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Oak Ridge, Tennessee 37831— 8723

September 17, 1991

Distribution

**ANNUAL SITE ENVIRONMENTAL REPORT - MIDDLESEX SAMPLING PLANT**

Enclosed for your information is a copy of the 1990 Annual Site Environmental Report for the U.S. Department of Energy's Middlesex Sampling Plant located in your region. This report is prepared and published annually for distribution to interested local, state, and federal agencies; members of the public; and the press.

If you have any questions on the content of this report or desire additional information, please contact me either directly at (615) 576-1830, or you may call toll-free at (800) 253-9759.

Sincerely,

William M. Seay, Deputy Director
and Acting New Jersey Site Manager
Former Sites Restoration Division

Enclosure

DOE/OR/21949-285

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-91OR21949

# MIDDLESEX SAMPLING PLANT ANNUAL ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

## Middlesex, New Jersey

September 1991

Bechtel National, Inc.

0189-0260.5

DOE/OR/21949-285

# MIDDLESEX SAMPLING PLANT
# ANNUAL ENVIRONMENTAL REPORT
# FOR CALENDAR YEAR 1990

MIDDLESEX, NEW JERSEY

SEPTEMBER 1991

Prepared for

United States Department of Energy

DOE Field Office, Oak Ridge

Under Contract No. DE-AC05-91OR21949

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

## EXECUTIVE SUMMARY

Environmental monitoring of the U.S. Department of Energy's (DOE) Middlesex Sampling Plant (MSP) and surrounding area began in 1980. MSP is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

It is DOE policy to conduct its operations in an environmentally responsible manner that provides protection of human health and the environment. To that end, DOE is committed to incorporating national environmental protection and restoration programs, minimizing risks to the public and the environment, and addressing potential environmental hazards before they pose a threat to public welfare or environmental quality.

Environmental monitoring programs have been established at DOE-managed sites to confirm adherence to DOE environmental protection policies; to determine the effects of site operations on human health and the environment; and to ensure compliance with legal and regulatory requirements imposed by federal, state, and local agencies. Environmental monitoring programs are developed and implemented on a site-specific basis to accommodate facility characteristics, applicable regulations, hazard potential, quantities and concentrations of materials released, extent and use of affected land and water, and local public interest or concern. The environmental monitoring program at MSP includes sampling networks for radon concentrations in air; external gamma radiation exposure; and radium-226, thorium-232, and total uranium concentrations in surface water, sediment, and groundwater. Additionally, several nonradiological parameters were measured in groundwater, surface water, and sediment.

Monitoring results are compared with applicable Environmental Protection Agency (EPA) standards; federal, state, and local applicable or relevant and appropriate requirements (ARARs); and/or

DOE derived concentration guidelines (DCGs). Environmental standards, ARARs, and DCGs are established to protect public health and the environment.

Results from the 1990 environmental monitoring program show that the concentrations of contaminants of concern were all below applicable standards, ARARs, and DCGs. These results are discussed in Sections 4.0 and 5.0; a brief summary is provided below. Because the site is used only for interim storage and no processing effluents are produced, all parameters, except for radon and direct gamma, are monitored on a periodic basis.

During 1990, average radon concentrations (including background) for each monitoring station at the boundary ranged from 0.4 to 1 pCi/L (0.02 to 0.04 Bq/L), well below the DOE guideline of 3.0 pCi/L (0.1 Bq/L). Additionally, radon flux measurements were collected to demonstrate that the site was in compliance with the limit of 20 pCi/m$^2$/s (0.74 Bq/m$^2$/s) set forth in 40 Code of Federal Regulations (CFR) Part 61, Subpart Q; the average radon flux rate for each pile was 0.09 pCi/m$^2$/s (3E-3 Bq/m$^2$/s). (Note: 1E-n is equal to 1 x 10$^{-n}$.) The average external gamma exposure rate at the site boundary was 55 mR/yr (excluding background), and the average onsite was 76 mR/yr (excluding background). The annual average background level for external gamma radiation was 64 mR/yr. Annual average concentrations of radium-226 and total uranium in surface water ranged from 0.3E-9 to 2.8E-9 and 3E-9 to 60E-9 $\mu$Ci/ml (0.01 to 0.1 and 0.1 to 2.2 Bq/L), respectively, well below the DCGs for water of 100E-9 and 600E-9 $\mu$Ci/ml (3.7 and 22 Bq/L). All thorium-232 annual averages were 0.1E-9 $\mu$Ci/ml (4E-3 Bq/L); the DCG for water is 50E-9 $\mu$Ci/ml (1.9 Bq/L). Annual average concentrations in sediment ranged from 0.7 to 6.0, 0.5 to 1.0, and 0.7 to 11 pCi/g (0.03 to 0.2, 0.02 to 0.04, and 0.03 to 0.41 Bq/g) for radium-226, thorium-232, and total uranium, respectively. Currently, there are no guidelines in effect for radionuclide concentrations in sediment; however, the radium-226 and thorium-232 concentrations in sediment were below the FUSRAP guideline of 5 pCi/g (0.19 Bq/g) in the top 15 cm (6 in.) of soil for these radionuclides in Main Stream. Elevated levels of radium-226 and

uranium-238 at the plant outfall and drainage ditch leading to Main Stream are being investigated. There are no guidelines for uranium in soil in the Middlesex area; however, except for third-quarter readings, uranium concentrations were near background levels. Annual average concentrations of radium-226, thorium-232, and total uranium in groundwater ranged from 0.3E-9 to 2.4E-9, 0.1E-9 to 1E-9, and 3E-9 to 123E-9 μCi/ml (0.01 to 0.09, 4E-3 to 0.04, and 0.1 to 4.6 Bq/L), respectively. All measured values were below the DOE DCGs for water.

To determine basic surface water quality, surface water sampling for specific conductance, pH, total organic carbon (TOC), total organic halides (TOX), and metals was initiated during the third quarter; third-quarter samples were also analyzed for volatile and semivolatile organic compounds. The averages for the third and fourth quarters ranged from 80 to 240 μmhos/cm for specific conductance, 6.9 to 7.4 for pH, 3.0 to 26 mg/L for TOC, and 27 to 70 μg/L for TOX. The only metals detected with regularity were boron, calcium, magnesium, manganese, sodium, and zinc. Organic sampling showed very little contamination of surface water with volatile compounds and no contamination with semivolatile compounds. Sediment samples were analyzed for metals during fourth-quarter sampling; aluminum, calcium, copper, iron, magnesium, manganese, nickel, and zinc were detected in every sampling location. Concentrations of metals in downstream locations did not differ significantly from those upstream. Chemical analyses were not performed to meet any regulatory requirements; therefore, there are no comparative standards for these parameters.

Quarterly groundwater samples were also analyzed for specific conductance, pH, TOC, and TOX. Samples collected during the third and fourth quarters were analyzed for metals, and third-quarter samples were also analyzed for volatile and semivolatile organic compounds; these parameters were monitored to determine basic groundwater quality. Annual average specific conductance ranged from 131 to 580 μmhos/cm, and annual average pH ranged from 5.9 to 7.8. Annual average TOC concentrations ranged from 1.3 to

629 mg/L, and annual average TOX concentrations ranged from 20 to 47 μg/L. The only metals detected with regularity were boron, calcium, iron, magnesium, manganese, sodium, and zinc. Generally, results for all parameters in upgradient and downgradient wells were similar. Organic sampling showed very little contamination of groundwater with volatile or semivolatile compounds. Carbon disulfide and trichloroethane were the only compounds found in above detection limits. Because chemical analyses were not performed to meet any regulatory requirements, there are no comparative standards for these parameters.

To verify that MSP is in compliance with the DOE public dose limit of 100 mrem/yr (1 mSv/yr) above background through all exposure modes from all DOE-controlled sources of radiation, the potential radiation dose was calculated for a hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site. Based on a conservative scenario, this hypothetical individual would receive an exposure excluding background of approximately 2.6 mrem/yr (0.026 mSv/yr), well below the DCG of 100 mrem/yr. Meteorological data to support dose calculations and determine compliance with 40 CFR Part 61, Subpart H, were obtained from the National Oceanic and Atmospheric Administration.

To verify that MSP was in compliance with Subpart H, the EPA AIRDOS model was used to calculate the dose to a hypothetical maximally exposed individual resulting from airborne radionuclides transported from the site. The calculated dose was 0.0034 mrem/yr (3.4E-5 mSv/yr), which is well below the 10 mrem/yr limit given in Subpart H. The population within an 80-km (50-mi) radius of MSP would receive a population dose of 0.28 person-rem/yr (0.0028 person-Sv/yr) from materials on the site. This collective population dose is extremely small compared with the collective population dose from natural background radiation of 9.6E+5 person-rem/yr (9.6E+3 person-Sv/yr) for the population within 80 km (50 mi) of the site.

During 1990, site activities were limited to environmental monitoring, a special study on stream sediments in the MSP

vicinity, and site maintenance. There were no nonroutine releases from the site; MSP was in compliance with all applicable regulations for releases from the site, as has been the case since it was included in FUSRAP in 1980.

## CONTENTS


| | Page |
|---|---|
| Figures | x |
| Tables | xi |
| Acronyms | xiii |
| Units of Measure | xv |
| 1.0 INTRODUCTION | 1 |
| 1.1 DOE INVOLVEMENT | 1 |
| 1.2 SITE HISTORY | 1 |
| 1.3 SITE DESCRIPTION | 2 |
| 1.4 LAND USE | 2 |
| 1.5 CLIMATE | 7 |
| 2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE | 9 |
| 2.1 PRIMARY REGULATORY GUIDELINES | 9 |
| 2.2 APPLICABLE ENVIRONMENTAL PERMITS | 14 |
| 2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS | 14 |
| 2.4 SUMMARY OF COMPLIANCE IN CALENDAR YEAR 1991 (FIRST QUARTER) | 14 |
| 3.0 ENVIRONMENTAL PROGRAM INFORMATION | 15 |
| 3.1 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM | 15 |
| 3.1.1 Environmental Monitoring Requirements | 15 |
| 3.1.2 Monitoring Networks | 16 |
| 3.1.3 Summary of Environmental Monitoring Data | 17 |
| 3.2 APPLICABLE ENVIRONMENTAL PERMITS | 19 |
| 3.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS | 19 |
| 3.4 SUMMARY OF ENVIRONMENTAL ACTIVITIES | 20 |
| 3.5 SELF-ASSESSMENTS | 20 |
| 4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM | 24 |
| 4.1 ENVIRONMENTAL MONITORING FOR RADIOLOGICAL CONTAMINANTS | 25 |
| 4.1.1 Radon Monitoring | 25 |
| 4.1.2 External Gamma Exposure Monitoring | 30 |
| 4.1.3 Surface Water Monitoring | 40 |
| 4.1.4 Sediment Monitoring | 44 |
| 4.1.5 Groundwater Monitoring | 48 |
| 4.2 POTENTIAL DOSE TO THE PUBLIC | 58 |
| 4.2.1 Maximally Exposed Individual | 60 |
| 4.2.2 Population Dose | 61 |
| 5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM | 64 |
| 5.1 SURFACE WATER MONITORING | 64 |
| 5.1.1 Program Description | 64 |
| 5.1.2 Data and Discussion | 65 |
| 5.1.3 Trends | 75 |
| 5.2 SEDIMENT MONITORING | 75 |
| 5.2.1 Program Description | 75 |
| 5.2.2 Data and Discussion | 75 |
| 5.2.3 Trends | 78 |

**CONTENTS**
(continued)


| | | Page |
|---|---|---|
| 5.3 | GROUNDWATER MONITORING | 78 |
| 5.3.1 | Program Description | 78 |
| 5.3.2 | Data and Discussion | 78 |
| 5.3.3 | Trends | 81 |
| 6.0 | GROUNDWATER PROTECTION PROGRAM | 92 |
| 6.1 | HYDROGEOLOGICAL CHARACTERISTICS | 92 |
| 6.1.1 | Site Hydrogeology | 92 |
| 6.1.2 | Groundwater Quality and Usage | 92 |
| 6.2 | GROUNDWATER MONITORING | 93 |
| 6.2.1 | Methods | 93 |
| 6.2.2 | Results and Conclusions | 97 |
| 7.0 | QUALITY ASSURANCE | 107 |
| REFERENCES | | 112 |
| APPENDIX A | METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA | A-1 |
| APPENDIX B | POPULATION EXPOSURE METHODOLOGY | B-1 |
| APPENDIX C | ENVIRONMENTAL STANDARDS | C-1 |
| APPENDIX D | PARAMETERS FOR ANALYSIS | D-1 |
| APPENDIX E | SAMPLE OBSERVATION WELL CONSTRUCTION LOGS AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS | E-1 |
| APPENDIX F | RADIATION IN THE ENVIRONMENT | F-1 |
| APPENDIX G | CONVERSION FACTORS | G-1 |
| APPENDIX H | DISTRIBUTION LIST FOR MIDDLESEX SAMPLING PLANT ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990 | H-1 |

## FIGURES


| Figure | Title | Page |
|---|---|---|
| 1-1 | Location of MSP | 3 |
| 1-2 | Map of the MSP Site | 4 |
| 1-3 | Aerial View of MSP | 5 |
| 1-4 | Generalized Land Use in the Vicinity of MSP | 6 |
| 4-1 | Radon and External Gamma Radiation Monitoring Locations at MSP | 26 |
| 4-2 | External Gamma Radiation Exposure Rates | 37 |
| 4-3 | Surface Water and Sediment Sampling Locations in the Vicinity of MSP | 41 |
| 4-4 | Groundwater Wells Monitored for Radiological and Chemical Contamination at MSP in 1990 | 51 |
| 6-1 | Monitoring Wells Used for Water Level Measurements at MSP in 1990 | 95 |
| 6-2 | Potentiometric Surface Map of Upper Groundwater System at MSP (1/10/90) | 98 |
| 6-3 | Potentiometric Surface Map of Upper Groundwater System at MSP (3/14/90) | 99 |
| 6-4 | Potentiometric Surface Map of Upper Groundwater System at MSP (6/15/90) | 100 |
| 6-5 | Potentiometric Surface Map of Upper Groundwater System at MSP (9/20/90) | 101 |
| 6-6 | Potentiometric Surface Map of Lower Groundwater System at MSP (1/10/90) | 103 |
| 6-7 | Potentiometric Surface Map of Lower Groundwater System at MSP (3/14/90) | 104 |
| 6-8 | Potentiometric Surface Map of Lower Groundwater System at MSP (6/15/90) | 105 |
| 6-9 | Potentiometric Surface Map of Lower Groundwater System at MSP (9/20/90) | 106 |

## TABLES


| Table | Title | Page |
|---|---|---|
| 1-1 | Summary of Climatological Data for the Newark Vicinity, 1990 | 8 |
| 3-1 | Sediment/Soil Sampling Results at Plant Outfall and Downstream Locations | 21 |
| 4-1 | Concentrations of Radon at MSP, 1990 | 28 |
| 4-2 | Trend Analysis for Concentrations of Radon at MSP, 1986-1990 | 31 |
| 4-3 | Average External Gamma Radiation Levels at MSP, 1990 | 34 |
| 4-4 | Trend Analysis for External Gamma Radiation Levels at MSP, 1986-1990 | 38 |
| 4-5 | Concentrations of Total Uranium, Radium-226, and Thorium-232 in Surface Water in the Vicinity of MSP, 1990 | 43 |
| 4-6 | Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations in Surface Water at MSP, 1986-1990 | 45 |
| 4-7 | Concentrations of Total Uranium, Radium-226, and Thorium-232 in Sediment in the Vicinity of MSP, 1990 | 47 |
| 4-8 | Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations in Sediment at MSP, 1986-1990 | 49 |
| 4-9 | Concentrations of Total Uranium, Radium-226, and Thorium-232 in Groundwater in the Vicinity of MSP, 1990 | 53 |
| 4-10 | Trend Analysis for Total Uranium, Radium-226, and Thorium-232 Concentrations in Groundwater at MSP, 1986-1990 | 55 |
| 4-11 | Summary of Calculated Doses for MSP, 1990 | 59 |
| 4-12 | Maximum Effective Dose to the General Public from MSP, 1990 | 63 |
| 5-1 | Reporting Limits for Organic Chemical Analyses of Surface Water and Groundwater at MSP During Third Quarter 1990 | 66 |

## TABLES

(continued)


| Table | Title | Page |
|---|---|---|
| 5-2 | Reporting Limits for Quarterly Metals Analyses of Surface Water, Sediment, and Groundwater at MSP | 69 |
| 5-3 | Analytical Results for Indicator Parameters in Surface Water at MSP, 1990 | 70 |
| 5-4 | Concentrations of Total Organic Carbon and Total Organic Halides in Surface Water at MSP, 1990 | 71 |
| 5-5 | Organic Compounds Detected in Surface Water at MSP During Third Quarter 1990 | 72 |
| 5-6 | Concentrations of Metals Detected in Surface Water at MSP, 1990 | 73 |
| 5-7 | Concentrations of Metals Detected in Sediment at MSP During Fourth Quarter 1990 | 76 |
| 5-8 | Analytical Results for Indicator Parameters in Groundwater at MSP, 1990 | 79 |
| 5-9 | Concentrations of Total Organic Carbon and Total Organic Halides in Groundwater at MSP, 1990 | 82 |
| 5-10 | Concentrations of Volatile and Semivolatile Organic Compounds Detected in Groundwater at MSP During Third Quarter 1990 | 84 |
| 5-11 | Concentrations of Metals Detected in Groundwater at MSP, 1990 | 86 |
| 6-1 | Selected Analyses of Groundwater from the Middlesex Region | 94 |
| 6-2 | MSP Monitoring Well Construction Summary | 96 |
| 7-1 | Summary Comparison of Water Sample Results (EPA and TMA/E) | 109 |
| 7-2 | Summary Comparison of Air, Soil, and Water Sample Results (EML and TMA/E) | 110 |

## ACRONYMS

| | |
|---|---|
| AEC | Atomic Energy Commission |
| ARAR | applicable or relevant and appropriate requirement |
| BNI | Bechtel National, Inc. |
| CAA | Clean Air Act |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CWA | Clean Water Act |
| CX | categorical exclusion |
| DCG | derived concentration guideline |
| DOE | Department of Energy |
| EA | environmental assessment |
| EE/CA | engineering evaluation/cost analysis |
| EPA | Environmental Protection Agency |
| FR | Federal Register |
| FUSRAP | Formerly Utilized Sites Remedial Action Program |
| MED | Manhattan Engineer District |
| MML | Middlesex Municipal Landfill |
| MSP | Middlesex Sampling Plant |
| NEPA | National Environmental Policy Act |
| NESHAPs | National Emission Standards for Hazardous Air Pollutants |
| NJAC | New Jersey Administrative Code |
| NJDEP | New Jersey Department of Environmental Conservation |
| NJRS | New Jersey Revised Statutes |
| NJSA | New Jersey Statutes Annotated |

## ACRONYMS

(continued)

| | |
|---|---|
| PCB | polychlorinated biphenyl |
| PERALS | photon/electron-rejecting alpha liquid scintillation |
| QA | quality assurance |
| QC | quality control |
| RCRA | Resource Conservation and Recovery Act |
| TCL | Target Compound List |
| TCLP | toxicity characteristic leaching procedure |
| TETLD | tissue-equivalent thermoluminescent dosimeter |
| TMA/E | Thermo Analytical/Eberline |
| TOC | total organic carbon |
| TOX | total organic halides |
| TSCA | Toxic Substances Control Act |
| USC | United States Code |

## UNITS OF MEASURE

| | |
|---|---|
| Bq | becquerel |
| C | Celsius |
| Ci | curie |
| cm | centimeter |
| F | Fahrenheit |
| ft | foot |
| ft msl | feet above mean sea level |
| g | gram |
| h | hour |
| ha | hectare |
| in. | inch |
| km | kilometer |
| L | liter |
| m | meter |
| mg | milligram |
| mi | mile |
| µCi | microcurie |
| µg | microgram |
| µmos | micromhos |
| ml | milliliter |
| mm | millimeter |
| mph | miles per hour |
| mR | milliroentgen |
| mrem | millirem |
| mSv | millisievert |
| pCi | picocurie |
| rem | roentgen equivalent man |
| s | second |
| Sv | sievert |
| yd | yard |
| yr | year |

# 1.0 INTRODUCTION

Environmental monitoring of the U.S. Department of Energy's (DOE) Middlesex Sampling Plant (MSP) and surrounding area began in 1980. This document describes the environmental monitoring program, the program's implementation, and the monitoring results for 1990.

## 1.1 DOE INVOLVEMENT

MSP is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a DOE program to decontaminate or otherwise control sites where residual radioactive materials remain from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has authorized DOE to remedy.

## 1.2 SITE HISTORY

The MSP facility was established in 1943 by the Manhattan Engineer District (MED) to sample, store, and/or ship uranium, thorium, and beryllium ores. In 1955, the Atomic Energy Commission (AEC), successor to MED, terminated the operation and later used the site for storage and limited sampling of thorium residues. In 1967, AEC activities ceased, onsite structures were decontaminated, and the site was certified for unrestricted use under criteria applicable at that time.

Between 1968 and 1980, the site changed hands, first to the General Services Administration, and then to the Department of the Navy for use as a U.S. Marine Corps reserve training center. In 1980, custody of MSP was returned to DOE, which then initiated remedial action to clean up vicinity properties. The Middlesex Municipal Landfill (MML), a vicinity property established in the mid-1940s, began to receive soil contaminated with pitchblende (high-grade uranium ore) in 1948, which resulted in contaminated soil being placed over existing fill at MML. By 1974, solid waste

disposal ceased at MML. Early radiological surveys indicated that 0.2 ha (0.5 acre) of MML required remediation; in 1984, approximately 12,000 $m^3$ (16,000 $yd^3$) of contaminated soil was returned to MSP for interim storage. Later investigations showed the contaminated area to be 1.2 ha (3.0 acres). By 1986, remediation at MML was essentially complete; 23,900 $m^3$ (31,200 $yd^3$) of contaminated soil was returned to MSP for interim storage. In 1987, MML was turned over to the Borough of Middlesex.

## 1.3 SITE DESCRIPTION

MSP occupies approximately 3.9 ha (9.6 acres) in north-central New Jersey within the Borough of Middlesex (Middlesex County) (Figure 1-1). The MSP property includes four buildings and two storage piles that total 50,748 $m^3$ (66,372 $yd^3$) of waste (Figure 1-2). More than 70 percent of the MSP site is paved with asphalt. The site, currently being used for interim storage of radioactively contaminated soil, is entirely fenced and public access is restricted. Figure 1-3 is an aerial photograph of the site.

## 1.4 LAND USE

As shown in Figure 1-4, land use in the vicinity of MSP is predominantly industrial/residential with some forest and meadow land. The property is bordered by the Lehigh Valley Railroad to the north, vacant land to the south, residential/commercial property to the east, and a salvage yard to the west.

The principal sources of potable water in the MSP area are wells and surface water from the Raritan River. Numerous private wells are located within 1.6 km (1 mi) of MSP, a public well field (Sebrings Mill) is about 2 km (1.25 mi) northwest, and a surface water intake is about 5 km (3 mi) downstream of the site. Approximately 100 percent of the Borough of Middlesex use these sources.

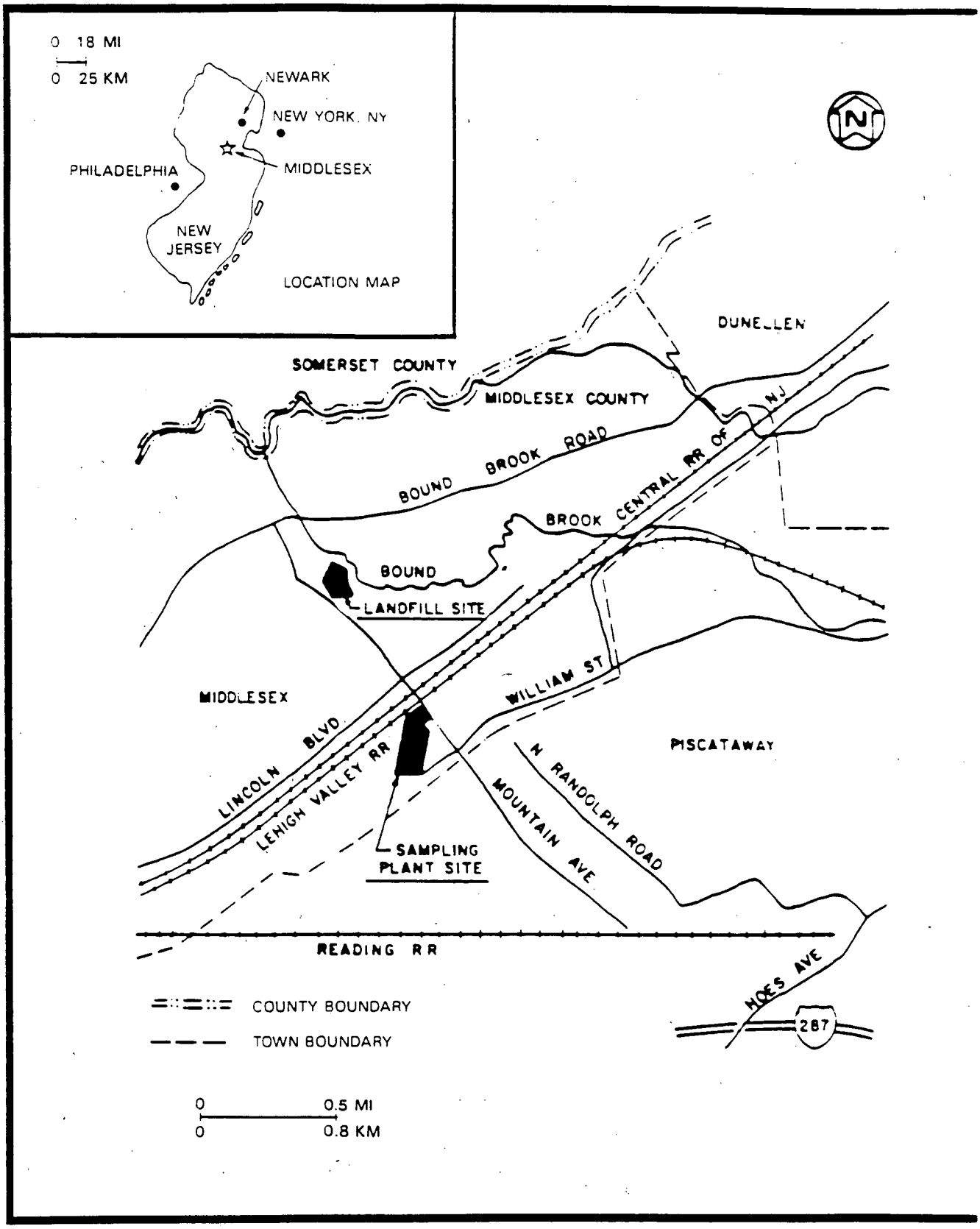


Figure 1-1 Location of MSP

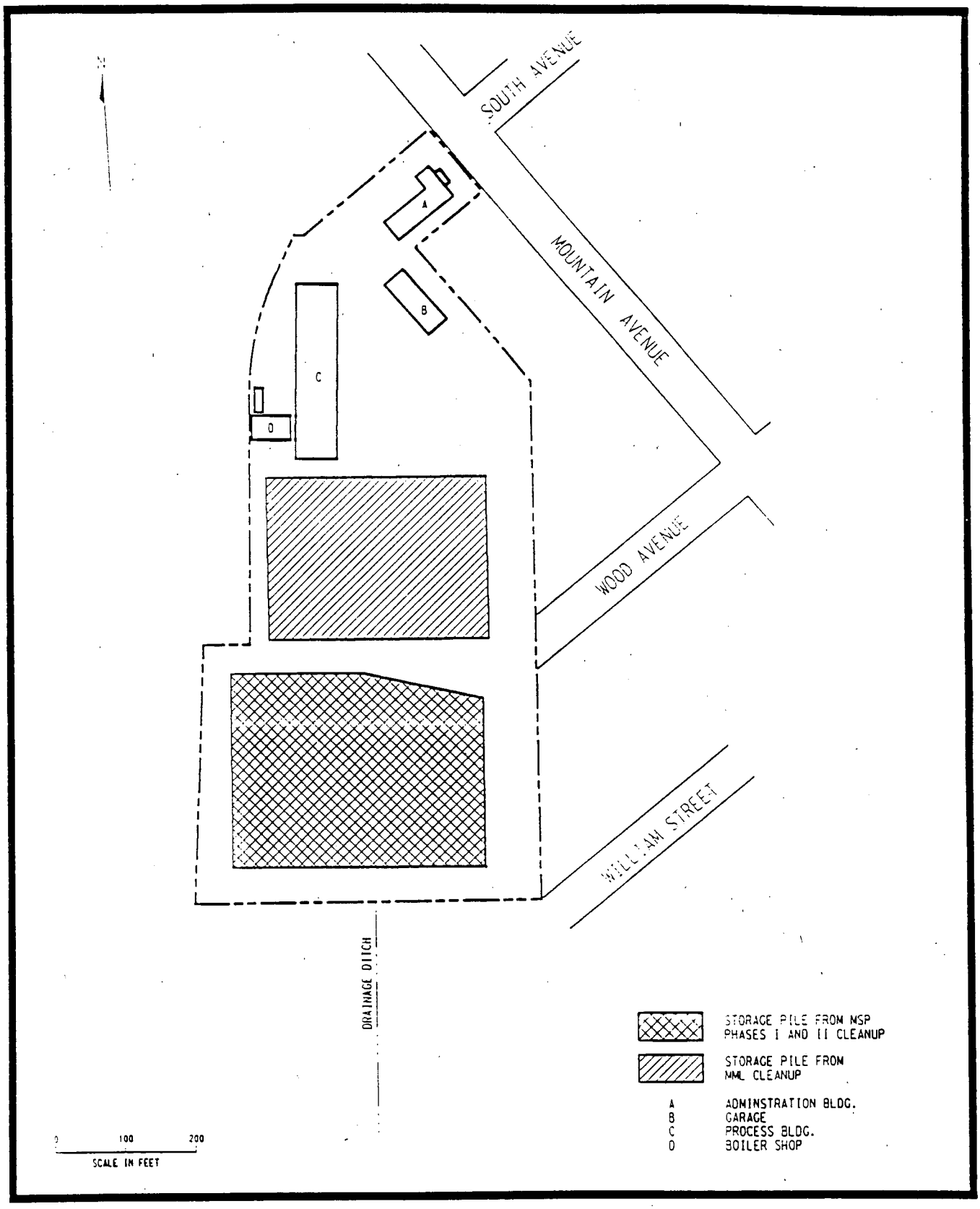


Figure 1-2 Map of the MSP Site

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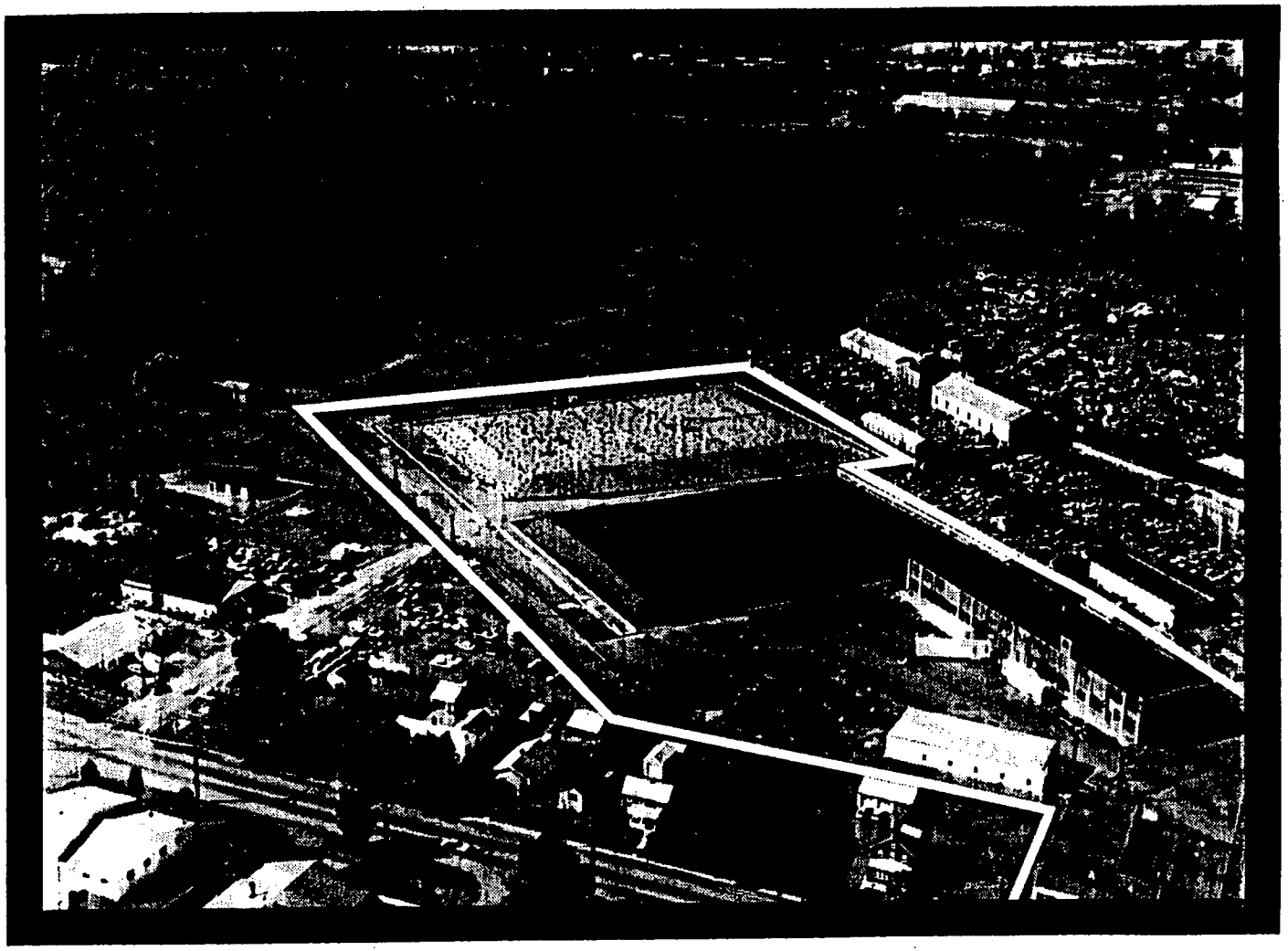
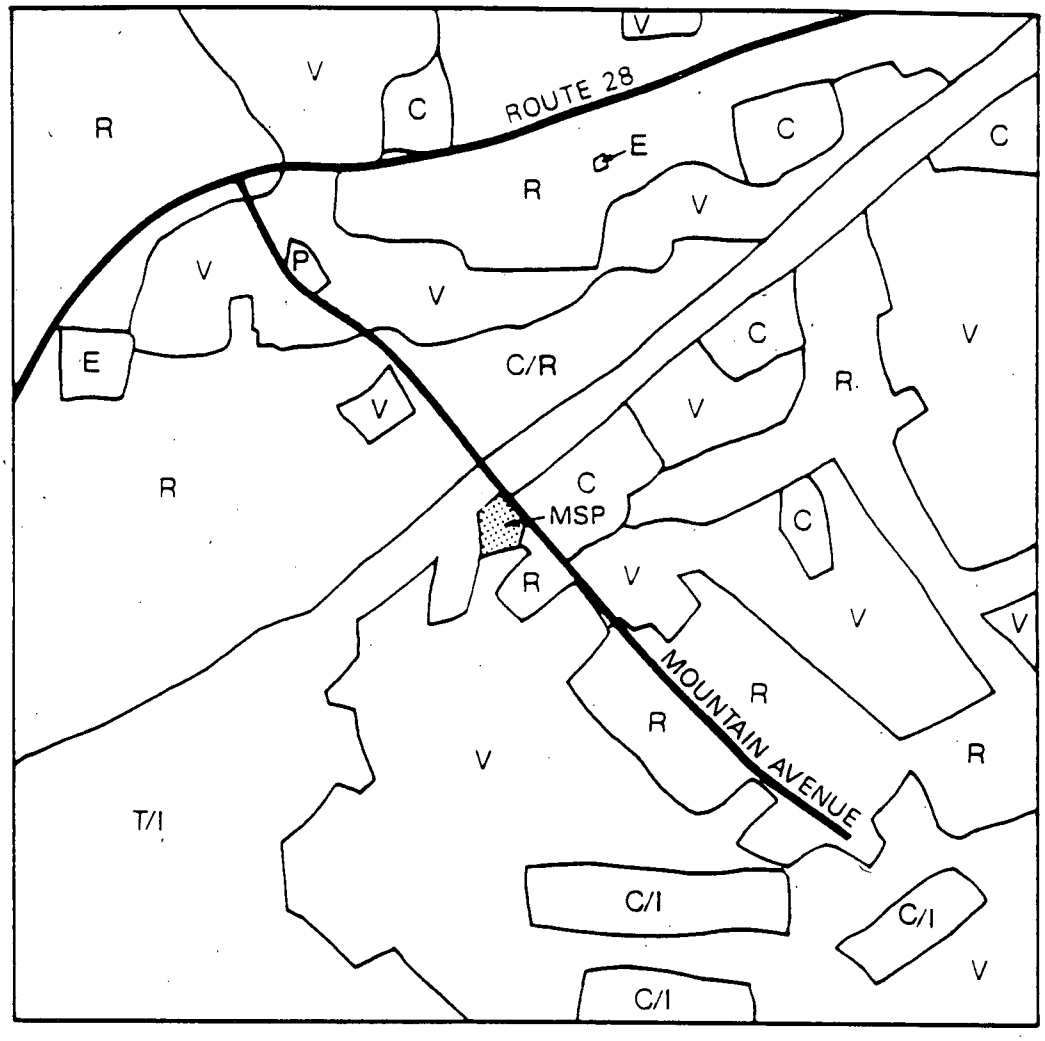


Figure 1-3 Aerial View of MSP




BASED ON AERIAL PHOTOGRAPHS, SITE VISITS, AND USGS TOPOGRAPHIC MAPS, 1:24000 SCALE, PLAINFIELD NJ QUADRANGLE, (PHOTO REVISED 1981) AND BOUND BROOK, (PHOTO REVISED 1970)

| | | | |
|---|---|---|---|
| R | RESIDENTIAL | C/I | COMMERCIAL/INDUSTRIAL |
| C | COMMERCIAL | T/I | TRANSPORTATION/INDUSTRIAL |
| C/R | MIXED RESIDENTIAL COMMERCIAL | V | VACANT |
| P | PUBLIC | E | EDUCATIONAL |

0 — 0.5 MI
0 — 0.8 KM

N

Figure 1-4 Generalized Land Use in the Vicinity of MSP

Surface water around the storage piles is conveyed via an underground drainage system to a settling basin and then to the easement ditch south of the site. From there it discharges into a small brook known as Main Stream.

The nearest residential areas are adjacent to the east side of the site; the residences are primarily mixed single- and multiple-family dwellings. The total population of the area lying within an 80-km (50-mi) radius of MSP is approximately 15 million (the population density is approximately 10,000 people per square mile).

## 1.5 CLIMATE

Table 1-1 is a summary of climatological data from the National Oceanic and Atmospheric Administration for the Newark vicinity for 1990. Temperature extremes ranged from -13 to 37°C (8.0 to 98°F). Average wind speeds ranged from 12.6 to 18.2 km/h (7.8 to 11.4 mph), and the predominant wind direction was from the west.

TABLE 1-1

SUMMARY OF CLIMATOLOGICAL DATA FOR

THE NEWARK VICINITY, 1990

| Month | Temperature (°F) | | | Total Precip (in.) | Wind | |
|---|---|---|---|---|---|---|
| | Min | Max | Avg | | Avg Speed (mph) | Resultant Direction |
| January | 22 | 66 | 40.4 | 4.72 | 9.6 | W |
| February | 8 | 66 | 39.8 | 1.71 | 11.1 | W |
| March | 13 | 86 | 44.9 | 2.81 | 9.9 | W |
| April | 32 | 94 | 53.3 | 3.98 | 9.9 | SW |
| May | 43 | 83 | 51.0 | 6.87 | 9.8 | W |
| June | 51 | 92 | 73.4 | 3.68 | 9.1 | SW |
| July | 58 | 98 | 77.8 | 4.98 | 8.8 | W |
| August | 58 | 93 | 76.6 | 7.71 | 8.3 | NW |
| September | 44 | 91 | 68.6 | 2.72 | 7.8 | W |
| October | 35 | 88 | 62.4 | 5.11 | 9.6 | SW |
| November | 29 | 79 | 50.0 | 2.82 | 11.4 | W |
| December | 21 | 67 | 42.3 | 5.19 | 10.5 | W |

Source: BNI 1991.

## 2.0 SUMMARY OF ENVIRONMENTAL COMPLIANCE

Throughout its history, MSP has been subject to evolving federal and state environmental regulations. The primary regulatory guidelines and limits are given in the DOE orders and authorized under six federal acts [the Clean Air Act (CAA); the Clean Water Act (CWA); the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the National Environmental Policy Act (NEPA)]. The following summaries describe compliance requirements as they existed in 1990, as well as anticipated regulatory requirements that may affect the site.

### 2.1 PRIMARY REGULATORY GUIDELINES

#### DOE Orders for Radionuclide Releases

Site releases must comply with specific DOE orders [5400 series and DOE Order 5820.2A, "Radioactive Waste Management" (DOE 1988)] that establish quantitative limits, derived concentration guidelines (DCGs), and dose limits for radiological releases from DOE facilities. The applicable guidelines and dose limits are presented in Appendix C. For Environmental Protection Agency (EPA) permitting purposes, DOE orders are treated as legal requirements, and remedial action activities conducted by DOE at its facilities are considered "federally permitted actions" [54 Federal Register (FR) 22524].

A review of environmental monitoring results for calendar year 1990 shows that MSP was in compliance with all applicable radionuclide release standards in DOE orders. Detailed monitoring results for radionuclides are presented in Section 4.0.

**Clean Air Act and National Emission Standards for Hazardous Air Pollutants**

The primary federal statute governing air emissions is the CAA [42 United States Code (USC) 7401 et seq.], as amended. Federal regulations governing air emissions are contained in 40 Code of Federal Regulations (CFR) Parts 50 through 87. New Jersey is a delegated state for implementation of National Emission Standards for Hazardous Air Pollutants (NESHAPs), per 40 CFR Section 61.04(AA); state requirements are codified in New Jersey Air Pollution Control Laws, Title 26, New Jersey Revised Statutes (NJRS), Chapter 2C, Air Pollution Control. However, New Jersey is not yet authorized to implement Subpart Q in lieu of EPA Region II.

The only potential sources of air emissions from MSP are radionuclide emissions from the waste piles. MSP does not have or require any state or federal air permits. Because it is a nonoperating facility, Subpart Q of NESHAPs is applicable (DOE 1990a). If the waste storage areas are modified in 1991, Subpart A will be applicable. A strategy for determining compliance with the radon flux standard in Subpart Q was approved by EPA in July 1990, and compliance with the EPA-approved strategy was attained and maintained in 1990.

Radionuclide emissions have been modeled using the EPA-approved computer model AIRDOS, and the effective dose to members of the public has been calculated. NESHAPs Subpart M contains the National Asbestos Emission Standards. Asbestos is present in pipes in the process building, and when the asbestos is removed, implementation of standards in Subpart M will be required.

Because EPA Region II has determined that the requirements imposed by the radionuclide NESHAPs are applicable during remedial actions, procedures for complying with Subpart Q will continue to be implemented when remedial action activities begin.

**Clean Water Act**

Waters discharged to navigable waters of the United States are regulated under the federal CWA, as amended (33 USC 1251 et seq.)

and its associated EPA regulations (40 CFR Parts 122, 136, 403, and 405 through 471). New Jersey requirements are codified in New Jersey Water Pollution Control Laws, Title 58, New Jersey Statutes Annotated (NJSA), Chapters 6A and 10.

A formal application for a stormwater discharge permit for a point-source discharge was submitted to the New Jersey Department of Environmental Protection (NJDEP) on January 19, 1990; the permit has not yet been issued to DOE.

On November 16, 1990, EPA promulgated changes to its stormwater regulations. Although these provisions did not affect reporting obligations for 1990, significant changes in compliance monitoring and reporting may occur in 1991.

**Resource Conservation and Recovery Act**

RCRA (40 USC 6901 et seq.) is the principal federal statute governing the management of hazardous waste. EPA regulations for implementing RCRA are contained in 40 CFR Parts 260 through 271. New Jersey is an authorized state for implementation of the RCRA program, and state RCRA requirements can be found in New Jersey Solid and Hazardous Waste Management Regulations, Title 7, New Jersey Administrative Code (NJAC), Chapter 26.

Neither RCRA-regulated wastes nor radioactive wastes containing RCRA-regulated wastes are known to be present at MSP. However, September 25, 1990, was the effective date for implementation of the new toxicity characteristic leaching procedure (TCLP) test for determining whether a solid waste exhibits the RCRA characteristic of toxicity. Soil samples taken from the two waste piles at MSP for toxicity analysis are currently being analyzed. Should any samples fail the TCLP or exhibit other RCRA characteristics, the applicability of RCRA will be reevaluated.

**Toxic Substances Control Act**

The most common toxic substances regulated by TSCA (15 USC 2601 et seq.) are polychlorinated biphenyls (PCBs) and asbestos. EPA

regulations regarding the production, use, storage, handling, and disposal of PCBs are codified in 40 CFR Part 761. New Jersey regulates the generation and disposal of asbestos in the New Jersey Solid and Hazardous Waste Management Regulations, Title 7, NJAC, Chapter 26. Like RCRA requirements, TSCA requirements will have to be met in CERCLA remedial actions where they are applicable or relevant and appropriate.

PCB management involves monitoring of in-service equipment; storage and disposal of equipment removed from service; cleanup and management of spill residues; and recordkeeping and reporting.

A small quantity of asbestos is present at MSP around piping in the process building. Before any asbestos waste is shipped offsite, the notification provisions mandated by New Jersey law will be complied with.

**Comprehensive Environmental Response, Compensation, and Liability Act**

CERCLA (42 USC 9601 et seq.) is the primary source of statutory authority for response actions to be conducted at MSP. EPA regulations governing cleanup activities are found in 40 CFR Part 300, which is the National Oil and Hazardous Substances Contingency Plan. CERCLA Section 121 mandates that CERCLA remedial actions comply with substantive requirements of environmental laws when they are applicable or relevant and appropriate. CERCLA mandates that applicable or relevant and appropriate requirements (ARARs) be attained during remedial actions and, to the greatest extent practicable considering the exigencies of the situation, during removal actions. ARARs are federal and state environmental statutes and regulations other than CERCLA that provide binding requirements for site-specific actions. There are three types of ARARs: (1) chemical-specific requirements that are usually health- or risk-based numerical values, (2) performance, design, or other action-specific requirements that are usually technology- or activity-based, and (3) location-specific requirements that are restrictions placed on concentrations of hazardous substances or

conduct of activities. ARARs are evaluated for their applicability throughout the CERCLA process. The ARAR identification process for MSP is continuing and will be completed before the final report is issued.

Unless all waste is removed from MSP, remediation of this site will be managed under the authority of CERCLA because wastes containing radionuclides are defined as hazardous substances under CERCLA. Any potential regulatory conflicts regarding removal action decisions will be resolved upon completion of an engineering evaluation/cost analysis (EE/CA) in fiscal year 1994. After the EE/CA is completed, the remedial design will be prepared for the removal action alternative chosen.

**National Environmental Policy Act**

Preparation of an environmental assessment (EA) may be required to complete remedial action activities for MSP. Documentation to justify a categorical exclusion (CX) for environmental monitoring and surveillance activities is being prepared. A CX is a class of DOE actions that normally does not require the preparation of an EA. An action for which a CX can be established is one that will have no potential for significant impact on human health and the environment. In November 1990, DOE proposed to amend its NEPA guidelines. Among the proposed revisions is an expansion of the list of CXs, including site characterization and environmental monitoring under CERCLA (55 FR 46444, September 7, 1990). The adoption of the amended guidelines will streamline the decision-making process when determining the appropriate level of NEPA documentation.

**Other Major Environmental Statutes and Executive Orders**

In addition to the aforementioned DOE orders and statutes, several other major environmental statutes have been reviewed for applicability. For example, the Federal Insecticide, Fungicide, and Rodenticide Act; the Endangered Species Act; the Safe Drinking

Water Act; and the National Historic Preservation Act have all been found to impose no current requirements on the MSP site. In addition, Executive Orders 11988 ("Floodplain Management") and 11990 ("Protection of Wetlands") and state laws and regulations have been reviewed for applicability and compliance. MSP is in compliance with, or not subject to, all applicable environmental statutes, regulations, and executive orders.

## 2.2 APPLICABLE ENVIRONMENTAL PERMITS

A formal application has been submitted for a point-source stormwater discharge permit for MSP in response to a notice of violation for discharge of stormwater runoff into a stream. The complete application was submitted on January 19, 1990; however, the permit has not yet been issued.

## 2.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

As stated, the preparation of an EA may be required to complete remedial action activities at MSP. Documentation to support a CX is being prepared, and the EE/CA is scheduled to be completed by 1994.

## 2.4 SUMMARY OF COMPLIANCE IN CALENDAR YEAR 1991 (FIRST QUARTER)

During the first quarter of calendar year 1991, full regulatory compliance continued in the same manner as during 1990 at MSP. Environmental monitoring continues, as does review of potentially applicable regulations for their impact on the site. NJDEP has taken no action on the stormwater permit application mentioned in the CWA section.

# 3.0 ENVIRONMENTAL PROGRAM INFORMATION

Routine monitoring for radiation, radioactive materials, and chemical substances on and off MSP is used to document compliance with appropriate standards, provide the public with information, provide a historical record for year-to-year comparisons, and identify environmental impacts. The environmental monitoring program assists in fulfilling the DOE policy of protecting public health and the environment.

The objectives of this report are to:

- Highlight significant programs and efforts
- Describe the environmental monitoring program
- Report 1990 radiological and nonradiological conditions of the site and surrounding areas
- Provide comparison of monitoring results and applicable regulations
- Provide trend analyses, where applicable, to indicate increases or decreases in contaminants
- Provide detailed information on the input and assumptions used in all dose calculations

The primary audience for the environmental monitoring results includes the general public; property owners; community interest groups; technical staffs of federal, state, and local government agencies; and regulatory personnel.

## 3.1 SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM

### 3.1.1 Environmental Monitoring Requirements

Requirements for environmental monitoring of radioactive materials are found in the DOE orders (5400 series) dealing with radiation protection of the public and the environment. These requirements include the monitoring of radionuclides in groundwater, surface water, and sediment at all DOE sites.

Requirements for environmental monitoring of airborne pollutants are found in NESHAPs; non-radon radionuclide and radon monitoring are required by NESHAPs. Radon monitoring was conducted at the MSP boundary to ensure compliance with DOE orders.

Requirements for environmental monitoring of nonradiological parameters are found in DOE Order 5400.1 (DOE 1989). Nonradiological parameters were monitored to obtain baseline information on groundwater, surface water, and sediment quality.

### 3.1.2 Monitoring Networks

The following common criteria were used in establishing the monitoring networks at MSP:

- All monitoring stations, except some groundwater wells and surface water and sediment sampling locations, are onsite and accessible only to employees and authorized visitors. All groundwater wells have locking caps to provide security.

- Some stations are located on or near the DOE site boundary to allow determination of exposure at the "fenceline" as required by DOE orders.

- Background stations are located offsite in areas known to be uncontaminated.

The medium-specific networks at MSP include:

- Twenty-seven radon monitoring stations (8 onsite, 17 at the site boundary, and 2 offsite)

- Twenty-seven gamma radiation monitoring stations (8 onsite, 17 at the site boundary, and 2 offsite)

- Five surface water monitoring locations (3 offsite downstream, 1 onsite downstream, and 1 offsite upstream)

- Five sediment monitoring locations (3 offsite downstream, 1 onsite downstream, and 1 offsite upstream)

- Twenty groundwater monitoring locations (3 onsite upgradient, 4 onsite downgradient, 2 offsite downgradient, and 1 offsite upgradient)

Details on the monitoring networks are provided in Sections 4.0 and 5.0.

### 3.1.3 Summary of Environmental Monitoring Data

The following subsections summarize environmental monitoring results for MSP for calendar year 1990. Detailed discussions of the radiological and nonradiological results are provided in Sections 4.0 and 5.0.

**Radon**

Annual average radon concentrations at the site boundary ranged from 0.4E-9 to 1E-9 $\mu$Ci/ml (0.02 to 0.04 Bq/L), including an average background level of 0.8E-9 $\mu$Ci/L (0.03 Bq/L) (Subsection 4.1.1). Radon concentrations at all monitoring locations along the site boundary were below the DOE guideline of 3E-9 $\mu$Ci/ml (0.1 Bq/L) for interim storage sites and remained close to background levels throughout the year. The only concentrations exceeding DOE guidelines were at stations located in the process building on site. Thoron monitoring was not conducted at MSP during 1990; however, it will be added to the environmental monitoring program in 1991.

Radon flux measurements were collected to demonstrate that the site was in compliance with the radon flux limit of 20E-9 $\mu Ci/m^2/s$ set forth in 40 CFR Part 61, Subpart Q. Both piles had average radon flux rates of 0.09E-9 $\mu Ci/m^2/s$ (3E-3 $\mu Ci/m^2/s$).

**External gamma radiation exposure**

The annual average external gamma radiation exposure level was 76 mR/yr onsite and 55 mR/yr at the property line, excluding an average background of 64 mR/yr. Detailed information on gamma radiation exposure monitoring can be found in Subsection 4.1.2.

**Surface water**

Surface water sampling was performed quarterly to determine concentrations of total uranium, radium-226, and thorium-232 and to assess any impact of site discharges to surface waters in the vicinity. Concentrations of radionuclides at downstream and upstream (background) sampling locations were essentially the same except for one total uranium value. Annual average concentrations ranged from 0.4E-9 to 2.8E-9 $\mu$Ci/ml (0.02 to 0.1 Bq/L) for radium-226 and from 3E-9 to 60E-9 $\mu$Ci/ml (0.1 to 2.2 Bq/L) for total uranium. Thorium-232 concentrations averaged 0.1E-9 $\mu$Ci/ml (4E-3 Bq/L). All radionuclide concentrations were below the DCGs of 100E-9 $\mu$Ci/ml (3.7 Bq/L) for radium, 50E-9 $\mu$Ci/ml (1.9 Bq/L) for thorium-232, and 600E-9 $\mu$Ci/ml (22 Bq/L) for total uranium.

**Sediment**

Sediment samples were collected in conjunction with surface water samples as a check for deposition of the contaminants of interest (total uranium, radium-226, and thorium-232). Average annual concentrations in sediment ranged from 0.7 to 6 pCi/g (0.03 to 0.2 Bq/g) for radium-226, 0.5 to 2 pCi/g (0.02 to 0.07 Bq/g) for thorium-232, and 0.7 to 11 pCi/g (0.03 to 0.4 Bq/g) for total uranium. Concentrations in downstream sediment were elevated compared with those found in upstream (background) samples (Subsections 3.4 and 4.1.4). There are currently no guidelines in effect for radionuclide concentrations in sediment; however, some of the radium-226 and thorium-232 values were greater than the 5 pCi/g (0.2 Bq/g) FUSRAP guideline for the top 15-cm (6-in.) layer

of soil (Appendix C). Radionuclide concentrations were comparable to the concentrations typically found in phosphate fertilizers (Appendix F).

**Groundwater**

Groundwater results were in general agreement with previous data. Quarterly groundwater samples were analyzed for total uranium, radium-226, thorium-232, and chemical indicator parameters [specific conductance, pH, total organic carbon (TOC), and total organic halides (TOX)], and metals. In addition, volatile and semivolatile organic compounds were analyzed for during the third quarter. Average annual concentrations in groundwater ranged from 0.3E-9 to 2.4E-9, 0.1E-9 to 1E-9, and 3E-9 to 123E-9 $\mu$Ci/ml (0.01 to 0.09, 0.004 to 0.04, and 0.1 to 4.6 Bq/L) for radium-226, thorium-232, and total uranium, respectively. Radionuclide concentration levels in all samples were below the DCGs of 100E-9, 50E-9, and 600E-9 $\mu$Ci/ml (3.7, 1.9, and 22 Bq/L) for radium-226, thorium-232, and total uranium, respectively. The groundwater quality is poor, but this is typical for an industrialized urban area.

## 3.2 APPLICABLE ENVIRONMENTAL PERMITS

A formal application for a point-source stormwater discharge permit was submitted for MSP on January 19, 1990; however, NJDEP has not yet issued the permit.

## 3.3 ENVIRONMENTAL IMPACT STATEMENTS AND ENVIRONMENTAL ASSESSMENTS

As stated in Section 2.0, documentation to support a CX is scheduled to be completed in fiscal year 1994, and an EE/CA is also scheduled for completion in 1994.

## 3.4 SUMMARY OF ENVIRONMENTAL ACTIVITIES

During spring 1990, a special study was begun to investigate elevated levels of radioactivity discovered during routine environmental monitoring of sediment downstream and in the vicinity of the MSP outfall and confluence (locations 1, 2, and 3 on Figure 4-3). A plan was designed to determine the extent of possible radioactive contaminants in the streambed. Location 2 was not sampled because of difficulties encountered by the sampling team; analytical results from locations 1 and 3 are given in Table 3-1. The levels of radioactivity in streambed sediments at location 1 are well above background for uranium-238 and DOE soil guidelines for radium-226, indicating that the contamination is probably due to radioactive particles setting out in the quiescent portions of the stream. This area was remediated in 1981. Results from location 3 show that average levels of radioactivity are near background. This study will be continued in 1991 to determine the extent of contamination downstream.

## 3.5 SELF-ASSESSMENTS

During 1990, DOE conducted two major self-assessments of the FUSRAP environmental monitoring program: one in June by the DOE Oak Ridge Operations Environmental Protection Division, the second in November by the DOE Headquarters Office of Environmental Audits. Findings from these two self-assessments focused on monitoring techniques, field documentation of monitoring events, and planning for environmental monitoring locations and events. As a result of the June assessed, corrective actions were developed and implemented before the next quarter's environmental monitoring. Actions remaining consist of developing environmental monitoring plans [required by DOE Order 5400.1 (DOE 1989)] to document the logic behind the environmental monitoring networks for FUSRAP sites. Work on these plans is currently under way; they are scheduled to be published by December 1991.

TABLE 3-1

SEDIMENT/SOIL SAMPLING RESULTS AT PLANT OUTFALL AND DOWNSTREAM LOCATIONS



| Sampling Location[a] | Matrix | Ra-226[b] | Th-232[b] | U-238[b] |
|---|---|---|---|---|
| Plant outfall (location 1) | | | | |
| Left culvert | Sediment | --[c] | --[c] | --[c] |
| Center culvert | Sediment | 7.3 | 0.9 | 4.2 |
| Right culvert | Sediment | 2.8 | 0.8 | 5.9 |
| 3 ft downstream | | | | |
| Left bank | Soil | 1.4 | 2.1 | 4.4 |
| Stream center | Sediment | 7.9 | 0.6 | 15 |
| Right bank | Soil | 8.5 | 1.8 | 19 |
| 8 ft downstream | | | | |
| Left bank | Soil | 1.4 | 1.9 | 4.7 |
| Stream center | Sediment | 22 | 3.3 | 36 |
| Right bank | Soil | 1.2 | 1.7 | 4.6 |
| 13 ft downstream | | | | |
| Left bank | Soil | 1.7 | 1.4 | 2.3 |
| Stream center | Sediment | 46 | 5.1 | 100 |
| Right bank | Soil | 1.4 | 1.7 | 2.4 |
| 18 ft downstream | | | | |
| Left bank | Soil | 1.4 | 2.2 | 4.8 |
| Stream center | Sediment | 54 | 5.9 | 100 |
| Right bank | Soil | 0.8 | 0.8 | 2.3 |
| 23 ft downstream | | | | |
| Left bank | Soil | 1.5 | 1.4 | 3.5 |
| Stream center | Sediment | 48 | 4.5 | 120 |
| Right bank | Soil | 1.4 | 2.6 | 5.0 |

TABLE 3-1

(continued)

| f 3 | | | | | |
|---|---|---|---|---|---|
| a | Matrix | Ra-226[b] | Th-232[b] | U-238[b] | 238[b] |
| am | | | | | |
| n 3)[d] | | | | | |
| nstream | | | | | |
| ank | Soil | 0.8 | 0.3 | 1.3 | |
| | Sediment | 0.5 | 0.6 | 1.4 | .7 |
| | Sediment | 0.7 | 0.7 | 2.7 | .8 |
| bank | Soil | 0.6 | 0.7 | 3.1 | .0 |
| | | | | | .5 |
| nstream | | | | | |
| nk | Soil | 0.8 | 0.4 | 1.8 | 4-3. |
| | Sediment | 0.5 | 0.3 | 1.4 | |
| | Sediment | 0.6 | 0.5 | 1.1 | alent |
| ank | Soil | 1.2 | 1.4 | 3.8 | |
| nstream | | | | | |
| nk | Soil | 2.1 | 0.8 | 2.7 | s |
| | Sediment | 0.9 | 0.8 | 1.6 | |
| | Sediment | 1.4 | 1.1 | 3.8 | |
| ank | Soil | 0.9 | 1.0 | 3.4 | |
| nstream | | | | | |
| nk | Soil | 4.1 | 1.6 | 14 | |
| | Sediment | 1.0 | 1.1 | 1.5 | |
| | Sediment | 1.1 | 1.3 | 2.7 | |
| ank | Soil | 4.5 | 1.4 | 8.1 | |
| nstream | | | | | |
| nk | Soil | 0.7 | 1.8 | 2.1 | |
| | Sediment | --[c] | --[c] | --[c] | |
| | Sediment | 0.8 | 0.6 | 2.7 | |
| nk | Soil | 0.8 | 0.8 | 2.7 | |
| nstream | | | | | |
| nk | Soil | 1.2 | 1.7 | 4.1 | |
| | Sediment | --[c] | --[c] | --[c] | |
| | Sediment | 1.4 | 1.1 | 3.5 | |
| nk | Soil | 3.4 | 1.6 | 7.8 | |

## 4.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

MSP is not an active site and produces no effluents. The only possibility for contamination to be released from the site would be through contaminant migration.

Radiological environmental monitoring at MSP in 1990 included sampling for:

- radon concentrations in air
- onsite external gamma radiation exposure
- radium-226, thorium-232, and total uranium concentrations in surface water, sediment, and groundwater

The monitoring systems included onsite, site boundary, and offsite stations to provide sufficient information on the site's potential effects on human health and the environment.

The information contained in this section of the report includes the quarterly radiological data for each sampling point, yearly averages, and trend information. The methodology for calculating the averages and standard deviations is provided in Appendix A. All quarterly data are reported as received from the laboratory; all calculated values (i.e., averages and standard deviations) have been rounded off using standard rules for significant figures. Where appropriate, data are presented using powers of ten. The number following the "E" denotes the exponent (e.g., $3.2 \times 10^{-1}$ is given as 3.2E-1).

Some of the quarterly results are reported using a "less than" (<) sign. This notation is used to denote specific sample results that are below the limit of sensitivity of the analytical method, based on a statistical analysis of parameters. For computing annual averages, quarterly values reported as less than a given limit of sensitivity are considered equal to that limit. The methodology use in calculating the averages and standard deviations is provided in Appendix A.

The following subsections discuss the monitoring program for possible radioactive contaminant migration and results for 1990.

## 4.1 ENVIRONMENTAL MONITORING FOR RADIOLOGICAL CONTAMINANTS

### 4.1.1 Radon Monitoring

One of the primary pathways of radiation exposure from the uranium-238 decay series arises from inhalation of the short-lived radon (radon-222) and radon daughter products. Radon is a radioactive (alpha-emitting) gas that is very mobile in air; monitoring is conducted at MSP to assess the impacts of the contaminants at the site on radon levels near the site. Thoron (radon-220), a radioactive gas from the thorium-232 decay series, was not included as part of the 1990 environmental monitoring program; however, thoron monitoring will be added to the program in 1991.

**Program description**

Radon concentrations were obtained quarterly using monitors that contain a piece of alpha-sensitive film enclosed in a small plastic two-piece cup. Radon diffuses through a seam or membrane (depending on the manufacturer of the detector) of the cup until the radon concentrations inside and outside the cup reach equilibrium. Alpha particles emitted from the radioactive decay of radon and its daughters create tiny tracks when they collide with the film. After they are collected, the films are placed in a caustic etching solution to enlarge the tracks; under strong magnification, the tracks are counted. The number of tracks per unit area (i.e., tracks/$mm^2$) is related through calibration to the radon concentration in air.

Radon detectors are maintained at 8 onsite, 17 site boundary, and 2 offsite locations; the onsite locations are shown in Figure 4-1. Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions. The offsite locations are used to measure background radon levels. One detector was retained at MML after ownership of that site was

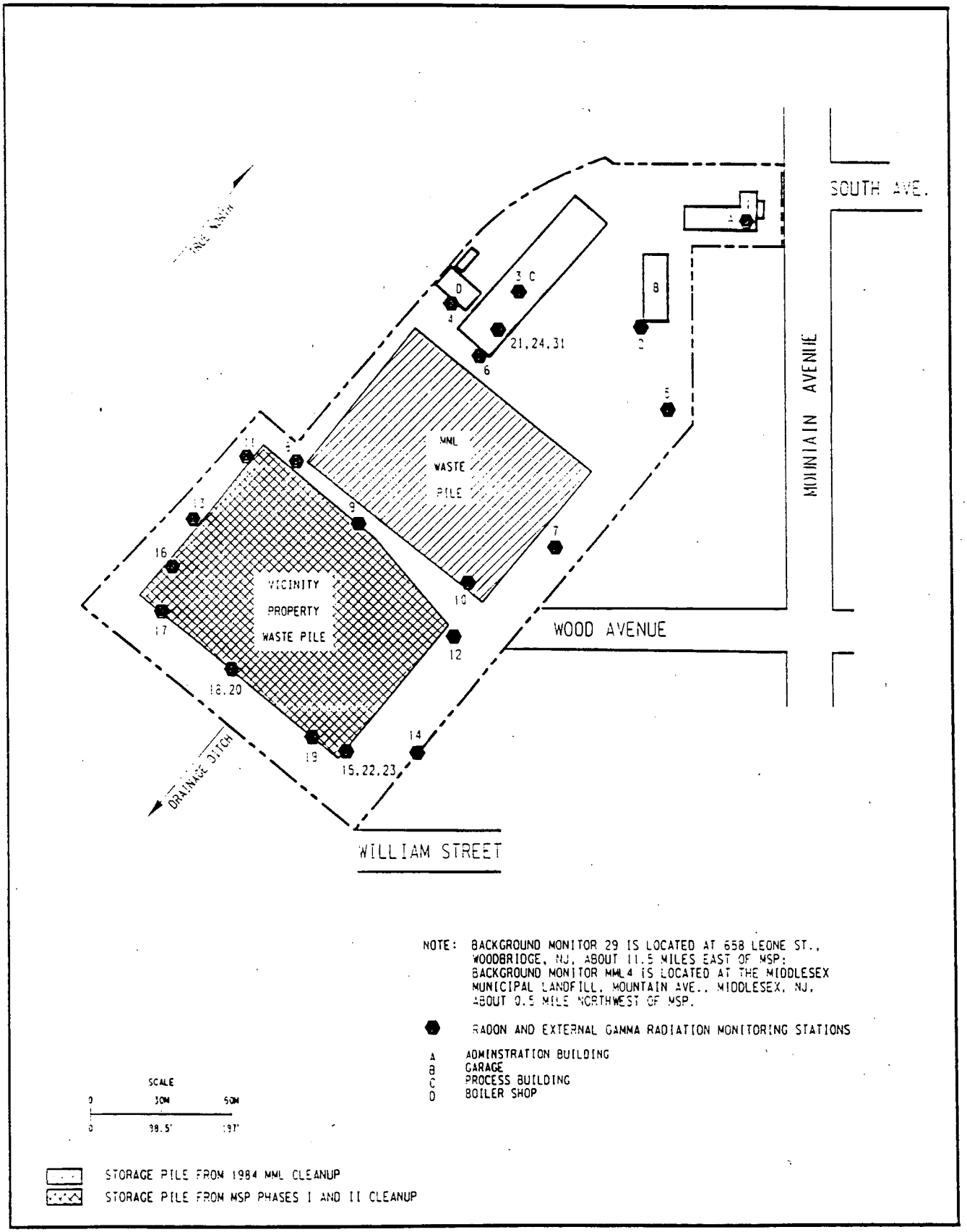



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Figure 4-1
Radon and External Gamma Radiation Monitoring Locations at MSP

transferred to the Borough of Middlesex. This location, listed in Table 4-1 as MML-4, is approximately 0.8 km (0.5 mi) northwest of MSP. The second detector, station 29, is located approximately 18.5 km (11.5 mi) east of MSP.

To determine the radon flux from the storage piles, 40 charcoal canisters were placed on the large pile and 30 were placed on the small pile. The canisters remained on the piles for 24 hours and were then removed, sealed, and shipped for analysis. No significant weather event occurred in the three days before or during the sampling event. Because radon is a gas, rain or snow could inhibit the normal radon flux rate and cause the resulting measurements to be lower than normal.

**Data and discussion**

The maximum quarterly ambient air radon concentration detected was 29.8E-9 $\mu$Ci/ml (1.1 Bq/L), at location 31 (inside the process building). Annual average concentrations at the site boundary ranged from 0.4E-9 to 1E-9 $\mu$Ci/ml (0.02 to 0.04 Bq/L) including background (see Table 4-1). No annual average concentration at the site boundary was higher than the DOE interim storage site guideline of 3E-9 $\mu$Ci/ml (0.1 Bq/L) above background at the boundary. Five locations onsite (stations 3, 21, 24, and 31, in the process building) had average concentrations of 16.2E-9, 18.9E-9, 15.4E-9, and 21.3E-9 $\mu$Ci/ml (0.599, 0.699, 0.570, and 0.788 Bq/L), respectively. As demonstrated by the perimeter monitoring locations, radon levels quickly decrease to below the DCGs and pose no threat to the surrounding environment or the public.

The results of radon flux monitoring demonstrated that both piles had average flux rates of 0.09E-6 $\mu Ci/m^2/s$ (3E-3 $Bq/m^2/s$) with minimum and maximum values of 0.01E-9 and 0.78E-6 $\mu Ci/m^2/s$ (4E-4 and 0.029 $Bq/m^2/s$), respectively. This demonstrates that both piles were in compliance with the radon flux limit of 20E-9 $\mu Ci/m^2/s$ (0.74 $Bq/m^2/s$) (an averaged value) set forth in 40 CFR Part 61, Subpart Q.

TABLE 4-1

CONCENTRATIONS[a,b] OF RADON

AT MSP, 1990



| Sampling Location[c] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| **Site Boundary** | | | | | | | |
| 2 | 1.1 | 0.4 | <0.3 | 0.6 | 0.3 | 1.1 | 0.6 |
| 4 | 3.2 | 0.4 | <0.3 | 1.3 | 0.3 | 3.2 | 1 |
| 5 | 0.9 | 0.3 | <0.3 | 0.6 | 0.3 | 0.9 | 0.5 |
| 7 | 1.8 | 0.3 | <0.3 | 0.4 | 0.3 | 1.8 | 0.7 |
| 8 | 0.5 | 0.3 | <0.3 | 0.5 | 0.3 | 0.5 | 0.4 |
| 11 | 2.2 | 0.3 | <0.3 | 0.6 | 0.3 | 2.2 | 0.9 |
| 12 | 1.2 | 0.5 | <0.3 | 0.3 | 0.3 | 1.2 | 0.6 |
| 13 | 2.2 | 0.4 | <0.3 | 1.0 | 0.3 | 2.2 | 1 |
| 14 | 0.9 | 0.3 | <0.3 | 0.3 | 0.3 | 0.9 | 0.5 |
| 15 | 1.0 | 0.8 | <0.3 | 0.3 | 0.3 | 1.0 | 0.6 |
| 16 | 0.7 | 1.0 | <0.3 | 0.3 | 0.3 | 1.0 | 0.6 |
| 17 | 0.6 | 1.9 | <0.3 | 0.5 | 0.3 | 1.9 | 0.8 |
| 18 | 1.0 | 2.5 | <0.3 | 0.7 | 0.3 | 2.5 | 1 |
| 19 | 1.0 | 1.5 | <0.3 | 1.0 | 0.3 | 1.5 | 1 |
| **Quality Control** | | | | | | | |
| 20[d] | 1.2 | 1.4 | <0.3 | 0.7 | 0.3 | 1.4 | 0.9 |
| 22[d] | 1.0 | 3.1 | <0.3 | 1.2 | 0.3 | 3.1 | 1 |
| 23[d] | 0.6 | 0.3 | <0.3 | 0.6 | 0.3 | 0.6 | 0.5 |
| **Onsite** | | | | | | | |
| 1 | 1.1 | 1.5 | 0.7 | 2.3 | 0.7 | 2.3 | 1 |
| 3[e] | 17.8 | 15.1 | 15.8 | 16.1 | 15.1 | 17.8 | 16.2 |
| 6 | 9.2 | 3.2 | 3.4 | 2.6 | 3.2 | 9.2 | 4.6 |
| 9 | 0.7 | 0.5 | <0.3 | 1.4 | 0.3 | 1.4 | 0.7 |
| 10 | 1.7 | 0.5 | <0.3 | 0.3 | 0.3 | 1.7 | 0.7 |
| 21[e] | 21.2 | 10.6 | 21.2 | 22.4 | 10.6 | 22.4 | 18.9 |
| **Quality Control** | | | | | | | |
| 24[e] | 10.0 | 10.5 | 20.3 | 20.9 | 10.0 | 20.9 | 15.4 |
| 31[e] | 29.8 | 12.7 | 20.9 | 21.7 | 12.7 | 29.8 | 21.3 |
| **Background** | | | | | | | |
| MML-4[f] | 2.8 | 0.4 | <0.3 | --[h] | 0.3 | 2.8 | 1 |
| 29[g] | 0.9 | 0.3 | <0.3 | <0.3 | 0.3 | 0.9 | 0.5 |

TABLE 4-1

(continued)



[a]Concentrations are given in E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Background has not been subtracted from the values reported for boundary and onsite stations. Note: Concentrations at some stations were below values at background stations.

[c]Sampling locations are shown in Figure 4-1.

[d]Station 20 is a quality control for station 18; stations 22 and 23 are quality controls for station 15.

[e]Located in the process building.

[f]Located at the Middlesex Municipal Landfill, Mountain Ave., Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP.

[g]Located at 658 Leone St., Woodbridge, NJ, approximately 18.5 km (11.5 mi) east of MSP.

[h]Detector was damaged.

**Trends**

Comparisons of concentrations of radon in air measured from 1986 through 1990 are presented in Table 4-2. The expected values shown are based on calculation of the standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present. Table 4-2 shows that the standard deviations are relatively small and fairly consistent, and comparison of Tables 4-1 and 4-2 demonstrates that the annual average values fall within the expected range. Based on this information, there are no discernible trends. Annual average radon concentrations for 1990 fell within the expected value range of background locations for the site. This is a good indication that there is no upward trend in radon concentrations, which is to be expected because there have been no recent activities that would disturb radon sources.

### 4.1.2 External Gamma Exposure Monitoring

External gamma radiation levels are measured as part of the routine environmental monitoring program to confirm that direct radiation from MSP is not significantly increasing radiation levels above natural background levels and to ensure compliance with environmental regulations.

**Program description**

Since 1988, the external gamma radiation monitoring system has used tissue-equivalent thermoluminescent dosimeters (TETLDs) to provide realistic values of radiation dose to the tissues of the body. When exposed to penetrating radiation (such as gamma or cosmic radiation), thermoluminescent materials absorb and store a portion of the energy. If the material is heated, the stored energy is released as light, and the light is measured and used to calculate an equivalent dose.

TABLE 4-2

TREND ANALYSIS FOR CONCENTRATIONS[a]

OF RADON AT MSP, 1986-1990



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| Site Boundary | | | | | | | | |
| 2 | 0.6 | 1.0 | 0.3 | 0.4 | 0.6 | 0.6 | 0.24 | 0.2 - 1 |
| 4 | 1.0 | 0.8 | 0.7 | 1.8 | 1.3 | 1 | 0.4 | 0.2 - 1.8 |
| 5 | 0.8 | 0.8 | 0.6 | 0.4 | 0.5 | 0.6 | 0.2 | 0.30 - 0.94 |
| 7 | 1.0 | 0.9 | 0.3 | 0.4 | 0.7 | 0.7 | 0.3 | 0.1 - 1.3 |
| 8 | 1.0 | 0.6 | 0.3 | 0.4 | 0.4 | 0.5 | 0.3 | 0 - 1 |
| 11 | 1.1 | 1.0 | 0.3 | 0.4 | 0.9 | 0.7 | 0.3 | 0.1 - 1 |
| 12 | 0.9 | 0.4 | 0.5 | 0.4 | 0.6 | 0.6 | 0.2 | 0.2 - 1 |
| 13 | 0.9 | 1.4 | 0.4 | 0.4 | 1.0 | 0.8 | 0.4 | 0 - 2 |
| 14 | 1.2 | 0.9 | 0.4 | 0.4 | 0.5 | 0.7 | 0.3 | 0.1 - 1 |
| 15 | 0.3 | 0.3 | 0.4 | 0.6 | 0.6 | 0.4 | 0.1 | 0.2 - 0.6 |
| 16 | 0.7 | 0.8 | 0.3 | 0.5 | 0.6 | 0.6 | 0.2 | 0.2 - 1 |
| 17 | 0.7 | 0.7 | 0.4 | 0.5 | 0.8 | 0.6 | 0.2 | 0.2 - 1 |
| 18 | 0.8 | 1.0 | 0.6 | 0.4 | 1.1 | 0.8 | 0.3 | 0.2 - 1 |
| 19 | 1.1 | 1.3 | 0.4 | 0.6 | 1.0 | 0.9 | 0.3 | 0.3 - 2 |
| Quality Control | | | | | | | | |
| 20 | 1.1 | 1.5 | 0.5 | 0.5 | 0.9 | 0.9 | 0.4 | 0.1 - 2 |
| 22 | 0.9 | 1.6 | 0.3 | 0.4 | 1.4 | 0.9 | 0.5 | 0 - 2 |
| 23[d] | -- | -- | -- | -- | 0.5 | -- | -- | -- |
| Onsite | | | | | | | | |
| 1[d] | -- | -- | -- | -- | 1.4 | -- | -- | -- |
| 3[d] | -- | -- | -- | -- | 16.2 | -- | -- | -- |
| 6[d] | -- | -- | -- | -- | 4.6 | -- | -- | -- |
| 9[d] | 1.0 | 0.8 | 0.7 | -- | 0.7 | 0.8 | 0.1 | 0.5 - 1.1 |
| 10 | 1.0 | 0.7 | 0.4 | 0.4 | 0.7 | 0.6 | 0.2 | 0.2 - 1 |
| 21[d,e] | -- | -- | -- | -- | 18.9 | -- | -- | -- |

TABLE 4-2

(continued)



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| Quality Control | | | | | | | | |
| 24[d,e] | -- | -- | -- | -- | 15.4 | -- | -- | -- |
| 31[d,e] | -- | -- | -- | -- | 21.3 | -- | -- | -- |
| Background | | | | | | | | |
| MML-4[f] | 0.4 | 0.9 | 0.4 | 0.4 | 1.2 | 0.7 | 0.4 | 0 - 1 |
| 29[g] | 2.0 | 1.2 | 0.3 | 0.4 | 0.5 | 0.9 | 0.6 | 0 - 2 |

Note: Sources of 1986-1989 data are the annual environmental reports for those years (BNI 1987, 1988, 1989, 1990).

[a]Measured background has not been subtracted from the boundary and onsite values.
[b]Sampling locations are shown in Figure 4-1.
[c]Average value ±2 standard deviations.
[d]Added to the environmental program in 1990.
[e]Located in the process building.
[f]Located at the Middlesex Municipal Landfill, Mountain Ave., Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP.
[g]Located at 658 Leone St., Woodbridge, NJ, approximately 18.5 km (11.5 mi) east of MSP.

Each dosimetry station contains a minimum of four dosimeters. One dosimeter in each station will have been exposed for a full year at the end of each quarter, at which time the fully exposed dosimeter is exchanged with a new dosimeter. Each dosimeter contains five individual lithium fluoride chips that were preselected on the basis of having a reproducibility of ±3 percent across a series of laboratory exposures. The responses are averaged, and the average value is then corrected for the shielding effect of the shelter housing (approximately 8 percent). The corrected value is then converted to milliroentgen per year (mR/yr). (In determining exposure, 1 mR/yr is approximately equal to 1 mrem/yr.) Although TETLDs are state of the art, the dosimeter accuracy is approximately ±10 percent at levels between 100 and 1000 mR/yr and ±25 percent at radiation levels in the range of 70 mR/yr.

External gamma radiation levels are measured at 8 onsite, 17 site boundary, and 2 offsite locations, as shown in Figure 4-1. Background radiation level radiation detectors are at the same locations as the background radon detectors.

**Data and discussion**

The results of external gamma radiation monitoring are presented in Table 4-3. The annual average gamma radiation exposure level was 76 mR/yr onsite and 55 mR/yr at the site boundary (excluding background); the average background level was 64 mR/yr. The highest annual average level at the site boundary was 136 mR/yr (location 11), and all quarterly levels at this location were 119 mR/yr or above, excluding background. A hypothetical individual standing at location 11 for the entire year would receive a dose in excess of the 100 mrem/yr DOE guideline. The DOE long-term radiation protection standard of 100 mrem/yr in excess of background includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). Information on public exposure can be found in Subsection 4.2.

TABLE 4-3

AVERAGE EXTERNAL GAMMA RADIATION LEVELS[a,b] AT MSP, 1990



| Sampling Location[c] | Quarter 1 | 2 | 3 | 4 | Average |
|---|---|---|---|---|---|
| **Site Boundary** | | | | | |
| 2 | 86 | 77 | 81 | 63 | 77 |
| 4 | 47 | 37 | 36 | 20 | 35 |
| 5 | 75 | 73 | 74 | 46 | 67 |
| 7 | 28 | 27 | 27 | 8 | 23 |
| 8 | 59 | 63 | 61 | 51 | 59 |
| 11 | 157 | 137 | 131 | 119 | 136 |
| 12 | 122 | 109 | 96 | 75 | 101 |
| 13 | 61 | 61 | 65 | 54 | 60 |
| 14 | 36 | 28 | 27 | 19 | 28 |
| 15 | 51 | 55 | 57 | 42 | 51 |
| 16 | 52 | 52 | 52 | 12 | 42 |
| 17 | 23 | 34 | 24 | 9 | 23 |
| 18 | 38 | 29 | 27 | 10 | 26 |
| 19 | 29 | 32 | 40 | 88 | 47 |
| | | | | Average | 55 |
| **Quality Control** | | | | | |
| 20[d] | 0[e] | 0 | 0 | 0 | 0 |
| 22[d] | 43 | 45 | 52 | 68 | 52 |
| 23[d] | 88 | 82 | 89 | 96 | 89 |
| **Onsite** | | | | | |
| 1 | 13 | 11 | 13 | 0 | 9 |
| 3[f] | 51 | 54 | 53 | 47 | 51 |
| 6 | 128 | 121 | 118 | 117 | 121 |
| 9 | 105 | 84 | 92 | 70 | 88 |
| 10 | 78 | 87 | 88 | 90 | 86 |
| 21[f] | 99 | 100 | 89 | 103 | 98 |
| | | | | Average | 76 |
| **Quality Control** | | | | | |
| 24[f,g] | 39 | 47 | 51 | 47 | 46 |
| 31[f,g] | 100 | 104 | 96 | 109 | 102 |
| **Background** | | | | | |
| MML-4[h] | 61 | 65 | 53 | --[i] | 60 |
| 29[j] | 66 | 70 | 60 | 75 | 68 |
| | | | | Average | 64 |

TABLE 4-3

(continued)



[a]Levels are given in units of mR/yr. Dosimeters evaluated each quarter have been in place for 1 year.

[b]Measured background has been subtracted from the readings taken at the boundary and onsite sampling stations.

[c]Sampling locations are shown in Figure 4-1.

[d]Station 20 is a quality control for station 18; stations 22 and 23 are quality controls for station 15.

[e]A zero indicates that the measured value was not distinguishable from background levels.

[f]Located in the process building.

[g]Stations 24 and 31 are quality controls for station 21.

[h]Located at Middlesex Municipal Landfill, Mountain Ave., Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP.

[i]TETLD is missing.

[j]Located at 658 Leone St., Woodbridge, NJ, approximately 18.5 km (11.5 mi) east of MSP.

The background external gamma radiation value for a given location is not constant because the value is affected by a combination of both natural terrestrial and cosmic radiation sources and by factors such as the location of the detector in relation to surface rock outcrops, stone or concrete structures, or highly mineralized soil. Detectors also are influenced by site altitude, annual barometric pressure cycles, and the occurrence and frequency of solar flare activity (Eisenbud 1987).

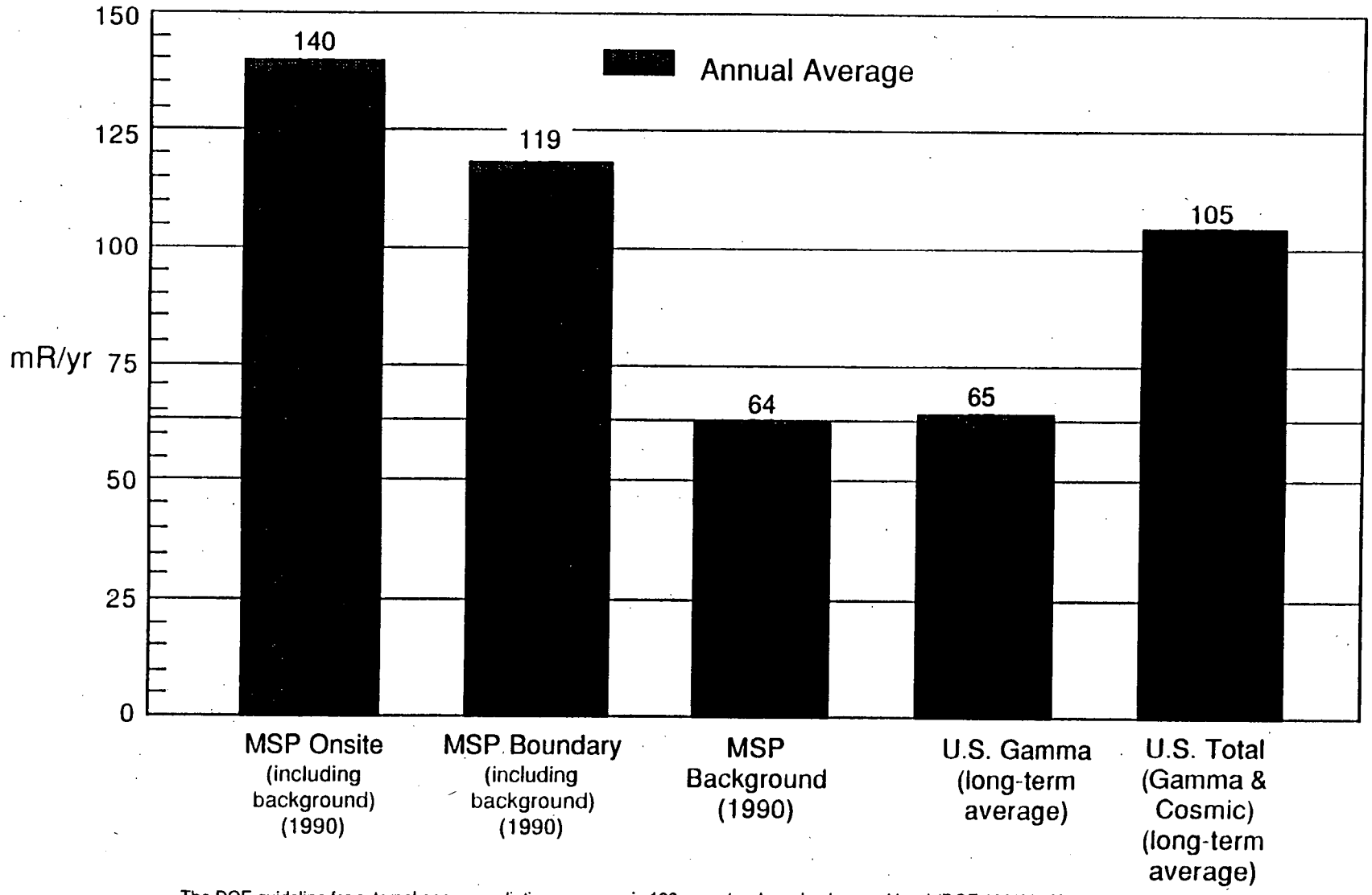
Because of these factors, the background radiation level is not constant from one location to another even over a short time. Thus it is not abnormal for some stations at the boundary of a site to have an external gamma radiation value less than the background level measured some distance from the site.

For comparison, Figure 4-2 shows the average annual external radiation levels for locations onsite, at the site boundary, and offsite; and for the nation. Based on these data, the radioactive waste stored at MSP does not present a health threat to the public from external gamma radiation because the levels are low and access to the material is restricted.

**Trends**

Comparisons of external gamma exposure levels measured from 1986 through 1990 are presented in Table 4-4. The expected value ranges shown are based on calculation of the standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a station consistently falls outside the expected range, then a trend could be present.

In general, all of the 1990 quarterly values fell within the expected range, which indicates an absence of trends. Additionally, several of the standard deviations for site boundary stations were considerably larger than those for the background stations. These fluctuations could be due to the precision of the




The DOE guideline for external gamma radiation exposure is 100 mrem/yr above background level (DOE 1990b). Note: 1 mrem is approximately equivalent to 1 mR.
*Source:* Martin Marietta Energy Systems, Inc., 1989. *Portsmouth Gaseous Diffusion Plant Site Environmental Report for 1988*, ES/ESH-8/V4, Oak Ridge, Tenn.

Figure 4-2
External Gamma Radiation Exposure Rates

TABLE 4-4

TREND ANALYSIS FOR EXTERNAL GAMMA RADIATION LEVELS[a,b]

AT MSP, 1986-1990



| Sampling Location[c] | Annual Average Level 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[d] |
|---|---|---|---|---|---|---|---|---|
| **Site Boundary** | | | | | | | | |
| 2 | 75 | 60 | 112 | 86 | 77 | 82 | 17 | 48 - 120 |
| 4 | 41 | 31 | 48 | 20 | 35 | 35 | 9.4 | 16 - 54 |
| 5 | 125 | 99 | 115 | 55 | 67 | 92 | 27 | 38 - 150 |
| 7 | 22 | 17 | 25 | 14 | 23 | 20 | 4 | 12 - 28 |
| 8 | 46 | 23 | 65 | 48 | 59 | 48 | 16 | 16 - 80 |
| 11 | 121 | 94 | 155 | 125 | 136 | 130 | 22 | 86 - 170 |
| 12 | 72 | 55 | 142 | 90 | 101 | 92 | 30 | 32 - 152 |
| 13 | 33 | 40 | 61 | 51 | 60 | 49 | 15 | 19 - 79 |
| 14 | 29 | 19 | 32 | 16 | 28 | 25 | 11 | 3 - 57 |
| 15 | 37 | 27 | 50 | 35 | 51 | 40 | 9.5 | 21 - 59 |
| 16 | 36 | 17 | 34 | 36 | 42 | 33 | 9.0 | 15 - 51 |
| 17 | 25 | 13 | 31 | 20 | 23 | 22 | 5.8 | 10 - 34 |
| 18 | 28 | 14 | 21 | 15 | 26 | 21 | 6 | 9 - 33 |
| 19 | 32 | 13 | 38 | 30 | 47 | 32 | 13 | 7 - 57 |
| **Quality Control** | | | | | | | | |
| 20[e] | 3 | 0[f] | 0 | 0 | 0 | 0.6 | 1.3 | 0 - 3 |
| 22[e] | 43 | 20 | 48 | 54 | 52 | 43 | 14 | 15 - 71 |
| 23[g] | -- | -- | -- | -- | 89 | -- | -- | -- |
| **Onsite** | | | | | | | | |
| 1[g] | -- | -- | -- | -- | 9 | -- | -- | -- |
| 3[g] | -- | -- | -- | -- | 51 | -- | -- | -- |
| 6[g] | -- | -- | -- | -- | 121 | -- | -- | -- |
| 9[g] | 67 | 49 | 96 | -- | 88 | 75 | 21 | 33 - 117 |
| 10 | 60 | 44 | 115 | 66 | 86 | 74 | 24 | 26 - 120 |
| 21[g,h] | -- | -- | -- | -- | 98 | -- | -- | -- |

TABLE 4-4

(continued)



| Sampling Location[c] | Annual Average Levels 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[d] |
|---|---|---|---|---|---|---|---|---|
| Quality Control | | | | | | | | |
| 24[e,g,h] | -- | -- | -- | -- | 46 | -- | -- | -- |
| 31[e,h] | -- | -- | -- | -- | 102 | -- | -- | -- |
| Background | | | | | | | | |
| MML-4[i] | -- | -- | -- | 58 | 60 | 59 | 1.0 | 57 - 61 |
| 29[j] | 71 | 71 | 90 | 76 | 68 | 75 | 7.8 | 59 - 91 |

Note: Sources for 1986-1989 data are the annual environmental reports for those years (BNI 1987, 1988, 1989, 1990).

[a]Levels are given in units of mR/yr.

[b]Measured background has been subtracted from the readings taken at onsite and boundary stations.

[c]Sampling locations are shown in Figure 4-1.

[d]Average value ±2 standard deviations.

[e]Stations 24 and 31 are quality controls for station 21; stations 21, 22, and 23 are quality controls for station 15.

[f]A zero indicates that the measured value was not distinguishable from background levels.

[g]Location was added to the environmental monitoring program in 1990.

[h]Located in the process building.

[i]Located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Established in April 1988.

different detectors used over the last five years. Since 1987, there has been no work at MSP that would significantly change the gamma exposure levels.

### 4.1.3 Surface Water Monitoring

Surface water monitoring is conducted to ensure compliance with environmental regulations and to determine whether runoff from MSP contributes to surface water contamination in the area.

**Program description**

Surface water samples were collected quarterly at sampling locations established on discharge routes from the site. Sampling points were located upstream (location 4), to establish background conditions; downstream (locations 1, 2, and 3), to determine the effect of runoff from the site on the surface waters in the vicinity; and onsite (location 5) (Figure 4-3).

Surface water samples were analyzed quarterly for total uranium, radium-226, and thorium-232. Total uranium in surface water is typically measured using the fluorometric method, which has been proven to be a very sensitive and dependable method for determining trace concentrations of uranium. The first step in the method is dispensing a measured aliquot (typically 0.1 ml) of sample onto a flux pellet made of sodium fluoride (98 percent) and lithium fluoride (2 percent). The flux pellet is dried, and the uranium is then fused to the pellet by a rotary fusion burner. After cooling, the fluorescence of the fused pellet is measured by a fluorimeter. The measured fluorescence of the pellet is directly proportional to the concentration of total uranium in the sample as compared with spikes, standards, and blanks.

Radium-226 concentrations were determined by radon emanation. This method for detecting radon consists of precipitating radium-226 as sulfate and transferring the treated sulfate to a radon bubbler, where the radon-222 is allowed to come to equilibrium with its radium-226 parent. The radon-222 is then

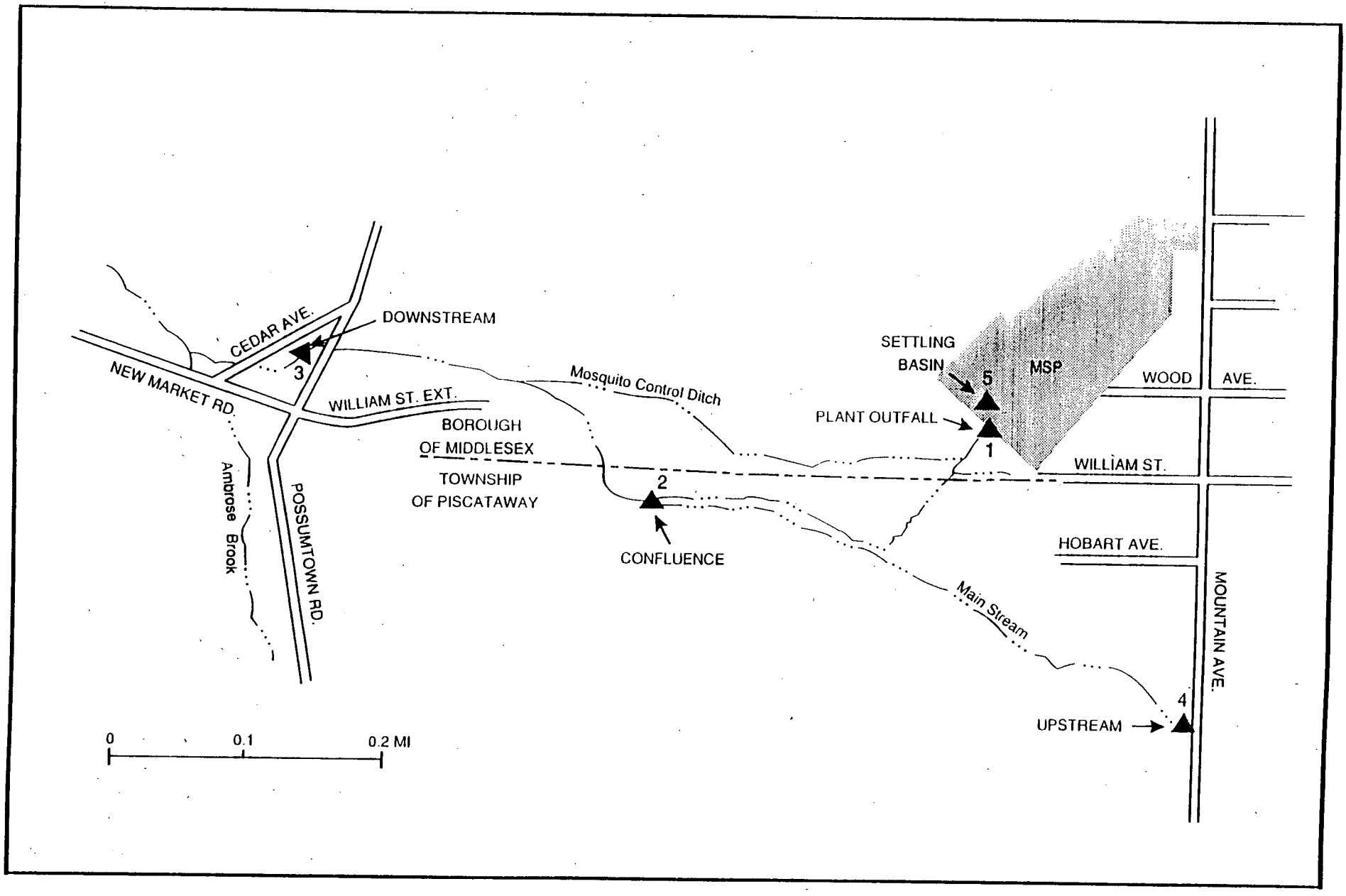



Figure 4-3 Surface Water and Sediment Sampling Locations in the Vicinity of MSP



1.17.26.15.1

withdrawn into a scintillation cell and counted by the gross alpha technique. The quantity of radon-222 detected in this manner is directly proportional to the quantity of radium-226 originally present in the sample.

Thorium-232 concentrations were determined by the photon/electron-rejecting alpha liquid scintillation (PERALS) method. This method begins with the coprecipitation of radionuclides from a sample by using lead sulfate. Radium is separated onto barium sulfate and precipitated with diethylene-triamine-pentaacetate solution. Thorium is then separated sequentially from barium sulfate supernate by extraction into di(2-ethylhexyl)phosphoric acid. The thorium is then counted on the PERALS instrument. This method has approximately a 95 percent recovery rate for thorium in samples.

**Data and discussion**

Table 4-5 presents 1990 concentrations of total uranium, radium-226, and thorium-232 in surface water. The annual average concentration of total uranium at the upstream (background) location was 3E-9 μCi/ml (0.1 Bq/L); the range at all other locations was 3E-9 to 60E-9 μCi/ml (0.1 to 2.2 Bq/L). As shown, sampling location 1 (the plant outfall) had an average concentration of 60E-9 μCi/ml (2.2 Bq/L). Elevated levels at downstream locations are being investigated (see Subsection 3.4). All uranium concentrations were well below the DCG of 600E-9 μCi/ml (22 Bq/L).

Annual average radium-226 concentrations at the upstream location were 0.4E-9 μCi/ml (0.02 Bq/L) and ranged from 0.3E-9 to 2.8E-9 μCi/ml (0.01 to 0.1 Bq/L) at downstream and onsite locations. The majority of the radium-226 concentrations remained close to background throughout the year; the exception was location 1, where concentrations averaged approximately seven times background. All locations had concentrations that were well below the DCG of 100E-9 μCi/ml (3.7 Bq/L).

TABLE 4-5

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN SURFACE WATER IN THE VICINITY OF MSP, 1990

| Sampling Location[b] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| | | | **Total Uranium** | | | | |
| 1 | 59 | 57 | 64 | --[c] | 57 | 64 | 60 |
| 2 | <3 | <3 | <3 | --[c] | 3 | 3 | 3 |
| 3 | <3 | <3 | <3 | 2[d] | 1.9 | 3 | 3 |
| 4[e] | <3 | <3 | <3 | 0.3[d] | 0.3 | 3 | 3 |
| 5 | <3 | <3 | <3 | 5[d] | 3 | 5 | 4 |
| | | | **Radium-226** | | | | |
| 1 | 1.4 | 4.9 | 2.2 | --[c] | 1.4 | 4.9 | 2.8 |
| 2 | <0.1 | 0.5 | 0.2 | --[c] | 0.1 | 0.5 | 0.3 |
| 3 | 0.2 | 0.4 | 0.1 | 1.2 | 0.1 | 1.2 | 0.5 |
| 4[e] | 0.3 | 0.3 | 0.4 | 0.6 | 0.3 | 0.6 | 0.4 |
| 5 | 0.4 | 0.3 | 0.6 | 1.7 | 0.3 | 1.7 | 0.8 |
| | | | **Thorium-232[f]** | | | | |
| 1 | -- | <0.1 | <0.1 | --[c] | 0.1 | 0.1 | 0.1 |
| 2 | -- | <0.1 | <0.1 | --[c] | 0.1 | 0.1 | 0.1 |
| 3 | -- | <0.1 | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 |
| 4[e] | -- | <0.1 | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 |
| 5 | -- | <0.1 | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 |

[a]Concentrations are given in units of E-9 $\mu$Ci/ml.
Note: 1E-9 $\mu$Ci/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figure 4-3.

[c]No data available.

[d]Total uranium concentration determined by summing the concentrations of uranium-234, uranium-235, and uranium-238; all others determined by the fluorometric method.

[e]Location 4 serves as a background monitoring location.

[f]Analysis for thorium-232 did not begin until second quarter.

The annual average concentration of thorium-232 at all monitoring locations was 0.1E-9 μCi/ml (4E-3 Bq/L). Thorium-232 concentrations remained at background levels throughout the year and were well below the DCG of 50E-9 μCi/ml (1.9 Bq/L).

**Trends**

Comparisons of annual average radionuclide concentrations measured in surface water from 1986 through 1990 are presented in Table 4-6.
The expected value ranges shown are based on calculation of the standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. In general, the ranges were fairly consistent between data sets and quarterly results for 1990 fell within the expected range of values. The exception was location 1, which had a relatively large expected range; however, this large range is due to the higher average value and there is no detectable trend.

### 4.1.4 Sediment Monitoring

Sediment monitoring is conducted to determine whether contaminants are collecting in onsite and/or offsite sediment and to ensure compliance with environmental regulations.

**Program description**

Sediment samples were collected quarterly at the surface water sampling locations shown in Figure 4-3. Sampling points were located upstream (location 4), to establish background conditions; onsite (location 5); and downstream (locations 1, 2, and 3), to determine the effect of the site on the sediment in the vicinity.

TABLE 4-6

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-232 CONCENTRATIONS[a] IN SURFACE WATER AT MSP, 1986-1990

| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| | | | | **Total Uranium[d]** | | | | |
| 1 | 56 | 54 | 47 | 34 | 60 | 50 | 10 | 30 - 71 |
| 2 | 23 | 5 | 3 | 3 | 3 | 7 | 7 | 0 - 21 |
| 3 | 21 | 3 | 4 | 5 | 3 | 7 | 7 | 0 - 21 |
| 4[e] | 3 | 3 | 3 | 3 | 3 | 3 | 0 | 3 - 3 |
| 5 | 3 | 3 | 4 | 3 | 4 | 3 | 0.5 | 2 - 4 |
| | | | | **Radium-226** | | | | |
| 1 | 2.2 | 1.7 | 2.0 | 1.7 | 2.8 | 2.1 | 0.41 | 1.3 - 2.9 |
| 2 | 1.0 | 0.7 | 0.3 | 0.6 | 0.3 | 0.6 | 0.3 | 0 - 1 |
| 3 | 1.1 | 0.6 | 0.2 | 0.6 | 0.5 | 0.6 | 0.3 | 0 - 1 |
| 4[e] | 0.2 | 0.7 | 0.2 | 1.0 | 0.4 | 0.5 | 0.3 | 0 - 1 |
| 5 | 0.5 | 0.7 | 0.3 | 0.7 | 0.8 | 0.6 | 0.2 | 0.2 - 1 |
| | | | | **Thorium-232[f]** | | | | |
| 1 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 2 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 3 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 4[e] | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 5 | -- | -- | -- | -- | 0.1 | -- | -- | -- |

Note: Sources of data for 1986-1989 are the annual environmental reports for those years (BNI 1987, 1988, 1989, 1990).

[a]Concentrations are given in units of E-9 $\mu$Ci/ml. Note: 1E-9 $\mu$Ci/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figure 4-3.

[c]Average value ±2 standard deviations.

[d]Total uranium concentrations were determined either by summing the isotopic analysis results for uranium-234, uranium-235, and uranium-238 or by the fluorometric method.

[e]Location 4 serves as a background monitoring station.

[f]Thorium-232 monitoring began in second quarter 1990; no trend analysis can yet be done.

Sediment samples were analyzed for radium-226, thorium-232, and total uranium. Radium-226, thorium-232, and isotopic uranium were eluted in solution, organically extracted, electroplated to a stainless steel disc, and counted by alpha spectrometry. Total uranium concentrations were calculated by summing the results for the isotopic uranium analyses.

Currently, there are no DCGs for radionuclides in sediment; therefore, sediment concentrations have been compared with FUSRAP soil guidelines (Appendix C).

**Data and discussion**

Table 4-7 presents 1990 concentrations of total uranium, radium-226, and thorium-232 in sediment. The annual average total uranium concentration was 0.7 pCi/g (0.03 Bq/g) at the upstream location and ranged from 1.5 to 11 pCi/g (0.06 to 0.41 Bq/g) at downstream locations. The onsite location had an annual average value of 8.5 pCi/g (0.32 Bq/g). Total uranium levels remained close to background throughout the year, with the exception of third-quarter readings at locations 1 and 5.

The annual average concentration of radium-226 was 0.7 pCi/g (0.03 Bq/g) at the upstream location and ranged from 0.8 to 6.0 pCi/g (0.03 to 0.22 Bq/g) at downstream locations. The onsite location had an annual average of 5.3 pCi/g (0.2 Bq/g). Radium levels remained close to background throughout the year, with the exception of third-quarter readings at locations 1 and 5; all other radium-226 concentrations were below the FUSRAP soil guideline of 5 pCi/g for the top 15 cm (6 in.) of soil.

The annual average concentration of thorium-232 in sediment was 0.7 pCi/g (0.03 Bq/g) at the upstream location and ranged from 0.5 to 2.0 pCi/g (0.02 to 0.07 Bq/g) at downstream locations. The onsite location had an annual average value of 0.6 pCi/g (0.02 Bq/g). Thorium-232 levels remained close to background throughout the year and were below the FUSRAP soil guideline.

TABLE 4-7

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN SEDIMENT IN THE VICINITY OF MSP, 1990

| Sampling Location[b] | Quarter 1[c] | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| | | | **Total Uranium[d]** | | | | |
| 1 | -- | 3.2 | 18.8 | 9.7 | 3.2 | 18.8 | 11 |
| 2 | -- | 5.4 | 1.9 | ND[e] | 1.9 | 5.4 | 3.7 |
| 3 | -- | 1.1 | 2.0 | 1.3 | 1.1 | 2.0 | 1.5 |
| 4[f] | -- | 0.5 | 1 | 0.7 | 0.5 | 1 | 0.7 |
| 5 | -- | 2.9 | 18 | 4.6 | 2.9 | 18 | 8.5 |
| | | | **Radium-226** | | | | |
| 1 | -- | 2.0 | 11 | 4.9 | 2.0 | 11 | 6.0 |
| 2 | -- | 3 | 0.7 | ND | 0.7 | 3 | 2 |
| 3 | -- | 1 | 0.7 | 0.7 | 0.7 | 1 | 0.8 |
| 4[f] | -- | 1 | 0.8 | 0.2 | 0.2 | 1 | 0.7 |
| 5 | -- | 3.2 | 10 | 2.6 | 2.6 | 10 | 5.3 |
| | | | **Thorium-232** | | | | |
| 1 | -- | <2 | 0.6 | 0.3 | 0.3 | 2 | 1 |
| 2 | -- | 3 | 0.2 | ND | 0.2 | 3 | 2 |
| 3 | -- | <1 | 0.3 | 0.3 | 0.3 | 1 | 0.5 |
| 4[f] | -- | 1.2 | 0.6 | 0.3 | 0.3 | 1.2 | 0.7 |
| 5 | -- | 1 | 0.5 | 0.3 | 0.3 | 1 | 0.6 |

[a]Concentrations are given in units of pCi/g.
Note: 1 pCi/g is equivalent to 0.037 Bq/g.

[b]Sampling locations are shown in Figure 4-3.

[c]Samples were not collected during the first quarter because the ground was frozen.

[d]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[e]ND - no data available.

[f]Location 4 serves as a background monitoring location.

**Trends**

Comparisons of annual average radionuclide concentrations measured in sediment from 1986 through 1990 are presented in Table 4-8. The expected values shown are based on calculation of the standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. All annual average concentrations of radionuclides in sediment in 1990 fell within the expected ranges and were comparable to concentrations typically found in fertilizers (Appendix F). Radium-226 and total uranium concentrations at location 1 (outfall) and location 5 (settling basin) are dependent on area rainfall. At location 1, high flow rates at the outfall tend to wash out accumulations of sediment and carry then farther downstream. A special study has been implemented to investigate radionuclide migration in this area (see Subsection 3.4). Radioactivity appears to be increasing at location 5, probably due to rainfall washing site sediment into the settling basin.

### 4.1.5 Groundwater Monitoring

Groundwater monitoring is conducted to provide information on potential migration of contaminants through the groundwater system and to ensure compliance with environmental regulations.

**Program description**

The groundwater monitoring well system is designed to provide sufficient coverage of both upgradient and downgradient aquifer conditions (Figure 4-4). The groundwater system at MSP consists of two systems, designated upper and lower. Groundwater flows from north to south in the upper system; well 1 is upgradient and wells 3 and 4 are downgradient. Groundwater flows from south to

TABLE 4-8

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-232 CONCENTRATIONS[a] IN SEDIMENT AT MSP, 1986-1990



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| | | | | **Total Uranium[d]** | | | | |
| 1 | 20.0[e] | 12.8[f] | 7.1 | 13.5 | 10.6 | 13 | 4.7 | 3.6 - 22 |
| 2 | 38.9 | --[g] | 6.0 | 31.8 | 3.7 | 14 | 13 | 0 - 40 |
| 3 | 8.5 | 5.8 | 9.7 | 12.6 | 1.5 | 7.6 | 3.8 | 0 - 15 |
| 4[h] | 3.4 | 2.1 | 7.8 | 2.8 | 0.7 | 3.4 | 2.4 | 0 - 8.2 |
| 5 | 2.2 | --[g] | 2.6 | 3.4 | 8.5 | 4.2 | 2.5 | 0 - 9.2 |
| | | | | **Radium-226** | | | | |
| 1 | 12.8 | 6.8[f] | 5.0 | 6.4 | 6.0 | 7.6 | 3.1 | 1.4 - 14 |
| 2 | 27.0 | --[g] | 1.9 | 15.2 | 1.9 | 6.3 | 6.3 | 0 - 19 |
| 3 | 11.1 | 0.7 | 3.9 | 5.4 | 0.8 | 4.4 | 3.8 | 0 - 12 |
| 4[h] | 1.1 | 0.7 | 2.0 | 1.0 | 0.7 | 1 | 0.5 | 0 - 2 |
| 5 | 1.8 | --[g] | 2.3 | 1.8 | 5.3 | 2.8 | 1.5 | 0 - 5.8 |
| | | | | **Thorium-232[i]** | | | | |
| 1 | -- | -- | -- | -- | 1.0 | -- | -- | -- |
| 2 | -- | -- | -- | -- | 1.6 | -- | -- | -- |
| 3 | -- | -- | -- | -- | 0.5 | -- | -- | -- |
| 4[h] | -- | -- | -- | -- | 0.7 | -- | -- | -- |
| 5 | -- | -- | -- | -- | 0.6 | -- | -- | -- |

Note: Sources of 1986-1989 data are the annual environmental reports for those years (BNI 1987, 1988, 1989, 1990).

Note: 1 pCi/g is equivalent to 0.037 Bq/g.

[a]Concentrations are given in units of pCi/g.

[b]Sampling locations are shown in Figure 4-3.

TABLE 4-8

(continued)



[c]Average value ±2 standard deviations.

[d]Total uranium concentrations were determined by summing the concentrations of uranium-234, uranium-235, and uranium-238.

[e]No sediment present during the second, third, and fourth quarters.

[f]Frozen in the first quarter; no sediment present during the second and fourth quarters.

[g]No sediment present at this location in 1987.

[h]Location 4 serves as a background monitoring location.

[i]Thorium-232 sampling began in 1990; inadequate data for trend analysis.

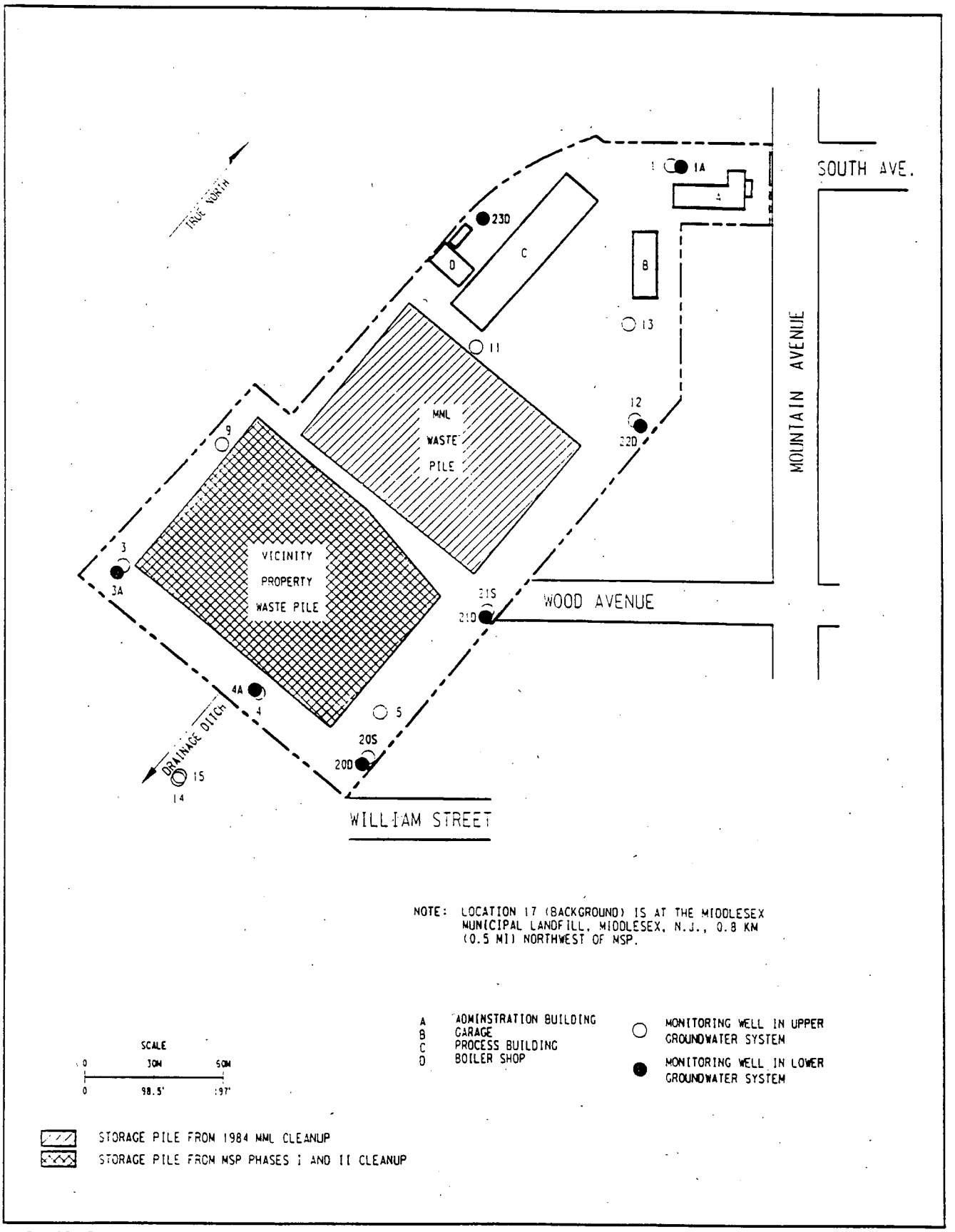



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Figure 4-4
Groundwater Wells Monitored for Radiological and Chemical Contamination at MSP in 1990

northeast in the lower groundwater system; wells 3A and 4A are upgradient and 21D and 22D are downgradient. Samples from upgradient wells are used to establish background conditions, and downgradient well samples determine the effect of the site on groundwater in the vicinity.

Quarterly groundwater samples were analyzed for radium-226, thorium-232, and total uranium in the same manner as surface water samples.

**Data and discussion**

Table 4-9 presents 1990 concentrations of total uranium, radium-226, and thorium-232 in groundwater. Annual average concentrations of total uranium ranged from 3.1E-9 to 17.7E-9 μCi/ml (0.11 to 0.655 Bq/L) at upgradient locations and from 3E-9 to 5.2E-9 μCi/ml (0.11 to 0.19 Bq/L) at downgradient locations. Total uranium concentrations were close to background levels and all were below the DCG of 600E-9 μCi/ml (22 Bq/L). Well 5 is installed in an area known to be contaminated; after the well was cleaned out in mid-1990, uranium concentrations decreased significantly.

Annual average radium-226 concentrations ranged from 0.5E-9 to 0.7E-9 μCi/ml (0.02 to 0.03 Bq/L) at upgradient locations and from 0.4E-9 to 1.2E-9 μCi/ml (0.02 to 0.044 Bq/L) at downgradient locations. Radium-226 concentrations were close to background levels and below the DCG of 100E-9 μCi/ml (3.7 Bq/L).

Annual average thorium-232 concentrations ranged from 0.2E-9 to 0.3E-9 μCi/ml (7E-3 to 11E-3 Bq/L) at upgradient and downgradient locations. Thorium-232 concentrations were close to background levels and below the DCG of 50E-9 μCi/ml (1.9 Bq/L).

**Trends**

Comparisons of annual average radionuclide concentrations in groundwater measured from 1986 through 1990 are presented in Table 4-10. The expected value ranges shown are based on

TABLE 4-9

CONCENTRATIONS[a] OF TOTAL URANIUM, RADIUM-226, AND THORIUM-232 IN GROUNDWATER IN THE VICINITY OF MSP, 1990



| Sampling Location[b] | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| | | | **Total Uranium[c]** | | | | |
| 1 | 5.4 | 12.2 | <3.4 | <3.4 | 3.4 | 12.2 | 6.1 |
| 1A | 12.9 | 10.2 | 8.8 | 4.0 | 4.0 | 12.9 | 9.0 |
| 3 | 2.4 | <3.4 | <3.4 | <3.4 | 2.4 | 3.4 | 3.1 |
| 3A | 2.2 | <3.4 | <3.4 | <3.4 | 2.2 | 3.4 | 3.1 |
| 4 | 5.4 | 8.1 | <3.4 | 4.0 | 3.4 | 8.1 | 5.2 |
| 4A | 34.7 | 14.2 | 8.8 | 13.2 | 8.8 | 34.7 | 17.7 |
| 5 | --[d] | 230.2 | --[d] | 16.7 | 16.7 | 230.2 | 123 |
| 9 | 3.3 | 43.3 | <3.4 | <3.4 | 3.3 | 43.3 | 13 |
| 11 | 19.8 | 69.0 | --[d] | --[d] | 19.8 | 69.0 | 41.4 |
| 12 | 16.5 | 10.8 | <3.4 | 10.7 | 3.4 | 16.5 | 10 |
| 13 | 5.4 | 13.5 | 6.1 | <3.4 | 3.4 | 13.5 | 7.1 |
| 14 | --[d] | --[d] | --[d] | --[d] | -- | -- | -- |
| 15 | 8.8 | <3.4 | <3.4 | <3.4 | 3.4 | 8.8 | 4.7 |
| 20D | 2.7 | <3.4 | <3.4 | <3.4 | 2.7 | 3.4 | 3.2 |
| 20S | 3.2 | <3.4 | <3.4 | 0.2 | 0.2 | 3.4 | 3 |
| 21D | 3.2 | <3.4 | <3.4 | 2.1 | 2.1 | 3.4 | 3.0 |
| 21S | 3.3 | <3.4 | <3.4 | <3.4 | 3.3 | 3.4 | 3.4 |
| 22D | 5.4 | <3.4 | <3.4 | --[d] | 3.4 | 5.4 | 4.0 |
| 23D | 5.4 | <3.4 | <3.4 | <3.4 | 3.4 | 5.4 | 3.9 |
| MML-17[e] | <3.4 | <3.4 | <3.4 | <3.4 | 3.4 | 3.4 | 3.4 |
| | | | **Radium-226** | | | | |
| 1 | 0.2 | 0.6 | 0.5 | 0.6 | 0.2 | 0.6 | 0.5 |
| 1A | 0.1 | 0.3 | 0.9 | 0.2 | 0.1 | 0.9 | 0.4 |
| 3 | 2.1 | 0.1 | 0.7 | 0.7 | 0.1 | 2.1 | 0.9 |
| 3A | 0.8 | 0.2 | 0.4 | 0.5 | 0.2 | 0.8 | 0.5 |
| 4 | 2.8 | 0.2 | 0.5 | 1.3 | 0.2 | 2.8 | 1.2 |
| 4A | 1.5 | 0.2 | 0.5 | 0.4 | 0.2 | 1.5 | 0.7 |
| 5 | --[d] | 0.2 | --[d] | 0.3 | 0.2 | 0.3 | 0.3 |
| 9 | 2.0 | 1.7 | 1.2 | 4.6 | 1.2 | 4.6 | 2.4 |
| 11 | 3.9 | 0.5 | --[d] | --[d] | 0.5 | 3.9 | 2.2 |
| 12 | 3.2 | 0.2 | 0.6 | 5.3 | 0.2 | 5.3 | 2.3 |
| 13 | 0.1 | 0.3 | 0.5 | 0.4 | 0.1 | 0.5 | 0.3 |
| 14 | --[d] | --[d] | --[d] | --[d] | -- | -- | -- |
| 15 | 0.2 | 0.6 | 0.7 | 0.6 | 0.2 | 0.7 | 0.5 |
| 20D | 1.0 | 0.4 | 0.4 | 0.4 | 0.4 | 1.0 | 0.6 |
| 20S | 1.0 | 0.2 | 0.5 | <0.1 | 0.1 | 1.0 | 0.5 |
| 21D | 0.7 | <0.1 | 0.4 | 0.3 | 0.1 | 0.7 | 0.4 |

TABLE 4-9

(continued)



| Sampling Location[b] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| | | | **Radium-226** (cont'd) | | | | |
| 21S | 1.3 | 0.1 | 0.4 | 0.4 | 0.1 | 1.3 | 0.6 |
| 22D | 0.2 | 0.5 | 0.5 | --[d] | 0.2 | 0.5 | 0.4 |
| 23D | 0.1 | 0.5 | 0.6 | 0.5 | 0.1 | 0.6 | 0.4 |
| MML-17[e] | 0.1 | 0.3 | 0.7 | 0.6 | 0.1 | 0.7 | 0.4 |
| | | | **Thorium-232** | | | | |
| 1 | --[f] | <0.1 | <0.3 | 0.1 | 0.1 | 0.3 | 0.2 |
| 1A | --[f] | <0.1 | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 |
| 3 | 0.3 | --[f] | <0.1 | 0.1 | 0.1 | 0.3 | 0.2 |
| 3A | <0.2 | 0.3 | <0.5 | 0.1 | 0.1 | 0.5 | 0.3 |
| 4 | <0.2 | <0.1 | <0.1 | 0.6 | 0.1 | 0.6 | 0.3 |
| 4A | 0.4 | <0.1 | <0.3 | <0.1 | 0.1 | 0.4 | 0.2 |
| 5 | --[d] | 0.1 | --[d] | <0.1 | 0.1 | 0.1 | 0.1 |
| 9 | <0.2 | <0.1 | <0.1 | <0.1 | 0.1 | 0.2 | 0.1 |
| 11 | 0.4 | <0.1 | --[d] | --[d] | 0.1 | 0.4 | 0.3 |
| 12 | 0.9 | <0.1 | <0.1 | 2.7 | 0.1 | 2.7 | 1.0 |
| 13 | --[f] | 0.1 | <0.7 | <0.1 | 0.1 | 0.7 | 0.3 |
| 14 | --[d] | --[d] | --[d] | --[d] | -- | -- | -- |
| 15 | --[f] | <0.1 | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 |
| 20D | <0.2 | <0.1 | <0.1 | <0.1 | 0.1 | 0.2 | 0.1 |
| 20S | 0.3 | <0.1 | <0.2 | <0.3 | 0.1 | 0.3 | 0.2 |
| 21D | <0.2 | <0.1 | <0.2 | <0.1 | 0.1 | 0.2 | 0.2 |
| 21S | 0.2 | <0.1 | <0.1 | <0.1 | 0.1 | 0.2 | 0.1 |
| 22D | --[f] | <0.1 | <0.3 | ND | 0.1 | 0.3 | 0.2 |
| 23D | --[f] | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| MML-17[e] | --[f] | <0.1 | <0.1 | 0.1 | 0.1 | 0.1 | 0.1 |

[a]Concentrations are given in units of E-9 $\mu$Ci/ml.
Note: 1E-9 $\mu$Ci/ml is equivalent to 0.037 Bq/L.
[b]Sampling locations are shown in Figure 4-4.
[c]Total uranium concentrations were determined either by summing the isotopic analysis results for uranium-234, uranium-235, and uranium-238 or by fluorometric analysis.
[d]Well did not recover sufficiently to be sampled after purging.
[e]Background well located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.
[f]No data available.

TABLE 4-10

TREND ANALYSIS FOR TOTAL URANIUM, RADIUM-226, AND THORIUM-232 CONCENTRATIONS[a] IN GROUNDWATER AT MSP, 1986-1990



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| | | | | **Total Uranium[d]** | | | | |
| 1 | 3 | 3 | 12 | 4 | 6 | 6 | 3 | 0 - 12 |
| 1A | 8 | 9 | 9 | 9 | 9 | 9 | 0.4 | 8 - 10 |
| 3 | 2 | 1 | 3 | 3 | 3 | 2 | 0.8 | 0.4 - 4 |
| 3A | 8 | 6 | 12 | 5 | 3 | 7 | 3 | 1 - 13 |
| 4 | --[e] | 1 | 7 | 6 | 5 | 5 | 2 | 1 - 9 |
| 4A | 12 | 13 | 20 | 17 | 18 | 16 | 3.0 | 10 - 22 |
| 5 | 20 | 82 | 192 | 131 | 123 | 110 | 57 | 0 - 220 |
| 9 | 3 | 2 | 5 | 4 | 13 | 5 | 4 | 0 - 10 |
| 11 | 143 | 20 | 67 | 42 | 41 | 63 | 43 | 0 - 150 |
| 12 | 2 | 1 | 7 | 7 | 10 | 5 | 3 | 0 - 10 |
| 13 | 3 | 3 | 5 | 3 | 7 | 4 | 2 | 0 - 8 |
| 14 | 3 | 3 | --[e] | 3 | --[e] | 3 | 0 | 3 - 3 |
| 15 | 3 | 3 | 4 | 4 | 5 | 4 | 0.8 | 2 - 6 |
| 20D | 2 | 2 | 3 | 2 | 3 | 2 | 0.5 | 1 - 3 |
| 20S | 1 | 1 | 4 | 2 | 3 | 2 | 1 | 0 - 4 |
| 21D | 2 | 2 | 3 | 3 | 3 | 3 | 0.5 | 2 - 4 |
| 21S | 1 | 0.4 | 2 | 1 | 3 | 2 | 1 | 0 - 4 |
| 22D | 3 | 3 | 3 | 3 | 4 | 3 | 0.4 | 2 - 4 |
| 23D | 3 | 3 | 4 | 3 | 4 | 3 | 0.5 | 2 - 4 |
| MML-17[f] | 3 | 3 | 3 | 4 | 3 | 3.2 | 0.4 | 2.4 - 4.0 |
| | | | | **Radium-226** | | | | |
| 1 | 0.2 | 0.3 | 0.3 | 0.9 | 0.5 | 0.4 | 0.3 | 0 - 1 |
| 1A | 0.3 | 0.3 | 0.3 | 0.7 | 0.4 | 0.4 | 0.2 | 0 - 0.8 |
| 3 | 0.7 | 0.3 | 1.2 | 1.6 | 0.9 | 0.9 | 0.4 | 0.1 - 2 |
| 3A | 0.5 | 0.5 | 0.9 | 1.0 | 0.5 | 0.7 | 0.2 | 0.3 - 1 |

TABLE 4-10

(continued)



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| | | | | **Radium-226** (cont'd) | | | | |
| 4 | --[e] | 0.4 | 2.0 | 2.1 | 1.2 | 1 | 0.7 | 0 - 2 |
| 4A | 0.5 | 0.6 | 1.0 | 0.9 | 0.7 | 0.7 | 0.2 | 0.3 - 1 |
| 5 | 0.4 | 0.6 | 2.4 | 2.4 | 0.3 | 1 | 1 | 0 - 3 |
| 9 | 0.8 | 0.8 | 2.8 | 7.0 | 2.4 | 3 | 2 | 0 - 7 |
| 11 | 0.6 | 0.5 | 4.1 | 4.7 | 2.2 | 2 | 2 | 0 - 6 |
| 12 | 0.3 | 0.3 | 2.3 | 2.2 | 2.3 | 2 | 1 | 0 - 4 |
| 13 | 0.2 | 0.4 | 0.3 | 0.7 | 0.3 | 0.3 | 0.2 | 0 - 0.7 |
| 14 | 0.1 | 0.1 | --[e] | 1.0 | --[e] | 0.4 | 0.4 | 0 - 1 |
| 15 | 0.2 | 0.3 | 0.4 | 0.8 | 0.5 | 0.4 | 0.2 | 0 - 0.8 |
| 20D | 0.5 | 0.3 | 0.8 | 0.8 | 0.6 | 0.6 | 0.2 | 0.2 - 1 |
| 20S | 0.5 | 0.3 | 1.1 | 0.7 | 0.5 | 0.6 | 0.3 | 0 - 1 |
| 21D | 0.4 | 0.4 | 0.9 | 0.7 | 0.4 | 0.6 | 0.2 | 0.2 - 1 |
| 21S | 0.5 | 0.4 | 0.7 | 0.9 | 0.6 | 0.6 | 0.2 | 0.2 - 1 |
| 22D | 0.3 | 0.4 | 0.3 | 0.7 | 0.4 | 0.4 | 0.2 | 0 - 0.8 |
| 23D | 0.3 | 0.3 | 0.3 | 0.6 | 0.4 | 0.4 | 0.1 | 0.2 - 0.6 |
| MML-17[f] | 0.1 | 0.2 | 0.7 | 0.7 | 0.4 | 0.4 | 0.3 | 0 - 1 |
| | | | | **Thorium-232**[g] | | | | |
| 1 | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 1A | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 3 | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 3A | -- | -- | -- | -- | 0.3 | -- | -- | -- |
| 4 | -- | -- | -- | -- | 0.3 | -- | -- | -- |
| 4A | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 5 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 9 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 11 | -- | -- | -- | -- | 0.3 | -- | -- | -- |
| 12 | -- | -- | -- | -- | 1.0 | -- | -- | -- |

TABLE 4-10

(continued)



| Sampling Location[b] | Annual Average Concentration 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation | Expected Range[c] |
|---|---|---|---|---|---|---|---|---|
| | | | | **Thorium-232[g]** (cont'd) | | | | |
| 13 | -- | -- | -- | -- | 0.3 | -- | -- | -- |
| 14 | -- | -- | -- | -- | -- | -- | -- | -- |
| 15 | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 20D | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 20S | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 21D | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 21S | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| 22D | -- | -- | -- | -- | 0.2 | -- | -- | -- |
| 23D | -- | -- | -- | -- | 0.1 | -- | -- | -- |
| MML-17[f] | -- | -- | -- | -- | 0.1 | -- | -- | -- |

Note: Sources of 1986-1989 are the annual environmental reports for those years (BNI 1987, 1988, 1989, 1990).

[a]Concentrations are given in units of E-9 μCi/ml. Note: 1E-9 μCi/ml is equivalent to 0.037 Bq/L.

[b]Sampling locations are shown in Figure 4-4.

[c]Average value ±2 standard deviations.

[d]Total uranium concentrations were determined either by summing the isotopic analysis results for uranium-234, uranium-235, and uranium-238 or fluorometric analysis.

[e]Well did not recover sufficiently to be sampled after purging in all four quarters.

[f]Background well located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.

[g]Thorium sampling began in 1990; inadequate data for trend analysis.

calculation of the standard deviation of the yearly means. The expected range provides a rough check on whether there are any trends present in the data. If the range varies a great deal from location to location, or if a location consistently falls outside the expected range, then a trend could be present. Annual averages for 1990 tended to fall within the expected ranges, indicating an absence of trends. No trend analysis was conducted for thorium-232 because sampling was initiated in 1990 and there is insufficient information available to conduct a trend analysis.

## 4.2 POTENTIAL DOSE TO THE PUBLIC

This section contains information on exposures to the general public and the hypothetical maximally exposed individual from the radioactive materials at MSP. As expected for a relatively stable site such as MSP, all calculated doses were below the DOE guidelines. Doses to the general public can come from either external or internal exposures. Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides deposited inside the body are called internal exposures. The distinction is important because external exposures occur only when a person is near the external radionuclides, but internal exposures continue as long as the radionuclides reside in the body.

To assess the potential health effects of the materials stored at MSP, radiological exposure pathways were evaluated and radiation doses were calculated for a hypothetical maximally exposed individual and for the population within 80 km (50 mi) of the site. The combined effect from all the pathways from all DOE sources can then be compared with the DOE guidelines. The pathways considered are surface water, groundwater, air, and direct exposure. Exposures from radon and radon daughters are not considered in these calculations because radon exposure is controlled through compliance with boundary concentration requirements (Appendix B). All doses presented in this section are estimated and do not represent actual doses. A summary is provided in Table 4-11.

TABLE 4-11

SUMMARY OF CALCULATED DOSES[a] FOR MSP, 1990

| Type | Dose to Hypothetical Maximally Exposed Individual (mrem/yr)[b] | Collective Dose for Population Within 80 km of Facility (person-rem/yr)[b] |
|---|---|---|
| Direct gamma radiation[c] | 2.6 | --[d] |
| Drinking Water | --[d] | --[d] |
| Ingestion | --[d] | --[d] |
| Air immersion | --[d] | --[d] |
| Inhalation[e] | 0.0034 | 0.28 |
| Total | 2.6 | 0.28 |
| Background[f] | 64 | 9.6E+5[g] |
| DOE guideline[h] | 100 | --[i] |
| Percent of guideline (excluding background) | 2.6 | --[i] |

[a]Does not include radon.

[b]1 mrem/yr = 0.01 mSv/yr; 1 person-rem/yr = 0.01 person-Sv/yr.

[c]Does not include contribution from background.

[d]No credible exposure pathway identified.

[e]Calculated using EPA's AIRDOS model (Version 3.0).

[f]Direct gamma exposure only.

[g]Calculated by the following: 64 mrem/yr x 15E+6 people.

[h]Source: DOE 1990b.

[i]No DOE guideline.

### 4.2.1 Maximally Exposed Individual

The hypothetical maximally exposed individual is assumed to be an individual who lives 10 m (30 ft) from the site; using this assumption, the following doses have been calculated.

**Direct exposure**

The calculated yearly dose to a person spending 80 percent of his time at a residence 30 m (100 ft) from the western boundary of the site was determined by using the average of the annual average values for the TETLDs along the western boundary (TETLDs 11, 13, and 16). The average exposure rate was 75 mR/yr above background (Table 4-3) at this site boundary. This dose is determined using the equation given in Appendix B for direct exposure. The calculated dose received by the hypothetical maximally exposed individual from exposure to gamma radiation was 2.6 mrem/yr (0.026 mSv/yr), well below the DOE guideline of 100 mrem/yr. This is an extremely conservative approach because it is unlikely that an individual would be on the property 80 percent of the time and the calculation does not account for any shielding provided by the house.

**Drinking water pathway**

Only one pathway, either groundwater or surface water, is used to determine the hypothetical maximally exposed individual's committed dose. Maximally exposed individuals would obtain 100 percent of their drinking water from either surface water or groundwater in the vicinity of the site.

Concentrations of total uranium, radium-226, and thorium-232 in offsite groundwater are barely detectable above normal background. Because there are no wells in the immediate vicinity of the site that are used for drinking purposes, groundwater is not a credible exposure pathway; therefore, the dose contribution of these radionuclides to the maximally exposed individual was not

calculated. There was also no credible exposure from surface water because radionuclide concentrations upstream and downstream at MSP on Main Stream are essentially equivalent.

**Air pathway**

The hypothetical maximally exposed individual would work adjacent to and live near the site throughout the year. Air doses determined using version 3.0 of EPA's AIRDOS model were found to be negligible [0.0034 mrem/yr (3.4E-5 mSv/yr)]. This dose is well below the 10 mrem/yr (0.01 mSv/yr) limit given in 40 CFR Part 61, Subpart H. The 1989 AIRDOS compliance report is provided in Appendix H; the appendix also gives the calculated amount of each primary radionuclide of concern released to the air in 1990.

**Total dose**

The total dose for the hypothetical maximally exposed individual would be the sum of the doses calculated for each exposure pathway. When these doses are added together, the total dose is 2.6 mrem/yr (0.26 mSv/yr) for the hypothetical maximally exposed individual. This dose is comparable to the dose an individual would receive from a round-trip cross-country flight from New York City to Los Angeles because of greater amounts of cosmic radiation at higher altitudes (Appendix F).

### 4.2.2 Population Dose

The collective dose to the general population living within 80 km (50 mi) of the site is calculated as follows.

**Direct exposure**

MSP is located in an industrial area and thus is remote from the general population. Both distance from the site and

intervening structures reduce direct gamma exposure from MSP (see Table 4-12). Therefore, it is assumed that there is no detectable exposure for the general population.

**Drinking water pathway**

Because the radionuclides were found in low concentrations in both groundwater and surface water and no credible exposure scenario was identified for the hypothetical maximally exposed individual, the collective population dose from drinking water is insignificant compared with other pathways.

**Air**

The AIRDOS model provides an effective dose equivalent for contaminants transported via the atmospheric pathway at different distances from the site (Table 4-12). The collective dose for the general population within 80 km (50 mi) of MSP was calculated using these effective dose equivalents and the population density. The calculated collective population dose was 0.28 person-rem/yr (0.0028 person-Sv/yr).

**Total population dose**

The total population dose is the sum of the doses from all exposure pathways. Because the only pathway with a major potential contribution to the collective population dose is the atmosphere, the total population dose is equal to that calculated for the atmospheric pathway [0.28 person-rem/yr (0.0028 person-Sv/yr)].

TABLE 4-12

MAXIMUM EFFECTIVE DOSE TO THE GENERAL PUBLIC FROM MSP, 1990

| Distance from the Site (m) | Effective Dose Equivalent (mrem/yr)[a,b] | Population Dose (person-rem/yr)[c,d] |
|---|---|---|
| 0 - 1,000 | 3.4E-3[e] | 0.013 |
| 1,000 - 3,000 | 3.8E-4 | 0.012 |
| 3,000 - 10,000 | 5.8E-5 | 0.021 |
| 10,000 - 80,000 | 9.2E-6 | 0.23 |
| | Total Dose | 0.28 |

[a]To be conservative, the effective dose equivalent used for each range was that for the distance closest to the site. DOE DCG is 100 mrem/yr above background.

[b]Values were obtained using AIRDOS (Appendix B).

[c]A population density of 10,000 person/mi$^2$ (3.9E-3 person/m$^2$) was used in the calculation.

[d]Calculated using:
Population dose = population density x $\Pi$ x [(outer radius)$^2$ - (inner radius)$^2$] x effective dose equivalent.

[e]Effective dose equivalent for 300 m.

# 5.0 NONRADIOLOGICAL ENVIRONMENTAL PROGRAM

Nonradiological environmental monitoring systems at MSP include surface water, sediment, and groundwater monitoring. The monitoring systems include onsite, site boundary, and offsite stations to provide sufficient information on the site's potential effects on human health and the environment. Nonradiological parameters are monitored as specified by EPA; DOE directives; and federal, state, and local statutes, regulations, and requirements applicable to DOE. MSP is not an active site; therefore, the only "effluents" would be contaminant migration.

## 5.1 SURFACE WATER MONITORING

Nonradiological surface water monitoring is conducted mainly to determine whether runoff from MSP contributes to surface water contamination in the area.

### 5.1.1 Program Description

The nonradiological surface water monitoring program at MSP was initiated in the third quarter of 1990. Samples were collected from the same locations as those for the radiological surface water monitoring system (Figure 4-3); see Subsection 4.1.3.

Surface water samples were analyzed quarterly for indicator parameters; metals analysis began during third-quarter sampling. In addition, samples were collected and analyzed for volatile and semivolatile organic compounds during the third quarter. Indicator parameters include pH, specific conductance, TOC, and TOX. As the name implies, indicator parameters are gross indicators of the presence of contaminants and major changes in water chemistry. Specific conductance and pH provide an indication of the inorganic composition of water. Specific conductance measures the capacity of water to conduct an electrical current and, generally, increases with elevated concentrations of dissolved solids or salinity. Acidity or alkalinity of the water is

expressed as pH; a change in pH affects the solubility and mobility of chemical contaminants. TOC and TOX indicate organic content: TOC measures the total organic content of the water but is not specific to a given organic contaminant, and TOX measures organic compounds containing halogens (e.g., halogenated hydrocarbons).

Table 5-1 lists the volatile and semivolatile organic compounds analyzed for during third quarter 1990. Metal ions are normal constituents of groundwater; however, the presence of very high concentrations of toxic heavy metals associated with the materials stored at MSP could indicate an impact resulting from site activities. Table 5-2 lists the metals for which surface water at MSP is analyzed.

### 5.1.2 Data and Discussion

Analytical results for indicator parameters show that the surface water is of somewhat better quality than might be expected in similar areas of mixed residential/commercial establishments. As shown in Table 5-3, the average specific conductance ranged from 80 to 240 μmhos/cm and pH varied from 6.9 to 7.4. Average TOC levels varied from 3.0 to 26 mg/L, and TOX levels ranged from 27 to 70 μg/L (Table 5-4).

Organic sampling showed very little contamination of surface water with volatile compounds and no contamination with semivolatile compounds. Table 5-5 lists the volatile and semivolatile compounds detected in surface water at MSP. Chloroform was the only volatile found above laboratory detection limits and was only detected in one location (at 5 μg/L). Because methylene chloride, chloroform, and bromodichloromethane were found in blanks associated with surface water analysis, their presence is attributed to laboratory contamination.

Concentrations of metals detected in surface water at MSP during 1990 are presented in Table 5-6. Only boron, calcium, magnesium, manganese, sodium, and zinc were detected with regularity. Boron and manganese, found in all locations, ranged

TABLE 5-1

REPORTING LIMITS FOR ORGANIC CHEMICAL ANALYSES OF SURFACE WATER AND GROUNDWATER AT MSP DURING THIRD QUARTER 1990



| Compound | Reporting Limit (µg/L) |
|---|---|
| **Volatile Organic Compounds** | |
| Chloromethane | 10 |
| Bromomethane | 10 |
| Vinyl chloride | 10 |
| Chloroethane | 10 |
| Methylene chloride | 3 |
| Acetone | 10 |
| Carbon disulfide | 5 |
| 1,1-dichloroethene | 5 |
| 1,1-dichloroethane | 5 |
| 1,2-dichloroethene (total) | 5 |
| Chloroform | 5 |
| 1,2-dichloroethane | 5 |
| 2-butanone | 10 |
| 1,1,1-trichloroethane | 5 |
| Carbon tetrachloride | 5 |
| Vinyl acetate | 10 |
| Bromodichloromethane | 5 |
| 1,2-dichloropropane | 5 |
| Cis-1,3-dichloropropene | 5 |
| Trichloroethene | 5 |
| Dibromochloromethane | 5 |
| 1,1,2-trichloroethane | 5 |
| Benzene | 5 |
| Trans-1,3-dichloropropene | 5 |
| Bromoform | 5 |
| 4-methyl 1-2-pentanone | 10 |
| 2-hexanone | 10 |
| Tetrachloroethene | 5 |
| 1,1,2,2-tetrachloroethane | 5 |
| Toluene | 5 |
| Chlorobenzene | 5 |
| Ethylbenzene | 5 |
| Styrene | 5 |
| Xylene (total) | 5 |

TABLE 5-1

(continued)



| Compound | Reporting Limit (µg/L) |
|---|---|
| **Semivolatile Organic Compounds** | |
| Phenol | 10 |
| Bis(2-chloroethyl)ether | 10 |
| 2-chlorophenol | 10 |
| 1,3-dichlorobenzene | 10 |
| 1,4-dichlorobenzene | 10 |
| Benzyl alcohol | 10 |
| 1,2-dichlorobenzene | 10 |
| 2-methylphenol | 10 |
| Bis(2-chloroisopropyl)ether | 10 |
| 4-methylphenol | 10 |
| N-nitroso-di-n-propylamine | 10 |
| Hexachloroethane | 10 |
| Nitrobenzene | 10 |
| Isophorone | 10 |
| 2-nitrophenol | 10 |
| 2,4-dimethylphenol | 10 |
| Benzoic acid | 50 |
| Bis(2-chloroethoxy)methane | 10 |
| 2,4-dichlorophenol | 10 |
| 1,2,4-trichlorobenzene | 10 |
| Naphthalene | 10 |
| 4-chloroaniline | 10 |
| Hexachlorobutadiene | 10 |
| 4-chloro-3-methylphenol | 10 |
| 2-methylnaphthalene | 10 |
| Hexachlorocyclopentadiene | 10 |
| 2,4,6-trichlorophenol | 10 |
| 2,4,5-trichlorophenol | 50 |
| 2-chloronaphthalene | 10 |
| 2-nitroaniline | 50 |
| Dimethylphthalate | 10 |
| Acenaphthylene | 10 |
| 2,6-dinitrotoluene | 10 |
| 3-nitroaniline | 50 |
| Acenaphthene | 10 |
| 2,4-dinitrophenol | 50 |
| 4-nitrophenol | 50 |
| Dibenzofuran | 10 |
| 2,4-dinitrotoluene | 10 |
| Diethylphthalate | 10 |
| 4-chlorophenyl-phenylether | 10 |
| Fluorene | 10 |

TABLE 5-1

(continued)



| Compound | Reporting Limit (µg/L) |
|---|---|
| **Semivolatile Organic Compounds** (cont'd) | |
| 4-nitroaniline | 50 |
| 4,6-dinitro-2-methylphenol | 50 |
| N-nitrosodiphenylamine (1) | 10 |
| 4-bromophenyl-phenylether | 10 |
| Hexachlorobenzene | 10 |
| Pentachlorophenol | 50 |
| Phenanthrene | 10 |
| Anthracene | 10 |
| Di-n-butylphthalate | 10 |
| Fluoranthene | 10 |
| Pyrene | 10 |
| Butylbenzylphthalate | 10 |
| 3,3'-dichlorobenzidine | 20 |
| Benzo(a)anthracene | 10 |
| Chrysene | 10 |
| Bis(2-ethylhexyl)phthalate | 10 |
| Di-n-octyl phthalate | 10 |
| Benzo(b)fluoranthene | 10 |
| Benzo(k)fluoranthene | 10 |
| Benzo(a)pyrene | 10 |
| Indeno(1,2,3-cd)pyrene | 10 |
| Dibenzo(a,h)anthracene | 10 |
| Benzo(g,h,i)perylene | 10 |

TABLE 5-2

REPORTING LIMITS FOR QUARTERLY METALS ANALYSES OF SURFACE WATER, SEDIMENT, AND GROUNDWATER AT MSP

| Analyte | Reporting Limit (µg/L) |
|---|---|
| Aluminum | 200 |
| Antimony | 60.0 |
| Arsenic | 500 |
| Barium | 200 |
| Beryllium | 5.0 |
| Boron | 60.0 |
| Cadmium | 5.0 |
| Calcium | 5000 |
| Chromium | 10.0 |
| Cobalt | 50.0 |
| Copper | 25.0 |
| Iron | 100 |
| Lead | 500 |
| Lithium | 100 |
| Magnesium | 5000 |
| Manganese | 15.0 |
| Molybdenum | 100 |
| Nickel | 40.0 |
| Potassium | 5000 |
| Selenium | 500 |
| Silver | 10.0 |
| Sodium | 5000 |
| Thallium | 500 |
| Vanadium | 50.0 |
| Zinc | 20.0 |

TABLE 5-3

ANALYTICAL RESULTS FOR INDICATOR PARAMETERS IN SURFACE WATER AT MSP, 1990

| Sampling Location[a] | Quarter[b] 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|
| **Specific Conductance (μmhos/cm)** | | | | | |
| 1 | 249 | 158 | 158 | 249 | 204 |
| 2 | 245 | 178 | 178 | 245 | 212 |
| 3 | 232 | 182 | 182 | 232 | 207 |
| 4[c] | 303 | 176 | 176 | 303 | 240 |
| 5 | 59 | 100 | 59 | 100 | 80 |
| **pH (standard units)** | | | | | |
| 1 | 7.2 | 7.3 | 7.2 | 7.3 | 7.3 |
| 2 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 |
| 3 | 7 | 7.2 | 7 | 7.2 | 7 |
| 4[c] | 6.9 | 6.8 | 6.8 | 6.9 | 6.9 |
| 5 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 |

[a]Sampling locations are shown in Figure 4-3.

[b]Surface water sampling was initiated in third quarter.

[c]Upstream sampling location.

TABLE 5-4

CONCENTRATIONS OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDES IN SURFACE WATER AT MSP, 1990

| Sampling Location[a] | Quarter[b] 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|
| **Total Organic Carbon (mg/L)** | | | | | |
| 1 | 3.5 | 5.8 | 3.5 | 5.8 | 4.7 |
| 2 | 46.6 | 5.2 | 5.2 | 46.6 | 26 |
| 3 | 12.2 | 3.4 | 3.4 | 12.2 | 7.8 |
| 4[c] | 3.4 | 2.6 | 2.6 | 3.4 | 3.0 |
| 5 | 4.6 | 2.3 | 2.3 | 4.6 | 3.5 |
| **Total Organic Halides (μg/L)** | | | | | |
| 1 | <20 | 77 | 20 | 77 | 49 |
| 2 | 35 | 67 | 35 | 67 | 51 |
| 3 | 30 | 110 | 30 | 110 | 70 |
| 4[c] | 58 | 65 | 58 | 65 | 62 |
| 5 | <20 | 33 | 20 | 33 | 27 |

[a]Sampling locations are shown in Figure 4-3.

[b]Surface water sampling was initiated in third quarter.

[c]Upstream sampling location.

TABLE 5-5

ORGANIC COMPOUNDS DETECTED[a] IN SURFACE WATER

AT MSP DURING THIRD QUARTER 1990

| Sampling Location[b] | Compound | Concentration (μg/L) |
|---|---|---|
| 2 | Methylene chloride | 2[c,d] |
| | Chloroform | 1[d] |
| 3 | Methylene chloride | 2[c,d] |
| 4[e] | Methylene chloride. | 1[c,d] |
| | Chloroform | 5 |
| | Bromodichloromethane | 1[c,d] |

[a]No semivolatile organics were detected.

[b]Sampling locations are shown in Figure 4-3.

[c]Indicates an estimated value -- either when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed or when the mass spectral data indicate the presence of a compound that meets the identification criteria, but the result is less than the specified detection limit but greater than zero.

[d]Indicates that the analyte was found in the associated blank as well as in the sample. Indicates possible/probable blank contamination.

[e]Upstream sampling location.

TABLE 5-6

CONCENTRATIONS[a] OF METALS DETECTED IN SURFACE WATER AT MSP, 1990



| Sampling Location[b] | Metal | Quarter[c,d] 3 | Quarter[c,d] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 1 | Boron | 280 | 379 | 280 | 379 | 330 |
| | Calcium | 29,200 | 27,000 | 27,000 | 29,200 | 28,100 |
| | Iron | <100 | 390 | 100 | 390 | 250 |
| | Lead | <500 | 3.5 | 3.5 | 500 | 250 |
| | Magnesium | 8,240 | 7,970 | 7,970 | 8,240 | 8,105 |
| | Manganese | 218 | 258 | 218 | 258 | 238 |
| | Sodium | 13,600 | 14,000 | 13,600 | 14,000 | 13,800 |
| | Zinc | 224 | 259 | 224 | 259 | 242 |
| 2 | Boron | 110 | 124 | 110 | 124 | 117 |
| | Calcium | 23,800 | 25,900 | 23,800 | 25,900 | 24,850 |
| | Magnesium | 6,980 | 7,280 | 6,980 | 7,280 | 7,130 |
| | Manganese | 26.2 | 20.7 | 20.7 | 26.2 | 24 |
| | Sodium | 12,100 | 12,400 | 12,100 | 12,400 | 12,250 |
| | Zinc | <20 | 20.4 | 20 | 20.4 | 20 |
| 3 | Aluminum | 417 | <200 | 200 | 417 | 309 |
| | Boron | 109 | 130 | 109 | 130 | 120 |
| | Cadmium | 10.4 | <5 | 5 | 10.4 | 8 |
| | Calcium | 22,900 | 25,700 | 22,900 | 25,700 | 24,300 |
| | Iron | 104 | 101 | 101 | 104 | 103 |
| | Magnesium | 6,370 | 7,220 | 6,370 | 7,220 | 6,800 |
| | Manganese | 31.7 | 16.6 | 16.6 | 31.7 | 24 |
| | Sodium | 12,800 | 12,600 | 12,600 | 12,800 | 12,700 |
| | Zinc | 105 | 44.4 | 44.4 | 105 | 75 |
| 4[e] | Boron | 74.9 | <60 | 60 | 74.9 | 67 |
| | Calcium | 26,300 | 24,700 | 24,700 | 26,300 | 25,500 |
| | Lead | <500 | 3.3 | 3.3 | 500 | 250 |
| | Magnesium | 7,580 | 7,340 | 7,340 | 7,580 | 7,460 |
| | Manganese | 19.6 | <15 | 15 | 19.6 | 17 |
| | Sodium | 12,400 | 11,400 | 11,400 | 12,400 | 11,900 |

TABLE 5-6

(continued)



| Sampling Location[b] | Metal | Quarter[c,d] 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 5 | Boron | <60 | 199 | 60 | 199 | 130 |
| | Calcium | 6,920 | 8,430 | 6,920 | 8,430 | 7,680 |
| | Copper | <25 | 289 | 25 | 289 | 157 |
| | Iron | <100 | 4.9 | 4.9 | 100 | 52 |
| | Manganese | 144 | 218 | 144 | 218 | 181 |
| | Sodium | <5,000 | 9,650 | 5,000 | 9,650 | 7,300 |
| | Zinc | 77.3 | 222 | 77.3 | 222 | 150 |

[a]Concentrations are reported in units of μg/L.

[b]Sampling locations are shown in Figure 4-3.

[c]Initiated in third quarter.

[d]Analytical methods for lead used during the third quarter were not as sensitive as those used during the fourth quarter.

[e]Upstream sampling location.

in average concentration from 67 to 330 and 17 to 238 μg/L, respectively. Because these metals were detected at both upstream and downstream locations at similar concentrations, the site does not appear to be contributing these metals to the surface water. Calcium and sodium were also found in samples from all locations in both quarters at average concentrations ranging from 7680 to 28,100 and 7300 to 13,800 μg/L, respectively.

### 5.1.3 Trends

Indicator analyses such as TOC and TOX are used as gross indicators for the presence of organics. These indicator parameters can fluctuate greatly between sampling events; therefore, trend analysis is not feasible. In cases where broad-screen organic analyses are performed to support a site characterization or remedial investigation, the data will be presented in the annual environmental report, but trend analyses will not be performed.

## 5.2 SEDIMENT MONITORING

Sediment monitoring was conducted to determine whether nonradiological contaminants are collecting in onsite or offsite sediments.

### 5.2.1 Program Description

Sediment samples collected from the same locations as those in the nonradiological program were analyzed for metals (Table 5-2) beginning in the fourth quarter of 1990.

### 5.2.2 Data and Discussion

Table 5-7 lists the concentrations of metals detected in sediments. Aluminum, calcium, copper, iron, magnesium, manganese, nickel, and zinc were found at every sampling location. Although

TABLE 5-7

CONCENTRATIONS OF METALS DETECTED IN SEDIMENT

AT MSP DURING FOURTH QUARTER 1990



| Sampling Location[a] | Metal | Concentration (µg/g) |
|---|---|---|
| 1 | Aluminum | 3,740 |
| | Arsenic | 2.5 |
| | Calcium | 1,630 |
| | Chromium | 8.8 |
| | Copper | 37.8 |
| | Iron | 11,500 |
| | Magnesium | 2,900 |
| | Manganese | 284 |
| | Nickel | 14.1 |
| | Zinc | 779 |
| 2 | Not requested | |
| 3 | Aluminum | 2,730 |
| | Calcium | 1,820 |
| | Chromium | 7.7 |
| | Copper | 46.4 |
| | Iron | 13,100 |
| | Magnesium | 2,350 |
| | Manganese | 197 |
| | Nickel | 31.8 |
| | Zinc | 89.4 |
| 4[b] | Aluminum | 3,440 |
| | Calcium | 2,650 |
| | Copper | 22.2 |
| | Iron | 10,200 |
| | Magnesium | 2,350 |
| | Manganese | 163 |
| | Nickel | 9.6 |
| | Zinc | 58.9 |
| 5 | Aluminum | 4,600 |
| | Barium | 109 |
| | Cadmium | 1.3 |
| | Calcium | 8,690 |
| | Cobalt | 11.8 |
| | Copper | 105 |
| | Iron | 25,000 |

TABLE 5-7

(continued)



| Sampling Location[a] | Metal | Concentration (μg/g) |
|---|---|---|
| 5 (cont'd) | Lead | 172 |
| | Magnesium | 3,710 |
| | Manganese | 1,440 |
| | Nickel | 30 |
| | Vanadium | 17.6 |
| | Zinc | 831 |

[a]Sampling locations are shown in Figure 4-3.

[c]Upstream sampling location.

some of these metal concentrations are large, downstream concentrations do not differ significantly from those upstream.

### 5.2.3 Trends

Because the metals analysis was only conducted during one quarter, there is insufficient information to perform a trend analysis.

## 5.3 GROUNDWATER MONITORING

Groundwater monitoring was conducted to provide information on potential migration of nonradiological contaminants through the groundwater system and to ensure compliance with environmental standards.

### 5.3.1 Program Description

Groundwater samples were collected from the same locations as those in the radiological groundwater monitoring system (Figure 4-4); see Subsection 4.1.5. Quarterly groundwater samples were analyzed for the indicator parameters and for the metals listed in Table 5-2. In addition, volatile and semivolatile organic compounds (see Table 5-1) were analyzed during the third quarter.

### 5.3.2 Data and Discussion

Analytical results for indicator parameters show that the groundwater is of somewhat better quality than might be expected in a similar area of mixed residential/commercial establishments; poor-quality groundwater is typical of industrial/urban areas. As shown in Table 5-8, averages for specific conductance ranged from 131 to 580 $\mu$mhos/cm, and pH varied from slightly acidic (pH 5.7) to slightly basic (pH 7.8). Average TOC levels varied from 1.3 to 629 mg/L, and TOX levels ranged from below detectable limits to

TABLE 5-8

ANALYTICAL RESULTS FOR INDICATOR PARAMETERS

IN GROUNDWATER AT MSP, 1990



| Sampling Location[a] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| **Specific Conductance (μmhos/cm)** | | | | | | | |
| 1 | --[b] | 145 | 115 | 134 | 115 | 145 | 131 |
| 1A | --[b] | 202 | 195 | ND | 195 | 202 | 199 |
| 3 | 434 | 412 | 416 | 367 | 367 | 434 | 407 |
| 3A | 556 | 558 | 528 | 508 | 508 | 558 | 538 |
| 4 | 180 | 210 | 149 | 167 | 149 | 210 | 177 |
| 4A | 264 | 325 | 233 | 202 | 202 | 325 | 256 |
| 5 | --[c] | 158 | --[c] | 271 | 158 | 271 | 215 |
| 9 | 623 | 561 | 669 | 468 | 468 | 669 | 580 |
| 11 | 186 | 166 | --[c] | --[c] | 166 | 186 | 176 |
| 12 | 143 | 1420 | 159 | 221 | 143 | 1420 | 486 |
| 13 | --[b] | 138 | 129 | 128 | 128 | 138 | 132 |
| 14 | --[c] | --[c] | --[c] | --[c] | -- | -- | -- |
| 15 | --[b] | 534 | 527 | 558 | 527 | 558 | 540 |
| 20D | 331 | 357 | 347 | 420 | 331 | 420 | 364 |
| 20S | 186 | 187 | 174 | 211 | 174 | 211 | 190 |
| 21D | 325 | 345 | 343 | 576 | 325 | 576 | 397 |
| 21S | 156 | 161 | 137 | 175 | 137 | 175 | 157 |
| 22D | --[b] | 562 | 565 | --[c] | 562 | 565 | 564 |
| 23D | --[b] | 399 | 413 | 494 | 399 | 494 | 435 |
| MML-17[d] | --[b] | 248 | 280 | 327 | 248 | 327 | 285 |
| **pH (standard units)** | | | | | | | |
| 1 | --[b] | 6.9 | 6.8 | 7.4 | 6.8 | 7.4 | 7.0 |
| 1A | --[b] | 6.6 | 6.5 | 6.5 | 6.5 | 6.6 | 6.5 |
| 3 | 6.0 | 7.4 | 7.2 | 7.4 | 6.0 | 7.4 | 7.0 |
| 3A | 7.5 | 6.6 | 7.1 | 7.4 | 6.6 | 7.5 | 7.2 |
| 4 | 6.9 | 5.7 | 6.3 | 6.9 | 5.7 | 6.9 | 6.5 |
| 4A | 6.6 | 5.8 | 5.9 | 6.8 | 5.8 | 6.8 | 6.3 |
| 5 | --[c] | 5.6 | --[c] | 5.8 | 5.6 | 5.8 | 5.7 |
| 9 | 7.4 | 7.0 | 7.0 | 7.3 | 7.0 | 7.4 | 7.2 |
| 11 | 7.2 | 6.6 | --[c] | --[c] | 6.6 | 7.2 | 6.9 |
| 12 | 6.5 | 6.8 | 6.4 | 6.3 | 6.3 | 6.8 | 6.5 |
| 13 | --[b] | 7.0 | 6.7 | 7.1 | 6.7 | 7.1 | 6.9 |
| 14 | --[c] | --[c] | --[c] | --[c] | -- | -- | -- |
| 15 | --[b] | 7.4 | 7.5 | 7.9 | 7.4 | 7.9 | 7.6 |

TABLE 5-8

(continued)



| Sampling Location[a] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| | | | **pH** (cont'd) | | | | |
| 20D | 8.0 | 8.0 | 7.8 | 7.5 | 7.5 | 8.0 | 7.8 |
| 20S | 6.8 | 5.6 | 5.8 | 5.9 | 5.6 | 6.8 | 6.0 |
| 21D | 8.0 | 7.7 | 7.6 | 7.3 | 7.3 | 8.0 | 7.7 |
| 21S | 6.0 | 5.9 | 5.8 | 5.8 | 5.8 | 6.0 | 5.9 |
| 22D | --[b] | 7.6 | 7.6 | --[c] | 7.6 | 7.6 | 7.6 |
| 23D | --[b] | 7.4 | 7.1 | 7.6 | 7.1 | 7.6 | 7.4 |
| MML-17[d] | --[b] | 7.9 | 8.8 | 8.2 | 7.9 | 8.8 | 8.3 |

[a]Sampling locations are shown in Figure 4-4.

[b]No data available.

[c]Well did not recover sufficiently to sample after purging.

[d]Background well located at Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.

47 μg/L (Table 5-9). Although a few quarterly TOC observations were considerably higher than those for the other three quarters (well 9, second quarter; well 13, fourth quarter; well 15, fourth quarter), there was no observation of a well with a sustained elevated reading.

Analytical results showed very little contamination of groundwater with volatile or semivolatile compounds (Table 5-10). Carbon disulfide and trichloroethane were the only volatiles found in excess of laboratory detection limits. Trichloroethane was found in only one well (21D) at very low levels (66 μg/L). This compound is a halogenated volatile that could have originated from degreasers and cleansers used in this area.

Metals analysis was initiated during the third quarter of 1990; concentrations of metals detected in groundwater are presented in Table 5-11. No definite conclusions regarding metal contaminants in the groundwater may be drawn from the 1990 sampling and analyses because of the limited amount of sampling performed. Only boron, calcium, iron, magnesium, manganese, sodium, and zinc were detected with regularity. Although concentrations of some of these common elements appear high, they constitute a relatively large percentage of Earth's composition and are, therefore, expected to be present in relatively large amounts in groundwater. Because they were usually found in similar concentrations in both upgradient and downgradient wells, it can be concluded that the site is not contributing these metals to groundwater. In addition to being found onsite, all of these metals were detected in similar concentrations at background sampling location MML-17.

Calcium and sodium were found in all wells at concentrations ranging from 6910 to 86,500 μg/L and below the detection limit to 86,500 μg/L, respectively, with no apparent correlation between well location or aquifer sampled.

### 5.3.3 Trends

Because nonradiological sampling was not begun until 1990, there is insufficient information to perform a trend analysis.

TABLE 5-9

CONCENTRATIONS OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDES IN GROUNDWATER AT MSP, 1990



| Sampling Location[a] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| **Total Organic Carbon (mg/L)** | | | | | | | |
| 1 | --[b] | 55 | 8.3 | 20.8 | 8.3 | 55 | 28 |
| 1A | --[b] | 2.0 | 1.6 | 18.8 | 1.6 | 18.8 | 7.5 |
| 3 | 11.2 | 11.2 | 10.3 | 9.4 | 9.4 | 11.2 | 11 |
| 3A | 8.3 | 8.4 | 7.6 | 8.7 | 7.6 | 8.7 | 8.3 |
| 4 | 3.5 | 3.4 | 2.9 | 4.6 | 2.9 | 4.6 | 3.6 |
| 4A | 4.8 | 3.3 | 2.6 | 5.6 | 2.6 | 5.6 | 4.1 |
| 5 | --[c] | 2.8 | --[c] | 4.8 | 2.8 | 4.8 | 3.8 |
| 9 | 8.8 | 40.6 | 7.1 | 12.9 | 7.1 | 40.6 | 17 |
| 11 | 1.9 | 18.7 | --[c] | --[c] | 1.9 | 18.7 | 10 |
| 12 | 2.7 | 3.8 | 2.6 | 2.1 | 2.1 | 3.8 | 2.8 |
| 13 | --[b] | 7.7 | 10.4 | 40.2 | 7.7 | 40.2 | 19 |
| 14 | --[c] | --[c] | --[c] | --[c] | -- | -- | -- |
| 15 | --[b] | 3.0 | 3.0 | 1880 | 3.0 | 1880 | 629 |
| 20D | 0.87 | 3.2 | 0.96 | 2.1 | 0.87 | 3.2 | 1.8 |
| 20S | 3.1 | 3.1 | 3.9 | 3.7 | 3.1 | 3.9 | 3.5 |
| 21D | 0.77 | 1.1 | 1.1 | 2.3 | 0.77 | 2.3 | 1.3 |
| 21S | 4.4 | 2.4 | 2.8 | 2.8 | 2.4 | 4.4 | 3.1 |
| 22D | --[b] | 1.8 | 2.2 | --[c] | 1.8 | 2.2 | 2.0 |
| 23D | --[b] | 2.5 | 1.9 | 16.4 | 1.9 | 16.4 | 6.9 |
| MML-17[d] | --[b] | 1.1 | 1.1 | 6.1 | 1.1 | 6.1 | 2.8 |
| **Total Organic Halides (μg/L)** | | | | | | | |
| 1 | --[b] | <20 | <20 | <20 | 20 | 20 | 20 |
| 1A | --[b] | 27 | <20 | <20 | 20 | 27 | 22 |
| 3 | 24 | <20 | <20 | 38 | 20 | 38 | 26 |
| 3A | 61 | <20 | <20 | 59 | 20 | 61 | 40 |
| 4 | 27 | <20 | 66 | <20 | 20 | 66 | 33 |
| 4A | 98 | <20 | 37 | 31 | 20 | 98 | 47 |
| 5 | --[c] | <20 | --[c] | 34 | 20 | 34 | 27 |
| 9 | <20 | <20 | <20 | 30 | 20 | 30 | 23 |
| 11 | 72 | <20 | --[c] | --[c] | 20 | 72 | 46 |
| 12 | 24 | <20 | <20 | <20 | 20 | 24 | 21 |
| 13 | <20 | <20 | <20 | 26 | 20 | 26 | 22 |
| 14 | --[c] | --[c] | --[c] | --[c] | -- | -- | -- |
| 15 | --[b] | 76 | <20 | 23 | 20 | 76 | 40 |

TABLE 5-9

(continued)



| Sampling Location[a] | Quarter 1 | 2 | 3 | 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|---|
| **Total Organic Halides** (cont'd) | | | | | | | |
| 20D | <20 | <20 | <20 | <20 | 20 | 20 | 20 |
| 20S | 44 | <20 | <20 | <20 | 20 | 44 | 26 |
| 21D | 46 | <20 | <20 | 100 | 20 | 100 | 47 |
| 21S | <20 | <20 | <20 | 40 | 20 | 40 | 25 |
| 22D | --[b] | --[b] | <20 | --[c] | 20 | -- | -- |
| 23D | --[b] | <20 | <20 | <20 | 20 | -- | -- |
| MML-17[d] | --[b] | --[b] | --[b] | --[b] | -- | -- | -- |

[a]Sampling locations are shown in Figure 4-4.

[b]No data available.

[c]Well did not recover sufficiently to sample after purging.

[d]Background well located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.

TABLE 5-10

CONCENTRATIONS OF VOLATILE AND SEMIVOLATILE ORGANIC COMPOUNDS DETECTED IN GROUNDWATER AT MSP DURING THIRD QUARTER 1990



| Sampling Location[b] | Compound | Concentration (μg/L) |
|---|---|---|
| | **Volatile Compounds** | |
| 1A | Methylene chloride | 3[b,c] |
| 3 | Methylene chloride | 3[b,c] |
| 3A | Methylene chloride | 2[b,c] |
| 4 | Methylene chloride | 2[b,c] |
| 4A | Methylene chloride<br>Carbon Disulfide | 3[b,c]<br>5 |
| 9 | Methylene chloride | 2[b,c] |
| 11[d] | | |
| 12 | Methylene chloride<br>Toluene | 4[b,c]<br>1[b] |
| 13 | Methylene chloride | 3[b,c] |
| 14[d] | | |
| 15 | Methylene chloride | 3[b,c] |
| 20D | Methylene chloride<br>Acetone<br>Toluene | 4[b,c]<br>2[b,c]<br>1[b] |
| 20S | Methylene chloride | 3[b,c] |
| 21D | Methylene chloride<br>Trichloroethene | 3[b,c]<br>66 |
| 21S | Methylene chloride | 4[b,c] |
| 22D | Methylene chloride | 2[b,c] |
| 23D | Methylene chloride | 2[b,c] |

TABLE 5-10

(continued)



| Sampling Location[b] | Compound | Concentration (μg/L) |
|---|---|---|
| | **Volatile Compounds** (cont'd) | |
| MML-17[e] | Methylene chloride | 3[b,c] |
| | **Semivolatile Compounds** | |
| 3 | Di-n-butylphthalate | 1[b,c] |
| | Bis(2-ethylhexyl)phthalate | 5[b,c] |
| 3A | Di-n-butylphthalate | 1[b,c] |
| | Bis(2-ethylhexylphthalate | 4[b,c] |
| 4A | 1,2,4-trichlorobenzene | 2[b] |
| | Bis(2-ethylhexyl)phthalate | 2[b,c] |
| 9 | Di-n-butylphthalate | 1[b] |
| 20D | Di-n-butylphthalate | 1[b,c] |
| | Bis(2-ethylhexyl)phthalate | 2[b,c] |
| 21S | Di-n-butylphthalate | 2[b,c] |
| | N-nitrosodiphenlamine(1) | 4[b] |

[a]Sampling locations are shown in Figure 4-4.

[b]Indicates an estimated value--either when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed or when the mass spectral data indicate the presence of a compound that meets the identification criteria, but the result is less than the specified detection limit but greater than zero.

[c]Indicates that the analyte was found in the associated blank as well as in the sample; indicates possible/probable blank contamination.

[d]Well did not recover sufficiently to sample after purging.

[e]Background well located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.

TABLE 5-11

CONCENTRATIONS[a] OF METALS DETECTED IN GROUNDWATER AT MSP, 1990



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 1 | Aluminum | <200 | 1,450 | 200 | 1,450 | 825 |
| | Boron | 126 | 132 | 126 | 132 | 129 |
| | Calcium | 12,800 | 6,910 | 6,910 | 12,800 | 9,860 |
| | Copper | 26.4 | 44.4 | 26.4 | 44.4 | 35.4 |
| | Iron | <500 | 2,660 | 500 | 2,660 | 1,580 |
| | Lead | <100 | 33 | 33 | 100 | 66 |
| | Manganese | 35.3 | 110 | 35.3 | 110 | 72.7 |
| | Sodium | 6,290 | ND | 6,290 | 6,290 | 6,290 |
| | Zinc | 60.6 | 145 | 60.6 | 145 | 103 |
| 1A | Boron | 147 | 191 | 147 | 191 | 169 |
| | Calcium | 20,400 | 15,600 | 15,600 | 20,400 | 18,000 |
| | Iron | <500 | 140 | 140 | 500 | 320 |
| | Magnesium | 7,000 | 5,450 | 5,400 | 7,000 | 6,230 |
| | Sodium | 10,300 | 8,810 | 8,810 | 10,300 | 9,560 |
| | Zinc | 62.4 | 26.4 | 26.4 | 62.4 | 44.4 |
| 3 | Aluminum | <200 | 2,300 | 200 | 2,300 | 1,300 |
| | Boron | 341 | 168 | 168 | 341 | 255 |
| | Calcium | 55,300 | 55,400 | 55,300 | 55,400 | 55,350 |
| | Iron | <500 | 3,140 | 500 | 3,140 | 1,820 |
| | Magnesium | 15,400 | 16,000 | 15,400 | 16,000 | 15,700 |
| | Manganese | 3,710 | 2,980 | 2,980 | 3,710 | 3,350 |
| | Sodium | 14,800 | 15,900 | 14,800 | 15,900 | 15,350 |
| | Zinc | 46.4 | 87.7 | 46.4 | 87.7 | 67.1 |
| 3A | Aluminum | <200 | 1,280 | 200 | 1,280 | 790 |
| | Boron | 215 | <60 | 60 | 215 | 140 |
| | Calcium | 80,400 | 86,500 | 80,400 | 86,500 | 83,450 |
| | Iron | <500 | 1,400 | 500 | 1,400 | 950 |
| | Magnesium | 20,400 | 22,200 | 20,400 | 22,200 | 21,300 |
| | Manganese | 2,250 | 851 | 851 | 2,250 | 1,550 |
| | Sodium | 18,600 | 21,400 | 18,600 | 21,400 | 20,000 |

TABLE 5-11

(continued)



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 4 | Aluminum | <200 | 50,200 | 200 | 50,200 | 25,200 |
| | Barium | <200 | 459 | 200 | 459 | 330 |
| | Boron | 136 | <60 | 60 | 136 | 98 |
| | Calcium | 8,210 | 16,000 | 8,210 | 16,000 | 12,105 |
| | Chromium | <10 | 59.5 | 10 | 59.5 | 35 |
| | Copper | <25 | 38.2 | 25 | 38.2 | 32 |
| | Iron | <100 | 84,600 | 100 | 84,600 | 42,400 |
| | Lead | <500 | 10.7 | 10.7 | 500 | 505 |
| | Magnesium | <5,000 | 28,600 | 5,000 | 28,600 | 16,800 |
| | Manganese | 222 | 1,120 | 222 | 1,120 | 671 |
| | Nickel | <40 | 101 | 40 | 101 | 71 |
| | Potassium | <5,000 | 13,900 | 5,000 | 13,900 | 9,450 |
| | Sodium | 14,200 | 18,400 | 14,200 | 18,400 | 16,300 |
| | Vanadium | <50 | 98 | 50 | 98 | 74 |
| | Zinc | 87.7 | 400 | 87.7 | 400 | 244 |
| 4A | Boron | 244 | <60 | 60 | 244 | 152 |
| | Calcium | 23,600 | 22,100 | 22,100 | 23,600 | 22,850 |
| | Iron | <100 | 246 | 100 | 246 | 123 |
| | Magnesium | 9,210 | 8,310 | 8,310 | 9,210 | 8,760 |
| | Manganese | 261 | 272 | 261 | 272 | 267 |
| | Sodium | 19,800 | 18,800 | 18,800 | 19,800 | 19,300 |
| | Zinc | 45.6 | 29.7 | 29.7 | 45.6 | 37.7 |
| 5 | Aluminum | --[d] | 17,000 | | | |
| | Barium | --[d] | 304 | | | |
| | Calcium | --[d] | 13,700 | | | |
| | Chromium | --[d] | 18 | | | |
| | Iron | --[d] | 25,300 | | | |
| | Lead | --[d] | 3.8 | | | |
| | Magnesium | --[d] | 15,400 | | | |
| | Manganese | --[d] | 593 | | | |

TABLE 5-11

(continued)



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 5 (cont'd) | Nickel | --[d] | 44.4 | | | |
| | Potassium | --[d] | 6,550 | | | |
| | Sodium | --[d] | 19,100 | | | |
| | Zinc | --[d] | 128 | | | |
| 9 | Boron | 440 | 412 | 412 | 440 | 426 |
| | Calcium | 81,400 | 46,400 | 46,400 | 81,400 | 63,900 |
| | Iron | 1,880 | 3,510 | 1,880 | 3,510 | 2,700 |
| | Magnesium | 29,600 | 14,400 | 14,400 | 29,600 | 22,000 |
| | Manganese | 2,500 | 649 | 649 | 2,500 | 1,580 |
| | Potassium | 6,560 | 6,040 | 6,040 | 6,560 | 6,300 |
| | Sodium | 21,900 | 17,100 | 17,100 | 21,900 | 19,500 |
| | Zinc | 32 | 45.9 | 32 | 45.9 | 39 |
| 11[e] | | | | | | |
| 12 | Aluminum | <200 | 39,600 | 200 | 39,600 | 19,900 |
| | Barium | <200 | 312 | 200 | 312 | 256 |
| | Boron | 199 | <60 | 60 | 199 | 130 |
| | Calcium | 14,400 | 18,100 | 14,400 | 18,100 | 16,250 |
| | Chromium | <10 | 43.7 | 10 | 43.7 | 26 |
| | Copper | <25 | 65.7 | 25 | 65.7 | 45 |
| | Iron | <100 | 58,500 | 100 | 58,500 | 29,300 |
| | Magnesium | 5,170 | 24,600 | 5,170 | 24,600 | 14,885 |
| | Manganese | 51.5 | 924 | 51.5 | 924 | 488 |
| | Nickel | <15 | 84.4 | 15 | 84.4 | 50 |
| | Potassium | <5,000 | 11,900 | 5,000 | 11,900 | 8,450 |
| | Sodium | 9,310 | 14,000 | 9,310 | 14,000 | 11,660 |
| | Vanadium | <20 | 57.7 | 57.7 | 57.7 | 57.7 |
| | Zinc | 52.9 | 280 | 52.9 | 280 | 167 |
| 13 | Aluminum | <200 | 2,920 | 200 | 2,920 | [illegible] |
| | Boron | [illegible] | [illegible] | | | |

TABLE 5-11

(continued)



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 13 (cont'd) | Calcium | 10,700 | 8,330 | 8,330 | 10,700 | 9,520 |
| | Iron | 206 | 3,950 | 206 | 3,950 | 2,080 |
| | Manganese | <15 | 54.8 | 15 | 54.8 | 35 |
| | Sodium | 9,330 | 7,260 | 7,260 | 9,330 | 8,300 |
| | Zinc | 153 | 41.5 | 41.5 | 153 | 97.3 |
| 14[e] | | | | | | |
| 15 | Aluminum | <200 | 296 | 200 | 296 | 448 |
| | Barium | <200 | 202 | 200 | 202 | 201 |
| | Boron | 67.5 | 182 | 67.5 | 182 | 125 |
| | Calcium | 73,500 | 63,500 | 63,500 | 73,500 | 68,500 |
| | Iron | <100 | 429 | 100 | 429 | 265 |
| | Magnesium | 17,900 | 9,520 | 9,520 | 17,900 | 13,710 |
| | Manganese | 262 | 780 | 262 | 780 | 521 |
| | Sodium | 15,500 | 15,800 | 15,500 | 15,800 | 15,650 |
| | Zinc | 38.6 | 40.4 | 38.6 | 40.4 | 39.5 |
| 20D | Barium | 346 | 368 | 346 | 368 | 357 |
| | Boron | 64.8 | <60 | 60 | 64.8 | 62 |
| | Calcium | 54,300 | 56,700 | 54,300 | 56,700 | 55,500 |
| | Magnesium | 5,770 | 5,900 | 5,770 | 5,900 | 5,840 |
| | Sodium | 11,600 | 11,900 | 11,600 | 11,900 | 11,750 |
| | Zinc | 48.4 | 51.2 | 48.4 | 51.2 | 49.8 |
| 20S | Boron | 162 | 60 | 60 | 162 | 111 |
| | Calcium | 15,400 | 14,500 | 14,500 | 15,400 | 14,950 |
| | Iron | <100 | 1,520 | 100 | 1,520 | 810 |
| | Magnesium | 5,640 | 5,380 | 5,380 | 5,640 | 5,510 |
| | Manganese | 342 | 344 | 342 | 344 | 343 |
| | Sodium | 12,400 | 13,100 | 12,400 | 13,100 | 12,750 |
| | Zinc | 32.3 | 63.4 | 32.3 | 63.4 | 47.9 |

TABLE 5-11

(continued)



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| 21D | Barium | 494 | 516 | 494 | 516 | 505 |
| | Calcium | 55,400 | 54,000 | 54,000 | 55,400 | 54,700 |
| | Magnesium | 6,900 | 6,530 | 6,530 | 6,900 | 6,720 |
| | Sodium | 11,300 | 15,300 | 11,300 | 15,300 | 13,300 |
| | Zinc | <20 | 91.8 | 20 | 91.8 | 56 |
| 21S | Aluminum | <200 | 291 | 200 | 291 | 246 |
| | Boron | 255 | 102 | 102 | 255 | 179 |
| | Calcium | 14,300 | 15,400 | 14,300 | 15,400 | 14,850 |
| | Iron | <100 | 486 | 100 | 486 | 293 |
| | Manganese | <15 | 22.1 | 15 | 22.1 | 19 |
| | Sodium | 7,750 | 9,020 | 7,750 | 9,020 | 8,390 |
| | Zinc | 39.9 | 33.1 | 33.1 | 39.9 | 36.5 |
| 22D | Barium | 481 | --[d] | | | |
| | Boron | 90.7 | --[d] | | | |
| | Calcium | 83,400 | --[d] | | | |
| | Magnesium | 17,400 | --[d] | | | |
| | Sodium | 18,100 | --[d] | | | |
| | Zinc | 21.1 | --[d] | | | |
| 23D | Aluminum | <200 | 296 | 200 | 296 | 248 |
| | Barium | <200 | 202 | 200 | 202 | 201 |
| | Boron | <60 | 182 | 60 | 182 | 120 |
| | Calcium | <5,000 | 63,500 | 5,000 | 63,500 | 34,300 |
| | Iron | <100 | 429 | 100 | 429 | 265 |
| | Magnesium | <5,000 | 9,520 | 5,000 | 9,520 | 7,260 |
| | Manganese | <15 | 780 | 15 | 780 | 398 |
| | Sodium | <5,000 | 15,800 | 5,000 | 15,800 | 10,400 |
| | Zinc | <20 | 40.4 | 20 | 40.4 | 30 |

TABLE 5-11

(continued)



| Sampling Location[b] | Metal | Quarter[c] 3 | Quarter[c] 4 | Min | Max | Avg |
|---|---|---|---|---|---|---|
| MML-17[f] | Aluminum | <200 | 1,900 | 200 | 1,900 | 10,500 |
| | Barium | 335 | 422 | 335 | 422 | 379 |
| | Boron | 111 | 102 | 102 | 111 | 107 |
| | Calcium | 30,100 | 31,000 | 30,100 | 31,000 | 30,550 |
| | Copper | <25 | 33.8 | 25 | 33.8 | 29 |
| | Iron | <100 | 2,280 | 100 | 2,280 | 1,180 |
| | Magnesium | 9,040 | 10,100 | 9,040 | 10,100 | 9,570 |
| | Manganese | 91.1 | 147 | 91.1 | 147 | 119 |
| | Sodium | 10,900 | 11,300 | 10,900 | 11,300 | 11,100 |
| | Zinc | <20 | 164 | 164 | 164 | 164 |

[a]Concentrations are reported in units of μg/L.

[b]Sampling locations are shown in Figure 4-4.

[c]Metals analysis was initiated in third quarter.

[d]Well did not recover sufficiently to sample after purging.

[e]No metals found above the detection limit.

[f]Background well located at the Middlesex Municipal Landfill, Middlesex, NJ, 0.8 km (0.5 mi) northwest of MSP. Reinstated in October 1988.

# 6.0 GROUNDWATER PROTECTION PROGRAM

## 6.1 HYDROGEOLOGICAL CHARACTERISTICS

### 6.1.1 Site Hydrogeology

The MSP site, which lies in the Triassic Lowlands region of north-central New Jersey (Geraghty and Miller 1976), slopes gently to the south. Soils at the site represent weathered bedrock and fill material composed predominantly of silty to sandy loams ranging in thickness from 0.46 to 2.4 m (1.5 to 8.0 ft). Red shale of the Triassic Brunswick Formation is the bedrock unit underlying the soils at MSP (Weston 1980).

The two types of water-bearing material that occur within 9.1 m (30 ft) of the ground surface are the red shale of the Brunswick Formation and the overlying unconsolidated deposits. Some wells developed in the Brunswick (the lower groundwater system) are screened at depths ranging from 4.6 to 15.3 m (15 to 50 ft); others are open holes at total depth and there is no documentation for the top of the open interval. The water table in the lower groundwater system occurs at approximately 2.4 to 9.1 m (8 to 30 ft) below the ground surface. The water table in the unconsolidated deposits (upper groundwater system) occurs at a depth of 0.6 to 3.0 m (2 to 10 ft). Wells in the upper groundwater system are screened at depths ranging from 1.5 to 4.6 m (5 to 15 ft).

### 6.1.2 Groundwater Quality and Usage

Water quality in the unconsolidated deposits in the MSP area is reportedly good. Most chemical concentrations are low, but water quality varies according to the composition of the sediments. The Brunswick Formation is a major aquifer in the western part of Middlesex County and in adjoining Essex County. It generally produces very hard water that is also high in total dissolved solids and is slightly alkaline, and the quality of water from the Brunswick Formation varies greatly with locality and depth. In

general, water obtained from nearer the surface is of better quality (Geraghty and Miller 1976). Table 6-1 presents analyses of selected samples of groundwater from both the unconsolidated deposits (upper groundwater system) and the Brunswick Formation (lower groundwater system) in the Middlesex region.

A well canvass of the area within a 4.8-km (3-mi) radius of MSP conducted in 1987 and 1988 yielded records for 74 wells drilled between 1954 and 1984. Sixty-nine of these wells were drilled to obtain water for domestic purposes. None of these private wells supplied water specifically for drinking, and no public water supply wells were identified during the well canvass.

## 6.2 GROUNDWATER MONITORING

### 6.2.1 Methods

The hydrogeological interpretations presented here are based on groundwater levels measured in 14 monitoring wells during 1990. Groundwater levels were measured weekly using an electric downhole probe water level indicator. Groundwater monitoring wells (Figure 6-1) were installed at the MSP site in two phases by Roy F. Weston, Inc.--Phase I in 1980 and Phase II in 1981. A summary of well construction details is shown in Table 6-2. Examples of well construction details are provided in Appendix E. Further information on site geology, hydrogeology, and well installation methods can be found in Weston (1980).

Water level measurements from monitoring wells are used to prepare two types of graphic exhibits (hydrographs and potentiometric surface maps) that show hydrogeological conditions at the site. Hydrographs are line graphs that display changes in water levels for each monitoring well throughout the year (Appendix E). The MSP hydrographs also include bar graphs of U.S. Weather Service precipitation records for the Middlesex area as an aid in evaluating the influence of precipitation on water level behavior.

TABLE 6-1

SELECTED ANALYSES OF GROUNDWATER FROM THE MIDDLESEX REGION[a]

| Parameter | Range of Analytical Results[b] | |
|---|---|---|
| | Upper Groundwater System (1971) | Lower Groundwater System (1957-1973) |
| Chloride (Cl) | 14-32 (2) | 5.0-38 (19) |
| Sulfate ($SO_4$) | 5-72 (2) | 12-784 (17) |
| Nitrate ($NO_3$) | 16.7-17.3 (2) | 0.0-24 (15) |
| Total Dissolved Solids | 76-370 (2) | 210-3700 (18) |
| Alkalinity ($CaCo_3$) | 16-180 (2) | 38-209 (19) |
| pH | 6.2-7.4 (2) | 6.3-8.0 (21) |
| Iron (Fe) | --[c] | 0.02-5.0 (16) |
| Manganese (Mn) | 0.09-0.3 (2) | 0-0.55 (16) |
| Total Hardness ($CaCO_3$) | 40-328 (2) | 82-1620 (20) |

[a]Data from Geraghty and Miller (1976).
[b]In mg/L except for pH (standard units). Numbers in parentheses represent number of samples taken.
[c]Not analyzed for.

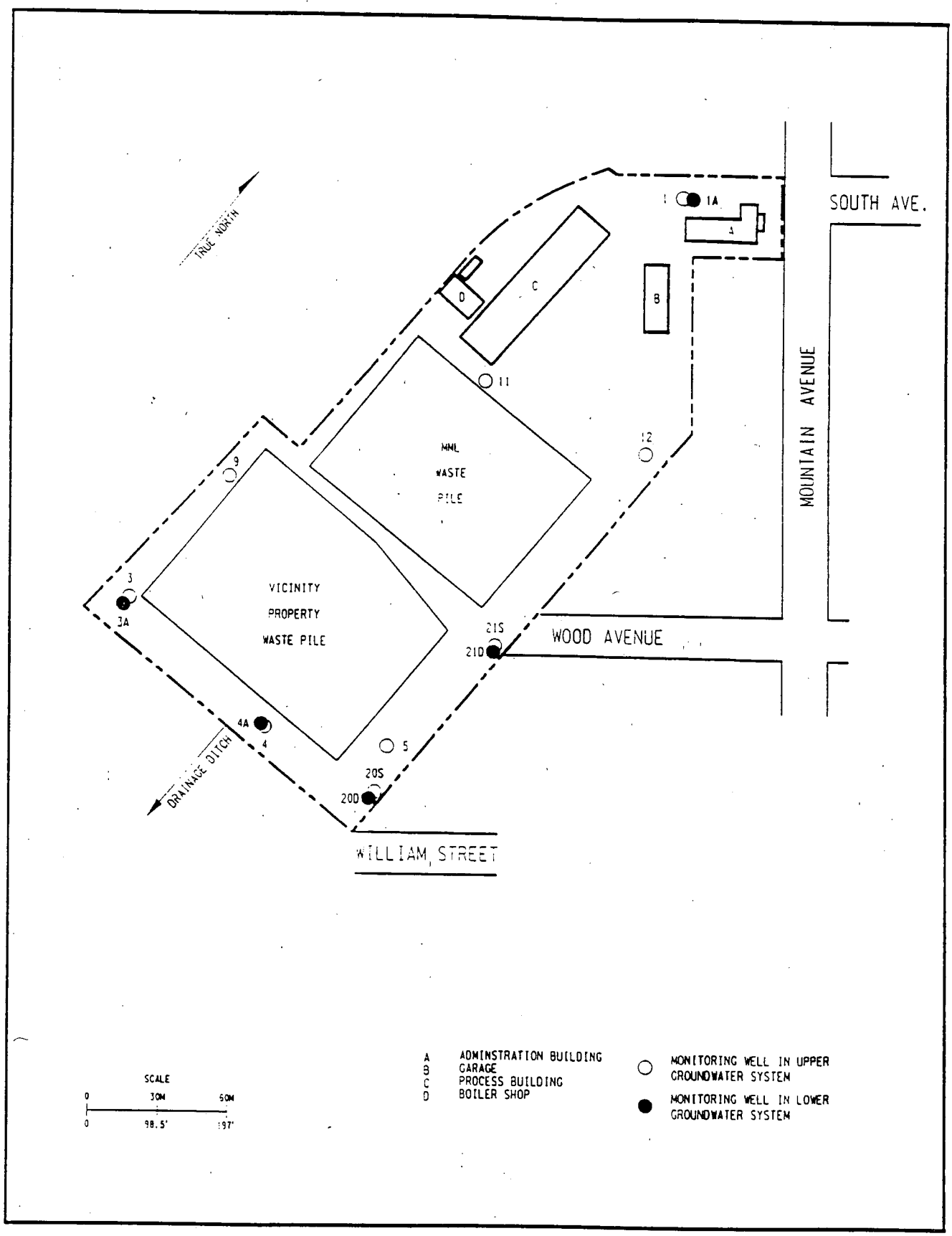


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Figure 6-1
Monitoring Wells Used for Water Level Measurements at MSP in 1990

TABLE 6-2

MSP MONITORING WELL CONSTRUCTION SUMMARY[a]

| Well Number | Completion Date | Total Depth [m (ft)] | Monitored or Screened Interval Below Ground [m-m (ft-ft)] | Construction Material[b] |
|---|---|---|---|---|
| | | **Phase I Wells** | | |
| 1 | May 1980 | 3.05 (10.0) | 1.1 - 3.05 (3.5-10.0) | PVC |
| 1A | May 1980 | 15.3 (50.0) | Open[c] | PVC[d] |
| 3 | May 1980 | 3.05 (10.0) | 0.30 - 3.05 (1.0-10.0) | PVC |
| 3A | May 1980 | 15.3 (50.0) | Open[c] | PVC[d] |
| 4 | May 1980 | 3.05 (10.0) | 0.50 - 3.05 (1.5-10.0) | PVC |
| 4A | May 1980 | 9.2 (30.0) | Open[c] | PVC[d] |
| 5 | May 1980 | 3.05 (10.0) | 1.1 - 3.05 (3.5-10.0) | PVC |
| 9 | May 1980 | 3.05 (10.0) | 0.0 - 3.05 (0.0-10.0) | PVC |
| 11 | May 1980 | 3.05 (10.0) | 0.30 - 3.05 (1.0-10.0) | PVC |
| 12 | May 1980 | 3.05 (10.0) | 0.30 - 3.05 (1.0-10.0) | PVC |
| 13[e] | May 1980 | 3.05 (10.0) | 0.9 - 3.05 (3.0-10.0) | PVC |
| 14[e] | May 1980 | 4.6 (15.0) | 1.2 - 4.6 (4.0-15.0) | PVC |
| 15[e] | May 1980 | 1.5 (5.0) | 0.0 - 1.5 (0.0-5.0) | PVC |
| | | **Phase II Wells** | | |
| 20D | July 1981 | 15.3 (50.0) | 12.2 - 15.3 (40.0-50.0) | PVC |
| 20S | July 1981 | 3.05 (10.0) | 0.90 - 3.05 (3.0-10.0) | PVC |
| 21D | July 1981 | 15.3 (50.0) | 12.2 - 15.3 (40.0-50.0) | PVC |
| 21S | July 1981 | 3.05 (10.0) | 0.9 - 3.05 (3.0-10.0) | PVC |
| 22D[f] | July 1981 | 15.3 (50.0) | 12.2 - 15.3 (40.0-50.0) | PVC |
| 23D[f] | July 1981 | 15.3 (50.0) | 12.2 - 15.3 (40.0-50.0) | PVC |

[a]Wells installed by Roy F. Weston, Inc.

[b]PVC - polyvinyl chloride.

[c]Open at total depth; no documentation for top of open interval.

[d]PVC conductor in overburden; open hole in bedrock.

[e]Water level not measured in 1990.

[f]Water level measured only in December 1990.

NOTE: Water level elevations for wells monitored in 1990 are shown as hydrographs in Appendix E.

The amount of slope (gradient) and flow direction of the MSP groundwater system were determined from potentiometric surface (water level) maps. These maps are prepared by plotting water level measurements for selected dates (representative of all four seasons) on a base map and contouring the values.

### 6.2.2 Results and Conclusions

All the hydrographs prepared for water levels measured in 1990 are shown in Appendix E. Conclusions derived from these hydrographs and from the potentiometric surface maps are presented in the following sections.

#### Upper Groundwater System

Hydrographs of wells screened in the upper groundwater system do not show a seasonal variation in water levels. This confirms observations made in 1989 (BNI 1990). Water levels in many of the wells appear to act similarly, but they do not appear to be directly related to precipitation events.

The general flow pattern for groundwater in the upper system at MSP is to the south (Figures 6-2 through 6-5). Flow in this system is influenced by a leaky conduit, that runs from north to south underneath the site. The generalized groundwater flow gradient was 0.01. All flow gradients were calculated using the southern flow direction. Both the flow direction and gradient were similar to those determined for 1989 (BNI 1990).

#### Lower Groundwater System

Hydrographs of wells screened in the lower groundwater systems also do not show a seasonal variation in water levels, probably because of the lack of precipitation during the normally wetter months. This confirmed observations made in 1989 (BNI 1990). Except for well 1A, water levels appear to act similarly in each well. Water levels do not appear to be responsive to precipitation.

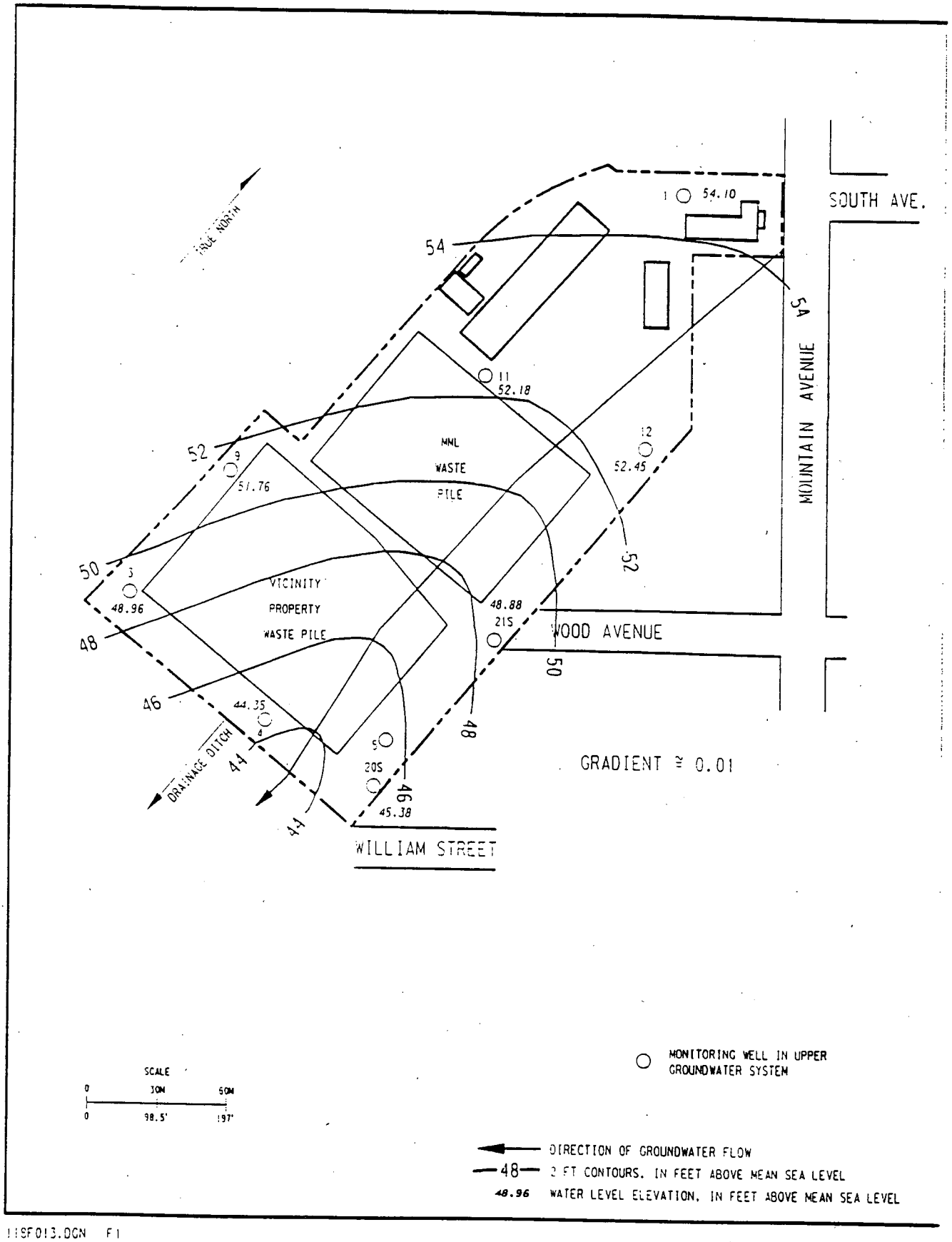


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Figure 6-2
Potentiometric Surface Map of Upper Groundwater System at MSP (1/10/90

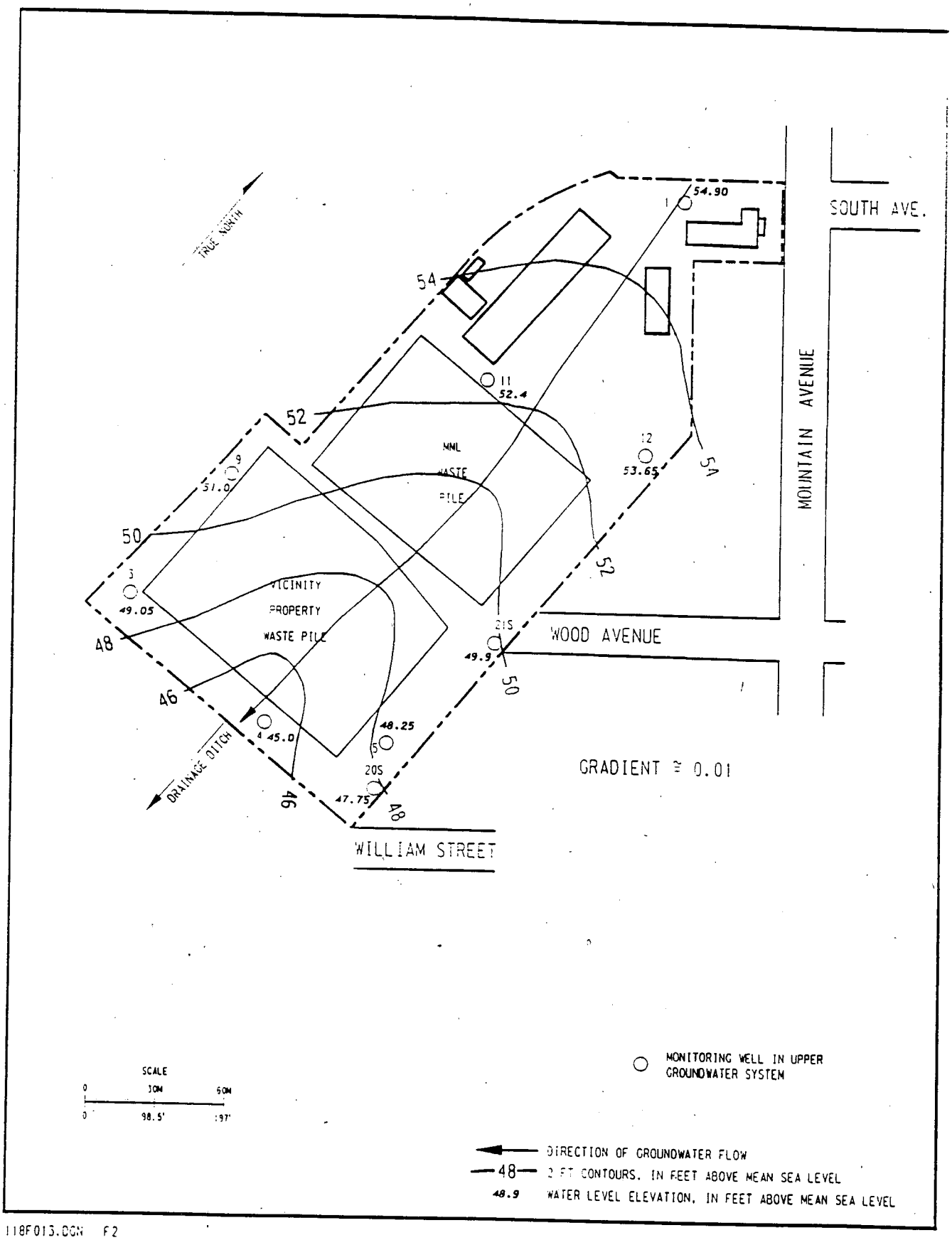


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Figure 6-3
Potentiometric Surface Map of Upper Groundwater System at MSP (3/14/90)

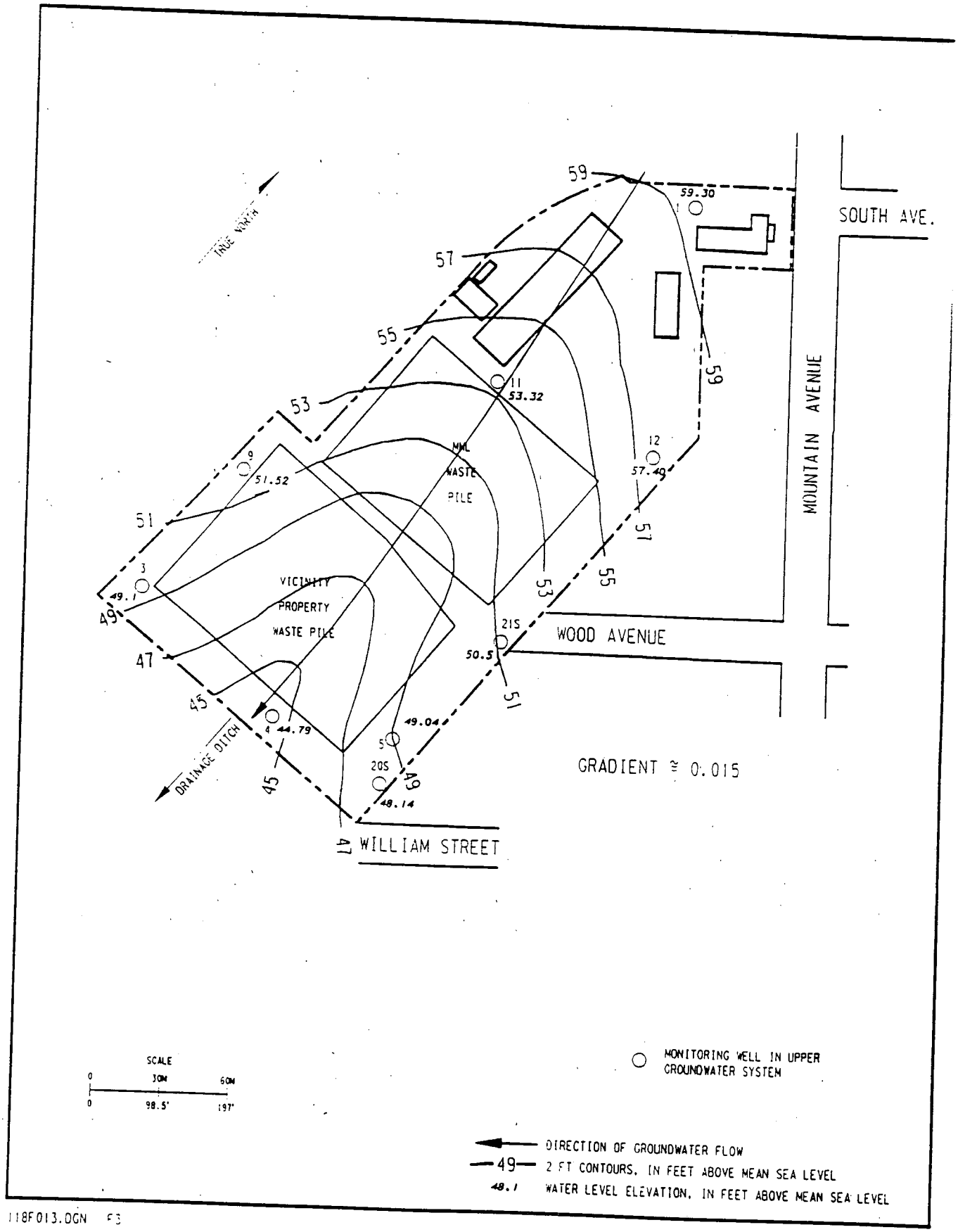


Figure 6-4
Potentiometric Surface Map of Upper Groundwater System at MSP (6/15/90)

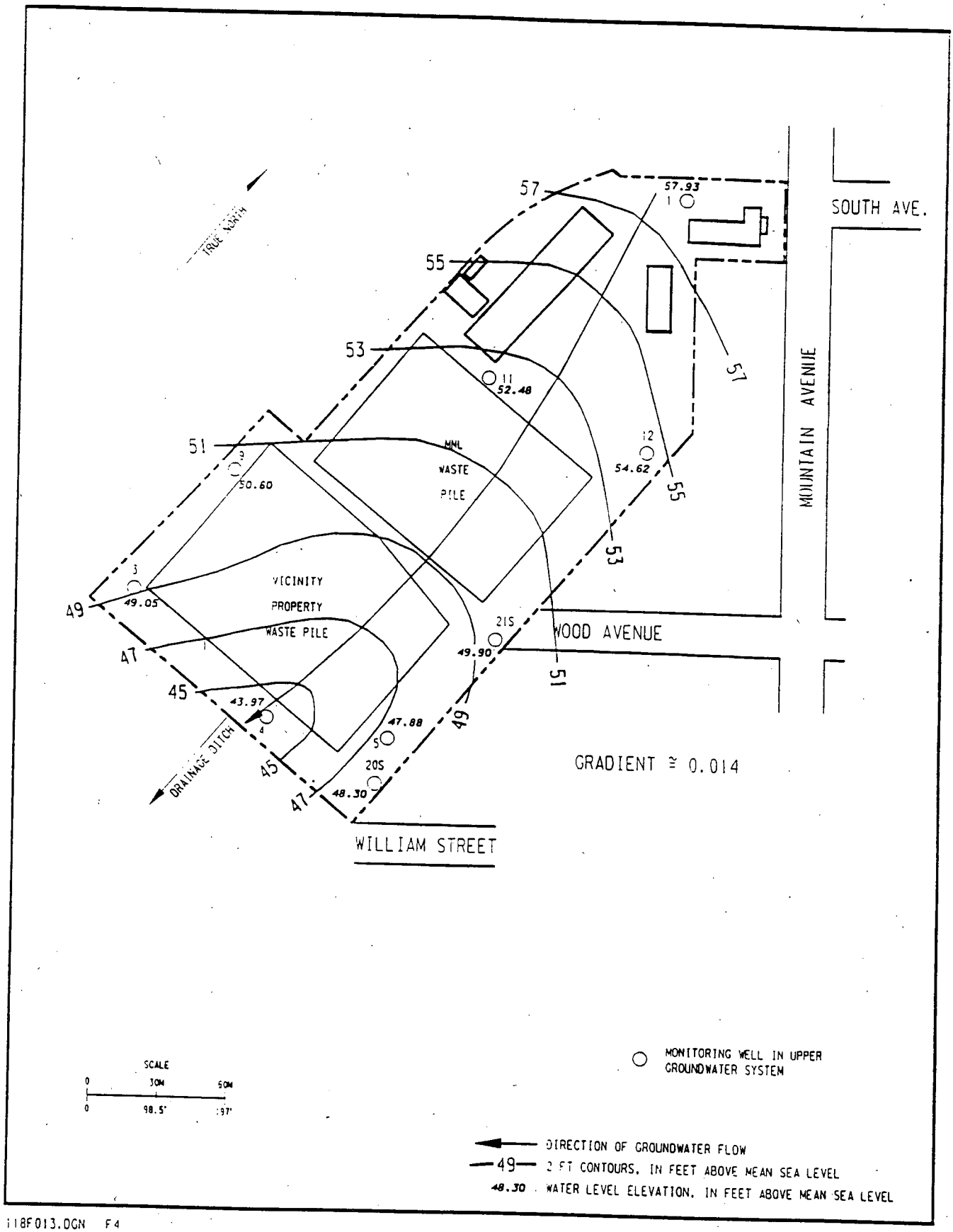


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Figure 6-5
Potentiometric Surface Map of Upper Groundwater System at MSP (9/20/90)

The general flow pattern at MSP is toward the center of the site (Figures 6-6 through 6-9). Groundwater from the southern end of the site drains to the northeast, whereas groundwater from the northern end of the site drains to the southeast. The generalized groundwater flow gradient to the southeast was 0.03, and the generalized flow gradient to the northeast was 0.024. The value calculated for flow to the northeast for 1990 was similar to that calculated for flow to the northeast in 1989 (BNI 1990). Groundwater levels from the northern end of MSP were not collected in 1989.

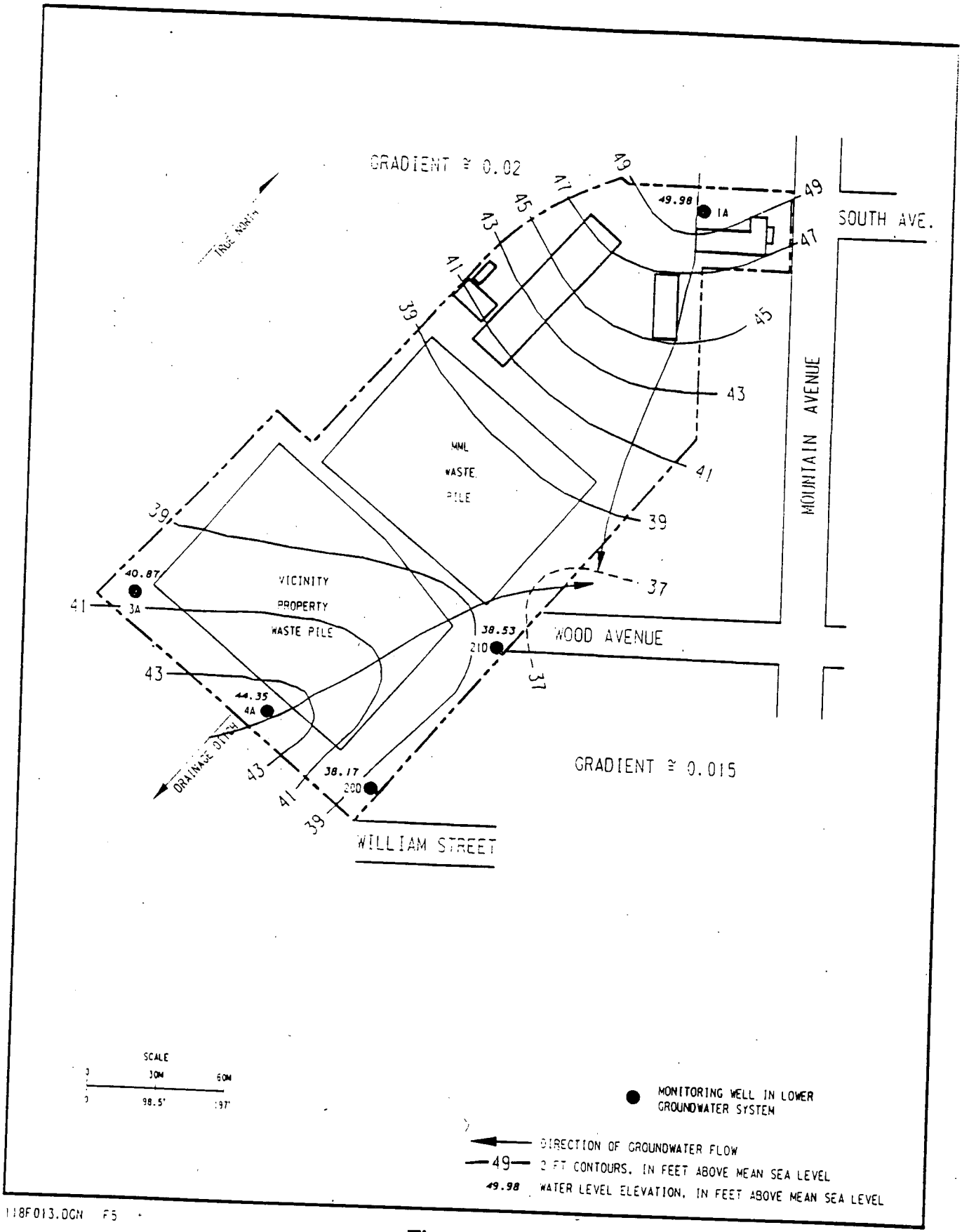


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Figure 6-6
Potentiometric Surface Map of Lower Groundwater System at MSP (1/10/90)

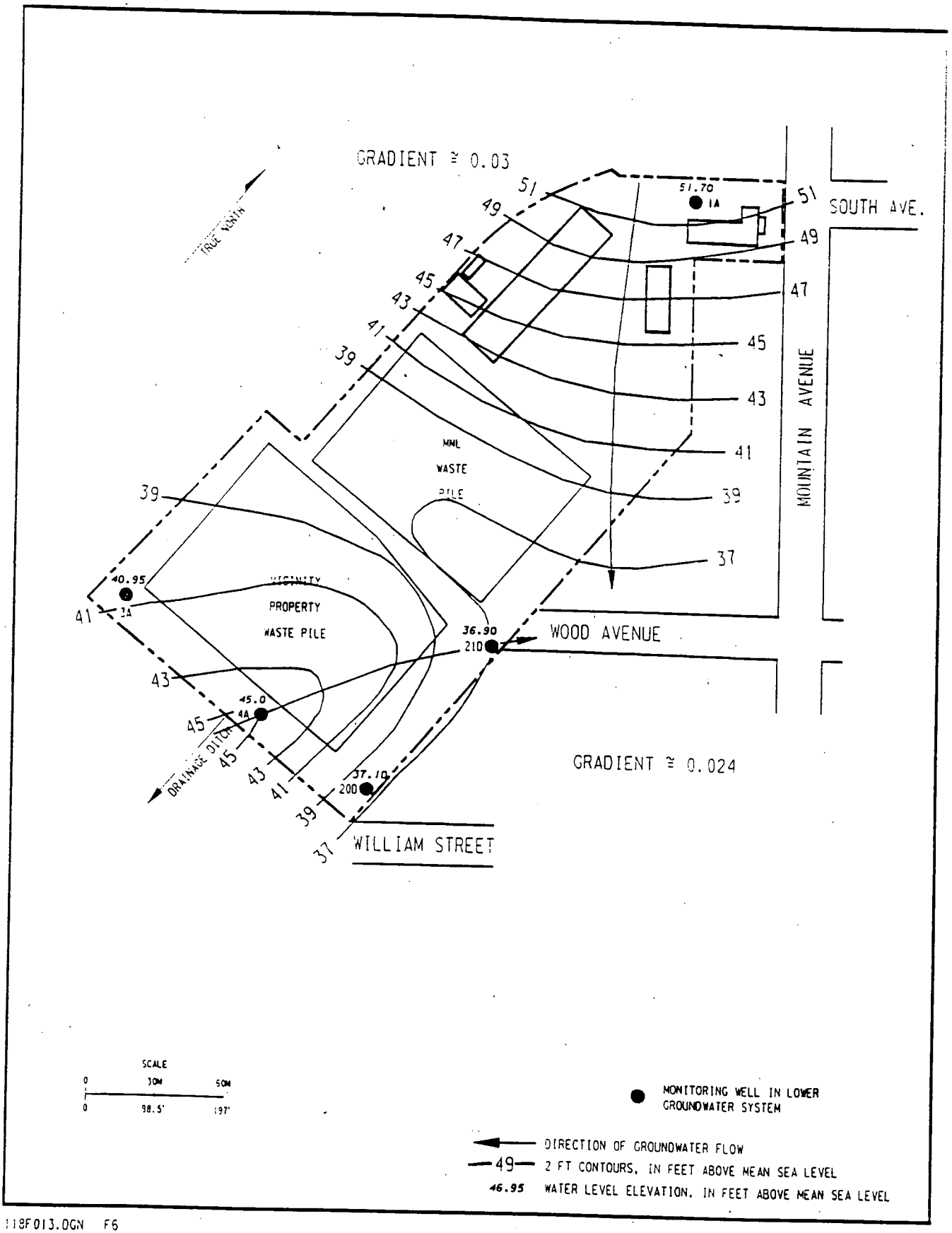


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Figure 6-7
Potentiometric Surface Map of Lower Groundwater System at MSP (3/14/90)

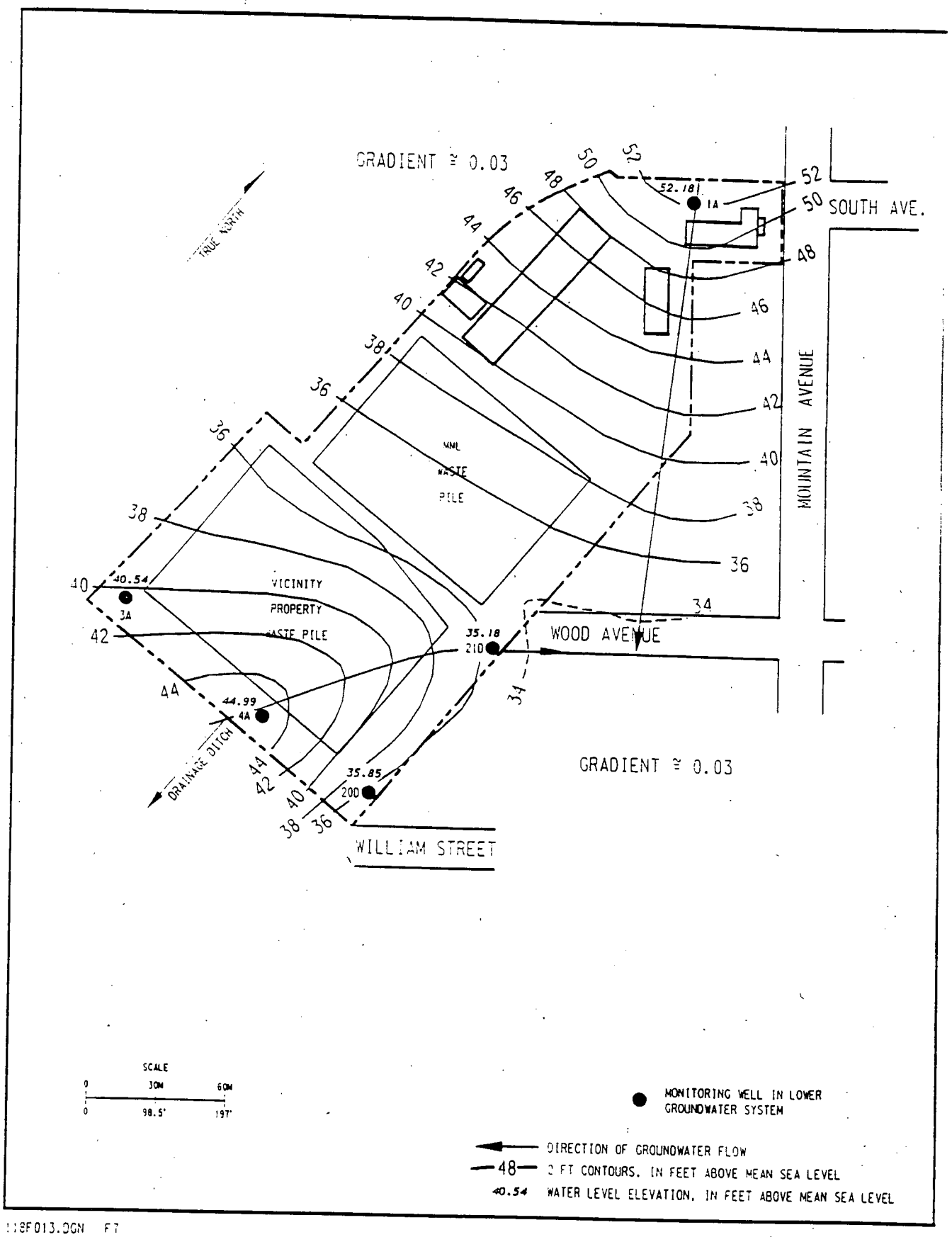


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Figure 6-8
Potentiometric Surface Map of Lower Groundwater System at MSP (6/15/90)

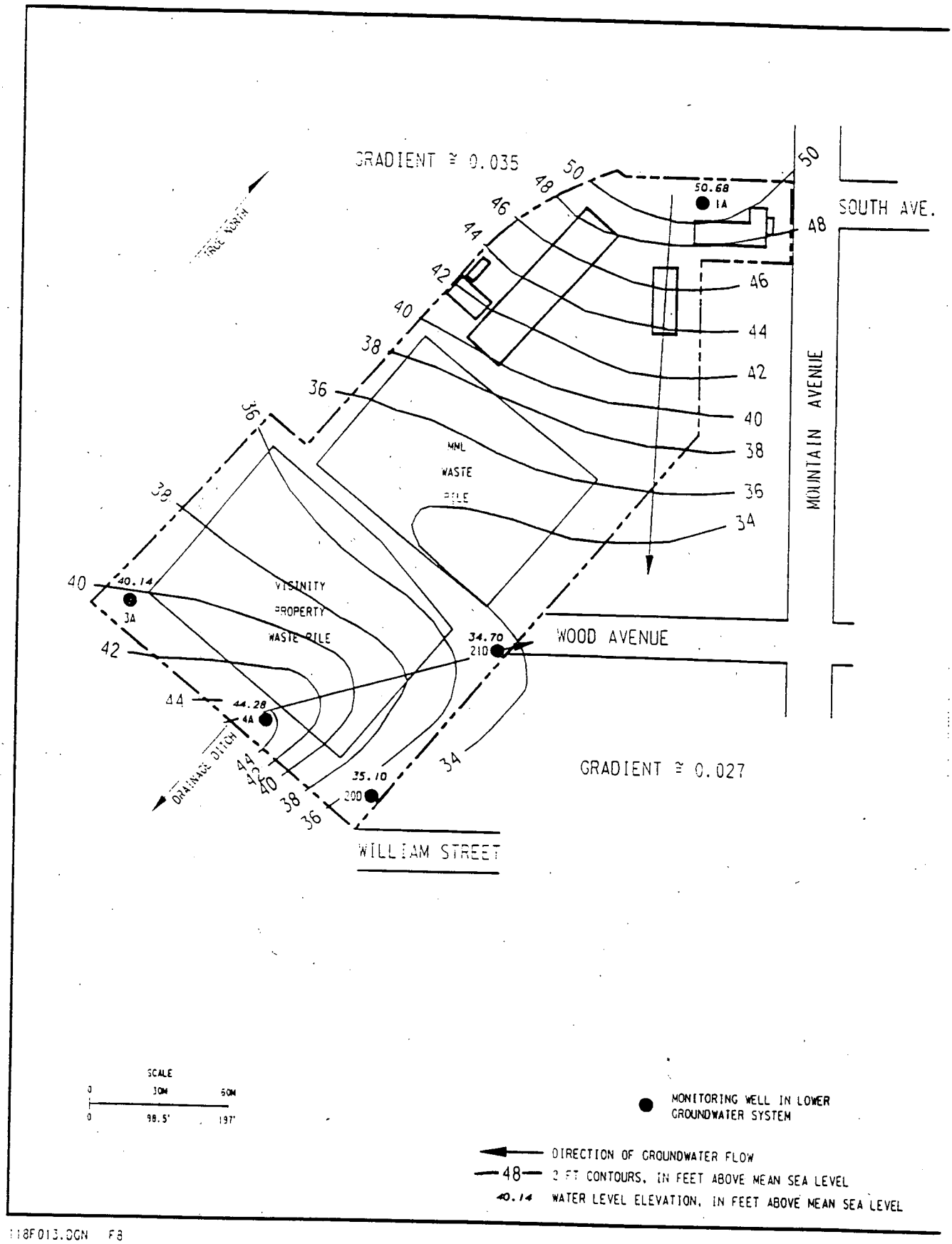


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Figure 6-9
Potentiometric Surface Map of Lower Groundwater System at MSP (9/20/90

## 7.0 QUALITY ASSURANCE

A comprehensive quality assurance (QA) program involving sampling, data management, and analysis is maintained to ensure that the data reported are representative of actual concentrations in the environment. The QA program meets the requirements of DOE Order 5700.6B and ANSI/ASME NQA-1.

QA sampling requirements are ensured through the following:

- Samples at all locations are collected using established procedures as outlined in the FUSRAP Integrated Environmental Monitoring Instruction Guide, 191-00-IG-003

- The sampling program design provides for trip blanks, matrix spike and spike duplicates, field blanks (daily), and quality control (QC) duplicate sampling (minimum of 1 in 20)

- Chain-of-custody procedures are performed to maintain traceability of samples and corresponding analytical results

Data management QA is achieved through:

- Completion and recording of parameter-specific data review checklists for each analysis report

- Use of calculation sheets for documenting computations

- Double checking and concurrence on calculations
  - By the originator
  - By an independent, equally qualified second party

- Report preparation and presentations

System QA audits are conducted by Bechtel National, Inc. (BNI) FUSRAP project QA personnel to verify adherence to laboratory

procedures and to evaluate the appropriateness and effectiveness of the procedures. Audit team leaders and auditors are trained and certified in accordance with project procedures. Technical specialists participate as auditors under the direction of the audit team leader when warranted by the nature of the activities being audited. Audit reports are prepared for each audit conducted, and audit findings that require corrective action and followup are documented, tracked, and resolved, as verified by the project QA supervisor.

Routine radioanalyses are performed under subcontract by Thermo Analytical/Eberline (TMA/E), Albuquerque, New Mexico. This laboratory participates in the collaborative testing and interlaboratory comparison program with EPA at Las Vegas, Nevada. In this program, samples of various environmental media (water, milk, air filters, and soil) containing one or more radionuclides in known amounts are prepared and distributed to participating laboratories. After analysis, results are forwarded to EPA for comparison with known values and with the results from other laboratories. This program enables the laboratory to regularly evaluate the accuracy of its analyses and take corrective action, if needed. Table 7-1 summarizes results of the comparison studies for water samples. TMA/E also participates in the DOE Environmental Measurements Laboratory interlaboratory quality assessment program. This program consists of receiving and analyzing environmental samples (air filters, water, and soil) on a quarterly basis for specific radiochemical analyses (Table 7-2).

Interlaboratory comparison of the TETLD results is provided by participation in the International Environmental Dosimeter Project sponsored jointly by DOE, EPA, and the Nuclear Regulatory Commission.

Chemical analyses are performed under subcontract by Weston Analytical Laboratory, Lionsville, Pennsylvania. Weston's standard practices manual has been reviewed and accepted by BNI. Weston maintains an internal QA program and is audited by BNI FUSRAP personnel on a semiannual basis. The internal QA program involves the following for inorganic chemical analyses:

TABLE 7-1

SUMMARY COMPARISON OF WATER SAMPLE RESULTS[a,b]

(EPA and TMA/E)

| Analysis and Sample Date | Value (pCi/L)[c] EPA | TMA/E | Ratio (TMA/E:EPA)[d] |
|---|---|---|---|
| Alpha | | | |
| 1/90 | 12.0 ± 5.0 | 9.33 ± 1.5 | 0.78 |
| 4/90 | 90 ± 12.0 | 96 ± 12 | 1.07 |
| 5/90 | 22.0 ± 6.0 | 26.3 ± 2.3 | 1.20 |
| 9/90 | 10.0 ± 5.0 | 11.0 ± 1.0 | 1.10 |
| Beta | | | |
| 1/90 | 12.0 ± 5.0 | 11.7 ± 2.1 | 0.98 |
| 4/90 | 52.0 ± 5.0 | 46.0 ± 6.0 | 0.88 |
| 5/90 | 15.0 ± 5.0 | 15.0 ± 1.0 | 1.0 |
| 9/90 | 10.0 ± 5.0 | 11.0 ± 1.0 | 1.10 |
| Ra-226 | | | |
| 3/90 | 4.9 ± 0.7 | 6.1 ± 0.4 | 1.24 |
| 4/90 | 5.0 ± 0.8 | 2.8 ± 0.1 | 0.56 |
| 7/90 | 12.1 ± 1.8 | 10.1 ± 0.1 | 0.84 |
| 9/90 | 12.1 ± 1.8 | 10.1 ± 0.1 | 0.84 |
| Ra-228 | | | |
| 3/90 | 12.7 ± 1.9 | 15.9 ± 0.4 | 1.25 |
| 4/90 | 10.2 ± 1.5 | 10.5 ± 1.5 | 1.03 |
| 9/90 | 5.1 ± 1.2 | 4.9 ± 1.2 | 0.96 |
| U (Natural) | | | |
| 3/90 | 4.0 ± 6.0 | 4.0 ± 0.0 | 1.0 |
| 4/90 | 20.0 ± 6.0 | 18.7 ± 1.5 | 0.94 |
| 7/90 | 20.8 ± 3.0 | 19.8 ± 1.1 | 0.95 |

[a]Results from EPA Interlaboratory Comparison Program.

[b]Samples were for comparison only and not site-specific.

[c]1 pCi/L is equivalent to 0.037 Bq/L.

[d]This ratio can be used to determine the accuracy of TMA/E's analytical procedures.

TABLE 7-2

SUMMARY COMPARISON OF AIR, SOIL, AND WATER SAMPLE RESULTS[a,b]

(EML and TMA/E)

| Sample Type | Analysis (09/07/90) | Value | | Ratio (TMA/E:EML)[c] |
|---|---|---|---|---|
| | | EML | TMA/E | |
| Air (Bq/fil) | U-234 | 0.013 | 0.022 ± 0.012 | 1.69 |
| Air (Bq/fil) | U-238 | 0.013 | 0.021 ± 0.012 | 1.62 |
| Soil (Bq/kg) | U-234 | 28.3 | 23.9 ± 1.1 | 0.85 |
| Soil (Bq/kg) | U-238 | 27.3 | 23.4 ± 1.0 | 0.86 |
| Water (Bq/L) | U-234 | 0.236 | 0.232 ± 0.019 | 0.98 |
| Water (Bq/L) | U-238 | 0.244 | 0.250 ± 0.041 | 1.03 |

[a]Results are from the DOE Environmental Measurements Laboratory (EML) interlaboratory quality assessment program.

[b]Samples were for comparison only and not site-specific.

[c]This ratio can be used to determine the accuracy of TMA/E's analytical procedures.

- Initial calibration and calibration verification
- Continuing calibration verification
- Reagent blank analyses
- Matrix spike analyses
- Duplicate sample analyses
- Laboratory control sample analyses
- Interlaboratory QA/QC

For organic chemical analyses the QA program involves:

- Gas chromatography/mass spectrometry instrumentation for both volatile and semivolatile compound analysis
- Initial multilevel calibration for each Target Compound List (TCL) compound
- Matrix spike analyses
- Reagent blank analyses
- Interlaboratory QA/QC
- Continuing calibration for each TCL compound
- Addition of surrogate compounds to each sample and blanks for determining percent recovery information

Currently, Weston participates in drinking water, wastewater, and/or hazardous waste certification programs and is certified (or pending) in 35 such state programs. Continuing certification hinges upon Weston's ability to pass regular performance evaluation testing.

Weston's QA program also includes an independent overview by its project QA coordinator.

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# APPENDIX A

# METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

## METHODOLOGY FOR STATISTICAL ANALYSIS OF DATA

Average annual concentrations are calculated by averaging the results of all four quarters of sampling. When possible, sampling results are compiled in computer spreadsheets and the minimum, maximum, and average values are calculated for all quarters of data.

Minimums and maximums are derived by comparing sampling results and determining the lowest and highest for the year. An example is given below.

**Thorium-230 Results** (pCi/L)

| Sampling Location | Quarter 1 | 2 | 3 | 4 | Minimum Value | Maximum Value |
|---|---|---|---|---|---|---|
| 1 | 13 | 7 | 12 | 5 | 5 | 13 |

Because 5 pCi/L is less than any other result, it is entered into the minimum value column; 13 pCi/L, the greatest result reported, is entered into the maximum value column.

Average annual concentrations are calculated by adding the results for the year and dividing by the number of quarters for which data have been taken and reported (usually four). An example is given below.

First, results reported for the year are added.

$$13 + 7 + 12 + 5 = 37$$

Next, the sum of all results is divided by the number of quarters for which data were taken and reported. In this example there were data for all four quarters.

$$37 \div 4 = 9.25$$

Because there are two single-digit numbers (5 and 7), the result is rounded to 9 (number of significant figures is 1). This value is entered into the average value column.

**Thorium-230 Results** (pCi/L)

| Sampling Location | Quarter 1 | 2 | 3 | 4 | Average Value |
|---|---|---|---|---|---|
| 1 | 13 | 7 | 12 | 5 | 9 |

Expected concentration ranges are calculated to provide a basis for trend analysis of the data. These expected ranges are calculated by taking the average of the annual average concentrations for the past five years (when possible) and calculating a standard deviation for these data. The lower expected range is calculated by subtracting two standard deviations from the average value, and the upper range is calculated by adding two standard deviations to the average values. An example of these calculations is shown below.

**Thorium-230 Results** (pCi/L)

| Sampling Location | Year 1986 | 1987 | 1988 | 1989 | 1990 | Average Value | Standard Deviation |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 5 | 14 | 8 | 5 | 8 | 4 |

The formula for calculation of the standard deviation of a sample xi, ..., xn is:

$$S = \sqrt{S^2} = \sqrt{\frac{\sum (x_i - \overline{x})^2}{n - 1}}$$

Where S = Standard deviation

$x_i$ = Individual values

$\overline{x}$ = Average of values

n = Number of values

| n | $x_i$ | $\bar{x}$ | $(x_i - \bar{x})$ | $(x_i - \bar{x})^2$ |
|---|---|---|---|---|
| 1 | 10 | 8.4 | 1.6 | 2.6 |
| 2 | 5 | 8.4 | -3.4 | 11.56 |
| 3 | 14 | 8.4 | 5.6 | 31.36 |
| 4 | 8 | 8.4 | -0.4 | 0.16 |
| 5 | 5 | 8.4 | -3.4 | 11.56 |

$$\sum (X_i - \bar{x})^2 = 57.24$$

$$S = \sqrt{\frac{57.24}{5 - 1}} = \sqrt{\frac{57.24}{4}} = \sqrt{14.31} = 3.78,$$

which rounds to 4 because there is only one significant figure.

The calculation for the expected ranges for this example is shown below.

Lower expected range: $8 - 2(4) = 0$
Upper expected range: $8 + 2(4) = 20$ (rounded to one significant figure)

Annual average values for the current year are compared with these ranges to indicate a possible anomaly or trend. If a discernible trend is found from this comparison, the data are presented in the appropriate section of the report.

# APPENDIX B
# POPULATION EXPOSURE METHODOLOGY

# POPULATION EXPOSURE METHODOLOGY

## DOSE CALCULATION METHODOLOGY

DOE Order 5400.5 requires that the impacts of the site on both the hypothetical maximally exposed individual and the population within 80 km (50 mi) of the site be evaluated. For radioactive materials, this evaluation is usually conducted by calculating the dose received by a hypothetical maximally exposed individual and the general population and comparing this dose with DOE guidelines. This appendix describes the methodology used to calculate the doses given in Subsection 4.2.

## PATHWAYS

The purpose of the dose calculation is to identify the potential routes or pathways that are available to transmit either radioactive material or ionizing radiation to the receptor. In general, the pathways are (1) direct exposure to gamma radiation, (2) atmospheric transport of radioactive material, (3) transport of radioactive material via surface water or groundwater, (4) bioaccumulation of radioactive materials in animals used as a food source, and (5) uptake of radioactive materials into plants used as a food source. For FUSRAP sites, the primary pathways are direct gamma radiation and transport of radioactive materials by the atmosphere, groundwater, and surface water. The others are not considered primary pathways because FUSRAP sites are not located in areas where significant sources of livestock are raised or foodstuffs are grown.

Gamma rays can travel until they expend all their energy in molecular or atomic interactions. In general, these distances are not very great and the exposure pathway would affect only the maximally exposed individual.

Contamination transported via the atmospheric pathway takes the form of contaminated particulates or dust and can provide a

potential dose only when it is inhaled. Doses from radon are intentionally excluded; radon exposure is controlled through compliance with boundary concentration requirements.

Contamination is transported in surface water when runoff from a rainfall event or some other source of overland flow carries contamination from the site to the surface water system. This contamination only poses an exposure problem when the surface water is used to provide municipal drinking water or to water livestock and/or to irrigate crops. Contamination is transported via groundwater when contaminants migrate into the groundwater system and there is a potential receptor.

### Primary Radionuclides of Concern

The primary radionuclides of concern for these calculations are uranium-238, uranium-235, uranium-234, thorium-232, radium-226, and the daughter products (excluding radon). For several of the dose conversion factors used in these calculations, the contributions of the daughters with half-lives less than one year are included with the parent radionuclide. Table B-1 lists the pertinent radionuclides, their half-lives, and dose conversion factors for ingestion.

## DOSE CALCULATION METHOD

### Direct Exposure

As previously indicated, direct exposure is only important in calculating the dose to the hypothetical maximally exposed individual. The dose from direct gamma exposure is determined by using data collected through the TETLD program (described in Section 4.0). These data provide a measure of the amount and energy (in units of mR/yr) of the ionizing radiation at 1 m (3 ft) above the ground. For the purposes of this report, it is assumed that the maximally exposed individual lives 30 m (100 ft) from the site and spends 80 percent of his time at the residence.

TABLE B-1

RADIONUCLIDES OF INTEREST

| Radionuclide | Half-life[a] | Dose Conversion Factor[b] for Ingestion (mrem/pCi) |
|---|---|---|
| Uranium-238 | 4.51E+9 years | 2.5E-4 |
| Thorium-234 | 24.1 days | --[c] |
| Protactinium-234 m | 1.17 minutes | --[c] |
| Protactinium-234 | 6.75 hours | --[c] |
| Uranium-234 | 4.47E+5 years | 2.6E-4 |
| Thorium-230 | 8.0E+4 years | 5.3E-4 |
| Radium-226 | 1602 years | 1.1E-3 |
| Uranium-235 | 7.1E+8 years | 2.5E-4 |
| Thorium-231 | 25.5 hours | --[d] |
| Protactinium-231 | 3.25E+4 years | 1.1E-2 |
| Actinium-227 | 21.6 years | 1.5E-2 |
| Thorium-227 | 18.2 days | --[e] |
| Radium-223 | 11.43 days | --[e] |
| Thorium-232 | 1.41E+10 years | 2.8E-3 |
| Radium-228 | 6.7 years | 1.2E-3 |
| Actinium-228 | 6.13 hours | --[f] |
| Thorium-228 | 1.91 years | 7.5E-4 |

[a]Source: Radiological Health Handbook (HEW 1970).

[b]Source: Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentrations and Dose Conversion Factors for Inhalation Submersion (EPA-520/1-88-020) and International Dose Conversion Factors for Calculation of Dose to the Public (DOE/EH-0071).

[c]Included in the uranium-238 dose conversion factor.

[d]Included in the uranium-235 dose conversion factor.

[e]Included in the actinium-227 dose conversion factor.

[f]Included in the radium-228 dose conversion factor.

Therefore, the dose from direct gamma radiation to the hypothetical maximally exposed individual is 2.6 mrem/yr (0.026 mSv/yr).

This exposure scenario should provide a very conservative estimate of the dose from direct gamma exposure to the hypothetical maximally exposed individual.

**Surface Water**

Exposures from contaminants in surface water are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the surface water dose calculation consist of measurements of concentrations of contaminants in surface water at the site and of the amount of dilution provided by tributaries or rivers between the site and the intake. Thus, the dose to the maximally exposed individual can be calculated by the following:

$$D_s = \sum_{i=1}^{N} Ci \times (Fs \div Fi) \times Ua \times DCFi$$

Where $D_s$ = Committed effective dose from surface water

$Ci$ = Concentration of the $i^{th}$ radionuclide in surface water at the site

$Fs$ = Average annual flow of surface water at the site

$Fi$ = Average flow of surface water at the intake

$Ua$ = Annual consumption of liquid (approx. 730 L/yr)

$DCFi$ = Dose conversion factor for the $i^{th}$ radionuclide

To determine the dose to the population, the same equation would be used and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that for the population dose, the intake point is probably not the same as that for the maximally exposed individual.

The approach outlined above should provide a very conservative dose calculation for the surface water pathway because it does not account for radionuclides settling out or for any municipal water treatment.

**Groundwater**

Exposures from contaminants in groundwater are important in calculating the dose to both the hypothetical maximally exposed individual and the nearby population. The data used to support the groundwater dose calculations consist of measurements of the concentration of the contaminants in groundwater and an estimate of the dilution that occurs between the measurement location and the intake point. The dose for the maximally exposed individual can be calculated by using the following equation:

$$Dgw = \sum_{i=1}^{N} (Ci) \times (D) \times (Ua) \times (DCFi)$$

Where
- Dgw = Committed effective dose from groundwater
- Ci = Concentration of the $i^{th}$ radionuclide in groundwater at the site
- D = Estimated dilution factor
- Ua = Annual consumption of water (approx. 730 L/yr)
- DCFi = Dose conversion factor for the $i^{th}$ radionuclide

To determine the dose to the population, the same equation would be used and the dose would be multiplied by the population group served by the drinking water supply. It is important to note that the population intake point is usually different from that of the maximally exposed individual.

The approach given above should provide a conservative dose calculation for the groundwater pathway because it does not account for any water treatment.

**Atmospheric**

The dose to the hypothetical maximally exposed individual from particulate radionuclides transported via the atmospheric pathway is calculated using EPA's computer model AIRDOS. Doses to the general public via this pathway are also calculated using AIRDOS for an individual 8 km (5 mi) from the site, and the resulting dose is then multiplied by the population within 80 km (50 mi).

The release of particulates was calculated using a model for wind erosion because there were no other mechanisms for releasing particulates from the site. The wind erosion model used was taken from the DOE "Remedial Action Priority System Mathematical Formulation." The input into the model consisted of site-specific average soil concentrations, local meteorological data (Section 1.0), and areas of contamination.

The site was modeled as two areas: the interim storage piles and the remainder of the site. Assumptions used in the calculation model were (1) an assumed particle size of 0.05 mm, (2) the pile cover is modeled assuming that the contamination is 99 percent covered by vegetation, and (3) there were very few mechanical disturbances at the site per month.

# APPENDIX C

# ENVIRONMENTAL STANDARDS

## ENVIRONMENTAL STANDARDS

The DOE long-term radiation protection standard of 100 mrem/yr in excess of background level includes exposure from all pathways except medical treatments and exposures from radon (DOE 1990b). Evaluation of exposure pathways and resulting dose calculations are based on assumptions such as the use of occupancy factors in determining dose due to external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represent actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Use of such assumptions results in calculated doses that more accurately reflect the exposure potential from site activities.

## DERIVED CONCENTRATION GUIDELINES

As referenced in Section 2.0, DOE orders provide the standards for radionuclide emissions from DOE facilities. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," provides the procedures and requirements for radionuclide releases.

Applicable standards are found in Chapter III of DOE Order 5400.5 and are set as derived concentration guidelines (DCGs). A DCG is defined as the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (e.g., ingestion of water, inhalation), would result in an effective dose equivalent of 100 mrem. The following table provides reference values for conducting radiological environmental protection programs at operational DOE facilities and sites.

| Radionuclide | F1 Value[a] | Ingested Water DCG (μCi/ml) | Inhaled Air DCGs[b] | | |
|---|---|---|---|---|---|
| | | | D | W | Y |
| Radium-226 | 2E-1 | 1E-7 | -- | 1E-12 | -- |
| Thorium-230 | 2E-4 | 3E-7 | -- | 4E-14 | 5E-14 |
| " 232 | 2E-4 | 5E-8 | -- | 7E-15 | 1E-14 |
| Uranium-234 | 2E-3 | 5E-6 | -- | -- | 9E-14 |
| " 235 | 2E-3 | 5E-6 | -- | -- | 1E-13 |
| " 238 | 2E-3 | 6E-6 | -- | -- | 1E-13 |
| Radon-222[c] | 3E-9 | 3E-9 | -- | -- | 3E-9 |
| " 220[c] | 3E-9 | 3E-9 | -- | -- | 3E-9 |

[a]F1 is defined as the gastrointestinal tract absorption factor. This measures the uptake fraction of ingestion of a radionuclide into the body.

[b]Inhaled air DCGs are expressed as a function of time. D, W, and Y represent a measure of the time required for contaminants to be removed from the system (D represents 0.5 day; W represents 50 days; and Y represents 500 days).

[c]DOE is reassessing the DCGs for radon. Until review is completed and new values issued, the values given in the chart above will be used for releases from DOE facilities.

**SOIL GUIDELINES***

Guidelines for residual radioactivity in soil established for FUSRAP are shown below.

| Radionuclide | Soil Concentration (pCi/g) Above Background |
|---|---|
| Radium-226<br>Radium-228<br>Thorium-230<br>Thorium-232 | 5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer. |
| Other Radionuclides | Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use. |

***Source:** U.S. Department of Energy, "Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Surplus Facilities Management Program Sites," Revision 2, March 1987.

**POTENTIAL STATE ARARS**

The following list of New Jersey laws and regulations have been identified as potential ARARs for the management of MSP. Where differences between state and federal requirements exist, the more restrictive requirement will apply.

| Potential ARAR | Requirement |
|---|---|
| New Jersey Environmental Cleanup Responsibility Act, Title 13, New Jersey Statutes Annotated (NJSA), Chapter 1K, Subchapter 6 (13:1K-6 et seq.) | Provides rules for the orderly closing of operations and transfer of real property utilized for the generation, handling, storage, and disposal of hazardous substances and waste. Imposes preconditions on any closure or transfer of these operations by requiring the adequate preparation and implementation of acceptable cleanup procedures. |

| | |
|---|---|
| New Jersey Hazardous Waste Facilities Siting Act, 13 NJSA 1E-49 et seq. | Provides rules to ensure proper treatment, storage, and disposal of hazardous waste by providing for the siting, design, construction, operation, and use of acceptable hazardous waste facilities. |
| New Jersey Underground Storage Tank Law, 58 NJSA 10A-21 et seq. | Provides for the registration, testing, monitoring, and cleanup of underground storage tanks to detect leaks and discharges as early as possible. |
| New Jersey Solid and Hazardous Waste Management Regulations, Title 7, New Jersey Administrative Code (NJAC), Chapter 26 | Establishes the state equivalent of the federal Resource Conservation and Recovery Act. The act also regulates asbestos and sanitary landfills and establishes fees and a fee schedule to fund the program. |
| New Jersey Underground Storage Tank Rules, 7 NJAC, Chapter 14B | Establishes regulations for underground storage tanks, registration requirements, and sets forth penalties for violations of these provisions. |
| New Jersey Environmental Cleanup Responsibility Act Rules, 7 NJAC, Chapter 26B | Provides rules governing the implementation of the Environmental Cleanup Responsibility Act, which regulates the closing, characterization, and cleanup of regulated industrial facilities. |
| New Jersey Solid and Hazardous Waste Disclosure Rules, 7 NJAC 26-16 et seq. | Provides standards of conduct and ability for those persons who wish to operate a solid or hazardous waste facility or engage in the transport of solid or hazardous waste. Establishes a licensing program to exclude from positions of responsibility persons deficient in reliability, expertise, and competence from participating in these industries. |

| | |
|---|---|
| New Jersey Toxic Catastrophe Prevention Act Program Rules, 7 NJAC, Chapter 31 | Provides rules for owners and operators of facilities required to register with NJDEP because they manage extraordinarily hazardous substances in the registration quantity established for such substances. The rules are intended to protect the public from catastrophic accidents from chemical releases of extraordinarily hazardous substances to the environment. |
| New Jersey Rules on Confidentiality of Hazardous Waste Information, 7 NJAC 26-17 et seq. | Sets forth procedures for making information received by NJDEP in administering the hazardous waste program available to the public and maintaining confidentiality of certain parts of that information. |
| New Jersey Air Pollution Control Laws, Title 26, New Jersey Revised Statutes (NJRS), Chapter 2 C, Air Pollution Control | Empowers the New Jersey Department of Health to formulate, promulgate, amend, and repeal codes and regulations that prevent and control air pollution. |
| New Jersey Regulations on Permits and Certificates, 7 NJAC 27-8 et seq. | Establishes requirements for permitting air control apparatus and establishes program fees to fund the permitting program. |
| New Jersey Regulations on Volatile Organic Substances, 7 NJAC 27-16 et seq. | Provides rules for the storage, transfer, and other source operations to minimize the amount of volatile organic substances into the atmosphere in excess of the emission rates contained in this rule. |
| New Jersey Regulations on Toxic Substances, 7 NJAC 27-17 et seq. | Provides rules for emissions of specific toxic volatile organic substances, including permit requirements, emission standards, and test procedures. |
| New Jersey Testing Procedures for Volatile Organic Substances, 7 NJAC 27B-3 et seq. | Prescribes sampling and analytical procedures for determining the presence and concentrations of volatile organic substances. |

| | |
|---|---|
| New Jersey Testing Procedures for Opacity Emissions, 7 NJAC 27B-2 et seq. | Promulgates procedures for determining whether a discharge exceeds opacity standards. |
| New Jersey Air Administrative Penalties Rules, 7 NJAC 27A-3 et seq. | Promulgates civil administrative penalties for violations of air emission standards, as well as civil administrative penalties for other violations of New Jersey's air rules. |
| New Jersey Water Pollution Control laws, 58 NJSA, Chapters 6A and 10 | Establishes rules for the prevention and response to the discharge of petroleum and other hazardous substances to waters of the state. This law also establishes the New Jersey Pollutant Discharge Elimination System (NJPDES). |
| New Jersey Water Quality Planning Act, 58 NJSA 11A et seq. | This act was promulgated to restore and maintain the chemical, physical, and biological integrity of the waters of the state, and develop waste treatment management planning processes to ensure adequate control of sources of water pollutants. |
| New Jersey Hazardous Substance Discharge Law, 13 NJSA 1K-15 et seq. | Establishes reporting requirements for owners and operators of active or inactive industrial facilities who know or suspect a hazardous substance discharge. Provides the method and information required in the report, as well as penalties for failure to report a hazardous substance discharge. |
| New Jersey Safe Drinking Water Act, 58 NJSA 12A-1 et seq. | Empowers the state to promulgate and enforce regulations to maintain the quality of drinking water; to establish minimum standards for drinking water; and regulate the collection, treatment, monitoring, storage, and distribution of potable water. |

| | |
|---|---|
| New Jersey Rules on Discharge of Petroleum and Other Hazardous Substances, 7 NJAC 1E-1.1 et seq. | Regulates every discharge of petroleum and other hazardous substances except those in compliance with a permit. Sets forth reporting, design, and maintenance requirements for major facilities handling petroleum or hazardous substances. |
| New Jersey Pretreatment Regulations, 7 NJAC, Chapters 5 and 9 | Provides water quality standards for the discharge of pollutants into state waters. |
| New Jersey Pollutant Discharge Elimination System Regulations, 7 NJAC 14A-1 et seq. | Provides procedures and guidelines for implementation and operation of the NJPDES permit program. Regulates the discharge of pollutants to surface and groundwater, and regulates the discharge of industrial pollutants to publicly and privately owned treatment works. |
| New Jersey Civil Penalties and Hearings Regulations, 7 NJAC 14-8.1 et seq. | Establishes rules for the assessment of civil penalties for violations of water quality standards, effluent limitations, or permit violations. |
| New Jersey Hazardous Substance Discharge Reports and Notices Rules, 7 NJAC 1E-5.1 et seq. | Establishes requirements governing the implementation of the Hazardous Substance Discharge Reports and Notices Act by setting reporting and notice procedures to be followed by industrial facilities. |
| New Jersey Drinking Water Regulations, 7 NJAC 10-1 et seq. | Implements the New Jersey Safe Drinking Water Act by specifying maximum contaminant levels, treatment techniques, testing procedures, sampling frequencies, and quality control. |

| | |
|---|---|
| New Jersey Surface Water Quality Standards, 7 NJAC 9-4 et seq. | Establishes rules for defining classes of waters and use designations; establishes water-quality-based effluent limitations, procedures for modification of water-quality-based effluent limitations, and procedures for reclassifying water uses. |
| New Jersey Groundwater Quality Standards, 7 NJAC, Chapter 9 | Contains rules for the enhancement of groundwater resources, use classifications, quality criteria, and designated uses of the groundwaters of the state. |
| New Jersey Wetlands Act, 13 NJSA, Chapter 9A | Establishes requirements for the protection of the state's wetlands. |
| New Jersey Freshwater Wetlands Protection Act, 13 NJSA, Chapter 9B | Establishes requirements for the protection of New Jersey's freshwater wetlands. |
| New Jersey Freshwater Wetlands Regulations, 7 NJAC, 7A | Provides regulations to implement the New Jersey Freshwater Wetlands Protection Act. |

**POTENTIAL FEDERAL ARARs**

In addition to the federal regulations identified in Section 2.0, the following have been identified as potential ARARs.

| Potential ARAR | Requirement |
|---|---|
| Occupational Safety and Health Administration General Industry Standards, 29 CFR 1910 | Health and safety standards are established for hazardous waste operations, including limits for exposure to noise and certain hazardous materials. |

| | |
|---|---|
| Occupational Safety and Health Administration Standards Hazardous Waste Operations and Emergency Response, 29 CFR 1910 | General worker protection requirements are established, as are requirements for worker training and the development of emergency response plan and a safety and health program for employees. Procedures are established for hazardous waste operations, including decontamination of radioactive waste, shipping and transport, and container handling. |
| Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, 40 CFR 192 | Contains limited permissible concentrations of radium, thorium, radon, and gamma radiation. |
| Radiation Protection for Occupational Workers, DOE Order 5480.11 | Standards and program requirements are established for worker protection from ionizing radiation, including derived air concentration guides for inhalation and immersion. The basic dose limit of 100 mrem/yr also applies to any member of the public entering a controlled area. |
| Standards for Protection Against Radiation, 48 FR 20721 | The standard for uranium-238 in inhaled air is 3E-12 $\mu$Ci/ml daily, 1E-12 $\mu$Ci/ml weekly; the standard for thorium-232 in inhaled air is 4E-15 $\mu$Ci/ml weekly and 8E-15 $\mu$Ci/ml yearly; the standard for thorium-230 in inhaled air is 2E-14 $\mu$Ci/ml yearly; and the standard for radium-226 in inhaled air is 9E-13 $\mu$Ci/ml weekly. |

# APPENDIX D

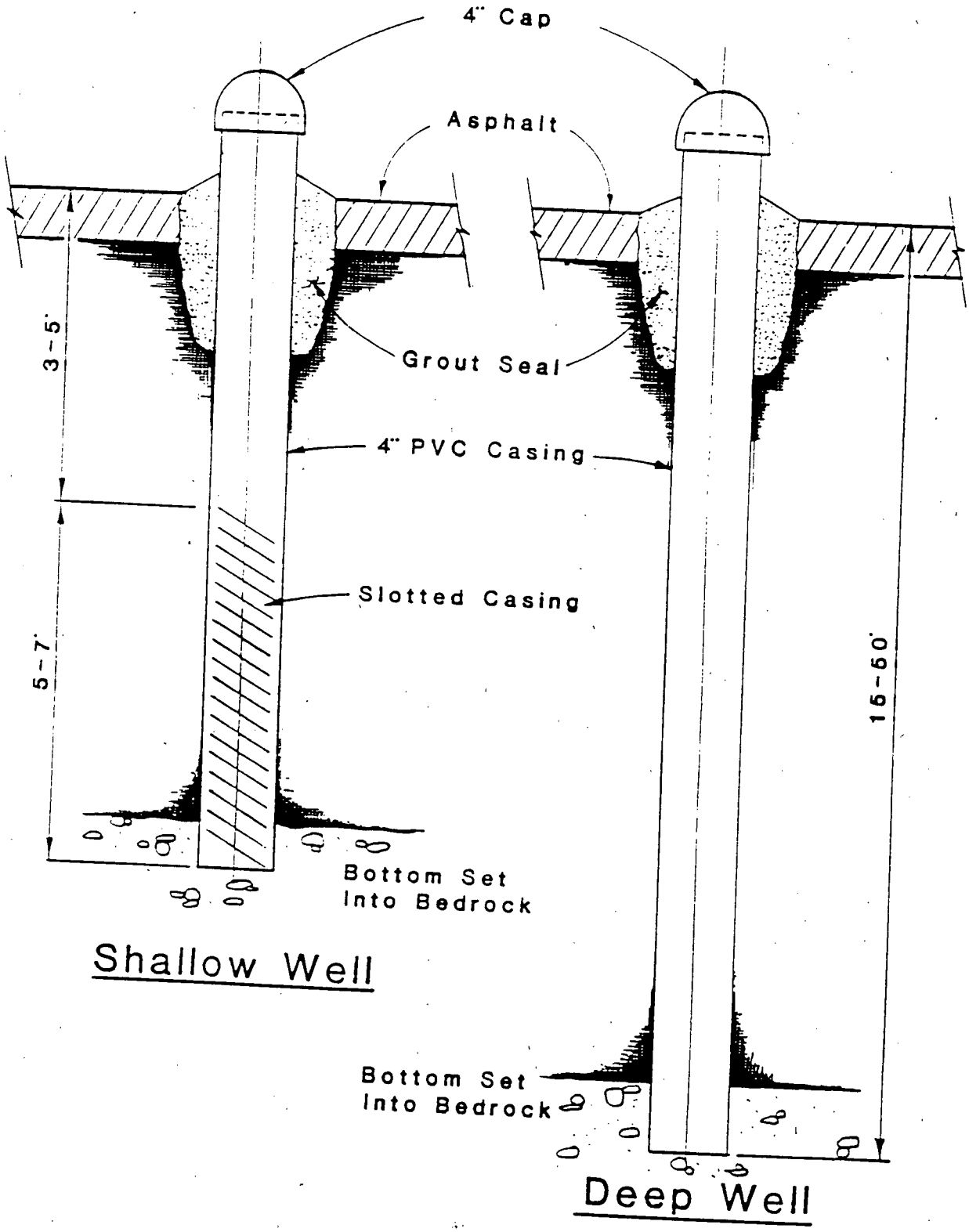
# PARAMETERS FOR ANALYSIS

## PARAMETERS FOR ANALYSIS AT MSP, 1990

| Medium | Parameter | Technique |
|---|---|---|
| Groundwater | Total uranium | Fluorometric |
| | Radium-226 | Emanation |
| | Thorium-232 | Gamma spectrometry |
| | Total organic halides | Carbonaceous analyzer |
| | Total organic carbon | Coulometric determination |
| | Total metals: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, vanadium, zinc | Inductively coupled plasma atomic emission spectrophotometry (ICPAES) |
| | Arsenic, lead, mercury, selenium, thallium | Atomic absorption (AA) spectrophometry |
| | Specific conductance | Electrometric |
| | pH | Electrometric |
| Surface Water | Total uranium | Fluorometric |
| | Radium-226 | Emanation |
| | Thorium-232 | Gamma spectrometry |
| Sediment | Total uranium | Alpha spectrometry |
| | Radium-226 | Gamma spectrometry |
| | Thorium-232 | Gamma spectrometry |
| Air | Radon-222 | Track-etch |
| | External gamma radiation | Thermoluminescence |

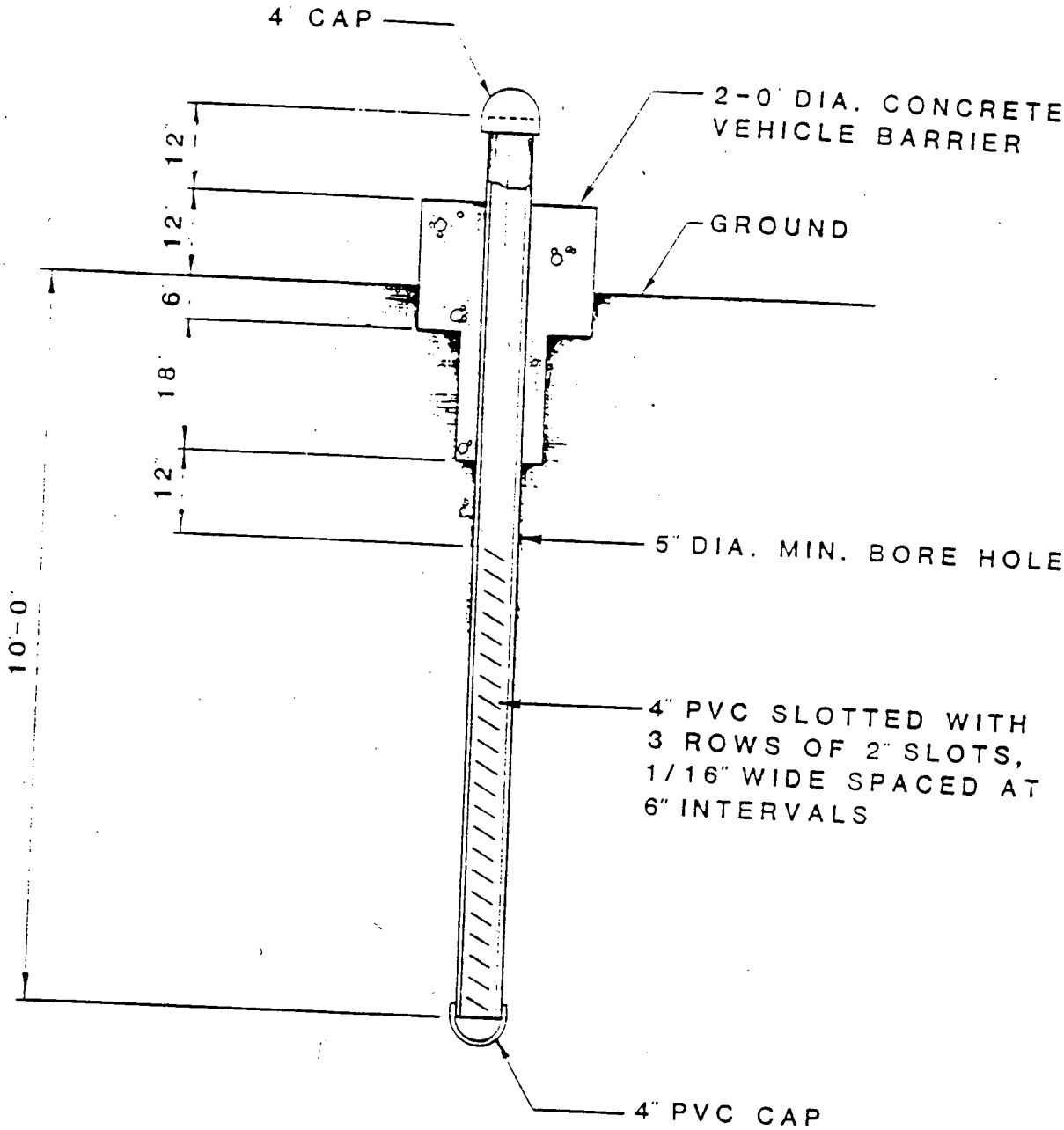
# APPENDIX E

## SAMPLE OBSERVATION WELL CONSTRUCTION LOGS AND HYDROGRAPHS SHOWING WATER LEVEL ELEVATIONS



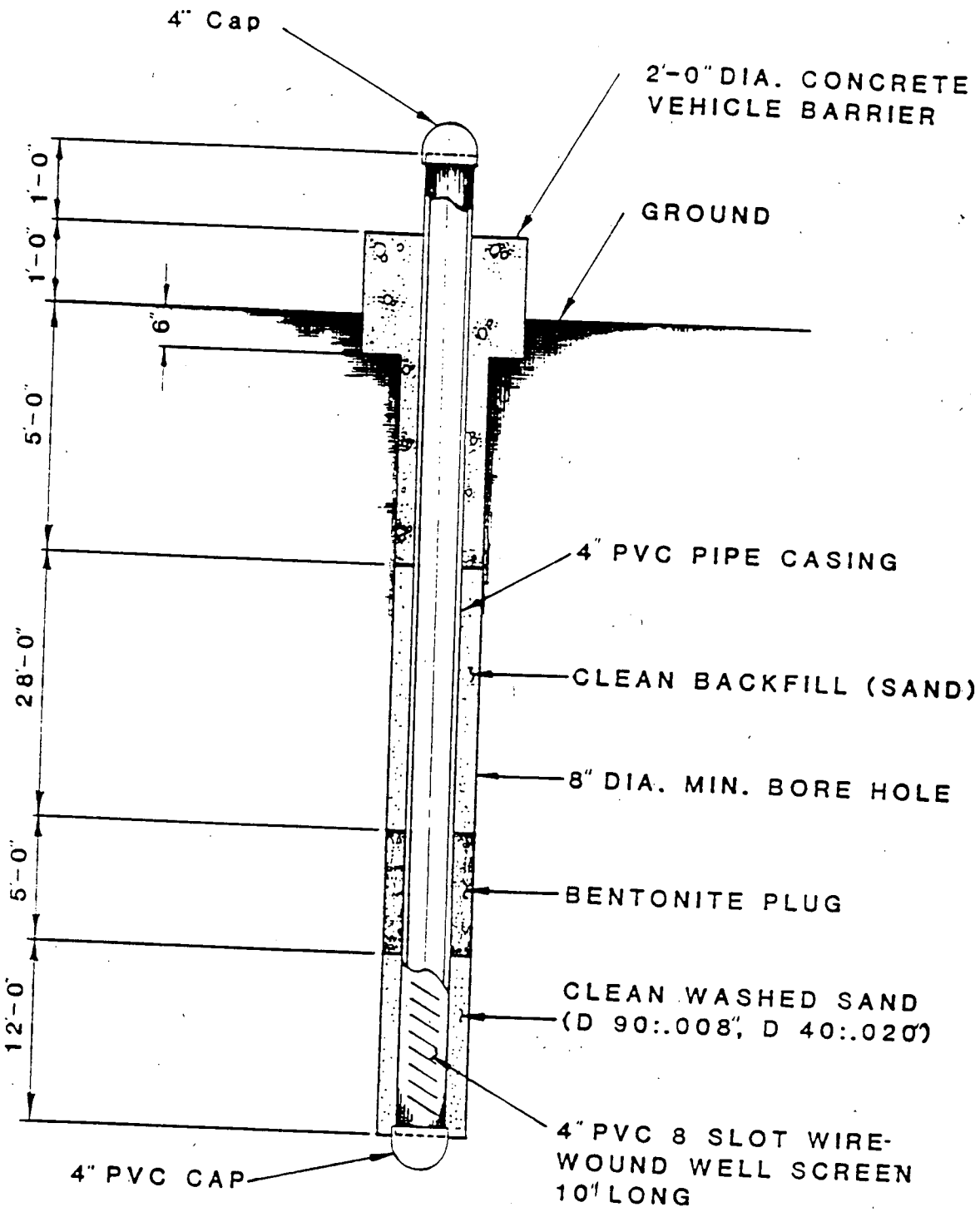

# MONITORING WELL INSTALLATION DETAIL

PHASE I



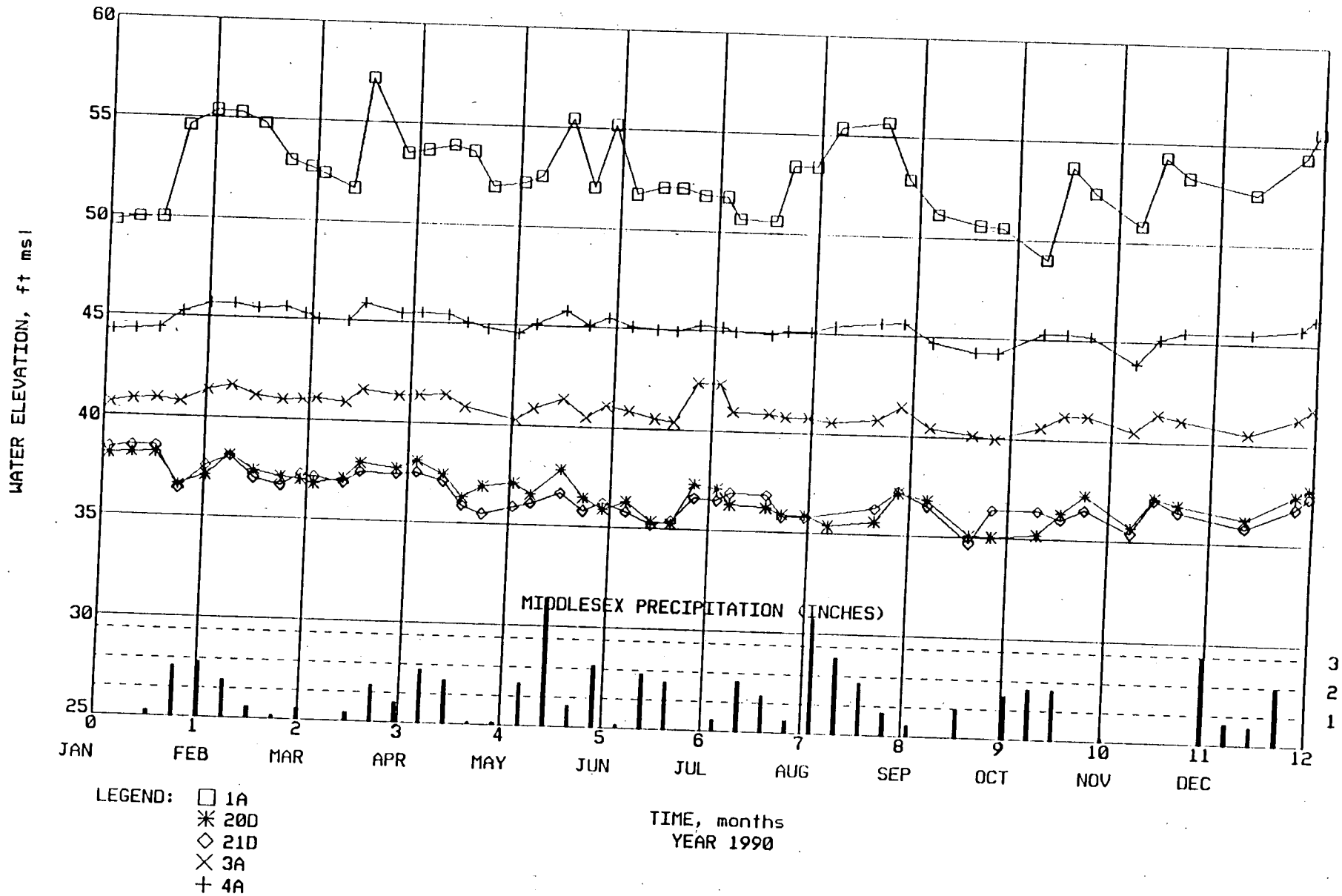

# SHALLOW MONITORING WELL INSTALLATION DETAIL

(PHASE II)

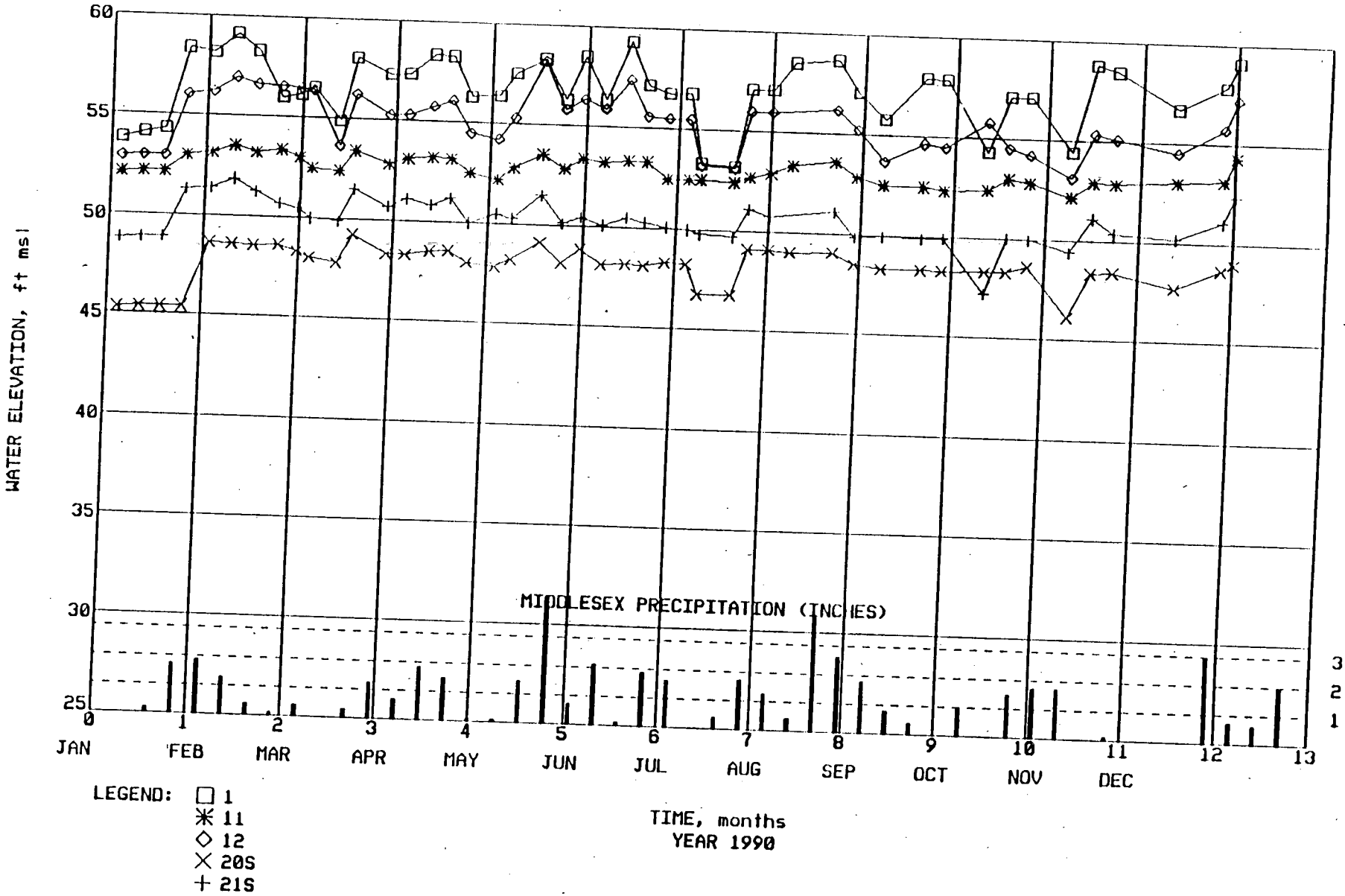



# DEEP MONITORING WELL INSTALLATION DETAIL

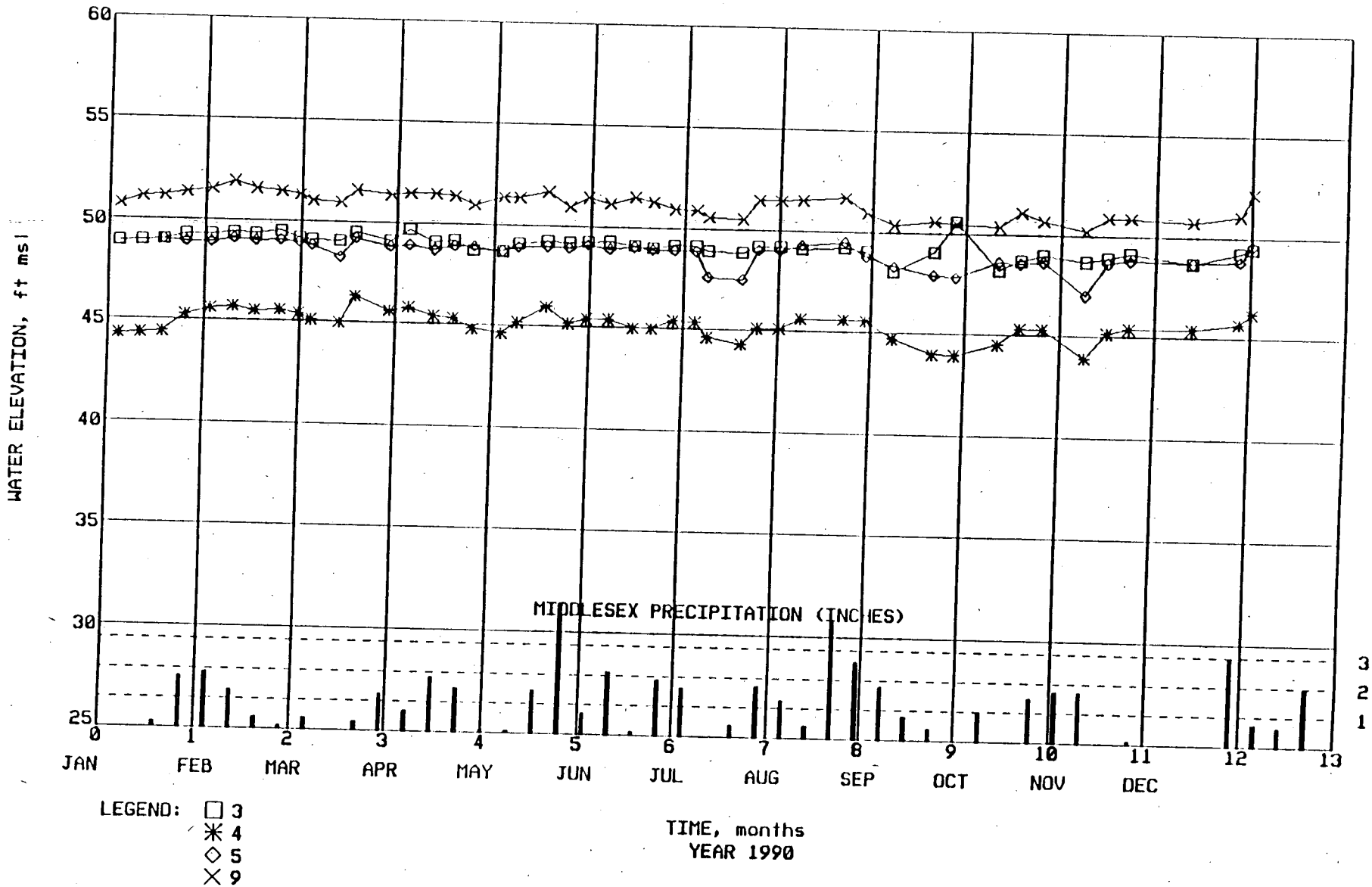
(PHASE II)




MSX HYDROGRAPHS - LOWER GROUNDWATER SYSTEM




MIDDLESEX HYDROGRAPHS - UPPER GROUNDWATER SYSTEM




MIDDLESEX HYDROGRAPHS - UPPER GROUNDWATER SYSTEM

# APPENDIX F

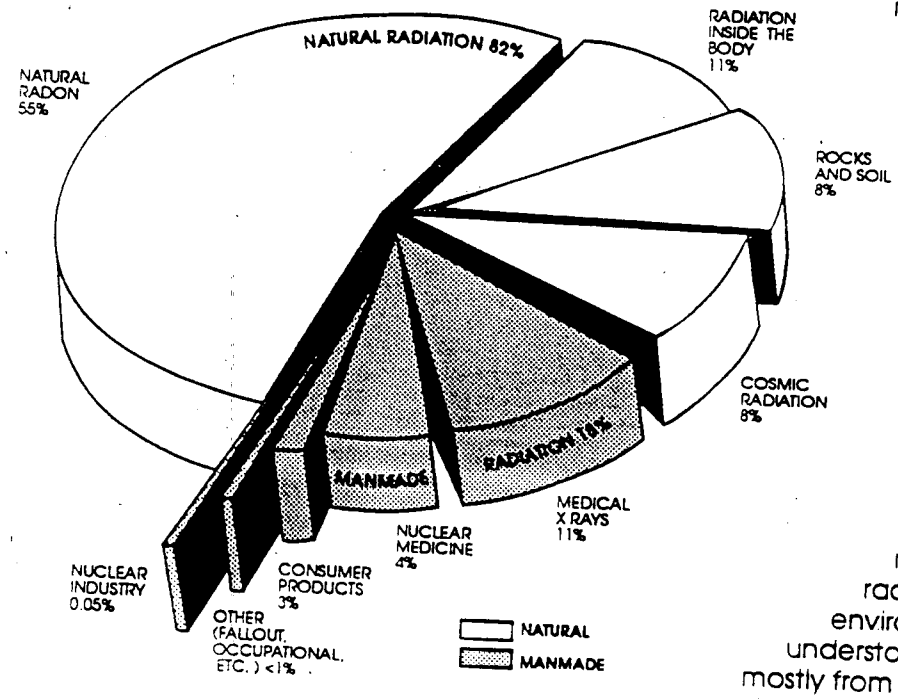
# RADIATION IN THE ENVIRONMENT

# Radiati
# in t
# Environme

Radiation is a natural part of our environment. When our planet was formed, radiation w present—and radiation surrounds it still. Natural radiation showers down from the distant reac the cosmos and continuously radiates from the rocks, soil, and water on the Earth itself.

During the last century, mankind has discovered radiation, how to use it, and how to cont As a result, some manmade radiation has been added to the natural amounts present in our environment.

**Sources of Radiation**




Many materials—both natur manmade—that we come int contact with in our everyda are radioactive. These mc are composed of atoms release energetic partic waves as they change more stable forms. The particles and waves c referred to as *radiatic* and their emission as *radioactivity*.

As the chart on th shows, most environme radiation (82%) is from sources. By far the large source is radon, an odorl colorless gas given off by r radium in the Earth's crust. V radon has always been presen environment, its significance is be understood today. Manmade radia mostly from medical uses and consume products—adds about eighteen percent tc total exposure.

## TYPES OF IONIZING RADIATION

Radiation that has enough energy to disturb the electrical balance in the atoms of substanc passes through is called *ionizing radiation*. There are three basic forms of ionizing radiation.

### Alpha

Alpha particles are the largest and slowest moving type of radiation. They are easily stopped by a sheet of paper or the skin. Alpha particles can move through the air only a few inches before being stopped by air molecules. However, alpha radiation is dangerous to sensitive tissue inside the body.

### Beta

Beta particles are much smaller and faster moving than alpha particles. Beta particles pass through paper and can travel in the air for about 10 feet. However, they can be stopped by thin shielding such as a sheet of aluminum foil.

### Gamma

Gamma radiation is c of electromagnetic wave travels at the speed of It takes a thick shield of lead, or concrete to stop gc rays. X rays and cosmic ra similar to gamma radi X rays are produce manmade devices; cosmi reach Earth from outer spc

# Units of Measure

Radiation can be measured in a variety of ways. Typically, units of measure show either 1) the total amount of radioactivity present in a substance, or 2) the level of radiation being given off.

The radioactivity of a substance is measured in terms of the number of transformations (changes into more stable forms) per unit of time. The *curie* is the standard unit for this measurement and is based on the amount of radioactivity contained in 1 gram of radium. Numerically, 1 curie is equal to 37 billion transformations per second. The amounts of radioactivity that people normally work with are in the millicurie (one-thousandth of a curie) or microcurie (one-millionth of a curie) range. Levels of radioactivity in the environment are in the picocurie, or pCi (one-trillionth of a curie) range.

Levels of radiation are measured in various The level of gamma radiation in the air is measur the *roentgen*. This is a relatively large unit, so measurements are often calculated in milliroent Radiation absorbed by humans is measured in *rad* or *rem*. The rem is the most descriptive bec it measures the ability of the specific type of radiation to do damage to biological tissue. A typical measurements will often be in the m (mrem), or one-thousandth of a rem, range. In the international scientific community, absc dose and biological exposure are expressed in and *seiverts*. 1 gray (Gy) equals 100 rad. 1 seive equals 100 rem. On the average, Americans receive about 360 mrem of radiation a year. of this (97%) is from natural radiation and medic exposure. Specific examples of common sourc radiation are shown in the chart below.

## RADIATION IN THE ENVIRONMENT

Because the radioactivity of individual samples varies, the numbers given here are approximate or represent an average. They are shown to provide a perspective for concentrations and levels of radioactivity rather than dose.

mrem = millirem
pCi = picocurie

### Cosmic Radiation

Cosmic radiation is high-energy gamma radiation that originates in outer space and filters through our atmosphere.

Sea Level ..... 26 mrem/year
(increases about 1/2 mrem for each additional 100 feet in elevation)
Atlanta, Georgia (1,050 feet) ..... 31 mrem/year
Denver, Colorado (5,300 feet) ..... 50 mrem/year
Minneapolis, Minnesota (815 feet) ..... 30 mrem/year
Salt Lake City, Utah (4,400 feet) ..... 46 mrem/year

### Terrestrial Radiation

Terrestrial sources are naturally radioactive elements in the soil and water such as uranium, radium, and thorium. Average levels of these elements are 1 pCi/gram of soil.

United States (average) ..... 26 mrem/year
Denver, Colorado ..... 63 mrem/year
Nile Delta, Egypt ..... 350 mrem/year
Paris, France ..... 350 mrem/year
Coast of Kerala, India ..... 400 mrem/year
McAipe, Brazil ..... 2,558 mrem/year
Pocos De Caldas, Brazil ..... 7,000 mrem/year

### Buildings

Many building materials, especially granite, contain naturally radioactive elements.

U.S. Capitol Building ..... 85 mrem/year
Base of Statue of Liberty ..... 325 mrem/year
Grand Central Station ..... 525 mrem/year
The Vatican ..... 800 mrem/year

### Radon

Radon levels in buildings vary, depending on geographic location, from 0.1 to 200 pCi/liter.

Average Indoor Radon Level ..... 1.5 pCi/liter
Occupational Working Limit ..... 100.0 pCi/liter

### Food

Food contributes an average of 20 mrem/year, mostly from potassium-40, carbon-14, hydrogen-3, radium-226, and thorium-232.

Beer ..... 390 pCi/liter
Tap Water ..... 20 pCi/liter
Milk ..... 1,400 pCi/liter
Salad Oil ..... 4,900 pCi/liter
Whiskey ..... 1,200 pCi/liter
Brazil Nuts ..... 14 pCi/g
Bananas ..... 3 pCi/g
Flour ..... 0.14 pCi/g
Peanuts & Peanut Butter ..0.12 pCi/g
Tea ..... 0.40 pCi/g

### Medical Treatment

The exposures from medical diagnosis vary widely according to the required procedure, the equipment and film used for x rays, and the skill of the operator.

Chest X Ray ..... 10 mrem
Dental X Ray,Each ..... 100 mrem

### Consumer Goods

Cigarettes–two packs/day (polonium-210) ..... 8,000 mrem/
Color Television ..... <1 mrem/
Gas Lantern Mantle (thorium-232) ..... 2 mrem/
Highway Construction ..... 4 mrem/
Airplane Travel at 39,000 feet (cosmic) ..... 0.5 mrem/
Natural Gas Heating and Cooking (radon-222) ..... 2 mrem/
Phosphate Fertilizers ..... 4 mrem/

**Natural Radioactivity in Florida Phosphat Fertilizers (in pCi/gram)**

| | Normal Superphosphate | Concentrated Superphosphate | Gypsu |
|---|---|---|---|
| **Ra-226** | 21.3 | 21.0 | 33.0 |
| **U-238** | 20.1 | 58.0 | 6.0 |
| **Th-230** | 18.9 | 48.0 | 13.0 |
| **Th-232** | 0.6 | 1.3 | 0.3 |

Porcelain Dentures (uranium) ..... 1,500 mrem/yea
Radioluminescent Clock (promethium-147) ..... <1 mrem/yea
Smoke Detector (americium-241) ..... 0.01 mrem/yea

**International Nuclear Weapons Tes Fallout** from pre–1980 atmospheric tests (average for a U.S. citizen) ..... 1 mrem/yea


**References**

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Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980. Committee on the Biological Effects of Ionizing Radiation. National Academy Press, 1984.
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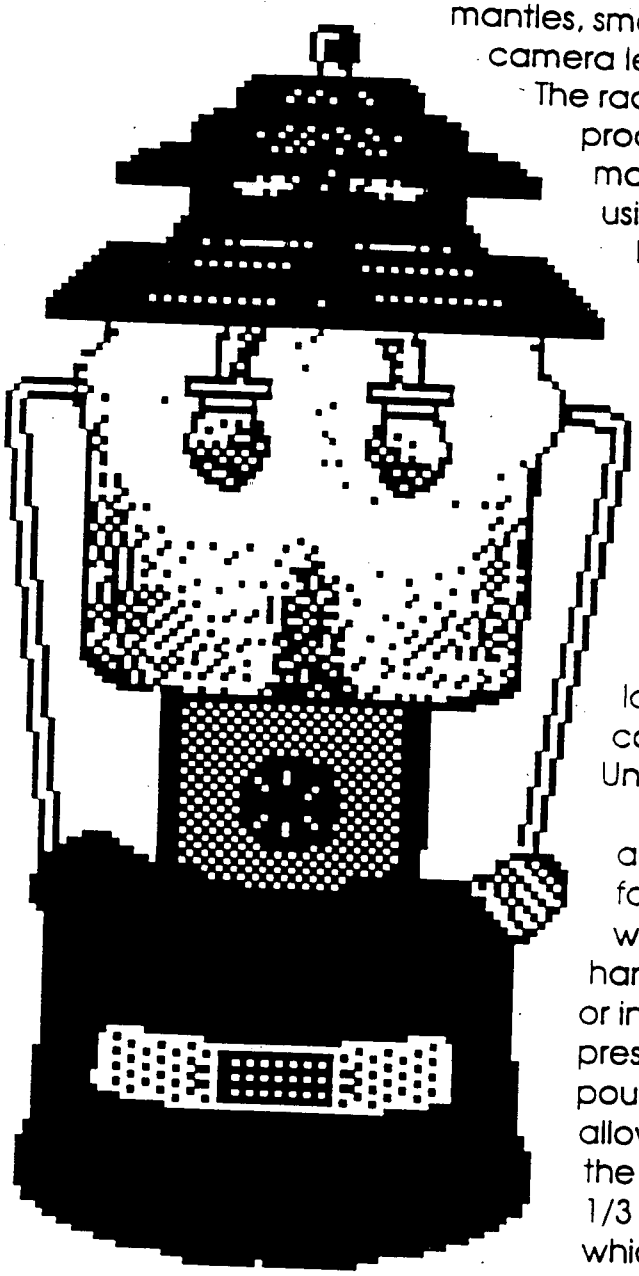
Radioactivity in Consumer Products. U.S. Nuclear Regulatory Commission, 1978.

# PERSPECTIVE: Radioactivity in Gas Lantern Mantles

## Around the House

Many household products contain a small amount of radioactivity. Examples include gas lantern mantles, smoke detectors, dentures, camera lenses, and anti-static brushes. The radioactivity is added to the products either specifically to make them work, or as a result of using compounds of elements like thorium and uranium in producing them. The amount of radiation the products gives off is not considered significant. But with today's sensitive equipment, it can be detected.



## Lanterns: In a New Light

About 20 million gas lantern mantles are used by campers each year in the United States.

Under today's standards, the amount of natural radioactivity found in a lantern mantle would require precautions in handling it at many Government or industry sites. The radioactivity present would contaminate 15 pounds of dirt to above allowable levels. This is because the average mantle contains 1/3 of a gram of thorium oxide, which has a specific activity ( a measure of radioactivity) of approximately 100,000 picocuries per gram. The approximately 35,000 picocuries of radioactivity in the mantle would, if thrown onto the ground, be considered low-level radioactive contamination.



From information provided by W.L. Beck, Bechtel National, Inc.

# APPENDIX G
# CONVERSION FACTORS

TABLE G-1

CONVERSION FACTORS

| | | |
|---|---|---|
| 1 yr | = | 8,760 h |
| 1 L | = | 1,000 ml |
| 1 $\mu$Ci | = | 1,000,000 pCi |
| 1 pCi | = | 0.000001 $\mu$Ci |
| 0.037 Bq/L | = | $10^{-9}$ $\mu$Ci/ml = 1 pCi/L |
| 0.037 Bq/L | = | 0.000000001 $\mu$Ci/ml |
| 1 $\mu$Ci/ml | = | 1,000,000,000 pCi/L |
| $1E^{-6}$ = 1E-6 = 1E-06 | = | 0.000001 = $1 \times 10^{-6}$ |
| $1E^{-7}$ = 1E-7 = 1E-07 | = | 0.0000001 = $1 \times 10^{-7}$ |
| $1E^{-8}$ = 1E-8 = 1E-08 | = | 0.00000001 = $1 \times 10^{-8}$ |
| $1E^{-9}$ = 1E-9 = 1E-09 | = | 0.000000001 = $1 \times 10^{-9}$ |
| $1E^{-10}$ = 1E-10 | = | 0.0000000001 = $1 \times 10^{-10}$ |

# APPENDIX H

# CLEAN AIR ACT COMPLIANCE REPORT

# FOR MIDDLESEX SAMPLING PLANT

40 CFR Part 61
National Emission Standards
for Hazardous Air Pollutants

# CLEAN AIR ACT COMPLIANCE REPORT
(Version 3.0 November 1989)

Facility: Middlesex Sampling Plant
Address: 239, Mtn. Ave. P.O Box 426
Middlesex , NJ. 08846
Annual Assessment for Year: 1990
Date Submitted: 3/20/91

Comments:

Prepared By:

Name: Bechtel National inc.
Title: FUSRAP
Phone #: (615) 576-4611

Prepared for:
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

METEOROLOGICAL AND PLANT INFORMATION SUPPLIED TO PROGRAM----

AVERAGE VERTICAL TEMPERATURE GRADIENT OF THE AIR (DEG K/METER)

| | |
|---|---|
| IN STABILITY CLASS E | 0.0728 |
| IN STABILITY CLASS F | 0.1090 |
| IN STABILITY CLASS G | 0.1455 |

PLUME DEPLETION AND DEPOSITION PARAMETERS

| NUCLIDE | GRAVITATIONAL FALL VELOCITY (METERS/SEC) | DEPOSITION VELOCITY (METERS/SEC) | SCAVENGING COEFFICIENT (1/SEC) | EFFECTIVE DECAY CONSTANT IN PLUI (PER DAY) |
|---|---|---|---|---|
| U-238 | 0.000 | 0.00180 | 0.121E-04 | 0.000E+( |
| U-234 | 0.000 | 0.00180 | 0.121E-04 | 0.000E+( |
| U-235 | 0.000 | 0.00180 | 0.121E-04 | 0.000E+( |
| RA-226 | 0.000 | 0.00180 | 0.121E-04 | 0.000E+( |
| TH-232 | 0.000 | 0.00180 | 0.121E-04 | 0.000E+( |

FREQUENCIES OF WIND DIRECTIONS AND RECIPROCAL-AVERAGED WIND SPEEDS

| WIND TOWARD | FREQUENCY | WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G |
| N | 0.141 | 0.00 | 3.02 | 4.73 | 5.11 | 3.33 | 1.43 | 0.00 |
| NNW | 0.028 | 1.19 | 1.98 | 4.42 | 3.91 | 3.16 | 1.39 | 0.00 |
| NW | 0.029 | 0.00 | 1.98 | 3.32 | 3.96 | 2.98 | 1.68 | 0.00 |
| WNW | 0.028 | 0.00 | 1.95 | 3.12 | 3.72 | 2.94 | 1.20 | 0.00 |
| W | 0.049 | 0.00 | 1.59 | 2.44 | 3.91 | 2.75 | 1.31 | 0.00 |
| WSW | 0.043 | 0.00 | 1.49 | 2.76 | 3.95 | 2.95 | 1.46 | 0.00 |
| SW | 0.048 | 1.19 | 1.63 | 3.07 | 4.48 | 3.26 | 1.87 | 0.00 |
| SSW | 0.047 | 0.00 | 1.84 | 3.89 | 4.94 | 3.77 | 1.80 | 0.00 |
| S | 0.082 | 1.19 | 2.60 | 3.87 | 5.59 | 3.97 | 1.78 | 0.00 |
| SSE | 0.061 | 1.19 | 2.67 | 3.97 | 6.17 | 3.97 | 1.46 | 0.00 |
| SE | 0.086 | 0.00 | 2.74 | 4.37 | 6.81 | 4.07 | 1.77 | 0.00 |
| ESE | 0.059 | 0.00 | 2.00 | 3.98 | 6.73 | 3.97 | 1.66 | 0.00 |
| E | 0.092 | 0.00 | 2.16 | 3.69 | 6.02 | 3.85 | 1.74 | 0.00 |
| ENE | 0.080 | 0.00 | 2.15 | 3.81 | 4.66 | 3.63 | 1.81 | 0.00 |
| NE | 0.060 | 0.00 | 2.48 | 3.90 | 4.32 | 3.39 | 1.85 | 0.00 |
| NNE | 0.068 | 0.00 | 2.16 | 3.82 | 4.92 | 3.48 | 1.67 | 0.00 |

FREQUENCY OF ATMOSPHERIC STABILITY CLASSES FOR EACH DIRECTION

| SECTOR | FRACTION OF TIME IN EACH STABILITY CLASS | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G |
| N | 0.0000 | 0.0300 | 0.2042 | 0.6347 | 0.0890 | 0.0421 | 0.0000 |
| NNW | 0.0051 | 0.0224 | 0.1778 | 0.6169 | 0.1039 | 0.0740 | 0.0000 |
| NW | 0.0000 | 0.0213 | 0.1184 | 0.6929 | 0.0847 | 0.0826 | 0.0000 |
| WNW | 0.0000 | 0.0176 | 0.0765 | 0.7082 | 0.0959 | 0.1017 | 0.0000 |
| W | 0.0000 | 0.0259 | 0.0692 | 0.6788 | 0.0969 | 0.1292 | 0.0000 |
| WSW | 0.0000 | 0.0295 | 0.0773 | 0.6385 | 0.1043 | 0.1504 | 0.0000 |
| SW | 0.0029 | 0.0351 | 0.0774 | 0.6372 | 0.1262 | 0.1211 | 0.0000 |
| SSW | 0.0000 | 0.0341 | 0.1081 | 0.6200 | 0.1518 | 0.0859 | 0.0000 |
| S | 0.0017 | 0.0229 | 0.0960 | 0.6580 | 0.1492 | 0.0722 | 0.0000 |
| SSE | 0.0023 | 0.0181 | 0.0786 | 0.6961 | 0.1634 | 0.0415 | 0.0000 |
| SE | 0.0000 | 0.0128 | 0.0532 | 0.7688 | 0.1267 | 0.0384 | 0.0000 |
| ESE | 0.0000 | 0.0141 | 0.0433 | 0.7504 | 0.1296 | 0.0625 | 0.0000 |
| E | 0.0000 | 0.0189 | 0.0871 | 0.6810 | 0.1317 | 0.0814 | 0.0000 |
| ENE | 0.0000 | 0.0199 | 0.1448 | 0.5329 | 0.2053 | 0.0971 | 0.0000 |
| NE | 0.0000 | 0.0383 | 0.1512 | 0.4917 | 0.2185 | 0.1003 | 0.0000 |
| NNE | 0.0000 | 0.0182 | 0.1230 | 0.6261 | 0.1683 | 0.0644 | 0.0000 |

FREQUENCIES OF WIND DIRECTIONS AND TRUE-AVERAGE WIND SPEEDS

| WIND TOWARD | FREQUENCY | WIND SPEEDS FOR EACH STABILITY CLASS (METERS/SEC) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G |
| N | 0.141 | 0.00 | 3.70 | 5.36 | 6.19 | 3.57 | 1.96 | 0.00 |
| NNW | 0.028 | 1.67 | 3.15 | 5.05 | 5.13 | 3.38 | 1.91 | 0.00 |
| NW | 0.029 | 0.00 | 3.15 | 4.44 | 5.02 | 3.17 | 2.16 | 0.00 |
| WNW | 0.028 | 0.00 | 2.54 | 4.36 | 5.12 | 3.12 | 1.69 | 0.00 |
| W | 0.049 | 0.00 | 2.34 | 3.44 | 5.33 | 2.86 | 1.83 | 0.00 |
| WSW | 0.043 | 0.00 | 2.33 | 3.42 | 5.14 | 3.13 | 1.98 | 0.00 |
| SW | 0.048 | 1.67 | 2.62 | 3.90 | 5.61 | 3.49 | 2.28 | 0.00 |
| SSW | 0.047 | 0.00 | 2.78 | 4.37 | 5.71 | 3.96 | 2.24 | 0.00 |
| S | 0.082 | 1.67 | 3.07 | 4.27 | 6.44 | 4.11 | 2.23 | 0.00 |
| SSE | 0.061 | 1.67 | 3.34 | 4.38 | 6.90 | 4.11 | 1.98 | 0.00 |
| SE | 0.086 | 0.00 | 3.45 | 4.83 | 7.58 | 4.18 | 2.22 | 0.00 |
| ESE | 0.059 | 0.00 | 2.83 | 4.66 | 7.42 | 4.11 | 2.15 | 0.00 |
| E | 0.092 | 0.00 | 3.18 | 4.38 | 6.99 | 4.03 | 2.20 | 0.00 |
| ENE | 0.080 | 0.00 | 3.25 | 4.10 | 5.52 | 3.85 | 2.25 | 0.00 |
| NE | 0.060 | 0.00 | 3.30 | 4.42 | 5.22 | 3.63 | 2.27 | 0.00 |
| NNE | 0.068 | 0.00 | 3.24 | 4.62 | 6.00 | 3.71 | 2.15 | 0.00 |

CLEAN AIR ACT COMPLIANCE REPORT 3/20/91 10:43 AM

Facility: Middlesex Sampling Plant
Address: 239, Mtn. Ave. P.O Box 426 City: Middlesex State:
Comments:
Year: 1990

| | Dose Equivalent Rates to Nearby Individuals (mrem/year) |
|---|---|
| Effective Dose Equivalent | 0.0034 |
| Highest Organ Dose is to LUNGS | 0.0260 |

EMISSION INFORMATION

| Radio-nuclide | Class | Amad | Area #1 (Ci/y) | Area #2 (Ci/y) | Area #3 (Ci/y) |
|---|---|---|---|---|---|
| U-238 | Y | 1.0 | 5.4E-07 | 4.1E-07 | 8.6E-07 |
| U-234 | Y | 1.0 | 5.2E-07 | 3.9E-07 | 8.3E-07 |
| U-235 | Y | 1.0 | 2.3E-08 | 1.7E-08 | 3.8E-08 |
| RA-226 | Y | 1.0 | 5.4E-07 | 4.1E-07 | 6.0E-07 |
| TH-232 | Y | 1.0 | 0.0E-01 | 0.0E-01 | 4.0E-08 |
| Total Area (m**2) | | | 8.8E+03 | 6.7E+03 | 2.3E+04 |

SITE INFORMATION

| | | | |
|---|---|---|---|
| Wind Data | LEA0435.WND | Temperature (C) | 12 |
| Food Source | LOCAL | Rainfall (cm/y) | 121 |
| Distance to Individuals (m) | 300 | Lid Height (m) | 1000 |

*NOTE: The results of this computer model are dose estimates. They are only to be used for the purpose of determining compliance and reporting per 40 CFR 61.93 and 40 CFR 61.94.

# ORGAN DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL

| ORGAN | DOSE EQUIVALENT RATE TO THE ORGAN (mrem/y) |
|---|---|
| GONADS | 6.3E-05 |
| BREAST | 6.4E-05 |
| RED MARROW | 3.9E-04 |
| LUNGS | 2.6E-02 |
| THYROID | 6.3E-05 |
| ENDOSTEUM | 4.7E-03 |
| REMAINDER | 2.8E-04 |
| EFFECTIVE | 3.4E-03 |

# DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL BY PATHWAY FOR ALL RADIONUCLIDES

| | EFFECTIVE DOSE EQUIVALENT (mrem/y) | DOSE EQUIVALENT TO THE ORGA WITH THE HIGHEST DOSE LUNGS (mrem/y) |
|---|---|---|
| INGESTION | 2.4E-04 | 2.7E-05 |
| INHALATION | 3.1E-03 | 2.6E-02 |
| AIR IMMERSION | 6.4E-11 | 5.4E-11 |
| GROUND SURFACE | 2.1E-06 | 1.6E-06 |
| TOTAL: | 3.4E-03 | 2.6E-02 |

Middlesex Sampling Plant

# DOSE TO THE MAXIMALLY EXPOSED INDIVIDUAL BY RADIONUCLIDE FOR ALL PATHWAYS

| RADIONUCLIDE | EFFECTIVE DOSE EQUIVALENT (mrem/y) | DOSE EQUIVALENT TO THE ORGAI WITH THE HIGHEST DOSE LUNGS (mrem/y) |
|---|---|---|
| U-238 | 1.0E-03 | 8.1E-03 |
| U-234 | 1.1E-03 | 8.8E-03 |
| U-235 | 4.8E-05 | 3.6E-04 |
| RA-226 | 1.1E-03 | 8.0E-03 |
| TH-232 | 6.3E-05 | 3.4E-04 |
| TOTAL : | 3.4E-03 | 2.6E-02 |

# EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF DISTANCE IN THE DIRECTIONS OF THE MAXIMALLY EXPOSED INDIVIDUAL FOR ALL RADIONUCLIDES AND ALL PATHWAYS

DIRECTION : NORTH

| DISTANCE (meters) | EFFECTIVE DOSE EQUIVALENT (mrem/y) |
|---|---|
| 300 | 3.4E-03 |
| 1000 | 3.8E-04 |
| 3000 | 5.8E-05 |
| 10000 | 9.2E-06 |
| 80000 | 3.6E-07 |

# EFFECTIVE DOSE EQUIVALENT AS A FUNCTION OF ALL DISTANCES AND ALL DIRECTIONS FOR ALL RADIONUCLIDES AND ALL PATHWAYS

| DIRECTIONS: / DISTANCE (METERS): | N | NNE | NE | ENE | E | ESE | SE | SSE |
|---|---|---|---|---|---|---|---|---|
| 300 | 3.4E-03 | 2.2E-03 | 2.2E-03 | 2.7E-03 | 2.6E-03 | 1.6E-03 | 1.8E-03 | 1.6E-03 |
| 1000 | 3.8E-04 | 2.2E-04 | 2.2E-04 | 2.9E-04 | 2.8E-04 | 1.6E-04 | 2.0E-04 | 1.6E-04 |
| 3000 | 5.8E-05 | 3.4E-05 | 3.5E-05 | 4.5E-05 | 4.3E-05 | 2.5E-05 | 3.1E-05 | 2.5E-05 |
| 10000 | 9.2E-06 | 5.5E-06 | 5.7E-06 | 7.3E-06 | 7.0E-06 | 4.0E-06 | 5.1E-06 | 4.1E-06 |
| 80000 | 3.6E-07 | 2.2E-07 | 2.3E-07 | 2.9E-07 | 2.7E-07 | 1.6E-07 | 2.2E-07 | 1.7E-07 |

| DISTANCE (METERS): | S | SSW | SW | WSW | W | WNW | NW | NNW |
|---|---|---|---|---|---|---|---|---|
| 300 | 2.3E-03 | 1.6E-03 | 1.8E-03 | 2.1E-03 | 2.3E-03 | 1.3E-03 | 1.0E-03 | 1.1E-03 |
| 1000 | 2.4E-04 | 1.6E-04 | 1.9E-04 | 2.1E-04 | 2.4E-04 | 1.3E-04 | 1.1E-04 | 1.0E-04 |
| 3000 | 3.8E-05 | 2.4E-05 | 2.9E-05 | 3.2E-05 | 3.6E-05 | 1.9E-05 | 1.7E-05 | 1.6E-05 |
| 10000 | 6.2E-06 | 3.9E-06 | 4.7E-06 | 5.0E-06 | 5.5E-06 | 3.0E-06 | 2.6E-06 | 2.4E-06 |
| 80000 | 2.5E-07 | 1.5E-07 | 1.7E-07 | 1.5E-07 | 1.6E-07 | 8.8E-08 | 9.3E-08 | 8.4E-08 |

# APPENDIX I

## DISTRIBUTION LIST FOR MIDDLESEX SAMPLING PLANT ENVIRONMENTAL REPORT FOR CALENDAR YEAR 1990

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## Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey

**July 1979**

**Final Report**

Prepared for

U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology

Under
Contract No. EW-76-C-13-1658

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Division of Environmental Control Technology

Under
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CONTENTS (Cont)


| Appendix | Title | Page |
|---|---|---|
| A | GLOSSARY | A-1 |
| B | POTENTIAL HEALTH IMPACTS | B-1 |
| C | POPULATION DOSE CALCULATIONS | C-1 |
| D | DESCRIPTION OF EARLY DECONTAMINATION OF THE RECTORY OF THE CHURCH OF OUR LADY OF MOUNT VIRGIN AND THE PROPERTY AT 432 WILLIAM STREET | D-1 |

## LIST OF FIGURES


| Number | Title | Page |
|---|---|---|
| 1-1 | General Area of Sampling Plant and Vicinity. . . | 1-8 |
| 1-2 | Locations of Associated Properties in the Vicinity of the Site . . . . . | 1-9 |
| 1-3 | Location of Storage Area . . . . . | 1-10 |
| 2-1 | Descriptive Map. . . . . | 2-15 |
| 2-2 | Topographical and Surface Drainage Map . . . . . | 2-16 |
| 2-3 | Simplified Stratigraphic Column, Northern Middlesex and Northern Somerset Counties, New Jersey . . . . . | 2-17 |
| 2-4 | Soil Classifications in Area of Site . . . . . | 2-18 |
| 2-5 | Flood Plains and Approximate Location of Wells in Vicinity of Site. . . . . | 2-19 |
| 2-6 | Newark Airport Surface Wind Rose (Cumulative Data from 1951 through 1960) . . . . . | 2-20 |
| 2-7 | Population Distribution around Site. . . . . | 2-21 |
| 2-8 | Land Use . . . . . | 2-22 |
| 2-9 | Population and Employment Outlook for Area within 1 Mile of Site. . . . . | 2-23 |
| 2-10 | Uranium-238 Radioactive Decay Chain (Abbreviated) and Mechanisms of Transporting Radioactivity from Uranium to Man. . . . . | 2-24 |

LIST OF TABLES


| Number | Title | Page |
|---|---|---|
| 1-1 | Actions Associated with Proposed Options for Remedial Action for the Middlesex Sampling Plant and Associated Properties. . . . . | 1-11 |
| 2-1 | Soil Properties. . . . . | 2-25 |
| 2-2 | Summary of Measurements of Radioactivity . . . . | 2-26 |
| 3-1 | Summary of Environmental Impact Associated with Option A. . . . . | 3-25 |
| 3-2A | Summary of Environmental Impacts Resulting from Option B for the Associated Properties. . . | 3-26 |
| 3-2B | Summary of Environmental Impacts Resulting from Option B for the Sampling Plant Site. . . . | 3-27 |
| 3-3A | Summary of Environmental Impacts Resulting from Option C for the Associated Properties. . . | 3-28 |
| 3-3B | Summary of Environmental Impacts Resulting from Option C for the Sampling Plant Site. . . . | 3-29 |
| 3-4A | Summary of Environmental Impacts Resulting from Option D for the Associated Properties. . . | 3-30 |
| 3-4B | Summary of Environmental Impacts Resulting from Option D for the Sampling Plant Site. . . . | 3-31 |
| 3-5A | Summary of Environmental Impacts Resulting from Option E for the Associated Properties. . . | 3-32 |
| 3-5B | Summary of Environmental Impacts Resulting from Option E for the Sampling Plant Site. . . . | 3-33 |
| 3-6A | Summary of Environmental Impacts Resulting from Option F for the Associated Properties. . . | 3-34 |
| 3-6B | Summary of Environmental Impacts Resulting from Option F for the Sampling Plant Site. . . . | 3-35 |
| 4-1 | Advantages and Disadvantages of Options A through F. . . . . | 4-6 |
| 4-2 | Remedial Action Cost Estimates (in Thousands of 1979 Dollars). . . . . | 4-8 |

LIST OF TABLES (Cont)


| Number | Title | Page |
|---|---|---|
| 4-3 | Summary of Health Benefits to Public for Options A through F. . . . . | 4-9 |
| 4-4 | Cost-Benefit Ratios. . . . . | 4-10 |

# CHAPTER 1

# INTRODUCTION AND BACKGROUND

# CHAPTER 1

# INTRODUCTION AND BACKGROUND

The United States Government has instituted a program known as the "Formerly Utilized MED/AEC Sites Remedial Action Program," or FUSRAP. This remedial action program for Manhattan Engineer District/Atomic Energy Commission Sites was initiated in 1974 by the AEC, continued under the Energy Research and Development Administration (ERDA), and presently is being managed by the Department of Energy (DOE). The objectives of the FUSRAP program include determination of the radiological conditions of former MED/AEC sites, identification of the options for remedial actions that could be undertaken along with their respective costs, and analysis of the environmental impacts of these actions.

As a result of the FUSRAP effort, radioactive contamination above background level has been measured at the Middlesex Sampling Plant site and on associated properties in Middlesex and Piscataway, New Jersey. Detailed descriptions of the radiological conditions at the Middlesex Sampling Plant site and associated properties are presented in three separate reports(1-3) prepared by DOE's Oak Ridge National Laboratory (ORNL). Options for remedial action that could be undertaken at these locations have been described in a companion Engineering Evaluation report.(4)

## 1.1 PURPOSE

The purpose of this Environmental Analysis report is to present information regarding the existing environment and to analyze potential environmental impacts that pertain to the present radiological conditions and the impacts which might be associated with implementation of the various options for remedial action.

If one of these remedial action options is selected, this report could be used to determine whether additional environmental documentation would be required. This report is therefore developed in general accordance with the guidelines for an Environmental Assessment as prescribed in 10 CFR 1021.12.

## 1.2 SUMMARY DESCRIPTION OF THE SITE AND ASSOCIATED PROPERTIES

The contaminated properties include the Middlesex Sampling Plant and the associated properties (Figures 1-1 and 1-2). The associated properties include those that are adjacent to or near the site, the Rectory of the Church of Our Lady of Mount Virgin at the corner of Harris and Drake Streets, and a residence at 432 William Street in Piscataway. (The options for remedial action and impacts of the Middlesex Landfill site, also shown in Figure 1-1, are presented in separate reports.(5-6))

The Middlesex Sampling Plant and associated properties are not treated as a composite, but are analyzed individually in terms of measured radioactive contamination and in terms of the environmental impacts of the proposed remedial actions.

### 1.2.1 Middlesex Sampling Plant

The former Middlesex Sampling Plant was a storage depot and sampling plant for uranium and thorium ores from 1943 to 1955. The Sampling Plant is located in the Borough of Middlesex in north Middlesex County, New Jersey, as shown in Figure 1-1. The site is just north of the Township of Piscataway, New Jersey. It is on the west side of Mountain Avenue and south of the Central Railroad of New Jersey and the Lehigh Valley Railroad, with a street address of 239 Mountain Avenue. The site is designated as Lots 1A, 30-42, 45, and 46 of Block 318 of the Borough of Middlesex, County of Middlesex, State of New Jersey.

The site, owned by the federal government, was occupied until recently by the Sixth Motor Transport Battalion of the U.S. Marine Corps and served as a reserve training center. There are seven buildings on site. All buildings and soil on site are contaminated, and radiation measurements(1) indicate radioactivity levels exceeding proposed DOE guidelines for radium in soil and radon daughter concentration at some locations. (See Appendix A for a glossary of terms used in this report.)

### 1.2.2 Associated Properties

#### Adjacent and Nearby Properties

The associated properties adjacent to or nearby the Sampling Plant site where contamination has been found are shown in Figure 1-2. These locations include residences, commercial buildings, and vacant lots. Radiological survey measurements(2) do not indicate that the homes on these properties are contaminated with radioactivity. The measurements do show that contamination exists near the surface of these properties, clearly indicating that wind and water migration of radioactivity from the Sampling Plant was the source.

#### Church Rectory

The Rectory of the Church of Our Lady of Mount Virgin is located approximately 0.3 mi west of the site, as shown in Figure 1-1. The Rectory is a three-story structure above ground with a basement below ground level. Elevated concentrations of radium and external gamma radiation levels were found in the soils surrounding this building, and elevated $^{222}Rn$ concentrations were measured inside the building.(2)

432 William Street

The 432 William Street property, located in Piscataway Township about 0.8 mi east of the site, is a one-story private residence with a partial basement and a detached garage. Measurements show that external gamma radiation and radium concentration found in the soils surrounding this residence exceed natural background levels because of the presence of radioactive materials.(2) A detailed description of the pertinent environmental conditions of the site and associated properties is presented in Chapter 2.

## 1.3 BASIC OPTIONS FOR REMEDIAL ACTION

Six options (A through F) were described in the Engineering Evaluation report.(4) These six options were derived from the following five basic options for correcting radioactive contamination.

### 1.3.1 Option I - No Action

In this option, no action would be taken at all; i.e., the property would remain unchanged. The no action option requires consideration as one of the possible courses of action available to the remedial action program. The analysis of this option also reflects the present impacts of the current conditions for comparison with the other options.

### 1.3.2 Option II - Minimal Action

Minimal action implies that no action would be taken regarding the contaminants, per se. It would only involve measures which would effectively limit public exposure to radioactive sources, such as restricting access to a contaminated property.

This option generally would require that the property be (a) purchased by a government agency and held in perpetuity, (b) controlled by fencing and posting with appropriate warning signs, (c) maintained, and (d) radiologically surveyed periodically for land, air, and water pollution.

### 1.3.3 Option III - Stabilization or Entombment

Stabilization refers to the in situ covering of a contaminated area of ground with compacted clean fill. Stabilization with at least 2 ft of compacted clay materially reduces the radon emanation and external gamma exposure from the contaminants.(7) Entombment involves the total encapsulation of a pile of contaminated material by a permanent casing, such as concrete.

### 1.3.4 Option IV - Partial Decontamination

Partial decontamination involves action toward reducing active or potentially active sources of further contamination. In buildings, for example, long-lived transferable alpha contamination might be cleaned up or covered over with an epoxy film to check its spread. Radon gas and radon daughter concentrations can be reduced to appropriate levels by ventilation, filtration, or other suitable methods. Restrictions on access to the site may be required.

### 1.3.5 Option V - Decontamination and Restoration

Decontamination and restoration implies that all contamination from a property would be removed. Contaminated soils would be excavated to one of two decontamination criteria:

Criterion A - Decontaminate to radium $^{226}Ra$ concentration of 5 pCi/g above natural background levels

Criterion B - Decontaminate to natural radium background level for the area (approximately 1.0 to 1.7 pCi/g)

Although the optional criteria for decontamination levels for soils of 5 pCi/g above natural background or cleanup to background values have been selected for use in this evaluation, at the time of the remedial action operations it may be practical to remove the contamination to levels less than 5 pCi/g. The decisions on removal to lower levels would be in keeping with the ALARA (as low as reasonably achievable) philosophy.

The razed contaminated buildings and excavated soils and debris would be transported to an appropriate disposal site. Upon decontamination, the property would be restored by backfilling and seeding or by landscaping and would be available for unrestricted use.

The five basic options (I-V) include the range of remedial actions considered for the former Middlesex Sampling Plant and associated properties. The complex situation involving both private properties and the government-owned property does not permit a clear selection of any one of the basic options. Because of the lack of an appropriate disposal site for the contaminated materials, time-phased combinations of these options should be considered. Six options for remedial action are presented which combine the most practical basic options for each property. These proposed options for remedial action are described in Paragraph 1.4, and the actions associated with each proposed option are listed in Table 1-1.

## 1.4 PROPOSED OPTIONS FOR REMEDIAL ACTION

The following proposed options for the remedial action

program at the former Middlesex Sampling Plant and associated properties are composed of combinations of the basic options given in Paragraph 1.3.

### 1.4.1 Option A - No Action

In this option, no action would be taken at all; i.e., the property would remain unchanged. This option requires consideration. It also is used to present impacts of the current conditions for comparison with the other options.

### 1.4.2 Option B - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Permanent On-Site Storage

The associated properties would be decontaminated and restored. Contaminated materials from the associated properties would be transported to the Sampling Plant site and stored permanently in Area A, shown in Figure 1-3.

At the Sampling Plant site, drains in the former Process Building would be plugged and the contaminated yard drains would be removed and stored with the contaminated material in Area A.

Contaminated material in Area A would be sealed in an impermeable membrane and then stabilized with a soil cover to reduce gamma radiation and radon exhalation. The existing fence would be effective in restricting access to the entire site. A surveillance and maintenance program would be required to assure that the contaminated materials were contained.

### 1.4.3 Option C - Decontamination and Restoration of Associated Properties and a Portion of the Site; Permanent On-Site Storage

As in Option B, the associated properties would be decontaminated and restored. Contaminated materials would be stored permanently in Area A at the Sampling Plant site.

In some instances, decontamination of structures would be possible and economically feasible. However, decontamination of structures also can involve extensive and costly efforts in excess of the cost to demolish them. Moreover, success would not be assured. The buildings at the Middlesex Sampling Plant are old and the nature of their construction makes decontamination efforts generally inadvisable.

Buildings in Area B of the Sampling Plant site would be razed and Area B would be decontaminated and restored for unrestricted use. The contaminated materials would be sealed in an impermeable membrane and stored permanently in Area A, which then would be stabilized to reduce gamma radiation and radon exhalation. Area A would be fenced to restrict access. A

surveillance and maintenance program would be required to assure containment of the contaminated materials.

### 1.4.4 Option D - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Temporary On-Site Storage

This option is similar to Option B, except that the contaminated materials would be stored temporarily in Area A of the Sampling Plant site. After a remote disposal site was selected and prepared to receive the contaminated materials, the temporary storage pile would be removed and the entire site decontaminated and restored.

During Phase I, the associated properties would be decontaminated and restored and the contaminated materials temporarily stored in Area A. As in Option B, yard drains would be removed and process building drains would be plugged to present spread of contamination. Access to the entire site would be restricted by the existing fence during the temporary storage period. A surveillance and monitoring program would be required during this interim period.

After a remote disposal site has been prepared to accept the contaminated materials, Phase II can begin. Phase II would involve transport of the contaminated materials temporarily stored in Area A to the disposal site, razing of all buildings, and complete decontamination and restoration of the entire site for unrestricted use.

There is a possibility that the contaminated material would be removed from the Rectory and from the property at 432 William Street before any other remedial action would be taken. The highlights of the operations that would be involved are given in Appendix D. However, the environmental impacts relating to this potential subcase of Option D are not discussed in this environmental analysis, but are similar to those given for Option D.

### 1.4.5 Option E - Decontamination and Restoration of Associated Properties and a Portion of the Site; Temporary On-Site Storage

This option is similar to Option C, except that contaminated materials would be stored temporarily in Area A. After a remote disposal site has been prepared, the contaminated materials would be removed and Area A would be decontaminated and restored.

During Phase I, the associated properties would be decontaminated and restored and the contaminated materials would be stored in Area A. Buildings in Area B would be razed and Area B would be decontaminated and restored for unresricted use. The contaminated materials would be stored temporarily in Area A.

Area A would be fenced and access would be restricted. A surveillance and monitoring program would be required during the interim storage period.

After a remote disposal site has been selected and prepared to receive the contaminated materials, Phase II would be initiated. In Phase II, Area A would be decontaminated and restored for unrestricted use and all contaminated material would be transported to the remote disposal site.

### 1.4.6 Option F - Decontamination and Restoration of Associated Properties and the Sampling Plant Site; Direct Removal to Remote Site

After a remote disposal site has been selected and prepared to receive contaminated material from Middlesex, the associated properties would be decontaminated and restored. Contaminated materials would be transported to the remote disposal site.

Buildings at the Sampling Plant site would be razed and the site would be decontaminated and restored for unrestricted use. Contaminated materials would be transported to the remote disposal site.

## 1.5 APPROACH TO IMPACT ANALYSIS

This report presents the analysis of possible environmental impacts of the existing radiological conditions at the Sampling Plant site and associated properties, and the impacts associated with implementing the proposed options for remedial action presented in Paragraph 1.4 which are from the Engineering Evaluation report.(4)

Current conditions are described in Chapter 2 and form the bases for the analysis of the present impacts. These are described in Chapter 3 under the "no action" option. Also included in Chapter 3 are the impacts that occur during and after the remedial actions. A discussion of the environmental tradeoffs, based upon short- and long-term impacts of each remedial action in terms of advantages and disadvantages, is presented in Chapter 4.

The appendices include a glossary of technical terms (Appendix A), calculations of health impacts (Appendices B and C), and a description of the efforts involved in the early decontamination of the Rectory of the Church of Our Lady of Mount Virgin and the property at 432 William Street (Appendix D).

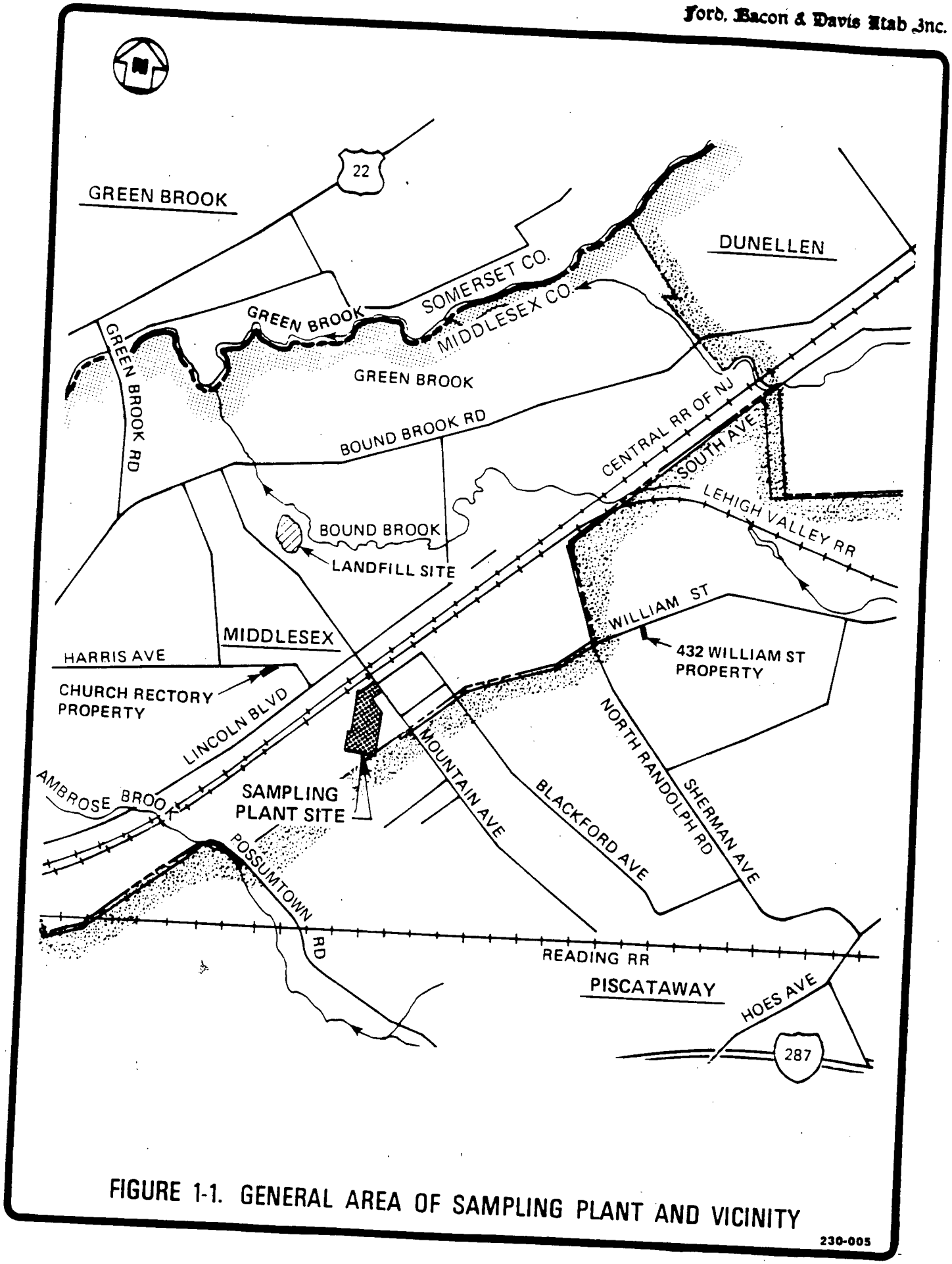


FIGURE 1-1. GENERAL AREA OF SAMPLING PLANT AND VICINITY

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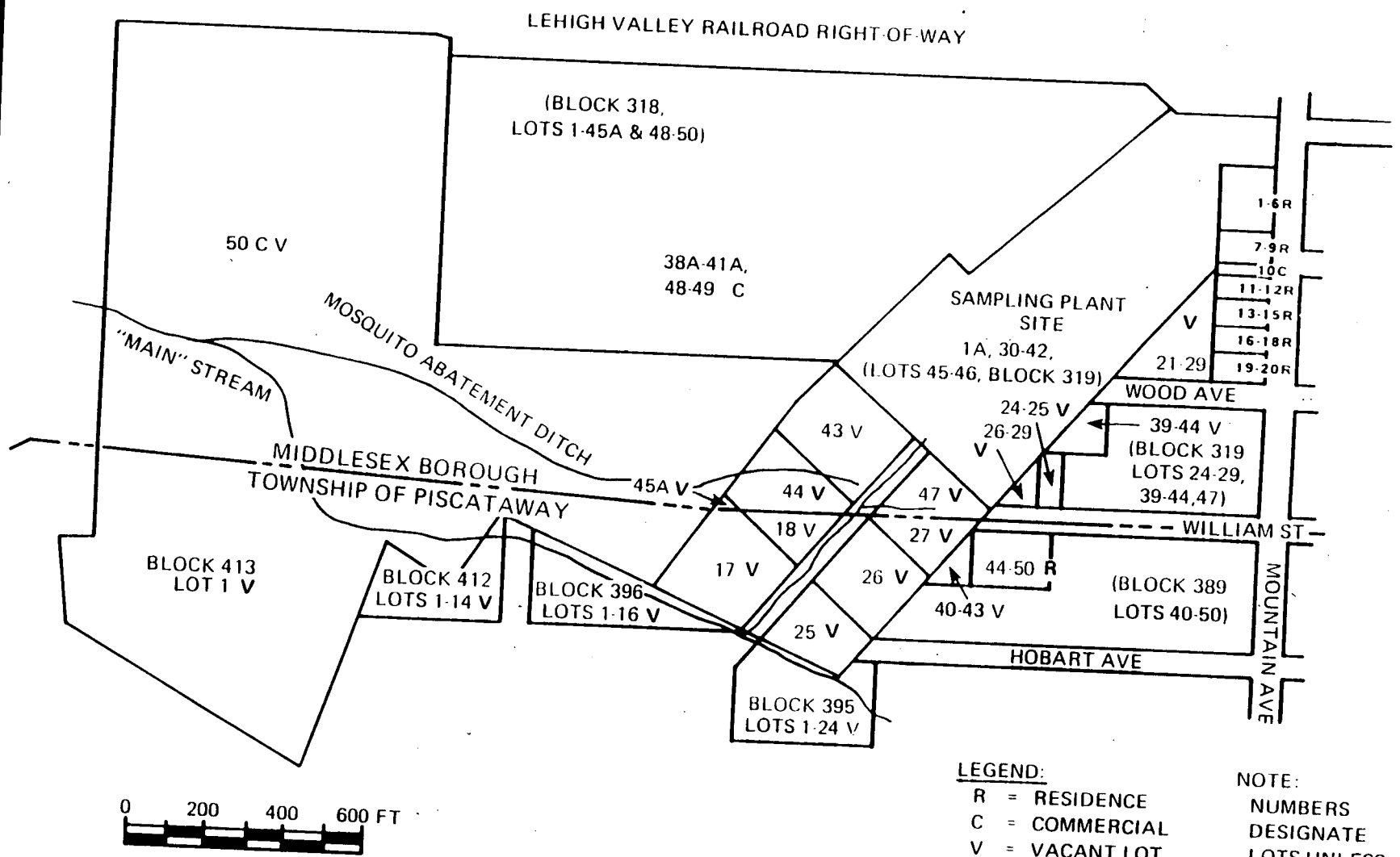


**FIGURE 1-2. LOCATIONS OF ASSOCIATED PROPERTIES IN THE VICINITY OF THE SITE**

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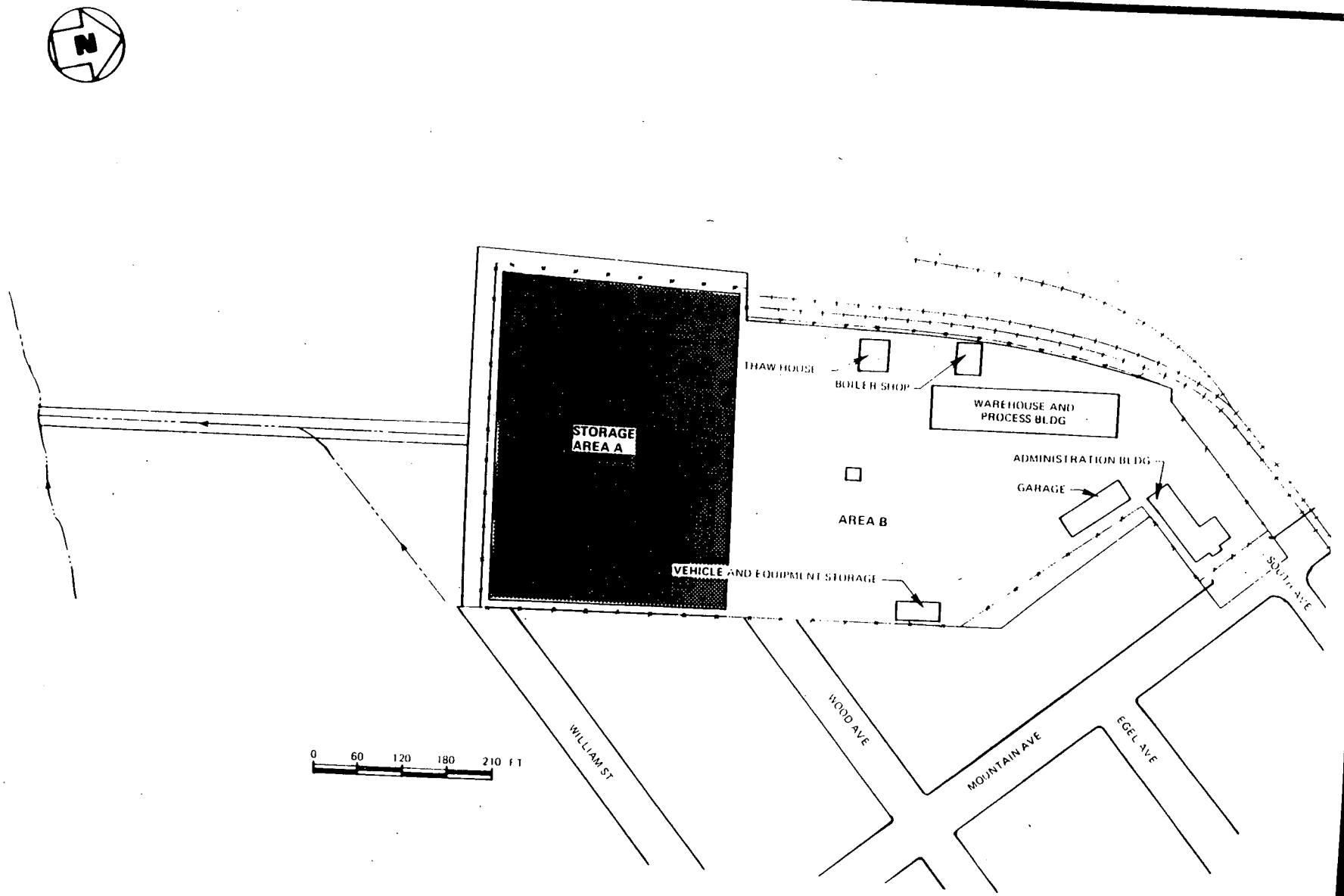


FIGURE 1-3. LOCATION OF STORAGE AREA

230-005



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TABLE 1-1

ACTIONS ASSOCIATED WITH PROPOSED OPTIONS FOR REMEDIAL ACTION FOR THE MIDDLESEX SAMPLING PLANT AND ASSOCIATED PROPERTIES

---

**Option A**

Associated Properties: No Action

Site: No Action

**Option B**

Associated Properties: Decontamination and Restoration

1) Excavate contaminated soils and materials
2) Store contaminated materials permanently on site (Area A)
3) Backfill and landscape

Site: Partial Decontamination; Permanent On-Site Storage

1) Excavate, backfill and seal surface of Area A with liner
2) Remove yard drain; store in Area A
3) Cover pile in Area A
4) Plug process building drain
5) Restrict entire site using existing fence
6) Perform maintenance and surveillance

**Option C**

Associated Properties: Decontamination and Restoration

1) Excavate contaminated soils and materials
2) Store contaminated materials permanently on site (Area A)
3) Backfill and landscape

Site: Decontamination and Restoration of Area B; Permanent On-Site Storage

1) Raze buildings, remove drains and excavate all contaminated soils in Area B
2) Excavate, backfill and seal Area A with liner
3) Store contaminated materials permanently in Area A and cover
4) Backfill and vegetate Area B
5) Restrict Area A with fence
6) Perform maintenance and surveillance

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TABLE 1-1 (Cont)

| | |
|---|---|
| Option D | Associated Properties: Decontamination and Restoration<br><br>1) Excavate contaminated soils and materials<br>2) Store contaminated materials temporarily on site in Area A<br>3) Backfill and landscape<br><br>Site: Phase I - Partial Decontamination; Temporary On-Site Storage<br><br>1) Excavate, backfill and seal surface of Area A with liner<br>2) Remove yard drain<br>3) Plug process building drain<br>4) Store contaminated materials temporarily in Area A<br>5) Restrict entire site using existing fence<br>6) Perform maintenance and surveillance<br><br>Phase II - Decontamination and Restoration of Site; Removal of Contaminated Materials to Remote Disposal<br><br>1) Remove materials temporarily stored on site<br>2) Raze buildings and excavate contaminated soils<br>3) Transport contaminated materials to permanent remote disposal site<br>4) Backfill and vegetate |
| Option E | Associated Properties: Decontamination and Restoration<br><br>1) Excavate contaminated soils and materials<br>2) Store contaminated materials temporarily on site (Area A)<br>3) Backfill and landscape<br><br>Site: Phase I - Decontamination and Restoration of Area B; Temporary On-Site Storage<br><br>1) Raze Buildings, remove drains and contaminated soils in Area B<br>2) Store contaminated materials temporarily in Area A and cover<br>3) Backfill and vegetate Area B<br>4) Restrict Area A with fence<br>5) Perform maintenance and surveillance |

TABLE 1-1 (Cont)

| | |
|---|---|
| | Phase II - Decontamination and Restoration of Area A; Removal of Contaminated Materials to Remote Storage<br>1) Remove materials temporarily stored on site<br>2) Excavate contaminated soils and materials in Area A<br>3) Backfill and vegetate Area A<br>4) Transport contaminated materials to permanent remote disposal site |
| Option F | Associated Properties: Decontamination and Restoration<br>1) Excavate contaminated soils and materials<br>2) Transport to permanent remote disposal site<br>3) Backfill and landscape<br><br>Site: Decontamination and Restoration; Direct Removal to Remote Disposal<br>1) Raze buildings, remove drains, and excavate contaminated soils<br>2) Transport to permanent remote disposal site<br>3) Backfill and vegetate |

## CHAPTER 1 REFERENCES


1. H. W. Dickson, R. W. Leggett, F. F. Haywood, W. A. Goldsmith, W. D. Cottrell, and W. F. Fox; "Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey"; DOE/EV-0005/1; ORNL; Oak Ridge, Tennessee; Nov 1977.

2. "Radiological Survey of Properties in the Middlesex, New Jersey Area"; DOE report (to be published).

3. "Radon and Radon Daughter Measurements at and near the Former Middlesex Sampling Plant, Middlesex, New Jersey"; DOE report (to be published).

4. "Engineering Evaluation of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey"; FBDU 230-001; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah 84108; July 1979.

5. "Engineering Evaluation of the Middlesex Municipal Landfill Site, Middlesex, New Jersey"; FBDU 230-004; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah 84108; July 1979.

6. "Environmental Analysis of the Middlesex Municipal Landfill Site, Middlesex, New Jersey"; FBDU 230-008; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah 84108; July 1979.

7. R. F. Overmyer, V. C. Rogers, and C. M. Jensen; "Reduction of Radon Flux from Uranium Tailings"; Ford, Bacon & Davis Utah Inc., Salt Lake City, Utah; paper presented at the American Mining Congress; Las Vegas, Nevada; Oct 9-12, 1978.

# CHAPTER 2

# DESCRIPTION OF EXISTING ENVIRONMENT

# CHAPTER 2

# DESCRIPTION OF EXISTING ENVIRONMENT

The purpose of this chapter is to describe the present conditions and environment of the Middlesex Sampling Plant site and the associated properties. The environmental impacts from the radioactive contamination and the impacts associated with the proposed options for remedial action are based on the description of the site and associated properties. The present physical environment is examined in terms of topograpny, geology, hydrology, meteorology, and ecology. Socioeconomic factors, future growth, and economic potentials also are discussed.

A discussion of the present radiation environment of the site and associated properties is also presented and compared with natural background radiation levels and proposed radiation guidelines. This information provides the basis for determining health impacts (Chapter 3) as a result of the proposed options for remedial action.

## 2.1 DESCRIPTION OF SAMPLING PLANT AND ASSOCIATED PROPERTIES (1-3)

### 2.1.1 Sampling Plant Site

The Sampling Plant site has seven buildings in an area of about 9.6 acres. Figure 2-1 is a map of the site showing buildings, paved areas, fencing, and off-site drainage. Presently, a major portion of the site is covered with an asphalt surface. The site is surrounded by a 6-ft-high chain-link fence. The drainage ditch from the site (Figure 2-2) empties into Main Stream and Ambrose Brook, which discharges some 2 mi downstream into the Raritan River.

### 2.1.2 Associated Properties

#### Adjacent and Nearby Properties

The drainage area south of the site is open and serves as a drainage basin for the vicinity. This area contains brush, small trees, grasses, and small animal life. A drainage ditch flows from the south end of the site to Main Stream. The ditch is about 600 ft long. Main Stream (Figures 1-2 and 2-2) flows southwesterly from the site through a heavily wooded area for approximately 2,800 ft where it joins Ambrose Brook.

The properties included here are adjacent to the site or contiguous with adjacent properties surrounding the site. Locations are shown in Figure 1-2.

Rectory of the Church of Our Lady of Mount Virgin

The Rectory is located approximately 0.3 mi to the west of the Sampling Plant site, as shown in Figure 1-1. It is a three-story structure, with a basement below ground surface. The grounds are landscaped with trees, flowers, lawns, and shrubbery. The Rectory property also has concrete walkways, a garage, and asphalt pavement.

432 William Street

The William Street property is located about 0.8 mi east of the Sampling Plant site, as shown in Figure 1-1. It is a private residence consisting of a one-story dwelling with a partial basement and has a detached garage. The driveway is asphalt and there are two small concrete slabs on this property, one at the front and one to the rear of the residence. The southwesterly part of the yard is fenced with a 4-ft-high chainlink fence. Inside the fence is a cinder-block barbecue structure. The front and back yards are predominantly lawns with an assortment of trees and shrubs.

## 2.2 PHYSICAL ENVIRONMENT

### 2.2.1 Topography

The topographic character of the Sampling Plant site, as well as of the surrounding areas and other associated properties, is generally flat with an elevation of approximately 55 ft above sea level. Elevations of the Sampling Plant vicinity are indicated in Figure 2-2.

### 2.2.2 Geology

The unconsolidated materials in the vicinity of the site reflect its relatively recent geologic history of glaciation and post-glacial environments. Underlying these deposits are the Triassic shales of the Brunswick Formation.[4,5] These sedimentary strata are the upper unit of the Triassic system, which includes the Brunswick, Lockatong and Stockton Formations, as shown in Figure 2-3.

The dominant soil types are silty to sandy loams with observed thicknesses over bedrock ranging from 1.5 to 8 ft. The common characteristics of the upper soil type include shallow slopes, a seasonably high water table, and a hign frost action potential. Other characteristics vary with the soil types; for example, drainage varies from poor to moderate and the soil permeability is from slow to moderately rapid.[4,6] Figure 2-4 shows the distribution of soil types in the vicinity of the site. Table 2-1 indicates the various characteristics of the soil types. Much of the original soil has been disturbed,

covered, or removed as a result of urban development in the area. Many soils have the ability to adsorb and thus reduce the concentration of various radionuclides as they percolate through the soil on which they are deposited. Because of the mixed character of these soils, this ability cannot readily be determined.

### 2.2.3 Hydrology

Hydrological aspects of the site area are important to provide a foundation to determine possible ground and surface water contamination. This background information helps to determine wnether a water pollution potential exists as an impact for later discussion.

There are abundant surface waters in the area. They include two rivers, several streams, numerous intermittent drainages, lake impoundments, as well as several man-made surface and subsurface systems. The surface waters and their flood plains are shown in Figure 2-5. Surface waters in the vicinity of the site are shown in Figure 2-2. At or near the Sampling Plant site, subsurface systems include: a sewer system which runs along Mountain Avenue and connections to this line; a water main serving the site; and several drains under the site which collect surface runoff that is directed towards a drainage easement ditch south of the site.

The drainage easement ditch carries surface drainage from the Sampling Plant site 600 ft south to Main Stream, as shown in Figure 2-2. Main Stream runs westward to Ambrose Brook, which eventually joins the Raritan River. A storm drainage system collects surface runoff east of the site and routes it through a 30-in.-diameter drain at the end of William Street and into a ditch which empties into the drainage easement ditch south of the site. No representative flow measurements are available.

A mosquito abatement ditch (Figure 2-2) whose source begins west of the drainage ditch and flows westward, joins Main Stream about 1,700 ft west of its origin. Another small ditch originates just to the south of the site and west of the drainage easement ditch; however, it would carry away little water. A "dry" ditch is located along the northern margin of the site paralleling the railroad tracks. There also is evidence of water flowing onto and off the site during and after intense rainstorms.

While the quality of the surface waters in Middlesex County varies, in general the major streams are not suitable as potable water.(7) The Raritan River is considered unsuitable for drinking water below the confluence of the Raritan and Millstone Rivers, because of heavy concentrations of municipal and industrial wastes discharged into the river from various point sources. The Millstone River is located about 2.5 mi upstream

from where Green Brook enters the Raritan River. Below the Fieldville Dam in Piscataway, the presence of salt in the river further compounds the water quality problem. Ambrose Brook and Bound Brook are not used as sources of potable water.

The Middlesex Water Company has diversion rights on the Raritan River, downstream from the site. Although the company is not presently using these rights and prefers to obtain water from the Delaware and Raritan Canal, the future prospect of such use does exist.

Ground water in Middlesex County occurs in unconsolidated deposits and in bedrock aquifers.(8) The major ground water reservoirs in the vicinity of the site consist of the Triassic sandstones and shales of the Brunswick Formation. Geologic mapping also indicates the presence of the Farrington and Old Bridge sands (Cretaceous age) as important aquifers(8) in the county, but these are not present in the site area.

The Brunswick Formation is largely a fracture aquifer.(8) Generally, it is unconfined in exposed outcroppings. Where this formation is overlain by other sediments, by zones of low permeability, or by unfractured Brunswick shales it becomes confined. The open nature of the fracture aquifer means that there is little natural filtration and purification once water reaches this formation.

There are a number of private water supply wells within 1 mi of the site that are registered with the New Jersey State Department of Conservation and Economic Development, as shown in Figure 2-5.(9) A few unrecorded wells which the New Jersey State Department of Environmental Protection has monitored also are shown in Figure 2-5.(10) The list of wells is incomplete, as some wells may not be registered with this agency. The Elizabethtown Water Company's Sebrings Mill Well Field, a little over 1 mi to the northwest, is shown in Figure 2-5.(11) This well field supplies as much as 1,296,000 gal/day.

Excellent aquifers exist elsewhere in Pleistocene aged stratified drift. At the site, however, this aquifer is only a thin, unconfined surface zone. The shallow unconfined ground water flows southwest to Main Stream. Although there is a possibility of contaminating ground water aquifers, sample analyses of well water do not indicate contamination from the site reaches deep aquifers, and the shallow aquifers are not tapped near the site.

### 2.2.4 Meteorology

Meteorological data are required for determination of the impact of existing conditions, and whether short-term degradation to the air quality of the immediate site vicinity (0.5 mi) or to population centers to the north and northeast may

result from remedial action work.

The Sampling Plant site is approximately 2.5 mi from a National Weather Service precipitation and temperature station at Plainfield, New Jersey, and 40 mi from a full weather service station at the Newark Airport. The following data are based on weather data[12,13] collected during the period 1941 to 1976.

Winds are predominantly from the southwest at a mean speed of 10.2 mi/hr. During January, the average wind velocity is from the northeast at 11.1 mi/hr. During February and March, winds are from the northwest at average velocities of 11.6 and 12.0 mi/hr, respectively. April is the transition month when the winds come from the west-northwest at an average velocity of 11.3 mi/hr. During the remainder of the months, the winds are primarily from the southwest. (See Figure 2-6 for the wind rose.)

Average annual snowfall is 27.5 in., with as few as 1.9 in. recorded during the winter of 1972-1973, and a maximum recording of 73.5 in. during the winter period of 1960-1961. Average annual precipitation is 41.64 in., with a low of 26.09 in. during 1965 and a high of 53.30 in. during 1952. Total moisture is spread evenly throughout the year.

### 2.2.5 Ecology

In 1973, a publication prepared by David Fairbrothers and Mary Hough[14] indentified rare and endangered plant species in New Jersey. The authors identified 19 species in their presentation as existing in Middlesex County. Eight of these species are considered to be endangered, eight are rare, and the remaining three are of an undetermined status. Listed in the publication as endangered species are the following plants:

| Scientific Name | Common Name |
|---|---|
| Habenaria ciliaris | Yellow fringed orchid (orange plume) |
| Habenaria cristata | Crested yellow orchid |
| Lathyrus venosus | Vetchling or wild pea |
| Artemisia caudata | Wild wormwood |
| Triglochin maritima | Seaside arrow grass |
| Ranunculus flabellaris | Yellow water-buttercup |
| Eleocharis diandra | Spike rush |
| Limosella subulata | Mudwort |

Rare species include the following plants:

| Scientific Name | Common Name |
|---|---|
| Carez limosa | Mud sedge |
| Pyrus angustifolfa | Wild crab apple |
| Populus heterophylla | Swamp or black cottonwood |
| Viola brittoniana | Britton's violet |
| Utricularia purpurea | Purple bladderwort |
| Phoradendron flavescens | American mistletoe |
| Polygala paucifolia | Flowering wintergreen or fringed polygala |
| Polygala mariana | Milkwort |

The three plant species whose status is "undetermined;" i.e., current status is either rare or endangered but information currently available is inadequate to ascertain precise status accurately, are as follows:

| Scientific Name | Common Name |
|---|---|
| Liparis lilifolia | Lily-leaved or large twayblade |
| Habenaria peramoena | Purple fringless orchid |
| Micranthemum micranthemoides (Nutt.) (Hemianthus micranthemoides) | Nuttall's micranthemum |

A similar breakdown and description of rare and endangered species of animal life in this locale are not available. Although the State of New Jersey's Department of Environmental Protection Division of Fish, Game and Shellfisheries official list of "Endangered, Threatened, Peripheral and Undetermined Wildlife Species in New Jersey"(15) is quite extensive, none of these species has been identified to exist principally in or to be indigenous to the areas of the site.

Since the Sampling Plant site and associated properties consist of about 20 acres, a relatively small area is involved in the program. Further, none of the above species of flora has been identified within the vicinity of the site.

Effects on native and established flora and fauna are presented in Chapter 3 under the impacts associated with the proposed options.

## 2.3 SOCIOECONOMIC FACTORS OF THE SITE AND VICINITY

The proximity of the Sampling Plant site and the associated properties is such that individual treatment of this topic at each location is not justified. Instead, this section discusses the socioeconomic environment as applicable to the Middlesex area in general.

### 2.3.1 Present Population

For the purpose of health effects calculations, the

residential population in 16 sectors at distances of 0.50, 0.75, and 1 mi from the site was estimated from a count of residences within each sector.[16,17] The population estimates are shown in Figure 2-7. The residential population within 1 mi of the site boundary is estimated to be 9,700 people living in approximately 2,750 dwellings.

### 2.3.2 Epidemiologic Studies

Epidemiology entails the study of the determinants of disease and illness in mankind, and the application of measures towards their prevention. In this case, such a study may include the subclinical effects in people due to long-term radiation exposure.

In the past, no epidemiologic information or surveys were conducted in the area of the site partly because the need for such data was not recognized at the time, and the work at the Sampling Plant site was done on a wartime emergency basis. There are no data available to indicate any effects on the health or physical wellbeing of individuals in the site vicinity. Calculated health impacts in Chapter 3 are compared with available cancer statistics for New Jersey.[18]

### 2.3.3 Land Use and Population Growth Potential

As shown in Figure 2-8, the area near the Middlesex Sampling Plant site is a mixture of industrial, commercial, and residential land. The land south of the site, in Piscataway, has shown a trend of slower development than other areas in the vicinity because of less convenient highway and railroad access. However, since the completion of Interstate 287, the area has become increasingly more attractive for development. Future activity probably will include the development of residential areas south and southeast of the site, and the development of industrially zoned land from about 0.5 to 1 mi to the south and southwest.[16,17]

Land use in Middlesex is not expected to change greatly from current plans and usage. The Middlesex 1976 Master Plan[16] calls for creating a homogeneous industrial zone along South Avenue and Lincoln Boulevard, replacing nursery and greenhouse properties with resedential areas, and developing vacant lands outside the flood-control areas shown in Figure 2-5.

Little unimproved or vacant land is available for residential development in Middlesex. However, residential population in Middlesex conceivably could increase by as much as 1,600 people if vacant lands are developed as planned.

There are several hundred acres of vacant land to the south of the site, in Piscataway. The Township of Piscataway

recently has passed a new master plan calling for the development of several residential areas on sections of this vacant land.[17,19] If the plan is followed, population in Piscataway within 1 mi of the site could increase by as much as 12,000 people. This area is likely to develop as a result of the availability of railroad and freeway systems and because of its proximity to New York City. In addition, growth is projected to occur rapidly in the next 10 to 15 yr, followed by a period of slower development. Population in this area probably would not decrease; therefore, the present population is assumed to be a lower limit. For an upper limit, the population is projected to grow by approximately 14,500 residents over the next 25 yr. These residential population projections are shown in Figure 2-9.

The projected population figures are used to estimate population dose rates in Appendix C.

### 2.3.4 Economic Potential

Future employment is more difficult to project than population because a single large manufacturing or industrial complex could increase employment in the immediate area by as much as 15%. There are approximately 250 acres of vacant industrial property in the area, as well as considerable underutilized space for other enterprises affecting the economy. If present trends for low-density employment, such as specialized industrial and warehousing development, remain unchanged in Middlesex and Piscataway, the number of employees is not likely to increase by more than 1,900. If space were utilized more efficiently and if several high-density industries were moved into the area, the number of employees might increase by as much as 4,000. Conversely, if a severe depression affected several industries in the area, a decrease in the employment force of up to 10% could last for several years. These high and low estimates are included in the employment estimates shown in Figure 2-9.

Employment figures for the area were based on a fraction of the total employment for Middlesex and on various industrial guides and maps of Piscataway.[20,21] There were approximately 4,450 people employed at firms located within a 1-mi distance from the site with 3,200 of these assumed to be located in Middlesex and 1,250 in Piscataway. Most of the employees in Piscataway are located in an industrial area between 0.75 and 1 mi south of the site.

The approximate 9.6-acre Sampling Plant site is zoned for industrial use, with land surrounding it zoned for single-family residences, and for commercial or public use.[16,17] Immediately to the south in Piscataway, the area is mostly vacant land but is presently zoned residential. Approximately 15% to 20% of the land within 1 mi of the site is vacant property. Railroad spur lines are accessible to most of the

industrially zoned areas and to the Sampling Plant site. The availability of rail service, the proximity of the freeway system, residential areas for workers, and the closeness to New York City make the site economically desirable land.

Plans to extend William Street across the southern portion of the site have been under consideration for many years.(19) Such action would allow development of a large area in the Township of Piscataway.

The Sampling Plant and some properties adjacent to or near the site were assessed (1977 figures) as follows:

| Acreage | Assessment ($) | Assessment ($/acre) |
|---|---|---|
| 9.6 | 288,300 | 30,000 |
| 1.2 | 26,600 | 22,000 |
| 19.9 | 346,200 | 17,400 |
| 6 | 104,500 | 17,400 |
| 1.5 | 20,000 | 17,400 |

Borough officials at Middlesex indicate that the 1977 assessed valuation is 85.17% of the market value, which is based upon recent property sales. Using this criterion, the market value of the 9.6-acre site in the tabulation above would therefore be $35,244/acre. Local realtors and borough officials state that the current market value of the Sampling Plant site after decontamination would be between $35,000 and $40,000/acre, in 1978 dollars.

## 2.4 RADIATION ENVIRONMENT OF THE SITE

### 2.4.1 Radiation Hazards to Man and Exposure Mechanisms

#### Natural Radioactive Elements

There are naturally occurring radionuclides present in minute quantities throughout our environment. Radiation from these sources and cosmic radiation constitute natural "background radiation." Background exposure from natural background radiation can be altered by man's actions at a given location; for example, by laying topsoil of different radionuclide content, building a house of cool wood or hot brick, etc.

The principal isotope of uranium is uranium-238 ($^{238}U$), which undergoes radioactive decay to a new element at a characteristic rate called the half-life. The daughter product of this decay is itself radioactive, giving rise to a series or chain of subsequent radioactive decays. The uranium chain includes $^{230}Th$ (thorium), $^{226}Ra$ (radium), $^{222}Rn$ (radon), and radon daughter products. This chain finally ends at a stable, nonradioactive isotope of lead. While most members of the

chain, such as uranium, radium, and lead, are chemically reactive solids, radon is a chemically inert gas. Radon therefore tends to emanate from the earth in areas where uranium and radium are present. Although these radionuclides occur in nature, their concentrations in uranium ore are several orders-of-magnitude greater than in average natural soils and rocks. These radionuclides are the principal products of concern in this report, and they represent the contaminants considered for remedial actions at the Sampling Plant and the associated properties.

The types of radiation that result from decay within the uranium-238 chain are called alpha ($\alpha$), beta ($\beta$), and gamma ($\gamma$) radiations. The biological effects of radiation are related to the amount of energy deposited within the body, either on the body surface or internally, by alpha particles, beta particles, and gamma rays. The types of radiation emitted by some of the members of this chain are included in Figure 2-10, although not all members of this decay chain are shown in this figure.

Radon tends to concentrate in buildings which do not have adequate ventilation. In locations where uranium and radium are concentrated in soil, such as natural uranium ore bodies or at mill tailings piles, air concentration of radon and radon daughters can occur well in excess of proposed DOE guidelines. This mechanism also produces radon concentration levels in areas of trace quantities of uranium in soil, but concentrations of concern do not generally occur.

Pathways of Radiation to Man

Some of the mechanisms by which radioactivity from uranium reaches man are illustrated in Figure 2-10. There are two primary means by which people are exposed to the radiation: by taking radioactive materials into the body, and by being exposed to highly penetrating gamma rays. The first of these is divided into ingestion (which means eating contaminated foods or drinking contaminated liquids) and inhalation (which here refers to the breathing-in of radioactive material).

Radioactive materials may be trapped in the lungs by inhalation of radon daughters produced by decay of radon in the air. A very small fraction of inhaled radon decays in the lungs and is retained as radon daughters.

Inhalation of radioactive particulates may occur if radioactive dust is picked up by mechanical activities or by wind from areas that do not have a ground cover. Dust, which can increase radiation exposure, may be expected from any excavation activities, but dust control procedures would be employed during any remedial action work at these properties.

Ingestion of radioactive material may occur in several ways. The two principal ways are: by drinking water which

contains leached radionuclides such as radium, and by eating food which has been grown in contaminated earth or has radioactive dust on its surface. Food plants may take up radioactive material while growing in contaminated soil. Cattle that feed on contaminated forage will have elevated levels of radionuclides in the meat.

Gamma rays, known to be highly penetrating, are similar in effect to X-rays and may cause damage to any part of the body. Gamma radiation from uranium ores and residues arises mainly from decay of $^{214}Bi$.

Radiological measurements provide an indication of the amount of radiation that is being transmitted via food, air and water pathways. Such measurements should be performed using control or background samples to determine background radiation levels, and samples should be taken near the site to determine if radionuclide concentrations above background levels are present.

Calculation of Health Effects

For this report, health effects are defined to be incidents of excess cancer cases (morbidity).(22) The radiation exposure from materials containing uranium and its decay daughters occurs from the absorption within the body of emitted alpha and beta particles and gamma radiation. The biological effects of radiation are related to the type and energy of the radiation. The dose from radiation is therefore measured in terms of the energy deposited per unit mass of material. One rad is the dose that corresponds to the absorption of 100 ergs/g of material. The relative amount of damage caused by a given amount of energy from the different types of radiation is called the "quality factor." The equivalent dose, in units of the rem, is the product of the energy deposition in rads and the quality factor. In this analysis, it is assumed that a gamma exposure of 1 R in air is equivalent to a dose of 1 rem in soft tissue.

Radiation exposure from $^{222}Rn$ daughters is expressed in terms of working level month (WLM), which is equivalent to exposure to a radon daughter concentration of 1 WL for 170 hr. The definition of a WL is given in Appendix A. Total population exposures and health risks from $^{222}Rn$ daughter inhalation are based upon these units instead of the rem.

The methodology used in estimating the dose rates and health effects associated with the radioactive contamination at the affected sites is given in Appendices B and C. The following risk estimators are used to obtain the number of potential health effects:(23)

$^{222}Rn$ daughters - 180 health effects per $10^6$ person WLM total cumulative exposure

external gamma - 100 health effects per year for $10^6$ person-rem continuous exposure to gamma radiation

The above are absolute risk estimators rather than relative risk, and are based on exposure to the particular radiation source for a lifetime.

It should be emphasized that a projected cancer rate does not mean that a cancer case will occur in a given number of years, or that any one case can be specifically attributed to radon daughter inhalation. All that can be stated is that an individual's risk is increased by his exposure to radon daughters (or other ionizing radiations such as diagnostic X-rays) and that the total cancer rate to a given population may be expected to increase with such exposure.

### 2.4.2 Proposed Radiation Exposure Guidelines

The use of radioactive materials and radiation for scientific, industrial, and medical purposes causes exposure to workers in industry and to the general public. Guidelines have been developed to place an upper limit on such exposures to assure public safety. The limits established for exposures to the general public are much lower than those established for workers in the nuclear industry.(24)

The DOE Division of Operational and Environmental Safety has drafted the following proposed remedial action guidelines.(25) (These guidelines have been used to indicate the radiation level at which remedial actions are indicated until such time as applicable federal guidelines are developed by the EPA.):

| Type of Measurement | Remedial Action Indicated If Radiation Level Exceeds |
|---|---|
| Radium in soils | 0.02 WL above natural background (5 pCi/g above natural background) |
| Radon daughter concentration | 0.02 WL above natural background |
| External gamma exposure rate | 170 mR/yr above natural background (20 μR/hr) for continuous exposure, 80 μR/hr for occupational exposure (2,000 hr/yr) |
| Transferable alpha | 20 dpm/100 $cm^2$ |

The remedial action guideline value for radium in soil is based on a limit of 0.02 WL above natural background for radon daughter concentration in a structure on the contaminated

area. This WL limit has been related to a radium concentration in the soil of 5 pCi/g above natural background to an infinite depth.(25)

Measured average natural background levels in the Middlesex vicinity are given in Paragraph 2.4.3. For simplicity, the conservative infinite depth 5 pCi/g above natural background value is used for $^{226}Ra$ concentration in contaminated soil as the remedial action criterion, even though the extent of the contamination is usually only a few feet deep.

### 2.4.3 Radiation Measurements and Natural Background Radiation Levels

This section compares the natural background radiation levels in the vicinity not affected by past operations at the Sampling Plant to levels measured at the Sampling Plant site and associated properties.

Extensive radiological surveys have been conducted at the Middlesex Sampling Plant site and at the associated properties.(3,26-28) The associated properties contain radioactive contamination from the Sampling Plant site. The radioactive contamination is significantly above natural background at some of these locations. A summary of some of the measurements is given in Table 2-2. The average natural background radiation and radium concentration also are listed in Table 2-2.

The main radiological parameters used in this analysis include: radium concentrations in the soils of the Sampling Plant and associated properties, which range up to a factor of 6,000 times greater than natural background; radon and radon daughter concentrations in the atmosphere around the sites, which range up to a factor of 6 times greater than natural background; external gamma radiation levels in the vicinity of the sites, which range up to a factor of 30 times above natural background; and transferable alpha surface contamination at the Sampling Plant, which is about 20 times the guideline value. Thus, at many areas of the sites being studied, the radiation values exceed DOE's proposed guidelines for this study.

As an example of these measurements, the radon concentrations in the Rectory as measured in June 1978 are summarized in the following tabulation:(3)

| Location | Concentration (pCi/l) | WL(50%) | WL(100%) |
|---|---|---|---|
| Room 9 (basement) | 31.4 | 0.16 | 0.31 |
| Room 2 (basement) | 20.7 | 0.11 | 0.21 |
| Street Level | 0.9 | 0.005 | 0.009 |

The value listed for WL(100%) equates the air concentration of radon to a radon daughter working level assuming complete equilibrium, while the value for WL(50%) equates the concentration to a working level assuming 50% equilibrium. Although individual measurements fluctuate considerably, experience has shown that equilibrium values inside structures usually average less than 50%, so use of the 50%-equilibrium value provides a conservative estimate of the potential hazard.[23] It can be seen that the concentration in the basement of the Rectory is well above the proposed guidelines for either equilibrium assumption, while the concentration at street level inside the Rectory is less than the guideline of 0.02 WL above background. However, care should be taken in attempting to interpret these data, since in many studies concentrations have been observed to fluctuate considerably from day to day, or even within a day. Data were taken during the summer when ventilation is usually better; thus, the annual averages could exceed these values.

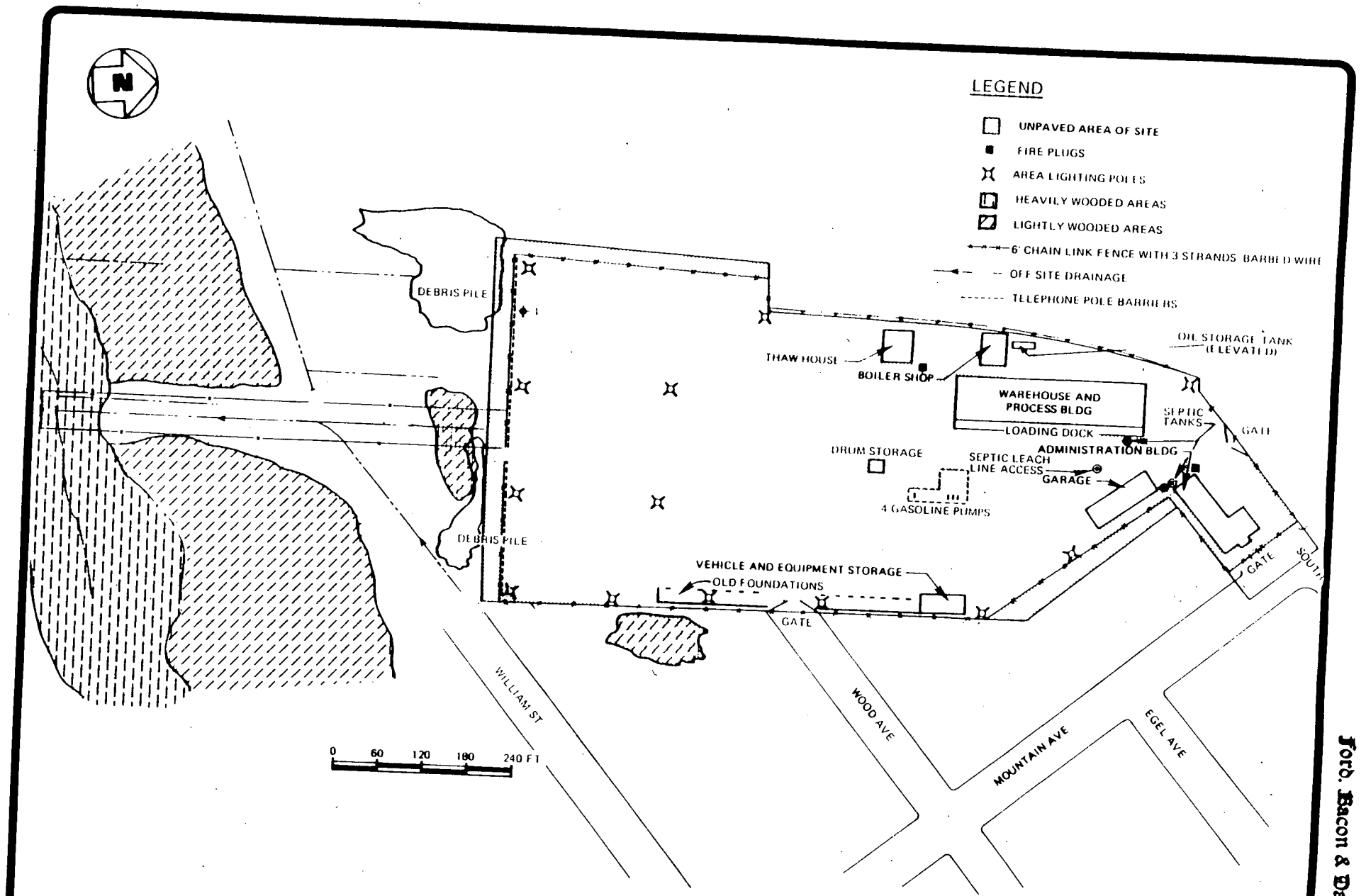


FIGURE 2-1. DESCRIPTIVE MAP

230-005



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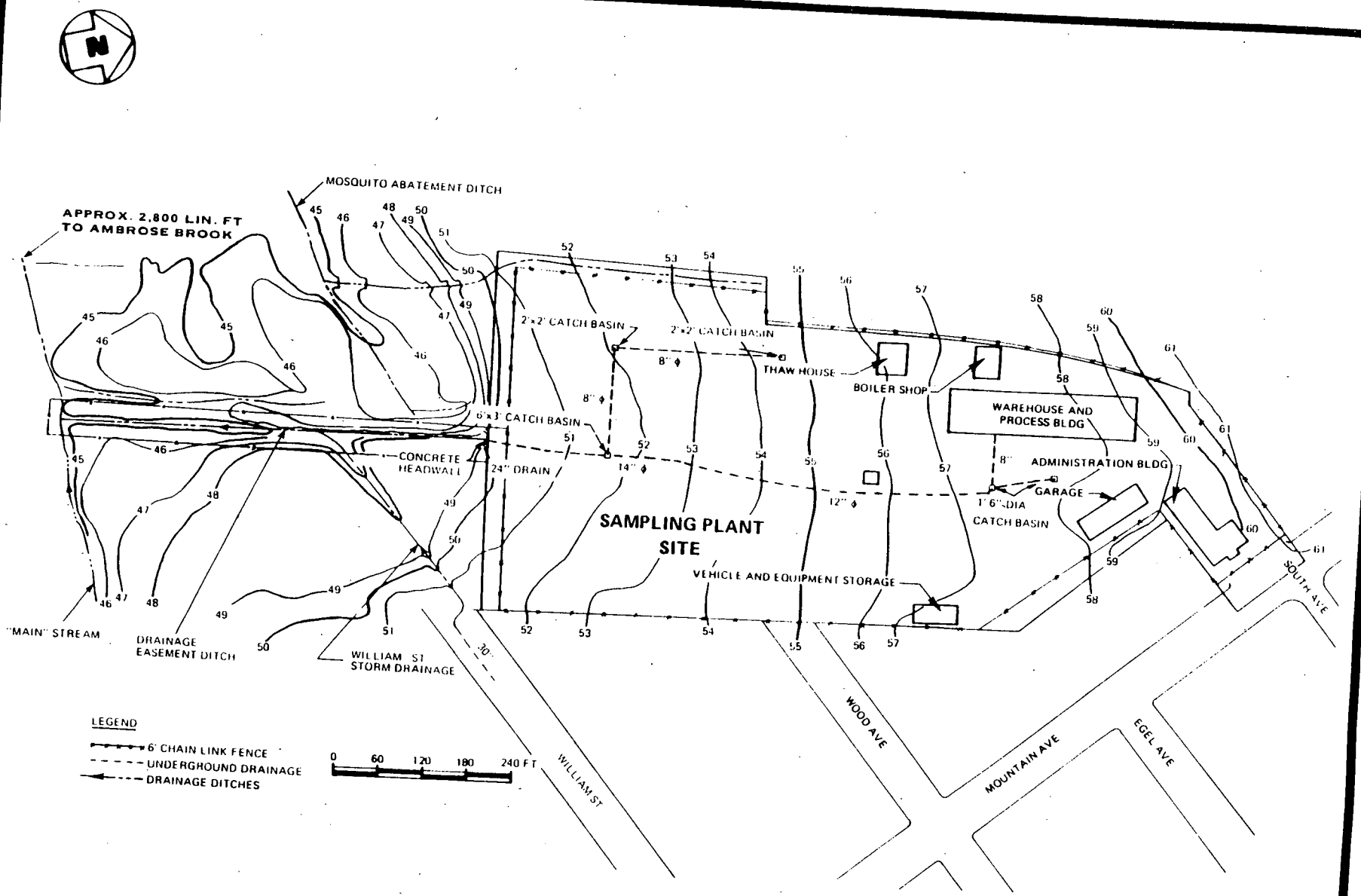


FIGURE 2-2. TOPOGRAPHICAL AND SURFACE DRAINAGE MAP

230-005



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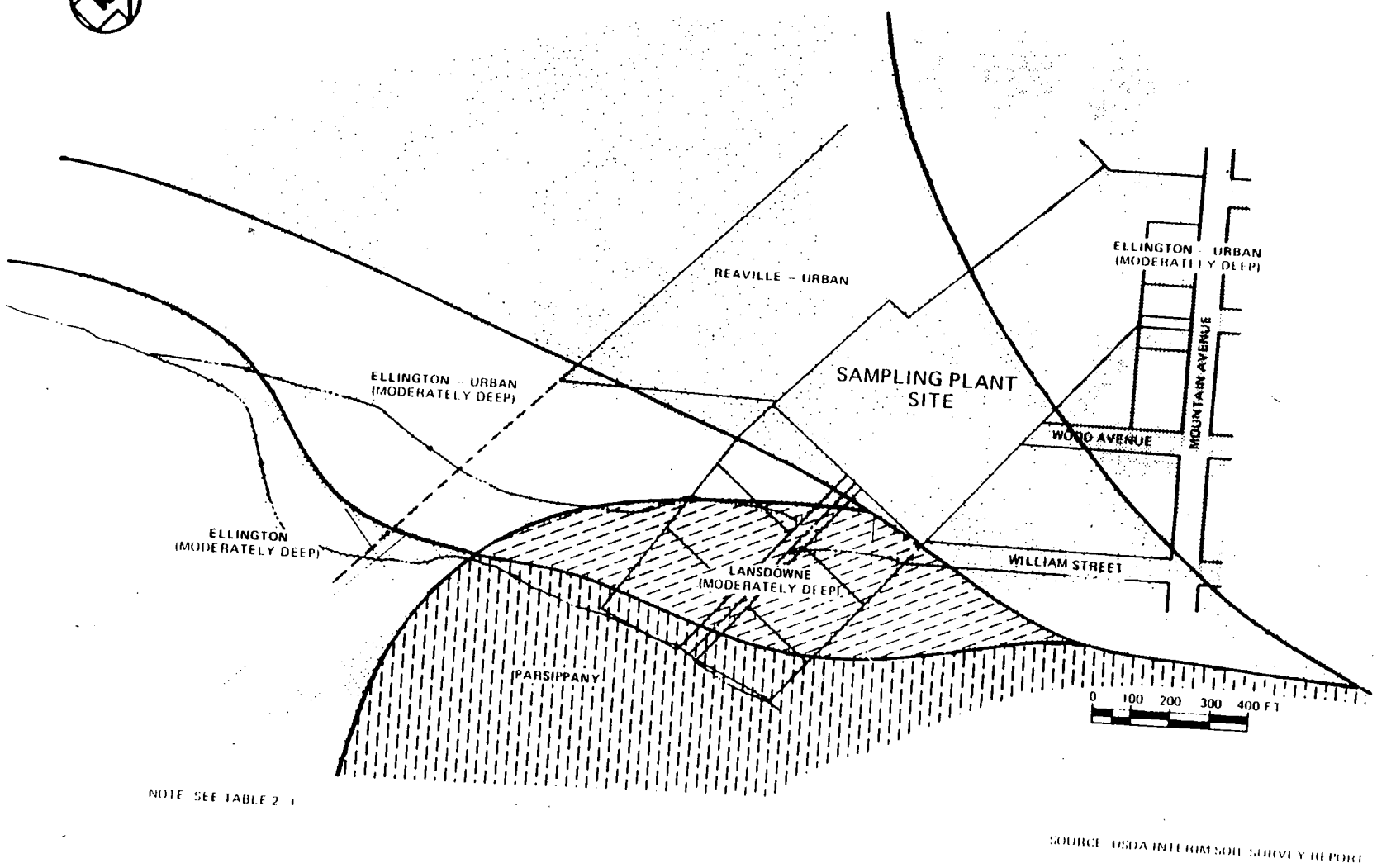
| SYSTEM | FORMATION | THICKNESS (FT) | CHARACTER |
|---|---|---|---|
| QUATERNARY | ALLUVIUM | 0-50 | SILT, SANDS & MUD; NOT IMPORTANT AS AQUIFER |
| | GLACIAL DEPOSITS: LACUSTRINE DEPOSITS | 0-60 | CLAYS, SILTS, AND SOME SANDS; AQUICLUDE |
| | GLACIAL DEPOSITS: STRATIFIED DRIFT | 0-60 | SANDS, GRAVELS, SILTS, AND CLAYS; LOCALLY IMPORTANT AQUIFER |
| | RIVER DRIFT | 0-50 | SANDS, GRAVELS, SILTS, AND CLAYS; LOCALLY IMPORTANT AQUIFER |
| | PENSAUKEN FORMATION | 0-70 | CLAYEY SAND & GRAVEL; AQUIFER; LOCALLY TAPPED BY DOMESTIC WELLS |
| CRETACEOUS | MAGOTHY FORMATION | 25-175 | DARK LIGNITIC SAND AND CLAY CONTAINING SOME GLAUCONITE NEAR THE TOP; NOT IMPORTANT AS AN AQUIFER; LOW YIELDS DOMESTIC PURPOSES |
| | RARITAN FORMATION | 150-300 | SANDS AND CLAYS, CHIEFLY LIGHT COLORED; SAND LENSES ARE MAJOR AQUIFERS |
| TRIASSIC (NEWARK GROUP) | BRUNSWICK FORMATION | 6000-8000 | SOFT RED SHALE WITH SOME SANDSTONE BEDS. THREE EXTENSIVE BASALT FLOWS ARE INTERBEDED; MAJOR AQUIFER |
| | LOCKATONG FORMATION | 3500 | HARD DARK ARGILLITE WITH LOCAL THIN BEDS OF SANDSTONE (FLAGSTONE); LITTLE IMPORTANCE AS AS AQUIFER |
| | STOCKTON FORMATION | 2300-3100 | GRAY FELDSPATHIC SANDSTONE (ARKOSE), CONGLOMERATE, AND RED SHALE; LITTLE IMPORTANCE AS AN AQUIFER |
| OLDER ROCK FORMATIONS | | | |

FIGURE 2-3. SIMPLIFIED STRATIGRAPHIC COLUMN, NORTHERN MIDDLESEX AND NORTHERN SOMERSET COUNTIES, NEW JERSEY (3)

230-005




NOTE SEE TABLE 2-1

SOURCE USDA INTERIM SOIL SURVEY REPORT

FIGURE 2-4. SOIL CLASSIFICATIONS IN AREA OF SITE

230-005

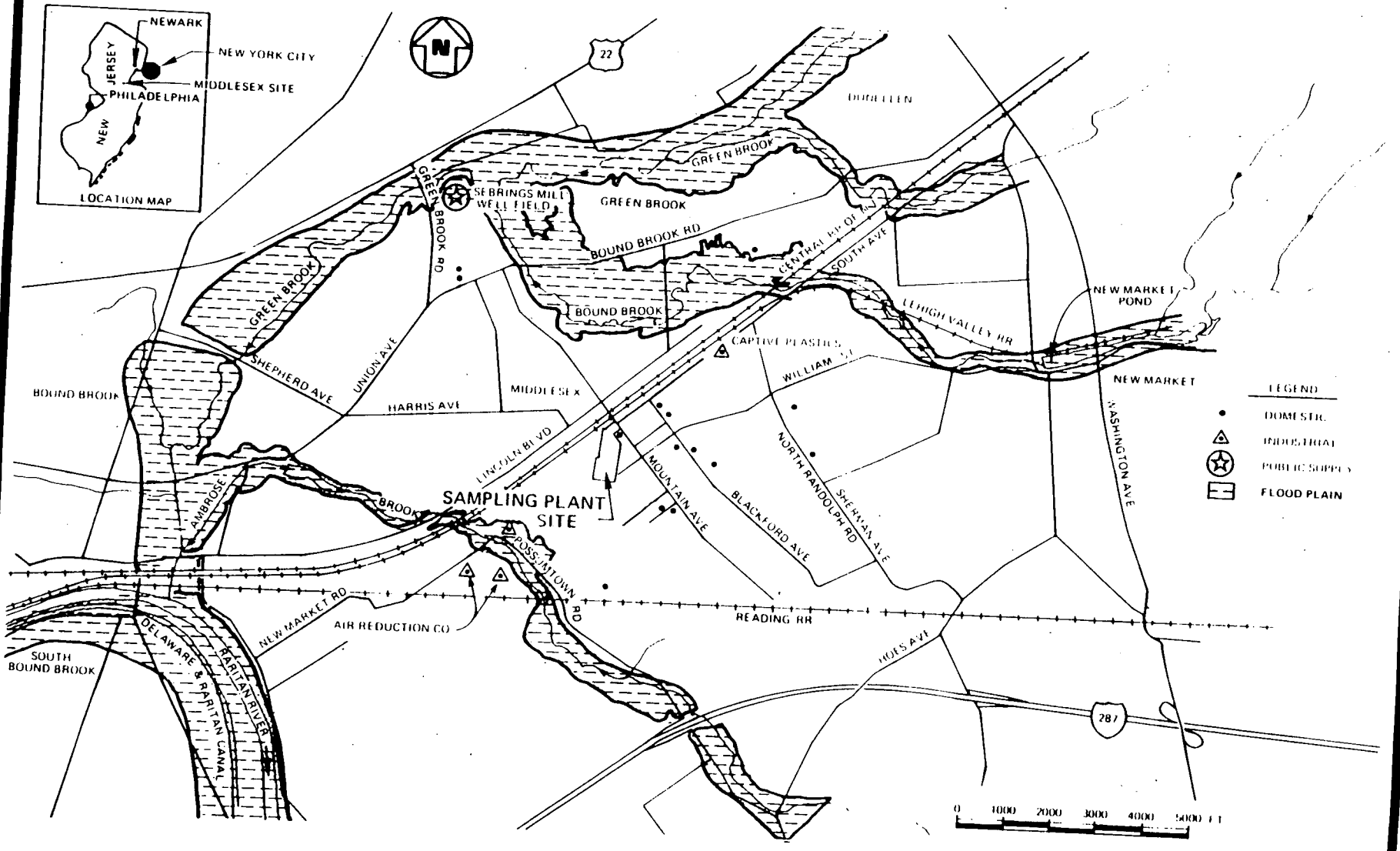



FIGURE 2-5. FLOOD PLAINS AND APPROXIMATE LOCATION OF WELLS IN VICINITY OF SITE

230-005



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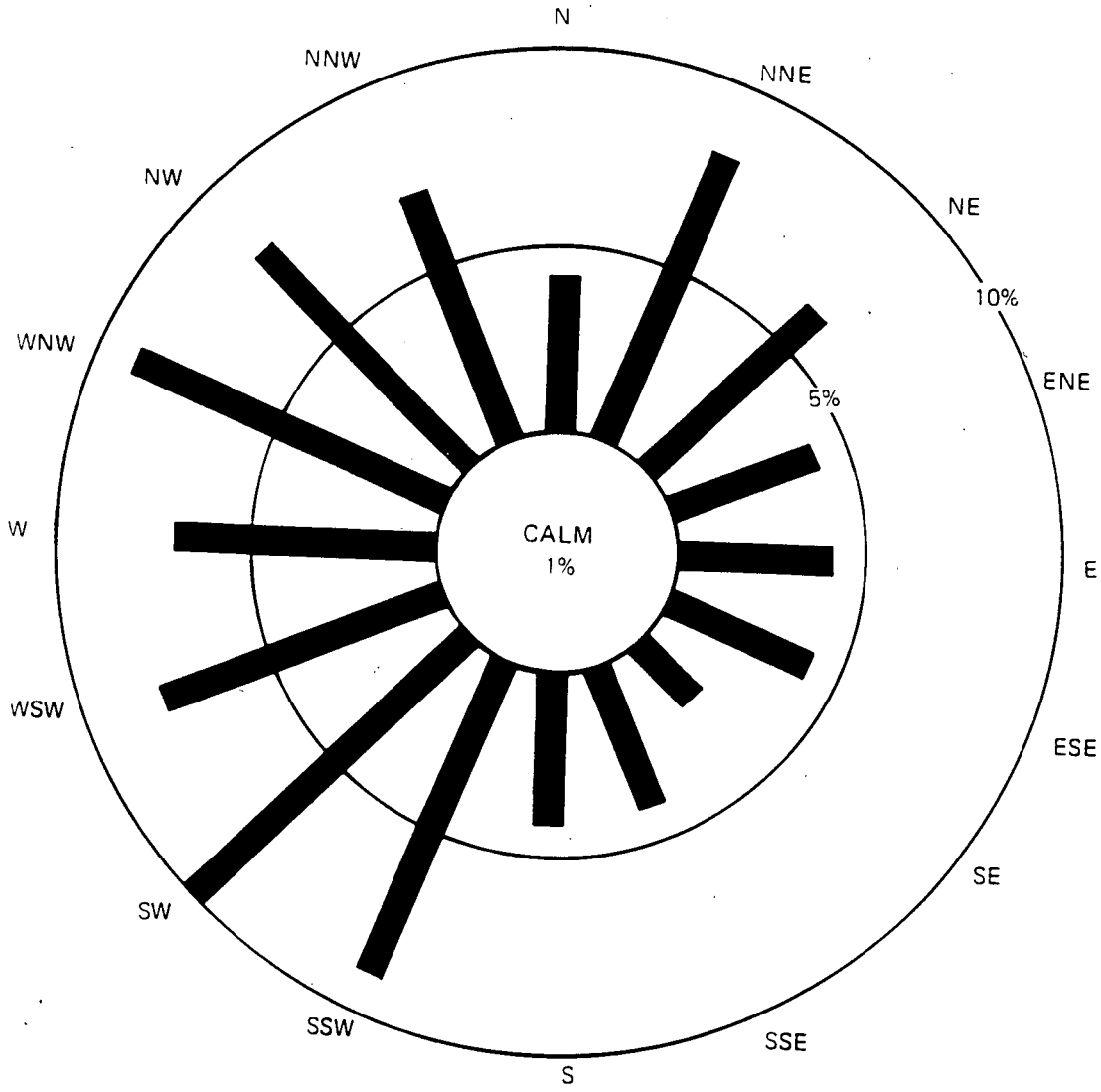
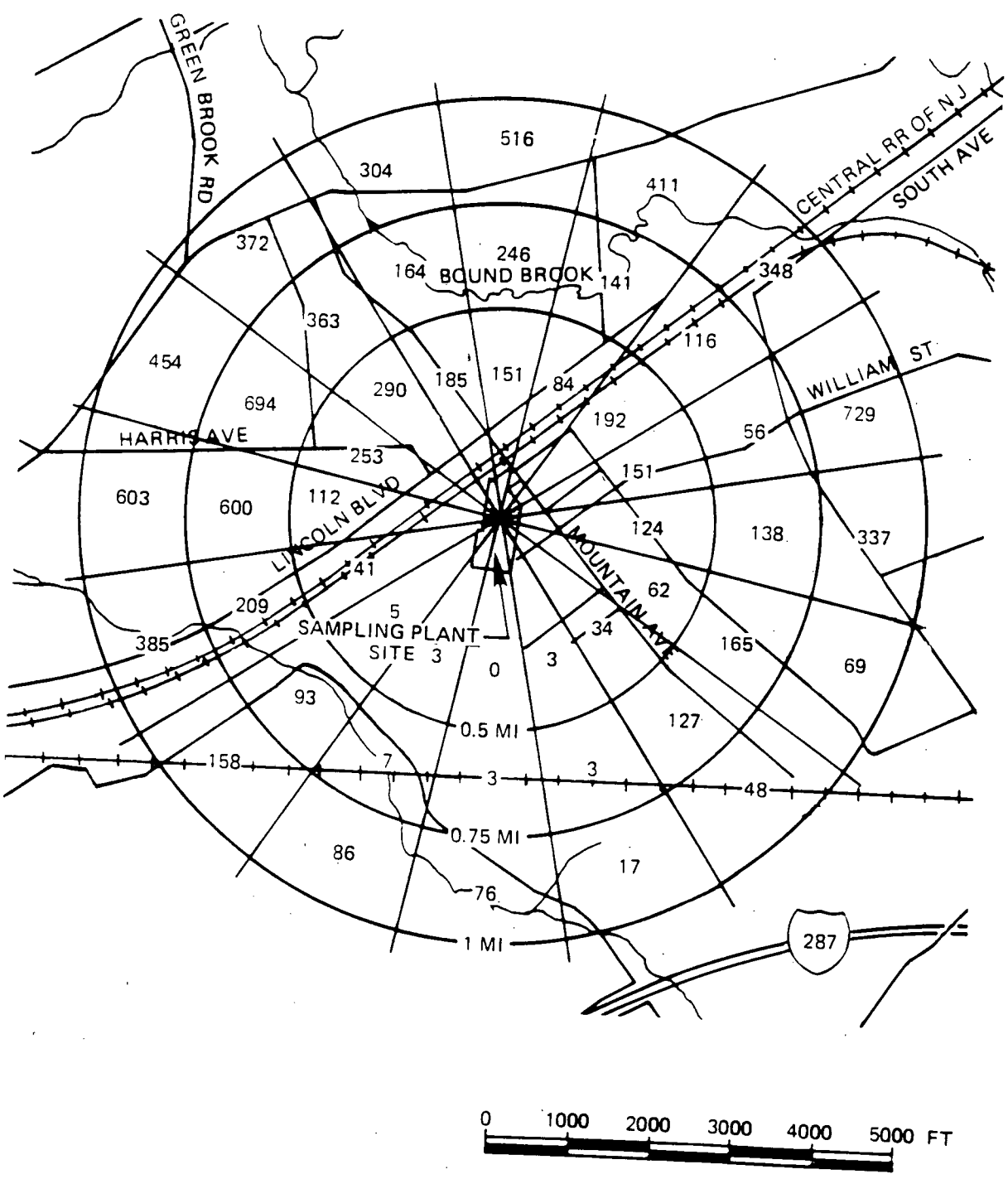



FIGURE 2-6. NEWARK AIRPORT SURFACE WIND ROSE
(CUMULATIVE DATA FROM 1951 THROUGH 1960)

230-005




NOTE: NUMBERS REPRESENT POPULATION ESTIMATES PER SECTOR

FIGURE 2-7. POPULATION DISTRIBUTION AROUND SITE

230-005

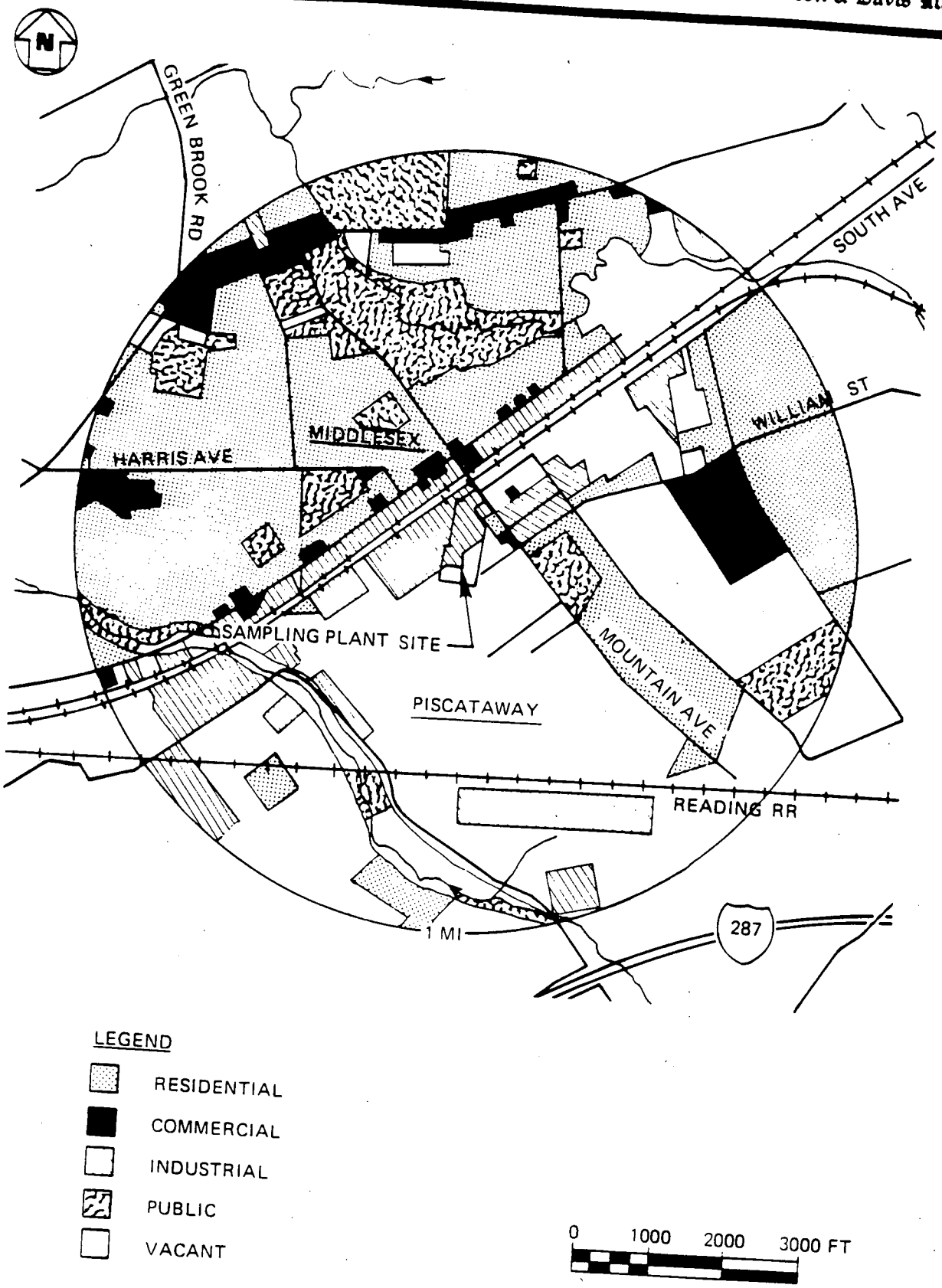
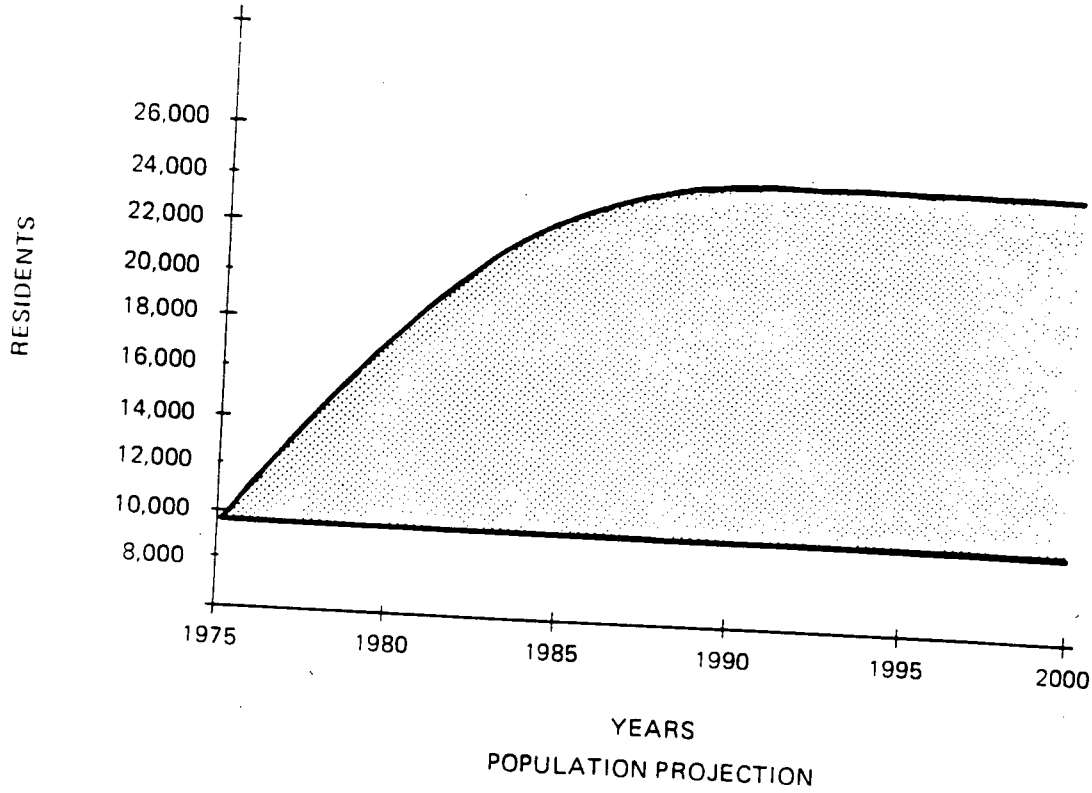
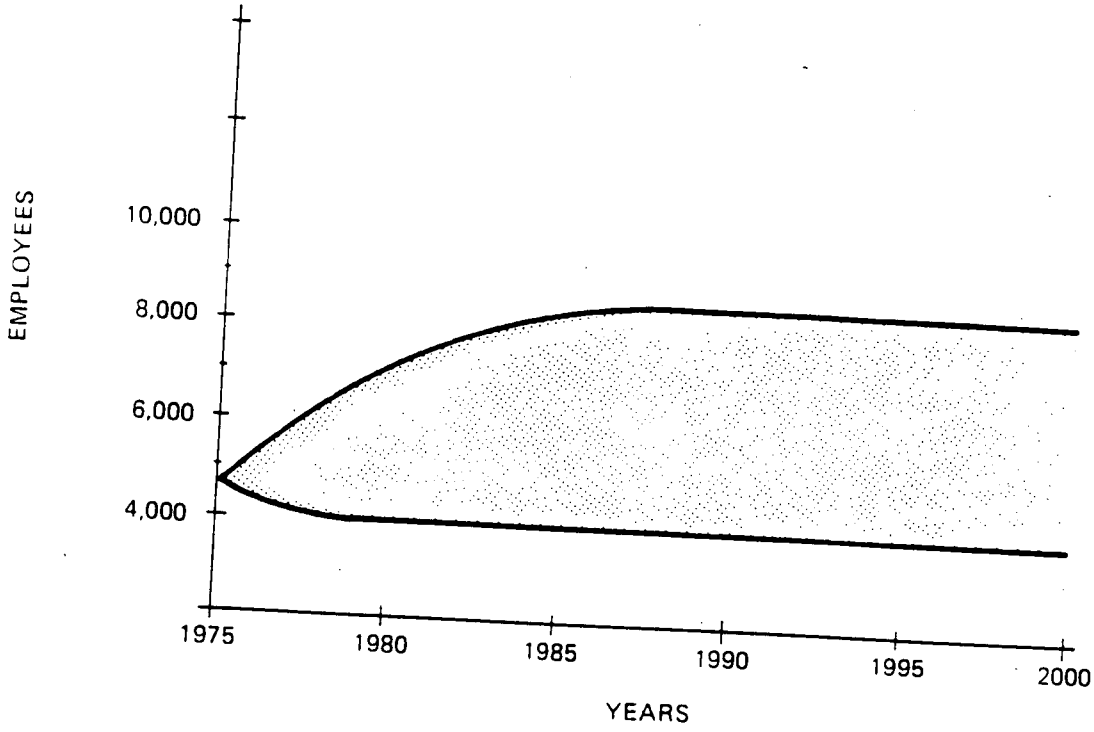



FIGURE 2-8. LAND USE

230-005




POPULATION PROJECTION




EMPLOYMENT OUTLOOK

FIGURE 2-9. POPULATION AND EMPLOYMENT OUTLOOK FOR AREA WITHIN 1 MILE OF SITE

230-005

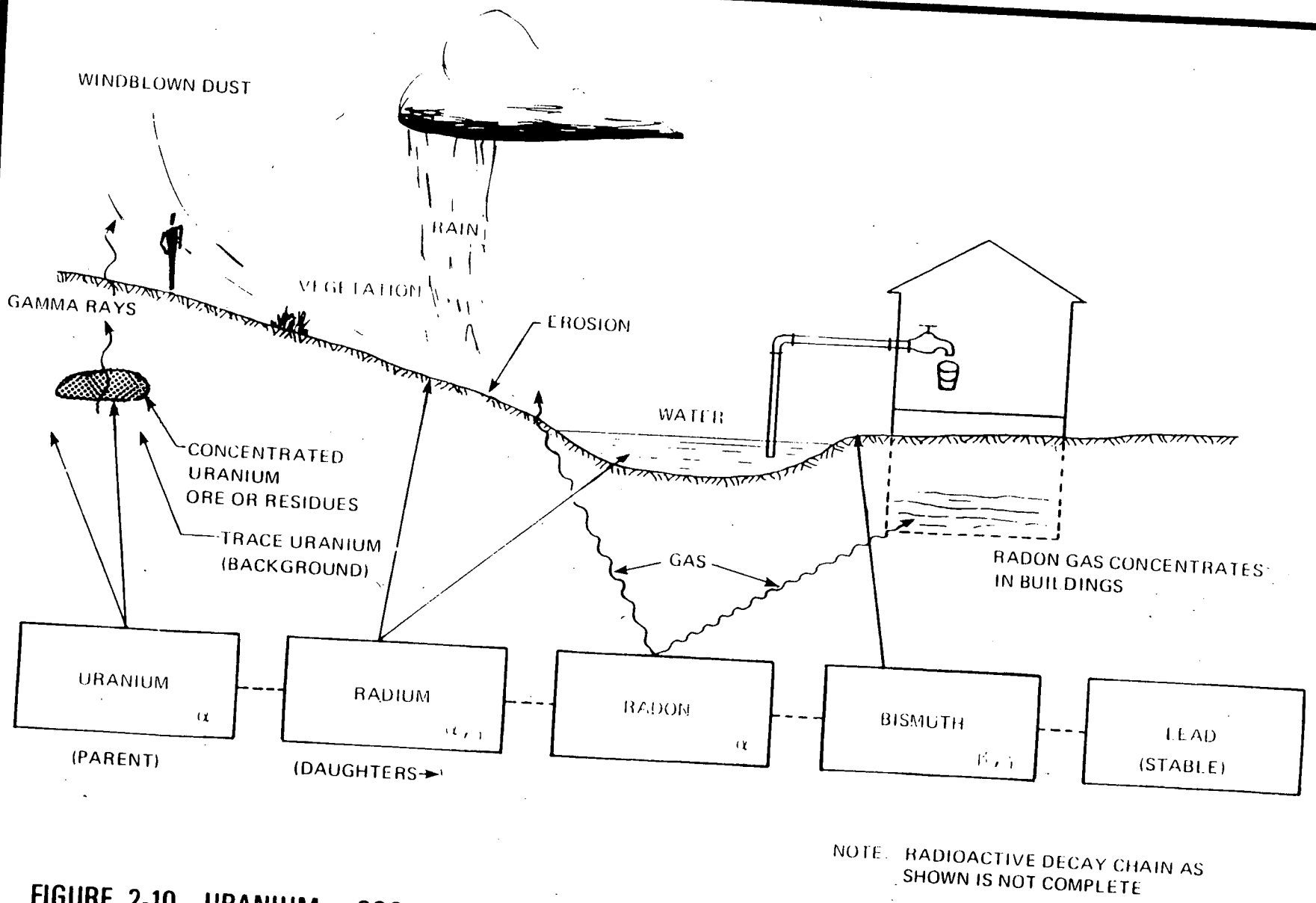



**FIGURE 2-10. URANIUM - 238 RADIOACTIVE DECAY CHAIN (ABBREVIATED) AND MECHANISMS OF TRANSPORTING RADIOACTIVITY FROM URANIUM TO MAN**

230-005



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TABLE 2-1

SOIL PROPERTIES[a,b]

| Soil | Description | Slopes (%) | Depth to Seasonally High Water Table (ft) | Depth to Bedrock (ft) | Drainage | Permeability | Available Water Capacity | Compaction | Stream Overflow Hazard | Frost Action Potential |
|---|---|---|---|---|---|---|---|---|---|---|
| Ellington (moderately deep variant) | Reddish sandy loams of the stream terraces or outwash plains | 0-5 | 1-4 | 2.5-3 | moderately well | moderate to moderately rapid | moderate | fair to good | none to slight | high |
| Reaville | Silt loams derived from weathered shale | 0-5 | 5-3 | 1.5-3.5 | moderately well | moderately slow | moderate to low | fair to poor | none | high |
| Lansdowne (moderately deep variant) | Gray-red fine silty loams | 0-3 | 1-2.5 | 1.5-3.5 | moderately well | slow | moderate | fair to poor | none to slight | high |
| Parsippany | Silty to sandy loams Lacustrine soils | 0-2 | 0-1 | > 5 | poorly | slow | high | poor | none to rare | high |
| Any Urban Areas | Too variable - normal interpretations are not made | | | | | | | | | |

[a]See Figure 2-4
[b]Source U.S.D.A. Interim Soil Survey Report

TABLE 2-2

SUMMARY OF MEASUREMENTS OF RADIOACTIVITY

| Parameter | Sampling Plant Site | Adjacent and Nearby Properties | Rectory and William Street | Remedial Action Guidelines and Natural Background |
|---|---|---|---|---|
| Radium in Soil ($^{226}Ra$ pCi/g soil) | 0.4 - 577 | 0.5 - 2401 | 1 - 9800 | 5 + 1.7 |
| Radon Daughters (WL) | 0.003 - 0.15 | 0.002 - 0.040 | -- | 0.02 + 0.009 |
| External Gamma (μR/hr) | 14 - 342 | 8 - 235 | 7 - 330 | 20 + 10 |
| Transferable Surface Contamination (dpm/100 $cm^2$) | 0 - 375 | No data | No Long-Lived α-Contamination | 20 |

Data from references 1, 24, and 25.

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# CHAPTER 3

# ENVIRONMENTAL IMPACTS OF THE PROPOSED REMEDIAL ACTIONS

# CHAPTER 3

# ENVIRONMENTAL IMPACTS OF THE PROPOSED REMEDIAL ACTIONS

This chapter describes the environmental impacts associated with the proposed options for remedial action which are discussed in the companion Engineering Evaluation report and summarized in Table 1-1 of Chapter 1.

The options, exclusive of the no action option, are formulated to limit or reduce exposure from radioactive contaminated materials and thus ensure minimum impact on the environment without undue risk to health or safety. The impacts associated with each option are presented to reflect these considerations, and the means for minimizing or controlling the various impacts are offered.

## 3.1 IMPACTS OF THE PROPOSED OPTIONS FOR REMEDIAL ACTION

In this section the pertinent environmental impacts associated with the proposed options for remedial action are discussed. The proposed options (A through E) include practical combinations of the basic options at the Sampling Plant site and associated properties, and the time-phasing of the remedial actions to accomplish the work. Option A (no remedial action) is identical to the basic Option I. Each of the options is supplemented by tables to summarize the associated impacts. The impacts are identified on these tables as either short-term adverse (STA), short-term beneficial (STB), long-term adverse (LTA), long-term beneficial (LTB), no effect, or not applicable to the specific impact of concern (indicated by asterisks).

The impacts generally are presented to show the prolonged impact arising because of the remedial action. In several options it is necessary to present the impacts that will occur during implementation of the remedial action, during temporary on-site storage, and the ultimate impacts resulting after completion of the particular remedial action.

Option A (no action) is presented so that the existing conditions can be compared with the various impacts of the remaining proposed options for remedial action. Option A is impractical for the associated properties because of health, sociopolitical, and economic reasons.

Because there are private residences and commercial establishments involved for the associated properties, the options applicable to the Sampling Plant site may not be the most appropriate for the associated properties. The availability of disposal sites also would influence the selection of remedial actions and the time scale for implementation.

It is expedient, therefore, to consider each of the basic options as a building block in constructing the proposed options for remedial action for dealing with both the site and the associated properties for short-term and long-term actions. The rationale for considering short-term and long-term actions is to identify impacts occurring during remedial action work and impacts resulting from temporary or permanent on-site storage of contaminated materials.

The six proposed options representing a range of remedial actions are presented in Table 1-1, Chapter 1. For some options, the operations are performed in timed phases. A Phase I operation of a specific option would allow immediate decontamination efforts to be undertaken without the necessity of a final commitment on a permanent disposal site. Phase II of the overall remedial action would address the issues of permanent disposition of the Sampling Plant site and the contaminated materials.

In selecting a range of practical options, several factors were considered with the goal of making the proposed actions acceptable to concerned indivduals, to the Borough of Middlesex, to the Township of Piscataway, to governmental bodies involved, and to the general public. Options involving stabilization of associated properties, where at least 2 ft of compacted fill would be placed on the properties of individual residences or commercial establishments, were not considered to be socio-politically practical.

Therefore, the principal option considered for the associated properties is "decontamination and restoration". The major decision involves how and where the contaminated materials are to be permanently stored. In Options B and C, the Sampling Plant site is designated as a permanent repository. In Options D and E the site is used for temporary storage, awaiting selection of a permanent disposal site. In Option F, direct removal to a remote site for permanent storage is involved; however, this option could not be implemented until a remote disposal site became available.

For the Sampling Plant site, the options presented include partial decontamination, decontamination and restoration of part of the site, and decontamination and restoration of the entire site. Temporary or permanent storage on site or direct removal of contaminants to a remote site for permanent storage are further actions considered. Entombment of contaminated materials on the Sampling Plant site is considered to be more impractical than stabilization. Entombment is feasible from an engineering point of view but is considerably more expensive and does not provide substantially increased benefits.

### 3.1.1 Option A - No Action

This option is presented as the basis to examine the environmental impacts and risks associated with the present conditions of the Sampling Plant site and associated properties. If no action is taken, radiation levels will not be reduced on these properties, and radiation exposures will remain unchanged. A summary of the impacts is shown in Table 3-1.

ASSOCIATED PROPERTIES

Adjacent Properties

a) Ambient Radiation Impacts

Land adjacent to the Sampling Plant site has become contaminated primarily as a result of wind and water transport of radioactive material. The result has been an increase in the gamma radiation levels on adjacent properties. Ambient radiation levels now range from natural background to about 6 times natural background on occupied land adjacent to the site boundaries.(1) South of the site along the drainage ditch, higher values have been measured.

Radon gas is emanating from the site and from contaminated areas of the adjacent properties, but preliminary measurements of working levels in two adjacent residences have been below the guideline values at which remedial action may be necessary.(1) The measured values of radon concentrations in these two residences averaged 0.5 pCi/l,(1) which appears to be 5 to 10 times the natural background values.

b) Ground and Surface Water Impacts

South of the site, radioactive contamination has been measured in surface drainage areas.(1) Some contamination from the site has been carried down the drainage ditch into Main Stream. At the junction of Main Stream and Ambrose Brook, $^{226}Ra$ concentration was about 7 times higher than the concentration in a sample taken 100 yd downstream from the junction where the radium concentration drops to natural background.(2) No direct impact on ground and surface waters from contamination has been identified at the other adjacent properties or in local water wells.(2) The possibility exists for contamination of unconfined ground water by leaching of contaminated soils or by erosion of contaminated soils into surface water during periods of heavy precipitation. No long-term monitoring program has been undertaken to verify these short-term sampling results.

c) Land Use Impacts

A portion of the land to the south of the site along the drainage ditch has been fenced to restrict access and limit exposure to radiation. This restriction will continue until

the land is decontaminated; otherwise, the health effect risk would increase significantly to individuals occupying a dwelling built on the highly contaminated soil near the drainage ditch.

d) Health Impacts

The average $^{222}Rn$ concentration measured in two residences adjacent to the site was 0.5 pCi/l, including natural background. Indoor working level measurements in these two residences were 0.004 WL and 0.0032 WL, including background.[1] Background working levels measured on the first floor of dwellings in the Middlesex area averaged 0.006 WL.[1] Using 0.004 WL as a conservative value, the risk to the residents of these properties for contracting lung cancer is $4 \times 10^{-5}$/yr, based on the methodology presented in Appendix B. This value is less than the average lung cancer risk to New Jersey residents from all causes of $5 \times 10^{-4}$/yr.[3,4] Vegetables could be grown on the property adjacent to the site. The potential population dose is estimated using the methodology and uptake factors given in reference 5. For an average soil contamination of 20 pCi/g and for a total garden production of 200 kg/yr, the bone dose rate is 0.04 mrem/yr, which is a small fraction of natural background radiation. Calculations for estimating the health impacts resulting from radioactivity are given in Appendices B and C.

e) Socioeconomic Impacts

In terms of employment potential, the adjacent properties south of the Sampling Plant site could be subject to a LTA impact because of the presence of radioactive contamination. Few, if any, interested persons would consider industrial or commerical development of the adjacent properties if the area potentially would subject workers to undue radiation exposures.

The adjacent properties, including occupied residences, would suffer LTA socioeconomic impacts in terms of decreased land values. It is expected that property values generally will continue to rise in the Middlesex area. The adjacent properties would not be desirable to prospective buyers because of the presence of radioactive contamination. Therefore, the property value should remain relatively static.

Church Rectory

a) Ambient Radiation Impacts

Gamma radiation and radon concentration are above natural background levels in the basement of the Rectory. This condition has a potential health impact. The magnitude of the impact is discussed in the following health impacts Paragraph c).

If no action is taken to reduce radiation levels, there will be an LTA impact because of the elevated radiation levels, this would result in continued exposure to the users of the Rectory.

b) Ground and Surface Water Impacts

The radioactive material at the Rectory has not been shown to cause a water pollution problem. Water in the soil is not used locally for drinking or irrigation. Radiological surveys of the immediate area have shown that surface runoff has not spread contamination.(6) Thus, the nearby ground and surface waters are not impacted.

c) Health Impacts

The average measured radon concentration in the basement office area,(7) assuming 50% radon daughter equilibrium, would result in an associated potential individual lung cancer risk of $6 \times 10^{-4}$/yr. The calculation assumes an occupancy factor of 0.5 for the basement area. If a normal 40-hr week is assumed, the individual lung cancer risk to workers in the Rectory basement offices would be about $2 \times 10^{-4}$/yr. Ventilation, air circulation, or other measures could reduce radon daughter concentrations to below the guideline level, which would reduce the radiological impact significantly.

The presence of contaminated materials around the Rectory increases the gamma radiation level to 1.5 times natural background levels at the Church, which is a negligible amount. Outside the Rectory the levels range up to about 20 times higher than the average natural gamma radiation background. The health risk to individuals exposed for half of the time to increased gamma radiation levels inside the Rectory would equal about $2 \times 10^{-5}$/yr.

d) Socioeconomic Impacts

The radioactive materials around the Rectory could lead to adverse socioeconomic effects on the clergy and the parishioners. Since users of the Rectory may be apprehensive because of the presence of contaminated material, the possibility of diminished attendance and visitation represents an impact. Also, future increased economic valuation of this property may not be realizable if the radioactive material remains in its present location.

432 William Street

a) Ambient Radiation Impacts

In the front yard of the house, external gamma radiation measurement at 1 m above the surface ranged from 50 to 330 μR/hr, or a maximum of about 40 times natural background

radiation. Inside the house, gamma measurements ranged up to 17 μR/hr, or about twice natural background levels.[6]

No radon or radon daughter measurements were performed in the residence, but a conservative estimate of 10 pCi/l was assumed for radon concentration to estimate the potential health impact. (For comparison, the highest average radon concentration measured on the street level of the Rectory was 1.2 pCi/l.) At 50% equilibrium, the calculated radon daughter concentration could be as high as 0.05 WL. If radon concentrations are this high, potential exposures would be up to 2.5 times the suggested guideline levels.

b) Ground and Surface Water Impacts

No direct environmental impact relative to a water pollution potential has been identified as a result of the present conditions of this property.

c) Health Impacts

Using the assumed radon daughter concentration of 0.05 WL, an occupant of the residence would have a potential risk of contracting lung cancer of $4 \times 10^{-4}$/yr. The individual dose to an occupant from gamma radiation would be 88 mR/yr above natural background based upon the highest measured radiation level in the house. This is about half of the guideline level, resulting in an estimated health risk of $9 \times 10^{-6}$/yr.

d) Socioeconomic Impacts

The only direct socioeconomic impact associated with leaving the property in its present condition is a probable reduction in value of the property.

SAMPLING PLANT

a) Ambient Radiation Impacts

Based on ORNL data,[1] outdoor radon concentrations on site appear to be about 3 times the natural background concentration in the Middlesex vicinity. In most areas of the site, gamma radiation ranges from 2 to 7 times the average natural gamma background in the vicinity.[1] In a few locations the gamma radiation is 20 to 50 times the average natural background value.

b) Ground and Surface Water Impacts

There are abundant water supplies in the area; and while some contamination from the Sampling Plant site has been carried downstream, water sample analyses indicate that the amount of contamination in the water is relatively small at Ambrose Brook.[2] However, soil sampling[1] of the drainage ditch

south of the site indicates soil contamination. The on-site drainage system apparently is the principal means whereby contamination was transported to the off-site drainage ditch. Presently, a major portion of the site is covered with an asphalt surface which has stablized the contamination so that it is less subject to wind and water erosion.

The dissolved radium concentrations in surface waters near the site do not exceed the EPA's 1976 Interim Drinking Water Standards,(8) except for water in the drainage ditch south of the site. By the time the water in the drainage ditch reaches Main Stream, the $^{226}Ra$ concentration is about 1 pCi/l.(2) It is not reasonable to assume that people regularly drink water from the drainage ditch because of plentiful potable water supplies; consequently, no population exposures are calculated for this pathway.

As described in Chapter 2, there is a maximum depth of 8 ft of soil above the Brunswick shale at the site. Although contamination of this shallow unconfined aquifer is possible, it is not tapped near the site. All of the well water and tap water samples taken near the site contained less than 1 pCi/l of radium,(2) well within the acceptable limits of the 1976 Drinking Water Regulations. This indicates that contaminated water from the site is not a source of recharge to the Brunswick Formation. No long-term ground water monitoring results are available to verify this conclusion.

c) Erosion Impacts

Erosion presents a possible LTA impact. Erosion and removal of radioactive materials from the site by heavy rainfall can create additional contamination at downstream locations. However, the asphalt paving significantly reduces the erosion potential.

d) Air Quality Impacts

Most of the contaminated soil at the site is covered with asphalt and is protected temporarily from wind erosion. Some contamination was scattered off site prior to application of the asphalt paving, but the fraction of dose now due to airborne radioactive dust is negligible. Other potential impacts affecting air quality are addressed in the above paragraph on ambient radiation impacts.

e) Land Use Impacts

In its present condition, site use will be restricted severely. This property is zoned industrial and is in a desirable industrial location with easy access to rail service and the interstate system. However, the availability of other vacant land in the vicinity minimizes the impact caused by the site not being available for unrestricted use.

f) Health Impacts

The potential health effects from radon daughter inhalation by previous occupants of the site buildings were calculated assuming 14 people were present 240 hr/mo, and an additional 220 people were present 24 hr/mo.

It is estimated that the highest total health risk from radon daughter inhalation would be about $4 \times 10^{-4}$/yr, for individuals working in the Process Building for 240 hr/mo. For the population at risk at the Sampling Plant, about 0.01 health effects/yr would be expected.

The highest external gamma exposure to workers in the Process Building would be about 55 mR/yr, giving a total population exposure rate of 1.8 manrem/yr. This gives a total health effect risk of $2 \times 10^{-4}$/yr expected for estimated use of the site by its former occupants.

g) Socioeconomic Impacts

The presence of contamination on the site has an LTA effect on site land value. As mentioned earlier, local realtors in the Middlesex area and borough officials indicate that the current market value of the Sampling Plant site is between $35,000 to $40,000/acre. This estimate assumes that the site is free of radioactive contamination and has no structures on it. Thus, the total value of the site would be between $350,000 and $400,000.

The present radiological condition of the site also has an LTA effect on employment since commercial or industrial development of the site cannot occur until the contamination is removed.

### 3.1.2 Option B - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Permanent On-Site Storage

ASSOCIATED PROPERTIES

This section presents an examination and discussion of the environmental impacts during and after implementation of the proposed remedial actions[9] for the associated properties and the Sampling Plant site. Decontamination to 5 pCi/g of radium in soil above natural background or to the natural background are the levels being considered in the proposed remedial actions. Reduction of radiation contamination to 5 pCi/g above natural background compared with reduction to the natural background radiation level represents a change in the ultimate radiological impacts of only a few percent. The magnitude of a particular impact may differ considerably at adjacent and off-site properties (see Table 3-2A).

Excavation

It is expected that the excavation of 25,300 $yd^3$ (an estimated 34,100 tons) of contaminated soils and debris from the associated properties will result in a radiation decontamination level of 5 pCi/g of $^{226}Ra$ in soil above natural background. To achieve natural background decontamination requires the excavation of an estimated 38,000 $yd^3$ (approximately 51,200 tons) of soil and debris from these properties.(2)

Summarized in Table 3-2A are various radiological health, safety, and land use impacts, as well as possible access inconveniences, increased accident potentials, and minimal STA impacts on air quality and noise levels. Possible disruption of the flora and fauna are expected to occur during implementation of Option B remedial actions. Short-term impacts from decontamination will occur mostly during excavation and restoration of the properties.

The operations required for excavation will have short-term impacts on most of the categories considered. No impact is projected for the soils since they are assumed to be already contaminated, and thus no change will occur.

a) Ambient Radiation Impacts

Ambient radioactivity levels may increase temporarily as a result of disturbing the contaminated soils. This increase is considered to be an STA impact because it occurs only for the duration of the remedial action work. The ambient radioactivity levels in air decrease as the distance from the source increases.

The workers will be most affected by these increases because they are in the immediate vicinity of the increase. They therefore will be trained in controlling ambient radiological increases and spread of contamination.

b) Erosion Impacts

Soil erosion by surface runoff could affect surface water quality. This would occur particularly in the area south of the Sampling Plant site by an increase in solids in the surface waters from erosion during the clearing-preparing, excavation, and restoration of the site and associated properties. This could be significant during a period of heavy rainfall while the exposed area would be unprotected by vegetation. Measures will be taken to control erosion until new vegetation is established. These actions could include diversion ditches, dikes, fiber mats, and other temporary erosion control measures.

To reduce the STA impacts during excavation operations, erosion controls will be instituted by minimizing the exposed surface area of contaminated soils and by use of berms adjacent

to any drainage areas. Controls for limiting the erosion and the increases in ambient radiological levels in water resources will be augmented by radiation monitoring on a continual basis to detect any spread of contamination during remedial operations.

c) Air Quality Impacts

The STA impacts on air quality during implementation of Option B would be incurred mainly in all three operational phases of the work, including: clearing and excavation, backfilling, and restoration.

Increased exhaust fume levels and radioactive dust could impact air quality. As mentioned previously, dust may be controlled through the use of water sprays. Exhaust fumes from excavation and construction equipment may be minimized through proper equipment maintenance.

d) Ecological Impacts

Vegetation removal from the associated properties is an unavoidable STA impact. Vegetation would be cut to ground level and disposed of by high-heat burning. The size of the area exposed at any one time would be minimized.

None of the rare, undetermined or endangered plants or other botanical species identifed in New Jersey have been shown to exist near the Sampling Plant site; therefore, no impacts upon such species are expected to result. The cleared portion of the vacant land south of the site will be planted with grass and, if not used for other purposes, natural restoration will occur. Long-term impacts on the ecology will occur if the decontaminated lands are developed.

Fauna also will be impacted on an STA basis during Option B remedial operations. None of the rare or endangered wildlife species have been identified or shown to exist upon the site area, but lack of habitat to any established fish and wildlife species represent a potential environmental impact within this area of concern. No economically important game animals or fish are present in the contaminated areas. During implementation of this remedial action, the major foreseeable impact on the fauna will be disruption of their habitat and loss of sustenance.

e) Land Use Impacts

During excavation operations at the associated properties, access to the residences or commercial properties may be interrupted or restricted. However, efforts will be made to ensure a minimum of inconveniences during this remedial action. This adverse impact would be of short-term duration.

Solid wastes other than radioactive wastes, such as above-ground landscape debris, could have an STA impact on area solid waste disposal sites. The impact of this additional volume of material will be reduced by the use of high-heat burning. The resulting ash will be dispoed of along with the contaminated soils. Nonburnable solid waste will be disposed of at local waste disposal sites.

f) Cost Impacts

The cost impacts in terms of dollars spent for Option B are broken down separately to reflect individual expenses associated with excavation, backfilling, and restoration of associated off-site properties. These operations are necessary for implementation and completion of all options. The cost for these operations are tabulated in Chapter 4 and in Appendix C in the Engineering Evaluation report.(9) The cost impact draws attention to the function of expenditures in achieving a clean environment which has a reduced risk of producing latent health effects. Cost as an adverse impact implies that large amounts of moneys are required in order to conduct the remedial action.

g) Noise Impacts

During implementation of Option B, noise is considered to be an unavoidable STA impact. The noise increases above present levels are produced by equipment and trucks during excavation and during restoration operations. All operations will be conducted during normal daylight hours so as not to cause a noise problem during other hours of the day. Proper maintenance of the equipment and the use of bafflers and mufflers will help minimize these noise levels.

h) Health Impacts

In excavating and loading the estimated 34,100 tons (5 pCi/g criterion) or 51,200 tons (background criterion) of radioactive contaminated materials from all associated properties, it is estimated that a maximum dose of about 27 mrem to the whole body to each worker could result over the 6-wk period required to complete the operations (see Appendix B, Paragraph B.2.1). This exposure is less than the Federal Radiation Council guideline levels, and therefore should be acceptable. Nevertheless, this is considered to be an STA impact because the individual's whole body burden in terms of lifetime radiation exposure is increased by a small amount during this 6-wk period.

Excavation and loading of a maximum of 47,300 tons of radioactive materials from only the adjacent and nearby properties are estimated to result in a maximum dose of about 7 mrem to each worker over a 6-wk period. This exposure is less than study guideline levels and therefore should be acceptable, but the effect on health is viewed as an STA impact for the

reasons previously stated. Furthermore, the excavation and removal of an estimated 3,000 tons of contaminated soils and debris from the grounds around the Rectory will result in an estimated dose of about 12 mrem to each worker over a 3-wk period, which is considered to be an acceptable value; however, this is still considered to be an STA impact.

The removal of contaminated materials, consisting of approximately 900 tons, to achieve the background radiation level at the William Street location, can be achieved with no worker receiving more than 8 mrem in the 2-wk period estimated as necessary to complete the cleanup work. If one truckload is accidentally dumped, the workers could also receive about 1 mrem exposure during reloading.

The maximum exposure to an individual living within 10 m of the transport route during the transport of materials from the Rectory and William Street locations is estimated to be less than 0.005 mrem, which is a negligible dose over the time period. Individuals, whether engaged in the remedial action work or not, would receive about 10 mrem from natural background radiation during the 6-wk period.

i) Safety Impacts

Traffic accidents due to an increase in the number of trucks using local streets and roads are a potential STA impact. It is estimated that 2,500 14-$yd^3$ truckloads[9] of contaminated materials will be moved from the adjacent properties directly to the site without using public roads to achieve decontamination to background levels. Approximately 160 truckloads of contaminated soil would be removed from the Rectory and approximately 50 truckloads from 432 William Street. Statistically, less than one traffic accident is predicted during the off-site remedial actions.

The haulage of clean fill could require up to 2,700 truckloads of soil requiring the use of public roads. Using Interstate Commerce Commission accident statistics discussed in a later section of this report, less than one traffic accident is predicted based upon the ton-miles involved in the restoration effort.

To reduce the accident risk as an impact of concern, a safety program should be instituted to assure safe conditions of vehicles and safe actions of vehicle operators.

j) Transportation Network Impacts

Traffic congestion from required excavation operations in Option B at the associated properties would be minimal. Planning and coordination of hauling activities with local authorities would reduce any impact even further. For example,

most of the haulage operation could take place at times other than periods of peak traffic flow.

k) Socioeconomic Impacts

Impacts associated with implementation of Option B include short-term benefits (STB) to area employment, STA impacts on aesthetics, but no applicable effects on land values during excavation.

It is very likely that the workers would be drawn from the local area as well as from outside the vicinity. Any influx of workers probably would not place undue hardships on the area with respect to living accommodations, schools, or social facilities during these remedial action operations.

Both STA and LTA impacts may result to property owners of the associated areas during excavation and backfilling operations if the materials are to be removed to the Sampling Plant site for either temporary or permanent storage. The creation of a storage pile as high as 10 ft above ground elevation on the Sampling Plant site may be aesthetically displeasing, even though the pile is seeded.

Through proper planning and coordination, adverse impacts can be minimized on the overall quality of life as reflected by socioeconomic factors. Dissemination of information to the public is an important activity needed during Option B remedial actions. This would be of great help in diminishing the reactions of a concerned public.

Backfill

Potential impacts as a consequence of backfilling operations for Option B at the associated properties are listed in Table 3-2A and are discussed in the following paragraphs.

a) Soil Impacts

The amount of soil required for backfill material could create a local impact; however, it is projected that any soils derived from areas outside the site will be taken primarily from overburden materials excavated from new construction projects. New Jersey conservation laws do not permit borrow pit operations,(10) and therefore no source impacts are expected.

b) Cost Impacts

The cost impact of backfilling is part of the overall cost impact of the remedial actions and is the same as previously discussed.

c) Noise Impacts

An STA impact from noise level increases from earthmoving equipment will occur during backfilling operations. The same measures used to mitigate the effects of noise impact from excavation will be utilized during this phase.

d) Safety Impacts

The impact on safety during backfilling operations is expected to be adverse but of short-term. The same contributing conditions are present for both backfilling and excavation, except that additional transport distance is expected in obtaining clean fill from a new construction site. Less than one traffic accident is predicted during backfill operations.

e) Transportation Network Impacts

Transportation networks also will experience STA impacts during this phase as previously described for excavation operations.

f) Socioeconomic Impacts

Socioeconomic benefits in terms of employment for the area are the same as for excavation. Aesthetics will be impacted for a short term as previously described under the excavation operation.

Restoration

The impacts that result upon completion of restoration of the associated properties will have the effect of canceling out the previous adverse impacts either by being of long-term benefit (LTB), or there will be no further impact. (See Table 3-2A.)

SAMPLING PLANT

Impacts of partial decontamination of the Sampling Plant site and storage of contaminated materials under Option B are summarized in Table 3-2B.

Deactivation of Drainage Systems

Removal of the outside drainage system and plugging the process building drainage system will result in a long-term benefit to the environment by eliminating further spread of contaminated material from the on-site drainage system into the off-site drainage ditch to the south.

The workers involved in carrying out this remedial action will receive some exposure from slightly increased ambient radiation levels of radioactive particulates during excavation,

and from removal of the storm drain system. This is because workers will be in the immediate vicinity of the increased levels. They therefore should be supplied with protective clothing and with respirators and dosimeters as required for personal safety. Monitoring and periodic maintenance will be needed and the site will have restricted use under Option B.

Preparation of Storage Area

The presence of additional contaminated soils and materials could increase the potential for contamination of surface and ground water in the vicinity and for recontamination of surrounding properties. Therefore, upon completion of excavation and backfill of Area A, the storage area would be prepared by installing a tough, impermeable base liner, that would prevent contaminated materials from moving away from the pile. Careful attention would be given to limiting the spread of contamination as the storage pile is formed.

Storage Procedures

As the contaminants are moved into place on the storage pile, they would be spread out, shaped, and compacted with rollers, being careful not to puncture the liner fabric. Chemical stabilizers would be applied to eliminate a dust hazard.

Atmospheric migration of radon gas off site from the storage pile and resultant health impacts are calculated in Appendix C. If no action were taken to reduce radon emanation, the potential health effects are estimated to be $4 \times 10^{-4}$/yr for the present population within 5 mi. Additional data are given in Appendix C. To reduce radon emanation from the pile, the bottom liner would be sealed to a similar membrane cover and then several feet of clay or soil would be placed on top. These actions could reduce the radon flux by at least a factor of 10. There would be several STA impacts during preparation of the storage area as shown in Table 3-2B, but no long-term impact. Short-term adverse impacts dealing mainly with industrial safety and air quality are the key elements of the action.

Apply Cover and Revegetate

The storage pile would be capped with the same material as the liner and thermally welded to it to form a hermetic seal. Nothing would diffuse through the membrane except in the unlikely case of rupture. To protect and stabilize the pile even further, it would be covered with at least 2 ft of clean compacted clay or soil. Topsoil then would be added and seeded to prevent erosion. The impacts as a result of this work when completed would be largely long-term and beneficial. Few or no impacts will occur upon flora or fauna since the area is presently covered with asphalt pavement.

Safety impacts would be of short-term duration because of the potential for industrial-type injuries and accidents which might occur during implementation of this task.

Use of the entire site would be restricted under Option B, but LTB impacts would result from the containment of contaminated materials.

The remaining impacts that are a result of remedial action at the Sampling Plant are summarized in Table 3-2B.

### 3.1.3 Option C - Decontamination and Restoration of Associated Properties and a Portion of the Site; Permanent On-Site Storage

ASSOCIATED PROPERTIES

This Option reflects the same remedial actions and therefore the same impacts described under Option B for these properties. (See Table 3-3A.) The remedial action includes excavation of soils and materials associated with the off-site drainage sytem. Also involved is the removal of contaminated soils from residential and commercial properties and from vacant lots. The excavated areas are to be restored to their original grade with clean fill. The drainage system, lawns, landscaping, etc., are to be replaced.

SAMPLING PLANT

An analysis of the impacts associated with decontamination and restoration of Area B at the Sampling Plant site under Option C is summarized in Table 3-3B.

Raze Buildings

There will be no impacts that would apply or have a significant effect on the environment in terms of mineral resources and soils, erosion, flora, fauna, overall land use at the site, transportation networks, or land values specifically related to the act of razing on-site buildings.

Short-term adverse impacts will occur as a potential increase in ambient radiation levels. To mitigate this impact, careful control of dust will be required during the demolition operation. Short-term adverse impacts also may result from increased equipment noise, exposure of workers to slightly elevated radiation levels, and possibly from industrial accidents which might occur during razing operations.

As discussed in the Engineering Evaluation,[9] the cost impact of razing the buildings will be less than the cost of attempting to decontaminate the buildings for unrestricted use.

Employment in the area may show a STB impact for workers involved in the construction trades, and businesses will benefit in providing goods or services to these personnel.

Excavation

The potential environmental impacts arising during this remedial action will be essentially of a short-term nature and will occur during the excavation, backfilling, storage, and restoration operations. The actions will impact physical environmental qualitites such as air quality and noise levels. Socioeconomic impacts, both adverse and beneficial, also will occur. Impacts from implementing remedial action during Option C are summarized in Table 3-3B. The impacts are listed for each type of operation.

Many of the impacts listed occur during several operations. Therefore, it is convenient to discuss the impacts only generally now and to refer only to major changes in the magnitude of an impact.

It is projected that ambient radiological levels may increase slightly over present levels during the implementation of Option C because of releases of radioactive air particulates (dust) or radon gas. An increase in ambient radiological levels can occur during excavation of contaminated soils, during removal of the storm drainage system, and during demolition of the buildings at the Sampling Plant.

Under this option, radioactivity levels in ground and surface waters could increase if erosion by wind and rain were not prevented during excavation operations. Erosion controls should be instituted by minimizing the exposed surface area of contaminated soils and installation of a clean drainage system. The controls for limiting erosion and increases in ambient radiological levels outdoors would be augmented by radiation monitoring on a continual basis to detect any spread of contamination during remedial operations.

The same impacts as previously mentioned are expected to occur for Option C at the Sampling Plant site. These impacts on air quality and noise levels are also indicated in the impact summary listed in Table 3-3B.

Backfilling

A summary of projected impacts during this part of Option C operations for the Sampling Plant are outlined in Table 3-3B. Backfilling decreases the magnitude or eliminates entirely some of the previous impacts associated with this remedial action. Most of the remaining impacts are short term for adverse effects and long term for beneficial effects.

Storage Procedures

If the contaminated materials are stored on the plant site permanently, the health effect rates estimated for this situation are the same as those given for Option B. Radiological impacts from storing off-site materials at the Sampling Plant site will be mainly from the emanation of radon. Unless special measures were taken to reduce radon emanation from the storage pile, the risk for lung cancer to the population within 5 mi would be about $4 \times 10^{-4}$/yr. The pile would be covered as discussed in Option B to reduce radon flux. No increase in off-site gamma exposures would result from the pile.

A summary of the impacts associated with storage procedures is presented in Table 3-3B. Area A, the permanent storage area, would have several impacts that are potentialy adverse and of long duration, such as potential impacts on ground and surface water quality.

Covering and Revegetation

Ultimate impacts as a result of stabilization of the pile are generally long-term and beneficial in reducing radon flux and ambient radiation. Vegetation would be established to control erosion of the cover material. Short-term adverse impacts would occur with respect to noise, safety, and transportation networks during implementation of this action. Also, a short-term benefit to employment would result during implementation of Option C.

Monitoring and periodic maintenance would be needed with a long-term impact on costs. The storage site (Area A) would be fenced and would have restricted access.

Restoration of Area B

As seen in Table 3-3B, most of the impacts associated with restoration of Area B are LTB impacts for Area B. Area B would be available for unrestricted use after restoration.

### 3.1.4 Option D - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Temporary On-Site Storage

ASSOCIATED PROPERTIES

A summary of the impacts that are expected to occur upon implementation and completion of the remedial actions is presented in Table 3-4A. The impacts are the same as those discussed under Option B for these properties. However, this option also involves eventual removal of the contaminated materials from temporary storage at the Sampling Plant site to a remote disposal location. Traffic accident potential is a major concern, and could be the most significant STA impact.

## SAMPLING PLANT - Phase I, Partial Decontamination

### Deactivation of the Drainage Systems

In Table 3-4B the impacts that may be related to this portion of the remedial action are summarized. The impacts are similar to those indicated in Option B for the Sampling Plant. There are no long-term impacts associated with Phase I, since this phase includes temporary storage and the means to contain the contamination until decontamination and restoration are accomplished in Phase II.

### Preparation of Storage Area

The temporary storage of contaminated soils and materials from associated properties on the Sampling Plant site has a smaller potential for contaminating surface and ground waters in the vicinity and recontaminating surrounding properties than a permanent storage pile. Nevertheless, the storage area would be prepared by installing a base liner, and careful attention would be given to limiting the spread of contamination as the storage pile is formed. A membrane cover would be placed over the pile and sealed to the bottom liner to contain the radon. A layer of soil would be placed on top of the cover to protect it and to reduce gamma radiation to natural background levels. Other impacts associated with preparation of the storage site (Area A) are the same as those described in Option B and are shown in Table 3-4B.

### Storage Procedures

The impacts associated with the preparation of the storage area are the same as those previously described under Option B and are repeated in Table 3-4B. Use of the entire site would be restricted until Phase II is completed.

## SAMPLING PLANT - Phase II, Decontamination and Restoration of Sampling Plant

The radiological impacts from cleanup of the Sampling Plant site include those resulting from removal of the temporary storage pile for the off-site contamination. In addition to the removal of the storage pile, approximately 46,500 tons to 62,000 tons of materials must be moved from the site, depending on the decontamination criterion chosen. Much of the decontamination effort will be directed towards demolishing the Process Building. Increases in the release of radioactive dust and radon will occur, but additional exposures to the off-site population will be minimal as a result of the operational control procedures and the relatively short time span needed for the remedial action.

The total material to be moved, including the temporary storage pile for the off-site contaminated material, ranges

from 80,600 tons to 113,000 tons.[9] Table 3-4B contains a summary of the impacts which may occur during this phase.

Removal of Stored Materials

In Table 3-4B are given the impacts expected to occur during removal of the storage pile. Transportation by rail of the 51,200 tons of contaminated materials from the associated properties to a remote disposal site would result in about 0.05 accidents for a 100-mi haulage distance and 1.4 accidents for a 2,750-mi distance. By truck, the expected number of accidents would be about 5 times higher.

Razing of Buildings

Impacts associated with this area of the remedial action are also summarized in Table 3-4B, and were previously discussed under Option C for the Sampling Plant.

Excavation of Site

Impacts of this operation are the same as those discussed in Option C for the Sampling Plant. The impacts are summarized in Table 3-4B.

Transporting Contaminated Materials to Remote Site

Impacts associated with the transportation of contaminated materials under Option D are indicated in Table 3-4B. If the contaminated material were transported by truck to a remote disposal location, the driver would receive an estimated 0.006 mrem/mi. This assumes the use of a 20-ton truck containing contaminated materials at an average $^{226}Ra$ concentration of 150 pCi/g.

The safety impacts are of major importance although they are only STA impacts. The following statistics are presented to emphasize the impact of safety in terms of transportation accident potentials.

Potential environmental risks associated with transportation of contaminated materials by both railroad and motor carrier have been calculated on the basis of shipping 113,200 tons of contaminated materials[9] between 100 and 2,750 mi, resulting in a total of 11 to 310 million ton-miles of shipping.

In 1976, total rail freight traffic in the United States was 796 billion ton-miles[11] with a corresponding 8,041 total accidents of which 6,328 were derailments[12] for an incident frequency of $1.01 \times 10^{-8}$ accidents of all types per ton-mile and $7.95 \times 10^{-9}$ derailments per ton-mile. Based on these statistics, the range of probabilities for similar incidents is 0.1 to 3 accidents for transporting contaminated materials.

Total Interstate Commerce Commission (ICC) regulated motor carrier freight traffic in the United States for 1976 was 490 billion ton-miles.(12) The corresponding accident statistics were 25,666 accidents involving all materials shipped with 2,520 associated fatalities, for an accident and fatality frequency of $5.24 \times 10^{-8}$ fatalities per ton-mile involving all materials shipped, and $5.14 \times 10^{-9}$ fatalities per ton-mile. Based on these statistics, the range of probabilities for similar incidents in transporting the Sampling Plant contaminated materials are 0.6 to 16 accidents and 0.05 to 2 fatalities. Any spills of contaminated materials that may occur would be cleaned up and transported to the original destination. Any impacts would be less than those occurring during the initial loading of the material.

Restoration of Site

Long-term beneficial health and economic impacts are expected after site restoration. Several STA impacts that will occur during implementation of the restoration procedures are shown in Table 3-4B. Upon completion of restoration the entire Sampling Plant site would be available for unrestricted use and adverse health impacts would be eliminated.

### 3.1.5 Option E - Decontamination and Restoration of Associated Properties and a Portion of the Site; Temporary On-Site Storage

ASSOCIATED PROPERTIES

The same general remedial action procedures utilized in Option B for the associated properties will apply to Option E; therefore, the impacts will be the same. Table 3-5A contains the summary of impacts under Option E.

SAMPLING PLANT - Phase I, Decontamination and Restoration of Area B at Sampling Plant

A summary of the impacts associated with this phase of the remedial action is presented in Table 3-5B. The impacts resulting from decontamination and restoration of Area B are the same as those of Option C. In this option, contaminated material would be stored temporarily in Area A until a remote disposal site is selected and prepared to receive the contaminated material for permanent storage.

Razing of Buildings

An STA impact on ambient radioactivity levels may result because of demolition operations. Similarly, air quality may be adversely affected for a short time because of increased dust and exhaust fumes from demolition and earthmoving equipment. Noise levels will show an STA impact due to the operation of the construction equipment to be utilized in this task. The

health impacts, especially on the workers, may be a minor STA impact. Safety will show an STA impact because of the increased potential for injuries and accidents while the buildings are being razed.

A short-term benefit to employment for area workers engaged in this type of activity would occur.

Excavation of Area B

This task involves the removal of the drainage system and excavation of contaminated soils in Area B. The impacts as a consequence of this operation are the same as those discussed for the razing of buildings. An increased potential for surface water contamination would be an STA impact. These impacts have been discussed in earlier sections of this chapter.

Storage Procedures

The same impacts as described in the preceding sections are expected to occur during site preparation and storage pile construction. (See Table 3-5B.) The impacts are generally STA impacts, except for the short-term benefit of employment. Also, no further impacts should occur from erosion during storage pile construction, if proper procedures are employed. The impacts associated with temporary storage on the site of off-site contaminated material are the same as those discussed under Option D.

Restoration of Area B

The restoration of Area B of the Sampling Plant site will leave the area available for unrestricted use. Table 3-5B is a summary of the net long-term effect of the impacts that will occur as a result of the completion of this action. These impacts are generally long-term benefits. The STA impacts listed for costs, noise, health and safety may result during the implementation of this task.

Soil sources would not be impacted because soils to be used in this restoration task would be brought in from various excavation projects in progress at the time of remedial action. Transportation networks would be impacted during the hauling of backfill to Area B. The remaining operations would occur on the site and would have little impact on normal traffic.

SAMPLING PLANT - Phase II, Decontamination and Restoration of Sampling Plant

Long- and short-term impacts will result from removal of the stored materials, excavation of Area A, transporting the contaminated materials to a remote disposal site, and restoration of Area A. (See Table 3-5B.)

Removal of Stored Materials

Excavation, restoration, and transportation are involved in removal of the contaminated materials from the storage pile. Short-term adverse impacts will occur in all impact categories under consideration during the implementation of this part of the remedial action.

Excavation of Area A

The impacts associated with the excavation of Area A will be the same as those occurring during excavation of Area B. These impacts are indicated in Table 3-5B.

Transporting Contaminated Materials to a Remote Site

Table 3-5B is a summary of impacts that will occur during and after completion of this remedial action phase. After transporting all the radioactive contaminants to a remote disposal location, long-term benefits will be experienced in terms of reduced ambient radiation levels. Ground and surface waters will benefit because the potential contamination source is removed. Air quality will benefit because the radon and radon daughter concentrations will be reduced to natural background levels.

The other impacts are related to the performance of this part of the remedial action while it is in progress. These are STA impacts. Industrial safety constitutes the greatest potential STA impact. The accident risks outlined for Option D are applicable to the industrial safety impacts considered here.

Restoration of Area A

This task completes the Phase II activities of Option E at the Sampling Plant site. Table 3-5B shows the summary of the impacts that are expected to occur. The long-term benefits will follow completion of this task and the STA impacts will occur while restoration is in progress. The two major long-term benefits involve the removal of radioactive contamination with the subsequent reduction in potential health effects in the population and the availablity of the entire site for unrestricted use resulting in a land use benefit.

### 3.1.6 Option F - Decontamination and Restoration of Associated Properties and the Site; Direct Removal to Remote Disposal Site

ASSOCIATED PROPERTIES

The impacts associated with this remedial action are summarized in Table 3-6A. These impacts are similar to the impacts associated with Options D and E, except that in Option F

contaminated materials are moved directly to a remote location for disposal without temporary storage. Therefore, the STA impacts discussed in Options D and E during interim storage on site will not occur.

In Options D and E, involving temporary storage of contaminated materials on site, increased costs are incurred for storage site preparation and rehandling of the contaminated materials. Although the cost of Option F still will be an adverse impact, the amount will be substantially less for direct transport to a remote site. However, Option F cannot be accomplished until a remote disposal site has been selected and prepared to receive the contaminated materials, therefore, remedial action cannot begin as early as the other options.

SAMPLING PLANT

In this operation, all radioactive contaminated materials and contaminated buildings would be removed from the Sampling Plant site and hauled directly to a remote disposal location. This accomplishes decontamination of the site and ends the potential for radiation exposure to residents in the site vicinity.

Almost all impacts, listed in Table 3-6B, are STA impacts. Health and safety impacts during transport to a remote disposal site are STA impacts. The magnitude of the accident potential has been discussed previously. The ultimate impacts under site restoration are long-term benefits. The two major long-term benefits are the removal of all contaminated materials from the area with subsequent reduction in potential health effects, and the availability of the entire site for unrestricted use. Impacts associated with the consequences that may occur at selected remote disposal locations are not within the scope of this report.

TABLE 3-1

SUMMARY OF ENVIRONMENTAL IMPACTS
ASSOCIATED WITH OPTION A

| | Church Rectory | 432 William Street | Adjacent Properties | Sampling Plant |
|---|---|---|---|---|
| **Physical Impacts** | | | | |
| 1. Mineral Resources and Soils | * | * | * | * |
| 2. Ambient Radiation | LTA | LTA | LTA | LTA |
| 3. Ground and Surface Waters | * | * | LTA | LTA |
| 4. Erosion | * | * | LTA | * |
| 5. Air Quality | * | * | * | * |
| **Biological Impacts** | | | | |
| 1. Flora | * | * | * | * |
| 2. Fauna | * | * | * | * |
| **Socioeconomic Impacts** | | | | |
| 1. Land Use | * | * | LTA | LTA |
| (A) Solid Waste | * | * | * | * |
| 2. Costs | * | * | * | * |
| 3. Noise | * | * | * | * |
| 4. Health | LTA | LTA | LTA | LTA |
| 5. Safety | * | * | * | * |
| 6. Transportation Networks | * | * | * | * |
| 7. Employment | * | * | LTA | LTA |
| 8. Land Values | LTA | LTA | LTA | LTA |
| 9. Aesthetics | * | * | * | LTA |

LEGEND LTB - Long-term beneficial impact LTA - Long-term adverse impact STB - Short-term impact
STA - Short term adverse impact * - Not affected or doesn't apply

TABLE 3-2A

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM OPTION B FOR THE ASSOCIATED PROPERTIES

| | I. Applicable to All | | | II. Adjacent & Nearby Properties | III. 432 William Street & Rectory |
|---|---|---|---|---|---|
| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage | |
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Radiation | STA | * | LTB | * | STA |
| 3. Ground and Surface Waters | * | * | LTB | * | * |
| 4. Erosion | STA | * | LTB | * | * |
| 5. Air Quality | STA | * | LTB | STA | STA |
| **Biological Imapcts** | | | | | |
| 1. Flora | STA | * | LTB | * | LTB |
| 2. Fauna | STA | * | LTB | * | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | LTB | STA | LTB |
| (A) Solid Waste | STA | * | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB |
| 8. Land Values | * | * | LTB | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | STA | LTB |

LEGEND LTB - Long-term beneficial impact
STA - Short-term adverse impact
LTA - Long-term adverse impact
STB - Short-term adverse impact
* - Not affected or doesn't apply

TABLE 3-2B

SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM OPTION B FOR SAMPLING PLANT SITE

| | Deactivate Drainage Systems | Prepare Storage Area | Storage Procedures | Apply Cover and Revegetate |
|---|---|---|---|---|
| **Physical Impacts** | | | | |
| 1. Mineral Resources and Soils | * | * | * | * |
| 2. Ambient Radiation | LTB | STA | STA | LTB |
| 3. Ground and Surface Waters | STA | STA | STA | LTB |
| 4. Erosion | * | STA | STA | LTB |
| 5. Air Quality | * | STA | STA | LTB |
| **Biological Impacts** | | | | |
| 1. Flora | * | STA | * | LTB |
| 2. Fauna | * | STA | * | LTB |
| **Socioeconomic Impacts** | | | | |
| 1. Land Use | | | | |
| (A) Solid Waste | * | STA | LTA | LTB |
| 2. Costs | STA | * | * | * |
| 3. Noise | STA | STA | STA | STA |
| 4. Health | STA | STA | STA | STA |
| 5. Safety | STA | * | STA | LTB |
| 6. Transportation Networks | STA | STA | STA | STA |
| 7. Employment | STA | STA | STA | * |
| 8. Land Values | STB | STB | STB | * |
| 9. Aesthetics | LTB | * | * | LTB |
| | * | STA | STA | LTB |

LEGEND LTB - Long-term beneficial impact
STA - Short term adverse impact
LTA - Long-term adverse impact
STB - Short-term impact
* - Not affected or doesn't apply

TABLE 3-3A

SUMMARY OF ENVIORNMENTAL IMPACTS RESULTING FROM OPTION C FOR THE ASSOCIATED PROPERTIES

| | I. Applicable to All | | | II. Adjacent & Nearby Properties | III. 432 William Street & Rectory |
|---|---|---|---|---|---|
| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage | |
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Ambient Radiation | STA | * | LTB | * | STA |
| 3. Ground and Surface Waters | * | * | LTB | * | * |
| 4. Erosion | STA | * | LTB | * | * |
| 5. Air Quality | STA | * | LTB | STA | STA |
| **Biological Imapcts** | | | | | |
| 1. Flora | STA | * | LTB | * | LTB |
| 2. Fauna | STA | * | LTB | * | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | LTB | STA | LTB |
| (A) Solid Waste | STA | * | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB |
| 8. Land Values | * | * | LTB | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | STA | LTB |

LEGEND LTB - Long-term beneficial impact LTA - Long-term adverse impact STB - Short-term adverse impact
STA - Short-term adverse impact * - Not affected or doesn't apply

TABLE 3-3B

SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM OPTION C FOR THE SAMPLING PLANT SITE

| | Raze Buildings | Excavate Site | Backfill Site | Storage Procedures | Restore Area B | Cover & Revegetate Site |
|---|---|---|---|---|---|---|
| **Physical Impacts** | | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * | * |
| 2. Ambient Radiation | STA | STA | * | LTA | LTB | LTB |
| 3. Ground and Surface Waters | STA | STA | * | LTA | LTB | LTB |
| 4. Erosion | * | STA | LTB | * | LTB | LTB |
| 5. Air Quality | STA | STA | * | STA | LTB | LTB |
| **Biological Impacts** | | | | | | |
| 1. Flora | STA | STA | * | * | LTB | LTB |
| 2. Fauna | STA | STA | * | * | LTB | LTB |
| **Socioeconomic Impacts** | | | | | | |
| 1. Land Use | STA | STA | STA | LTA | LTB | LTB |
| (A) Solid Waste | STA | * | * | * | * | * |
| 2. Costs | STA | STA | STA | LTA | STA | LTA |
| 3. Noise | STA | STA | STA | STA | STA | STA |
| 4. Health | STA | STA | LTB | LTA | LTB | LTB |
| 5. Safety | STA | STA | STA | STA | STA | STA |
| 6. Transportation Networks | * | * | STA | * | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB | STB |
| 8. Land Values | * | * | LTB | LTA | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | LTB | LTB | LTB |

LEGEND LTB - Long-term beneficial impact LTA - Long-term adverse impact STB - Short-term impact
STA - Short term adverse impact * - Not affected or doesn't apply

TABLE 3-4A

SUMMARY OF ENVIORNMENTAL IMPACTS RESULTING FROM OPTION D FOR THE ASSOCIATED PROPERTIES

| | I. Applicable to All | | | II. Adjacent & Nearby Properties | III. 432 William Street & Rectory |
|---|---|---|---|---|---|
| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage | |
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Ambient Radiation | STA | * | LTB | * | STA |
| 3. Ground and Surface Waters | * | * | LTB | * | * |
| 4. Erosion | STA | * | LTB | * | * |
| 5. Air Quality | STA | * | LTB | STA | STA |
| **Biological Imapcts** | | | | | |
| 1. Flora | STA | * | LTB | * | LTB |
| 2. Fauna | STA | * | LTB | * | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | LTB | STA | LTB |
| (A) Solid Waste | STA | * | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB |
| 8. Land Values | * | * | LTB | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | STA | LTB |

LEGEND LTB - Long-term beneficial impact LTA - Long-term adverse impact STB - Short-term adverse impact
STA - Short-term adverse impact * - Not affected or doesn't apply

SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM OPTION D FOR THE SAMPLING PLANT SITE

| | Phase I Partial Decontamination | | | Phase II Decontamination and Restoration | | | | |
|---|---|---|---|---|---|---|---|---|
| | Deactivate Drainage Systems | Prepare Storage Area | Storage Proce-dures | Remove Stored Materials | Raze Build-ings | Excavte Building | Trans-port to Remote Site | Restore Site |
| **Physical Impacts** | | | | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * | * | * | * |
| 2. Ambient Radiation | STA | * | STA | STA | STA | STA | STA | LTB |
| 3. Ground and Surface Waters | STA | * | STA | STA | STA | STA | * | LTB |
| 4. Erosion | STA | * | STA | STA | * | STA | * | * |
| 5. Air Quality | STA | * | STA | STA | STA | STA | STA | LTB |
| **Biological Impacts** | | | | | | | | |
| 1. Flora | * | STA | * | * | STA | STA | * | LTB |
| 2. Fauna | * | STA | * | * | STA | STA | * | LTB |
| **Socioeconomic Impacts** | | | | | | | | |
| 1. Land Use | STA | STA | STA | STA | STA | STA | LTB | LTB |
| (A) Solid Waste | STA | * | * | * | STA | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA | STA | * | STA |
| 4. Health | STA | STA | STA | STA | STA | STA | STA | LTB |
| 5. Safety | STA | * | * | STA | * | STA | STA | STA |
| 6. Transportation Networks | * | STB | STB | STB | STB | STB | STB | STB |
| 7. Employment | STB | * | * | LTB | * | STA | LTB | LTB |
| 8. Land Values | * | STA | STA | LTB | STA | STA | * | LTB |
| 9. Aesthetics | STA | | | | | | | |

LEGEND LTB - Long-term beneficial impact
STA - Short term adverse impact
LTA - Long-term adverse impact
STB - Short-term impact
* - Not affected or doesn't apply

TABLE 3-5A

SUMMARY OF ENVIORNMENTAL IMPACTS RESULTING FROM OPTION E FOR THE ASSOCIATED PROPERTIES

| | I. Applicable to All | | | II. Adjacent & Nearby Properties | III. 432 William Street & Rectory |
|---|---|---|---|---|---|
| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage | |
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Ambient Radiation | STA | * | LTB | * | STA |
| 3. Ground and Surface Waters | * | * | LTB | * | * |
| 4. Erosion | STA | * | LTB | * | * |
| 5. Air Quality | STA | * | LTB | STA | STA |
| **Biological Imapcts** | | | | | |
| 1. Flora | STA | * | LTB | * | LTB |
| 2. Fauna | STA | * | LTB | * | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | LTB | STA | LTB |
| (A) Solid Waste | STA | * | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB |
| 8. Land Values | * | * | LTB | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | STA | LTB |

LEGEND LTB - Long-term beneficial impact LTA - Long-term adverse impact STB - Short-term adverse impact
STA - Short-term adverse impact * - Not affected or doesn't apply

SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM OPTION E FOR THE SAMPLING PLANT SITE

| | Phase I Decontamination and Restoration of Area B | | | | Phase II Decontamination and Restoration | | | |
|---|---|---|---|---|---|---|---|---|
| | Raze Buildings | Excavate Area B | Storage Procedures | Restore Area B | Remove stored Materials | Excavate Area A | Trans-port to Remote Site | Remote Area A |
| **Physical Impacts** | | | | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * | * | * | * |
| 2. Ambient Radiation | STA | STA | STA | LTB | STA | STA | LTB | * |
| 3. Ground and Surface Waters | * | STA | STA | LTB | STA | STA | LTB | LTB |
| 4. Erosion | * | STA | * | LTB | * | STA | * | * |
| 5. Air Quality | STA | STA | STA | LTB | STA | STA | LTB | LTB |
| **Biological Impacts** | | | | | | | | |
| 1. Flora | STA | STA | * | LTB | STA | STA | * | LTB |
| 2. Fauna | STA | STA | * | LTB | STA | STA | * | LTB |
| **Socioeconomic Impacts** | | | | | | | | |
| 1. Land Use | STA | STA | STA | LTB | STA | STA | * | LTB |
| (A) Solid Waste | STA | * | * | * | STA | * | STA | * |
| 2. Costs | STA | STA | STA | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA | STA | * | STA |
| 4. Health | STA | STA | STA | STA | STA | STA | STA | LTB |
| 5. Safety | STA | * | * | STA | * | * | STA | STA |
| 6. Transportation Networks | STB | STB | STB | STB | STB | STB | STB | STA |
| 7. Employment | * | * | * | LTB | * | * | * | LTB |
| 8. Land Values | STA | STA | STA | LTB | STA | STA | * | LTB |
| 9. Aesthetics | | | | | | | | |

LEGEND LTB - Long-term beneficial impact
STA - Short term adverse impact
LTA - Long-term adverse impact
STB - Short-term impact
* - Not affected or doesn't apply

TABLE 3-6A

SUMMARY OF ENVIORNMENTAL IMPACTS RESULTING FROM OPTION F FOR THE ASSOCIATED PROPERTIES

| | I. Applicable to All | | | II. Adjacent & Nearby Properties | III. 432 William Street & Rectory |
|---|---|---|---|---|---|
| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage | |
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Ambient Radiation | STA | * | LTB | * | STA |
| 3. Ground and Surface Waters | * | * | LTB | * | * |
| 4. Erosion | STA | * | LTB | * | * |
| 5. Air Quality | STA | * | LTB | STA | STA |
| **Biological Imapcts** | | | | | |
| 1. Flora | STA | * | LTB | * | * |
| 2. Fauna | STA | * | LTB | * | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | LTB | STA | LTB |
| (A) Solid Waste | STA | * | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB | STB |
| 8. Land Values | * | * | LTB | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | LTB | LTB |

LEGEND LTB - Long-term beneficial impact
STA - Short-term adverse impact
LTA - Long-term adverse impact
STB - Short-term adverse impact
* - Not affected or doesn't apply

TABLE 3-6B

SUMMARY OF ENVIRONMENTAL IMPACTS
RESULTING FROM OPTION F FOR THE SAMPLING PLANT SITE

| | Raze Buildings | Excavation Site | Backfill Site | Restore Site | Transport Materials to remote site |
|---|---|---|---|---|---|
| **Physical Impacts** | | | | | |
| 1. Mineral Resources and Soils | * | * | * | * | * |
| 2. Ambient Radiation | STA | STA | * | LTB | STA |
| 3. Ground and Surface Waters | STA | STA | * | LTB | * |
| 4. Erosion | * | STA | * | LTB | * |
| 5. Air Quality | STA | STA | * | LTB | STA |
| **Biological Impacts** | | | | | |
| 1. Flora | STA | STA | * | LTB | * |
| 2. Fauna | STA | STA | * | LTB | * |
| **Socioeconomic Impacts** | | | | | |
| 1. Land Use | STA | STA | STA | LTB | * |
| (A) Solid Waste | STA | STA | * | * | * |
| 2. Costs | STA | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA | STA |
| 4. Health | STA | STA | * | LTB | STA |
| 5. Safety | STA | STA | STA | STA | STA |
| 6. Transportation Networks | * | * | STA | STA | STA |
| 7. Employment | STB | STB | STB | STB | STB |
| 8. Land Values | * | * | * | LTB | LTB |
| 9. Aesthetics | STA | STA | STA | LTB | LTB |

LEGEND LTB - Long-term beneficial impact
STA - Short term adverse impact
LTA - Long-term adverse impact
STB - Short-term impact
* - Not affected or doesn't apply

## CHAPTER 3 REFERENCES


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# CHAPTER 4

# TRADEOFFS OF THE PROPOSED REMEDIAL ACTIONS

# CHAPTER 4

# TRADEOFFS OF THE PROPOSED REMEDIAL ACTIONS

Environmental tradeoffs involve a comparison of advantages and disadvantages of each remedial action option in terms of its impacts. Tradeoffs also entail a consideration of land use, health, safety, and estimated costs for remedial actions at properties of concern. The advantages and disadvantages include consideration of impacts resulting from present conditions, impacts that might occur during implementation of remedial actions, and the potential impacts that could occur upon completion of the proposed remedial actions.

This tradeoff summary considers only the impacts of greatest magnitude. Cost estimates may be obtained from the Engineering Evaluation report.(1)

## 4.1 ADVANTAGES AND DISADVANTAGES OF THE PROPOSED OPTIONS FOR REMEDIAL ACTION

### 4.1.1 Option A - No Action

Under this "no action" option, the area would be left as it now is. The option is included so that the impacts of the present conditions can be compared with the impacts of the other options. The advantage of this option is that no costs would be incurred. However, the health impacts discussed in Chapter 3 would continue to occur until the materials were removed.

### 4.1.2 Option B - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Permanent On-Site Storage

Option B involves decontamination and restoration of the associated properties to reduce radiation exposure from contaminated materials. Access would be controlled to the Sampling Plant site where the contaminants are proposed to be stored permanently. The storage pile would be covered to reduce gamma radiation and radon flux to natural background levels.

The advantage of this option is the comparatively low financial expenditure or cost impact required for its implementation. The main disadvantage is that there is no reduction of potential health effects at the site, which would require restricted access and use of the site. Removal of contaminated materials from the associated properties would eliminate the potential health impacts from this source.

### 4.1.3 Option C - Decontamination and Restoration of Associated Properties and a Portion of the Site; Permanent On-Site Storage

This option also involves permanent storage and stabilization of the radioactive contaminants from the associated properties at the Sampling Plant site, as well as decontamination and restoration of a portion of the site. The storage pile would be covered to reduce the external gamma radiation and radon flux to natural background levels.

The main advantage of this option is that the potential health impacts would be eliminated at the associated properties and at the decontaminated portion of the site, which then may be released for unrestricted use. The disadvantages include the restricted access and use of the area where contaminated materials would be stored, the necessity for perpetual monitoring and maintenance, and the potential for recontamination of restored areas in the future.

### 4.1.4 Option D - Decontamination and Restoration of Associated Properties; Partial Site Decontamination; Temporary On-Site Storage

Partial decontamination of the Sampling Plant site and total decontamination and restoration of the associated properties are included in Option D during Phase I. Radioactive contaminants from adjacent and associated properties would be removed and temporarily stored on the site along with contaminated materials from the Sampling Plant for removal at a later time.

Upon completion of Phase I, the source of potential health impacts would be removed from the associated properties. Further spread of contamination from the site would be prevented. Upon completion of Phase II, the entire site would be released for unrestricted use and all contaminated materials would be permanently stored at a remote site. This option would allow decontamination to begin at the associated properties before a permanent storage area was ready to accept contaminated materials from Middlesex properties.

There are disadvantages with this option. The Sampling Plant site would be a restricted area prior to completion of Phase II. Excavation and removal of the storage pile would lead to additional impacts, such as increased traffic accident potential, not incurred with permanent storage at the Sampling Plant site. Double handling of the contaminated materials would increase costs over direct removal.

### 4.1.5 Option E - Decontamination and Restoration of Associated Properties and a Portion of the Site; Temporary On-Site Storage

Option E includes decontamination and restoration of the associated properties and a portion of the Sampling Plant site. Phase I involves temporary on-site storage until a permanent disposal site is ready to receive the contaminated materials. The temporary storage pile would be covered to reduce gamma radiation and radon flux to natural background levels. During Phase II all contaminated materials would be removed to a remote site for permanent disposal.

The advantages of this option include the elimination of potential health effects at the associated properties and at the decontaminated portion of the Sampling Plant site, which then would be available for unrestricted use. Restoration of the associated properties could proceed prior to the availability of a permanent disposal site.

There also are disadvantages. The temporary storage area would not be available for unrestricted use until completion of Phase II. Removal of the storage pile would result in additional impacts during Phase II, such as increased traffic accident potential if trucks were used for haulage to the remote disposal site. Double handling of contaminated materials would increase the remedial action costs over direct removal.

### 4.1.6 Option F - Decontamination and Restoration of Associated Properties and the Site; Direct Removal to Remote Disposal Site

Under this option total decontamination and restoration of the Sampling Plant site and the associated properties would be accomplished without temporary storage at the site. The radioactive contaminants would be removed from these properties and transported directly to a remote disposal facility. This action could not be implemented, however, until an appropriate remote disposal location was identified and developed.

Total decontamination of the site and associated properties would eliminate the potential health impact from the low-level radioactive contamination and allow for unrestricted use of the site. Direct removal would eliminate double handling costs and the need for a monitoring and maintenance program at the site.

The major disadvantage would be the time delay necessary to implement this option. Implementation could not occur until a remote permanent disposal site was selected and prepared. Truck haulage of the contaminated materials would result in an increased traffic accident potential.

## 4.2 SUMMARY AND DISCUSSION

The advantages and disadvantages for the proposed remedial action options are given in Table 4-1. Cost breakdowns for each option are summarized in Table 4-2, taken from the Engineering Evaluation report.(1) The health benefits accruing from reduced radiation exposure to the public in the vicinity of the site are tabulated in Table 4-3. The health benefits are taken to be the reduction or elimination of potential health effects (cancer cases) caused by exposure to radiation levels above natural background by means of the pathways discussed in Chapter 3, and Appendices B and C. The health effects avoided are calculated over a 50-yr exposure period. The calculated reduction in health effects at the Sampling Plant site is the result of vacating the site. If personnel continue to occupy the site, fewer health effects would be avoided for each option.

Implementation of remedial action options that include decontamination and restoration of the Sampling Plant site and associated properties with disposal of contaminated materials at a remote disposal site would be a long-term environmental benefit. This benefit, with resulting reduction in health risk, would be achieved at the expense of STA impacts such as increased noise, increased traffic and accident potential, temporary air quality degradation, removal and replacement of vegetation, and slightly increased exposure to workers.

The additional lung cancer risks from present contamination levels at the adjacent properties are less than the average lung cancer risk from all causes in New Jersey. The individual cancer risks from contamination at the Sampling Plant site, the Rectory, and possibly at 432 Williams Street with the assumed occupancy rates are about equal to the lung cancer risk from all causes in the state. Decontamination and restoration of the Sampling Plant site and associated properties would remove further health risks.

Two criteria for decontamination have been considered: a radium concentration of 5 pCi/g above natural background, and natural background levels of radium concentration. The 5-pCi/g criterion is related to a radon daughter concentration of 0.02 WL in a structure built upon contaminated soil. Only the Rectory may have contaminated material beneath a portion of the foundation. With this exception, cleanup to the 5-pCi/g level would result in only a few percent difference in exposure to residents compared with decontamination to natural background levels. However, the volume of material removed for cleanup to natural background would be approximately 40% more than the material removed to achieve 5 pCi/g above natural background. This is significant in terms of accident potential and cost.

A major impact of removing the contaminated materials to a remote site is the impact of increased traffic accident

potential. Accident potential increases with the volume of material removed and the haulage distance. The risk of traffic accident fatalities during haulage of contaminated materials and backfill by truck is comparable with the health risk from the present conditions. Rail haulage accident statistics indicate an accident potential factor of 6 less than that for truck haulage.

The final impact discussed here is public reaction, which is difficult to quantify but is of major importance. The remedial action option selected may be dependent primarily on public reaction. Accomplishment of a remedial action program should allay concerns of area residents and, depending upon the option selected, allow development of a portion or all of the Sampling Plant site.

## 4.3 COST BENEFIT OF OPTIONS FOR REMEDIAL ACTION

Each of the options for remedial action has an associated number of health effects (cancer cases) tnat could be avoided as a result of the remedial actions that would reduce radiation levels in the area from activities that were conducted at the Sampling Plant site. These avoided health effects are the health benefits described in Paragraph 4.2 and shown in Table 4-3. The cost for each option is shown in Table 4-2. The cost-benefit ratios are calculated from these data and are listed in Table 4-4. Because no disposal site in the East has been identified, the cost associated with Options D through F are for transport of the contaminated materials to the Nevada Test Site. This results in high cost-benefit ratios whereas low cost-benefit ratios are desirable. The cost-benefit ratio for any other disposal site may be calculated by first determining the cost of the option, exclusive of transportation, as described in the Engineering Evaluation,(1) adding the new transportation cost, and then dividing that total cost by the health benefits shown in Table 4-4.

TABLE 4-1

ADVANTAGES AND DISADVANTAGES OF OPTIONS A THROUGH F

| Option | Advantages | Disadvantages |
|---|---|---|
| A | | 1) Radioactivity levels remain unchanged; exposure potential remains unchanged |
| B | 1) Lowest cost<br>2) Accomplished quickly<br>3) Buildings in Area B could be used by government for storage<br>4) Associated properties decontaminated<br>5) No long-haul distance involved | 1) Contamination remains permanently on site<br>2) Entire site permanently restricted<br>3) Buildings not usable for personnel unless decontaminated and ventilated<br>4) Indefinite radiological monitoring and surveillance required |
| C | 1) Area B available for unrestricted use<br>2) No long-haul distance involved<br>3) Associated properties decontaminated | 1) Contamination remains permanently on site<br>2) Area A permanently restricted<br>3) Indefinite radiological monitoring and surveillance required |
| D | 1) Phase I accomplished quickly<br>2) Allows time for selecting remote disposal site<br>3) Buildings in Area B could be used temporarily by government for storage<br>4) Associated properties decontaminated immediately; site decontaminated in Phase II | 1) Contamination remains temporarily on site<br>2) Area A restricted until Phase II completed<br>3) Double handling of off-site materials<br>4) Possible long-haul distance<br>5) Buildings not usable for personnel unless decontaminated and ventilated |

TABLE 4-1 (Cont)

| Option | Advantages | Disadvantages |
|---|---|---|
| E | 1) Area B available after Phase I action for unrestricted use<br>2) Allows time for selecting remote disposal site<br>3) Associated properties decontaminated immediately; Area A decontaminated in Phase II | 1) Contamination remains temporarily on site<br>2) Area A restricted until Phase II is completed<br>3) Double handling of all contaminated materials<br>4) Possible long-haul distance |
| F | 1) All properties decontaminated and restored | 1) Cannot be initiated until remote disposal site is available<br>2) Possible long-haul distance |

# TABLE 4-2.
# COST ESTIMATES (IN THOUSANDS OF 1979 DOLLARS)

| REMEDIAL ACTION ITEM | REMEDIAL ACTION OPTION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A[a] | B | | C | | D[b] | | E[b] | | F[b] | |
| | | CRITERION A | CRITERION B | CRITERION A | CRITERION B | CRITERION A | CRITERION B | CRITERION A | CRITERION B | CRITERION A | CRITERION B |
| DECON. & RESTORE ASSOC. PROP. | (NO ACTION) | 365 | 550 | 365 | 550 | 365 | 550 | 365 | 550 | 350 | 500 |
| DECON. & RESTORE AREA A | | -- | -- | -- | -- | 175* | 225* | 205* | 265* | 125 | 175 |
| DECON. & RESTORE AREA B | | -- | -- | 300 | 400 | 300* | 400* | 300 | 400 | 300 | 400 |
| PLUG ALL DRAIN SYSTEMS | | 4 | 4 | -- | -- | -- | -- | -- | -- | -- | -- |
| PLUG PROC. BLDG DRAIN ONLY | | -- | -- | -- | -- | 2 | 2 | -- | -- | -- | -- |
| REMOVE YARD DRAIN ONLY | | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | -- | -- |
| PREPARE SITE A FOR STORAGE | | 60 | 65 | 60 | 65 | 40 | 40 | 40 | 40 | -- | -- |
| CONSTRUCT PILE | | 25 | 35 | 40 | 50 | 25 | 35 | 40 | 50 | -- | -- |
| COVER PILE | | 175 | 190 | 200 | 215 | 125 | 140 | 150 | 165 | -- | -- |
| FENCE & POST SIGNS, AREA A | | 2 | 2 | 5 | 5 | 2 | 2 | 5 | 5 | -- | -- |
| ENGINEERING 10% & CONTINGENCY 15% | | 203 | 262 | 300 | 384 | 327 | 427 | 358 | 456 | 221 | 303 |
| HEALTH PHYSICS COVERAGE | | 50 | 75 | 100 | 125 | 50/75* | 75/75* | 100/25* | 125/25* | 110 | 135 |
| SITE MAINTENANCE & SURVEILLANCE | | 125 | 125 | 125 | 125 | 125 | 125 | 125 | 125 | -- | -- |
| TOTAL | (NO COST) | 1,014 | 1,313 | 1,500 | 1,924 | 1,616 | 2,101 | 1,718 | 2,211 | 1,106 | 1,513 |
| PHASE I VOLUME ($yd^3$) | | -- | -- | -- | -- | 26,300 | 38,850 | 44,300 | 62,450 | -- | -- |
| PHASE I WEIGHT (TONS) | | -- | -- | -- | -- | (35,800) | (52,900) | (60,000) | (84,400) | -- | -- |
| TOTAL VOLUME ($yd^3$) | | 36,300 | 53,250 | 54,300 | 76,850 | 54,300* | 76,850* | 54,300* | 76,850* | 54,300 | 76,850 |
| TOTAL WEIGHT (TONS) | | (53,250) | (74,100) | (80,600) | (113,200) | (80,600)* | (113,200)* | (80,600)* | (113,200)* | (80,600) | (113,200) |

(a) OPTION A IS NOT A REMEDIAL ACTION
* PHASE II
(b) TRANSPORTATION COSTS TO THE NEVADA TEST SITE, VIA RAIL, ARE ESTIMATED TO BE $12,375,000 FOR CRITERION A, AND $17,393,750 FOR CRITERION B

230-005



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TABLE 4-3

SUMMARY OF HEALTH BENEFITS TO PUBLIC FOR OPTIONS A THROUGH F

| | Health Effects (Cancer Cases) Avoided Over 50-Yr Period | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OPTIONS | | | | | | | | | | | |
| | A | | B | | C | | D | | E | | F | |
| | AP[a] | SP[b] | AP | SP | AP | SP | AP | SP | AP | SP | AP | SP |
| From direct radon inhalation | 0 | 0.7[c] | 0.4 | 0.7 | 0.4 | 0.7 | 0.4 | 0.7 | 0.4 | 0.7 | 0.4 | 0.7 |
| From radon transport | 0 | 0 | neg[e] | (0.02)[d] | neg | (0.02)[d] | neg | 0.02 | neg | 0.02 | neg | 0.02 |
| From direct gamma exposure | 0 | 0 | $2x10^{-2}$ | $9x10^{-3}$ | $2x10^{-2}$ | $9x10^{-3}$ | $2x10^{-2}$ | $9x10^{-3}$ | $2x10^{-2}$ | $9x10^{-3}$ | $2x10^{-2}$ | $9x10^{-3}$ |
| From ingestion pathway | 0 | 0 | $2x10^{-5}$ | 0 | $2x10^{-5}$ | 0 | $2x10^{-5}$ | 0 | $2x10^{-5}$ | 0 | $2x10^{-5}$ | 0 |
| Total | 0 | 0.7[c] | 0.42 | 0.69 | 0.42 | 0.69 | 0.42 | 0.73 | 0.42 | 0.73 | 0.42 | 0.73 |
| Case Totals | 0.7 | | 1.11 | | 1.11 | | 1.15 | | 1.15 | | 1.15 | |

[a]AP = Associated Properties
[b]SP = Sampling Plant
[c]Vacating personnel from site, not removal of contamination
[d]Storage of contamination materials from associated properties on site (negative benefit)
[e]Neg = negligible

TABLE 4-4

COST-BENEFIT RATIOS

| Option | Option Cost ($000) | Health Benefit[a] | Cost-Benefit Ratio ($/Health Benefit) |
|---|---|---|---|
| B | 1,014 | 1.11 | 914,000 |
| C | 1,500 | 1.11 | 13,514,000 |
| D | 13,991 | 1.15 | 12,166,000 |
| E | 14,093 | 1.15 | 12,255,000 |
| F | 13,481 | 1.15 | 11,723,000 |

[a]Health effects avoided for decontamination to Criteria A

## CHAPTER 4 REFERENCES

1. "Engineering Evaluation of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey;" FB&DU 230-001; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah 84108, July 1979.

# APPENDIX A

# GLOSSARY

# GLOSSARY

| Terms/Abbreviations | Definitions |
|---|---|
| absorbed dose | Radiation energy absorbed per unit mass. |
| aesthetics | Pertains to that which is pleasing to the visual senses; an attitude that is usually individually subjective. |
| alpha particle ($\alpha$) | A positively charged particle emitted from certain radioactive materials. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of the common radiations ($\alpha, \beta, \gamma$), and is not dangerous unless alpha-emitting sustances have entered the body. |
| ambient radiation level | The existing radiation level at a given location at a specific time or time period. Ambient levels reflect radiation from contaminated material in addition to natural background radiation. |
| aquifer | A water-bearing formation below the surface of the earth; the source of wells. A confined aquifer is overlain by relatively impermeable rock. An unconfined aquifer is one associated with the water table. |
| background radiation | Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth. |
| beta particle ($\beta$) | A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged |

| | |
|---|---|
| | beta particle is called a positron. Beta radiation can cause skin burns and beta emitters are harmful if they enter the body. |
| endangered species | A species whose survival is in jeopardy. Its peril may result from destruction of habitat, change in habitat, over-exploitation by man, predation, adverse interspecific competition, disease, or because an area is at the edge of its geographical range. An endangered species must receive protection, or extinction probably will follow. |
| dose equivalent | A term used to express the effective radiation dose when modifying factors have been considered (the numerical product of absorbed dose and quality factor). |
| external gamma radiation | Gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources. |
| exposure | Magnitude of radiation to which a person is subjected. It is defined as the measured electrical charge produced per unit mass of air. |
| exhalation | Emission of radon from earth (usually thought of as coming from a uranium tailings pile, but actually from any location). |
| fauna | Animal life including mammals, birds, fish, reptiles. |
| fixed alpha | Particulate alpha-emitting isotopes which have become imbedded in otherwise nonradioactive surfaces and which cannot be removed by standard decontamination techniques. |

| | |
|---|---|
| flora | Plant life, both land and aquatic species. |
| gamma background | Natural gamma ray activity everywhere present, originating from two sources: (1) a cosmic radiation component, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural external gamma radiation from both sources ranges from about 60 to about 125 mrem/yr. |
| gamma ray ($\gamma$) | High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power. |
| ground water | Subsurface water in the zone of full saturation which supplies wells and springs. |
| half-life | The time required for one-half of the radioactive atoms present at any given time to decay with emission of radiation. |
| impact | The effect brought about by a proposed action to alter an existing condition; an impact may be adverse or beneficial. |
| Interim Drinking Water Standards | Title No. 40 of the Code of Federal Regulations, Chapter 1, Part 141, dated Dec 24, 1975, became effective June 24, 1977. |
| isotope | One of two or more species of atoms with same atomic numbers (the same chemical element) but with different atomic weights. Isotopes usually have very nearly the same chemical properties, but somewhat different physical properties. |
| manrem | A unit used in health physics to compare the effects of different amounts of radiation on groups |

| | |
|---|---|
| | of people. It is obtained by multiplying the average dose equivalent to a given organ or tissue (measured in rems, which see) by the number of persons in that population. |
| μR/hr | Microroentgen per hour ($10^{-6}$R/hr) |
| mR/hr | Milliroentgen per hour ($10^{-3}$R/hr) |
| maximum permissible concentration | The highest concentration in air or water of a particular radionuclide permissible for occupational or general exposure without taking steps to reduce exposure. |
| pCi/l | Picocurie per liter ($10^{-12}$Ci/l). |
| pCi/g | Picocurie per gram ($10^{-12}$Ci/g). |
| pCi/$m^2$-s | Picocurie per meter squared-second ($10^{-12}$Ci/$m^2$-sec) |
| quality factor | An assigned factor which denotes the modification of the effectiveness of a given absorbed dose by the linear energy transfer. |
| rad | The basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs of radiation energy per gram of absorbing material. |
| radioactivity | The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation. |
| radioactive decay chain | A succession of nuclides each of which transforms by radioactive disintegration into the next until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product. |

| | |
|---|---|
| radium | A radioactive element, chemically similar to barium, formed as a daughter product of uranium ($^{238}U$). The most common isotope of radium, $^{226}Ra$, has a half-life of 1,620 yr. Radium is present in all uranium-bearing ores. Trace quantities of both uranium and radium are found in all areas, contributing to the gamma background. |
| radon | $^{222}Rn$, a radioactive, chemically inert gas, having a half-life of 3.8 days; formed as a daughter product of $^{226}Ra$. |
| radon background | Low levels of radon gas found in an area, due to the presence of radium in the soil. |
| radon concentration | The amount of radon per unit volume. In this assessment, the average value for a 24-hr period of atmospheric radon concentrations, determined by collecting data for each 30-min period of a 24-hr day and averaging these values. |
| radon daughter | One of several short-lived radioactive daughter products of radon (several of the daughters emit alpha particles). |
| radon daughter concentration | The concentration in air of short-lived radon daughters, expressed usually in pCi/l; also measured in terms of the working level (WL). |
| radon flux | The quantity of radon emitted from a surface in a unit time per unit area (typical units are in $pCi/cm^2$-s). |
| rare species | A rare species is not currently threatened with extinction, but it occurs in such small numbers that it may become endangered if its environment deteriorates |

| | |
|---|---|
| | further or other limiting factors are altered. Continued observation of its status is essential. |
| recharge | The process by which water is absorbed and added to the zone of saturation of an aquifer, either directly into the formation or indirectly by way of another formation. |
| roentgen (R) | A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying 1 electrostatic unit of electrical charge, either positive or negative, in 1 cubic centimeter of dry air under standard conditions (numerically equal to $2.58 \times 10^{-4}$ coulombs/kg). |
| rem | The unit of dose equivalent of any ionizing radiation which produces the same biological effect as a unit of absorbed dose of ordinary X-rays, numerically equal to one rad of absorbed dose multiplied by the appropriate quality factor for the type of radiation. The rem is the basic recorded unit of accumulated dose to personnel. |
| socioeconomic | Pertaining to and affecting society and the economy in a general way or to smaller parts as within one area. |
| transferable alpha | Particulate alpha-emitting isotopes, found on surfaces usually in the form of dust, which can be removed from the surface by dry or wet wiping using the smear technique. |
| undetermined species | A species whose status is undetermined may be either rare or endangered, but currently available information is inadequate to determine its status accurately. More |

information is needed to determine if the species now exists in dangerously low numbers.

| | |
|---|---|
| working level (WL) | A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products RaA, RaB, RaC, and RaC' that are present under equilibrium conditions in a liter of air containing 100 pCi of $^{222}Rn$. It does not include decay or RaD (22-yr half-life) and subsequent daughter products. |
| working level month (WLM) | One WLM is equal to the exposure received from 170 WL-hours. |

# APPENDIX B

# POTENTIAL HEALTH IMPACTS

# APPENDIX B

## POTENTIAL HEALTH IMPACTS

Potential health impacts have been estimated for the Middlesex Sampling Plant site and associated properties. The methodology and parameters used in the analysis are contained in this appendix. Measured radiation data are from ORNL (1,2).

### B.1 HEALTH EFFECTS FROM CONTINUAL RELEASES

Inhalation of radon daughters, external gamma exposure and ingestion of contaminated vegetation are the major exposure mechanisms quantified in this analysis.

The basic equation used to obtain the health effect risk from radon daughter inhalation is given in eq (B-1):

$$R_1 = CUf_tK_r \qquad \text{(B-1)}$$

where

$R_1$ = annual individual risk for lung cancer from the radiation ($yr^{-1}$)

$C$ = radon daughter concentration (WL)

$U$ = conversion of WL to $\frac{WLM}{yr}$ for continuous occupancy (50)

$f_t$ = occupancy factor (dimensionless)

$K_r$ = risk estimator ($1.8 \times 10^{-4}$ health effects per yr per WLM/yr)

The expression for the annual cancer risk from external gamma exposure is:

$$R_c = Df_tK_g \qquad \text{(B-2)}$$

where

$R_c$ = annual individual risk for cancer from radiation ($yr^{-1}$)

$D$ = gamma dose rate (rem/yr)

$K_g$ = risk estimator ($1 \times 10^{-4}$ health effects per yr per rem/yr)

The expression for the annual cancer risk from ingestion of contaminated material is similar to eq (B-1) and is:

$$R_i = C_rf_rU_iK_i \qquad \text{(B-3)}$$

where

$R_i$ = annual individual risk for cancer from the ingested material ($yr^{-1}$)

$C_r$ = concentration of contaminant in the soil (pCi/g)

$f_r$ = plant transfer function (pCi/g vegetation per pCi/g soil)

$U_i$ = usage factor (g vegetation ingested/yr)

$K_i$ = risk estimator (health effects/yr per pCi/yr ingested) (3)

The parameters $f_r$, $U_i$ were obtained from reference 4.

The total cancer rate, CR, is obtained by multiplying the individual risk given in the above equations by the numbers of people at risk, P.

### B.1.1 Health Effects from Sampling Plant Contamination

The health effect to workers inside the buildings from radon daughter inhalation was calculated from eq (B-1) with the following parameters:

Administration Building

$C$ = 0.012 WL above background

$f_t$ = 0.33 (240 hr/mo)

$P$ = 7

Process Building

$C$ = 0.15 WL above background

$f_{t1}$ = 0.033 (24 hr/mo)

$P_1$ = 220

$f_{t2}$ = 0.33

$P_2$ = 7

Individual risk to the full-time USMC personnel is as follows:

(1) Administration Building (7 personnel)

$$R = CUf_t K_r = (0.012)\ (50)\ (0.33)\ (1.8 \times 10^{-4})$$

$$= 3.6 \times 10^{-5}/yr$$

(2) Process Building (7 personnel)

$$R = (0.15)\ (50)\ (0.33)\ (1.8 \times 10^{-4})$$

$$= 4.5 \times 10^{-4}/yr$$

Individual risk for the USMC reserve personnel is as follows:

(3) Process Building (220 personnel)

$$R = (0.15)\ (50)\ (0.033)\ (1.8 \times 10^{-4})$$

$$= 4.5 \times 10^{-5}/yr$$

The New Jersey average lung cancer risk from all causes is $4.9 \times 10^{-4}/yr$.(5,6)

The projected cancer rate, CR, is obtained by multiplying the individual risks listed above by the number of people exposed to these risks, and by adding these rates for the total rate for the Sampling Plant.

$$CR = 3.6 \times 10^{-5}\ (7) + 4.5 \times 10^{-4}\ (7) + 4.5 \times 10^{-5}\ (220)$$

$$= 1.3 \times 10^{-2}/yr$$

The CR to the workers from external gamma radiation, obtained in a similar fashion is:

$$CR = 1.8 \times 10^{-4}/yr$$

B.1.2 Health Effects from Adjacent and Nearby Properties

Radon is emitted from contaminated soils around the plant site. Radon WL measurements and radon concentrations were made in two residences adjacent to the site. Radon concentration averaged 0.5 pCi/l including background radon, and WL values were 0.004 and 0.0032 including background.(1) However, background WL measurements in the Middlesex vicinity averaged 0.006 WL on the first floor of dwellings(1); thus radon daughter concentrations from the Sampling Plant site in these adjacent residences are negligible. Using 0.004 WL to calculate the health risk is very conservative and leads to an upper limit on cancer risk:

$$R = (4 \times 10^{-3})\ (50)\ (1.8 \times 10^{-4}) = 3.6 \times 10^{-5}/yr$$

B.1.3 Rectory

The estimated radon daughter concentration is 0.13 WL. This is taken from the average measured radon concentration of 25 pCi/l in the basement office area, and assumes a 50% equilibrium of radon and radon daughters. Using eq (B-1) with

50% occupancy the value of $5.6 \times 10^{-4}$/yr is obtained for R1.

### B.1.4 432 William Street

The estimated radon daughter concentration is 0.05 WL, which results in a $R_1$ of $4.5 \times 10^{-4}$/yr.

## B.2 DOSE RATES AND HEALTH EFFECTS FROM THE REMEDIAL ACTION

Calculations of the dose rates and health effects that potentially could result from exposures during the remedial action are considered in four parts:

(a) Impacts from cleanup of the off-site properties

(b) Impacts from transportation to the Sampling Plant site

(c) Impacts from storage on the Sampling Plant site (Appendix C)

(d) Impacts from transportation from the Sampling Plant site

Details of the calculations for the first two parts are presented below.

### B.2.1 Doses from Cleanup of Off-Site Properties

No health effects from inhalation of radon daughters or of contaminated dust are estimated; it is assumed that workers will be wearing appropriate respiratory equipment during cleanup.

The whole-body gamma dose to a maximum worker is obtained from estimated average exposures and expected cleanup time periods. For adjacent and nearby properties the value is as follows:

mean $\gamma$level = 30 μR/hr

D = 30 μR/hr x 40 hr/wk x 6 wk = 7.2 mR ≃ 7 mrem

For cleanup of the Rectory:

mean $\gamma$level ≃ 100 μR/hr

D = 100 μR/hr x 40 hr/wk x 3 wk = 12 mR

For 432 William Street:

mean $\gamma$level ≃ 100 μR/hr

D = 100 μR/hr x 40 hr/wk x 2 wk = 8 mR

### B.2.2 Doses from Transporting the Off-Site Material to the Sampling Plant Site

The following expression, derived at FB&DU, is used to calculate the gamma dose to an observer standing 10 m away from the trucks as the off-site contaminated material is hauled to the Sampling Plant site.

$$O_d = (5.3 \times 10^{-2}) \frac{R}{r} \left[\frac{1}{v} + \frac{f_d T}{d}\right] \qquad \text{(B-4)}$$

where

$O_d$ = observer exposure ( μR)

R = radium content in transported soil (pCi)

v = velocity of trucks (cm/hr)

T = total time for transport (hr)

d = distance of transport (cm)

r = distance between observer and road (cm)

$f_d$ = fraction of tailings lost during transport

Parameters used in the calculation are:

| Parameter | Rectory | William Street |
|---|---|---|
| r | $10^3$ cm | $10^3$ cm |
| R | $2.9 \times 10^{11}$ pCi | $1.7 \times 10^{11}$ pCi |
| v | $4.8 \times 10^6$ cm/hr (30 mph) | $4.8 \times 10^6$ cm/m |
| d | $8 \times 10^4$ cm (0.5 mi) | $8 \times 10^4$ cm |
| $f_d$ | $10^{-5}$ | $10^{-5}$ |
| T | 120 hr | 80 hr |

This gives $O_d$ = 3.2 μR for the Rectory and 1.9 μR for the William Street location.

### B.2.3 Doses from Transporting the Materials Stored at the Sampling Plant Site

The radiation dose to an observer standing 10 m from the road as the total contaminated material is transported from the Sampling Plant Site is calculated as in Paragraph B.2.2. For an average concentration of 150 pCi/g, the observer could receive a total radiation dose of 0.6 mrem.

A driver of one of the trucks would receive a maximum dose of 78 mrem during the term (conservatively, 19 wk) that the contaminated material was being transported from the Sampling Plant site. This value is calculated using a gamma exposure

rate of 0.13 mR/hr to the driver, which correlates to an average radium concentration of 150 pCi/g.

## B.3 SUMMARY OF HEALTH IMPACTS

Tables B-1 and B-2 are summaries of the calculations of the individual and population health effects from direct inhalation and external gamma exposure at the Sampling Plant and the associated properties. These health impacts are the result of the present conditions and are associated with Option A, the "no action" alternative.

TABLE B-1

HEALTH EFFECTS FROM DIRECT INHALATION

| Location | Avg Radon and Radon Daughter Concentrations pCi/l[b] | WL[c] | Dose to Lung WLM/yr | mrem/yr | Health Effects/yr | Population Effects: Population Number of People (24 hr/day equiv) | Population Lung Dose manrem/yr | Population Health Effects/yr |
|---|---|---|---|---|---|---|---|---|
| Sampling Plant[a] | | | | | | | | |
| Proc. Bldg. | 2.9 | 0.15 | 2.7 | $2.9 \times 10^3$ | $5.0 \times 10^{-4}$ | 10 | 72 | $1.3 \times 10^{-2}$ |
| Adm. Bldg. | 2.4 | 0.012 | 0.20 | $2.4 \times 10^2$ | $3.6 \times 10^{-5}$ | 2 | 1.4 | $2.5 \times 10^{-4}$ |
| Nearby Properties | 0.5 | 0.004 | 0.2 | $5.0 \times 10^2$ | $3.6 \times 10^{-5}$ | 32 | 6.1 | $1.1 \times 10^{-3}$ |
| Rectory | 25 | 0.13 | 3.1[e] | $3.1 \times 10^4$ | $5.6 \times 10^{-4}$ | 10[d] | 310 | $5.6 \times 10^{-3}$ |
| 432 William Street | 10[d] | 0.05 | 2.5 | $2.5 \times 10^4$ | $4.5 \times 10^{-4}$ | 2[d] | 50 | $9.0 \times 10^{-4}$ |

(a) Assumed Occupancy: Administration Building, 7 people for 240 hr/mo; Process Building, 7 people for 240 hr/mo and 220 people for 24 hr/mo.
(b) Measured values above natural background.
(c) Based on 50% equilibrium, not measured values.
(d) Estimated
(e) Based on 50% occupancy.

TABLE B-2

HEALTH EFFECTS FROM EXTERNAL GAMMA RADIATION

| Location | Maximum Gamma Rates μR/hr (b) | Individual Dose mrem/yr | Health Effects/yr | Population Effects: Population Number of People (24 hr/day equiv) | Population Lung Dose manrem/yr | Population Health Effects/yr |
|---|---|---|---|---|---|---|
| Sampling Plant (a) | | | | | | |
| Proc. Bldg. | 19 | 61 | $6.1 \times 10^{3}$ | 10 | 1.6 | $1.6 \times 10^{-4}$ |
| Adm. Bldg. | 9 | 26 | $2.6 \times 10^{2}$ | 2 | 0.18 | $1.8 \times 10^{-5}$ |
| Adjacent Residences | 5 | 44 | $4.4 \times 10^{-6}$ | 24 (c) | 1.0 | $1.1 \times 10^{-4}$ |
| Adjacent Commercial | 30 | 60 | $6.0 \times 10^{-6}$ | 8 (c) | 0.5 | $4.8 \times 10^{-5}$ |
| Rectory | 37 | 160 (d) | $1.6 \times 10^{-5}$ | 10 (c) | 1.6 | $1.6 \times 10^{-4}$ |
| 432 William Street | 10 | 88 | $8.1 \times 10^{-6}$ | 2 (c) | 0.18 | $1.8 \times 10^{-5}$ |

(a) Assumed Occupancy: Administration Building, 7 people for 240 hr/mo; Process Building, 7 people for 240 hr/mo and 220 people for 24 hr/mo.
(b) Measured values above natural background.
(c) Estimated
(d) Based on 50% occupancy.

## APPENDIX B REFERENCES


1. H.W. Dickson, et al., "Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey"; DOE/EV-0005/1; ORNL; Oak Ridge, Tennessee, Nov 1977.

2. R.W. Leggett, F.F. Haywood, W.D. Cottrell, D.J. Crawford, E.B. Wagner, D.L. Anderson, D.J. Christian, R.W. Doane, and W.H. Shinpaugh; "Radiological Surveys of Properties in the Middlesex, New Jersey Area"; to be published as a DOE report.

3. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation"; Report Advisory Committee on Biological Effects of Ionizing Radiation; NAS, National Research Council; Nov 1972.

4. "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," NUREG-1.109; NRC, Office of Standards Development; Mar 1976.

5. 1977 Cancer Facts and Figures; American Cancer Society, Inc.; New York City, New York, 1976; based on National Cancer Institute Third National Cancer Survey.

6. Rand McNally estimated 1977 population for New Jersey.

# APPENDIX C

# POPULATION DOSE CALCULATIONS

# APPENDIX C

# POPULATION DOSE CALCULATIONS

## C.1 RADON GAS DIFFUSION

The atmospheric diffusion and transport of radon gas from the site is calculated using a Gaussian Plume model and the methodology described in reference 1.

The meteorology used in the calculations was obtained from U.S. Weather Bureau information for Newark, New Jersey. For conservatism, Stability Classes D and E were each assumed to prevail 50% of the time. The contaminated area was modeled as a cylinder in order to accommodate model constraints. The total source area of the contaminated material storage pile was conserved in the modeling. An average radon flux value of 3.2 $pCi/m^2$-s was obtained for the contaminated materials,(2) which is a conservative estimate in close agreement with the measured average flux value of 2.7 $pCi/m^2$-s at the sites.(3)

## C.2 POPULATION DOSE CALCULATIONS

The airborne concentrations of radon gas are calculated as a function of radius from the site. The population dose is obtained by taking the product of the average dose to an individual in a given radial sector with the number of people in that sector. The population distribution for present conditions used in the calculations is described in Chapter 2 and shown in Table C-1, which summarizes the population dose rate due to the radon gas emitted by the contamination stored on site from the Sampling Plant and the associated properties. Within 5 mi the dose rate is 23 manrem/yr.

## C.3 PROJECTEO POPULATION DOSE RATES

The following population projections are based upon the projected growth patterns provided from Middlesex and Piscataway sources as discussed in Chapter 2.

A total increase of 1,600 people is assumed to be uniformly distributed in Middlesex within 1 mi from the site. The projected increase of 12,000 in Piscataway within 1 mi of the site is such a large increase that the resulting total projected population of approximately 14,000 is also assumed to be uniformly distributed within the 1-mi radius. From 1 to 5 mi from the site, an annual growth rate of 2% was used. These population projections for 25 yr in the future are shown in Table C-2.

The projected population dose rates are calculated by comparing the projected population with the present population.

The projected population dose rate from contaminated materials from the associated properties stored on site is 38 manrem/yr. Since the population growth is assumed to be uniformly distributed, the projected population dose rate is increased by the ratio of projected population to present population.

TABLE C-1

SUMMARY OF POPULATION DOSE RATES FOR ATMOSPHERIC MIGRATION OF RADON FROM CONTAMINATED MATERIALS AT THE SITE

| Radial Annulus (mi) | Population in Sector (people) | Average Radon Concentration in Sector (pCi/l) | Average Individual Dose Rate[a] (mrem/yr) | Population Dose Rate (manrem/yr) | Health Effects (Cancers/yr) |
|---|---|---|---|---|---|
| 0-0.1 | 1 | $2.6 \times 10^{-2}$ | 67 | 0.067 | $1.2 \times 10^{-6}$ |
| 0.1-0.5 | 1,700 | $9.8 \times 10^{-4}$ | 2.5 | 4.3 | $7.7 \times 10^{-5}$ |
| 0.5-0.75 | 3,100 | $3.9 \times 10^{-4}$ | 1.0 | 3.1 | $5.6 \times 10^{-5}$ |
| 0.75-1.00 | 4,900 | $2.1 \times 10^{-4}$ | 0.54 | 2.7 | $4.9 \times 10^{-5}$ |
| 1.0-1.5 | 8,200 | $9.7 \times 10^{-5}$ | 0.25 | 2.0 | $3.6 \times 10^{-5}$ |
| 1.5-2.5 | 4,500 | $5.1 \times 10^{-5}$ | 0.13 | 5.9 | $1.1 \times 10^{-4}$ |
| 2.5-3.5 | 20,000 | $3.3 \times 10^{-5}$ | 0.085 | 1.7 | $3.1 \times 10^{-5}$ |
| 3.5-4.0 | 32,000 | $1.9 \times 10^{-5}$ | 0.049 | 1.6 | $2.9 \times 10^{-5}$ |
| 4.0-5.0 | 50,000 | $1.6 \times 10^{-5}$ | 0.041 | 2.1 | $3.8 \times 10^{-5}$ |
| | 164,900 | | | 23 | $4.2 \times 10^{-4}$ |

[a]Based on 0.005 WL/pCi/l, 10 rem/WLM

TABLE C-2

SUMMARY OF PROJECTED POPULATION DOSE RATES FOR ATMOSPHERIC MIGRATION OF RADON FROM CONTAMINATED MATERIALS AT THE SITE

| Radial Annulus (mi) | Projected[a] Population in Sector (people) | Average Radon Concentration in Sector (pCi/l) | Average Individual Dose Rate[b] (mrem/yr) | Population Dose Rate (manrem/yr) | Health Effects (Cancers/yr) |
|---|---|---|---|---|---|
| 0-0.1 | 1 | $2.6 \times 10^{-2}$ | 67 | 0.067 | $1.2 \times 10^{-6}$ |
| 0.1-0.5 | 2,800 | $9.8 \times 10^{-4}$ | 2.5 | 7.0 | $1.3 \times 10^{-4}$ |
| 0.5-0.75 | 5,100 | $3.9 \times 10^{-4}$ | 1.0 | 5.1 | $9.2 \times 10^{-5}$ |
| 0.75-1.00 | 8,100 | $2.1 \times 10^{-4}$ | 0.54 | 4.4 | $7.9 \times 10^{-5}$ |
| 1.0-1.5 | 13,400 | $9.7 \times 10^{-5}$ | 0.25 | 3.4 | $6.0 \times 10^{-5}$ |
| 1.5-2.5 | 73,800 | $5.1 \times 10^{-5}$ | 0.13 | 9.6 | $1.7 \times 10^{-4}$ |
| 2.5-3.5 | 33,500 | $3.3 \times 10^{-5}$ | 0.085 | 2.9 | $5.1 \times 10^{-5}$ |
| 3.5-4.0 | 52,200 | $1.9 \times 10^{-5}$ | 0.049 | 2.6 | $4.6 \times 10^{-5}$ |
| 4.0-5.0 | 82,300 | $1.6 \times 10^{-5}$ | 0.041 | 3.4 | $6.1 \times 10^{-5}$ |
| | 271,200 | | | 38.5 | $6.9 \times 10^{-4}$ |

[a]Projected population in 25 yr.
[b]Based on 0.005 WL/pCi/l, 10 rem/WLM

## APPENDIX C REFERENCES


1. D.H. Salde, ed; "Meteorology and Atomic Energy 1968," TID-24190; Atomic Energy Commission; Jul 1968.

2. F.F. Haywood, P.T. Perdue, D.J. Christian, R.W. Leggett, B.S. Ellis, and D.L. Anderson; "Radon and Radon Daughter Measurements at and near the Former Middlesex Sampling Plant, Middlesex, New Jersey"; DOE report (to be published).

3. H.W. Dickson, et al.; "Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey"; DOE/EV-0005/1; Oak Ridge National Laboratory; Oak Ridge, Tennessee; Nov 1977.

# APPENDIX D

## DESCRIPTION OF EARLY DECONTAMINATION OF THE RECTORY OF THE CHURCH OF OUR LADY OF MOUNT VIRGIN AND THE PROPERTY AT 432 WILLIAM STREET

APPENDIX D

# DESCRIPTION OF EARLY DECONTAMINATION OF THE RECTORY OF THE CHURCH OF OUR LADY OF MOUNT VIRGIN AND THE PROPERTY AT 432 WILLIAM STREET

The Department of Energy and the Borough of Middlesex, New Jersey have held meetings to consider the early decontamination of the Rectory of the Church of Our Lady of Mount Virgin and the property at 432 William Street. This decontamination action would be undertaken prior to the initiation of the remedial action plan for the Middlesex Sampling Plant site and other associated properties.

Early decontamination of the Rectory property and the property at 432 William Street would involve placing the contaminated soil and materials in containers. These containers would then be stored temporarily in the Process Building at the Middlesex Sampling Plant site. Various types of containers could possibly be used. For the purpose of determining costs, 55-gal steel drums with heavy plastic liners of the type used for long-term storage of radioactive materials are proposed. Any decision on the use of containers or steel drums is dependent upon completion of the NEPA process.

The purpose of this appendix is to determine the additional costs for early decontamination of the Rectory property and the property of 432 William Street. These costs are based on using 55-gal steel drums with temporary storage in the Process Building at the Sampling Plant site.

Both the Rectory property and the property at 432 William Street would involve the removal of lawns, shrubbery, pavements, and walkways. The contaminated soil would be excavated and loaded into 55-gal steel drums by using special drum filling and handling equipment. The drums would then be placed on pallets, hauled by truck, and stored in the Process Building at the Middlesex Sampling Plant site. After decontamination, the excavated areas of both properties would be backfilled with clean materials, the walkways and pavements replaced, and lawns and shrubbery replanted.

At the Rectory property, excavation to an average depth of approximately 3 ft would be required to remove the contaminated soil to natural background levels. Approximately 2,200 $yd^3$ of contaminated materials would be involved. Approximately 8,800 55-gal steel drums would be required to store this contaminated material. Approximately 1,800 $yd^3$ of contaminated materials would be involved in removal to 5 pCi/g above natural background levels. This would result in the use of 7,200 drums.

At 432 William Street, excavation to an average depth of 2 ft would be required to remove the contaminated soil to natural background levels. Approximately 650 $yd^3$ of contaminated materials would be involved. Approximately 2,600 55-gal steel drums would be required for storage of this contaminated material. Approximately 500 $yd^3$ of contaminated soil would be involved in removal to 5 pCi/g above natural background levels. This would result in the use of 2,000 drums.

The additional cost for early decontamination of the Rectory property and the property at 432 William Street is estimated to be $385,000 for decontamination to Criterion A and $310,000 for Criterion B. There are two optional criteria levels for decontamination: 5 pCi/g above background or background radium concentration. However, at the time of remedial action, where feasible, one may remove soil to less than 5 pCi/g. This would be in keeping with the ALARA (as low as reasonably achievable) philosophy. This cost is in addition to the amount which would be spent under Options B through E for remedial action. These additional costs include the cost of 55-gal steel drums with heavy plastic liners, the cost of special drum filling and handling equipment, and the significantly higher overall labor costs for filling and handling drums of contaminated materials. Transportation costs would be slightly higher because of the additional weight of the drums. Approximately 40 working days would be required to complete decontamination and restoration in accordance with Criterion A and 30 working days for Criterion B.

The environmental impacts that would occur as a result of implementing the remedial actions necessary under this early decontamination effort are very similar to those described under Option D.

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# ENVIRONMENTAL ASSESSMENT OF THE PROPERTIES ADJACENT TO AND NEARBY THE FORMER MIDDLESEX SAMPLING PLANT, MIDDLESEX, NEW JERSEY

OCTOBER 1980

FOR

NATIONAL LEAD COMPANY OF OHIO

BY

Ford, Bacon & Davis Utah Inc.

The energy engineers.

375 CHIPETA WAY, SALT LAKE CITY, UTAH 84108 · 801 583 3773

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OCTOBER 1980

For

NATIONAL LEAD COMPANY OF OHIO

By

FORD, BACON & DAVIS UTAH INC.
375 Chipeta Way
Salt Lake City, Utah 84108

## FOREWORD

al Assessment has been prepared by the
nergy Systems group of Ford, Bacon & Davis
l Lead Company of Ohio. It is submitted
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y of Ford, Bacon & Davis directed the
Manager. Messers. D.C. Rich, presently
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Page


. . . . . ii
. . . . . iv
. . . . . v

. . . . . 1

. . . . . 2

ION. . . . . 2

RADIOLOGICAL,
MENT . . . . . 5

SEQUENCES DURING
. . . . . 6

. . . . . 6
. . . . . 10
. . . . . 10
Plant. . . . . 11

AFTER
ACTION . . . . . 12

. . . . . 12
. . . . . 12
Plant. . . . . 13

EMEDIAL
. . . . . 13

. . . . . 16

ON . . . . . 17

. . . . . 29

. . . . . C-1

NE AROUND
PLANT SITE. . . D-1

ENTAL
. . . . . A-1

RONMENTAL
. . . . . B-1

## LIST OF FIGURES


| Number | Title | Page |
|---|---|---|
| 1 | Site Location. . . . . | 18 |
| 2 | Locations of Contaminated Properties Adjacent to and Nearby the Sampling Plant Site . . | 19 |
| 3 | Extent of Radium Contamination in the Soil . . . . | 20 |
| 4 | Location of Temporary Storage Area . . . . . | 21 |
| 5 | Results of EG&G "Imp" Survey of 312 Mountain Ave . | 22 |
| 6 | Surface Exposure Rates and Analysis of Soil Samples at 312 Mountain Avenue . . . . . | 23 |

## LIST OF TABLES


| Number | Title | Page |
|---|---|---|
| 1 | Summary of Measurements of Radioactivity | 24 |
| 2 | Health Effects Due to Radioactivity | 25 |
| 3 | Health Benefits to Public from Decontamination | 26 |
| 4 | Summary of Environmental Impacts Resulting from the Proposed Remedial Action | 27 |
| 5 | Sound Levels From Constuction Equipment | 28 |

# ENVIRONMENTAL ASSESSMENT OF THE PROPERTIES ADJACENT TO AND NEARBY THE FORMER MIDDLESEX SAMPLING PLANT, MIDDLESEX, NEW JERSEY

The Department of Energy (DOE) has proposed a decontamination and restoration action to clean up the radioactive contamination on 28 properties adjacent to and nearby the former Middlesex Sampling Plant at 239 Mountain Avenue in Middlesex, New Jersey (see Figure 1). These properties are to be decontaminated and restored to allow continued residential and commercial use with a reduced level of radioactive exposure to the inhabitants. Also, presently undeveloped property would become available for future development without restrictions due to its radiological condition. As a prescribed step in the Formerly Utilized Sites Remedial Action Program (FUSRAP),(1) an environmental assessment serves to (a) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; (b) aid in the DOE's compliance with the National Environmental Policy Act when no environmental impact statement is necessary; and (c) facilitate preparation of a statement when one is necessary. These three steps are also specified in Section 1508.9(a) of the Council on Environmental Quality Regulations for Implementing the National Policy Act.

This Environmental Assessment is based primarily on a radiological report,(2) an environmental analysis report,(3) and three engineering reports(4,5,6) prepared previously. The previous reports are more extensive in that they cover not only the properties discussed here, but also the Sampling Plant site, a rectory of the Church of Our Lady of Mount Virgin, and a residence at 432 William Street in Piscataway. A NEPA determination has been made for these two properties and the remedial action has been completed. This Environmental Assessment presents a summary of the material pertinent to the properties adjacent to and nearby the Sampling Plant.

If the remedial action work is performed, it is possible that contamination will be found on other properties during the decontamination process. The environmental implications specifically applicable to any new area of contamination will be reviewed and a NEPA determination will be made before decontamination is performed on that property.

## 1.0 PURPOSE

The purpose of this Environmental Assessment is to present the environmental consequences of implementing a radioactive decontamination and restoration action on the contaminated properties adjacent to and nearby the Middlesex Sampling Plant site. In accordance with 40 CFR 1508.9,(7) the alternatives are also briefly reviewed.

This report describes the proposed action as well as the alternatives which have been considered previously.(4) The physical and socioeconomical aspects of the present environment which would be affected by the action are described. Also described in the report are: the impacts due to current conditions, those which would result during the remedial action, and those which would result after the action is completed.

## 2.0 NEED FOR REMEDIAL ACTION

The radioactivity measured on the properties ranges as high as 2401 pCi of $^{226}Ra$ per gram of soil, 0.04 WL of $^{222}Rn$, and 235 μR/hr of external gamma (Table 1). A remedial action is necessary to reduce the potential health effects from exposure to the elevated levels of radioactivity. The radiological health impacts due to the present condition of the properties, as calculated in Reference 3 and summarized in Table 2, indicate that there is a potential for $1.3 \times 10^{-3}$ health effects per year.

The health benefits gained by removing the contamination are listed in Table 3. The total health effects avoided over a 50-yr period are estimated to be $7 \times 10^{-2}$. Therefore, if the contamination were not removed, the three exposure pathways listed--inhalation, direct gamma, and ingestion of food grown in contaminated soil--would result in a 7% chance of one person in the area dying during a 50-yr period due to cancer caused by the radiation. This estimate, however, assumes the present population distribution to be constant over the next 50 years. It is possible that employment and population within one mile from the site could be increased to more than double. If such an increase did occur, then the probability of a death due to cancer could be greater than 14% over the next 50 years. To date, there has been no observation of actual effects caused by the radiation on the health or physical well-being of individuals in the vicinity of the contamination.

The vacant areas, however, will be desirable for development because of future growth potential in the area. The area south of the Sampling Plant site contains a higher concentration of radioactivity(2) than the area around the residences and commercial establishments to the east. The present radiological condition therefore could impair the future development of the vacant areas. The value of all the contaminated properties might be depressed, and if depressed, would remain so until the contamination is removed.

## 3.0 DESCRIPTION OF REMEDIAL ACTION

The DOE proposes to conduct a remedial action in the near future to decontaminate the radiologically contaminated portions of 28 properties adjacent to and nearby the former Middlesex

Sampling Plant site, (see Figure 2). (Reference 5 contains a list of property owners.) The contamination covers about 10 acres on residential, commercial, and vacant properties (see Figure 3). This contamination has resulted from wind and water transport of contaminated materials from the Sampling Plant site, and from leaching of the contamination through the soil. Much of the contamination to the south resulted from general sheet flow runoff from the Sampling Plant site before the construction of the drain system was completed.

The project will entail the clearing of the contaminated area, high-heat burning of combustible material, and excavation and removal of about 23,000 $yd^3$(4) of soil and debris. The high-heat burning can be done using a portable unit, such as the Air Curtain Combustion Unit made by Camran Corporation, which is licensed by the State of New Jersey as meeting air emission standards. The materials to be burned are bushes and trees on the residential and commercial properties as well as natural growth on the undeveloped properties. Appendix A is a list of these plantings as previously inventoried. To decontaminate the area, the soils will be excavated to a depth sufficient to reach a radiation level of 5 pCi/g of $^{226}Ra$, or "a superceding criteria promulgated by USEPA, and determined by the New Jersey Department of Environmental Protection (NJDEP) and DOE to be applicable to conditions at Middlesex."(8) The depth of the contamination varies from about 2 ft on the east and west of the Sampling Plant to about 5 ft near the drainage ditch on the south. The exact limits and depths would be determined at the time of excavation. No buildings on the properties are known to be contaminated and thus are not involved in the decontamination. The contaminated material would be hauled across property lines (avoiding the use of local streets) to the Sampling Plant site where it would be temporarily stored and stabilized (see Figure 4). Monitoring wells have been located around the storage area to determine if any radioactivity has entered the shallow aquifers and if an increased level of radioactivity enters the aquifers due to the storage pile.

An asphalt storage pad has been prepared and sealed over an impermeable membrane to assure that no contamination is leached from the pile into the ground. The contaminated material will be totally covered with a rubberized material which will be tied down and sealed under the pile. This results in a sealed envelope around the contamination which will not allow water to leach through the contamination. A drain system has been built around the storage pad which directs any runoff water into a settling basin. This drain system will prevent material from being eroded from the pile of contamination and will not allow it to pass beyond the area.

Decontamination activities could involve removal of improvements such as lawns, ground cover, small trees, shrubs, fences, paved or graveled driveways, sidewalks, swimming pools, etc. The items that could be affected for each property are given

in Reference 5.

After the DOE has certified that decontamination is complete, radiologically clean material would be used to backfill the area excavated. The driveways and sidewalks would be replaced, and the area revegetated as close to the original condition as practical. This work will be performed with the approval of the property owners as far as possible. It is estimated that the excavation operations would require approximately 8 wk. The total project would require approximately 6 mo for completion. (See References 4, 5, and 6 for a more complete description of the decontamination and restoration procedures.)

Decontamination and restoration of the properties in the near future would reduce the levels of continuous exposure to the local inhabitants. It would also allow unhampered development of the undeveloped areas. If development were to continue without decontamination, later decontamination would involve excavation and restoration of the new development as well. It is possible that this would involve major buildings, homes, and streets. This could be avoided by not allowing future development until the area is totally decontaminated and restored. Such a restriction, however, would place hardships on the owners of the property. It also places possible restrictions on the revenue of the local political authority since any new commercial establishment in that area would theoretically attract more tax dollars.

The proposed remedial action would store the contamination temporarily at the Sampling Plant. That property is presently owned by the U.S. government and is fenced. Wells have been placed around the area to monitor the ground water. An area is prepared where the contamination can be stored. The Sampling Plant itself is contaminated, and there is already a pile of contaminated materials stored there from two other local sites which have recently been decontaminated. The Sampling Plant is immediately adjacent to all of the contamination, although some of the properties are set back behind other contaminated properties.

The contaminated materials therefore can be very readily stored at the Sampling Plant. The presence of such a pile of contaminated material could, however, still cause some fear and misunderstanding among the local citizens. When a permanent disposal site is selected and prepared all contamination at the Sampling Plant could be removed to the permanent disposal site. The Sampling Plant site could then be re-used by the government or sold to others who could use it for other purposes.

The buildup of contaminated material at the Sampling Plant site will cause a slight increase in radon emanation from the area. The slight increase in exposure for a person living full time at the fenceline of the Sampling Plant has been

estimated to be a maximum of 7.3 mrem/yr. This exposure is discussed in more detail in Appendix B.

## 4.0 EXISTING AFFECTED PHYSICAL, RADIOLOGICAL, AND SOCIOECONOMICAL ENVIRONMENT

The area of concern is generally flat, and the elevation is about 55 ft above sea level. The dominant soil types are silty to sandy loams from 1.5 to 8 ft thick over bedrock. The common characteristics of the upper soil type include shallow slopes and a seasonably high water table.(3)

Surface waters in the vicinity of the site are shown in Figure 2. A mosquito abatement ditch (see Figure 2) that begins west of the drainage ditch flows westward, then joins Main Stream about 1,700 ft west of its origin. Another small ditch that originates just to the south of the Sampling Plant site and west of the drainage easement ditch carries little water away from the area. A "dry" ditch is located along the northern margin of the Sampling Plant site paralleling the railroad tracks. There also is evidence of water flowing onto and off of the Sampling Plant site during and after intense rainstorms.(3,4)

At or near the Sampling Plant site, subsurface systems include: a sewer system, which runs along Mountain Avenue, and connections to this line; a water main serving the area; and several drains under the Sampling Plant site which collect surface runoff and which direct the collected water towards a drainage easement ditch south of the site.(3)

Average annual precipitation is 41.64 in. The recorded low is 20.09 in. during 1965, and the high is 53.30 in. recorded in 1952. Total moisture is spread evenly throughout the year. Average annual snowfall is 27.5 in., with as few as 1.9 in. recorded during the winter of 1972-1973, and a maximum recording of 73.5 in. during the winter period of 1960-1961.

Although there is a possibility of the existing contamination leaching into ground water aquifers, sample analyses of well water do not indicate that contamination from the area reaches deep aquifers; and shallow aquifers are not tapped near the area.(3)

To reduce the possibility of contamination leaching into the aquifer, the ground beneath the pile of contaminated soil has been prepared with an asphalt pad, and the pile will be covered with a rubberized material, as discussed in Section 3.0.

If significant increased contamination is ever detected entering the ground water aquifers after the pile is in place, the contaminated soil will have to be removed to a distant site.

Winds are predominantly from the southwest at a mean speed of 10.2 mi/hr. During January, the average wind velocity is from the northeast at 11.1 mi/hr. During February and March, winds are from the northwest at average velocities of 11.6 and 12.0 mi/hr, respectively. During the remainder of the months, the winds are primarily from the southwest.

The State of New Jersey Department of Environmental Protection Division of Fish, Game and Shellfisheries has an official list of "Endangered, Threatened, Peripheral and Undetermined Wildlife Species in New Jersey." None of these species has been identified to exist principally in or to be indigenous to the areas of the site.

None of the rare or endangered plant species has been identified on the properties. The amount of growth removed from the undeveloped properties should not significantly affect any wildlife species.

There have been no structures on the properties which have been identified on the National Register of Historic places.

## 5.0 POTENTIAL ENVIRONMENTAL CONSEQUENCES DURING REMEDIAL ACTION

The proposed remedial action would impact the environment directly and indirectly. The direct effects are those impacting the immediate physical environment, such as air quality. The indirect effects are those affecting the general human environment, such as depletion of oil resources. Since most of the impacts cannot be quantified, they are described as being: Short Term Beneficial (STB), Short Term Adverse (STA), Long Term Benefical (LTB), and Long Term Adverse (LTA). Table 4 summarizes the environmental impacts resulting from the proposed remedial action. Appendix C is a generic list of environmental impacts which have been considered.

Although negative impacts could occur, most of these will be controlled or reduced by the use of proper procedures. The mitigating measures to be used to reduce the negative impacts are discussed in Section 5.3.

### 5.1 Direct Effects(3)

Air quality would be subjected to an STA impact during clearing, excavation, backfilling, and restoration operations. Increased exhaust fume levels and radioactive dust might reduce air quality. This impact will be minimized by effective control procedures as discussed in Section 5.3.

Air particulate samples were collected near the Rectory before, during, and after the remedial actions there. A minor increase in radioactivity was noted. The radioactive isotope with the most restrictive maximum permissable concentration of the $^{238}U$ alpha emitting progeny is $^{230}Th$ with a maximum

permissable concentration of $8 \times 10^{-8}$ Ci/cc. The maximum radioactivity detected during remedial action was $2.3 \times 10^{-8}$ Ci/cc, more than a factor of 3 below the most restrictive guideline.

External gamma radiation levels might increase temporarily as a result of excavating the contaminated soils. This increase would be an STA impact since it occurs only for the duration of the remedial action work. The workers in the immediate vicinity of the increase would be affected most. High-heat burning probably would not increase ambient radiation levels because plant uptake of the radionuclides is small. It is estimated that a maximum dose of about 10 mrem to the whole body (from gamma rays) to each worker could result over an 8-wk period required to complete the excavation of contaminated material. (See paragraph B.2.1 of Appendix B in Reference 3.) This exposure is less than the Federal Radiation Council Guideline level of 27 mrem in 8 wk (calculated, see Table 1). Nevertheless, this exposure would be a minor LTA impact because the individual's whole body burden in terms of lifetime radiation exposure would be increased by a small amount during the period required for the decontamination of these properties.

Health effects from radiation are assesed in terms of the excavation and loading of an estimated 23,000 $yd^3$ of contaminated materials. Since radiation exposure is cumulative, a short-term exposure constitutes a long-term impact on the health of a person. This impact is expected to be minor. The estimated dose of 10 mrem to each worker corresponds to a probabiilty of $10^{-6}$ of causing cancer. In percentages, this is 0.0001 percent chance that an individual worker will die from cancer caused by working on these properties for 8 weeks.

Soil erosion might result in an STA impact. Although this has a potential for being significant during a period of heavy rainfall, the excavation and storage will be performed in such a way as to prevent such an occurrence. If it did occur, the worst effects would probably be unsightly erosion and sedimentation.

Surface water quality also might experience an STA impact due to soil erosion. This would occur particularly in the area south of the Sampling Plant site because of an increase in solids in the surface waters from erosion during the clearing, preparation, excavation, restoration, and storage operations. However, the work will be performed in such a way as to preclude such an occurrence. During remedial action operations at the Rectory and 432 William Street, the soil was excavated and bermed in such a way that no solids were carried from the properties in the runoff.

Soil. New Jersey conservation laws do not permit borrow pit operations. It is projected that any soils derived from areas outside the site would be taken primarily from overburden

materials excavated from new construction projects. Investigation has shown sufficient construction projects are in progress to enable obtaining the necessary soils. If, for some reason, sufficient soil is not available, the project would have to be delayed until the soil became available.

Vegetation removal before excavation begins would be an unavoidable STA impact. However, none of the rare, undetermined, or endangered plants or other botanical species identified in New Jersey has been shown to exist near the Sampling Plant site; therefore, no impacts upon such species would result.

Fauna would be impacted on an STA basis during the decontamination. None of the rare or endangered wildlife species has been identified or shown to exist upon the site area; nevertheless, the lack of habitat represents a potential environmental impact to fauna. No economically important game animals or fish are present in the contaminated areas. During this remedial action, the major foreseeable impact on the fauna would be the disruption of their habitat and loss of sustenance.

Mineral resources in terms of potential energy-producing materials or substances of strategic value are not known to be within the area of these operations. Consequently, potential impacts on mineral resources would be nonexistent.

Socioeconomic impacts associated with implementation of decontamination and restoration would include STB impacts to area employment, STA impacts on aesthetics, but no applicable effects on land values during excavation. Any influx of workers would be minimal and would not place hardships on the area with respect to living accomodations, schools, or social facilities during the remedial action operations. During the remedial action at two other properties in Middlesex which were recently decontaminated, approximately 40 people were utilized, of which half were from outside the area. It is estimated that approximately the same number of people in the same proportions will be involved at these properties.

Some STA impacts could result to property owners during excavation operations since the materials are to be stored on the site. The creation of a storage pile as high as 8 ft above ground elevation might be aesthetically displeasing, even if the pile were seeded.

Access to residential and commercial properties would be restricted. This restricted access would result in an STA impact. Impact will be held to a minimum by proper organization of the excavation efforts and minimizing the time required to perform the work. No access will be denied and no relocation of any tenants will be required. Since no structures are

contaminated, they will not be affected directly. Any inconveniences will be minimized during the period of performance.

Traffic would have a very minor STA impact. Since no roads would be used to transfer the materials to the Sampling Plant, general traffic would be impacted only by the additional workers traveling to the site, the transport of equipment to the site, and the transport of the backfill. The national average for motor-vehicle accidents in 1978 was 3.39 deaths and 131.65 disabling injuries per 100,000,000 miles traveled.(9) It is estimated that there will be a round-trip haul distance of about 40 miles for the backfill and it will be transported in 10-$yd^3$ loads. It is also assumed there will be 40 workers who will travel 20 miles per day extra within the area for 12 weeks and 20 workers for an additional 14 weeks. This results in a 0.57% chance of a traffic fatality and a 22.1% chance of a disabling injury caused by increased traffic within the local area.

Public utilities might have an STA impact if services were disrupted as a result of clearing or excavating operations. However, it will be required that any disruption will be only momentary (long enough to change to temporary services, if required). This should not be required for water and sewer since they are below the depth of the contamination. It may be necessary to connect temporary power and telephone lines if they hang low enough to hamper the excavation. Any disruption for a significant time interval will be accidental and will affect only the individual residence.

Industrial accidents create an additional area of STA impacts. The industrial accidents during remedial action can be estimated by assuming 16.7 accidents per 100 man-yr of work. This was the average rate of total accidents for 1976 and 1977 in heavy construction, excluding highways.(10) Assuming a crew of 20 men for 12 weeks of work, there is an 77% chance of 1 accident. This means that each worker would have a 4% chance of being involved in an accident.

Noise would be an unavoidable STA impact. The noise increases above present levels would be produced by equipment and trucks during clearing, excavation, and restoration operations.

Table 5 shows estimated noise levels typical of the types of equipment to be used. During remedial action of the Rectory and 432 William Street, no record was kept of the noise levels. No complaints of noise were registered, however, until sandblasting of walls was begun. Since complaints were raised, the sandblaster was exchanged for less noisy equipment. It is expected that no equipment will be used which exceeds appropriate standards.

## 5.2 Indirect Effects

Public funds would experience an LTA impact, in general, but an STB impact on the local area. The cost for performing the proposed work would come from the federal government through the Department of Energy. Part of this cost would aid in improving the local economy by providing additional work to the local contractors. Other workers from outside the area would also spend their money on the local market during the time they are there.

Petroleum supplies would experience a minor LTA impact. The potential impact, however, would be negligible since the only petroleum used would be that necessary to operate the equipment.

Local political objectives are in agreement with the decontamination and restoration of the properties. The local citizens are, in fact, highly in favor of the proposed remedial action and would like to see it consummated quickly.

## 5.3 Mitigating Measures

Through proper planning and coordination, adverse impacts will be minimized. Dissemination of information to the public will be provided during remedial actions to help in diminishing the reactions of a concerned public.

During the excavation, dust will be controlled through the use of water sprays. Any person working in an area of high dust will wear a filter mask. During the remedial action at the Rectory and 432 William Street, dust masks and personal respirators were not necessary. Only at one time did a worker use a dust mask while chipping tar paper off from basement walls. The main dust control method used was sprinkling of the ground. Calcium chloride was also used as a dust suppressent while digging trenches at the Sampling Plant. Dust masks, respirators, and the chemical dust suppressent were available for use at any time if needed. They shall also be available during the proposed remedial action at the adjacent properties.

All workers will use changing facilities provided at the Sampling Plant to change into specific clothing during working hours. At the end of each day, this clothing will be left at the Sampling Plant. It will be appropriately laundered before each use. When necessary, shoe covers will be used to help avoid the spread of any contaimination. Through these and any other appropriate methods of industrial hygiene, no contamination will be carried from the site or enter the lungs of a worker.

Exhaust fumes from excavation and construction equipment will be minimized through proper equipment maintenance.

Proper maintenance and the use of bafflers and mufflers also will be required to minimize noise levels.

External gamma radiation levels will be controlled by using the water sprays as well as by training the workers in methods for preventing the spread of contamination. Continual radiation monitoring will be implemented to help detect and to prevent any spread of contamination, and to ensure adequate decontamination measures. Public access to work areas will be restricted to avoid public exposure to and spread of contamination.

Erosion controls will be instituted by minimizing the exposed surface area of contaminated soils and by use of berms adjacent to any drainage areas. Other actions could include use of diversion ditches, dikes, fiber mats, and other temporary erosion control measures as needed.

Efforts will be made to ensure a minimum of disruptions and inconveniences to the local residents and workers during the remedial action operations. Planning and coordination of hauling activities with local authorities will reduce any traffic impact even further. For example, local streets will be used for these operations at times other than periods of peak traffic flow. All operations will be conducted during daylight hours so as not to cause a noise problem during the night. Air particulate and radon measurements will be taken at the site during the remedial action to insure compliance with state and federal regulations.

## 5.4 Effects at the Sampling Plant

Since the Sampling Plant is adjacent to the properties to be decontaminated, the effects on air and noise will be indistinguishable from the effects caused by the remedial action operations. The contamination will be controlled in such a way that the air quality is not reduced significantly. The noise will be caused by the same types of equipment as at the excavation sites. And since the Sampling Plant is further away from any residences than the properties to be decontaminated, the effects should be even less.

External gamma exposure, health effects, and industrial accidents to those workers at the Sampling Plant are included in the estimates presented above. The estimated effects to each individual are the same as for each individual worker at the excavation sites.

The contamination will be stored as previously described so the water quality will not be affected.

There will be no effect at the Sampling Plant on the rest of the subjects listed for the adjacent properties.

## 6.0 ENVIRONMENTAL CONSEQUENCES AFTER COMPLETION OF THE REMEDIAL ACTION

Most of the environmental consequences which remain after the remedial action would be LTB impacts. The reduction in radiological contamination would reduce the health risks and could increase the land values. These impacts are listed in Table 3.

### 6.1 Direct Effects

Air quality would experience an LTB impact compared with present conditions. The radon flux would be reduced since the contaminated soil would be removed.

External gamma radiation levels would be reduced, resulting in an LTB impact. The soil, excavated down to 5 pCi of $^{226}Ra$ radiation per gram of soil, would be covered with clean fill, which would reduce the surface radiation even more.

Health effects would be lowered, resulting in an LTB impact. This would occur as a result of a reduced exposure potential from the radon flux, and because there would be no exposure potential from external gamma radiation.

Ecology would experience STA impacts only until the vegetation on the decontaminated lands were reestablished. The cleared portion of the vacant land south of the site would be planted with grass. Also, if not used for other purposes, this land would experience natural restoration.

Surface water quality would experience a minor LTB impact since any precipitation runoff would not contain contaminated materials.

Socioeconomic LTB impacts could result since the properties could increase in value and might be utilized more economically since all properties would be available for full use with no radiological restrictions. The commercial and residential properties could be used as they presently are, but they would have reduced readioactive exposure. The undeveloped lands would be available for development.

At the present time a major commmercial and residential development has been proposed for the area south of the Sampling Plant. DOE has requested that the development be phased so that the part on contaminated soil will be developed last.

### 6.2 Indirect Effects

The indirect effects should remain as stated in Section 5.2. The expended public funds and petroleum supplies could not be recovered, resulting in LTA impacts. Similarly, the

political objectives would have LTB impacts with the removal of the contamination from the residential and commercial properties.

## 6.3 Effects at the Sampling Plant

There will be an impact on the use of the land at the Sampling Plant. As long as the contamination remains, the land cannot be utilized for other developments. The federal government would have to maintain the land in a reserved status. It could not be used for pusposes such as a marine base as it has been in the past.

There will be a small quantity of 222Rn being emitted from the pile as long as it remains. This radon emission has been analyzed with two separate methods; the method which uses a maximum possible emission rate has been added as Appendix D. Even the maximum exposure projected for a person living in a house at the fenceline is only 7.3 mrem/yr.

## 7.0 ALTERNATIVE OPTIONS TO THE REMEDIAL ACTION

The following six options have been discussed previously(4) and have been considered as alternatives to the remedial action:

(a) No Action

(b) Minimal Action - restricting public access to the contaminated property

(c) Stabilization or Entombment - in situ covering or total encapsulation of contaminated soils

(d) Partial Decontamination - cleanup of contaminated areas, particularly within buildings.

(e) Decontamination and restoration of the properties in the near future with permanent storage at the Sampling Plant.

(f) Direct disposal to a remote, permanent disposal site.

No action would leave the contamination at the present levels (see Table 1), which are above the present guidelines. The levels of radioactive exposure would remain the same, and the fears and anxieties of the people would continue. Development in the area may be retarded, but, if not, the exposure rates would increase as the population within the contaminated area increased. It is expected that over the next 50 years there will be approximately a 7% chance of one health effect in the area. This rate assumes that the present levels of contamination continue and the population remains

as at present. An increased population would increase this probability.

Minimal action is normally applied to vacant lands which are stable. In Middlesex the contaminated properties would have to be purchased and fenced. Since the area is suburban, fencing off homes and commercial establishments may not be desirable. Part of the area would have to be stabilized to avoid any future erosion by wind or water. Such stabilization would be significant in some areas south of the Sampling Plant, especially through the drainage area where the water runs constantly. Perpetual monitoring of the area would be required to assure that no contamination leached into the ground water. The homes and buildings in the area would become attractive nuisances and could readily develop into an eyesore. The large fence around the area within a suburban environment would emphasize the eyesore. Perpetual maintenance of the grounds and buildings would be required to reduce the distraction of the area. Such maintenance could become extensive if all of the lands and buildings are to be maintained in a condition comparable to the immediate neighborhood. The nearby residents would not desire an eyesore which significantly reduces the value of their lots.

Stabilization would also require purchasing the property. The entire area would have to be cleared of all buildings and growth. Sufficient cover material would have to be built up over the area to permanently stabilize it. The present guideline for this cover material is 10 ft. An earthen cover 10 ft high in a suburban area would probably not be desirable to the surrounding residents. The visual pollution of such a mound may readily reduce the real estate values. The cover would need to be seeded to reduce the undesirable effects. This area still would require perpetual maintenance to maintain the growth as an enhancement and not as an emphasis of the eyesore. Perpetual monitoring also would be required to assure that no contamination leaked into the ground water.

Partial decontamination is often performed in buildings or in areas with spots of high radioactive contamination. The hot spots are removed to reduce the immediate levels of exposure until total decontamination can be achieved. The properties around the Middlesex Sampling Plant have no significant hot spots which demand immediate decontamination. The projected health effects from a short delay of the entire cleanup project would be very low. If there is reason to delay the decontamination and restoration, the entire remedial action should be delayed.

Permanent Disposal at the Sampling Plant. It is possible to leave the contaminated material at the Sampling Plant. This would require more permanent preparation of the storage area. The contaminated material would require a 10-ft layer of cover material to abide by presently proposed guidelines and restrict

any radon emanation. This would result in a storage pile approximately 18 ft high, which is 8 ft higher than presently allowed in Middlesex. A pile this high would create significant visual pollution and may deter developers from improving the surrounding area, even through it had been decontaminated and restored. Real estate values may be adversely affected. Perpetual monitoring and maintenance would be required. The permanent presence of the pile on the Sampling Plant would restrict any other use of the Sampling Plant.

Direct Removal to a Permanent Remote Disposal Site. It is possible to remove the contamination directly to a permanent remote disposal site. There are, however, no commercial disposal sites available at the present time. A possible government disposal site is the Nevada Test Site. This would result in a transport distance of approximately 2,750 mi, which would significantly increase the cost of the decontamination.

It is possible to delay the decontamination until another permanent disposal site closer to Middlesex has been prepared. There are presently no plans for such a disposal site, and the NEPA process has not been started. It would therefore require a significant delay before the material could be removed. The advantages lost by not completing near-term decontamination are listed in Section 3.0.

A significant advantage of direct disposal to a remote site is the reduced cost by avoiding temporary disposal. The expense of piling and compacting the contaminated material and covering it with rubberized material could be avoided. Although this cost is much less than the cost of transportation to the Nevada Test Site, there will be some transportation involved wherever the remote disposal site is located.

Direct disposal would also avoid any visual pollution caused by the presence of the pile. Monitoring and maintenance would be avoided. It would remove all possibilities of engendering fear among the local citizens.

One other option suggested is decontamination and restoration of the properties with temporary storage at a nearby site different from the Sampling Plant. This was not considered to be a viable option since:

(a) The Sampling Plant is already owned by the federal government. Any other site would have to purchased.

(b) Transportation to any other site would have more significant environmental impacts.

(c) The storage pad at the Sampling Plant has already been prepared and sealed and a drainage system has been installed.

(d) Monitoring wells have already been located around the storage pad at the Sampling Plant.

(e) The Sampling Plant already contains a pile of contaminated material excavated from 2 other properties.

(f) The storage is only expected to be temporary. Storing contamination temporarily at two locations when one would be sufficient is not logical.

(g) The sentiment of the local residents would be strongly opposed to storing the contamination at any other location.

## 8.0 NEWLY DISCOVERED CONTAMINATION

As mentioned previously, it is possible that during remedial action operations additional areas of relatd contamination could be discovered. If it is discovered, each area of contamination will be evaluated for any environmental impacts. If contamination is located on properties adjacent to those being decontaminated, it is expected that all environmental impacts would be the same as those impacts for the properties which are the subject of this report. It is possible, however, that there will be some impacts which differ. If appropriate, a NEPA determination will be made for new areas of contamination.

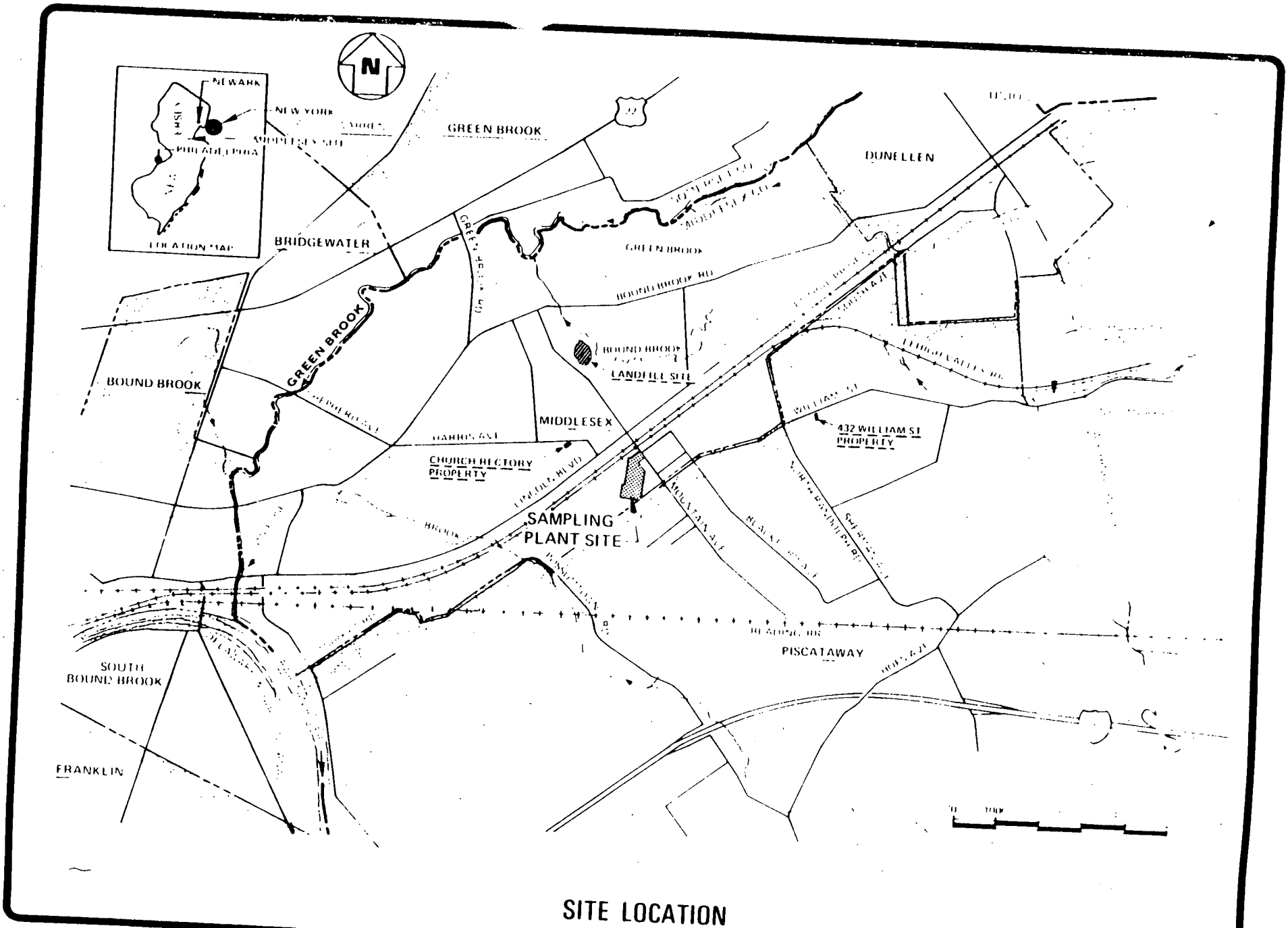
Just prior to printing the final copy of this report, an additional area of minor contamination was discovered. To avoid the expense of re-drafting this report with words and figures which represent all 29 known properties, this property has been added to this report as newly discovered contamination. Only those environmental impacts which are different for this property will be discussed.

This additional property is owned by Joseph Kays. It is located at 312 Mountain Avenue, directly across from the Ianiero property. There appears to be an area of approximately 100 $yd^2$ which has slightly elevated concentrations of $^{226}Ra$. Figure 5 shows the location and results of a surface survey. Figure 6 shows the results of soil sample analyses.

This property appears to have only minor contamination which will not cause any environmental impacts, except one, different from the other 28 properties. The only impact different will be the need to cross Mountain Avenue to transport the contamination to the Sampling Plant site. This impact will be very minor and should cause no significant problems. The contamination from both the Rectory and 432 William Street was transported along local roads without incident. The contamination on this property is much less than the contamination was on those properties. The transport distance on public roads is negligible in comparison.

## 9.0 SOURCES CONSULTED

The Environmental Analysis(3) was distributed to 39 different people and organizations for review and comment (see Appendix D). Timothy Poff of National Lead of Ohio was consulted concerning the dust control methods used while performing remedial action at the Rectory and 432 William Street. He also provided information concerning the air quality data collected during that remedial action. EG&G of Idaho was consulted concerning the recently identified contamination at the Joseph Kays property.




SITE LOCATION

FROM REFERENCE 4

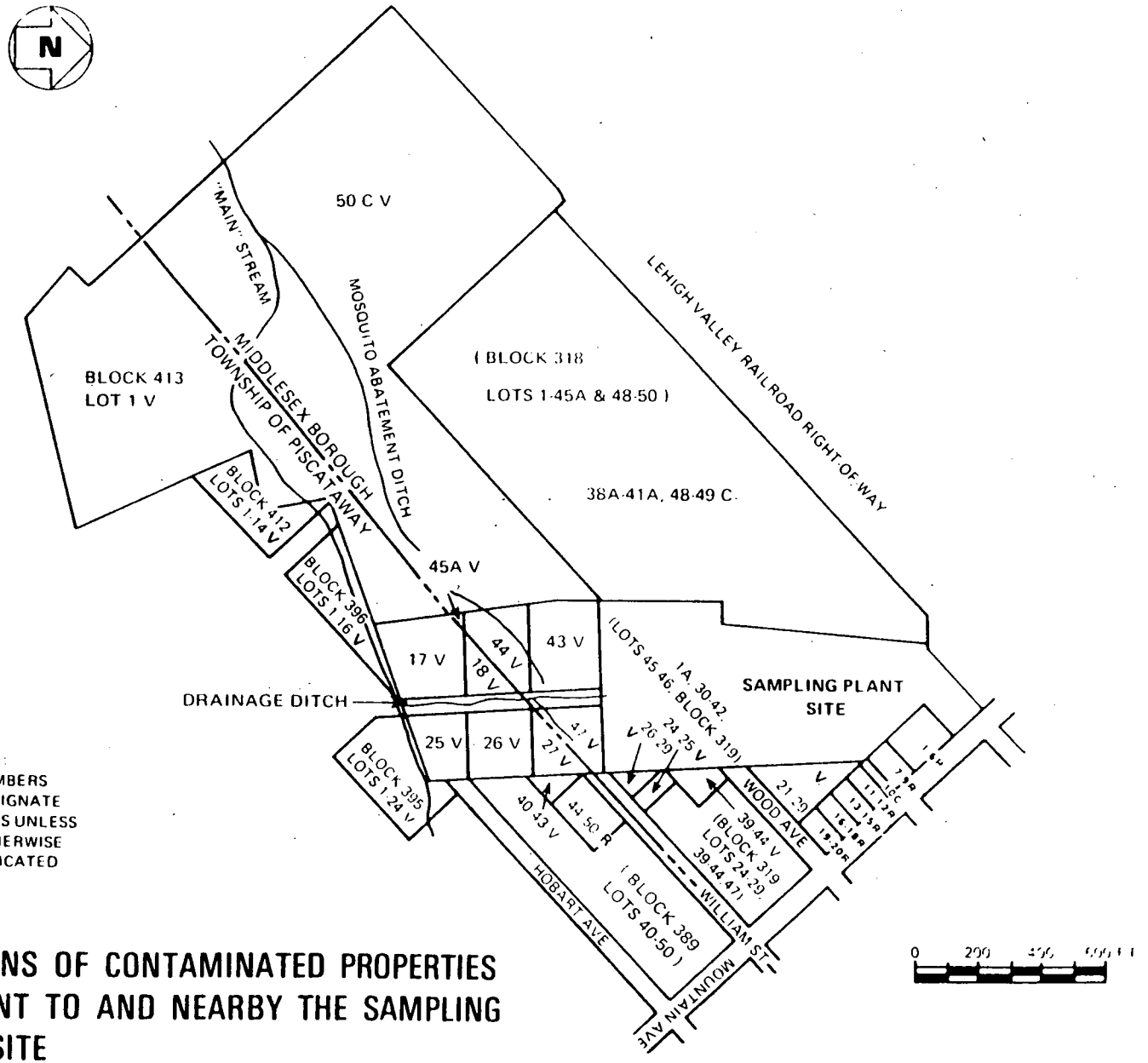
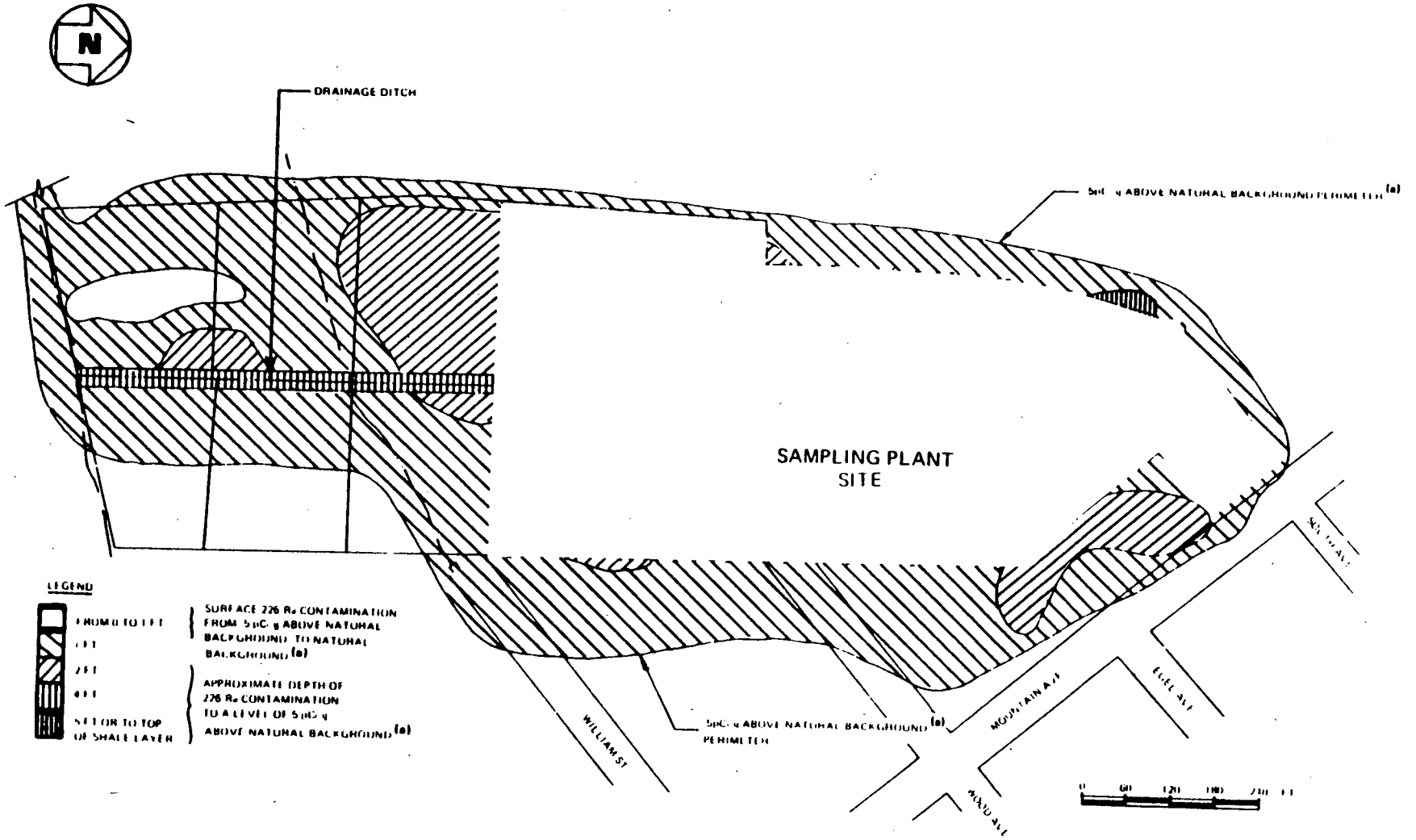



FIGURE 2 LOCATIONS OF CONTAMINATED PROPERTIES ADJACENT TO AND NEARBY THE SAMPLING PLANT SITE

FROM REFERENCE 4




(a) NOTE THAT THIS FIGURE WAS DRAWN DURING WORK ON A PREVIOUS REPORT THE PRESENT GUIDELINE FOR CONTAMINATION REMOVAL IS 5 pCi/g of $^{226}Ra$, INCLUDING BACKGROUND.

FIGURE 3 EXTENT OF RADIUM CONTAMINATION IN THE SOIL

FROM REFERENCE 4

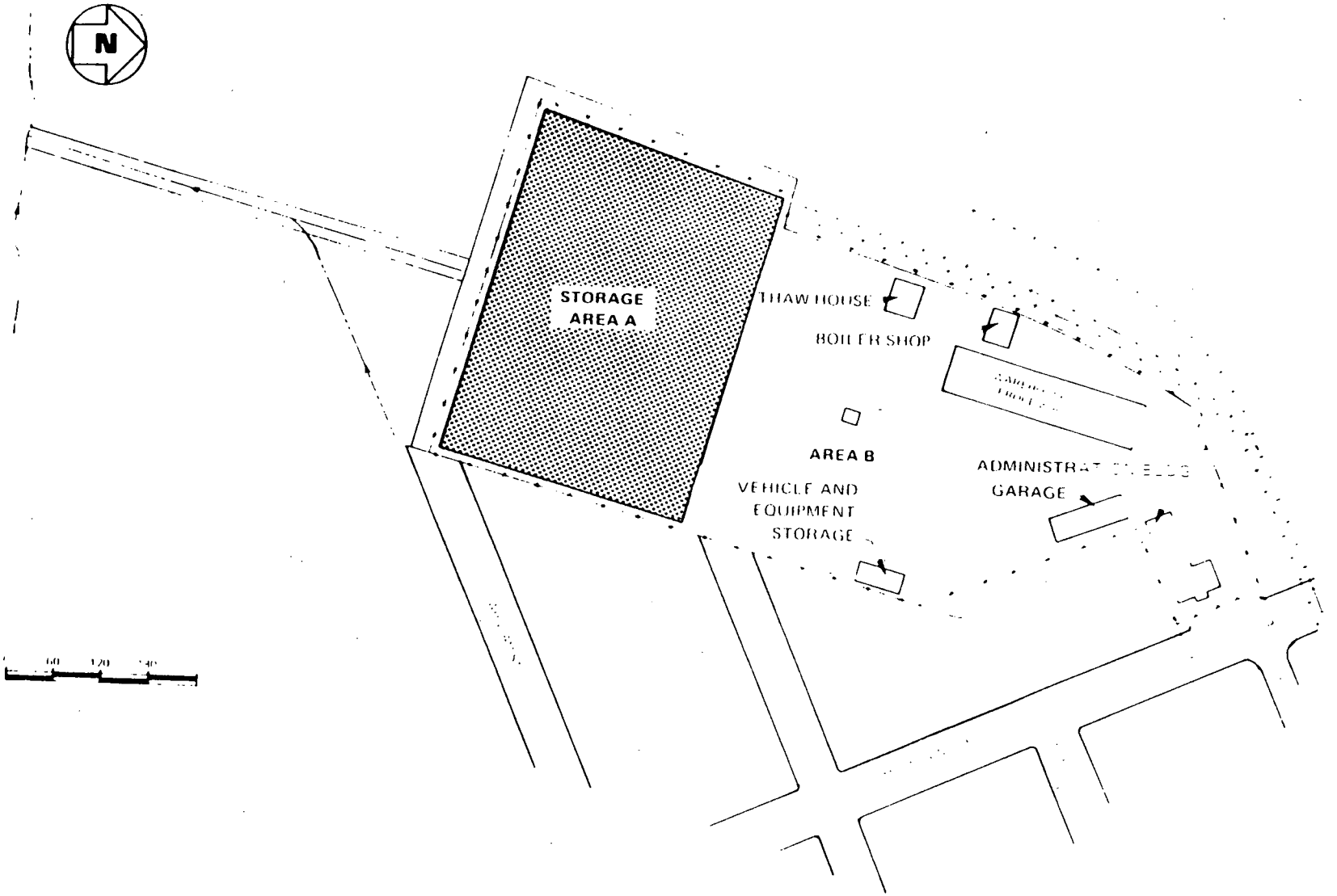



FIGURE 4 LOCATION OF TEMPORARY STORAGE AREA

FROM REFERENCE 4

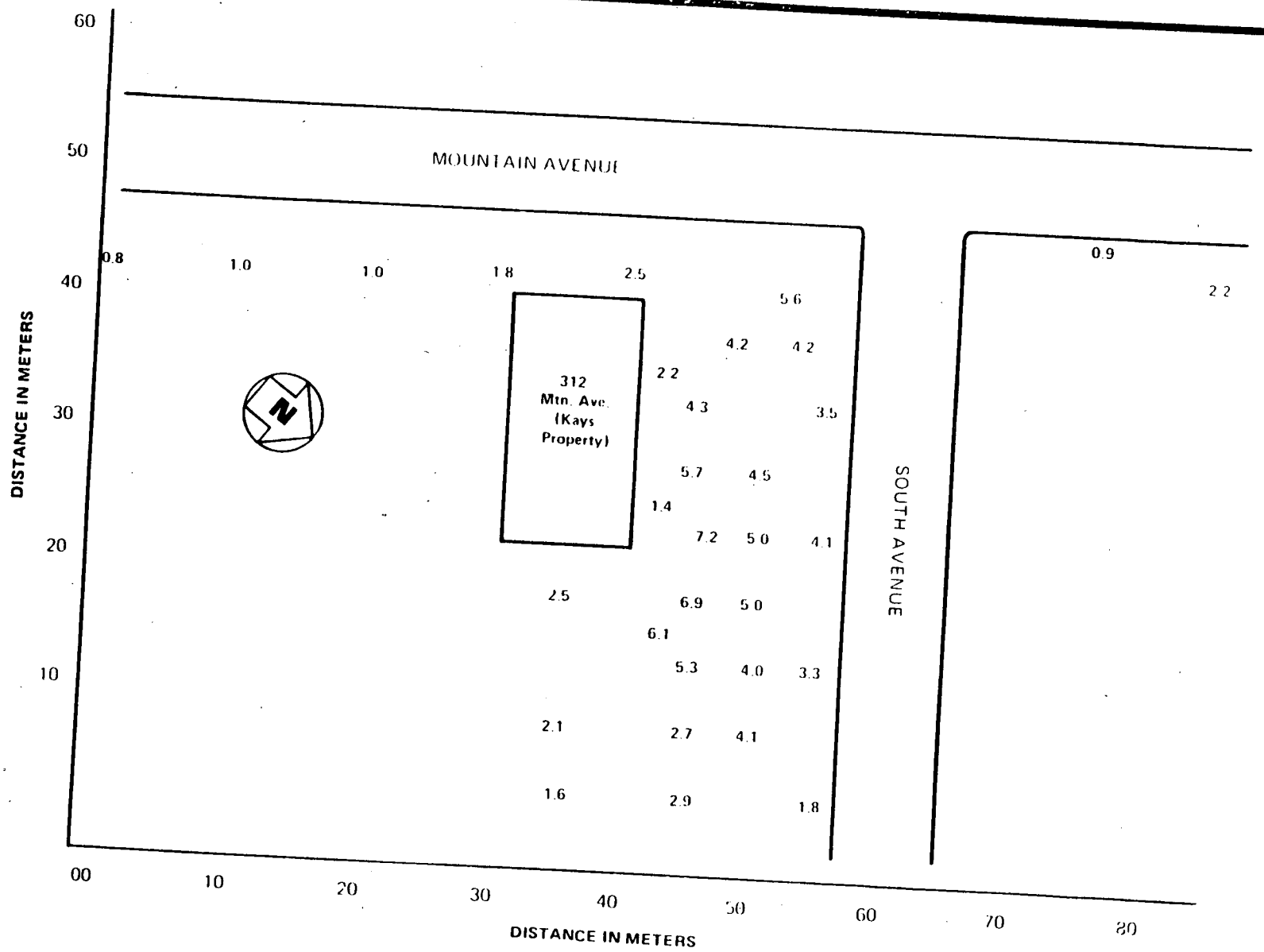
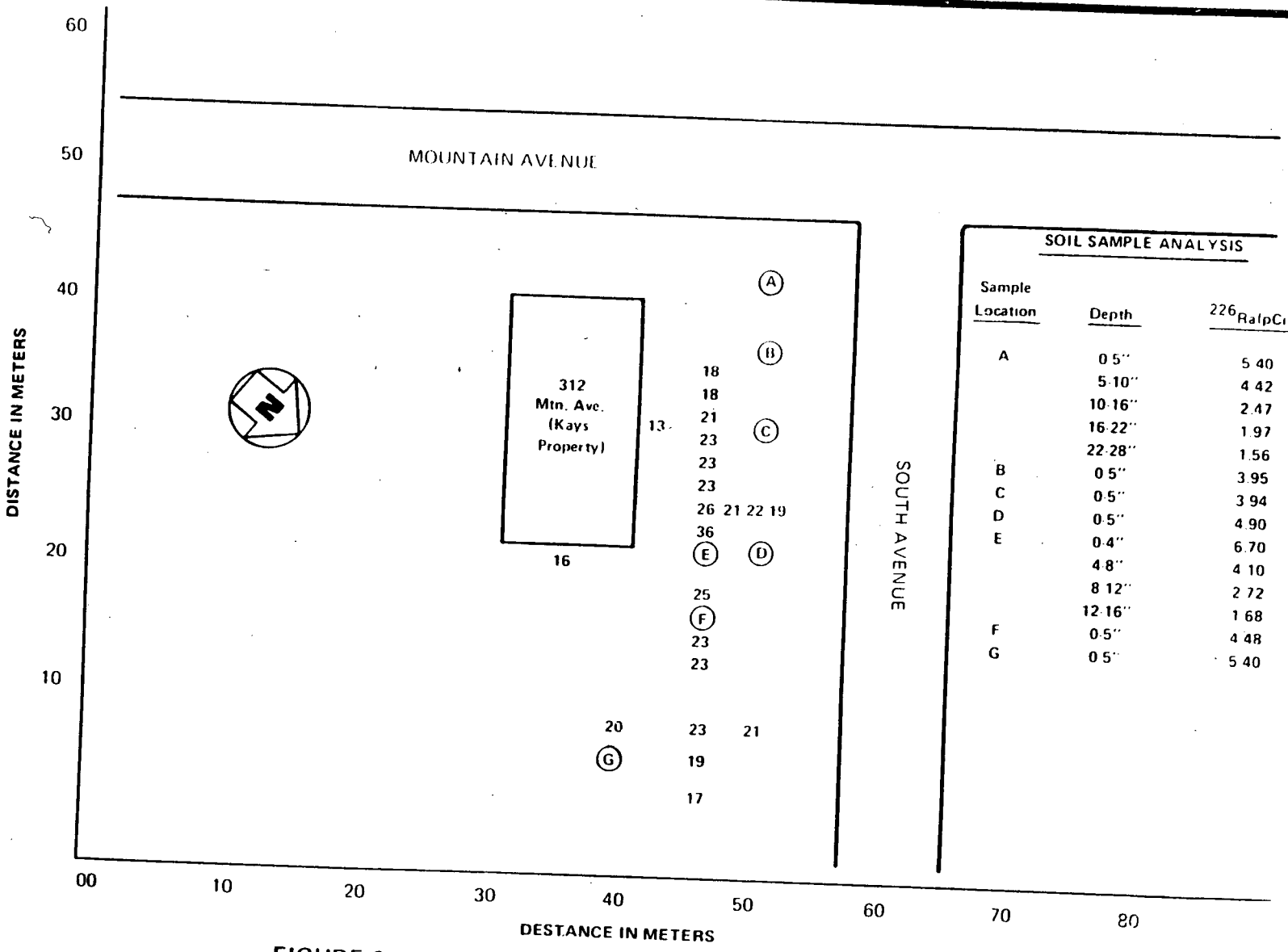



FIGURE 5 RESULTS OF EG&G "IMP" SURVEY OF 312 MOUNTAIN AVENUE



Ford, Bacon & Davis Utah Inc.




SOIL SAMPLE ANALYSIS

| Sample Location | Depth | $^{226}$Ra(pCi/g) |
|---|---|---|
| A | 0-5" | 5.40 |
| | 5-10" | 4.42 |
| | 10-16" | 2.47 |
| | 16-22" | 1.97 |
| | 22-28" | 1.56 |
| B | 0-5" | 3.95 |
| C | 0-5" | 3.94 |
| D | 0-5" | 4.90 |
| E | 0-4" | 6.70 |
| | 4-8" | 4.10 |
| | 8-12" | 2.72 |
| | 12-16" | 1.68 |
| F | 0-5" | 4.48 |
| G | 0-5" | 5.40 |

FIGURE 6 SURFACE EXPOSURE RATES AND SOIL SAMPLES AT 312 MOUNTAIN AVENUE

(No. are $\mu$R/hr at the surface; (A) denotes soil sample locations)

TABLE 1

SUMMARY OF MEASUREMENTS OF RADIOACTIVITY(1)

| Parameter | Measurement on Properties | Natural Background | Remedial Action Guidelines (above Natural Background) |
|---|---|---|---|
| Radium ($^{226}Ra$) in Soil | 0.5-2401 | 1.7 | 5(2) |
| Radon Daughters (WL) | 0.002-0.040 | 0.009 | 0.02 |
| External Gamma Radiation (μR/hr) | 8-235 | 10 | 20 |
| Transferable Surface Contamination (dpm/100 cm2) | No data | -0- | 20 |

(1) Data from References 2, 11, and 12.
(2) Although other guidelines are mentioned in the above references, a decontamination criterion of 5 pCi of $^{226}Ra$ per gram of soil has been established by agreement with the State of New Jersey and the Borough of Middlesex.(8)

TABLE 2

HEALTH EFFECTS DUE TO RADIOACTIVITY

| | Average Radon and Radon Daughter Concentrations | | Dose to Lungs | | Maximum Gamma Rates | Individual Dose | Health Effects | Population Effects | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | pCi/l[a] | WL | WLM/yr[a] | mrem/yr | μR/hr | mrem/yr | per yr | Number of People (24 hr/day equivalent) | Lung Dose mrem/yr | Health Effects per yr |
| Direct Inhalation | 0.5 | 0.004 | 0.2 | $5.0 \times 10^{2}$ | -- | -- | $3.6 \times 10^{-5}$ | 32 | 6.1 | $1.1 \times 10^{-3}$ |
| External Gamma: | | | | | | | | | | |
| Residences | -- | -- | -- | -- | 5 | 44 | $4.4 \times 10^{-6}$ | 24[b] | 1.0 | $1.1 \times 10^{-4}$ |
| Commercial | -- | -- | -- | -- | 30 | 60 | $6.0 \times 10^{-6}$ | 8[b] | 0.5 | $4.8 \times 10^{-5}$ |
| Total | 0.5 | 0.004 | 0.2 | $5.0 \times 10^{2}$ | 35 | 104 | $4.6 \times 10^{-5}$ | 64 | 7.6 | $1.3 \times 10^{-3}$ |

[a] Measured values above natural background.
[b] Estimated, from Reference 3.

TABLE 3

HEALTH BENEFITS TO PUBLIC FROM DECONTAMINATION(1)

| Exposure Path | Health Effects Avoided Over 50-Yr Period |
|---|---|
| From Direct Radon Inhalation | $6 \times 10^{-2}$ |
| From Direct Gamma Exposure | $8 \times 10^{-3}$ |
| From Ingestion Pathway | $2 \times 10^{-5}$ |
| Total | $7 \times 10^{-2}$ |

(1)From Reference 3.

TABLE 4

SUMMARY OF ENVIRONMENTAL IMPACTS RESULTING FROM THE PROPOSED REMEDIAL ACTION(1)

| | Excavation | Backfill | Restoration | Transport of Contaminated Materials to Sampling Plant for Permanent Storage |
|---|---|---|---|---|
| **Physical Impacts** | | | | |
| 1. Mineral Resources and Soils | * | * | * | * |
| 2. Radiation | STA | * | LTB | * |
| 3. Ground and Surface Waters | * | * | LTB | * |
| 4. Erosion | STA | * | LTB | * |
| 5. Air Quality | STA | * | LTB | STA |
| **Biological Impacts** | | | | |
| 1. Flora | STA | * | LTB | * |
| 2. Fauna | STA | * | LTB | * |
| **Socioeconomic Impacts** | | | | |
| 1. Land Use | STA | STA | LTB | STA |
| (A) Solid Waste | STA | * | * | * |
| 2. Costs | STA | STA | STA | STA |
| 3. Noise | STA | STA | STA | STA |
| 4. Health | STA | * | LTB | STA |
| 5. Safety | STA | STA | STA | STA |
| 6. Transportation | STA | STA | STA | STA |
| 7. Employment | STB | STB | LTB | STB |
| 8. Land Values | * | * | LTB | LTB |
| 9. Aesthetics | STA | STA | LTB | STA |

(1) From Reference 3.

LEGEND:

LTB - Long-term beneficial impact
LTA - Long-term adverse impact
STB - Short-term beneficial impact
STA - Short-term adverse impact
* - Not affected or does not apply

TABLE 5

SOUND LEVELS FROM CONSTRUCTION EQUIPMENT(1)

| Source | Sound level, dB(A) at indicated distance in meters from source | | | | |
|---|---|---|---|---|---|
| | 15m | 30m | 61m | 152m | 305m |
| Trucks, cranes, bulldozers, etc., with diesel-type internal combustion engines | 70-95 | 64-89 | 58-83(2) | 50-75 | 40-69 |
| Air compressors and other stationary sources, typically diesel powered | 76-86 | 70-80 | 65-74 | 56-66 | 50-60 |
| Pile driver | 105 | 99 | 93 | 85 | 79 |
| Front-end loaders | 73-86 | 67-80 | 61-74 | 53-66 | 47-60 |

(1) From Reference 13
(2) Sound levels above 80 dB(A) are usually produced by a combination of several pieces of equipment operating at the same time.

## REFERENCES


1. "A Background Report for the Formerly Utilized MED/AEC Sites Remedial Action Program;" draft report; Contract No. EY-76-C-03-1101 (PA-10); The Aerospace Corporation; Aug 1979.

2. "Radiological Survey of the Middlesex Sampling Plant, Middlesex, New Jersey;" H.W. Dickson, R.W. Leggett, F.F. Haywood, W.A. Goldsmith, W.D. Cottrell, and W.F. Fox; DOE/EV-0005/1; ORNL, Oak Ridge, Tennessee; Nov 1977.

3. "Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey;" FBDU 230-005; Ford, Bacon & Davis Utah Inc., Salt Lake City, Utah; July 1979.

4. "Engineering Evaluation of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey;" FBDU 230-001; Ford, Bacon & Davis Utah Inc., Salt Lake City, Utah; July 1979.

5. Middlesex Sampling Plant and Associated Properties; Compilation of Remedial Action Descriptions; Ford, Bacon & Davis Utah Inc., Salt Lake City, Utah; Apr 1979.

6. Remedial Action Plan for Off-Site Properties, Middlesex Sampling Plant Site, Borough of Middlesex, New Jersey; National Lead Company of Ohio; Dec 8, 1979.

7. Title 40, Code of Federal Regulations, Chapter V, Council for Environmental Quality; Federal Register; Vol 43, No. 230, Section 1508.9; Nov 29, 1978.

8. Letter to Mayor M.S. Matuskiewicz, Borough of Middlesex, from Sheldon Myers, Acting Deputy, Assistant Secretary for Nuclear Waste Management, DOE; November 23, 1979.

9. "Accident Fact, 1979 Edition;" National Safety Council; Chicago, Illinois; 1979.

10. "Occupational Injuries and Illnesses in 1977 - Summary;" Report 561; U.S. Department of Labor, Bureau of Labor Statistics; 1979.

11. Title 10, Code of Federal Regulations, Part 20.

REFERENCES (Cont)

12. Letter to W.E. Mott, ECT, Department of Energy; from Hal Hollister, DOE, Division of Operational and Environmental Safety; May 22, 1978.

13. "Report to the President and Congress on Noise;" Senate Document 96-63; U.S. Government Printing Office, Washington, D.C., 1972.

# APPENDIX A

# PLANTINGS INVENTORY

APPENDIX A(1)

PLANTINGS INVENTORY

| QUANTITY | TREES |
|---|---|
| 2 | Salix blanda<br>Mild White Willow |
| 1 | Salix discolor<br>Pussy Willow |
| 5 | Populus nigra (var italica)<br>Lombardy Poplar |
| 1 | Juglans nigra<br>Black Walnut |
| 1 | Betula alba<br>White Birch |
| 2 | Betula populifolia<br>Gray Birch |
| 3 | Quercus palustris<br>Pin Oak |
| 16 | Morus alba<br>White Mulberry |
| 1 | Malus coronaria<br>Charlotte Crab Apple |
| 13 | Malus pumila (var niedzwetzkyana)<br>Fruiting Apple Red Tip Crab Apple |
| 3 | Malus floribunda<br>Japanese Crab Apple |
| 3 | Prunus glandulosa<br>Dwarf Flowering Cherry |
| 7 | Prunus sp (Prunus mahaleb)<br>Sweet Cherry |
| 3 | Robinia pseudoacacia<br>Black Locust |
| 6 | Acer saccharinum<br>Silver Maple |
| 15 | Acer platanoides<br>Norway Maple |

| QUANTITY | TREES |
|---|---|
| 19 | Acer rubrum<br>Red Maple |
| 2 | Sambucus canadensis<br>Canadian Elder |
| 1 | Tamarix gallica<br>French Tamarisk |
| 1 | Ilex opaca<br>American Holly |
| 1 | Juglans sp<br>Persian Walnut |
| 1 | Ficus carica (var)<br>Common Fig Tree |
| 3 | Taxus hatfieldi<br>Hatfield's Yew |
| 33 | Taxus hicksi<br>Hick's Yew |
| 52 | Taxus cuspidata (Henery)<br>Henery Japanese Yew |
| 2 | Juniperis virginiana<br>Eastern Red Cedar |
| 4 | Juniperis Pfitzeriana<br>Chinese Juniper |
| 5 | Pica pungens<br>Blue Spruce |
| 7 | Juniperis chinensis<br>Chinese Juniper |
| 1 | Chamaecyparis plumosa aurea<br>Ornamental Cedar |
| 1 | Cryptomeras lobbi<br>Ornamental Redwood |
| 1 | Rininus communis<br>Castor Oil Plant |

| QUANTITY | TREES |
| --- | --- |
| 2 | (Retinospora) Chamaecyparis plumosa<br>False Cypress Plum |
| 6 | Mimosaceae (mimosa) |
| 1 | Populus tremula<br>American Aspen |
| 2 | Fruiting Plum |

| QUANTITY | SHRUBS |
|---|---|
| 27 | Ligustrum ovalifolium<br>California Privet |
| 4 | Spiraea vanhouttei<br>Bridal Wreath |
| 2 | Berberis thunbergi<br>Japanese Barberry |
| 3 | Buxus sempervirens<br>Dwarf Boxwood (common type) |
| 1 | Rhododendron nudiflorum<br>Pink Azalea |
| 7 | Spiraea thunbergi<br>Thungberg's Wreath |
| 1 | Rosa Rugosa<br>Japanese Rosebush |
| 6 | Cornus florida<br>Flowering Dogwood |
| 10 | Syringa vulgaris<br>Common Lilac |
| 1 | Philadelphus virginalis<br>Virginal Mock-Orange Bush |
| 4 | Forsythia intermedia<br>Spring Glory |
| 3 | Kalmia latifolia<br>Mountain Laurel (Calico Bush) |
| 2 | Rosa floribunda (Multiflora)<br>(Climbing) Multiflowered Rosebush |
| 1 | Cactaceae sp<br>Cactus |
| 1 | Buxus microphylla koreana<br>Korean Box |
| 10 | Hibiscus syriacus<br>Rose of Sharon (Altea Shrub) |

| QUANTITY | SHRUBS |
| --- | --- |
| 9 | Kerria japonica<br>Japanese Keria Garden |
| 2 | Philadelphus floribunda<br>Sweet Mock Orange |
| 1 | Rosa officinalis (vulgaris)<br>Common Rosebush |
| 1 | Hydrangea annebelle<br>Annebelle's Water Vessel(or Hydrangea) |
| 3 | Hydrangea paniculata (grandiflora)<br>Peegee Hydrangea |

| QUANTITY | SHRUBS |
| --- | --- |
| 1 | Hedera helix<br>English Ivy (in tub) |

| QUANTITY | HERBACEOUS CATEGORY (FLOWERING) |
|---|---|
| 4 | Covallaria majalis<br>(European) Lily-of-the-Valley |
| 11 | Rosa odorata (HYB)<br>(Hybrid) Tea Rose |
| 1 | Lilium tigrinum (HYB)<br>(Hybrid) Tiger Lily |
| 1 | Cydonia Japonica<br>Japanese Quinca |
| 6 | Paesonia officinalis<br>Common Peony |
| 6 | Iris versicolor<br>Blue Flag Iris |
| 2 | Iris cristata<br>Crested Iris |
| 1 | Althea Rosa<br>Hollyhock |
| 5 | Sedum variegatum<br>(Stonecrop or Orpine) Variegated Sedum |
| 3 | Rhododendron obtusum (HYB)<br>(or Azalea hinodegiri)<br>Kurume Azalea |
| 6 | Chrysanthemum<br>Golden Flower |
| 3 | Hemerocallis fulva<br>Orange Day Lily |
| 1 | Hemerocallis flava<br>Yellow Day Lily |
| 3 | Rhododendron (HYB)<br>(Hybrid) Rose Tree |
| 2 | (Funkia) Hosta albo-marginata<br>Plantain Lily |
| 1 | Aquilegia sp<br>Columbine |

| QUANTITY | HERBACEOUS CATEGORY (FLOWERING) |
| --- | --- |
| 1 | Allum schoenoprasum<br>Chives |
| 1 | Foeniculum vulgare<br>Common Fennel |

| QUANTITY | FERNS |
| --- | --- |
| 4 | Yucca filamentosa<br>Yucca Plant (Spanish Bayonet or Adam's Needle) |
| 1 | Nephrolepis exaltata<br>Tall Sword Fern |

| QUANTITY | VINES |
| --- | --- |
| 1 | Polygonum aubertii<br>Silver Lace Vine |
| 4 | Vitis Labrusca<br>Fox Grapevine |

## APPENDIX A REFERENCES

1. "Middlesex Sampling Plant and Associated Properties; Compilation of Remedial Action Descriptions;" Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah; Apr 1979.

# APPENDIX B

## EXPOSURE RATES AT THE FENCELINE AROUND THE FORMER MIDDLESEX SAMPLING PLANT SITE

# APPENDIX B

# EXPOSURE RATES AT THE FENCELINE AROUND THE FORMER MIDDLESEX SAMPLING PLANT SITE

## 1.0 INTRODUCTION

The former Sampling Plant at Middlesex, New Jersey is the designated storage site for a temporary pile of radioactively contaminated soil and material. The Sampling Plant site itself (hereafter referred to as "site"), as well as the area immediately surrounding it, contains radioactive contamination in soil greater than that which occurs naturally. Due to the existing contamination, radon-222 gas emanates from the soil and results in possible radiation doses to the population in the immediate vicinity. The maximum possible radiation dose rate within 0.1 mile of the site, attributable to the enhanced radioactivity resulting from man's activities, has been estimated to be 67 mrem/yr. This drops to 2.5 mrem/yr between 0.1 and 0.5 mile from the site.[1]

The consolidation of the off-site contamination at the site will result in a slightly increased concentration of radon-222 in the vicinity of the site. The purpose of this discussion is to present the estimated increase in dose rate at the site fenceline due to the temporary storage of contaminated material on the site.

## 2.0 PILE CONTENT

The temporary storage pile will consist of material from three general sources: first, contaminated material excavated from the site during preparation of the storage area; second, two contaminated properties away from the site—the Rectory of the Church of Our Lady of Mount Virgin and 432 William Street; and third, the contaminated properties adjacent to and nearby the site. A small pile will initially be built with material from the first two sources. During the following year material from the third source will be added.

## 3.0 FIRST YEAR PILE

The quantities of contaminated materials from the second and third sources[2] and the total radioactivity added to the site from these areas have been estimated. The amount of material to be excavated from the site is unknown. It is also likely that some excess material will be excavated from the off-site properties.

### 3.1 Rectory

At the Rectory the average surface and subsurface concentrations of radium-226 are approximately 330 pCi/g and 90 pCi/g, respectively. These averages have been estimated using the concentrations determined at specific locations where samples were taken and analyzed. The samples were taken at points showing high gamma radiation levels at the surface[3] and therefore these numbers should give a conservatively high estimate.

It was estimated that there are approximately 1800 $yd^3$ of contaminated soil[2] with an average radium-226 concentration of 210 pCi/g. This results in a radium-226 activity of about $4.6 \times 10^{11}$ pCi, or about 0.5 Ci.

### 3.2 William Street

At 432 William Street the average radium-226 concentration in the soil samples was about 500 pCi/g.[3] It was estimated that there are 500 $yd^3$ of contaminated soil [2] with an average radium-226 concentration of 500 pCi/g. This results in a total radium-226 activity of about $3.1 \times 10^{11}$ pCi, or 0.3 Ci.

The total radium-226 activity to be added to the site from these two properties was therefore estimated to be about 0.8 Ci and the average concentration is expected to be about 290 pCi/g.

### 3.3 Radon Flux

To obtain an upper limit estimate on the possible increase in exposure rates, the average contamination which was calculated for the material from the off-site properties is applied to the entire pile resulting from the first year's activities.

The radium content and distribution in the pile determine the radon flux that emanates. The radon flux can be calculated using appropriate mathematics.[4] Figure 1[5] is a graph showing the approximate flux from a pile of mill tailings. It was conservatively assumed that the material in the pile is comparable to dry tailings which, as can be seen, produces the highest flux. The pile created the first year with the material from the Rectory and 432 William Street was estimated to be about 44 yd (132 ft) long by 44 yd (132 ft) wide by 2.7 yd (8 ft) high. The estimated 2,300 $yd^3$ of contaminated soil on the two properties would result in a pile only about 1.2 yd (3.6 ft) high. An estimated height of 2.7 yd therefore allows for 2,800 $yd^3$ of other material, either from the site or excess material from the two properties. It was estimated that the entire pile will have the same average radium-226 concentration of 290 pCi/g.

From Figure 1, it is estimated that the radon flux would be about 300 $pCi/m^2$-sec. This is the flux without any cover material over the pile. However, the pile will be covered with a rubberized material, called EPDM by the manufacturer, Carlisle Tire and Rubber Co. The radon flux will be reduced by at least 90 percent.[6] Therefore, the resulting radon-222 flux from the pile covered with EPDM is not expected to exceed 30 $pCi/m^2$-sec.

### 3.4 Dose Rate

The Ford, Bacon & Davis Utah computer code INHDOSE considers source and meteorological conditions to calculate the possible individual dose rates due to radon-222 inhalation. From a flux of 30 $pCi/m^2$-sec from the first-year pile, the maximum possible dose to the bronchial epithelium of an individual standing at the east fenceline 24 hours a day, 365 days a year is calculated to be about 6.0 mrem/yr. The possible dose rates to similar individuals at the south and west fencelines are 4.5 and 1.4 mrem/yr, respectively.

### 3.5 Comparisons to Other Sources of Radiation Doses

The purpose for estimating exposure to radioactivity is that an extensive amount of radioactive exposure can result in cancer. The federal guidelines for whole body exposure to any individual from radiation from artificial sources is 500 mrem/yr.[7] The risk of cancer can be described in terms of "health effects." One health effect (HE) is one case of cancer. The health effects due to the federal guideline of 500 mrem/yr have been estimated at $5 \times 10^{-5}$ HE/yr per person. The maximum possible dose at the site fenceline of 6 mrem/yr per person corresponds to

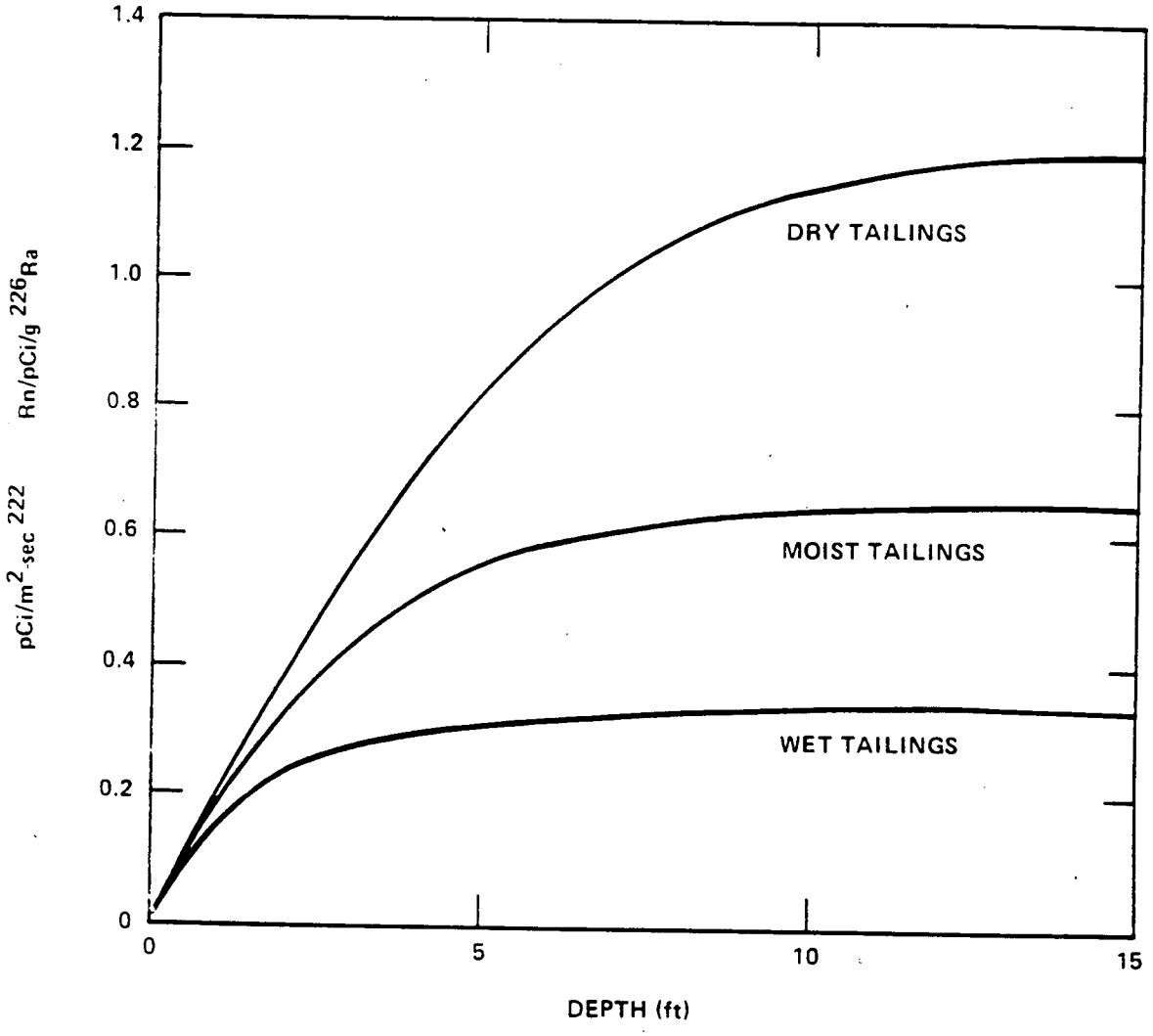



FIGURE 1. GRAPHIC REPRESENTATION OF RADON EMANATION FROM WET, MOIST, AND DRY TAILINGS AS A FUNCTION OF $^{226}Ra$ CONCENTRATION AND DEPTH OF TAILINGS.

FROM REFERENCE 5

a risk of approximately $6 \times 10^{-7}$ HE/yr per person. This means that if the small first-year pile were left without increase and 24,000 people stood at the east fenceline continuously for an average lifetime of 70 years, there would probably be one case of lung cancer caused by the emanations from the pile.

The maximum possible dose at the site fenceline can be compared to the approximate increase in whole body dose of 2 mrem which a person receives from a single transcontinental high-altitude flight.[8] The possible whole body dose to an individual from watching an average of 2 hours of television per day has been estimated to be 0.30 mrem/yr.[9] The whole body dose to an individual due to cosmic radiation in the Middlesex area is approximately 40 mrem/yr.[10] The whole body dose to an individual due to external gamma radiation in the area is about 88 mrem/yr.[1] The naturally-occurring radon in dwellings in the area has been measured to average 0.009 WL (Working Levels),[3]* which is approximately equal to a risk of $6 \times 10^{-5}$ HE per person (assuming a person spends 75 percent of the time indoors). The maximum possible dose at the site fenceline due to the small pile is approximately 1 percent of the dose caused by naturally-occurring radon-222.

## 4.0 COMPLETE PILE

During the second year, the contaminated properties adjacent to and nearby the site will be cleaned up. This material will be added to the small pile from the previous year to form a pile about 100 yd (300 ft) wide by 133 yd (400 ft) long by 2.7 yd (8 ft) high.

The average radium-226 concentration in all soil samples taken on the properties around the site is approximately 60 pCi/g. It was estimated that there are 23,000 $yd^3$[2] of soil with this average contamination. The total radium-226 activity in this soil would therefore be approximately 1.7 Ci. When this soil is added to the pile, the total radium-226 activity would be about 2.5 Ci. The average concentration would be about 80 pCi/g. The total contaminated volume of material from the off-site properties would be about 25,300 $yd^3$. This would result in a pile about 1.9 yd (5.7 ft) high. A 2.7 yd. pile would allow for about 10,200 $yd.^3$ of other material, both from the site and excess material excavated along with the contamination.

### 4.1 Radon Flux

Using an average concentration of 80 pCi/g and a pile height of 2.7 yd, the radon-222 flux was estimated to be about 8.4 $pCi/m^2$-sec with the EPDM cover over the pile.

### 4.2 Dose Rate

Utilizing the INHDOSE computer code to perform the calculations, it was determined that the maximum possible dose rate to the bronchial epithelium of an individual standing continuously at the fenceline is about 7.3 mrem/yr at the east boundary, 5.9 mrem/yr at the south boundary and about 3.4 mrem/yr at the west boundary.

The maximum possible dose rate of 7.3 mrem/yr per person caused by emanations from the complete pile is approximately $7 \times 10^{-7}$ He/yr per person. One person out of about 20,000

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*1 pCi/l of radon-222 in equilibrium with its daughters results in 0.001 WL. The maximum allowed concentration for uranium miners is 0.3 WL.

standing at the east fenceline continuously for an average lifetime of 70 years would probably contract cancer because of radiation received from the pile.

### 4.3 Comparisons to Other Sources of Radiation Doses

The maximum possible dose rate of 7.3 mrem/yr per person is approximately 1.2 percent of the dose from naturally-occurring radon-222. The cancer risk is equivalent to approximately 8 percent of the whole body dose received from naturally-occurring external gamma radiation and about 18 percent of the whole body dose due to cosmic radiation.

## 5.0 SUMMARY AND CONCLUSION

The maximum increase in possible dose rate to the bronchial epithelium of an individual at the fenceline due to radon-222 emanating from the entire pile is about 1.2 percent of the dose received from the naturally-occurring radon-222 in the area. The emanations from the pile result in a cancer risk comparable to that incurred by the typical individual in twenty four years of watching television or taking two roundtrip transcontinental high-altitude flights.

The increase in cancer risk caused by the temporary storage pile of contaminated material is only a small percentage of the cancer risk due to naturally-occurring radioactivity.

## REFERENCES


1. "Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey"; FBDU-230-005; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah; July 1979.

2. "Engineering Evaluation of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey"; FBDU 230-001; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah; July 1979.

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6. Barg, D. C., "Impermeable Tailings Cover Materials"; Ford, Bacon & Davis Utah Inc.; Salt Lake City, Utah; May 1980.

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9. "Evaluation of Television Contribution to the Annual Genetically Significant Radiation Dose of the Population"; U. S. PUblic Health Service, Radiological Health Data and Reports; July 1971.

10. "The Effects on Populations of Exposure to Low Levels of Ionizing Radiations"; Advisory committee on the Biological Effects of Radiation, Division of Medical Sciences, National Academy of Science, National Research Council; November 1972.

# APPENDIX C

# GENERIC CHECKLIST OF ENVIRONMENTAL IMPACTS

## APPENDIX C

## GENERIC CHECKLIST OF ENVIRONMENTAL IMPACTS[1]

This checklist is to ensure potential areas of environmental impact have been considered in the evaluation of this project. Any required comments are presented in Sections 4 and 5 of the text.

| | Yes | No |
|---|---|---|
| Land Form - Will the project result in: | | |
| o Unstable slopes, embankments, or excavations? | ___ | X |
| o Significant modifications of geological structures? | ___ | X |
| o Disruption, displacement, compaction, or covering of the soil? | STA | ___ |
| o Changes in ground contours, shorelines, stream channels, riverbanks, or tidelands? | STA | ___ |
| o Destruction, covering, or modification of unique geologic or physical features? | ___ | X |
| o Increased wind or water erosion of soils, either on or off the site? | STA | ___ |
| o Changes in deposition or erosion of beach sands or changes in siltation, deposition, or erosion that may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake? | ___ | X |
| o Exposure of people to or property affected by earthquakes, landslides, mudslides, or ground failure? | ___ | X |
| o Foreclosure on future uses of site on a long-term basis? | ___ | X |
| Air - Will the project result in: | | |
| o Substantial air pollutant emissions or deterioration of ambient air quality? | STA,LTB* | ___ |

*Short-Term Adverse, Long-Term Beneficial

| | Yes | No |
|---|---|---|
| • Objectionable odors? | STA | ___ |
| • Alteration of air movements, temperature or humidity (e.g. fogging or icing)? | ___ | X |
| • Local or regional climate changes? | ___ | X |
| **Water** - Will the project result in: | | |
| • Changes in currents or water movements in marine or fresh waters? | ___ | X |
| • Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff? | STA | ___ |
| • Alterations to the course or flow of flood waters? | ___ | X |
| • Change in the amount of surface water in any water body? | ___ | X |
| • Discharges into surface waters or alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity? | ___ | X |
| • Alteration of the direction or rate of flow of groundwaters? | ___ | X |
| • Change in the quantity of groundwaters, either through direct additions or withdrawals or through interceptions of an aquifer by drilling or excavations? | ___ | X |
| • Alterations in groundwater quality? | ___ | X |
| • Contamination of public water supplies? | ___ | X |
| • The requirement to obtain an NPDES (National Pollutant Discharge Eliminate System) Permit (Clean Water Act)? | X * | ___ |
| • Violation of State Stream Quality Standards? | STA* | ___ |

*This impact will need to be discussed further with the State of New Jersey.

| | Yes | No |
|---|---|---|
| • Discharge to a public sewer system? | ___ | X |
| • Location in a riveting or coastal floodplain (especially high hazard areas)? | ___ | X |
| • Substantial reduction in the amount of water otherwise available for public water supplies? | ___ | X |
| • Exposure of people or property to water-related hazards such as flooding or tidal waves and subject to DOE floodplain/wetlands regulations (10 CFR 1022)? | ___ | X |
| • Location in a state's coastal zone and subject to consistency with the state CZM plan? | ___ | X |
| Solid Waste - Will the project generate significant solid waste or litter? | LTA | ___ |
| Noise - Will the project: | | |
| • Increase existing noise and vibration? | STA | ___ |
| • Expose people to excessive noise? | ___ | X |
| Light and Glare - Will the project create problems involving light and glare? | ___ | X |
| Plant Life - Will the project: | | |
| • Change the diversity or productivity of species or number of any species of plants (including trees, shrubs, grass, crops, microflora, and aquatic plants)? | STA | ___ |
| • Reduce the numbers or affect the habitat of any unique, rare, or endangered species of plants? (Check State and Federal lists of endangered species.) | ___ | X |
| • Introduce new species of plants into an area or create a barrier to the normal replenishment of existing species? | ___ | X |

| | Yes | No |
|---|---|---|
| • Reduce acreage or create damage to any agricultural crop? | ___ | X |
| **Animal Life** - Will the project: | | |
| • Change the diversity of species or affect breeding or numbers of any species of animals (including birds, mammals, reptiles, amphibians, fish and shellfish, benthic organisms, insects, or microfauna)? | STA | X |
| • Reduce the habitat or numbers of any unique, rare, or engangered species of animals? (Check State and Federal lists of endangered species.) | ___ | X |
| • Introduce new, species of animals into an area or create a barrier to the migration or movement of animals or fish? | ___ | X |
| • Harm existing fish or wildlife habitat? | STA | ___ |
| • Cause attraction, entrapment, impingement, or entrainment of animal life? | ___ | X |
| • Cause emigration resulting in human-wildlife interaction problems? | ___ | X |
| **Land Use** - Will the project substantially alter the present or planned land use of an area? | ___ | X |
| **Natural Resources** - Will the project: | | |
| • Increase the rate of use of any natural resources? | ___ | X |
| • Substantially deplete any nonreusable natural resources? | ___ | X |
| • Be located in an area designated or being considered for wilderness, wild and scenic river, national park, or ecological preserve? | ___ | X |

| | Yes | No |
|---|---|---|
| Energy - Will the project: | | |
| • Use substantial amounts of fuel or energy? | ___ | X |
| • Substantially increase the demand upon existing sources of energy or require the development of new sources of energy? | ___ | X |
| Accident Risk - Does the project involve risk of explosion or release of potentially hazardous substances (including, but not limited to oil, pesticides, chemicals, radiation, or other toxic substances) in the event of an accident or upset conditions? | ___ | X |
| Population - Will the project alter the location, distribution, density, or growth rate of the human population in an area? | ___ | X |
| Housing - Will the project affect housing patterns or create a demand for additional housing? | LTB | ___ |
| Transportation and Traffic Circulation - Will the project result in: | | |
| • Generation of substantial additional vehicular movements? | ___ | X |
| • Effects on existing parking facilities or demands for new parking? | ___ | X |
| • Substantial impact upon existing transportation systems? | ___ | X |
| • Alterations to present patterns of circulation or movement of people and/or goods? | ___ | X |
| • Alterations to waterborne, rails or air traffic? | ___ | X |
| • Increase in traffic hazards to motor vehicles, bicyclists, or pedestrians? | ___ | X |
| • Construction of new roads or trails? | ___ | X |

| | Yes | No |
|---|---|---|
| Public Service - Will the project have an effect upon, or result in a need, or new or altered governmental services in any of the following areas: | | |
| • Fire protection | ___ | X |
| • Police protection? | ___ | X |
| • Schools? | ___ | X |
| • Parks or other recreational facilities? | ___ | X |
| • Other governmental services? | ___ | X |
| Utilities - Will the project result in a need for new systems or substantial alterations to the following utilities: | | |
| • Power or natural gas? | ___ | X |
| • Communications systems? | ___ | X |
| • Water? | ___ | X |
| • Sewer or septic tanks? | ___ | X |
| • Storm water drainage? | ___ | X |
| • Solid waste and disposal? | ___ | X |
| Human Health - Will the project: | | |
| • Create any health hazard or potential health hazard? | ___ | X |
| • Expose people to potential health hazard? | STA,LTB | X |
| Economic - Will the project have any adverse effect on local, regional, or national economic conditions? | ___ | X |
| • Will the project cause boom-town type of development? | ___ | X |
| • Will the project have any adverse effect on tourism? | ___ | X |

| | Yes | No |
|---|---|---|
| • Will the project have any adverse effect on land values? | ___ | X |
| • Will the project have any adverse effect on employment? | ___ | X |
| Community Reaction - Is the project: | | |
| • Potentially controversial? | ___ | X |
| • In conflict with locally adopted environmental plans and goals? | ___ | X |
| Aesthetics - Will the project: | | |
| • Change any scenic vista or view open to the public? | ___ | X |
| • Create an aesthetically offensive site open to the public view (out of place in an aesthetic sense with character or design of surrounding area)? | LTA | ___ |
| • Significantly change the visual scale or character of the vicinity? | ___ | X |
| Recreational, Educational, Religious, and Scientific - Will the project affect the quality or quantity of existing recreational, educational, religious, or scientific opportunities? | ___ | X |
| Archaeological, Cultural, and Historical - Will the project alter significant archaeological, anthropological, paleontological, cultural, or historical sites, structures, objects, or buildings (e.g., be subject to the Historic Preservation Act of 1974)? | ___ | X |

## APPENDIX C REFERENCES

1. A Generic Program Plan for the Formerly Utilized MED/AEC Sites Remedial Action Program, Draft; Environmental Control Technology Division, Assistant Secretary for Environment, U.S. Department of Energy; June 1979.

# APPENDIX D

## DISTRIBUTION LIST OF THE ENVIRONMENTAL ANALYSIS REPORT

# APPENDIX D

## DISTRIBUTION LIST OF THE ENVIRONMENTAL ANALYSIS REPORT

The following is the distribution list used for the report, Environmental Analysis of the Former Middlesex Sampling Plant and Associated Properties, Middlesex, New Jersey.

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