SITE ENVIRONMENTAL REPORT

January - December, 1993

Bates Linac Radiation Protection Office

March, 1994

MIT Bates Linear Accelerator Center
Massachusetts Institute of Technology
Laboratory for Nuclear Science
PO Box 95
Middleton, Massachusetts 01949

Table of Contents

		Page
I.	SUMMARY	3
II.	INTRODUCTION	3
III.	COMPLIANCE	5
IV.	ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION	5
V.	GROUNDWATER PROTECTION	7
VI.	QUALITY ASSURANCE	7
VII.	PERMITS	8

I. EXECUTIVE SUMMARY

Environmental monitoring at Bates in 1993 demonstrates that boundary dose rates and population exposure levels are within normal variations in background levels.

A total dose of 0.09 mRem above background was measured at the east monitoring station and 0.19 mRem above background at the west station during 2669.8 hours of beam operations in 1993. Boundary monitoring stations are located at the east and west ends of the facility and are equipped with instrumentation capable of measuring contributions from scattered gamma and neutron radiation plus gaseous activity.

The gaseous activity consisted principally of ^{15}O and ^{13}N. A total of 16.96 Ci was released in 1993. Following the comply code, the predicted effective dose equivalent at the maximally exposed individual was 0.027 mRem, a level that satisfies the requirements for compliance.

The laboratory water consumption records indicate 3.2×10^6 gallons of water were used in 1993 lab operations. The majority was ultimately released via the evaporative cooler system located at the north wall of the gallery and the remaining transferred to groundwater via the sanitary leaching field. Summary data from quarterly samples obtained at the groundwater drain outside the east end of the south hall and several drainage basins indicate no measurable dose to the population from this pathway.

Continuous air particulate sampling conducted at the east and west boundary stations indicate no detectable contribution from Bates operations in 1993.

II. INTRODUCTION

The Massachusetts Institute of Technology, Bates Linear Accelerator, occupies a rural 91 acre site in Middleton, Massachusetts, 20 miles northeast of Boston. It is bounded on the south and west by undeveloped county land and on the north and east by private holdings. A distance of 500 feet separates the site buildings from the boundaries, except in the east where the shortest distance is 300 feet. (figure 1)

The laboratory is situated on a glacial drumlin at an elevation of 200 feet above sea level and rising 100 feet above

surrounding terrain. The prevailing regional winds are westerly, from SW to NW at an average velocity of 12 mph approximately 70% of the time.

Liquid effluent from Bates consists mainly of groundwater runoff from foundation underdrains under the accelerator (vault, BSY) and its experimental areas and from the sanitary leaching field (see figure 1 for location). The site runoff flows toward Nichols Brook (1750 feet to the north) which provides an estimated dilution factor of 10^5 to the site effluent. Nichols brook flows to the Ipswich River which serves as a drinking water source to communities downriver, and which eventually empties into the Ipswich Bay.

The laboratory is oriented east-west and is comprised of an accelerator vault, beam switchyard, three experimental areas and a storage ring.

The accelerator vault is composed of a 600-foot accelerating section and a parallel guide to permit beam recirculation. The maximum energy for a recirculated beam is 950 MeV.

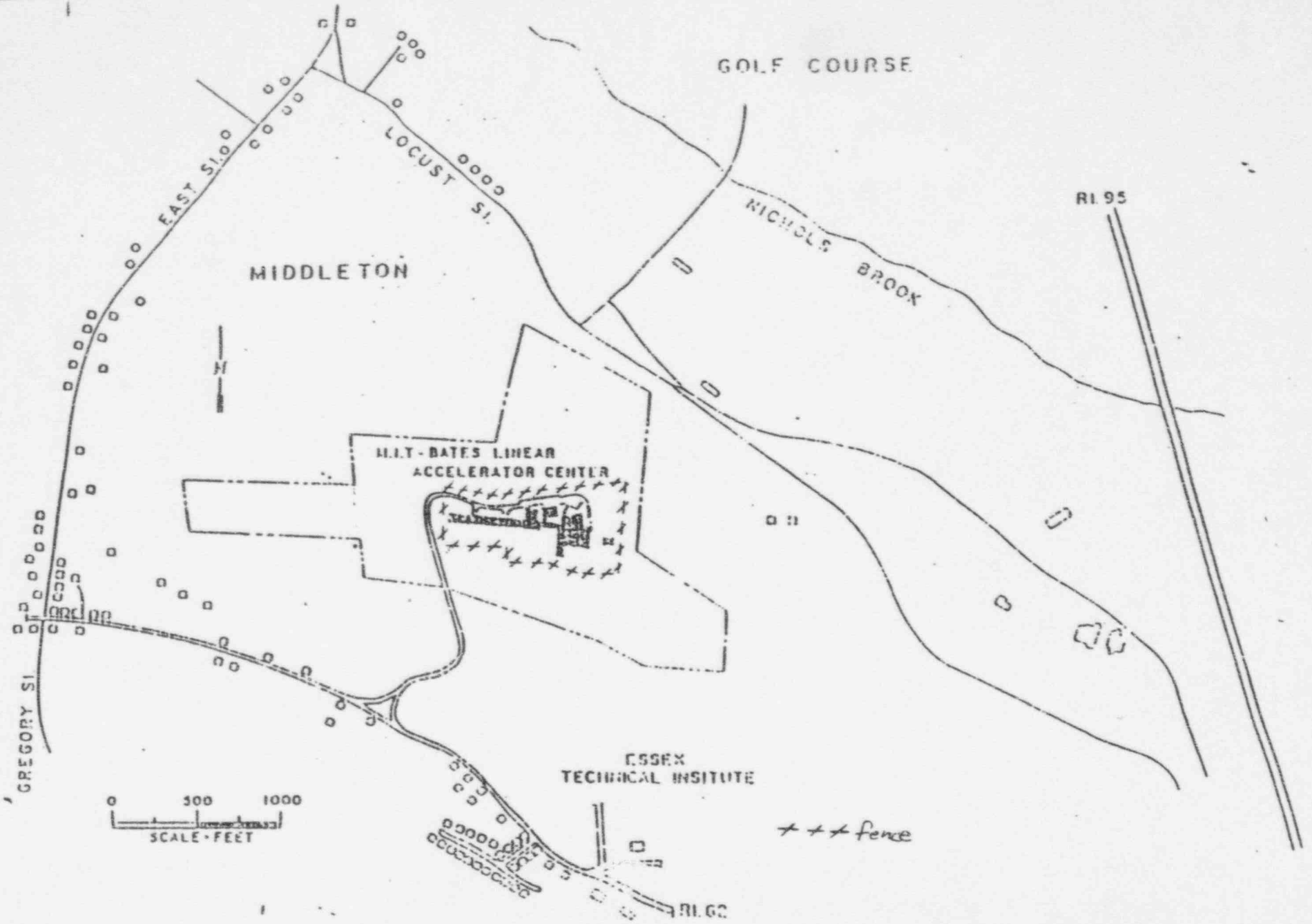
The beam switchyard is designed for beam definition and contains the main bending magnets and a high power variable slit assembly.

The experimental areas include three main areas referred to as the North Hall, the South Hall, and the 14° Area. The North Hall is used primarily for electron scattering studies. The South Hall, constructed in 1979, contains three experimental lines and a storage ring. The storage ring was constructed in 1990 as an extension to the south hall facility for C.W. beam experimentation. Experiments in this area include electron scattering, proton scattering studies, and polarized electron studies. The South Hall is designed for beam sharing and multiple secondary experiments with several spectrometers operational. The 14° Area is used primarily for beam tune-up operations and a limited amount of target activation studies.

III. COMPLIANCE SUMMARY

The Bates Linear Accelerator has successfully complied with all environmental regulations and statutes throughout 1993 and for the first quarter of 1994.

Specifically, the federal regulation applicable to the Bates



SITE PLAN

Figure II

Commonwealth of Massachusetts
Department of Labor and Industries
DIVISION OF OCCUPATIONAL HYGIENE
1001 WATERTOWN STREET
WEST NEWTON, MASSACHUSETTS 02165

TEL: (617) 969-7177
FAX: (617) 727-4581

CHRISTINE E. MORRIS
Secretary
Commissioner

PAUL ABOODY
Director

05/04/1994

LASER780

Mr. Frank Massé, MIT Laser Safety Officer
c/o Bernadette Johnson
Lincoln Laboratory, HW 45-287
Lexington MA

Dear Mr. Massé:

This is to confirm our receipt of the laser registration application relating to aircraft use of a "homemade" pulsed green laser to study algael growth in the Massachusetts Bay.

We have accepted the application, and filed it under DLI Laser file number 780. A copy of the submitted material has been forwarded to DPH Radiation Control, and will be kept of file there also.

Bob Watkins of DPH Radiation Control suggested that you might clear the application with the FAA if you have not already done so.

Approved:

Paul Aboody
Director

Very truly yours,

Dick Adams

L. Richards Adams
Industrial Radiation Control Officer

cc Bob Watkins, DPH

operation is the EPA National Emission Standards for Hazardous Air Pollutants (NESHAPs) 40 CFR 61 subpart H regulation. For 1993 emissions, the maximum dose to the nearest receptor (as predicted by the comply code without wind rose considerations) was 0.027 mRem. Air emissions are monitored by in-line counting, a method approved by EPA (method B-2) under 40 CFR 61. First quarter 1994 monitoring results indicate (by comply code) the maximum dose to the nearest receptor was 0.0002 mRem.

Laboratory activities involving other pertinent environmental regulations are summarized below:

NEPA - The DOE has issued NEPA clearance for all the calendar 1993 activities which fall under this regulation. These documents include analysis of radiological impact.

IV. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

A. Radiological Emissions and Doses

An integrated total of 16.96 Ci of gaseous radionuclides consisting of 8.48 Ci of ^{15}O and 8.48 Ci of ^{13}N were released from the Bates Linac in 1993. Following the comply code, this calculates to an effective dose equivalent exposure of 0.027 mRem at the site of the maximally exposed individual.

B. Environmental Monitoring

1. Penetrating Radiation

Monitoring equipment at the east and west boundary stations (figure 1) provides continual monitoring of leakage gamma and neutron radiation scattered from beam and dump areas. Experience over the operating life-time of this facility has indicated that these stations receive the highest penetrating radiation levels measurable anywhere along the property bounds of this facility.

The equipment consists of sensitive gamma and neutron detectors which operate continuously, with which the background radiation and machine related additions to background radiation are continuously integrated and recorded.

A total dose of 0.09 mRem above background was measured at

the east monitoring station and 0.19 mRem above background at the west station during 2669.8 hours of beam operations in 1993.

2. Gaseous Release

Beam areas at Bates are continually exhausted at 15 x 10^3 CFM through a 90 foot stack to permit immediate personnel access to experimental areas and prevent build-up of gaseous activities in the restricted areas. Experimental data has shown ^{15}O and ^{13}N produced from (γ, η) reactions in air as the principle components of the exhaust plume. Argon-41 has not been detected as a constituent in either plume.

The exhaust gas is continuously monitored in the stack base prior to release. Emission of ^{15}O and ^{13}N are calculated by correcting the release for the specific radionuclide contribution determined through half-life separation studies. Radiation monitoring data is remoted to the central computer facility where it is integrated and continuously recorded.

3. Water Sample Analysis

Duplicate water samples are obtained quarterly at two Nichols Brook locations, at a seasonal site brook which flows from the site to Nichols Brook (which would include drainage from the leaching field), and at an on-site central drain catch basin which intercepts the groundwater leaving the vault area as it surfaces to run off toward Nichols Brook. (Figure II)

A 2 liter sample is obtained at each location and counted on a gamma-ray spectroscopy system for a period of one hour. The sample results are compared with a domestic water background standard (from the on-site water tap) to determine gamma emitter concentrations due to accelerator operation. The Minimum Detectable Activity (MDA) of the system is 3.2 x 10^{-8} $\mu Ci/cm^3$. A measurement for pure beta emitters is also made on each sample by liquid scintillation counting. Unless there is a clearly positive result from this liquid scintillation measurement, the gamma-ray measurement is the measurement of record.

A total of 12 duplicate water samples were obtained in

1993. The dominant radionuclides which could be produced as a result of Linac operation include ^{15}O, ^{13}N, and ^{11}C. The gamma activity concentration in the water samples varied from 3.3×10^{-8} $\mu Ci/cm^3$ to $1.1 \times 10^{-7} \pm 3.3 \times 10^{-8}$ $\mu Ci/cm^3$. None of the samples were statistically significant with respect to background. (table 1)

4. Particulate Analysis

Outside air is continuously drawn through 2" millipore filters at 1 CFM. The samples are analyzed by both multi-channel gamma-ray spectroscopy and by beta proportional counter such that the minimum detectable activity is 1.0×10^{-14} $\mu Ci/cm^3$. The nuclides most likely to be observed in our routine operations include ^{7}Be, ^{24}Na, ^{56}Mn, and ^{63}Ni. The samples are obtained at the east boundary stations.

The particulate beta and gamma activity concentration varied from 5.9×10^{-14} to $1.6 \times 10^{-13} \pm 6.7 \times 10^{-14}$ $\mu Ci/cm^3$. (table II)

The estimate dose by pathway and collective dose resulting from the Bates operation in 1993 is shown in Tables III and IV respectively.

V. GROUNDWATER PROTECTION

See section IV. Environmental Program above.

VI. QUALITY ASSURANCE

Whole body exposure rates are continuously monitored at the east and west boundary stations with an unshielded GM tube interfaced with a Ludlum scaler. The system is calibrated against a National Institute of Standards and Technology traceable ^{226}Ra standard prior to each run and shutdown period. All calibration data is recorded in the instrument log.

Water samples (21) are counted for a period of one hour on a shielded 3" x 3" NaI crystal interfaced with a Canberra Multi-Channel Analyzer. Each sample is compared to a reference (21) background standard to determine the gross gamma activity. The system is routinely checked with a NIST traceable volume standard. Acceptable operating conditions exist when the integrated count on the standard is within 2 standard

deviations of the established value. An integrated total >26 indicates an unacceptable counting condition requiring repair and/or re-calibration of the counting system.

Gaseous activity is monitored at the base of the main facility with a NaI detector mounted within the plenum volume and interfaced with a Ludlum 2200 scaler. Calibration is established by placing the tube within a known concentration of ^{15}O ^{13}N, correcting for geometry and recording its response. The system is cross referenced with a 0.5 mCi ^{60}Co source prior to each run and shutdown period. All calibration data is maintained in the instrument log. Particulate monitoring is not performed in-stack, rather reliance on the particulate monitoring described in item III. D. is emphasized.

Bates is currently involved in the sample analysis intercomparison program administered through DOE-EML.

VII. PERMITS

Hazardous Waste Disposal permit

EPA Identification Number MAD 000769828

Issued to: MIT Bates Linear Accelerator
21 Manning Road
Middleton MA 01949

TABLE I

WATER SAMPLE ANALYSIS

TOTAL SAMPLES	MINIMUM ($\mu Ci/cm^3$)	MAXIMUM ($\mu Ci/cm^3$)	AVERAGE ($\mu Ci/cm^3$)	% STANDARD [1]
12	$0 \pm 3.3 \times 10^{-8}$	$1.1 \times 10^{-7} \pm 3.3 \times 10^{-8}$	$9.7 \times 10^{-9} \pm 3.3 \times 10^{-8}$	<< 1%

[1] DCG = 1×10^{-2} $\mu Ci/cc$

TABLE II

AIR PARTICULATE ANALYSIS

TOTAL SAMPLES	MINIMUM ($\mu Ci/cc$)	MAXIMUM ($\mu Ci/cc$)	AVERAGE ($\mu Ci/cc$)	% STANDARD [1]
29	$5.53 \times 10^{-15} \pm 5.9 \times 10^{-14}$	$1.76 \times 10^{-13} \pm 6.7 \times 10^{-14}$	$9.07 \times 10^{-14} \pm 6.1 \times 10^{-14}$	<< 1%

[1] DCG = 5×10^{-8} $\mu Ci/cc$

TABLE III

1993 DOSE ESTIMATES BY PATHWAY

Pathway	Maximum Individual Annual Dose (mRem)	% Standard
Penetrating	0.19	<< 1
Airborne	2.7×10^{-2} mRem (2.7×10^{-4} mSv)	<< 1
Particulate	----	----
Water	----	----

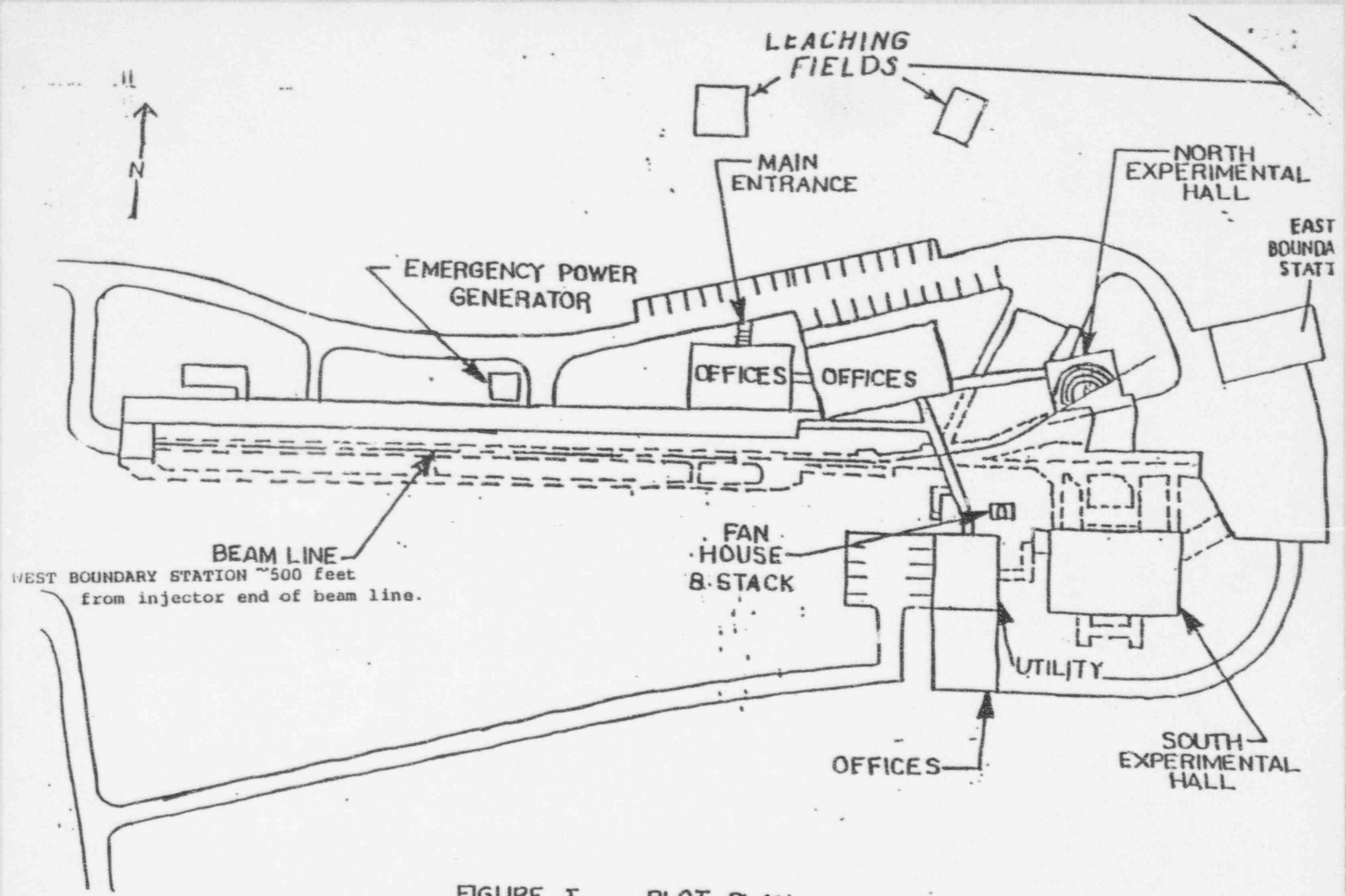


FIGURE I PLOT PLAN