

Contents

Message from the Laboratory Director	iii
Executive Summary	v
Acknowledgments	xvii
List of Figures	xxv
List of Tables.....	xxvii

CHAPTER 1: INTRODUCTION

1.1 Laboratory Mission.....	1-1
1.2 History	1-2
1.3 Research and Discoveries	1-3
1.4 Facilities and Operations	1-4
1.5 Location, Local Population, and Local Economy	1-5
1.6 Geology and Hydrology.....	1-5
1.7 Climate	1-10
1.8 Natural Resources.....	1-11
1.9 Cultural Resources.....	1-13
References and Bibliography.....	1-13

CHAPTER 2: ENVIRONMENTAL MANAGEMENT SYSTEM

2.1 Integrated Safety Management, ISO 14001, and OHSAS 18001	2-2
2.2 Environmental, Safety, Security, and Health Policy	2-5
2.3 Planning.....	2-6
2.3.1 Environmental Aspects	2-6
2.3.2 Legal and Other Requirements	2-6
2.3.3 Objectives and Targets.....	2-6
2.3.4 Environmental Management Programs	2-6
2.3.4.1 Compliance.....	2-7
2.3.4.2 Groundwater Protection.....	2-7
2.3.4.3 Waste Management	2-7
2.3.4.4 Pollution Prevention and Minimization.....	2-9
2.3.4.5 Water Conservation.....	2-15
2.3.4.6 Energy Management and Conservation.....	2-15
2.3.4.7 Natural and Cultural Resource Management Programs.....	2-17
2.3.4.8 Environmental Restoration	2-17
2.3.4.9 EPA Performance Track Program.....	2-19
2.4 Implementing the Environmental Management System.....	2-19
2.4.1 Structure and Responsibility	2-19
2.4.2 Communication and Community Involvement.....	2-21

2.4.2.1	Communication Forums	2-21
2.4.2.2	Community Involvement in Cleanup Projects	2-22
2.4.3	Monitoring and Measurement	2-22
2.4.3.1	Compliance Monitoring	2-22
2.4.3.2	Restoration Monitoring	2-23
2.4.3.3	Surveillance Monitoring	2-23
2.4.4	EMS Assessments	2-23
2.5	Environmental Stewardship at BNL	2-26
	References and Bibliography	2-27

CHAPTER 3: COMPLIANCE STATUS

3.1	Compliance with Requirements.....	3-2
3.2	Environmental Permits.....	3-2
3.2.1	Existing Permits.....	3-2
3.2.2	New or Modified Permits	3-7
3.2.2.1	Hazardous Waste Management Permit.....	3-7
3.2.2.2	Air Emissions Permits	3-7
3.3	NEPA Assessments.....	3-7
3.4	Preservation Legislation	3-8
3.5	Clean Air Act.....	3-8
3.5.1	Conventional Air Pollutants.....	3-8
3.5.1.1	Boiler Emissions	3-8
3.5.1.2	Ozone-Depleting Substances.....	3-8
3.5.2	Hazardous Air Pollutants.....	3-9
3.5.2.1	Maximum Available Control Technology.....	3-9
3.5.2.2	Asbestos.....	3-9
3.5.2.3	Radioactive Airborne Emissions.....	3-9
3.6	Clean Water Act.....	3-10
3.6.1	Sewage Treatment Plant.....	3-10
3.6.1.1	Chronic Toxicity Testing.....	3-11
3.6.2	Recharge Basins and Stormwater	3-14
3.7	Safe Drinking Water Act	3-14
3.7.1	Potable Water.....	3-16
3.7.2	Cross-Connection Control	3-16
3.7.3	Underground Injection Control.....	3-18
3.8	Preventing and Reporting Spills.....	3-21
3.8.1	Preventing Oil Pollution and Spills	3-22
3.8.2	Emergency Reporting Requirements	3-22
3.8.3	Spills and Releases	3-22
3.8.4	Major Petroleum Facility License	3-25
3.8.5	Chemical Bulk Storage.....	3-25
3.8.6	County Storage Requirements.....	3-25

3.9 RCRA Requirements	3-26
3.10 Polychlorinated biphenyls	3-26
3.11 Pesticides	3-27
3.12 Wetlands and River Permits.....	3-27
3.13 Endangered Species Act.....	3-27
3.14 External Audits and Oversight	3-28
3.14.1 Regulatory Agency Oversight.....	3-28
3.14.2 DOE Assessments/Inspections	3-29
3.14.2.1 Environmental Multi-Topic Assessment.....	3-29
3.14.2.2 Hazardous Material Transportation.....	3-29
3.14.2.3 EMS Desk Assessment	3-30
3.14.2.4 Nevada Test Site Inspection.....	3-30
3.14.3 Enforcement Actions and Memos.....	3-31
References And Bibliography	3-31

CHAPTER 4: AIR QUALITY

4.1 Radiological Emissions.....	4-1
4.1.1 Brookhaven Medical Research Reactor.....	4-1
4.1.2 High Flux Beam Reactor	4-3
4.1.3 Brookhaven Linac Isotope Producer	4-4
4.1.4 Evaporator Facility.....	4-4
4.1.5 Target Processing Laboratory.....	4-4
4.1.6 Additional Minor Sources.....	4-5
4.1.7 Nonpoint Radiological Emission Sources	4-5
4.2 Facility Monitoring.....	4-5
4.3 Ambient Air Monitoring.....	4-5
4.3.1 Gross Alpha and Beta Airborne Activity.....	4-6
4.3.2 Airborne Tritium	4-7
4.4 Nonradiological Airborne Emissions.....	4-8
References and Bibliography.....	4-10

CHAPTER 5: WATER QUALITY

5.1 Surface Water Monitoring Program	5-1
5.2 Sanitary System Effluents	5-1
5.2.1 Sanitary System Effluent–Radiological Analyses	5-3
5.2.2 Sanitary System Effluent–Nonradiological Analyses	5-5
5.3 Process-Specific Wastewater.....	5-8
5.4 Recharge Basins.....	5-10
5.4.1 Recharge Basins – Radiological Analyses	5-11
5.4.2 Recharge Basins – Nonradiological Analyses	5-12
5.4.3 Stormwater Assessment.....	5-17
5.5 Peconic River Surveillance.....	5-17
5.5.1 Peconic River – Radiological Analyses.....	5-17

5.5.2 Peconic River – Nonradiological Analyses.....	5-19
References and Bibliography.....	5-24

CHAPTER 6: NATURAL AND CULTURAL RESOURCES

6.1 Natural Resource Management Program	6-1
6.1.1 Identification and Mapping	6-1
6.1.2 Habitat Protection and Enhancement	6-2
6.1.2.1 Salamander Protection Efforts	6-3
6.1.2.2 Eastern Box Turtle.....	6-4
6.1.2.3 Other Species.....	6-4
6.1.3 Population Management	6-5
6.1.3.1 Wild Turkey	6-5
6.1.3.2 White-Tailed Deer	6-6
6.1.4 Compliance Assurance and Potential Impact Assessment.....	6-6
6.2 Upton Ecological and Research Reserve.....	6-7
6.3 Monitoring Flora and Fauna	6-8
6.3.1 Deer Sampling	6-8
6.3.1.1 Cs-137 in White-Tailed Deer	6-8
6.3.1.2 Strontium-90 in Deer Bone	6-13
6.3.2 Small Mammal Sampling.....	6-15
6.3.3 Other Animals Sampled	6-15
6.3.4 Fish Sampling	6-15
6.3.4.1 Radiological Analysis of Fish.....	6-16
6.3.4.2 Fish Population Assessment.....	6-17
6.3.4.3 Nonradiological Analysis of Fish.....	6-17
6.3.5 Aquatic Sampling	6-21
6.3.5.1 Radiological Analysis.....	6-21
6.3.5.2 Metals in Aquatic Samples.....	6-22
6.3.5.3 Pesticides and PCBs in Aquatic Samples.....	6-22
6.3.6 Peconic River Post-Cleanup Monitoring.....	6-22
6.3.6.1 Sediment Sampling.....	6-23
6.3.6.2 Water Column Sampling.....	6-24
6.3.6.3 Fish Sampling.....	6-24
6.3.6.4 Wetland Sampling	6-24
6.3.7 Vegetation Sampling.....	6-26
6.3.7.1 Garden Vegetables	6-26
6.3.7.2 Grassy Plants	6-26
6.4 Other Monitoring.....	6-26
6.4.1 Soil Sampling.....	6-26
6.4.2 Basin Sediments	6-26
6.4.3 Chronic Toxicity Tests.....	6-26
6.4.4 Radiological Monitoring of Precipitation.....	6-26

6.5 Wildlife Programs	6-26
6.6 Cultural Resource Activities	6-29
References and Bibliography	6-29

CHAPTER 7: GROUNDWATER PROTECTION

7.1 The BNL Groundwater Protection Management Program.....	7-1
7.1.1 Prevention.....	7-1
7.1.2 Monitoring.....	7-2
7.1.3 Restoration	7-2
7.1.4 Communication.....	7-2
7.2 Groundwater Protection Performance	7-3
7.3 Groundwater Monitoring	7-3
7.4 Supplemental Monitoring of Water Supply Wells	7-4
7.4.1 Radiological Results	7-4
7.4.2 Nonradiological Results.....	7-8
7.5 Environmental Surveillance Program	7-8
7.6 Environmental Restoration Groundwater Monitoring Program	7-9
7.7 Groundwater Treatment Systems	7-11
References and Bibliography	7-14

CHAPTER 8: RADIOLOGICAL DOSE ASSESSMENT

8.1 Direct Radiation Monitoring	8-1
8.1.1 Ambient Monitoring	8-2
8.1.2 Facility Area Monitoring.....	8-4
8.2 Dose Modeling.....	8-6
8.2.1 Dose Modeling Program	8-7
8.2.2 Dose Calculation Methods and Pathways	8-9
8.2.2.1 Maximally Exposed Individual	8-9
8.2.2.2 Effective Dose Equivalent	8-9
8.2.2.3 Dose Calculation: Fish Ingestion	8-9
8.2.2.4 Dose Calculation: Deer Meat Ingestion	8-9
8.3 Sources: Diffuse, Fugitive, “Other”	8-9
8.3.1 Brookhaven Graphite Research Reactor	8-10
8.3.2 Former Hazardous Waste Management Facility	8-10
8.3.3 High Flux Beam Reactor.....	8-11
8.3.4 National Synchrotron Light Source II.....	8-13
8.4 Dose from Point Sources	8-13
8.4.1 Brookhaven Linac Isotope Producer	8-13
8.4.2 High Flux Beam Reactor.....	8-13
8.4.3 Brookhaven Medical Research Reactor	8-13
8.4.4 Unplanned Releases.....	8-14
8.5 Dose from Ingestion	8-14
8.6 Dose to Aquatic and Terrestrial Biota	8-14

8.7 Cumulative Dose	8-14
References and Bibliography	8-15
CHAPTER 9: QUALITY ASSURANCE	
9.1 Quality Program Elements.....	9-1
9.2 Sample Collection and Handling	9-2
9.2.1 Field Sample Handling.....	9-3
9.2.1.1 Custody and Documentation	9-3
9.2.1.2 Preservation and Shipment.....	9-3
9.2.2 Field Quality Control Samples	9-3
9.2.3 Tracking and Data Management	9-4
9.3 Sample Analysis.....	9-5
9.3.1 Qualifications	9-5
9.4 Verification and Validation of Analytical Results.....	9-5
9.4.1 Checking Results	9-6
9.5 Contract Analytical Laboratory QA/QC	9-6
9.6 Performance or Proficiency Evaluations	9-6
9.6.1 Summary of Test Results.....	9-7
9.6.2.1 Radiological Assessments	9-7
9.6.2.2 Nonradiological Assessments	9-7
9.7 Audits	9-7
9.8 Conclusion.....	9-9
References and Bibliography	9-9
Appendix A: Glossary.....	A-1
Acronyms and Abbreviations	A-1
Technical Terms.....	A-4
Appendix B: Understanding Radiation.....	B-1
Appendix C: Units of Measure and Half-Life Periods	C-1
Appendix D: Federal, State, and Local Laws and Regulations Pertinent to BNL.....	D-1

List of Figures

Figure 1-1. Major Scientific Facilities at BNL.....	1-6
Figure 1-2. Major Support and Service Facilities at BNL.....	1-8
Figure 1-3. BNL Groundwater Flow Map.....	1-9
Figure 1-4. BNL 2006 Wind Rose.....	1-10
Figure 1-5. BNL 2006 Monthly Mean Temperature versus 58-Year Monthly Average.....	1-11
Figure 1-6. BNL 2006 Annual Mean Temperature Trend (58 Years).....	1-11
Figure 1-7. BNL 2006 Monthly Precipitation versus 58-Year Monthly Average.....	1-12
Figure 1-8. BNL 2006 Annual Precipitation Trend (58 Years).....	1-12
Figure 2-1a. Hazardous Waste Generation from Routine Operations, 1997 – 2006.....	2-8
Figure 2-1b. Mixed Waste Generation from Routine Operations, 1997 – 2006.....	2-8
Figure 2-1c. Radioactive Waste Generation from Routine Operations, 1997 – 2006.....	2-8
Figure 2-1d. Hazardous Waste Generation from ER and Nonroutine Operations, 1997 – 2006.....	2-9
Figure 2-1e. Mixed Waste Generation from ER and Nonroutine Operations, 1997 – 2006.....	2-9
Figure 2-1f. Radioactive Waste Generation from ER and Nonroutine Operations, 1997 – 2006.....	2-9
Figure 2-2. BNL Water Consumption Trend.....	2-17
Figure 2-3. BNL Building Energy Performance, 1985 – 2015.....	2-18
Figure 3-1. Maximum Concentrations of Copper Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-12
Figure 3-2. Maximum Concentrations of Iron Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-12
Figure 3-3. Maximum Concentrations of Lead Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-12
Figure 3-4. Maximum Concentrations of Mercury Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-13
Figure 3-5. Maximum Concentrations of Nickel Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-13
Figure 3-6. Maximum Concentrations of Silver Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-13
Figure 3-7. Maximum Concentrations of Zinc Discharged from the BNL Sewage Treatment Plant, 2002–2006.....	3-14
Figure 4-1. Air Emission Release Points Subject to Monitoring.....	4-2
Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1997–2006).....	4-3
Figure 4-3. BNL On-Site Ambient Air Monitoring Stations.....	4-6
Figure 4-4. Airborne Gross Beta Concentration Trend Recorded at Station P7.....	4-8
Figure 5-1. Schematic of BNL's Sewage Treatment Plant (STP).....	5-2
Figure 5-2. Tritium Concentrations in Effluent from the BNL Sewage Treatment Plant (2006).....	5-5
Figure 5-3. Sewage Treatment Plant/Peconic River Annual Average Tritium Concentrations (1992-2006).....	5-6
Figure 5-4. Tritium Released to the Peconic River, 15-Year Trend (1992–2006).....	5-6
Figure 5-5. Cesium-137 in the BNL Sewage Treatment Plant Influent and Effluent (1992–2006).....	5-6
Figure 5-6. BNL Recharge Basin/Outfall Locations.....	5-10
Figure 5-7. Schematic of Potable Water Use and Flow at BNL.....	5-11
Figure 5-8. Sampling Stations for Surface Water, Fish, and Shellfish.....	5-18

Figure 6-1. Population Density of Deer — Fall 2006.....	6-2
Figure 6-2. Deer Sample Locations, 2002—2006.....	6-10
Figure 6-3. Comparison of Cs-137 Average Concentrations in Deer, 2006.....	6-14
Figure 6-4. Trend of Cs-137 Concentrations in Deer Meat at BNL and Within 1 Mile of BNL, 1998 – 2006.....	6-14
Figure 6-5. Methylmercury Sample Locations.....	6-25
Figure 7-1. Groundwater Protection Performance, 1998 – 2006.....	7-3
Figure 7-2. Groundwater Flow and Water Table Elevation (December 2006) with Supply and Remediation Wells Shown.....	7-5
Figure 7-3. Extent of VOC Plumes.....	7-6
Figure 7-4. Extent of Radionuclide Plumes.....	7-7
Figure 7-5. Locations of BNL Groundwater Remediation Systems.....	7-12
Figure 8-1. On-Site TLD Locations.....	8-2
Figure 8-2. Off-Site TLD Locations.....	8-3
Figure 9-1. Flow of Environmental Monitoring QA/QC Program Elements.....	9-2
Figure 9-2. Summary of Scores in the Radiological Proficiency Evaluation Programs.....	9-8
Figure 9-3. Summary of Scores in the Nonradiological Proficiency Evaluation Programs.....	9-8

List of Tables

Table 2-1.	Elements of the Environmental Management System (EMS) and their Relationship to OHSAS 18001 and Integrated Safety Management (ISM) – Review of EMS Implementation at BNL.....	2-2
Table 2-2.	BNL Pollution Prevention, Waste Reduction, and Recycling Projects.....	2-11
Table 2-3.	BNL Recycling Program Summary.	2-16
Table 2-4.	Summary of BNL 2006 Environmental Restoration Activities.	2-20
Table 2-5.	Summary of BNL 2006 Sampling Program Sorted by Media.	2-24
Table 3-1.	Federal, State, and Local Environmental Statutes and Regulations Applicable to BNL.	3-2
Table 3-2.	BNL Environmental Permits.	3-5
Table 3-3.	Analytical Results for Wastewater Discharges to Sewage Treatment Plant Outfall 001.....	3-11
Table 3-4.	Analytical Results for Wastewater Discharges to Outfalls 002–008 and 010.....	3-15
Table 3-5.	Potable Water Wells and Potable Distribution System: Analytical Results (Maximum Concentration, Minimum pH Value).	3-17
Table 3-6.	Potable Water Wells: Analytical Results for Principal Organic Compounds, Synthetic Organic Chemicals, Pesticides, and Micro-Extractables.....	3-19
Table 3-7.	Summary of Chemical and Oil Spill Reports.	3-23
Table 3-8.	Summary of Other Environmental Occurrence Reports.	3-24
Table 3-9.	Existing Agreements and Enforcement Actions Issued to BNL, with Status.	3-30
Table 4-1.	Airborne Radionuclide Releases from Monitored Facilities.....	4-3
Table 4-2.	Gross Activity in Facility Air Particulate Filters.....	4-7
Table 4-3.	Gross Activity Detected in Ambient Air Monitoring Particulate Filters.	4-7
Table 4-4.	Ambient Airborne Tritium Measurements in 2006.....	4-8
Table 4-5.	Central Steam Facility Fuel Use and Emissions (1996–2006).	4-9
Table 5-1.	Tritium and Gross Beta Activity in Water at the BNL Sewage Treatment Plant (STP).....	5-4
Table 5-2.	Gamma-Emitting Radionuclides and Strontium-90 in Water at the BNL Sewage Treatment Plant.....	5-7
Table 5-3.	BNL Sewage Treatment Plant (STP) Water Quality and Metals Analytical Results.....	5-9
Table 5-4.	Radiological Analysis of Samples from BNL On-Site Recharge Basins.	5-12
Table 5-5.	Water Quality Data for BNL On-Site Recharge Basin Samples.....	5-13
Table 5-6.	Metals Analysis of Water Samples from BNL On-Site Recharge Basins.....	5-14
Table 5-7.	Radiological Results for Surface Water Samples from the Peconic and Carmans Rivers.....	5-19
Table 5-8.	Water Quality Data for Surface Water Samples Collected along the Peconic and Carmans Rivers.....	5-20
Table 5-9.	Metals Analysis in Surface Water Samples Collected along the Peconic and Carmans Rivers.....	5-21
Table 6-1.	New York State Threatened, Endangered, Exploitably Vulnerable, and Species of Special Concern at BNL.	6-3
Table 6-2.	Radiological Analyses of Deer Tissue (Flesh, Liver, Bone).	6-1
Table 6-3.	Radiological Analyses of Small Mammals (Squirrels) and Other Animals.	6-15
Table 6-4.	Radiological Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.....	6-17
Table 6-5.	Metals Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.	6-18
Table 6-6.	Pesticide and PCB Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.....	6-21
Table 6-7.	Radiological Analyses of Aquatic Vegetation and Sediment from the Peconic River and Carmans River System, Lower Lake.....	6-22
Table 6-8.	Metals Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake.....	6-23

Table 7-1. Summary of BNL Groundwater Monitoring Program, 2006.....	7-2
Table 7-2. Potable Well Radiological Analytical Results.	7-8
Table 7-3. Potable Water Supply Wells Water Quality Data.....	7-9
Table 7-4. Total Metals Concentration Data for Potable Water Supply Well Samples.....	7-10
Table 7-5. BNL Groundwater Remediation Systems Treatment Summary for 1997 through 2006.	7-13
Table 8-1. On-Site Direct Radiation Measurements.....	8-4
Table 8-2. Off-Site Direct Radiation Measurements.	8-6
Table 8-3. Facility Area Monitoring.	8-7
Table 8-4. MEI Effective Dose Equivalent From Facilities or Routine Processes.....	8-8
Table 8-5. BNL Site Dose Summary.	8-12