Fermi National Accelerator Laboratory
P. O. Box 500, Batavia, Illinois 60510

Fermilab 91/57
1104.100
UC-41

FERMILAB

SITE ENVIRONMENTAL REPORT

FOR CALENDAR YEAR 1990

by

J. Donald Cossairt, Editor

D. W. Grobe

May 1, 1991

Contributors:

**V. R. Cupps, A. J. Elwyn, P. J. Hojsak,
K. Isakson, P. Kesich, E. Mieland, T. M. Miller**

**Operated by Universities Research Association, Inc.
Under Contract with the United States Department of Energy,
Chicago Operations Office, Batavia Area Office**

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

1.0 EXECUTIVE SUMMARY FOR CY-1990

This report summarizes the environmental status of Fermi National Accelerator Laboratory (Fermilab) for Calendar Year 1990 (CY-1990). It includes descriptions of the Fermilab mission, the status of compliance with applicable environmental regulations, planning and activities to accomplish compliance, and a comprehensive review of environmental surveillance, monitoring, and protection programs.

1.1 Compliance

Throughout its development, the Fermilab facility has exhibited a concern for protection of the environment. This has led to a philosophy of respecting environmental protection concerns at all stages of design and operation. Fermilab continues to be operated in compliance with DOE orders and other Federal, State, and local environmental laws and regulations. These include the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA), the Safe Drinking Water Act (SDWA), the Toxic Substances Control Act (TSCA), and the National Environmental Policy Act (NEPA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Endangered Species Act (ESA), the National Historic Preservation Act (NHPA), Executive Order 11988 "Flood Plain Management" and Executive Order 11990 "Protection of Wetlands." Accelerator operations have traditionally caused relatively little impact on the environment. Fermilab's radiological and nonradiological effluents and emissions are well within applicable standards. Specifically with respect to the CAA, the offsite dose equivalent due to airborne radionuclide emissions and the monitoring thereof are in compliance with 40 CFR 61, Subpart H. Fermilab continues to be operated in compliance with these laws and regulations. There were no abnormal occurrences which had an impact on the facility and its operations in CY-1990.

1.2 Environmental Program Information Summary

Monitoring and surveillance are critical elements of an effective environmental protection program. Fermilab has established and implemented comprehensive environmental monitoring and surveillance programs that ensure compliance with legal and regulatory requirements imposed by Federal, State, and local agencies and that provide for the measurement and interpretation of the impact of Fermilab operations on the public and the environment. The surveillance and monitoring activities are selected to be responsive to both routine and potential releases of penetrating radiation and liquid or airborne effluents.

1.3 Environmental Radiological Program Information

1.3.1 Airborne Emissions

As a result of operation of the accelerator, some airborne radionuclides are released from the target stations in the experimental areas and at the Antiproton Source used to produce the antiprotons. During CY-1990 a total of 78 Curies (2.9×10^{12} Bq) were released from the vent stacks in these areas. ^{11}C, ^{13}N, ^{38}Cl, ^{39}Cl and ^{41}Ar have been identified in these airborne emissions (Bu89) resulting in a maximum dose equivalent at the site boundary due to airborne radioactivity of 0.031 mrem (3.1×10^{-4} mSv) on the east side of the site.

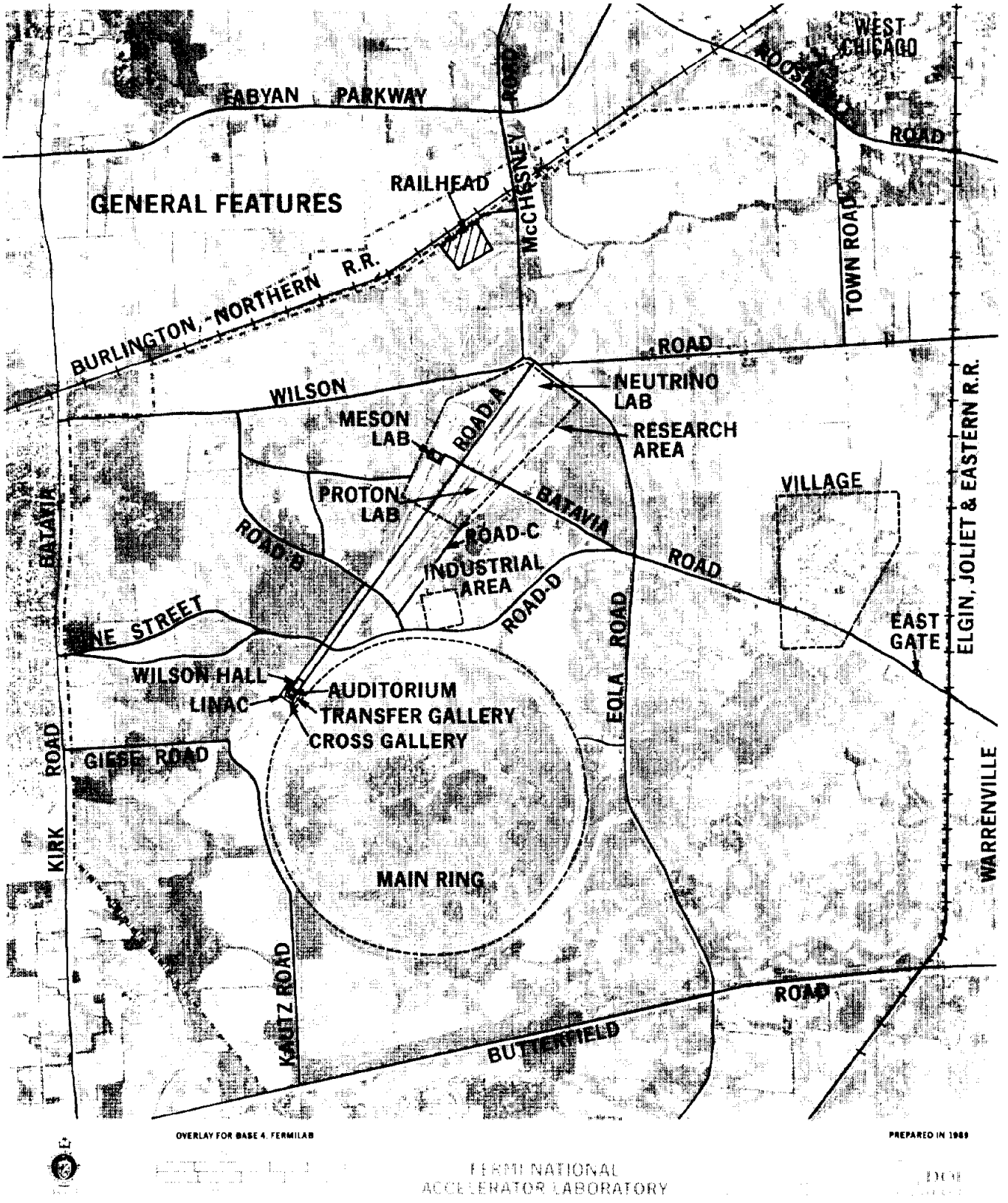
1.3.2 Penetrating Radiation

Other sources of ionizing radiation due to accelerator operations are due to operation of the fixed target experimental areas. These operations produce ionizing radiation in the form of muons. The maximum effective dose equivalent at the Fermilab site boundary for CY-1990 was determined to be 16 mrem (0.16 mSv) near the northeast corner of the site due to the operations of the MW beamline in the Meson Area. At this point the site boundary is a significant distance away from the nearest residence. At the location of the nearest residence exposed to muons from this beamline, the maximum effective dose equivalent is 8.2 mrem (8.2×10^{-2} mSv). The NM beam in the Neutrino Area delivered 2.8 mrem at the site boundary to a different location also near the northeast corner of the site. All other beamlines delivered less than 2 mrem to various locations. (See Section 5.2 for more details.) The measurements which form the basis of this assessment of effective dose equivalent also include the use of detectors sensitive to neutrons. No neutron fields of environmental significance were identified during CY-1990 operations.

The maximum site boundary dose rate (fence line assuming 24 hr/day exposure) from the radioactive material stored at the Railhead (Fig. 1) was 1.1 mrem (1.1×10^{-2} mSv) for CY-1990. The Railhead is closer to the site boundary than is the nearest house, making the actual maximum radiation exposure to an individual offsite much lower. The maximum individual potential radiation exposure due to radiation from the Railhead was 0.2 mrem (2×10^{-3} mSv) during CY-1990.

The total potential radiation exposure to the general offsite population from operations during CY-1990 was 8.0 person-rem (8.0×10^{-2} person-Sv) (Table 10). This is higher than the estimate of 1.9 person-rem (1.9×10^{-2} person-Sv) for CY-1989 due to the operations of the accelerator in the fixed target mode with the accompanying production of muons. Since the exposure to the offsite population is only from penetrating radiation and short-lived airborne radionuclides, the 50 year dose commitment from operations in CY-1990 will be the same as the effective dose equivalent received in CY-1990 reported here.

FIGURE 1


GENERAL FEATURES
FABYAN PARKWAY
RAILHEAD
McCHESNEY ROAD
WEST CHICAGO
ROOSEVELT ROAD
TOWN ROAD
BURLINGTON, NORTHERN R.R.
WILSON ROAD
NEUTRINO LAB
MESON LAB
ROAD-A
RESEARCH AREA
VILLAGE
PROTON LAB
BATAVIA ROAD
ROAD-B
ROAD-C
INDUSTRIAL AREA
ROAD-D
EOLA ROAD
EAST GATE
ELGIN, JOLIET & EASTERN R.R.
PINE STREET
WILSON HALL
LINAC
AUDITORIUM
TRANSFER GALLERY
CROSS GALLERY
KIRK ROAD
GIESE ROAD
MAIN RING
KAUTZ ROAD
BUTTERFIELD ROAD
WARRENVILLE
OVERLAY FOR BASE 4, FERMILAB
PREPARED IN 1969
FERMI NATIONAL ACCELERATOR LABORATORY
DOE

1.3.3 Surface Water Discharges

The offsite release of tritium (^{3}H) in surface water totaled approximately 2024 mCi (7.5 X 10^{10} Bq), compared with 908 mCi (3.4 X 10^{10} Bq) in CY-1989 (Co90). (See a more detailed explanation in Section 5.4.3.) The increase was the result of more water from reportable discharges leaving the site during CY-1990. Water left the site via the Kress Creek spillway for 74% of the year in CY-1990 compared with 61% the year before. The primary source of tritium in water reaching Casey's Pond from drainage ditches in the Research Area was tritiated water discharging from an underdrain system beneath a target and beam dump system. The target was the primary target in the Neutrino Area. The target received most of the protons accelerated by Fermilab. After the CY-1982 operating period ended, the target was moved to a new location with a different underdrain system. Thus, the tritium released in CY-1990 was essentially from operations before CY-1983.

A summary of offsite releases of radioactive effluents in CY-1990 is given in Table 1.

Table 1

Summary of Radioactivity Released to the Offsite Environment in CY-1990

Release Point	Radionuclide	Pathway	Release in (Ci)	Release in (Bq)
Target Stations	^{11}C, ^{13}N, ^{41}Ar	Air	78	2.9 X 10^{12}
Debonding Oven	^{3}H	Air	0.0018	6.7 X 10^{7}
Kress Creek Spillway	^{3}H	Water	2.024	7.5 X 10^{10}

1.3.4 Groundwater

Radioactivation of soil can occur in some areas of beam targets and dumps. Samples of groundwater are taken routinely from wells onsite. There has been no measurable accelerator-produced radioactivity in these wells. Monitoring wells installed to allow sampling of the vadose zone in localized areas of soil activation have shown small but measurable tritium levels.

1.4 Environmental Non-Radiological Program Information

1.4.1 Airborne Emissions

Operating permits have been obtained for all applicable sources of airborne emissions. Operations are reviewed at least annually to ensure that permitted equipment continues to operate and be maintained in accordance with permit conditions. Fermilab is not a large source of air pollutants. Air pollution permits at Fermilab set conditions for open burning and limits on amounts of nitrogen oxides that can be emitted from boilers and on total organic emissions from a freon degreaser. There have been no known instances of non-compliance emissions.

1990

1.4.2 Surface Water Discharges

Current Fermilab operations result in a discharge of cooling, storm, and certain treated waters to the surface waters on site. Fermilab does not currently have a NPDES permit but is in the process of investigating these onsite discharges so that a permit application can be completed. Samples of water are taken annually from selected surface waters onsite and analyzed for trace metals, various organics, and pH. These parameters were selected as improbable, yet possible, contaminants originating from various sources onsite. (See Table 2.)

1.4.3 Groundwater

Public water systems supplied by three onsite wells were monitored for bacterial and chemical contaminants as required in the regulations and rules of the Illinois Department of Public Health (IDPH) and Illinois Environmental Protection Agency (IEPA) regarding public water systems. All results showed the drinking water supplies to be in compliance.

Samples from wells used to monitor for chromates in an old perforated pipe field yielded measurable levels of chromium. Concentrations were below the maximum concentration limits set established for drinking water in the Safe Drinking Water Act (SDWA).

2.0 INTRODUCTION

2.1 Site Mission

The Fermilab facility consists of a series of proton accelerators which became operational in 1972, producing higher energy protons than any other accelerator in the world. The primary purpose of the installation is fundamental research in high-energy physics.

2.2 Major Activities

As a result of accelerator improvements, the original design energy of 200 GeV (billion electron volts) was gradually raised and operation at 400 GeV was routine between 1976 and 1982 using conventional magnets. In 1982, a ring of superconducting magnets became operational which doubled the particle energy to 800 GeV. Up to 1986 this research was performed by extracting protons from the final accelerator, the Tevatron. These protons were directed onto fixed targets after being extracted from the superconducting synchrotron. Colliding beam studies, collisions of protons and antiprotons each having 900 GeV, were conducted for the first time in 1987. These collisions are detected at four locations inside the Tevatron. Cancer patients are treated using neutrons released by the interactions of 66 MeV protons from the Linac (linear accelerator), the second stage of the series of accelerators.

Table 2

Chemical Analysis of Kress Creek
CY-1990

Parameter	General Use Standards (a) mg/l	Kress Creek on-site 1/90 mg/l	Kress Creek on-site 9/90 mg/l	Kress Creek off-site 1/90 mg/l	Kress Creek off-site 9/90 mg/l	Fox River inflow 9/90 mg/l
Aluminum	NA	0.07	0.47	0.19	0.53	0.51
Cadmium	0.05	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium, total	1.0	0.016	0.011	0.008	0.005	0.007
Chromium, hexavalent	0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide, total	0.025	<0.001	0.009	0.001	<0.002	<0.002
Iron	1.0	0.26	0.72	0.48	0.75	0.92
Lead	0.1	0.05	<0.04	<0.04	<0.04	<0.04
Manganese	1.0	0.14	0.08	0.04	0.05	0.06
Nickel	1.0	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.005	<0.005	0.007	<0.005	<0.005	<0.005
Zinc	1.0	0.014	0.017	0.007	0.016	0.090
FOG	(b)	2	<1	5	<1	2
PCB-1016	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1221	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1232	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1242	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1248	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1254	-	<0.001	<0.001	<0.001	<0.001	<0.001
PCB-1260	-	<0.001	<0.001	<0.001	<0.001	<0.001
pH (Units)	6.5-9.0	7.72	7.59	7.78	7.60	7.70

NA = not available.

(a) Standards are from State of Illinois Rules and Regulations, Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter I: Pollution Control Board, Part 302: Water Quality Standards, Subpart B: General Use Water Quality Standards.

(b) Section 302.203 from (a) above:
"Waters of the State shall be free from unnatural sludge or bottom deposits, floating debris, visible oil..."

1990

When the proton beam is extracted for fixed target physics from the 2 km (1.2 mile) diameter main accelerator, the protons are delivered to three different experimental areas onsite. These are the Meson, Neutrino, and Proton Laboratories located in the Research Area (Fig. 1). These three areas received proton beams for the first time in 1972 when extraction of protons from the accelerator was achieved. For colliding beam studies, antiprotons are produced by extracting 120 GeV protons from the ring of conventional magnets inside the main accelerator tunnel. These protons strike a fixed target at the Antiproton Area (see Fig. 2) and the negatively charged antiprotons are collected. Radioactivity is produced as a result of the interaction of the accelerated protons with matter. Operation of the accelerator produces some airborne radioactivity as well as some radiation which penetrates the shielding material. Also, some radioactivation occurs in the water used to cool beam components and in the soil around the accelerator tunnel and external beamlines. A thorough evaluation has been made of the onsite discharges as well as the potential for offsite releases of radioactive and nonradioactive effluents.

2.3 Operational Highlights

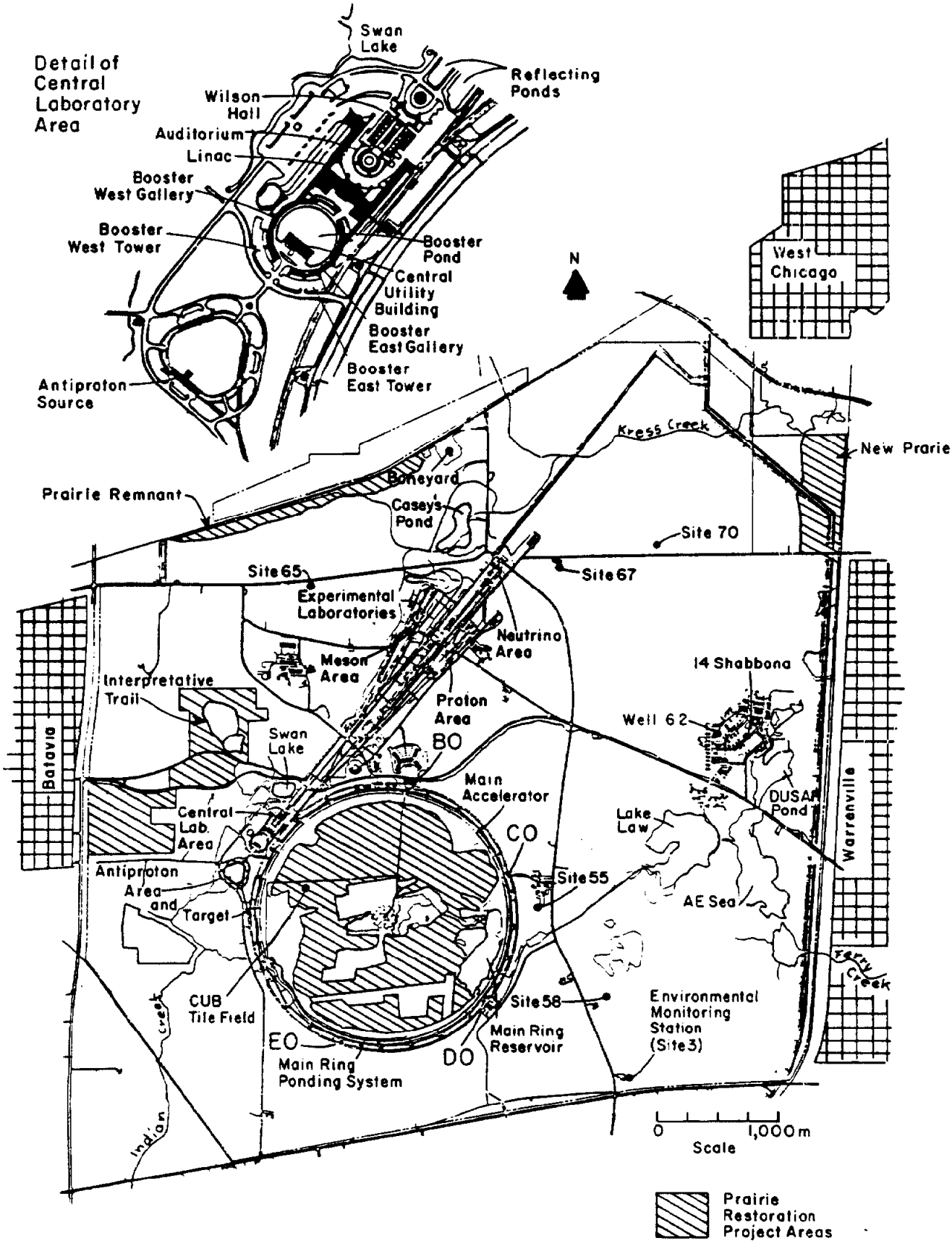
During CY-1990, operation of the high-energy accelerators at Fermilab consisted of a fixed target run using 800 GeV beams of protons and antiprotons. This period of operations began in January with an initial period of accelerator studies. In February, operations delivering 800 GeV protons to the Meson, Neutrino, and Proton Areas began. Simultaneously, 120 GeV protons were delivered to the Antiproton Target to produce antiprotons which are collected in a storage ring and used in a special fixed target experiment there. Operations continued in this manner through most of August. A short period of accelerator operations also occurred in December 1990.

2.4 Site Description

Fermilab is located in Kane and DuPage Counties in the greater Chicago area (Fig. 3) on a 27.5 km^2 (10.6 $mile^2$) tract of land in an area which is rapidly changing from farming to residential use. There are many municipalities in the vicinity, resulting in a distinct pattern of increasing population concentration eastward toward Chicago (Fig. 4).

The land within the site boundary was primarily farmland before the State of Illinois acquired it for the DOE Fermilab site. Much of the land, approximately 6.6 km^2 (1623 acres) in CY-1990, has remained in crop production, primarily corn. A total of 2.7 km^2 (677 acres) has been planted in native prairie vegetation to date. The site also includes areas of upland forest, floodplain woods, oak savanna, prairie remnant, non-native grassland, old fields, pastureland, fence rows, and various types of wetlands. In addition to the research accelerators, man-made structures onsite include various administrative, research, storage, and other support facilities. The small village of Weston, population 380 at the time the land was acquired for Fermilab, was located on the eastern side of the property (Fig. 1). The remaining housing complex now provides residences for visiting scientists.

Figure 2 - Fermilab Site



1990

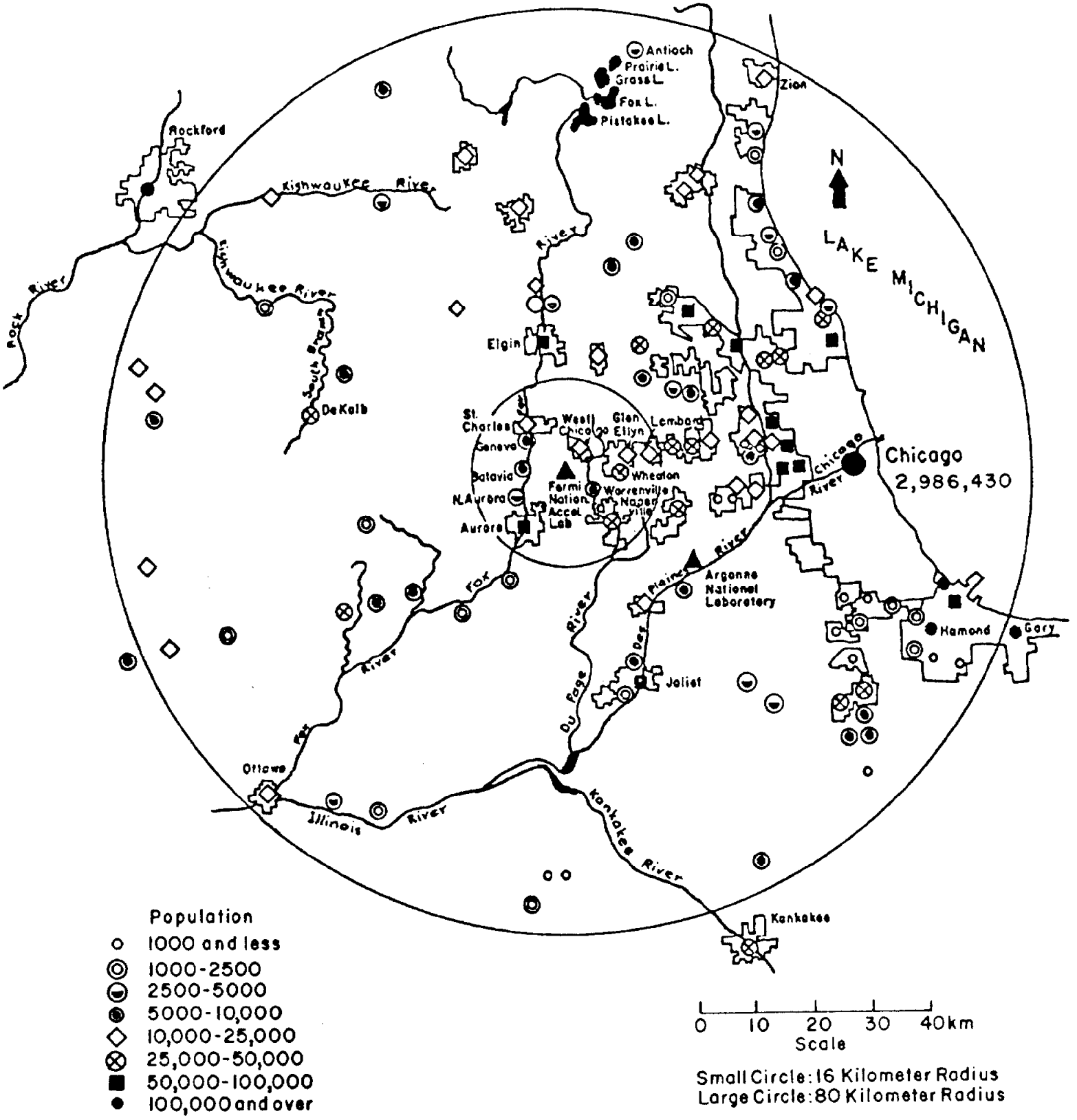
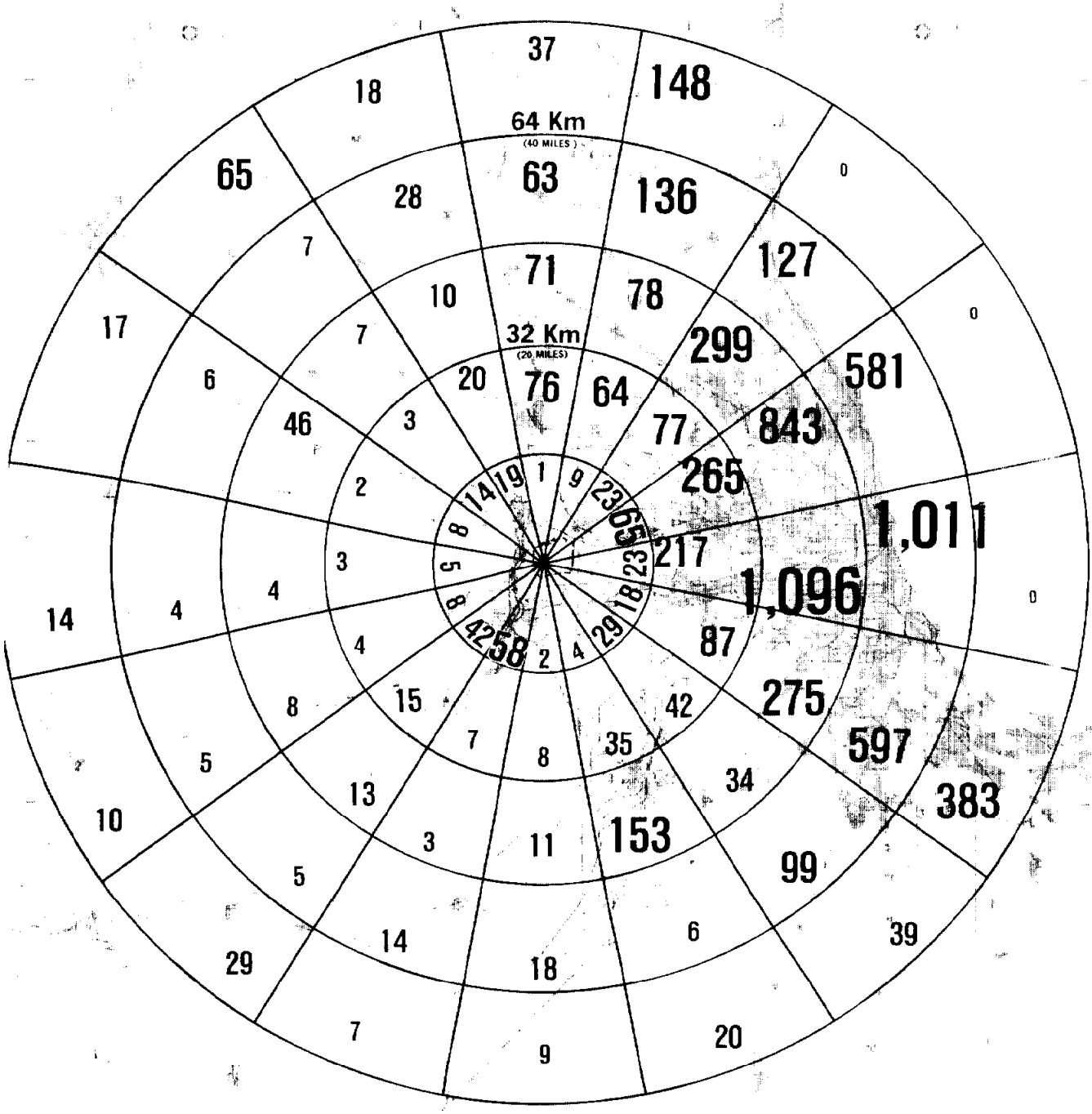


Figure 3- Location of Fermilab and Population Concentrations within 80 km (50 mi.)

1990

FIGURE 4



NOTE: NUMBERS REPRESENT NEAREST 1000.

POPULATION DISTRIBUTION -1980
(1980 CENSUS)

OVERLAY FOR BASE 1, FERMILAB

REGIONAL AREA SURROUNDING FERMI NATIONAL ACCELERATOR LABORATORY

PREPARED IN 1982

DOE

2.5 Surface Characteristics of the Site

The two major environmental features near the Laboratory are the Fox River to the West, and the west branch of the DuPage River which passes east of the site (Fig. 3). The Fox River flowed south with an average of 2450 million liters (647 million gallons) (as measured at Algonquin, IL) per day from October 1, 1989 through September 30, 1990. The west branch of the DuPage River flows south at an average rate (near Warrenville) of 281 million liters (74 million gallons) per day for the same period through Warrenville (Fig. 3) (Du91). The rainfall in the vicinity of Fermilab taken by the Illinois Water Survey during 1990 was 118 cm (46.4 in) (Il91). The land on the site is relatively flat as a result of past glacial action. The highest area, with an elevation of 244 m (800 ft) above mean sea level (MSL) is near the western boundary. The lowest point, with an elevation of 218 m (715 ft) above MSL, is toward the southeast. The drainage of the surface water as shown in Fig. 5 is toward the southeastern corner of the Laboratory, toward the DuPage River. A smaller portion drains toward the southwest to Indian Creek and then toward the Fox River.

2.5.1 Industrial Water Ponding Systems

There are several water systems used for cooling magnets and for fire protection: The Industrial Cooling Water (ICW) System consists of Casey's Pond (Fig. 2) at the end of the Neutrino Beamline and underground mains to fire hydrants and sprinkler systems throughout the Central Laboratory Area and Experimental Areas. Casey's Pond is supplied by surface drainage and can be supplied by pumping from the Fox River. The pond holds 68,000,000 liters (18,000,000 gal.).

The Swan Lake/Booster Pond System (Fig. 2) is used for cooling purposes at the Central Utility Building (CUB). Water is pumped from the Booster Pond into a ditch in which it runs by way of a small West Pond into Swan Lake. The water is then returned to the Booster Pond by a return ditch. Water is also pumped from Swan Lake to NS1 Service Building (near G9 in Fig. 6) for cooling purposes, from which it returns by a surface ditch. This system can be supplied water from the ICW System and it overflows into Indian Creek (Figs. 2 and 5).

The Main Ring Ponding System consists of a series of interconnecting canals completely encircling the interior of the Main Ring with a large reservoir pond inside the Main Ring Ponding System (Fig. 2). This water is used in heat exchangers at the service buildings for cooling the Main Ring magnets. The system is generally supplied by surface drainage, although make-up water can be pumped from Casey's Pond. The system overflows into Lake Law (Figs. 2 and 5).

FIGURE 5

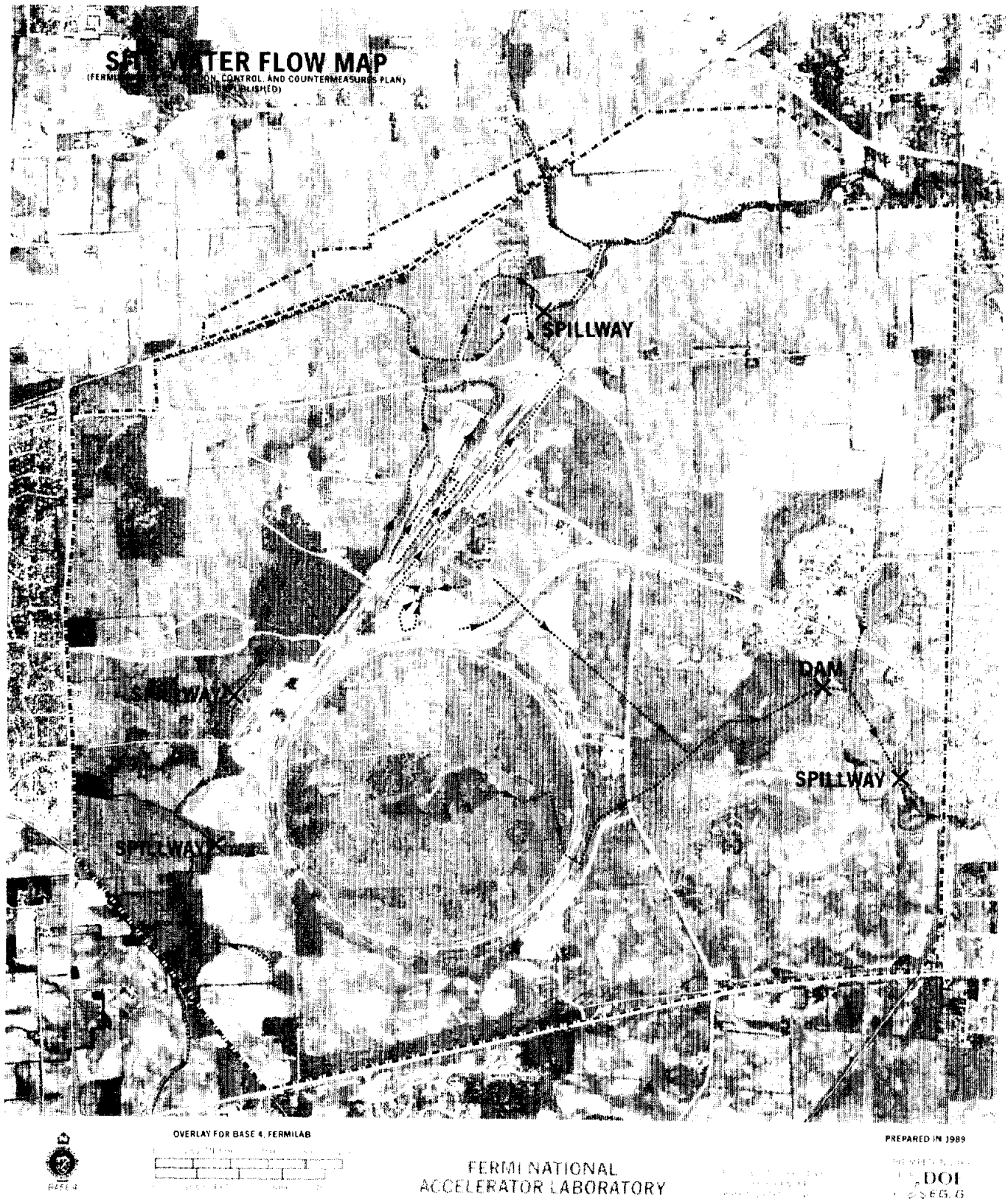
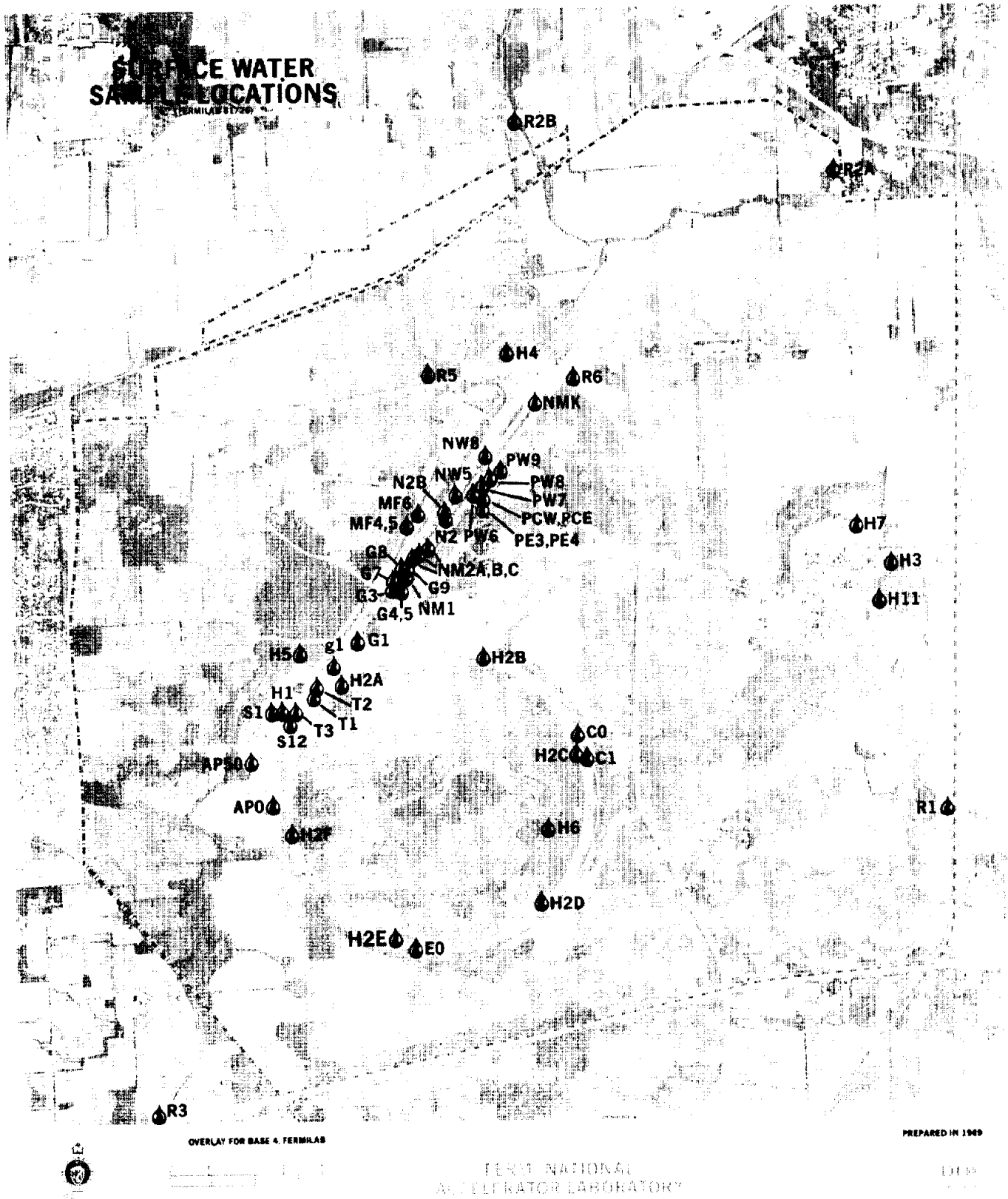

SPILLWAY
DAM
SPILLWAY
SPILLWAY
OVERLAY FOR BASE 4, FERMILAB
PREPARED IN 1989
FERMI NATIONAL
ACCELERATOR LABORATORY
DOE

FIGURE 6


SURFACE WATER
SAMPLE LOCATIONS
R2B
R2A
H4
R5
R6
NMK
NW8
PW9
NW5
PW8
N2B
PW7
MF6
PCW,PCE
MF4,5
N2
PW6
PE3,PE4
G8
G7
NM2A,B,C
G9
G3
G4,5
NM1
G1
g1
H5
H2B
H2A
H1
T2
S1
T1
T3
S12
C0
H2C
C1
APS0
APO
R1
H2F
H6
H2D
H2E
E0
H7
H3
H11
R3
OVERLAY FOR BASE 4, FERMILAB
PREPARED IN 1969
FERMI NATIONAL
ACCELERATOR LABORATORY

2.6 Sewage Treatment

On December 22, 1986, the Village sewage collection system was connected to the City of Warrenville system and has been delivering sewage to the Naperville Springbrook Treatment Plant via that system since then. The Naperville plant is a modern sewage treatment system with ample capacity. The Main Site sewer system was connected to the City of Batavia system June 26, 1979, and has been delivering sewage to the Batavia sewage treatment plant since that time. The IEPA terminated the NPDES permit for the Village Oxidation Pond on May 12, 1987, at the Department of Energy's request.

2.7 Domestic Water Supplies

The primary drinking water supply at Fermilab in CY-1990 was provided by a well pumping from an aquifer approximately 70 m (220 ft) deep. This well (W-1 in Fig. 7) is located in the Central Laboratory Area. A second well (W-3 in Fig. 7) pumps from the same aquifer and supplies water to the Main Site system when demand exceeds the capacity of the Central Laboratory well (W-1 in Fig. 7). Since January 28, 1987, the Village system is supplied from Warrenville, the neighboring community to the East. A new well (W-5 in Fig. 7), became operational in November 1988 to supply water to colliding beams experiment facility at D0.

The Main Site system is chlorinated at the Central Utility Building when Well #1 is providing water. The alternate supply source, Well #3, has its own reservoir and chlorinator. Monthly samples for total coliform per 100 ml were sent to IEPA for analysis for both systems. The new system at D0 is also a chlorinated system but uses sodium hypochlorite rather than chlorine gas. The chlorine level in these chlorinated drinking water supplies is tested each workday. The average use from Well #1 and Well #3 combined was approximately 389,113 liters/day (102,804 gal./day) during CY-1990. Zero violations occurred in CY-1990 for the D0 and Main Site supplies.

2.8 Subsurface Characteristics of the Site

A number of studies have documented the hydrogeologic regime in the vicinity of the Fermilab site (DOE88, Pf74, Sa82, Vi85, Vi88). The geology of the Fermilab area can be generally characterized as about 100 feet (30.5 m) of glacial till composed primarily of low permeability clay that overlies a bedrock of Silurian dolomite (Sa82) and forms a barrier to the downward percolation of water (La71). There is some lack of knowledge about the hydraulic properties and flow characteristics of the glacial deposits that lie above the dolomite at any given location. This is due to the sporadic occurrence of occasional sand and gravel deposits. The glacial deposit regions are most likely recharged by ponds and wetlands. Irregular sand and gravel lenses occur across the region (Ze62).

FIGURE 7

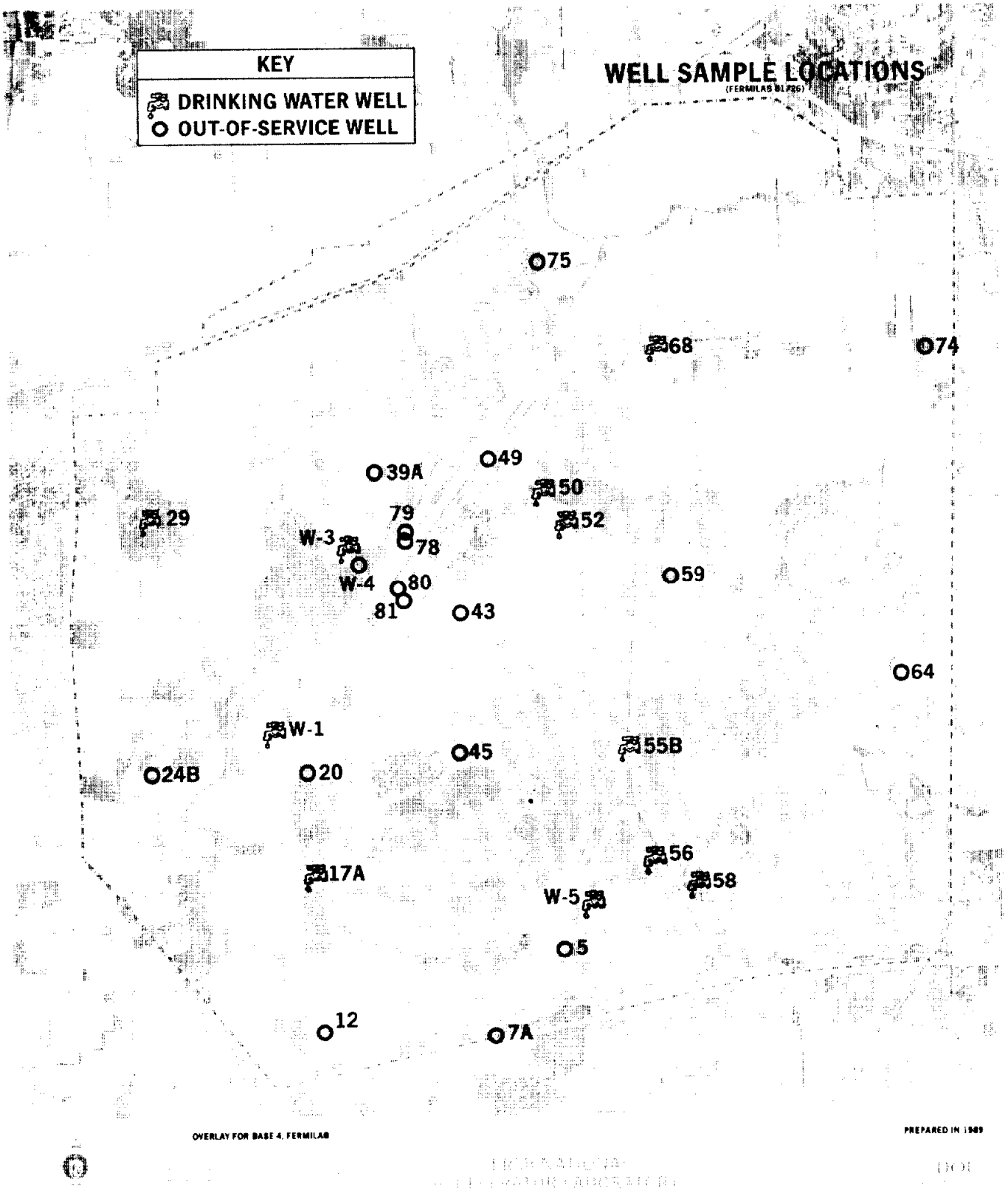

KEY
DRINKING WATER WELL
OUT-OF-SERVICE WELL
WELL SAMPLE LOCATIONS
75
68
74
49
39A
50
29
79
52
W-3
78
W-4
80
59
81
43
64
W-1
45
55B
24B
20
56
17A
58
W-5
5
12
7A
OVERLAY FOR BASE 4, FERMILAB
PREPARED IN 1989

FIGURE 8

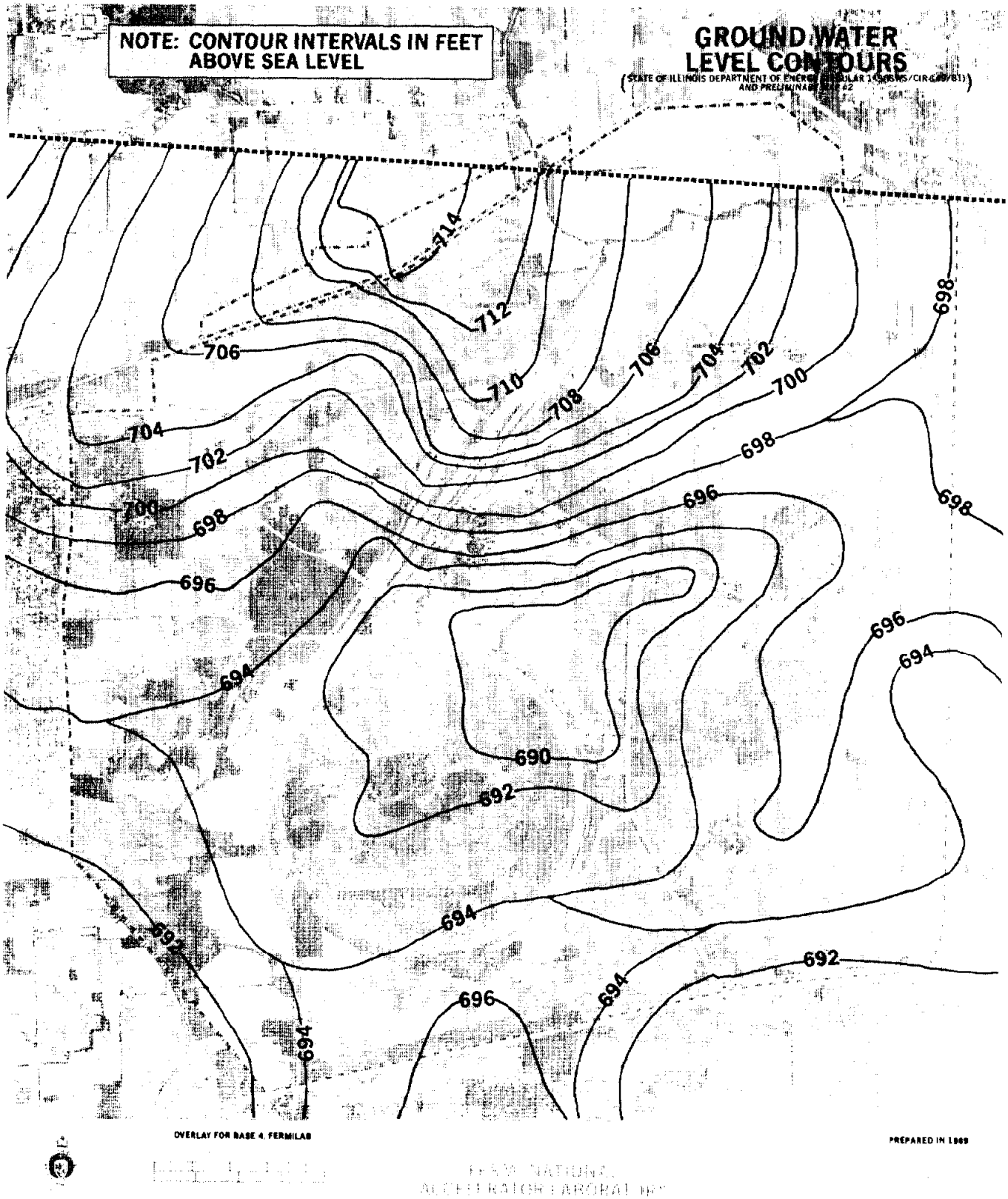
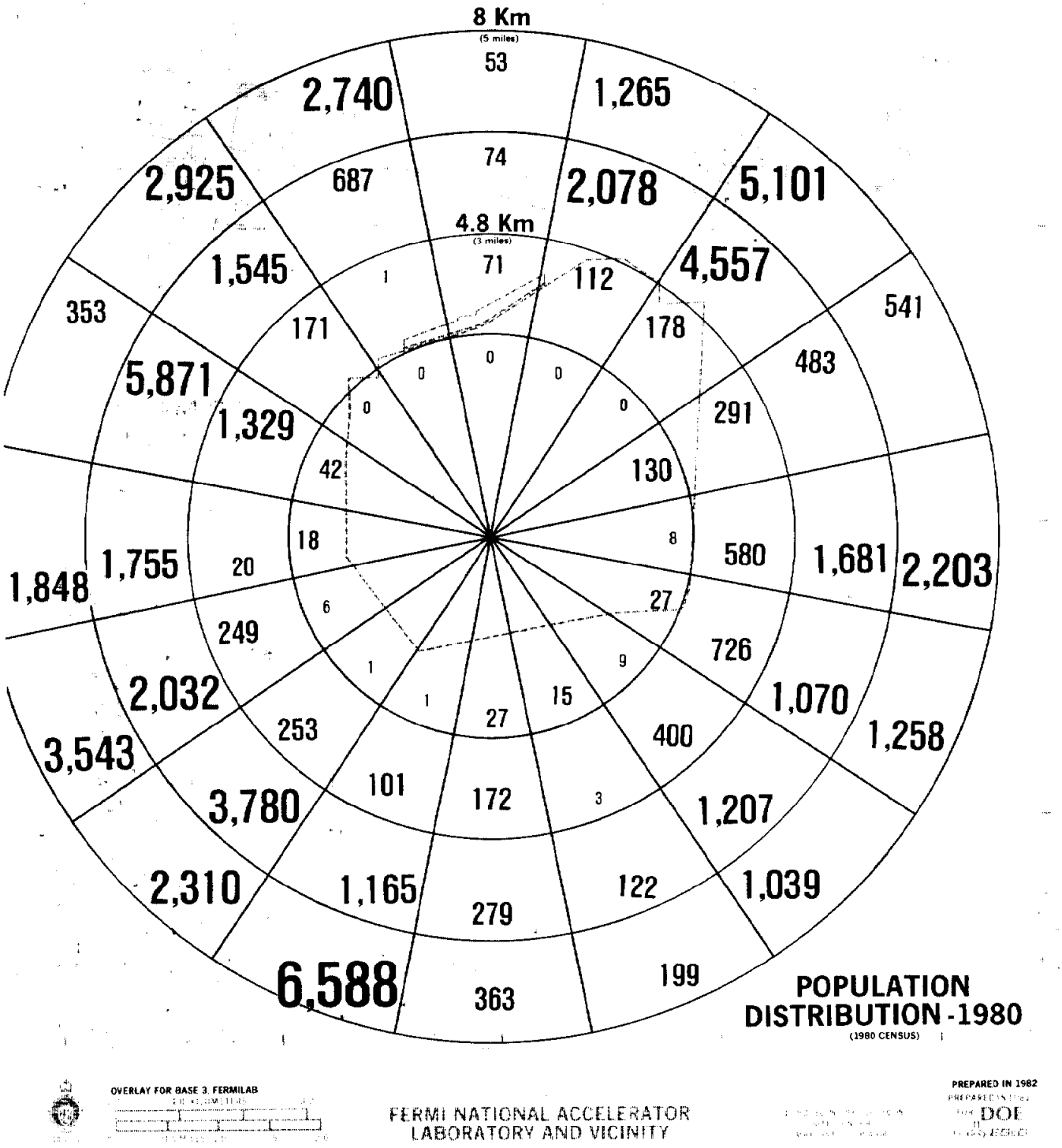

NOTE: CONTOUR INTERVALS IN FEET ABOVE SEA LEVEL
GROUND WATER LEVEL CONTOURS
714
712
706
710
708
706
704
702
700
698
704
702
700
698
696
698
696
694
696
694
690
692
694
692
694
696
694
692
694
OVERLAY FOR BASE 4, FERMILAB
PREPARED IN 1969

Table 3

Incremental Population Data in Vicinity of Fermilab, 1980

DISTANCE, KILOMETERS FROM CENTER OF MAIN RING	LATITUDE = 41.832					LONGITUDE = 88.251			
	0-8	8-16	16-32	32-48	48-64	64-80	80-97	97-113	113-128
DISTANCE, MILES DIRECTION	0-5	5-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
N	198	1110	77247	75658	63188	37183	30696	28459	149892
NNE	3455	5821	68274	76075	120930	145415	100858	173092	87495
NE	9836	12718	78701	292724	139718	0	0	0	0
ENE	1445	63784	263526	840460	551913	0	0	0	0
E	4472	18423	218631	1107254	924752	0	0	33317	56442
ESE	3081	15075	92242	268040	597113	379986	196888	78056	17600
SE	2655	25167	37956	34405	106938	38944	24651	11963	10027
SSE	339	3262	44203	148699	7962	21154	70503	10828	13195
S	841	1336	8604	10301	17011	11089	6640	4354	11967
SSW	7855	49656	8635	3492	17420	6373	25217	24588	10469
SW	6344	35851	13598	15566	5317	30917	36362	13671	13226
WSW	5830	2205	5578	6322	4509	10930	8474	11704	12175
W	3641	971	2941	5339	5111	13693	8445	28768	49103
WNW	7595	851	3018	42762	6723	21231	40449	13891	37012
NW	4641	9607	3297	7974	7358	65288	157549	71682	28229
NNW	3428	15152	22722	10674	29830	17952	29399	24276	58430
TOTAL	65656	260989	949173	2945745	2605793	800155	736131	528649	555262
CUMULATIVE TOTAL	65656	326645	1275818	4221563	6827356	7627511	8363642	8892291	9447553

FIGURE 9


8 Km
(5 miles)
4.8 Km
(3 miles)
53
74
71
112
2,740
1,265
2,925
687
2,078
5,101
1,545
4,557
353
171
178
541
483
5,871
1,329
291
42
130
1,848
1,755
20
18
8
580
1,681
2,203
6
27
249
726
2,032
1
9
1,070
1,258
253
1
27
15
400
3,543
3,780
101
172
3
1,207
2,310
1,165
279
122
1,039
6,588
363
199
POPULATION
DISTRIBUTION - 1980
(1980 CENSUS)
OVERLAY FOR BASE 3, FERMILAB
FERMI NATIONAL ACCELERATOR
LABORATORY AND VICINITY
PREPARED IN 1982
DOE

boundaries are Batavia (pop. 17,076), Warrenville (pop. 11,333), West Chicago (pop. 14,786), and Aurora (pop. 99,581). See Fig. 3. The Site Environmental Report for CY-1991 will reflect 1990 U.S. Census data.

3.0 COMPLIANCE SUMMARY

This summary addresses the status of compliance with applicable regulations at Fermi National Accelerator.

Clean Air Act - The major Federal law regulating the air emissions of the Department of Energy's (DOE's) processes and facilities is the Clean Air Act (CAA). Under the authority of the CAA the Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for concentrations of the criteria's pollutants: sulfur dioxides, particulate matter, carbon monoxide, ozone, nitrogen oxides, and lead. The National Emissions Standards for Hazardous Air Pollutants (NESHAPs) have also been established to control emissions of listed hazardous air pollutants (e.g., radionuclides, asbestos). Fermilab has obtained Illinois Environmental Protection Agency (IEPA) operating permits for both radiological and non-radiological emissions sources onsite. Fermilab is not a large source of air pollutants and there were no known instances of noncompliance emissions in CY-1990.

Clean Water Act - Under the authority of the Clean Water Act (CWA) the Environmental Protection Agency (EPA) has promulgated regulations for monitoring liquid effluent discharges to surface water bodies and to publicly-owned treatment systems. Under Section 402 of the Act the National Pollutant Discharge Elimination System (NPDES) is established, whereby that agency issues permits to facilities that directly discharge pollutants to the waters of the United States. Facilities that discharge to a municipal or publicly-owned wastewater system do not have to obtain a NPDES permit but must ensure that industrial discharges remove or treat all pollutants that could pass through the municipal system untreated or could adversely affect the performance of the municipal system. Fermilab does not currently have a NPDES permit. Industrial discharges are characterized and municipal approval for sewerage is sought prior to release. Current Fermilab operations result in a discharge of cooling, storm, and certain treated waters to the surface waters onsite. The Laboratory is in the process of investigating these onsite discharges and preparing a NPDES permit application.

In CY-1990 a permit application, as required by Section 404 of the CWA due to the involvement of wetlands, was submitted to the Army Corps of Engineers for the proposed Fermilab Main Injector project .

Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)/Superfund Amendments and Reauthorization Act of 1986 (SARA) - The CERCLA/SARA legislation establishes a program to identify sites where hazardous substances have been released into the environment and ensures the cleanup of these sites. The intent of CERCLA is to provide for response to and cleanup of environmental

problems that are not adequately covered by the permit programs of other environmental laws including the CAA, CWA, SDWA, and RCRA. CERCLA site notification has been filed for two sites at the Laboratory: the Meson Hill where asbestos was deposited from 1970 to 1980 and the old Main Ring Perforated Pipe Field where chromate contamination associated with cooling tower "blowdown" containing zinc chromate was discharged from 1974 to 1976. A preliminary assessment report on the Main Ring Perforated Pipe Field was submitted to the United States Environmental Protection Agency (USEPA) in CY-1990.

Endangered Species Act and the Fish and Wildlife Coordination Act - In conjunction with the Fermilab Main Injector Environmental Assessment, field surveys were conducted at the proposed project site with findings indicating no state or federally listed endangered or threatened species of plants, invertebrates, or vertebrates that would be affected by the proposed construction.

Executive Orders 11988, "Floodplain Management" and 11990, "Protection of Wetlands" - Planning for the proposed Fermilab Main Injector, located in a floodplain and "wetlands," has addressed requirements in these orders.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) - This act applies to storage and uses of herbicides and pesticides at Fermilab. In CY-1990 pesticides were handled in accordance with FIFRA.

The Migratory Bird Treaty Act - An ornithologist was employed to prepare recommendations and precautions for the protection of a great blue heron rookery that exists inside the proposed Fermilab Main Injector site. Although this area would not be directly disturbed by construction activities, these recommendations and precautions would ensure that the project would have no significant impact on the heron rookery or on other migratory birds.

National Environmental Policy Act (NEPA) - NEPA requires that projects with potentially significant impacts to the environment be carefully reviewed and reported in documents such as Environmental Evaluations (EEs), Environmental Assessments (EAs), or Environmental Impact Statements (EISs). Compliance with NEPA is achieved by a review process that includes consideration of environmental impact in planning Laboratory activities and projects.

National Historic Preservation Act, Archaeological Resources Protection Act - Compliance with these Acts was accomplished through a program of reviewing all proposed land-disturbing projects to assess potential impacts on cultural resources and by continuing efforts to survey the entire site for new cultural resources. Phase I archaeological surveillance has been completed for the entire site. A programmatic agreement for an archaeological resources management plan at Fermilab has been approved by the Illinois State Historic Preservation Officer but is still under review by the Advisory Council on Historic Preservation.

Resource Conservation and Recovery Act of 1976 (RCRA) - RCRA establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste. Fermilab holds an

interim status RCRA permit to operate a hazardous waste storage facility (HWSF) pending approval of a Part B application for a RCRA permit. Following the removal in 11/89 of a leaking gasoline underground storage tank (LUST) at 30 Sauk, the IEPA requested that hydrogeological studies be completed at the site to determine the extent of subsurface contamination. Monitoring wells were installed and a thorough evaluation has been submitted to the IEPA for review. It is anticipated that no further action will be required and that closure will be approved. The Laboratory continues to monitor other underground storage tanks (USTs) for petroleum releases through monthly inventory control measures and annual tank tightness testing. IEPA conducted a RCRA Facility Assessment of Fermilab in March 1990. Fermilab was found to be in compliance with the requirements.

Safe Drinking Water Act - The Safe Drinking Water Act (SDWA) of 1974 was established to provide safe drinking water to the public. To comply with this Act the EPA has established National Primary Drinking Water Regulations (NPDWR) applicable to public water supplies. These regulations set maximum contaminant levels (MCLs) on bacteriological, chemical, and physical contaminants that may have an adverse effect on consumer health if found in public water systems. Illinois has obtained primary responsibility for enforcement and administration of national SDWA regulations by adopting the NPDWRs through the Illinois Environmental Protection Act. Primary responsibility for the drinking water portions of the State Act has been delegated to the IEPA. In Illinois non-transient, non-community wells (NTNC) are regulated the Illinois Department of Public Health (IDPH). The two NTNC supplies onsite are regulated by IDPH regulations. A satellite supply connected to the City of Warrenville public water supply is regulated by the IEPA. The three distribution systems were sampled for bacteriological and chemical contaminants in CY-1990. All results were in compliance with regulatory limits. An internal audit conducted in October 1990 of onsite public water supplies resulted in recommendations to formally document monitoring requirements.

Another provision of the SDWA established programs to prevent contamination of underground sources of drinking water by underground injection of contaminated fluids. Fermilab continues to operate two permitted Class V underground injection wells onsite: a septic field at D0 and a tile field inside the Main Ring for resin regeneration effluent containing water, salt, trace quantities of heavy metals (primarily copper), and radionuclides (principally Be-7). (See Sections 4.5.4 and 5.5.3 for further discussion.)

Toxic Substance Control Act (TSCA) - The application of TSCA requirements to Fermilab involves the regulation of PCBs. During CY-1990 all remaining high voltage PCB capacitors were disposed of offsite. Also in CY-1990, in response to the 1987 DOE Survey indicating a possible noncompliance with 40 CFR 761, a thorough evaluation was undertaken at two of twenty-four sites around the Main Ring where transformer oil containing 2-5% PCB's was historically drained onto the ground as part of a sampling procedure to verify dielectric properties. Results of CY-1990 assessments will be presented to the USEPA along with a request for guidance in clean-up requirements. There were no known noncompliances in CY-1990.

3.1 Current Issues and Actions

Past practices and spill incidents have resulted in some areas of localized contamination which are in various stages of characterization and cleanup. These areas are addressed in the Department of Energy's Five-Year Plan for Environmental Restoration and Waste Management and include two leaking underground gasoline storage tanks (which were removed during CY-1989), small PCB spills at various transformer/capacitor installations, a mineral oil spill from a ruptured non-PCB transformer, and a drain tile field used for the disposal of cooling water in which chromates were used as a corrosion inhibitor. None of these areas pose any threat to the health and safety of the public or site workers. Evaluations of possible remediation of these areas continues to the present.

Other sections of this report document continued environmental monitoring efforts and progress in the solution of the problems described above. Especially pertinent are efforts to address the recommendations of the DOE Environmental Survey which was conducted in September of 1987. Thirteen of the recommendations of the Survey have now been acted upon and have been considered closed out by DOE-CH-ESHD. Efforts at addressing the remaining seven are underway. Also, Fermilab has implemented strengthened procedures to comply with DOE NEPA procedures in its reviews of all projects. Efforts to implement the National Historic Preservation Act (NHPA) continued this year.

3.2 Environmental Permits

Fermilab now has 6 air emissions permits and 2 open burning permits from the Illinois Environmental Protection Agency and a RCRA interim status from the same agency for its hazardous waste storage facility. Efforts continue to secure a RCRA Part B permit for the hazardous waste storage facility. The RCRA Part B permit application was first submitted on 11/8/88 with revised submittals on 11/15/89, 6/17/90, and 12/13/90. The next revision is due 5/31/91. The air pollution permits cover radionuclide emissions and the operation of 8 boilers used for heating buildings, gasoline dispensing tanks, a vapor degreaser, and a grit blaster. The open burn permits cover the conduct of prairie burning in connection with land management and the large-scale prairie reconstruction project and of burning associated with firefighting training. Inspections by IEPA and the USEPA have identified no noncompliances with conditions of these permits.

3.3 Summary for January 1 through April 1, 1991

Efforts to address environmental protection issues are continuing in CY-1991 including the following:

Phase I data-gathering and investigation efforts for a NPDES Permit application for cooling, storm, and treated water discharges onsite were initiated to comply with the CWA.

A survey to identify any potential cross-connections between potable and non-potable water supplies onsite was initiated to comply with IEPA regulations implementing the SDWA. The absence of a formal cross-connection control program was a deficiency noted in a December 1988 IEPA engineering evaluation of the Village public water supply.

An IEPA RCRA inspection conducted at the Lab in the first quarter of 1991 resulted in one apparent violation in failure to provide Land Ban notification for each manifested shipment of mineral spirits to a reclamation facility. This apparent violation was expeditiously resolved with the IEPA.

4.0 ENVIRONMENTAL PROGRAM INFORMATION

4.1 Environmental Program Description

The National Environmental Policy Act of 1969, as amended, mandates the Federal Policy to restore and enhance the environment and to attain the widest range of beneficial use without degradation. Since its inception, Fermilab has endeavored to protect and enhance the environment. For over ten years a prairie reconstruction project has been in progress on the 1.57 km^2 (388 acre) plot inside the main accelerator ring (Main Ring in Fig. 2). In the past several years the prairie project has been expanded to include areas outside the ring (Fig. 2). The total outside the ring is 1.13 km^2 (289 acres). A new prairie tract 0.30 cm^2 (83 acres) was planted in CY-1990. In 1989 Fermilab was designated a National Environmental Research Park (ParkNet).

In other efforts to enhance the environment, farm houses were moved from their original locations to a site at the south end of the Village (Fig. 1) and renovated to provide housing for scientists performing experiments at Fermilab rather than abandoned and allowed to deteriorate. Some farm wells were maintained for monitoring and others were properly sealed to prevent inadvertent contamination of the aquifer. Ponds and lakes were created to control surface run-off and to provide cooling water for the accelerator and experimental areas. Over 40,000 trees have been planted to improve the environment. In addition, strong emphasis has been placed on the control of chemical and radioactive materials as potential sources of environmental pollution. Adequate shielding has been provided for preventing exposure from penetrating radiation.

The Fermilab environmental and effluent radiological monitoring program follows the guidance given in the Department of Energy (DOE) 5400 series of Orders and in the reports A Guide for Environmental Radiological Surveillance at DOE Installations (Co81) and A Guide for Effluent Radiological Measurements at DOE Installations (Co83). This includes adherence to the standards given in other existing DOE orders. The Environment, Safety, and Health Section is the Laboratory organization who is primarily responsible for the environmental protection program at Fermilab.

Emphasis has been placed on potential environmental exposure pathways appropriate to high-energy physics laboratories. These pathways include external exposure and internal exposure. The external exposure is from direct penetrating radiation and airborne, short-lived, radionuclides. The internal exposure is from ^{3}H and ^{22}Na in water, primarily potential drinking water. There is one unique characteristic at Fermilab which requires consideration. That is the use of large volumes of sand and gravel in two locations to assist in stopping the high-energy protons and secondary particles. Although the groundwater beneath these two areas is protected by membranes impervious to water and by underdrain systems designed to collect the water, radiological monitoring of soil and water is carried out to ensure that no radioactivity reaches drinking water supplies. (See Sections 5.4 and 5.5.) Monitoring results are also reported for nonradioactive pollutants. Included as pollutants are pesticides used in weed, insect, rodent, and algae control.

4.2 Summary of Environmental Monitoring Performed in CY-1990

Fermilab performed extensive environmental monitoring in CY-1990,on three types of accelerator-produced radiation: penetrating, airborne, and waterborne. During this year of operation in the fixed target mode, by far the dominant source of penetrating radiation was muons from the experimental areas. The airborne radionuclides ^{11}C, ^{13}N, ^{38}Cl, ^{39}Cl, and ^{41}Ar as well as the waterborne radionuclides ^{3}H (tritium) and ^{22}Na were monitored. For airborne effluents continuously operating stack monitors recorded the concentration released from the stacks emitting the radioactivity. Surface water and groundwater samples were analyzed to determine concentrations of tritium and other accelerator-produced radionuclides. The fraction of the year the water left the site was determined by weekly inspections of the Kress Creek spillway. Additional monitoring for radionuclides in soil and sediment on the site was been done to investigate other possible pathways to the offsite environment.

The data on radioactive effluents was reported to the Department of Energy via the Effluent and On-Site Discharge Information Systems operated for the Department of Energy by EG&G, Idaho.

The results during the operations in CY-1990 were in compliance with the applicable standards in every case. In particular, the highest site boundary penetration radiation level was 13% of the relevant standard in CY-1987, 1.6% in CY-1988, 1.1% in CY-1989, and 16% in CY-1990. Airborne radionuclide concentrations and waterborne concentrations were below detection limits. See Section 8.0 for applicable standards.

Monitoring for bacterial and chemical pollutants in onsite drinking water systems was accomplished in CY-1990. Public water supplies were sampled monthly for coliform in accordance with the sampling plan submitted to IEPA. The new required sampling for the 8 volatile organic compounds (VOC's) and the unregulated contaminants was also accomplished this year. Results were in compliance with SDWA standards for all the wells sampled.

The Laboratory performs coliform tests on unchlorinated well water supplies that service old farmhouses, now offices, on the site. When greater than four colonies per 100 ml are found in a sample, the well is chlorinated and subsequently retested. No fecal coliform was found in these unchlorinated supplies and thus chlorination of these wells was not necessary in CY-1990.

4.3 Description of Environmental Permits

Table 4 lists environmental permits for Fermilab along with their current issue dates and expiration dates.

Table 4

List of Fermilab Environmental Permits

Issuing Agency Type, and No.	Description	Current Issue Date	Expiration Date
IEPA-air Appl.#86020057	Gasoline dispensing tanks	10/19/90	10/16/95
IEPA-air Appl.#87110096	5 gas-fired hot water boilers 1 propane-fired boiler 1 grit blaster	1/15/88	11/24/92
IEPA-air Appl.#89090071	2 gas-fired hot water boilers	11/28/89	11/20/94
IEPA-air Appl.#88010042	Vapor degreaser	4/14/88	3/31/93
IEPA-air Appl.#79070012	Magnet debonding oven	11/2/89	3/5/94
IEPA-air Appl.#89080089	Radionuclide emissions from accelerator operations	10/30/89	8/28/94
IEPA-open burn Appl.#B9010089	Prairie ecological management	11/2/90	11/30/91
IEPA-open burn Appl.#B9003090	Fire extinguisher training	4/16/91	4/16/92
RCRA IEPA I.D.890105010 U. S. I.D.IL6890030046	Hazardous waste storage facility (part B application pending)	interim	status
IL Dept of Public Works Permit No. 12170	Water intake from Fox River	1/7/69	12/31/09

Emco Wheaton coaxial vapor recovery systems have been installed on all gasoline dispensing equipment at Fermilab under a permit (I.D. No. 043807AAI, Application No. 86020057) issued by the Illinois Environmental Protection Agency (IEPA). There have been no compliance problems with the systems.

Fermilab has an IEPA permit (I.D. No. 043807AAI, Application No. 87110096) for three natural gas boilers at the Central Utility Building (Fig. 2), two natural gas boilers at the Wide Band Lab in the Proton Area (Fig. 2), and one

1990

propane gas boiler at Industrial Building #2 in the Industrial Area (Fig. 1). A grit blast operation at Industrial Building #2 is also included on the latter permit.

IEPA has a permit (I.D. No. 043807AAI, Application No. 89090071) (initially issued on November 28, 1990, to Fermilab) for two natural gas fired hot water boilers, one each at Lab A (Neutrino Area) and the Meson Detector Building. These boilers are replacements for existing electric hot water boilers at each facility.

Fermilab has received a permit (I.D. No. 043807AAI, Application No. 88010042) for operation of a vapor degreaser at Industrial Building #3 in the Industrial Area.

The magnet debonding oven has an Illinois Environmental Protection Agency permit (I.D. No. 043807AAI, Application No. 79070012). There have been no cases of noncompliance.

Fermilab has an IEPA permit (I.D. No. 089801AAD, Application No. 89080089) initially issued October 30, 1989, for radionuclide emissions associated with accelerator operations. The other source of radionuclide emissions at Fermilab is the debonding oven. This facility debonds failed magnets for repair by decomposing epoxy at a high temperature (800^{o}F). A revised IEPA permit (I.D. No. 043807AAI, Application No. 79070012) was issued on November 2, 1989.

Fermilab has an IEPA air pollution control open burning permit (I.D. No. 089801, Application No. B8903024) for 200 acres heavy and 100 acres light cover prairie for ecological management. A version of this permit was first issued March 14, 1989. Burning occurred in the spring of 1990 on a number of the prairie tracts. Open burning was conducted in such a manner as not to create a visibility hazard on roadways, railroad tracks, or airfields. Other standard conditions for open burning were also carried out. Because of the large size of the Laboratory property (6800 acres), the smoke from the fire caused no offsite problems.

Also, Fermilab has an IEPA permit (I.D. No. 043807, Application No. B8909039) to allow burning of one gallon of motor fuel per session of firefighting instruction. This was initially issued on September 26, 1989.

Fermilab has interim status under the Resource Conservation and Recovery Act (RCRA) (USEPA I.D. No. IL6890030046) to operate a hazardous waste storage facility. This status will continue until the Illinois Environmental Protection Agency has approved Fermilab's Part B application which was submitted in November 1989. The application is currently in the technical review process. The facility is in compliance with the RCRA regulations. Regulated chemical wastes are stored in the facility as well as a limited amount of radioactive mixed waste. Typical regulated chemical wastes are hazardous wastes, polychlorinated biphenyls (PCBs), and used oil. The only drum quantity radioactive mixed waste (RMW) is ^{241}Am and lead debris from a fire in 1987. Request for permission to dispose of this

material has been submitted to DOE. Only wastes generated by Fermilab are stored at the facility awaiting proper disposal elsewhere.

The Lab has a permit from the Illinois Department of Public Works (Permit No. 12170) that allows water to be taken from the Fox River for use onsite.

No permit was needed for the septic field installed near D0 (north of W-5 in Fig. 7). It was classified as a Class 5W32 injection well in CY-1988. The CUB tile field (Fig. 2) was also classified as a Class 5W20 injection well in CY-1988. As mentioned elsewhere in this report, Fermilab is in the process of preparing a sitewide NPDES permit for the release of storm, cooling, and treated water to surface waters onsite.

4.4 National Environmental Policy Act (NEPA) Activities & Program

The Secretary of Energy issued SEN-15-90 in February 1990 which specified increased formality in reviewing all DOE actions under provisions of this law. Fermilab has responded to the procedures specified by this SEN by implementing a program of reviewing all of its activities at the purchase requisition level. Documentation of this program was included in the Fermilab Environment, Safety and Health Manual (formerly called the Fermilab Safety Manual) in January 1991. Formal requests for determinations under Section D of DOE's procedures as specified in the Code of Federal Regulations are made under the auspices of the ES&H Section. Before they were phased out on September 30, 1990, memoranda-to-file (MTF) were issued by DOE for six projects. Three of these were for parking lot or hardstand improvements. One was for an unheated storage building constructed on an existing gravel hardstand at the Railhead storage area. The fifth was for the construction of a radiation detector calibration building. The sixth MTF covered the installation of survey monuments to provide more accurate alignment survey reference points. In addition, 16 categorical exclusion determinations were issued for Fermilab projects by DOE during CY-1990. The Laboratory also submitted extensive comments to DOE in an attempt to support the effort to develop a more useful list of categorical exclusions.

4.4.1 Environmental Assessment for the Fermilab Main Injector

A major NEPA activity being conducted during CY-1990 was the preparation of a draft environmental assessment for the proposed Fermilab Main Injector. This project would construct a 150 GeV synchrotron to replace the Main Ring. This accelerator would be housed in a separate underground beam enclosure located in the Southwest corner of the Fermilab site. A variety of studies of the environment affected by the construction of this accelerator are included within the scope of the draft environmental assessment. Other activities related to the environmental protection aspects of this project which occurred during CY-1990 included the submission of an application for a Section 404 Permit to the U.S. Army Corps of Engineers because of the involvement of wetlands and analysis of airborne radionuclide emissions in

order to prepare requests for approval to construct under 40 CFR 61. This assessment also includes a detailed wetlands assessment and mitigation plan, archaeological studies, and habitat studies for birds, insects, mammals, amphibians, and reptiles.

4.5 Summary of Significant Environmental Activities

4.5.1 Prairie Reconstruction Activities

In the early 1970's Fermilab began a prairie reconstruction project on a 1.57 square km (388 acre) plot inside the main accelerator ring. Beginning in 1984 additional plots outside the ring have been planted, resulting in a current total of approximately 2.7 square kilometers (677.4 acres) planted in native grasses.

4.5.2 Summary of Prehistoric Archaeological Work at Fermilab

Phase I archaeological surveys of both prehistoric and historic cultural resources have now been completed for the entire site (Lu90). In CY-1990 three new sites were defined and tested while investigating collector finds in farm tract N-4E, an area to be impacted by the proposed construction of the Fermilab Main Injector. Four sites located in prairie tract #17 two new and two previously identified, were also investigated as this land was converted to prairie (Bi91). With the addition of the five sites identified in CY-1990, the total number of known prehistoric archaeological areas at Fermilab is now 32.

4.5.3 Removal of PCB Capacitors

The Laboratory has continued its aggressive program to remove large PCB capacitors. As a result the initial inventory of over 2000 large PCB capacitors was reduced from 106 to 16 by the end of CY-1989. In order to comply with an October 1988 date for polychlorinated biphenyl (PCB) control, Fermilab has removed large PCB capacitors from the Booster accelerator tunnel and from the Capacitor Tree adjacent to the Master Substation (northwest corner of intersection of Roads A and B in Fig. 1). During CY-1990 the remaining large high voltage PCB capacitors have been shipped offsite for disposal in accordance with regulations.

4.5.4 Environmental Survey Items

The U.S. Department of Energy Environmental Survey for Fermi National Accelerator Laboratory was conducted from September 14 to September 25, 1987. The purpose of this effort was to identify, via baseline surveys, existing environmental problems and areas of environmental risk at Fermilab. This survey was part of a larger effort to rank the findings on a DOE-wide basis and to establish priorities for addressing the environmental problems found. The Survey team consisted of two members from the DOE Headquarters in Washington, D.C., and seven independent

specialists with expertise in dealing with different types of environmental problems. Fermilab continues to semiannually submit to DOE a detailed status report called the Environmental Survey Action Plan. The major survey action items, along with routine waste handling operations, are incorporated in the DOE's Five-Year Plan for Environmental Restoration and Waste Management. The following summarizes significant action in response to this Survey.

The Survey team found that the missing mineral oil from the T82A transformer spill (Ba86) in 1985 could have potentially been as high as 22,710 liters (6000 gal.). During the Survey approximately 475 liters (125 gal.) was located in a vault under the Capacitor Tree near the Master Substation. This oil entered the vault by flowing down an open electrical cable duct on the transformer pad the night the spill occurred. Oil also is collecting in a sump in an underground enclosure about 7.5 m (25 ft) east of the transformer pad. The sump collects water near the footings of the enclosure about 6 m (20 ft) below the ground surface. In CY-1986 about 190 liters (50 gal.) of oil was collected. In CY-1987 about 208 liters (55 gal.) more was collected. In CY-1988, 38 liters (10 gal.) was collected. None was recovered in CY-1989 or in CY-1990. Monitoring wells have been used to study the risk of groundwater contamination from this source. During 1989, an assessment by an outside consultant was completed. It was concluded that this leak is an improbable source of groundwater contamination. (See Co90a for a more complete discussion.)

The Survey team suggested that discharges of chromates (Ba75a) from 1974 to 1976 to the old CUB perforated pipe field may be a source of soil and groundwater contamination. In 1988 five shallow (4.6 m or 15 ft) sampling holes and two deeper (11.6 m or 38 ft) holes were drilled in the perforated pipe field to search for chromates. The soil samples were analyzed for chlorides and total chromium. Sodium chloride from regeneration of resins has been discharged continually into that area since 1972 and provides a good tracer (Ba73). A distinct chloride plume was found showing migration along the top of the low permeability clay layer (Yorkville till) toward the southeast. The only chromium level above background was near the surface and that sample did not have hexavalent chromium above the detection limit of 10 mg/kg. One boring hole was made downstream of the chloride plume. Samples from that hole did not contain any elevated chromium levels. Thus, there is no evidence for migration of chromates in advance of the chloride plume. The holes were cased and water from them will be sampled in the future to monitor for chromates. Surface sampling was conducted during CY-1990 by an outside consultant. The EP toxicity test for chromium from a sample inside and immediately surrounding the perforated pipe resulted in leachate concentrations of less than 100 micrograms/liter. This is much less than the 5 milligrams/liter threshold for declaring this material to be hazardous waste, but it would still be considered regulated waste. Water sampling from the monitoring wells show concentrations far below the maximum given in the Safe Drinking Water Act. These studies have concluded that the perforated tile field poses no threats or significant groundwater contamination, soil contamination, and sediment contamination. There is also no evidence for migration of the chromates. A preliminary assessment documenting these conclusions was submitted to USEPA Region 5 on October 24, 1990. It is planned to phase out this tile field by sending the effluent to the City of Batavia sewage system.

Some PCB spills occurred during removal of the capacitors from the Capacitor Tree and some PCB contamination remained from earlier leaks at the time of the Survey. Cleanup work was already in progress at the time of the Survey. The team listed this contamination in their findings. The total amount of PCB spilled is estimated to be below the reportable quantity of 4.54 kg (10 lbs) (40CFRa). Three cleanup efforts were made in CY-1988. The sampling at the end of each cleanup indicated residuals above the TSCA cleanup criterion of 10 parts per million (ppm) PCB. During 1989, the fourth cleanup was done. The metal surfaces of the Capacitor Tree have been successfully cleaned and a contaminated manhole cover replaced. Sampling results indicate that TSCA cleanup requirements have been met except for the bottom of one of the manholes where some contaminated sludge was found. Cleanup efforts using the services of a subcontractor continued in CY-1990 and CY-1991 with progress towards successfully meeting the TSCA cleanup requirements.

The Survey team also identified PCB spills at the locations of transformers at 24 sites around the main accelerator. These originated from small amounts of oil spilled in the course of testing fluid for its dielectric properties. During CY-1990 an assessment of two such sites was performed to assess the spread of this contamination within the framework of a possible cleanup in accord with TSCA requirements. The assessment determined PCB concentrations in soil in excess of 10 ppm to be localized in the gravel hardstand underlying the transformers with little or no penetration of the clay on which the hardstands sit. The results of this assessment will be reviewed in CY-1991.

Soil radioactivation has occurred due to prior accelerator operations near the N01 and M01 target areas (Neutrino Area and Meson Area primary targets in Fig. 10) and the NW4 beam dump (Neutrino Area Encl. 100 Upstream Dump in Fig. 10) as a result of fixed target experiments. The Survey team was not satisfied with the characterization of the soils beneath the underdrains or the groundwater monitoring systems in use at that time. Nine 45^{0} sampling holes were made beneath the target areas and beam dump in CY-1988 and CY-1989 for the purposes of sampling the soil for ^{3}H and ^{22}Na, searching for a high permeability sand and gravel layer which could shunt radioactivity laterally away from wells, and for sampling the deeper laying aquifer nearby. Monitoring wells for future shallow water sampling at these locations were also installed in these holes. (See Fig. 11.) This monitoring program was described more fully last year (Co90 and Co90a).

The soil borings did not find any sand and gravel layer beneath the Neutrino Area primary target which would provide a mechanism to carry radionuclides away horizontally. There was evidence for some sand and gravel around elevation 218 m (715 ft) near the M01 target and around 217 m (712 ft) near the NW4 beam dump and at other places onsite. There has been no evidence found for a continuous layer which could provide a pathway for the horizontal movement of water over large distances. There is also no evidence of downward migration of radionuclides posing a risk to groundwater.

FIGURE 10

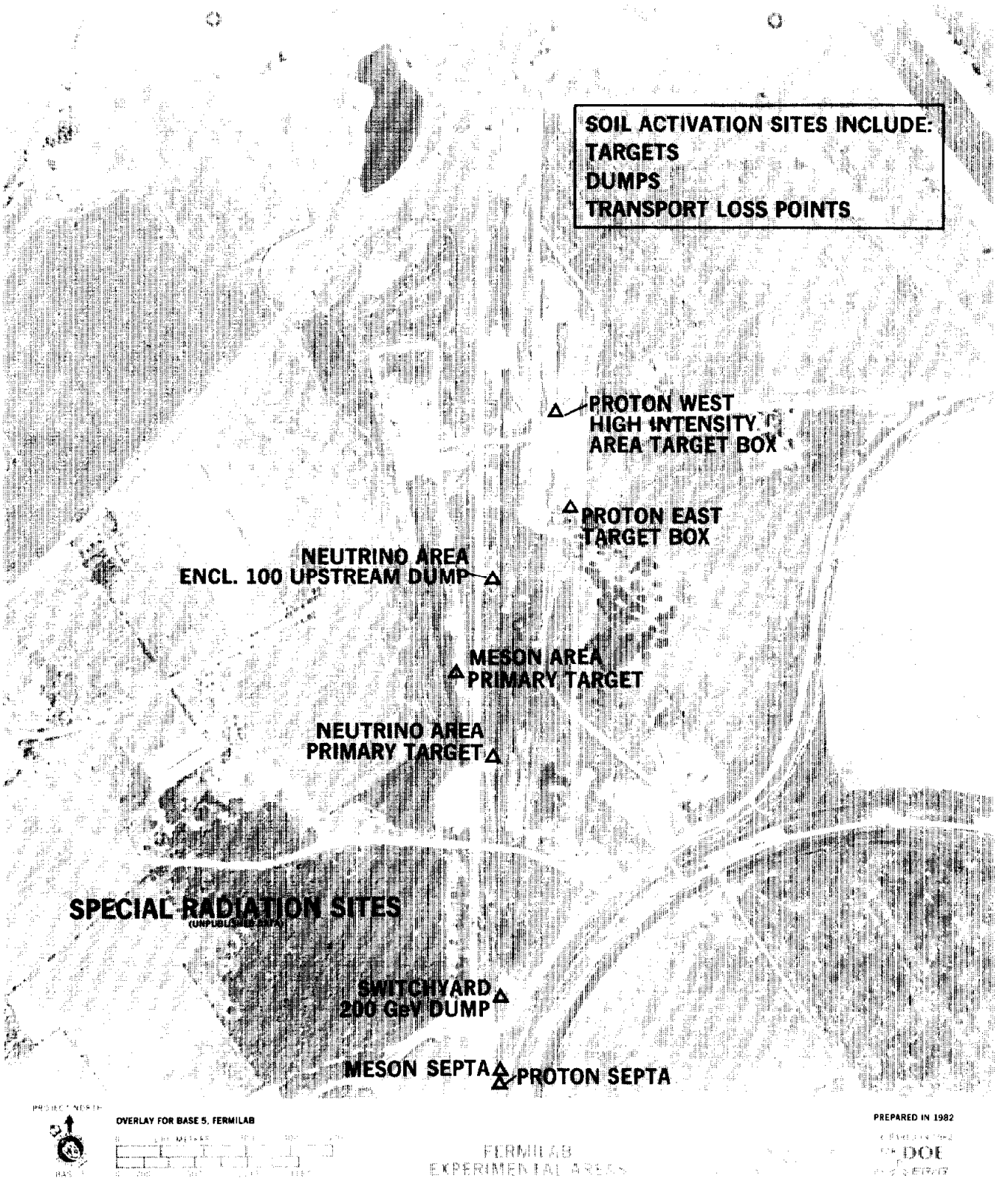
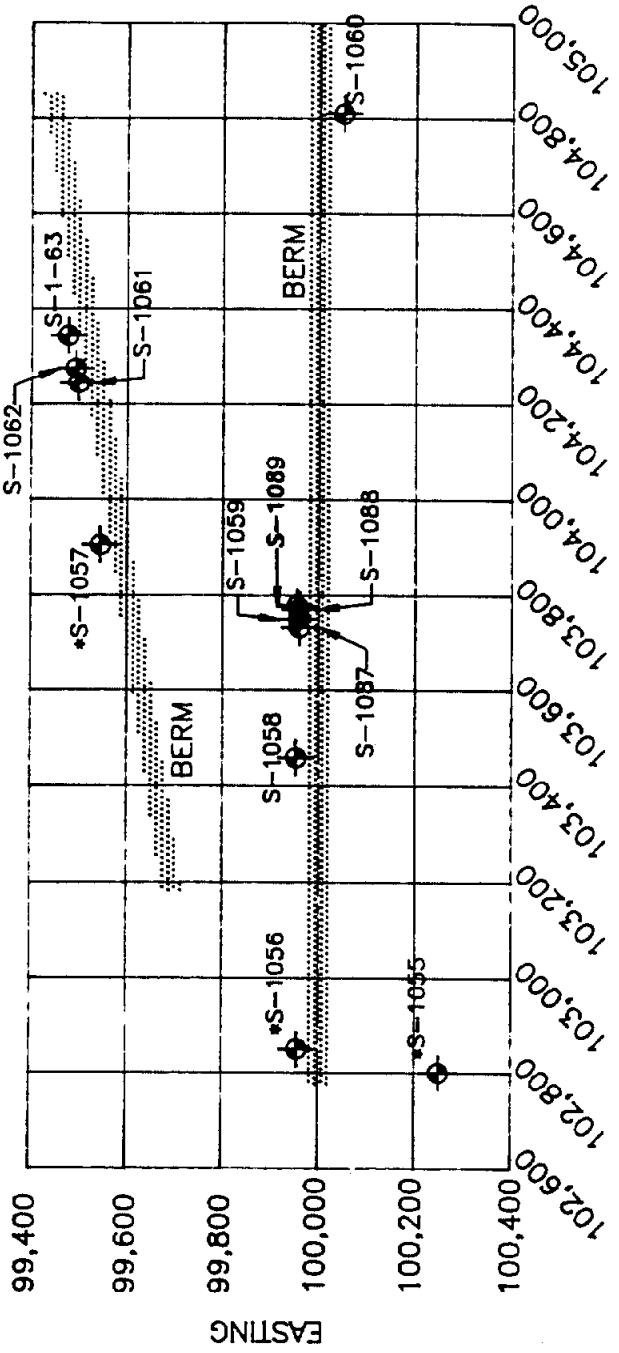

SOIL ACTIVATION SITES INCLUDE:
TARGETS
DUMPS
TRANSPORT LOSS POINTS
PROTON WEST
HIGH INTENSITY
AREA TARGET BOX
PROTON EAST
TARGET BOX
NEUTRINO AREA
ENCL. 100 UPSTREAM DUMP
MESON AREA
PRIMARY TARGET
NEUTRINO AREA
PRIMARY TARGET
SPECIAL RADIATION SITES
SWITCHYARD
200 GeV DUMP
MESON SEPTA
PROTON SEPTA
OVERLAY FOR BASE 5, FERMILAB
PREPARED IN 1982
FERMILAB
EXPERIMENTAL AREAS
DOE

FIGURE 11

MONITORING WELL AND BORING LOCATION DIAGRAM

FERMI NATIONAL ACCELERATOR LABORATORY

FOR ENVIRONMENTAL SAFETY GROUP



BORING	EASTING	NORTHING	ELEV.
*S-1055	100250.0	102800.0	746.2'
*S-1056	99955.0	102850.0	752.4'
*S-1057	99544.6	103905.8	750.6'
S-1058	99952.7	103459.7	750.4'
S-1059	99958.9	103749.9	747.5'
S-1060	100049.0	104810.1	751.4'
S-1061	99498.9	104243.7	753.4'
S-1062	99492.9	104274.6	754.1'
S-1063	99477.3	104344.6	757.3'
S-1087	99959.4	103731.8	946.0'
S-1088	99960.0	103770.9	945.6'
S-1089	99953.7	103777.5	944.6

* = BEDROCK WELL

STS Consultants Ltd.
Consulting Engineers

BORING LOCATION DIAGRAM
ANGLE HOLES AT NEUTRINO TARGET AREA
FERMI NATIONAL ACCELERATOR LABORATORY
BATAVIA , ILLINOIS

DRAWN BY	GRS	10-89
CHECKED BY	DLG	10-89
APPROVED BY		
SCALE 1"=400'	FIGURE NO. 1	
STS DRAWING NO. 25635-XH		

1990

4.5.5 Leaking Underground Gasoline Tanks (LUSTS)

During 1989 two underground gasoline storage tanks were removed because they were found to be leaking. One was located at Site 55 and the other was at 30 Sauk in the Village area. These tanks, and surrounding contaminated soil, were removed and disposed of properly. The Illinois Environmental Protection Agency has approved of final closure plans for the Site 55 excavation. Additional information, requested by IEPA has been submitted to support final closure for the LUST at 30 Sauk. Both excavations have been backfilled to remove general safety hazards to Laboratory personnel and to members of the public.

4.5.6 ParkNet

There were a total of twelve projects either completed or ongoing under the ParkNet program in 1990. These projects were all conducted by researchers from institutions other than Fermilab. (See Table 5.) The studies were designed to add to the baseline data on the Fermilab site, to address land management questions, or to analyze more specific ecological questions. ParkNet continues to cooperate with the Fermilab Prairie Committee to determine the most appropriate management of reconstructed prairie areas.

At the request of DOE-OHER, the Lab agreed to produce a video presentation of the ParkNet sites around the country.

5.0 ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Environmental Radiation Monitoring

Three types of accelerator-produced radiation are monitored: penetrating radiation, airborne radioactivity, and waterborne radioactivity. These radiations usually have direct pathways to the offsite population. Other more indirect and improbable pathways, such as through the food chain, have received much less attention. The decision to monitor is based on the type of operation, the radionuclides released, the potential hazard and the experience from previous monitoring results here and at other high-energy physics laboratories. Given the fact that the areas of Kane and DuPage counties which have grown the most rapidly during the 1980's are the eastern part of Kane and the western part of DuPage, in the assessment of collective effective dose equivalent which follows the 1980 population figures will be escalated by 20%, a slightly conservative assumption.

Table 5

ParkNet Projects

Investigator(s)	Institution	Project Description	Status
Jastrow, Julie	Argonne	Development of Soil in Restored Prairie	Complete
Crego-McCarrin, Cathy	Northern Illinois University	Insect Galls on Solidago	Complete
Panzer, Ron	Northeastern Illinois University	Insect Study	Complete
Weis, Arthur	University of California - Irvine	Eurosta Galls on Solidago	Ongoing
Byre, Vicky	Chicago Academy of Science	Avian inventory	Complete
Mengler, Jeff	Environmental S/E	Plant diversity in Big, Ring, Pine St. woods	Complete
Reinhart, Debra	University of Chicago	Comparison of Prairie and pasture soils	Complete
Brand, Ray/Stratton, Gail	Wheaton College	Collembola and Spider communities in prairie	Complete
Mierzwa, Ken	Chicago Herp. Soc.	Herpetological inventory	Complete
Janzen, Fred	University of Chicago	Temperature-dependent sex determination in turtles	Cancelled
Anderson, Roger	Illinois State University	Ordination of existing data	Ongoing
Juliano, Steve	Illinois State University	Collection of Aedes triseriatus larvae	Ongoing
Jewell, Melissa	Miami University (OH)	Population structure of small mammals in prairie	EAC pending*
Hennen, Mary	Chicago Academy of Science	Behavior/Ecology of bluebirds	No proposal

*Project is pending Environmental Advisory Committee (EAC) approval.

5.2 Penetrating Radiation

During CY-1990 the Tevatron was operated in the fixed target mode. The significant sources of offsite radiation exposure due to penetrating radiation were muons from the experimental areas (Meson, Neutrino and Proton) and the gamma rays from the Railhead storage area.

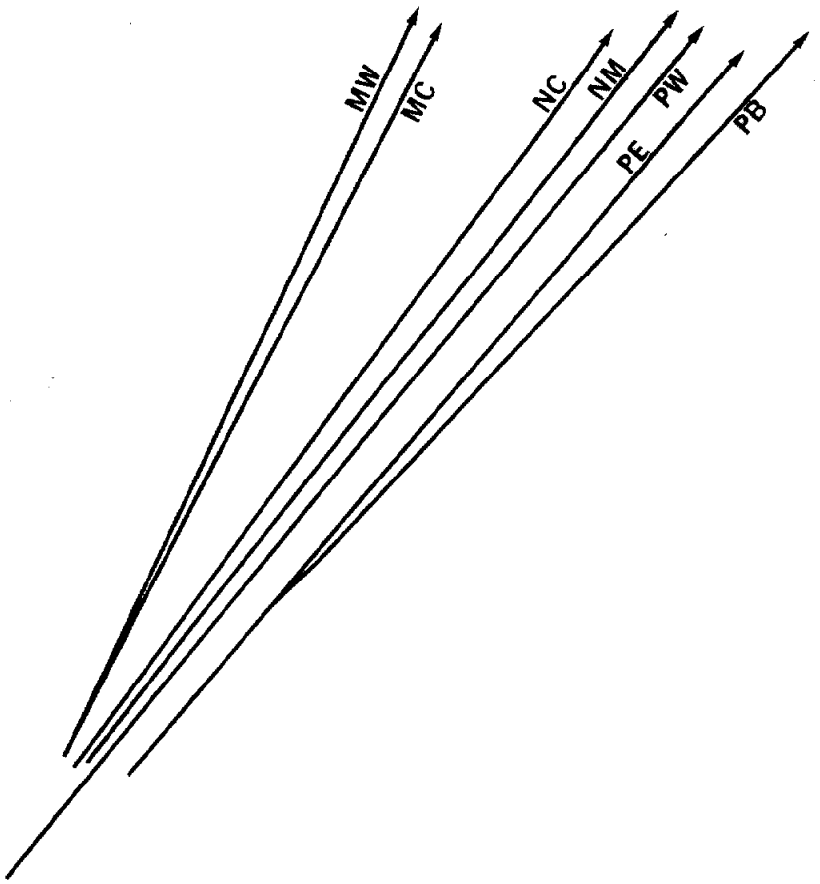
A network of detectors was used to monitor penetrating radiation. Typically, there are approximately 100 detectors deployed around the site with the primary purpose of controlling onsite radiation. The majority of these detectors were connected to a data logger which automatically recorded the radiation levels for subsequent examination (Aw71). In CY-1990 three detectors were used primarily for environmental radiation monitoring. One was a large volume, 110 liter, ionization chamber (called a Hippo) used to detect gamma rays and charged particles at its location near the Boneyard at the Railhead (Fig. 2). There was another Hippo at Site 3 (Fig. 2) near the site boundary. The last was a tissue-equivalent ion chamber located at 14 Shabbona in the Village (Fig. 2). Approximately 70 environmental TLD's, exchanged and read each quarter, provide additional information on radiation levels sitewide and at the site boundary.

As described in more detail elsewhere (Co83, El88), the muon fields on and near the Fermilab site boundary are measured by use of scintillation counters mounted in a vehicle, the Mobile Environmental Measurements Laboratory (MERL). The raw data consists of measurements of the normalized muon fluence (muons/cm^2 per 10^{12} protons) obtained during scans transverse to the muon trajectories. These data are based on average counts (background-corrected) in each of two plastic scintillation paddles. The fluence is converted to effective dose equivalent delivered during the calendar year by multiplying this normalized fluence by the total number of protons delivered during the year and using a fluence-to-dose conversion factor determined by G.R. Stevenson (St83). This factor has a value of 1 mrem/25000 muons/cm^2 (or 40 fSv-m^2). The only significant muon radiation fields produced by Fermilab operations occur to the northeast of the site. The peaks are located along extensions of the beamlines leading protons to the fixed target beamlines and are shown on Fig. 12. This is because the production of muons sufficiently energetic to penetrate shielding are restricted to forward angles with respect to proton beams incident on a target.

During the fixed target operations conducted in CY-1990, 7 beamlines produced muon fluences which are readily measured. Three of these beamlines (designated MW, MC, and MP) are in the Meson area while the fourth, called NM, is in the Neutrino area. These four beamlines are, by far, the most significant source of the muons. In the Proton Area, the PW, PE, and PB beamlines produce muon radiation fields which are barely measurable near the site boundary. The configurations of all 7 of these beamlines are quite similar to the way they existed during the fixed target run of 1987-1988. In general, measurements of the muon radiation fields made during the CY-1990 fixed target run agree well with

1990

FIGURE 12



PENETRATING RADIATION (MUON) DIRECTIONS

(FERMILAB REPORT TM-1518 1988)

OVERLAY FOR BASE 4, FERMILAB

PREPARED IN 1989

those observed in 1987-1988. There are no locations beyond the site boundary where the muon radiation fields of adjacent beamlines overlap significantly. Table 6 gives the effective dose equivalent at the site boundary due to each proton beamline producing a measurable muon fluence during CY-1990. The muon fluences have been determined to obey an inverse-square law dependence upon the distance from the source of the muons (i.e., generally the production target which is struck by the accelerated proton beam). This phenomenon is used to correct fluence measurements made on roads near the site boundary to values shown in Table 6 which are for the actual site boundary. A complete discussion is given by Cossairt and Elwyn (Co91).

Table 6

Maximum Effective Dose Equivalent at Site Boundary Due to Muons in CY-1990

Beamline	Maximum Effective Dose Equivalent Offsite (mrem)	(mSv)
MW*	15.9	0.159
MC*	0.54	0.0054
MP*	1.75	0.0175
NM	2.77	0.0277
PW	0.03	0.0003
PE	0.28	0.0028
PB	0.46	0.0046

*For these beamlines, the distances from the site boundary to the nearest residence are rather large. The maximum effective dose equivalent at the nearest residence for these three beamlines are 8.2 mrem (0.082 mSv) for MW, 0.31 mrem (0.0031 mSv) for MC, and 1.22 mrem (0.0122 mSv) for MP.

The primary radioactive materials storage area onsite, the Boneyard, is also the primary source of offsite gamma radiation. Activated accelerator components and shielding, primarily iron and concrete, are stored in the Boneyard at the Railhead (Fig. 1) for future disposal or reuse following radioactive decay. As shown in Fig. 2 the Boneyard, which is a secure area, lies close to the site boundary. In 1987 radioactive material was moved into a new cave constructed at the southwest corner of the Boneyard. In addition, there was an area nearby designated for radioactive material storage for future use. A large amount of low-level radioactive material is stored in that area. The site boundary dose for CY-1990 was determined using thermoluminescent dosimeters (TLD's) and the large volume ion chamber (Hippo). Data obtained previously using a hand-held NaI (Tl) scintillator established the rate of decrease with distance (Ba89). The radiation level at the nearest point to the site boundary was 1.1 X 10^{-2} mSv (1.1 mrem) for CY-1990. The maximum exposure to the individual living closest to that point on the site boundary would have been 2 X 10^{-3} mSv (0.2 mrem) for CY-1990, assuming 24 hour per day occupancy. The distance from the site boundary to the residence was 460 m (1500 ft). Thus, the dose to a member of the public in CY-1990 from the Boneyard was lower than the site boundary (fence line) dose.

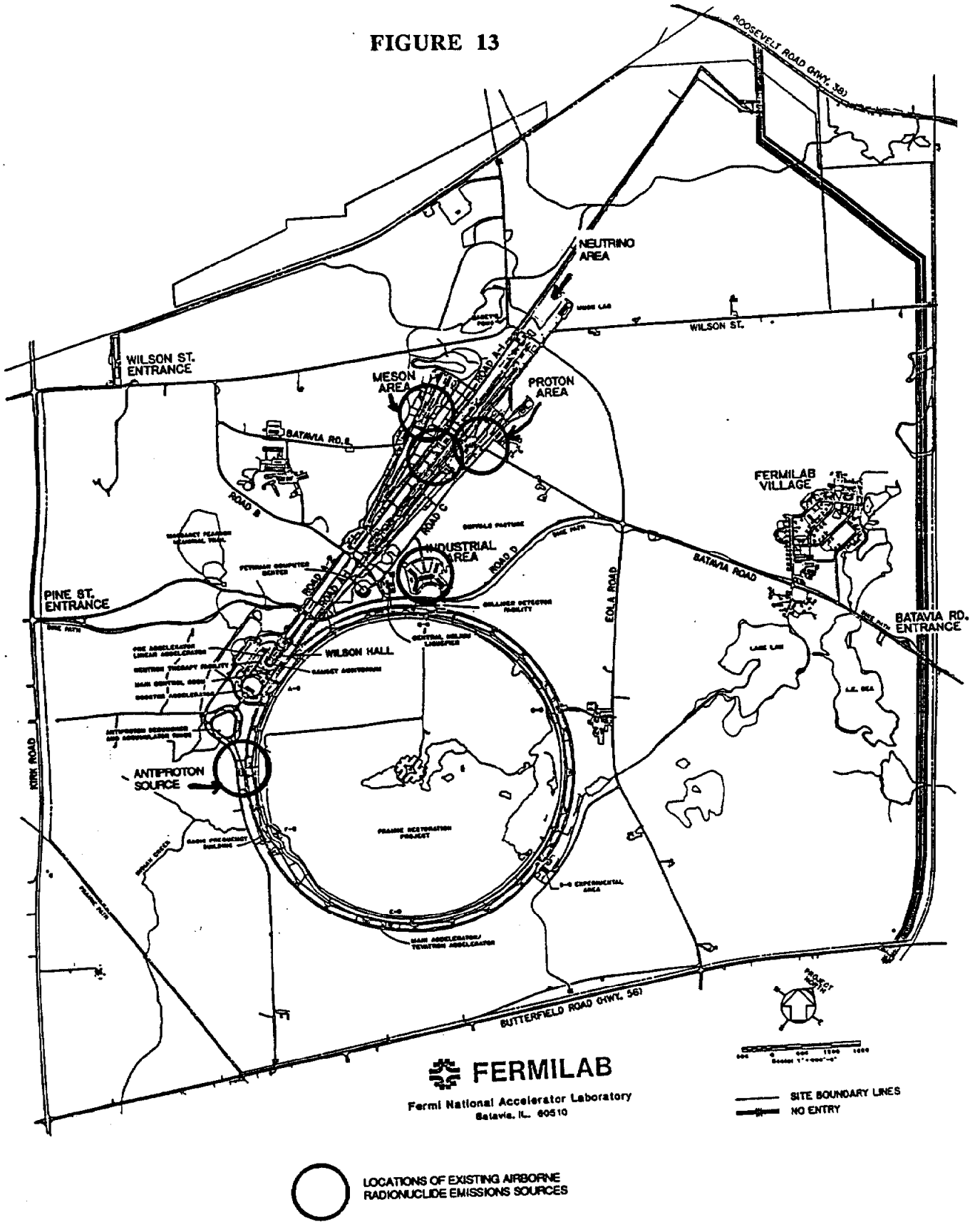
5.3 Airborne Radioactivity

Radioactivation of air in measurable concentrations will occur wherever the proton beam or the spray of secondary particles resulting from its interactions with matter passes through the air. The beamlines through which the protons extracted from the Tevatron are delivered to the experimental areas (Meson, Neutrino, and Proton) and from the Main Ring to the Antiproton Source consist of evacuated beam pipes that minimize the interactions of the protons with air in order to prevent unacceptable loss of beam. At the target stations, where these beams of protons produce secondary beams of much lower intensity used in experiments, there are unavoidable short distances through which the protons are in air. Also, at the target stations a large flux of secondary particles which are not useful for experiments are produced. Thus the radioactivation of the air is concentrated at the major target stations. Monitoring of such activation is carried out for purposes of personnel exposure control. Under no circumstances is the offsite concentration of airborne radioactivity expected to approach the limits for uncontrolled areas. Fig. 13 shows the location of principle points of radionuclide emission due to accelerator operations.

During the period from February to August of CY-1990 both the fixed target program and the Antiproton Source were in operation. A small amount of operation of the Antiproton Source also occurred during December. In the latter mode 120 GeV protons were focused onto a target (Antiproton Source in Fig. 13) to produce antiprotons. During CY-1990 the antiprotons were used in a physics experiment within the storage rings associated with the Antiproton Source. This target was a source of radioactive gas resulting from interaction in air of secondary particles leaving this target. Because this target is heavily shielded and the air volume is small, there are many thermal neutrons also radioactivating the air. The result is a mixture of primarily ^{11}C and ^{41}Ar with smaller amounts of ^{13}N, ^{38}Cl, and ^{39}Cl in air. The ^{41}Ar has a half-life of 1.8 hours and is produced by neutron capture in ^{40}Ar. Air contains about 1% argon which is essentially ^{40}Ar. Interaction of high-energy secondary particles with nitrogen and oxygen in the air produces 20 minute half-life ^{11}C and 10 minute half-life ^{13}N. Interaction of high energy neutrons with argon in the air is probably the source of 37 minute half-life ^{38}Cl and 58 minute half-life ^{39}Cl (Bu89).

Fixed target operations with 800 GeV protons extracted from the Tevatron similarly produced airborne radionuclide emissions. The principle sources of these emissions were recorded by Geiger-Müller based stack monitors. The composition of the radionuclide emissions from these sources had been measured previously (Bu89) and are, in general, similar to those noted for the Antiproton Source with the same radionuclides present. Three stack monitor outputs were logged continuously to record these emissions. These monitored the Meson Target Stations, the NM Target Station, and the PB Target Station. The Meson Target Station monitor actually records the emissions of 4 target stations located in the same building (the Meson Detector Building). Table 7 lists the totals of the activities released for accelerator operations conducted during CY-1990 for all four of the stack monitors. The grand total for all of Fermilab accelerator operations can be found in Table 1.

FIGURE 13



Map of the Fermilab site show existing facilities including locations of existing sources of radionuclide emissions.

1990

Table 7

Airborne Radioactivity Released Due to Accelerator Operations During CY-1990

Stack Monitor	Activity Released (Curies)	Activity Released (Becquerel X 10^{11})
Antiproton Source	22.7	8.40
Meson Target Stations	27.0	10.00
NM Target Station	11.7	4.33
PB Target Station	16.6	6.14
Total	**78.0**	**28.87**

The site boundary concentrations were calculated using the computer program AIRDOSE-PC (Mo79, Mo86) (a Gaussian plume diffusion model). Meteorological conditions for O'Hare Airport about 43 km (27 mile) away were used as input. The terrain between Fermilab and the airport is relatively flat and thus these meteorologic conditions are expected to be valid. The maximum effective dose equivalent to a member of the population residing offsite due to Fermilab accelerator operations was determined to be 0.031 mrem (3.1 X 10^{-4} mSv). This value amounts to 0.31% of the 10 mrem/year (0.1 mSv/year) limit in effect during CY-1990. This limit replaced the former 25 mrem/year limit because of the promulgation of the National Emission Standard for Hazardous Air Pollutants (NESHAP) for radionuclides on December 15, 1989 in 40 CFR 61, Subpart H. These stack monitors use EPA-approved monitoring procedures even though strict conformance with the monitoring requirements specified in the regulations are required only for release points which have the potential of exceeding 1% of the standard (0.1 mrem/year).

A debonding oven was placed in operation during CY-1979 in the Industrial Area (Fig. 13). Its purpose is to debond magnets by decomposing the epoxy adhesives at high temperatures. Most of these conventional magnets are radioactive and have failed after years of accelerator operation in the Main Ring tunnel. The gaseous effluent was measured during the acceptance test on June 8, 1979 (conducted for the Illinois EPA) and contained only ^{3}H at very low-levels. The tests were primarily performed to measure nonradioactive emissions. The test utilized a typical 6 m (20 ft) long magnet reading 0.8 mrem/hr (8 X 10^{-3} mSv) at 0.3 m (1 ft) from the surface and 8 mrem/hr (8 X 10^{-2} mSv) in the bore tube where the protons traveled. The total amount of ^{3}H released from this magnet was 5.92 X 10^{6} Bq (160 μCi) at a stack concentration of 4.81 X 10^{-4} Bq/ml (1.3 X 10^{-8} μCi/ml) or about 13 percent of the Derived Concentration Guide corresponding to a dose of 100 mrem/year (1 mSv/year) delivered to a member of the general public who inhaled air at this concentration at his residence (DOE90a). The stack is approximately 10 m (30 ft) high. Using the computer program AIRDOS-PC required by 40 CFR 61, Subpart H, gives a negligible effective dose equivalent applicable Concentration Guide at the site boundary.

Six radioactive magnets were debonded in CY-1990, corresponding to an estimated total release of 6.7 X 10^{7} Bq (1.8 X 10^{-3} Ci) of ^{3}H. The radioactivity in the magnets was similar to that in the 1979 test thus the 1979 data are still valid. In CY-1990 the wind conditions were similar to those in past years.

1990

All effective dose equivalents due to the release of airborne radionuclides reported here have been calculated for the site boundary assuming the nearest resident to be present at that location. This is appropriate given the relatively high population density along the eastern site boundary and the fact that, due to the prevailing westerly winds, the highest site boundary effective dose equivalent from this source also occurs at that location.

5.4 Monitoring Surface and Groundwater for Accelerator-Produced Radioactivity

All current Fermilab water sampling locations for detection of accelerator-produced activity in surface and groundwater are shown in Figs. 6, 7, and 11.

5.4.1 Groundwater Radiological Surveillance

Radioactivation of soil can occur near the primary beam targeting and beam dump areas. Older targeting stations and dumps were designed with "bathtubs" to contain radionuclides produced in these areas, preventing their migration to the aquifer. Later design strategies substituted massive concrete and steel shields within beam enclosures to minimize soil radioactivation and groundwater contamination. Water samples from 41 wells/monitoring holes are analyzed at least once and as often as four times per year. Sampling frequency is determined by a well's proximity to areas of soil activation. Many of the groundwater samples are taken from old out of service farm wells onsite. Additional wells and boring holes have been installed to provide better monitoring in areas of potential soil activation. Fermilab's groundwater protection strategies are documented in The Fermilab Groundwater Protection Plan.

Samples of water are taken routinely from wells and boring holes located on the FNAL site. These samples are analyzed for accelerator-produced radionuclides (^{3}H, ^{7}Be, ^{22}Na, ^{45}Ca, ^{54}Mn, ^{60}Co) at groundwater sensitivities. (See Table 17.) The grab method is used in most cases to collect water samples. Procedures are documented in the Environmental Protection Procedures Manual (EPPM). Sample frequency is based on the following rationale:

1) Wells located the closest to areas of maximum soil activation (targets and dumps) and/or those in the direction the water is expected to flow in the aquifer are sampled quarterly (Wells 39A, 43, 45A, 49, 59, 78, 79, 80, 81, S-1059, S-1087).

2) The following wells located near the Main Ring or Fixed Target Beamlines are sampled semiannually (Wells W-1, W-3, W-4, W-5, 5, 17A, 20, 24B, 29, 55B, S-1088 and S-1089). They are sampled less frequently than those in #1 because they have reduced potential for radioactivation.

3) Wells located near the site boundary, backups to more frequently sampled wells, or drinking water supplies other than those already listed are sampled annually (Wells 7A, 12, 50, 52, 56, 58, 64, 68, 74, 75A, S-1058, S-1060, S-1061, S-1062, S-1063).

5.4.2 Groundwater Sampling for Radioactivity

Fermilab has been monitoring for some parameters in groundwater onsite for many years. Current groundwater monitoring relies primarily on sitewide monitoring of old farm wells that have been maintained, including over 65 samples per year from 30 wells (Fig. 7) which draw water from the dolomite aquifer. This program concentrates on analysis for accelerator-produced radiochemicals ^{45}Ca, ^{54}Mn, ^{22}Na, ^{60}Co, ^{3}H, and ^{7}Be. To date no measurable concentrations of these radionuclides have ever been detected in well samples. In all cases the lower limit of detection was at least an order of magnitude below the applicable Derived Concentration Guide (DCG's) for accelerator-produced isotopes taken from the DOE Order 5400.5 and EPA Regulations set forth in 40 CFR 141. The DOE DCG's used for this purpose are those which correspond to the delivery of a committed effective dose equivalent of 4 mrem per year (4×10^{-2} mSv per year) to a person using the water as his sole source. Limited chemical analysis has also been done on samples from a number of onsite wells. Pumping of these water supply wells draws water from beneath much of the aerial extent of the site providing information on the overall quality of groundwater that reaches this aquifer. This method will detect only those contaminants that reach the drinking water aquifer in detectable concentrations after being subjected to dilution. This method would not detect in a timely manner contaminants migrating vertically through the glacial till overlying the aquifer or those moving horizontally in sand lenses or in layers within the till. The groundwater monitoring for radiochemicals has been improved by adding vadose zone monitoring in the two areas where soil radioactivation may be a potential source for groundwater contamination.

5.4.2.1 Distribution Wells

There are three wells onsite that supply two public drinking water systems servicing various areas of the Lab (W-1, W-3, and W-5). These are also sampled for accelerator-produced radionuclides.

5.4.2.2 Boring Holes

Boring/monitoring holes have been installed at target areas on the Meson and Neutrino Fixed Target Beamlines. (See Section 5.5.2.)

5.4.3 Surface Water Sampling for Radioactivity

In early beam enclosures "bathtubs" were installed underneath primary beam target stations and dumps to contain the radionuclides produced in the environs of the beam targets or dumps and to prevent their further migration to the aquifer. Later beamline designs incorporated massive steel and concrete shields within beam enclosures to minimize radioactivation of surrounding soil and eliminating the need for "bathtubs." Water collected by underdrains within the "bathtubs" is received in retention pits. Underdrains that collect water from outside "bathtubs" and from around footings of buildings and beam enclosures discharge to onsite surface waters via ditches. Radionuclide concentrations are monitored in selected sumps, ditches, and surface waters (See Fig. 6).

5.4.3.1 Surface Water Sampling Plan

To provide information to estimate annual onsite and offsite releases of radioactive effluents for annual EIS/ODIS reporting, samples of water are taken routinely from sumps, retention pits, and monitoring holes located within the accelerator ring and fixed target tunnel enclosures.

5.4.3.2 EIS/ODIS Reporting

Fermilab uses the following criteria for reporting radioactive effluent releases (offsite) and discharges (onsite) to DOE in its Annual EIS/ODIS Report:

1. Any one time release or discharge which is greater than the concentration guide of 37 Bq/ml (1000 pCi/ml) for tritium, or the equivalent for any other radionuclide, and greater than 3.7×10^7 Bq (1 mCi) total activity.

2. Any ongoing release or discharge with an average concentration greater than .74 Bq/ml (20 pCi/ml) of tritium, or the equivalent for any other radionuclide, and greater than 3.7×10^7 Bq (1 mCi) total activity for the calendar year.

An annual routine sampling plan is developed by the ES&H Section Environmental Protection Group in consultation with Accelerator Division and Research Division Radiation Safety Officers. Sample sites are selected by their proximity to target areas, closed loop (recirculating) cooling systems, and areas of soil radioactivation resulting from accelerator operations. Generally speaking, sumps closest to areas of maximum soil activation are sampled most frequently. Five sumps that have been reported as EIS-ODIS discharge points N01SP4, M01SP3, NW4SP1, NTSBSP1 and NTSBSP2 (G9, MF5, N2, G4, and G5 in Figure 6) are scheduled for more frequent sampling. Sample frequency is

dependent upon the concentrations seen in the sump water at that location. A summary of sumps with detectable tritium levels can be found in Table 8.

Table 8

Tritium Detected in Sump Water Samples
(Concentration (C) in Ci/ml (Bq/ml)

Collection Point	Number of Samples	*C Max	*C Min	*C Mean	Percentage of Concentration Guide (%)*
AP0	0	-	-	-	-
MØ1SP2	4	4.82×10^{-11} (1.78)	$<3.0 \times 10^{-12}$ ($<1.1 \times 10^{-1}$)	1.44×10^{-11} (5.33×10^{-1})	7.2×10^{-1}
MØ1SP3	6	9.58×10^{-11} (3.54)	2.53×10^{-11} (9.36×10^{-1})	5.07×10^{-11} (1.88)	2.54
NØ1SP3	1	1.42×10^{-11} (5.25×10^{-1})	1.42×10^{-11} (5.25×10^{-1})	1.42×10^{-11} (5.25×10^{-1})	7.1×10^{-1}
NØ1SP4	6	1.99×10^{-10} (7.36)	1.34×10^{-11} (4.96×10^{-1})	5.89×10^{-11} (2.18)	2.95
NM1SP	2	6.88×10^{-12} (2.54×10^{-1})	5.33×10^{-12} (1.97×10^{-1})	6.11×10^{-12} (2.26×10^{-1})	3.1×10^{-1}
NTSBSP1	4	3.34×10^{-11} (1.24)	1.47×10^{-11} (5.44×10^{-1})	2.07×10^{-11} (7.66×10^{-1})	1.04
NTSBSP2	4	3.55×10^{-11} (1.31)	2.5×10^{-12} (9.25×10^{-2})	1.31×10^{-11} (4.85×10^{-1})	6.6×10^{-1}
NW4SP1	5	2.49×10^{-10} (9.21)	2.34×10^{-11} (8.66×10^{-1})	8.05×10^{-11} (2.98)	4.03
NW5 Manhole	0	-	-	-	-

*C Max is the highest concentration detected in a sample from that location
C Min is the lowest
C Mean is the average
Concentration Guide for Tritium is 2.0×10^{-9} Ci/ml (74 Bq/ml)

Using the aforementioned criteria we reported 3 liquid discharge points and 4 liquid effluent releases for CY-1990. The sumps reported as contributing to these discharge points were M01SP3, N01SP4, NW4SP1, NTSBSP1, and NTSBSP2. The reported discharge points were the ditches receiving the waters from these sumps and emptying into Kress Creek. The total offsite release to surface waters attributable to these sumps, though not measurable in surface water samples, is calculated based on average radionuclide concentrations found in sumps and sump discharge volumes. In CY-1990 an estimated total of 7.5×10^{10} Bq (2024 mCi) of tritium was released offsite by these sumps. This is an increase over the 3.4×10^{10}Bq (908 mCi) tritium reported in CY-1989. This increase reflects the 13% increase in water leaving the site and calculated increases in activity contributed by both NW4SP1 (5.1×10^{10} Bq or 1370 mCi) and NTSBSP1 (1.4×10^{10} Bq or 375 mCi). Although the average tritium concentration for both sumps was relatively low, the hour meters showed copious quantities of water being pumped out by these sumps. The relatively heavily

1990

rainfall recorded in CY-1990 is responsible for this large volume. There were no one time releases of waters with concentrations greater than 37 Bq/ml (1000 pCi/ml) tritium in CY-1990.

In addition to the air discharge point reported last year (AP0 stack), radionuclide emissions were reported in CY-1990 for the Magnet Debonding Oven, the PB-4 stack, the NM-2 stack, and the M05 stack.

5.4.3.3 Surface Water Surveillance for Radioactivity

Although radionuclides associated with FNAL operations are routinely identified in sumps discharging into ditches onsite, concentrations are well below applicable standards and remain undetectable in all ditch, pond, creek, and lake sampling locations. Samples are taken annually from ditches, ponds, creeks, and lakes onsite (Fig. 6) including locations where creeks enter and exit the site. These samples are analyzed for accelerator-produced radionuclides (^{3}H, ^{7}Be, ^{22}Na, ^{45}Ca, ^{54}Mn, and ^{60}Co). Sampling procedures are site-specific and are documented in the Environmental Protection Procedures Manual (EPPM).

Casey's Pond and the ditches that receive water from the experimental areas and drain to Casey's Pond are sampled annually for accelerator-produced radionuclides. Kress Creek is sampled each week the water is observed leaving site via the Kress Creek spillway. Surface water from the experimental areas (Fig. 5) left the site via Kress Creek for approximately 74% of the year in CY-1990, a 13% increase over CY-1989.

5.5 Soil and Sediment Surveillance

Surface soil and vegetation samples are collected at selected locations. The purpose of the sampling at Fermilab is to detect the possible build-up of contaminants from the deposition of airborne and waterborne radioactive effluents released from FNAL facilities.

5.5.1 Soil/Sediment Sampling

An assessment of contributions from operations is made by comparing results from samples collected near release points onsite with those collected from onsite background locations. In addition, results obtained from each location are compared to results obtained from the same location in previous years. In CY-1990 the radiochemical composition of soil/sediment was measured at 13 sample sites. At each ventilation stack location one composite sample of soil was taken. Sampling procedures are documented in the Environmental Protection Procedures Manual (EPPM). The CY-1990 soil/sediment sampling results are in Table 9.

Table 9

CY-1990 Soil/Sediment Sampling Results

Location	Concentration in Ci/ml (Bq/ml) Be-7	Na-22	Mn-54	Co-57	Co-60	Zn-65	Cs-137
Indian Creek 900910EM04	ND	ND	ND	ND	ND	ND	1.1±0.3 E-13 (4.1±1.1 E-3)
Kress Creek (on) 900907EM03	ND	ND	ND	ND	ND	ND	7.0±3.0 E-14 (2.6±1.1 E-3)
Kress Creek (off) 900907EM02	ND	ND	ND	ND	ND	ND	ND
Ferry Creek 900907EM01	ND	ND	ND	ND	ND	ND	3.1±0.6 E-13 (1.2±0.2 E-2)
AP0 Stack 900910EM02	2.58±0.56 E-12 (9.5±2.1 E-2)	ND	ND	ND	ND	ND	ND
AP0 Stack*	3.71±0.94 E-12 (1.4±0.4 E-1)	ND	ND	ND	ND	ND	ND
N01 Stack 900905EM02	ND	ND	ND	ND	ND	ND	2.5±1.0 E-13 (9.3±3.7 E-3)
N01 Stack*	ND	ND	ND	ND	ND	ND	1.0±0.4 E-13 (3.7±1.5 E-3)
N01 Spur Stack 900905EM04	ND	ND	ND	ND	ND	ND	ND
N01 Spur Stack*	ND	ND	ND	ND	ND	ND	ND
M01 Stack 900905EM06	ND	ND	ND	ND	ND	ND	4.0±2.0 E-14 (1.5±0.7 E-3)
M01 Stack*	ND	ND	ND	ND	ND	ND	ND
N01SP4 Sump 900905EM01	9.2±2.5 E-13 (3.4±0.9 E-2)	6.0±2.0 E-14 (2.2±0.7 E-3)	ND	ND	ND	ND	ND
NW4SP1 Sump 900905EM03	3.67±0.71 E-12 (1.4±0.3 E-1)	2.8±0.6 E-13 (1.0±0.2 E-2)	3.1±0.6 E-13 (1.2±0.2 E-2)	4.0±2.0 E-14 (1.5±0.7 E-3)	2.0±0.3 E-13 (7.4±1.1 E-3)	3.7±1.0 E-13 (1.4±0.4 E-2)	ND
M01SP3 Sump 900905EM05	8.1±2.9 E-13 (3.0±1.1 E-2)	1.8±0.5 E-13 (6.7±1.9 E-3)	1.48±0.26 E-12 (5.5±1.0 E-2)	ND	ND	ND	ND
Site 12 900910EM01	ND	ND	ND	ND	ND	ND	ND
CUB Tile Field 900910EM03	3.75±0.77 E-12 (1.4±0.3 E-1)	ND	ND	ND	ND	ND	1.1±0.3 E-13 (4.1±1.1 E-3)

*Dried Sample
ND - Not Detectable

NOTE: After analyzing for gammas the samples from the stack locations were distilled and the water collected for H-3 analysis. The results of this analysis was not completed in time include in this publication.

The presence of ^{137}Cs (Table 9) indicates fallout from previous atmospheric nuclear testing. The ^{60}Co appears to be accelerator-produced based on the location. The ^{7}Be is most likely accelerator-produced. The radionuclides ^{22}Na and ^{54}Mn are only accelerator-produced. Note that ^{7}Be is slightly elevated in the sample from the CUB Tile Field and comparable in value to the AP0 stack (dried sample) and the NW4SP1 sump discharge soil concentrations.

5.5.2 Soil Activation

Because the percolation rates for water in Fermilab soils are calculated to be very low, certainly less than 1 m (3 ft) per year (Il78), analyses of well waters do not provide the early warning desired for detection of accelerator-produced radioactivity in the groundwater. On the other hand, these low percolation rates also make the probable transit times of the radionuclides in the water to be long compared with their lifetimes. To provide such warning soil samples were taken from the vicinity of targets and other locations where proton interactions result in some radioactivation of the soil. Because the major long-lived radionuclides leachable from Fermilab soils are ^{3}H and ^{22}Na, quantitative measurements were made only on those (Bo72). Most of the soil activation occurred around the Neutrino Area primary target located in the Target Tube until 1982. Between 1982 and 1988 the target was located in a new enclosure 300 ft south of the Target Tube. At the end of February 1988 the neutrino production program was completed. During CY-1988 and CY-1989, additional boring holes were installed in the vicinity of the Neutrino Area primary target to provide an early warning of possible downward migration. This work was discussed in detail last year (Co90a). Results obtained during CY-1990 found some samples concentrations of tritium from these wells with ^{3}H concentrations as high as 1.3 Bq/ml (3.5×10^{-5} μCi/ml), slightly more than the .74 Bq/ml (2×10^{-5} μCi/ml) standard for community drinking water supplies specified in 40 CFR 141.

In CY-1983 a new target and dump system was put into operation to abort any errant protons inside the Main Ring tunnel. The well-shielded dump was placed just outside the tunnel (near C1 in Fig. 6). It was provided with a sampling underdrain which normally is not pumped (Ba86, Ba75b). The drains adjacent to the Main Ring tunnel lead to sump pits equipped with pumps, hence water in the region around the tunnel and above the underdrains is normally kept free of standing water. The region below the Main Ring drains is not. The abort dump itself is sealed watertight. Drains inside have remained dry. The part of the dump below the Main Ring tunnel drains sits in water, permitting leaching of tritium produced in the sand and gravel surrounding the dump. Water samples from the underdrain beneath the dump contain tritium and ^{22}Na. The concentrations are below the DOE Derived Concentration Guides for release to surface waters. (See Table 17.)

5.5.3 Beryllium-7

Concurrent with the production of ^{3}H with a 12 year half-life is the production of ^{7}Be with 53 day half-life in the closed cooling water systems. The ^{7}Be is chemically active and is easily removed from the water by the resins used

to maintain water purity. The tritium remains in the cooling water system. These resins are regenerated in two separate systems located at the Central Utility Building. The effluent from these two systems is sent to a settling tank for removal of almost all of the radioactivity before it is sent to the clay tile field inside the Main Ring (see Sect. 6.10 and Fig. 2). There it percolates into the soil about 60 cm (2 ft) below the surface. The short half-life of ^{7}Be and its strong chemical affinity with the soil ensure that any residual radioactivity released will place no burden on the environment. The amount of ^{7}Be discharged to the tile field in CY-1990 was very small; however trace amounts were detected in the CUB Tile Field soil. (See Table 9.)

5.6 Assessments of Potential Radiation Dose to the Public

The maximum dose equivalent rate at the site boundary in CY-1990 from Fermilab operations was 15.9 mrem (0.159 mSv) for CY-1990 due to muons from the Meson Area (see Section 5.2). The point where that exposure occurred is along the northeastern site boundary. This is approximately 5% of the average effective dose equivalent to individuals of 300 mrem (3 mSv) due to natural sources (NRC90). The effective dose equivalent at the site boundary due to the Boneyard was 1.1 mrem (1.1×10^{-2} mSv) during CY-1990 but decreased to only 0.2 mrem (2×10^{-3}mSv) at the location nearest residence, to the north of the site. The maximum effective dose equivalent at the site boundary due to airborne radioactivity was 0.031 mrem (3.1×10^{-4} mSv) to the east of the site. Thus the three principle sources of radiation exposure at the site boundary are located at different places along the site boundary so that no offsite resident is exposed to significant exposure from more than one of them.

The radiation exposure to the general population from operation of Fermilab in CY-1990 was approximately 8.0 person-rem (8.0×10^{-2} person-Sv) (Table 10). This exposure was from penetrating radiation and from airborne radionuclides. This total is to be compared with a total of approximately 2.4×10^{6} person-rem (2.4×10^{4} person-Sv) to the population within 80 km (50 mile) from natural background radioactivity. Based on typical United States radiation exposures from diagnostic x-rays, nuclear medicine treatments, and other artificial sources an additional 5×10^{5} person-rem (5×10^{3} person-Sv) would be expected for the population within 80 km (50 mile) of Fermilab in CY-1990 (NRC90). (NOTE: Increased natural background exposures taken from this ref. (NRC90) include the effects of improved understanding of the indoor radon problem.)

The magnet debonding oven was used to debond 6 radioactive magnets in CY-1990. The resulting ^{3}H release from the debonding oven stack had negligible impact on individual or collective effective dose equivalent to members of the public.

Table 10

Summary of Collective Effective Dose Equivalent for CY-1990 Within a 50 mile (80 km) Radius of Fermilab

Source	Collective Effective Dose Equivalent person-rem	person-Sv
penetrating radiation from muons	5.93	5.93×10^{-2}
penetrating radiation from the Boneyard (gamma rays)	1.20	1.20×10^{-2}
airborne radioactivity from the target stations	0.82	8.2×10^{-3} [b]
Total	**7.95**	**7.95×10^{-2}**

[b]Population dose from airborne radioactivity calculated using AIRDOSE-EPA rather than AIRDOS-PC since the latter does not presently have the capability to perform this calculation.

Some releases of radioactive water occurred from sumps collecting water from under areas where protons interacted. About 74% of this volume of water left the site while Casey's Pond (Fig. 2), the reservoir receiving water from discharges in the three external areas to which protons are delivered, was full. The mean concentration of tritium during the period of release was less than one percent of the Derived Concentration Guide for prolonged exposure to the general population. Also, drinking water in the area is taken from wells rather than from the creek receiving the discharge. Hence, the dose from the release was negligible. The component of the annual effective dose equivalent to members of the public due to airborne emissions is restricted to 10 mrem (0.1 mSv) by DOE 5400.5 and by 40 CFR 61, Subpart H. The applicable annual limit on effective dose equivalent for public drinking water standards is 4 mrem (4×10^{-2} mSv) according to DOE 5400.5 and 40 CFR 141.

5.6.1 Radon Assessment

During late CY-1989 and early CY-1990, DOE contracted with UNC Geotech through its Grand Junction Projects Office to conduct an indoor radon study of its major facilities in response to Public Law 100-551, the Indoor Radon Abatement Act. This included the collection of air samples from various buildings using alpha-track screening measurements and also drinking water samples. Fermilab participated in this study and was allocated 137 air sampling detectors along with 3 water samples. The air samples were installed in virtually every laboratory building in November 1989 and removed and submitted for reading in February 1990. Beam enclosures were excluded because the operations of the fixed target program would have caused prompt radiation fields sufficient to render the radon measurements invalid. (The beam enclosures are unoccupied during such operations.) The relevant concentration in air for comparison is the USEPA's residential standard of 4 pCi/liter (.15 Bq/L). The following distribution of the results was obtained:

<1 pCi/liter	107 detectors
1-2 pCi/liter	22 detectors
2-4 pCi/liter	7 detectors
>4 pCi/liter	1 detector.

1990

The single reading in excess of the 4 pCi/liter (.15 Bq/liter) standard was a value of 6.9 pCi/liter (.25 Bq/liter) found in the basement of a house used by Security personnel in the Emergency Services Department. In response to this survey, a sub-slab suction system was installed to reduce the radon concentration. Measurements subsequent to this modification recorded a concentration of 1.4 pCi/liter (.05 Bq/liter).

Water samples were taken for three wells used for general drinking water supplies onsite (Wells 1, 3, and 5). The radon concentrations for these wells were found to be 11 (300), 4.4 (120), and 3.7 (100) Bq/liter (pci/liter), respectively. These values are typical of those found at many DOE facilities. This study is documented in a written report (DOE90b).

6.0 ENVIRONMENTAL MONITORING FOR NONRADIOACTIVE POLLUTANTS

6.1 Conventional Air Emissions

Monitoring of conventional emissions is in accordance with the requirements of applicable Federal, State, and local regulations authorized by the Clean Air Act (42 U.S.C. 7401, et. seq.), Section 118. Operating permits have been obtained from the Illinois Environmental Protection Agency (IEPA), Division of Air Pollution Control, for all applicable Fermilab sources of airborne emissions (Table 11). Permitted equipment operates as described in the application on file with the IEPA. Operations will, at a minimum, be reviewed annually at the time of submission of the annual Air Emission Reports as required by IEPA (Ill. Adm. Code 201.302) to ensure that the permitted equipment continues to operate and be maintained in accordance with permit conditions. Operations are also reviewed when applying for renewal of an existing operating permit. Annual emissions reports are submitted to IEPA indicating whether maximum emissions have increased, remained the same, or decreased based on comparison of operating parameters in the application on file with that agency.

Table 11

Fermilab IEPA Air Pollution Permit Conditions

Application No.	Description	Special Conditions
86020057	Gasoline dispensing tanks	
87110096	5 gas-fired hot water boilers	WBL boilers
	1 propane-fired boiler	<1.2 tons/yr nitrogen oxides
	1 grit blaster	
89090071	2 gas-fired hot water boilers	Lab A<0.12 lb/hr nitrogen oxides
	(Lab A & Meson Detector	Lab A<0.45 tons/yr nitrogen oxides
	Bldg)	
		Meson Det. Bldg. <0.26 lb/hr nitrogen oxides
		Meson Det. Bldg. <0.98 tons/yr nitrogen oxides
88010042	Vapor Degreaser (IB3)	<1 ton/yr organic emissions
79070012	Magnet Debonding Oven	25 mrem/yr whole body*
	(IB2)	75 mrem/yr critical organ to any member
89080089	Radionuclide emissions	25 mrem/yr whole body*
	from accelerator operations	75 mrem/yr critical organ to any member

*Conditions superseded by more stringent provisions of 10 CFR 61, Subpart H.

1993

6.2.1 Chlorine

In addition to the routine chlorination of the Main Site water system and the swimming pool, a chlorination system for the Swan Lake cooling pond system has proved successful in helping to eliminate the need for chromate treatment of the cooling towers. Chlorine is added to the cooling water for a period of 30 minutes four times a day at a rate which results in a chlorine concentration of 0.5 ppm as the cooling water leaves the equipment. Only one piece of equipment within the plant is chlorinated at a time. Consequently the concentration of chlorine entering the Swan Lake system is significantly reduced from 0.5 ppm.

6.2.2 Bromine

Bromine was used for the first time in 1987 for water treatment at Fermilab. Water pumped from Casey's Pond was treated with a 1-Bromo-3chloro-5,5-dimethyl hydantoin chemical in a pellet form. This chemical, Nalco 85WT-037/7343, is supplied by Nalco Chemical Company, One Nalco Center, Naperville, Illinois 60566. The bromamines formed when the chemical reacts with agricultural based amines are more effective biocides than chloramines. Thus, better control of biological growth in the heat exchangers in the Research Area is expected using this treatment instead of chlorination. No treatment has been done in the past because air towers rather than industrial water heat exchangers were used. A comprehensive monitoring program to minimize the amount of chemical required has been initiated. The total available halogen was adjusted to be 0.2 g/liter or less in the water as it leaves the heat exchangers. The total amount of Nalco 85WT-037 used in CY-1990 was only 159 kg (350 lbs).

6.2.3 Heavy Metals and Other Toxic Materials

No heavy metals were used for water treatment of the cooling towers. The chlorinated Swan Lake cooling pond water was passed through the cooling system and a biodispersant, Nalco 7349, was added which lifted deposits from the metal surfaces so they could be oxidized by the chlorine. It was applied at a rate of 25 ml/min for 180 minutes per day. Nalco 7349 is a polyglycol manufactured by Nalco Chemical Company. Another Nalco product, Nalco 1332, was applied continuously to maintain less than 1 mg/liter with a peak total phosphorus concentration of 1-2 ppm. Nalco 1332 is an organophosphorus compound which prevents scale information. It does not have the toxic properties of organic phosphorus esters found in some restricted-use pesticides (Wo81). In CY-1990 a total of 7,165 kg (15,800 lbs) of Nalco 1332 was used and 500 gal. (1893 liters) of Nalco 7349.

Although it was necessary to chemically treat some waters with aquazine to control the growth of algae and weeds during CY-1990, efforts were made to keep these treatments as low as possible in order to protect wildlife and fish. Aquazine is biodegradable and no environmental impact is expected. There is a program to look for persistent chemicals

in the Fermilab environment periodically. (See Section 6.3.1 for more information about algae control.) Pesticide applications to surface waters in CY-1990 are listed in Table 12.

Copper was applied to Fermilab surface water for algae control. It was applied as a copper-ethanolamine complex which prevents the copper from precipitating out with carbonates and bicarbonates in the water. Copper solution from the etching of printed circuit boards was disposed of as hazardous waste or recycled. Chromate treatment of the cooling towers has been replaced by biodegradable treatments. The environmental impact from heavy metals is and should continue to be negligible.

6.3 Pesticides

Site Pest Control Program - Licensed Fermilab personnel applied the following pesticides onsite for aquatic algae, annual and perennial weeds and grasses, and mosquito control in CY-1990. All pesticides were EPA registered and were applied according to the manufacturer's instructions and Federal, State, and local guidelines.

6.3.1 Surface Waters

Aquatic Algae - These pesticides were applied to control and maintain water quality onsite by inhibiting the growth of algae. Applications of aquatic herbicides/algicides were done to no more than half of a body of water at one time to avoid stressing fish populations due to oxygen depletion in the water from decaying algae.

Aquazine EPA #100-570 - A total of 705.2 kg (1554.8 lb) of Aquazine, containing 80% of the active ingredient Simazine [2-chloro-4,6-bis(ethylamino)-s-triazine], was applied to 194.4 acres of water in CY-1990.

Cutrine Plus EPA #8959-10AA - A total of 248.4 liters (65.6 gal.) of Cutrine Plus, containing 9% of the active ingredient copper, was applied to 38.3 acres of water in CY-1990. The copper is contained in a mix of copper-ethanolamine complexes. The ethanolamines prevent the precipitation of copper with carbonates and bicarbonates in water eliminating the problem of toxic accumulations of copper in the sediments that can occur with non-chelated copper compounds like copper sulfate.

Table 12

Pesticide Applications to Surface Waters at FNAL in CY-1990

Treatment Area	Acres	# of Applications	Aquazine Total Applied (kg)	Cutrine Plus # of Applications	Total Applied (liters)
Booster Pond	5.3	1	19.1	3	36.0
Center Reflecting Pond	3.0	1	10.9	2	13.6
East Reflecting Pond	2.8	1	10.2	0	0
Main Ring Ponds	150.0	1	544.2	0	0
Swan Lake	28.8	1	104.5	3	196.1
Swan Lake Ditch	1.2	0	0	1	2.7
West Pond	4.5	1	16.3	0	0

6.3.2 Annual and Perennial Weeds and Grasses

These pesticides were applied around the bases of trees, sign posts, foundations, LP gas tanks and fire hydrants in the following areas for landscape maintenance: Fermilab Village and Sauk Circle, East Gate Area, Batavia Road, D Road, Pine Street, B Road, A-1 Road, A-2 Road, West Wilson Road, CDF, Industrial Center, New Muon and Bubble Chamber, EOAC, and Sites 38, 50, 52, 56, 58, and 64:

Roundup EPA #524-308-AA - Isopropylamine Salt of N-(phosphonomethyl) Glyphosate, 41.0%

Surflan EPA #1471-113 - Oryzalin (3,5-dinitro-N^4, N^4-dipropylsulfanilamide), 40.4%

Equal amounts of each pesticide (1.5 oz) were mixed in a tank and applied at a rate of one tank per 1000 ft^2.

6.3.3 Mosquitoes

A pesticide was applied at Fermilab during June, July, August, and September of CY-1990 for the purpose of mosquito control. Two sitewide applications occurred with one extra application to Sites 29 and 58. Lakes, streams, ponds, and those areas with a high concentration of motor vehicles were avoided.

This pesticide was: Cythion ULV EPA #241-208AA - Malathion [S-(1,2-Dicarbethoxyethyl)-0, 0-dimethyl-dithio phosphate], 91.0%

It was applied as an ultra low volume fog at a rate of 2 ounce per minute.

1993

6.3.4 Miscellaneous Pest Control

A licensed contract exterminator was retained during CY-1990 for miscellaneous pest control in kitchens, laboratories and living areas throughout the site. (See Table 13.)

Table 13

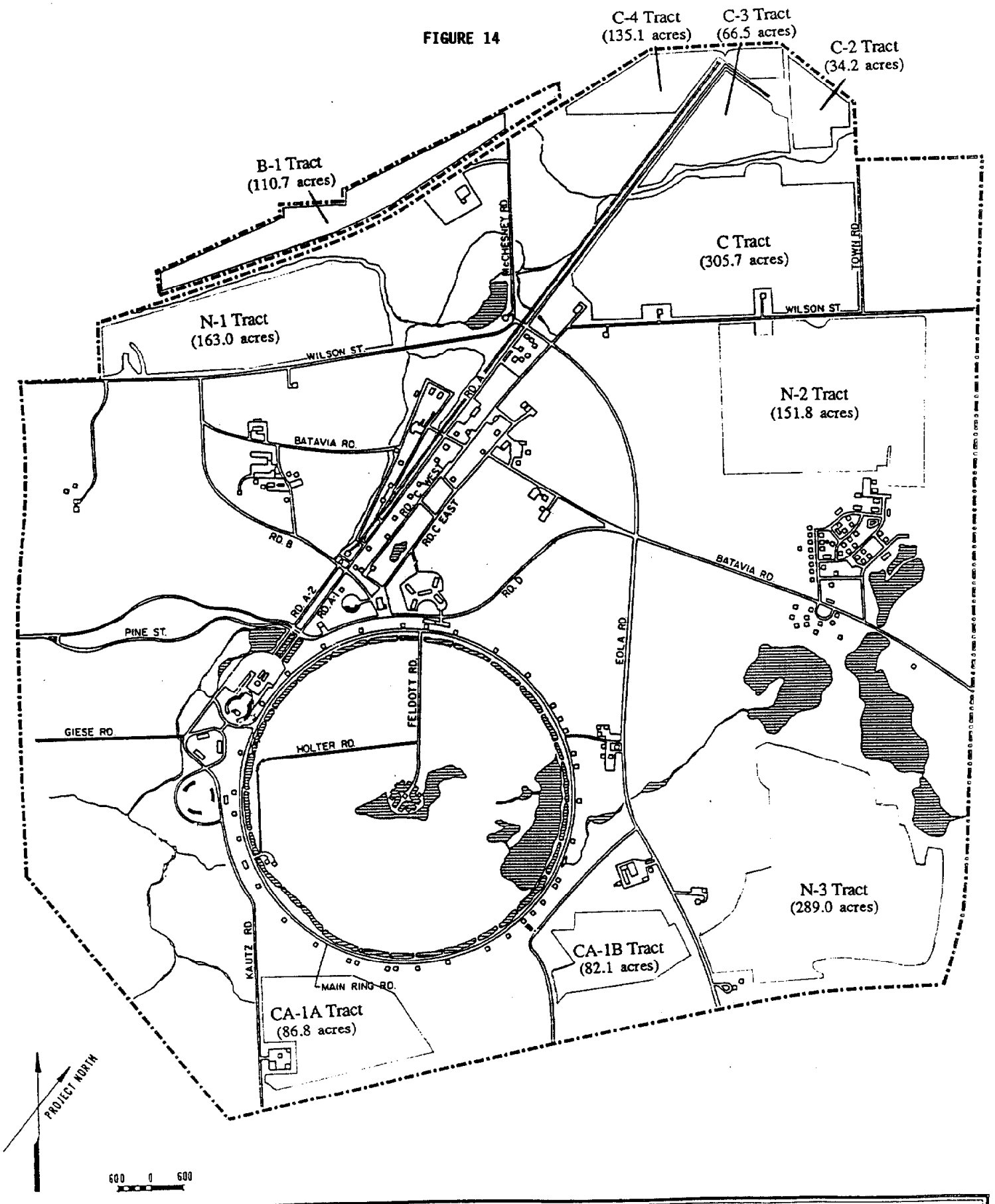
Pesticides Applied by Licensed Contractor in CY-1990

Pesticide	EPA Reg No.	Active Ingredient
AC Formula	56-56	Chlorophacinone 0.005%
Contrac Pellets	12455-36	Bromodiolone 0.005%
Talon-G Pellets	10182-38&40	Brodifacoum 0.005%
Weather-Blok	10182-48	Brodifacoum 0.005%
Baygon 2% Bait	3125-121	Propoxur 2.0%
Maxforce Bait	1730-67	Hydramethylnon 1.65%
Combat Bait	1730-68	Hydramethylnon 0.9%
Pro Roach Kill	45385-20203	Boric Acid 99.0%
Ficam D	45639-3	Bendiocarb 1.0%
Ficam W	45639-1	Bendiocarb 0.5 & 0.25%
Demon WP	10182-71	Cypermethrin .2 & .1%
Tempo 20 WP	3125-380	Cyfluthrin 0.1 & 0.05%
Empire 20	464-629	Chlorpyrifos 0.4 & 0.2%
Dursban LO	464-571	Chlorpyrifos 0.5 & 0.25%
Gencor 9%	2724-351-50809	Hydroprene 0.07%
PT230 Tri-Die	499-223-AA	Pyrethrins Silica Gel 0.3%
PT240 Permadust	499-220-AA	Boric Acid 20.0%
PT250 Baygon	499-157-ZA	Propoxur 1.0%
PT270 Dursban	499-147	Chlorpyrifos 0.5%
PT280 Orthene	499-230	Acephate 1.0%
PT265A Knoxout	499-228	Diazinon 1.0%
PT515 Waspfreeze	499-240	Phenothrin 0.25%
PT565 Plus	499-285	Pyrethrins D-Trans Allenthrin 0.25%
ZP Tracking Powder	12455-16AA	Zinc Phosphide 10.0%
Rozol Tracking Powder	7173-172	Chlorophacinone 0.2%

6.3.5 Agricultural Pest Control Program

During CY-1990 Fermilab leased 5.76 km^2 (1,424.9 acres) of land to farmers for agricultural production (Fig. 14). Licensed contractors were hired by the leasees. Table 14 lists the pesticides applied to farm tracts.

FIGURE 14



Leased Farm Tracts CY 1990
Fermi National Accelerator Laboratory

1990

Table 14

Pesticides Applied to Leased Farm Tracts CY-1990

Pesticide	EPA Reg No.	Active Ingredient
Aatrex 4L	100-479	Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) 42.2%
Aatrex 9-0	100-585	Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) 85.5%
Banvel	55947-1	Dimethylamin salt of dicamba (3,6-dichloro-o-anisic acid) 48.2%
Pesticide	EPA Reg. No.	Active Ingredient
Basagran	7969-45	Sodium Bentazon [3-(1-methylethyl)-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] 42.0%
Bladex 90DF	352-495	Cyanazine [2-{[4-chloro-6-(ethylamino)-s-triazine-2-yl] amino}-2-methylpropionitrite] 90.0%
Counter 15G	241-238	Terbufos [s{[(1,1-dimethylethyl) thio] methyl} 0,0-diethyl phosphorodithioate] 15.0%
Crop Oil		Light petroleum oil and emulsifier (Petroleum Hydrocarbon 83.0%)
Force 1.5G	10182-130	Tefluthrin (2,3,5,6-tetrafloro-4-methylphenyl + 2-chloro-3,3,3,-trifloro-2,2-dimethylcyclopropanecarboxylate) 1.5%
Fusilade	10182-104	Fluazifop-p-butyl [butyl(r)-2-(4,5-trifloromethyl-2-pyridenyloxy) phenoxypropanoate] 13.1%
Lasso	524-314-AA	Alachlor [2-chloro-2,6-diethyl-N-(methoxymethyl) acetanilide] 45.1%
Marksman	55947-39	Potassium salt of dicamba (3,6-dichloro-o-anisic acid) 13.4% Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) 22.2%
Pursuit	241-310	Imazethapyr [Ammonium Salt of (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]] 21%

6.4 Polychlorinated Biphenyls

An inventory of polychlorinated biphenyls (PCBs) still on the site is maintained. PCB inspections are performed and records are maintained as required by TSCA (40CFR761.180). As of January 1, 1991, there were 41 PCB transformers and 13 PCB contaminated transformers in use or in storage for use. The inventory of large PCB capacitors in use, in storage for use, or in storage for disposal was reduced from 16 to 0 in CY-1990. The capacitors were disposed by incineration in an offsite EPA-approved incinerator.

1990

6.5 Hazardous Wastes

Responsibility for disposal of hazardous waste was assigned to the Environment, Safety and Health Section (formerly called the Safety Section) in CY-1979 and a hazardous waste handling and storage facility was developed at Site 55 (Fig. 2). This facility is roofed and fenced, and has a hardstand and 4 concrete containment areas. This facility was intended for inside storage of hazardous materials which are for future use. This usage of Site 3 for storage was phased out in CY-1989. In CY-1982 a PCB storage building was constructed at Site 55 which is much farther from the site boundary than Site 3. This structure now houses all PCB items awaiting disposal. In CY-1984 a heated chemical waste storage building was added at Site 55. This facility was completed in 1985 and has a hood and an indoor shower and eyewash. It also has indoor containment areas to segregate acids and bases. Typical wastes are solvents, oils, laboratory chemicals, asbestos, acids, and bases.

Over the years it has been the practice to deposit excess materials such as lumber, concrete, building materials and earth on the Meson Area shielding hill; (north of the Meson Lab, Fig. 1) adding shielding to scatter muons. To assure that none of these materials is hazardous to the environment and none will contribute to the contamination of surface or groundwaters, a program to control such deposition was developed during 1979. Rules have been promulgated and responsibility for access and control has been assigned to the Roads and Grounds group which operates a permit system for deposition. In 1982 burial of wood, paper and other wood products on the hill was halted.

In order to efficiently organize the collection of drum quantities hazardous waste, a number of satellite accumulation areas have been established to collect the waste. An ongoing program has been established to improve these areas by including provision for secondary containment for the ones that are outdoors. At Site 55, wastes are stored in a hazardous waste storage facility. The permit status of this facility is discussed in Section 4.3.

6.6 Chlorides

The potential environmental impact of release of chlorides from the resin regeneration process into the CUB clay tile field (Fig. 2) has been evaluated. The regeneration process uses sodium hydroxide and hydrochloric acid, yielding sodium chloride (salt) and water. Assuming the salt released in one year (before CY-1986) all ends up in the nearest drinking water well (W-1 in Fig. 7) and is diluted in the water normally pumped from the well for one year the concentration would be less than 25% of the applicable limit of 250 mg/liter. Thus, the environmental impact should be minimal. Disposal of large volumes of salt in the CUB Tile Field was halted in CY-1986.

1770

6.7 Ethylene Glycol

A release of coolant water containing ethylene glycol occurred from a sump pit from the west side of the Meson Detector Building. The discharge impacted sediments in a nearby drainage ditch. The impacted soils were excavated from the ditch and stockpiled under plastic sheeting. On November 30, 1990, Eichleay Engineers, Inc. (EEI), performed a sampling of the stockpiled soils for the full span of state mandated disposal parameters. In addition, water samples were taken from the sump outlet to determine if the water discharged from the sump contained any compounds regulated under the Clean Water Act.

Analytical results of the stockpiled soil indicated that the soil was nonhazardous material, neither regulated as hazardous nor as special waste according to Illinois Administrative Code and Title 40 CFR 261. The analytical results of the liquid being discharged from the sump indicated that it contained no compounds regulated by the Clean Water Act (Ei91).

6.8 Chlorofluorocarbons

A mixture of chlorofluorocarbons (Freon 115 and 116) having high vapor pressure became contaminated with oil (about 10% by volume) when a bubble chamber piston seal failed. The mixture was placed in a propane gas storage tank awaiting disposal. During early CY-1988 a leaking valve was discovered on the propane tank. Approximately 520 liters (137 gal.) of chlorofluorocarbons had vented. The remaining Freon mixture has been transferred into compressed cylinders and was shipped for disposal to a RCRA permitted facility during CY-1990.

6.9 SARA Title III Chemical Inventory Findings

In early CY-1991 Fermilab conducted a sitewide chemical inventory in accordance with the reporting requirements for CY-1990 or SARA Title III. Additional information on quantities, onsite locations was also collected to facilitate reporting for:

Section 304:	Emergency Notification;
Section 311-312:	Community Right to Know Requirements; and
Section 313:	Toxic Chemical Release Reporting.

Reporting had been completed under Section 311-312 for hazardous chemicals used in $\geq$10,000 lbs and extremely hazardous substances $\geq$500 lbs or the threshold planning quantities, whichever was lower.

The majority of these chemicals are used in the Central Utility Building, Sites 38, 43, 65, the transformers for the Main Ring and utilities, Meson, Neutron, and Proton areas.

Other chemicals for which we have received MSDS's have been reported to local emergency planning committees and the State Emergency Response Commission. These lists are updated annually.

An inventory of all hazardous chemicals, regardless of quantity, was also taken. This information was submitted to the local Fire Department, to inform them of the location and quantities of all flammable, corrosive, toxic and reactive chemicals. This information is used primarily to protect them when responding to a fire or other emergency onsite.

A list of the large quantity chemicals used at Fermilab during CY-1990 is shown below:

Table 15

LARGE QUANTITY CHEMICAL MATERIALS IN THE SARA TITLE III INVENTORY FOR CY-1990

Material Category	Amount (lbs)
Heat Transfer/Antifreeze Liquids	81,548
Ethylene glycol	
Petroleum Hydrocarbons	
Gasoline	1,085,118
Diesel	197,457
Solvent	
Freon 113 (1,1,2-Trichloro-1,2,2-trichfluoroethane	21,568
Corrosives	
Hydrochloric Acid	27,019
Sodium Hydroxide	47,569
Toxics (extremely hazardous)	
Chlorine	2,850
Polychlorinated Biphenyls	~15,000
Scintillation Fluid (contains 1,2,4-Trimethyl Benzene)	32,400

6.10 Environmental Occurrences

On December 14, 1990, a sheen of oil was noted on the cooling pond named Swan Lake. This oil appeared to be a few gallons of light mineral oil and was contained and absorbed to the extent possible. Further investigation revealed the source of this oil to be a sump pump in an underground enclosure and may have been due the T82A

transformer spill event of 1985 described more fully in Section 4.5.4. This event was promptly reported in accordance with procedures specified in DOE Order 5000.3A (DOE90c). Because it was a visible sheen of oil, it was also reported in accordance with regulations to the National Response Center, the Illinois Emergency Services and Disaster Agency (IESDA) and the DuPage County Local Emergency Planning Committee (DLEPC).

Also in December 1990 a small spill (approximately 1 cup) of PCB transformer oil occurred at one of the Main Ring transformers. This spill is superimposed on the older spills discussed in section 4.5.4. Immediate cleanup of all visible traces was accomplished. Long-term cleanup will be coordinated with that of the other Main Ring sites, since this spill cannot be separated from the older spills

Trace amounts of heavy metals and copious quantities of sodium chloride have been discharged into the CUB Tile Field (tile field in Fig. 2) inside the Main Ring in the past. Copper is the primary heavy metal. It is an impurity removed by the ion exchange resins used to keep the conductivity of closed loop water systems low. These mixed-bed resins are regenerated using hydrochloric acid and sodium hydroxide. When the two chemicals combine after traversing the resins, salt (NaCl) is formed. Trace amounts of ^{7}Be are also removed (Section 5.5.3). A settling tank was used beginning in CY-1986 to remove salt and ^{7}Be from the effluent from resin regeneration. The salt is being stored to allow ^{7}Be levels to decrease by radioactive decay. Concentration of the radionuclides by reducing the water content with a press and then drying the salt in an oven has resulted in detection of ^{60}Co in the salt.

There were no activities during CY-1990 which created problems with respect to nonradioactive airborne effluents. Heating is accomplished by use of natural gas, liquefied propane gas, or electricity. The bulk of the heating is supplied by natural gas fired boilers located in the Central Utility Building. These boilers are adjusted annually to maintain proper combustion efficiency.

7.0 QUALITY ASSURANCE IN CY-1990

Routine environmental water samples collected by the Environment, Safety and Health Section's Environmental Protection Group were analyzed for radiochemicals by International Technology (IT) Corporation, 1550 Bear Creek Road, Oak Ridge, Tennessee 37831 in the first half of 1990. Other samples were counted at the Fermilab Activation Analysis Laboratory (AAL). By mid-year, dissatisfaction with the degenerating turnaround time for results provided by IT Corporation and subsequent notification of IT Corporation's compliance problems at its California facility led to our suspension of their use. Up to that point we had been satisfied with their quality assurance as measured by our spikes and by their performance in the EML program. Some samples from the second half of CY-1990 were analyzed at the AAL but most were sent

to a new vendor, TMA/Eberline. Delay in negotiating the specifications and cost of the necessary analysis has meant that the results for the samples sent to TMA/Eberline are not available at this time.

Environmental samples collected for chemical analysis in 1990 were sent to our contracted vendor, National Environmental Testing, Inc. (NET), Bartlett, Illinois. At NET, the samples were extracted and analyzed using standard EPA methods. Because confidence levels specified by Fermilab depend upon the intended use of the data, those levels were set by Fermilab following consultation with NET for each project.

7.1 Quality Assurance in Sampling Procedures

Samples at all locations are collected using documented procedures. These procedures ensure that samples are representative of the media from which they are collected and will yield reliable and consistent results. The EP Group of the ES&H Section has developed an Environmental Protection Group Procedures Manual (EPPM) that documents all monitoring and surveillance procedures in use. Specific procedures have been developed in accordance with established standards, practices, and protocols.

7.2 Quality Assurance in Analysis

Samples are analyzed using standard analytical procedures. Data quality is verified by a continuing program of analytical laboratory quality control, participation in interlaboratory cross-checks, and replicate sampling and analysis. When applicable to analysis requested, analytical labs must be certified. A range of radiochemical spikes are used to test our vendor's ability to achieve the required sensitivity for each parameter and reliability in detecting accelerator-produced radionuclides at or below the concentration guide standards (Table 16). Fermilab's Activation Analysis Laboratory (AAL), formerly called the Nuclear Counting lab (NCL), and our primary vendor contracted for radioanalysis both participate in DOE's EML quality assurance program. NET is certified for potable water analyses by the Illinois Environmental Protection Agency (IEPA) and participates in the USEPA's quality assurance program for analysis of water supplies (WS) and water pollutants (WP). NET has been selected as a participant in the USEPA's Contract Laboratory Program (CLP).

Fermilab and IT Corporation results in the DOE Environmental Measurements Laboratory (EML) quality assurance program (Sa90, Sa91) are found in Tables 18, 19, 20 and 21. The results of both IT Corporation and the AAL in Fermilab's radiochemical spike quality assurance program can be found in Table 16. The range of radiochemical spikes were prepared to test the ability to achieve the required sensitivity for each parameter and the reliability in detecting accelerator-produced radionuclides at or below the concentration guide standards (Table 17).

Table 16

Fermilab QA Program Results for IT Corporation and Fermilab AAL

Spike Number	Radionuclide	Prepared Conc. (Bq/ml)	Vendor Conc. (Bq/ml)	NCL Conc. (Bq/ml)	Ratio of Prepared to Vendor	Ratio of Prepared to NCL
9001	H-3	4.29E+00	4.44E+00	4.43E+00	1.03E+00	1.03E+00
9013	H-3	4.29E+00	4.40E+00	4.16E+00	1.03E+00	9.68E-01
9003/8911	H-3	4.33E-01	3.65E-01		8.43E-01	
9023/8921	H-3	4.33E-01	3.26E-01		7.54E-01	
9033/8909	H-3	1.42E+00	1.28E+00		8.99E-01	
9043/8919	H-3	1.42E+00	1.27E+00		8.88E-01	
9004	H-3	2.12E-01	1.69E-01	2.92E-01	7.96E-01	
9014	H-3	2.12E-01	1.60E-01	2.93E-01	7.56E-01	1.38E+00
9005	H-3	2.63E-01	2.83E-01	4.37E-01	1.07E+00	1.38E+00
	Co-60	4.03E-02	3.92E-02	3.92E-02	9.72E-01	1.66E+00
	Mn-54	7.25E-02	7.99E-02	8.77E-02	1.10E+00	9.72E-01
	Na-22	3.31E-01	3.21E-01	3.35E-01	9.71E-01	1.21E+00
9015	H-3	2.63E-01	2.77E-01	4.22E-01	1.05E+00	1.01E+00
	Co-60	4.03E-02	3.74E-02	4.07E-02	9.27E-01	1.60E+00
	Mn-54	7.25E-02	7.81E-02	7.47E-02	1.08E+00	1.01E+00
	Na-22	3.31E-01	3.02E-01	3.23E-01	9.12E-01	1.03E+00
9006	H-3	2.10E+00	2.13E+00	2.22E+00	1.02E+00	9.77E-01
9016	H-3	2.10E+00	2.05E+00	2.32E+00	9.79E-01	1.06E+00
9007	H-3	2.61E-01	3.44E-01	2.18E-01	1.32E+00	1.11E+00
	Co-60	4.07E-03	<3.70E-03			8.37E-01
	Mn-54	3.81E-02	2.62E-02	2.55E-02	6.86E-01	
	Na-22	1.26E-02	<1.11E-02	1.30E-02		6.70E-01
9017	H-3	2.61E-01	2.50E-01	2.07E-01	9.60E-01	1.03E+00
	Co-60	4.07E-03	<3.70E-03			7.94E-01
	Mn-54	3.81E-02	2.58E-02	3.77E-02	6.76E-01	
	Na-22	1.26E-02	<1.11E-02	1.04E-02		9.90E-01
9012	H-3	2.55E-01		2.41E-01		8.24E-01
	Co-60	3.74E-02		3.89E-02		9.43E-01
	Mn-54	1.81E-02		1.63E-02		1.04E+00
	Na-22	5.66E-02		5.14E-02		8.98E-01
9022	H-3	2.55E-01		2.07E-01		9.08E-01
	Co-60	3.74E-02		3.85E-02		8.13E-01
	Mn-54	1.81E-02		2.07E-02		1.03E+00
	Na-22	5.66E-02		6.29E-02		1.14E+00
9032	H-3	4.08E+00		3.60E+00		1.11E+00
9042	H-3	4.08E+00		3.54E+00		8.81E-01
9052	H-3	1.02E-01		<1.85E-01		8.68E-01
9062	H-3	1.02E-01		<1.85E-01		

Table 17

Specifications for the Analyses of Accelerator-Produced Radionuclides in Water

Radionuclide	CONCENTRATION GUIDE FOR POPULATION (pCi/ml) Surface Water	Groundwater	SPECIFIED SENSITIVITY AND PRECISION* (pCi/ml) Surface Water	Groundwater
^{3}H	2000	20	3.0	1.0
^{7}Be	1000	40	0.5	0.5
^{22}Na	10	0.40	0.3	0.22
^{45}Ca	50	2	0.3	0.006
^{54}Mn	50	2	0.1	0.07
^{60}Co	5	0.2	0.1	0.02

* The precision and sensitivity are stated for the 95% confidence level (approximately two standard deviations). The precision required is the value specified or ±10 percent, whichever is the lesser precision. The sensitivity is taken to be the minimum concentration which can be detected within the 68 percent confidence level.

7.2.1 Analytical Procedures at IT Corporation

IT Corporation analyzed water samples using similar procedures to those described previously (Ba82). Liquid scintillation counting is done using the scintillator "Pico-FluorLLT" and a counting system, both of which were manufactured by Packard Instrument Co., Inc., 2200 Warrenville Road, Downers Grove, Illinois 60515. Gamma spectroscopy is done with intrinsic germanium semiconductor detectors with efficiencies 20% to 30% that of a 7.6 cm diameter X 7.6 cm high NaI (Tl) scintillator. Alpha detection is done using a scintillation counter after whatever specific chemical separation is required. Screening for ^{45}Ca is done by liquid scintillation counting. Any necessary chemical separation of ^{45}Ca is followed by beta counting using gas-flow proportional counters (Ha88).

The samples were subjected to the appropriate one of the following analyses:

Type 1a: Test for ^{3}H (tritium), ^{7}Be, ^{22}Na, ^{45}Ca, ^{54}Mn, and ^{60}Co at surface water sensitivities.

Type 2a: Test for all of the above at groundwater sensitivity plus total radium (the sum of ^{223}Ra, ^{224}Ra, and ^{226}Ra) and total thorium (the sum of ^{228}Th and ^{232}Th).

Type 3a: Chemical separation of ^{45}Ca before its determination, otherwise the same as Type 1a.

Type 4a: ^{3}H only, at surface water sensitivity.

Type 5a: Chemical separation of ^{45}Ca and analysis for ^{45}Ca only, using surface water sensitivity.

Type 6a: The same as Type 1a except at groundwater sensitivity.

Type 7a: The same as Type 4a except at groundwater sensitivity following distillation.

Type 8a: Test for gross alpha, gross beta, ^{3}H, ^{131}I, and ^{134}Cs at groundwater sensitivity. This analysis is performed on drinking water systems onsite which supply water to more than 25 people during the workday.

Type 9a: Test for Sr-90 only, at groundwater sensitivity.

Separate analysis of two aliquots from the same sample bottle is indicated by changing the letter "a" to the letter "b" on the Type designation.

The specifications for the above analyses are given in Table 17.

Table 18

EML Quality Assurance Program Results for IT Corporation (Sa90)

Sample Date	Sample Type	Isotope	SER	Reported Value	% Error	EML Value	Rp/EML	Ratio +/-	Units
3/90	Air	^{7}Be	1	0.468E+02	12	0.514E+02	0.91	0.14	Bq/filter
"	"	^{54}Mn	1	0.101E+02	10	0.960E+01	1.05	0.12	"
"	"	^{57}Co	1	0.652E+01	8	0.650E+01	1.00	0.11	"
"	"	^{60}Co	1	0.927E+01	10	0.940E+01	0.99	0.12	"
"	"	^{90}Sr	1	0.248E+00	13	0.240E+00	1.03	0.22	"
"	"	^{134}Cs	1	0.166E+02	5	0.182E+02	0.91	0.09	"
"	"	^{137}Cs	1	0.205E+02	9	0.204E+02	1.00	0.10	"
"	"	^{144}Ce	1	0.326E+02	10	0.312E+02	1.04	0.12	"
"	"	^{239}Pu	1	0.350E-01	17	0.390E-01	0.90	0.19	"
"	"	^{241}Am	1	0.540E-01	14	0.504E-01	1.00	0.19	"
"	"	UG_U	1	0.220E+01	17	0.201E+01	1.09	0.21	"
3/90	Soil	^{40}K	1	0.584E+03	18	0.608E+03	0.96	0.18	Bq/kg
"	"	^{90}Sr	1	0.413E+03	10	0.665E+03	0.62	0.06	"
"	"	^{137}Cs	1	0.162E+05	11	0.175E+05	0.93	0.10	"
"	"	^{239}Pu	1	0.187E+03	17	0.212E+03	0.88	0.16	"
"	"	^{241}Am	1	0.118E+03	14	0.106E+03	1.11	0.19	"
"	"	ug_U	1	0.120E+02	12	0.103E+02	1.17	0.15	"
3/90	Veg.	^{40}K	1	0.334E+03	16	0.323E+03	1.03	0.19	"
"	"	^{90}Sr	1	0.744E+02	10	0.702E+02	1.06	0.12	"
"	"	^{137}Cs	1	0.279E+02	13	0.285E+02	0.98	0.14	"
"	"	^{239}Pu	1	0.486E+00	34	0.333E+00	1.46	0.51	"
"	"	^{241}Am	1	0.131E+01	51	0.307E+00	4.27	2.22	"

Table 18 (cont.)

Sample Date	Sample Type	Isotope	SER	Reported Value	% Error	EML Value	Ratio Rp/EML	+/-	Units
"	"	ug_U	1	0.970E-01	23	0.418E-01	2.32	0.56	"
3/90	Water	^{3}H	1	0.190E+04	10	0.196E+04	0.97	0.10	"
"	"	^{54}Mn	1	0.107E+03	10	0.103E+03	1.04	0.12	Bq/liter
"	"	^{57}Co	1	0.195E+03	7	0.198E+03	0.98	0.09	"
"	"	^{60}Co	1	0.184E+03	7	0.206E+03	0.89	0.08	"
"	"	^{90}Sr	1	0.113E+03	9	0.111E+03	1.02	0.11	"
"	"	^{134}Cs	1	0.417E+03	6	0.462E+03	0.90	0.08	"
"	"	^{137}Cs	1	0.191E+03	9	0.198E+03	0.96	0.11	"
"	"	^{144}Ce	1	0.450E+03	10	0.403E+03	1.12	0.13	"
"	"	^{239}Pu	1	0.121E+01	12	0.104E+01	1.16	0.18	"
"	"	^{241}Am	1	0.882E+00	17	0.860E+00	1.03	0.20	"
"	"	ug_U	1	0.710E-01	16	0.788E-01	0.90	0.15	"

Table 19

EML Quality Assurance Program Results for Fermilab (Sa90)

Sample Date	Sample Type	Isotope	SER	Reported Value	% Error	EML Value	Ratio Rp/EML	+/-	Units
3/90	Air	^{7}Be	1	0.476E+02	13	0.514E+02	0.93	0.15	Bq/filter
"	"	^{7}Be	2	0.470E+02	13	0.514E+02	0.91	0.15	"
"	"	Mn_{54}	1	0.889E+01	13	0.960E+01	0.93	0.13	"
"	"	Mn_{54}	2	0.898E+01	13	0.960E+01	0.94	0.13	"
"	"	^{57}Co	1	0.526E+01	9	0.650E+01	0.81	0.10	"
"	"	^{57}Co	2	0.536E+01	9	0.650E+01	0.82	0.10	"
"	"	^{60}Co	1	0.874E+01	9	0.940E+01	0.93	0.11	"
"	"	^{60}Co	2	0.844E+01	9	0.940E+01	0.90	0.10	"
"	"	^{134}Cs	1	0.166E+02	6	0.182E+02	0.91	0.10	"
"	"	^{134}Cs	2	0.163E+02	6	0.182E+02	0.90	0.10	"
"	"	^{137}Cs	1	0.188E+02	13	0.204E+02	0.92	0.13	"
"	"	^{137}Cs	2	0.182E+02	13	0.204E+02	0.89	0.13	"
"	"	^{144}Ce	1	0.278E+02	11	0.312E+02	0.89	0.11	"
"	"	^{144}Ce	2	0.264E+02	13	0.312E+02	0.85	0.12	"
3/90	Soil	^{40}K	1	0.627E+03	10	0.608E+03	1.03	0.11	Bq/kg
"	"	^{137}Cs	1	0.187E+05	10	0.175E+05	1.07	0.11	"
"	"	^{241}Am	1	0.949E+02	10	0.106E+03	0.90	0.13	"
3/90	Veg.	^{40}K	1	0.287E+03	10	0.323E+03	0.89	0.12	"
"	"	^{137}Cs	1	0.280E+02	10	0.285E+02	0.98	0.11	"
3/90	Water	^{3}H	1	0.203E+04	3	0.196E+04	1.04	0.05	Bq/liter
"	"	^{54}Mn	1	0.101E+03	9	0.103E+03	0.98	0.11	"
"	"	^{57}Co	1	0.180E+03	7	0.198E+03	0.91	0.08	"
"	"	^{60}Co	1	0.186E+03	6	0.206E+03	0.90	0.08	"
"	"	^{134}Cs	1	0.424E+03	4	0.462+03	0.92	0.06	"
"	"	^{137}Cs	1	0.189E+03	10	0.198E+03	0.95	0.11	"
"	"	^{144}Ce	1	0.426E+03	8	0.403E+03	1.06	0.10	"

Table 20

EML Quality Assurance Program Results for IT Corporation (Sa91)

Sample Date	Sample Type	Isotope	SER	Reported Value	% Error	EML Value	Ratio Rp/EML	+/-	Units
9/90	Air	^{54}Mn	1	0.355E+02	5	0.333E+02	1.07	0.06	Bq/filter
"	"	^{57}Co	1	0.125E+02	4	0.114E+02	1.10	0.06	"
"	"	^{60}Co	1	0.238E+02	7	0.254E+02	0.94	0.07	"
"	"	^{90}Sr	1	0.160E+00	43	0.930E-01	1.72	0.78	"
"	"	^{134}Cs	1	0.171E+02	6	0.163E+02	1.05	0.07	"
"	"	^{137}Cs	1	0.164E+02	3	0.157E+02	1.04	0.04	"
"	"	^{144}Ce	1	0.177E+02	5	0.165E+02	1.07	0.07	"
"	"	^{239}Pu	1	0.470E-01	14	0.510E-01	0.92	0.19	"
"	"	^{241}Am	1	0.430E-01	13	0.360E-01	1.19	0.18	"
"	"	ug_U	1	0.115E+01	11	0.985E+00	1.17	0.13	"
9/90	Soil	^{40}K	1	0.545E+03	13	0.513E+03	1.06	0.15	Bq/kg
"	"	^{90}Sr	1	0.630E+01	20	0.833E+01	0.76	0.21	"
"	"	^{137}Cs	1	0.201E+03	10	0.196E+03	1.03	0.14	"
"	"	^{239}Pu	1	0.130E+01	15	0.115E+01	1.13	0.19	"
"	"	^{241}Am	1	0.150E+01	33	0.738E+00	2.03	0.75	"
"	"	ug_U	1	0.210E+01	19	0.219E+01	0.96	0.18	"
9/90	Veg.	^{40}K	1	0.109E+04	13	0.103E+04	1.06	0.16	"
"	"	^{90}Sr	1	0.760E+03	14	0.889E+03	0.85	0.13	"
"	"	^{137}Cs	1	0.190E+02	13	0.182E+02	1.04	0.16	"
"	"	^{239}Pu	1	0.107E+00	51	0.959E-01	1.12	0.57	"
9/90	Water	^{3}H	1	0.424E+04	10	0.390E+04	1.09	0.15	Bq/liter
"	"	^{54}Mn	1	0.306E+03	4	0.301E+03	1.02	0.05	"
"	"	^{57}Co	1	0.141E+04	2	0.130E+04	1.08	0.04	"
"	"	^{60}Co	1	0.509E+03	3	0.491E+03	1.04	0.05	"
"	"	^{90}Sr	1	0.115E+02	3	0.993E+01	1.16	0.07	"
"	"	^{134}Cs	1	0.363E+03	3	0.355E+03	1.02	0.06	"
"	"	^{137}Cs	1	0.403E+03	4	0.390E+03	1.03	0.06	"
"	"	^{144}Ce	1	0.917E+03	4	0.923E+03	0.99	0.05	"
"	"	^{239}Pu	1	0.870E+00	8	0.109E+01	0.80	0.07	"
"	"	^{241}Am	1	0.550E+00	5	0.567E+00	0.97	0.09	"
"	"	ug_U	1	0.200E-01	15	0.189E-01	1.06	0.16	"

1990

Table 21

EML Quality Assurance Program Results for Fermilab (Sa91)

Sample Date	Sample Type	Isotope	SER	Reported Value	% Error	EML Value	Ratio Rp/EML	+/-	Units
9/90	Air	^{54}Mn	1	0.332E+02	9	0.333E+02	1.00	0.10	Bq/filter
"	"	^{54}Mn	2	0.327E+02	10	0.333E+02	0.98	0.10	"
"	"	^{57}Co	1	0.118E+02	6	0.114E+02	1.04	0.08	"
"	"	^{57}Co	2	0.117E+02	6	0.114E+02	1.03	0.08	"
"	"	^{60}Co	1	0.226E+02	7	0.254E+02	0.89	0.07	"
"	"	^{60}Co	2	0.222E+02	7	0.254E+02	0.87	0.06	"
"	"	^{134}Cs	1	0.161E+02	4	0.163E+02	0.99	0.05	"
"	"	^{134}Cs	2	0.160E+02	5	0.163E+02	0.98	0.05	"
"	"	^{137}Cs	1	0.157E+02	10	0.157E+02	1.00	0.11	"
"	"	^{137}Cs	2	0.156E+02	10	0.157E+02	0.99	0.11	"
"	"	^{144}Ce	1	0.165E+02	10	0.165E+02	1.00	0.11	"
"	"	^{144}Ce	2	0.161E+02	9	0.165E+02	0.98	0.10	"
9/90	Soil	^{40}K	1	0.610E+03	22	0.513E+03	1.19	0.27	Bq/kg
"	"	^{137}Cs	1	0.214E+03	10	0.196E+03	1.09	0.14	"
9/90	Veg.	^{40}K	1	0.103E+04	10	0.103E+04	1.00	0.12	"
"	"	^{137}Cs	1	0.168E+02	10	0.182E+02	0.92	0.12	"
9/90	Water	^{3}H	1	0.406E+04	5	0.390E+04	1.04	0.11	Bq/liter
"	"	^{54}Mn	1	0.297E+03	10	0.301E+03	0.99	0.10	"
"	"	^{57}Co	1	0.135E+04	7	0.130E+04	1.04	0.08	"
"	"	^{60}Co	1	0.508E+03	7	0.491E+03	1.03	0.08	"
"	"	^{134}Cs	1	0.375E+03	5	0.355E+03	1.06	0.07	"
"	"	^{137}Cs	1	0.413E+03	10	0.390E+03	1.06	0.11	"
"	"	^{144}Ce	1	0.875E+03	8	0.923E+03	0.95	0.08	"

7.2.2 Additional Quality Assurance Efforts

The scope of the environmental protection program at Fermilab has broadened over the years. The Laboratory has doubled in personnel from the number employed when the first proton beam was extracted from the main accelerator in 1972. Regulations have changed. Much more emphasis is now being placed on control of hazardous wastes and other nonradioactive pollutants.

As the inventory of radionuclides with potential for release to the environment has grown, the environmental monitoring program has expanded. More remote pathways have been explored and additional sampling points have been added. Special investigations have been made to measure concentrations and to detect any unexpected movement of radionuclides. These investigations would provide any necessary early warnings, giving time to take action before an offsite problem occurs.

Fermilab has a number of closed water systems which build up inventories of radionuclides, primarily tritium. These are sampled periodically to provide information useful for spill control. The precautions taken are imposed based upon the potential environmental impact. Once the concentration exceeds that which can be released according to DOE regulations, then a spill plan is written and becomes part of the Laboratory's Spill Prevention, Control and Countermeasures Plan (SPCC Plan).

In addition, the Laboratory has strengthened its waste collection and auditing programs. Hazardous waste generators on the site are now required by regulation (40CFRc) to have a waste minimization program. The Laboratory documents these efforts in an annual report to the State of Illinois. This report also gives the quantities and types of hazardous waste generated, stored onsite, and disposed of off the site. The Laboratory does not have an onsite hazardous waste disposal facility.

8.0 REFERENCES

The appropriate Radiation Protection Standard for penetrating radiation applied to individuals in uncontrolled areas was taken from the DOE Order 5400.5. The annual dose limit for whole body exposure is 100 mrem (1 mSv) including all exposure modes.

The Concentration Guides used in the analyses of the surface water samples for radioactivity were taken from DOE Order 5400.5 (DOE90a) and Derived Concentration Guides (DCG); Concentrations of Radionuclides in Water and Air that could be Continuously Consumed or Inhaled, Respectively, and Not Exceed an Effective Dose Equivalent of 100 mrem/year (1 mSv/year). These Derived Concentration Guides are based on guidance given in International Commission on Radiological Protection (ICRP) Publications 23, 26, and 30, Pergamon Press, New York. The source for EPA guidance on radon exposure is document EPA-OPA-86-004, issued in August 1986. The recommended residential limit is 4 pCi/liter (11 Bq/liter).

For analysis of groundwater samples for all radionuclides other than tritium, 4% of the Derived Concentration Guide values specified in DOE Order 5400.5 (DOE90a) were used as concentration guides. These corresponding to 4 mrem/year (4×10^{-2} mSv/year) to a full-time consumer of such water to be consistent with the USEPA's limit specified in 40 CFR 141 pertaining to community drinking water systems. For tritium, however, 40 CFR 141 specifically states a limit of 2×10^{-5} μCi/ml for tritium (compared with 8×10^{-5} μCi/ml obtained as 4% of the DOE 5400.5 DCG). The smaller value as specified by USEPA is used as the concentration guide for that radionuclide. The specified sensitivity and precision of the analyses are sensitive at 10% or less of these concentration guides.

The Air and Water Pollution Standards for nonradioactive pollutants were taken from Chapters 2 and 3 of the State of Illinois Pollution Control Board Rules and Regulations (Il75). The water's onsite were considered to be in the "general use" category. The value for total hexavalent chromium for general water quality of 0.05 mg/liter. The Standards for total copper at the discharge point and for general water quality are 1.0 and 0.02 mg/l respectively, for silver are 0.1 and 0.005 mg/liter respectively, and for cyanide are 0.025 mg/liter for both. The maximum contaminant level for chloride in water for general use is 500 mg/liter and the level of total dissolved solids is 1000 mg/liter. In public drinking water the standards for chloride and total dissolved solids are 250 mg/liter and 500 mg/liter, respectively (Ilb). The Air Quality Standards limit the release for oxides of nitrogen to 136 g (0.3 lbs) per 252 million calories (per million Btu's) of actual heat input in any one hour. Release of sulfur dioxide shall not exceed 2000 ppm (Il75).

The appropriate regulations for PCBs and hazardous wastes are found in the U.S. Code of Federal Regulations 40 CFR 761 and 40 CFR 260-265, respectively. The concentration limit is 2 ppm for human consumption of fish.

40CFR761.180 U.S. Code of Federal Regulations 40 CFR 141, 142, and 143.

40CFRa U.S. Code of Federal Regulations 40 CFR 302, Table 302.4.

40CFRc U.S. Code of Federal Regulations 40 CFR 260-265.

Aw71 Awschalom, M., et al. "Radiation Monitoring at NAL: Instruments and Systems," International Conference on Protection Against Accelerator and Space Radiation, CERN Report 71-16, p. 1035, Geneva, Switzerland, July 1971.

Ba73 Baker, S. I. National Accelerator Laboratory Environmental Monitoring Report for Calendar Year 1972, March 1973.

Ba75a Baker, S. I. National Accelerator Laboratory Environmental Monitoring Report for Calendar Year 1974, April 1975.

Ba75b Baker, S. I. "Soil Activation Measurements at Fermilab," Third ERDA Environmental Protection Conference, Chicago, September 23-26, 1975, ERDA-92, pp. 329-347.

Ba82 Baker, S. I. Fermi National Accelerator Laboratory Environmental Monitoring Report for Calendar Year 1981, Fermilab Report 82/22, May 1982.

Ba85 Baker, S.I. Fermi National Accelerator Laboratory Environmental Monitoring Report for Calendar Year 1984, Fermilab Report 85/32, May 1985.

Ba86 Baker, S. I. Fermi National Accelerator Laboratory Environmental Monitoring Report for Calendar Year 1985, Fermilab Report 86/37, May 1986.

Ba89 Baker, S. I. Fermi National Accelerator Laboratory Site Environmental Report for Calendar Year 1988, Fermilab Report 89/63, May 1989.

Bi91 Bird, M. C. and R. Lurie, "Report of the 1990 Field School Investigations at Fermi National Accelerator Laboratory: Antiproton Collider Hall 204 and Pine Street Prairie Restoration Area," Cultural Resource Management Report, 92, February 21, 1991.

1490

Bo72 Borak, T. B., et al. Health Physics 23, 679 (1972).

Bu89 Butala, S. W., S. I. Baker, and P. W. Yurista. Health Physics 57, 909 (1989).

Co81 Corley, J. P., et al. A Guide For Environmental Radiological Surveillance at U.S. Department of Energy Installation. U.S. Department of Energy Report DOE/EP-0023, July 1981.

Co83 Corley, J. P., and C. D. Corbit. A Guide for Effluent Radiological Measurements at DOE Installations. U.S. Department of Energy Report DOE/EP-0096, July 1983.

Co90 Cossairt, J. D., and D. W. Grobe. "Summary of Subsurface Exploration Near the Neutrino and Meson Target Areas," E.P. Note #2, March, 1990.

Co90a Cossairt, J.D. Fermi National Accelerator Laboratory Site Environmental Report for Calendar Year 1989. Fermilab Report 90/51, May 1990.

Co91 Cossairt, J.D. and A.J. Elwyn. "Calculation of Dose Equivalents Due to Offsite Muons for Calendar Year 1990," E.P. Note 5, February 1991.

Cs62 Csallany and Walton. Yields of Deep Sandstone Wells in Northern Illinois, Illinois State Water Survey Report of Investigation 43.

DOE88 U.S. Department of Energy, Final Environmental Impact Statement on the Superconducting Super Collider, Volume I, Chapter 4, 1988.

DOE90a Radiation Protection of the Public and the Environment, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C., June 5, 1990 (latest version).

DOE90b "Results of the Department of Energy Indoor Radon Study," DOE/ID/12584-75 prepared by UNC Geotech, August 1990.

DOE90c "Occurrence Reporting and Processing of Operations Information," U.S. Department of Energy, Washington, D.C., May 30, 1990.

Du82 Durfee, R. C. Oak Ridge National Laboratory, private communication, 1982.

Du91 Duncker, J. United States Department of the Interior, Geological Survey, 102 East Main St., Urbana, Illinois 61801, March 1990.

Ea70 Early, A. M. 1970. NAL 1970 Archaeological Survey: The Prehistoric Occupations of the National Accelerator Laboratory Site.

Ea71 Early, A. M. 1971. 1971 Salvage Excavations National Acceleratory Laboratory.

Ei91 Eichleay Engineers, Inc., "Soil Characterization Sampling in an Excavated Soil Pile Near the West Meson Detector Building, Fermi National Accelerator Laboratory, Batavia, Illinois," February 4, 1991.

El88 Elwyn, A.J., J.D. Cossairt, and W.S. Freeman, "The Monitoring of Accelerator-Produced Muons at Fermilab," Fermilab-CONF 001107, Proceedings of the 22nd Midyear Topical Meeting of the Health Physics Society, San Antonio, Texas, December 4-8, 1988.

Ha88 J. Harvey, IT Corporation, private communication, 1988.

Il75 Illinois Environmental Protection Act, Chapter 111.5, Illinois Revised Statutes, Section 1012 (f) (1975). Illinois Revised Statutes, Illinois Pollution Control Board Rules and Regulations, Chapter 3, Part II.

1990

Il78 Measurements and Calculations by R. Schicht and A. Wehrmann, Illinois State Water Survey, private communication, 1978.

Il91 Measurements made onsite by State of Illinois Water Survey Division, 101 North Island Ave., Batavia, Illinois 60510. (Reported March, 1990.)

Ilb Illinois Revised Statutes Part VIII Public Drinking Water, IEPA Supplement No. 1 304D, Table 2.

Ki85 Kirk, J.R., et al. Water Withdrawals in Illinois, 1984, Illinois State Water Survey Circular 163.

La71 Landon, R. A., and J. P. Kempton. Stratigraphy of the Glacial Deposits at the National Accelerator Laboratory Site, Batavia, Illinois, Circular 354, Illinois State Geological Survey, Champaign, Illinois, 1971.

Lu90 Lurie, R. Report on the Wooded Areas Survey, Gazebo Site 1990 Testing, Collector Interviews, and Review of Prehistoric Site Status and Location at Fermi National Accelerator Laboratory, Batavia, Illinois. Cultural Resource Management Report, 56, January 28, 1990.

Mo79 Moore, R. E., et al. "AIRDOSE-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides," Oak Ridge National Laboratory Report ORNL-5532, June 1979.

Mo86 Moore, R. E., et al. "CAAC, Code System for Implementation of Atmospheric Dispersion Assessment Required by the Clean Air Act," Oak Ridge National Laboratory Report CCC-476, December 1986.

NRC90 National Research Council: Health Effects of Exposure to Low Levels of Ionizing Radiation, BEIR Report National Academy Press, 1990.

Pf74 Pfingsten, C.W., et al. Ground Water Flow Study, National Accelerator Laboratory, near Batavia, Illinois, Soil testing Services, Inc., Northbrook, Illinois, 1974.

Sa81 Sasman, R.T., et al. Verification of the Potential Yield and Chemical Quality of the Shallow Dolomite Aquifer in DuPage County, Illinois, Illinois State Water Survey, Circular 149, 1981.

Sa82 Sasman, R. T., et al. Water Level Trends, Pumpage, and Chemical Quality in the Cambrian-Ordovician Aquifer in Illinois 1971-1980, Illinois State Water Survey, Champaign, Illinois (1982).

Sa90 Sanderson, C. G. and M. S. Feiner. Semiannual Report of the Department of Energy, Operational Safety, Health, and Environment Division - Quality Assurance Program, U.S. DOE Environmental Measurements Laboratory Reports EML-530, July 1990.

Sa91 Sanderson, C. G. and S. C. Scarpitta. Semiannual Report of the Department of Energy, Deputy Assistant Secretary for Environment, Quality Assessment Program, U.S. DOE Environmental Measurements Laboratory Report EML-535, January 2, 1991.

St83 Stevenson, G.R., "Dose and Dose Equivalent from Muons," CERN Report TISI-RP1099, European Organization for Nuclear Research, CERN, Geneva, Switzerland, 1983.

Su59 Suter, M., et al. Preliminary Report on Groundwater Resources of the Chicago Region, Illinois, Illinois State Water Survey and Geological Survey Cooperative Groundwater Report 1, 1959.

Vi 85 Visocky, A.P., et al. Geology, Hydrology and Water Quality of the Cambrian and Ordovician Systems in Northern Illinois, Illinois State Water Survey, Illinois State Geological Survey, U.S. Geological Survey Cooperative Groundwater Report 10, Champaign, Illinois, 1985.

Vi88 Visocky, A.P., et al. Groundwater Investigations for Siting the Superconducting super Collider in Northeastern Illinois. ISWS/CIR-170/88, Illinois State Water Survey, Champaign, Illinois, 1988.

Wo81 Wolf, C. H. Nalco Chemical Company, private communication, 1981.

Ze62 Zeizel, A.J., et al. Groundwater Resources of DuPage County, Illinois, Illinois State Water Survey and Geological Survey, Cooperative Groundwater Report 2, 1962.

9.0 ACKNOWLEDGMENTS

Paul Kesich compiled much of the environmental monitoring data. Contributing authors are listed on the cover. The figures containing photos were recently updated versions of those in the Fermi National Accelerator Laboratory Graphic Overview System complied for the Department of Energy by H. Berry, Z. Burson, and others in the EG&G Energy Measurement Group, P.O. Box 1912, Las Vegas, Nevada 89101.

10.0 DISTRIBUTION LIST

No. of Copies	Recipient
32	U.S. Department of Energy Chicago Operations Office (10) Office of Environmental Compliance (5) (EH-22) Office of Environmental Audit (2) (EH-24) Office of NEPA Project Assistance (2) (EH-25) J. Farley (ER-65) A. E. Mravca (12)
4	Illinois U.S. Congressional Delegation
10	Chicago Area Press
52	Fermi National Accelerator Laboratory

J. Peoples, Director
K. Stanfield, Deputy Director
B. Chrisman, Associate Director
D. Theriot, Associate Director
R. Rubinstein, Assistant Director
C. Anderson
R. Auskalnis
D. Austin
J. Barry
D. Bogert
D. Bowron
S. Butala
H. Casebolt
D. Cathey
D. Cossairt
V. Cupps
R. Dorner
G. Dugan
A. Elwyn
J. Finks, Jr.
W. Fowler
W. Freeman
P. Garbincius
M. Gerardi
K. Graden
D. Grobe
R. Hall
M. Harrison
P. Hojsak
K. Isakson
P. Kesich
F. Krueger

1990

V. Kuchler
B. Lach
A. Leveling
R. Lewis
E. Major
P. Mantsch
F. Markley
C. Marofske
R. Mau
E. Mieland
T. Miller
W. Nestander
T. Pawlak
T. J. Sarlina
C. Turner
L. Vonasch
R. Walton
S. Wilson
T. Yamanouchi
C. Zonick

2 Argonne National Laboratory
C. L. Cheever, N. Golchert

1 Battelle Columbus Laboratory
G. Kirsch

1 Battelle, Pacific Northwest Laboratories
R. Jaquish

3 Brookhaven National Laboratory
R. Miltenberger, J. Naidu, R. Casey

1 CEBAF
G. Stapleton

1 EG&G Energy Measurements Group, Las Vegas, H. Berry

3 Illinois Environmental Protection Agency
R. Carlson, T. Denning, M. Swartz

1 Illinois Historic Preservation Agency
W. G. Farrar

2 Illinois State Geological Survey
D. Gross, J. Kempton

1 Illinois State Natural History Survey
W. Brigham

1 Illinois State Water Survey
K. Benson

1 Lawrence Livermore National Lab
R. Thomas

1 Los Alamos National Laboratory
J. Miller

2 Oak Ridge National Laboratory
R. Durfee, P. Rohwer

1 Princeton Plasma Physics Laboratory
J. Stencel

1 Stanford Linear Accelerator Center
G. Warren

2 SSC Laboratory
S. Baker, L. Coulson

6 U.S. Environmental Protection Agency
V. Adamkus, W. Gunter (2), L. Johnson, T. McLaughlin, N. Philippi

1 U.S. Geological Survey
J. Duncker

1990