

# 1 ENVIRONMENT, SAFETY, & HEALTH, AND QUALITY ASSURANCE

## 1.1 INTRODUCTION

Brookhaven National Laboratory is committed to the success of the mission objectives of the National Synchrotron Light Source II and to the safety of its users, staff, and the public. The NSLS-II Project Director is responsible for achieving this objective. The NSLS-II Environmental Safety and Health Manager is responsible for ensuring that an ES&H system is established, implemented, and maintained in accordance with requirements. The ES&H Manager will provide oversight and support to the project participants to ensure a consistent ES&H program.

It is our vision to provide a “Best in Class” safety program. We view such a program as essential to the safety of the workers as well as the successful completion of the project. We will seek to provide an injury free work environment and will measure our performance by comparison with only those who have achieved recognition as “Best in Class.” To achieve this vision, safe working conditions and practices are an absolute requirement for all staff and contractors. We expect all design and work to be performed with this goal in mind. We will not be satisfied unless our ES&H program as well as our new facility are both recognized as “Best in Class.” To accomplish this vision, it is essential that ES&H be fully integrated into the project and be managed as tightly as quality, cost and schedule.

An ES&H Program Plan [1.1] with this vision in mind has been prepared by the ES&H Manager and approved by the NSLS-II Project Director. This plan specifies that the program implemented for NSLS-II shall satisfy its ES&H commitments by:

1. Establishing an Integrated Safety Management Program that implements the DOE Policy, DOE P 450.4, “Safety Management System Policy,” the BNL Subject-Based Management System topic areas, and the requirements of the DOE “Accelerator Safety Order.” The program will protect the environment and the safety of workers and the general public by assuring that:
  - a. Facilities, systems, and components needed to meet mission requirements are fully defined and are designed, constructed, and operated in accordance with applicable BNL and DOE requirements
  - b. Potential hazards to personnel associated with all NSLS-II systems, structures, and components are identified and controlled through the timely preparation of safety assessment documents
  - c. Potential risks to the environment are addressed through the timely and comprehensive preparation of appropriate National Environmental Protection Act documentation
  - d. ISO 14001 and OHSAS 18001 criteria are implemented to assure that all ES&H risks are identified and addressed
  - e. Requirements in 10 CFR Part 835, part 850, and Part 851 are fully implemented to protect worker safety and health
2. Implementing a QA program that follows DOE Order 414.1-2A, “Quality Assurance Management System Guide,” and incorporates quality requirements from BNL’s SBMS subject area Graded Approach for Quality Requirements.
3. Implementing an effective construction safety programs to ensure worker safety on the NSLS-II site during construction. All work performed on the NSLS-II site will be conducted in accordance with the NSLS-II Environmental, Safety, and Health Plan.

4. Performing Independent Design Reviews on systems, structures, and components designated as “safety significant” or “safety class” in the SAD or as defined through QA classifications described in the NSLS-II QA Plan.
5. Providing appropriate training to ensure that project staff are adequately trained and qualified to perform their assigned work safely. Job training assessments will be conducted for all staff to ensure knowledge of job-related hazards and their controls. All project staff are responsible for ensuring that their training and qualification requirements are fulfilled, including continuing training to maintain proficiency and qualifications.
6. Developing and implementing operating procedures to control work on NSLS-II technical systems.
7. Performing and documenting safety inspections of all project facilities and work areas, and ensuring prompt correction of any issues identified in the inspection.
8. Reporting and investigating occurrences and incidents in accordance with the BNL Occurrence Reporting Policies and Procedures as defined in the BNL SBMS. Any incident, accident, or other abnormal event will be properly communicated and investigated via established procedures.

Policies and requirements to ensure implementation of these expectations will be established and communicated to all staff, contractors, and vendors.

## 1.2 FINAL HAZARD ANALYSIS (FHA)

A principal component of an effective ES&H program is to ensure that all hazards have been properly identified and controlled through design and procedure. To ensure that these issues are understood at the preliminary design phase, a Final Hazard Analysis [1.4] has been conducted to identify the hazards that will be encountered during the project’s construction and operational phases. This analysis is an update of the Preliminary Hazard Analysis developed during the Conceptual Design. No new significant issues were identified in this update, and it was re-confirmed that the NSLS-II will be classified as an “Accelerator Facility,” as defined in DOE Order 420.2B, “Safety of Accelerator Facilities.”

Generally, all the hazards and their risks anticipated to be encountered at NSLS-II as identified in the FHA are well known to the accelerator community. Years of experience with such facilities at BNL and within the DOE complex have generated well-defined design criteria and controls to eliminate and/or control these risks. Table 1.1 below summarizes the hazards that have been considered, and the codes and standards that apply to the reduction of risk associated with each hazard.

This Hazard Analysis process began concurrent with the conceptual design, to ensure that all significant hazards were identified and adequately addressed in the early design work. Each of these issues will be followed as design advances and as construction and installation work commence. A Baseline Hazards List [1.2] was developed as the first step in identifying the potential hazards. This list utilized the best available information, encompassing data from the NSLS-II conceptual design, existing NSLS safety-basis documentation, subject-matter expertise (with conventional facilities, accelerator systems, and ES&H) and lessons-learned from the DOE’s accelerator community covering design criteria, regulatory requirements, and related occurrences. It also included preliminary (pre-mitigation) risk assessments that identified risk categories before incorporating the ES&H-related design and operational controls that are postulated to mitigate those risks. The identified hazards then were further developed in the PHA [1.3] issued in December 2006, where the proposed ES&H design enhancements were taken into consideration. The FHA re-analyzed the risks, including these enhancements and, in certain cases, operational controls, to establish a post-mitigation risk category. The FHA was supported by extensive discussions and review of hazards with personnel responsible for the design of all major systems associated with NSLS-II. This process provides a realistic assessment of the residual ES&H risks posed by the NSLS-II facility and is input to the preliminary design.

Fifteen of the hazards reviewed in the FHA are mitigated to Low risk or below and one hazard remains at a Moderate level, Construction. While the FHA adequately addresses all risks and their design as well as operational controls, the Construction category will be given a high level of attention during the Title 1 and subsequent design processes to ensure that its risks are adequately controlled.

A brief review of each hazard and the means of mitigating risks are provided in the following sections.

**Table 1.1 Hazards Considered in FHA and Applicable Codes and Standards.**

FHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – FHA-1	<b>Construction hazards</b> Site clearing Excavation Work at elevations (steel, roofing) Material handling Utility interfaces, (electrical, steam, chilled water, compressed air) Miscellaneous finishing work Weather-related conditions Transition to Operations	BNL SBMS Construction Safety subject area 29 CFR 1926, Safety and Health Regulations for Construction 10 CFR Part 851, Appendix A, Functional Area 1, Construction Safety
NSLS-II – FHA-2	<b>Natural phenomena hazards</b> Seismic Flooding Wind Snow & Ice Lightning	DOE Order 420.2B Safety of Accelerator Facilities DOE Guide 420.2-1 Accelerator Facility Safety Implementation Guide DOE Order 420.1B Facility Safety DOE STD 1020-2002 Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities DOE STD 1021-93 Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems and Components. DOE STD 1022-94 Natural Phenomena Hazards Site Characterization Criteria. DOE STD 1023-95 Natural Phenomena Hazards Assessment Criteria. New York State Building Code
NSLS-II – FHA-3	<b>Environmental hazards</b> Construction impacts Storm-water discharge (construction and operations) Operations impacts Soil & groundwater activation Air activation Cooling-water activation (HVAC and machine) Oils/chemical/biological leaks Discharge/emission points (atmospheric, ground and sanitary system)	BNL SBMS National Environmental Policy Act (NEPA) and Cultural Resources Evaluations subject area. NYSDEC Petroleum bulk storage, SCDHS Article 12 40 CFR 61 - Subpart A, National Emissions Standards for Hazardous Air Pollutants (NESHAPS) 6 NYCRR 200 – 234 – NYSDEC Prevention and Control of Air contamination and Air Pollution National Environmental Policy Act (NEPA) of 1969, as amended (42 USC 4321-4347) Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 CFR 1500-1508) DOE NEPA Regulations (10 CFR 1021)

FHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – FHA-4	<b>Waste hazards</b> Construction phase Facility maintenance Experimental operations Industrial Hazardous Radiological Biological/Medical	BNL SBMS Biosafety in Research subject area BNL SBMS Hazardous Waste Management subject area BNL SBMS Industrial Waste and Radioactive Waste Management subject area BNL SBMS Interim Procedure 2006-001 Approach to Nano-material ESH. 6 NYCRR Part 371, Identification and Listing of Hazardous Wastes 6 NYCRR Part 374.3, Standards for Universal Waste 40 CFR 262.11, Hazardous Waste Determination (EPA 1987) 40 CFR 273, Standard for Universal Waste Management 6 NYCRR Part 374-2 and 225-2, Used Oil Specifications 10 CFR Part 851, Appendix A, Functional Area 8, Occupational Medicine
NSLS-II – FHA-5	<b>Fire Hazards</b> Construction materials Storage/Housekeeping Flammable/combustible solids/ liquids Flammable gasses Egress/access Electrical Lightning	BNL SBMS Fire Safety subject area NFPA 101 Life Safety Code NFPA 45 Fire Protection for Laboratories Using Chemicals Elevator Std DOE Standard 1066-99 10 CFR Part 851, Appendix A, Functional Area 2, Fire Protection
NSLS-II – FHA-6	<b>Electrical hazards</b> Low voltage/high current High voltage/high power Non-NRTL certified equipment Arc flash Electrical shock Cable tray overloading/mixed utilities Mechanical damage to cables	BNL SBMS Electrical Safety subject area NFPA 70 National Electrical Code NFPA 70 E Standard for Electrical Safety in the Workplace NFPA 70 B Recommended Practice for Electrical Equipment Maintenance 10 CFR Part 851, Appendix A, Functional Area 10, Electrical Safety
NSLS-II – FHA-7	<b>Noise</b> Equipment exceeding ACGIH noise limits	BNL SBMS Noise and Hearing subject area OSHA 29 CFR 1910.95 Occupational Noise Exposure
NSLS-II – FHA-8	<b>Cryogenic and Pressure hazards</b> Oxygen deficiency Thermal Pressure	BNL SBMS Cryogenics Safety subject area American Society of Mechanical Engineers (ASME) Boilers and Pressure Vessel Code, sections I through XII including applicable Code Cases, (2004). * ASME B31 (ASME Code for Pressure Piping) as follows: (i) B31.1—2001—Power Piping, and B31.1a—2002—Addenda to ASME B31.1—2001; (ii) B31.2—1968—Fuel Gas Piping; (iii) B31.3—2002—Process Piping; (iv) B31.4—2002—Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids; (v) B31.5—2001—Refrigeration Piping and Heat Transfer Components, and B31.5a—2004, Addenda to 29 CFR 1910.134, OSHA Respiratory Protection Standard 10 CFR Part 851, Appendix A, Functional Area 4, Pressure Safety
NSLS-II – FHA-9	<b>Confined space hazards</b> Asphyxiation Impact with mechanical systems	BNL SBMS Confined Space subject area 29 CFR 1910.146, Permit-required confined spaces

FHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – FHA-10	<b>Ozone hazards</b> Breathing impairment Tissue damage	BNL Subject Areas DOE G 420.2-1, Accelerator Facility Implementation Guide OSHA Permissible Exposure Limit (PEL) NIOSH Recommended Exposure Limit (REL)
NSLS-II – FHA-11	<b>Chemical/hazardous materials, nanomaterials, biological materials</b> Toxic Extremely toxic Compressed gas Carcinogens, mutagens, teratogens, reproductive Nanomaterials Biological/medical materials Combustibles Explosives Flammable gases/liquids/solids Lead (shielding) Beryllium articles	BNL SBMS Working with Chemicals subject area BNL SBMS Biosafety in Research subject area BNL SBMS Approach to Nanomaterial ESH interim procedure 49 CFR Department of Transportation ANSI Z358.1-2004 Emergency Eyewash and Shower Equipment OSHA 1910 10 CFR Part 851, Appendix A, Functional Areas 6, Industrial Hygiene; 7, Biological Safety; and 8, Occupational Medicine
NSLS-II – FHA-12	<b>Accelerator/Beamline hazards</b> Vacuum/Pressure Over-heating High pressure heating (bake-out) water Compressed gas Electrical Heavy equipment handling Static magnetic Cryogenic Mechanical (moving shutters, valves and actuators) Radiological	BNL SBMS Subject Areas DOE Order 420.2B Safety of Accelerator Facilities DOE G 420.2-1, Accelerator Facility Implementation Guide 10 CFR Part 851, Appendix A
NSLS-II – FHA-13	<b>Ionizing radiation hazards</b> Prompt radiation (synchrotron radiation scatter, neutrons, bremsstrahlung) Radioactive contamination Activation (equipment) Radioactive material (dispersibles, sealed sources, storage, surface contamination)	BNL SBMS Radiological Safety subject areas BNL Radiological Control Manual 10 CFR Part 835, Occupational Radiation Protection
NSLS-II – FHA-14	<b>Lasers and other non-ionizing radiation hazards</b> Lasers RF & microwave Static magnetic fields Visible light Infrared Ultraviolet	BNL SBMS Laser Safety subject area BNL SBMS Static Magnetic Fields subject area RF and Microwave Safety subject area ANSI Z136.1-2000 Safe Use of Lasers
NSLS-II – FHA-15	<b>Material handling hazards</b> Overhead cranes/hoists Fork trucks Manual material handling Delivery area distribution Manual movement of materials Suspect/counterfeit equipment	BNL SBMS Lifting Safety subject area ASTM B30 Overhead Cranes 10 CFR Part 851, Appendix A, Functional Area 9, Motor Vehicle Safety

FHA Identifier	Hazard List	Applicable NSLS-II ES&H Regulations, Standards, Codes, Order
NSLS-II – FHA-16	<b>Experimental operations</b> Electrical equipment Transportation of hazardous materials Biological/Medical materials Chemicals (corrosive, reactive, toxic, flammable) Nanomaterials (particulates) Falls from elevations Ionizing radiation Ozone production Slips, trips, falls Machine & hand tools Stray static magnetic fields Research gasses (corrosive, reactive, toxic, flammable)	BNL SBMS Work Planning and Control For Experiments and Operations subject area and other related subject areas 10 CFR Part 851, Appendix A, Functional Areas 2, Fire Protection; 3, Explosives Safety; 4, Pressure Safety; 6, Industrial Hygiene; 7, Biological Safety; 8, Occupational Medicine; 10, Electrical Safety

### 1.2.1 Construction Hazards (NSLS-II FHA – 1)

BNL has a mature construction safety program, with recent experience in constructing the Research Support Building (64,000 sq ft) and the Center for Functional Nanomaterials (94,500 sq feet). Lessons-learned from these two projects, as well as from other construction projects in the DOE complex, coupled with the existing program, will control risk at the NSLS-II facility. Typical construction hazards anticipated at the NSLS-II construction site include the following:

- Site clearing
- Excavation
- Work at elevations (steel, roofing)
- Utility interfaces, (electrical, steam, chilled water, compressed air)
- Material handling
- Miscellaneous finishing work
- Weather-related conditions
- Transition to Operations

#### 1.2.1.1 Construction Hazards – Mitigating Factors (Design)

- Engineered and approved excavation systems
- Engineered and approved fall-protection systems
- Permanent fall-protection systems incorporated into facility's roof systems (for future maintenance)
- Modern code-compliant construction equipment with the required safety controls

#### 1.2.1.2 Construction Hazards – Mitigating Factors (Operational)

- Strict adherence to 29 CFR 1926, OSHA Construction Standard
- Integrated Safety Management (contractually flowed down to subcontractors)
- Contractor-Required Health and Safety Plan (flowed down to subcontractors)
- NSLS-II Construction Safety Plan
- Construction Safety Professional on staff
- Pre-qualification of contractors and subcontractors based on their Experience Modification Rate; Days Away, Restricted, Transfer rate; and Total Recordable Case rate
- Independent third-party inspections of construction safety program
- Dedicated onsite construction safety professionals
- Phase hazards analysis for high-risk activities (e.g., site clearing, work at elevations)
- Pre-excavation search for utilities and other legacy systems
- Contractor-safety incentive program
- Frequent ES&H communication with contractor and subcontractors at plan-of-day, “tool box” meetings
- Major construction equipment inspected before arriving on site

### 1.2.2 Natural Phenomena Hazards (NSLS-II FHA-2)

Natural Phenomena Events, include high winds, floods, and earthquakes. The NSLS-II design will be governed by the Building Code of the State of New York (BCNY). The BCNY specifies design criteria for wind loading, snow loading, and seismic events. NSLS-II was determined to be a Performance Category 1 facility per DOE STD-1021-93. It will contain only small quantities of activated, radioactive, and hazardous chemical materials. If a NPH were to cause significant damage, the impact would be mission related and would not pose a hazard to the public or the environment.

### 1.2.2.1 NPE Mitigating Factors (Design)

- Performance Classification designation PC-1
- Strict conformance to Building Codes State of New York
- Snow-loading criteria: 45 psf ground, 30 psf+ drift where applicable
- Wind design: 120 mph (with 3-second gust)
- Seismic design: to 0.25g acceleration velocity
- Lateral load building design
- Lightning-protection system per NFPA (National Fire Protection Association) 780
- Pitched roofs on structures to preclude localized flooding/roof leaks
- Site drainage designed to shed water

### 1.2.2.2 NPE Mitigating Factors (Operational)

- Limited and controlled quantities of hazardous materials
- BNL Site Emergency Plan
- NSLS-II site emergency plan
- Emergency drills
- NEXRAD facility on BNL site for early notification of severe weather

## 1.2.3 Environmental Hazards (NSLS-II FHA 3)

Environmental hazards from NSLS-II include the potential for releasing, in amounts beyond regulatory limits, oils, solvents, chemicals, and radioactive material to the soil, groundwater, air, or sanitary system. The principal initiators for such a release would be the failure of equipment, impact from a natural phenomenon, fire, or a violation of procedures/processes.

The NSLS-II facility established a goal of obtaining Leadership in Energy and Environmental Design (LEED) certification that contains requirements for sustainable design principles, pollution prevention, and waste minimization during construction and operations.

### 1.2.3.1 Environmental Hazards – Mitigating Factors (Design)

- Closed-loop cooling systems
- Minimal need for the regeneration of filter beds and the use of water-treatment chemicals
- Handling and storage facility for control of waste water
- Design to Suffolk County Article 12 (secondary containment) requirements
- Radiation loss points evaluated to determine shielding requirements to protect environment from soil activation
- NSLS-II will include sustainable design principles with the goal of obtaining LEED certification

### 1.2.3.2 Environmental Hazards – Mitigating Factors (Operational)

Implementation of an environmental management program designed to international standards (ISO 14001), where chemical use is minimized through review, and less hazardous chemicals and processes are substituted where possible. Controls are based on the following:

- Environmental Management System manual
- Environmental Compliance Representative input
- Significant Environmental Aspect matrix
- Chemical Management System database
- Process Assessments



- ES&H Committee, Beamline Review Committee, design reviews
- Work Planning, Experimental Safety Reviews, Tier I inspections
- Training/qualification
- NSLS-II NEPA Environmental Assessment and Finding of No Significant Impact
- NESHAP evaluation
- Soil and water sampling
- Use of oil-less pumps and synthetic oils
- HEPA-filtered hoods

#### **1.2.4 Waste Hazards (NSLS-II FHA-4)**

Waste-related hazards from NSLS-II include the potential for releasing waste materials (oils, solvents, chemicals, and radioactive material) to the environment, injury of personnel, and a possible reactive or explosive event. Typical initiators would be transportation accidents, incompatible materials, insufficient packaging/labeling, failure of the packaging, a natural phenomenon or a procedural violation.

The types and volume of wastes that will be generated by NSLS-II are not anticipated to differ markedly from those generated by the existing NSLS. During a typical year of operation, NSLS-II will generate 3,000 to 5,000 pounds (1,400 to 2,300 kilograms) of waste.

##### **1.2.4.1 Waste Hazards – Mitigating Factors (Design)**

- Two 90-day waste accumulation areas on opposite sides of ring
- 90-day areas are designed with 2-hr fire rating, independent exhaust ventilation, fire detection, alarm pull box, communications (phone) system, access control (card reader), and secondary containment

##### **1.2.4.2 Waste Hazards – Mitigating Factors (Operational)**

- NSLS-II chemical use and waste production will be minimized through review; less hazardous chemical and processes will be substituted where possible
- Local Satellite Accumulation Areas in laboratories or at beamlines
- 90-day weekly inspections
- Periodic New York State Department of Environmental Conservation inspections of the 90-day areas and Satellite Accumulation Areas
- Hazardous Waste Generator training
- Experimental Safety Review process
- Work planning and control
- Facility-Specific safety orientation
- Tier I inspections
- Process Assessment Forms
- Tritium sampling program for accelerator's cooling-water systems
- Waste reduction, pollution prevention, and recycling
- HazMat transportation procedures per DOT

#### **1.2.5 Fire Hazards (NSLS-II FHA – 5)**

Operational experience at accelerators throughout the DOE complex has demonstrated that most fires in accelerator facilities are electrically initiated, typically by component failure. However, other sources of fire are considered in the design of the NSLS-II facility. They include the combustibility of building construction materials, the accumulation of combustible materials by occupants, the use of pyrophoric or reactive materials, improper storage or use of flammable materials, lightning storms, and static discharge.

### 1.2.5.1 Fire Hazards – Mitigating Factors (Design)

- Design to Business Occupancy BCNY and appropriate NFPA standards
- Preliminary Fire Hazards Analysis
- Noncombustible construction throughout facility
- Early-warning fire-detection systems (e.g., HSSD, smoke detectors, rate of rise detectors, pre-alarm)
- Fully sprinklered, including a fire department standpipe service (except hutches)
- Draft curtains and manually activated exhausts around ring to limit spread of heat and smoke
- Redundant Water Supplies
  - Two feeds to NSLS-II
  - Well gridded water supply system
  - Supply for three days without electric power
- Emergency power supply for essential systems
- Hazardous material storage areas: rated, vented, alarmed
- Lightning protection system for facilities
- Adequate grounding systems

### 1.2.5.2 Fire Hazards – Mitigating Factors (Operational)

- Manual fire suppression provided by sufficient portable fire-extinguishers
- Alarm systems to alert occupants and summon fire department (e.g., fire alarm bells/strobes, manual pull stations, connected to on-site fire department)
- Full-time, BNL Fire/Rescue Group with mutual aid arrangements with local fire departments
- Ongoing Tier I inspection program to minimize combustibles and ignition sources
- Ignition-source control programs (cutting/welding permits, no smoking policy)
- Experimental Safety Review and Work Planning to minimize fire hazards of experiments and other work within the facility
- Fire evacuation drills

## 1.2.6 Electrical Hazards (NSLS-II FHA – 6)

The NSLS-II will have a large amount of facility-related and experimental electrical equipment. Electrical hazards from NSLS-II include the potential for serious injury, death, and equipment damage. Electrical shock and arc flash can be caused by exposed conductors, defective and substandard equipment, lack of adequate training, or improper procedures.

### 1.2.6.1 Electrical Hazards – Mitigating Factors (Design)

- Design to NFPA 70 and 70 E National Electric Code
- Provide adequate power distribution (beamlines and laboratories) to reduce need for extension cords
- Provide segregated power and utility distribution; no over-loading (cable/utility trays)
- Electrical and mechanical equipment rooms adequately sized and accessible from outside of ring
- Electrical distribution/disconnect equipment located in unobstructed areas (physically marked to provide clear access)
- Protect equipment and cables from mechanical and other hazards
- NRTL-certified equipment if available, all non-NRTL certified by BNL EEI program
- Conduct arc flash calculations, determining PPE requirement, and label all electrical panels and switches
- Assess need and feasibility for remote operation of high voltage switches and breakers to prevent human contact during opening and closing
- Implement Lockout/Tagout capability into design of energized equipment

### **1.2.6.2 Electrical Hazards – Mitigating Factors (Operational)**

- Non NRTL-certified equipment inspected and certified by an Electrical Equipment Inspector
- Engineering and beamline design reviews
- Operation of equipment at <50 volts where feasible
- SBMS procedures for electrical safety
- Electrical safety training
- Operational procedures to keep electrical equipment unobstructed
- Tier I inspection program

### **1.2.7 Noise Hazards (NSLS-II FHA – 7)**

Hazards from noise include overexposure of personnel to ACGIH and OSHA occupational exposure limits and permanent hearing loss, also known as Permanent Threshold Shift. NSLS-II will incorporate a wide variety of equipment that will produce a range of noise. Support equipment (e.g., pumps, motors, fans, machine shops, and general HVAC) all contribute to point source- and overall ambient-noise levels. While noise will typically be below the ACGIH 8-hr time-weighted average, certain areas with mechanical equipment could exceed that criterion and will require periodic monitoring, posting, and the use of Personal Protective Equipment. Ambient background noise is of a greater concern from the standpoint of users' comfort, stress level, and fatigue. Background noise in the accelerator and experimental areas at the existing NSLS is a common quality-of-life complaint and may be distracting and tiring.

#### **1.2.7.1 Noise – Mitigating Factors (Design)**

- Use low noise equipment (fans) in HVAC systems
- Incorporate sound-absorbing materials into structure (wall and ceilings) and around equipment
- Use of water or whisper fan cooling for equipment
- Achieve Noise Criterion of 60 or better

#### **1.2.7.2 Noise – Mitigating Factors (Operational)**

- Baseline and periodic area noise surveys, and postings
- Personnel noise dosimetry
- Noise-exposure medical protocol where required
- New equipment reviews for noise levels as part of procurement and installation process
- Local sound proofing, if needed
- Personal protective equipment

### **1.2.8 Cryogenic, Including Pressure Hazards (NSLS-II FHA – 8)**

Cryogenic hazards at NSLS-II will include the potential for oxygen-deficient atmospheres due to catastrophic failure of the cryogenic systems, thermal hazards (cold burns) from cryogenic components, and pressure hazards. Initiators could include the failure or rupture of cryogenic systems from overpressure, failure of insulating vacuum jackets, mechanical damage or failure, deficient maintenance, or improper procedures.

Large volumes of liquid nitrogen will be piped into and around the NSLS-II facility from a centralized distribution point located outside of the ring building. In addition, dewar vessels (typically up to 500 liters) will be used locally in experiments.

Liquid nitrogen and liquid helium will be used for cooling experimental samples such as protein crystals, and also to cool beamline equipment, such as detectors, for enhanced sensitivity. Similarly, liquid coolants will chill accelerator components such as magnetic insertion devices, to make them superconducting (i.e., have zero resistance to electrical current) as well as equipment located within beamline front end optical enclosures.

Other pressurized systems include the facility compressed air distribution system providing air pressurized to 100 psig, the facility compressed nitrogen system pressurized to 100 psig used within the experimental program and compressed air cylinders (typically 2000 psig) used for the experimental program. Pressurized systems present hazards of asphyxiation, fire, injury from fragments or missiles or contact with toxic gases produced by system failure.

#### **1.2.8.1 Cryogenic and Pressure Hazards – Mitigating Factors (Design)**

- Design cryogenic and other pressure systems per ASME and ANSI codes or equivalent
- Evaluate failure scenarios and provide PDH sensors and alarms as required
- Provide interlocks and automatic exhaust system/quench installed
- Provide relief mechanisms in all piping and dewar systems
- Design review process
- Initial system pressure testing
- Major systems reviewed by BNL Cryogenic and Pressure Safety sub-committee and testing completed as required by SBMS

#### **1.2.8.2 Cryogenic and Pressure Hazards – Mitigating Factors (Operational)**

- NSLS-II facility-specific access training
- Compressed-gas safety training
- Cryogen safety awareness training
- Oxygen Deficiency Hazard training
- ODH classification and controls
- System-specific training
- Personal protective equipment

### **1.2.9 Confined Space Hazards (NSLS-II FHA – 9)**

Hazards from confined spaces could result in death or injury due to asphyxiation, compressive asphyxiation, smoke inhalation, or impact with mechanical systems. Initiators would include failure of cryogenic systems releasing gas, fire, or the failure of mechanical systems or chemical spills.

Two types of confined spaces should be considered for the NSLS-II facility. The first are those associated with the facility's support/maintenance and typically include sump pits and HVAC plenums that would only be accessed by Plant Engineering's maintenance personnel or vendor personnel. NSLS-II staff and users would not have access to these spaces. The second category is those confined spaces created by the experimental programs and may include pits for support equipment or large tanks installed to recover inert gases.

#### **1.2.9.1 Confined-Space Hazards – Mitigating Factors (Design)**

- Definition of confined space criteria for designers – “design out,” where possible
- Design of multiple means of egress, where possible
- Adequately size mechanical enclosures to provide for maintenance

### **1.2.9.2 Confined-Space Hazards – Mitigating Factors (Operational)**

- Identification and posting of all confined spaces
- Facility-specific safety orientation to identify spaces
- Work Planning and Control program
- Interface with site's maintenance personnel identify their confined spaces

### **1.2.10 Ozone Hazards (NSLS-II FHA-10)**

Synchrotron radiation produced by the storage ring dipole bending magnets and insertion devices can generate significant levels of ozone when the unattenuated beam passes through air. Experience at the current NSLS demonstrated that in some instances, ozone concentrations may approach or exceed the ACGIH Threshold Limit Values and precautions are needed to control potential exposures.

#### **1.2.10.1 Ozone Hazards – Mitigating Factors (Design)**

- Direct the beam path through evacuated or inert gas atmosphere containing pipes
- Minimize beam's horizontal and vertical dimensions
- Minimize beam path's length
- Filter beam to eliminate lower photon energies
- Scrub air round beam path with ozone filters
- Install ozone monitoring at potential problem areas

#### **1.2.10.2 Ozone Hazards – Mitigating Factors (Operational)**

- Experimental and beamline review program
- Delay personnel entry time to allow ozone to degrade

### **1.2.11 Chemicals and Hazardous Materials, Including Nano-materials and Biological Materials (NSLS-II FHA – 11)**

The use of chemical and hazardous materials (HazMat) at NSLS-II could result in injury and death, or in exposures that exceed regulatory limits. Initiators could be experimental operations, transfer of material, failure of packaging, improper marking/labeling, failure of fume hood or glove box, reactive or explosive event, improper selection (or lack) of personal protective equipment, or a natural phenomenon.

#### **1.2.11.1 Chemical and HazMat Hazards – Mitigating Factors (Design)**

- Dedicated Chemical Storage Area with segregation, ventilation, fire-protection system, flammable, and O<sub>2</sub> monitors and access control
- Chemical delivery area located adjacent to loading dock
- Each lab designed based on anticipated use and future use (user input in design process, historical inventories/hazards considered)
- Labs designed for Biosafety Level 2 materials
- Vented chemical storage cabinets in laboratories and at beamlines as determined
- Gas cabinets for toxic and highly toxic gasses, individual venting and purging capacity and exterior access
- Double-wall stainless tubing for toxic and highly toxic gas distribution
- Dedicated storage for biological and infectious materials
- Bulk gas piped in, (Liquid Nitrogen, Gaseous Nitrogen, Air); limit number of individual cylinders

- Exhausted fume hoods in laboratories meeting industry consensus standards (specialized hoods such as HEPA filters for nanomaterials and radioactive materials, where necessary)
- Covered centralized location for storing gas. Satellite locations due to size of ring.
- Safety showers and eyewashes in each wet laboratory (tepid water)
- Loading dock with leveling system to reduce material handling
- All lead material encapsulated/painted
- Hutches with exhaust ventilation to exterior of building

#### **1.2.11.2 Chemical and HazMat Hazards – Mitigating Factors (Operational)**

- Experimental safety review to determine type and use of chemicals, nanomaterials and biologicals; minimize quantities in use and in storage
- Compliance with BNL Subject Area and part 851 requirements for handling chemicals, including nano and biological materials
- Chemical Inventory control system (barcode); Chemical Management System (CMS)
- Lab Standard/Hazcom or other required training
- Transport of materials per DOT and BNL Hazardous Material Transportation Manual (HMTM)
- Assess needs for exposure monitoring
- Safety protocols for workers using or machining lead

#### **1.2.12 Accelerator/Beamline Hazards (NSLS-II FHA – 12)**

Hazards from the accelerator and beamlines include the loss of vacuum and cooling water system control, compressed air and gas, electrical, material handling, and static magnetic, cryogenic, mechanical and also scattered radiation.

The accelerator and beamlines will have various types of electrical equipment and associated power supplies. High-power equipment includes vacuum pumps, vacuum gauges, detectors and beam-position monitors (higher voltage-biased system).

Two important hazards are synchrotron scatter from beamline optics and bremsstrahlung radiation from loss of high-energy electrons from the orbit. Both hazards are found along the beamline. Synchrotron scatter will mostly be from the first optical elements. Bremsstrahlung radiation is confined to the beamline vacuum chamber with lead collimators until it can be directed into a beam stop. On many beamlines, the synchrotron light is offset from the bremsstrahlung cone at the monochromator and can be stopped there. For lines that have insufficient offset, a backstop is placed in the hutch behind the endstation.

##### **1.2.12.1 Accelerator/Beamline Hazards – Mitigating Factors (Design)**

- Engineered safety-systems in place will protect the ring and beamlines from vacuum, cooling-water flow, extreme temperatures, and compressed air faults
- Vacuum faults will cause the accelerator's interlock systems to close the sector and front-end valves, thus dumping beam; beamline interlocks will close a beamline valve and/or a front-end valve; insertion device beamline interlocks will close the fast valve and dump RF
- Reduced cooling water flow or loss of temperature control is sensed, causing the accelerator's interlocks to dump RF and causes beamline interlocks to close the safety shutters
- Elevated magnet temperature would turn off the magnet's power supply; if sensed on ring components, would dump RF; if sensed in the pump room water, would dump RF and magnet power supplies.
- Loss of primary compressed air supply from the Central Chilled Water Facility alerts the control room
- Loss of backup compressed air supply (affecting operation of front-end masks, safety shutters, and fast valves) alerts the control room

### **1.2.12.2 Accelerator/Beamline Hazards – Mitigating Factors (Operational)**

- Safety Analysis Document and Accelerator Safety Envelope
- Operational procedures
- Systems design review

### **1.2.13 Ionizing Radiation Hazards (NSLS-II FHA – 13)**

Potential hazards from ionizing radiation include prompt radiation (x-rays, neutrons, bremsstrahlung) produced during machine operation, induced activity in machine components, and experimental radioactive material (use, storage). Typical initiators of radiation exposure would include operating machines, maintenance work, and use of radioactive materials. Accidental exposure could result from failure of an interlock or other protective system, inadequate design or control of shielding, or an inadequate procedure.

Management and control of ionizing radiation hazards will follow the requirements in 10 CFR 835, Occupational Radiation Protection, the BNL SBMS Radiological Safety subject areas, and the BNL Radiological Control Manual. The facility will be designed and operated in a manner to maintain radiation exposure to staff, users, and the general public personnel within DOE and BNL dose limits and control levels [1.6]–[1.11].

A full discussion of radiation shielding at NSLS-II is given in Chapter 15.

#### **1.2.13.1 Ionizing Radiation – Mitigating Factors (Design)**

- Well designed shielding for accelerators (including roof) and hutches to reduce dose to administrative levels
- Interlock systems, e.g. beam dumps if interlock broken, emergency stop capability, audible/visual alarms
- Redundant interlock systems for accelerator enclosures and beamline hutches
- Redundantly monitored radiation safety critical devices (e.g., transfer line beam stops, beamline safety shutters) with reach back to upstream devices if there is a failure
- Real-time beam loss monitoring system for injection and storage-ring operation
- Shielding around penetrations to minimize leakage, e.g. single-block concrete construction wherever possible, tongue-and-groove to eliminate line of sight, shielding labyrinths and chicanes
- Office areas/staff lounges and other public areas, e.g. walkways, should not be exposed to significant radiation fields produced by machine operators or by equipment

#### **1.2.13.2 Ionizing Radiation – Mitigating Factors (Operational)**

- Radiological protection program incorporating requirements of 10 CFR 830 and 835, and BNL SBMS subject areas and BNL Radiological Control Manual
- Strict configuration control of shield and interlock systems
- Routine area monitoring of dose levels by passive dosimeters for neutrons and gammas on the experimental floor (and other occupied areas subject to radiation)
- Radiological safety training, e.g. GERT, Radiation Worker I
- Facility-specific Safety Orientation and ES&H Orientations
- Work planning and control procedures for work in radiation areas or with radioactive materials
- ALARA designs and committee reviews
- Administrative control levels and limits specified in Accelerator Safety Envelope

### **1.2.14 Lasers and other Non-Ionizing Radiation Hazards (NSLS-II FHA – 14)**

Anticipated non-ionizing radiation hazards at NSLS-II include radio frequency, microwave, static magnetic, visible light, infrared, ultraviolet and laser hazards. The NSLS-II accelerators and storage rings will depend on the reliable operation of pulsed klystrons and continuous-wave high-power radio-frequency (RF)

systems for injecting electrons and maintaining the stored beam. Both of these devices generate electromagnetic radiation within the RF and microwave energy ranges of 500 MHz to 3 GHz) and, in addition, pose significant electrical hazards. The devices typically are operated and maintained such that these energies will be shielded and, therefore, will not thermally or electrically expose nearby personnel.

The NSLS-II operations and experimental programs will use Class 1, 2, 3a, 3b, and 4 lasers. Some lasers will occupy permanent locations, while others will be part of short-term beamline experiments, in place for just days to weeks at a time. Lasers, particularly those in Class 3b and 4, will require written laser controlled area standard operation procedures for each device to control exposure, and associated electrical and industrial hygiene hazards, e.g. exposure to solvents, dyes, and halogen gases.

#### **1.2.14.1 Lasers and other Non-Ionizing Radiation Hazards – Mitigating Factors (Design)**

- Commercial equipment designed with integral enclosure shielding and interlock systems
- Laser labs will address ANSI design requirements, including control of exposed beams and interlock systems
- Use of gas cabinets for lasers using halogens (fluorine gas) vented exterior to the building

#### **1.2.14.2 Lasers and other Non-Ionizing Radiation Hazards – Mitigating Factors (Operational)**

- Baseline and routine surveys for stray static magnetic fields, RF, and microwave
- Training for static magnetic fields, RF, microwave hazards
- Laser safety training
- Equipment ES&H review
- Laser Safety Officer reviews, especially of written procedures for Class 3b and 4 lasers
- Experiment safety reviews
- Personnel protective equipment

#### **1.2.15 Material-Handling Hazards (NSLS-II – FHA – 15)**

The consequences of hazards encountered in material handling include serious injury or death to equipment operators and bystanders, damage to equipment, and interruption of the program. These hazards could be initiated by a dropped or shifted load, equipment failure such as from suspect/counterfeit bolts and rigging equipment, improper procedures, or insufficient training or qualification of operators.

##### **1.2.15.1 Material-Handling Hazards – Mitigating Factors (Design)**

- Hoists and attach points designed to ASTM/ANSI standards
- Gases piped in to reduce handling of cylinders
- Adequate aisle space for maneuvering loads

##### **1.2.15.2 Material-Handling Hazards – Mitigating Factors (Operational)**

- Hoists and lifts proof tested after installation and any modification
- Routine inspection and maintenance of hoists and forklifts and rigging equipment
- Only trained and qualified personnel allowed to use hoists and fork trucks
- Hoists and forklifts are locked to prevent unauthorized use
- Inspection before each use as required by SBMS to assure proper operating conditions
- Ensure areas are adequately protected from the forklifts and other traffic



### 1.2.16 Experimental Hazards (NSLS-II – FHA – 16)

The consequences from experimental operation hazards range from minor to severe injuries, possible death, and danger to the experimental, accelerator, or facility equipment, as well as a programmatic impact. Initiators would include the release or unexpected reaction of hazardous material, the failure of protective systems, the use of radioactive materials and of biological materials, operators' error, lack of training, poorly designed/installed equipment, failure of equipment, unexpected chemical reactions, and undefined hazards or risks from material not considered in experimental safety reviews. Many of the anticipated hazards are discussed in the specific hazard-analysis sections, e.g., ozone, non-ionizing radiation.

Inert and other research gases will be used in experiments; inert gases include nitrogen, helium, and argon. Small amounts of flammable gases, such as hydrogen, propane, and butane, may be required. Various toxic gases, such as hydrogen sulfide, carbon monoxide, or nitrogen oxides might also be used in liter quantities. Small-scale use of oxygen and the halogens also is anticipated. Liquid nitrogen and liquid helium will be used to cool experimental samples such as protein crystals.

The NSLS-II team continues to work with the DOE "nano" community to share the latest information on the hazards of nanoparticles and to fully implement the Secretarial Policy Statement on Nanoscale Safety (DOE P 456.1). Future changes in design guidance and equipment/systems may be necessary due to emerging information.

#### 1.2.16.1 Experimental Hazards – Mitigating Factors (Design)

- Each laboratory designed based on its anticipated use and future use (user input in design process, historical inventories/hazards considered).
- Facility designed for Bio-safety Level 2.
- Chemical fume hoods installed in laboratories will be appropriate to experimental activity conducted, HEPA filtered hoods for nanomaterial particulate and radiological dispersible work (once through systems)..
- An adequate power designed into laboratory to support equipment/future growth (GFCI protected).
- Equipment bonding system installed.
- Adequate chemical storage.
- Vented storage cabinets for flammable gases in laboratories
- Laboratories designed for easy access/egress, process flow, ease of cleaning
- Laboratories located in proximity to beamlines reducing travel with experimental materials
- Facility and laboratories designed to meet OSHA 1910 (walkways, stairs, egress)
- Safety shower and eye wash in each chemical laboratory (hands-free, tepid water)

#### 1.2.16.2 Experimental Hazards – Mitigating Factors (Operational)

- Experimental safety review program
- Control of hazardous materials (inventory, storage)
- ES&H support staff (subject-matter experts, monitoring technicians )
- Principal Investigator's R2A2 and training
- Adequate beamline staffing

## 1.3 NEPA COMPLIANCE

In compliance with the National Environmental Protection Act (NEPA) and its implementing regulations (10 CFR 1021 and 40 CFR 1500-1508) and in accordance with the requirements of DOE Order 451.1B, an Environmental Assessment (EA) was prepared to evaluate the potential environmental consequences of

constructing and operating NSLS-II at DOE's preferred site (BNL) has been carried out [1.11]. The EA analyzed the potential environmental consequences of the facility and compared them to the consequences of a No Action alternative. The assessment included detailed analysis of all potential environmental, safety, and health hazards anticipated as the design, construction, and operation of the facility progresses. The EA determined that there would be no significant impact from the construction and operation of the proposed facility and that an Environmental Impact Statement (EIS) was not required. A Finding of No Significant Impact (FONSI) was approved by the DOE Brookhaven Site Office (BHSO) Manager and made available to the general public and project stakeholders [1.12].

## 1.4 QUALITY ASSURANCE

NSLS-II management will design and build a world-class user facility for scientific research with the assistance of a fully involved Quality Assurance (QA) Program.

The NSLS-II Project Director is responsible for achieving performance goals. The NSLS-II Quality Assurance Manager is responsible for ensuring that a quality system is established, implemented, and maintained in accordance with requirements. The QAM will provide oversight and support to the project participants to ensure a consistent quality program.

A QA Program Plan [1.13] has been prepared by the QA Manager and approved by the NSLS-II Project Director. This plan specifies the program requirements that apply to all NSLS-II work. The primary objective of the QA program is to implement quality assurance criteria in a way that achieves adequate protection of the workers, the public, and the environment, taking into account the work to be performed and the associated hazards. The objectives include:

- “Designing in” quality and reliability
- Assuring that all personnel involved in the project uphold the NSLS-II Quality Assurance Plan
- Promoting early detection of problems to minimize failure costs and impact on schedule
- Developing appropriate documentation to support construction and operational requirements
- Assuring that personnel have the necessary training as needed before performing critical activities, especially activities that have environmental, safety, security, or health consequences.
- Defining the general requirements for design and readiness reviews, including environmental, safety, security, and health issues related to NSLS-II and contractor hardware, software, and processes.

## References

- [1.1] NSLS-II Environment, Safety, and Health Plan.
- [1.2] NSLS-II Baseline Hazards List, March 2006
- [1.3] NSLS-II Preliminary Hazards Analysis; December 2006
- [1.4] NSLS-II Final Hazard Analysis (currently under review by DOE/BHSO)
- [1.5] NSLS-II Technical Note 00012; “Preliminary Radiological Considerations for the Design and Operation of NSLS-II Linac”; PK Job and WR Casey July 25, 2006.
- [1.6] NSLS-II Technical Note 00013; “Preliminary Radiological Considerations for the Design and Operation of NSLS-II storage Ring and Booster Synchrotron; PK Job and WR Casey July 25, 2006.
- [1.7] NSLS-II Technical Note 00014; “Preliminary Shielding Estimates for NSLS-II Beamlines and Front Ends”; PK Job and WR Casey July 25, 2006.
- [1.8] J. Panakkal, W.R. Casey, “Preliminary Activation Analysis of Accelerator Components and Beam Stops at the NSLS-II”; NSLS-II Technical Note 00015; August 1, 2006.
- [1.9] NSLS-II Technical Note 00016; “Preliminary Activation Analysis of Soil, Air and Water near the NSLS-II Accelerator Enclosures”; PK Job and WR Casey August 15, 2006.

- [1.10] NSLS-II Technical Note 00021; “Shadow Shields in the Storage Ring of NSLS II”; PK Job and WR Casey September , 2006
- [1.11] NSLS-II Technical Note 00032; “Preliminary Material Requirement for the Supplementary Shielding at NSLS-II”; PK Job and WR Casey July 18, 2007
- [1.12] NSLS-II Environmental Assessment.
- [1.13] Finding of No Significant Impact for NSLS-II Project, approved by BHSO, September 27, 2006.
- [1.14] NSLS-II Quality Assurance Plan.

