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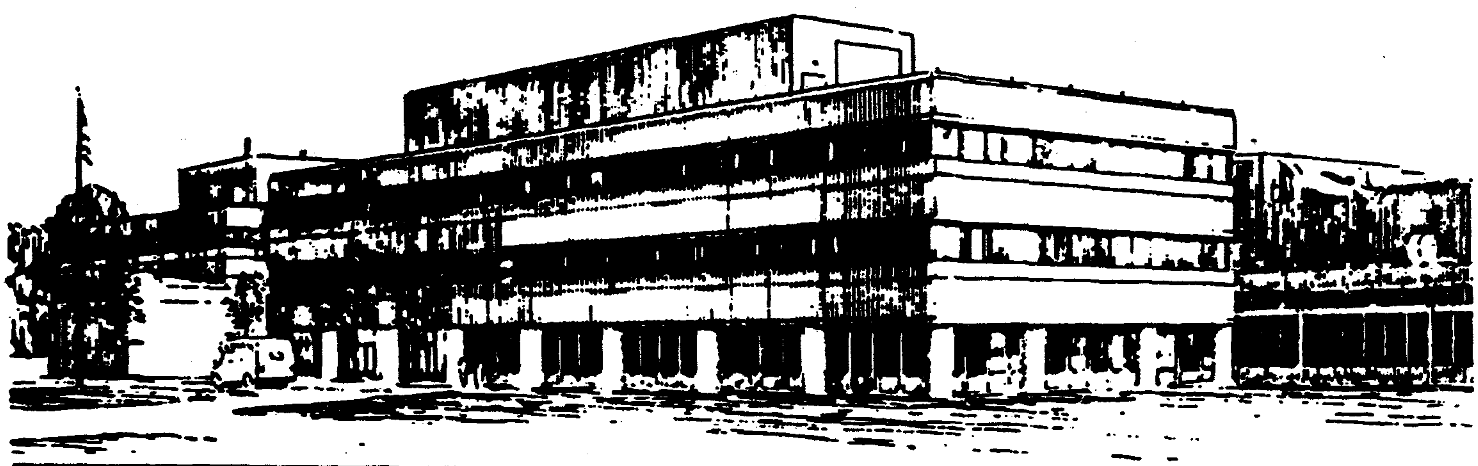
Princeton Plasma Physics Laboratory
Annual Site Environmental Report for Calendar Year 1996

by

Virginia L. Finley and Jerry D. Levine

March 1998

PRINCETON
PLASMA PHYSICS
LABORATORY



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PRINCETON PLASMA PHYSICS LABORATORY (PPPL)

ANNUAL SITE ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1996

By

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and

J. D. Levine

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P.O. Box 451
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Operated under Contract
DE-AC02-76-CHO-3073

Princeton Plasma Physics Laboratory (PPPL)
Certification of Monitoring Data for
the Annual Site Environmental Report for 1996

Contained in the following report are data for radioactivity in the environment collected and analyzed by Princeton Plasma Physics Laboratory's Radiological Environmental Monitoring Laboratory (REML). The REML is located on-site and is certified for analyzing radiological parameters through the New Jersey Department of Environmental Protection's Laboratory Certification Program, Certification Number 12471. Non-radiological surface and ground water and soil samples are analyzed by NJDEP certified subcontractor laboratories - QC., Inc., Reliance Laboratory, or Core Laboratory, subcontractor to Harding Lawson Associates. To the best of our knowledge, these data, as contained in the "Annual Site Environmental Report for 1996," are documented and certified to be correct.

Signed:

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Princeton Plasma Physics Laboratory

Annual Site Environmental Report

for Calendar Year 1996 - Abstract

The results of the 1996 environmental surveillance and monitoring program for the Princeton Plasma Physics Laboratory (PPPL) are presented and discussed. The purpose of this report is to provide the U.S. Department of Energy and the public with information on the level of radioactive and non-radioactive pollutants, if any, that are added to the environment as a result of PPPL's operations.

During Calendar Year 1996, PPPL's Tokamak Fusion Test Reactor (TFTR) continued to conduct fusion experiments. Having set a world record on November 2, 1994, by achieving approximately 10.7 million watts of controlled fusion power during the deuterium-tritium (D-T) plasma experiments, researchers turned their attention to studying plasma science experiments, which included "enhanced reverse shear techniques." Since November 1993, more than 700 tritium-fueled experiments were conducted, which generated more than 4.9×10^{20} neutrons and 1.4 gigajoules of fusion energy.

In 1996, the overall performance of Princeton Plasma Physics Laboratory was rated "excellent" by the U. S. Department of Energy in the Laboratory Appraisal report issued in early 1997. The report cited the Laboratory's consistently excellent scientific and technological achievements and its successful management practices, which included high marks for environmental management, employee health and safety, human resources administration, science education, and communications.

Ground-water investigations continued under a voluntary agreement with the New Jersey Department of Environmental Protection. PPPL monitored for the presence of non-radiological contaminants, mainly volatile organic compounds (components of degreasing solvents) and petroleum hydrocarbons (past leaks or releases of diesel fuel from underground storage tanks). Also, PPPL's radiological monitoring program characterized the ambient, background levels of tritium in the environment and from the TFTR stack; the data are presented in this report.

During 1996, PPPL completed the removal of contaminated soil from two locations that were identified through the monitoring program: petroleum hydrocarbons along a drainage swale and chromium adjacent to the cooling tower.

Virginia L. Finley and Jerry D. Levine, authors

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List of Acronyms

AFS	Air Facility Subsystem
AGT	above ground tank
AHC	aromatic hydrocarbons
AIRS	Aerometric Information Retrieval System
AIRDOS-EPA	Air Model for USEPA
ALARA	as low as reasonably achievable
APEC	area of potential concern
AR or AR-41	Argon, Argon-41
BOD	biological oxygen demand
BN	base neutral priority pollutant organic compounds
BPX	Burning Plasma Experiment
Bq	Becquerel
BTEX	Benzene, toluene, ethylbenzene, and xylenes
C_4	C site of James Forrestal Campus, part of PPPL site
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAS	Coil Assembly and Storage Building
CASL	Calibration and Service Laboratory
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFCs	chlorofluorocarbons
CFR	Code of Federal Regulations
Ci	Curie (3.7 ^{E10} Becquerel)
CICADA	Central Instrumentation, Control, and Data Aquisition
Cl or Cl-40	Chlorine, Chlorine-40
cm	centimeter
COD	chemical oxygen demand
CS	C site stellarator (PPPL)
CWA	Clean Water Act
CY	calendar year
D	deuterium
D&D	decontamination and decommissioning
D-D	deuterium-deuterium
D-T	deuterium-tritium
D-11, D-12	detention basin monitoring wells number 11 and 12
DATS	differential atmospheric tritium sampler
DMR	discharge monitoring report
DOE	Department of Energy
DOE-CH	Department of Energy - Chicago Operations Office
DOE-EH	Department of Energy - Environment and Health
DOE-HQ	Department of Energy - Headquarters
DOE-OFE	Department of Energy - Office of Fusion Energy
DOE-PG	Department of Energy - Princeton Group
D&R	Delaware & Raritan (Canal)
DRCC	Delaware & Raritan Canal Commission
DSN	discharge serial number
EA	Environmental Assessment
EDE	effective dose equivalent
EM-30	Waste Management - DOE
EM-40	Environmental Restoration - DOE
EML	Environmental Monitoring Laboratory (DOE)
ENLP	Environmental, Nuclear Licensing, and Permitting group of Support Services (PPPL)
EO	Executive Order
EPA	Environmental Protection Agency (US)
EPCRA	Emergency Planning and Community Right to Know Act
ERDA	Energy Research and Development Agency, DOE predecessor agency
ER/WM	Environmental Restoration/Waste Management
ESA	Endangered Species Act
ES&H	Environment, Safety, and Health
F&EM	Facilities and Environmental Management Division

List of Acronyms

FCPC	Field Coil Power Conversion Building
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FSAR	Final Safety Analysis Report
FSCD	Freehold Soil Conservation District (Middlesex and Monmouth Counties)
g	gram
GBq	giga Becquerel or 10^9Bq
GP	General Permit (Wetlands)
GPMP	Groundwater Protection and Monitoring Program
GW	ground water
H-3	tritium
HMSF	Hazardous Material Storage Facility
HQ	Headquarters
HRS	Hazard Ranking System
HT	tritium (elemental)
HTO	tritiated water
HVAC	heating, ventilation, and air-conditioning
ICRF	Ion Cyclotron Radio Frequency
IC_{25}	inhibition concentration 25 percent
JFC	James Forrestal Campus
km	kilometer
kV	kilovolt (thousand volts)
LEC	liquid effluent collection (tanks)
LEPC	Local Emergency Planning Committee
LLNL	Lawrence Livermore National Laboratory
LOB	Laboratory Office Building
LOI	Letter of Interpretation (Wetlands)
LLW	Low level waste (radiological waste)
m	meter
MCHD	Middlesex County Health Department
MeV	million electron volts
MG	Motor Generator (Building)
mg/L	milligram per liter
MOU	Memorandum of Understanding
mrem	milli radiation equivalent man
mR/h	milliRoentgen per hour
MSDS	Material Safety Data Sheet
m/s	meters per second
msl	mean sea level
mSv	milliSievert
MW	monitoring well
n	neutron
N or N-	Nitrogen
NAAQS	National Ambient Air Quality Standards
NB	Neutral beam
NBPC	Neutral Beam Power Conversion Building
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic and Preservation Act
NIST	National Institute of Standards and Technology
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection (prior to 1991 and after July 1994)
NJDEPE	New Jersey Department of Environmental Protection and Energy (1991 to June 1994)
NJPDES	New Jersey Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observable effect concentration
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

List of Acronyms

NRC	Nuclear Regulatory Commission
NRC	National Response Center
NSTX	National Spherical Torus Experiment
nSv	nanoSievert
OH	ohmic heating
P1, P2	piezometer 1 and 2
PBX-M	Princeton Beta Experiment - Modification
PCAST	Presidential Committee Science and Technology
PCBs	polychlorinated biphenyls
PCE	perchloroethylene, tetrachloroethene, or tetrachloroethylene
pCi/L	picoCuries per liter
PFC	Princeton Forrestal Center
PLT	Princeton Large Torus
POTWs	publicly owned treatment works
ppb	parts per billion
ppm	part per million
PPPL	Princeton Plasma Physics Laboratory
PSTP	Proposed Sie Treatment Plan for the Federal Facility Compliance Act
RAA	Remedial Alternative Assessment
RACT	reasonably achieveable control technology
RCRA	Resource Conservation and Recovery Act
REAM	remote environmental atmospheric monitoring (station)
REML	Radiological Environmental Monitoring Laboratory
RESA	Research Equipment Storage and Assembly Building
RI	Remedial Investigation
RMS	Remote Monitoring Station
RQ	reportable quantity
S or S-	Sulfur
SAD	Safety Assessment Document
SARA	Superfund Amendments and Reauthorization Act of 1986
SBRSA	Stony Brook Regional Sewerage Authority
SDWA	Safe Drinking Water Act
SF_6	sulfur hexafluoride
SPCC	Spill Prevention Control and Countermeasure
SNAP	significant new alternatives policy
S&R	shutdown and removal (TFTR)
T	tritium
TBq	tera Becquerel or 10^{12}Bq
TCA	trichloroethane
TCE	trichloroethene or trichloroethylene
TCLP	toxic characteristic leaching procedure (RCRA)
TDS	total dissolved solids
TFTR	Tokamak Fusion Test Reactor
TPH	total petroleum hydrocarbons
TR	trailer atmospheric monitors
TRI	Toxic Reduction Inventory (CERCLA)
TPX	Tokamak Physics Experiment
TSCA	Toxic Substance Control Act
TSDS	tritium storage and delivery system
TSS	total suspended solids
TW	test wells
TWA	treatment works approval
USDA	US Department of Agriculture
USGS	US Geological Survey
USEPA	US Environmental Protection Agency
UST	underground storage tanks
VOCs	volatile organic compounds
χ/Q	atmospheric dilution factor (NOAA)
µg/L	micrograms per liter
µSv	microSievert

List of Exhibits Contained in the Text

NOTE: ***The above exhibits (except Exhibits 2-1 and 6-2) are text tables. All data tables are located in Section 11.0 beginning on page 60.***

1.0 EXECUTIVE SUMMARY

This report presents the results of the environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year (CY96). The report is prepared to provide the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, if any, added to the environment as a result of PPPL operations. This report will also summarize environmental initiatives, assessments, and programs that were undertaken in 1996. The objective of the Annual Site Environmental Report is to document evidence that PPPL's environmental protection programs protect the environment and the public health.

The Princeton Plasma Physics Laboratory has engaged in fusion energy research since 1951 (Fig. 1). The long-range goal of the U.S. Magnetic Fusion Energy Research Program is to develop and demonstrate the practical application of fusion power as an alternative energy source. In 1996, PPPL had one of its two large tokamak devices in operation—the Tokamak Fusion Test Reactor (TFTR) (Fig. 2). The other device, the Princeton Beta Experiment-Modification or PBX-M, did not operate in 1996 (Fig.3).

During CY96, PPPL continued to conduct fusion experiments at TFTR. Having set a world record on November 2, 1994, by achieving approximately 10.7 million watts of controlled fusion power during the deuterium-tritium (D-T) plasma experiments, researchers turned their attention to studying "enhanced reversed shear techniques." The enhanced reversed shear techniques involve a magnetic-field configuration, which dramatically reduces plasma turbulence and increases particle confinement in the interior regions of the plasma.

In addition to surpassing the goal of 10 million watts set for the TFTR project, since November 1993 when deuterium-tritium experiments began in TFTR, more than 700 tritium shots were pulsed into the reactor vessel generating approximately 4.9×10^{20} neutrons and 1.4 gigajoules of fusion energy. These achievements represent steps forward toward the reality of a commercial fusion reactor in the twenty-first century. For twenty-two years—since December 1973, when the goal of D-T experiments was presented to the Energy Research and Development Administration (ERDA-the predecessor of the Department of Energy or DOE)—PPPL has planned and designed, constructed, operated, and maintained TFTR culminating in the success of D-T experiments.

In 1996, the performance of the Princeton Plasma Physics Laboratory was rated "excellent" by the U.S. Department of Energy in the Laboratory Appraisal report issued early in 1997 [DOE97]. The report cited the Laboratory's consistently excellent scientific and technological achievements, its successful management practices, and included high marks in a host of other areas including environmental management, employee health and safety, human resources administration, science education, and communications.

To strengthen the idea that fusion will provide an environmentally attractive and economically viable energy option for the next century, PPPL continued its environmental monitoring programs. In CY96, PPPL's radiological monitoring program measured on-site and off-site tritium in air, making comparisons with baseline data. Capable of detecting small changes in the ambient levels of tritium in the air, highly sensitive monitors are located at six off-site stations within 1 km of TFTR and at a baseline location. On-site tritium levels in the air are monitored by a tritium monitor in the TFTR stack, as required by National Emission Standard for Hazardous Air Pollutants (NESHAPs) regulations with limits set by the U.S. Environmental Protection Agency, and by four facility site boundary monitors. Also included in PPPL's radiological environmental monitoring program are soil, precipitation, surface, ground, and waste water monitoring.

The results of the radiological monitoring program for 1996 were: 1) radiation exposure, via airborne and sanitary sewer effluents, were measured at low levels; 2) the total maximum off-site dose from all sources—airborne, sanitary sewerage, and direct radiation—was 0.43 mrem/year— a fraction of the 10 mrem/year TFTR design objective and the 100 mrem/year DOE limit; and 3) the total airborne exposure at the nearest business was 0.10 mrem/year, which is well below the 10 mrem/year NESHAPs limit (see Table 2).

PPPL's non-radiological environmental monitoring program demonstrates compliance with applicable environmental requirements, which includes monthly surface water monitoring for New Jersey Pollutant Discharge Elimination System (NJPDES) discharge permit, NJ0023922. Three discharge locations are identified by Discharge Serial Numbers (DSN): DSN001—basin outfall, DSN002—a storm water discharge for the west side of C site, and DSN003—a filter back wash discharge from the Delaware & Raritan Canal pump house. Also, PPPL is required to conduct quarterly chronic toxicity testing at DSN001. As required by the NJPDES ground-water (GW) permit, NJ0086029, PPPL collects quarterly ground-water samples from seven monitoring wells and twice annual samples from the detection basin inflows.

In 1996, PPPL continued its remedial investigation and remedial alternative assessment for C and D sites of the James Forrestal Campus, which is leased to the Department of Energy (DOE) by Princeton University. Since 1989, ground-water data has revealed contamination of low levels of volatile organic compounds (most probably from solvents) in three locations on-site. In February 1993, Princeton

University signed a voluntary agreement, or memorandum of understanding (MOU), with the New Jersey Department of Environmental Protection. PPPL's work plan included ground-water sampling, soil sampling, and soil removal from two locations, which exceeded the New Jersey Soil Cleanup Standards.

PPPL has and continues to emphasize environment, safety, and health (ES&H) in accordance with DOE requirements at the facility. The expectations are that the Laboratory will excel in ES&H as it has in its fusion research program. The efforts are geared not only to fully comply with applicable local, state, and federal regulations, but also to achieve a level of excellence that includes state-of-the-art monitoring and best management practices, as well as an institution that serves other research facilities with invaluable information gathered from such a unique program as fusion.

2.0 INTRODUCTION

2.1 General

Beginning in December 1993, TFTR began deuterium-tritium (D-T) experiments and in 1994, set new records by producing over ten million watts of energy. The TFTR is a toroidal magnetic fusion energy research device in which a deuterium-tritium (D-T) plasma is magnetically confined and heated to extremely high temperatures by neutral-beam injectors and radio-frequency waves. The TFTR began its first full year of operation in CY83; TFTR produced its greatest number of D-D neutrons in 1990 and 1995 (Exhibit 2-1). The second highest, total, number of neutrons produced in one year occurred in 1994 when 1.98×10^{20} neutrons were produced from D-D and D-T operations; neutron production in 1995 was higher with a total of 2.27×10^{20} neutrons. 1996 was the third highest neutron production of 1.01×10^{20}. Neutron generation is an actual measurement based on data from neutron detectors.

Exhibit 2-1. TFTR Neutron Production 1987-1996

Year	Deuterium-Deuterium Total Neutron Production	Year	Deuterium-Tritium Total Neutron Production
1987	3×10^{18}		
1988	9.04×10^{18}		
1989	6.4×10^{18}		
1990	2.3×10^{19}		
1991	1.56×10^{18}		
1992	1.53×10^{19}		
1993	7.2×10^{18}	1993	1.65×10^{19}
1994	1.3×10^{19}	1994	1.85×10^{20}
1995	2.3×10^{19}	1995	2.04×10^{20}
1996	1.73×10^{19}	1996	8.34×10^{19}

Due to federal budget reductions, the experiments and therefore, the operations of TFTR, were to be concluded in early 1997. Also affected by the budget reduction, the Decontamination and Decommissioning (D&D) project for TFTR was placed on indefinite hold.

During the Calendar Year 1996 (CY96), events within the federal government created a climate of change for all government agencies. The U. S. Congress's initiative to eliminate the federal deficit and balance the budget caused reductions in discretionary spending across all sectors, including a reduction of one-third for the fusion energy program. To meet the challenges of a reduced budget and changed priorities, DOE's Office of Energy Research published its "Strategic Plan for the Restructured U.S. Fusion Energy Sciences Program," in August 1996. The plan called for a refocusing from an energy technology development program to a fusion energy sciences program. This plan incorporated many of the recommendations from the "Report of the Fusion Review Panel," prepared by the President's Committee of Advisors on Science and Technology (PCAST), in July 1995.

DOE's change in focus caused PPPL to plan an early CY97 shut-down of its primary device, the Tokamak Fusion Test Reactor (TFTR). Also, PPPL's management needed to respond to other changes called for in DOE's strategic plan.

As stated in the Strategic Plan, the new Mission of the Fusion Energy Sciences Program is: "Advanced plasma science, fusion science, and fusion technology - the knowledge base needed for an economically and environmentally attractive fusion energy source." In order to support this mission, PPPL management presented its vision of PPPL's role as a National Center for Fusion Science. Firstly, TFTR experiments/operations would conclude in early 1997, with a safe shutdown completed by September 1997. Data analysis would continue to assess the scientific and technical achievements. Next, pursuit of national and international collaborations would be accomplished through programs which would send PPPL researchers to other facilities and invite others to collaborate at PPPL.

In 1996, PPPL continued its collaboration with the Korean fusion science and technology program. The accelerated and improved National Spherical Torus Experiment (NSTX) program, a national collaboration with the Oak Ridge National Laboratory, Columbia University, and the University of Washington (Seattle), is a major effort to produce a smaller and more economical tokamak fusion reactor or volumetric neutron source. NSTX was originally proposed for C site to replace the Princeton Large Torus or PLT; this earlier plan called for the construction phase to begin in FY97. The revised plan is for NSTX to be located in the former TFTR Hot Cell on D site, the design to be completed in 1997, and the construction of this device to begin in 1998. The first plasma is scheduled for the spring of 1999.

2.2 Description of the Site

The Princeton Plasma Physics Laboratory site is in the center of a highly, urbanized region extending from Boston, Massachusetts, to Washington, D.C., and beyond. The closest urban centers are New Brunswick, 14 miles to the northeast, and Trenton, 12 miles to the southwest. Major metropolitan areas, including New York City, Philadelphia, and Newark, are within 50 miles of the site. As shown in Figure 4, the site is in central New Jersey within Middlesex County, with the municipalities of Princeton, Plainsboro, Kingston, West Windsor, and Cranbury in the immediate vicinity. The Princeton area continues to experience a substantial increase in new business moving into the Route 1 corridor near the site. Also, the main campus of Princeton University, located primarily within the Borough of Princeton, is approximately three miles to the west of the site.

A demographic study or population study of the surrounding 50 kilometers was completed in CY87 as part of the requirement for the Environmental Assessment for the former Burning Plasma Experiment (BPX) [Be87a]. This information is necessary in order to calculate the dose rates each year. Other information gathered and updated from previous TFTR studies included socioeconomic information [Be87b] and an ecological survey [En87].

PPPL is located on the C and D sites of the James Forrestal Research Campus of Princeton University. The site is surrounded by undisturbed areas with upland forest, wetlands, and a minor stream (Bee Brook) flowing along its eastern boundary and by open, grassy areas and cultivated fields on the west. In an aerial photo (Fig. 1), the general layout of the facilities at the C and D sites of Forrestal Campus is viewed; the specific location of TFTR is at D site (on the left side of photo).

The D site is surrounded completely with a chain-linked fence for the controlled access to the TFTR. As an unfenced site with access controls for security reasons, PPPL openly operates C site, allowing the public access for educational purposes. This free access of C site warranted a thorough evaluation of on-site discharges, as well as the potential for off-site releases of radioactive and toxic non-radioactive effluents. An extensive monitoring program, which is tailored to these needs, was instituted and expanded over recent years. The PPPL radiological environmental monitoring program generally follows the guidance given in two DOE reports; <u>A Guide for: Environmental Radiological Surveillance at U.S. Department of Energy Installations</u> [Co81] and <u>Environmental Dose Assessment Methods for Normal Operations at DOE Nuclear Sites (PNL-4410)</u> [St82].

The environmental monitoring program document contains the requirement for adherence to standards given in DOE Orders, in particular, DOE Order 5400.5, "Radiation Protection of the Public and the Environment" [DOE93a]. The order pertains to permissible dose equivalents and concentration guides and gives guidance on maintaining exposures "to as low as reasonably achievable" (ALARA). On December 14, 1993, 10 CFR 835, became effective and replaced DOE Order 5480.11, "Radiation Protection for Occupational Workers," guidelines for DOE nuclear facilities [DOE89]. While issuance of this regulation did not have a major impact on PPPL operations, the regulation did incorporate some changes in personnel monitoring requirements. Specific criteria for implementing the requirements on TFTR are contained in the TFTR Technical Safety Requirements document (OPR-R-23). These criteria are shown in Table 1.

The emphasis of the radiation monitoring program was placed on exposure pathways appropriate to fusion energy projects at PPPL. These pathways include external exposure from direct penetrating radiation. During TFTR D-T experiments, external exposure from airborne radionuclides, such as argon-41 (Ar-41), nitrogen-13 (N-13), nitrogen-16 (N-16), and internal exposure from radionuclides, such as tritium (H-3) in air and water, are being monitored. Six major critical pathways are considered as appropriate (see Exhibit 2-2). Prompt radiation, that which is emitted immediately during operations, was also considered and is measured. The radiation monitoring program, described in the TFTR Final Safety Analysis Report [FSAR82], was updated to reflect the current environment around TFTR (see Exhibit 2-3). A tritium monitor was installed on the TFTR stack in late 1990. About 183.5 Ci (118.625 HTO and 64.88 Ci HT), 6.8 TBq of tritium, were released from the stack in 1996.

Exhibit 2-2. Critical Pathways Discharge Pathway

Path I.D.		
A1	Atmospheric --->	Whole Body Exposure
A2	Atmospheric --->	Inhalation Exposure
A3	Atmospheric --->	Deposition on Soil & Vegetation, Ingestion, Whole Body Exposure
L1	Liquid Water Way --->	Drinking Water Supply --> Man
L2	Liquid Water Way --->	External Exposure
L3	Liquid Water Way --->	Fish ---> Man

Preliminary meteorological data and its associated methodology were reported in Section 2 of the 1982 TFTR FSAR. Subsequently, improved methodologies were implemented. A meteorological tower was erected and began operation in November 1983 (Notes: previous reports included the meteorlogical data; this compilation was discontinued. However, the data is still being collected and saved.) [Mc83, Ku95]. The improved measurements and methodologies are included in the updated FSAR prepared for deuterium-tritium operations.

A tracer gas-release test was conducted during the period from July to September 1988 to look at site-specific air-diffusion parameters. These tests were commissioned to determine actual site conditions *versus* model predictions in relation to future activities. The test results indicated that actual dispersion and dilution of effluents in the vicinity of PPPL are enhanced by up to a factor of 16 over that predicted by Nuclear Regulatory Commission approved standard Gaussian diffusion models [St89]. Additionally, as a result of these tracer gas-release tests, a 10-m wind speed and wind-direction sensor was added to the meteorological tower in 1990 to monitor PPPL on-site meteorology more precisely. The U.S.

Environmental Protection Agency (EPA) was petitioned through the Department of Energy-Princeton Group (DOE-PG) to use the more realistic c/Q values from these tests in the AIRDOS-EPA model used for the National Emission Standards for Hazardous Air Pollutants (NESHAPs) calculations. Approval was received in 1991.

Exhibit 2-3. Radiation Monitoring Program Covering Critical Pathways

Type of Sample	Critical Path I.D.	Sample Point Description	Sampling Frequency	Analysis
Surface	L1,L2,L3 & A3	1) Cooling Water Discharge Drainage 2) Bee Brook upstream & downtream 3) D&R Canal	Monthly	Tritium and Gamma Spectroscopy
Soil & Sod	A3	Within 1 km radius		Tritium and Gamma Spectroscopy
Biota (Fruits & Vegetables)	A3	Within 3 km radius	Seasonal	Tritium & Gamma Spectroscopy
Surface Water	L1, L2	Liquid Effluent Collection Tanks	As Required by Rate of Filling	Tritium and Gamma Spectroscopy, Volume
Air	A1-A3	Test Cell	Continuous	Activated Air (Gross b H-3 (HT and HTO)
Air	A1-A3	Vault	Continuous	H-3 (HT and HTO)
Air	A1-A3	HVAC Discharge (Stack)	Continuous	Activated Air (Gross b) HT and HTO, Particulates, Volume
Direct & Air (on-site)		4 Locations at TFTR Facility Boundary	Continuous	g, n, H-3 (HT and HTO), Gross b for activated air
Direct & Air (off-site)		6 locations off site with 1 km radius	Continuous integrated)	H-3 (HT and HTO)

H-3 = tritium
HT = elemental tritium
HTO = tritiated water

Gross b = Gross beta
g = gamma
n = neutron

The DOE Order 5400.1, "General Environmental Protection Program" [DOE90], requires PPPL to have an environmental radiological and non-radiological monitoring plan that contains meteorological, air, water, ground water, and radiological plans [PPPL92]. This environmental monitoring plan was completed in CY91, with revisions made in CY92 and CY95. Further revisions are planned for CY98.

3.0 1996 COMPLIANCE SUMMARY

3.1 Environmental Compliance

The Princeton Plasma Physics Laboratory's (PPPL) goal is to be in compliance with all applicable state, federal, and local environmental regulations. As a part of PPPL's Project Mission Statement, PPPL initiates those actions that enhance its compliance efforts and fully document how PPPL is meeting the requirements. The compliance status of each applicable federal environmental statute is listed below:

3.1.1 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

PPPL is not involved nor has been involved with CERCLA-mandated cleanup actions. As a result of the 1991 DOE-HQ Tiger Team assessment, an action plan was developed to conduct a more comprehensive documentation for CERCLA inventory of past hazardous substances. The CERCLA inventory was completed in 1993 [Dy93] and no further CERCLA actions were warranted by the results of the inventory.

3.1.2 Resource Conservation and Recovery Act (RCRA)

The Laboratory is in compliance with all terms and conditions required of a hazardous waste generator. In 1996, PPPL shipped off site approximately 59 tons (53.5 metric tons) of waste to facilities permitted to treat, store, or dispose of hazardous wastes. The three largest sources of waste generated at PPPL were 1) RCRA-regulated, chromium-contaminated soil removed around the C site cooling tower and base-neutral-contaminated soil along a swale embankment (the southwest section of C site), 2) non-RCRA, New Jersey-regulated (manifested and handled within strict regulations) waste oil, and 3) batteries containing acid (hazardous under RCRA), which were sent to a recycler [PPPL96b].

PPPL is also in compliance with the requirements of the RCRA-mandated Underground Storage Tank Program (also see 3.1.6 and 3.3.3). Following 40 CFR 280 and New Jersey regulations, PPPL removed five underground storage tanks in 1994. In January 1995, PPPL discontinued service from one tank, which was then abandoned in-place in accordance with the New Jersey Underground Storage Tank regulations. As directed by the the NJ Department of Environmental Protection (NJDEP) State Case Manager, PPPL submitted the Site Assessment report as part of the Remedial Investigation and Remedial Alternative Assessment Report in March 1997[HLA97].

3.1.3 National Environmental Policy Act (NEPA)

Fifty-six (56) PPPL activities received NEPA reviews in 1996, with all of these determined to be Categorical Exclusions according to the NEPA regulations and guidelines of the Council on Environmental Quality (CEQ) and DOE, or covered in a previously approved environmental assessment (EA).

No EAs or Environmental Impact Statements (EISs) were completed or in progress in 1996.

3.1.4 Clean Air Act (CAA)

PPPL was in compliance with the requirements of the CAA in 1996. The last required Air Emission Survey for 1994 was submitted in 1995 to NJDEP, who in turn submits the survey to the US Environmental Protection Agency (USEPA). The data were incorporated into a national database, the Aerometric Information Retrieval System (AIRS), and the Air Facility Subsystem (AFS) where it became public information.

In August 1995, PPPL submitted a request for Annual Emission Statement Non-Applicability to the NJDEP. In support of this non-applicability statement PPPL determined the maximum annual quantity of air contaminants 1) allowed to be emitted by permit from all permitted sources, 2) emitted from all unpermitted source operations operating at their maximum design capacity, and 3) emitted as fugitive emissions. The only regulated air contaminant that has the potential to be emitted by PPPL source operations above the air contaminant thresholds is nitrogen oxides (NO_x). The air contaminant reporting threshold for NO_x in accordance with NJAC 7:27-21.2 is 25 tons per year. PPPL determined that its potential to emit NO_x from permitted sources operating under federally enforceable permit conditions is below this threshold. In March 1996, the NJDEP approved PPPL's exemption for the non-applicability statement.

In addition to filing the non-applicability statement, PPPL submitted a negative declaration for the New Jersey Operating Permit Program. The CAA Title V Operating Permit program is implemented through the state of New Jersey. The negative declaration for the PPPL site was submitted to the NJDEP in August 1995 and was approved in March 1996 with an effective approval date of November 29, 1995. This effective approval date reflects the date that the TFTR emergency diesel generator operating hours were reduced and hence reduced the facility's potential to emit NO_x above the 25 ton-per-year threshold. The TFTR emergency diesel generator permit was the last of the PPPL permits to be amended as part of the negative declaration preparation.

As a result of a self-assessment by PPPL, the DOE Tiger Team assessment findings, and the Clean Air Act Amendments (CAAA) of 1990, preparation of a detailed air emission inventory was completed in May 1994. The purpose of the inventory was to estimate significant air emissions from each source so that a manageable air emission control program could be established. The inventory includes air emission quantities, point and fugitive emission sources, air-emission producing activities, and permit applicability. The air emission inventory is updated on a tri-annual basis and was partially revised during preparation of the negative declaration and non-applicability statement documents.

In October 1995, PPPL requested of the NJDEP a total fuel use limit for all four boilers. The NJDEP granted that request and imposed a maximum annual fuel use limitation for the C site boilers of 227,370 gallons of #4 fuel oil and 88.6 million cubic feet of natural gas. Prior to this date each boiler was limited by a specific fuel use for #4 fuel oil and natural gas. This arrangement did not allow the boilers to operate at maximum efficiency because specific boilers would be restricted to burn oil during optimal environmental conditions. PPPL continues to operate successfully within the above stated limitations.

In 1996, PPPL complies with the Stratospheric Ozone Protection Program of the Clean Air Act. More specifically, PPPL currently complies with Section 608 of the Act, which prohibits the venting of ozone-depleting substances through the use of certified refrigerant recovery units. In October 1996, PPPL submitted an inventory of Class I and II ozone-depleting substances (chlorofluorocarbons or CFCs) to DOE. In addition, PPPL safely disposes of equipment containing ozone-depleting substances by removing refrigerant to specified levels before disposal of the equipment. PPPL employs trained and certified technicians to service and repair equipment containing ozone-depleting substances and to operate the Laboratory's four refrigerant recovery units.

As requested by NJDEP in March 1995, PPPL determined the amount of sulfur hexafluoride (SF_6) released annually from TFTR operations. The amount of SF_6 needed to maintain the SF_6 systems can range from 28,060 pounds per year to 36,340 pounds per year. SF_6 was used in the modulator regulators, the ICRF, and the NB high voltage and ion source enclosures. With the shutdown of TFTR, SF_6 is being removed from the systems and stored for future use.

PPPL is working with its Procurement and Materiel Control Divisions to meet requirements of Executive Order 12843, "Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances." The ER/WM and Maintenance & Operations Divisions are working to identify and inventory present and future uses of class I and class II ozone-depleting substances.

3.1.5 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

PPPL added a stack sampler to the Tokamak Fusion Test Reactor (TFTR) facility for tritium releases, which has been independently verified as meeting National Emission Standard for Hazardous Air Pollutants (NESHAPs) radionuclide emission monitoring requirements. In August 1993, PPPL received USEPA's concurrence on this determination. In 1996, the levels of tritium released during TFTR deuterium-tritium (D-T) operations were measured: 118.625 curies of tritiated water or HTO and 64.88 curies of elemental tritium or HT (see Table 4) [GA97].

In 1996, the effective dose equivalent to a person at the business nearest PPPL, due to radionuclide air emissions, was 0.1 mrem (1 μSv), which is significantly lower than the NESHAPs standard of 10 mrem/yr (Table 2). During their most-recent inspection of PPPL facilities in May 1994, representatives from USEPA Region II indicated that PPPL was in compliance with NESHAPs requirements.

3.1.6 Clean Water Act (CWA)

PPPL is in compliance with the requirements of the CWA. An assessment of ground water has been undertaken as part of an effort that followed identification of leaking underground storage tanks (USTs) containing heating oil and vehicle fuel. Quarterly ground water monitoring reports for petroleum hydrocarbons and volatile organic compounds are submitted to NJDEP (see Section 6.1.3 C).

Under the CWA and "New Jersey Discharge of Petroleum and Hazardous Substances" regulation (New Jersey Administrative Code Title 7, Chapter 1E), PPPL reported one release, which involved tritiated water, to the NJDEP in CY 1996. On October 28, 1996, approximately five (5) gallons of tritiated water, water containing 0.1 mCi of tritium, was splashed onto the gravel. The release was the result of the steam generator relief valve opening during the operation of the liquid effluent collection tank evaporator. The water splashed over the evaporator dike onto the gravel on the ground. The operation of the evaporator was halted until it was moved into an enclosure.

Exhibit 3-1. 1996 Release Reports

NJDEP CASE #	PPPL #	TITLE	TYPE of RELEASE
96-10-28-1313-43	ER96-01	Evaporator Spill Incident	Tritiated water

3.1.7 National Pollutant Discharge Elimination System (NPDES)

In 1995, PPPL operated under the requirements of New Jersey Pollutant Discharge Elimination System (NJPDES) surface water discharge permit (NJ0023922). The NJDEP issued the renewed surface water permit on January 21, 1994, effective date of March 1, 1994 [NJDEP94]. The NJPDES surface water permit will expire on February 28, 1999.

Effective March 1, 1994, the monitoring locations in the permit are the detention basin outfall, monitoring point DSN001, the site's storm water runoff that does not drain to the detention basin—DSN002, and the filter backwash discharge (DSN003) at the Delaware & Raritan Canal pump house. These three locations are designated as monthly sampling points.

Due to natural scouring of the swale that leads to DSN002, there were a number of exceedances of the total suspended solids (TSS) limit (twice in 1995 and once in 1996). For that reason, PPPL and DOE-PG requested that the NJDEP consider eliminating the TSS limit from the permit conditions. As the result of meeting with NJDEP Bureau of Standard Permitting and Stormwater Management representatives, the requirement to sample DSN002 was eliminated from the NJPDES surface water permit effective June 1, 1996.

PPPL completed the identification of wastewater streams into the Stony Brook Regional Sewerage Authority (SBRSA) system. A site sanitary survey was completed in 1993 and updated in 1995. It is estimated that approximately 3 percent of the combined sewerage flow from PPPL is classified as industrial wastewater and 97 percent as domestic wastewater. In December 1993, SBRSA issued a draft industrial discharge permit to PPPL, for which PPPL and DOE-PG submitted comments. In February 1995, SBRSA issued a revised final permit requiring sampling of only the liquid effluent collection (LEC) tank discharge. Following discussions with SBRSA, PPPL and DOE-PG agreed to report LEC tank data to SBRSA on a monthly basis (tritium, pH, and temperature). The SBRSA industrial discharge permit was changed from a permit to a license in February 1996 with the elimination of the annual sampling requirement. Monthly sampling for tritium, pH and temperature at the LEC tanks remains a requirement of the license. The PPPL worked to eliminate the photo laboratory waste stream as an industrial flow to the sanitary sewer. Filters were installed to remove silver from the photographic process wash and rinse water. Future discharges may be totally eliminated through the use of digital photography.

3.1.8 Safe Drinking Water Act (SDWA)

The PPPL receives its drinking water from the Elizabethtown Water Company. While Elizabethtown is responsible for providing safe drinking water, PPPL periodically tests incoming water quality. In 1994, PPPL installed a new backflow prevention system beneath the elevated water tower. In the event of a fire or other emergency situation, PPPL can switch from the Delaware & Raritan Canal water (nonpotable) to potable water for its water supply.

On a quarterly frequency, PPPL inspects and pressure tests the back flow prevention equipment at both locations: the main potable water connection and the new system beneath the elevated water tower. The back flow prevention equipment prevents contamination of the potable water supply *via* a large cross-connection. In the presence of a representative from the Middlesex County Health Department (MCHD), the systems are inspected each quarter (for the first three quarters of 1996) at the point where Elizabethtown Water enters C site (main connection) and beneath the water tower. In December 1996, PPPL began its inspections without the MCHD representative. On an annual basis, these systems are completely disassembled, inspected, and tested in the presence of both MCHD and the Elizabethtown Water Company representatives. In order to maintain an uncontaminated potable water supply, other cross-connection equipment is tested annually.

3.1.9 Toxic Substance Control Act (TSCA)

PPPL is in compliance with the terms and conditions of TSCA for the protection of human health and the environment by requiring that specific chemicals be controlled and regulations restricting use be implemented. The last PPPL polychlorinated biphenyl (PCB) transformers were removed from the site in 1990. At the end of 1996, there were 653 PCB capacitors, which met the regulation criteria, remaining on-site. These capacitors are located in buildings with concrete floors and are protected from the weather, and of the 653 capacitors, 640 capacitors also have secondary containment. There are no plans at this time to remove and/or replace these capacitors.

3.1.10 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Application of herbicides, pesticides, and fertilizers is performed by certified subcontractors who meet all the requirements of FIFRA. PPPL Facilities and Environmental Management Division (F&EM) monitors this subcontract (see Table 21).

3.1.11 Endangered Species Act (ESA)

PPPL occupies 72 acres of the Forrestal Campus of Princeton University. The 1975 "Final Environmental Statement for the Tokamak Fusion Test Reactor Facilities," the approved "Environmental Assessment (EA) for the TFTR Deuterium-Tritium (D-T) Modifications," and the approved "TFTR Decommissioning and Decontamination (D&D) and Tokamak Physics Experiment (TPX) Environmental Assessment" have indicated that there are no endangered species on-site. [ERDA75] [DOE92] [DOE93b]

In the fourth quarter of 1992 and in the first quarter of 1993, the NJDEP, Division of Parks and Forestry, Natural Heritage Data Base [Dy93], reported that there are no records for rare plants, animals, or natural communities on the PPPL site. There are records for a number of occurrences of rare species that may be on or near waterways surrounding the site. As the Natural Heritage data is based on a literature search and on individuals' observations of endangered species in the vicinity of PPPL and is not based on site-specific surveys and/or observations, the data obtained from this database are not considered definitive. Should PPPL plan any "major construction activity," prior to the start of the activity, a survey will be conducted as part of a NEPA document, if required.

3.1.12 National Historic Preservation Act (NHPA)

There are no identified historical or archaeological resources at PPPL. No buildings or structures have been identified as historical [Gr77].

3.1.13 Executive Orders (EO) 11988, "Floodplain Management"

The PPPL is in compliance with EO 11988, "Floodplain Management." Delineation of the 500 and the 100-year floodplains was completed in February 1994. The 500-year and the 100-year floodplains are located at the 85-foot elevation and at the 80-foot elevation above mean sea level, respectively [NJDEP84] (see Fig. 35).

A Stream Encroachment Permit application is required for construction within the flood hazard area and the 100-year floodplain as regulated in NJAC 7:13 *et seq*. An application was filed with the NJDEP in August 1992 for the detention basin upgrade project, specifically, for the modifications to the discharge area. The permit was approved and became effective in November 1992 and remains in effect until November 23, 1997. The detention basin upgrade project, which includes the replacement of an existing headwall for the discharge of the detention basin, began in August 1994, and the entire project was completed in 1996.

In 1995, PPPL began preparing a site-wide stormwater management plan. It would include the proposed second cell detention basin, which was in the conceptual design phase. In the process, PPPL discovered that the Princeton Forrestal Center (PFC) the management group for Princeton University's corporate office and research complex, included the PPPL site in their Stormwater Management Plan. This plan was submitted to the Delaware Raritan Canal Commission (DRCC) in 1980 and a Certificate of Approval was signed on May 20, 1980. The 72-acre parcel that PPPL occupies is included in PFC's stormwater management plan-Phase I. The 72-acre parcel is part of the Bee Brook watershed and therefore includes PPPL in the PFC stormwater plan.

One condition of the PFC Storm Water Management Plan is that the average density of development not exceed a maximum of 60% impervious coverage in developable areas. PPPL meets the 60% impervious coverage limit and is in compliance with the stormwater requirements . PPPL determined that the second detention basin was not required. The Site-Wide Stormwater Management Plan was completed in February 1996 [SE96]

3.1.14 Executive Orders (EO) 11990, "Protection of Wetlands"

PPPL is in compliance with the EO 11990, "Protection of Wetlands." Formal study and delineation of wetland boundaries within the PPPL 72-acre site are complete. Using infrared film for aerial photographs, the presence of wetland-type vegetation was found on the north and eastern boundaries of the Laboratory property. In July 1993, an "Application for a Letter of Interpretation" (LOI) for the entire 72-acre site was filed with the NJDEP Land Use Regulation Program. The LOI application included: US Geological Survey (USGS) topographic maps, National Wetlands Inventory maps, US Department of Agriculture (USDA) Soil Conservation maps, aerial photographs, and vegetation maps. These maps were used to prepare the delineation program and the target critical areas.

Wetland boundaries were flagged based on an analysis of the soil type, vegetation identification, and area hydrology, *i.e.*, depth to ground water. Soil profiles to determine soil type were conducted through soil borings, which were also analyzed for indications of seasonal high water table. A wetlands delineation map that indicated the boundary, sequential flag numbers, and soil boring locations was prepared (see Fig. 23).

The Land Use Regulation Program within NJDEP continues to be the lead agency for establishing the extent of state and federally regulated wetlands and waters. The U.S. Army Corps of Engineers retains the right to re-evaluate and modify the wetlands boundary determinations at any time.

In 1996, PPPL applied for and received General Permits 4 and 14, for activities required by the Remedial Investigation and Remedial Assessment Alternatives program. General Permit #4 was needed for the removal of soil in a swale that was found to be contaminated above the NJ Soil Cleanup Standards for base neutral compounds. General Permit #14 was necessary for the installation of two ground water monitoring wells to be installed in the wetlands south of the CAS/RESA buildings, where volatile organic compounds in adjacent wells were detected.

3.1.15 Executive Order 12856, "Federal Compliance with Right-to-Know and Pollution Prevention Requirements," and Superfund Amendments and Reauthorization Act (SARA) Title III, Emergency Planning and Community Right-to-Know Act (EPCRA)

Emergency Planning and Community Right-to-Know Act, Title III of the 1986 SARA amendments to CERCLA created a system for planning responses to emergency situations involving hazardous materials and for providing information to the public regarding the use and storage of hazardous materials. Under the reporting requirements of Executive Order 12856 and the SARA Title III, PPPL has complied with the following:

Exhibit 3-2. Summary of PPPL Reporting Requirements

EPCRA 302-303: Planning Notification	YES [✓]	NO [ ]	NOT REQ. [ ]
EPCRA 304: EHS Release Notification	YES [ ]	NO [ ]	NOT REQ. [✓]
EPCRA 311-312: MSDS/Chemical Inventory	YES [✓]	NO [ ]	NOT REQ. [ ]
EPCRA 313: TRI Inventory	YES [ ]	NO [ ]	NOT REQ. [✓]

In 1996, PPPL submitted an annual chemical inventory to be in compliance with SARA Title III (EPCRA 312). This inventory reports the quantities of chemicals listed on the CERCLA regulations that are stored on site.

Under SARA Title III, PPPL provides to the applicable emergency response agencies: 1) an inventory of hazardous substances stored on site; 2) Materials Safety Data Sheets (MSDS); and 3) completed SARA Tier I forms listing each hazardous substance stored by users above a certain threshold planning quantity (typically 10,000 pounds, but lower for certain compounds). Exhibit 3-3 lists hazardous compounds at PPPL, reported under SARA Title III for 1996 [PPPL1996a].

Exhibit 3-3. Hazard Class of Chemicals at PPPL

Compound	Fire	Sudden Release of Pressure	Reactive	Acute Health Hazard	Chronic Health Hazard
Carbon dioxide		✓		✓	
Chlorodifluoromethane		✓		✓	
Dichlorodifluoromethane (CFC 12)		✓		✓	
Fuel Oil	✓				
Gasoline	✓				✓
Helium		✓			
Nitrogen		✓			
Petroleum Oil	✓				
Polychlorinated Biphenyls					✓
Sulfur Hexafluoride		✓			
Sulfuric acid			✓	✓	
Trichlorotrifluoroethane (CFC 113)				✓	

Section 304 of SARA Title III requires that the Local Emergency Planning Committee (LEPC) and state emergency planning agencies be notified of accidental or unplanned releases of certain hazardous substances to the environment. To ensure compliance with such notification provisions, a Laboratory-wide procedure, ESH-013, "Non-Emergency Environmental Release—Notification and Reporting," includes SARA Title III requirements. The NJDEP administers SARA Title III reporting for the USEPA and has modified the Tier I form to include SARA Title III reporting requirements and NJDEP reporting requirements.

Because PPPL's use of chemicals listed on the Toxic Release Inventory (TRI) is below the threshold amounts, PPPL is technically not required to submit the TRI. Following DOE's guidance issued in 1994, PPPL completed an annual submittal to DOE for 1996 that included the TRI cover page and laboratory exemption report.

3.1.16 Federal Facility Compliance Act (FFCA)

The Federal Facility Compliance Act (FFCA) requires the Department of Energy (DOE) to prepare "Site Treatment Plans" for the treatment of mixed waste, waste containing both hazardous and radioactive components. Based on the possibility of the site generating mixed waste, which could require treatment on site, PPPL was identified on the list of DOE sites that would be included in the FFCA process [PPPL95c]. In 1995, PPPL prepared its "Proposed Site Treatment Plan (PSTP) for Princeton Plasma Physics Laboratory (PPPL)."

PPPL has developed an approach where any potential mixed waste would be treated in the original accumulation container within 90 days of generation of the hazardous waste. This treatment option was discussed with the State of New Jersey and USEPA Region II regulators, who were in agreement with this approach. Based on their agreement, this approach will keep PPPL in compliance with the applicable Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions. However, DOE will provide the state and USEPA with annual updates and will keep the regulators apprised of the status of activities. If mixed wastes were generated that could not be treated in the original accumulation containers, PPPL would notify the regulators and provide them with a revised "Site Treatment Plan" [PPPL95c].

3.2 Current Issues and Actions

3.2.1 Air Issues and Actions

Several small, fundamental projects at PPPL that capture the intent of Section 612, "Significant New Alternatives Policy Program (SNAP)," are underway. In 1996, proposals for alternative refrigerants and retrofits for large equipment (chilled water systems) that use ozone-depleting substances were submitted to DOE for approval and funding. Through PPPL's Waste Minimization and Pollution Prevention program, PPPL is continuing to examine substitute degreasing compounds, especially for future TFTR shutdown and removal activities.

In 1996, PPPL received approval from NJDEP for a negative declaration and a non-applicability statement for the CAA Operating Permit Program and the NJDEP Annual Emission Statement, respectively. In support of the negative declaration and non-applicability statement, several amendments were made to existing permits. The TFTR emergency diesel generator was limited to 200 hours of operation per year and the boilers were limited to a ten ton per year emission rate based on fuel limitations. Through these amendments PPPL determined that its potential to emit NO_x from permitted sources is 23 tons per year. This estimate is based upon exagerated fuel consumption. The actual NO_x emissions from PPPL permitted sources based on actual fuel consumption and operating hours during CY96 was 1.9 tons per year.

3.2.2 NJPDES Surface Water Permit No. NJ0023922 Issues and Actions

During CY1996, two non-compliances were reported: one for total suspended solids (TSS) and one for chemical oxygen demand measured at DSN002 (stormwater) (see Table 21). At DSN002, located at the southwestern boundary of C site, two exceedances were reported for the stormwater discharge samples collected in April 1996. These exceedances were attributed to natural sediments in the ditch and not to PPPL activities or soil disturbances. PPPL and DOE-PG submitted a request to NJDEP for modifications to the permit addressing this issue. Modification to DSN002 requirements within the PPPL surface water permit were made and distributed for public comment in February 1996. The permit modification eliminating the DSN002 sampling requirement was effective on June 1, 1996.

During NJDEP's review of the TFTR deuterium-tritium (D-T) Environmental Assessment (EA), an issue regarding the elevated temperature in Bee Brook at location B2 was raised. The New Jersey Surface Water Quality Standards limit the temperature of the discharged water to a maximum increase of 2.8°C (5.0°F) above ambient water temperature at any time. It has been noted that there are times in the winter when the delta t (Dt or the difference in temperature between the discharged and surface waters) was greater than the 2.8°C limit. PPPL suspected the higher temperature was caused by ground water pumped to dewater various building foundations. The temperature of groundwater measures a near constant 12.8° C (55°F) all year round, while in the winter surface water temperatures drop to as low as 0°C (32°F). For 1996, the approximate amount of groundwater pumped to dewater D site (TFTR and MG basements) and C site (LOB and CS basements) was 300,000 gallons per day.

In September 1996, the NJDEP conducted its annual inspection of the facility including records maintenance. The inspector rated PPPL "acceptable," with no deficiencies noted.

Under NJPDES requirements, Chronic Toxicity Testing continued bi-monthly from March through September and then quarterly beginning in December 1996. The test organisms, *Pimephales promelas* or fathead minnows, survived in 100 percent concentration of PPPL's detention basin discharge over the test period in all tests.

3.2.3 NJPDES Ground-Water Permit No. NJ0086029 Issues and Actions

In 1989, PPPL and DOE-PG requested an adjudicatory hearing on the requirements of the New Jersey Pollutant Discharge and Elimination System (NJPDES Permit No. NJ0086029) discharge to groundwater permit. PPPL and DOE-PG protested the placement in PPPL's permit of three monitoring wells on A and B sites of the James Forrestal Campus; the basis for the protest was that these locations are not on DOE leased-property, but are on property under Princeton University's control. Despite a pending adjudicatory hearing, the DOE-PG and PPPL have complied with all permit-mandated activities. These activites included the installation of five ground-water monitoring wells, quarterly sampling of seven wells, twice annual sampling of the detention basin inflows, and a hydrological study as discussed below.

The ground water discharge permit (NJ0086029) expired on December 31, 1994. The renewal application was prepared and included a report on ground-water quality based on quarterly ground water samples collected from December 1989 through February 1994 [Fi94a]. In this application, the PPPL and DOE-PG requested that NJDEP delete from the permit the three off-site wells, for which the adjudicatory hearing was requested. As of December 1996, NJDEP has not issued a new NJPDES ground water permit; PPPL and DOE-PG continue to comply with the requirements of the expired permit. DOE-PG has requested that the NJDEP review past ground water data and reduce the frequency and number of sampling locations in the renewed permit. NJDEP is currently reviewing the data and a decision to reduce sampling locations, sampling frequency and parameters is pending.

One of the requirements of the NJPDES permit was to conduct a site-wide hydrological study. Based on quarterly ground-water monitoring data and the site-wide hydrological studies (presence of volatile organic compounds in ground water), NJDEP required further investigation of James Forrestal Campus. A Memorandum of Understanding (MOU) was signed by Princeton University in February 1993. Princeton University has responsibility for investigating A/B sites, and PPPL and DOE-PG have responsibility for C and D sites.

Under the terms of the MOU, PPPL has conducted several rounds of environmental characterization and remediation. In 1995, after the NJDEP granted "conditional approval" of PPPL's Remedial Investigation Work Plan, soil and ground water samples were collected and analyzed for the seven (7) identified areas of potential concern (APECs). Results from these samples indicated that only two (2) APECs contained chemicals above the most stringent NJDEP Soil Cleanup Criteria applicable. In 1996, contaminated soil and sediments were removed from these APECs for off-site treatment and disposal. Post-excavation sampling confirmed that the NJDEP Soil Cleanup Criteria were met by the remedial actions.

In 1996, PPPL also installed four new monitoring wells south of the CAS/RESA Building area in order to fully delineate the extent of ground water contamination in this area. These wells and other ground water characterization activities lead to the identification of a new APEC near the former PPPL Annex Building (see Figure 13). The Remedial Investigation activites conducted in 1995 and 1996 are documented in the Remedial Investigation Report prepared by Harding Lawson Associates, which was submitted to NJDEP in March 1997 [HLA97]. Characterization and possible limited soil remediation in the former Annex Building area is planned for 1997.

3.2.4 Tiger Team and Self-Assessments Issues and Actions

PPPL was audited by a DOE Tiger Team between February 11, 1991, and March 12, 1991. During PPPL's own self-assessment performed in late 1990, PPPL had identified over 70 percent of the Tiger Team findings. There were 54 environmental findings, none of which represented situations that presented an immediate risk to public health or to the environment or that warranted an immediate cessation of operations. Of these findings, 38 were related to requirements of DOE Orders, federal or state regulations, or PPPL directives or procedures. Sixteen of the findings were related to best-management practices. In addition, there were 166 safety and health concerns and 26 management concerns. An Action Plan was finalized by PPPL in April 1991 and approved and officially released by DOE/HQ in April 1992. Of the 612 milestones addressing the 300 Tiger Team findings and concerns, 99 percent have been completed as of early 1997.

3.3 Environmental Permits

PPPL Environmental Restoration/Waste Management Division maintains a list of Environmental permits (see Exhibit 3-4) which is updated bi-monthly. A discussion of the environmental permits required by the applicable statutes is found in Sections 3.0 or 6.0, "Environmental Non-Radiological Program Information."

Exhibit 3-4. PPPL Environmental Permits

Permit No.	Permit Type	Effective Date	Expiration Date	Status
0086029	NJPDES Groundwater	4/1/89	12/31/96	In compliance. Renewal applic. submitted toNJDEP7/5/94.
0023922	NJPDES Surface water	1/21/94 Effective 3/01/94	02/28/99	In compliance. Chronic toxicity testing back to quarterly schedule.
092187	TFTR Diesel Exhaust	10/24/89	10/24/99	Current.
096074	C-site Diesel Exhaust	6/28/90	6/28/00	Current..
094831	Hot Cell Degreaser Vent	3/30/90	6/16/97	Id. No. 15952 Current. *Permit modifications in progress.*
826	Elizabethtown Water Physical Connection	4/1/93	3/31/98	Current.
061295	Boiler #2 Stack Vent	3/31/82	7/11/97	Current. Temporary 90-day permit.
061296 *118817*	Boiler #3 Stack Vent Mod. to Boiler #3	3/31/82 10/21/94	7/6/97	Current. Temporary 90-day permit.
061297	Boiler #4 Stack Vent	3/31/82	7/11/97	Current.Temporary 90-day permit
061299	Boiler #5 Stack Vent	3/31/82	7/11/97	Current.Temporary 90-day permit
061298	Oil Tank Vent #2	3/31/82	3/31/97	Cancelled.
0128306	Medical Waste Gener.	7/22/91	7/21/98	Current.
DR-18A	D&R Canal Water Use	7/1/84	6/30/2009	Current.
12471	REML Laboratory Certification	7/1/91	6/30/98	Current
111580	CAS Dust Collector	3/10/93	3/10/98	Current.
113444	FED Dust Collector	7/23/93	7/23/98	Current.
113445	Shop Dust Collector	7/23/93	7/23/98	Current.
separate list	Well Permits	NA	NA	Current.
114785	Air Permit - AGT 15,000 gal. Diesel Oil	10/25/93	10/25/98	Current.
119065	Air Permit - AGT 25,000 gal.# 4 Oil	10/25/94	10/25/99	Current.
22-93-NC	SBRSA Industrial Discharge Permit	2/15/95	2/25/98	Current
1218-91-0001.8 & .9	Wetlands Permits (GP4 and GP14)	9/18/96	3/16/97	GP4-Sediment removal in swale SW area of C site GP14-Monitoring well installation S of CAS/RESA.
1218-91-0001.2	Wetlands—Letter of Interpretation	1/13/94	1/13/99	Wetlands Delineation Plan completed 5/94.
92-0363	FSCD- Detention basin modifications	6/16/93	12/16/96	FSCD reps. visited site in Aug.; Project completed
95-0025	FSCD-Radwaste Facility	4/12/95	4/12/97	FSCD reps. visited on 8/21/95. Need to notify of Project complet.
10944W	Water Use Registration	6/10/96	NA	Wells 4&5 annual report monthly use

4.0 ENVIRONMENTAL PROGRAM INFORMATION

4.1 Summary of Radiological Monitoring Programs

Monitoring for sources of potential radiological exposures is extensive. Begun in 1981, real-time prompt gamma and/or neutron environmental monitoring on the TFTR site established baselines prior to machine operation. In 1996, the following air stations were monitored:

Exhibit 4-1. Radiological Air Monitoring Stations

Station Name	Number/Description	Figure
Remote Environmental Air Monitoring (REAM)-off site	Stations *REAM 1- 6*: Tritium	7
TFTR radiological monitoring system (RMS) on D site	8 Neutron detectors and gamma ionization detectors and passive tritium monitors at *TR 1-4*:	6
Radiological monitoring system (RMS) at property line stations	2 Neutron detectors and gamma ionization detectors at Northeast (*RMS-NE*) and Southeast (*RMS-SE*)	6

Water samples are collected at the same locations for both non-radiological and radiological samples that are analyzed for tritium, HTO (Exhibit 4-2).

Exhibit 4-2. Radiological and Non-Radiological Water Monitoring Stations

Station #	Location/Figure #	Description
B1	Off-site / 6	Bee Brook Upstream of discharge from detention basin
B2	Off-site /6	Bee Brook Downstream of discharge from detention basin
C1	Off-site / 8	Delaware & Raritan Canal (Plainsboro)
D1	On-site / 6	D site Manhole-stormwater sewer
D2	On-site / 6	DSN001 Surface Water Discharge from the detention basin
E1	On-site / 6	Elizabethtown Water Company - potable water supply
M1	Off-site / 8	Millstone River - Plainsboro & West Windsor boundary- Route 1
P1	Off-site / 8	Plainsboro Surface Water - Millstone River
P2	Off-site / 8	Plainsboro Surface Water - Devils Brook

In general, the tritium content of the soil mirrors the tritium content in the precipitation, which can be highly variable over the year due to the amount of tritium in the atmosphere.

The most recent and comprehensive assessment of population distribution in the vicinity of PPPL was completed for the Burning Plasma Experiment (BPX) Environmental Assessment (EA) [Be87a]. PPPL is situated in the metropolitan corridor between New York City to the northeast and Philadelphia to the southwest. Census data indicate that approximately 16 million people live within 80 km (50 miles) of the site and approximately 212,000 within 16 km (10 miles) of PPPL.

The overall, integrated, effective-dose equivalent (EDE) from all sources (excluding natural background) to a hypothetical individual residing at the nearest business was calculated to be 0.11 mrem (1 μSv) for CY96 (see Table 2). Detailed person-rem calculations for the surrounding population were not performed, because the value would be insignificant in comparison to the approximately 100 mrem (1 mSv) each individual receives from the natural background, exclusive of radon, in New Jersey. However, scaling and estimating[1] were performed and yielded a value of 6.0 person rem (0.06 person-Sievert) out to 80 km (also see Table 2).

4.2 Summary of Non-Radiological Monitoring Program

During CY 96, PPPL operated under the current NJPDES surface water permit, No. NJ0023922, which became effective on March 1, 1994. As stated in the permit conditions, PPPL monitored monthly the discharge of the detention basin, discharge serial number—DSN001 or D2. Once each month, the water quality at DSN001 is assessed by monitoring the temperature, pH, petroleum hydrocarbons, total suspended solids, chemical oxygen demand, chlorine-produced oxidants, and flow. Additional parameters measured are biological oxygen demand, phenols, ammonia-nitrogen, and total dissolved solids. Monthly data exists for D2 beginning in 1984.

Monthly sampling of two additional discharge points continued: DSN002—a storm water and emergency fire protection system discharge (Fig. 6) until June 1996 and DSN003— a filter backwash discharge located at the Delaware and Raritan Canal pump house (Fig. 7).

As a requirement of the permit, a chronic toxicity characterization study was conducted to test the DSN001 effluent. Bimonthly study results were reported to NJDEP for March through September 1996. Quarterly study results were submitted for the December 1996 test. *The bimonthly frequency was due to test results in December 1994 and March 1995, when the test organism, the fathead minnow (Pimephales promelas,)* suffered mortality in the 25-percent effluent concentration tests. After six consecutive successful test results, the frequency returned to quarterly testing.

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[1]Scaling was done using the ratio of the actual released amount of airborne radionuclides to the quantities cited in the TFTR D-T EA multiplied by the calculated dose. For calculating the liquid component, assumptions are described in Table 2, Note 14. Other sources are negligible contributors.

At the start of the study in 1994, two test species were used, the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). In the first three of five test sequences, the fathead minnow had 100 percent survival; the water flea had 100 percent survival in all tests. Based on those results, the NJDEP eliminated the requirement to continue the waterflea (*Ceriodaphnia dubia*) testing. Quarterly chronic toxicity testing was conducted with the fathead minnow (*Pimephales promelas*) only. In 1995, the NJDEP proposed a group modification, which included using a statistical test inhibition concentration or IC_{25}, which is a more precise indication of chronic effects upon organisms than hypothesis tests performed in the past[1]. Based on PPPL and DOE-PG's decision to accept the group modification, the permit limit for the IC_{25} is 100 percent. The NJDEP directed that the testing frequency be changed to bimonthly instead of quarterly until the results of the toxicity study consistently achieved no observable effect concentration or NOEC of 100 percent.

NJDEP required a monitoring program to determine if ground water is being impacted from the five former underground storage tanks removed in 1989. PPPL had a total of eleven underground storage tanks; five tanks were removed in 1989, five more tanks were removed in 1994, and one tank was abandoned in-place in 1995. In accordance with ground-water monitoring program requirements (separate and distinct from the NJPDES groundwater discharge permit requirements), 10 monitoring wells, located near the former tanks, were monitored for total petroleum hydrocarbons (TPHs) and volatile organic compounds quarterly (beginning in June 1996). Once a month, 30 wells were measured for water elevations with corresponding contour maps prepared for each month. By measuring the water elevation in these wells monthly, elevations can be used to track changes in direction of ground water and fluctuations in water elevations across the site. In November 1995, new equipment, *i.e.*, dedicated in-well pumps, were installed in these monitoring wells. The elevations of the top of the wells required that a new survey be conducted. As the survey was not performed until 1997, contour maps were not generated. Analytical results were compiled in four quarterly reports and will be submitted to NJDEP pending the drawing of the contour maps.

Under the NJPDES-required ground-water program, Discharge Permit No. NJ0086029, 7 ground-water monitoring wells were sampled quarterly in 1996 (Exhibit 6-2 and Figs. 6 and 7). Exhibit 4-3 presents the required parameters, wells, frequency, and permit standard. All New Jersey ground-water permits that were due to expire in 1994 were extended two years and expired on December 31, 1996. NJDEP,

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[1]The linear interpolation method is used to calculate a point estimate of the effluent concentration causing an effect on the test organisms. The point estimate of the concentrations can be used to evaluate the precision of the test. The hypothesis tests used in the past, however, do not provide the opportunity to calculate a quantitative estimate of the inter- or intra-laboratory variability.

under the adopted NJPDES regulations, extended expiration dates for all permits until a new ground-water discharge permit could be issued.

Exhibit 4-3. NJPDES NJ0086029 Ground Water Discharge Standards and Monitoring Requirements for Ground Water Monitoring Wells

Parameters (these wells only)	Standards	Feb.	May	Aug.	Nov.
Ammonia-Nitrogen	0.5 mg/L		X	X	X
Base/Neutral Extractable	See Note below			X	
Chloride	250 mg/L			X	X
Chromium (hex.) & compounds - (D-12, MW-14, MW-15, MW-16)	0.05 mg/L			X	X
Lead and compounds	0.05 mg/L			X	X
pH- field determined	Standard Units	X	X	X	X
Petroleum Hydrocarbons				X	
Phenols	0.3 mg/L			X	X
Specific Conductance - field determined	mmho/cm	X	X	X	X
Sulfate	250 mg/L	X	X	X	X
Total Dissolved Solids	500 mg/L	X	X	X	X
Total Organic Carbon				X	
Total Organic Halogen				X	
Total Volatile Organic -D-11,D-12,TW-3	See Note below		X	X	
Tritium - (D-11, D-12, TW-3)				X	

Elevation of top of casing, depth to water table from top of casing and from ground level reported every quarter.
All monitoring wells D-11, D-12, MW-14, MW-15, MW-16, TW-2, and TW-3 are sampled except where so noted.
Note: 40 CFR Part 136-Methods 624 and 625 shall be used to identify and monitor for the volatile organic compounds and base/neutral toxic pollutants as identified in Appendix B of the NJPDES Regulations (NJAC 7:14A-1 *et seq.*).

In 1993, Princeton University entered into an agreement with the Department of Environmental Protection to investigate and to potentially remediate ground-water contamination. In September 1994, PPPL prepared a revised work plan for the remedial investigation required under the Memorandum of Understanding (MOU) and submitted it to NJDEP (see Sections 3.2.3 and 6.1.3 C for further discussion of the MOU).

In December 1996, a round of ground-water samples was performed for all monitoring wells, including the four newly installed wells on the south side of C site (Fig. 6). The results exceeded the New Jersey Ground Water Quality Standards for volatile organic compounds, mainly tetrachloroethene and trichloroethene (Table 34); this monitoring activity lead to the identification of a new APEC located near the former Annex Building where hazardous materials had been stored prior to the construction of the Hazardous Materials Handling Facility or HAZMAT Building..

4.3 Environmental Permits

Environmental permits held by DOE-PG are listed in Exhibit 3-3 and are discussed in Section 3.0, "Environmental Compliance Summary" and Section 6.0, "Environmental Non-Radiological Program Information," of this report.

4.4 Environmental Impact Statements and Environmental Assessments

No Environmental Impact Statements or Environmental Assessments were prepared in 1996.

4.5 Summary of Significant Environmental Activities at PPPL

4.5.1 Tritium in the Environment

In the August 1995 sample for well TW-1, located north of the TFTR stack, the tritium concentration was found to be above background or baseline concentration, 789 *versus* 150 picoCuries/Liter (pCi/L), respectively. As a result of this finding, PPPL began an investigation into the cause of the concentration increase. More wells and ground water sumps were sampled, underground utilities were tested for leaks, soil was tested, and roof drains were sampled. In addition, on and off-site rain water sampling stations were established and sampled.

Results of this program were that no leaks were found emanating from underground utilities - soil results supported this finding. Drain samples from the liquid effluent collection tank roof as well as soil samples next to drain spouts showed that tritium contentrations were elevated. Rain water samples showed elevated levels of tritium during October 1996 (21,140 pCi/L at station R1North) when TFTR was opened for maintenance activities and atmospheric releases were also elevated. Numerous scientific studies have documented the effects of atmospheric tritium releases and the subsequent "washout" in precipitation. Rain droplets act as a scrubber and wash tritiated water vapor (HTO) out of the plume from the stack [Mu90]. Water infiltrates into the ground, and eventually, some of the tritium reaches the ground water table and monitoring wells. The highest concentration of tritium in the ground water in 1996 was 1288 pCi/L at TW-1 on April 12, 1996.

Ground water results showed that tritium concentrations fluctuate over time. PPPL believes that the tritium concentration in the atmosphere, the amount of precipitation (rainfall), and the time of year all have an effect on the concentration in the ground water. Monitoring of ground water, precipitation, and the TFTR vent stack will continue in 1997.

4.5.2 New Jersey Pollutant Discharge Elimination System Ground and Surface Water Permits

Representatives from DOE, NJDEP, and PPPL met to discuss the NJPDES ground-water permit pre-draft conditions. Mixing of surface and ground water occurred within the previously unlined detention basin and was regulated in the ground-water permit through required measurements of the detention basin water quality. This concern of surface and ground-water mixing has been eliminated since the installation of a detention basin liner in October 1994. The issue of volatile organic compounds present in the ground water is being addressed by the Remedial Investigation conducted under the MOU between Princeton University and the NJDEP (see Section 3.2.3). NJDEP was concerned about water quality in the detention basin and the possibility of a liner breach causing ground water contamination beneath the detention basin. In 1996, PPPL collected additional data, including water quality and flow measurements to better understand the ground water and surface water that flows through the basin. A draft report was prepared but was not submitted to NJDEP due to pending changes to the NJPDES regulations.

In May 1997, the NJPDES regulations (NJAC 7:14A) were adopted. The ground water discharge program was modified, and the Ground Water Pollution Plan or GWPP was offered as an option to the conventional discharge permit. In order for PPPL to apply for the GWPP option, the above report on ground water monitoring requires revision and updating to include data collected in 1997.

4.5.3 Waste Minimization Activities and Pollution Prevention Awareness

PPPL site-wide Waste Minimization/Pollution Prevention Program accomplished the following in 1996. The hazardous waste recycling program continued with PPPL's solid waste stream reduced by the recycling of 95,832 pounds of paper, 16,280 pounds of aluminum cans, plastic and glass bottles. These accomplishments are attributable to the continuation of the Sanitary Waste Evaluation [PPPL97]. In 1996, approximately 400,000 Curies of tritium was shipped to Savannah River for reprocessing; in 1995, 235,196 Curies (Ci) of waste tritium was recycled at Savannah River. This represents a diversion of 2,040 cubic feet of low-level waste (LLW) from burial and an associated cost avoidance of $1.43 million.

4.5.4 Storm Water Management

In 1996, PPPL completed the preparation of a site-wide stormwater management plan. Originally, a proposal for a second detention basin was included. PPPL found that the Princeton Forrestal Center (PFC), the management group for Princeton University's corporate office and research complex, had

PPPL's 72 acres included as part of the Bee Brook watershed in its Stormwater Management Plan. When the PFC plan was recognized as protecting PPPL from stormwater flooding, the second detention basin was cancelled. One constraint of the PFC Stormwater Management Plan is a limit of 60 percent impervious cover of developable land. Excluding the stream protection corridor (used as retention capacity for stormwater runoff) and delineated wetlands, PPPL was at 55.5 percent developed as of November 1995. In 1996, by removing temporary trailers and completing the Stormwater Pollution Prevention Plan, PPPL acted to lower this percentage and maintain stormwater quality.

4.5.5 Environmental Training

In 1996, PPPL employees continued to participate in the 8-hour refresher course for the "Health and Safety for Hazardous Waste Site Investigation Personnel" or OSHA HAZWOPER refresher, which was taught on site by instructors from the Environmental and Occupational Health Sciences Institute (EOHSI). Employees had the opportunity to attend this course or the 40-hour OSHA HAZWOPER course at EOHSI's Piscataway, New Jersey facility. EOHSI is jointly sponsored by the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School and Rutgers, the State University of New Jersey. Through a grant from the Department of Energy, EOHSI provided this training.

5.0 ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Radiological Emissions and Doses

5.1.1 Penetrating Radiation

The TFTR commenced high power Deuterium-Tritium operations in December 1993, which continued through Calendar Years 1994-1996 (CY94-96). These operations are a potential source of neutron and gamma/x-ray exposure. The Princeton Beta Experiment Modification (PBX-M) did not operate in CY96.

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem per year (10 mSv/y), the appropriate project manager must petition the PPPL Environment, Safety, and Health (ES&H) Executive Board for an exemption. This value (1,000 mrem per year limit) is 20 percent of the DOE legal limit for occupational exposure. In addition, the Laboratory applies the DOE ALARA (as low as reasonably achievable) policy to all its operations. This philosophy for control of occupational exposure means that environmental radiation levels, as a result of experimental device operation, are also very low and acceptable.

The design objective for TFTR is to remain less than 10 mrem per year (0.1 mSv/y) above natural background at the PPPL site boundary from all operational sources of radiation. The TFTR produces D-D (2.4 MeV) and D-T (14.0 MeV) neutrons and gamma/x-rays in the range of 0 to 10 MeV.

In 1993, the number of neutrons produced was 7.2×10^{18} for D-D and 1.65×10^{19} for D-T [Ja94]. In 1994, TFTR continued an extensive D-T operations schedule and increased the neutron production to 1.3×10^{19} D-D and 1.85×10^{20} D-T [Ja95]. With the continuence of D-T operations in 1995, neutron production increased to 2.3×10^{19} D-D and 2.04×10^{20} D-T [Ja96]. For 1996, TFTR's neutron production was 1.73×10^{19} D-D and 8.34×10^{19} D-T [Ja97].

The TFTR real-time site boundary monitors are Reuter-Stokes Sentri 1011 pressurized ionization chambers and ^{3}He-moderated neutron detectors. Electronics in the ionization chambers were modified to allow integration of any prompt gamma/c radiation resulting from a TFTR machine pulse which may be above natural background. Data are stored and processed using the Central Instrumentation, Control, and Data Acquisition (CICADA) computer system. Four of these monitoring stations are placed at the TFTR facility boundary and two are located at the PPPL property line (see Fig. 6, locations T1 to T4, RMS-NE and RMS-SE). In addition, eight ionization chambers of lower sensitivity, paired with neutron monitors, are located nearer the TFTR device (four outside the test cell wall, three in the basement, and one on the roof). These eight detector locations are for personnel safety and are not used as indicators of environmental conditions. However, data collected from them are used to help correlate the environmental measurements. Besides the moderated ^{3}He, and fission neutron detectors, passive area dosimeters were also used for monitoring neutron and gamma/c dose equivalents at various locations throughout the TFTR facility. Monitors are calibrated and traceable to the National Institute of Standards and Technology (NIST).

5.1.2 Sanitary Sewage

Drainage from TFTR sumps is collected in the Liquid Effluent Collection (LEC) tanks; each of three tanks has a total capacity of 15,000 gallons. Prior to release of these tanks to the sanitary sewer system, *i.e.*, Stony Brook Regional Sewerage Authority (SBRSA), a sample is collected and analyzed for tritium concentration and gross beta. All samples for 1996 showed the effluent amount and concentrations of radionuclides (tritium) to be within the allowable limits set by New Jersey regulations (1 Ci/y for all radionuclides) and by 40 CFR 141.16 and DOE Order 5400.5 (2×10^{6} pCi/liter for tritium). In Table 12, the 1996 total amount of tritium released to the sanitary sewer was 0.951 Curies, about ninety-five percent of the 1.0 Curie per year allowed by New Jersey regulations.

5.1.3 Radioactive and Mixed Waste

In CY96, low-level radioactive wastes were stored on-site, either in the Radioactive Waste Facility or within a controlled area of TFTR. The low-level radioactive shipments made in 1996 consisted of 1,997.7 cubic feet (ft^{3}) of material, with an activity of 31,903 Curies (Ci). No shipments of low-level radioactive mixed waste were made in 1996.

5.1.4 Airborne Emission

A. Differential Atmospheric Tritium Samplers (DATS)

A Differential Atmospheric Tritium Sampler (DATS) is used to measure elemental (HT) and oxide (HTO) tritium at the TFTR stack and at eleven (11) remote environmental sampling locations: 4 TFTR facility boundary trailers (T1 to T4), 6 remote environmental air monitoring stations (REAMS 1 to 6) and one baseline station. In 1995, the baseline location was moved from Montgomery Township to Hopewell Township, NJ. All of the aforementioned sampling is performed continuously.

Projected dose equivalent at the site boundary from emissions of airborne radioactivity (HTO, HT, Ar-41, N-13, N-16, Cl-40, and S-37) was 0.37 mrem (3.7 mSv) (see Table 2). Projected dose equivalent at the nearest off-site business from airborne emissions of these radionuclides was 0.10 mrem (1.0 μSv). Installed in 1992, the stack sampling system continues to provide tritium emissions data for 1996 (Table 4 and Fig. 14) for any tritium concentrations exceeding the minimal detectable levels of the DATS. Engineering changes to ensure representative sampling of tritium were completed and the stack sampling system was accepted by EPA for use in complying with NESHAPS. Measurements at the TFTR D site facility boundary have shown ambient levels in the range of 3.9 to 5,800 pCi/m^3 of elemental and oxide tritium concentrations (Table 10 and Figs. 9 and 11). Measurements from off-site monitoring stations are shown in Table 11 and Figures 10 and 12, "Air Tritium (HT)" and "Air Tritium (HTO)," respectively. These measurements were made with the DATS [Gr88b]. Ar-41, N-13, N-16, Cl-40, and S-37 are air activation products from neutrons produced during TFTR experiments.

In November 1983, a three-level, 60-meter tower was installed for gathering meteorological data. Analysis indicates that the site is dominated by neutral to moderately stable conditions, with moderately unstable to extremely unstable conditions occurring less than a few percent of the time. Average surface winds are about 2.1 meters per second (m/s) and rise to about 4.1 m/s at 60 m [Ko86].

5.2 Unplanned Releases

There were no unplanned releases in CY96.

5.3 Environmental Monitoring

5.3.1 Waterborne Radioactivity

A. Surface Water

Surface-water samples at thirteen locations (five on-site: D1, DSN001, SSG, CMH, and DMH; and eight off-site: B1, B2, B3, C1, DSN003, M1, P1, and P2) have been analyzed for tritium (Table 5). Locations C1 (Delaware & Raritan Canal) and the baseline (Rock Brook in Montgomery Township) were replaced by DSN003 (PPPL's discharge from the pump house on the D&R Canal) in November 1995. Five of these locations have been monitored since CY82. Downstream sampling occurs after the mixing of effluent and ambient water is complete. Locations are indicated on Figures 6 (on-site) and 7 and 8 (both are off-site locations).

In August 1995, the method for analyzing tritium in environmental water samples was modified. The electrolysis procedure was eliminated; the tritium analysis included a 5-hour count time, which proved to be a more efficient way to process samples without losing reliability. A second result was that the method detection limit changed from previously below 100 pCi/L to between 100 and 200 pCi/L.

Tritium analysis by liquid scintillation methods has shown tritium values to be generally less than or comparable to the baseline level (Table 5 and Figs. 18-20), with one exception at Station P2. In August 1996, an off-site location, P2-Devil's Brook, tritium was detected at 1468 pCi/Liter. As an explanation for this data, it is unlikely that the source is tritium from TFTR for the following reasons: 1) at the time of the sample, no increases in tritium oxide in stack effluent or in tritium concentrations in precipitation were also observed and 2) no other surface water locations closer to PPPL exhibited elevated tritium concentrations during this period.

Rain water samples collected and analyzed in 1996 ranged from less than 100 to 21,140 pCi/liter (see Tables 3 and 7 and Figs. 15 and 16), which varies from the 1995 range of 19 to 2561 pCi/liter (see Table 9). During the weeks of October 2 through October 30, 1996, TFTR released 64.240 Curies HTO and 25.380 Curies HT; these releases occurred during a outage period when equipment was being upgraded and/or repaired. These releases account for approximately 48.8 percent of the annual 1996 total for tritium released to the atmosphere. The highest level observed in the rain water (21,140 pCi/Liter) was collected on October 21, 1996, that is, during the same period when elevated atmospheric releases were also observed. Based on this data and associated literature [JAERI 88, Mu77, Mu83, Mu90], it is believed that the observed increase in tritium concentrations in rain water is due to washout by precipitation of some of the tritium released from the TFTR stack. Monitoring of tritium concentrations in rain water will continue.

In April 1988, PPPL initiated the collection of precipitation. While 1988 was a dry year, 1989 and 1990 were relatively wet years with over 55 inches (140 cm) and 50.3 inches (128 cm) of precipitation in 1989 and 1990, respectively; also at 51 inches (130 cm), 1994 was a wet year. The years 1991, 1992, and 1993 had average amounts of total precipitation: 1991 - 45 inches (114 cm), 1992 - 42 inches (107 cm), and 1993 - 42.7 inches (109 cm) (Table 9 and Fig. 5)[Ch94]. In 1995, the driest year since precipitation was monitored, the annual rainfall was 35.6 inches (90 cm). In contrast, 1996 was the wettest year since precipitation was monitored with 61.0 inches (155 cm) (Table 3).

B. Ground Water

Twelve on-site wells-TW-7, TW-8, MW-12S, D-11R and D-12 on C site, and TW-1, TW-2, TW-3, TW-4, TW-5, TW-9 and TW-10 on D site (Fig. 6)-were sampled in 1996. Since the onset of D-T operations, ground water results (Table 6 and Fig.17) were slightly elevated in TW-1; for 1996, TW-1 showed tritium concentrations ranging from 530 pCi/Liter to 1288 pCi/Liter. Beginning in August 1995, more frequent ground water monitoring and sampling of different wells began. This increase in scope of ground water monitoring was prompted by the increase in tritium level in well TW-1.

An investigation into the potential sources also began in the fall of 1995. Leak tests and checks of lines and equipment in the area near TW-1 (north side of D site) were performed; none were found to be leaking tritiated water into the ground water. From PPPL's environmental monitoring data and the available scientific literature [JAERI 88, Mu77, Mu83, Mu90], the most likely source of the tritium detected in the on-site ground water samples is from the atmospheric venting of tritium from TFTR operations and the resulting "wash-out' during precipitation. Ground water monitoring of the wells and the foundation sump (dewatering sump for the TFTR and Motor Generator buildings) will continue.

C. Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. In April 1984, a sampling point at the input to PPPL was established (E1 location) to provide baseline data for water coming onto the site. Radiological analysis has included gamma spectroscopy and tritium-concentration determination. In 1996, tritium measurements of potable water ranged from 99 to 261 pCi/liter (Table 5).

5.3.2 Foodstuffs

There were no foodstuffs gathered for analysis in CY96.

5.3.3 Soil and Vegetation

Surface soils and vegetation are among the best indicators of tritium deposition after a release [Jo74], [Mu77], [Mu82], [Mu90]. Therefore, baselines were established using these matrices. Off-site sampling locations were established in late 1985 (see Fig. 7). In 1991, some sampling points were relocated because of construction during 1990 in some local sampling areas. Also, sampling points were relocated to be near the air-monitoring stations.

For those soil samples collected in 1996 from on-site locations, concentrations ranged from 126 pCi/liter to 2845 pCi/liter (Table 8). Increases observed in the soil samples correlate with the elevated levels in tritium oxide stack releases and precipitation concentrations (see Section 5.3.1).

6.0 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

6.1 New Jersey Pollutant Discharge Elimination System (NJPDES) Program

6.1.1 Surface and Storm Water

To comply with permit requirements of the New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0023922, PPPL submitted to NJDEP monthly discharge monitoring reports (DMRs) for Discharge Serial Number (DSN)—DSN001 (PPPL designation-D2), DSN002, and DSN003 (see Tables 20 to 22). During CY96, PPPL was within allowable limits for all testing parameters at DSN001 and DSN003. The last exceedance at DSN001 was reported in November 1993 for total suspended solids (73 mg/L *vs.* 50 mg/L—the permit limit). In May 1995, an exceedance occurred for DSN003 (filter back wash for the pumps at the Delaware & Raritan Canal) when total suspended solid result was 50 mg/L (monthly average limit is 20 mg/L).

Stormwater discharge was sampled at DSN002, which is located at the southwestern edge of the site. During a precipitation event which causes runoff following a 72-hour dry period, samples for petroleum hydrocarbons were collected at 15, 30, and 45 minutes after the onset of a discharge (Table 21); all other samples were collected at 15-minute intervals. Exceedances of the total suspended solid limit (monthly maximum 50 mg/L) and the chemical oxygen demand (COD) limit (100 mg/L) were reported in April (266 mg/L, 137 mg/L, respectively). The probable cause of the exceedances appears to be the disturbance of sediments at the bottom of the ditch during heavy flow. The DOE-PG and PPPL worked with NJDEP's Stormwater Permitting Branch to revise the NJPDES permit; PPPL began the development of a site-wide Stormwater Pollution Prevention Plan. Effective June 1, 1996, DSN002 is no longer monitored to meet requirements of the permit.

Detention basin inflows or influents are monitored twice each year, in May and August (see Tables 19 and 32), pursuant to the PPPL NJPDES ground water discharge permit, NJ0086029. Volatile organic compounds were detected at Inflow 2 in concentrations above method detection limits for volatile organic compounds—tetrachloroethene (4.43 μg/L), and chloroform (1.7 μg/L). Located on the west side of the detention basin, Inflow 1 receives water from the C site MG basement sumps, C and D site cooling tower and boiler blowdown, and non-contact heat exchanger cooling water, as well as stormwater. Located on the north side of the detention basin, Inflow 2 receives ground water from the D site TFTR and MG basement sump pumps and stormwater from the transformer yard sumps.

Based on 12 months of flow data, greater than 110 million gallons of water were discharged from the detention basin in CY96. Modifications to the detention basin included installation of a permanent oil boom in the detention basin and a fence around the perimeter of the detention basin. The project was completed with installation and operation of the detention basin oil sensors and an outfall exit valve mechanism. Presently, the detention basin is operated in a flow-through mode.

6.1.2 Chronic Toxicity Characterization Study

In 1996, chronic toxicity testing for DSN001 effluent continued. In all chronic toxicity tests, *Pimephales promelas* (fathead minnow) was the only test species required [NJDEP95a]. NJDEPchose the fathead minnow as the more sensitive species for the Chronic Toxicity Biomonitoring requirements (Table 20). For all tests in 1996, the survival rate, as defined by the NJ Surface Water Quality Standards, was 100 percent no observable effect concentration (NOEC). The last unsuccessful test occurred in March 1995, the fathead minnows survived in the 50 percent dilution, *i.e.*, mortality was observed in the 100 percent effluent test. Chronic toxicity testing continued on a quarterly frequency until March 1996, then bimonthly from May to September 1996, and returning to quarterly in December 1996.

6.1.3 Ground Water

Since 1989, PPPL has monitored ground-water quality in seven wells in compliance with the NJPDES ground-water discharge permit, NJ0086029; four of the seven wells are located on PPPL C and D sites, and three wells are located on A and B sites. The wells on A & B sites are not on DOE-leased property, but are on the adjacent James Forrestal Campus property. The permit also contained a requirement for conducting a site hydrological study, including soil sampling or a soil gas survey.

The permit, NJ0086029, was issued effective April 1, 1989, and the expiration date was extended to December 31, 1996. The DOE-PG submitted to NJDEP the NJPDES permit renewal application in July 1994. Included in that application was the "Ground Water Quality Report for the NJPDES Permit Renewal Application Permit No. NJ0086029," which summarized data from 1989 to 1994 [Fi94a].

A. Hydrological Studies from 1989 to 1993

In 1989, DOE-PG and PPPL prepared a work plan for the hydrological study. The purpose of that study was to delineate and define the sources of contamination for ground-water contaminants which were detected during the USGS study (see Fig. 21) [USGS87] [DOE89c] [PPPL89d,f] [NJDEP90]. NJDEP gave its approval of the plan with the following conditions [NJDEP90a]:

- Soil sampling and/or soil gas survey.
- Determining the Direction of Ground Water Flow — ground water modeling must be performed.
- TFTR Cone of Influence — must identify details of dewatering activities.
- Detention Basin Impact — must monitor the impact to ground water of unlined detention basin.
- Contaminant Source Location — on-site historical usage of solvents/hazardous substances must be investigated.

The soil gas survey was completed in September 1990. [Ne90] Soil vapors were tested for three volatile organic compounds and one group of compounds: tetrachloroethene (PCE), trichloroethene (TCE), trichloroethane (TCA), and aromatic hydrocarbon compounds (AHC). The selection of the three compounds—PCE, TCE, and TCA (solvents commonly used to clean metal)—was based on their past use at PPPL. AHC are compounds present in petroleum products, such as gasoline and fuel oil.

Results from this site-wide survey identified anomalies in five areas (see Exhibit 6-2):

AREA #	LOCATION
1	North and east of the Plant Maintenance and Engineering Building [now known as Facilities & Environmental Management Building], including the cooling tower area.
2	Through the eastern half of the Receiving Warehouse Building and extending southward toward the Coil Assembly and Storage Building (CAS).
3	Southwestern corner of the CAS Building.
4	Northeast of the TFTR Neutral Beam Power Conversion and Mockup Buildings.
5	West of TFTR Field Coil Power Conversion (FCPC) Building.

The results of the soil gas survey are summarized below:

Exhibit 6-1. Summary of 1990 Soil Gas Survey Results

Area Number	PCE	TCE	AHC	TCA
1	✓	✓	✓	✓
2	✓	✓		✓
3	✓			
4	✓	✓		✓
5				✓

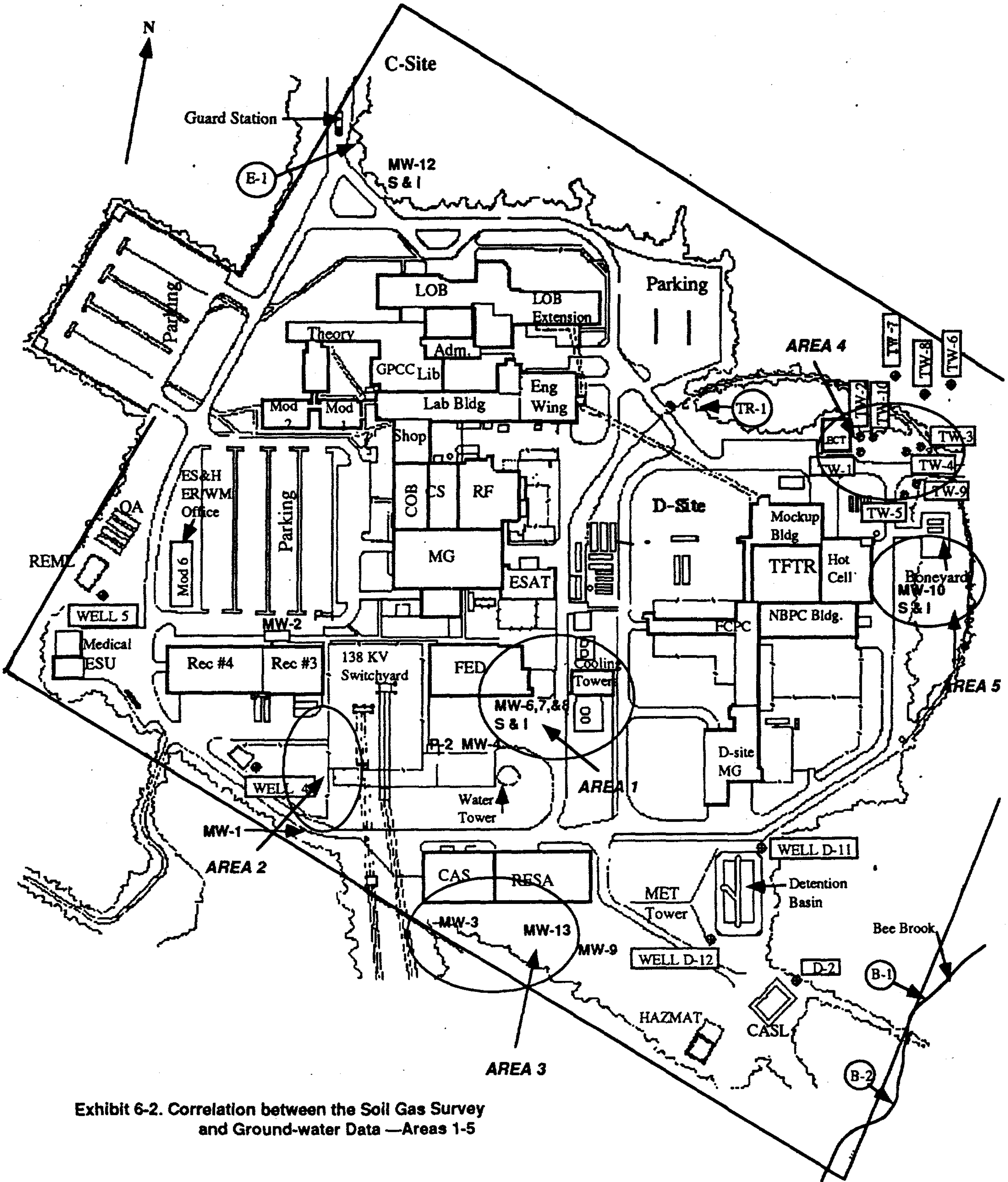

Exhibit 6-2. Correlation between the Soil Gas Survey and Ground-water Data —Areas 1-5

In December 1990, the ground-water quality study began with the drilling of sixteen ground-water monitoring wells and two piezometers. Samples were collected in January 1991 and analyzed for volatile organic compounds, semi-volatile organic (base/neutral) compounds, polychlorinated biphenyls (PCBs) and pesticides, metals, and total petroleum hydrocarbons. The results of this study showed a correlation of soil gas survey results and ground water for the following areas only: *in Area 1*—where five underground storage tanks were removed in 1990, semi-volatile organics in ground water correlated with aromatic hydrocarbons in the soil survey, and *in Areas 1 and 3* —volatile organic compounds (PCE, TCE, and TCA) were detected in both ground-water samples and in the soil gas survey. [MP91a,b] [DOE91b,d,e] No correlation between ground-water quality and soil gas survey results were shown for Areas 2 and 5; no ground-water samples were collected in Area 4 and, so no relationship can be drawn.

In January 1993, ground water samples from wells sampled in January 1991, including the NJPDES wells were collected [DOE93c] [MP93]. This study confirmed the presence of chlorinated solvents and other compounds that were detected in the same wells in 1991. The study also showed that dissolved contaminants have not migrated to areas previously found having no contaminants above the detection limits. In those wells where contamination was found in 1991, concentrations were lower in the 1993 samples.

The sump pump systems beneath the D site buildings (TFTR and D site MG building) continue to control ground-water movement by creating a shallow cone of depression. Influenced by the cone of depression, the direction of ground water on C and D sites is radially toward the sump pump systems (see Figure 22). The modelling effort planned for CY96 was postponed, but it may be included in a future ground-water study and/or cleanup assessment report.

To assess the detention basin's impact on ground water, water levels in the detention basin and nearby wells (D-11, D-12, and MW-9—as the control well) were measured in March 1991 [MP91c] [DEP91a] [DOE91c]. Results revealed that the detention basin did not appear to discharge to surrounding ground water, but instead ground water was discharging to the detention basin at all times except when water in the detention basin was at maximum height. Because a mounding effect was not observed, any contamination that reaches the detention basin would not flow into the surrounding ground water except when the detention basin was at maximum water height; at that time, the flow reverses and water would flow from the detention basin into the ground water. These results were obtained prior to the lining of the detention basin in 1994, and therefore, contact of detention basin water to ground water is practically none.

In 1991, "(The) Solvent and Hazardous Constituent Usage Survey" was prepared. It documented that a large quantity of tetrachloroethene (PCE) was stored and ultimately used in the CAS/RESA buildings [MP91f] [DEP91b] [DOE91g]. Also documented was the presence of petroleum hydrocarbons and solvents in most buildings at PPPL. The solvent, 1,1,1-trichloroethane (TCA) was and is widely used throughout the site. Substitute solvent and/or degreaser products for the commonly used halogenated solvents are available and used wherever appropriate.

B. NJPDES Quarterly Ground Water Monitoring Program from 1989 to 1996

In this section, the NJPDES Quarterly Ground Water Monitoring Program from 1989 to 1996 is discussed in three parts: A and B site wells (MW-14, MW-15, and MW-16); C and D site wells (D-11, D-12, TW-2, and TW-3); and the detention basin Inflows 1 and 2.

Since November 1989, three A and B site wells—MW-14, MW-15, and MW-16—have been sampled quarterly (see Tables 28 and 33). All results were below permit standards with one exception: in August 1994, the 4-Bromophenyl-phenyl Ether (base/neutral compound) was detected at 110 µg/l for MW-14. The cause of this anomaly is unknown; no other parameters were found above the detection limits for the 1996 sampling event. These wells are also sampled by Princeton University's environmental contractor, [EN91], and are included in the University's ground water monitoring program. In the NJPDES permit renewal application, PPPL and DOE-PG made a formal request to NJDEP that these wells be removed from ground-water permit requirements.

The C and D site wells—D-11 or D-11R, D-12, TW-2, and TW-3—have been sampled quarterly since November 1989. A new well, D-11R, was installed in September 1996 as a replacement for D-11, which was then abandoned. When the under-drain system beneath the detention basin liner was installed in October 1994, the level of ground water dropped sufficiently to render well D-11 dry. In 1996, all ground water results, except for volatile organic compounds, were below permit standards (see Tables 29-32). Volatile organic compounds in ground-water samples are discussed in the following paragraph and in the following section "Regional Ground Water Monitoring Program."

The detection of tetrachloroethene (PCE) was observed in at least one ground-water sample analyzed for volatile organic compounds from November 1989 to August 1996, with two exceptions-May 1990 and May 1996 events. Otherwise, PCE was consistently detected in wells D-11 and/or D-12. In well TW-3, PCE was periodically detected. However, higher concentrations of PCE were found in this well (TW-3) at concentrations of 26 µg/L and 36 µg/L. Other VOCs have been detected either in levels below the method detection limits (J or T values) or sporadically, *e. g.*, 1,1-dichloroethane and trichloroethene

(TCE) in well D-12, which was the case in August 1996. Also detected in D-12 was cis-1,2-dichloroethene.

Detention basin inflows are sampled twice annually—in May and August. PCE was found five times in Inflow 2 samples: August 1990, September 1991, August 1993, August 1994, and August 1996. The compound 1,1,1-trichloroethane (TCA) was detected once in Inflow 2 during August 1990. PCE was detected once in Inflow 1 during August 1993. Of these VOCs, only PCE and chloroform were detected in the Inflow 2 sample collected during August 1996.

C. Regional Ground Water Monitoring Program

In 1993, a Memorandum of Understanding (MOU) was signed between Princeton University, the land owner of the James Forrestal Campus, and the NJ Department of Environmental Protection (NJDEP). In this MOU, a remedial investigation and remedial alternative assessment were required. For C and D site, PPPL's environmental subcontractor prepared a draft work plan for the remedial investigation, which included a ground-water investigation [HLA94]. The Remedial Investigation is discussed in Section 3.2.3 and is fully documented in the Remedial Investigation Report prepared by Hading Lawson Associates and submitted to NJDEP in early 1997 [HLA97].

The Regional Ground Water Monitoring Program studies are discussed in Section 6.1.3 A, "Hydrological Studies from 1989 to 1993," of this report. In evaluating data from those studies, the NJPDES Quarterly Ground Water Monitoring Program, and remedial investigation results, an overall pattern appears for volatile organic compounds (VOCs) found in ground water monitoring wells at PPPL. In Table 31, the VOC that is most commonly detected and present in the highest concentrations is tetrachloroethene (PCE at 126 μg/l in well MW-13). The potential source of the PCE appears to be located near the CAS/RESA buildings to the south (Area 3), where VOCs were historically used and stored. MW-13, located next to the CAS/RESA buildings, is upgradient of other wells located in Area 1 and also the detention basin (see Exhibit 6-2). The highest concentrations of contaminants would be expected in those wells closest to the source. In 1996, PPPL installed four new monitoring wells in the vicinity of the CAS/RESA Building (including two wells in the wetlands). These wells and other ground water characterization activities lead to the identification of a new APEC near the location of the former PPPL Annex Building in the woods southwest of CAS/RESA. Additional characterizeration in the former Annex Building area is planned for 1997.

The second area where PCE is detected in the ground water is an area due north of TFTR (Area 4-undeveloped wetlands), as indicated by results from wells TW- 1, -3, and -7 (Table 34). The presence of PCE in some deeper monitoring wells (TW-3) indicates a potential off-site source of VOCs, possibly as part of regional ground water contamination. PPPL has no record of using chlorinated solvents in this area.

The C and D site sump pump systems (TFTR-S1, LOB-S3, MG-S2, MG-S4, MG-S5, and MG-S6) were also sampled at the same time wells were sampled in June 1994, March and May 1995, December 1996 (Table 34). Occurrence of PCE in all the sumps except MG-S5 can be attributed to the PCE present in the ground water.

From August 1991 to December 1996, PPPL has collected ground-water samples from wells located near the former underground storage tanks for annual (August) analysis of volatile organic compounds (VOCs) and quarterly total petroleum hydrocarbons (TPHCs). Ground-water samples are collected from wells P-2, MW-4, MW-5S, MW-5I, MW-6S, MW-6I, MW-7S, MW-7I, MW-8S, and MW-8I and analyzed for TPHCs. Once a month, ground-water elevations are measured in a total of thirty ground-water monitoring wells on C and D sites. From these data the ground-water flow contours for the entire PPPL site are mapped at one foot intervals.

In each quarterly report, results of analytical data and monthly contour maps were submitted to NJDEP (see Tables 24 to 27) [MP91g,h] [MP92a,c] [RES92a,b][RES93a,b,c] [AAC94a,c,d,e] [AAC95a,b,c,d]. Results of VOC analyses are discussed above. For twenty quarters, total petroleum hydrocarbons were detected predominately in the intermediate (I wells) ground-water zone. In general, intermediate wells are bedrock wells open from 30 to 45 feet below grade or at elevations of 45 to 60 feet above mean sea level (msl). A change in analytical methodology from 418 Freon extraction method to the gas chromatography method (5081) resulted in a change in the method detection limit of less than 5 mg/L.

6.2 Non-Radiological Programs

The following sections briefly describe PPPL's environmental programs required by federal, state, or local agencies. The programs were developed to comply with regulations governing air, water, wastewater, soil, land use, and hazardous materials and with DOE orders or programs.

6.2.1 Non-Radiological Emissions Monitoring Programs

A. Airborne Effluents

PPPL maintains New Jersey Department of Environmental Protection (NJDEP) air permits for its four boilers located on C site. The permit certificate numbers 061295 through 061299 will expire in 1997. In 1994, PPPL received the permit amendments to the existing air permits for Boilers #2, #4, and #5; PPPL modified these boilers to burn natural gas and fuel oil, prior to the submittal of the permit applications to NJDEP. After the re-submittal of the Boiler #2 application for correction of a fuel-use error, NJDEP issued a permit amendment for Boiler #2 to burn both fuel types in 1995. In 1995, PPPL submitted a permit amendment for proposed modifications to Boiler #3, which would allow the boiler to burn natural gas orfuel oil as appropriate. Upon receiving approval from NJDEP, these modifications to Boiler #3 were made. In 1996, PPPL operated all boilers with natural gas as the primary fuel.

Measurements of actual boiler emissions are not required. Emissions were initially calculated and then recalculated for the amendments and alterations to the boiler permits, using NJDEP and AP-42 [EPA] formulas. These formulas are based on the appropriate boiler emission factors, percent sulfur content of the fuel and number of gallons of oil burned per hour in each boiler. To optimize boiler efficiency and to reduce fuel cost in accordance with DOE Order 4330.2D, "In-House Energy Management," [DOE88b] PPPL utilizes an outside contractor to tune all the boilers on an annual basis and provide a report; for each boiler, the report includes the boiler efficiency, oxygen content, flue-gas temperature and carbon-dioxide content of the stack gas for both oil and natural gas fuels. PPPL boiler operatations Chief Engineer maintains a record of this information on file.

A permit modification for the Hot Cell degreaser was submitted to NJDEP to allow venting of the degreaser to the Tokamak Fusion Test Reactor (TFTR) stack. Discussions with NJDEP involved the definition of the word "stack." The TFTR stack is unlike conventional stack in an industrial setting, and therefore, the uniqueness of the TFTR stack had to be established. The NJDEP agreed that this stack should be regulated under the Environmental Protection Agency's (EPA) National Emissions Standard for Hazardous Air Pollutants (NESHAPs) program, which it is. The permit modification for the Hot Cell degreaser was approved, and modifications were completed.

Applications for air permit modifications for the C and D site emergency diesel generators were prepared. PPPL requested that 1) a change in the fuel type from #2 fuel oil to #1 fuel oil and 2) a reduction in the number of operation hours be made in these permits in support of limiting the amount of nitrogen oxides (NO_X) released from these generators. In 1996, the permit modifications were approved by NJDEP. These changes were essential to the Operating Permit Negative Declaration and Emission Statement Non-Applicability exemptions for they were the basis for determining that PPPL's sources in total emit below the threshold of 25 tons of NO_X per year.

Five additional air permits are maintained by PPPL: two permits for two above-ground storage tanks and three permits for three dust collectors. The above-ground storage tank permit No. 114785 was issued on October 25, 1993, and expires on October 25, 1998. The above-ground storage tanks (25,000 and 15,000 gallon capacities) emit volatile organic compounds that originate from #4 fuel oil and #1 diesel oil, respectively. The F&EM and CAS dust collector emissions originate from general wood-working operations. The Shop building dust collector emissions originate from metal working operations.

B. Drinking Water

Potable water is supplied by the public utility, Elizabethtown Water Co. The PPPL used approximately 27.82 million gallons in CY96 [An97]. In 1994, a cross-connection was installed beneath the water tower to provide potable water to the tower for the fire-protection system and other systems. Consequently, potable water usage showed an decrease from 1995 (40.7 million gallons) to 1996 (27.82 million gallons), which is closer to 1994 water usage (28.6 million gallons).

C. Process (non-potable) Water

In 1986, a multimedia sand filter with crushed carbon was installed to allow the D site cooling tower make-up water to be changed from potable water to process-water (non-potable) supply. In 1987, PPPL made a changeover from potable water to Delaware & Raritan (D&R) Canal non-potable water for the cooling-water systems. Non-potable water is pumped from the D&R Canal as authorized by a permit agreement with the New Jersey Water Supply Authority. The present agreement gives PPPL the right to draw up to half a million gallons of water per day for process and fire-fighting purposes for the period beginning July 1984 and ending on September 30, 2001.

Filtration to remove solids, chlorination, and corrosion inhibitor is the primary water treatment at the canal pump house. Located at the canal pump house, the filter-backwash, discharge number (DSN003), is a separate discharge point in the NJPDES surface-water permit and is monitored monthly (Table 22). PPPL used approximately 96.2 million gallons of canal water during CY96 [An97], which is almost fifty-percent above the CY95 usage of 67.2 million gallons. A sampling point (C1) was established to provide baseline data for process water coming on-site. Table 14 indicates results of water quality analysis at the canal.

D. Surface Water

Surface water is monitored for potential non-radioactive pollutants both on-site and at surface-water discharge pathways (upstream and downstream) off-site. Other sampling locations—Bee Brook (B1 & B2), D site Ditch #5 (D1), Delaware & Raritan Canal (C1), Millstone River (M1), and Plainsboro (P1 & P2) sampling points (See Figs. 6-8, and Tables 13-18)—are not required by regulation, but are a part of PPPL's environmental monitoring program.

E. Sanitary Sewage

Sanitary sewage is discharged to the publicly-owned treatment works operated by South Brunswick Township, which is part of the Stony Brook Regional Sewerage Authority (SBRSA). During 1994, due to malfunctioning metering devices, an estimated volume was agreed to by PPPL, South Brunswick Sewerage Authority, and the Township of Plainsboro. The estimated volume was based on historical data of approximate flow rates from PPPL. This volume was adjusted for the interconnections with Forrestal Campus A and B sites and a private business. For FY96, PPPL estimates a total discharge of 8.76 million gallons of sanitary sewage to the South Brunswick sewerage treatment system [JA97].

In 1994, the Industrial Discharge Permit (22-93-NC) was received and comments were submitted by PPPL and DOE-PG to Stony Brook Regional Sewerage Authority (SBRSA). In 1996, the SBRSA permit was changed to a license and required monthly measurement of radioactivity, flow, pH and temperature at the LEC tanks (the designated compliance and sampling location) and annual sampling for chemcial oxygen demand only. During 1996, PPPL performed monthly radiological and non-radiological analyses to meet these license requirements (see Table 35).

By switching to a digital photography format, PPPL is working to eliminate photo laboratory waste as an industrial flow to the sanitary sewer. In the meantime, filters were installed to remove silver from the wash and rinse water of the photographic process.

F. Spill Prevention Control and Countermeasure

PPPL maintains a Spill Prevention Control and Countermeasure Plan (SPCC), which was revised in 1995 [VNH96]. The SPCC Plan is incorporated as a supplement to the PPPL Emergency Preparedness Plan.

G. Herbicides and Fertilizers

During CY96, the use of herbicides and fertilizers was managed by PPPL's Facilities and Environmental Management Division (F&EM) utilizing outside contractors. These materials are applied in accordance with state and federal regulations. Chemicals are applied by certified applicators.

Table 23 lists quantities applied during CY96. No herbicides or fertilizers are stored on site; therefore, no disposal of these types of regulated chemicals is required by PPPL.

H. Polychlorinated Biphenyls (PCBs)

At the end of 1996, PPPL's inventory of equipment containing polychlorinated biphenyls (PCBs) was 653 large, regulated capacitors. No PCB capacitors were removed in 1996. However, as they are taken out of service, the disposal records are listed in the Annual Hazardous Waste Generators Report [PPPL96b].

I. Hazardous Wastes

The last Hazardous Waste Generator Annual Report (EPA ID No. NJ1960011152) was submitted for 1995 in accordance with EPA requirements [PPPL96b]. A description of Resource Conservation and Recovery Act (RCRA) compliance is found in Section 3.1.2 of this report. The 1996-1997 Hazardous Waste Generator Annual Report will be submitted in 1998.

J. DOE-HQ Environmental Survey

In 1988, a comprehensive environmental survey was conducted by DOE-HQ and outside subcontractors. No significant environmental impact findings were noted at PPPL during this survey. In 1989, a plan of action for findings was forwarded to DOE. With installation of the detention basin liner in 1994—the longest-lead time item—all findings have been closed out.

Soil sampling for petroleum hydrocarbons from former spills and for chromium in soils from previous use in cooling towers was accomplished in November 1988 [DOEx]. At the time data was evaluated from this sampling, DOE determined that no follow-up action by PPPL was warranted. In 1994, NJDEP re-reviewed DOE's data and required as part of the Remedial Investigation/Remedial Alternative Assessment Program further soil sampling around the C site cooling tower for chromium contamination. Soil sampling was conducted and detected low levels of chromium in soil next to the former chromium reduction pits. This soil was removed in CY96 and this action item was closed.

6.2.2 Continuous Release Reporting

Under CERCLA's reporting requirement for the release of a listed hazardous substance in quantities equal to or greater than its reportable quantity, the National Response Center is notified and the facility is required to report annually to EPA. Because PPPL has not released any CERCLA-regulated hazardous substances, no "Continuous Release Reports" have been filed with EPA.

6.2.3 Environmental Occurrences

One release was reported to the NJDEP Hotline, and a confirmation report submitted in CY96 (Exhibit 3-1). In accordance with reporting requirements, notifications were made to the NJDEP, because these release events posed a potential threat to the environment. No reports to the National Response Center

(NRC) were made since there were no releases that exceeded reportable quantities (RQ) for any listed substance.

Under the CWA and "New Jersey Discharge of Petroleum and Hazardous Substances" regulation (New Jersey Administrative Code Title 7, Chapter 1E), PPPL reported one release, which involved tritiated water, to the NJDEP in CY 1996. On October 28, 1996, approximately five (5) gallons of tritiated water containing 0.1 mCi of tritium, was splashed onto the gravel. The release was the result of a steam generator relief valve opening during the operation of the liquid efflluent collection tank evaporator. The water splashed over the evaporator dike onto the gravel on the ground. The operation of the evaporator was halted until it was moved into an enclosure.

6.2.4 SARA Title III Reporting Requirements

NJDEP administers the Superfund Amendments and Reauthorization Act (SARA) Title III (also known as the Emergency Reporting and Community Right-to-Know Act) reporting for EPA Region II. The modified Tier I form includes SARA Title III and NJDEP specific reporting requirements. PPPL submitted the 1995 SARA Title III report to NJDEP in February 1996 [PPPL95a] No significant changes from the previous year were noted. Though PPPL does not exceed threshold amounts for chemicals listed on the Toxic Release Inventory (TRI), PPPL completed the TRI cover page and laboratory exemptions report for 1996, and submitted these documents to DOE.

The SARA Title III report included information about twelve compounds used at PPPL. Of the twelve, six compounds are in their gaseous form and are therefore classified as sudden release of pressure hazards; three gaseous compounds are also classified as acute health hazards: carbon dioxide, chlorodifluoromethane, and dichlorodifluoromethane (CFC-12). There are seven liquid compounds; nitrogen is used in both gaseous and liquid forms. Fuel oil, gasoline, and petroleum oil are flammables; trichlorotrifluoroethane (CFC-113) and sulfuric acid are the liquid compounds that are classified as acute health hazards; sulfuric acid is also reactive. PCB's and gasoline are listed as chronic health hazards.

7.0 GROUNDWATER PROTECTION

The focus of PPPL's Ground Water Program is the "Groundwater Protection Management Plan" (GPMP), required by DOE Order 5400.1, "General Environmental Protection Program." The purpose of the GPMP is to provide a written plan, for use as a management tool, to ensure the protection of ground water investigations conducted at the site. Implementation of the GPMP has taken place in parallel with several ground water investigations conducted on-site. These investigations have been performed as required by NJDEP to address potential impacts from former underground storage tanks (USTs) and the detention basin. Prior to NJDEP-required investigations, the U.S. Geological Survey (USGS) performed an investigation in the vicinity of TFTR to evaluate the effects of a potential spill of radioactive water. Also, PPPL conducted a soil vapor survey, which was used to locate monitoring wells. To evaluate potential ground-water impacts from on-site activities, ground-water investigations at the site have resulted in monitoring of 38 wells and two piezometers. Remedial investigations and remedial alternative assessment studies at PPPL are on-going as required by conditions of the Memorandum of Understanding (MOU). Also at the end of 1995, PPPL increased its sampling of tritium in the environment, which includes ground, sump, surface, and rain water monitoring samples each month.

The results of the investigations cited above are summarized in the following sections of this report: Section 6.1.3 (A)— "Hydrological Studies from 1989 to 1993;" Section 6.1.3 (B) —"NJPDES Quarterly Ground Water Monitoring Program;" and Section 6.1.3 (C) — "Regional Ground Water Monitoring Program."

Generally, all the parameters measured in the above investigations meet the New Jersey Ground Water Quality Standards. The exceptions are the detection of two volatile organic compounds consistently found in certain wells: tetrachloroethene and trichloroethene in sixteen of thiry-two ground-water monitoring wells. In 1990, PPPL initiated, as required by the New Jersey Pollutant Discharge Elimination System (NJPDES) permit, a hydrologic investigation to characterize the ground water quality and determine ground water flow and direction. Numerous studies and tasks were performed to meet this requirement and are discussed in the above sections in this report. The ground water monitoring results showed the presence of volatile organic compounds (VOCs) —mainly, tetrachloroethene, trichloroethene, and trichloroethane—in a number of shallow wells on C site; in a number of intermediate depth wells, petroleum hydrocarbons were detected. These VOCs are commonly used or contained in solvents or metal degreasing agents, all of which have been used or are currently in use at PPPL. The source of the petroleum hydrocarbons are believed to have originated from former underground storage tanks, which were removed when PPPL detected petroleum hydrocarbons in the surrounding soils. In 1994, the remaining USTs were removed and replaced with above-ground storage tanks.

The correlation between the soil gas survey conducted in 1990 and the ground-water data collected from 1991 through 1994 exist for Areas 1 and 3 (see Exhibit 6-2). In *Area 1*, adjacent to the Facilities and Environmental Management (F&EM) Division, the presence of chlorinated solvents, trichloroethane, trichloroethene, and tetrachloroethene, and total petroleum hydrocarbons were confirmed through monitoring of the ground water. In *Area 3*, south of the Coil Storage and Assembly (CAS) building and the Research Equipment Storage and Assembly (RESA) building, ground water was found to be contaminated with the three chlorinated solvents. Only tetrachloroethene was detected in the soil gas survey.

In *Area 2*, south of the Receiving Warehouse, there was no apparent correlation between the findings of the soil gas survey and ground-water quality; while the soil gas survey indicated the presence of the three chlorinated solvents, ground water was found to be uncontaminated in this area. Also in *Area 5*, east of TFTR, no correlation was found between the presence of trichloroethane during the soil gas survey and its absence in the ground water. Of the three chlorinated solvents found during the soil gas survey in *Area 4*, northeast of TFTR and the Mockup Buildings—only tetrachloroethene was detected in ground-water samples.

The foundation dewatering sumps located on D site largely influence the ground-water gradient. The sumps create a shallow cone of depression drawing the ground water toward them. Under natural conditions, the ground-water flow is to the south/southeast toward Bee Brook. It appears that all the ground water on the site, except on the edges of the site, is drawn radially toward the D site sumps.

Under the terms of the MOU, PPPL has conducted several rounds of environmental characterization and remediation. In 1995, after the NJDEP granted "conditional approval" of PPPL's Remedial Investigation Work Plan, soil and ground water samples were collected and analyzed for the seven (7) identified areas of potential concern (APECs). Results from these samples indicated that only two (2) APECs contained chemicals above the most stringent NJDEP Soil Cleanup Criteria applicable. In 1996, contaminated soil and sediments were removed from these APECs for off-site treatment and disposal. Post-excavation sampling confirmed that the NJDEP Soil Cleanup Criteria were met by the remedial actions.

In 1996, PPPL also installed four new monitoring wells south of the CAS/RESA Building area in order to fully delineate the extent of ground water contamination in this area. These wells and other ground water characterization activities lead to the identification of a new APEC near the former PPPL Annex

Building (see Figure 13). The Remedial Investigation activites conducted in 1995 and 1996 are documented in the Remedial Investigation Report prepared by Harding Lawson Associates, which was submitted to NJDEP in March 1997 [HLA97]. Characterization and possible limited soil remediation in the former Annex Building area is planned for 1997.

In the August 1995 sample for well TW-1, located north of the TFTR stack, the tritium concentration was found to be above the background or baseline concentration, 789 *versus* 150 picoCuries/Liter (pCi/L), respectively. As a result of this finding, PPPL began its investigation into the cause of the concentration increase. More wells and ground water sumps were sampled, underground utilities were tested for leaks, soil was tested, and roof drains were sampled. In addition, rain water sampling stations were established and sampled.

The results of this program were that no leaks were found emanating from the underground utilities, and the soil results supported this finding. The drain samples from the liquid effluent collection tank roof showed that tritium contentrations were elevated as well as soil samples next to drain spouts. Rain water samples showed elevated levels of tritium during October 1996 (21,140 pCi/L at station R1North, the nearest station to well TW-1) when TFTR was opened for maintenance activities, and the atmospheric releases are also elevated. A number of documents have described the effect of tritium releases and rain. Rain droplets act as a scrubber and wash tritiated water vapor (HTO) out of the plume from the stack [Mu90]. The water infiltrates into the ground, and eventually, some of the tritium reaches the ground water table and the monitoring wells. The highest concentration of tritium in the ground water in 1996 was 1288 pCi/L at TW-1 on April 12, 1996.

The ground water results showed that the tritium concentrations fluctuate over time. PPPL believes that the tritium concentration in the atmosphere, the amount of precipitation (rainfall), and the time of year all have an effect on the concentration in the ground water monitoring. Monitoring of ground water, precipitation, and the TFTR vent stack will continue in 1997.

8.0 QUALITY ASSURANCE

Analysis of environmental samples for radioactivity was accomplished in-house by the Radiological Environmental Monitoring Laboratory (REML). REML procedures follow the DOE's Environmental Measurements Laboratory's EML HASL-300 Manual [Vo82] or other nationally recognized standards. Approved analytical techniques are documented in REML procedures [REML90]. PPPL participates in the EPA (Las Vegas) program as part of maintaining its radiological certification. For non-radiological parameters, PPPL receives proficiency evaluation samples from EPA (Cinncinati, OH). These programs provide blind samples for analysis and subsequent comparison to values obtained by other participants, as well as to known values.

In CY84, PPPL initiated a program to have its REML certified by the State of New Jersey through the EPA Quality Assurance (QA) program. REML complies with EPA and NJDEP QA requirements for certification. In March 1986, REML facilities and procedures were reviewed and inspected by EPA/Las Vegas and NJDEP. The laboratory was certified for tritium analysis in urine (bioassays) and water and has been recertified in these areas annually since 1988.

In 1996, PPPL followed its internal procedures, EN-OP-001—"Surface Water Sampling Procedure," EN-OP-002—"Ground Water Sampling Procedures," and EN-OP-008—"Stormwater Sampling Procedures." These procedures provide in detail descriptions of all NJPDES permit-required sampling and analytical methods for collection of samples, analyses of these samples, and quality assurance/quality control requirements. All subcontractor laboratories and/or PPPL employees are required to follow these procedures. Chain-of-custody forms are required for all samples; holding times are closely checked to ensure that the analysis was performed within established holding times and that the data is valid. Field blanks are required for all ground water sampling, and trip blanks are required for all volatile organic compound analyses. Subcontractor laboratories used by PPPL are certified by NJDEP and participate in the state's QA program; the subcontractor laboratories must also follow their own internal quality assurance plans [QC96].

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11.0 TABLES

Table 1. TFTR Radiological Design Objectives and Regulatory Limits[a]

CONDITION		PUBLIC EXPOSURE[b]		OCCUPATIONAL EXPOSURE	
		REGULATORY LIMIT	DESIGN OBJECTIVE	REGULATORY LIMIT	DESIGN OBJECTIVE
<u>ROUTINE OPERATION</u> Dose equivalent to an individual from routine operations (rem per year, unless otherwise indicated)	NORMAL OPERATIONS	0.1 Total, 0.01[c] Airborne, 0.004 Drinking Water	0.01 Total	5	1
	ANTICIPATED EVENTS $(1 > P \geq 10^{-2})$	0.5 Total (including normal operation)	0.05 per event		
<u>ACCIDENTS</u> Dose equivalent to an individual from an accidental release (rem per event)	UNLIKELY EVENTS $10^{-2} > P \geq 10^{-4}$	2.5	0.5	(e)	(e)
	EXTREMELY UNLIKELY EVENTS $10^{-4} > P \geq 10^{-6}$	25	5[d]	(e)	(e)
	INCREDIBLE EVENTS $10^{-6} > P$	NA	NA	NA	NA

P = Probability of occurrence in a year.

(a) All operations must be planned to incorporate the radiation safety guidelines, practices and procedures included in PPPL ESHD 5008, Section 10.

(b) Evaluated at the PPPL site boundary.

(c) Compliance with this limit is to be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office.

(d) For design basis accidents (DBAs), i.e., postulated accidents or natural forces and resulting conditions for which the confinement structure, systems, components and equipment must meet their functional goals, the design objective is 0.5 rem.

(e) See PPPL ESHD-5008, Section 10, Chapter 12 for emergency personnel exposure limits.

Table 2. Summary of 1996 Emissions and Doses From TFTR

Radiolnuclide & Pathway	Quantity Released in 1996[1]	EDE at Site Boundary	EDE at Nearest Business[2]	Population Dose within 80 km[3]
Tritium (air)	118.66 Ci HTO[4], 64.52 Ci HT	3.2×10^{-1} mrem[5]	8.8×10^{-2} mrem[6]	5.9 person-rem[7]
Ar-41 (air)	7.48 Ci[4]	3.0×10^{-2} mrem[8]	8.4×10^{-3} mrem[6]	4.4×10^{-2}person-rem[9]
N-13 (air)	4.41 Ci[4]	1.2×10^{-2} mrem[8]	3.4×10^{-3} mrem[6]	1.5×10^{-3} person-rem[9]
N-16 (air)	0.34 Ci[4]	2.3×10^{-5} mrem[8]	6.4×10^{-6} mrem[6]	Negligible
Cl-40 (air)	0.55 Ci[4]	4.5×10^{-3} mrem[8]	1.3×10^{-3} mrem[6]	Negligible
S-37 (air)	0.56Ci[4]	6.0×10^{-3} mrem[8]	1.7×10^{-3} mrem[6]	Negligible
Direct/Scattered n/g Radiation	------------------------	3.6×10^{-2} mrem[10]	9.1×10^{-3} mrem[11]	Negligible
Tritium (HTO) (water)	9.51×10^{-1} Ci[12]	1.9×10^{-2} mrem[13]	------------------------	2.6×10^{-2} person-rem[14]
Total	------------------------	4.3×10^{-1} mrem	1.1×10^{-1} mrem	6.0 person-rem
Background	------------------------	600 mrem[15]	600 mrem[15]	1.6×10^{6} person-rem

[1]*Tritium (HTO and HT) quantities are as measured by the TFTR passive stack monitor and as calculated from* projected releases from the RWSB. Ar-41, N-13, N-16, Cl-40, and S-37 quantities are based on production of 1.731 E19 D-D neutrons and 8.338 E19 D-T neutrons in 1996, using methodology of JL-542, Rev.1, 2/5/93 for releases during D-T operation; & 8.37 E-20 Ci Ar-41 per DD neutron derived from DOE 6/18/90 letter to EPA..

[2]At Princeton Bank Building, 351 meters east of TFTR stack.

[3]Based on year 1995 population figures as utilized for TFTR D-T EA. See Table 4 of Bentz and Bender, 1987.

[4]Measured for tritium released from the TFTR stack and calculated from projected tritium releases from the RWSB (see *footnote #1); per table compiled by D. Jassby, 1/3/97 for other air emissions (i.e., source of neutron production data).*

[5]Based on NOAA X/Q [Start, 1989] and JL-457, 7/2/92, Table 1 (1% of HT releases are assumed to convert to HTO); (118.85 Ci x 2.6 E-03 mrem/Ci) + (0.6452 Ci x 2.6 E-03 mrem/Ci) + (63.8748 Ci x 1.05 E-07 mrem/Ci). For RWSB releases, based on JL-844; 4/8/96 (0.0335 Ci x 0.19625 mrem/Ci).

[6]Based on 28% of the NOAA X/Q at the site boundary [Start, 1989] for TFTR stack releases, and 8.3% of X/Q at the site boundary for RWSB releases (LJ-844, 4/8/96).

[7]Scaling from values used for the TFTR D-T EA, we get (183.37 Ci/500 Ci) x 16.2 person-rem = 5.9 person-rem.

[8]Based on NOAA X/Q [Start, 1989] and JL-457, 7/2/92, Table 1; Ar-41: 7.48 Ci x 4.0 E-03 mrem/Ci. N-13: 4.41 Ci x 2.8 E-03 mrem/Ci. N-16: 0.34 Ci x 6.71 E-05 mrem/Ci. Cl-40: 0.55 Ci x 8.2 E-03 mrem/Ci. S-37: 0.56 Ci x 1.08 E-02 mrem/Ci.

[9]Scaling from values used for the TFTR D-T EA, we get for Ar-41: (7.48 Ci/115 Ci) x 0.67 person-rem = 4.4 E-02 person-rem; for N-13: (4.41 Ci/434 Ci) x 0.149 person-rem = 1.5 E-03 person-rem.

[10]Based on 1996 neutron production (see Note 1) and neutron and gamma radiation dose per neutron given in Table 4 of PPPL Report PPPL-3020, "Measurements of TFTR D-T Radiation Shielding Efficiency," 11/94.

[11]Based on inverse square decrease between site boundary (176 meters) and nearest business (351 meters).

[12]Released from Liquid Effluent Collection Tanks (LECT) to Stony Brook Sewer Authority treatment facility via PPPL sanitary sewer system.

[13]Based on usage of 1 E10 liters/yr for Stony Brook treatment facility, as per TFTR D-T EA, the dose to a person who drank all his/her water from the waterway (Millstone River) into which the treatment facility discharged in 1996 would be [(9.51 E-01 Ci/yr)(/1 E10 l/yr)] x [(4 mrem)/(2 E-08 Ci/l)] = 9.9 E-03 mrem

[14]Based on use of Millstone River as drinking water source for 500,000 people for 1 day per year (estimate by Elizabethtown Water Company of actual use is a few hours once every several years).

[15]Based on 100 mrem annual background dose exclusive of radon, plus dose due to exposure to average radon concentration in Plainsboro homes (Memo, J. Greco to J. Levine, 11/13/90, "Radon Dose Equivalent," JMG-160).

Table 3. Precipitation and Tritium in Precipitation (C site Station) at PPPL for 1996

Start Date	Week	Inch	Inch/Month	Month	Acc.	Tritium pCi/L
1-Jan-96	1	0.500	Blizzard 22"	1/7-1/8	0.500	
8-Jan-96	2	0.400			0.900	
15-Jan-96	3	1.100			2.000	
22-Jan-96	4	1.750			3.750	
29-Jan-96	5	0.250	4	January	4.000	<122
5-Feb-96	6	0.200			4.200	
12-Feb-96	7	0.275			4.475	
19-Feb-96	8	0.725			5.200	
26-Feb-96	9	0.525	1.725	February	5.725	
4-Mar-96	10	1.950			7.675	
11-Mar-96	11	0.125			7.800	
18-Mar-96	12	1.000			8.800	
25-Mar-96	13	1.300	4.375	March	10.100	234
1-Apr-96	14	1.750			11.850	
8-Apr-96	15	0.800			12.650	
15-Apr-96	16	1.475			14.125	
22-Apr-96	17	0.425			14.550	266
29-Apr-96	18	1.575	6.025	April	16.125	
6-May-96	19	1.500			17.625	
13-May-96	20	0.250			17.875	
20-May-96	21	0.300			18.175	
27-May-96	22	0.150	2.2	May	18.325	
3-Jun-96	23	0.975			19.300	293
10-Jun-96	24	3.500			22.800	
17-Jun-96	25	4.050			26.850	
24-Jun-96	26	1.275	9.8	June	28.125	
1-Jul-96	27	0.225			28.350	
8-Jul-96	28	3.775			32.125	
15-Jul-96	29	1.050			33.175	131
22-Jul-96	30	1.075			34.250	
29-Jul-96	31	3.350	9.475	July	37.600	
5-Aug-96	32	0.850			38.450	
12-Aug-96	33	0.000			38.450	
19-Aug-96	34	0.825			39.275	
26-Aug-96	35	0.000	1.675	August	39.275	
2-Sep-96	36	1.055			40.330	
9-Sep-96	37	0.250			40.580	360
16-Sep-96	38	2.950			43.530	
23-Sep-96	39	0.850			44.380	
30-Sep-96	40	0.100	5.205	September	44.480	
7-Oct-96	41	2.075			46.555	
14-Oct-96	42	4.400			50.955	
21-Oct-96	43	0.000			50.955	
28-Oct-96	44	0.225	6.7	October	51.180	3941
4-Nov-96	45	0.750			51.930	
11-Nov-96	46	0.000			51.930	
18-Nov-96	47	0.075			52.005	
25-Nov-96	48	3.925	4.75	November	55.930	
2-Dec-96	49	2.400			58.330	
9-Dec-96	50	1.800			60.130	<121
16-Dec-96	51	0.400			60.530	
23-Dec-96	52	0.505			61.035	
30-Dec-96	53	0.000	5.105	December	61.035	

Table 4. Tritium Released from the TFTR Stack for 1996

Monitoring From	Monitoring To	HTO (Ci)	HT (Ci)	Total (Ci)	YTD (Ci)
03-Jan-96	10-Jan-96	0.521	0.212	0.733	0.733
10-Jan-96	17-Jan-96	0.094	0.996	1.090	1.823
17-Jan-96	24-Jan-96	0.553	0.656	1.209	3.032
24-Jan-96	31-Jan-96	0.560	0.356	0.916	3.948
31-Jan-96	07-Feb-96	0.236	0.091	0.327	4.275
07-Feb-96	14-Feb-96	0.310	0.315	0.625	4.900
14-Feb-96	21-Feb-96	0.197	0.480	0.677	5.577
21-Feb-96	28-Feb-96	0.359	0.260	0.619	6.196
28-Feb-96	06-Mar-96	0.523	0.239	0.762	6.958
06-Mar-96	13-Mar-96	0.451	0.258	0.709	7.667
13-Mar-96	20-Mar-96	0.409	0.376	0.785	8.452
20-Mar-96	27-Mar-96	0.508	0.448	0.956	9.408
27-Mar-96	03-Apr-96	0.601	0.624	1.225	10.633
03-Apr-96	10-Apr-96	0.582	0.613	1.195	11.828
10-Apr-96	17-Apr-96	0.398	0.160	0.558	12.386
17-Apr-96	24-Apr-96	1.408	0.113	1.521	13.907
24-Apr-96	01-May-96	0.388	0.400	0.788	14.695
01-May-96	08-May-96	0.954	0.296	1.250	15.945
08-May-96	15-May-96	0.900	0.370	1.270	17.215
15-May-96	22-May-96	0.307	0.273	0.580	17.795
22-May-96	29-May-96	0.391	0.093	0.484	18.279
29-May-96	05-Jun-96	0.496	0.197	0.693	18.972
05-Jun-96	12-Jun-96	0.967	0.619	1.586	20.558
12-Jun-96	19-Jun-96	0.334	0.330	0.664	21.222
19-Jun-96	26-Jun-96	2.856	2.219	5.075	26.297
26-Jun-96	03-Jul-96	1.052	0.256	1.308	27.605
03-Jul-96	10-Jul-96	0.419	0.096	0.515	28.120
10-Jul-96	17-Jul-96	0.363	0.086	0.449	28.569
17-Jul-96	24-Jul-96	0.872	0.214	1.086	29.655
24-Jul-96	31-Jul-96	1.128	0.439	1.567	31.222
31-Jul-96	07-Aug-96	0.634	0.357	0.991	32.213
07-Aug-96	14-Aug-96	0.494	0.470	0.964	33.177
14-Aug-96	04-Sep-96	10.498	2.804	13.302	46.479
04-Sep-96	11-Sep-96	1.784	1.497	3.281	49.760
11-Sep-96	18-Sep-96	1.684	0.608	2.292	52.052
18-Sep-96	25-Sep-96	5.660	7.940	13.600	65.652
25-Sep-96	02-Oct-96	9.520	12.014	21.534	87.186
02-Oct-96	09-Oct-96	17.440	6.780	24.220	111.406
09-Oct-96	16-Oct-96	10.700	8.180	18.880	130.286
16-Oct-96	23-Oct-96	20.200	6.440	26.640	156.926
23-Oct-96	30-Oct-96	11.900	3.980	15.880	172.806
30-Oct-96	06-Nov-96	2.050	0.304	2.354	175.160
06-Nov-96	13-Nov-96	1.462	0.255	1.717	176.877
13-Nov-96	20-Nov-96	0.848	0.179	1.027	177.904
20-Nov-96	27-Nov-96	0.750	0.153	0.903	178.807
27-Nov-96	04-Dec-96	0.723	0.128	0.851	179.658
04-Dec-96	11-Dec-96	0.962	0.217	1.179	180.837
11-Dec-96	18-Dec-96	0.839	0.127	0.966	181.803
18-Dec-96	31-Dec-96	1.339	0.362	1.701	183.504

Table 5. Tritium Concentrations in Surface Water for 1996 (in pCi/L)

Date	B1	B2	C1	D1	DSN 1	DSN 3	E1	M1	P1	P2	SSG	CMH	DMH
1/3										<116			
1/4			258		<108								
2/5					338								
3/5					221	<129							
3/29	261	306			496								
4/1											253		
4/5					198								
4/11					194								
4/17					176								
4/25					315	<122							
4/26	311	275											
5/2					167						149		
5/6	333	383		288		243	230		212	252			
5/9												257	3495
5/14					324								
5/21			266					230					
6/6	297	306			338	257	261		275				
7/10					194	99	99		135				
8/6	284	396	248	257	482	275	252	221	288	1468			
8/14			see Note		550								
9/6					473	329	<105		<105				
9/12	<105	338											
10/9							140		315				
10/16	216	338			275								
11/8					329	<117							
11/15	207	230											
12/6					577	<120							
12/18	410	653											

Key:

Blank indicates no measurement B1 = Bee Brook (upstream)
B2 = Bee Brook (downstream)
B3 = Bee Brook (far upstream)
C1 = Delaware & Raritan Canal (non-potable water supply)
CMH - C site manhole #15
D1 =PPPL D site (upstream of discharge)
DMH - D site manhole #51-7
DSN1 = downstream of basin discharge, sometimes referred to as D2
DSN3 = PPPL pump house discharge on Delaware & Raritan Canal (non-potable water supply)
E1 = Elizabethtown Water Company (potable water supply)
M1 = Millstone River (downstream)
pCi/L = picoCuries/Liter
P1 = Cranbury Brook (upstream)
P2 = Devil's Brook(upsteam)
SSG - storm sewer grill 953

Note: After 8/14, C1 no longer monitored; continued monitoring DSN3, which is same water source as C1. See Figures 18-20.

Table 6. Tritium Concentrations in Ground Water (Wells and Sump) for 1996 (in pCi/L)

Date	TW -1	TW -2	TW -3	TW -4	TW -5	TW -7	TW -8	TW -9	TW -10	MW -12S	D-12	TFTR	D MG
1/5										236	129		
1/16												532	
1/12	945	301			365								
2/9	530				217				217		265		
2/22	967				377								
2/23												542	
2/29	990				448								
3/1												448	
3/6												378	
3/7	1225				527								
3/13												527	
3/14	1234				559								
3/21	1063				473		500			347	225	590	
3/27												577	
3/28	1122				509								
4/3	1108				351							351	
4/11	1243				410							423	
4/17												451	
4/18	1288	455			523		378		252	320	225		
4/25	1059				536							464	
5/2	973				496	261	320	239			360		
5/6	1117												
5/8					509								
5/16												532	
5/17	1140				500	266		194		225	261		
6/6	978				550	216		275		279	275		
6/7												149	
7/1	1216				473		284		185	203	135		
7/16												1086	
7/27	1125												
8/6											297		
8/14												759	451
8/15	1140		378		644		360			266			
9/12										649			
10/17	1207				437		396					545	
11/6		378	243										
11/8												509	
11/19	874				374		230	<126	<126		<126		
12/5												451	671
12/6	1221	496		329		284					194		

D-12 = well located next to basin (south of D site and TFTR)
D MG = D site motor generator building sump, which pumps ground water to basin
MW-12S = well located upgradient next to main gate security booth
TFTR = air shaft sump, which pumps ground water to basin
TW-1 through TW-10 = wells located north of TFTR

Table 7. Tritium Concentrations in Precipitation for 1996 (in pCi/L)

Date	R1E	R1N	R1ND	R1S	R1W	R2E	R2N	R2S	R2W	BSLN	REAM 1
1/29	986	1137		556		387	895	<122	<122		
2/9	363	388		969	315	436	412	660	236		
2/27	119	653		869	122	604	541	410	473		
3/12	207	306	211	2437	225	1158	239	559	243		
3/27		239									
3/29	653	211		730	369	478	212	<128	252		
4/11	982	149	<127	4059	153	527	135	1360	419		
4/17	369	216	198	293	838	635	<122	<122	<122		
5/2	167	1514	527	540	464	333	788	149	288		
5/14	1730	1396	1401	1356	1450	748	1077	306	811		
6/11		4586	5176	2527	3266	649	1437	270	162		
6/13	4248	793	838	563	423	1617	923	1964	1095		
6/21	802	518	824	487	590	559	626	333	455		
7/1											279
7/7	504	910	973	806	234	175	833	365	<106		
7/15											108
7/16	252	176	203	266	333	162	<100	126	108		
7/30	1203	491	469	2162	374		365	626	243		
8/2	<103	104	149	428	550	284	266	383	392		
8/6	752	144	185	234	162						
8/14						743		405	131		
9/9										297	275
9/10	7234	1059	1207	2203	883	3000	329	523	1122		
9/18	149	180	144	1009	374	225	<105	626	622		
10/7											113
10/9										302	
10/11	9613	20,310	13,000	10,270	2977	7153	2595	2910	1090		
10/21	443	21,140	18,970	2968	16,560	1410	12,950	1608	17,320		
10/28										117	
11/27	3072	1982	1883	2414	878	3005	1581	694	252		
12/2	671	451	914	1635	1860	572	369	1491	167	131	<119
12/9	401	158	<120	1941	982	<120	<120	1144	360		
12/18	423	279	247	1468	770	225	261	883	869		

KEY:
BSLN - Baseline located in Hopewell Township, NJ
D = duplicate
E = east
N = north
pCi/L = picoCuries/Liter
R = Rain water
S = south
1 = 250 feet from TFTR stack
2 = 500 feet from TFTR stack

See Figures 15 and 16.

Table 8. Tritium Concentrations in Soil for 1996 in picoCuries/Kg

Sample Location/Depth (ft)	2/15/96	7/16/96
LECT 4.1 (0 - 1.25)	1447	
LECT 4.2 (3 -4)	1199	
LECT 4.3 (6 -7)	723.4	
LECT 4.4 (8-9)	1078	
LECT 5.1 (0-1)	1122	
LECT 5.2 (3-4)	744.6	
LECT 5.3 (5-6)	500.0	
LECT 5.4 (7-8)	755.9	
LECT 6.1 (6.5-7.25)	700.9	
LECT 7.1 (6 - 7.25)	355.4	
LECT 8.1 (2.75-4)	843.2	
LECT 8.2 (5.5-6.5)	660.8	
LECT 9.1 (2.75-4)	1138	
LECT 9.2 (5.5-6.5)	937.8	
LECT 11.1 (3-4)	1725	
LECT 11.2 (1.5-2.5)	2845	
LECT 16.4 (8-9)		337.8
LECT 17.1 (0-2.5)		306.3
LECT 17.2 (3.5-7)		369.4
LECT 18.1 (0.5-4)		126.1
LECT 18.2 (4-6)		270.3
LECT 18.3 (6-8)		364.9
LECT 19.1 (1-4)		331.4
LECT 19.2 (4-6.5)		252.3

Table 9. Annual Range of Tritium Concentration in Precipitation from 1985 to 1996

Year	Tritium Range picoCuries/Liter	Precipitation Inches
1985	45 to 160	
1986	40 to 140	
1987	26 to 144	
1988	34 to 105	
1989	7 to 90	55.345
1990	14 to 94	50.332
1991	10 to 154	45.075
1992	10 to 83.8	41.86
1993	24.5 to 145	42.731
1994	32.2 to 1130.4	51.26
1995	<19 to 2561	35.625
1996	<100 to 21,140	61.035

See Figures 5 and 15.

Table 10. Tritium in Air (TR 1-4 and Baseline) for 1996 (picoCuries/m^3)

Month	Trailer 1 HTO	Trailer 2 HTO	Trailer 3 HTO	Trailer 4 HTO	Baseline HTO
January	4.40	14.00	20.00	5.84	1.66
February	6.90	5.38	26.00	4.57	2.94
March	3.94	7.87	18.80	6.11	2.44
April	12.40	26.40	20.20	13.40	3.27
May	15.20	16.60	16.80	9.24	4.85
June	32.30	43.70	102.00	11.00	4.20
July	20.20	13.90	37.80	111.00	5.79
August	22.50	19.90	98.50	14.80	2.78
September	109.00	171.00	315.00	61.00	8.67
October	109.00	185.00	288.00	87.40	6.52
November	15.00	32.50	49.60	14.50	2.87
December	25.30	18.00	37.80	19.40	3.01

Month	Trailer 1 HTO	Trailer 2 HTO	Trailer 3 HTO	Trailer 4 HTO	Baseline HTO
January	5.24	5.53	7.53	5.37	3.42
February	5.07	4.52	6.43	4.77	5.97
March	4.39	5.90	6.48	48.80	4.12
April	4.96	5.73	6.60	106.80	2.94
May	8.04	7.22	7.73	7.89	4.37
June	8.03	14.20	24.40	9.72	2.95
July	17.90	4.74	8.95	4.05	5.09
August	23.30	5830.00	22.50	21.20	14.00
September	58.30	84.30	147.00	23.00	6.90
October	64.70	30.40	56.20	27.30	9.03
November	8.08	7.48	11.00	8.98	4.45
December	5.78	8.87	7.10	10.80	6.49

All measurement values are in average picoCuries/Cubic meter.

Trailers 1-4 are located on D site.
Baseline is located in Hopewell Township, NJ.

HTO is tritium oxide.
HT is elemental tritium.

See Figures 9 and 11.

Table 11. Tritium in Air (REAM 1-6 and Baseline) for 1996 (picoCuries/m^3)

Month	REAM 1 HTO	REAM 2 HTO	REAM 3 HTO	REAM 4 HTO	REAM 5 HTO	REAM 6 HTO	Baseline HTO
January	2.81	2.47	2.12	4.20	2.80	3.91	1.66
February	2.57	2.95	5.03	5.16	2.44	3.01	2.94
March	2.55	2.32	3.14	3.42	2.75	4.16	2.44
April	3.12	29.10	2.58	3.89	3.86	3.21	3.27
May	3.96	4.17	5.41	6.27	5.86	5.26	4.85
June	6.36	5.92	8.89	8.70	19.10	7.25	4.20
July	4.94	4.20	4.17	8.64	6.96	4.22	5.79
August	4.64	5.09	10.90	9.85	9.11	3.93	2.78
September	8.37	7.76	24.10	31.40	18.40	9.85	8.67
October	28.00	8.22	21.10	32.20	16.20	8.03	6.52
November	2.82	3.56	5.93	9.89	6.44	2.79	2.87
December	2.70	4.56	4.14	5.06	5.14	2.53	3.01

Month	REAM 1 HT	REAM 2 HT	REAM 3 HT	REAM 4 HT	REAM 5 HT	REAM 6 HT	Baseline HT
January	12.60	5.21	3.71	5.39	3.62	5.69	3.42
February	5.60	4.69	4.39	4.86	4.55	4.73	5.97
March	3.17	4.08	4.47	3.80	4.74	6.23	4.12
April	3.20	3.85	2.75	3.12	3.30	4.20	2.94
May	6.43	5.33	4.29	5.94	4.60	5.09	4.37
June	6.54	3.83	3.30	3.80	4.31	3.01	2.95
July	8.33	3.35	6.16	3.76	4.04	2.66	5.09
August	7.46	4.64	4.72	5.25	5.29	3.84	14.00
September	10.20	5.57	80.20	17.80	15.00	8.04	6.90
October	7.58	5.50	261.00	181.00	11.80	6.16	9.03
November	3.37	3.49	7.38	4.11	6.14	5.37	4.45
December	3.03	3.90	3.33	3.18	8.25	3.28	6.49

All measurement values are in average picoCuries/Cubic meter.

REAM 1-6 are located off- site, within a radius of 0.5 miles from PPPL.
Baseline is located in Hopewell Township, NJ.

HTO is tritium oxide.
HT is elemental tritium.

See Figures 10 and 12.

Table 12. Tritium Released from Liquid Effluent Collection (LEC) Tanks in 1996

Sample Date	Tank No.	Tank Vol. (gal)	Titirum LLD (Ci)	Tank Tritium Activity (Ci)	Tank Cumulative Activity (Ci)
1/17/96	2	6900	0.000015	0.00413	0.00413
2/15/96	3	7500	0.000018	0.00457	0.00870
3/13/96	3	6000	0.00000983	0.00344	0.0121
4/12/96	3	9300	0.0000161	0.0119	0.0241
5/1/96	3	11250	0.0000206	0.0214	0.0482
5/23/96	3	1200	0.0000209	0.0375	0.0857
6/6/96	3	10800	0.0000143	0.0276	0.113
6/12/96	3	12150	0.0000152	0.0248	0.138
6/17/96	3	12450	0.0000144	0.0214	0.159
6/25/96	3	12750	0.0000166	0.0213	0.181
7/3/96	3	12750	0.0000158	0.0261	0.207
7/10/96	3	12750	0.0000158	0.0232	0.230
7/16/96	3	12750	0.0000151	0.0201	0.250
7/19/96	3	9000	0.0000120	0.0114	0.262
7/26/96	3	12750	0.0000162	0.0204	0.282
8/2/96	3	12750	0.0000149	0.0200	0.302
8/6/96	3	12750	0.0000161	0.0444	0.346
8/14/96	3	11550	0.0000157	0.0735	0.420
8/15/96	3	4800	0.00000616	0.0121	0.432
8/21/96	3	10050	0.0000132	0.0762	0.508
8/28/96	1	12000	0.0000163	0.0684	0.577
9/3/96	2	7950	0.0000115	0.00753	0.584
9/5/96	2	7950	0.00000970	0.00718	0.591
9/6/96	2	12300	0.0000159	0.00461	0.596
9/11/96	2	8700	0.0000108	0.0252	0.621
9/16/96	2	7500	0.00000994	0.0298	0.651
9/20/96	2	12750	0.0000168	0.0365	0.687
9/21/96	2	7800	0.0000135	0.0169	0.704
11/11/96	2	2700	0.00000387	0.00958	0.714
11/25/96	1	3300	0.00000473	0.00419	0.718
12/2/96	1	3300	0.00000459	0.00778	0.726
12/12/96	1	5100	0.00000787	0.0287	0.755
12/16/96	2	11700	0.0000169	0.0799	0.834
12/17/96	2	13500	0.0000201	0.0588	0.893
12/18/96	2	12075	0.0000168	0.0576	0.951
Total discharge		341,625 gal.			

LLD= low level of detection

Table 13. Surface Water Analysis for Bee Brook, Locations B1 and B2 for 1996

Parameters, Units	*B1 5/6/96*	*B1 8/6/96*	*B2 5/6/96*	*B2 8/6/96*
Chromium, mg/l	<0.00390	<0.00500	<0.00390	<0.00500
pH, units	6.9	7.58	6.9	7.27
Phenolics as phenol, mg/l	<0.00500	<0.00500	0.00500	<0.00500
Chemical Oxygen Demand, mg/l	64.0	7.40	44.0	17.4
Biochemical Oxygen Demand, 5-day total, mg/l	<2.00	<2.00	3.60	<2.00
Temperature, °C	12.8	21.1	13.9	21.7
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500	<0.500	<0.500
Ammonia-N, mg/l	<0.100	<0.100	<0.100	<0.100
Total Suspended Solids, mg/l	<2.00	<2.00	5.0	8.00
Total Dissolved Solids, mg/l	168	130	174	286
Flow, Approximate GPM	433.97	6614.19	1246.20	1284.02

Table 14. 1996 Surface Water Analysis for D&R Canal, C1, and Ditch #5, D1

Parameters, Units	*C1 5/6/96*	*C1 8/6/96*	*D1 5/6/96*	*D1 8/6/96*
Chromium, mg/l			<0.00390	<0.00500
pH, units	6.8	7.02	7.0	6.71
Phenolics as phenol, mg/l	<0.00500	<0.00700	<0.00500	<0.00500
Chemical Oxygen Demand, mg/l	8.00	10.9	16.0	9.40
Biochemical Oxygen Demand, 5-day total, mg/l	<2.00	<2.00	2.10	<2.00
Temperature, °C	15.0	24.4	15.6	22.2
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500	<0.500	<0.500
Ammonia-N, mg/l	<0.100	<0.100	<0.100	<0.100
Total Suspended Solids, mg/l	10.0	16.0	6.00	2.00
Total Dissolved Solids, mg/l	84.0	122	136	194
Flow, Approximate GPM				

Blank indicates no measurement.

Table 15. 1996 Surface Water Analysis for the Millstone River, M1

Parameters, Units	*M1 5/6/96*	*M1 8/6/96*
pH, units	6.7	6.68
Phenolics as phenol, mg/l	<0.00500	<0.00500
Chemical Oxygen Demand, mg/l	24.0	16.6
Biochemical Oxygen Demand, 5-day total, mg/l	<2.00	<2.00
Temperature, °C	16.7	25.0
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500
Ammonia-N, mg/l	0.400	<0.100
Total Suspended Solids, mg/l	8.00	7.00
Total Dissolved Solids, mg/l	132	148

Table 16. 1996 Surface Water Analysis for Elizabethtown Drinking Water on C Site at Guard Booth, E1

Parameters, Units	*E1 5/6/96*	*E1 6/4/96*	*E1 7/10/96*	*E1 8/6/96*	*E1 9/6/96*	*E1 10/9/96*
pH, units	6.8				6.9	
Phenolics as phenol, mg/l				<0.00500		
Chemical Oxygen Demand, mg/l	<2.00	63.0	8.00	4.50	10.0	8.00
Biochemical Oxygen Demand, 5-day total, mg/l				<2.00		
Temperature, °C	15.0					
Petroleum Hydrocarbons by IR, mg/l	<0.500	1.20	<0.500	<0.500	0.790	<0.500
Ammonia-N, mg/l				0.100		
Total Suspended Solids, mg/l	<2.00	<2.00	<2.00	<2.00	<2.00	3.00
Total Dissolved Solids, mg/l				260		

Blank indicates no measurement.

Table 17. 1996 Surface Water Analysis for Plainsboro Location, P1

Parameters, Units	*P1 5/6/96*	*P1 6/4/96*	*P1 7/10/96*	*P1 8/6/96*	*P1 9/6/96*	*P1 10/9/96*
pH, units	6.5				6.9	
Phenolics as phenol, mg/l	<0.00500			<0.00500		
Chemical Oxygen Demand, mg/l	28.0	<2.00	14.0	21.3	12.0	17.0
Biochemical Oxygen Demand, 5-day total, mg/l	2.20			<2.00		
Temperature, °C	16.7			26.7		
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500	<0.500	<0.500	0.770	<0.500
Ammonia-N, mg/l	<0.100			<0.100		
Total Suspended Solids, mg/l	21.0	6.00	6.00	10.0	4.00	7.00
Total Dissolved Solids, mg/l	116			108		

Blank indicates no measurement.

Table 18. 1996 Surface Water Analysis for Plainsboro, Location, P2

Parameters, Units	*P2 5/6/96*	*P2 8/6/96*
pH, units	6.5	6.43
Phenolics as phenol, mg/l	<0.00500	<0.00500
Chemical Oxygen Demand, mg/l	28.0	29.8
Biochemical Oxygen Demand, 5-day total, mg/l	2.20	<2.00
Temperature, °C	16.7	21.7
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500
Ammonia-N, mg/l	<0.100	<0.100
Total Suspended Solids, mg/l	21.0	2.00
Total Dissolved Solids, mg/l	116	104

Table 19. 1996 Detention Basin Influents Analysis (NJDPES NJ0086029)

Parameters, Units	*Inflow 1 5/6/96*	*Inflow 1 8/6/96*	*Inflow 2 5/6/96*	*Inflow 2 8/8/96*
pH, units	7.3	7.27	7.2	7.19
Phenolics as phenol, mg/l	0.00800	0.0100	<0.00500	<0.00500
Chemical Oxygen Demand, mg/l	16.0	24.8	12.0	<2.00
Biochemical Oxygen Demand, 5-day total, mg/l	<2.00	<2.00	<2.00	<2.00
Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500	<0.500	<0.500
Ammonia-N, mg/l	<0.100	<0.100	<0.100	<0.100
Settleable Solids, %	<0.200	<0.0500	<0.200	<0.0500
Total Dissolved Solids, mg/l	120	420	258	268
Chromium, mg/l	<0.00390	<0.00500	<0.00390	<0.00500
Total Volatile Organics by GC/MS, µg/l		None Detected		
Chloroform				1.70T[1]
Tetrachloroethene				4.43T[1]

Blank indicates no measurement.

[1] *T indicates an estimated value.*

Table 20. Monthly Surface Water Analysis for NJPDES NJ0023922 — DSN001 (Ditch #5-D2) for 1996

Permit Limit	Parameters, Units	1/4	2/5	3/5	4/22	5/6	6/4
NA	Chromium total, mg/l	<0.05	<0.05	<0.020		<0.00390	
6.0 - 9.0	pH, units	7.26	7.22	6.70	7.10	7.3	7.8
NA	Phenolics as Phenol, mg/l	<0.050	<0.050	<0.050		<0.00500	
50 mg/l	Chemical Oxygen Demand, mg/l	<10.0	<5.1	9.1	16.0	32.0	<2.00
NA	Biochemical Oxygen Demand, 5-day total, mg/l	<2.0	<2.0	2.9		<2.00	
10 mg/l	Petroleum Hydrocarbons by IR, mg/l	<1.0	<1.0	<1.0	<0.500	<0.500	1.50
NA	Chlorine Produced Oxidants as chlorine, free, mg/l		0.11			0.08	
NA	Chronic Toxicity NOEC (% effluent) IC_{25} (% effluent) P. promelas			100 87		100 100	
NA	Ammonia-N, mg/l	<0.5	<0.5	<0.5		<0.100	
50 mg/l	Total Suspended Solids, mg/l	6.0	<5.0	<5.0	6.0	5.0	8.00
NA	Total Dissolved Solids, mg/l	290	190	140		182	
30°C max.	Temperature _C	5.6	6.2	10.1	16.1	15.6	18.9
NA	Flow, GPM	3837.50	366.69	340.66	348.34	333.74	307.05

Permit Limit	Parameters, Units	7/10	8/6	9/6	10/9	11/8	12/6
NA	Chromium total,mg/l		<0.00500			<0.0100	
6.0 - 9.0	pH, units	7.4	6.96	7.2	7.5	7.59	6.2
NA	Phenolics Phenol, mg/l		0.00800			0.00700	
50 mg/l	Chemical Oxygen Demand, mg/l	8.00	26.3	8.00	8.00	3.20	12.5
NA	Biochemical Oxygen Demand, 5-day total, mg/l		<2.00		<2.00	<3.00	
10 mg/l	Petroleum Hydrocarbons by IR, mg/l	<0.500	<0.500	0.660	<0.500	<0.500	<0.500
NA	Chlorine Produced Oxidants as chlorine, free, mg/l		0.07	0.11		0.12	
NA	Chronic Toxicity NOEC (% effluent) IC_{25} (% effluent) P. promelas	100 >100		100 >100			100 >100
NA	Ammonia-N, mg/l		<0.100		<0.100	<0.100	
50 mg/l	Total Suspended Solids, mg/l	2.00	8.00	13.00	3.00	3.00	11.0
NA	Total Dissolved Solids, mg/l		392		148	180	
30°C max.	Temperature _C	21.7	24.4	24.4	15.6	18.0	9.00
NA	Flow, GPM		336.23	925.38	191.16	402.67	267.24

Blank indicates no sample obtained for the monitoring period.

Table 21. Monthly Surface Water Analysis for Stormwater—DSN002 (NJPDES NJ0023922) for 1996

Permit Limit	Parameters, Units	1/96	2/96	3/96	4/96	5/96
50 mg/l	Total Suspended Solids, mg/l	NF	NF	NF	**266**	12.0
15 mg/l	Petroleum Hydrocarbons-15 min., mg/l	NF	NF	NF	<0.500	1.00
15 mg/l	Petroleum Hydrocarbons- 30 min., mg/l	NF	NF	NF	<0.500	<0.500
15 mg/l	Petroleum Hydrocarbons-45 min., mg/l	NF	NF	NF	<0.500	<0.500
6.0 - 9.0	pH, units	NF	NF	NF	6.67	6.61
100 mg/l	Chemical Oxygen Demand, mg/l	NF	NF	NF	**137**	20.0
NA	Temperature °C	NF	NF	NF	18.8	14.7
NA	Phenolics, as phenol, mg/l	NF	NF	NF		
NA	Ammonia-N, mg/l	NF	NF	NF		
NA	Total Dissolved Solids, mg/l	NF	NF	NF		
NA	Biochemical Oxygen Demand, mg/l	NF	NF	NF		
NA	Chromium, mg/l	NF	NF	NF		

NF - (No Flow) No rain event to cause a stormwater flow at DSN002.
Blank indicates no measurement.

Table 22. Monthly Surface Water Analysis for the Canal Pump House — DSN003 (NJPDES NJ0023922) for 1996

Permit Limit								
Monthly Avg.	Daily Max.	Parameters, Units	1/4	2/5	3/5	4/22	5/6	6/4
NL	NL	Chlorine Produced Oxidants, mg/l		0.18			0.31	
20 mg/l	60 mg/l	Total Suspended Solids, mg/l	<5.0	<5.0	7.0	8.00	<2.00	11.0
10 mg/l	15 mg/l	Petroleum Hydrocarbons, mg/l	<1.0	<1.0	<1.0	<0.500	<0.500	<0.500
NA	6.0 - 9.0	pH, units	7.79	8.15	6.90	6.3	6.5	7.2
NA	NA	Chemical Oxygen Demand, mg/l						
NA	NA	Temperature °C	0.8	0.3	5.10	15.6	16.7	18.3
NA	NA	Phenolics, as phenol, mg/l	<0.05	<0.05	<0.05		<0.005	
NA	NA	Ammonia-N, mg/l	<0.50	<0.50	<0.50		<0.100	
NA	NA	Total Dissolved Solids, mg/l	220	100	83		104	
NA	NA	Biochemical Oxygen Demand, mg/l	2.2	12	2.6		<2.00	
NA	NA	Chromium, mg/l	<0.05	<0.05	<0.020		<0.0039	

Permit Limit								
Monthly Avg.	Daily Max.	Parameters, Units	7/10	8/6	9/6	10/9	11/8	12/6
NL	NL	Chlorine Produced Oxidants, mg/l			0.22			0.25
20 mg/l	60 mg/l	Total Suspended Solids, mg/l	16.0	16.0	7.00	13.0	10.0	9.00
10 mg/l	15 mg/l	Petroleum Hydrocarbons, mg/l	<0.500	<0.500	0.750	<0.500	0.660	<0.500
NA	6.0 - 9.0	pH, units	7.2	7.06	7.4	7.5	6.9	6.4
NA	NA	Chemical Oxygen Demand, mg/l					9.50	
NA	NA	Temperature °C		24.4	19.4	16.7	13.0	8.00
NA	NA	Phenolics, as phenol, mg/l		<0.005			0.0050	
NA	NA	Ammonia-N, mg/l		<0.100			<0.100	
NA	NA	Total Dissolved Solids, mg/l		128			134	
NA	NA	Biochemical Oxygen Demand, mg/l		<2.00			<3.00	
NA	NA	Chromium, mg/l		<0.005			<0.010	

Flow is estimated to be 7,500 gallons per day (gpd) based upon the rating of the pumps in the canal pump house the duration of the cycle and the number of cycles per day.
Blank indicates no measurement.
NL - No Limit

Table 23. Application of Herbicides and Fertilizers in 1996

Herbicides and Fertilizers	Amounts Used
NPK fertilizer	900 pounds
Roundup	53.75 gallons
Lime	2,100 pounds

Table 24. Total Petroleum Hydrocarbons Results from Quarterly Ground Water Monitoring Program for 1996 (in mg/l)

Well Number	3/96	6/96	9/96	12/96
P-2	5.0U	**1.7**	5.0U	5.0U
MW-4	5.0U	**1.3**	5.0U	5.0U
MW-5S	5.0U	**1.3**	5.0U	5.0U
MW-5I	5.0U	**1.8**	5.0U	5.0U
MW-6S	5.0U	**1.3**	5.0U	5.0U
MW-6I	5.0U	**1.8**	5.0U	5.0U
MW-7S	5.0U	**1.5**	5.0U	5.0U
MW-7I	5.0U	**1.7**	5.0U	5.0U
MW-8S	5.0U	**1.1**	5.0U	5.0U
MW-8I	5.0U	**2.1**	5.0U	5.0U

U - Indicates a compound was analyzed for but not detected.
For results marked with a "U," the numerical value is the compound method detection limit.

Table 25. Ground Water Monitoring Program Volatile Organic Compounds Results — June 1996 (in µg/l) — Sampled by PPPL & Analyzed by Reliance Lab

Parameter	P-2 6/18/96	MW-4 6/18/96	MW-5S 6/18/96	MW-5I 6/18/96	MW-6S 6/18/96	MW-6I 6/18/96
Target VOC						
1,1-Dichloroethene	1.1U	1.1U	1.1U	1.1U	1.1U	1.1U
1,1-Dichloroethane	0.8U	0.8U	0.8U	0.8U	0.8U	0.8U
1,1,1-Trichloroethane	1.U	1.U	1.U	1.U	**4.5**	1.U
Trichloroethene	0.8U	0.8U	0.8U	**7.2**	0.8U	0.8U
Tetrachloroethene	0.9U	0.9U	**7.2**	**2.1**	**1.9**	0.9U
Chloroform	0.8U	0.8U	0.8U	0.8U	0.8U	0.8U
Total Conc. Target VOC	0	0	**7.2**	**9.3**	**6.4**	0
Non-Target Semi-VOCs (Number of Compounds)	**3**	0	0	0	0	**2**
Non-Target VOC (Number of Compounds)	0	0	0	**3**	**1**	**1**

Parameter	MW-7S 6/18/96	MW-7I 6/18/96	MW-8S 6/18/96	MW-8I 6/18/96	Trip Blank 6/18/96*
Target VOC					
1,1-Dichloroethene	**3.7**	1.1U	1.1U	1.1U	1.1U
1,1-Dichloroethane	**16.8**	0.8U	0.8U	0.8U	0.8U
1,1,1-Trichloroethane	**10**	1.U	1.U	1.U	1.U
Trichloroethene	**2.9**	0.8U	**2.4**	0.8U	0.8U
Tetrachloroethene	**12.5**	0.9U	**23.6**	0.9U	0.9U
Chloroform	0.9U	0.8U	**1.0**	0.8U	0.8U
Total Conc. Target VOC	**45.9**	0	**27**	0	0
Non-Target Semi-VOCs (Number of Compounds)	0	0	0	0	0
Non-Target VOC (Number of Compounds)	(1)	(1)	(1)	0	0

** No Trip Blank collected*

Target VOCs are Priority Pollutant VOCs.

Non-Target are VOCs detected other than those priority pollutants.

VOC - volatile organic compounds, 40 CFR Method 624

U - Indicates a compound was analyzed but not detected. For results marked "U," the numerical value is the compound detection limit.

Table 26. Ground Water Monitoring Program

Volatile Organic Compound Results — September 1996 (in mg/l)

Sampled by PPPL & Analyzed by Reliance Lab

Parameter	***P-2 9/30/96***	***MW-4 9/30/96***	***MW-5S 9/30/96***	***MW-5I 9/30/96***	***MW-6S 9/27/96***	***MW-6I 9/30/96***
Target VOC						
1,1-Dichloroethene	1.1U	1.1U	1.1U	1.1U	**1.5**	1.1U
1,1-Dichloroethane	0.8U	0.8U	0.8U	**1**	**6**	0.8U
1,1,1-Trichloroethane	1.U	1.U	1.U	1.U	**4.7**	1.U
Trichloroethene	0.8U	0.8U	0.8U	**6.7**	**2.5**	0.8U
Tetrachloroethene	0.9U	0.9U	**2.7**	**2.2**	**10.5**	0.9U
Chloroform						
Total Conc. Target VOC	0	0	**2.7**	**10**	**25.2**	0
Non-Target Semi-VOCs (Number of Compounds)	**102 (1)**	**145 (2)**	**118 (1)**	**57 (1)**	**107 (2)**	**255 (5)**
Non-Target VOC (Number of Compounds)	0	0	0	0	0	**17 (2)**

Parameter	***MW-7S 9/30/96***	***MW-7I 9/30/96***	***MW-8S 9/30/96***	***MW-8I 9/30/96***	***Trip Blank 9/30/96***
Target VOC					
1,1-Dichloroethene	**2.7**	1.1U	1.1U	1.1U	1.1U
1,1-Dichloroethane	**10.9**	0.8U	0.8U	0.8U	0.8U
1,1,1-Trichloroethane	**7.6**	1.U	1.U	1.U	1.U
Trichloroethene	0.8U	0.8U	0.8U	0.8U	0.8U
Tetrachloroethene	**8.2**	0.9U	**15**	0.9U	0.9U
Chloroform	0.9U	0.8U	0.8U	0.8U	0.8U
Total Conc. Target VOC	**29.4**	0	**15**	0	0
Non-Target Semi-VOCs (Number of Compounds)	**36 (2)**	**27 (1)**	**127 (1)**	**68 (2)**	0
Non-Target VOC (Number of Compounds)	**7.6 (1)**	0	0	0	**5 (1)**

U - Indicates a compound was analyzed but not detected. For results marked "U," the numerical value is the compound detection limit.
VOC - volatile organic compounds, 40 CFR Method 624

Table 27. Ground Water Monitoring Program

Volatile Organic Compound Results — December 1996 (in mg/l)

Sampled by Harding Lawson Associates

Parameter	***P-2 12/11/96***	***MW-4 12/11/96***	***MW-5S 12/5/96***	***MW-5I 12/5/96***	***MW-6S 12/5/96***	***MW-6I 12/5/96***
Target VOC						
1,1-Dichloroethene	1.1U	1.1U	0.059U	**1.21JN**	0.59U	0.59U
1,1-Dichloroethane	0.8U	0.8U	0.097U	**1.53JN**	**0.852JN**	**0.852JN**
1,1,1-Trichloroethane	1.U	1.U	0.18U	**0.476JN**	0.18U	0.18U
Trichloroethene	0.8U	0.8U	0.15U	**9.87JN**	0.15U	0.15U
Tetrachloroethene	0.9U	0.9U	**0.838JN**	**2.11JN**	0.23	0.23
Total Conc. Target VOC	0	0	**0.838**	**15.196**	**0.852**	**0.852**
Non-Target Semi-VOCs (Number of Compounds)	0	0				
Non-Target VOC (Number of Compounds)	0	0				

Parameter	***MW-7S 12/5/96***	***MW-7I 12/5/96***	***MW-8S 12/5/96***	***MW-8I 12/5/96***	***Trip Blank 12/11/96****
Target VOC					
1,1-Dichloroethene	**2.44**	0.059U	0.059U	0.059U	1.1U
1,1-Dichloroethane	**9.14JN**	0.097U	**1.52JN**	0.097U	0.8U
1,1,1-Trichloroethane	**7.13JN**	0.18U	0.18U	0.18U	1.U
Trichloroethene	**1.45JN**	**0.264N**	**0.892JN**	0.15U	0.8U
Tetrachloroethene	**7.54JN**	**0.246N**	**7.43JN**	**0.238JN**	0.9U
Total Conc. Target VOC	**27.70**	**1.36**	**9.842**	**0.238**	0
Non-Target Semi-VOCs (Number of Compounds)					
Non-Target VOC (Number of Compounds)					

J Detected below the method
N Tentatively Identified Compound (TIC) was presumptively found.
U - Indicates a compound was analyzed but not detected. For results marked "U," the numerical value is the compound detection limit.
VOC - volatile organic compounds, 40 CFR Method 624/8260.

Table 28. Ground Water Analysis for Wells MW-14, MW-15, and MW-16 for 1996

Parameters Units	***NJPDES Permit Standard***	***MW-14 2/9***	***MW-14 5/7***	***MW-14 8/5***	***MW-14 11/6***
Chromium, mg/l	*0.05*			<0.01	<0.01
Lead, dissolved, mg/l	*0.05*			<0.002	<0.002
pH, units		5.29	5.22	4.90	5.07
Phenolics as phenol, mg/l	*0.3*			0.015	<0.005
Nitrate-Nitrogen, mg/l	*10*			1.4	1.6
Total Organic Carbon, mg/l				<1	
Total Organic Halides, mg/l				0.0089	
Petroleum Hydrocarbon by IR, mg/l				<0.5	
Ammonia-Nitrogen, mg/l	*0.5*		<0.1	<0.1	<0.1
Chloride, mg/l	*250*			3.8	3.4
Total Dissolved Solids, mg/l	*500*	44	50	84	70
Sulfate, mg/l	*250*	14	17.2	22.1	18.3
Conductivity, umhos/cm^2		67.9	36.6	*	44

Parameters Units	***NJPDES Permit Standard***	***MW-15 2/9***	***MW-15 5/7***	***MW-15 8/5***	***MW-15 11/6***
Chromium, mg/l	*0.05*			<0.01	<0.01
Lead, dissolved, mg/l	*0.05*			<0.002	<0.002
pH, units		6.00	6.53	5.95	6.35
Phenolics as phenol, mg/l	*0.3*			0.005	0.013
Nitrate-Nitrogen, mg/l	*10*			<0.4	<0.4
Total Organic Carbon, mg/l				<1.0	
Total Organic Halides, mg/l				<0.005	
Petroleum Hydrocarbon by IR, mg/l				<0.5	
Ammonia-Nitrogen, mg/l	*0.5*		<0.1	<0.1	<0.1
Chloride, mg/l	*250*			<2	2.9
Total Dissolved Solids, mg/l	*500*	12	150	56	80
Sulfate, mg/l	*250*	6	45.4	8.6	12.8
Conductivity, umhos/cm^2		66	48	*	73

Parameters Units	***NJPDES Permit Standard***	***MW-16 2/9***	***MW-16 5/7***	***MW-16 8/5***	***MW-16 11/6***
Chromium, mg/l	*0.05*			<0.01	<0.01
Lead, dissolved, mg/l	*0.05*			<0.002	0.002
pH, units		6.47	5.93	6.16	6.38
Phenolics as phenol, mg/l	*0.3*			<0.005	0.011
Nitrate-Nitrogen, mg/l	*10*			1.73	0.9
Total Organic Carbon, mg/l				2.0	
Total Organic Halides, mg/l				0.0266	
Petroleum Hydrocarbon by IR, mg/l				<0.5	
Ammonia-Nitrogen, mg/l	*0.5*		<0.1	<0.1	<0.1
Chloride, mg/l	*250*			6.7	5.7
Total Dissolved Solids, mg/l	*500*	190	56	214	218
Sulfate, mg/l	*250*	51	9.25	44.7	43
Conductivity, umhos/cm^2		351	215	*	340

Blank indicates no measurement.
** No data due to equipment failure.*

Table 29. Ground Water Analysis for Wells D-11R and D-12 for 1996

Parameters Units	NJPDES Standard	D-12 2/9/96	D-12 5/7/96	D-12 8/5/96	D-12 11/6/96	D-11R 11/6/96
Chromium, mg/l	0.05			<0.01	<0.01	
Lead, dissolved, mg/l	0.05			<0.002	<0.002	<0.002
pH, units		5.27	5.89	5.27	5.98	6.56
Phenolics as phenol, mg/l	0.3			0.008	<0.01	0.005
Nitrate-Nitrogen, mg/l	10			<0.4	<0.4	<0.4
Total Organic Carbon, mg/l				5.7		
Total Organic Halides, mg/l				0.0275		
Petroleum Hydrocarbon by IR, mg/l				<0.5		
Ammonia-Nitrogen, mg/l	0.5		<0.5	<0.1	<0.1	<0.1
Chloride, mg/l	250			19.4	19.1	15.8
Total Dissolved Solids, mg/l	500	120	142	214	258	184
Sulfate, mg/l	250	28	29	32.7	29.8	12.2
Conductivity, umhos/cm^2		220	221	*	282	291
Tritium, pCi/L				292.8	<126	170

Note: D-11 not sampled until new well D-11R installed in Oct. 1996 and sampled in November. Under drain system installed In Oct.1994, causing a lowering of the ground water level..

Table 30. Ground Water Analysis for Wells TW-2 and TW-3 for 1996

Parameters Units	NJPDES Standards	TW-2 2/9/96	TW-2 5/7/96	TW-2 8/5/96	TW-2 11/6/963
Chromium, mg/l	0.05				<0.01
Lead, dissolved, mg/l	0.05			<0.002	<0.002
pH, units		7.14	7.47	7.35	7.36
Phenolics as phenol, mg/l	0.3			0.006	0.013
Nitrate-Nitrogen, mg/l	10			<0.4	<0.4
Total Organic Carbon, mg/l				<1.0	
Total Organic Halides, mg/l	*			0.0054	
Petroleum Hydrocarbon by IR, mg/l				<0.5	
Ammonia-Nitrogen, mg/l	0.5		<0.1	<0.1	<0.1
Chloride, mg/l	250			16.3	17.7
Total Dissolved Solids, mg/l	500	190	216	260	228
Sulfate, mg/l	250	16	18.6	20.9	24.5
Conductivity, umhos/cm^2		383	320	*	384

Parameters Units	NJPDES Standards	TW-3 2/9/96	TW-3 5/8/96	TW-3 8/5/96	TW-3 11/6/96
Chromium, mg/l	0.05				
Lead, dissolved, mg/l	0.05			<0.002	<0.002
pH, units		7.39	7.15	7.10	7.17
Phenolics as phenol, mg/l	0.3			0.007	<0.005
Nitrate-Nitrogen, mg/l	10			<0.4	<0.4
Total Organic Carbon, mg/l				<1.0	
Total Organic Halides, mg/l				<0.005	
Petroleum Hydrocarbon by IR, mg/l				<0.5	
Ammonia-Nitrogen, mg/l	0.5		<0.1	<0.1	<0.1
Chloride, mg/l	250			13.4	9.1
Total Dissolved Solids, mg/l	500	190	236	242	210
Sulfate, mg/l	250	3	24	21.5	19.6
Conductivity, umhos/cm^2		467	324	*	358
Tritium, pCi/L				378.4	243

*Blank indicates no measurement. *No data available due to equipment failure.*

Table 31. Ground Water Volatile Organics Analytical Results from Wells D-12, and TW-3— May 1996 (in µg/l)

Parameter	*DEP GW Quality Criteria*	*D-12 5/7/96*	*TW-3 5/7/96*	*Trip Blank 5/7/96*
Methyl Chloride (Chloromethane)	*30*	<10	<10	<10
Methyl Bromide (Bromomethane)	*10*	<10	<10	<10
Vinyl Chloride	*0.08*	<10	<10	<10
Chloroethane	*NL*	<10	<10	<10
Methylene Chloride	*400*	<5	<5	<5
Acrolein	*NA*	<50	<50	<50
Acrylonitrile	*0.06*	<50	<50	<50
1,1-Dichloroethane	*70*	<5	<5	<5
1,2-Dichloroethane	*0.3*	<5	<5	<5
1,1-Dichloroethene	*1*	<5	<5	<5
1,2-trans-Dichloroethene	*100*	<5	<5	<5
1,2-Dichloropropane	*0.5*	<5	<5	<5
1,3-trans-Dichloropropene	*0.2*	<5	<5	<5
Chloroform	*6*	<5	<5	<5
1,1,1-Trichloroethane	*30*	<5	<5	<5
1,1,2-Trichloroethane	*3*	<5	<5	<5
Trichloroethene	*1*	<5	<5	<5
Carbon Tetrachloride	*0.4*	<5	<5	<5
Bromodichloromethane	*0.3*	<5	<5	<5
Chlorodibromomethane	*10*	<5	<5	<5
Benzene	*0.2*	<5	<5	<5
2-Chloroethyl Vinyl Ether	*NL*	<10	<10	<10
Bromoform	*4*	<5	<5	<5
Tetrachloroethene	*0.4*	<5	<5	<5
1,1,2,2-Tetrachloroethane	*2*	<5	<5	<5
Toluene	*1,000*	<5	<5	<5
Chlorobenzene	*4*	<5	<5	<5
Ethylbenzene	*700*	<5	<5	<5
1,4-Dichlorobenzene	*75*	**3.03 T**	<5	<5

**Note: D-11 was no sampled due to insufficient water for sample collection; since Oct. 1994, under-drain system in operation, which lowered ground water levels.*
T Value reported is less than criteria of detection.

Table 32 Volatile Organics Analytical Results from Wells TW-3 and D-12, and Detention Basin Inflows 1 and 2 — August 1996 (in μg/l)

Parameter	*DEP GW Quality. Criteria*	*TW-3 8/5/96*	*D-12 8/5/96*	*Inflow 1 8/1/96*	*Inflow 2 8/1/96*	*Trip Blank 8/5/96*
Methyl Chloride (Chloromethane)	*30*	<10	<10	<10	<10	<10
Methyl Bromide (Bromomethane)	*10*	<10	<10	<10	<10	<10
Vinyl Chloride	*0.08*	<10	<10	<10	<10	<10
Chloroethane	*NL*	<10	<10	<10	<10	<10
Methylene Chloride	*400*	<5	<5	<5	<5	<5
Acrolein	*NA*	<50	<50	<50	<50	<50
Acrylonitrile	*0.06*	<50	<50	<50	<50	<50
1,1-Dichloroethane	*70*	<5	**2.04T**	<5	<5	<5
1,2-Dichloroethane	*0.3*	<5	<5	<5	<5	<5
1,1-Dichloroethene	*1*	<5	<5	<5	<5	<5
1,2-trans-Dichloroethene	*100*	<5	<5	<5	<5	<5
1,2-Dichloropropane	*0.5*	<5	<5	<5	<5	<5
1,3-trans-Dichloropropene	*0.2*	<5	<5	<5	<5	<5
Chloroform	*6*	<5	<5	<5	**1.7 T**	<5
1,1,1-Trichloroethane	*30*	<5	<5	<5	<5	<5
1,1,2-Trichloroethane	*3*	<5	<5	<5	<5	<5
Trichloroethene	*1*	<5	**2.99T**	<5	<5	<5
Carbon Tetrachloride	*0.4*	<5	<5	<5	<5	<5
Chlorodibromomethane	*0.3*	<5	<5	<5	<5	<5
Bromodichloromethane		<5	<5	<5	<5	<5
Benzene	*0.2*	<1	<1	<1	<1	<1
2-Chloroethyl Vinyl Ether	*NL*	<10	<5	<10	<10	<10
Bromoform	*4*	<5	<10	<5	<5	<5
Tetrachloroethene	*0.4*	<5	<5	<5	**4.43T**	<5
1,1,2,2-Tetrachloroethane	*2*	<5	<5	<5	<5	<5
Toluene	*1,000*	<5	<5	<5	<5	<5
Chlorobenzene	*4*	<5	<5	<5	<5	<5
Ethylbenzene	*700*	<5	<5	<5	<5	<5
cis-1,2-Dichloroethene	*10*	<5	**3.4T**	<5	<5	<5

T Value reported is less than criteria of detection.
**Note: D-11 was not sampled due to insufficient water for sample collection; since Oct. 1994, under-drain system in operation, which lowered ground water levels. Replacement well, D-11R, drilled in October 1996.*

Table 33. Ground Water Base Neutrals Analytical Results— August 1996 (in µg/l)

Parameter	***D-12 8/5***	***MW-14 8/5***	***MW-15 8/5***	***MW-16 8/5***	***TW-2 8/5***	***TW-3 8/5***
Acenaphthene	<10	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10	<10
Benzidine	<50	<50	<50	<50	<50	<50
Benzo (a)anthracene	<10	<10	<10	<10	<10	<10
Benzo (a)pyrene	<10	<10	<10	<10	<10	<10
Benzo (b)fluoranthene	<10	<10	<10	<10	<10	<10
Benzo (k)fluoranthene	<10	<10	<10	<10	<10	<10
Benzo (g,h,i)perylene	<10	<10	<10	<10	<10	<10
bis(2-Chloroethoxy)methane	<10	<10	<10	<10	<10	<10
bis(2-Chloroethyl)ether	<10	<10	<10	<10	<10	<10
bis(2-Chloroisopropyl)ether	<10	<10	<10	<10	<10	<10
Bis(2-Ethylhexyl)phthalate	**19.7B**	**8.97B**	**19B**	**30.1B**	**5.4TB**	**3.28TB**
4-Bromophenyl-phenylether	<10	<10	<10	<10	<10	<10
N-Butylbenzylphthalate	<10	<10	<10	<10	<10	<10
2-Chloronaphthalene	<10	<10	<10	<10	<10	<10
4-Chlorophenyl-phenylether	<10	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10	<10
1.2,5,6 Dibenzanthracene	<10	<10	<10	<10	<10	<10
1,2-Dichlorobenzene	<10	<10	<10	<10	<10	<10
1,3-Dichlorobenzene	<10	<10	<10	<10	<10	<10
1,4-Dichlorobenzene	<10	<10	<10	<10	<10	<10
3,3-Dichlorobenzidine	<20	<20	<20	<20	<20	<20
Diethylphthalate	<10	<10	<10	<10	<10	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10
Di-n-butylphthalate	<10	<10	<10	<10	<10	<10
2,4-Dinitro-2-methylphenol	<10	<10	<10	<10	<10	<10
2,4-Dinitrotoluene	<10	<10	<10	<10	<10	<10
2,6-Dinitrotoluene	<10	<10	<10	<10	<10	<10
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10
1,2-Diphenylhydrazine	<10	<10	<10	<10	<10	<10
Fluoranthene	<10	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10	<10
Hexachlorobenzene	<10	<10	<10	<10	<10	<10
Hexachlorobutadiene	<10	<10	<10	<10	<10	<10
Hexachlorocyclopentadiene	<10	<10	<10	<10	<10	<10
Hexachloroethane	<10	<10	<10	<10	<10	<10
Indeno (1,2,3-cd)pyrene	<10	<10	<10	<10	<10	<10
Isophorone	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10
Nitrobenzene	<10	<10	<10	<10	<10	<10
N-nitrosodimethylamine	<10	<10	<10	<10	<10	<10
N-Nitroso-di-n-propylamine	<10	<10	<10	<10	<10	<10
N-Nitrosodiphenylamine	<10	<10	<10	<10	<10	<10
Phenathrene	<10	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10	<10
1,2,4-Trichlorobenzene	<10	<10	<10	<10	<10	<10

Note: D-11 did not yield sufficient water for sample collection due to basin underdrain system in operation.
T Value reported is less than criteria of detection.
B Found in method blank.

Table 34. Volatile Organic Compounds Exceeding NJDEP Groundwater Quality Standard for Class II-A Aquifers — June 1994, March 1995 and May 1995, and December 1996

Well or Sump Number		PCE (µg/L)				TCE (µg/L)				Ben-zene (µg/L)	
Date Sampled	*6/94*	*3/95*	*5/95*	*12/96*	*6/94*	*3/95*	*5/95*	*12/96*	*6/94*	*3/95*	*5/95*
Stand.	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
D-11/ D-11R	**1.9**	**4.62**	**1.35**	**5.36JN**	<1	<1	<1	**2.22JN**	<1	<1	<1
D-12	**11**	**9.87**	**10.6**	**5.53JN**	**1.7**	**5.16**	**5.43**	0.262JN	<1	<1	<1
TFTR-S1	**3**	**5.37**	**4.16**	**4.2JN**	<1	<1	<1	0.266JN	<1	<1	<1
MG-S2	**30**	**39.3**	**58.7**	**42.8JN**	**2.1**	**4.96**	<10	**3.71JN**	<1	<1	<1
LOB-S3	**2.3**	**2.14**	**2.01**	**1.01JN**	<1	<1	<1	<0. 15	<1	<1	<1
MG-S4	**2.3**	**9.5**	**4.44**	**2.05JN**	**2.1**	**1.08**	**4.89**	0.382JN	<1	<1	<1
MG-S5	<1	<1	<1	0.304JN	<1	<1	<1	<0.15	<1	<1	<1
MG-S6	**11**	**20.9**	**8.66**	**19JN**	<1	**1.8**	<1	**1.44JN**	<1	<1	<1
MW-3	**25**	**14.7**	**15.4**	**5.83JN**	<1	<1	<1	<0.15	<1	<1	<1
MW-3 D				**9.12JN**				<0.15			
MW-5I	**3.6**	**5.53**	<1	**2.11JN**	**5.2**	**8.1**	**5.8**	**9.87JN**	<1	<1	<1
MW-5ID				**2.74JN**				<0.15			
MW-6S	**2.8**	NC	**13.1**	**36.7JN**	<1	**8.15**	**25.1**	**9.82JN**	<1	<1	<1
MW-7I	**7.4**	**6.87**	**2.79**	0.246JN	**3**	**4.13**	**2.21**	0.264JN	0.8 T	**1.03**	<1
MW-7S	**12**	**13.8**	**17.2**	**7.54JN**	**2**	**3.48**	**4.5**	**1.45JN**	<1	<1	<1
MW-8S	**14**	**9.23**	**7.48**	**7.43JN**	**1.6**	**1.62**	**1.38**	0.892JN	<1	<1	<1
MW-9	**78**	**89.9**	**79.8**	**113 JN**	**1.7**	<5	<10	<3	<1	<1	<1
MW-9I				0.18JN				<0.15			
MW-10I				0.296JN				<0.15			
MW-13	**120**	**126**	**111**	**111JN**	**1.8**	<10	<10	<3	<1	<1	<1
MW-13I				**9.62JN**				0.152JN			
MW-17				**2.55JN**				<0.15			
MW-18				0.722JN				0.146JN			
TW-1	**1.7**	<1	**1.57**	0.932JN	<1	<1	<1	<0.15	<1	<1	<1
TW-2	**2.2**	<1	<1	0.638JN	<1	<1	<1	<0.15	<1	<1	<1
TW-3	**14**	<1	**5.15**	<0.23	<1	<1	<1	<0.15	<1	<1	<1
TW-4	<1	<1	<1	13.5JN	<1	**1.07**	**1.12**	**1.16JN**	<1	<1	<1
TW-7	**30**	**3.75**	**21.7**	<0.23	**1.3**	<1	<2.5	0.282JN	<1	<1	<1
TW-10	<1	**1.34**	<1	0.576JN	<1	<1	<1	0.328JN	<1	<1	<1

Blank indicates either no sample collected because (1) duplicates not previously collected at this well or (2) newly installed wells (MW-9I, MW-13I, MW-17, or MW-18).

Bold indicates above the NJDEP Ground water Quality Standard for Class IIA- Aquifers.

D = Duplicate sample

J = Estimated vale

N = Tentatively identified compound based on presumptive evidence

PCE = Perchloroethene, tetrachloroethene, or tetrachloroethylene

TCE = 1,1,1-Trichloethene or 1,1,1-Trichloroethylene

NC = Not collected

T = Value reported is less than criteria detection

Table 35. Sanitary Sewer Non-Radiological Analytical Results for 1996

1996	pH	Temperature °F
January	6.21	61.0
February	6.89	56.7
March	7.09	—
April	NR	NR
May	6.77	57.0
June	6.41	73.0
July	6.56	72.1
August	—	—
September	607	70.9
October	NR	NR
November	7.04	69.1
December	6.85	63.3

— No data available
NR= no release

Table 36. Quality Assurance Data for Radiological and Non-Radiological Samples for 1996

QA Sample & Date	PPPL Result	True Value	Control Range
Inter-DOE 3/96 test: Environmental Measurements Laboratory -Tritium (pCi/L)	534.005	590.06	531.055 - 649.066
USEPA (WP035			
pH (S.U.)	4.34	4.40	4.22 - 4.4
pH (S.U.)	5.57	5.50	5.46 - 5.62
Total residual chlorine (mg/L)	2.35	2.80	2.54 - 3.6
Total residual chlorine (mg/L)	0.36	0.410	0.295 - 0.624
USEPA (WP036)			
pH (S.U.)	8.71	8.73	8.54 - 9.01
Total residual chlorine (mg/L)	0.33	0.690	0.543-0.834

12.0 FIGURES

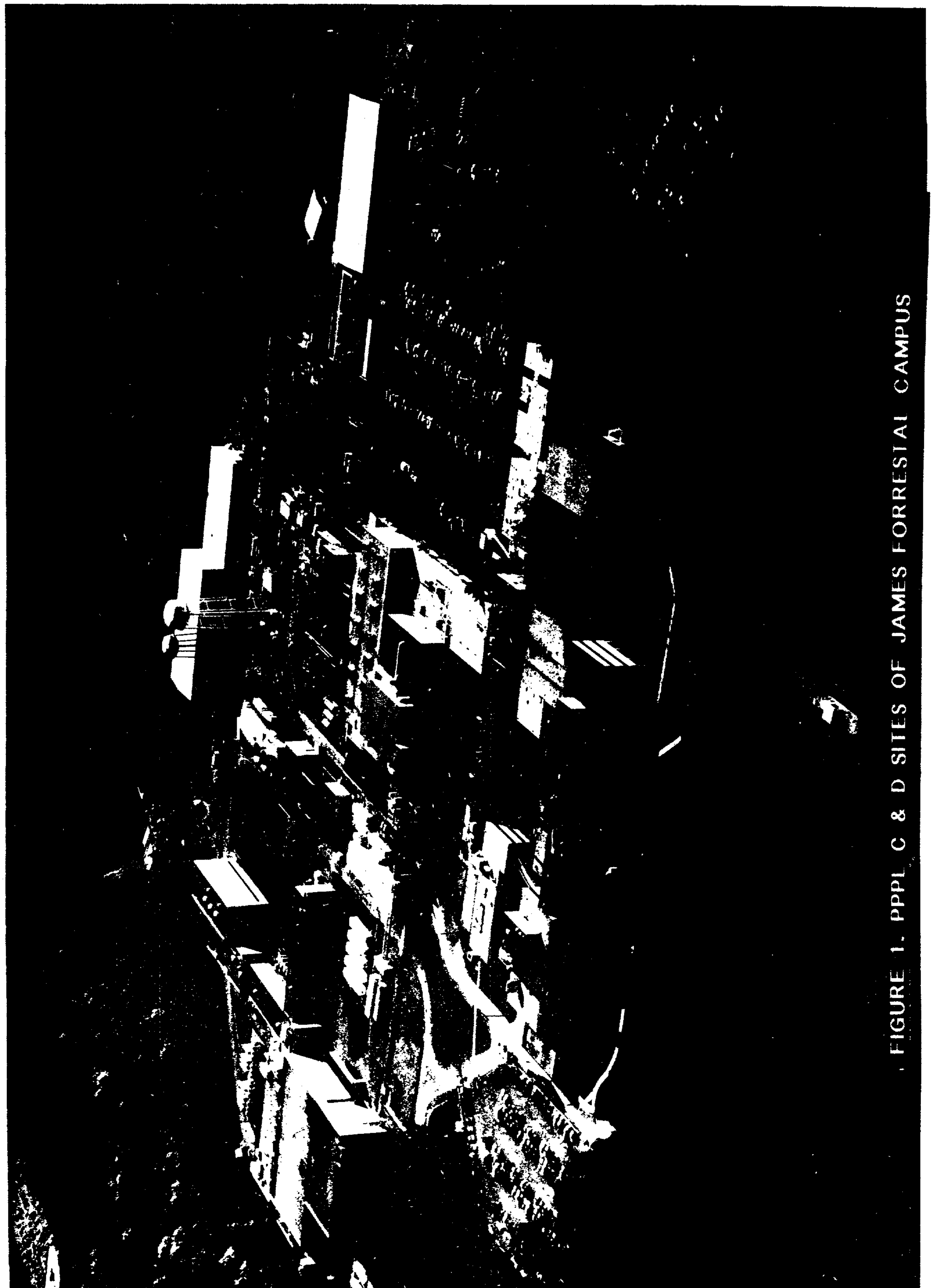


FIGURE 1. PPPL C & D SITES OF JAMES FORRESTAL CAMPUS

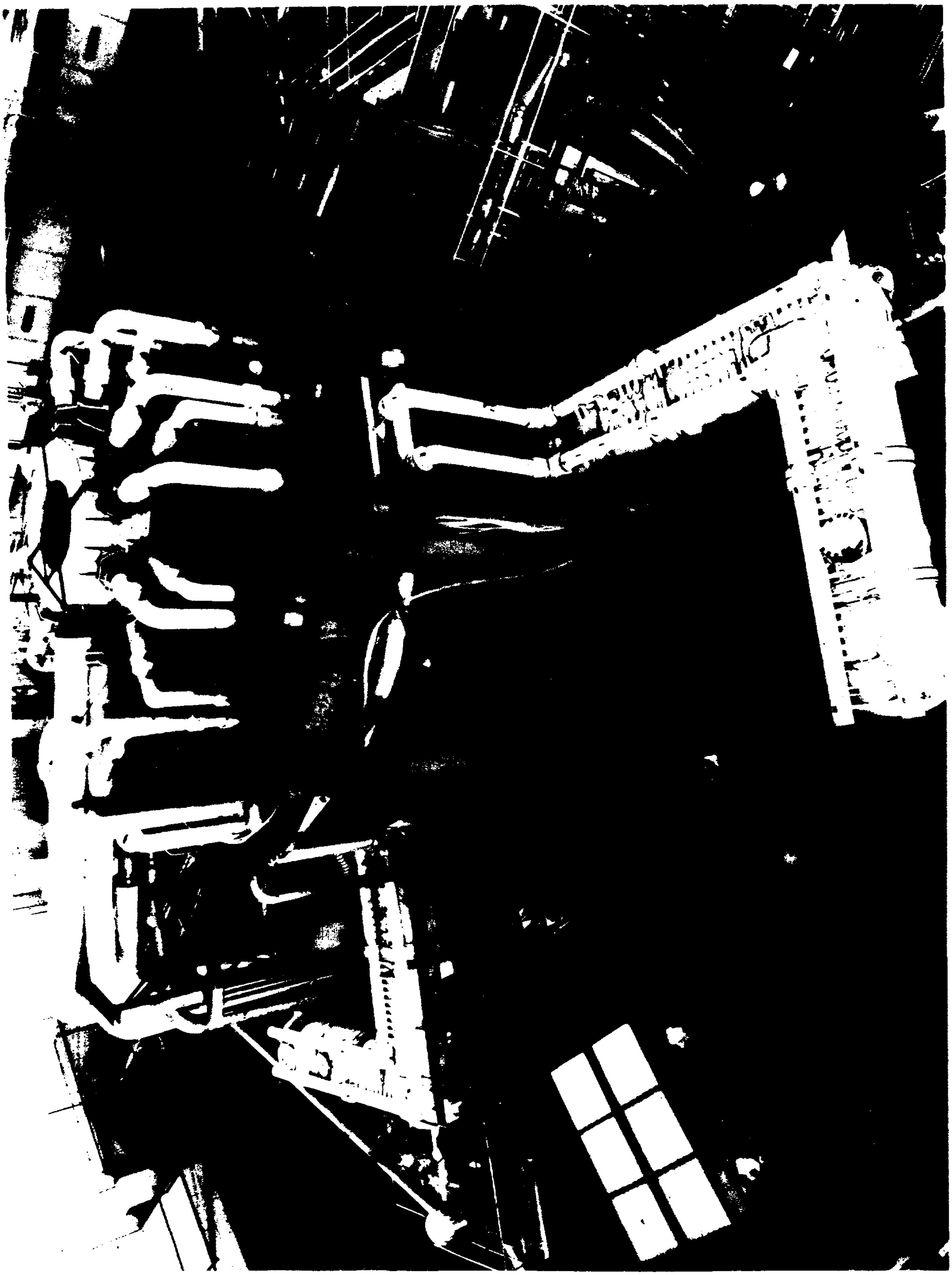


FIGURE 2. THE TOKAMAK FUSION TEST REACTOR

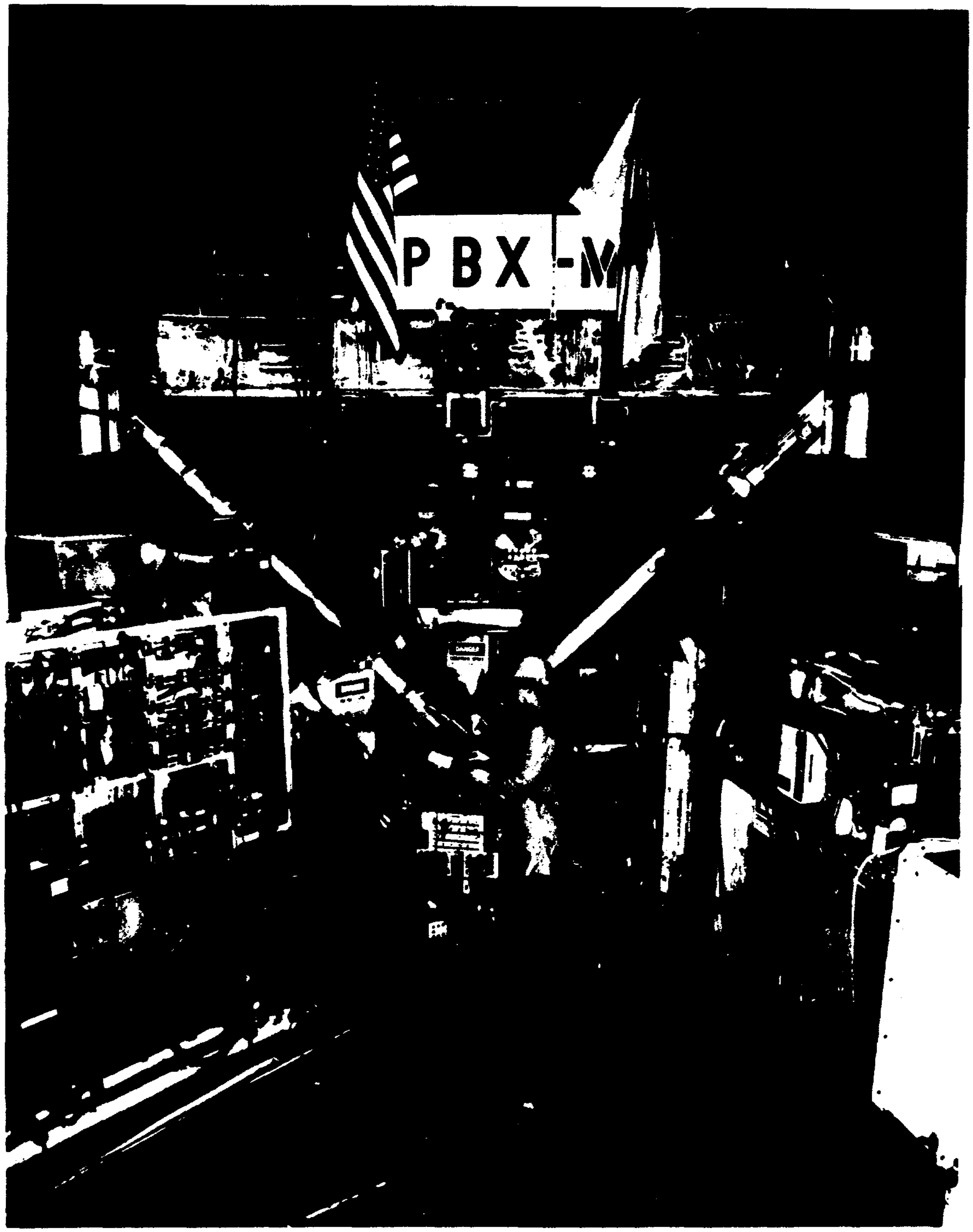


FIGURE 3. THE PRINCETON BETA EXPERIMENT-MODIFICATION

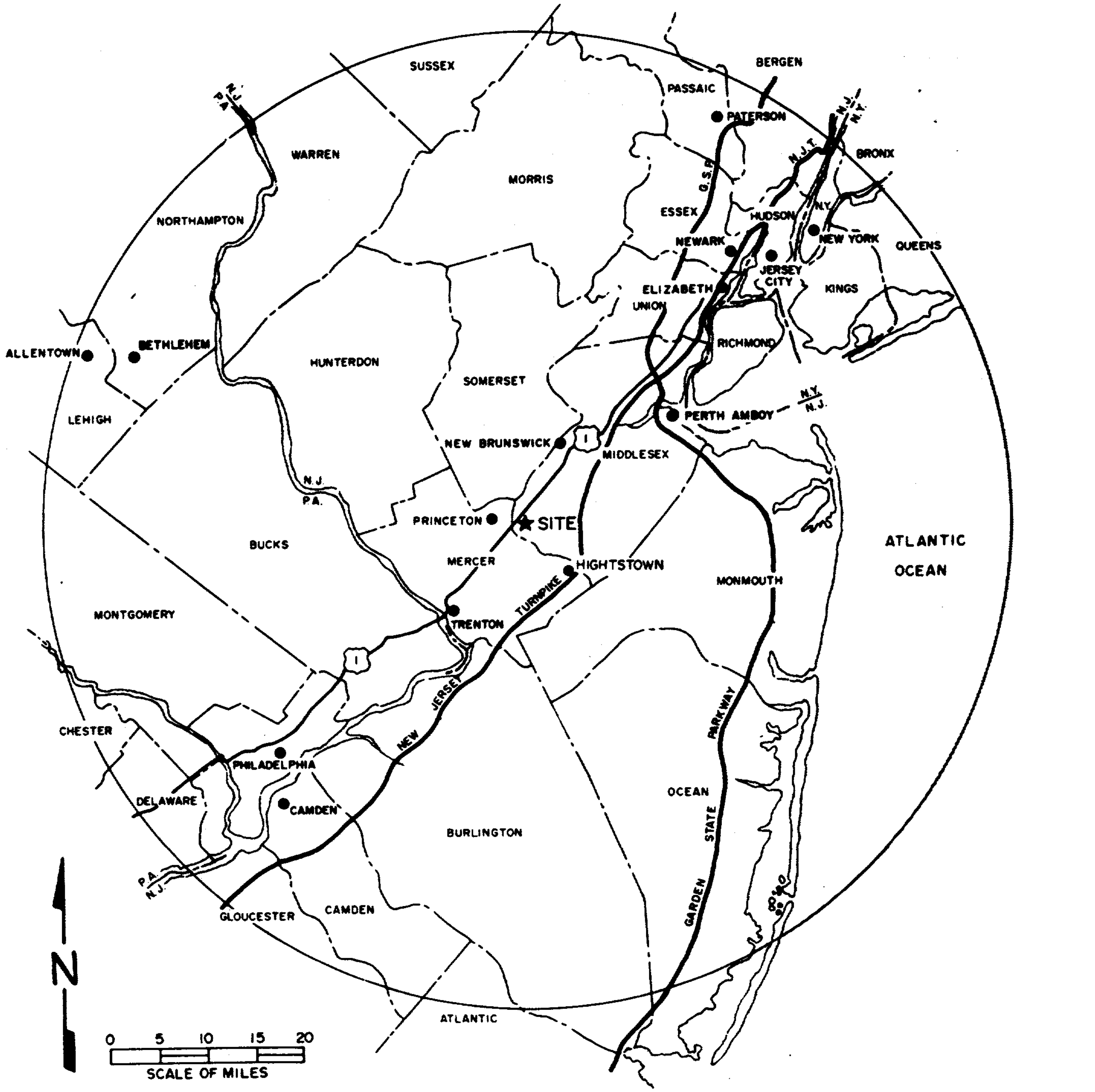
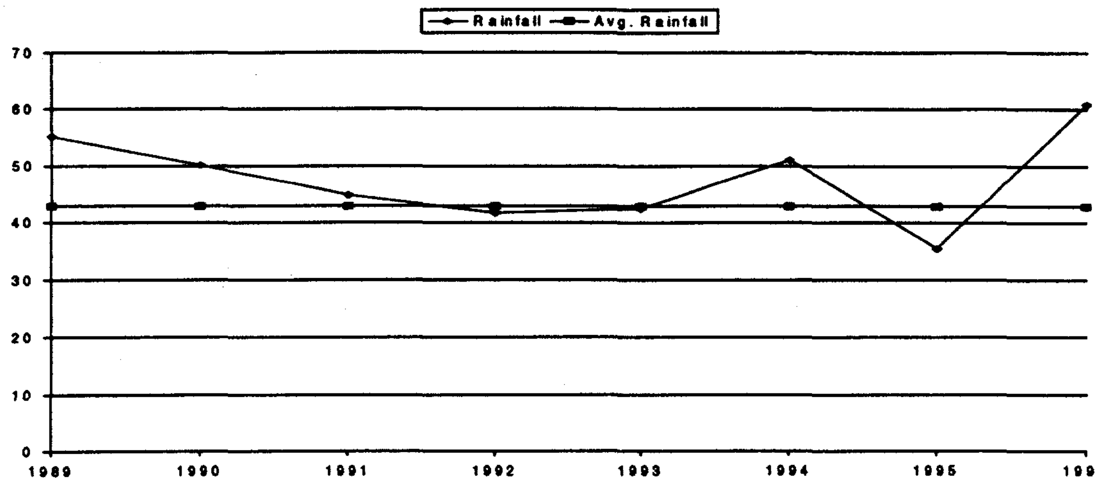


FIGURE 4. Region Surrounding the TFTR Site (50 Mile Radius Shown)

Figure 5. Annual Total Precipitation at PPPL from 1989 to 1996 (in inches)



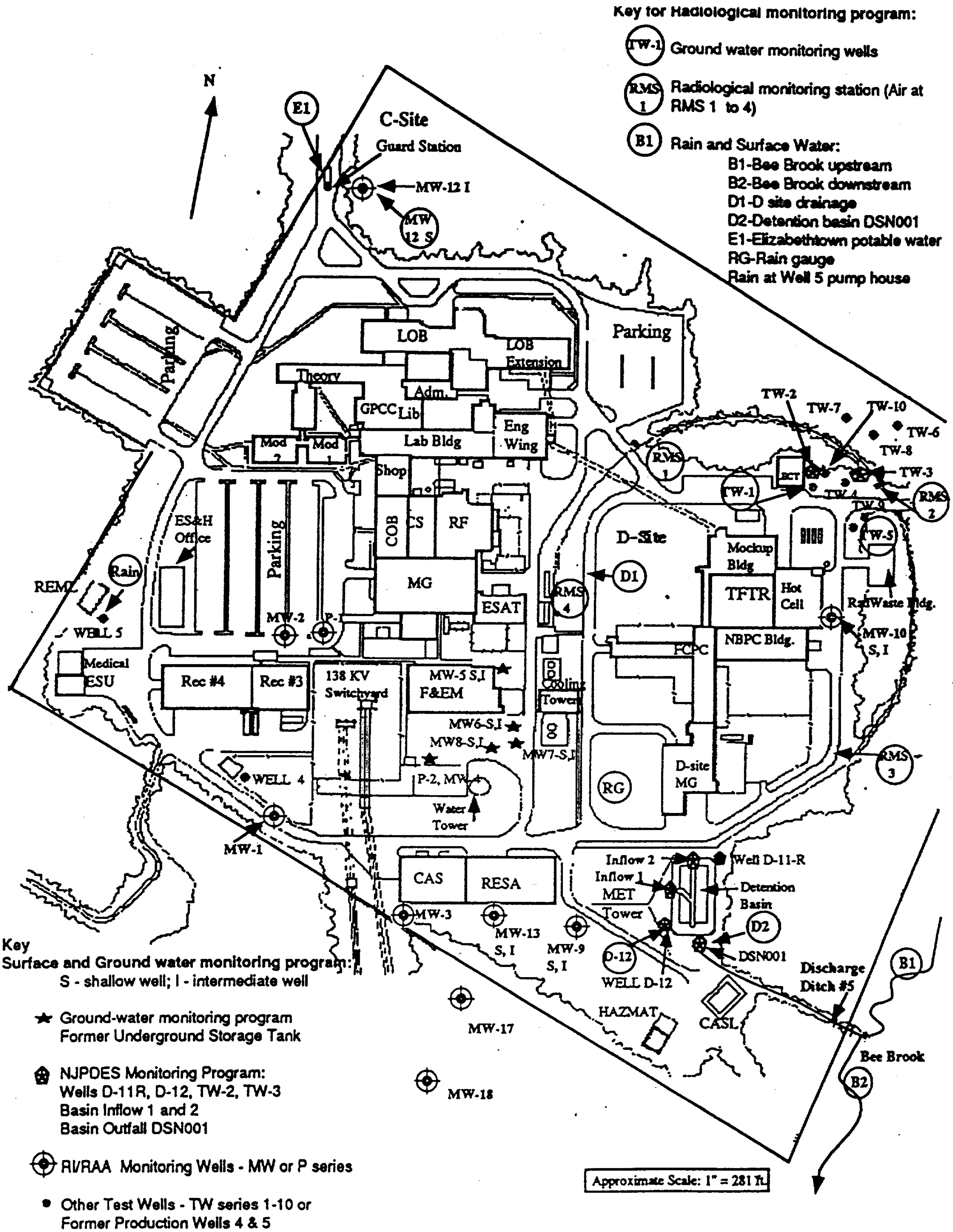


FIGURE 6. C & D SITE ENVIRONMENTAL MONITORING LOCATIONS

KEY: OFF-SITE MONITORIN

+ D&R CANAL PUMP HOUS

* WELLS

° REAM TRITIUM

AIR,SOIL,RAIN STATIONS

FIGURE 7. OFF-SITE MONITORING LOCATIONS

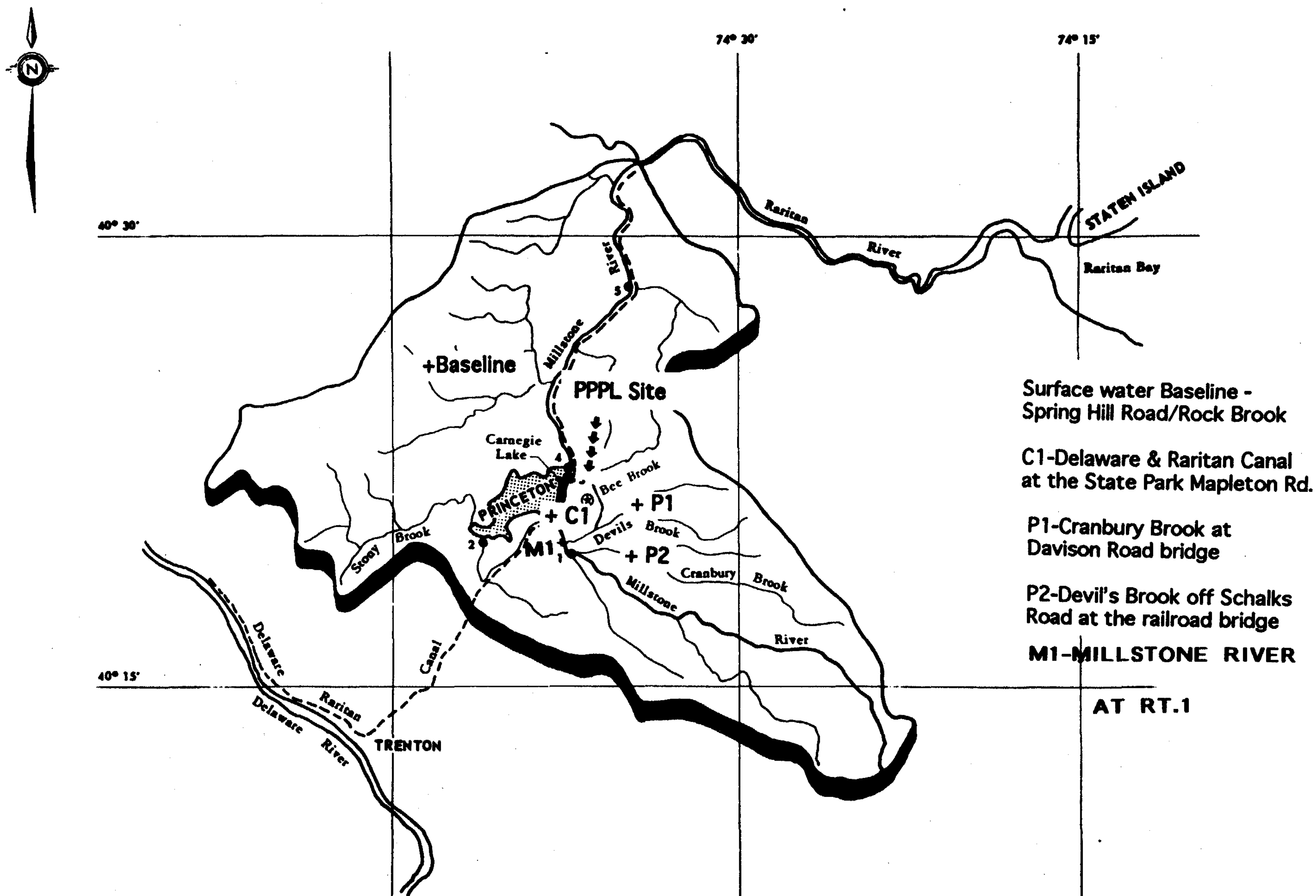


FIGURE 8. MILLSTONE RIVER BASIN MONITORING LOCATIONS

Figure 9. Tritium in Air (TR 1-4 And Baseline) For 1996 (HT)

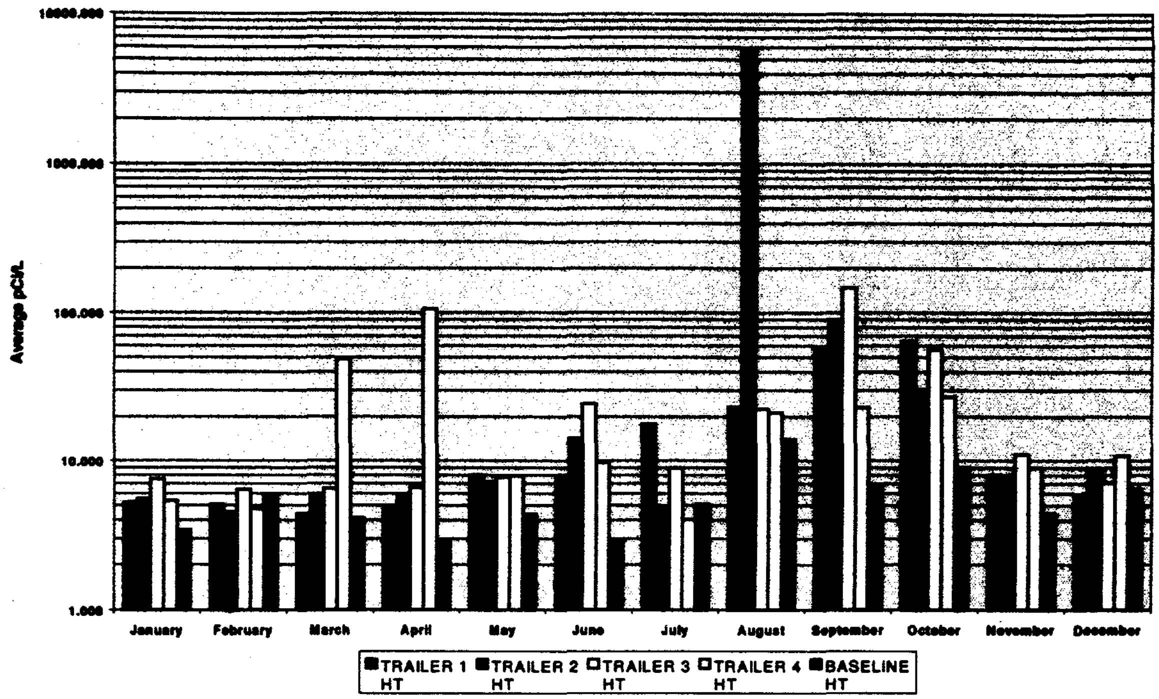


Figure 10. Tritium in Air (REAM 1-6 And Baseline) For 1996 (HT)

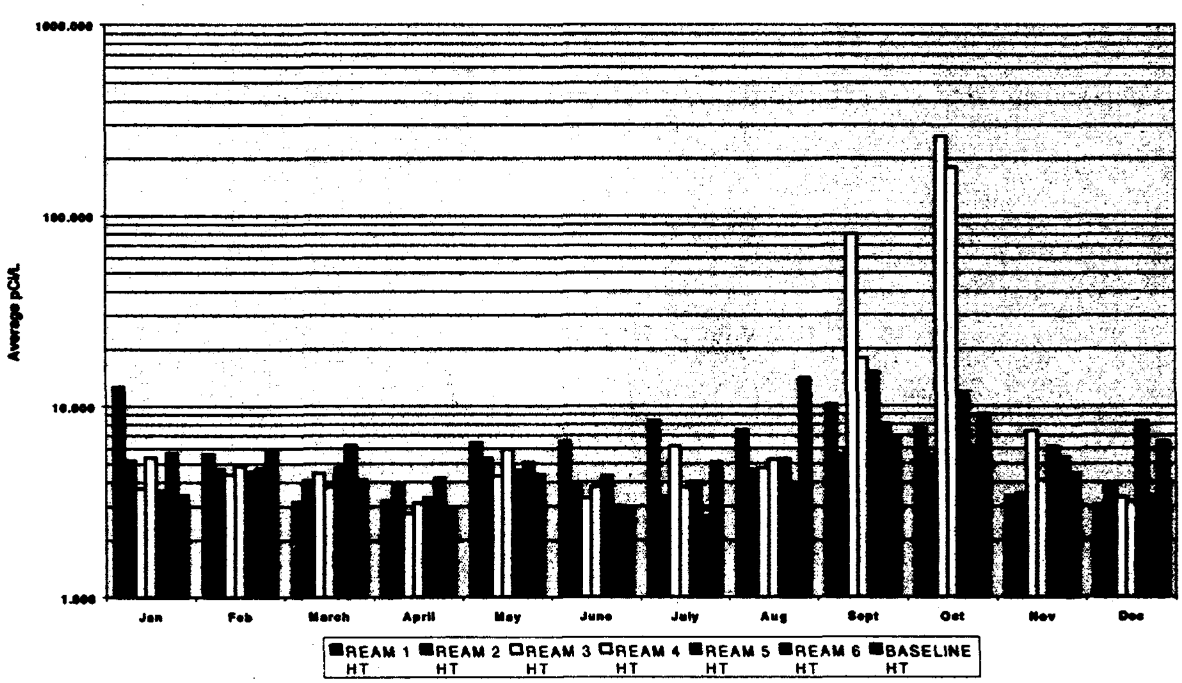


Figure 11. Tritium In Air (TR 1-4 And Baseline) For 1996 (HTO)

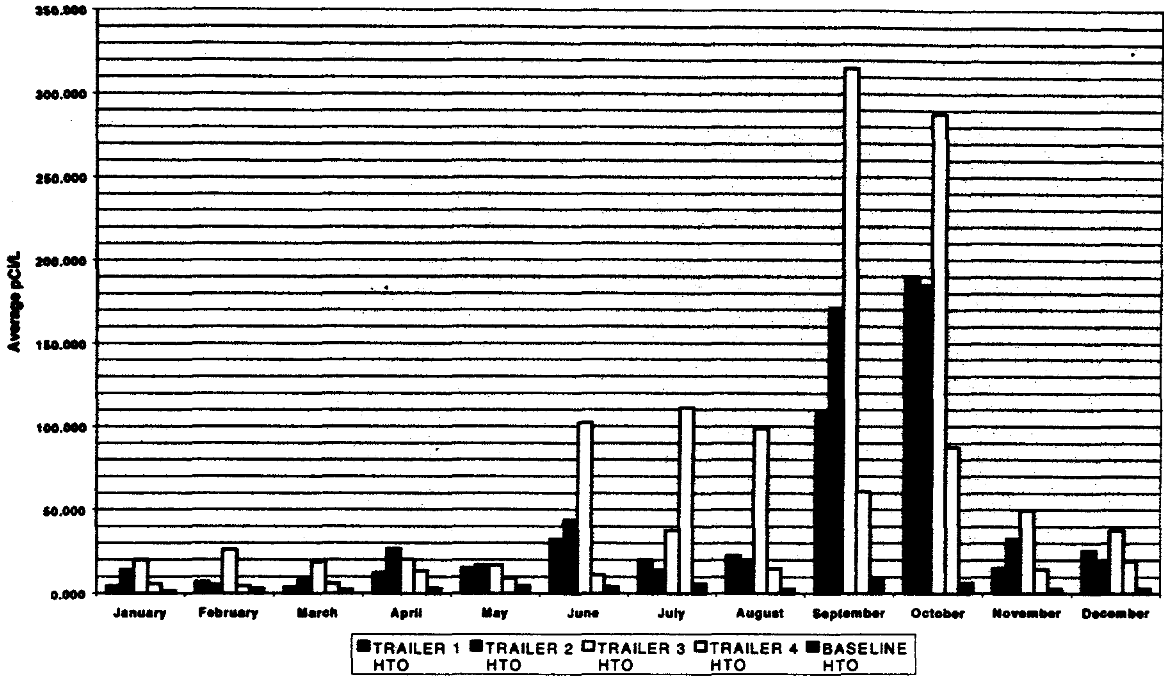
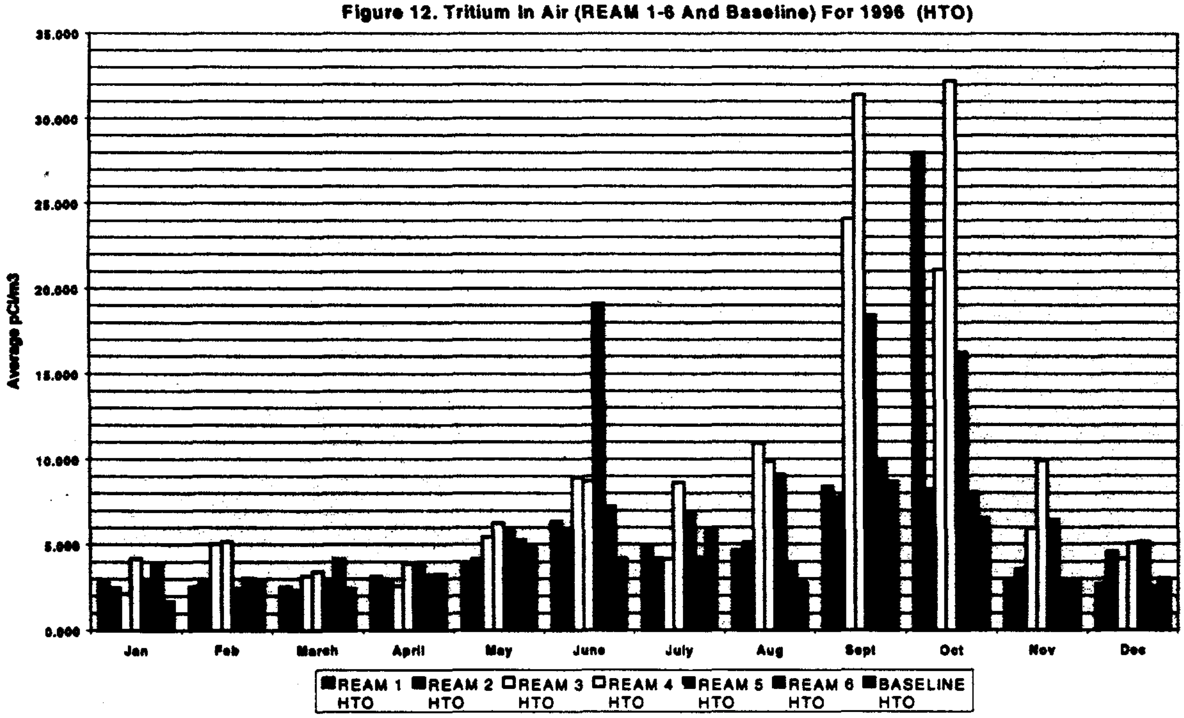


Figure 12. Tritium In Air (REAM 1-6 And Baseline) For 1996 (HTO)



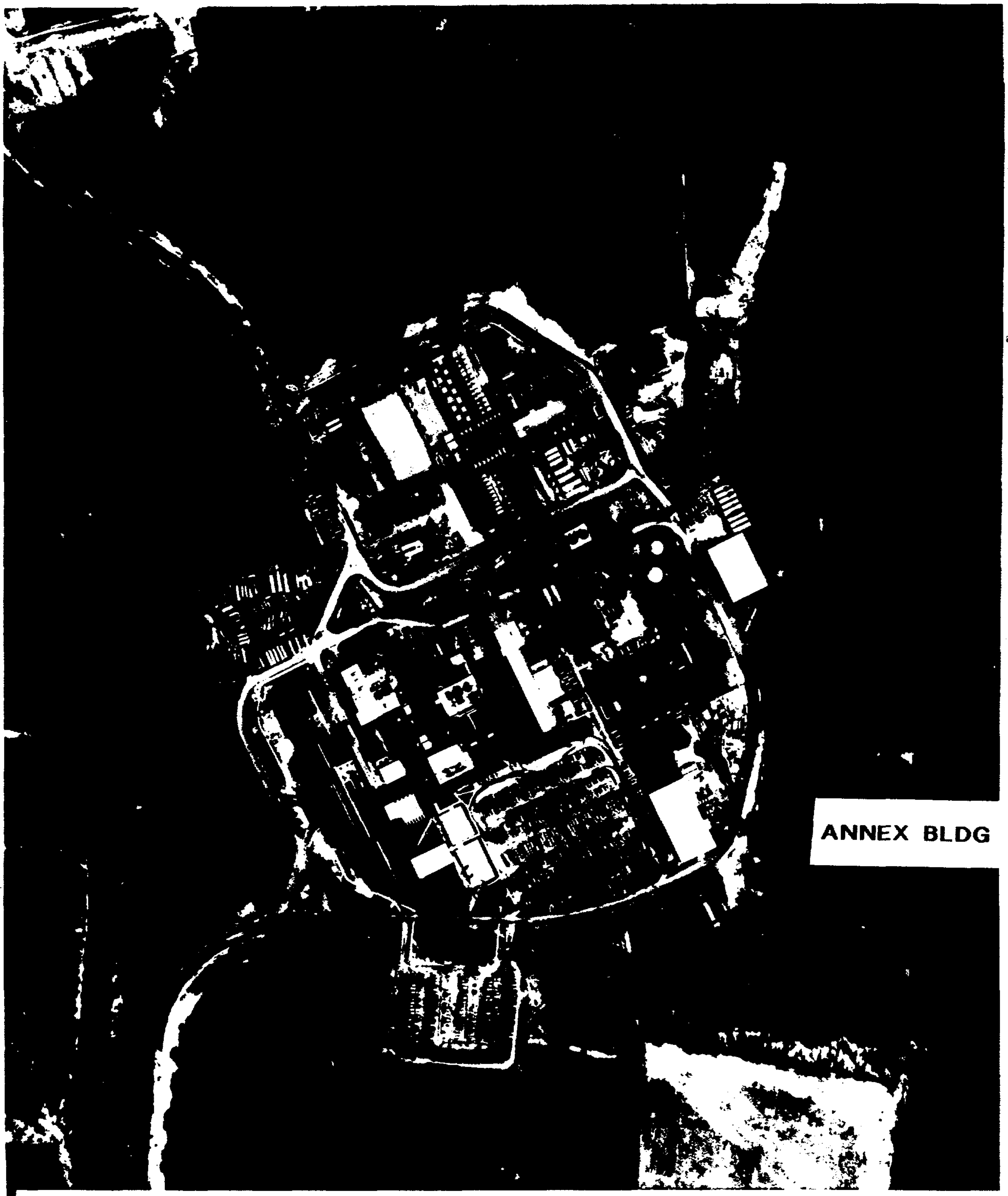


FIGURE 13. 1975 AERIAL OF PPPL INCLUDING ANNEX BUILDING

Figure 14. 1996 Monthly Stack Releases Summary

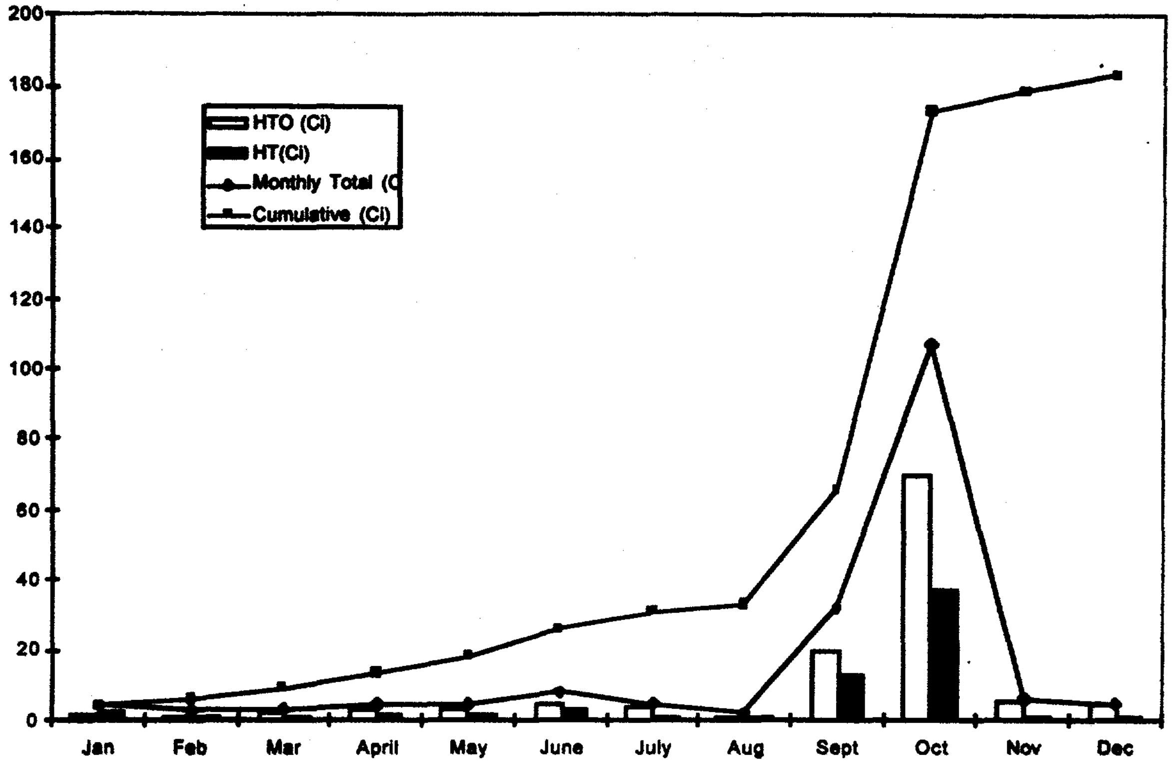


Figure 15. 1996 Tritium Results in Rain Water (R1 stations) (picoCuries/Liter)

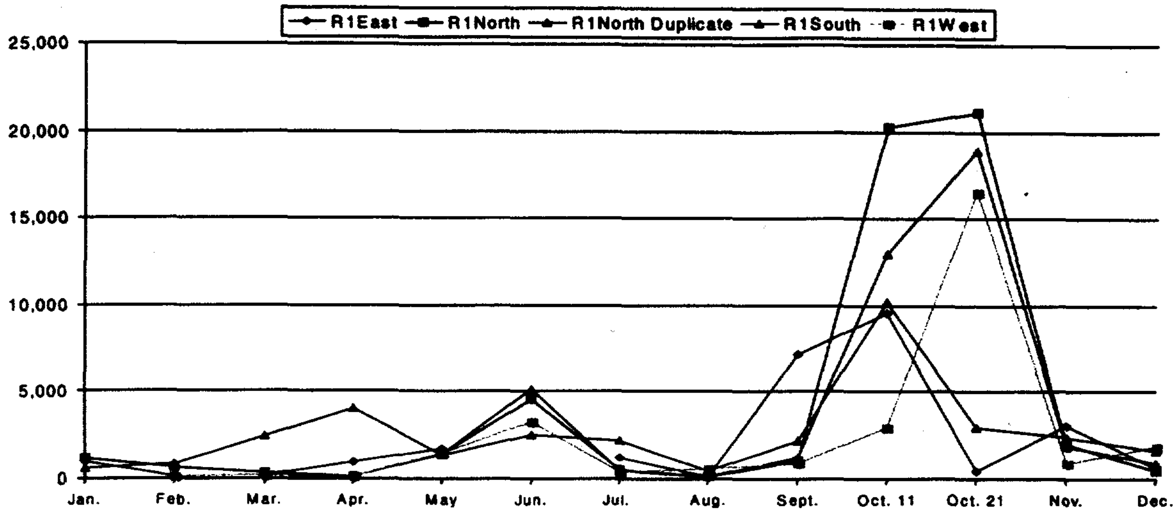


Figure 16. 1996 Tritium Results in Rain Water (R2 stations) (in picoCuries/Liter)

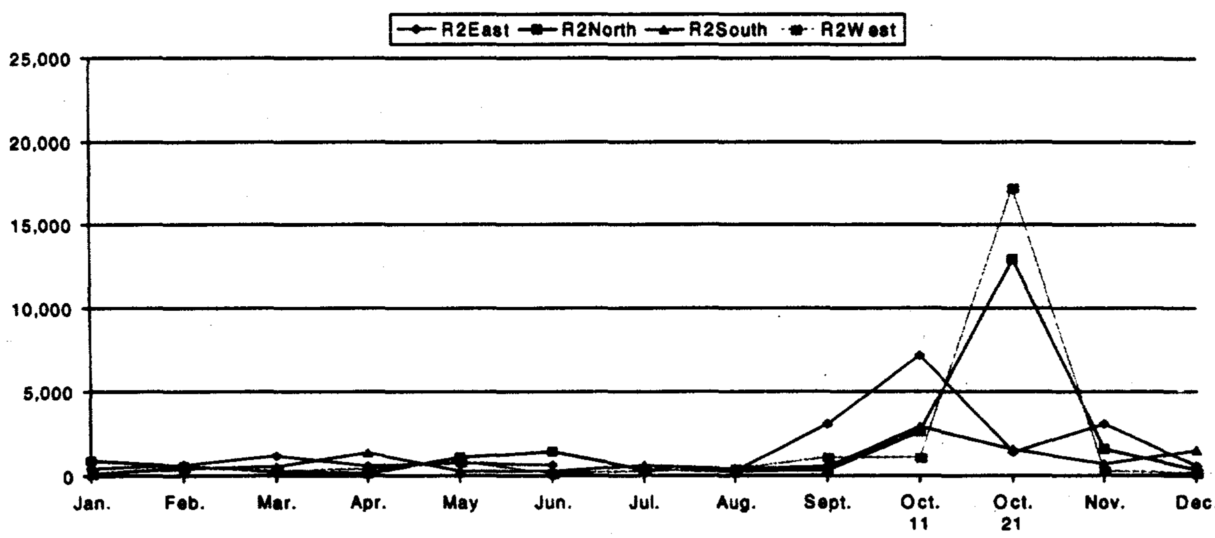


Figure 17. 1996 Tritium (HTO) Concentrations in Ground Water (picoCuries/Liter)

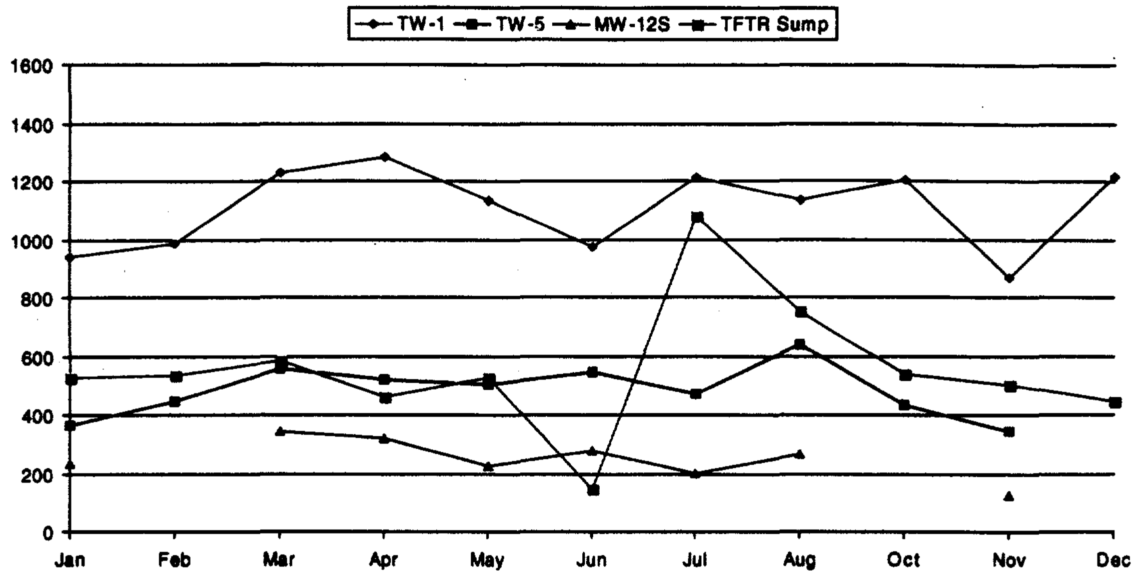


Figure 18. 1996 Tritium (HTO) Concentration in PPPL Discharge and Bee Brook (picoCuries/Liter)

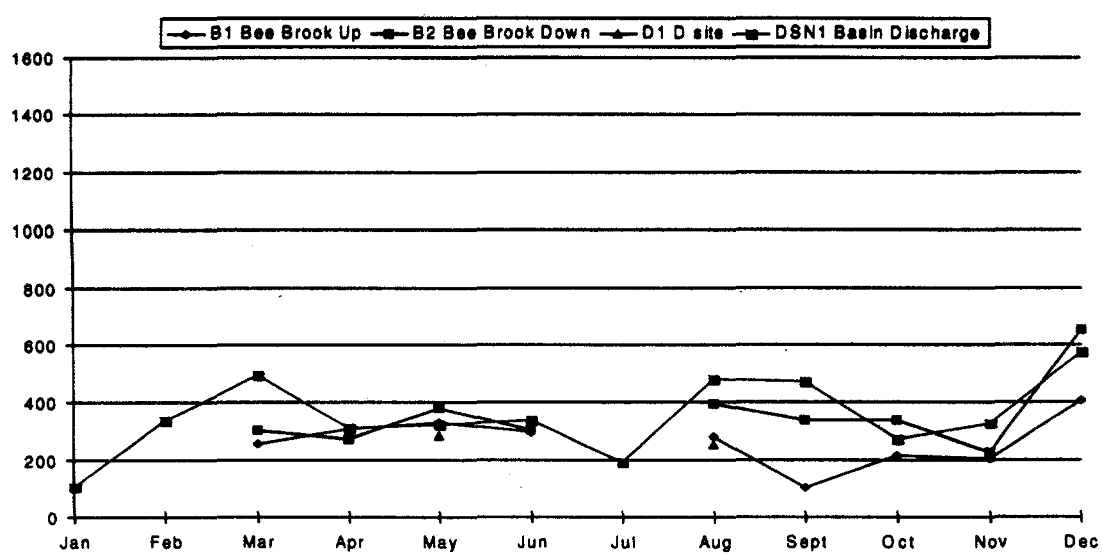


Figure 19. 1996 Tritium (HTO) Concentrations in Millstone River and Tributaries (picoCuries/Liter)

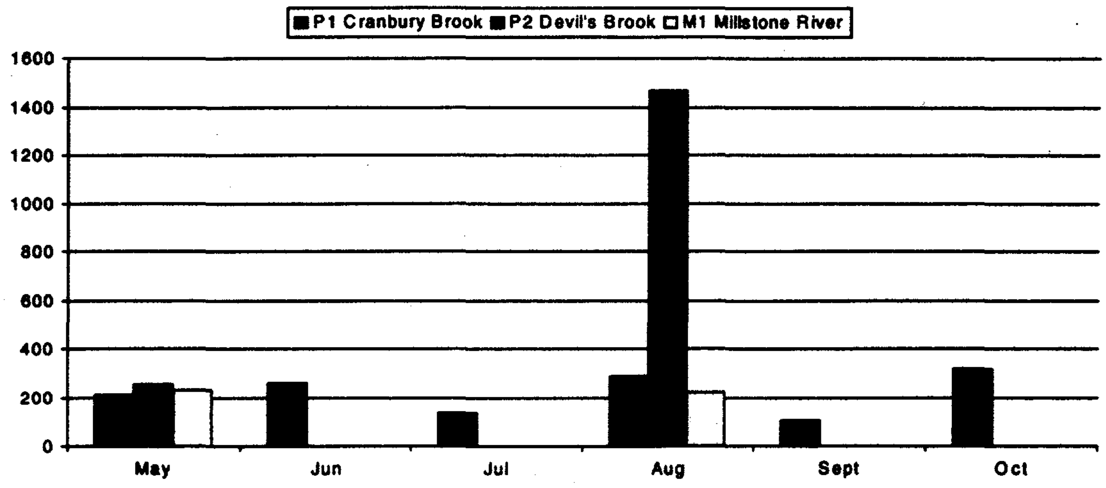
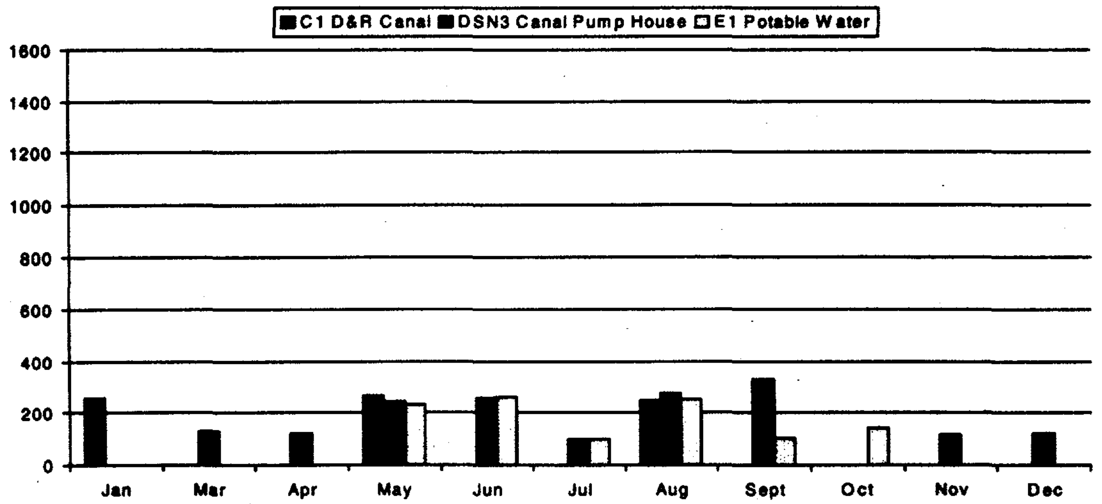
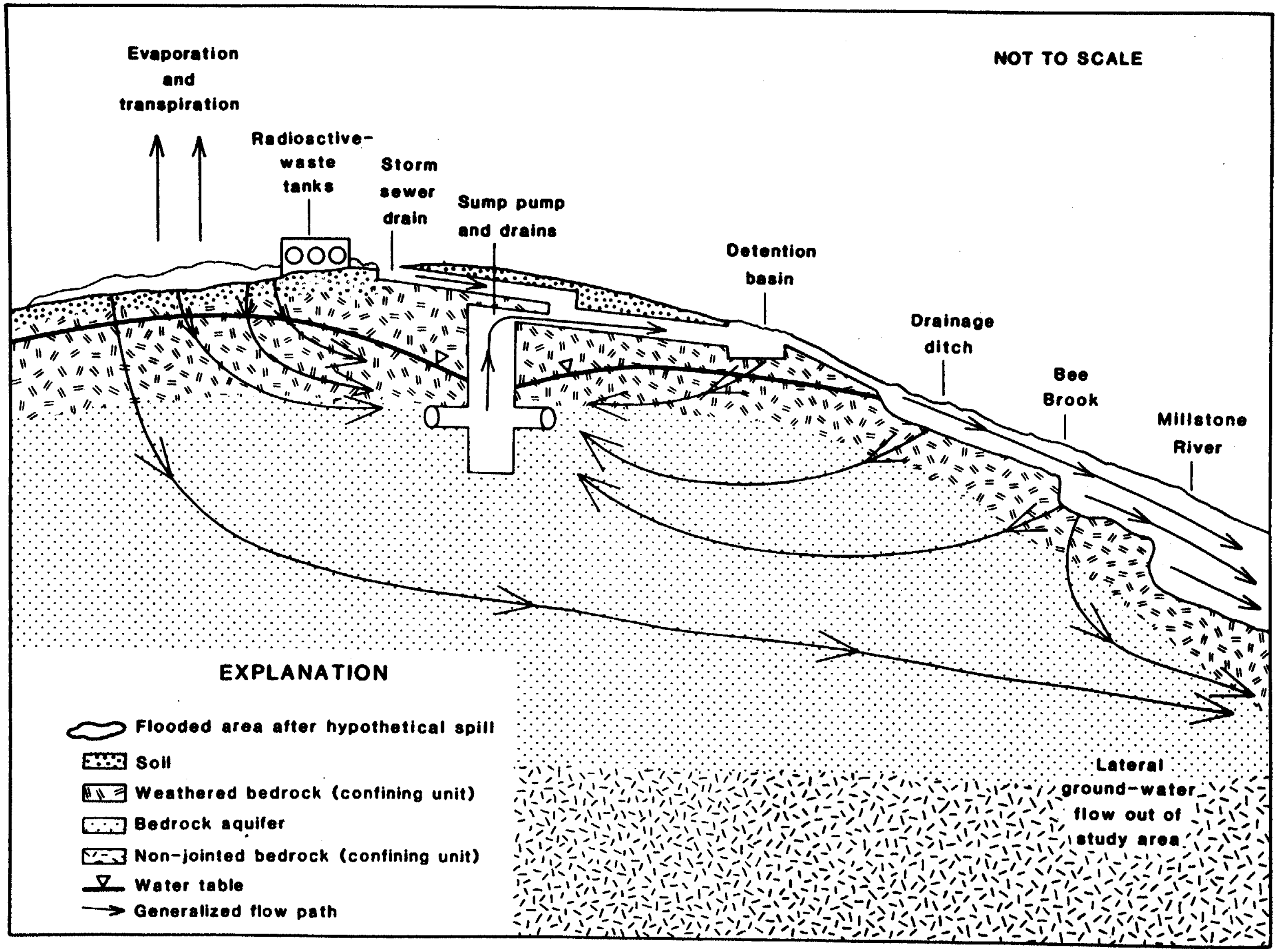


Figure 20. 1996 Tritium (HTO) Concentrations in Surface Water Baseline Locations (picoCuries/Liter)

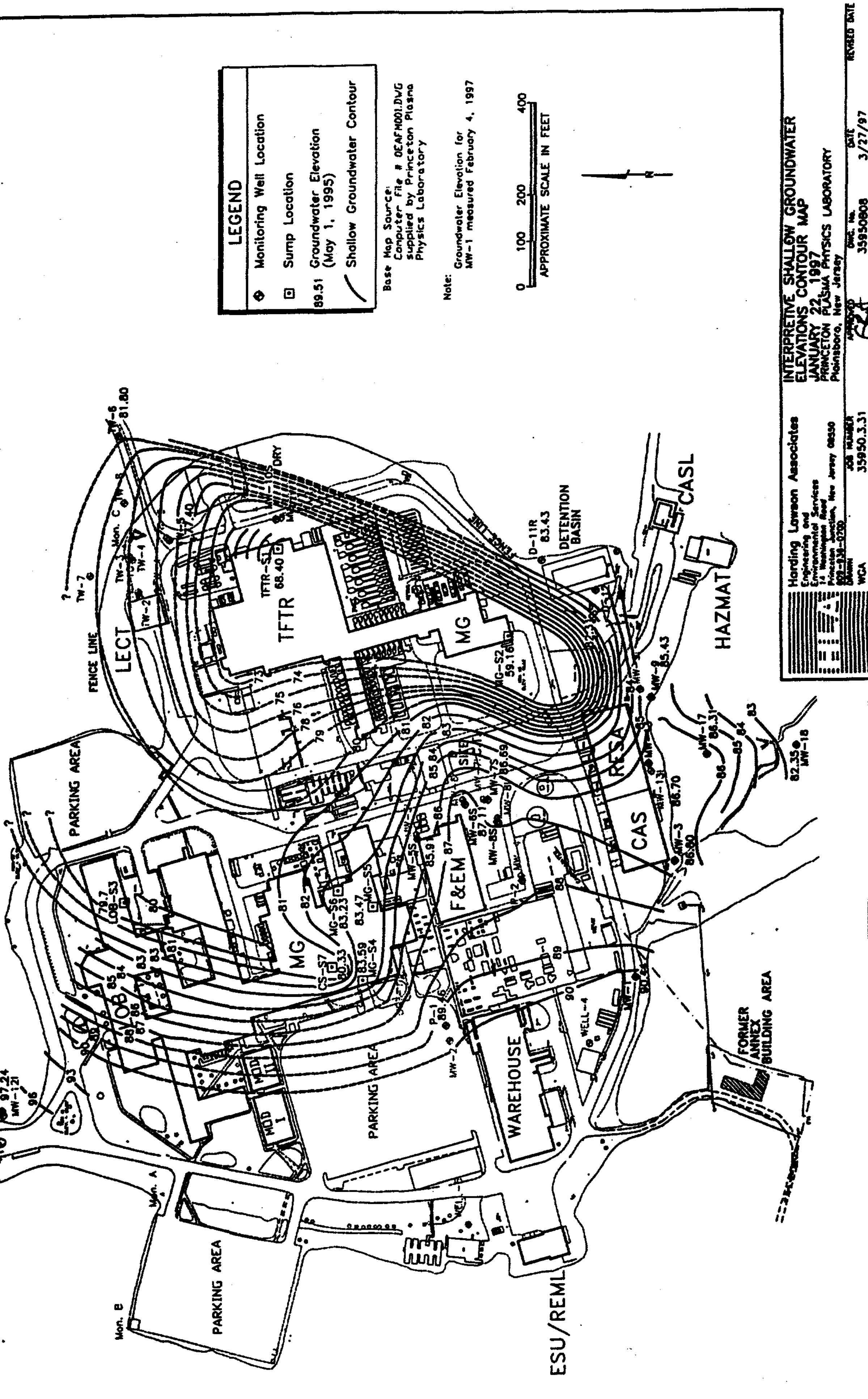


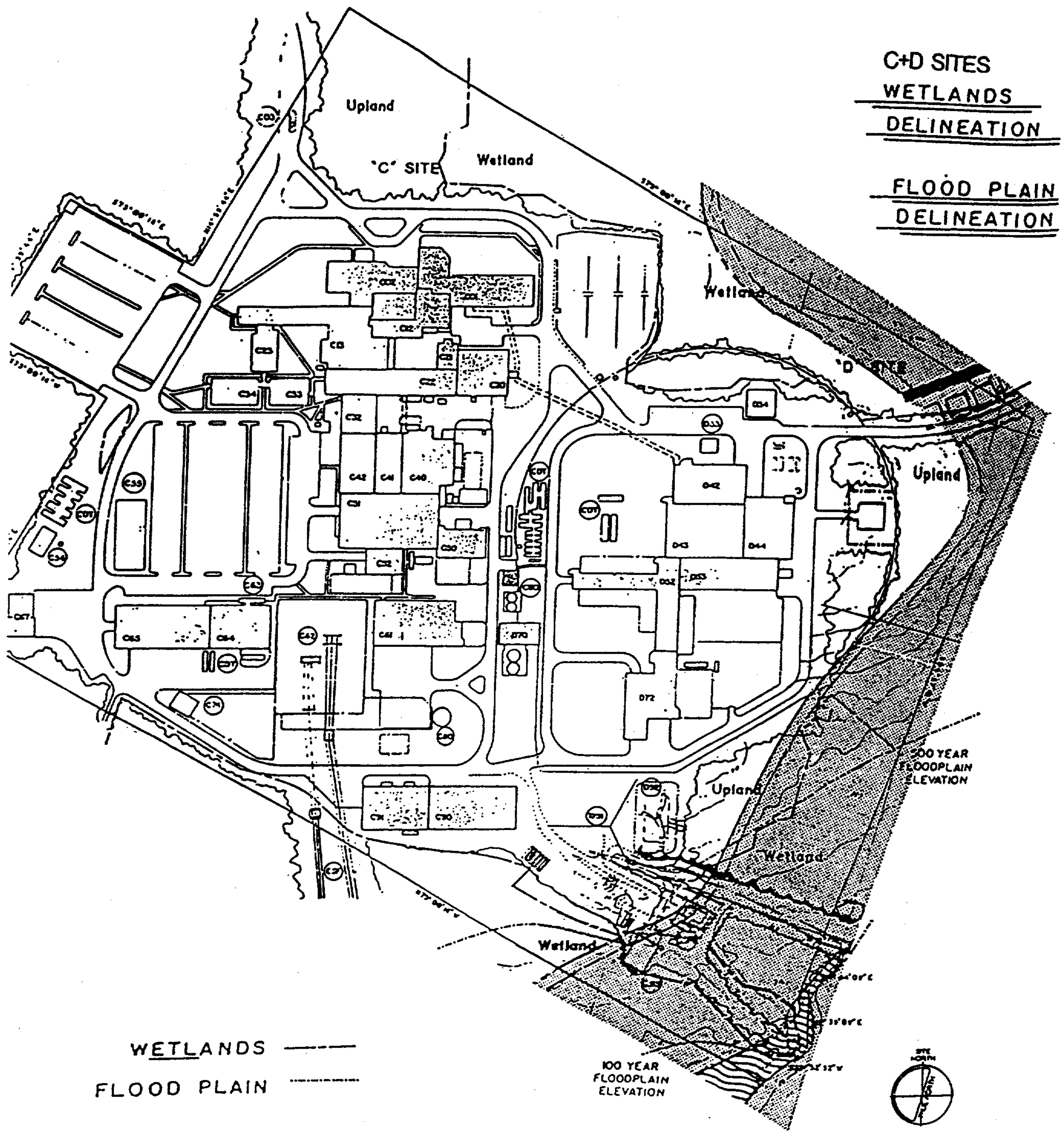


-Schematic representation of hydrogeologic framework and potential flow paths of spilled water.

FIGURE 21. POTENTIOMETRIC SURFACE OF BEDROCK AQUIFER AT PPPL

FIGURE 22. SHALLOW GROUND WATER ELEVATIONS CONTOUR MAP





SHADE INDICATES STREAM PROTECTION CORRIDOR PER PRINCETON FORRESTAL CENTER STORMWATER MANAGEMENT PLAN, 1980

0 100 300 600 FT

SITE PLAN
PRINCETON UNIVERSITY
PLASMA PHYSICS LABORATORY

FIGURE 23. PPPL FLOOD PLAIN & WETLANDS BOUNDARY

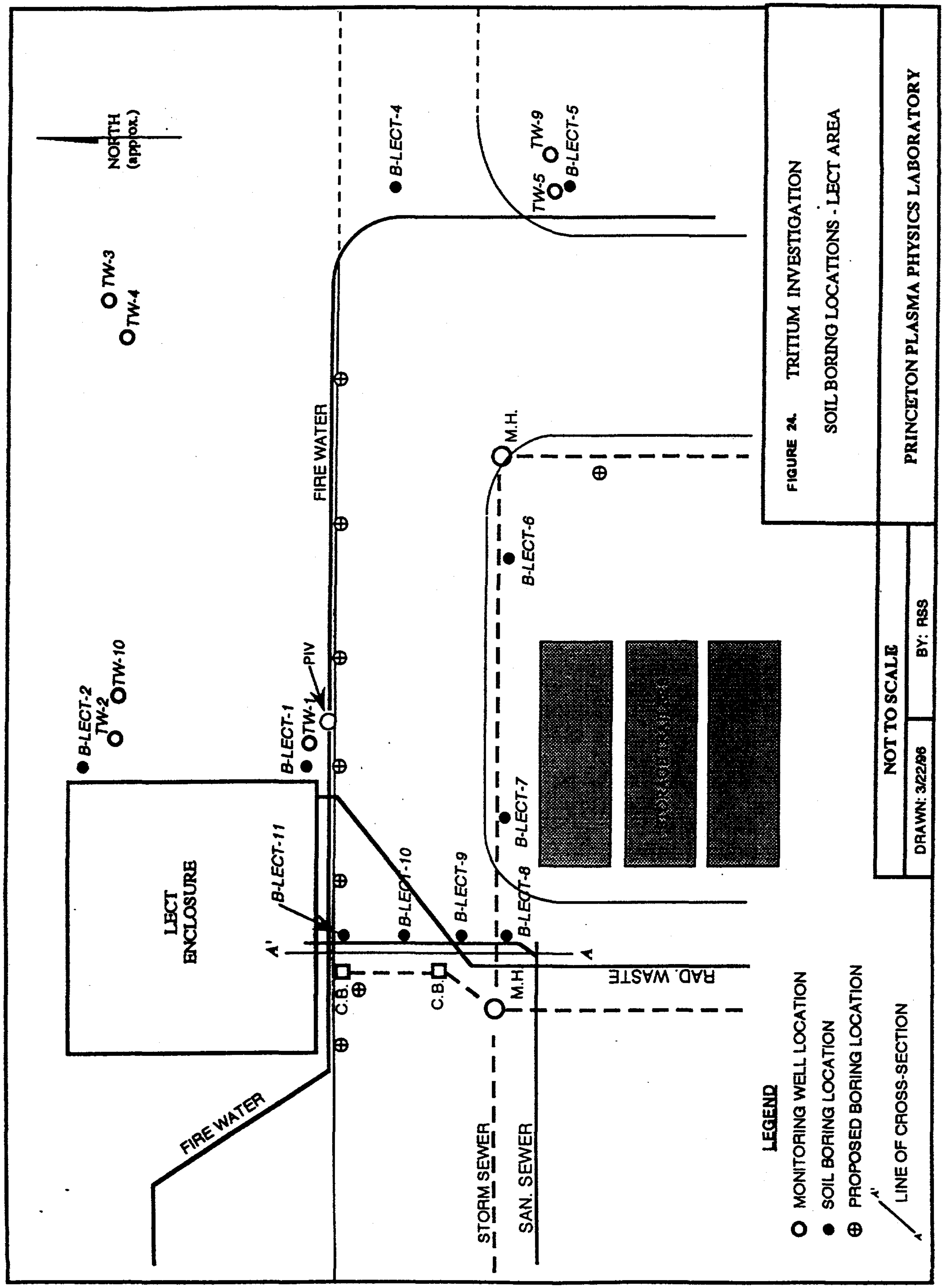


FIGURE 24. TRITIUM INVESTIGATION
SOIL BORING LOCATIONS - LECT AREA

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