Fire Hazard Analysis
Building 911
Accelerator Department Support Facility

Brookhaven National Laboratory

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Date of Last Survey: August 1990
Date of Report: September 30, 2006

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1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for Building 911, Accelerator Department, at Brookhaven National Laboratory (BNL), Upton, NY. This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 911 to ascertain whether the facility meets the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose Building 911 and (2) that are inherent in the building or operations. The adequacy of the fire safety features in the building and the degree of compliance of the facility with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the building and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment value were calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 8, Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. Hazard Severity. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

a. Category I. May cause death, permanent total disability, or loss of a facility/asset.

b. Category II. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

c. Category III. May cause minor injury, occupational illness, or property damage.

d. Category IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected

populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	Mishap Probability			
	A	**B**	**C**	**D**
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

Building 911 was constructed in two stages: the first stage is mostly one-story with insulated metal panels on steel frame walls and a Class II insulated steel deck roof; the second stage is a three story addition with concrete block, metal face walls and a Class I insulated steel deck roof.

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in Building 911, Accelerator Support Facility. The FHA includes an analysis of the fire and life safety features of the facility to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that Building 911 does not comply with DOE Order 420.1 Fire Protection objectives. The following recommendations are the result of this evaluation.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

Finding: Doorways in the walls separating the Annex from the remainder are protected with 3-hour fire protection-rated doors except for the door at the northwest end of the Annex, First Floor, outside of Room A108. The cross-corridor doors in this location are non-rated wood doors with non-fire protection-rated glazed vision panels. In order to maintain the fire separation of the Annex from the remainder of the building, these doors should be replaced with 3-hour fire doors as are provided elsewhere.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-01: Provide 3-hour fire doors at the intersection of the east-west corridor along the south wall of Drafting Room A-110 and the north-south corridor connecting the courtyard with the exit near Room A108. The doors should be arranged to swing in the direction of egress travel into the north-south corridor (See Section 4.3.2).

Finding: Doors held open by fusible links are not permitted except for existing horizontal sliding doors complying with the special provisions for business or industrial occupancies (See Section 4.3.2 & 8.7).

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-02 (LSC90-911-7): The fire doors across the corridor in the east end of the Annex, on the north side of the stairway, are presently held open by fusible links on the door closers. These closers are not in compliance with NFPA 80, Fire Doors and Windows and should be removed. If it is desired to have the doors held open, they should be automatic-closing, arranged to close on actuation of smoke detection devices on either side of the doorway, in accordance with NFPA 80 (See Section 4.3.2).

Finding: Numerous, unprotected penetrations including those for pipes, cables, and conduit occur in the wall separating the Power Room and Pump Room and the Main Terminal Room from the AGS Control Room. The unprotected penetrations would likely reduce the fire resistance of the wall such that the wall cannot be credited as a fire barrier. Through-penetration firestopping should be provided. In addition, holes in the wall caused by the routing of utilities should be filled with grout or mortar.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-03 (LSC90-911-6): Seal unprotected openings between the Cable Tunnel and the Pedestrian Tunnel with a UL listed or FM approved material having a minimum of 1-hour fire resistance rating.

Provide protection for the vertical opening between the first and second floors in the Terminal Rooms, either by sealing penetrations between the two rooms or by providing a 1-hour fire resistive enclosure around the two rooms (such as is done with a stairwell).

Seal any openings in the wall between the pedestrian tunnel and the terminal room with material having at least a 2-hour fire resistance rating (See Section 4.3.4).

Finding: At the time of this survey clear access to the FDC located on the east wall was hampered by two parked vehicles.

Hazard Severity	IV
Mishap Probability	C
Risk Assessment Code	5

Recommendation HAI-06-911-04: Fire department connections should be maintained accessible to the fire department at all times. Areas should be posted and parking limits enforced (See Section 5.1.2).

Finding: Automatic sprinkler protection is provided throughout most of the building, however a number of areas are either unprotected or the existing protection does not meet code requirements for adequacy of coverage. The following areas were observed to lack coverage or have inadequate coverage:

- The Power Room, which is separated from the rest of Building 911 by a 3-hour fire barrier.
- The small room located within the high-bay Room 112B, Magnetic Measurement Area. The high-bay area has sprinkler protection. The small room appears to have been added without extending the existing sprinkler coverage.
- In the stairwell/hallway area next to Control Rom 113 and Kitchen 114.
- The corridor area between Electronics Shop 143 and Room 140.
- The first and second floor of the annex area.
- The southwest area of the second floor (Rooms 241 – 248).
- The higher ceiling area on the west side of Room 241-C. Room 241-C has sprinkler protection but this area has inadequate coverage due to differing ceiling heights.
- The south side of Room 241-D. Room 241-D has sprinkler protection but this area has inadequate coverage due to differing ceiling heights.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-05: Sprinkler protection should be provided to those areas currently unprotected. In addition, existing sprinkler coverage should be upgraded to comply with code requirements (See Section 5.1.3).

Finding: Manual pull stations are not provided at all exits as required by the Life Safety Code.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-06: Provide manual pull stations (mounted at 48-inches above the finished floor to the actuating handle) at the following exits (See Section 5.2.1):

- Basement - exit to areaway stair.
- First Floor - West exit from the Seminar Room, North exit from the main lobby, East exit from the Pump Room, North exit from the Power Supply Room, South loading opening exit from the Magnetic Measurement Area Room 112B, West exit from the Vacuum lab Room 160, South exit from Room 144 and South exit from Electronics Shop 143.

Finding: Alarm notification provided by audible alarm bell/gong appliances installed generally in public corridors will not provide proper audibility throughout the building.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-07: Provide additional audible alarm notification devices to achieve 70 decibels in all occupiable/public areas in the building in accordance with NFPA 72. A test of the system audibility should be conducted to determine areas requiring additional devices. Some areas that potentially do not have compliant alarm audibility include but are not limited to the following (See Section 5.2.1):

- Basement – The North portion of the floor.
- First Floor – The North corridor containing Rooms 112-138; Rooms 160, 144, 143 and 112B, Pump room, North-East fan room, Multipole room, the room above the Multipole room and Kitchen Room 114.

- Second Floor – The South corridor containing Rooms 244B-A206; portion of the central North-South corridor containing Rooms 241E-211; corridor containing Rooms 212-238; Room 222; South-West Mechanical Rooms (two) and the Air-conditioning Equipment Room.
- Third Floor – The Work Area/rooms A-306-310.

Finding: Bell/gong appliances including an integral strobe installed generally in public corridors do not provide proper visible alarm notification throughout the building.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-08: Provide additional visible alarm notification in the building to comply with public area coverage in accordance with NFPA 72. Areas that do not have compliant visual alarm coverage include but are not limited to the following (See Section 5.2.1):

- Basement – The North portion of the floor.
- First Floor – The Seminar room, the main entrance Lobby, all rest rooms, conference room 112, Control Room 113, the North corridor containing Rooms 112-138; Rooms 160, 144, 143 and 112B, Pump room, North-East fan room, Multipole room, the room above the Multipole room and Kitchen Room 114.
- Second Floor – The Computer Room 220, The South corridor containing Rooms 244B-A206; portion of the central North-South corridor containing Rooms 241E-211; corridor containing Rooms 212-238; Room 222; South-West Mechanical Rooms (two) and the Air-conditioning Equipment Room.
- Third Floor – The Work Area/rooms A-306-310.

Finding: Duct smoke detection or fan shutdown relays were not identified during this survey. Duct smoke detection is required on the main supply side duct(s) when the unit exceeds 2,000 CFM, and additionally on the main return duct(s) when the unit exceeds 15,000 CFM per NFPA 90A. NOTE: The Mechanical Code of New York State (Section 606) does not require duct smoke detection in supply air duct(s); only in return air duct(s) of units that exceed 2,000 CFM, and in the return duct-riser point on each floor when serving more than one floor and when more than 15,000 CFM (See Section 5.3).

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-09: Provide duct smoke detection for the shutdown of all air-handling units (not fans dedicated as exhaust only) with a capacity greater than 2,000 cubic feet/minute (CFM), in accordance with NFPA 90A (See Section 5.3).

Finding: Smoke detection for recall of the passenger and freight elevators was not observed during this survey.

Hazard Severity	IV
Mishap Probability	C
Risk Assessment Code	5

Recommendation HAI-06-911-10: Provide smoke detection in the passenger and freight elevator lobbies and associated machine rooms with automatic recall to the primary and alternate floors as required by ANSI A117.1 (See Section 5.3).

Finding: Significant amounts of exposed polystyrene insulation building materials are used in the construction of this facility.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-06-911-11 (FMR74-911-5.d): The expanded polystyrene used for insulation in the south wing tunnel between the AGS and the Control Room on piping in the center of the tunnel should be removed or protected by an approved non-combustible covering (See Section 6.3).

Finding: A lightning protection system is not provided for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-12: Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.5.1).

Finding: MPFL and MCFL loss potentials exceed defined thresholds.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-05 (repeated): Automatic sprinkler protection should be provided throughout the building. This includes those areas currently without sprinkler protection and the correction of inadequate coverage in areas with sprinkler protection (See Section 7.5).

Finding: The common path of travel from the First Floor terminal rooms is approximately 230 ft as measured from the Main Terminal Room 115 into the AGS Ring tunnel. Exit signage directs occupants into the corridor between the Magnetic Measurement Area and the Control Room to the original building lobby near Room 105.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-13: Access to other buildings from the AGS Ring tunnel was not obtained during this survey. If access to other buildings from the AGS Ring tunnel is possible, then egress signage should be provided in the tunnel indicating egress travel in both directions (See Section 8.2.4 & 8.2.5).

Finding: A clear aisle width of 28 in. must be maintained as required by LSC [§7.3.4.1.2]. In the Third Floor work area, the egress aisle along the offices was observed to be obstructed by transient items (equipment and carts) such that the egress width is less than 28 inches.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-14: A clear aisle width of 28 in. must be maintained as required by LSC [§7.3.4.1.2] (See Section 8.4).

Finding: A means of egress route is provided from the egress stairway adjacent to Room 217 through a 69-in. clear height doorway to the pump room roof from which an exterior stairway leads up to the grated platform for the magnet evaporative coolers and to the grade-level roadway via a steel stair (down seven risers). This path is coincident with a wooden boardwalk on the pump room roof. The boardwalk leads back to an egress door for the air-conditioning equipment room (i.e., a dead end condition).

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-15: Signage should be provided to direct occupants to the exterior metal stair leading to the cooling platform (See Section 8.4).

Finding: The egress stairway adjacent to Rooms 109 and 217 is unenclosed at both the First and Second Floors and discharges into the original building lobby. An exit placard is located to the right of the stairway directing occupants into the boiler room.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-16: This exit placard should be removed as egress into the more hazardous boiler room is not permitted. An exit sign is provided above the doorway to the interior courtyard. From the courtyard, three doorways are provided to re-enter the building. LSC does not specifically address exit discharge into a courtyard. A more straightforward means to reach the exterior may be provided via the corridor through the office area to the east exit adjacent to Office A128 (See Section 8.6).

Finding: The egress stairway adjacent to the main entry lobby at the southeast corner of the building continues past the First Floor to serve the Basement. Stairs that continue more than one-half story beyond the level of exit discharge shall be interrupted at the level of exit discharge by partitions, doors, or other effective means [LSC §7.7.3]. The stairway landing at the First Floor is located adjacent to the courtyard and the main lobby. Glass storefront doors are provided into the courtyard. The glass storefront doors are considered to adequately indicate that occupants have reached the level of discharge. However, signage should be provided to direct occupants to use the main lobby exit instead of the courtyard as the exit.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-17 (LSC90-911-9): Provide "Not an Exit" signs at the two ground floor doors (old and new lobbies) that lead to the courtyard. Provide a "Not an Exit" sign in the stair off of the new lobby in the area of the stair leading to the basement (See Section 8.6). If acceptable signage cannot be provided, then an interruption gate should be provided to prevent occupants from descending past the First Floor.

Finding: A continuous and safe path of egress is not provided across the roof as required by code.

Hazard Severity	IV
Mishap Probability	C
Risk Assessment Code	5

Recommendation HAI-06-911-18 (LSC90-911-8): Provide a continuous safe means of egress from the third floor roof exit door adjacent to room A-310 northeast, then northwest

across the room to where it meets grade. Two ways are suggested. To provide the safe path while protecting the roof from damage install a boardwalk or form a path of "tread pads" (See Section 8.10).

Finding: The corridor walls cannot be considered as complying with the BCNYS requirements for 1-hour fire partitions due to the presence of non-rated corridor doors and unprotected openings and penetrations.

Hazard Severity	IV
Mishap Probability	C
Risk Assessment Code	5

Recommendation HAI-06-911-19: Corridor doors should be provided and unprotected openings and penetrations appropriately sealed to provide a 1-hour fire resistance rating as required by the BCNYS for partially- or non-sprinklered buildings (See Section 8.11.4). The installation of automatic sprinkler protection throughout the building will also satisfactorily address this finding.

Finding: The building contains five stairways that serve as required means of egress. Four of the egress stairways are not fully enclosed at all floor levels

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-06-911-20 (LSC90-911-5): A prior recommendation (LSC90-911-5) to enclose the four egress stairways has been retained in principle and modified for this FHA (See Section 8.11.6).

The following is a summary of recommendations and their relative priority.

Rec.No.	Recommendation	RAC
HAI-06-911-1	Provide 3-hour fire doors at Annex separation.	3
HAI-06-911-2	Replace fusible links with smoke activated doors	4
HAI-06-911-3	Seal unprotected openings.	3
HAI-06-911-4	Maintain access to fire department connection.	5
HAI-06-911-5	Provide sprinkler protection in unprotected areas.	3
HAI-06-911-6	Provide additional manual pull stations.	4
HAI-06-911-7	Provide additional audible alarm notification.	4
HAI-06-911-8	Provide additional visible alarm notification.	4
HAI-06-911-9	Provide duct smoke detection.	4
HAI-06-911-10	Provide smoke detection for elevator recall.	5
HAI-06-911-11	Remove or protect polystyrene foam insulation.	4
HAI-06-911-12	Provide a lightning protection system.	3
HAI-06-911-13	Common path of travel: AGS Ring tunnel	3
HAI-06-911-14	Maintain clear aisle width of 28 inches	3
HAI-06-911-15	Signage to direct occupants to exterior metal stair.	3
HAI-06-911-16	Remove exit placard.	3
HAI-06-911-17	Provide “Not an Exit” signs.	3
HAI-06-911-18	Provide roof level safe path of egress.	5
HAI-06-911-19	Corridor wall upgrades.	5
HAI-06-911-20	Enclose four egress stairs.	3

1.3.2 Outstanding Recommendations from Previous Reviews

LSC90-911-1: Replace the pair of non-rated doors across the corridor outside of room A-108 with 1-1/2-hour fire protection rated doors. These doors should be self-closing. If it is desired to have the doors held open, they should be automatic-closing, arranged to close upon actuation of smoke detection devices on either side of the doorway.

LSC90-911-3: Provide an exit sign at the door to the Vacuum Group from the west side of the Assembly Room south of the roll-up fire door.

LSC90-911-4: Replace the fire escape ladder serving as the second exit from the rooms above the Multipole Room. The new ladder should meet the requirements of ANSI-A 14.3.

LSC90-911-5: Enclose four stairways with 1-hour fire rated walls and 1-hour fire protection rated doors as follows:

- Stair next to first floor room 143: enclose at first and second floors by adding fire doors across corridors as needed;
- Stair off of main Annex lobby; enclose at first floor with walls and doors as needed;
- Stair off of old 911 lobby; enclose at first and second floor with walls and/or doors as needed; and

- Stair north of AGS Control Room; enclose at second floor with walls and door, replace non-rated door into tunnel with a 1-1/2-hour fire protection rated door.

  NOTE: Stairway doors should be self-closing. If any stairway door is desired to be held open, it should be automatic-closing, arranged to close upon actuation of a smoke detection device on either side of the door. Further, actuation of any door-release smoke detector in a stairway should release all doors in that stairway that are held open.

LSC90-911-6: Seal unprotected openings between the Cable Tunnel and the Pedestrian Tunnel with material having at least a 1-hour fire resistance rating.

Provide protection for the vertical opening between the first and second floors in the Terminal Rooms, either by sealing penetrations between the two rooms or by providing a 1-hour fire resistive enclosure around the two rooms together (such as is done with a stairwell).

Seal any openings in the wall between the pedestrian tunnel and the terminal room with material having at least a 2-hour fire resistance rating.

LSC90-911-7: The fire doors across the corridor in the east end of the Annex, on the north side of the stairway, are presently held open by fusible links on the door closers. Remove these closers. If it is desired to have the doors held open, they should be automatic-closing, arranged to close on actuation of smoke detection devices on either side of the doorway.

LSC90-911-8: Provide a continuous safe means of egress from the third floor roof exit door adjacent to room A-310 northeast then northwest across the room to where it meets grade. Two ways are suggested to provide the safe path while protecting the roof from damage; install a boardwalk, or form a path of "tread pads", which could be added to the scope of the re-roofing project that is upcoming within the next few years (reportedly FY92).

LSC90-911-9: Provide "Not an Exit" signs at the two ground floor doors (old and new lobbies) that lead to the courtyard. Provide a "Not an Exit" sign in the stair off of the new lobby in the area of the stair leading to the basement.

FMR74-911-1.n: Automatic sprinkler protection should be provided in Building No. 911 in the electronics shop and offices in the south wing of the original building (Rooms 241 to 249). Protection should be at 130 ft^2 spacing, ordinary hazard pipe schedule and 212° F heads.

FMR74-911-2: Open cable trays more than one high should be provided tight fitting bottoms constructed of a non-combustible material. Polyvinyl chloride bags filled with vermiculite should be placed in trays at no more than 30 ft. intervals, providing a cover of at least two bags in length. This protection should be provided for all cable trays both inside and outside of buildings. In addition, dead grass and brush should be removed from areas where cable trays are located outside. Small east-west cable tunnels within experimental buildings should be provided with similar fire stops.

Where trays rise vertically within buildings, automatic sprinklers should be provided at about 15 ft. intervals vertically and at the top of the vertical rise. Sprinklers should be provided with 6 in. water shields above heads.

FMR74-911-5.d: The expanded polystyrene used for insulation in the south wing tunnel between the AGS and the Control Room on piping in the center of the tunnel should be removed or protected by a Factory Mutual approved non-combustible covering.

FMR74-911-5.e: The expanded polystyrene used for insulation in the three air conditioning rooms on the roof (one over the pump room, 20 ft x 60 ft; and two over the machine shop, 20 ft. x 20 ft) should be removed or protected by a Factory Mutual approved non-combustible covering.

FMR74-911-10: To provide reliability for the critical control rooms at Building No. 911, 929 and 930 a double shot Halon system should be provided. This additional reliability can be provided by connecting an additional set of Halon cylinders to the existing system so that a reserve supply is available should it be required at any time. Where not provided, cross zoned products of combustion detectors should be the method of Halon discharge instead of fixed temperature detectors. A suitable alternate to double shot Halon would be to provide automatic sprinkler protection.

PLC84-911-5.2.12: Automatic sprinklers on a wet pipe system should be installed in the AGS ring from magnet F-10 to G-1 and from G-10 to G-16. This is part of previous FM recommendation 1d. Cabling in these areas could provide a fire propagation path in the beam extraction areas. Programmatic impact would affect all experiments utilizing the AGS ring for an estimated three month period.

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted on August 8, 2006, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The Building Code of New York State 2002 Edition (BCNYS)

International Code Council (ICC), International Building Code (IBC) 2003 Edition;

ICC, International Fire Code (IFC) 2003 Edition;

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

Factory Mutual Property Loss Prevention Data Sheets – See Section 9 (Reference Documents) of this report for a complete list.

3.0 LOCATION

Building 911 is located in the central west region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

4.0 CONSTRUCTION

4.1 Occupancy Classification

The building contains the offices of the accelerator department staff; a seminar room; the Alternating Gradient Synchrotron (AGS) Control Room; the Westinghouse Main Magnet Power Supply; the Pump Room; light laboratories and shops; and an assembly area with power and rigging equipment. The following occupancy classifications are based on LSC and BCNYS criteria:

Use	LSC Occupancy Classification	BCNYS Group Classification
Offices	Existing business	Group B
Seminar room	Existing assembly	Group A-3
Dry laboratories and shops	Existing business	Group B
Computer rooms	Existing business	Group B
High-bay Magnetic Measurement Area, Vacuum Lab, Electronics Shop and similar spaces	General Industrial	Group F-1
Power generation	Special-Purpose Industrial	Group F-1
Building service mechanical or electrical equipment rooms	Classified as part of the predominant occupancy	Incidental use area

Since credited fire resistance-rated separations are not provided between occupancies, the building is classified as a mixed occupancy consisting of assembly, business and industrial occupancies based on LSC criteria [§6.1.14.2.2]. The means of egress facilities, type of construction, protection, and other safeguards must comply with the most restrictive fire and life safety requirements of the occupancies involved [§6.1.14.3.2].

4.2 Construction Type

Building 911 consists of two parts; the original is part two-story and part one-story; and the Annex is three-stories with a partial basement. Both are steel frame construction with noncombustible siding, some of masonry and some of metal sandwich panels. Drawings for the Annex dated August 1968 indicate that the floors of the Annex were designed as 2½-in. concrete slabs on 3-in. steel decks. Unprotected steel floor decks were observed. The overall building construction is unprotected and noncombustible.

The building construction type is most nearly either BCNYS Type IIA or IIB and NFPA Type II (111) or II (000).

Life Safety Code

The LSC does not specify a minimum construction type for existing business and industrial [§39.1.6; §40.1.6] occupancies. The LSC permits an assembly occupancy with an occupant load of not more than 1,000 persons and located at the level of exit discharge to be within a building of Type II(000) construction regardless of automatic sprinkler protection [LSC Table 13.1.6]. The seminar room has an occupant load of 190 persons and is located on the First Floor which is the level of exit discharge based on the LSC definition in Section 3.3.72.1. Thus, the existing construction complies with LSC requirements.

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type.

Section 506 and 507 of the IBC contain allowable area increases based on the location of the building and sprinkler protection, if provided. In accordance with Section 506.3, the basic allowable area limitation of Table 503 can be increased 200 percent for multiple-story buildings that are protected throughout by an approved automatic sprinkler system. Building 911 is not fully-sprinklered and the allowable height and area increases can not be applied.

The BCNYS also permits an increase in allowable areas for buildings that have more than 25 percent of their perimeter on a public way or open space having a minimum width of 20 feet [IBC, 506.2]. The area increase due to frontage is determined in accordance with the following equation:

$$If = 100[F/P - 0.25]\ W/30, \text{ where:}$$

If = Area increase due to frontage.

F = Building perimeter which fronts on a public way or open space having 20 feet open minimum width (feet).

P = Perimeter of entire building (feet).

W = Width of public way or open space (feet). The width (W) must be at least 20 feet and W/30 cannot exceed 1.0.

Building 911 adjoins public ways or open spaces exceeding 30 feet on three sides of the building (west, south and east) for an open perimeter percentage of approximately 80%. Therefore, the allowable frontage increase is 55 percent. The applicable height and area limitations for Groups A-3, B and F-1 are provided in Table 4.2-1.

The building area is approximately 52,700 gross square feet (First Floor). Based on the application of a nonseparated uses approach, the building would not comply with the most stringent area limitations for Group A-3 for either assumed construction type. A 3-hour fire barrier would be required to separate the 3,230-sq ft Group A-3 occupancy from the Group B and F-1 occupancies.

Table 4.2-1. Allowable Height and Areas for BCNYS Groups A-3, B and F-11

	Group A-3		**Group B**		**Group F-1**	
	Type IIA	**Type IIB**	**Type IIA**	**Type IIB**	**Type IIA**	**Type IIB**
Base Height	65 ft 3 stories	55 ft 2 stories	65 ft 3 stories	55 ft 2 stories	65 ft 4 stories	55 ft 2 stories
Base Area (ft^2)	15,500	9,500	37,500	23,000	25,000	15,500
Street Frontage Increase(ft^2)	8,525	5,225	20,625	12,650	13,750	8,525
Increased Area (ft^2)	24,025	14,725	58,125	35,650	38,750	24,025

Note: The maximum allowable areas include an increase for 80% open perimeter/street frontage.

However, a separated uses approach would not result in compliance as the intermingled Group B and F-1 fire area would exceed the area limitations for Group F-1. If sprinkler protection is provided throughout the building, the building would comply with the height and area limitations for all conditions except nonseparated uses with Type IIB construction (Group A-3 area limitation of 33,725 sq ft).

Since no change of occupancy or reconfiguration of spaces is planned for the building, the non-compliance with BCNYS height and area limitations, which are primarily intended for new construction, are considered as acceptable.

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building.

4.3.1 Fire Areas

The building is subdivided such that multiple fire areas are possible. A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling

assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions.

In general, the fire barrier walls in Building 911 consist of concrete masonry units of varying thickness. Although concrete masonry walls possess inherent fire resistance, the duration of fire resistance of the concrete masonry walls could not be determined based on visual observations.

4.3.2 Annex Area

The Annex, which was constructed in 1968, is separated from the remainder of the building by fire-resistive walls. Based on a review of prior fire safety analyses, the walls are considered to be 3-hour fire barriers and are provided on the First and Second Floors.

Doorways in these walls are protected with 3-hour fire protection-rated doors except for the door at the northwest end of the Annex, First Floor, outside of Room A108. The cross-corridor doors in this location are non-rated wood doors with non-fire protection-rated glazed vision panels. In order to maintain the fire separation of the Annex from the remainder of the building, these doors should be replaced with 3-hour fire doors as are provided elsewhere (**See Recommendation HAI-06-911-01**).

The LSC requires all fire doors to be self-closing or automatic-closing in accordance with Section 7.2.1.8 [§8.3.3.3.]. Doors are permitted to be automatic-closing in any building with low or ordinary hazard contents where the doors close (release of hold-open device) upon actuation of smoke detectors or loss of power to the hold-open device [LSC §7.2.1.8.2]. Doors held open by fusible links are not permitted except for existing horizontal sliding doors complying with the special provisions for business or industrial occupancies (See Section 8.7) (**See Recommendation HAI-06-911-02**).

The AGS Ring tunnels are separated from the building by fire doors. Access to the AGS Ring tunnel fire doors was not available at the time of the walkthrough.

4.3.3 Control Room Fire Area

The Control Room on the First Floor has been identified as a critical operations area for the facility. The Control Room (Room 113) is within a fire area that includes the terminal rooms on the First and Second Floors and Conference Room 112. DOE Order 420.1 mandates that Control Room 113, Conference Room 112, and Main Terminal Room 115 form a fire area that is separated from the remainder of the building by reinforced concrete (AGS tunnel) concrete masonry (corridor) or gypsum board (Rooms 111 and 112A) walls. Design drawings (5/26/1988 MCR Control Room Modifications) indicate that the separation walls provide a minimum fire resistance of one hour and that fire dampers are provided in duct penetrations of these walls. The presence of fire dampers could not be verified.

Cable penetrations through the Second Floor assembly between the Main Terminal Room 115 and Terminal Room 222 are not adequately protected with firestopping. The hazardous products of combustion from a fire in the Main Terminal Room could spread through the unprotected penetrations into Terminal Room 222.

Polyethylene bags containing vermiculite are positioned on cables on the floor of the Main Terminal Room (See Photograph 1). Based on communications with the accompanying facility personnel, the vermiculite bags are intended to resist fire spread along the cables. The bags are not listed for such use. UL-listed or FM-approved firestopping should be provided to limit fire spread into adjacent spaces (**See Recommendation HAI-06-911-03**).

Photograph 1

Terminal Room 222 is separated from the vacuum group room by a concrete masonry wall. The doors in the wall are not fire doors and several unprotected penetrations were observed (**See Recommendation HAI-06-911-03**).

In general, to limit the potential for fire damage from adjacent spaces into the terminal rooms and the Control Room, listed or approved fire doors should be provided and penetrations through

the walls and floors should be fire stopped or sealed in accordance with the building code (**See Recommendation HAI-06-911-03**).

4.3.4 Power Plant and Pump Room Fire Areas

Previous fire safety analyses state that a 3-hour fire barrier wall is provided to separate the Power Room from the rest of Building 911. The wall is nominally constructed of 6-in. concrete masonry.

Numerous, unprotected penetrations including those for pipes, cables, and conduit occur in the wall separating the Power Room and Pump Room. The unprotected penetrations would likely reduce the fire resistance of the wall such that the wall cannot be credited as a fire barrier. Through-penetration firestopping should be provided. In addition, holes in the wall caused by the routing of utilities should be filled with grout or mortar (**See Recommendation HAI-06-911-03**). Upon implementation of these recommendations, the wall could be considered as a fire barrier.

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing installed systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the vicinity of Building 911 has a static supply pressure of 58 pounds per square inch (PSI) at low elevated tank levels. The water supply system in the area can supply about 3,200 GPM at 20 PSI (based on the Water Distribution Model Analysis developed by the Fire Protection Engineering Group during the summer of 2004.)

Frost Proof Fire hydrants are provided within 300 ft of each facility. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

Building 911 has two 8 inch ductile sprinkler lead-ins connected to an 8 inch main along Rutherford Drive. One lead-in is for the sprinkler system that enters the south side of the building. The other lead-in supplies the east side sprinkler system. Both lead-ins have Post Indicating Valves (PIV). The PIVs are located less than 40 feet from the building as required by code. However, there is no cost-benefit rationale for relocating the PIVs to comply with this requirement. The PIVs are gate valve type valves with electric tamper switches and locks.

Each sprinkler system riser is provided with a Fire Department Connection (FDC). The FDCs are located on the east and south sides of the building. At the time of this survey clear access to the FDC located on the east wall was hampered by two parked vehicles (**See Recommendation HAI-06-911-04**). The nearest hydrant is less than 100 feet from the fire department connections as required by code. The two 2 ½ inch outlets on the FDCs conform to National Standard Thread couplings standard. The piping between the Fire Department Connections and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the discharge side of the Alarm Check Valves.

5.1.3 Sprinkler Systems

Automatic sprinkler protection is provided throughout most of the building. The following rooms or areas do not have sprinkler protection or have inadequate coverage (**See Recommendation HAI-06-911-05**):

- The Power Room, which is separated from the rest of Building 911 by a 3-hour fire barrier.
- The small room located within the high-bay Room 112B, Magnetic Measurement Area. The high-bay area has sprinkler protection. The small room appears to have been added without extending the existing sprinkler coverage.
- In the stairwell/hallway area next to Control Rom 113 and Kitchen 114.
- The corridor area between Electronics Shop 143 and Room 140.
- The first and second floor of the annex area.
- The southwest area of the second floor (Rooms 241 – 248).
- The higher ceiling area on the west side of Room 241-C. Room 241-C has sprinkler protection but this area has inadequate coverage due to differing ceiling heights.
- The south side of Room 241-D. Room 241-D has sprinkler protection but this area has inadequate coverage due to differing ceiling heights.

5.1.3.1 Alarm Check Valve Assembly

Each sprinkler system has a 6-inch Alarm Check Valve assembly manufactured by the Reliable Sprinkler Company. The alarm check valves are UL and FM listed and provides the required alarm signals for flow activation to the building fire alarm panel.

5.1.3.2 Wet Pipe Sprinkler System Sizing Method

Complete drawings of the installed sprinkler systems could not be located for all areas. However, based on the age of the system and a review of available drawings the systems appear to have been designed, at least in part, by the pipe schedule method. The system installation does not comply with NFPA 13 – see section 5.1.3 for further discussion.

5.1.4 Fire Standpipe Systems

A standpipe system is provided in the building. The system consists of 1-1/2 inch hose connections located mainly in the east side office areas. Hose connections (without hose) are located in the two stairs serving the Annex and the stair adjacent to Electronics Shop 143.

5.1.5 Halon Suppression System

The Main Terminal Room 115 on the First Floor includes a Halon fire suppression system that is operated by a control panel manufactured by Fenwal. This system/panel is monitored by the building fire alarm system for general alarm and trouble conditions. Computer Rooms 220-222 on the Second Floor are provided with an early warning smoke detection (AnaLaser) system manufactured by Fenwal. This system is also monitored by for general alarm and trouble conditions by the building fire alarm system.

5.2 Fire Alarm Systems

The facility has a fire alarm system that is connected to the Site Fire Alarm system. The two systems are as follows.

5.2.1 Building Fire Alarm System

The building fire alarm system is a conventional, hard-wired type and consists of a Gamewell model series FlexAlarm Fire Alarm Control Panel (FACP). Manual pull stations are not provided at all exits as required (**See Recommendation HAI-06-911-06**). The system also includes spot type heat detectors that are installed in all areas of the 3-story addition at the South-East portion of the building. The system monitors waterflow and valve tamper switches for the areas provided with sprinklers (the original North-West portion of the building).

The building fire alarm system transmits (via telephone line/modem technology) alarm, trouble, and supervisory signals, on a per zone and type of device basis, to the central Site Fire Alarm System located in the on-site Fire House (refer to Section 5.2.2 of this analysis report for information on the Site Fire Alarm System).

A manual fire alarm system is required in accordance with the Building Code of the State of New York (BCSNY), 2002 edition, Section 907.2.2. An automatic fire alarm system (smoke or heat detection) is also required in areas of Group 'B' occupancy that have an occupant load of more than 100 persons that are not protected with sprinklers per Section 9.2.2.1 of the BCCNY. A fire alarm system, initiated by manual means, is required in accordance with the Life Safety Code (LSC), 2000 edition, Section 39.3.4.

Alarm notification is provided by audible alarm bell/gong appliances installed generally in public corridors. Some of the bell/gong appliances include an integral strobe for visual alarm notification. Based on observations the coverage is not adequate (**See Recommendation HAI-06-911-07 and -08**).

5.2.2 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class "A" System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by uses the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication "loops." It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

Spot type heat detectors are installed in all areas of the 3-story addition at the South-East portion of the building. Computer Rooms 220-222 on the Second Floor are provided with an early warning smoke detection (AnaLaser) system manufactured by Fenwal.

Duct smoke detectors or elevator recall smoke detectors were not observed (**See Recommendation HAI-06-911-09 and -10**).

5.4 Fire Extinguishers

Portable fire extinguishers are required in existing business occupancies [§39.3.5].

Multiple types of fire extinguishers are provided in the building. The Halon 1211 fire extinguishers are provided in several locations most notably in the Control Room and Vacuum Lab. The Motor Generator Room in the Power Plant is provided with a 75-lb CO_2 extinguisher with hose reel. This extinguisher was last tested in February 1989. A CO_2 extinguisher is provided in the Magnetic Measurement Area. Multipurpose ABC fire extinguishers are provided in many areas within rooms and in corridors. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Building Materials, Special Occupancies, Exterior Hazard Exposure, and Natural Hazard Exposure. The following is an evaluation of Building 911 for each category.

6.1 Special Occupancies

6.1.1 Vital and Important Records Storage

Vital records are those records which are essential to the mission and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or significant extra expense. Based on the above definitions there are no vital or important records stored within Building 911.

6.1.2 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 911.

6.1.3 Cooling Towers

Cooling towers associated with the main magnets are located on the roof of the building. The towers are Baltimore Air Coil Company Model VFL-0963-PCR towers consisting of stainless steel construction. An inspection of the interior of the towers was not possible. They do not present an exposure hazard to the facility.

6.1.4 Electrical Substations

Two transformer areas are located adjacent to Building 911. One is located on the east side of the building adjacent to the Pump Room and Power Room; the other is located on the north side of the building adjacent to the Power Supply Room.

The east side transformer area contains two transformers; one contains approximately 540 gallons of silicone fluid and is located approximately 5 feet from the building; the other transformer contains approximately 350 gallons of oil and is located approximately 30 feet from the building.

The north side transformer area contains two transformers. This area could not be accessed; however the transformers were similar in size to the transformers located on the east side of the building. These transformers are located approximately 25 feet from the north wall of the facility and are located in an area with rock bed that slopes away from the building.

The transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The transformers do not present an exposure hazard to the facility or each other.

6.1.5 Flammable Liquid and Gas Storage

Flammable liquids and gases are appropriately stored and secured. Flammable liquid storage cabinets are used in various locations. In addition, storage and use of gas bottles is segregated. Bottles are adequately secured against falling.

6.1.6 Cables and Raceways

A significant amount of cabling exists in the terminal rooms supporting the AGS Ring and the Control Room. Polyethylene bags containing vermiculite are positioned on cables on the floor of the Main Terminal Room (See Section 4.3.3 Photograph 1). Based on communications with the accompanying facility personnel, the vermiculite bags are intended to resist fire spread along the cables. The bags are not listed for such use. UL-listed or FM-approved firestopping should be provided to limit fire spread into adjacent spaces.

6.2 Housekeeping in Vital Areas

Good housekeeping and control of combustibles was observed during this survey. The Collider-Accelerator department self-inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.3 Building Materials

Significant amounts of exposed polystyrene insulation building materials are used in the construction of this facility. The insulation is in both sprinklered and unsprinklered areas in the building (**See Recommendation HAI-06-911-11**).

6.4 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

6.4.1 Elements Outside of the Facility

The following is a summary of fire exposures to Building 911. All exposures are evaluated using FM Data Sheet 1-20 “Protection against Exterior Fire Exposure.” These exposures do not present an undue hazard to Building 911.

6.4.1.1 North Exposures

Exposures to the North are minimal. Building 918 is located approximately 150 feet away. Building 912 is located adjacent to Building 911 and is connected via an underground tunnel and does not present an exposure. Two transformers are located approximately 25 feet north of the exterior wall of Building 911.

6.4.1.2 South Exposures

Exposures to the South are minimal. Building 925 is located approximately 200 feet away.

6.4.1.3 East Exposures

Exposures to the East are minimal. Building 703 is located approximately 200 feet away.

6.4.1.4 West Exposures

Exposures to the West are minimal. The building roof line on the west side is at grade level due to the slope of the surrounding terrain.

6.4.2 Components of the Facility

Exposures between components of the facility are minimal. Sprinkler protection and passive fire barriers are in place to provide separation between components of the facility.

6.5 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.5.1 Lightning Potential

The lightning damage potential for Building 911 is a concern based on NFPA 780 Annex L "Lightning Risk Assessment" calculation. Following the Risk Assessment methodology the expected lightning frequency (Nd) of 0.0074 is greater than the tolerable lightning frequency (Nc) of 0.0002 (calculations shown in appendix B of this report). NFPA 780 recommends that a lightning protection system be installed when the expected frequency is greater than the tolerable frequency (**See Recommendation HAI-06-911-12**).

6.5.2 Windstorm Potential

The Long Island area basic wind speed (3-second gust) is 120 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS figure 1609.4. The ground roughness exposure category for the Building 911 area is 'Exposure B." Based on the calculations this building should have roof assemblies classified as "Class 90" rated assemblies. The roof is reportedly in bad condition. Repair or replacement of the roof is subject to availability of funding. Because the condition of

the roof is known, additional recommendations related to the roof are not made as a result of this analysis.

6.5.3 Brush Fire Potential

An analysis was completed consistent with the requirements and guidelines of NFPA 1144 *Protection of Life and Property from Wildfire* (2002) to determine the wildfire risk to Building 911. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire protection, and utilities.

Based on the analysis, the hazard from wildfire to Building 911 is "LOW." Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.5.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation" dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.5.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation."

Ground water runoff from a severe rainstorm could be a concern for Building 911 due to the surrounding terrain. However, further evaluation is beyond the scope of this analysis.

6.6 Toxic Fire Potential

There are no known toxic materials present in the building that present a release potential due to fire.

6.7 Biological Fire Potential

There are no known biological materials present in the building that present a release potential due to fire.

6.8 Radiation Fire Potential

There is a small calibration source located in a room in the Northeast corner of Room 143, Electronics Shop. However, the source is sealed and is in a non-dispersible form.

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility (http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp). The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

The operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are generically described in this report, are required for this facility.

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

Based on this definition there is no high value equipment located within Building 911.

7.4 Critical Process Equipment

The following areas were identified as being critical to ongoing operations of the facility and the AGS:

First Floor:

- Multipole Room
- Power Supply Room
- AGS Control Room 113
- Main Terminal Room

Second Floor:

- Vacuum Group Room
- Server Room 220

- Network Hub Room 119A

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

MPFL scenarios are considered for three areas within the building; the Annex, the Power Room; and the balance of the building. Although the AGS Control Room is constructed with a fire-rated separation the rating is only 1-hour and is not considered a separate fire area for the purposes of an MPFL determination. The MPFL scenarios discussed in this section assume that unprotected penetrations in fire area barriers are adequately protected as recommended. Without a compliant separation the building would be considered as one fire area.

The following fire area tabulations are utilized when determining the MPFL and MCFL loss potentials.

Fire Area	Building Area (ft^2)
Annex	38,800
First Floor (14,800 ft^2)	
Second Floor (12,000 ft^2)	
Third Floor (12,000 ft^2)	
Power Room/Pump Room Area	7,800
Balance of Building	54,800
Balance of First Floor (30,900 ft^2)	
Balance of Second Floor (23,900 ft^2)	
Approximate Overall Building Area	101,400

Annex

The Annex is separated from the rest of the building by a 3-hour rated fire barrier (See Section 4.3.1). The total floor area of the three floors of the Annex is approximately 38,000 ft^2. The Annex consists mainly of office space with an associated moderate amount of combustible materials.

An office fire scenario is expected to involve primarily paper-based materials, book cases, furnishings, and computer equipment. Full-scale test data of office occupancies indicate that fire growth may be rapid, reaching 1-2 MW within 2-4 minutes [Sardqvist, 1993; Babrauskas, 2002]. Test data of some office arrangements indicate that the peak heat release rate could exceed 5-MW for short durations and that the average heat release rate could exceed 1-MW for 20-minutes [Madrzykowski et al., 1992]. Specific fuel packages that may be located in an office, such as a computer system or a bookshelf, may have a heat release rate that exceeds 500-kW [Babrauskas, 2002; Sardqvist, 1993].

An office fire within the Annex could reach flashover conditions for heat release rates and fire durations that are typical for fuel packages normally located in an office area. Flashover indicates that the temperature inside the area would be sufficiently hot to cause multiple fuel package ignitions within the space and result in loss of all contents. Associated compartment temperatures at flashover are generally accepted to be between 500°C (900°F) to 600°C (1100°F). Flashover is generally defined as the transition from a growing fire to a fully developed fire. Fully developed fires impose extensive thermal and physical stresses on fire barriers, the failure of which could lead to fire spread throughout the area.

Power Room and Pump Room

The Power and Pump Room fire area is separated from the rest of the building by a 3-hour rated fire barrier (See Section 4.3.1). The total area of this fire area is approximately 7,800 ft^2. This area contains a Tech Shop, office space, power supply rooms and an AC Generator set in the MG Room which serves as a backup and is also used for low energy experiments. There is a minor amount of combustible materials located throughout the area. The fan rooms at the north end of the area contain polystyrene insulation on the HVAC ducts.

Balance of Building

This fire area consists of all building areas not included in the Annex and Power and Pump Room fire areas. The total area of this fire area is approximately 55,000 ft^2. The AGS Control Room is included within this fire area since it is separated by walls having a fire resistance rating of one-hour fire (See Section 4.3.3).

7.5.2 MPFL Calculation

The building has a replacement value of approximately $38 million. The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement value divided by the floor area of the building ($38,000,000/100,663 ft^2 = $377/$ft^2$ ($400/$ft^2$)).

The content and equipment value is calculated based on the following assumptions:

- An average of \$20/ft^2 for content and equipment value within predominantly office areas.
- An average of \$100/ft^2 for content and equipment value within the industrial and experimental areas of the building.
- The AGS Control Room is estimated to have a replacement value of approximately \$2 million (adjusted for inflation at 3% per year) [Memo from P. Ingrassia to J. Levesque: Subject: AGS Main Control Room Modifications, Bldg. 911, dated March 10, 1988].

Annex Area (38,000 ft^2)		
Building	38,800 ft^2 x \$400/ft^2 =	\$15,520,000
Contents	38,800 ft^2 x \$20/ft^2 =	\$776,000
	MPFL	\$16,296,000
Power Room and Pump Room (7,800 ft^2)		
Building:	7,800 ft^2 x \$400/ft^2 =	\$3,120,000
Contents:	7,800 ft^2 x \$100/ft2 =	\$780,000
	MPFL	\$3,900,000
Balance of Building (54,800 ft^2)		
Building:	54,800 ft^2 x \$400/ft^2 =	\$21,920,000
Contents	54,800 ft^2 x \$100/ft^2 =	\$5,480,000
	MPFL	\$27,400,000

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

The maximum credible fire scenario is one in which automatic suppression systems function as designed. The sprinkler design criterion for this building is based on an ordinary hazard pipe schedule method. For the purposes of the MCFL determination a design area of 1,500 ft^2, typical for an ordinary hazard system design, is assumed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area this floor area was used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

Annex Area (38,000 ft^2)		
Building	38,800 ft^2 x \$400/ft^2 =	\$15,520,000
Contents	38,800 ft^2 x \$20/ft^2 =	\$776,000
	MCFL	\$16,296,000
Power Room and Pump Room (7,800 ft^2)		
Building:	1,500 ft^2 x \$400/ft^2 =	\$600,000
Contents:	1,500 ft^2 x \$100/ft^2 =	\$150,000
	MCFL	\$750,000
Balance of Building(1) (54,800 ft^2)		
Building:	3,000 ft^2 x \$400/ft^2 =	\$1,200,000
Contents:	3,000 ft^2 x \$100/ft^2 =	\$300,000
	MCFL	\$1,500,000

Note (1): An area of 3,000 ft^2 was used for the MCFL determination in this fire area due to inadequate sprinkler coverage or lack of sprinklers. For instance, Rooms 241-250 in the southwest portion are included in this fire area but do not have sprinkler protection. A fire occurring in an area with inadequate or no sprinkler protection can be expected to extend beyond a normal design area before being controlled.

The MCFL for the Annex area is the same as the MPFL since this area is not protected by an automatic sprinkler system.

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Annex	\$16,296,000	\$16,296,000
Power Room and Pump Room	\$4,000,000	\$750,000
Balance of Building	\$27,000,000	\$1,500,000

Based on the MPFL loss potentials automatic sprinkler protection is required throughout the building. Areas with inadequate sprinkler coverage should be upgraded to comply with code requirements (**See Recommendation HAI-06-911-05**).

7.6 Recovery Potential

The recovery time to rebuild the AGS Control Room could exceed three months [Memo from P. Ingrassia to J. Levesque: Subject: AGS Main Control Room Modifications, Bldg. 911, dated March 10, 1988].

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. Minimums of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 911 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency. Roadways are located on the north, east and south sides of the building. Access on the west side is provided by the AGS loop road which is elevated due to terrain and is located at the roof level of the facility on this side.

7.9 Security Considerations Related to Fire Protection

There are no security restrictions for this facility that would hamper fire department response to an emergency.

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101, the Life Safety Code (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures.

Since the building contains multiple occupancies, the LSC allows a mixed occupancy or a separated occupancy approach. In a mixed occupancy, the means of egress facilities must comply with the most restrictive fire and life safety requirements of the occupancies involved. In separate occupancies, separate means of egress must be provided from each. Where exit access from an occupancy traverses another occupancy, the multiple occupancy must be treated as a mixed occupancy [§6.1.14.1.2]. Where exit access from one occupancy traverses another occupancy, the multiple occupancy must be treated as a mixed occupancy. In the case of Building 911, the assembly occupancy requirements are typically the most restrictive. Based on the fire barrier separations recommended to separate the Annex, which includes the assembly seminar room, from the remainder of the building, the assembly occupancy criteria would only apply to the Annex.

8.1 Occupancy Load Factor and Calculations

The occupant load per floor level for code purposes is calculated in Table 8.1-1 based on applicable occupant load factors specified in LSC Table 7.3.1.2. An occupant load factor of 300 sq ft per person was applied to special-purpose industrial and mechanical/electrical equipment areas. Factors for these spaces are not specified in the LSC.

Table 8.1-1
Occupant Load Calculation

	Floor Area (sq ft)	**Occupant Load Factor (sq ft per person)**	**Occupant Load (persons)**
Basement	2,900	300	10
First Floor			
Seminar room	3,200	Fixed seats	190
Boiler and power generation plant (including mezzanine, office and shops)	12,600	300	42
Remainder of floor including offices, workshops and control room	36,900	100	369
Total First Floor	52,700		601
Second Floor	19,200	100	192
Third Floor	9,600	100	96

The total building occupant load for code compliance purposes is899 persons. This occupant load exceeds the probable actual number of occupants.

8.2 Means of Egress

8.2.1 Number and Arrangement of Exits

The LSC requires that a floor with an occupant load of 500 or fewer persons must have a minimum of two means of egress [§7.4.1.1]. Additional exits may be required for compliance with exit capacity or arrangement of exits criteria.

The First Floor is provided with several exits to grade around the perimeter of the building. The Second Floor is provided with five egress stairways and three emergency roof exits. The Third Floor is provided with two egress stairways and an emergency exit via the 2nd Floor roof. The Basement level is provided with two means of egress consisting of the partially-enclosed stairway leading up to the main lobby and an exterior stairway located in an areaway adjacent to the seminar room.

8.2.2 Capacity of Exits

The egress capacity provided from a floor or portion thereof must be sufficient to accommodate the occupant load. The egress capacity for an egress component is based on the width of the component. For stairways, the factor of 0.3 in. of stair width per person is applied. For doors, ramps, corridors, and other level components, the factor of 0.2 in. of width per person is applied.

Street floor exits (i.e., First Floor) must be sufficient for the occupant load of the street floor plus the required capacity of stairs discharging through the street floor [LSC §39.2.3.3]. This requirement applies to open stairways discharging within the First Floor.

The required egress capacity for the First Floor excluding the power generation and boiler plant and the seminar room can be conservatively estimated to be 369. Assuming that the occupant loads of the Basement (one-half), Second and Third Floor are added to the required capacity for the First Floor in accordance with LSC §39.2.3.3, the required capacity is 662 persons. The required exit width is 133 in. (662 persons × 0.2 in. per person). There are three primary exits to grade from the First Floor: 1) adjacent to A108, 2) vestibule adjacent to A125, and 3) main lobby. The minimum width of an existing egress door leaf is permitted by the LSC to be 28 in. [§7.2.1.2.4(4)]. The egress widths of the existing doors are each a minimum of 28 in. by a sampling of field measurements.

The aggregate width of these exits is approximately 140 in. (28 in. + 56 in. × 2) which exceeds the required exit width of 133 in. The exit capacity provided is considered adequate based on the potential use of emergency roof exits, exit doors serving individual spaces (e.g., Electronics Shop 145) and the conservative occupant load calculation which assumes simultaneous occupancy of staff offices and workshops and labs.

The egress capacities for the Basement, Second and Third Floors are adequate.

8.2.3 Travel Distance

The exit access travel distance is the distance from an occupiable point to the nearest exit or exit enclosure. The maximum exit access travel distances for the occupancies involved are provided in Table 3.2.3 [LSC §13.2.6; §39.2.6; §40.2.6].

Occupancy	Maximum Allowable Exit Access Travel Distance (ft) (sprinklered)
Assembly	150
Business	200
General Industrial	200
Special-Purpose Industrial	300

Where open stairways serve as means of egress, the travel distance must include the travel on the stairway and the distance to reach an outside door or other exit [§7.6.2].

The building is in general compliance with exit access travel distance limitations.

8.2.4 Common Path of Travel

The maximum allowable common path of travel for business and industrial occupancies is 75 ft and 50 ft respectively. The common path of travel from mechanical equipment rooms, boiler rooms, and similar spaces is permitted to be not more than 100 ft [LSC §7.12.1(1) (c)]. A common path of 20 ft is permitted in assembly occupancies.

The common path of travel from mechanical equipment rooms, boiler rooms, and similar spaces is permitted to be not more than 100 ft [LSC §7.12.1(1) (c)]. The common path of travel from the Third Floor work area and adjoining offices is approximately 120 ft when measured to a point in the corridor in front of the southeast egress stairway. In order to address this excessive common path of travel deficiency, an emergency escape route is provided at the west end of the work area. These provisions are further discussed in Section 8.4.

The common path of travel from the First Floor terminal rooms is approximately 230 ft as measured from the Main Terminal Room 115 into the AGS Ring tunnel. Exit signage directs occupants into the corridor between the Magnetic Measurement Area and the Control Room to the original building lobby near Room 105. Access to other buildings from the AGS Ring tunnel was not obtained during this survey. If access to other buildings from the AGS Ring tunnel is possible, then egress signage should be provided in the tunnel indicating egress travel in both directions (**See Recommendation HAI-06-911-13**).

8.2.5 Dead Ends

Dead-end corridors must not exceed 50 ft in industrial and business occupancies [LSC §39.2.5.2; Table 40.2.5]. The BCNYS limits dead-end corridors to not more than 20 ft in non-sprinklered or partially-sprinklered buildings. A dead-end condition of approximately 125 ft

occurs on the First Floor in the corridor between the Magnetic Measurement Area and the Control Room. This deficiency may be addressed by providing egress into the AGS Ring tunnel (**See Recommendation HAI-06-911-13)**.

8.2.6 Security Considerations Related to Fire Protection

The building does not have special access controls to restrict egress or fire rescue ingress except that access is controlled on doors from the corridor to the suite containing computer/network rooms, the vacuum group and terminal room on the Second Floor. The fire department should have access to this suite in the event of an emergency.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §]. The building complies with the separation of means of egress criteria as required by the BCNYS and LSC in all areas.

8.3 Exit Signs and Emergency Lighting

Exit signage is required in accordance with Section 7.10 of the LSC. Exit signs should be placed in corridors and in rooms required to have at least two means of egress. Internally-illuminated exit signs and exit placards are provided in the building. No deficiency was identified with respect to the distribution and placement of exit signs.

Emergency lighting for means of egress is required in accordance with Section 7.9 of the LSC. Emergency lighting is required in a building classified as a business occupancy where the business occupancy is subject to 100 or more occupants above the level of exit discharge, the building is two or more stories in height above the level of exit discharge, or the business occupancy is subject to 1,000 or more total occupants [§39.2.9.1]. Emergency lighting is required in industrial occupancies [§40.2.9.1] except special-purpose industrial occupancies without routine human habitation. The power and boiler plant receive routine maintenance by building personnel. Emergency lighting is provided throughout the building. Ceiling light fixtures connected to the emergency generator are distributed in most areas. Emergency light modules equipped with battery packs are provided elsewhere.

8.4 Emergency Roof Exits

A means of escape is defined as a way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out [LSC §3.3.152]. Means of escape routes are considered to be provided via fire escape ladders (refer to “Fire Escape Ladders” in Section 8.8) to one of the roofs from which access to grade is provided. The following means of escape routes are provided in the building:

- A means of escape route is provided from Room 241-C to the Vacuum Lab roof. From this roof level, a fixed vertical ladder is provided up to the high-bay roof above the

Magnetic Measurement area. Access to the grade-level roadway is provided directly from this roof.

- A means of escape route is provided from the Third Floor work area to the Second Floor roof. From the Second Floor roof, access to the grade-level roadway is provided at the west side of the building. This means of escape route is provided to address the common path of travel from the work area and adjoining offices to the southeast egress stairway. This distance is approximately 120 ft when measured to a point in the corridor in front of the southeast egress stairway. A maximum common path of travel of 100 ft is permitted from a business occupancy.

  A clear aisle width of 28 in. must be maintained as required by LSC [§7.3.4.1.2]. In the Third Floor work area, the egress aisle along the offices was observed to be obstructed by transient items (equipment and carts) such that the egress width is less than 28 in. (**See Recommendation HAI-06-911-14**).

  A means of egress route is provided from the egress stairway adjacent to Room 217 through a 69-in. clear height doorway to the pump room roof from which an exterior stairway leads up to the grated platform for the magnet evaporative coolers and to the grade-level roadway via a steel stair (down seven risers).

  This path is coincident with a wooden boardwalk on the pump room roof. The boardwalk leads back to an egress door for the air-conditioning equipment room (i.e., a dead end condition). Signage should be provided to direct occupants to the exterior metal stair leading to the cooling platform (**See Recommendation HAI-06-911-15**).

8.5 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. In general, the building complies with this requirement. Intervening rooms through which required egress occurs are accessory and not higher hazard to the area served.

Corridors must provide exit access without passing through any intervening rooms other than corridors, lobbies and spaces permitted to be open to the corridor [LSC §7.5.1.2]. Two of the emergency roof exits must be accessed via enclosed rooms (conference room 242 and drafting room 241-C). The LSC permits exit access from existing corridors through a room to access an exit provided that the path of travel is marked with exit signs, the egress doors comply with Section 7.2.1, and the arrangement is not prohibited by the applicable occupancy chapter [§7.5.1.2.1]. The emergency access to the roof is clearly identified with signage, the doors into the intervening rooms are in general compliance with requirements for egress doors (provided the doors are not lockable), and the provisions of Section 7.5.1.2.1 are not prohibited for the business and industrial occupancies. The doors leading to the roof do not comply with the minimum clear height requirement. The door height issue is further discussed in Section 8.9.

However, the existing conditions comply with the intent of Section 7.5.1.2.1 and are considered acceptable.

8.6 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. The LSC permits a maximum of 50 percent of the required number of exits to discharge inside the building provided the level of discharge is fully-sprinklered or the area of discharge is sprinklered and separated from the remainder of the building by fire barriers [§7.7.2.2; §7.7.2.4]. The enclosure of the stairways is further discussed in Section 8.11.6.

The egress stairway leading down from the Vacuum Group and Terminal Room 222 is unenclosed at the Second Floor and discharges into the AGS Ring pedestrian tunnel via a vestibule. Occupants using this stairway may re-enter the building and reach the exterior via First Floor corridors.

The egress stairway adjacent to Rooms 109 and 217 is unenclosed at both the First and Second Floors and discharges into the original building lobby. An exit placard is located to the right of the stairway directing occupants into the boiler room. This exit placard should be removed as egress into the more hazardous boiler room is not permitted (**See Recommendation HAI-06-911-16**). An exit sign is provided above the doorway to the interior courtyard. From the courtyard, three doorways are provided to re-enter the building. LSC does not specifically address exit discharge into a courtyard. A more straightforward means to reach the exterior may be provided via the corridor through the office area to the east exit adjacent to Office A128.

The egress stairway adjacent to Electronics Shop 143 and Rooms 239 and 250 is unenclosed at both floors. An exit placard is provided on the wall separating the corridor from Drafting Room A-110 directing occupants to the exit doorway on the south side of the building.

The egress stairway adjacent to the main entry lobby at the southeast corner of the building is separated from the Second Floor by a pair of fire doors, but is not enclosed or separated at the First Floor. This stairway continues past the First Floor to serve the Basement. Stairs that continue more than one-half story beyond the level of exit discharge shall be interrupted at the level of exit discharge by partitions, doors, or other effective means [LSC §7.7.3]. The stairway landing at the First Floor is located adjacent to the courtyard and the main lobby. Glass storefront doors are provided into the courtyard. The glass storefront doors are considered to provide adequate visual indication for occupants to realize they have reached the level of discharge. However, signage should be provided to direct occupants to use the main lobby exit instead of the courtyard as the exit. If acceptable signage cannot be provided, then an interruption gate should be provided to prevent occupants from descending past the First Floor.

A prior recommendation to provide a “NOT AN EXIT” signage at the discharge of egress stairways on the First Floor has been retained for this FHA (**See Recommendation HAI-06-911-17**).

8.7 Horizontal Sliding Doors

A horizontal sliding door is provided in a means of egress on the First Floor adjacent to the Electronics Shop. Approved, existing horizontal-sliding or vertical-rolling fire doors are permitted in means of egress under the following conditions [LSC §39.2.2.2.7; §40.2.2.2.4]:

- They are held open by fusible links.
- The fusible links are rated at not less than 165°F.
- The fusible links are located not more than 10 ft above the door.
- The fusible links are in immediate proximity to the door opening.
- The fusible links are not located above a ceiling.
- The door is not credited with providing any protection for life safety purposes (i.e., property protection only).

Based on visual observations of the door, the door appears to comply with these criteria and may be allowed to remain as a means of egress.

8.8 Fire Escape Ladders

Fire escape ladders complying with 7.2.9 are permitted in industrial and business occupancies [§40.2.2.10; §39.2.2.10]. Fire escape ladders are permitted as means of egress only where one of the following conditions exists:

- Access to unoccupied roof spaces as permitted by 7.2.8.3.4.
- Secondary means of egress from boiler rooms or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.
- Means of egress from towers and elevated platforms around machinery or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.

Fire escape ladders are provided in the following locations (egress from interior occupied spaces only):

1. Mezzanine above the Multipole Room – ladder from platform down to Power Supply room.
2. Room 241-C to Vacuum Lab roof – ladder up to roof of high-bay Magnetic Measurement room.
3. Room 242 to Vacuum Lab roof – ladder up to roof of high-bay Magnetic Measurement room.

The LSC would not explicitly permit the continued use of the fire escape ladders as means of egress under the existing conditions. However, the construction of new code-compliant exits to serve the affected areas is not considered feasible. The intent of providing the fire escape ladders

is as secondary, emergency exits (means of escape) to be used in the event that the primary exits are not available or untenable. The continued use of the fire escape ladders is acceptable provided that recommended fire protection upgrades such as the installation of automatic sprinklers are implemented.

8.9 Door Heights

Emergency exit doors are provided from the Second and Third Floors for access to the roofs. The typical emergency exit door provides a clear height of 5 ft 9 in. (69 in.) Means of egress are required to provide a headroom clearance of not less than 6 ft 8 in. at doorways [LSC §7.1.5.1]. Due to the constraints of the existing building construction and the relative familiarity of building occupants with these emergency exits, the existing deficient emergency exit doors are considered acceptable for secondary egress.

8.10 Discharge to Roofs

Exits are permitted to discharge to roofs or other sections of the building where the following criteria are met and with approval by the authority having jurisdiction [LSC §7.7.6]:

- The roof/ceiling assembly construction has a fire-resistance rating not less than that required for the exit enclosure.
- A continuous and safe means of egress from the roof is available.

Two fire escape ladder exits discharge to the high-bay Magnetic Measurement roof/ceiling assembly which is not fire resistance-rated. From this roof, access directly to grade (an access road) is provided on the northwest side of the building.

In addition, emergency roof access is provided from the north egress stairway adjacent to Room 217 and from the air conditioning equipment room. This exit route leads across the Pump Room roof, up an exterior steel stairway to the Main Magnet Evaporative Cooler equipment platform from which a steel grate stairway (seven risers down) provides access to grade.

A prior recommendation to provide a designated path across the roof has been retained for this FHA (**See Recommendation HAI-06-911-18**).

8.11 Barriers

8.11.1 Occupancy Separations

8.11.2 Incidental Use Areas

Incidental use areas or hazardous areas are considered those spaces that pose a relatively higher hazard than the predominant occupancy of the area in which they are located. Such spaces are not necessarily classified as high-hazard (Group H) occupancies. Hazardous areas include general storage rooms, boiler or furnace rooms, and maintenance shops. The LSC requires hazardous areas to be separated from adjoining areas by a 1-hour fire resistance-rated barrier without windows or protected by automatic fire suppression systems [LSC §8.7.1.1].

Rooms with severe hazards such as maintenance shops with woodworking and painting are required to have both fire barrier enclosure and automatic fire suppression.

The Boiler Room is not adequately protected in accordance with the LSC or BCNYS, because the room is not sprinklered and the fire resistive enclosure/separation is not maintained. Electronics Shop 143, Vacuum Lab 160, and Magnetic Measurement Area 112B are sprinklered and thus comply with the code requirements.

8.11.3 Separation of Means of Egress

8.11.4 Exit Access Corridors

Exit access corridor walls are typically constructed of concrete masonry and extend from the floor to the underside of the floor slab above. Fire resistance-rated corridor walls are not required in existing assembly [LSC §13.3.6], existing business [LSC §39.3.6], and industrial occupancies [LSC §40.3.6].

The BCNYS requires exit access corridors serving occupancies in Groups A, B or F in non- or partially-sprinklered buildings to be enclosed with 1-hour fire partitions [BCNYS Table 1004.3.2.1].

Corridor doors (from adjacent spaces) are typically non-rated. Penetrations through the corridor walls were observed to generally be unprotected. The corridor walls are not considered to provide the required fire resistance due to the unprotected openings and penetrations.

The BCNYS requires exit access corridors in non- or partially-sprinklered buildings and serving occupancies in Groups A, B or F to be enclosed with 1-hour fire partitions. Although the exit access corridor walls are typically constructed of concrete masonry and could provide an acceptable level of fire resistance, the corridor walls cannot be considered as complying with the BCNYS requirements due to the presence of non-rated corridor doors and unprotected openings and penetrations (**See Recommendation HAI-06-911-19**).

8.11.5 Vertical Opening Barriers

8.11.6 Egress Stairways

Vertical openings, including stairways, are required to be enclosed with fire-resistive construction to limit fire and smoke spread to other floors. The building contains five stairways that serve as required means of egress.

Vertical openings must be enclosed or protected in accordance with LSC Section 8.6 unless otherwise permitted by the following [LSC §39.3.1.1; §40.3.1]:

1. Unenclosed vertical openings in accordance with 8.6.8.2 shall be permitted.
2. Exit access stairs shall be permitted to be unenclosed in two-story, single-tenant spaces that are provided with a single exit in accordance with 39.2.4.2(5).

3. Unprotected vertical openings shall be permitted in buildings complying with all of the following:

    a. Where protected throughout by an approved automatic sprinkler system in accordance with 9.7.1.1(1);

    b. Where no unprotected vertical opening serves as any part of any required means of egress; and

    c. Where required exits consist of exit doors that discharge directly to grade in accordance with 7.2.1, outside stairs in accordance with 7.2.2, smokeproof enclosures in accordance with 7.2.3, or horizontal exits in accordance with 7.2.4.

Four of the egress stairways are not fully enclosed at all floor levels:

1. The egress stairway leading down from the Vacuum Group and Terminal Room 222 is unenclosed at the Second Floor.
2. The egress stairway adjacent to Rooms 109 and 217 is unenclosed at both the First and Second Floors and discharges into the original building lobby.
3. The egress stairway adjacent to Electronics Shop 143 and Rooms 239 and 250 is unenclosed at both floors.
4. The egress stairway adjacent to the main entry lobby at the southeast corner of the building is separated from the Second Floor and Third Floor by a pair of fire doors, but is not enclosed or separated at the First Floor.

The following methods may be implemented to address the lack of protection of these stairways:

1. Provide new 1-hour fire resistance-rated walls and 1-hour fire doors to enclose the stairways.
2. Provide cross-corridor fire doors to separate the portion of the corridor providing access to/from the stairway from the remainder of the corridor. Seal through-penetrations of the corridor walls in the protected area with approved or listed firestopping. This approach utilizes existing wall construction to create enlarged fire-resistive stair enclosures.
3. Provide draft curtains and closely-spaced sprinklers to protect the floor opening created by the stairway as is permitted by the building code for non-egress stairways.

    Note: Options #2 and #3 are not intended for code compliance, but to mitigate the hazards posed by the unprotected vertical openings.

A prior recommendation (LSC90-911-5) to enclose the four egress stairways has been retained in principle and modified for this FHA (**See Recommendation HAI-06-911-20**).

8.12 Fire Protection Systems Required by Code

Automatic sprinkler protection is required to address some of the conditions found in the building. These are discussed elsewhere in this report.

8.13 Operational Requirements that are Required by Code

When performed, cutting and welding operations in the building are required to be conducted in accordance with NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition.

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2004 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

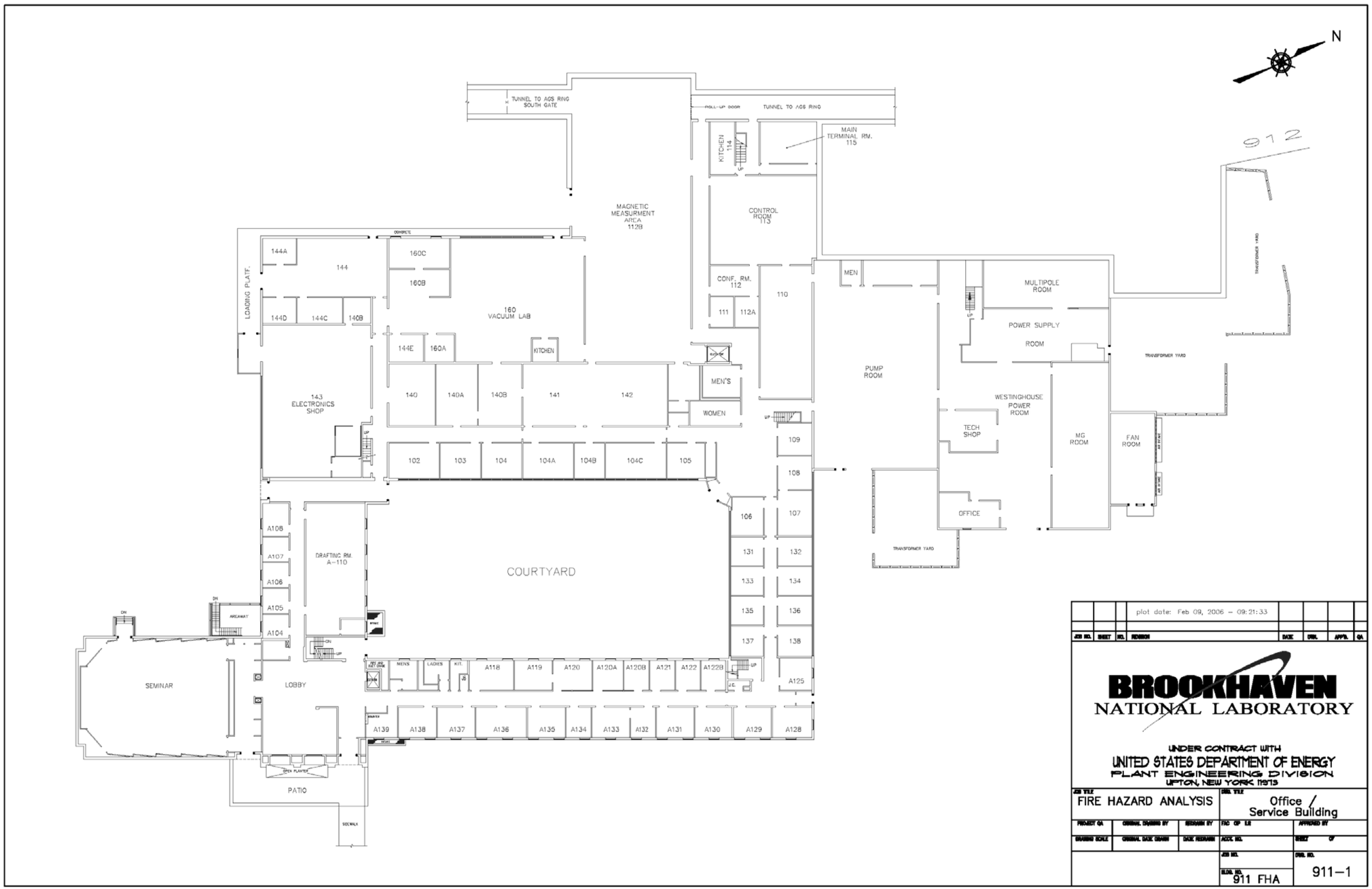
9.2 FM Global Loss Prevention Data Sheets

1-6, Cooling Towers

5-4, Transformers

APPENDIX A –

FHA FIGURES



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BROOKHAVEN NATIONAL LABORATORY

UNDER CONTRACT WITH
UNITED STATES DEPARTMENT OF ENERGY
PLANT ENGINEERING DIVISION
UPTON, NEW YORK 11973

JOB TITLE: FIRE HAZARD ANALYSIS	DWG. TITLE: Office / Service Building
PROJECT QA:	ORIGINAL DRAWING BY:
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APPROVED BY:	DRAWING SCALE:
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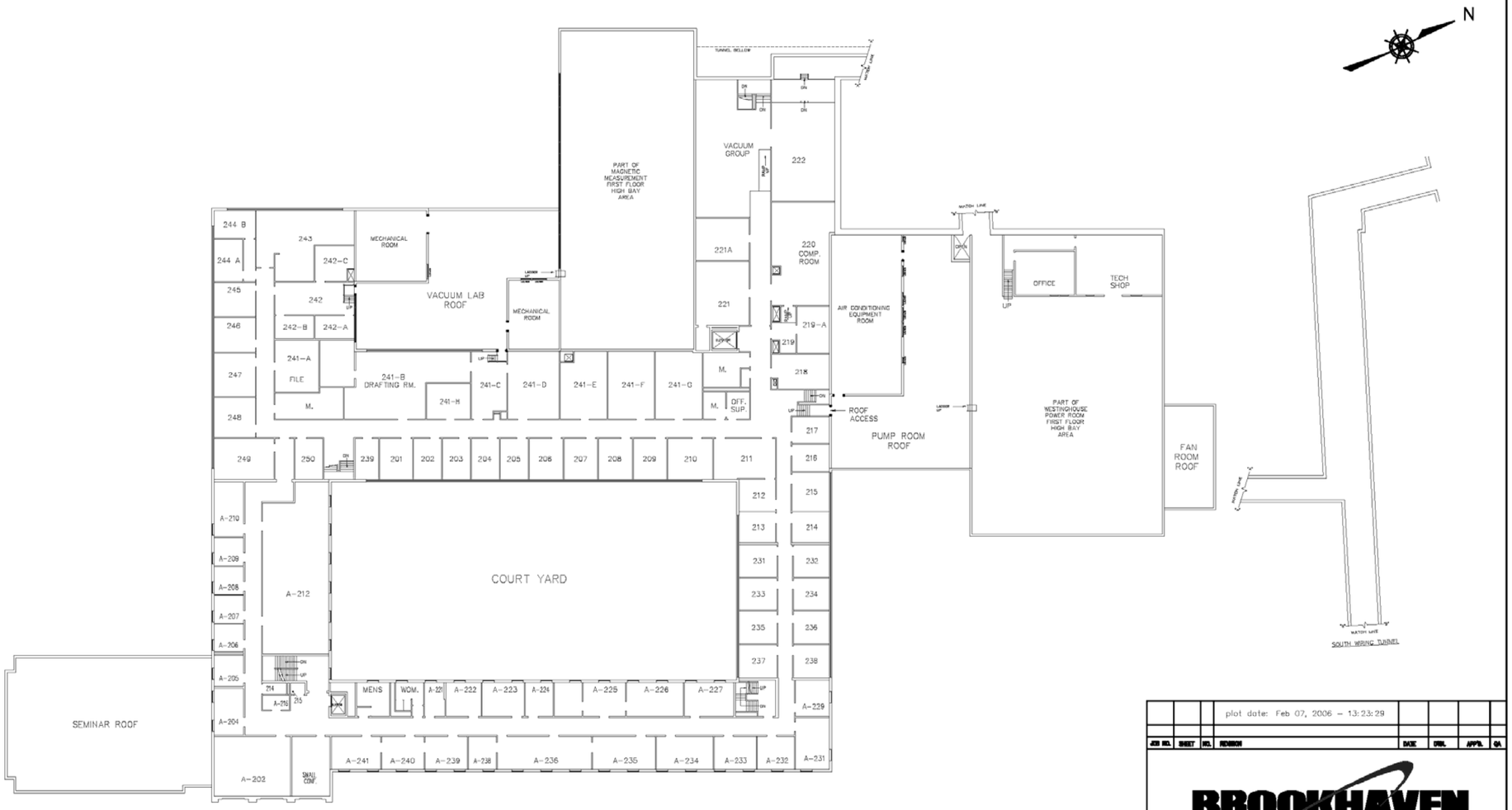
BLDG. NO.: 911 FHA	



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JOB TITLE: FIRE HAZARD ANALYSIS	DWG. TITLE: Office / Service Building
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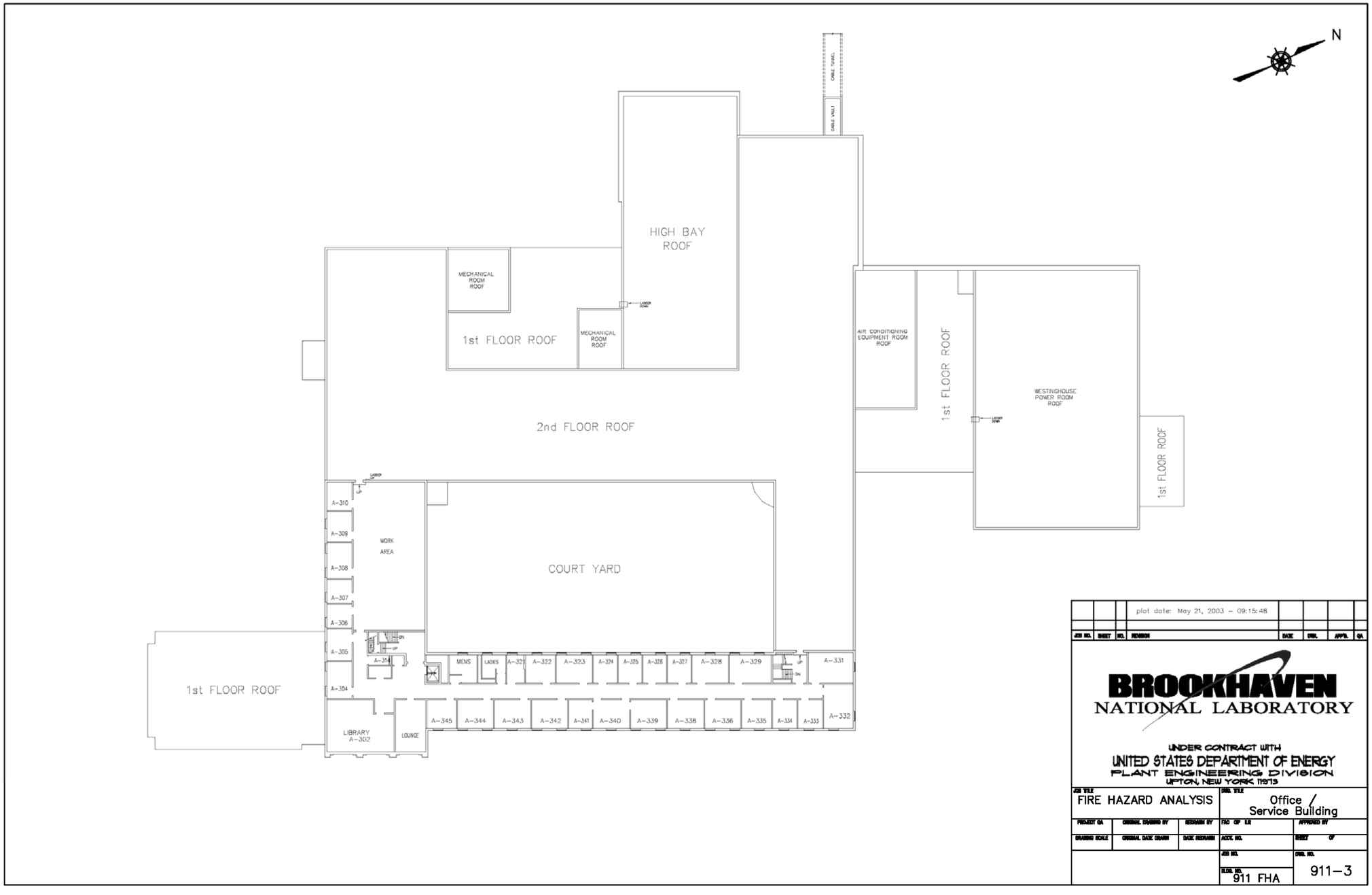
BLDG. NO. 911 FHA	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CABLE VAULT
HIGH BAY ROOF
MECHANICAL ROOM ROOF
1st FLOOR ROOF
MECHANICAL ROOM ROOF
2nd FLOOR ROOF
AIR CONDITIONING EQUIPMENT ROOM ROOF
1st FLOOR ROOF
WESTINGHOUSE POWER ROOM ROOF
1st FLOOR ROOF
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A-304
WORK AREA
COURT YARD
1st FLOOR ROOF
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MENS
LADIES
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LIBRARY A-302
LOUNGE
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UPTON, NEW YORK 11973
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DWG. TITLE
Office / Service Building
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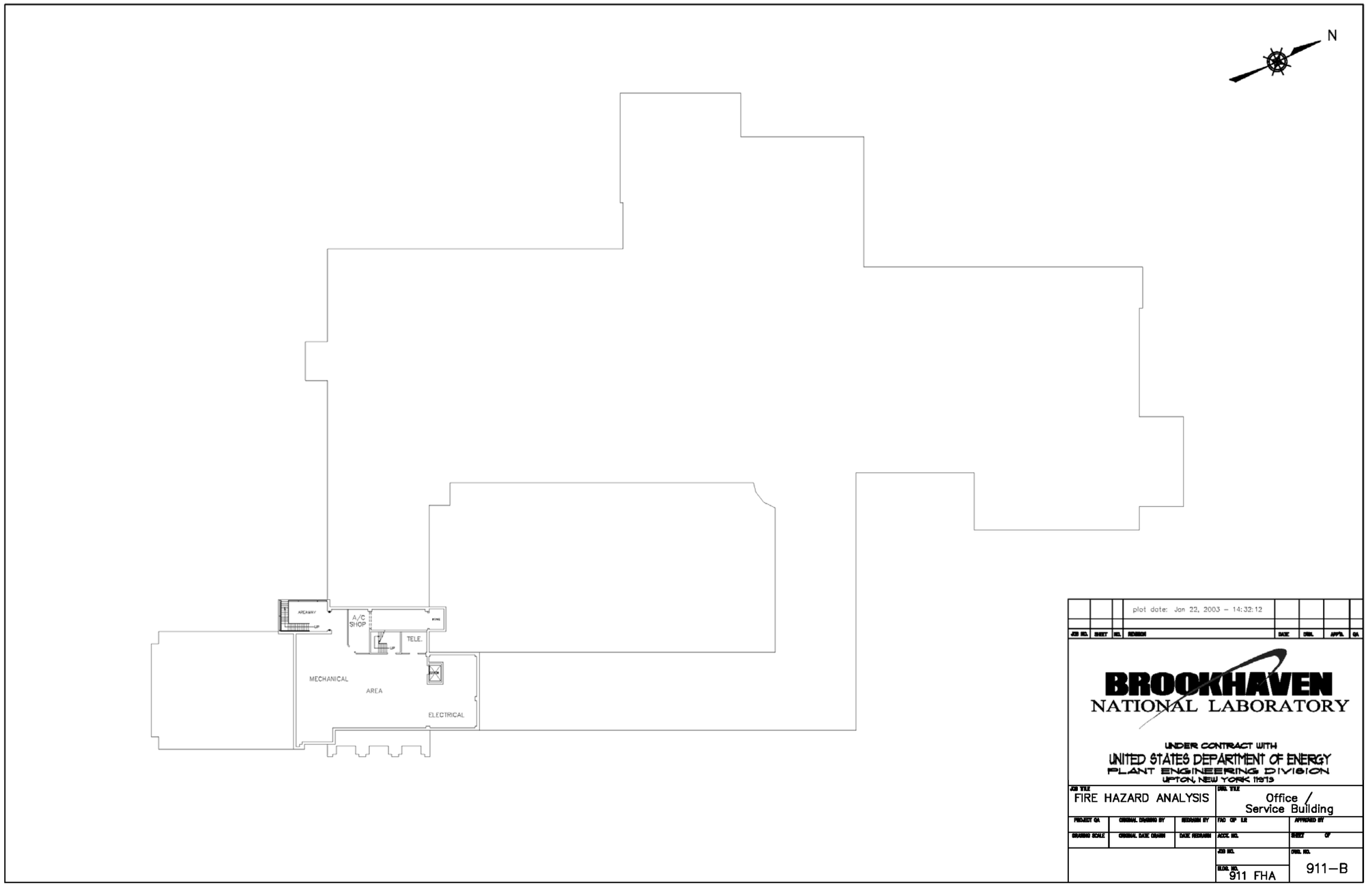
911-3



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JOB TITLE: FIRE HAZARD ANALYSIS			DWG. TITLE: Office / Service Building	
PROJECT QA	ORIGINAL DRAWING BY	REDRAWN BY	FAC. OP. LIT.	APPROVED BY
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			BLDG. NO. 911 FHA	

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0074** and the tolerable lightning frequency (Nc) is **0.0002**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d = **0.0074** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **0.25** = the environmental coefficient

(A_e) = **14,702** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	**200**	Feet
Width (W)	**100**	Feet
Height (H)	**45**	Feet

0.25

Figure H.4.2(a) Results **14,702** sq. meters

Figure H.4.2(b) Results **5,319** sq. meters

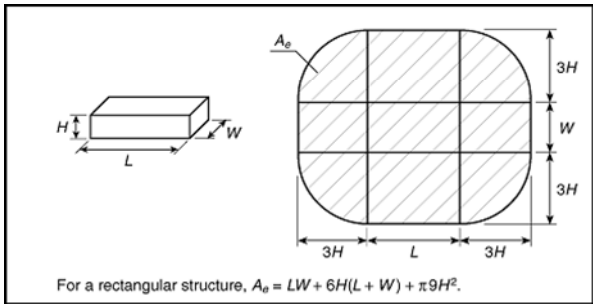
Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

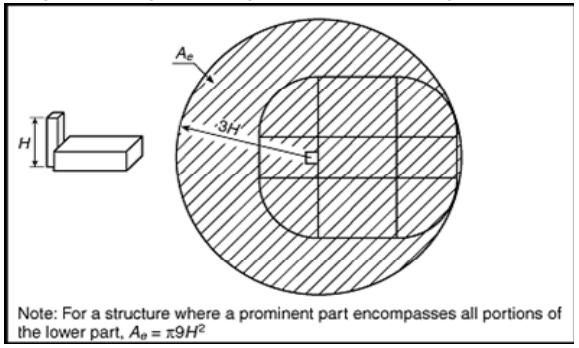
0.25

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

Assume **1.0**

C_2 — Structural Coefficients			
	Roof		
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required

APPENDIX C –

DETERMINATION OF WILDFIRE HAZARD SEVERITY USING NFPA 1144

ELEMENT	POINTS
A. Means of Access	
1. Ingress and egress	
a. Two or more roads in/out	**0**√
b. One road in/out	7
2. Road width	
a. >= 24 ft	0
b. >= 20 ft and < 24 ft	**2**√
c. < 20 ft	4
3. All-season road condition	
a. Surfaced road, grade <5%	**0**√
b. Surfaced road, grade > 5%	2
c. Non-surface road, grade < 5%	2
d. Non-surface road, grade > 5%	5
e. Other than all-season	7
4. Fire Service Access	
a. <= 300 ft with turnaround	**0**√
b. > 300 ft with turnaround	2
c. < 300 ft with no turnaround	4
d. >= 300 ft with no turnaround	5
5. Street Signs	
a. Present	**0**√
b. Not present	5
B. Vegetation (Fuel Models)	
1. Characteristics of predominate vegetation within 300 ft.	
a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
2. Defensible space	
a. More than 100 ft of vegetation treatment from the structures	1
b. 71 ft to 100 ft of vegetation treatment from the structures	
c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
d. < 30 ft of vegetation treatment from the structures	25
C. Topography Within 300 of Structures	
1. Slope < 9%	**1**√
2. Slope 10% to 20 %	4
3. Slope 21% to 30%	7

4.	Slope 31% to 40%	8
5.	Slope > 41%	10

D. Additional Rating Factors

1.	Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2.	Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3.	Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4.	Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1.	Class A roof	0
2.	Class B roof	**3**√
3.	Class C roof	15
4.	Nonrated	25

F. Building Construction

1.	Materials		
	a.	Noncombustible/fire-resistive siding, eaves, and deck	**0**√
	b.	Noncombustible/fire-resistive siding and combustible deck	5
	c.	Combustible siding and deck	10
2.	Building setback relative to slopes of 30% or more		
	a.	>= 30 ft to slope	1
	b.	< 30 ft to slope	5

G. Available Fire Protection

1.	Water source availability		
	a.	Pressurized water source availability	
		500 gpm hydrants <= 1000ft apart	**0**√
		250 gpm hydrants <= 1000ft apart	1
	b.	Nonpressurized water source availability	
		>= 250 gpm continuous for 2 hours	3
		< 250 gpm continuous for 2 hours	5
	c.	Water unavailable	10
2.	Organized response resources		
	a.	Station <= 5 miles from structure	**1**√
	b.	Station > 5 miles from structure	3
3.	Fixed fire protection		
	a.	NFPA 13	**0**√
	b.	None	5

H. Placement of Gas and Electric Utilities

1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5

I. Total **18**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 32 = A LOW Hazard