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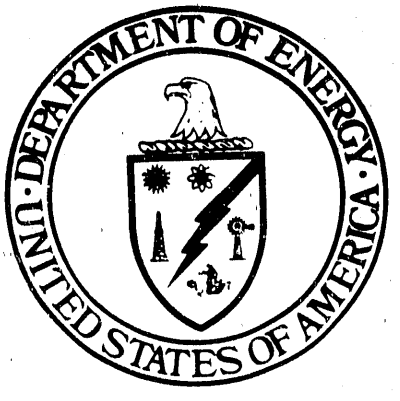

Environmental Survey
Preliminary Report

Fermi National Accelerator Laboratory
Batavia, Illinois

October 1988

PREFACE
TO
THE DEPARTMENT OF ENERGY
FERMI NATIONAL ACCELERATOR LABORATORY
ENVIRONMENTAL SURVEY PRELIMINARY REPORT

This report contains the preliminary findings based on the first phase of an Environmental Survey at the U.S. Department of Energy (DOE) Fermi National Accelerator Laboratory (Fermilab), located at Batavia, Illinois. The Survey is being conducted by DOE's Office of Environment, Safety and Health.

The Survey is a portion of the larger, comprehensive DOE Environmental Survey encompassing all major operating facilities of DOE. The DOE Environmental Survey is one of a series of initiatives announced on September 18, 1985, by Secretary of Energy, John S. Herrington, to strengthen the environmental, safety, and health programs and activities within DOE. The purpose of the Environmental Survey is to identify, via a "no-fault" baseline Survey of all the Department's major operating facilities, environmental problems and areas of environmental risk. The identified problem areas will be prioritized on a Department-wide basis in order of importance in 1989.

The preliminary findings are subject to modification based on comments from the Chicago Operations Office concerning their technical accuracy. The modified findings will be incorporated into the Environmental Survey Summary Report.

October 1988
Washington, D.C.

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Introduction

This report presents the preliminary findings from the first phase of the Environmental Survey of the U.S. Department of Energy (DOE) Fermi National Accelerator Laboratory (Fermilab), conducted September 14 through 25, 1987.

The Survey is being conducted by an interdisciplinary team of environmental specialists, led and managed by the Office of Environment, Safety and Health's Office of Environmental Audit. Individual participants for the Survey team are being supplied by a private contractor. The objective of the Survey is to identify environmental problems and areas of environmental risk associated with Fermilab. The Survey covers all environmental media and all areas of environmental regulation. It is being performed in accordance with the DOE Environmental Survey Manual. This phase of the Survey involves the review of existing site environmental data, observations of the operations performed at Fermilab, and interviews with site personnel.

Site Description

Fermilab is a high-energy physics research facility located on 27.5 km^2 (10.6 mi^2) of Federally owned property in DuPage and Kane Counties 48 km (30 mi) west of the center of Chicago, Illinois. Since its inception in 1967, the facility has been operated for the DOE by Universities Research Association, Incorporated, a consortium of 56 research-oriented universities. Fermilab houses a series of particle accelerators, including the world's most powerful, used to generate high-intensity proton beams that can be extracted and made available for experimental use. These experiments are designed to study fundamental subatomic particles, their properties and interactions, to gain a firmer understanding of the basic constituents of the physical universe. With the aid of computers and advanced electronics, Fermilab has been able to duplicate conditions one ten-billionth of one trillionth of a second after the universe was born. By studying tiny fragments of primordial-like matter, it becomes possible to explain processes by which such matter came to its present condition. Fermilab has about 2,200 full-time employees, including more than 400 scientists and engineers. In addition, there have also been as many as 3,000 visiting experimenters doing on-site research on a part-time or short-term basis.

Representatives of Fermilab, DOE Chicago Operations Office, and the Survey team met with three representatives of state and local agencies on June 30, 1987, at Fermilab to discuss their concerns.

The questions from the attendees were general in nature, and no major issues, environmental or otherwise, were raised.

Summary of Findings

The major preliminary findings of the Environmental Survey of Fermilab are as follows:

- Three areas on-site have received hazardous substances and may be potential sources of soil and/or groundwater contamination. The full nature and extent of contamination are not known.

- Soil radioactivation has occurred and continues to occur in selected areas as a result of fixed-target experiments. The nature and extent of the accelerator-produced radionuclide contamination and migration below the underdrain systems have not been fully characterized.

- Inadequacies in the present groundwater monitoring system may result in lack of early detection of potential groundwater contamination.

Overall Conclusions

The Survey found no environmental problems at Fermilab that represent an immediate threat to human life. The preliminary findings identified at Fermilab by the Survey team do indicate that there are a few areas of actual or potential soil contamination. However, the site does not appear to have the problems resulting from past practices that are associated with many other DOE facilities. The site has no known areas of groundwater contamination.

The environmental problems described in this report vary in terms of their magnitude and risk. A complete understanding of the significance of some of the environmental problems identified requires a level of study and characterization that is beyond the scope of the Survey. Actions currently under way or planned at the site will contribute toward meeting this requirement.

Transmittal and Follow-up of Findings

The preliminary findings of the Environmental Survey of Fermilab were shared with the Chicago Operations Office and the site contractor at the Survey closeout briefing held September 25, 1987. By October 29, 1987, the Chicago Operations Office had developed a draft action plan to address the

Survey preliminary findings. A final action plan addressing all the Survey findings cited herein will be prepared by the Chicago Operations Office within 45 days of receiving this Preliminary Report. Those problems that involve extended studies and multi-year budget commitments will be the subject of the Environmental Survey Summary Report and the DOE-wide prioritization.

Within the Office of the Assistant Secretary for Environment, Safety and Health, the Office of Environmental Guidance and Compliance has immediate responsibility for monitoring environmental compliance and the status of the Fermilab Survey findings. The Office of Environmental Audit will continue to assess the environmental problems through a program of systematic environmental audits that will be initiated toward the conclusion of the DOE Environmental Survey in 1989.

1.0 INTRODUCTION

The purpose of this report is to present the preliminary findings made during the Environmental Survey, September 14 through 25, 1987, at the U.S. Department of Energy's (DOE) Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. Fermilab is operated for DOE by Universities Research Association, Inc. As a Preliminary Report, the contents are subject to revision. Revisions to the preliminary findings based on Chicago Operations Office technical review will be incorporated into the Environmental Survey Summary Report.

The Fermilab Survey is part of the larger, comprehensive DOE Environmental Survey effort announced by Secretary John S. Herrington on September 18, 1985. The purpose of the Environmental Survey is to identify, via a "no fault" baseline Survey of all the Department's major operating facilities, existing environmental problems and areas of environmental risk. The identified problem areas will be prioritized in 1989 on a Department-wide basis in order of importance. The prioritization will enable DOE to more effectively address environmental problems and allocate the resources necessary to correct these problems. Because the Survey is "no fault" and is not an "audit," it is not designed to identify specific, isolated incidents of noncompliance or to analyze environmental management practices. Such incidents and/or management practices are, however, used in the Survey as a means of identifying existing and potential environmental problems and risk.

The Fermilab Environmental Survey is being conducted by an interdisciplinary team of environmental specialists headed and managed by the Office of Environment, Safety and Health's Office of Environmental Audit. A complete list of Survey participants and their affiliations is included in Appendix A.

The Survey team focused on all environmental media, using Federal, state, and local environmental statutes and regulations, accepted industry practices, and professional judgment to make the preliminary findings included in this report. The team carried out its activities in accordance with the guidance and protocols in the DOE Environmental Survey Manual. Substantial use of existing information and of interviews with knowledgeable field office and site-contractor personnel accounted for a large part of the on-site effort. A summary of the site-specific Survey activities is presented in Appendix B, and the Survey Plan is presented in Appendix C.

The preliminary Survey findings are presented in Chapters 3 and 4 in the form of existing and potential environmental problems. Chapter 3 includes those findings that pertain to a specific environmental medium (e.g., air or soil), while Chapter 4 includes those that are non-media specific (e.g., waste management, radiation, and quality assurance). Because the findings vary greatly in

terms of magnitude, risk, and characterization, and consequently require different levels of management attention and response, they are further divided into four categories within each of the sections in Chapters 3 and 4.

The criteria for placing a finding into one or more of the four categories are as follows:

Category I includes only those findings which, based upon the information available to the Team Leader, involve an immediate threat to human life. Findings of this type shall be immediately conveyed to the responsible Environmental Safety and Health personnel at the scene or in control of the facility or location in question for action. Category I findings are those environmental problems where the potential risk is highest, the confidence in the finding, based on the information available, is the strongest, and the appropriate response to the finding is the most restrictive in terms of alternatives.

Category II findings encompass one or more of the following situations:

- Multiple or continuing exceedances, past or present, of a health-based environmental standard where there is immediate potential for human population exposure, or a one-time exceedance where residual impacts pose an immediate potential for human population exposure.

- Evidence that a health-based environmental standard may be exceeded, as discussed in the preceding situation, within the timeframe of the DOE-wide Survey.

- Evidence that the likelihood is high for an unplanned release due to, for example, the condition or design of pollution abatement or monitoring equipment or other management practices.

- Noncompliance with significant regulatory procedures, i.e., those substantive technical regulatory procedures designed to directly or indirectly minimize or prevent risks, such as inadequate monitoring or failure to obtain required permits.

Category II findings include those environmental problems where the risk is high but the definition of risk is broader than in Category I. The information available to the Team Leader is adequate to identify the problem but may be insufficient to fully characterize it. Finally, in this category, more discretion is available to the Operations Offices and Program Offices as to the appropriate response; however, the need for that response is such that management should not wait for the completion of

the entire DOE-wide Survey to respond. Unlike Category I findings, a sufficient, near-term response by the Operations Office may include further characterization prior to any action taken to rectify the situation.

Category III findings encompass one or both of the following criteria:

- The existence of pollutants or hazardous materials in the air, water, groundwater, or soil resulting from DOE operations that pose or may pose a hazard to human health or the environment.

- The existence of conditions at a DOE facility that pose or may pose a hazard to human health or the environment.

Category III findings are those environmental problems for which the broadest definition of risk is used. As in Category II, the information available to the Team Leader may not be sufficient to fully characterize the problem. Under this category, the range of alternatives available for response, and the corresponding timeframes for response, are the greatest. Environmental problems included within this category will typically require lengthy investigation and remediation phases, as well as multi-year budget commitments. These problems will be included in the DOE-wide prioritization effort to ensure that DOE's limited resources are used effectively.

In general, the levels of pollutants or materials that constitute a hazard or potential for hazard are those that exceed some Federal, state, or local regulations for release of, contamination by, or exposure to such pollutants or materials. However, in some cases, the Survey may determine that the presence of some nonregulated material is in a concentration that presents a concern for local populations or the environment that is sufficient to be included as an environmental problem. Likewise, the presence of regulated materials in concentrations, even though below those established by regulatory authorities, that nevertheless present a potential for hazard or concern may be classified as an environmental problem. In general, however, conditions that meet regulatory or other requirements, where such exist, should not present a potential hazard and will not be identified as an environmental problem.

Conditions that pose or may pose a hazard are generally those which are violations of regulations or requirements (e.g., improper storage of hazardous chemicals in unsafe tanks). Such conditions present a potential hazardous threat to human health and the environment and should be identified as an environmental problem. Additionally, potentially hazardous conditions are those where the likelihood of the occurrence of release is high.

The definition of the term environmental problem is broad and flexible to allow for the wide differences among the DOE sites and operations. Therefore, a good deal of professional judgment must be applied to the identification of environmental problems.

Category IV findings include instances of administrative noncompliance and management practices that are indirectly related to environmental risk, but are not appropriate for inclusion in Categories I-III. Such findings can be based upon any level of information available to the Team Leader, including direct observations by the team members. Findings in this category are generally expected to lend themselves to relatively simple, straightforward resolution without further evaluation or analysis. These findings, although not part of the DOE-wide prioritization effort, will be passed along to the Operations Offices and appropriate Program Office for appropriate action.

Based on the professional judgment of the Team Leader, the findings within categories are arranged in order of relative significance. Comparing the relative significance of one finding to another, either between categories within a section or within categories between sections, is neither appropriate nor valid. The categorization and listing of findings in order of significance within this report is only the first step in a multi-step iterative process to prioritize DOE's problems.

The next phase of the Survey process is sampling and analysis (S&A). The results generated by the S&A effort are used to assist the Survey team in further defining the existence of environmental problems and risks identified during the Survey. However, based on the on-site Fermilab Survey, no Survey-related sampling needs were identified.

It is clear that the findings and observations in this report are highly varied in terms of magnitude, risk, and characterization. Consequently, the priority, magnitude, and timeliness of near-term responses require careful planning to ensure appropriate and effective application. The information in this Preliminary Report, albeit preliminary, will assist the Chicago Operations Office in the planning of these near-term responses.

The Chicago Operations Office submitted a draft action plan dated October 29, 1987, in response to the preliminary findings presented at the conclusion of the on-site Survey activities and summarized in the Fermilab Survey Status Report dated October 23, 1987. The draft action plan for addressing findings from the Fermilab Survey has been reviewed by the Office of Environmental Guidance and Compliance (OEG), which has immediate responsibility for monitoring the status and overseeing the adequacy of corrective actions taken by the Operations Office in response to the Survey findings.

As required in the December 2, 1987, memorandum from the Assistant Secretary for Environment, Safety and Health to the Operations Office Managers entitled, Follow-up of Environmental Survey Findings, the Chicago Operations Office will prepare and submit a final action plan to the Deputy Assistant Secretary (DAS) for Environment within 45 days of receiving this Preliminary Report. The final action plan for the Fermilab Survey will address all of the preliminary findings cited herein and incorporate OEG's comments on the draft action plan.

2.0 GENERAL SITE INFORMATION

2.1 Site Setting

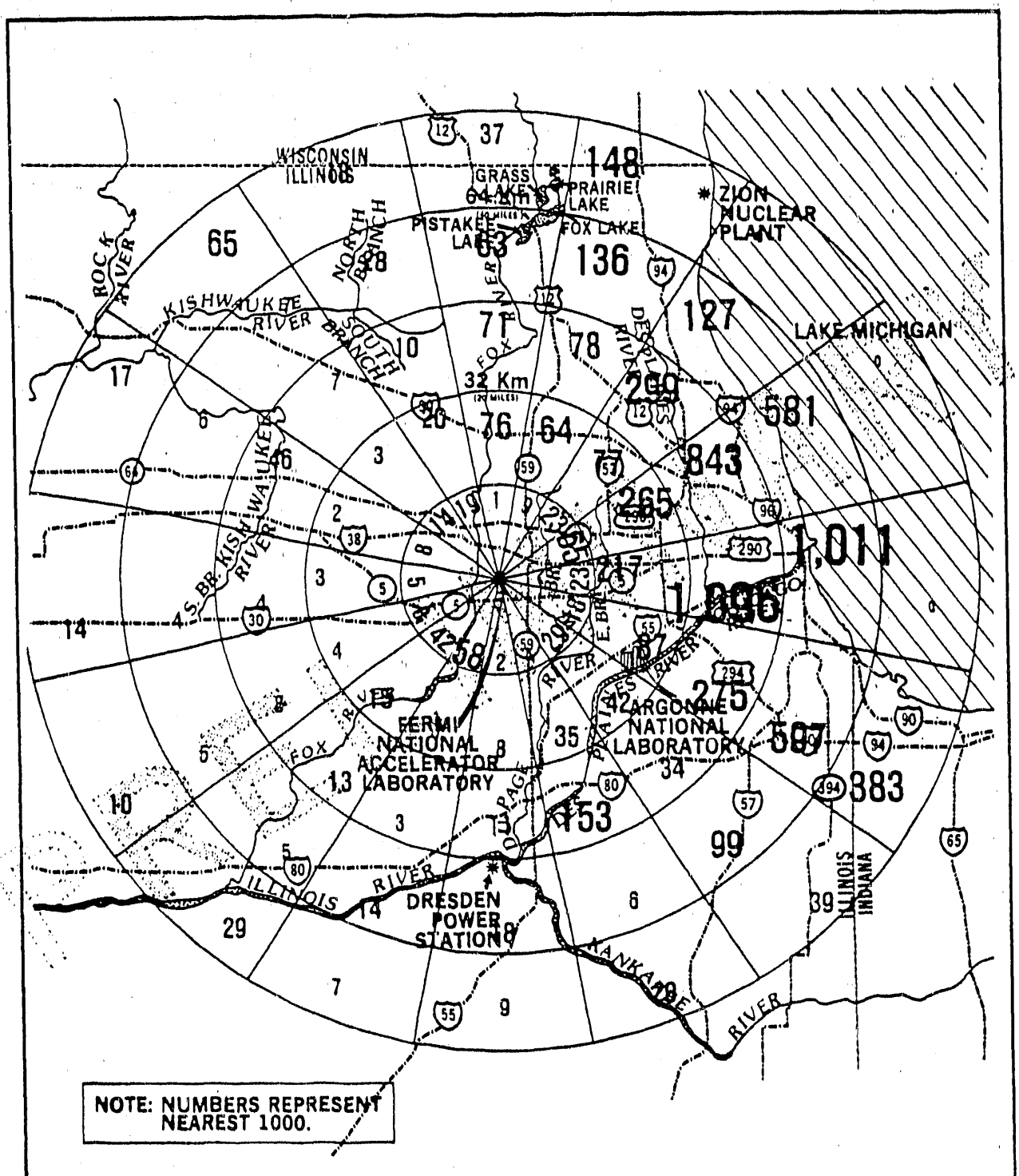
Fermilab is located on a 27.5 km^2 (10.6 mi^2) tract of level land 48 km (30 miles) west of the center of Chicago. The locale was originally farmland but has rapidly changed to residential use due to Chicago's westward movement for additional living space. There are three communities within 3 km (2 miles) of the laboratory boundaries: Batavia (population 13,550), Warrenville (population 9,400), and West Chicago (population 13,110). More than 7.7-million people live within an 80-km (50-mile) radius of Fermilab, with the densest population of 5.5-million people living in the ENE to ESE sector. Refer to Figure 2-1 for more detailed population distribution information. Fermilab has approximately 2,200 full-time employees, including more than 400 scientists and engineers. There are also as many as 3,000 visiting experimenters doing on-site research part-time at Fermilab.

The site is roughly in the form of a square, 5 km (3 miles) on each side (Refer to Figure 2-2). The land is flat, with the highest point, elevation 244 meters (800 feet) near the western edge and the lowest point, elevation 218 meters (715 feet) at the southeast corner (Hollingsworth, 1971). The climate is variable, ranging from low temperatures of −28°C (−19°F) in winter to highs of 36°C (97°F) in mid-summer. The monthly average relative humidity reading is 74 percent, with a range of 26–100 percent. The average annual rainfall is approximately 80 cm (31 inches) with monthly averages ranging from 0.25 cm (0.1 inch) in February to over 18 cm (7 inches) in June. Winds tend to blow from the southwest, but on occasion will come from any direction.

Some of the farmland within Fermilab's borders is leased to licensees for agricultural use, principally, the growing of corn. Also, Fermilab has undertaken one of largest prairie restoration efforts in the country, starting within the main acceleration ring in 1972 and extending outside the ring in 1984–1986. Controlled burning has aided in the growth of several endangered species of plants, some of which were introduced from other prairie environments, and others which, though always present on-site, could not compete well until restoration improved their living conditions (Baker, 1987).

2.2 Overview of Major Site Operations

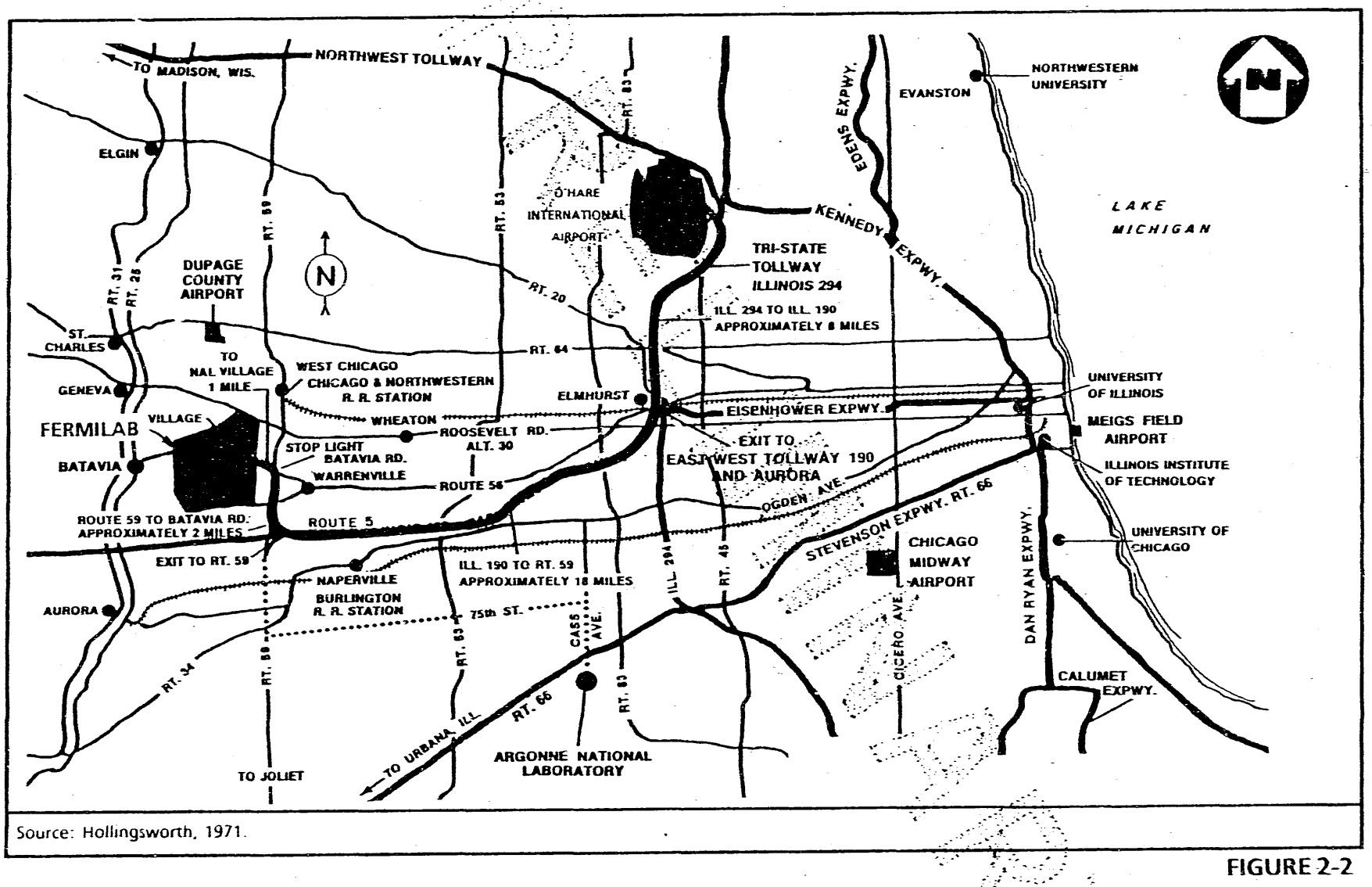
Fermilab consists of a series of particle accelerators designed to produce high-energy protons for use in research exploring the basic structure of all matter. Unlike most DOE facilities, the end result of this effort does not yield a product, nor does it produce power for transmission off-site. Instead, the



Source: Baker, 1987.

FIGURE 2-1

POPULATION DISTRIBUTION - 1980
FERMILAB - BATAVIA, IL



Source: Hollingsworth, 1971.

FIGURE 2-2

SITE LOCATION MAP
FERMILAB - BATAVIA, IL

experiments are designed to study elementary sub-atomic particles, their properties and interactions, in order to have a better understanding of the basic constituents of the physical universe.

Particle studies begin with the Cockroft-Walton generator. Electrons are added to hydrogen atoms in an ion source contained inside the generator. The resulting ions, which are protons with two attached electrons, emerge from the high-voltage accelerator with an energy of 750 thousand electron volts (750 KeV).

Because ions (and, at a later stage, protons) have electric charge, they can be controlled by surrounding them with a magnetic field. The magnetic field is appropriately altered electronically to keep the particles on the desired path as they travel at nearly the speed of light. This principle continues throughout the accelerators and the experimental systems. The ions enter the Linear Accelerator (LINAC), approximately 150 meters (500 feet) long, where they are accelerated to an energy of 200 million electron volts (200 MeV). The LINAC contains 290 copper electrodes between which oscillating electric fields are induced and tuned in such a way as to generate the electrical equivalent of a surf wave. The ions are accelerated as they ride this electrical wave.

Next, they are injected into the booster accelerator, a circular machine located in a tunnel 6 meters (20 feet) below the ground. It is a rapid-cycling synchrotron, approximately 150 meters (500 feet) in diameter, which goes through its accelerating cycle 15 times per second. The ions are stripped of their electrons, leaving protons which are increased in energy to 8 billion electron volts (8 GeV) in the booster. It normally cycles 13 times in rapid succession, loading 13 pulses into the main accelerator for further acceleration.

The protons are injected from the booster into the main accelerator, a synchrotron 2,000 meters (6,562 feet) in diameter, about 6.3 km (3.9 miles) in circumference. The main accelerator tunnel has two rings of magnets. The upper ring contains 1,000 conventional copper-coiled, water-cooled magnets; the lower ring, 1,000 superconducting helium-cooled magnets.

The accelerator can be operated either as a collider, or used to provide a single proton beam for fixed-target experiments. In both cases, the greater part of acceleration takes place in the superconducting ring because superconducting technology requires far less electrical power. In the collider mode of operations extremely high energies are produced because of an additive effect from the collisions. When collisions occur between two beams of particles traveling in opposite directions, the center-of-mass energy of the collisions is the sum of the energy of the two colliding beams. One-trillion-electron-volt protons colliding with 1-trillion-electron-volt antiprotons produce

collisions of 2 trillion electron volts (2 TeV) at their center. By comparison, a beam of 1-trillion-volt protons colliding with a fixed target yields a collision of 43 billion electron volts (43 GeV).

Fermilab's collisions require a beam of protons and a beam of antiprotons, circulating in opposite directions in the main accelerator, colliding at designated points in experimental apparatus, which intersects the beam path. To produce antiprotons, once every 2 seconds a batch of 2×10^{12} protons is accelerated to 120 GeV in the main ring, extracted and transported to the antiproton source target station, and focused on a production target. The resulting antiprotons are collected and stochastically cooled in a debuncher ring, then transferred to the accumulator ring where several thousand bursts are merged into a single beam, cooled further, and accumulated. (Stochastic cooling is a technique used to create a more densely packed antiproton beam.) This is the crucial ingredient of an antiproton source, since each burst of 2×10^{12} 120-GeV protons produces only 6×10^{7} usable antiprotons. Since 2×10^{11} antiprotons are needed to achieve the desired luminosity, more than 3,000 bursts of antiprotons must be collected and cooled. (Luminosity refers to the characteristics of the beam which produce interaction.)

The cooling systems are designed to increase the antiproton density while accumulating many antiprotons per hour. In four hours it is possible to collect the needed antiprotons and to increase their density to achieve the desired luminosity in the accelerator. Three bunches of antiprotons are injected into the upper ring of the accelerator at 8 billion electron volts (8 GeV), accelerated to 150 billion electron volts (150 GeV), then passed down to the lower ring of magnets. Three bunches of protons, traveling in the opposite direction, have been previously injected, accelerated, and stored in the same ring.

The six bunches--equally spaced around the ring--are accelerated to as high as 1 trillion electron volts (1 TeV). At the appropriate time, the collision mechanism is activated and the colliding beam experiments can began. A "detector device" is required to observe the proton-antiproton collisions and to interpret the interactions. The experimental group that designed, built, and now uses the detector has more than 200 physicists from ten U.S. universities, three national laboratories, two Italian institutions, and three Japanese universities. This collision detector is located on the northern side of the main accelerator ring across from the Industrial Area.

Since many experiments study particles other than protons, the proton beam must be converted into other types of particle beams. This is done by steering the protons onto stationary (fixed) targets. As the 800 GeV protons interact with the target, many types of particles with a variety of energies are produced. By using special magnets, all unwanted particles are bent away from the beamline. Thus,

only the desired particles can reach the detectors that are located downstream in underground or enclosed areas.

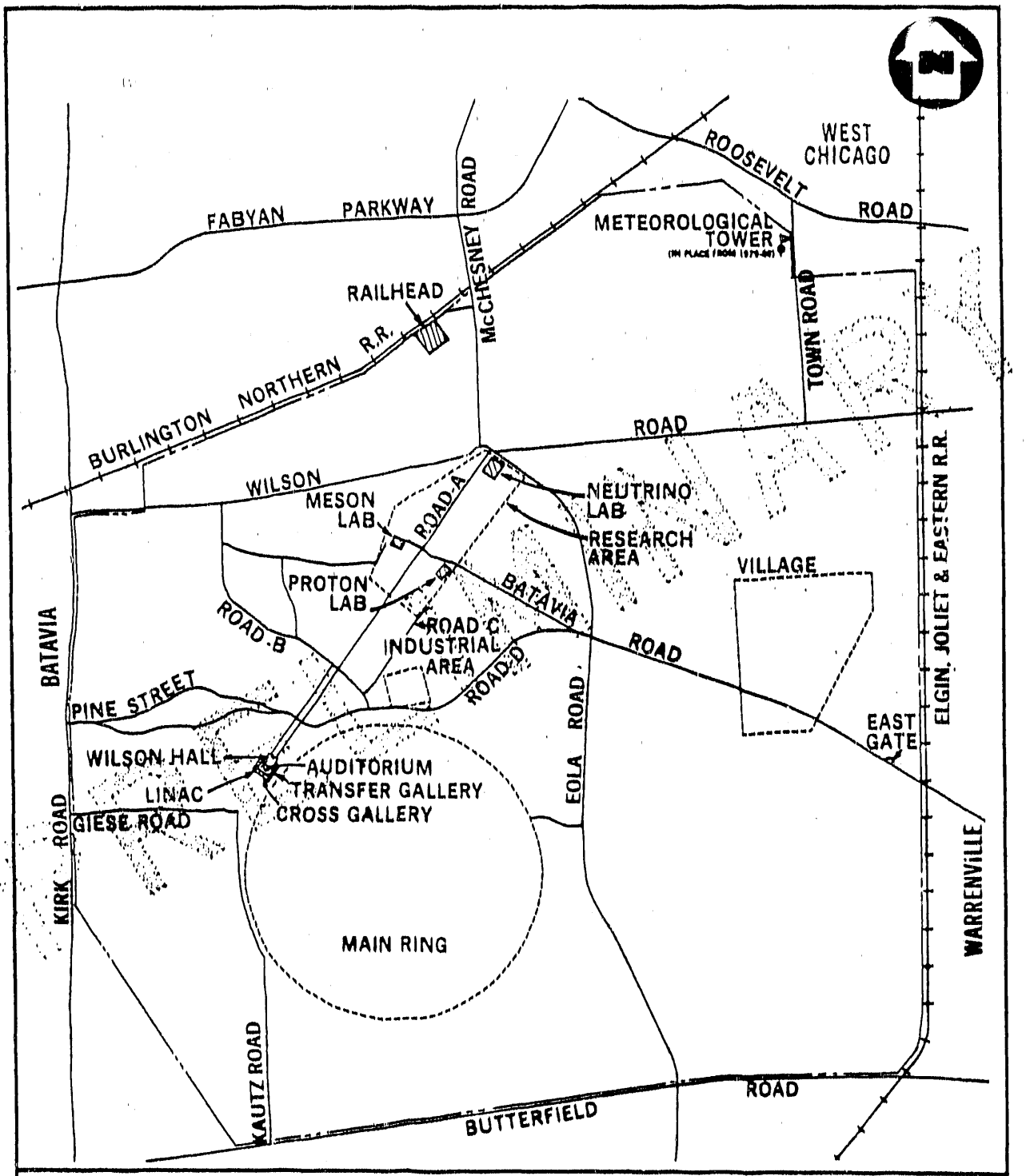
Once the proton beam has been accelerated, it is extracted from the ring. The single proton beam is split into three separate proton beams and steered to three experimental areas: (1) the proton area (2) the neutrino area and (3) the meson area. Each beam can be split again, providing proton beams for ten or more experiments simultaneously. The experimental areas' beamlines are operated from a centrally located operations center. These three fixed-target experimental areas are located on the northern side of the ring. For the purpose of orienting directions at Fermilab, the beamline along which these areas have been located has been termed "Project North" to distinguish it from true or magnetic north. "Project North" is roughly aligned in the northeast direction.

There are four major support facilities at Fermilab. The first is the Industrial Area (also referred to as the "magnet facility") located just off the northern side of the ring, across Road D from the collider detector facility (see Figure 2-3). Operations in this group of buildings include parts cleaning and degreasing, magnet assembly and testing, and debonding of magnets that are radioactive and have failed during operation of the accelerator.

Another major support facility is the 16-story central laboratory and office building, Robert Rathbun Wilson Hall. This building houses offices and laboratories used by most of Fermilab's permanent staff and by many visiting researchers. Administrative offices, a library, numerous small laboratories, computer facilities, a cafeteria, medical offices, conference rooms, and public information facilities are all located in Wilson Hall.

A third important support facility is the Central Utilities Building (CUB) southwest of Wilson Hall. Steam is generated using natural gas as the primary fuel, with diesel fuel as a back-up source. The building houses two, large, ion-exchange systems for removing radioisotopes from cooling water and also contains chlorination facilities for treating potable waters prior to distribution.

The fourth major support facility consists of the former Village of Weston, which was acquired for use as housing and research space for a number of permanent and temporary scientific personnel. The complex contains a machine shop, development laboratories, photoprocessing facilities, and printed circuit-board manufacturing facilities. It also incorporates a group of former farmhouses, which have been moved and re-erected across Batavia Road from the village to serve as temporary housing for outside researchers and their families while working at Fermilab. The village was formerly served by its own sewage treatment facility but has recently been tied in to the neighboring community of Warrenville.



Source: Baker, 1987.

FIGURE 2-3

SITE GENERAL FEATURES
FERMILAB - BATAVIA, IL

A few other outlying operational sites exist in former farmhouses on-site. There is also a herd of American bison (buffaloes) pastured in an area just east of the Industrial Area (magnet facility). The herd is part of Fermilab's effort to preserve the land in an environmentally safe manner and to demonstrate that science and nature can coexist effectively.

2.3 State/Federal Concerns

During the pre-Survey visit to the site, a meeting was held on June 30, 1987, at Wilson Hall with representatives of DOE's Batavia Area Office, Chicago Operations Office, Fermilab staff, and representatives from the Illinois State Water Survey and the City of Warrenville. DOE's invitation to participate in this meeting was also extended to USEPA Region V, Illinois EPA, and the Cities of Batavia and Aurora, but these groups did not send representatives.

The purpose of this meeting was to explain the purpose and scope of the Survey to the different agencies and to identify any environmental concerns they might have. Repesentatives were asked to express their concerns about Fermilab so that these concerns could be reviewed during the Survey. The representatives did not identify any existing environmental problems or raise any major environmental concerns about Fermilab. However, representatives of the City did express a general concern over future groundwater quality in the area and changes in surface runoff patterns as a result of building and development.

3.0 MEDIA-SPECIFIC SURVEY FINDINGS AND OBSERVATIONS

The sections in this chapter pertain to existing or potential environmental problems in the air, soil, water, and groundwater media. Each section is media specific and includes a summary of the available background environmental information, a description of the pollution sources and controls, a review of the environmental monitoring program, and a categorization and explanation of the environmental problems found by the Survey team related to each medium.

3.1 Air

3.1.1 Background Environmental Information

Air quality standards in Illinois are identical to National S andards. These are shown in Table 3-1. DuPage and Kane counties, in which Fermilab is located, are part of the metropolitan Chicago Interstate Air Quality Control Region (AQCR), which includes two Indiana counties to the east of Chicago and nine Illinois counties surrounding Chicago. The nine Illinois counties include DuPage and Kane counties. The AQCR has a number of nonattainment areas with respect to total suspended particulates (TSP) and ozone. However, the portions of the AQCR, in which Fermilab is located, are designated attainment areas for TSPs. Most of the TSP nonattainment areas are in the heavily populated eastern counties. In DuPage County, the majority of the townships have a nonattainment status. Kane County (the westernmost county in the AQCR) has only two townships (Aurora and Elgin) that are classified "does not meet secondary standards." With respect to ozone, both Kane and DuPage counties have a nonattainment status. However, air quality statewide is improving. The Illinois Annual Air Quality Report (IEPA, 1987) states that "the number of sites (in Illinois) recording one or more days with ozone above 0.12 parts per million (ppm) (the primary and secondary standard) decreased from 12 in 1985 to 5 in 1986." There were no sites in the AQCR recording more than one day above 0.12 ppm. Neither of the sites in DuPage and Kane counties recorded any days above 0.12 ppm (during 1986).

The AQCR is a designated attainment area with respect to sulfur dioxide (SO_2), nitrogen oxides (NO_x), lead (Pb), and carbon monoxide (CO). The attainment status for CO was achieved at the end of 1986.

Fermilab is not required to operate a meteorological tower. If a need exists (such as determining the direction of an accidental release, or calculating the dispersion of stack effluents to the property lines), Fermilab uses information on wind speed and direction obtained from O'Hare Airport (located

TABLE 3-1

SUMMARY OF NATIONAL AND ILLINOIS AMBIENT AIR QUALITY STANDARDS[a]
FERMILAB - BATAVIA, ILLINOIS

Pollutant	Time of Average	Primary Standard (At 25°C and 760 mm of Hg)	Secondary Standard
Particulate Matter (TSP)	Annual geometric mean 24 hour	75 µg/m^3 260 µg/m^3	60 µg/m^3 150 µg/m^3
Sulfur Dioxide (SO_2)	Annual arithmetic mean 24 hour 3 hour	0.03 ppm (80 µg/m^3) 0.14 ppm (365 µg/m^3) None	None None 0.5 ppm (1,300 µg/m^3)
Carbon Monoxide (CO)	8 hour 1 hour	9 ppm (10 mg/m^3) 35 ppm (40 mg/m^3)	Same as primary Same as primary
Photo-Chemical Oxidants (O_3)	1 hour/day - Federal	0.12 ppm (235 µg/m^3)	Same as primary
Nitrogen Dioxide (NO_2)	Annual arithmetic mean	0.053 ppm (100 µg/m^3)	Same as primary
Lead (Pb)	Quarterly arithmetic mean	1.5 µg/m^3	Same as primary

Source: IEPA, 1987.

(a) All standards with averaging time of 24 hr or less are not to be exceeded more than once per year.

about 43 km [27 mi] east of Fermilab). During the period January 1979 through April 1980, a meteorological tower was operated at Fermilab (see Figure 2-3) as part of a study to determine the baseline air quality (Davé and Charboneau, 1980). The study was necessary to provide information on a proposed coal gasification test facility. The composite wind rose for that time period is shown in Figure 3-1. Winds from the south to east quadrant dominate, accounting for about 35 to 40 percent of the winds.

If necessary, data collected at DuPage County Airport (DCA) (about 5 km [3 mi] north) can be used to evaluate accidental releases. The 1980 Baseline Air Quality Report concluded that the data from Argonne National Laboratories (ANL) 25 km (15 mi) southeast of Fermilab, the DCA data, and on-site data showed "fairly good agreement. Wind directions were found to be no more than 10–20° apart.".

Data from DCA is rarely used except as backup, since it cannot be provided in a readily usable form. However, since readily usable data are available from O'Hare and ANL, the use of DCA data, although this is probably the most representative site data, does not appear to be essential.

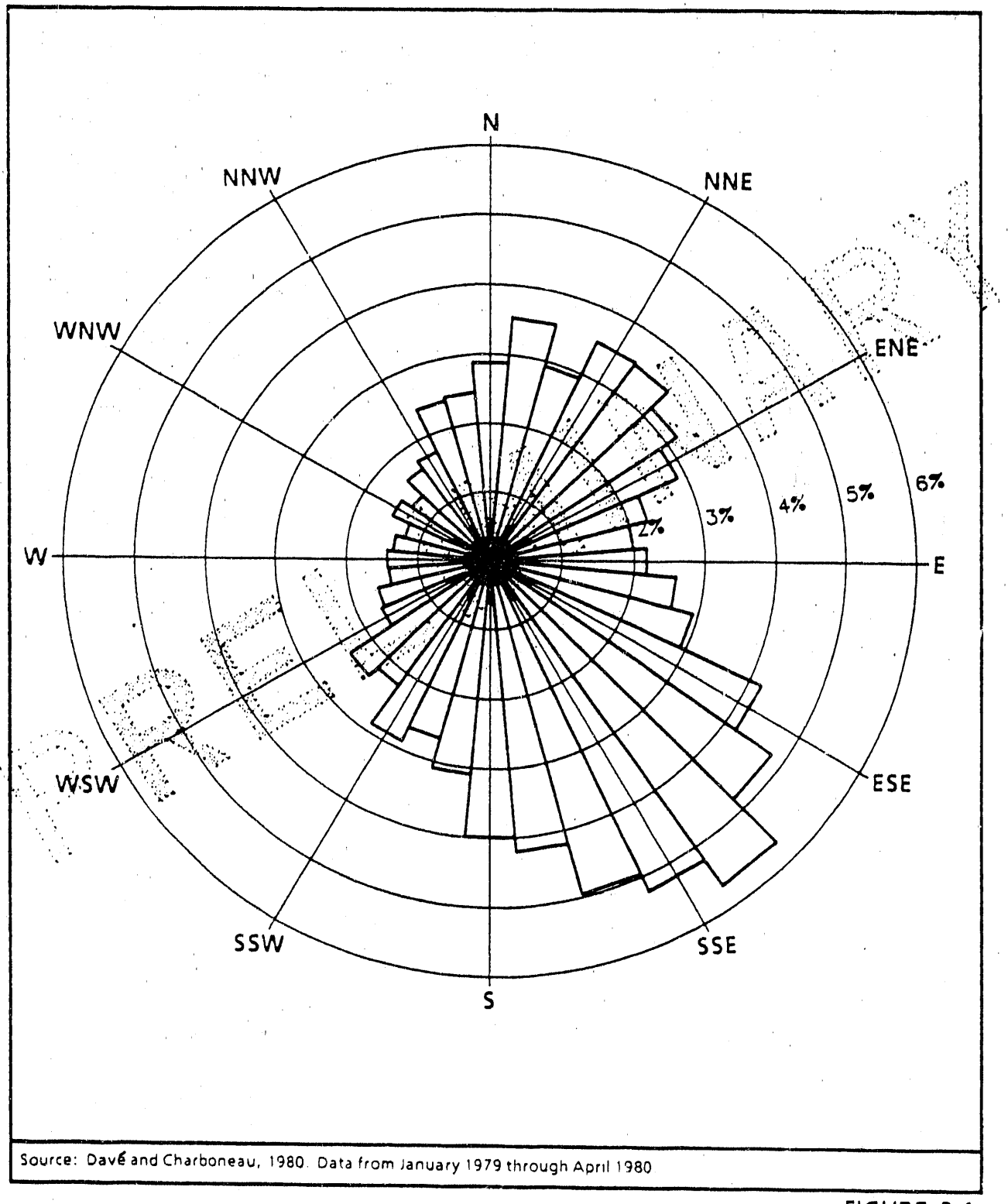
The above study of baseline air quality included measurements (from January 1979 through April 1980) of eight parameters related to the criteria air pollutants. These included SO_2, ozone, total hydrocarbons, nitric oxide, NO_x, and CO. In addition special studies were conducted for metals and anions.

Composite averages for each of the eight parameters are shown in Table 3-2 along with standard deviation and the hourly maximum. For comparison, national (and Illinois) ambient air quality standards are shown in Table 3-1. Pollutant data arranged in accordance with ambient air quality standards are presented in Table 3-3.

In general all data agree with the attainment status of Kane and DuPage counties mentioned above; that is, the area air quality during this time period was better than standards for TSP, SO_2, CO, NO_x, and Pb but not for ozone and the related parameter, nonmethane hydrocarbons.

As expected, high ozone levels (as well as high levels of SO_2, CO, NO_x, and hydrocarbons) were found more frequently when winds were from the highly populated areas (from the east).

Results of the specialized metal and anions studies revealed that levels were above the detection limit for only five metals: copper, iron, manganese, lead, and titanium. Only lead has an ambient air



Source: Davé and Charboneau, 1980. Data from January 1979 through April 1980

FIGURE 3-1

COMPOSITE WIND ROSE
FERMILAB - BATAVIA, IL

TABLE 3-2

BASELINE AIR QUALITY COMPOSITE GAS AVERAGE (ppm)
JANUARY 1979 – APRIL 1980
FERMILAB - BATAVIA, ILLINOIS

	SO_2	O_3	THC[a]	NO	NO_x	CO
Composite Average	0.027	0.022	4.22	0.015	0.030	1.5
Standard Deviation	0.027	0.019	1.67	0.026	0.033	1.2
Hours of Data	6,096	9,504	6,427	8,513	9,153	8,130
Hourly Maximum	0.149	0.129	14.74	0.3	0.313	9.1

Source: Adapted from Davé and Charboneau, 1980.

[a] Expressed as ppm CH_4.

TABLE 3-3

BASELINE AIR QUALITY
POLLUTANT DATA IN ACCORDANCE WITH STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS
FERMILAB - BATAVIA, ILLINOIS (1979)

Pollutant	Time of Average	Maximum Average Value (ppm for gases)	Date of Maximum	Time of Maximum (Hour)	2nd Maximum Average Value (ppm for gases)	Date of 2nd Maximum	Time of 2nd Maximum (Hour)	No. of Violations (Primary Std.)	No. of Violations (Secondary Std.)
TSP	Annual[a]	46 µg/m³	---	---	---	---	---	0	0
	24 hr	118 µg/m³	06/20/79	---	106 ug/m³	10/18/79	---		
SO_2	Annual[b]	0.027	---	---	---	---	---	0	0
	24 hr	0.112	07/07/79 to 07/08/79	16-19	0.100	07/12/79 to 07/13/79	12-12	0	0
		0.133	07/12/79	16-19	0.133	07/08/79	10-13	0	0
CO	8 hr	7.5	11/08/79 to 11/09/79	21-5	6.4	04/23/79	0-8	0	0
	1 hr	9.1	12/11/79	0-1	8.5	11/08/79	21-22	0	0
O_3	1 hr	0.129	07/12/79	15-16	0.124	08/06/79	15-16	75	75
	1 hr/day	0.129	07/12/79	5	0.124	08/06/79	15-16	1	1
NMHC[c]	3 hr	0.77	12/20/79	6-9	0.64	12/09/79	6-9	9	9
NO_2	Annual[b]	0.014	---	---	---	---	---	0	0
		(µg/m³)							
Pb	1st QR 79	.037	---	---	---	---	---	0	0
	2nd QR 79	.043	---	---	---	---	---	0	0
	3rd QR 79	-	---	---	---	---	---	0	0
	4th QR 79	.068	---	---	---	---	---	0	0
	1st QR 80	.053	---	---	---	---	---	0	0

Source: Davé and Charboneau, 1980.

a Annual refers to annual geometric mean.

b Annual refers to annual arithmetic mean.

c NMHC (non-methane hydrocarbons): currently used only as a guide to attainment of the ozone standard.

quality standard and, as seen in Table 3-3, the concentration for lead is below the standard by more than an order of magnitude. Concentrations for the five metals and the anions are shown in Table 3-4.

Air quality with regard to accelerator-produced radionuclides in the vicinity of Fermilab is excellent. Recent reports from the EPA gamma ambient monitoring program showed an exposure rate of 9.7 microrem/hr (85 mrem/yr) for the Chicago, Illinois, Station (July through September 1986). This rate compares favorably with the nationwide average of 10.7 microrem/hr (94 mrem/yr) for 22 stations reporting in the same period.

3.1.2 General Description of Pollution Sources and Controls

Primary airborne sources of radionuclide emissions at Fermilab consist of the neutrino-area stack and the antiproton stack, both of which emit carbon-11, and the debonding oven, a source of tritium.

Radionuclide air emissions for recent years are summarized in Table 3-5. Off-site emissions are very low for the two principal radionuclides, carbon-11 and tritium. Total emissions in 1986 resulted in a total potential exposure to the general off-site population (living within 80 km) of 0.003 person-rem compared to 1.2 person-rem in 1985. Exposure from natural background radiation is 1,000,000 person-rem. Because of the short half-life of carbon-11 (20 minutes), the 50-year dose commitment from 1986 operations will be the same as the exposure received in 1986.

Tritium

Emissions of tritium (mostly tritiated water) are extremely low. Emissions in recent years from several Fermilab sources are shown in Table 3-6. An evaporator to dispose of tritiated water collected from closed-loop cooling systems commenced operation in 1981. This was the prime source of tritium air emissions in 1981, 1982, and 1983. The evaporator has not operated since 1983 and was decommissioned in 1984.

Prior to 1981 the principal source of airborne tritium was a meson-area target box ventilation system. In 1980 modifications were made to the system, including changing to a flow-through air purging system replacing the helium purge system. The modifications reduced tritium concentrations to nondetectable.

TABLE 3-4

BASELINE AIR QUALITY – CONCENTRATIONS OF METALS AND ANIONS
FERMILAB - BATAVIA, ILLINOIS

Parameter	Concentrations $\mu g/m^3$
Copper	0.08
Iron	0.9
Manganese	0.04
Lead	0.1
Titanium	0.1
Other Metals Studied (1)	ND(2)
Sulfate	7.0
Nitrate	4.0

Source: Davé and Charboneau, 1980

(1) Aluminum, antimony, arsenic, boron, barium, beryllium, bismuth, cadmium, calcium, chromium, cobalt, gallium, lithium, magnesium, mercury, nickel, phosphorus, potassium, rubidium, selenium, silicon, silver, sodium, strontium, vanadium, zinc, and zirconium.

(2) Not detected.

TABLE 3-5

RADIONUCLIDE AIR EMISSIONS
(CURIES)
FERMILAB - BATAVIA, ILLINOIS

Year	Carbon-11[1]	Tritium[2]
1979	4,000	0.28
1980	1,300	0.24
1981	1,450	0.42
1982	1,050	0.063
1983	None	0.042
1984	None	0.001
1985	150	0.003
1986	3.4	0.003

Source: Baker, 1980, 1981, 1982b, 1983b, 1984, 1985, 1986a and 1987.

(1) A mixture of $C^{11}O_2$ and $C^{11}O$.
(2) Mostly tritiated water (HTO).

TABLE 3-6

TRITIUM AIR EMISSIONS
(MILLICURIES)
FERMILAB - BATAVIA, ILLINOIS

Year	Debonding Oven[a]	Evaporator	Meson Target Box	Total
1979	4		280	284
1980	3		240	243
1981	5	420		425
1982	5	58		63
1983		42		42
1984	1			1
1985	3			3
1986	3			3

Source: Baker, 1980, 1981, 1982b, 1983b, 1984, 1985, 1986a and 1987.

(a) 1980-1986 estimates based on 1979 measurements.

Currently the only source of airborne tritium is the debonding oven commissioned in 1979. The oven is used to debond magnets by decomposing the epoxy adhesives at high temperatures. An acceptance test conducted for the Illinois EPA June 8, 1979, showed tritium as the only detectable radionuclide and no nonradioactive emissions of any consequence (Almega, 1979). The total amount of tritium was 160 μCi, at a stack concentration of 1.5×10^{-8} μCi/ml or about 7 percent of the DOE concentration guide. Results of calculations using AIRDOS-EPA to model the concentrations at the site boundary showed a negligible concentration.

Because the magnets being debonded have similar radiation levels (measured at the surface of each oven), the 1979 data is used to estimate current tritium emissions. Where radiation levels are different, it is assumed that the amount of tritium released varies directly as the radiation level at the oven surface. In 1986, 19 magnets were debonded corresponding to a total release of 3 mCi. Operation at similar levels is anticipated in the future.

Carbon-11

Carbon-11, the principal radionuclide component of air emissions, is produced at the primary target in the neutrino area. Carbon-11 (primarily carbon-11 dioxide and carbon-11 monoxide) is produced by the activation of air by secondary particles. Prior to 1985 all of the carbon-11 was produced in the neutrino area and vented through the labyrinth stack. Air flow was a nominal 3,700 m^3/Hr (2,175 cfm). The stack is 3 meters (9.8 feet) high and is located 1,600 meters (5,250 feet) from the site boundary. In 1986 a new target in the antiproton area was placed in operation. Similar to the labyrinth stack, this is also a source of airborne carbon-11. Stack height is similar (3 meters). Distance to the site boundary and air flow are slightly different; however, modeling (using AIRDOS-EPA) results indicate little effect at the site boundary from either source.

HEPA Filters

Fermilab has a program of utilizing high-efficiency particulate air (HEPA) filters for collection of airborne radioactive and nonradioactive toxic contamination in areas of maintenance, cleanup, and routine operations where the possibility of such contamination exists (Fermilab, 1986a). Locations using HEPA filters include (1) the chemistry hood at No. 21 Shabbona Building, (2) the compactor at Site 67 and (3) the area at AP-0 at the downstream end of the prevault beam enclosure (to protect against toxic emissions in the event of a failure of the lithium focusing lens). In addition, 10 portable vacuum cleaners use HEPAs for the final filtration. Fermilab has prepared a description of the program describing each use, ordering and receiving, cleaning and maintenance, testing and disposal of filters (Fermilab, 1986a).

Ventilation Systems

Fermilab has 61 ventilation systems, which are surveyed annually for air velocity (Davis and Zuehlke, 1987). While several are connected with items mentioned in the above discussion on permits and the HEPA Program, most are connected to laboratory hoods and other small sources that need to be vented to the outside air. Other than those mentioned above and in Finding 3.1.4.4.1, permits are not required.

Nonradioactive Emissions

Fermilab currently has only three sources covered by permits from the Illinois Environmental Protection Agency (IEPA). These include the debonding oven, the gasoline dispensing tanks, and a permit to conduct open burning (for fire-fighting training). In 1987, at the suggestion of IEPA, permit applications were submitted (Coulson, 1987a) for several additional facilities. These consisted of two vapor degreasers and five natural-gas-fired boilers. Several additional facilities for which permits appear to be needed are discussed in Finding 3.1.4.4.1

A number of organic solvents used at Fermilab contribute to air emissions. Those used in large quantities are summarized and air emissions estimated in Table 3-7. Over a period of many years, Fermilab has attempted to phase out the use of hydrocarbon solvents and chlorinated hydrocarbons. Most of these solvents have been replaced with Freon-113 (1,1,2-trichloro-1,2,2-trifluoroethane). This solvent is used extensively in vapor degreasers, cold parts cleaning, and surface cleaning. Several other Freon products are used in special applications (Coulson, 1987b).

All of the Freons are implicated to some extent in the depletion of the ozone layer and resulting increase in ionizing radiation. It is uncertain at present how future regulations will restrict the use of Freons such as those used at Fermilab.

Emissions from the degreasers and other solvent uses are shown in Table 3-7. Total Freon emissions are estimated at about 18,600 kg (41,000 pounds) per year. Airborne emissions of other solvents (methyl chloroform, acetone, isopropyl alcohol, and mineral spirits) total an estimated 7,250 kg (16,000 pounds) per year.

TABLE 3-7

ORGANIC AIR EMISSIONS
FERMILAB - BATAVIA, ILLINOIS

Compound	Annual Purchases		Estimated Percent Volatilized	Air Emissions (Pounds)
	Gallons	Pounds		
CFC-113 (Trichloro-trifluoroethane)	3,000[a]	39,000	76[b]	29,640
CFC-11 (Trichloro-fluoromethane)	425	5,230	100	5,230
CFC-12 (Dichloro-difluoromethane)	180	1,970	100	1,970
CFC-22 (Chloro-difluoromethane)	320	4,385	100	4,385
Methyl chloroform (1,1,1-trichloroethane)	660[c]	7,920	93	7,360
Acetone	150[c]	988	93	915
Isopropyl alcohol	1,100[c]	7,210	93	6,700
Mineral spirits	220[c]	1,250	93	1,160

Source: Coulson, 1987b and Finks, 1987.

a Annual purchases average about 3,000 gallons. Purchases in CY-1986 were 6,360 gallons (82,800 pounds).
b 721 gallons sent to recycle in 1986.
c 1986 purchases.

Three natural gas boilers, located at the central utilities building (CUB), are rated at 15 million BTU/hour each. These can also be fired with No. 2 diesel fuel. Annual oil consumption is about 750 l (200 gal) (sulfur content, 0.3 percent) for each boiler. Two natural gas boilers at the Wide Band Laboratory are each rated at 1.67 million BTU/hour. Two other natural gas boilers located at the new Muon Laboratory are each rated at 750,000 BTU/hour. The propane-fired boiler, located at the Industrial No. 2 Buildings, is also rated at 750,000 BTU/hour. Average firing rates of all boilers are well below rated capacity. Total annual consumption of natural gas is 1.22 million cubic meters (43 million cubic feet).

3.1.3 Environmental Monitoring Program

Ambient Air Monitoring

Because of the extremely small quantities of radionuclides emitted at Fermilab (as discussed earlier), no ambient air sampling is performed. In addition, because of the high air quality, there is no sampling for nonradioactive species. In the opinion of the survey team, this is an acceptable policy, as long as the dose calculations from stack emissions continue to indicate doses similar to current levels. Fermilab's present network of 120 radiation detectors for monitoring radiation at various locations on-site, discussed in Section 4.3, would serve to warn of any substantial increase in unmonitored radionuclide emissions, other than tritium (since tritium has no gamma radiation).

Emissions Monitoring

The only stack monitoring conducted at Fermilab is performed at the neutrino stack (near Building NS-1) and the antiproton stack (near Building AP-0). Monitoring at both locations is specific for carbon-11.

Airborne concentrations of carbon-11 containing some carbon-11 dioxide ($C^{11}O_2$) and carbon-11 monoxide ($C^{11}O$) are monitored at the neutrino target area south labyrinth stack and the antiproton stack by two different instruments. Johnston Laboratories Inc. Triton monitors (direct reading, Model 955B) are used for personnel exposure control. This instrument is normally used to measure tritium but can be used as a direct monitor of carbon-11. The meter reading of the 955B is greater for a given concentration of carbon-11 than for the same concentration of tritium because the beta particle emitted by carbon-11 has a much higher end-point energy than the tritium beta. The meter reading for carbon-11 (or nitrogen-13 or oxygen-15) is approximately five times that for tritium. Hence, the meter reading is divided by five in determining the concentration of carbon-11. The instrument is calibrated using tritiated methane (Gronemeyer, 1983). For estimating stack releases,

which are used to model off-site concentrations, a pancake radiation detector Model 7311 manufactured by LND, Oceanside, New York, is used. This instrument is field calibrated against the Triton and periodically directly calibrated against primary standards. Off-site concentrations have been a small fraction of DOE concentration guidelines and are expected to continue at similar levels. The calculated off-site dose from carbon-11 in 1986 was 0.0002 millirem compared with the NESHAP standard of 25 millirem/year.

Possible methods of reducing the amounts of carbon-11 emitted have been reviewed (Moore, 1984). Possible control methodologies consist of providing additional holdup space between the source and stack to provide time for radioactive decay or installing equipment (catalytic oxidation of $C^{11}O$ to $C^{11}O_2$ followed by caustic scrubbing to remove $C^{11}O_2$) to remove the carbon-11 prior to venting. The report on review of controls concluded: "Considering the large capital costs . . . additional effort should be made to find a more cost-effective alternative for reducing carbon-11 emissions if such reductions become necessary."

No actual measurement is made of current emissions of tritium to the atmosphere. As seen in Table 3-6, emissions of tritium to the atmosphere since 1984 have been in the range of 1 to 3 millicuries per year. The emissions are solely from the debonding oven. Emissions are estimated by assuming that tritium emissions are directly proportional to the total radiation level of the surface of each magnet debonded, and that the conversion factor found in the 1979 testing mentioned previously (magnet) is still valid. The 1979 test showed a tritium stack concentration of 1.3×10^{-8} nCi/ml, or about 7 percent of the derived concentration guide corresponding to 100 millirem per year. Dispersion calculations using the AIRDOS-EPA Program showed a negligible concentration at the site boundary.

3.1.4 Findings and Observations

3.1.4.1 Category I

None

3.1.4.2 Category II

None

3.1.4.3 Category III

None

3.1.4.4 Category IV

1. Unpermitted Sources. Three air emissions sources at Fermilab lack the required registration/permits. These are the Branson vapor degreaser, in Industrial Building No. 3; machining operations in the shop near Laboratory No. 2 controlled by a baghouse; and the high-efficiency filter used to guard against accidental release of lithium at the neutrino stack. Although no environmental problems are apparent, lack of proper registration or permits can lead to fines.

3.2 Soil

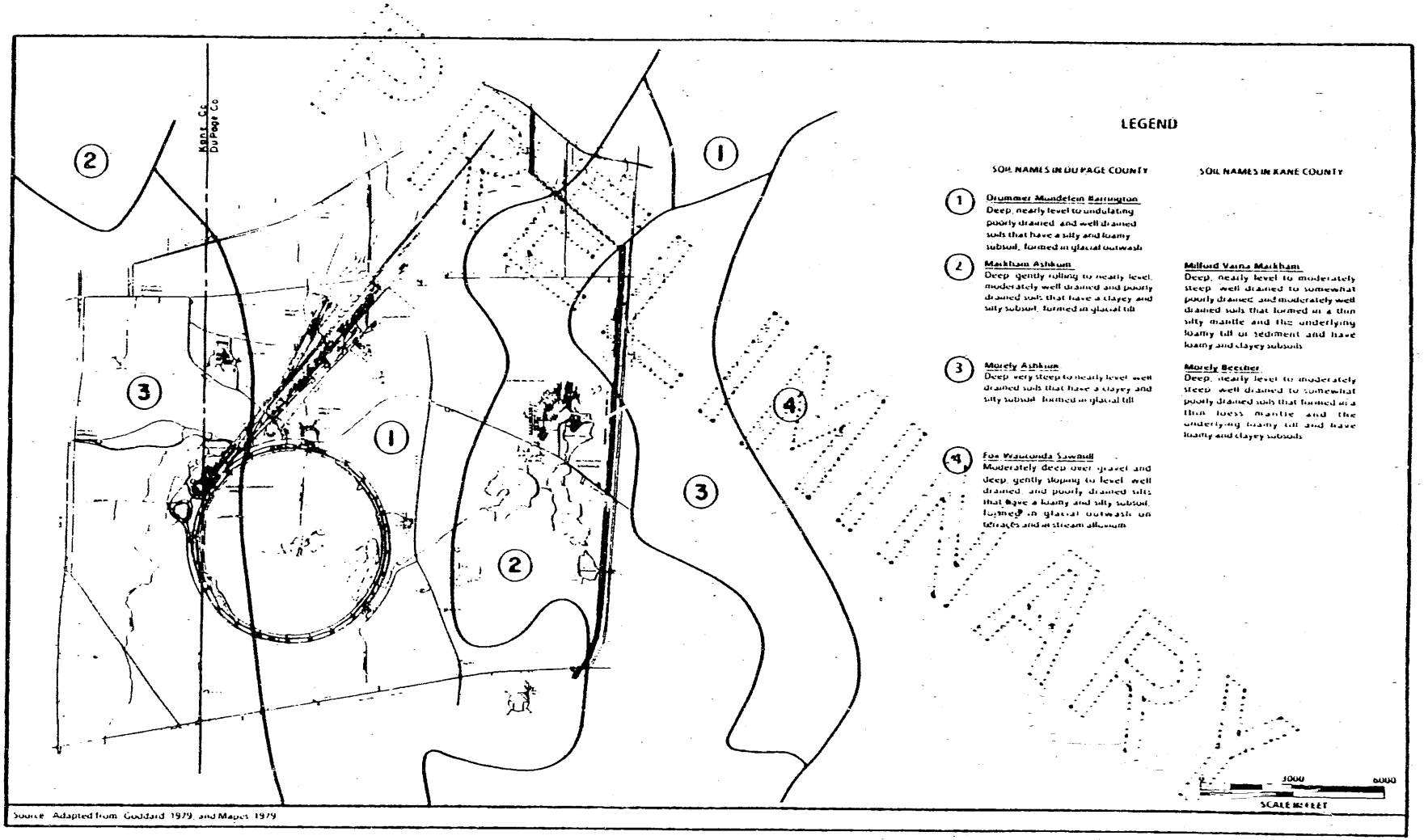
3.2.1 Background Environmental Information

Soils at the Fermilab site have been mapped by the U.S. Department of Agriculture in cooperation with the Illinois Agricultural Experimental Station and are published in Soil Surveys for the two counties occupied by the site (Goddard, 1979, and Mapes, 1979). This mapping was performed primarily for use by farmers, ranchers, and agronomists and, as such, used soil classifications in relation to the needs of those land users. The site soils are classified in series and groups, based on physical characteristics, and are somewhat associated with the geologic formations or land forms upon which the soils are formed. Figure 3-2 shows the soil units mapped at the Fermilab site.

The major soil unit mapped at the site is the Drummer-Mundelein-Barrington association. It is generally described as "deep, nearly level to undulating, poorly drained, somewhat poorly drained, and well drained soils that have a silty and loamy subsoil; formed on glacial outwash" (Goddard, 1979). The second largest unit is the Markham-Ashkum association, generally described as "deep, gently rolling to nearly level, moderately well-drained and poorly drained soils that have a clayey and silty subsoil; formed on glacial till" (Goddard, 1979). Other soil units mapped at the site include the Wauconda, Grays, and Elliot silt loams; the Peotone silty clay loam; and the Muskego and Houghton mucks (Goddard, 1979). Table 3-8 presents a compilation of some of the physical characteristics of these soils taken from the Soil Surveys.

Land use at the site prior to Fermilab construction consisted of farming, primarily corn and soybeans. Thus, background levels of radionuclides and organic chemicals should be similar to those in nearby areas off-site. Background activities in Illinois soils are reported with values ranging from 0.49 to 1.2 pCi/g (average 1.1 ± 0.45) for thorium-232 and 0.64 to 1.4 pCi/g (average 0.96 ± 0.43) for Uranium-238 (Myrick et al., 1983). However, the previous operation of a rare earths facility processing thorium mill tailings in West Chicago (NRC, 1987), approximately 1.6 km (1 mile) from the northeastern site boundary, may have altered the natural background count in the northeast portion of the site. The present on-site contribution of thorium or uranium from past processing operations is unknown. Operation of the accelerator does not produce these radionuclides.

There are no Federal or state regulations that limit the concentration of uranium or thorium in soils. However, there is some guidance available from both the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE). The NRC, in a memorandum pertaining to a Branch Technical Position on the disposal or on-site storage of residual thorium or uranium, established derived concentration limits for various disposal options (Dircks, 1981). One of these options applies



Source: Adapted from Goddard 1979, and Mapes 1979

FIGURE 3-2

SOIL CHARACTERISTICS AND PROPERTIES
FERMILAB - BATAVIA, IL

TABLE 3-8

SOIL CHARACTERISTICS AND PROPERTIES
FERMILAB - BATAVIA, ILLINOIS

Soil Name	Depth	Permeability	Soil Reaction	Liquid Limit	Plasticity Index	Shrink Swell Potential	USC	USDA Texture
	(in)	(in/hr)	pH					
Elliott	0-11	0.6-2.0	5.6-7.3	30-50	10-20	M	CL, ML	Silt loam
	11-37	0.2-0.6	5.6-7.8	30-52	11-26	M	CH, CL	Silty clay, Silty clay loam
	37-60	0.2-0.6	7.4-8.4	28-45	11-24	M	CL	Silty clay loam, clay loam
Drummer	0-15	0.6-2.0	5.6-7.3	30-50	15-30	M	CL	Silty clay loam
	15-45	0.6-2.0	5.6-7.3	30-50	15-30	M	CL	Silty clay loam, silt loam, clay loam
	46-56	0.6-2.0	6.1-8.4	30-50	15-30	M	CL	Loam, silt loam, clay loam
	56-60	0.6-2.0	6.6-8.4	20-35	7-20	L	SC, CL	Stratified sandy loam to silty clay loam
Ashkum	0-37	0.2-0.6	5.6-7.8	45-65	20-35	M	CL, CH	Silty clay loam, silty clay
	37-60	0.2-0.6	6.1-8.4	35-50	15-30	M	CL	Silty clay loam
Peotone	0-13	0.2-0.6	5.6-6.5	40-65	15-35	H	OH, CH, CL, OL	Silty clay loam
	13-43	0.2-0.6	6.1-7.8	41-70	17-39	H	CH, CL	Silty clay loam
	43-60	0.06-0.2	6.6-8.4	30-60	14-29	H	CL, CH	Silty clay loam, silt loam

TABLE 3-8
SOIL CHARACTERISTICS AND PROPERTIES
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

Soil Name	Depth	Permeability	Soil Reaction	Liquid Limit	Plasticity Index	Shrink Swell Potential	USC	USDA Texture
	(in)	(in/hr)	pH					
Mundelein	0-12	0.6-2.0	5.6-7.3	30-50	5-20	L	ML, OL	Silt loam
	12-36	0.6-2.0	5.6-7.3	35-50	15-25	M	CL	Silty clay loam, clay loam, loam
	36-60	0.6-2.0	6.1-8.4	<35	NP-20	L	SC, SM, ML, CL	Stratified silt loam to fine sand
Barrington	0-14	0.6-2.0	5.6-7.3	30-40	8-18	L	CL	Silt loam
2 to 5 percent slopes	14-33	0.6-2.0	5.6-6.5	35-50	11-25	M	CL	Silty clay loam
	33-60	0.6-2.0	6.6-8.4	25-40	5-15	L	CL, SM-SC, SC, CL-ML	Stratified silt loam to fine sand
Markham	0-12	0.6-2.0	5.6-6.5	23-40	6-17	L	CL, CL-ML	Silt loam
2 to 5 percent slopes	12-28	0.06-0.6	5.1-7.8	40-54	15-28	M	CL, CH	Silty clay, silty clay loam
	28-60	0.06-0.6	7.4-8.4	30-45	13-26	M	CL	Silty clay loam, clay loam
Wauconda	0-10	0.6-2.0	6.1-7.3	20-35	6-15	L	CL, CL-ML	Silt loam
	10-36	0.6-2.0	5.6-7.8	30-45	15-30	M	CL	Silty clay loam
	36-60	0.6-6.0	7.4-7.8	<30	NP-15	L	ML, CL, SM, SC	Loam, silt loam, sand

TABLE 3-8
SOIL CHARACTERISTICS AND PROPERTIES
FERMILAB - BATAVIA, ILLINOIS
PAGE THREE

Soil Name	Depth	Permeability	Soil Reaction	Liquid Limit	Plasticity Index	Shrink Swell Potential	USC	USDA Texture
	(in)	(in/hr)	pH					
Grays	0-13	0.6-2.0	5.6-6.5	25-40	8-20	L	CL	Silt loam
2 to 5 percent slopes	13-35	0.6-2.0	5.6-6.5	30-45	15-25	M	CL	Silty clay loam, silt loam
	35-60	0.6-6.0	7.4-8.4	15-40	NP-20	L	ML, CL, SM, SC	Stratified silt loam to very fine sand
Muskego	0-27	0.2-6.0	5.6-7.3	-	-	-	PT	Sapric material
	27-60	0.06-0.2	6.6-8.4	-	-	-	OH, OL	Coprogenus earth
Houghton	0-59	0.2-6.0	5.6-7.8	-	-	-	PT	Sapric Material

Source: Adapted from Goddard, 1979

Legend
< - "less than"
NP - Nonplastic
L - Low
M - Moderate
H - High
USC - Unified Soil Classification
CH - High Plasticity Clay
CL - Low Plasticity Clay
ML - Low Plasticity Silt
OH - High Plasticity Organic Silt
OL - Low Plasticity Organic Silt
PT - Peat
SC - Clayey Sand
SM - Silty Sand

to wastes with sufficiently low concentrations of uranium or thorium that they would present no health risk and could be disposed of in any manner. The acceptable concentrations for this disposal option were derived by the NRC using radiation dose guidelines recommended by the U.S. Environmental Protection Agency (EPA) for protection against transuranium elements present in the environment (EPA, 1977). The derived concentration limits are natural thorium, 10 pCi/g; depleted uranium, 35 pCi/g; enriched uranium, 30 pCi/g; and natural uranium, 10 pCi/g. The concentration limits for natural thorium and natural uranium are based on the assumption that all the daughter products of these elements are present in secular equilibrium. The radium isotopes are the daughter products that are used to establish the limits.

DOE has established guidelines for residual radioactivity at Formerly Utilized Sites Remedial Action Program (FUSRAP) sites and Remote Surplus Facilities Management Program (SFMP) sites (DOE, 1985; Gilbert et al., 1985). The guidelines specify concentrations for thorium-232, thorium-230, radium-228, and radium-226 of 5 pCi/g averaged over the first 15 cm (6 in) of soil below the surface. These guidelines take into account the in-growth of the daughters and assume secular equilibrium. For other radionuclides or mixtures, the soil concentration guidelines must be derived, on a site-specific basis, from a basic dose limit of 100 mrem/year to an individual, from all pathways.

There are no regulatory standards for nonradiological contaminant concentrations in soil as there are for drinking-water supplies or for air. A determination of "safe" or "acceptable" levels in soils depends on contaminant migration pathways (e.g., wind or water erosion or leaching to the groundwater) and potential human exposure routes (e.g., ingestion of soils by children or farm animals, ingestion of contaminated groundwater, or inhalation of fugitive dust containing contaminants). Therefore, acceptable levels must be determined on a site-specific and chemical-specific basis.

3.2.2 General Description of Pollution Sources and Controls

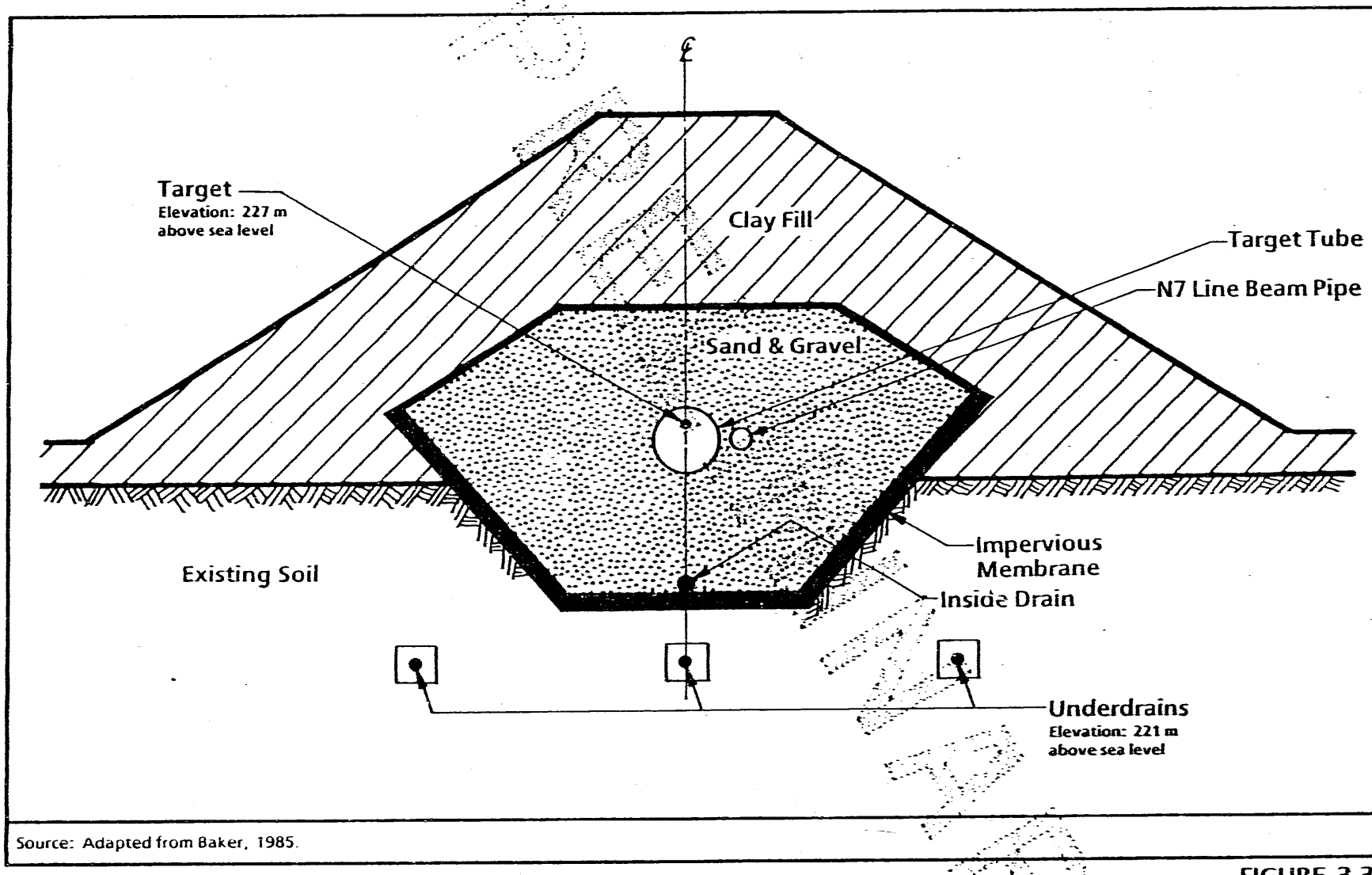
Soils can become contaminated by air emissions, surface runoff, storage and disposal activities, spills, and resuspension of contaminated materials from other areas. Because soil monitoring is limited in terms of areas sampled and constituents analyzed, the Survey team in some cases used process information and physical evidence of contamination to identify a number of known soil contamination sources. Actual sources of soil contamination from operations and past practices are described below. These areas primarily consist of diffuse and/or large areas where soils have been contaminated. Discrete areas of soil contamination, such as those areas where isolated spills or releases have occurred, are addressed in greater detail in Sections 4.5.1 and 4.5.2, although they are briefly described in the subsequent text.

Areas of known or suspected soil contamination are as follows:

Experimental Area Targets and Beam Dumps. Operation of the accelerator produces radionuclides through direct soil activation resulting from particle scattering when the beam strikes targets and dumps, when the beam passes through dumps, and may contaminate soil when subdrain sump effluent is discharged to surface drainages. Subdrains below the target areas collect percolating water that has either leached radionuclides from activated soil or has been directly activated. These subdrains lead to sumps that are analyzed as described in Section 3.2.3 and discharged to surface drainage ditches, where the surface water or soils can become contaminated.

The system for control of soil activation consists of shielding at targets and beam dumps The shielding methods, materials, and calculations have evolved through use, observations, and measurements of performance made by Fermilab personnel (VanGinneken and Awschalom, 1975; Baker, 1978; Baker, 1975; and Borak, et al., 1972). The current design ideology is intended to provide extensive shielding by surrounding the target and dump structures with steel. Earlier target areas in the neutrino and meson primary target areas utilized only specially selected, bank-run sand and gravel that were low in sodium content. The soils surrounding the target tubes in these areas are contaminated with radionuclides and, as such, are also considered potential sources of groundwater contamination (see Section 3.4.2).

As a method of controlling the transport of radionuclides in the soils, the target halls have been constructed with a subdrain system inside a lined collection basin approximately 3 meters (10 feet) below the target tube. A second set of underdrains is located outside and approximately 1 meter (3 feet) below the collection basin. These underdrains are intended to intercept and remove percolating water that has leached radionuclides from the shallower soil around the target tubes, or water carrying radionuclides leaking from holes (if any) in the liner. Figure 3-3 shows a cross section through the old primary target tube at the old neutrino area. The subdrains and underdrains lead to either retention pits or sumps in the enclosures, where the water is monitored. There are differences in the construction of some of the retention pits at the points at which they drain into the sumps. Some of the retention pits have a direct connection to the sump that allows unrestricted flow, and some have pipes at different levels in the pitwall that can be closed with a threaded plug. The current practice is to physically segregate the retention pit water (which usually is more radioactive) from the sumps to limit the maximum radiation level that can be released to the surface drainage ditches by pumping the sumps. Since the retention pits also collect spills from leaks or from maintenance of the RCW system, the segregation of the two pits further controls releases of radioactive water. Refer to Section 3.3 for additional details.



Source: Adapted from Baker, 1985.

FIGURE 3-3

CROSS SECTION OF NEUTRINO - AREA PRIMARY TARGET
FERMILAB - BATAVIA, IL

CUB Perforated Pipe Field. The former disposal of cooling water laden with heavy metals (Zn, Cu, Cr^{+6}) in the CUB perforated pipe field has resulted in contamination of the soil in that area. The depth and areal extent of the contamination is unknown and has not been characterized beyond a series of shallow, hand-dug samples to a depth of 1.5 meters (5 feet), collected in 1982 (Baker, 1982a, Baker, 1982b) and 1985. (Refer to Section 4.5.1 for additional details.) There are no liquid effluent containment controls in operation at this facility, since it is intended to dispose of wastewater from the CUB-treatment facility.

Main Substation Area. Soil in the vicinity of the main substation is contaminated with PCBs resulting from a series of past spills of PCBs from capacitors and mineral oil from a main transformer. The PCB spills occurred over a period of years until the capacitors were removed in July 1987. The failure of a main transformer in January 1985 resulted in a spill of mineral oil containing 1.3 ppm of PCBs (Baker, 1986a). The PCB contamination is discussed in more detail in Section 4.5.1. No controls on these sources are currently in place. However, remedial planning is underway.

Site 38 Shipping, Receiving, and Warehouses. There have been several historic spills of small quantities of oil, solvents, paint thinner, and other similar chemicals in the Site 38 area. Although many of these spills were cleaned up by Fermilab, apparently only visual confirmation of the absence of soil staining was used as a measure of the completeness of the cleanup effort of the earlier events. It is estimated by the Survey that the combined impact of these spills is small, based on historical data available, and that although small isolated areas of soil contamination may exist, widespread soil and groundwater contamination as a result of the spills is not likely at Site 38. See Finding 4.5.2.4.

3.2.3 Environmental Monitoring Program

Fermilab performs environmental monitoring throughout the year at locations selected by the Environmental Protection (EP) group of the Safety Section. Among the samples collected are soil, silt, and vegetation. Samples are collected for both accelerator-produced radionuclides and for nonradioactive chemical contaminants.

3.2.3.1 Radionuclide Monitoring

Samples of silt and vegetation to be analyzed for radionuclides are collected annually. Routine sampling locations are presented in Table 3-9. In addition to the routine sampling locations, the EP group considers whether additional areas may be in need of sampling for the upcoming year, based

TABLE 3-9

ANNUAL SAMPLE LOCATIONS: SILT AND VEGETATION
FERMILAB - BATAVIA, ILLINOIS

Feature Sampled	General Sampling Location
Kress Creek	Site Boundary North East
Ferry Creek	Site Boundary East
Indian Creek	Site Boundary South West
T-3	Sump Output @ A0
NW4SP1	Sump Output East of Berm
PW6SP2	Sump Output North of PS5
MO1SP2	Sump Output East of MS1
NW1SP6	Sump Output West of NS1
CUB Tile Field	Main Ring Center
NW1 Labyrinth Stack	Entrance South of NS1
M1 Stack	South Side of MS1
N1 Spur Stack	North of TSB
Boneyard	Near Evaporator

Source: Fermilab, Undated.

on occurrences such as known beam losses, discharges of radioactive water from the sumps, ventilation from the enclosures, and historical analytical results. Sampling frequency is increased or sampling repeated at locations where anomalous analytical results are reported.

Sample analysis for specific accelerator-produced radionuclides (Be-7, Na-22, Mn-54, and Co-60) is performed at the Fermilab Nuclear Counting Laboratory. Tritium is analyzed at Teledyne Isotopes, Inc., in Northbrook, Illinois. Tables 3-10 and 3-11 present CY-1986 sediment and vegetation sampling results, respectively.

Fermilab has developed a system of indirectly monitoring the potential for soil activation resulting from beam interaction with targets and dumps. The system uses aluminum and copper tags placed at selected locations in the enclosures. The tags, which can easily be removed and monitored for activation, function as relative indicators of soil activation. For comparison, soil radioactivation is predicted, based on tag measurements as input to a cascade simulation program developed by Fermilab called CASIM. Correlation of predicted soil radioactivation with soil recovered from sampling adjacent to the enclosures has been sufficient to validate the program. The model was validated at the D0 enclosure on the main ring, and because of the similarity in soil types, would also be valid in the experimental area. The tag system has not been used since 1982, in the Experimental Areas, when the superconducting magnets were put in service, but the tags remain in place and are available for use. It continues to be used by the Accelerator Division in their areas.

In addition to the tag system in the enclosures, a series of 25 soil borings and pipes placed in the structures during construction have been used, some of which are still available for measuring radiation at several locations. Twenty-one of the boreholes were located in the experimental area, and four in the main ring. The borings were cased and loaded with sample containers filled with soil, and a tag was emplaced. The soil and tags were retrieved periodically and sent to the laboratory for analysis of radionuclides. As mentioned above, monitoring of the soil by this method has not been used since 1982, when the superconducting magnets were installed. Use of the superconducting magnets requires that the beam be maintained in the guides or the magnets will revert to normal. Such reversion indicates that the beam has become misaligned, and some secondary particles could strike the tunnel wall and surrounding soil. Of the 25 original boreholes, 13 that have not been destroyed by new construction are still available. Of these, four boreholes and pipes installed to monitor water in the subdrains and bathtubs beneath the target enclosures are still in use and are monitored at least annually. Results of tritium analyses from water samples collected from a borehole inside the bathtub beneath the new neutrino-area target hall revealed concentrations as high as 29 pCi/ml (20 pCi/ml is the drinking water standard). The other three holes have shown values for tritium of up to 2,200 pCi/ml and 171 pCi/ml in the PW6 and C0 enclosures, respectively.

TABLE 3-10

CY 1986 SEDIMENT SAMPLING RESULTS
FERMILAB - BATAVIA, ILLINOIS

Location	Concentration (pCi/g dry weight)				
	^{7}Be	^{22}Na	^{54}Mn	^{60}Co	^{137}Cs(a)
Ferry Creek	--	--	--	--	0.88 ± 0.08
Indian Creek	--	--	--	--	0.08 ± 0.02
Kress Creek	2.0 ± 1.2	--	--	--	0.15 ± 0.02
MF5 Sump	--	0.29 ± 0.05	0.56 ± 0.06	0.28 ± 0.03	0.07 ± 0.02
N1 Sump	2.6 ± 0.9	0.33 ± 0.03	0.12 ± 0.02	0.39 ± 0.03	0.08 ± 0.02
N2 Sump	1.9 ± 1.2	0.08 ± 0.03	0.07 ± 0.03	--	0.10 ± 0.02
PW8 Sump	3.3 ± 1.6	--	0.17 ± 0.04	--	--
T3 Sump	3.1 ± 1.4	0.59 ± 0.05	--	--	0.07 ± 0.02
CUB Tile Field	--	0.06 ± 0.03	0.07 ± 0.03	0.17 ± 0.02	0.38 ± 0.04

Source: Baker, 1987.

(a) ^{137}Cs indicates fallout from previous atmospheric nuclear testing.
-- Not detected.

TABLE 3-11

CY 1986 VEGETATION SAMPLING RESULTS
FERMILAB - BATAVIA, ILLINOIS

Location	Concentration (pCi/g dry weight) (pCi/ml of soil moisture for ^{3}H)				
	^{3}H	^{7}Be	^{22}Na	^{54}Mn	^{60}Co
Ferry Creek	*	5 ± 3	--	--	--
Indian Creek	*	12 ± 4	0.24 ± 0.11	--	--
Kress Creek	*	21 ± 8	--	--	--
MF5 Sump	*	13 ± 8	14 ± 1	1.2 ± 0.2	--
N1 Sump	*	6 ± 4	2.3 ± 0.2	--	0.17 ± 0.09
N2 Sump	*	17 ± 3	--	--	--
PW8 Sump	*	33 ± 7	0.15 ± 0.12	--	--
T3 Sump	*	12 ± 2	--	--	--
N1 Labyrinth Stack	64 ± 6	17 ± 4	--	--	--
N1 Muon Line Stack	192 ± 19	14 ± 3	--	--	--
N1 Spur Stack	59 ± 6	23 ± 5	--	--	--
CUB Tile Field	*	25 ± 5	--	--	--

Source: Baker, 1987

-- Not detected
* Not analyzed

The high levels were the result of recirculating cooling-water spills.

3.2.3.2 Nonradioactive Pollutant Monitoring

Samples for nonradioactive chemicals are obtained on a nonroutine basis in areas where suspected pollutants may have been released. The specific locations and contaminant parameters to be analyzed are selected by the EP group and are scheduled for sampling during the upcoming year along with the scheduling of sampling for radionuclides. Sampling locations and parameters scheduled for CY-1987 are listed in Table 3-12.

3.2.3.3 Procedures

Collection for both radioactive and chemical samples is performed using similar procedures, as described below (Allen, 1987a):

- Samples of sediment are collected by scraping the top centimeter of material on a ditch bottom or side into the sample container using the sample container as the collection device. The sediment sample is collected within arm s reach of the shoreline.
- Soil samples are collected by pushing a hand-held "thief" into the soil and retrieving a plug of soil. The barrel of the sampler is approximately 5/8-inches in diameter and 8-inches long. The sampler is decontaminated by washing with soap and water, but not rinsed with acetone or hexane (as standard procedures call for). See Finding 3.2.4.4(a).
- Vegetation samples are clipped with scissors, placed in a plastic trash bag, and sealed with a twist-tie. The scissors are decontaminated with soap and water.

Sample collection techniques and decontamination procedures were not observed during the on-site Survey visit. However a complete review of the written soil-sampling procedures was conducted during the Survey.

Chain-of-custody forms and sample logs are filled in by the sampler for use on the site only. The forms do not accompany the samples to the off-site laboratory.

TABLE 3-12

PLANNED CY 1987 SAMPLING FOR NONRADIOACTIVE CHEMICALS
FERMILAB - BATAVIA, ILLINOIS

Month	Location	Type	Parameters
May	Main Ring Pond at A-0	Silt	Chromates, sulfates, copper, oil, PCBs, and chloride
	Swan Lake	Silt	Silver, cyanide
August	CUB Catch Basin	Silt	PCBs
September	Photo Lab Sump	Sediment	Cyanide, silver, pH, and suspended solids
October	Farmlands	Soil	Pesticides

Source: Adapted from Fermilab, Undated.

3.2.4 Findings and Observations

3.2.4.1 Category I

None

3.2.4.2 Category II

None

3.2.4.3 Category III

1. Soil Radioactivation. Soil radioactivation has occurred and continues to occur in the soil near at least three areas as a result of fixed-target experiments (see Figure 3-4). These areas are:

   - The old primary target hall and decay pipe in the neutrino area (N01 enclosure)
   - The old meson target box (M01 enclosure)
   - The neutrino area primary beam dump (NW4 or enclosure 100 N02)

   While extensive sampling of surface waters and sumps is conducted, the nature and extent of accelerator-produced radionuclide contamination and migration in subsurface soils below the underdrains is not fully characterized or monitored. Lack of monitoring in the subsurface below the underdrains but above the groundwater precludes early detection of contaminant migration. The radionuclides considered leachable that could migrate to the groundwater are Na-22 and tritium. These two radionuclides can move in percolating water and have half-lives longer than many of the other accelerator-produced radionuclides known to be present in the soil and percolating water at these areas. See Finding 3.4.4.3.1(b) for additional information.

3.2.4.4 Category IV

1. Deficiencies In Soil-Sampling Procedures. The accuracy and reliability of soil-monitoring data reported by the on-site and off-site laboratories may be suspect because of deficiencies in the soil-sampling procedures. The following deficiencies were noted:

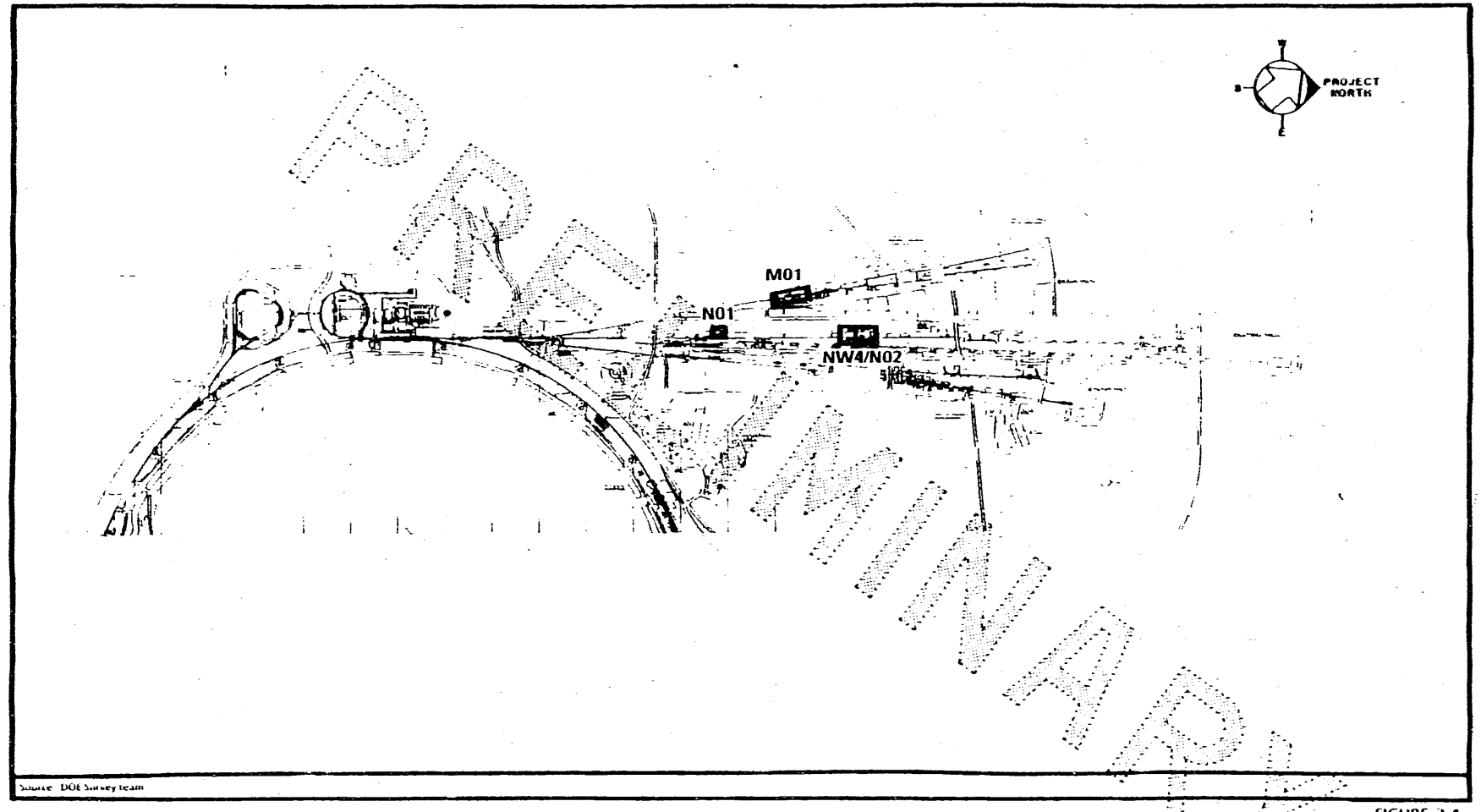


FIGURE 3-4

PRINCIPAL SOIL RADIOACTIVATION AREAS
FERMILAB - BATAVIA, IL

- Cross-contamination of soil samples could occur because the equipment for taking soil samples is not rinsed with acetone or hexane between samples. The equipment is washed with soap and water but not rinsed with acetone or hexane, a standard decontamination practice.

- The Sampling Procedures used by the EP group do not include sufficient information to lead a sampler through the complete process from start to finish.

- There was no listing or description of the sampling equipment needed to take each of the various types of soil and vegetation samples.

- There were no written procedures for the decontamination of sampling equipment used for soil samples that will be analyzed for nonradioactive contaminants, (e.g., metals, organics, and pesticides).

- There were no written procedures outlining how to prevent contamination of sampling equipment prior to taking a sample.

- There were no written procedures describing how to preserve, store, and ship samples.

- The chain-of-custody forms do not accompany the samples to the off-site laboratories; hence, chain-of-custody is technically broken for such samples.

3.3 Surface Water/Drinking Water

3.3.1 Background Environmental Information

The two principal surface-water features in the vicinity of Fermilab are the Fox River, which flows south through Batavia about 3 km (2 miles) west of the Laboratory, and the west branch of the DuPage River, which flows south through Warrenville less than 1 km (0.5 miles) east of the site. Fermilab is unaffected by flooding on either of these surface-water bodies. Annual average flow for the Fox River at Batavia is 1,900 million liters (500 million gallons) per day, whereas the west branch of the DuPage River at Warrenville averages 265 million liters (70 million gallons) per day (Baker, 1987).

The long-term, annual, average precipitation on-site is 79.8 cm (31.4 inches), ranging from low monthly averages of 0.25 cm (0.1 inch) in February to more than 17.8 cm (7.0 inches) in June (Hollingsworth, 1971). The topography of the site is relatively flat, dropping only 26 meters (85 feet) from the highest elevation at the western boundary to the lowest point at the southeast corner. Most of the rainfall is retained on-site for use in various cooling operations.

Three prime sources of water are available in this area of Illinois:

- Shallow wells - There are two wells in shallow aquifers supplying an average of 70,000 gallons per day to the Fermilab Site. Well 62, formerly used to supply the village, is now only used for fire protection.

- The Fox River - This river west of the site ranges in flow from a minimum of 30 million liters (8 million gallons) per day to a maximum of 20,000 million liters (5,200 million gallons) per day. The year-round, average, daily flow is 1,900 million liters (500 million gallons).

- Deep wells - The principal water source for some of the neighboring communities is the Cambrian and Ordovician aquifer system at 360 to 480 meters (1,200 to 1,600 feet) deep This aquifer recharges more slowly than the shallow aquifer.

Fermilab uses the first two sources above to furnish all its water needs. Most of the rainfall is collected and used as cooling water on-site to replace water lost through evaporation. As the need arises (e.g., in 1986 when rainfall was only 57.4 cm [22.6 inches]), Fermilab has permission from the State of Illinois to withdraw water from the Fox River for use as make-up to cooling operations.

Shallow wells scattered about the site provide water for local uses and for all potable and sanitary needs.

Several other important surface-water features are associated with Fermilab operations. Refer to Figure 3-5 for an illustration of these entities. Three natural water courses--Kress Creek, Ferry Creek, and Indian Creek--convey water off-site from Fermilab. Of these, only Kress Creek enters from off-site. The others originate from ponds and basins on-site. Kress Creek enters Fermilab at the north central boundary, then turns east, eventually leaving near the northeast corner. Ferry Creek rises from a series of ponds, natural and man-made, in the southeast quadrant of Fermilab, and leaves the site near its southeast corner. Indian Creek rises near the Central Laboratory Area and flows south, leaving the site near the southwest corner.

Each of these creek basins has its own definite floodplain zone, as depicted on Figure 3-6. These floodplain zones also include the natural and man-made ponds, lakes, and basins associated with each drainage system, as follows:

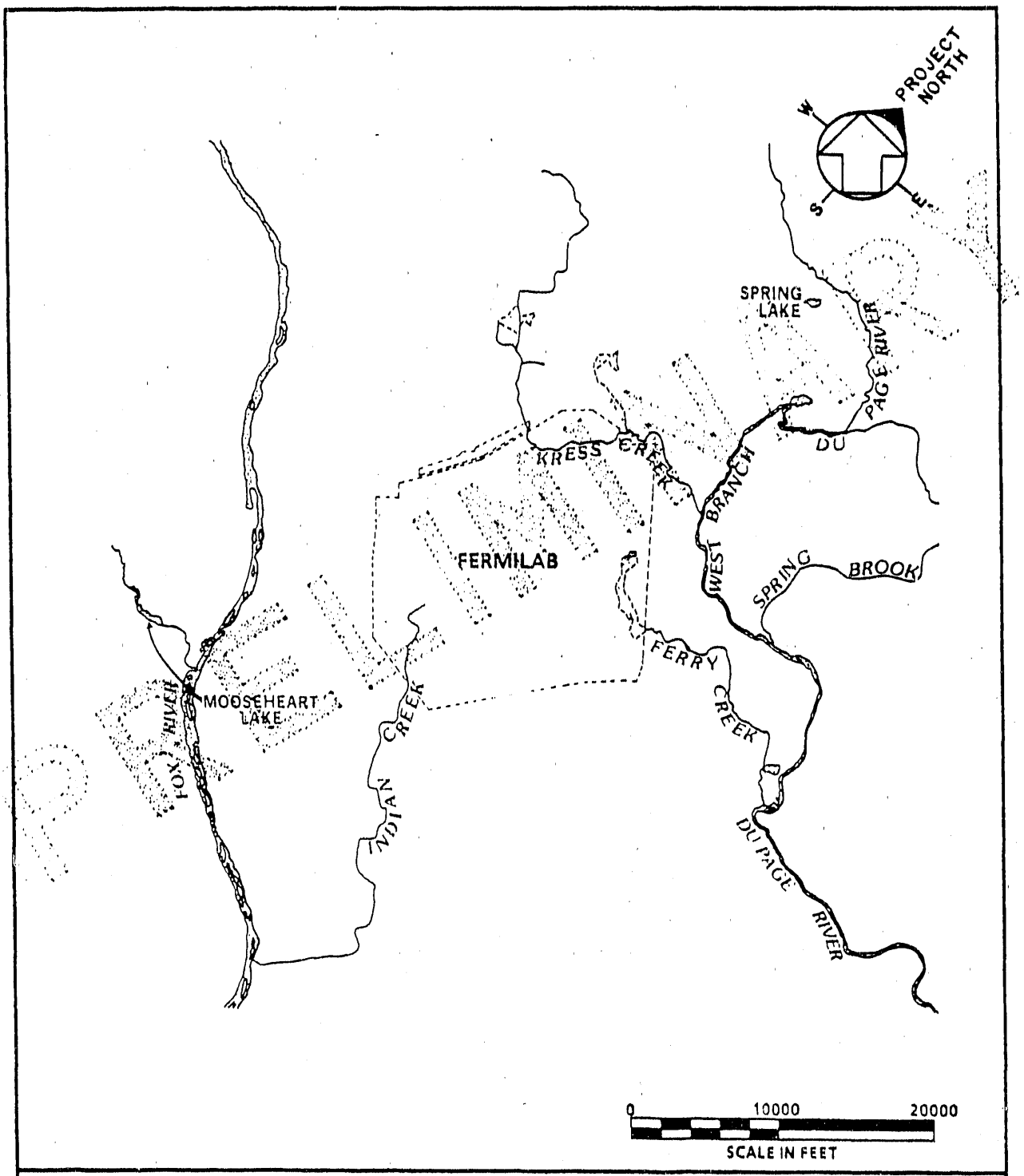
- The Kress Creek basin includes Casey's Pond, which can retain 68 million liters (18 million gallons) of water, and a number of drainage ditches used to convey water from the experimental area to Casey's Pond.

- The Ferry Creek basin includes Lake Law, the DUSAF Pond and the adjacent Village Oxidation Pond, the AE Sea, and the Sea of Evanescence. Main Ring Ponding System water also overflows to Lake Law but is not within the Ferry Creek floodplain.

- The Indian Creek basin includes Swan Lake, the Booster Ponds, West Pond, and a system of ditches to and from the NS1 Service Building.

Lake Logo and the Main Ring Reservoir collect and hold surface water for the Main Ring Ponding System, which consists of a series of interconnecting canals completely encircling the interior of the Main Ring. If the amount of surface water available falls below needs, make-up water can be pumped from Casey's Pond to the Main Ring Ponding System.

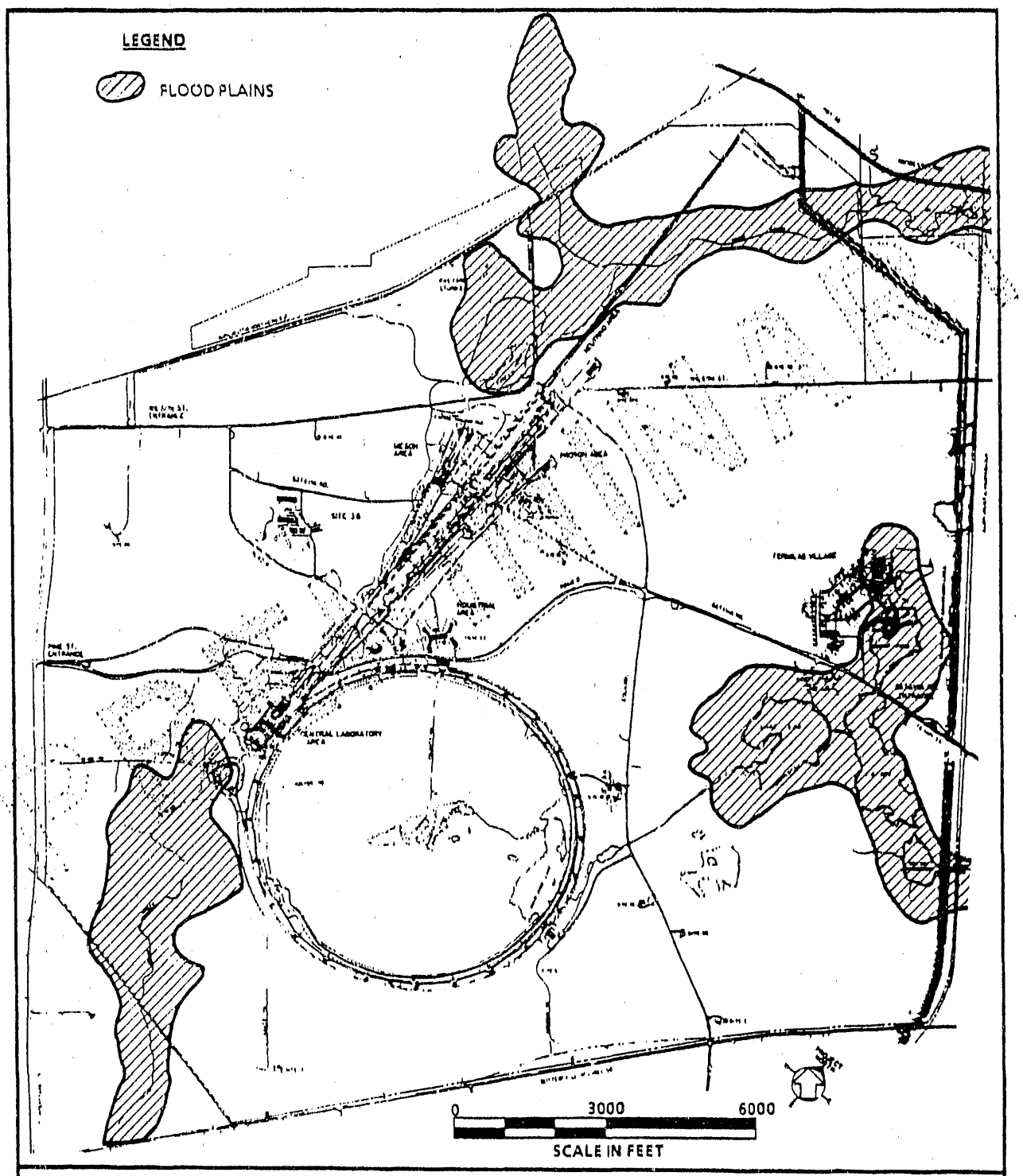
In addition to the drainage ditches cited above for conveying water to various collection and containment systems, other ditches have been installed to channel stormwater runoff into the same



Source: DOE, 1982.

FIGURE 3-5

SURFACE - WATER FEATURES
FERMILAB - BATAVIA, IL



Source: DOE, 1982.

FIGURE 3-6

FLOOD - PLAIN ZONES
FERMILAB - BATAVIA, IL

systems for use as cooling water. Basic drainage patterns are shown in Figure 3-7, and make use of the basins described above. The typical rate of flow of the ditches in the experimental area is approximately 0.13 meters per second (0.44 feet per second) (Fermilab, 1986b; 1987a). Drainage Area A in Figure 3-7 drains to Casey's Pond, which in turn overflows into Kress Creek via weirs. This release to the creek occurred only 19 percent of the time in 1986. Drainage Area B, the Village Area, eventually releases water off-site via Ferry Creek, but only after long-term holding in the series of lakes and ponds identified above. Drainage Area C is the Main Ring Area, which overflows through a spillway between ring points C3 and C4 into a ditch. This ditch conveys the releases to Lake Law for long-term settling prior to release to Ferry Creek. The fourth area, Drainage Area D, contains the Central Laboratory, including the Switchyard. Water levels and overflows are controlled via stop logs, which control the volumes released to Indian Creek.

With respect to drinking water sources, all of the Village Area's demands are now being met (since January 1987) by water purchased from the nearby city of Warrenville. Prior to that time, an 80-meter (261-foot) well (No. 62) provided 45 to 57 million liters (12 to 15 million gallons) per year for all village needs. The well is being maintained in ready condition to provide water for fire suppression.

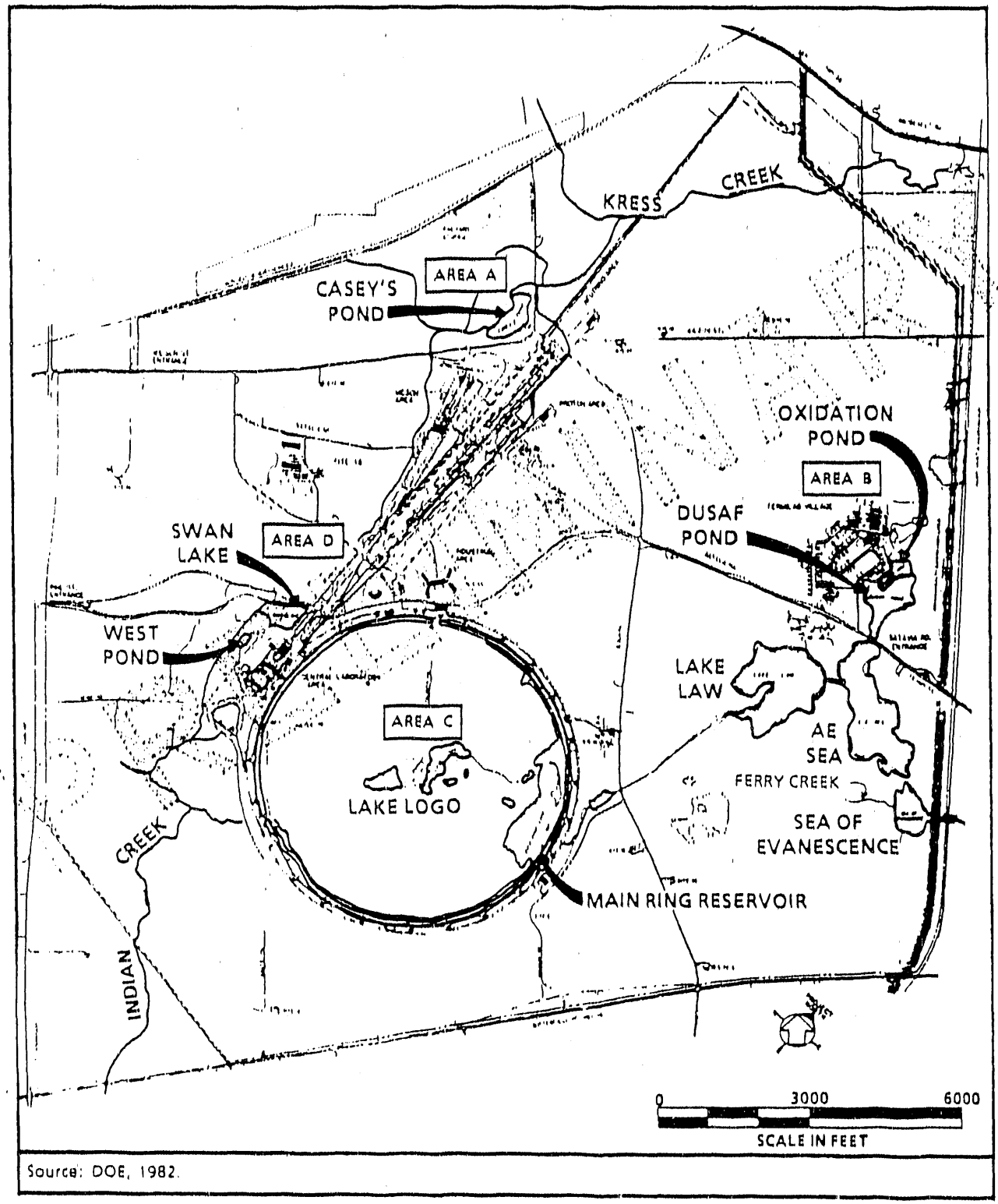
The rest of Fermilab's potable water needs are being met by two on-site wells:

- No. 1 in the Central Laboratory Area provides at least 95 percent of the total Fermilab requirement.
- No. 3 near the warehouse provides the remainder.

In 1986, a low-consumption year, Well No. 1 pumped 95 million liters (25 million gallons), whereas Well No. 3 pumped 1.5 million liters (0.4 million gallons). Among the neighboring communities, all use either the deep aquifer referred to above or the shallow aquifer used by Fermilab to satisfy their potable water needs. The nearest downstream consumer of surface water as a source of potable water is the city of Peoria on the Illinois River, more than 200 km (125 miles) southwest of Fermilab.

3.3.2 General Description of Pollution Sources and Controls

Fermilab personnel have identified the major sources of polluted or radioactively contaminated wastewaters on-site. As is the case with most DOE facilities, radioactivity sources are tightly controlled, whereas chemical or physical pollutants may have been the subject of less attention. Because of the types of operations on-site, the impacts from Fermilab's nonradioactive contaminants



Source: DOE, 1982.

FIGURE 3-7

BASIC DRAINAGE PATTERNS
FERMILAB - BATAVIA, IL

are not as extensive as those noted on other DOE sites. The following discussion identifies pollution sources by type of operations or by the site's physical lay-out, rather than making distinctions between radioactive and nonradioactive sources.

The two ion-exchange resin regeneration systems at the Central Utilities Building (CUB) are designed to remove heavy metals (primarily ^{7}Be, ^{54}Mn, and ^{60}Co) along with calcium and other nonradioactive impurities from spent-resin beds so that resins may be reused in controlling conductivity in closed-loop systems. The regeneration process uses sodium hydroxide and hydrochloric acid solutions, and generates a waste brine, which is mainly sodium chloride and chlorides of the metals cited above. On a year-round basis, a 12,000-liter (3,200-gallon) batch of brine solution is generated every 3 to 10 days, or about once a week on the average. This wastewater is allowed to settle, dropping out suspended solids, and is then pumped to a tile field within the Main Ring, where it is allowed to percolate into the ground. Analysis of the spent regenerants indicates a pH from 2.1 to 12.3 while still in the system, but more typically a pH from 8 to 11 when pumped to disposal. Chemical analyses indicate minor concentrations of heavy metals (e.g., copper at 0.3 mg/l; zinc at 0.27 mg/l; and hexavalent chromium at <0.02 mg/l). Analysis of radionuclides indicates ^{7}Be at <0.5 to 2.9 pCi/ml; ^{45}Ca at <0.3 pCi/ml; ^{60}Co at <0.1 to 7.0 pCi/ml; and ^{22}Na at <0.3 to 0.3 pCi/ml. Tritiated water activity was reported at <1.0 to 11.8 pCi/ml. During the winter, the tile field to which the wastewaters are pumped occasionally freezes, along with the pipeline itself. In the past, some batches were released to the CUB Booster Pond, which is part of the Indian Creek basin. This practice had the potential for inadvertent releases of low-level radioactivity off-site, although no such releases were ever documented. Radioactivity measurements are performed on every resin tank before regeneration. If the field is frozen and a tank equals or exceeds 1 mR/hr on contact, that tank is held until the field thaws. The wastewater from the regeneration of tanks with readings below 1 mR/hr on contact is allowed to settle, dropping most of the radioactivity, before being discharged to the Booster Pond. The current practice of using the settling tank was begun in 1979 for the Main Ring closed loop system resins and in 1986 for the remaining resin tanks. Since 1987, the release of radionuclides to the CUB tile field and Booster Pond has been negligible.

Photoprocessing operations at Wilson Hall and the Village generate a small amount of spent developer and fixer solutions, along with dilute rinsewaters from print washing operations. The laboratory on the fourteenth floor of Wilson Hall uses very small volumes of developer and fixer, about 7.5 liters (2 gallons) of each solution every 6 weeks. The operation in the basement is considerably larger, but is primarily involved in making transparencies and graphic arts for use in seminars and training sessions. There currently is no use of silver solutions, as was common in the past. However, when this laboratory was using silver solutions, rinses were diverted to Swan Lake rather than to the Batavia sewage treatment plant. DOE concern over this practice eventually led to

having nearly all (99+ percent) film processing done by outside laboratories after September 26, 1986 (Cardona, 1987). Now that there are no silver solutions involved and all chemicals used are biodegradable, rinses are sent to two closed sumps located below the process machines. From there the wastewaters are pumped out to the sanitary sewer system, which conveys Wilson Hall wastes to the city of Batavia. In the unlikely event that leaking, concentrated solutions have spilled into the collection system, the sumps can be pumped out into plastic collection tanks and the waste hauled off-site. The city of Batavia's wastewater treatment plant manager was provided with usage rates of all photoprocessing chemicals used in Wilson Hall and with typical effluent data for three regulated photoprocessing pollutants: silver at 0.04 mg/l, cyanide at <0.01 mg/l, and pH at 8.0 standard units (Baker, 1986b) prior to release of photoprocessing wastewaters to the sanitary sewer. Batavia approved Fermilab's request for permission to resume discharges to Batavia's system, since all quantities and concentrations were "well within limits established by City Ordinance" (Musser, 1986), and photoprocessing effluents began flowing to Batavia again on November 25, 1986 (Cardona, 1987).

A third photoprocessing operation is conducted in the Research Division's Printed Circuit Board Laboratory in the village. Small volumes of rinses and spent solutions are drained to the sewer that formerly led to the Village Oxidation Pond. All Village sanitary lines were connected to the Warrenville sanitary system as of December 22, 1986 (Rihel and Bowron, 1987), but the Survey team found no evidence that any notice was provided to Warrenville that small amounts of diluted process wastewaters could be released to its system. Warrenville, in turn, discharges all sanitary wastes to the Naperville-Springbrook Regional Sewage Treatment Plant. This plant is considerably larger than Batavia; therefore, impacts from 30 to 40 liters (8 to 10 gallons) per month would be miniscule. Fermilab did seek permission from Batavia to release photoprocessing wastewaters from Wilson Hall to that system, but has yet to take the same steps with respect to Warrenville and the Naperville-Springbrook system.

Another Village source of wastewater is the Printed Circuit Laboratory's ferric chloride etching solutions. Spent solutions had been released to the Village Oxidation Pond until late in 1979, when the practice was stopped in compliance with Fermilab's self-appraisal recommendation AW-79-I (Read, 1979). Currently only the rinsewaters from this operation enter the sanitary sewer, but these rinses are contaminated with iron (up to 94 mg/l) and copper (up to 2.5 mg/l) and are at pH values between 4 and 6.5. Flow rates are low, since the facility only operates intermittently (current schedules show 2 days per week. Therefore, a 320-liter (85-gallon) batch of ferric chloride solution lasts for 6 months).

The Village's Cut Shop operations in Laboratory No. 1 are another source of contaminated wastewaters, but in this case, spent coolant is released directly to the driveway rather than to the sanitary sewer system (see Finding 3.3.4.4). Approximately 1,100 to 1,500 liters (290 to 400 gallons) per month of highly diluted water-soluble cutting oil are involved. Some of these may percolate slowly into the ground; the remainder follow storm sewers into the nearby pond. In the same area, the large, printed circuit-board-making operations in Laboratory No. 8 also generate approximately 115 liters (30 gallons) per month of wastewater containing fine residues from cleaning and polishing finished boards. Finished boards up to 6.7 meters (22 feet) long are placed flat on a table and manually polished using Scotchbrite pads. Copper metal particles and pad fragments are rinsed off into a 208-liter (55-gallon) drum to settle out, but some of the solid material floats and is allowed to drain off to the ground outside the building (see Finding 3.3.4.4).

The major remaining source of contaminated wastewater in the Village is the old Oxidation Pond itself. It served as a single-stage aerated lagoon typically treating 0.25 to 0.60 million liters (66,000 to 160,000 gallons) per day of domestic waste, including some of the process flows described above. Stringent BOD and TSS requirements mandated by NPDES (National Pollutant Discharge Elimination System) Permit No. IL0025941 proved to be very difficult to achieve. Data for 1986 indicated violation of BOD_5 concentration limits for 10 out of 12 months and of TSS limits for 8 out of 12 months. Data are presented in Table 3-13. DOE staff proposed to IEPA that the oxidation pond be bypassed and that sewage flows be sent to the City of Warrenville system (Mravca, 1986). This was begun on December 22, 1986, and at Fermilab's request, the NPDES Permit was terminated by IEPA, effective April 29, 1987 (McSwiggin, 1987). Fermilab staff plans to maintain aeration and water levels at or near present levels in an effort to reduce BOD_5 content. The ultimate goal is to keep the pond for future recreational and ornamental use and to ensure that the pond immediately downstream does not dry up. Data for the first 7 months of 1987 indicate very gradual die-away of BOD_5 and erratic performance with respect to TSS concentrations. Results of analysis are given in Table 3-14.

In addition to the Village and Main Area sewage collection systems, which rely on off-site treatment at Naperville-Springbrook and Batavia respectively, eight or more other locations at remote sites are served by septic tanks. Only domestic wastes are released to septic tanks, which are pumped out as needed on varying schedules, depending on use rates. Six of the eight known installations were inspected, and no problems were noted. Tank locations for Sites 52 and 57 were not obvious, but are assumed to be comparable to those observed (i.e., without problems). In fact, Site 57 was a farmhouse using a domestic septic tank. This farmhouse no longer stands on the site. In 1972 or 1973, it was moved to the Village as part of a housing cluster that now serves as a dormitory.

TABLE 3-13

MONTHLY AVERAGE REPORT FOR CY 1986
VILLAGE SEWAGE TREATMENT PLANT
FERMILAB - BATAVIA, ILLINOIS

Parameter	Permit[1] Limit	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC[2]
pH, units	6–9	8.1	8.2	8.6	8.2	8.9	8.2	8.4	8.5	8.3	7.7	7.8	7.8
BOD_5, mg/l	10	12*	18*	17*	17*	22*	32*	19*	17*	18*	10	9	14*
Suspended Solids, mg/l	12	12	12	20*	20*	45*	58*	2	28*	9	15*	16*	16*
Fecal Coliform #/100 ml	400	0	0	0	0	0	28	0	0	0	0	0	0

Source: Baker, 1987.

*Violation Report Filed
(1) Permit limit for NPDES Point 001. Permit Terminated on April 29, 1987.
(2) Sewage permanently diverted to City of Warrenville on December 22, 1986.

TABLE 3-14

MONTHLY AVERAGE REPORT FOR FIRST SEVEN MONTHS OF 1987
VILLAGE SEWAGE TREATMENT PLANT
FERMILAB - BATAVIA, ILLINOIS

Parameter	January	February	March	April	May	June	July
pH, units	8.5	7.9	8.3	7.5	9.0	7.9	7.4
BOD_5, mg/l	74	19	33	22	27	13	10
Suspended Solids, mg/l	39	22	14	22	19	16	103
Fecal Coliform #/100 ml	NA	NA	NA	12	58	0	0
Flow, mgd	0	0	0	0	0	0	0

Source: Aqualab, Inc., 1987a.

NA: Not Analyzed

Recirculating cooling water for the magnets and other equipment on-site (including fire protection) is obtained from three interrelated ponding systems (refer to Figure 3-7). These ponding systems may be a source of low levels of contaminants or pollutants. The Industrial Cooling Water (ICW) System uses Casey's Pond as its main reservoir and provides water for the Central Laboratory Areas, the Experimental Areas, and most of the Industrial Area. Incoming water reaches Casey's Pond by surface drainage and is also provided via a dedicated pipeline from the Fox River at Batavia. This latter source provides Fermilab with fresh water for 2 or 3 weeks at a time during the summer months when evaporative losses are at their peak. Until recently, return flow from Casey's Pond to the Experimental Areas and the Central Laboratory Areas was chlorinated as it left the Casey's Pond pumphouse to prevent the growth of bacteria, mold, yeasts, and algae in heat exchangers and piping. The presence of agricultural runoff introduces large amounts of amines to this system. Amines react with chlorine to form chloramines, which are not very effective as biocides. While the Survey team was on-site, Fermilab was replacing the chlorination system with a bromine-based chemical injection to provide improved biological control. An extensive biocide monitoring program has been designed to measure the effectiveness of control and to evaluate the residual concentration of Total Available Halogen (TAH) in the water. This latter measurement is particularly important from an environmental stand-point during those periods when this system releases water directly to Kress Creek. Tests are conducted to confirm that <0.2 mg/l of TAH remains in the effluent to the creek (Selby, 1987).

The second, large, recirculating, cooling-water system involves the Swan Lake/Booster Pond loop, which serves to furnish the needs of the Central Utilities Building (CUB). Water from CUB flows into the Booster Pond, from which it is pumped to a small ditch leading to West Pond and into Swan Lake. A return ditch conveys cooled water back to Booster Pond. Water from Swan Lake also is pumped to the NS1 Service Building in the Switchyard Area for cooling use. Warm water returns to Swan Lake via a surface drainage ditch. Incoming water is either precipitation or water from the ICW system. A spillway can be adjusted to prevent or allow flow discharge into the headwaters of Indian Creek.

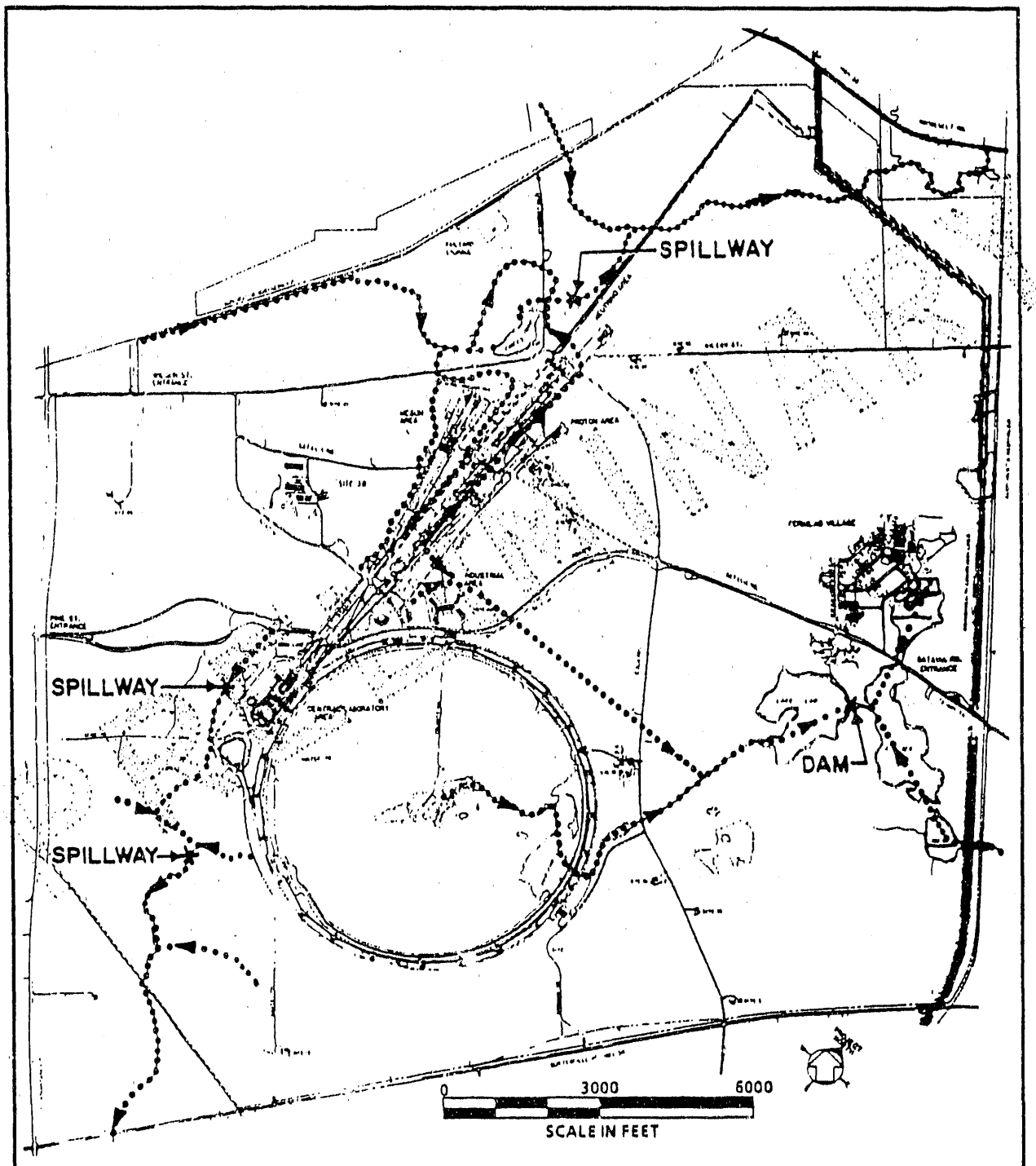
The third large system is the Main Ring Ponding System, a series of interconnecting canals which completely encircle the interior of the Main Ring, plus two reservoirs within the ring--Lake Logo and the Main Ring reservoir. This cooling water is used in heat exchangers at all service buildings associated with the Main Ring magnets. Most of the water originates as surface drainage, although make-up water can be pumped from Casey's Pond when necessary. Any excess water overflows to Lake Law and eventually reaches Ferry Creek.

Overflows from the three recirculating, cooling-water systems are controlled by manually placing or withdrawing stop logs in spillways leading to Kress Creek, Indian Creek, or to the Sea of Evanescence

upstream of Ferry Creek. Flow leaving Lake Law is regulated by a dam. Refer to Figure 3-8 for locations of these controls. The Fermilab Spill Prevention, Control, and Countermeasures (SPCC) Plan contains detailed instructions for trapping and holding spills within any of these loops and at other locations where hazardous or radioactive materials may be accidently released (Fermilab, 1987a). The plan makes use of sandbags and temporary control devices (weirs, oil booms) in addition to containment in ponds, lagoons, and lakes by raising the level of stop logs and spillways.

IEPA has questioned Fermilab's lack of NPDES permits to cover release of cooling waters to "Waters of the State on the Main Site (the Swan Lake/Booster Pond System and the Main Ring Ponding System)," citing 35 Illinois Administrative Code 309.102(a) as an authority (Denning, 1986). This citation identifies discharges that require NPDES permits, and "heat" is included among the list of materials defined as "pollutants." IEPA assumed that any releases identified as "cooling water discharge" must contain sufficient heat to fit the definition of pollutants, so a compliance inquiry letter was dispatched on January 2, 1986, giving DOE 20 days to reply. DOE did so on or about February 28, contending that "DOE does not believe there is a need for NPDES permits for Fermilab cooling water discharges" because neither source releases enough heat in the summer to raise the receiving body's temperature more than 5°F. Heat loads have been reduced substantially due to the addition of superconducting magnets in the Main Ring and the Switchyard. DOE contends that heat loads from Fermilab discharges cause negligible, if any, change in temperature to waters of the state. Since the laboratory operations were scheduled to be shut down for the summer of 1986, Fermilab offered to conduct background measurements then, so that those results could be compared with operations in 1987 to verify temperature impacts (Mravca, 1986). IEPA has not responded, either to Fermilab's offer or to any future action, with respect to Fermilab's compliance inquiry.

Buildings and enclosures in the Switchyard and Experimental Areas have footings equipped with sumps designed to collect and hold surface water until radioactivity measurements can be completed. The sumps are then, based on results of analyses, pumped to the surface and transferred to Casey's Pond via drainage ditches, or controlled as a radioactivate waste (held for decay, solidified, or evaporated). The radioactivity is man-made, and enters the water from beam lines or from contact with activated soil. Individual sources are located at the Meson line; M-East; Meson 3 MP, MC and MW; NW-1 closed loops No. 1 and No. 2 for target trains; NW-4 neutrino line; Neutrino 5; PE-3/PS-4; Proton 4; PC-4, and PS-5/PW-6. All sources are covered under Fermilab's SPCC Plan (Fermilab, 1987a).



Source: DOE, 1982.

FIGURE 3-8

SPILLWAYS AND DAMS
FERMILAB - BATAVIA, IL

Several other small-volume sources of wastewater were also observed during the Survey. For example, industrial area operations make use of a portable, Cleanomat detergent washing (degreasing) machine to clean metal laminates for further use. About once a week, or when the cleaning solution gets dirty, the machine is drained to the nearest driveway or parking lot. Total volume per batch is estimated to be 190 to 300 liters (50 to 80 gallons) weekly. The oily washwaters flow off the paved surfaces into nearby swampy lowlands in the Industrial Area (see Finding 3.3.4.4). When observed, the machine was in use in Building No. 2, but it is easily moved from building to building as needed.

As part of its pollution source control program, Fermilab has prepared and implemented a comprehensive SPCC Plan in accordance with 40 CFR Part 12 (Fermilab, 1987a). The Plan has been revised and updated twice to keep current with ongoing changes in site operations. Guidance is given on possible quantities, flow rates, and directions to nearest receptor for all hypothetical accidental releases of oily materials or hazardous substances (raw materials and wastes). Appropriate containment structures are described, and diversionary equipment for emergency use has been provided. The SPCC contains specific instructions on a step-by-step basis for use of all spill control methods. Practical demonstrations and mock release incidents have been used to give site personnel experience in handling the equipment and reacting properly to emergency situations. Emphasis has been placed on documentation of events and proper notification of agencies and authorities in a timely manner. Overall, Fermilab's SPCC demonstrates fully the benefits of examining possible pathways to the environment so that advance planning can minimize the likelihood of any migration of oils or hazardous materials off-site.

With respect to drinking water sources and controls, Section 3.3.1 identified sources as Warrenville city water for the Village Area (since January 28, 1987) and on-site Wells No. 1 and No. 3 for all other major Fermilab users. A few scattered sites still use shallow wells originally developed for use when the sites were farm homesteads. The Warrenville city water supply is distributed as received to the Village Area's potable water distribution system. Water from Wells No. 1 and No. 3 have automatic chlorination prior to entering the distribution systems (Well No. 1 at the CUB and Well No. 3 at the wellhead). Chlorine residuals are recorded on a strip chart, and total volume pumped is also accounted for daily. Backflow prevention devices are installed to prevent cross contamination from nonpotable sources. Fermilab utilities' personnel routinely inspect these devices to ensure that they function properly at all times. Coliform samples are checked monthly by IEPA's Division of Public Water Supplies. Although no fecal coliform was found in 1986, 1 sample from the CUB on the Main Site's distribution sample exhibited a total coliform count of 4 colonies per 100 ml sample. This amount exceeded the permissible limit of 2 colonies/100 ml. Resampling and analysis for 2 consecutive days after the report was received (1 week after the original sample) gave satisfactory

readings below the 2 colonies/100 ml limit. Fermilab believes that the IEPA sample collected originally was inadvertently contaminated during or after collection and was not representative of the Main Site water supply. A misunderstanding did develop regarding the need for public notice in such cases. Public notice was not posted until more than 3 months after the incident, and then only after IEPA requested information on the notice. Fermilab has modified its procedures to ensure that public notification will be given at the proper time if future incidents occur (Coulson, 1986a). This commitment was fulfilled in mid-1987 when Fermilab posted a notice that it had failed to submit the required number of bacteriological samples or sample analysis reports. The required sampling period was April 27, 1987, through May 24, 1987, but Fermilab's samples did not arrive at the IEPA laboratory until May 27, 1987. This constituted a violation even though results of all analyses were within mandated limits.

3.3.3 Environmental Monitoring Program

Since the NPDES Permit requirements no longer apply, all surface water monitoring done at Fermilab is voluntary in nature rather than mandated by regulations. State requirements do, however, apply to drinking water consumed on-site. Most of the monitoring frequencies and sample selections depend on site activities and analytical data generated in the previous year. Three groups are involved in sample collection and analysis. Business Services and the Environment and Safety group do most of the so-called routine analyses of surface waters, drinking waters, and cooling waters. Radiation Physics and the Environment and Safety group do non-routine analyses and special project assessments, including beam dumps, closed-loop coolants, radioisotopes, beam-line retention tanks, and sumps. Schedules are developed early in the year to ensure that all locations are effectively covered. Sample matrices include the obvious ones, like surface water, plus less obvious ones like parking lot catch basins for PCBs in silt; effluents from the printed circuit laboratory ferric chloride etcher for copper, iron and pH; photoprocessor laboratory sumps for cyanide, silver, TSS, and pH; ponding systems water for chloride, chromates, sulfates, copper, oils and greases, and PCBs; and potable water wells for total and fecal coliforms. Frequencies vary from daily for residual chlorine in potable water to annually or less often for wells or sumps of infrequent use. All three creeks are routinely sampled at least 3 times a year, and Kress Creek is sampled monthly whenever water is flowing over the spillway from the laboratory. The more remote surface waters--the Fox River and the west branch of the DuPage River--are sampled annually, even though neither river is used as a drinking water supply (Baker, 1987).

Certain laboratory operations receive special attention. For example, batches of treated regenerants from the CUB ion exchange systems are routinely analyzed for pH; hexavalent chromium; copper; zinc; ^{7}Be; ^{54}Mn; ^{60}Co; ^{45}Ca; ^{3}H; and ^{22}Na. Sumps, dumps, and retention tanks are analyzed for

radionuclides associated with the specific operations involved (e.g., ^{137}Cs; total radium; total thorium). Also, the laboratory collects fish and mollusks where available to measure PCB and metals concentrations. At points where radioactive effluents may be discharging, Fermilab collects sediment and vegetation samples to determine whether there is any potential for radioactivity to concentrate in those media. Samples are analyzed for ^{7}Be; ^{22}Na; ^{54}Mn; and ^{60}Co. Sediments are also analyzed for ^{137}Cs, whereas vegetation is analyzed for ^{3}H.

Several deficiencies were noted by the Survey team while observing Fermilab's sampling and analysis procedures. Although no obvious errors or impacts on environmental quality were found as a direct result of these deficiencies, practices presently in use do not provide the level of confidence necessary to defend the validity of the data in case of outside scrutiny. Written protocols are not readily available, preservation techniques were inadequate, chain-of-custody forms do not follow the samples off-site, and decontamination and cleaning of sampling equipment was done in a way that cross-contamination could have occurred. Samples for dissolved oxygen were collected in plastic bottles, rendering all results questionable. Refer to Section 3.3.4.4 for further details on this problem, and to Section 3.4.4.4 for similar findings on groundwater sampling.

Analytical data for the former Village Area sewage treatment plant are provided in Tables 3-13 and 3-14 for 1986 and 1987, respectively. Site-wide water quality data for the creeks, Casey's Pond, and the Fox River are provided in Table 3-15 for 1986 and Table 3-16 for the first half of 1987. Note that general standards were met consistently for all except fecal coliform. BOD_5 values tended to be low, and suspended solids on-site were at least as low as the Fox River. Site-wide radionuclides measurements were also made for all these sampling points and the west branch of the DuPage River up and downstream of Ferry and Kress Creeks. All measurements for all sample points in the years 1985 through 1987 were at or below background values of 0.50 pCi/ml for ^{7}Be; 0.30 pCi/ml for ^{45}Ca; 0.10 pCi/ml for ^{60}Co; 3 pCi/ml for ^{3}H; 0.10 pCi/ml for ^{54}Mn; and 0.30 pCi/ml for ^{22}Na.

Analytical data for tritium measurements made on-site in 1986 appear in Table 3-17, where they are compared with the relevant DOE Derived Concentration Guide (DCG). Note that even the highest concentrations at N_1 and N_2 sumps are less than 20 percent of the relevant standard.

Data for fish and mollusks are found in Table 3-18 covering samples collected between July 16, 1981, and May 23, 1986. Results for PCBs are compared with Lake Michigan salmon (stomach fat sample). The latter sample showed inconsistent results, since the total PCB content was less than the sum of its parts.

TABLE 3-15

SITE-WIDE WATER QUALITY REPORT FOR CY1986
FERMILAB - BATAVIA, ILLINOIS

	pH Units		Dissolved Oxygen (mg/l)		BOD_5 (mg/l)		Suspended Solids (mg/l)		Fecal Coliform (#/100 ml)	
	April	Sept.	April	Sept.	April	Sept.	April	Sept.	April	Sept.
Ferry Creek	8.4	8.4	9.8	8.2	5.8	6.8	26	84	0	772
Kress Creek	8.2	8.2	12.1	8.6	3.6	1.3	24	14	304	138
Indian Creek	8.2	8.7	12.6	8.4	2.8	1.9	18	47	320	304
Casey's Pond	8.5	8.5	10.2	8.3	2.4	1.8	19	14	22	30
Fox River	8.8	8.5	11.5	8.9	6.1	4.8	53	79	160	535
General Standards	6.9 – 9.0		Not less than 5.0 at any time		*		*		Mean of 200	

Source: Baker, 1987.

* There are standards for effluent from treatment works or wastewater sources, but no general standards.

TABLE 3-16

SITE-WIDE WATER QUALITY REPORT FOR FIRST HALF OF CY 1987
FERMILAB - BATAVIA, ILLINOIS

	pH, Units	Dissolved Oxygen mg/l	BOD_5 mg/l	Suspended Solids mg/l	Fecal Coliform #/100ml
Ferry Creek	8.2	8.9	7.2	64	30
Kress Creek	7.8	8.7	2.5	10	396
Indian Creek	7.8	9.0	2.1	16	16
Casey's Pond	8.3	8.7	1.9	0	44
Fox River	8.3	8.7	7.2	97	20
General Standards	6.0-9.0	Not less than 5.0 at any time	*	*	Mean of 200

Source: Aqualab, Inc. 1987b.

* There are standards for effluent from treatment works or wastewater sources, but no general standards.

TABLE 3-17

TRITIUM DETECTED IN ON-SITE WATER SAMPLES
TRITIUM CONCENTRATION C (μCi/ml)*
FERMILAB - BATAVIA, ILLINOIS

Collection Point	No. of Samples Collected	C Maximum	C Maximum Error	C Minimum	C Minimum Error	C Mean	Percentage of Relevant Standard
C1 Sump	1	4.0×10^{-6}	1.4×10^{-6}	4.0×10^{-6}	1.4×10^{-6}	4.0×10^{-6}	0.2
D1 Sump	4	$<3.0 \times 10^{-6}$	—	$<3.0 \times 10^{-6}$	—	$<3.0 \times 10^{-6}$	<0.15
G4 Sump	2	7.4×10^{-5}	1.9×10^{-6}	5.8×10^{-5}	1.7×10^{-6}	6.6×10^{-5}	3.3
G5 Sump	2	6.5×10^{-6}	9.0×10^{-7}	$<3.0 \times 10^{-6}$	—	4.8×10^{-6}	0.24
G7 Sump	3	1.8×10^{-5}	1.0×10^{-6}	$<3.0 \times 10^{-6}$	—	9.4×10^{-6}	0.47
MF4 Sump	5	1.8×10^{-5}	1.1×10^{-6}	2.8×10^{-6}	7.0×10^{-7}	6.7×10^{-6}	0.33
MF5 Sump	6	1.2×10^{-4}	3.0×10^{-6}	6.1×10^{-5}	2.1×10^{-6}	8.9×10^{-5}	4.45
N1 Sump**	8	3.2×10^{-4}	4.2×10^{-6}	1.4×10^{-4}	2.0×10^{-6}	2.1×10^{-4}	10.5
N2 Sump**	8	4.9×10^{-4}	5.0×10^{-6}	9.8×10^{-5}	2.6×10^{-6}	3.2×10^{-4}	16.0
N2B Sump	1	2.5×10^{-6}	1.5×10^{-6}	2.5×10^{-6}	1.5×10^{-6}	2.5×10^{-6}	0.125
G3 Sump	1	3.9×10^{-6}	8.0×10^{-7}	3.9×10^{-6}	8.0×10^{-7}	3.9×10^{-6}	0.2
NM2 Sump	2	6.4×10^{-5}	1.8×10^{-6}	2.6×10^{-5}	1.2×10^{-6}	4.5×10^{-5}	2.3
PW7 Sump	2	3.1×10^{-6}	9.0×10^{-7}	2.5×10^{-6}	7.0×10^{-7}	2.8×10^{-6}	0.1
PW8 Sump***	4	7.3×10^{-4}	4.1×10^{-6}	2.5×10^{-6}	7.0×10^{-7}	2.3×10^{-4}	11.5
PW9 Sump	4	1.9×10^{-4}	2.3×10^{-6}	3.8×10^{-6}	8.0×10^{-7}	6.2×10^{-5}	3.1

Source: Baker, 1987

* C Max is the highest concentration detected in any sample from that location and C Min is the lowest. C Mean is the average for all samples from one location.

** The high concentrations in these sumps are assumed to be due to the accumulation during the period of time that the sumps were not pumping automatically. This period of time was about 75 percent of the year. The sumps were pumped only a few times manually during the year.

*** The high concentration in this sump sample was the result of a leak into the sump totaling less than .5 mCi of tritium.

TABLE 3-18

FISH AND MOLLUSKS COLLECTED ON- AND OFF-SITE
FERMILAB - BATAVIA, ILLINOIS

Date	Type	Water Source	Total PCB mg/kg	Aroclor 1254 mg/kg	Aroclor 1260 mg/kg	Silver mg/kg	Copper mg/kg	Zinc mg/kg
07/16/81	Fish	Booster Pond	0.78	–	–	–	–	53
11/19/81	Fish	Swan Lake	0.00	–	–	–	–	–
11/19/81	Fish	Main Ring (C-4)	–		–	–	0.38	–
10/26/84	Salmon (Stomach Fat)	Lake Michigan	1.0	<1.0	1.3	–	–	–
5/22/86	Fish (Bottom Feeder)	Booster Pond	0.0358	0.0089	0.0269	0.19	5.7	–
5/22/86	Fish (Pan Fish)	Booster Pond	0.688	0.131	0.557	0.34	3.86	–
5/23/86	Mollusks	Booster Pond	0.560	0.300	0.260	–	–	–

Source: Fermilab, 1987b.

Radionuclide analyses of sediments in 1986 indicated low levels of 5 elements, even in N_1 and N_2 sumps where tritium values were at their peak. Refer to Table 3-10 for data on ^{7}Be, ^{22}Na, ^{54}Mn, ^{60}Co, and ^{137}Cs. Vegetation around the same location plus three stacks expected to be releasing limited amounts of radioactivity was analyzed for ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, and ^{60}Co. Data are presented in Table 3-11.

Data exist for numerous other sampling points in 1986, but the overall thrust of the entire monitoring effort points to good control of Fermilab's radioactive and non-radioactive contaminants. Impacts on receiving streams are very minor or at background levels. The overall program accurately characterizes the surface water quality.

3.3.4 Findings and Observations

3.3.4.1 Category I

None

3.3.4.2 Category II

None

3.3.4.3 Category III

None

3.3.4.4 Category IV

1. Contaminated Wastewater Released to The Ground. Several small-volume sources of contaminated wastewaters are discharged to the nearest paved surfaces or to the ground without adequate control or treatment. Although no environmental problems were observed, such practices could ultimately contribute to the pollution of soils or groundwaters beneath the surface with oils or heavy metals. Specific examples of such releases include the following:

   - 1,100 to 1,500 liters (290 to 400 gallons) per month of oily plasma burner coolant from laboratory No. 1's cut shop is drained to the driveway adjacent to the building. Analyses indicate oil and grease concentrations at 28 mg/l; iron at 2 to 58 mg/l; chromium, copper,

manganese, and nickel at 2, 1.35, 3.8, and 1.8 mg/l, respectively. From the driveway the coolant either percolates into the ground or is flushed into the storm drainage system.

- 190 to 300 liters (50 to 80 gallons) per week of oily detergent washwaters from a portable Cleanomat degreasing machine are released to the driveways and parking lots in the industrial area, from which they are flushed into the nearby swampy lowlands. When observed, the machine was in use in Building No. 2, but it is portable enough to be hauled wherever needed. Metal laminates are degreased by this machine, transferring residual oils and possibly heavy metals to the washwater. The potential for soil and groundwater contamination exists as a result of this practice.

- Approximately 115 liters (30 gallons) per month of rinsewaters from the polishing of copper-based printed circuit boards are released directly to the ground from laboratory No. 8 in the Village. The bulk of the metallic copper in this wastewater is recovered by simple settling in a 115-liter (30-gallon) plastic container, but the supernatant does contain floating pieces of Scotchbrite pads in which copper particles are embedded. This material is transferred to the ground, where it accumulates at the surface, or is carried to the DUSAF pond by stormwater runoff. In either case, a potential for contamination of soil, groundwater, or surface water exists.

2. Deficiencies in Sampling Procedures. Although the Fermilab analytical laboratories have a sampling quality assurance program in effect, there are some deficiencies in its implementation. The Survey team did not find evidence of invalid data, but the sampling practices presently used are not sufficient to defend the validity of the data. The specific sampling problems and potential consequences are discussed below:

   - The surface water sampling procedures for the radiochemical and chemical measurements are not available in a detailed sampling protocol for the samples collected by the Safety Section. The lack of formal procedures makes it difficult to verify proper sample collection. Also, a new or temporary person substituting during the regular sampler's absence can sample improperly without a sampling manual for guidance.

   - The water samples are not always properly preserved by cooling for organic compound analysis or by the addition of acid for metals analyses. Since metals are known to plate-out on the surface of the container if the sample is not at a pH of less than 2.0, the data obtained can be erroneous. Organic compounds are subject to biological and chemical changes on standing. These effects can be greatly reduced by cooling below 4°C and

storage in the dark. Sample preservation techniques when used, and sample holding times prior to analysis were not recorded in an appropriate logbook for later verification.

- Although chain-of-custody forms are available and used, they are not properly signed at each transfer of the sample and do not accompany the sample to the contractor's off-site laboratory. This can result in difficulty in proving the reliability of the results obtained, since documentation that the correct sample was analyzed cannot be provided. This deficiency occurs at both laboratories (the Nuclear Counting Laboratory and the Water Laboratory).

- Surface water samples at most locations (except the sample collected at the oxidation pond) are collected for both laboratories by filling a container at one point (e.g., below the surface at one point near the shore). This practice can result in obtaining a non-representative sample. Streams, ponds, and lakes are not homogenous in water quality. For example, channeling occurs in rivers and streams; thus the collection of a sample near the shore at one point may not adequately reflect the water quality of the river or stream.

- Inadequate cleaning of water sampling equipment between samples was observed during a sampling trip with the sampler for the Environmental Protection Group. This practice can contaminate samples leading to erroneous results. This is probably a consequence of not having a detailed sampling protocol as discussed above.

- The bottle used to collect the sample for dissolved oxygen is not the recommended type. At present, a plastic bottle is used, which may be permeable to air. Typically, samples for dissolved oxygen are collected in a glass bottle with a glass stopper so that the bottle can be filled without trapping air in the bottle.

3.4 Hydrogeology

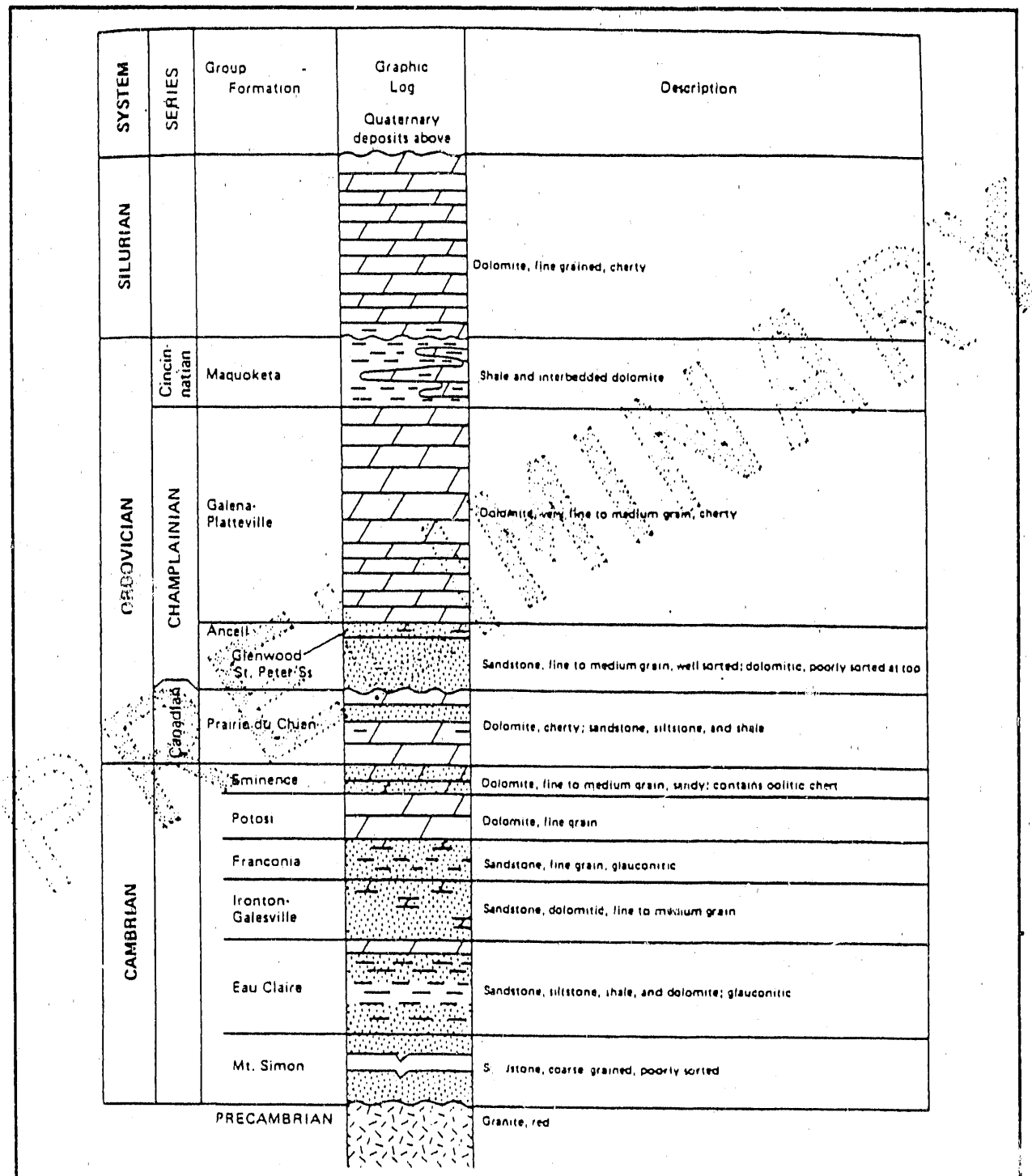
3.4.1 Background Environmental Information

3.4.1.1 Regional Geology

The Fermilab site lies within an area of North America that has been relatively stable since the Precambrian period more than 600 million years in the past. As such, the underlying geologic formations are relatively undisturbed. The oldest rocks in the area are the crystalline Precambrian granites and gneisses that form the basement complex of the Canadian Shield. This stable rock platform played host to sedimentation in shallow transgressive and regressive seas during the Paleozoic Cambrian through Pennsylvanian periods. Sedimentation during that time consisted of coarse- to fine-grained materials now represented by cyclic sequences of sandstone, shale, and carbonate beds. The stratigraphic column of the bedrock typical in the north-central Illinois area is presented in Figure 3-9. These sedimentary rocks are estimated to range from 610 to 1,220 meters (2,000 to 4,000 feet) in thickness near the site, and have been measured at thicknesses of up to 4,600 meters (15,000 feet) in the Illinois Basin to the southeast.

The stability of the region since the lower Paleozoic era is evident from the lack of major structural disturbances such as folding and faulting resulting in substantial topographic relief. The region is typified by nearly flat bedding, which dips southeast toward the Illinois Basin at an average of approximately 100 feet in 5 to 10 miles (Kempton et al., 1985). These gentle dips are caused by a structural high, approximately 100 miles northwest of the site, referred to as the Wisconsin Arch. Although the area is relatively undisturbed, minor folding and faulting have occurred in the distant geologic past. Figure 3-10 shows these structural features.

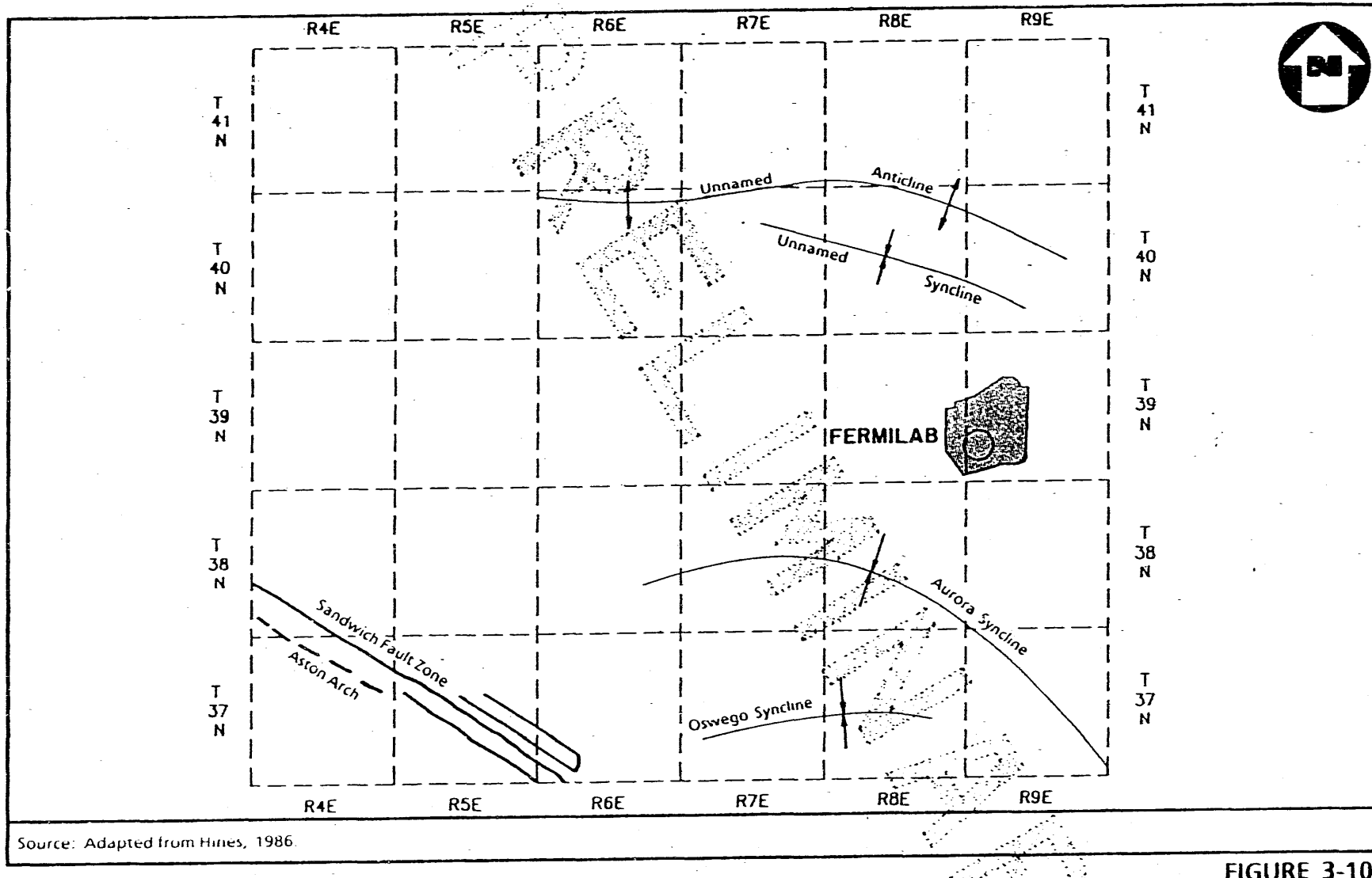
Erosion has removed most evidence of rocks younger than the Silurian bedrock in the vicinity of Fermilab. Only glacial sediments of sand, gravel, and clay exist above the bedrock. These unconsolidated materials were produced and deposited during several stages of continental glaciation that occurred during the Pleistocene epoch. These sediments occasionally range in thickness up to 150 meters (500 feet) where older river valleys are filled with sand and gravel. The current landscape is relatively flat, and the thickness of glacial sediments generally mirrors the bedrock topography with thicknesses between 30 and 46 meters (100 and 150 feet); however, substantial areas of glacial sediments exist with thicknesses of less than 30 meters (100 feet) (Kempton, et al., 1985).



Source: Kempton et al., 1985.

FIGURE 3-9

BEDROCK STRATIGRAPHY
FERMILAB - BATAVIA, IL



Source: Adapted from Hines, 1986.

FIGURE 3-10

STRUCTURAL FEATURES
FERMILAB - BATAVIA, IL

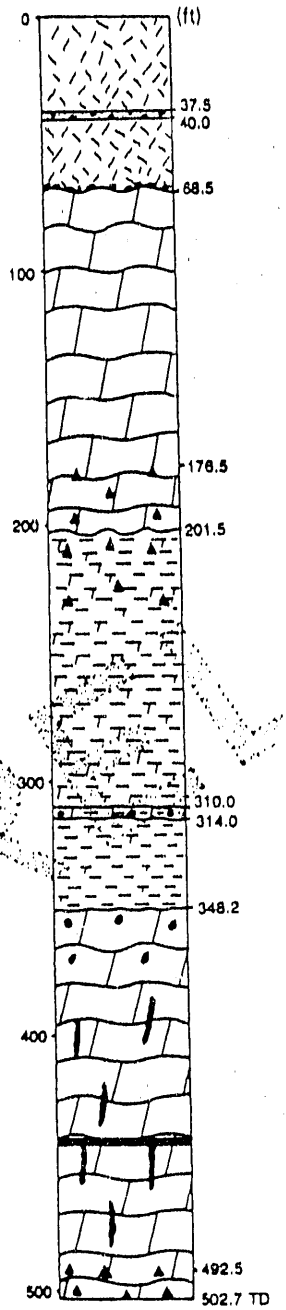
The last glacial stage to affect the area is referred to as the Wisconsin Glaciation. The retreat of the glaciers from this stage resulted in the freshest glacial features visible in the topography of the area. These features include closed basins and lakes, poorly integrated drainage lines, more outwash plains, small areas of good till plain, and a lack of loess cover (Thornbury, 1965). The result of these features is a relatively featureless plain of low relief.

3.4.1.2 Site Geology

The geology of the Fermilab site is well known from the numerous studies performed there by Federal and state agencies, and by private consultants for design and construction of the site facilities. Some of the most recent subsurface studies have included deep engineering borings. Figure 3-11 is a partial stratigraphic column at the site constructed from data from Test Hole F-1 drilled during the fall 1984 test drilling program for the Superconducting Super Collider (SSC) siting studies (Kempton, et al., 1987).

The bedrock stratigraphy at the site above the Precambrian basement consists of Cambrian through Silurian age sediments, approximately 1,220 meters (4,000 feet) thick. The earliest of the sediments are Cambrian sandstones and dolomite. These sediments are approximately 800 meters (2,600 feet) thick and range from the basal Mt. Simon Formation, a poorly sorted, coarse-grained sandstone, through the Eminence Formation, a fine- to medium-grained dolomite containing oolitic chert. Two regionally important formations, the Ironton Sandstone and the Galesville Sandstone, comprise an aquifer.

The sediments of the Ordovician period range from the Prarie du Chien Formation, which conformably overlies the Eminence Formation, to the Maquoketa Formation. The Prarie du Chien is composed of interbedded cherty dolomite and sandstone with minor siltstone and shale. It is variable in thickness from 0 to 120 meters (0 to 400 feet), and is unconformably overlain by the Ancell Group. The St. Peter Sandstone and Glenwood Formation of the Ancell Group comprise another regional aquifer. The St. Peter Sandstone is 46 to 76 meters (150 to 250 feet) thick and is described as a pure white, fine- to medium-grained, rounded, well sorted, friable sandstone. The overlying Glenwood Formation is approximately 23 meters (75 feet) thick and contains poorly sorted sandstone, silty dolomite, and shale. The Ancell Group is conformably overlain by the Galena and Platteville Groups. They consist of approximately 110 meters (350 feet) of dolomite with minor chert, shale partings, and limestone.



QUATERNARY SYSTEM
PLEISTOCENE SERIES
WEDRON FORMATION
YORKVILLE TILL MBR.
Till; olive-gray loam (0.0–37.5 ft)
Gravel (37.5–40.0 ft)
MALDEN TILL MBR.
Till; grey silty clay (40.0–68.5 ft)

SILURIAN SYSTEM
KANKAKEE AND JOLIET DOLOMITE (undifferentiated)
Dolomite, light olive gray, light greenish gray, and pinkish gray, very fine-grained, wavy beds separated by thin greenish gray shaly partings slightly vuggy in zones (68.5–176.5 ft)

ELWOOD DOLOMITE FORMATION
Dolomite, as above, but cherty (176.5–201.5 ft)

ORDOVICIAN SYSTEM
MAQUOKETA SHALE GROUP (undifferentiated)
Greenish gray dolomitic shale and shaly dolomite; pyrite; cherty in upper 30 feet (201.5–310.0 ft)

Dolomite, light olive gray, coarse-grained, fossiliferous, oil in vugs (310.0–314.0 ft)

Shale, olive gray, dolomitic, laminated (314.0–348.2 ft)

GALENA DOLOMITE GROUP
WISE LAKE DOLOMITE FORMATION
Dolomite, yellowish brown, fine- to medium-grained, vesicular and vuggy, in wavy beds separated by thin shaly partings; some pyrite in vugs; numerous clay-filled solution joints; bentonite bed at 348.2–492.5 ft and clay filled joint at 440.6–444.5 ft

DUNLEITH DOLOMITE FORMATION
Dolomite, as above, but cherty (492.5–502.7 ft)

Source: Kempton, et al., 1985.

FIGURE 3-11

STRATIGRAPHIC COLUMN FOR TEST HOLE F-1
FERMILAB - BATAVIA, IL

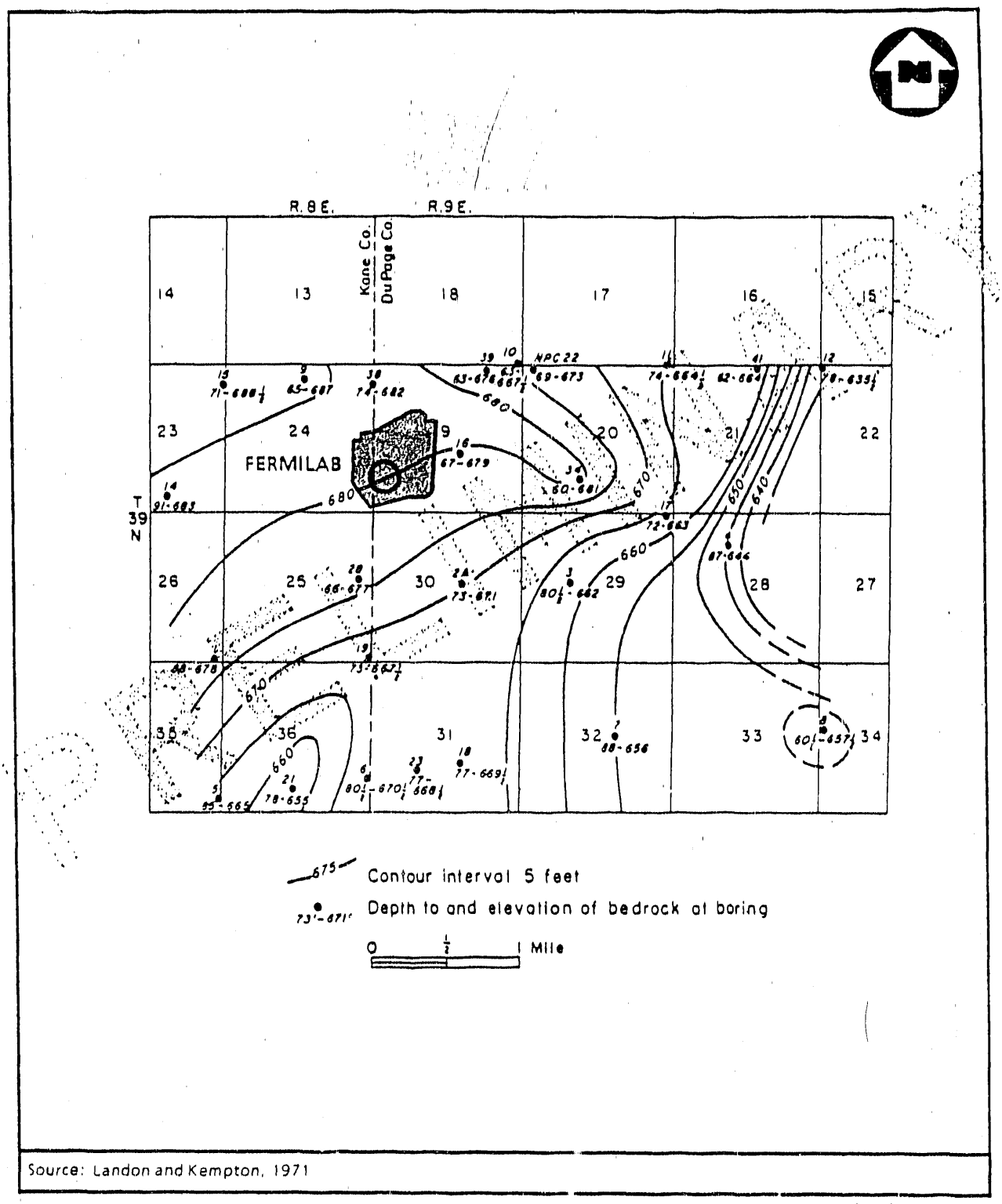
The Maquoketa Formation conformably overlies the Galena Group. It is approximately 40 meters (130 feet) thick at Fermilab (Kempton et al., 1985). The lithology of the Maquoketa is highly variable ranging from shale to argillaceous dolomite to dolomite. It is considered to be a confining unit for the underlying Cambrian and Ordovician aquifers in the Chicago area.

The contact between the Ordovician Maquoketa Formation and the Silurian Edgewood, Joliet, and Kankakee Formations is an erosional unconformity. The thickness of Silurian dolomite is approximately 43 meters (140 feet) at Fermilab (Kempton et al., 1985). The Silurian dolomites are described as fine-grained, with shaly partings and minor chert. The surface of the Silurian dolomite is the top of bedrock at the site. Almost all of the younger rocks have been removed by erosion or glaciation. The bedrock surface lies beneath approximately 18 to 30 meters (60 to 100 feet) of glacial drift. A topographic map of the bedrock surface is shown on Figure 3-12.

Glacial deposits form the overburden at the Fermilab site. These consist of seven separate tills, with two sand and gravel layers over some portion of the site. The glacial sediments have been studied in detail, and subdivided into five informal units shown in Table 3-19 (Landon and Kempton, 1971). Some uncertainty exists with interpretation of the stages of the glacial units at the site. An earlier interpretation (Landon and Kempton, 1971) is that the tills are mostly of the Wisconsin Stage Wedron Formation overlying the Winnebago Formation. A more recent interpretation (Kempton et al., 1985) is that the Wedron Formation overlies the bedrock and the Winnebago Formation is not present at the site. However, some outwash sand and gravel deposited directly below the Wedron Formation may be related to outwash and tills of the Winnebago Formation (Kempton et al., 1985). The current interpretation is that the tills are the Yorkville and Malden Members of the Wedron Formation. These tills appear to be separated by either a lacustrine silt, or an outwash sand and gravel layer on the order of 1 to 3 meters (3 to 10 feet) thick at an approximate elevation of 216 meters (710 feet) msl. A subsurface profile in the vicinity of the experimental area is shown on Figure 3-13.

3.4.1.3 Groundwater Regime and Usage

The groundwater regime at Fermilab exists as a system of three aquifers. The uppermost is the glacial drift composed of sand and gravel layers that are highly variable with respect to thickness, areal extent, and yield. The two other water-bearing zones are the Silurian dolomite and the Cambrian and Ordovician strata. These two are considered regional aquifers.



Source: Landon and Kempton, 1971

FIGURE 3-12

TOPOGRAPHIC MAP OF THE BEDROCK SURFACE
FERMILAB - BATAVIA, IL

TABLE 3-19

SUMMARY OF DATA FOR GLACIAL DEPOSITS
FERMILAB - BATAVIA, ILLINOIS

Unit	Subunit	Till No.		Sand	Silt	Clay	Qu	W	DD	LL	PI
A		Loess, Silt, Sand	No. samples	15	15	15	No	43	10	40	40
			Mean	8	67	25	data	24.9	94	41.4	21.6
B		1	No. samples	107	107	107	7	97	36	90	90
			Mean	9	53	38	3.2	16.5	115.3	27.9	12.4
		2	No. samples	30	30	30	No	29	7	30	30
			Mean	8	44	48	data	18.5	114.0	30.6	14.5
C	C1	3 Sand and gravel, Silt	No. samples	21	21	21	1	16	No	15	15
			Mean	33	45	22	5.2	12.8	data	21.5	8.1
	C2	4	No. samples	37	37	37	2	31	11	29	29
			Mean	26	47	27	3.0	11.8	130.2	22.6	9.6
		5	No. samples	37	37	37	8	37	10	29	29
			Mean	20	43	37	2.6	15.0	122.1	28.0	13.5
D		6	No. samples	81	81	81	No	101	53	106	106
			Mean	8	36	56	data	20.8	107.0	39.3	18.9
E		7 Sand and gravel	No. samples	29	29	29	No	25	2	25	25
			Mean	40	45	15	data	10.1	127.5	16.6	4.7

Source: Landon and Kempton, 1971.

Explanation

Qu - Unconfined compressive strength in tons/ft^2 (undisturbed)
W - natural moisture content in percent
DD - Dry density in pounds/ft^3
LL - Liquid limit in percent
PI - Plasticity index

Sand, silt, and clay in percent of less than 2 mm fraction

Sand 2-0.062 mm
Silt 0.062-0.0039 mm
Clay < 0.0039 mm

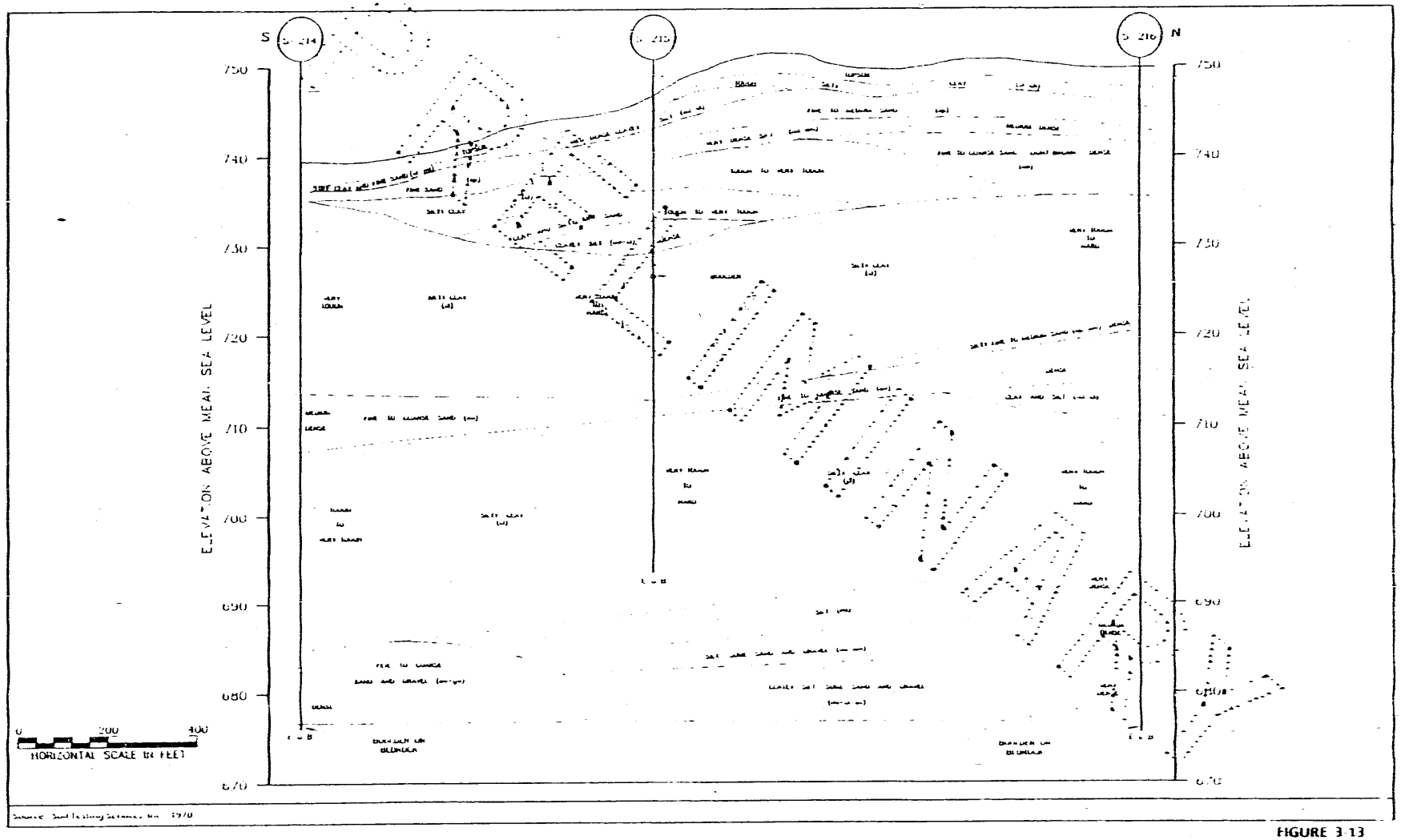


FIGURE 3-13

SUBSURFACE PROFILE IN THE EXPERIMENTAL AREA
FERMILAB – BATAVIA, IL

The glacial drift aquifer yields water from the sand and gravel layers. There is evidence of two water-bearing zones within the glacial drift at the site. The upper layer is considered to be a perched water table that occurs within a layer that has been described in some areas to be a silty sand, and in other areas to be a fine to coarse sand. This is apparently an outwash deposit that overlies the uppermost clayey till. Water-level measurements in this upper, perched, water table in several piezometers installed in the experimental area have ranged in elevation from approximately 220 to 230 meters (730 to 745 feet) above mean sea level (msl) with corresponding depths ranging from less than 0.3 to approximately 3 meters (1 to 10 feet) below the surface (Hall et al., 1969a). Some areas in the western portion of the site where ground surface elevations are highest are expected to have higher water levels in this upper, perched, water table, as evidenced by measurements in Well F-3. These measurements indicate water at elevation 230 meters (753 feet) msl, corresponding to a depth of 1.6 meters (5.25 feet) below ground surface (Sasman, 1987). It is estimated that seasonal fluctuations in the water level in this upper zone may vary by as much as 3 meters (10 feet) (Hall et al., 1969b). Values for the Coefficient of Permeability in the upper zone range from 1.2×10^{-3} meters/min to 1.8×10^{-6} meters/min (4×10^{-3} feet/min to 6×10^{-6} feet/min) (Hall et al., 1969b). No data is available on water quality, and this shallow, perched, water table is not used for drinking water at Fermilab.

A second perched water table occurs associated with the sand and gravel layer between the upper and lower till sequences. Water levels measured in piezometers installed in this sand and gravel layer were reported to range from an approximate elevation of 216 to as high as 224 meters (710 to 735 feet) msl, corresponding to depths ranging from 3.4 to 11.3 meters (11 to 37 feet) below the surface. The areal extent, thickness, and water quality of this sand and gravel layer have not been characterized. No wells draw on this aquifer for drinking water supplies at Fermilab.

The till members that separate and in some areas confine these perched water tables have been evaluated by several methods, and estimates of the vertical permeability and vertical flow velocities in them have been made. Estimates of groundwater flow rates range from a high of 3×10^{-3} meters/day (1×10^{-2} feet/day) (Smith, 1971) to a low of 3.7×10^{-5} meters/day (1.2×10^{-4} feet/day) (Pfingsten and Kastman, 1978).

The Silurian dolomite aquifer is the most commonly used regional aquifer in the site area. Annual usage at the site was estimated to be approximately 155 million liters (41 million gallons) in 1986 from 11 wells (ISWS, 1986). Estimates for the yield from each of these wells are presented in Table 3-20. Locally, the City of Warrenville uses the Silurian dolomite aquifer for its water supply.

TABLE 3-20

1986 WATER-WELL USE
FERMILAB - BATAVIA, ILLINOIS

Well Number	Total Gallons Used
FNAL 1	25,017,000
FNAL 3	410,000
FNAL 4*	180,000
F-17A	200,000
F-29A	109,000
F-50B	250,000
F-52	350,000
F-55B	450,000
F-56	100,000
F-58	425,000
F-62	13,654,650
F-68B	25,000

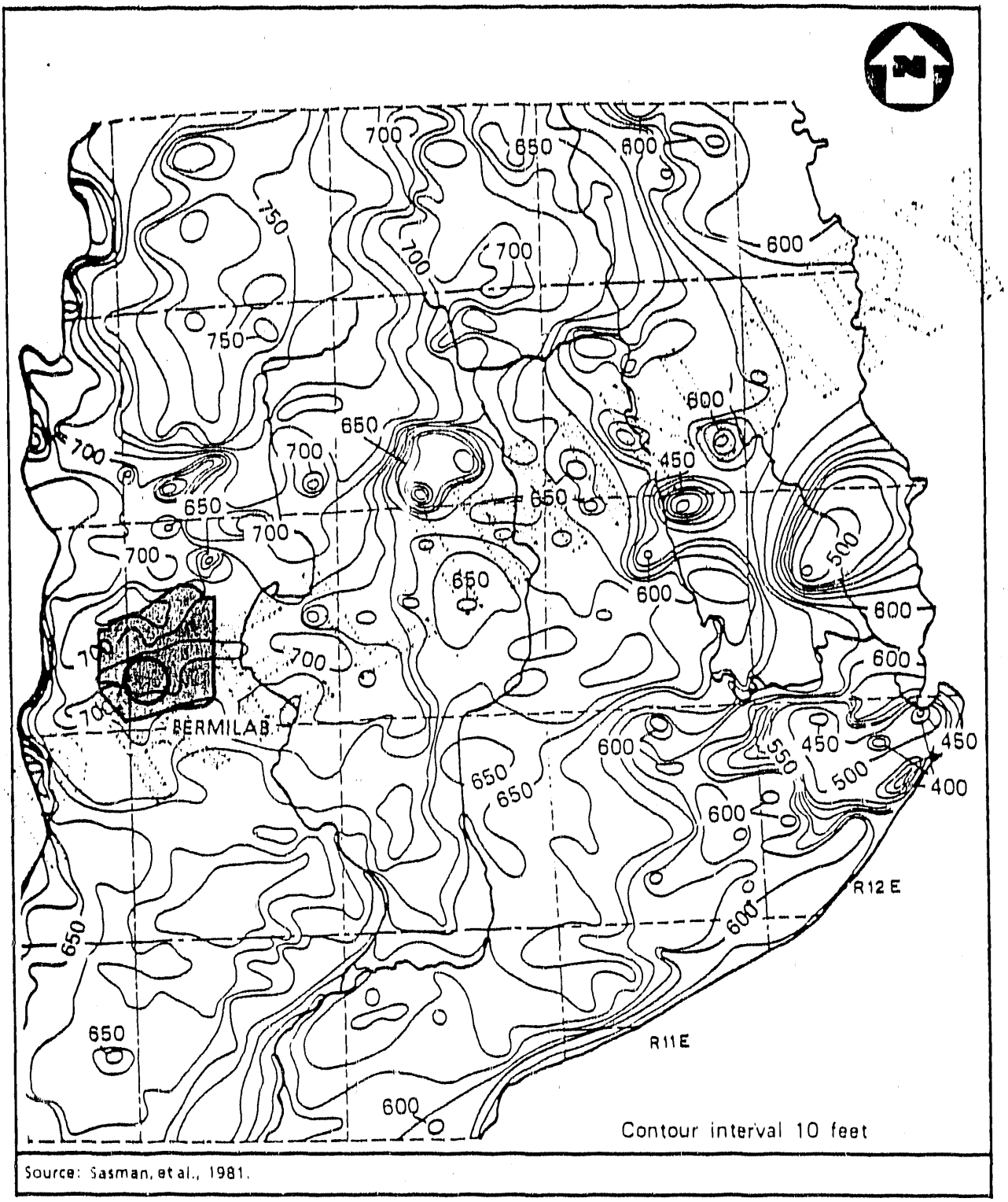
Source: Adapted from Sasman, et al., 1981.
* Well in Cambrian-Ordovician Aquifer

The city's well No. 5, located approximately 975 meters (3,200 feet) southeast of the site boundary corner, reportedly supplied 290 million liters (77 million gallons) in 1986 (Ludwigs, 1987). Approximately 30 other private and municipal water supply wells are cataloged by the Illinois State Water Survey (ISWS) to lie within 0.6 km (1 mile) of the site boundary. The current operational status of these wells is not known.

Piezometric surface elevations of the Silurian dolomite aquifer range from approximately elevation 215 meters (705 feet) msl in the north central portion of the site near Casey's Pond, to elevation 209 meters (685 feet) msl in the southern and eastern half of the site. The average regional gradient is a minimum of 2 meters/km (10 feet per mile), and the potentiometric surface generally slopes downward to the east (Sasman et al., 1981). Figure 3-14 shows the regional piezometric surface of the Silurian dolomite aquifer in 1979.

The average flow velocity in the Silurian dolomite aquifer in the Fermilab Village area has been estimated to be in the range of 1 to 2 meters/day (3 to 6 feet/day) with a maximum of 4 meters/day (13 feet/day) (Schicht, 1969). More recent studies report hydraulic conductivities ranging from 1×10^{-3} cm/sec (2×10^{-3} feet/min) to 4×10^{-6} cm/sec (8×10^{-6} feet/min) (Kempton et al., 1987). Because of the overlying sand and gravel, groundwater flow is not restricted to the dolomite bedrock. As such, the groundwater flow and subsequent velocities are dependent upon the character of the overlying sediments and the solution channels formed in the dolomite. These solution channels are the result of weathering along pre-existing fractures or bedding planes in the dolomite and provide secondary porosity that is significant within the upper 7.6 meters (25 feet) of the weathered zone. Below that depth, solution features generally decrease, and flow rates decrease.

Groundwater quality is monitored in the Silurian dolomite aquifer at the site for drinking water standards and other selected parameters. Section 3.4.3 provides details on the monitoring program. Water quality test results from January 1986 sampling are presented in Table 3-21. These results show that most of the parameter concentrations are below the maximum level standards for drinking water. The exceptions are total dissolved solids (TDS), sulfates, and iron in six, one, and ten of the thirteen wells, respectively. Although hardness is not reported, it is regionally reported to average just below 500 mg/l in the Silurian aquifer (Sasman et al., 1981). Table 3-22 presents concentrations for some selected parameters in the Silurian dolomite aquifer. Background levels for radium in wells at Fermilab ranged from 0.07 to 3.0 pCi/l. No accelerator-produced radionuclides were detected (Baker and Schamber, 1972). The regional mean and range of the water quality parameters, when compared to the Fermilab well data, indicate that the site water quality does not



Source: Sasman, et al., 1981.

FIGURE 3-14

PIEZOMETRIC SURFACE OF THE SILURIAN DOLOMITE AQUIFER, 1979
FERMILAB - BATAVIA, IL

TABLE 3-21

JANUARY 1986 WATER-QUALITY SUMMARY (mg/l)
FERMILAB, BATAVIA, ILLINOIS

Parameter	Total Dissolved Solids	Chloride	Fluoride	Nitrate + Nitrite Nitrogen	Sulfate	Chromium	Cadmium
Standard	500	250	1.8	10	250	0.05	0.010
1 RAW (Dupl.)	490	16.0	0.8	<0.05	149.0	<0.001	<0.001
1 Raw	523	12.0	0.8	<0.05	161.0	<0.001	<0.001
1 Dist.	533						
3 Raw	530	18.0	0.7	<0.05	164.0	<0.001	<0.001
3 Dist.	797.0						
62 Raw	423.0	8.0	0.8	<0.5	69.0	<0.001	<0.001
62 Dist.	450.0						
17 A	537.0	22.0	0.8	<0.05	108.0	<0.001	<0.001
29	830	24.0	0.9	<0.05	450.0	<0.001	<0.001
50	530	32.0	0.6	<0.05	108.0	<0.001	<0.001
52	517.0	22.0	0.6	<0.05	109.0	<0.001	<0.001
55	443.0	30.0	0.5	<0.05	62.0	<0.001	<0.001
56	340.0	2.0	0.7	<0.05	<5.0	<0.001	<0.001
58	330.0	<1.0	0.7	<0.05	18.0	<0.001	<0.001
68	420.0	8.0	0.8	<0.05	76.0	<0.001	<0.001
43							
20	440.0	2.0	1.0	<0.05	38.0	<0.001	<0.001
45	44.0	6.0	0.6	<0.05	37.0	<0.001	<0.001

TABLE 3-21
JANUARY 1986 WATER-QUALITY SUMMARY (mg/l)
FERMILAB, BATAVIA, ILLINOIS
PAGE TWO

Parameter	Mercury	Silver	Lead	Zinc	Iron	Copper	Manganese
Standard	0.002	0.05	0.005	5.0	1.0*	5.0	0.15*
1 RAW (Dupl.)	<0.0001	0.001	<0.01	0.005	0.68	<0.001	0.010
1 Raw	<0.0001	<0.001	<0.01	0.004	0.75	<0.001	0.011
1 Dist.			<0.01	0.180	1.71	0.017	
3 Raw	<0.0001	<0.001	<0.01	0.092	2.13	0.206	0.205
3 Dist.			<0.01	0.012	0.30	0.007	
62 Raw	<0.0001	<0.001	<0.01	0.015	0.60	0.004	<0.013
62 Dist.			<0.01	0.041	0.24	0.052	
17 A	<0.0001	<0.001	<0.01	0.149	1.50	0.005	0.010
29	<0.0001	<0.001	<0.01	0.302	0.83	0.003	0.017
50	<0.0001	<0.001	<0.01	0.072	1.80	<0.001	0.018
52	<0.0001	<0.001	<0.01	0.313	2.20	0.004	0.035
55	<0.0001	<0.001	<0.01	0.066	2.00	<0.001	0.017
56	<0.0001	<0.001	<0.01	0.260	3.10	<0.001	0.025
58	<0.0001	<0.001	<0.01	0.673	0.45	<0.001	<0.001
68	<0.0001	<0.001	<0.01	2.20	1.54	<0.001	0.009
43							
20	<0.0001	<0.001	<0.01	0.424	1.74	0.075	<0.001
45	<0.0001	<0.001	<0.01	0.148	3.10	0 014	0.010

TABLE 3-21
JANUARY 1986 WATER-QUALITY SUMMARY (mg/l)
FERMILAB, BATAVIA, ILLINOIS
PAGE THREE

Parameter	Cyanide	2,4-D	Gasoline	Total Organic Carbon	Trihalo-Methane	Trichloro-ethane	Trichloro-ethylene
Standard	0.1	0.1			0.1 µg/l	0.2 µg/l	0.005 µg/l
1 RAW (Dupl.)	<0.001	<2.0	<10.0	2.7	**	<1.0	<1.0
1 Raw	<0.001	<2.0	<10.0	3.2		<1.0	<1.0
1 Dist.							
3 Raw	<0.001	<2.0	<10.0	2.9		<1.0	<1.0
3 Dist.							
62 Raw	<0.001	<2.0	<10.0	2.5		<1.0	<1.0
62 Dist.							
17 A	<0.001			3.3		<1.0	<1.0
29	<0.001						
50	<0.001			8.0		<1.0	<1.0
52	<0.001	<2.0					
55	<0.001		<10.0	2.9		<1.0	<1.0
56	<0.001		<10.0				
58	<0.001	<2.0		2.6			
68	<0.001	<2.0					
43			<10.0	2.6		<1.0	<1.0
20	<0.001						
45	<0.001						

TABLE 3-21
JANUARY 1986 WATER-QUALITY SUMMARY (mg/l)
FERMILAB, BATAVIA, ILLINOIS
PAGE FOUR

Parameter	Benzene	Ammonium	Sodium	pH (units)
Standard	zero	1.5		6.5 - 9.0
1 RAW (Dupl.)		0.49	31.4	7.63
1 Raw	<1.0	0.81	30.5	7.55
1 Dist.		0.81		
3 Raw	<1.0	<0.05	30.5	7.55
3 Dist.				
62 Raw	<1.0	0.48	19.8	7.42
62 Dist.				
17 A		0.82	25.5	7.43
29		1.14	49.0	7.58
50				7.49
52				7.64
55		0.36	19.1	7.45
56		0.39	19.1	7.41
58		0.42	17.4	7.40
68		0.76	19.4	7.40
43		0.79	31.3	2.6
20				
45				

TABLE 3-21
JANUARY 1986 WATER-QUALITY SUMMARY (mg/l)
FERMILAB, BATAVIA, ILLINOIS
PAGE FIVE

*Trihalomethanes	Chloroform (µg/l)	Dichlorobromethane (µg/l)	Dibromochloromethane (µg/l)	Bromoform (µg/l)
Well # 1 Dist.	<1.0	15.0	5.9	<1.0
Well #62 Dist.	<1.0	6.8	2.5	<1.0
**Well #1 Raw Dupl.	<1.0	<1.0	<1.0	<1.0

Source: Adapted from Mottashed, 1986.
* Note: Non-community water supplies exempted.
\+ Proposed Federal Limits.
§ Standard for waters in general use.

TABLE 3-22

1979 WATER QUALITY FOR 282 WELLS IN THE SILURIAN DOLOMITE AQUIFER
FERMILAB - BATAVIA, ILLINOIS

Parameter	High	Low	Median
TDS (mg/l)	1,832	259	625
Hardness as $CaCO_3$ (mg/l)	1,360	134	481
Sulfate (mg/l)	864	0.1	166
Chloride (mg/l)	450	0	22
Sodium (mg/l)	317	4.1	30.2
Total Organic Carbon (mg/l)	16.5	0.2	1.6
Fluoride (mg/l)	1.6	0.1	0.3
Total Iron (mg/l)	53.6	0.0	1.2
Nitrate (mg/l)	63.2	0.0	0.2

Source: Adapted from Sasman et al., 1981

appear to be extraordinary with respect to iron and TDS's exceeding drinking water standards. The high sulfate present in Well 29 is an individual, isolated occurrence and therefore is not representative of the site in general.

The Cambrian and Ordovician aquifer is the major source of regional groundwater for municipal and commercial supplies. It contains three water-bearing zones: (1) the Cambrian Elmhurst-Mt. Simon aquifer; (2) the Cambrian Ironton-Galesville aquifer; and (3) the Ordovician Ancell aquifer. The Ironton and Galesville Sandstones are the most productive formations of the three from which approximately 600 million liters/day (158 mgd) was withdrawn in 1985 (Sasman et al., 1986). Well FNAL-4 at Fermilab draws from the Ironton-Galesville aquifer, with a measured water level at elevation 47 meters (154 feet) msl in 1987 (Sasman, 1987) indicating a downward gradient from the Silurian dolomite aquifer above it. Reported usage for Well FNAL-4 was estimated at 680,000 liters (180,000 gallons) in 1986 (ISWS, 1986).

Fermilab does not use this aquifer for drinking water supply, but does monitor for radium and thorium. Analyses from July 1985 show 5.16 ± 0.49 pCi/l total radium and <0.02 pCi/l total thorium. The regional values for radium (Ra-226 and Ra-228) range from 2.3 to 50.2 pCi/l, with thorium concentrations below the detection limit of 0.01 µg/l in the Cambrian and Ordovician aquifers (Gilkeson, 1985). The Fermilab values fall within the lower part of the typical range of values for these radionuclides.

3.4.2 General Description of Pollution Sources and Controls

Fermilab has three source-areas that may pose a threat to groundwater. Two of these source-areas are essentially inactive (i.e., they are no longer receiving contaminants) and one area is presently receiving waste discharge. One of the inactive areas and the active area are the result of site operations. The other inactive area is the result of a transformer oil spill in January 1985. These areas represent potential sources of groundwater contamination and are described as follows:

CUB Perforated Pipe Field. The old CUB perforated pipe field inside the main ring formerly received wastes derived from the treatment of cooling water fluids, which contained chromates to inhibit corrosion. Soils in the disposal area have been sampled to a depth of 1 5 meters (5 feet) and analyzed for chloride, chromate, copper, lead, sulfates, and zinc. Although the use of chromates was discontinued in 1978, the tile field area continues to receive wastes in the form of salt solutions containing chloride, Be-7, Mn-54, Co-60, calcium, and other nonradioactive impurities that were in the cooling water from the regeneration of ion exchange column resins. The disposal field system of underground piping was rebuilt in 1982 with the new CUB clay tile field overlapping the old CUB

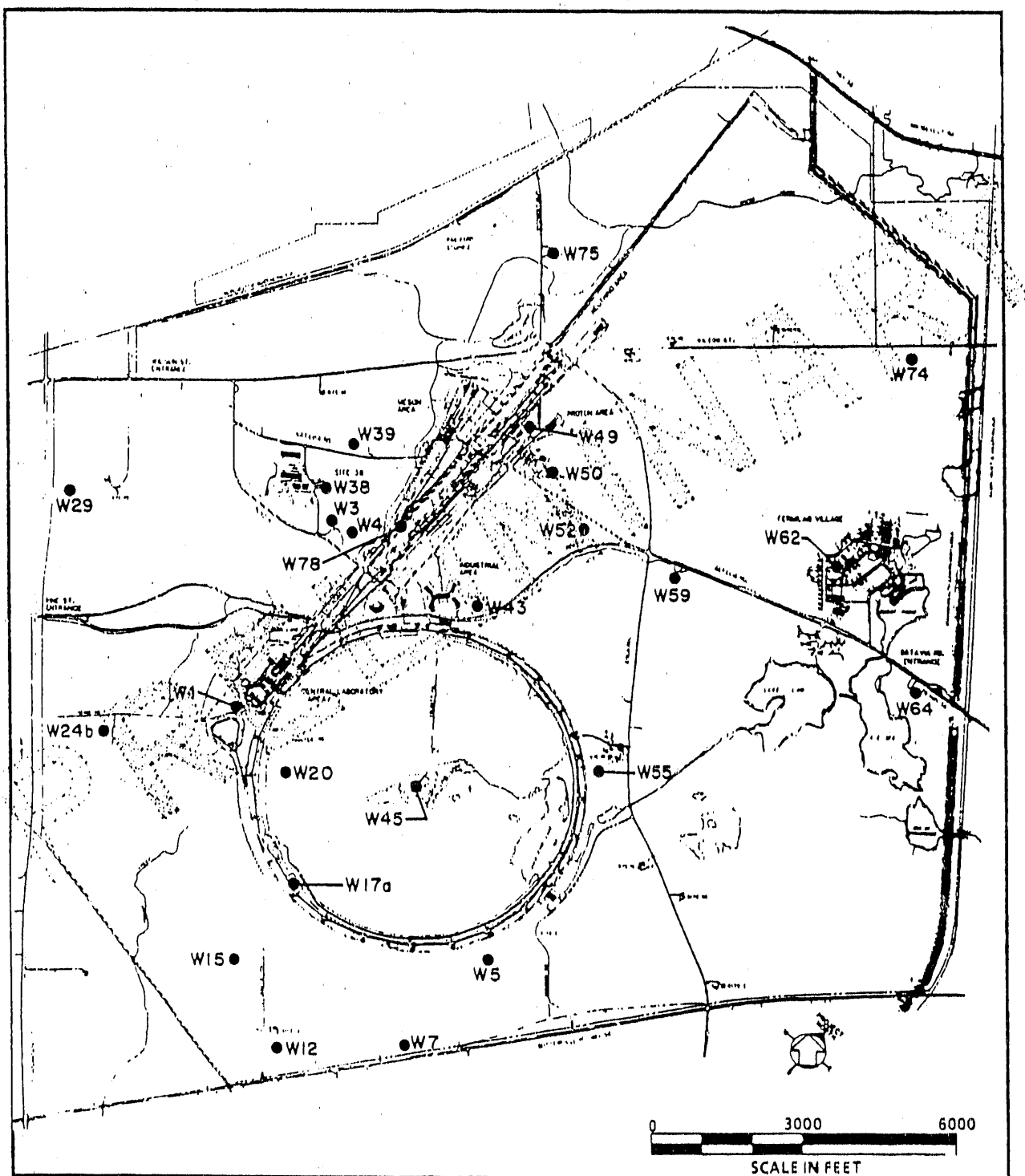
perforated pipe field in part. There are no surveyed, as-built records of the construction, but notes from Fermilab Environmental Group personnel indicate an approximate area of less than 0.4 hectares (1 acre) was used for the piping network. Finding 4.5.2.3 provides more detail on the nature of the contaminants and historical quantities discharged there.

January 1985 Transformer Oil Spill. The failure of a transformer in the main substation, in January 1985, released a quantity of mineral oil estimated to be as much as 23,000 liters (6,000 gallons). The oil is a potential source of groundwater contamination and has been encountered in a sump approximately 15 meters (50 feet) east of the pad, and an electric vault beneath the Capacitor Tree approximately 15 meters (50 feet) south of the pad. The subsurface has not been sampled or characterized in the area near the spill. Finding 4.5.2.3.1 provides more detail on this potential source.

Soil Activation at Targets and Dumps. Soil activation from beam-target interaction and beam-dump pass-through in the area of the old primary target areas of the neutrino and meson beam lines, as well as the neutrino area primary target area dump, are a potential source of groundwater contamination. Leachable radionuclides have been detected and are regularly monitored in sumps connected to underdrains beneath these older structures. New designs for these types of facilities provide for additional steel shielding to reduce soil activation, but the older target areas with soil shielding have been, and remain, activated. These two older target halls are no longer in use. Section 3.2.2 describes the typical older target-hall configuration and known soil contamination.

3.4.3 Environmental Monitoring Program

Fermilab has planned for and performed environmental monitoring since 1970. As part of that program, both on-site and off-site groundwater wells were sampled. On-site wells that were not used in the monitoring program were sealed with cement as they were abandoned. Wells used for the current monitoring program have had protective, lockable enclosures installed and are protected from accidental vehicle collisions by four metal posts set in a concrete apron. Each well is identified with an engraved plastic label attached to a steel fencepost placed adjacent to the well. The well locations are shown on Figure 3-15.



Source: Adapted from Baker, 1984.

FIGURE 3-15

WELL LOCATIONS
FERMILAB - BATAVIA, IL

3.4.3.1 Groundwater Radionuclide Monitoring

As part of the program, groundwater sampling for radionuclides was initially performed prior to experimental work in the target areas. This sampling effort provided an early baseline and thus serves as background data. This initial groundwater monitoring consisted of sampling the existing on-site farm wells and local municipal supplies. These samples were analyzed for radium, thorium, and the five most common radionuclides anticipated to be formed by operation of the accelerator: Be-7, Na-22, Ca-45, Mn-54, and H-3 (tritium). The analyses indicated none of the accelerator-produced radionuclides were present above detection limits, but radium and thorium were relatively high (Baker and Schamber, 1972). Table 3-23 shows radium concentrations found in the local water supplies and on-site wells.

The monitoring program has continued with changes to the program being made annually by the Environmental Group at Fermilab based on previous results, anticipated need, and potential sources. Current plans for groundwater monitoring are, in part, based on guidance contained in the Department of Energy document: A Guide for Environmental Radiological Surveillance at DOE Installations. The well water sampling schedule is based on the following rationale (Baker, 1987):

- Wells 38/39, 43, 49, and 78 are sampled quarterly because they are closest to the areas of maximum soil activation (near targets and beam dumps) and are in the direction in which the water is expected to flow in the aquifer.
- Wells 1, 5, 17A, 20, and 45 are sampled semiannually because they are near the accelerator.
- The remaining wells are sampled annually because they are near the site boundary or serve as back-ups to more frequently sampled wells or as drinking water supplies.
- The one deep well is sampled annually to look for long-term trends or changes in percolation down to that level.

Sample collection procedures for radionuclides are included in an undated, internal Fermilab document titled: "Sampling Procedures" (Fermilab, undated). The procedures contain, among other things, a list of wells and their sampling category (i.e., annual, quarterly sampling) instructions for purging wells, pump sanitation, and instructions for actions to be taken when positive tritium results are reported.

TABLE 3-23

RADIUM IN LOCAL WATER SUPPLIES
FERMILAB - BATAVIA, ILLINOIS

Location	Radium Concentration (pCi/ml)
NAL Deep Well	0.0075
Well #55	0.002
Well #50	0.002
Well #21	0.003
Batavia	0.030
Aurora	0.024
Well #43	0.003
Well #21	0.0005
Well #43	0.001
Well #64	0.0009
Well #50	0.0008
Well #29	0.0008
Well #49	0.0007
NAL Village	0.0008
NAL Deep Well	0.0122
North Aurora	0.00275
NAL Village	0.0004
Well #39	0.001
West Chicago	0.012
NAL Village	0.001
Well #52	0.0001
Well #29	0.00007
Wheaton	0.00004
Well #75	0.0001
Well #74	0.0003
Well #21	0.0002
Well #50	0.0004

TABLE 3-23
RADIUM IN LOCAL WATER SUPPLIES
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

Location	Radium Concentration (pCi/ml)
Aurora	0.0006
Well #49	0.0004
Well #68	0.0008
Warrenville	0.019
West Chicago	0.028
Geneva	0.022
Batavia	0.024
North Aurora	0.022
Aurora	0.020
NAL Deep Well	0.016
NAL Deep Well	0.005
NAL Deep Well	0.006

Source: Baker and Schamber, 1972.

During the on-site Survey, groundwater sampling was observed at wells with dedicated centrifugal pumps only; W-78, W-49, and W-43. (None of the wells without dedicated pumps were scheduled for sampling during the Survey). The same procedures were used for each well. A portable generator was connected to the well and was used to power the pump for both purging and sampling. Purging consisted of pumping the well at the maximum pump discharge rate for 10 minutes. Water level, temperature, pH, conductivity, and discharge rate were not measured prior to, during, or after either purging or sampling. Purge water was discharged onto the ground adjacent to the well through a 3-foot section of garden hose. The hose was not decontaminated by any means other than rinsing with well water between each use. Sampling was performed by partially closing the spigot on the well discharge pipe so that the flow from the hose could be directed into the sample bottles without splashing uncontrollably from the force of the discharge (visually estimated at 38 to 57 lpm (10 to 15 gpm) by the Survey team).

All samples are recorded on a field log and labeled with the date, sampler's initials, the sample number taken in sequence that day, and the type of analysis to be performed. The label is self adhesive and written upon with waterproof ink.

Chain-of-custody procedures are included on the back of the chain-of-custody form, which is used only on-site. The form does not accompany the samples to the off-site laboratory.

Historically, analyses for radionuclides have been performed off-site, but now may also be performed on-site at the Nuclear Counting Laboratory. Samples are currently being analyzed by IT Corporation in Oak Ridge, Tennessee. The samples are analyzed mostly for specific accelerator-produced radionuclides, with the exception of one analysis type, Type 2a, which is for total radium and total thorium. Two specified sensitivities, one for groundwater and one for surface water, are listed in Table 3-24 for accelerator-produced radionuclides. The sample analysis types are as follows (Baker, 1987) :

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

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

Type 3a: Chemical separation of Ca-45 before its determination; otherwise the same as Type 1a.

Type 4a: H-3 only, at surface water sensitivity.

TABLE 3-24

SPECIFICATIONS FOR THE ANALYSES OF
ACCELERATOR-PRODUCED RADIONUCLIDES IN WATER
FERMILAB - BATAVIA, ILLINOIS

Radionuclide	Concentration Guide for Population (μCi/ml)		Specified Sensitivity and Precision* (μCi/ml)	
	Prolonged Period of Exposure	Community Water System	Surface Water	Groundwater
^{3}H	2×10^{-3}	2×10^{-5}	3×10^{-6}	1×10^{-6}
^{7}Be	1×10^{-3}	4×10^{-5}	5×10^{-7}	5×10^{-7}
^{22}Na	1×10^{-5}	4×10^{-7}	3×10^{-7}	2×10^{-8}
^{45}Ca	5×10^{-5}	2×10^{-6}	3×10^{-7}	6×10^{-9}
^{54}Mn	5×10^{-5}	2×10^{-6}	1×10^{-7}	7×10^{-8}
^{60}Co	5×10^{-6}	2×10^{-7}	1×10^{-7}	2×10^{-8}

Source: Baker, 1987.

* The precision and sensitivity are stated for the 95 percent 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.

Type 5a: Chemical separation of Ca-45 and analysis for Ca-45 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, H-3, I-131, and Cs-134 at groundwater sensitivity. This analysis is performed on drinking water systems on-site which supply water to more than 25 people during the work day.

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

Separate analyses of two aliquots from the same sample bottle are requested by changing the letter "a" to the letter "b" on the Type designation.

Analyses of groundwater for accelerator-produced radionuclides have not resulted in reproducible values above the detection limits since commencement of the monitoring program. The importance of this observation is discussed in greater detail in the Soil Section and Findings 3.2.4.3.1 and 3.4.4.3.1(b).

3.4.3.2 Nonradioactive Pollutant Monitoring

Fermilab performs monitoring for nonradioactive pollutants in the groundwater at water supply wells and other selected non-water supply wells. Treated water for drinking supplies is monitored on-site for pH, chlorine, and fecal coliform. Analyses are conducted monthly for pH and coliform, and daily for chlorine. Samples are also sent to the IEPA quarterly as required by state regulations. Section 3.3.3 provides more details on drinking water quality. In CY 1983 a comprehensive program of sampling the on-site wells for nonradioactive pollutants was begun on a biennial basis. The program initially included 12 metals, TDS, chloride, fluoride, sulfate, nitrate plus nitrite, pH, and cyanide. In CY 1985 the program was expanded to include ammonium, trichloroethylene, trichloroethane, total organic carbon, gasoline, benzene, and trihalomethanes (in the distribution system). The biennial sampling is based upon State of Illinois regulations due to go into effect in 1989. Table 3-21, shown previously, provides the results of analyses performed in January 1986.

Sampling procedures previously reported for radionuclide monitoring are used for nonradioactive pollutants as well. However, sample preservatives and instructions for collecting samples for volatile organics analysis are supplied by the analytical laboratory, Aqualab, Inc., of Bartlett, Illinois. The laboratory also provides coolers for shipping (Allen, 1987a). No other variations in purging, decontamination, or collection procedures were reported.

Analytical methods reported to be used by Aqualab, Inc., are from "Methods for Chemical Analysis of Water and Wastes," EPA, 1979, and "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater," EPA, July 1982 (Mottashed, 1986).

3.4.4 Findings and Observations

3.4.4.1 Category I

None

3.4.4.2 Category II

None

3.4.4.3 Category III

1. Inadequacies in the Present Groundwater Monitoring System. The lack of monitoring wells or vadose zone monitors close to potential and known sources of soil contamination may result in undetected groundwater contamination. Three areas on-site are potential sources of groundwater contamination, and lack adequate groundwater monitoring. These three areas may be contaminated by radionuclides, PCBs, oil, chlorides, or sulfates.

   a. Old CUB Perforated Pipe Field. Existing wells used for monitoring (W-17A, W-20 and W-45) are not located close enough to the pipe field to provide detection of contamination in the Silurian dolomite aquifer until the pollutants have migrated anproximately 450 meters (1,500 feet). The Silurian dolomite aquifer is used for drinking water on-site and by the City of Warrenville, in the downgradient direction off-site.

      The old CUB perforated pipe field received discharges of fluids resulting from the regeneration of ion exchange resins used to treat circulating cooling water and chromate from the cooling-water system. The old CUB perforated pipe field has been replaced by the CUB clay tile field constructed in essentially the same location. The new CUB clay tile field continues to receive fluids from the regeneration of ion exchange resins containing chloride, sulfates, Be-7, Mn-54, and Co-60. Chromates are no longer used by Fermilab for cooling-water treatment.

Soil sampling has extended to a depth of 1.5 meters (5 feet) and has revealed that contamination exists from past practices. Finding 4.5.2.3 provides details on the known contamination. Characterization or monitoring has not been performed below a depth of 1.5 meters (5 feet). The presence of shallow, perched water tables, which may allow lateral migration of pollutants in the sand and gravel layers within the glacial drift, are known to occur on-site. The lack of subsurface characterization in the area, coupled with the fact that monitoring wells are 450 meters (1,500 feet) away and cased through the glacial drift, may result in the potential for groundwater contamination to exist undetected in an area roughly 20 hectares (50 acres) in size.

b. Old Neutrino and Meson Target Halls, and the Neutrino Primary Dump. Three of the four existing wells used for monitoring the experimental areas are not located close enough to the source areas to provide timely detection of contamination in the Silurian dolomite aquifer. Contaminants would have to migrate from 430 to 640 meters (1,400 to 2,100 feet) to reach wells W-38/-39 (same location), W-43, and W-49. The fourth well, W-78, is located approximately 38 meters (125 feet) downgradient from the M01 enclosure (Meson target box) of the Meson line. This well was installed specifically for monitoring purposes and was constructed with approximately 21 linear meters (70 feet) open to the Silurian dolomite. Because the length open to the formation is relatively long, there is a potential for dilution of contaminant concentrations entering the well from a shallow water-bearing zone by cleaner water inflow from deeper water-bearing zones in the well.

The presence of a shallow, perched water table may allow lateral migration of pollutants in the sand and gravel layer present at approximate elevation 216 meters (710 feet) msl, approximately 4.5 meters (15 feet) below the underdrain system. This perched water table is not monitored or characterized well enough in the experimental area to define the gradient, flow direction, and velocity of groundwater flow. Although this perched zone is not used for drinking water supply on-site, it may serve as a pathway to reduce travel times for pollutants to reach the groundwater table or to migrate off-site to potential receptors. The wells currently used to monitor the Silurian dolomite are cased through this zone and thus are not capable of monitoring it. Because no shallow wells or vadose-zone monitoring devices have been installed to monitor the subsurface beneath these source areas, few data are available on the concentration of radionuclides there. Soils and percolating groundwater beneath the underdrains for the Neutrino Area Primary Target were sampled by one soil boring drilled in 1984. Analyses of the soil moisture in the samples recovered from this 45-degree-angle boring revealed tritium concentrations of 10.8 ± 0.4 pCi/ml (20 pCi/ml is the drinking water standard) at the

elevation of the lowest underdrain (elevation 221 meters (725 feet) msl), and less than 1 pCi/ml 5.5 meters (18 feet) below the underdrain. These samples represent only one small area of the subsurface at one point in time and thus do not provide characterization. The sumps that receive underdrain water from this area contain concentrations of tritium as high as 600 ± 60 pCi/ml, but are typically less than 300 pCi/ml. A more detailed discussion of the analytical data is contained in Section 3.2.3.

c. Main Substation Oil Spill. The area of the main substation is not monitored or characterized well enough to evaluate the disposition of mineral oil unaccounted for in the January 1985 spill or the extent of PCB contamination from spills during the life of the Capacitor Tree until removal of the capacitors in 1987. The nearest wells are W-1 and W-3, located 1,220 meters (4,000 feet) and 244 meters (800 feet) away, respectively. Both are site water supply wells drawing from the Silurian dolomite. Well W-4, although close by, is not used for water supply, and is open to the Cambrian Ironton-Galesville aquifer below a depth of 321 meters (1,052 feet). Because of the depth, the opportunity for dilution, and the intervening Maquoketa shale, well W-4 is not likely to be affected by this source.

Fugitive oil believed to be from the transformer spill has been encountered in the sump for enclosure F-2 located approximately 15 meters (50 feet) east of the transformer pad. An estimated 190 liters (50 gallons) of oil was recovered during CY 1986 from that sump (Baker, 1987). During the on-site Survey, oil was also discovered in the electric vault beneath the Capacitor Tree. The quantity was estimated to be approximately 475 liters (125 gallons). The migration pathway to these two subsurface enclosures has not been positively identified and may be either electric conduits or the soil. The full extent of vertical and horizontal migration of the oil is not known.

PCBs are known to have been spilled during operation, and during removal of the capacitors from the Capacitor Tree. Several small areas on the ground in the immediate vicinity of the Capacitor Tree are contaminated with PCBs. There is not enough information available to estimate a quantity. However, site personnel believe less than 4.5 kg (10 pounds) were spilled (Allen, 1987b). The site is currently preparing to hire a consultant to provide guidance for remedial measures in the PCB spill area. Findings 4.5.2.3.1 and 4.5.2.3.2 provide more detail on this source area.

The presence of shallow, perched water tables in the area may allow more rapid lateral and vertical migration of these contaminants and therefore potentially reduce travel time

to drinking water supplies. The lack of characterization and monitoring may allow contaminants to reach a site water supply well prior to detection.

3.4.4.4 Category IV

1. Lack of Adequate Groundwater Sampling Procedures. The accuracy and reliability of the groundwater monitoring data reported from the analytical laboratory may be suspect because of several QA/QC problems associated with Fermilab sampling procedures.

   a. Dedicated Sample Pumps. Underestimation of volatile compound concentrations may occur because of the use of dedicated centrifugal submersible pumps in the wells. These types of pumps are susceptible to cavitation, which tends to volatilize dissolved gases. Subsequently these gases can be lost during bottle filling.

   b. Decontamination Procedures. Sampling equipment decontamination and cleaning procedures are not proper for either inorganic or organic sampling. The use of a garden hose (vinyl with a rubber seal) to convey water to the sample bottles from the well, and using only bleach to decontaminate the non-dedicated pump (Allen, 1987a), can lead to contamination of the samples by the hose and residue from the bleach, respectively. Although only minor in apparent effect, the lack of proper decontamination procedures would render the quality of analyses suspect because of sample quality.

   c. Purging Procedures. Purging methods do not contain any mechanism for evaluating the purge effectiveness. Inadequate purging can allow an unrepresentative sample to be collected. In order to collect a sample representative of the formation water quality, it is necessary to purge all of the water from the well casing, filter medium, and the rock or soil adjacent to the well that may contain water that has been affected by the well. Accepted procedures call for a minimum of three well volumes and the stability of indicators (pH, temperature, and conductivity) that are monitored during discharge, whichever takes longer. The purge formula used by Fermilab to pump the well for ten minutes does not specifically use either well volume or indicator monitoring to ensure that formation water is being sampled.

   d. Uncertainty Regarding Well Construction. As-built records are not available regarding pump intake elevation, length of the well open to the formation, and other physical details of construction. Definitive characterization of the subsurface relative to potential contamination is difficult without knowing: (1) what elevations are being sampled; (2) if

dilution of the sample horizon may be occurring because the well is open to a large length of the formation; and (3) if the wells are sealed in the formation adequately so that leakage or contamination from higher elevations is not flowing down the outside of the casing to the sample intake zone.

e. The groundwater sampling procedures for the radiochemical and chemical measurements are not available in a detailed sampling protocol. The lack of formal procedures makes it difficult to verify proper sample collection, and cannot assure consistent sampling practices through time. In addition, a new or temporary person substituting during the regular sampler's absence is left to sample without a guidance manual or complete procedures which may lead to improper sampling.

4.0 NON-MEDIA-SPECIFIC FINDINGS AND OBSERVATIONS

This section discusses findings and observations pertaining to waste management, toxic and chemical materials, radiation, quality assurance, and inactive waste sites and releases. These discussions do not include a background environmental information section because the areas addressed are not necessarily tied to one medium, as was the case with the discussions in Section 3.0. These discussions include an environmental monitoring program section, where appropriate and where information was available. The findings for hazardous, radioactive, mixed, and solid waste management are summarized in a section addressing waste management.

4.1 Waste Management

This section describes sources of waste; handling procedures for waste; and waste treatment, storage, and disposal facilities. The waste types evaluated include hazardous, radioactive, mixed (radioactive and hazardous), and solid waste (nonradioactive and nonhazardous).

4.1.1 General Description of Pollution Sources and Controls

DOE Order 5480.2, titled Hazardous and Radioactive Waste Management, issued December 13, 1982, (rescinded October 5, 1987) and DOE Order 5820.2, titled Radioactive Waste Management, issued December 6, 1984, are the principal DOE orders regulating waste management at DOE sites. The Resource Conservation and Recovery Act (RCRA) of 1976, the 1984 RCRA amendments, and associated regulations issued by U.S. Environmental Protection Agency (EPA) established the standards used by the Survey as the basis for evaluating hazardous and mixed waste handling procedures and facilities.

Illinois regulations regarding hazardous waste are generally similar to those of EPA, although certain EPA regulations are being implemented by EPA until Illinois is granted authority for their implementation. The State of Illinois has a category of wastes called Special wastes. This category includes hazardous wastes and nonhazardous industrial process waste such as asbestos and pollution-control wastes. Hauling permits for Special wastes are required for transportation of Special wastes and transportation is permitted only to facilities licensed to receive Special wastes. Illinois solid waste regulations govern the transport and disposal of solid wastes, i.e., wastes with no radioactivity, PCBs, or hazardous constituents.

4.1.1.1 Hazardous Waste Management

Hazardous wastes are defined by RCRA regulations. Wastes can be hazardous either by being listed as a hazardous waste in the RCRA regulations or by failing one of the following four characterization tests: reactivity, ignitability, corrosivity, or extraction procedure (EP) toxicity.

Hazardous wastes are not directly produced by the high-energy physics experiments that are conducted at Fermilab facilities. These facilities include a series of proton accelerators used to produce high-energy protons, which are directed onto fixed targets, and anti-proton sources for conducting collision experiments involving protons and anti-protons. Small quantities of a variety of hazardous wastes are produced by support activities in numerous locations, including machine shops, magnet fabrication and repair facilities, laboratory operations, and maintenance activities. Small quantities of chemical wastes are defined by Fermilab to be less than 19 liters (5 gallons) in volume. These generally consist of unused chemicals and laboratory wastes. Large-quantity chemical wastes, as defined by Fermilab, are those wastes constituting 19 liters (5 gallons) or more in volume. Table 4-1 describes the types, quantities, and location of hazardous wastes generated at Fermilab from July 1, 1986, to July 1, 1987.

Small quantities of hazardous, radioactive, and mixed wastes are generated at numerous locations at Fermilab. This results in the need for Waste Accumulation Areas (WAAs) where wastes are accumulated and temporarily stored prior to pickup and transport to the appropriate waste management facility. There they are processed and/or stored prior to off-site shipment to treatment or disposal facilities. Hazardous, mixed, and Special wastes are transported to the Site 55 Hazardous Waste Management Facility. Radioactive wastes are taken to Site 67 or the Boneyard. Radioactive and Special wastes are further discussed in Sections 4.1.1.2 and 4.1.1.4, respectively.

The Survey team made several general observations regarding conditions and practices relating to WAAs. WAAs at Fermilab were generally located outdoors. Small quantities of liquid wastes such as solvents, acids, and bases were contained in small plastic and glass containers. Drums were used to store larger quantities. Labeling practices were found to conform to applicable regulations. Secondary containment to prevent spills from contaminating adjacent soils was provided in only one case. In many cases the WAA was located on top of a permeable surface, hence spills or leaks might directly contaminate the subsurface. Refer to Finding 4.1.2.4.1 for a more detailed listing of conditions observed at WAAs.

TABLE 4-1

HAZARDOUS WASTE GENERATION
JULY 1, 1986, TO JULY 1, 1987
FERMILAB - BATAVIA, ILLINOIS

Location	Waste	Total Volume (Gallons)
Booster East Tower	Freon TF Recycle	65
Booster East Tower	Mineral Spirits	55
Booster East Tower	Safety Kleen	57
Booster East	Safety Kleen	24
Central Helium Liquefier	Acetone	55
Central Helium Liquefier	Anti Freeze and Freon	5
Central Helium Liquefier	Freon TF Recycle	165
Central Helium Liquefier	Safety Kleen	42
Central Helium Liquefier	Scale Remover	5
Cross Gallery	Acetone and Methyl Alcohol	5
Cross Gallery	Freon TF Recycle	180
Cross Gallery	Mineral Spirits	55
Linear Accelerator	Acetone	10
Linear Accelerator	Methyl Alcohol	10
Linear Accelerator	Freon TF Recycle	5
Old Fire Barn	Alcohol Ethyl	55
Old Fire Barn	Copper Brite 481F	70
Old Fire Barn	Freon TF Recycle	55
South East Annex	Acetone	10
South East Annex	Methyl Alcohol	10
South East Annex	Freon TF Recycle	5
South West Annex	Acetone	10
South West Annex	Methyl Alcohol	10
Site 38	Mineral Spirits	165
Site 38	Safety Kleen	352
Site 38	Windshield Washer Solvent	55

TABLE 4-1
HAZARDOUS WASTE GENERATION
JULY 1, 1986, TO JULY 1, 1987
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

Location	Waste	Total Volume (Gallons)
Site 55 Roads and Grounds	Agitene	55
Site 55 Roads and Grounds	Gasoline and Motor Oil	55
Site 55 Roads and Grounds	Laquer Thinner	55
Site 55 Roads and Grounds	Lead Traffic Paint	5
Site 55 Roads and Grounds	Methyl Ethyl Ketone	305
Site 55 Roads and Grounds	Mineral Spirits	55
Site 55 Roads and Grounds	Reflective Compound	55
Site 55 Roads and Grounds	Safety Klean	135
Site 55 Roads and Grounds	Trichloroethane	5
Site 55 Roads and Grounds	V.M and P Naphtha	55
High-Intensity Laboratory	Freon TF Recycle	5
Laboratory 6	Beryllium Wire/Alcohol	4
Collider Detector Facility	Acetone	55
Collider Detector Facility	Ethyl Alcohol	55
Collider Detector Facility	Isopropyl Alcohol	5
Collider Detector Facility	Freon TF Recycle	110
Collider Detector Facility	Trichloroethane	110
Industrial Building 4	Isopropyl Alcohol	110
Laboratory 8 Printed-Circuit Cleaning	Freon TF Recycle	55
Laboratory E Cyrogenics	Ethyl Alcohol and Trichlorethylene	5
Laboratory 3 Cryogenics	Acetone	55
Laboratory 3 Cryogenics	Freon TF Recycle	330
Laboratory 3 Cryogenics	Ultrasonic Cleaner #222	5
Laboratory 6 Research	Lead Contaminated H_2O	55
Laboratory 6 Research	Lead Contaminated Solids	960
Laboratory 6 Research	Trichloroethane	10
Laboratory 7 Research	Formica Adhesive	5

TABLE 4-1
HAZARDOUS WASTE GENERATION
JULY 1, 1986, TO JULY 1, 1987
FERMILAB - BATAVIA, ILLINOIS
PAGE THREE

Location	Waste	Total Volume (Gallons)
Meson West	Oxalic Acid and H_2O	1,155
New Muon	Acetone	5
New Muon	Freon TF Recycle	280
Proton Assembly Building	Toluene	5
Printed Circuit Laboratory	Isopropyl Alcohol	15
Printed Circuit Laboratory	Ferric Chloride	330
Printed Circuit Laboratory	Ferric Chloride Rinse	440
Target Service Building	Acid Battery	7
Wilson Hall	Toner Premix	55
Wide Band	Trichloroethane	5
Boneyard	Sulfuric Acid	55
Laboratory 8	Beryllium-Contaminated H_2O	55
Laboratory 8	Beryllium-Contaminated Solids	480
Site 67	Solvent and Oil	60
Industrial Building 2	Floor Sealer Arcrete	55
Industrial Building 2	Trichloroethane	5
Industrial Building 3	Acetone	55
Industrial Building 3	Isopropyl Alcohol	55
Industrial Building 3	Freon TF Recycle	165
Laboratory 2 Machine Shop	Agitene	10
Laboratory 2 Machine Shop	Super Safety Solvent	5
Laboratory 4 Machine Shop	Mineral Spirits	55
Machine Repair	Mineral Spirits	110
Wilson Hall Machine Shop	Mineral Spirits	55
Material Building 37 Shabbona	Acetone and MEK	5
Material Building 37 Shabbona	Toluene and Acetone and MEK	5

Source: Fermilab, 1987c.

Hazardous waste storage permits are not required for WAAs, although certain RCRA regulatory requirements are applicable. These include separation of incompatible wastes, labeling all containers holding hazardous waste as hazardous waste containers, recording accumulation start dates on each container, and not exceeding the 90-day storage limit. Although requirements for impermeable surfaces and secondary containment (which are applicable to permitted hazardous waste storage facilities) do not apply to WAAs, it is considered good practice to comply with these requirements.

Site 55 Hazardous Waste Storage Facility

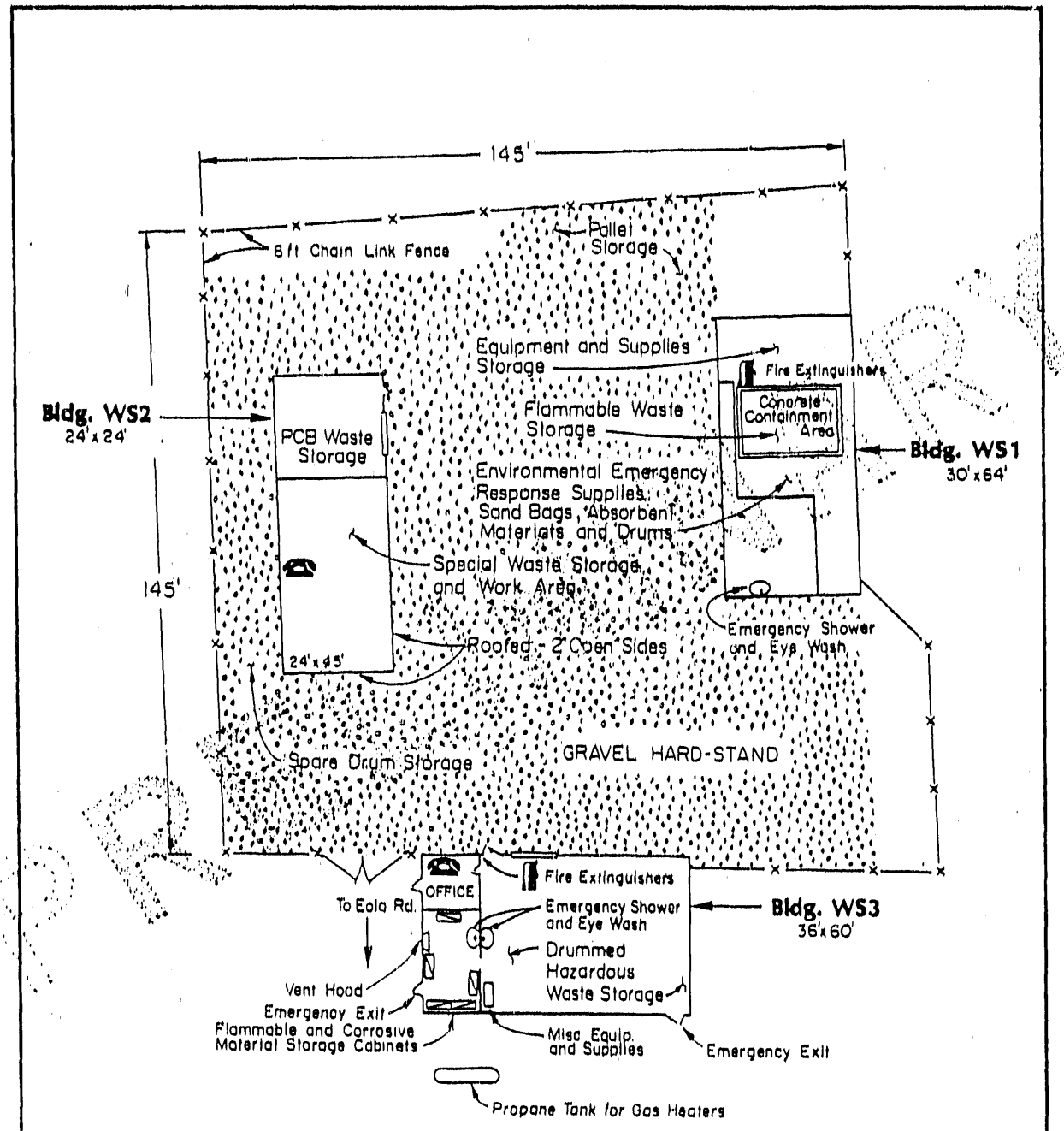
The Site 55 Hazardous Waste Storage Facility is the processing and storage area for hazardous wastes, mixed wastes, and Special wastes (see Section 4.1.1.4 for details on Special wastes). The facility is operated by the Environment and Safety Group of the Safety Section of Fermilab. The hazardous waste storage and process areas are located within an enclosed building (WS3) with impermeable concrete surfaces and secondary containment. Other sections of the Site 55 Hazardous Waste Storage Facility are used for the outdoor storage of Special wastes and for the storage of radioactive PCB wastes in a roofed area. Figure 4-1 describes the facility.

The Hazardous Waste Storage Facility is an interim-status facility. The Illinois Environmental Protection Agency (IEPA) has not called for Fermilab to submit a RCRA Part B permit application. In an inspection conducted by IEPA in October 1985, the agency did not cite any technical deficiencies. The only deficiencies cited related to paperwork inadequacies in the Facility Contingency Plan and RCRA Part A notification. Both deficiencies were corrected by Fermilab in November 1985.

Underground Storage Tanks

Subtitle I of the Resource Conservation and Recovery Act (RCRA) requires EPA to promulgate regulations for underground storage tanks (USTs) holding chemical substances listed in Section 101(14) of CERCLA; e.g., petroleum and substances derived from petroleum (fuel oil, gasoline, diesel fuel, etc.). These RCRA Section 280 regulations are separate from the hazardous waste tank regulations in Sections 264 and 265 of RCRA, which pertain to tanks containing listed or characteristic hazardous wastes.

EPA promulgated regulations in Section 280.3 of the RCRA regulations requiring notification to state-designated agencies of all USTs in service as of May 8, 1986, or taken out of service after January 1, 1974.



Source: Fermilab, 1985.

FIGURE 4-1

SITE 55 HAZARDOUS WASTE STORAGE FACILITY
FERMILAB - BATAVIA, IL

Fermilab made the required notification to Illinois. Section 4.2.2 gives details on the USTs described in the Fermilab notification. These tanks have not been integrity tested (see Finding 4.2.6.4.4 for further details).

EPA proposed technical standards for USTs containing chemicals and petroleum-based substances in April 1987. However these regulations are not yet in effect.

4.1.1.2 Radioactive Wastes

DOE Order 5480.2 defines radioactive wastes as "solid or fluid materials of no value containing radioactivity; discarded items such as clothing, containers, equipment rubble, residues or soils contaminated with radioactivity or soils, rubble, equipment or other items containing induced radioactivity such that the levels exceed safe levels for unconditional release." Fermilab considers any material to be radioactive if it shows a radioactivity level twice the background level.

Fermilab does not generate any high-level or transuranic (TRU) wastes. Radioactive wastes are produced at Fermilab by radioactivation, caused by beam loss of accelerator components, equipment, and associated fluids (cooling water, pump oils, etc.). Radioactive wastes are also produced from targets and beam dumps and from materials located close to targets and beam dumps. The dose rates for wastes generated at locations other than those areas where the beam is intentionally targeted or dumped, are typically less than 100 mrem/hr at 30 centimeters (12 inches) from these items. Waste materials from locations near the targets or beam dumps may have dose rates greater than 100 rem/hr at 30 centimeters (12 inches). The volume of radioactive waste with a dose rate of greater than 1 rem/hr at 30 centimeters (12 inches) is less than 1 percent of the radioactive wastes generated.

The radionuclides present in the solid radioactive wastes vary depending on the material radiated. The specific activity (concentration of the radionuclides present) of the waste depends upon the length of time during which the waste item was exposed to the beam and the time the waste item has been allowed to decay without exposure to the beam. The main radioactive isotopes present in iron or steel are Mn-54, Co-60, and Be-7 with half-lives of 300 days, 5.2 years, and 53 days, respectively. In aluminum the main isotopes are Na-22 and Be-7, with half-lives of 2.6 years and 53 days, respectively. Depending upon the radioactive isotope present, in many cases storage will allow the activity to decay to low levels or levels below regulatory concern due to the relatively short half-lives of these radionuclides.

The radioactive Solid Wastes, which Fermilab must dispose of, consist of very large pieces of steel in the form of shielding, magnets, and beam line components. Often the steel and magnets weigh more than 10,000 kilograms (11 tons) and are in excess of 6 meters (20 feet) long. The size and weight of such items, along with typical rauiation levels of 1 to 100 rem/hr, make their shipment to off-site facilities difficult. These solid radioactive wastes, which comprise the majority of Fermilab's waste in both weight and volume are stored at the Boneyard, where radioactivity is allowed to decay.

Smaller waste items of radioactive equipment and components are also produced. These include noncompactible items such as tubing, cables, batteries, nuts, absorbents, pipes, and small electric motors. Fermilab also produces compactible radioactive wastes, including items such as protective clothing, wrappings, rags, paper, and cardboard boxes. These wastes are handled at the Site 67 Radioactive Waste Management Facility.

The sources of radioactive waste at Fermilab are the following:

- Accelerators: Staging Area, Booster-Proton, Proton Assembly repair room, Radio Frequency repair area, some service buildings, and Anti-Proton Target Hall.
- Research Division: MS1, MS2, MS3, Detector Building 1 NS1, NS2, Target Service Building, PS1, PS2, PS3, PS4, PS5, PS6, High-Intensity Laboratory, Laboratory 6, and Laboratory 7.
- Site 68, Counting Laboratory, Chemistry Laboratory.
- Hot shop and Magnet Facility.

Radioactive aqueous wastes generated at Fermilab are a result of spallation processes which produce radioactivity in water contained in cooling loops (recirculating systems) near targets and other beam loss points. However, only a minor fraction of the total radioactive waste activity in wastes produced at Fermilab is in liquid form. Radioactive isotopes of concern in water are tritium and Be-7. The tritium remains in the cooling water. Be-7 is removed by ion-exchange resins and appears in the discharge from the regeneration of these resins (see Section 3.3 for further details).

At Fermilab smaller, non-compactible radioactive waste items and drums of compactible radioactive wastes are generally collected from the same WAAs used for the accumulation of hazardous and Special wastes. Pickup of larger items of radioactive waste is generally performed in accordance with requirements specific to the waste material. This often involves the use of heavy equipment such as

cranes and flat-bed trucks. Pickups are scheduled on the second and fourth Tuesday of each month. Radiation physics personnel review information submitted by the generator for completeness and supervise the pickup.

The quantity and activity level of radioactive waste produced from accelerator components and equipment have decreased since the installation of superconducting magnets and are expected to decrease further. The superconducting magnets that have been recently installed are much more sensitive to beam loss than the conventional iron magnets. Beam loss results in the radioactivation of components and equipment. Since the beam must be more tightly controlled, less beam loss occurs; therefore, both the quantity and activity level of radioactive wastes decreases.

Radioactive Waste Management Facilities - Boneyard and Site 67

The Boneyard is used for long-term storage and is one of two facilities at Fermilab where radioactive wastes are processed and stored. The Boneyard facility is a fenced area of 18 meters by 45 meters (60 x 150 feet). A 2.5-meter (8 feet) berm extends along the side closest to the site boundary side to reduce the radiation level at the site boundary. Materials requiring long-term storage (more than one year) are typically larger items such as radioactive steel shielding and magnets, highly contaminated beam targets, and activated materials that were close to beam targets and dumps. These items are stored at the Boneyard to allow the activation level of the wastes to decrease and/or preparation of the wastes for shipment to the burial site at Hanford (Richland, Washington).

Radioactive solid wastes with radioactivity readings greater than 100 mrem/hour are stored in "caves" in the Boneyard. Caves are buildings in which shielding is provided on the sides and the top to reduce local exposure and skyshine to surrounding areas. The activity level of most solid wastes stored in the caves will decrease, over a period ranging from several months to decades, to levels low enough to allow off-site shipment. Some items considered too large or too radioactive for off-site shipment are being stored indefinitely. In June 1987 Fermilab had 336 cubic meters (440 cubic yards) of this type of waste. Fermilab is in the process of decommissioning old caves and inventorying the materials contained inside. Materials requiring further storage to allow additional decreases in radioactivation levels will be stored in new caves. The remaining material will either be processed or shipped off-site.

In June 1986, Fermilab initiated a unique program to utilize larger, low-level, noncompactible, radioactive waste items, mainly accelerator equipment and components, in the construction of shielding material used for new cave walls. The waste items are packed into steel boxes, and the

boxes filled with concrete. This results in a shielding block of a higher density than ordinary concrete shielding blocks which can be utilized as a building material for shielding.

At the time of the Survey, 31 shielding blocks utilizing radioactive waste items had been constructed. Fermilab maintains an inventory of materials for each block describing each item of filler material, its size, weight, and contact dose rate. Dose rates of each block at contact, 0.3 meters (1 foot), and 1 meter (3.3 feet) are recorded before and after concreting. Total activity and the radioactive isotopes present are also recorded for each block. The location of each block used in the construction of caves is also recorded. Tables 4-2 and 4-3 show the inventory of the waste items in two typical blocks.

A review of the inventory records showed in most cases that the dose rates of the blocks at 0.3 meters (1 foot) were less than 1 mr/hr after concreting. The isotopes in the waste material in the blocks are Mn-54, Na-22, and Co-60. Due to the relatively short half-lives of the isotopes, 300 days, 2.6 years, and 5.2 years, respectively, the activation levels of these waste-material shielding blocks will decrease significantly over time. At the time that the caves are decommissioned, those blocks which still are considered radioactive can be shipped for disposal without further processing.

Fermilab intends to construct shielding blocks for use as shielding equipment in accelerator components. Steel boxes specially strengthened to prevent bulging at the sides of the boxes will be utilized. This will be done to utilize radioactive waste material that is not needed for cave construction and would otherwise have to be shipped for disposal.

Radioactive waters were formerly treated in an evaporator located at the Boneyard. This unit was decommissioned in 1984.

Site 67 is the main processing area for liquid, compactible, and small noncompactible radioactive wastes. Solidification of liquid wastes, compaction of compactible wastes, sorting and screening of wastes, and shipment preparation takes place at Site 67.

Radioactive oils, resins, and waters are solidified by Radiation Physics personnel. These liquids contain primarily Be-7 and H-3 in concentrations ranging from 1,000 pCi/ ml to 150,000 pCi/ml. The solidification procedure utilizes Portland cement and silicate. Slightly varying procedures are used for oils, waters, and resins. The radioactivity concentration is limited to 20,000 pCi/ml for each drum of solidified radioactive wastes to meet burial site (Hanford) limits of 20 mCi/cubic meter (15.4 mCi/cubic yard).

TABLE 4-2

SHIELD BLOCK INVENTORY – S-2
FERMILAB - BATAVIA, ILLINOIS

CONSTRUCTION DATE: June 13, 1986

PHYSICAL

Length	Width	Height	Approximate Weight of Filler	Total Weight
21 feet	2 feet	3 feet	23,140 lbs.	36,140 lbs.
Description of Filler Material: Three magnets, 2 beam stops, steel beam, miscellaneous steel, aluminum, copper, cable.				

RADIOLOGICAL

Total Activity	Isotopes	
	Mn-54	Co-60
445 mCi	405 mCi	40 mCi

DOSE RATES

Distance	Before Concrete mr/hr	After Concrete mr/hr
Surface	60.0	15.0
1 Foot	17.0	9.0
1 Meter	6.5	3.8

TABLE 4-2
SHIELD BLOCK INVENTORY – S-2
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

WASTE MATERIALS

Item	Size	Weight (Pounds)	Contact Dose Rate mr/hr
Magnet	17" x 13" x 10'	8,000	250.0
Beam stop	13" x 21" x 53"	1,020	0.5
Beam stop	18" x 21" x 53"	1,020	0.5
Miscellaneous steel, aluminum, and cable		400	0.8
Magnet	17" x 13" x 10'	8,000	8.0
Steel	12" x 8" x 5'	2,000	0.2
Magnet	10" x 10" x 4'	1,500	0.3
Miscellaneous steel, aluminum, copper	74.8 ft^3	1,200	1.2

Source: Zonick, 1987a.

TABLE 4-3

SHIELD BLOCK INVENTORY – S-4
FERMILAB - BATAVIA, ILLINOIS

CONSTRUCTION DATE: October 20, 1986

PHYSICAL

Length	Width	Height	Approximate Weight of Filler	Total Weight
21 feet	3 feet	3 feet	16,300 lbs.	31,300 lbs.
Description of Filler Material:	Steel frames, small magnets, aluminum plates, steel plate, copper pipe, cut up steel stands, steel pipe, miscellaneous steel, copper, and aluminum.			

DOSE RATES

Distance	Before Concrete mr/hr	After Concrete mr/hr
Surface	7.0	4.5
1 Foot	3.5	2.3
1 Meter	1.8	1.2

TABLE 4-3
SHIELD BLOCK INVENTORY – S-4
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

WASTE MATERIALS

Item	Size	Weight lbs	Contact Dose Rate mr/hr
2 Pcs. Steel Frame	2' x 3' x 2-1/2'	1,500	0.2
5 Magnets Aluminum & Copper	5" x 7" x 6'	1,750	60.0 14.0 16.0 15.0 15.0
20 Pcs. Aluminum Plate	30" x 39" x 1/4"	200	0.3
20 Pcs. Aluminum Plate	30" x 39" x 1/8"	100	0.3
1 Pc. Steel Plate	18" x 60" x 1"	300	0.3
1 Pc. Steel Plate	12" x 12" x 1-1/2"	350	0.3
1 Pc. Steel Plate	5-1/2" x 78" x 4"	650	0.2
1 Pc. Steel Plate	24" x 6" x 58"	2,500	0.2
3 Pcs. Copper Pipe	2-1/2" x 1/2 wall x 12'	600	0.3
5 Pcs. Copper Pipe	1-1/2" D x 1/4 wall x 12'	500	0.3
1 Pc. Steel Pipe	4" D x 1-1/4 wall x 10'	200	0.1
6 Pcs. Magnet Stands	22" x 28" x 10"	1,050	0.2
23 Pcs. Cut up Steel Stands	1-1/2" x 4" x 53"	900	1.0
1 Skid Steel	Unknown	950	0.2
3 Pcs. Steel	5" x 5" x 18'	650	0.4
1 Pc. Steel	3' x 4" x 1'	150	15.0
1 Skid Steel	4' x 2' x 2'	1,550	0.3
3 Pcs. Steel Blocks	8" x 12" x 12"	1,500	0.6
1 Pc. Steel	3' x 4" x 1-1/2"	250	10.0
1 Pc. Steel	3' x 4" x 4"	250	5.0
Misc. Steel, Copper, & Aluminum	3.5' x 4' x 3' 157.39 ft^3	400	1.5

Source: Zonick, 1987a.

The radioactive waste compactor at Site 67 is used to reduce the total volume of radioactive waste shipped. Usually a total of 4 to 6 bags of wastes is compacted per drum, with the total depending upon the volume and composition of the bag contents. The compactor is also used for crushing radioactive fluorescent bulbs. Compacted drums are sealed and prepared for shipment to Hanford. Items are sorted prior to compaction to separate compactible from noncompactible wastes. Such sorting prevents possible damage to the compactor.

Wastes are screened to separate radioactive from nonradioactive wastes. Screening of materials in boxes and drums takes place at Site 67, and bulk scrap is screened at the Boneyard. The screening process utilizes visual inspection and Bicron or Pancake checks of radioactivity levels. Items such as soft-drink containers, luncheon wastes, and construction debris usually are not radioactive. Such materials are segregated and then checked for radioactivity levels. Those materials that are not greater than 2,000 cpm above background by Bicron reading or greater than 100 cpm above background by Pancake reading are considered to be nonradioactive and are either disposed of as nonradioactive wastes, or in some cases are salvaged. The extent of the volume reduction attainable by segregating radioactive and nonradioactive wastes and compaction can be seen in Table 4-4, which presents the results from screening waste drums.

Fermilab presently uses Hanford for disposal of radioactive wastes. Other sites have been used previously. Table 4-5 describes volumes, curie content, weight, and disposal sites for radioactive waste shipments from Fermilab.

4.1.1.3 Mixed Wastes

Mixed wastes are hazardous wastes that contain radioactive constituents. Fermilab also defines radioactive polychlorinated biphenyl (PCB) wastes, radioactive asbestos, and certain radioactive metals as mixed wastes. Until recently, radioactive hazardous wastes fell into a grey area of regulation. However, EPA and DOE agreed on May 1, 1987, that radioactive hazardous wastes will be subject to both RCRA hazardous waste and DOE radioactive waste regulations.

TABLE 4-4

QUALITY ASSURANCE CHECK SHEET FOR 55-GALLON DRUMS [a]
FERMILAB · BATAVIA, ILLINOIS

Drum No.	Generating Location	Contact Dose Rate mr/hr	Percent Nonradioactive	Comments
667	D-O	0.15	20	Pepsi can, newspaper, McDonal[illegible]up, main ring section gaskets, cigarette w[illegible]apers, nuts, bolts, garbage
907	D-O	0.15	20	Protective clothing, steel, bolts, kay trys, mashin, miscellaneous cigarette wrappers, nut shells in bag
1076	D-O	0.05	40	Dust mop heads, Pepsi can, newspaper, wire, plastic, floor sweepings, copper coil
1081	TSB	0.1	5	Floor sweepings, cable, protective clothing
1079	D-O	2.0	5	Aluminum foil, bolts, rags, hose, Coke can, paper, plastic, copper tubing, wire, water
915	D-O	1.0	5	Magnet flanges, wire, cable, aluminum, gloves, drum 1/2 full
1008	D-O	0.1	5	Air filters, wire, plastic, floor sweepings, rope
1090	NS-1	0.01	5	Steel, 1/2 full
962	PS-6	0.01	20	Wire, insulation, boxes, styrofoam cups, garbage, copper pipe, floor sweepings, Gatorade bottle
247	Manny Acc.	0.02	20	1/3 full steel and steel slag
746	Meson	0.02	10	1/3 full steel and steel slag
964	PS-6	0.02	95	Floor sweepings, wire, fiberglass insulation, Raid can, cardboard boxes
825	PS-4	0.5	95	Herculite, floor sweepings, rags, 1/2 30-gallon drum, cable, battery, garbage cups
1016	PAB	0.1	2	Plastic, Herculite, extension cords, paint brushes, cardboard, floor sweepings, rags, boots
1046	NS-2	0.5	10	Floor sweepings, cable, wire, Herculite, rope
1088	PK-68	0.01	20	Steel and steel slag 1/3 full 4 x 4 board

TABLE 4-4
QUALITY ASSURANCE CHECK SHEET FOR 55-GALLON DRUMS
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

Drum No.	Generating Location	Contact Dose Rate	Percent Nonradioactive	Comments
1059	TSB	0.4	20	Cable, rags, paper, cardboard box, kaydry box, mashin, flux remover, cans, watemin hose
1058	TSB	0.05	90	Isopropyl alcohol can, WD-40 can, cardboard boxes, kaydrys, garbage bags, wire pulling lube bottle
No #	Unknown	2.5	10	Mop bucket, plastic beads, beam tube bellows
88	PS-6	0.05	80	Electric motor, steel and slag rags, coffee can, magnet flange, wire, paper
1030	TSB	0.3	5	Rubber hose, wire, steel
503	PS-4	0.1	60	Water filters, floor sweepings, steel, plastic, wet oil dry, nylon rope, WD-40 can
175	EAD	0.5	5	Concrete, wire, beam tube flange, beam tube clamps

Source: Zonick, 1987b.

(a) Five men 8 hours each to sort and screen 23 drums resulting in 1-1/2 drums (after volume reduction) of burial site material (floor sweepings with small nuts and bolts, etc.).

TABLE 4-5

OFF-SITE RADIOACTIVE WASTE SHIPMENT
FERMILAB - BATAVIA, ILLINOIS

Year	Volume (Cubic Feet)	Activity (Ci) (a)	Weight (Tons)	Disposal Site
FY 1986	7,450	7.9	134	Hanford
FY 1985	1,100	0.5	18	Hanford
FY 1984	10,300	8.6	268	Hanford
FY 1983	14,000	8.3	230	Hanford
FY 1982	28,000	17.3	222	Hanford
FY 1981	8,660	10.4	98	Hanford
FY 1980	0	0	0	
FY 1979	7,000	2.3	75	Sheffield or Barnwell
FY 1978	6,000	181	161	Sheffield or Barnwell
FY 1977	2,321	16.6	37	Sheffield or Barnwell
FY 1976	562	0.29	3	Sheffield or Barnwell

Source: Zonick, 1987c.

(a) Ci - Curie

Fermilab considers the following materials to be mixed wastes if radioactive, regardless of their RCRA status.

- Scintillating oil
- Lead
- Polychlorinated biphenyls (PCBs)
- Beryllium
- Solvents in oil
- Cadmium
- Lead in batteries
- Mercury (batteries)
- Nickel
- Lithium
- Oxygen cells

Fermilab procedures (Zonick and Allen, 1986) call for all Class I-or-below mixed waste to be stored at the Site 55 Hazardous Waste Management Facility. Class II-or-above mixed wastes are to be stored at the Boneyard. Fermilab defines Class I radioactive wastes to mean those with an exposure dose rate ranging from twice background at contact to 1 mR/hr at 0.3 meters (1 foot). Class II means those radioactive wastes with an exposure dose rate of 1 mR/hr to 10 mR/hr at 0.3 meters (1 foot). Storage of Class I wastes takes place at Site 55, since this class only requires storage in designated areas. Class II and above wastes require handling by persons trained in radiation safety and therefore require storage in the Boneyard, where personnel are trained in radiation safety.

During the on-site Survey, the only Fermilab-designated mixed wastes being stored consisted of 6 lead batteries and 49 PCB containing capacitors at Site 55, and 4 drums of beryllium targets and an indium target in the radioactive material storage yards next to the Boneyard. The beryllium and indium targets are stored inside a concrete vault built from shielding blocks. The other Fermilab-designated mixed wastes are not routinely generated. The wastes presently being stored will require long-term storage until disposal or treatment options for mixed wastes become available. The lead batteries are expected to decrease in activity below Class I levels (less than twice background) and thus be capable of being handled as nonradioactive wastes.

The Boneyard is adjacent to the radioactive equipment and component storage areas. The storage areas are fenced off from both the Boneyard and the rest of the site and are used for long-term storage. Waste materials, with the exception of the beryllium and indium targets, are not stored in this area.

4.1.1.4 Solid Waste

Solid wastes are those wastes without radioactive, hazardous, or PCB constituents. The Illinois-designated category of Special wastes (excluding hazardous wastes) is included in this discussion of solid wastes.

Fermilab has only one on-site, solid waste disposal facility. This site is Meson Hill, which is an earthen hill at the end of the beam lines. The hill serves two purposes by providing radiation shielding in addition to being the central site for disposal of earthen materials (e.g., dirt, rock, gravel, sand) and construction wastes (e.g., concrete, bricks, sheetrock, roofing, small non-salvageable metallic items, asphalt, plastic, and glass). Materials that are prohibited from disposal include putresibles, chemicals, liquids, salvageable metals, radioactive substances, and asbestos. Fermilab Site Services Department is responsible for upkeep of Meson Hill, controlling access, and issuing dumping permits. The Safety Section inspects dumped materials for compliance with Fermilab dumping policy.

Solid wastes, other than earthen materials, Special wastes, and radioactive wastes are collected in dumpsters throughout the site. A contract hauler transports the solid wastes to an off-site sanitary landfill for disposal. The site currently used is Midway Landfill in Batavia, Illinois.

Fermilab has initiated a program to check all solid-waste dumpsters for the presence of radioactive wastes. A radiation technician checks each dumpster for radioactive materials immediately prior to its pickup by the contract hauler. A specially modified Thyac is passed over the entire dumpster as close as possible to the contents. Readings in excess of 4,000 cpm are considered a violation. If violations are found, the dumpster is secured and the generator is notified to remove the radioactive materials.

Nonhazardous Special Wastes

The State of Illinois has a category of wastes called Special wastes, which includes hazardous and nonhazardous industrial process wastes and pollution control wastes. Special waste hauling permits are required for the off-site transportation of Special wastes, which can be transported only to facilities licensed to receive Special waste. (See Section 4.1.1.1 for details on hazardous Special wastes.)

Nonhazardous Special wastes are generally accumulated in the same WAAs and collected in the same manner as hazardous Special wastes. On-site storage of Special wastes takes place at the Site 55 Hazardous Waste Facility. The storage area is outdoors on a gravel surface. On-site treatment and/or disposal of nonhazardous Special wastes does not take place at Fermilab. Treatment and/or disposal takes place at off-site commercial facilities.

In 1986, the principal nonhazardous Special wastes generated at Fermilab consisted of 30,300 liters (8,000 gallons) of ethylene glycol and water from cooling systems; 15,000 liters (4,000 gallons) of waste oil from engines, vacuum pumps, and compressors; 3,800 liters (1,000 gallons) of cutting oils and water from machine operations; and 400 drained, lead batteries from automobiles and from emergency lighting.

Village Oxidation Pond

The Village Oxidation Pond was used for treatment of 190,000 liters (50,000 gallons) per day of sanitary wastewater until December 22, 1986. At that time sanitary wastewater from the village was diverted to the City of Warrenville sanitary wastewater collection system. Fermilab is retaining the pond for ornamental and future recreational use. In the interim, the pond is being continuously aerated. Approximately 2,800 to 5,600 cubic meters (100,000 to 200,000 cubic feet) of sludge in a layer 15 to 30 centimeters (6 to 12 inches) in depth remains in the pond. It is Fermilab's intention to leave the sludge in place. However, the IEPA may require that the sludge be removed and disposed of or treated. Negotiations will be held on this matter, pending results of sludge analysis as the aeration process continues. Section 3.3.2 has additional details on the Village Oxidation Pond.

Asbestos Wastes

Fermilab also generates asbestos wastes from asbestos removal projects. Asbestos wastes are collected in special dumpsters and sent off-site for disposal (asbestos removal is discussed in Section 4.2.4). Table 4-6 describes shipments and off-site disposal sites utilized by Fermilab since June 1982. In the 1970s some asbestos wastes may have been disposed of in Meson Hill. However, any asbestos in Meson Hill is securely buried. Present procedures for Meson Hill prohibit the disposal of asbestos wastes. Fermilab does not produce radioactive asbestos wastes.

TABLE 4-6

ASBESTOS SHIPMENTS
FERMILAB - BATAVIA, ILLINOIS

Shipment Date	Quantity (Cubic Yards)	Description	Disposal Site
06/16/82	20	Transite sheets and contaminated solids	CID, Calumet City, Illinois
08/04/82	15	Transite sheets	CID, Calumet City, Illinois
05/31/84	5.3	Asbestos-containing solids	Wayne Disposal, Dearborn, MI
12/03/84 12/04/84	42	Building demolition waste	Wayne Disposal, Dearborn, MI
12/26/85	0.7	Insulation and contaminated solids	Wayne Disposal, Dearborn, MI
09/06/85	1	Asbestos-contaminated solids	Wayne Disposal, Dearborn, MI
06/16/86	2.4	Asbestos-contaminated solids	Wayne Disposal, Dearborn, MI
02/16/86	10	Pipe insulation and transite sheets	Midway Landfill, Batavia, Illinois
07/29/87	10	Pipe insulation and transite sheets	Midway Landfill, Batavia, Illinois

Source: Allen, 1987c

4.1.2 Findings and Observations

4.1.2.1 Category I

None

4.1.2.2 Category II

None

4.1.2.3 Category III

None

4.1.2.4 Category IV

1. Waste Accumulation Areas. Lack of, or inadequate, secondary containment and the presence of permeable surfaces in waste accumulation areas for liquid, radioactive, and Special wastes could result in the release of hazardous substances to the environment in the event of a spill.

   Waste accumulation areas (WAAs) are used throughout the site to aggregate hazardous, radioactive, and Special wastes prior to pickup and delivery to the Site 55 hazardous and Special waste processing and storage facility, the Boneyard, or the Site 67 radioactive waste facility. WAAs are needed due to the generation of wastes in small quantities by numerous generators throughout the facility. Applicable RCRA requirements for WAAs include labeling of containers holding hazardous waste, and removal of the container within 90 days from the date on which the container was first placed in the WAA and accumulation of hazardous waste began in the container. Adherence to requirements applicable to RCRA-permitted storage facilities, for impermeable surfaces and spill containment capacity, is technically not required for WAAs but is considered good practice. Given that the nature of the risks posed by the wastes is the same for both WAAs and permitted storage areas, not implementing the impermeable surface and spill containment requirements increases the potential for the release of hazardous and/or radioactive constituents from WAAs.

   Table 4-7 summarizes Survey team observations on WAAs and waste storage areas. It provides details on WAAs lacking secondary containment and impermeable surfaces.

TABLE 4-7

WASTE ACCUMULATION AREAS
FERMILAB - BATAVIA, ILLINOIS

Area	Waste	Comments
Site 67	Radioactive Oils	Storage Area inside building, Storage Area diked with plastic liner, but liner could be punctured.
Site 55	Ethylene Glycol, Oils, Motor Oils	Gravel surface, no containment storage area for Special wastes.
COE East (WAAs)	Oils	No containment.
Site 55 Roads (WAAs)	Wastes Motor Oil	No containment, permeable surface.
Old Fire Burn (WAAs)	(See Comments)	No containment, no wastes during Survey.
Village Machine Shop (WAAs)	Oils	No containment, release would have access to storm sewer.
IB-3 (WAAs)	Freon, Oils, Solvents	No containment.
IB-2 (WAAs)	Oils	No containment, on concrete but adjacent to soils.

Source: DOE Survey team.

4.2 Toxic and Chemical Materials

4.2.1 Toxic Substances Management

The Survey assessed the use and storage of toxic and chemical materials (e.g., polychlorinated biphenyls [PCBs], pesticides, herbicides, asbestos, solvents, and fuels) at Fermilab.

4.2.1.1 Procurement

When a requisition for purchase of a chemical is received by the Purchasing Department, a copy is sent to the Environment and Safety (E&S) Group. This group reviews the toxicity information available in material safety data sheets and the general toxicological literature to determine whether any potential problems can result from its use. If the material is toxic, the requisitioner will be requested to use an appropriate product that is safer. When a toxic substance must be used, the safety office is alerted to follow-up on its use and eventual disposal. The purchase and use of highly toxic materials can be prohibited by the Safety Section.

4.2.1.2 Inventory Control

A computer file inventory of the toxic and chemical materials in use at Fermilab is maintained by the E&S Group. This file contains substances such as asbestos, cyanides, beryllium, hydrochloric acid, fluorine, lithium, degreasing solvents, liquid propane, Diala AX oil, etc. The E&S Group also maintains a file of material safety data sheets. There are more than 1,900 in the current file.

4.2.2 Toxic Chemical Storage

There are a number of hazardous chemicals used at the Fermilab complex. These are stored at various locations. Table 4-8 was prepared from the Spill Prevention Control and Countermeasures (SPCC) Plan (Fermilab, 1987a), as well as Survey observations, and presents the hazardous chemicals, their storage sites, or usage location. The storage of PCBs, petroleum products, and radioactive substances is not included in this table, since it is discussed in Sections 4.2.3.3, 4.2.6.4(4), and 4.3.2.

Site 3 is designated by Fermilab as the Hazardous Materials Storage Area. These are materials which are being held for future use. The substances stored at this facility include PCB capacitors, lithium metal, alkali solutions, tetrakis, and miscellaneous laboratory chemicals. The lithium, tetrakis, and miscellaneous chemicals are stored in a temperature-controlled room.

TABLE 4-8

HAZARDOUS CHEMICALS AND PESTICIDE STORAGE AREAS
FERMILAB - BATAVIA, ILLINOIS

Hazardous Substances	Location
Hydrochloric Acid (1,265 gal)	Site 38, Gas Shed
Hydrochloric Acid (55 gal)	Central Utilities Building
Hydrofluoric Acid (2 gal)	Materials Development Laboratory
Sulfuric Acid (26 gal)	Materials Development Laboratory
Nitric Acid (21 gal)	Materials Development Laboratory
Acetic Acid (15 gal)	Materials Development Laboratory
Sodium Hydroxide (55 gal)	Central Utilities Building
Sodium Hydroxide (935 gal)	Site 38, Gas Shed
Beryllium (~100 lbs)	AP4 Line between Booster and Antiproton Area
Beryllium (~535 lbs)	Enclosure NMK, Muon Beam Line
Beryllium (~800 lbs)	Target Service Building
Cadmium	Site 3 Barn (lower level)
Chlorine Gas Cylinders (6)	Central Utilities Building
Chlorine Gas Cylinders (2)	Laboratory 8
Chlorine Gas Cylinders (9)	Site 38, Gas Shed
Chlorine Gas Cylinders (5)	Village Swimming Pool
Chlorine Gas Cylinders (2)	Village Well
Chlorine Gas Cylinders (3)	Well No. 3
Cyanide Plating Kits	Laboratory 8, PC Laboratory, West Booster, Wilson Hall (ground floor)
Lithium	APO Service Building
Lithium	Site 3 Barn (upper level)
Mercury (54 lbs)	Target Service Building
Herbicides and Insecticides	Site 3 Shed
Insecticides	28 Sauk Boulevard
Aquacides	Site 38
Solvents	Site 38

Source: Fermilab, 1987a;
DOE Survey team.

Petroleum products such as gasoline, fue oil, and diesel fuel are stored in aboveground or underground tanks in various areas throughout the Laboratory. Table 4-9 describes some of the aboveground tanks currently in use at Fermilab and presents some problems observed by the Survey team. The underground storage tanks for petroleum products that are subject to RCRA requirements are discussed in Section 4.1.1.1 and described in Table 4-10. These underground tanks have not been integrity tested.

The Fermilab SPCC Plan covers the use and storage of fluids such as oils, chemicals, and other hazardous materials that would be of concern if they were released into the environment. The plan identifies specific spill-prevention and spill-response measures, as well as the reporting and notification requirements in the event of a spill. The SPCC Plan was reviewed and updated in August 1987 by the Fermilab Safety Section.

4.2.3 PCB Sources

4.2.3.1 Transformers

In service at Fermilab are 63 transformers that contain PCB or PCB-contaminated oil. The transformers are located at many sites throughout the facility. One of these transformers contains Askarel with a PCB concentration of 700,000 ppm, 48 contain coolant with PCB concentrations from 700 ppm to 51,000 ppm, and 14 contain oil with a PCB concentration range of 65 ppm to 498 ppm. In addition, five spare transformers containing fluid contaminated with PCBs are stored at the Railhead. These are protected by shielding blocks to prevent damage by moving vehicles and are inspected at least on a quarterly basis. A program is in effect to remove the remaining Askarel-filled transformer and to reduce the PCB concentration in all transformer fluids to less than 50 ppm as rapidly as possible.

The Survey team inspected most of the PCB and PCB-contaminated transformers and found evidence of some small leaks (see Finding 4.2.6.2.1) and incorrect labeling (see Finding 4 2.6.4.2). Several PCB-contaminated transformers (50–500 ppm) were labeled as PCB transformers (> 500 ppm PCBs).

The Safety Section's personnel are aware of these problems, and efforts to solve them have been under way. The staff has also tested soil samples at the site of a non-PCB oil spill that occurred on June 15, 1987, from transformer D2-3. The soil under the drain valve was found to contain 364 µg/g PCBs. This contamination may have occurred before PCBs were regulated (July 1979) and may be an

TABLE 4-9

ABOVEGROUND STORAGE TANKS
FERMILAB - BATAVIA, ILLINOIS

Area	Tank Volume (Gallons)	Substances Stored	Survey Observations
Site 50	500	Gasoline	No containment, gravel base, potential for soil contamination, tank on stilts with no vehicle guards.
	500	Diesel Oil	
	500	Gasoline	
Site 56	500	Gasoline	No containment, potential soil contamination, all tanks looked rusted, hoses in deteriorated condition, strong odor of motor fuels, tanks on stilts with no vehicle guards.
Site 56	250	Diesel Fuel	
Site 56	500	Gasoline	
CO Services	500	Gasoline	No containment, tank rusted at supports, valve wet with a slow leak observed.
Railhead	5,000	Scintillation Fluid	No containment; on-ground, stainless-steel tanker truck unit.
Laboratory C	5,000	Scintillation Fluid	No containment; gravel surface, stainless-steel tank.
Meson Assembly	250	Gasoline	No containment, gravel surface.
Facility Operations	500	Diesel Fuel	No containment, three portable tanks transported about site, gravel surface, oil odor present but no leaks observed.

Source: DOE Survey team.

TABLE 4-10

UNDERGROUND STORAGE TANKS
FERMILAB-BATAVIA, ILLINOIS

Area	Volume (Gallons)	Substance Stored	Construction Material	Corrosion Protection	Age (years)
Site 38	12,000	Gasoline	Fiberglass	None	3
Site 38	2,000	Gasoline	Fiberglass	None	7
Site 55	2,000	Gasoline	Fiberglass	None	12
Site 55	2,000	#2 Diesel	Fiberglass	None	12
Central Utility Bldg.	11,000	#2 Diesel	Steel	None	14
Village	10,000	Gasoline	Fiberglass	None	12
Central Utility Bldg.	12,000	#2 Diesel	Steel	None	14
Vehicle Maintenance*	600	Used oil	Fiberglass	None	7
Laboratory	250	Used oil	Aluminum	None	8

Source: Coulson, 1986b.

*Removed from ground April 17, 1986; No evidence of oil leakage.

indication that the soil around other transformers could also contain significant amounts of PCBs. An attachment to a memo (Beddingfield, 1987a) states, "There is a possibility of >65 contaminated sites around the ring (below drain valves at each transformer and in between service building and main ring road where truck was parked)." See Finding 4.5.2.3.4 for further details. In addition, a large spill of transformer fluid containing a low level of PCB contamination (1.3 ppm) occured during January 1985. Failure of transformer T82A at the master substation resulted in the release of a large volume of oil. The amount of oil lost into the ground has been estimated to be between 12,500 and 24,200 liters (3,300 and 6,398 gallons). See Finding 4.5.2.3.1 for further details.

4.2.3.2 Capacitors

The Laboratory's SPCC Plan identifies 1,609 large PCB capacitors in use, in storage for future use, or in storage for disposal (FermiLab, 1987a). The 734 large, PCB capacitors located in the Capacitor Tree were removed during June/July 1987 and placed in storage for disposal. The locations of the large capacitors are shown in Table 4-11.

Leaks and spills from PCB-containing capacitors in the capacitor tree have contaminated the "cap" tree, the gravel and asphalt under the tree, and nearby soil and manhole cover (Beddingfield, 1987a). Fermilab has initiated a cleanup of the "cap" tree and surrounding area. See Finding 4.5.2.3.2 for details.

4.2.3.3 PCB Storage

PCB materials are primarily stored at Site 3, Site 55, and at the Railhead. Site 55, the Hazardous Waste Storage Facility, is used to store various oils, PCB materials, and chemicals prior to disposal. The three buildings at this site have containment areas to prevent spills from reaching the environment. At the time of the Survey, this site contained large, PCB capacitors in the PCB Storage Building (WS2). Some PCB capacitors also are stored in the lower level of the barn at Site 3. These are stored on a sloping concrete floor, which drains into a containment area. In addition, five spare transformers are stored at the Railhead. One of these contains 4,490 liters (1,186 gallons) of fluid contaminated with 513 ppm PCBs, and the other four contain 5,200 liters (1,375 gallons) of oil contaminated with PCBs in the range of 124 to 21,484 ppm.

TABLE 4-11

LOCATION OF LARGE CAPACITORS
FERMILAB-BATAVIA, ILLINOIS

Location	Number
Booster (in tunnel)	137
Booster RF (22 inside, 52 outside)	74
Main Ring RF (18 inside, 57 outside)	75
Site 3 (23 for future use)	383
Site 55 (for disposal)	940

Source: Fermilab, 1987a.

Fermilab's designated areas for storage of PCB items awaiting disposal generally meet the regulatory requirements; however, they are too small to accommodate one of the large (5,200 liters [1,375 gallons] of fluid), PCB transformers. The regulations allow storage for disposal for up to 1 year if the storage area complies with certain requirements. In the absence of an adequate storage-for-disposal area, the regulations allow storage of PCB transformers for 30 days. Therefore, removal of one of the large PCB transformers would require that all the procedures necessary be completed and that the unit be in transport from Fermilab to the final disposal site within 30 days (EPA, 1986).

4.2.4 Asbestos

4.2.4.1 Background

Asbestos materials have been used extensively at Fermilab. Asbestos-containing construction materials were used in ceilings, walls, insulation, and pipes in many buildings. A program has been underway for some time to identify, remove, or enclose friable asbestos. The E&S Group monitors all removal or remodeling activities that involve asbestos to ensure that friable asbestos does not become airborne. Fermilab maintains records of asbestos-containing sites and discourages further use of this material. The location of asbestos and asbestos-containing materials is an ongoing program, and all employees are encouraged to report these materials when encountered.

4.2.4.2 Removal and Enclosure

Many projects have been completed that involve the removal or enclosure of asbestos. For example, the Wonder building and other smaller buildings of similar construction (Quonset hut type, containing asbestos) were demolished in 1984, the walls of Laboratory A have been covered over with a dry wall, the NC9 Building was completely removed, the asbestos shingles were removed from a building during the summer of 1986, and the pipe insulation in the Wilson Hall emergency generator exhaust system was removed in early 1987. In areas where asbestos has not been removed (e.g., the Moore Gallery) air monitoring and inspection for friability are conducted on a semiannual basis. The samples are analyzed by using Phase Contrast Microscopy in an AIHA-accredited laboratory. IEPA has conducted two inspections and did not find any problems.

4.2.4.3 Disposal

The removal of asbestos and asbestos-containing materials is done by Fermilab employees that have been properly trained, and the process is closely monitored by the E&S Group. Also, photographs of

the process are taken and kept on file. The materials removed are double-bagged and disposed of at an approved off-site landfill (see Table 4-6).

There is some indication that asbestos-containing materials (e.g., transite) were buried at the Meson Shielding Hill landfill prior to 1979. This landfill is listed as a potential decommissioning problem area in the Fermilab Decontamination and Demolitions file.

4.2.5 Pesticides

4.2.5.1 Background

A variety of pesticides are required for the control of weeds, algae, insects, and rodents on the 10.6-square-mile Fermilab site. The Laboratory formalized a set of pesticide-handling procedures in December 1979 and made them available to the appropriate workers. Approximately 93 hectares (2,300 acres) of the land is used for agricultural purposes, primarily corn production, and the licensees of this land also use herbicides and insecticides. These chemicals are applied by licensed contractors and require the approval as well as the supervision of the appropriate Fermilab personnel. The pesticides for general use in the non-agricultural areas are applied by trained Fermilab personnel from the Roads and Grounds Department. The Supervisor of this group is a licensed applicator. Weather conditions and forecasts are considered in the scheduling of pesticide application. In addition, records are kept concerning the chemicals used, the area treated, and the personnel involved in their application.

4.2.5.2 Pesticide Inventory and Application

A number of EPA-registered herbicides, insecticides, and rodenticides are used at Fermilab. Although some variations occur in the specific chemicals applied from year to year, those utilized during calendar year 1986 are typical (Baker, 1987). These include the following:

- 2,4-D Amine was used for the control of broad leaf weeds in the bison pasture. It was applied to approximately 32 hectares (80 acres).

- Chipco Turf Kleen was also used to control broad leaf weeds and was applied to approximately 1.2 hectares (3 acres) of turf areas around Wilson Hall and the nearby pond and lake.

- Roundup was applied around the bases of trees and signposts in some areas to control weeds. The total amount used was approximately 30 liters (8 gallons).

- Lasso-atrazine herbicide was applied to 582 hectares (1,437 acres) of land used for corn production.

- Counter insecticide was applied to 933 hectares (2,306 acres) of land under corn production.

- Bicep-6L herbicide was applied to 352 hectares (869 acres) of land under corn production.

- Spike 80-W was applied to approximately 17 hectares (41 acres) to control weeds around storage areas, parking lots, and hardstand areas at electrical substations, service buildings in the experimental areas, and the Bubble Chamber yard.

- CYTHION Premium Grade Malathion was applied for mosquito control at 11 sites.

- Contrac Rat and Mouse Bait was placed at 40 outdoor electrical substations to reduce rodent nesting in the equipment.

- Dipel was used to treat approximately 100 trees for the control of the eastern tent caterpillar.

- Aquazine was added to the Village Oxidation Pond, the main ring ponding system, the Swan Lake/Booster Pond System, and the reflecting pond to control algae growth. A total of 980 kg (2,160 pounds) were used.

- Dalapon has been used in the past to treat an estimated 34 kilometers (21 miles) of drainage ditches for control of the common cattail.

During the summer of 1987, Lorsban 15G was applied to the agricultural land to control the corn borer. This insecticide was applied by spraying from a helicopter by a licensed contractor under the supervision of Fermilab personnel. However, no surface water samples were collected for analysis after application to determine whether there was any effect on surface water quality. Collecting and analyzing surface water samples after future applications of this insecticide would ensure that the surface waters are not affected by the aerial application. See Finding 4.2.6.4.5.

4.2.5.3 Storage Facilities and Disposal Practices

Most of the pesticides are stored indoors at the Site 3 shed. This building is secured and well maintained. The individual chemicals are separated and neatly stored. Some insecticides and the aquacides are stored in buildings at 28 Sauk Boulevard and Site 38 (see Table 4-8). All of the empty containers are triple-rinsed prior to disposal.

4.2.6 Findings and Observations

4.2.6.1 Category I

None

4.2.6.2 Category II

1. Leaking PCB and PCB-Contaminated Transformers. Four transformers containing PCBs were found to have small leaks or an oil stain indicating a recent leak. The specific PCB transformers and the problems observed are shown below:

Transformer Identification	PCB Concentration (ppm)	Problem Observed
D2-3	<50	Past leak from Conservator, small leak at valve.
GR-1 (Giese Road)	479	Epoxy plug to repair missing radiator tube was leaking; leak stopped and tube repaired on September 18, 1987.
CU-2	1,000	Oil stain under valve.
F1-1	34,000	Leak from drain valve found by Fermilab staff and stopped. The spill area was covered and warning signs were in place at the time the Survey team inspected the transformers. Cleanup was planned but not completed prior to the end of the Survey.

4.2.6.3 Category III

None

4.2.6.4 Category IV

1. PCB Annual Report. PCB annual inventory reports from 1979–1986 are incomplete because they do not list total numbers of PCB transformers nor the total weight of PCBs in PCB transformers. The reports fully describe each transformer (location, amount, concentration) but do not provide the summaries required by the regulations. Although not an environmental problem, this accounting error is a violation of TSCA requirements.

2. Labeling PCB-Contaminated Transformers. Incorrect labeling of PCB-contaminated transformers could lead to misjudgment of which transformers are properly labeled. Fermilab has routinely labeled PCB-contaminated transformers (50 to 500 ppm PCBs) with labels designating the units as PCB transformers (>500 ppm PCBs). Although this procedure was developed as a conservative practice, it can lead to confusion regarding which transformers are correctly designated and which are not. Table 4-12 identifies mislabeled transformers observed by the Survey team.

3. Lack of Secondary Containment – Aboveground Chemical Product Storage Tanks. The lack of secondary containment and the presence of permeable surfaces for aboveground gasoline and fuel oil storage tanks and a scintillation oil tank may result in contamination of soils in the event of a spill.

   Aboveground fuel tanks are located in various areas around Fermilab where contractors and Fermilab vehicles obtain fuel. The locations and numbers of the tanks vary depending upon the level and type of activities occurring at the time. The Survey team evaluated the eleven motor fuel tanks and two scintillation oil tanks in use during the Survey. In several instances dispensing equipment and/or tanks were in a deteriorated condition. Also, strong odors of motor fuels were noted and in one instance a slow leak was observed. Table 4-9 describes the tanks, their volumes, the quantity stored, and Survey observations.

4. Underground Chemical Product Storage Tanks - Lack of Integrity Testing. Undetected releases of motor fuels and oils to the soil from underground tanks could occur as a result of the lack of integrity testing of the tanks.

   The Survey team identified seven underground tanks used for the storage of gasoline, diesel fuel, and fuel oil. All the tanks are subject to proposed RCRA regulations regarding underground storage tanks used for the storage of hazardous liquids including gasolines and

TABLE 4-12

MISLABELED TRANSFORMERS
FERMILAB-BATAVIA, ILLINOIS

Transformer Identification	PCB Concentration (ppm)	Problem Observed
GR-1 (Giese Road)	479	Labeled as a PCB transformer.
ML-3A	100	Labeled as a PCB transformer.
PL-3	317	Labeled as a PCB transformer.
Village Lab 6	141	Labeled as a PCB transformer.
Village Lab 7	235	Labeled as a PCB transformer.
ML-4A	264	Labeled as a PCB transformer.
NL-10	498	Labeled as a PCB transformer.

Source: DOE Survey team.

fuels (see Section 4.1.1 for details). Integrity testing of these tanks is not required at this time. However, based on evidence from similar tanks used nationwide and the lack of corrosion protection, it is possible that leaks may develop in one or more tanks.

Fermilab relies on inventory control to detect leakage. However, USEPA studies have shown that inventory control is not sufficiently sensitive to detect all leaks. Leaks occurring at a sufficient rate to contaminate significant areas of the soil would be undetected by inventory control.

Table 4-10 describes the underground tanks of concern at Fermilab.

5. Lack of Sampling and Analysis of Surface Waters After Aerial Application of Pesticide. The application of the insecticide Lorsban 15G by Lorsban helicopter can result in the contamination of nearby surface waters. Lorsban 15G contains the cholinesterase inhibitor chlorpyrifos which is extremely toxic to fish and aquatic organisms. Thus, drift and runoff from treated areas may be hazardous to fish and aquatic organisms in adjacent surface waters. Appropriate sampling and analysis can ensure that this pesticide is not contaminating aquatic systems at Fermilab.

4.3 Radiation

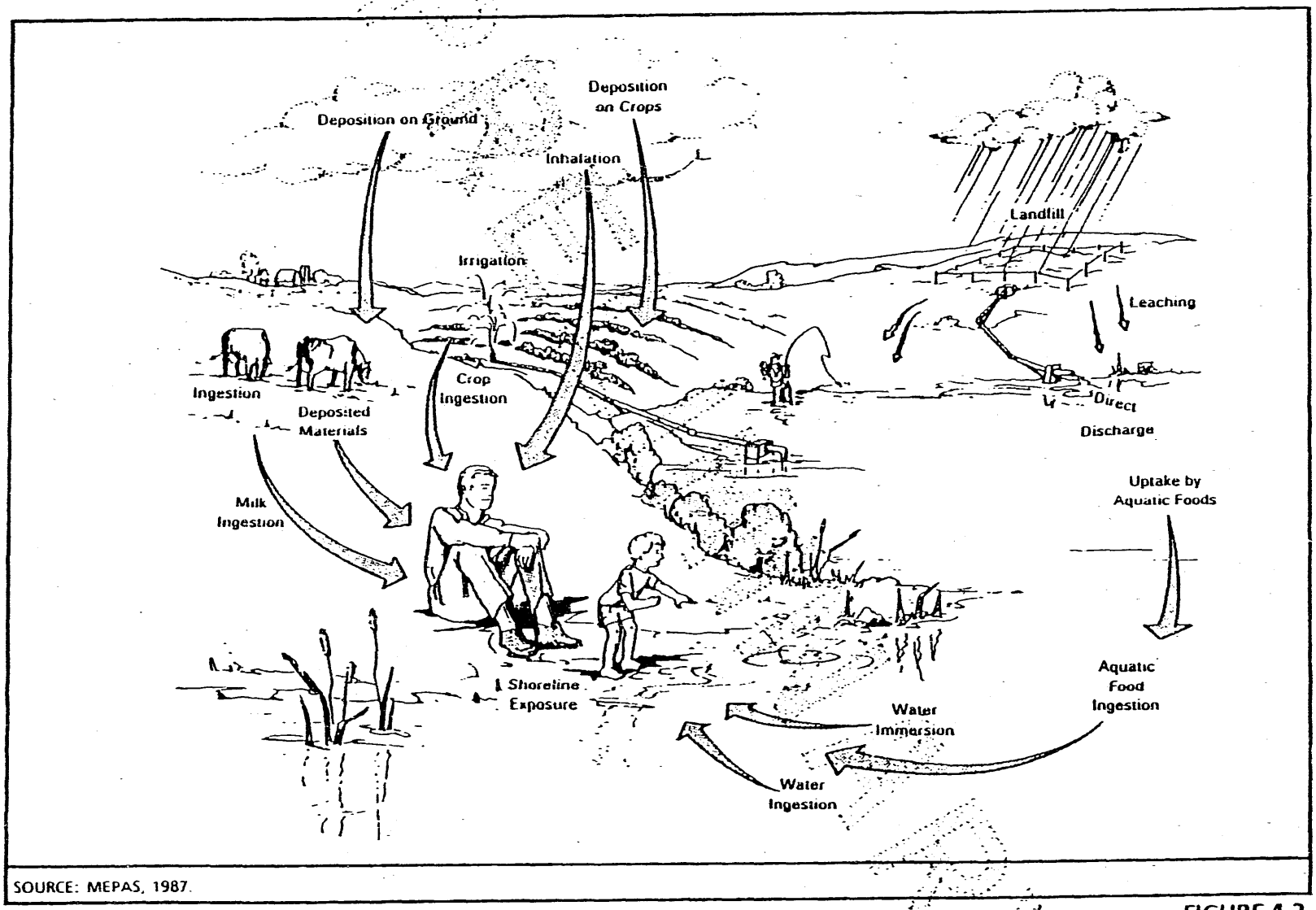
4.3.1 Background Environmental Information

The Fermilab radiation site setting can be described as a subset of each of the previous media settings (i.e., air, soils, surface water, and hydrogeology). Each of these primary pathways is responsible for radionuclide transport and potential contamination of ambient air, soils, drinking water, groundwater, vegetation, and food. Figure 4-2 depicts graphically some of these transport/exposure scenarios (MEPAS, 1987).

Background radiation in the vicinity of Fermilab is a consequence of both natural and manmade sources. These sources include cosmic radiation; natural radioactive materials in the soils and building materials; fallout from past atmospheric weapons detonations; releases of radioactive materials from nuclear power plants and other facilities handling radioactive materials worldwide; and the intake of radioactive materials in air, drinking water, and food. The most significant exposure is that to the lungs from background levels of radon. The annual average effective dose equivalent for natural background in the United States is approximately 189 millirem/year (mrem/yr) (United Nations, 1982). This dose is detailed in Table 4-13. About one-half of the dose equivalent is attributable to the inhalation of radon-222 and its decay products. Previously accepted estimates of background doses did not include the radon contribution and were set at about 100 mrem/year.

The data in Table 4-13 were derived in accordance with the approach recommended by the International Commission for Radiation Protection (ICRP) in ICRP Reports 26 and 30. This approach allows direct comparison of the effective dose for different organs by reflecting the distribution of and organ sensitivity to various radionuclides. This is accomplished by applying "weighting factors" to the doses received by individual organs. The weighting factors are expressed as the fraction of the total risk for the entire body attributable to the organ. The sum of the dose equivalents for the individual organs provides an estimate of the total effect of the radiation on the whole body.

The EPA reports gamma radiation dose rates on a quarterly basis for select locations throughout the United States in Environmental Radiation Data (EPA, 1987). During the most recent reporting period of July-September 1986, measured dose rates equivalent to an annual dose of approximately 85.0 mrem ± 2.5 mrem were reported for the Chicago, Illinois, monitoring location. Natural background radiation dose to the population within an 80-km (50-mile) radius of Fermilab is approximately one million (1,000,000) person-rem (DOC, 1982 and Bushong, 1977).



SOURCE: MEPAS, 1987.

FIGURE 4-2

TRANSPORT/EXPOSURE SCENARIOS
FERMILAB - BATAVIA, IL

TABLE 4-13

AVERAGE ANNUAL EFFECTIVE DOSE EQUIVALENT TO HUMANS FROM NATURAL BACKGROUND RADIATION FERMILAB - BATAVIA, ILLINOIS

Organ	Annual Effective Dose Equivalent (mrem)
Gonads	24
Breast	14
Lung (Total)	100
Red Bone Marrow	13
Bone Surfaces	6
Thyroid	3
Other	29
Total(1)	189

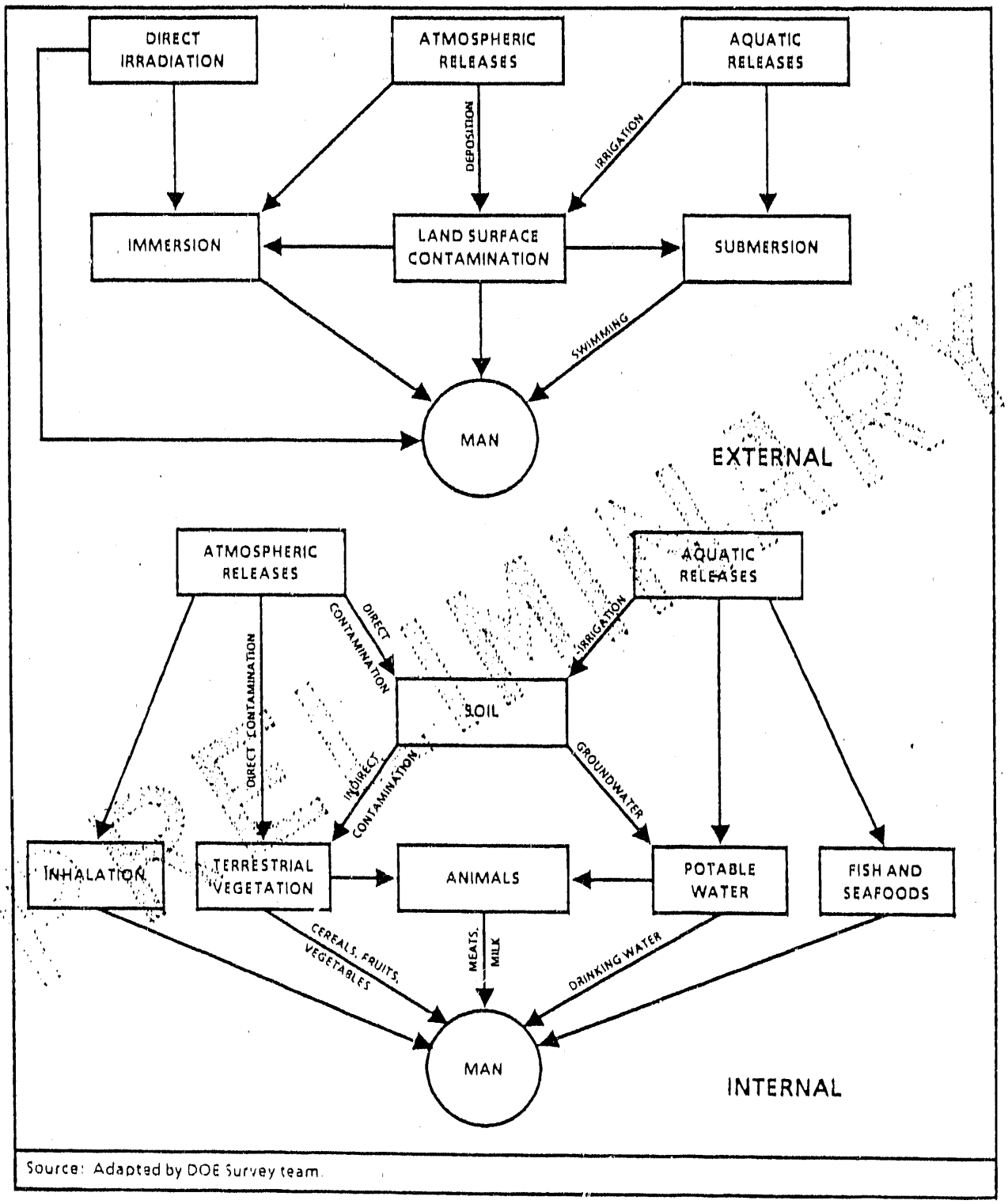
Source: United Nations, 1982.

(1) Total represents the product of the appropriate weighting factor times the annual dose equivalent for pulmonary, trachial/bronchial, and mean doses.

As required by DOE Order 5484.1 Chapter III, 4d2d1-3, Fermilab makes an annual "assessment and reporting of potential dose to the public." In 1985 DOE adopted an interim radiation protection standard for environmental activities to be implemented in calendar year 1985 (Vaughan, 1985). It is DOE policy to follow the guidance of the National Council on Radiation Protection and Measurements (NCRP) to the extent practicable with respect to radiation protection standards. A comprehensive revision of previous NCRP recommendations on a basic radiation protection standard is still under development. However, current NCRP guidance is available regarding protection of the public in its September 18, 1984, advice to the Environmental Protection Agency published under the title "Control of Air Emissions of Radionuclides." In this document, the NCRP endorses the recommendation of the International Commission on Radiological Protection (ICRP) to limit the continuous exposure to any member of the public from other than medical sources and natural background to 100 mrem per year whole body dose-equivalent. The previously recommended limit of 500 mrem per year is retained for non-continuous exposures. This recommendation is now adopted as an interim standard for DOE environmental activities for the sum of all exposure pathways.

Immersion, or external penetrating radiation exposure from radionuclides in air, and external penetrating radiation exposure from radionuclide land-surface contamination, also known as ground-plane irradiation, are additional direct radiation issues. Environmental penetrating radiation monitoring programs, in conjunction with soil radionuclide monitoring on-site, demonstrate that public exposure is well below permissible limits and, with exceptions as noted in Section 3.2, is essentially indistinguishable from background levels.

Radiation exposures are received from external sources and from radionuclides taken into the body by inhalation of air and ingestion of water and foodstuffs. Radionuclides taken into the body will continuously irradiate the body until they are removed through either radioactive decay or metabolic processes. Consequently, internal dose estimates are calculated as "50-year dose commitments." These are obtained by integrating the total dose received by an individual's body over an assumed remaining lifetime of 50 years. Principal pathways for exposure of humans from radionuclides released from Fermilab are shown in Figure 4-3. The dose to the various major organs are considered for various exposure pathways. The radiation doses received by a specific organ are weighted and summed to determine the total dose.



Source: Adapted by DOE Survey team

FIGURE 4-3

PATHWAYS FOR EXPOSURE OF MAN FROM
ATMOSPHERIC AND AQUATIC RELEASES OF RADIOACTIVE EFFLUENTS
FERMILAB - BATAVIA, IL

4.3.2 General Descriptions of Pollution Sources and Controls

Operation of the accelerator at current energies and intensities results in production of penetrating radiation outside the shielding surrounding target and dump areas. Muons (heavy electrons which have the same capacity for human damage as electrons or gamma rays), neutrons, and gamma rays are the three forms of penetrating radiation associated with Fermilab operations. As shown in Figure 4-4, primary sources of radiation are the beam tube areas where muons and neutrons are produced and gamma rays are produced from activated materials stored there. Figure 4-5 shows in greater detail the muon penetrating radiation directions.

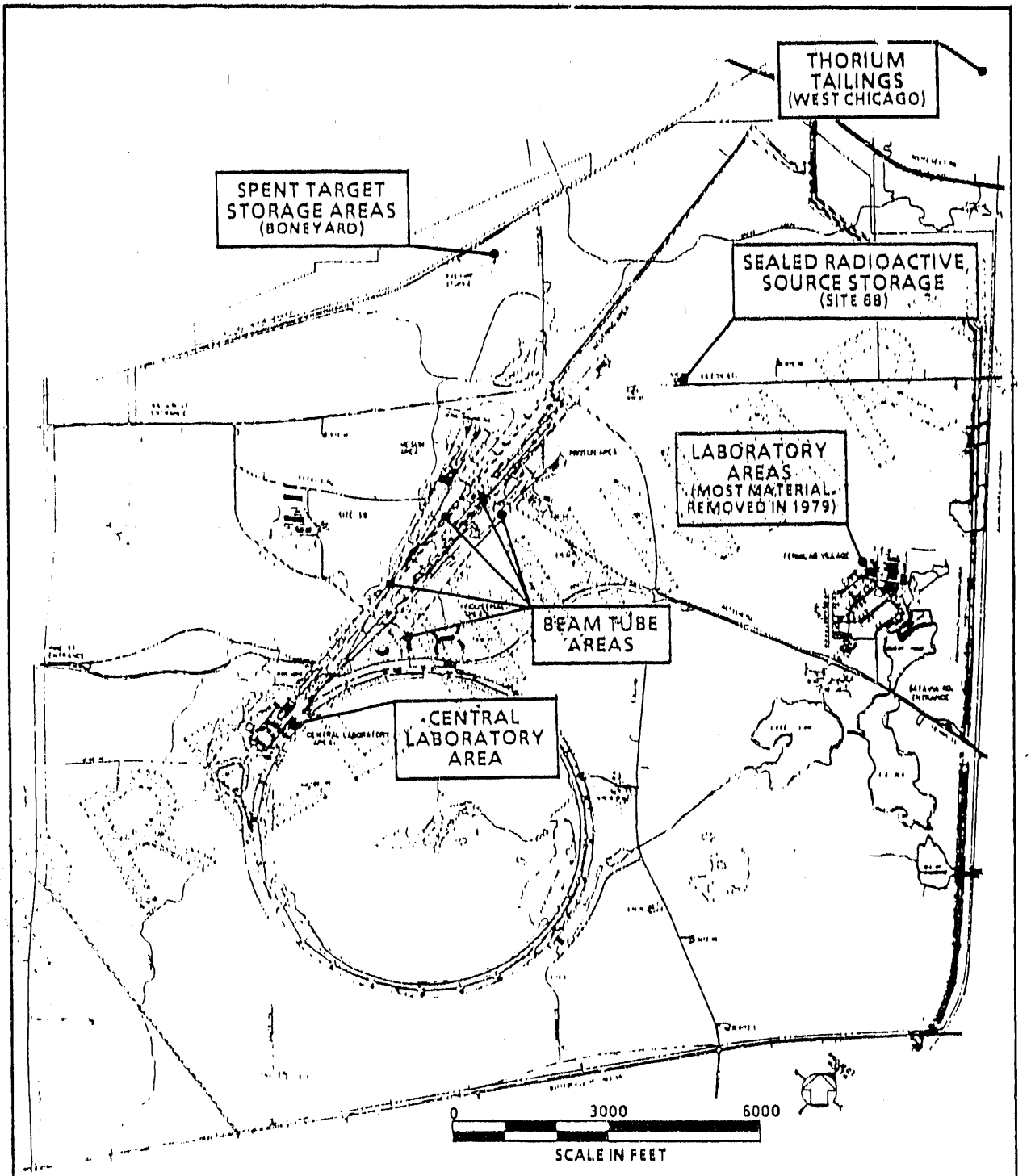
Controls employed at Fermilab for these sources of radiation are primarily shielding and distance. The third generally accepted radiation control method, reducing the time of exposure, is used to control occupational and visitor personnel exposures.

Shielding calculations, particle interactions, energy deposition density calculations, and associated environmental consequences are described in great detail in Vandinneken and Awschalom, 1975. The major environmental radiation consequence of accelerator operations is soil activation which has been described in Section 3.2 and in Baker, 1978; Baker, 1975; and Borak, et al., 1972.

Major sources of airborne radionuclide emissions contributing to public dose are the Neutrino Area Stack, Antiproton Area Stack, and, to a lesser degree, the magnet debonding oven.

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. Along most proton beam lines (paths of the protons from the accelerator) the protons travel inside evacuated pipes. Thus, radioactivation of air is now usually caused by secondary particles (Baker, 1987). Because of the short half-life of the major radionuclide emitted (20 minutes for ^{11}C), low quantities as a percentage of acceptable doses, and lack of cost-effective control technologies, no reductions of ^{11}C emissions prior to release take place. Doses attributable to ^{11}C are extremely low and are discussed in the environmental monitoring section of this section.

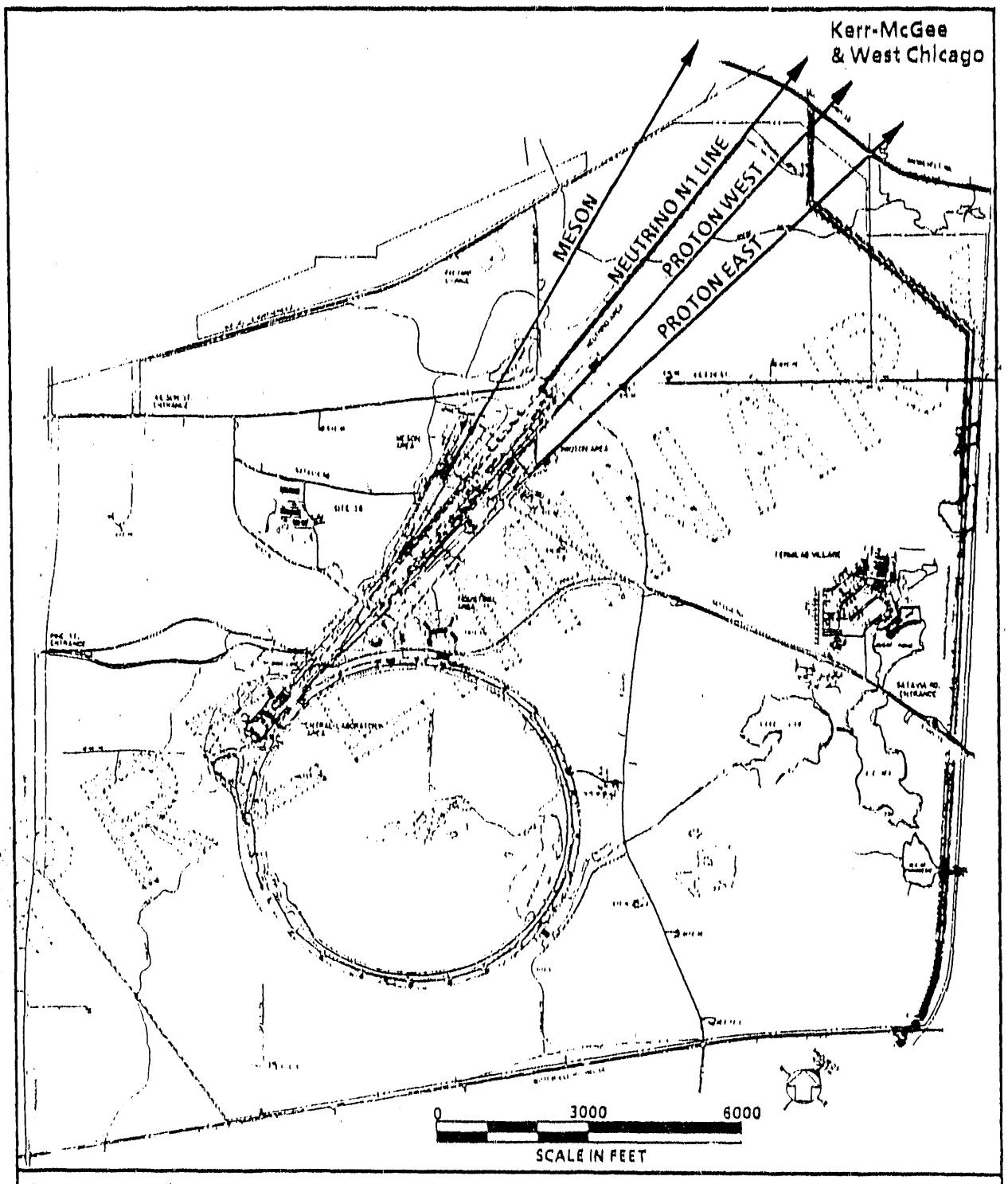
During a calibration study, information became available that other air activation products may be present in small concentrations (Butala, 1987). The relative contributions, if any, of ^{15}O, ^{13}N, and ^{41}Ar will be evaluated using AIRDOS sometime prior to publishing the 1987 Environmental Monitoring Report.



Source: Adapted from DOE, 1982.

FIGURE 4-4

SOURCES OF RADIATION
FERMILAB - BATAVIA, IL



Source: Adapted from DOE, 1982

FIGURE 4-5

PENETRATING RADIATION (MUON) DIRECTIONS
FERMILAB - BATAVIA, IL

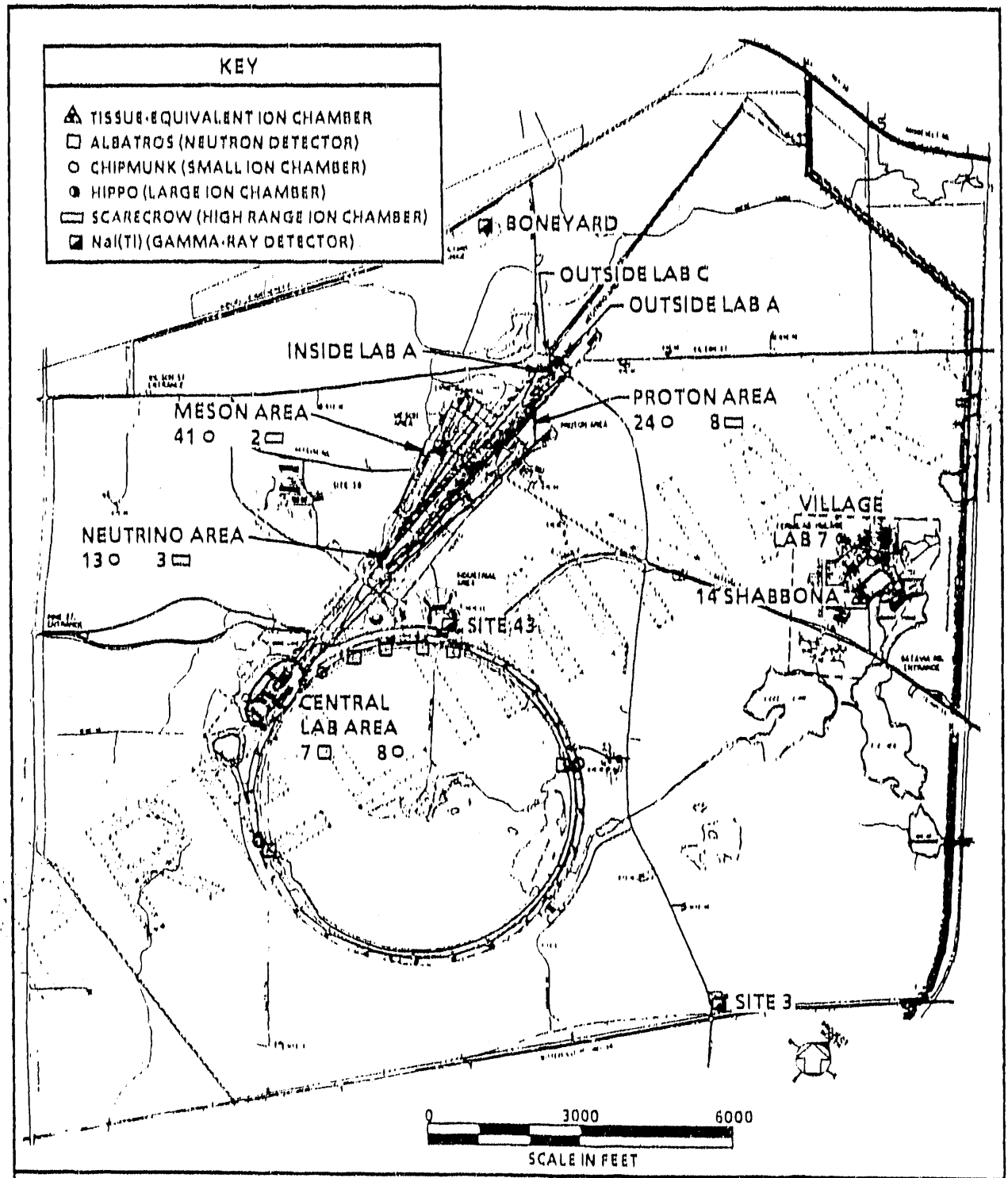
A magnet debonding oven was placed in operation in CY 1979 in the Industrial Area. Its purpose is to debond magnets by decomposing the epoxy adhesives at high temperatures. Most of these magnets are radioactive and have failed during accelerator operations. The gaseous effluent was measured during the acceptance test conducted June 8, 1979, for the Illinois EPA. Measurements were primarily performed to evaluate nonradioactive emissions. The test utilized a typical 6-meter (20-foot) long magnet reading 0.8 mrem/hr at 0.3 meter (1 foot) from the surface and 8 mrem/hr in the bore tube where the protons traveled. The total amount of ^{3}H released from this magnet was 160 µCi at a stack concentration of 1.3×10^{-8} µCi/ml (Almega, 1987). These values are used to calculate emissions (described in Section 4.3.3) from debonding activities which occur only about every 6 months. No control technology is employed for reducing tritium emissions. Administrative limitation of the number of magnets debonded would be employed, if necessary, to limit these emissions.

During accelerator operations, some radioactivation of the soil (see Finding 3.2.4.3.1) will occur (Borak, et al., 1972 and Gollon, 1978). Leaching of these radionuclides into the groundwater (see Finding 3.4.4.3) provides a possible mechanism for transport of Fermilab-produced radionuclides into the surface run-off water and aquifer. Closed-loop recirculating cooling systems are also potential sources of radionuclide emissions as a consequence of radioactivation. Analyses are conducted for ^{3}H, ^{7}Be, ^{22}Na, ^{45}Ca, ^{54}Mn, and ^{60}Co.

Controls employed to prevent unacceptable releases of these radionuclides primarily consist of engineering control measures to capture soil activation leachate as described in Section 3.2 in conjunction with environmental sample analyses.

4.3.3 Environmental Monitoring Program

Penetrating radiation monitoring is performed utilizing a network of approximately 120 detectors deployed around the site as shown in Figure 4-6. The majority of these detectors are connected to a data logger which automatically records radiation levels for subsequent examination (Awschalom, 1971). There is one tissue-equivalent ion chamber which is a plastic sphere designed to have a similar dose response as the human body. Albatros neutron detectors had been used for about 10 years (1972–1982) when they were taken out of service. Failure to detect operationally related radiation, plus development of two alternative measurement techniques (low and high range ion chambers called chipmunks and scarecrows) led to the elimination of the Albatros. There is one highly sensitive ion chamber (called the Hippo) still in operation near the boneyard which can measure more subtle changes in radiation levels. The Sodium Iodide Detector [NaI(Tl)] is located at the Site 3 environmental station and is used for measuring background levels of gamma radiation.



Source: Adapted from DOE, 1982.

FIGURE 4-6

RADIATION DETECTOR LOCATIONS
FERMILAB - BATAVIA, IL

Because the nature of accelerator operations is constantly changing in terms of experiments conducted and operating hours, a Mobile Environmental Radiation Laboratory (MERL) is used for determining site boundary exposure levels, and for locating the source and direction of penetrating radiation including muons and neutrons (Moore and Velen, 1974; Moore, 1976; Cossairt, 1983; and Cossairt and Coulson, 1983).

The MERL is a four-wheeled-drive vehicle equipped with two 20-cm x 20-cm (8 inch x 8 inch) scintillation counters, one approximately 15 cm (6 inch) behind the other, for muon detection. It also has a DePangher "long counter" for neutron detection.

As shown in Table 4-14, maximum potential site-boundary (fence-line) doses from penetrating radiation are well below DOE guidelines. The unusually low dose for 1986 is a result of the extended shutdown from October 1985 through CY-1986 to construct the new proton-antiproton collision facilities. Thus, 1986 monitoring data primarily reflects impacts from earlier accelerator operations and limited testing toward the end of the year.

Future fence-line doses will be affected by two contradicting operational characteristics. Fermilab refers to two "modes" of operation: (1) fixed-target which has been the only mode of operation until early 1987 and (2) colliding mode which will study the high-energy physics associated with proton-antiproton collisions. The collision mode will not generate highly collimated penetrating radiation as is the case with fixed-target interactions. Therefore, fence-line radiation doses during the estimated 6-month colliding mode operating cycle will possibly drop to levels which may be indistinguishable from background. Conversely, the quest for higher energies also produces slightly higher energy secondary radiation (primarily a problem during fixed-target mode) which will tend to increase fence-line doses during the 6-month fixed-target operating mode. The greatly decreased operating time (about 50 percent less) is likely to be a more significant factor toward reducing dose than the slightly more energetic radiations produced from higher energy proton-fixed-target interactions.

4.3.4 Findings and Observations

4.3.4.1 Category I

None

TABLE 4-14

MAXIMUM POTENTIAL FENCE-LINE
RADIATION EXPOSURE[a]
FERMILAB - BATAVIA, ILLINOIS

Calendar Year	Site Boundary Penetrating Radiation Dose (mrem)	Percent of DOE 100 mrem Concentration Guide
1986[b]	0.0007	0.0007
1985	1.5	1.5
1984	0.8	0.8
1978-1982 (average)	3 (average)	3 (average)

Source: Adapted by DOE Survey team.

(a) Assumes 24 hour/day occupancy.
(b) See Section 4.3.3 for discussion of operational characteristics during 1986.

4.3.4.2 Category II

None

4.3.4.3 Category III

None

4.3.4.4 Category IV

None

4.4 Quality Assurance

4.4.1 General Descriptions of Data Handling Procedures

4.4.1.1 Fermilab Facilities

There are two analytical laboratories at Fermilab conducting environmental measurements. These are the Nuclear Counting Laboratory and the Water Laboratory. The Nuclear Counting Laboratory is part of the Environmental Protection Group, which is in the Safety Section, and is responsible for radiochemical measurements. The Water Laboratory is part of the Facilities Management Group, which is in the Business Services Section, and conducts some water and wastewater analyses. In addition, Fermilab utilizes outside laboratories extensively for both the radiological and chemical analyses.

The Nuclear Counting Laboratory has gamma, X-ray, and alpha detection equipment available for radioactive sample analysis. The quality assurance activities are coordinated by the Group Leader, who also supervises the operation of the laboratory. The Group Leader coordinates the laboratory's participation in the DOE Environmental Measurements Laboratory's interlaboratory performance program, as well as the analyses of the general quality control samples such as blanks, spiked samples, duplicates, and standards. Approximately 10 percent of the samples analyzed are for quality assurance purposes. In general, this laboratory has obtained acceptable values (within ± 10 percent of the true value) in the DOE interlaboratory performance test program.

The environmental samples for radiological analysis and some chemical measurements are collected by a member of the Environmental Protection Group's staff. These samples include on-site surface water, groundwater, soil, sediment, and vegetation (see Figure 3-15 and Sections 3.2.3, 3.3.3, and 3.4.3). At the time of the Survey, the sampling procedures were not available in an appropriate sampling protocol. However, preparation of a detailed sampling procedures manual is currently under way.

The Water Laboratory conducts some water and wastewater analyses and sampling; however, its activities have been limited since the use of the Village Oxidation Pond has been discontinued.

Samples for environmental analysis are collected at the Village Oxidation Pond, Ferry Creek, Kress Creek, Indian Creek, Casey's Pond, Fox River, E Sector of the Main Ring pond, the Central Utilities Building deionizer system, and 13 wells used for drinking water at Fermilab (see discussion in Section 3.3.3 for details). These samples are analyzed for pH, biochemical oxygen demand,

suspended solids, coliform, chlorine, total dissolved solids, hardness, alkalinity, chloride, fluoride, nitrite, nitrate, sulfate, arsenic, cadmium, chromium, mercury, selenium, silver, barium, lead, zinc, copper, manganese, and cyanide. The Water Laboratory analyzes some samples only for pH, coliform, suspended solids, biochemical oxygen demand, and dissolved oxygen. The sampling and analytical methods used are described in Standard Methods for the Examination of Water and Wastewater (APHA, 1985) and in the Yellow Springs Instrument Company's instruction manual for dissolved oxygen (YSI, 1983). The laboratory does not have a separate manual containing only the specific methods used by the laboratory analyst. However, the references mentioned above are kept in the laboratory and are readily available to the analyst.

The Water Laboratory has a quality assurance plan in effect that includes the use of chain-of-custody forms, sample tags, log books, calibration and maintenance of instruments and equipment, as well as the analysis of split samples with a regulatory agency and the contract laboratory. The laboratory supervisor also coordinates the quality assurance activities.

Both analytical laboratories are relatively small and there is no evidence that the data obtained has been compromised by the supervisors performing the functions of the quality assurance coordinator. However, it should be noted that it is accepted laboratory practice to have the quality assurance activities coordinated by a person operating outside the laboratory line management structure.

4.4.1.2 Contract Laboratories

Fermilab uses off-site analytical laboratories for most of the environmental analyses required by regulatory agencies. The laboratories currently under contract include IT Corporation (Oak Ridge, Tennessee) for radiological measurements, Aqualabs, Inc. (Bartlett, Illinois) for organic and inorganic chemical analyses, and Natlsco Environmental Sciences Laboratory (Long Grove, Illinois) for asbestos. Generally, Fermilab monitors the contract laboratories through the use of QA/QC samples such as blanks, duplicates, and spikes. The contract laboratory conducting the radiological measurements is also required to participate in the DOE/EML Sample Exchange Program. Although there were some problems with one of the contract laboratories in the past, the current vendor laboratories are performing well. Based on a review of the information available concerning the qualifications of the current contract laboratories (e.g., quality assurance program, results of quality control samples, performance evaluation test results, and laboratory certifications), the Survey team found no reason to believe that the contract laboratories were not providing reliable analytical services.

4.4.2 Findings and Observations

4.4.2.1 Category I

None

4.4.2.2 Category II

None

4.4.2.3 Category III

None

4.4.2.4 Category IV

1. Deficiencies in the Analytical Laboratories. Some deficiencies in the implementation of proper analytical quality control procedures were noted. The specific laboratory problems and potential consequences are presented below:

   - The Nuclear Counting Laboratory does not keep a manual containing the analytical procedures at the laboratory. Thus, in the absence of the regular analyst, a new or temporary analyst would have difficulty in conducting the analyses, thereby increasing the potential for error.

   - The analysts at the Nuclear Counting Laboratory and the Water Laboratory do not sign or initial the laboratory notebooks at the conclusion of each day's analyses. Therefore, if a significant question arises concerning the results reported, it would be difficult to establish full defensibility for the data. A complete quality control program requires the authentication of the results in the form of the analyst's signature or initials.

   - The calculations made as part of the analysis are not checked by a second person at either laboratory. Thus, any calculation errors made by the analysts will not be corrected and this can result in less reliable data.

   - The instrument used for dissolved oxygen measurements at the Water Laboratory is not calibrated by a colorimetric procedure such as the modified Winkler method. According

to the procedure published by the American Society for Testing and Materials, more reliable results are obtained by calibrating the dissolved oxygen instrument against a second procedure.

- Some of the analytical reagents in the Nuclear Counting Laboratory and the Water Laboratory were not dated when received. This practice may result in the use of inferior reagents which will reflect on the results obtained.

4.5 Inactive Waste Sites and Releases

4.5.1 General Description of Pollution Sources and Controls

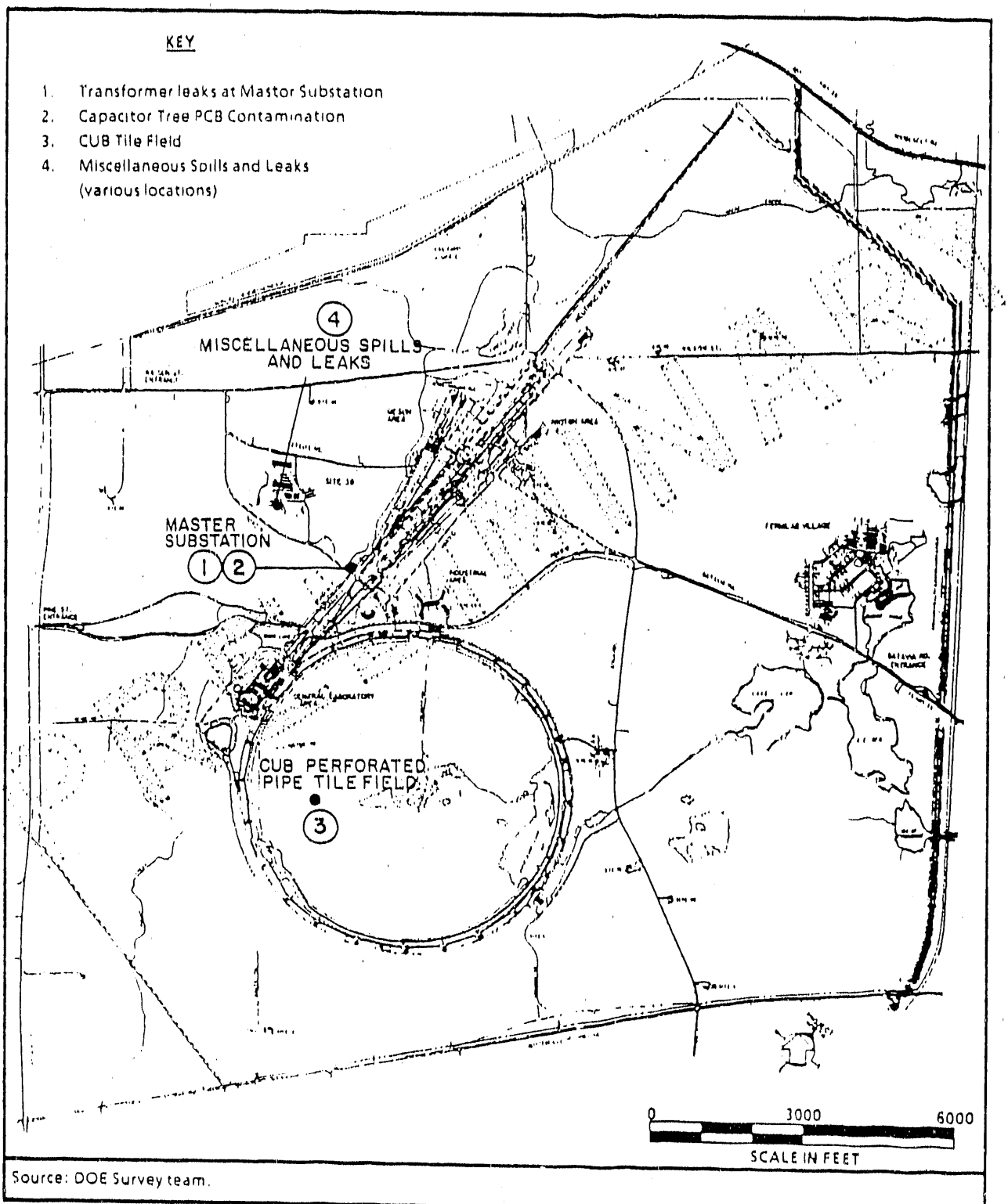
The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established (1) notification requirements, (2) liability standards, and (3) response authority for dealing with releases of hazardous substances to the environment. Also known as "Superfund," CERCLA's scope is expansive. The EPA and state agencies can undertake or order study or cleanup when there is a release or the substantial threat of a release of a hazardous substance to the environment.

Superfund was substantially expanded by the Superfund Amendments and Reauthorization Act (SARA) of 1986. In addition to significantly increasing the size of the fund to finance cleanups, SARA creates a response authority for petroleum underground storage tank releases (technically an amendment to RCRA), and mandates community right-to-know and emergency preparedness programs (Title III). SARA also obligates Federal facilities to comply with the same regulations and policies as other entities. Hence, except for certain limited national security waivers, Federal facility cleanup plans for sites on the National Priorities List must undergo EPA review and concurrence.

This section introduces the actual and potential sources of hazardous substance releases to the environment at Fermilab. The Findings and Observations, Section 4.5.2, provides more detail on these sources.

Fermilab was constructed from 1969 to 1971, and began operation in 1972. Fermilab appears to have relatively few environmental problems from past incidents of uncontrolled releases of hazardous substances, compared to many other DOE facilities, because it has operated during a period of increasing environmental regulation and awareness. In addition, Fermilab is primarily a research laboratory producing relatively small volumes of chemical wastes. Fermilab did not submit to EPA a CERCLA Section 103(c) notification pursuant to the April 1981 regulations [see Finding 4.5.2.4(1)], or a Phase I installation assessment report to DOE pursuant to DOE Order 5480.14.

The six sites listed and summarized briefly below are the sites initially identified by Fermilab and the Survey team as potential sources of soil, groundwater, or surface water contamination at Fermilab due to past releases of hazardous substances. Of these potential sources, the first four (illustrated in Figure 4-7) are known to be actual areas of contamination and are discussed in detail in Findings 4.5.2.3(1), (2), (3), and (4), respectively. The latter two potential sources do not appear to



Source: DOE Survey team.

FIGURE 4-7

LOCATION OF CERCLA SITES
FERMILAB - BATAVIA, IL

present a risk to human health or the environment and are presented here for information purposes, but are not listed in Section 4.5.2 as Findings.

- Master Substation Transformer Leaks. Miscellaneous spills during filling, sampling, and flushing, as well as a massive failure of Transformer Number 82A, which resulted in the release of approximately 22,700 liters (6,000 gallons) of mineral oil (PCB concentration 1.3 ppm).

- Capacitor Tree PCB Contamination. Miscellaneous leakage and spills occurred during operation (1971-1986) and decommissioning (1987). Mineral oil containing high concentrations (60,000 ppm) of PCBs spilled on the capacitor "tree" structure, manhole, soil, and asphalt from several of the 734 capacitors on the capacitor "tree." The PCBs were low-chlorination species (Aroclor-1216 primarily Monochlorobiphenyl) and, hence, are relatively less persistent than other highly chlorinated PCBs.

- Main Ring/CUB Perforated Pipe Field. Chromate-based corrosion inhibitor, Be-7, and salt were discharged to a tile field within the Main Ring.

- Miscellaneous Spills. Numerous small spills of hazardous substances at Fermilab present actual or potential sources of soil and groundwater contamination. Because of their persistence in the environment, PCB spills and leaks from transformers present the most widespread problem. Site 38 is the location of the most frequent non-PCB hazardous substance spills and leaks.

- Meson Hill. Asbestos (Transite) and demolition debris (lumber, concrete, and pipes) were disposed of in a hill area north of the experimental areas for shielding of radioactivity.

- Boneyard. Located at the railhead on the northern border of Fermilab, the boneyard is used for storage of radioactive waste. Prior to 1981, drums of hazardous waste were stored there, but there is no evidence of spillage or leaks.

4.5.2 Findings and Observations

4.5.2.1 Category I

None

4.5.2.2 Category II

None

4.5.2.3 Category III

1. Master Substation Transformer Leaks. Transformer oil (1.3 ppm PCB) that leaked from transformer 82A and the other transformers in the master substation may be a source of groundwater contamination and soil contamination.

Oil constituents as well as low levels of PCBs, and possibly phosphate ester and chlorinated hydrocarbons, may contaminate Fermilab's on-site drinking water and process water supply wells. Too little information is presently available on the quantity and disposition of the oil and the groundwater regime to assess the impact to Fermilab's wells and the underlying aquifer.

In January 1985 a failure of transformer T82A at the Master substation, directly along "project north" (Northeast) from the Wilson Hall high-rise building (see Figure 4-7) caused a release of as much as 24,200 liters (6,398 gallons) of transformer oil from cracks in the transformer shell (Coulson, 1985). The amount of oil lost may be as little as 12,500 liters (3,300 gallons), assuming a 3,800-liter (1,000-gallon) error by the weighmaster for the recovered oil tankers, and a residual in the T82A shell of 760 liters (200 gallons).

The location and disposition of this lost oil is not known. A preliminary investigation by Fermilab personnel and the Survey team indicated that most of the mineral oil is probably in the vadose zone under the gravel bedding of the master substation. Fermilab personnel excavated three test trenches in the gravel of the substation but found only a very thin oil film floating on the water in one of the test pits. Because of this absence of oil in the gravel immediately beneath the substation, the oil has either percolated down below the gravel bedding into the soil below, or flowed via appurtenances (pipes, conduit bedding, etc.) away from the substation.

There are two appurtenances adjacent to the master substation T82A pad, according to Fermilab construction blueprints. First, immediately outside the fence east of the master substation is a manhole-tunnel access to the F2 sump of the neutrino beamline. The bedding of this beam access tunnel is drained into a sump at the end of this tunnel. This sump is fitted with a simple float-actuated pump which pumps the accumulated water up to the surface and

out into a nearby drainage ditch on the south side of the master substation. Fermilab Accelerator Division personnel observed oil in this drainage ditch and traced it back to the F2 access tunnel sump in June 1986. The Accelerator Division personnel reset the float level on the automatic pump to ensure that the oil was not pumped out to the drainage ditch, and then hand-pumped approximately 56 to 76 liters (15 to 20 gallons) of oil from the surface of the sump to carboys lowered and hauled up through the manhole. This hand-pumping operation has continued for the past year and a half prior to September, 1987. Every opportunity for access to the sump provided by a shutdown of the beamline (approximately 30 times, between June 1986 and September 1987), Accelerator Division personnel regularly enter the manhole and skim oil off of the surface of the water in the sump.

As shown in Table 4-15 and Figure 4-8, this regular collection operation has yielded approximately 280 liters (75 gallons) of oil. Figure 4-8 only shows 220 liters (58 gallons) because of uncertainty in the accuracy of the initial 56 to 76 liters (15 to 20 gallons) collected. This collection of oil from the sump has probably prevented any oil from being pumped into the surface water drainage ditch. The Survey team observed green vegetation and a range of invertebrate life in the ditches and creeks draining southward from the Master Substation into which the F5 sump is pumped. By contrast, the Survey team observed several inches of dead and discolored vegetation bordering the water along the drainage ditch flowing north, upstream of a small inverted dam constructed to prevent off-site surface water releases of oil. The cause of this dead vegetation is probably not the T82A oil release, but rather accumulated, small, runoff discharges from the substation.

The apparent route of the oil in reaching the F2 sump suggests that oil from the substation (probably from the T82A release) migrated to the soil below the gravel bedding of the substation. The total vertical distance from the T82A transformer pad to the gravel F2 access tunnel underdrain is approximately 6 meters (20 feet) [the elevation of T82A is 228.2 meters (748.75 feet] above sea level [ASL], while the F2 underdrain is located at 222.2 meters [729 feet] ASL). The horizontal distance from the eastern edge of the pad to the F2 underdrain is approximately 8 meters (25 feet). If the oil is assumed to have percolated downward in a cylindrical pattern with the center at the eastern edge of the pad and the outside edge at the F2 underdrain, then the volume of this minimum cylinder zone beneath the transformer is 1,112 cubic meters (39,270 cubic feet). If a pore space of 0.20 (20 percent) is assumed, then 222 cubic meters (7,854 cubic feet) of pore space is available in this cylindrical zone for liquid infiltration, which is equivalent to 222,400 liters (58,748 gallons). Hence, approximately 10 percent of the available pore space in this area may be occupied by the missing 23,000 liters (6,000 gallons) of mineral oil from T82A. This estimate indicates that the

TABLE 4-15

MINERAL OIL COLLECTED FROM F2 SUMP (GALLONS)
FERMILAB - BATAVIA, ILLINOIS

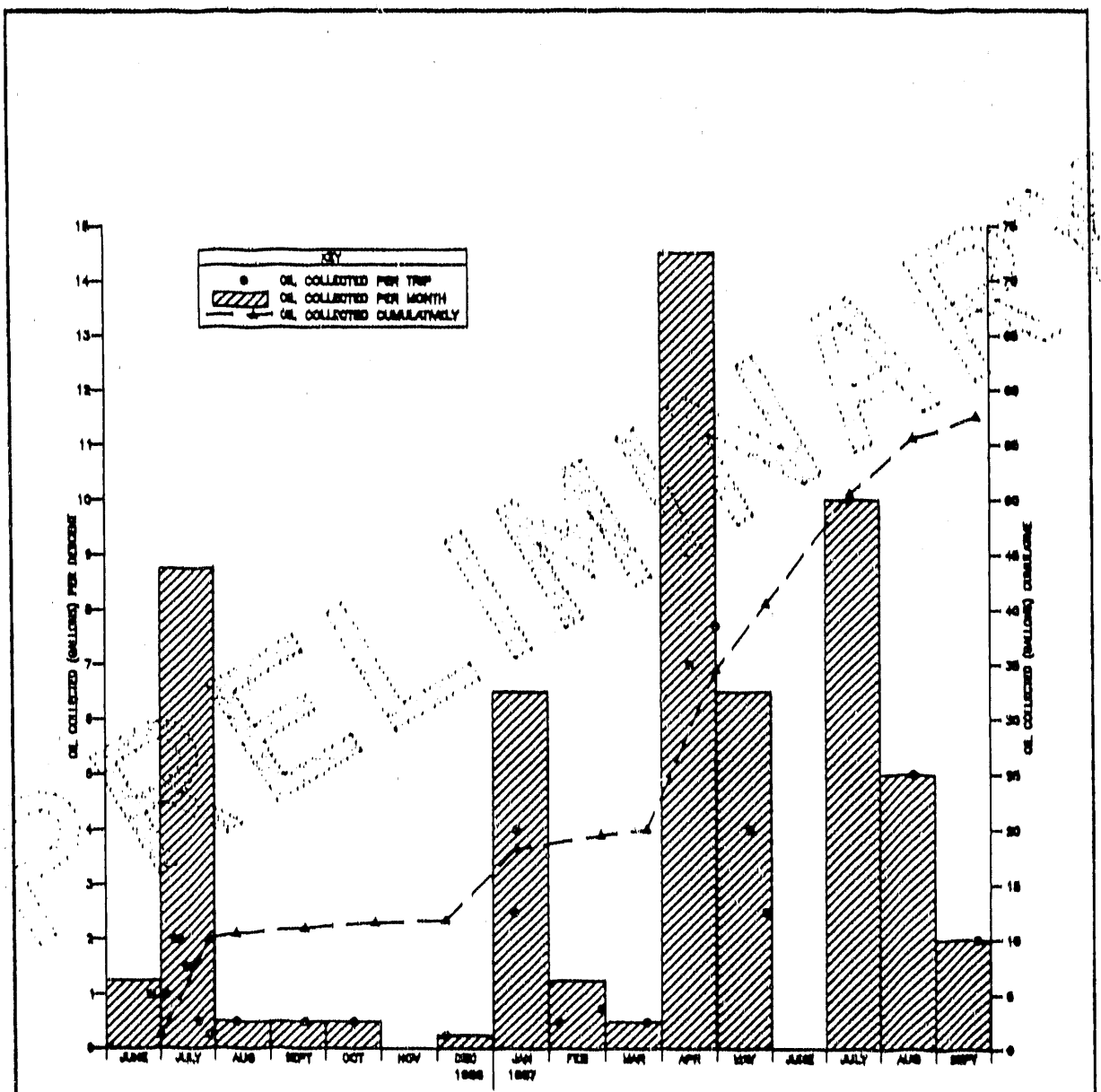
Date	Per Day	Per Month	Cumulatively
06/11/86	15-20		
06/25/86	1		
06/30/86	0.25	1.25	1.25[a]
07/03/86	1		
07/08/86	2		
07/11/86	2		
07/15/86	1.5		
07/18/86	1.5		
07/22/86	0.5		
07/28/86	0.25	8.75	10
08/12/86	0.5	0.5	10.5
09/19/86	0.5	0.5	11
10/16/86	0.5		
10/28/86	-	0.5	11.5
12/05/86	0.25	0.25	11.75
01/12/87	2.5		
01/13/87	4	6.5	18.25
02/05/87	0.5		
02/26/87	0.75	1.25	19.5
03/23/87	0.5	0.5	20
04/16/87	7		
04/30/87	7.5	14.5	34.5

TABLE 4-15
MINERAL OIL COLLECTED FROM F2 SUMP (GALLONS)
FERMILAB - BATAVIA, ILLINOIS
PAGE TWO

Date	Per Day	Per Month	Cumulatively
05/19/87	4	-	-
05/28/87	2.5	6.5	41
07/14/87	10	10	51
08/19/87	5	5	56
09/23/87	2	2	58
TOTAL			73-78

Source: Beddingfield, 1987b.

(a) Approximately 15-20 gallons were collected prior to June 25, 1986, but accurate estimates were not made until after the initial one time collection on June 11.



SOURCE: DOE Survey team

FIGURE 4-8

MINERAL OIL COLLECTED FROM F2 SUMP
FERMILAB - BATAVIA, IL

soil beneath the substation is a potential and likely location for the missing oil. It is likely that the oil has flowed further, both horizontally and vertically, than the F2 underdrain. The presence of oil in the F2 sump indicates that it has flowed at least this far.

The second appurtenance adjacent to the master substation is the capacitor tree located to the south. During the Survey, Fermilab personnel and a Survey team member reviewed available blueprints of the capacitor tree and master substation. This review revealed the presence of conduits leading from T82A to a vault beneath the capacitor tree. This vault is a concrete cylinder with an internal diameter of 3.7 meters (12 feet), accessible by a manhole from the surface Based on this observation, Fermilab personnel and a Survey team member opened the manhole and probed the standing liquid inside with a dipstick and found that there was mineral oil floating on the water. Fermilab personnel later measured the oil layer with a Coliwasa and found that it was 4.5 cm (1-3/4 inches) thick. Assuming a surface area of 10.7 square meters (116 square feet), there was 473 liters (122 gallons) of oil in the vault. If some oil is assumed to remain in the gravel bedding or conduit connected to the vault, then a maximum of 760 liters (200 gallons) could be contained in the capacitor tree vault and connections.

The route of migration for the oil to the capacitor tree vault is not clear, but it appears to have traveled through the conduit. Essentially, the oil could have flowed through the 5-cm (2-inch)-diameter steel conduit, or the gravel bedding around the concrete encasing the conduit. Detailed blueprints of the capacitor tree vault indicated that the vault is sealed except for the steel fittings for the conduits to feed cables from the transformer. Hence, it appeared unlikely that the oil could have flowed through the bedding and into the vault, although cracks in the vault could have allowed oil to seep in. The fact that the vault contained several feet of water suggested that there are cracks in the vault. The blueprints also showed that the steel conduit exits the ground through the pad under T82A. There are 16 separate conduit lines arising from two sides of T82A pad. Another field visit revealed that the conduit lines rose approximately 4 inches from the concrete pad, except for one line, which was cut off only 5 cm (2 inches) above the pad. Survey team interviews with Fermilab personnel who participated in the emergency response to contain the T82A leak revealed that during the night of sandbagging the perimeter of the pad and pumping the oil, the depth of oil on the pad exceeded 5 cm (2 inches). The exits of the conduit from the pad are not normally visible because they are covered by a heavy sheet-metal shroud that is screwed into place. The bottom of this shroud is not watertight against the pad, however, and could have easily allowed oil to flow under it and into the low-tipped conduit. Hence, the oil apparently flowed down this conduit and into the capacitor tree vault, when Fermilab personnel

sandbagged the perimeter of the T82A pad to contain the oil from the leaking transformer. In doing so they contained most of the oil that had spilled from the transformer within the dike and thereby prevented it from flowing into the surrounding gravel pad, but inadvertently caused a maximum of 760 liters (200 gallons) to flow into the capacitor tree vault.

In summary, approximately 22,700 liters (6 000 gallons) of mineral oil were unaccounted for from the failure of T82A. A maximum of 760 liters (200 gallons) are in the capacitor tree vault and connected conduit, and 285 liters (75 gallons) have been recovered from the F2 sump via the underdrain system around the access tunnel. The balance of approximately 21,650 liters (5,720 gallons) of mineral oil is probably located in the soil pore space below the master substation gravel. The threat to groundwater is probably small because of the low PCB concentration (1.5 ppm) and the lipophilicity (low water solubility) of mineral oil and PCBs. The exact nature and extent of contamination remains to be determined. The lack of further characterization of the nature and extent of contamination, including vadose zone monitoring (see Section 3.4.2.3) could result in groundwater contamination, if any, going undetected [see Finding 3.4.4.3.1(c)].

2. Capacitor Tree PCB Contamination. Leaks and spills from PCB-containing capacitors in the "capacitor tree" near the Master Substation have contaminated the "cap" tree, the gravel and asphalt under the tree, nearby soil, and a manhole cover. Contaminated soil could runoff to surface water. Fermilab has initiated a cleanup of the cap tree and surrounding area. The type of PCBs in the capacitors was revealed in a "fingerprinting" analysis to be Aroclor-1216, the lowest percentage (16 percent) chlorination of the class of different PCB products that were commercially sold. This type of Aroclor (predominantly mono-chlorobiphenyl) is less persistent in the environment than other types of PCBs.

Three different types of leaks and spills have caused the contamination on and around the capacitor tree. First, chronic leakage occurred from capacitors in the tree. The number of leaking capacitors in the tree prior to the 1987 cleanup was probably fewer than 16 of the 734 capacitors in the tree. (Each capacitor weighed 44.4 kg [98 pounds] and contained an average of 14.8 liters [3.92 gallons] of PCB oil.) Fermilab personnel counted 16 "suspected leakers" in the tree during the 1987 cleanup. Some of these showed evidence of stains near seams, but no evidence of dripping from the capacitor. In only one case (capacitor No. A68U&L) was there evidence of oil dripping to the ground.

Another source of PCB contamination from the capacitor tree is at least one specific incident of capacitors failing and leaking. In April 1980, four capacitors short-circuited and leaked onto

the asphalt and gravel urider the cap tree. The four leaking capacitors were removed the next day and disposed of. The asphalt was cleaned by soaking up the oil with "oil-dry" and sweeping, followed by scrubbing with detergent water. PCB contamination of the asphalt determined by wipe samples showed 60,200 mg/kg PCBs. Following the soaking and scrubbing described above, another wipe sample was taken. Before the results of the analysis were returned, however, the asphalt area was repaved. The results of these post-cleanup wipe samples revealed 190 ppm PCBs on the asphalt before paving. There is no information available on the quantity of PCB oil that leaked, or the quantity cleaned up.

Finally, several small spills occurred during the 1987 cleanup due to handling mishaps. The total amount spilled during these incidents was probably less than the contents of a single capacitor (14.8 liters or 3.92 gallons). In one incident, PCB oil spurted from the severed top of a capacitor when pressure was applied during banding of a group of capacitors on a pallet. Oil from this capacitor contaminated adjacent capacitors on the pallet. Another spill occurred during the 1987 cleanup when the wheel of a fork lift struck a manhole, causing a capacitor to tumble off the pallet and crack against the manhole cover. Some soil has been removed (as of September 1987), and the area has been covered with clear polyethylene and opaque herculite anchored by 10 cm by 15 cm (4 inch by 6 inch) timbers. Analysis and subsequent cleanup of this spill is ongoing.

On September 17, 1987, approximately one-third of the removed capacitors were transported off-site by Chemical Waste Management to their pyrolysis plant in Model City, New York.

3. Main Ring/CUB Perforated Pipe Field. Discharges of CrO_3 from 1974 to 1976 to the old Central Utilities Building (CUB) perforated pipe tile fields ("Main Ring Waste Disposal Area") may be a source of groundwater contamination, soil contamination, and sediment contamination. Discharges to the tile field were contaminated with a chromate-based corrosion inhibitor, Be-7, and salt. The primary contaminant of concern is the chromate because of its persistence and solubility. The relatively short half-life of Be-7 (53.28 days) and low concentrations and small volumes of the salt suggest that these contaminants are not significant concerns. The amount of CrO_3 discharged was approximately 2,300 kg (5,000 pounds). Chromium (VI) could migrate undetected to the aquifer and contaminate the drinking water and process water source wells on-site. Because of the lack of groundwater monitoring in perched lenses in the vadose zone, contamination will not be detected until it reaches the groundwater approximately 23 meters (75 feet) below the surface at concentrations high enough to be detected in the high-volume wells that are being monitored (see Finding 3.4.4.3.1[a]). Because of the distance to off-site wells, and the relatively low quantity of waste, it is unlikely

that off-site wells will be threatened, however, there is no comprehensive groundwater information to support or refute this inference.

From 1974 to December 1, 1976, chromate corrosion inhibitors (primarily Nalco 7371) were used in the CUB cooling water. The amount of chromate discharged to the perforated pipe field can be estimated by using purchasing records for the product used during that period, or by extrapolating from cooling water blowdown data. The estimation using purchase records is summarized in Table 4-16.

According to information provided by Nalco and reported by Fermilab personnel, approximately 2,720 kg (6,000 pounds) of Nalco 7371 were shipped to Fermilab in 1975 and approximately 1,360 kg (3,000 pounds) in 1976. During 1974, a similar concentration of chromates was maintained in the system by mixing zinc and chromates on-site. According to the Nalco Material Safety Data Sheet for 7371, this product contains approximately 35 percent chromate. Assuming that all of the chromates were used and ultimately discharged, and that 1974 usage was an average of the usage recorded for 1975 and 1976, then approximately 2,140 kg (4,725 pounds) of chromate was discharged to the perforated pipe field. This estimate may serve as a reasonable upper-bound estimate.

A similar total discharge amount can be obtained by multiplying the blowdown discharge rate times the chromate concentration. The data sources and calculations for this estimate are given in Table 4-17. Assuming a blowdown rate of 95 lpm (25 gpm) and a chromate concentration of 15 mg/liter, then approximately 2,240 kg (4,937 pounds) of chromate was discharged to the CUB perforated pipe tile field from 1974 to 1976.

The old Main Ring waste disposal area was located in roughly the same location as the existing CUB tile field, south of Holter Road and west of Feldott Road. The Illinois Pollution Control Board standard for chromium VI is 0.3 mg/l at the discharge point and 0.05 mg/l ambient for general use. In 1975, surface water samples taken by Fermilab where effluent upwelling from CUB was ponding revealed 22 mg/l chromium. In 1976, the average concentration of similar samples was 9.4 mg/l. In 1982, soil borings of the CUB tile field area up to 1.5 meters (5 feet) deep revealed very low ($\leq$ 0.55 mg/kg) concentrations of hexavalent chromium. Because of the high solubility of chromium, the chromate discharged in 1974-1976 has probably migrated downward below the reach of the 1.5-meter (5-foot) borings.

TABLE 4-16

CHROMATE USAGE ESTIMATE BASED ON PURCHASE RECORDS
FERMILAB - BATAVIA, ILLINOIS

Year	NALCO 7371 Usage (Pounds)[a]
1975	6,000
1976	3,000
TOTAL	9,000
9,000 pounds x 0.35 CrO_4[b] = 3,150 pounds CrO_4 used during 1975 and 1976	
+ 1,575 pounds[c] CrO_4 used during 1974	
TOTAL CHROMATE USED = 4,725 pounds	

Source: Bowron, 1987; Nalco, 1987.

(a) Bowron, D. (Fermilab). Personal Communication with Jim Werner (DOE Survey Team), September 1987.
(b) Nalco, 1987.
(c) Assumed to be 1/2 of the amount used for 1975 and 1976 combined.

TABLE 4-17

CHROMATE USAGE ESTIMATE BASED ON BLOWDOWN RATE AND CONCENTRATION FERMILAB - BATAVIA, ILLINOIS

25 gpm[a] x 1,440 minutes/day = 36,000 gallons/day
x 365.25 days/year = 13,149,000 gallons/year
x 3.785 l/gal = 49.7 x 10^6 liters/year
x 15 mg/l[b] = 746.5 x 10^6 mg/year
÷ 1,000 mg/g = 746,534 grams/year
÷ 28.35 g/oz = 26,332 ounces/year
÷ 16 oz/lb = 1,645.7 pounds/year
x 3 years = 4,937 pounds

Source: Bowron, 1987; Baker, 1977.

(a) Bowron, D. (Fermilab) Personal Communication with Jim Werner (DOE Survey Team) September 1987.

(b) Baker, S. I. Fermilab Environmental Monitoring Report for Calendar Year 1976.

4. Miscellaneous Spills. There are numerous locations at Fermilab where leaks and spills of hazardous substances have not been adequately characterized or cleaned up. Historical leaks and spills of hazardous substances at Fermilab are primarily a potential soil contamination problem, and probably do not pose a significant groundwater contamination threat. The lack of precise historical or analytical information on the location, nature, and extent of this contamination may result in inadvertent exhumation of the contaminated soil, possibly resulting in a direct contact hazard and inappropriate disposal.

The current system of identifying and responding to releases of hazardous substances appears adequate, but past incidents may not have been handled well. For example, a recent (January 1983) spill of 0.95 liters (1 quart) of oil onto Main Ring pond was detected and cleaned up within hours of the release (Allen, 1983). Although this individual incident is inadequate to demonstrate a foolproof system of release detection and response, a review of the Fermilab files by the Survey team encompassing the period from 1980 to 1987 (files prior to 1980 were not available) indicates that Fermilab has policed spills and leaks in recent years, using Environmental Protection Officers in each Division/Section, with the Safety Section providing technical assistance. The Safety Section was organized in 1978 as a Staff-level department to provide assistance and oversight to Line departments.

The one shortcoming of the recent spill response program is the apparent lack of consistent followup sampling to confirm that cleanup has been effective. In some cases, contaminated soil and asphalt has been removed until background levels of contamination are found. In other cases, visual evidence of discoloration seems to have been used and no post-cleanup sampling and analyses were performed. The exception to this inconsistency is the recent cleanup of PCB spills and leaks (see Sections 4.5.2.1 and 4.5.2.2). Because of the institutional and regulatory distinction, historical spills and leaks of hazardous substances at Fermilab may be divided into two categories: (1) PCB and (2) non-PCB.

There are approximately 65 locations around the Main Ring at Fermilab where PCB contamination may have occurred. This contamination may have resulted largely from spills and leaks of transformers and other equipment containing PCBs prior to the promulgation of regulations controlling PCBs in July 1979. Currently, there are 63 transformers containing PCB-contaminated oil at Fermilab (see Section 4.2.3.1). Fermilab personnel believe that PCB contaminants may be present at almost all 65 locations. In addition, PCB contamination may have also occurred at a location between a service building and a Main Ring road where a transformer oil transfer truck was parked. A complete assessment of the transformer locations has not yet been completed.

There is no information available on whether PCB-contaminated equipment was used or stored at locations other than these 65 sites currently in use. PCB contamination may have occurred at locations where non-contaminated equipment is now in service but where PCB or PCB-contaminated equipment was previously located.

For example, approximately 284 liters (75 gallons) of non-PCB oil was spilled from transformer D2-3 on June 15, 1987 (Beddingfield, 1987c). When the soil and the concrete pad near the spill were sampled and wipe-tested, however, PCB contamination was found This finding suggests that PCB contamination exists not only where PCB-contaminated equipment was previously used or stored, but also where the equipment was subsequently replaced with non-PCB equipment. The existing PCB contamination was probably caused by previous spills of transformer oil. At transformer D2-3 a 60-cm by 86-cm (24-inch by 34-inch)-deep hole was excavated to try to clean up the contaminated soil (Beddingfield, 1987d) It is not clear whether the spill was cleaned up to meet the April 2, 1987, (40 CFR 761) PCB Cleanup Policy.

Fermilab personnel have identified known PCB leaks and spills in addition to larger projects such as the capacitor tree and master substation. For example, on May 5, 1987, transformer F1-1, containing 34,000 ppm PCBs, was found to be "damp" around the drain valve (Beddingfield, 1987e) After repeated attempts to clean up the contaminated soil and concrete pad a 60-cm by 86-cm (24-inch by 34-inch)-deep hole was excavated to remove contaminated soil), the area was covered with plywood and plastic until a large-scale plan could be developed and implemented to deal with such leaks According to Fermilab personnel, "There is a possibility of greater than 65 contaminated sites around the ring," and "a program should be developed and implemented as soon as possible ." (Beddingfield, 1987d).

Spills and leaks of non-PCB hazardous substances at Fermilab appear to have been focused at Site 38 maintenance and paint shops, but little documentation was available on these releases at other sites. Fermilab files document numerous incidents of hazardous substances releases between 1980 and 1987. More than half of these incidents occurred at Site 38 even though there were other areas at Fermilab that generated more hazardous waste than Site 38. For example, 2,950 liters (780 gallons) of hazardous waste per year were generated at Site 55 compared to the 2,165 liters (572 gallons) of waste generated at Site 38 (see Table 4-1). It should be noted that these are relatively small volumes of waste. If this pattern of spills and leaks also occurred during previous years from 1969 to 1980, then residual soil contamination is probably present at Site 38. Individually, each spill or leak was relatively small, but the

combined impact of these incidents may be environmentally significant. The following nine summary descriptions of spills at Site 38 illustrate the scale of the contamination.

- April 1980: Hydrochloric acid drum punctured. Soda ash neutralized acid, rainfall aided dilution. (Fermilab, 1980a).

- December 1980: Ten drums containing unknowns removed from along fence. Two contain PCBs. One leaking (Fermilab, 1980b).

- March 1981: 190 drums found at Site 38.
  - 86 drums "totally or almost empty"
  - 34 drums "red and probably contain oil or oil and water"
  - 66 drums "blue and probably contain ethylene glycol or ethylene glycol and water"
  - 3 drums contain unknowns (Allen, 1981).

- March 1983: 20 drums of unidentified liquid. "At least 3 of the drums were leaking" (Allen, 1983a).

- March 1983: 45 drums of material picked up; may include the above mentioned 20 drums of unidentified liquid.
  - 18 drums scintillator oil and water (from spill cleanup in 1981)
  - 10 drums transformer oil
  - 17 drums unknowns (Allen, 1983b).

- April 1983: "Paint thinner and possibly other solvents dumped or spilled on the gravel hardstand at the solvent storage area." Sampling revealed Napthol Spirits, Stoddard Solvent 66/3 was in the liquids. Twenty drums of contaminated soil and gravel were exhumed and disposed as a hazardous waste, but no post-cleanup analysis was available (Baker, 1983a).

- October 1984: Freon 113 spill at Site 38 (Coulson, 1984).

- March 1985: Two drums (one labeled "Naptha," the other labeled "Flammable") found to have leaked "several gallons." Stained soil in same area was noted to have been found in June 1983. No other documentation of the June 1983 leak was available (Allen, 1985).

- May 1987: Oil stain on gravel behind "High Usage Parts Building" at Site 38 (Allen, 1987b).

These spills and leak incidents reflect only a partial listing of the activity at one location (Site 38) where releases occurred most frequently. Failure to investigate fully the locations of past leaks and spills of hazardous substances could result in inadvertent exhumation of contaminated soil and potential direct contact. Because of the relatively short period of operation of the facility and the small volume of hazardous substance generation at Fermilab (see Table 4-1), most of the past releases are probably relatively small. Aside from the three areas described above, Site 38 may be the only site where past spills and leaks of hazardous substances will require more detailed physical study and remedial action may be warranted based on a thorough file review.

4.5.2.4 Category IV

1. Lack of a CERCLA 103(c) Notification. Fermilab has not submitted to EPA a compliant CERCLA Section 103(c) notification pursuant to the April 1981 regulations.

A compliant CERCLA notification would include information on all of the Phase I sites, as well as the Solid Waste Management Units (SWMUs) listed in the Part B permit application. These facilities are not covered by the limited exceptions and exclusion to the CERCLA notification requirement. The purpose of this CERCLA notification requirement is to provide information on potential environmental and health problems associated with facilities that treated, stored, or disposed of hazardous substances. Inclusion in this notification does not constitute an implicit judgment that a problem exists but rather that the potential for a problem exists. The notification is the first step in a process that sorts out which sites pose a threat and determines the relative degree of that threat.

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APPENDIX A

SURVEY PARTICIPANTS

APPENDIX A

SURVEY PARTICIPANTS

Larry Weiner	DOE Headquarters	DOE Team Leader
Susan Barisas	DOE Headquarters	DOE Assistant Team Leader
Timothy Joseph	DOE, CH	CH Survey Representative
Ronald Kolzow	DOE, CH	CH Survey Representative
Joseph Crist	NUS Corporation	Air
Joseph Boros	NUS Corporation	Surface Water
Douglas Detman	NUS Corporation	Groundwater/Soil
Ralph Basinski	NUS Corporation	Waste Management
S. Charles Caruso	NUS Corporation	Toxic and Chemical Materials/ Quality Assurance
Mark Francis*	NUS Corporation	Radiation/Health and Safety
James Werner	ICF Corporation	Inactive Waste Sites and Releases/ Health and Safety

* NUS Coordinator
CH-Chicago Operations Office

APPENDIX B

SITE-SPECIFIC SURVEY ACTIVITIES

APPENDIX B
SITE-SPECIFIC SURVEY ACTIVITIES

B.1 Pre-Survey Preparation

The U.S. Department of Energy (DOE) Office of Environmental Audit, Assistant Secretary for Environment, Safety and Health, selected a Survey team for the Fermi National Accelerator Laboratory (Fermilab) in June 1987. Mr. Lawrence A. Weiner was designated the DOE Team Leader, with Ms. Susan Barisas serving as the Assistant Team Leader. Mr. Timothy Joseph and Ronald Kolzow were the Chicago Operations Office (CH) Survey Team representatives during the on-site phase of the Survey. The remainder of the team was composed of contractor specialists from the NUS Corporation and its subcontractor, ICF. These specialists and their fields of expertise are presented below.

Speciality	Name
Air	Joseph Crist
Surface Water	Joseph Boros
Waste Management	Ralph Basinski
Inactive Waste Sites	James Werner
Hydrogeology	Douglas Detman
Radiation	Mark Francis*
QA/Toxics	Charles Caruso

* NUS Coordinator

Survey team members began reviewing Fermilab general environmental documents and reports in August 1987.

Mr. Weiner, Ms. Barisas, and Messrs. Francis, Basinski, Boros, and Werner conducted a pre-Survey site visit on June 29-30, 1987, to become familiar with key DOE and Fermilab personnel. They toured the facility and completed a cursory review of the documents assembled in response to an information request submitted on May 21, 1987. The request listed environmental documents and reports required by the Survey team for survey planning purposes. Messrs. Maury Walsh and William Piispanen, Battelle Columbus Division (BCD), also attended the pre-Survey site visit to gather

information related to potential Survey sampling. During the pre-Survey visit, a meeting was held with representatives of the DOE Batavia Area Office, CH, and Fermilab, as well as officials of the City of Warrenville and the Illinois State Water Survey. The purpose of this meeting was to review environmental issues of concern to the agency and local government and explain the scope of the Survey.

The Survey team reviewed the information received during the pre-Survey visit and prepared a Survey Plan (see Appendix C) for the Fermilab Site. This plan described the specific approach to the Survey for each of the technical disciplines and included a proposed schedule for the on-site activities. A Health and Safety Plan was also prepared for use by the Survey team.

B.2 On-Site Activities

The on-site phase of the Survey was conducted during the period of September 14-25, 1987. The opening meeting was held on September 14, 1987, at Fermilab and was attended by representatives from DOE headquarters, CH, Fermilab, NUS Corporation, and ICF Corporation. Discussions during this meeting primarily concerned the purpose of the Survey, logistics at Fermilab, and an introduction of the key personnel involved in the Survey.

During the Survey, team members reviewed pertinent file documents including permits and applications, background studies, engineering drawings, accident reports, chemical releases, and spills, as well as various operating logbooks. The accelerator research and associated processes were carefully analyzed to identify existing and potential pollutants. Site operations and monitoring procedures were observed, where possible. Extensive interviews were held with Fermilab personnel concerning environmental controls, operations, monitoring and analysis, regulatory permits,and waste management.

The Survey team members met daily to report observations, discuss findings, and evaluate progress. These meetings were also useful for planning schedule changes, if required, to meet the overall objectives of the Survey.

A site close-out briefing was held on September 25, 1987, at which the DOE assistant team leader presented the Survey team's preliminary findings and observations. The findings were considered preliminary pending additional research and review.

B.3 Sampling and Analysis

Based on the on-site Fermilab Survey, no Survey-related sampling needs were identified.

B.4 Report Preparation

The Environmental Survey Preliminary Report for the Fermilab site will be prepared for DOE review. The preliminary findings are subject to modification based on comments from the Chicago Operations Office concerning the technical accuracy of the findings. The modified findings will be incorporated into the Environmental Survey Summary Report.

APPENDIX C

SURVEY PLAN

ENVIRONMENTAL SURVEY PLAN

FOR THE U.S. DEPARTMENT OF ENERGY

FERMI NATIONAL ACCELERATOR LABORATORY

SEPTEMBER 14-25, 1987

BATAVIA, ILLINOIS

SEPTEMBER 1987

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ENVIRONMENTAL SURVEY PLAN

FERMI NATIONAL ACCELERATOR LABORATORY

SEPTEMBER 14 - 25, 1987

BATAVIA, ILLINOIS

1.0 INTRODUCTION

The Fermi National Accelerator Laboratory (Fermilab) Survey is part of the larger Department of Energy (DOE)-wide Environmental Survey effort announced by Secretary John S. Herrington on September 18, 1985. The purpose of this effort is to identify, via "no fault" baseline Surveys, existing environmental problems and areas of environmental risk at DOE facilities, and to rank them on a DOE-wide basis. This ranking will enable DOE to more effectively establish priorities for addressing environmental problems and allocate the resources necessary to correct these problems. Because the Survey is "no fault" and is not an "audit," it is not designed to identify specific isolated incidents of noncompliance, or to analyze environmental management practices. Such incidents and/or management practices will, however, be used in the Survey as a means of identifying existing and potential environmental problems.

The Fermilab Survey will be conducted in accordance with the protocols and procedures contained in the May 16, 1986, draft Environmental Survey Manual.

2.0 SURVEY IMPLEMENTATION

The Environmental Survey of Fermilab will be managed by t e Team Leader, Larry Weiner and the Assistant Team Leader, Susan Barisas from the Office of Environmental Audit (OEV). Mr. Timothy Joseph will erve as the Chicago Operations Office (CHO) representative on the Enviror ental Survey team. Technical support is provided by NUS Corporation and ICF ersonnel as follows:

Joseph Crist	Air/TSCA (Toxic Materials)
Doug Detman	Soil/Hydrogeology
Joseph Boros	Surface Water/Drinking Wate
Ralph Basinski	RCRA (Solid, Hazardous, an Radioactive Wastes)
Charles Caruso	QA/TSCA
Mark Francis	NUS Coordinator/Radiation
James Werner (ICF)	CERCLA (Inactive Sites)

2.1 Pre-Survey Activities

Pre-Survey activities began early in May, 1987, when urvey team members submitted requests for information to the Team Leade for materials they needed. This was followed by a May 21, 1987, memora lum from Lawrence A. Weiner (OEV) to Roger Mayes (CHO) and Fermilab (via CHO) announcing the pre-Survey site visit and requesting additional Survey-relat d information.

The pre-Survey site visit, June 29-30, 1987, was conduct d by Mr. Weiner, Ms. Barisas, and Messrs. Francis, Basinski, Boros, and Werne . The purpose of the visit was to become familiar with the site, identif potential areas of concern for purposes of the Survey, collect the document requested in the May 21 memorandum, and coordinate plans for the upcoming Survey with CHO and Fermilab personnel. Messrs. Maury Walsh and William Piispanen, Battelle, Columbus Division (BCD) who will manage the sampling an analysis portion of the Survey also attended the pre-Survey site visit. D ring this pre-Survey visit, the team met with representatives of the Batavia rea Office (BAO), CHO and Fermilab, and officials of the City of Warrenville d the Illinois State Water Survey. Team representatives toured the facili y and collected the documents assembled by site personnel in response to th information request memorandum. These documents were transferred to NUS ittsburgh offices in July for use by team members during the planning tage of the Survey. Additional information was requested during the pre-Surv y site visit and has been received. This Survey plan is based upon the infor ition received by the Survey team as of September 1, 1987.

2.2 On-Site Activities and Survey Reports

The on-site portion of the Environmental Survey wil be conducted from September 14, 1987 through September 25, 1987. Tentativ agendas for each of

the Survey team members are provided as attachments. It is expected that modifications to these agendas will be made as appropriate to minimize disruption of site activities, and to enhance Survey efficiency and effectiveness. All modifications to agendas will be coordinated with site personnel designated as Survey contacts.

The on-site activities of the Survey team will consist of discussions with, among others, environmental, safety, operations, waste management, purchasing, and warehousing personnel; a review of files and documents (including classified documents, if any) unavailable prior to the on-site portion of the Survey; and process-specific and area-specific tours of the facility.

The Preliminary Report for the Fermilab Survey will be prepared from information gathered by Survey team members prior to, during, and after on-site activities. Each team member in addition to identifying environmental problems and areas of environmental risk will also be gathering information from which they will write the following sections of the Preliminary Report:

- o Background Environmental Information
- o General Description of Pollution Sources and Controls
- o Environmental Monitoring Program

A closeout briefing will be conducted on Friday, September 25, to describe the preliminary findings of the Survey team. A copy of the closeout notes will be left with CHO and Fermilab. A Preliminary Report of the Fermilab Survey will be prepared within 2 to 3 months from the conclusion of the Survey. The Preliminary Report will be sent to CHO and FermiTab for review and comment.

Approximately 3 months after the results are available from the sampling and analyses (S&A) portion of the Survey (discussed below) an Interim Report will be prepared by the Survey team. The Interim Report will incorporate comments to the Preliminary Report and the data from the S&A results. The Interim Report will be made available to the public, upon request.

Upon completion of the Environmental Survey effort a Summary Report will be prepared and will contain a DOE-wide list of environmental problems. The report will be used as an information base for the ranking of DOE's environmental problems.

2.3 Sampling and Analysis

Based on available site environmental information and the results of the on-site Survey activities, the Fermilab Survey team will identify Survey-related sampling needs. Implementation of the S&A phase of the Fermilab Survey will begin approximately 6 months after the completion of the on-site Survey activities. This effort is expected to have a 2-4 week duration and will be conducted by BCD. Mr. Maury Walsh will be the BCD Team Leader for the S&A phase of the Fermilab Survey. The BCD sampling team will draft a sampling plan based upon the sampling needs identified by the Survey team. The Assistant Team Leader (Ms. Barisas) will coordinate the review of this sampling plan with CHO, Fermilab and EPA's Environmental Monitoring Systems Laboratory (EMSL) in Las Vegas. EMSL has quality assurance and data validation responsibility for the S&A phase of the Environmental Survey.

Analysis of Survey-related samples will be performed by BCD following the protocols specified in the May 16, 1986, draft Environmental Survey Manual and the Fermilab Sampling Plan. Results of the sampling and analysis will be transmitted to the Survey team leader for incorporation into the interim report.

3.0 AIR

3.1 Issue Identification

The air-related Survey activities will involve an assessment of the air emissions at the site, the administrative and emission controls applied to the sources, and the ambient air monitoring systems. The emphasis of the Survey will be on operational and procedural practices associated with the emission sources and the emission control equipment, fugitive emission sources, both within and outside the buildings, and mitigative procedures applied to fugitive emission sources. Close liaison will be maintained with the radiation team member because of the importance of air-rad issues. Close liaison will also be maintained with the QA/TSCA team member because of the interaction of several TSCA regulations and air regulations. Facility visits will be coordinated through the Fermilab Safety Section.

The general approach to the Survey will include a review of existing air permits, pending applications, and standard operating procedures. Processes and control equipment will be inspected for compliance with DOE ALARA requirements for radionuclide emissions. The Survey will also review the nonradiological air contaminants from the different buildings at the site, evaluate any existing controls applied to the air emissions, and assess the need for additional monitoring or emission controls to characterize or reduce the environmental consequences of the emissions.

The ambient air monitoring system will be evaluated to assess the adequacy of the existing monitoring program to characterize environmental impacts of the air emissions from the facility. The activities involved in this part of the Survey will include the inspection of the ambient air quality samplers, a review of documentation applicable to the ambient air data acquisition, and an evaluation of the processing procedures used to assure the accuracy of the data.

Areas of particular interest will include emissions of the criteria pollutants (e.g., sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide and lead) as well as regulated hazardous air pollutants (e.g., radioactive-bearing particulates, beryllium, and asbestos). Although not currently listed as hazardous air pollutants, chlorinated solvents, and freons will be included in this review.

In addition, the use of organic solvents will be assessed as a potential or actual source of emissions to determine if they are adequately characterized, monitored, and controlled. The organic emissions assessment will focus on those substances that the EPA intends to list as hazardous or toxic air pollutants (e.g., methylene chloride, trichloroethylene, perchloroethylene).

Fugitive emissions from the resuspension of contaminated soils will be evaluated as a potential means of the airborne release of radionuclides and hazardous materials from the facility. Consideration will be given to historical and current operations to determine the potential for soil contamination and windborne releases.

Several areas of specific interest have been identified during a review of available documentation:

- Control and record keeping for solvent usage, e.g., in vapor

degreasers and parts cleaners.

- o Control and monitoring of beryllium, radionuclides, and freon emissions.
- o Emission potential of fugitive dust sources such as roads.
- o Potential for asbestos emissions during building decontamination or demolition.
- o Effluent sampling and monitoring operations.

Throughout the survey, emphasis will be placed on assessing the available data to characterize the overall environmental impact of plant operations.

3.2 Records Required

Files will be reviewed as part of the Survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the Survey include, but will not be limited to, the following:

- o PSD ledger
- o Air effluent sampling and QA procedures
- o Ambient air sampling and QA procedures
- o Contractor stack test results
- o Effluent beryllium sampling results
- o Laboratory records on TSP analyses (ambient)
- o Any other documents pertinent to air emissions from Fermilab buildings

4.0 HYDROGEOLOGY AND SOILS

4.1 Issue Identification

The hydrogeology/soils portion of the Survey will center on evaluating the physical and chemical characterics of groundwater and soils, and the actual or potential impacts that Fermilab activities have on these two media.

Each potential source of groundwater/soil contamination will be visited. Many of these visits will be coordinated with the RCRA, CERCLA, and Surface Water team members. Areas of the site to be visited include:

- Spent targets and scrap storage at the "Boneyard".
- Radioactive materials storage area at the "Fitzgerald barn".
- Laboratory areas at the village.
- Soils and sumps at target, beam dumps, and the main ring.
- Clay tile field and Booster Pond.
- Surface water run-of collection system ponds and lakes.
- Master substation and ditch where PCBs were spilled from a transformer failure in 1985.
- Swan Lake received effluent from photography laboratory solutions, and potentially received cooling tower water treatment chemicals.
- Hazardous materials storage area.
- Pesticide storage area.
- Gasoline dispensing system.

Evaluations conducted at the site will include field visits to monitoring well locations for the purpose of observing well construction, security, purging and sampling equipment, equipment decontamination, purging and sampling methods, sample collection, packaging, preservation, and chain-of-custody documentation. Soil and sediment sampling areas will be visited to observe locations, equipment, methods, packaging, chain-of-custody, and decontamination. A reconnaissance of potential off-site generators and receptors will be performed in accessible areas. Discussions with personnel responsible for sample collection and monitoring plan formulation will be held on an on-going basis during field visits and on-site document review.

Information relative to the site geology and surficial soils, groundwater regime, and environmental monitoring programs and data will be reviewed and evaluated prior to, during, and after the site Survey visit as part of the assessment.

4.2 Records Required

Files will be reviewed as part of the Survey including documents not yet reviewed or received. Specific documents and files to be reviewed as part of the site Survey visit include, but will not be limited, to:

- Sampling procedures and analytical protocols.
- Chemical and analytical data for groundwater, soil, and sediments.
- Additional geologic and/or hydrologic investigations including unpublished work.
- Groundwater and soil monitoring program plan.
- As-built structural and mechanical drawings of the sumps and

subsurface drainage systems associated with targets and beam dump areas.

- o As-built structural and mechanical drawings of the radioactive and hazardous material storage facilities on site. This includes such facilities as the gasoline dispensing system, and equipment maintenance areas where solvents, cleaners, degreasers, and other petroleum products may be stored and/or handled.
- o Design drawings or concepts for future structures to store radiological or chemical hazardous wastes on either temporary or long term basis (prior to final disposition at a permitted facility).

5.0 SURFACE WATER/DRINKING WATER

5.1 Issue Identification

The focus of the surface water/drinking water portion of the survey will be on the possible release of polluted or contaminated wastewaters to surface waters, the Batavia or Warrenville sanitary sewer systems, or groundwater aquifers underlying Fermilab. Potential pathways for off-site migration of pollutants include:

- o Spills or leaks into permeable soil areas.
- o Releases to the sanitary sewers or to storm drains without retention, chemical or radiological analysis, or treatment.
- o Inadvertant loss of coolants to the surface waters.
- o Disposal of solvents, pesticides, or other hazardous and toxic materials to active septic tanks.

A review of available information indicates that considerable attention has been paid to control of radiological releases and elimination of toxic metal pollutants. However, less documentation exists on the fate of trace levels of toxic organics in wastewaters. The survey will assess the potential for organic contamination of wastewaters, as well as review present conditions of wastewater control, collection and disposal. In the past, Fermilab operated its own wastewater treatment system to treat domestic and laboratory wastes from the Village Area. Although this facility was permanently shut down in December 1986, the oxidation pond is still being operated and its effluent monitored. This operation will be reviewed, together with an inspection of the connections which diverted wastes from this area to the City of Warrenville sewage collection system. Records of past operations and current monitoring records for the existing system will be examined.

The survey will include identification of potential discharges to surface waters, or the local sanitary authorities, which may not be addressed in operating permits or other documents from Fermilab. The Survey will also address the possibility of cross-contamination of the potable water piping system by either the sanitary of industrial water systems. Measures taken at Fermilab to prevent back-flow of process wastewater or sanitary sewer flows into the drinking water piping systems will be reviewed, along with Fermilab's self-monitoring reports (required under primary drinking water regulations). Copies of standard operating procedures (SOPs), operating logbooks, and maintenance records will be reviewed with respect to wastewater monitoring and control systems. Fermilab field practices will be observed to determine how closely SOP's are being followed. Interviews with managers and operators of monitoring equipment and wastewater control systems will be conducted in order to understand modifications or significant deviations, if any, from written SOP's.

A walk-through of selected buildings will be made to observe normal routines, including maintenance activities which generate wastewaters. Various discharge and monitoring points will be reviewed, and actual sampling and analytical procedures will be observed. Spillways and dams associated with surface water releases from Casey's Pond to Kress Creek; from Lakes Logo and Law to Ferry Creek; and from Swan Lake and West Pond to Indian Creek will be inspected. Operation of the Main Ring Ponding System and its Reservoir will be reviewed. Site surface drainage characteristics, such as culverts, ditches, tile fields and diversion channels will also be examined. The impact

of changes resulting from ongoing construction activities will also be evaluated.

Selected buildings and areas to be visited include, but are not necessarily limited to, the following:

Wilson Hall	Photolabs; catacombs
Central Utilities Building	Ion exchange water conditioners
Experimental Areas	Closed cooling solution loops; sumps; retention pits; septic tanks
Village Area	Printed circuit boardmaking; pool; Labs 2 and 8; former sewage treatment plant; monitoring station; well #62
Antiproton Area	Closed cooling solution loop
Sites 29,50,52,55,56, 57,DO and NTSB	Septic Tanks

5.2 Records Required

Files will be reviewed as part of the survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the survey include, but will not be limited to, the following:

- Recent analytical data on wastewater releases to the local POTWS.
- Notices of violations relating to wastewater releases.
- Standard operating procedures for wastewater collection, holding and disposal.
- Sampling protocols and logbooks.
- Wastewater lab tracking reports.
- Monitoring equipment maintenance records.
- Detailed drawings of the domestic water supply, storage and distribution system.
- Records of drinking water quality.
- SPCC plan, or its equivalent.
- Internal memos or correspondence relating to surface water/drinking water problems, e.g., back-flow prevention measures.
- Memos and correspondence relating to minimizing infiltration of rainwater/groundwater into sanitary sewers during wet seasons, and exfiltration of sanitary wastewaters into soil or groundwater during dry seasons. Include data on comparison of flow monitoring with precipitation readings, if such data exists.
- Any information on water quality/sludge characteristics for the Fermilab oxidation basin.
- Other records as determined on-site.

6.0 SOLID/HAZARDOUS/RADIOACTIVE WASTE

6.1 Issue Identification

The solid/hazardous/radioactive waste Survey will be carried out by reviewing and evaluating all activities generating solid wastes, and the treatment, storage, recycling and disposal practices involved in the handling of solid wastes including handling of wastes by commercial off-site facilities.

Management of all solid waste streams including mixed wastes, hazardous wastes, radioactive wastes and non-hazardous wastes will be reviewed. The review will generally consist of several activities. 1) Physical facilities where wastes are generated, accumulated, stored, treated, recycled or disposed will be inspected; 2) Personnel involved in these activities will be interviewed; 3) Files will be reviewed. Based on these activities the potential for releases that may contaminate the environment will be evaluated.

Wastes generated by Fermilab differ significantly from wastes produced by DOE production facilities. Production facilities generate a small variety of wastes in consistent volumes because of the long-term consistency in industrial processes. Research facilities such as Fermilab conduct experiments which are diverse and change over time. These experiments and support facilities result in the generation of a large variety of wastes, but usually in small quantities. Fermilab considers a large quantity chemical waste to be any waste in excess of five gallons. Experimental facilities such as Fermilab also have many points at which wastes may be generated. Thus, Fermilab can be characterized as a typical DOE laboratory facility where a large number of sources generate a wide variety of wastes, usually in small volumes and generally containing toxic, radioactive and/or hazardous constituents.

Consequently, increased emphasis will be placed on reviewing general waste management procedures, and reviewing compliance with Fermilab procedures and DOE, Illinois, and federal waste regulations.

Initial emphasis will be placed on Fermilab facilities which generate significant quantities of hazardous and radioactive waste, and waste treatment, storage and disposal facilities.

Radioactive waste generating and handling processes which will be evaluated include:

- Industrial Facility - Waste Generation and Recycling
- Meson Hill - Solid Waste Disposal
- Central Laboratory Facilities - Waste Generation
- Boneyard - Rad Waste Storage and Processing
- Site 67 - Rad Waste Processing and Storage
- Central Utility Building
- Site 55 - Haz. Waste Storage
- Site 68 - Rad Waste Storage

Radioactive accelerator components and equipment contaminated by beam losses from normal operations constitute the main sources of radioactive waste. These waste materials, often weighing in excess of 10,000 kg, contain radiation levels too high for immediate shipment are stored in the Boneyard and Site 67 and Site 68. Smaller quantities of compactible solids and liquids

are treated by methods including evaporation, solidification, compaction, and crushing, at Site 67 and the Boneyard.

Hazardous wastes and radioactive PCB capacitors are processed and stored at a hazardous waste storage facility at Site 55. Freons are recycled at a unit in the Industrial Area.

Solid wastes that do not contain radioactive, hazardous or putresible components, such as earthen materials, construction debris, and wood are dumped at Meson Hill to serve as shielding material.

These waste management activities as well as significant waste generating sources including the Central Laboratory Area, Industrial Area, Central Utility Building and Garages will be evaluated for compliance with applicable regulations and adherence to good management practices.

Waste handling practices that will be reviewed include the following:

- Waste minimization and recycling.
- Waste characterization, segregation and manifesting.
- Treatment and decontamination.
- Waste accumulation, packaging, and storage procedures
- Waste management practices, including training, inventory control, record keeping, inspection protocols, and contingency planning.

Operations and practices will be compared with existing descriptions and written procedures. Information gathered on waste generation points and waste streams will be used to find any sources of waste not previously identified or properly characterized, which may have potential to affect the environment.

Discussions will be held with those individuals knowledgeable of waste management practices in order to develop an understanding of past and existing waste management practices.

The review of solid/hazardous/radioactive waste practices will be coordinated with the CERCLA and Hydrogeologic Surveys to identify past and present releases that may pose a threat to the environment; the radiological Survey to define problems with wastes containing radioactive constituents; and the Surface Water/Drinking Water Survey because water and wastewater treatment produces solid waste.

6.2 Records Required

Files will be reviewed as part of the Survey, including documents not yet reviewed or received (e.g., individual files and documents not yet identified). Specific documents and files to be reviewed as part of the Survey include, but will not be limited to, the following:

- Part A & B Applications.
- Underground tank storage notification & associated records.
- Inspection records (state, local and federal).
- Groundwater monitoring, sampling, and analytical documentation.
- Release notification and Unusual Occurence Reports.
- Biannual Hazardous Waste Generation Report.
- Radioactive Waste Shipping Records.
- Waste inventory documentation.

- Enforcement action documents.
- Internal facility inspection documentation.
- Correspondence with regulatory agencies on solid waste.
- Records dealing with the reuse/recycling of wastes.
- Training records.
- Rad Waste Managment Program.
- Site Waste Management Plan.

7.0 TSCA (TOXIC/HAZARDOUS SUBSTANCES)

7.1 Issue Identification

The toxic substances Survey will consider new materials and process-related chemicals used at Fermilab as well as the usage, handling, storage and disposal of polychlorinated biphenyls (PCBs), asbestos, pesticides (including herbicides and biocides) and any other hazardous substances. The condition and environmental monitoring of underground storage tanks used for storage of materials, other than wastes, will also be inspected. The tracking control and management of toxic/hazardous substances will be evaluated through discussions with the appropriate Fermilab personnel and tours of selected plant facilities. This information along with records of usage will be evaluated to determine the potential for environmental contamination.

The Survey will address inventory control of PCB-containing and PCB-contaminated electrical equipment, hydraulic systems and heat transfer equipment. The condition of plant equipment containing PCBs and the potential for environmental contamination will also be evaluated. For example, inspections will be made of the Askarel filled transformers (Village Barn, Sites 1-B-1, MSS-1, CG-1, CU-1, CU-2 and NL-10), the PCB contaminated transformers (Labs 5, 6 and 7; Giese Road site; sites BW-2, E-1, ML-3A, ML-4A, ML-13, and PL-3), the PCBs stored in the Hazardous Materials Storage Area, the PCBs under asphalt at the Capacitor Tree, and the many oil-filled transformers with greater than 500 ppm PCBs around the main accelerator ring. Any obsolete, stored or used PCB equipment will be inspected for condition, proper containment, and protection. Plant storage records for PCBs will be reviewed and disposal practices for non-radioactive PCB materials will also be addressed.

Fermilab projects involving the demolition/disposal of asbestos and asbestos-containing materials will be reviewed to identify pathways of contamination. Asbestos removal and disposal practices will be evaluated, and asbestos disposal areas will be visited. For example, the potential decommissioning problem areas containing asbestos such as the walls of Lab A, in the Meson Shielding Hill, and the ceiling of Wonder Building will be inspected.

Pesticide purchase, usage, and application records as well as the applicator training program will be reviewed. The pesticide storage areas (e.g., site 3) and disposal practices will be examined to assess the risk for environmental contamination.

The management, inventory, and control of chlorofluorocarbons ("freons") will be examined. Other toxic and hazardous materials purchase and usage records will be reviewed. Areas where these materials are stored and used will be visited and handling procedures will be evaluated. For example, inspections will be made of the Warehouse at site 38 (contains bases and nitric acid), the Gas Shed at site 38 (contains bottled gas and hydrochloric acid) and the Beryllium Storage Shed at Lab 8.

Interviews will be held with those individuals knowledgeable of toxic/hazardous substances practices. This will be accomplished during facility tours, and discussions with individuals involved in the handling of toxic materials. The objective is to develop an understanding of current and past practices. Discussions will be held with personnel from at least the following groups:

- The Safety Section
  - Environment and Safety Group
  - Hazardous Waste Storage Facility
  - Chemistry Lab
  - Hazardous Chemical/Material
  - Environmental Protection Officers

- Business Services Section
  - Roads and Grounds Group (pesticide supervisor)

7.2 Records Required

As part of the survey, files will be reviewed including documents not previously received or reviewed (e.g., classified documents, individual files, documents not previously identified). Specific documents and files to be reviewed as part of the Survey include, but will not be limited to, the following:

- Toxic/hazardous substances inventory and chemical purchase records.
- Toxic substances labeling and tracking system overview.
- Procedures for purchasing, handling, storing, using and disposing of toxic substances.
- PCB transformer/capacitor inspection records (1981-present).
- Storage and inspection records for PCB contaminated equipment (1981-present) including radioactively contaminated and non-radioactive items.
- Disposal records for non-radioactively contaminated PCB items (1981-present).
- Procedures for storage, handling, and disposal of PCB fluids.
- Correspondence with Fermilab Fire Department regarding PCB electrical equipment, especially any records of fires involving PCB equipment.
- Locations of all Fermilab Plant buildings and areas containing asbestos.
- Procedures for asbestos removal, handling, and disposal as well as environmental monitoring information.
- Records of asbestos use in plant equipment and support facilities.
- Identification of active and inactive asbestos disposal areas at Fermilab.
- Pesticide/herbicide training, handling, storage, and disposal records and standard operating procedures.
- Pesticide annual reports (1981-1985).
- Special procedures involving handling, storage, use and disposal of chlorofluoroalkanes (e.g., freons) and any chloroorganic solvents.
- Inventory and environmental monitoring reports and procedures for underground storage tanks (1981-present).
- Other records as determined on-site.

8.0 RADIATION

8.1 Issue Identification

Radiological issues to be addressed during the environmental Survey will center around the air, soil, surface water, and groundwater media. Each of the above mentioned media will be evaluated for radiation concerns by collecting background information and data (including ambient data), identifying existing and decommissioned radiation pollution sources and associated controls, and finally by reviewing environmental monitoring programs designed to gather data on identified pollution sources.

The Survey will also evaluate rad-waste management practices, direct radiation exposure issues, dose assessment methodologies, and radiochemistry quality assurance programs for environmental monitoring data. Review of rad-waste programs including management practices for low-level, transuranic, rad-hazardous (mixed), and adherence to Fermilab procedures will be a major focus of the radiation portion of the Survey. A more detailed discussion of this subject is provided in section 6.0 of the work plan. The radiological evaluations will be closely coordinated with the other specialists on the Survey team.

Because radiation issues cut across all media evaluated during the Survey, the attached daily agenda has been organized in an attempt to overlap the other specialists' activities when they are evaluating radiation issues. Some inefficiencies are to be expected as a result of this dual coverage approach, however, every effort has been made to minimize duplication. To improve the effectiveness of radiation evaluations, Mr. Francis will rely heavily on the expertise and assistance of various Fermilab personnel for accomplishing Survey objectives and pointing out where work plan inefficiencies exist. Discussions with operating and supervisory personnel will also be utilized to provide needed information critical for complete evaluation. Reports, records, and other data associated with continuous, intermittent and any accidental or unscheduled releases should be readily accessible for review.

8.2 Records Required

Files will be reviewed as part of the Survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the Survey include, but will not be limited to, the following:

- Radiation-related ambient air quality information.
- Background radiation data for soil, surface water, and groundwater.
- Inventories of air, soil, surface water, and groundwater radionuclide release points and quantities.
- Vegetation radionuclide monitoring data.
- Unscheduled or accidental release reports.
- Radioanalytical quality assurance programs and procedures.
- Dose assessment methodologies, including assumptions, calculations, reporting, etc.
- Building plot plans with process and equipment locations.
- Description of radiation monitoring equipment practices and procedures (e.g., calibration, maintenance, etc.).

- Reports or recommendations for upgrading radiation monitoring systems.
- Reports prioritizing new radiation monitoring installations.
- Off-site and on-site radionuclide sampling point criteria.
- Rad-waste management practices, policies, procedures, and communication mechanisms.
- NESHAPS/DOE Subpart H 61.90-61.98 reports.
- Information regarding employee radiation exposure data.
- Historical rad-waste disposal activity logs and locations.
- State, County, and local radiation regulations.

9.0 QUALITY ASSURANCE

9.1 Issue Identification

The quality assurance phase of the Survey will consist mainly of an evaluation of the present sampling and analysis methodology utilized at Fermilab and any contract laboratories performing analyses on Fermilab's environmental samples. The objective will be to critically review the quality assurance methods for collecting environmental samples, for identifying and transporting samples to the lab, for the selection of the analytical methods and for performing the analyses for specific pollutants, as well as for evaluating and reporting the data. The purpose of the quality assurance evaluation will be to determine whether appropriate procedures are being utilized at Fermilab. Some features of the quality assurance programs relating to environmental management which will be evaluated consist of:

- the qualifications of the analysts and samplers;
- instrument and equipment calibration and maintenance;
- sample collection, sample handling, and chain-of-custody procedures;
- laboratory quality control results;
- data reduction and reporting; and
- documentation including logbook, review of calculations and data storage, as well as plans for corrective actions.

An overall survey of the Fermilab environmental monitoring quality assurance program will be conducted. All of the sampling and analytical procedures will be critically reviewed to determine whether they conform to the approved requirements and are being applied properly.

The principal contacts at Fermilab will be members of the sampling and environmental analytical staff. Discussions will be held with laboratory managers, analysts and samplers. The environmental laboratories and sampling sites will be visited to assess all of the quality assurance/quality control procedures required to produce valid analytical data. For example, the Water Laboratory at Fermilab will be visited as well as some of the many surface water sampling points on Fox Creek, Kress Creek, Indian Creek, Casey's Pond, the west branch of the Dupage River, Fox River, etc. In addition, some of the well sampling locations, and the pesticide and herbicide sampling points will be inspected.

9.2 Records Required

Part of the Survey will consist of a review of pertinent files. This will include documents not previously reviewed or received, such as classified documents (if any), individual files, and documents which have not been identified at this time. Some specific documents and files to be reviewed in this phase of the Survey include, but will not be limited to, the following:

- Quality assurance plans for Fermilab and all supporting analytical laboratories.
- Manuals for environmental sampling and analysis procedures used at Fermilab.
- QA audits of environmental sampling and analysis at Fermilab (1981-present).

- Annual or periodic QA summary reports for Fermilab.
- Summaries of results of QA sample analyses on external performance evaluation samples, e.g., those from the EPA and DOE's Environmental Measurements Laboratory.
- Training/education records for sample collection personnel and Fermi laboratory staff.
- Laboratory notebooks, standard data reporting forms and sampling logbooks.
- Maintenance, repair and calibration records for laboratory and field instruments.
- Results of internal precision and accuracy studies of environmental analyses.
- Results of any interlaboratory analyses of standard samples.

10.0 INACTIVE WASTE SITES/RELEASES (CERCLA)

10.1 Issue Identification

The Survey will attempt to identify environmental problems and potential risks associated with the historical handling, storage and disposal of hazardous substances at Fermilab. This aspect of the Survey will be coordinated with the RCRA and hydrogeology team members. The Survey will focus on current and future risks related to the following:

- o Past land disposal practices (or and off-site);
- o Past spills/releases from tanks, pipes, pits, trenches;
- o Potential for future spills/releases; and
- o On-going remedial action program

Facilities that have handled or are currently handling hazardous, mixed, and low-level radioactive substances at Fermilab will be evaluated.

The following areas identified in Fermilab documents will be evaluated:

1. Boneyard
2. Meson Hill
3. Site 55
4. Labs (e.g., B and D Bubble Chambers)

The status of activities undertaken pursuant to DOE Order 5480.14 will be assessed. Records of past off-site disposal from Fermilab will be reviewed.

Sites that have undergone or are undergoing remediation will be addressed. Records and analytical data in support of the site cleanup will be reviewed. Also, inactive tanks or containers that may have held hazardous substances will be identified and their status assessed. Former storage areas and staging locations will be included in this effort. The team will also want to review the environmental records pertaining to the past management, disposal (on-site and off-site), clean-up, and regulatory compliance.

Contacts for this portion of the Survey will include personnel from the Safety Section.

10.2 Records Required

Files will be reviewed as part of the Survey, including documents not yet reviewed or received (e.g., classified documents, individual files, documents not yet identified). Specific documents and files to be reviewed as part of the Survey include, but will not be limited to, the following:

- o Past waste management plans.
- o SOPs regarding management of hazardous substances, disposal area and storage areas.
- o Hazardous substances inventories.
- o Listing of areas used for hazardous substances storage, receiving and shipping, and disposal.
- o Historical files on past operations and processes, substances used, and methods of handling and disposal.

- Files on past off-site waste handling and disposal.
- Records of facility expansion and building rubble disposal.
- Descriptions and Notifications of inactive waste sites and potential areas of contamination.
- Description of all waste management facilities, including buried tanks and structures (existing and removed).
- Historical aerial and surface photographs of the facility.
- "Interview files" for the draft Phase I Installation Assessment report.
- Files pertaining to any radiometric surveys of the site grounds.
- Documents pertaining to past, current, and proposed remedial actions (e.g., Capacitor "tree") at Fermilab.
- Environmental records pertaining to past facility responses to hazardous substance spills and releases.

Discipline AIR/TSCA

Team Member J. Crist

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Records Review (e.g. Air Permits, Air Emissions Inventory, PCB Records)	-Inspection of HEPA Filters & Associated Controls -Inspection of Air Sampling Stations -Debonding Oven (w/M. Francis)	-Labyrinth Stack & Associated Controls -Boneyard Evaporators -Central Utility Plant (214)	-Minor Air Sources (e.g., degreasers & parts cleaners) -Machine Shops (including 109 & 924) -Garages (052, 060, 924, 928, 930, 968) w/R. Basinski	-PCB Inspection (all locations) including: -Capacitor Tree Site 3 -Bldg. WS2 -Askarel Filled Transformers -Oil Filled Transformers -Review Inspection Records -Inspect PCB Storage Areas (w/C. Caruso)
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Review of Asbestos Handling, Storage, Training, Disposal, etc. (w/C. Caruso) -Potential Decommissioning Areas including: -Wonder Building -Lab A -Meson Shielding Hill	-Review of Pesticide Program including: Use, Handling, Storage, Training, Disposal, etc. (w/C. Caruso) -Review of Ambient Air Monitoring Stations	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

Discipline HYDROGEOLOGY

Team Member D. DETMAN

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Observe Wells; location, surface, construction, depth, water level, and as-built records	-Observe sampling*, purging equipment & methods -Sampling equipment & methods -Observe* sample collection technique, packaging, preservation, chain-of-custody, and decontamination	-Observe soil*& sediment sampling; location, equipment, methods, packaging, chain-of-custody, & decontamination	-Continue Tuesday & Wednesday activities as needed. -Begin review of sampling documentation & evaluation of historical analytical data	-Review as-built records on subdrain collection system & wastewater disposal system
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Field: Visit potential source areas; haz. materials & storage facilities, operating areas w/ stored haz. products & areas where spills have occurred. Observe surface drainage & potential soil contamination pathways. Review w/ Jim Werner	-Field: Continue Monday's activities w/visits to activated soil areas & radiation source & activated materials storage areas. Review w/Mark Francis	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

* Observe if possible - will reschedule if necessary.

Discipline SURFACE WATER

Team Member J. BOROS

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Tour Photolabs in Wilson Hall -Review Operations at Central Utilities Bldg; Observe Booster Pond	-Tour Surface Water Features: Dams & Spillways; Release Points; Casey's Pond; Lake Logo, Main Ring Cooling Ponds & Reservoir; Lake Law; Swan Lake; West Pond; Industrial Cooling Water System; Kress and Indian Creeks	-Tour Village: PC Board-Making; Laboratories 2 & 8; Well #62; Swimming Pool; Abandoned Sewage Treatment Plant; Sewer Connection to Warrenville; Oxidation Pond; DUSAF Pond; A.E. Sea; Sea of Evanescence & Ferry Creek	-Tour Experimental Area Facilities -Review: Closed Loop Cooling Systems at Meson, Neutrino & Proton Areas; Sumps N-1,N-2,MF-4,MF-5, PW-8 and NM-2; Retention Pits at N-1 and NØIRP	-Tour Wells #1 & #3. Discuss Potable Water Systems & Backflow Prevention Program. -Tour Closed Loop Cooling System at Anti-Proton Area
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Tour Septic Tanks: Site 29; Site 50; Proton Pole Bldg.; Site 52; Site 55 (include tour of Haz. Waste Mgmt. Fac.); Site 56; Site 57; and Neutrino Testing Services Building	-Review all Water-Related Environmental Monitoring Records	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

Discipline SOLID WASTE

Team Member R. BASINSKI

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. [illegible]
-Orientation & Introductory Meetings, etc. -S-38 Warehouse Gas Shed -S-55 Haz. Waste Storage -TSB-624 Beryllium Storage	-Radioactive Material & Waste Storage Areas: -Boneyard -Railhead -Lundy Barn w/J. Werner -S-68 Clay Tile Field Ring & CUB	-Wilson Hall Labs & Waste Areas & Satellite Waste Storage Areas -S-67	-Industrial Area Bldgs. 1-4 -Labs 1,2,4,5 -Garages (052, 060, 924, 928, 930, 968) with J. Crist	
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-S-3 Hazardous Material & PCB Storage & Pesticide -Meson Hill w/J. Werner	-Shabbone Area -S&A Meetings -Revisits -Central Utility Bldg. (CUB)	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

Discipline QA/TSCA

Team Member S.C. CARUSO

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Begin QA/QC Program review of Environmental Analytical Labs including: -general requirements -organization -records required	-Review QA/QC of Environmental Labs. Evaluate organic & inorganic analytical labs including: -Policies -Manuals -Sample Tracking -Data Management -Maintenance & Calibration -Training -Spikes, Blanks, Splits, etc.	-QA/QC evaluation of Environmental Radiation Laboratories including: -Policies -Manuals -Sample Tracking -Data Management -Maintenance & Calibration -Training -Spikes, Blanks, Splits, etc.	-Review Environmental Sampling Procedures -Evaluate QA/QC procedures of off-site (contract) labs and FNAL's program to verify these labs are following procedures	-PCB inspections, all locations including: -Capacitor Tree Site 3 -Bldg. WS2 -Askarel filled transformers -Oil filled transformers -Review Inspection Records -Inspect PCB Storage Areas (w/Joe Crist)
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Review of Asbestos Program including: Use, Handling, Storage, Training, Disposal, etc. (w/Joe Crist) -Potential Decommissioning Areas including: -Wonder Building -Lab A -Meson Shielding Hill	-Review of Pesticide Program including: Use, Handling, Storage, Training, Disposal, etc. (w/ Joe Crist)	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

Discipline RADIATION

Team Member M. FRANCIS

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Review of Environmental Radiation Monitoring Programs (general) Air (RAD) Soil (RAD) Surface Water (RAD) Groundwater (RAD)	-Review of Air Radiation Sources ^{11}C Release Points ^{3}H Release Points -Debonding Oven -Inspection of HEPA Filters & Associated Controls (w/J. Crist)	-Review Environmental Radiation Laboratory Procedures (w/C. Caruso -Review of Water Radiation Sources (w/J. Boros)	-Experimental Areas Tour -Meson Area -Neutrino Area -Proton West Area -Proton East Area -Muon Hall -Meson Lab -Proton Lab -Visit 14 (Shabbone Sr-90 w/J. Werner)	-Review Direct Radiation Sources -Fixed Target Areas -Collider Area -Accelerators -Beam Lines -Review Radiation Detection Program
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Review Dose Assessment Activities including: -Methodology -Pathways -Maximally Exposed Individual -Fence-line Doses -Review Special Radiation Sites	-Visit Activated Soil Areas, Radiation Source & Activated Materials Storage Areas (w/ D. Detman) -Soil activation monitoring locations ^{54}Mn & ^{22}Na	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

Discipline CERCLA

Team Member J. WERNER

MONDAY, SEPT. 14	TUESDAY, SEPT. 15	WEDNESDAY, SEPT. 16	THURSDAY, SEPT. 17	FRIDAY, SEPT. 18
-Orientation & Introductory Meetings, etc. -Contact Archives for Purchase & Disposal Records	-Review Records -Visit Site 55 -Visit Labs: -B(15' bubble ch.) -D(30" bubble ch.) -Visit Boneyard, Lundy Barn, Railhead (w/R. Basinski)	-Review Records -Visit Industrial Area -Visit/Review Records Capacitor Tree Cleanup	-Visit CUB Tile Field -Review Records -Visit 14 (Shabbone Sr -90 Contam.) (w/M. Francis)	-Revisit -Visit Site 3 (Haz. Mat. Stor. Area, & Pesticide Storage) (w/J. Crist & C. Caruso)
MONDAY, SEPT. 21	**TUESDAY, SEPT. 22**	**WEDNESDAY, SEPT. 23**	**THURSDAY, SEPT. 24**	**FRIDAY, SEPT. 25**
-Records Review -Visit Meson Hill (w/R. Basinski) -Revisits	-Records Review -Revisits	-Writing and/or revisits day plus sampling & analysis review	-Writing day	-Survey Close-out with Fermilab personnel

APPENDIX D

CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS

APPENDIX D

CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AIRDOS	Estimation of radiation dose caused by airborne radionuclides in areas surrounding nuclear facilities
ALARA	As Low As Reasonably Achievable
APHA	American Public Health Association
AQCR	Air Quality Control Region
Avg.	Average
BOD_5	Biochemical Oxygen Demand (5-day)
°C	Degrees Celsius (or Centigrade)
C^{11}	Carbon, Mass Number 11
CASIM	Cascade Simulation Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CG	Concentration Guide
CH	High plasticity clay
CH_4	Methane
Ci	Curie(s)
CL	Low plasticity clay
cm	Centimeter(s)
CN	Cyanide
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CUB	Central Utilities Building
CY	Calendar Year
D-38	Uranium containing higher concentrations of ^{238}U than found in nature
DCA	DuPage County Airport
DCG	Derived Concentration Guide
DL	Discharge Limit
DOE	U. S. Department of Energy
DOT CL	U. S. Department of Transportation Classification

APPENDIX D
CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS
PAGE TWO

E	East
EDTA	Ethylenediamine tetra-acetic acid (or its salts)
e.g.	(exempli gratia) for example
EPA	Environmental Protection Agency
ESE	East-southeast
et al.	(et alii, alioe, or alia) and others
°F	Degrees Fahrenheit
FAA	Federal Aviation Administration
Fermilab	Fermi National Accelerator Laboratory
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	Fiscal Year
Gal	Gallon(s)
GLP	Good Laboratory Practice(s)
GMP	Good Management Practice(s)
gpd	Gallons Per Day
H-3	Tritium
ha	Hectare(s)
HEPA	High Efficiency Particulate Air
hr	Hour
H-T	Tritiated Hydrogen Gas
HTO	Tritiated Water
I	Interstate
ICRP	International Commission on Radiological Protection
i.e.	(id est) that is
IEPA	Illinois Environmental Protection Agency
Inc.	Incorporated
kg	Kilogram(s)
km	Kilometer(s)
l	Liter(s)

APPENDIX D
CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS
PAGE THREE

LSA	Low Specific Activity
m	Meter(s)
Max.	Maximum
µCi	Microcurie(s)
µCi/g	Microcurie(s) per gram
mCi	Millicurie(s)
ug	Microgram(s)
mg	Milligram(S)
ML	Low plasticity silt
ml	Milliliter(s)
mm	Millimeter(s)
mrem	Millirem(s)
mrem/yr	Millirem(s) per year (10^{-3} roentgen equivalent man/year)
MSDS	Material Safety Data Sheets
msl	Mean Sea Level
N	North
NA	Not analyzed
NBS	National Bureau of Standards
NCRP	National Council on Radiation Protection and Measurements
ND	None Detected
NE	Northeast
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NMHC	Non-Methane Hydrocarbons
NNE	North-northeast
NNW	North-northwest
NO	Nitric Oxide
No.	Number(s)
NO_2	Nitrogen Dioxide
NOS	Not Otherwise Specified
NO_X	Nitrogen Oxides

APPENDIX D
CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS
PAGE FOUR

NP	Non-plastic
NPDES	National Pollutant Discharge Elimination System
NRC	U. S. Nuclear Regulatory Commission
NRHC	Nonreactive Hydrocarbons
NW	Northwest
O_3	Ozone
OH	High plasticity organic silt
OL	Low plasticity organic silt
ORM-A	Other Regulated Material (e.g , irritant)
ORM-B	Other Regulated Material (e.g., corrosive)
ORM-C	Other Regulated Material (e.g., 49 CFR 177.101 Listing)
ORM-E	Other Regulated Material (e.g., hazardous wastes)
Pb	Lead
PCB	Polychlorinated biphenyl
pCi	Picocurie(s)
Pcs	Pieces
pH	Negative logarithm of the hydrogen ion concentration
PM_{10}	Particulate matter 10 microns or less in diameter
ppb	Parts Per Billion
ppm	Parts Per Million
PT	peat
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RCW	Recirculating Cooling Water
s	Second(s)
S	South
S&A	Sampling and Analysis

APPENDIX D
CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS
PAGE FIVE

SARA	Superfund Amendments and Reauthorization Act of 1986
SC	Clayey sand
SDM	Standard Deviation of the Mean
SE	Southeast
SM	Silty sand
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedure(s)
SPCC	Spill Prevention, Control and Countermeasures
sq. mi.	Square Mile(s)
SSE	South-southeast
SSW	South-southwest
SW	Southwest
SWMU	Solid Waste Management Unit(s)
TCDD	Tetrachlorodibenzo-p-dioxin
TDS	Total Dissolved Solids
THC	Total Hydrocarbons
TICH	Total Identifiable Chlorinated Hydrocarbons
TLD	Thermoluminescent Dosimetry
TOC	Total Organic Carbon
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
TTLC	Toxic Threshold Limit Concentration
^{235}U	Uranium-235
^{238}U	Uranium-238
U-238	Uranium-238
U.S.	United States

APPENDIX D
CHEMICAL SYMBOLS, ABBREVIATIONS, AND ACRONYMS
PAGE SIX

USC	Unified Soil Classification
UST	Underground Storage Tank
VOC	Volatile Toxic Organic Compounds
W	West
WAA	Waste Accumulation Area(s)
WNW	West-northwest
WSW	West-southwest
Yd^3	Cubic Yards
Yr	Year(s)
α	Alpha
β	Beta
σ	Sigma
%	Percent
'	Minute(s)
"	Second(s)
~	Approximately
≥	Greater than or equal to
>	Greater than
<	Less than

END

DATE FILMED

11 / 16 / 90