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Brookhaven National Laboratory
Brookhaven LINAC Isotope Producer Facility

Facility Environmental Monitoring Report

Calendar Year 2000

BROOKHAVEN
NATIONAL LABORATORY

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Brookhaven National Laboratory
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Summary of Results*: Analysis of environmental samples collected at the BLIP from January 1999 through June 2000 indicate that the engineered and operation controls implemented during 1998 have been highly effective in preventing additional impacts to air and groundwater quality. During May-June 2000, BNL and DOE undertook additional protective measures by injecting a colloidal silica grout to reduce the permeability of the activated soils. However, groundwater monitoring conducted after the grout was injected indicated that the grout had displaced residual contaminated soil pore water. This contaminated water quickly entered the aquifer, and resulted in a short-term impact to groundwater quality in the BLIP area. Tritium concentrations up to 56,500 pCi/L were detected in a well located approximately 40 feet downgradient of the BLIP target vessel. By the end of December 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard.*

Direct air monitoring of BLIP emissions indicate that 1068 Ci of oxygen-15 and 275μCi of tritium were released during CY 2000. Because the half-life of oxygen-15 is so short (only 122 second), these releases are not considered a hazard to the environment or public. Although, tritium has half-life of 12.3 years, the release quantity was insignificant from risk prospective.

Background

When the BLIP is operating, the LINAC delivers a 200 MeV beam of protons that impinge on a series of eight targets located within the BLIP target vessel. During irradiation, the BLIP targets are located at the bottom of a 30-foot underground tank. The targets rest inside a water-filled 18-inch diameter shaft that runs the length of the tank, and are cooled by a 500 gallon closed loop primary cooling system. During irradiation, several radionuclides are produced in the cooling water, and activation of the soils immediately outside of the tank occurs due to the creation of secondary particles produced at the target. Air emissions from the BLIP facility pass through a HEPA filtration system. Following filtration, small quantities of oxygen-15 and tritium are released to the atmosphere.

As part of a 1985 redesign of the vessel, leak detection devices were installed, and the open space between the water filled shaft and vessel's outer wall is used as secondary containment system for the primary vessel. The BLIP target vessel system conforms to

Suffolk County Article 12 requirements, and is registered with SCDHS. The BLIP facility also has a 500 gallon-capacity UST used for liquid radioactive waste (change out water from the BLIP primary system). The waste tank and its associated piping system conform to Article 12 requirements, and are registered with SCDHS.

In 1998, BNL conducted an extensive evaluation of groundwater quality near the BLIP facility. Tritium concentrations of 52,000 pCi/L and sodium-22 up to 151 pCi/L, were detected in a temporary well installed approximately 50 feet downgradient of the BLIP target vessel. Elevated levels of tritium (11,400 pCi/L) and sodium-22 (at 38 pCi/L) were also detected in shallow groundwater samples collected from a temporary well that was installed 150 feet downgradient of the BLIP. Due to the activation of soils and the detection of tritium and sodium-22 in groundwater, the BLIP facility has been designated as AOC 16K under the Environmental Restoration program.

Starting in 1998, BNL made improvements to the stormwater management program at BLIP in an effort to prevent rainwater infiltration of the activated soils below the building. The BLIP building's roof drains were redirected away from the building, paved areas were resealed, and an extensive gunnite (cement) cap was installed on three sides of the building. In May-June 2000, BNL undertook additional protective measures by injecting a colloidal silica grout into the activated soils. The grout reduces the permeability of the soils, thus further reducing the potential of rainwater leaching radionuclides out of the soil and into groundwater.

Environmental Monitoring Program

As required by DOE Order 5400.1, BNL has established an environmental monitoring program at the BLIP facility to evaluate potential impacts to environmental quality from its operation, and to demonstrate compliance with DOE requirements and applicable federal, state and local laws and regulations.

The environmental monitoring program for the BLIP facility is described in the BNL Environmental Monitoring Plan (Daum *et al*. 2000 and BNL, 2001). The monitoring programs are summarized below.

Monitoring Results

Groundwater

During 1999 and early 2000, seven new groundwater monitoring wells were installed as a means of verifying that the engineered and administrative controls described above are effective in protecting groundwater quality.

Groundwater monitoring data collected from January 1999 to July 2000 indicated that the corrective actions taken during 1998 were highly effective in preventing the release of

tritium and sodium-22 from the activated soils surrounding the BLIP target vessel (see Table 1). Both tritium and sodium-22 were not detected in samples collected in April 2000. However, significant increases in tritium and sodium-22 concentrations were observed in groundwater samples collected after the silica grout injection process in early June. Samples collected in early July indicated tritium and sodium-22 concentrations of 5,700 pCi/L and 57 pCi/L respectively. Samples collected in early October indicated tritium concentrations that exceeded the drinking water standard of 20,000 pCi/L. The maximum tritium concentration was 56,500 pCi/L in samples from monitoring well 064-67, located approximately 40 feet downgradient of the BLIP vessel. In accordance with the BNL Groundwater Contingency Plan, BNL and DOE notified the regulatory agencies of this situation and increased the groundwater sampling frequency to bi-weekly. At the request of the agencies, the well sampling frequency was increased to weekly starting December 1, 2000. The maximum sodium-22 concentration was 299 pCi/L detected in Well 064-67 on December 1, 2000. By December 21, 2000, tritium concentrations dropped to below the 20,000 pCi/L drinking water standard in wells located approximately 40 feet downgradient of BLIP. Concurrently, as the slug of tritium continued to migrate downgradient of the BLIP, concentrations in Well 064-50 increased to 20,000 pCi/L by December 28, 2000. Well 064-50 is located approximately 150 feet downgradient of BLIP. Table 1 provides a summary of tritium and sodium-22 data for CY 2000. Tritium concentration trends are depicted on Figure 2.

Following the detection of elevated tritium concentrations in October, BNL conducted a review of the grouting process. Findings of this review suggest that that grout displaced residual vadose zone soil pore water that was contaminated with tritium. The pattern of decreasing tritium concentrations in wells directly downgradient of BLIP indicate a short-term (pulsed) tritium release and that the plume has dissipated quickly in the aquifer. Although the grouting process had a short-term impact on groundwater quality, it is believed that the process will provide long-term benefits in reducing the permeability of the contaminated soil shielding. Information on the potential for displacing residual pore water will be used to improve this innovative grouting technology.

Air Monitoring

Air emissions from the BLIP facility pass through a HEPA filtration system. Air emissions are monitored by fixed, continuously operating sampling devices: silica gel to sample tritiated water vapor, a particulate matter filter (0.3 microns) for analysis of gamma-emitting radionuclides, and a TEDA-loaded charcoal cartridge for radioiodine detection. Radiological gases emissions, such as oxygen-15, are estimated by the fluence rate and hours of machine operation in micro-ampere-hours. The conversion factor and measured activity (i.e., mCi/micro-ampere-hrs) are used in estimating the curies of emissions. The conversion factor used for the previous years was 0.30 mCi/uA-hrs, but to estimate CY 2000, a conversion factor of 10.8 mCi/uA-hrs was used. This conversion factor was increased based on discovery of mathematical error in previous calculations. However, this increase in emissions does not significantly impact the dose to members of the public because it is in the form of gas and very short half-life (122 seconds).

During CY 2000, 1,068 Ci of oxygen-15 were released from BLIP. This is a significant increase from 1999, when 12.3 Ci of oxygen-15 were released. Oxygen-15 emissions were estimated directly from the number of machine micro-ampere-hours of operation hours in 2000. Tritium[1] air emissions for the calendar year 2000 were 275 μCi, which is significant decrease from 43,100 micro Curie in 1999. The air emissions were well below the derived concentration guide limits for the members of the public. Therefore, it can be safely concluded that there was negligible impact to the environment from air emissions from BLIP operations.

Future Monitoring Actions

It is recommended that:

- Groundwater samples should continue to be collected quarterly until CY 2002. In CY 2002, monitoring should be reduced to semiannually, and be limited to upgradient wells 054-61 and 064-46 and downgradient wells 064-47, 064-48 and 064-67.
- The air monitoring program will be continued at its current level with improved sampling and analytical methods for short-lived radionuclides, stack flow rate calibration, and data verification and validation.

References

BNL, 2001. Brookhaven National Laboratory Environmental Monitoring Plan, CY 2001 Update (January 2001). BNL-52584 (Update).

Daum, M., Dorsch, W., Fry, J., Green, T., Lee, R., Naidu, J., Paquette, D., Scarpitta, S., and Schroeder, G., 2000. Brookhaven National Laboratory, Environmental Monitoring Plan 2000 (March 31, 2000). BNL-52584.

[1] Tritium data needs qualitative verification and validation for air emissions.

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Brookhaven LINAC Isotope Producer (BLIP)
Groundwater Monitoring - Tritium and Sodium-22 Results for CY 2000
(pCi/L)

Table 1

Well	Radionuclide	January 12	March 7 (a)	April 4	July 11
64-46 (upgradient)	Tritium Sodium-22	<316 ND	NS	<331 ND	<356 3.7 +/- 1.3
54-61 (upgradient)	Tritium Sodium-22	<343 ND	NS	<331 ND	<356 ND
64-47 (~40 feet downgradient)	Tritium Sodium-22	<343 1.2 +/- 0.9	NS	<331 ND	5,700 +/- 412 57.1 +/- 6.9
64-48 (~40 feet downgradient)	Tritium Sodium-22	495 +/-215 2.6 +/- 1.4	NS	<331 ND	3,630 +/- 351 23.7 +/- 3.3
64-67 (~40 feet downgradient)	Tritium Sodium-22	NI	2,290 +/-281 2.1 +/-1.2	<331 ND	2,820 +/- 318 19.0 +/- 2.8
64-49 (~150 feet downgradient)	Tritium Sodium-22	<343 ND	NS	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	<343 ND	NS	NS	NS
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	ND	NS	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
NI: Well not installed before this period.
(a): Initial sampling of new Well 064-67.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

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Groundwater Monitoring - Tritium and Sodium-22 Results for CY 2000
(pCi/L)

Table 1 (Continued)

Well	Radionuclide	October 11	November 1	November 9	December 1
64-46 (upgradient)	Tritium Sodium-22	<320 2.3 +/- 1.2	<321 ND	NS	NS
54-61 (upgradient)	Tritium Sodium-22	<320 ND	<321 2.5 +/- 1.2	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	<320 2.5 +/- 1.0	445 +/- 231 6.1 +/- 1.7	<328 ND	471 +/- 227 ND
64-48 (~40 feet downgradient)	Tritium Sodium-22	2,440 +/- 303 14.0 +/- 2.2	4,680 +/- 392 30.3 +/- 3.3	5,610 +/- 416 54.3 +/- 5.1	3,650 +/- 355 10.7 +/- 1.7
64-67 (~40 feet downgradient)	Tritium Sodium-22	56,500 +/- 1,160 (b) 88.0 +/- 7.8	54,200 +/- 1,120 219 +/- 17.8	47,400 +/- 1,080 233 +/- 18.8	31,100 +/- 875 299 +/- 24
64-49 (~150 feet downgradient)	Tritium Sodium-22	NS	<321 ND	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	NS	5,800 +/- 414 ND	NS	14,900 20.0 +/- 2.5
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	<321 5.1 +/- 1.2	NS	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
NI: Well not installed before this period.
(b): To confirm initial results, the November 1, 2000 sample was reanalyzed. Reanalysis indicated tritium concentrations of 57,800 +/- 1,180 pCi/L and 58,700 +/- 1,200 pCi/L.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

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Groundwater Monitoring - Tritium and Sodium-22 Results for CY 2000
(pCi/L)

Table 1 (Continued)

Well	Radionuclide	December 8	December 15	December 21	December 28
64-46 (upgradient)	Tritium Sodium-22	NS	NS	NS	NS
54-61 (upgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-47 (~40 feet downgradient)	Tritium Sodium-22	454 +/- 232 ND	366 +/- 209 ND	396 +/- 230 ND	377 +/- 216 ND
64-48 (~40 feet downgradient)	Tritium Sodium-22	3,210 +/- 341 12.4 +/- 1.8	2,080 +/- 284 15.4 +/- 2.1	1,380 +/- 277 13.6 +/- 2.1	1,660 +/- 278 11.3 +/- 1.9
64-67 (~40 feet downgradient)	Tritium Sodium-22	25,100 +/- 788 255 +/- 21	20,300 +/- 682 248 +/- 20	15,800 +/- 642 188 +/- 15.9	16,500 +/- 644 185 +/- 15.0
64-49 (~150 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS
64-50 (~150 feet downgradient)	Tritium Sodium-22	17,600 +/- 672 20.9 +/- 2.5	16,900 +/- 635 19.7 +/- 2.3	14,400 +/- 602 23.3 +/- 2.7	20,000 +/- 710 25.5 +/- 3.1
64-02 (~450 feet downgradient)	Tritium Sodium-22	NS	NS	NS	NS

ND: Radionuclide not detected.
NS: Well not sampled during this period.
Note: Drinking water standard for tritium = 20,000 pCi/L; for sodium-22 = 400 pCi/L.

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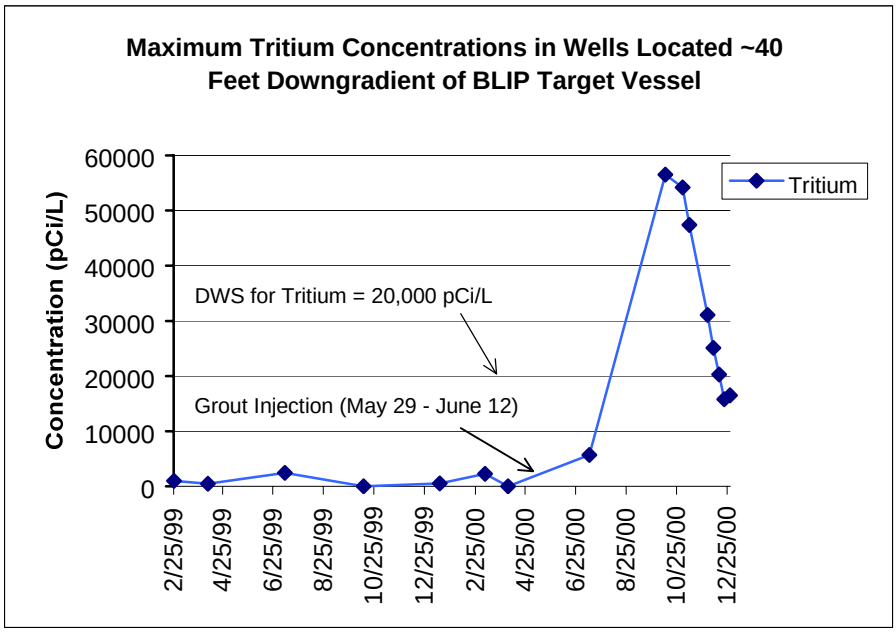
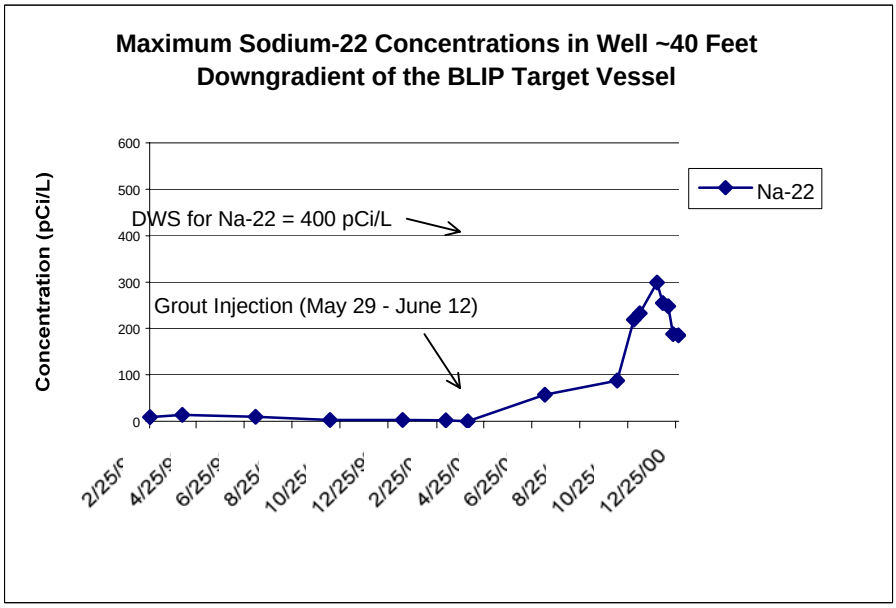
Brookhaven LINAC Isotope Producer
Tritium and Sodium-22 Concentration Trends in Groundwater during CY 2000
Figure 2





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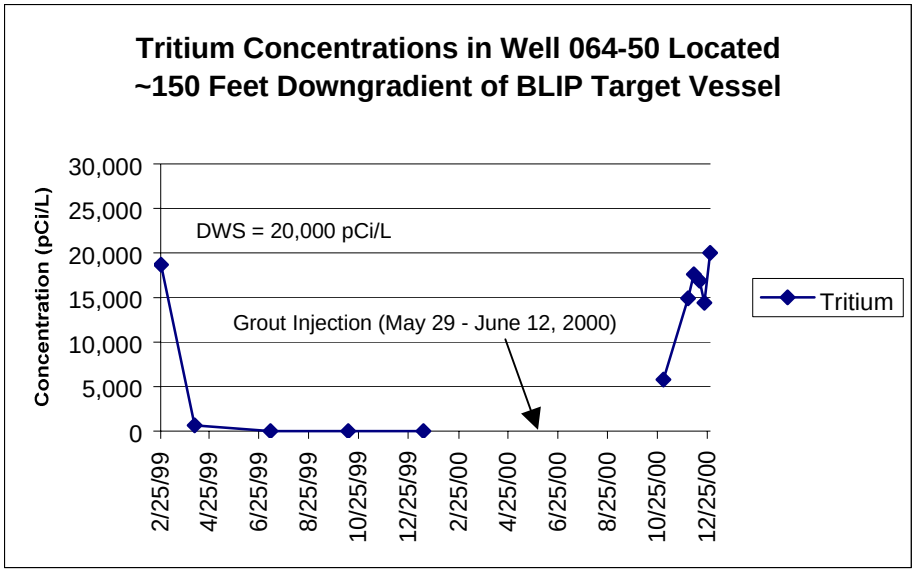
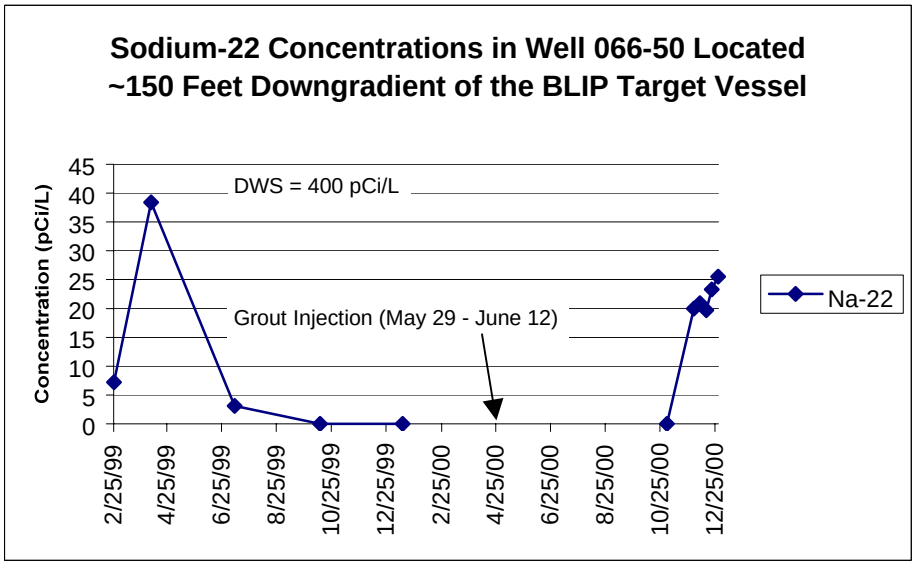
Tritium and Sodium-22 Concentration Trends in Groundwater during CY 2000
Figure 3





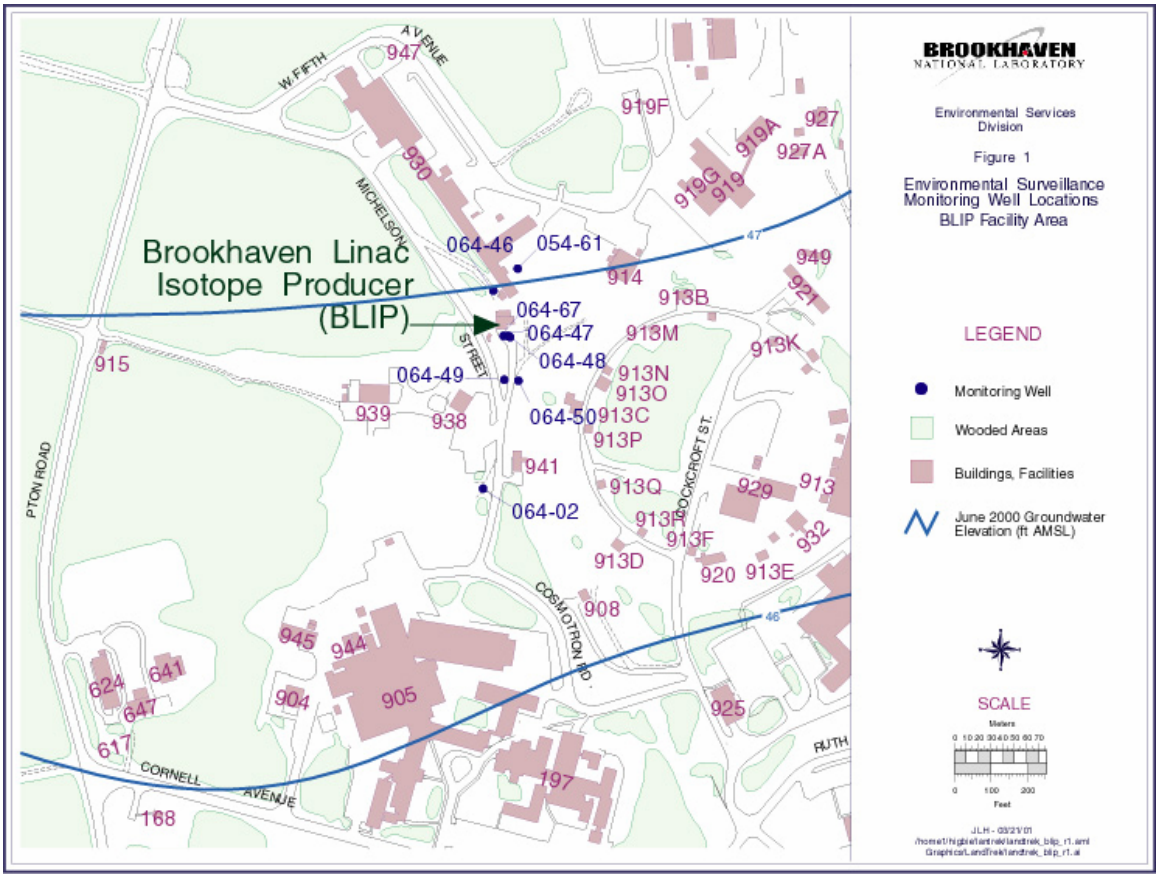

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Figure 1
Environmental Surveillance
Monitoring Well Locations
BLIP Facility Area
Brookhaven Linac
Isotope Producer
(BLIP)
LEGEND
Monitoring Well
Wooded Areas
Buildings, Facilities
June 2000 Groundwater
Elevation (ft AMSL)
SCALE
Meters
Feet
W.FIFTH AVENUE
MICHELSON STREET
PTON ROAD
BROOKHAVEN AVENUE
COSMOTRON RD.
RUTH
CORNELL AVENUE
064-46
054-61
064-67
064-47
064-48
064-49
064-50
064-02
947
930
919F
919A
927
927A
919G
919
914
913B
949
921
913M
913K
915
913N
913O
913C
913P
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