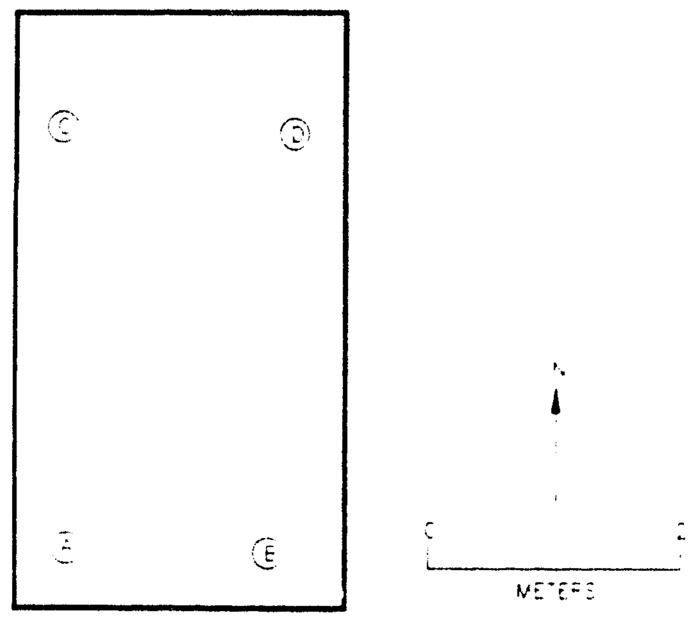

FIGURE [33]. Floor Plan of the Emergency Generator Building Showing Survey Locations

TABLE 28

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
LODGE BUILDING
NUCLEAR LAKE SITE

Location[a]	Total Contamination ($dpm/100\ cm^2$) Alpha	Total Contamination ($dpm/100\ cm^2$) Beta-Gamma	Removable Contamination ($dpm/100\ cm^2$) Alpha	Removable Contamination ($dpm/100\ cm^2$) Beta
A	99	<410	<3	7
B	45	470	<3	<6
C	<25	<410	<3	<6
D	<25	<410	<3	<6
E	27	<410	<3	<6
F	45	<410	<3	<6
G	<25	<410	<3	<6
H	<25	<410	<3	<6
I	<25	<410	<3	<6

[a]Refer to Figure 29.

TABLE 29

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
EMERGENCY GENERATOR BUILDING
NUCLEAR LAKE SITE

Location[a]	Total Contamination (dpm/100 cm^2)		Removable Contamination (dpm/100 cm^2)	
	Alpha	Beta-Gamma	Alpha	Beta
A	<25	730	<3	<6
B	<25	<410	<3	<6
C	36	<410	<3	<6
D	<25	<410	<3	<6

[a]Refer to Figure 30.

DISCUSSION

Appendix D presents guidelines used by two federal agencies, the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE), in determining whether sites may be released from radiological controls for unrestricted use by the general public. For residual contamination of building and equipment surfaces the two agencies follow identical guidelines; the NRC has established lower concentrations for some radionuclides in soil than has the DOE. Both agencies have adopted the same guidance levels for radium and thorium in soil, based on Environmental Protection Agency (EPA) standards. For these reasons, residual contamination levels at the Nuclear Lake site will be compared to NRC guidelines which are shown below.

Surface Contamination Guidelines

Alpha (based on plutonium)

100 dpm per 100 cm^2, averaged over 1 m^2
300 dpm per 100 cm^2, maximum over 100 cm^2
20 dpm per 100 cm^2, removable

Beta-gamma (based on Cs-137 and uranium)

5,000 dpm per 100 cm^2, averaged over 1 m^2
15,000 dpm per 100 cm^2, maximum over 100 cm^2
1,000 dpm per 100 cm^2, removable

Soil Contamination Guidelines

Radionuclide	Average Concentration Above Background (pCi/g)
Cs-137	15
Pu-239	25
Am-241	30
U-238 (process uranium - natural isotopic abundances)	17

A summary of the areas surveyed and their current radiological status is shown in Table 30.

The results of magnetometry and ground penetrating radar survey identified between 50 and 60 metallic anomalies on the bottom of Nuclear Lake. Visual inspection and probing of "target" sites were unsuccessful in confirming "targets," and in-situ gamma measurements did not identify the presence of significant gamma contamination. Sediment samples from "target" locations from other areas in the lake contained Cs-137, Pu-239/240, and U-238 concentrations above baseline soil levels. These concentrations were, however, within the above guidance levels established by the NRC. The elevated radionuclide levels in lake sediments may be attributable to the affinity of microorganisms to concentrate metal ions, released into lake during facility operation. Microorganisms will remove and retain metal ions, such as Cs-137, from their environment. Over long periods of time, these ions will become concentrated in sediment. Although inspection and measurements did not identify the "targets" as containers of radioactive waste, further inspections are considered warranted to confirm the nature of anomalies.

Many of the buildings had no elevated areas and typically had surface and soil contamination levels of less than 10% of the applicable guidelines. Surveys of building drains, which have a high potential to retain contamination, did not identify any residual contamination levels exceeding guideline values.

The elevated measurement associated with the Shield Mock-Up Building was a single soil sample collected at the end of a downspout.

Samples from septic systems at the Plutonium Facility and Remote Assembly Building, typically contained radionuclide concentrations less than 10% of the soil guidance levels. The sludge sample from the Plutonium Facility septic tank had the highest level of plutonium (5.95 pCi/g), but was still well within the 25 pCi/g guideline.

Several individual alpha measurements in the Plutonium Facility vault were at or above 100 dpm per 100 cm^2; however, none exceed the 300 dpm per 100 cm^2 maximum. The averages of 5 measurements in each 1 m^2 block surveyed were less than the 100 dpm per 100 cm^2 and, therefore, satisfy the guideline for plutonium surface contamination.

TABLE 30

CURRENT RADIOLOGICAL STATUS OF
AREAS COMPRISING THE NUCLEAR LAKE SITE
PAWLING, NEW YORK

Area or Building	Elevated Radionuclides Levels Present	Contamination Exceeding Typical Guideline Levels	Comments
Nuclear Lake	Yes	No	Elevated radionuclide concentrations in sediment samples
Lodge	No		
Emergency Generator Building	No		
Sodium Tent	No		
Engineering Building	No		
Remote Assembly Building	No		
Shield Mock-Up Building	Yes	No	Elevated Cs-137 concentration in a soil sample
Multiple Failure	Yes	Yes	Small floor area with fixed beta-gamma contamination
Critical Facility	No	No	
Plutonium Facility	Yes	Yes	5 rooms have floors with fixed beta-gamma and alpha contamination Isolated areas of Pu-239 and Cs-137 soil contamination outside Pu and Waste disposal facilities
Waste Disposal Facilty	No	No	

Samples of paint from building surfaces contained plutonium levels below 100 dpm per 100 cm^2 and this satisfies the guidelines.

Surveys of other indoor building surfaces identified one small floor area in the Multiple Failure Building and 5 rooms in the Plutonium Facility with floor contamination above guideline levels. This contamination was almost entirely fixed in the surface with removable levels within the 20 dpm per 100 cm^2 for this category of contaminant; potential for migration and spread is, therefore, small under current conditions of building use. It should be noted that the 1974 ATCOR report identified residual contamination levels exceeding current guidelines (1974 plutonium guidelines were higher than current values) in the same areas of the Plutonium Facility.

Other surfaces in the Plutonium Facility and Multiple Failure Building were within guideline levels, as were all other buildings surveyed. No items of equipment or debris within the buildings were identified as having residual contamination exceeding guidelines. Several of the buildings contained small quantities of chemical reagents such as concentrated sulfuric acid. Labels on many of the reagent containers are missing or are not legible.

There are a few isolated areas of Pu-239 and Cs-137 soil contamination around the Plutonium Facility and the Waste Disposal Building, which exceed the NRC guideline levels. Some of the Cs-137 contamination is below the surface and is needed to define the extent of this contamination. Sampling and direct measurements around other buildings did not identify surface areas or equipment and debris with residual contamination.

Water samples from drainage streams and wells contained radionuclide concentrations comparable to baseline water and well below EPA drinking water standards of 15 pCi/l gross alpha and 50 pCi/l gross beta. One sample from a concrete sump in the Critical Facility contained 99 pCi/l of gross beta activity; however, this elevated level is believed to be the result of natural activity which has leached from the concrete. Concrete is composed of materials which contain naturally occurring K-40, uranium, and thorium; when submersed in water for extended periods of time, small amounts of these radionuclides will become dissolved in the water.

SUMMARY AND RECOMMENDATIONS

At the request of the United States Department of the Interior, the Radiological Site Assessment Program of ORAU conducted a survey at the Nuclear Lake Site located near Pawling, New York. Radiological information included direct radiation levels inside and outside of buildings, contamination levels on building surfaces, and concentrations of radionuclides in soil, sediment, and water. Magnetometry and ground penetrating radar were also conducted to identify the presence of metallic objects on the lake bottom.

The survey identified multiple (over 50) objects on the lake bottom. Although these "targets" could not be confirmed and direct measurements and sampling at their locations did not indicate significantly elevated radiation levels or radionuclide concentrations, further investigation of these targets is considered warranted. To reduce the potential for contamination of personnel and the lake during such activities - it is suggested that the lake level should be lowered to expose any "targets" being investigated.

Sampling and measurements in drains and septic systems at the Plutonium Facility and Remote Assembly Building indicates that these systems do not contain contamination levels exceeding typical federal guidelines.

Cesium 137 and plutonium 239/240 surface contamination levels in five rooms of the Plutonium Facility exceed current guidelines for unrestricted use. Further radiological surveys would be necessary to define the extent of this contamination and develop appropriate remedial action plans. One small area of Cs-137 contamination was also detected on the floor of the Multiple Failure Building. Contamination levels in all other buildings satisfy guidelines for unrestricted use.

Several small areas of Cs-137 and Pu-239/240 soil contamination were also identified outside the Plutonium Facility and Waste Disposal Building. Some of the Cs-137 contamination was subsurface and further sampling would be required to define the extent of this contamination.

At the present time, the areas of concern identified in this report are not open to the public and access is restricted by security fences, locked doors, and caretaker service provided by the National Park Service. In the event that these physical barriers are breached, the risk of harm very slight because the radioactive material is fixed in the building structures and therefore has a very low potential for migration. Fixed material is not an inhalation or ingestion hazard. With several exceptions exposure rates throughout the facility were in the range of background; no external hazard is associated with those areas of elevated gamma radiation, based on the limited extent of the radiation, relatively low levels, and low potential occupancy time.

Although radiological conditions at the Nuclear Lake site, as determined from this study, do not, in ORAU's opinion, constitute a hazard to personnel and the environment, there are unknown objects in the lake and the suggestion of possible subsurface contamination at several locations. Further activities to characterize and subsequently remove or resolve these issues are recommended.

REFERENCES

1. Final Survey Results After Decontamination, Gulf United Nuclear Fuels Corporation Plutonium Facility, Pawling, New York, ATCOR, Inc., Peekskill, New York, January 1974.

2. UNC Facility Survey and Radiological Analysis, Nuclear Energy Services, Inc., Danbury, Connecticut, July 1984.

3. Letter from C. W. Gillert, Acting Chairperson, Nuclear Lake Management Committee to D.A. Richie, United States Department of Interior, July 1985.

APPENDIX A

SURVEY PLAN FOR THE NUCLEAR LAKE SITE

PROPOSED SURVEY PLAN
FOR PORTIONS OF THE
NUCLEAR LAKE SITE
PAWLING, NEW YORK

I. Introduction

Beginning in 1958, nuclear fuels processing and research were conducted at an area near Pawling, New York, known as Nuclear Lake. Initial operations were performed by Nuclear Development Corporation; subsequently the site was also owned and operated by United Nuclear Corporation and Gulf-United Nuclear Corporation. Oxide fuels, fabricated and tested at the site, were primarily uranium of various U-235 enrichments; however, thorium and plutonium were also used. Testing facilities included several small experimental reactors, and irradiated fuel elements and other reactor materials contained a wide variety of fission and activation products. In 1972, activities at the site were discontinued. The site was decontaminated and surveyed, and a report, indicating that the facilities satisfied the criteria for decommissioning, was prepared by ATCOR. The Nuclear Regulatory Commission license for the site was terminated in 1975. In 1979 the property was acquired by the National Park Service for the purpose of relocation of the Appalachian National Scenic Trail.

Additional surveys of portions of the property were conducted by Nuclear Energy Services, under contract with the National Park Service. Results of that survey, presented in a July 1984 report, identified a small area of residual contamination in the former Waste Disposal Building. No other evidence of contamination in excess of the limits for unrestricted use was noted, although a storage vault in the Plutonium Facility was locked and could not be accessed for survey.

Prepared by the Manpower Education, Research, and Training Division of Oak Ridge Associated Universities, Oak Ridge, Tennessee, under Interagency Agreement DOE No. 40-859-86, NPS No. 0631-0001-100, between the U.S. Department of Interior's National Park Service and the U.S. Department of Energy.

June 9, 1986

In addition to the storage vault, studies and reviews by the Nuclear Lake Management Committee have raised concerns regarding residual contamination in building drains, septic tank and drain field systems, sediments in Nuclear Lake, and building interior paint. The possibility that containers of radioactive or other hazardous wastes were discarded into Nuclear Lake has also been indicated by the Management Committee. At the request of the National Park Service, the Radiological Site Assessment Program of Oak Ridge Associated Universities will conduct investigations and radiological surveys at Nuclear Lake site, concentrating on resolution of these areas of concern.

II. Site Description

The Nuclear Lake site occupies approximately 460 hectares, between the towns of Pawling and Beeman, in eastern New York. There are nine buildings on the site; four of these - the Plutonium Facility, Waste Disposal Building, Critical Facility, and Shield Mock-up Building - have a history of use for processing or storage of radioactive materials. The area around the buildings includes access roads, paths, utilities and service areas, and parking lots. There is a 20 hectare man-made lake, known as Nuclear Lake, and other small streams and wetland areas. The remainder of the site consists of small, steep hills and valleys; most of the area is thickly wooded and access is limited.

III. Purpose

The purpose of the ORAU survey is to determine the extent and levels of radioactive material contamination, if any, that may remain on the land and facilities at the Nuclear Lake property. Findings will be compared with guidelines and criteria currently being used by the Department of Energy (DOE), Nuclear Regulatory Commission (NRC), and Environmental Protection Agency (EPA) for sites being released for unrestricted use by the general public.

IV. **Responsibility**

Work described in this survey plan will be performed under the supervision of Mr. J.D. Berger, CHP, Program Manager or the Radiological Site Assessment Program of the Manpower Education, Research, and Training Division of Oak Ridge Associated Universities.

V. **Procedures**

A. Document Review

ORAU will review documentation in the NRC licensing files and any additonal documents or information that may be available from the former licensee and agencies such as the Nuclear Lake management Committee, for guidance concerning site design and operating history.

B. Gridding

1. Reference grids will be established in areas of the two septic tanks and drain fields for the Plutonium Facility. Grid intervals will be 5 m.

2. A reference grid will be established on Nuclear Lake. Grid intervals will be 100 m; the grid will be subdivided into 10 m intervals over a 50 m x 50 m area in the area of the Plutonium Facility outfall pipe.

3. At other locations, where direct measurements indicate residual contamination, grids will be established to enable referencing of samples and measurements. Grid sizes will be determined in the field, based on findings as the survey progresses.

4. Other samples and measurements will be referenced to existing building or site landmarks.

C. Magnetometer Surveys

1. Ground-penetrating radar surveys will be performed to identify the locations of septic tank and drain fields servicing the Plutonium Facility. Similar surveys will be performed for the septic tanks and drain field servicing other buildings, if preliminary monitoring of drain piping and traps indicates a potential for contamination of these systems.

2. Metal detection scans will be performed throughout Nuclear Lake to identify the presence of containers on the lake bottom. Scan intervals will be about 20 m.

D. Direct Measurements

1. Gamma scans will be performed inside buildings and out to 10 m around the outside of buildings. Scans of drain openings, outfalls, retention tanks, drainage streams and ditches, roads, parking areas, equipment, containers, and debris will also be performed. All areas of elevated direct radiation will be noted for further investigations.

2. Alpha and beta contamination levels (total and smearable) will be performed on drain openings, equipment, containers, and debris.

E. Sampling

1. Core samples will be obtained from the septic tank and drain field areas, using split spoon samplers with a hollow-stem auger drilling rig. Coring will be performed to the depth of natural soil. Although the numbers and locations of coring will be determined by findings as the survey progresses, a minimum of 6-8 locations is anticipated for each site.

2. Sediment samples will be obtained at each of the grid intervals established on Nuclear Lake. Sampling will be performed by driving piping into the sediment to obtain cores representing depths of at least 30 cm.

3. Sediment core samples will be obtained from the drainage stream below the dam and from other surface drainage pathways. Water samples will be obtained from each of these locations.

4. Samples of paint will be obtained from interior surfaces of buildings used for radioactive materials work. From 6-8 samples will be taken in each of these buildings.

5. Residues will be collected from liquid collection pits, tanks, and drain systems in buildings with a history of radioactive material use. Water samples will also be obtained from these locations, if available.

6. Samples of soil, sediment, construction material, debris, etc. will be collected at locations, identified by direct measurements as having elevated radiation levels.

F. Other Activities

1. The Plutonium Facility vault will be accessed. The vault floor and lower wall areas will be gridded in 1 m intervals. Alpha, beta and gamma scans will be performed and all surfaces will be surveyed for total and smearable contamination.

2. Visual inspections of areas in Nuclear Lake, identified by the metal detecting scans, will be performed by divers. Samples of container contents and sediments in the container vicinity will be obtained.

3. Residual contamination in the Waste Disposal Building will be removed.

G. **Background and Baseline Determinations**

Samples of soil and sediment, and water will be obtained at 6-8 locations around the Nuclear Lake site for the purpose of establishing baseline radionuclide concentrations. Direct measurements of exposure rates will be performed at each of the sampling locations.

H. Sample Analysis

Samples will be returned to ORAU laboratories in Oak Ridge, Tennessee for analysis. Sediment, soil, paint, and residue samples will be analyzed by gamma spectrometry. Analysis for plutonium 239/240 will also be performed on these samples. Additional analyses will be conducted, if appropriate, based on these initial analytical findings.

Smears and water samples will be analyzed for gross alpha and gross beta contamination. Water samples exceeding 15 pCi/l gross alpha or 50 pCi/l gross beta will be analyzed for specific radionuclide concentrations.

I. Quality Assurance and Control

Laboratory and field survey procedures are consistent with DOE, NRC, and EPA procedures for low-levels of radionuclides in environmental media. Procedures are documented in manuals developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program.

With the exception of the measurements conducted with portable gamma scintillation survey meters, instruments are calibrated with NBS-traceable standards. The calibration procedures for the portable gamma instruments are performed by comparison with an NBS calibrated ionization chamber.

Quality control procedures on all instruments include daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA and EML Quality Assurance Programs.

VI. Tentative Schedule

Onsite work will commence within 4-6 weeks after the survey plan is reviewed and comments resolved. The survey is expected to require about 3 weeks of onsite work. Analysis of samples and tabulation of data will be completed about 6 weeks after site work, and a draft report will be submitted for comment approximately 10 weeks after completion of site activities. Comments on the draft report will be incorporated into a final report and copies provided about 3 weeks after receipt of the comments.

APPENDIX B

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

APPENDIX B

Major Sampling and Analytical Equipment

The display or descrip on of a specific product is not to be construed as an endorsement of that product or its manufacturer by the authors on their employer.

A. Direct Radiation Measurements

Eberline "RASCAL"
Portable Ratemeter-Scaler
Model PRS-1
(Eberline, Sante Fe, NM)

Eberline PRM-[illegible]
Portable Ratemeter
(Eberline, Sante Fe, NM)

Victoreen Beta-Gamma "Pancake" Probe
Model [illegible]
(Victoreen, Inc., Cleveland, OH)

Eberline Beta-Gamma "Pancake" Probe
Model [illegible]
(Eberline, Sante Fe, NM)

Victoreen Gamma Scintillation (NaI) Probe
Model [illegible]
(Victoreen, Inc., Cleveland, OH)

Eberline Alpha Scintillation Probe
Models AC-[illegible]
(Eberline, Sante Fe, NM)

Ludlum Alpha Beta Floor Monitor
Model 239-1
(Ludlum, Sweetwater, TX)

Ludlum Model 2220
Portable Scaler-Ratemeter
(Ludlum, Sweetwater, TX)

Ludlum Portable Scaler
Model 22[illegible]
(Ludlum Measurements, Inc., Sweetwater, TX)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-[illegible]
(Reuter-Stokes, Cleveland, OH)

B. Laboratory Analyses

Automatic low-background Alpha-Beta Counter
Model LB5110-2080
(Tennelec, Inc., Oak Ridge, TN)

Manual Low-Background Alpha-Beta Counter
Model LB1000 Series
(Tennelec, Inc., Oak Ridge)

Ge(Li) Detector
Model LGC220SD, 23% efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield, SPG-16
(Applied Physical Technology, Smyrna, GA)

High-Purity Germanium Coaxial Well Detector
Model [illegible]-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, [illegible]
(Gamma Products, Inc., Palos Hills, IL)

High-Purity Germanium Coaxial Photon Detector
Model [illegible]-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, G-16
(Gamma Products, Inc., Palos Hills, IL)

Intrinsic Germanium Detector
Model [illegible]
(Princeton-Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield, SPG-16-KB
(Gamma Products, Inc., Palos Hills, IL)

Multichannel Analyzer
ND-66/[illegible] System
(Nuclear Data, Inc., Schaumburg, IL)

Alpha Spectrometry System
Tennelec Electronics, EG&G ORTEC
Surface Barrier detectors
(Tennelec, Inc., EG&G, Oak Ridge, TN)

Multichannel Analyzer
ND-[illegible]
(Nuclear Data, Inc., Schaumburg, IL)

APPENDIX C

MEASUREMENT AND ANALYTICAL PROCEDURES

APPENDIX C

Measurement and Analytical Procedures

Surface Scans

Surface scans were performed by passing the probes slowly over the surface. The distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. Identification of elevated levels was based on increases in the audible signal from the recording or indicating instrument. Alpha and beta-gamma scans of large surface areas on the floor of the facility were accomplished by use of a gas proportional floor monitor, with a 600 cm^2 sensitive area. The instrument is slowly moved in a systematic pattern to cover 100% of the accessible area. Combinations of detectors and instruments for the scans were:

- Beta-Gamma - G-M probe with PRM-6 ratemeter.
- Beta-Gamma - G-M probe with "RASCAL" scaler/ratemeter.
- Gamma - NaI scintillation detector (3.2 cm x 3.8 cm crystal) with PRM-6 ratemeter.
- Alpha - ZnS probe with "RASCAL" scaler/ratemeter.
- Alpha Beta - Gas proportional floor monitor with PRM-6 ratemeter or Ludlum Model 2220 scaler/ratemeter.

For scanning purposes, increases in audible signals which correspond to approximately [illegible] and [illegible] dpm/100 cm^2 for alpha and beta-gamma and 3 µR/hr above background for exposure rate can be detected. Areas exceeding the ambient background count rate range were marked for further measurements and/or sampling.

Total Alpha and Beta-Gamma Contamination Measurements

Measurements of total alpha radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model AC-3-7 alpha scintillation probes. Measurements of total beta-gamma radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model

HP-260 thin-window "pancake" G-M probes. Count rates (cpm) were converted to disintegration rates (dpm/100 cm^2) by dividing the net rate by the 4 π efficiency and correcting for the active area of the detector. Although other factors (i.e. backscatter) can affect the calibration, they are consideted insignificant for the measurements performed. Effective window areas were 59 cm^2 for the ZnS detectors and 15 cm^2 for the G-M detectors. Background count rates for ZnS alpha probes averaged approximately 1 cpm; the average background count rate was approximately 40 cpm for the G-M detectors. The measurement sensitivities for total alpha and beta-gamma contamination measurements are 25 dpm/100 cm^2 and 400 dpm/100 cm^2 respectively.

Removable Alpha and Beta-Gamma Contamination Measurements

Smear measurements were performed on numbered filter paper disks, 47 mm in diameter. Smears were sealed in labeled envelopes with the location and other pertinent information recorded. A ZnS alpha scintillation counting system was used to initially evaluate individual smears at the site; smears were then returned to Oak Ridge and recounted using a low-background alpha-beta proportional system. The measurement sensitivities for removable alpha and beta-gamma contamination measurements are 3 dpm/100 cm^2 and 6 dpm/100 cm^2 respectively. The measurement sensitivities for removable alpha and beta-gamma contamination measurements are 3 dpm/100 cm^2 and 6 dpm/100 cm^2 respectively.

Gamma Exposure Rate Measurement

Measurements of gamma exposure rates were performed using primarily Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation detectors containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Count rates were converted to exposure rates (μR/h) using factors determined by comparing the response of the scintillation detector with that of a Reuter Stokes Model RSS-111 pressurized ionization chamber at locations on the Nuclear Lake. At several locations, the exposure rates at 1 m above the surface were measured using the Reuter Stokes pressurized ionization chamber directly.

Soil and Sediment Sample Analysis

Gamma Spectrometry

Soil and sediment samples were dried, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 800 g of soil. Net soil weights were determined and the samples counted using intrinsic germanium and Ge(Li) detectors coupled to a Nuclear Data Model ND-680 pulse height analyzer system. Background and Compton stripping, peak, search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

U-235 - 0.144 MeV
U-238 - 0.094 MeV from Th-234 (secular equilibrium assumed)
Th-232 - 0.911 MeV from Ac-228 (secular equilibrium assumed)
Cs-137 - 0.662 MeV

Minimum detectable concentrations will vary with sample quantity, density and analysis time. Typical values for U-238 were 0.7 to 1.7 pCi/g and for Cs-137 were 0.02 to 0.27 pCi/g. Spectra were also reviewed for the presence of other radionuclides at concentrations above those normally encountered in environmental media.

Isotopic Plutonium

Aliquots of soil were acidified and evaporated to dryness. The residues were then dissolved by pyrosulfate fusion and precipitated by barium sulfate. The barium sulfate precipitate was redissolved and plutonium separated by liquid-liquid extraction. The purified plutonium was then precipitated with a cerium fluoride carrier and counted using surface barrier detectors (ORTEC), alpha spectrometers (Tennelec), and an ND-66 Multichannel Analyzer (Nuclear Data). Minimum detectable concentrations will vary depending on sample quantity and recovery efficiency. Typical values for Pu-238 were 0.02 to [illegible] pCi/g and for Pu-239,[illegible] were 0.1[illegible] to 0.7[illegible] pCi/g.

Water Sample Analysis

Gross Alpha and Gross Beta

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45 µm membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid. A known volume of each sample was evaporated to dryness and counted for gross alpha and gross beta using a Tennelec Model LB-5110 low-background proportional counter. Minimum detectable concentrations were 0.25 pCi/l and 0.75 pCi/l for gross alpha and gross beta.

Isotopic Plutonium

An aliquot of water was acidified and evaporated to dryness. The residue was dissolved by pyrosulfate fusion. The alpha emitters were precipitated by barium sulfate. After precipitation the barium sulfate was redissolved. A liquid-liquid extraction was performed to isolate the plutonium. Cesium fluoride as a carrier was added to precipitate the purified plutonium. The plutonium was then counted using surface barrier detectors (ORTEC), alpha spectrometers (Tennelec), an ND-66 Multiple Channel Analyzer (Nuclear Data). Minimum detectable concentrations for Pu-238 were 0.02 pCi/l to 0.03 pCi/l and for Pu-239/240 was 0.4 pCi/l. Values will vary with sample quantity and recovery efficiency.

Paint Samples Analysis

Samples were dissolved by pyrosulfate fusion and precipitated with barium sulfate. The barium sulfate precipitate was redissolved and the plutonium separated by liquid - liquid extraction. The plutonium and uranium was then precipitated with a cerium fluoride carrier and counted using surface barrier detectors (ORTEC), alpha spectrometers (Tennelec), and an ND-66 Multichannel Analyzer (Nuclear Data). The minimum detectable activity for Pu-238 and Pu-239/240 is 1 dpm/100 cm^2 for both isotopes.

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report, represent the 95% confidence levels for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. When the net sample count was less than the 95% statistical deviation of the background count, the sample concentration was reported as less than the detection capability of the measurement procedure. Because of variations in background levels, sample volumes or weights, measurement efficiencies, and Compton contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument. Additional uncertainties of ± 6 to 10%, associated with sampling and laboratory procedures, have not been propagated into the data presented in this report.

The uncertainty associated with survey instrument measurements, based on the reproducibility of the instrument reponse to the same source is less than 10% most portable instruments using count rate displays only are ± 20% - they would be better for digital scaling instruments for all portable survey instruments used.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in manuals, developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program.

With the exception of the measurements conducted with portable gamma scintillation survey meters, instruments were calibrated with NBS-traceable standards. The calibration procedures for the portable gamma instruments are performed by comparison with an NBS calibrated pressurized ionization chamber.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA and EML Quality Assurance Programs.

APPENDIX D

EXAMPLES OF RADIOLOGICAL GUIDELINES
USED BY FEDERAL AGENCIES

APPENDIX D

EXAMPLES OF RADIOLOGICAL GUIDELINES USED BY FEDERAL AGENCIES

This Appendix presents guidelines currently being used by the Department of Energy and the Nuclear Regulatory Commission for the purpose of cleanup and release of formerly utilized radiological sites for unrestricted use. These guidelines are treated by these agencies as target values and may be modified by the responsible regulatory agency, based on site specific conditions and consideration of the ALARA philosophy. They are provided here, primarily to provide the reader with an idea of the approximate levels of interest.

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT
PRIOR TO RELEASE FOR UNRESTRICTED USE
OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE
OR SPECIAL NUCLEAR MATERIAL

U.S. Nuclear Regulatory Commission
Division of Fuel Cycle & Material Safety
Washington, D.C. 20555

July 1982

the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. They survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 dpm βγ/100 cm^2	15,000 dpm βγ/100 cm^2	1000 dpm βγ/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

Guidelines for Residual Concentrations of Thorium and Uranium Wastes in Soil

On October 23, 1981, the Nuclear Regulatory Commission published in the Federal Register a notice of Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." This document establishes guidelines for concentrations of uranium and thorium in soil, that will limit maximum radiation received by the public under various conditions of future land usage. These concentrations are as follows:

Material	Maximum Concentrations (pCi/g) for various options			
	1[a]	2[b]	3[c]	4[c]
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10	50	--	500
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10	—	40	200
Depleted Uranium:				
Soluble	35	100	--	1,000
Insoluble	35	300	--	3,000
Enriched Uranium:				
Soluble	30	100	—	1,000
Insoluble	30	250	—	2,500

[a]Based on EPA cleanup standards which limit radiation to 1 mrad/yr to lung and 3 mrad/yr to bone from ingestion and inhalation and 10 µR/h above background from direct external exposure.
[b]Based on limiting individual doses to 170 mrem/yr.
[c]Based on limiting equivalent exposure to 0.02 working level or less.
[d]Based on limiting individual doses to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.

Option 1 concentrations permit unrestricted use of the property and is the guideline applicable to surface soils. Options 2, 3, and 4 apply to buried wastes and assume that intrusions into the burial sites may occur. Regardless of the concentrations in the buried materials, surface soil must meet the Option 1 concentration guidelines.

ADDITIONAL GUIDELINES FOR RADIONUCLIDE CONCENTRATIONS IN SOIL AT NRC SITES BEING RELEASED FOR UNRESTRICTED USE

Radionuclide	Average Concentration Above Background (pCi/g)
Cs-137	15
Pu-239	25
Am-241	30

U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Revision 2, March 1987)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactive material, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Department of Energy, 1986) and subsequent guidance. More detailed information on applications of the guidelines presented herein, including procedures

* A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

for deriving site-specific guidelines for allowable levels of residual radioactive material from basic dose limits, is contained in "A Manual for Implementing Residual Radioactive Material Guidelines" (U.S. Department of Energy 1987) referred to herein as the "supplement".

"Residual radioactive material" is used in these guidelines to describe radioactive materials derived from operations or sites over which the Department of Energy has authority. Guidelines or guidance to limit the levels of radioactive material to protect the public and environment are provided for: (1) residual concentrations of radionuclides in soil material, (2) concentrations of airborne radon decay products, (3) external gamma radiation level, (4) surface contamination levels, and (5) radionuclide concentrations in air or water resulting from or associated with any of the above.

A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). The basic dose limits are used for deriving guidelines for residual concentrations of radionuclides in soil material. Guidelines for residual concentrations of thorium and radium in soil, concentrations of airborne radon decay products, allowable indoor external gamma radiation levels, and residual surface contamination concentrations are based on existing radiological protection standards or guidelines (U.S. Environmental Protection Agency 1983; U.S. Nuclear Regulatory Commission 1982; and Departmental Orders). Derived guidelines or limits based on the basic dose limits for those quantities are only used when the guidelines provided in the existing standards cited above are shown to be inappropriate.

A "guideline" for residual radioactive material is a level of radioactivity or of the radioactive material that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactive material presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement. The basis for the guidelines is generally a presumed worst case plausible scenario for a site.

An "Authorized Limit" is a level of residual radioactive material or radioactivity that must not be exceeded if the remedial action is to be considered completed and the site is to be released for unrestricted use. The Authorized Limit for a site will include limits for each radionuclide or group of radionuclides, as appropriate, associated with the residual radioactive material in the soil or in surface contamination of structures and equipment, and in the air or water, and, where appropriate, a limit on external gamma radiation resulting from the residual material. Under normal circumstances, expected to occur at most sites, Authorized Limits for residual radioactive material or radioactivity are set equal to guideline values. Exceptional conditions for which Authorized Limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the conditions do not exceed the Authorized Limits or approved supplemental limits as defined in Section F.1 at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the site conditions exceed the approved limits, or if there is potential to exceed the dose limit if the site use was not restricted (Section F.2). The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). For sites to be released for unrestricted use, the intent is to reduce residual radioactive material to levels that are as far below Authorized Limits as reasonable considering technical, economic, and social factors. At sites where the residual material is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as reasonably achievable. Procedures for implementing ALARA policy are discussed in the supplement. ALARA policies, procedures, and actions shall be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic dose limit for the annual radiation dose received by an individual member of the general public is 100 mrem/year. The internal committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), plus dose from penetrating radiation sources external to the body shall be used for determining the dose. This dose shall be described as the "Effective Dose Equivalent". Every effort shall be made to ensure that actual doses to the public are as far below the dose limit as is reasonably achievable.

Under unusual circumstances it will be permissible to allow potential doses to exceed 100 mrem/year where such exposures are based upon scenarios which do not persist for long periods and where the annual life time exposure to an individual from the subject residual radioactive material would be expected to be less than 100 mrem/year. Examples of such situations include conditions that might exist at a site scheduled for remediation in the near future or a possible, but improbable, one-time scenario that might occur following remedial action. These levels should represent doses that are as low as reasonably achievable for the site. Further, no annual exposure should exceed 500 mrem.

C. GUIDELINES FOR RESIDUAL RADIOACTIVE MATERIAL

C.1 Residual Radionuclides in Soil

Residual concentrations of radionuclides in soil shall be specified as above-background concentrations averaged over an area of 100 sq meters. Generic guidelines for thorium and radium are specified below. Guidelines for residual concentrations of other radionuclides shall be derived from the basic dose limits by means of an environmental pathway analysis using site-specific data where available. Procedures for these derivations are given in the supplement.

If the average concentration in any surface or below surface area less than or equal to 25 sq meters exceeds the Authorized Limit or guideline by a factor of $(100/A)^{1/2}$, where A is the area of the elevated region in square meters, limits for "Hot Spots" shall also be applicable. These Hot Spot Limits depend on the extent of the elevated local concentrations and are given in the supplement. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate soil limit irrespective of the average concentration in the soil.

Two types of guidelines are provided, generic and derived. The generic guidelines for residual concentrations of the Ra-226, Ra-228, Th-230, and Th-232 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the appropriate guideline is applied as a limit to the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that 1) the dose for the mixtures will not exceed the basic dose limit, or 2) the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity"). Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

C.2 <u>Airborne Radon Decay Products</u>

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and a reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions by DOE are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h and shall comply with the basic dose limit when an appropriate use scenario is considered. This requirement shall not necessarily apply to structures scheduled for demolition or to buried foundations. External gamma radiation levels on open lands shall also comply with the basic dose limit considering an appropriate use scenario for the area.

C.4 Surface Contamination

The generic guidelines provided in the Table 1, Surface Contamination Guidelines are applicable to existing structures and equipment. These guidelines are adapted from standards of the U.S. Nuclear Regulatory

* A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

TABLE 1 SURFACE CONTAMINATION GUIDELINES

Radionuclides [2]	Allowable Total Residual Surface Contamination (dpm/100 cm^2) [1] Average [3, 4]	Maximum [4, 5]	Removable [4, 6]
Transuranics, Ra-226, Ra-226, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β-γ	15,000 β-γ	1,000 β-γ

1 As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2 Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3 Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

4 The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5 The maximum contamination level applies to an area of not more than 100 cm^2.

6 The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

Commission (1982)* and will be applied in a manner that provides a level of protection consistent with the Commission's guidance. These limits apply to both interior and exterior surfaces. They are not directly intended for use on structures to be demolished or buried, but, should be applied to equipment or building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

C.5 Residual Radionuclides in Air and Water

Residual concentrations of radionuclides in air and water shall be controlled to levels required by DOE Environmental Protection Guidance and Orders, specifically DOE Order 5480.1A and subsequent guidance. Other Federal and/or state standards shall apply when they are determined to be appropriate.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVE MATERIAL

The Authorized Limits shall be established to: 1) ensure that, as a minimum, the Dose Limits specified in Section B will not be exceeded under the worst case plausible use scenario consistent with the procedures and guidance provided, or 2) where applicable generic guidelines are provided, be consistent with such guidelines. The Authorized Limits for each site and vicinity properties shall be set equal to the generic or derived guidelines except where it can be clearly established on the basis of site specific data, including health, safety and socioeconomic considerations, that the guidelines are not appropriate for use at the specific site. Consideration

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* These guidelines are functionally equivalent to Section 4 - Decontamination for Release for Unrestricted Use of NRC Regulatory Guide 1.86, but are applicable to Non-Reactor facilities.

should also be given to ensure that the limits comply with or provide an equivalent level of protection as other appropriate limits and guidelines (i.e., state, or other Federal). Documentation supporting such a decision should be similar to that required for supplemental limits and exceptions (Section F), but should be generally more detailed because it covers an entire site.

Remedial actions shall not be considered complete unless the residual radioactive material levels comply with the Authorized Limits. The only exception to this requirement will be for those special situations where the supplemental limits or exceptions are applicable and approved as specified in Section F. However, the use of supplemental limits and exceptions should only be considered if it is clearly demonstrated that it is not reasonable to decontaminate the area to the Authorized Limit or guideline value. The Authorized Limits are developed through the project offices in the field (Oak Ridge Technical Services Division for FUSRAP) and approved by the headquarters program office (the Division of Facility and Site Decommissioning Projects).

E. <u>CONTROL OF RESIDUAL RADIOACTIVE MATERIAL AT FUSRAP AND REMOTE SFMP SITES</u>

Residual radioactive material above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A and subsequent guidance or superceding orders require compliance with applicable Federal, and state environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1C, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations as revised by DOE 5480.1 change orders and the 5 August 1985 memorandum from Vaughan to Distribution

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental Safety, and Health Appraisal Program

f. 5483.1A, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5000.3, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 <u>Interim Storage</u>

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing Federal, or state standards.

c. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactive material shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The Federal government shall have title to the property or shall have a long-term lease for exclusive use.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring as appropriate, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate Federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 $pCi/m^2/s$, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b. of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a. of this section (E.3).

d. Groundwater shall be protected in accordance with Appropriate Departmental orders and Federal and state standards, as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactive material should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The Federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. SUPPLEMENTAL LIMITS AND EXCEPTIONS

If special site specific circumstances indicate that the guidelines or Authorized Limits established for a given site are not appropriate for a portion of that site or a vicinity property, then the field office may request that supplemental limits or an exception be applied. In either case, the field must justify that the subject guidelines or Authorized Limits are not appropriate and that the alternative action will provide adequate protection giving due consideration to health and safety, environment and costs. The field office shall obtain approval for specific supplemental limits or exceptions from headquarters as specified in Section D of these guidelines and shall provide to headquarters those materials required for the justification as specified in this section and in the FUSRAP and SFMP protocols and subsequent guidance documents. The field office shall also be responsible for coordination with the state or local government of the limits or exceptions and associated restrictions as appropriate. In the case of exceptions, the field office shall also work with the state and/or local governments to insure that restrictions or conditions of release are adequate and mechanisms are in place for their enforcement.

F1. Supplemental Limits

The supplemental limits must achieve the basic dose limits set forth in this guideline document for both current and potential unrestricted uses of the site and/or vicinity property. Supplemental limits may be applied to a property or portion of a property or site if, on the basis of a site specific analysis, it is determined that certain aspects of the property or portion of the site were not considered in the development of the established Authorized Limits and associated guidelines for the site, and as a result of these unique characteristics, the established limits or guidelines either do not provide adequate protection or are unnecessarily restrictive and costly.

F2. Exceptions

Exceptions to the Authorized Limits defined for unrestricted use of the site may be applied to a portion of a site or a vicinity property when it is established that the Authorized Limits cannot be achieved and restrictions on use of the site or vicinity property are necessary to provide adequate protection of the public and environment. The field office must clearly demonstrate that the exception is necessary, and the restrictions will provide the necessary degree of protection and that they comply with the requirements for control of residual radioactive material as set forth in Part E of these guidelines.

F3. Justification for Supplemental Limits and Exceptions

Supplemental limits and exceptions must be justified by the field office on a case by case basis using site specific data. Every effort should be made to minimize the use of the supplemental limits and exceptions. Examples of specific situations that warrant the use of supplemental standards and exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that can reasonably be anticipated.

c. Where it is clear that the scenarios or assumptions used to establish the Authorized Limits do not under plausible current or future conditions, apply to the property or portion of the site identified and where more appropriate scenarios or assumptions indicate that other limits are applicable or necessary for protection of the public and the environment.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. A site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactive material must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
Basic Dose Limits	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
Generic Guidelines for Residual Radioactivity	
Residual Concentrations of Radium and Thorium in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A and subsequent guidance
Long-Term Management	DOE Order 5480.1A and subsequent guidance; 40 CFR 192; DOE order 5820.2

H. <u>REFERENCES</u>

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ADDITIONAL GUIDELINES FOR RADIONUCLIDE CONCENTRATIONS IN SOIL WHICH HAVE BEEN USED AT FORMERLY UTILIZED DOE SITES

Radionuclide	Average Concentration Above Background (pCi/g)
U-238	35 - 75
Pu-239	100
Am-241	20
Cs-137	80

APPENDIX E

GLOSSARY

GLOSSARY

Activation: The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

Activity: Radioactivity, the spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the nuclei of an unstable nuclide. As a result of this emission, the radioactive material is converted (or decays) into a different nuclide (daughter), which may or may not be radioactive. Ultimately, as a result of one or more stages of radioactive decay, a stable (nonradioactive) nuclide is formed.

Aerial survey: A search for sources of radiation by means of sensitive instruments mounted in a helicopter or airplane. Generally, the instrumentation records the intensity, location, and spectral analysis of the radiation.

Alpha particle: A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons bound together, and hence is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive material, and can be stopped by a sheet of paper.

Atomic number: Represents the number of protons in the nucleus of an atom and determines the place of the element in the periodic table. In a neutral atom, the number of protons in the nucleus equals the number of electrons outside the nucleus of the atom.

Background radiation: The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements. It is also called natural radiation. The term may also mean radiation that is unrelated to a specific experiment. Levels vary, depending on location.

Baseline concentration: The concentration of a given substance typically encountered in the area under consideration, i.e. the normal or naturally occurring level.

Beta particle: An elementary particle emitted from a nucleus during radioactive decay, with a single electrical charge and a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

Contamination: Undesired radioactive materials that have been deposited on surfaces, are internally ingrained into structures or equipment, or that have been mixed with another material.

Curie: A special unit of activity. One curie equals 3.7×10^{10} nuclear disintegrations per second. Several fractions of the curie are in common usage:

-- Millicurie - one thousandth of a curie. Abbreviated as mCi.

-- Microcurie - one millionth of a curie. Abbreviated as µCi.

-- Nanocurie - one billionth of a curie. Abbreviated as nCi.

-- Picocurie - one trillionth of a curie. Abbreviated as pCi.

Daughter: The product of radioactive decay of a nuclide. (also see Parent).

Decay, radioactive: The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the number of original radioactive nuclides in a sample. It involves the emission from the nucleus of alpha particles, beta particles, or gamma rays; or the nuclear capture or ejection of orbital electrons; or fission. Also called radioactive disintegration.

Decontamination: Those activities employed to reduce the levels of contamination.

Dose: A measure of the quantity of radiation absorbed in a unit mass of a medium. The unit of dose is the rad.

Dose rate: The radiation dose delivered per unit time and measured, for example, in rads per hours.

Exposure: A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen.

Exposure rate: The radiation exposure per unit time. Measured, for example, in roentgens per hour.

Gamma radiation: High-energy, short-wave length electromagnetic radiation of nuclear origin (radioactive decay). Gamma rays are the most penetrating of the three common types of radiation.

Ground Penetrating Radar Survey: A survey of subterranean features whereby a wavetrain of electromagnetic radiation (short wave length, high frequency) is transmitted downward into the earth when the wavetrain encounters interfaces between materials of different electromagnetic properties, the wave is partially reflected. A surface receiver detects the energy reflected back by the reflecting object, and the travel time between transmission and detection is recorded. This time interval can be converted to depth if the velocity of propagation is known.

Guideline levels: Target level concentrations of radionuclides set by regulatory agencies for example, Nuclear Regulatory Commission, Department of Energy, etc., such that the residual radioactive contamination from previous operations will not pose a potential risk to the environment of the site or the health and safety of those occupying the site presently or in the future.

Half-life: The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.

Isotope: Isotopes are any of two or more species of atoms of a chemical element with the same atomic number and position in the periodic table. They have nearly identical chemical behavior but with differing atomic masses or mass numbers and different physical properties. Several isotopes of plutonium are: 1) Pu with 94 protons and 144 neutrons in the nucleus; 2) Pu with 94 protons and 145 nutrons in the nucleus; and 3) Pu with 94 protons and 146 nutrons in the nucleus.

Limited Direct Measurements: A limited number of measurement points selected in a nonsystematic fashion to provide independent proof that radiological data developed by another organization are accurate and adequately represent the radiological condition of the property.

Magnetometry Survey: A survey whereby a change in the earth's external magnetic field caused by the presence of a ferromagnetic material is measured.

Mass Number: The mass number of an element is the sum of the number of protons and neutrons in the nucleus of an atom. Some examples are: 1) He, atomic number 2 and mass number 4; 2) Pu, atomic number 94, and mass number 239; and 3) Cs, atomic number 55 and mass number 137.

Microrad (µrad): A submultiple of the rad, equal to one-millionth of a rad. (see rad).

Microroentgen (µR): A submultiple of the roentgen, equal to one-millionth of a roentgen. (see roentgen).

Millirem (mrem): A submultiple of the rem, equal to one-thousandth of a rem. (see rem).

Natural uranium: Uranium as found in nature, containing 0.7 percent of uranium-235, 99.3 percent of uranium-238. It is also called normal uranium.

Natural thorium: Thorium as found in nature. Natural thorium contains equal activity level of thorium-232 and thorium-228.

Parent: A radionuclide which disintegrates or decays to produce another nuclide which is also radioactive. This second radionuclide is known as the daughter product.

Periodic table: It is an arrangement of chemical elements based on the periodic law which is a law in chemistry whereby the elements, when arranged in the order of their atomic numbers show a periodic variation in most of their properties.

Picocurie (pCi): One-trillionth (10^{-12}) of a curie.

Rad: The unit of absorbed dose. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. One rad equals 0.01 joules/kilogram of absorbing material.

Plutonium (Pu): A radioactive metallic element with atomic number 94. The most common isotope has an atomic weight of 239. It is formed by the decay of neptunium that under goes slow radioactive decay with the emission of a helium nucleus (alpha particle) to form uranium-235. Minute quantities are associated with uranium in pitchblend, but it is mainly produced in nuclear reactors. Pu-239 has a half life of approximately 24,000 years.

Radiation: Energetic nuclear particles including neutrons, alpha particles, beta particles, x-rays, and gamma rays (nuclear physics). Also includes electromagnetic waves (radiation) of any origin.

Radioactivity: The property of certain nuclides of spontaneously emitting particles, or gamma radiation. Often shortened to "activity."

Radionuclide: A general term applicable to any radioactive form of the elements, a radioactive nuclide.

Radium (Ra): A radioactive metallic element with atomic number 88. As found in nature, the most common isotope has an atomic weight of 226. It occurs in minute quantities associated with uranium in pitchblend, carnotite, and other minerals; the uranium decays to radium in a series of alpha and beta emissions. By virtue of being an alpha- and gamma-emitter, radium is used as a souce of illuminescence and as a radiation source in medicine and radiography. The isotope of radium with an atomic weight of 228 is found in the thorium decay series.

Radon (Rn): The heaviest element of the noble gases, produced as a gaseous emanation from the radioactive decay of radium. Its atomic number is 86. All isotopes are radioactive. Rn-222 is an isotope with a half-life of 3.82 days.

Rare earths: A group of 15 chemically similar metallic elements, including elements 57 through 71 on the Periodic Table of the Elements, also known as the Lanthanide Series.

Rem: A special unit of dose equivalent, numerically equal to the absorbed dose in rads multiplied by various modifying factors for quantity, type, and distribution of the radiation.

Roentgen (R): A unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying one electrostatic unit of electrical charge (either positive or negative) in one cubic centimeter of dry air under standard conditions.

Scans: The process whereby successive small portions of an area or an object are examined in detail with a device capable of detecting the presence or localization of radioactive material.

Secular Equilibrium: The state which prevails when the rate of formation of a radioactive material equals the material's rate of decay. Although, by theory, this condition is never completely achieved, it is essentially established in the thorium decay series as it occurs in nature.

Survey: An evaluation of the radiation hazards incidental to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions.

Thorium (Th): A naturally occurring radioactive element with atomic number 90 and, as found in nature, an atomic weight of approximately 232.

Thorium series: The series (sequence) of nuclides resulting from the radioactive decay of thorium-232. Many man-made nuclides decay into this sequence. The end product of the sequence in nature is lead-208.

Uranium (U): A radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principle natural isotopes are uranium-235 (0.7 percent of natural uranium) and uranium-238 (99.3 percent of natural uranium). Natural uranium also includes a minute amount of uranium-234.

Uranium series: The series (sequence) of nuclides resulting from the radioactive decay of uranium-238. The end product of the series is lead-206.

EXPLANATION OF SYMBOLS AND UNITS

Symbols	Unit	English Equivalents
cm	centimeter (x 10^{-2} meters)	0.394 inches
g	gram	0.032 ounces
h	hour	------------
kg	kilogram (x 10^{3} grams)	2.2 pounds
km	kilometer (x 10^{3} meters)	0.622 miles
l	liter	0.264 gallons
m	meter	3.28 feet
ml	milliliter (x 10^{-3} liters)	0.061 cubic inches
mrem	millirem (x 10^{-3} rem)	------------
pCi	picocurie (x 10^{-12} curies)	------------
μCi	microcurie (x 10^{-6} curies)	------------
μrad	microrad (x 10^{-6} rads)	------------
μR	microroentgen (x 10^{-6} roentgens)	------------
Pu	Plutonium	------------
R	Roentgen	------------
Ra	Radium	------------
Rn	Radon	------------
U	Uranium	------------
Th	Thorium	------------
ha	Hectare	2.47 acres

APPENDIX F

GROUND PENETRATING RADAR AND
MEASUREMENT SURVEYS OF THE
NUCLEAR LAKE SITE

GC-TR-86-1734

GROUND PENETRATING RADAR AND MAGNETOMETRY SURVEYS OF THE NUCLEAR LAKE SITE; PAWLING, NEW YORK

Prepared for

RADIOLOGICAL SITE ASSESSMENT PROGRAM OF
OAK RIDGE ASSOCIATED UNIVERSITIES, INC.
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Prepared by

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Newton Centre, Massachusetts 02159

October, 1986

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1.0 INTRODUCTION

A geophysical survey integrating magnetometry, electrical resistivity, and ground penetrating radar (GPR) was conducted during the period of September 15-25, 1986, at the Nuclear Lake Site near Pawling, in Dutchess County, New York. This survey was performed under contract to the Oak Ridge Associated Universities (ORAU) in support of their assessment of the radiological conditions at the site.

The geophysical investigation consisted of two phases. Phase I consisted of land based GPR surveys of two separate areas on the site to identify the locations of subsurface septic tanks, drain pipes, and leaching fields. Phase II consisted of combined magnetometry and GPR surveys on the lake to identify the presence of metal drums in Nuclear Lake.

This report presents the results of both phases of the geophysical investigation along with site conditions encountered and field methods used. Theoretical bases of geophysical techniques utilized are also described. The results of this investigation will allow further radiological assessment of the site to proceed in a safe and efficient manner.

2.0 NUCLEAR LAKE SITE DESCRIPTION

The Nuclear Lake Site is a 1137 acre parcel that, in addition to the 53 acre lake, contains a number of structures: an access road, parking lots, buildings, land, and utilities (Figure 2.1). The site is heavily wooded and public access is restricted. A view of the area (Area A) over which the first of the two land based GPR surveys of Phase I was conducted is presented in Figure 2.2. Area A includes the wooded and paved area south of the plutonium facility and west of the waste disposal building, the paved parking lot area west of the plutonium facility and south of the engineering building, the wooded area north of the plutonium facility, and the grassy area west of the engineering building. A leaching field with subsurface piping is believed to be beneath the area west of the waste disposal building (per conversation with the ORAU on-site representative). Elevation remains fairly constant over this area.

A view of the area (Area B) over which the second of the two land based GPR surveys of Phase I was conducted is presented in Figure 2.3. Area B consists of a grassy area and gravel driveway south of the remote assembly building. A septic system associated with the remote assembly building is known to exist beneath this area (per conversation with the ORAU on-site representative). Elevation over this area increases from the gravel driveway to the base of the remote assembly building.

A view of Nuclear Lake, which was surveyed in Phase II, is presented in Figure 2.4. The lake is about 800 meters long by 300 meters wide with an average depth of about 13 feet. Near shore areas are fairly steep and rocky. The lake bottom is heavily littered with felled trees, many of which are exposed on the surface. A fairly thick layer of sediment was observed to blanket the lake bottom in near shore areas. A small island exists in the southern portion of the lake, northeast of the earthen dam area. An area of shallow rocks, some exposed above the surface of the lake, exists approximately 100 meters north of the small island. The shoreline of the lake is characterized by steeply dipping rock walls and heavily wooded areas. The lake water is murky due to high organic content and visibility with depth is limited. The lake surface remained fairly calm throughout the duration of the survey.

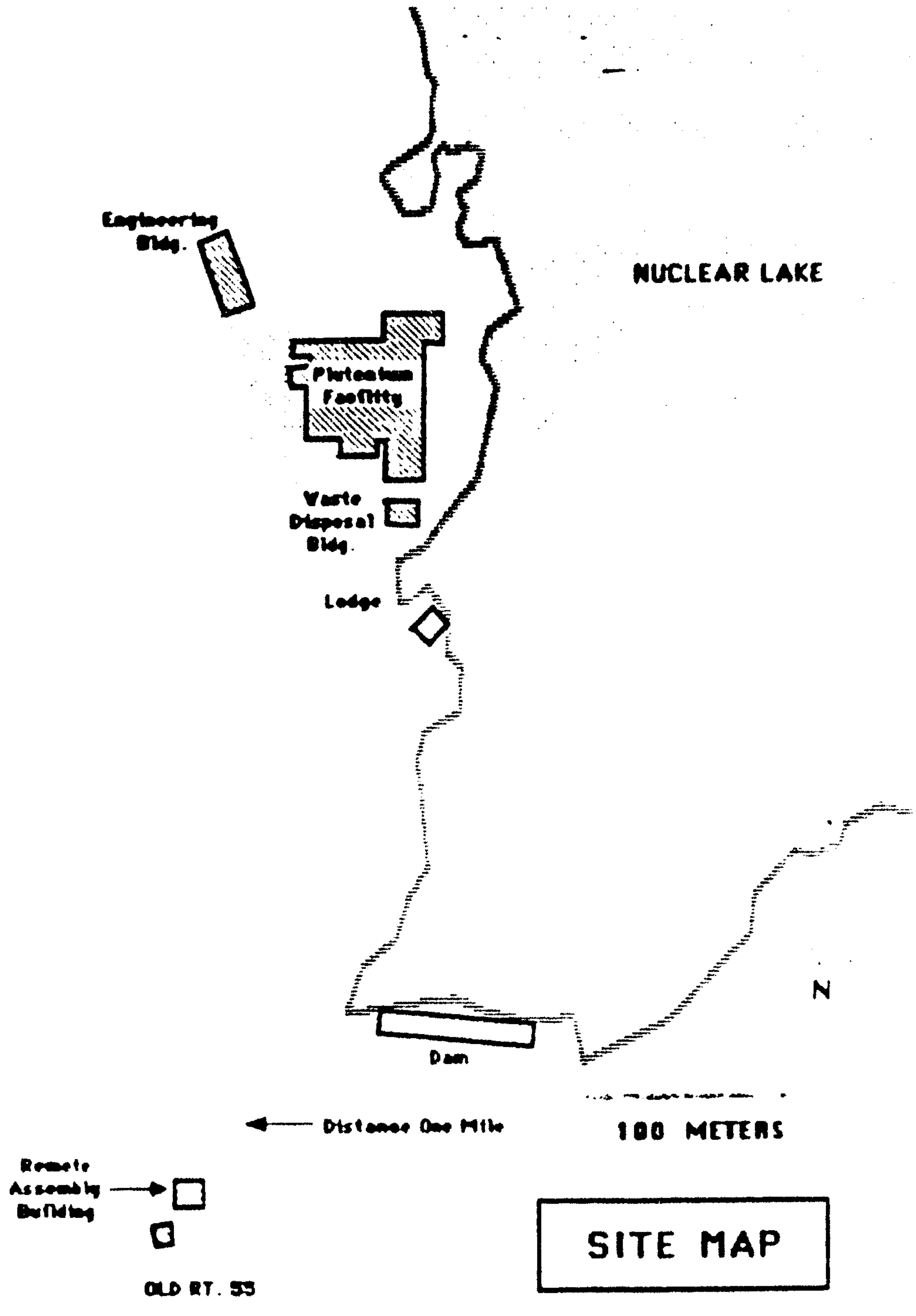


Figure 2.1. Map of the Nuclear Lake site near Pawling, in Dutchess County, New York.

(A) East facing view of wooded and paved area south of the plutonium storage facility.

(B) North facing view of paved area west of the plutonium storage facility and south of the engineering building.

Figure 2.2. Views of Area A.

Figure [illegible]. View of Area B. Pictured are the gravel driveway and grassy area south of the remote assembly building.

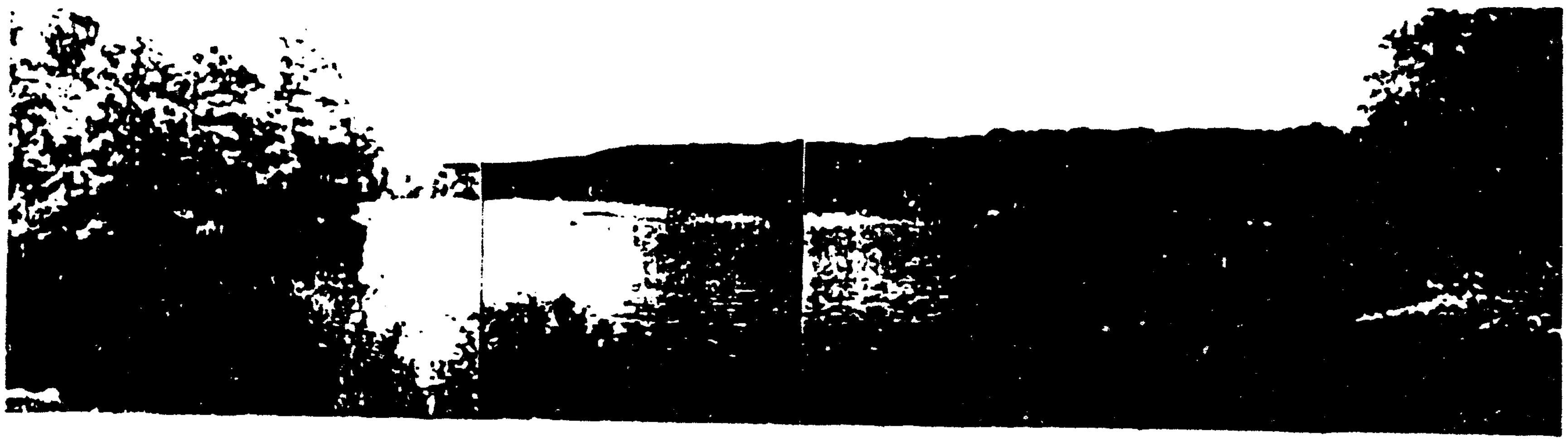


Figure 2.4. View of Nuclear Lake as observed from the earthen dam area facing north.

3.0 FIELD OPERATIONS

3.1 Area A

A grid system with 5 meter centers was established over Area A. Bulk resistivity measurements using a Wenner spread (Figure A-3) with a spacing of a = 1 meter were used for the purpose of estimating the maximum possible depth of electromagnetic penetration. The average of two readings taken along the 5 east line (Figure 3.1.1) just west of the asphalt parking lot was 310 ohm-meters (3.27×10^{-3} Si/meter). From Figure A-1 and soil conditions at the site, the maximum depth of electromagnetic penetration with the 300 MHz antenna was estimated to be 23 feet.

The antenna was manually towed over the site at a rate of about 1 ft/sec. A series of radar scan lines spaced 1 meter apart were run from west to east between the 40 and 70 south lines south of the plutonium facility and west of the waste disposal building. Another series of scan lines was then run from south to north over the same area between the 5 and 25 east lines (Figure 3.1.1).

A series of radar scan lines spaced 2.5 meters apart were run from west to east between the 0 and 20 south lines (Figure 3.1.2). Another series of scan lines spaced 5 meters apart was then run from south to north between the 15 east and 20 west lines. A time window of 100 nsec was used for these scans. Four scan lines spaced 1 meter apart were also run from south to north over a suspected burial pit northwest of the plutonium facility. A time window of 160 nsec was used for these scans in an effort to attain deeper penetration into the ground.

3.2 Area B

A grid system with 5 meter centers was established over Area B (Figure 3.2.1). The 300 MHz antenna was manually towed over this area at a rate of about 1 ft/sec. A series of radar scan lines spaced 5 meters apart was run from the area south of the gravel driveway towards the remote assembly building to the north. Another series of radar scan lines, spaced 1 meter apart, was then run from west to east over the same area. A time window of 100 nsec was used for these scans.

3.3 Nuclear Lake

A grid system with 100 meter centers was established on Nuclear Lake. Marker buoys were located at points of intersection (Figure 3.3.1). A rope extended along the 0 east line across the center of the lake served as a center line and main positional reference for geophysical surveys on the lake. Marker buoys were attached at intervals of 10 meters along ropes extended along the 300 and 600 south lines from the center line to both the eastern and western shores of the lake.

The magnetometry survey of Nuclear Lake was conducted with a Forster Ferex 4.021 fluxgate magnetometer. A series of north-south trending scan lines spaced 10 meters apart were conducted at an approximate rate of 0.5 meters/sec over the entire surface of the lake (Figure 3.3.2). A dead reckoning method utilizing an on-board compass and the marker buoys located along the 300 and 600 south lines was used to maintain course heading along each line.

Each scan was conducted with the sensor probe of the magnetometer suspended from a wooden boom extended a distance of 1.5 meters from the stern of the survey boat (Figure 3.3.3). With the exception of shallow areas, the sensor probe was towed a distance of 4 meters below the surface of the lake. A non-metallic weight was attached to the sensor head to maintain this depth.

The magnetometer was turned on and warmed up for approximately 15 minutes before conducting any scans. The control unit was placed into the static difference mode and the sensitivity switch was set to position 3. This configuration provided for a full scale deflection of ± 30 gammas and provided audio output upon the detection of vertical magnetic gradients in excess of ± 6 gammas per 40 cm of probe separation. The Forster gradiometer, in this configuration, is capable of the detection of a 55 gallon steel drum located a maximum distance of about 3 meters from the sensor probe. Due to time constraints and positioning difficulties, a line spacing of 10 meters was used which meant that a zone of about 4 meters in width between lines may not have received adequate coverage. It was possible, however, to increase the instrument sensitivity in many of the deeper areas to provide audio output upon the detection of smaller gradients and, therefore, reduce the width of this zone considerably.

Upon the detection of an anomalous gradient, via the audio output of the control unit, the instrument sensitivity was decreased by switching the sensitivity switch to position 10. This sensitivity setting provided audio output upon the detection of magnetic gradients in excess of ± 20 gammas per 40 cm of probe separation. The immediate area was scanned and a marker buoy was dropped overboard if audio output was still observed.

Diurnal variations in the total magnetic field intensity were recorded by repeatedly measuring the total magnetic field intensity at fixed base station location on the island in the middle of the lake throughout the duration of the survey. The diurnal was found not to vary by more than 34 gammas per survey period.

The radar survey of Nuclear Lake was conducted with the 300 MHz antenna suspended from a wooden platform a distance of 5 feet from the stern of the survey boat directly on the surface of the lake (Figure 3.3.4). Six parallel north-south trending radar scans spaced 10 meters apart were run over the center of the lake between the 5 west and 60 east lines. Another north-south trending scan line was also run along the 100 east line (Figure 3.3.5). Radar scans were then run over areas of anomalous magnetic gradient previously detected and marked in the magnetic survey of the lake (Figure 3.3.5).

The horizontal beam width of the Geophysical Survey Systems, Inc. (GSSI) 300 MHz antenna used in this survey is ± 45° (Figure A-3). The width of the zone of total coverage of the lake bottom on either side of a radar scan is, therefore, equal to the depth of the lake at any particular point along the line. Nearly 100 % coverage of the lake bottom was achieved in the area between the 5 west and 60 east lines over which the six parallel northsouth scans were conducted. This estimate is based upon an average lake depth of 15 feet (4.57 meters) observed over this area and a line spacing of 10 meters.

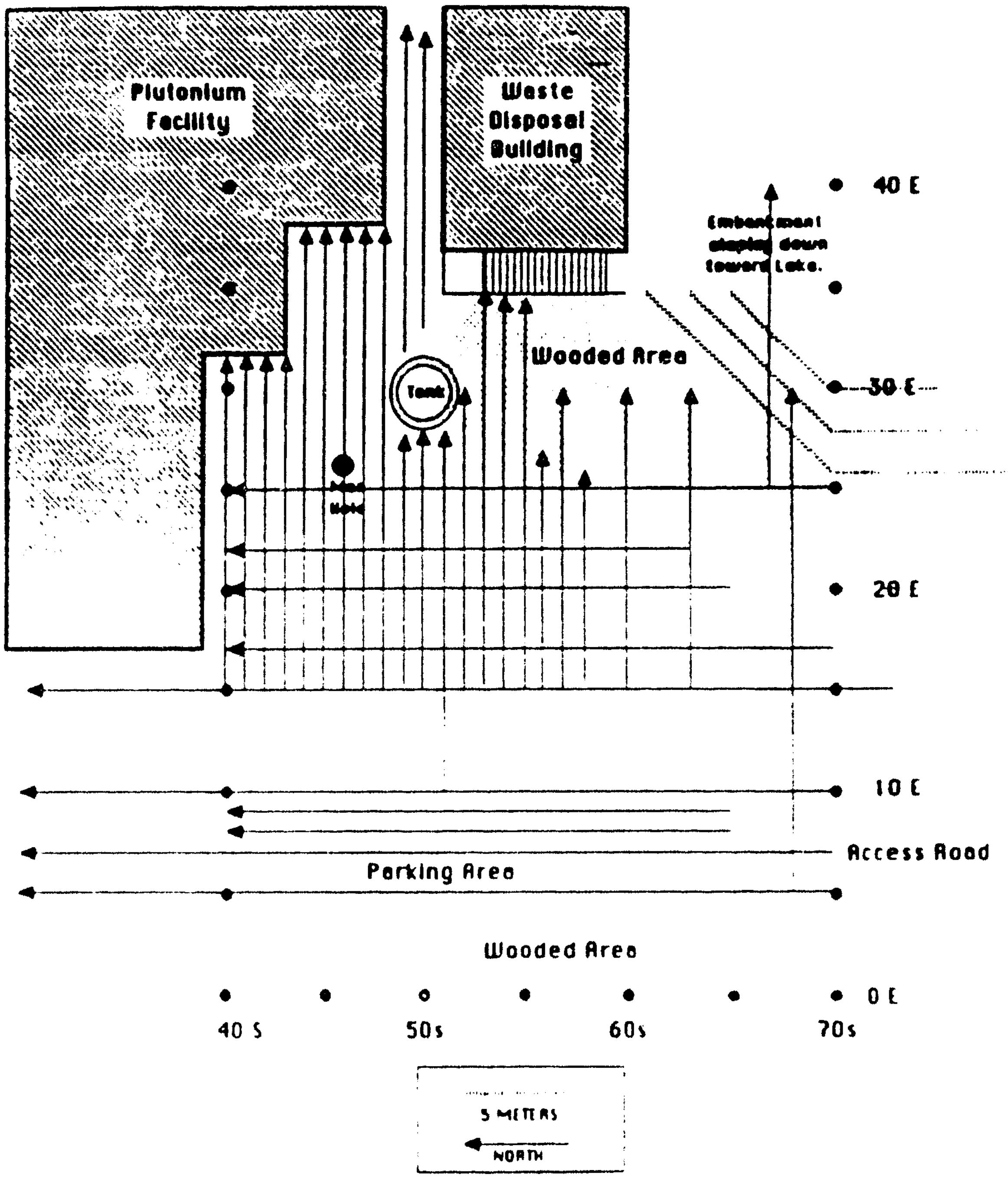


Figure 3.1.1. Radar scan lines conducted over the wooded and paved area south of the plutonium storage facility in Area A.

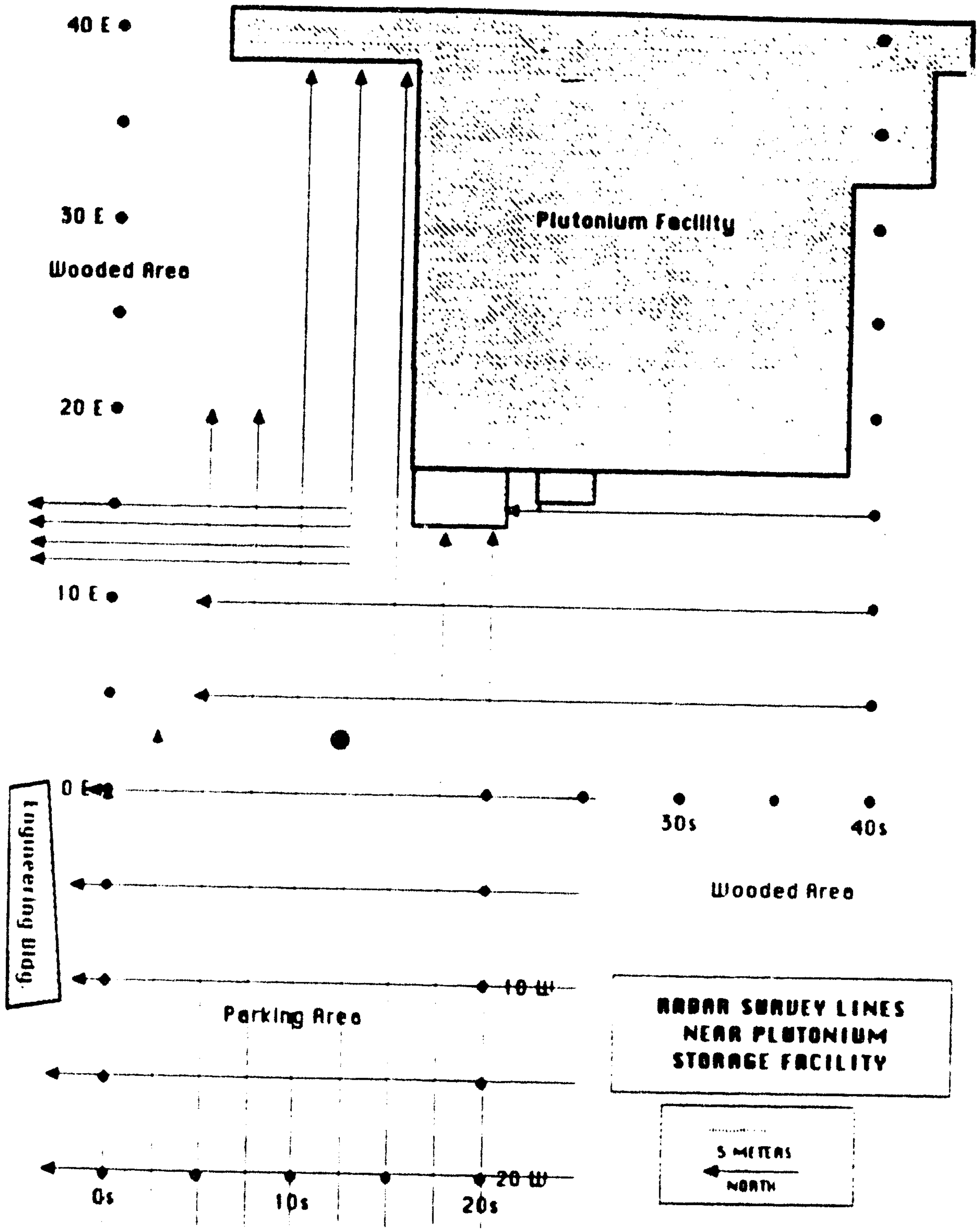


Figure 3.1.2. Radar scan lines conducted over the paved area west of the plutonium storage facility and south of the engineering building in Area A.

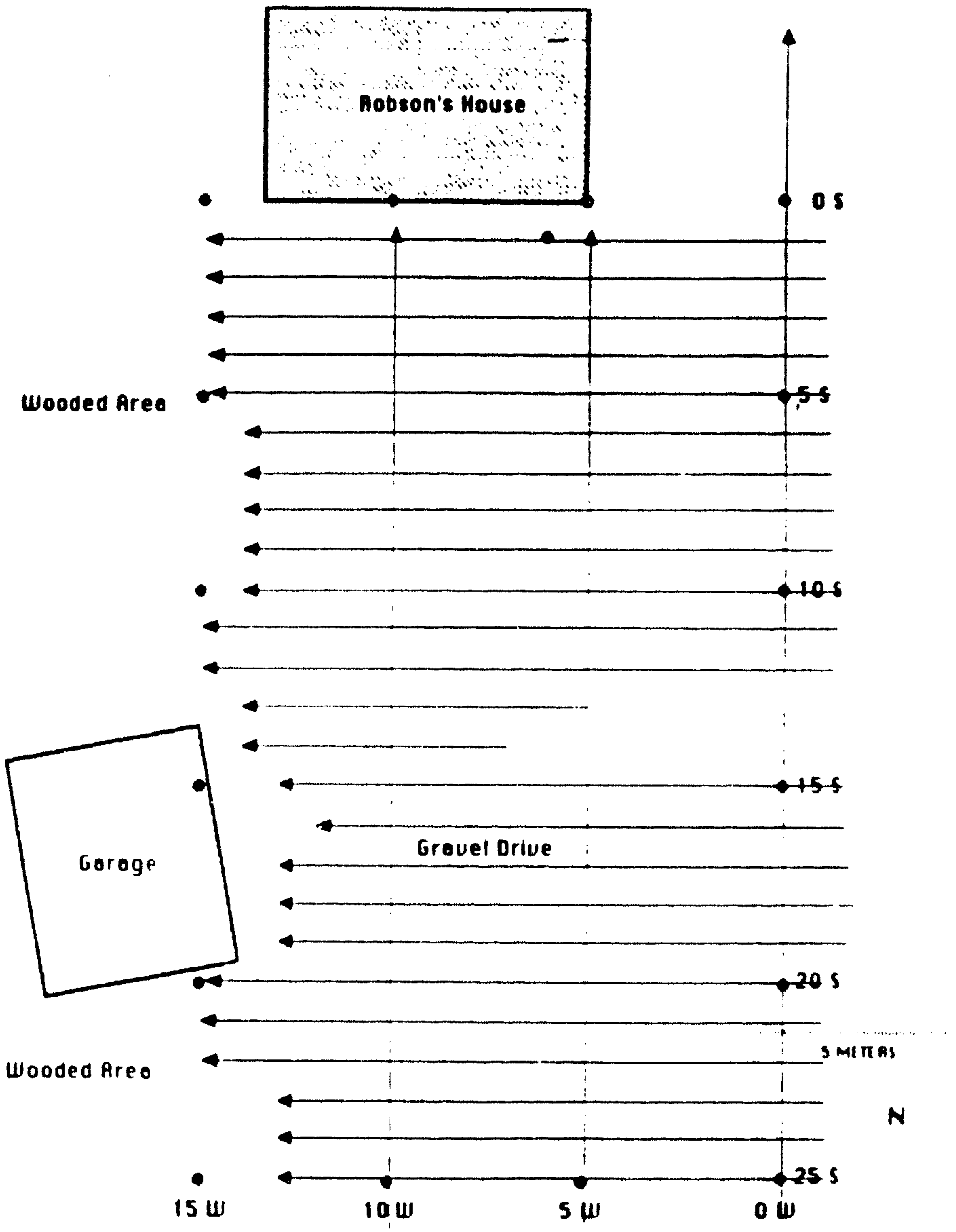


Figure 3.1.1. Radar scan lines conducted over the gravel driveway and the grassy area south of the remote assembly building in Area B.

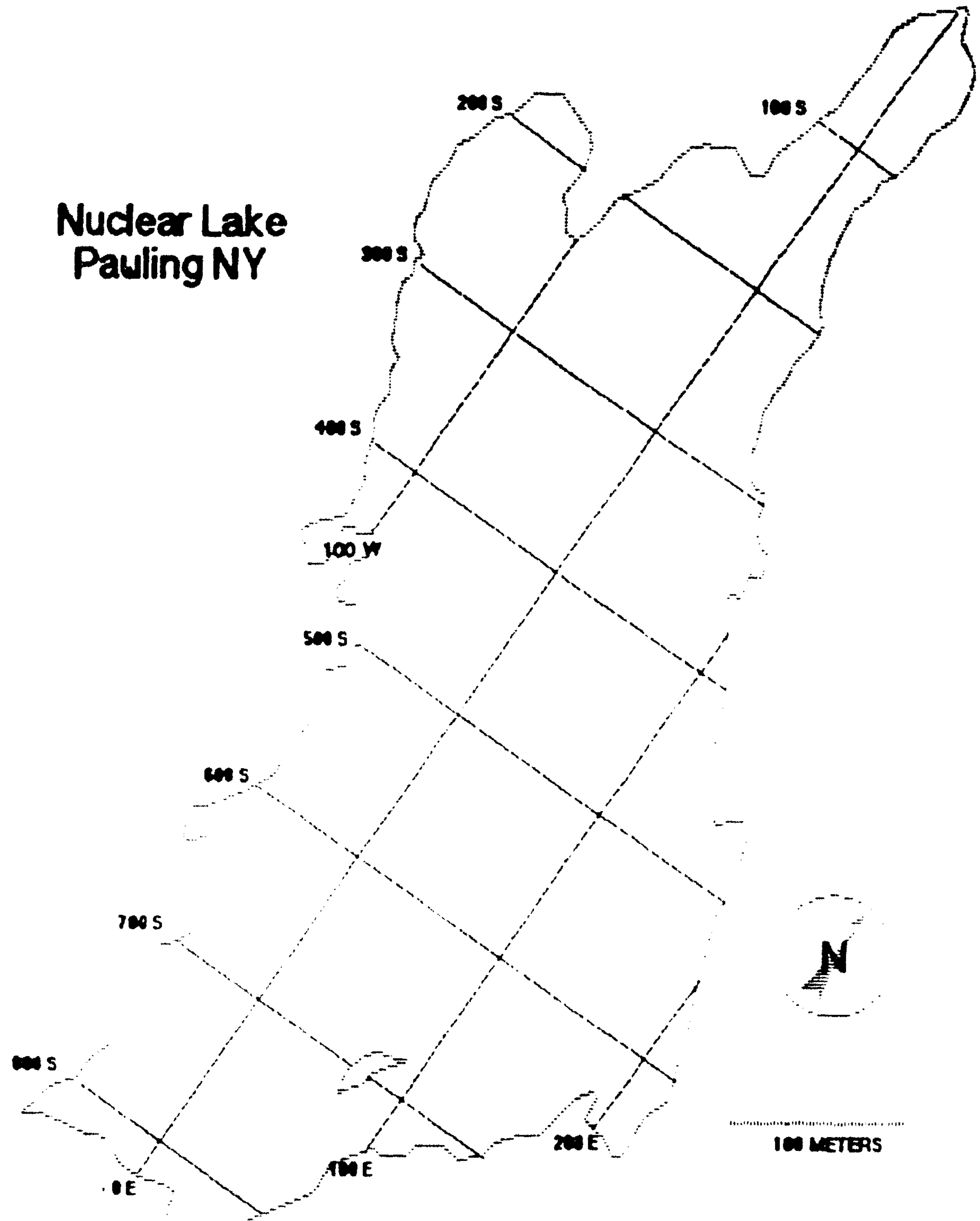


Figure 3.3.1. Grid system with 100 meter centers established on Nuclear Lake.

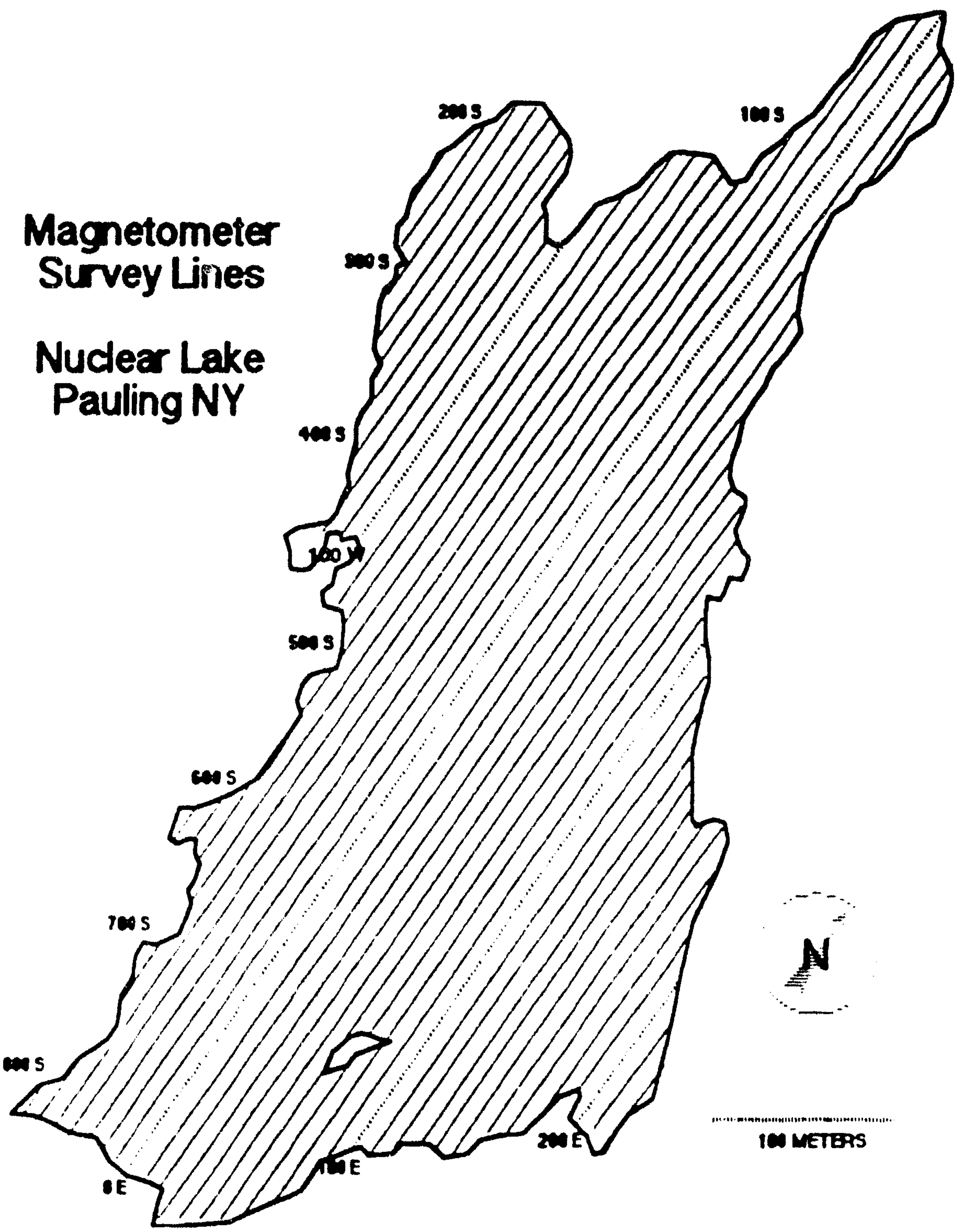


Figure 3.3.2. Magnetic scan lines conducted over Nuclear Lake.

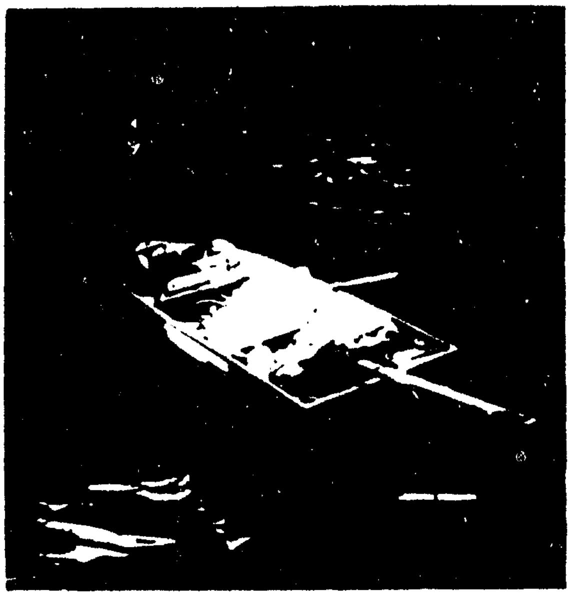
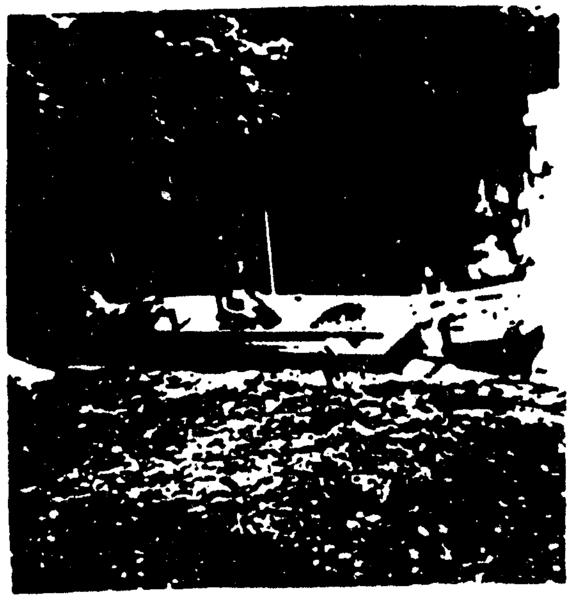


Figure 3.3.3. Survey boat equipped for the magnetic survey of Nuclear Lake.



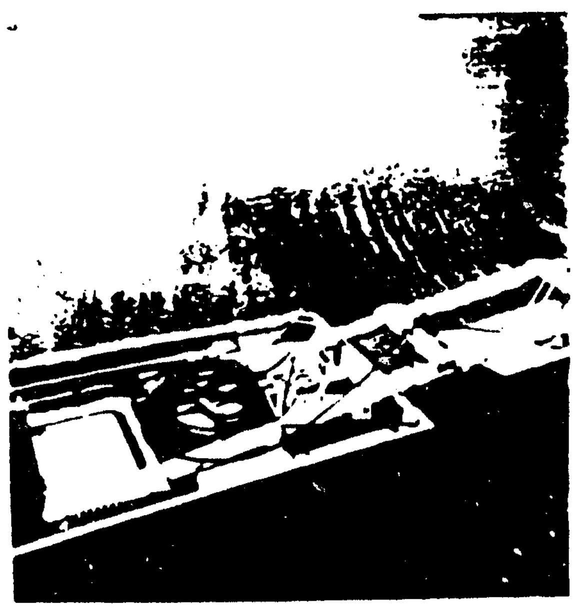


Figure 3.3.4. Survey boat equipped for GPR survey of Nuclear Lake.

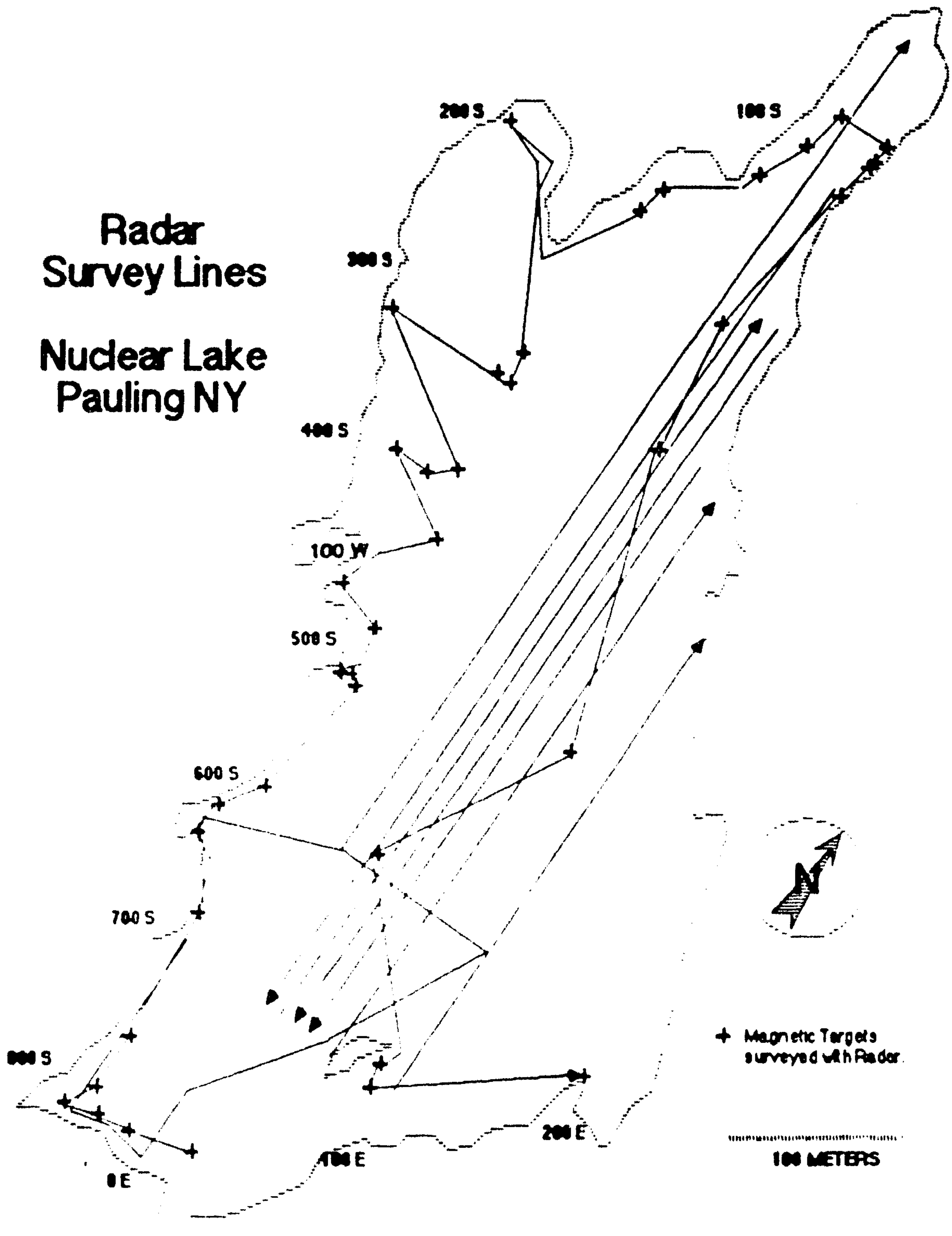


Figure 3.3.5. Radar scan lines conducted over Nuclear Lake.

4.0 DISCUSSION OF RESULTS

4.1 Area A

The soil in this area was observed to be fairly sandy with high water content. The velocity of electromagnetic propagation was, therefore, estimated to be 4.35 cm/sec from Table A-1 and Equation A-1. This value was then used to obtain depth estimates to subsurface reflectors observed in radar profiles taken over this area.

Typical examples of radar profiles obtained are displayed in Figures 4.1.1 and 4.1.2. Figure 4.1.1 is a radar profile obtained over the paved area along the 20 east line south of the plutonium facility. Hyperbolae corresponding to reflections from eight underground pipes are prominently displayed in the profile. Figure 4.1.2 is a radar profile obtained over the grassy area along the 12.5 south line north of the plutonium facility. A deep reflective mass, approximately 11 feet deep, is observed in this profile.

Figure 4.1.3 presents a map of subsurface features observed in radar profiles taken over the area south of the plutonium facility in Area A. The location and extent of each underground pipe were marked directly on the pavement with spray paint upon completion of the survey. With the exception of two pipes running from the plutonium facility to the cement retention tank, all pipes in the area appear to be associated with a manhole near the center of the parking lot. The suspected leaching field is believed to exist beneath the wooded and paved area west of the waste disposal building near the access road.

Figure 4.1.4 presents a map of subsurface features observed in radar profiles taken over the area north and west of the plutonium facility in Area A. A total of three shallow underground pipes were observed in this area, none of which are believed to be associated with the manhole near the center of the parking lot. Other features of interest include a deep reflective mass beneath the grassy area north of the plutonium facility and an area of disturbed earth indicative of a possible trench. A weak reflection was observed to exist at an approximate depth of 9 feet beneath this area. Radar scans along lines 15 and 20 west were continued north along the western side of the engineering building. However, no features of interest were observed.

4.2 Area B

The soil in this area is fairly similar to that of Area A. The same velocity of electromagnetic propagation was, therefore, used to obtain estimations of depths to subsurface reflectors. Typical examples of radar profiles obtained are displayed in Figures 4.2.1 and 4.2.2. Figure 4.2.1 is a radar profile obtained along the 15 south line, south of the former remote assembly building. A shallow underground pipe, approximately 1.5 feet deep is observed in this profile. Figure 4.2.2, a radar profile obtained along the 0 west line, displays the deep reflector observed to exist southeast of the former remote assembly building.

Figure 4.2.3 presents a map of subsurface features observed in radar profiles taken over Area B. Features of interest include three shallow underground pipes associated with a septic system currently in use at the building, a shallow reflector adjacent to the building, a deep reflector southwest of the building, and three areas of shallow metallic debris in the southern portion of the site. The location and extent of these features were marked with spray paint on the ground surface of the area upon completion of the survey.

4.3 Nuclear Lake

Figure 4.3.1 presents a map of magnetic targets detected with the Forster fluxgate gradiometer during the magnetometry survey of Nuclear Lake. Targets are numbered and the approximate coordinates of each are listed in Table 4-1. As previously mentioned, each target corresponds to a magnetic gradient in excess of ± 20 gammas. Actual target locations may differ by as much as ± 5 meters from marked locations due to positioning difficulties on the lake encountered during the survey. Many of the targets observed near the shore of the lake are believed to be associated with bedrock outcroppings.

Figure 4.3.4 presents a map of prominent reflectors observed in radar profiles taken over Nuclear Lake. The approximate location, depth, and size of each reflector are presented in Tables 4-2 and 4-3. Reflective targets detected in the GPR survey of the lake appear to be fairly isolated, and most exist between the 300 and 500 south lines, east of the 0 east line. Reflective targets corresponding to magnetic targets are associated with magnetic gradients greater than ± 20 gammas. Reflective targets that do not correspond to magnetic targets possess magnetic gradients less than ± 20 gammas. Due to positioning difficulties encountered during the lake surveys, the possibility exists that GPR scans may not have been run directly over each magnetic target previously detected. Therefore, magnetic targets that do not correspond to reflective targets can not be ruled out as possible metallic objects.

TABLE 4-1

Estimated Coordinates of Magnetic Targets Located on Nuclear Lake

Magnetic Target Number	Location	Target Number	Location
1	805S, 10W	21	320S, 85W
2	807S, 30W	22	320S, 75W
3	813S, 60W	23	300S, 80W
4	795S, 44W	24	190S, 172W
5	760S, 35W	25	190S, 70W
6	680S, 55W	26	177S, 60W
7	653S, 77W	27	135S, 20W
8	620S, 77W	28	106S, 10W
9	595S, 65W	29	80S, 5W
10	512S, 68W	30	80S, 30E
11	510S, 65W	31	90S, 30E
12	512S, 60W	32	95S, 30E
13	485S, 58W	33	120S, 35E
14	467S, 87W	34	220S, 5E
15	440S, 85W	35	300S, 20E
16	420S, 58W	36	475S, 75E
17	390S, 110W	37	593S, 10E
18	390S, 90W	38	686S, 85E
19	390S, 70W	39	707S, 90E
20	330S, 152W	40	630S, 190E
		41	795S, 20E

TABLE 4-2

Estimated Coordinates and Depths of Reflective Targets
Detected in GPR Survey of Nuclear Lake

Scan Line (meters)	Location Along Scan (meters)	Depth (feet)	Size (meters)
5W	353S	11	1.7
5W	557S	15	1.6
10E	180S	10	0.7
10E	343S	11	1.3
10E	364S	11	2.0
10E	400S	11	0.6
10E	473S	12	1.0
20E	372S	11	0.8
20E	464S	12	2.0
30E	362S	10	1.3
30E	442S	12	0.9
60E	338S	9	2.5
60E	358S	10	1.8
60E	402S	11	1.5
100E	485S	12	1.6
100E	541S	12	0.6

TABLE 4-3

Estimated Depths of Reflective Targets Corresponding to Magnetic Targets Previously Detected in the Lake

Magnetic Target Number	Depth (feet)	Size (meters)
7	4	0.3
10	2	0.3
11	5	0.3
17	6	0.3
19	10	0.6
26	8	0.2
27	4	0.2
28	3	0.1
29	4	0.6
33	3	0.3
38	1	0.2
39	7	0.2

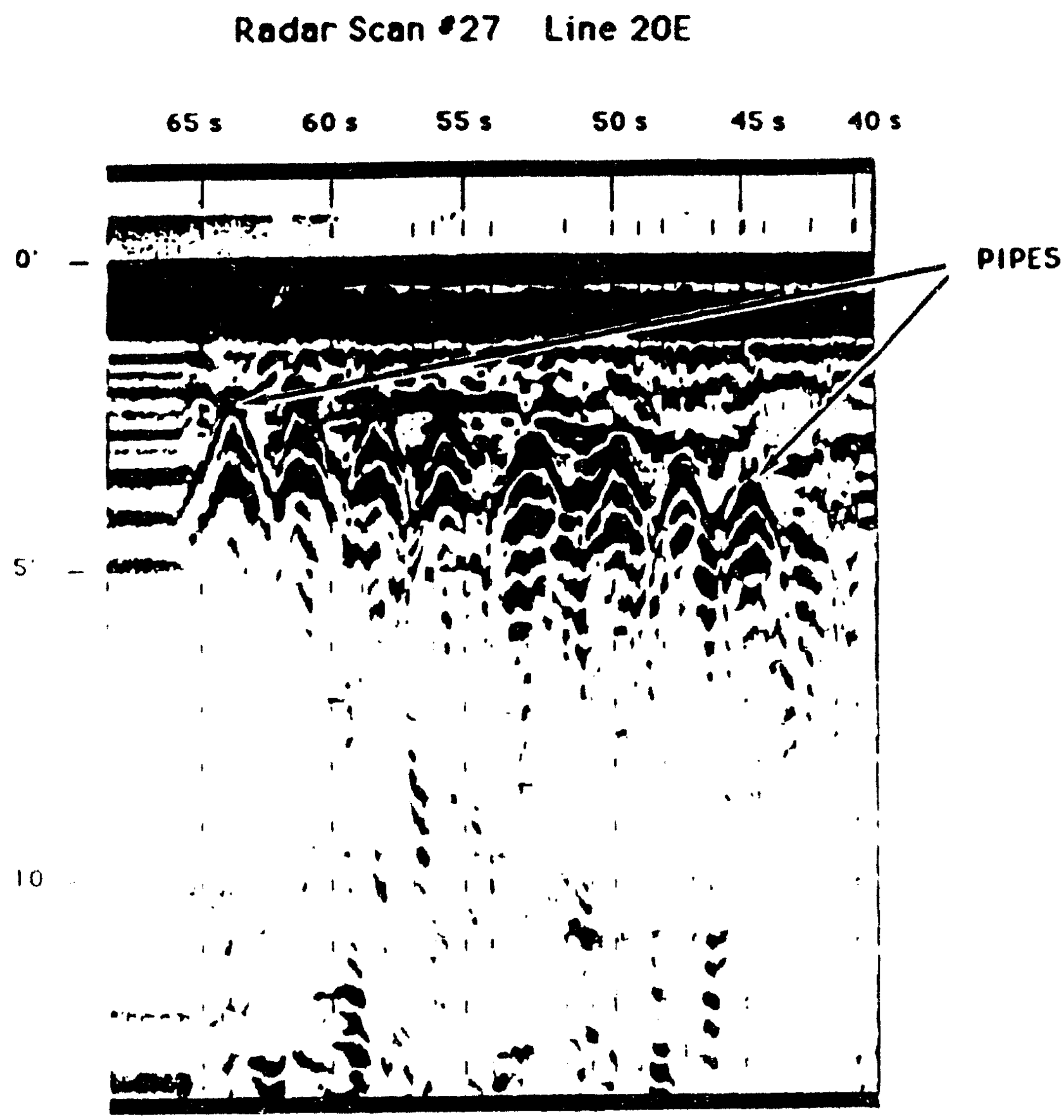


Figure 4.1.1. Radar profile taken along the 30 east line south of the plutonium storage facility.

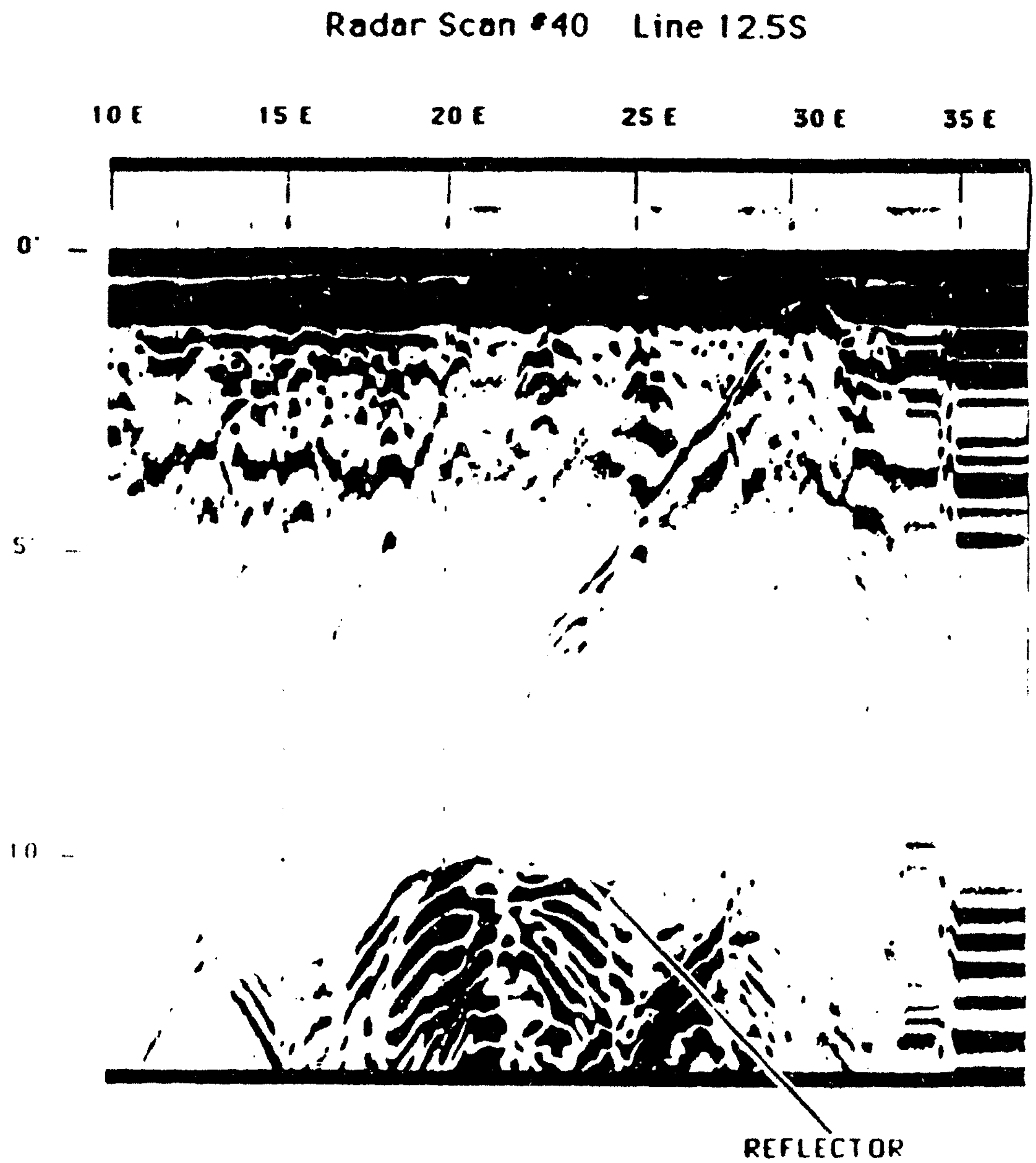


Figure 4.1.2. Radar profile taken along the 12.5 south line north of the plutonium storage facility.

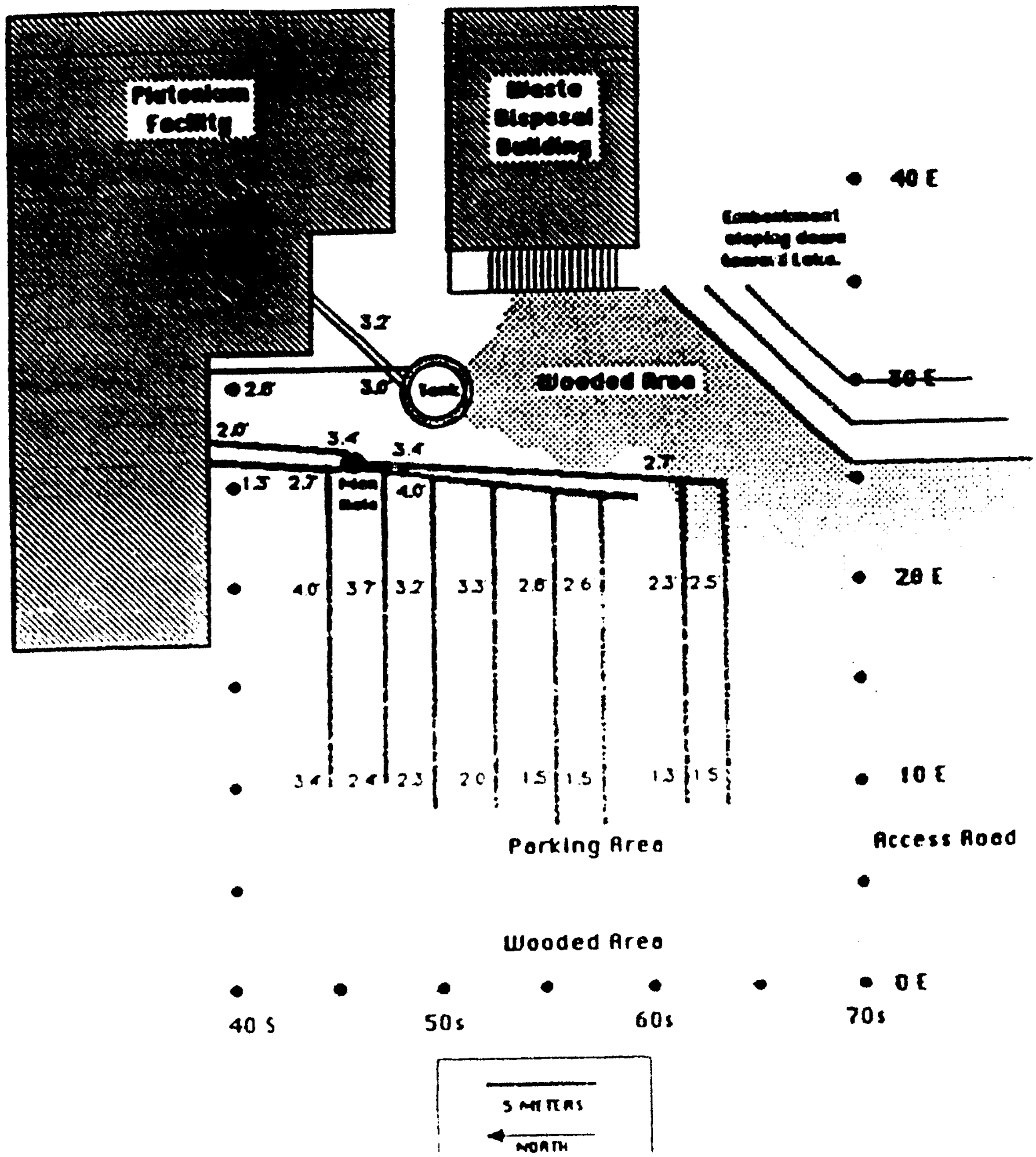


Figure 4.1.3. Map of subsurface features observed in radar profiles taken over the area south of the plutonium storage facility in Area A. Approximate depths, in feet, subsurface features are as indicated.

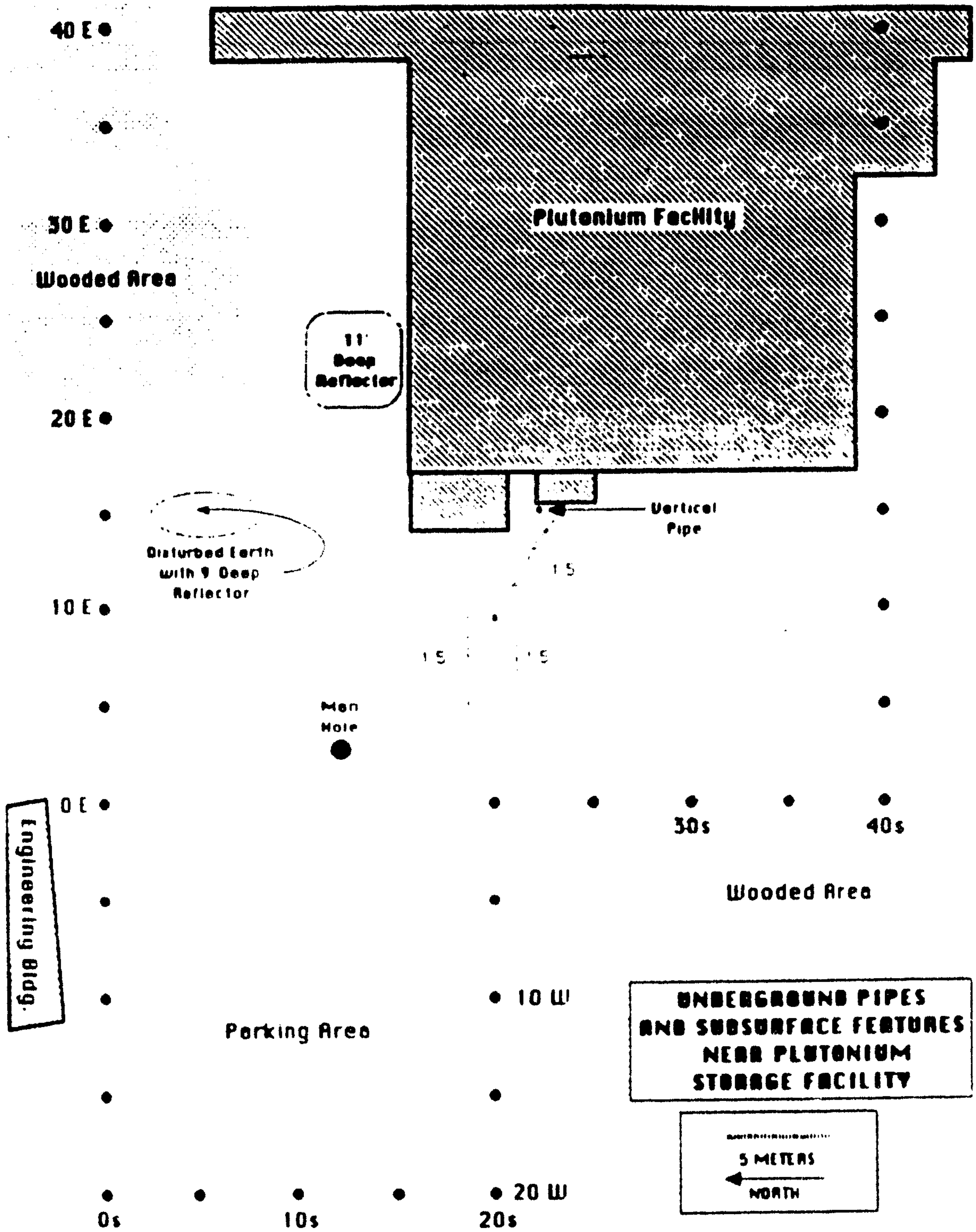


Figure 4.1.4. Map of subsurface features observed in radar profiles taken over the area north and west of the plutonium storage facility in Area A.

Radar Scan #62 Line 15S

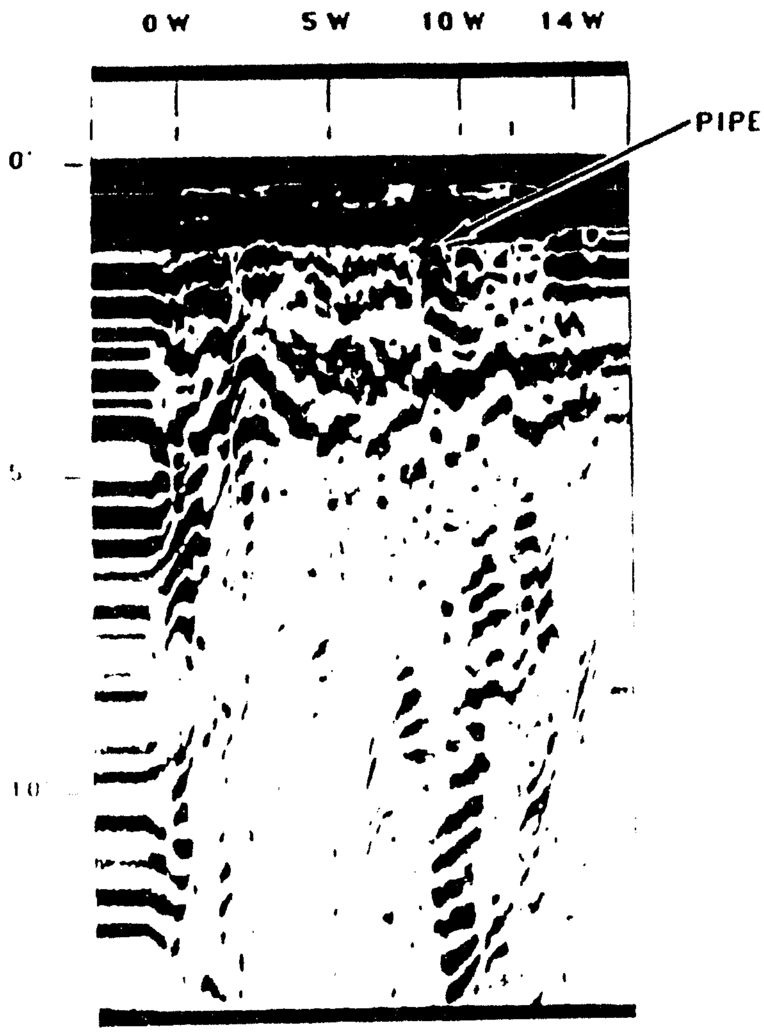
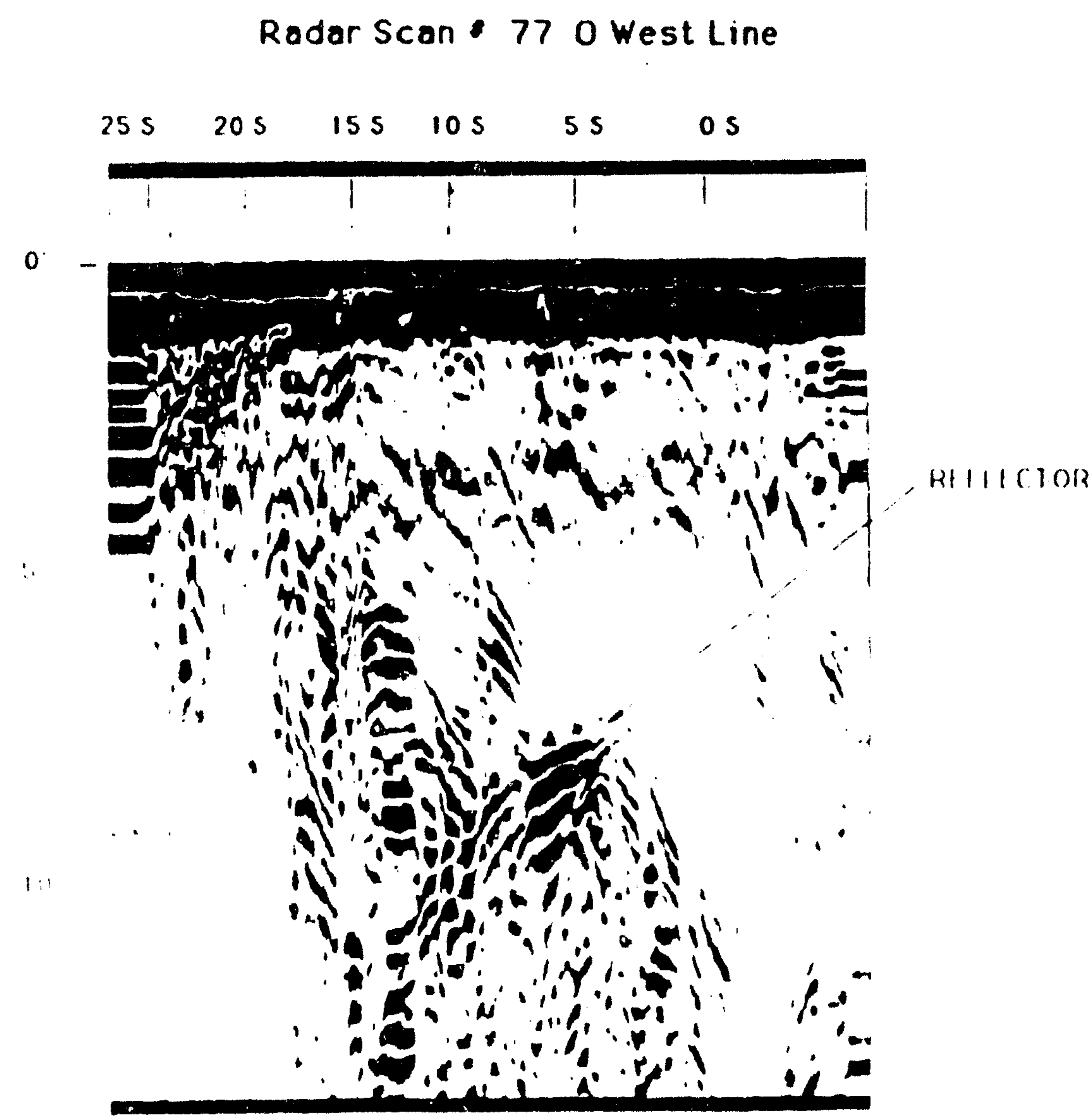


Figure 4.2.1. Radar profile taken along the 15 south line, south of the former remote assembly building in Area 5, displaying the signature of a shallow pipe.



[illegible] along the [illegible] West line [illegible] assembly building in Area [illegible] reflector.

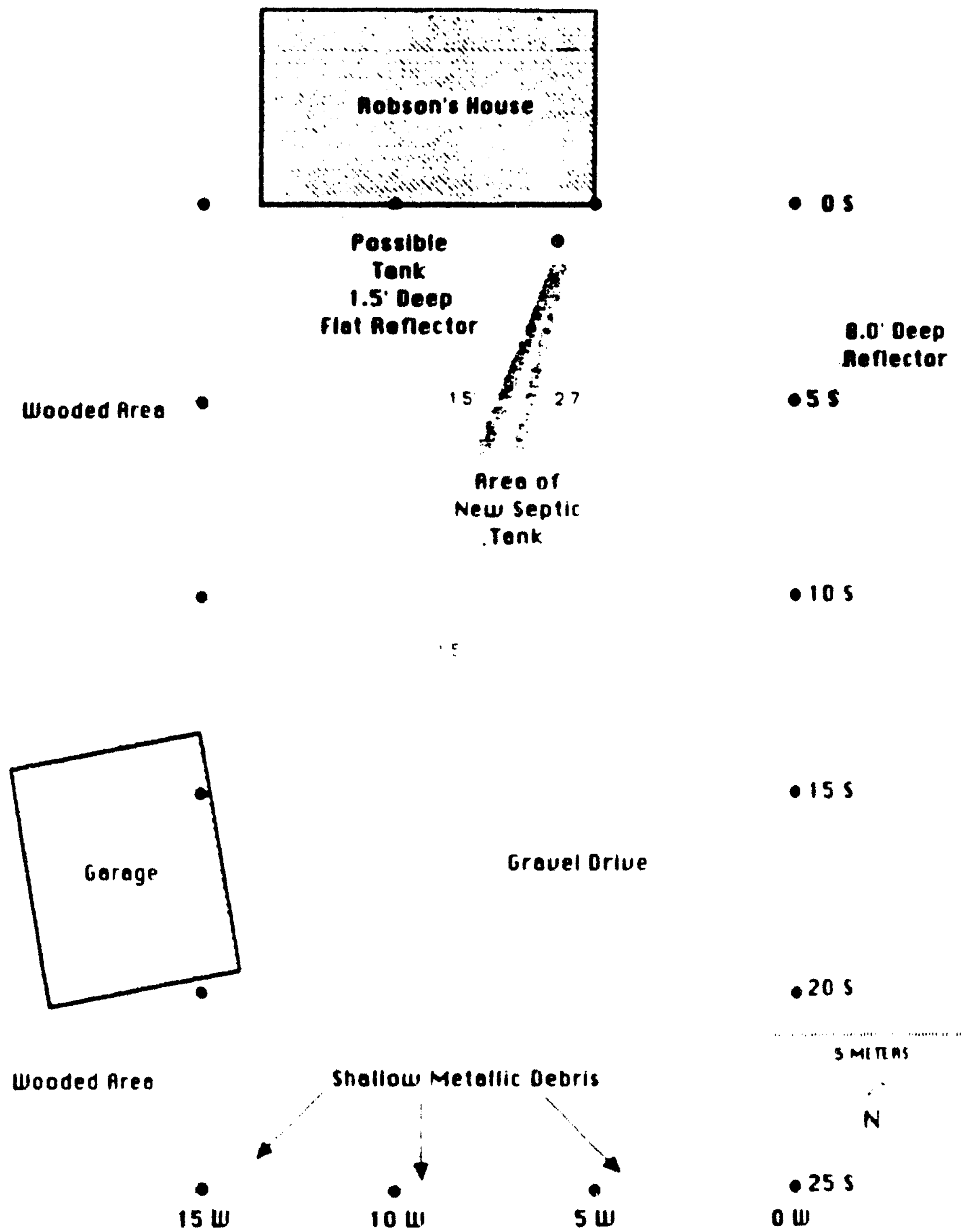


Figure 4.1.3. Map of subsurface features observed in radar profiles taken over the area south of the remote assembly building in Area B.

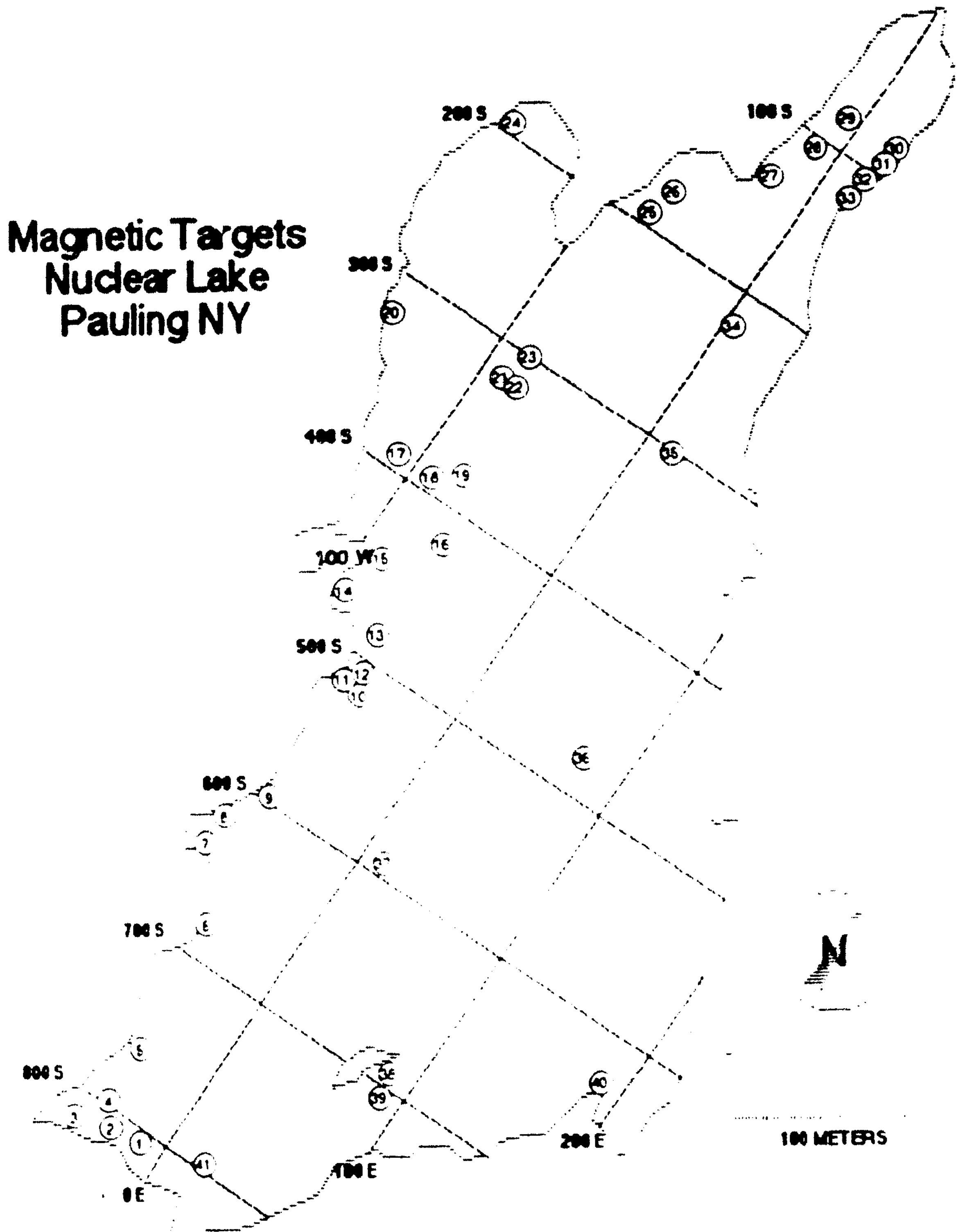
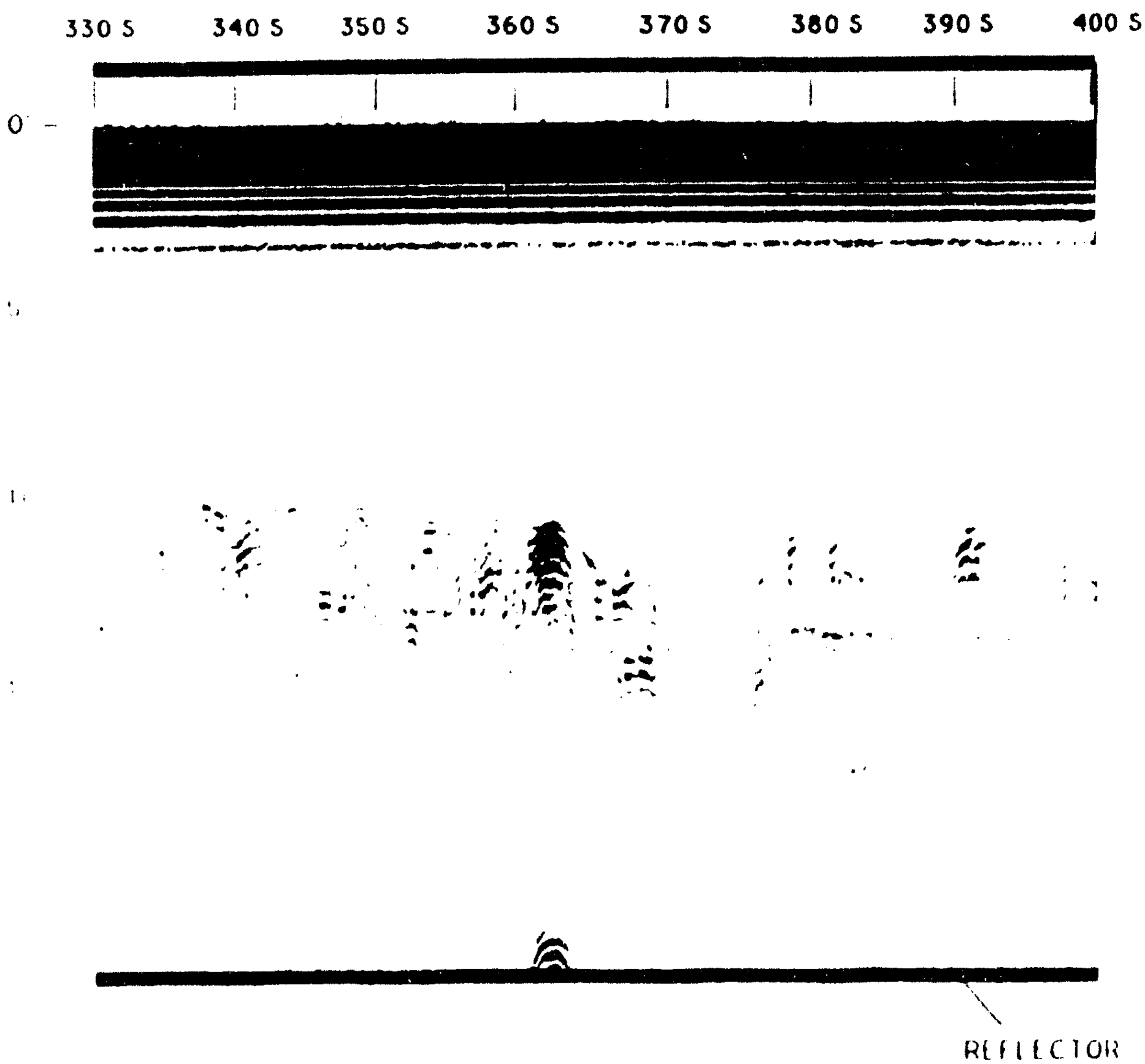


Figure 4.1.1. Map of magnetic targets observed in the magnetometry survey of Nuclear Lake.

Lake Radar Scan Line 30 E



Radar Scan to Calibrate Depth of Lake Bottom

Approximate depth to Metal reflector on lake bottom 13'

Figure 4.3.3. Radar profile taken over a reflective target at a known depth of 13 feet.

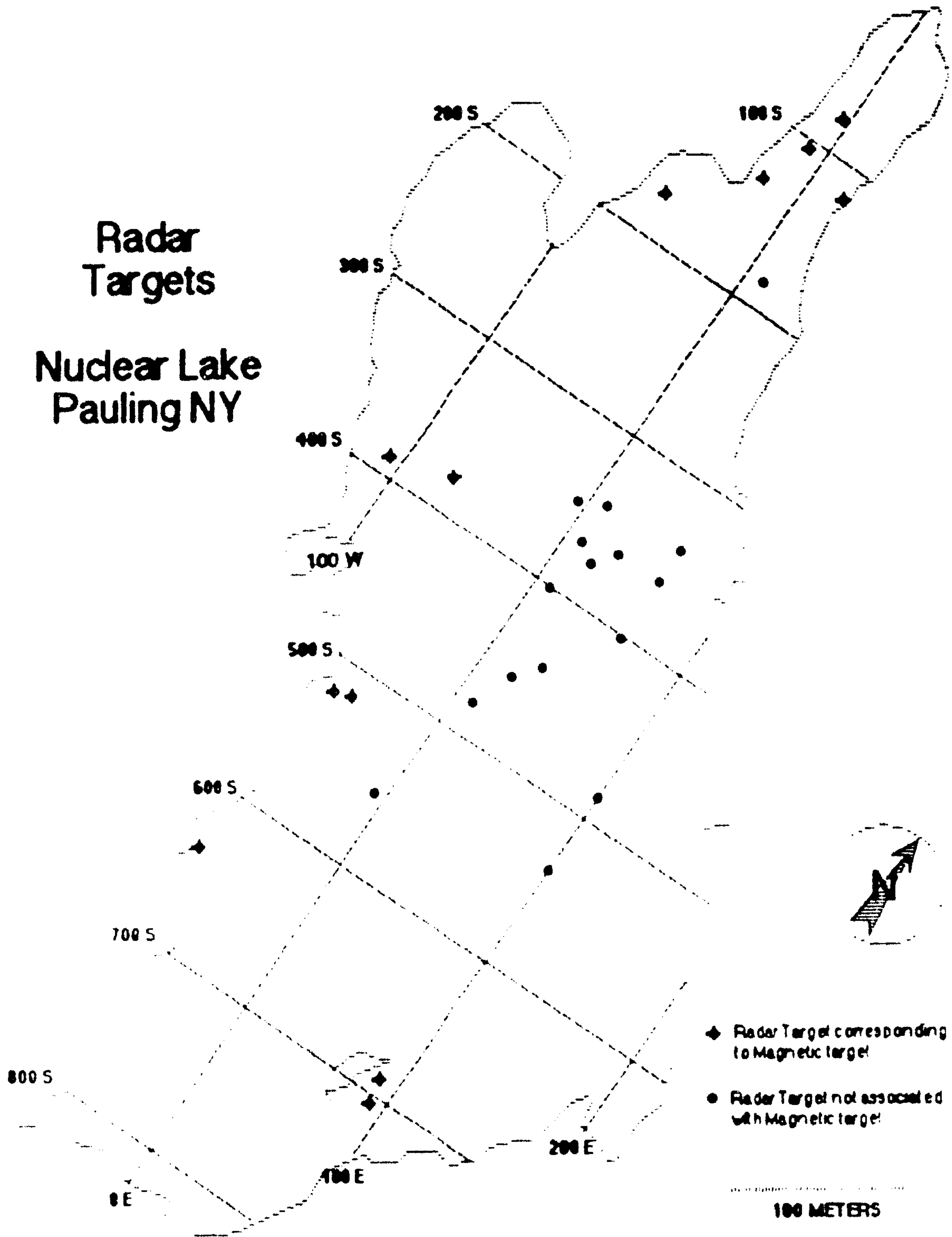


Figure 4.3.4. Map of reflective targets observed in the GPR survey of Nuclear Lake.

5.0 CONCLUSIONS

The radar data acquired in the GPR surveys of Areas A and B is of high quality. Soil in the area is such that penetration depths in excess of 20 feet were attained. Radar scan lines conducted over each area were spaced so as to provide maximum site coverage as well as accurate locations of underground pipes and subsurface features observed in the data.

Navigation was a major problem in surveys conducted on Nuclear Lake. Actual scans may have deviated by as much as 5 meters east or west of desired course headings due to wind currents. The possibility exists that some targets may have gone undetected. Of primary concern was the fact that the center line extended along the 0 east line across the lake stretched significantly throughout the course of the survey. Markers placed along this line at 100 meter centers were observed to have deviated by as much as 10 meters north or south of the desired location.

Appreciable concentrations of magnetic or reflective targets were not observed at any one location on the lake. The results of the lake survey, however, does indicate the presence of random metallic objects on the lake bottom. It is GEO-CENTERS' opinion that targets indicate in Tables 4-1, 4-2, and 4-3 warrant further investigation.

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GC-TR-86-1734

APPENDIX A:

Geophysical Field Measurement Techniques

Geophysical Field Measurement Techniques

This section describes the geophysical techniques used in this survey. Section A.1 reviews the theory of GPR, and Section A.2 describes GPR instrumentation. Section A.3 reviews the theory and technique of electrical resistivity. Section A.4 reviews the theory of magnetometry and provides a description of how the technique was used in this survey.

Ground Penetrating Radar

The principle of ground penetrating radar (GPR) involves the generation of a wavetrain of electromagnetic radiation in the frequency range of 10 to 1000 MHz at the surface of the earth. In accordance with the laws of classical electromagnetism, the wave propagates through the subsurface with material dependent attenuation. When the wavetrain encounters interfaces between materials of different electromagnetic properties, the wave is partially reflected. This reflected energy is then detected by the surface receiver, and the travel time between transmission and detection is recorded. If the velocity of propagation is known, the time interval measured can be converted into a depth.

The velocity of propagation of the electromagnetic wave through the earth can be determined as a result of the calibration process. For earth materials with a relatively effective dielectric constant, ϵ_{er}, the velocity of propagation, v_m, of the electromagnetic wave is approximated by:

$$v_m = \frac{\omega}{\beta} = \frac{c}{\epsilon_{er}^{1/2}} \qquad \text{(A-1)}$$

where:

$\omega = 2\pi f$ = angular frequency of the electromagnetic radiation

f = frequency hertz

$c = 3 \times 10^8$ m/sec, the propagation velocity of electromagnetic energy in free space

β = phase constant, or the imaginary part, of the propagation constant of the medium through which the electromagnetic wave travels.

The phase constant, β, is obtained from γ, the complex propagation constant of the medium through which the electromagnetic wave travels. The propagation constant, γ, is derived from Maxwell's equations describing the behavior of electromagnetic fields and is defined as:

$$\gamma = \alpha + j\beta = (-\omega^2 \mu \varepsilon + j\omega\mu\sigma)^{1/2} \qquad \text{(A-2)}$$

where:

α = attenuation constant of the medium

μ = magnetic permeability of the medium

ε = effective dielectric permitivity of the medium

ω = angular frequency of the electromagnetic energy

σ = effective electrical conductivity of the medium

In common earth materials there is a trade-off between the depth of electromagnetic penetration and the resolution of subsurface structure. The depth of penetration is determined by the frequency of the induced electromagnetic energy as well as the electromagnetic properties of the material through which the energy travels. Signal attenuation, A, is approximated by:

$$A = 20 \log e^{\alpha} = 8.68\alpha \text{ (dB/m)} \qquad \text{(A-3)}$$

Attenuation increases with increasing frequency. By increasing the frequency of the energy induced, through the use of different antennas, the depth of penetration is decreased, while finer resolution of shallower structure is attained.

The amount of energy reflected at any electromagnetic interface is described by the complex reflection coefficient:

$$\rho = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} \qquad \text{(A-4)}$$

where:

ρ = complex reflection

η_1 = complex impedance of upper layer

η_2 = complex impedance of lower layer

The complex impedance is given by:

$$\eta = \frac{j\omega\mu}{\gamma} \qquad \text{(A-5)}$$

where γ is the electromagnetic propagation constant defined in Equation A-2.

A summary of the physical properties of common media which affect the propagation and attenuation of electromagnetic signals is shown in Table A-1. Careful analysis of reflected radar pulses, combined with a knowledge of the electromagnetic properties of the soil through which they propagate can provide information regarding location, depth, and composition of buried objects. For example, metallic objects have different electromagnetic properties than soils and will, therefore, give rise to strong reflections and a phase shift. Geologic interfaces give relatively weak reflections and no significant phase shift.

A more quantitative picture of the penetration performance of the GPR is shown in Figure A-1. Here, the range (for different electromagnetic frequencies) is plotted directly as a function of attenuation in various media. The plots result from calculations assuming the return signal is from a rough plane reflector.

Ground Penetrating Radar Instrumentation

The equipment required in GPR consists of an antenna, a transmitter, a control unit, a data output device, and a power supply. A radar antenna is a radio antenna designed to provide a high signal-to-noise ratio and either emits a radar pulse, receives a radar pulse, or does both. The transmitter, when triggered, generates a short duration pulse ranging from 1 to 6 nanoseconds. The pulse repetition rate is typically 50 KHz which is controlled by a 50 KHz clock.

The control unit consists of a transmit-receive selector, a radar signal receiver system, and an ancillary signal processing unit. The transmit-receive selector switches the antenna from the transmit mode to the receive mode and disables the pulse transmitter a few nanoseconds after the transmitter is triggered. The receiver system amplifies the reflected signal received by the antenna and transforms the signal from radio frequencies to audio frequencies so that the signal can be displayed or recorded. The reflected signals, which are sinusoidal in shape, are intensity modulated and transformed into a series of dark and light bands. The more positive or negative signal amplitudes appear as darker bands, while signal amplitudes closer to zero appear as lighter bands. The ancillary signal processing unit performs a variety of functions in order to apply various filters to the data.

A Geophysical Survey Systems, Inc. (GSSI) System 7 was used to conduct this survey. Figure A-2 presents a block diagram of a typical GPR system. A number of antennas are available ranging from 10 MHz (GEO-CENTERS' proprietary deep penetrating antenna) to 300 MHz. Table A-2 summarizes the characteristics of several of the available antennas. The radiation pattern of a 300 MHz GSSI antenna is presented in Figure A-3.

Electrical Resistivity Techniques and Instrumentation

Earth resistivity surveys have been used for many years in exploration for ground water and mineral deposits and in the study of engineering properties of earth materials. Equipment to measure resistivity consists of a controlled source of electric current, a device for measuring the potential differences generated by the current passing through the earth and a number of electrodes for coupling the current into the earth. The volume of subsurface material influencing the resistivity measurement is controlled by the spacing and geometry of the electrodes. While any array of four or more electrode contacts can be used in studying earth resistivity, relatively few electrode configurations have been accepted as standard arrays in practice. Figure A-3 shows the three most common electrode arrays used in the resistivity method. Many factors are considered in the choice of array configurations for a given problem. Susceptibility to geological noise, ease of array movement, and the nature of the assumed structure are a few of these factors.

For each of the three (3) electrode configurations in Figure A-4, the apparent resistivity, ρ_a, can be calculated from:

$$\rho_a = 2\pi \frac{V}{I} a, \text{ Wenner array} \qquad \text{(A-6a)}$$

where:

V = potential difference
I = induced electric current
a = spacing between electrodes

$$\rho_a = \pi \frac{V}{I} (b) \left[\left(\frac{L}{b}\right)^2 - 1/2 \right], \text{ Schlumberger Array} \qquad \text{(A-6b)}$$

where:

b = distance between potential electrodes
L = half the distance between current electrodes

$$\rho_a = \pi \frac{V}{I} (L) \left[\left(\frac{L}{b}\right)^2 - 1 \right], \text{ Double Dipole Array} \qquad \text{(A-6c)}$$

where:

b = distance between current electrodes and between potential electrodes

L = distance between mid-points of current electrodes and potential electrodes

Measurements of bulk soil resistivity can be used to estimate expected penetration depth of the GPR. Figure A-5 shows maximum radar range as a function of electrical resistivity (DC conductivity). From a few measurements of resistivity on the site of interest, the expected depth of penetration can be estimated for a range of frequencies. The best antenna for the application can then be selected, providing the optimum trade-off between penetration and resolution.

<u>Magnetometry</u>

The magnitude and direction of the earth's magnetic field are functions of location, particularly latitude. In the continental United States, the magnetic field intensity varies from approximately 0.50 gauss (0.50 gauss = 50,000 nanotesla (nT) = 50,000 gammas (γ)) in the south to approximately 0.60 gauss (60,000 γ) in the north. The magnetic field intensity at a certain location varies with time as well and daily, or diurnal, fluctuations may vary by as much as 50γ or more.

All materials exhibit magnetism since they are made up of moving charges. The degree to which a material can become magnetized is determined by its magnetic susceptibility. The magnetic susceptibility of ferromagnetic materials - those containing iron, nickel, or cobalt - typically ranges from 1 to 10 cgs units. Susceptibilities of naturally occurring rocks and sediments are normally several orders of magnitude smaller.

A dipole is a pair of equal charges, or poles, of opposite signs that are infinitely close together. All materials can be thought of as a continuous distribution of dipoles. In the presence of the earth's magnetic field, these dipoles become aligned in such a way as to produce a dipole moment and induce a dipole magnetic field in the material (Telford et. al., 1976). In ferromagnetic materials, the dipole magnetic field induced is large due to an interaction between the individual charges or poles. The strength and direction of the dipole magnetic field will also be affected by the permanent, or remnant, dipole moment of the object. The magnitude of the permanent dipole moment of a material depends upon its magnetic and thermal history.

The dipole magnetic field created by a ferromagnetic object is superimposed upon the external magnetic field of the earth and, if sufficiently large, it can be detected as a magnetic anomaly. Magnetic anomalies are detected by forming the vector difference:

$$\Delta T = M - B_e \qquad \text{(A-7)}$$

where:

ΔT = the dipole magnetic field anomaly

M = the dipole magnetic field measured

B_e = the ambient magnetic field of the earth

The basic expression for estimating the maximum amplitude of the total magnetic field anomaly associated with a point dipole is:

$$\Delta T = \frac{M}{r^3} \qquad \text{(A-8)}$$

where:

- M = the magnitude of the induced dipole magnetic moment (pole-cm).
- r = the radial distance (cm) from the ferromagnetic object producing the anomaly to the field sensor.

Equation A-8 states that the magnitude of the total magnetic field anomaly associated with a point dipole decays approximately as $1/r^3$.

A simple model has been developed and is commonly used to calculate the maximum amplitude of the total magnetic field anomaly associated with a point dipole (Gendzwill, 1981). This model assumes that the dipole moment of the ferromagnetic object producing the anomaly is congruent with the earth's magnetic field vector. The total magnetic field anomaly, ΔT, is calculated from:

$$\Delta T = \frac{M\ (1 \times 10^5)\ 3d^2 - r^2}{r^5} \qquad \text{(A-9)}$$

where:

- $d = X \cos I - Z \sin I$
- $r^2 = X^2 + Y^2 + Z^2$
- I = the inclination of the dipole moment (in degrees)
- X = the horizontal N-S distance (cm) from the field sensor to the object. Positive X values north of the object. Negative X values south of the object.
- Y = the horizontal E-W distance (cm) from the field sensor

to the object. Positive Y values west of the object. Negative Y values east of the object.

Z = the vertical distance (cm) from the horizontal plane of the field sensor to the object. Positive Z values below the horizontal plane. Negative Z values above the horizontal plane.

M = the magnitude of the induced dipole magnetic moment (pole-cm).

ΔT = the total magnetic field anomaly (gammas).

Solving Equation A-9 for the induced dipole magnetic moment yields:

$$M = \frac{(1\times10^{-5})\ \Delta T\ r^5}{3d^2 - r^2} \qquad \text{(A-10)}$$

The larger the induced dipole magnetic moment of an object, the larger the strength of the total magnetic field associated with the object. Measurements of the total magnetic field anomaly associated with an object can be used to calculate the induced dipole moment of the object via Equation A-10. From this calculation, the relative size of the object can be ascertained.

Magnetometers are used to detect anomalies in the magnetic field of the earth produced by ferromagnetic objects. Proton precession and optically pumped alkali-vapor sensors measure the scalar magnitude but not the direction of the magnetic field vector. These are orientation insensitive scalar instruments and are known as total field magnetometers. Fluxgate sensors measure the component of the magnetic field vector along the axis of the sensor cores and are capable of measuring the magnitude and direction of the magnetic field vector. When the sensor cores are oriented parallel to the direction of the magnetic field vector, a value of the total magnetic field can be obtained.

Proton precession magnetometers are based upon the idea that protons, in the presence of a magnetic field, will align their spin axes along the direction of the field. A change in the field causes the protons to precess to a different spin axis alignment. This precession is measured as a frequency proportional to the strength of the magnetic field. Proton precession sensors consist of a coil mounted around a container filled with a fluid having a large amount of free protons. A calibrated polarizing current is applied to the coil and the resulting magnetic field aligns the proton spin axes. Upon removal of the polarizing current, the protons precess to realign their spin axes with the ambient magnetic field. The precession, or larmor frequency, is measured and converted into an audio or digital display that is a measure of the total magnetic field. Proton precession magnetometers commercially available include the Geometrics G-856 and the Scintrex MP2.

Optically pumped sensors use the strength of the magnetic field to control the intensity of light being focused in a photocell. These sensors consist of an alkali-vapor lamp, a lens and filter system, an alkali-vapor light absorption cell mounted in an RF coil, and a photodetector. Common alkali vapors used are either cesium, rubidium, or helium. Light emitted from the lamp is conditioned by the lens and filter system and passed in to the absorption cell. Light passing out of the absorption cell is focused on the photodetector, and the resulting electric signal is fed back to the RF coil. This creates a self-sustained oscillation, or resonance, that is monitored at the photodetector. The opacity of the absorption cell varies according to the ambient magnetic field. Changes in the magnetic field cause the oscillation frequency to shift. The oscillation frequency is processed and converted into an audio or digital display that is a measure of the total magnetic field. A commercially available optically pumped sensor is the Varian 49-554 cesium vapor magnetometer.

Fluxgate sensors consist of two parallel cores of a magnetic material such as mu-metal, permalloy, ferrite, etc., that has a very high permeability at low magnetic fields. These cores approach saturation in very weak magnetic fields. The two cores are each wound with primary and secondary coils that are of opposite polarities. The two primary coils are connected in series and energized by a low frequency (50-1000 Hz) current. This current is sufficient to magnetize the cores to saturation, in opposite polarity, twice each cycle.

The secondary coils, which consist of many turns of fine wire, are connected to a differential amplifier that detects the magnetic flux in each core. In the absence of an external magnetic field, the saturation of the cores is symmetrical and of opposite sign near the peak of each half-cycle. As a result, the outputs from the two secondary windings cancel. In the presence of an external magnetic field component parallel to the cores, saturation occurs earlier for one half-cycle than the other. This produces an unbalance because the fluxes measured in each core do not cancel. The height of the voltage pulses output from the differential amplifier is proportional to the amplitude of the biasing field of the earth. A current through an additional coil nullifies most of the background, or regional, magnetic field so that the sensor is sensitive to small changes in the earth's magnetic field. The fluxgate probe can be used to measure small magnetic fields and vertical gradients ranging from 1 γ to 1 x 10^7 γ.

Fluxgate sensors that are commercially available include the Schonstedt GA-22 and the Forster Ferex 4.021. The Forster Ferex 4.021 consists of two fluxgate probes, one above the other, that are electronically balanced and separated by a distance of 40 cm. The sensor can be operated in a "static difference" mode in which the difference in magnetic field, or vertical gradient, between the two sensors is measured. Seven linear sensitivity ranges are available with this instrument. It can be set so as to measure gradients between ± 10 γ, ± 30 γ, ± 100 γ, ± 300 γ, ± 1000 γ, ± 3000 γ, and ± 10,000 γ. An audio output is provided when gradients in excess of 20% of the maximum for a particular range setting are detected.

The gradient, then, is the difference in the intensity of the magnetic field as measured at each sensor, divided by the distance between the two sensors. The gradient is measured at the midpoint between the two sensors. The vertical gradient can be expressed by taking the derivative with respect to distance, r, of Equation A-8:

$$\frac{d\Delta T}{dr} = \frac{-3M}{r^4} = \frac{-3}{r}\frac{M}{r^3} = \frac{-3\Delta T}{r} \qquad \text{(A-11)}$$

Equation A-10 states that the vertical magnetic gradient associated with a point dipole magnitude of decays as $1/r^4$. The magnitude of the vertical magnetic gradient associated with a point dipole decays at a much greater rate than does the magnitude of the total magnetic field anomaly associated with a point dipole. Measurements of vertical magnetic gradients are useful because the regional magnetic field has been effectively from the measurement removed so that weaker anomalies are better defined. Also, diurnal fluctuations are removed from the measurement.

TABLE A-1

Approximate VHF Electromagnetic Parameters of
Typical Earth Materials

Material	Approximate Conductivity σ (mho/m)	Approximate Dielectric Constant	Depth of Penetration
Air	0	1	Max (km)
Limestone	10^{-9}	7	
Granite (dry)	10^{-8}	5	
Sand (dry)	10^{-7} to 10^{-3}	4 to 6	
Bedded Salt	10^{-5} to 10^{-4}	3 to 6	
Freshwater Ice	10^{-5} to 10^{-3}	4	
Permafrost	10^{-4} to 10^{-2}	4 to 8	
Sand, Saturated	10^{-4} to 10^{-2}	30 to 50	
Freshwater	10^{-4} to 3×10^{-2}	81	
Silt, Saturated	10^{-3} to 10^{-2}	10	
Rich Agricultural Land	10^{-2}	15	
Clay, Saturated	10^{-2} to 1	8 to 12	
Seawater	4	81	Min (cm)

TABLE A-2

Selected Radar Parameters for Calculating Maximum Range

System	GEO-CENTERS' Proprietary Design	Standard GSSI Systems	
Center frequency	10 MHz	80/120 MHz	300 MHz
Parameter			
P_s (Peak) (Watts)	2.5×10^3	50	12
P_{min} (Watts)	2.5×10^{-8}	5×10^{-10}	1.2×10^{-10}
Q	-110 dB	-110 dB	-110 dB
$E_t = E_r$	5% (-13 dB)	5% (-13 dB)	5% (-13 dB)
$G_t = G_R$	1.585 (2 dB)	1.585 (2 dB)	1.585 (2 dB)

where:

P = power (watts)
Q = radar system performance factor
E = transmit/receive efficiency
G = transmit/receive gain factor

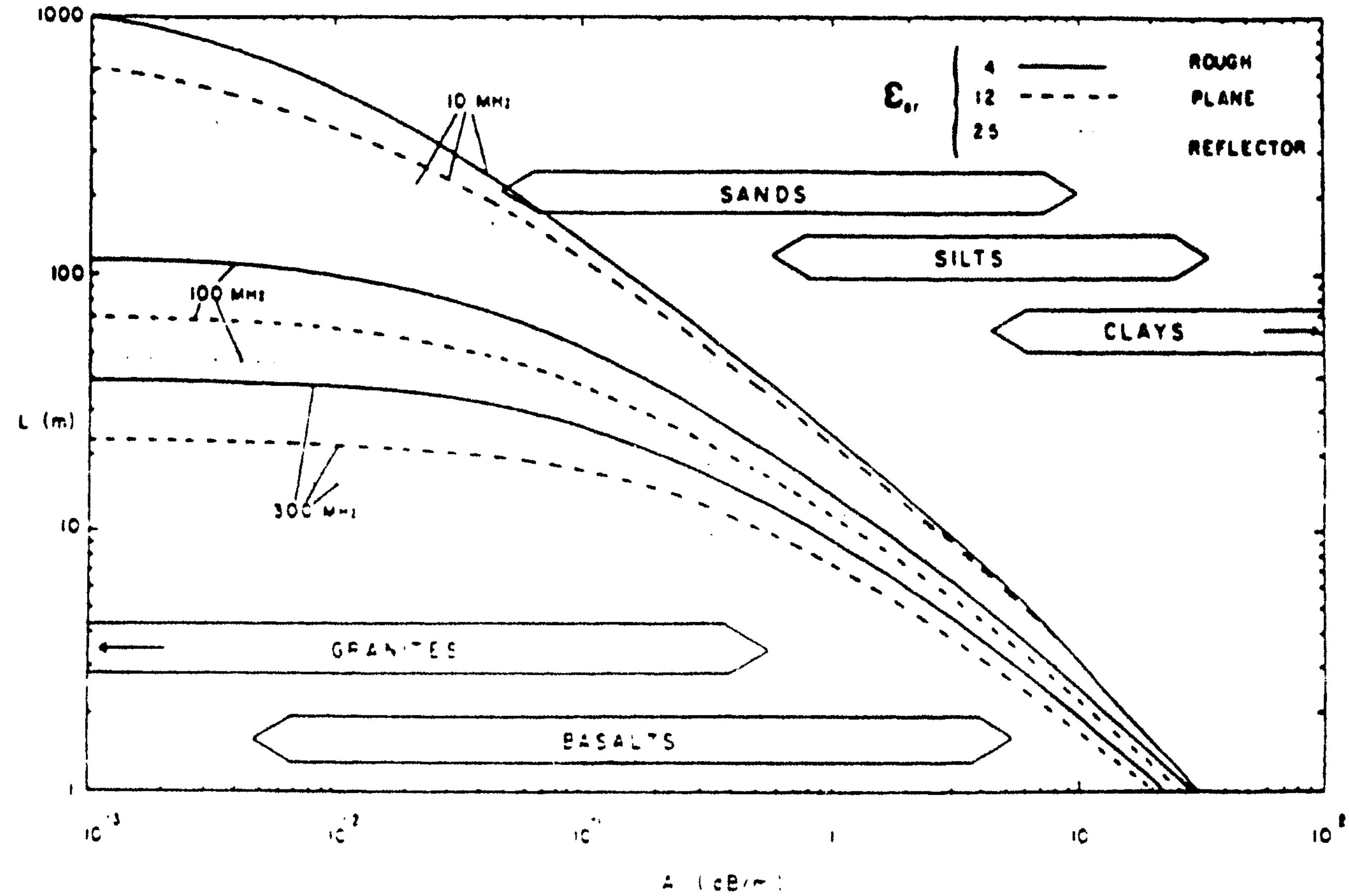


Figure A-1. Variation of maximum depth of penetration (L) as a function of attenuation (A) for different frequencies and dielectric constants. Typical ranges of attenuation for different earth materials are shown (after Horton et. al., 1981).

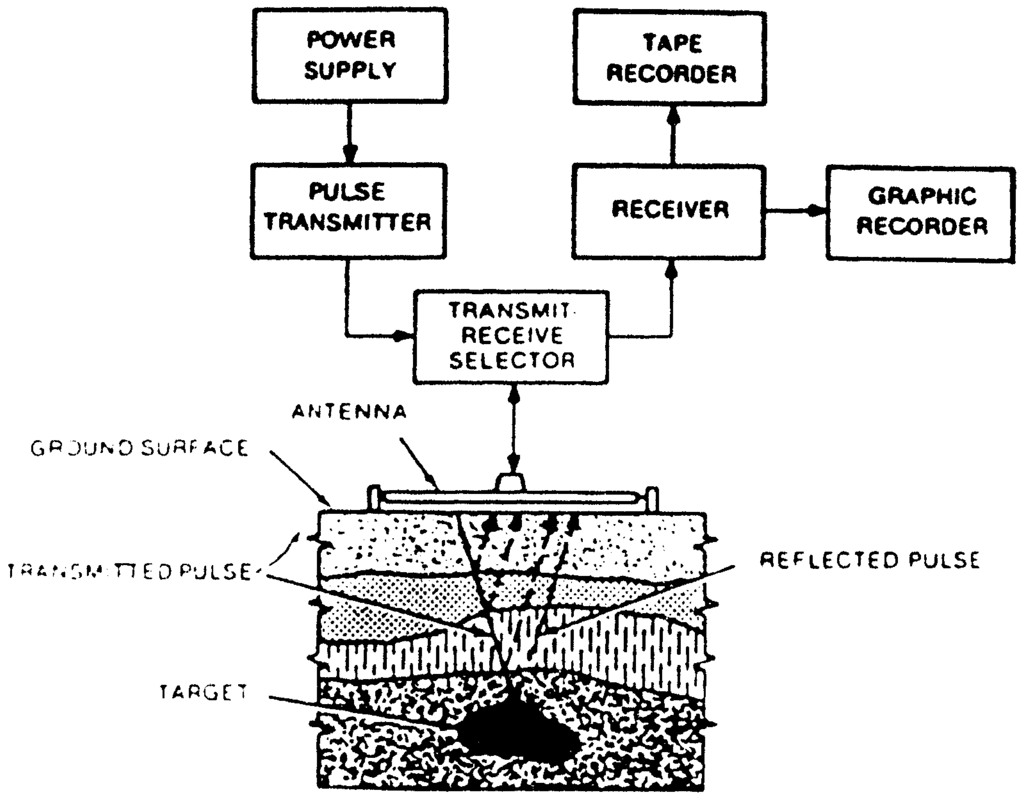


Figure A-2. Ground penetrating radar (GPR) system, block diagram.

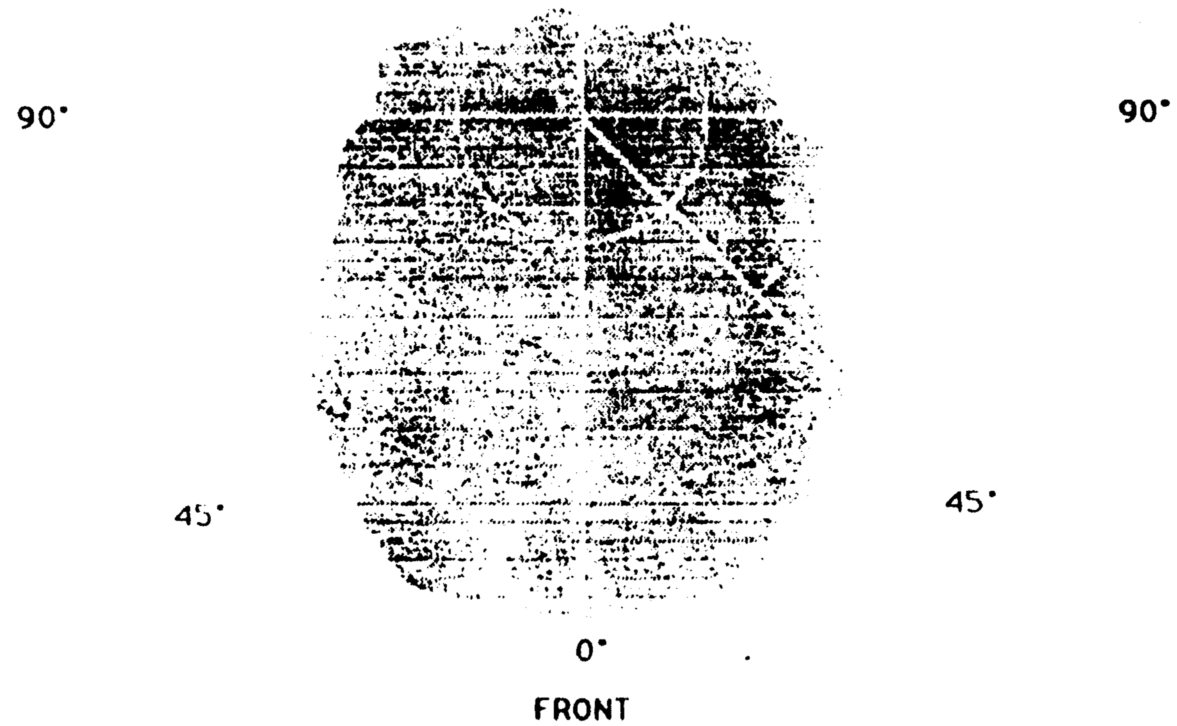
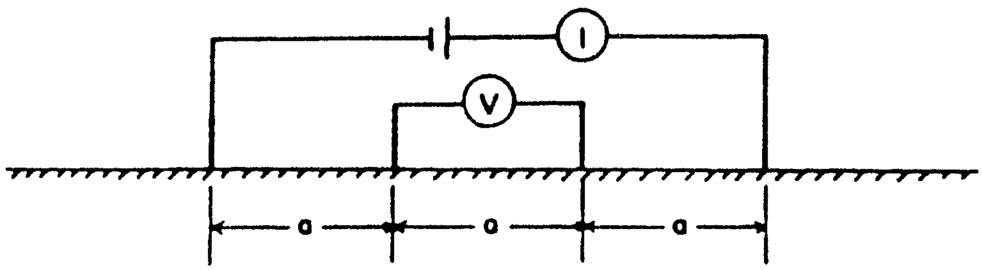
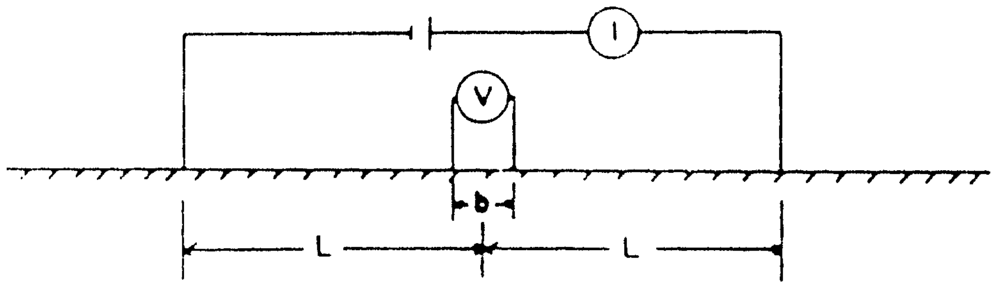


Figure A-3. Radiation pattern of a 300 MHz Geophysical Survey Systems, Inc. (GSSI) antenna.

a) Wenner Spread



b) Schlumberger Spread



c) Double-Dipole Spread

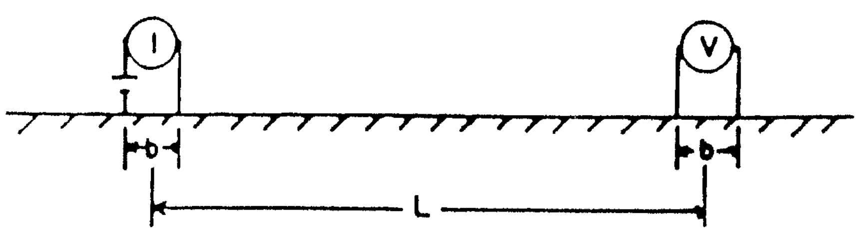


Figure A-4. Common electrode configurations for resistivity arrays.

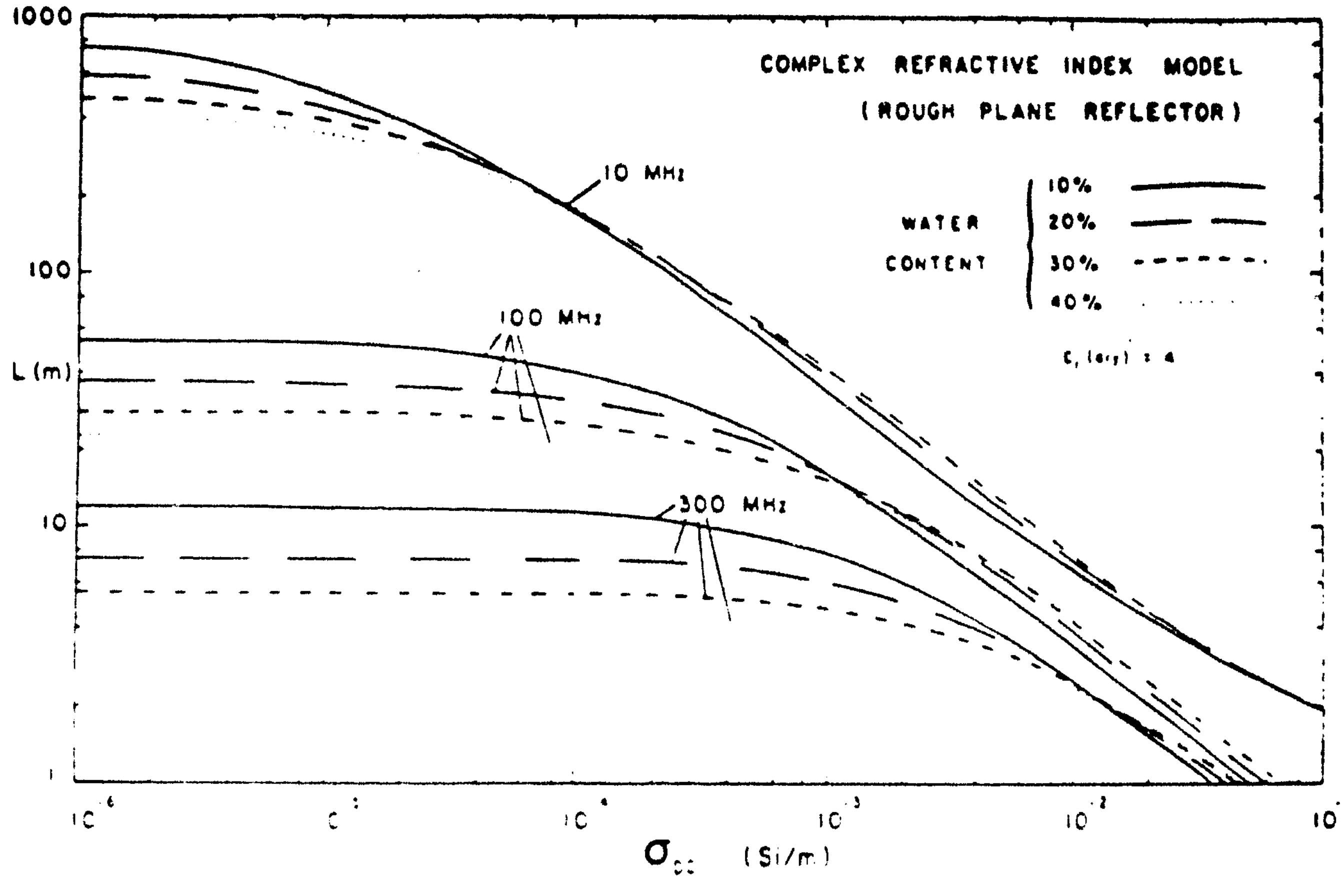


Figure A-5. Radar range (L) as a function of DC conductivity (σDC) at different frequencies. Plots are based on a Complex Refractive Index Soil Model and reflection from a rough plane reflector (after Horton et. al., 1981).

SEP 25 1989

Mr. James D. Berger, Director
Environmental Survey and Site
Assessment Program
Oak Ridge Associated Universities
Post Office Box 117
Oak Ridge, Tennessee 37831

Dear Mr. Berger:

This letter provides authorization for 2 individuals to attend a meeting to be held in Rockville, Md. at NRC headquarters on September 26, 1989 with the Department of the Interior to discuss the Nuclear Lake site in NY. Cost estimate details should be provided in the next monthly report.

This work should be performed under the Interagency Agreement entitled "Radiological Evaluation Assistance for Formerly Licensed Sites", FIN A9093. Funding for this task was previously provided via an executed SF173.

If you have any questions, please give me a call at FTS 492-0656.

Original Signed By

David Tiktinsky, Technical Assistance
Project Manager
Program Management, Policy Development
and Analysis Staff, NMSS

cc: R. Kernard, ORAU

Distribution:
DTiktinsky
GBeveridge
GLaRoche, IMNS
JSwift, IMNS
GBidinger, IMNS
FIN A9093
NMSS r/f

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Office of Nuclear Material Safety and Safeguards
Items of Interest
Week Ending September 29, 1989

Pete -
for your
files + future
reference
LB

INDUSTRIAL AND MEDICAL NUCLEAR SAFETY

Fuel Cycle Safety

Meetings with the Babcock and Wilcox Company and with National Park Service Representatives

On September 26, 1989, Babcock and Wilcox (B&W) personnel met with staff members of the Fuel Cycle Safety Branch, the Division of Low-Level Waste Management and Decommissioning, and Region I to describe B&W's plans for groundwater monitoring at the B&W site in Parks Township, Pennsylvania. The proposed monitoring is intended to provide information about the groundwater in the vicinity of previous on-site waste disposals. The staff informed the B&W representatives that the proposal for initial studies, which include drilling and installing monitor wells to obtain specific subsurface information as well as initial monitoring data, appeared reasonable. It was noted that this information should serve as a basis for a B&W plan for continued long-term groundwater monitoring. The staff reiterated its request that a schedule for implementation be included in the plan when formally submitted.

On September 26, 1989, staff members of the Office of Nuclear Material Safety and Safeguards, the Office of General Counsel, and Region I met with representatives of the National Park Service, Department of the Interior, to discuss the status of the former Gulf United Nuclear Corporation site near Pawling, New York. Also present at the meeting were staff members of Oak Ridge Associated Universities, technical assistance contractor for the NRC, who performed the most recent radiological survey of the site now held by the National Park Service. The purpose of the meeting was to obtain current information regarding the site from the Park Service and to discuss potential further site characterization and remediation actions.

Both of the above meetings and topics are related to actions discussed at the hearing held August 3, 1989, by the Subcommittee on Environment, Energy, and National Resources, House Committee on Government Operations, chaired by Representative Mike Synar.

HIGH-LEVEL WASTE MANAGEMENT

Technical Exchange with DOE on Tectonic Models

A technical exchange on tectonic models was conducted with DOE on September 26, 1989. The purpose of this exchange was to discuss NRC's draft Technical Position on tectonic models, as well as the relationship of tectonic models to DOE's program for characterizing the Yucca Mountain site. Representatives from the Nuclear Waste Technical Review Board and the Advisory Committee on Nuclear Waste also participated. The open technical discussions improved the understanding of each agency's position and facilitated planning for future interactions to discuss outstanding concerns.

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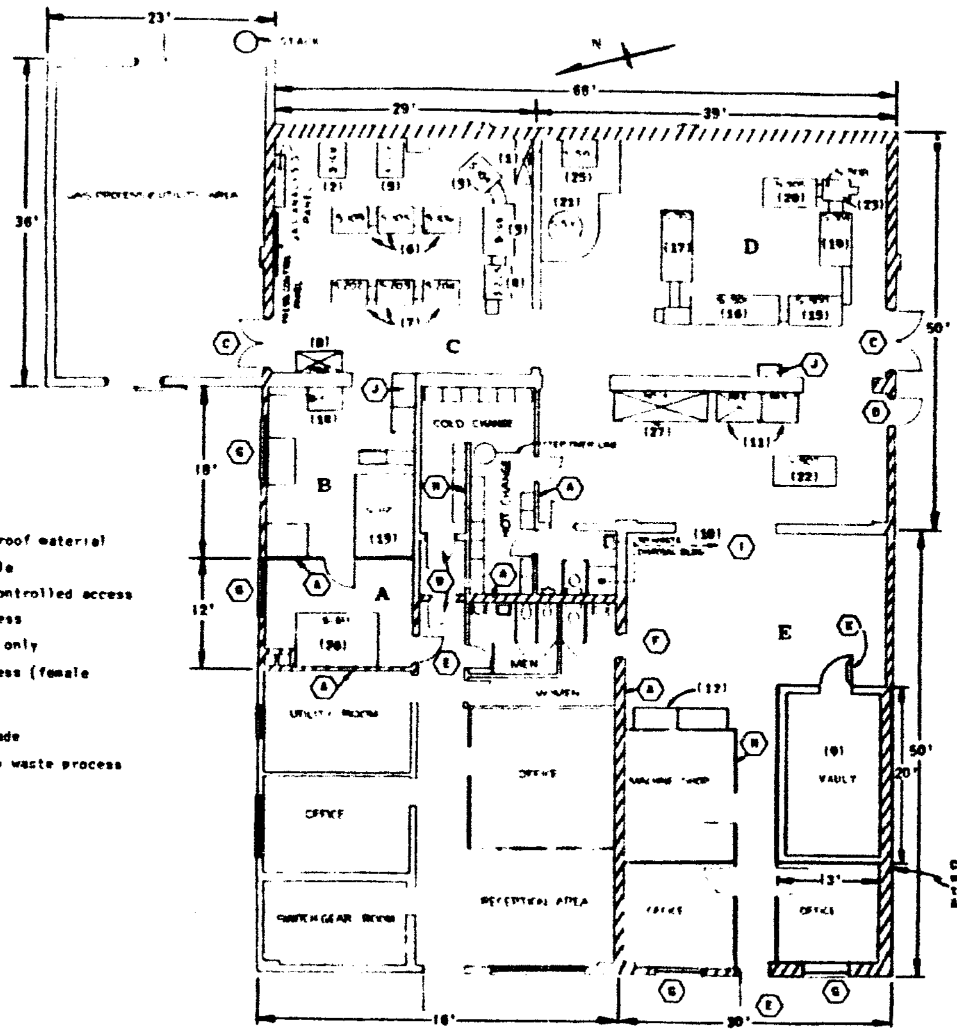

Notes:

- Ⓐ Floor to ceiling wall, fireproof material
- Ⓑ All floors vinyl-asbestos tile
- Ⓒ Double doors with gas seal-controlled access
- Ⓓ Gastight door-controlled access
- Ⓔ Gastight door-emergency exit only
- Ⓕ Gastight door-controlled access (female employee-for future use)
- Ⓖ Seal window
- Ⓗ Floor to ceiling wall barricade
- Ⓘ Drain from sink and shower to waste process building basement
- Ⓙ Criticality alarm
- Ⓚ Combination lock vault door

Criticality Zones

- (1) Counting hood
- (2) Decontamination box
- (3) Fabrication boxes
- (4) Furnace box
- (5) Weighing box
- (6) Metallography boxes
- (7) Chemistry boxes
- (8) Chemistry hood
- (9) Vault
- (10) Waste area
- (11) Furnace hood
- (12) Pouch holder
- (13) X-ray diffraction area
- (14) Oxygen analysis box
- (15) Vacuum furnace box
- (16) Fabrication box
- (17) Oxide blending and cold pressing box
- (19) Centerless grinding box
- (20) Pellet inspection and loading box
- (21) Welding box
- (22) Wet chemistry box
- (23) Cleaning box
- (25) Vibratory compaction box
- (26) Microprobe box
- (27) Decontamination hood

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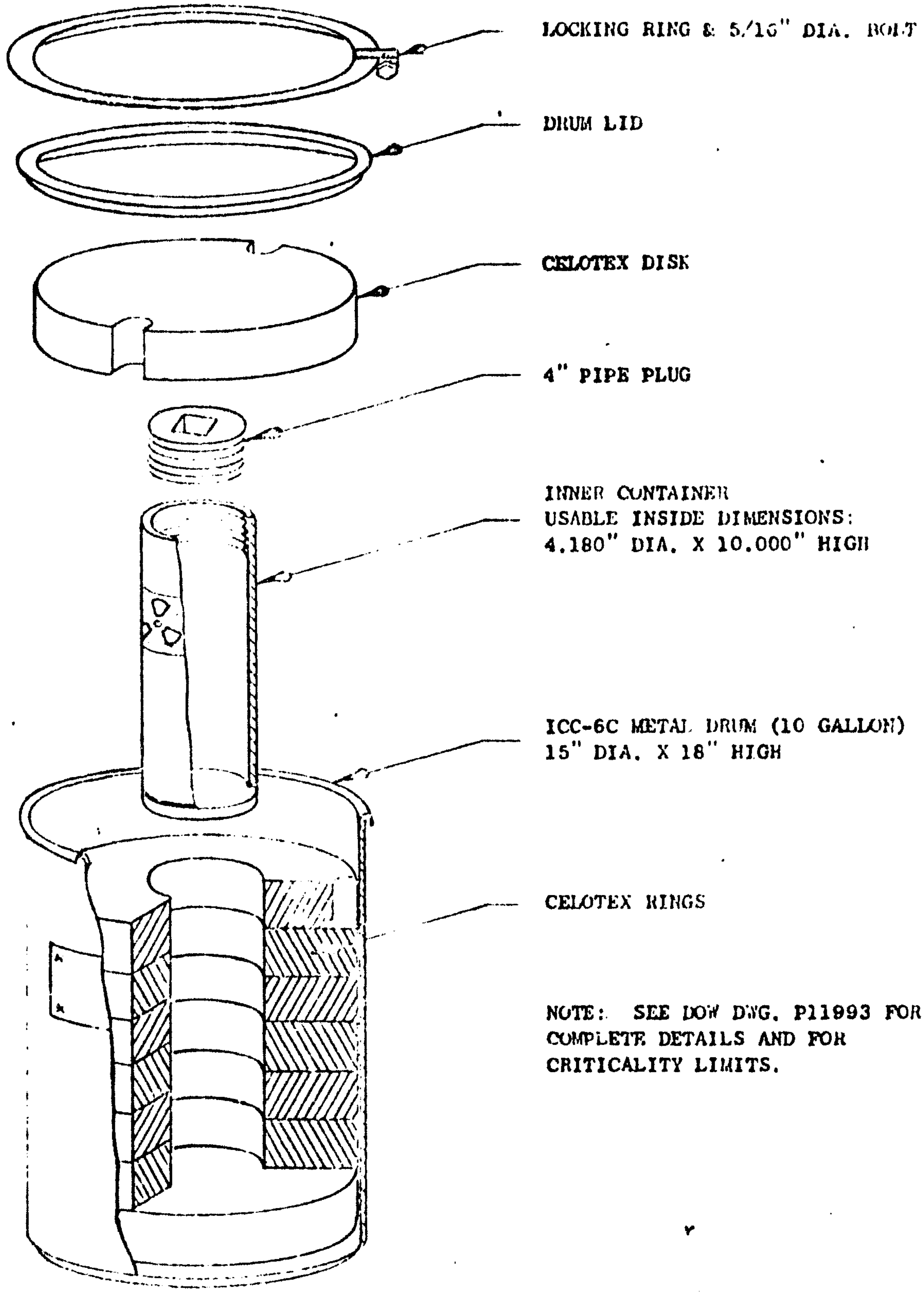
For Div of Compliance

Fig. 1 — Plutonium Research Laboratory



RFD CONTAINER - MODEL 1518

EXPLODED VIEW

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(1)

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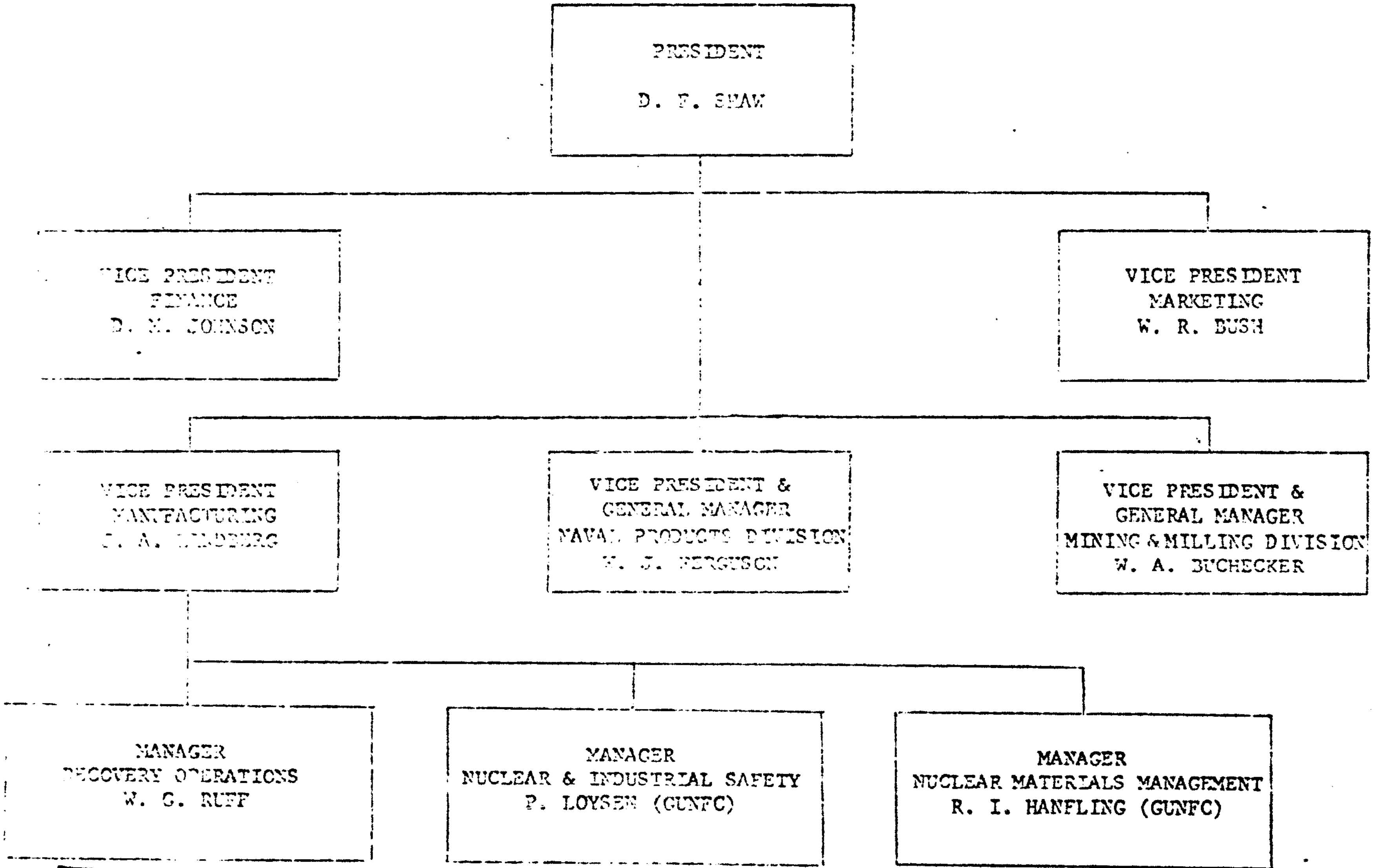
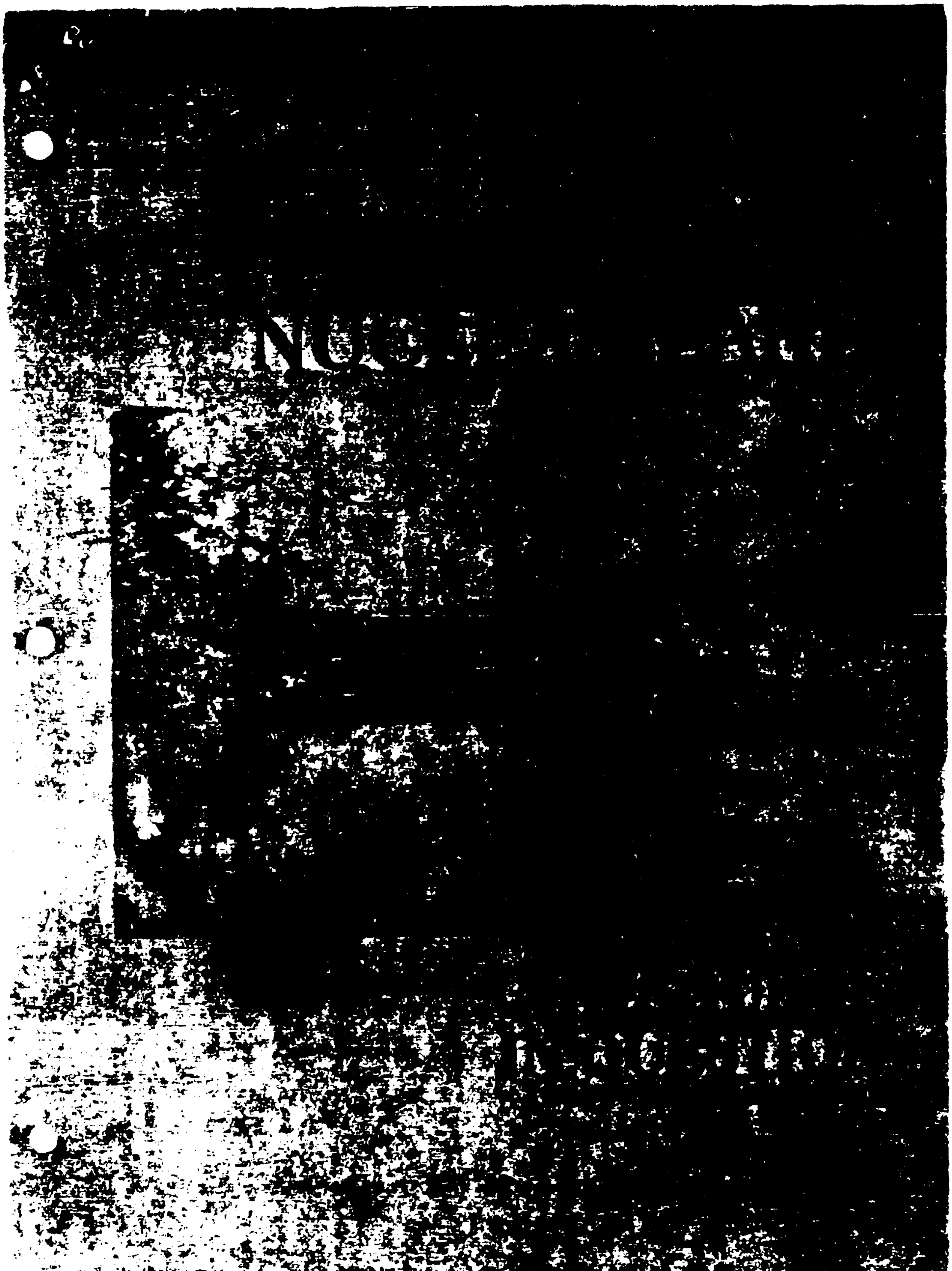
Revised 6-6-67

PARTIAL ORGANIZATION CHART - UNITED NUCLEAR CORPORATION





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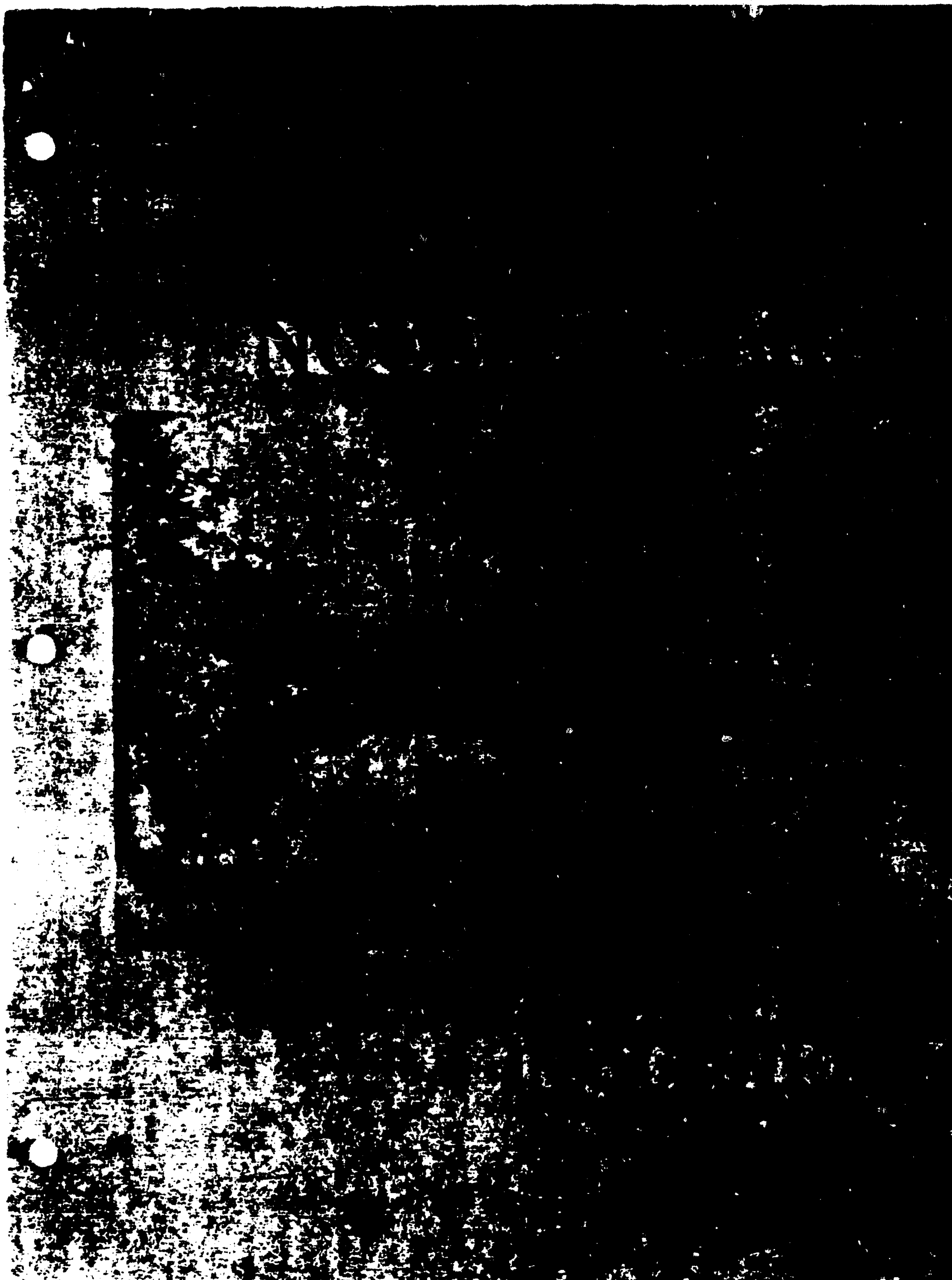

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NUCLEAR LAKE
A RESOURCE IN QUESTION

January 18, 1982

Prepared by:
Nuclear Lake Management Site Clearance Subcommittee
in cooperation with
The Appalachian Trail Conference
Dutchess County Cooperative Extension

NUCLEAR LAKE MANAGEMENT

SITE CLEARANCE SUB COMMITTEE

Charles P. Shaw	Chairman
Craig Davis	(past member)
Karen Day	
John Franceshi	(past member)
Jane Geisler	
Sibyll Gilbert	
Warren Hill	(past member)
William Hubbard	
Eric Kiviat	(past member)
Bob Leone	
Kenneth Lutters	
Warren Martin	(past member)
Bonny MacLeod	
Jean Valla	(past member)
Gordon Wright	
Eric Gillert	Chairman, Long Range Planning Committee
John Guerin	Chairman, Nuclear Lake Management Committee

ACKNOWLEDGEMENTS

On behalf of the members of the Nuclear Lake Site Clearance Sub-Committee, I offer sincere thanks to all those who provided time from their busy schedules to assist in the preparation of this publication.

During the past two years a great number of individuals helped bring this study into being, including those who gave the study its impetus and helped formulate the initial concepts. In mentioning some, I run the risk of omitting others, whose forgiveness I hearby request.

In the course of preparing this report we have received invaluable assistance and cooperation from the following individuals, organizations and agencies: ***Eugenia M. Barnaba****, Manager of Technical Services, Resource Information Lab, Cornell University;* ***Arlynn Ingram****, Research Support Specialist, Resource Information Lab, Cornell University;* ***Dr. Ervin J. Fenyves****, Acting Director, Center for Environmental Studies, The University of Texas at Dallas;* ***Dr. Thomas Cashman****, Chief of Toxics and Radiation, NYS Department of Environmental Conservation;* ***Robert Vrana****, Engineer, Dutchess County Department of Health;* ***William Hogan****, Cooperative Extension Agent, Dutchess County Cooperative Extension Association.*

Sincere thanks is extended to ***Representatives of the Harlem Valley Alliance, U.S. Nuclear Regulatory Commission, NYS Department of Interior, National Park Service, and NYS Department of Health*** *who so quickly responded to written communications and requests for information.*

The Sub Committee is especially indebted to the following personnel of Dutchess County Cooperative Extension Association: ***Mrs. Barbara Mallen****, Commercial Artist for preparing the graphics and study layout,* ***Mrs. Joyce Sampson****, Compugraphic operator for typesetting;* ***Mrs. Dana Matlock*** *and* ***Mrs. Emmy Germond*** *for typing and proof reading all drafts;* ***Mr. Gordon VanderMark*** *for printing and* ***Mrs. Betty Stowe*** *for collating this study.*

Financial assistance for printing by the ***National Park Service, Appalachian Trail Project office.***

Finally, a special acknowledgment to all those who remain anonymous from our lack of ability to recall numerous occasions that someone offered a critical piece of information or advice at just the right moment.

Despite all this fine assistance, any errors and ommissions, of course, are the responsibility of the Site Clearance Sub Committee.

Charles P. Shaw, Chairman
Site Clearance Sub Committee

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VI. ACCIDENT, CLEAN-UP AND DECOMMISSIONING

VII. COMPILATION OF DATA

VIII THE AERIAL RADIOLOGIC SURVEY

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Introduction

Nuclear Lake is 1137 acres of property located on the boundary between the towns of Pawling and Beekman in Dutchess County, New York. The Site contains a 50 acre lake and is noted locally for its scenic beauty and diversity of plant life. From 1958 to 1972, the property housed a nuclear fuels processing and research facility and thus received the name "Nuclear Lake".

In 1979, the 1137 acre parcel was acquired by the National Park Service for the purpose of relocating the Appalachian Trail. The purchase was made upon the recommendation of the Dutchess County Appalachian Trail Relocation Committee: a group formed by the Park Service in 1976, to help identify suitable parcels of land in southern and eastern Dutchess County, through which the Appalachian Trail could be rerouted. The Relocation Committee, composed of local government agencies, private citizens and groups, and individuals interested in recreation, open space and hiking, identified the Nuclear Lake property for its strong scenic appeal and its potential for local and regional recreational use.

Upon purchase of the land, the National Park Service formed a local citizens committee called the Nuclear Lake Management Committee. This committee was comprised of representatives from local and state government, recreation, environmental groups and educational institutions. Its function was to study the Nuclear Lake site and develop management plans for its future use by hikers and the community at large. At its first meeting in July of 1979, the Nuclear Lake Management Committee constituted two subcommittees to plan individually for the site's short and long term uses.

At the August 1979 meeting of the Long Range Planning Committee, representatives from the Harlem Valley Alliance, a regional public interest group, requested that the committee investigate past industrial practices and the potential for radioactive contamination at the site. Although the property had been cleared for unrestricted use by all government agencies involved in decommissioning the facility, concerns raised by the HVA, local government and others, made it apparent that additional review was needed. In response to that need, the Site Clearance Subcommittee was formed and charged with investigating the site's safety for future public use.

Although some members of the Site Clearance Subcommittee have scientific training, most are concerned citizens and lack the expertise to technically review and evaluate the available data. The members determined that the most appropriate role for the Subcommittee would be to prepare a report that would abstract all available information which could be obtained from government agency and facility records. The report would objectively reconstruct activities and conditions on the site. This information would then be presented in a manageable form to the scientific community and the public for their review. This study, "Nuclear Lake - A Resource In Question" represents the efforts of the

Subcommittee to prepare such a report. Work began in August 1979 and ended in September 1981.

Once the study has been reviewed by the scientific community and the general public, the Site Clearance Subcommittee will assemble all comments and formulate recommendations which will be passed on to the Nuclear Lake Management Committee.

Method

NUCLEAR LAKE MANAGEMENT COMMITTEE & SUBCOMMITTEES

In August 1979, the Nuclear Lake Management Committee was formed by request of the National Park Service, to provide guidance on the management of the Nuclear Lake property located in Pawling, New York.

The 34 member Nuclear Lake Management Committee has representation from the following groups:

1) Dutchess County Department of Parks Recreation Conservation
2) Dutchess County Department of Planning and Transportation
3) National Park Service
4) NYS Office of Parks and Recreation
5) Dutchess County Environmental Management Council
6) Dutchess County Cooperative Extension Association
7) Town of Beekman Conservation Advisory Council
8) Town of Pawling Conservation Commission
9) Town of Beekman Recreation Commission
10) Town of Pawling Recreation Commission
11) Supervisors from towns of Beekman and Pawling
12) County Legislators from Beekman and Pawling
13) Dutchess Community College
14) NY NJ Trail Conference
15) Cary Arboretum of the NYS Botanical Gardens
16) Appalachian Trail Conference
17) Dutchess County Legislature Recreation Subcommittee
18) New York State Department of Environmental Conservation
19) Federation of Dutchess County Fish & Game Clubs, Inc.
20) Private citizens and organizations.

Three Subcommittees were established by the members of the Nuclear Lake Management Committee: the Long Range Planning Committee, Short Range Planning Committee, and the Site Clearance Subcommittee.

The function of the Long Range Planning Committee is to develop a Natural Resource Inventory and Management Plan for the Nuclear Lake property. The Management Plan would:

1) state community goals as they affect the Nuclear Lake property;
2) be consistent with the objectives of the relocation of the Appalachian Trail;
3) define a rational boundary between the Appalachian Trail uses and commercial areas;
4) define fiscal responsibilities for prospective improvements and their maintenance costs;
5) would provide a definition of management responsibilities;
6) fit in with the recreational needs, potential land use pattern and resource pattern of the southern Dutchess County area;

7) would provide guidance for the National Park Service Appalachian Trail Conference and other groups,
8) propose uses that do not exceed the carrying capacity of the site;
9) encourage the consistency of local planning efforts with the use of the property.

The Short Range Planning Committee was organized as a management group to make recommendations to the National Park Service regarding:

1) the security and/or disposal of chemicals, waste materials, laboratory equipment and miscellaneous debris located in the buildings or on the property;
2) the temporary control of use and access to the property such as the management of hunting, fishing and woodcutting activities;
3) temporary security of the property which includes the posting signs, placing locks on the buildings and the front gate, and maintaining a caretaker for the property.

The Site Clearance Subcommittee which is part of the Long Range Planning Committee, was established to investigate the past operations of the United Nuclear Corporation for the purpose of determining the site's safety for public use. The Subcommittee's functions include:

1) gathering available information and data and assembling this information into the study, "Nuclear Lake - A Resource In Question";
2) determines if further studies or testing on the site are needed and the extent of such studies;
3) forming Study Review Teams wh would evaluate the study and make recommendations as to whether the property poses a he th risk to the public.

SITE CLEARANCE SUBCOMMITTEE PROGRAM PROCEDURES

The Site Clearance Subcommittee activities include the following:

1) inventory, define and prioritize potential problems;
2) determine the goals and objectives of the Subcommittee;
3) research and abstract information for incorporation into the study;
4) present the study to the Study Review Teams and the public for their comments and recommendation;
5) review and assemble the recommendations from the Review Teams and public, and present them to the Nuclear Lake Management Committee.

RESOURCES UTILIZED BY THE SUBCOMMITTEE FOR PREPARATION OF THIS STUDY INCLUDE:

1) Certain records concerning United Nuclear Corporation (UNC) operations - these include daily operation log books, operation manuals, health and safety memos, test results and other reports;

2) certain records from the New York State Department of Environmental Conservation, which include health and safety [illegible] memos, field inspection reports, inter-office and inter-agency memos, various permits and results of radiological tests on environmental conditions at the site;
3) certain records from the Nuclear Regulatory Commission (formerly known as U.S. Atomic Energy Commission) - which include operating permits and licenses for UNC and radiological test data;
4) ATCOR Corporation - reports on decontamination procedures;
5) New York State Health Department and Dutchess County Health Department - records, including permits, inter-office and inter-agency memos and radiological test results;
6) miscellaneous local government memos and correspondence from the towns of Beekman and Pawling.

ADDITIONAL STUDIES AND TESTS

Additional studies and tests were undertaken during the year and a half in which the Site Clearance Subcommittee conducted its work. The results of these studies have been incorporated into this document and include:

1) Gamma Analysis of Soil, Water and Vegetation from Nuclear Lake, New York - performed by University of Texas at Dallas, October - December 1979.
2) Aerial Radiologic Survey of the United Nuclear Facility at Nuclear Lake near Pawling, New York, conducted by EG & G Inc. in May 1980.
3) Sequential Photographic Analysis of Nuclear Lake, Dutchess County, conducted by the Resource Information Laboratory, Cornell University, Ithaca, New York July 1980.
4) Nuclear Lake Radiological Fish Sampling, conducted by New York State Department of Health, April 17, 1980.
5) Chemical Analysis of Nuclear Lake Water Samples, conducted by the Dutchess County Department of Health, January 1980.

DOCUMENT PREPARATION PROCEDURES:

Since August 1979, the Subcommittee has been meeting on an average of twice a month in an effort to prepare this study. The document preparation procedures were as follows:

1. Determine the resources and data available to the committee;
2. determine how the data would be organized and assembled into the study;
3. develop a format to be used throughout the study;
4. designate research responsibilities to committee members;
5. each section researched and written by the committee members;
6. each section reviewed and edited for objectivity and content by the entire committee;

7) assemble and print the study;
8) form Study Review Teams to review the study, analyze the information and make comments and recommendations;
9) Present and distribute the study to the public and encourage their review.

STUDY REVIEW TEAMS:

Study Review Teams were formed by the Site Clearance Subcommittee. Their function is to review this study "Nuclear Lake - A Resource In Question" and to make recommendations as to the site's safety for unrestricted public use. The teams are comprised of scientists and individuals from government agencies, academic institutions, business and private organizations located throughout the country. Below is a list of teams that have been approached and asked to review this document. Additionally, the study will be presented to the public. Any requests (from organizations not listed here) to comment on this study are encouraged and will be acknowledged.

Suggested List of Study Review Teams*

Government Agencies

- N.Y.S. Dept. of Environmental Conservation, [illegible] Radiation Section and Division of Solid Waste
- Nuclear Regulatory Commission, [illegible] Branch
- National Parks Service, North Atlantic Region
- N.Y.S. Department of Health
- N.Y.S. Labor Dept.
- Environmental Protection Agency, Region 2
- Dutchess County Environmental Management Council
- U.S. Geological Survey, Water Resources Division, N.Y. District
- New York State Attorney General's Office, Environmental Protection Bureau

Academic Institutions

- Cornell University, Resource Information Laboratory and Department of Natural Resources
- Massachusetts Institute of Technology
- Scientists' Institute for Public Information
- University of Texas, Center for Environmental Studies
- Dutchess Community College, Natural Resources Conservation Program
- New York University Medical Center, Institute of Environmental Medicine
- State University of New York at Stonybrook
- University of Pittsburgh
- Trinity Pawling School

Private Organizations / Individuals

- Environmental Defense Fund
- Environmental Action Foundation
- New York Public Interest Research Group
- Cary Arboretum of the N.Y. Botanical Gardens
- Sierra Club - Mid-Hudson Group - Atlantic Chapter
- Coalition for Conservation Justice
- Union of Concerned Scientists
- Appalachian Trail Conference
- Committee for Nuclear Responsibility
- Harlem Valley Alliance
- Critical Mass
- Mount Kisco Medical Group
- Natural Resource Defense Council
- Center for Farm and Food Research Inc.

- Numerous individual scientists representing several corporations in Dutchess County, N.Y.

*For information about the [illegible] make up of each study review team contact Site Clearance Committee Chairman, Charles Shaw at area code 914 [illegible] or write Dutchess County Cooperative Extension, Farm and Home Center, Millbrook, N.Y. 12545

I. History of Lake Development

DAM & LAKE DEVELOPMENT

On October 20, 1936, Mr. Herbert M. Teets, owner of the property commonly known as Nuclear Lake, applied to the Department of Public Works for permission to construct a small dam on a stream which meandered through a large wetland and eventually flowed into Whaley Lake Stream, in the town of Beekman, New York. (See Figure 1-1, 1948 USGS Topographic Map "Poughquag" Quadrangle), (1). Though the application was approved, the dam was not built at that time.

Mr. Teets' 1936 Application for Construction (2) indicated that:

1. The watershed areas above the proposed dam drains entirely into the "Nuclear Lake Swamp" area and is 1.6 square miles;
2. The natural material of the bed on which the proposed dam would rest consists of "granite";
3. Facing downstream the nature of material composing the right and left banks of the stream consists of "granite";
4. The proposed dam would have been 15' high, creating a lake area at spillcrest elevation of 54 acres impounding 23,500,000 cubic feet of water.

Analysis of October 26, 1941 aerial photographs (3) points out some earlier natural features of the "Nuclear Lake Property" (see Figure IV-1). The area was originally composed of a large wooded wetland located within hilly irregular wooded terrain. The large wetland is part of a series of wooded wetlands interconnected by a network of streams. The northern portion of the large wetland was higher in elevation, suggesting that this wetland drained generally toward its central section and emptied out at the most southerly point.

During dry periods it appeared that vehicular traffic was possible through the NW corner of the wetland, as a portion of what appeared to be an underdeveloped narrow road was clearly visible cutting across this corner.

Several intermittent and perennial streams flowed directly into the various wetlands on the property. One main stream originating at the higher elevations of the eastern side of the property flowed across the large wooded wetland eventually feeding into one of the smaller wetland areas. Surface runoff occurring from the hillsides in combination with the flow from the intermittent streams, forms the "Nuclear Lake" property watershed.

In general all stream flow is in a southerly direction through inter-connected wetlands, eventually joining Whaley Lake Stream. Whaley Lake Stream flows westward to Garden Hollow Brook, combining with Fishkill Creek. (See Figure 1-1); Fishkill Creek flows into the Hudson River.

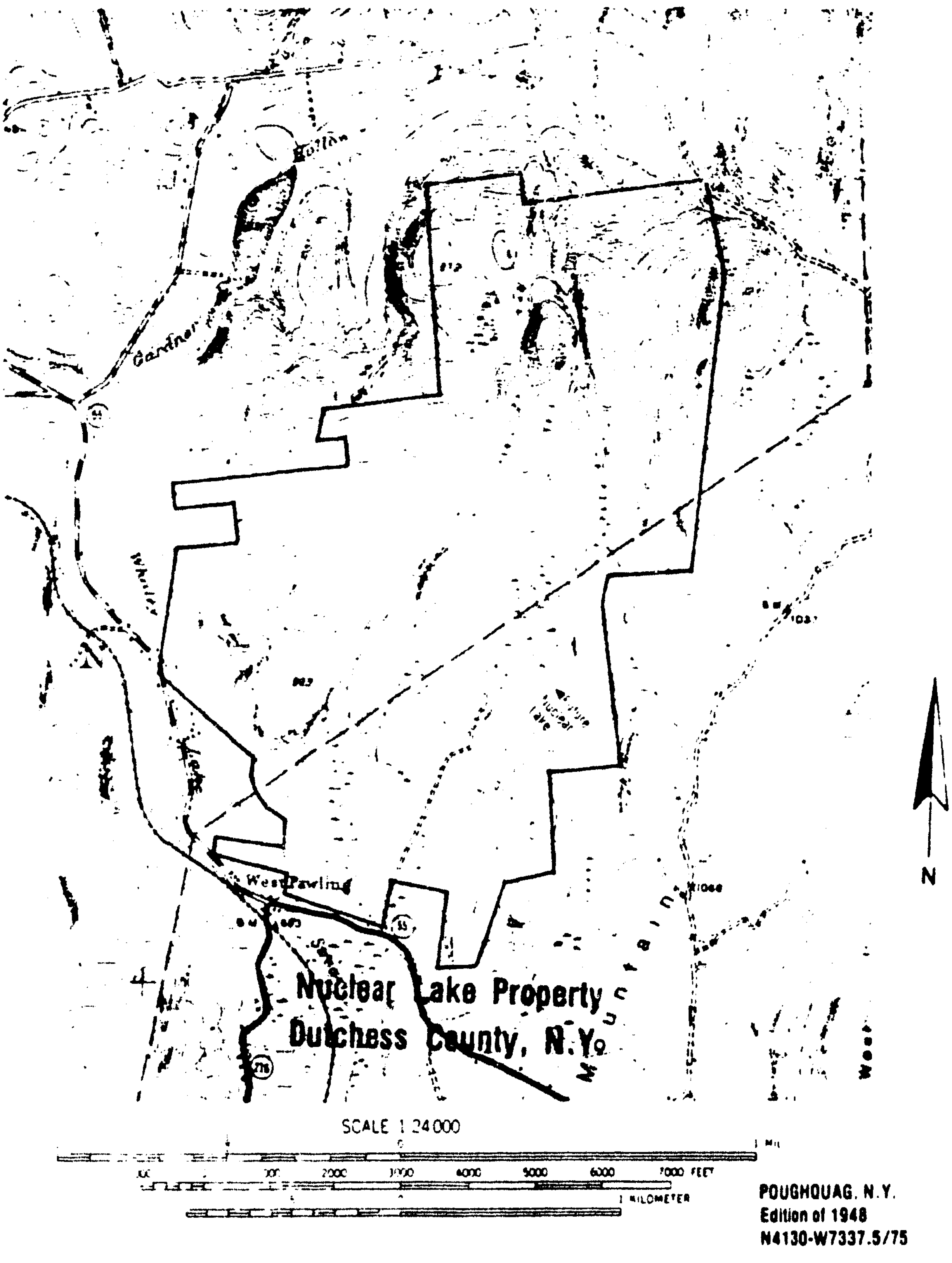

Figure I-1 - A segment of 1948 USGS Topographic Map. Poughquag Quadrangle, showing Nuclear Lake as a large wetland prior to construction of the dam which formed the lake. Superimposed is the boundary of the Nuclear Lake Property owned by the National Park Service.

The 1941 aerial photograph analysis also points out that narrow dirt roads accessed the property from north and south and that the entire area was thickly wooded with deciduous trees predominating.

In March 1946, Mr. Milton Chazen and Mr. L. Ryder, new owners of the property, applied to the State of New York Department of Public Works, to construct a dam in the same location as the 1936 Teets' proposal. The Chazen-Ryder Application for Construction (4) indicated that:

1. The watershed area above the proposed dam is 1.5 square miles.
2. The natural material on which the proposed dam would rest consists of hard yellow clay down to bedrock.
3. Facing downstream, the nature of the material composing the right and left banks of the stream consists of rock.
4. The proposed dam was to be 20' long, 16' high, made of concrete and constructed on an apron of reinforced concrete, 30' wide and 6" thick. This dam would create a lake area at spillcrest elevation of 52 acres, impounding 18,000 cubic feet of water.
5. The dam would also contain a built-in spillway constructed of 24" box culvert or 24" cast iron pipe with a suitable gate valve. The spillway was designed to discharge 181 cubic feet per second.

The Application for Construction was approved on March 23, 1946 (5). The dam was subsequently built. However, rather than being a concrete dam, it was an "earthen type dam" possibly containing a concrete core wall (6). There was no spillway in the dam itself, but to the east of the dam an overflow channel was cut through natural ground. (See Figure I-2). Along the channel, a small "lock type" dam was constructed and used to raise or lower the level of the lake by three or four feet. The water impounded originally created a lake to be used for recreational pruposes. Earlier records show the lake to have the name, "Pawling Pond".

An analysis of October 16, 1948 aerial photographs (3), verifies that a dam had been constructed across an outlet on the southern end of the main wetland area. (See Figure IV-2). The lake formed by the dam measured approximately 50 acres as seen previously on the 1941 photography. Wetland vegetation disappeared under water except for three small "islands". Lake boundary vegetation thickened and filled in to some extent along the northern and western shorelines. There existed some marshy beach along the northern boundary, but generally the wooded shoreline met the waterline directly. The photography showed the main dam clearly, but the overflow channel was not visible beneath the heavy tree canopy.

April 11, 1955, aerial photographs were also analyzed (3). This analysis clearly shows details of the dam, control structure, stream patterns, access roads and two structures near the lake. (See Figure IV-3). The water level in the lake appeared higher. No beach area was evident. Two of the three small islands that appeared in the 1948 photographs have disappeared and the marsh area that was once present along the northern shoreline, is gone.

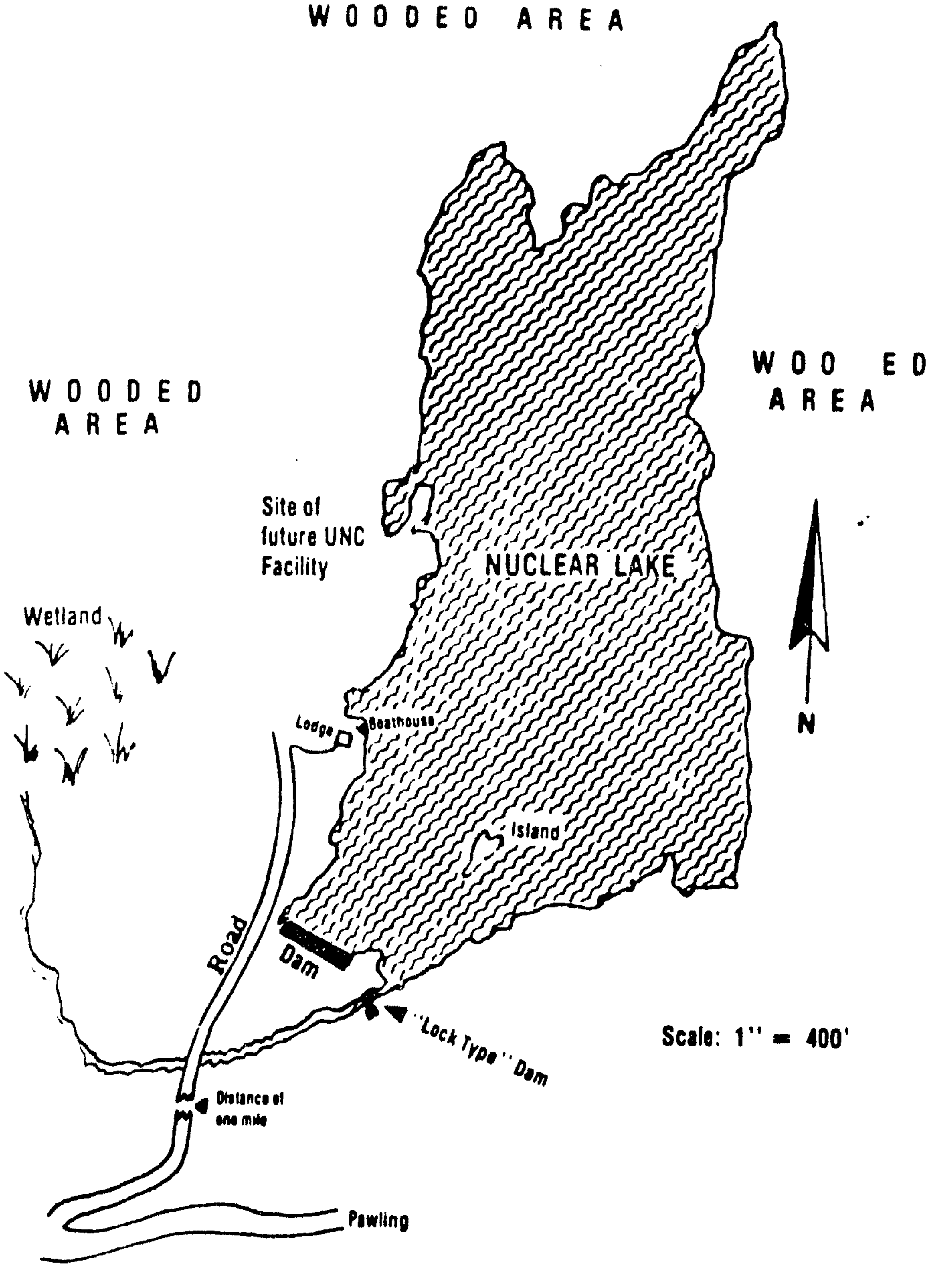

Figure 1-2 - Shows Nuclear Lake, location of both main dam and "lock-type" dam, and surrounding land area after dam construction, 1948

Wetlands around the lake are still present as in earlier photographs but some have dried up, some have become smaller and some have changed configuration. Two structures are present along the western shoreline approximately a fourth of the distance up the lake from the dam. These structures appear to be the hunting lodge mentioned in other background information, and the other, by its location directly on the lake, a boathouse.

On November 28, 1979, the dam was field inspected by Mr. Norman Benson, District Manager of the Dutchess County Soil and Water Conservation District, to ascertain if the existing structure was safe and free from danger of failure. Mr. Benson's inspection report showed the dam to be sound and not likely to fail, though some recommendations to improve its strength were made. Mr. Benson's report in its entirety is found below.

Mr. Charles Shaw, Environmental Specialist
Dutchess County Cooperative Extension
Nuclear Lake Management Committee
Site Clearance Sub-Committee Chairman

Dear Mr. Shaw,

At your request I examined the dam on Nuclear Lake in the Township of Pawling and found it to be sound and in no immediate danger of failure. However, I have a few recommendations that will improve the safety of the dam and further diminish the chances of dam failure.

Number one is to remove the water height control structure in the outlet stream east of the dam to keep the lake at its present level and to allow for more flow capacity at times of heavy runoff. The stream channel should be cleaned of debris from the water control structure back to the lake outlet to allow for a free flow of water, especially in times of heavy runoff. The lower lake level takes pressure off the top of the dam and allows for more free board.

Number two, remove the two culvert pipes from the top of dam and fill the ditches that are left when the pipes are removed with a tight clay material to the top height of the present pipes and pack it well, then seed with a grass mixture and mulch. These two culvert pipes are not equipped with anti-seep collars and, therefore, have some soil erosion around them. Should these culverts become plugged at a time of high water on the dam, these culverts could wash out causing a dam failure.

Number three is to fill an eroded area on the top of the dam east of where the present culvert pipes are. Fill this area with a tight clay material the width of the top of the dam and west to the point where the culvert pipes were removed and at that same depth. This tight clay material should be packed as tight as possible and then grass seeded and mulched. Lime and fertilizer should also be added for better results. The eastern end of the dam should not be disturbed as it has a heavy grass cover and, because of its somewhat lower elevation, will act as a safe emergency spillway in case of an extra heavy runoff storm when the stream could not handle all the lake overflow.

The dam appears to have a concrete core and well tied in at both ends into the bedrock. There appears to be no leaks in the dam. The dam is a solid 20 feet wide on top and 32 plus feet wide just below the water line except for the one eroded spot on top, the dam is only 9 feet wide at this point and was mentioned above as a spot to be repaired.

If you have any further questions or comments feel free to write or call me.

Sincerely yours,

Norm Benson
District Manager
Dutchess County Soil & Water Conservation District

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2. State of New York, Department of Public Works, Division of Engineering; Application for the Con struction of a Dam; Dam No. 230-1097; October 20.
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7. Memo from Mr. Norman Benson, District Manager, Dutchess County Soil and Water Conservation District, to Charles P. Shaw, Executive Director, Dutchess County Environmental Management Council; November 28, 1979.

II. Environmental Conditions of Site

"This charter was compiled from available information without recourse to detailed field surveys."

Geology

Major bedrock types on the 1137 acre Nuclear Lake property are schist and gneiss: in addition, quartzite, phyllite and carbonates (limestone and dolostone) could be present in small areas, TABLE 1 (1). Gneiss surrounds the lake and extensive schist occurs a little east of the lake.

A fault divides the gneiss and the schist just east of the lake (1). The fault comes up from the south (SSW-NNE) and at a point approximately east of the lake it forks at an angle of about 25°, one branch continuing NNW, the other NNE. The fault shows as a distinct pair of small escarpments on the topographic map (2).

The gneiss and schist have low background gamma radiation counts (3). Not far off the property younger pegmatite dikes with slightly higher counts occur; such dikes might also be present on the property. Phyllite, if present, might have slightly higher counts than the gneiss and schist.

Occasional crystals of galena, chalcopyrite, or other minerals may also be present in the bedrock and if present would contribute some lead, copper or silver to the environment.

TABLE 1 Geological formations Nuclear Lake property and vicinity From Geological Map of New York 1970 (1)

Symbol	Formation	Age
bg	Biotite granitic gneiss	Precambrian
€ev	Everett Schist - locally with minor meta-graywacke lenses	Cambrian
€pg	Poughquag quartzite - locally conglomeratic	Cambrian
OCw	Wappinger Group - limestone dolostone	Cambrian-Ordovician
Ow	Walloomsac Formation phyllite schist meta-graywacke	Ordovician

Topography

The lowest point on the property is about 600 feet above sea level - in the west - and the highest point about 1,050 feet in the northeast (2). However, the local relief of small valleys and adjacent hilltops on the property is mostly 50-100 feet. The trend of the valleys and ridges is mostly SSW-NNE (Figure II -1). Steep slopes (over 15%) and bedrock at or very near the ground surface characterize much of the property (4). Lake surface elevation is 758 ft. (2).

Hydrology

Nuclear Lake is artificial; the dam was built in 1946-47 (5). The pre-existing wetland was not dredged, but simply flooded during lake construction. The lake's surface areas has been reported as 38 acres (4), 0.06 square miles (about 38 acres) (14); 45 acres (10), 29 acres (Chapter I, page 2), and 50 acres (Chapter I, page 2). Estimates from the 1960 Topographic Map (2) indicate it to be 37-38 acres. Shoreline is about 1.3 miles (14).

The entire watershed of Nuclear Lake is in the extreme eastern end of the Fishkill Creek drainage basin, tributary to the Hudson River estuary at Beacon, New York. Although some areas less than one-half mile east of Nuclear Lake drain east to the Housatonic River, no part of the Nuclear Lake property drains eastward and there are no apparent surface water connections between the two drainage basins.

The waters and wetlands of the property are shown in Fig. II - 2 (21). Most of the watershed of Nuclear Lake is on the property. However, the west and north edges of the property drain into Gardner Hollow Brook (6). Note: Tributary 2 of Gardner Hollow Brook is not continuous with the inlet at the northeast corner of Nuclear Lake as was shown in Planning Guidelines for Dutchess County Drainage, Plate 1 (6).

The Nuclear Lake outlet stream leaves the south end of the lake, swings west and passes through a series of wetlands into which the small stream west of the lake also drains. These wetlands are continuous with wetlands along Whaley Lake Stream which flows out of Whaley Lake (1½ miles to the south) and swings west (leaving the wetlands) at Rt. 55. The entire wetland complex between Nuclear Lake and Whaley Lake is between 690 and 700 ft. elevation, excepting the small wetland just SW of Nuclear Lake which is between 700 and 710 ft - still 50 feet below Nuclear Lake. The wetland formerly occupying the lake site was between 740 and 750 ft. (2).

For additional detailed information concerning changes in the drainage patterns and wetlands on and around the Nuclear Lake Property refer to Chapter IV - Sequential Air Photo Analysis, of this report.

It is not known if there are any springs on the property. The groundwater of the general area is soft, often tainted with hydrogen sulfide, and yields about 16 gallons per minute from drilled wells (4).

Figure II-1 - A segment of the 1960 USGS Topographic map Poughquag Quadrangle showing elevation and slope data for the Nuclear Property. Superimposed is the boundary of the Nuclear Lake Property owned by the National Park Service

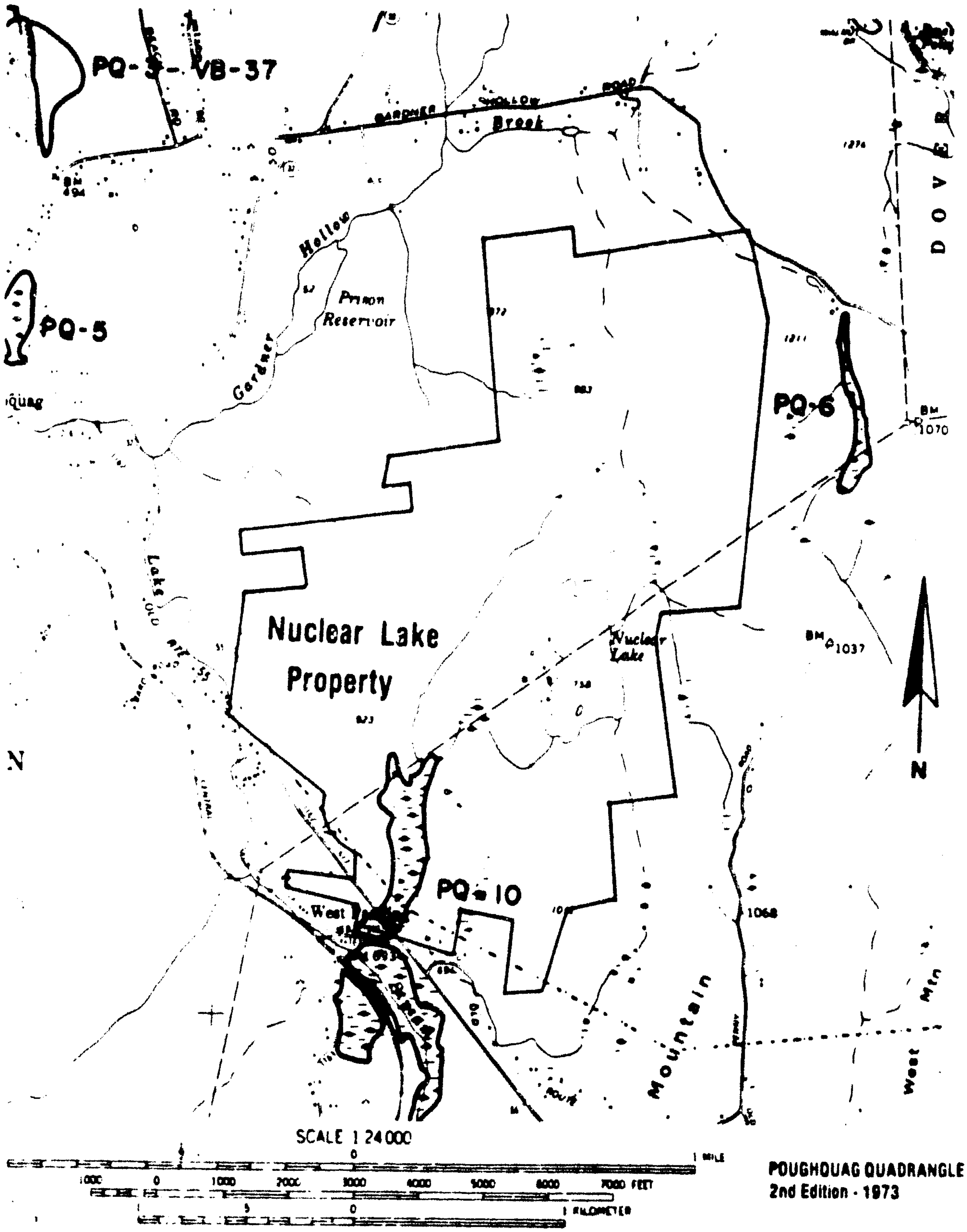

Figure II-2 - A segment of 1973 Poughquag Quadrangle showing surface waters and wetlands on the Nuclear Lake Property. Superimposed is the boundary of the Nuclear Lake Property owned by the National Park Service

Soils

Fig. II - 3 is a generalized soil map of the property. The soils are derived predominantly from glacial till (ground-up rock materials of various particle sizes and diverse origins). These soils are acidic (8); exceptions being wetland and calcareous soils. The wetland soils consist of fine material and contain more organic matter from plants than do the till soils. Small areas of calcareous (limy) soils derived from carbonate rock outwash occur near the southwest corner of the property (Fig. II - 4); these soils are alkaline. Soil mapping of this type (8) is not finely detailed and it is likely that small areas of wetland or calcareous soils occur on the property but are not mapped.

The depth of wetland sediment in the lake basin was not recorded when Nuclear Lake was built (5). However, a boring in the wetland about 0.7 mile north of Whaley Lake and 300 ft. south of Rt. 55, revealed much from the surface to a depth of 2 ft. and silt below that (13), but no borings were reported from the Nuclear Lake property.

All soil types of the Nuclear Lake property and vicinity are listed in TABLE 2.

TABLE 2 Soil types Nuclear Lake property and vicinity According to Soil Survey Dutchess County New York (8)

Symbol	Soil; Parent material	Slope %
Ch	Chatfield stony loam ledgy hilly phase glacial till chiefly granite & gneiss	15-30
Co	Copake gravelly loam nearly level & undulating phase.	0-8
Cs	Copake gravelly loam steep phase glacial outwash chiefly calcareous sandstone limestone & slate	25-45
Gc	Gloucester gravelly loam rolling phase. glacial till. chiefly granite & gneiss	5-15
Gl	Glouster stony loam rolling phase glacial till chiefly granite & gneiss	5-15
Hc	Hollis Channery loam rolling phase glacial till. chiefly schist	5-15
Rd	Rough stony land: variable	25-60
Sk	Stockbridge gravelly loam gently sloping & sloping phases. glacial till. chiefly limestone & slate	0-15
Wt	Whitman stony silt loam. glacial till chiefly schist, granite & gneiss	0-3

Vegetation

The terrestrial vegetation is predominantly hardwood forest (4, 17, 18). An evaluation of color aerial photographs taken in May 1980, (see Chapter VIII) gives an impression of extensive rocky, thin-soiled, dry hardwood forest of small to moderate tree size, broken by small pockets of other plant communities in wetlands and other sheltered sites. This impression was borne out by the limited information available, at least for the areas along the driveway and around the buildings (16-17), which support an oak woods (white oak is the commonest tree) with scattered hemlock, red oak, tulip, black birch, flowering dogwood, witch-hazel, mountain-laurel, and other trees and shrubs. Lichens (crustose or foliose species) are present on tree trunks.

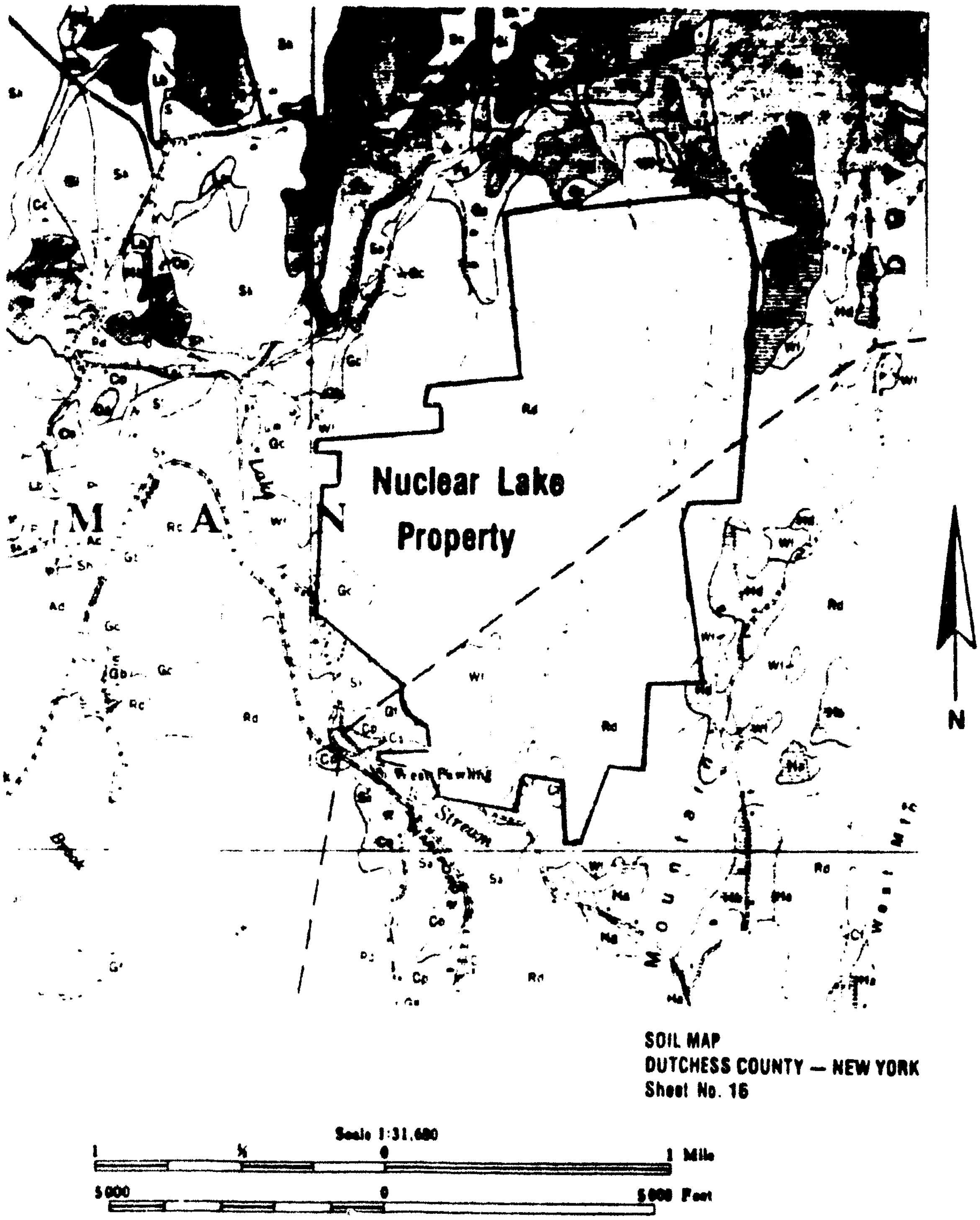

Figure II-3 - Segment of Soils map Poughquag Quad showing generalized soils types found on the Nuclear Lake Property. Superimposed is the Nuclear Lake Property owned by the National Park Service.

The wetlands, largely wooded, have numerous red maples mostly of small size, also yellow birch, alder, royal fern, skunk cabbage, tussock sedge and other species (16). No spagnum moss has been noted. Purple loosetrifle, cattail and alder are among the species of the lake shoreline. A list of the observed flora is in Table 3.

At the time of lake construction (1946-47), shrubs and small trees covered the wetland on the lake site (5). The wetland has been described as a "boggy swamp", at the bases of woody plants. At this time, the lake's surroundings were "second growth" forest, including "poplar, shrub oak, some maple" (5). The trees were not large because the American Brass Company had cut over the whole area for charcoal at an unreported date (5). As is common elsewhere in eastern Dutchess County, charcoal production pits may be present on the Nuclear Lake property.

TABLE 3 Plants observed on the Nuclear Lake property (4, 16, 17)

TREES	HERBS	FERNS AND ALLIES
Red maple	Sedge	Horsetail
Black birch	Tussock sedge	Christmas fern
Yellow birch	Strawberry	Sensitive fern
American chestnut	Grasses	Cinnamon fern
Flowering dogwood	Purple loosestrife	Royal fern
Beech	Orchids	
Red ash	Skunk-cabbage	**SHRUBS**
Red cedar	Coltsfoot	
Tulip	Cattail	Alder
White oak		Witch-hazel
Red oak		Mountain-laurel
Willow		Bramble
Sassafras		Blueberry
Hemlock		Viburnum

Animals

A list of species reported on the property is in TABLE 4. This was compiled from a number of sources but should not be considered complete.

The area was listed as "United Nuclear Corporation" (UNC) in Where to Bird in Dutchess County (10) which stated that migrant waterfowl used the lake in early spring and late fall. Typical woodland birds may be seen on the property. The Ralph T. Waterman Bird Club visited the property on 19 March and 26 October 1977, 18 March, 24 June, and 14 October 1978, and 31 January 1979. Mr. Benson, former caretaker of the property, operated bird feeders there (9).

Whaley Lake had a breeding pair of bald eagles until at least 1891 (11) and perhaps into the early 1900's (12).

TABLE 4 Animals observed on or near the Nuclear Lake property, 1977-80 (9, 16, 18, 19, 20)

MAMMALS

Beaver *
Eastern chipmunk
Woodchuck
Bobcat *
Whitetail deer

BIRDS

Great blue heron
Canada goose
Greater scaup
Turkey vulture
Goshawk
Sharp-shinned hawk
Ruffed grouse
Mourning dove
Chimney swift
Belted kingfisher
Common flicker
Pileated woodpecker
Hairy woodpecker
Eastern kingbird
Great crested flycatcher
Eastern phoebe
Least flycatcher
Eastern wood pewee
Tree swallow
Blue jay
Common crow
Black-capped chickadee
Tufted titmouse
White-breasted nuthatch
Brown creeper
House wren
Grey catbird
American robin
Wood thrush
Veery
Blue-gray gnatcatcher
Ruby-crowned kinglet
Starling
Red-eyed vireo
Warbling vireo
Black-and-white warbler
Worm-eating warbler
Blue-winged warbler
Yellow warbler
Yellow-rumped warbler
Black-throated green warbler
Chestnut-sided warbler
Prairie warbler
Ovenbird
Northern waterthrush
Louisiana waterthrush
Common yellowthroat
Canada warbler
American redstart
Red-winged blackbird
Northern oriole
Common grackle
Scarlet tanager
Cardinal
Rose-breasted grosbeak
Indigo bunting
American goldfinch
Rufous-sided towhee
Dark-eyed junco
Chipping sparrow
White-throated sparrow
Swamp sparrow
Song sparrow
Black-throated blue warbler

REPTILES

Snapping turtle
Painted turtle

AMPHIBIANS

Spring peeper

FISHES

Brown trout *
Brook trout *
Northern pike +
Chain pickerel
Creek chubsucker
Brown bullhead
White perch
Pumpkinseed
Bluegill
Largemouth bass
Yellow perch

***Reported near the Nuclear Lake property and probably occurs there.**
+ Two were liberated in Nuclear Lake in 1979 (Charles Shaw, pers. comm.).

Many UNC documents refer to testing "Salamanders" from the stream and "perch" and "catfish" from the lake, for radioactivity (15). During October 1956, the NYS Conservation Department stocked Nuclear Lake with several fish species taken from Kurk Lake in Putnam County, New York (22). A list of these fish species can be found in TABLE 5.

TABLE 5. New York State Conservation Department Fish Stocking Report For Nuclear Lake (22)

Fish Species	Number Stocked	Weight (lbs.)	Average Size (Inches)
Bullheads	?773	2773	12
Yellow Perch	1915	1315	10
Sunfish	815	220	8
Rock Bass	485	95	5
White Perch	284	340	13
Chub Suckers	62	62	12
Golden Shinners	120	60	9

In December 1979, the New York State Department of Conservation, using gill nets, collected 122 fish samples for radiological testing. All samples were reported to be in good condition (no sores or lesions nc·ed). Most were under five years old except for a few perch estimated to be 6-7 years old. TABLE 6 lists these species collected.

TABLE 6. New York State Department of Environmental Conservation Records of fish collected for radiological testing

Species	Number	Weight
Yellow perch	93	1/2 - 1 lb each
Pumpkin seed	4	
Chain pickeral	6	
Large mouth bass	3	
White perch	3	
Brown bullhead	4	4 lb 1 oz - Total

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III. UNC History and Operations

OWNERSHIP

Between 1934 and 1942, Herbert Teets acquired approximately ten parcels in the towns of Beekman and Pawling, which comprise the large majority of the present 1137 acre Nuclear property (1).

In 1945 the property was sold to Joseph Chazen and Leland Rider. The dam creating the lake was constructed shortly after this, and in 1953, Chazen sold his interest in the property to Ryder (1).

In April 1955, Leland Ryder sold the property to Southern Dutchess Corporation. During the next few years Nuclear Development Corporation of America (NDA) obtained several construction permits and licenses for development of the Remote Experimental Station at Pawling. (See figure III-1). In March 1958, the property was transferred from Southern Dutchess Corporation to NDA (1).

In May 1961, Nuclear Development Corporation of America (NDA) assets, personnel and licenses to operate were transferred to United Nuclear Corporation (UNC). During the next few years, portions of the UNC operations were conducted under a contract with the United States Atomic Energy Commission. Also during this period several parcels were acquired by New York State for realignment of Route 55 (2).

In April 1962, United Nuclear Corporation merged with Sabre-Pinon, which subsequently changed its corporate name to United Nuclear Corporation (UNC). Through the merger a "new" UNC was formed and licensed (3).

In July 1971, United Nuclear Corporation (UNC) signed a lease agreement with Gulf United Nuclear Fuels Corporation (GUNFC), which made the operation of the Remote Experimental Station a joint venture. UNC retained ownership of the property and facilities, and GUNFC held the licenses to operate. The new corporation was called Gulf United Nuclear Corporation (GUNC) (4).

GUNC requested termination of its License SNM-871 on March 11, 1974, and by July 14, 1975, when the license was terminated by the Nuclear Regulatory Commission, the company was known as General Atomic Company (15)

In November 1977, United Nuclear Corporation sold the property to Harpoon, Inc. (5).

In June 1979, Harpoon, Inc. sold the 1137 acre parcel to the United States of America (USA), Department of the Interior, National Park Service for relocation of the Appalachian National Scenic Trail (6).

FACILITY DEVELOPMENT AND USE

The property currently contains a number of structures, access road, parking lots and utilities. A plan of the UNC Remote Experimental Station showing all structures is provided as Figure III-2. Following is a description of each structure's construction and function while the site was used as a nuclear research facility. The description has been taken from available information.

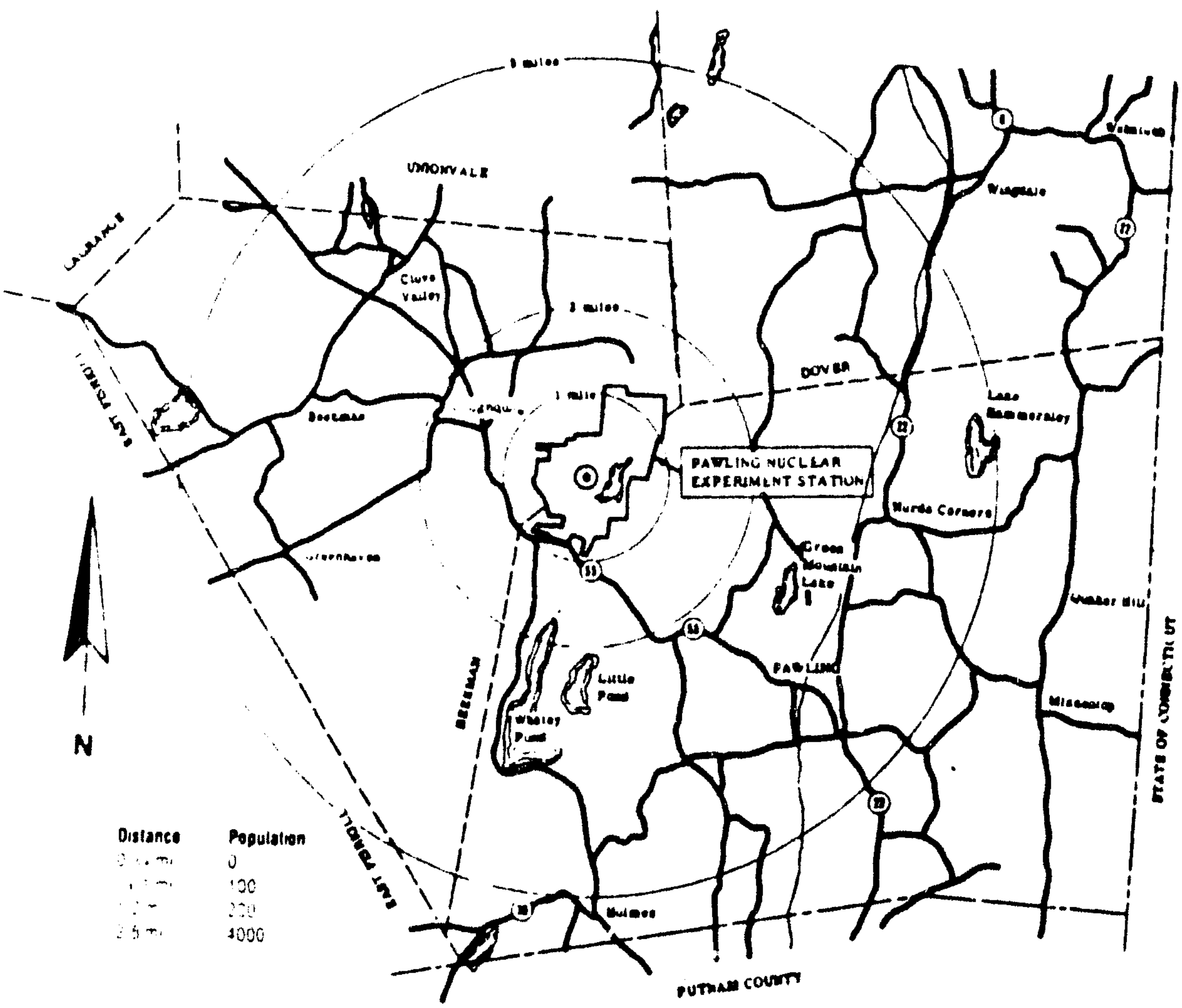

Figure III-1 - Remote Nuclear Experiment Station at Pawling

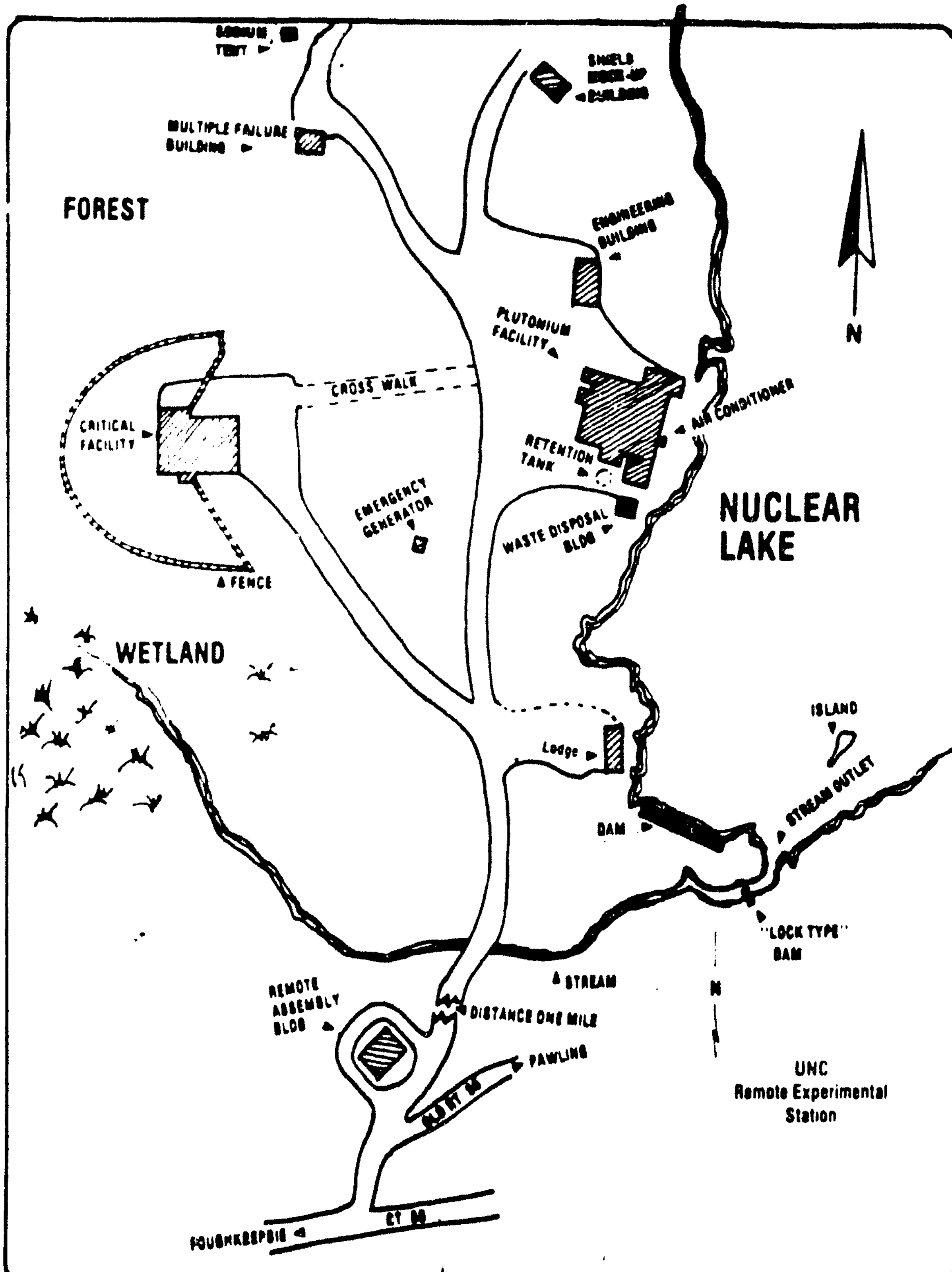

Figure III-2 - Remote Experimental Station - Plant Layout

A. LODGE (Figure III-3)

Location and Construction:
This single story "wooden hunting lodge" existed prior to 1955 (7). It has a stone foundation, stone fireplace, and is located near the lake shore south of the Plutonium Facility.

Function and Uses:
In 1963 and 1967 it was being used for storage.

Figure III-3 - The Lodge (1981 Photo)

B. BOATHOUSE

Location and Construction:
A small wood frame structure was located on the lake shore near the lodge prior to 1955 (7). It was also called garage.

Function and Uses:
The building was converted for storage of the fire trailer which held a 300 gallon tank, hoses and a pump used for fire protection within the complex (8). A "pond plug" was installed in the floor to permit rapid filling of the trailer tank (9). In 1970, all employees were warned that the building was collapsing (10). The structure does not now exist although a portion of its stone foundation is visible below the lake surface.

2. PLUTONIUM FACILITY (Figure III-4)

Location and Construction:

The building is located close to the west edge of the lake, north of the Waste Storage Building and east of the Engineering Building. It was one of the initial "testing and experimental labs" constructed in 1956 (7, 11, 12). Between 1966 and 1971, portions of the building were removed and other sections added. The present structure contains 8800 square feet. It is partially one story and partially 1½ stories, made of concrete block with two additions on the south side.

Several plans for alterations were reviewed between 1963 and 1966. During 1967, the detached Gas House on the northwest corner was removed and replaced by a 24' by 36' concrete block addition to the main structure. At the same time a 30' by 50' concrete block addition was constructed on the southwest corner. This required reconstruction of the sub-surface sewage disposal system (13, 14). Plans for this system were approved by the Dutchess County Department of Health in February 1967. It was constructed on the south side of the building, by June 1967, and included a 900 gallon tank and a leach field 5-7' deep (15, 16). After 1970, a 28' by 32' metal addition was constructed on the southeast corner of the facility.

Figure III-4 - The Plutonium Facility (1981 Photo)

Function and Uses:
The building was one of the two locations in which the use and storage of Special Nuclear Material was authorized. Much of the waste products discussed in Chapter V were generated in this building. The "Operating Manual" for this facility is available (8). The entire building was called the "Hot Laboratory" for several years and contained separate "Alpha Lab" and "Gramma Lab" sections (7, 9, 17, 24). Figure III-5 shows the floor plan for the building.

The Alpha Lab contained "a large number of interconnected glove boxes connected to very extensive gas handling facilities" and by 1961, the activities included the use of "unirradiated Pu and natural uranium both in the metallic and dissolved form" (25). It was within this portion of the building that the explosion occurred in 1972. (See Chapter VI).

The Gamma Lab had "several shielded caves" for work on irradiated fuel elements and handled small amounts of Special Nuclear Material (24, 26). Other portions of the building contained the Change Room, Decontamination Room, storage area and safe, bathrooms, offices and a small chemistry lab/dark room (7, 8, 27). (See figure III-5). In July 1966, the Gamma Lab facility was being dismantled (28).

The handling of plutonium in this building was discussed in 1957, and the "Plutonium Laboratory was first operated in August 1961". (29, 30). Use of plutonium and uranium-235 (U-235) in a proposed fuel fabrication process was discussed in March 1964. The major product produced in the fabrication process was uranium oxide - Plutonium Oxide (UO_2-PuO_2) in the form of pellets (7, 76).

In 1970, two amendments to this license were requested. One involved "Non-destruction assay operations" in a shielded area to be constructed on the south side of the building. This is the concrete block addition to the existing structure and was to have interior walls of concrete on three sides ranging in thickness from 18 to 36 inches. The second request was for an additional "6 gloves boxes and a continuous sintering furnace" which did not require building expansion. (32, 33).

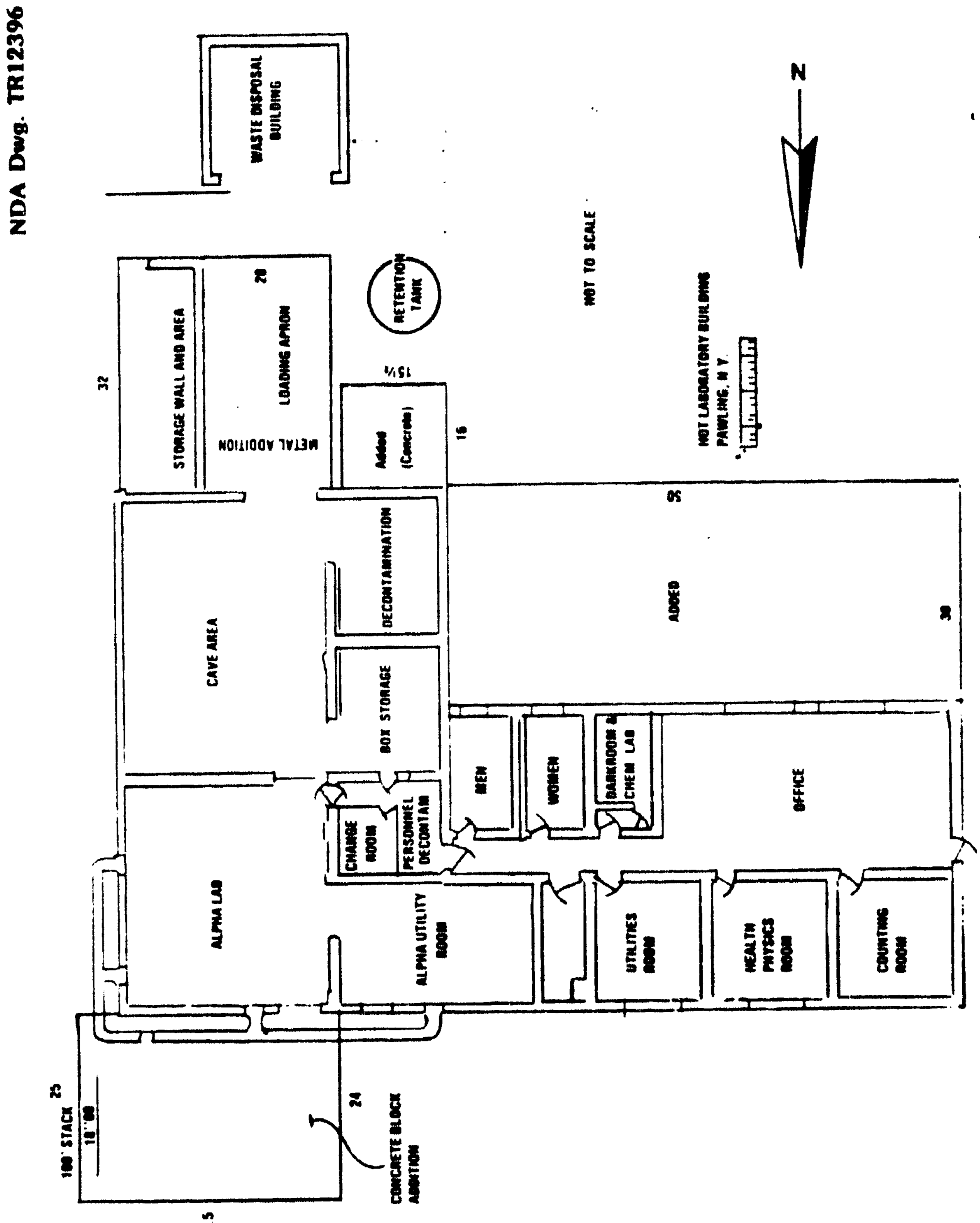

Figure III-5 - Plutonium Facility - Building Layout (May, 1961)

3. CRITICAL FACILITY (Figure III-6)

Location and Construction:
This 6000 square foot building is located on the edge of the complex, approximately 400 feet west of the Plutonium Facility. It has a separate parking area on the west side and the other sides of the building are surrounded by an 8 foot chain link radiation exclusion fence designed to keep people and animals from wandering too close to the building during operation. A large wetland system is adjacent on the southwest.

Construction began in 1956 and there have been no apparent exterior additions. The building was constructed of "structural steel with non-load-bearing masonry walls". The west end of the building consisted of the 25' by 60' by 38' high reactor room. It had provisions for two reactor locations and had two concrete pits in the floor. These measured 10' by 20' by 10' deep and 8' in diameter by 8' deep, and both were constructed without drains. A 4 foot thick poured concrete shield wall separated the reactor room from the other parts of the building. The remainder of the building is one story concrete block. Both sections have flat reinforced roofs (24, 34).

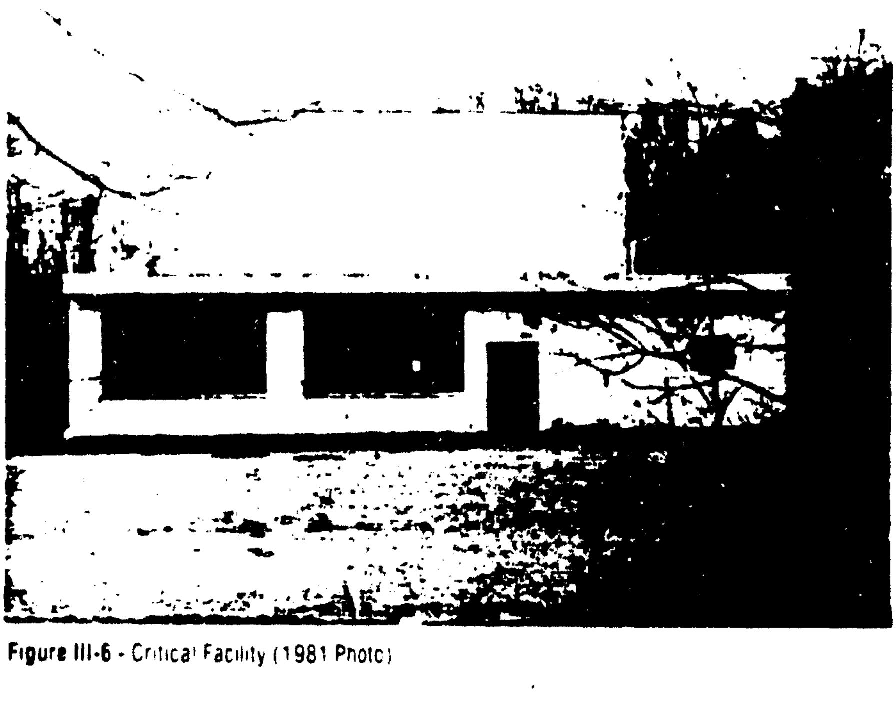

Figure III-6 - Critical Facility (1981 Photo)

Function and Uses:
This building housed two test reactors and later the Proof Test Facility, all of which were critical assemblies. It was operated under Facility License R-49 and was the other authorized location for the storage and use of Special Nuclear Material. Like the other facilities it was subject to Industrial Code Rule No. 38 of the New York State Labor Law (34, 37). By October 1957, some 2,000 gallons of borated water had been accumulated in one of the pits in the reactor room. It was noted that the water would not be needed after a short period of time, although it was stored here until at least 1965 and is discussed in Chapter V (30, 35, 36).

In June 1956, Nuclear Development Corporation of America (NDA) received a Construction Permit to build the Critical Experimental Facility. In 1958, NDA received another permit for the construction of a low power, heavy water "Pawling Research Reactor" to be housed in the Critical Facility Building. Later in October 1958, a "License to Operate" the Pawling Research Reactor was issued to NDA by the United States Atomic Energy Commission (USAEC). Subsequent amendments to this license in 1960-62, refer to the operation of another "low power, tank-type critical assembly" called the "Pawling Lattice Test Rig (PLATR)" (7, 18, 19, 38, 39, 46). PLATR utilized Polonium-Berylium (PlBe) and RadonBerylium (RaBe) as neutron sources.

In February 1963, a United Nuclear Corporation preliminary report on expansion of the Critical Facility structure and operation was prepared. Although the expansion did not occur, the report detailed the existing uses within the building. These included the Pawling Research Reactor in one of the two reactor positions and noted that the other position was vacant. The accompanying plan labelled the reactor as "PLATR" rather than the Pawling Research Reactor. Other portions of the building included a control room, accountable fuel storage vault, machine shop, electronics shop, counting room, bathrooms and office space. (See Figure III-8 for floor plan to the Critical Facility). "Split Bed Critical Assembly" and "Shield Mock-Up Reactor" and although the Construction Permits were issued, the necessary additions to the building were not constructed (7, 17).

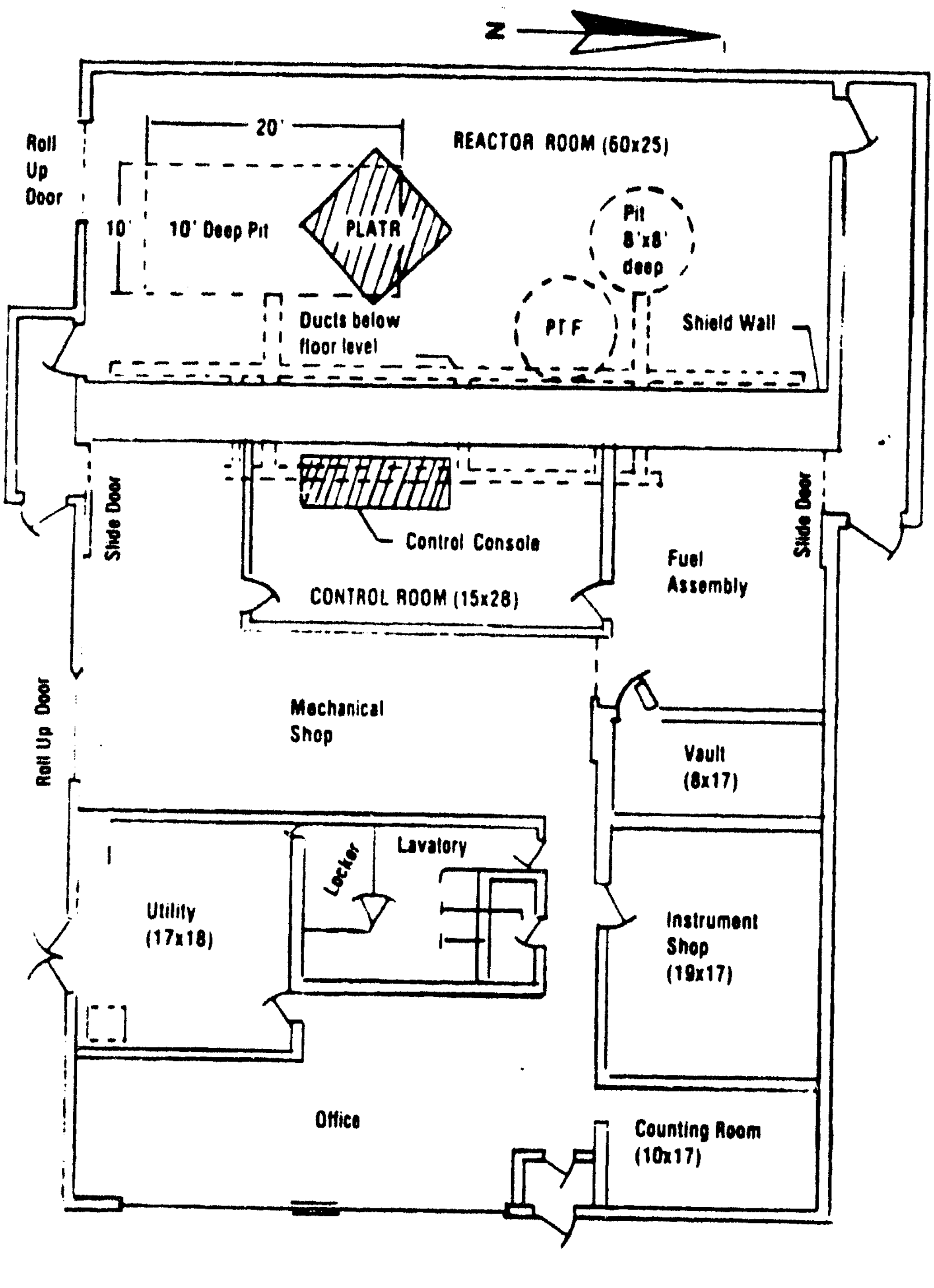

Figure III-7 - Critical Facility - Building Layout (April 1967)

In April 1967, USAEC reviewed the UNC proposal to construct "a light water moderated, zero power critical assembly which would be used for the purpose of providing a final reactivity test for manufactured assemblies", known as the Proof Test Facility (PTF). It was located in the reactor room within a new 4 foot diameter by 14'' high aluminum tank, and involved UO2 pellets fabricated in the Plutonium Facility (24, 76). The PTF operated initially in December 1967, operating changes were made in 1968, and it was mentioned again as being in operation in 1969. Operation of the PTF was authorized by USAEC License CX-25 (41, 42).

In March 1964, it was noted that "enriched fuel" was stored in the vault and "natural fuel: was stored in the reactor room (26). In September 1965, the facility was considered for use "as a Cobalt-60 (CO-60) irradiation site" and the borated water was still being stored there (36). In 1965-67 several Special Nuclear Material License and Facility License amendments were issued regarding increased storage limits for Uranium-235 (U-235), Uranium Oxide-2 (UO-2), fuel rods, Plutonium-239 (PU-239) and sealed source Plutonium-Berelyum (PuBe) in the Critical Facility Building (37, 69, 72, 73).

4. ENGINEERING BUILDING (Figure III-8)

Location and Construction

The building is a 2400 square foot, single story concrete block structure with a flat roof. It is located north of the Plutonium Facility about 350 feet northeast of the Critical Facility Building (7). The date of construction is uncertain although it was occupied by November 1957 (7, 12). No additions to this structure were noted. It was also referred to as the Experimental Engineering Building and Engineering Services Building (7, 46, 47).

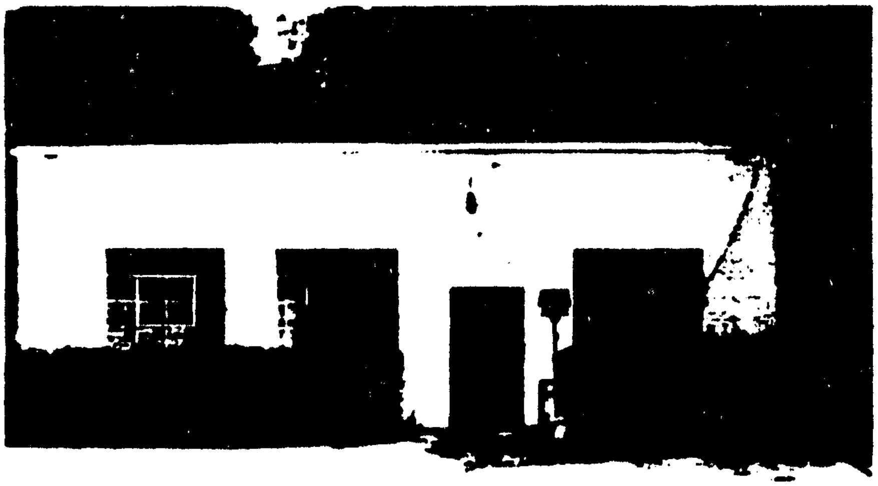

Figure III-8 - Engineering Building (1981 photo)

Function and Uses.
Through 1963, it was used partially for storage and partially for housing the site maintenance department, shop and garage: (7). In late 1957, and early 1958, single failure equipment and sodium were stored here while work continued on the Multiple Failure Building, the Shield Mock-Up Building and the Sodium Storage Tent (46, 47). The building contained bathrooms and in April 1958, the ladies room was converted to a Health and Safety room (48). four employees worked in the building on a regular basis in 1960 (49). Staff training courses were held in the "Conference Room" in early 1967. A description of existing facilities in April 1967, included a dark room, a chemistry laboratory and the Health Physics and Safety department (24, 50).

5. MULTIPLE FAILURE BUILDING (Figure III-9)

Location and Construction:
This is a 20' by 20' pre-fabricated steel building on a concrete slab, located 440' north-northeast of the Critical Facility Building. The building was in place by 1957, and a 15' by 20' loading platform was added in November 1957 (7, 51).

Figure III-9 - Multiple Failure Building (1980 photo)

Function and Uses:
In early 1958, multiple failure experiments utilizing sodium were begun in the building. A drum outside collected drained water and the used sodium was returned to the Sodium Storage Tent in the original container (48, 52). Like the Shield Mock-Up Building, other experiments with lithium were conducted here and it was noted that "no radioactive materials were involved in these experiments at any time" (53). The building was being used for storage in 1963.

6. SHIELD MOCK-UP BUILDING (Figure III-10)

Location and Construction:
This is a 20' by 30' by 20' high pre-fabricated steel building on a concrete slab, located at the outer edge of the complex. It is 720' north-northeast of the Critical Facility Building and was constructed in late 1957 (7, 20, 46).

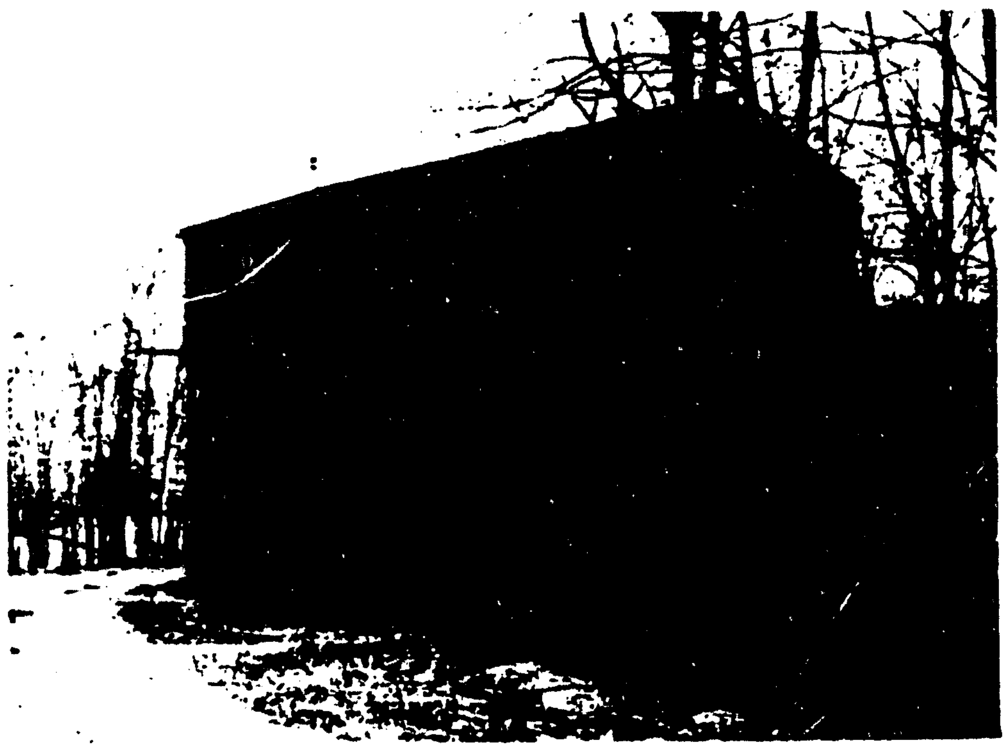

Figure III-10 - Shield Mock-Up Building (1980 photo)

Function and Uses:
The building was referred to as one of two "Liquid Metal experiment building" and was operational in April 1958. Experiments with stable sodium and lithium were conducted here until about 1963 (7, 24, 48, 53). After this the building was used for storage. In 1971, it was noted that the building was authorized for the storage of up to "250 grams of solid waste" (54). Following the accident in 1972, the building was used for "storage of drums containing contaminated waste resulting from the clean-up of the Plutonium Facility" (55).

7. SODIUM STORAGE TENT (Figure III-11)

Location and Construction:
The sodium tent is a 15' by 15' concrete pad on a concrete block foundation, located about 1000 feet north of the Critical Facility Building. The floor was sheet steel with a tent erected over it and wood railing along the sides. It was constructed in 1958, and required considerable clearing of vegetation around it to reduce the fire hazard (47, 56).

Figure III-11 - Sodium Storage Tent (1980 photo)

Function and Uses:
Containers of sodium and used sodium from the operations in the Multiple Failure Building were stored here (48).

8. WASTE STORAGE BUILDING AND RETENTION TANK (Figure III-12)

Location and Construction:
The Waste Storage Building is a 20' by 20' two story prefabricated galvanized steel "Armco" located on a concrete block foundation (7). It is located immediately adjacent to the Plutonium Facility. The Retention Tank is an in-ground concrete tank having a capacity of approximately 4,500 gallons and is located directly in front of the Waste Storage Building (57).

Figure III-12 Waste Storage Building and Retention Tank (1980 photo)

Function and Uses:
The Retention Tank is shown in a 1956 aerial photograph of the complex. In May 1957, the "retention tank at the Hot Laboratory" contained 4,000 gallons of low level radioactive waste water (34). (See Chapter IV and V).

The Waste Storage Building was also constructed early in the development of the property. In the 1959 application for a permit to discharge radioactive liquid wastes below the maximum permissable concentrations, the procedure included the use of this building. Liquid wastes from the Plutonium Facility laundry, shower and several sinks were carried by a pipe to the Waste Storage Buiding, where they were stored in 55 gallon drums. The drums were analyzed, diluted if necessary in the lower level of the building, then discharged to the lake through a 2" PVC pipe. The point of discharge was approximately 50 feet off shore in about 12 feet of water. The discharge pipe was held three feet below the surface and secured by a series of floats and anchors (8, 12, 49, 58). The permit for the described discharges was issued in November 1960 (58).

In 1964, a request to store a "hot" Sectioning Box in the building was denied until the box was decontaminated (17). In 1968, the building was being used to store valuable equipment and a sprinkler system was proposed. It was called the "Equipment Storage Building" at that time (59).

9. MAIN PARKING LOT (Refer to Sequential Analysis. Chapter IV)

10. EMERGENCY GENERATOR BUILDING

Location and Construction:
This 8' by 16' concrete block building has a steel garage-type door, concrete floor and corrugated metal roof. It is located near the road within the complex and was in place by late 1957. (45).

Function and Uses:
This housed a diesel emergency electric generator which provided back-up power for the facility (7, 24).

15. REMOTE ASSEMBLY BUILDING (See Figure III-13)

Location and Construction:
This is a 24' by 28' two story wood frame structure with a full basement which existed prior to 1955. It is located at the vehicular entrance to the site on Old Route 55, approximately one mile from the lake and building complex. A well on the north serves the building and a septic system is located on the south side. A wood garage is located slightly to the southeast.

Figure III-13 - Remote Assembly Building (1980 photo)

Function and Uses:
This "company-owned house" was occupied as a dwelling at least during 1963 and was vacant by 1967 (7, 24). As part of the facility's emergency procedures, this building was designated as the "Remote Assembly Building" in 1967. Various equipment including meters, air-samplers, protective clothing, bedding, operating manuals, and a telephone was stored here for use in an emergency (60-63). The building was used for drills and for the evacuation during the December 1972 accident. Site personnel were decontaminated in this building on that occasion (55, 81). A system to collect water from the shower and wash facility was not in place until November 1973. (64).

The building is currently occupied as a dwelling under Special Use Permit from the National Park Service (65).

APPLICATIONS, PERMITS AND LICENSES

The following is a compilation of information relating to permits and licenses requested by, or issued to the various corporations involved in the Pawling Remote Experimental Station. Attempt has been made to organize the available information by subject rather than strict chronology.

A. DAM CONSTRUCTION

1. Herbert M. Teets to New York State Department of Public Works (NYSDPW):
   "Application for the Construction or Reconstruction of a Dam", submitted by Ralph L. MacDonald, dated October 14, 1936 (66).
2. Milton Chazen to NYSDPW:
   "Application for the Construction or Reconstruction of a Dam", dated March 21, 1946 (66).
3. NYSDPW to Milton Chazen:
   Approval of plans for dam construction with stipulations, dated March 23, 1946 (66).

B. CRITICAL EXPERIMENT FACILITY

1. Nuclear Development Corporation of America (NDA) to United States Atomic Energy Commission (USAEC):
   Application for a Class 104 license to construct, possess and operate a critical experiment facility, dated March 5, 1956; amended April 13 and May 10, 1956, and November 26, 1957 (67).

2. USAEC to NDA:
Construction Permit No. CPCX-3 issued for construction of the critical experiment facility, dated June 11, 1956 (67).
3. USAEC to NDA:
License No. CX-8, Docket No. 50-23, to possess the critical experiment facility issued expiration date of June 11, 1966 (67).
4. NDA to USAEC:
Application for a Class 104 license authorizing the construction and operation of a heavy water-moderated and reflected training and research nuclear reactor, dated April 2, 1958; amended June 30, 1958 and refers to the Pawling Research Reactor (68).
5. USAEC to NDA:
Construction Permit No. CPRR-29 issued for construction of the Pawling Research Reactor, dated October 7, 1958 (68).
6. Facility License No. R-49
   a. Issued by USAEC for operation of the Pawling Research Reactor in the Critical Facility Building, dated October 22, 1958 (7).
   b. R-49 Amendment #1 issued for operation of the Pawling Lattice Test Rig in the Critical Facility Building, dated February 25, 1960 (7).
   c. R-49, Amendment #2, Docket No. 50-101, issued for revisions in the operation of the Pawling Research Reactor and the Pawling Lattice Test Rig, dated July 13, 1961 (66).
   d. R-49, Amendment #3, issued for revision of the Pawling Lattice Test Rig experimental program, dated January 29, 1962 (7).
   e. NOTE: By June 1967, this License was revised again to permit 150 kg of U-235 in the Reactor Room of the Critical Facility Building (69).
7. United Nuclear Corporation to USAEC:
Application for a class 104 license authorizing Construction and operation of a Split Bed Critical Assembly in an addition to the Critical Facility Building, dated March 4, 1963; amended June 20 and August 20, 1963 (40).
8. USAEC to UNC:
Construction Permit No. CPCX-22, Docket No. 50-207, issued for construction of Split Bed Critical Assembly, dated October 30, 1963 (40).
9. UNC to USAEC:
Application for a Class 104 license authorizing con-construction and operation of Shield Mock-Up Reactor (SMR) Critical Assembly in an addition to the Critical Facility Building, dated March 4, 1963 (40).
10. USAEC to UNC:
Construction Permit No. CPRR-76, Docket No. 50-207, issued for construction of Shield Mock-Up Reactor dated October 30, 1963 (40).

C. LOW LEVEL RADIOACTIVE DISCHARGES

1. Nuclear Development Corporation of America (NDA) to New York State Department of Health (NYSDOH): "Application for the Approval of Plans and for a Permit to Discharge Refuse or Waste Matter from an Industrial Establishment into the Waters of the State", dated December 23, 1959; supplemented April 12 and September 23, 1960; for discharges from the Plutonium Facility (66).
2. NYSDOH to NDA: "Permit to Discharge Sewage or Wastes Into the Waters of the State" issued November 11, 1960 (5B).
3. NYSDOH to United Nuclear Corporation (UNC): "Permit to Discharge Sewage or Wastes Into the Waters of the State" issued January 11, 1962; supersedes #12 above and increased the permitted alpha activity limit (66).
4. UNC to US ARMY CORPS of ENGINEERS: "Application for Permit to Discharge or Work in Navigable Water and their Tributaries". dated June 30, 1971; for scrub water discharges from the Plutonium Facility (66).

D. SEWAGE TREATMENT

1. UNC to NYSDOH: "Application for Approval of Plans and/or for Permit to Construct and Operate Waste Treatment Works and to Discharge Wastes into the Waters of the State", dated January 5, 1967; sewage from the Plutonium Facility to a new sub-surface disposal system (66).
2. Dutchess County Department of Health to UNC: Approval of sewage disposal plans, dated February 2, 1967 (70).

E. SPECIAL NUCLEAR MATERIAL

1. United States Atomic Energy Commission (USAEC) to Nuclear Development Corporation of America: Special Nuclear Material License issued January 31, 1956 "to receive and possess" for storage only at the White Plains location, 500 grams of enriched uranium. Upon completion of the facility at Pawling, permission to proceed was to be issured. (71).
2. United Nuclear Corporation to USAEC: Application for Special Nuclear Material License, dated January 25, 1965, supplemented June 17, September 14, October 29, November 29, 1965, and January 14, May 25, July 11, and August 19, 1966 (72).

3. USAEC to UNC:
Special Nuclear Material License No. SNM-871 issued December 27, 1965 (72).
4. UNC to USAEC:
Request for revision of License SNM-871 for temporary Storage of increased amounts of U-235 and Pu-239 in the Critical Facility Building, dated November 29, 1965 (37).
5. UNC to USAEC:
Request for revision of license SNM-871 for an in the amount of U-235 and plutonium authorized to be stored in the Critical Facility, dated January 14, 1966 (73).
6. USAEC to UNC:
Special Nuclear Material License SNM-871, Amendment No. 3, issued September 1, 1966, changing authorized places of use and/or storage of U-235 and plutonium; locations are the Plutonium Lab, Gamma Lab, and Critical Facility (storage) (72).
7. USAEC to UNC:
Special Nuclear Material License No. SNM-993 issued January 16, 1967 ro 83.5 kg. of U-235 contained in UO_2 fuel rods for storage only in the Reactor Room of the Critical Facility; to expire on June 30, 1967 or upon amendment to Facility License R-49 (66).

NOTE: By June 1967, License SNM-871, Amendment NO. 4, was in effect and specified amounts authorized in the Critical Facility vault (storage only) and Critical Facility (PuBe sealed source) (69).

8. UNC to USAEC:
Request for revision of license SNM-871 for non-destructive assay operations in a shielded area to be added to the Plutonium Facility, dated October 7, 1970 (32).
9. UNC to USAEC:
Request for revision of license SNM-871, Docket No. 70-903, for six glove boxes and a continous sintering furnace in the Plutonium Facility, dated December 24, 1970 (33, 74).
10. GULF NUCLEAR FUELS COMPANY to US NUCLEAR REGULATORY COMMISSION:
Request for termination of Special Nuclear Material License #SNM-871, dated March 11, 1974 (75).
11. NUCLEAR REGULATORY COMMISSION to GENERAL ATOMIC COMPANY:
Termination of Special Nuclear Material License #SNM-871 and release of site for unrestricted use, dated July 14, 1975 (66, 75).

F. PROOF TEST FACILITY:

1. UNC to USAEC:
"Application for permission to consturct and operate the Proof Test Facility (PTF) within the Critical Facility Building, dated April 28, 1967; amended June 9, 1967 (76,77).

2. USAEC to UNC:
   Construction Permit No. (missing), Docket No. 50-207, issued for construction of the Proof Test Facility, dated August 4, 1967 (78).
3. USAEC to UNC:
   License CX-25 issued for Proof Test Facility; date and License are not available (42).

G. RADIOACTIVE MATERIALS LICENSE:

1. UNC to NEW YORK STATE DEPARTMENT OF LABOR (NYSDOL):
   Application for Radioactive Materials License, dated March 29, 1963, pursuant to Industrial Code Rule No. 38, "Radiation Protection: (79).
2. NYSDOL to UNC:
   Radioactive Materials License No. 289-1460 issued August 19, 1966; superceded License No. 289-0355, Reference No. 4 (79).
3. NEW YORK STATE DEPARTMENT OF LABOR to UNITED NUCLEAR CORPORATION:
   Radioactive Materials License No. 289-1460, Reference No. 2, issued October 28, 1966; referenced only, revision is not available (79).

4. NYSDOL to UNC:
   Radioactive Materials License No. 289-1460, Reference No. 2, Amendment No. 2, issued April 19, 1967 for use of Sr90, sealed source, not to exceed 1.5 millicuries (66).
5. NYSDOL to UNC:
   Radioactive Materials License No. 289-1460, Reference No. 3, issued September 6, 1968 (80).

H. OTHER:

1. UNC to NEW YORK STATE DEPARTMENT OF CONSERVATION:
   "Application for Fishing Preserve License", dated September 14, 1970 (66).

UNC MATERIALS USE

Table 7 is a revised summary of the various licenses authorizing the use and storage of radioactive materials at UNC's Remote Experimental Station. The licenses were in effect in 1964 and were amended several times during the Corporations operating years. Detailed information relating to storage capabilities, form of storage use and handling may be found in Reference Nos., 69, 71, 72 and 73.

Table 7. UNC Radioactive Materials Use

A. Facility License No. R-49 (7)

Location	Material	Quantity
1. Critical Facility (Reactor Room)	Uranium 235	150 Kg

B. Special Nuclear Material License No. SNM-871 (69)

Location	Material	Quantity
1. Plutonium Facility	Plutonium or Uranium 235	Pu = 30 Kg — U-235 + 4 Kg
2. Critical Facility Vault (Storage only)	Pu-Be Sealed Source	Pu 0.080 Kg

C. N.Y. State Radioactive Materials License No. 289-1460 (66)

Materials	Form	Quantity
1. Polonium 210	1. Sealed sources (Po-Be Mound Laboratory or Isotope Specialists Inc. Type)	1. 100 curies
2. Cobalt 60	2. Sealed sources (Atomic Energy of Canada, Ltd. and ORNL design)	2. 400 millicuries
3. Strontium 90	3. Sealed source (Jordan Electronics Co. Model)	3. 15 microcuries
4. Uranium, Natural	4. Any	4. 5000 kilograms (1.7 curies)
5. Thorium	5. Any	5. 20,000 grams (2.3 millicuries)
6. Hydrogen 3 (Tritium)	6. Any	6. 1 curie
7. Carbon 14	7. Any	7. 20 millicuries
8. Caesium 137	8. Any	8. 100 millicuries
9. Iron 59	9. Any	9. 20 curies
10. Strontium 90	10. Sealed Source	10. 1.5 millicurie
11. Promethium 147	11. Any	11. 15 microcuries
12. Chromium 51	12. Any	12. 20 curies
13. Tungsten 185	13. Any	13. 15 microcuries
14. Ruthenium 106	14. Any	14. 15 microcuries
15. Zirconium 95	15. Any	15. 300 curies
16. Phosphorus 32	16. Any	16. 5 curies
17. Iodine 131	17. Any	17. 30 curies
18. Gold 198	18. Any	18. 60 millicuries
19. Cobalt 60	19. Any	19. 10 millicuries
20. Cobalt 58	20. Any	20. 10 millicuries
21. Iridium 192	21. Any	21. 20 curies
22. Uranium, Depleted	22. Any	22. 5000 kilograms (1.7 curies)
23. Any radioactive material with atomic number between Z = 3 and Z = 83 inclusive	23. Unsealed solids	23. Not to exceed 100 curies of any radionuclide nor a total of 2000 curies
24. Kytpton 85	24. Gas	24. 10 curies
25. Xenon 133	25. Gas	25. 10 curies
26. Cobalt 58	26. Unsealed Solid	26.) Total not to exceed 20
27. Cobalt 60	27. Unsealed solid	27.) curies
28. Niobium 95	28. Unsealed solid	28.)
29. Tantalum 182	29. Unsealed solid	29.)
30. Zinc 65	30. Sealed source (Numec or Monsanto manufacture)	30. One (1) source of 32 millicuries One (1) source of 5 millicuries One (1) source of 1.5 millicuries Total - 38.5 millicuries

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2. USAEC, Docket No. 50-101 to NDA; Oct. 29, 1961.
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7. UNC-Development Division-NDA, Preliminary Hazards Summary Report for Performance of Shield Mock-Up and Critical Experiments at the Pawling Nuclear Experiment Site; 2/63.
8. UNC-Development Division-NDA, NDA Pawling Hot Laboratory Operating Manual; revision of May 10, 1961.
9. H&S - 266; 8/13/65.
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26 H&S - 400; 10/30/64.
27. Dut. Co. Dept. of Health to R.L. Howard; 8/06/57.
28. H&S - 660; 7/13/66.
29. H&S - 2460; 5/25/75.
* 30. HSP - 125; 10/4/57.
31. H&S - 313; 3/06/64.
32. UNC (H&S-2353) To USAEC; 10/07/70.
33. UNC (H&S-2695) To USAEC; 12/24/70.
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* 35. HSW - 121; 10/02/57.
36. H&S - 527; 9/10/65.
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43. H&S - 2286; 4/16/70.
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45. H&S - 120; 10/01/57.
46. HSP - 163; 12/02/57.
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48. HSP - 218, 4/30/58.
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53. UNC To NYS Dept. of Env. Cons.; 6/04/64.
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63. H&S - 839, 8/8/67.
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68. USAEC, Construction Permit No. CPRR-29, Docket No. 50-101; 10/7/58.
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79. NYS Dept. of Labor To UNC, New York State "Radioactive Materials License No. 289-1460, Ref. No. 1; 8/19/66.
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* H&S, HSP, HSW and PS refer to Health and Safety Reports written by UNC personnel.

IV. Sequential Air-Photo Analysis

An Application of Sequential Air Photo Analysis to the Identification and Mapping of Land use Changes over time on the Nuclear Lake Property. Dutchess County, N.Y.

by
Eugenia M Barnaba and Arlynn W Ingram
December 17, 1980

RESOURCE INFORMATION LABORATORY
CORNELL UNIVERSITY
ITHACA, NEW YORK

Ernest E Hardy, Director

INTRODUCTION

At the request of the Nuclear Lake Site Clearance Committee the Resource Information Laboratory undertook a project to prepare a series of map overlays illustrating the sequential changes in land use over time of the Nuclear Lake area in Dutchess County, using aerial photographs.

The following years of black and white aerial photographs were used in developing the documented history:

October 26, 1941	Scale 1:28,800
October 16, 1948	1:15,840
April 11, 1955	1:20,000
June 10, 1960	1:20,000
March 24, 1962	1:15,840
1966 (undated)	1:21,192
April 28, 1968	1:24,000
April 12, 1970	1:12,000
April 20, 1971	1:21,200
February 24, 1974	1:17,664

In addition to the use of photographs, supplementary background information was collected and incorporated into the analysis through auxiliary reports and personal conversations with members of the Site Clearance Committee.

While aerial photographs have received wide use since the 1930's it must be recognized that there are certain limitations to the kinds and extent of information which can be extracted. For example, air photo interpretation is not pure science; much inference based on photographic observations and known data enters into the decision-making process.

In addition, interpretation is totally dependent upon the quality of the available photography. Properties of film and camera and skill of the photographer are factors. Time of day and season of the year aid or inhibit interpretation through presence or absence of tree canopy, depth of shadow, and extent of light reflectance. Late fall or early spring, 10:00 a.m. to 2:00 p.m. on a cloudless day, provide the best possible conditions for optimum aerial photo quality as regards nature's input.

As far as this study is concerned, photographic observations recorded on map overlays and almost all the written documentation are based on photography of varying quality.

Hopefully this information when assessed carefully, will contribute significantly to a better understanding of the overall history and present condition of Nuclear Lake.

DESCRIPTION OF TECHNIQUE

Stereopairs of black and white aerial photography taken of Nuclear Lake and surrounding terrain, beginning in 1941 and ending in 1974, were analyzed for successive changes over that period of time. A two-power stereoviewer was used for general overview and a four-power stereoviewer for detailed analysis. Differentiation of activity, natural or man-made, is detected through changes in pattern, texture and tone.

Wetlands can be located and boundaries delineated using standard black and white prints. However, wetland boundaries are detected best with infrared photography which was not available.

Wetland vegetation on standard prints is reflected in mixtures of tones of gray, and in differences of texture and vegetative height. Differing vegetative heights are clearly discernible whether trees, shrubs, emergents, floating vegetation or bog mats. Textures generally are irregular because of the intermix of species within the wetland itself and/or in contrast with surrounding land cover.

At the same time that the imagery is reviewed and items identified, boundaries are traced and point items are marked in pencil directly on one of the stereopairs. All the information is therefore reserved directly on the photography ready for transfer to a map overlay.

Usually a collection of several years of photography of a given area over a period of time includes photography at several different scales. Each year of photography is accomodated to a single fixed scale, usually that of a base map. The use of the Bausch and Lomb Zoom Transfer Scope allows scale differences, photograph to base map, to be resolved mechanically. The adjusted image on the photograph is reflected onto the overlay placed over the base map. Detail is then traced directly onto the overlay.

In the Nuclear Lake study, ten years of photography were analyzed. A set of ten overlays were produced on a base map at the scale of 1:7,200 or 1"=600'. The overlays paired with the documentation provide a history of the development of the UNC property over a 33 year time span.

GLOSSARY

Dam — as defined by secondary data

Depression — a unique characteristic denoting a hollow

Disposal pit — as defined by secondary data

Forest land — **Fn**. These are natural stands having at least 50 percent or more of the land covered, with trees in excess of 30 feet in height, regardless of age, species, or diameter. The natural progression from **Fc** is to **Fn**. It is therefore often difficult to consistently identify an accurate boundary between these two units. (As defined by the N.Y.S. LUNR INVENTORY.)

Rubble, rubbly — A miscellaneous confused mass or group of broken or worthless things. (As defined by Webster's New Collegiate Dictionary.)

Streams — perennial: contain water throughout the year except for infrequent periods of severe drought.
— intermittent: contain water only part of the year.

Vegetated — vegetation established in or on. (As defined by Webster's New Collegiate Dictionary.)

Wetlands — Two basic categories of wetlands are used, condensing the several types of inland and coastal wetlands that could be defined. (See the wetlands survey of New York State by the Fish and Wildlife Service of the U.S. Department of the Interior.) For the most part, wetlands are confined to relatively level lands and may cross only one contour line in 1000 feet. However, some may be found on slopes where, due to rock structure or underlying clay hardpan, the surface soils are perennially wet and soggy. In either case, wetlands may have varying water levels and should not be thought of as just "swamps."

Due to the spring photography from which wetlands were mapped, clear distinction could not be made between those areas seasonally wet and those permanently wet. As a result, for some purposes, the amount of wetlands mapped may be considered somewhat exaggerated.

Some examples are:

Wb — Marshes, shrub wetlands, and bogs. These are areas ranging from those waterlogged but with no standing water to those with as much as 3 feet of water. Vegetation is predominantly shrub-size and smaller and trees do not exceed 30 feet in height. The vegetative cover corresponds to the definition of brushland, **Fc**. The area, however, is a wetland area.

Ww — Wooded wetlands. Distinction between **Wb** and **Ww** is made on the basis of vegetative cover. **Ww** is covered by trees at least 30 feet in height — corresponding to the definition of **Fn**. The area may be waterlogged with no standing water or may have standing water of varying depth.

AIR PHOTO INTERPRETATION *(For a summary of 10 years of air photo interpretation, see Tables 8 and 9)*

1. October 26, 1941 — Sunday
Map #1 (See Figure IV-1)
Scale of Photography: 1:28, 800

The photography is somewhat blurred so the imagery does not stand out clearly. The study area is thickly wooded with deciduous trees predominating and the fall photography shows the trees still in full leaf although changing color. Stream flow patterns, narrow roads, trails , and changes in topography tend to be lost under the trees.

This photography shows the future Nuclear Lake as a large wooded wetland located within hilly, irregular terrain, part of a series of wetlands interconnected by a network of streams. This particular wetland typically reveals its boundary through contrast of darker gray tones and vegetative texture to the lighter gray tones and vegetative texture of the surrounding terrain. Four finger-like indentations along the west boundary at "a" display subtle differences of lighter tone and texture suggesting conditions here are different from the main body of the wetland and surrounding terrain. The northern portion of the wetland at "b" has a similar appearance. This suggests higher, drier conditions along the shoreline here and that the wetland drains generally toward its central section and empties out the most southerly point at "c". Some dissection by small channels along the western shore is present at "d". One such channel connects the main wetland with one of the finger-like indentations.

During dry periods it appears that vehicular traffic was possible through the NW corner of the wetlands, as a portion of what appears to be an undeveloped narrow road is clearly visible cutting across this corner.

Other streams flow directly into the main wetland. One stream is clearly visible as it crosses the wetland in a southwesterly direction. Other runoff occurs from hillsides surrounding the site. Generally all stream flow is in a southerly direction through interconnected wetlands eventually joining Whaley Lake Stream. Whaley Lake Stream flows westward to Gardner Hollow Brook combining with Fishkill Creek.

Narrow dirt roads access the area from the north and the south.

Structures present on both sides of the property access road and along Route 55, appear to be residential.

2. October 16, 1948 — Saturday
Map #2 (See Figure IV-2)
Scale of Photography: 1:15, 840

The quality of photography is good, but again, dense tree canopy prohibits thorough analysis of drainage patterns, narrow rods, trails, and wetland edges. However, the angle of photography allows the west shoreline, north shoreline and damsite at "e" excellent exposure. Trees and tree shadows obscure sections of remaining shoreline and such delineations may not be reliable. Further, finish on the photograph will not accept pencil, making detailed delineation impossible.

A dam at "e" has been constructed on the southern end of the site wetland obstructing the natural outlet. Wetland vegetation has disappeared under water except for a small island and two other, small vegetated spots. According to available background information, the dam was constructed sometime between March 1946, when application was made to the Department of Public Works for permission for construction, and October 1948, date of photography.

According to reports, there is a small "lock-type" dam on the overflow channel which is used to raise or lower the level of the lake by three or four feet. The photography shows the main dam clearly at "e", but the overflow channel and lock-type dam is lost beneath heavy tree canopy.

The lake formed by the dam has almost completely covered the entire wetland area as seen previously on the 1941 photography.

Wetland indentations at "a" have all but disappeared and have filled in with thick, tall vegetation; only a remnant remains. Marshy beach is present along the north shore with some deposits of debris, possibly decaying wetland vegetation. Otherwise wooded shoreline meets waterline directly.

Structures along the property access road remain as before. Three more residences have been added along Route 55.

3. April 11, 1955 — Monday
Map = 3 (See Figure IV-3)
Scale of Photography: 1:20,000

Stereopairs are not available for 1955. Analysis is based on single photos and whatever stereo properties can be obtained using two unpaired photos from two separate flight lines.The season of photography is early spring. Trees have not yet leafed out. Although stereo imagery is limited, some details such as the dam, control structure, hunting lodge, stream patterns and access road stand out clearly.

The water level in the lake is higher because the mars formerly present along the northern shoreline has disappeared and is now under the water of the lake.

The cove at "d" appears to have developed through channel erosion and changes in lake level.

Wetlands are still present as before, but some identifed earlier have dried up, become smaller or changed configuration. A wetland has developed below the dam at "e".

Two structures are present along the western shoreline approximately a fourth of the distance up the lake from the dam. One of these structures appears to be the hunting lodge (1a.) mentioned in the draft report, Nuclear Lake — A Resource in Question, March 12, 1980. The structure north of the lodge on the edge of the lake (1b), by its location and smaller size suggests it functions as a boathouse.

The narrow dirt access road is present as before in 1941 and 1948. Other trails are faintly detectable and are probably no more than footpaths.

Trails are detected by breaks in vegetation and loose soil reflecting to camera angle. Trails or segments of trails are not visible consistently on each year of photography analyzed. They may have been abandoned long enough to have lost camera reflectance. The sun angle at the moment of exposure may expose a trail that existed all along, but during previous photographing was hidden in shadow. A trail abandoned long enough will tend to fill in with brush or become covered over with canopy from adjacent vegetation.

4. June 10, 1960 — Friday
Map = 4 (See Figure IV-4)
Scale: 1:20,000

The quality of the photography is good. However, June photography shows the trees well leafed out covering much of the ground detail. Shadows fall to the west and are quite pronounced, eliminating from view anything within the shadow range. Fortunately, the west shoreline is well exposed.

The Remote Experimental Station (UNC) complex has been constructed and is composed of six main structures:

Site 1. a. Lodge
b. Boathouse
Site 2. Plutonium Lab
Site 3. Critical Experimental Facility
Site 4. Engineering Facility (Shop)
Site 5. Multiple Failure Building
Site 6. Shield Mock-up Building

Also present within the complex grounds are:

Site 7. Small clearing
Site 8. Storage building
Site 9. Main parking lot
Site 10. Emergency generator

Present along the main access road just off Route 55:

Site 11. Remote Assembly Building

All site structures are displayed well within cleared areas. The cleared areas adjacent to the Plutonium Lab and the Remote Assembly Building are larger compared to the clearings around the other buildings and probably are reserved for parking area.

The Plutonium Lab at Site #2 has five distinct segments with correspondingly different flat roof levels; the Critical Experimental Facility at Site #3 has two segments with two flat roof levels; the Engineering Building at Site $4 has one segment with one flat roof; the two remaining buildings within the main complex, Multiple Failure Building at Site #5 and Mock-up Building at Site #6, are composed of one segment each with pitched roof.

There is an object within the clearing at Site #7, but tree shadow prevents a well exposed view. The little that can be seen is rectangular more than square, larger and taller than a car.

At Site #8, only the waste storage building is visible; if the storage pit is there, it is hidden under tree canopy. (Reference to back-up information.)

The generator is visible at Site #10.

The Lodge is shielded by tree canopy, but the boathouse is well exposed at water's edge and traffic patterns, which are quite pronounced here, indicate this area is well used.

The main access road from Route 55 has been improved up to a point just before entering complex. From this point the road appears to narrow. Traffic patterns within the complex are present but appear unimproved.

An indistinct trail is inferred by detection of a break through the trees and glimpses of the trail on the ground through the break where lack of shadows and presence of reflectance permit. It begins on the northern edge of the complex at the lake's western shore and just touches the clearing at Site #7. Continuing on southerly in a wide loop around the main complex, it joins the access road approximately where it enters the complex. This trail may be the fire lane mentioned in company records. Not enough of the trail itself is visible to determine its width. Segments of other trails are visible and inferred on the same basis. More trails may be present but not enough visual evidence is present to justify inclusion.

There is a depression adjacent to and south of the Multiple Failure Building at Site #5 which may have been created by moving earth around during construction activity. The tones are varied shades of light gray which indicates recent disturbance.

The structures present as the Remote Assembly Building at Site #11 appear to be the original structures constructed at that site. They are at the same locations and do not appear to be newly constructed. The second structure present probably is a garage or storage building.

Small depressions are visible in areas where wetlands were present before. Tree canopy and shadow do not allow a delineation of precise boundaries or detection of degree of wetness. A small wetland has dveloped between Plutonium Facility at Site #2 and shoreline. It may be a reappearance of a remnant of the original wetland indentation.

Tree canopy covers the stream pattern well, eliminating any possibility of accurate study. The western shoreline shows some minor fill-in.

5. March 24, 1962 — Sunday
Map = 5 (See Figure IV-5)
Scale of Photography: 1:15, 840

The lake is frozen, but thawed at outlet near dam. There is light snow cover which is detectable in depressions and on north-facing slopes. Streams, wetlands and ponds are thawed. Shoreline is well exposed. Tree canopy does not hinder analysis of activity, shadows present minor problems, and photographic quality is excellent. Drainage patterns are well established as mapped. A major highway construction project is underway along the south border of the property.

From this point on in documentation, each site as numbered will be dealt with in numerical sequence, year by year, after a general description.

1 **Lodge** is visible

2 No detectable change in **Plutonium Facility** itself, but the small wetland present in 1960 is no longer visible suggesting it has been filled. The land surface at this location is bare of vegetation, the dulled gray tone shows soil has settled and compacted somewhat. Two or three vehicles are in the parking lot.

3 The fence around the **Critical Facility** is visible, a small parking area is visible bordered along its eastern edge by a small pond. A footpath connects this facility to the main parking area. There is a tank on the roof with a connecting pipe and two other barely detectable objects, possibly vents. A **gate** is visible at the beginning of the driveway to this building

5 **Loose material** present west of building and downslope behind **Multiple Failure Building** (See 12, Map #5) gives land surface here a "rubbly" look

6 The land surface along the western edge of this clearing is disturbed. One spot, somewhat rounded & slightly concave appears as though the land surface here in relation to the surrounding area is to some extent sunken compacted. Other **depressions** or **pits** may also be present along this clearing but they are not readily detectable

7 Reports indicate that this **clearing** contains a **cement slab**; the structure present here is the **Sodium Tent**. All the land surface in the clearing appears disturbed loose surface material responds to the camera in very light tones. A trail from the complex crosses the clearing along its eastern edge and continues uphill to the north

8 The **Retention Tank** is just visible west of the **Waste Storage Building** at the edge of a shadow. Loose material is visible behind the Waste Storage Building down the unvegetated bank to the edge of the lake.

9 **Main Parking lot** — undefined, doesn't appear to have a hard surface as yet

10 No Detectable Change

11 The **Remote Assembly Building** appears to be the original structure present in 1941 along the second smaller structure behind it — probably a garage or storage building. The power line clearing is north of the main structure. A small excavation is present in the power line clearing.

12 A large **man-made depression** is visible here composed of loose material, there is no vegetation and water is ponded in the lowest part

6. 1966 — (Photographs Undated)
Map #6 (See Figure IV-6)
Scale of Photography: 1:21, 192

1 No Detectable Change - except for 2 vehicles parked in circular drive
2 No Detectable Change
3 Ponded area adjacent to clearing has become smaller in area and is almost dry.
4 No Detectable Change
5 No Detectable Change
6 No Detectable Change
7 No Detectable Change
8 No Detectable Change
9 Parking lot has been enlarged and defined Several vehicles present (4-5)
10 No Detectable Change
11 Excavation in clearing has been covered over It is still however detectable as a depression having darker tone than surrounding area indicates some settling of soil No vegetation is detectable One vehicle can be seen near the main structure
12 Some settling of loose material is evident. vegetation has begun to appear and the pond present before appears smaller

7. April 28, 1968 — Sunday
Map #7 (See Figure IV-7)
Scale of Photography: 1:24,000

1 No Detectable Change - except for development of a small wetland just below the south side of the lodge at "la"
2 The Plutonium Facility has expanded at its southwest corner A single story addition has been constructed Another section of the original structure at the northeast corner has been enlarged. A section at the southeast corner has been removed
3 No Detectable Change
4 Small objects about the size of 55 gallon barrels are present at edge of clearing in front of Engineering Facility at "B"
5. Several rectangular objects at least the size of cars are stacked in front of the Multiple Failure Building at the edge of the clearing. small objects the size of barrels can be seen upslope and slightly west of building at "B".
6 The pit seen in 1962 photos is still detectable Lack of vegetation in this vicinity may indicate presence of other pits
7 No Detectable Change.
8 Two objects smaller than the 6ft diameter of the Retention Tank are present near the tank at "B" Loose material evidenced by light tones and no vegetation is present down the bank behind the Storage Building This unconsolidated material has been seen on previous photos

8. April 12, 1970 — Sunday
Map #8 (See Figure IV-8)
Scale of Photography: 1:12,000

1 No Detectable Change
2 No Detectable Change
3 No Detectable Change
4 There are 3 or 4 small miscellaneouus objects under the trees at the edge of clearing in front of Engineering Facility about the size of 55 gallon barrels
5 The number of rectangular objects stacked at this location have increased. The small objects unslope are still present
6 Piles of material of different sizes and shapes are present within the clearing around the Mock-Up Building Depression seen on earlier photo is no longer detectable. The land surface west of building is unvegetated.
7 The clearing around Sodium Tent displays light tones with darker mottling, indicating presence of loose material
8 At least 3 objects resembling barrels smaller than Retention Tank, are present at "B". A small depression has appeared in the embankment just below Storage Building. The bank continues to be unvegetated
9 Light tones and no vegetation indicates a fill-in of a depressed area west of the parking lot addition at "P"
10 No Detectable Change
11 No Detectable Change
12 Vegetation has grown on the slope of the depression and the pond is showing some vegetation

9. April 20, 1971 — Tuesday
Map #9, (See Figure IV-9)
Scale of Photography: 1:21, 200

1 The boathouse is no longer present, although activity in the vicinity of the boathouse has continued
2 A new addition to the Plutonium Facility has been constructed at the southeast corner.
3 The pond adjacent to the clearing used as a small parking area is no longer present.
4 No Detectable Change
5 No Detectable-Change
6 Miscellaneous debris is detectable in the clearing and the land surface east of building is unvegetated indicating some type of recent disturbance
7 The Sodium Tent is visible as a dulled gray toned spot. This may indicate the tent has been removed and only the platform remains. The general tone of the clearing has changed, become darker and duller, indication that the activity here has also changed, possibly demonstrating a lack of activity.
8 Objects identified on earlier photos are no longer present. The small depression is no longer detectable and loose material is present on the slope. As before, vegetation is not growing on this slope.
9 Several vehicles are present.
10 N Detectable Change
11 No Detectable change
12 The pond and/or wetland are no longer present. The slope and depression are well vegetated.

10. February 24, 1974 — Sunday
Map #10 (See Figure IV-10)
Scale of Photography: 1:17,6664

1 What appears to be miscellaneous debris is present down the bank near the location of the former boathouse and in the former wetland below lodge.
2 Miscellaneous objects in a pile are visible just north of building evidenced by a mix of very light tones (reflectance of objects) with very dark tones (shadows of objects). Detection is inconclusive here because of the shadow of the building. There is a pronounced lack of vegetation at the NE corner of building simiiar in location to that detected on '62 photography, indicating recently disturbed land surface.
3 No Detectable Change
4 No Detectable Change
5 No Detectable Change
6 The clearing adjacent to the building appears clear of debris except for under bordering trees. A depression not seen on previous photos is present at edge of clearing. The land surface around it appears disturbed. Two trails lead from clearing down the slope to the lake.
7 The clearing at this location appears somewhat vegetated. An object is still visible here - it may be part of former stucture.
8 The bank shows vegetation not visible before. The pit is still present as in 1970.
9 No Detectable Change
10 No Detectable Change
11 No Detectable Change
12 No Detectable Change
13 A small amount of miscellaneous debris is present below the dam.

NOTE: For a summary of air phot interpretation data on all 10 years of photography, see the matrices Tables 8 and 9.

Table 8. Air Photo Interpretation **General Data Summary Matrix** for 10 years of Photography

	Map #1 **October 26 1941** **Sunday**	**Map #2** **October 16 1948** **Saturday**	**Map #3** **April 11, 1965** **Monday**	**Map #4** **June 18, 1980**	**Map #5** **March 24, 1982** **Sunday**
Photo Quality and Limitations	Scale 1 28 800 Photos slightly blurred Dense tree canopy limits display of ground patterns Back-up data used	Scale 1 15 840 Photo quality good Dense tree canopy (as above)	Scale 1 20 000 No stereopairs available Two dimensional detail good No leaf cover Lack of good stereo imagery limits extent of analysis	Scale 1 20.000 Photo quality good Dense tree canopy (as above) Pronounced shadows West shoreline well exposed for reasons cited in Map #2	Scale 1 15.840 Photo quality excellent No tree canopy Minor shadow problems. Small amounts of snow in depressions and on north facing slopes (Note This is the best photograph to date.)
Property in General	Hilly irregular terrain deciduous cover predominant Series of interconn-ected wetlands Structures at 11 are present	One large wetland now a lake Smaller wetlands W of lake present area heavily wooded	Area heavily wooded Some wetlands have disappeared become smaller or changed shape New wetland S of dam	UNC complex constr-ucted Clearing around bldgs Wetlands in complex appear as disappears	Fencing gates and other development within main complex Remainder of property is unchanged Power line cut passes N of buildings at #11 Highway construction S edge of property
Lake Site	Appears as a large wetland Shoreline indented in 4 places different tones & textures here suggest higher-drier wetland conditions Area on N portion shows similar charac-teristics Small section of W shoreline dissected by small streams at d	Lake and dam at e retain water covering most of large wetland One wooded island present Shoreline indentations at a has disappeared Small marshy areas with deposits of debris present along N shore Tree growth is gener ally up to lake edge Lake covers stream bed on east	Water level in lake higher Lake expanded in size marsh along N shoreline now part of lake A cove at d is created by erosion and changes in lake level No sign of former SW streambed	W shoreline shows minor filling in New small wet spot between bldg at #2 and lake	
Road-Trails	Narrow dirt roads enter site from N and S Road along W shore crosses NW corner of future lake	Narrow dirt road remains as above road across former wetland corner now under water A segment of a trail is visible	Narrow dirt road remains as above Other faintly detectable trails* are probably footpaths width not determinable	Main access road has been improved from Rt 55 N to complex. Inimproved roadways within complex Indistrict trail possibly the fire lane borders the complex Segments of other trails visible.	Parking area expanded Paths within complex present New trail from bldg at #4 to lake Trail from complex - N present
Drainage Pattern	Interconnected Pere nnial streams generally run N to S	Dam construction at e caused changes in wetland Streams on site not mappible due to heavy tree canopy	Pre-dade NE to SW stream gone Stream present in SW wetland flows under Rt 55 Mappable observations for stream SE of Lake Site	Obscured	Drainage patterns well established as cited above (Map #3) New Rt 55 and culvert constructed
Precipitation** **(Inches)**	Aug 2 39 Sept 87 Year 27 17	Aug 2 35 Sept 78 Year 50 50	Feb 3 00 Mar 4 30 Year 50 90	Apr 3.38 May 3 32 Year 39 41	Jan 3 21 Feb 4 66 Year 37 55

***Trails may not be visible in each year of photography because of photgraphic limitations.**

****Source: U.S. Environmental Data Service Climatological Data, New York.**

	Map #6 1966	Map #7 April 28, 1968 Sunday	Map #8 April 12, 1970 Sunday	Map #9 April 20, 1971 Tuesday	Map #10 February 24, 1974 Sunday
	Scale 1 21 192 Photo undated Photo quality fair Season is early spring or late fall with no leaf cover Little shadow problem	Scale 1 24 000 Photo quality good Light canopy Terrain visible	Scale 1 12,000 Photo quality excellent No tree canopy	Scale 1 21,200 Photo quality fair No tree canopy Finish on print will not accept pencil	Scale 1 17 664 Photo quality excellent No tree canopy Finish on print will not accept pencil
	Property remains unchanged Highway construction completed Gate leading to critical facility not seen	Property in general remains unchanged Gate appears on road leading to main complex	Property in general remains unchanged	Property in general remains unchanged	Property in general remains unchanged
	Lake has changed configuration especially at the NE corner & E edge where stream enters lake An island appears on the W	Main island is slightly smaller Shoreline on S appears altered Another island may be developing 66 island on W shows shallow connection to shoreline	Major island remains smaller as in '68 Shoreline on S shows more indentation Cove area changed in shape	Slight shoreline changes along S edge of lake Cove in E shoreline has decreased slightly in size & changed shape "Island" off W shore is again a peninsula	Season is late winter Lake is frozen partially thawed along the shore & around island Shoreline again shows changes
	Trails through woods present as mapped Trail from complex - N connects with another intersecting a stream N and edge of lake S	Trail from complex - N well established Segment extend trail farther N Two new walkways N&S of building #2 to edge of lake Other trails present	Roads and most trails previously cited present Walkways N&S of bldg #2 not detectable Trail S of lake extends E uphill turns S descends to a small wet depression	Roads show no change Observable trails mapped	Access road has deteriorated needs repair Observable traisl mapped
	Wetland along access road narrow part is a pond Other drainage patterns well established	Wetlands W of lake larger than in 66 Wetlands along access road has enlarged pond is gone Drainage disrupted by road construction is establishing a new pattern	Drainage patterns in general as previously cited Small wetland S of dam reappears Wetland along access road is slightly smaller, stream visible ponding has reoccured	Drainage patterns in general continue as previosly cited	Drainage patterns continue as previously cited
	Undated Photo Year 51 6	Feb .83 Mar 3 48 Year 40 06	Feb 2 83 Mar 1 85 Year 32 59	Feb 3 58 Mar 3 05 Year 46 11	Dec 8 65 Jan 4 20 Year 43 95

Table 9 Air Photo Interpretation **Site Specific Data Matrix** for 10 years of Photography on 12 selected sites

	Site #1 Lodge/Boathouse	**Site #2 Plutonium Lab**	**Site#3 - Critical Experiment Facility**	**Site #4 Engineering Facility**	**Site #5 — Multiple Failure Bldg.**	**Site #6 Mock-Up Bldg.**	
1941							
1948							
1955	Hunting Lodge and Boathouse constructed at the SE lake shore						
1960	Lodge hidden under trees Boathouse visible Site well trafficed	Facility has been constructed Five-segmented building each with a flat roof Small wet spot between building and lake Minor filling along west shore of lake	Facility has been constructed A two-segment building each with flat roof	Facility has been constructed One-segment building with a flat roof	Bldg has been constructed One-segment bldg with a pitched roof	Bldg has been constructed One segment bldg with a pitched roof	
1962	Same	Small wet spot is gone Surrounding area bare of vegetation Soil has settled and compacted	Fence erected on the site Small parking area front of bldg Small pond is east of parking area Pathway to main parking lot appears Tank and pipes on roof Gate is at driveway entrance	Objects of various sizes north side of bldg Trail north of bldg to shore of lake	Loose material west of bldg and downslope behind bldg	Land surface western edge of clearing disturbed A pit-like depression is barely visible	
1966	Same	Same	Pond smaller & nearly dry Gate no longer visible	Same	Same	Same	
1968	Small wet spot appears below the lodge	Building additions added along SW & NE sides of lab A section at SW corner has been removed	Same	Barrel-size objects are near bldg	Rectangular car-sized objects stacked in front of bldg	Depression is still visible Other areas unvegetated may indicate presence of other pits	
1970	Same	Same	Same	3-4 misc barrel-size objects at edge of site	Barrel-size object west of bldg Smaller objects still visible	Piles of objects of misc sizes & shapes visible Pit-like depression has disappeared Vegetation missing east of bldg	
1971	Boathouse is gone Site still in active use	Building addition added at SE corner	The pond is gone	Misc objects are no longer detectable	Same	Misc debris in clearing east of bldg	
1974	Misc debris visible near boathouse and in former wet spot below lodge	Misc objects piled north of building Vegetation missing at the same location (NE corner) as in 62	Same	Same	Same	Debris removed from clearing A depression visible at edge of clearing Two footpaths from clearing lead to lake	

	Site #7 Small Clearing	Site #8 Waste Storage Bldg	Site #9 Main Parking Lot	Site #10 Emergency Generator	Site #11 - Remote Assembly Bldg	Site #12 Depression
					House/Garage is visible at Rt 55	
					Same	
					Same	
	Rectangular object larger than a car visible	Bldg is visible	A cleared area is visible adjacent to the Plutonium Lab unimproved	Generator is visible near driveway to Site #3	Large clearing around bldg	Depression is located behind bldg at Site#5 possibly created during construction
	Structure present is the Sodium Tent* Land surface in clearing is disturbed *Referred to in secondary data sources	Retention tank is visible Loose material behind the storage bldg down the bank to the edge of the lake	Same	Same	The clearing and excavation north of bldg s are associated with power line construction	Loose material is visible Ponding has occurred in deepest part of depression
	Same	Same	The cleared area is enlarged and more defined	Same	Excavation is covered over clearing still bare of vegetation	Some vegetation has established The pond is smaller
	Same	Same plus Two small objects are near the retention tank	The parking area has expanded to the west across the road Walkways are well defined	Same	A trail probably a footpath leads from clearing north into woods	Loose material is still visible The pond is slightly larger
	Same	Three barrel size objects near tank Small pit in embankment below tank Loose material is visible as before	Fill is visible west of newer parking lot	Same	Same	Depression no longer visible More vegetation established Pond shows vegetation
	Site shows lack of use Tent structure may have been removed	Barrel size objects gone Loose material visible & the slope continues bare Pit-like depression not visible	Same	Same	Same	The pond is gone The area appears vegetated
	Area shows vegetation Some object still visible may be part of former structure No longer a cleared area	The slope shows some vegetation The pit in embankment is visible again	Same	Same	Same	Same

LEGEND

Map Legend to be used with Air Photo Interpretation Maps Nos. 1-10 (Figures IV-1 to IV-10)

Land Use Boundary	
Roads - improved	
- unimproved	
Trails	
Buildings	
Small Structures	
Abandoned	(a)
Parking Lot	
Gate	
Fence	
Powerline Right-of-Way	
Disposal Pit/Retention Tank	
Barrels	B
Dam	
Cleared Areas	Cl
Natural Forest Cover	Fn
Streams - perennial	
- intermittent	
Wetlands - perennial	
- intermittent	
Wet Spots	
Shoreline	
Shallow Areas	
Water	
Depression	
Identifier	
Pit-Like Depressions	

Figure IV-1 - October 26, 1941 Aerial Photographic Interpretation Map of The Nuclear Lake Property

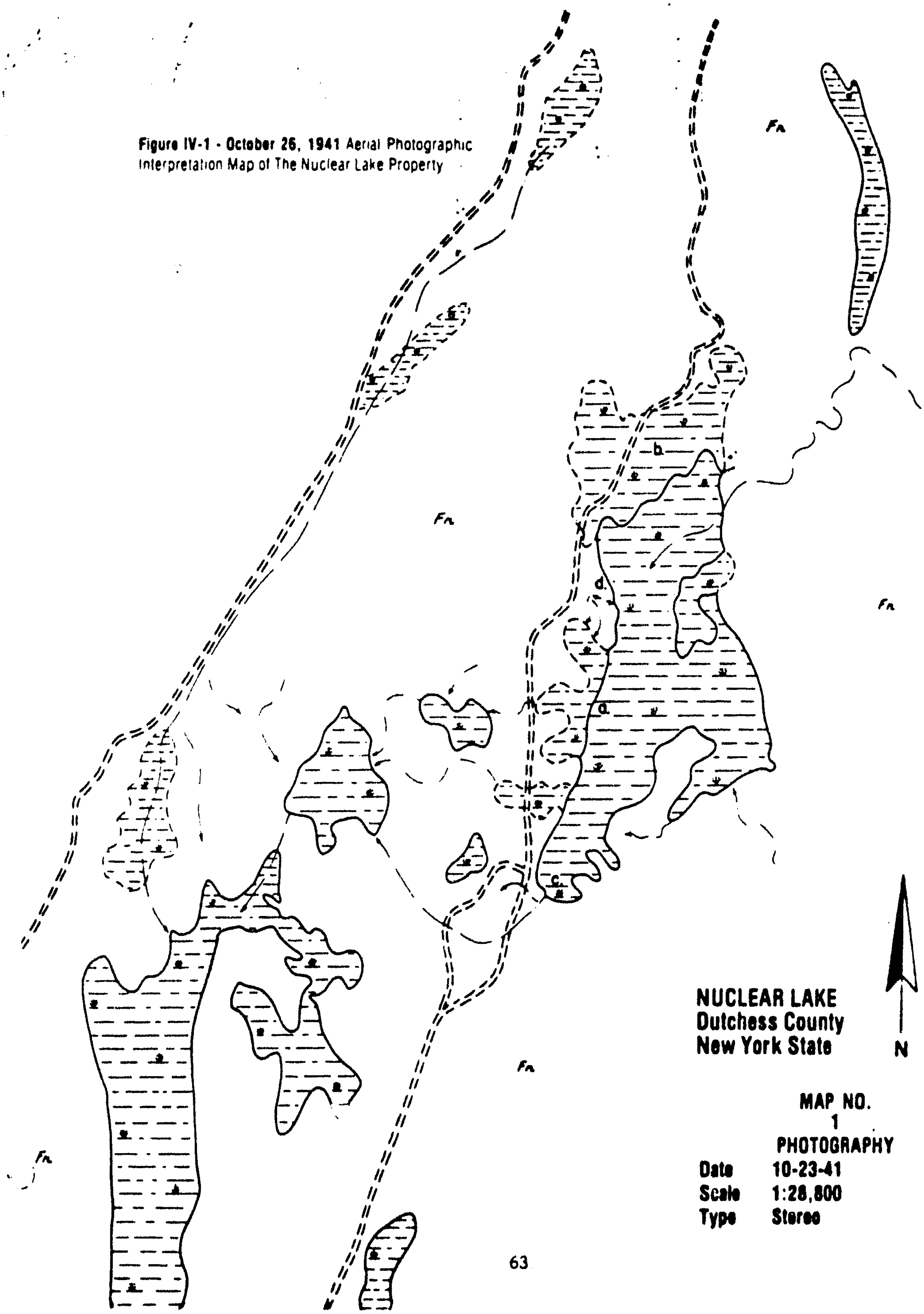


Figure IV-2 - October 16, 1948 Aerial Photographic Interpretation Map of The Nuclear Lake Property

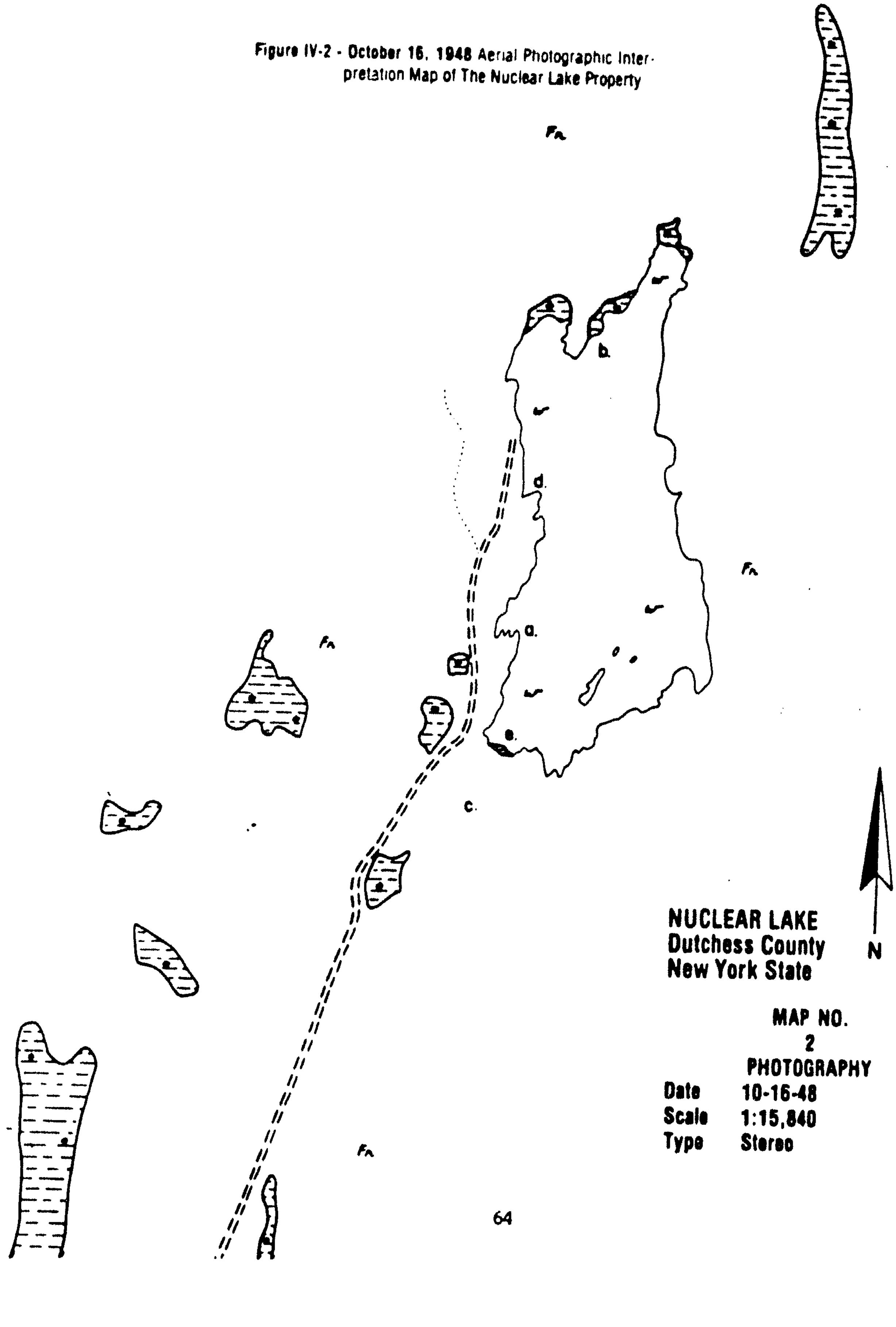


Figure IV-3 · April 11, 1955 Aerial Photographic Interpretation Map of The Nuclear Lake Property

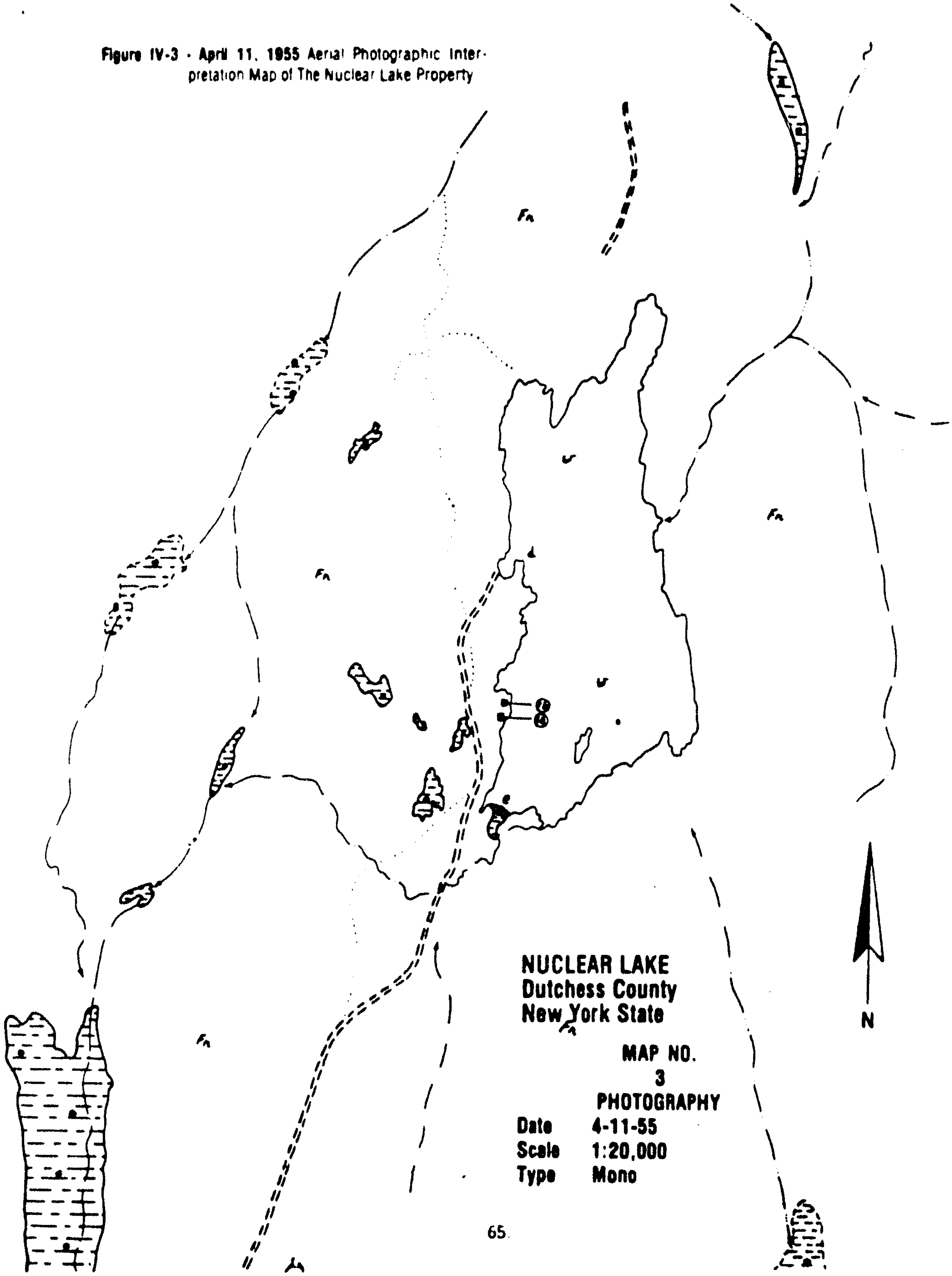


Figure IV-4 - June 10, 1960 Aerial Photographic Interpretation Map of The Nuclear Lake Property

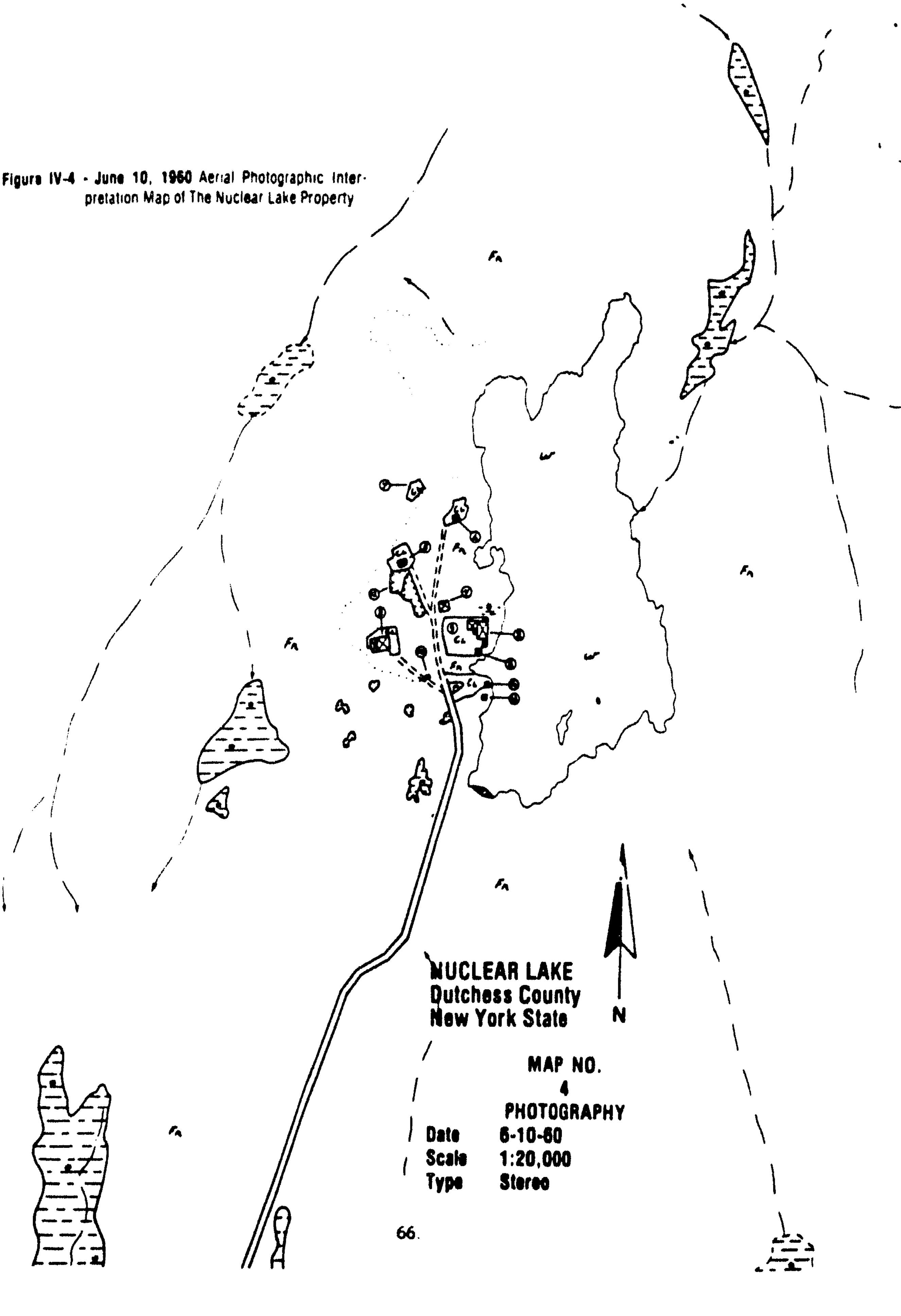


Figure IV-5 - March 24, 1962 Aerial Photographic Interpretation Map of The Nuclear Lake Property

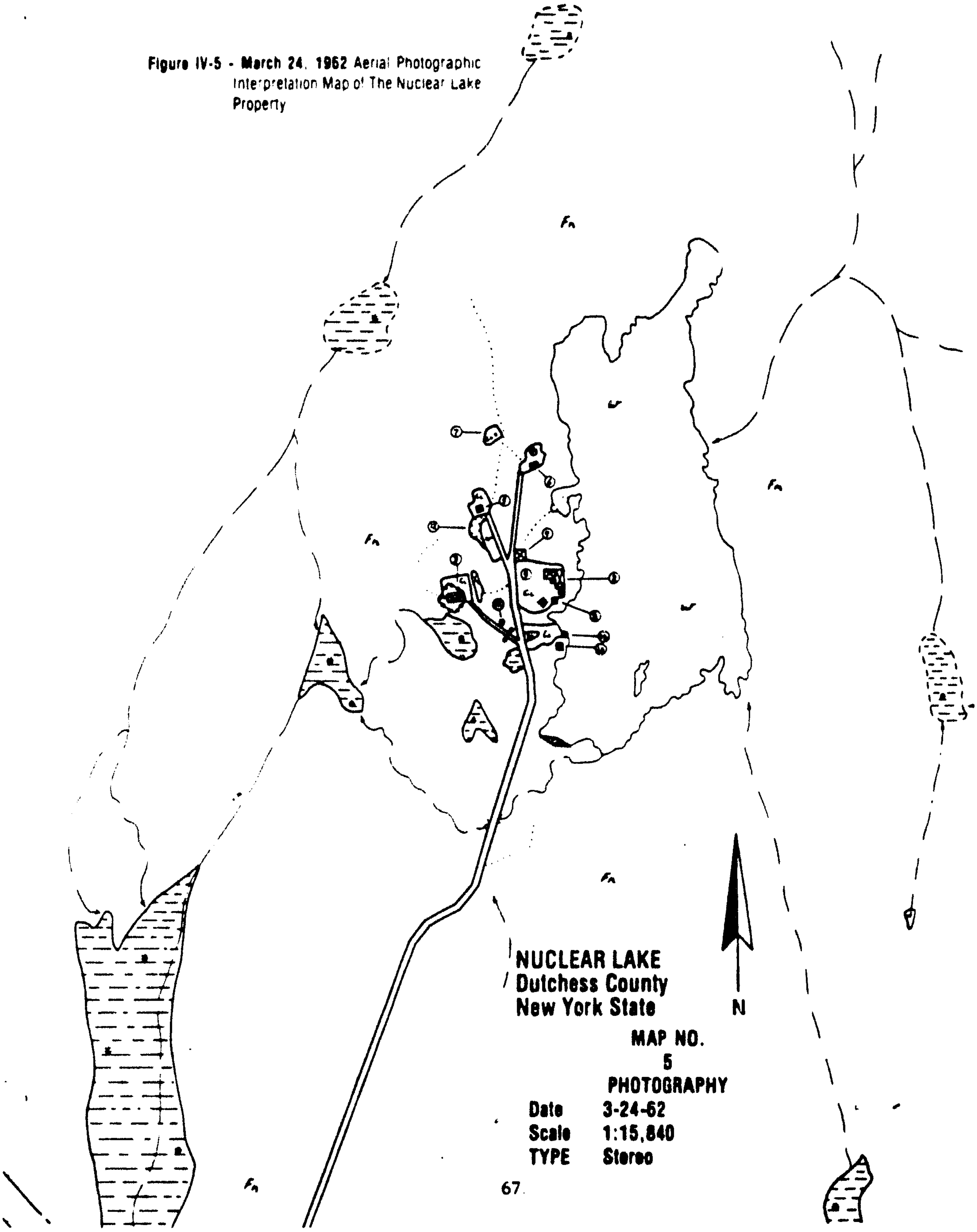


Figure IV-6 - 1966 Aerial Photographic Interpretation Map of The Nuclear Lake Property

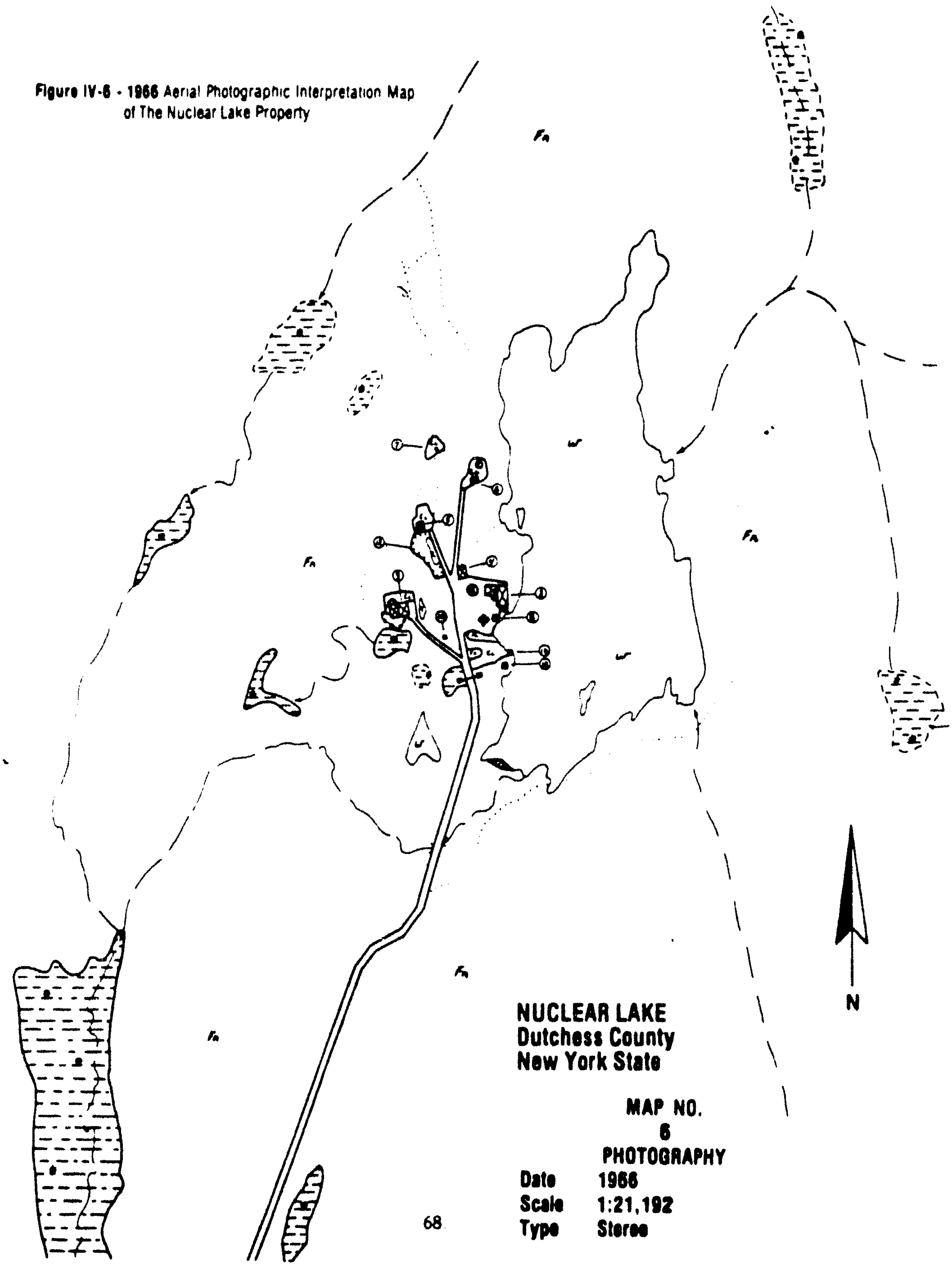


Figure IV-7 - April 28, 1968 Aerial Photographic Interpretation Map of The Nuclear Lake Property

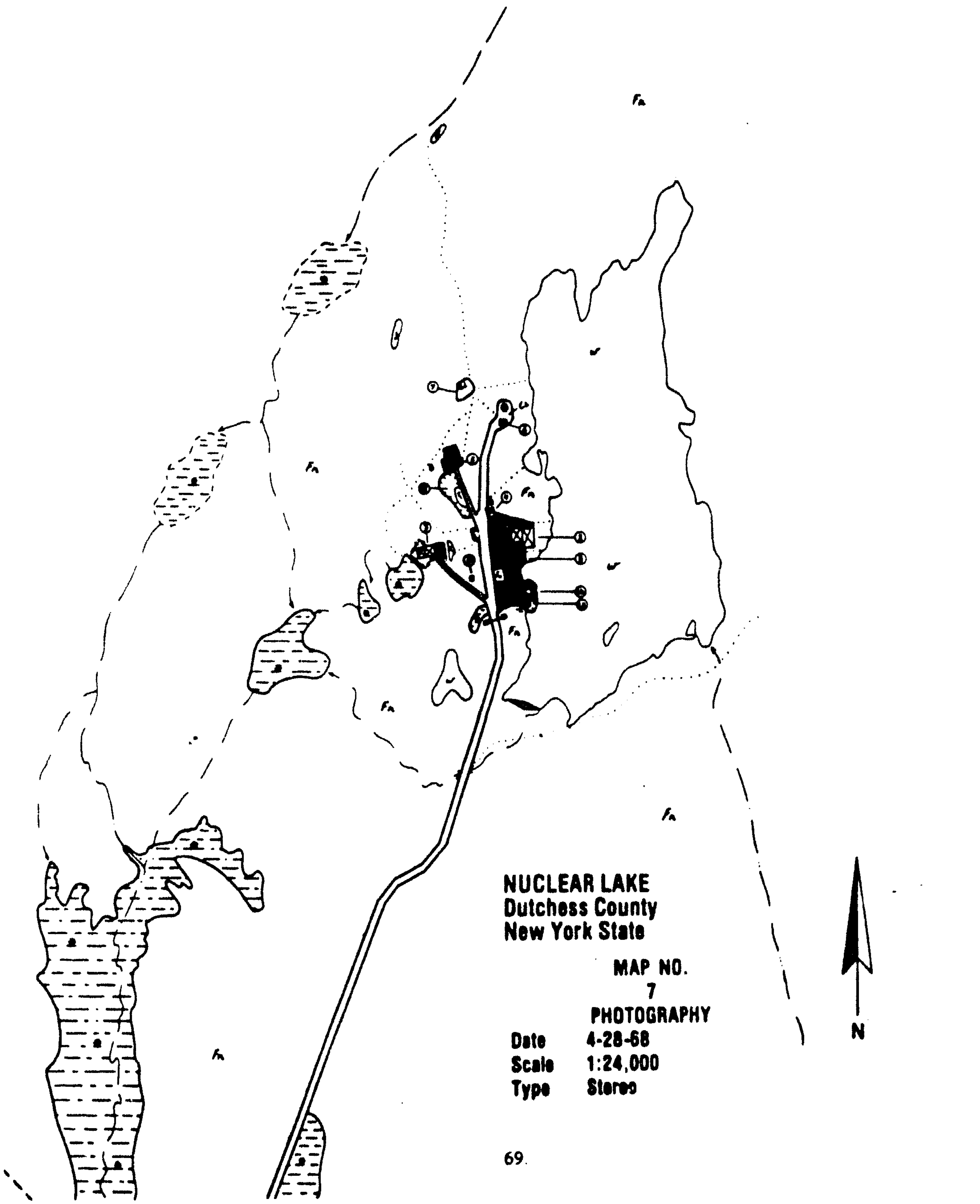


Figure IV-8 - April 12, 1970 Aerial Photographic Interpretation Map of The Nuclear Lake Property

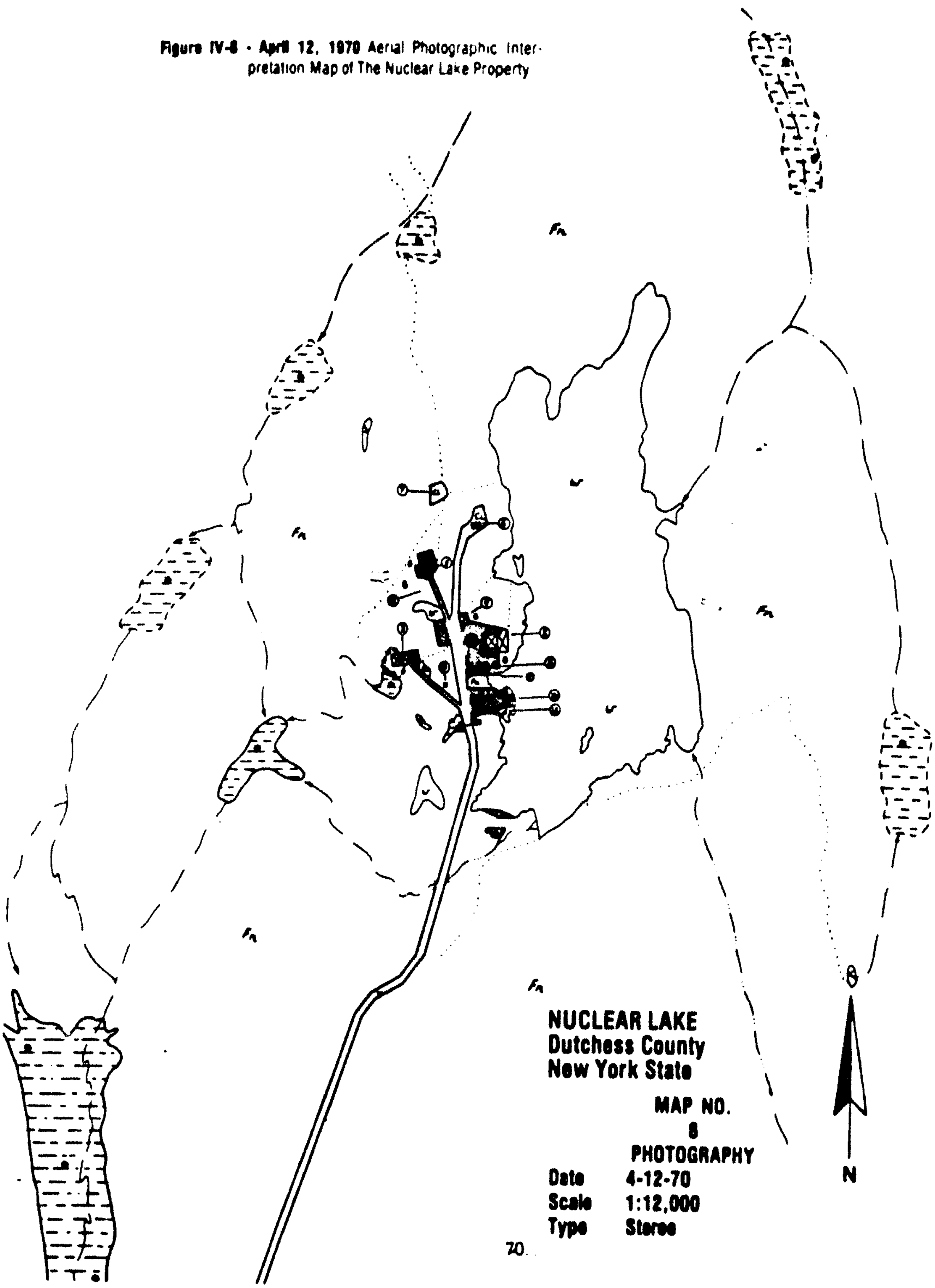


Figure IV-9 - April 20, 1971 Aerial Photographic Interpretation Map of The Nuclear Lake Property

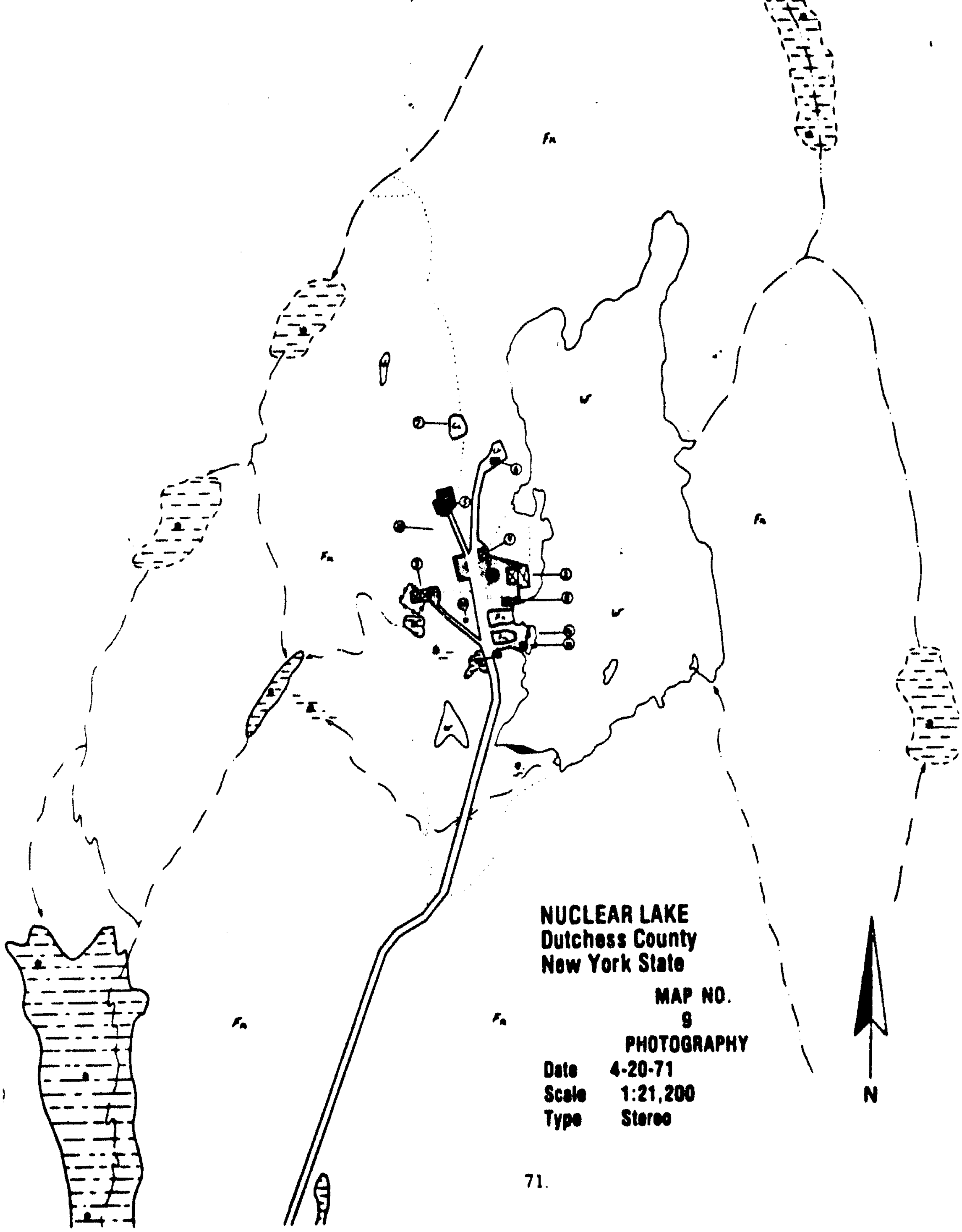
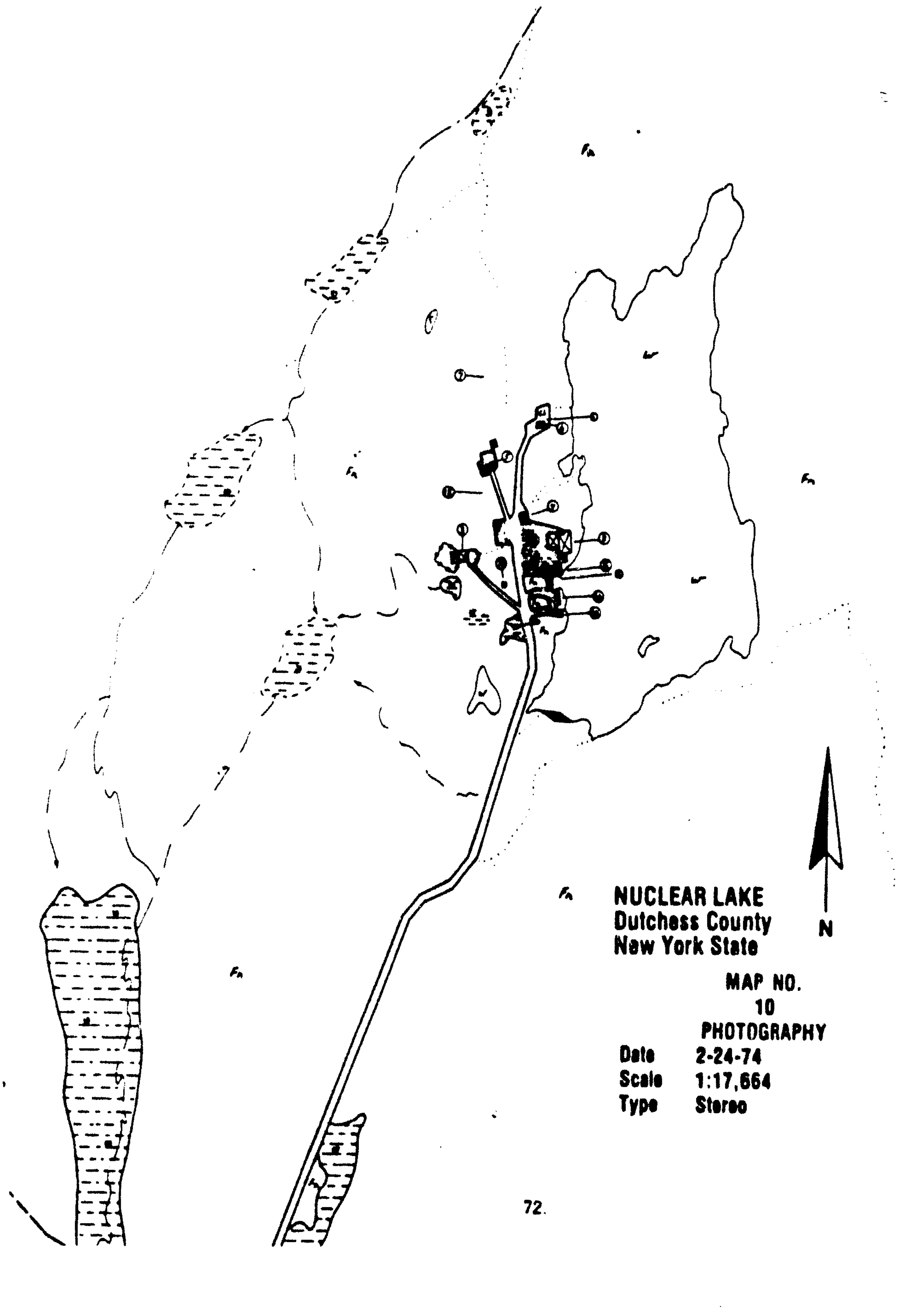


Figure IV-10 - February 24, 1974 Aerial Photographic Interpretation Map of The Nuclear Lake Property



REFERENCES

1. Dames and Moore, 1966. Report of the Foundation Investigation-Proposed Alpha Laboratory Expansion. Pawling, New York.

2. Site Clearance Subcommittee, The Nuclear Lake Management, 1980. Nuclear Lake - A Resource in Question, Draft.

   Chapter V - Waste and Waste Disposal Problems, Final Draft.

   Chapter VI - Accident - 1972, Final Draft.

3. Map: Lake and UNC Complex

4. Sketch: Pawling Plant Layout
   Complex with Fire Lane

5. U.S.G.S. Topographic Map (several years) 1901 reprinted 1909, 1928 inaccurate, 1948, 1960.

6. Appalachian National Scenic Trail - Segment 269, Dutchess County, New York.

V. Waste and Waste Water

PLUTONIUM FACILITY - WASTE WATER

From 1957 to 1971 UNC faced problems in disposing of low-level radioactive waste water generated at the Plutonium Lab during its operating years. This liquid effluent resulted from water used in decontamination operations and came from several sources which included:

1. Laundry Waste Water (31) - primarily laundry water from washing machines used to wash laboratory uniforms contaminated with radioactive material.
2. Sink and Shower Waste Water (31) - discharge from some sinks and one shower in the Plutonium facility.
3. Scrub Waste Water (47) - water from washing the laboratory floor.

Following is a summary of UNC's disposal solutions for these wastes.

May 1957 - UNC considered several solutions to the problem of disposing certain amounts of low level radioactive waste water generated at the Plutonium Lab during normal operations. In Feb. 1958, it was estimated (22) that:

> "5-10 gallons of sink water and 50 gallons of laundry water will be generated per month. This is a total of 60 gallons of slightly contaminated waste water per month."

The Retention Tank (refer to Chapter III, page 37) with a capacity of 4500 gallons was used to store some of the waste water as it was generated (1). By the end of 1957 approximately 4000 gallons was in storage waiting to be analyzed and disposed of (8). A waste water analysis made in April and May 1957, showed (1):

	April 8, 1957 cu/ml	May 9, 1957 cu/ml
Top sample	118,000 x 10 -15	669 x 10 -15
Middle sample	858 x 10 -15	890 x 10 -15
Bottom sample	1,552 x 10 -15	1250 x 10 -15

The May 1957 Report (1) stipulated that if there was no or low strontium present, dilution might offer an easy solution to disposal.

July 1957 - UNC personnel expressed concern (2) that draining low level waste water into the retention tank created a handling problem out of proportion to the amount of waste generated. A new system for handling these wastes in the future was being looked at. During this time two alternative disposal solutions were considered:

1. Hire an outside firm to handle the waste water (6).
2. Hire a local sewage disposal company to haul the wastes to private sewage disposal pits (7).

Both of these options were eventually ruled out.

November 1957 - an assay of the waste water (8) showed:

Gross Beta	6.76 x 10 -7 uc/ml
Cesium 137	0.21 x 10 -7 uc/ml
Sr. 90	1.26 x 10 -7 uc/ml

Sr 90 accounts for 18.7% of the activity and Cs 137 accounts for 3.1% of the activity.

Mid-November 1957 - The Dutchess County Department of Health assisted UNC in finding a sewage disposal plant along the Hudson River that would take the waste water (10) (11). A Health Department memo (12) indicated:

"The water could be discharged into pits on the property but for public relation reasons the corporation does not desire to follow this practice. It has been suggested and approved by our Central Office to discharge the water into the Hudson River. It is our desire that this be done south of Poughkeepsie so as not to influence the water supply of the City of Poughkeepsie."

In December 1957 the City of Beacon's Disposal Plant turned down a request to have their plant used (15) (16) (17).

December 1957 - another disposal scheme was considered by UNC. This included several alternative approaches to disposing retention tank waste water at the Pawling site (18). The solutions considered were to:

1. Pump the waste from the tank to the middle of the lake, where the moving stream would enhance mixing and assure carrying the liquid to the overflow, preventing accumulation of the wastes (18);
2. Pump the water from the retention tank directly into the stream that flows out of the lake (18).
3. Wait until the lake freezes over and spread the liquid over the surface of the lake resulting in a phenomenally large dilution (18);
4. Purchase an evaporating system and evaporate the liquid (18).

January 1958 - the wastes were still being stored (19) (20) and UNC felt they should consider:

1. "...some method of disposal which will not involve the Health Department" (21).
2. "...not writing any request for solution of this problem to any official agency since the amount and cost of disposing the waste is low in comparison to the unfavorable publicity" (21).

February 1958 - three additional methods of disposal were considered (22):

1. Evaporation
2. Ion Exchange
3. a) Indefinite storage at present site.
   b) Indefinite storage in a similar pit located somewhere in the woods at Pawling.

After a cost benefit analysis of each method, it was concluded that the ion exchange method was the most feasible and should be used (22) (23).

November 1959 - UNC advised the Dutchess County Health Department (27):

"that approximately 500 gallons of liquid waste had been passed through ion exchange units. The filtered effluent was collected in 55 gallon drums and, if an assay showed a concentration less than the maximum permissible concentration, these wastes were discharged to the lake. Difficulties were experienced with the ion exchange units apparently due to suspended material in the wastes."

In the meantime laundry and sink waste water continued to be generated in Plutonium Facility. The water was collected in barrels and assayed to determine if the content was below the Maximum Permissible concentrations (MPC). Based on decay calculations, a schedule for dumping the barrels into the lake was determined. Between July 22, 1959, and October 16, 1959, at least 45 barrels were scheduled for dumping in this manner (28).

One analysis (28) of the laundry water samples conducted on May 29, 1959 on a 100 channel analyzer showed the samples varied from 200 x to 10 x above MPC.

During 1959 the option of obtaining an industrial waste discharge permit from the N.Y.S. Department of Health was discussed with UNC employees (29,30). Following is a brief summary of UNC permit application procedures:

December 22, 1959 (31) - UNC (then NDA) applies to the N.Y.S. Health Department to discharge from 400-1000 gallons per month of laundry, sink and shower waste water. The discharge would be through a pipe leading from the Waste Storage Building to the Lake (See Figure V-1).

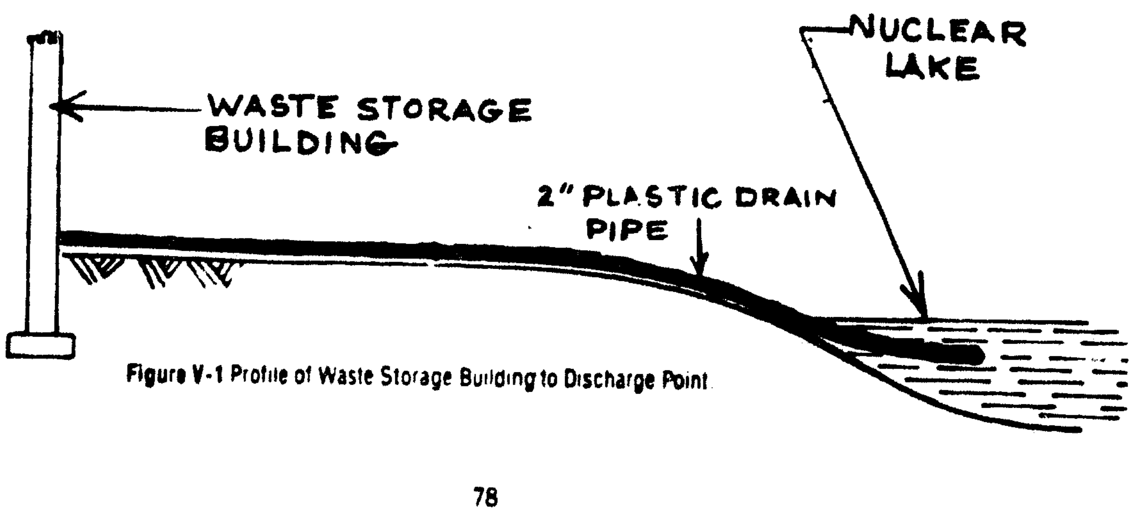


Figure V-1 Profile of Waste Storage Building to Discharge Point

Jan. 26, 1960 - N.Y.S. Health Department asks UNC for supplemental Information for the Application (32) to include:

1. Estimates of amount of radioactive isotope to be discharged.
2. Methods of sampling.
3. Method of dilution to reduce the waste below MPC.

April 12, 1960 - UNC responds to the request for supplemental information (33):

"In response to your three questions:

1. It is estimated that the maximum amount of radioactive material discharged per year will be 1 milligram of plutonium (60 Microcuries) and 4 microcuries of gross fission products....
2. The waste liquid will be collected in 55 gallon tanks. The liquid will be agitated by hand, a sample will be taken and an aliquot of this will be analyzed.
3. If a tank is above the MPC it will be diluted before discharge. Dilution will be accomplished by mixing the contaminated liquid with tap water in a 55 gallon tank. This liquid will then be analyzed and released for discharge if it is below the MPC. The water supply is an artesian well, approximately 200 feet deep, which delivers over 14 gallons per minute."

November 23, 1960 - N.Y.S. Health Department issues UNC their discharge permit (36).

October 26, 1961 - UNC waste disposal records (38) indicate that 200 gallons of alpha emittings waste have been dumped into the lake. The wastes were contained in 4-50 gallon drums and had the following concentrations:

Drum 1	**1.09×10^{-9} uc/ml**
Drum 2	**1.8×10^{-10} uc/ml**
Drum 3	**Background**
Drum 4	**Background**

Six more drums or about 300 gallons of alpha emitting waste had not been analyzed. It was estimated (38) that about 10 gallons per day of alpha wastes were generated at the site at this time.

Late 1961 - UNC requests (101) to modify their permits to increase the allowable discharge concentration of Plutonium-239 from 1.5×10^{-6} uc/ml to 5×10^{-6} uc/ml. Based upon 10,000 gal./yr. the maximum amount of Plutonium to be discharged would be 20 uc.

January 11, 1962 - UNC's request is approved by the N.Y.S. Department of Health (39)

June 6, 1968 - A dramatic increase in lake water radiation levels occurs (see Chapter VII, Table 22) (42).

June 30, 1971 - UNC applied to the Department of the Army Corps of Engineers for a permit (47) to discharge 20 gal./mo. of scrub water from washing laboratory floors in the Plutonium Facility. The scrub water was to be collected, analyzed and if found to be within allowable limits discharged directly into the lake via a pipe (see Figure V-1).

No further references relating to Plutonium Facility Waste Water were available.

BORATED WASTE WATER DISPOSAL

Between October 1957 and April 1970, seven available UNC Health and Safety memos relate to the disposal of borated waste water. The water (2000 gallons) was generated in 1957 and was stored in pits (concrete tanks) in the Critical Facility Building for over 13 years. Following is a summary of UNC's borated waste water disposal solution:

October 1957 - UNC noted three disposal alternatives (48) (49):

1. Removal by tank truck for dumping in the Hudson River or the Ocean;
2. Evaporation and disposal of the borate as a solid;
3. Removal from the site by a private company.

July 1965 the 2,000 gallon quantity of borated water in storage was analyzed (50). It was found to be neutral (pH 7) when collected and to contain 0.083 grams/ml of boron (this amounted to 732 Kg of boron). The Dutchess County Department of Health informed UNC that the water could be dumped on the site. UNC staff felt, however, that this would create a fire hazard. Again, removal of the water from the site and evaporation were suggested. The latter proposal involved digging "several holes in remote areas at Pawling," filling them with the borated water, allowing the water to evaporate, then covering the holes (50). Later in 1965, the borated waste water was still in the Critical Facility Building (51,52).

June 1968 - a piping change in the "Poison Water System" in the Critical Facility Building was made to prevent the stored waste water from mixing with other water (53).

April 1970 - UNC stated that "...three (3) years ago, we disposed of approximately 800 gallons of borated water that had been lying dormant in the Critical Facility" (54).

No other references are available concerning borated water.

SODIUM WASTE

Between September 1957 and May 1974, several memos and reports refer to the problems of disposing heavily oxidized waste liquid sodium. Heavily oxidized waste sodium resulted when clean sodium was used in research and development work (SDR) at the Pawling Facility. Following is a summary of the problems UNC encountered in dealing with this waste.

September 12, 1957 - faced with the problem of disposing of 100 pound lots of waste sodium related to SDR development work, UNC sought suggestions from Knolls Atomic Power laboratory (KAPL) relating to sodium disposal methods (56).

February 24, 1958 - UNC considered selling the used sodium back to the supplier, Ethyl Corporation.

May 1958 - after a site visit, an Ethyl Corporation representative decided they "were not set up to take back used sodium" (61).

May 26, 1958 - UNC had, at this time, 50 gallons of waste sodium on hand with a probable accumulation of an additional 60 gallons within a month. This sodium had a large oxide content which made it useless for reclamation. The cost of shipping the waste was comparable with the cost of disposing of it at Pawling. UNC decided to carry out a disposal program on site; several approaches were considered: (61)

1. Burning
2. Aging
3. Reacting with water
4. Reacting with iso-propyl alcohol
5. Reacting with steam

July 2, 1958 - UNC personnel decided that burning and aging were economically feasible methods for disposal at the Pawling site.

1. Burning involved "preparing a pit (hole in the ground) one foot deep and five feet by five feet in cross section. The woods would be cleared 50 feet around the pit and a small fence placed around the hole. Kerosene soaked rags would be used as fuel, with the sodium placed on top of the burning rags" (62).
2. Aging involved "digging a hole in the ground six feet deep and ten feet by ten feet in cross section. The bottom of the hole would be lined with rocks. A steel grating or screen would be placed across the hole, five feet below ground level. The hole would be fenced in and a roof placed over it to prevent rain from coming in directly. The land would be cleared for at least 50 feet around the hole" (62).

It was estimated that by the end of 1958 more than 200 gallons (1400 pounds) of sodium waste would need to be disposed of.

July 3, 1958 - February 24, 1970 - No information on sodium disposal available.

February 25, 1970 - UNC disposed of a small quantity of sodium at Pawling. Two experiments using a heavily oxidized piece of sodium - weighing approximately one pound, were tried. In one, a pound of sodium was ignited with kerosene. In the second, a pound of sodium was thrown into a large tank of water.

"The purpose of our experiment was to determine if we could dispose of waste liquid metal without arousing the concern of our Pawling neighbors" (63).

As a result of the experiments UNC concluded:

1. "We cannot dispose of large quantities of sodium by burning at Pawling. The smoke would be so dense that we would arouse unnecessarily the concern of our Pawling neighbors. We can burn small quantities (one pound) without any problems, but the manhours involved would be significant" (63).

2. "Water is out for sodium disposal." "Approximately five seconds after entering the water, it reacted as expected - with a bang" (63).

May 16, 1974 - A representative of the Bureau of Radiation of the NYS department of Environmental Conservation, interviewed a former UNC Site Director (Director during 1950's and early 1960's) concerning disposal of sodium wastes, and in a memo (64) states that the former Director...

"...had witnessed the placing of small cans (about the size of a gallon paint can) into the lake containing sodium wastes. The cans were then punctured with a 22 caliber rifle and a considerable explosion resulted" and that "small amounts of sodium were disposed of in the lake by the above mentioned method but there were never any barrel quantities of sodium disposed of at the NDA Facility."

No further references to waste sodium disposal were available.

AIR CONDITIONER WASTE WATER

June 1965 - The air conditioners in the Plutonium Lab generated water at the approximate rate of 45 gallons per day (65). This water had to be analyzed before it could be disposed of. This presented a problem for the operating people at UNC because they could not get the samples analyzed fast enough to prevent a storage build-up. In an attempt to solve the problem consideration was given to the following methods of analysis and disposal (65):

1. Have UNC Chemistry Section of the Materials Department perform the analysis and store the water in 55 gallon drums in the Waste Disposal Building while awaiting results;

2. Run the water directly into the Retention Tank (capacity 4500 gal.) and when a significant volume (2000-3000 gal.) was built up, have the analysis performed by the Materials Department;

3. Have a commercial vendor perform the analysis and store the water as in item #1 or #2;

4. Train a technician at Pawling to perform the analysis as water is generated;

5. Turn off the air conditioner.

August 1965 - it was decided that UNC's Health and Safety Department would collect the samples and the Materials Department would analyze them (66).

No further references related to disposal of air conditioner waste water were available.

LITHIUM WASTE

January 1962 - it was noted in the UNC daily log book (67) that two UNC employees "disposed of some lithium in a 55 gallon drum down near the lodge - big explosions while AEC here."

March 6, 1970 - in a memo (68), a UNC Health and Safety Officer referred to lithium as being the most abundant waste.

> "While preparing for this exercise I noted that most of the waste at Pawling is lithium. This can be disposed of in water without a violent reaction, but again the time required would be significant."

No other references concerning lithium waste disposal are available.

SEWAGE WASTES

Plutonium Facility: During its initial operating years, 1957-1967, the Pu Facility had an 800 gallon septic tank and a leach field located under the main parking lot, south of the facility (see Figure V-2) (75). By 1966, it was estimated that the system received 300 gallons per day of septic wastes from the 10-12 people working at the facility.

1966 - Plans for expansion of the Plutonium Facility required that the earlier system be removed and replaced (see Chapter III, page 27 for details).

February 27, 1967 - The Dutchess County Department of Health approved UNC plans for the construction of a new system (77). The new system was located south of the earlier system (see Figure V-2) and served 20 employees with an estimated sewage waste flow of 600 gallons per day (78). The system consisted of a 900 gallon concrete tank with 8 laterals in the leach field and is 110 feet from the nearest well (76).

Biological wastes, water from a sump sink and drinking fountain and effluent from a face bowl were discharged into the system (80).

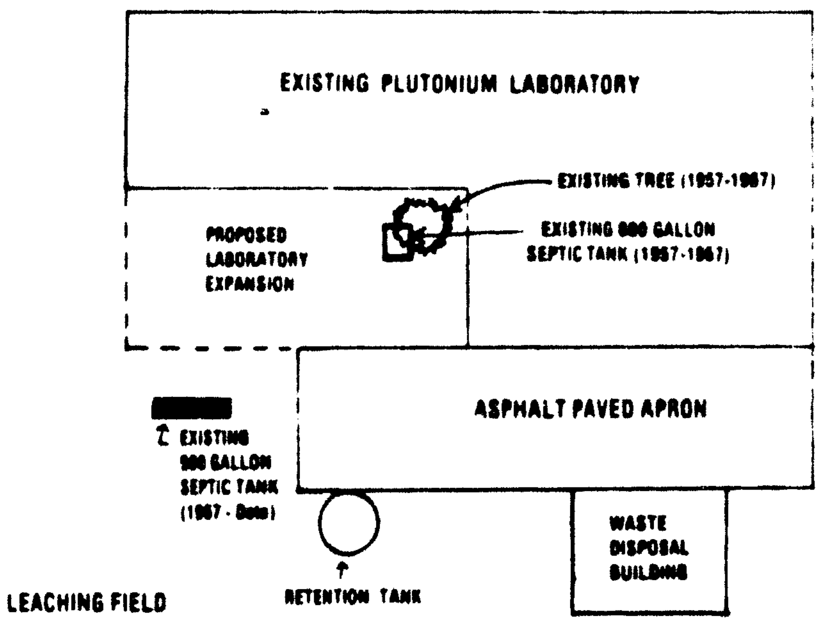


Figure V-2 Location of Plutonium Facility Septic Systems 1957 - Date

June 1970 - UNC personnel looked into the possibility of having soil near the drain fields of the septic system serving the Pu Lab, tested for radioactivity (82-84):

"It would cost approximately $250 to obtain a soil sample near the drain fields of the septic system serving the Plutonium Laboratory. The fields are approximately five to seven feet deep and run under the parking area and the road. This would require a drilling rig to obtain a soil sample in order to prevent too much damage to the paved area."

The sampling idea was ultimately abandoned (84) because "the cost of doing these things would be prohibitive:..."

Critical Facility: The Critical Facility had its own separate septic system. No reference information relating to the system's location, size, type, waste, etc. were available.

Engineering Facility: The Engineering Facility had its own separate septic system (see chapter III, page 34). No reference information relating to the system's location, size, type, waste, etc. was available.

Remote Assembly Building: After the 1972 Pu Facility accident, site personnel were decontaminated in the Remote Assembly Building (55) (81). No provisions were incorporated to collect radioactive liquid wastes for analysis prior to their release into the septic system. In 1973, a waste system was installed to collect and analyze the waste wash water prior to release.

No further information relating to any of the facilities septic systems location, size, type, waste, etc., was available.

COOLING WATER

March 1956 - Reference was made to the use of lake water by UNC for cooling purposes. Residents along the stream draining the lake were concerned that the stream's water might become radioactive and requested information on the matter from the Dutchess County Department of Health. A reply, (87) in the form of a memo from the Department of Health to the Beekman Town Supervisor indicated:

"...The Health Department is responsible for the proper disposal of any radioactive wastes from the plant." "You can be assured this office would not knowingly permit any operations where such danger might occur. I believe the information as to the amount of water to be used from the Lake is exaggerated for if such water is used, it is for cooling purposes only and would not be made radioactive or contain any radioactive waste material."

1958 - 1965 - during the expansion of the Plutonium Facility, consideration was given to installing a Cooling Water System. Two alternative proposals were considered.

June 1958 - A proposal to withdraw lake water, use it as a heat exchanger, then discharge the water back into the lake (89) was made. It was noted that "lake water if used for such purposes only, would not be made radioactive or contain any radioactive waste material." Concern was expressed over what the effect of an increase in the temperature of the lake would have on fish and algal populations (88).

August 1966 - Plans were developed to pipe cooling water up from underground sources, use it as a cooling water supply then return it underground (90).

No further information concerning the use of cooling water was available.

SOLID WASTE DISPOSAL

Reference (80) dated April 16, 1970, discusses the disposal of solid waste generated at the Plutonium Facility.

"Solid waste generated in the Plutionium Laboratory may be placed in three catagories, (a) waste generated in the process operation, (b) bulk waste generated in the laboratory operations outside of the glove boxes and hoods, and (c) paper waste generated in the engineers' offices located in the laboratory. Items (a) and (b) are treated as contaminated, and are packaged and shipped out for land burial. The paper waste, item (c) is treated as the remaining Pawling solid waste is treated. That is, it is either burned in our incinerator, or it is transported to a local dump and used as landfill."

Reference (40) June 7, 1965, mentions that "All solid waste is shipped out for land burial at Oak Ridge and/or Nuclear Fuels Services in West Valley, N.Y."

ALLEGED DUMPING OF BARRELS OF UNKNOWN WASTES

Around 1959, while fishing, a resident of the Town of Pawling reported (102) that he had noticed a number of black barrels marked "Danger, Radioactive Wastes" on the Nuclear Lake property. When the resident asked a UNC employee (guard) how the barrels were disposed of, he indicated that they were loaded into a row boat, at night, taken to the center of the lake and then dumped. A summary of that report can be found in the insert.

In 1974 (15 years later) the NYS DEC requested that its Bureau of Radiation investigate the incident (64). The resident of the Town of Pawling was contacted on May 14, 1974. He indicated that he had personally seen the barrels standing by the side of the lake but did not actually see anyone take them out and dump them in the middle of the lake. Three former UNC employees were also contacted by the Bureau of Radiation during May 1974. One indicated that at no time were barrels containing radioactive wastes taken to the middle of the lake and dumped. He further stated that all disposal of such wastes was accomplished by dumping the liquids below MPC value into the lake from the shoreline. A second employee said that he had never heard of or seen any such actions. The third employee said he had never disposed of any radioactive material in the lake by using a row boat, and that the only wastes disposed of in the lake were those below MPC value, and they were released from shore. Based on the foregoing investigation, the Bureau of Radiation concluded that "no radioactive materials were ever disposed of by dumping the wastes, barrels and all, into the center of the lake from a row boat."

A Pawling resident reported that (102)

Years ago while fishing he noticed a number of black barrels marked "Danger – Radioactive Waste" at the entrance to the UNC property. The resident asked the guard how these barrels were disposed of. According to the resident, the guard indicated that they were loaded into a row boat, one at a time, and rowed at night to the center of Nuclear Lake and dumped there.

The resident contacted NYS Department of Environmental Conservation in White Plains, N.Y. Their advice was that if the barrels were at the bottom of the lake they were best left undisturbed to rust and leak slowly.

The resident also notified the Dutchess County Department of Health and spoke to an engineer regarding sodium dumping in the lake. He questioned the engineer on the legality of the Health Department's permit to UNC which permitted them to dump sodium into the lake. The resident reported that the engineer became very mad.

EXHAUST SYSTEMS - STACK EMMISSIONS

Few references describing the structure and operation of UNC's exhaust systems were available. However, several memos generally describe the system serving the Plutonium Facility. A summary of these references are listed below.

February 28, 1963 (91) - Stack Blowers - "The existing blowers may not have the capacity to serve the Alpha Lab and the new facility."

August 5, 1963 (92) - Gamma Lab Exhaust System - "Health and Safety recommends a minimum linear velocity of 100 feet per minute at a window height of thirteen inches for the Hood in the existing Decon Room of the Gamma Lab. We also recommend a minimum of five room air changes per hour in this room. In the event a similar exhaust system is included in the new decontamination room, the above specifications will apply also."

October 30, 1964 - Plutonium Lab Exhaust System - "From a Health and Safety point of view, a good exhaust system is a necessity in operations such as this; and we have a good system."

- Gamma Lab Exhaust System - "This system should be replaced. It was adequate when operations started in this Lab, but it is marginal at this time."

August 25, 1970 - Plutonium Lab Exhaust System - "We are continually adding to this exhaust system without determining if the system can handle the additional load. In the Performance Test Program we require a single glove break test. J. Andersen has stated that he will perform two (2) simultaneous glove break tests. This will give some indication about the adequacy of the exhaust system."

During 1969 and 1970 - air samples of the gaseous effluents in the stack serving the Plutonium Facility were collected and analyzed. The results reported were (97):

	Average Yearly Activity Recorded	Pu-239 Permissible Concentration for Occupational Exposure	Pu-239 Permissible Concentration for The General Public
1969	2 x 10 -14 uCi/ml	6 x 10 -13 uCi/ml	6 x 10 -14 uCi/ml
1970	3 x 10 -15 uCi/ml	6 x 10 -13 uCi/ml	6 x 10 -14 uCi/ml

Other gaseous effluent analysis can be found in the data tables, Chapter VII.

No further references concerning Exhaust Systems and Stack Emmissions were available.

BUILDING CONTENTS

An inventory of items remaining in each of the buildings on the Nuclear Lake property has been compiled and listed here. The inventory resulted from several field inspections of the property by members of the Nuclear Lake Site Clearance Committee, the last field inspection was made on Tuesday, August 25, 1981 (100). (See Chapter III for building structures, floor plans and photographs.)

Plutonium Facility (See Figures III-4 and III-5) - This concrete building has been stripped of most materials, debris and fixtures. Items remaining include:

- 3 sealed barrels marked "UNC - Radioactive - fissile material - Empty"
- sealed plastic bag of paper wastes
- three work benches
- miscellaneous electronic equipment
- a locked concrete vault used to store Radioactive material
- plumbing and appliances from two bathrooms, the "decontamination room" and boiler room remain

Critical Facility (See Figures III-6 and III-7) - This concrete building contains numerous pieces of equipment miscellaneous items and scattered debris, including:

- work benches, desks, locks and filing cabinets
- electronic equipment
- an open concrete vault used for Uranium storage
- bathroom plumbing and appliances
- miscellaneous paper wastes and scattered material.

Engineering Building or Shop (See Figure III-8) - This building contains materials, debris and equipment including such items as:

- miscellaneous office debris (paper wastes, literature, paperclips, ets.)
- numerous bottles of chemicals (many types)
- a shop full with work benches, parts, paint, equipment, tools and miscellaneous debris and materials.
- several rooms containing electronic equipment and office equipment.

Multiple Failure Building (See Figure III-9) - Many items still remain in this-one room metal building, including:

- 33 light fixtures (4' x 2') wrapped and sealed in clear plastic bags (taped closed)
- an empty wooden cabinet
- 5 filing cabinets, 1 desk, 1 locker (all empty)
- miscellaneous equipment and scattered debris.

Shield Mock-Up Building (See Figure III-10) - Few materials remain in this one-room metal building, including:

- heaters and wall fixtures
- electrical wiring and some miscellaneous scattered debris.

Waste Storage Building (See Figure III-2) - Both the upstairs and downstairs of this two-room structure contains miscellaneous items including the following:

- UPSTAIRS - 6 bottles of boric acid, several large air filters, gutter connections, miscellaneous small bottles of chemicals, boxes of respirator filters for masks, 2 large boxes of empty freond cans, several bottles of penetrant dye and octail, insulation peeling off the walls and miscellaneous debris.

- DOWNSTAIRS - small autoclave, florescent light fixture, empty drums, exhaust hood, graphite pipes, barrel carriers and piping from the waste disposal system (still intact).

Emergency Generator Building (See Chapter III, page 38) - This small 8' x 16' structure is empty except for several miscellaneous items and bits of depris.

Retention Tank (See Figure III-12) - This 8' diameter 14' deep concrete structure contains approximately 1' of water.

Lodge (See Figure III-3) - This wood frame structure contains such items as:

- 3 barrels marked "UNC - Radioactive - fissile material"
- several cartons of unused empty cans
- electical equipment
- glove box glass
- photographic equipment
- numerous "bats" (animals).
- wall lockers
- miscellaneous equipment and materials.

Remote Assembly Building (See Figure III-13) - This building is presently a residence. No materials associated with UNC operations are present.

OUTSIDE BUILDING CONTENTS

Several areas on the Nuclear Lake Property contain miscellaneous debris and materials left over from the plant's operating years. Following is an inventory of those materials. The inventory was compiled after members of the Site Clearance Committee made several field investigations of the property (100).

Behind the Engineering Facility - A number of empty barrels, pieces of metal, wooden skids, equipment parts and barrels containing trash and miscellaneous debris remain scattered behind this building (See Figure V-3).

Figure V-3 Materials behind the Engineering Building

Near the Sodium Tent - A large pile of 6' to 8' diameter piping and several metal ducts have been placed in a wooded area near the Sodium Tent (See Figure V-4).

Figure V-4 Piping and Ducts in the Woods near the Sodium Tent

Behind the Dam - Several empty 5 gallon chemical containers, small drums, miscellaneous brush, wood and debris have been left here.

Outside the Multiple Failure Building - Barrels containing trash and debris, a metal safe (cut open) and miscellaneous objects, still remain (see Figure V-5). Also, four barrels connected to the building by a system of pipes are buried in the ground behind the building (see Figure V-6).

Figure V-5 Materials outside the Multiple Failure Building

Figure V-6 Barrels buried behind the Multiple Failure Building

Outside the Plutonium Facility - A large airconditioning unit, a system of piping, gutters and drain pipes still remain attached to the building. Two buried pipes connected to the gutter system (one leading to woods on the north, the other to the cove on the south of the building) still remain. One barrel of trash, a car hood and miscellaneous debris are found scattered about the building (see Figure V-7).

Figure V-7 Air Conditioning unit behind the Plutonium Facility

Outside the Critical Experimental Facility - Several empty barrels, large steel plates and miscellaneous debris are located about the building. Gutters and drain pipes remain attached to the building. Two buried pipes connected to the gutter system leading to the wetland southeast of the building remain. A system of piping and airconditioning units remain on the roof. Surrounding the building on three sides is a 6' high chain link fence.

Outside the Shield Mock-Up Building - A stack of wooden skids, pieces of metal and some miscellaneous debris remains. A buried drain pipe leading from the building to the woods and one pipe leading from the building directly into the ground is present.

Area North of Multiple Failure Building - Twentysix concrete slabs (6' X 12' X 6'), two concrete slabs (6' X 4' X 1') (see Figure V-8) and ten large concrete blocks (4' X 5' X 2') containing holes (4' to 6' diameter) (see Figure V-9) have been placed here.

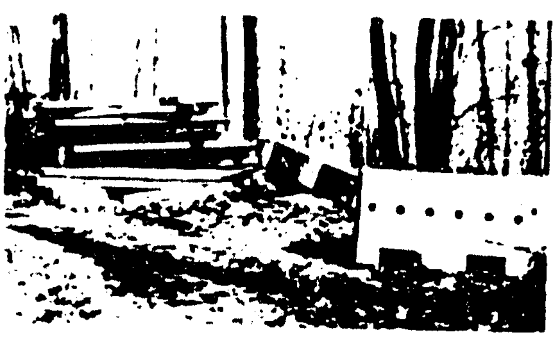


Figure V-8 Concrete Slabs north of the Multiple Failure Building

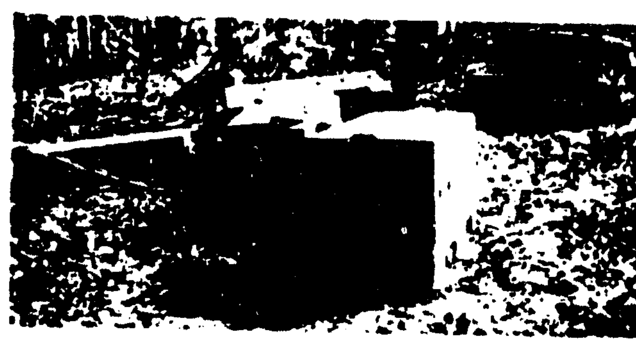


Figure V-9 Concrete Blocks north of the Multiple Failure Building

Wells and Septic System - The piping and well casing for the wells of the Critical Facility and Plutonium and Engineering Facility remain intact. The septic systems for each of these facilities also remain.

Outside Waste Disposal Building - A buried 2' plastic pipe leading from near the building to the "cove" area of the lake reamins (see Figure V-1).

Outside the Lodge - Three large concrete blocks 4' X 5' X 2' containing 6" diameter holes (see Figure V-9) have been placed here. Some miscellaneous debris is scattered about the building.

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VI Accident, Clean-Up and Decommissioning

SUMMARY OF THE ACCIDENT

On December 21, 1972, at approximately 2:55 pm, a chemical explosion occurred at the Plutonium (Pu) facility releasing solid and particulate plutonium oxide to the lab area. The explosion took place in a plexiglass glove box in the metallography line which consisted of three such boxes used to prepare and examine fuel pellets. Air leaking into the box, volatile material, and the absence of a gas analyzer used to monitor the atmosphere were believed to collectively cause the explosion (1), (2,) and (25).

At the time of the incident, 2 grams of two high fixed oxide sintered pellets were being prepared for ceramographic examination. An analysis of the material can be found in Table 10.

Table 10. Analysis of Oxide Pellets in the Pu Facility during the Dec. 21, 1972 accident.

		Pellet S-617	Pellet S-618
Plutonium	238	0335%	.0324%
	239	87 289%	87 266%
	240	11 224%	11 247%
	241	1 332%	1.323%
	242	1322%	1311%
Uranium	234	3157%	3820%
	235	40 022%	48 87%
	236	1273%	1546%
	238	59 535%	50 59%

Note: The americium-241 contribution was 080 ugr/30 ugr of total Pu. Americium-243 contribution was 006 ugr/20 of total Pu. The licensee stated and the analysis records confirmed that the ratio of plutonium to uranium was 17% to 83 %, respectively (1).

The employee working directly with the box sustained facial cuts and radiation exposure at 3860 MPC/hr, (maximum permissible concentration / hour). Another employee in the lab sustained exposure at 350 MPC/hr. All twelve employees on site at the time gathered in the Remote Assembly Building approximately .9 miles from the Plutonium Facility to undergo decontamination procedures.

After all employees had evacuated the building, a second explosion took place. The fire that was believed to follow the initial explosion may have caused a bottle of flammable solvent to heat up, rupture and disperse, thereby fueling the second explosion. (25)

The latter explosion is suspected of having blown out two exterior windows on the north side of the building and two exterior doors on the south, spreading radioactive contamination to the outside environment. (See Figure VI-1.) The following day, the area was re-entered. Windows and doors were sealed. Extensive damage to the metallography line was found.

Immediately following the accident, United Nuclear Corporation (UNC) supplemented its routine environmental monitoring program and took special samples to determine levels of contamination. Samples of air, snow, ice, watershed and soil were included. Sampling results are listed in Table 11.

Weather data for the night of the accident can be found in the insert on the next page (28)

Table 11. Results of Environmental Sampling Following the Dec. 21, 1972 Accident

Sample	Location	Max. Conc. Pu-239/240
Snow & ice	About the Pu Facility	6.3 x 10 -7 uCi/ml
Lake Water	Nuclear Lake - West Shore	No detectable activity
Soil	About the Pu Facility	From .00 dpm/gram to .53 dpm/gram
Direct Surveys	Outside - immediate area of broken windows	5000 dpm
Direct Surveys	Outside - immediate area of door	Less than 200 dpm
Direct Surveys	Other outside areas about	Below detection limit of 100 dpm

Stack sample records prior to and subsequent to the accident, were reviewed. The sample results obtained are shown in Table 12, below. UNC stated that approximately 5.6 uCi of activity was released from the Pu Facility via the stack.

Table 12. Stack sample results prior to and subsequent to the Dec. 21, 1972 accident

#	Start Date	Time	Stop Date	Time	Results uCi/ml*
1	12/19/72	4:50 pm	12/22	6:45 am	5.94 x 10 -12
2	12/22/72	6:45 am	12/22	2:45 pm	No Sample
3	12/22/72	2:45 pm	12/22	7:30 pm	7.4 x 10-12
4	12/22/22	7:30 pm	12/22	8:30 pm	No Sample
5	12/22/72	8:30 pm	12/23	10:15 am	7.5 x 10-13
6	12/23/72	10:15 am	12/23	8:00 pm	No Sample
7	12/23/72	8:00 pm	12/24	4:30 pm	1.81 x 10-14
8	12/24/72	4:30 pm	12/26	2:00 pm	8.15 x 10-15
9	12/26/72	2:00 pm	12/27	4:00 pm	4.0 x 10-14

***minimum of 24 hour decay**

Note: According to the United Nuclear Corporation, sample numbers 2, 4, and 6 were not obtained because of inability to restart the sample pump and improper installation of sampling paper.

WEATHER DATA
DUTCHESS COUNTY AIRPORT — POUGHKEEPSIE, NY
SURFACE WEATHER OBSERVATIONS

December 21, 1972
Time 1500 hours Fog. Visibility 2½ miles
Wind direction 070°. Velocity 4 knots/hour
Freezing drizzle Barometric Pressure 29 94. Temp 32°
Time 1600 hours Visibility 2½ miles
Wind direction 080°. Velocity 6 knots/hour
Ceiling 3000/ft (balloon reading at 1700 hours)
Barometric Pressure 29 96 Temp 32°

STEWART AIRPORT — NEWBURGH, NEW YORK
SURFACE WEATHER OBSERVATIONS

Time 1550 Indefinite ceiling · partially obscured.
Visibility 1/8 mile Freezing drizzle. Fog
Wind calm, no reading, remained calm all day
Barometric Pressure 29 580. Temp 31°

SUMMARY

The accident occurred on Dec 21, 1972 at 2 55 pm The prevailing weather conditions that entire day were fog, freezing drizzle little or no wind At 1500 hours (3.00 pm) the Surface Weather Observation recorded at Dutchess County Airport was as follows visibility 2½ miles wind direction 070° (equivalent to out of the NE heading SW, towards Green Haven), velocity 4 knots/hour (equivalent to 4.6/MPH) There was fog and freezing drizzle The barometric pressure was 29.94 and the temperature was 30° F.

At 1600 hours (4 00 pm) the same record indicates a very slight shift in wind direction to 080° and a slight increase in wind velocity to 6 knots/hr (7 MPH) At about midnight of Dec 21, the wind direction changed to 030° (out of the N, NE) speed increased to 8 knots/hour There were slight changes in weather conditions until Dec 22 at 1900 hours the wind became calmer yet and a high temperature of 39° was recorded at 1500 hours

Conditions recorded at Stewart Airport (Newburgh NY) were essentially the same Winds were even calmer

Dutchess County Airport has the nearest weather station to Nuclear Lake It is located about 12 miles in a westerly direction from Nuclear Lake and is about 165 ft above sea level The Nuclear Lake Property ranges in elevation from 600 ft to 1050 ft The lake surface elevation is 758 ft

Ref Surface Weather Observations from Poughkeepsie NY and Stewart Airport NY, from the National Climatic Control Center, NOAA Environmental Data Service.

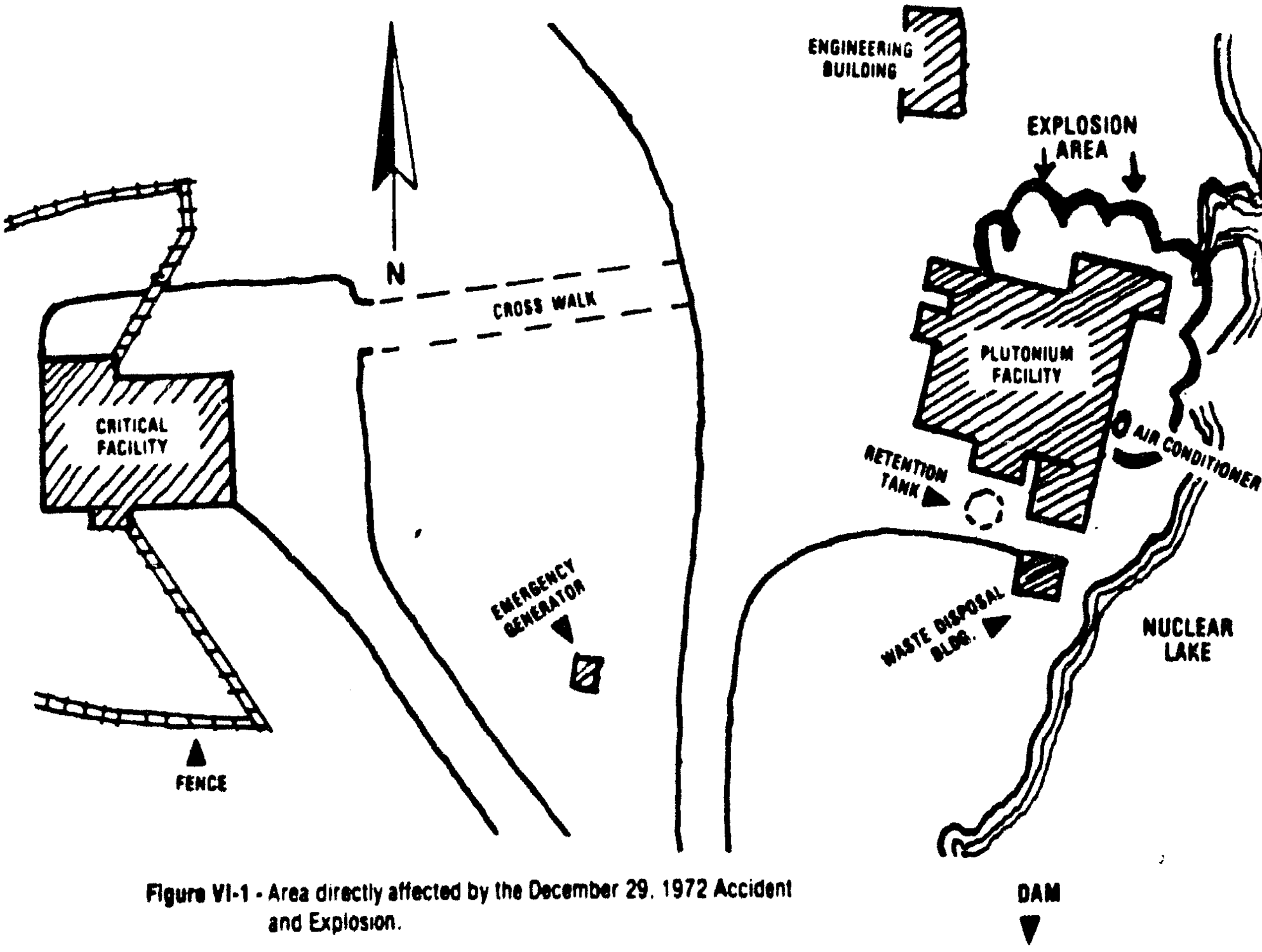


Figure VI-1 - Area directly affected by the December 29, 1972 Accident and Explosion.

Air samples taken daily at 13 locations within the Pu Facility between December and March 1973, indicated levels of alpha activity to range from 10^{-9} uci/ml to 10^{-13} uci/ml. (2)

Subsequent decontamination of the facility was conducted by UNC both independently and under contract to ATCOR, Inc. The decontamination procedure involved soil removal outside the Pu Facility, removal of ceilings and walls in contaminated areas and the reported packaging, shipment, and burial of 360 drums and 40 boxes of contaminated waste in "approved locations".

Throughout the decontamination procedures many references specifically characterize radionuclide concentration in air, soil, and wipes of the physical plant as "excessive". These references include USAEC inspection reports for December 21, 1972 (1) - March 27, 1973 (2) - October 30, 1973 (6) and April 9, 1974 (7).

Sampling of the fish, air, water, soil and buildings was conducted over a period of two years (1972-1974). These tests were carried out by United Nuclear Corporation, ATCOR Inc., NYS Department of Environmental Conservation (DEC), NYS Department of Health, NYS Department of Labor, NYS Atomic Energy Council (NYSAEC), and U.S. Atomic Energy Commission (USAEC) subsequently called Nuclear Regulatory Commission (NRC). Results of these tests are found in data tables throughout this study.

In October 1973, UNC requested permission to terminate its facility license. Approval of the request rested in part upon a determination that the soils affected by the accident were decontaminated to acceptable levels.

However, at that time no federal or New York State standards existed for plutonium in soil. The development of ad hoc standards became an issue for DEC and NYSAEC, with both agencies differing in their approach to sampling and determining what constituted permissable levels.

NYSAEC favored the application of an ad hoc standard (2dpm/gm Pu in dry soil) which had been developed by the Colorado State Health Department. DEC questioned the application of this standard for New York's less arid climate and opposed the analytical techniques that AEC used to arrive at concentration levels. A detailed discussion of the applicability of Colorado's standard of 2 dpm/gm can be found in references 11 and 12.

DEC argued that only the minus 35 mesh portion of the screen should have been used to collect soil samples. NYSAEC supported the use of both the minus 35 and plus 35 mesh portions. DEC and NYSAEC also differed in the interpretation of the data. In order to define the level of plutonium concentrations in the area, NYSAEC averaged the results of all the soil samples. DEC objected to this approach and was supported by the Colorado State Health Department and the NYS Health Department in its contention that the figure for Pu concentration should reflect the maximum amount of the substance found in a single sample. Based on this approach, DEC insisted that further soil removal was necessary to bring Pu contamination down to acceptable levels.

While NYSAEC stated that DEC was ultimately responsible for setting clearance criteria for the site, the agency firmly maintained that no additional work was needed at UNC. Believing it had no legal support for its position, DEC relaxed its stand and the site was cleared for unrestricted use by the AEC on July 14, 1975.

CLEAN-UP AND DECOMMISSIONING (1972-1974)

Below is a chronological summary of clean-up activities following the accident:

7/23/73 A U.S. Atomic Energy Commission inspection report (3) noted:

> Quite an amount of **low specific activity waste** (containing less than 0.1 grams Pu is being collected in plastic lined 55 gallon drums during decontamination. The waste is ultimately buried ...) - (71 drums of waste are being improperly stored outside building). Proper procedures for preparing containers for shipment were not followed

8/21/73 The drums of waste being "improperly stored" were prepared for shipment to a licensed burial site and moved into the "Transition Building" (known as Waste Storage Building) where they awaited shipment (4).

10/23/73 UNC requests permission from the U.S. Atomic Energy Commission to dismantle the Pawling Lattice Test Rig (PLATR) and the Pawling Test Facility (PTF) located in the Critical Facility Building (5). A dismantling plan was submitted and a Radiation Survey of the Critical Facility was made. (See Table 13 for survey results. Additional detailed radiological survey results of the inside of the Critical Facility can be found in Reference (5).

Table 13 Results of Critical Facility Radiation Survey*

	Mr/Hr
Outdoors by Reactor Room	0.02 - 0.05
Control Room	0.02
PLATR Area	0.01 - 0.05
PTF Area**	0.12 - 0.15

*** Measurements made with a Texas Nuclear Model 2650.**

**** Measurements in PTF Area affected by a nearby fuel bundle (5mr/hr 1/).**

10/30/73 USAEC report (6) states:

UNC contracts ATCOR Inc., Park Mall, Peekskill, New York, to complete decontamination of Pu Facility. The report confirms drums of waste previously stored in the "Transition Building", are gone.

UNC is sampling stacks daily. Three environmental samples are being taken on a weekly basis (near generator shack, critical facility, and mock-up facility).

ATCOR Inc., plans to remove glove boxes, hoods, ventilation system and stack for burial at "approved locations". The Pu Facility floors were painted to fix contamination. Decontamination proceeds under ATCOR "By-product Materials License #31-11640-02".

11/26/73 USAEC inspection report (8) states that:

Although the plutonium is in the oxide form (MPC = 4x10 -11 uCi/m1) the licensee used the MPC for soluable plutonium-239 (2x1 -12 uCi/m1) for controlling exposure to employees. Review of air sample records from March 23 to October 26 1973 showed that subsequent to September 25, 1973 no air sample station showed more than 2x10 - 12 uCi/m1 Pu 239/m1. Prior to June 1 1973 air sample concentrations in the vicinity of the research laboratory where the explosion involving plutonium occurred exceeded 4x10 -11 uCi/m1 during decontamination activity. The maximum concentration measured was 9 8x10 -10 uCi Pu-239/m1 at the 1.5 station on March 29, 1973

2. Stack air sampling from March 25 to November 22, 1973, showed that the air sample filter had been changed daily except on weekends. The MPC for insoluble plutonium-239 discharged to unrestricted area is $1x10^{-12}$ uCi/ml.

Although the plutonium processed in the facility was in the oxide form and assumed to be insoluble, the licensee controlled the discharge via the stack so that it would comply with the MPC for soluble plutonium-239 (6x10 -14 uCi/m1). The record showed that for the period from March 28 to May 23, 1973 twenty daily samples were in excess of 6x10 -14 uCi/m1. The maximum was 2 5x10 -13 uCi/m1. In all these cases each sample was counted after only 24 hour delay rather than after a longer period. The average concentration of insoluble plutonium-239 discharged from the stack for the period examined was less than 6x10 -14 uCi/m1 "

3. Three environmental air samples were operated within the plant area. The filter paper for each sampler was changed weekly. Sampler locations were near the Generator Shack, the Critical Facility and the Mock-up Facility.

Records of air sampler results were examined for the period from March 2 to November 14 1973. The maximum plutonium-239 concentration noted was 9 6x10 -15 uCi/m1 (MPC = 1x10 -12 uCi/m1)

4. Fifteen soil samples were taken from various sections of the plant property on October 26, 1973. The results of these samples had not yet been received from the vendor to whom they were sent for analysis.

5. Contamination surveys conducted by taking wipes and making direct reading instrument surveys for the period from March 26 to October 26, 1973, were examined.

"The records showed that contamination levels up to several hundred thousand dpm per 100 cm 2 (both wipe and direct reading) were measured in the vicinity of the explosion location. Measurements were generally below 100 dpm/100 cm 2 in areas which were remote from the area of the explosion "

1/21/74 A DEC report (26) indicated Pu levels in air are 10 - 1000 x higher than normal for other areas of New York State.

1/25/74 ATCOR Inc., releases final survey results after decontamination procedures are completed. Their Report (27) Final Survey Results After Decontamination, stated that the Plutonium Facility and environs have levels of contamination that are below the limits for release for unrestructed use. The report further states that in order to reach these levels it was necessary to:

Remove and dispose of as radioactive waste all glove boxes hoods exhaust ducts filters piping manifolds exhaust blowers exhaust stack and floor tiles in addition certain concrete block walls were found to be internally contaminated and had to be removed disposed of and replaced as well as certain sections of roof edge and rain gutters

A summary of ATCOR Inc's final survey results in graphically divided areas of 10 square meters where contamination of the environment may have existed can be found in Table 14. Survey results of all areas of the Pu Facility have not been reported here. However, all radiological survey results have been documented in the ATCOR Radiological Survey Logs Project 892A.

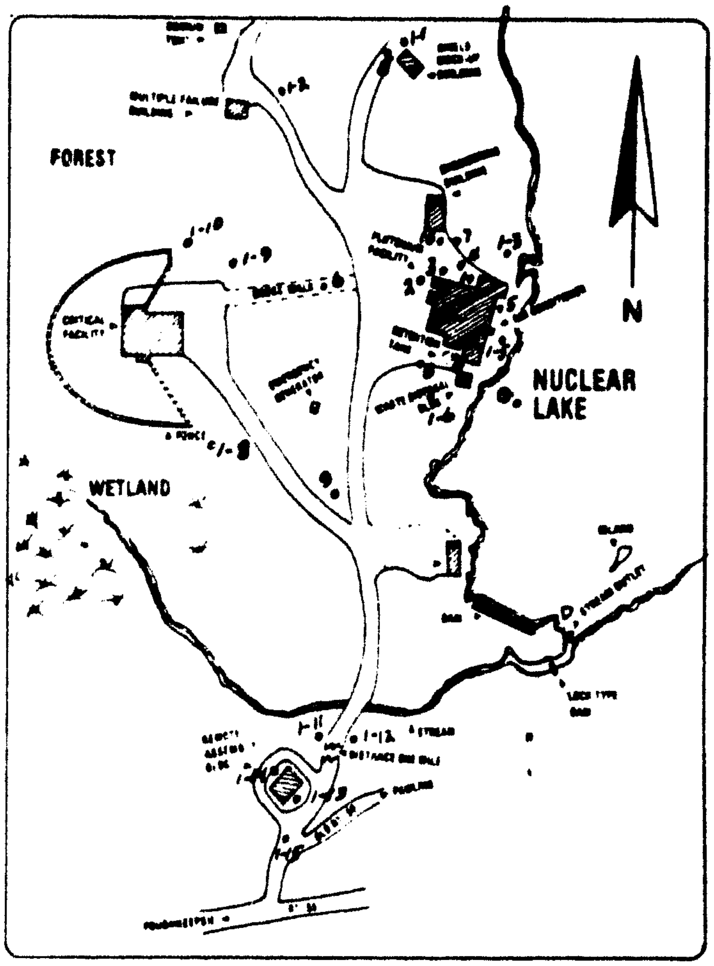
TABLE 14 A SUMMARY OF ATCOR INC'S FINAL SURVEY RESULTS TAKEN JANUARY 22 and 24 1974 (27)

Sample No**	Location	SOIL SAMPLE RESULTS — IN dPM/gm (dry)* Pu 238	Pu 239	U 234	U 235	U 238
1	Front of Gas House	0 34	0 87			
2	Entrance to Pu Facility	0 00	0 93			
3	Driveway to Gas House	0 07	1 01			
4	N of E Spec Lab	0 00	0 18			
5	Rear of Research Lab	0 06	0 05 ±	0 16	0 00	0 00
6	Foot Path to Critical Fac	0 45	0 27	0 21	0 00	0 00
7	Between Eng & Pu Fac	0 00	0 00	0 34	0 00	0 00
8	Front of Mock up Door	0 00	0 00	0 00	0 00	0 00
9	Jct of CF & Pu Fac Road	0 05	0 03	0 18	0 00	0 16
10	Front Eng Bldg	0 00	0 00	0 75	0 00	0 45
1-1	N-E of Mock up Ent	1 92	0 43	0 00	0 00	0 00
1-2	N-E of MF Bldg	3 40	1 35	0 00	0 00	0 00
1-3	N of Gas House Ent	2 29	0 56	0 18	0 00	0 00
1-5	Between Pu Fac & Lake	4 05	0 49	0 00	0 00	0 00
1-6	S of Pu Fac	0 68	0 37	0 2	0 0	0 1
1-8	S E of CF Parking Lot	4 47	2 57	0 1	0 00	0 1
1-9	N E of CF Parking Lot	0 68	0 16	0 1	0 0	0 1
1-10	N W of CF Parking Lot	1 82	0 59	0 2	0 00	0 1
1-11	50 from Rd - ½ to RAA (N)	0 81	0 41	0 1	0 0	0 1
1-12	50 from Rd ½ to RAA (S)	1 46	0 44	0 0	0 0	0 1
1-13	Front Lawn - Remote Assembly	0 13	0 00	0 9	0 00	0 5
1-14	Back lawn - Remote Assembly	0 36	0 08	1 7	0 3	0 1
1-15	Near GUNFC Sign (old Rt 55)			0 00	0 00	0 27
A	Pu Facility Septic Tank	68 ± 2 dpm/l	0 56 dpm/l	0 00 dpm/l	0 00 dpm/l	0 00 dpm/l
A	Pu Facility Septic Tank (Rerun)	0 45 dpm/l	0 82 dpm/l			
B	Waste Pit - S of Pu Fac	0 79	0 05			

*All Results in dpm/gm (dry) unless otherwise indicated

**See Figure VI-2 for location plotted on a map of the area.

Figure VI—2 Location of ATCOR Inc and U S A E C sampling stations



4/24/74 The USAEC confirms (7) that ATCOR Inc.,

> "carried out all work necessary to reduce contamination levels to below those specified in the **Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for By-product Source or Special Nuclear Material** as issued by the Directorate of Licensing."

In effect the USAEC considers that site acceptable for unrestricted use.

9/16/74 The Radiological Health Section of the State of New York Department of Labor, based on its own survey, confirms that decontamination of the Pawling Site is in compliance with Section 38.29. "Vacation Installations and Property" of Industrial Code Rule 38 and subsequently cancelled UNC's license to operate (9).

11/26/74 USAEC and NYS Radiological Science Laboratory data on soil and mud samples taken near the Plutonium Facility before (see Table 15) and after (see Table 16) the soil was removed from the vicinity of the laboratory is released. (10).

Table 15 Results of Analyses of Samples Taken by the U S AEC and New york State at Gulf-United Nuclear Corporation (Pawling New York) Before Removal of Soil in the vicinity of the Plutonium Laboratory

Sample Identification and location*	Analysis Performed By	239/240 Pu (dpm/g dry soil)	238 Pu (dpm/g dry soil)
1 Under window blown out during Pu glove box explosion	U S AEC**	12 2 ± 3	76 ± 02
4 Across driveway from window	NYS	644 ± 088	022 ± 007
7 Across driveway from window farther from the Laboratory than Sample B	U S AEC	11 ± 01	001 ± 003
5 Between Plutonium Laboratory and the Lake	U S AEC*	5 3 ± 1	34 ± 02
	NYS	290 ± 044	088 ± 066
1-2 North East of the Multiple Failure Bldg	U S AEC	30 ± 01	28 ± 004
— Near the critical facility (not shown on the sketch)	NYS	198 ± 044	015 ± 011
C Mud Sample at Shoreline near the Plutonium Laboratory	NYS	044 ± 013	013 ± 007
D Mud Sample near the dam at the lake outlet	NYS	046 ± 015	029 ± 013
— Mud Sample from the lake outlet stream near Route 55 (not shown)	NYS	029 ± 006	009 ± 004

***See figure VI-2 for sampling points**
****Four of five soil samples taken, mixed together, and analyzed for plutonium**

Table 16 Results of analyses of Soil Samples Taken by the AEC at Gulf-United Nuclear Corp (Pawling N Y) after Removal of Soil in the vicinity of the Plutonium Laboratory

Sample Identification and Location*	Analysis Performed By	239/240 Pu (dpm/g dry soil)	238 Pu (dpm/g dry soil)
1 Under window blown out during Pu glove box explosion	U S AEC**	49 ± 02	036 ± 005
5 Between Plutonium Laboratory and the Lake	U S AEC	2 65 ± 2	17 ± 03
— Near the parking lot between the Plutonium Laboratory and the Engineering Bldg Sample taken at a low spot (precise sample location not indicated on sketch)	U S AEC	1 18 ± 06	086 ± 01
— Control sample taken along the roadside several miles from the Pawling site	U S AEC	001 ± 001	001 ± 003

***See figure VI-2 for sketch of sampling points**
****Six samples taken, mixed together, and analyzed for plutonium**

11/26/74 Forty five (55 gallon) drums of contaminated soil (approximately 330 cu. ft.) were removed from vicinity of the Pu lab. According to USAEC (10) this included the top six inches of soil (3' x 35') between the wall which contained the window that blew out and the driveway, and the removal of low spots in the vicinity of Plutonium Lab.

The USAEC offers NYS DEC the opportunity to challenge USAEC's "Licenses termination" and "site release for unrestructed use" criteria. "The primary responsibility for establishing the State's environmental criteria for the Pawling site rests with the DEC." (10).

12/11/74 DEC waits for U.S. Environmental Protection Agency standards for plutonium levels in soil before it clears the site for unrestructed public use.

DEC considers using the standards set by the State of Colorado (2 DPM of Pu/gr dry soil) but is unclear about how these standards were calculated and wants to know if the limit is an average limit or a maximum for an individual sample. DEC also questioned the standards relative to climate. Colorado has an arid climate. "Would there be a higher limit for areas of higher precipitation such as in New York State?" (11)(14).

12/30/74 Colorado Health Department responds to DEC inquiries, indicating the arbitrary nature of the standards for Pu in soil (12).

FALL 1974 Residual levels of Plutonium 238 and 239 were detected in the soil immediately adjacent to the Plutonium Facility onsite. Prior to release of the land for unrestructed use DEC recommended to the Nuclear Regulatory Commission (NRC) (formerly USAEC) that further decontamination of areas containing the higher concentrations of plutonium be conducted. (13). Table 17 summarizes 1974 radiation levels for tests conducted by NYS DEC on soil and mud. Other 1974 sample results on air, fish and water can be found in Chapter VII.

1/13/75 NYS Department of Health comments (10) to DEC on Plutonium standards for Soil Contamination:

It would appear that an interim standard of 2 dpm/gm dry soil should be adequately conservative particularly when one considers all the inherent difficulties in establishing a measured value. Questions such as depth of collection, inclusion of vegetation, total area of collection, etc. can cause errors of one or two orders of magnitude. I would suggest that for the sake of conservation the standard should specify 2 dpm/gm dry soil as a maximum value, not as an average vaue

Table 17. N.Y.S. Department of Environmental Conservation 1974 Summary of Radiation Levels in soil and mud at Nuclear Lake, Pawling, NY (13)

Soil and Mud - pCi/kg

Station-Location Dutchess County	Sample	Site	Pu-238	Pu-239,240
Pawling	Soil	#1 3	10±3	290± 38
General Atomic	Soil	#1 5	4 0±3 0	130± 20
Company (UNC)	Soil	#1 8	7 0±5 0	90± 20
Laboratory	Mud	Lake near		
(all samples		Point	6 0±3 0	20±6
taken on	Mud	Dam	< 2	17±6
5/29/74)	Mud	at Route 55	2 7±1 7	13±3

1/23/75 DEC plans to resample an area 20' x 60' located on the east side of the plutonium facility between the facility and the lake. (See Figure VI-3) (15).

The results of the resampling are listed in Table 18.

Table 18 Results of NYSDEC soil resampling from a 20' x60' area east of the Pu Facility (21)

Results (dpm/gms)

Area*	PU-238	PU-239	Wgt. +35 mesh (gms)	Wgt -35 mesh (gms) **
1	1 63	24 0	2384	503
2	08	1 55	2526	593
3	06	1 13	2608	666
4	2	3 4	2438	722
5	04	83	2420	598
6	02	33	47	688

*Samples were taken on the east side of the Plutonium Facility (see Figure VI-3). Each sample consists of three cores approximately 3"x3"x2" deep.

** Only Minus 35 mesh analyzed

2/04/75 DEC report states maximum value of 12.2 dpm/gm Pu 239 in soil sample under blown out window before clean-up. After clean-up Pu 239 concentrations ranged from 0.49 - 2.65 dpm/gm.

3/31/75 NYS Labor Department confirms to DEC its support for 2.0 dpm on Pu/gm dry soil as an "ad hoc standard for the Pawling site".(22)

Results from the January 1975 DEC resampling effort (Table 18) shows that one small 10' X 10' portion, areas 1 & 4 of the site has a level of 24 dpm Pu/gm of dry soil. DEC plans to have this section further decontaminated and resampled. (17).

5/06/75 DEC receives results of further soil analysis, conducted by the Idaho Health Services Laboratory for areas 1, 4 and 4A (see Table 19), (Reference 18 and 19).

Table 19 Results of April 25 1975 soil sampling representing a 500 square foot area on the Nuclear Lake Property

Area*	-35 Mesh Fraction			+35 Mesh Fraction			Weighted Average	
	238 Pu (dpm/gm)	239 Pu (dpm/gm)	Weight (gms)	238 Pu (dpm/gm)	239 Pu (gms)	Weight (dpm/gm)	238 Pu (dpm/gm)	239 Pu (dpm/gm)
1	0.42 ± 0.02	1 ± 0.1	187	0.016 ± 0.002	0.208 ± 0.005	1138	0.073 ± 0.005	1.04 ± 0.02
4	[illegible] ± 0.01	2.66 ± .07	253	0.017 ± 0.002	0.245 ± 0.005	808	0.058 ± 0.004	0.82 ± 0.02
4A	[illegible] ± 0.01	3.52 ± .08	345	0.007 ± 0.001	0.065 ± 0.002	788	0.066 ± 0.004	1.12 ± 0.03

* See Figure VI-4 for sampling location

6/19/75 DEC recommends to NRC that further decontamination of areas 1, 4, 4A by removal of 4-6 inches of soil (550 sq. ft.) be carried out. (20).

DEC - NRC controversy regarding sampling techniques using different portions of mesh screens results. DEC will accept results on soil samples that were sufficiently fine to filter through a - 35 mesh screen. NRC wants to average results of samples from - 35 and +35 portions (20).

DEC also requests that background levels for Pu be established for Pawling site.

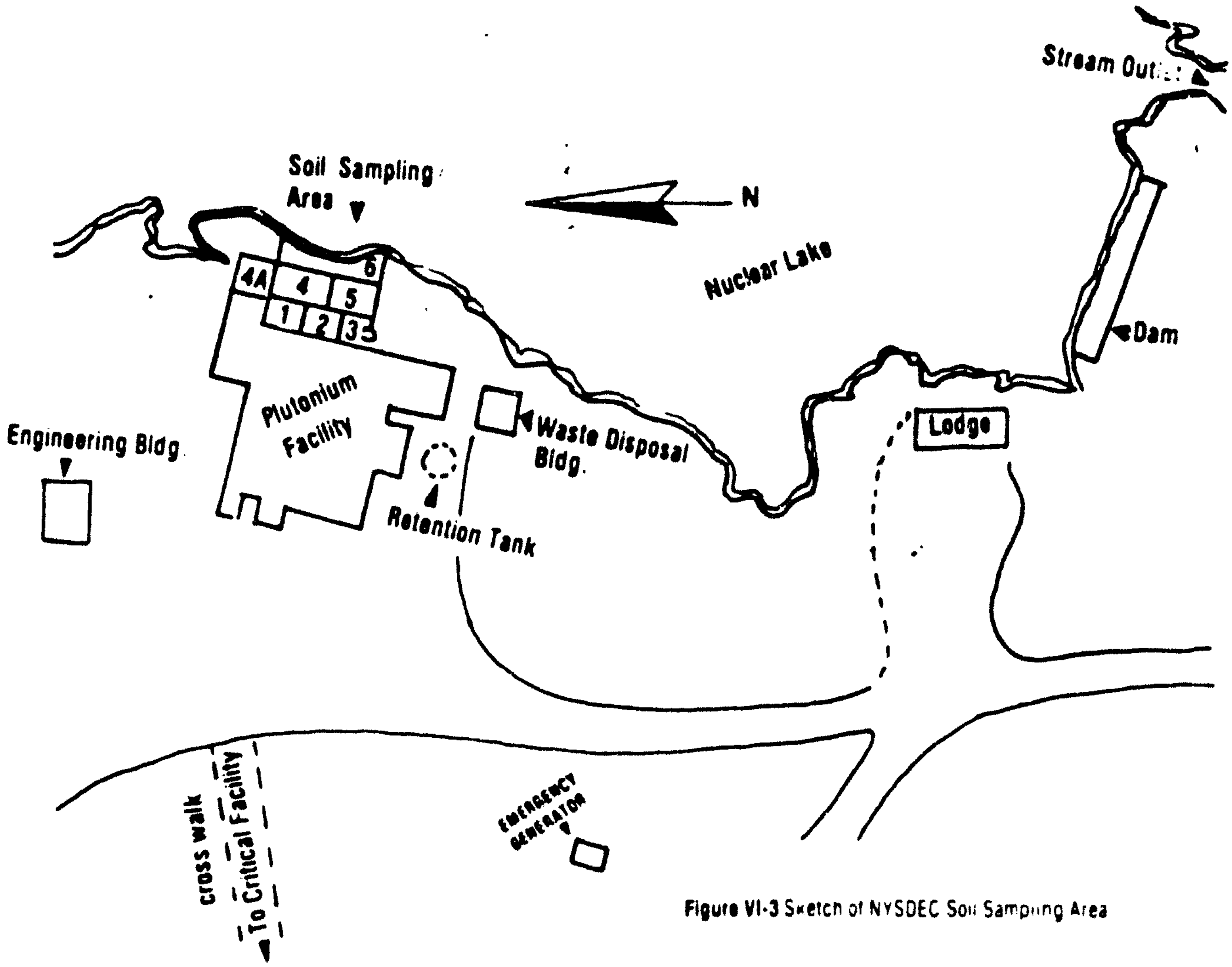


Figure VI-3 Sketch of NYSDEC Soil Sampling Area

7/14/75 NRC states (13) (23):

> The area of contamination has been narrowed down by removing soil over the past year until the last set of samples met the NYS referenced criteria of 2 dpm/gm of samples — and feel the Pawling site represents an insignificant risk to the public and see no reason the licensees' request should not be approved.

The NRC subsequently terminated UNC's licenses, deleted the Pawling site as an authorized place of use for special nuclear materials and released it for unrestricted use.

7/16/75 DEC feels it has no legal or scientific grounds to contest NRC decision. (24).

There is no indication that any further decontamination was carried out.

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1. U.S. Atomic Energy Commissions (AEC) Directorate of Regulatory Operations, Reg. 1, RO Inspection Report No. 70-903; Inspection Dates, 12/21,22,26,27,29/72.

2. USAEC, Directorate of Regulatory Operations, RO Inspection Report No. 70-903/73-01; Docket No. 70-903; Inspection Dates 3/27-30/73.

3. USAEC, Directorate of Regulatory Operations; RO Inspecspection Report No. 70-903/73-02; Docket No. 70-903; Inspection Dates 6/28,29/73.

4. Memo from GUNC (UNC), to Mr. Robert T. Carlson, USAEC, Directorate of Regulatory Operations, Reg. 1; 8/21/73.

5. GUNC (UNC), Report No. RA:LM-73-111 - 10/23/73.

6. USAEC, Directorate of Regulatory Operations, Reg. 1; RO Inspection Report No. 70-903/73-03; Docket No. 70-903; Inspection Dates 10/30,31/73.

7. USAEC, Directorate of Regulatory Operations, Reg. 1; RO Inspection Report Nos. 70-903/74-01; Docket No. 70-903; 50-101-/74-02, Docket No. 50-101; 50-290/74-02, Docket No. 50-290; Inspection Dates 4/9-11, 15-16/74.

8. USAEC, Directorate of Regulatory Operations, Reg 1. RO Inspection Report No. 70-903/74-17; Docket #70-903; Inspection Dates 9/05/74.

9. Memo from State of New York Department of Labor to Dr. Fred Strnisa, NYS Department of Commerce Atomic Energy Council, 9/16/74.

10. Memo from NYS Department of Commerce Atomic Energy Council to Thomas Cashman, Director of Bureau of Radiation, NYS DEC; 11/26/74.

11. Memo from NYS DEC Bureau of Radiation, to Mr. A. J. Hazle, Division of Occupational and Radiological Health, Colorado Department of Health, 12/11/74.

12. Memo from Colorado Department of Health to NYS DEC, Bureau of Radiation; 12/30/74.

13. 1974 Annual Report of Environmental Radiation in NYS; NYS Department of Environmental Conservation; pp 61-63.

14. Memo from NYS Department of Health Division of Laboratories and Research, to Mr. Cashman, NYS DEC Bureau of Radiation; 1/13/75.

15. Inter-office Memo; NYS DEC; from Mr. Kelleher to Mr. Cashman; 1/23/75.

16. Inter-Office Memo; NYS DEC; from Mr. Prins; 1/27/75.

17. Inter-office Memo; NYS DEC; from Mr. Strnisa to Mr. Cashman; 3/31/75.

18. Memo from US NRC Reg. 1 to NYS Atomic Energy Council, NYS Department of Commerce; 5/06/75.

19. Memo from US NRC Reg. 1 to NYS Atomic Energy Council, NYS Department of Commerce; 6/09/75.

20. Inter-office Memo, NYS DEC; from Mr. Cashman to Dr. Strnisa; 6/19/75.

21. Memo from Mr. Richard Cunningham, Acting Director of Materials and Fuel Cycle Facility Licensing, NRC, Washington, D.C.; 7/07/75.

22. Memo from Dr. Bradley, NYS Department of Labor to Tom Cashman, NYS DEC Bureau of Radiation, 3/07/75.

23. Memo from Mr. W. T. Crow, Fuel Cycle Licensing Branch 1, Division of Materials and Fuel Cycle Facility Licensing, NRC to Mr. D. T. Farney, UNC (General Atomic Company), 7/14/75.

24. Memo from Mr. Perrinian to Mr. Cashman, 7/16/75.

25. Report of Incident At Gulf United's Plutonium Facility At Pawling, New York, Gulf United Nuclear Fuels Corporation, Elmsford, New York; 1/19/73.

26. USAEC, Directorate of Regulatory Operations; RO Inspection Report No. 70-903/73-04, Docket No. 70-903; Dates of Inspection 10/30-31/73.

27. Final Survey Results After Decontamination Gulf United Nuclear Fuels Corporation Plutionuim Facility, Pawling, New York, January, 1974; ATCOR, Inc. Park Mall, Peekskill, N.Y.

28. Surface Weather Observations, Poughkeepsie and Newburgh, N.Y. December 21, 1972 - January, 20, 1973. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Asheville, N.C. 28801.

VII Compilation of Data

RADIOACTIVITY LEVELS IN LAKE AND STREAM WATER

Tables 20-24 summarizes all available data for radioactive material in surface lake and stream water on the Nuclear Lake property from 1956 - 1980.

Table 20 - summarizes data taken from NDA (UNC) Chemistry Section Analytical Laboratory Reports (1). Lake water samples were routinely prepared and analyzed by NDA during this time, 1956 - 1957.

Table 20 RADIOACTIVITY LEVELS IN NUCLEAR LAKE WATER — Nuclear Development Corporation of America* — Test results 1956 - 1957 (1)

Sampling Date	Sampling Location**	Results Gross Beta (curies/ml)
11/23/56	Lake Water	7.8×10^{-15}
11/30/56	Lake Water	6.8×10^{-15}
12/06/56	Lake Water	6.8×10^{-15}
12/12/56	Lake Water	0.3×10^{-15}
12/19/56	Lake Water	5.11×10^{-15}
12/27/56	Lake Water	6.80×10^{-15}
1/03/57	Lake Water	7.60×10^{-15}
1/18/57	Lake Water	4.86×10^{-15}
1/23/57	Lake Water	7.78×10^{-15}
1/30/57	Lake Water	9.76×10^{-15}
2/06/57	L-1	5.4×10^{-15}
2/18/57	L-2	4.88×10^{-15}
2/26/57	Lake Water	6.06×10^{-15}
3/13/57	L-1	5.56×10^{-15}

*Nuclear Development Corporation of America later known as United Nuclear Corporation

**See Figure VII-1 Sample Location Map - for location of sampling points

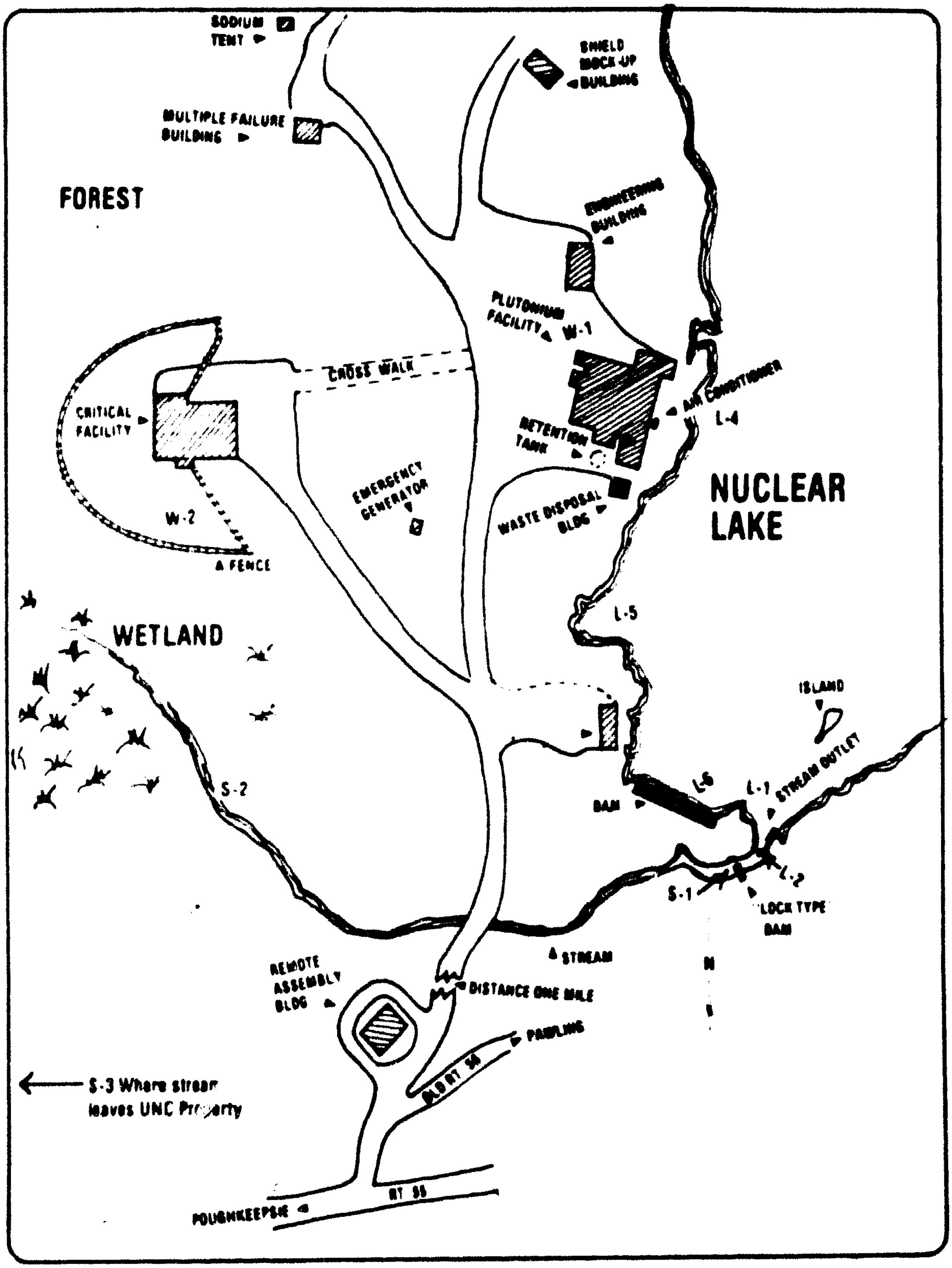


Figure VI-1 Sample Location Map for sampling points from tables 20 - 27

Table 21 - summarizes data taken from N.Y.S. Department of Health, Radiologic Laboratory Determination Reports (2). From 1964 - 1965 Dutchess County Department officials routinely collected lake water samples and had them analyzed for a number of radioactive materials.

TABLE 21 RADIOACTIVITY LEVELS IN NUCLEAR LAKE WATER — NYS Department of Health — Test results Monthly samples 1963 - 1965 (2)

Test Results - (pc/liter unless otherwise noted)***

Date*	Samp Loc **	Gross Beta	Gross Gamma	Cs-137	I-131	ZrNb-95	Ba-140	Mn-54
3 11 63	L 2	0.023	21	< 20	< 20	< 20	< 20	—
4 08 63	L 2	0.032	< 20	< 20	< 20	< 20	< 20	—
5 08 63	L 2	0.019	< 20	< 20	< 20	< 20	< 20	—
6 07 63	L 2	0.009	< 20	< 20	< 20	< 20	< 20	—
7 09 63	L 2	0.054	24	< 20	< 20	22	< 20	—
8 09 63	L 2	0.049	22	< 20	< 20	27	< 20	—
9 05 63	L 2	0.014	< 20	< 20	< 20	< 20	< 20	—
10 07 63	L 2	0.022	< 20	< 20	< 20	< 20	< 20	—
11 08 63	L 2	0.025	< 20	< 20	< 20	< 20	< 20	—
12 09 63	L 2	0.019	< 20	< 20	< 20	< 20	< 20	—
1 06 64	L 2	0.007	< 20	< 20	< 20	< 20	< 20	—
2 10 64	L 2	0.016	59	< 20	< 20	< 20	< 20	—
3 09 64	L 2	0.020	34	< 20	< 20	< 20	< 20	—
4 06 64	L 2	0.006	< 20	< 20	< 20	< 20	< 20	—
5 11 64	L 2	0.012	< 20	< 20	< 20	< 20	< 20	—
6 03 64	L 2	0.008	42	< 20	< 20	< 20	< 20	—
7 14 64	L 2	0.004	41	< 20	< 20	< 20	< 20	—
8 12 64	L 2	0.008	< 20	< 20	< 20	< 20	< 20	—
9 15 64	L 2	0.008	< 20	< 20	< 20	< 20	< 20	—
10 19 64	L 2	0.003	32	< 20	< 20	< 20	< 20	—
11 16 64	L 2	0.005	< 20	< 20	< 20	< 20	< 20	—
12 15 64	L 2	S ****	[illegible]	< 20	< 20	< 20	< 20	< 20
1 14 65	L 2	0.005	42	< 20	< 20	< 20	< 20	< 20
2 15 65	L 2	0.007	33	< 20	< 20	< 20	< 20	< 20
3 10 65	L 2	0.005	< 20	< 20	< 20	< 20	< 20	< 20
4 23 65	L 2	0.007	31 ± 11	0 ± 13	12 ± 16	0 ± 11	0 ± 14	8 ± 11
5 11 65	L 2	0.005	42 ± 11	0 ± 15	13 ± 19	0 ± 14	0 ± 21	3 ± 13
6 16 65	L 2	0.006	0 ± 10	0 ± 15	2 ± 20	0 ± 15	0 ± 21	0 ± 13
7 12 65	L 2	0.005	0 ± 8	0 ± 14	0 ± 15	3 ± 14	0 ± 38	0 ± 10
8 16 65	L 2	0.005	7 ± 8	4 ± 15	3 ± 16	0 ± 13	18 ± 39	0 ± 11

9/65 - 12/66 — No test results located in Health Department Records

1/67 - 12/69 For test results see Table 22

*Refers to date sample was collected — in all cases sample was a surface water grab

In all cases sample was taken at outlet of Nuclear Lake. **See Figure VII—1 Sample Location Map - for location of sampling points

***Gross Beta results reported in pc/ml — in all cases sample volume was 500 ml or less. All other results reported in pc/liter — in all cases sample volume was approximately 2 liters

****S — Insufficient Sample

Note: No test results for lake water between January 1965 and December 1966 were available.

Table 22 - summarizes data taken from N.Y.S. Department of Health memoranda (3) (18) and Radiologic Laboratory Determination Reports (4). From January 1967 - December 1969 Dutchess County Department of Health officials routinely collected lake water samples and had them analyzed for Gross Beta Activity.

TABLE 22 RADIOACTIVITY LEVELS IN NUCLEAR LAKE WATER — NYS Dept. of Health Test Results 1967 - 1969 (3) (4) (18)

Sampling Date	Sampling Location*	Results Gross Beta (pCi/L)**
1/10/67	Lake Water	4
3/17/67	Lake Water	5
4/17/67	Lake Water	4
6/14/67	Lake Water	4
9/12/67	Lake Water	3
9/16/67	Lake Water	2
11/15/67	Lake Water	3
12/19/67	Lake Water	2
1/15/68	Lake Water	7
2/01/68	Lake Water	32
3/19/68	Lake Water	88
4/10/68	Lake Water	4
5/07/68	Lake Water	3
7/16/68	Lake Water	4
8/05/68	L3	4
8/20/68	L6	2
9/16/68	Lake Water	3
10/14/68	Lake Water	3
11/13/68	Lake Water	3
12/09/68	Lake Water	3

*See Figure VII-1 Sample Location Map for location of Sampling points

**Margin of error = ±1.50 pCi/l

March 6, 1968 - a Department of Health Analysis (3) for the February 1, 1968 test results indicated:

> that the level of gross beta activity is approximately ten times higher than the average value found throughout 1967. This may have resulted from fallout from the Chinese test on Christmas Day; however, I would like to verify this fact by taking another sample from the same spot for radiological analysis.

April 25, 1968 - a Department of Health Analysis (18) of the February 1, and March 19, 1968 test results noted:

> that there has been a rather dramatic rise in the gross beta concentrations in the pond at United Nuclear. I understand from Mr. Czerwinskyj that you have already looked into the matter and that the company maintains that they have not released any beta activity. I suggest that once we have the result for the sample taken in the middle of April and if it is high compared to 4 or 5 pCi/l we undertake an investigation to determine where the activity originates and what radionuclides are involved. For the time being, however, I suggest that we wait.

Table 23 - lists the N.Y.S. Department of Environmental Conservations (N.Y.S. DEC) summary of radioactivity levels in Nuclear Lake water from 1970 - 1975. More detailed information on sampling procedures and results can be found in the N.Y.S. DEC Annual Report of Environmental Radiation in New York State (5a - 5g) for each year represented in the table.

The N.Y.S. DEC 1974 Annual Report (5c) noted:

> Although operations at the General Atomic Company (UNC) Pawling, New York site ceased in 1973, the Department of Environmental Conservation continued to monitor the air and water. Soil and fish samples were also collected in 1974 after the plant shutdown. No contribution from past plant operations could be found in the air, water or fish.

Table 24a - summarizes the test results from stream water sampled on UNC property. Results for 1957 samples were taken from NDA (UNC) Chemistry Section Analytical Laboratory Reports (6). Results for 1959 - 1975 samples are from N.Y.S. Department of Health Radiologic Laboratory Determination Reports (7).

Table 24b - summarizes the test results from stream water sampled off UNC property, all results are from N.Y.S. Department of Health Radiologic Laboratory Determination Reports (7).

Table 23 RADIOACTIVITY LEVELS IN NUCLEAR LAKE WATER — N.Y.S. Department of Environmental Conservation — Yearly Summary 1970 - 1975 (5)

Sampling Year	No. of Samples		Gross Beta (Results in pCi/L)	H-3 (Results in pCi/L)	Gross Alpha (Results in pCi/L)	Sampling Location **
1970	16	Avg	3			Lake Water
		Max	7			
		Min	2			
1971	12	Avg	4			Lake Water
		Max	11			
		Min	2			
	2	Avg		N.D.*		
		Max		N.D.		
		Min		N.D.		
1972	9	Avg	3			Lake Water
		Max	5			
		Min	2			
	8	Avg			N.D.	
		Max			N.D.	
		Min			N.D.	
1973	11	Avg	3			Lake Water
		Max	6 ± 2			
		Min	N.D.			
	7	Avg			N.D.	
		Max			N.D.	
		Min			N.D.	
1974	6	Avg	< 4			Lake Water
		Max	6 ± 3			
		Min	< 3			
	6	Avg			< 1	
		Max			< 1 1	
		Min			< 0.7	
1975	5	Avg	< 4			Lake Water
		Max	7 ± 2			
		Min	< 3			
	5	Avg			< 1	
		Max			< 1	
		Min			< 1	

*N.D. — None Detected

**See Figure VII-1 Sample Location Map for location of sampling points

Table 24 a — RADIOACTIVITY LEVELS IN STREAM WATER — on the Nuclear Lake Property — Test Results 1957 - 1975 (6, 7)

Sampling Date	Test Facility	Sampling Location *	Sample Type **	Gross Beta
3/25/57	NDA (UNC)	Stream	— —	20.2×10^{-15} curies/ml
3/25/57	NDA (UNC)	S-3	3 day composite	3.75×10^{-15}
4/08/57	NDA (UNC)	Stream	5 day composite	38.8×10^{-15}
4/17/57	NDA	Stream	3 day composite	6.47×10^{-15}
4/22/57	NDA	S-3	2 day composite	3.58×10^{-15}
4/24/57	NDA	S-3	2 day composite	4.81×10^{-15}
5/01/57	NDA	Stream	2 day composite	3.94×10^{-15}
5/03/57	NDA	S-3	4 day composite	1.98×10^{-15}
5/14/57	NDA	S-3	4 day composite	3.85×10^{-15}
5/21/57	NDA	S-3	2 day composite	4.20×10^{-15}
6/14/57	NDA	S-3	— —	4.61×10^{-15}
7/08/57	NDA	S-2	— —	3.99×10^{-15}
7/18/57	NDA	S-2	— —	3.94×10^{-15}
7/25/57	NDA	S-2	— —	6.93×10^{-15}
8/22/57	NDA	S-2	— —	8.47×10^{-15}
1/19/59	N.Y.S. Dept. of Health	S-1	Surface Grab	$1.2 \pm 0.2 \times 10^{-8}$ uc/ml
[illegible]/16/61	N.Y.S. Dept. of Health	S-[illegible]	Surface Grab	0.009 uuc/ml
8/13/69	N.Y.S. Dept. of Health	S-3	Surface Grab	4 ± 1 pC/l
9/09/69	N.Y.S. Dept. of Health	S-3	Surface Grab	4 ± 1 pC/l
12/15/69	N.Y.S. Dept. of Health	S-3	Surface Grab	2 ± 1 pC/l
[illegible]	N.Y.S. Dept. of Health	S-3	Surface Grab	2 ± 1 pC
4/22/75	N.Y.S. Dept. of Health	S-3	Surface Grab	4 ± 2 pC/l

*See Figure VII - 1 Sample Location Map for location of sampling points

** Test results are recorded into the same units reported in the data sources

Table 24b - RADIOACTIVITY LEVELS IN STREAM WATER — off the Nuclear Lake Property Test Results 1959 - 1961 (7)

Sampling Date	Test Facility	Sampling Location *	Sample Type	Gross Beta
[illegible]	N.Y.S. Dept. of Health	Whaley Lake Stream at Rt. 216	Surface Grab	$3.[illegible] \pm 1.6 \times 10^{-9}$ uc/ml
	N.Y.S. Dept. of Health	Whaley Lake Stream	Surface Grab	$9.9 \pm [illegible] \times 10^{-9}$ uc/ml
[illegible]/16/61	N.Y.S. Dept. of Health	Whaley Lake Stream at Rt. 216	Surface Grab	0.003 uuc/ml
	N.Y.S. Dept. of Health	Whaley Lake Stream	Surface Grab	0.002 uuc/ml

*See Chapter II Figure II - 1 for sampling location

CHEMICAL, PHYSICAL AND BIOLOGICAL DATA FOR LAKE AND WELL WATER

Tables 25 and 26 summarize all available data for chemical, physical and biological parameters of lake and well water from the UNC property.

Table 25 - summarizes chemical and physical test data for lake water. During 1956 - 1957 data was gathered by the N.Y.S. DEC Bureau of Fish and Wildlife (8). In January 1980, Camo Pollution Control, Inc. (at the request of the Dutchess County Department of Health) conducted a series of tests on the chemical constiuents of the lake water.

Feburary 14, 1980 - an analysis (9) of the January 1, 1980 test by Camo Pollution Control Inc. indicated:

"In our estimation that area of the State is classified as Class D surface water. In comparison to the discharge standards to SA groundwaters the three (3) Nuclear Lake samples appear to be within compliance except for iron (L-5, L-1) and pH (L-5, L-1). Not knowing the origin of the three (3) samples (i.e. discharges to the lake or actual lake samples) this comparison is for reference purposes only. The samples do not appear to be those from a hazardous source for the parameters investigated; of course no organic constituents were requested for analysis."

TABLE 25 CHEMICAL AND PHYSICAL DATA FOR NUCLEAR LAKE WATER — (8-9)

Test Date	Test Fac	Samp Loc **	Depth	Water Temp	O 2	pH (in units)	Zinc	Na	Pb	Hg (in ppb)	Chrome + 6	Chrome	Iron	Grease Oil	Toc	Cl	Cd	Spec Cond (in micromhos /cm)
8/08/56	DEC	Lake	1	79°F	4.0	— —												
			10	71°F	0.5	— —												
1/24/57	DEC	L 4	1	32°F	— —	— —												
			5	34°F	10.4	6.0												
2/08/57	DEC	L 4	1	32°F	— —	— —												
			5	39°F	— —	— —												
			10	39°F	— —	— —												
			14	40°F	9.8	— —												
1/18/80	Camo Pollution Control Inc	L 5	1m		— —	5.7	0.11	3.1	0.05	1.3	< 0.03	< 0.03	9.01	< 0.7	58	42	< 0.01	66
		L 1	1m		— —	5.5	0.22	4.5	0.07	3.3	< 0.03	< 0.03	20.8	10.0	55	50	< 0.01	69
		L 6	1m		— —	6.0	0.06	3.5	0.02	< 1.0	< 0.03	< 0.03	0.50	3.2	23	42	< 0.01	65

*All results are expressed in mg/L unless noted otherwise

**All sampling locations are plotted on FIGURE VII 1 SAMPLE LOCATION MAP

Table 26 - summarizes the chemical, physical and biological data on the Plútonium Facility and Critical Facility well water. Most tests were conducted by NDA (UNC) Chemistry Section (10) (13) and the N.Y.S. Department of Health (11) (12).

TABLE 26 WELL WATER (CHEMICAL PHYSICAL, BIOLOGICAL) DATA, for wells on the Nuclear Lake Property 1956 - 1959 (10-14)

Sampling or Testing Date	Testing Facility	Sampling Location *	Parameters and Results		
9/13/56	NYS Dept of Health	(W-1) Pu Lab Well	Well depth		175 ft
			Dist. from septic tank		125 ft
			Dist. from leach field		90 ft
		(W-2) Critical Facility CF Well	Well depth		167 ft
			Dist. from septic tank		70 ft
			Dist. from leach field		85 ft
11/02/56	UNC NDA Chemistry section	W-1 Pu Lab	Sample 1	pH	6.75
				non-volatiles	129 ppm
				non-volatiles on ignition	54 ppm
11/12/56	UNC NDA Chemistry section	(W-1) Pu Lab	Sample 2	pH	7.0 units
				non-volatiles	66 ppm
				non-volatiles	52 ppm
11/28/56	UNC NDA Chemistry section	W-2 CF	Sample 1	pH	7.35 units
				non-volatiles	132 ppm
				non-volatiles on ignition	54 ppm
			Sample 2	non-volatiles	111 ppm
				non-volatiles on ignition	92 ppm
11/19/56	UNC NDA Chemistry section	W-1 Pu Lab	Sample 1	Total Hardness	4.3 ppm Ca Co3 or 2.15 grains/gal
			Sample 2	Total Hardness	4.2 ppm Ca CO3 or 2.10 grains/gal
		W-2 CF	Sample 1	Total Hardness	[illegible].1 ppm Ca CO3 or 3.55 grains/gal
			Sample 2	Total Hardness	7.1 ppm Ca CO3 or 3.55 grains/gal
11/20/56	NYS Dept. of Health	W-2 CF Fountain	Agar Plate Count		> 5000 per ml
			MPN Co		< 2.2 per 100 ml
1/02/57	UNC (NDA) chemistry section	(W-1) Pu Lab	Sample 1	pH	6.97
				Total Hardness	2.50 grains Ca CO3/gal
				non-volatiles	26 ppm
			Sample 2	Total Hardness	2.59 grains Ca CO3/gal
				non-volatiles	18.4 ppm
1/07/57	UNC (NDA) chemistry section	(W-1) Pu Lab	Sample A	Major Constituents in decreasing amts	Mg Ca Si
				Minor Constituents in decreasing amts	Cu Zm Mm Fe Al (trace) Cr none Ni none
		(W-1) Pu Lab	Sample B	Major constituents in decreasing amts	Mg Ca Fe Si Ni
				Minor Constituents in decreasing amts	Cu Zm Mm Al Cr (trace)
			Sample B	in all cases had more of each element present	

Table 26 Well Water continued on next page

Table 26 Well Water Continued

Sampling or Testing Date	Testing Facility	Sampling Location*	Parameters and Results	
7/24/62	Dur Co Dept of Health	W 1 Pu Lab Tap in Pump Room Deep Sink	Agar Plate Count	58 per ml
			MPN of Coliform group	< 2 2 per 100 ml
			Turbidity	7 units
			Color	20 units
			Chlorides	2 ppm
			Nitrates	0 ppm
			Manganese	0 05 ppm
			pH	6 5 units
			Alkalinity	67 ppm
			Hardness	68 ppm
			Copper	< 0 05 ppm
			Odor	0 units
			Taste	0 units
			Carbon Dioxide	44 ppm
			Iron	0 6 ppm
			Conductance	140 micromhos/cm
			Fluorides	< 0 05 ppm
			Ammonia Free	0 01 ppm
			Nitrites	0 001 ppm
5/01/67	Dur Co Dept of Health	W 1 Pu Lab	Agar Plate Count	18 per ml
			MPN of Coliform Group	< 2 2 per 100 ml
		W 2 CF	Agar Plate Count	120 per ml
			MPN of Coliform Group	< 2 2 per 100 ml
		(W 1) Eng Facility EF	Agar Plate Count	0 per ml
			MPN of Coliform Group	< 2 2 per 100 ml
9/29/69	Dur Co Dept of Health	(W 1) Pu Lab Bathroom sink	Agar Plate Count	12 per ml
			MPN of Coliform Group	< 2 2 per 100 ml
10/10/69	UNC Assoc Analytical Lab	(W 1) Pu Lab	Identification of Residue From Well	Iron oxide Lg amts
				Iron sulfides Lg amts
				Acid-unsoluable siliceous matter lesser amts

*All sample locations are plotted on the sample location map (Figure VII- 1)

A Department of Health analysis (12) of the bacteriological content (Agar Plate Count - MPN Col.) in well water samples taken on 11/20/56, 7/24/62, 5/01/67 and 9/29/69 noted that.

"The bacteriologic examination of the sample of water shows the absence of bacteria of the coliform group and therefore the absence of pollution of animal of human origin and therefore of satisfactory sanitary quality when sample was collected."

RADIOACTIVITY LEVELS IN VEGETATION, FISH AND WILDLIFE

Table 27 - summarizes radioactive test results from 1956 - 1979 on a variety of organisms collected on the UNC property. Results from 1956 - 1957 are from NDA (UNC) Chemistry Section Alalytical Laboratory Reports (15). Results from 1970 - 1979 are from N.Y.S. DEC Annual Reports of Environmental Radiation in N.Y.S. (16) and a special N.Y.S. DEC Nuclear Lake Fish Sampling Report (17).

TABLE 27 RADIOACTIVITY LEVELS IN VEGETATION, FISH AND WILDLIFE FROM NUCLEAR LAKE PROPERTY — Test Results 1956 - 1979 (15. - 17)

Type of Organism	Sampling Date	Sampling Loc. *	Test Facility	Gross Beta (d/m/gm of Body wgt.)	Gross Beta (d/m/gm of ashed material)	Sr-90 (d/m/gm of ashed material)	Other (pCi/kg)
Vegetation	2/24/56	CF and Pu Lab Area	UNC (NDA)	— —	690	— —	
Land Vegetation	10/25/56	360° Around Building	UNC (NDA)	— —	806	— —	
Aquatic Plants	10/26/56	Lake	UNC (NDA)	— —	557	— —	
1 Catfish	1/21/57	Lake	UNC (NDA)	— —	110		
1 Fish	2/26/57	Lake	UNC (NDA)	21	601	— —	
1 Fish	2/26/57	Lake	UNC (NDA)	— —	— —	100	
Reeds	3/21/57	Cove Area(L 5)	UNC (NDA)	— —	7509	— —	
3 Perch 1	3/22/57	Lake	UNC (NDA)	5	102	— —	
2				5	86	— —	
3				4	78	— —	
1 Perch	4/11/57	Lake	UNC (NDA)	64	148	Conc	
Land vegetation		?	UNC (NDA)	— —	429	— —	
3 Samples 1	4/23/57	?	UNC (NDA)	— —	429	— —	
2	2/24/56			— —	393	— —	
3				— —	546	— —	
Salamanders	4/23/57	?	UNC (NDA)	3	58	— —	
Reeds	4/30/57	Cove Area(L 5)	UNC (NDA)	— —	139	— —	
2 Baby Catfish 1	5/01/57	Lake	UNC (NDA)	7	135	— —	
2				3	55		
Catfish	5/18/57	Lake	UNC (NDA)	4	118	— —	
3 Catfish	7/24/57	Lake	UNC (NDA)	4	69	— —	
Bass	6/14/70	Lake	NYS DEC	— —	— —	— —	Cs 137 791 Co-60 N.D. Ru-106 N.D. Cs 134 N.D. Sr 90 177
Flesh-Bass Bluegill Pickerel	5/29/74	Lake	NYS DEC	— —	— —	— —	Pu 238 < 0.03 Pu 239 240 < 0.02
Bone - Bass Bluegill Pickerel	5/29/74	Lake	NYS DEC	— —	— —	— —	Pu 238 0.6
Bullheads	12/13/79	Lake	NYS DEC	— —	— —	— —	Cs 134 < 10 Cs 137 390 Ru 106 50 K 40 2800 Pu 238 < 4 Pu 239 240 < 0.18

*See Figure VII-1 Sample Location Map - for location of sampling points

A N.Y.S. DEC analysis (5a) of the 6/14/70 test result on bass noted:

> "A bass was collected from the pond on the United Nuclear property and analyzed for gamma emitters and strontium-90. The pond receives a small discharge from United Nuclear but mainly receives run-off from precipitation and would be expected to have strontium-90 and cesium-137 from weapons testing fallout. The fish indicates slightly higher results for cesium-137 than some of the larger lakes.

Another N.Y.S. DEC analysis (5c) of 5/29/74 test data indicated that:

> "Although operations at the General Atomic Company Pawling, New York site ceased in 1973, the Department of Environmental Conservation continued to monitor the air and water. Soil and fish samples were also collected in 1974 after the plant shutdown. No contribution from past plant operations could be found in the air, water or fish."

A third N.Y.S. DEC analysis (17) for samples collected on 12/13/79 reported that:

> The report indicates that plutonium-238, plutonium-239, 240, cesium-134 and ruthenium-106 were not detected in the sample tested. The 390 picocuries/kg of cesium-137 is considered to be normal for a lake supplied principally by surface drainage and having very little silt loading. Potassium-40 is a naturally occurring isotope and the value reported is normal. The lab has indicated that there were problems with the perch samples and the tests are being re-run. The results will be available at a later date."

<u>RADIOACTIVITY LEVELS IN AIR</u>

From 1956 - 1969 routine analysis of air samples and fallout activity of the UNC facility were conducted by the UNC personnel. During the late 1950's and early 1960's records (19) show that UNC performed daily background counts on air samples and analyzed fallout papers every 24 to 48 hours. In later years fallout samples from several locations on the UNC property were analyzed on a weekly and monthly basis. The test results for these years of analysis are too extensive to include in this study but are readily available.

<u>Table 28</u> - summarizes data taken from N.Y.S. DEC, Annual <u>Reports</u> of Environmental Radiation in New York State (5a - 5g) from 1970 - 1976.

Table 28 — Radioactivity Levels in Air Samples From Nuclear Lake Property — Test Results 1970-1974
1970 - 1974 (5a - 5e)

Sampling Date	No. of Samples		Results (in pCi/m3) Gross Beta	Pu-238	Pu-239, 240
1970	36	Avg	0.21		
		Max	0.51		
		Min	0.06		
1971	49	Avg	0.27		
		Max	0.79		
		Min	0.03		
1972	44	Avg	0.09		
		Max	0.30		
		Min	0.02		
1973					
2/23–3/02				1.6×10^{-4}	$<8 \times 10^{-5}$
3/23–3/30				1.1×10^{-4}	1.9×10^{-3}
4/20–5/18				$4 \pm 2 \times 10^{-5}$	1.3×10^{-4}
5/18–6/18				$<9 \times 10^{-6}$	$<7 \times 10^{-6}$
6/18–7/13				$<4 \times 10^{-5}$	$<9 \times 10^{-6}$
7/13–8/03				1.1×10^{-4}	$9 \pm 4 \times 10^{-5}$
9/07–10/12				$<5 \times 10^{-5}$	$<6 \times 10^{-5}$
10/12–11/09				$<2 \times 10^{-5}$	1.0×10^{-4}
11/09–11/30				$<2 \times 10^{-5}$	$<1 \times 10^{-5}$
11/30–1/04				$<1 \times 10^{-5}$	$<2 \times 10^{-5}$
1974	10	Avg	0.05		
		Max	0.10		
		Min	0.03		
1/04/74–2/01/74				$<2 \times 10^{-5}$	$<4 \times 10^{-5}$
2/01/74–3/22/74				$<6 \times 10^{-6}$	1.5×10^{-5}

A N.Y.S. DEC analysis of their 1973 test data indicates:

"The results indicate plutonium in the on-site air samples that may be due to operations at the site. The yearly average concentration of plutonium, including that from weapons testing, was 0.2% of the allowable USAEC limit.

The small air flow rate used for the air particulate sampler, approximately one cubic foot per minute, does not provide the necessary sensitivity to clearly distinguish between plutonium in weapons testing fallout and low levels of plutonium originating on-site. The installation of a high volume sampler to provide the improved sensitivity was being considered but was not installed as the plant operation was discontinued in 1973.

Decommissioning of the site was started in October 1973. Buildings and grounds have been decontaminated. The State is evaluating levels of plutonium in soil samples before releasing the site for general use."

Additional data relating to air sampling can be found in Chapter V, page 89 and Chapter VI, pages 98 and 102.

RADIOACTIVITY LEVELS IN SOIL AND MUD

All available data on radioactivity levels in soil and mud samples collected on the Nuclear Lake property can be found in the text of Chapter VI and Tables 14, 15, 16, 17, 18, and 19.

A N.Y.S. DEC analysis (5c) of the data in Table 17 indicated:

> "Residual levels of plutonium-238 and plutonium-239 were detected in the soil immediately adjacent to the plutonium facility onsite. Prior to release of the land for unrestricted use, the Department recommended to the Nuclear Regulatory Commission the decontamination of areas containing the higher concentrations of plutonium. Decontamination was carried out by the General Atomic Company and the land was released for unrestricted use by the Nucelar Regulatory Commission on July 14, 1975

REFERENCES

1. NDA - Nuclear Development Corporation of America, Chemistry Section, Analytical Reports; nine separate reports. Source; NDA Log Book.

2. NYS Dept. of Health, Radiologic Laboratory Determination Reports; thirty-five separate reports; dated from 1963 - 1965. Source: Dutchess County Dept. of Health.

3. NYS Dept. of Health memo; March 6, 1968.

4. NYS Dept. of Health Radiologic Laboratory Determination Reports; ten separate reports; dated from January 1968 - December 1968.

5. Annual Report of Environmental Radiation in New York State; NYS Dept. of Environmental Conservation:

5a - 1970	Annual Report;	56 pp.	06/18/71
5b - 1971	Annual Report;	45 pp.	07/07/72
5c - 1972	Annual Report;	50 pp.	RAD-P3 (04/74)
5d - 1973	Annual Report;	64 pp.	RAD-P3 (8c-09/74)
5e - 1974	Annual Report;	67 pp.	RAD-P3 (800-03/76)
5f - 1975	Annual Report;	66 pp.	RAD-P3 (600-07/77)
5g - 1976	Annual Report;	60 pp.	RAD-P3 (06/79)

6. NDA - Nuclear Development Corporation of America, Chemistry Section, Analytical Laboratory Reports; fifteen separate reports dated from 03/05/57 - 08/22/57. Source: NDA Log Book.

7 NYS Dept. of Health Radiologic Laboratory Determination Reports; seven separate reports; dated from 01/19/59 - 04/22/75. Source: Dutchess County Dept. of Health.

8. NYS Dept. of Environmental Conservation Fish Stocking Report; Bureau of Fish and Wildlife; 10/31/56.

9. Analysis of Nuclear Lake Samples - Camo Pollution Control Inc., Hyde Park, N.Y. 02/14/80.

10. NYS Dept. of Health Water Supply Information Reports; 09/13/56 and 11/20/56. Source: Dutchess County Dept. of Health.

11. Dutchess County Dept. of Health; Bacteriological Examination of Water Reports; six separate reports; dated from 07/24/62 - 09/29/69.

12. Analysis of Water Supply for United Nuclear Corporation - Dutchess County; City of Kingston Laboratory, Kingston, N.Y.; 07/30/62.

13. NDA - Weekly Report for the General Chemistry Group; 10/05/56.

14. NDA - Nuclear Development Corporation of America, Chemistry Section, Analytical Laboratory Reports; four separate reports; dated Jaunuary 1957. Source: NDA Log Book.

15. NDA - Nuclear Development Corporation of America, Chemistry Section, Analytical Laboratory Reports; sixteen separate reports; dated 02/24/56 - 07/24/57. Source: NDA Log Book.

16. Same as Reference 5a and 5c.

17. NYS Dept. of Health memo and Radiologic Laboratory Determination Report: 04/21/80.

18. NYS Dept. of Health memo; 04/25/68.

VIII. The Aerial Radiologic Survey

EG&G
Energy Measurements Group

Summary Report
The Aerial Radiologic Survey
Of
The United Nuclear Facility
At
Nuclear Lake Near Pawling, New York
Date of Survey: May 1980

Approved For Publication

J. Robert Mueller, EG&G, Inc.

Herbert F. Hahn, Department of Energy

Performed by EG&G, Inc. Under
Contract No De-AM-80-76Nv01183
with the United States Department of Energy

WAMD - 011
September 5, 1980

METHOD

The aerial Measurements System operated by EG&G, Inc., for the United States Department of Energy, was used to conduct an Aerial Radiologic Survey over the decommissioned United Nuclear Corporation facility near Pawling, New York, in May 1980. The purpose of this survey was to establish if any fixed gamma photon emitting material(s) was present at this site and if so, to affect precise location and quantification of such material(s).

To this end, a Boeing 105 helicopter, fitted with gamma radiation detection equipment, was flown in routinely employed, standard operative manner (in re height, speed, navigational parameters, etc.) over the area shown in Figure VIII-I.

For this particular survey, two distinct operative modes of gamma detection were employed; Mode 1 (M_1 -- high energy (50 KEV-3000 KEV) and Mode 11 (M_{11}) -- low energy (12 KEV-300-KEV). M_1 represents that region of energy where most man-made gamma emitting radionuclides would normally be detected. M_{11} represents that energy region where gamma radiation indicative of most transuranic activity would be detected. Since Plutonium activity was the major activity of interest, and indirect method of detection was necessary. Plutonium is primarily an alpha (a) emitter; thus direct detection and quantification with the airborne system used was not feasible. Therefore, the M_{11} mode was utilized in an effort to detect ^{241}Americium, a gamma photon emitting daughter product of the Plutonium activity. Furthermore, an effort was made to enhance the detectability of low energy gamma emitting radioactivity by having the helicopter hover over the formerly used laboratory buildings near the lake. This was done to increase the counting time over the locations most likely to be the site of a possible radioactive source, thus increasing the probability of detection. In analyzing the gamma radiation activity data thus obtained, normal environmental (natural background) gamma radiation was subtracted rendering an accurate assay of any fixed gamma radioactivity.

ANALYSIS

Subsequent analysis of collected data clearly indicate that no man-made gamma photon activity (M_1) above normal environmental background levels was detected. Additionally, the airborne system employed detected no evidence of transuranic activity (M_{11}).

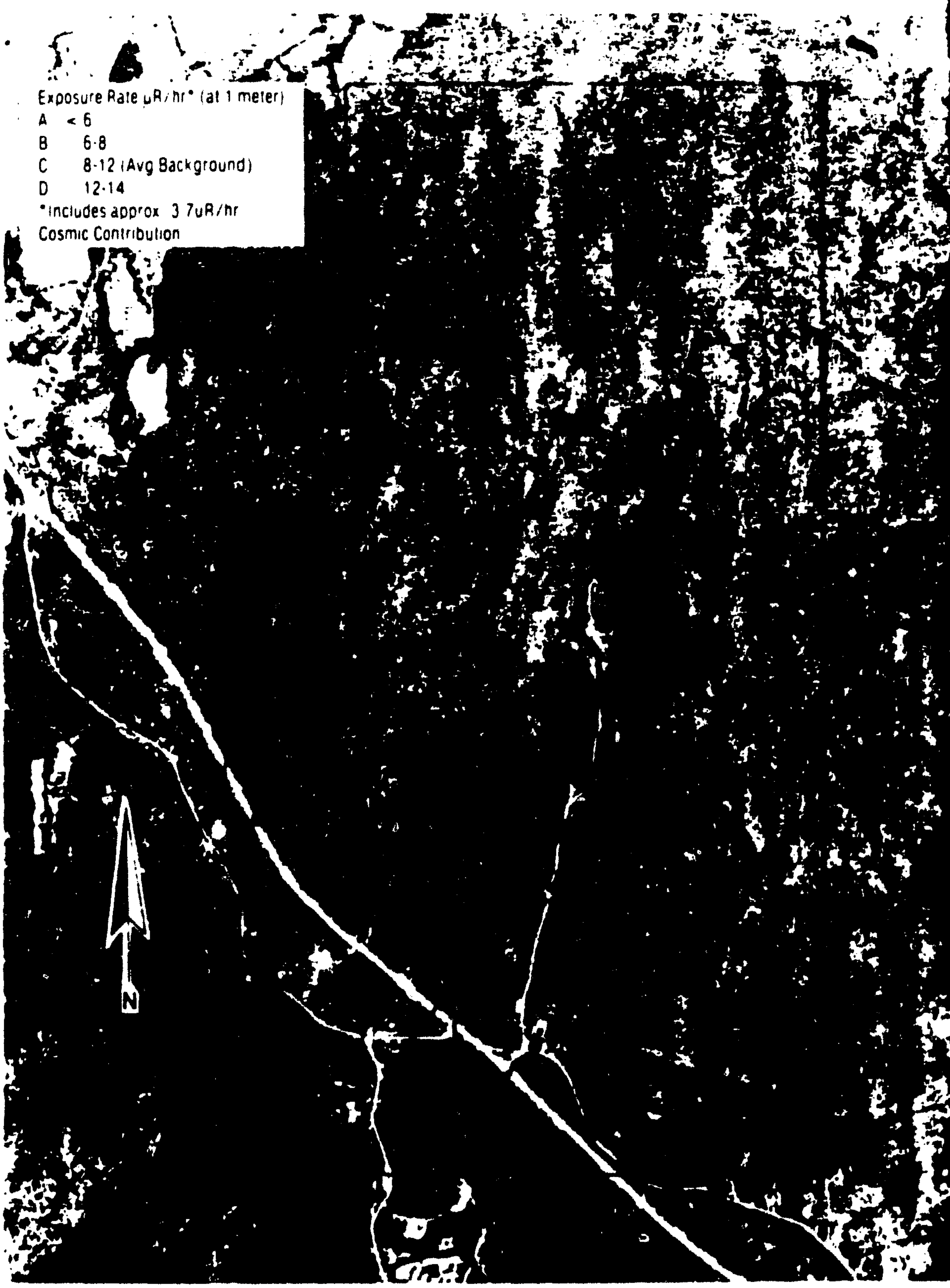


Figure VIII-1. Aerial Radiologic Survey Area

IN ADDENDUM:

Gamma radiation exposure levels* within the survey area vary from approximately 6 μR/hour (A level) over submerged regions to a maximum of 14 μR/hour (D level) over other areas. These variations are reasonable and compatible with the geology of the survey area. Terrestrial gamma radiation emanating from the lake bottom has been absorbed or attenuated by the lake water (A level) while higher activity (D level) is characteristic of the outcroppings of strata that occur in the area.

The average (C level) exposure rate range measured for the overall survey areas is 8 - 12 μR/hour. These levels are in reasonable agreement for the State average of 12 μR/hour.

(*) All exposure rates are normalized for one (1) meter above ground level.

nes
NUCLEAR
ENERGY
SERVICES, INC.

July 21, 1983
Reference No. WER-047

Mr. John A. Guerin
Chairman
Nuclear Lake Management Committee
Birch Drive
Pleasant Valley, NY 12569

Subject: Nuclear Lake Survey
NES Proposal No. 8380-106

Dear Mr. Guerin:

Nuclear Energy Services, Inc. (NES) is pleased to submit its proposal to conduct a radiological survey of your Nuclear Lake property in Pawling, New York.

This radiological survey is to be only a screening process to address areas we discussed on July 11, 1983. If contamination is found, further analyses, surveys, and cleanup are beyond the scope and cost of this proposed study.

NES proposes to perform the following tasks:

1. Radiological instrument survey of the site buildings to detect fixed radioactive contamination (beta and gamma).

2. Smear surveys of the site buildings to detect loose radioactive contamination (beta, gamma, and alpha). Approximately fifty smears will be taken and analyzed.

3. Radiological instrument survey of the areas immediately adjacent to the site buildings; and those portions of the Appalachian Trail that traverse the Nuclear Lake property.

A1128

SHELTER ROCK ROAD, DANBURY, CT 06810 (203) 796-5000
WRITER'S DIRECT DIALING NO. (203) 796-5395

Mr. John A. Guerin
Reference No. WER-047
page 2

4. Collection of environmental samples for radiochemical analysis as follows:

a. Six soil and six vegetation samples along that portion of the Appalachian Trail that passes through the Nuclear Lake Property;

b. Seven soil samples in the grid layout behind the Plutonium Facility (one sample from each grid);

c. Two sediment, two water and two aquatic vegetation samples (if available) each from the plant outfall, stream outlet, and north end (background) areas of Nuclear Lake. Based on previous study results, fish samples are not necessary;

d. One water sample from the Retention Tank south of the Plutonium Facility.

5. Review the results of previously performed studies as supplied by the Nuclear Lake Management Committee.

6. Submittal of a final report that will contain the survey and laboratory results and the conclusions that can be drawn from this survey and from previous studies.

All environmental samples will be sent to an appropriate radiochemical laboratory for gamma scans, gross beta and gross alpha analyses.

NES proposes to perform these efforts for a firm fixed price of $12,285 which includes all labor, laboratory fees, travel and office expenses, and report preparation costs associated with this scope of work.

The problem areas you wish addressed by this study are identical to the ones I encountered and resolved in 1981 when I was manager of a partially decommissioned nuclear power reactor. My resume is enclosed for your information and review. I will be the Project Manager for this effort.

NUCLEAR LAKE

The New York Times
Metropolitan Report

B2 THE NEW YORK TIMES, MONDAY, MARCH 24, 1986

Appalachian Trail Site Feared to Be Hazardous

By ELIZABETH KOLBERT
Special to The New York Times

PAWLING, N.Y., March 18 — This summer a new stretch of the Appalachian Trail is to open through a 1,000-acre tract of National Park land here. The new stretch, which winds for two miles through rolling hills, was blazed carefully to avoid a shimmering pond with the ominous name of Nuclear Lake.

The lake, the site of a plutonium spill in 1972, has been at the center of a debate between area residents and the National Park Service. Since the Park Service acquired the tract seven years ago, residents have argued that a trail through the site represents a serious health risk.

"It's immoral to use a nuclear waste site as a possible playground," said Janet Griffin, a member of the Harlem Valley Alliance.

For almost 20 years, this scenic tract in southern Dutchess County was the site of a nuclear fuel testing plant run by the United Nuclear Corporation. After an explosion that broke windows of one building and splattered plutonium dust, the plant was closed and a two-year cleanup of the site undertaken.

Nuclear Lake was declared fit for unrestricted use by the Federal Nuclear Regulatory Commission in 1975, although New York State included it on a list of possibly-contaminated sites in 1983.

In 1979 the Federal Government purchased the site for almost $1 million for the Appalachian Trail.

Tests Are Recommended

But an outcry from residents, who said they feared that the cleanup had been incomplete, quickly brought these plans to a standstill. The Nuclear Lake Management Committee, an advisory board to the Park Service, concluded after reading documents the company left in the buildings that radioactive waste water may have been dumped in the lake and the sewers. It recommended thorough testing of the lake and the sewers before allowing public access.

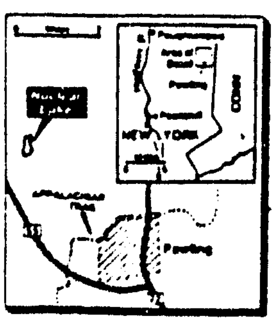
Since then, officials say, the testing has proceeded haltingly, slowed both by lack of funds and the park service's inexperience with nuclear contamination. Last month, the Nuclear Regulatory Commission ordered cleanup work on a contaminated area discovered in the old waste storage building.

But the New York/New Jersey Trail Conference, the group that oversees the Appalachian Trail in the two states, has decided that the path it has chosen through the Nuclear Lake site is safe. The group is moving ahead with its plans to open the trail to hikers this summer.

"Nothing has been found that says it shouldn't be opened," said Ron Rosen, chairman of the Dutchess County Appalachian Trail Management Committee, a volunteer organization that maintains the 30-mile stretch of the trail that runs through the county.

Moving Trail Off Roads

Mr. Rosen said the new path would bring the Appalachian Trail off local roads and back into the woods. The trail runs for 2,100 miles from Maine to Georgia, and the Nuclear Lake site was purchased as part of the National Park Service's continuing effort to obtain a wooded rights of way along its entire length.



The New York Times / March 24, 1986
The trail will be moved to within 1,200 feet of Nuclear Lake.

The New York Times / Jo...
Nuclear Lake in Pawling, N.Y. The National Park Service acquired the pond and 1,000-acre tract in 1979

But opponents say the trail group is being irresponsible by opening the path before testing is complete. "We keep saying, 'What's the rush?'" said John Franceschi, a founder of the Harlem Valley Alliance. "They cannot come up with an answer."

Charles Shaw, a Dutchess County Cooperative Extension agent and cochairman of the Nuclear Lake Management Committee, said he was not aware of the planned trail opening, which he said required the management committee's approval. He said his group did not plan to meet again until the tests it had recommended were completed.

Tests of Soil and Plants

But Carol Leone, an official of the Appalachian Trail Project Office of the National Park Service, said that the trail opening could proceed without the committee's approval. "The blazing has all been done," she said.

She said the park service would continue to seek ways to complete the recommended tests at the site.

Mr. Rosen said the path chosen for the trail was safe "in the sense that there's been nothing found to say it is otherwise."

Soil and vegetation samples taken along the trail, which runs 1,200 feet from the lake, have shown no traces of radioactivity and the area meets Federal standards for "unrestricted use," Mr. Rosen said. Besides, he said, "the road brings you as close to the facility as you are on the trail."

A major point of contention between the trail group and the protesters is whether opening the new path will encourage hikers to visit the lake. Both sides agree that the possibility that the lake bottom is contaminated means visitors should be barred from its immediate vicinity.

The New Yo...
Fred Gerry Jr. of State Department of Environmental Conservation p... sign warning hikers of possible danger of radioactivity near pond ar...

The park service restricts access to the lake with a gate and the National Park Service has printed hundreds of "no entry" signs that warn of "potential radioactive danger" at the lake. Trail volunteers plan to post the signs soon in a ring 800 feet from the lake.

The Appalachian Trail Conference also plans to place warning ... at the places where the trail ... Nuclear Lake site.

But critics say these measur... not enough. They say the new tr... only improve access to a spo... ought to be made inaccessible.

According to Mr. Rosen, the p... are "would rather see the lake ... pear from the face of the earth."

"But that's all history now," h... "This stuff was done."

He said the protesters should ... their energy to making sure the ... are completed. "In that area we ...

A1129

NUCLEAR ENERGY SERVICES, INC.
A UNIT of THE PENN CENTRAL CORPORATION

July 19, 1984
Ref. No. WMS-318

Mr. David Richie
Project Manager
National Park Service
Appalachian Trial Project Office
Harpers Ferry, WV 25425

Subject: Nuclear Lake Radiological Analysis

References: NES Purchase Order No. PX0123-4-0010
NES Project No. 5425

Dear Mr. Richie:

Nuclear Energy Services, Inc. is pleased to submit Final Report 81A1077 entitled "UNC Facility Survey and Radiological Analysis". The report details the contamination level assessment performed at the former UNC site near Pawling, NY. These activities were conducted in the early spring of 1984 under contract with the NPS. This report submission completes work conducted under the above reference Purchase Order.

NES is pleased to have served you in this effort. If we may be of assistance in other projects involving health physics or radioactive waste disposal, please do not hesitate to call.

Sincerely yours,

Nuclear Energy Services

John R May
General Manager
Waste Management Services

JRM/kmw

Enclosure

A1130

SHELTER ROCK ROAD, DANBURY, CT 06810 (203) 796-5000

nes NUCLEAR ENERGY SERVICES, INC.

UNC FACILITY SURVEY AND RADIOLOGICAL ANALYSIS

Prepared for the
National Park Service

By
Nuclear Energy Services, Inc.
Danbury, CT

Project Application 5425-200	Prepared By C.J. Marino	Date 5/7/84
APPROVALS		
TITLE/DEPT.	SIGNATURE	DATE
Project Manager	[signature]	7/19/84
Department Manager	[signature]	7/19/84
Quality Assurance Manager	[signature]	7-20-84
	CONTROLLED COPY	
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nes

REVISION LOG

NUCLEAR ENERGY SERVICES, INC.

DOCUMENT NO. 81A1077

REV NO	DATE	PAGE NO	DESCRIPTION	APPROVAL

TABLE OF CONTENTS

1. INTRODUCTION

1.1 HISTORY OF NUCLEAR LAKE AREA

The Nuclear Lake Area consists of 1,137 acres of property located on the boundary between the towns of Pawling and Beeman in New York State. The site contains a fifty (50) acre man-made lake and a small number of buildings as noted in Figure 3-2.

From 1958 to 1972, the property was used as a nuclear fuels processing and research facility, initially by Nuclear Development Corporation (NDA) and was subsequently owned and operated by United Nuclear Corporation (UNC). Ultimately, operation was transferred to Gulf United Nuclear Fuel Corporation.

Physically, the area is composed essentially of schist and gneiss with occasionally occuring pegmatite dikes and phyllite. The latter deposits generally have a slightly higher natural gamma radiation background than the schists or gneiss. The area is generally hilly and heavily forested with intermittent wetlands.

On 12/21/72, a chemical explosion occurred at the plutonium facility. Shortly afterwards, a second explosion occurred which released radioactive materials to the atmosphere and surrounding grounds. After decontamination of the facility, including some soil removal, the Nuclear Regulatory Commission (NRC) terminated the UNC license and released the site for unrestricted use.

1.2 SCOPE OF WORK

The site is currently owned by the National Park Service (NPS). To ensure the safety of the public, the NPS has chosen to have radiation surveys and physical sample analyses performed for an area of the site formerly utilized by UNC. This survey was conducted in conjunction with a similar survey performed at a neighboring section of the Appalachian Trail (see NES Report 81A1076, Rev. 0).

The scope of the survey undertaken by Nuclear Energy Services (NES) in February of 1984 is outlined below.

1. Survey of the buildings and pathways which exist in the area formerly utilized as a research facility for alpha, beta, and gamma radiation.

2. Seven (7) soil samples in the grid area behind the plutonium facility.

3. Removable contamination smears within all existing structures on-site.

4. Two (2) sediment, two (2) water, and two (2) aquatic vegetation samples each from the stream outlet and two locations at the dam (18 total samples). Background comparison will be made versus Ref. 1 and Ref. 3 data.

5. One (1) water sample from the Retention Tank south of the plutonium facility.

6. A review as performed of the existing site data as presented in "Nuclear Lake - A Resource In Question", Ref. 1. This review allowed a comparison of similar data between the NES results and the referenced document.

2. METHODOLOGY

The activities outlined below were carried out in accordance with the NES task plan for Project 5425, Task 200.

2.1 PERFORMANCE OF BUILDING AND STRUCTURES SURVEY

Survey techniques were based on standard NES procedures and accepted industry standard methods. As indicated on the data sheets of Section 3.1, the following information was gathered:

Gamma scan at 3 ft. from floor surface.

Gamma scan at 2 cm. from floor surface.

Beta scan at 2 cm. from floor surface.

Alpha scan at 2 cm. from floor surface.

An initial equipment check was performed which included voltage readings for the particular probes to be used as well as verification of instrument calibration within the past six (6) months.

The plan called for proceeding from building to building, taking radiation readings as indicated above and 100 cm^2 area smears for removable contamination in representative locations within each building. Background radiation readings in areas adjacent to the property line were performed. A continuous three (3) ft. survey was performed for gamma radiation while moving from building to building along existing pathways.

2.2 PERFORMANCE OF SOIL SAMPLING

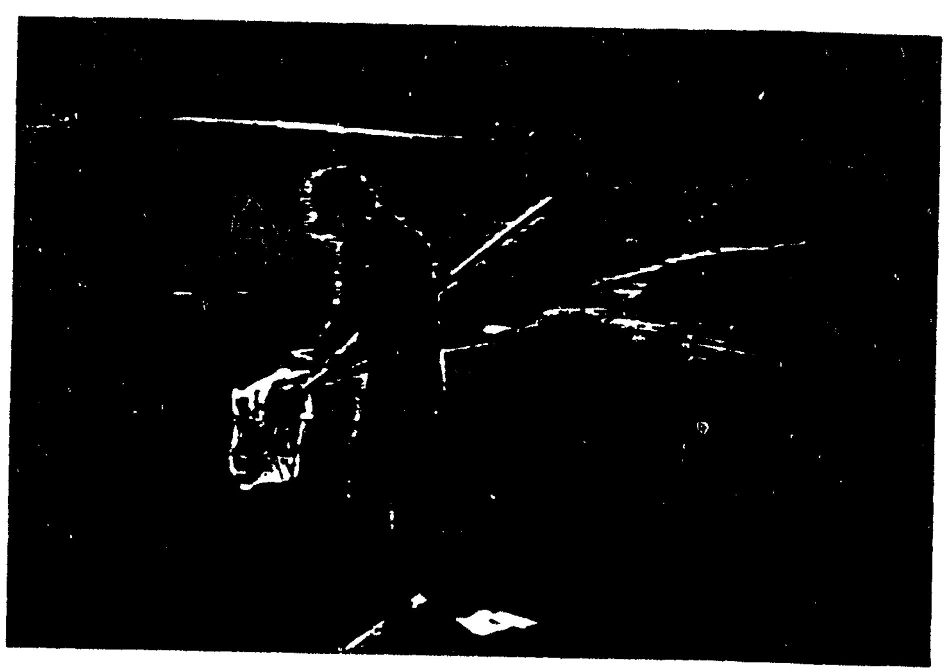
After the above building and structure survey, soil samples were taken. Beta/gamma surveys were performed during sampling activities as shown in the attached photographs.

Samples were procured by clearing loose debris and leaves from the point to be sampled. An approximately 2.5" diameter core was taken using a metal cylinder and digging instrument. Samples were taken at a maximum depth of 8". Each sample was held in a plastic container, labeled, sealed, and a record of the location made on the appropriate Field Survey Data Sheet.

2.3 PERFORMANCE OF VEGETATION AND SEDIMENT SAMPLING

At two areas above the dam and two at the stream outlet, sediment samples were obtained. A hand-operated dredging device was used to collect sufficient sample size for analysis (approx. 1 kg.).

Soil Sampling At Plutonium Building



Aquatic Vegetation Sample at Dam

Two cm. Survey at Hotspot in Waste Building

Removable 100 $cm.^2$ Swipe in Waste Building

Entrained water was decanted from the samples prior to sealing the plastic sample containers. Large rocks (more than 3 cm. diameter) were removed from the samples in the field.

At essentially the same points as the sediment samples were taken, aquatic vegetation was collected. Dredging poles and hooks were used to obtain the vegetation and place in plastic bags. The vegetation samples were later removed from the bags and placed in sealed packages of sufficient size for analysis. The vegetation taken included both rooted subsurface plants and moss.

Both sediment and aquatic vegetation samples were obtained at a maximum distance from shore of 30 ft. using an existing raft.

2.4 PERFORMANCE OF WATER SAMPLING

Water samples were taken from the lake at essentially the same four (4) points as the sediment and vegetation samples above. Each one gallon sample was obtained by sinking the plastic container at a point near the shoreline without disturbing the surrounding sediment.

In addition to lake water, one water sample was taken from within the facility Retention Tank. The surface of the tank water was frozen and existed at a level approximately 20' below ground level. It was necessary to drop rocks and a large tree limb into the tank in order to break through the several inches of ice. A plastic container was then lowered into the tank, filled, and removed for later analysis.

3. RESULTS

3.1 NES RADIATION SURVEY

Using a PRS-2 ratemeter, HP-270 beta/gamma probes and AC-3-7 alpha probe, a radiation survey was performed within and between the following buildings:

- Lodge
- Engineering Bldg.
- Shield Mock-Up Bldg.
- Multiple Failure Bldg.
- Plutonium Bldg.
- Critical Facility
- Waste Disposal Bldg.
- Generator Shed

Readings taken between the buildings ranged from 9-27 μR/hr β/γ and less than 40 CPM α over calibration. These levels are consistent with natural background values for this part of the state (Ref. 1,3). A total of fifty-eight (58) readings were taken within the buildings for combined beta/gamma and alpha.

A separate set of combined beta/gamma and gamma-only readings were taken in the waste disposal building after discovery of ambient fields ranging from 0.015 to 10.0 mR/hr β/γ. This set of data revealed a maximum reading of 25-30 mr/hr at contact with a 3 ft. X 3 ft. painted section of concrete floor as noted on Field Survey Maps 1 and 2 and their corresponding data sheets. A comparison of the combined β/γ and gamma-only readings show beta to be a significant contribution to the total field. Alpha readings appeared to be at background levels.

No other buildings were noted as having readings greater than background. However, a vault (15' X 12' X 20') in the plutonium facility was locked, denying the survey team access for internal inspection. The vault was previously used to store active source material. Also, the former remote assembly building is presently occupied by the caretaker for the site (James Robson) and his family. This area was also omitted from this survey.

In addition, several open and sealed drums were found scattered about the grounds and below the dam spillway. No notable radiation readings (β, γ, or α) were noted.

A total of ten (10) DOT-6M fissile II containers were found at various locations as noted on the data sheets. One container was broken open by NES to allow internal inspection. No radiation above background levels for alpha, beta, or gamma were noted.

Removable contamination smears were taken within each building for a gross representative accounting of local levels. All smears were counted with the Eberline MS-2 miniscaler and associated scintillation crystal and found to have no notable levels of contamination. This includes the area in the waste levels of contamination. This includes the area in the waste storage building noted for 25-30 MR/hr radiation levels. Results of the forty-seven (47) smears counted are shown on the appropriate Field Survey Data Sheet. Specific areas swiped included walls, floors, ceilings, I-beams, ventilation, ducting, glove box glass, window sills, and on earth-moving equipment.

3.2 NES SOIL SAMPLING

Seven soil samples were collected in the area behind the plutonium building near the shoreline as shown in the grid area (Figure 3-1). This area is the site of the materials release due to the chemical explosion of 1972. Laboratory analysis is correlated with sample location as follows:

Grid Area	NES Identification	Laboratory Identification
1	NES-S-7	43171
2	NES-S-8	43172
3	NES-S-9	43173
4	NES-S-10	43174
4a	NES-S-11	43175
5	NES-S-12	43176
6	NES-S-13	43177

Analysis of the samples was performed utilizing gamma isotopic, gross alpha, and gross beta techniques. The results are detailed in Tables 3-1 through 3-8.

3.3 NES VEGETATION AND SEDIMENT SAMPLING

Sediment and aquatic vegetation samples were taken from the parts of the lake noted on Field Survey Map 4. Laboratory analysis is correlated with sample location as follows.

Location	NES Identification	Laboratory Identification
Field Map 4, Point #1 (east shore of dam)	NES-S-14 NES-V-7	43178 43187
Field Map 4, Point #2 (west shore of dam)	NES-S-15 NES-V-8	43179 43188
Field Map 4, Point #3 (spillway entrance)	NES-S-16 NES-V-9	43180 43189
Field Map 4, Point #4 (overflow stream)	NES-S-17 NES-V-10	43181 43190

Results of the gamma isotopic, gross alpha, and gross beta analysis performed on each sample are shown in Tables 3-8 through 3-17.

3.4 NES WATER SAMPLING

Water samples were taken at the four locations specified in Section 3.3 for sediment and vegetation samples. In addition, a sample was successfully drawn from the Retention Tank as described in Section 2.4.

Laboratory analysis is correlated with sample location as follows:

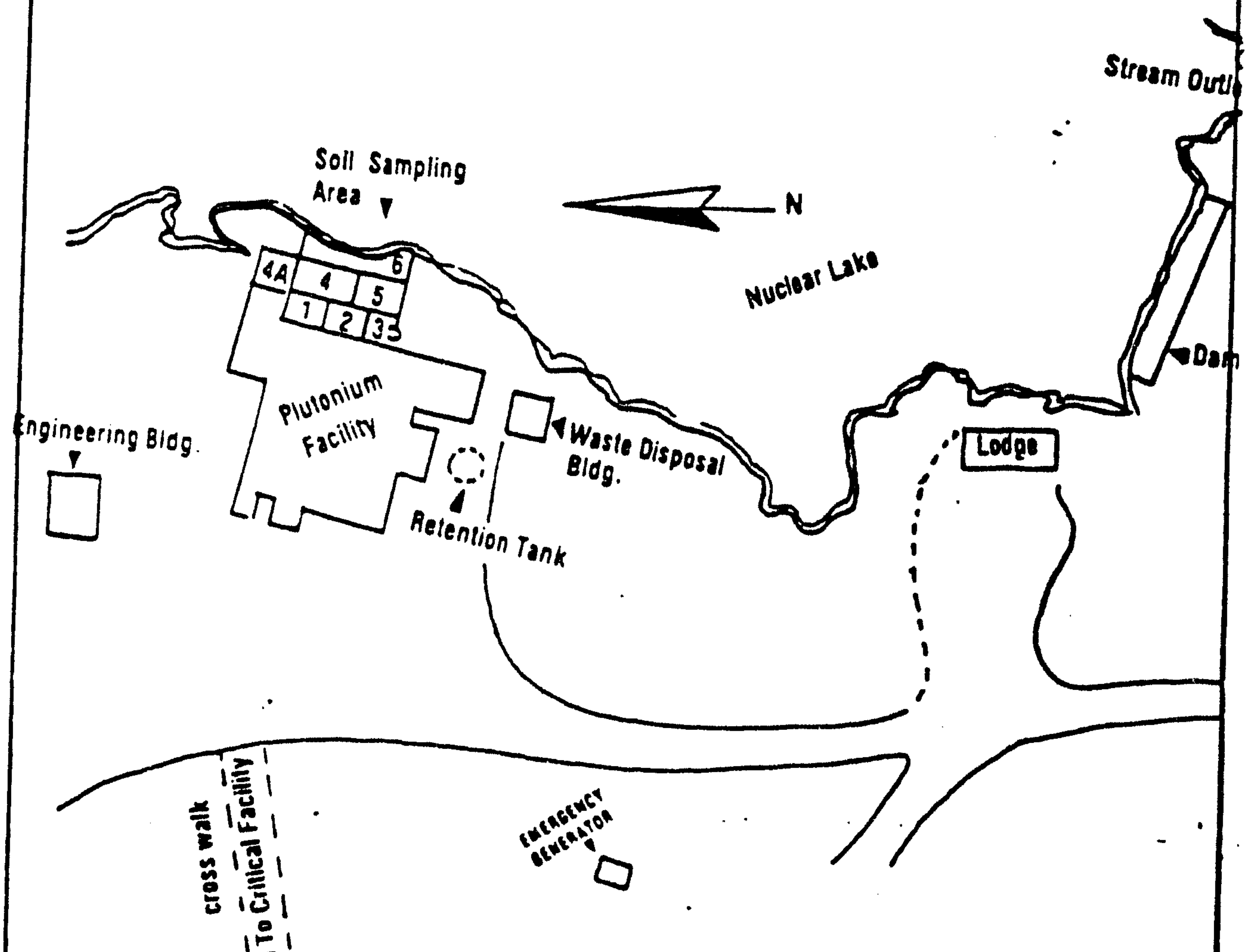
Location	NES Identification	Laboratory Identification
Field Map 4, Point #1	NES-W-1	43182
Field Map 4, Point #2	NES-W-2	43183
Field Map 4, Point #3	NES-W-3	43184
Field Map 4, Point #4	NES-W-4	43185
Figure 3-1, Retention Tank	NES-W-5	43186

Results of the gross beta, gross alpha, and gamma isotopic analysis are shown in Tables 3-18 through 3-23.

Please note that for all NES samples it is NES standard practice to use separate identification to mask the origin of each sample and whether or not it is a control, from the knowledge of laboratory personnel.

FIGURE 3-1

NYSDEC and NES SOIL SAMPLE GRID



NUCLEAR ENERGY SERVICES, INC

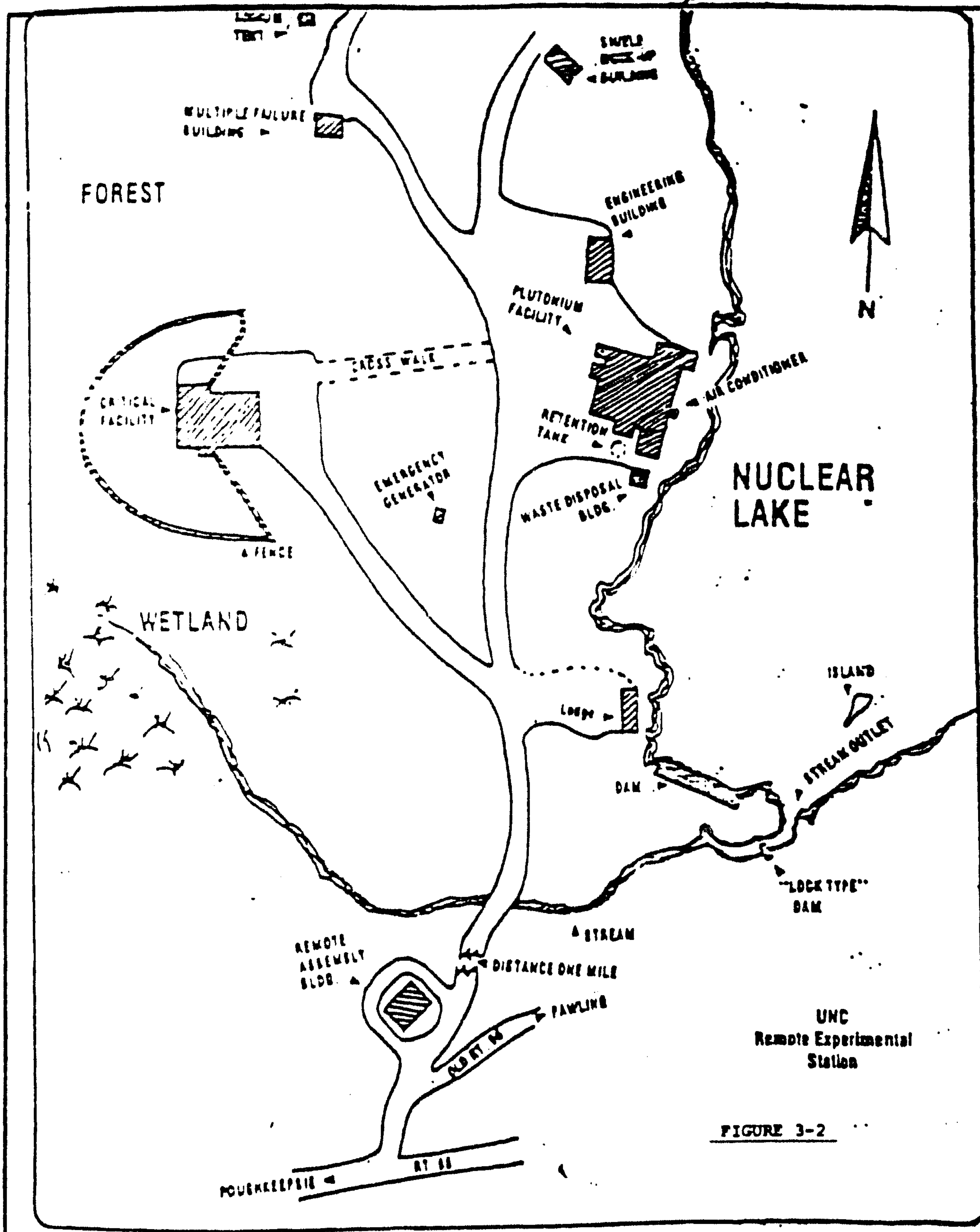


FIGURE 3-2

FIELD SURVEY DATA SHEET

LOCATION Plutonium Building
DATE SURVEYED 2/23/84 (b,g) 2/23/84 (a)
TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP 270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		19			Garage
2		15			Room #1
3		17			Room #2
4		20,10,13²			Room #3
5		12			Room #4 (Double)
6		20			Room #5
7		11,12			Labyrinth
8		16,22			Room #6
9		14			Top of Cell
10		25			Room #7 (Center)
11		14			Room #8
12				0-29	General Area
				N/A	

comments:

In μR/Hr for β/γ (β window opened unless otherwise noted).
In CPM for α

- Room 5 numbered counterclockwise from garage
- Found 1 DOT 6M container marked empty.

1. No access to cell unit.
2. Mezzanine Area.

technician

DOCUMENT NO. 81A1077
PAGE NO. 17 of 59

FIELD SURVEY DATA SHEET

LOCATION Lodge
DATE SURVEYED 2/23/84 (b,g) 2/23/84 (a)
TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP 270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		10			
2		11			
3		11			
4		10			
5		14			
6				19	General Area

comments:

Background = 10 CPM

Found 9 - DOT 6M Fissile Material
Shipping containers, marked empty

Opened one - No [illegible] > shore background.

technician

FIELD SURVEY DATA SHEET

LOCATION Engineering Building
DATE SURVEYED 2/23/84 (b,g) 2/23/84 (a)
TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		14			
2		16			
3		15			
4		11			
5		17			

comments:

No α readable
in μR/Hr

technician

FIELD SURVEY DATA SHEET

LOCATION Shield Mock-Up Building
DATE SURVEYED 2/23/84 (b,g) 2/23/84(a)
TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		12			W. Side
2		17			E. Side

comments:

Non readable
F/ℓ in μR/Hr.

technician

DOCUMENT NO. 81A1077

PAGE NO. 20 of 5

FIELD SURVEY DATA SHEET

LOCATION Multiple Failure Building

DATE SURVEYED 2/23/84 (b,g) 2/23/84(a)

TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP270 AC37

SERIAL NO. 549

WEATHER 50° Partly Sunny

MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		14			
2		22			
3		22			

Comments:

No α readable

β/γ in μ R/Hr.

technician

FIELD SURVEY DATA SHEET

LOCATION Critical Facility
DATE SURVEYED 2/23/84 (b,g) 2/23/84 (a)
TECHNICIAN C.J. Marino

INSTRUMENT PRS-2 HP270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. None

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		11			North Central
2		15			North East Room
3		12,12			Hallway
4		11			South East
5		12			Boiler Room
6		11			Garage
7		22			Garage Ante-Room
8		29			Electronics Bay
9		11			North West Room
10		27			Cell Room
11		19			North Hall
12		12			Pool Room
13		11			In Storage Pool
14				7	East Half

comments:

In μR/Hr for β/γ

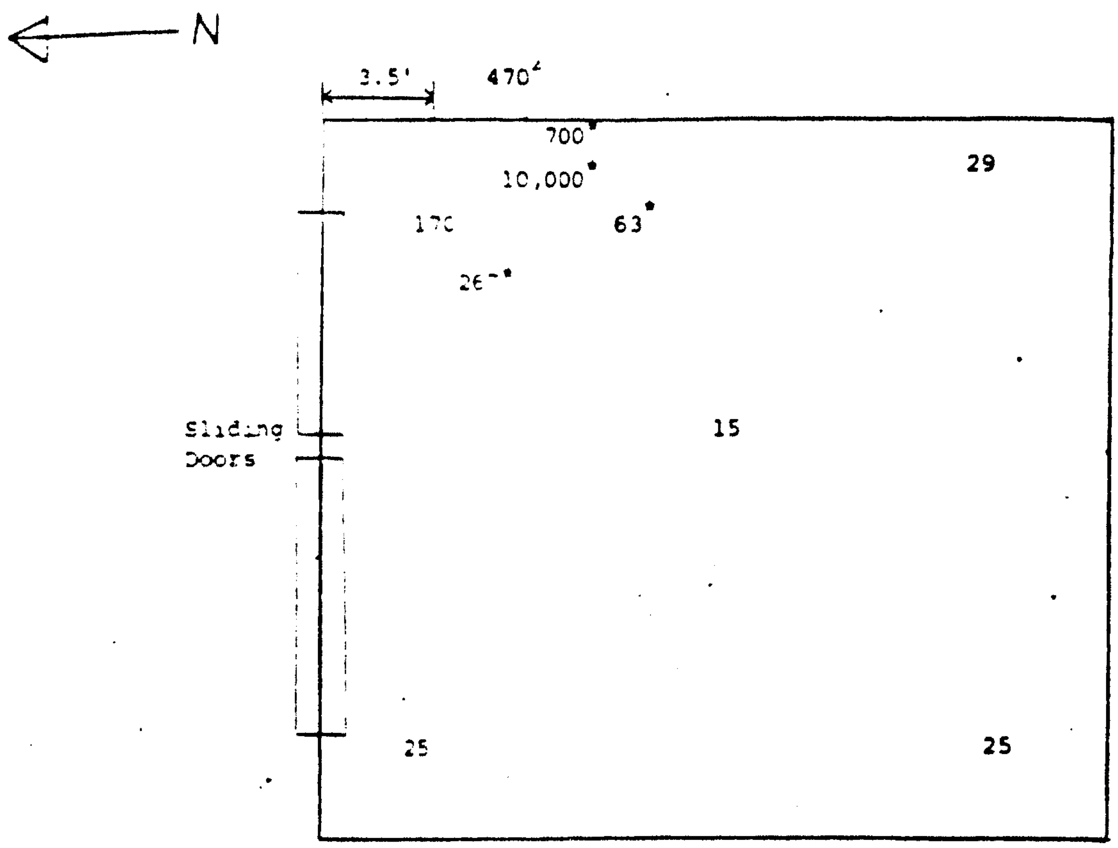
In CPM for α

technician

FIELD SURVEY MAP

MAP NO. 1
LOCATION Waste Disposal Bldg.
DATE 2/23/84
TECHNICIAN P.A. Proto

TERRAIN N/A
WEATHER Partly Sunny 50°



At 3 ft. in μR/Hr β/γ (not noted).

* at 2 cm.

∠ outside bldg., at 1 ft.

P.A. Proto
technician

FIELD SURVEY DATA SHEET

LOCATION Waste Disposal Building
DATE SURVEYED 2/23/84 (b,g) 2/23/84 (a)
TECHNICIAN [illegible] Marino

INSTRUMENT PRS-2 HP270 AC37
SERIAL NO. 549
WEATHER 50° Partly Sunny
MAP NO. 2

SAMPLE	3' GAMMA high/low	GAMMA (2 CM)	BETA (2 CM)	ALPHA (2 CM)	Description
1		106			Northeast Corner
2		61			
3		64			
4		1,000			
5		3,000			
6		25,000			
7		500*			
8		15,000*			
9		7[illegible]*			

comments:

Painted 1 m. by 1 m. Floor Area

In μR/Hr β/γ at 2 cm.

No α readable

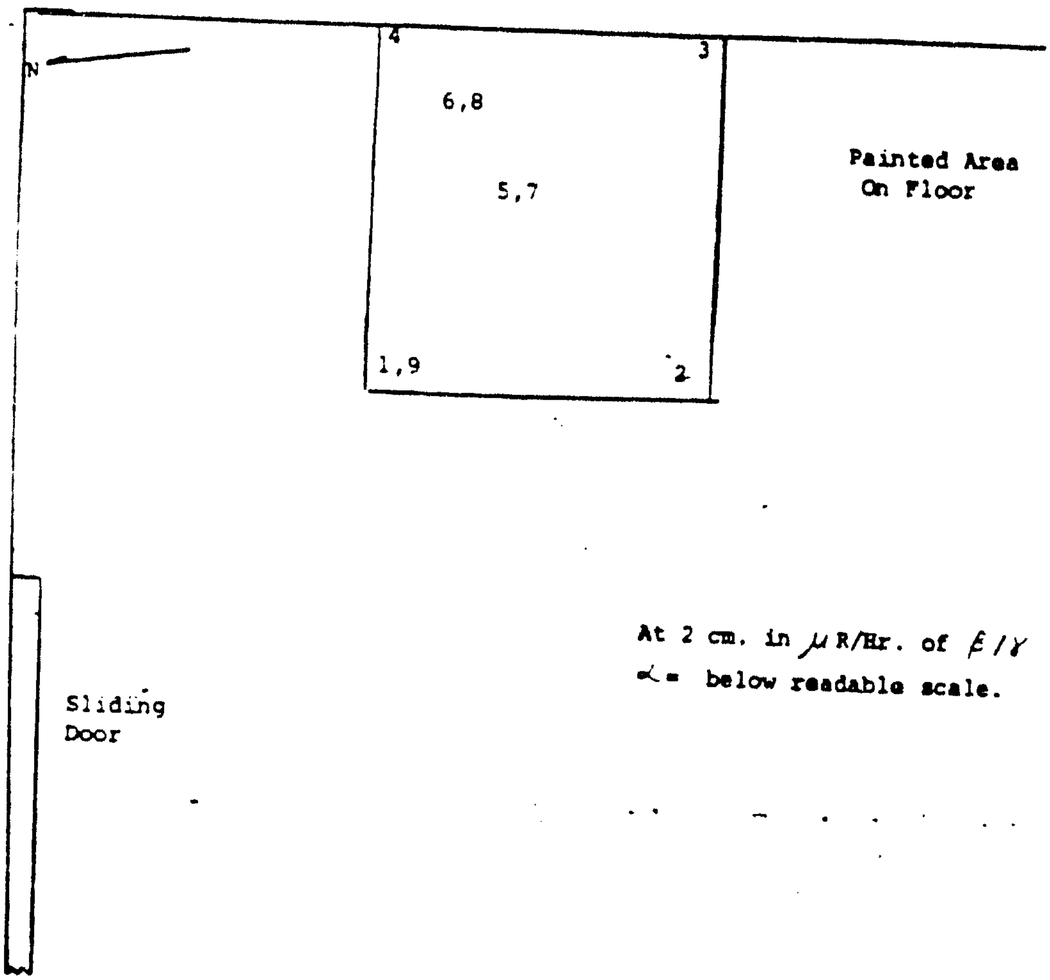
* Gamma only.

technician

FIELD SURVEY MAP

MAP NO. 2
LOCATION Waste Disposal Bldg.
DATE 2/23/84
TECHNICIAN P.A. Proto

TERRAIN Building Interior
WEATHER 50° Partly Sunny



At 2 cm. in μR/Hr. of β/γ
α = below readable scale.

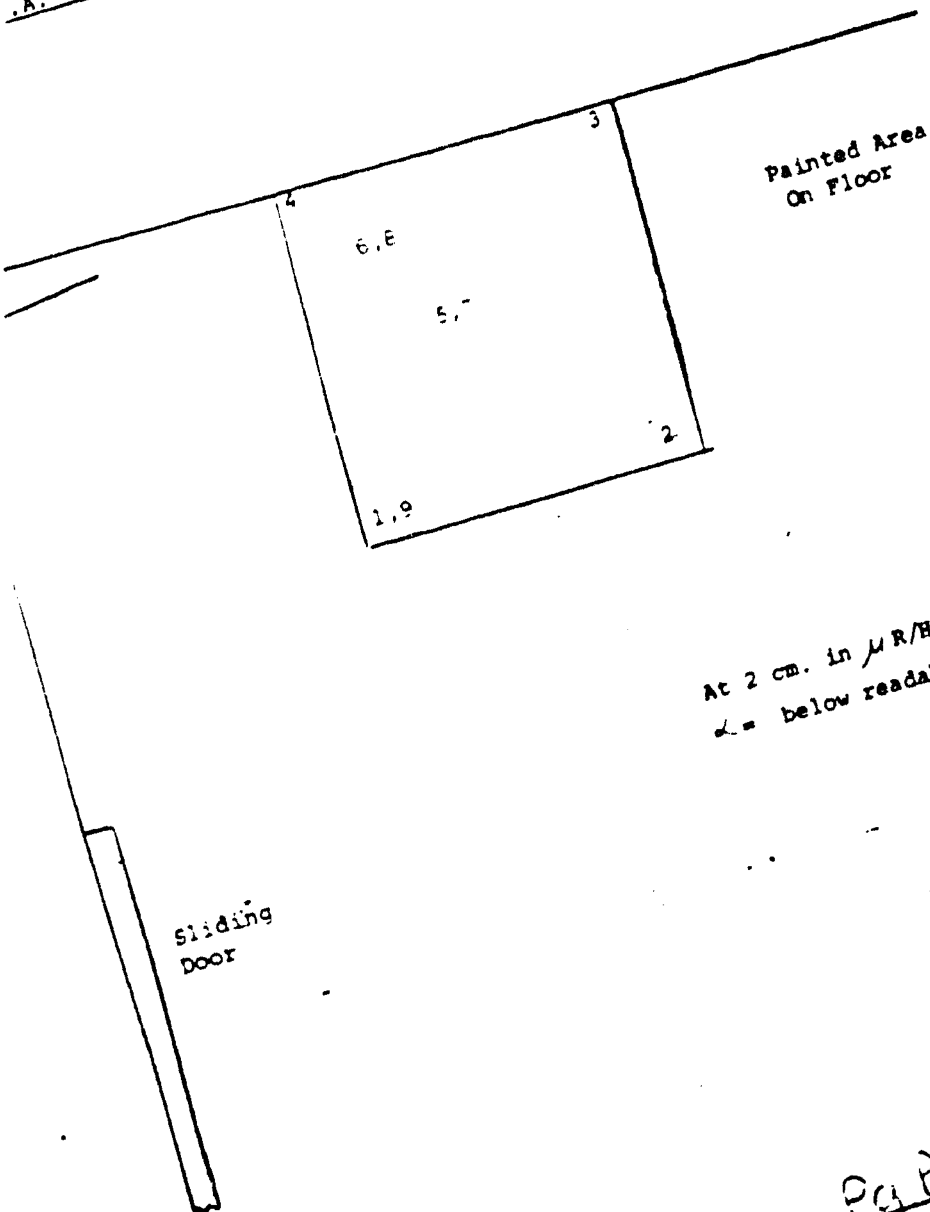
P.A.P.
technician

DOCUMENT NO. 8
PAGE NO. 24

FIELD SURVEY MAP

TERRAIN Building Interior
WEATHER 50° Partly Sunny

te Disposal Bldg.
23/84
.A. Proto



At 2 cm. in μR/Hr. of β/γ
α = below readable scale.

technician

DOCUMENT NO. 81A1077

FIELD SURVEY DATA SHEET #2

Location Nuclear Lake, NY

Date Sampled 2/23/84

Technician E.A. Proto

Smear Count Instrument Scintillation

Make and Model Eberline MS-2 Miniscaler

Weather N/A

Map No. 3 (Samples 14-18)

Sample No.	100 CM² Swipe CPM/DPM	Soil	Vegetation	Other
1	140/280	Background of Instrument		
2	127/254	Plutonium Bldg.-Rm.3 on I-Beam		
3	121/242	Plutonium Bldg.-Rm.1 on Floor		
4	125/250	Plutonium Bldg.-Rm.2 on Floor		
5	157/314	Plutonium Bldg.-Rm.3 on Floor		
6	114/228	Plutonium Bldg.-Rm.4 on Floor		
7	122/244	Plutonium Bldg.-Rm.5 in Vent Duct		
8	133/266	Background		
9	139/278	Plutonium Bldg. - Labryinth		
10	138/276	Plutonium Bldg.-Rm.6 on Floor		
11	120/240	Plutonium Bldg.-Rm.6 on Vault		
12	109/218	Plutonium Bldg.-Rm.2 on Wall		
13	121/242	Background		
14	140/280	Waste Bldg. Floor		
15	132/264	Waste Bldg. Floor		
16	111/222	Waste Bldg. Floor		
17	168/336	Waste Bldg. Painted Area		
18	126/252	Waste Bldg. Bare Area		
19	128/256	Background		
20	107/214	Generator Shed Floor		

Comments:

All background counts taken at the counting instrument with empty sample containers.

The above smears were counted on 3/5/84.

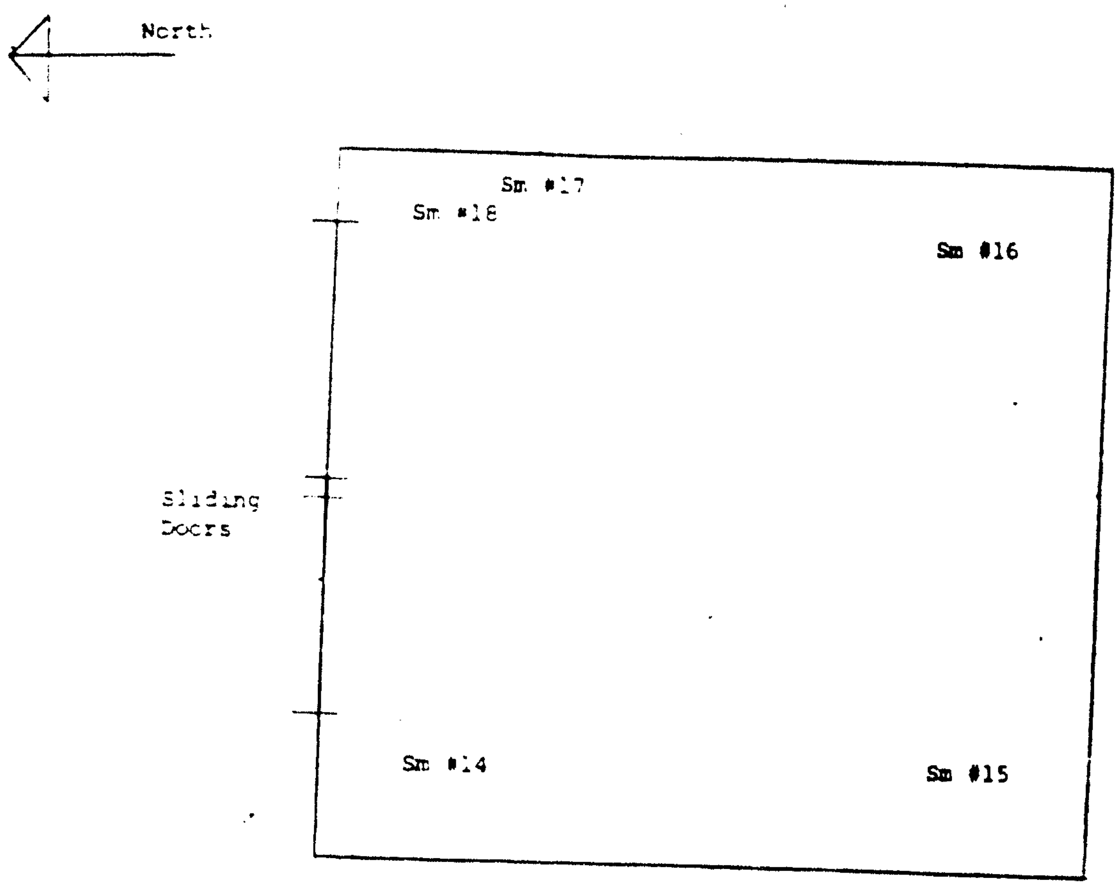
Technician

FIELD SURVEY MAP

MAP NO. 3
LOCATION Waste Disposal Bldg.
DATE 2/23/84
TECHNICIAN P.A. Proto

TERRAIN Building Interior
WEATHER 50° Partly Sunny

Smear Map



P.A. Proto
technician

FIELD SURVEY DATA SHEET #2

Location Nuclear Lake, NY
Smear Count Instrument Scintillation
Date Sampled 2/23/84
Make and Model Eberline MS-2 Miniscaler
Technician P.A. Proto
Weather N/A
Map No. None

Sample No.	100 CM² Swipe CPM/DPM	Soil / Vegetation / Other
1	140/280	Critical Facility S. East Room Floor
2	125/250	Critical Facility S. East Room Wall
3	123/246	Critical Facility Boiler Rm. Floor
4	154/308	Critical Facility Boiler Rm. Sump
5	116/232	Background
6	111/222	Critical Facility Boiler Rm. Wall
7	113/226	Critical Facility Garage Floor
8	144/288	Critical Facility Ante Rm. Floor
9	120/240	Critical Facility Electric Bay Floor
10	133/266	Critical Facility Electric Bay Wall
11	130/260	Background
12	133/266	Critical Facility N.West Rm. Floor
13	132/264	Critical Facility N.West Rm. Wall
14	139/278	Critical Facility Cell Rm. Floor
15	122/244	Critical FAcility - In Cell
16	106/212	Critical Facility Pool Rm. In Pool
17	107/214	Critical Facility Garage Backhoe Bucket
18	113/226	Waste Bldg. Lakeside @ Hot Area Outside
19	113/226	Background
20		

Comments:

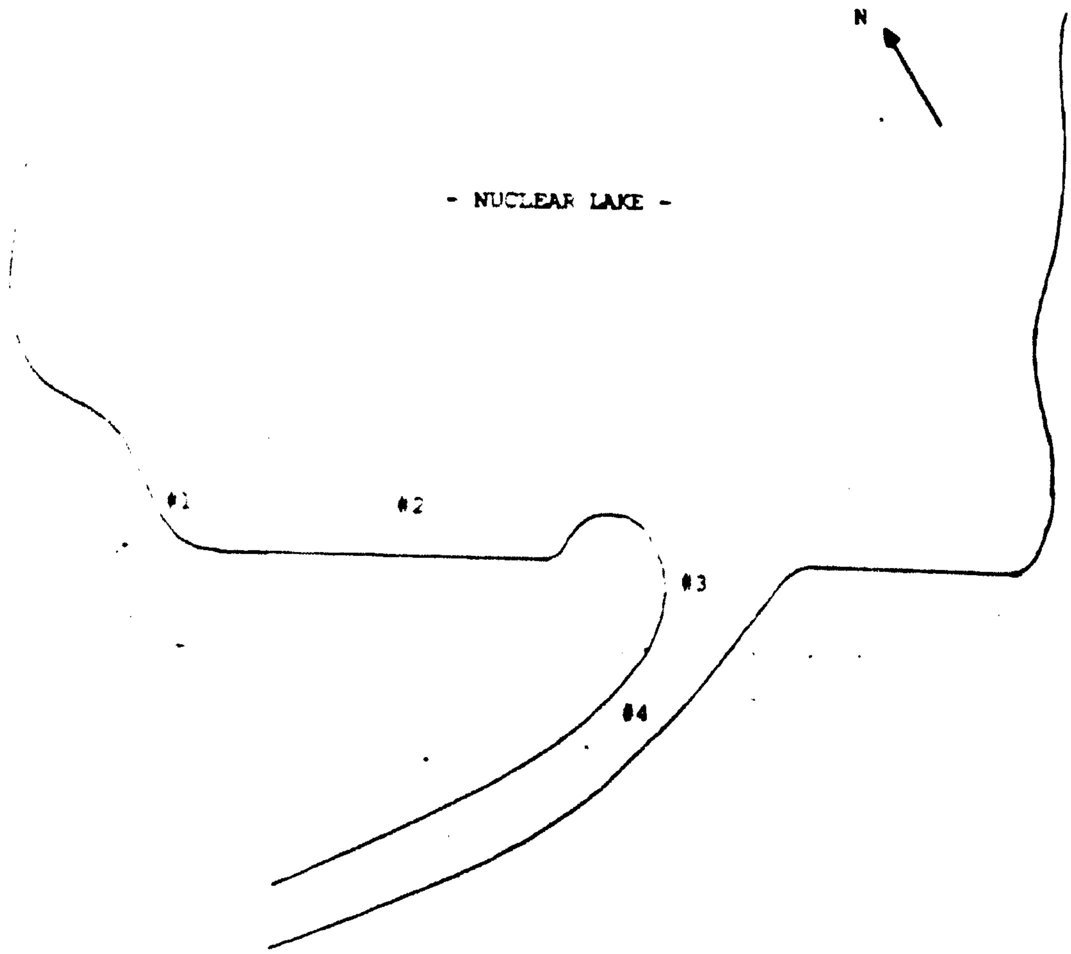
P.A. Proto
Technician

FIELD SURVEY MAP

MAP NO. 4
LOCATION Lake Dam & Spillway
DATE 2/23/84
TECHNICIAN Marino/Proto

TERRAIN Rocky, Wooded Shoreline
WEATHER 50°F Overcast

Sediment, vegetation, and liquid sample locations:



technician

MAILED

TABLE 3-1

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /1 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.14 kg
Elapsed Time : 7.46 days

Lab Sample No.: G43171
Sample Submission Code: NTS 07 0884
Other Analysis Requested: AB
Comment: NES-S-7

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	1.11E-01	(62 +- 35) E 1	120 E 1
Co-57	9.81E-01	(-23 +- 45) E-1	150 E-1
Ce-144	9.82E-01	(-102 +- 35) E 0	120 E 0
Ce-141	8.53E-01	(227 +- 95) E-1	320 E-1
Mo-99	1.56E-01	(28 +- 50) E 1	170 E 1
Se-75	9.58E-01	(33 +- 74) E-1	250 E-1
Cr-51	8.30E-01	(31 +- 55) E 0	180 E 0
I -131	5.26E-01	(8 +- 10) E 0	34 E 0
Be-7	9.87E-01	(6 +- 51) E 0	170 E 0
Ru-103	8.77E-01	(8 +- 63) E-1	210 E-1
xI -133	2.72E-03	----	----
Ba-140	6.68E-01	(4 +- 98) E-1	330 E-1
Cs-134	9.93E-01	(-92 +- 80) E-1	270 E-1
Ru-106	9.86E-01	(5 +- 55) E 0	180 E 0
* Cs-137	1.00E 00	(253 +- 77) E-1	260 E-1
Ag-110M	9.80E-01	(23 +- 89) E-1	300 E-1
Zr-95	9.24E-01	(-6 +- 13) E 0	42 E 0
Co-58	9.30E-01	(20 +- 67) E-1	220 E-1
Mn-54	9.84E-01	(-51 +- 73) E-1	240 E-1
*+ AcTh228	1.00E 00	(482 +- 37) E 0	100 E 0
TeI-132	2.04E-01	(-30 +- 21) E 1	71 E 1
Fe-59	8.92E-01	(15 +- 15) E 0	49 E 0
Zn-65	9.79E-01	(-14 +- 19) E 0	64 E 0
Co-60	9.97E-01	(-130 +- 96) E-1	380 E-1
*+ K -40	1.00E 00	(1208 +- 25) E 1	26 E 1
Sb-124	9.18E-01	(-44 +- 16) E 0	52 E 0

Notes:
* Activity greater than 3*standard deviation
+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

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1984

YAEC
Environmental Lab

TABLE 3-2
YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /1 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.15 Kg.
Elapsed Time 7.45 days

Lab Sample No.: G43172
Sample Submission Code: NTS 08 0884
Other Analysis Requested: AB
Comment: NES-S-8

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.11E-01	(77 +- 38) E 1	130 E 1
	Co-57	9.81E-01	(-22 +- 46) E-1	150 E-1
	Ce-144	9.82E-01	(23 +- 35) E 0	120 E 0
	Ce-141	8.53E-01	(2 +- 95) E-1	320 E-1
	Mo-99	1.56E-01	(-76 +- 53) E 1	180 E 1
	Se-75	9.58E-01	(-26 +- 77) E-1	260 E-1
	Cr-51	8.30E-01	(34 +- 55) E 0	180 E 0
	I -131	5.26E-01	(-13 +- 10) E 0	35 E 0
	Be-7	9.08E-01	(20 +- 52) E 0	170 E 0
	Ru-103	8.77E-01	(96 +- 66) E-1	220 E-1
x	Xe-133	2.74E-03	----	----
	Ba-140	6.68E-01	(-19 +- 11) E 0	38 E 0
	Cs-134	9.93E-01	(-1 +- 81) E-1	270 E-1
	Ru-106	9.86E-01	(16 +- 65) E 0	210 E 0
*+	Cs-137	1.00E 00	(908 +- 84) E-1	210 E-1
	Ag-110M	9.80E-01	(-9 +- 88) E-1	290 E-1
	Zr-95	9.24E-01	(10 +- 13) E 0	43 E 0
	Co-58	9.30E-01	(-79 +- 72) E-1	240 E-1
	Mn-54	9.84E-01	(-126 +- 73) E-1	250 E-1
*+	AcTh228	1.00E 00	(510 +- 36) E 0	98 E 0
	TeI-132	2.04E-01	(-19 +- 20) E 1	67 E 1
	Fe-59	8.92E-01	(-8 +- 15) E 0	52 E 0
	Zn-65	9.79E-01	(-5 +- 20) E 0	67 E 0
	Co-60	9.97E-01	(10 +- 97) E-1	380 E-1
*+	K -40	1.00E 00	(1112 +- 26) E 1	40 E 1
	Sb-124	9.18E-01	(-5 +- 13) E 0	45 E 0

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

MAILED

YAEC
Environmental Lab

TABLE 3-3
YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer: Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /1 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount: 0.15 Kg.
Elapsed Time: 7.45 days

Lab Sample No.: G43173
Sample Submission Code: NTS 09 0884
Other Analysis Requested: AB
Comment: NES-S-9

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.11E-01	(38 +- 56) E 1	190 E 1
	Co-57	9.81E-01	(27 +- 63) E-1	210 E-1
	Ce-144	9.82E-01	(-66 +- 48) E 0	160 E 0
	Ce-141	8.53E-01	(10 +- 12) E 0	42 E 0
	Mo-99	1.56E-01	(-7 +- 72) E 1	240 E 1
	Se-75	9.58E-01	(115 +- 97) E-1	320 E-1
	Cr-51	8.30E-01	(-74 +- 69) E 0	230 E 0
	I -131	5.26E-01	(1 +- 14) E 0	45 E 0
	Be-7	9.07E-01	(21 +- 69) E 0	230 E 0
	Ru-103	8.77E-01	(51 +- 85) E-1	280 E-1
x	I -133	2.72E-03	----	----
	Ba-140	6.68E-01	(-13 +- 13) E 0	43 E 0
	Cs-134	9.93E-01	(-63 +- 98) E-1	330 E-1
	Ru-106	9.86E-01	(-76 +- 87) E 0	290 E 0
*+	Cs-137	1.00E 00	(301 +- 17) E 0	44 E 0
	Ag-110M	9.80E-01	(3 +- 12) E 0	40 E 0
	Zr-95	9.24E-01	(-11 +- 16) E 0	53 E 0
	Co-58	9.30E-01	(-49 +- 90) E-1	300 E-1
	Mn-54	9.84E-01	(60 +- 73) E-1	190 E-1
*+	AcTh228	1.00E 00	(541 +- 48) E 0	140 E 0
	TeI-132	2.04E-01	(20 +- 26) E 1	88 E 1
	Fe-59	8.92E-01	(24 +- 20) E 0	66 E 0
	Zn-65	9.79E-01	(18 +- 25) E 0	84 E 0
	Co-60	9.97E-01	(-12 +- 13) E 0	51 E 0
*+	K -40	1.00E 00	(1414 +- 33) E 1	52 E 1
	Sb-124	9.18E-01	(15 +- 17) E 0	56 E 0

Notes
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

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TABLE 3-4

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 2 /29/84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.09 Kg
Elapsed Time 6.52 days

Lab Sample No.: G43174
Sample Submission Code: NTS 10 0884
Other Analysis Requested: AB
Comment: NES-S-10

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.4?E-01	(58 +- 49) E 1	160 E 1
	Co-57	9.8?E-01	(-104 +- 80) E-1	270 E-1
	Ce-144	9.84E-01	(-11 +- 60) E 0	200 E 0
	Ce-141	9.70E-01	(-10 +- 16) E 0	53 E 0
	Mo-99	1.97E-01	(-127 +- 73) E 1	240 E 1
	Se-75	9.63E-01	(-11 +- 13) E 0	44 E 0
	Cr-51	8.49E-01	(81 +- 92) E 0	310 E 0
	I -131	5.70E-01	(12 +- 18) E 0	60 E 0
	Be-7	9.19E-01	(5 +- 11) E 1	37 E 1
	Ru-103	8.92E-01	(-15 +- 14) E 0	46 E 0
x	I -133	5.71E-03	----	----
	Ba-140	7.03E-01	(-38 +- 21) E 0	71 E 0
	Cs-134	9.94E-01	(-15 +- 14) E 0	47 E 0
	Ru-106	9.88E-01	(17 +- 11) E 1	37 E 1
*+	Cs-137	1.00E 00	(918 +- 27) E 0	53 E 0
	Ag-110M	9.82E-01	(3 +- 16) E 0	52 E 0
	Zr-95	9.33E-01	(-14 +- 22) E 0	75 E 0
	Co-58	9.38E-01	(14 +- 11) E 0	37 E 0
	Mn-54	9.86E-01	(-11 +- 13) E 0	43 E 0
*+	AcTh228	1.00E 00	(594 +- 60) E 0	180 E 0
	TeI-132	2.49E-01	(-20 +- 32) E 1	110 E 1
	Fe-59	9.05E-01	(-21 +- 30) E 0	98 E 0
	Zn-65	9.82E-01	(14 +- 36) E 0	120 E 0
	Co-60	9.98E-01	(-11 +- 16) E 0	65 E 0
*+	K -40	1.00E 00	(1511 +- 41) E 1	68 E 1
	Sb-124	9.28E-01	(-5 +- 28) E 0	95 E 0

Notes

* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

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TABLE 3-5

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 2 /29/84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount: 0.08 Kg.

Elapsed Time : 6.51 days

Lab Sample No.: G43175
Sample Submission Code: NTS 11 0864
Other Analysis Requested: AB
Comment: NES-S-11
Station No.: 11 NENSSS011B

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.47E-01	(46 +- 47) E 1	160 E 1
	Co-57	9.83E-01	(144 +- 80) E-1	270 E-1
	Ce-144	9.84E-01	(-25 +- 63) E 0	210 E 0
	Ce-141	8.70E-01	(-11 +- 17) E 0	56 E 0
	Mo-99	1.97E-01	(-183 +- 77) E 1	260 E 1
	Se-75	9.63E-01	(-33 +- 16) E 0	52 E 0
	Cr-51	8.50E-01	(-4 +- 11) E 1	37 E 1
	I -131	5.70E-01	(12 +- 21) E 0	70 E 0
	Be-7	9.19E-01	(2 +- 12) E 1	40 E 1
	Ru-103	8.92E-01	(7 +- 15) E 0	46 E 0
x	I -133	5.75E-03	----	----
	Ba-140	7.03E-01	(2 +- 23) E 0	78 E 0
	Cs-134	9.94E-01	(3 +- 17) E 0	55 E 0
	Ru-106	9.88E-01	(1 +- 13) E 1	44 E 1
*+	Cs-137	1.00E 00	(2084 +- 44) E 0	80 E 0
	Ag-110M	9.82E-01	(22 +- 20) E 0	65 E 0
	Zr-95	9.33E-01	(8 +- 26) E 0	87 E 0
	Co-58	9.38E-01	(-21 +- 15) E 0	50 E 0
	Mn-54	9.86E-01	(-9 +- 15) E 0	50 E 0
*+	AcTh228	1.00E 00	(716 +- 78) E 0	240 E 0
	TeI-132	2.49E-01	(5 +- 32) E 1	110 E 1
	Fe-59	9.05E-01	(-16 +- 31) E 0	100 E 0
	Zn-65	9.82E-01	(-53 +- 40) E 0	130 E 0
	Co-60	9.98E-01	(-20 +- 20) E 0	83 E 0
*+	K -40	1.00E 00	(1379 +- 46) E 1	82 E 1
	Sb-124	9.28E-01	(8 +- 35) E 0	120 E 0

Notes:
- * Activity greater than 3*standard deviation
- \+ Peak is found
- x Decay correction less than .01

Approved by

E. L. Laurenzo

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YAEC
Environmental Lab

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TABLE 3-6

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /1 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount: 0.09 Kg.

Elapsed Time: 7.45 days

Lab Sample No.: G43176
Sample Submission Code: NTS 12 0884
Other Analysis Requested: AB
Comment: NES-5-12
Station No.: 12 NENSSS012B

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.11E-01	(58 +- 61) E 1	200 E 1
	Co-57	9.81E-01	(66 +- 74) E-1	250 E-1
	Ce-144	9.82E-01	(-73 +- 56) E 0	180 E 0
	Ce-141	8.53E-01	(18 +- 15) E 0	49 E 0
	Mo-99	1.56E-01	(61 +- 89) E 1	300 E 1
	Se-75	9.58E-01	(-4 +- 12) E 0	42 E 0
	Cr-51	8.30E-01	(-38 +- 87) E 0	290 E 0
	I -131	5.26E-01	(2 +- 17) E 0	56 E 0
	Be-7	9.07E-01	(-1 +- 10) E 1	34 E 1
	Ru-103	8.77E-01	(-2 +- 12) E 0	40 E 0
x	I -133	2.73E-03	----	----
	Ba-140	6.68E-01	(-55 +- 20) E 0	65 E 0
	Cs-134	9.93E-01	(-6 +- 13) E 0	45 E 0
	Ru-106	9.86E-01	(3 +- 10) E 1	34 E 1
*+	Cs-137	1.00E 00	(910 +- 25) E 0	49 E 0
	Ag-110M	9.80E-01	(8 +- 15) E 0	50 E 0
	Zr-95	9.24E-01	(43 +- 21) E 0	70 E 0
	Co-58	9.30E-01	(-10 +- 11) E 0	37 E 0
	Mn-54	9.84E-01	(-8 +- 11) E 0	38 E 0
*+	AcTh228	1.00E 00	(812 +- 66) E 0	200 E 0
	TeI-132	2.04E-01	(-28 +- 36) E 1	120 E 1
	Fe-59	8.92E-01	(3 +- 27) E 0	89 E 0
	Zn-65	9.79E-01	(2 +- 34) E 0	110 E 0
	Co-60	9.97E-01	(-6 +- 15) E 0	59 E 0
*+	K -40	1.00E 00	(1558 +- 39) E 1	65 E 1
	Sb-124	9.18E-01	(6 +- 27) E 0	89 E 0

Notes
* Activity greater than 3*standard deviation
+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

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TABLE 3-7

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 2 /29/84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.0? Kg
Elapsed Time 6.51 days

Lab Sample No.: G43177
Sample Submission Code: NTS 13 0884
Other Analysis Requested: AB
Comment: NES-S-13
Station No.: 13 NENSSS013B

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.47E-01	(116 +- 45) E 1	150 E 1
	Co-57	9.83E-01	(91 +- 79) E-1	260 E-1
	Ce-144	9.84E-01	(-104 +- 60) E 0	200 E 0
	Ce-141	8.70E-01	(3 +- 16) E 0	53 E 0
	Mo-99	1.97E-01	(-66 +- 68) E 1	230 E 1
	Se-75	9.63E-01	(-7 +- 13) E 0	45 E 0
	Cr-51	8.50E-01	(-61 +- 97) E 0	320 E 0
	I -131	5.71E-01	(-35 +- 18) E 0	60 E 0
	Be-7	9.19E-01	(-12 +- 97) E 0	320 E 0
	Ru-103	8.92E-01	(-1 +- 12) E 0	39 E 0
x	I -133	5.76E-03	----	----
	Ba-140	7.03E-01	(-42 +- 22) E 0	73 E 0
	Cs-134	9.94E-01	(33 +- 16) E 0	55 E 0
	Ru-106	9.88E-01	(73 +- 97) E 0	320 E 0
*+	Cs-137	1.00E 00	(1135 +- 30) E 0	48 E 0
	Ag-110M	9.82E-01	(-20 +- 18) E 0	60 E 0
	Zr-95	9.33E-01	(16 +- 22) E 0	72 E 0
	Co-58	9.38E-01	(0 +- 12) E 0	40 E 0
	Mn-54	9.86E-01	(-2 +- 13) E 0	43 E 0
*+	AcTh228	1.00E 00	(537 +- 62) E 0	190 E 0
	TeI-132	2.50E-01	(-29 +- 28) E 1	94 E 1
	Fe-59	9.05E-01	(-39 +- 29) E 0	96 E 0
	Zn-65	9.82E-01	(2 +- 34) E 0	110 E 0
	Co-60	9.98E-01	(26 +- 18) E 0	68 E 0
*+	K -40	1.00E 00	(1473 +- 44) E 1	68 E 1
	Sb-124	9.28E-01	(3 +- 27) E 0	88 E 0

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

MAILED

TABLE 3-8
YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/30/84
Date Received: 2 /27/84

Soil

	LAB. No. SAMPLE CODE	DATE of REFERENCE	DATE of ANALYSIS	VOLUME Gram	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Gram	MDC]
*	B43171	2 /23	3 /20	0.130	Beta	(105 +- 14)E-1	18E-1
	NTS 07 0884				Alpha	(50 +- 23)E-1	47E-1
	Comment:NES-S-7						
*	B43172	2 /23	3 /20	0.140	Beta	(159 +- 15)E-1	16E-1
*	NTS 08 0884				Alpha	(109 +- 27)E-1	44E-1
	Comment:NES-S-8						
*	B43173	2 /23	3 /20	0.123	Beta	(185 +- 17)E-1	18E-1
*	NTS 09 0884				Alpha	(142 +- 32)E-1	49E-1
	Comment:NES-S-9						
*	B43174	2 /23	3 /20	0.114	Beta	(280 +- 19)E-1	20E-1
*	NTS 10 0884				Alpha	(124 +- 32)E-1	53E-1
-	Comment:NES-S-10						
*	B43175	2 /23	3 /20	0.114	Beta	(322 +- 20)E-1	20E-1
*	NTS 11 0884				Alpha	(163 +- 35)E-1	52E-1
	Comment:NES-S-11						
*	B43176	2 /23	3 /20	0.119	Beta	(278 +- 19)E-1	19E-1
*	NTS 12 0884				Alpha	(119 +- 31)E-1	51E-1
	Comment:NES-S-12						
*	B43177	2 /23	3 /20	0.112	Beta	(259 +- 19)E-1	20E-1
*	NTS 13 0884				Alpha	(104 +- 30)E-1	54E-1
	Comment:NES-S-13						
*	B43178	2 /23	3 /20	0.105	Beta	(305 +- 20)E-1	21E-1
	NTS 14 0884				Alpha	(85 +- 30)E-1	56E-1
	Comment:NES-S-14						
*	B43179	2 /23	3 /20	0.113	Beta	(329 +- 21)E-1	20E-1
*	NTS 15 0884				Alpha	(187 +- 37)E-1	53E-1
	Comment:NES-S-15						
*	B43180	2 /23	3 /20	0.114	Beta	(267 +- 20)E-1	20E-1
*	NTS 16 0884				Alpha	(226 +- 40)E-1	53E-1
	Comment:NES-S-16						
*	B43181	2 /23	3 /20	0.108	Beta	(242 +- 21)E-1	21E-1
*	NTS 17 0884				Alpha	(260 +- 43)E-1	55E-1
	Comment:NES-S-17						

Notes:
* Activity is greater than 3*standard deviation

Approved by

MAILED

TABLE 3-9

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /2 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount: 0.13 kg
Elapsed Time : 8.53 days

Lab Sample No.: G43178
Sample Submission Code: NTS 14 0884
Other Analysis Requested: AB
Comment: NES-S-14

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	8.07E-02	(89 +- 44) E 1	150 E 1
	Co-57	9.78E-01	(-2 +- 43) E-1	140 E-1
	Ce-144	9.79E-01	(-51 +- 34) E 0	110 E 0
	Ce-141	8.34E-01	(129 +- 92) E-1	310 E-1
	Mo-99	1.19E-01	(8 +- 69) E 1	230 E 1
	Se-75	9.52E-01	(-196 +- 80) E-1	270 E-1
	Cr-51	8.08E-01	(7 +- 59) E 0	200 E 0
	I -131	4.79E-01	(24 +- 13) E 0	43 E 0
	Be-7	8.95E-01	(70 +- 61) E 0	200 E 0
	Ru-103	8.61E-01	(14 +- 73) E-1	240 E-1
x	I -133	1.16E-03	----	----
	Ba-140	6.30E-01	(-16 +- 12) E 0	39 E 0
	Cs-134	9.92E-01	(-82 +- 83) E-1	270 E-1
	Ru-106	9.84E-01	(-14 +- 68) E 0	230 E 0
*+	Cs-137	9.99E-01	(1645 +- 23) E 0	31 E 0
	Ag-110m	9.77E-01	(-1 +- 96) E-1	320 E-1
	Zr-95	9.13E-01	(11 +- 13) E 0	44 E 0
	Co-58	9.20E-01	(70 +- 68) E-1	230 E-1
	Mn-54	9.81E-01	(-92 +- 72) E-1	240 E-1
*+	AcTh228	1.00E 00	(563 +- 38) E 0	110 E 0
	Te-132	1.62E-01	(-29 +- 26) E 1	86 E 1
	Fe-59	8.77E-01	(-5 +- 16) E 0	55 E 0
	Zn-65	9.76E-01	(-21 +- 19) E 0	64 E 0
	Co-60	9.97E-01	(-12 +- 10) E 0	41 E 0
*+	K -40	1.00E 00	(1364 +- 27) E 1	41 E 1
	Sb-124	9.06E-01	(3 +- 14) E 0	48 E 0

Notes
* Activity greater than 3*standard deviation
+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

DOCUMENT NO. 81A1077

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TABLE 3-10

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 2 /29/84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.08 kg

Elapsed Time 6.51 days

Lab Sample No.: G43179
Sample Submission Code: NTS 15 0884
Other Analysis Requested: AB
Comment: NES-S-15

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA (Pico Curie / Kilogram	MDC)
	Np-239	1.46E-01	(45 +- 59) E 1	200 E 1
	Co-57	9.83E-01	(-66 +- 92) E-1	310 E-1
	Ce-144	9.84E-01	(-9 +- 71) E 0	240 E 0
	Ce-141	8.70E-01	(-5 +- 19) E 0	64 E 0
	Mo-99	1.97E-01	(81 +- 87) E 1	290 E 1
	Se-75	9.63E-01	(25 +- 16) E 0	54 E 0
	Cr-51	8.50E-01	(3 +- 12) E 1	38 E 1
	I -131	5.70E-01	(4 +- 21) E 0	71 E 0
*+	Be-7	9.19E-01	(57 +- 11) E 1	25 E 1
	Ru-103	8.92E-01	(-11 +- 14) E 0	46 E 0
x	I -133	5.74E-03	----	----
	Ba-140	7.03E-01	(-30 +- 19) E 0	62 E 0
	Cs-134	9.94E-01	(-22 +- 16) E 0	55 E 0
	Ru-106	9.88E-01	(10 +- 13) E 1	44 E 1
*+	Cs-137	1.00E 00	(2707 +- 46) E 0	63 E 0
	Ag-110M	9.82E-01	(9 +- 18) E 0	58 E 0
	Zr-95	9.33E-01	(20 +- 25) E 0	83 E 0
	Co-58	9.38E-01	(18 +- 13) E 0	43 E 0
	Mn-54	9.86E-01	(-8 +- 14) E 0	48 E 0
*+	AcTh228	1.00E 00	(680 +- 69) E 0	200 E 0
	TeI-132	2.49E-01	(-14 +- 32) E 1	110 E 1
	Fe-59	9.05E-01	(-26 +- 31) E 0	100 E 0
	Zn-65	9.82E-01	(-42 +- 37) E 0	120 E 0
	Co-60	9.98E-01	(-20 +- 20) E 0	80 E 0
*+	K -40	1.00E 00	(1584 +- 47) E 1	80 E 1
	Sb-124	9.28E-01	(56 +- 29) E 0	95 E 0

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

Estelle Laurenzo

E. L. Laurenzo

MAILED

TABLE 3-11
YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MA

Report Date: 03/12/84
Analysis Date: 3 /2 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount: 0.11 Kg
Elapsed Time 8.38 days

Lab Sample No.: G43180
Sample Submission Code: NTS 16 0884
Other Analysis Requested: AB
Comment: NES-S-16

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA (Pico Curie / Kilogram	MDC)
	Np-239	8.45E-02	(114 +- 67) E 1	220 E 1
	Co-57	9.79E-01	(83 +- 61) E-1	200 E-1
	Ce-144	9.80E-01	(-26 +- 47) E 0	160 E 0
	Ce-141	8.36E-01	(-4 +- 13) E 0	43 E 0
	Mo-99	1.24E-01	(-187 +- 89) E 1	300 E 1
	Se-75	9.53E-01	(-114 +- 99) E-1	330 E-1
	Cr-51	8.11E-01	(-51 +- 73) E 0	240 E 0
	I -131	4.86E-01	(-24 +- 15) E 0	51 E 0
	Be-7	8.97E-01	(196 +- 85) E 0	280 E 0
	Ru-103	8.63E-01	(3 +- 10) E 0	34 E 0
x	I -133	1.31E-03	----	----
	Ba-140	6.35E-01	(-49 +- 17) E 0	58 E 0
	Cs-134	9.92E-01	(-10 +- 11) E 0	36 E 0
	Ru-106	9.84E-01	(82 +- 85) E 0	280 E 0
*+	Cs-137	9.99E-01	(651 +- 18) E 0	34 E 0
	Ag-110M	9.77E-01	(-11 +- 12) E 0	39 E 0
	Zr-95	9.15E-01	(15 +- 16) E 0	54 E 0
	Co-58	9.21E-01	(-222 +- 94) E-1	310 E-1
	Mn-54	9.82E-01	(-65 +- 63) E-1	150 E-1
*+	AcTh228	1.00E 00	(781 +- 48) E 0	130 E 0
	TeI-132	1.68E-01	(44 +- 37) E 1	120 E 1
	Fe-59	8.79E-01	(8 +- 22) E 0	75 E 0
	Zn-65	9.77E-01	(-48 +- 28) E 0	92 E 0
	Co-60	9.97E-01	(-11 +- 13) E 0	50 E 0
*+	K -40	1.00E 00	(1594 +- 33) E 1	53 E 1
	Sb-124	9.08E-01	(4 +- 22) E 0	73 E 0

Notes:
* Activity greater than 3*standard deviation
+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

MAILED

TABLE 3-12

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energv Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 2 /29/84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Soil

Sample Amount 0.11 Kg
Elapsed Time 6 53 days

Lab Sample No.: G43181
Sample Submission Code: NTS 17 0884
Other Analysis Requested: AB
Comment: NES-S-17

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA (Pico Curie / Kilogram	MDC)
	Np-239	1.46E-01	(68 +- 43) E 1	140 E 1
	Co-57	9.83E-01	(10 +- 72) E-1	240 E-1
	Ce-144	9.84E-01	(-74 +- 54) E 0	180 E 0
	Ce-141	8.70E-01	(-9 +- 14) E 0	48 E 0
	Mo-99	1.96E-01	(3 +- 62) E 1	210 E 1
	Se-75	9.63E-01	(15 +- 11) E 0	38 E 0
	Cr-51	8.49E-01	(125 +- 82) E 0	270 E 0
	I -131	5.70E-01	(-18 +- 15) E 0	50 E 0
**	Be-7	9.18E-01	(249 +- 67) E 0	160 E 0
	Ru-103	8.91E-01	(-12 +- 10) E 0	33 E 0
	xI -133	5.67E-03	----	----
	Ba-140	7.02E-01	(-5 +- 16) E 0	52 E 0
	Cs-134	9.94E-01	(3 +- 14) E 0	46 E 0
	Ru-106	9.88E-01	(-35 +- 84) E 0	280 E 0
**	Cs-137	1.00E 00	(410 +- 19) E 0	41 E 0
	Ag-110m	9.82E-01	(29 +- 14) E 0	48 E 0
	Zr-95	9.33E-01	(39 +- 20) E 0	68 E 0
	Co-58	9.38E-01	(-11 +- 11) E 0	35 E 0
	Mn-54	9.86E-01	(38 +- 13) E 0	41 E 0
**	AcTh228	1.00E 00	(771 +- 57) E 0	160 E 0
	TeI-132	2.48E-01	(-40 +- 25) E 1	84 E 1
	Fe-59	9.05E-01	(5 +- 23) E 0	76 E 0
	Zn-65	9.82E-01	(-2 +- 27) E 0	90 E 0
	Co-60	9.98E-01	(-10 +- 14) E 0	55 E 0
**	K -40	1.00E 00	(1968 +- 41) E 1	41 E 1
	Sb-124	9.28E-01	(-36 +- 22) E 0	72 E 0

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

MAILED

TABLE 3-13

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/13/84
Analysis Date: 3 /6 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Mixed Vegetation

Sample Amount: 1.08 Kg.
Elapsed Time: 12.46 days

Lab Sample No.: G43187
Sample Submission Code: NTG 07 0884
Other Analysis Requested: AB
Comment: NES-V-7/VEGETATION

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	2.54E-02	(5 +- 23) E 1	77 E 1
	Co-57	9.69E-01	(-100 +- 71) E-2	240 E-2
	Ce-144	9.70E-01	(-13 +- 56) E-1	190 E-1
	Ce-141	7.67E-01	(43 +- 17) E-1	55 E-1
	Mo-99	4.48E-02	(-43 +- 30) E 1	180 E 1
	Se-75	9.31E-01	(11 +- 14) E-1	47 E-1
	Cr-51	7.32E-01	(-30 +- 12) E 0	38 E 0
	I -131	3.42E-01	(8 +- 29) E-1	98 E-1
*+	Be-7	8.50E-01	(1087 +- 28) E 0	58 E 0
	Ru-103	8.03E-01	(36 +- 13) E-1	42 E-1
x	I -133	5.18E-05	----	----
	Ba-140	5.09E-01	(-33 +- 26) E-1	86 E-1
	Cs-134	9.89E-01	(-12 +- 14) E-1	47 E-1
	Ru-106	9.77E-01	(12 +- 12) E 0	39 E 0
*+	Cs-137	9.99E-01	(964 +- 31) E-1	63 E-1
	Ag-110M	9.66E-01	(10 +- 17) E-1	57 E-1
	Zr-95	8.76E-01	(3 +- 23) E-1	77 E-1
	Co-58	8.85E-01	(-13 +- 13) E-1	44 E-1
	Mn-54	9.73E-01	(-13 +- 12) E-1	43 E-1
*+	AcTh228	1.00E 00	(390 +- 68) E-1	240 E-1
	TeI-132	7.02E-02	(14 +- 10) E 1	33 E 1
	Fe-59	8.26E-01	(-18 +- 29) E-1	95 E-1
	Zn-65	9.65E-01	(9 +- 32) E-1	110 E-1
	Co-60	9.96E-01	(13 +- 19) E-1	76 E-1
*+	K -40	1.00E 00	(737 +- 35) E 0	76 E 0
	Sb-124	8.66E-01	(-18 +- 33) E-1	110 E-1

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

MAILED

TABLE 3-14

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/13/84
Analysis Date: 3 /6 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Mixed Vegetation

Sample Amount: 0.48 Kg.
Elapsed Time : 12.45 days

Lab Sample No.: G43188
Sample Submission Code: NTG 08 0884
Other Analysis Requested: AB
Comment: NES-V-8/VEGETATION

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	2.54E-02	(24 +- 53) E 1	180 E 1
	Co-57	9.69E-01	(9 +- 16) E-1	53 E-1
	Ce-144	9.70E-01	(-3 +- 12) E 0	41 E 0
	Ce-141	7.67E-01	(63 +- 37) E-1	120 E-1
	Mo-99	4.48E-02	(-44 +- 65) E 1	220 E 1
	Se-75	9.31E-01	(13 +- 31) E-1	100 E-1
	Cr-51	7.32E-01	(-14 +- 24) E 0	79 E 0
	I -131	3.42E-01	(77 +- 63) E-1	210 E-1
*+	Be-7	8.50E-01	(2416 +- 55) E 0	71 E 0
	Ru-103	8.03E-01	(-7 +- 24) E-1	82 E-1
x	I -133	5.20E-05	----	----
	Ba-140	5.10E-01	(-85 +- 48) E-1	160 E-1
	Cs-134	9.89E-01	(-38 +- 31) E-1	100 E-1
	Ru-106	9.77E-01	(28 +- 19) E 0	62 E 0
*+	Cs-137	9.99E-01	(205 +- 27) E-1	62 E-1
	Ag-110M	9.66E-01	(28 +- 33) E-1	110 E-1
	Zr-95	8.76E-01	(-7 +- 46) E-1	150 E-1
	Co-58	8.85E-01	(8 +- 23) E-1	78 E-1
	Mn-54	9.74E-01	(29 +- 24) E-1	81 E-1
+	AcTh228	1.00E 00	(7 +- 10) E 0	39 E 0
	TeI-132	7.03E-02	(13 +- 21) E 1	69 E 1
	Fe-59	8.26E-01	(-21 +- 55) E-1	180 E-1
	Zn-65	9.65E-01	(68 +- 66) E-1	220 E-1
	Co-60	9.96E-01	(-8 +- 39) E-1	160 E-1
*+	K -40	1.00E 00	(322 +- 51) E 0	160 E 0
	Sb-124	8.66E-01	(18 +- 66) E-1	220 E-1

Notes.
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenzo

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TABLE 3-15

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmentel Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/13/84
Analysis Date: 3 /6 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Mixed Vegetation

Sample Amount: 0.61 Kg
Elapsed Time 12.46 days

Lab Sample No.: G43189
Sample Submission Code: NTG 09 0884
Other Analysis Requested: AR
Comment: NES-V-9/VEGETATION

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA (Pico Curie / Kilogram	MDC)
	Np-239	2.53E-02	(33 +- 50) E 1	170 E 1
	Co-57	9.69E-01	(-14 +- 14) E-1	47 E-1
	Ce-144	9.70E-01	(-1 +- 11) E 0	35 E 0
	Ce-141	7.67E-01	(37 +- 31) E-1	100 E-1
	Mo-99	4.47E-02	(-65 +- 59) E 1	200 E 1
	Se-75	9.31E-01	(21 +- 25) E-1	82 E-1
	Cr-51	7.32E-01	(1 +- 18) E 0	61 E 0
	I -131	3.42E-01	(57 +- 49) E-1	160 E-1
*+	Be-7	8.50E-01	(3561 +- 57) E 0	75 E 0
	Ru-103	8.03E-01	(28 +- 23) E-1	78 E-1
x	I -133	5.17E-05	----	----
	Ba-140	5.09E-01	(-16 +- 45) E-1	150 E-1
	Cs-134	9.89E-01	(13 +- 24) E-1	81 E-1
	Ru-106	9.77E-01	(-12 +- 18) E 0	60 E 0
*+	Cs-137	9.99E-01	(189 +- 25) E-1	67 E-1
	Ag-110m	9.66E-01	(15 +- 27) E-1	89 E-1
	Zr-95	8.76E-01	(-29 +- 35) E-1	120 E-1
	Co-58	8.85E-01	(-1 +- 21) E-1	69 E-1
	Mn-54	9.73E-01	(16 +- 20) E-1	65 E-1
+	AcTh228	1.00E 00	(211 +- 90) E-1	330 E-1
	TeI-132	7.01E-02	(-13 +- 18) E 1	59 E 1
	Fe-59	8.26E-01	(-28 +- 49) E-1	160 E-1
	Zn-65	9.65E-01	(-25 +- 53) E-1	180 E-1
	Co-60	9.96E-01	(5 +- 29) E-1	120 E-1
*+	K -40	1.00E 00	(279 +- 42) E 0	140 E 0
	Sb-124	8.66E-01	(1 +- 61) E-1	200 E-1

Notes
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01

Approved by

E. L. Laurenze
E. L. Laurenze

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TABLE 3-16

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN P. MAY

Report Date: 03/13/84
Analysis Date: 3 /6 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Mixed Vegetation ●

Sample Amount 0.76 Kg
Elapsed Time 12.46 days

Lab Sample No.: G43190
Sample Submission Code: NTG 10 0884
Other Analysis Requested: AB
Comment: NES-V-10/VEGETATION

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA (Pico Curie / Kilogram	MDC)
	Np-239	2.54E-02	(122 +- 93) E 1	310 E 1
	Co-57	9.69E-01	(1 +- 25) E-1	84 E-1
	Ce-144	9.70E-01	(-10 +- 19) E 0	64 E 0
	Ce-141	7.67E-01	(104 +- 55) E-1	180 E-1
	Mo-99	4.48E-02	(14 +- 97) E 1	320 E 1
	Se-75	9.31E-01	(24 +- 41) E-1	140 E-1
	Cr-51	7.32E-01	(-32 +- 32) E 0	110 E 0
	I -131	3.42E-01	(49 +- 85) E-1	280 E-1
*+	Be-7	8.50E-01	(3762 +- 65) E 0	120 E 0
	Ru-103	8.03E-01	(1 +- 34) E-1	110 E-1
x	I -133	5.17E-05	----	----
	Ba-140	5.09E-01	(-80 +- 47) E-1	160 E-1
	Cs-134	9.89E-01	(-44 +- 32) E-1	110 E-1
	Ru-106	9.77E-01	(-13 +- 28) E 0	92 E 0
*+	Cs-137	9.99E-01	(1157 +- 11) E 0	13 E 0
	Ag-110m	9.66E-01	(-5 +- 38) E-1	130 E-1
	Zr-95	8.76E-01	(-36 +- 50) E-1	170 E-1
	Co-58	8.85E-01	(-38 +- 28) E-1	93 E-1
	Mn-54	9.73E-01	(-69 +- 32) E-1	110 E-1
*+	AcTh228	1.00E 00	(320 +- 15) E 0	38 E 0
	Te1-132	7.01E-02	(-10 +- 23) E 1	75 E 1
	Fe-59	8.26E-01	(56 +- 60) E-1	200 E-1
	Zn-65	9.65E-01	(69 +- 72) E-1	240 E-1
	Co-60	9.96E-01	(9 +- 34) E-1	130 E-1
*+	K -40	1.00E 00	(5001 +- 96) E 0	140 E 0
	Sb-124	8.66E-01	(56 +- 53) E-1	180 E-1

Notes:
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01
● Sandy soil present in sample.

Approved by

Estella Laurenzo
E. L. Laurenzo

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TABLE 3-17

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/30/84
Date Received: 2 /27/84

Mixed Vegetation

	LAB. No. SAMPLE CODE	DATE of REFERENCE	DATE of ANALYSIS	VOLUME Gram	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Gram]	MDC
*	B43187	2 /23	3 /20	0.071	Beta	(231 +- 27)E-1	31E-1
*	NTG 07 0884				Alpha	(143 +- 33)E-1	51E-1
	Comment:NES-V-7/VEGETATION						
*	B43188	2 /23	3 /20	0.069	Beta	(142 +- 24)E-1	32E-1
	NTG 08 0884				Alpha	(50 +- 24)E-1	51E-1
	Comment:NES-V-8/VEGETATION						
*	B43189	2 /23	3 /20	0.048	Beta	(515 +- 41)E-1	45E-1
*	NTG 09 0884				Alpha	(136 +- 35)E-1	58E-1
	Comment:NES-V-9/VEGETATION						
*	B43190	2 /23	3 /20	0.112	Beta	(375 +- 23)E-1	20E-1
*	NTG 10 0884				Alpha	(264 +- 43)E-1	53E-1
-	Comment:NES-V-10/VEGETATION						

Notes:
* Activity is greater than 3*standard deviation

Approved by

[signature]

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TABLE 3-18

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR JOHN R. MAY

Report Date: 03/20/84
Analysis Date: 3 /5 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Ground Water

Sample Amount: 3.68 Kg
Elapsed Time 10.40 days

Lab Sample No.: G43182
Sample Submission Code: NWG 01 0884
Other Analysis Requested: AB
Comment: NES-W-1

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	4.65E-02	(-13 +- 13) E 1	42 E 1
Co-57	9.74E-01	(6 +- 65) E-2	220 E-2
Ce-144	9.75E-01	(17 +- 48) E-1	160 E-1
Ce-141	8.01E-01	(-16 +- 13) E-1	43 E-1
Mo-99	7.48E-02	(5 +- 14) E 1	46 E 1
Se-75	9.42E-01	(68 +- 91) E-2	300 E-2
Cr-51	7.71E-01	(-83 +- 65) E-1	220 E-1
I -131	4.08E-01	(-3 +- 16) E-1	53 E-1
Be-7	8.73E-01	(31 +- 59) E-1	190 E-1
Ru-103	8.33E-01	(-66 +- 78) E-2	260 E-2
xI -133	2.64E-04	----	----
Ba-140	5.69E-01	(10 +- 13) E-1	43 E-1
Cs-134	9.90E-01	(-49 +- 78) E-2	260 E-2
Ru-106	9.81E-01	(77 +- 58) E-1	190 E-1
Cs-137	9.99E-01	(5 +- 67) E-2	220 E-2
Ag-110M	9.72E-01	(168 +- 97) E-2	320 E-2
Zr-95	8.95E-01	(10 +- 12) E-1	41 E-1
Co-58	9.03E-01	(35 +- 75) E-2	250 E-2
Mn-54	9.77E-01	(-197 +- 73) E-2	240 E-2
Ac Th228	1.00E 00	(-53 +- 34) E-1	140 E-1
Tel-132	1.09E-01	(78 +- 38) E 0	130 E 0
Fe-59	8.52E-01	(25 +- 16) E-1	53 E-1
Zn-65	9.71E-01	(19 +- 17) E-1	57 E-1
Co-60	9.96E-01	(-2 +- 11) E-1	43 E-1
*+ K -40	1.00E 00	(95 +- 14) E 0	42 E 0
Sb-124	8.87E-01	(1 +- 23) E-1	77 E-1

Notes
* Activity greater than 3*standard deviation
\+ Peak is found
x Decay correction less than .01
Reporting level ratio = 0.000

Approved by

Russell Mellor.

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TABLE 3-19

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /2 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Ground Water

Sample Amount: 3.49 Kg
Elapsed Time 8.14 days

Lab Sample No.: G43183
Sample Submission Code: NWG 02 0884
Other Analysis Requested: AB
Comment: NES-W-2

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	9.05E-02	(48 +- 62) E 0	210 E 0
Co-57	9.79E-01	(-12 +- 62) E-2	210 E-2
Ce-144	9.80E-01	(25 +- 45) E-1	150 E-1
Ce-141	8.41E-01	(16 +- 12) E-1	39 E-1
Mo-99	1.31E-01	(-10 +- 74) E 0	250 E 0
Se-75	9.54E-01	(41 +- 85) E-2	280 E-2
Cr-51	8.16E-01	(12 +- 57) E-1	190 E-1
I -131	4.96E-01	(1 +- 11) E-1	38 E-1
Be-7	8.99E-01	(25 +- 57) E-1	190 E-1
Ru-103	8.67E-01	(-122 +- 69) E-2	230 E-2
xI -133	1.58E-03	----	----
Ba-140	6.43E-01	(9 +- 11) E-1	36 E-1
Cs-134	9.93E-01	(43 +- 75) E-2	250 E-2
Ru-106	9.85E-01	(8 +- 55) E-1	180 E-1
Cs-137	9.99E-01	(-65 +- 69) E-2	230 E-2
Ag-110M	9.78E-01	(70 +- 86) E-2	290 E-2
Zr-95	9.17E-01	(0 +- 13) E-1	43 E-1
Co-58	9.23E-01	(95 +- 64) E-2	210 E-2
Mn-54	9.82E-01	(-1 +- 66) E-2	220 E-2
AcTh228	1.00E 00	(52 +- 32) E-1	120 E-1
TeI-132	1.76E-01	(5 +- 21) E 0	71 E 0
Fe-59	8.82E-01	(4 +- 15) E-1	50 E-1
Zn-65	9.77E-01	(10 +- 17) E-1	55 E-1
Co-60	9.97E-01	(-97 +- 99) E-2	400 E-2
+ K -40	1.00E 00	(42 +- 85) E-1	250 E-1
Sb-124	9.10E-01	(-12 +- 17) E-1	56 E-1

Notes.
\+ Peak is found
x Decay correction less than .01
Reporting level ratio = 0.000

Approved by

E. L. Laurenze

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TABLE 3-20

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/12/84
Analysis Date: 3 /2 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Ground Water

Sample Amount: 3.59 kg
Elapsed Time: 8.14 days

Lab Sample No.: G43184
Sample Submission Code: NWG 03 0884
Other Analysis Requested: AB
Comment: NES-W-3

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	9.05E-02	(3 +- 86) E 0	290 E 0
Co-57	9.79E-01	(79 +- 79) E-2	260 E-2
Ce-144	9.80E-01	(-154 +- 58) E-1	190 E-1
Ce-141	8.41E-01	(-18 +- 15) E-1	51 E-1
Mo-99	1.31E-01	(-134 +- 82) E 0	270 E 0
Se-75	9.54E-01	(4 +- 11) E-1	37 E-1
Cr-51	8.16E-01	(4 +- 77) E-1	260 E-1
I -131	4.96E-01	(33 +- 16) E-1	54 E-1
Be-7	8.99E-01	(203 +- 71) E-1	240 E-1
Ru-103	8.67E-01	(-185 +- 85) E-2	280 E-2
xI -133	1.58E-03	----	----
Ba-140	6.43E-01	(-6 +- 15) E-1	49 E-1
Cs-134	9.93E-01	(-28 +- 90) E-2	300 E-2
Ru-106	9.85E-01	(-101 +- 89) E-1	300 E-1
Cs-137	9.99E-01	(164 +- 91) E-2	300 E-2
Ag-110M	9.78E-01	(-5 +- 12) E-1	40 E-1
Zr-95	9.17E-01	(5 +- 15) E-1	52 E-1
Co-58	9.23E-01	(-70 +- 82) E-2	270 E-2
Mn-54	9.82E-01	(-33 +- 89) E-2	300 E-2
AcTh228	1.00E 00	(-55 +- 42) E-1	170 E-1
TeI-132	1.76E-01	(14 +- 27) E 0	89 E 0
Fe-59	8.82E-01	(5 +- 17) E-1	55 E-1
Zn-65	9.77E-01	(29 +- 18) E-1	61 E-1
Co-60	9.97E-01	(-28 +- 14) E-1	59 E-1
K -40	1.00E 00	(-22 +- 15) E 0	61 E 0
Sb-124	9.10E-01	(-1 +- 25) E-1	82 E-1

Notes:
x Decay correction less than .01
Reporting level ratio = 0.000

Approved by

E. L. Laurenze

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TABLE 3-21

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 03/20/84
Analysis Date: 3 /2 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Ground Water

Sample Amount 3.62 kg
Elapsed Time 8.14 days

Lab Sample No.: G43185
Sample Submission Code: NWG 04 0884
Other Analysis Requested: AB
Comment: NES-W-4

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	9.05E-02	(-87 +- 66) E 0	220 E 0
Co-57	9.79E-01	(38 +- 68) E-2	230 E-2
Ce-144	9.80E-01	(38 +- 48) E-1	160 E-1
Ce-141	8.41E-01	(2 +- 13) E-1	44 E-1
Mo-99	1.31E-01	(-34 +- 68) E 0	230 E 0
Se-75	9.54E-01	(81 +- 97) E-2	320 E-2
Cr-51	8.16E-01	(-45 +- 66) E-1	220 E-1
I -131	4.96E-01	(-15 +- 12) E-1	40 E-1
Be-7	8.99E-01	(-54 +- 56) E-1	190 E-1
Ru-103	8.67E-01	(-104 +- 79) E-2	260 E-2
xI -133	1.58E-03	----	----
Ba-140	6.43E-01	(-10 +- 13) E-1	42 E-1
Cs-134	9.93E-01	(21 +- 84) E-2	280 E-2
Ru-106	9.85E-01	(32 +- 60) E-1	200 E-1
Cs-137	9.99E-01	(49 +- 68) E-2	230 E-2
Ag-110m	9.78E-01	(46 +- 88) E-2	290 E-2
Zr-95	9.17E-01	(-15 +- 12) E-1	40 E-1
Co-58	9.23E-01	(19 +- 73) E-2	240 E-2
Mn-54	9.82E-01	(10 +- 68) E-2	230 E-2
AcTh228	1.00E 00	(-6 +- 34) E-1	130 E-1
TeI-132	1.76E-01	(4 +- 22) E 0	73 E 0
Fe-59	8.82E-01	(-7 +- 15) E-1	51 E-1
Zn-65	9.77E-01	(-33 +- 17) E-1	58 E-1
Co-60	9.97E-01	(0 +- 10) E-1	42 E-1
K -40	1.00E 00	(-2 +- 12) E 0	47 E 0
Sb-124	9.10E-01	(23 +- 21) E-1	69 E-1

Notes:
\+ Peak is found
x Decay correction less than .01
Reporting level ratio = 0.000

Approved by

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TABLE 3-22

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

YAEC
Environmental Lab

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention Mr JOHN R. MAY

Report Date: 03/13/84
Analysis Date: 3 /7 /84
Date Received: 2 /27/84
Reference Date: 2 /23/84

Ground Water

Sample Amount 3.71 Kg
Elapsed Time 13.13 days

Lab Sample No.: G43186
Sample Submission Code: NWG 05 0884
Other Analysis Requested: AB
Comment: NES-W-5
Station No.: 05

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	2.08E-02	(-11 +- 26) E 1	87 E 1
Co-57	9.67E-01	(-16 +- 67) E-2	220 E-2
Ce-144	9.69E-01	(129 +- 51) E-1	170 E-1
Ce-141	7.56E-01	(-9 +- 15) E-1	49 E-1
Mo-99	3.78E-02	(-22 +- 26) E 1	87 E 1
Se-75	9.27E-01	(-2 +- 10) E-1	35 E-1
Cr-51	7.20E-01	(-51 +- 77) E-1	260 E-1
I -131	3.22E-01	(23 +- 22) E-1	72 E-1
Be-7	8.43E-01	(-14 +- 66) E-1	220 E-1
Ru-103	7.94E-01	(12 +- 90) E-2	300 E-2
x I -133	3.03E-05	----	----
Ba-140	4.91E-01	(-1 +- 18) E-1	61 E-1
Cs-134	9.88E-01	(-171 +- 91) E-2	300 E-2
Ru-106	9.76E-01	(-61 +- 75) E-1	250 E-1
Cs-137	9.99E-01	(-118 +- 88) E-2	290 E-2
Ag-110M	9.64E-01	(13 +- 11) E-1	36 E-1
Zr-95	8.69E-01	(11 +- 17) E-1	56 E-1
Co-58	8.79E-01	(-42 +- 87) E-2	290 E-2
Mn-54	9.71E-01	(-84 +- 84) E-2	280 E-2
AcTh228	1.00E 00	(36 +- 37) E-1	140 E-1
TeI-132	6.07E-02	(19 +- 83) E 0	280 E 0
Fe-59	8.17E-01	(29 +- 18) E-1	61 E-1
Zn-65	9.63E-01	(29 +- 16) E-1	52 E-1
Co-60	9.95E-01	(10 +- 13) E-1	52 E-1
K -40	1.00E 00	(-6 +- 12) E 0	49 E 0
Sb-124	8.60E-01	(-8 +- 23) E-1	78 E-1

Notes:
x Decay correction less than .01
Reporting level ratio = 0.000

Approved by

E. I. Laurenzo

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APR . . 1984

YAEC
Environmental Lab

TABLE 3-23

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Nuclear Energy Services, Inc.
Attention: MR. JOHN R. MAY

Report Date: 04/04/84
Date Received: 2 /27/84

Ground Water

	LAB. No. SAMPLE CODE	DATE of REFERENCE	DATE of ANALYSIS	VOLUME Kg	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram]	MDC
*	B43182 NWG 01 0884 Comment:NES-W-1	2 /23	4 /2	0.245	Beta	(1259 +- 22)E-1	24E-1
					Alpha	(-5 +- 28)E-1	93E-1
*	B43183 NWG 02 0884 Comment:NES-W-2	2 /23	3 /20	0.488	Beta	(208 +- 33)E-2	47E-2
					Alpha	(-41 +- 36)E-2	130E-2
*	B43184 NWG 03 0884 Comment:NES-W-3	2 /23	3 /20	0.488	Beta	(192 +- 33)E-2	46E-2
					Alpha	(13 +- 44)E-2	120E-2
*	B43185 NWG 04 0884 Comment:NES-W-4	2 /23	3 /20	0.488	Beta	(303 +- 34)E-2	46E-2
					Alpha	(-39 +- 34)E-2	120E-2
*	B43186 NWG 05 0884 Comment:NES-W-5	2 /23	3 /20	0.488	Beta	(266 +- 34)E-2	46E-2
					Alpha	(13 +- 43)E-2	120E-2

Notes:
* Activity is greater than 3*standard deviation

Approved by

[signature]

4. COMPARATIVE COMPILATION

4.1 PREVIOUS SURVEY AND SAMPLING DATA

Radiological surveys were performed at the site by the following agencies (Ref. 1) during the course of license termination in the 1970's.

NDA	Nuclear Development Corp. of America (UNC)	1956-57
NYSDH	New York State Dept. of Health	1959-75
NYSDEP	New York State Dept. of Environmental Protection	1970-75
CPC	Camo Pollution Control, Inc.	1980
DDH	Dutchess County Dept. of Health	1962-69

These surveys were performed on the property immediately adjacent to the lake, where the UNC buildings and structures are situated (see Figure 3-2). Samples were taken in this area of water, vegetation, soil, fish, wildlife, and the air.

A comparison of the resultant termination survey data has been made with that collected and detailed in Section 3 by NES during February, 1984.

Table 4-1 compares NES radiation readings to the levels found by aerial survey in May of 1980. In all areas except the Waste Storage Bldg., NES values are essentially at background levels as noted by EG&G. The Waste Storage Building contains floor level radiation well in excess of background contribution and normal statistical deviation. At the writing of this document, no data was available for a room-by-room comparison of NES data to whatever ground level radiation surveys, if any, were taken during the 1970's.

Table 4-2 shows results of soil sampling by NYSDEC and NES in identical grid areas outside the Plutonium Building, as well as additional soil samples.

Table 4-3 details data collected pertaining to aquatic vegetation samples obtained by NES as compared to data for local vegetation of all types (both land and aquatic).

Table 4-4 lists the comparative radiological data for water samples at the facility.

TABLE 4-1
MEASURED AMBIENT RADIATION AND LOOSE CONTAMINATION LEVELS

Location	Survey Performance		Ambient Radiation Levels	Loose Contamination Levels[1]
Lodge	NES	2/84	10-14 μR/Hr.	228-256 DPM
Engineering Bldg.	NES	2/84	11-17 μR/Hr.	220-270 DPM
Shield Mock-Up Bldg.	NES	2/84	12-17 μR/Hr.	206-268 DPM
Multiple Failure Bldg.	NES	2/84	11-22 μR/Hr.	242-266 DPM
Plutonium Bldg.	NES	2/84	10-25 μR/Hr.	218-314 DPM
Critical Facility	NES	2/84	11-29 μR/Hr.	236-288 DPM
Waste Disposal Bldg.	NES	2/84	15-25,000 μR/Hr.	222-336 DPM
Generator Shed	NES	2/84	7-14 μR/Hr.	214 DPM
General Grounds	NES	2/84	12-24 μR/Hr.	-
Background Levels	NES	2/84	8-24 μR/Hr.	212-280 DPM
General Grounds Aerial Survey	EG&G	5/80	6-14 μR/Hr.	-

[1] β/γ using scintillation counter.

TABLE 4-2
SOIL SAMPLE COMPARISON

Location	Survey Identification	DPM/gm Pu - dry	DPM/gm Gross α	DPM/gm Gross β	DPM/gm Total Gamma	Comments
Grid #1 (Fig. 3-1)	NYSDEC 1/23/75	25.63	-	-	-	
	NYSDEC 4/25/75	0.224/1.42	-	-	-	
	NES 2/23/84	-	0.19	0.39	0.50	+35/-35 Mesh
Grid #2 (Fig. 3-1)	NYSDEC 1/23/75	1.63	-	-	-	
	NES 2/23/84	-	0.40	0.39	0.47	
Grid #3 (Fig. 3-1)	NYSDEC 1/23/75	1.19	-	-	-	
	NES 2/23/84	-	0.525	0.68	0.58	
Grid #4 (Fig. 3-1)	NYSDEC 1/23/75	3.6	-	-	-	
	NYSDEC 4/25/75	0.262/2.85	-	-	-	
	NES 2/23/84	-	0.459	1.04	0.65	+35/-35 Mesh
Grid #4a (Fig. 3-1)	"	-	-	-	-	
		0.072/3.72	-	-	-	
		-	0.603	1.19	0.64	+35/-35 Mesh
Grid #5 (Fig. 3-1)	NYSDEC 1/23/75	0.87	-	-	-	
	NES 2/23/84	-	0.44	1.03	0.69	
Grid #6 (Fig. 3-1)	NYSDEC 1/23/75	0.35	-	-	-	
	NES 2/23/84	-	0.385	0.96	0.66	
Lake Sediment at Dam and Lake Outlet	NYSDEC 11/26/74	0.075	-	-	-	
	NES 2/23/84	-	0.31-0.96	0.89-1.22	0.63-0.82	
0.5 Mi due West of Lake	NES 12/5/83	-	0.56	1.20	1.26	

TABLE 4-3
VEGETATION SAMPLE COMPARISON

Location	Survey Identification		Results, DPM/gm Gross α	Gross β	Total γ
Critical Facility & Pu Lab Area	NDA (UNC)	2/24/56	-	690.	-
General Grounds	NDA (UNC)	10/25/56	-	806.	-
General Grounds	NDA (UNC)	-	-	429.	-
Aquatic Vegetation	NDA (UNC)	10/26/56	-	557.	-
Aquatic Vegetation	NDA (UNC)	3/21/57	-	7,509.	-
Aquatic Vegetation	NDA (UNC)	4/30/57	-	139.	-
Aquatic Vegetation	NES-V-7	2/23/84	0.529	0.855	0.08
	NES-V-8	2/23/84	0.185	0.525	0.118
	NES-V-9	2/23/84	0.503	1.906	0.157
	NES-V-10	2/23/84	0.977	1.388	0.431
0.5 Mi. due West of Lake	NES-V-2	12/5/83	0.159	1.310	0.140

TABLE 4-4

WATER SAMPLE COMPARISON

Location	Survey Identification	Results, pCi/l Gross α	Gross β	ISO γ
Lake	NDA (UNC) 11/56-3/57	-	0.3-9.76	-
Dam/Spillway	NDA (UNC) 2/57-3/57	-	4.88-5.56	-
Spillway	NYS Dept. of Health 3/63-8/65	-	3-54	0-70[1]
Lake	NYS Dept. of Health 1/67-12/68	-	2-88[2]	-
Lake	NYS DEC 1970	-	2-7	-
	1971	-	2-11	-
	1972	-	2-5	-
	1973	-	3-6	-
	1974	<1.1	<3-6	-
	1975	<1.0	<3-7	-
Lake Composite	NDA (UNC) 3/57-5/57	-	1.98-4.81	-
Lake	NYS Dept. of Health 1/59-4/75	-	2-12	-
Stream	NDA (UNC) 3/57-5/57	-	3.94-38.8	-
Dam/Spillway	NES-W-1 2/84	<MDC[3]	0.005	0.009
	NES-W-2 2/84	<MDC	7.7E-05	0.003
	NES-W-3 2/84	4.8E-06	7.1E-05	0.002
	NES-W-4 2/84	<MDC	1.1E-04	0.001
Retention Tank	NES-W-5 2/84	4.8E-06	9.8E-05	0.002

1 - Gross Gamma

2 - Total Gamma Isotopic From Section 3.

3 - MDC = Minimum Detectable Concentration

TABLE 4-4
WATER SAMPLE COMPARISON

Location	Survey Identification	Results, pCi/ℓ Gross α	Gross β	ISO γ
Lake	NDA (UNC) 11/56-3/57	-	0.3-9.76	-
Dam/Spillway	NDA (UNC) 2/57-3/57	-	4.88-5.56	-
Spillway	NYS Dept. of Health 3/63-8/65	-	3-54	0-70[1]
Lake	NYS Dept. of Health 1/67-12/68	-	2-88[2]	-
Lake	NYS DEC 1970	-	2-7	-
	1971	-	2-11	-
	1972	-	2-5	-
	1973	-	3-6	-
	1974	<1.1	<3-6	-
	1975	<1.0	<3-7	-
Lake Composite	NDA (UNC) 3/57-5/57	-	1.98-4.81	-
Lake	NYS Dept. of Health 1/59-4/75	-	2-12	-
Stream	NDA (UNC) 3/57-5/57	-	3.94-38.8	-
Dam/Spillway	NES-W-1 2/84	<MDC[3]	0.005	0.009
	NES-W-2 2/84	<MDC	7.7E-05	0.003
	NES-W-3 2/84	4.8E-06	7.1E-05	0.002
	NES-W-4 2/84	<MDC	1.1E-04	0.001
Retention Tank	NES-W-5 2/84	4.8E-06	9.8E-05	0.002

1 - Gross Gamma

2 - Total Gamma Isotopic From Section 3.

3 - MDC = Minimum Detectable Concentration

4.2 UNRESTRICTED RELEASE CRITERIA

The unrestricted release criteria against which these results may be judged consist of:

A. Plutonium Concentration
in soil - New York State/NRC : ≤ 2 DPM Pu/gm dry soil

B. Radiation Levels in
Unrestricted
Areas - 10 CFR 20.105(b)(1) :< 2 mR/hr

C. Removable Surface
Contamination - Reg. Guide 1.86 :< 1000 dpm/100cm^2

5. DISCUSSION OF RESULTS

During the course of performing the contracted scope of work, NES discovered the existence of a localized area in the Waste Storage Building concrete floor that contained fixed residual radioactivity in excess of the limits established by the NRC 1982 guidelines for unrestricted access. This finding was reported to the National Park Service (Ref. 4) which in turn reported the finding to the NRC.

It is NES' recommendation that this residual radioactivity should be removed, packaged and transported to a licensed commercial disposal facility.

NES performed a very limited scope of sampling, analysis and radiation surveying. Except for the fixed radioactive contamination found in the Waste Storage Building, NES' efforts did not uncover any other residual radioactivity in excess of established limits for unrestricted access. However, due to the limited scope of the investigation, the data is inadequate to conclude that, once having decontaminated the Waste Storage Building, the entire site is free of any remaining residual radioactivity.

APPENDIX A
DATA FORMAT AND MINIMUM DETECTABLE CONCENTRATION VALUES
LABORATORY SAMPLES

Numerical values presented in the data tables are stated in terms of a computer E format, a format utilized to denote a power of 10. A datum quoted as 6E-02 should be interpreted as 6×10^{-2}. The concentration value and its associated 1 sigma uncertainty for a particular radionuclide in the sample are stated in parenthetical form. A datum stated as (6 ± 2) E-3 should be interpreted as $6 \times 10^{-3} \pm 2 \times 10^{-3}$.

All Minimum Detectable Concentrations (MDC), concentration and 1 sigma (68%) uncertainty values have been rounded to at least two significant digits. In all cases, the radionuclide concentration (whether positive or negative), one sigma uncertainty and the MDC values have been tabulated for each sample.

The quoted uncertainty term does not represent the propagation of all possible errors associated with the analytical technique but only the random uncertainty associated with the radioactive decay process (counting statistics). Estimates of the additional systematic (S) and random (R) uncertainties are: Calibration curves (S), $\pm 5\%$; sample positioning (source to detector) (R), $< \pm 2\%$; laboratory gravimetric or volumetric determinations made in the field by sponsor company personnel cannot be quantified and do not enter into the uncertainties quoted in this report. Information stated on the sample submittal form accompanying each sample is taken "as is", with no rounding techniques applied.

In order to quote the overall (both random and systematic) uncertainty of the final result at the 68% confidence level <u>only</u>, the equation stated below should be utilized.

$$\text{Total Relative Uncertainty} = \left[\left(t_v(P)\, s_x\right)^2 + \frac{\zeta_n(P)}{3} \sum_j \delta_j^2 \right]^{1/2}$$

and for the 68% confidence level:

$$\text{Total Relative Uncertainty} = \left[S_x^2 + \frac{1}{3} \sum_j \delta_j^2 \right]^{1/2}$$

where S_x is the relative total random uncertainty
tv(P) is student t statistic for the confidence level desired (tv(P=68%) = 1)

σ_j is the relative upper estimate of the systematic uncertainty of the j type

$\zeta_n(P)$ is variate in a normal distribution for the confidence level desired (ζ_n(P=68%) = 1)

The MDC values quoted in this report are a posteriori based on the definition stated in Section D-08 of HASL 300 with modifications to conform to NUREG's 0472 and 0473 dated 1978. Each MDC value is determined according to the equation:

$$MDC = \frac{(K_\alpha + K_\beta)\, So}{C}$$

where K_α is the value for the upper percentile of the standardized variate corresponding to the preselected risk for concluding falsely the activity is present (α).

K_β is the corresponding value for the predetermined degree of confidence for detecting the presence of activity ($1 - \beta$).

So is the estimated standard error for the net sample activity.

C is the constant comprised of the various parameters needed to convert the instrument's Lower Limit of Detection (LLD) (quoted in terms of CPM) to the sample's a posteriori MDC concentration (pCi/weight or volume).

When it is assumed that the gross activity and background count rates are approximately the same and $K_\alpha = K_\beta$, the above equation reduces to:

$$MDC = \frac{2K_\alpha \; 2 \cdot S_b}{C}$$

where S_b is the observed background standard error.

According to the instrument MDC requirements stated in NRC Regulatory Guide 4.8, the K_α and K_β values must correspond to the 95 percent confidence limit. Applying these criteria, the above equation reduces to:

$$MDC = \frac{4.66 * S_b}{C}$$

Under the current technical interpretation of the statistical criteria for the instrument LLD, the LLD value should serve only as an <u>a priori</u> estimate of detection capability for the instrumentation and not as an absolute level of activity that can or cannot be detected. Multiple determinations of a known activity analyzed for a length of time sufficient to achieve a LLD equal to the known activity will show a normal distribution about the LLD. That is, fifty percent of the analyses will be distributed below the LLD and fifty percent will be distributed above the LLD. However, ninety-five percent of the analyses would predict the presence of activity. Therefore, the MDC values are listed in the tables for the sole purpose of indicating that USNRC guides and possible plant operating technical specifications concerning MDC values have been met. Other statistical tests or criteria should be utilized to determine if the stated concentration is statistically different from zero or significantly greater than baseline concentration.

APPENDIX B

REFERENCES

1. "Nuclear Lake - A Resource in Question", Appalachian Trail Conference/Dutchess County Cooperative Extension, 1/18/82.

2. "Nuclear Lake - Recommendations and Action Plan for Future Use", Nuclear Lake Management Committee, 1982.

3. "Appalachian Trail Survey and Radiological Analysis", NES 81A1076, 1984.

4. Letter JRM-192, Nuclear Lake Radiation Survey, J. R. May (NES) to D. Richie (National Park Service), 3/2/84.

THE COUNTY OF DUTCHESS

APPALACHIAN TRAIL PROJECT OFFICE
JUL 11 1985
NATIONAL PARK SERVICE

David A. Richie
United States Department of Interior
National Park Service
Appalachian Trail Project
Harpers Ferry Center
Harpers Ferry, West Virginia 25425

Dear Mr Richie:

The Nuclear Lake Management Committee has completed a review of the Nuclear Energy Services'(NES) radiological study of the Nuclear Lake property. That review was designed to determine whether all of the recommendations of the committee's Site Clearance Sub-Committee had been addressed. Upon completion of the review, we have determined that three radiological testing recommendations have not, as yet, been undertaken. They are: testing of lake bottom sediments, exploration of the lake bottom for barrels, and testing of the on-lot sewerage disposal systems.

In response, the committee formed a subcommittee to develop recommendations for testing that would address these needs. Their recommendations were discussed and approved for transmittal to your agency by the Nuclear Lake Management Committee on June 26, 1985. Copies of the proposed testing programs are attached.

The committee is also concerned that the NES testing program did not include the locked vault in the Critical Facility. Prior to closing its testing program, the National Park Service must see to it that this vault is opened and its contents tested.

The Nuclear Lake Management Committee will not be meeting until such time as the recommendations set forth in the attachments to this letter have been undertaken or unless unusual circumstances merit a meeting. It is our intention to meet at an appropriate time in the future to discuss the committee's future activities and whether it can play a meaningful role in planning for the future use of this valuable resource.

Very truly yours

E.W. Gillert

Eric W. Gillert
Acting Chairperson
Nuclear Lake Management Committee

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eg.
Attachments

Nuclear Lake Management Committee
Subcommittee on Septic System Testing
Recommendations
June 26, 1985

As per Nuclear Lake Management Committee's request, the subcommittee has developed the following recommendations for testing the septic systems on the Nuclear Lake property.

Assumptions: This testing program is based on the assumption that Plutonium used at this facility was inadvertantly washed into the subsurface systems that were designed to dispose of sanitary wastes and wash water. Further, the subcommittee assumed that contamination would move through the components of the septic system. Those components include; the drain line, septic tank, septic tank outfall, the distribution box, leach field, and soils in close proximity to the leach field pipes. EDTA was used in the process of "washing down" the facility after the accident and during the decommissioning process. As a result of contact with the Institute of Ecosystem Studies, the subcommittee found that the use of this solvent would not increase the potential for the migration of Plutonium beyond the immediate area of the leach fields. Plutonium adhears to soil particles readily even when EDTA is present.

Testing recommendations:

1. The septic tank should be located and uncovered. Samples should then be taken from the mouth of the inlet pipe. Additional samples should also be taken from the residue in the bottom of the tank in the vicinity of the inlet and in close proximity to the outfall.

2. The distribution box should be located if, indeed the system include such a structure. When located and uncovered, samples should be taken from any residue in the inlet pipe and from any sediments that are found in the bottom of the box.

3. The location and configuration of the leach field must be determined. Based upon that determination, the piping system should be exhumed particularly at the extreme ends of the piping system. Simultaneously, soil samples should be taken next to the pipe particularly in those areas adjacent to the perforations or, in the case of ceramic tiles, next to open joints.

4. Shallow soil test holes should also be dug adjacent to the leach field pipes in a manner designed to determine if any migration has occured.

5. Each sample must be indexed to the sampling location and tested for Plutonium.

6. The results of this testing will allow an analyst to track the migration of any contamination through the septic system if any were introduced to the system. If contamination is found in the soil samples taken in the test holes within the leach field area, it may be appropriate to undertake further testing of the groundwater of this portion of the site. If, however, no contamination is found in the samples, we should assume that either no contaminates were introduced or that any that were introduced did not migrate to the farthest reaches of the system and did not enter the groundwater system.

Nuclear Lake Management Committee

Subcommittee on Lake Testing

Recommendations

26 June 1983

INTRODUCTION

This subcommittee was formed to present recommendations on two separate issues relating to the contamination of Nuclear Lake: (1) The alleged dumping of barrels of waste material in the lake, and (2) the direct release of radionuclides into the lake, either from waste discharged through the effluent pipe in the Waste Disposal building or from the explosion of 21 Dec 1972. Since these two issues require entirely different detection methods, we will report on them separately below.

Recommendations for Testing

for Direct Release of Radionuclides

RECOMMENDATION

To detect whether significant amounts of radioactivity were dumped directly into the lake, intensive sampling of the radioactivity of the surface sediments of Nuclear Lake should be carried out in the areas near the Plutonium Facility and the outfall of the effluent pipe from the Waste Disposal Building. Additionally, random samples should be taken elsewhere in the lake.

EXPLANATION OF RECOMMENDATION

Many radionuclides, including plutonium, tend to attach to particles and sink out of solution when released into natural waters. Therefore, it is far more likely that any plutonium released into Nuclear Lake is now held in the lake sediments, not in the lake water; nor would we expect the plutonium to have washed out of the lake. Because of this, previous samples measuring the radioactivity of the lake water are of limited use in determining whether the lake received (or now contains) significant amounts of radioactivity. Furthermore, there appears to have been only a few tests of the radioactivity of the lake sediments, taken near the lake outlet and the dam. Because plutonium is so insoluble under most conditions, it is more likely that it would have remained near the place that it entered the lake (probably near the Plutonium Facility) than that it moved to the lake outlet. Therefore, we do not feel that this testing is sufficient to establish the extent of radioactive contamination of Nuclear Lake sediments, and we strongly recommend that further testing of sediments be done to determine whether Nuclear Lake is contaminated with a significant amount of radioactivity.

The two most likely sources of radioisotopes at Nuclear Lake appear to be the explosion in the Plutonium Facility on 21 Dec 1972 and the discharge of waste waters from the Waste Disposal Building into the lake. Therefore, sampling should be concentrated in the areas near the Plutonium Facility and the outfall of the waste disposal pipe. Less intensive sampling should be done as one moves away from these sites. Although we suspect that contamination is most likely to occur in these areas if anywhere, it would also be desirable (if feasible) to take exploratory samples from other parts of the lake to confirm our suspicion.

It is not possible for us to make detailed recommendations about sampling methods without knowing more about Nuclear

Lake and its sediments. Nonetheless we can offer a few guidelines. Since the radioisotopes were added to the lake relatively recently, it is very likely that the highest levels of radiation occur in the uppermost few centimeters of sediment. It is necessary to collect samples of these surface sediments unmixed with deeper sediments to assess the extent of contamination of the lake and the degree of exposure to radiation of the biota, including people. Depending on the types of sediments found in Nuclear Lake, appropriate sampling methods might include hand-held diver cores or gravity cores taken from a boat.

Also, it is important that the sampling design used be adequate to give a good estimate of the amount of radioactivity in the areas that we think may have been contaminated. Lake sediments are patchy in their physical and chemical properties, including their ability to hold substances such as plutonium. Also, we cannot pinpoint the exact locations where radionuclides might have entered the lake. Therefore, we recommend that the areas near the Plutonium Facility and the outfall pipe from the Waste Disposal building be sampled thoroughly. Ideally, such a sampling scheme will be designed after an initial field survey of the bathymetry and sediment characteristics of the survey area, but we offer the following as an example of the thoroughness of sampling that we are recommending (see attached sketch map). Samples could be taken just below the outfall from the Waste Disposal building and in two concentric circles at different distances from the outfall. In addition, three series of samples could be taken near the Plutonium Facility: at the shoreline, perhaps twenty to thirty feet offshore, and at the bottom of the slope in deep water (to check if contaminated particles were washed into deep water). Whatever the design chosen, it should be sufficient to demonstrate or deny with confidence the presence of radioactive contamination in Nuclear Lake sediments. Of course, if significant contamination is found, further sampling will be desirable.

Finally, we point out that a lake that has been contaminated with radioisotopes would be of great interest as a research site to ecological researchers. A scientist interested in environmental radiochemistry might be willing to work in cooperation with the NPS to conduct the recommended survey of Nuclear Lake at reduced cost. The NPS should explore this possibility.

Lake Bottom Barrel Survey Recommendations

INTRODUCTION

Heresay evidence indicates that there is a need to determine if there are any 55 gallon drums ("barrels") on the bottom of the lake. Consultation with divers and experts in the field of underwater search and recovery indicate that a combination of visual and instrumental search can determine the presence of drums on the lake bottom. The best way to proceed at each stage is dependent on the results of the previous steps. For example, the lake bottom sediment testing should be done prior to this survey, so that if it does not turn up any concentration of radioactivity then the risks involved in sending divers down are probably low enough as to be acceptable.

The combination most likely to succeed depends on the condition of the lake bottom. Since the creation of the lake left significant quantities of tree trunks on the bottom, then side-scan sonar is not likely to be helpful. Similarly, the use of a PDR (precision depth recorder) is not likely to work for the same reasons. Underwater photography can be used once a suspicious area has been located, but this could result in higher costs. As stated above, given no evidence of lake-bottom radioactivity AFTER additional testing, then allowing divers to investigate should pose no unacceptable risks. Finally, the use of a magnetometer (sensitive metal detector) is likely to pinpoint drums (and distinguish them from smaller metallic waste objects) UNLESS there is a lot of iron-bearing rock below the lake bottom which would trigger a large number of false positive reports.

RECOMMENDATIONS

1. That the lake-bottom sediment testing (recommendations submitted above) be done PRIOR to the procedures described herein, to help indicate the degree of risk involved in sending divers down. If this testing is NEGATIVE (no radioactivity above background levels), then the next step to be taken would be arranging for a diving expedition, perhaps with photographic or magnetometer equipment along. If this testing is POSITIVE (significant radioactivity found), then divers should NOT be asked to enter the lake, and additional work should be done by instruments.

2. That a Request for Proposal (RFP) be issued for a grid search of the lake (upon completion of item 1 above, assuming NEGATIVE results). The intent of this search would be to first locate potential sites of drums on the lake bottom, using one or a combination of approaches,

as deemed most feasible by the responding organization, such as the following: (a) underwater photography, (b) magnetometer (sensitive metal detector), or (c) diving itself. The RFP should specify that the search procedure should concentrate on the area within 500 feet of the buildings and the area between that area and the dam/outlet. Other areas can be spot-checked (e.g., northern and eastern regions of the lake). If the above approaches indicate that a suspicious site or sites is found, then the position should be indicated by marker buoys, and divers should investigate the bottom at close range, taking suitable precaution to avoid disturbing the potential problem area. The contractor should submit a report of the site(s) located, with underwater photographs if possible, including map(s) showing the marked suspicious site(s), if any. We expect this procedure can be done in two days, with the contractor supplying the required boat, diving apparatus, buoys, instrumentation, insurance certificate, etc., in a likely cost range of $ 1500 to $ 5000. While it may be possible to appeal to local diving clubs for help, the potential for risks requires both a waiver and proof of insurance in any case. The RFP should specify that, for the area for which we desire a close search, that grid spacing be defined (based on the choice of divers or instruments used) so that essentially no bottom area be missed in those portions of the lake; this may require grid spacing of 25 to 60 feet.

3. If any of the procedures used in item 2 above do result in drums being located, our expert sources indicate that it should be possible to report their presence to the EPA and within reason to expect that we can demand that the EPA remove the drums at government expense.

4. In any case, the report of the grid survey should be kept on record at the Dutchess County Farm and Home Center, the New York/New Jersey Trail Conference office, the Appalachian Trail Conference office, and the National Park Service AT Project office.

The subcommittee wishes to thank those people who assisted in developing these recommendations, including Marsh Scuba Supply, Poughkeepsie; Mid-Hudson Diving Center, Kingston; Mr. Kirk Wright, scientific diving consultant; Dr. Ruth Turner, Harvard University and Woods Hole Oceanographic Institute; Dr. Robert Ballard, Geologist at Woods Hole; Dr. Jonathan Cole, Aquatic Microbiologist, Institute of Ecosystem Studies; and Mr. Clyde Asbury, graduate student, Cornell University. Most of those consulted have expressed a willingness to be of further help if requested, for example, in reviewing the RFP prior to its release. Additionally, the subcommittee requests that the Park Service review the RFP (and any contract draft) prior to release, to determine if it meets the recommendations of the experts contacted.

Subcommittee members:

Ron Rosen, Dutchess County AT Management Committee

Dave Straver, Institute of Ecosystem Studies, Cary Arboretum

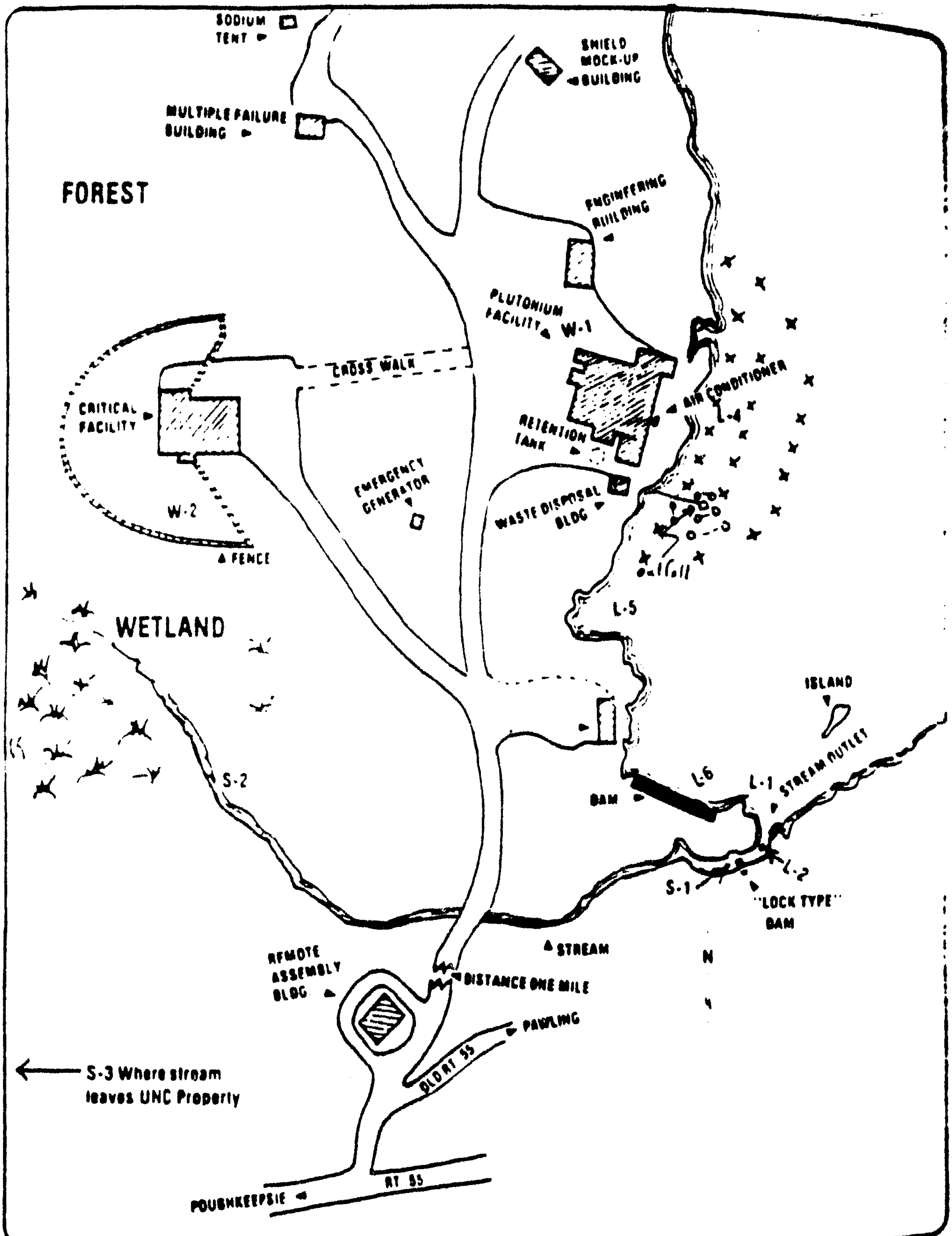

Figure VI-1 Sample Location Map for sampling points from tables 20 - 27

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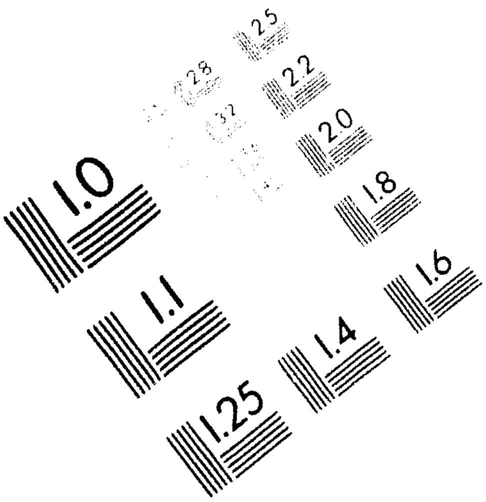
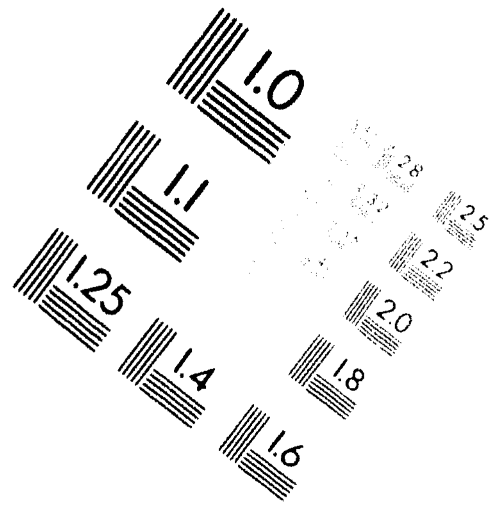
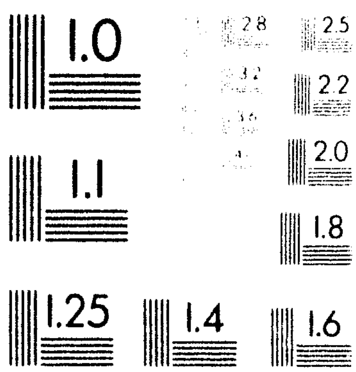
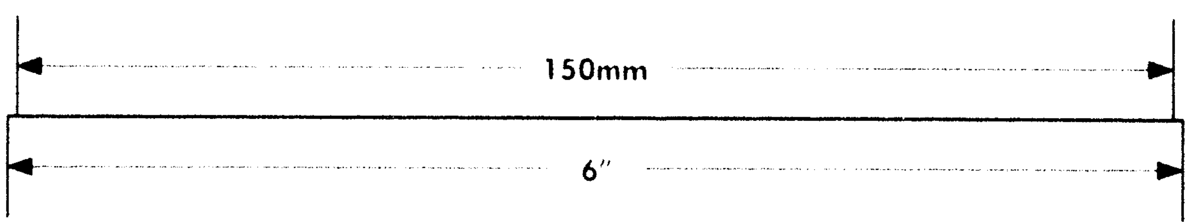
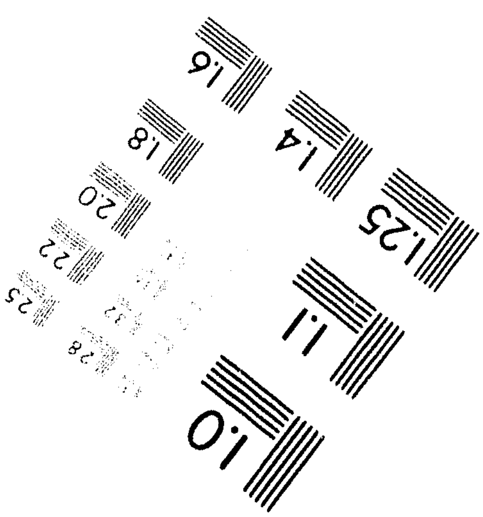
IMAGE EVALUATION TEST TARGET (MT-3)











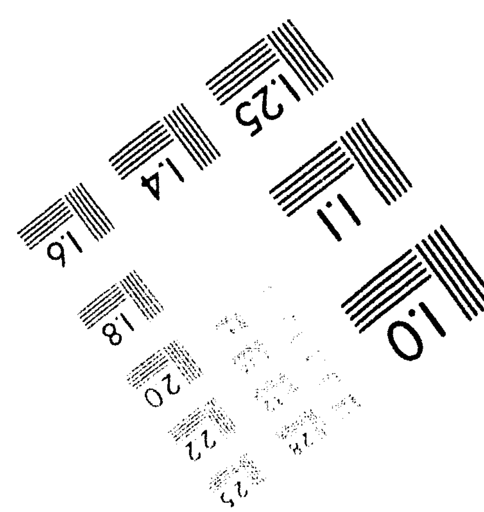


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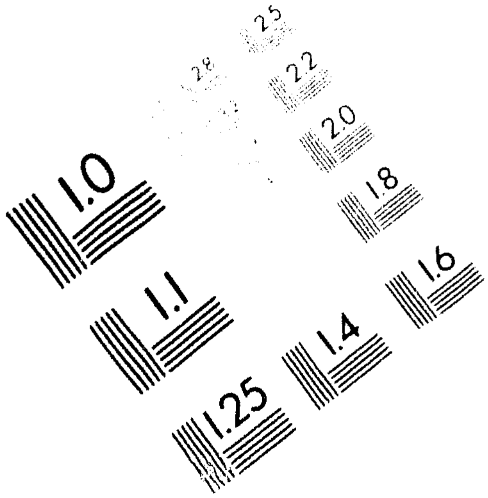
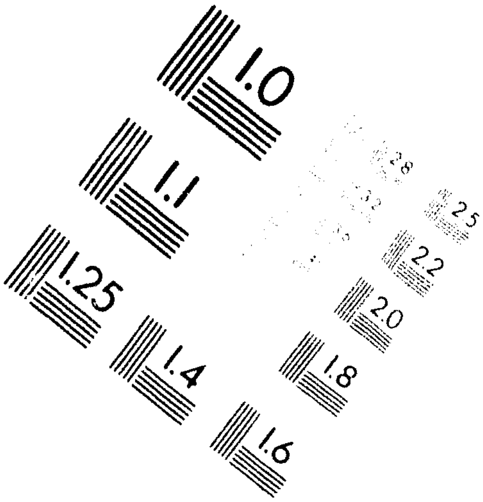
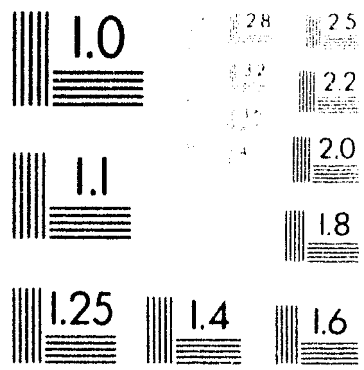
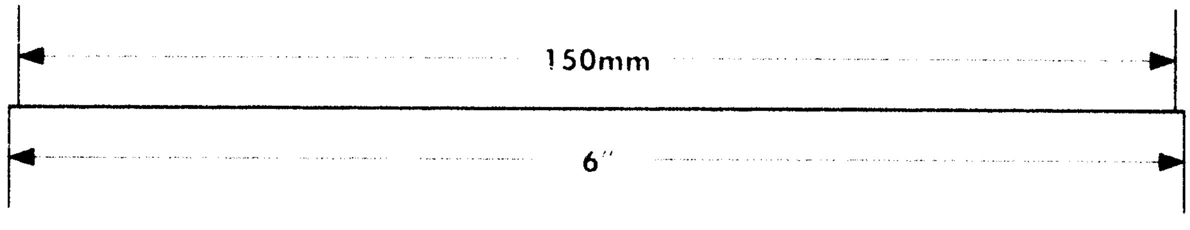
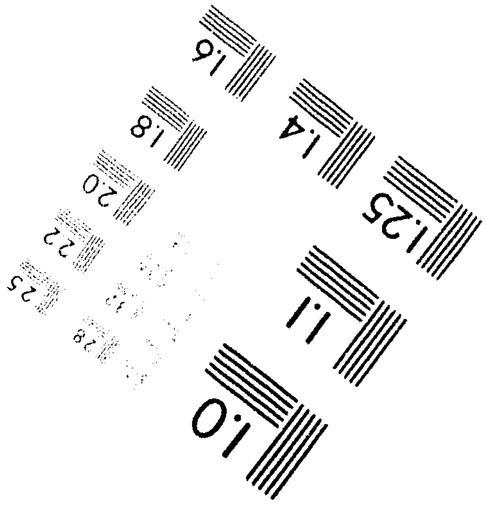
IMAGE EVALUATION TEST TARGET (MT-3)

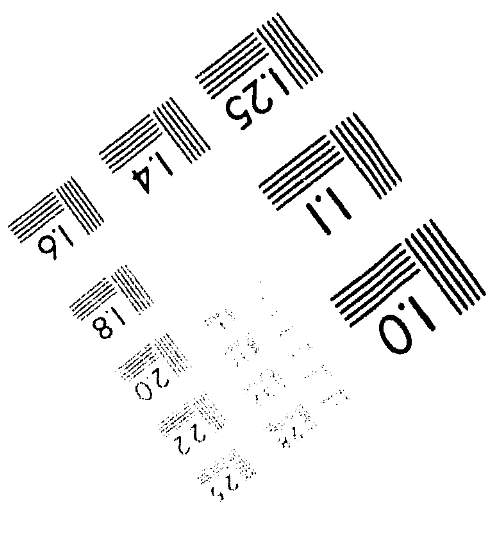












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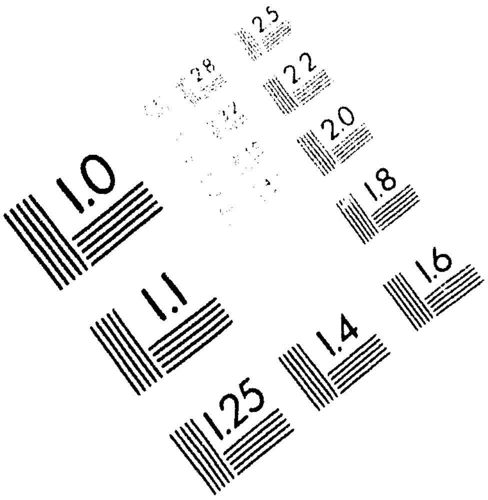

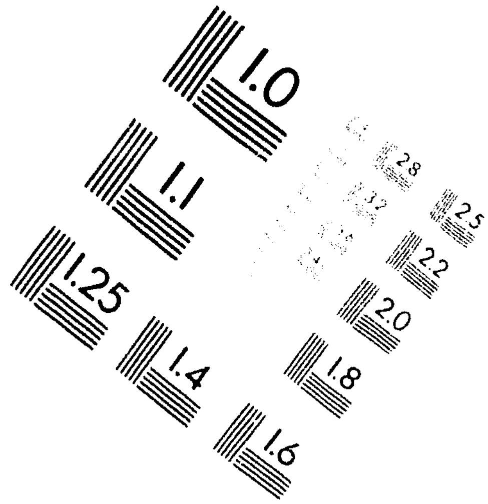

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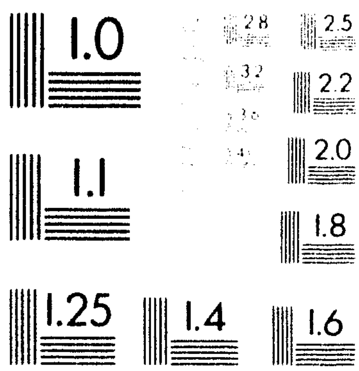

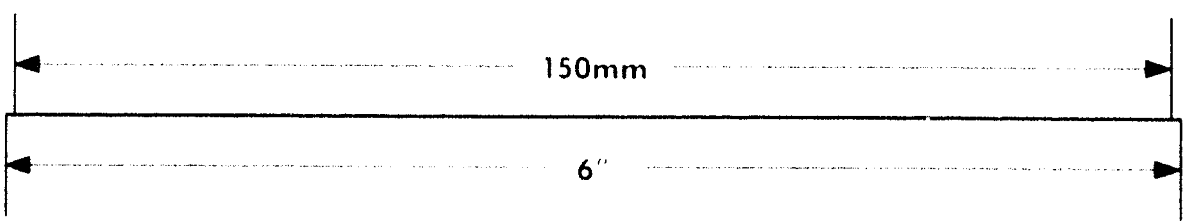

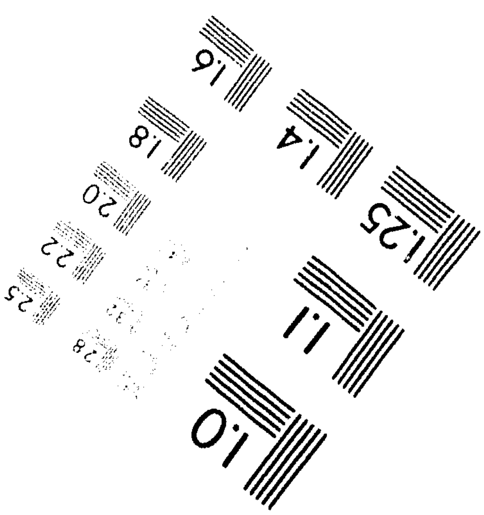

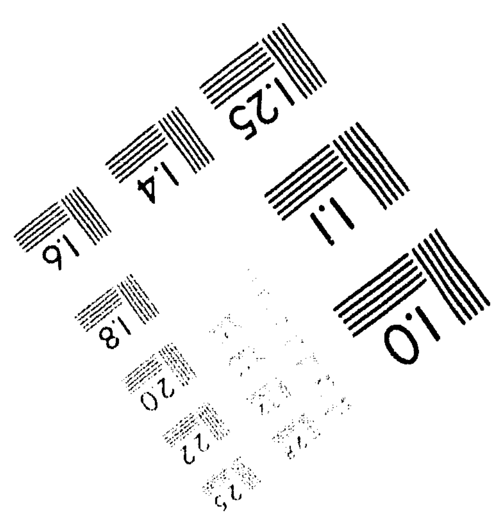

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