HFBR Tritium Plume

Tritium Investigation and Remediation at Brookhaven National Laboratory

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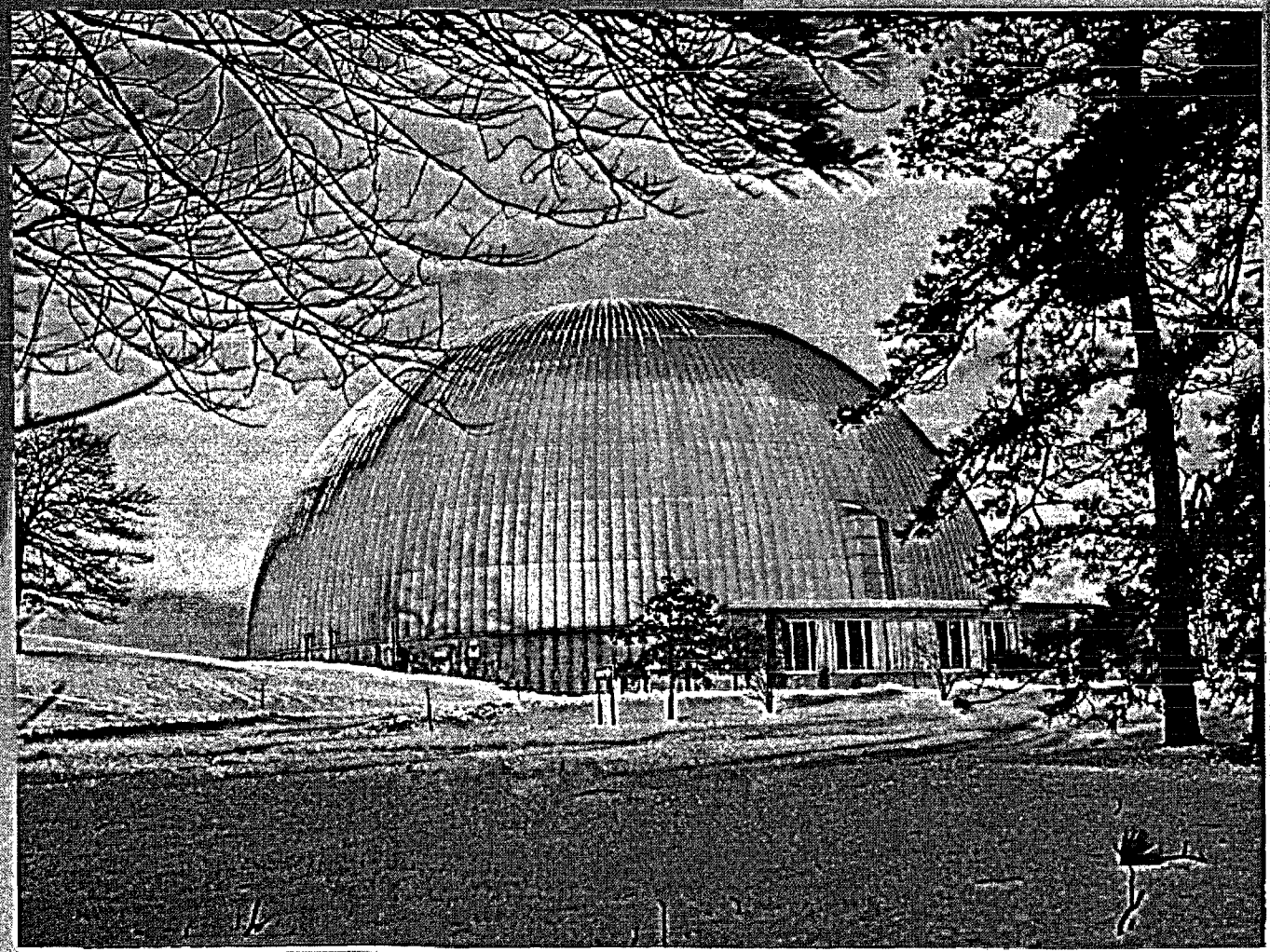
September 19, 2006

High Flux Beam Reactor (HFBR)



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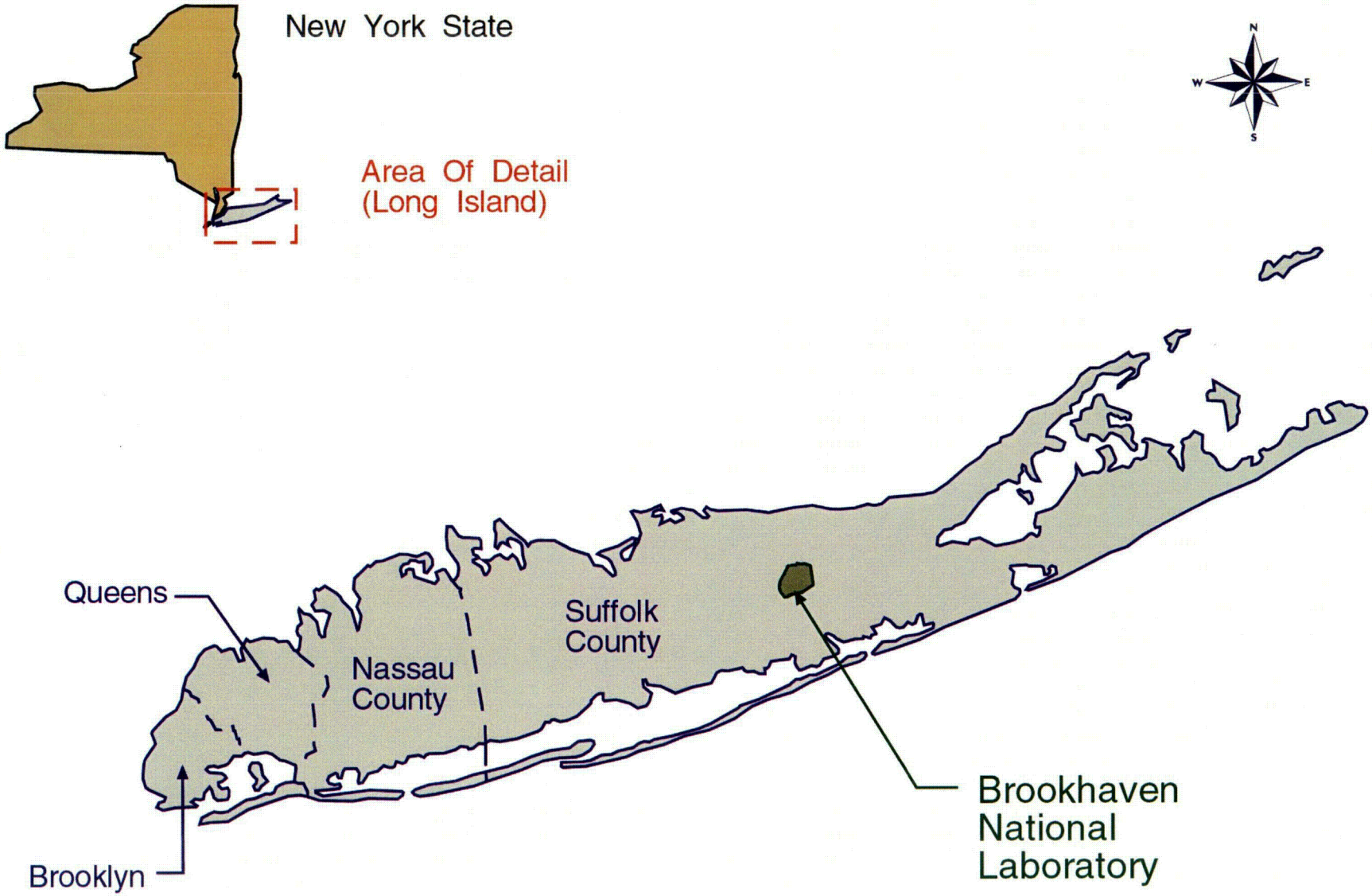

Figure 1

BNL Location Map

MLD - 11/08/96

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Brookhaven National Laboratory

- Department of Energy, National Laboratory Established in 1947
- 2700 Employees
- ~5300Acres

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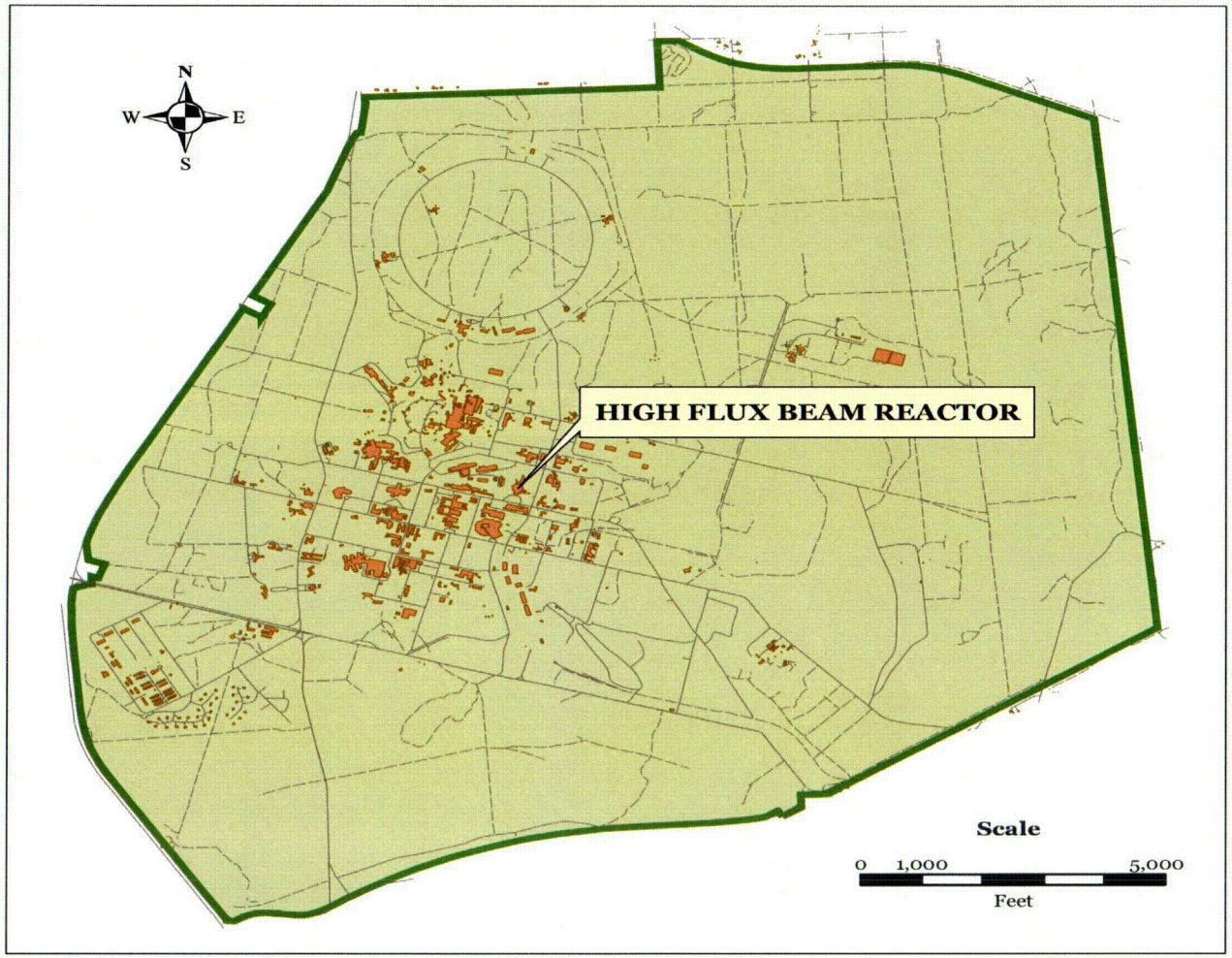
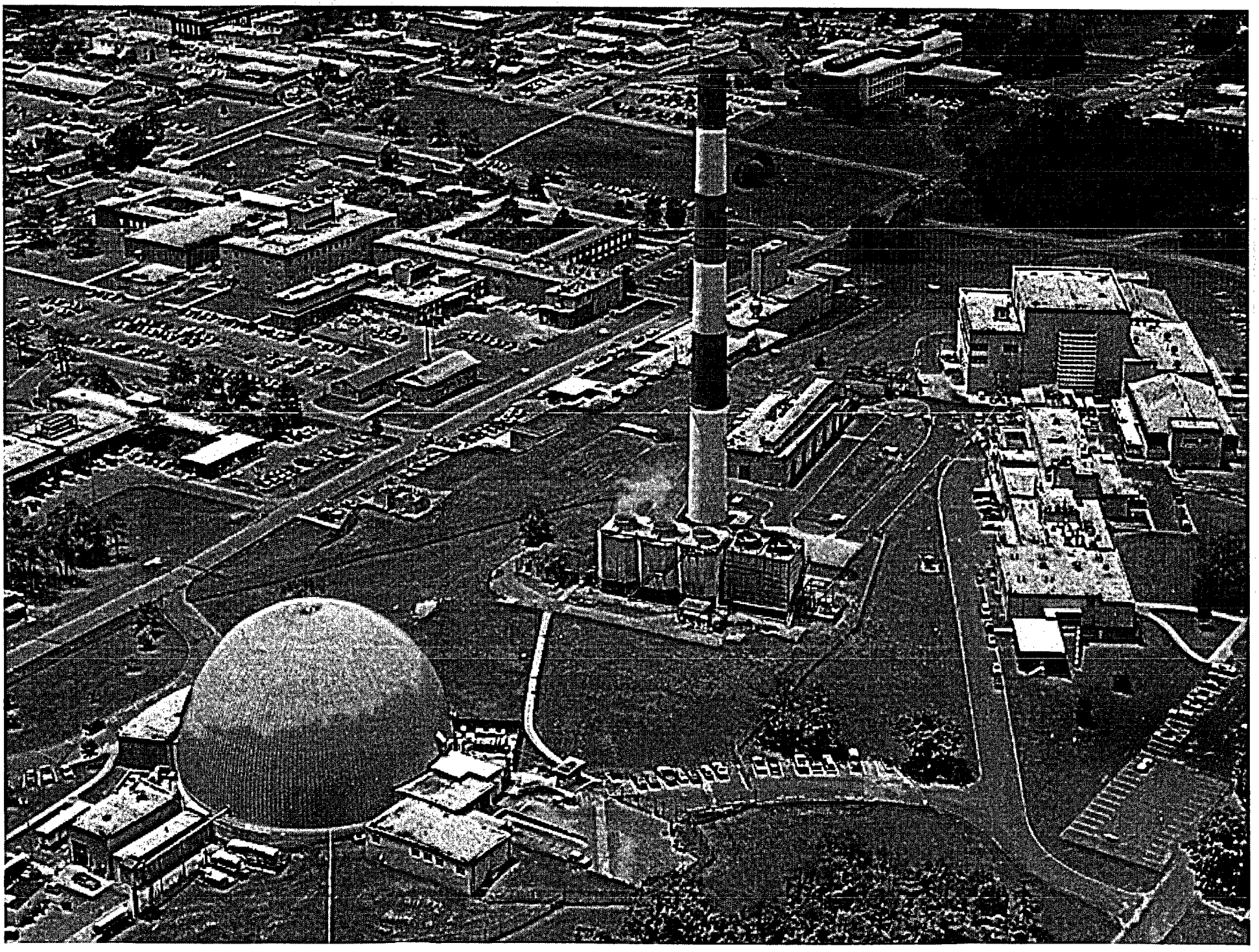
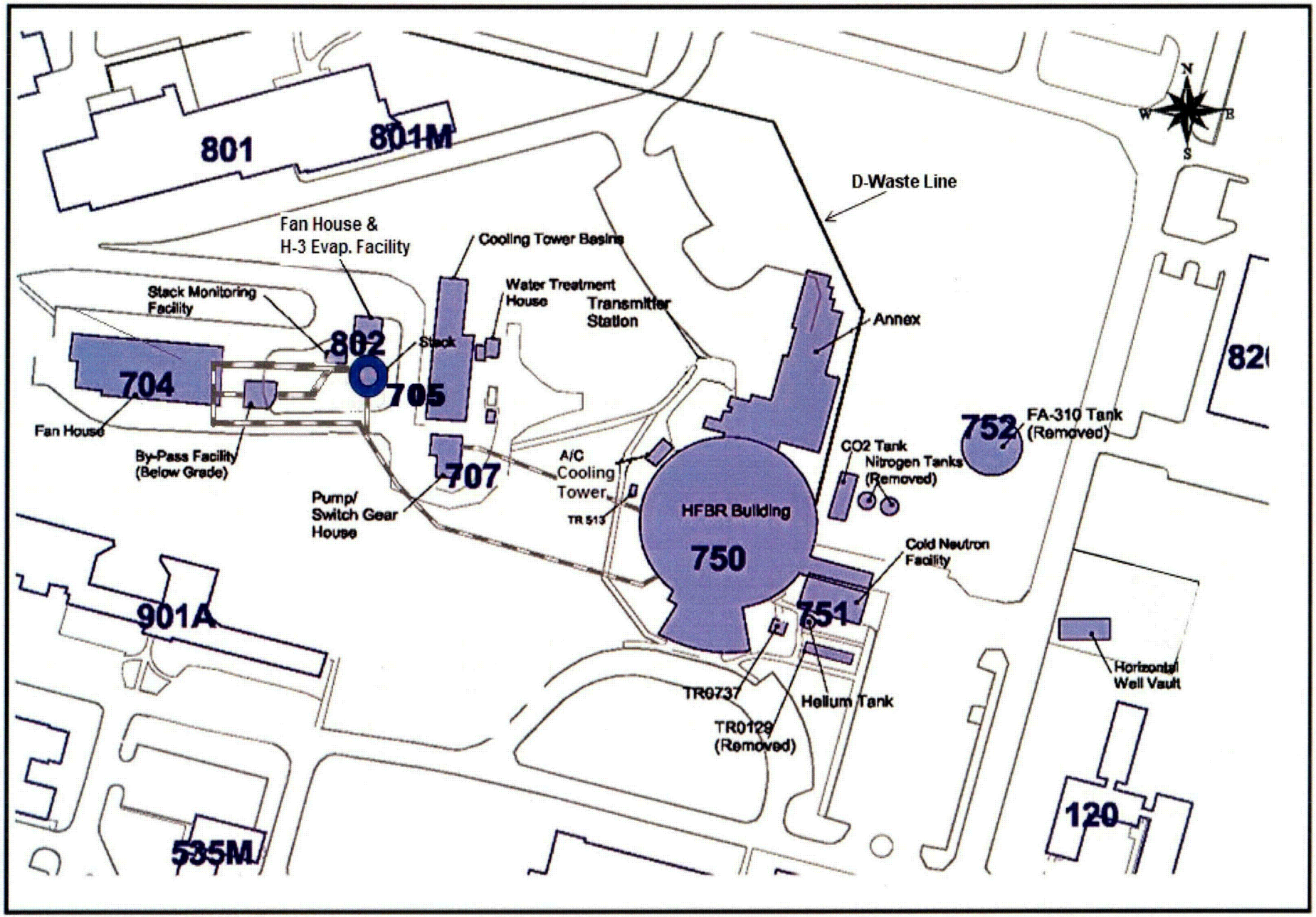
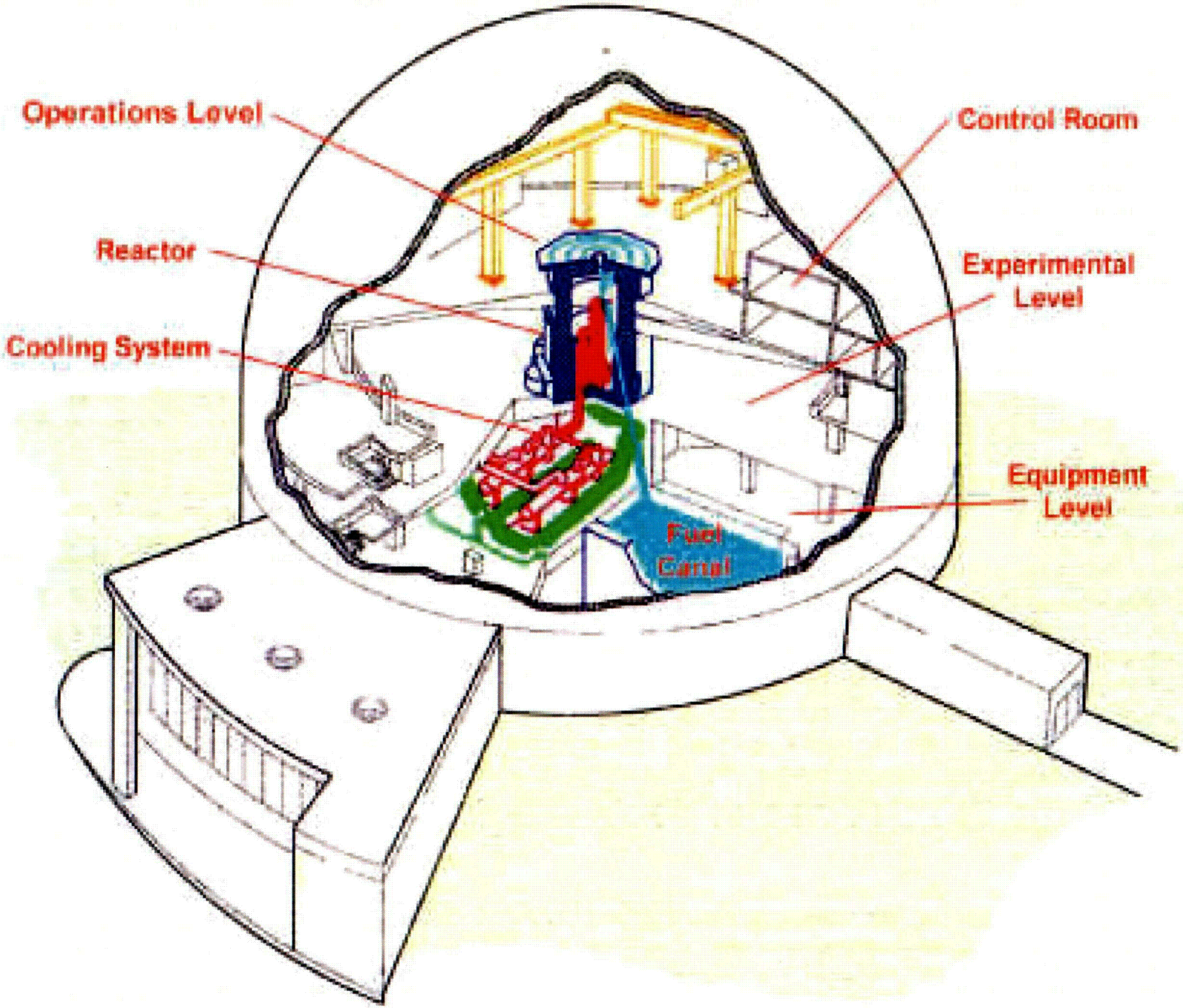
HFBR Location



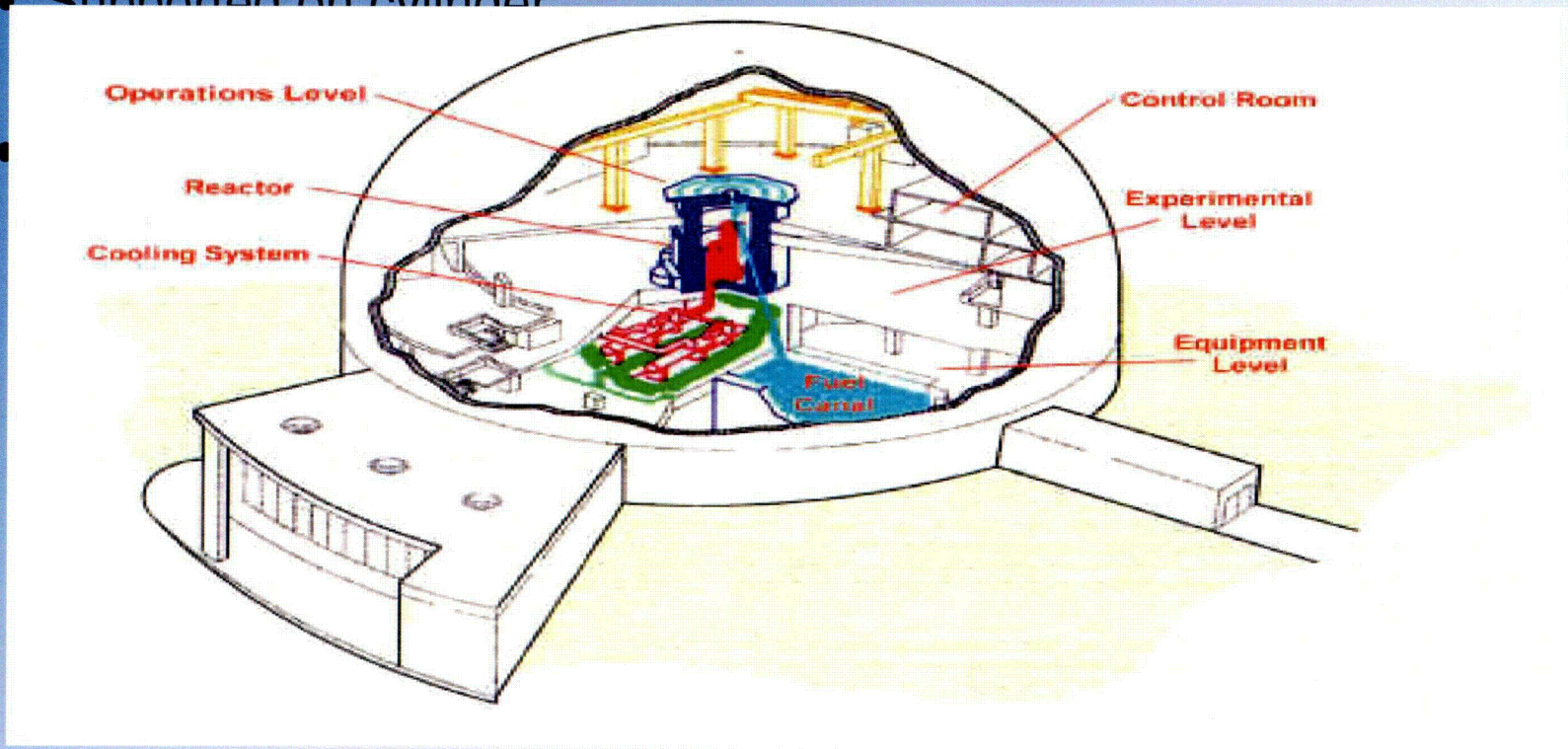



801
801M
D-Waste Line
Fan House &
H-3 Evap. Facility
Cooling Tower Basins
Stack Monitoring
Facility
Water Treatment
House
Transmitter
Station
Annex
802
Stack
704
705
Fan House
By-Pass Facility
(Below Grade)
707
Pump/
Switch Gear
House
A/C
Cooling
Tower
TR 513
HFBR Building
750
752
FA-310 Tank
(Removed)
CO2 Tank
Nitrogen Tanks
(Removed)
Cold Neutron
Facility
751
901A
TR0737
Helium Tank
TR0129
(Removed)
Horizontal
Well Vault
535M
120
N
W
E
S


Operations Level
Reactor
Cooling System
Control Room
Experimental Level
Equipment Level
Fuel Canal

Building 750

- Hemispherical dome (inside diameter 176' 8")
  - Supported on cylinder
  -



Reactor History

- Originally designed power level of 40 megawatts
- Achieved criticality on October 31, 1965
- Shut down in 1989 to reanalyze the safety impact of a hypothetical loss-of-coolant accident
- Restarted in 1991 at 30 megawatts

Reactor History (continued)

- Shutdown in 1996 for routine maintenance and refueling
- December 1996, tritium discovered in groundwater down gradient of the HFBR
- The source was determined to be the spent fuel pool
- Remediation of the tritium plume and the HFBR Spent Fuel Pool being performed CERCLA
- Secretary of Energy announced permanent closure based on program budget concerns in November 1999

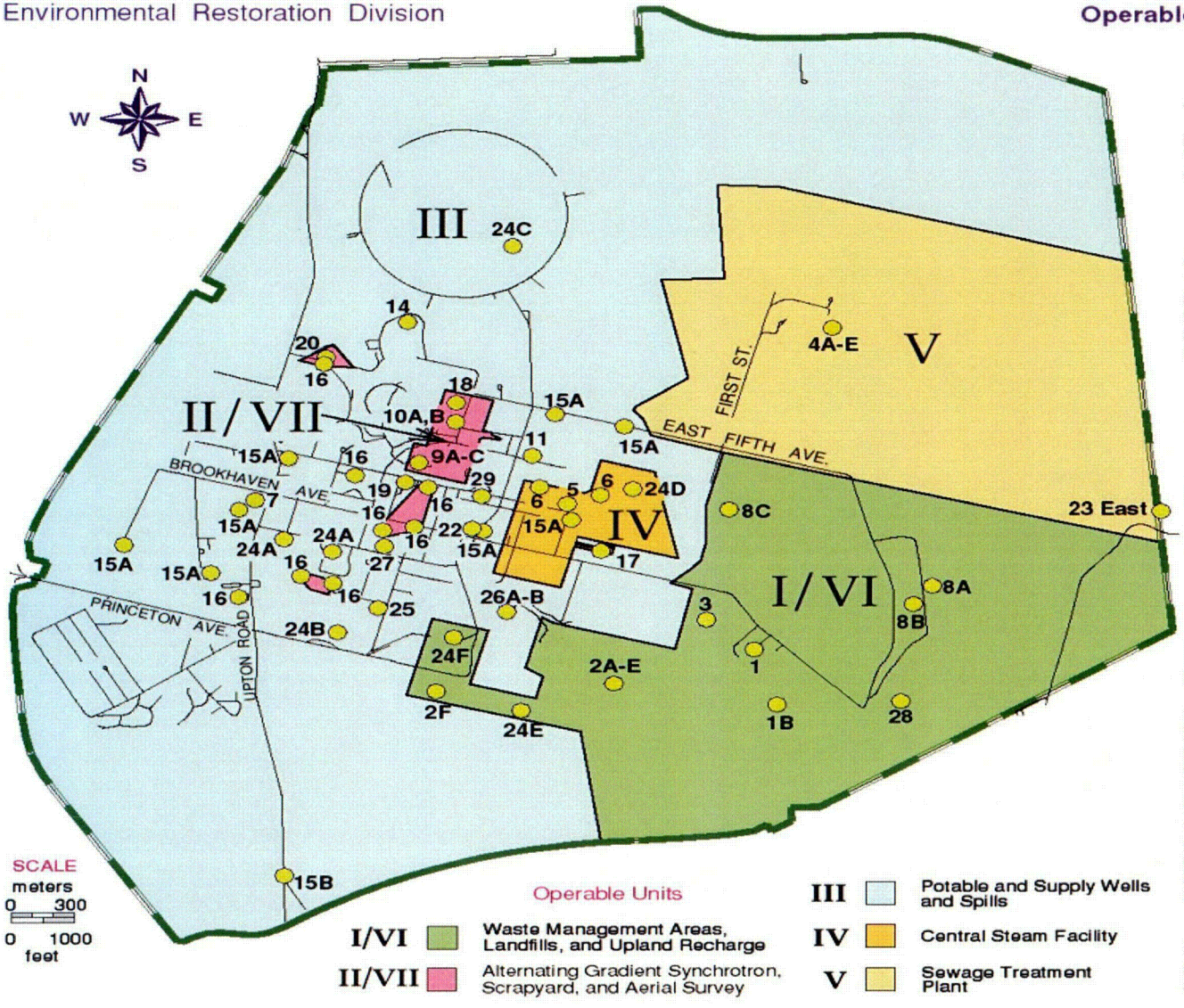
Regulatory Framework

- BNL is a federal Superfund site (CERCLA)
- 1992 Interagency Agreement (IAG)
  - Department of Energy, U.S. EPA Region II and New York State
    - Suffolk County also actively involved
- BNL has 30 Areas of Concern divided into seven Operable Units/Study Areas

Groundwater Contamination

- Volatile organic compounds (VOCs) (7000 ug/l)
- Tritium (5.1×10^6 pCi/l)
- Strontium-90 (3200 pCi/l)

Operable Units & Areas of Concern



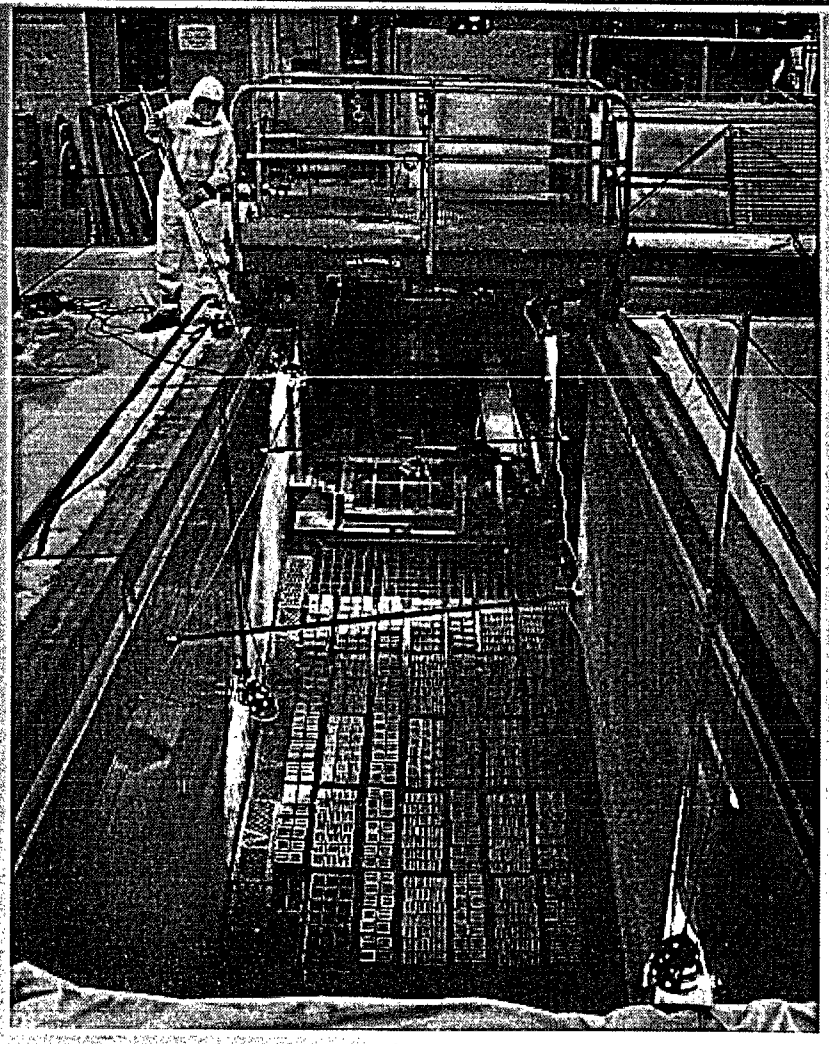
Operable Units and Areas of Concern

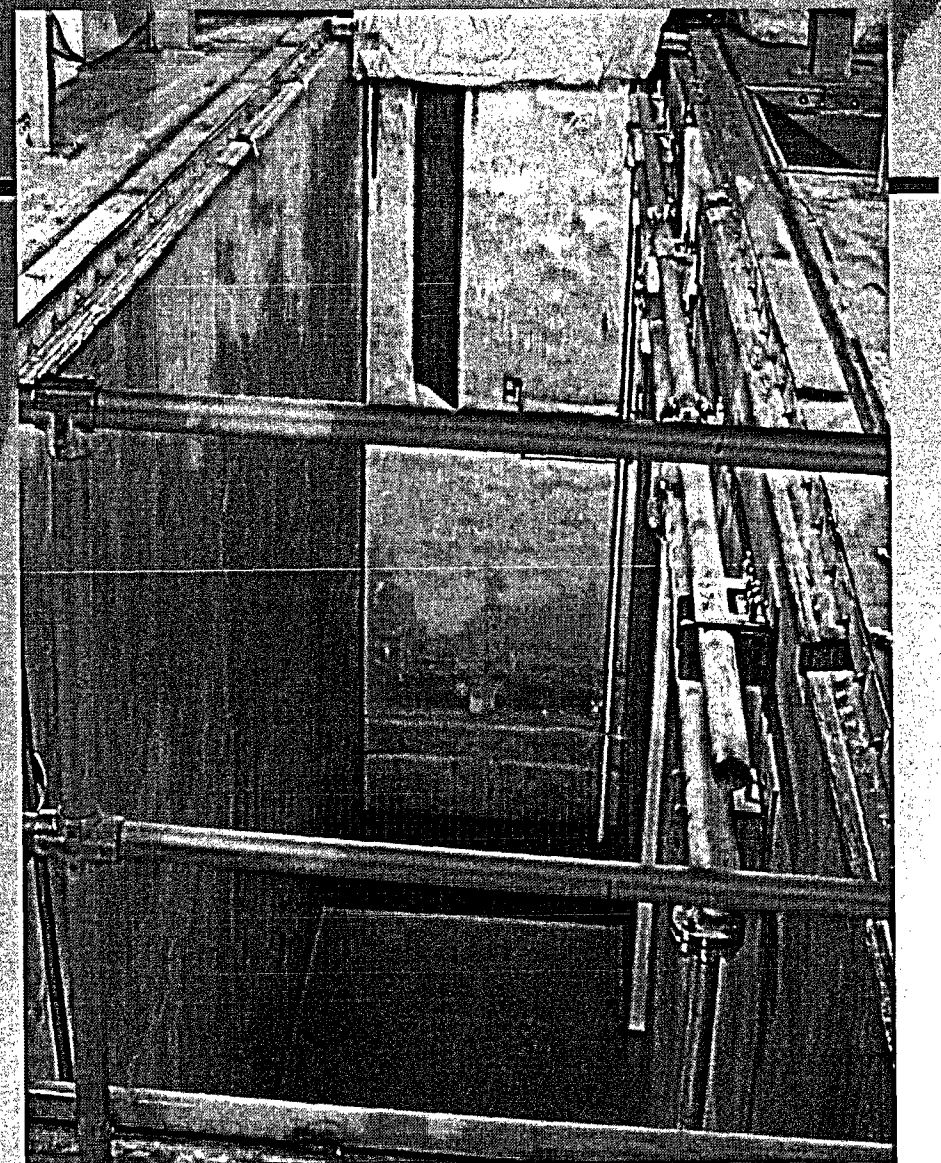
Areas of Concern

1	Hazardous Waste Management Facility
1B	Groundwater
2A-E	Former/Interim Landfills, Slit Trench, and Chemical/Animal/Glass Holes
2F	Ash Pit
3	Current Landfill
4A-E	Sewage Treatment Plant (A - Sludge Drying Beds; B - Sand Filter Beds; C - Imhoff Tanks; D - Hold-Up Ponds; E - Satellite Disposal Area)
5	Central Steam Facility
6	Building 650 Sump and Sump Outfall Area
7	Paint Shop
8A	Upland Recharge/Meadow Marsh
8B	Biology Fields
8C	Gamma Field
9A-C	Brookhaven Graphite Research Reactor (A - BGRR Canal; B - Underground Ductwork; C - Spill Sites)
10	Waste Concentration Facility (WCF)
10A	Tanks D-1, D-2, D-3 at the WCF
10B	Underground Pipes at the WCF
11	Building 830 Pipe Leak
12	Underground Storage Tanks (not shown)
13	Cesspools and Septic Tanks (not shown)
14	Bubble Chamber Spill Area
15A	Potable/Supply Wells
15B	Monitoring Well 130-02
16	Radiologically Contaminated Surface Soils
17	Area Adjacent to Former Low-Mass Criticality Facility
18	AGS Storage Yards
19	TCE Spill Area
20	Particle Beam Dump, North End of Linear Accelerator
21	Leaking Sewer Pipes (not shown)
22	Old Firehouse
23 East	Eastern Tritium Plume
24A	Process Supply Wells 104, 105
24B	Recharge Basin HP
24C	Recharge Basin HN
24D	Recharge Basin HO
24E	Recharge Basin HS
24F	Weaver Drive Basin HW
25	Heavy Machine Shop (Building 479)
26A-B	Warehouse Area (A - Building 208; B - Former Scrapyard/Drum Storage Area South of Building 96)
27	Building 464
28	EDB Plume
29	HFBR Spent Fuel Pool and Tritium Plume

Spent Fuel Canal

- Canal chemistry:
  - Trace amounts of Co, Zn, Cr & Mn
  - Tritium ranging from 40 million pCi/l to 140 million pCi/l
- Leaked for 12 years
  - 6 to 9 gal/day
  - Total release of 5 to 6 curies of tritium





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Canal Liner

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HFBR Initial Characterization

- Well Drilling (piezometers, geoprobes, vertical profiles)
- Sampling (tritium gross alpha & beta, VOCs)
- Groundwater modeling (MODFLOW, MT3D) Detailed conceptual site model already existed

HFBR Initial Characterization

- 3 Geoprobes
- 9 Drill rigs with support crews
- Vertical profiles being installed 18 hours a day
- 5 analytical labs (48 hour TAT)

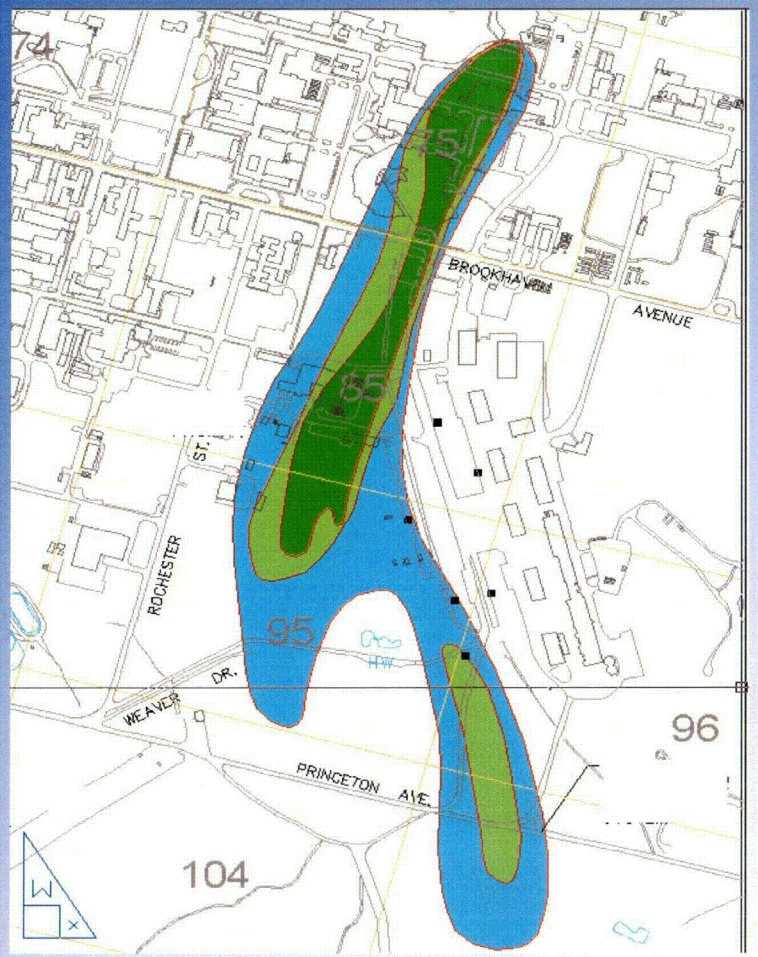
HFBR Initial Characterization

- 30 Piezometers
- 51 Monitoring Wells
- 45 Geoprobes
- 77 Vertical Profile temporary wells
- 1900 Samples (Tritium, VOCs, etc)
- Approximate costs $1,500k

HFBR Continued Monitoring

- Monitoring well network of 159 wells
- Augmented by temporary wells (vertical profiles and geoprobes)
- Annual Monitoring costs $180k

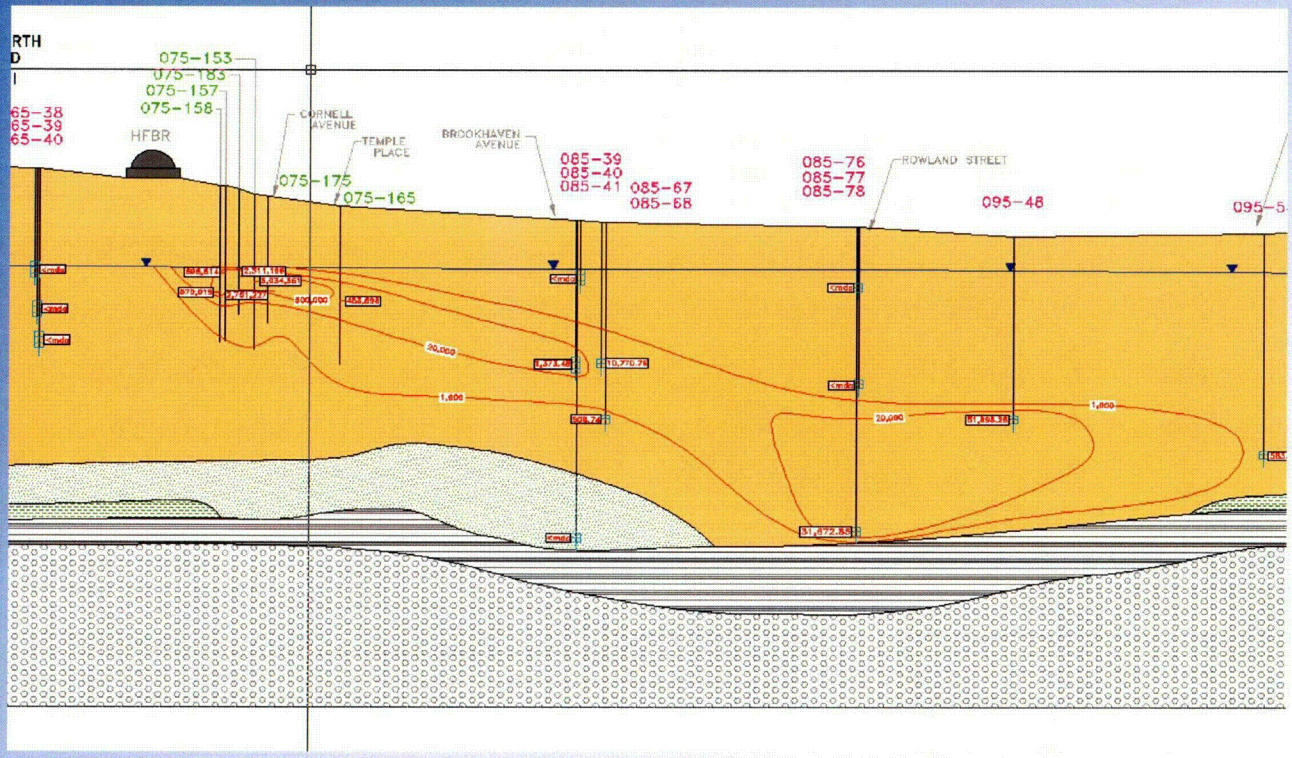
HFBR Tritium Plume – 1997



LEGEND

- VERTICAL PROFILE BORING
- MONITORING WELL
- 1,000 - 4,999 pCi/L TRITIUM CONCENTRATION
- 5,000 - 19,999 pCi/L TRITIUM CONCENTRATION
- 20,000 - 499,999 pCi/L TRITIUM CONCENTRATION

HFBR Tritium Plume Cross Section - 1999



Clean Up Goals

OU III Record of Decision

- Clean up to MCLs in 30 years of less
- Prevent or minimize further migration of tritium in the groundwater (plume growth)

HFBR Tritium Plume Remediation

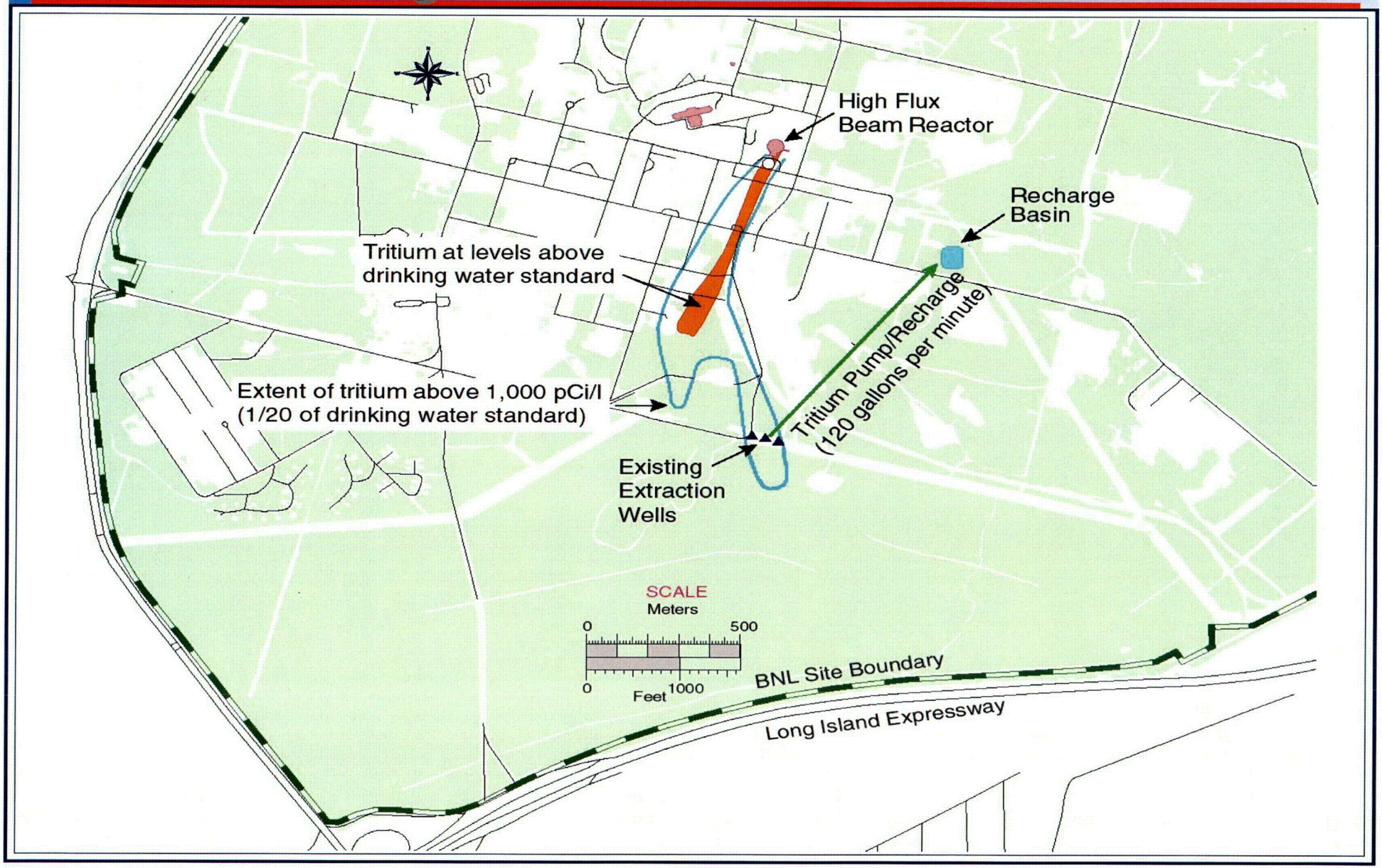
- Hydrogeologic Evaluation based on iterative Monitoring and Modeling resulted in three-fold approach:
  - Pump and recharge system at leading edge of plume.
  - Low flow pumping near the HFBR (source).
  - Monitored Natural Attenuation of the entire plume (plume management).

Tritium Plume Pump and Recharge System Design

Modeling provided groundwater flow direction, capture zone estimate, time to cleanup, and pumping well locations/rate. Quarterly monitoring verified capture and plume behavior.

- Designed and built plume pump and recharge system at the end of the plume in 1997 with carbon treatment for VOCs.
- Pump and recharge system designed to provide more time for plume to decay and attenuate on BNL site.

HFBR Tritium Plume Pump and Recharge - 1997



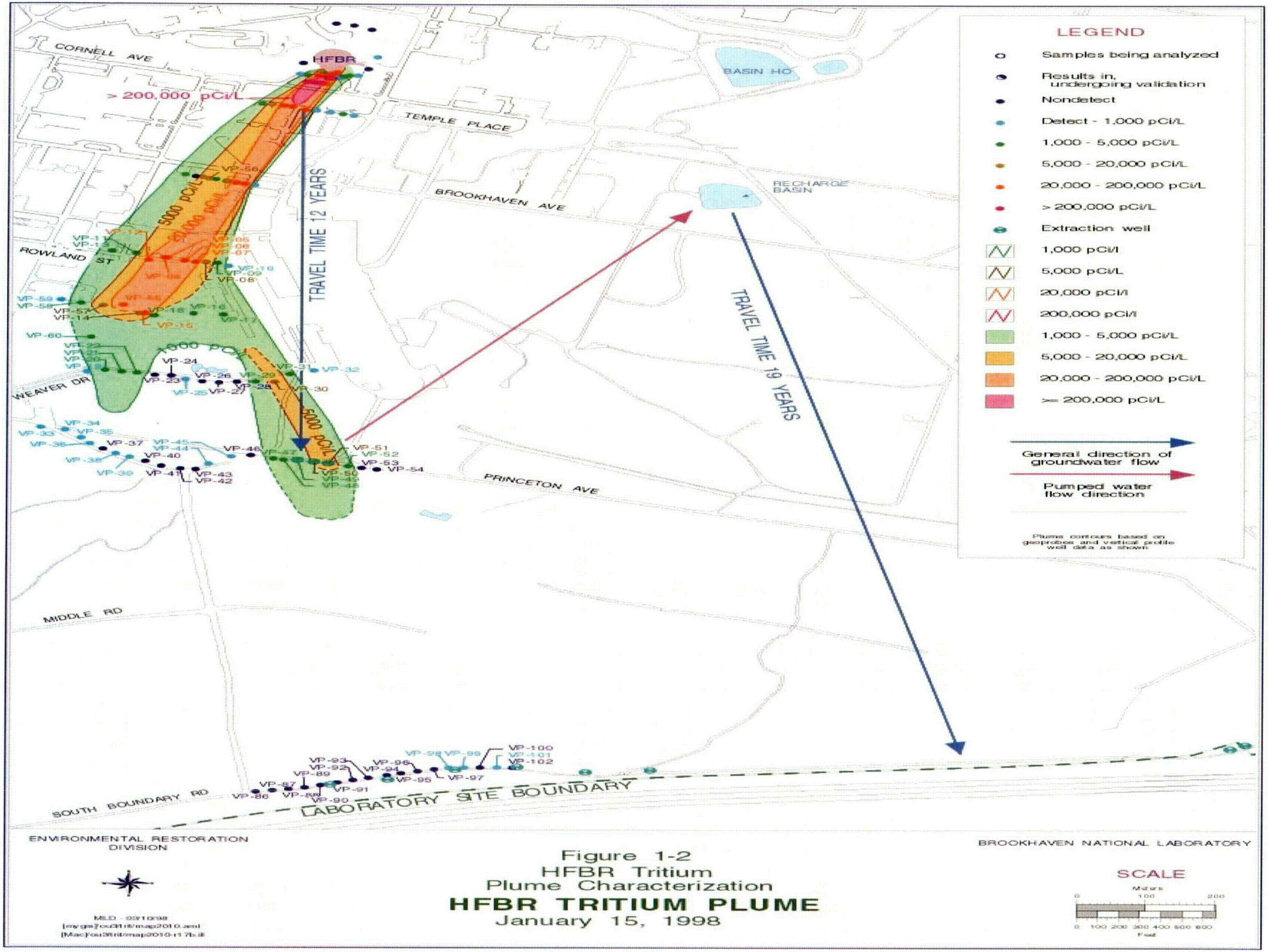


Figure 1-2
HFBR Tritium
Plume Characterization

HFBR TRITIUM PLUME

January 15, 1998

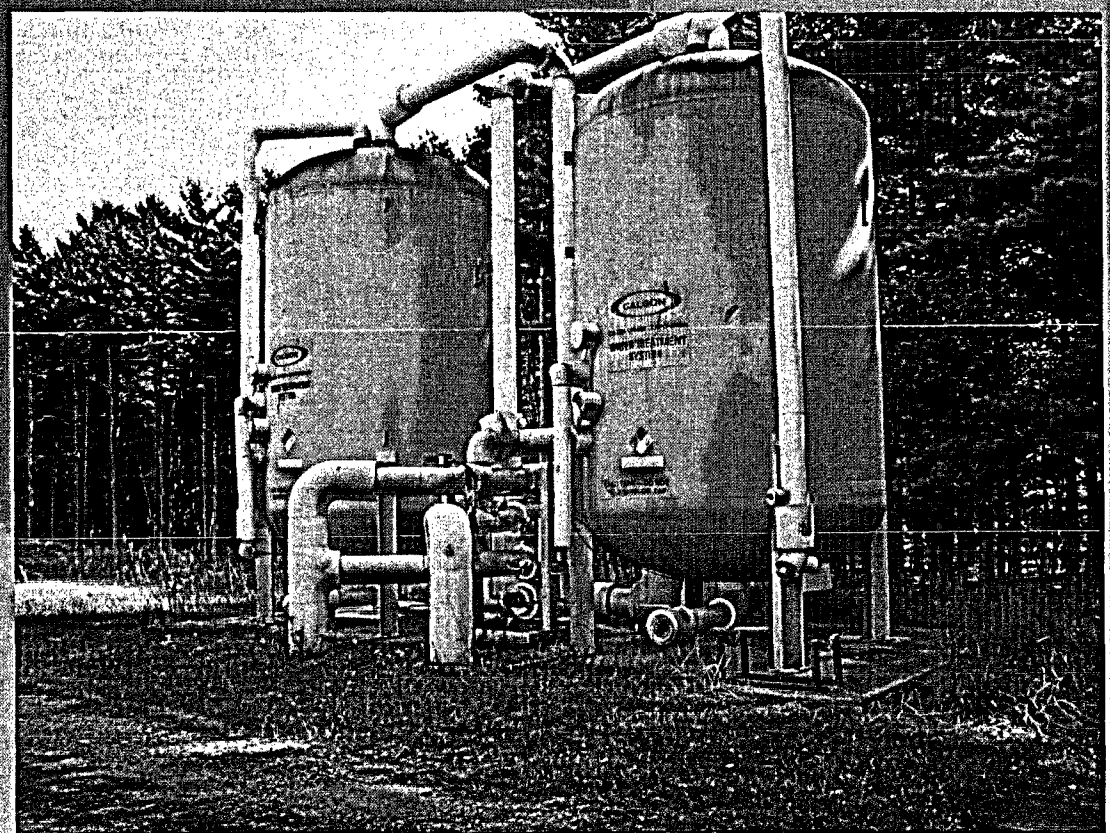
Tritium Plume Pump and Recharge System Operation

Modeling provided groundwater flow direction, time to cleanup, and pumping well locations/rate. Quarterly monitoring verified capture and plume behavior.

- 3 extraction wells
- Total of 120 gpm (3 x 40 gpm)
- Carbon treatment for VOCs
- After three years of pumping, system placed in standby mode in September 2000.

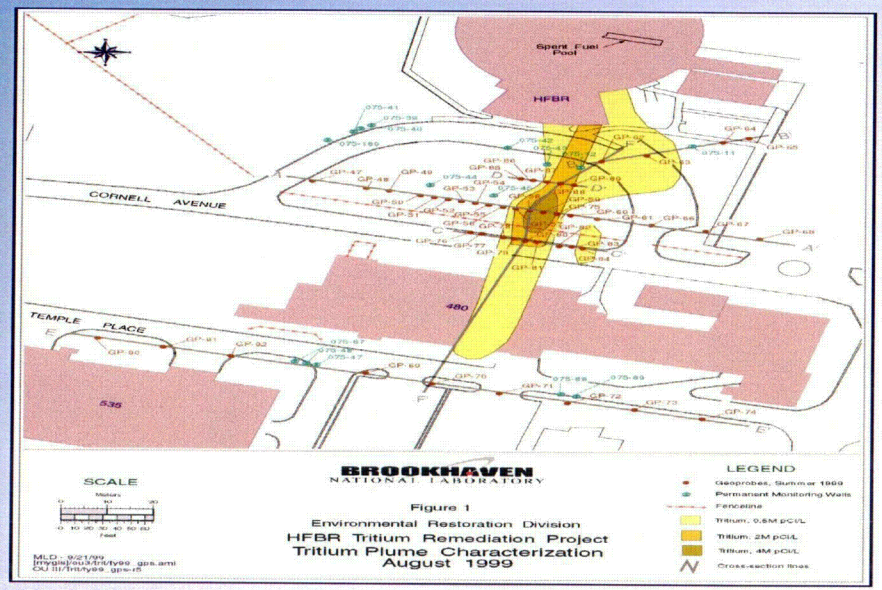
Tritium Plume

Carbon Treatment for VOCs



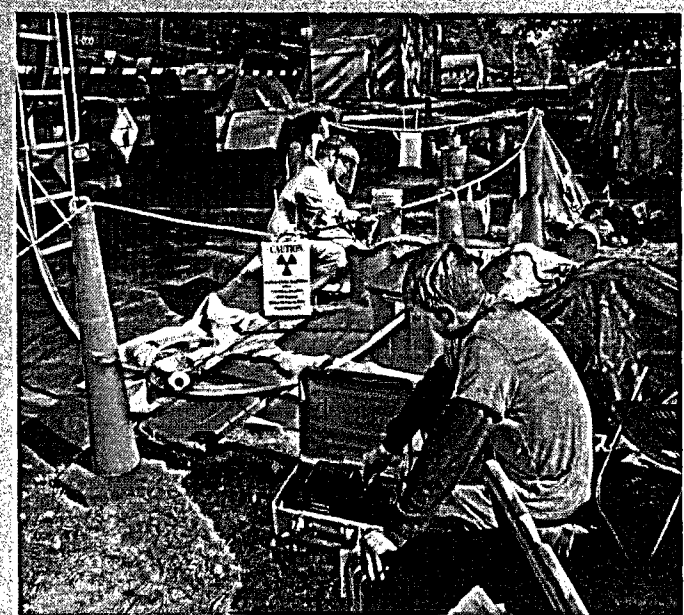
Tritium Plume Low Flow Extraction Design

Modeling provided pumping trigger concentration (750,000 pCi/L) and stop concentration (500,000 pCi/L) based on travel time to pump and recharge extraction wells and tritium dispersion and decay. Monitoring provided verification of the results.

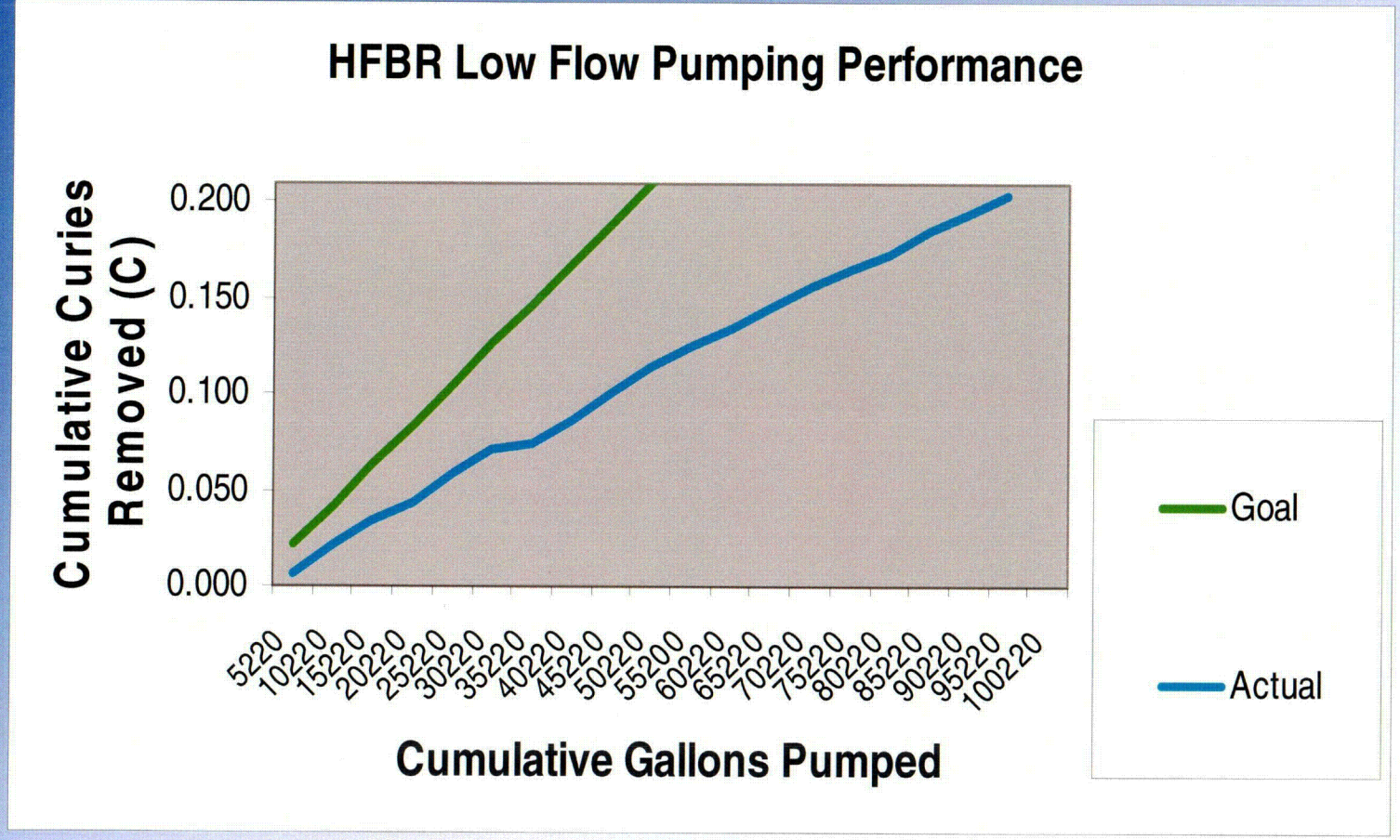


Tritium Plume Low Flow Pumping Operation

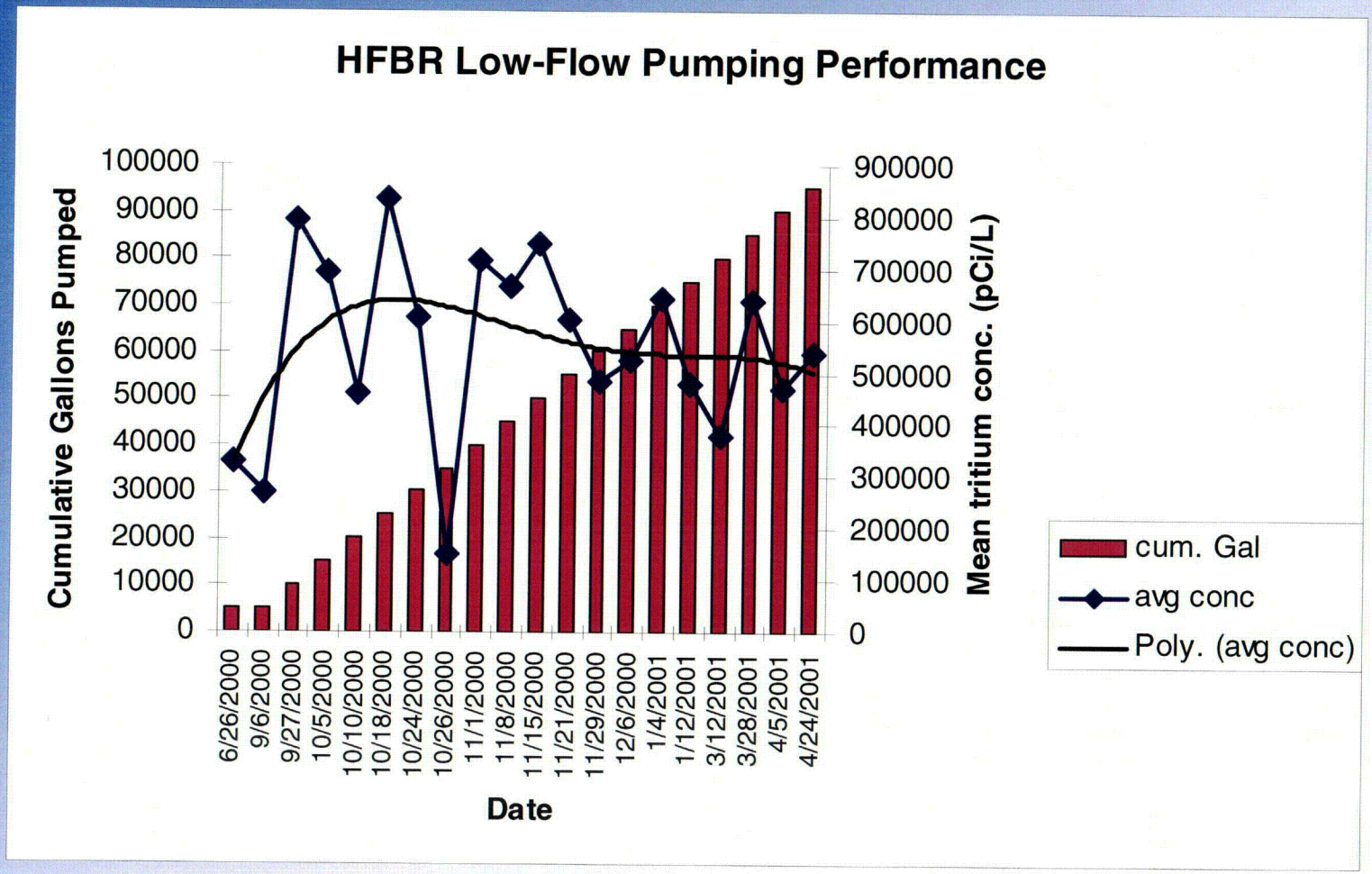
- High concentrations at the head of the plume near the source were extracted if concentrations exceeded 750,000 pCi/L.
- Total of 95,000 gallons and approximately 0.2 Ci out of 1.0 Ci were extracted.
- System inactive since April 2001.



Tritium Plume Low Flow Pumping Results



Tritium Plume Low Flow Pumping Results



Tritium Plume Management

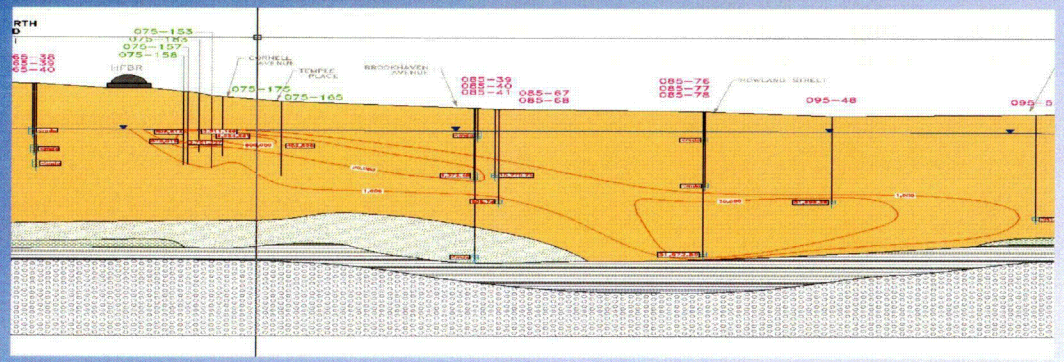
- Quarterly, semi-annual and annual monitoring provide verification of modeled plume behavior.
- Geoprobes, vertical profiles and permanent wells are used to maximize efficiency.
- Iterative approach results in improved model verification and increased monitoring efficiency.

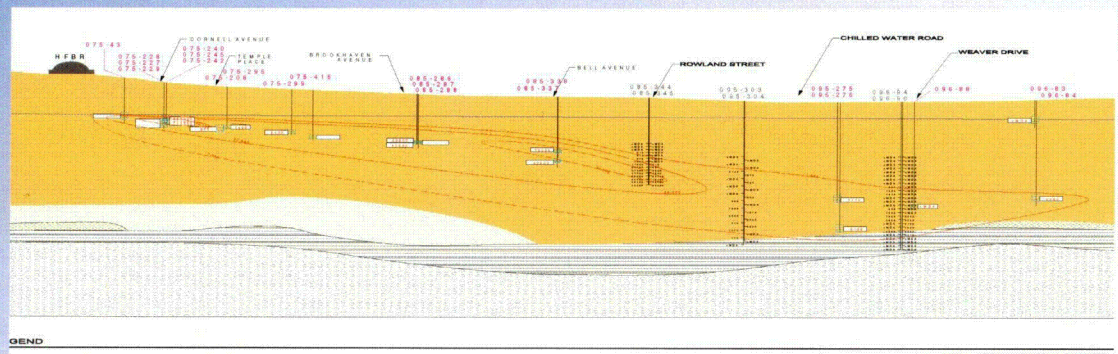
HFBR Tritium Plume 1997 - 2004

There has been significant success in plume management.

HFBR Tritium Plume Cross Section – 1999 and 2004

The plume has remained within its original envelope and concentrations have decreased ~5X.





HFBR Tritium Plume - Current Status and Lessons Learned

- Downgradient portion is naturally attenuating.
  - Pump restart trigger of 20,000 pCi/L at Weaver Drive never exceeded.
- Upgradient portion is attenuating but receiving additional tritium from the unsaturated zone beneath the HFBR.
  - Influence of regional groundwater elevation.
  - Low flow pumping trigger level has not been exceeded since 2001.
- Monitored Natural Attenuation to continue~10 yrs.
- Permanent wells for monitoring tritium in most groundwater may have some drawbacks.
- Temporary wells (Geoprobes) more accurate and cost effective.