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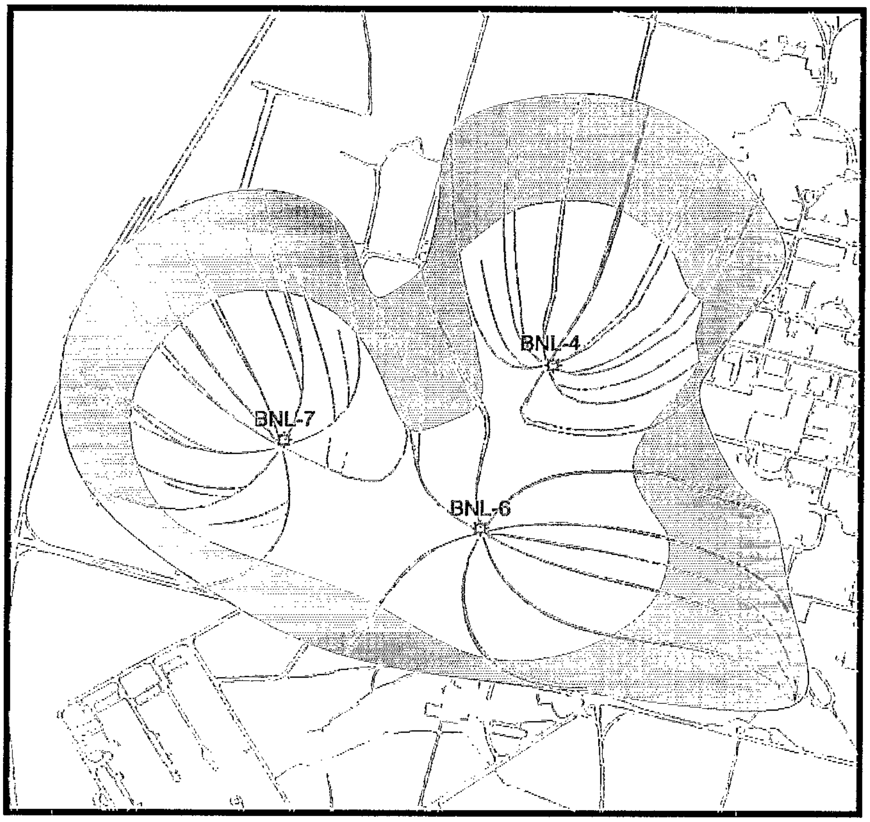
Brookhaven National Laboratory

Source Water Assessment for Drinking Water Supply Wells

December 27, 2000



Brookhaven National Laboratory
Operated by
Brookhaven Science Associates
Upton, NY 11973

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Brookhaven National Laboratory

Source Water Assessment for Drinking Water Supply Wells

December 27, 2000

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Environmental Services Division
Groundwater Protection Program

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Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

Executive Summary

The water supply for Brookhaven National Laboratory is obtained exclusively from six onsite wells that draw water from the Upper Glacial aquifer. These wells pump approximately 2.2-million gallons of water per day to meet the site's need for drinking water, process cooling water and fire protection. The 1996 amendments to the Safe Drinking Water Act require the preparation of Source Water Assessments for all sources of water that are used to supply public drinking water. The BNL Source Water Assessment was prepared to satisfy this requirement. Together with BNL's Environmental Management System, this Source Water Assessment is designed as a management tool to further protect the sole source aquifer system underlying the BNL site. Furthermore, the careful delineation and protection of BNL's source water areas will ensure that BNL operations are not adversely impacted due to the loss of one or more supply wells as a result of contamination.

The groundwater source areas for each water supply well were identified using the BNL Regional Groundwater Model. The extent of these source areas was compared to the inventory of known and potential sources of contamination identified as part of BNL's Environmental Restoration and Environmental Protection programs.

The BNL water supply system meets all water quality standards and has sufficient pumping and storage capacity to meet current and anticipated future operational demands. Because BNL's water supply is drawn from the shallow Upper Glacial aquifer, BNL's source water is susceptible to contamination. The quality of the water supply is being protected through (1) a comprehensive program of engineered and operational controls of existing aquifer contamination and potential sources of new contamination, (2) groundwater monitoring, and (3) potable water treatment.

This evaluation concluded that the source water for BNL's Western Well Field (comprised of Supply Wells 4, 6, and 7) has relatively few threats of contamination and that identified potential sources are already being carefully managed. The source water for BNL's Eastern Well Field (comprised of Supply Wells 10, 11, and 12) has moderate threats to water quality, primarily from several existing volatile organic compound and tritium plumes. The g-2 Tritium Plume and portions of the Operable Unit III volatile organic plume fall within the delineated source water area for the Eastern Well Field. In addition, portions of the much slower migrating strontium-90 plumes associated with the Brookhaven Graphite Research Reactor, Waste Concentration Facility and Building 650 lie within this source area. However, the rate of travel in the aquifer for strontium-90 is about one-twentieth of that for tritium and volatile organic compounds. Therefore, the time of travel to the supply wells for the strontium-90 plumes is significantly greater than 5 years. The Laboratory has been carefully monitoring plume migration, and has made adjustments to water supply operations.

Although a number of BNL's water supply wells were impacted by VOC contamination in the late 1980s, recent routine analysis of water samples from BNL's supply wells indicate that no drinking water standards have been reached or exceeded. The high quality of the water supply strongly indicates that the operational and engineered controls implemented over the past ten years have effectively protected the quality of the water supply.

Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

List of Acronyms

AGS	Alternating Gradient Synchrotron
AOC	Area of Concern
BGRR	Brookhaven Graphite Research Reactor
BLIP	Brookhaven LINAC Isotope Producer
BMRR	Brookhaven Medical Research Reactor
BNL	Brookhaven National Laboratory
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CY	Calendar Year
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GPMP	Groundwater Protection Management Program
MGD	Million Gallons per Day
MTBE	Methyl Tertiary Butyl Ether
NYSAWQS	New York State Ambient Water Quality Standard
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDWS	New York State Drinking Water Standard
OU	Operable Unit
pCi/L	Pico Curies per Liter
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SC	Suffolk County
SCDHS	Suffolk County Department of Health Services
SPDES	State Pollution Discharge Elimination System
SWAP	Source Water Assessment Program
TCA	1,1,1-trichloroethane
TCE	Trichloroethylene
TVOC	Total (cumulative concentration) Volatile Organic Compounds
µg/l	Micrograms per Liter
UST	Underground Storage Tank
VOC	Volatile Organic Compounds
WCF	Waste Concentration Facility
WMF	Waste Management Facility
WTP	Water Treatment Plant

Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

Table of Contents

Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

List of Figures

Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

List of Tables

Brookhaven National Laboratory
Source Water Assessment for Drinking Water Supply Wells

1.0 Introduction

The 1986 Amendments to the Safe Water Drinking Act (SWDA) authorized states to develop Wellhead Protection Programs that were designed to protect areas surrounding drinking water supply wells against contaminants that may have adverse effects on human health. Congress amended the SDWA in 1996, and required states to evaluate all sources of water (e.g., well, stream, lake or reservoir) that are used to supply public drinking water. Source Water Assessments (SWA) are required to determine where the public drinking water originates, list actual and possible sources of contamination located within the source area, and evaluate the likelihood that a source could be contaminated. The proposed period for conducting Source Water Assessments in New York is 2000 through 2001 (*NYS Source Water Assessment Program Plan*, November, 1999). The New York State Department of Health (NYSDOH) has delegated the development of the SWAP at the local level on Long Island to the Nassau and Suffolk County Health Departments.

Nassau and Suffolk Counties have a long history of groundwater management programs, beginning with the Nassau-Suffolk Comprehensive Development Plan (1972) that considered water quality issues, such as heavy metals and other toxic materials. The Long Island 208 Study (Koppelman 1978) was the first comprehensive attempt at water quality management on Long Island. The 208 Plan delineated eight major hydrogeologic zones on Long Island based on groundwater flow patterns and determined the areas that contribute recharge to the Upper Glacial and Magothy aquifers, which are used as sources of public drinking water. The Long Island Comprehensive Special Groundwater Protection Area Plan (1992) established nine special groundwater protection areas that are deemed critical for the maintenance of good water quality in the Upper Glacial and Magothy aquifers. In addition, the principal and primary aquifers have been defined and mapped through a cooperative program with the U.S. Geological Survey (Scorca *et al.* 1999). These concepts were forerunners of the Safe Drinking Water Act's Wellhead Protection Program, which is a pollution prevention program designed to protect groundwater sources that are relied upon by public drinking water systems.

The BNL SWAP was prepared as a proactive approach to address the SDWA requirements. Many of the elements and management aspects of the SWAP have already been developed and instituted as part of BNL's ongoing environmental management system. These program elements are described in BNL's Groundwater Protection Management Program Description (Paquette *et al.* 1998). The goal of BNL's source water assessment is the further protection of the sole source aquifer. Protection of this valuable resource will ensure that BNL can supply a clean source of drinking water and ensure that ongoing scientific research and fire protection operations are not adversely impacted due to the loss of one or more water supply wells due to contamination. The content of the BNL SWAP is consistent with the requirements outlined in the *NYS Source Water Assessment Program Plan* (NYSDOH, 1999), and with Nassau and Suffolk County's proposed plan for conducting source water assessments for public water supply wells on Long Island (*Long Island Source Water Assessment Program – Technical Work Plan*, 1999).

2.0 Groundwater Resources at BNL

There are three distinct water-bearing units underlying the BNL site: the Upper Glacial aquifer, Magothy aquifer, and the Lloyd aquifer. All six of BNL's active drinking water supply wells are completed (i.e., screened) in the Upper Glacial aquifer (Figure 1). The BNL process water supply wells shown on Figure 1 are not used for potable water supply and are not the subject of this source water assessment. In the vicinity of BNL, the Suffolk County Water Authority uses both the Upper Glacial and Magothy aquifers for public water supply. Figure 2 shows a generalized hydrogeological cross section through Long Island and the BNL site. The hydrogeologic characteristics of the Upper Glacial aquifer are briefly described below. Detailed descriptions on the hydrogeology of the BNL site can be found in deLaguna 1963; Warren *et al.* 1968; and Scorca *et al.* 1999.

2.1 Upper Glacial Aquifer

The Upper Glacial aquifer is composed of Pleistocene-aged deposits that extend from land surface to 130 feet to 200 feet below land surface. The broadly stratified, glacio-fluvial outwash deposits are composed primarily of silica-rich medium to coarse-grained sand and gravel. Thin layers of silt and clay have been observed within the outwash deposits, but do not represent significant barriers to groundwater flow. The hydraulic conductivity of the outwash deposits range from 80 to 200 ft/day. Near surface silt and clay deposits are located along the lowlands of the Peconic River watershed.

Groundwater in the Upper Glacial aquifer beneath BNL generally exists under unconfined conditions. However, in the areas along the Peconic River where low permeability near surface silt and clay deposits exist, semi-confined conditions may occur. Depth to groundwater varies from several feet below land surface within the lowlands near the Peconic River, to as much as 75 feet in the higher elevation areas located in the central and western portions of the site. The groundwater table is in the Upper Glacial aquifer. Shallow groundwater flow directions in the BNL area are influenced by natural drainage systems, varying between being eastward along the Peconic River, southeastward toward the Forge River, and southward toward the Carmans River (Figure 3). Additionally, supply and water treatment well pumping and recharge-induced stresses on the aquifer system are considerable in the central area of the site. Groundwater flow directions in the southwest corner of the site are also influenced by municipal water supply pumpage.

2.2 Classification of Groundwater Quality

The Nassau/Suffolk Aquifer System has been designated by the U.S. Environmental Protection Agency (EPA) as a Sole Source aquifer system, pursuant to Section 1424(e) of the Safe Drinking Water Act (SDWA). Groundwater in the sole source aquifers underlying the BNL site is classified as "Class GA Fresh Groundwater" by the State of New York (6 NYCRR Parts 700-705). The best usage of Class GA groundwater is as a source of potable water supply. As such, federal drinking water standards, NYS Drinking Water Standards (NYSDWS), and NYS Ambient Water Quality Standards (NYSAWQS) for Class GA groundwater are used as groundwater protection and remediation goals.

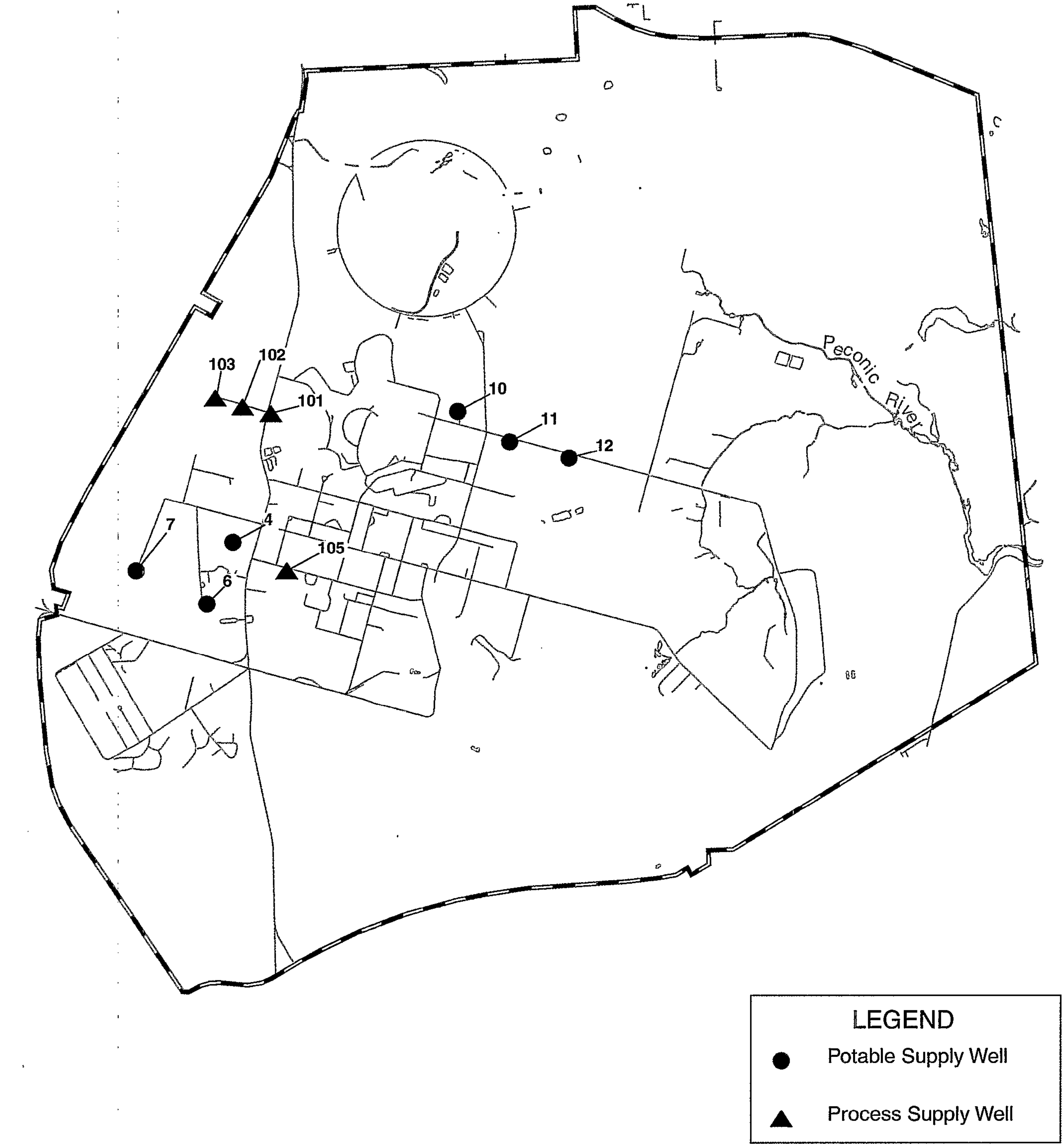

Figure 1
Location of BNL Supply Wells

Source Water Assessment for Drinking Water Supply Wells

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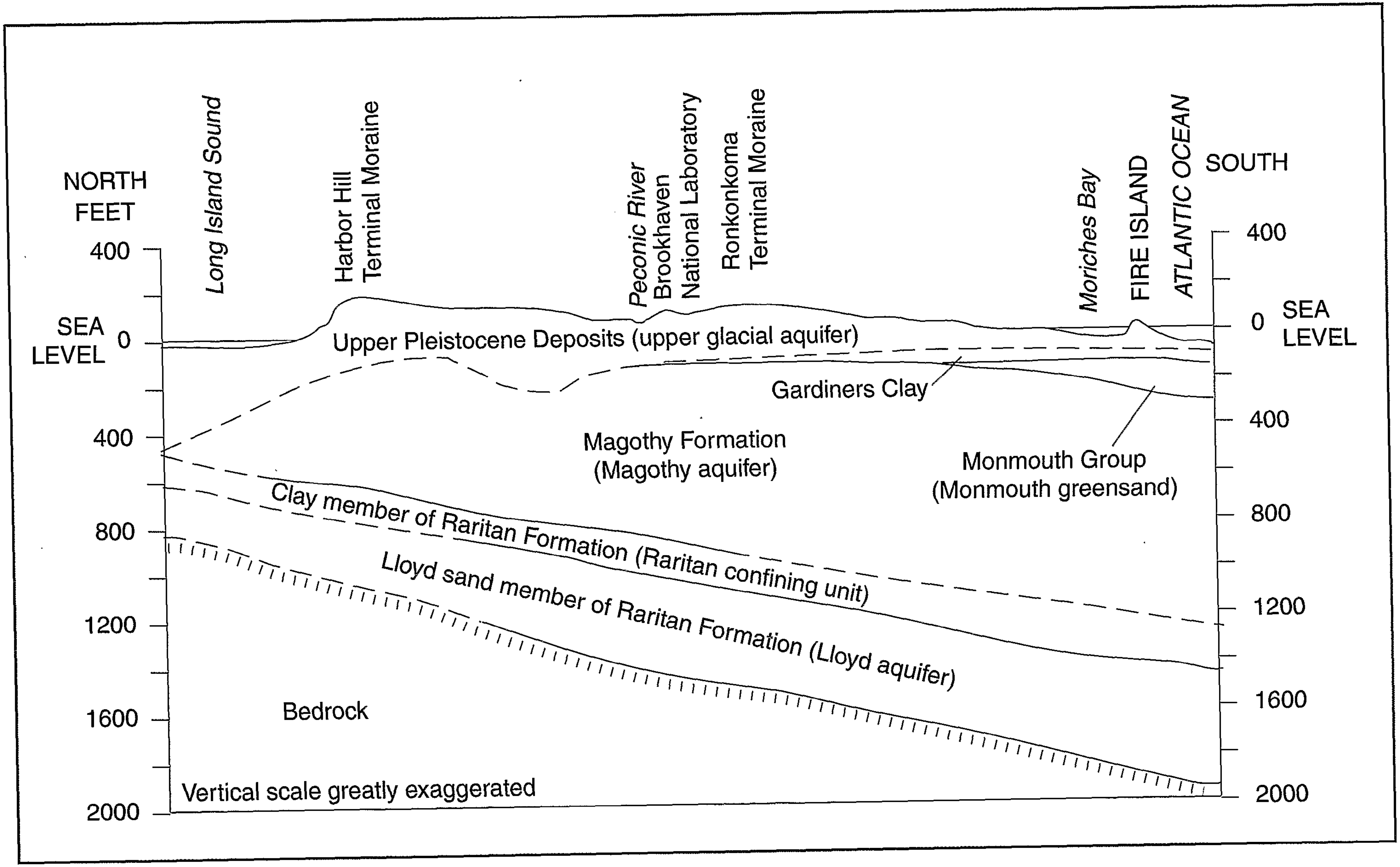
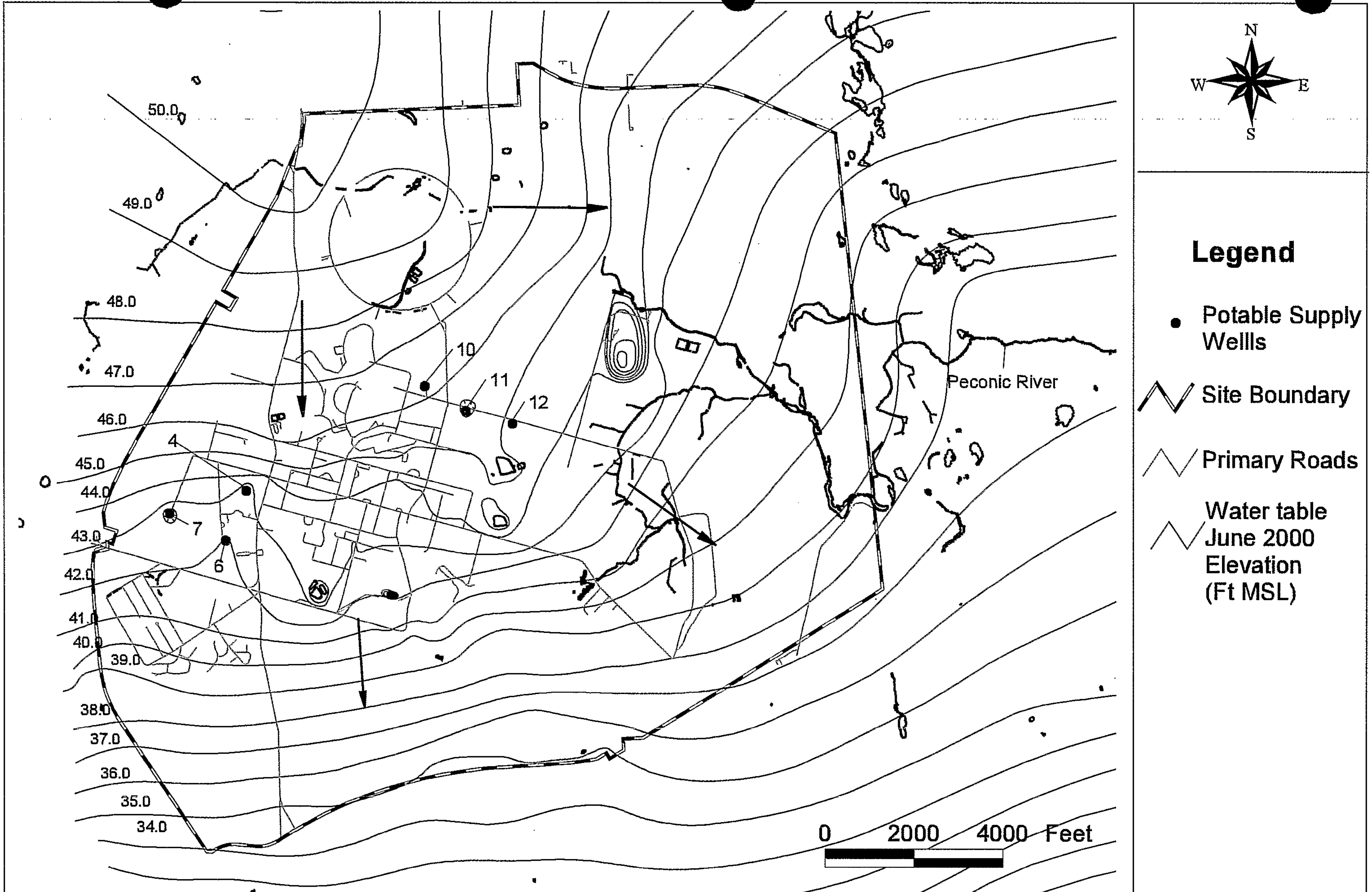
Generalized Geologic Cross Section In the Vicinity of Brookhaven National Laboratory

Figure 2





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Shallow Upper Glacial Aquifier Groundwater Contours

Source Water Assessment

Figure 3

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BNL evaluates the potential impact of radiological and nonradiological levels of contamination by comparing analytical results to NYS and DOE reference levels. Nonradiological data from groundwater samples collected from surveillance wells are usually compared to NYSAWQS [6 NYCRR Part 703.5]. Radiological data are compared to the NYSDWS (for tritium, strontium-90, and gross beta), NYSAWQS (for gross alpha, radium-226, and radium-228), and 40 CFR 141/DOE DCGs (for determining the 4 mrem/yr dose for other beta-/gamma-emitting radionuclides).

3.0 Groundwater Use at BNL

3.1 Water Supply System

The drinking water supply at BNL is obtained exclusively from six supply wells that are screened in the Upper Glacial aquifer. BNL potable water Supply Wells 4, 6, and 7 comprise BNL's Western Well Field, and Wells 10, 11 and 12 comprise the Eastern Well Field. Figure 1 shows the locations of the BNL potable supply wells. Historically, BNL has operated a number of large capacity process water supply wells used to provide water for heating and cooling purposes (Wells 101, 102, 103 and 105). The use of these wells was discontinued in 1999, and water for all cooling and heating is now being provided using the drinking water supply system. The BNL supply wells are operated under New York State Department of Environmental Conservation (NYSDEC) Long Island Well Permit 1-4722-00032/00113 granted to the U.S. Department of Energy on September 14, 1998. BNL submits an annual Water Pumpage Report to the NYSDEC that summarizes total pumpage for all BNL potable and process supply wells, and groundwater treatment (remediation) system wells.

Each BNL potable supply well is capable of delivering up to 1,200 gallons per minute (gpm) to the potable water system. The six potable wells are used in rotation to meet the daily water supply requirements for the site. During 1999, the average water usage at BNL was 2.2 million gallons per day (MGD). Most of the water (approximately 75 percent) is returned to the aquifer by way of onsite recharge basins and permitted discharges to the Peconic River. Under normal hydrologic conditions most of the water discharged to the Peconic River recharges to the Upper Glacial aquifer before leaving the BNL site.

3.2 Water Supply Management

Managing groundwater consumption at BNL and understanding the effects of groundwater withdrawals on the regional hydrogeological regime are important components of the BNL Groundwater Protection Program. The Upper Glacial aquifer is highly permeable, and yields significant quantities of water throughout the BNL area. The present rate of groundwater pumpage at BNL, coupled with significant recharge after use, results in only a minor net loss in the quantity of water stored in the Upper Glacial aquifer. However, since pumping of supply wells and subsequent recharge of this water does cause significant changes in groundwater (and possibly contaminant) flow directions and velocities, conservation of water by minimizing pumping is important. Since the early 1990s, total pumpage from the potable wells has been reduced from approximately 3.5 MGD to 2.2 MGD. This reduction has been realized by the implementation of water conservation projects, which have included distribution system upgrades to prevent water loss and the identification and correction of wasteful water use practices.

Assessment of future water supply requirements are outlined in the *BNL Water Utility Master Plan, 1989-2000* (BNL, 1989). The Master Plan includes an assessment of needed water supply system upgrades (e.g., new distribution lines, treatment and storage facilities, and well modifications and replacements), daily water demands, fire fighting capabilities, and predicted growth. Based upon assessments of predicted growth in employee population and potential water demands for planned future research and support facilities, the current supply well network is capable of providing adequate supply of both potable and non-contact cooling water for the site. However, to maintain proper flow and pressure conditions, modifications to the existing distribution system may be required. Possible locations of future supply wells are provided in Section 6 of this SWAP.

3.3 Potable Water Treatment Systems

Potable water obtained from BNL's Western Supply Well Field (Wells 4, 6, and 7) contains naturally occurring iron at concentrations that exceed the NYSDWS of 0.3 mg/L. Before entering the distribution system, this water is first treated at the BNL Water Treatment Plant (WTP) using a conventional lime softening process to precipitate the iron from solution. Water obtained from the Eastern Well Field (Wells 10, 11 and 12) is low in iron, and therefore does not require treatment. Chlorination of the water supplied from Wells 4, 6, and 7 is accomplished by the use of sodium hyprochlorite at the WTP. Individual sodium hypochlorite dosing systems are installed at Wells 10, 11, and 12. Water obtained from the Upper Glacial aquifer is naturally slightly acidic, with a pH in the range of 5.5 to 6.5 Standard Units (SU). To reduce the corrosivity of the water, sodium hydroxide is added to maintain the pH of the potable water at approximately 8 SU. By increasing the alkalinity of the water, the dissolution of lead from older soldered pipe joints is reduced. Occasionally, raw (untreated) water pumped from some of the water supply wells has contained volatile organic compounds (VOC) at concentrations slightly exceeding NYSDWS. Water obtained from the eastern area Wells 10, 11, and 12 is treated at the wellhead for VOCs using large capacity carbon filters. Water from western area Wells 4, 6, and 7 is treated for VOCs at the Water Treatment Plant by the use of air stripping towers.

3.4 Potable Water Monitoring Program

The SDWA requirements pertaining to the distribution and monitoring of public water supplies are applicable to any water supply that has at least five service connections or regularly serves at least 25 individuals. The Laboratory supplies water to a population of approximately 3,500 employees and visitors and must, therefore, comply with these regulations. The SCDHS - Bureau of Drinking Water specifies the annual minimum monitoring requirements for all potable-water suppliers. If a contaminant were to be detected in a supply well sample at concentrations exceeding applicable drinking water standards, the well is immediately shutdown and an investigation into the source of the contamination is conducted. Follow-up actions, including the collection of additional samples for confirmatory analyses and communications with water users and regulatory agencies is described in the *BNL Groundwater Contingency Plan* (BNL 2000).

For drinking water supplies, the federal maximum contaminant levels (MCLs) set forth in 40 CFR 141 (primary MCLs) and 40 CFR 143 (secondary MCLs) apply. In addition, DOE Order 5400.5, Radiation Protection of the Public and Environment, establishes Derived Concentration Guides (DCGs) for radionuclides not covered by existing federal or state regulations. On an annual basis, BNL prepares a *Potable Water System Sampling and Analysis Plan* that outlines sampling procedures and schedules for monitoring the BNL's potable water supply system (see

Chaloupka, 2000). Routine monitoring of the potable wells and the potable-water distribution system by BNL exceeds the prescribed minimum monitoring requirements. The monitoring program consists of: monthly bacteriological analyses; quarterly analyses for Principal Organic Compounds (POCs); annual analysis for Synthetic Organic Compounds (SOCs) and pesticides; semi-annual inorganic chemicals analyses; and annual analyses of micro-extractables and asbestos. Potable water samples are collected by BNL personnel, and are analyzed by New York State Department of Health (NYSDOH) certified contractor laboratories using standard USEPA methods. BNL prepares monthly *Water System Operations Reports* that are submitted to the SCDHS - Bureau of Drinking Water. These reports include a summary of all analytical data. In addition to the SCDHS requirements, BNL maintains a supplemental sampling and analysis program for the BNL potable well system that includes more frequent analyses for radionuclides (see Daum *et al.*, 2000).

4.0 Source Water Assessment for BNL Potable Supply Wells

The delineation policies of the Wellhead Protection Program established a "baseline" two-zone wellhead protection area for all public systems using groundwater supplies and allow flexibility for locally initiated refinements or revisions (NYSDOH, 1999). This policy emphasized regional aquifer management for wells in unconsolidated aquifers like those found on Long Island. Most source water assessments use an intermediate fixed radius (e.g., one mile) delineation approachor a more sophisticated computer modeling approach. Source water areas for BNL's potable water wells were determined using the BNL Regional Groundwater Model. The BNL Regional Groundwater Model has undergone periodic calibration and refinement processes, and is used extensively for the BNL Environmental Restoration program.

4.1 BNL Groundwater Model

The calibrated groundwater flow model (developed for BNL by Arcadis, Geraghty & Miller, Inc. [1996, 1999]) was used to simulate the groundwater flow regime under two water supply operating scenarios. A particle track analysis was then performed to trace the groundwater flow paths in the study area. The analysis code of the groundwater flow path used was a semi-analytical particle-tracking scheme known as MODPATH (Pollack 1994). The flow path was delineated using reverse particle tracking, whereby particles were introduced into the modeled supply well and tracked backwards along flow path lines. The two-year and five-year travel time zones were delineated using this approach. This zone, defined by time-of-travel approach, is consistent with USEPA guidance on Wellhead Protection (USEPA, 1987). Because of BNL's extensive environmental protection and monitoring programs, the two and five year travel time zones are considered adequate for source water protection planning.

Groundwater models are a simplified representation of the complex groundwater system. Particle-tracking codes simulate advective transport only (the dominant contaminant transport mechanism at BNL) and neglect contaminant attenuation processes (e.g., dispersion, sorption, chemical reactions, and dilution), which can slow the rate of migration. Because particle tracking does not simulate dispersion (which can cause low levels of contamination to migrate ahead of its center of mass), it needs to be applied cautiously to compute the first arrival of measurable contamination. Nevertheless, particle tracking is recognized as a suitable planning technique if applied carefully.

4.2 Water Supply Pumping Scenarios

The groundwater flow direction and rate in the Upper Glacial aquifer at BNL is strongly influenced by water supply and remediation pumping and recharge. In 1999, the average BNL potable water demand was approximately 2.2 MGD. Given variations in water use demands throughout the year due to fluctuations in seasonal temperatures, experiment run times, and worker and guest population, predicting future water demand is challenging. However, the 1999 potable water pumpage volume is considered a reasonable estimate for future water consumption needs, and was therefore used as representative volume for this source water evaluation. If this demand were to change significantly in the future, then the source water assessment would have to be updated.

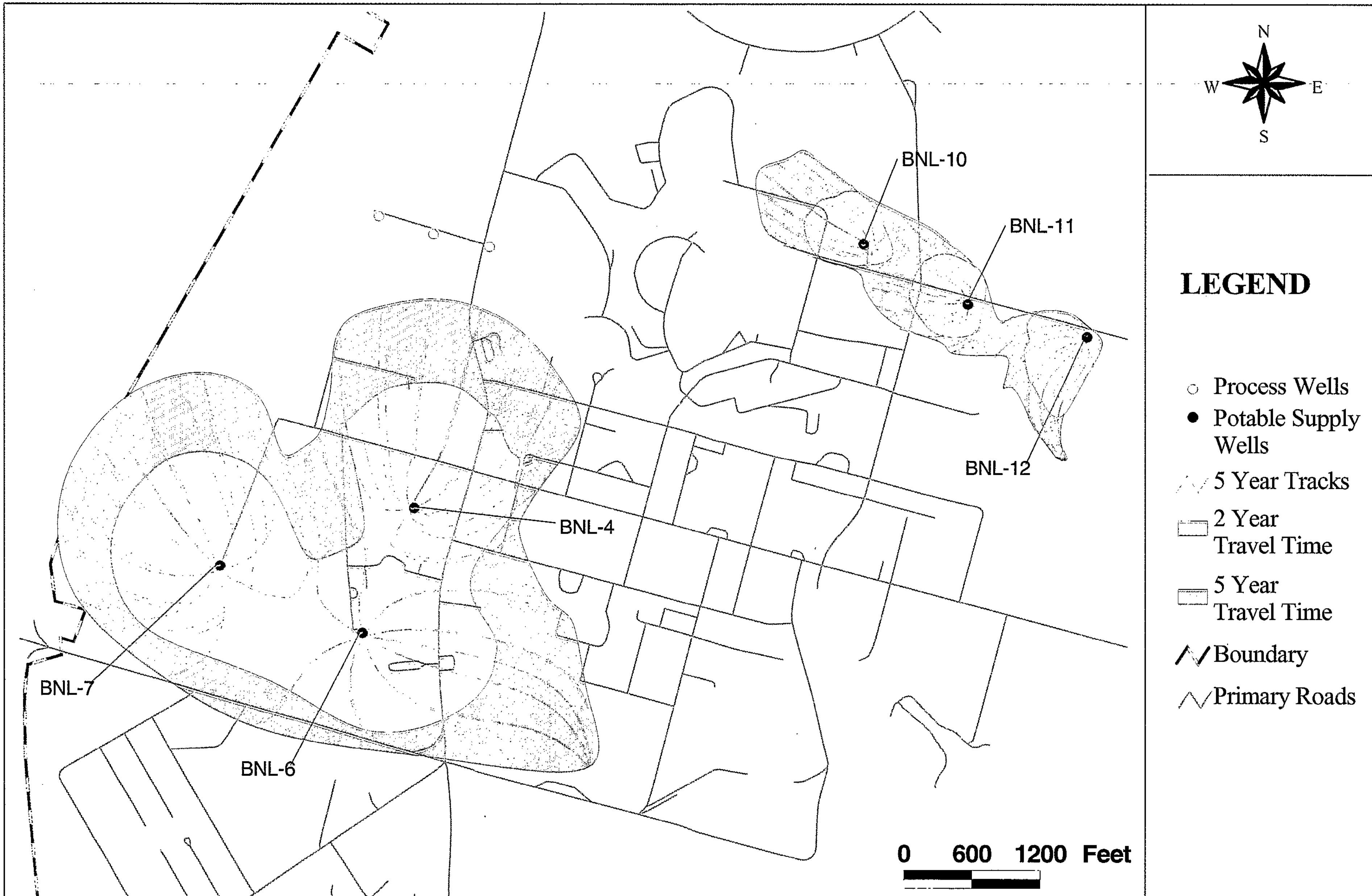
While all six potable supply wells are in use each year, they are cycled on and off during any given period. Because water derived from Wells 4, 6, and 7 requires treatment for the removal of naturally occurring iron, and the treatment plant has a minimum and maximum operating rate, the site-pumping rate is not split among the two well fields. Operationally, either the Western or Eastern Well Field is the primary source of water at any one time. Certain wells operate in the "lead" position, which means that they produce the majority of the water to meet demand. Although the other wells are operational, they are used in the lag position and provide a lower volume of water to the distribution system.

Based on current forecasts for the next five years (2000-2005), it is anticipated that Wells 4, 6, and 7 (the Western Well Field) will be operated in the "lead" position, and supply approximately 85% of the annual demand. Wells 10, 11, & 12 (the Eastern Well Field) will supply about 15% of annual demand. Each well cycles on for a few days, and the cycle rotates. The modeled pumping rates are based on average annual demand for a particular well field and assume that the pumpage is divided equally among wells in that well field. For the purposes ofthe source water assessment, two pumping scenarios were evaluated. Under Scenario 1, the Western Well Field pumpage is 85% of demand (1.8 MGD), whereas the Eastern Well Field pumpage provides 15% of demand (0.32 MGD). Conversely, under Scenario 2 the Western Well Field pumpage provides 15% of demand (0.32 MGD), whereas the Eastern Well Field provides 85% of demand (1.8 MGD). The defined source water areas under both of these pumping scenarios are presented as Figures 4 and 5. These results indicate that during periods of "lead position" withdrawals (i.e., when a well field is supplying 85% or more of the average demand) the two-year source water areas extend approximately 1,000 feet away from each supply well. Under "lead position" pumping conditions, the five-year source water areas typically extend up to 1,700 feet from each supply well.

5.0 Susceptibility of the Water Supply Wells to Contamination

This section evaluates the inventory of known and potential contaminant source areas located within the water supply source areas to determine whether the water supply is adequately protected. It also identifies any activities that may need additional operational and/or engineered controls to increase the level of protection.

Historically, the operations of a number of BNL potable and process supply wells were impacted by groundwater contamination. In the late 1980s and early 1990s, the operations of six of BNL's drinking water supply wells were severely impacted by VOC contamination (primarily due to the solvent 1,1,1-trichloroethane). As a result, three older wells (Wells 1, 2 and 3) were permanently



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Water Supply Source Water Areas

Pumping Scenario 1

Figure 4

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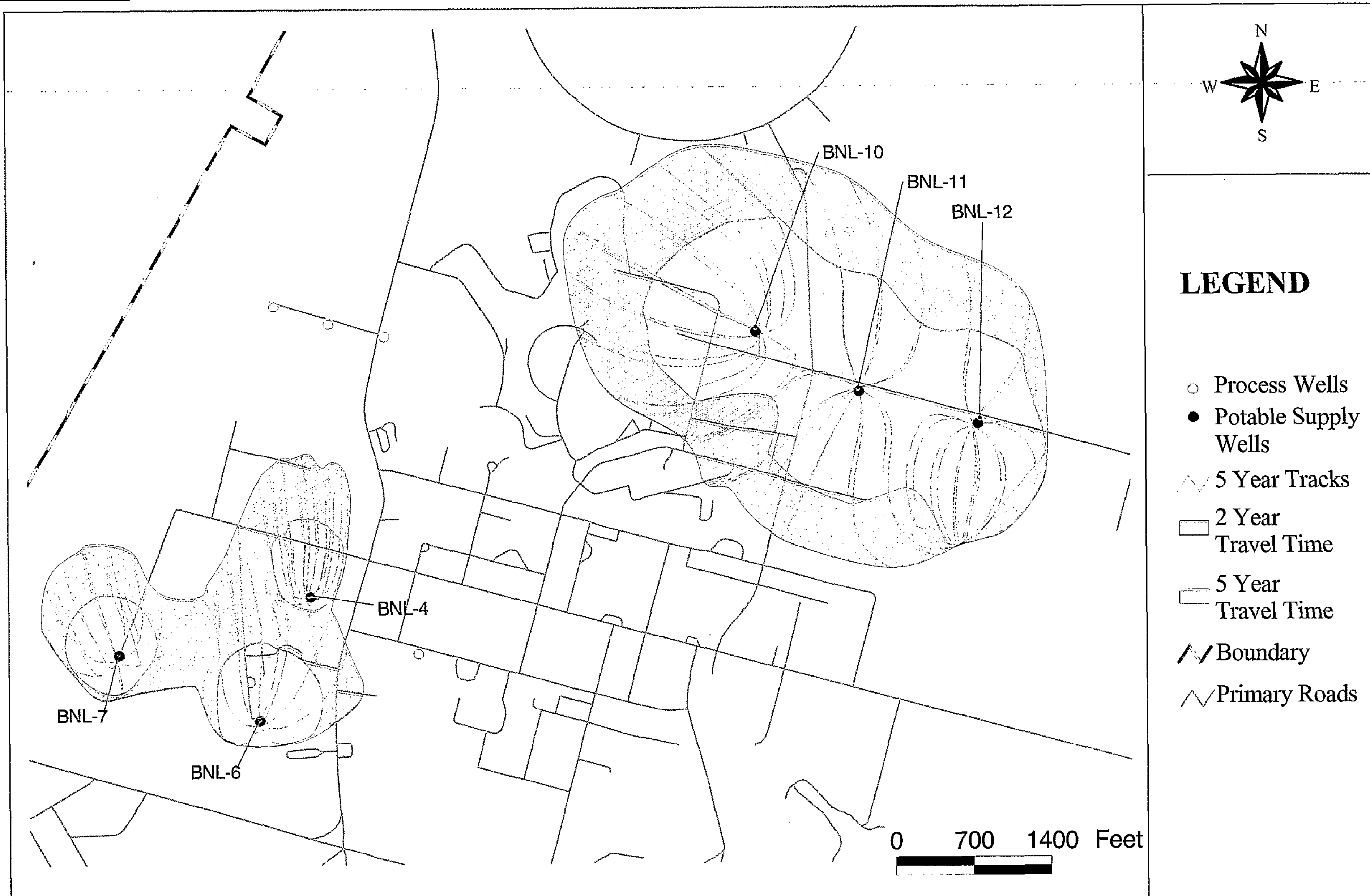

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Water Supply Source Water Areas

Scenario 2

Figure 5

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decommissioned, and large capacity carbon filters were installed on the remaining three impacted wells (Eastern Areas Wells 10, 11 and 12). Although trace amounts of VOCs were detected in samples from Western area Well 4 (primarily 1,1,1-trichloroethane at concentrations <5 μg/L), the operation of this well was not impacted. Over the past several years, BNL's drinking water was in full compliance with all county, state, and federal regulations, and no (untreated) water samples collected at the supply wells were found to have contaminant concentrations that exceeded NYSDWS. This strongly indicates that the operational and engineered controls that were put in place during the 1990s have effectively protected the quality of the drinking water supply.

5.1 Inventory of Known or Potential Contaminant Source Areas

The inventory of known or potential contaminant source areas located within the defined source water regions for each well field include:

- Existing VOC and radionuclide plumes originating from a variety of source areas (see Figures 6 and 7).
- Hazardous and Radioactive Waste Storage Areas BNL (Satellite Accumulation Areas, 90-Day Accumulation Areas, and the centralized Waste Management Facility (WMF).
- Investigation Derived Waste (IDW) storage areas (i.e., wastes generated during environmental investigations).
- Class V Underground injection control (UICs) devises which include sanitary and other wastewater disposal systems, such as drywells, cesspools, septic tanks, and leach fields (Figures 6 and 7).
- Existing groundwater contamination plumes that are being managed as part of the Environmental Restoration program.
- Activated soil-shielding areas at the Alternating Gradient Synchrotron (AGS) Facility (Figures 8 and 9).
- Facilities with activated water systems such as the AGS and Brookhaven Medical Research Reactor facilities (Figures 8 and 9).
- Underground and above ground storage tanks and bulk chemical and radioactive liquid waste storage areas (Figures 10 and 11).
- Sanitary lines that run from research and support facilities to the Sewage Treatment Plant (Figures 12 and 13)[1].
- Accidental spills of chemicals or radioactive materials.
- Use of fertilizers and pesticides.

The impacts of each of these potential vulnerabilities are summarized in Tables 1 and 2. Environmental monitoring programs associated with the known or suspected source areas is described in greater detail in the *BNL Groundwater Protection Management Program Description* (Paquette *et al.*, 1998), the *BNL Environmental Monitoring Plan* (Daum *et al.*, 2000), and the BNL Groundwater Monitoring Report (see Dorsch *et al.*, 2000).

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1 During 1990 to 2000, BNL replaced or re-lined approximately 51,000 linear feet of sanitary line. This represents approximately 50 percent of the sanitary lines at BNL. Primary focus of this program has been to replace or line the larger trunk lines that extend from the central, developed portion of the site to the Sewage Treatment Plant.

5.2 Comparison of Well Source Areas and Inventoried Contaminant Sources

The known or potential contaminant source areas described above were mapped against the two- and five-year groundwater travel times for each well field for both scenarios presented in Section 4. Figures 6, 8, 10, and 12 show the relationship between water supply source water areas under Scenario 1 (the current and anticipated long-term operational condition) and known or potential contaminant source areas and existing plumes. Table 1 provides a summary of known or potential contaminant source areas and current operational and engineered controls for the source water areas defined under Scenario 1. Figures 7, 9, 11, and 13 show the relationship between water supply source areas under Scenario 2 (possible operational condition) and known or potential contaminant source areas and existing plumes. Table 2 provides a summary of known or potential contaminant source areas within the defined source water areas for each well field for Scenario 2.

The source water for supply Wells 4, 6, and 7 has relatively few threats to contamination. Those identified are already being carefully managed. The source water for supply wells 10, 11, and 12 has a moderate number of threats, primarily from tritium and VOCs. Although the source water area includes a portion of the strontium-90 plumes associated with the Brookhaven Graphite Research Reactor, Waste Concentration Facility and Building 650 Sump Outfall, it has been demonstrated that strontium migrates at one-twentieth the rate of groundwater flow. Hence their time of travel to the supply wells in this operational mode is significantly greater than 5 years. Nevertheless, these issues require careful monitoring and water supply operational changes as necessary.

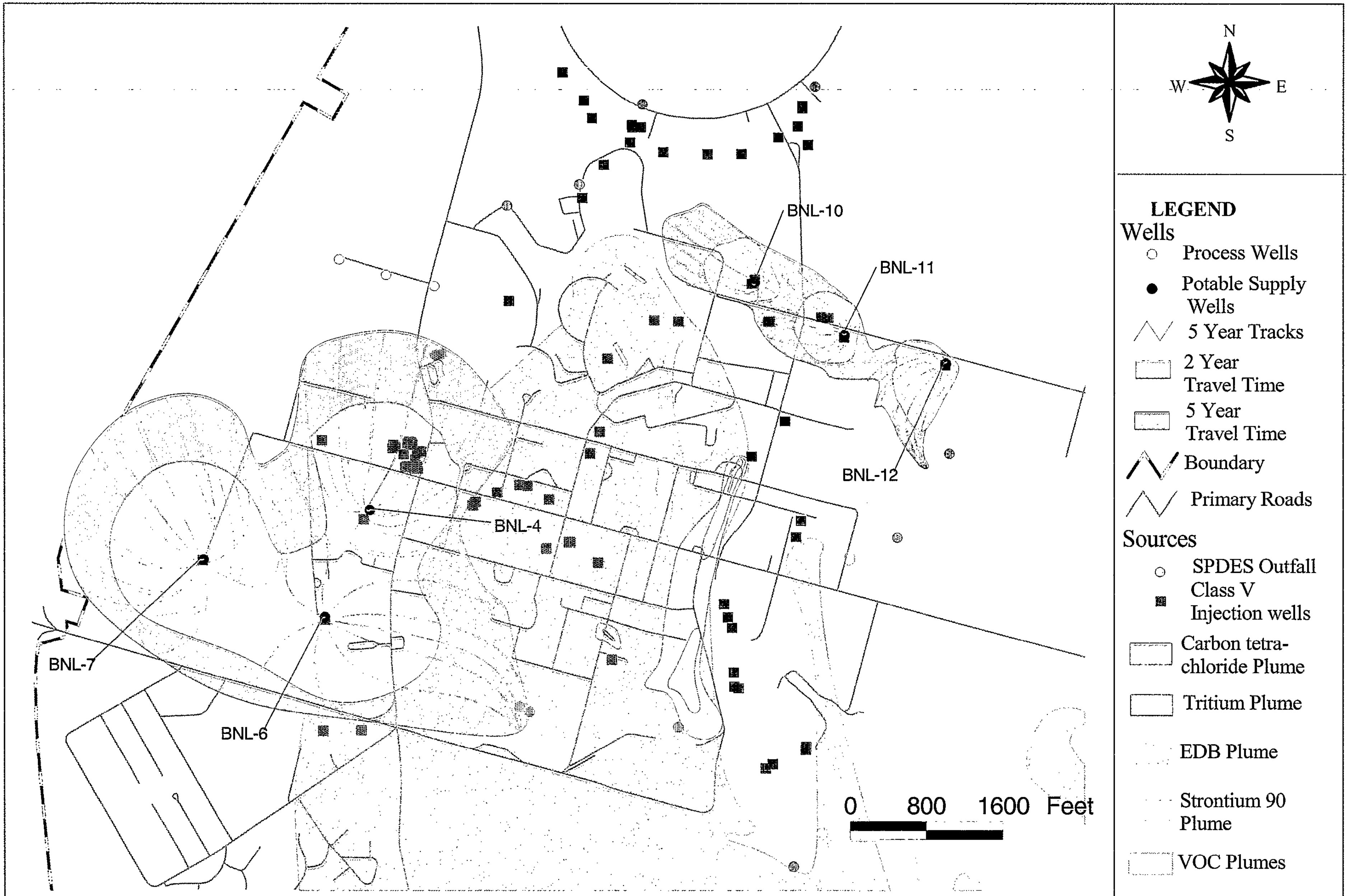
6.0 Future Water Supply

According to the BNL Water Utility Master Plan: 1989-2000 (BNL, 1989), BNL's water supply infrastructure is capable of meeting current and projected usage demand. Nevertheless, if the water quality in the existing source water areas is unexpectedly and significantly degraded, a contingency plan should be made to develop a new source of water supply. This contingency plan will be included in future revisions of BNL's Water Utility Master Plan.

Identifying potential installation locations for a future water supply well or well field is a complex task, and is beyond the scope of this SWAP. In general, some of the important siting criteria include:

- New supply wells can be easily connected to existing water distribution and power systems.
- Wells can be completed (screened) in aquifer material that provides good production (or yield) and good water quality (i.e., low in naturally occurring metals such as iron).
- Groundwater withdrawals would not adversely impact current or planned remedial activities (i.e., divert plume away from an existing or planned treatment system).
- Low risk of being impacted by existing or potential contaminant sources and the need for new treatment systems.
- No impact to surface water hydrology (e.g., Peconic River or associated wetlands).

Based on these criteria, several areas of the BNL site were identified as potential installation sites for new water supply wells (Figure 14). One potential well installation area is located to the east-northeast of the Eastern Well Field. Use of groundwater in this area would be the preferred alternative because it has naturally low levels of iron and has not been impacted by site



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Water Supply Source Water Areas and Locations of Existing Plumes, Underground Injection Control Devices and SPDES Outfalls - Pumping Scenario 1

Figure 6

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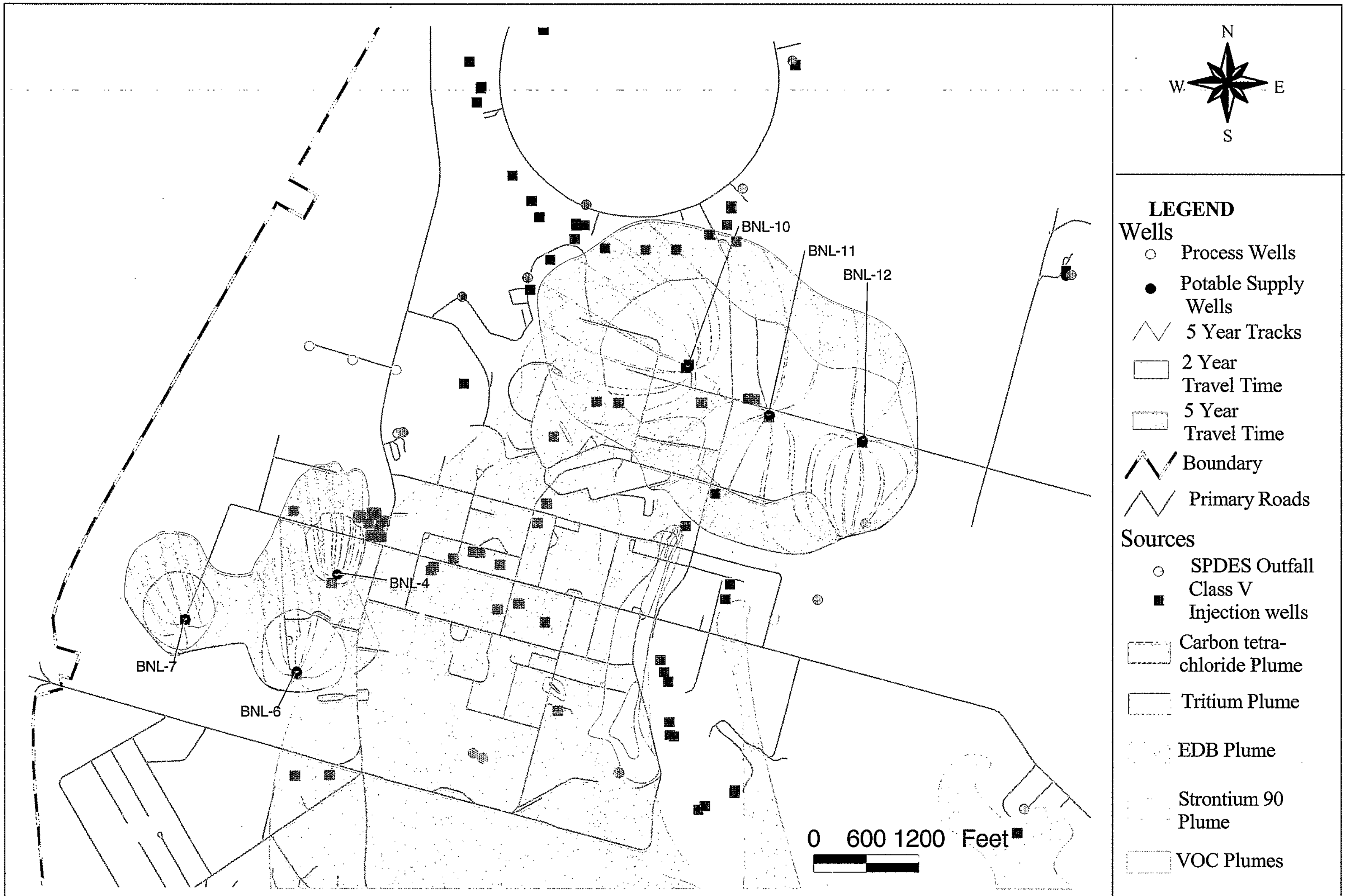

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Water Supply Source Water Areas and Locations of Existing Plumes, Injection Control Devices, and SPDES Outfalls - Pumping Scenario 2

Figure 7

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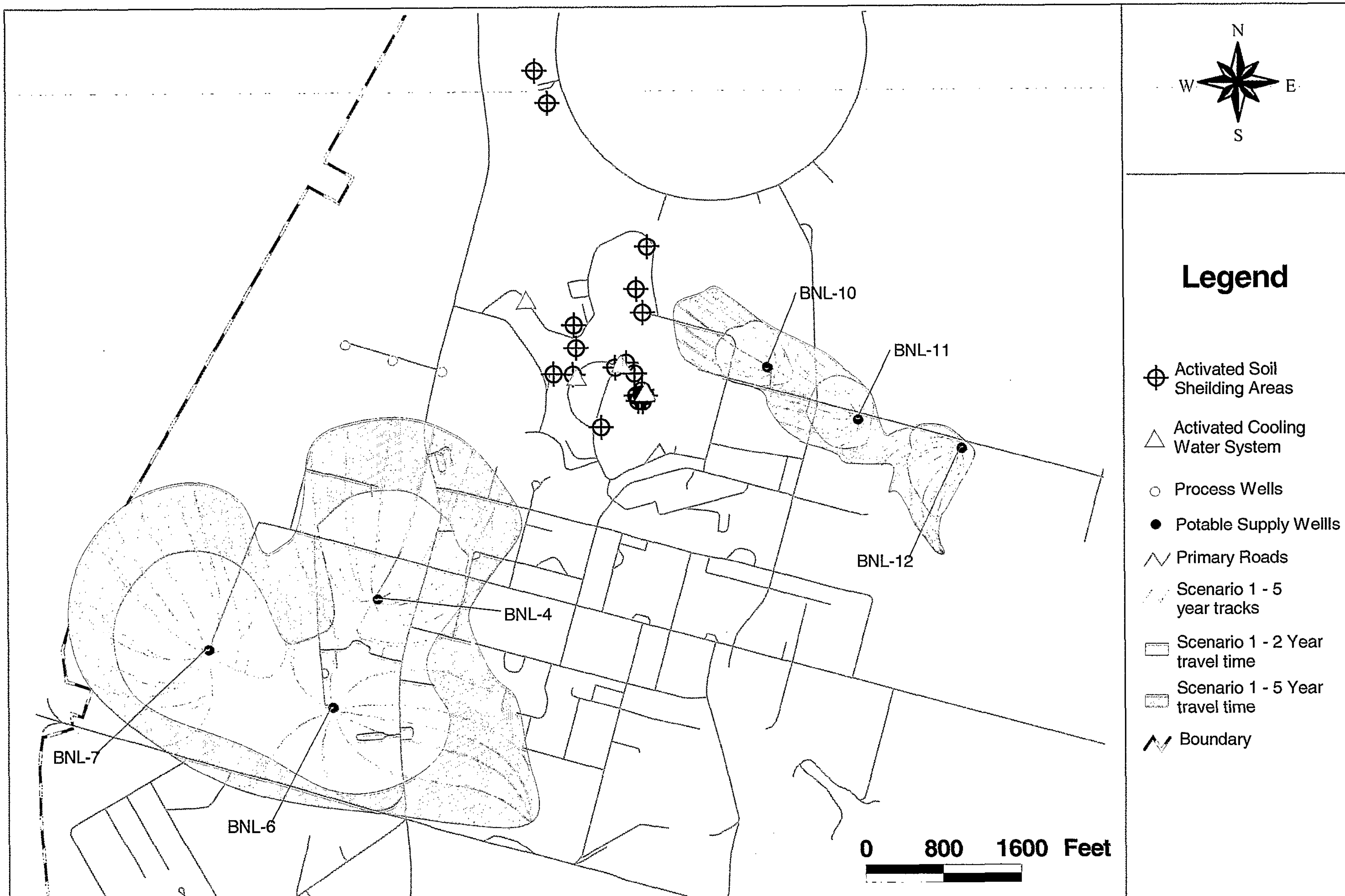

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Water Supply Source Water Areas and Locations of Activated Soil Shielding and Activated Cooling Water Systems - Pumping Scenario 1

Figure 8

11/20/00
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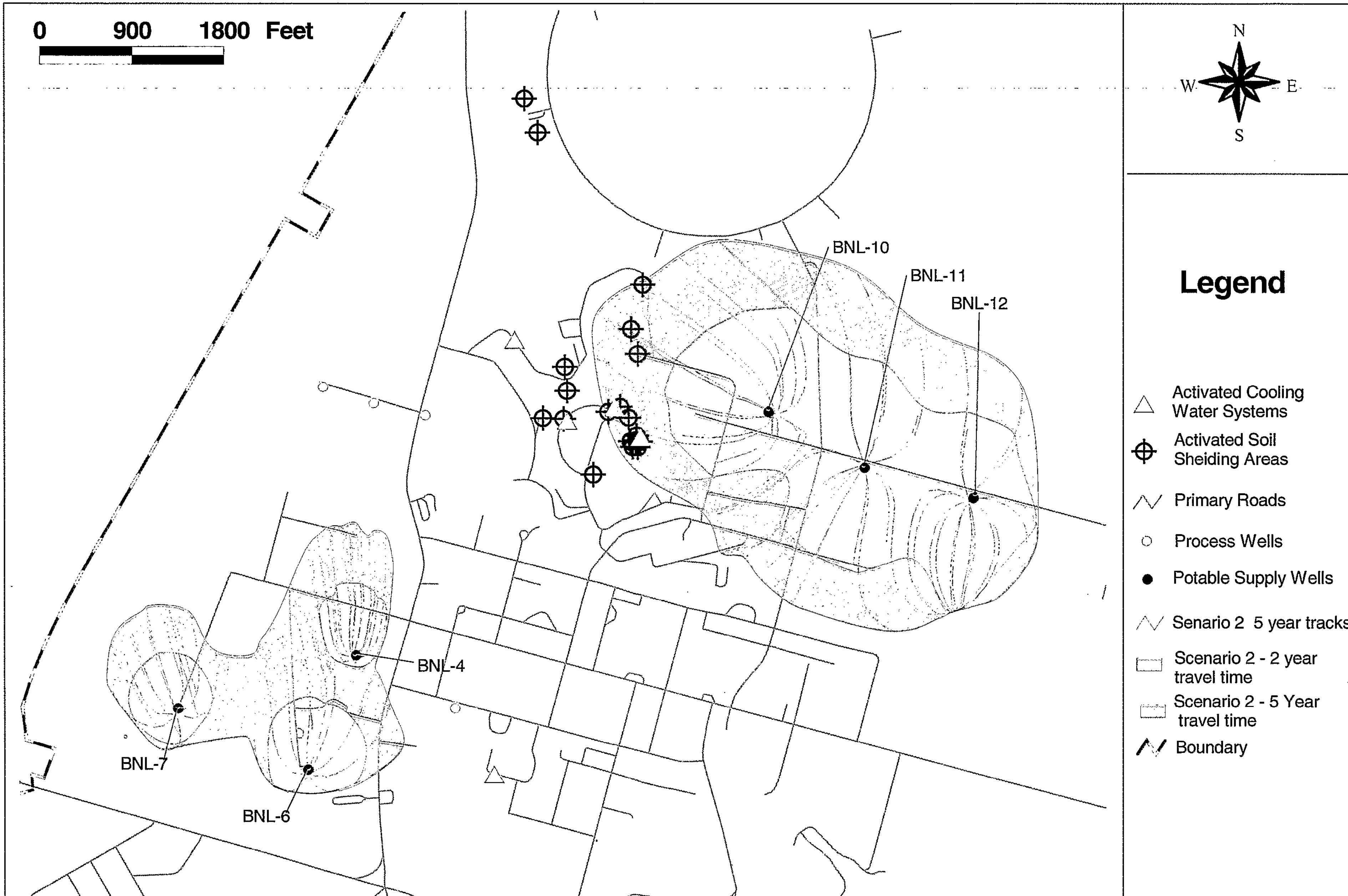

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Water Supply Source Areas and Locations of Activated Soil Shielding and Activated Cooling Water Systems - Pumping Scenario 2

Figure 9

JLH 11/21/00
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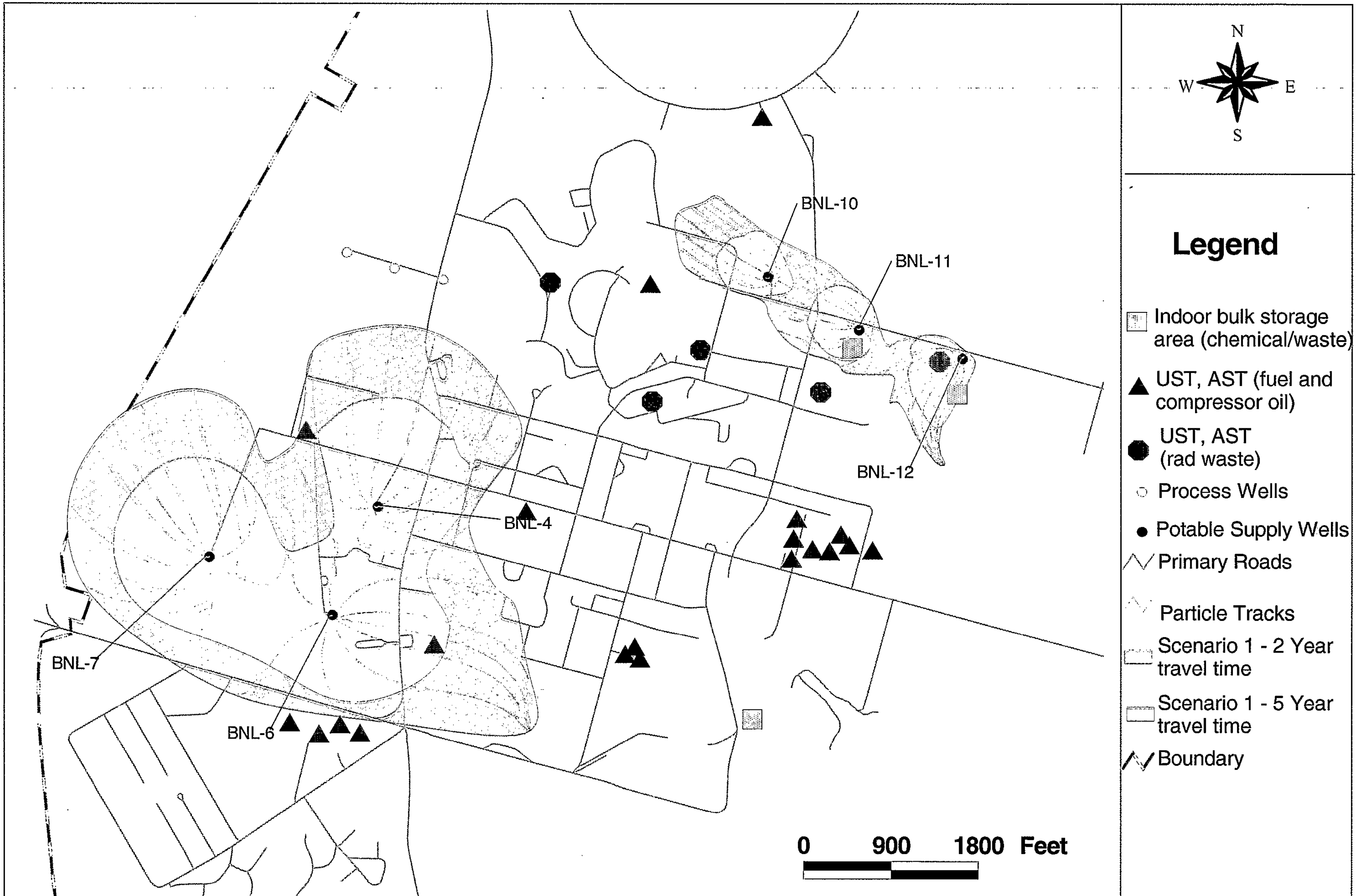

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Water Supply Source Water Areas and Loctions of Underground and Above Ground Storage Tanks and Bulk Chemical and Radiological Storage Areas - Pumping Scenario 1

Figure 10

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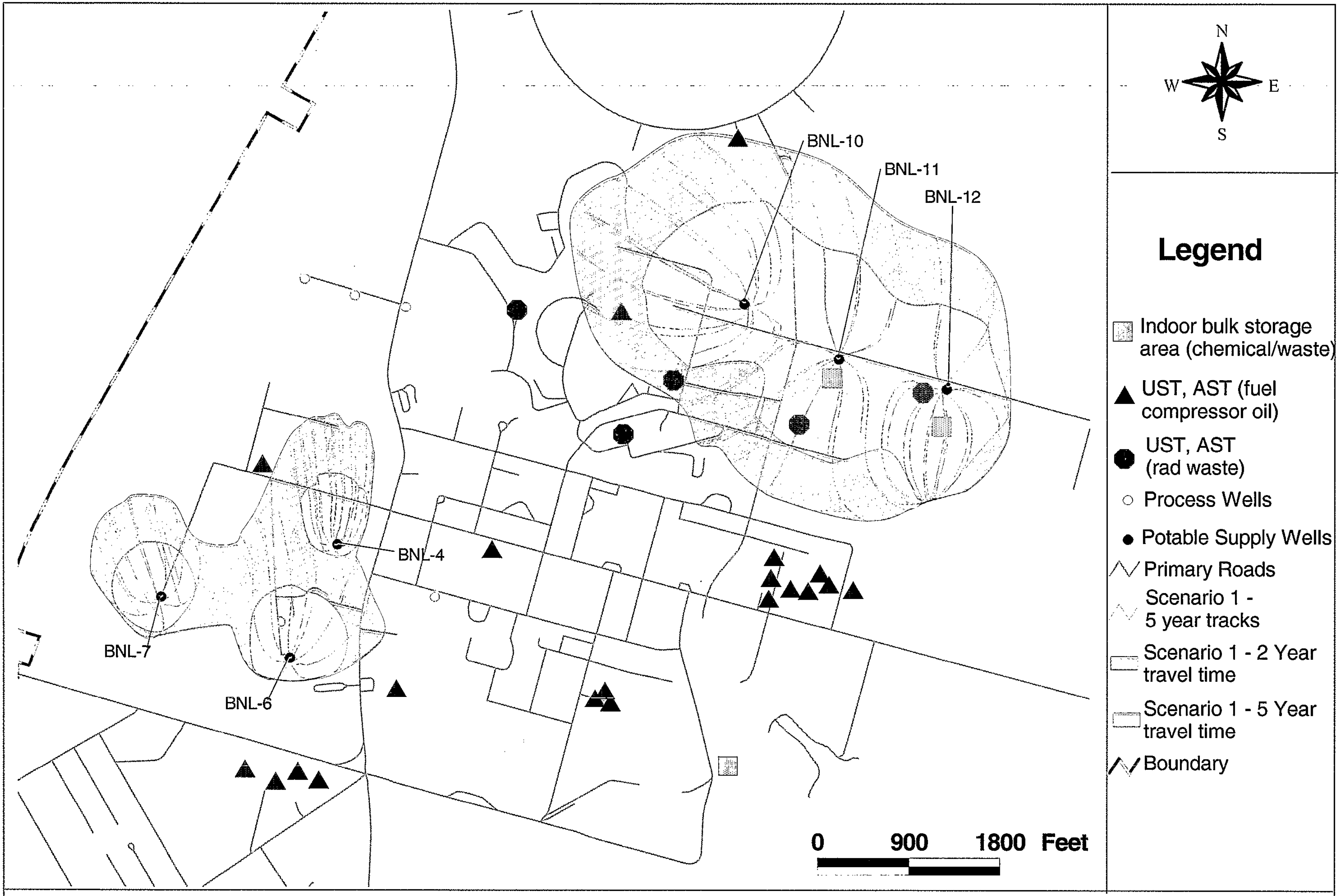

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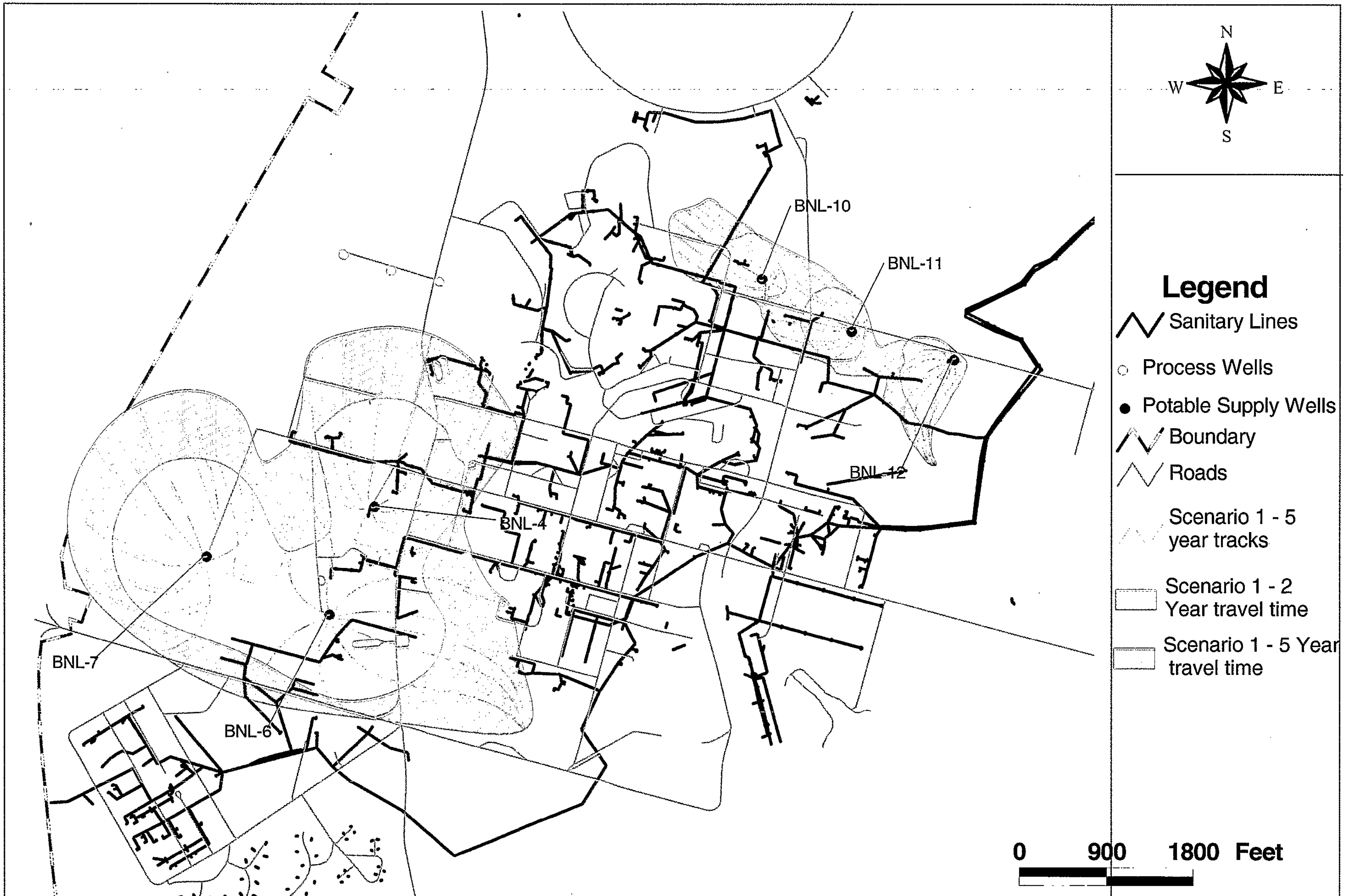
Water Supply Source Water Areas and Locations of Underground and Above Ground Storage Tanks and Bulk Chemical and Radiological Storage Areas - Pumping Scenario 2

Figure 11

JLH - 11-22-00
r:/gos/av_projects/groundwater/source_water_assessment/scrwtrassmnt2/UST2



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Water Supply Source Water Areas and Locations of Sanitary Sewer Lines Pumping Scenario 1

Figure 12

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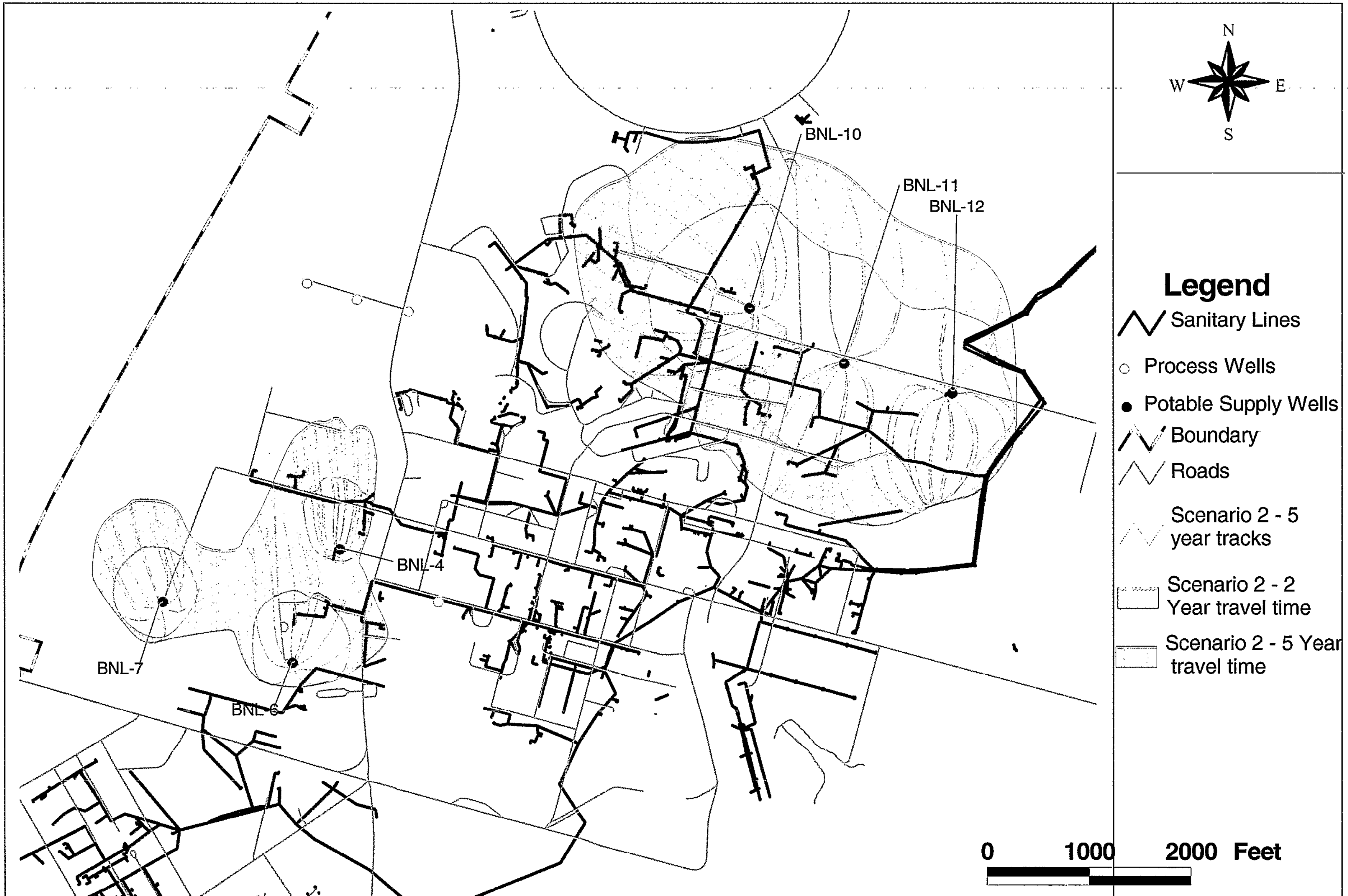

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Water Supply Source Areas and Locations of Sanitary Sewer Lines Pumping Scenario 2

Figure 13

JLH 12-8-00
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Table 1
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Western Well Field

Source Type	Facility/Plume	Threat	Current Groundwater Quality	Controls
Operating Facility	Water Treatment Plant Recharge Basin	Backwash from iron filters.	No identifiable impacts from WTP operations.	• Outfall monitoring (SPDES Program) • Groundwater monitoring (Environmental Surveillance Program).
	Basin HP/ OU III Groundwater Treatment system recharge basin	• Liquid polyphospate (anti-foulant) in BMRR non-contact cooling water, • OU III Groundwater treatment system is designed to meet DWS before discharge, but could be a threat if fail safes do not operate as designed.	No identifiable impacts from Basin HP/OU III Treatment Plant operations.	• Groundwater monitoring (Environmental Restoration Program). • Fail-safe engineered controls to shut OU III system down, if operational parameters are off-normal (Environmental Restoration Program)
	Class V Injection wells (multiple locations)	Accidental discharges or spills to these recharge features.	No identifiable impacts from Class V injection wells located in this source water area.	• Some UIC targeted for closure (EPA Phase II Agreement). • Connection of facilities to BNL Sanitary System. • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures) • BNL Spill Response Program
	Accidental Spills	Petroleum products (e.g., gasoline, hydraulic fluids)	Shallow soils have been impacted by historical and recent spills. No identifiable impacts to groundwater quality.	• BNL Spill Response Program – most heavily contaminated soils were removed.
	BMRR	Primary cooling water contains high levels of tritium	Groundwater has been impacted by low level tritium contamination (concentrations < NYSDWS)	• Groundwater monitoring (Environmental Surveillance Program). • All piping systems conform with SC Article 12 requirements. All floor drains are properly sealed. • Operating procedures are in place for the proper handling and storage of primary water.
	Motor Pool Area	Petroleum storage and dispensing	Groundwater has been impacted by historical use of solvents. 1,1,1-trichloroethane is detected at concentrations above NYSDWS. Low level MTBE detected, but below NYSDWS.	• Groundwater monitoring (Environmental Surveillance Program) . • Product inventory (BNL standard operating procedures) • Double-walled storage tanks with leak detection (conform with SC Article 12 requirements). • Paved work areas.

Table 1 (Continued)
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Western Well Field

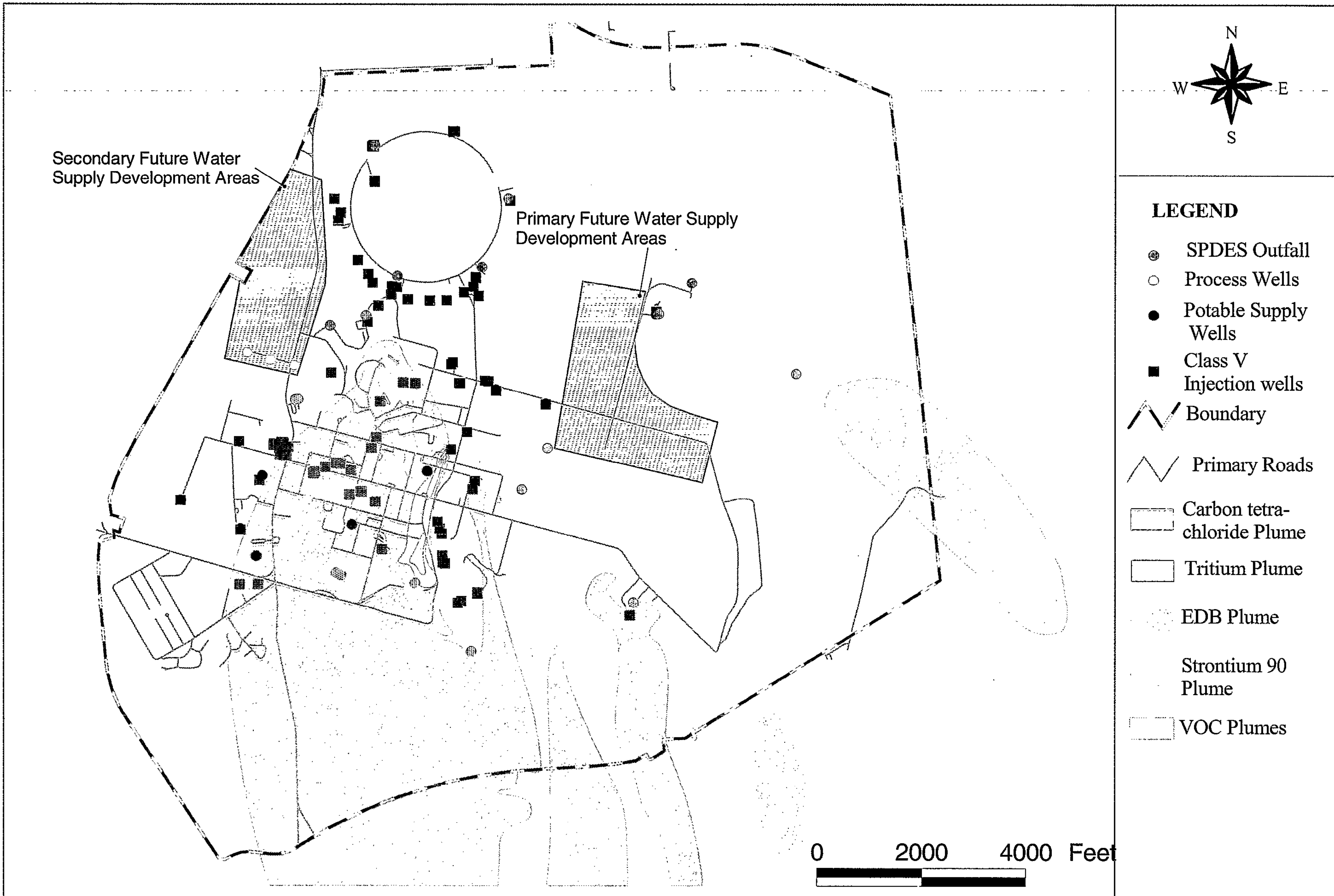
Source Type	Facility/Plume	Threat	Current Groundwater Quality	Controls
Operating Facility	Biology Greenhouse Area	Use of pesticides and heavy metals.	No identifiable impacts from greenhouse operations.	• Groundwater monitoring (Environmental Surveillance Program). • Procedures are in place for the proper use and storage of pesticides and herbicides. • Applicators are NYS Licensed.
	Paint Shop	Use of solvents	Historical spillage of solvents impacted soils near shop. Are suspected to have contributed to historical low level VOC contamination detected in Well 4.	• Contaminated soils were removed. • Groundwater monitoring (Environmental Restoration program). • Procedures are in place for the proper use, storage and disposal of paints and paint thinners.
	Sanitary Lines	Sanitary Line Leakage – possible release of bacteria and low level VOCs and radionuclides.	There are no indications that releases from sanitary lines located within the Source Water Areas are impacting groundwater quality.	• Laboratory-wide procedures prohibit the unauthorized disposal of chemical or radioactive waste to the sanitary system. • Supply Well water is routinely tested for chemical, radioactive and bacteriologic contaminants. • Drinking water is treated by chlorination.
Existing Groundwater Plumes	Western edge off the OU III VOC plume.	Historical discharge of solvents to land surface and cesspools in the AGS operations areas.	TVOC (primarily 1,1,1-trichloroethane) detected in monitoring wells at concentrations less than 50 μg/L. Low level 1,1,1-trichloroethane (< NYSDWS) is occasionally detected in Supply Well 4	• Groundwater monitoring (Environmental Surveillance and Restoration Programs). • Active remediation systems to improve groundwater quality. • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures).

Table 2
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Eastern Well Field

Source Type	Facility/Plume	Threat	Current Groundwater Quality	Controls
Operating Facility	Waste Management Facility	VOCs and low level radioactive waste are stored at this facility	No identifiable impacts from WMF operations.	• State-of-the-Art-Storage facility • Facility operated in accordance with NYSDEC RCRA permit • Groundwater monitoring (Environmental Surveillance Program)
	Recharge Basin HO	Non-contact cooling water from AGS Stormwater runoff	No identifiable impacts from Basin HO operations.	• Operational controls to minimize accidental chemical releases (BNL Procedures). • Effluent monitoring (SPDES Permit).
	AGS Beam Stops and Target Areas	Activated soil shielding – potential rainwater leaching of tritium and Na-22 to groundwater.	Three tritium plumes with concentrations above drinking water standards have been identified within this source water area (e.g., g-2/VQ12 Magnet area, Former E-20 Catcher area, and Former U-Line Stop area)	• Impermeable caps have been installed to prevent leachate generation (BNL procedures) • Operational controls to minimize soil activation (BNL Procedures) • Groundwater monitoring (Environmental Surveillance Program)
	Class V Injection wells (multiple locations)	Historical discharge of solvents to land surface and cesspools in the AGS operations areas.	TVOC (primarily 1,1,1-trichloroethane) detected in nearby monitoring wells at concentrations less than 50 µg/L. Low level 1,1,1-trichloroethane	• Some contaminated UICs were remediated and closed (Environmental Restoration Program). • Some UIC targeted for closure (EPA Phase II Agreement). • Connection of facilities to BNL Sanitary System. • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures) • BNL Spill Response Program
	Accidental Spills	Petroleum products (e.g., gasoline, hydraulic fluids)	Shallow soils have been impacted by historical and recent spills. No identifiable impacts to groundwater quality.	• BNL Spill Response Program – most heavily contaminated soils were removed.

Table 2 (Continued)
BNL Source Water Assessment for Drinking Water Supply Wells
Contaminant Source Inventory for Eastern Well Field

Source Type	Facility/Plume	Threat	Current Groundwater Quality	Controls
Operating Facility	Sanitary Lines	Sanitary Line Leakage – possible release of bacteria and low level VOCs and radionuclides.	There are no indications that releases from sanitary lines located within the Source Water Areas are impacting groundwater quality.	• Laboratory-wide procedures prohibit the unauthorized disposal of chemical or radioactive waste to the sanitary system. • Supply Well water is routinely tested for chemical, radioactive and bacteriologic contaminants. • Drinking water is treated by chlorination.
	Shotgun Range	Potential lead (Pb) contamination	Recent monitoring of nearby surveillance and water supply wells has not identified lead in groundwater.	• Groundwater monitoring (Environmental Surveillance Program). • Although lead does not readily leach out of soils, current operational restrictions prohibit the use of lead shot at the range.
Existing Groundwater Plumes	Brookhaven Graphite Research Reactor	Historical operations at BGRR have release Sr-90 to soils and groundwater	Sr-90 has been detected at concentrations above drinking water standards in monitoring wells located downgradient of BGRR.	• Decontamination and decommissioning of facility, groundwater monitoring, and active remediation of soils and groundwater (Environmental Restoration Program). • Retardation of Sr-90 in aquifer.
	Waste Concentration Facility	Historical operations at WCF have release Sr-90 to soils and groundwater	Sr-90 has been detected at concentrations above drinking water standards in monitoring wells located downgradient of the WCF.	• Active remediation of soils and groundwater, and groundwater monitoring (Environmental Restoration Program). • Retardation of Sr-90 in aquifer. • Storage facilities meet SC Article 12 requirements. • Operational controls.
	Building 650 Sump and Sump Outfall	Historical operations at Building 650 have release Sr-90 to soils and groundwater	Sr-90 has been detected at concentrations above drinking water standards in monitoring wells located downgradient of these release points.	• Active remediation of soils and groundwater , and groundwater monitoring (Environmental Restoration Program). • Retardation of Sr-90 in aquifer.
	Low level area of the OU III VOC plume.	Historical discharge of solvents to land surface and cesspools in the AGS operations areas.	TVOC (primarily 1,1,1-trichloroethane) detected in monitoring wells at concentrations less than 50 μg/L. Low level 1,1,1-trichloroethane (< NYSDWS) is occasionally detected in Supply Well 4.	• Groundwater monitoring (Environmental Surveillance and Restoration programs). • Proper control, storage, and transportation of chemical and radioactive materials (RCRA regulations, DOT regulations, and BNL standard operating procedures).



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Potential Water Supply Development Areas

Figure 14

JLH - 12/19/00

r:/Av_projects/groundwater/source_water_assessment/scrwtrassmnt2/figure8 operations. The second alternate water supply area is located in the northwest section of the BNL site. Disadvantages to use of groundwater from this second area include high levels of naturally occurring iron and possible low-levels of volatile organic compounds originating from offsite sources (e.g., residential and commercial properties located to the northwest of BNL).

Other water supply alternatives include:

- Convert inactive AGS Cooling Water Supply Well 102 into a potable supply well. Because of the naturally high iron content of groundwater in this area, water obtained from Well 102 would require treatment at the Water Treatment Plant prior to distribution.
- Install a new deeper well at the same location of an existing impacted Upper Glacial well, with the new well properly sealed and screened in a confined portion of the Magothy aquifer.
- Connect to existing or new Suffolk County Water Authority well field(s) located offsite to satisfy full or partial water supply requirements.

In all cases, the BNL Regional Groundwater Model would be used to determine the source water areas for new water supply wells, and assess the potential effects of water withdrawals on existing contaminant plumes and surface water features such as the Peconic River and associated wetlands.

7.0 Conclusions

The BNL water supply system meets all water quality standards and has sufficient pumping and storage capacity to meet current and anticipated future operational demands. Because BNL's water supply is drawn from the shallow Upper Glacial aquifer, BNL's source water is susceptible to contamination. The quality of the water supply is being protected through (1) a comprehensive program of engineered and operational controls of existing aquifer contamination and potential sources of new contamination, (2) groundwater monitoring, and (3) potable water treatment.

The BNL Source Water Assessment found that the source water for BNL's Western Well Field (comprised of Supply Wells 4, 6, and 7) has relatively few threats of contamination and identified potential sources are already being carefully managed. The source water for BNL's Eastern Well Field (comprised of Supply Wells 10, 11, and 12) has a moderate number of threats to water quality, primarily from several existing volatile organic compound and tritium plumes. The g-2 Tritium Plume and portions of the Operable Unit III VOC plume fall within the delineated source water area for the Eastern Well Field. In addition, portions of the much slower migrating strontium-90 plumes associated with the Brookhaven Graphite Research Reactor, Waste Concentration Facility and Building 650 lie within the Eastern source water area. However, the rate of travel in the aquifer for strontium-90 is about one-twentieth of that for tritium and volatile organic compounds. The Laboratory has been carefully monitoring plume migration, and has made adjustments to water supply operations. Although a number of BNL's water supply wells were impacted by VOC contamination in the late 1980s, recent routine analysis of water samples from BNL's supply wells indicate that no drinking water standards have been reached or exceeded. The high quality of the water supply strongly indicates that the operational and engineered controls implemented over the past ten years have effectively protected the quality of the water supply.

8.0 Acknowledgements

Albert H. Jaroszewski (Dvirka and Bartilucci, Consulting Engineers), William Chaloupka (BNL Plant Engineering), and Robert Lee (BNL Environmental Services Division) provided technical support for this project. Jennifer Higbie (BNL Environmental Services Division) provided graphics support.

9.0 References

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